Part 2

Pure Water Southern California

PROGRAM TITLE

Large-Scale Recycled Water Project Feasibility Study

U.S. Department of Interior, Bureau of Reclamation

January 19, 2024

PURE WATER SOUTHERN CALIFORNIA

Partnering Agencies:

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

LOS ANGELES COUNTY SANITATION DISTRICTS

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LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF FUTURE AGREEMENTS FOR THE PURCHASE AND DELIVERY OF ADVANCED TREATED WATER FOR REPLENISHMENT OF THE MAIN SAN GABRIEL GROUNDWATER BASIN

A. This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan), SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT (SGVMWD), and THE WATERMASTER FOR THE MAIN SAN GABRIEL GROUNDWATER BASIN (Watermaster), who may be referred to individually as "Party" or collectively as "Parties."

RECITALS

B. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water (AWT Water) from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

C. If the Program is approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of AWT Water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins for indirect potable reuse (IPR) through replenishment of those Basins. Delivery locations along the alignment will consist of either existing or new groundwater spreading basins or new or existing injections wells.

D. The AWT Conveyance System could also deliver some of the AWT Water to Member Agencies in the Los Angeles and Long Beach Harbor areas for delivery to industrial customers of those Member Agencies. Additionally, some of the AWT Water may be delivered through an extension of the AWT Conveyance System to certain Metropolitan treatment plants for direct potable reuse (DPR) through raw water augmentation.

E. Water rights have been adjudicated in the Main San Gabriel Basin (the "Basin") according to the Judgment in Los Angeles County Superior Court; Civil Action No. 924128 entitled "Upper San Gabriel Valley Municipal Water District vs. City of Alhambra, et al." (herein referred to as "the Judgement"). The Judgment also established the Watermaster as the agency responsible for managing the Basin and authorized Watermaster to purchase Supplemental Water, as defined in the Judgment, for replenishment of the Basin.
Watermaster purchases Supplemental Water from three Responsible Agencies, as defined in the Judgment, which have a course of Supplemental Water to the Basin.

F. The San Gabriel Valley Municipal Water District, as State Water Project Contractor and not a Metropolitan member agency, is also named as a Responsible Agency under the Judgment and sells water to Watermaster.

G. SGVMWD delivers water to the Main San Gabriel Basin at various locations. The Watermaster has contracted with Los Angeles County Department of Public Works (LA County Public Works) for introduction of water into the Basin. LA County Public Works operates the spreading basins and related facilities that introduce water into the Basin, including SGVMWD water delivered for replenishment of the Basin. Introduction of AWT Water into the Basin may require additional facilities, separate from the existing facilities currently utilized by LA County Public Works to introduce Metropolitan potable water into the Basin.

H. At times, SGVMWD may not have sufficient quantities of imported water to meet the Watermaster's immediate Supplemental Water requirements to deliver into the Basin. To ensure additional consistency and reliability of SGVMWD deliveries, SGVMWD is interested in purchasing and receiving AWT Water to be delivered by Metropolitan via the AWT Conveyance System to meet the Watermaster's replenishment demands for the Basin.

I. Due to the size, complexity and anticipated capital investment required of Metropolitan for the Program, it will be beneficial for all Parties to coordinate and collaborate, as appropriate, during the developmental stages of the Program. Such coordination and collaboration will ensure that the system is planned, designed, constructed, and operated in a manner consistent with the best interests of the Parties and to ensure delivery of AWT Water into the Basin is feasible. Coordination and collaboration between the Parties is also necessary to ensure the development of a commitment by Three Valleys and Upper San Gabriel Valley District to purchase AWT Water from the Program.

TERMS

1. INTENT OF THE PARTIES:
   a. The Parties intend to develop a plan to ensure that deliveries of AWT Water from the Program can be introduced into the Basin. To that end, the Parties intend to:

      i. Collaborate to provide all information to the Watermaster, LA County Public Works, or any regulatory agency, may need to approve introduction of AWT Water into the Basin;

      ii. Identify and examine potential water quality issues and specifications related to the Program that may affect the Watermaster's, or any regulatory agency's approval;

      iii. Identify any related research, testing, and other technical work necessary to address any concerns raised by the Watermaster, or regulatory agency, in connection with approval of introduction of AWT Water into the Basin;

      iv. Collaborate on regulatory developments related to introduction of AWT Water into the Basin;

v. Collaborate to develop an agreement with LA County Public Works for its operation of facilities necessary to introduce AWT Water into the Basin, including construction of new facilities that may be required for introduction of AWT Water into the Basin;

vi. Develop plans for any new infrastructure that may be necessary to introduce AWT Water into the Basin; identify opportunities to expand scope of water deliveries to include other responsible agencies and adjacent groundwater basins; and

vii. Develop additional areas for collaboration and support, as identified by the Parties.

b. It is the intent of the Parties to collaborate in the development of a set of agreements between the Parties for:

i. the long-term purchase and receipt of at least 6,000 AFY AWT Water by SGVMWD with a maximum range of 60,000 to 80,000 AFY AWT, collectively, for all parties, and Metropolitan's delivery of AWT Water to SGVMWD;

ii. the Watermaster's approval of delivery of AWT water into the Basin, pursuant to a purchase agreement between Metropolitan and SGVMWD; and

2. NON-BINDING INTENT

The provisions of this LOI represent a statement of the Parties' general intent only and shall not be binding on either Party. No Party shall have any obligation to enter into any agreement listed in Section 1.b., or otherwise, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms, and conditions of any agreements developed pursuant to Section 1.b. are subject to approval by the General Manager and the board of Directors of the SGVMWD, the General Manager and the Board of Directors of Metropolitan, the Executive Officer and Board of the Watermaster. No Party shall have any legal obligations to the other unless and until all of the terms and conditions of each of the proposed agreements have been negotiated and agreed to by all Parties and set forth in the agreements, approved by the legislative bodies of all Parties, and signed and delivered by all Parties.

3. NOTICES AND CORRESPONDENCE

Any notice or correspondence under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to : jbednarski@mwdh2o.com

San Gabriel Valley Municipal Water District
Post Office Box 1299
Azusa, CA 91702
Attn: Darin Kasamoto, General Manager
With a courtesy copy by email to: dkasamoto@sgvmwd.com

Main San Gabriel Basin Watermaster
725 North Azusa Avenue
Azusa, CA 91702
Attn: Anthony C. Zampiello, Executive Officer
With a courtesy copy by email to: tonyz@watermaster.org

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party.

4. COUNTERPARTS
This Agreement may be executed in counterparts, and signatures transmitted via facsimile or electronic mail shall be deemed to be originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
Adel Hagekhalil

By: ______________________
General Manager

Date: 6/14/2022

APPROVED AS TO FORM:
Marcia Scully

By: ______________________
General Counsel

SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT
Darin J. Kasamoto

By: ______________________
General Manager

Date: 3/17/22

APPROVED AS TO FORM & LEGALITY:
James D. Ciampa

By: ______________________
General Counsel

Date: 3/14/2022

MAIN SAN GABRIEL BASIN WATERMASTER
Anthony Zampiello

By: ______________________
Executive Officer

Date: 5-12-2022

APPROVED AS TO FORM & LEGALITY:

By: ______________________
Legal Counsel

Date: May 11, 2022

CAP
CENTRAL ARIZONA PROJECT

1110 W Washington St. Suite 310 · Phoenix, AZ 85007 · 602-771-8500   P.O. Box 43020 · Phoenix, AZ 85080 · 623-869-2333

August 26, 2020

Gloria D. Gray, Chairwoman
Metropolitan Water District of Southern California
P.O. Box 54153
Los Angeles, CA 90054-0153

Dear Chairwoman Gray:

The Arizona Department of Water Resources (ADWR) and the Central Arizona Water Conservation District (CAWCD) would like to pursue collaborative efforts toward the development of the Metropolitan Water District of Southern California's (MWD) Regional Recycled Water Program (Project). The Project will purify wastewater to produce high quality water that could be reused and potentially offset use of imported water supplies including Colorado River water.

ADWR and CAWCD believe that significant opportunities to augment the Colorado River could emerge from MWD's Project. Supply augmentation supports our mutual interest– increasing the reliability and resiliency of the Colorado River water supply. Over the years, water managers across the Colorado River basin have worked collectively to address the shared goals of increasing the reliability and resiliency of the water supply provided by the Colorado River through conservation and augmentation. CAWCD, in partnership with MWD and the Southern Nevada Water Authority ("SNWA") have jointly invested in water conservation and augmentation projects such as Brock Reservoir, the Pilot Operation of the Yuma Desalting Plant, and the Pilot System Conservation Project. More recently, ADWR, MWD, SNWA, and Colorado River Commission of Nevada (CRC-NV) entered into an ICS capacity sharing agreement to more effectively use the available ICS storage capacity provided in the Lower Basin Drought Contingency Plan ("LBDCP"). Moreover, one of the goals of the Governor's Water Augmentation, Innovation and Conservation Council, established by Arizona Governor Doug Ducey, is to investigate long-term water augmentation strategies for the state of Arizona. ADWR and CAWCD recognize the potential for MWD's Project to augment Colorado River supplies in the Lower Basin, including supplies that could benefit water users in Arizona.

ADWR and CAWCD are pleased to submit this Letter of Interest in participating with MWD on development of the Project including collaborating on any regulatory changes that may be necessary to facilitate potential exchanges of augmented Lower Basin Colorado River supplies. We look forward to continuing our long history of cooperation and collaboration as we work toward opportunities that will benefit the entire Lower Colorado River Basin.

Sincerely,

Thomas Buschatzke
Director
Arizona Department of Water Resources

Theodore C. Cooke, D.B.A.
General Manager
Central Arizona Water Conservation District

LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF FUTURE AGREEMENTS FOR THE PURCHASE AND DELIVERY OF ADVANCED TREATED WATER FOR REPLENISHMENT OF THE CENTRAL GROUNDWATER BASIN

A. This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan) and THE CENTRAL BASIN MUNICIPAL WATER DISTRICT (Central), who may be referred to individually as "Party" or collectively as "Parties."

RECITALS

B. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation Districts) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water (AWT Water) from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

C. If the Program is approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of AWT Water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins for indirect potable reuse (IPR) through replenishment of those Basins. Delivery locations along the alignment will consist of either existing or new groundwater spreading basins or new or existing injection wells.

D. The AWT Conveyance System could also deliver some of the AWT Water to Member Agencies in the Los Angeles and Long Beach Harbor areas for delivery to industrial customers of those Member Agencies. Additionally, some of the AWT Water may be delivered through an extension of the AWT Conveyance System to certain Metropolitan treatment plants for direct potable reuse (DPR) through raw water augmentation.

E. Water rights have been adjudicated in the Central Basin (the "Basin") according to the Judgment in Los Angeles County Superior Court; Civil Action No. C786656 entitled "Central and West Basin Water Replenishment District, etc. v. Charles E. Adams, et al (herein referred to as "the Judgment"), which has been amended over time. The Judgment also establishes a Watermaster, which includes three bodies; 1) the Administrative Body, comprised of WRD, who administers the Watermaster accounting and reporting functions, 2) the Water Rights Panel, comprised of water rights holders who are selected through election and/or appointment, enforces issues related to pumping rights within the Judgments, and 3) the Storage Panel, which is comprised of the Water Rights Panel and the WRD Board of Directors, who together approves certain groundwater storage efforts. The Water Replenishment District of Southern California's (WRD) service area overlies the Central Basin and engages in activities of capturing, purchasing, and producing supplemental water for replenishing the Basin. Central is a responsible agency under the Judgment and sells water to WRD for the replenishment of the Basin. Central is also a member agency of Metropolitan and purchases water for the replenishment of the Basin.

F. Furthermore, as specified in the Judgment, there exists a total of 330,000-acre-feet of available dewatered space within the Basin. That dewatered space is allocated between the Adjudicated Storage Capacity and a Basin Operating Reserve. In accordance with the Judgment, WRD may use the Basin Operating Reserve to manage available sources of water and otherwise fulfill its replenishment functions.

G. The WRD Board of Directors adopted the "WIN 4 ALL" Program to work with the pumping community, to plan and develop groundwater storage and augmentation projects that will utilize the available dewatered space within the Basin for increased regional sustainability and to provide water supply resiliency. The AWT supplies developed within the Program could serve as a potential water supply source for future groundwater augmentation and storage project development. As a responsible agency under the Judgement that sells replenishment water to WRD,A, and as a Metropolitan member agency, Central could serve as a purchaser of AWT supplies from the Program for Basin projects developed within the WIN 4 ALL Program.

H. Metropolitan delivers water to service connections for Central, at which point Metropolitan no longer controls or owns the water. Introduction of AWT Water into the Basin may require additional facilities, separate from the existing facilities.

I. At times, Metropolitan may not have sufficient quantities of imported water to meet the replenishment requirements to deliver into the Basin. To ensure additional consistency and reliability of Metropolitan deliveries, Central is interested in purchasing and receiving AWT Water by Metropolitan via the AWT Conveyance System to meet the replenishment demands for the Basin.

J. Due to the size, complexity and anticipated capital investment required of Metropolitan for the Program, it will be beneficial for all Parties to coordinate and collaborate, as appropriate, during the developmental stages of the Program. Such coordination and collaboration will ensure that the system is planned, designed, constructed and operated in a manner consistent with the best interests of the Parties and to ensure delivery of AWT Water into the Basin is feasible. Coordination and collaboration between the Parties is also necessary to ensure the development of a commitment by Central to purchase AWT Water from the Program.

TERMS

1. INTENT OF THE PARTIES:

   a. The Parties intend to develop a plan to ensure that deliveries of AWT Water from the Program can be introduced into the Basin. To that end, the Parties intend to:

i. Collaborate to provide all information the Watermaster, LA County Public Works, or any regulatory agency, may need to approve introduction of AWT Water into the Basin;

ii. Identify and examine potential water quality issues and specifications related to the Program that may affect the Watermaster's, or any regulatory agencies, approval;

iii. Identify any related research, testing, and other technical work necessary to address any concerns raised by the Watermaster, or regulatory agency, in connection with approval of introduction of AWT Water into the Basin;

iv. Collaborate on regulatory developments related to introduction of AWT Water into the Basin;

v. Develop plans for any new infrastructure that may be necessary to introduce AWT Water into the Basin; Identify opportunities to expand scope of water deliveries to include other responsible agencies and adjacent groundwater basins; and

vi. Develop additional areas for collaboration and support, as identified by the Parties.

b. It is the intent of the Parties to collaborate in the development of a set of agreements between the Parties for:

i. the long-term purchase and receipt of up to 69,000 AFY AWT Water by Central and Metropolitan's delivery of AWT Water to Central;

ii. the Storage Panel's approval of delivery of AWT water into the Basin, pursuant to a purchase agreement between Metropolitan and Central.

2. NON-BINDING INTENT

The provisions of this LOI represent a statement of the Parties' general intent only and shall not be binding on either Party. No Party shall have any obligation to enter into any agreement listed in Section 1.b., or otherwise, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms and conditions of any agreements developed pursuant to Section 1.b. are subject to approval by the General Manager and the Board of Directors of Central. No Party shall have any legal obligations to the other unless and until all of the terms and conditions of each of the proposed agreements have been negotiated and agreed to by all Parties and set forth in the agreements, approved by the legislative bodies of all Parties, and signed and delivered by all Parties.

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Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

Central Basin Municipal Water District
6252 Telegraph Road, Commerce, CA 90040
Attn: Dr. Alejandro Rojas, General Manager
With a courtesy copy by email to: AlexR@centralbasin.org

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

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THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Adel Hagekhalil

By: ______________________

General Manager

Date: 8/25/2021

APPROVED AS TO FORM:

Marcia Scully

By: M Scully

General Counsel

CENTRAL BASIN MUNICIPAL WATER DISTRICT

Dr. Alejandro Rojas

DocuSigned by:

By: Alejandro Rojas

F4D6598A4B7944F

General Manager

Date: 8/24/2021

APPROVED AS TO FORM & LEGALITY:

Robert Baker, General Counsel

DocuSigned by:

By: Robert Baker

General Counsel

Date: 8/24/2021

LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF FUTURE AGREEMENTS FOR THE PURCHASE AND DELIVERY OF ADVANCED TREATED WATER FOR REPLENISHMENT OF THE CENTRAL AND WEST COAST GROUNDWATER BASINS

A. This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan), the CITY OF LONG BEACH acting through its Board of Water Commissioners (Long Beach), the CITY OF TORRANCE (Torrance), and the WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA (WRD), who may be referred to individually as "Party" or collectively as "Parties."

RECITALS

B. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water (AWT Water) from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

C. If the Program is approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of AWT Water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins for indirect potable reuse (IPR) through replenishment of those Basins. Delivery locations along the alignment will consist of either existing or new groundwater spreading basins or new or existing injection wells.

D. The AWT Conveyance System could also deliver some of the AWT Water to Member Agencies in the Los Angeles and Long Beach Harbor areas for delivery to industrial customers of those Member Agencies. Additionally, some of the AWT Water may be delivered through an extension of the AWT Conveyance System to certain Metropolitan treatment plants for direct potable reuse (DPR) through raw water augmentation.

E. Water rights have been adjudicated in the West Coast Basin and Central Basin (the "Basins") according to the Judgment in Los Angeles County Superior Court; Civil Action No. C786656 entitled "Central and West Basin Water Replenishment District, etc. v. Charles E. Adams, et al., and Civil Action No. C506806 entitled "California Water Service Co., et. al. vs City of Compton, et al. (herein collectively referred to as "the Judgments"), which have been amended over time. The Judgments also establish a Watermaster, which includes three bodies: 1) the Administrative Body, comprised of WRD, who administers the Watermaster accounting and reporting functions, 2) the Water Rights Panel, comprised of water rights holders who are selected through election and/or appointment, enforces issues related to pumping rights within the Judgments, and 3) the Storage Panel, which is comprised of the Water Rights Panel and the WRD Board of Directors, who together approves certain groundwater storage efforts. WRD's service area overlies the Basins and engages in activities of capturing, purchasing, and producing supplemental water for replenishing the Basins. Long Beach is a water rights holder under the Judgments for the Central Basin and is a member agency of Metropolitan. Torrance is a water rights holder under the Judgment for the West Coast Basin and is a member agency of Metropolitan. Long Beach and Torrance purchase water from Metropolitan and are capable of selling water to WRD for replenishment of the Basins.

F. WRD is leading the development of a Regional Brackish Water Reclamation Program (Brackish Program) to remediate a brackish groundwater plume in the West Coast Basin and utilize unused groundwater rights to provide to a new water supply for potable consumption. WRD and the Brackish Program Stakeholders are currently completing a Feasibility Study to evaluate potential project location, capacities, and treatment technologies. WRD and the Stakeholders have identified Brackish Program capacity alternatives of up to 20,000 acre-feet per year. If the Brackish Program is finalized and approved by the WRD Board of Directors, it will also include a groundwater replenishment component to mitigate basin water level impacts and constrain plume migration. Replenishment scenarios, locations and quantities are still in development. Torrance is one of several Stakeholders participating in the Regional Brackish Water Reclamation Program and is interested in purchasing and receiving AWT Water by Metropolitan via the AWT Conveyance System to meet WRD's additional replenishment demands associated with the Brackish Program.

G. Furthermore, as specified in the Judgments, there exists a total of 450,000 acre-feet of available dewatered space within the Basins (330,000-acre-feet total in the Central Basin and 120,000 acre-feet in the West Coast Basin). That dewatered space is allocated between the Adjudicated Storage Capacity and a Basin Operating Reserve. In accordance with the Judgments, WRD may use the Basin Operating Reserve to manage available sources of water and otherwise fulfill its replenishment functions. As parties to the Judgments, Long Beach and Torrance may utilize the space available in the Adjudicated Storage Capacity for groundwater storage and/or augmentation projects in the Basins, by any means authorized under the Amended Judgments.

H. The WRD Board of Directors has recently adopted the "WIN 4 ALL" Program to work with the pumping community, including Long Beach and Torrance, to plan and develop groundwater storage and augmentation projects that will utilize the available dewatered space within the Basins for increased regional sustainability and to provide water supply resiliency. The AWT supplies developed within the Program could serve as a potential water supply source for future groundwater augmentation and storage project development. As Metropolitan member agencies, Long Beach and Torrance could serve as purchasers of AWT supplies from the Program for projects developed within the WIN 4 ALL Program.

I. Due to the size, complexity and anticipated capital investment required of Metropolitan for the Program, it will be beneficial for all Parties to coordinate and collaborate, as appropriate, during the developmental stages of the Program. Such coordination and collaboration will ensure that the system is planned, designed, constructed and operated in a manner consistent with the best interests of the Parties and to ensure delivery of AWT Water into the Basins is feasible. Coordination and collaboration between the Parties is also necessary to ensure the development of a commitment by Long Beach and Torrance to purchase AWT Water from the Program.

TERMS

1. INTENT OF THE PARTIES.

   a. The Parties intend to develop a plan to ensure that deliveries of any AWT Water produced by the Program can be introduced into the Basins. To that end, the Parties intend to:

      i. Collaborate to provide all information any regulatory agency may need to approve introduction of AWT Water into the Basins;

      ii. Identify and examine potential water quality issues and specifications related to the Program that may affect the any regulatory agency's approval for introduction of AWT Water into the Basins;

      iii. Identify any related research, testing, and other technical work necessary to address any concerns raised by any regulatory agency in connection with approval of introduction of AWT Water into the Basins;

      iv. Collaborate on regulatory developments related to introduction of AWT Water into the Basins;

      v. Develop plans for any new infrastructure that may be necessary to introduce AWT Water into the Basins; and

      vi. Develop additional areas for collaboration and support, as identified by the Parties.

   b. It is the intent of the Parties to collaborate in the development of a set of agreements between the Parties setting forth:

      i. The cost of obtaining AWT Water;

      ii. Locations of infrastructure to deliver AWT Water into the Central and West Coast Basins; and

      iii. The long-term purchase and receipt of up to 81,000 AFY of AWT Water in total by Long Beach and WRD via MWD member agencies, including Long Beach and Torrance, to be used for groundwater replenishment, augmentation, and storage projects within the Basins and for commercial and industrial purposes in the Harbor areas.

2. NON-BINDING INTENT

The provisions of this LOI represent a statement of the Parties' general intent only, and shall not be binding on either Party. No Party shall have any obligation to enter into any agreement listed in Section 1.b., or otherwise, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms and conditions of any agreements developed pursuant to Section 1.b. are subject to approval by the Board of Water Commissioners of the City of Long Beach, the City Council of Torrance, the Board of Directors of WRD, and the General Manager and the Board of Directors of Metropolitan. No Party shall have any legal obligations to the other unless and until all of the terms and conditions of each of the proposed agreements have been negotiated and agreed to by all Parties and set forth in the agreements, approved by the legislative bodies of all Parties, and signed and delivered by all Parties.

3. NOTICES AND CORRESPONDENCE

Any notice or correspondence under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

Long Beach Water Department
1800 E. Wardlow Road
Long Beach, CA 90807
Attn: Christopher J. Garner, General Manager
With a courtesy copy by email to: dean.wang@lbwater.org

City of Torrance
20500 Madrona Avenue
Torrance, CA 90503
Attn: Craig Bilezerian, Public Works Director
With courtesy copies by email to: adarlak@torranceca.gov
: cschaich@torranceca.gov
: mknapp@torranceca.gov

Water Replenishment District of Southern California
4040 Paramount Boulevard
Lakewood, CA 90712
Attn: Robb Whitaker, General Manager
With a courtesy copy by email to: dgatza@wrd.org

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Either Party may change the address listed in this section by providing five days' notice to the other Party.

4. COUNTERPARTS

This Agreement may be executed in counterparts, and signatures transmitted via facsimile or electronic mail shall be deemed to be originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Jeffrey Kightlinger

By: ______________________
General Manager

Date: 9/10/20

APPROVED AS TO FORM:

Marcia Scully

By: M Scully
General Counsel

BOARD OF WATER COMMISSIONERS OF THE CITY OF LONG BEACH, ACTING FOR AND ON BEHALF OF THE CITY OF LONG BEACH AND ON ITS OWN BEHALF

Christopher J. Garner

By: ____________________

General Manager

Date: 8/12/20

APPROVED AS TO FORM & LEGALITY:

Charles Parkin, City Attorney

By: ____________________

Deputy City Attorney

CITY OF TORRANCE

Patrick J. Furey

By: ____________________

Mayor

Date: ____________________

ATTEST:

Rebecca Poirier,MMC

BY: ____________________

City Clerk

APPROVED AS TO FORM:

Patrick Q Sullivan

By: ____________________

City Attorney

BOARD OF WATER COMMISSIONERS OF THE CITY OF LONG BEACH, ACTING FOR AND ON BEHALF OF THE CITY OF LONG BEACH AND ON ITS OWN BEHALF

Christopher J. Garner

By: ______________________________

General Manager

Date: ______________________________

APPROVED AS TO FORM & LEGALITY:

Charles Parkin, City Attorney

By: ______________________________

Deputy City Attorney

CITY OF TORRANCE

Patrick J. Furey

By: ______________________________

Mayor

Date: 7/20/2020

ATTEST:

Rebecca Poirier, MMC

BY: ______________________________

Erv City Clerk Rebecca Poirier

APPROVED AS TO FORM:

Patrick Q Sullivan

By: ______________________________ JOCELYN N. SARIGUMBA

FOR City Attorney

WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

Robb Whitaker

By: ______________________

General Manager

Date 8/20/2020

APPROVED AS TO FORM & LEGALITY:

H. Francisco Leal

By: Francisco Leal

District Counsel

LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF A FUTURE MEMORANDUM OF UNDERSTANDING RELATED TO ADVANCED TREATED WATER DELIVERY SYSTEMS BETWEEN THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA AND THE LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan) and the LOS ANGELES COUNTY FLOOD CONTROL DISTRICT (LACFCD), who may be referred to individually as "Party" or collectively as "Parties."

BACKGROUND

A. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

B. If the Program is finalized and approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of treated water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins. The alignment of the AWT Conveyance System could potentially include facilities and property owned by the LACFCD and delivery locations along the alignment could potentially include existing groundwater spreading basins operated by the LACFCD. Metropolitan has divided the pipeline alignment into five segments for consideration of a phased construction approach.

C. Due to the size, complexity and anticipated capital investment required of the Program, Metropolitan desires to coordinate and collaborate with the LACFCD, as appropriate, during the developmental stages of the Program. Such coordination and collaboration will help ensure that the AWT Conveyance System is planned, designed, constructed, and operated in a manner consistent with the facilities and property of the LACFCD, and will enable the parties to explore the feasibility and desirability of utilizing the facilities and property of the LACFCD in the AWT Conveyance System.

TERMS

1. INTENT AND COMPONENTS:

   a. It is the intent of the Parties to collaborate in the development of a potential future MOU memorializing the respective roles and responsibilities of the Parties in regard to a cooperative study of the feasibility, benefits and challenges of utilizing the facilities and property of the LACFCD in the AWT Conveyance System.

   b. The cooperative study could include the following topics:

      i. Help ensure continuity and compatibility of the AWT Conveyance System with LACFCD's facilities, operations, and property;
      ii. Identify and examine potential water quality issues and specifications related to utilizing the LACFCD's facilities and property in the AWT Conveyance System;
      iii. Identify related research, testing, and other technical collaborations;
      iv. Identify potential opportunities for collaboration on regulatory developments related to the Program and LACFCD's facilities, operations, and property; and
      v. Identify additional areas for collaboration and mutual support.

   c. The Parties intend that the potential future MOU could include collaboration on any additional, more detailed studies that the Parties determine are necessary to evaluate the feasibility, benefits and challenges of utilizing the facilities and property of the LACFCD in the AWT Conveyance System. These studies may include the economic and technical feasibility, financing needs, right of way and permitting requirements, environmental and regulatory compliance obligations, brine discharge requirements, and engineering, construction, operational, and water quality specifications.

2. The provisions of this LOI represent a statement of the Parties' general intent only and shall not be binding on either Party. Neither Party shall have any obligation to enter into any MOU, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that whether or not to enter into any future MOU as well as the terms and conditions of that MOU are subject to approval by the Chief Engineer of the Los Angeles County Flood Control District or its Board of Supervisors, as appropriate, and the Metropolitan Board of Directors, and that no Party shall have any legal obligations to the other unless and until all of the terms and conditions of the proposed MOU have been negotiated and agreed to by all Parties and set forth in the proposed MOU, and signed and delivered by all Parties.

3. NOTICES

   Any notice under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

Los Angeles County Flood Control District
900 S. Fremont Ave.
Alhambra, CA 91803
Attn: Dan Lafferty, Deputy Director
With a courtesy copy by email to: dlaffi@dpw.lacounty.gov

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by United States. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party. The Parties are signing this LOI in duplicate originals.

4. COUNTERPARTS

This LOI may be executed in counterparts, and signatures transmitted via facsimile or electronic mail shall be deemed to be originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
Jeffrey Kightlinger

By: [signature]
General Manager

Date: 8/18/20

APPROVED AS TO FORM:
Marcia Scully

By: [signature]
General Counsel

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT,
A body corporate and politic

By ______________________
For Chief Engineer

Date: 8/5/20 ______

APPROVED AS TO FORM:

MARY C. WICKHAM
County Counsel

By ______________________
Deputy

CSD C# 4940

REGIONAL RECYCLED WATER PROGRAM
AGREEMENT

This REGIONAL RECYCLED WATER PROGRAM AGREEMENT ("**Agreement**") is between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA ("**Metropolitan**") and COUNTY SANITATION DISTRICT NO. 2 OF LOS ANGELES COUNTY ("**Sanitation District**"), who may be referred to individually as "**Party**" or collectively as "**Parties.**"

The Sanitation District is the administrative district and agent for the Joint Outfall System[1] of the County Sanitation Districts of Los Angeles County, and in that capacity operates the Joint Water Pollution Control Plant ("**Joint Plant**") in Carson, California.

The Parties wish to develop a Regional Recycled Water Program ("**Program**") with the aim of producing up to 150 million gallons per day ("**MGD**") of advanced treated water ("**Purified Water**") from the Joint Plant for use within Metropolitan's service area.

The Program would benefit Metropolitan and its member agencies by diversifying regional supplies, improving storage and delivery capabilities, and providing a new source of high quality, reliable, and drought-resistant water.

The Program would benefit the Sanitation District by demonstrating the removal of salts and other constituents from the Joint Plant's secondary-treated effluent is feasible, allowing it to be reclaimed and reused in a beneficial manner.

THEREFORE, the Parties agree as follows:

1. **EFFECTIVE DATE:** The Agreement will be effective on the last date of execution by the Parties of the following: (a) this Agreement; (b) the Ground Lease Agreement specified in Exhibit A, Section A1.a; and (c) the Source Water Supply Agreement specified in Exhibit A, Section A2.a., except that Metropolitan's duties to indemnify the Sanitation District with respect to CEQA matters as set forth in Section 4 arise immediately upon Metropolitan's execution of this Agreement.

2. **TERM OF AGREEMENT:** The term of this Agreement will be twenty years from the Effective Date ("**Agreement Term**"), unless terminated earlier by agreement of the Parties.

[1] The members of the Joint Outfall System are County Sanitation Districts Nos. 1, 2, 3, 5, 8, 15, 16, 17, 18, 19, 21, 22, 23, 28, 29, and 34 of Los Angeles County and South Bay Cities Sanitation District of Los Angeles County and are referred to as the "**Joint Outfall Districts.**"

3. PROGRAM AND PROJECT INTENT

a. The goal of the Program is to produce up to 150 MGD of Purified Water from the Joint Plant that is suitable for groundwater recharge and other uses within Southern California.

b. The Program would consist of the following projects (collectively "**Projects**"):

   i. Demonstration Project: Under the **Demonstration Project**, Metropolitan would design, construct, operate, and maintain a small-scale advanced water treatment facility on the Joint Plant property to treat secondary effluent from the Joint Plant with the aim of producing approximately 1 MGD of Purified Water. The principal purpose of the Demonstration Project is to assess the viability of and optimal parameters for proceeding with the Full-Scale Project described below.

   ii. Full-Scale Project: If the Demonstration Project is successful, then the Parties may undertake a **Full-Scale Project**, subject to compliance with all laws. Under the Full-Scale Project, Metropolitan would design, construct, operate, and maintain large-scale advanced water treatment facilities on Sanitation District property to treat secondary effluent from the Joint Plant with the aim of producing up to 150 MGD of Purified Water. The Full-Scale Project may be constructed in multiple phases.

4. CALIFORNIA ENVIRONMENTAL QUALITY ACT

a. For purposes of the California Environmental Quality Act ("**CEQA**"), Metropolitan shall be the lead agency for the Demonstration Project and, if appropriate, for the Full-Scale Project. The Sanitation District shall provide in-kind staff assistance to Metropolitan in preparation of any CEQA documentation. Metropolitan shall be responsible for all other costs of CEQA compliance, and shall indemnify, defend, and hold harmless the Sanitation District and its directors, employees, and agents from any losses, claims, or legal actions of any nature arising out of or relating to the Program or projects' compliance with CEQA.

b. Project construction will not commence until the Parties have: (i) completed all necessary environmental reviews and public hearing processes; (ii) obtained all required permits, approvals and authorizations; and (iii) negotiated, executed, and delivered the Ground Lease Agreement and Source Water Supply Agreement described in Exhibit A.

5. PROJECT DESCRIPTIONS

a. Demonstration Project: This Agreement is binding only with respect to the Demonstration Project, the terms and conditions of which are set forth below and in Exhibit A ("**Demonstration Project Terms**").

b. Full-Scale Project:

i. The Agreement is not a binding commitment upon the Parties to proceed with the Full-Scale Project. Rather, the terms and conditions that are set forth in this Agreement and in Exhibit B with respect to the Full-Scale Project are proposed terms only ("**FSP Proposed Terms**").

ii. Either Party may decide, in its sole discretion, whether and on what terms to proceed with the Full-Scale Project following completion of the Demonstration Project and any environmental review required under CEQA.

iii. If the Parties decide to proceed with the Full-Scale Project, then the final terms and conditions applicable to that project ("**FSP Final Terms**") will be set forth in one or more separate agreements. It is the Parties' present intent that the FSP Final Terms be consistent with the FSP Proposed Terms. However, the FSP Final Terms may deviate from the FSP Proposed Terms. The Parties agree to negotiate in good faith regarding any changes to the FSP Proposed Terms, but each Party retains discretion to negotiate any changes it deems necessary or desirable.

6. NOTICES

a. Any notice under this Agreement must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attention: John Bednarski, Section Manager
With a courtesy copy by email to: jbednarski@mwdh2o.com

County Sanitation District No. 2 of Los Angeles County
1955 Workman Mill Road
Whittier, CA 90601
Attn: Technical Services Department Head
With a courtesy copy by email to: pfriess@lacsd.org

b. A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

c. Either Party may change the address listed in section 6.a above by providing five days notice to the other Party.

7. **AGREEMENT ADMINISTRATORS**:

a. The following persons are designated as the **Agreement Administrators:**

For Metropolitan Water District:
John Bednarski, Section Manager
Tel: 213-217-5526
Email: jbednarski@mwdh2o.com

For the Sanitation District:
Philip L. Friess, Department Head, Technical Services
Tel: 562-699-7411 x 2501
Email: pfriess@lacsd.org

b. A Party's Agreement Administrator will be the primary point of contact and authorized representative for that Party and shall be responsible for obtaining on that Party's behalf any approvals, authorizations or permits that may be necessary under this Agreement.

c. Each Party may designate a different person to serve as its Agreement Administrator by providing the other Party with five days notice of any such change.

8. **RECORDS RETENTION AND INSPECTION:** Each Party shall maintain, and shall cause its employees, agents, representatives, subcontractors and suppliers to maintain, all records, regardless of form or type, related to any activities undertaken or obligations performed pursuant to this Agreement, including any and all project-related documents, reports, data, analyses, plans, specifications, drawings, photographs and financial information ("**Records**"). Records must be maintained for a period of four years following the end of the Agreement Term or the conclusion of any litigation arising out of or related to this Agreement, whichever is later. Each Party may inspect, review, copy, transcribe and/or download the other Party's Records upon five days notice to that Party.

9. **WORKING COMMITTEE:** The Parties shall establish a working committee ("**Working Committee**") to oversee and manage, on a day-to-day basis, any work or activities conducted pursuant to this Agreement. The Working Committee should be comprised of appropriate managerial, technical, and support staff from each Party. However, each Party retains sole discretion to determine which of its staff to appoint to the Working Committee.

10. **DISPUTE RESOLUTION:** The Parties shall attempt to resolve any dispute, claim, controversy or disagreement arising from or relating to this Agreement ("**Dispute**") in a prompt, equitable, and amicable manner. Any Dispute will be submitted first to the Working Committee. If the Working Committee does not resolve the Dispute within fifteen days after submittal, then the Dispute will be referred to the Parties' Agreement Administrators. If the Agreement Administrators do not resolve the Dispute within thirty days after referral, then either Party may pursue any legal or equitable remedies it may

have with respect to that Dispute. The timeframes provided in this section may be extended by mutual agreement of the Parties.

11. **INDEMNITY:** Subject to the CEQA indemnity above and more specific indemnities set forth in any lease agreement or water supply contract, each Party will indemnify the other Party as set forth below.

   a. The Sanitation District shall defend, indemnify and hold harmless Metropolitan and its Board of Directors, officers, agents, contractors, subcontractors of any tier, and employees ("**Metropolitan Parties**") from all suits, claims, causes of action or liability of any kind ("**Claims**") arising out of or in connection with (i) the acts or omissions of the Sanitation District and its Board of Directors, officers, agents, contractors, subcontractors or any tier, and employees ("**Sanitation District Parties**") under this Agreement; (ii) any work performed by the Sanitation District Parties pursuant to this Agreement; and (iii) the condition of the Joint Plant outside the leasehold areas. This duty to defend, indemnify, and hold harmless will not apply to any suits, claims, causes of action or liability resulting from the willful misconduct or active negligence of any Metropolitan Parties. The Sanitation District shall have any contractor it hires in connection with the Demonstration Project name Metropolitan and the Metropolitan Parties as additional insureds on any policies of insurance required of that contractor by the Sanitation District.

   b. Metropolitan shall defend, indemnify and hold harmless the Sanitation District Parties from all Claims arising out of or in connection with: (i) the acts or omissions of the Metropolitan Parties under this Agreement; (ii) any work performed by the Metropolitan Parties pursuant to this Agreement; and (iii) Metropolitan's leasehold for the Demonstration Project Site. This duty to defend, indemnify, and hold harmless shall not apply to any suits, claims, causes of action or liability resulting from the willful misconduct or active negligence of the Sanitation District Parties. Metropolitan shall have any contractor working on the Demonstration Project name the Sanitation District and its affiliates, directors, officers, agents, and employees as additional insureds on any policies of insurance required of that contractor by Metropolitan.

12. **NO PARTNERSHIP; INDEPENDENT CONTRACTORS:** The Parties do not by this Agreement intend to create any partnership or joint power authority. In performing any work under this Agreement, Metropolitan and the Sanitation District are acting as independent contractors and all employees of each Party are solely the employees of that Party and not the agents or employees of the other Party.

13. **WAIVER:** No delay or failure by either Party to exercise or enforce at any time any right or provision of this Agreement will be considered a waiver of that right or provision, unless the waiver is made in writing signed by the Party granting the waiver, which need not be supported by consideration. No single waiver will constitute a continuing or subsequent waiver.

14. **SEVERABILITY:** If any provision of this Agreement is held illegal, invalid, or unenforceable, in whole or in part, then that provision will be modified to the minimum extent necessary to make it legal, valid, and enforceable, and the legality, validity, and enforceability of the remaining provisions shall not be affected.

15. **ASSIGNMENT:** Neither Party shall transfer or assign any of its rights or duties under this Agreement without the written consent of the other Party, which consent shall not be unreasonably withheld.

16. **JURISDICTION AND VENUE:** This Agreement is made and will be interpreted under the laws of the State of California. Venue for any action will be the Superior Court of Los Angeles County, California.

17. **ENTIRE AGREEMENT:** This Agreement and the attached Exhibits constitute the entire agreement of the Parties with respect to the Program. This Agreement may not be modified except by a writing signed by both Parties.

The Parties are signing this Agreement in duplicate originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By:______________________
General Manager

APPROVED AS TO FORM:

By:______________________
General Counsel

COUNTY SANITATION DISTRICT NO. 2 OF LOS ANGELES COUNTY

By:______________________
Chairperson

NOV 1 6 2015

ATTEST:

By:______________________
Secretary to the Board

APPROVED AS TO FORM:
Lewis Brisbois Bisgaard & Smith, LLP

By:______________________
District Counsel

EXHIBIT A

SPECIFIC TERMS AND CONDITIONS APPLICABLE TO THE DEMONSTRATION PROJECT

A1. Construction and Operation of Treatment Facility

a. Location: The Parties shall agree upon a suitable location within the boundaries of the Joint Plant for construction and operation of the Demonstration Project (**"Demonstration Project Site"**). The Demonstration Project Site will be leased to Metropolitan at no cost for the duration of the Agreement Term, subject to execution of a separate ground lease agreement (**"Ground Lease Agreement"**) consistent with this Agreement.

b. Capacity: The Demonstration Project is anticipated to have the capacity to produce approximately 1 MGD of Purified Water. The exact design and configuration of this facility will be determined by Metropolitan in its sole discretion.

c. Construction:

i. Within two years after the Effective Date, Metropolitan shall complete all necessary permitting (including compliance with CEQA) and design and construct the Demonstration Project, which may include the following unit processes: ozone, biological granular activated carbon, microfiltration, membrane bioreactor, reverse osmosis, advanced oxidation processes (e.g., hydrogen peroxide, ultraviolet light), ion-exchange and nitrogen removal (e.g., nitrification and denitrification). Metropolitan shall design and construct any power feeds, raw water supply lines, waste stream lines, and other process lines required for the Demonstration Project (**"Ancillary Facilities"**) from suitable tie-in locations at the Joint Plant. The Parties shall agree upon tie-in locations for the Ancillary Facilities prior to the commencement of **Final Design**, defined for the purposes of this agreement as 50% design completion, for the Demonstration Project. Metropolitan shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

ii. Prior to the commencement of construction activities, Metropolitan shall make reasonable efforts to determine whether any hazardous wastes or materials (**"Hazardous Wastes"**) or contaminated soil or groundwater (**"Contamination"**) exists in, on, or under the Demonstration Project Site. If prior to or during construction of the Demonstration Project Metropolitan determines that any Hazardous Wastes or Contamination are present and will be impacted by construction, then Metropolitan shall notify the Sanitation District of the condition immediately after making its determination and shall cease activities as necessary to avoid further disturbing the site. The Parties shall meet and confer to develop an approach to mitigating the condition as cost-effectively as possible. However, unless the Parties agree otherwise, the Sanitation District shall be responsible for removing, disposing and/or treating all pre-existing Hazardous

Wastes and Contamination and for remediating the site as needed to permit construction of the Demonstration Project. Any delays caused by or resulting from these removal or remediation activities will not be considered a breach of this Agreement. Metropolitan shall be responsible for removal, disposal and/or treatment of all other wastes, deposited, produced, or generated during construction of the Demonstration Project.

d. Ownership and Operation:

   i. Metropolitan will be the owner of the Demonstration Project, including any Ancillary Facilities, and shall operate and maintain them for the duration of the Agreement Term. Except as provided otherwise, Metropolitan shall be responsible for all costs associated with operation and maintenance of the Demonstration Project including any Ancillary Facilities.

   ii. In the event that the Demonstration Project is not able to operate for any reason, Metropolitan shall divert untreated Source Water back into the Joint Plant for disposal. Metropolitan shall give the Sanitation District reasonable notice before taking any such action.

   iii. Either Party may utilize the Demonstration Project for public outreach purposes, which may include providing tours of the facility to members of the public. Neither Party shall deny or impose unreasonable restrictions on the use of and access to the Demonstration Project for such purposes.

e. Removal of Demonstration Project: At the conclusion of the Demonstration Project or this Agreement, whichever comes first, the Sanitation District may purchase the Demonstration Project and Ancillary Facilities for their salvage value, as determined by an independent appraisal. If the Sanitation District does not purchase these facilities, then within two years after notice from the Sanitation District, Metropolitan shall remove all facilities and improvements constructed by Metropolitan associated with the Demonstration Project, including any Ancillary Facilities, and return the Demonstration Project Site to its pre-project condition.

f. Permits and Authorizations: Metropolitan shall obtain any and all permits, authorizations, and approvals needed to construct and operate the Demonstration Project and Ancillary Facilities, and shall comply with any and all laws, rules and regulations applicable to the construction and operation of the Demonstration Project and Ancillary Facilities. The Sanitation District shall cooperate with Metropolitan in securing such permits, authorizations, and approvals.

g. Utilities: The Sanitation District shall be responsible for providing, at no cost to Metropolitan, any and all utility connections and services needed to construct and operate the Demonstration Project, including power, potable water, sewer, and solid waste collection services.

h. Right of Inspection: Upon reasonable notice, the Sanitation District may enter the Demonstration Project Site for the purpose of construction or operations.

A2. Provision of Source Water

a. General Obligation: The Sanitation District shall provide, at no cost to Metropolitan, secondary effluent from the Joint Plant ("**Source Water**") in an amount sufficient to meet the treatment capacity of the Demonstration Project as constructed. Prior to commencement of Final Design, the Parties shall agree upon the schedule and criteria for delivery of Source Water to the Demonstration Project. The provision of Source Water is subject to execution of a separate supply agreement ("**Source Water Supply Agreement**") consistent with this Agreement. Metropolitan acknowledges that circumstances beyond the control of the Sanitation District may adversely impact the quality or volume of Source Water available to the Demonstration Project. If any such circumstances occur, the Sanitation District's Chief Engineer may temporarily limit the amount of Source Water made available to the Demonstration Project.

b. Source Water Delivery Facilities:

i. Construction: Within two years after the Effective Date, the Sanitation District shall complete any necessary permitting and design and construct all facilities necessary to deliver Source Water to the Demonstration Project ("**Source Water Delivery Facilities**"). In addition, the Sanitation District shall design and construct any other facilities necessary to provide the tie-ins at the Joint Plant ("**Tie-In Facilities**") for the Ancillary Facilities specified in Section A1.c.i. The Sanitation District shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

ii. Ownership and Operation: The Sanitation District shall be the sole owner of the Source Water Delivery and Tie-In Facilities and shall operate and maintain these facilities for the duration of the Agreement Term. The Sanitation District shall be responsible for all costs associated with operation and maintenance of the Source Water Delivery and Tie-In Facilities.

iii. Permits and Authorizations: Sanitation District shall obtain any permits, authorizations needed to construct and operate the Source Water Delivery and Tie-In Facilities and shall comply with all laws, rules and regulations applicable to the construction and operation of such facilities. Metropolitan shall cooperate with Sanitation District in securing such permits, authorizations and approvals.

A3. Distribution and Use of Purified Water

a. Metropolitan shall convey all Purified Water produced by the Demonstration Project to a suitable location within the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project. The Sanitation District shall be responsible for any subsequent distribution, use or disposal of the Purified Water, and will be entitled to any revenues resulting from that distribution, use, or disposal. The Sanitation District shall obtain and maintain any permits necessary to distribute or use Purified Water from the Demonstration Project.

b. The Sanitation District is not obligated to use any Purified Water, and any Purified Water that is not utilized for non-potable reuse applications will be disposed at the Joint Plant at no cost to Metropolitan.

c. Metropolitan makes no representations, warranties or guarantees of any kind as to the quantity or quality of Purified Water produced by the Demonstration Project.

A4. Disposal of Treatment Residuals

a. The Sanitation District shall be responsible for disposal of any residuals generated by the treatment of Source Water at the Demonstration Project ("**Treatment Residuals**"), including membrane filtration backwash, reverse osmosis brine concentrate and other waste streams (such as acids, anti-scalants, dispersants, and membrane cleaning agents). Metropolitan shall return all Treatment Residuals to a suitable location at the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project.

b. Connection of the Demonstration Project to the Joint Plant for purposes of disposing of Treatment Residuals will not be considered a sewer connection. The Sanitation District shall not assess or collect from Metropolitan any charge or fee of any kind associated with the disposal of Treatment Residuals.

A5. Laboratory Analyses and Data Sharing

a. The Parties shall jointly conduct sampling and laboratory analyses as necessary to monitor and determine the treatment efficacy of the Demonstration Project. The Sanitation District shall be responsible for all sampling and laboratory analyses upstream of the Demonstration Project and Metropolitan shall be responsible for all sampling laboratory analyses within and downstream of the Demonstration Project. If potential cost savings and efficiencies would result from further collaboration on sampling or laboratory analyses, the Parties will meet and confer to determine if a revised division of responsibilities is warranted.

b. The Parties shall share all water quality and process data associated with operation of the Joint Plant and the Demonstration Project during the Agreement Term.

A6. Development of Full-Scale Project Requirements

a. Source Water Criteria: The Parties acknowledge the importance of establishing and maintaining Source Water flow and quality to ensure the long-term success of the Program. Accordingly, the Parties shall meet and confer to develop water quality and flow criteria for the Source Water that will ensure continuous and cost effective treatment at any Full-Scale Project facilities constructed during subsequent phases of the Program. The Parties also shall meet and confer to develop appropriate enhancements to the Sanitation District's industrial wastewater pretreatment program aimed at controlling the entry of contaminants into the Source Water.

b. Additional Studies and Evaluations: The Parties shall cooperate with each other in conducting and preparing any additional studies, evaluations and plans necessary to assess the economic and technical feasibility, financing needs, right-of-way and permitting requirements, environmental and regulatory compliance obligations, and engineering, construction and operational specifications for the Full-Scale Project ("**Additional Studies and Evaluations**"). Unless agreed otherwise, each Party shall be solely responsible for the costs of any Additional Studies and Evaluations it conducts or prepares.

A7. Pursuit of Grant and Loan Funding: The Parties shall jointly pursue grant and loan funding in support of the Demonstration Project. Any grant and loan funding received will be distributed based on the percentage of Demonstration Project facility design and construction costs contributed by each Party in support of the Demonstration Project, not including any fees waived or in-kind services provided by either Party.

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EXHIBIT B

PROPOSED TERMS AND CONDITIONS APPLICABLE TO THE FULL-SCALE PROJECT

B1. Construction and Operation of Treatment Facilities

a. Location: The Parties shall agree upon a suitable location within the boundaries of the Joint Plant for construction and operation of the Full-Scale Project ("**Full-Scale Project Site**") up to 35 acres. Subject to a separate Full-Scale Project ground lease agreement, the Full-Scale Project Site property will be leased to Metropolitan for the following rent: (i) First Year of Lease -- $5,000 per acre in 2015 dollars, adjusted using the Los Angeles-Riverside-Orange County Consumer Price Index for All Urban Consumers or the equivalent successor index ("**CPI**") to the effective date of the lease ("**Base Rent**"); (ii) Subsequent Years of Lease -- Base Rent adjusted annually for inflation using the CPI, but in no event will the adjustment ever be less than zero. The term of the Full-Scale Project ground lease will begin when the construction of the Full-Scale Project commences.

b. Capacity: The Full-Scale Project is anticipated to have the capacity to produce approximately 150 MGD of Purified Water at full build out. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree upon the maximum capacity for that phase. However, the exact design and configuration of each phase will be determined by Metropolitan in its sole discretion.

c. Construction:

i. Metropolitan shall design and construct the Full-Scale Project, which may include the following unit processes: ozone, biological granular activated carbon, microfiltration, membrane bioreactor, reverse osmosis, advanced oxidation processes (e.g., hydrogen peroxide, ultraviolet light), ion-exchange and nitrogen removal (e.g., nitrification and denitrification). Metropolitan shall design and construct any power feeds, raw water supply lines, waste stream lines, and other process lines required for the Full-Scale Project ("**Ancillary Facilities**") either from suitable tie-in locations at the Joint Plant (for Source Water and Treatment Residuals) or directly from utility providers (for potable water, power, and any other utilities). The Parties shall agree upon tie-in locations for the Ancillary Facilities prior to the commencement of Final Design. Metropolitan shall be responsible for the costs of these design and construction activities, except to the extent they are covered by other entities.

ii. The Parties acknowledge that the property potentially available for the Full-Scale Project Site has been undergoing remediation. Prior to the commencement of construction activities for the first phase of the Full-Scale Project, Metropolitan shall make reasonable efforts to determine the extent to which any hazardous wastes and material ("**Hazardous Wastes**") or contaminated soil or groundwater

("**Contamination**") will be impacted by construction. The Parties shall meet and confer to develop an approach to mitigating the condition as cost-effectively as possible. However, unless the Parties agree otherwise, the Sanitation District shall be responsible for removing, disposing and/or treating all pre-existing Hazardous Wastes and Contamination and for remediating the site as needed to permit construction of the Full-Scale Project. Any delays caused by or resulting from these removal or remediation activities will not be considered a breach of this Agreement. Metropolitan shall be responsible for removal, disposal and/or treatment of all other wastes, deposited, produced, or generated during construction of the Full-Scale Project.

d. Ownership and Operation:

   i. Metropolitan will be the owner of the Full-Scale Project, including any Ancillary Facilities, and shall operate and maintain them for the duration of the Program, which is anticipated to have minimum of duration of fifty years. Except as provided otherwise, Metropolitan shall be responsible for all costs associated with operation and maintenance of the Full-Scale Project and Ancillary Facilities.

   ii. In the event that the Full-Scale Project is not able to operate for any reason, Metropolitan shall divert untreated Source Water back into the Joint Plant for disposal. Metropolitan shall give the Sanitation District reasonable notice before taking any such action.

e. Removal of Full-Scale Project: At the conclusion of the Program, the Sanitation District may purchase the Full-Scale Project including any Ancillary Facilities for their salvage value, as determined by an independent appraisal. If the Sanitation District does not purchase these facilities, then within five years after notice from the Sanitation District, Metropolitan shall remove all facilities and improvements constructed by Metropolitan associated with the Full-Scale Project and Ancillary Facilities and return the Full-Scale Project Site to its pre-project condition.

f. Permits and Authorizations: Metropolitan shall obtain any and all permits, authorizations, and approvals needed to construct and operate the Full-Scale Project and Ancillary Facilities, and shall comply with any and all laws, rules and regulations applicable to the construction and operation of the Full-Scale Project and Ancillary Facilities. The Sanitation District shall cooperate with Metropolitan in securing such permits, authorizations, and approvals.

g. Utilities: Except for the provision of Source Water as set forth in Section B2, the disposal of treatment residuals as set forth in Section B4, and sewer services, Metropolitan shall be responsible for providing any and all utility connections and services needed to construct and operate the Full-Scale Project, including power, potable water, and solid waste collection services.

h. Right of Inspection: Upon reasonable notice, the Sanitation District may enter the Full-Scale Project Site for the purpose of inspecting construction or operations.

B2. Provision of Source Water

a. General Obligation: The Sanitation District shall provide, at no cost to Metropolitan, secondary effluent from the Joint Plant ("**Source Water**") in an amount sufficient to meet the treatment capacity for each phase of the Full-Scale Project as constructed. The provision of Source Water is subject to execution of a separate supply Full-Scale Project agreement ("**Source Water Supply Agreement**") consistent with this Agreement.

b. Source Water Criteria:

   i. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree upon the water quality and flow criteria that will apply to any Source Water delivered to the project during that phase ("**Source Water Criteria**"). Once these Source Water Criteria are established, the Sanitation District shall not make any changes in the Joint Plant's facilities, operations or design that may significantly adversely affect the quality or quantity of Source Water, unless required to meet regulatory or other legal requirements. The Parties shall meet and confer in good faith to determine appropriate actions if changes are required. In addition, the Sanitation District shall not enter into any agreement to provide secondary-treated effluent from the Joint Plant to another entity or project that could significantly reduce the amount of Source Water available to the Full Scale Project without the consent of Metropolitan.

   ii. Metropolitan acknowledges that circumstances beyond the control of the Sanitation District may adversely impact the quality or volume of Source Water available to the Full-Scale Project. If any such circumstances occur, the Sanitation District's Chief Engineer may temporarily limit the amount of Source Water made available to the Full-Scale Project. The Sanitation District shall use its best efforts, including modifying Joint Plant operations, to re-establish the availability of Source Water meeting the agreed-upon Source Water Criteria as soon as reasonably possible. In the event of a decrease in availability of Source Water, the Chief Engineer shall promptly notify Metropolitan.

   iii. The Sanitation District will not be liable for any costs or damages incurred by Metropolitan arising out of or relating to any temporary interruption in service or limitation of availability of Source Water ("**Temporary Interruption**") due to either decreased influent flows, operation difficulties, or an inability of the Sanitation District to meet NPDES requirements. Metropolitan hereby releases and covenants not to sue the Sanitation District from or for any and all claims and actions arising out of a Temporary Interruption.

c. Source Water Facilities

   i. Construction: The Sanitation District shall permit, design and construct all facilities necessary to provide the tie-ins at the Joint Plant ("**Tie-In Facilities**"), as specified in section B1.c.i. The Sanitation District shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

ii. Ownership and Operation: The Sanitation District shall be the sole owner of the Tie-In Facilities and shall operate and maintain these facilities for the duration of the Program. The Sanitation District shall be responsible for all costs associated with operation and maintenance of the Tie-In Facilities.

iii. Permits and Authorizations: Sanitation District shall obtain any permits, authorizations and approvals needed to construct and operate the Tie-In Facilities and shall comply with all laws, rules and regulations applicable to the construction and operation of such facilities. Metropolitan shall cooperate with Sanitation District in securing such permits, authorizations and approvals.

d. Source Water Control Program: Prior to commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree on a program for controlling the entry of contaminants into the Source Water delivered to the Full-Scale Project during that phase.

e. Acceptance of Non-Specification Source Water: The Sanitation District shall immediately notify Metropolitan if for any reason the Sanitation District is, or anticipates that it will be, unable to meet the Source Water Criteria agreed to by the Parties pursuant to section B2.b above in the Source Water delivered to Metropolitan ("**Non-Specification Source Water**"). Metropolitan shall use reasonable efforts to accept Non-Specification Source Water for treatment at the Full-Scale Project. However, Metropolitan may reject any Non-Specification Source Water if Metropolitan determines based on its sole judgment that such Source Water may cause significant damage to the Full-Scale Project or cannot be treated to applicable standards in a cost-effective manner.

B3. Distribution and Use of Purified Water:

a. Metropolitan Rights and Responsibilities: Except as otherwise set forth in this Section B3, Metropolitan shall be responsible for and have discretion over any distribution, use or disposal of all Purified Water.

b. Sanitation District Allocation: Metropolitan shall provide Purified Water to the Sanitation District ("**District Allocation**") at no cost based on the treatment capacity of the Full-Scale Project as follows:

i. 0 to 60 MGD: 600 acre-feet per year (AFY);

ii. 61 to 100 MGD: 1,200 AFY;

iii. 101 to 150 MGD: 1,800 AFY.

c. Delivery: Metropolitan shall deliver the District Allocation to groundwater basins within the Sanitation District's Joint Outfall service area where Metropolitan has facilities suitable for this purpose. The District Allocation will be delivered together with Metropolitan's distribution of Purified Water. The allocation between groundwater basins is at the Sanitation District's discretion. Any agreements for the replenishment use of the District's Allocation are the responsibility of the Sanitation District.

d. Participation within Sanitation District Service Area: [SUBJECT TO FURTHER NEGOTIATION]

e. Option: The Sanitation District has option to purchase up to 1 MGD of additional Purified Water at Metropolitan's cost of treatment for Joint Plant uses. Joint Plant uses include those uses identified and implemented during the Demonstration Project. Delivery and use of Purified Water under this option is the responsibility of the Sanitation District.

B4. Disposal of Treatment Residuals

a. The Sanitation District shall be responsible for disposal of any residuals generated by the treatment of Source Water at the Full-Scale Project, including membrane filtration backwash, reverse osmosis brine concentrate and other waste streams (such as acids, anti-scalants, dispersants, and membrane cleaning agents), in accordance with all applicable laws, rules and regulations.

b. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree to the quantity and quality of Treatment Residuals to be disposed at the Joint Plant during that phase. If the anticipated quantity and quality of Treatment Residuals would interfere with the Sanitation District's ability to discharge its Joint Plant waste streams in compliance with applicable laws, rules and regulations, the Parties shall agree to meet and confer to develop actions within their respective treatment operations to ensure such compliance.

c. Metropolitan shall return all Treatment Residuals to suitable locations at the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project.

d. As needed, Metropolitan will treat non-brine components of Treatment Residuals to standards generally applicable to current industrial waste dischargers to the Sanitation District's Joint Outfall System.

e. Connection of the Full-Scale Project to the Joint Plant for purposes of disposing of Treatment Residuals will not be considered a sewer connection. The Sanitation District shall not assess or collect from Metropolitan any charge or fee of any kind associated with the disposal of Treatment Residuals at the Joint Plant, subject to the meet and confer provisions in B4.b.

B5. Laboratory Analyses and Data Sharing

a. The Parties shall jointly conduct sampling and laboratory analyses as necessary to monitor and determine the treatment efficacy of the Full-Scale Project. The Sanitation District shall be responsible for all sampling and laboratory analyses upstream of the Full-Scale Project and Metropolitan shall be responsible for all sampling laboratory analyses within and downstream of the Full-Scale Project. If potential cost savings and efficiencies would result from further collaboration on sampling or laboratory analyses, the Parties shall meet and confer to determine if a revised division of responsibilities is warranted.

b. The Parties shall share all water quality and process data associated with operation of the Joint Plant and the Full-Scale Project during the term of the Program.

B6. Pursuit of Grant and Loan Funding: The Parties shall jointly pursue grant and loan funding in support of the Full Scale Project. Any grant and loan funding received will be distributed based on the percentage of Full Scale Project facility design and construction costs contributed by each Party in support of the Full Scale Project, not including any fees waived or in-kind services provided by either Party. Each Party may, upon 10 days notice, inspect the Program-related books and records of the other Party.

LETTER OF INTENT TO COLLBORATE ON THE DEVELOPMENT OF A FUTURE MEMORANDUM OF UNDERSTANDING RELATED TO ADVANCED TREATED WATER DELIVERY SYSTEMS BETWEEN THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA AND CITY OF LOS ANGELES, THROUGH THE LOS ANGELES DEPARTMENT OF WATER AND POWER

This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan) and CITY OF LOS ANGELES (City), by and through THE LOS ANGELES DEPARTMENT OF WATER AND POWER (LADWP), who may be referred to individually as "Party" or collectively as "Parties."

BACKGROUND

A. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

B. If the Program is finalized and approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of treated water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial customers of Member Agencies in the Los Angeles and Long Beach Harbor areas. Metropolitan has divided the pipeline alignment into five segments for consideration of a phased construction approach.

C. LADWP and the City's Bureau of Sanitation (LASAN) are currently developing a comprehensive program (City Program) to purify and reuse 100% of available secondary effluent from the Hyperion Water Reclamation Plant (HWRP) by 2035. Under the City Program, LASAN will be pilot-testing treatment processes that will ultimately lead to the retrofit of the HWRP to produce advanced treated water. LADWP is also currently developing a masterplan with the Water Replenishment District of Southern California (WRD) that will evaluate the most optimal locations to convey this water into the underlying aquifers within the West Coast and Central Groundwater Basins. At a future date, there may be opportunities for LADWP to convey some of its advanced treated water into Metropolitan's planned AWT Conveyance System as a potential supplemental supply source to the water source produced by the Metropolitan AWT Facility. There may also be opportunities for Metropolitan's advanced treated water to flow into the LADWP system. Both options could create flexibility for both plants.

D. Due to the size, complexity and anticipated capital investment required of both Metropolitan's and the City's programs, it will be beneficial for both organizations to coordinate and collaborate, as appropriate, during the developmental stages of both programs. Such coordination and collaboration will ensure that both systems are planned, designed, constructed and operated in a manner consistent with the best interests of the customers of each organization and its constituents.

TERMS

1. INTENT AND COMPONENTS:

a. It is the intent of the Parties to collaborate in the development and utilization of AWT supplies produced from their respective facilities, while minimizing areas of potential conflict or duplication of activities.

b. Metropolitan and LADWP intend to develop a plan to coordinate the potential integration of Metropolitan's Program and the City's Program. This collaboration will examine the operational and institutional integration of the water and facilities of the respective program. To that end, the Parties intend for the plan through a future MOU to:

i. Ensure continuity, compatibility, and flexibility of both Metropolitan and LADWP's recycled water infrastructure to meet future supply conditions;
ii. Identify and examine potential water quality issues and specifications related to integrating the two programs;
iii. Provide for related research, testing, and other technical collaborations;
iv. Provide for collaboration on regulatory developments related to both programs; and
v. Develop additional areas for collaboration and support as identified by the Parties.

c. The Parties intend to develop an MOU that will include conducting and preparing any additional studies necessary to evaluate the integration of these two programs. These studies may include the economic and technical feasibility, financing needs, right-of-way and permitting requirements, environmental and regulatory compliance obligations, brine discharge requirements, and engineering, construction, operational, and water quality specifications.

2. The provisions of this LOI represent a statement of the Parties' general intent only, and shall not be binding on either Party. Neither Party shall have any obligation to enter into the MOU, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms and conditions of the proposed MOU are subject to approval by the

General Manager of the Los Angeles Department of Water and Power, the Board of Commissioners of the Los Angeles Department of Water and Power, the Los Angeles City Council, the General Manager of Metropolitan, and the Metropolitan Board of Directors, and that no Party shall have any legal obligations to the other unless and until all of the terms and conditions of the proposed MOU have been negotiated and agreed to by all Parties and set forth in the proposed MOU, which have been approved by the Board of Water and Power Commissioners and the Los Angeles City Council, and signed and delivered by all Parties.

3. NOTICES

Any notice under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

Los Angeles Department of Water
111 North Hope Street
Los Angeles, CA 90012
Room 1460
Attn: David Pettijohn, Director of Water Resources
With a courtesy copy by email to: David.Pettijohn@ladwp.com

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party.

The Parties are signing this LOI in duplicate originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By: ______________________
General Manager

Date: July 16, 2019

APPROVED AS TO FORM:

By: ______________________
General Counsel

LOS ANGELES DEPARTMENT OF WATER AND POWER

By: ______________________ for
General Manager

Date: July 15, 2019

APPROVED AS TO FORM & LEGALITY:

Michael F. Feuer
LOS ANGELES CITY ATTORNEY

By: ______________________
~~Deputy~~ City Attorney
Melanie A. Tory
7/15/19

LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF FUTURE AGREEMENTS FOR THE PURCHASE AND DELIVERY OF ADVANCED TREATED WATER FOR REPLENISHMENT OF THE MAIN SAN GABRIEL GROUNDWATER BASIN

A. This LETTER OF INTENT (LOI) is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA (Metropolitan), THREE VALLEYS MUNICIPAL WATER DISTRICT (Three Valleys), UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT (Upper District), and THE WATERMASTER FOR THE MAIN SAN GABRIEL GROUNDWATER BASIN (Watermaster), who may be referred to individually as "Party" or collectively as "Parties."

RECITALS

B. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water (AWT Water) from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plant in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

C. If the Program is approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of AWT Water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins for indirect potable reuse (IPR) through replenishment of those Basins. Delivery locations along the alignment will consist of either existing or new groundwater spreading basins or new or existing injection wells.

D. The AWT Conveyance System could also deliver some of the AWT Water to Member Agencies in the Los Angeles and Long Beach Harbor areas for delivery to industrial customers of those Member Agencies. Additionally, some of the AWT Water may be delivered through an extension of the AWT Conveyance System to certain Metropolitan treatment plants for direct potable reuse (DPR) through raw water augmentation.

E. Water rights have been adjudicated in the Main San Gabriel Basin (the "Basin") according to the Judgment in Los Angeles County Superior Court; Civil Action No. 924128 entitled "Upper San Gabriel Valley Municipal Water District vs. City of Alhambra, et al." (herein referred to as "the Judgment"). The Judgment also established the Watermaster as the agency responsible for managing the Basin and authorized Watermaster to purchase Supplemental Water, as defined in the Judgment, for replenishment of the Basin. Watermaster purchases Supplemental Water from three Responsible Agencies, as defined in the Judgment, which have a course of Supplemental Water to the Basin.

F. Three Valleys and Upper District are named as Responsible Agencies under the Judgment and sell water to the Watermaster for replenishment, and are member agencies of Metropolitan. Metropolitan is a party to the Judgment, which permits it to deliver water to Three Valleys and Upper District for replenishment of the Basin. The San Gabriel Valley Municipal Water District, as State Water Project Contractor and not a Metropolitan member agency, is also named as a Responsible Agency under the Judgment and sells water to Watermaster.

G. Metropolitan delivers water to service connections for Three Valleys and Upper District, at which point Metropolitan no longer controls or owns the water. The Watermaster has contracted with Los Angeles County Department of Public Works (LA County Public Works) for introduction of water into the Basin. LA County Public Works operates the spreading basins and related facilities that introduce water into the Basin, including Metropolitan water delivered to Three Valleys and Upper District for replenishment of the Basin. Introduction of AWT Water into the Basin may require additional facilities, separate from the existing facilities currently utilized by LA County Public Works to introduce Metropolitan potable water into the Basin.

H. At times, Metropolitan may not have sufficient quantities of imported water to meet the Watermaster's immediate Supplemental Water requirements to deliver into the Basin. To ensure additional consistency and reliability of Metropolitan deliveries, Three Valleys and Upper District are interested in purchasing and receiving AWT Water by Metropolitan via the AWT Conveyance System to meet the Watermaster's replenishment demands for the Basin.

I. Due to the size, complexity and anticipated capital investment required of Metropolitan for the Program, it will be beneficial for all Parties to coordinate and collaborate, as appropriate, during the developmental stages of the Program. Such coordination and collaboration will ensure that the system is planned, designed, constructed and operated in a manner consistent with the best interests of the Parties and to ensure delivery of AWT Water into the Basin is feasible. Coordination and collaboration between the Parties is also necessary to ensure the development of a commitment by Three Valleys and Upper District to purchase AWT Water from the Program.

TERMS

1. INTENT OF THE PARTIES:

   a. The Parties intend to develop a plan to ensure that deliveries of AWT Water from the Program can be introduced into the Basin. To that end, the Parties intend to:

      i. Collaborate to provide all information the Watermaster, LA County Public Works, or any regulatory agency, may need to approve introduction of AWT Water into the Basin;

      ii. Identify and examine potential water quality issues and specifications related to the Program that may affect the Watermaster's, or any regulatory agency's, approval;

iii. Identify any related research, testing, and other technical work necessary to address any concerns raised by the Watermaster, or regulatory agency, in connection with approval of introduction of AWT Water into the Basin;

iv. Collaborate on regulatory developments related to introduction of AWT Water into the Basin;

v. Collaborate to develop an agreement with LA County Public Works for its operation of facilities necessary to introduce AWT Water into the Basin, including construction of new facilities that may be required for introduction of AWT Water into the Basin;

vi. Develop plans for any new infrastructure that may be necessary to introduce AWT Water into the Basin; Identify opportunities to expand scope of water deliveries to include other responsible agencies and adjacent groundwater basins; and

vii. Develop additional areas for collaboration and support, as identified by the Parties.

b. It is the intent of the Parties to collaborate in the development of a set of agreements between the Parties for:

i. the long-term purchase and receipt of at least 6,500AFY AWT Water by Three Valleys and at least 35,000 AFY AWT Water by Upper District, with a maximum range of 60,000 to 80,000 AFY AWT, collectively, for both parties, and Metropolitan's delivery of AWT Water to Three Valleys and Upper District;

ii. the Watermaster's approval of delivery of AWT water into the Basin, pursuant to a purchase agreement between Metropolitan and each of Three Valleys and Upper District; and

2. NON-BINDING INTENT

The provisions of this LOI represent a statement of the Parties general intent only and shall not be binding on either Party. No Party shall have any obligation to enter into any agreement listed in Section 1.b., or otherwise, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms and conditions of any agreements developed pursuant to Section 1.b. are subject to approval by the General Manager and the Board of Directors of Three Valleys, the General Manager and the Board of Directors of Upper District, the General Manager and the Board of Directors of Metropolitan, the Executive Officer and Board of the Watermaster. No Party shall have any legal obligations to the other unless and until all of the terms and conditions of each of the proposed agreements have been negotiated and agreed to by all Parties and set forth in the agreements, approved by the legislative bodies of all Parties, and signed and delivered by all Parties.

3. NOTICES AND CORRESPONDENCE

Any notice or correspondence under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

Three Valleys Municipal Water District
1021 E. Miramar Avenue
Claremont, CA 91711
Attn: Matthew H. Litchfield, General Manager/Chief Engineer
With a courtesy copy by email to: mlitchfield@tvmwd.com

Upper San Gabriel Valley Municipal Water District
602 E. Huntington Drive, Suite B
Monrovia, CA 91016
Attn: Tom A. Love, General Manager
With a courtesy copy by email to tom@usgvmwd.org

Main San Gabriel Basin Watermaster
725 North Azusa Avenue
Azusa, CA 91702
Attn: Anthony C. Zampiello, Executive Officer
With a courtesy copy by email to: tonyz@watermaster.org

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party.

4. COUNTERPARTS

This Agreement may be executed in counterparts, and signatures transmitted via facsimile or electronic mail shall be deemed to be originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Jeffrey Kightlinger

By: ______________________

General Manager

Date: July 14, 2020

APPROVED AS TO FORM:

Marcia Scully

By: ______________________

General Counsel

THREE VALLEYS MUNICIPAL WATER DISTRICT

Matthew Litchfield P.E.

By: ______________________

General Manager

Date: June 16, 2020

APPROVED AS TO FORM & LEGALITY:

Steven M. Kennedy

By: ______________________

General Counsel

Date: June 16, 2020

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT

Thomas A. Love

By: ______________________________

General Manager

Date: May 26, 2020

APPROVED AS TO FORM & LEGALITY:

Steven O'Neill

By: ______________________________

General Counsel

Date: May 26, 2020

MAIN SAN GABRIEL BASIN WATERMASTER

Anthony Zampiello

By: ______________________________

Executive Officer

Date: ______________________________

APPROVED AS TO FORM & LEGALITY:

By: ______________________________

Legal Counsel

Date: ______________________________

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT
Tom A. Love

By: ______________________________
General Manager

Date: ______________________________

APPROVED AS TO FORM & LEGALITY:

By: ______________________________
General Counsel

Date: ______________________________

MAIN SAN GABRIEL BASIN WATERMASTER
Anthony Zampiello

By: ______________________________
Executive Officer

Date: 6-5-2020

APPROVED AS TO FORM & LEGALITY:
Frederic Fudacz

By: ______________________________
Legal Counsel

Date: 6-15-2020

LETTER OF INTENT TO COLLBORATE ON THE DEVELOPMENT OF A FUTURE DEVELOPMENT AGREEMENT RELATED TO ADVANCED TREATED WATER DELIVERY SYSTEMS BETWEEN THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA AND THE SOUTHERN NEVADA WATER AUTHORITY

This LETTER OF INTENT ("LOI") is made by and between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA ("Metropolitan") and the SOUTHERN NEVADA WATER AUTHORITY ("SNWA"), who may be referred to individually as "Party" or collectively as "Parties."

BACKGROUND

A. SNWA is a Nevada joint powers authority and political subdivision of the State of Nevada, created by agreement dated July 25, 1991, as amended November 17, 1994, and January 1, 1996, pursuant to Nevada Revised Statutes § 277.180, inclusive. Metropolitan is a water district established under the California Metropolitan Water District Act, codified in Section 109-1 et seq., of the Appendix to the West's Annotated California Water Code, for the purpose of serving water to the coastal plain of southern California. The Parties have collaborated on previous projects and agreements involving water supplies and continue to seek new strategies to help maximize the availability of limited water supplies.

B. Metropolitan and SNWA are working together to develop a Regional Recycled Water Program ("Project"). The objective of the Project is to produce up to 150 million gallons per day ("MGD") of advanced treated water from a new advanced water treatment ("AWT") facility located at Los Angeles County Sanitation District's Joint Water Pollution Control Plant in Carson, California ("Metropolitan AWT Facility"). The Project's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

C. If the Project is finalized and approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations ("AWT Conveyance System"). The AWT Conveyance System could potentially deliver up to 150 MGD of treated water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial customers of Member Agencies in the Los Angeles and Long Beach Harbor areas, or raw water augmentation. Metropolitan has divided the pipeline alignment into five segments for consideration of a phased construction approach.

D. Due to the size, complexity and anticipated capital investment required for the Project, SNWA will assist in the Project development by providing resources to assist with the planning, design, and construction of the Project. These resources may include, but are not limited to, time, materials, expertise, and financial investment.

E. The Parties intend to exchange Project water volumes for MWD Colorado River allocation water volumes, conditioned upon final Project authorization and pursuant to the terms of the Development Agreement.

TERMS

1. **Intent**: It is the intent of the Parties to lay the foundation for a cooperative working relationship, to establish the role of each Party in that relationship as they continue to work together to further their common goal of developing the Project, and to lay the foundation for a joint development agreement to develop the Project and allocate future water disbursements ("Development Agreement").

2. **Additional Parties**: The Parties recognize that other entities may be of assistance from time to time in various capacities and that the Parties may desire to add such entities as Parties to this LOI or to the Development Agreement. Accordingly, the Parties may at any time agree in writing to add Parties to this LOI, and anticipate including within the Development Agreement provisions for the addition of Parties by mutual, written consent.

3. **Development Agreement**: The Parties anticipate that the Development Agreement will describe the scope of the Project, including studies, planning, design, and construction; describe the distribution and allocation of resources to be provided by each Party toward the development of the Project; commit the Parties to future water distributions upon Project completion; and provide for the ongoing relationship between the Parties as it relates to the Project upon Project completion. Ancillary agreements with third parties may also be necessary as will regulatory changes. The Parties will cooperate to implement such agreements and regulations, inclusive of Colorado River operational rules providing any necessary flexibility for contemplated water exchanges.

4. **Project Representative**: Each Party will designate a project representative to represent the Parties on all issues relating to the Project. Within 30 days of the execution of this LOI, the Parties will identify their respective Project Representative through the notice provisions provided in Section 8 this LOI.

5. **Project Workplans**: Prior to executing the Development Agreement, the Parties may develop a project workplan ("Project Workplan") that will define tasks to be completed, an approximate schedule for completing the tasks, and, if necessary, the funding or personnel requirements for such tasks. The Project Representatives will oversee the task of developing the Project Workplan and shall review and revise the Project Workplan as necessary.

6. **Technical Collaboration**: The Parties acknowledge that the Project will require advanced technical skills and expertise and that sharing such information is an essential component of their collaboration. To support technical collaboration throughout the Project, the Parties agree to:

a. Share information and technology to the greatest extent allowable under their governing legislation and confidentiality requirements;

b. Reasonably provide personnel as necessary to assist in implementing shared information and technology;

c. Subject to applicable public records laws, maintain all records of Parties in the strictest confidence and use them solely for purposes directly related to such services or as required by law;

d. Develop technological enhancements that allow interfaces of common information needs, as appropriate; and

e. Ensure that sufficient system security provisions shall be utilized by the Parties.

7. **Funding and SNWA Staff Time**:

a. If necessary, funding for the Project prior to the effective date of the Development Agreement will be provided for in a Project Workplan. The Parties agree that such funding will come from a variety of sources. However, the Parties understand that they will each be responsible for a share of the costs related to the Project.

b. SNWA's participation in funding for the Project will require approval from the SNWA Board of Directors. Until such approval, SNWA may commit SNWA staff time and resources necessary to facilitate the development process in a timely manner and may assume and be responsible for all internal costs associated with that process, including, but not limited to, the costs of reviewing, analyzing, and commenting upon the Project, environmental studies and review, Project Workplans, Transaction Documents, lobbying efforts, and necessary reports.

c. The ability to complete the services identified in this LOI are contingent upon the availability of sufficient funds in the budgets approved by the Parties' respective governing bodies.

8. **Non-Binding**: The provisions of this LOI represent a statement of the Parties' general intent only, and shall not be binding on either Party. Neither Party shall have any obligation to enter into the Development Agreement, and no course of conduct of the Parties shall evidence any binding obligations.

9. **Notices**: Any notice under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: Deven Upadhyay
With a courtesy copy by email to DUpadhyay@mwdh2o.com

Southern Nevada Water Authority
1001 South Valley View Boulevard
Las Vegas, NV 89153
Attn: General Manager
With a courtesy copy by email to greg.walch@lvvwd.com

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party.

[Signatures Next Page]

The Parties are signing this LOI in duplicate originals.

SOUTHERN NEVADA WATER AUTHORITY

By: ______________________

John J. Entsminger
General Manager

Date: 3.12.20

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By: ______________________

Jeffrey Kightlinger
General Manager

Date: March 12, 2020

LETTER OF INTENT TO COLLABORATE ON THE DEVELOPMENT OF A FUTURE MEMORANDUM OF UNDERSTANDING RELATED TO THE PRODUCTION, DISTRIBUTION, AND DELIVERY OF ADVANCED TREATED WATER WITHIN THE LOS ANGELES REGION

This Letter of Intent (LOI) is made by and between the Metropolitan Water District of Southern California (Metropolitan) and West Basin Municipal Water District (West Basin), who may be referred to individually as "Party" or collectively as "Parties".

Background

A. Metropolitan and County Sanitation No. 2 of Los Angeles County (Sanitation District) are working together to develop a Regional Recycled Water Program (Program). The objective of the Program is to produce up to 150 million gallons per day (MGD) of advanced treated water from a new advanced water treatment (AWT) facility located at the Sanitation District's Joint Water Pollution Control Plan in Carson, California (Metropolitan AWT Facility). The Program's development may be phased, starting at lower levels of production with the potential to build up to 150 MGD of production as demands and conditions warrant.

B. If the Program is finalized and approved by Metropolitan's Board of Directors, it will also include plans for the development of a conveyance system consisting of approximately 60 miles of pipeline and a series of pump stations (AWT Conveyance System). The AWT Conveyance System could potentially deliver up to 150 MGD of treated water to the Central, West Coast, Orange County and Main San Gabriel Groundwater Basins. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial customers of Member Agencies in the Los Angeles and Long Beach Harbor areas. Metropolitan has divided the pipeline alignment into five segments for consideration of a phased construction approach.

C. Additionally, some of the AWT Water may be delivered through an extension of the AWT Conveyance System to certain Metropolitan treatment plants for direct potable reuse (DPR) through raw water augmentation.

D. West Basin is a proven leader in the development of recycled water, including advanced water treatment. In 1995, West Basin completed construction of the Edward C. Little Water Recycling Facility (ECL Facility) in El Segundo, California. Since operations began, West Basin has expanded the ECL Facility five times, and produces five (5) designer qualities of recycled water, including advanced water treatment for groundwater recharge in the West Coast Basin annually.

E. West Basin is in the process of developing a Recycled Water Master Plan in coordination with its retail customer agencies, the Water Replenishment District of

Southern California (WRD), and Los Angeles Department of Water and Power (LADWP), that will define the path towards utilizing 70 MGD of secondary effluent from Hyperion Water Reclamation Plant (HWRP), evaluate available capacity within its existing system for water transfers to neighboring agencies, and identify potential opportunities for additional groundwater recharge, storage, and augmentation within the West Basin service area. Opportunities to interconnect future Metropolitan, West Basin, and other regional AWT systems may enhance groundwater recharge capability, improve supply reliability to local anchor customers, and reduce overall capital costs of future systems.

F. In addition to expanding the use of recycled water, West Basin has approved implementation of a 20 MGD ocean water desalination facility (Project), conditioned upon West Basin's ability to secure all relevant permits, development of project cost estimates, development and approval of a financial evaluation and plan, completion of a cost and benefit analysis of implementing the Project, and development and approval of design and project delivery documents.

G. Due to the size, complexity and anticipated capital investment required of Metropolitan's Program, the development of West Basin's Recycled Water Master Plan and potential related recycled water projects identified to expand the use of recycled water in the region, the recently approved implementation of a 20 MGD ocean water desalination Project, and any future projects developed within the West Basin service area, it will be beneficial for both organizations to coordinate and collaborate, as appropriate, during the developmental stages of each program and project. Such coordination and collaboration will ensure that both systems are planned, designed, constructed and operated in a manner consistent with the best interests of the customers of each organization and its constituents.

TERMS

1. INTENT AND COMPONENTS:

   A. It is the intent of the Parties to collaborate in the development and utilization of AWT supplies produced from their respective facilities, while minimizing areas of potential conflict or duplication of activities.

   B. Metropolitan and West Basin intend to develop a plan to coordinate the potential integration of Metropolitan's, West Basin's, and other AWT water recycling programs. To that end, the Parties intend to plan through a future MOU to:

i. Collaborate to provide all information any regulatory agency may need related to approve the potential introduction of AWT Water into the West Coast Basin and integration of the Parties' respective programs and projects;

ii. Identify and examine potential water quality issues and specifications related to the potential introduction of AWT Water into the West Coast Basin and integration of the Parties' respective programs and projects;

iii. Provide for related research, testing, and other technical collaborations related to the potential introduction of AWT Water into the West Coast Basin and integration of the Parties' respective programs and projects;

iv. Provide for collaboration on regulatory developments related to the potential introduction of AWT Water into the West Coast Basin and integration of the Parties' their respective programs and projects; and

v. Develop additional areas for collaboration and support, as identified by the Parties.

C. The Parties intend to develop an MOU that will include conducting and preparing any additional studies necessary to evaluate the potential introduction of AWT Water into the West Coast Basin and integration of new facilities and AWT supplies with existing facilities, infrastructure, and existing AWT supplies and additional capacity of existing facilities and infrastructure. These studies may include the economic and technical feasibility, financing needs, right of way and permitting requirements, environmental and regulatory compliance obligations, brine discharge requirements, and engineering, construction, operational, and water quality specifications.

2. The provisions of this LOI represent a statement of the Parties' general intent only, and shall not be binding on either Party. Neither Party shall have any obligation to enter into the MOU, and no course of conduct of the Parties shall evidence any binding obligations. Each Party fully understands that the terms and conditions of the proposed MOU are subject to approval by the General Manager of West Basin, the West Basin Board of Directors, the General Manager of Metropolitan, and the Metropolitan Board of Directors; and that no Party shall have any legal obligations to the other unless and until all of the terms and conditions of the proposed MOU have been negotiated and agreed to by all Parties and set forth in the proposed MOU, which have been approved, and signed and delivered by all Parties.

3. NOTICES

Any noticed under this LOI must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attn: John Bednarski, Group Manager, Engineering Services
With a courtesy copy by email to: jbednarski@mwdh2o.com

West Basin Municipal Water District
17140 South Avalon Blvd.
Carson, CA 907446
Attn: Patrick Sheilds, General Manager
With a courtesy copy by email to: Patricks@westbasin.org

A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

Either Party may change the address listed in this section by providing five days' notice to the other Party.

4. COUNTERPARTS

This Agreement may be executed in counterparts, and signatures transmitted via facsimile or electronic mail shall be deemed to be originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Jeffrey Kightlinger

By: ______________________

General Manager

Date 5/13/2021

APPROVED AS TO FORM:

Marcia Scully

By: ______________________

General Counsel

WEST BASIN MUNICIPAL WATER DISTRICT

Patrick Sheilds

By: ______________________

General Manager

Date: 05/12/2021

APPROVED AS TO FORM & LEGALITY:

Steven O'Neill

By: ______________________

General Counsel

Appendix B

Engineering Reports

Appendix B.1: Final A.K. Warren Secondary Treatment Facilities Plan 2050 (2020)

Appendix B.2: OPC for NdN tMBR Train Draft Final TM (2022)

Appendix B.3: Final Feasibility Design Report Backbone Conveyance (2020)

Appendix B.4: Final Distributed Treatment TM (2022)

Appendix B.1

Final A.K. Warren Secondary Treatment Facilities Plan 2050 (2020)

Nitrogen Treatment Facilities Plan 2050

SCH #2022090654

Revision: Revised Draft

Los Angeles County Sanitation Districts

A.K. Warren Water Resource Facility
December 2023

DOC 7093647

CONTENTS

Tables

Figures

ACRONYMS and ABBREVIATIONS

$	March 2023 U.S. dollar(s)
%	percent
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
µg/L	microgram(s) per liter
A_2O	anaerobic-anoxic-oxic
AADF	annual average daily flow
AB	Assembly Bill
ACS	American Community Survey
anammox	anaerobic ammonium oxidation
AOB	ammonium oxidizing bacteria
AQMP	Air Quality Management Plan
AS	activated sludge
aSRT	aerobic solids retention time
ATCM	Airborne Toxic Control Measure
AWP Facility	Advanced Water Purification Facility
B&C&B	Biostimulation, Cyanotoxins, and Biological
BAAQMD	Bay Area Air Quality Management District
BAC	biological activated carbon
BAF	biological active filter
BMP	best management practice
BNR	biological nutrient removal
BOD_5	biochemical oxygen demand, 5-day
$BOD_5 20°C$	5-day biochemical oxygen demand at 20 degrees Celsius
BU	beneficial use
CAAQS	California Ambient Air Quality Standards
Cal/OSHA	California Division of Occupational Safety and Health
Cal-EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CCAA	California Clean Air Act
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CDWS	California drinking water standards

CEC	constituent of emerging concern
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESA	California Endangered Species Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHSC	California Health and Safety Code
CI	compression ignition
CII	commercial, industrial, and institutional
CIPP	cured-in-place-pipe
CMOM	capacity, management, operations, and maintenance
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COD	chemical oxygen demand
CPRC	California Public Resources Code
CTR	California Toxics Rule
CTS	Centrate Treatment Station
CUP	conditional use permit
CWA	Clean Water Act
CWC	California Water Code
DAF	dissolved air flotation
DAFT	dissolved air flotation thickening
DAS	densified activated sludge
DDT	dichlorodiphenyltrichloroethane
DDW	Division of Drinking Water
Demonstration Plant	Grace F. Napolitano Pure Water Southern California Innovation Center (formerly the Advanced Purification Center)
DLR	detection limit for purposes of reporting
DO	dissolved oxygen
DOF	California Department of Finance
DPR	direct potable reuse
DRP	Los Angeles County Department of Regional Planning
DWR	Department of Water Resources
E/I	electrical/instrumentation
EPA	U.S. Environmental Protection Agency
FCAA	Federal Clean Air Act

FEB	flow equalization basin
FESA	Federal Endangered Species Act
Flex MBR	flexible membrane bioreactor
FOG	fats, oil, and grease
FORCO	Fletcher Oil and Refinery Company
g/bhp-hr	gram(s) per brake horsepower-hour
g/kWh	gram(s) per kilowatt-hour
GHG	greenhouse gas
gpcd	gallon(s) per capita per day
gpd	gallon(s) per day
gpd/ft^2	gallon(s) per day per square foot
GRRP	Groundwater Replenishment Reuse Project
GRRR	Groundwater Replenishment Reuse Regulation
ha	hectare(s)
HA	health advisory
HAP	hazardous air pollutant
Hazen	Hazen and Sawyer
HFPO-DA	hexafluoropropylene oxide dimer acid
hp	horsepower
HPOAS	high-purity oxygen activated sludge
HPOLE	high-purity oxygen Ludzack-Ettinger
HRSG	Heat Recovery Steam Generator
HSWA	Hazardous and Solid Waste Amendments of 1984
HWCA	Hazardous Waste Control Act
IFAS	Integrated Fixed-Film Activated Sludge
IPR	indirect potable reuse
IRP	Integrated Water Resources Planning
IRWUS	Indoor Residential Water Use Study
ISWP	Inland Surface Waters Plan
JAA	Joint Administration Agreement
Jacobs	Jacobs Engineering Group Inc.
JES	Joint Executive Summary
JOA	Joint Outfall Agreement
JOS	Joint Outfall System
JTAP	Joint Water Pollution Control Plant Technical Analysis Project
JWPCP	Joint Water Pollution Control Plant
kg/ha	kilogram(s) per hectare

$kgNO_3$-N/kgMLVSS	kilograms nitrate (as nitrogen) per kilogram mixed-liquor volatile suspended solids
$kgNO_3$-N/m^3	kilogram nitrate (as nitrogen) per cubic meter
kW	kilowatt(s)
kWh	kilowatt-hours
LARWQCB	Los Angeles Regional Water Quality Control Board
LBWRP	Long Beach Water Reclamation Plant
LCWRP	Los Coyotes Water Reclamation Plant
LS	lump sum
LWDS	Liquid Waste Disposal Station
M&I	municipal and industrial
MABR	membrane aerated biofilm reactor
MBBR	moving bed biofilm reactor
MBR	membrane bioreactor
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCRT	mean cell residence time
MD	mainstream deammonification
Metropolitan	Metropolitan Water District of Southern California
MF	membrane filtration; microfiltration
MG	million gallon(s)
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mgCOD/L	milligram(s) chemical oxygen demand per liter
MGD	million gallon(s) per day
mgN/L	milligram(s) nitrogen per liter
$mgNO_3$-N/L	milligram(s) nitrate (as nitrogen) per liter
mgO_2/L	milligram(s) oxygen per liter
mgP/L	milligram(s) phosphorus per liter
mgTSS/L	milligram(s) total suspended solids per liter
ml	milliliter(s)
ml/L	milliliter(s) per liter
MLE	Modified Ludzack-Ettinger
MLSS	mixed liquor suspended solids
mm	millimeter(s)
MPN/mL	most probable number per milliliter
mt	metric ton(s)
MW	megawatt(s)

N/A	not applicable
NAAQS	national ambient air quality standards
NAHC	Native American Heritage Commission
NdN	nitrification and denitrification
NEPA	National Environmental Policy Act
ng/l	nanogram(s) per liter
NH_3-N	nitrogen in terms of ammonia nitrogen
NHPA	National Historic Preservation Act
NHx	ammonia/ammonium
NMFS	National Marine Fisheries Service
NMHC	non-methane hydrocarbon
NO_2	nitrogen dioxide
NO_3	nitrate
N-only	nitrification only
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRCY	nitrified mixed-liquor recycle
NRDC	Natural Resources Defense Council
NTR	National Toxics Rule
NTU	nephelometric turbidity unit
O&M	operations and maintenance
O_2	oxygen
O_3	ozone
OAL	Office of Administrative Law
OEHHA	Office of Environmental Health Hazard Assessment
OES	Office of Emergency Services
OPC	Ocean Protection Council
OPR	Office of Planning and Research
PAD	post-aerobic digestion
PCA	Porter-Cologne Water Quality Control Act of 1969
PCB	polychlorinated biphenyls
PCGR	per capita generation rate
PdNA	partial denitrification with anammox
PE	primary effluent
PF	peaking factor
PFAS	per- and polyfluorinated substances

PFBS	perfluorobutane sulfonate
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
PM_{10}	respirable particulate matter
$PM_{2.5}$	fine particulate matter
PO_4	phosphate
POTW	Publicly Owned Treatment Works
ppd	pound(s) per day
psig	pound(s) per square inch gauge
PT	primary treatment
Pure Water	Pure Water Southern California
RAS	return-activated sludge
RCRA	Resource Conservation and Recovery Act
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
SAA	Streambed Alteration Agreement
Sanitation Districts	Los Angeles County Sanitation Districts
SB	Senate Bill
SBR	sequencing batch reactor
SCAB	South Coast Air Basin
SCAG	Southern California Council of Governments
SCAQMD	South Coast Air Quality Management District
SCCWRP	Southern California Coastal Water Research Project
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
SE	secondary effluent
SEA	significant ecological area
SEATAC	Significant Ecological Areas Technical Advisory Committee
SHPO	State Historic Preservation Officer
SIP	Statewide Implementation Policy
SJCWRP	San Jose Creek Water Reclamation Plant
SMBR	secondary membrane bioreactor
SND	simultaneous nitrification denitrification
SNMP	Salt and Nutrient Management Plan
SO_2	sulfur oxides

SP	solids processing
SR-110	State Route 110
SRF	State Revolving Fund; Slurry Receiving Facilities
SSO	sanitary sewer overflow
ST	secondary treatment
STLC	soluble threshold limit concentration
SWAR	Surface Water Augmentation Regulations
SWP	State Water Project
SWPPP	storm water pollution prevention plan
SWRCB	California Water Resources Control Board
SWSAP	Surface Water Source Augmentation Project
TAF	thousand acre-feet
TAG	Technical Advisory Group
TBAF	tertiary biological active filter
TBD	to be determined
TCDD	2,3,7,8-tetrachlorodibenzo p-dioxin
TDS	total dissolved solids
TEF	Total Energy Facility
THM	trihalomethane
TICH	total identifiable chlorinated hydrocarbons
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TM	Technical Memorandum
TMBBR	tertiary moving bed biofilm reactor
TMBR	tertiary membrane bioreactor
tMF	tertiary microfiltration
TN	total nitrogen
TOC	total organic carbon
TPD	ton(s) per day
TSDF	treatment, storage, and disposal facilities
TSS	total suspended solids
TST	Test of Significant Toxicity
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
UWMP	Urban Water Management Plan
VOC	volatile organic compound
VPSA	Vacuum Pressure Swing Adsorption

Warren Facility	A.K. Warren Water Resource Facility
WAS	waste-activated sludge
WDR	waste discharge regulation
WNWRP	Whittier Narrows Water Reclamation Plant
WQO	water quality objective
WRP	water reclamation plant
WRR	water reclamation requirement
WSCP	Water Shortage Contingency Plan
WSDM Plan	Water Surplus and Drought Management Plan

1 INTRODUCTION

1.1 Background

The Los Angeles County Sanitation Districts (Sanitation Districts) have partnered with the Metropolitan Water District of Southern California (Metropolitan) on Pure Water Southern California (Pure Water), which will produce up to 150 million gallons per day (MGD) of purified recycled water from wastewater at the Sanitation Districts' largest wastewater treatment plant, the A.K. Warren Water Resource Facility (Warren Facility), formerly known as the Joint Water Pollution Control Plant (JWPCP). The purified water will be delivered via a new conveyance system, up to 60 miles long, to groundwater basins within Metropolitan's service area for groundwater replenishment, and possibly to water treatment plants for direct potable reuse (DPR). The new full-scale Advanced Water Purification Facility ("AWP Facility") would be constructed within portions of the Warren Facility buffer area (referred to as the Joint Plant Site), including the former Fletcher Oil and Refining Company (FORCO) land. The Joint Plant Site is owned by the Sanitation Districts.

The Sanitation Districts have prepared this Warren Facility Nitrogen Treatment Facilities Plan 2050 (Facilities Plan) to identify a recommended approach to secondary and tertiary treatment facilities design and implementation that will meet the regulations, performance, and capacity needs of both the Joint Outfall System (JOS) and Pure Water through the year 2050.

1.2 Los Angeles County Sanitation Districts

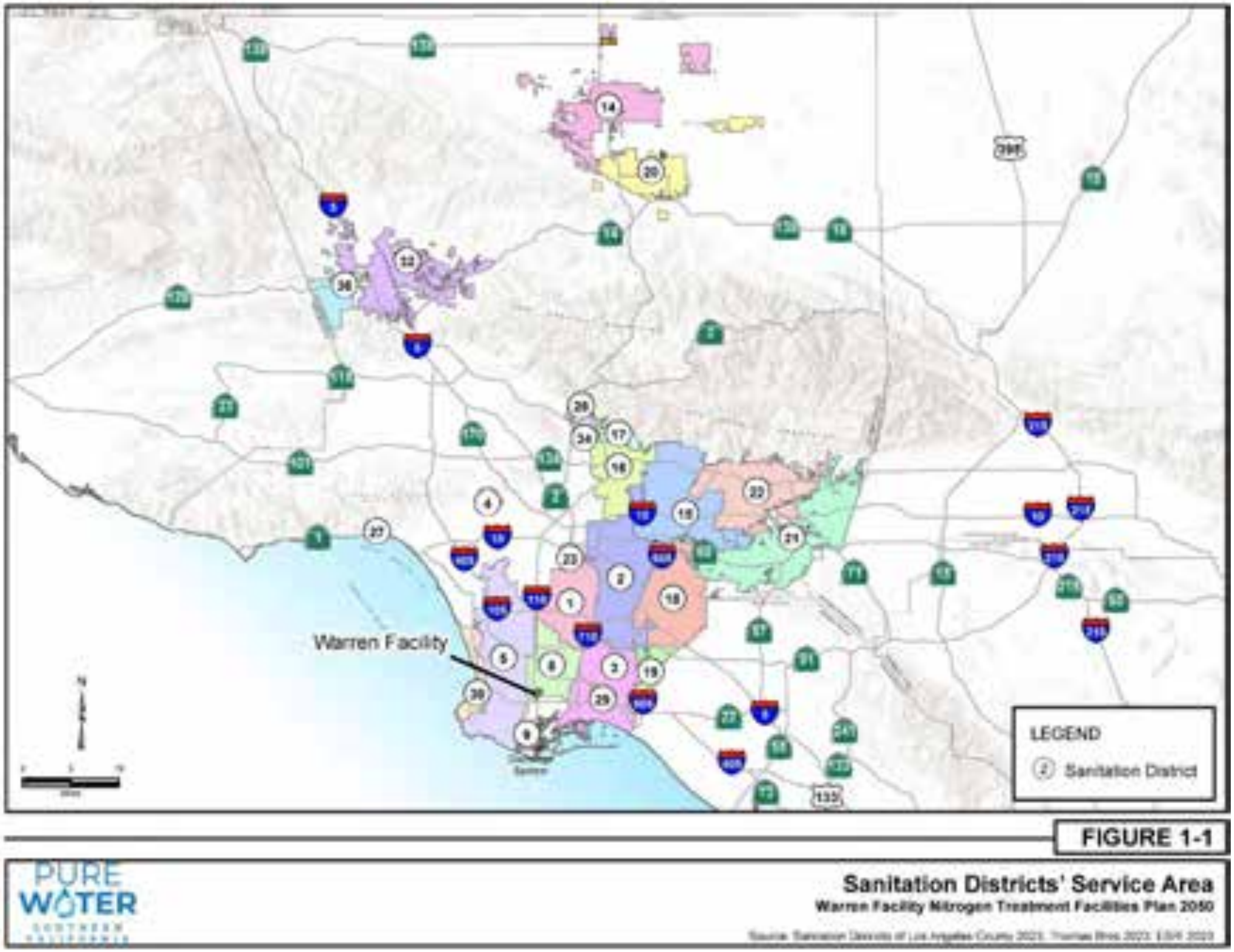
The Sanitation Districts are a confederation of independent special districts that serve the wastewater and solid waste management needs of approximately 5.6 million people in Los Angeles County. The Sanitation Districts' service area covers approximately 850 square miles and encompasses 78 cities and unincorporated territory within the county.

The Sanitation Districts were formed under the authority provided by the County Sanitation District Act of 1923 (Act). To allow for a more efficient means of wastewater management, the Act authorized the formation of sanitation districts determined by drainage areas rather than political boundaries. Provisions of the Act authorize the Sanitation Districts to construct, operate, and maintain facilities for the collection, treatment, and management of wastewater and industrial wastes generated throughout the Sanitation Districts' service area. In 1949, the Act was amended to allow the Sanitation Districts to provide solid waste management services, including refuse transfer and resource recovery. In 2015, the Act was again amended to allow the Sanitation Districts to manage, treat, and reuse stormwater and dry weather runoff. The Sanitation Districts' service area and the boundaries of individual sanitation districts are shown on **Figure 1-1**.

The Sanitation Districts consist of 24 separate sanitation districts working cooperatively under a Joint Administration Agreement (JAA) and benefiting from a centralized administrative staff headquartered in Whittier, California. Each district has a separate board of directors consisting of the presiding officers of the governing bodies of the local jurisdictions situated within that district. Each district is required to pay its proportionate share of the joint administration costs, pursuant to the terms of the JAA.

The Sanitation Districts own, operate, and maintain over 1,400 miles of main trunk sewers and 11 wastewater treatment plants with a total permitted dry weather capacity of 652 MGD. The sewerage system currently conveys and treats approximately 400 MGD of wastewater. Approximately 100 MGD of the tertiary treated water is beneficially reused for a variety of applications including landscape and agricultural irrigation, industrial process water, recreational impoundments, wildlife habitat maintenance, and groundwater replenishment via surface spreading or injection.

Figure 1-1. Sanitation Districts' Service Area



The Sanitation Districts also operate a solid waste management system that serves the needs of a large portion of the county. This system includes two active sanitary landfills, two landfill energy recovery facilities, and two materials recovery/transfer facilities. The Sanitation Districts have a waste-by-rail system consisting of the Puente Hills Materials Recovery Facility, the Puente Hills Intermodal Facility, and Mesquite Regional Landfill.

In addition, the Sanitation Districts maintain four closed sanitary landfills and one closed refuse-to-energy facility and participate in ownership of the Southeast Resource Recovery Facility, a refuse-to-energy facility. Altogether, the Sanitation Districts' solid waste management sites provide about one fifth of the countywide solid waste management needs. The local collection and transportation of solid waste to Sanitation Districts' facilities is the responsibility of the jurisdictions within the Sanitation Districts' service area.

1.2.1 Mission Statement

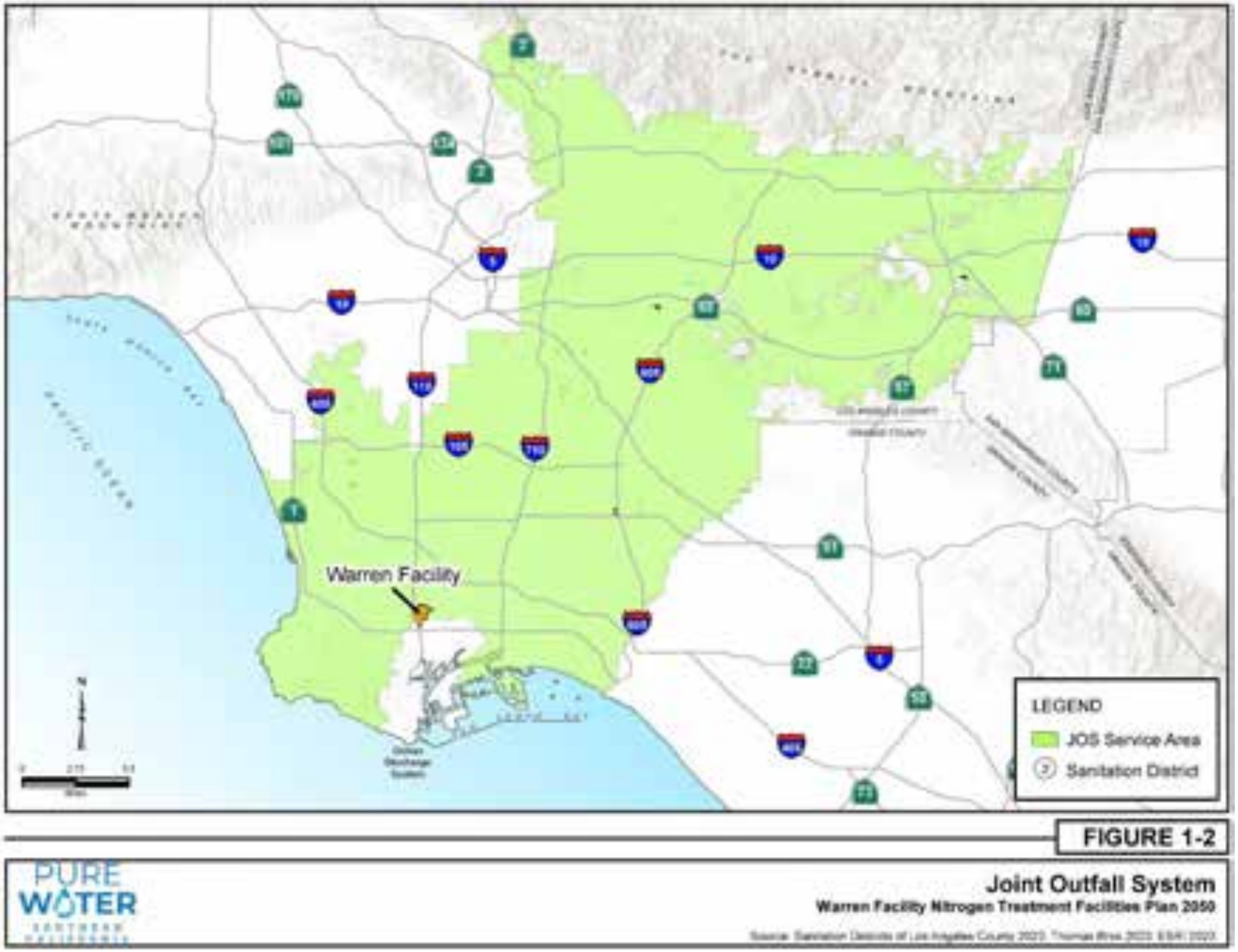
The Sanitation Districts' mission is to protect public health and the environment through innovative and cost--effective wastewater and solid waste management, and, in doing so, convert waste into resources such as recycled water, energy, and recycled materials.

1.3 Joint Outfall System

Consistent with the Sanitation Districts' regional approach to wastewater management, seventeen of the districts in the metropolitan Los Angeles area are signatory to a Joint Outfall Agreement (JOA) that provides for a combined investment in wastewater conveyance and treatment facilities. These 17 districts, collectively known as the Joint Outfall Districts, are located in the metropolitan Los Angeles area in the eastern and southern portions of Los Angeles County. The Joint Outfall Districts extend south from the San Gabriel Mountains to the Palos Verdes Peninsula and are bound on the east by Orange and San Bernardino Counties, on the west by the Santa Monica Bay and the cities of Glendale and Los Angeles, and on the south by the San Pedro Bay. Sanitation District No. 2 is the appointed agent for the 17 districts with respect to matters necessary to carry out the purposes of the JOA.

The Joint Outfall Districts have constructed a regional, interconnected system of wastewater conveyance and treatment facilities known as the JOS that provides wastewater management services for 5.1 million people in 73 cities as well as some unincorporated areas of Los Angeles County. The JOS service area is shown in **Figure 1-2**. The service area, which covers approximately 600 square miles, generally slopes downward from the northeast to the southwest. The JOS was designed to take advantage of this regional topography. Wastewater is collected by approximately 8,500 miles of city- and county-owned local sewers and then conveyed, primarily via gravity, through the Sanitation Districts' sewers that interconnect seven JOS wastewater treatment plants with a total treatment capacity of 592.5 MGD.

Figure 1-2. Joint Outfall System



1.3.1 JOS Wastewater Treatment System

The JOS has conceptually developed into two wastewater treatment subsystems: a downstream (or coastal) subsystem and an upstream (or inland) subsystem.

The coastal subsystem consists of the Warren Facility, located in Carson. The Warren Facility has a permitted dry weather capacity of 400 MGD and provides secondary treatment and disinfection to all influent wastewater, inclusive of domestic, commercial, and industrial contributors. All Warren Facility effluent is discharged approximately two miles out in the Pacific Ocean. The Warren Facility also provides centralized solids processing for all JOS wastewater treatment facilities.

The inland subsystem consists of six upstream water reclamation plants (WRPs), with a combined permitted capacity of 193 MGD, which capture wastewater selectively routed from predominately residential areas. All recycled water produced at the WRPs that is not reused is discharged to nearby rivers or creeks and eventually flows to the ocean. In addition to producing effluent suitable for reuse, the WRPs can bypass all or a portion of their influent flows to the Warren Facility for treatment.

1.4 A.K. Warren Water Resource Facility

The Warren Facility is located at 24501 South Figueroa Street in Carson, California. The plant is bordered by State Route 110 (SR-110) to the west, Sepulveda Boulevard to the north, commercial and residential land uses east of Main Street, and commercial and residential land uses south of Lomita Boulevard. The Warren Facility occupies approximately 420 acres, of which approximately 200 acres are used as a buffer area between the operational process areas and the surrounding residential neighbors. The buffer areas, some of which extend into the city of Los Angeles, include the Wilmington Boys and Girls Club, the Wilmington Athletic Complex, the Bixby Marshland, the Carson Depot Commercial Center, and landscaping and nursery areas. The Joint Plant Site at which the proposed AWP Facility for Pure Water will be constructed is within the Warren Facility buffer area. An aerial view of the Warren Facility is shown in **Figure 1-3**.

The Warren Facility has a peak sanitary treatment capacity of 700 MGD, and a permitted dry weather flow capacity of 400 MGD. The current daily flow is approximately 250 MGD, serving a population of approximately 3 million people. The plant provides secondary treatment by pure oxygen activated sludge with disinfection of the entire flow. Effluent is conveyed approximately six miles to the White Point Manifold Structure and discharged through two ocean outfalls approximately two miles offshore. There are two additional outfalls reserved for emergency use.

The Warren Facility accepts food waste slurry for anaerobic digestion. Solids generated as part of the treatment and digestion processes are stabilized, dewatered, and trucked off-site for disposal or beneficial reuse. Energy recovery systems are also situated at the site, as are buildings housing administrative and maintenance functions.

Figure 1-3. A.K. Warren Water Resource Facility

1.5 Pure Water Southern California

The Sanitation Districts have partnered with Metropolitan to develop Pure Water, a large-scale regional recycled water program which will produce up to 150 MGD of purified recycled water from wastewater at the Warren Facility. Pure Water involves construction of new wastewater treatment facilities and an AWP Facility to treat effluent from the Warren Facility, as well as a new regional conveyance system and associated infrastructure to utilize the purified water to augment regional water supplies. Pure Water will purify primary or secondary wastewater effluent from the Warren Facility through advanced water treatment processes for potable reuse in Southern California at an area within Warren Facility that will be referred to as the Joint Treatment Site.

Water from Pure Water will be used primarily to recharge groundwater basins through spreading facilities and injection wells and to augment water supplies at water treatment plants owned and operated by Metropolitan. In addition, agencies would be able to connect to the proposed conveyance facilities to serve industrial users. Pure Water will be constructed in a phased approach with the ultimate capacity of the program considering the availability of source water at the Warren Facility, the anticipated water demands of member agencies for groundwater replenishment and raw water augmentation, and the available space at the Joint Treatment Site.

1.6 Past Facilities Planning Efforts

In 1949, the Chief Engineer and General Manager of the Sanitation Districts prepared a visionary report recognizing the key role that recycled water would have in Southern California. The report recommended the adoption of a policy looking toward reclamation. A subsequent report in 1958 reaffirmed the findings of the 1949 report and called for the construction of the Whittier Narrows WRP (WNWRP) to demonstrate the feasibility of full-scale water reclamation. The rationale for inland water recycling on a system-wide level in the JOS was formally presented in the 1963 A Plan for Water Reuse and in the 1965 Plan A.

1.6.1 1.2.1 A Plan for Water Reuse (1963)

In 1963, A Plan for Water Reuse (Parkhurst 1963) was prepared at the request of the Sanitation Districts' Board of Directors. This report concluded that inland water reclamation would (1) augment the Los Angeles Basin's water resources, (2) avoid the capital-intensive alternative of providing hydraulic relief capacity in large diameter downstream sewers, and (3) achieve "pay-as-you-go" financing of sewerage facilities through modular plant expansions scheduled at time intervals based on actual population growth rates. This report called for numerous relatively small WRPs located near potential recycled water users throughout the JOS. The report was intended to provide a basis for immediate action and for future facilities planning.

1.6.2 Plan A (1965)

In October 1965, the Sanitation Districts' Boards of Directors adopted Plan A (Sanitation Districts 1965), a long-range master plan for the development of the JOS through the year 2005. Central to this master plan was the staging of three new relatively large inland secondary treatment plants beside the San Gabriel River, and expansion of the existing WNWRP. The modular expansion of inland plants would provide maximum reuse potential, as well as timely hydraulic relief of trunk sewers leading to the Warren Facility.

1.6.3 JOS Facilities Plan (1977)

During the early 1970s, legislative actions of the state and federal governments, combined with a decrease in the rate of population growth in Los Angeles County and the planned implementation of the State Water Project to bring water from Northern California to Southern California, changed the basic assumptions under which the 1965 JOS Plan A was developed. Actions by the Los Angeles Regional Water Quality Control Board (LARWQCB) under the Porter Cologne Water Quality Act of 1970 required changes in solids removal and biosolids management at the Warren Facility to meet more rigorous effluent standards. In 1972, the State Ocean Plan and the Clean Water Act (CWA) required several major changes in the JOS including the provision of full secondary treatment at the Warren Facility and the implementation of an industrial source control program to control discharges of heavy metals, synthetic organic pollutants, and other incompatible pollutants to the sewer system.

In response, tertiary treatment facilities were constructed at JOS WRPs. The implementation of the State Water Project effectively improved the mineral quality of the water supply and wastewater. It also increased the costs and energy requirements associated with conventional water supplies. The totality of these changes warranted a re-evaluation of the 1965 JOS Plan A, which ultimately took the form of the 1977 JOS Facilities Plan (1977 Plan) (Sanitation Districts 1977).

The stated goals of the 1977 Plan were to (1) bring the JOS into compliance with state and federal water quality legislation, (2) provide wastewater conveyance, treatment, and disposal facilities necessary to serve the population tributary to the JOS through the year 2000, and (3) maximize the potential for water reuse in the JOS. At the time the 1977 Plan was developed, wastewater management agencies located in critical air basins were required to base their facilities plans on the lowest population projection for the service area. Therefore, the 1977 Plan was based on California Department of Finance (DOF) Series E-0 population projection that identified a zero-growth condition in the JOS during the planning period (1976–2000).

Accordingly, the 1977 Plan recommended system upgrades and emphasized inland treatment and reuse of wastewater. Proposed system upgrades included the construction of facilities to provide full secondary treatment at the Warren Facility and tertiary treatment at all WRPs. To facilitate increased water reuse in the JOS, the 1977 Plan proposed to expand the aggregate capacity of the WRPs from 125 to 150 MGD (through expansions at the Long Beach WRP (LBWRP) and San Jose Creek WRP (SJCWRP) while downscaling the permitted dry weather capacity of the Warren Facility from 385 MGD to between 265 and 300 MGD.

1.6.4 JOS 2010 Master Facilities Plan (1995)

During the 1980s, the actual JOS population growth rate was higher than that predicted by the 1977 Plan. The original population projection for the year 2000 was 3.65 million, while the actual population in 1995 was approximately 4.6 million. This difference resulted in the generation of significantly larger wastewater flows within the JOS. The 1977 Plan predicted year 2000 average day dry weather flows between 415 and 450 MGD. In 1989, the actual JOS flows were approximately 524 MGD. These larger flows necessitated the accelerated construction of projects recommended in the plan as well as the additional expansion of facilities beyond the plan's recommendations. The permitted capacity of the Warren Facility remained at 385 MGD.

In the late 1980s and early 1990s, the JOS experienced a decrease in wastewater flows. One contributing factor was weather- and water-supply-related. Drought conditions occurred and were accompanied by water restrictions that reduced per-capita wastewater generation within the JOS. Also during this period, there was an economic downturn that affected commercial and industrial wastewater generation. The overall result was that the 1995 peak flows were down to 470 MGD from the 1989 high of 524 MGD.

Following the completion of the 1977 Plan, amendments to the CWA were implemented including Section 301(h), which allowed the EPA to modify the requirements for full secondary treatment of municipal wastewater for ocean discharge. To obtain a 301(h) waiver, an applicant was required to demonstrate no adverse impact on the marine environment from discharge. In the state of California, requirements for marine discharge are also specified in the State Ocean Plan. The Sanitation Districts determined that both the federal and state requirements could be achieved by chemically enhanced primary treatment and partial secondary treatment. The Sanitation Districts constructed these facilities at Warren Facility and applied for the modification to full secondary treatment requirements per Section 301(h). Ultimately, this permit modification was not granted, and the Sanitation Districts negotiated a consent decree that included the implementation of full secondary treatment at the Warren Facility.

The planning review required by the terms of this consent decree was contained within the JOS 2010 Master Facilities Plan (2010 Plan) published in 1995 (Sanitation Districts 1995). The stated planning objectives for the 2010 Plan were to (1) provide full secondary treatment for all flows as required by a Consent Decree between the Sanitation Districts, the United States, the state of California, the Natural Resources Defense Council, and Heal the Bay, and (2) provide wastewater conveyance, treatment, and reclamation/disposal facilities to meet JOS service area needs through the year 2010 in a cost-effective and environmentally sound manner.

The 2010 plan recommended 400 MGD of dry weather secondary treatment capacity at the Warren Facility. The plan provided detailed design criteria, site layouts, and a schedule indicating the implementation and commencement of facilities for operation by the year 2002. The recommended improvements to the Warren Facility were implemented.

1.6.5 Plan for Beneficial Reuse of Reclaimed Water (1995)

To comply with one of the requirements of the Consent Decree that the Sanitation Districts entered into with the U.S. Environmental Protection Agency (EPA), the LARWQCB, the Natural Resources Defense Council (NRDC) and Heal the Bay, the Sanitation Districts prepared a Plan for Beneficial Reuse of Reclaimed Water (1995 Plan for Beneficial Reuse).

The stated goals of the 1995 Plan for Beneficial Reuse were to (1) identify and evaluate the potential for reuse of reclaimed water produced, including a review and update of the relevant sections of the 1982 Orange and Los Angeles Counties Water Reuse Study and other appropriate subsequent studies prepared by the Districts or by water supply agencies, (2) delineate and examine the impediments to the use of reclaimed water, including technical, regulatory, and institutional barriers, and (3) propose a strategy for avoiding or overcoming the identified impediments.

The 1995 Plan for Beneficial Reuse emphasized the need for the Sanitation Districts to implement the 2010 Plan to build additional treatment capacity at the water reclamation plants to increase the available reclaimed water supply, to work with water suppliers during preparation of their Urban Water Management Plans to identify water recycling projects that can be considered as additional water supplies, and to actively participate in planning processes for new water recycling projects and provide technical assistance when applicable. As described above, the Sanitation Districts implemented improvements to the Warren Facility based on the recommendations of the 2010 Plan. Additionally, the Sanitation Districts have consistently pursued a policy of working with water suppliers to identify and implement water recycling projects.

1.6.6 Joint Outfall System Water Reuse Plan (2022)

The JOS Water Reuse Plan charted a course for the future of the JOS recycled water program with the goal of maximizing reuse to meet increasing demand for recycled water despite production declines due to drought and water conservation. The JOS Water Reuse Plan recommended the following: 1) install new diversion structures at strategic locations near various WRPs to increase residential and commercial wastewater flows and limit industrial wastewater flows into the plants, and 2) focus on groundwater recharge projects rather than non-potable reuse projects, since the former eliminates the need for a separate distribution system and storage.

1.7 Need for Project (Warren Facility Nitrogen Treatment)

The Sanitation Districts' mission is to convert waste into resources such as recycled water. To fulfill this mission, the Sanitation Districts is partnering with Metropolitan on Pure Water to achieve the following objectives:

1. Provide a new high-quality local water source that is reliable, cost-effective, and climate-change resilient to help meet regional water demands, with expedited or phased deliveries of such supplies where feasible.
2. Diversify Metropolitan's water supply portfolio, increase regional operational flexibility, and provide opportunities for improved coordination and future integration with other water supply and distribution systems.
3. Contribute to the water supply and water quality of local groundwater basins.
4. Provide improved wastewater treatment to maximize beneficial reuse of wastewater that would otherwise be discharged into the ocean, while complying with water quality requirements for ocean discharge.
5. Further statewide goals of increasing use of recycled water as a sustainable, environmentally sound water source for indirect and direct potable reuse.
6. Reduce reliance on imported water supplies and provide greater resilience of local water supplies.
7. Increase the locally available water supply to protect against seismic events and service disruptions.

Treated water from Pure Water could be used to recharge three groundwater basins: Main San Gabriel, West Coast, and Central. One of the key requirements of the Groundwater Replenishment Regulations in Title 22 California Code of Regulations (CCR) Division 4, Chapter 3, is that the concentration of total nitrogen (TN) in recycled or recharge water must not exceed 10 milligrams per liter (mg/L) (State Water Resources Control Board [SWRCB], 2015). In addition to Title 22 criteria, recycled water must also comply with water quality standards and objectives in applicable Water Quality Control Plans (Basin Plans), Salt and Nutrient

Management Plans (SNMPs), and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater.

In the future, treated water from Pure Water may also be blended with raw water at Metropolitan's Weymouth and Diemer water treatment plants for raw water augmentation, a form of DPR. California Water Code (CWC) 13561.2(a) requires the Division of Drinking Water (DDW), as part of the SWRCB, to adopt uniform criteria for DPR (i.e., DPR regulations) on or before December 31, 2023. DDW has released draft regulations specifying standards for pathogen control and chemical control and expects to finalize the DPR regulatory package by the stated deadline. Metropolitan has identified a total nitrate as nitrogen objective of 10 mg N/L for groundwater replenishment, and 6.4 mg N/L for raw water augmentation. However, in order to meet the non-degradation policy for Metropolitan's water supply sources, water produced for raw water augmentation should meet a 5 mg N/L limit, targeting 4 mg N/L. Historically, the secondary effluent (SE) at the Warren Facility has an average ammonia-nitrogen content of 44 mg N/L, far exceeding the limits for groundwater replenishment and raw water augmentation. The existing high-purity oxygen activated sludge (HPOAS) treatment process at the Warren Facility was neither designed to oxidize ammonia to nitrate nor to remove nitrogen from the effluent. Nitrogen management at the Warren Facility and AWP Facility will be crucial for potable reuse to meet water quality objectives. Pilot- and demonstration-scale studies have been completed at the Warren Facility that evaluated approaches to provide advanced treatment. Examples of the completed studies include evaluation of tertiary membrane bioreactor (nitrification only and nitrification/denitrification [NdN]), tertiary moving bed bioreactor, secondary conventional activated sludge, and secondary membrane bioreactor. These studies have shown that with additional advanced treatment, the Warren Facility effluent can be beneficially reused to supplement local potable supplies through groundwater recharge.

Additional bench and pilot scale studies are currently underway to demonstrate the feasibility of various process components considered for PWSC as listed in **Table 1-1**.

Table 1-1. Pilot and Demo Scale Studies

Project	Technologies Tested	Scale	Year Started	Year Completed
Joint Water Purification Pilot Program	▪ N-only TMBR ▪ tMF ▪ RO ▪ UV/AOP	Pilot	2010	2012
Centrate Nitrogen Removal at the JWPCP: A Pilot-Scale Evaluation of ANITA™Mox	ANITA™Mox ▪ MBBR ▪ IFAS ▪ Sidestream	Pilot	2013	2014
Tertiary NDN BAF Pilot Testing	tBAF	Pilot	2014	2016
Evaluation of Low-Pressure Membrane Fouling Potential of JWPCP Secondary Effluent	tMF	Pilot	2017	2018
Mainstream ANITA™Mox Pilot Testing at the JWPCP	ANITA™Mox ▪ IFAS ▪ Mainstream	Pilot	2017	2018

Project	Technologies Tested	Scale	Year Started	Year Completed
Tertiary NDN Troubleshooting	tNDN ▪ SBR	Bench + Pilot	2020	2021
Evaluation of Sidestream Deammonification with MABR	MABR ▪ Sidestream	Bench	2020	2022
Densified Activated Sludge Pilot Testing	DAS	Pilot	2022	2023
HPOLE Full-Scale Testing	HPO Ludzack Ettinger BNR	Full	2022	2023
Tertiary MBBR / PdNA Pilot Testing	tNDN/PdNA	Pilot	2022	2023
N-only Tertiary MBR Testing	tN-only • MBR	Demo	2019	2021
Secondary MBR Testing	sNDN • MBR	Demo	2022	2023
Tertiary NDN Pilot Testing	tNDN ▪ MBR	Pilot	2022	2023

BNR = biological nutrient removal
DAS = densified activated sludge
HPO = high purity oxygen
HPOLE = high-purity oxygen Ludzack-Ettiger
IFAS = Integrated fixed film activated sludge
MABR = membrane aerated biofilm reactor
MBBR = moving bed bioreactor
MBR = membrane bioreactor
SBR = sequencing batch reactor
sNDN = secondary nitrification-denitrification
tBAF = tertiary biologically active filter
TMBR = Tertiary membrane bioreactor
tMF = tertiary microfiltration
tN-only = tertiary nitrification
tNDN = tertiary nitrification-denitrification

1.8 Project Objectives

The goal of this Facilities Plan is to identify a project that meets the Warren Facility and Pure Water objectives in a cost-effective and environmentally sound manner. The objectives of this Facilities Plan are as follows:

1. Identify a project that is consistent with the objectives of Pure Water as described in Section 1.7,
2. Meet Pure Water program’s water quality requirements, and
3. Provide flexible nitrogen treatment facilities that can be cost-effectively operated and modified to support any necessary future improvements or comply with emerging regulatory requirements or water quality goals for the time period between now and 2050.

1.9 Document Organization

This document consists of Sections 1 through 8. Section 1 provides an overview of the Warren Facility and defines the need for a project and the project's objectives. Sections 2 and 3 provide the regional and regulatory settings for the Warren Facility. Section 4 provides a description of water and wastewater characteristics as well as projections for future wastewater management needs based on population forecasts. The existing Warren Facility wastewater treatment facilities and effluent management system are described in Section 5. Section 6 describes the development and screening of the project alternatives. The recommended project is detailed in Section 7. Section 8 provides the references used in preparation of this document.

A list of acronyms and abbreviations is included after the Table of Contents. Supporting information is included as appendices.

2
PLANNING AREA CHARACTERISTICS

2.1 Introduction

2.1.1 Planning Area

The JOS is a regional, interconnected system of wastewater conveyance and treatment facilities in the greater metropolitan Los Angeles area, extending south from the San Gabriel Mountains to the Palos Verdes Peninsula and bounded on the east by Orange and San Bernardino Counties, on the west by the Santa Monica Bay and the cities of Glendale and Los Angeles, and on the south by the San Pedro Bay. The Warren Facility is the largest treatment facility in the JOS and receives all JOS flows not treated at the six upstream WRPs. Flows treated at the Warren Facility are discharged to the Pacific Ocean. The Warren Facility also provides centralized solids processing for all JOS wastewater treatment facilities.

The JOS service area, water reclamation plants within the JOS, and the Warren Facility are shown in **Figure 2-1**.

2.2 Physical Setting

2.2.1 Climate

Prevailing winds in the Los Angeles Region originate from the west and southwest. Moist air from the Pacific Ocean is carried inland into the Los Angeles Basin until it is forced upward by the surrounding mountains. The resulting storms, most common from November through March, are typically followed by dry periods during summer months. Differences in topography are responsible for large variations in temperature, humidity, precipitation, and cloud cover throughout the region. The coastal plains, which are noted for their subtropical "Mediterranean" climate, are characterized by pronounced seasonal changes in rainfall (mild rainy winters and warm dry summers) but relatively modest transitions in temperature. The inland slopes and basins are characterized by more extreme temperatures and little precipitation. Precipitation generally occurs as rainfall, although snowfall can occur at higher elevations.

Average annual temperature in the vicinity of the Warren Facility ranges from 58 degrees Fahrenheit (°F) to 75°F. During the dry season (April through October), average temperatures range from 56°F to 81°F; during the wet season (November through March), the range is from 48°F to 74°F. Total annual precipitation is about 11 inches, averaging about 0.1 inches per month during the dry season and 2 inches per month during the wet season. A monthly climate summary for the Warren Facility services area from 2015 - 2019 is shown in **Table 2-1**.

Figure 2-1. Joint Outfall System Service Area, WRPs, and Warren Facility

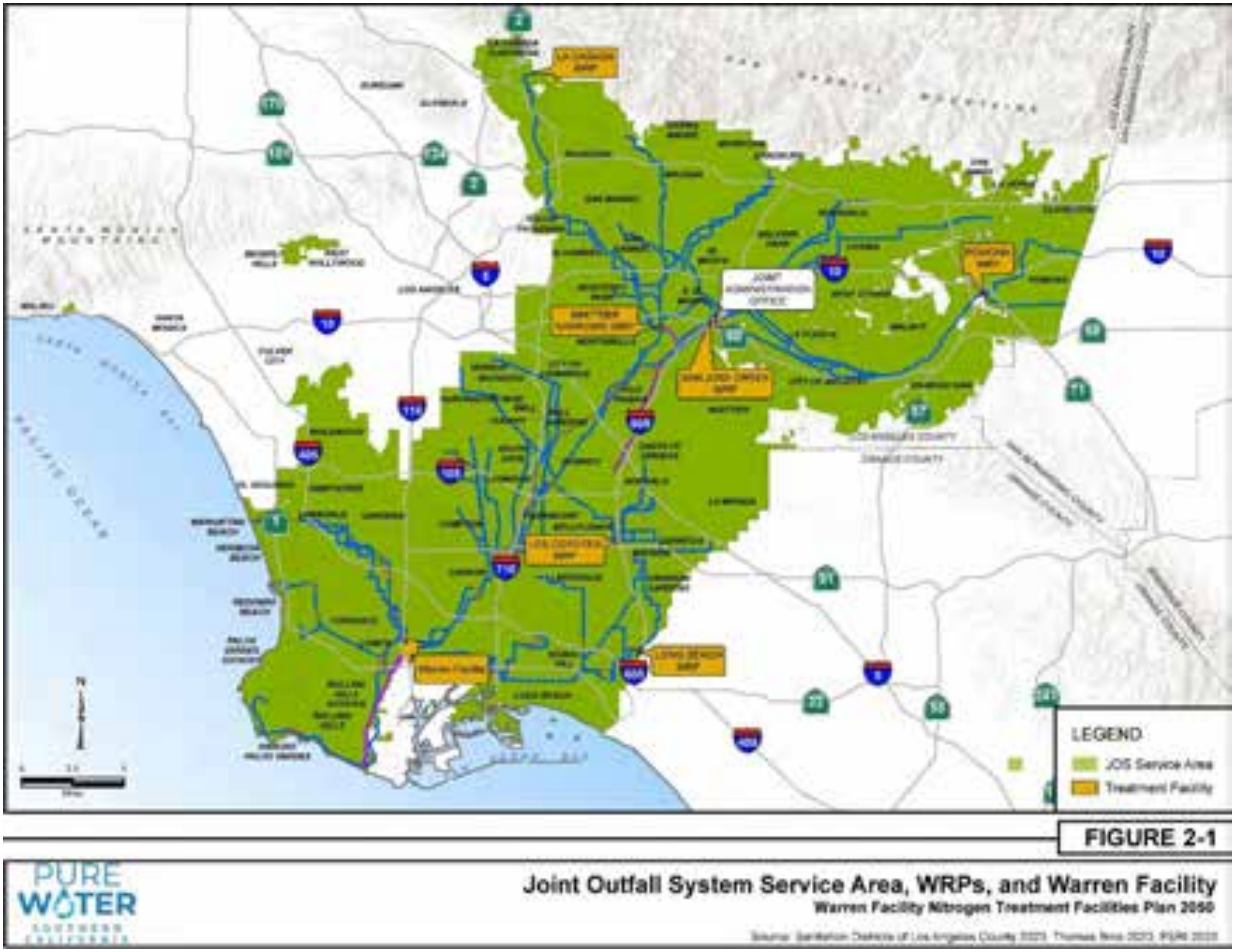


Table 2-1. Monthly Climate Summary from 2015 - 2019

Temperature and Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average Temperature/ Average Monthly Precipitation
Average Maximum Temperature (°F)	68	68	71	74	71	77	83	84	83	81	74	67	75
Average Minimum Temperature (°F)	51	48	54	56	58	63	67	68	67	62	54	48	58
Average Total Precipitation (inches)	3.8	1.9	1.0	0.1	0.3	0.0	0.1	0.0	0.2	0.2	1.1	2.2	0.9

Source: https://www.wunderground.com/history/daily/us/ca/wilmington/KLGB, Long Beach Airport (Daugherty Field) Station. January 2015 – December 2019

2.2.2 Geography and Topography

As the terminus of the JOS sewer network, the Warren Facility manages wastewater from the entirety of the JOS except for residential and commercial flows captured for recycling at upstream WRPs. The JOS, and by extension the Warren Facility, provides wastewater management services to communities within the San Gabriel Valley, the Los Angeles Coastal Plain, and the mountain foothills. Geographically, the JOS is bounded by the San Gabriel Mountains to the north, the Verdugo Mountains to the west, the Pacific Ocean to the west and south, and Orange and San Bernardino Counties and the Puente and San Jose Hills to the east. Major geographic and topographic features within and surrounding the Warren Facility service area and the JOS are shown on **Figure 2-2**. Due to the southward sloping topographic gradient within this area, the Los Angeles and San Gabriel Rivers and the Rio Hondo generally flow southward into the San Pedro Bay. The Sanitation Districts utilize the regional topography to provide gravity flow throughout the majority of the JOS.

2.2.3 Geology and Tectonics

The JOS lies within two adjoining geomorphic provinces: the Peninsular Ranges and the Transverse Ranges. The Peninsular Ranges geomorphic province extends south from the southeastern terminus of the Santa Monica Mountains and the foothills of the San Gabriel Mountains into Baja California and includes the southern portion of the JOS service area. The Transverse Ranges geomorphic province trends east-west along the northern border of the Peninsular Ranges geomorphic province and includes the northern portion of the JOS service area. The Coastal Plain lies within the Peninsular Ranges geomorphic province, while the San Gabriel Valley lies within the transition zone separating these two geomorphic provinces.

The Warren Facility is located in the west-central portion of the Los Angeles basin, a deep sediment filled structural depression that occupies the northwestern end of the Peninsular Ranges.

The Warren Facility lies on the coastal margin of the Los Angeles basin approximately 5 miles northwest of San Pedro Bay.

2.2.3.1 Seismic Hazards

As shown on **Figure 2-3**, the JOS and the Warren Facility are located in a seismically active region. The documented active faults closest to the Warren Facility include the Palos Verdes Hills fault zone and the Newport-Inglewood structural zone. Because of the number of active faults in Los Angeles County, the JOS and the Warren Facility are within the highest seismic hazard risk zone as defined by both the California Department of Conservation Division of Mines and Geology and the Uniform Building Code standards.

Figure 2-2. Major Geographic and Topographic Features within the JOS

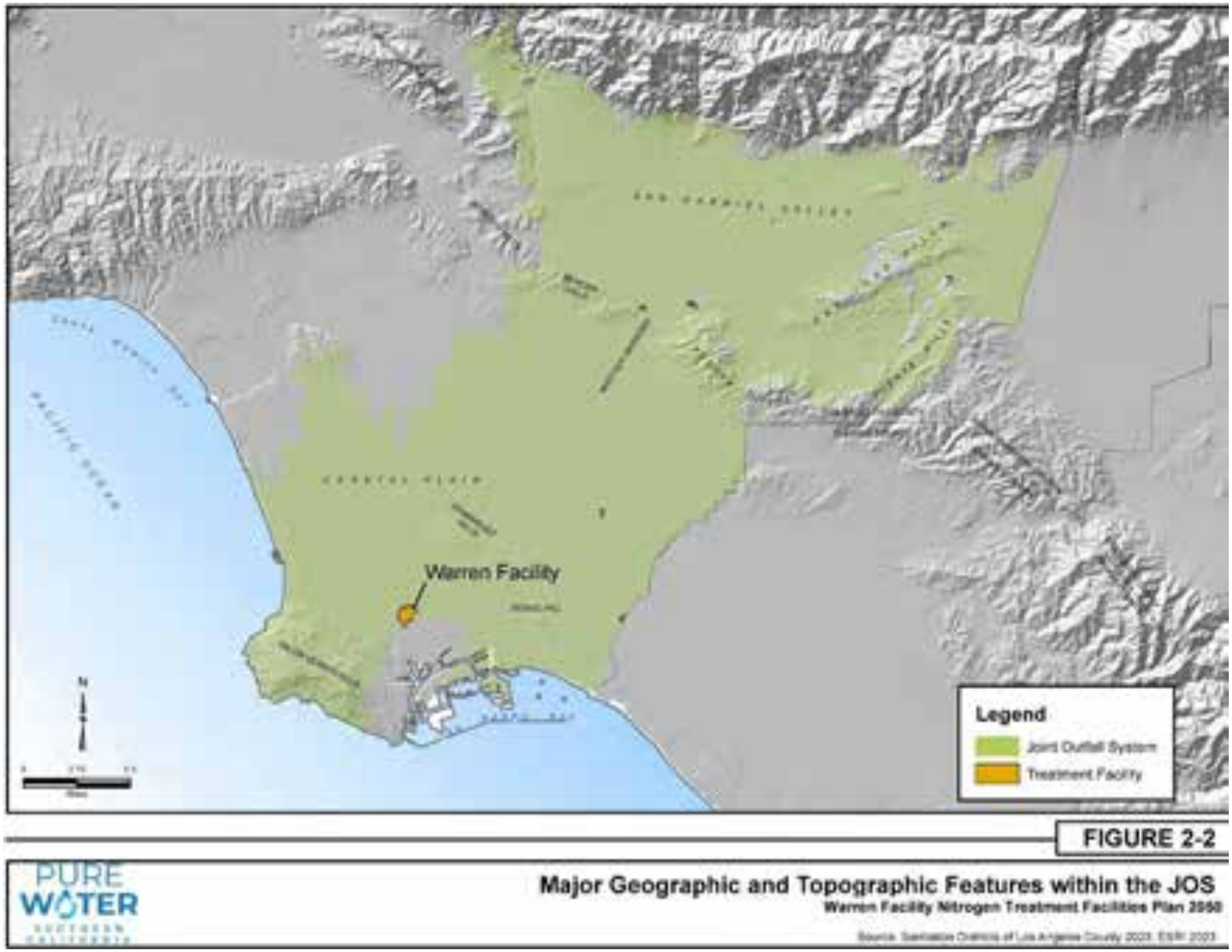
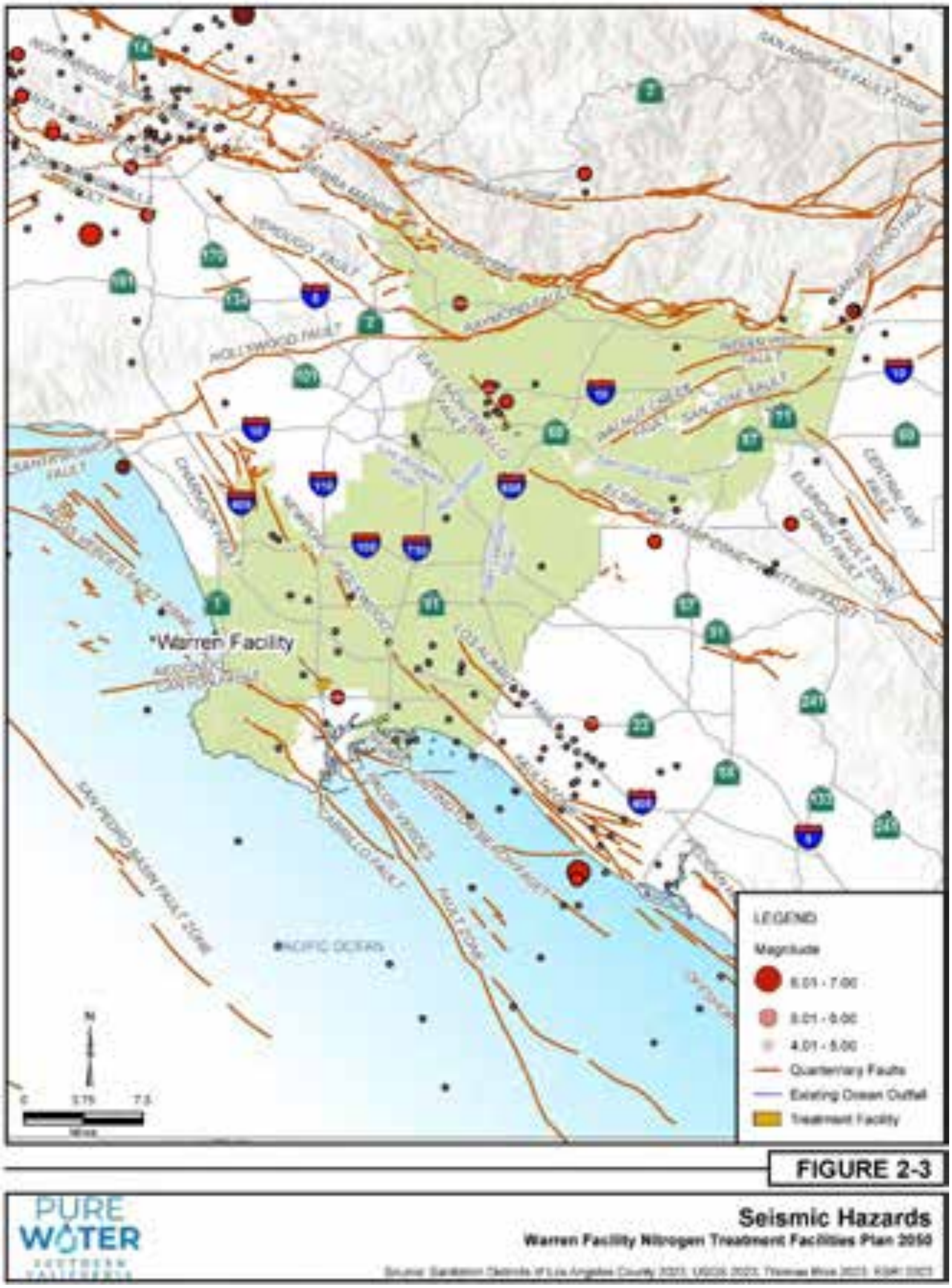


Figure 2-3. Seismic Hazards



2.2.4 Hydrology

2.2.4.1 Surface Water

The major hydrologic features in the JOS and the Warren Facility service area are the Los Angeles River Basin, San Gabriel River Basin, and Los Angeles Coastal Plain as identified in the Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles, and Ventura Counties. Precipitation in the Los Angeles area is characterized by intermittent but regular rainfall during winter months, with about 90 percent of the annual precipitation occurring between November and March. Rainfall during the summer months is usually negligible. Precipitation as snow is common in higher elevations of the upper watersheds of the San Gabriel Mountains. Monthly precipitation totals are quite variable, but annual precipitation usually averages 10 to 20 inches. Annual precipitation typically is highest in the mountains and higher inland areas.

Major rivers of the region include the Los Angeles River, San Gabriel River, and Rio Hondo. The major creeks include the San Jose and Coyote Creeks. Other water bodies near or tributary to these streams are Big Dalton Wash; Puddingstone Wash and Reservoir; Legg Lake; and the Morris, Cogswell, Santa Fe, and San Gabriel Reservoirs. These water bodies are shown on **Figure 2-4**.

2.2.4.2 Groundwater

As shown in **Figure 2-5**, the major groundwater basins in the JOS and the Warren Facility service area include the Coastal Plain of Los Angeles, San Gabriel Valley, and Upper Santa Ana Valley Basins. Sub-basins within these major basins include the Central, West Coast, Raymond, Claremont Heights, Live Oak, Puente, Spadra, and Pomona Basins (Metropolitan, 2007). Groundwater is a significant source of water supply for some areas within the JOS, and the replenishment of aquifers is vital to maintain the utility of these supplies. Imported water and recycled water are used to reduce water quality problems associated with groundwater overdraft and subsequent seawater intrusion into coastal plain aquifers.

2.2.5 Air Quality

The JOS and the Warren Facility service area lie completely within the South Coast Air Basin (SCAB), which is regulated by the South Coast Air Quality Management District (SCAQMD). The SCAB covers an area of approximately 6,745 square miles with a population of 14.6 million, and includes the metropolitan areas of Los Angeles, San Bernardino, and Riverside Counties, and all of Orange County as shown on **Figure 2-6**. It is bounded on the northwest by Ventura County and on the south by San Diego County. The northern boundary runs roughly along the Angeles National Forest, north of the ridge lines of the San Gabriel and San Bernardino Mountains. The eastern border runs north–south through the San Bernardino and San Jacinto Mountains. The Banning Pass area is excluded from the air basin. The western boundary is the entire shoreline of Los Angeles and Orange Counties.

The air quality in the SCAB has improved significantly over the last several decades. However, of the national ambient air quality standards (NAAQS) established for the six criteria pollutants (ozone, lead, sulfur dioxide, nitrogen dioxide, carbon monoxide, respirable particulate matter [PM_{10}], and fine particulate matter [$PM_{2.5}$]) and the additional four pollutants with state standards (sulfates, hydrogen sulfide, vinyl chloride, and visibility reducing particles), the SCAB is designated as a nonattainment area for federal and state standards for ozone and $PM_{2.5}$.

In addition to the NAAQS, greenhouse gas (GHG) regulations apply to the JOS and the Warren Facility service area. The California Global Warming Solutions Act of 2006 (also known as Assembly Bill [AB] 32) established a comprehensive program of regulatory and market mechanisms to achieve reductions of GHGs. A scoping plan was adopted by the California Air Resources Board on December 12, 2008. The AB 32 scoping plan contains the main strategies that the state of California will use to reduce the GHGs that cause climate change. The scoping plan has a range of GHG reduction actions that include direct regulations, alternative compliance mechanisms, monetary and nonmonetary incentives, voluntary actions, market-based mechanisms such as a cap-and-trade system, and an AB 32 cost of implementation fee regulation to fund the program. The latest amendment to the scoping plan in 2022 sets a goal of reducing anthropogenic GHG emissions to 85 percent below 1990 levels by 2045, as directed by The California Climate Crisis Act (also known as AB 1279).

Figure 2-4. Surface Water Resources

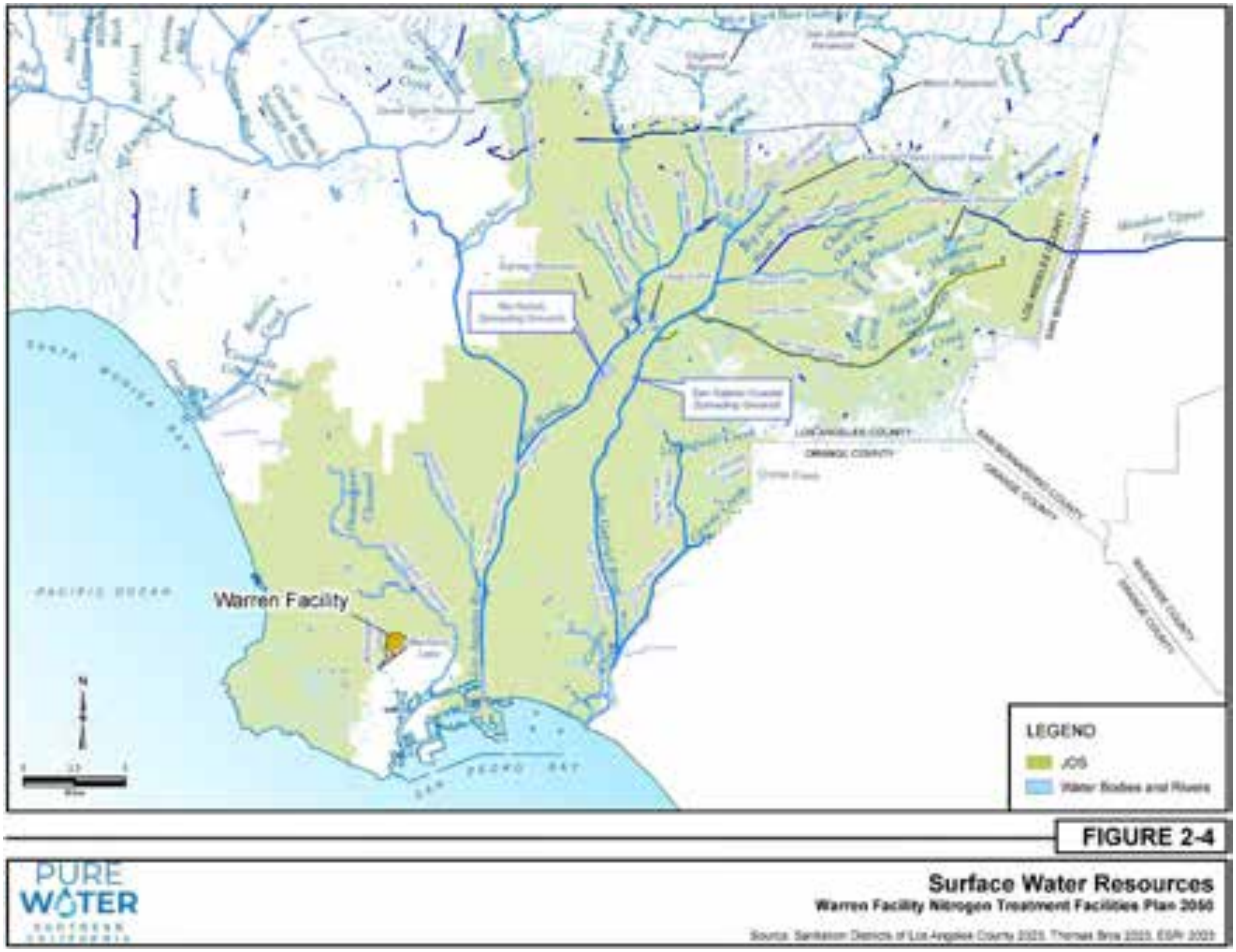


Figure 2-5. Regional Groundwater Basins

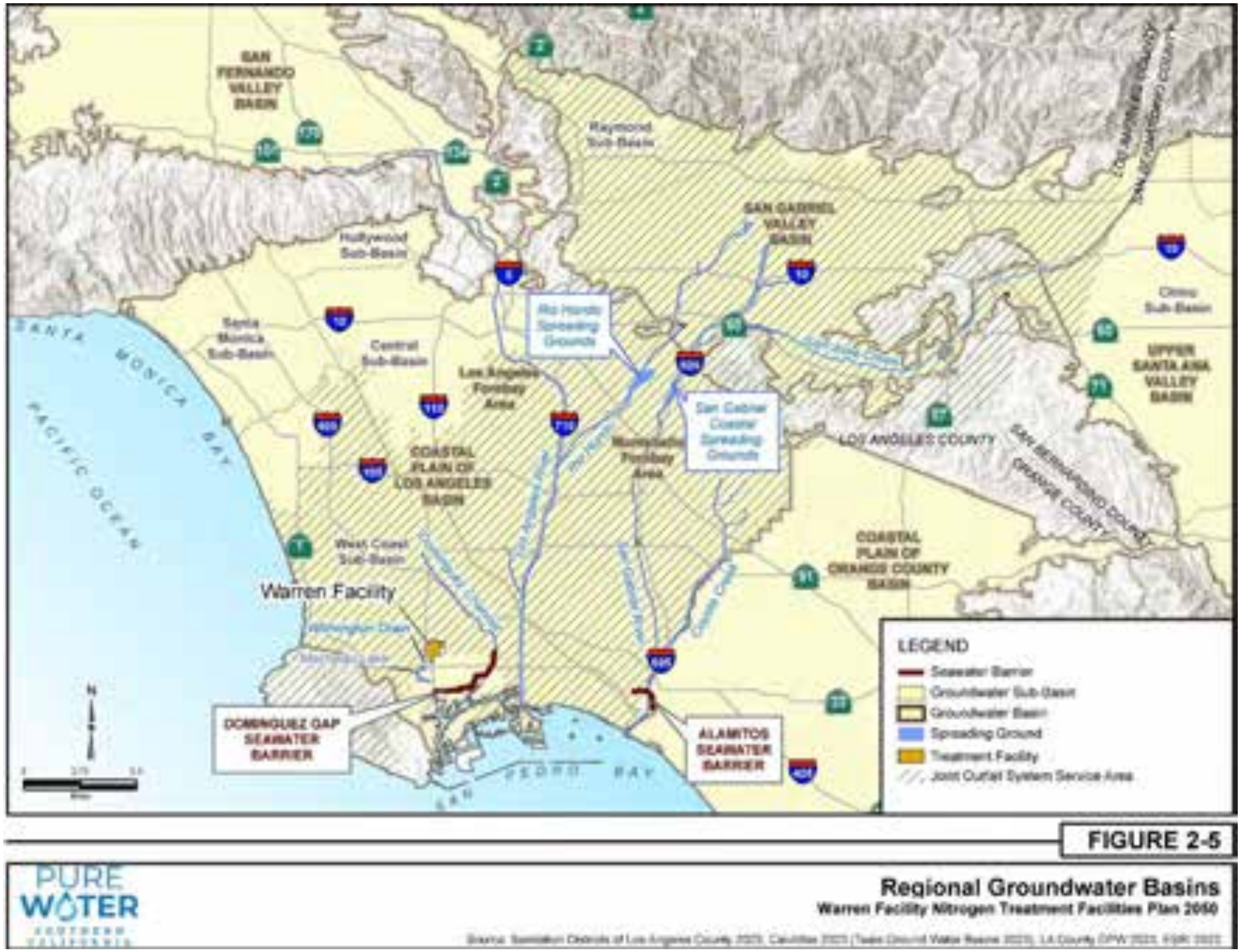


Figure 2-6. South Coast Air Basin

2.3 Demographics

A socioeconomic profile of the existing population, housing, income, and employment of the JOS service area and Los Angeles County is provided in this section. The analysis presented in this section is based on information provided by the U.S. Census Bureau, the Southern California Association of Governments, the California Department of Finance, and the American Community Survey.

2.3.1 Population

In 1950, approximately 4.2 million people resided in Los Angeles County; by 2020, the population had more than doubled to approximately 10 million. This represents an increase of 5.8 million residents over 70 years, or an average growth rate of approximately 1.2 percent per year. In the last census decade (2010–2020), the population of the county grew by 200,000 (or 0.2 percent per year), which is approximately two thirds the population increase of the previous decade. Approximately half of the county population resides within the JOS service area (based on a comparison of 2010 through 2020 population values). Population growth trends within the JOS service area are shown in **Table 2-2**.

Table 2-2. Historical Population in JOS Service Area

Year	Historical Population
2010	4,832,177
2011	4,848,298
2012	4,873,514
2013	4,913,211
2014	4,927,079
2015	4,951,626
2016	4,945,193
2017	4,933,405
2018	4,935,484
2019	4,928,235
2020	4,879,644

The Southern California Association of Governments' (SCAG's) 2024-2045 Regional Transportation Plan/Sustainable Communities Strategy (RTP20) projects that the population in the JOS service area will grow to 5.4 million by 2045, representing an increase of about 10 percent compared to 2020.

2.3.2 System Users

In 2020, there were 4,879,644 people living in the JOS service area. Out of this population, 23 percent were below the age of 18, 63 percent were between the ages of 18-65, and 14 percent were above the age of 65. The racial and ethnic distribution in the JOS was 17 percent White, 8 percent Black, 18 percent Asian, 54 percent Latino, and 3 percent Other. The information was obtained from the American Community Survey (ACS) 2021 data, which is tied in with the census.

2.3.3 Housing

Based on the ACS 2021 data, within the JOS service area, there are a total of 1,680,658 housing units. Out of the total housing units, 95% are occupied and 5% are vacant.

Vacancy rates are defined as the percentage of unoccupied units in the total available housing stock. Low vacancy rates indicate that the housing market is constrained. The JOS service area's vacancy rate of 5 percent indicates a housing shortage.

The median price of housing in the JOS service area is $562,480.

2.3.4 Income and Employment

According to the ACS 2021 data, in the JOS service area, 2,702,970 people are employed.

The average household income in the JOS service area is $82,693/year.

2.4 Land Use

The current land use in the JOS service area is shown in **Table 2-3**. The data are obtained from the 2024-2045 SCAG RTP 20. More than 50 percent of the land in the service area is used for residential purposes. The Warren Facility is bordered by SR-110 to the west, and a mixture of low-density residential, commercial, and industrial areas, with recreational open space to the north, south, and east.

Table 2-3. JOS Service Area Land Use

Existing and Planned Land Use Category	Percent of the Total Area
Residential	63%
Park/Recreation	12%
Industrial	14%
Public Facility	4%
Commercial	7%

3
LAWS AND REGULATIONS

3.1 Introduction

The collection and treatment of wastewater and its associated residuals (e.g., reverse osmosis concentrate, sludge, biosolids) and the management of treated wastewater effluent for ocean discharge and reuse is subject to federal, state, and local regulations. Furthermore, federal and state funding for capital projects is contingent upon the fulfillment of additional regulatory requirements. This section provides a broad summary of federal, state, and local laws, regulations, and plans that must be considered when planning for wastewater treatment and effluent management facilities and water reuse projects.

3.2 Regulations Governing Discharges to Federal and State Waters

This section discusses existing and anticipated regulations pertaining to discharges to federal and state waters that affect the operation of Publicly Owned Treatment Works (POTWs). The Warren Facility is subject to the federal regulations listed in Section 3.2.2 below and state regulations listed in Section 3.2.3 below because it discharges to waters of the United States and waters of the state (i.e., territorial marine waters of the Pacific Ocean). The federal regulations are implemented through implementation of National Pollutant Discharge Elimination System (NPDES) permits and the state regulations are implemented through implementation of Waste Discharge Requirements (WDRs).

3.2.1 Evolution of Federal Regulations

3.2.1.1 Refuse Act

Federal regulation of discharges to bodies of water began in 1899 with the passage of the Refuse Act, which was primarily intended to protect navigation by preventing discharges that might interfere with the use of the nation's waterways as transportation corridors.

3.2.1.2 Water Pollution Control Act

The Water Pollution Control Act of 1948 was the first federal legislation to address water quality, which had been historically regulated on state and local levels. This act reaffirmed that water pollution control was primarily a state responsibility but did provide the federal government with the authority to conduct investigations, research, and surveys. In 1956, the Water Pollution

Control Act was amended to include provisions for federal grants to support the construction of POTWs and direct federal regulation of waste discharges.

3.2.1.3 Water Quality Control Act

The Water Quality Control Act, enacted in 1965, required states to establish federally approved ambient water quality standards for interstate watercourses and to develop federally approved implementation plans for controlling pollution sufficiently to meet these standards.

3.2.2 Federal Regulations Governing Discharges from POTWs

3.2.2.1 Clean Water Act

The 1972 amendments to the federal Water Pollution Control Act marked the beginning of the current system of federal water quality regulation and increased the level of federal grant funding for municipal wastewater treatment facilities. Goals of the 1972 amendments included elimination of pollutant discharges to navigable waters of the United States (U.S.) by 1985 and protection of fishable and swimmable waters, wherever attainable, by 1983. The 1972 amendments initiated the NPDES permit program, which required the issuance of discharge permits for all municipal and industrial point sources that discharge into waters of the U.S.

The 1972 amendments preserved the system of state established water quality criteria promulgated under the 1965 Water Quality Control Act, but the states were additionally required to review and update these standards every three years and submit revisions to the EPA for approval. Water quality standards associated with the designated uses of the navigable waters for such waters were to be established. These standards were to consider the water's use and value for public water supplies; propagation of fish, aquatic life, and wildlife; recreation; and agricultural, industrial, navigation, and other purposes. Where compliance with identified technology-based standards was not sufficient to ensure attainment of approved water quality standards, the 1972 amendments directed the permitting agency to impose water quality based, effluent limitations in permits.

The federal Water Pollution Control Act was amended a third time in 1977, and the amended act was renamed the CWA. The 1977 amendments extended some of the deadlines identified in 1972 and more clearly delineated the manner in which conventional and toxic water pollutants were to be treated. The 1977 CWA required that toxic pollutants be managed through the effluent guidelines program for major industrial dischargers or the pretreatment program for specified industries discharging to POTWs.

The CWA was amended again in 1987 which (1) ended the construction grant program and replaced it with the State Revolving Fund (SRF) loan program for the construction of municipal sewerage facilities, (2) required states to promulgate water quality standards for toxic water pollutants for which advisory water quality criteria had been developed pursuant to §304(a) of the CWA, and (3) established new requirements for states to develop and implement programs to control nonpoint source pollution. To address nonpoint source pollution, the 1987 amendments also required the issuance of NPDES permits for stormwater discharges associated with municipal, industrial, and construction activities.

3.2.2.2 National Pretreatment Program

The National Pretreatment Program, established through the CWA in Title 40, Part 403 of the Code of Federal Regulations (CFR) (40 CFR Part 403), requires the implementation of pretreatment programs for POTWs with capacities greater than 5 MGD that receive pollutants that may interfere with POTW operations. POTWs are required to prohibit or limit discharges of pollutants from industrial facilities that could pass through the treatment processes into receiving waters, interfere with treatment plant operations, or limit biosolids management options. Smaller POTWs with significant industrial contributions, treatment process problems, or violations of effluent limitations (related to influent quality) are also required to implement pretreatment programs. As part of the National Pretreatment Program, federal standards have been established to regulate the quality of wastewater discharged to the sewer system from specific types of industries.

POTWs are responsible for developing, implementing, and enforcing their own pretreatment programs. If POTWs fail to properly administer pretreatment programs, they are subject to oversight by state and federal regulatory agencies including enforcement actions, penalties, fines, or other remedies provided for by the CWA.

The Sanitation Districts developed and implemented an industrial wastewater pretreatment program in 1972 with the adoption of the Wastewater Ordinance. The purpose of this Ordinance was to establish controls on users of the Sanitation Districts' sewerage system in order to protect the environment and public health, and to provide the maximum beneficial use of the Sanitation Districts' facilities. Local industrial wastewater discharge limits (local limits) were established to ensure compliance with effluent limits specified in the NPDES and WDR permit limits for each treatment plant, as well as to protect treatment plant operations and biosolids quality. Local limits for industrial wastewater dischargers were adopted in 1975, and the EPA approved the Sanitation Districts' program in March 1985. The pretreatment program has been very successful in reducing the discharge of contaminants.

The existing industrial local limits are presented in **Table 3-1**. The Sanitation Districts regularly reviews these limits to determine if modifications are needed. Modifications to the discharge limits may be made if determined necessary to maintain biosolids quality and/or meet NPDES and WDR permit limits.

Table 3-1. Sanitation Districts JOS Industrial Wastewater Effluent Limitations

Constituent	Instantaneous Maximum Limit (mg/L)
Arsenic	3
Cadmium	15
Chromium (Total)	10
Copper	15
Cyanide (Total)	10
Lead	40
Mercury	2
Nickel	12
Silver	5

Constituent	Instantaneous Maximum Limit (mg/L)
TICH[a]	Essentially None[b]
Zinc	25

[a] TICH include pesticides such as aldrin, dieldrin, chlordane, dichlorodiphenyltrichloroethane, endrin, hexachloro-cyclohexane, toxaphene, and polychlorinated biphenyls.

[b] TICH must be maintained below detection levels.

TICH = total identifiable chlorinated hydrocarbons

In addition to the limits in **Table 3-1**, the following numeric requirements from the Sanitation Districts' Wastewater Ordinance apply:

- The pH of the wastewater discharged shall not be below 6.0 at any time.
- The dissolved sulfide concentration of the wastewater shall not exceed 0.1 mg/L at any time.
- The temperature of the wastewater shall not exceed 140°F at any time, and shall not cause the wastewater influent to a Sanitation Districts' treatment plant to exceed 104°F.

3.2.2.3 National Toxics Rule and California Toxics Rule

In 1992, EPA promulgated toxic pollutant water-quality criteria for California in the National Toxics Rule (NTR). EPA promulgated the California Toxics Rule (CTR) in response to litigation that overturned two statewide water quality control plans in 1994, the Inland Surface Waters Plan (ISWP) and the Enclosed Bays and Estuaries Plan. The CTR took effect in May 2000 and established numeric criteria for the remaining priority toxic pollutants to meet the requirements of §303(c)(2)(B) of the CWA. The NTR and CTR criteria are regulatory criteria adopted pursuant to §303(c) of the CWA that apply to inland surface waters and enclosed bays and estuaries in California that are waters of the U.S. The NTR and CTR include criteria for the protection of aquatic life and human health. Aquatic life and human health criteria (consumption of organisms only) apply to all inland surface waters and enclosed bays and estuaries, while human health criteria (consumption of water and organisms) apply to all waters with a municipal and domestic water supply beneficial use (BU) designation. The SWRCB and the Regional Water Quality Control Boards (RWQCBs) identify and designate BUs for all waterbodies in the state. The most stringent applicable criteria for the designated BUs are translated to effluent limitations in permits.

3.2.2.4 CWA §404 and §401 Permits

§404 of the CWA established a permit program for regulation of the discharge of dredged material or fill into waters of the U.S. The permit program is administered by the Secretary of the Army, acting through the United States Army Corps of Engineers. §404 authorizes the EPA to regulate the discharge of any dredged material or fill that can cause adverse effects on municipal water supplies, recreational areas, wildlife, fisheries, or shellfish beds.

§401 of the CWA provided the authority for the state operated 401 Water Quality Certification Programs. The 401 Water Quality Certification process is used by the state to regulate water quality impacts from hydrologic modification projects that require §404 permits. In California, the RWQCBs oversee the §401 Water Quality Certification process.

3.2.3 State Regulations Governing Discharges from POTWs

3.2.3.1 The Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act of 1969 (PCA) established the current legal framework for water quality regulation in California. The PCA requires the SWRCB to adopt water quality control plans and policies for the protection of water quality. The PCA also established nine RWQCBs that develop regional water quality control plans (Basin Plans) and implement water quality protection programs at the local level. A water quality control plan must:

- Identify the BUs of the waters to be protected.
- Establish water quality objectives (WQOs) for the reasonable protection of those BUs.
- Establish an implementation program for achieving WQOs.

The SWRCB is the primary agency responsible for formulating policies to protect surface waters and groundwater supplies within the State of California. The SWRCB adopts and implements statewide water quality control plans (i.e., California Ocean Plan; California Thermal Plan; ISWP; Enclosed Bays and Estuaries Plan) and cross-region water quality control plans (i.e., Bay-Delta Plan). The SWRCB has delegated authority for the day-to-day administration and enforcement of the PCA at the regional level to the RWQCBs. Each RWQCB develops a basin plan that identifies water resources within its region and specifies the BUs for each of these resources. Each basin plan must be approved by the SWRCB, the Office of Administrative Law (OAL), and the EPA. Basin plans are generally reviewed and updated every three years.

The Warren Facility is under the jurisdiction of the LARWQCB. The LARWQCB is responsible for administering and enforcing the regional water quality control plans, NPDES permits, WDRs, and pretreatment programs within the Los Angeles Basin.

The PCA authorizes the RWQCBs to regulate all discharges to water and/or land to protect water quality. The RWQCBs issue WDRs to all dischargers of waste in accordance with §13263 of the CWC. After consultation with the SWRCB DDW, the RWQCBs issue water reclamation requirements (WRRs) to recycled water projects to protect public health, safety, and welfare in accordance with §13523 of the CWC. The WDRs and WRRs are periodically reviewed and updated by the RWQCBs. Authority delegated to RWQCBs includes the issuance of WDRs and WRRs, review of self-monitoring reports submitted by dischargers, performance of independent compliance checks, and enforcement for non-compliance. Enforcement actions, which may be taken by RWQCBs under the authority provided by the PCA, range from orders requiring corrective actions to monetary penalties levied for failure to comply with permit provisions.

The RWQCBs have also been delegated responsibilities associated with administering and enforcing the provisions of the CWA. For discharges to waters of the U.S., NPDES/WDRs permits are adopted and implemented. Under Chapter 5.5 of the PCA, WDRs are deemed equivalent to NPDES permits issued under the CWA. Thus, NPDES permits are generally issued as both federal and state permits in California and generally have both a State Order number and an NPDES permit number.

3.2.3.2 CWC §1211

CWC §1211 states that before a wastewater treatment plant owner may make "any change in the point of discharge, place of use, or purpose of use of treated wastewater, the owner of any wastewater treatment plant shall obtain approval of the [SWRCB] board for that change."

§1211 only applies when this change results in a decreased flow to any portion of a watercourse (CWC§1211[b]). Consultation with the California Department of Fish and Wildlife is required, and a Wastewater Change Petition must be filed and publicly noticed by the SWRCB Division of Water Rights. If the proposed change is expected to have an adverse impact to biological resources, the applicant must include mitigation measures, which may include a minimum discharge rate.

3.2.3.3 Statewide Implementation Policy

In March 2000, the SWRCB adopted a policy establishing provisions to implement the priority toxic pollutant criteria in the CTR and NTR and implement priority pollutant objectives in the Basin Plans. The Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (also known as the Statewide Implementation Policy or SIP) establishes provisions for translating CTR criteria, NTR criteria, and basin plan WQOs for toxic pollutants into NPDES permit effluent limits and for determining compliance with criteria/objectives. The SIP also includes the method for calculating 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) equivalents, implementation of chronic toxicity control requirements, development of site-specific objectives, and the process for granting exceptions from priority toxic pollutant criteria.

3.2.3.4 California Ocean Plan

The State Water Board adopted the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) in 1972, as amended. The Ocean Plan was developed to protect the beneficial uses of California’s marine waters through establishing water quality objectives and implementation provisions in statewide water quality control plans and policies. The Ocean Plan specifies effluent limitations for waste discharged into the ocean and seawater intake. The Ocean Plan has been amended five times to establish new provisions and requirements to protect ocean waters. The latest amendment occurred in 2019 and revised statewide bacteria water quality objectives and implementation options to protect recreational users from the effects of pathogens. The WDRs regulating discharges from the Warren Facility incorporate the effluent limitations and monitoring and testing provisions of the Ocean Plan.

The Ocean Plan allows the LARWQCB to establish more restrictive water quality objectives and effluent limitations than those set forth in the Ocean Plan as necessary for the protection of the beneficial uses of ocean waters. Pursuant to this provision and to implement the recommendation of the Water Quality Advisory Task Force (Working Together for an Affordable Clean Water Environment, A final report presented to the California Water Quality Control Board, Los Angeles Region by Water Quality Advisory Task Force, September 30, 1993) that was adopted by the LARWQCB Board on November 1, 1993, performance goals that are more stringent than those based on Ocean Plan objectives are prescribed in the Warren Facility NPDES permit.

The performance goals are based upon the actual performance of the Warren Facility and are specified only as an indication of the treatment efficiency of the facility. Performance goals are intended to minimize pollutant loading (primarily for toxics), while maintaining the incentive for future voluntary improvement of water quality whenever feasible, without the imposition of more stringent limits based on improved performance.

3.2.4 Local Regulations Governing Discharges from POTWs

3.2.4.1 Water Quality Control Plan-Los Angeles Region

The *Water Quality Control Plan-Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (Basin Plan) was adopted by the LARWQCB on June 13, 1994. Chapters 2 and 7 of the Basin Plan were updated in November 2011 and September 2011, respectively. The Basin Plan provides the basis for the RWQCB's regulatory program by designating BUs for all surface and groundwater bodies and setting forth narrative and numeric WQOs that must be maintained or attained to protect those BUs. The Basin Plan also identifies general types of water quality problems that can threaten BUs of water resources in the basin and identifies required or recommended control measures for these problems. RWQCB Orders are based on applicable WQOs and/or prohibitions specified in the Basin Plan. The Basin Plan is reviewed and updated every three years or as necessary (CWA §303[c]). The most recent Triennial Review began in 2020 and was completed in March 2022. The findings of the Triennial Review are summarized in Resolution No. R20-004.

3.3 Warren Facility Discharge Regulations

Ocean discharges of treated effluent from the Warren Facility are governed by an NPDES permit that must be reissued every five years. The primary purpose of the limitations, prohibitions, and provisions in the Warren Facility NPDES permit is to implement the objectives of the California Ocean Plan, which was designed to maintain the indigenous marine life and a healthy and diverse marine community. The current NPDES permit Order No. R4-2023-0181 went into effect on July 1, 2023.

3.3.1.1 NPDES Permit Requirements

Treated effluent from the plant is currently discharged to the Pacific Ocean through a system of tunnels and submarine outfalls two miles offshore. The four outfalls are located at White Point, San Pedro, off the Palos Verdes Peninsula. Two of the outfalls, Discharge Points 001 and 002, are used for continuous discharge of treated wastewater. The NPDES permit prohibits discharges to Discharge Points 003 and 004 except when Discharge Points 001 and 002 are impacted by certain emergency situations, preventive maintenance, and capital improvement activities as specified in the permit. The permit includes an extensive set of final effluent limits and performance goals for Discharge Points 001 and 002, and separate final effluent limits for chlorine residual and various synthetic toxicants for Discharge Points 003 and 004. Effluent limitations are based on the CWA, Ocean Plan water quality objectives, and wasteload allocations prescribed in the *Santa Monica Bay Total Maximum Daily Load for DDTs and PCBs.* Final effluent limitations for major wastewater constituents for Discharge Points 001 and 002 are listed in **Tables 3-2 through 3-4**. The complete set of effluent limitations for Discharge Points 001, 002, 003, and 004 can be found in the NPDES permit.

Table 3-2. NPDES Permit Limits for Major Wastewater Constituents for Warren Facility Ocean Discharge Points 001 and 002

Parameter	Minimum Sampling Frequency	Unit	Effluent Limitations			
			Average Monthly[a]	Average Weekly[a]	Maximum Daily[a]	Instantaneous Maximum[b]
$BOD_5$20°C	Weekly	mg/L	30	45	-	-
		lbs/day[c]	96,300	145,000	-	-
TSS	Weekly	mg/L	30	45	-	-
		lbs/day[c]	96,300	145,000	-	-
pH	Weekly	pH units	6.0 (instantaneous minimum) – 9.0 (instantaneous maximum)			
Oil and Grease	Weekly	mg/L	15	22.5	45	75
		lbs/day[c]	48,200	72,200	144,500	240,800
Settleable Solids	Weekly	ml/L	0.5	0.75	1.5	3.0
Turbidity	Weekly	NTU	75	100	-	225
Temperature	Daily	°F	-	-	100	-
Removal Efficiency for $BOD_5$20°C and TSS		%	85			

[a] The maximum daily, average weekly and average monthly effluent limitations shall apply to flow weighted 24-hour composite samples. They may apply to grab samples if the collection of composite samples for those constituents is not appropriate because of the instability of the constituents.

[b] The instantaneous maximum effluent limitations shall apply to grab samples.

[c] The mass emission rates are calculated using 385 MGD, consistent with the water-quality based limits in the previous permit: lbs/day = 0.00834 x Ce (effluent concentration in μg/L) x Q (flow rate in MGD). During storm events when flow exceeds 400 MGD, the mass emission rate limitations shall not apply.

μg/L = micrograms per liter
$BOD_5$20°C = 5-day biochemical oxygen demand at 20 degrees Celsius
mg/L = milligrams per liter
ml/L = milliliters per liter
NTU = nephelometric turbidity units
TSS = total suspended solids

Table 3-3. NPDES Permit Limits for Marine Aquatic Life Toxicants for Warren Facility Ocean Discharge Points 001 and 002

Constituent	Units	Effluent Limitations		
		Average Monthly	Maximum Daily	Instantaneous Maximum
Chlorine Residual	μg/L	330	1,300	10,000
	lbs/day	1,100	4,300	32,200
Chronic Toxicity[a] Macrocystis pyrifera	Pass or Fail (TST)[b]	-	Pass	-

[a] The Chronic Toxicity final effluent limitation is protective of both the numeric acute and chronic toxicity 2019 Ocean Plan water quality objectives.

[b] TST = Test of Significant Toxicity. The discharge is subject to determination of "Pass" or "Fail" from a chronic toxicity test using the TST statistical t-test approach described in the National Pollutant Discharge Elimination System Test of Significant Toxicity Implementation Document (EPA 833-R-10-003, 2010), Appendix A, Figure A-1, Table A-1, and Appendix B, Table B-1.

Table 3-4. NPDES Permit Limits for Human Health Toxicants (Carcinogens) for Warren Facility Ocean Discharge Points 001 and 002

Constituent	Average Monthly Effluent Limits	
	μg/L	lbs/day
Benzidine	0.012	0.039
Chlordane	0.0038	0.012
DDT	0.0158	-
3,3'-Dichlorbenzidine	1.4	4.5
Dieldrin	0.0067	0.021
Hexachlorobenzene	0.035	0.11
PCBs	0.00035	-
TCDD Equivalents	$6.5x10^{-5}$	$2.1x10^{-6}$
Toxaphene	0.035	0.11

DDT = Dichlorodiphenyltrichloroethane
PCBs = Polychlorinated biphenyls as aroclors
TCDD = 2,3,7,8 -Tetrachlorodibenzo-p-dioxin

In addition to effluent limits and performance goals, the Warren Facility NPDES permit contains narrative and numeric receiving water limitations for chemical, physical, and biological parameters that are designed to protect the quality of the receiving water (Pacific Ocean shoreline and adjacent areas as defined in the permit). The receiving water limitations are based on the water quality objectives from the California Ocean Plan.

Bacteria

The NPDES permit requires discharges to be adequately disinfected. To meet this requirement, the effluent must be tested for total coliform bacteria, fecal coliform, and *Enterococcus*. Total coliform and *Enterococcus* must be sampled daily, while fecal coliform must be sampled at least 5 times per month. Total coliform bacteria cannot exceed a 30-day geometric mean density of 1,000 per 100 milliliters (mL) or 10,000 per 100 mL in a single sample. Fecal coliform density cannot exceed a 30-day geometric mean density of 200 per 100 mL or 400 per 100 mL in a single sample. *Enterococcus* cannot exceed a 30-day geometric mean density of 30 per 100 mL or 110 per 100 mL in 10% of samples in a calendar month. Lastly, total coliform density cannot exceed 1,000 per 100 mL in a single sample if the ratio of fecal-to-total coliform exceeds 0.1.

Physical Characteristics

The NPDES permit specifies that discharges must not cause floating particulates and oil and grease to be visible, cause aesthetically undesirable discoloration on the ocean surface, significantly reduce the transmittance of natural light, or change the rate of deposition or the characteristics of inert solids in ocean sediments such that benthic communities are degraded.

Chemical Characteristics

The NPDES permit prohibits discharges from changing the chemical composition of the receiving water and marine sediments to levels that would degrade indigenous biota or cause impairment of beneficial uses.

Biological Characteristics

The NPDES permit prohibits discharges from degrading marine life communities, adversely affecting marine resources used for human consumption in ways that would be undesirable to humans or harmful to human health, or containing substances that result in biochemical oxygen demand that adversely affects the beneficial uses of the receiving water.

3.4 Regulations Governing Drinking Water

3.4.1 Federal Regulations

3.4.1.1 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), passed in 1974, established a national program for protecting the quality of drinking water supplied by public water suppliers. Under the SDWA, the EPA issued minimum water quality standards that must be established by all states. Under the SDWA, states with approved drinking water protection programs, such as California, have implementation and enforcement authority.

3.4.2 State Regulations

3.4.2.1 California Drinking Water Standards

California drinking water standards (CDWS) are promulgated by the Division of Drinking Water (DDW), formerly California Department of Public Health (CDPH), under the California Safe Drinking Water Act. Typically, the CDWS are the same as the federal standards. Recycled water that is used to recharge groundwater or that is discharged to a surface water body designated as a drinking water supply must generally meet CDWS for trace constituents.

3.4.2.2 Perchlorate Management

In 2007, DDW adopted a maximum contaminant level (MCL) of 6 µg/L and public health goal (PHG) of 1 µg/L for perchlorate. On October 6, 2020, the SWRCB adopted a proposal to lower the perchlorate detection limit for purposes of reporting (DLR) through a two-step process. The perchlorate DLR was lowered from 4 µg/L to 2 µg/L effective July 1, 2021, and will be lowered again to 1 µg/L effective January 1, 2024. With a revised DLR, new occurrence data can be collected to support the development of a revised California MCL for perchlorate, if appropriate.

3.5 Regulations Governing Recycled Water Use

Recycled water treatment, distribution, and use are governed by various statewide statutes, regulations, and policies. Local regulations are in effect to prevent cross-connections and ensure public health protections.

3.5.1 State Regulations

State requirements for production, discharge, distribution, and use of recycled water are contained in the following codes:

- CWC, Division 6 - Conservation, Development, and Utilization of State Water Resources, §§10610 through 10655, and Division 7 - Water Quality, §§13000 through 13633.
- California Health and Safety Code (CHSC), Division 6 - Sanitary Districts, §6512, and Division 104 - Environmental Health Sciences, §§116800 through 116820.
- CCR, Title 22 - Social Security, Division 4 - Environmental Health, Chapter 3 - Recycling Criteria, §§60001 through 60355.
- CCR, Title 17-Public Health, Division 1 - State Department of Health, Chapter 5, Sanitation (Environmental), Subchapter 1, Engineering (Sanitary), Group 4, Drinking Water Supplies, §§7583 through 7605.

3.5.1.1 CWC

Division 7, Chapter 7, of the CWC addresses requirements for water recycling. This chapter requires DDW (formerly CDPH) to establish water recycling criteria and gives the RWQCBs responsibility for prescribing WRRs. In addition, Division 7, Chapter 7, of the CWC defines the allowable uses of recycled water, requires that certain applications use recycled water rather than potable water where recycled water is available at a cost-effective price, authorizes use of expert panels to develop new regulations, and sets water recycling goals.

CWC §§1210 through 1212, added in 1980, focus on the definition of property rights to recycled water and require that the owner of a wastewater treatment plant obtain approval from the SWRCB prior to making any change to the point of discharge, place of use, and/or purpose of use of recycled water.

3.5.1.2 Non-Potable Reuse

In 1975, the CDPH prepared Title 22 regulations for non-potable use of recycled water. Title 22 was subsequently revised in 1978 to conform with the 1977 amendments to the CWA and revised again in December 2000.

Title 22 establishes four categories of non-potable recycled water:

- Undisinfected Secondary Recycled Water: oxidized effluent.
- Disinfected Secondary-23 Recycled Water: oxidized and disinfected effluent that does not exceed a median concentration of 23 most probable number (MPN)/mL of total coliform bacteria in a 7-day period and does not exceed 240 MPN/mL in more than one sample in any 30-day period.
- Disinfected Secondary-2.2 Recycled Water: oxidized and disinfected effluent that does not exceed a median concentration of 2.2 MPN/100 mL total coliform bacteria in a 7-day period and does not exceed 23 MPN/100 mL in more than one sample in any 30-day period.
- Disinfected Tertiary Recycled Water: oxidized, coagulated, clarified, filtered, and disinfected effluent that does not exceed a median concentration of 2.2 MPN/100 mL

total coliform bacteria in a 7-days period, does not exceed 23 MPN/100 mL is more than one sample in any 30-day period, and never exceeds 240 MPN/100mL. There are also requirements for filter loading rates, filter effluent turbidity, and the disinfection system CT and modal contact time.

A partial list of authorized non-potable recycled water uses associated with the Title 22 categories of recycled water quality is presented in **Table 3-5**. In addition to defining permitted uses of recycled water and treatment requirements, Title 22 defines sampling and analysis requirements, requires preparation of an engineering report prior to production or use of recycled water, specifies general design criteria for treatment facilities, establishes reliability requirements, and addresses alternative methods of treatment.

Table 3-5. Suitable Uses of Non-Potable Recycled Water

Use[a]	Disinfected Tertiary Recycled Water	Disinfected Secondary-2.2 Recycled Water	Disinfected Secondary-23 Recycled Water	Undisinfected Secondary Recycled Water
Surface Irrigation				
Parks, playgrounds, and school yards	Allowed	Not Allowed	Not Allowed	Not Allowed
Residential landscaping	Allowed	Not Allowed	Not Allowed	Not Allowed
Unrestricted access golf courses	Allowed	Not Allowed	Not Allowed	Not Allowed
Cemeteries and freeway landscaping	Allowed	Allowed	Allowed	Not Allowed
Restricted access golf courses	Allowed	Allowed	Allowed	Not Allowed
Supply for Impoundments				
Nonrestricted recreational impoundment	Allowed[b]	Not Allowed	Not Allowed	Not Allowed
Restricted recreational impoundment	Allowed	Allowed	Not Allowed	Not Allowed
Other Uses				
Flushing toilets and urinals	Allowed	Not Allowed	Not Allowed	Not Allowed
Industrial process water that may contact workers	Allowed	Not Allowed	Not Allowed	Not Allowed
Structural fire fighting	Allowed	Not Allowed	Not Allowed	Not Allowed
Decorative fountains	Allowed	Not Allowed	Not Allowed	Not Allowed
Commercial laundries	Allowed	Not Allowed	Not Allowed	Not Allowed
Commercial car washes, including hand washes if water is not heated, where public is excluded from washing process	Allowed	Not Allowed	Not Allowed	Not Allowed
Industrial boiler feed	Allowed	Allowed	Allowed	Not Allowed
Nonstructural fire fighting	Allowed	Allowed	Allowed	Not Allowed
Soil compaction	Allowed	Allowed	Allowed	Not Allowed
Mixing concrete	Allowed	Allowed	Allowed	Not Allowed
Dust control on roads and streets	Allowed	Allowed	Allowed	Not Allowed

Use[a]	Disinfected Tertiary Recycled Water	Disinfected Secondary-2.2 Recycled Water	Disinfected Secondary-23 Recycled Water	Undisinfected Secondary Recycled Water
Cleaning roads, sidewalks, and outdoor work areas	Allowed	Allowed	Allowed	Not Allowed
Industrial process water that may not contact workers	Allowed	Allowed	Allowed	Not Allowed

[a] This list is not all inclusive.

[b] With monitoring for viruses, bacteria, and protozoa cysts.

3.5.1.3 SWRCB Recycled Water Policy

On December 11, 2019, the SWRCB adopted the most recent Water Quality Control Policy for Recycled Water (Resolution No. 2018-0057). The purpose of the policy is to encourage the safe use of recycled water, provide direction to RWQCBs, proponents of recycled water projects, and the public regarding appropriate criteria to be used by the SWRCB and RWQCBs in issuing permits for recycled water projects, and maximize consistency in the permitting of recycled water projects. The policy includes language that:

- Establishes goals to increase and track the use of recycled water in California.
- Clarifies the roles of state agencies in regulating use of recycled water in California.
- Defines approach for development and implementation of salt and nutrient management plans for groundwater basins.
- Describes permitting options and antidegradation analyses for non-potable recycled water projects, groundwater recharge projects, and surface water augmentation projects.
- Establishes monitoring requirements for Constituents of Emerging Concern for indirect potable reuse projects.

3.5.1.4 SWRCB General Order WRRs

The Governor and the California Legislature encourage development of water recycling facilities so that recycled water may be made available to help meet the growing water requirements of the state. In response, the SWRCB adopted Order WQ 2016-0068-DDW (Statewide Water Reclamation Requirements for Recycled Water Use, General Order WRRs) to streamline the permitting process and develop a consistent permitting approach for use of non-potable recycled water. Recycled water producers, distributors, and users may submit a Notice of Intent and receive permit authorization through receipt of a Notice of Applicability.

3.5.1.5 Indirect Potable Reuse

Indirect potable reuse (IPR) is the planned use of recycled water to replenish drinking water supplies with a suitable environmental barrier. There are two types of IPR projects: Groundwater Replenishment Reuse Projects (GRRP) and Surface Water Source Augmentation Projects (SWSAP). The Groundwater Replenishment Reuse Regulations (GRRRs) were incorporated into Title 22 on June 18, 2014. The GRRRs allow surface spreading with disinfected tertiary recycled water/diluent and full advanced treated recycled water. Direct injection is only allowed with full advanced treated recycled water. The Surface Water Augmentation Regulations (SWARs) were incorporated into Title 22 on October 1, 2018. The SWARs allow the planned placement of full advanced treated recycled water into a surface water reservoir that is used as a drinking water source.

The IPR criteria include requirements for treatment, pathogenic microorganism control, wastewater source control, diluent water, response retention time, and monitoring and reporting of various water quality constituents.

3.5.1.6 Title 17

The focus of Title 17 is the protection of potable water supplies through control of cross connections with potential contaminants. Examples of potential contaminants include sewage; non-potable water supplies such as recycled water, irrigation water, and auxiliary water supplies; fire protection systems; and hazardous substances. Title 17, Group 4, Article 2 (Protection of Water System), Table 1, specifies the minimum backflow protection required on a potable water system when there is a potential for contamination of the potable water supply.

3.5.1.7 Recycled Water Guidelines

To assist in compliance with Title 22, DDW has prepared a number of guidelines for production, distribution, and use of recycled water. Additionally, DDW recommends the use of recycled water distribution guidelines prepared by the California Nevada Section of the American Water Works Association. These guidelines include:

- Guidelines for the Preparation of an Engineering Report on the Production, Distribution, and Use of Recycled Water.
- Manual of Cross-Connection Control/Procedures and Practices.
- Guidelines for the Distribution of Non-potable Water.
- Guidelines for the Use of Recycled Water.
- Guidelines for the Use of Recycled Water for Construction Purposes.

3.5.1.8 Recycled Water Administration

In the State of California, recycling requirements are administered by the SWRCB, the RWQCB, and DDW. The direct involvement of each agency during a water recycling project is as follows:

- The SWRCB adopts statewide policies, regulations, and general permits. The SWRCB Division of Financial Assistance issues loans and grants. The SWRCB Division of Water Rights approves petitions for a change in place and/or purpose of use of recycled water in accordance with the CWC.
- The RWQCBs prepare, adopt, implement, and enforce WRRs in accordance with the CWC and Title 22.
- DDW reviews and accepts Engineering Reports, provides permit conditions to the RWQCBs, and approves final plans for cross-connection control and pipeline separations in accordance with Title 17.

3.5.2 Recycled Water Local Regulations

Local requirements focus on the distribution and use of recycled water and, primarily, on the user systems. Local requirements generally emphasize cross connection control. The state regulations and guidelines discussed above are the governing requirements. The Los Angeles County Department of Public Health generally establishes more specific requirements for separation and construction of potable and recycled water systems, specifies guidelines for user systems, and establishes criteria for identification of recycled water facilities.

3.6 Regulations for Collection System Management

While the 1972 CWA placed a great deal of emphasis on establishing treatment processes and establishing permit limits to protect receiving water quality, the importance of avoiding conveyance system overflows and plant bypasses during high flow events is also recognized. This section provides an overview of the federal and state requirements pertinent to the management of flows in the collection system.

3.6.1 Federal Regulations

The EPA proposed a draft Sanitary Sewer Overflow (SSO) Rule in 2001 that would require municipalities to establish the capacity of the wastewater conveyance system under a strict SSO prohibition. The SSO Rule is also commonly referred to as CMOM, which stands for capacity, management, operations, and maintenance. Three provisions of the proposed SSO Rule emphasize the capacity relevance of managing SSOs and their impact on public health and the environment. These include:

- Provide adequate capacity to convey base and peak flows.
- Take all feasible steps to stop and mitigate impacts of SSOs.
- Undertake a system evaluation and capacity assurance program.

These provisions are found in both the general standards and the CMOM program components.

3.6.2 State Regulations

California adopted Statewide General WDRs for Sanitary Sewer Systems in 2006 (Order No. 2006-0003-DWQ). The Statewide General WDRs apply to all public entities that own/ operate sanitary sewer systems greater than one mile in length that convey wastewater to POTWs. The WDRs include requirements to properly operate and maintain sewage collection systems, respond to spills, and to report spill occurrences. The WDRs were reissued in 2022 (Order WQ 2022-0103-DWQ) and became effective on June 5, 2023.

3.7 Regulations Governing Air Quality

3.7.1 Federal Regulations

3.7.1.1 Federal Clean Air Act

The Federal Clean Air Act (FCAA), passed in 1963 and amended significantly in 1970, 1977, and 1990, requires the EPA to establish NAAQS for air pollutants. The EPA has promulgated NAAQS for criteria pollutants, including carbon monoxide (CO), ozone(O_3), sulfur oxides (SO_2), nitrogen oxides (NO_X), PM_{10}, $PM_{2.5}$, and lead. Depending on the pollutant, NAAQS for ozone, NO_X, SO_X, PM_{10} and $PM_{2.5}$ are based on statistical calculations over 1 to 3 year periods. The

FCAA requires the EPA to reassess the NAAQS at least every 5 years to determine whether adopted standards are adequate to protect the public health. State governments, in turn, must develop attainment plans to meet these NAAQS by a specific date. As outlined in the CHSC §39602, the California Air Resources Board (CARB) is designated as the air pollution control agency of the state and is responsible for developing a SIP as required by the FCAA. Areas not meeting the NAAQS, referred to as nonattainment areas, are required to implement specified air pollution control measures. In California, responsibility for air pollution control measures is divided between the CARB and local air districts. A brief description of the applicable titles of the FCAA follows.

3.7.1.2 Greenhouse Gases

The EPA's Mandatory GHG Reporting Rule (Title 40 of CFR, Part 98 [40 CFR Part 98]) was adopted October 30, 2009. The Reporting Rule explicitly states that centralized domestic wastewater treatment systems are not required to report emissions. However, any stationary combustion of fossil fuels taking place at a wastewater treatment facility may be considered a "large" source of GHGs if they emit a total of 25,000 metric tons (mt) or more of carbon dioxide equivalent (CO_2e) emissions per year.

3.7.1.3 Hazardous Air Pollutants

In 1977, the amendments made to the FCAA mandated the EPA to establish National Emission Standards to safeguard public health and welfare by addressing Hazardous Air Pollutants (HAPs). These HAPs comprise specific volatile organic compounds (VOCs), pesticides, herbicides, and radionuclides that have been scientifically proven to pose a tangible hazard through studies on human and mammalian exposure. The 1990 amendments to the FCAA further enhanced the control program for HAPs, resulting in the identification of 189 substances and chemical families as HAPs.

3.7.1.4 Conformity Rule

Section 176(c) of the FCAA states that a federal agency cannot issue a permit or support an activity unless the agency determines it would conform to the most recent EPA-approved SIP. This means that projects using federal funds or requiring federal approval must not (1) cause or contribute to any new violation of a NAAQS, (2) increase the frequency or severity of any existing violation, or (3) delay the timely attainment of any standard, interim emission reduction, or other milestone (EPA 2010a).

Based on the present NAAQS attainment status of the SCAB, a federal action will conform to the SIP if its annual emissions remain below 100 tons of CO and $PM_{2.5}$, 70 tons of PM_{10}, and 10 tons of NO_X or VOCs (EPA 2010b). These de minimis thresholds apply to the proposed construction and operation activities pertaining to the federal action. If the proposed action exceeds one or more of the de minimis thresholds, a more rigorous conformity determination is the next step in the conformity evaluation process. SCAQMD Rule 1901 adopts the guidelines of the General Conformity Rule.

3.7.2 State Regulations

The FCAA entrusts the states with the regulation of air pollution control and the enforcement of the NAAQS. In the state of California, the legislative authority for air quality management and regulation has been granted to CARB, alongside subsidiary responsibilities assigned to air quality management districts and air pollution control districts at the regional and county levels. CARB, which joined the California EPA in 1991, bears the responsibility of ensuring the implementation of the California Clean Air Act (CCAA) of 1988, responding to the FCAA, and regulating emissions from motor vehicles and consumer products.

To meet these responsibilities, CARB has implemented the California Ambient Air Quality Standards (CAAQS), which generally impose more stringent regulations compared to the NAAQS. As previously mentioned, an ambient air quality standard outlines the maximum allowable level of a pollutant in outdoor air over a specific time, ensuring public health remains unaffected. To achieve compliance with the corresponding CAAQS, concentrations of each pollutant must remain below the applicable CAAQS within a given geographical area. When pollutant levels consistently remain below the CAAQS and do not exceed the standards more than once per year, the air quality is deemed to be in compliance or "in attainment." For O_3, CO, SO_2 (both 1-hour and 24-hour averages), NO_2, PM_{10}, and $PM_{2.5}$, the CAAQS establish specific values that must not be surpassed. In contrast, all other pollutants must not equal or surpass the designated limits which include:

- Hydrogen sulfide.
- Sulfate.
- Vinyl Chloride.
- Visibility Reducing Particles (i.e., particles that reduce visibility for airport safety, scenic enjoyment, road safety, etc.).

3.7.2.1 California Clean Air Act

The CCAA, which was signed into law in 1988, requires attainment of state ambient air quality standards by the earliest practicable date. The CCAA is generally more stringent than the FCAA. Vehicular sources and consumer products are the primary responsibility of the CARB, while local air districts are primarily responsible for stationary and portable sources (CHSC §39002). The CARB retains oversight authority over the local air districts.

As with the CCAA, nonattainment areas that do not meet the NAAQS are required to implement specified air pollution control measures. The CCAA divides nonattainment areas, based on background pollutant levels, into categories with progressively more stringent requirements. Each air district that is located in a nonattainment area is required to submit an Air Quality Management Plan (AQMP) to the CARB.

3.7.2.2 Stationary Internal Combustion Engine Regulations

California's Airborne Toxic Control Measure (ATCM) for Stationary Compression Ignition Engines applies to stationary diesel engines used in both non-agricultural and agricultural operations. The purpose of this ATCM is to reduce diesel particulate matter and criteria pollutant emissions from stationary diesel-fueled compression ignition (CI) engines.

Permits to Operate require the stationary emergency standby engines be in compliance with the CARB ATCM for Stationary Compression Ignition Engines. The ATCM closely aligns with federal New Source Performance Standards for Stationary Compression Ignition Internal Combustion Engines (which are codified in Title 40 of CFR, Part 60 [40 CFR Part 60], Standards of Performance for New Stationary Sources).

The ATCM requires:

- A 0.15 gram per brake horsepower-hour (g/bhp-hr) particulate matter emission limit for all new emergency standby stationary compression ignition engines greater than or equal to 50 horsepower (hp).
- Annual maintenance and testing hours be limited to no more than 50 hours per calendar year; or limited to fewer hours if required by local air districts.
- New emergency standby engines meet the applicable non-methane hydrocarbon plus nitrogen oxides ($NMHC+NO_X$), hydrocarbon, and CO Tier 2 or Tier 3 non-road compression-ignition engine emission standards, and Tier 4 standards that do not require add-on controls. **Table 3-6** shows emission limits for engine sizes comparable to those currently in use at the Warren Facility.

Table 3-6. ATCM Emission Standards for New Stationary Emergency Standby Diesel Fueled Compression-Ignition Engines[a]

Maximum Engine Power	Particulate Matter g/bhp-hr (g/kWh)	NMHC+Nox g/bhp-hr (g/kWh)	CO g/bhp-hr (g/kWh)
100 ≤ hp < 175 (75 ≤ kW < 130)	0.15 (0.20)	3.0 (4.0)	3.7 (5.0)
175 ≤ hp < 750 (130 ≤ kW < 560)	0.15 (0.20)	3.0 (4.0)	2.6 (3.5)
hp > 750 (kW > 560)	0.15 (0.20)	4.8 (6.4)	2.6 (3.5)

[a] May be subject to additional emission limitations as specified in current applicable local rules, regulations, or policies. Applicable to model years 2008 and later.

g/kWh = grams per kilowatt-hour
hp = horsepower
kW = kilowatts.

In December 2020, the EPA issued Tier 4 emissions standards for off-highway diesel engines. Engines meeting Tier 4 standards must comply with the limits listed in **Table 3-7**.

Table 3-7. EPA Tier 4 Emission Standards

Pollutant	Limit (g/bhp-hr)
NOx	0.5
Non-Methane Hydrocarbon	0.14
Particulate Matter	0.02
CO	2.6

Air quality districts in California are beginning to adopt the EPA's Tier 4 standards, the strictest to date, for their emergency diesel engines. As of June 2021, both the Bay Area Air Quality Management District (BAAQMD) and the Sacramento Metro Air Quality Management District have adopted Tier 4 standards as the best available control technology for standby engine operations. Under BAAQMD's new standards, any new or modified source with the potential to emit ten pounds per day (ppd) or more of any pollutant must install a best available control technology. It is likely that more air quality districts within California may adopt similar standards in compliance with Tier 4.

3.7.2.3 ATCM for Diesel Particulate Matter From Portable Engines

Effective February 19, 2011, diesel-fueled portable engines with a rated brake horsepower of 50 or greater are subject to the CARB's ATCM. The ATCM imposes fuel and diesel particulate matter emission requirements for in-use and new portable diesel engines. This ATCM requires all portable in use diesel engines to be certified to meet federal or California standards for newly manufactured nonroad engines pursuant to:

- Title 40 of CFR, Part 89 (40 CFR Part 89), Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines.
- OR Title 13 of CCR, Section 2423 (13 CCR 2432), Exhaust Emission Standards and Test Procedures - Off-Road Compression-Ignition Engines. 13 CCR 2432 establishes certification requirements for Off Road Compression-Ignition engine.

Per this ATCM, the portable engine can only use the following types of fuels: CARB diesel fuel, a verified alternative diesel fuel, or CARB diesel fuel with verified alternative diesel fuel additives.

For CARB Diesel Fuel Specifications and Test Methods see Title 13, California Code of Regulations, Sections 2281-2285, 2299-2299.5 California Code of Regulations, Division 3, Chapter 5 Article 2.

3.7.2.4 GHG Legislation

The U.S. Supreme Court's ruling in the 2007 case Massachusetts v. EPA held that the EPA has authority to regulate GHG emissions from new vehicles under the FCAA. In 2007, the California State Attorney General decided that the federal ruling gave California the right to regulate GHGs. Consequently, GHG emissions can be regulated in the state of California and the associated emission reduction plans can be enforced through existing air quality laws.

In September 2006, AB 32 California Global Warming Solutions Act was signed into law. AB 32 required CARB to act as the lead agency to implement regulations requiring public and private agencies statewide to reduce GHG emissions to 1990 levels by 2020. California met the AB 32 target of reducing GHG emissions to 1990 levels well ahead of the goal and is focused on achieving carbon neutrality by 2045.

Building on this success, Senate Bill (SB) 32 California Global Warming Solutions Act was adopted in 2016 requiring the state to implement a target of reducing emissions by 40 percent below 1990 levels by 2030. The intent of SB 32 was to set the state on track for achieving a reduction goal of 80 percent below 1990 levels by 2050. In addition to this, Governor Brown issued Executive Order B-55-18 in 2018 to establish statewide carbon neutrality by 2045.

GHGs regulated under both AB 32 and SB 32 that are relevant to wastewater treatment plants are carbon dioxide, methane, and nitrous oxide. The legislation does not target wastewater treatment process emissions specifically, but it does cover electricity generating units and onsite general stationary combustion sources (e.g., wastewater reclamation facility engines, boilers, and flares).

Pursuant to AB 32, GHG estimates are based on CARB's Regulation for the Mandatory Reporting of GHG Emissions (Title 17 of CCR, Sections 95100-95157). To align itself with the EPA's GHG Reporting Rule, CARB's regulation incorporated by reference certain requirements in the EPA's Final Rule on Mandatory Reporting of GHGs (40 CFR Part 98). Specifically, section 95100(c) of CARB's regulation incorporated those requirements promulgated by EPA as published in the Federal Register.

CARB lists two thresholds against which wastewater treatment facilities must check if they are required to report GHG emissions. The reporting thresholds shown in **Table 3-8** include emissions from both fossil fuel (i.e., natural gas and diesel) and non-fossil fuel or biogenic (i.e., biogas) sources. The threshold calculation includes emissions from the natural gas engines, boilers, and flares. (Note, it does not include emissions from the emergency standby diesel engines.)

Table 3-8. GHG Emissions Threshold for Reporting Years 2011 and Beyond

Equipment	Threshold
Electricity Generating Unit	≥ 10,000 mt CO_2e per year
General Stationary Combustion	≥ 10,000 mt CO_2e per year

In addition to mandatory reporting of GHGs, CARB adopted a GHG cap-and-trade program that became effective in January 2012. This program states that agencies emitting 25,000 mt or more of fossil fuel-based (i.e., natural gas and diesel) CO2e emissions per year beginning in 2011 or any subsequent year will be capped and required to pay for allowances and eventually reduce their emissions over time.

Office of Planning and Research California Environmental Quality Act Guidelines on GHGs

The California Governor's Office of Planning and Research (OPR) developed amendments to the California Environmental Quality Act (CEQA) Guidelines for addressing GHG emissions. These amendments became effective on March 18, 2010, when the OAL approved them. OPR did not define or set a CEQA threshold at which GHG emissions would be considered significant. Instead, the lead agency would assess the significance of impacts from GHG emissions on the environment by considering a threshold that applies to the project and evaluate feasible mitigation measures.

A primary lead agency holds the authority to choose between a quantitative or qualitative analysis or the application of performance standards when assessing the significance of GHG emissions resulting from a specific project. The lead agency is required to take into consideration the project's compliance with regulations or requirements implemented to execute a statewide, regional, or local plan aimed at reducing or mitigating GHG emissions. Additionally, the CEQA guidelines permit the lead agency to explore practical measures for mitigating the substantial impact of GHG emissions, which may involve implementing project features or off-site actions that result in emission reductions. The amended regulations do not set a specific threshold for GHG emissions but instead grant the primary agency the flexibility to establish, adopt, and implement its own significance thresholds or utilize those established by other agencies or experts.

In the SCAB, the SCAQMD has set a significance threshold for purposes of CEQA. The SCAQMD threshold will be used for evaluating potential GHG impacts of the Clearwater Program.

May 2008 Attorney General GHG CEQA Guidance Memo

In 2008, the California State Attorney General's office released a CEQA guidance memo related to GHG analysis and mitigation measures. The memo provides examples of mitigation measures that could be used in a diverse range of projects.

3.7.3 Local Regulations

3.7.3.1 SCAQMD

CARB takes on the responsibility of regulating mobile emission sources within the state, while the enforcement of standards and regulation of stationary sources is delegated to local air quality management districts and air pollution control districts. In the specific region of the SCAB, SCAQMD plays a vital role as the regional agency responsible for the regulation and enforcement of air pollution control regulations at the federal, state, and local levels. SCAQMD carries out a range of important activities, including operating monitoring stations in the SCAB area, formulating rules and regulations pertaining to stationary sources and equipment, compiling emissions inventory, developing air quality management planning documents, and conducting source testing and inspections.

To achieve clean air goals, SCAQMD develops AQMPs that outline control measures and strategies for attaining compliance with the CAAQS and NAAQS within the SCAB. These plans are carefully designed and encompass various measures to address specific pollutants. Once established, SCAQMD translates these measures into enforceable regulations aimed at controlling and reducing emissions of criteria pollutants from stationary sources and equipment.

By working in collaboration with CARB, SCAQMD plays a crucial role in ensuring effective air pollution control and regulation in the SCAB region, contributing to the improvement of air quality and the protection of public health.

SCAQMD is responsible for stationary and indirect source control, air monitoring, enforcement of delegated mandates, and attainment plan preparation for Orange County; the non-desert portions of Los Angeles, Riverside, and San Bernardino Counties; and the Riverside County portions of the Salton Sea Air Basin and the Mojave Desert Air Basin.

3.8 Regulations Governing Biosolids Management

All solids generated within the JOS are processed at the Warren Facility. The disposal of solids and beneficial use of biosolids are subject to federal and state regulations. Depending upon the type and level of treatment provided, solids/biosolids are placed into different classifications, which determine allowable uses of these materials.

3.8.1 Federal Regulations

3.8.1.1 Sewage Sludge Standards

The EPA promulgated Standards for the Use or Disposal of Sewage Sludge, Title 40 of CFR, Part 503 (40 CFR Part 503) in 1993. Part 503 is a comprehensive, risk-based regulation that protects human health and the environment from pollutants of concern that can be present in biosolids. Biosolids are sewage sludges/solids that have been treated/stabilized to a degree suitable for beneficial use. 40 CFR Part 503 specifies general requirements, pollutant limits, management practices, and operational standards for various biosolids management options such as land application, surface disposal, and incineration. It provides the basis for classifying biosolids as Class A or Class B depending on the level of pathogen reduction, the degree of vector attraction reduction, and the concentration of regulated pollutants in the biosolids. Both Class A and Class B biosolids are protective of public health and the environment.

All wastewater treatment plant solids produced in the JOS are processed at the Warren Facility, which produces Class B biosolids. Class B biosolids may be applied in bulk to agricultural land, forest, public contact sites (e.g., public parks, ball fields, cemeteries, etc.) or a reclamation site provided either the cumulative loading rates or the pollutant concentrations listed in **Table 3-9** are not exceeded and the applicable Part 503 site restrictions are maintained.

Table 3-9. Pollutant Concentration Standards for Biosolids

Constituent	Ceiling Concentration[a] (mg/kg)	Pollutant Concentration[a] (mg/kg)	Cumulative Loading Rate (kg/ha)
Arsenic	75	41	41
Cadmium	85	39	39
Copper	4,300	1,500	1,500
Lead	840	300	300
Mercury	57	17	17
Molybdenum	75	–	–
Nickel	420	420	420
Selenium	100	100	100
Zinc	7,500	2,800	2,800

Source: EPA, 40 CFR Part 503 - Standards for the Use or Disposal of Sewage Sludge 1997

[a] Dry weight basis

mg/kg = milligrams per kilogram
kg/ha = kilogram per hectare

3.8.1.2 Priority Pollutants

Warren Facility's NPDES permit also requires biosolids monitoring of pollutants listed under section 307 (a) of the CWA.

3.8.2 State Regulations

The SWRCB enacted State Water Quality Order No. 2000-10-DWQ in August 2000, which was later replaced by State Water Quality Order No. 2004-0012-DWQ to establish general WDRs for the beneficial use of biosolids. The land application requirements are more restrictive than those contained in 40 CFR Part 503 and are designed to account for conditions specific to California soils and local environments through the issuance and oversight of General Order Permits.

Biosolids are also subject to Title 22 of the California Code of Regulations, Article 1, Chapter 11, Division 4.5 to determine hazardousness. The Warren Facility measures Title 22 Soluble Threshold Limit Concentrations (STLCs) on a quarterly basis.

3.9 Regulations Governing Hazardous Materials

3.9.1 Federal Regulations

The EPA is the principal federal agency regulating hazardous materials. As such, the EPA broadly defines a hazardous waste as one that is specifically listed in EPA regulations, that has been tested and meets one of the characteristics (e.g., toxicity) established by the EPA, or that has been declared hazardous by the generator based on its knowledge of the waste. In general, federal regulations applicable to hazardous wastes are contained in Titles 29, 40, and 49 of the CFR. The main federal regulations pertaining to hazardous materials are discussed in the following sections.

3.9.1.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA), including the Hazardous and Solid Waste Amendments of 1984 (HSWA), imposes regulations on hazardous waste generators, transporters, and operators of treatment, storage, and disposal facilities (TSDFs). The HSWA also requires the EPA to establish a comprehensive regulatory program for underground storage tanks.

3.9.1.2 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, establishes a comprehensive national program to identify active and abandoned waste disposal sites that pose a threat to human health or the environment. CERCLA created a fund to pay for the cleanup of abandoned sites for which no responsible parties could be identified.

3.9.1.3 Superfund Amendment Reauthorization Act

The Superfund Amendment and Reauthorization Act Title III (community right-to-know laws) is the set of statutes that grants individuals information regarding chemicals located in their communities or workplace and that provides emergency preparedness for reaction to environmental accidents.

3.9.1.4 Hazardous Materials Transportation Act

The Hazardous Materials Transportation Act governs the transportation of hazardous materials. These regulations are promulgated by the United States Department of Transportation and enforced by the EPA.

The California Environmental Protection Agency (Cal-EPA) has been granted primary responsibility by the EPA for administering and enforcing hazardous materials management plans. In particular, the state has acted to regulate the transfer and disposal of hazardous waste. Hazardous waste haulers are required to comply with regulations that establish numerous standards, including criteria for handling, documenting, and labeling the shipment of hazardous waste (Title 26 of CCR, Section 25160 et seq. [26 CCR 25160 et seq.]). Hazardous waste TSDFs are also highly regulated and must meet standard criteria for processing, containment, and disposal of hazardous materials (26 CCR 25220).

3.9.2 State Regulations

Cal-EPA defines a hazardous material more generally as a material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released (26 CCR 25501). Note that hazardous materials include raw materials and products, such as bulk chemicals stored for the operation of a typical POTW.

California state regulations governing hazardous materials are as stringent as, or in some cases, more stringent than, federal regulations. State regulations include requirements for detailed planning and management to ensure that hazardous materials are properly handled, stored, and disposed of in order to reduce human health risks.

3.9.2.1 Hazardous Materials Release Response Plans and Inventory Act

The Hazardous Materials Release Response Plans and Inventory Act (also known as the Business Plan Act) requires a business using hazardous materials to prepare a plan describing the facility, inventory, emergency response plans, and training programs. The Sanitation Districts prepare this plan biennially and submit it to the Los Angeles County Fire Department, Hazardous Materials Division.

3.9.2.2 Hazardous Waste Control Act

The state equivalent of RCRA is the Hazardous Waste Control Act (HWCA). The HWCA created the State Hazardous Waste Management Program, which is similar to the RCRA program but is generally more stringent. The HWCA establishes requirements for the proper management of hazardous substances and wastes with regard to criteria for (1) identification and classification of hazardous wastes; (2) generation and transportation of hazardous wastes; (3) design and permitting of facilities that recycle, treat, store, and dispose of hazardous wastes; (4) treatment standards; (5) operation of facilities; (6) staff training; (7) closure of facilities; and (8) liability requirements.

3.9.2.3 Emergency Services Act

Under the California Emergency Services Act, the state developed an emergency response plan to coordinate emergency services provided by all governmental agencies. The plan is administered by the California Office of Emergency Services (OES). OES coordinates the responses of other agencies, including the EPA, the Federal Emergency Management Agency, the California Highway Patrol, the RWQCBs, the AQMDs, and the county disaster response offices. Local emergency response teams, including the fire, police, and sheriff’s departments, provide most of the services to protect public health.

3.10 Regulations Governing Environmental Impacts

3.10.1 Federal Regulations

3.10.1.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA), enacted in 1970, came in response to a national sentiment that federal agencies should take more direct responsibility in providing greater protection for the environment. NEPA is the nation's basic charter for the protection of the environment. It establishes environmental policy for the nation, provides an interdisciplinary framework for federal agencies to prevent environmental damage, and contains procedures to ensure that federal agency decision makers take environmental factors into account (Bass, Herson, and Bogdan 1996).

The four main purposes of NEPA include:

- Declare a national policy that will encourage productive and enjoyable harmony between people and the environment.
- Promote efforts that will prevent or eliminate damage to the environment and biosphere and stimulate health and welfare.
- Enrich the understanding of the ecological system and natural resources important to the nation.
- Establish a Council on Environmental Quality.

NEPA applies to all federal agencies and most of the activities they manage, regulate, or fund that affect the environment. Under NEPA, the lead agency is the federal agency with the primary responsibility for complying with NEPA for a proposed action.

3.10.2 State Regulations

3.10.3 CEQA

The CEQA, enacted in 1970, was modeled after NEPA. CEQA applies to all proposed discretionary activities that will be carried out or approved by California public agencies, such as the Sanitation Districts, unless such activities are specifically exempted. Under CEQA, the "Lead Agency" is the agency with the principal responsibility to approve a project and therefore is the agency responsible for preparing a CEQA document for a proposed project.

The purpose of CEQA is to minimize environmental damage. Key objectives of CEQA are to disclose to decision makers and the public the significant environmental effects of the proposed project to enable them to understand the environmental consequences of a project and to balance the benefits of a project against the environmental costs. Major elements of CEQA include (1) disclosing environmental impacts, (2) identifying and preventing environmental damage, (3) fostering intergovernmental coordination, (4) enhancing public participation, and (5) disclosing agency decision making (Bass, Herson, and Bogdan 1996).

3.11 Regulations for Endangered Species

3.11.1 Federal Regulations

3.11.1.1 Federal Endangered Species Act

The Federal Endangered Species Act (FESA) regulates the take of species listed as threatened or endangered. Take is broadly defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Consultation with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) may be required under FESA for implementation of the Pure Water program.

Section 7

Section 7 of FESA applies when a project involves a federal action such as issuing a federal permit or federal funding. Section 7 requires the federal agency to consult with the USFWS and/or NMFS regarding the potential effect of the agency's action on those species listed as threatened or endangered. Section 7 compliance also applies to agencies applying for SRF loans because some of the funding is from federal sources. This consultation typically results in preparation of a biological opinion that specifies whether the proposed action is likely to jeopardize the continued existence of the listed species or result in adverse modification of critical habitat. The biological opinion may include an incidental take statement if the proposed action would result in the take of a listed species incidental to the federal action.

Section 9

Section 9 of FESA prohibits all persons subject to the jurisdiction of the United States from taking, importing, exporting, transporting, or selling any fish or wildlife species listed as endangered or threatened.

Section 10

Although Section 9 prohibits the take of a federally listed species, Section 10 of FESA is the mechanism that may allow an incidental take of such species. The USFWS may issue a take permit for any taking that is incidental to, and not for the purpose of, carrying out an otherwise lawful activity. Along with the application for an incidental take permit, the applicant must submit a conservation plan that specifies likely impacts that would result from the take, mitigation measures to minimize those impacts, funding for the mitigation, and a project alternatives analysis.

3.11.2 State Regulations

3.11.2.1 California Endangered Species Act

Under the California Endangered Species Act (CESA), all state lead agencies (as defined by CEQA) preparing initial studies, negative declarations, or EIRs must consult with the California Department of Fish and Game (CDFG) to ensure that any action authorized, funded, or carried out by that lead agency is not likely to jeopardize the continued existence of any endangered or threatened species. This CESA consultation requirement does not apply to local lead agencies, such as the Sanitation Districts.

Section 2080 of CESA prohibits any party from importing into the state, exporting out of the state, or taking, possessing, purchasing, or selling within the state any part or product of any endangered or threatened species (except as provided in the Native Plant Protection Act or California Desert Native Plants Act). Through Section 2081 of CESA, CDFG may enter into a management agreement with the project applicant to allow for an incidental take, as the USFWS and NMFS may under Section 10 of FESA. Under CESA, take is defined as to hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

3.11.2.2 California Fish and Game Code

Sections 1601–1616 of the California Fish and Game Code apply to any state or local government agency or any public utility that proposes to substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake. Sections 1601–1616 require application to the CDFG to obtain a Streambed Alteration Agreement (SAA).

This agreement is negotiated between the CDFG and the applicant. The agreement may contain mitigation measures, such as erosion control, intended to reduce the effect of the activity on fish and wildlife resources. The agreement may also include monitoring to assess the effectiveness of the proposed mitigation measures.

3.11.3 Local Regulations

3.11.3.1 Significant Ecological Areas

Significant ecological areas (SEAs) were developed by the Los Angeles County Department of Regional Planning (DRP) as a way to protect biotic diversity, including habitat for endangered species. In 1972, the original SEA report was prepared and submitted to the DRP to be used as background information for the 1973 County of Los Angeles General Plan. A second SEA study, completed in 1976 and amended in the 1980 County of Los Angeles General Plan, identified 61 SEAs within the county. The most recent SEA study, completed in 2001 and amended in the 2035 County of Los Angeles General Plan, identifies 31 SEAs within the county, several of which are combinations of previous SEAs.

Although SEAs do not preclude development or construction, they promote open space conservation. SEAs require another level of scrutiny in the CEQA review process by the Significant Ecological Areas Technical Advisory Committee (SEATAC). SEATAC reviews proposed projects to ensure consistency with SEA-recommended management practices before a SEA conditional use permit (CUP) can be issued and the project can be approved.

The Sanitation Districts could be required to obtain a CUP for construction of new facilities within a proposed SEA if the SEA is currently in place or is adopted prior to the start of construction of any proposed JOS facilities.

3.12 Regulations for Cultural Resources

3.12.1 Federal Regulations

3.12.1.1 National Historic Preservation Act

A programmatic agreement between the SWRCB and the State Historic Preservation Officer (SHPO) requires that projects receiving federal funds administered by the SWRCB (such as SRF loan funding) comply with Section 106 of the National Historic Preservation Act (NHPA). Because the Sanitation Districts may seek to finance projects associated with the Clearwater Program MFP with SRF loan funds, compliance with Section 106 of the NHPA would be required. In addition, Section 106 compliance would be required because federal permits are required for the ocean work being proposed under the Clearwater Program.

The Section 106 review process is implemented by means of a five-step procedure including: (1) the identification and evaluation of historic properties, (2) an assessment of the effects of the undertaking on properties that are eligible for listing on the National Register of Historic Places, (3) a consultation with the SHPO and other agencies for the development of an agreement that addresses the treatment of historic properties, (4) the receipt of comments on the agreement or results of the consultation from the Advisory Council on Historic Preservation, and (5) project implementation subject to conditions imposed by the consultation and any agreements.

3.12.2 State Regulations

The state requirements for cultural resources are outlined in Sections 5020 through 5024.6, 21084, and 21084.1 of the California Public Resources Code (CPRC). In general, compliance with the requirements of Section 106 of the NHPA is sufficient to ensure compliance with CEQA.

Other state requirements are outlined in Section 7050.5 through 7055 of the CHSC and Sections 5097 through 5097.998 of the CPRC, which provide for the protection of Native American remains and identify special procedures to be followed when Native American burial sites are found. When remains are found, the Native American Heritage Commission (NAHC) and the County Coroner must be notified.

The NAHC provides guidance concerning the most likely Native American descendants and the treatment of human remains and associated artifacts. Compliance with the provisions of these laws is separate from the requirements of the NHPA and CEQA.

3.13 Other Applicable Laws and Regulations

3.13.1 Federal Regulations

3.13.1.1 State Revolving Fund

Other applicable laws and regulations that apply to this Facilities Plan include federal requirements in accordance with the SRF loan program beyond those of FESA and NHPA. These requirements are described in the sections that follow.

Executive Order 11988

This executive order relating to floodplain management was prepared in 1979 to avoid, to the extent possible, long- and short-term adverse impacts associated with the occupation and modification of floodplains and to avoid direct or indirect support of development in floodplains. This order requires that the agency reviewing the proposed action consider alternatives to avoid adverse effects and incompatible development in floodplains. If the only practicable alternative is to site a project in the floodplain, and the reviewing agency concurs, then the action must be designed or modified to minimize potential harm to the floodplain. Furthermore, a notice containing an explanation of why the proposed action is to be located in the floodplain must be prepared and circulated.

Executive Order 11990

This executive order was prepared to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. The order requires early public review of any plans or proposals for new construction in wetlands, in addition to notification of the federal Office of Management and Budget regarding compliance with the order. The order establishes several factors that should be considered during evaluation of the effects of a project on the survival and quality of wetlands including public health and welfare, maintenance of natural systems, and other uses of wetlands in the public interest.

Executive Order 11593

This executive order provides for the protection and enhancement of the cultural environment. Compliance with Section 106 of NHPA and with CEQA fulfills the requirements of this order.

Executive Order 12898

This executive order effectively expands the scope of complaints that may be filed with EPA under Title VI of the Civil Rights Act of 1964 to include issues of environmental justice. Environmental justice complaints typically allege that facilities generating adverse impacts associated with pollution and/or potential pollution are systemically sited in and/or permitted to operate in minority communities.

Disproportionate adverse impacts on minority communities associated with pollution generated by facilities may constitute discrimination. Executive Order 12898 directs the EPA to address environmental justice concerns through the permitting process and applies to the permitting decisions of all agencies that receive or act as a conduit for federal monies.

The EPA's Title VI regulations apply to all programs and activities carried out by departments or agencies that receive EPA funding either directly or indirectly. The SWRCB administers a number of funding programs, including SRF, which are partially funded by federal monies. The SWRCB has delegated permitting authority vested in it by state and federal laws to the local RWQCBs, including the LARWQCB. Accordingly, all of the permitting decisions of the LARWQCB, including the issuance, modification, or renewal of the Warren Facility, are subject to the mandates of Executive Order 12898 and the EPA guidelines implementing that order.

3.13.2 State Regulations

3.13.2.1 Worker Safety

Worker safety laws protect public health in the workplace. These laws are administered and enforced by the California Division of Occupational Safety and Health (Cal/OSHA). The laws apply to normal operational activities and include all provisions for standard injury and illness prevention, construction requirements, and requirements for the handling of chemicals and prevention of infection and disease. Worker safety programs directly benefit public health by reducing the number of accidents and injuries that occur. Worker safety laws also protect worker and public safety by requiring specific training, handling, transportation, and storage procedures for hazardous materials.

3.13.3 Local Regulations

3.13.3.1 Storm Water Pollution Prevention Plan

A storm water pollution prevention plan (SWPPP) is generally required as part of a construction permit for large projects or facilities that are within a drainage basin of a water of the U.S. The major objectives of a SWPPP are to help identify sources of sediment and other pollutants that affect the quality of storm water discharges and to describe and ensure implementation of best management practices (BMPs). The SWPPP emphasizes the use of appropriately installed and maintained storm water pollution reduction BMPs.

Required elements of a SWPPP include:

- A site description addressing the elements and characteristics specific to the site
- BMPs for erosion and sediment controls
- BMPs for construction waste handling and disposal
- Implementation of approved local plans
- Proposed post-construction controls, including a description of local post-construction erosion and sediment control requirements
- Non-stormwater management
- Routine visual inspections
- Development of a Construction Site Monitoring Plan

3.14 Future Regulations

3.14.1 Future Regulations for NPDES Compliance

3.14.1.1 Ocean Nitrogen Discharge

The receiving water limitations in the Warren Facility NPDES permit are based on the water quality objectives from the Ocean Plan. The standards specified in the Ocean Plan are developed through a regulatory process involving SWRCB and input from coastal regional water boards, municipalities, environmental groups, and other stakeholders. The current Ocean Plan (SWRCB,

2019) and Warren Facility NPDES permit identify performance standards for ammonia, but do not dictate numeric limits for ammonia, inorganic nitrogen, or other nutrients. However, the regulatory and scientific communities have been evaluating the contribution of anthropogenic nutrient discharges to the emergence of marine harmful algal blooms (HAB), which can compromise ocean ecosystems and pose a health risk to humans.

The Southern California Coastal Water Research Project (SCCWRP), an intergovernmental research agency, has been evaluating the effects of nutrient loads from POTWs on ocean acidification and hypoxia in the Southern California Bight, to which the Warren Facility discharges treated effluent. Based on these preliminary evaluations, the Sanitation Districts anticipates that in the future, the Ocean Plan may be revised to mandate a seasonal inorganic nitrogen load reduction of up to 60 percent. However, validation of SCCWRP's research is ongoing, and future amendments to the Ocean Plan will be subject to a public review process. As of this time, the SWRCB has not identified a timeline or intent to incorporate a nitrogen limit for POTW discharges into the Ocean Plan. Given the uncertainty around the potential for ocean nutrient discharge limits, the evaluations for ocean outfall nitrogen reductions used a flexible approach to determine what is feasible/reasonable for the Warren Facility.

3.14.1.2 Biostimulation, Cyanotoxins, and Biological Condition Provisions (formerly Biointegrity and Biostimulation)

The State Water Board is considering statewide WQOs for nutrients, other biostimulatory substances, and cyanotoxins, and a program of implementation under the Biostimulation, Cyanotoxins, and Biological (B&C&B) Condition Provisions (State Water Board, 2023a). Currently under consideration are statewide numeric or narrative WQOs and regulatory control options for point and non-point sources in California's freshwater wadeable streams and rivers, non-wadeable streams and rivers, lakes, and reservoirs. While incident sunlight, temperature, flow rate, substrate, and other factors play a major role in B&C&B, the regulatory focus is generally limited to controlling nutrients. The B&C&B provisions will be established as a statewide policy for water quality control and will include a water quality control plan component. While the State Water Board holds the B&C&B provisions as priority[1] for 2023, there has been little movement on developing the provisions.

3.14.1.3 Per- and Polyfluorinated Substances (PFAS)

On April 28, 2022, the EPA released draft aquatic life water quality criteria for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) as shown in **Table 3-10** (EPA, 2023a; EPA, 2023b). The draft criteria represent a scientific assessment of the ecological effects of PFOA and PFOS on aquatic organisms. When finalized, the criteria will become national recommended aquatic life criteria that can be adopted by states and tribes as water quality standards for specific waterbodies and beneficial uses. Since the values are non-regulatory, states and tribes have the option to modify the criteria based on site-specific conditions or develop other numeric criteria that are scientifically based and protective of designated beneficial uses. The draft water column criteria (and benchmarks for estuarine/marine systems) are shown in the following table. In addition, the EPA is proposing tissue-based criteria for fish (whole body, muscle) and invertebrates (whole body). The draft water quality criteria were posted in the Federal Register in May 2022, and the public comment period ended on July 5, 2022. There has been no update from the EPA since the public comment period ended.

[1] The State Water Board appears to be more focused on ocean acidification and hypoxia than the B&C&B.

Table 3-10. Draft Aquatic Life Water Quality Criteria

Compound	Freshwater Acute Water Column	Freshwater Chronic Water Column	Estuarine/Marine Acute Water Column Benchmark
PFOA	49 mg/L	0.094 mg/L	7.0 mg/L
PFOS	3.0 mg/L	0.0084 mg/L	0.55 mg/L

On December 5, 2022, the EPA released supplemental guidance (EPA, 2022a) to States on how to use the NPDES permit program to address PFAS pollution in wastewater. The purpose of the guidance is to provide information to permit writers on how to use existing authorities (such as industrial pretreatment program provisions and monitoring requirements) in NPDES permits as the EPA continues to finalize its Effluent Limitation Guidelines for PFAS. For POTWs, the guidance notes the absence of a final methods testing for PFAS under the CWA and recommends use of draft EPA Method 1633 to guide monitoring activities. Additionally, the guidance suggests POTWs identify and locate all possible industrial users that may be subject to a PFAS pretreatment program, along with the volume of pollutants contributed to the POTWs by the industrial users. With regard to biosolids, the guidance recommends (where appropriate) that states work with POTWs to reduce PFAS in biosolids through the following steps: (1) Use draft EPA Method 1633 to analyze presence of PFAS in biosolids, (2) Indicate the presence of PFAS in biosolids from industrial sources, and (3) Validate PFAS reductions with regular monitoring of biosolids.

3.14.1.4 Constituents of Emerging Concern (CECs)

At the request of the State Water Board, a Science Advisory Panel developed and recommended a risk-based screening framework to identify CECs for monitoring in California's aquatic ecosystems in 2012. The 2012 Science Advisory Panel applied the framework using existing information to three representative receiving water scenarios to identify a list of appropriate CECs for initial monitoring, developed an adaptive phased monitoring approach, and suggested development of bioanalytical screening and predictive modeling tools to improve assessment of the presence of CECs and their potential risk to the environment. The State Water Board, in conjunction with the Ocean Protection Council (OPC) and a group of stakeholder advisors, reconvened a group of leading scientists in October 2020 to address the issues associated with CECs in the State's aquatic systems. The 2022 Science Advisory Panel was comprised of seven experts in chemistry, biochemistry, toxicology, chemical and risk assessment, engineering, and coastal and marine environmental health science. The Science Advisory Panel worked with State Water Board Division of Water Quality to develop an updated risk screening approach and an initial prioritization of CEC compounds of interest based on a complex statewide CEC dataset, as well as compound-specific toxicological data. The 2022 Science Advisory Panel released a final report in December 2022 (State Water Board, 2023b), which resulted in the recommendations for four products that will help the state develop a "monitoring process for CECs based on sound, up-to-date scientific principles." These include:

- Guidance to Structure, Quality Assurance and Visualization of CECs Covered by the Existing State Water Board CEC Dataset.
- Guidance to Use Other Sources to Inform a CEC Monitoring Program.
- An Updated Risk-Based Approach to Assess and Identify CECs for Monitoring in California Receiving Waters.
- Establish Sound Foundation for Statewide and Regional CEC Monitoring in California.

3.14.1.5 Microplastics

Microplastics are being studied by the State Water Board to assess the environmental impact of the plastics on aquatic organisms. Specifically, the two methods of microplastics impacts are food dilution (e.g., starvation due to filling the gut with microplastics instead of food) or translocation of microplastic particles into tissues and organs (Walther, pers. comm., 2021).

Microplastics are largely removed via surface skimming during primary treatment and are then sent to the landfill. Any remaining microplastic particles captured during later treatment phases would end up in the biosolids. Food waste slurry serves as a major source of microplastics to the wastewater stream and was identified by the EPA as a major source of microplastics to biosolids (EPA, 2021). The current concern is regarding loadings of microplastic particles from effluent discharged to surface waters and from biosolids that are land applied. A statewide POTW microplastics treatment efficiency study was funded by the OPC in 2019 (OPC, 2020) and will serve to inform the State Water Board and legislators about the amount of microplastics being discharged to receiving waters via wastewater effluent and biosolids.

A definition of microplastics in drinking water was adopted by the State Water Board in July 2020 (State Water Board, 2020), and this definition may be applied to other matrices in the future. The State Water Board is currently developing draft standard methods for analyzing microplastics in drinking water, guidelines for accrediting qualified laboratories, a four-year plan for testing and reporting in drinking water slated to begin in 2022, and quantitative guidelines for interpreting the results (State Water Board, 2022a).

3.14.2 Future Regulations for Potable Water Recycling

3.14.2.1 PFAS

On October 31, 2022, the State Water Board DDW issued an NL of 3 nanograms per liter (ng/L) and Response Level of 20 ng/L for perfluorohexane sulfonic acid (PFHxS) in drinking water (State Water Board, 2022b). The Office of Environmental Health Hazard Assessment (OEHHA) released draft Public Health Goals for PFOS and PFOA in July 2021. DDW has asked OEHHA to consider grouping of PFAS for regulatory purposes. The PFOS and PFOA MCL rulemaking process will begin in 2023 with final adoption of MCLs in 2025.

The SDWA authorizes the EPA to issue health advisories (HAs) for contaminants that are not subject to National Primary Drinking Water Regulations. HAs primarily serve as information to drinking water systems and officials responsible for protecting public health when emergency spills or other contamination situations occur. On June 15, 2022, the EPA issued interim updated drinking water HAs (EPA, 2022b) for PFOA (0.004 ng/L) and PFOS (0.02 ng/L) that replaced the HAs issued by the EPA in 2016. At the same time, the EPA also issued final HAs for two other PFAS, perfluorobutane sulfonic acid and its potassium salt, perfluorobutane sulfonate (PFBS) (2,000 ng/L) and hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt (GenX) (10 ng/L). In chemical and product manufacturing, GenX chemicals are considered a replacement for PFOA, and PFBS is considered a replacement for PFOS.

On March 14, 2023, the EPA released proposed PFAS National Primary Drinking Water Regulations as shown in **Table 3-11** (EPA, 2023c). The proposed regulations establish legally enforceable MCLs and non-enforceable health-based maximum contaminant level goals (MCLGs) for six PFAS compounds, including PFOA, PFOS, perfluorononanoic acid (PFNA), PFBS, HFPO-DA (GenX), and PFHxS. In addition, the proposed regulations include monitoring, public notification, and treatment requirements. When finalized, the rule will apply to operation of public drinking water systems nationwide and is anticipated to be applied by DDW and the Regional Water Board for operation of facilities that produce recycled water for potable purposes (e.g., IPR by Groundwater Replenishment). The proposed MCLs and MCLGs are shown in the following table. The individual MCLs are based on concentrations that can be reliably measured using EPA draft Method 1633. Compliance with the Hazard Index will be determined by dividing the result of each PFAS compound by its assigned health based factor and calculating the sum of the resulting fractions.

Table 3-11. Proposed PFAS National Primary Drinking Water Regulations

Compound	Proposed MCLG	Proposed MCL
PFOA	0.0 ng/L	4.0 ng/L
PFOS	0.0 ng/L	4.0 ng/L
PFNA (health based factor = 10 ng/L)	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS (health based factor = 9 ng/L)		
PFBS (health based factor = 2,000 ng/L)		
HFPO-DA/GenX (health based factor = 10 ng/L)		

The proposed regulations will be published in the Federal Register, and the 60-day public comment period will begin on the publication date. After the end of the public comment period, the EPA will consider the comments received and finalize the regulations. This process is anticipated to be completed by the end of 2023, and, when final, the regulatory requirements will be implemented under the authority of the SDWA.

3.14.3 Future Requirements for Direct Potable Reuse

DPR is the planned introduction of recycled water either directly into a public drinking water system, or into a raw water supply immediately upstream of a drinking water treatment plant (raw water augmentation). CWC §13561.2(a) requires DDW, as part of the SWRCB, to adopt uniform criteria for DPR through raw water augmentation on or before December 31, 2023. DDW released an "Early Draft of the Anticipated Criteria for Direct Potable Reuse" in March 2021 and following a brief public comment period, released a revised version of the draft criteria on August 17, 2021 (DDW, 2021). An Expert Panel was convened to determine whether the draft criteria were adequately protective of public health. Four Expert Panel meetings were held in August 2021 through February 2022, and a final Expert Panel report with their findings was published on June 23, 2022. DDW subsequently released a response to the Expert Panel findings, which contained proposed changes to the August 2021 draft criteria. On July 21, 2023, DDW issued a Notice of Proposed Rulemaking and a revised draft of the DPR criteria. On October 17, 2023, the Water Board issued an updated draft (dated October 4, 2023) for a final, 15-day comment period, prior to moving forward. DDW intends to complete the DPR regulatory package by December 31, 2023, as required by law.

The draft DPR criteria include requirements for pathogen and chemical control, treatment, monitoring, mixing and blending with other source waters, enhanced source control, and project administration and interagency coordination.

4

WATER AND WASTEWATER PROJECTIONS

4.1 Water Use

Water use includes withdrawals from surface and groundwater supply sources, deliveries to meet water demands, releases from points of use, and returns to surface water and groundwater supply sources.

Water supply sources for the users in the Warren Facility service area include:

- Imported surface water (Colorado River and Sacramento-San Joaquin Delta)
- Local groundwater supplies
- Local surface water supplies
- Recycled water

Recurring droughts have led to increasing concerns about reliable water supplies and have resulted in water conservation throughout California. This has also led to an increased emphasis on diversifying water supplies, including maximizing water reuse.

4.1.1 Significance to Facilities Planning

The Sanitation Districts have consistently pursued a program of wastewater reclamation and reuse since 1963, as described in Section 1.6. As water resources become scarcer in response to rising demands and declining supplies, demand for recycled water in Southern California continues to increase. In fact, demand for recycled water exceeds supply at most of the Sanitation Districts' upstream WRPs.

Recycled water produced in Southern California has a variety of beneficial uses including landscape and agricultural irrigation, industrial cooling and process water, and groundwater recharge. The reuse potential of recycled water is directly influenced by the quality of the water supply. Conventional wastewater treatment processes at the Warren Facility have minimal effect on certain water quality parameters, particularly nitrogen and total dissolved solids (TDS). Implementation of nitrogen management facilities and advanced water treatment technology at the Joint Treatment Site is essential to delivering a high-quality water supply to the regions to be served by Pure Water. Sanitation Districts are committed to working with Metropolitan and the communities using recycled water to achieve cost-effective treatment upgrades as required to support the increased reuse of this important resource.

4.2 Water Supply

This section discusses different sources of water supply for Southern California, particularly within Metropolitan's service area, and the impacts of the sources on facilities planning for the Warren Facility. Water supplies within Southern California are composed of local and imported water resources. Local water resources consist primarily of groundwater but also include surface water and recycled water. Imported water resources are provided by Metropolitan via the Colorado River Aqueduct and the California Aqueduct.

4.2.1 Imported Water

Metropolitan is a consortium of 26 member agencies that provides drinking water to approximately 19 million people in parts of Los Angeles, Orange, San Diego, Ventura, Riverside, and San Bernardino Counties. Organized in 1928 following the adoption of the Metropolitan Water District Act by the California Legislature in 1927, Metropolitan currently delivers 1.7 billion gallons of water per day to its 5,200 square mile service area. Metropolitan imports water from two sources: the Colorado River via the Colorado River Aqueduct, and Northern California via the State Water Project's (SWP's) California Aqueduct.

Metropolitan was originally formed with the intent to build and operate an aqueduct to import water to Southern California from the Colorado River. Imported water from the Colorado River was designated to supplement local water supplies in the original 13 Metropolitan member cities. The 242-mile Colorado River Aqueduct was completed in 1941 and began deliveries of Colorado River water to Southern California the same year.

In 1951, the California Legislature authorized the construction of the Feather River Project, now known as the SWP, by the State Department of Water Resources (DWR). The purpose of the SWP is to transfer surplus water from Northern California to water-scarce regions in Central and Southern California. In 1972, Metropolitan began providing additional imported water via the SWP to meet increased demands in its service area.

4.2.1.1 Colorado River Water

Colorado River water supplies generally exhibit low levels of most water quality constituents. However, the salinity concentrations in the water delivered via the Colorado River supplies have typically been high.

Mineralization of Colorado River waters occurs naturally as water tributary to the river flows over and through soils within the watershed and as soluble salts are released through natural geologic weathering processes. Farming activities along the Colorado River also contribute significant amounts of salt to river water. Water imported via the Colorado River Aqueduct has the highest level of salinity of all of Metropolitan's sources of supply, with TDS averaging 630 mg/L.

Metropolitan has employed a number of strategies to avoid potential problems associated with the higher mineral content of the Colorado River Aqueduct supply source and contamination-related issues. To lower TDS levels in water supplies derived from the Colorado River, Metropolitan typically blends Colorado River water with SWP water that is lower in TDS.

Another compound of concern found in water from the Colorado River Aqueduct is perchlorate. Perchlorate enters the Colorado River system at the Las Vegas Wash near Henderson, Nevada. Perchlorate is also found in the groundwater basins within Metropolitan's service area from local sources. Metropolitan has adopted the Perchlorate Action Plan to proactively address this issue. As a result, the amount of perchlorate entering the Colorado River system from Henderson was reduced from approximately over 1,000 ppd in 2000 to 50 to 80 ppd as of early 2007. As a result of mitigation efforts, perchlorate levels at Metropolitan's Colorado River Aqueduct intake at Lake Havasu have decreased significantly in recent years from a peak of 9 µg/L in May 1998. Levels have remained less than 6 µg/L since October 2002 and have been typically less than 2 µg/L since June 2006.

Metropolitan provides treated water to Southern California through five treatment facilities: the Jensen Water Treatment Plant, located in the northwestern end of the San Fernando Valley; the Weymouth Water Treatment Plant, located in the northeastern end of the San Gabriel Valley; the Diemer Water Treatment Plant, located in the northwest corner of Orange County; the Skinner Water Treatment Plant, located in southwestern Riverside County; and the Mills Water Treatment Plant, located in northwestern Riverside County.

In general, the Jensen Filtration Plant serves the San Fernando Valley, the city of Los Angeles, and the South Bay area (e.g., Redondo Beach, Torrance); the Weymouth Filtration Plant serves the San Gabriel Valley and the southeastern and central portions of the Los Angeles Basin; the Diemer Water Treatment Plant serves Orange County; the Skinner Water Treatment Plant serves San Diego County, western Riverside County, and Moreno Valley; and the Mills Water Treatment Plant also serves western Riverside County and Moreno Valley. Treated water from the Jensen Plant is derived solely from SWP water; treated water from the Weymouth, Diemer, Mills and Skinner Plants is derived from a blend of SWP and Colorado River water.

4.2.1.2 State Water Project

Potable water provided by the SWP flows through the Sacramento-San Joaquin Delta. Measurements by the DWR and municipal agencies that treat and deliver SWP water indicate that concentrations of water quality constituents are generally low with respect to drinking water standards. TDS levels in SWP water are also relatively low. Water supplies from the SWP have average TDS concentrations of 250 mg/L for water supplied through the East Branch and 325 mg/L from the West Branch. SWP water delivered by the California Aqueduct has an average TDS concentration of 310 mg/L.

Treated SWP water has occasionally exceeded existing state and federal drinking water standards for trihalomethanes (THMs). THMs are a by-product of disinfection processes that employ chlorine as a disinfectant. They are suspected human carcinogens and are, therefore, regulated by state and federal safe drinking water laws. THMs form when halogens, such as chlorine and bromine, react with dissolved organic matter present in water. Metropolitan has used ozone as the primary disinfectant at each of its water treatment plants, since 2005, to substantially reduce the formation of disinfection byproducts (such as THMs). Chlorine as a disinfectant is applied when the ozone system is under maintenance or repair.

SWP water contains relatively high levels of naturally occurring organic matter, measured as total organic carbon (TOC), due to the influence of peat soils in the Sacramento-San Joaquin Delta. The presence of bromide in SWP water as a result of the ocean's influence on the Sacramento-San Joaquin Delta allows the formation of bromine containing THM compounds during chlorine disinfection.

Since 2010, the Delta Stewardship Council has developed, amended and begun implementing the Delta Plan to protect and improve the water quality of SWP supplies and resolve environmental issues. Metropolitan is one of the agencies that have implemented the Delta Plan. The Delta Plan consists of 14 regulatory policies and 95 recommendations to address current and predicted challenges related to the Delta's ecology, flood management, land use, water quality and water supply reliability. The Delta Plan has set water quality goals for TOC and bromide using a cost-effective combination of alternative source waters, source control, and treatment technologies. Measures have included the use of ozonation to disinfect SWP waters and a blending of SWP water or Colorado River water to lower the concentration of THMs.

The nutrient loading is also one of the issues in the SWP supplies. The primary sources of the nutrient loading are wastewater discharges, agricultural drainage, and nutrient rich soil in the Sacramento-San Joaquin Delta. Metropolitan's source water protection program will monitor the nutrient loadings and prevent future increases.

4.2.2 Groundwater

From 2011-2020, groundwater sources accounted for an average of about 65 percent of the local water supplies, with groundwater supplies in many basins throughout the Southern California region providing an annual average total production of about 1.27 million acre feet per year. There are several groundwater basins that provide water to Metropolitan's service area, including, but not limited to, the Raymond Basin, Upper Los Angeles River Area basins (which include San Fernando, Sylmar, Verdugo, and Eagle Rock Basins), Main San Gabriel Basin, Puente Basin, Central Basin, West Coast Basin, Six Basins, Hemet-San Jacinto Basin, Chino Basin, Cucamonga Basin, Ventura County Basins, and West San Jacinto Basins.

Groundwater yield comes from passive recharge from the percolation of rainfall and stream runoff and active recharge from spreading and injection of captured stormwater, recycled water, and imported water. In certain major drainage areas, runoff is retained in flood control reservoirs and released into spreading basins for percolation into the ground. In Los Angeles County, many groundwater recharge facilities located along the upper reaches of the Los Angeles River and San Gabriel River systems provide recharge to San Fernando, Raymond, Main San Gabriel, Central, and West Coast groundwater basins. The Orange County Water District operates a system of diversion structures and recharge basins along the Santa Ana River that captures much of the storm runoff, as well as water from reclamation facilities in Riverside and San Bernardino counties.

With the exception of the Main San Gabriel, Puente, and Spadra Basins, the water quality in these basins is generally good. Where contamination does occur, it tends to be highly localized. The most common contaminants are industrial solvents and nitrates. Groundwater from all of the basins generally exhibits low concentrations of TDS with a few exceptions. In coastal groundwater basins, TDS levels are highly elevated in locations of historic overdrafting and subsequent saltwater intrusion. Freshwater injection barrier wells have been employed at many of these locations to prevent further degradation of the groundwater aquifers. TDS levels are also elevated in regions affected by irrigated agriculture, dairy or livestock activities, and septic tanks in unsewered areas. TDS levels are also elevated in portions of coastal basins where saltwater intrusion has occurred. One strategy to prevent further degradation of these aquifers is the installation of freshwater-injection barrier wells.

4.2.3 Local Surface Water

Metropolitan's service area includes, among others, two major river systems, the Los Angeles and San Gabriel Rivers, and several large creek systems. Some precipitation in the area tributary to these rivers and creeks complements local water supply through groundwater recharge and incidental runoff into surface storage reservoirs further up in the watershed. Reservoirs hold the runoff for later direct use, and diversions from streams are delivered directly to local water systems. The historic average yield of these local surface supplies, which come from reservoir releases and stream diversions, is about 87 thousand acre-feet (TAF) per year from 2011-2020. The annual yield varies widely between wet and dry years, and most reservoirs that capture local surface runoff are operated with minimal carry-over storage.

4.2.4 Recycled Water

Another source of water supply for the region is recycled water. WRPs within Metropolitan's service area produced about 441,000 acre-feet of recycled water for reuse in 2020. The recycled water was used for landscape irrigation, industrial processes, and groundwater replenishment applications in the region.

Wastewater flows experience significantly higher salinity concentrations than the potable water supply. Salinity increases tend to be higher where specific commercial, industrial, or agricultural processes add brine wastes to the discharge stream or where brackish groundwater infiltrates into the sewer system.

Where wastewater flows have high salinity concentrations, the use of recycled water may be limited, or additional treatment may be required. Non-potable uses such as landscape irrigation and industrial reuse become problematic at TDS concentrations of over 1,000 mg/L. Some crops are particularly sensitive to high TDS concentrations, and the use of high-salinity recycled water may reduce yields of these crops. In addition, concern for the water quality in groundwater basins may lead to restrictions on the use of non-potable recycled water on lands overlying those basins.

These issues are exacerbated during times of drought when the salinity of imported water supplies increases. As a result, there is an increase in the salinity of wastewater flows and, therefore, a similar increase in recycled water salinity. Basin management plans may restrict the use of non-potable recycled water when its use would be most valuable. Therefore, to maintain the cost-effectiveness of recycled water, the salinity level of the region's potable water sources and wastewater flows must be properly managed. Pure Water will serve as a drought-tolerant supply, as the use of reverse osmosis (RO) technology will remove TDS from the purified water and thereby mitigate increased salinity in potable water supplies during times of drought.

4.3 Water Demand

4.3.1 Municipal Water Demand

The 2020 Urban Water Management Plan (UWMP) for Metropolitan includes the historical and projected municipal and industrial (M&I) water demands for the Los Angeles County portion of Metropolitan's service area. The UWMP is updated every five years and 2020 UWMP includes projections till 2045. The historical retail M&I water demand with conservation for Los Angeles County in 2000 was 1,738,000 acre-feet and it decreased to 1,313,000 acre-feet in 2015. It is projected that the water demand will increase to 1,455,000 acre-feet by the year 2045. Residential water use accounts for most of the water demand. More than 50 percent of the residential water demand is from single family households.

4.3.2 Other Water Demand

Other water demands include commercial, industrial, and institutional (CII) water use which represents about 15 percent of the total M&I demands in Los Angeles County. The CII (nonresidential) sector represents water that is used by businesses, services, government, institutions (such as hospitals and schools), and industrial (or manufacturing) establishments. Within the commercial/institutional category, the top water users include schools, hospitals, hotels, amusement parks, colleges, laundries, and restaurants. The major industrial users include electronics, aircraft, petroleum refining, beverages, and food processing in Southern California.

4.3.3 Water Conservation

Various conservation regulations have been implemented in Metropolitan's service area which include plumbing efficiency standards, urban water management, agricultural water management, recycled water reuse, and graywater use. There are programs offered by the federal, state, and local governments which encourage water conversation. The water demand described in Section 4.3.1 includes water savings due to conservation.

The estimated savings from the base year 1980 due to conservation in the Los Angeles County portion of Metropolitan's service area in 2000 was 166,000 acre-feet and increased to 368,000 acre-feet in 2015. The 2045 projected savings in the water demand due to conservation is 546,000 acre-feet.

The current indoor residential water use standards set by the California State Legislature per Water Code Section 10609.4 are 55 gallons per capita per day (gpcd) (2020), 52.5 gpcd (2025), and 50 gpcd (2030) (**Table 4-1**). However, the Water Code allows for the DWR, in coordination with the State Water Board, to conduct necessary studies in order to recommend a standard for indoor residential water use that more appropriately reflects best practices for indoor residential water use than the standard described in subdivision 10609.4. In 2018, the California legislature passed AB 1668 (Friedman) and Senate Bill 606 (Hertzberg) which created a new framework for setting customized water use targets for new urban water suppliers in California. In AB 1668 and SB 606, the State of California made a commitment to use the best available data and information to set water efficiency standards for urban water suppliers. Using four detailed analytical approaches, DWR in coordination with the State Water Board conducted an Indoor Residential Water Use Study (IRWUS) to estimate the reduction in statewide indoor water use. The study produced the following DWR and State Water Board joint draft standards recommendations of 55 gpcd (2020), 47 gpcd (2025), and 42 gpcd (2030).

It should be noted that these recommended standards are for indoor residential water use only and are only one part of many independent standards including indoor, outdoor, commercial, industrial, water losses, variances, and bonus incentives. Further, given that standards are not independently enforced, enforcement will be on the retail water supplier's total annual water use objective. It should also be noted that the minimum indoor water use is 35 gpcd per DWR's recent Working Group Meeting held April 22, 2021; therefore, once a supplier meets the 35 gpcd goal, there is no further requirement to decrease the gpcd.

Table 4-1. California State Standards and DWR Recommended Standards

Year	Current Statute (gpcd)	PCGR Recommended by DWR and State Water Board (gpcd)	Percent Decrease[a]
2020	55	55	N/A
2025	52.5	47	15%
2030	50	42	11%

[a] Percent decrease is the calculated decrease between 2020-2025 and 2025-2030.

4.4 Future Water Demand and Supply Balance

To provide reliability in water supply and demand planning, Metropolitan developed the Integrated Water Resources Planning (IRP) process in 1993. The first IRP was adopted in 1996 which analyzed different resources that would provide the region with reliable and affordable water supplies through 2020. The 1996 IRP was updated in 2004, 2010, and 2015.

The reliability evaluation conducted as part of the 1996 IRP process revealed that without future investments in local and imported supplies, the region may experience a supply shortage of at least 0.79 million acre-feet about 50 percent of the time (or once every other year) by 2020. Since 1996, Metropolitan, its member agencies, and other local agencies have strived to implement the goals identified in the IRP. Implementation and refinements to the IRP are conducted via annual reports to Metropolitan Board of Directors, as well as an IRP Report update every five years (in conjunction with the Regional UWMP update). The IRP updates have confirmed that these efforts have moved the region toward its goal of long-term regional water supply reliability.

The 2004 IRP Update emphasized conservation and local water supply development and included a “planning buffer” as redundancy to accommodate unforeseen circumstances. The 2010 IRP Update, which remained true to the original IRP goal of meeting “full service demands at the retail level under all foreseeable hydrologic conditions,” managed recent dramatic changes such as reduced water supply from the Colorado River and more stringent regulations that reduce water supply from the SWP. One component of the 2010 IRP Update was to establish foundational actions that detail strategies for securing additional water sources if changed conditions turn dramatic or persistent. These foundational actions, which will span an estimated eight years, include low-risk actions (i.e., feasibility studies, legislative efforts, public and stakeholder outreach, agency consultation for permitting, and research) undertaken to reduce the time necessary to make a project operational. Metropolitan will employ these foundational actions concurrent with the remaining components of the plan that focus on further development or study of four local resources including recycled water, seawater desalination, stormwater, and greywater (Metropolitan, 2010).

The 2015 IRP update emphasized the development and maintenance of local supplies and conservation. With this update, Metropolitan started a process to identify local and regional responsibilities, meet targets for regional reliability, and finance regional projects.

The 2020 IRP provides a fuller understanding of the lessons learned in the past 25 years; a key lesson being that the future is not predictable on the supply or demand side. Therefore, Metropolitan introduced scenario planning where all the plausible futures can be explored.

Climate change, regulatory requirements, and economic growth are the significant factors affecting the supply and demand of water and are assessed qualitatively in four scenarios.

1. Scenario A: Gradual climate change impacts, low regulatory impacts, and slow economic growth.
2. Scenario B: Gradual climate change impacts, low regulatory impacts, high economic growth.
3. Scenario C: Severe climate change impacts, high regulatory impacts, slow economic growth.
4. Scenario D: Severe climate change impacts, high regulatory impacts, and high economic growth.

The analysis found that SWP dependent areas are most vulnerable due to reduced reliability of SWP supplies and that actions identified in the implementation phase must prioritize improving reliability in these areas. Furthermore, the analysis emphasized the criticality of developing new local supplies to increase sustainability and reduce dependency on imported supplies.

4.5 Uncertainties and Possible Effects On Projections

The availability and usage of future water supplies are uncertain due to various factors that are beyond the control of Metropolitan and the Sanitation Districts. These factors affect future wastewater characteristics and flows. Some of the factors are listed below:

- Changing trends in water usage
- Future availability of imported water supply
- Climate change

4.5.1 Changing Trends in Water Usage

The population in the Warren Facility and Metropolitan's service area is expected to increase, but due to continued conservation measures and a predicted decrease in indoor residential water use standards, water usage is expected to increase at a less rapid pace than the rate of population growth. Water demand has remained consistently low since 2015. The implication of continuing low demands on Metropolitan and the region's other potable and recycled water suppliers must be considered. For example, lower indoor use results in less wastewater with more highly concentrated effluent. This potentially increases the cost of recycling. Coming full circle, California again faces severe drought, conditions on the Colorado River worsen, and the disruption of the COVID-19 global pandemic has shaken society's conceptions of normality, perhaps causing yet unseen ripple effects in water-using behavior trends (Metropolitan, 2020).

4.5.2 Imported Water Quality and Availability

Section 4.2.1 describes in detail the sources and quality of imported water. A variety of federal, state, and local programs have been initiated to enhance the supply capabilities and reliability of imported sources to consistently meet projected future demands. In addition, contingency analyses and long-range planning efforts have been undertaken to further improve the supply dependability in coping with potential interruptions or reductions to these sources.

Metropolitan conducted three analyses listed below per UWMP 2020 to evaluate supply reliability:

1. Water Service Reliability Assessment to compare available water supply sources with projected water use over the 20 years in 5-year increments, for a normal water year, a single dry water year, and a drought lasting 5 consecutive water years.
2. Drought Risk Assessment.
3. Water Shortage Contingency Plan (WSCP).

The WSCP is designed to be consistent with Water Surplus and Drought Management Plan (WSDM Plan), which was developed in 1999 and guides planning and operations during both shortage and surplus conditions.

The WSDM Plan identifies the expected sequence of resource management actions that will be executed during surpluses and shortages to minimize the probability of severe shortages and eliminate the possibility of extreme shortages and shortage allocations.

The guiding principle of the WSDM Plan is to manage Metropolitan's water resources and management programs to maximize the management of wet year supplies and minimize adverse impacts of water shortages to retail customers. From this guiding principle, Metropolitan developed the following supporting principles:

- Encourage efficient water use and economical local resource programs.
- Coordinate operations with member agencies to provide as much surplus water as possible in dry years.
- Pursue innovative transfer and banking programs to secure more imported water for use in dry years.
- Increase public awareness about water supply issues.

The WSDM Plan also declared that if mandatory import water allocations are necessary, they would be calculated on the basis of need, rather than historical purchases. The WSDM Plan contains the following considerations that would be utilized for an equitable allocation of imported water:

- Impact on retail consumers and regional economy.
- Investments in local resources, including recycling and conservation.
- Population growth.
- Changes and/or losses in local supplies.
- Participation in Metropolitan's non-firm (interruptible) programs.
- Investment in Metropolitan's facilities.

4.5.3 Climate Change

Water resources are highly sensitive to variations in weather and climate. The accumulation of greenhouse gases in the atmosphere may impact global climate patterns, thereby possibly affecting the availability of freshwater supplies and potentially altering the frequency and intensity of droughts and floods.

In 2022, the Sanitation Districts published the *Climate Change Vulnerability Assessment and Management Plan for A.K. Warren Water Resource Facility*. This report describes the effects of climate change and natural hazards such as floods, drought, extreme temperatures, wind, and wildfires on the treatment plant and collection system. The findings of the report are described below:

- Flooding can cause increased flows to the Warren Facility and collection system causing overflows. It can also damage equipment and infrastructure.
- Sea level rise will place additional pressure on effluent discharge pumps, create greater risk for coastal flooding during storms, and lead to increased groundwater intrusion, potentially damaging equipment and infrastructure.
- Droughts will reduce the influent wastewater flows, which can lead to increased wastewater concentrations and reduced availability of recycled water for reuse. Reduced wastewater flows can increase headspace in the pipes causing deposition, corrosion, and foul air issues in the pipelines.
- Extreme temperatures can result in accelerated corrosion in cementitious manholes and pipelines.
- Wind and wildfire do not have a direct impact on the wastewater flows, but can cause an increase in dust and debris in the air, respiratory impact, and electrical interruption at the Warren Facility.

While there is a high degree of certainty that there will be changes in the quantity and distribution of precipitation, there are considerable uncertainties associated with the rate at which these changes will take place and the specific nature of the impacts on local hydrologic conditions. In California, climate change may result in significant deviations from patterns observed in the last century including higher temperatures, reduced Sierra snowpack, earlier snowmelt, less snow and greater rainfall at higher elevations, and a rise in sea level. The timing and extent of these changes remains uncertain.

In December 2007, the Association of Metropolitan Water Agencies published a report titled Implication of Climate Change for Urban Water Utilities. Included within this report was a summary of the direct impacts of climate change on water utilities. A direct impact is defined as an impact resulting from climate change on a water utility's function and operation. Relative to the southwest United States, the report predicts warmer and probably drier overall conditions with more extreme droughts and heat waves with the following effects:

- Reduced quantities of surface water available from local runoff and water available to recharge groundwater aquifers.
- Increased evaporative losses in inter-basin transfers of surface waters.
- Increased changes in vegetation of watershed and aquifer recharge areas.
- Increased water temperature and water demand.

The report also predicts more intense rainfall events that would increase turbidity, sedimentation, and the risk of direct flood damage to water utility facilities. The challenge to accommodating these changes is to develop a strategy and the infrastructure to provide the needed water volumes at the locations and times they are requested. Reduced availability of water supplies could result in higher costs, increased water conservation within residences, increased water reuse, and reduced per capita wastewater generation. It is likely that water use reductions would result in a more concentrated wastewater flow that may require process adjustments and/or additional facilities at the wastewater treatment plants to handle the more concentrated waste stream.

4.6 Wastewater Characteristics

This section describes the influent and effluent characteristics of wastewater at the Warren Facility from January 2015 through December 2019. These characteristics were also used to project future concentrations and loads. Data from the COVID-19 years (2020-2022) is not included in the analysis due to the anomalous quality of the data.

4.6.1 Influent Quality

Flows at the Warren Facility are comprised of residential, commercial, and industrial sewage. The influent flow typically is comprised of about 19 percent industrial, with the remaining 81 percent coming from residential and commercial flows.

Typical influent parameters which are used to measure the strength of wastewater are chemical oxygen demand (COD), biochemical oxygen demand, 5-day (BOD_5), TSS, and nitrogen in terms of ammonia nitrogen (NH_3-N) and total kjeldahl nitrogen (TKN). A summary of influent characteristics in terms of ppd and mg/L from January 2015 through December 2019 for the Warren Facility is provided in **Table 4-2**.

Table 4-2. Warren Facility Primary Influent Load and Concentrations

Constituents	Current Conditions	
	Annual Average	Maximum Monthly
COD, ppd	2,012,000	2,213,000
BOD_5, ppd	981,000	1,079,000
TSS, ppd	1,161,000	1,277,000
TKN, ppd	159,300	175,200
NH_3-N, ppd	103,500	113,900
COD, mg/L	882	874
BOD_5, mg/L	430	426
TSS, mg/L	509	504
TKN, mg/L	70	69
NH3-N, mg/L	45	45

4.6.2 Effluent Quality

The quality of the treated effluent is regulated by the WDRs and NPDES permit issued by the LARWQCB. The current NPDES permit was adopted by the LARWQCB on May 25, 2023, and became effective on July 1, 2023.

Effluent from the plant is disinfected by chlorination and then pumped through a system of tunnels and submarine outfalls two miles offshore in the Pacific Ocean. The four outfalls are located at White Point, San Pedro, off the Palos Verdes Peninsula. Two of the outfalls (Discharge Points 001 and 002) are used for continuous discharge of treated wastewater. Discharges to Discharge Points 003 and 004 are prohibited except for emergency discharge of SE when the flow rate approaches the hydraulic capacity of 001 and 002, or during power outages, preventative maintenance, or capital improvement activities as specified in the permit.

Table 4-3 provides a summary of the SE concentrations of major wastewater constituents monitored at the Warren Facility and the corresponding NPDES limit. This analysis is based on data from January 2015 to December 2019. The Warren Facility NPDES waste discharge requirements include approximately 4,600 numeric limitations that must be met each year based on quantitative results of final effluent sampling and analyses. The Warren Facility has not had any discharge violations in the past six years. In May 2016, an apparent exceedance of the chronic toxicity daily maximum effluent limitation occurred. Subsequent analysis of the test data indicated the exceedance was more likely due to increased test precision (statistical power) and not associated with environmentally relevant toxicity. The Warren Facility field operation staff confirmed that plant operation was normal on May 9 and May 10, 2016. An evaluation of historical Warren Facility final effluent chronic toxicity results conducted from 2002 through April 2016 (225 individual tests) revealed no exceedances of the numeric objective prior to this result. In response to the May 2016 chronic toxicity effluent limitation exceedance, the Sanitation Districts immediately implemented accelerated toxicity testing using Giant Kelp and the first accelerated monitoring sample was collected in May 2016. Accelerated testing continued in June and July and concluded in August 2016; all completed valid tests exhibited no toxicity.

Table 4-3. Select Historical Secondary Effluent Quality and Current Permit Requirements/ Performance Goals

Constituent	Average Concentration (mg/L)	NPDES Limit Average Monthly or Performance Goal[a] (mg/L)
BOD_5	4	30
COD	54[b]/66[c]	-
TSS	10	30
TKN	46.5	-
NH_3-N	44	49
TP	0.70	-

[a] Value represents Average Monthly Limit for BOD_5 and TSS at Discharge Points 001 and 002, and Performance Goal for NH_3-N at Discharge Points 001 and 002.

[b] Average before COD analysis method change.

[c] Average after COD analysis method change.

4.6.3 Seasonal Variability

The analysis influent loading and effluent condition found a common influent load independent of any seasonal trend. Influent concentrations showed low-to-moderate seasonal variability, as concentrations were lower during the Winter wet weather season for influent BOD_5 and TSS. The additional wet weather flow did not influence removal efficiencies through the Warren Facility.

4.7 Wastewater Flow Projections

4.7.1 Methodology

Projections of wastewater flow rates are used to determine the required capacity of treatment. Over the 2050 planning horizon, population in the Warren Facility tributary area is projected to increase slightly while residential per capita generation rates (PCGRs) are projected to decrease slightly. This will in turn increase the amount of wastewater flows to be treated despite PCGRs slightly decreasing. The influent wastewater quality data presented in Section 4.6 provide a representative sample of recent conditions and are used alongside the projected populations and flows to project future conditions.

4.7.1.1 Historical Population

The historical population was derived from DOF population estimates for each city and is presented in Section 2.

4.7.1.2 Historical Flows and Adjustments

The historical flows and peaking factors for primary influent flow for the Warren Facility are detailed in **Table 4-4**. This analysis is based on calculated primary influent flow from January 2015 to December 2019.

Table 4-4. Historical Flows and Flow Peaking Factors, Primary Influent Flow

Flow Criteria	Historical 2015 – 2019	
	Flow, mgd	Peaking Factor
Minimum Day	218	0.82
Minimum Week	244	0.91
Average Annual	267	1.00
Maximum 30-Day	294	1.10
Maximum 7-Day	327	1.22
Maximum Day	426	1.59
Maximum Hour	633	2.13

4.7.2 Population Projections

The Pure Water program has been in development for over ten years. After the program feasibility study was completed in 2016, data from the 2016 SCAG RTP20 was selected as the baseline for population projections. **Table 4-5** summarizes the population projections based on this publication.

Table 4-5. Projected Population for Warren Facility Service Area

Parameter	Value
Estimated 2015 Population, millions[a]	4.9
Projected 2050 Population, millions[b]	5.45
Projected Population Growth	11-12%

[a] Based on 2015 DoF population estimates

[b] Based on 2016 SCAG population projections

4.7.3 Flow and Load Projections

Flow and load projections for the Warren Facility are based on a comprehensive evaluation of historical data from 2015 through 2019. The future average annual flow was calculated using an assumed 12 percent increase from current flows, corresponding to the projected population growth described in Section 4.7.2.

The Minimum Hour, Minimum Day, Minimum Week, Maximum 30-Day, Maximum 7-Day, Maximum Day, and Maximum Hour flows were developed by multiplying the annual average flow by the respective flow peaking factors developed from the 2015-2019 historical data. **Table 4-6** provides a summary of the current and future flows and flow peaking factors.

Table 4-6. Design Flows and Flow Peaking Factors

Flow Criteria	Flow Peaking Factor	Current Flow, MGD	2050 Flow, MGD
Minimum Hour	0.43	130[a]	132
Minimum Day	0.77	211	236
Minimum Week	0.91	249	279
Average Annual	1.00	274	307
Maximum 30-Day	1.11	304	341
Maximum 7-Day	1.18	323	362
Maximum Day	1.59	436	488
Maximum Hour	2.13	633[b]	700[c]

[a] The current minimum hour flows is based on observed minimum hourly flows from 2018 to 2019.

[b] The current maximum hour flow is based on using the peak flow observed from the 2017 design storm event.

[c] It is assumed that the future maximum hour flow will be equivalent to the Warren Facility secondary capacity of 700 MGD.

The future loads were developed from the historical 2015-2019 primary influent loads, population projections and considerations for Warren Facility design capacity. The average annual loads were assumed to increase in-line with population growth up to the design load capacity of the Warren Facility Additionally, the future loads are in-line with the Warren Facility design loading conditions. As such, no derating of the Warren Facility design flow was considered necessary.

The Minimum Day, Maximum 30-Day, Maximum 7-Day, and Maximum Day loads were developed by multiplying the annual average loads by the respective load peaking factors developed from the 2015-2019 historical data. For example, to determine the Maximum Month BOD_5load (BOD_{MM}) in pounds per day (ppd) from the Annual Average BOD_5load (BOD_{AA}) and the Maximum Month Peaking Factor (PF_{MM}), the following calculations were performed.

$$BOD_{MM}\text{ (ppd)} = BOD_{AA}\text{ (ppd)} * PF_{MM}$$

Current Conditions and Design Horizon concentrations were developed by dividing the mass loadings and then dividing by projected flow and conversion factor of 8.34 pounds per gallon to attain the concentration in mg/L. For example, to determine the BOD_5concentration in mg/L, the following calculations were performed.

$$BOD_{AA}\text{ (mg/L)} = BOD_{AA}\text{ (lbs/d)} / Flow_{AA}\text{ (MGD)} / 8.34\text{ (lbs/gal)}$$

The current load and peaking factors for primary influent BOD_5, COD, TSS, TKN, and NH_3-N are summarized in **Table 4-7**. This analysis is based on data from January 2015 to December 2019.

Table 4-7. Warren Facility Primary Influent Load and Load Peaking Factors

Criteria	BOD_5		COD[1]		TSS		TKN		NH_3-N	
	Load, ppd	PF	Load, ppd	PF	Load, ppd	PF	Load, ppd	PF	Load, ppd	PF
Minimum Day	701,000	0.71	1,224,000	0.67	884,000	0.76	152,000	0.96	94,900	0.91
Average Annual	986,000	1.00	1,840,000	1.00	1,170,000	1.00	158,000	1.00	104,000	1.00
Maximum Month	1,050,000	1.06	1,980,000	1.07	1,250,000	1.06	-	-	-	-
Maximum 30-Day	1,080,000	1.09	1,990,000	1.08	1,270,000	1.08	-	-	-	-
Maximum 7-Day	1,140,000	1.15	2,150,000	1.16	1,370,000	1.17	-	-	-	-
Maximum Day	1,330,000	1.35	2,630,000	1.42	1,740,000	1.48	-	-	-	-
Typical Sampling Frequency	1x week		3x week		5x week		1x quarter		1x month	

Table 4-8 provides a summary of the design load peaking factors.

Table 4-8. Design Load Peaking Factors

Load Criteria	Load Peaking Factor
Minimum Day	0.75
Average Annual	1.00
Maximum 30-Day	1.10
Maximum 7-Day	1.16
Maximum Day	1.40

Table 4-9 summarizes the current and future annual average and Maximum 30-day influent conditions based on the growth assumptions summarized in **Table 4-5**. The Maximum 30-day design loads at the design horizon are essentially equivalent to the original Warren Facility design loadings (BOD_5 within 1% and TSS within 5%).

Table 4-9. Flow and Load Projections for Warren Facility

Constituents	Current Conditions	Design Horizon			Notes
	Annual Average	Maximum 30-Day	Annual Average	Maximum 30-Day	
Flow, MGD	274	304	307	341	12% total increase in flow, Max 30 Day Peaking Factor (PF) = 1.11
COD, ppd	2,012,000	2,213,000	2,496,900	2,746,600	24% load increase in load, Max 30 Day PF = 1.10
BOD_5, ppd	981,000	1,079,000	1,217,700	1,339,500	
TSS, ppd	1,161,000	1,277,000	1,441,100	1,585,200	
TKN, ppd	159,300	175,200	197,700	217,500	
NH_3-N, ppd	103,500	113,900	128,500	141,400	
COD, mg/L	882	874	975	966	
BOD_5, mg/L	430	426	476	471	
TSS, mg/L	509	504	563	558	
TKN, mg/L	70	69	77	77	
NH3-N, mg/L	45	45	50	50	

4.8 Water Reuse and Reclamation

Treated effluent from the Warren Facility is currently discharged to the ocean. To beneficially reuse the effluent, the Sanitation Districts have partnered with Metropolitan to develop Pure Water, a large-scale regional recycled water program which will produce up to 150 MGD of purified recycled water from wastewater at the Warren Facility. Pure Water involves construction of an AWP Facility to treat effluent from the Warren Facility, as well as a new regional conveyance system and associated infrastructure to utilize the purified water to augment regional water supplies. Pure Water will purify primary or secondary wastewater effluent from the Warren Facility through advanced water treatment processes for potable reuse.

The purpose of this Facilities Plan is to identify a recommended approach to secondary and tertiary treatment facilities design and implementation that will meet the regulations, performance, and capacity needs of both the JOS and Pure Water through the year 2050.

4.8.1 Future Water Reuse

Water from Pure Water will be used primarily to recharge groundwater basins through spreading facilities and injection wells and to augment water supplies at water treatment plants owned and operated by Metropolitan. In addition, agencies would be able to connect to the proposed conveyance facilities to serve industrial users. Pure Water will be constructed in a phased approach with the ultimate capacity of the program considering both the availability of source water at the Warren Facility and the anticipated water demands of member agencies for groundwater replenishment and DPR application.

Treated water from Pure Water could be used to recharge three groundwater basins: Main San Gabriel, West Coast, and Central. Metropolitan has identified a nitrate objective of 10 mg-N/L for groundwater recharge into these basins. Future use applications of DPR would be associated with a 4 mg-N/L operating goal (limit 5 mg-N/L) consistent with Metropolitan Pumping Policy. The evaluation of Warren Facility modifications described in Sections 6 and 7 considered a slightly higher nitrate operating goal of 6.4 mg-N/L aligning with planning targets at the time of the conceptual design development (Jacobs, 2023, and Hazen, 2023). A subsequent evaluation, aimed to identify approaches for alignment between conceptual design development and Metropolitan Pumping Policy, indicated achieving and maintaining improved RO rejection provided the most cost-effective approach to achieve the DPR targets (Stantec, 2023a).

As identified in **Table 4-2**, the current nitrogen concentration in the treated effluent far exceeds these thresholds. The existing HPOAS treatment process at Warren Facility was neither designed to oxidize ammonia to nitrate nor to remove nitrogen from the effluent. Nitrogen management at the Warren Facility and AWP Facility will be crucial for potable reuse to meet water quality objectives. Pilot-scale studies have shown that with additional advanced treatment, the Warren Facility effluent can be beneficially reused to supplement local potable supplies through groundwater recharge.

5 FACILITIES DESCRIPTION

5.1 A.K. Warren Water Resource Facility

The Warren Facility is located at 24501 South Figueroa Street in Carson, California. The plant is bordered by SR-110 to the west, Sepulveda Boulevard to the north, commercial and residential land uses east of Main Street, and commercial and residential land uses south of Lomita Boulevard. Treatment facilities first went into operation at the Warren Facility in 1928. The plant has evolved through expansion and continual improvement to its present configuration as one of the largest wastewater treatment facilities in the world (Sanitation Districts, 2018). The existing Joint Outfall System service area is shown on **Figure 5-1**.

The total permitted capacity for annual average daily flow (AADF) for the plant is 400 MGD. The Warren Facility has design capacities of 400 MGD for average dry weather flow and 700 MGD for peak sanitary flow (Sanitation Districts, 2021).

Effluent is conveyed approximately six miles to the White Point Manifold Structure and discharged through two ocean outfalls approximately two miles offshore. There are two additional outfalls reserved for emergency use.

The Warren Facility accepts food waste slurry and fats, oil, and grease (FOG) at either the Liquid Waste Disposal Station or the Slurry Receiving Facilities for anaerobic digestion. Energy recovery systems are also situated at the site, as are buildings housing administrative and maintenance functions. Solids generated as part of the treatment and digestion processes are stabilized, dewatered, and trucked off-site for disposal or beneficial reuse.

5.1.1 Joint Plant Site

Effluent treated at the Warren Facility will be sent to the AWP Facility for advanced treatment. The AWP Facility, along with additional secondary and/or tertiary treatment and sidestream centrate treatment facilities as described in Sections 6 and 7 of this Facilities Plan, will be located on the east side of the Warren Facility and in an area south of the railroad tracks. This land is referred to as the Joint Plant Site. The 52-acre Joint Plant Site includes 16 acres of mostly vacant area, except for an existing warehouse and the Grace F. Napolitano Pure Water Southern California Innovation Center Demonstration Plant (Demonstration Plant), east of the HPOAS reactors, and 36 acres of vacant land which was formerly used by FORCO for oil development and refining activities (Stantec, 2023b). The FORCO area of the Joint Plant Site is currently undergoing soil and groundwater remediation to remove contamination from uncontrolled releases of petroleum hydrocarbon products that occurred during historical refinery operations at the property. An aerial photograph of the Joint Plant Site is depicted on **Figure 5-2.**

Figure 5-1. A.K. Warren Water Resource Facility

Figure 5-2. Joint Plan Site

5.2 Conveyance System

The off-site conveyance system comprises four types of sewers. Ranging from the smallest to the largest, these are lateral lines, local sewers, the Sanitation Districts trunk sewers, and joint outfall trunk sewers. In general, wastewater generated within the JOS service area flows from the smallest lines (laterals and local sewers), through the next largest lines (Sanitation Districts trunk sewers), and finally into the largest lines (joint outfall trunk sewers), eventually feeding into either the WRPs or the Warren Facility. **Figure 5-3** shows the sewer system for the entire JOS service area.

5.2.1 Laterals and Local Sewers

Most sewer lines located within the JOS service area are the responsibility of private property owners or local jurisdictions. The privately owned lateral lines connect residences and business to the local sewer, which are operated and maintained by either the cities in which the lines are located or Los Angeles County's Consolidated Sewer Maintenance District (within the Department of Public Works).

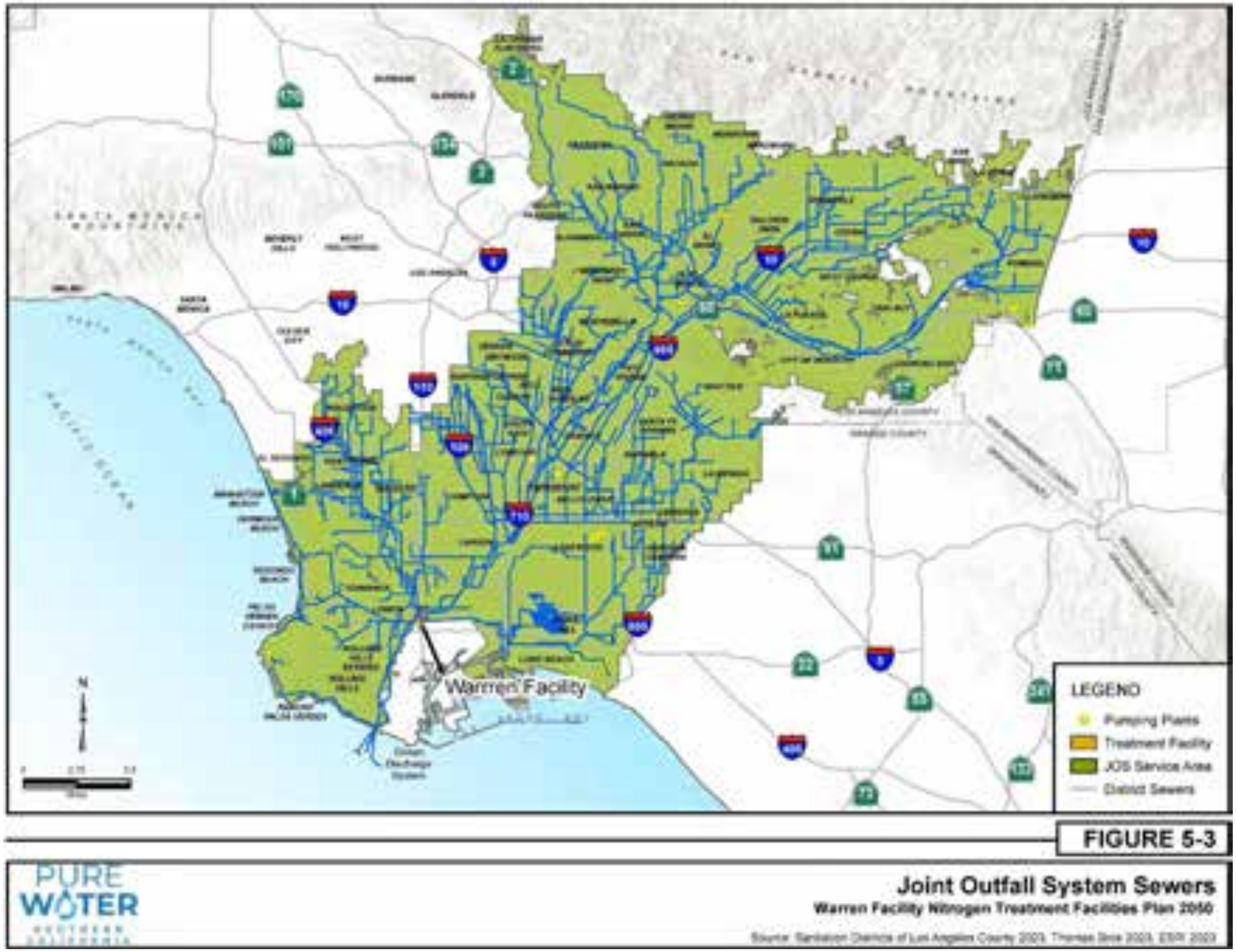
5.2.2 Sanitation Districts Trunk Sewers

The Sanitation Districts trunk sewers collect wastewater from the local sewers and/or laterals and convey it to the larger joint outfall trunk sewers. The Lomita trunk sewer, located in District 5, conveys wastewater directly to the Warren Facility site and discharges into the Joint Outfall A trunk sewer immediately upstream of the bar screens. The majority of this trunk sewer is constructed of cured-in-place-pipe (CIPP)-lined vitrified clay pipe ranging in diameter from 15 to 21 inches. The pipe size and material is 27-inch reinforced concrete where it enters the Warren Facility (Sanitation Districts, 2023).

5.2.3 Joint Outfall Trunk Sewers

Joint outfall trunk sewers form the backbone of the JOS conveyance system. The joint outfall trunk sewers collect wastewater from the Sanitation Districts trunk sewers or local sewers and convey it to the treatment plant for treatment and disposal. There are nine joint outfall trunk sewer lines designated Joint Outfall A to Joint Outfall J (there is no Joint Outfall I). Of these joint outfall trunk sewers, A, B, and D feed directly into the Warren Facility (Sanitation Districts, 2021). Joint outfall trunk A sewer is a 9-foot wide by 9-foot tall reinforced concrete box. Joint outfall trunk sewer B is a 10-foot wide by 12-foot-tall reinforced concrete box. Joint outfall D sewer is constructed of 108-inch diameter reinforced concrete pipe.

Figure 5-3. Joint Outfall System Sewers



5.2.4 On-Site Conveyance at the Warren Facility

In addition to the off-site conveyance system, the Warren Facility receives wastewater from the on-site Liquid Waste Disposal Station (LWDS) located east of South Figueroa Street and north of the railroad tracks. The LWDS receives and conveys septic waste, industrial wastewater, food waste slurry, and FOG to the headworks of the plant. The Warren Facility also receives food waste slurry and FOG at the Slurry Receiving Facilities (SRF) located west of South Figueroa Street near the rectangular digesters and pumps it directly to the digesters. The locations of the LWDS and SRF are depicted in **Figure 5-4.**

Trucks transporting septic waste, industrial wastewater, food waste slurry, and FOG are required to provide a sample of their loads to the LWDS site attendant. The attendant tests the sample for pH and electrical conductivity, records the data, and labels the sample bottle with the sample date and a delivery manifest number. For quality control purposes on food waste slurry, two random samples from each processor are analyzed per week for parameters such as total solids, volatile solids, and COD. Additionally, comprehensive quarterly analysis of food waste slurry samples from each processor is conducted to ensure compliance with the minimum standards specified in **Table 5-1** below.

Table 5-1. Food Waste Slurry Minimum Standards

Parameter	Standard
pH	2.8 – 7.0
Total Solids	< 16.0% g/g
Volatile Solids (% of Total Solids)	> 85%
Electrical Conductivity	< 15 milli-mho/cm
Volatile Acids (Acetic Acid Equivalents)	< 15,000 mg-Ac/L
Total COD	> 150,000 mg/L
Total BOD	> 80,000 mg/L
Specific Gravity @ 25°C	0.95 – 1.10
Kinematic Viscosity @ 25°C	< 200 cSt
Ammonia as Nitrogen (NH_3-N)	< 600 mg/L
Total Kjeldahl Nitrogen (TKN)	< 7,500 mg/L
Arsenic	< 1 mg/L
Calcium	< 3,000 mg/L
Chromium	< 2 mg/L
Magnesium	< 500 mg/L
Mercury	< 1 mg/L
Nickel	< 5 mg/L
Potassium	< 3,000 mg/L
Sodium	< 3,000 mg/L
Biochemical Methane Potential	> 0.25 L-CH_4/g-COD
Cadmium	< 12 mg/L

Parameter	Standard
Copper	< 15 mg/L
Lead	< 40 mg/L
Molybdenum	<1 mg/L
Selenium	< 5 mg/L
Zinc	< 25 mg/L
Film Plastic > 4 mm (Method TMECC 0306)	< 0.40% g/g by dry weight[1]
Glass > 4 mm (Method TMECC 0306)	< 0.50% g/g by dry weight[1]
Total Inerts > 4 mm (Film and hard plastics, glass, metals & rocks) Method TMECC 0306)	< 1.2% g/g by dry weight[1]

Acceptable range based on average results of three randomly selected loads.

Figure 5-4 shows the location of the LWDS and SRF.

Figure 5-4. Warren Facility Liquid Waste Disposal Station and Slurry Receiving Facility

5.3 Existing Warren Facility Treatment Processes

Wastewater processes at the Warren Facility include screening, grit removal, primary sedimentation, high purity oxygen activated sludge, secondary clarification, and disinfection. Treatment processes are described below (Sanitation Districts, 2023).

5.3.1 Primary Treatment

Influent entering the Warren Facility passes through nine bar screens and six aerated grit chambers. Material removed by the screens is conveyed to compactors for dewatering and disposal. Grinders are available to handle material as a backup to the compactors. The wastewater is then aerated in grit chambers to keep lighter organic solids in suspension while allowing heavier solids, such as sand, to settle to the bottom of the chamber. Grit slurry recovered from the bottom of the grit chamber is pumped to cyclone separators for dewatering. The grit solids are then discharged to grit classifiers for further dewatering and to remove lighter organic material. Grit is then transported off-site for disposal. Water and organic material from the process is returned to the influent channel of the grit chambers.

Wastewater enters each of the fifty-two primary sedimentation tanks through inlet gates. The velocity of the incoming wastewater is reduced from approximately 3 feet per second to 3 feet per minute, allowing heavier solids in the wastewater to settle to the bottom of the tank and floating material to rise to the surface. Flights push floatable material (skimmings) to the effluent end and push settleable solids (sludge) to the influent end for collection and further processing.

Raw sludge (3.5 percent - 4.5 percent solids concentration by weight) is withdrawn from the influent end of the tank by means of a series of collector pumps controlled by timers. The process is monitored by measuring the thickness of sludge blankets within the sedimentation tank. Water levels within the tank are maintained by effluent launders which are either surface weirs (30 tanks) or butterfly valves (22 tanks).

The primary sedimentation tanks remove about 75 percent of suspended solids and 45 percent of biological oxygen demand (BOD). The tanks and inlet channels are covered to control odors and convey air to an odor control station.

Table 5-2 provides design data for the sedimentation tanks. **Figure 5-5** depicts the process flow diagram for influent handling and primary treatment processes (Sanitation Districts, 2022a).

Table 5-2. Sedimentation Tank Design Data

Tank No.	Date Placed in Service	Dimensions per Tank (ft.)			Design Flow (mgd)		Average Overflow Rate (gpd/ft^2)	Detention Time (hours)
		L	W	H	Average	Peak		
15-22	06-21-1967	242	21	11.5	61.4	86	1,475	1.4
23-26	01-06-1950	300	18	8.5	96.1	115	1,271	1.4
27-30	04-06-1954							
31-36	08-14-1957							

Tank No.	Date Placed in Service	Dimensions per Tank (ft.)			Design Flow (mgd)		Average Overflow Rate (gpd/ft²)	Detention Time (hours)
		L	W	H	Average	Peak		
37-42	02-23-1961	300	18	10	76.4	107	1,290	1.4
43-46	09-19-1961							
47	12-30-1963							
48-52	12-30-1963	300	18	12	40.0	56	1,480	1.4
53-66	01-01-1973	300	21	12	125.5	176	1,420	1.5
				Total	**400**	**540**		

PE from the sedimentation tanks gravity flows to the forebay of the Secondary Influent Pump Station, where it is pumped and conveyed through a force main to the secondary treatment process, which is located at a higher elevation than the primary treatment process. After the installation of the new 18-foot tunnel, the Secondary Influent Force Main will be the only remaining single point of hydraulic failure risk. In the unlikely event PE must be discharged to the ocean, the Primary Standby Disinfection Station stores commercial sodium hypochlorite to chlorinate PE before it is pumped to the ocean.

5.3.2 Secondary Treatment

The existing secondary treatment facility at the Warren Facility consists of four pairs of biological reactors feeding into four sets of fifty-two final clarifiers. The reactors use high purity oxygen aeration, providing a smaller footprint than conventional activated sludge processes. Pure oxygen is generated in cryogenic towers, which separate oxygen from the air. The current high purity oxygen demand for the Warren Facility is between 300 and 325 tons per day (TPD). The Warren Facility currently has one operational cryogenic air separation unit with an oxygen production capacity of 325 TPD and two smaller backup units (Sanitation Districts, 2013). The backup cryogenic air separation units will be replaced with two Vacuum Pressure Swing Adsorption (VPSA) units each with an oxygen production capacity of 150 TPD. The VPSA units are anticipated to be installed by the end of 2025.

The Secondary Disinfection Station stores commercial sodium hypochlorite as a disinfection source for clarified SE.

Table 5-3 provides design criteria for major components of the secondary treatment system.

Table 5-3. Design Criteria for Secondary Treatment Processes

Plant Flow[a]	Value
Design Daily Flow	100 MGD each
Storm Flow Capacity	175 MGD each
Kinetic Parameters of Reactors[a]	
Tank Volume	10.52×10^6 GAL
Cell Residence Time (total sys. Solids)	3.5 DAYS
Return Activated Sludge Recycle Rate	
(% design flow)	30%

Plant Flow[a]	Value
Hydraulic Detention Time	
Hydraulic Detention Time	2.5 HRS
(+sludge recycle)	1.9 HRS
Biological Reactors[a]	
Quantity (Trains)	2
Liquid Stages (per Train)	4
Size Gas Stages (per Train)	12
Train Capacity (L x W)	250 FT. x 187.5 FT.
Gas Stage (L x W)	62.4 FT. x 62.5 FT.
Water Depth	15.0 FT.
Final Clarifiers[a]	
Type	Rectangular
Quantity	52
Dimensions (per clarifier)	167 FT. L x 21 FT. W
Average Water Depth	14 FT.
Overflow Rate (flow)	548 GPD/FT^2
Detention Time (flow)	4.58 HRS
Detention Time (flow+sludge recycle)	3.53 HRS

[a] Per reactor pair

Figure 5-6 depicts the process flow diagram for secondary treatment processes at the Warren Facility (Sanitation Districts, 2022a).

Figure 5-5. Process Flow Diagram for Influent Handling and Primary Treatment Processes

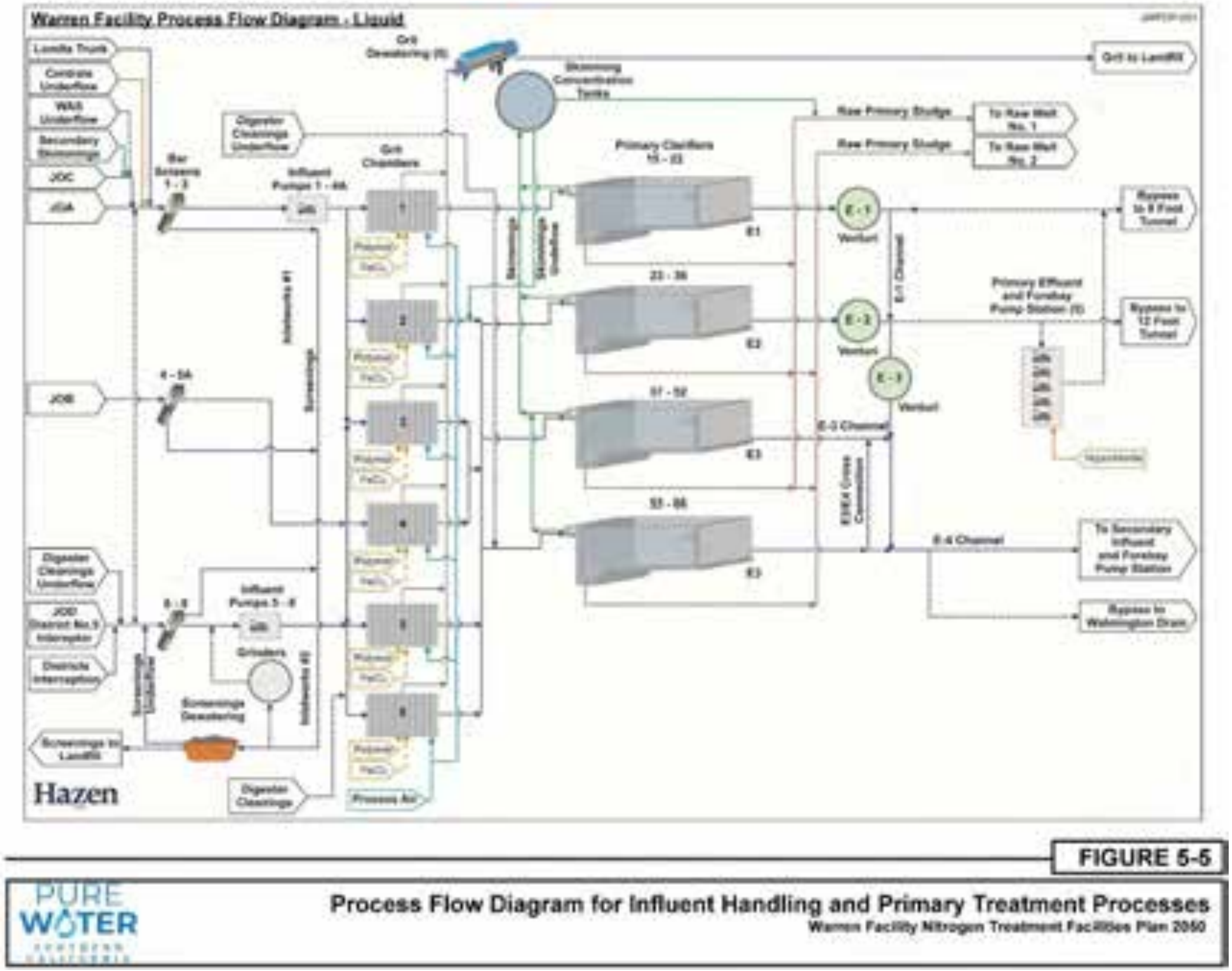
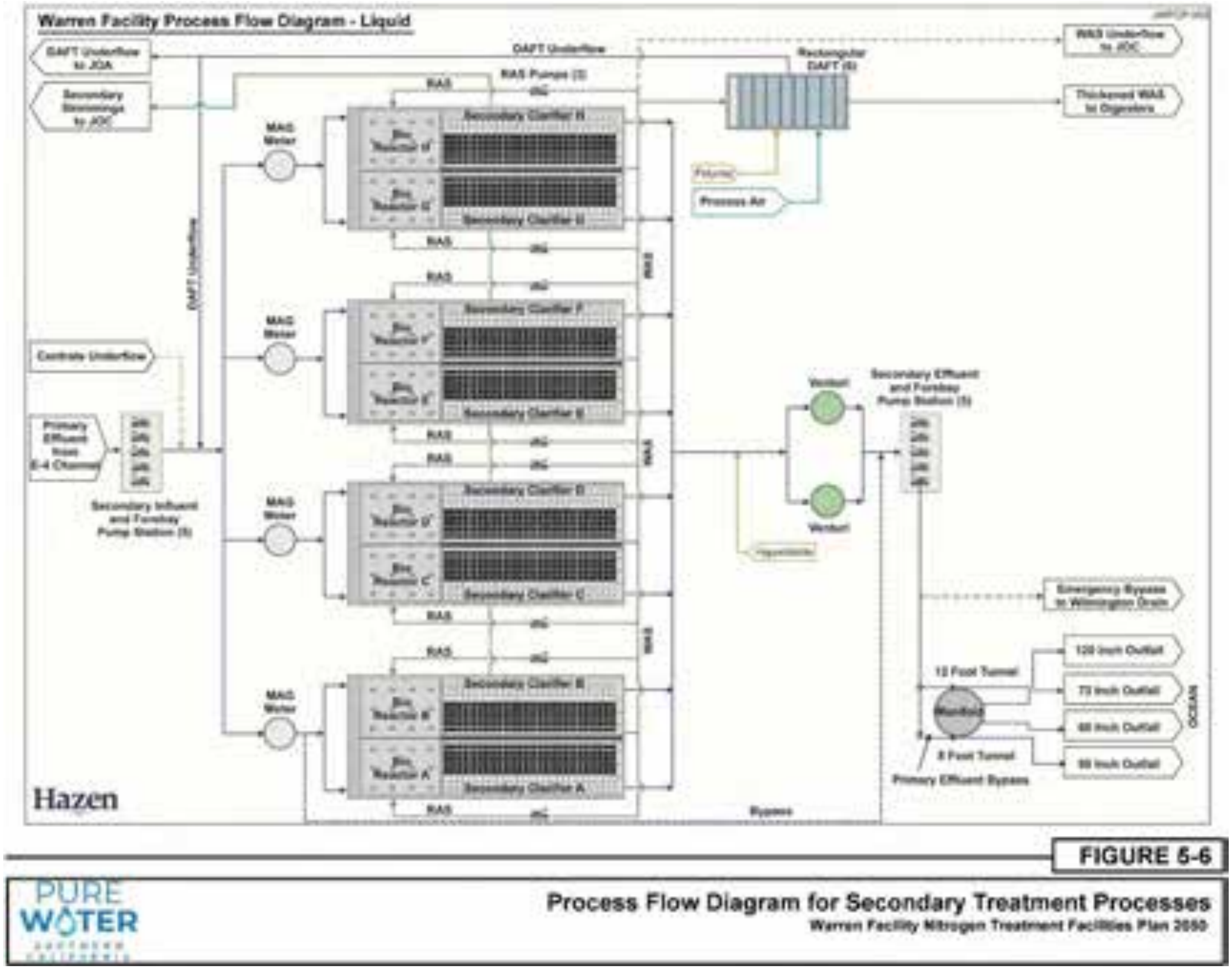


Figure 5-6. Process Flow Diagram for Secondary Treatment Processes



5.4 Effluent Management

The Warren Facility operates under a NPDES permit with WDRs issued by the LARWQCB (Sanitation Districts, 2022a). The WDR includes approximately 4,600 numeric limitations that must be met each year based on quantitative results of final effluent sampling and analyses. For the past several years, the Warren Facility successfully met 100% of these numeric limitations and qualified for a National Association of Clean Water Agencies Platinum Award.

As of October 2002, all wastewater treated at Warren Facility receives secondary treatment. Effluent from the plant is disinfected by chlorination and then, depending on plant flow and tidal conditions, either pumped or gravity flows through a system of tunnels and submarine outfalls two miles offshore in the Pacific Ocean. The four outfalls are located at White Point, San Pedro, off the Palos Verdes Peninsula. Two of the outfalls (Discharge Points 001 and 002) are used for continuous discharge of treated wastewater. Discharge Points 001 and 002 discharge approximately 65 percent and 35 percent of the effluent, respectively. Discharge Points 003 and 004 are used only for emergency discharge of SE when the flow rate approaches the hydraulic capacity of 001 and 002, or during power outages, preventative maintenance, or capital improvement activities as specified in the permit. If Discharge Points 001, 002, and 003 are in use, approximately 56 percent, 27 percent, and 17 percent of the effluent is discharged from each outfall, respectively. All four outfalls terminate in diffuser sections containing multiple ports through which effluent is discharged. The submarine outfalls terminate at a depth of 200 feet and are equipped with multi-port diffusers, which disperse the treated wastewater into the Pacific Ocean.

With Discharge Points 001 and 002 in service, the gravity flow capacity of the ocean discharge system at zero tide is approximately 415 MGD. The gravity flow capacity when all four outfalls are in service is 475 MGD at zero tide. The maximum hydraulic capacity of the tunnel and ocean outfall system with pumping is approximately 675 MGD. **Table 5-4** provides additional information on the outfalls.

Table 5-4. Warren Facility Ocean Outfalls

Discharge Point	Diameter	Length (ft.)	Diffuser Length (ft.)	Discharge Depth (ft.)	Year Completed
004	60” (standby)	5,000	380	110	1938
003	72” (standby)	6,500	450	160	1954
002	90”	8,500	2,400	200	1956
001	120”	11,900	4,440	200	1963

The locations of the plant and outfalls are shown in **Figure 5-7.** The existing 8- and 12-foot diameter tunnels are over 60 years old and will be replaced by the new 7 mile long, 18-foot internal diameter Clearwater Tunnel, which will increase the maximum hydraulic capacity of the system to approximately 900 MGD. The tunnel will connect to the existing offshore outfall pipes via a new manifold structure at Royal Palms Beach at White Point off the Palos Verdes Peninsula. Construction of the tunnel began in 2019 and is scheduled to be completed by 2026. At that time, the 60-inch ocean outfall will be taken out of service due to its poor condition. The two existing tunnels will be removed from service, inspected, and repaired as necessary, then be available as backups.

Figure 5-7. A.K. Warren Water Resource Facility Existing Ocean Discharge System

5.5 Solids Processing, Biosolids Management, and Power Generation

The Warren Facility provides centralized processing of residuals from all seven treatment plants within the JOS. Solids processing at the Warren Facility includes sludge thickening, sludge stabilization, sludge dewatering, and digester gas handling and power generation (Sanitation Districts, 2022b).

5.5.1 Sludge Thickening, Stabilization, and Dewatering

The primary and secondary solids removed from the wastewater are anaerobically digested and dewatered by centrifugation. Waste activated sludge (WAS) is thickened in the Dissolved Air Flotation (DAF) system. The first step of the DAF system entails dissolving air in water under pressure and mixing the air/water solution with WAS. The mixture then enters flotation tanks, where the pressure of the mixture is reduced to atmospheric pressure and thus, the dissolved air escapes out of solution forming tiny bubbles that float solids to the surface. The thickened waste activated sludge produced at the DAF is pumped to the digesters for further processing. Thickening is not required for primary solids (Sanitation Districts, 2002). The blend of waste activated and primary sludge is digested in twenty-four digestion tanks to reduce the solids and pathogen content, biologically stabilize the solids, and produce methane gas. Ferrous chloride is added to the digesters to remove dissolved sulfur compounds, thereby reducing the hydrogen sulfide concentration in the digester gas. The capacity of each digester is provided in **Table 5-5**.

Table 5-5. Digester Capacity

Digester	Capacity (ft^3)	Date Placed into Service
South Digesters[a]		
Z	499,000	1985
13	499,000	1995
14	499,000	1995
15	499,000	1995
16	499,000	1995
Subtotal	2,495,000	
North Digesters[a]		
1	494,000	3/71
2	494,000	7/72
3	494,000	5/73
4	494,000	11/73
5	494,000	11/77
6	494,000	7/77
7	494,000	8/82
8	494,000	8/82
9	494,000	6/83

Digester	Capacity (ft^3)	Date Placed into Service
10	494,000	6/83
11	494,000	7/83
12	494,000	7/83
17	494,000	6/03
18	494,000	7/03
19	494,000	7/03
20	494,000	7/03
21	494,000	8/03
22	494,000	9/03
23	494,000	12/03
Subtotal	9,386,000	
Total Digester Capacity	**11,881,000**	

[a] The South Digesters have a volume of 499,000 cubic feet and the North Digesters have a volume of 495,000 cubic feet due to the difference in their bottom configurations.

Digested sludge is screened to remove coarse material that may plug piping and centrifuges and impact centrifuge performance and the quality of the dewatered sludge (biosolids). Screened flow is discharged to the centrifuge feed pump stations where it is pumped to the centrifuges for dewatering. Polymer is injected with the sludge feed into the centrifuges to improve solids recovery and increase biosolids dryness. Dewatered biosolids (29 percent solids concentration by weight) is transported on belt conveyors to silos for storage.

Centrate from the centrifuges flows to the Centrate Treatment Station (CTS) where additional solids are recovered from the centrate. CTS is a dissolved air flotation facility that operates similar to DAF described above. Thickened centrate from CTS is pumped to the centrifuges for further processing. The clarified liquid is discharged to Joint Outfall A and/or B trunk sewers.

Figure 5-8 depicts the process flow diagram for solids processes.

Each year, the Warren Facility produces around 430,000 wet tons of biosolids (Sanitation Districts, 2022c). The end-product is transported in trucks for off-site management. The biosolids are directly applied to agricultural land as a soil amendment, landfilled, or composted and used as a soil amendment.

5.5.2 Digester Gas Handling and Power Generation

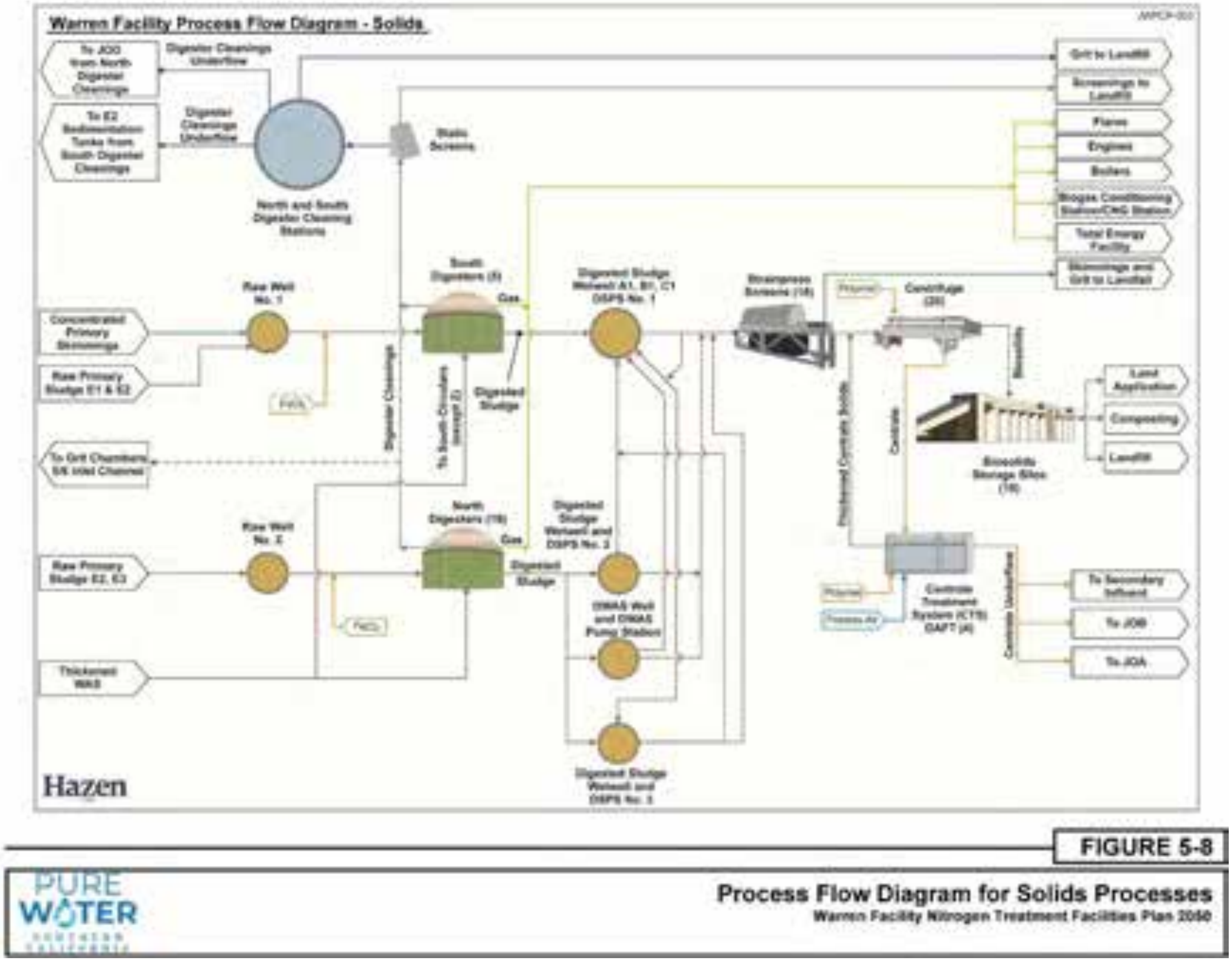
A by-product of the digestion process is methane gas, which is used to fuel gas turbines for power generation at the Total Energy Facility (TEF), boilers for digester heating steam at Boiler House No. 3, and engines that drive PE pumps at the Primary Effluent Pump Station. Digester gas is also treated at the Biogas Conditioning Station to produce renewable natural gas for vehicle fuel. Excess digester gas is flared at the North and South Flare Stations (Sanitation Districts, 2021).

The TEF allows the Warren Facility to be self-sufficient with respect to its energy requirements. It is capable of processing up to 6,000 standard cubic feet per minute (cfm) of digester gas. Gas sent to the TEF is pre-treated to remove moisture and particulates that can be harmful to the compressors and gas turbines. The gas is then routed to three fuel gas compressors that compress the gas from approximately 10 inches W.C. to 350 pounds per square inch gauge (psig) for use in the gas turbines. The high pressure gas passes through chillers to remove excess moisture and condensable hydrocarbons to prevent liquid carryover into the gas turbines. The chilled digester gas exiting the pre-treatment system is reheated prior to combustion in the gas turbines to reduce the relative humidity, thereby decreasing the chance of condensate forming on the turbine fuel control system. The three gas turbines are rated at 13,000 hp. The three generators have an output of 9.9 megawatts (MW) each.

Exhaust gas from the gas turbines is routed through the three Heat Recovery Steam Generators (HRSG) for combined cycle operation or through a bypass stack for simple cycle operation. The HRSG produces high-pressure steam to power the steam turbine and generator. The steam turbine generator is rated at 8.7 MW.

Figure 5-8 depicts the process flow diagram for the TEF.

Figure 5-8. Process Flow Diagram for Solids Processes



5.6 Odor Control

Odor control at the Warren Facility consists of eight Primary Treatment (PT) odor control stations, five Secondary Treatment (ST) odor control stations, and six Solids Processing (SP) odor control stations with a total air flow capacity of 444,100 cfm. The location and capacity of each odor control station is identified in **Tables 5-6 through 5-8**.

Table 5-6. Primary Treatment Odor Control Stations

Station	Process Ventilated	Odor Treatment	Blowers	Blower HP	Capacity (cfm)
P15	South Digester Cleanings and SRF No. 1	1 carbon adsorber	1	10	3,500
16A	North Digester Cleanings	1 carbon adsorber per station	1 per station	15 each	4,200 each
16B					
16C					
COF	Inlet Works, Influent Channels, Grit Chambers, Grit Screenings Building, Raw Sludge Wet Wells, and Skimmings Concentration Tanks	3 biotrickling scrubbers and 3 carbon adsorbers	2	433	60,000
E-1	E-1 Sedimentation Tanks	1 biotrickling scrubber and 2 carbon adsorbers	2	150	23,000
E-2	E-2 Sedimentation Tanks and E-2 Skimmings	2 biotrickling scrubbers and 3 carbon adsorbers	2	250	37,000
E-3	E-3 Sedimentation Tanks, E-3 Skimmings and E-3 Effluent Channel	4 biotrickling scrubbers and 3 carbon adsorbers	2	1,250	100,000

Table 5-7. Secondary Treatment Odor Control Stations

Station	Process Ventilated	Odor Treatment	Blowers	Blower HP	Capacity (cfm)
S1	Reactor A/B Inlet Channel	1 carbon adsorber	1	15	5,000
S2	Reactor C/D Inlet Channel	1 carbon adsorber	1	5	5,000
S4	Dissolved Air Flotation Tanks	1 carbon adsorber	1	7.5	3,000
S5	Reactor E/F Inlet Channel	1 carbon adsorber	1	4.7	2,000
S6	Reactor G/H Inlet Channel	1 carbon adsorber	1	4.7	2,000

Table 5-8. Solids Processing Odor Control Stations

Station	Process Ventilated	Odor Treatment	Blowers	Blower HP	Capacity (cfm)
SP1	Screening Building and Centrifuge Feed Pump Station No. 3 Wet Well	1 carbon adsorber	1	20	10,000
SP2	Centrifuge Building No. 1 Conveyor Belts	1 carbon adsorber	1	25	8,000
SP3	Centrifuge Building No. 2	1 carbon adsorber	1	30	12,000
SP5	Centrate Treatment Dissolved Air Flotation Tanks	1 packed tower and 1 carbon adsorber	1	25	5,000
East Biofilter	Truck Loading Station No.3, Silos 1-18, and Belts Nos. 42-44	5 biofilter cells	6	125	88,000
South Biofilter	Truck Loading Station No. 2, Beneath Silos 1-18, Transfer Battery No. 2 Belts, Transfer Gallery No. 3 Belts, and Belts 34-36	4 biofilter cells	5	125	68,000

5.7 Asset, Operation, and Maintenance Management Systems

5.7.1 Warren Facility Asset Management Program

The Warren Facility has an established Asset Management Program (Sanitation Districts, 2018) that facilitates decision-making on the appropriate balance between maintenance or replacements of physical assets to cost effectively mitigate risk while meeting stated levels of service for the plant. The Warren Facility has established the following levels of service and benchmarks to measure performance:

- Regulatory compliance – 100% compliance with NPDES and all other applicable permits (no violations)
- Odor complaints – Less than 6 events per year attributable to Warren Facility
- Worker safety impacts – No reportable accidents
- Community impacts – None
- Emergency financial impacts – None

These levels of service and associated benchmarks are achieved through the Warren Facility's comprehensive Asset Management Program. This program governs the documentation of equipment installation and routine preventative maintenance, and allows operators to evaluate the criticality and risk of each asset in order to identify and prioritize assets that need replacement. Factors considered include asset age, capacity constraints, technological improvements, and overall life-cycle costs.

Warren Facility staff utilize a computerized asset management system to track fleet and asset maintenance. Additionally, staff track purchasing, warehouse inventory, and budget through an enterprise resource planning system. Integration of these two systems allows Warren Facility staff to accurately track equipment life-cycle costs and plan infrastructure improvements.

5.7.2 Warren Facility Operations and Maintenance Program

Operations and maintenance practices at the Warren Facility are designed to facilitate a safe work environment, prevent failure of critical assets, and ensure maintenance tasks are performed in a cost-effective manner. These goals are achieved through training and cross-training of employees, effective communications between all disciplines responsible for plant operations, and proactive maintenance.

5.7.2.1 Staffing Practices

Plant operators are rotated periodically around the unit process areas to become familiar with the entire treatment plant process. This also provides for operators being qualified to work in any area of the plant in the event of temporary increased staffing requirements, or to fill in for operators who are on leave. Staffing of each electrical/instrumentation (E/I) and mechanical maintenance crew is periodically evaluated to determine if personnel need to be added or re-assigned based on workload.

An operations engineer is assigned responsibility for each major process area. This includes responsibility for providing engineering support for the operations, E/I, and maintenance staff, engineering of any required system modifications, and optimizing the preventive maintenance program for all of the assets in their assigned area. Each operations engineer creates and presents monthly training classes for each of the unit operations in the process areas for which they are responsible. If work is through an outside vendor, engineers are responsible for coordinating, with the third party, when the work will be scheduled, the cost, and what work is to be completed. If a larger problem arises that creates new design challenges, a special projects engineer may become responsible for resolving the issue. Special projects engineers are also involved in E/I and maintenance issues for miscellaneous projects related to stormwater management, underground storage tanks, hazardous materials, and odor control.

Warren Facility staff participate in regularly scheduled safety meetings and adhere to a written safety program that includes formal procedures for potentially hazardous tasks. A full-time on-site safety analyst routinely reviews work practices and performs semiannual safety inspections of all process areas.

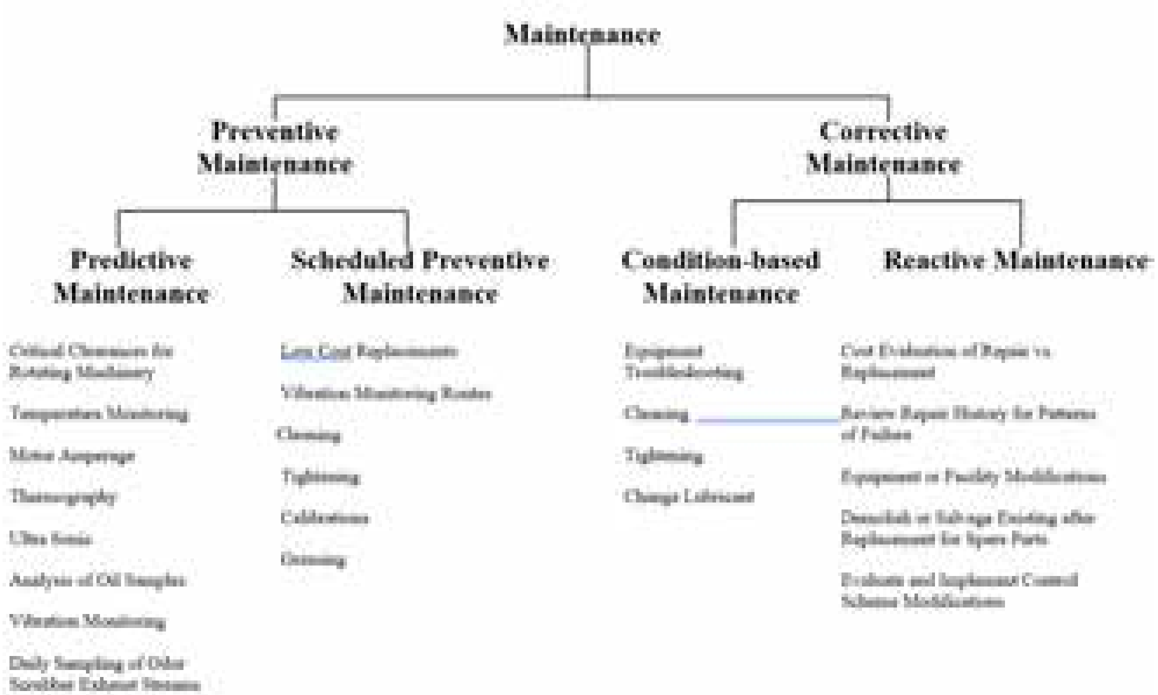
5.7.2.2 Maintenance

Warren Facility staff perform Preventive and Corrective Maintenance on all E/I and mechanical assets. Preventive Maintenance is maintenance that prevents equipment failure or unscheduled shutdown. The two categories that comprise Preventive Maintenance are Scheduled Preventive Maintenance and Predictive Maintenance. Scheduled Preventive Maintenance is time or usage based, and is based on either manufacturer recommendations or on patterns observed during Predictive Maintenance. Types of Scheduled Preventive Maintenance include low cost replacements of equipment components, and cleaning, tightening, greasing, and calibration of equipment. Predictive Maintenance is condition-based monitoring to analyze real-time data on critical assets and to predict when condition-based maintenance should occur. The purpose of Predictive Maintenance is to stabilize plant availability and minimize the quantity of assets that are out-of-service due to Reactive Maintenance. During Predictive Maintenance, Warren Facility staff analyze trends of wear indicators and other parameters. This includes routine analysis of vibration, oil samples, operating temperatures, critical clearances for rotating machinery, and odor scrubber exhaust stream samples.

Corrective Maintenance is either condition-based maintenance resulting from Predictive Maintenance tasks, or Reactive Maintenance due to the unscheduled maintenance of equipment after failure. Reactive Maintenance occurs after the unexpected failure of an asset. For most assets, Reactive Maintenance is assumed to be the last resort. However, less critical assets can be run to failure, and maintained or replaced after the asset fails. Reactive Maintenance involves reviewing the repair history of an asset to identify patterns of failure, evaluating the cost-effectiveness of repairing versus replacing the asset, and demolishing or salvaging equipment for spare parts after replacement.

Figure 5-9 summarizes the various maintenance tasks performed by Warren Facility staff.

Figure 5-9. Warren Facility E/I and Mechanical Maintenance Tasks



5.7.2.3 Instrumentation for Wastewater Monitoring

The Warren Facility utilizes distributed control systems and programmable logic controller systems to monitor wastewater parameters and assess impacts of operational changes. These data, together with laboratory data, are used to determine if the Warren Facility is meeting the levels of service required.

6
ALTERNATIVES ANALYSIS

6.1 Introduction

The overall goal of this Facilities Plan is to identify a recommended approach to nitrogen treatment facilities design and implementation that will meet the regulations, performance, and capacity needs of the Warren Facility and Pure Water program through the year 2050 in a cost-effective and environmentally sound manner. The facilities considered herein represent secondary treatment facilities as well as related tertiary treatment facilities that are implemented for the same purpose. Recommendations consist of system improvements, and Warren Facility upgrades and expansions, to accommodate projected future conditions within the service area. This Facilities Plan does not address Warren Facility unit processes not directly affected by nitrogen treatment considerations or the Pure Water program, including, but not limited to, the plant headworks, influent pumping, primary treatment, oxygen generation, disinfection, sludge thickening, anaerobic digestion, or dewatering.

The alternatives considered are driven by the needs of the Warren Facility and the planned Pure Water program. The major Pure Water components involve implementing BNR and using an AWP Facility to produce up to 150 MGD of water for IPR and potentially DPR. The nitrogen removal technology alternatives analysis described in this section of the Facilities Plan addresses the treatment facilities for one key component of the overall Pure Water program. Downstream advanced water treatment processes for potable reuse are discussed in full in other Pure Water program documents.

6.1.1 Section Organization

In this section, secondary, tertiary, and complementary nitrogen management approaches are analyzed. First, a comprehensive list of nitrogen management technology alternatives is developed and reviewed for possible implementation at the Warren Facility. The alternatives from this list are screened and narrowed down using “must have” criteria into a short list of feasible alternatives. The short list of alternatives is then subjected to a detailed scoring and ranking, with the highest-scoring alternative being identified at the conclusion of this section.

6.1.2 Background

The Warren Facility has a design average dry weather flow capacity of 400 MGD and currently treats approximately 250 MGD. The Warren Facility provides primary and secondary treatment, the latter of which is a HPOAS process, with treated SE discharging to the ocean outfall following chlorination. The Warren Facility currently provides limited treatment of nitrogen, and additional nitrogen treatment is needed to meet recycled water quality requirements and to meet anticipated future regulatory limits for effluent discharge to the ocean described in Section 3.14.1.1.

The Sanitation Districts have conducted several studies to investigate nitrogen treatment alternatives to be implemented at the Warren Facility, including *Evaluation of Technology Options for Nitrogen Treatment at the A.K. Warren Water Resource Facility Progress Update* (Sanitation Districts, 2016) and the *Nitrogen Management Evaluation for Full-Scale Advanced Water Treatment Facility* (Sanitation Districts and Metropolitan, 2018). Following these studies, the Sanitation Districts completed two phases of the Technical Analysis of Biological and Advanced Water Treatment Processes at the Warren Facility, referred to as JTAP. Phase 1 of JTAP (JTAP 1) evaluated treatment technology options that could be implemented at the Warren Facility to help meet water quality goals for the Pure Water program, including both biological processes and AWP Facility unit processes. A Joint Executive Summary

(JES) was prepared to summarize the key assumptions, design criteria, expected performance and operational reliability, and costs of each treatment process train considered (Hazen and Jacobs, 2021). Since completion of the JES, Metropolitan has refined the nitrogen goals for purified water and the facility production reliability requirements.

Additional pilot work has since been undertaken to study some of the nitrogen management approaches identified in JTAP 1. These include the NdN TMBR, NdN tertiary MBBR, and secondary BNR process. In addition to piloting JTAP alternatives, the Sanitation Districts are also conducting a full-scale demonstration that has modified operation of an existing HPOAS reactor to operate in NdN mode. This process is referred to as HPOLE. Application of the HPOLE process could potentially reduce project capital and operating costs of nitrogen management strategies considered for the Warren Facility and Pure Water.

In 2023, portions of JTAP 1 were updated to advance conceptual designs and to review the cost and feasibility information for alternative treatment trains, focusing on updates to the biological processes with limited modification to the JTAP 1 AWP Facility evaluations. The new work is referred to as JTAP Phase 2 (or JTAP 2).

California State Planning Priorities

Section 65041.1 of the California Government Code outlines the state planning priorities, which are intended to guide land use and development decisions in the state. One of the priorities mentioned in this section is the protection and enhancement of watersheds. Upgrading the Warren Facility wastewater treatment plant to provide biological nitrogen removal directly aligns with this priority.

Nitrogen is a common pollutant found in wastewater that can have detrimental effects on watersheds and ecosystems. By adopting and implementing new nitrogen removal technologies that help to reduce the potential for nitrogen pollution in receiving waters such as groundwater basins, rivers, lakes, and coastal areas, this project directly aligns with the California Government Code’s priorities.

Additionally, nitrogen removal technologies support the state’s goals of water conservation and water recycling. Treated wastewater with reduced nitrogen levels can be safely reused for various non-potable purposes, such as landscape irrigation, industrial processes, and indirect potable reuse such as groundwater recharge. For potential direct potable reuse, the drinking water MCLs for nitrate and nitrite must also be met. This reduces reliance on freshwater sources and supports sustainable water use practices, which are key priorities for California's planning objectives.

With Pure Water's AWP Facility planned for the Joint Plant Site, adjacent to the Warren Facility, the project also aligns with the state planning priorities to promote infill development and to ensure that infrastructure uses land efficiently.

6.1.3 Planning Growth Assumptions and Design Parameters

Based on the planning growth assumptions presented previously in this document, the Pure Water program is anticipated to be implemented in the following phases:

- 115-MGD Phase 1 to be completed (tentatively) in 2035, with potential for early water deliveries
- 150-MGD Phase 2 to be completed (tentatively) at a later date

The Pure Water program treatment facilities will be sized for the following scenarios:

- Phase 1 to produce 115 MGD (expandable to 150 MGD) for IPR and DPR
- Phase 2 to produce 150 MGD of water for IPR and DPR

Future Pure Water program efforts may establish revised flow targets or additional flow targets.

6.1.4 Wet Weather Considerations

As an end-of-the-line facility, the Warren Facility provides wet-weather capacity from its dedicated service area as well as wet weather relief for the upstream WRPs. As such, maintaining the wet weather capacity of Warren Facility is a critical consideration for any potential modifications. A thorough analysis of allowable wet weather strategies was completed in JTAP 1 and JTAP 2. Key wet weather constraints at Warren Facility include:

- Maintain Warren Facility peak flow capacity of 700 mgd
- HPOAS capacity is 103 mgd per train (JTAP 2)
- HPOAS peak flow is limited to the peaking factor observed in the influent of the facility. This criterion aims to protect the performance of the existing HPOAS process by providing sufficient peaking capacity within new processes to limit impacts on the existing HPOAS process performance.

6.1.5 Effluent Performance Requirements (Non-AWP Facility)

6.1.5.1 Current Ocean Outfall Requirements

Effluent limits for Discharge Points 001 and 002 from the Warren Facility are defined in NPDES permit (R4-2023-0181, which became effective on July 1, 2023). While no limit currently exists for nitrogen-based compounds, the Warren Facility has an effluent NH_3-N performance goal of 49 milligrams of nitrogen per liter (mgN/L). Performance goals are non-enforceable limits and are specified as an indication of the treatment efficiency of the plant. The permit indicates that the Warren Facility will maintain, if not improve, the effluent quality at or below the performance goal concentrations. Any two consecutive exceedances of the performance goals trigger the need for an investigation to determine the cause of the exceedances. The Pure Water program will result in RO concentrate from the AWP Facility being returned to the Warren Facility for further treatment or discharged to the ocean. However, the Pure Water program is expected to reduce ammonia-nitrogen concentrations and provide an overall reduction in mass loading of nitrogen to the outfall. Additional information on planning for future ocean discharge conditions, incorporating the impacts of the RO concentrate, is included in Section 7. **Table 6-1** summarizes the treatment performance requirements adapted from the NPDES Permit R4-2023-0181.

Table 6-1. Treatment Performance Requirements at Discharge Points 001 and 002 Adapted from NPDES Permit R4-2023-0181

Effluent Parameter	Average Monthly	Average Weekly
5-Day biochemical oxygen demand, mg/L	30	45
Total suspended solids, mg/L	30	45
Performance Goals		
NH_3-N, mg/L	49	N/A

N/A = not applicable

Future Ocean Outfall Nitrogen Limits

The potential for future nitrogen limits on ocean discharges has been an ongoing discussion for Utilities in Southern California. As discussed in Section 3.14.1.1, given the uncertainty around future potential ocean nutrient discharge limits, the evaluations for ocean outfall nitrogen reductions used a flexible approach to determine what is feasible and reasonable for the Warren Facility. For the purpose of screening and evaluating alternatives, a projected seasonal inorganic nitrogen limit of 20 mg/L, corresponding to a 60 percent load reduction, was assumed.

6.1.6 Advanced Water Purification Facility Product Water Goals

The requirements for AWP Facility product water have been well established through previous planning studies conducted by Metropolitan and the Sanitation Districts. This work considered water demand and water quality parameters required for groundwater recharge through a combination of direct injection and surface spreading. The project considers the AWP Facility product water flows up to 150 MGD with the possibility for future expansion to treat more flow up to full plant flows.

Product water will be required to meet applicable drinking water MCLs, comply with Groundwater Replenishment Regulations in the Title 22 CCR (such as the TOC limit of 0.5 mg/L for direct injection), and comply with water quality standards and objectives defined for the individual groundwater basins. **Table 6-2** summarizes key basin-specific water quality targets utilized to plan for groundwater recharge.

Table 6-2. Basin-Specific Product Water Targets

Constituent	Limit[a]	Compliance Interval	Basin
Boron[b]	0.5 mg/L	TBD	Main San Gabriel
Chloride	100 mg/L	TBD	Main San Gabriel
Sulfate	100 mg/L	TBD	Main San Gabriel

Constituent	Limit[a]	Compliance Interval	Basin
Total dissolved solids	450 mg/L	TBD	Main San Gabriel
Coliform bacteria	1.1/100 mL	7-day median	Orange County/ Central/West Coast
Nitrate	10 mg/L[c]	12-Month Running Average	Main San Gabriel/ Central/West Coast

[a] Adapted from Potential Regional Recycled Water Program Feasibility Study (Metropolitan, 2016)

[b] Direction from the Sanitation Districts is that boron limits and potential compliance will be investigated in subsequent projects. Additional treatment steps will not be included as part of this project to meet this specific limit.

[c] Also will not exceed 10 mg/L nitrogen as nitrate (NO_3)-N plus nitrite-N.

TBD = to be determined

Pursuant to *Technical Memorandum RRWP Nitrogen Limits Draft* (Metropolitan, 2022) and *Technical Memorandum Pure Water Nitrate Concentration Limit for Direct Potable Reuse* (Metropolitan, 2023), reflecting the incorporation of DPR into the program, the selected product water nitrogen targets will be as shown in **Table 6-3**.

Table 6-3. Metropolitan's Water Quality Objectives[a]

AWP Effluent Water Usage	TIN Nitrite + NO_3-N (mg/L)	Nitrite-N (mg/L)	NO_3-N (mg/L)	Ammonia (mg/L)
Groundwater recharge	10	1	10	N/A
Raw water augmentation	N/A	N/A	4[b,c]	N/A

[a] Represent monthly average targets.

[b] Based on Metropolitan Pumping Policies. Operating goal is 4 mg-N/L, with a limit of 5 mg-N/L

[c] Conceptual Designs developed utilizing previous target of 6.4 mg-N/L (Jacobs, 2023 and Hazen, 2023c)

N/A = not applicable
TIN = total inorganic nitrogen

Table 6-4 provides an overview of the targets utilized in the conceptual design development (Jacobs, 2023 and Hazen, 2023c). NO_3 targets for DPR via raw water augmentation as part of PWSC have been updated to a more stringent operating goal of 4 mg-N/L with an upper limit of 5 mg-N/L to align with the Metropolitan Pumping Policy. The *Draft Treatment Alternatives Analysis for Additional Nitrate Removal for PWSC* Technical Memorandum (TM) (Stantec, 2023a) provided additional analysis to align JTAP conceptual designs with the updated NO_3 targets, indicating that improved RO removal is the most cost-effective approach to achieve additional NO_3 removal.

Table 6-4. Pure Water Southern California Program RO Product Water Targets in Relation to Project Phasing Developed in JTAP

Project Phase	Flow (MGD)	Original TIN Nitrite + NO_3-N (mg/L)	Currently Planned TIN Nitrite + NO_3-N (mg/L)
Phase 1	115[a]	6.4 (operate at 10)[b]	5.0 (operate at 4.0)
Phase 2	150	6.4	TBD

[a] Although flow is expected to be conveyed to Weymouth for raw water augmentation, this quantity will make up less than 10 percent of the total water supply at Weymouth, thereby eliminating the need for Metropolitan to provide treatment for chemical control as stipulated in the draft DPR regulations (SWRCB, 2021).

[b] While the facility will be designed and constructed to meet a 6.4 mg/L target, it is expected to be operated to meet a 10 mg/L limit to save operations and maintenance (O&M) costs.

6.2 Alternatives Development and Analysis Process

Several technologies were considered to meet the nitrogen treatment needs of the Warren Facility, both for the Pure Water program and other potential future needs. Determination of the optimal approach in the form of a recommended alternative required the systematic assessment, ranking, and screening of options and alternatives. Starting with a comprehensive list of potential approaches, the total number of alternatives were reduced by an initial screening process. From the initial screening process, a short list of technologies emerged that were further screened by a formal evaluation and ranking process, resulting in the selected alternative.

6.2.1 Comprehensive List of Alternative Technologies

This section considers the comprehensive list of wastewater technologies to provide nitrogen management at the Warren Facility. The technologies consider replacement or retrofit of the existing biological treatment process (HPOAS), secondary and tertiary treatment, and sidestream or add-on treatment processes. Each of the nitrogen management technologies are briefly discussed in the following sections. The comprehensive list of alternatives is based on the original list developed in *Evaluation of Technology Options for Nitrogen Treatment at the A.K. Warren Water Resource Facility Progress Update* (Sanitation Districts, 2016) supplemented with additional technologies that have become more viable since the original 2016 evaluation.

6.2.1.1 Mainstream Treatment Technology Alternatives

Table 6-5 describes the mainstream nitrogen treatment technology alternatives that were considered and reviewed.

Table 6-5. Comprehensive List of Mainstream Technology Alternatives

Technology	Description
HPOAS Replacement: Air BNR-Activated Sludge (Air BNR-AS)	This alternative involves replacing the existing HPOAS process at the Warren Facility with Air BNR-AS. The Air BNR-AS system is based on the Modified Ludzak-Ettinger (MLE) configuration providing BNR. It involves a pre-anoxic zone ahead of aeration (aerobic zone), such that nitrate converted from ammonia (nitrification) in the aerobic zone becomes the oxygen source in the anoxic zone (denitrification). Several configurations are available for Air BNR-AS systems depending on plant effluent requirements. As both biological nitrogen and phosphorus removal are desired to assist in meeting treatment goals while reducing antiscalant use in the downstream RO system, the anaerobic-anoxic-oxic (A_2O) process was selected for the replacement plant under this alternative. The A_2O process allows for relatively robust biological phosphorus removal while also allowing for good nitrogen removal. The process typically requires a large footprint to achieve the desired effluent when compared to competing technologies.
HPOAS Retrofit: HPO BNR-Activated Sludge (HPO BNR-AS)	This alternative involves replacing the HPOAS process with HPO BNR-AS. HPO BNR-AS is similar to the HPOAS system but is retrofitted with anoxic zones to provide nutrient removal. An anoxic zone is created at the front end of the system, followed by the aerobic HPO reactor in which HPO is added to the headspace of the reactor for transfer to the liquid. A portion of the aerated effluent is recycled to the influent along with return-activated sludge (RAS). Incorporating biological phosphorus removal into this configuration can be challenging, although the unaerated zone could serve for both denitrification and biological phosphorus removal -(anoxic and anaerobic).

Technology	Description
HPOAS Retrofit: Integrated Fixed-Film Activated Sludge (IFAS)	IFAS is a hybrid treatment approach that utilizes suspended growth activated sludge in concert with neutrally buoyant plastic media that facilities biofilm growth. The media may be either fixed or free-floating, although the latter is far more common and would be the basis of this analysis. An IFAS system can be installed as an upgrade to an existing facility, utilizing existing tankage. However, IFAS requires the addition of fine screens on the PE feed to prevent buildup of debris within the system. In addition, media screens are used at the effluent end of the bioreactor to prevent media from escaping, and this can impact existing plant hydraulics from increased head loss through the screens.
HPOAS Retrofit: Secondary Membrane Bioreactor (SMBR)	This alternative considers implementing SMBR to treat PE from Warren Facility with either complete nitrification only (N-only) or NdN. SMBR would be implemented by retrofitting the current HPOAS reactors and secondary clarifiers. Depending on the configuration (N-only or NdN), it will affect how the reactors and secondary clarifiers would be modified (N-only aerobic and membrane zones, NdN-anoxic, aerobic, and membrane zones).
HPOAS Retrofit: BioMag®	The BioMag® process uses magnetite (fully inert iron ore particles) to enhance the settling velocity of the activated sludge mixed liquor. The addition of the magnetite particles, which can double the mixed-liquor suspended solids (MLSS) concentration, can greatly enhance the settling velocity, which allows the MLSS concentration to be increased and the clarifier can function at a much higher solids loading rate. Magnetite can be added to existing bioreactor tanks which substantially reduces the cost for implementation. A magnetic recovery system is installed on the WAS line to allow magnetite to be reused.
HPOAS Retrofit: Mobile Organic Biofilm (MOB™)	MOB™ technology can intensify nutrient removal by using mobile biofilms implemented within the activated sludge system. The mobile biofilms are multilayered and typically consist of a lignocellulosic material that is not readily biodegradable in an activated sludge process. The media is added to aeration basins and is selectively retained in the secondary process by screening the media from WAS, typically utilizing rotary drum screens. The MOB™ media can allow for lower suspended growth mean-cell residence times (MCRTs) due to the growth of nitrifiers on the media, while the presence of the media can improve the MLSS settling velocity. For these reasons, a MOB™ retrofit can often lead to an increase in secondary treatment capacity.
Greenfield SMBR	Similar to the SMBR HPOAS retrofit, MBR can be utilized to treat PE with appropriate prescreening. This alternative considers construction of SMBR in new tankage, allowing the HPOAS system to remain in full operation, thus operating HPOAS and SMBR in parallel as desired.
Tertiary Air BNR-AS	This approach would implement a separate Air BNR-AS system downstream of the existing HPOAS. It would consist of an aerobic reactor followed by an anoxic zone before clarification. It is anticipated that orthophosphate addition, and the addition of a carbon source, would be required to achieve low effluent TIN concentrations.
Tertiary MBBR (TMBBR)	This approach would implement a TMBBR downstream of the existing HPOAS. This approach is similar to the IFAS system, as it consists of plastic carrier elements to support biomass growth; however, the MBBR system does not require a RAS system, and in this case, the biofilm-based treatment process is operating on non-nitrified SE, and therefore the MBBR media would target nitrification in aerobic zone, and denitrification (with external carbon) in the unaerated zones.

Technology	Description
Flex MBR	The Flex MBR approach involves new bioreactors, membrane tanks, blowers, influent pumping, primary fine screening, and flow equalization to improve nitrogen management and pretreatment prior to the AWP Facility. Initial implementation of the Flex MBR – Tertiary (TMBR) process is designed to operate on non-nitrified SE. The biological treatment portion of MBR would be designed with an MCRT of 10 to 12 days to ensure complete nitrification, and the low biomass yield means that the TMBR typically operates at very low MLSS concentrations (~2,000 mg/L). External carbon can be added to an upfront anoxic zone to allow for some denitrification in an MLE process, although the system could be operated for N-only without denitrification (i.e., if denitrification is not needed). The Flex MBR can be transitioned to a secondary MBR (SMBR) system in the future to provide treatment of PE.
Tertiary Biological Active Filters (TBAF)	The TBAF process consists of tanks (cells) filled with media. The reactor can be designed with wastewater influent provided in an upward or downward flow, using floating or heavier than water media. The tightly packed media provide a surface for microbial growth and provide a degree of filtration. The attached-growth nature of the process enables retention of slow-growing organisms, such as nitrifiers. For nitrification, air is added to the bottom of the cell to provide oxygen to the nitrifiers. To allow for denitrification, additional unaerated cells are required with supplemental carbon addition. Periodic backwashing is required for wasting of biomass from the system, and this eliminates the need for downstream clarification.
Ammonia Stripping	This alternative would involve installation of ammonia stripping towers downstream of the existing HPOAS. To remove the ammonia nitrogen in wastewater, the pH of the wastewater needs to be increased to approximately 11 by adding a strong base, so that aqueous ammonia can be stripped out of solution. The alkaline wastewater is passed through a cross-flow or countercurrent flow packed tower, through which air is blown. Ammonia is stripped from falling water droplets into the air stream, then typically discharged to the atmosphere or recaptured as an ammonium salt.
Ion Exchange	Ion exchange has been used in wastewater to remove nitrogen compounds, heavy metals, and dissolved minerals. In an ion-exchange system, media (synthetic or naturally occurring) is housed in a column (bed). Important properties of ion-exchange materials include exchange capacity, media size, and durability. For ammonia removal, ammonium ions are removed from wastewater and become concentrated on the media; however, other cations (especially potassium) compete with ammonium for the exchange sites on the media. Once the media become exhausted (reaches the exchange capacity), the media need to be regenerated by passing through a strong brine solution and/or by backwashing.
Breakpoint Chlorination	Breakpoint chlorination involves supplying high doses of chlorine to wastewater to oxidize ammonia to primarily nitrogen gas. In the treatment process, sufficient chlorine is added to react with all oxidizable substances and ammonia in the wastewater. A continuous, large amount of chlorine is required to treat nitrogen in primary or SE.
Mainstream Deammonification (MD)	MD involves the application of deammonification to treat the main flow of a wastewater treatment plant. The bacteria groups responsible for deammonification are anaerobic ammonium oxidation (anammox) bacteria in symbiosis with ammonium-oxidizing bacteria (AOBs). Deammonification is favorable to treat nitrogen-rich wastewater, thus it can be challenging to implement MD due to the lower ammonium concentration, lower temperature of the wastewater, and the significant competition that nitrite-oxidizing bacteria pose to anammox bacteria. A newer version of MD, called partial denitrification anammox (PdNA) uses external carbon to drive partial denitrification to nitrite followed by anammox bacteria removing this generated nitrite with ammonia from the influent.

6.2.1.2 Sidestream or Secondary Enhancement Add-On Treatment Alternatives

Table 6-6 describes the comprehensive list of sidestream or secondary enhancement add-on nitrogen treatment technology alternatives that were reviewed.

Table 6-6. Comprehensive List of Sidestream or Secondary Enhancements Treatment Technologies

Approach	Technology	Description
Sidestream Treatment Technologies	RAS Re-aeration	This sidestream technology is typically implemented for a facility operating with an anoxic zone in secondary treatment (such as an MLE process). It involves directing the centrate to an upfront aerated zone within the bioreactor (termed a reaeration tank) that also includes a portion of the RAS as an input. Nitrifiers in the RAS convert ammonia to nitrite/nitrate and the effluent from this tank flows into the anoxic zone of the MLE process (PE is stepped to this anoxic zone rather than the reaeration zone), thereby allowing for denitrification of the nitrite/nitrate formed in the preceding reaeration tank. The reaeration tank can be relatively compact as it operates near the RAS concentration and therefore has a higher HRT than the balance of bioreactor. A key negative of this technology is that it requires a robust MCRT to ensure nitrifier growth at all times.
Sidestream Treatment Technologies	Post-aerobic Digestion (PAD)	Anaerobic digestion releases ammonia and phosphate, which when dewatered, can return nutrient loads back to the head of the plant. PAD involves utilizing an aerobic digester following anaerobic digestion to reduce nitrogen loads. The solids content of PAD is high compared to a mainstream process resulting in higher oxygen uptake rates that cause a low oxygen concentration in the reactor creating anoxic conditions for nitrogen removal. This technology has a few full-scale applications; however, there are very few peer-reviewed studies demonstrating the technology at full-scale.
Sidestream Treatment Technologies	Deammonification	Sidestream deammonification applies to treating sidestream liquors or recycle flows from the dewatering of anaerobically digested biosolids. Deammonification uses AOBs and anammox bacteria to convert the ammonia in the sidestream, which can contribute ~15-20 percent of the influent load to nitrogen gas. Typically, deammonification systems can achieve 75-80 percent nitrogen removal, with some residual ammonia and NO_3 present in the effluent. deammonification is the most widely used sidestream treatment process used at wastewater treatment plants.
Sidestream Treatment Technologies	Ion Exchange	Similar to mainstream treatment, ion exchange can be implemented to reduce nitrogen in sidestreams. Due to higher concentrations of nitrogen in sidestreams, ion-exchange systems would require more frequent regeneration and/or additional beds, although they would be more cost effective for sidestreams rather than mainstreams due to the lower flow. There has been limited use of ion exchange for sidestream treatment, although it has been piloted in a number of locations.

Approach	Technology	Description
Sidestream Treatment Technologies	Ammonia Stripping	Similar to mainstream treatment, ammonia stripping can be implemented to reduce nitrogen in sidestreams. Less chemical would be needed to raise the pH of the sidestream wastewater as there is significantly less water volume compared to the mainstream wastewater. There has been only limited application of ammonia stripping as a sidestream treatment process.
Secondary Enhancement	HPO Ludzack-Ettinger (HPOLE)	The HPOLE process can achieve NdN and phosphorus removal. For this add-on process, only a portion of the existing HPOAS reactors are reconfigured into a Ludzack-Ettinger process to achieve BNR. No major modifications to existing mechanical equipment or oxygen feed systems are required to implement HPOLE. To support nitrifying organisms, the aerobic solids retention time (aSRT) is increased from the existing HPOAS target of 1.5 days to approximately 6-8 days. HPOLE operation at a higher aSRT compared to the existing HPOAS reactors causes a reduced treatment capacity within the existing reactors. The RAS rate would also be increased from approximately 30% to 200% to increase the nitrate returned to the selector zone for denitrification. The HPOLE process has the ability to reduce the organic and nitrogenous loading, resulting in lower carbon demands and any downstream tertiary treatment process and allows these downstream processes to be smaller/have fewer units.

6.2.1.3 Comprehensive List Screening Criteria

A series of evaluation criteria were identified to screen the comprehensive list of alternative technologies to identify the feasible treatment alternatives for further evaluation. The screening criteria are briefly summarized in the following paragraphs. These criteria represent “must have” or “fatal flaw” criteria that must be met in order for an alternative to be feasible for further consideration.

Ability to Meet Treatment Objectives

As noted in Section 1, construction of an AWP Facility will treat effluent from the Warren Facility to produce purified recycled water to recharge groundwater basins and for possible DPR to meet DPR regulations (see Section 3.14.3). This criterion considers the technology’s capability to efficiently remove contaminants, pollutants, or particulate matter from the wastewater to align with regulatory requirements and environmental standards. One of the key requirements of the Groundwater Replenishment Regulations in Title 22 CCR Division 4, Chapter 3, is that the total nitrogen in recycled or recharged water must not exceed 10 mgN/L. In addition to the groundwater recharge limit, excess effluent from the Warren Facility will be discharged to the ocean and it is expected that the future effluent total nitrogen limits will be imposed. While the downstream RO system has a high rejection for both NH_3-N and NO_3, the future AWP Facility pretreatment process will require reliable year-round nitrification and a high degree of NO_3 removal to achieve these future limits. For these reasons, the nitrogen removal technologies will be screened on their ability to meet an effluent NH_3-N of 1.0 mgN/L and an effluent TIN of 10 mgN/L, with these limits chosen as a surrogate of robust nitrification and TN removal, respectively.

Technology Maturity

This screening alternative considers the advancements made in each technology, including their track record in full-scale (greater than 10 MGD) implementation at wastewater treatment facilities. Technology maturity considers the history of successful implementation, including performance and reliability, the ability to adapt to variable wastewater influent, and the ease of scalability for future planning/growth needs.

Implementation Constraints at the Warren Facility

Implementing new wastewater technologies in existing facilities presents unique challenges and constraints that need to be addressed for successful integration. Existing infrastructure limitations such as space availability, electrical capacity, and compatibility with existing processes must be carefully considered. Moreover, integrating new technologies requires careful consideration to minimize disruptions to ongoing operations and ensure a smooth transition.

Impact on the Existing Warren Facility Treatment Facility

The implementation of new wastewater technology in existing facilities can result in hydraulic and process challenges and constraints that need to be carefully addressed. Adapting the system to accommodate varying hydraulic conditions, ensuring proper sizing and distribution of flows, and optimizing hydraulic design are crucial considerations. Process constraints, including the compatibility of the new technology with existing treatment processes and the ability to achieve desired treatment objectives, must also be considered. The technologies are evaluated based on their overall impact to the existing facility.

6.2.1.4 Comprehensive List Screening Evaluation

The alternatives were evaluated against each criterion on a pass/fail (✓ = pass, X = fail) basis. **Table 6-7** presents the comprehensive list technology screening for mainstream technologies, and **Table 6-8** presents the screening of the sidestream processes.

Table 6-7. Mainstream Treatment Technologies Comprehensive List Screening Evaluation

Treatment Technology	Ability to Meet Treatment Objectives			Technology Maturity	Ability to Implement at the Warren Facility	Impact on Existing Plant		Final Evaluation
	Effluent Ammonia Less Than 1.0 mg/L	Effluent TIN Less Than 10 mg/L	Reliability			Hydraulics	Process Capacity	
HPOAS Replacement: Air BNR-AS	✓	✓	✓	✓	✓	✓	✓	✓
HPOAS Retrofit: HPO BNR-AS	✓	✓	X	✓	X	✓	X	X
HPOAS Retrofit: IFAS	✓	✓	✓	✓	X	X	✓	X
HPOAS Retrofit: SMBR	✓	✓	✓	✓	✓	✓	✓	✓
HPOAS Retrofit: BioMag	✓	✓	X	X	X	✓	✓	X
HPOAS Retrofit: MOB™	✓	✓	✓	X	X	✓	✓	X
Greenfield SMBR	✓	✓	✓	✓	✓	✓	✓	✓
Tertiary Air BNR-AS	✓	✓	✓	✓	✓	✓	X	X
TMBBR	✓	✓	✓	✓	✓	✓	✓	✓
TBAF	✓	✓	✓	✓	✓	✓	✓	✓
TMBR	✓	✓	✓	✓	✓	✓	✓	✓
Ammonia Stripping	✓	✓	X	✓	✓	✓	✓	X
Ion Exchange	✓	✓	X	X	✓	✓	✓	X
Breakpoint Chlorination	✓	✓	X	X	✓	✓	✓	X
Mainstream Deammonification	✓	✓	X	X	✓	✓	✓	X

Table 6-8. Sidestream Treatment Technologies Comprehensive List Screening Evaluation

Technology Alternatives		Ability to Meet Treatment Objectives: Effluent Ammonia Less Than 1.0 mg/L	Ability to Meet Treatment Objectives: Effluent TIN Less Than 10 mg/L	Ability to Meet Treatment Objectives: Reliability	Technology Maturity	Ability to Implement at the Warren Facility	Impact on Existing Plant: Hydraulics	Impact on Existing Plant: Process Capacity	Final Evaluation
Sidestream Treatment	RAS Re-aeration	N/A	N/A	✓	✓	X	✓	✓	X
	Post-aerobic digestion	N/A	N/A	✓	X	✓	✓	✓	X
	Deammonification	N/A	N/A	✓	✓	✓	✓	✓	✓
	Ion Exchange	N/A	N/A	✓	X	✓	✓	✓	X
	Ammonia Stripping	N/A	N/A	✓	X	✓	✓	✓	X
	Breakpoint Chlorination	N/A	N/A	✓	X	✓	✓	✓	X
HPOLE Retrofit (Add-on)		✓	✓	✓	✓	✓	✓	✓	✓

6.2.1.5 Options Eliminated Through Comprehensive List Screening

Of the mainstream processes, the following nine processes were eliminated based on their inability to meet all of the screening criteria, as summarized in **Table 6-7**:

- HPOAS Retrofit: HPO BNR-AS
- HPOAS Retrofit: IFAS
- HPOAS Retrofit: BioMag
- HPOAS Retrofit: MOBTM
- Tertiary Air BNR-AS
- Ammonia Stripping
- Ion Exchange
- Breakpoint Chlorination
- Mainstream Deammonification

In addition to the nine processes listed above, three additional mainstream processes were eliminated following JTAP 1 work:

1. HPOAS Replacement: Air BNR-AS—A conceptual design of the Air BNR-AS process was completed in JTAP 1 and described in the Task 2 Report – Analysis of Train 4 (Secondary BNR + Single-Pass RO) and Train 5 (Tertiary BNR + Single-Pass RO) (Hazen, 2021). The concept involved replacement of HPOAS Trains F-H with new BNR basins (Train 4) configured for nitrogen and phosphorus removal. New circular secondary clarifiers would be located east of the existing BNR processes. Implementation of the concept would have required sequential selective demolition of existing HPOAS basins with extensive shoring requirements. While achievable, this did require more sequencing and work next to reactors in service, which would make construction more complex than a facility built entirely on the Joint Plant Site. The Air BNR-AS process was also predicted to have the largest total footprint of the concepts evaluated in JTAP 1. The combined impact of construction feasibility and space constraints resulted in the Air BNR-AS process being eliminated from future concept refinement.
2. HPOAS Retrofit: SMBR—A conceptual design of the SMBR retrofit is described in Task 3 Report – Analysis of Train 2: Nitrification and Denitrification Secondary Membrane Bioreactor Retrofit + Single-Pass Reverse Osmosis, Technical Report (Jacobs, 2021a). This alternative involved retrofitting the SMBR into a portion of Warren Facility's existing HPOAS secondary treatment facility and converting the existing HPOAS tanks and final clarifiers to bioreactors with a new membrane complex located east of the existing HPOAS Trains G-H. The SMBR retrofit approach was not considered further following the JTAP 1 conceptual design due to implementation concerns identified in the conceptual design. Notably, the SMBR retrofit would not provide for an optimized process configuration and would cause limitations on recycle flows to facilitate conveyance within existing infrastructure. It would also create complex hydraulic constraints and flow split challenges between the existing HPOAS and new SMBR trains. Gravity flow from the bioreactors to the membrane tanks would place the membranes deep, while routing of the large conveyance ducts and pipelines for the process air, foul air collection, RAS, and nitrified mixed-liquor recycle (NRCY) would create significant challenges for O&M staff access and constructability.
3. TBAF—TBAF implementation was reviewed under the Nitrogen Management Evaluation for Full-Scale Advanced Water Treatment Facility (Sanitation Districts and Metropolitan, 2018) and was further considered as part of JTAP 1. During a "World of

Options" workshop held on December 15, 2020, several alternatives were reviewed and evaluated to determine the most viable alternative as summarized in the technical report. This comprehensive evaluation found that TBAF required more space, provided less potential mainstream seeding potential, and was less flexible for considerations compared to the Tertiary MBBR.

The following sidestream processes were eliminated from preliminary screening based on the analysis shown in **Table 6-8**:

1. RAS Re-aeration
2. Post-aerobic Digestion
3. Sidestream Ion Exchange
4. Sidestream Ammonia Stripping

6.2.1.6 Short List Mainstream Alternatives

The following mainstream technologies made the short list for further review and evaluation:

- Greenfield SMBR
- Flexible MBR (Flex MBR, initially operated in tertiary N-only mode)
- TMBBR

6.2.1.7 Short List Sidestream/Secondary Enhancement Add-On Process Alternatives

Through the JTAP 1 work, sidestream deammonification and the HPOLE retrofit were both selected as additional nitrogen removal technologies to be considered for implementation along with the mainstream short-listed technologies. These technologies are described as follows:

1. **Sidestream Treatment—**Currently, centrate from the solids processing centrifuges is returned to the headworks of the Warren Facility and accounts for approximately 15 to 20 percent of the Warren Facility's influent nitrogen load. Sidestream deammonification is a process that can be incorporated to provide treatment of high centrate nitrogen loads. The Sanitation Districts conducted a pilot test of Veolia's deammonification processes (MBBR & IFAS) between 2013 and 2014 to evaluate the performance under various operating conditions. Results from the pilot test indicated that a reduction of between 68 and 70 percent TIN could be achieved at Warren Facility. JTAP 1 identified that sidestream deammonification provided cost and performance benefits for the Pure Water program. As part of JTAP 2, *Task 6: Analysis and Refinement of Concept Design for Warren Facility Sidestream* (Hazen, 2023a), the sidestream deammonification concept was refined further. Following are notable benefits described in JTAP 1 and JTAP 2:

    - It is an established technology for efficient BNR of dewatering sidestreams.
    - Impacts on the Warren Facility operation are minimal, and increased operational flexibility is provided for the Warren Facility.
    - The nitrogen load returned to the Warren Facility influent is reduced, thereby providing an increased safety factor to meet the AWP Facility nitrogen objectives and potential future ocean nutrient limits for all mainstream technologies being considered.
    - Requirements for supplemental carbon for downstream BNR processes and overall energy requirements are reduced.

2. **HPOLE Retrofit—**A full-scale demonstration test of the HPOLE retrofit treatment process at the Warren Facility was conducted to demonstrate that NdN can be accomplished within the HPOAS reactors using a Ludzack-Ettinger approach. This testing consisted of a single HPOAS reactor being configured into the HPOLE mode. No major modifications to existing mechanical equipment or oxygen feed systems were required to implement the trial of HPOLE retrofit at the Warren Facility. To support the growth of nitrifying organisms, the aerobic MCRT was increased from the existing HPOAS target of approximately1.5 days to approximately 6 to 8 days. The RAS rate was also increased from approximately 30 percent to approximately 160 percent (to act as an internal recycle) to increase the NO_3 returned to the selector zone for denitrification. The HPOLE retrofit demonstration test demonstrated the following potential benefits:
   - Robust and reliable nitrogen removal (NdN) to meet the effluent nitrogen objectives.
   - Meaningful reduction in capital and operations costs for the Pure Water program.
   - Positive benefits for the Warren Facility, including reduced solids production.

As a result of the successful demonstration of the HPOLE concept, the conceptual design of an HPOLE retrofit encompassing two trains to provide 36 MGD of average day capacity was included in JTAP 2. HPOLE operates at a reduced capacity compared to the existing HPOAS reactors; however, due to reduced influent flow (water conservation measures, etc.), it was determined that HPOLE can be implemented within two trains of the existing. Additional details and performance expectations are summarized in *HPOLE Conceptual Design Development for PWSC Program Trains* (Hazen, 2023b). A conceptual site layout of the HPOLE and sidestream deammonification is depicted in **Figure 6-1**.

Figure 6-1. Conceptual Site Layout of HPOLE and Sidestream Deammonification

6.2.2 Short List Screening Criteria

Based on the analysis summarized in the preceding discussion, the remaining alternatives represent a short list of viable alternatives. The viable mainstream alternatives were evaluated with respect to their comparative ranking against a set of screening criteria. The following screening criteria were developed to enable a comparative evaluation of the alternative design concepts in terms of the following:

- **Flexibility to meet future needs (Weight 25 percent)—**This criterion assesses the ability of a treatment technology to adapt and accommodate changing regulatory requirements, technological advancements, and evolving environmental conditions. This criterion considers the flexibility of each alternative and the ability to adjust operational parameters to efficiently respond to future challenges and demands without significant disruptions or costly infrastructure modifications.
- **Environmental justice and community impacts (Weight 25 percent)—**This criterion advocates for the fair treatment and active participation of all individuals regarding the development, implementation, and enforcement of environmental laws and policies. These alternatives aim to address environmental concerns related to nitrogen removal, which can have significant impacts on water quality and public health if not treated in a reliable manner. By utilizing advanced nitrogen removal methods, the wastewater treatment plant can reduce the discharge of nitrogen compounds into water bodies, helping to protect ecosystems and ensure safe drinking water for communities. As the program moves forward, it is expected that environmental justice will be addressed for the program elements as a whole. Community impacts consider both the short-term (construction) and long-term (operational) impacts related to each alternative. This parameter takes into account both the extent of construction and the sensitivity of the surrounding areas affected.
- **O&M considerations (Weight 25 percent)—**This criterion examines the practical aspects associated with operating and maintaining the selected treatment alternative over its lifespan. It involves assessing factors such as the process complexity, technology redundancy and experience, and potential impacts to the existing processes at the Warren Facility.
- **Cost and schedule (Weight 25 percent)—**This criterion considers the capital costs, ongoing operational costs, and construction schedule constraints associated with each alternative.

Detailed evaluation criteria or sub-criteria were identified within each main category to represent the most pertinent issues and considerations for this project. Each sub-criterion was provided a weighting, and a score was assigned to each alternative design concept, relative to the other design concepts. Scores from 1 to 3 were assigned, with the higher score (3) given to the better performing option(s).

The final score for each alternative design concept was calculated as the sum of the score of each sub-criterion across all categories multiplied by the weighting assigned to that criterion. Within each primary criterion category, each sub-criterion was considered to have equal weight. With this approach, the alternative design concept that scored the highest would be considered the option that provided the most overall benefits to this project. **Table 6-9** summarizes the primary and sub-criterion evaluation methodology.

Table 6-9. Evaluation Criteria, Objectives, and Scoring

Category and/or Criteria	Performance Scales
Flexibility to Meet Future Needs (25 percent)	
Land Requirements (25 percent) – Considers site footprint of the alternative in square feet, availability of land for future flexibility, constructability, and future phasing.	▪ Smallest footprint – 3 ▪ Moderate footprint – 2 ▪ Largest footprint – 1
Ability to Meet Future Ocean N Discharge Limits and/or More Stringent N Limits for AWP Facility (25 percent) – Provides ability to modify operations to allow for achieving different water qualities that may be required with changing N limits.	▪ Largest capacity adjustability, including carbon addition – 3 ▪ Some capacity adjustability, including carbon addition – 2 ▪ Limited capacity adjustments, large need for carbon – 1
Suitability for DPR (25 percent) – Provides treatment compatibility with O_3 and biological activated carbon (BAC) filtration ahead of RO for DPR. Although alternative approaches, such as installing O_3/BAC downstream of RO are being investigated by Metropolitan, this category compares alternatives based on the anticipated requirement of the DPR regulations.	▪ No additional pretreatment equipment/processes required – 3 ▪ New pretreatment equipment/processes required, but flexibility exists for treatment train configuration – 2 ▪ New pretreatment equipment/processes required, with limited flexibility for treatment train configuration – 1
Ability to Transition to Full Flow Treatment (25 percent) – Provides ability for system to be modified for higher capacity scenarios with minimal disruption to the existing Warren Facility.	▪ Easily expanded to accommodate future flow (modular expansion) – 3 ▪ Moderate modifications to expand to future flow (additional unit processes – some modular expansion) – 2 ▪ Largest modifications to expand to future flow (additional unit processes – not modular) – 1
Environmental Justice and Community Impacts (25 percent)	
Greenhouse Gas Emissions (20 percent) – Estimates emissions based on design features/characteristics (based on energy and chemical usage).	▪ Lowest estimated carbon footprint – 3 ▪ Moderate estimated carbon footprint – 2 ▪ Largest estimated carbon footprint – 1
Average Energy Consumption (20 percent) – Minimizes ongoing operational energy usage.	▪ Lowest energy use – 3 ▪ Moderate energy use – 2 ▪ Highest energy use – 1
Traffic/Community (20 percent) – Minimizes impact to the surrounding area from operation of new facilities.	▪ Minimal truck traffic (fewer chemical deliveries) – 3 ▪ Moderate truck traffic – 2 ▪ Significant truck traffic – 1
Potential for Odor Issues (20 percent) – Minimizes potential for odors affecting the community.	▪ Potential for odor generation is minor or negligible, minor mitigation is required – 3 ▪ Potential for odor generation is moderate, with mitigation measures – 2 ▪ Potential for odor generation is significant, requiring significant infrastructure for mitigation – 1
Public Acceptability (20 percent) – Maximizes multiple barrier measures for safe treatment.	▪ Two-step or more treatment barriers – 3 ▪ One-step treatment barrier – 1

Category and/or Criteria	Performance Scales
O&M Considerations (25 percent)	
Complexity (25 percent) – Minimizes performance risks with a lower complexity system. Considers number of unit processes to operate.	▪ Low operational complexity – 3 ▪ Moderate operational complexity – 2 ▪ High operational complexity – 1
Technology Maturity (25 percent) – Provides treatment process operational experience in the industry, higher scoring for experience in pretreatment for AWP facilities and demonstration testing at the Grace F. Napolitano Pure Water Southern California Innovation Center.	▪ Pretreatment experience for the AWP Facility and demonstration testing at the Demonstration Plant – 3 ▪ No pretreatment experience for the AWP Facility and demonstration testing at the Demonstration Plant – 2 ▪ No pretreatment experience for the AWP Facility and no demonstration testing at the Demonstration Plant 1
Reliability and Risk (25 percent) – Maximizes reliability and minimizes risk by control measures available to maintain performance and compliance with discharge permit and interagency agreements.	▪ Control points are monitored and can be modified easily to adjust to changing influent. Tertiary treatment offers more reliability – 3 ▪ Control points are monitored and can be modified easily to adjust to changing influent. Secondary treatment lowers reliability and increases risk – 1
Impacts to Existing Warren Facility Operations (25 percent) – Minimize impact to existing operations (existing HPOAS treatment).	▪ Minimal impact to existing operations – 3 ▪ Moderate impact to existing operations – 2 ▪ Significant impact to existing operations – 1
Cost and Schedule (25 percent)	
Life-Cycle Costs (50 percent) – Minimize life-cycle cost.	A proportional scale between 3 and 1 based on a relative difference in net-present value (NPV) cost of each alternative, relative to others. NPVs within ±5 percent are scored the same.
Ability to Meet Required Schedule Milestones (50 percent) – Minimize key construction materials (concrete for tank/facility construction), which drive overall schedule duration.	▪ Smallest estimated volume of concrete – 3 ▪ Moderate estimated volume of concrete – 2 ▪ Largest estimated volume of concrete – 1

6.2.3 Short List Alternative Technologies

The alternatives identified in Section 6.2.1.6 were carried forward into the detailed (short list) alternatives analysis. The conceptual designs of the shortlisted alternatives were developed collaboratively under JTAP 1 and JTAP 2 such that each alternative provides a robust approach to producing both recycled water and effluent for continued ocean discharge. Each alternative considered the following overall design basis:

- The treatment alternative is sized to produce 150 MGD of water predominantly for IPR through groundwater replenishment and DPR.
- The Warren Facility is an end-of-the-line facility and will remain in service and readily able to meet discharge limits at all times during construction, future operations, and particularly during periods of wet weather. Any potential impacts on Warren Facility operations will be minimized.
- The new facilities will not negatively impact the Warren Facility's wet-weather flow capacity.
- Establishment of 92 percent overall online factor for AWP Facility production.

- Equalization is provided to minimize the necessary flow changes at the AWP Facility, with a goal of no more than 1 percent of the facility off-line coming from unavailability of flow.
- Odor control is considered to be commensurate with the Warren Facility's existing odor control to mitigate off-site odor impacts.
- Flexibility for future operations is considered to maximize adaptability to unanticipated O&M needs or potential changes in operation.
- The AWP Facility will produce an effluent with NO_3-N as described in Section 6.1.5.

6.2.3.1 Greenfield SMBR

The comprehensive report, *Task 4 Report – Analysis of Train 3: Nitrification and Denitrification Secondary Membrane Bioreactor Greenfield + Single-Pass Reverse Osmosis* (Jacobs, 2021b) was prepared to detail the alternative of constructing a new greenfield SMBR at the Warren Facility under JTAP 1. Further analysis and refinement of the proposed alternative was completed in 2023 under JTAP 2 and summarized in *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept for JTAP Train 1 (Tertiary MBR) and JTAP Train 3 (Greenfield MBR)* (Jacobs, 2023). However, JTAP 2 advanced a Flex MBR concept, in which the greenfield SMBR would be implemented by modifying the Flex TMBR concept. Thus, the JTAP 1 greenfield SMBR was considered for this alternatives analysis in order to directly compare secondary MBR and tertiary MBR.

Greenfield SMBR involves constructing a new SMBR facility at the Joint Plant Site. The SMBR would be operated in parallel with the existing HPOAS system. For SMBR, NdN is designed to meet the future ocean discharge limits for nitrogen as well as the treatment requirements ahead of the AWP Facility. It will also serve as a pathogen barrier, provide biological phosphorus removal to reduce scaling potential in downstream AWP Facility processes, and occupy a relatively compact footprint. Following SMBR treatment, the AWP Facility will provide RO, ultraviolet-light-based advanced oxidation process, and chemical treatment for finished water stabilization in the AWP Facility. The following key process components were developed for SMBR:

- **Fine screening—**A dedicated PE fine-screening facility will be used for flow feeding the SMBR facility.
- **Peak flow capacity—**The peak flow capacity provided for SMBR was sized to allow the Warren Facility to maintain the target wet-weather capacity of 700 MGD. To maintain the Warren Facility wet-weather peak capacity, SMBR was sized with peak hour flow capacity of 430 MGD. The remaining 270 MGD will be processed by the existing HPOAS trains consistent with the criteria identified in section 6.1.4.
- **Flow equalization—**SMBR includes whole plant PE equalization with volume of 40 MG. Integration of the equalization and RO break tank is recommended to maximize site utilization and simplify AWP Facility feed pumping.
- **Incorporation of Sidestream treatment**—Sidestream treatment using deammonification technology will be implemented at the Warren Facility prior to, or along with, Pure Water Phase 1. Sidestream treatment was shown to reduce chemical and energy demands and provide an overall cost benefit to Pure Water. Details of the proposed sidestream deammonification process configuration are described in *Task 6: Analysis and Refinement of Concept Design for JWPCP Sidestream Deammonification Treatment* (Hazen, 2023c).

- **Biological process configuration—**The SMBR configuration is based on an A_2O process configuration that partitions the modular bioreactor concept into anaerobic zones followed by anoxic and aerobic zones. The configuration includes a nitrified recycle directed to the anoxic zone to provide denitrification. The overall configuration is intended to achieve phosphorus removal to improve AWP Facility operability while achieving AWP Facility NO_3 targets.
- **Odor Control**—Odor control will be provided to treat odor sources from the pump station and the fine screening facility and for the bioreactors. For the pump station and fine screening facility, odor control will consist of aluminum covers over the conveyance channels, concrete and enclosures for the pump station and fine screening facility, ventilation equipment including fans, dampers and ducts, and a two-stage process, consisting of biotrickling filter followed by carbon adsorber technology. Odor control for the bioreactors will consist of concrete covers over the basins and conveyance channels, ventilation equipment including fans, dampers and ducts, and a single-stage process, consisting of carbon adsorber technology.

The SMBR alternative requires new system infrastructure that can be constructed on available land on the northern portion of the Joint Plant Site. No additional land acquisition is required. The SMBR general site layout is depicted in **Figure 6-2**.

Figure 6-2. Greenfield SMBR Site Plan General Layout

6.2.3.2 Flex MBR

The Flex MBR alternative is described in detail in the *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept Design for JTAP Train 1 (Tertiary MBR) and JTAP Train 3 (Greenfield Secondary MBR)* (Jacobs, 2023), which is also referred to as JTAP 2. The Flex MBR is planned to operate in tertiary mode during Phase 1 and Phase 2 of Pure Water but was conceived to be readily expandable to operate in secondary mode. The initial tertiary operation allows for the Flex MBR to achieve the water quality targets of Phase 1 and Phase 2 of Pure Water while reducing initial implementation and O&M costs and limiting the risk of incurring stranded assets. is The Flex MBR was conceived to readily adapt to changing nutrient or production phases and the ability to transition to secondary mode through minor process modifications and modular bioreactor expansions when needed. For the comparison of the short list of detailed alternatives, the consideration of Flex MBR is based on the initial operation in a tertiary mode.

The Flex MBR project, based on the conceptual design, includes new bioreactors, membrane tanks, blowers, influent pumping, PE fine screening, chemical storage and feed facilities, flow equalization, and odor control facilities. The overall treatment concept also incorporates the conversion of two of the existing HPOAS treatment trains to HPOLE bioreactors and the addition of sidestream deammonification on the existing centrate stream. Outside of the HPOLE process, sidestream deammonification, and connections to access PE and SE, no major modifications to existing Warren Facility processes are proposed as part of the selected project. That is, no major modifications are proposed to the Warren Facility's liquids, solids, or disinfection processes not described in this chapter. The RO concentrate from the AWP Facility processes is expected to be returned to the Warren Facility's outfall for ocean discharge. The following key process components were developed for Flex MBR:

- **Flex MBR**—The Flex MBR concept was developed to enable rapid transition between phases to a future SMBR configuration by enabling modular expansion of major infrastructure. Major components (e.g., channels, air headers) would also be designed to accommodate either operating mode, TMBR or SMBR (and other alternatives such as hybrid MBR), as well as approaches for PdNA. As such, expanding between phases and train concepts primarily requires additional trains to be added.
- **Peak flow capacity**
  - Implementation of the Flex MBR in tertiary mode does not impact the Warren Facility secondary process, enabling the Warren Facility to maintain the existing 700-MGD peak flow capacity. Initial TMBR implementation is sized to treat the peak diurnal flow (1.3x) to overcome filtrate storage deficits from diurnal low flows.
  - Future conversion to SMBR operational modes includes provisions to manage a peak hour flow of two times the average daily flow (i.e., 364 MGD in Phase 2). Excess flow will be managed by the HPOAS process or a potential future dedicated wet weather treatment process, maintaining the criteria identified in section 6.1.4.
- **Equalization –** Initial implementation of the Flex MBR – Tertiary (TMBR) will incorporate filtrate equalization located on the Joint Plant site, integrated into the RO break tank. Future transition to the Flex MBR – Secondary operating mode at Phase 2 flow targets or later can be associated with additional PE equalization as described in the JTAP 1 report, Task 2 Report – Analysis of Train 4 (Secondary BNR + Single-Pass RO) and Train 5 (Tertiary BNR + Single-Pass RO) (Hazen, 2021).
- **Screening**— Dedicated screening for the Flex MBR that is expandable to screen flows for future Pure Water phases or expansion to Flex MBR – Secondary (SMBR) will be incorporated.
- **Incorporation of sidestream treatment**—Sidestream treatment using deammonification technology will be implemented at the Warren Facility prior to, or along with, Pure Water Phase 1. Sidestream treatment was shown to reduce chemical and energy demands and provide an overall cost benefit to Pure Water. Details of the proposed sidestream deammonification process configuration are described in *Task 6: Analysis and Refinement of Concept Design for JWPCP Sidestream Deammonification Treatment* (Hazen, 2023c).
- **Incorporation of HPOLE—**From demonstration testing, the HPOLE process has demonstrated performance and cost benefits for the Flex MBR concept. The conceptual design incorporated the impacts on bioreactor sizing discussed in the JTAP 2 report. Details of the HPOLE process configuration are described in *HPOLE Conceptual Design Development for PWSC Program Trains* (Hazen, 2023b).

- **Biological process configuration**
  - Flex MBR concept**—**The bioreactor sizing reflects the advancement of the flex bioreactor concept that allows for improved operational flexibility and facilitates expansion between operating phases and future conversion to SMBR.
  - All biological trains are to be designed to achieve nitrogen targets based on the use of single-pass RO downstream. The Flex MBR is configured to enable operation as tertiary nitrification only (N-only), tertiary NdN, or secondary BNR (including nitrogen and phosphorus). The tertiary NdN process has the flexibility to operate with full SE utilizing external carbon (carbon mode) or with a blend of PE and SE (hybrid mode) to offset carbon demands.
  - In tertiary operation, the process is configured with an anoxic zone prior to aerobic zones to provide protection against carbon bleed through and potential membrane foulants in the PE for the hybrid approach, as well as to limit NO_2 accumulation.
- **Odor Control**—Odor control will be provided to treat odor sources from the pump station and the fine screening facility and for the bioreactors. For the pump station and fine screening facility, odor control will consist of aluminum covers over the conveyance channels, concrete and enclosures for the pump station and fine screening facility, ventilation equipment including fans, dampers and ducts, and a two-stage process, consisting of biotrickling filter followed by carbon adsorber technology. Odor control for the bioreactors will consist of concrete covers over the basins and conveyance channels, ventilation equipment including fans, dampers and ducts, and a single-stage process, consisting of carbon adsorber technology.

The conceptual design of Flex MBR considers an approach that allows for different MBR operating modes (N-only, NdN-carbon, NdN-hybrid MBR using SE and some PE, among others).

- **Flex MBR Supplemental Carbon Only Alternative—**No PE will be supplemented; denitrification will be driven by external carbon addition.
- **Flex MBR Hybrid Alternative—**Carbon addition is a combination of PE and/or SE for denitrification. This approach will provide additional carbon to the bioreactor to reduce supplemental carbon addition.

The Flex MBR alternative requires new system infrastructure that can be constructed on available land on the northern portion of the Joint Plant Site. No additional land acquisition is required. The Flex MBR general site layout is depicted in **Figure 6-3.** Flex MBR Site Plan General Layout

Figure 6-3. Flex MBR Site Plan General Layout

6.2.3.3 TMBBR

A comprehensive report, *Task 2 Report – Analysis of Train 4: (Secondary BNR + Single-Pass RO) and Train 5 (Tertiary BNR + Single-Pass RO)* (Hazen, 2021), was prepared to detail the alternative of constructing a new secondary and tertiary approach for BNR under JTAP 1. Further analysis led to the elimination of Train 4 as a viable alternative (as noted previously), and the conceptual design of TMBBR was refined under JTAP 2 *Task 3: Analysis and Refinement of Concept Design for Train 5 – Tertiary MBBR* (Hazen, 2023c). The TMBBR TBNR process includes a NdN MBBR facility that would consist of the following key process components:

- **Peak flow capacity—**TMBBR does not impact the Warren Facility secondary process, enabling the Warren Facility to maintain the existing 700-MGD peak flow capacity.
- **Flow equalization—**SE flow equalization is included, with a volume of 7.4 MG to provide a constant flow to the TMBBR.
- **Incorporation of HPOLE—**From demonstration testing, the HPOLE process has demonstrated performance and cost benefits for the TMBBR concept. The conceptual design incorporated the impacts on bioreactor sizing discussed in the JTAP 2 report. Details of the HPOLE process configuration are described in *HPOLE Conceptual Design Development for PWSC Program Trains* (Hazen, 2023b).

- **Incorporation of Sidestream treatment**—Sidestream treatment using deammonification technology will be implemented at the Warren Facility prior to, or along with, Pure Water Phase 1. Sidestream treatment was shown to reduce chemical and energy demands and provide an overall cost benefit to Pure Water. Details of the proposed sidestream deammonification process configuration are described in *Task 6: Analysis and Refinement of Concept Design for JWPCP Sidestream Deammonification Treatment* (Hazen, 2023c).
- **Biological process design—**SE from HPOLE reactors and a portion of the flow from the existing HPOAS facility will be treated by the NdN TMBBR to provide nitrogen removal. The eight basins will be configured to use a step feed approach. A portion of PE flow will be utilized to provide carbon for denitrification to reduce supplemental carbon requirements. The TMBBR reactors are configured with two anoxic, three aerobic, and one polishing zone. The basins are designed to implement PdNA, which is undergoing pilot testing by LACSD and Hazen.
- **AWT pretreatment facility—**Disk filtration followed by microfiltration (MF) will provide pretreatment ahead of RO.
- **Odor control—**Odor control will be provided for the pump station and the bioreactors. Odor control for the pump station will include a biotrickling filter with carbon adsorption. Off-gas from the bioreactors will be collected and treated by carbon adsorption odor control facility.

The conceptual design considers the following two approaches to provide carbon for treatment:

- **TMBBR Supplemental Carbon Only Alternative—**No PE will be supplemented; denitrification will be driven by external carbon addition.
- **TMBBR Hybrid Alternative—**Approximately 25 percent of the flow will be PE provided by a new PE pump station. This approach will provide additional carbon to reduce supplemental carbon.

The TMBBR alternative requires new system infrastructure that can be constructed on available land on the northern portion of the Joint Plant Site. No additional land acquisition is required. The TMBBR general site layout is depicted in **Figure 6-4**.

Figure 6-4. TMBBR Site Plan General Layout

6.2.4 Short List Screening Evaluation

The detailed evaluation process is consistent with the methodology developed in Section 6.2.2. The alternative design concept that scored the highest was considered to be the option that provided the most overall benefits to this project. The evaluation is detailed in **Table 6-10**.

Table 6-10. Short List Screening Evaluation

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Flexibility to Meet Future Needs | Weight: 25 percent									
Land Requirements[a] (25 percent)	Land occupied for facility is approximately 15.3 acres.	1	0.25	Land occupied for facility is approximately 8.3 acres.	3	0.75	Land occupied for facility is approximately 9.9 acres.	2	0.50

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Ability to Meet Future Ocean N Discharge Limits and/or more Stringent N Limits for the AWP Facility (25 percent)	Capacity for additional nitrogen removal without constructing more bioreactors is limited.	1	0.25	Additional nitrogen removal is achieved through carbon addition. The biological reactor has the capacity to treat additional nitrogen with carbon addition, without increasing reactor size.	3	0.75	Additional nitrogen removal may be achieved through additional biomass media and carbon addition. Limitations will be experienced first by the media fill fraction, then by the bioreactor volume once the fill fraction is maximized.	2	0.50

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Suitability for DPR (25 percent)	The size of O_3/BAC will depend on TOC in the MBR filtrate. Additional membrane filtration (MF) treatment will be required ahead of RO at the AWP Facility. No flexibility is provided for order of treatment.	1	0.25	The size of O_3/BAC will depend on TOC in the MBR filtrate. Following tertiary MBR treatment, MF would likely be required after O_3/BAC as pretreatment for RO. Some flexibility is provided for where O_3/BAC would be included in the treatment train. Provides a different mechanism for pathogen removal compared with MF.	2	0.50	TMBBR utilizes MF that can be easily incorporated with O_3/BAC for DPR.	3	0.75
Ability to Transition to Full Flow Treatment (25 percent)	Wet-weather flow treatment is already managed and can easily be expanded to full-flow treatment.	3	0.75	Flex MBR is modular and can be converted to SMBR for full flow treatment.	2	0.50	Conversion of TMBBR to full-flow treatment is more challenging because it requires an additional solids/liquids separation step prior to disk filtration.	1	0.25
Subtotal			**1.5**			**2.5**			**2.0**
Environmental Justice and Community Impacts | Weight: 25 percent									
Greenhouse Gas Emissions (20 percent)	This alternative has the highest carbon footprint at an estimated 26,400 tons carbon dioxide (CO_2) per year.	1	0.2	The alternative has the lowest carbon footprint at an estimated 15,800 tons CO_2 per year.	3	0.6	This alternative has a moderate carbon footprint at an estimated 18,200 tons CO_2 per year	2	0.4

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Average Energy Consumption (20 percent)	This alternative has the highest energy usage at 10.2 MW.	1	0.2	This alternative has the lower energy usage at 5.5 MW.	3	0.6	This alternative has moderate energy usage at 7.0 MW.	2	0.4
Traffic/ Community (20 percent)	No external carbon deliveries are required for treatment; traffic from truck deliveries is low.	3	0.6	Flex MBR requires supplemental carbon for treatment; ongoing truck traffic for chemical deliveries is moderate.	1	0.2	TMBBR requires supplemental carbon for treatment; ongoing truck traffic for chemical deliveries is moderate.	1	0.2
Potential for Odor Issues (20 percent)	SMBR has increased odor issues compared with existing secondary treatment (HPOAS).	1	0.2	Odors with continued HPOAS treatment are lower.	3	0.6	Odors with continued HPOAS treatment are lower.	3	0.6
Public Acceptability (20 percent)	SMBR provides one-step (secondary) treatment ahead of the AWP Facility. Risk is higher if issues arise with SMBR treatment.	1	0.2	TMBR provides two-step (secondary followed by tertiary) treatment ahead of the AWP Facility. Risk is lower and more flexibility is provided.	3	0.6	TMBBR provides two-step (secondary followed by tertiary) treatment ahead of the AWP Facility. Risk is lower, and more flexibility is provided.	3	0.6
	Subtotal		**1.4**			**2.6**			**2.2**
O&M Considerations | Weight: 25 percent									
Complexity[b] (25 percent)	Overall complexity is lower considering two major unit processes to operate, including fine screening and MBR.	3	0.75	Overall complexity is moderate considering three major unit processes to operate including secondary treatment, fine screening, and MBR.	2	0.5	Overall complexity is higher considering four major unit processes to operate, including secondary treatment, TMBBR, disk filters, and MF.	1	0.25

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Technological Maturity (25 percent)	SMBR has several installations in operation providing treatment ahead of the AWP Facility facilities. SMBR treatment has been tested at the Demonstration Plant.	3	0.75	TMBR technology is similar to SMBR, but treatment applications are limited ahead of the AWP Facility. TMBR treatment has been tested at the Demonstration Plant.	2	0.5	TMBBR has no installations as pretreatment for the AWP Facility and has not been tested at the Demonstration Plant.	1	0.25
Reliability and Risk (25 percent)	Risk is higher using single-step treatment (SMBR) ahead of the AWP Facility. SMBR requires managing wet-weather flows.	1	0.25	TMBR allows flow diversion before the AWP Facility, including wet-weather flows. Two-step treatment ahead of the AWP Facility improves reliability.	3	0.75	TMBBR allows flow diversion before the AWP Facility, including wet-weather flows. Two-step treatment ahead of the AWP Facility improves reliability.	3	0.75
Impacts to Existing Warren Facility Operations (25 percent)	SMBR requires parallel operation with existing HPOAS, thereby increasing operational complexity at Warren Facility. SMBR also changes management strategy of wet-weather flows.	1	0.25	TMBR has minimal impact to the existing Warren Facility and is not part of the facilities wet-weather management strategy.	3	0.75	TMBBR has minimal impact to the existing Warren Facility and is not part of the facilities wet-weather management strategy.	3	0.75
Subtotal			**2.0**			**2.5**			**2.0**
Cost and Schedule | Weight: 25 percent									
Life-Cycle Costs [c] (50 percent)	Approximately $2.5 billion	1	0.5	Approximately $1.8 billion	3	1.5	Approximately $1.8 billion	3	1.5

Criteria	Alternative A: Greenfield SMBR	Score 1 to 3	Weighted Score	Alternative B: Flex TMBR	Score 1 to 3	Weighted Score	Alternative C: TMBBR	Score 1 to 3	Weighted Score
Ability to Meet Required Schedule Milestones (50 percent)	Significant facility infrastructure requires a large amount of concrete, which impacts schedule.	1	0.5	Facility infrastructure is similar for TMBBR and TMBR, resulting in a lower volume of concrete, which improves overall schedule.	3	1.5	Facility infrastructure is similar for TMBBR and TMBR, resulting in a lower volume of concrete, which improves overall schedule.	3	1.5
Subtotal			**1.0**			**3.0**			**3.0**
Total Overall Weighted Score			**1.5**			**2.7**			**2.3**

[a] Land requirement excludes equalization basins – similar for all facilities.

[b] Complexity does not include odor facility, sidestream denitrification, or equalization facilities that are required for all alternatives.

[c] NPV with biogas credit.

6.2.5 Identification of Selected Alternative

The tiered screening analysis described in the preceding sections identified the Flex MBR as the highest scoring alternative. As a result, the Sanitation Districts selected Flex MBR as the approach to be implemented, with Flex MBR initially configured to operate in tertiary mode. The selected approach also includes incorporation of the HPOLE process and sidestream deammonification. Section 7 provides a detailed overview of the conceptual design, cost, and implementation plan associated with the Flex MBR.

The primary advantages of the Flex MBR approach are the planned modularity and flexibility that provides the Sanitation Districts the ability to adapt to evolving requirements of Pure Water and potential regulatory changes to their ocean discharge. Notably, the design of the Flex MBR allows for easy transition between production phases and provides significant operational flexibility that allows for various operating modes (N-only TMBR, NdN – Carbon TMBR, NdN–-Hybrid TMBR, PdNA TMBR, and SMBR). Initial operation in tertiary mode reduces initial implementation costs and limits the potential for stranded assets that could be realized with a larger initial SMBR implementation.

The following are considered key drivers influencing the implementation schedule of the Flex MBR. Each of these drivers is described in more detail in Section 7.

- **Production capacity—**Initial capacity phases are driven by Pure Water program requirements. The planned modularity allows for improved expansion to future production phases.
- **Tertiary operating mode—**The choice between operational modes will be driven by product water nitrogen requirements, RO NO_3 removal, and ocean discharge requirements. The initial operation is planned to operate in tertiary mode, with the potential for operation in N-only mode. Increasingly stringent nitrogen limits in the recycled water or ocean discharge, or reduced NO_3 removal through RO, would be expected to result in the decision to operate the Flex MBR in partial NdN mode.
- **Tertiary NdN-carbon supply—**Initial operation of the NdN concept would likely use external carbon dosing to meet carbon demands. The Flex MBR concept includes provisions to operate in a hybrid operating mode, with no modifications required, to offset external carbon dosing demands. The Flex MBR concept has also considered future modifications required to achieve PdNA to further offset carbon and energy demands.
- **SMBR Expansion—**Conversion to SMBR would primarily be considered as a response to regulations mandating additional nitrogen reduction in the ocean outfall discharge, more stringent requirements for source water to PWSC, or the existing HPOAS reactors reaching the end of their useful operating life. The conversion to SMBR would likely be associated with an expansion to accommodate the increased load on the Flex MBR. Major portions of the expansion would entail additional bioreactor trains, expansion of the membrane tanks, and incorporation of an internal recycle.
- **Expansion to full plant flow capability—**Transition to full-flow treatment could be driven by increased recycled water demands, ocean discharge regulations, or as a replacement of the existing HPOAS process as it nears the end of its useful life. Utilization of the Flex MBR to respond to increased recycled water demands or more stringent ocean discharge regulations could be accomplished with either Flex MBR

option (TMBR or SMBR). Addressing aging infrastructure could lead to the decision to employ the Flex MBR to operate as an SMBR to replace the existing HPOAS secondary process.

7
SELECTED PROJECT

7.1 Introduction

The Sanitation Districts have prepared this Facilities Plan to identify a recommended approach to secondary and tertiary treatment facilities design and implementation at the Warren Facility that will meet the regulations, performance, and capacity needs of both the JOS and the Pure Water program through the year 2050.

The Pure Water program is planned to consist of the secondary/tertiary facilities described herein, followed by the implementation of the AWP Facility consisting of single-pass RO, ultraviolet advanced oxidation, and purified water stabilization. The AWP Facility, which will be installed downstream of the MBR, is outside of the scope of this Facilities Plan and not addressed further in this section.

The Sanitation Districts would be responsible for the biological treatment facilities required to provide the desired nitrogen management prior to the reuse facilities. As discussed in Section 6, the Sanitation Districts' selected approach is to add a flexible MBR (Flex MBR) to the Warren Facility to improve nitrogen management and to provide overall pretreatment prior to the AWP Facility. The Flex MBR is planned for initial operation in tertiary mode (with either external carbon feed or hybrid influent flow as needed for denitrification), with the flexibility for later conversion to SMBR operation.

7.1.1 Section Organization

This section is organized into the following major topics:

- Selected Project Conceptual Design
- Cost Analysis
- Project Schedule
- Required Permits
- Additional Process Evaluations
- Key Issues to be Resolved

7.1.2 Project Description

The Flex MBR alternative is described in detail in the *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept Design for JTAP Train 1 (Tertiary MBR) and JTAP Train 3 (Greenfield Secondary MBR)* (Jacobs, 2023), which is also referred to as JTAP 2. The Flex MBR project, based on the conceptual design, includes new bioreactors, membrane tanks, blowers, influent pumping, PE fine screening, chemical storage and feed facilities, flow equalization, and odor control facilities. The overall treatment concept also incorporates the conversion of two of the existing HPOAS treatment trains to HPOLE bioreactors and the addition of sidestream deammonification on the existing centrate stream. Outside of the HPOLE process, SD, and connections to access PE and SE, no major modifications to existing Warren Facility processes are proposed as part of the selected project. That is, no major modifications are proposed to Warren Facility's liquids, solids, or disinfection processes not described in this chapter. The RO concentrate from the AWP Facility processes is expected to be returned to the Warren Facility's outfall for ocean discharge. Key features of the selected Flex MBR project, as described in Section 6 and repeated here, include the following:

- **Incorporation of Sidestream Treatment**—Sidestream treatment using deammonification technology will be implemented at the Warren Facility prior to, or along with, Pure Water Phase 1. Sidestream deammonification was shown to reduce chemical and energy demands and provide an overall cost benefit to Pure Water. Details of the proposed sidestream deammonification process configuration are described in *Task 6: Analysis and Refinement of Concept Design for JWPCP Sidestream Deammonification Treatment* (Hazen, 2023c).
- **Incorporation of HPOLE—**From demonstration testing, the HPOLE process has demonstrated performance and cost benefits for the Flex MBR concept. The conceptual designs will proceed with the impacts on bioreactor sizing discussed in the JTAP 2 report. Details of the HPOLE process configuration are described in *HPOLE Conceptual Design Development for PWSC Program Trains* (Hazen, 2023b). Each HPOLE train can process 18 MGD at average day and 50 MGD at peak hour. If needed, each HPOLE train can be alternatively operated in HPOAS mode with no infrastructure modification, allowing the plant to maintain its permitted dry weather capacity of 400 MGD.
- **Fine Screening—**Dedicated screening for the Flex MBR that is expandable to screen flows for future Pure Water phases or expansion to Flex MBR – Secondary (SMBR) will be incorporated.
- **Equalization and Flow Management**
  - Initial implementation of the Flex MBR – Tertiary (TMBR) will incorporate filtrate equalization located on the Joint Plant site, integrated into the RO break tank. Future transition to the Flex MBR – Secondary operating mode at Phase 2 flow targets or later can be associated with additional PE equalization as described in the JTAP 1 report, *Task 2 Report – Analysis of Train 4 (Secondary BNR + Single-Pass RO) and Train 5 (Tertiary BNR + Single-Pass RO)* (Hazen, 2021).
  - Initial TMBR implementation is sized to treat the peak diurnal flow (1.3x) to overcome filtrate storage deficits from diurnal low flows. Future conversion to SMBR operational modes includes provisions to manage a peak hour flow of two times the average daily flow (i.e., 364 MGD in Phase 2). Excess flow will be managed by the HPOAS process, discharge of extra MBR filtrate back to disinfection and on to the ocean outfall, or a potential future dedicated wet weather treatment process.
- **Biological Process**
  - Flex MBR concept**—**The bioreactor sizing reflects the advancement of the flex bioreactor concept that allows for improved operational flexibility and facilitates expansion between operating phases and future conversion to SMBR.
  - All biological trains are to be designed to achieve nitrogen targets based on the use of single-pass RO downstream. The Flex MBR is configured to enable operation as tertiary nitrification only (N-only), tertiary NdN, or secondary BNR (including nitrogen and phosphorus). The tertiary NdN process has the flexibility to operate with

full SE utilizing external carbon (carbon mode) or as a blend of PE and SE (hybrid mode) to offset carbon demands.

- In tertiary operation, the process is configured with an anoxic zone prior to aerobic zones to provide protection against carbon bleed through and potential membrane foulants in the PE for the hybrid approach, as well as to limit NO_2 accumulation.

7.1.3 Conservation of Water and Energy

The Flex MBR concept was designed to maximize energy and water efficiencies through key conceptual design decisions summarized as follows:

- **Energy efficiency:**
  - **Gravity flow:** The process utilizes gravity flow where possible to minimize intermediate pumping steps. A core example of this is the integration of membrane filtrate equalization with the RO break tank. Integration of these two tanks limits flow conveyance requirements.
  - **Bioreactor configuration:** The Flex MBR concept is designed as a two-pass bioreactor with feed and effluent located along a common pipe gallery. RAS pumping stations and blowers are located along the pipe gallery to minimize hydraulic losses between the bioreactors and major infrastructure. Integration of the two-pass bioreactor into the pipe gallery allows for low-head pumps to be utilized to convey flow, reducing overall energy requirements.
  - **Advanced BNR controls:** The bioreactor concept incorporates provisions to allow for incorporation of advanced controls to optimize aeration energy use and chemical feed systems. The advanced controls are envisioned to minimally include ammonium-based airflow control, most open valve blower control, and model-based control to optimize chemical use and aeration supply.
  - **Hybrid operation:** Utilization of external carbon is an effective approach to achieve nitrogen targets but is associated with notable chemical use. Operating with a blend of PE and SE, referred to as hybrid operation, is a concept incorporated to offset external carbon demands. The Flex MBR has been conceptually designed to operate utilizing external carbon or PE to support denitrification requirements.
  - **Flexibility for PdNA:** Like the motivation for hybrid operation, PdNA has the potential to significantly reduce energy and external carbon demands. Preliminary evaluation suggests an external carbon reduction of 50 to 60 percent and aeration reductions of 40 to 50 percent may be achievable. Future flexibility for PdNA has been incorporated into Flex MBR concept.
  - **Sidestream Nitrogen Treatment:** As noted, the concept includes the addition of sidestream deammonification to manage high nitrogen loads from the Warren Facility's digestion and dewatering processes. Conceptual design evaluations demonstrated significant reductions in external carbon and energy demands through the incorporation of sidestream deammonification.
- **Water efficiency:**
  - **Equalization:** To limit impacts of flow variability and maximize flow capture, the conceptual designs incorporate MBR filtrate equalization. Equalization was sized considering the overall online factor target for Pure Water of at least 92 percent. Of

the 8 percent offline allowance, conceptual designs focus on providing sufficient storage such that one percent or less would be attributable to insufficient flow.

- **MBR water efficiency:** Selection of an MBR compared to conventional MF advances water use efficiency by eliminating the recovery associated with MF and disk filtration. The MF-based trains evaluated in Section 6 are associated with an additional feed flow requirement of 10 MGD beyond what is required for the Flex MBR.

- **Construction efficiency:** A core benefit to the Flex MBR concept is the planned modularity and compactness of the design. The concept utilizes common wall construction to minimize concrete quantities, and associated water and energy use. The compact design also optimizes space, leaving room for future flexibility.

7.2 Selected Project Conceptual Design

7.2.1 Key Design Criteria

The *Updated Basis of Assumptions* TM (Hazen and Jacobs, 2023) defines global design criteria for all alternatives evaluated in JTAP, and the *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept Design for JTAP Train 1 (Tertiary MBR) and JTAP Train 3 (Greenfield Secondary MBR)* (Jacobs, 2023) provides a thorough overview of the basis of the Flex MBR design. **Table 7-1** summarizes key design criteria for the Flex MBR operating in tertiary mode from the JTAP 2 conceptual design. Two feasible operating modes for Flex MBR – Tertiary are shown: external carbon feed and hybrid (with some PE bypass to Flex MBR).

Table 7-1. Key Flex MBR Tertiary Design Criteria

Component	Units	Carbon Operating Mode	Hybrid Operating Mode
Biological System Requirements			
MCRT (excluding membrane tanks)	days	More than 10	More than 12
Aerobic hydraulic retention time	Hours	More than 2.5	More than 2.5
Maximum anoxic zone NO_3	mgN/L	Less than 0.25	0.5 – 2
Phase 1 operating target[b] AWP Facility feed NO_3 target[a] (maximum)	mgN/L	Less than 29.5 (37)	Less than 29.5 (37)
Phase 1 Design[b] and Phase 2 AWP Facility feed NO_3 target[a] (maximum)	mgN/L	Less than 19 (23.5)	Less than 19 (23.5)
Target AWP Facility feed PO_4	mgP/L	Less than 1	Less than 1
Membrane Tank Requirements			
Maximum membrane tank MLSS	mgTSS/L	10,000	10,000
Maximum membrane tank feed NH_x	mgN/L	Less than 1	Less than 1

Component	Units	Carbon Operating Mode	Hybrid Operating Mode
MBR Influent Requirements			
Phase 1 (115 MGD AWP Facility product) MBR average (peak[c]) flow	MGD	140 (182[c])	140 (182[c])
Phase 2 (150 MGD AWP Facility product) MBR average (peak) flow	MGD	180 (234[c])	180 (234[c])

[a] Target AWP Facility feed NO3 represents AWP Facility feed that achieves 80 percent of the AWP Facility production goal.

[b] Phase 1 is designed for more restrictive AWP Facility limits but expected to operate at higher limits

[c] Diurnal peak flow of 1.3 times.

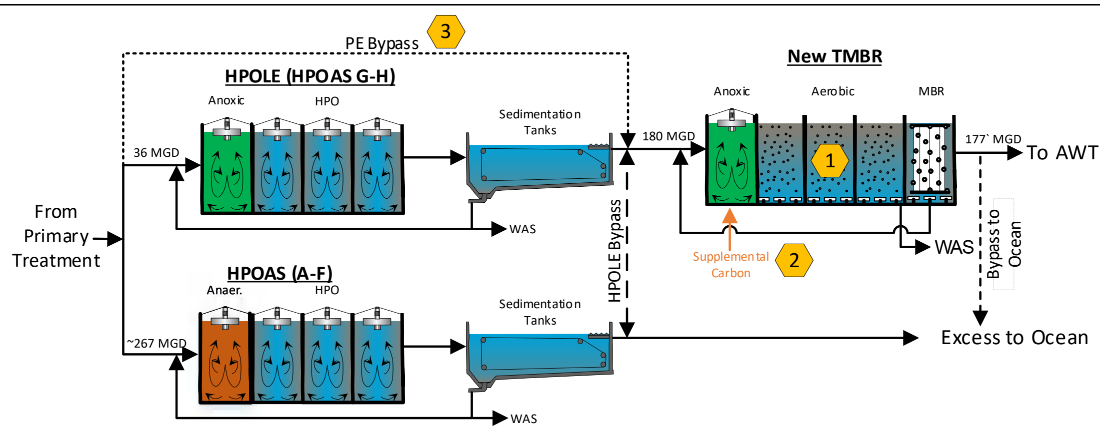
mgP/L = milligram(s) phosphorus per liter
mgTSS/L = milligram(s) total suspended solids per liter
PO_4 = phosphate

7.2.2 Biological Process Overview

The Flex MBR process has been configured to operate in four modes: 1) N-only TMBR, 2) Carbon-based NdN TMBR, 3) Hybrid NdN TMBR, and 4) Secondary MBR. **Table 7-2** provides a general overview of these operating conditions.

Table 7-2. Flex MBR Biological Process Configurations

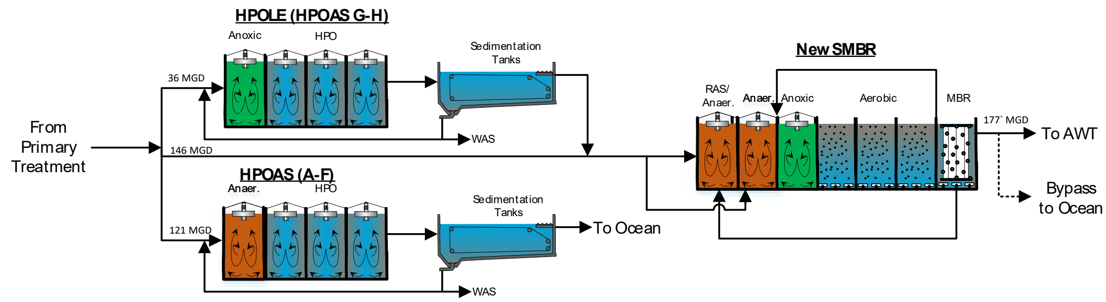
Process Configuration
Tertiary Operating Mode



1. N-only. A nitrifying TMBR serves to provide complete nitrification without supplemental carbon or PE diversion to achieve substantial denitrification. The anoxic zone shown may be equipped with diffusers to operate as a swing zone. Overall system components are very similar to SMBRs.
2. Carbon. By adding carbon into the unaerated zones, the NdN TMBR serves to provide complete nitrification and partial denitrification by using a Modified Ludzack-Ettinger configuration with a pre-anoxic zone. NO_3 is returned to the anoxic zone through the RAS and an optional NRCY. With lower recycle rates (<100%), only a RAS would be incorporated initially, but with higher recycle rates, a NRCY can be beneficial to reduce oxygen loading from the membrane tanks. External carbon is used for denitrification.
3. Hybrid. The hybrid TMBR approach builds on the baseline NdN configuration by using partial PE bypass feed to reduce external carbon demands associated with denitrification. The configuration includes a NRCY to improve operability and a backup carbon system to aid in redundancy.

Process Configuration

Secondary Operating Mode



1. When treating primarily PE (including HPOLE), the Flex MBR was configured as an A_2O process with a PE split between the first two unaerated zones. The step-feed of PE into these first two zones allows for improved protection of anaerobic conditions with high NO_3 RAS being denitrified prior to returning to the main anaerobic zone. In the process, RAS is returned to an anoxic/fermentation zone where it is mixed with a portion of the PE to promote denitrification/fermentation. The remaining PE is directed to the anaerobic zone. An anoxic zone and NRCY are also provided to improve NdN.
2. While the bioreactor initially configured in tertiary mode can readily be re-configured to enable secondary operation, the treatment capacity would be reduced as a consequence. Additional infrastructure (e.g., bioreactors, membrane tanks, etc.) would need to be added to maintain the original production targets with secondary operation.

Approximate flows shown ate future design conditions

Blue = aerobic
green = anoxic
orange = anaerobic

Steady-state modeling was completed for the Train 1 Flex TMBR considering both the carbon and hybrid approaches. When combined with HPOLE, tertiary operation can consist of four bioreactor trains in Phase 1 and five bioreactor trains in Phase 2. Each TMBR train is configured with five anoxic zones and seven aerobic zones with tapered aeration. The final aerated zone is tapered to low dissolved oxygen (DO) conditions (approximately 0.25 milligram oxygen per liter [mgO_2/L] to 0.5 mgO_2/L).

The total recycle rates (RAS and NRCY) were determined considering NO_3 and MLSS targets. The RAS rates were minimized to achieve a maximum MLSS concentration of 10,000 mgTSS/L in the membrane tank, with a minimum RAS flow set to be 35 percent. The goal of minimizing RAS rates is to reduce O_2 loading from the membrane tanks. Additional recirculation to achieve effluent NO_3 targets could be achieved through incorporation of the NRCY or additional RAS. The process refinement completed in JTAP 2 (Jacobs, 2023) indicated that only marginal increases to the RAS were required to achieve NO_3 targets. Accordingly, incorporation of the NRCY was not included for tertiary operation, but provisions remain in the conceptual design allowing for addition at a later time.

In addition to the effluent NO_3 targets, the recycle rate determination also considered the NO_3 concentration in the anoxic zone. For the carbon-based approach, a concentration of 0.5 mgN/L was targeted whereas the hybrid approach targeted between 1 and 2 mgN/L. The reduced target with the carbon-based approach is intended to limit the potential for partial denitrification (i.e., some partial denitrification to nitrite, rather than all the way to nitrogen gas), which can commonly occur when carbon limited conditions exist while feeding a highly degradable external carbon source such as MicroC. Partial denitrification under these conditions was experienced during initial NdN testing at the Demonstration Plant and during early operation of the NdN Pilot scale TMBR.

Table 7-3 summarizes the results for the carbon-based NdN TMBR approach. Even at the low RAS rates, the NdN TMBR is not expected to approach the 10,000 mgTSS/L threshold in the membrane tank operation. The conditions summarized in **Table 7-2** target NO_3 performance requirements (e.g., less than 19 mgN/L) for Phase 1 and Phase 2 to design criteria at future loading conditions. Additional simulations were completed under current loading conditions to establish life-cycle parameters. Phase 1 current loading simulations were completed to determine the carbon requirement in Phase 1 to achieve the less stringent NO_3 target of 29.5 mgN/L for life-cycle costing. No external carbon is predicted to be needed to achieve the higher 29.5 mgN/L target under current average day loads at Phase 1 flow requirements. **Figure 7-1** shows results from a dynamic simulation completed without carbon addition (e.g., N-only operation). Results from the N-only dynamic simulation predicts that that effluent NO_3 will be less than the 29.5 mgN/L Phase 1 target on approximately 60 percent of days. Depending on the averaging period selected for compliance in PWSC, external carbon may be required to achieve compliance.

For life-cycle costing, the carbon demand was estimated as 2.5 milligrams chemical oxygen demand per liter (mgCOD/L) per milligram NO_3 as nitrogen per liter ($mgNO_3$-N/L), consistent with dosing applied within the process model. The average dose needed when dosing chemical is predicted to be approximately 3,800 gpd. When averaged over the entire year (including days with no dosing), the average dose is estimated to be to near 1,600 gpd. Achieving compliance on weekly to monthly averaging periods would require the average dose to be applied daily. However, achieving more restrictive limits would result in increased annual carbon demands.

Figure 7-1. Predicted Effluent Nitrogen from Phase 1 Train 1 under Current Loading Conditions without Carbon Addition (PE or External Carbon)

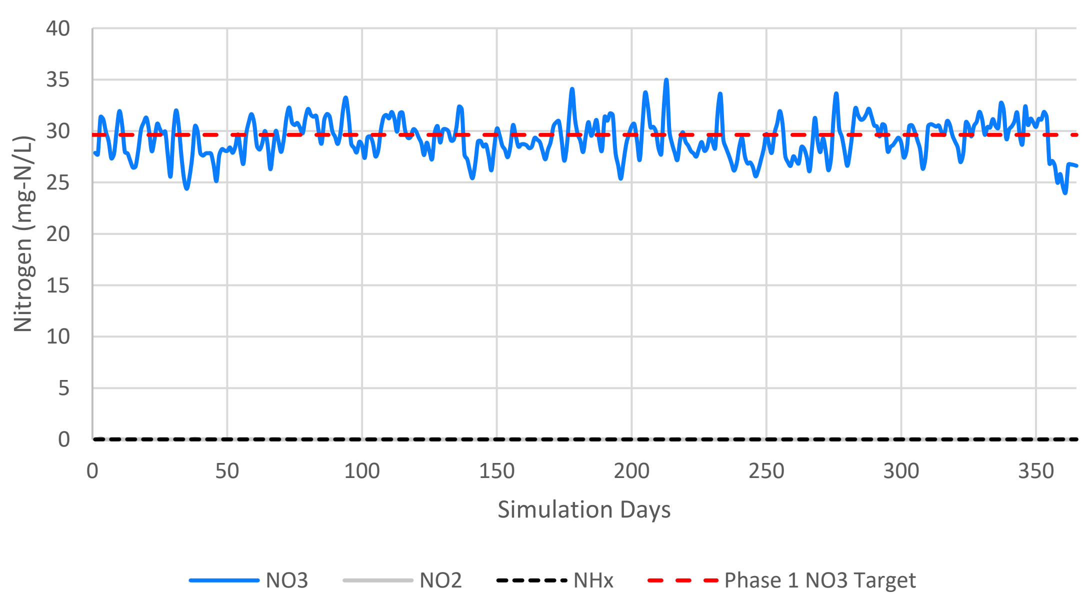


Table 7-4 summarizes the performance predictions for the NdN hybrid approach. Compared to the carbon-based NdN TMBR, hybrid operation is predicted to have increased MLSS concentrations in the bioreactors and membrane tanks as a result of the increased TSS loading from the PE. The proportion of PE utilized was modified to achieve NO_3 targets. The analysis completed in JTAP 2 (Jacobs, 2023) concluded that the diversion of PE would need to be

27 percent and 32 percent of the total flow for Phase 1 and Phase 2, respectively, to eliminate the need for carbon addition for the hybrid NdN TMBR with HPOLE in operation. NdN TMBR options, which are based on SE only as the TMBR feed (i.e., no PE blend), require up to 16,000 gpd of carbon addition to achieve the required effluent NO_3 target.

Similar to the carbon-based NdN TMBR, the hybrid TMBR alternative, does not require PE diversion on an average daily basis to achieve the higher NO_3 target. Maintaining compliance throughout the year is estimated to require an average PE diversion near 5 MGD to enable denitrification. As with the NdN TMBR, more restrictive compliance periods would require increased PE diversion.

Table 7-3. Process Modeling Results Summary for NdN TMBR at Future Design Conditions

Parameter	Phase 1			Phase 2		
	Current Average Day with HPOLE	Future Average Day with HPOLE	Future Maximum Month with HPOLE	Current Average Day with HPOLE	Future Average Day with HPOLE	Future Maximum Month with HPOLE
TMBR influent flow, MGD	139			180		
Trains, quantity	4			5		
Operational						
RAS rate, percent of reactor feed	50%	50%	60%	45%	60%	70%
NRCY rate, percent of reactor feed	0%	0%	0%	0%	0%	0%
Carbon use, gpd	0[a]	9,250	11,200	10,100	13,500	15,500
PE bypass, MGD	N/A	N/A	N/A	N/A	N/A	N/A
PE bypass, %	N/A	N/A	N/A	N/A	N/A	N/A
MLSS, mgTSS/L						
Membrane tank feed	740	1,490	1,820	1,310	1,600	1,880
Membrane tank	2,180	4,420	4,800	4,150	4,210	4,530
Performance						
NO_3 in last anoxic zone, mgN/L	11.18	0.5	0.3	0.44	0.4	0.3
Mass loading, kgNO_3-N/kgMLVSS	0.47	0.15	0.14	0.16	0.16	0.15
Volumetric loading rate, kgNO_3-N/m^3	0.26	0.19	0.22	0.17	0.21	0.24
Filtrate ammonia, mgN/L	0.01	0.02	0.03	0.02	0.02	0.03
Filtrate NO_3, mgN/L	28.8	19.0	19.0	19.0	18.9	19.0
Filtrate NO_2, mgN/L	0.00	0.00	0.01	0.00	0.00	0.01

[a] Supplemental carbon is not required to achieve 29.5 mgN/L on an average daily basis, but is expected to be needed on 40% of days, with an average use (when operating) of 3,800 gpd.

kgNO_3-N/kgMLVSS = kilogram(s) NO_3 (as nitrogen) per kilogram mixed-liquor volatile suspended solids
kgNO_3-N/m^3 = kilogram(s) NO_3 (as nitrogen) per cubic meter

Table 7-4. Process Modeling Results Summary for Hybrid NdN TMBR Alternatives

Parameter	Phase 1			Phase 2		
	Current Average Day with HPOLE	Future Average Day with HPOLE	Future Maximum Month with HPOLE	Current Average Day with HPOLE	Future Average Day with HPOLE	Future Maximum Month with HPOLE
TMBR influent flow, MGD	139			180		
Number of trains	4			5		
Operational						
RAS rate, percent of reactor feed	50%	65%	75%	65%	80%	90%
NRCY rate, percent of reactor feed	0%	0%	0%	0%	0%	0%
Carbon use, gpd	0	0	0	0	0	0
PE bypass, MGD	N/A[a]	37.5 (6[a])	39.0	48.0	56.0	57.5
PE bypass, %	N/A	27%	28%	27%	31%	32%
MLSS, mgTSS/L						
Membrane tank feed	740	3,260	3,850	2,980	3,710	4,320
Membrane tank	2,180	8,210	8,910	7,490	8,280	9,050
Performance						
NO_3 in last anoxic one, mgN/L	11.2	0.9	0.6	1.2	1.0	0.7
Mass loading, kg NO_3-N /kg MLVSS	0.47	0.09	0.09	0.10	0.09	0.09
Volumetric loading rate, kg NO_3-N/m^3	0.26	0.23	0.20	0.23	0.27	0.25
Filtrate ammonia, mgN/L	0.01	0.03	0.03	0.02	0.03	0.03
Filtrate NO_3, mgN/L	28.8	19.0	19.0	18.6	18.9	18.9
Filtrate NO_2, mgN/L	0.00	0.01	0.01	0.01	0.01	0.01

[a] PE bypass is not required to achieve 29.5 mgN/L on an average daily basis, but is expected to be needed on 40% of days, with a PE flow (when operating) of 5 MGD.

JTAP 2 (Jacobs, 2023) includes a redundancy evaluation to determine the reliability of the Flex MBR concept. Redundancy was evaluated for: 1) a half of one train out of service, and 2) without the HPOLE process included upstream, with each condition evaluated under maximum month loading conditions under the hybrid feed condition. The hybrid approach was selected due to the increased MLSS and O_2 requirements relative to the carbon-based approach so as to better understand the potential capacity constraints of the design.

For the second redundancy condition, the total loss of HPOLE was a conservative condition, whereas a more likely condition would be partial loss of HPOLE (e.g., one train). The total loss of HPOLE was considered as a conservative evaluation appropriate for this stage of conceptual design. A more thorough summary of the redundancy evaluations is provided in JTAP 2 (Jacobs, 2023). Key outcomes of the evaluation are summarized as follows:

- With less bioreactor volume, higher RAS rates, within bounds of the conceptual designs, are necessary to maintain a maximum MLSS of 10,000 mg/L in the membrane tank. The analysis confirmed that sufficient bioreactor volume is available to manage higher MLSS and O_2 requirements predicted in the redundancy conditions.
- Without HPOLE, increased PE diversion and/or carbon addition is required to achieve the design targets for Phase 1 and Phase 2, respectively. Under Phase 2 conditions, the increased carbon requirement is estimated at 2,400 gpd of MicroC or 14 mgd for the carbon and hybrid operating modes, respectively.

7.2.3 Bioreactor Design Concept

To facilitate the desired flexibility, a modular bioreactor design was conceived that uses a common bioreactor train volume that can be operated in multiple modes (e.g., TMBR, SMBR). The modular concept utilizes a two-pass bioreactor with a multi-purpose central channel and targeted swing zones. The proposed configuration allows for half of a bioreactor train (i.e., one pass) to be taken out of service to reduce the out of service volume for maintenance activities. The proposed bioreactor is partitioned into 12 equal zones to improve operational flexibility.

Figure 7-2 provides an overview of the modular bioreactor concept for NdN TMBR and SMBR with zone volumes summarized in **Table 7-5**.

Figure 7-2. Bioreactor Train Concept

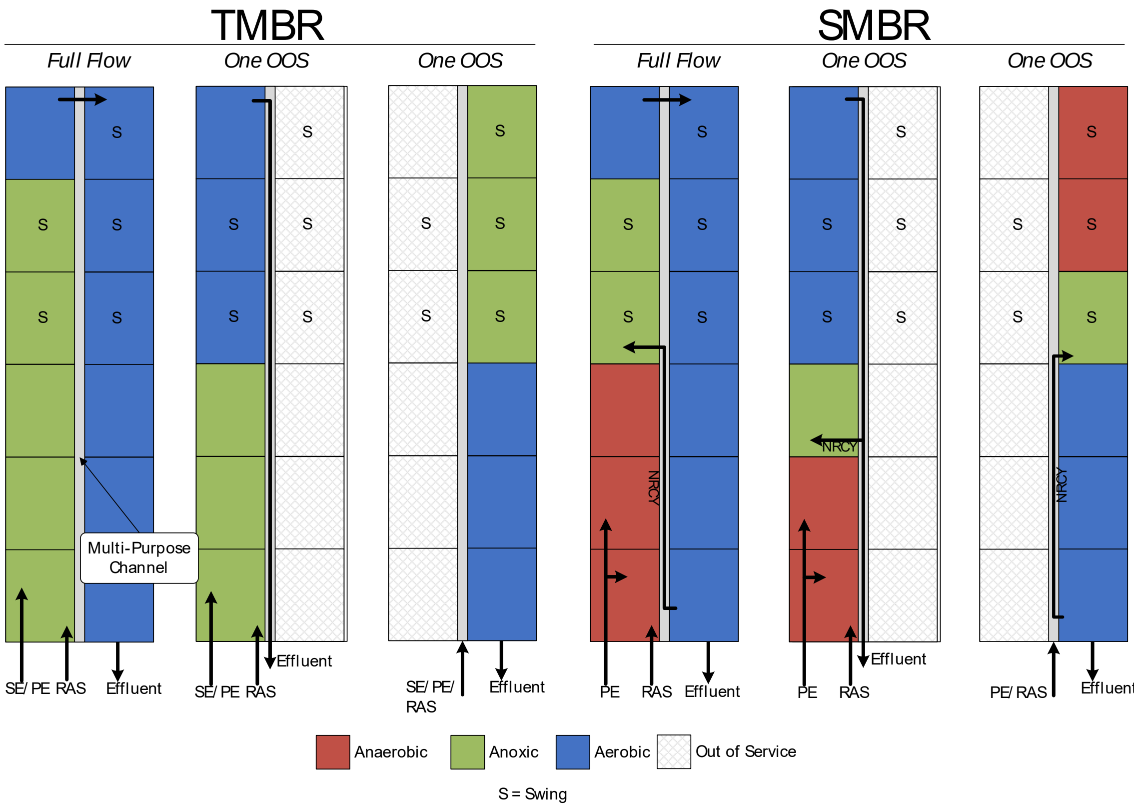


Table 7-5. Bioreactor Conceptual Configuration

TMBR Zone	SMBR Zone	Units	Volume per Basin[a]
Anoxic-1	Anaerobic-1	MG	0.483
Anoxic-2	Anaerobic -2	MG	0.483
Anoxic-3	Anaerobic -3	MG	0.483
Anoxic-4[b]	Anoxic-1[b]	MG	0.483
Anoxic-5[b]	Anoxic-2[b]	MG	0.483
Aerobic-1	Aerobic-1	MG	0.483
Aerobic-2[b]	Aerobic-2[b]	MG	0.483
Aerobic-3[b]	Aerobic-3[b]	MG	0.483
Aerobic-4[b]	Aerobic-4[b]	MG	0.483
Aerobic-5	Aerobic-5	MG	0.483
Aerobic-6	Aerobic-6	MG	0.483
Aerobic-7	Aerobic-7	MG	0.483
	Total	**MG**	**5.80**

[a] Each zone has a width of 38.4 ft, length of 67.3 ft, and sidewater depth of 25 ft.

[b] Zone includes swing zone capability to facilitate one half-train out of service.

A pipe gallery is implemented in between the bioreactors and the membrane tanks to facilitate flow conveyance between the reactors. The pipe gallery consists of two levels with feed piping located in the lower level and mixed liquor/RAS conveyance located on the upper level. Permeate pumping, process air blowers, and membrane air scour blowers are located in an equipment building south of the membrane tanks. Modular expansion of these two structures was envisioned for each phase. Major infrastructure (e.g., channels, air headers) will be designed to accommodate either operating mode, TMBR or SMBR (as well as other alternatives such as hybrid MBR as well as approaches for PdNA). As such, expanding between phases and train concepts primarily requires additional trains to be added.

JTAP 2 evaluations *HPOLE Conceptual Design Development for PWSC Program Trains* (Hazen, 2023a) and *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept Design for JTAP Train1 (Tertiary MBR) and JTAP Train 3 (Greenfield Secondary MBR)* (Jacobs, 2023) demonstrated benefits of HPOLE integration into the Flex MBR concept. The primary benefits included 1) improved NO_3 performance, 2) reduced external carbon demand, and 3) reduced bioreactor volume (1 x Flex Train). The Flex MBR concept was evaluated with and without HPOLE to evaluate site space requirements. **Figure 7-3** and **Table 7-6** provide an overview of the number of trains and phasing requirements of the modular bioreactor concept.

Figure 7-3. Bioreactor Phasing Plan

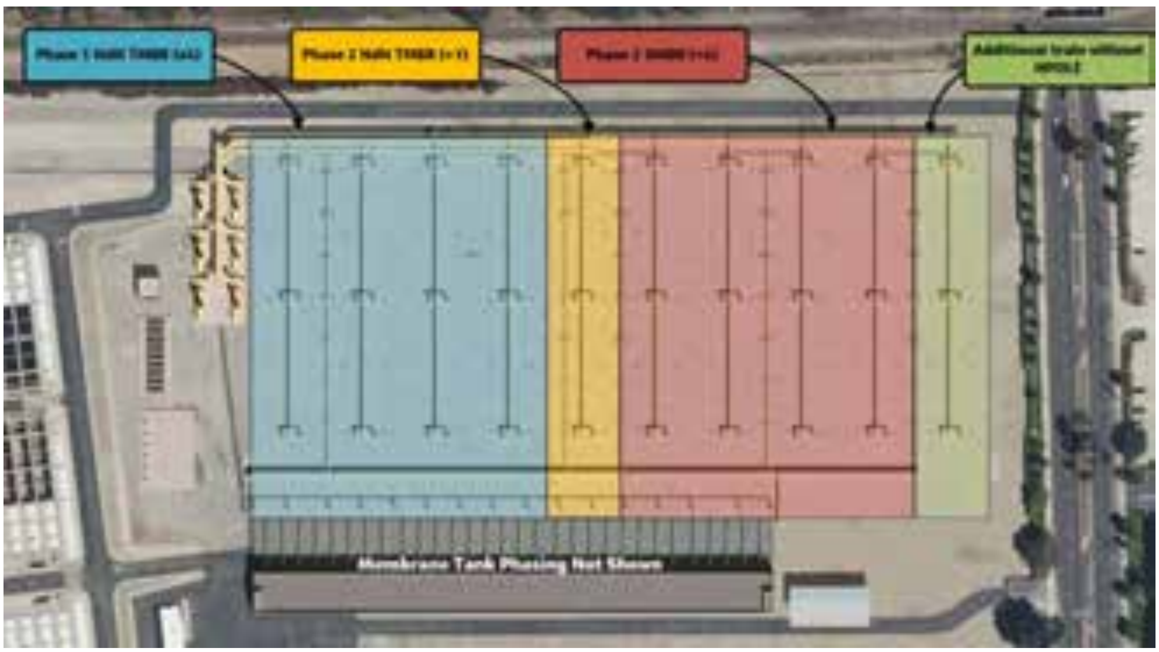


Table 7-6. Flex MBR Train Requirements

Parameter	Phase 1	Phase 2	Phase 2
AWP Facility production capacity, MGD	115	150	150
Operating mode	Tertiary	Tertiary	Secondary
Without HPOLE Operating			
Number of bioreactor trains	5	6	9
Approximate volume, MG (total)	29	35	52
With HPOLE Operating			
Number of bioreactor trains	4	5	10
Approximate volume, MG (total)	23	29	58

The bioreactor concept provides several advantages:

- **Phase expansion—**Expansion between phases relies on single train expansions that minimize disruption to existing operations.
- **Conversion to SMBR—**In the initial JTAP 1 concept, the transition from TMBR to SMBR required additional bioreactor volume through additional trains and the addition of unaerated volume. The Flex MBR concept allows for a much easier transition with less disruption to operation, with the required volume expansion achieved through the addition of whole trains and minimal modifications to equipment within the existing TMBR trains.
- **Flexibility—**The two-pass design, equal zone sizing, and multi-purpose channel afford for increased operational flexibility. The same bioreactor configuration can be operated as N-only TMBR, carbon-based NdN TMBR, hybrid NdN TMBR, or SMBR. The equal zone sizing allows for future incorporation of intensification approaches, such as PdNA or membrane-aerated biofilm reactors to be considered.
- **Redundancy—**The two-pass bioreactor design with multi-purpose channels also provides for greater redundancy by allowing for one pass (half-train) to be taken out of service for maintenance.

7.2.4 Major Infrastructure and Unit Processes

The *Task 1 and 2 Report – Analysis and Refinement of Flex MBR Concept Design for JTAP Train 1 (Tertiary MBR) and JTAP Train 3 (Greenfield Secondary MBR)* (Jacobs, 2023) provides a detailed overview of sizing and design criteria for each unit process. **Table 7-7** provides a summary of the major infrastructure elements recommended for implementation.

As noted previously, the treatment facilities to be implemented by the Sanitation Districts consist of the Flex MBR, operating for Phase 1 and Phase 2 in tertiary mode, along with the ancillary elements included in the table. Ultimately, the Flex MBR may be converted to an SMBR facility in the future based on key drivers occurring.

Table 7-7. Flex MBR – Tertiary Key Design Components

Component	Units	Phase 1	Phase 2
Operating mode	-	Tertiary	Tertiary
Secondary Effluent Pump Station (TMBR Feed)			
Size	MGD (hp)	47 (355)	
		86 (770)	
Quantity	#	3 duty: 1 86-MGD pump + 2 47-MGD pumps	4 duty: 2 86-MGD pumps + 2 47-MGD pumps
		1 standby: 86-MGD pump	1 standby: 86-MGD pump
Primary Effluent Pump Station (Hybrid only)			
Capacity, each	MGD (hp)	40 (355)	
Quantity	#	2 duty + 1 standby	

Component	Units	Phase 1	Phase 2
Fine Screens			
Screen opening	millimeters	2	
Capacity, each	MGD	45.6	
Quantity	#	4 duty + 1 standby	6 duty + 1 standby
Bioreactors			
Train volume	MG	5.8	
Quantity	#	4	5
Membrane Tanks and Equipment			
Membrane tank quantity	#	21 (20 duty + 1 standby)	25 (24 duty + 1 standby)
Membrane surface area per module	ft^2	530	
Modules per cassette	#	64	
Cassettes per tank	#	12 populated + 2 spare	
Flux, average (peak)	gfd	18 (23)	
Filtrate Pumps			
Capacity, each	MGD (hp)	9.8 (200)	
Quantity	#	21 (20 duty + 1 standby)	25 (24 duty + 1 standby)
Return Activated Sludge Pumps			
Total flow requirements, average (peak)	MGD	85 (241)	110 (314)
Pump quantity	#	6 duty + 2 standby[a]	9 duty + 3 standby[b]
Aeration Blowers			
Per train airflow, average (peak)	scfm	11,200 (14,900)	
Total airflow	scfm	44,800 (59,600)	56,000 (62,300)
Blower capacity	scfm (hp)	20,000 (1,430)	
		40,000 (2,000)	
Quantity	#	(2) 20,000 scfm, (2) 40,000 scfm	(2) 20,000 scfm, (2) 40,000 scfm
Membrane air scour blowers			
Airflow range per tank[c]	scfm	1,700-3,680	
Quantity	#	4 duty + 1 standby	5 duty + 1 standby
Blower capacity	scfm (hp)	17,500 (800)	
Chemical Storage			
Sodium hypochlorite storage	-	2 tanks @ 6,000 gallons	
Citric acid storage	-	2 tanks @ 6,000 gallons	
Carbon storage[d]	-	9 @ 20,000 gallons	12 @ 20,000 gallons
Phosphoric acid storage[d]	-	2 tanks @ 6,000 gallons	

Component	Units	Phase 1	Phase 2
Equalization			
Type	-	Filtrate	
Volume	MG	6-MG equalization + 2-MG RO Break Tank	
Odor Control – Fine Screening			
Total capacity	scfm	2,600	
Type	-	Biotrickling Filter	
Quantity	#	1 duty + 1 standby	
Odor Control – Bioreactors			
Total capacity		66,000	82,000
Type		Dual-bed carbon	
Quantity		2 duty + 1 standby	

[a] Includes two pump stations to achieve total capacity

[b] Includes three pump stations to achieve total capacity

[c] Range represents low airflow scour estimates to high scour requirements with additional spare cassettes populated

[d] Storage and chemical feed reduced with hybrid operation

7.2.5 Project Phasing

The layouts for the Flex MBR are reflective of the elements described in the previous sections of this document and the evaluation in the JTAP 2 report (Jacobs, 2023). The approach to sizing of the infrastructure facilitates conversion from TMBR to SMBR by adding new facilities, without replacement of early installed equipment. Construction will be staged to accommodate the phased implementation plan progressing from Phase 1 to Phase 2, with potential considerations for initial water deliveries. **Figure 7-4** provides an overview of the phasing plan, which is described in more detail in **Table 7-8**.

Figure 7-4. Flex MBR Site Plan Phasing to 150-MGD of Tertiary Operation

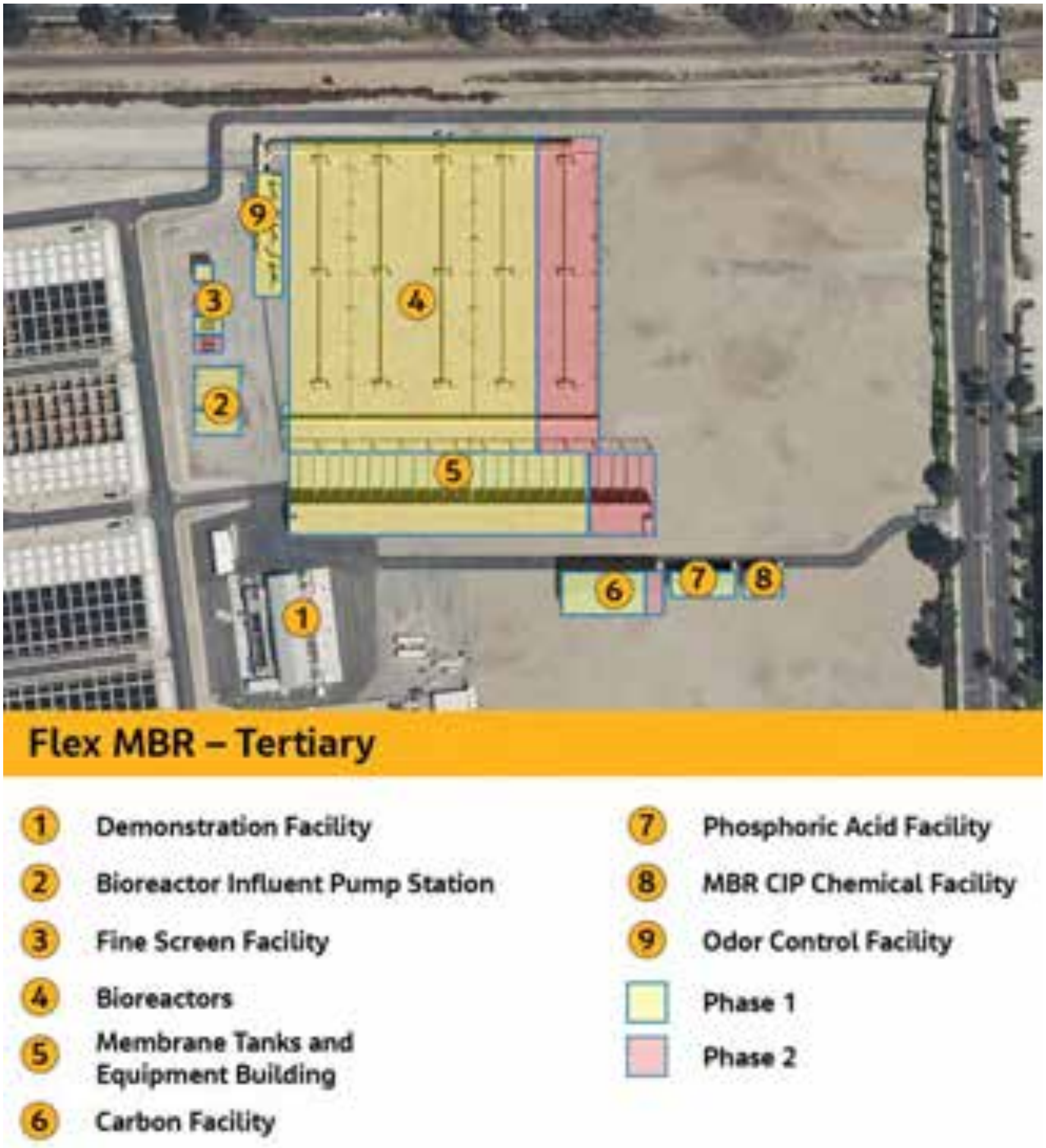


Table 7-8. Flex MBR Tertiary Construction Phasing for 115 and 150MGD AWP Facility Production Capacities

Facility	Phase 1 TMBR (115 MGD)	Phase 2 TMBR (150 MGD)
Supplemental PE pump station	Build pump station, install three pumps (for hybrid option only). No PE pump station required if utilizing supplemental carbon.	No additional pumps required.
Influent pump station (HPOAS/HPOLE effluent)	Build pump station, install two 47-MGD pump and two 86-MGD pumps.	Install one 86-MGD pump (maintain 47-MGD pumps).
Fine screening facility	Construct fine screening structure and install five fine screens.	Expand fine screening facility and add two fine screens.
Bioreactors	Build four bioreactors.	Add one bioreactor.
Process air blowers	Provide two 20,000-scfm and two 40,000-scfm blowers in MBR equipment building, with common process air header.	N/A
MBR system	Build MBR equipment building; build 21 membrane tanks with associated ancillary equipment.	Add four membrane tanks with associated ancillary equipment.
Air scour blowers	Provide five 17,500-scfm blowers in MBR equipment building with common process air header.	Provide one 17,500-scfm blower in MBR equipment building with common process air header.
RAS pump station	Build two pump stations with four pumps each.	Build pump station with four pumps, for Bioreactors 4 and 5.
WAS pump station	Build pump station with two pumps.	N/A
Sodium hypochlorite (membrane cleaning)	Build two tanks and two pumps.	Add two pumps.
Citric acid (membrane cleaning)	Build two tanks and two pumps.	Add two pumps.
Supplemental carbon	Build nine tanks (carbon), two tanks (hybrid), and eight pumps (carbon and hybrid).	Add three tanks and two pumps.
Phosphoric acid	Build two tanks and eight pumps, carbon based only.	N/A
Odor control for pump station and fine screen facility	Build biotrickling filter and carbon adsorber system.	N/A
Odor control for bioreactors	Provide three trains and three fans, with common foul air header.	N/A
MBR filtrate equalization	N/A	Build 8-MG (including RO break volume).
PE equalization	N/A	N/A

7.3 Cost Analysis

Economic evaluations for Flex MBR were completed by developing opinions of probable capital, O&M, and NPV costs. Opinions of probable costs are presented in this section and were developed using the conceptual design criteria described in the preceding sections and the JTAP 2 report (Jacobs, 2023), existing building information models, and the Jacobs conceptual engineering model, Replica™ Parametric Design, which generates detailed cost estimates using the design criteria input to be specific to this project, while also providing information from the same models for O&M cost estimates.

The costs presented herein are consistent with previous studies (Jacobs, 2021a, 2021b, and 2023) and follow assumptions identified in the *Updated Basis of Assumptions* TM (Hazen and Jacobs, 2023).

7.3.1 Expected Capital Cost

The opinions of probable capital cost presented herein represent independent, stand-alone costs for each train and each phase. In other words, the cost for Phase 1 represents the cost to build the full facilities to produce 115 MGD of treated water, whereas the cost shown for Phase 2 represents the cost to build the full facilities to produce 150 MGD of purified water without considering Phase 1. All costs are shown in current (March 2023) dollars and are not escalated to the midpoint of construction, per project convention.

Table 7-9 summarizes the capital cost estimates Flex MBR operating in Tertiary for the Phase 1 (115 MGD) and Phase 2 (150 MGD).

Table 7-9. Summary of Train 1 Capital Cost Estimates

Unit Process or Cost Parameter	Cost Factor	TMBR	
		Phase 1 (115 MGD)	Phase 2 (150 MGD)
Fine screening		$7,330,000	$9,560,000
Bioreactors		$66,021,000	$84,293,000
Blowers		$6,100,000	$9,052,000
MBR and equipment building		$144,931,000	$174,397,000
Chemicals (carbon and phosphoric)		$2,798,000	$3,248,000
Influent pumping		$13,628,000	$14,267,000
Odor control		$10,497,000	$10,497,000
Filtrate EQ		$0	$10,761,000[a]
Generator		$6,154,000	$8,210,000
Subtotal of project costs		$257,459,000	$324,285,000
Additional Project Costs			
Demolition	1.00%	$2,575,000	$3,243,000
Overall sitework	3.00%	$7,724,000	$9,729,000
Plant computer system	3.00%	$7,724,000	$9,729,000
Yard electrical	3.00%	$7,724,000	$9,729,000

Unit Process or Cost Parameter	Cost Factor	TMBR	
		Phase 1 (115 MGD)	Phase 2 (150 MGD)
Yard piping	10.00%	$25,746,000	$32,429,000
Subtotal with additional project costs		$308,952,000	$389,144,000
Tax (applied to 40% of total project cost)	9.50%	$11,741,000	$14,788,000
Subtotal with tax		$320,693,000	$403,932,000
Contractor Markups			
Overhead	15.00%	$48,104,000	$60,590,000
Subtotal		$368,797,000	$464,522,000
Profit	10.00%	$32,070,000	$40,394,000
Subtotal		$400,867,000	$504,916,000
Mob/bonds/insurance	5.00%	$16,035,000	$20,197,000
Subtotal		$416,902,000	$525,113,000
Contingency (applied to previous subtotal)	35.00%	$145,916,000	$183,790,000
Subtotal with markups		$562,818,000	$708,903,000
Location adjustment factor	112.9	$72,604,000	$91,449,000
Subtotal with location adjustment factor		$635,422,000	$800,352,000
Market adjustment factor	13.64%[a]	$86,672,000	$109,169,000
Construction costs (Jacobs estimates)		$722,094,000	$909,521,000
Additional Costs			
Sidestream nitrogen treatment[b]		$81,000,000	$81,000,000
Total construction costs		$803,094,000	$990,521,000[c]
Non-Construction Costs			
Permitting	LS[d]	$8,108,000	$10,000,000
Engineering	12.00%	$96,372,000	$118,863,000
Services during construction and startup	6.00%	$48,186,000	$59,432,000
Construction management	12.00%	$96,372,000	$118,863,000
Legal/administrative	LS[d]	$4,054,000	$5,000,000
Total non-construction cost		$253,092,000	$312,158,000
Total capital costs		$1,056,186,000	$1,302,679,000

[a] Applied in addition to 10 percent incorporated in project cost estimates, for 25 percent total market adjustment.

[b] Source: Hazen (2023c). Inclusive of contingency and adjustment.

[c] Incorporation of filtrate equalization would reduce downstream AWP Facility costs associated with the RO break tank. The 2-MG RO Break tank construction cost from JTAP 1 escalated by 25 percent for current market conditions is $8.8M.

[d] Applied to each phase proportionally based on the total construction cost.

LS = lump sum

7.3.2 Expected Life-Cycle Cost

Annual O&M costs were estimated for current conditions based on BioWin™ process models and the individual facility cost models, using the unit costs for power, consumables, and chemicals presented in the *Updated Basis of Assumptions* TM (Hazen and Jacobs, 2023). Costs include allowances for maintenance and repair, as well as mechanical equipment replacement. These costs were calculated as a percentage of the respective equipment costs for each item. Annual allowances for maintenance and repair were calculated as 3 percent of the equipment costs, except for facility models for which major replacement parts were itemized (e.g., MBR membranes); in those cases, the annual replacement cost was assumed to be 1.5 percent of the equipment costs. Allowances for major equipment repair were calculated as 5 percent of the equipment costs every 10 years. O&M costs are presented as current year (2023) costs, based on an average AWP Facility production flow of 115 MGD (Phase 1) and 150 MGD (Phase 2).

Table 7-10 summarizes the estimated annual O&M cost for the Flex MBR operating in tertiary mode for the two phases considered (Phase 1 and Phase 2).

Table 7-10. Summary of O&M Cost Estimates

Category	Phase 1 TMBR		Phase 2 TMBR	
	Carbon Based	Hybrid	Carbon Based	Hybrid
Energy				
Train associated equipment power	$4,911,000	$4,924,000	$6,767,000	$7,306,000
DAFT energy	$159,000	$154,000	$216,000	$184,000
Centrifuge energy	$230,000	$224,000	$312,000	$269,000
Building electrical	$227,000	$227,000	$282,000	$282,000
Chemicals (carbon, phosphoric, and membrane cleaning)				
MicroC	$2,045,000	$0	$12,912,000	$0
Phosphoric acid	$14,000	$0	$83,000	$0
Membrane cleaning	$540,000	$540,000	$657,000	$657,000
Biosolids disposal (includes screenings and biosolids)	$4,415,000	$4,301,000	$6,041,000	$5,113,000
Maintenance and Replacement				
Membrane replacement (annualized 10-year cost)	$1,667,000	$1,667,000	$1,984,000	$1,984,000
Odor control carbon replacement	$171,000	$171,000	$171,000	$171,000
Equipment repair, maintenance, and replacement	$2,003,000	$1,991,000	$2,810,000	$2,796,000
Warren Facility HPOAS				
HPOLE operation[a]	$3,125,000	$3,125,000	$3,125,000	$3,125,000
HPOAS credit	$0	-$163,000	$0	-$3,115,000
Train Associated Labor	$6,240,000	$6,240,000	$8,112,000	$8,112,000
Subtotal line items	$25,747,000	$23,401,000	$43,472,000	$26,884,000
O&M contingency (15% of energy, chemicals, residuals)	$1,881,000	$1,556,000	$4,090,000	$2,072,000
Subtotal Jacobs estimates	$27,628,000	$24,957,000	$47,562,000	$28,956,000
Additional Costs				
Sidestream nitrogen treatment (includes labor and contingency)[b]	$1,955,000	$1,955,000	$1,955,000	$1,955,000

Category	Phase 1 TMBR		Phase 2 TMBR	
	Carbon Based	Hybrid	Carbon Based	Hybrid
Total	**$29,583,000**	**$26,912,000**	**$49,517,000**	**$30,911,000**
Biogas credit	-$5,535,000	-$5,408,000	-$7,526,000	-$6,410,000
Total with Biogas Credit	**$24,048,000**	**$21,504,000**	**$41,991,000**	**$24,501,000**

[a] As described in Hazen (2023b).

[b] As described in Hazen (2023c).

A life-cycle cost analysis was performed using the capital and O&M costs based on a discount rate of 5 percent, respectively, and an amortization period of 20 years, as described in the *Updated Basis of Assumptions* TM (Hazen and Jacobs, 2023). Life-cycle costs were prepared as a NPV and presented in current (March 2023) dollars. Life-cycle costs were prepared as an NPV in current (March 2023) dollars.

Table 7-11 summarizes the projected life-cycle costs for the Flex MBR operating in tertiary mode for the two phases considered (Phase 1 and Phase 2).

Table 7-11. Life-Cycle Cost Estimate Summary

Description	Units	Tertiary			
		Phase 1 (Carbon)	Phase 1 (Hybrid)	Phase 2 (Carbon)	Phase 2 (Hybrid)
Annual AWP Facility production	MGD	115	115	150	150
Construction cost	$M	$804	$804	$991	$991
Non-construction cost	$M	$254	$254	$313	$313
Capital Cost	$M	$1,056	$1,056	$1,303	$1,303
NPV of Annual O&M Costs[a]	$M	$335	$302	$583	$351
NPV[a]	$M	$1,391	$1,358	$1,886	$1,654
NPV with Biogas Credit[b]	$M	$1,322	$1,290	$1,792	$1,574

[a] Life-cycle parameters used for NPV were based on the following assumptions: period = 20 years; discount rate = 5 percent.

[b] The biogas credit includes the proportion of estimated portion of biogas associated with implementation of the train.

$ = March 2023 U.S. dollars

7.3.3 Phasing Costs

The costs presented in Jacobs' JTAP 2 report (Jacobs, 2023) represent the costs to complete the Phase 1 and Phase 2 Flex MBR – Tertiary projects as separate, stand-alone construction projects. Therefore, the opinion of probable construction and capital costs for Phase 2 represents the cost to complete the complete Phase 2 project in its entirety. At this time, Pure Water is planned for Phase 1 implementation, with provisions for Phase 2 to be completed at a future date.

The costs shown in **Table 7-11** indicate the construction cost for Phase 1 (hybrid or carbon) is estimated to be approximately $804 million, with an estimated construction cost for Phase 2 (hybrid or carbon) of $991 million. Thus, the estimated construction cost for Phase 2 is $187 million more than Phase 1. Similarly, the estimated capital cost for Phase 2 is $247 million more than Phase 1. These differences in the estimated costs represent the difference in costs to implement each project separately. It should be noted that, as described in Jacobs' JTAP 2 report, the conceptual design of the Phase 1 project incorporates the consideration on a facility-by-facility basis of which project components would be constructed to readily accommodate expansion from Phase 1 to Phase 2.

With the current implementation plan for Pure Water, Phase 1 will be constructed (with operations beginning by a possible date of 2032 as described in Section 7.4), and then, Phase 2 will be designed and constructed as an expansion project to increase AWP Facility production capacity from 115 to 150 MGD by the year 2036. If the two phases are delivered out of a single design-build contract, the phasing costs may be near the difference of the two phases shown.

However, if Phase 1 construction is completed and a project is commissioned for Phase 2, the costs to expand the Flex MBR facilities are expected to be more than simply the difference in costs shown in **Table 7-11**. The reason for the additional cost associated with expanding Flex MBR capacity from Phase 1 to Phase 2 consists of the additional complexity associated with expanding capacity of an existing facility. In estimating the additional costs for the expansion project, the following represent key considerations for each unit process:

- **Civil work.** Additional efforts would be expected for excavation alongside of existing structures and to account for the delicate approach to prevent subgrade work from undermining adjacent slabs.
- **Structural work.** Additional efforts would be expected for drilling and doweling rebar connections to existing structures, to account for more difficult access for cranes and equipment since one side is blocked, and to reflect the additional difficulty in staging rebar and formwork for Phase 2 expansion.
- **Process/mechanical work.** Additional requirements would be expected to include piping fittings, rework at gates in walls to complete "future" connections, and more difficult to stage piping and equipment in future phase. Construction planning would be more complex and require organizing shutdowns and tie-ins, while keeping existing Phase 1 facilities operational.

For the additional project costs, the following factors would be increased to account for additional complexity, as follows:

- **Demolition work.** It is assumed that some sheeting or shoring may be left in place from the earlier phase, so there would be additional costs to remove in this later phase. Phase 2 will likely require removing doors, panels, and/or skylights for the installation of additional equipment. Also, when adding additional process equipment, construction work may need to disconnect portions of piping headers to install additional pumps, valves, blowers, or other equipment items.
- **Overall sitework.** It is assumed that work in Phase 2 may damage ground covers, roads, or other existing sitework, so additional costs would be incurred to return these features to their original condition.
- **Yard electrical.** For Phase 2, shutdown requests will need to be planned and organized but will add to installation complexity while the existing facility is operational. The work will necessitate additional efforts to install into existing electrical infrastructure and additional efforts on re-terminations.
- **Yard piping.** Some rework will be required to excavate down to existing lines and make connections, causing more effort on certain installations. Similar to the yard electrical work, it is assumed that there would be additional efforts for shutdowns and tie-ins while the plant is operational.

The non-construction costs for engineering, services during construction and startup, and construction management would also be expected to increase to reflect additional packages for implementation.

The considerations described in this section are expected to increase the estimated construction and capital costs by approximately 15 to 25 percent compared to the cost differences from Phase 1 to Phase 2 identified previously. **Table 7-12** summarizes the estimated phasing cost to expand a completed Phase 1 project to Phase 2, considering the added costs described herein.

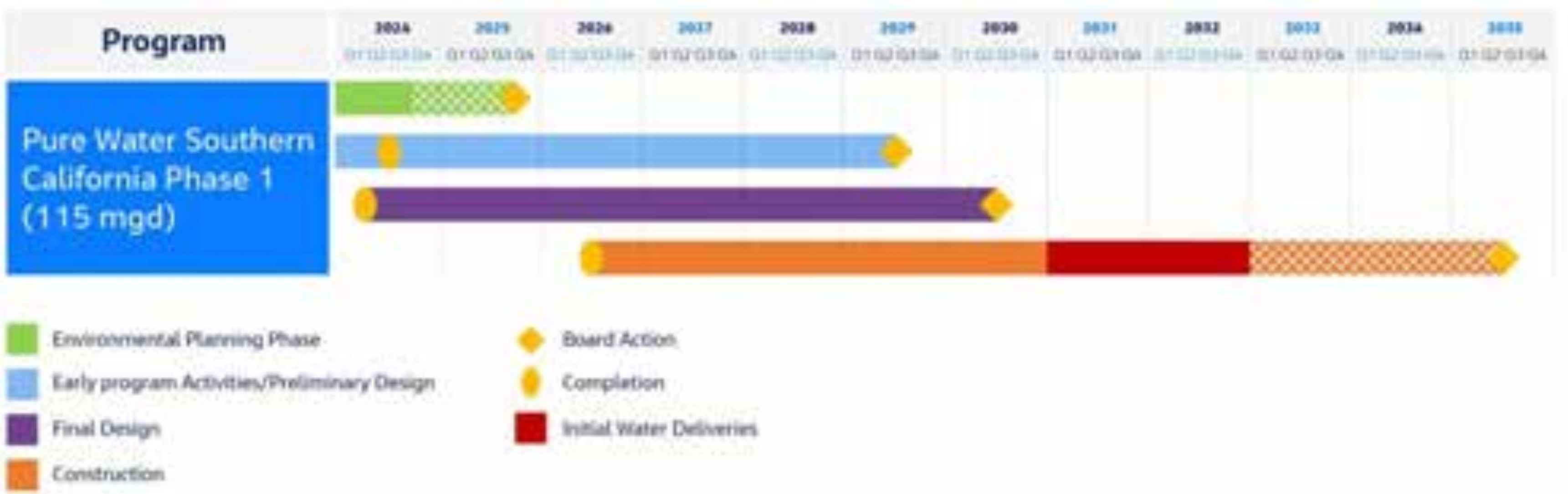
Table 7-12. Estimated Phasing Costs to Expand Phase 1 to Phase 2

Component	Construction Cost	Capital Cost (Construction + Non-Construction Costs)
Estimated cost difference, $M	187	247
Added phasing cost, $M	43	44
Total phasing cost, $M	230	291

7.4 Project Schedule

The implementation project schedule is still being refined, but key tentative milestone dates have been identified. The tentative project schedule is shown in **Figure 7-5**, which was adapted from the September 26, 2023, presentation given to the Subcommittee on Pure Water Southern California and Regional Conveyance's Quarterly update (Metropolitan, 2023). As shown, the implementation schedule is structured around completing startup and testing of Phase 1's 115 MGD AWP Facility in 2035, but the exact date will be determined by Metropolitan. A future Phase 2, with 150 MGD production capacity, is anticipated to be operational at a later date.

Figure 7-5. Pure Water – Tentative Implementation Schedule for Advanced Water Treatment Components



The schedule shown is for Pure Water's treatment components, with this focus to match the scope of this Facilities Plan. There are many additional elements of Pure Water, such as the conveyance facilities, that are occurring in parallel with the tasks shown.

The anticipated schedule does not show the anticipated future conversion to Flex MBR – Secondary. As noted in Section 6 of this Facilities Plan, the conversion of the Flex MBR system from tertiary to secondary operations would require a construction project for additional bioreactors, additional membrane tanks/equipment trains, whole plant equalization, and additional odor control (bioreactor odor control expansion and equalization odor control). This conversion would be the result of specific drivers occurring, such as the regulatory driver for reduction in the mass of nitrogen discharged from the existing ocean outfall system.

Similarly, the anticipated schedule does not show expansions to Flex MBR treatment capacity beyond Phase 2. Additional expansion plans may be developed for expanded reuse as Pure Water is further advanced.

7.5 Required Permits

A number of permits will be required during implementation of the selected project. The following permits have been identified as part of the initial list of required permits:

- Updated NPDES Permit and WDRs
- Water Reclamation Requirements
- Basin-specific Groundwater Recharge Permits or Master Reclamation Permit
- Updated SCAQMD Title V Permit
- Title 22 Engineering Report
- Construction and Excavation Permits for conveyance lines constructed within the public right of way

Additional permits will be identified and secured as the project progresses through implementation.

7.6 Additional Process Evaluations

The Flex MBR concept was selected due in part to its increased flexibility to respond to changes to AWP Facility nitrogen limits, AWP Facility production targets, and future ocean discharge regulations. The following subsections provide additional analysis to support planning for these conditions.

7.6.1 Flex MBR Conversion/Expansion to Secondary MBR

As discussed in Section 7.2.3, the Flex MBR concept was developed based on modular bioreactor design that uses a common bioreactor train volume that can be operated in multiple modes (e.g., TMBR, SMBR). Expanding to SMBR operation requires expansion of the bioreactors, through the addition of four to five trains, aligning with and without HPOLE operation, accordingly.

Figure 7-6 provides an overview of the site planning, and **Table 7-13** summarizes core areas of expansion required to transition to SMBR Operation following a Phase 2 TMBR configuration.

Figure 7-6. Flex MBR Site Plan Phasing to 150-MGD Secondary Operation

Table 7-13. Flex MBR 150MGD AWP Facility Secondary MBR Expansion

Facility	Phase 2 SMBR (150 MGD)
Supplemental PE pump station	PE delivered to fine screens via off-site equalization.
Influent pump station	Install two 86-MGD pumps (maintain 47-MGD pumps). Conversion to feed blend of PE and HPOLE effluent.
Fine screening facility	Add two fine screens.
Bioreactors	Add four bioreactors (with HPOLE). Add five bioreactors (without HPOLE). Add NRCY to all bioreactors (existing and new).
Process air blowers	Add one 40,000-scfm blower, with common process air header.
MBR system	Add five membrane tanks with associated ancillary equipment.
Air scour blowers	Provide one 17,500-scfm blower in MBR equipment building with common process air header.

Facility	Phase 2 SMBR (150 MGD)
RAS pump station	Build pump station with four pumps for Bioreactors 6 and 7 and pump station with five pumps, for Bioreactors 8 through 10.
WAS pump station	Build pump station with two pumps.
Sodium hypochlorite (membrane cleaning)	N/A
Citric acid (membrane cleaning)	N/A
Supplemental carbon	N/A
Phosphoric acid	N/A
Odor control for pump station and fine screen facility	Build larger biotrickling filter and carbon adsorber system.
Odor control for bioreactors	Expand pad to add three trains and three fans, with common foul air header.
MBR filtrate equalization	N/A
PE equalization	Build 40-MG tank off-site.

7.6.2 Achieving More Stringent AWP Facility Limits

The target AWP Facility NO_3 concentration has been an evolving design criterion throughout the JTAP projects having ranged from as stringent as 3.4 mgN/L (Orange County Ground Water Basin Criteria, no longer used) to as high as 10 mgN/L (Drinking Water Primary MCL). To facilitate adherence to these targets, the nitrogen removal processes were evaluated to achieve RO feed targets with a 10 to 20 percent safety factor.

JTAP 1 and 2 evaluated the RO NO_3 removal using vendor projection software at conservative conditions (e.g., worst-case temperature of 31.5°C, 10 percent per year decline in salt rejection, and uniformly aged RO membranes at the expected 5 year end of life). These projections resulted in a recommended planning RO NO_3 removal of 73 percent, with the understanding that this value was conservative for planning purposes. **Table 7-14** summarizes the AWP Facility planning target along with RO NO_3 feed targets evaluated in JTAP 1 (Jacobs, 2021c, 2021d, and 2021e) and JTAP 2 (Jacobs, 2023).

Table 7-14. JTAP 1 and 2 Nitrogen Targets

Condition	AWP Facility Effluent NO_3 (mgN/L)	RO NO_3 Removal[a] (%)	RO feed NO_3 Target (mgN/L)
JTAP 1, Phase 1 and 2	3.4	73	11[b]
JTAP 2, Phase 1	6.4 design (operate at 10)	73	19 design (operate at 29.5)[c]
JTAP 2, Phase 2	6.4	73	19[c]

[a] RO projections predict RO removal for 5-year aged membranes at 73%.

[b] 90% operating target for more stringent limits.

[c] 80% operating target.

The basis of design for JTAP 2 established an AWP Facility effluent quality of 6.4 mgN/L, although earlier phases could operate at a higher NO_3 concentration of 10 mgN/L. Following JTAP 2, Metropolitan conducted a study to assess approaches to achieve more stringent nitrogen targets. Results from this evaluation are summarized in the *Draft Treatment Alternatives Analysis for Additional Nitrate Removal for PWSC* TM (Stantec, 2023a). The evaluation considers the impact of improved RO NO_3 removal rates through single pass RO and two pass RO, additional NO_3 removal within Metropolitan's drinking water system at well heads, dedicated DPR NO_3 removal, improvements to NdN TMBR NO_3 removal, and incorporation of SMBR.

The following analysis provides an overview of approaches to improve NO_3 removal within the selected Flex MBR concept. Achieving lower AWP Facility NO_3 concentrations through improved bioreactor operation requires improved denitrification within the biological process. The process was evaluated at the 6.4 mgN/L condition considered in JTAP 2, the 3.4 mgN/L condition in JTAP 1, and a 4 mgN/L condition. Evaluation of these conditions is based on the conservative assumption of 73 percent RO rejection. All conditions were simulated in the BioWin™ model of the JTAP 2 Flex MBR concept at future design loads operating with carbon as the basis of denitrification. **Table 7-15** summarizes results from these evaluations.

As discussed above, achieving the JTAP 2 NO_3 targets can be achieved without separate incorporation of a NRCY. With the additional recycle requirements of the lower NO_3 targets, incorporation of a NRCY would be recommended to reduce oxygen loading from the membrane tanks (via RAS). While additional considerations are warranted to achieve lower targets, the Flex MBR concept enables achieving these targets with minimal modifications.

Table 7-15. Operating Requirements to Achieve NO3 Targets

AWP Facility Effluent NO_3,mgN/L	RO Feed Target[a] mgN/L	Carbon Use gpd	Recycle Rate (RAS + NRCY) %
6.4	19[b]	13,500	60%
4.0	13[c]	18,500	130%
3.4	11[c]	20,300	170%

[a] RO projections predict RO removal for 5-year aged membranes at 73%.

[b] 80% operating target

[c] 90% operating target for more stringent limits

The basis of the JTAP conceptual designs is through the use of vendor RO projection software based on application-specific assumptions. This approach is intended to be conservative to overcome the many site-specific considerations that may not be represented in the projection during design. Demonstration of site-specific RO removal, such as the data from the Demonstration Plant, could be utilized to demonstrate a higher RO removal rate. It is recommended that continued evaluation of the Demonstration Plant is leveraged to develop application specific design criteria.

7.6.3 Achieving Ocean Discharge Requirements

From a nutrient removal perspective, the current Warren Facility effluent discharge requirements only include an effluent ammonia goal of 49 mgN/L, and it is expected that facilities discharging to the ocean will not be penalized for increases in concentration as a result of the associated concentrate disposal from RO as part of AWP Facility. While current regulations do not necessitate nitrogen removal or concentrate treatment for discharge to the ocean outfall, future nitrogen mass reductions are a possibility.

As described in Section 3.14.1.1, the Sanitation Districts considered a potential mass reduction of up to 60 percent in TIN (or sum of NH_x-N, NO_2-N, and NO_3-N) on an average annual basis. The 60 percent mass reduction is calculated relative to the current Warren Facility configuration that discharges non-nitrified secondary effluent at the future average day conditions. The projected TIN load to the ocean from the existing HPOAS process configuration is 124,300 lb-N/d. Achieving the 60 percent mass reduction would result in a mass discharge limit of 49,720 lb-N/d on an average basis.

The Flex MBR concept described above provides reductions through the incorporation of sidestream deammonification (approximately 20 percent), mass diverted through AWP Facility flow distribution (5 to 10 percent, depending on AWP Facility nitrogen target), and denitrification provided within the Flex MBR operating mode. **Table 7-16** summarizes the predicted mass removal provided through the incorporation of trains to meet Pure Water flow and nitrogen targets. Mass removals are calculated at the future (2080) planning year for the NdN TMBR and SMBR configurations, including the impact of sidestream deammonification and AWP Facility diversion.

The mass removal was estimated at the JTAP basis of design RO NO_3 removal of 73 percent. The TMBR is predicted to provide 42 percent reduction in effluent nitrogen mass loading in Phase 1 and 49 percent reduction in Phase 2. Moving to SMBR provides a higher proportion of PE treated through NdN processes and achieves improved NO_3 removal performance relative to TMBR. As shown, Phase 2 SMBR would provide 58 percent reduction in effluent nitrogen mass loading, coming close to the target.

If higher NO_3 removal is observed in the RO, then the amount of NO_3 load directed to the ocean outfall would increase. For example, a 90 percent NO_3 removal in the Phase 2 TMBR operating at the same Flex MBR filtrate NO_3 concentration would yield 46 percent removal of nitrogen (compared to 49 percent in the baseline condition). If the NO_3 targets in the Flex MBR are increased to align with improved RO performance, further increases in the ocean discharge mass loading would be expected. At the extreme case where the Flex MBR can operate in N-only operation, the expected mass reduction would be associated with sidestream treatment and diversion to AWP Facility, totaling between 25 and 30 percent reduction.

Table 7-16. Ocean Mass Discharged at the Design Year

	Train 1 (NdN TMBR)			Train 3 (SMBR)
Parameter	**Phase 1 Design**	**Phase 1 Operation**	**Phase 2 Design/ Operate**	**Phase 2**
Nitrogen Concentration				
MBR filtrate, mgN/L	18.9	29.5	18.9	8.5
Ocean discharge (73% RO removal), mgN/L	46	52	50	41
Mass Removal[a]				
RO removal =73%	42%	34%	49%	58%

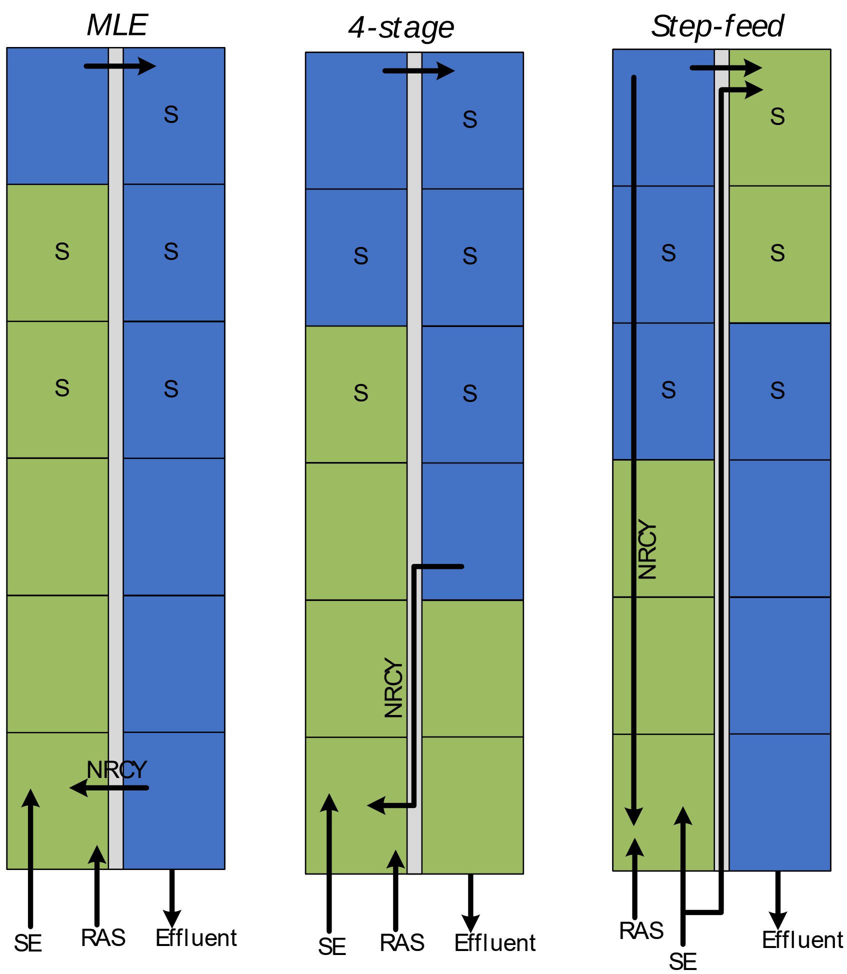
[a] Mass-based reductions calculated relative to predicted TIN discharge from HPOAS process, without HPOLE or AWP Facility pretreatment, under future loading conditions.

Achieving the 60 percent mass reduction target could be achieved through bioreactor operational or capital modifications, RO concentrate treatment, or TMBR WAS Seeding to the HPOAS

Trains not feeding the tertiary process. This evaluation focused on achieving the 60 percent mass reduction target through modifications to the Flex MBR operation/phasing, but TMBR WAS seeding and RO concentrate treatment were briefly considered in JTAP 1 during the original evaluation, *Task 9 Report Analysis of Trains 6, 7, and 8 (Membrane Bioreactor Options) for Whole-Plant Nitrogen Removal* (Jacobs, 2021f). Concentrate treatment is a viable approach that has been demonstrated at other facilities internationally, but implementation at this scale would be a first for the industry.

Achieving the targets entirely through improved nitrogen removal requires an MBR filtrate NO_3 concentration of approximately 6.5 mgN/L. The Flex MBR – Tertiary was evaluated under a number of scenarios, including (1) the baseline Flex MBR – Tertiary configuration, which is similar to a MLE configuration with the NRCY incorporated, (2) modification of process trains to a 4-stage Bardenpho configuration, and (3) a step feed configuration. **Figure 7-7** provides an overview of the three process trains considered. The 4-stage Bardenpho utilizes the first pass swing zones as aerobic while converting the last two aerobic zones in the second pass to be post anoxic zones fed with supplemental carbon feed. The step feed process utilizes the built-in flexibility of the swing zones and multi-purpose channel to achieve reduction targets. In the step feed or 4-stage configurations, during redundancy operation during which a half-train is taken offline, the original MLE configuration, as described in Section 7.2.3, would need to be brought online for that half-train, while the remaining trains could still be operated as step feed or the 4-stage process.

Figure 7-7. Alternative Flex MBR – Tertiary Configurations



Approaches to achieve the 60 percent reduction target within the Flex MBR concept include improved NdN performance (e.g., by dosing additional carbon or increased NRCY rates, altered process configuration, etc.), additional TMBR trains/capacity, or a combination of improved performance and increased capacity. All conditions were simulated in the BioWin™ model of the JTAP 2 Flex MBR utilizing external carbon at the Phase 2 capacity. As noted, this evaluation was completed at an RO removal rate of 73 percent to align with previous planning efforts.

The results from this evaluation are summarized considering 1) maximizing tertiary performance, 2) expanding tertiary capacity, and 3) converting to secondary treatment, with each category addressed in the following discussion. Biowin™ simulation results are summarized in **Table 7-17**.

- **Alternative 1 – Improved Performance.** Improved performance was evaluated for three configurations: Alternative 1A represents enhancement of the baseline MLE configuration, Alternative 1B represents conversion to a 4-stage process, and Alternative 1C represents a step feed process. The theory behind utilizing the 4-stage Bardenpho was to reduce carbon use relative to the baseline MLE configuration. However, maintaining residual anoxic NO_3 below the target 0.25 mgN/L required increased carbon dosing and recycle rates. Comparatively, the step feed process utilizes similar carbon dosing while minimizing overall recycle rates relative to maximizing denitrification within the baseline

MLE configuration and 4-stage Bardenpho. Additionally, maximizing the MLE performance would require a NRCY rate of 285 percent, which corresponds to a per train NRCY flow near 100 MGD, and the 4-stage process requires a NRCY of 400 percent. For comparison, the NRCY flow estimated for a future SMBR expansion was approximately 200 percent (40 MGD per train). The step feed process utilizes a NRCY rate of 110 percent that aligns well with the future SMBR NRCY flow rate of 40 MGD per train. With all approaches yielding similar carbon requirements, the higher NRCY requirements of the MLE and 4-stage process suggest that step feed approach should be considered as the representative approach to maximize tertiary performance.

- **Alternative 2 – Increased Capacity.** Two expansion scenarios of the Flex MBR – Tertiary were also considered. The first expansion assumes the Flex MBR operates at the 19 mgN/L target and requires three additional trains to manage the tertiary flow required (Alternative 2A). The second considers maximizing the denitrification within the bounds of the Flex MBR concept, including limiting the NRCY to 40 MGD per train (Alternative 2B). With the NRCY limited to 40 MGD per train, the achievable NO_3 concentration is near 11 mgN/L. Under the second scenario, only one additional train is required. Both approaches require similar external carbon demands, with a slight reduction for the higher 19 mgN/L target.
- **Alternative 3 – Secondary Conversion.** Achieving the nitrogen targets within SMBR operation requires modest increases in capacity or performance. Improving performance could be achieved through the addition of external carbon combined with an increase in the NRCY rate or simultaneous nitrification denitrification (SND). Four approaches of the SMBR were considered. Alternative 3A includes the SMBR at the Phase 2 production capacity with supplemental carbon addition, and Alternative 3B incorporates SND. Alternative 3C and Alternative 3D involve expansion of the SMBR or HPOLE capacity, respectively, with effluent discharging to the ocean. Alternative 3C requires an approximate 10 MGD increase in SMBR capacity, resulting in one additional train. Alternative 3D includes operation of an additional HPOLE train discharging to the ocean.

Table 7-17. Process Modeling Results to Achieve 60 Percent Mass Reduction

Alternative	Description	No. of HPOLE Trains	No. of Flex – MBR Trains	Filtrate NO_3 mgN/L	Filtrate Flow MGD	Carbon Use gpd	RAS Rate %	NRCY Rate %
Tertiary – Improved Performance (Alternative 1)								
1A	MLE + NRCY	2	5	6.5	176	24,500	60	285
1B	4-Stage Bardenpho	2	5	1.0	176	25,400	90	400
1C	Step Feed	2	5	6.5	176	25,500	90	110
Tertiary – Increased Capacity (Alternative 2)								
2A	JTAP Performance	2	8	19.0	260	21,800	70	0
2B	Improved Performance	2	6	11.0	195	23,000	60	115

Alternative	Description	No. of HPOLE Trains	No. of Flex – MBR Trains	Filtrate NO_3 mgN/L	Filtrate Flow MGD	Carbon Use gpd	RAS Rate %	NRCY Rate %
Secondary Conversion (Alternative 3)								
3A	Improved Performance + External Carbon	2	9	6.5	176	2,000	130	250
3B	Improved Performance + SND	2	9	4.5	176	0	130	250
3C	Increased Capacity	2	10	8.2	185	0	130	150
3D	HPOLE Expansion	3	9	8.2	176	0	130	150

The Flex MBR provides multiple opportunities to enhance nitrogen removal to achieve the potential 60 percent reduction target through improved performance, capacity expansions, secondary conversion, or a combination of approaches. While each approach can achieve these targets, they are associated with distinct tradeoffs. Reliance on tertiary process enhancements (Alternatives 1A–1C and 2B) generally require increased operational costs through increased carbon and internal recycle rates and/or increased process complexity. Expansion of the tertiary process (Alternatives 2A and 2B) minimizes recycle rates but adds additional capital costs to expand the process. Expansion to SMBR (Alternatives 3A-3D) eliminates the need for supplemental carbon addition but requires a significant increase in bioreactor volume and/or increased operation of HPOLE. These approaches should continue to be evaluated as more clarity becomes available of the magnitude and timing of future ocean nitrogen reductions.

In addition, preliminary bench screening and pilot testing of PdNA suggests that PdNA incorporation could reduce external carbon by 50 to 60 percent and aeration demands by 40 to 50 percent. Continued evaluation of the potential for PdNA incorporation should be considered as an approach to reduce operating cost and enhance performance.

7.6.4 Expanded Reuse (180 MGD Production)

The Flex MBR was evaluated for an expanded reuse scenario that represents a potential future condition in which an expanded Flex MBR and AWP Facility would be located on the Joint Plant Site. The expanded reuse (180-MGD produced) scenario was evaluated to assess the potential to fit TMBR and SMBR configurations on the existing Joint Plant Site. For site planning purposes, both trains were evaluated without the benefit of HPOLE upstream for conservatism. However, TMBR was evaluated with HPOLE upstream to understand treatment performance with the implementation of HPOLE.

Achieving 180 MGD of production requires approximately 215 MGD of feed flow without HPOLE. Operating as a TMBR requires two additional bioreactor basins (seven total) and five additional membrane tanks (30 total) beyond the Phase 2 concept presented in this conceptual design for 150 MGD. **Figure 7-8** provides an overview of expanded reuse concept applied to tertiary operation (without HPOLE). The site space allocated on the Joint Plant Site provides sufficient area to achieve the required TMBR feed flow, with space remaining for additional capacity (up to approximately three trains at 30 MGD each). TMBR with HPOLE upstream requires a total of six bioreactor basins to achieve the treatment goals.

Figure 7-8. Expanded Reuse (180 MGD Produced Flow) Train 1 (Flex MBR - Tertiary) Conceptual Site Plan

For the same expanded reuse scenario and without HPOLE, the SMBR configuration is predicted to require three additional bioreactor basins compared to the 150 MGD production target, for 12 total bioreactor trains. The membrane tank expansion will be heavily influenced by the required peak flow capacity required to maintain the Warren Facility's overall wet-weather plant capacity. For this assessment, it was assumed that the two-times peaking factor applied to the secondary concept design was maintained, providing a peak hour flow capacity of 430 MGD. The result is the addition of five more membrane tanks.

Figure 7-9 provides an overview of the Train 3 concept for the expanded reuse scenario. To fit the additional bioreactors required on the site space, the other facilities (screening, pumping, odor control) were relocated south of the membrane tanks. While this concept appears to fit within the Joint Plant Site boundaries, the evaluation has not considered key accompanying implementation considerations (e.g., pipe routing, road access, O&M access, constructability, and ancillary facilities) that will likely infringe on the available site space. Constructability of the concept shown will be challenging. Abandonment of HPOAS trains G and H would improve the viability of this layout. Modifications to the bioreactor (e.g., increased length-width) could also be considered to improve east to west access without infringing on the existing HPOAS trains. Creating additional available space on the Joint Plant Site or reducing bioreactor MCRT would also help to alleviate some of the challenges with fitting SMBR on the site. As this expanded reuse scenario progresses, more detailed site planning should be completed in conjunction with site planning for the AWP Facility to understand the implementation considerations more fully.

Figure 7-9. Expanded Reuse (180 MGD Produced Flow) Train 3 (Flex MBR – Secondary) Conceptual Site Plan

7.6.5 Whole-Plant Secondary Nitrogen Removal

The evaluation indicated that whole-plant nitrogen removal may not be required to achieve the potential TIN mass reductions anticipated in future regulations. However, potential approaches to achieve full-plant secondary treatment are considered to enable holistic site planning for future Warren Facility processes. As summarized in the *Updated Basis of Assumptions* TM (Hazen and Jacobs, 2023), the projected future (2080) average daily flow of 307 MGD and the associated projected future loadings (for 2080) were utilized as the foundation of this evaluation. The Phase 2 concept of the SMBR was sized for 182 MGD of average day capacity, which required 10 bioreactor basins (without HPOLE). The whole-plant conditions were simulated in the BioWin™ model of the Flex MBR, expanded to the sizing described earlier in this section. The model was utilized to evaluate two approaches to whole plant nitrogen removal:

- **SMBR Expansion.** Incorporation of a whole-plant Train 3 approach is estimated to require a total of 17 bioreactor trains (expansion by seven trains). Three potential locations were identified as options for the site of the additional capacity. Figure 7-10 provides an overview of the three approaches considered. Option C would require extensive site space to be reserved during the initial Pure Water phases. As whether whole-plant SMBR of this magnitude is implemented in the future carries significant uncertainty, it is recommended that future siting evaluations focus on locating within the abandoned HPOAS footprint (Option A) or site location north of the train tracks (Option B).

- **Option A:** If/when Train 3 is operational, a significant portion of the HPOAS process could be taken out of service and demolished to free up space on site for future use. This would allow for additional capacity to be added within the HPOAS footprint. Option A presents a potential option where HPOAS Reactors E-H are replaced with a Train 3 expansion.
- **Option B.** The Sanitation Districts have allocated space in the north-east corner of the existing property for future NdN processes. The potential location has limited existing structures, easing construction. The primary challenge with this location is the flow routing required to bring to and from the location.
- **Option C.** The additional capacity could be added on the Joint Plant Site if additional space could be made for future AWP Facility processes elsewhere. A potential location for the AWP Facility could include site space within the existing HPOAS reactors that could be abandoned in the future under this scenario.

- **Expanded implementation of HPOLE**. With 182 MGD of average day capacity provided through 10 Flex Trains operating in SMBR mode, an average day balance of 125 MGD (future flow) would remain to be processed by HPOLE trains. As described in HPOLE Conceptual Design Development for PWSC Program Trains (Hazen, 2023a), each HPOLE train can process near 18 MGD of PE at average day and 50 MGD at peak hour. At 18 MGD of capacity, the remaining 125 MGD balance can be processed by seven HPOLE trains, leaving one spare train. From a wet-weather perspective, the Warren Facility is required to process 700 MGD of peak hour capacity. The 10 SMBR trains and associated membrane tanks were conceived to provide 364 MGD of peak capacity, leaving a balance of 336 MGD of peak hour capacity. With seven HPOLE trains operating, the 336 MGD balance can be managed within the bounds of the HPOLE capacity. **Figure 7-11** provides an overview of the HPOLE approach.

The whole-plant approaches considered provide viable paths to achieve whole-plant nutrient removal, and both approaches provide an approximate 85 percent reduction in TIN, which can be extended to near 90 percent with treatment of RO concentrate. Expansion of the SMBR concept reduces the secondary footprint on the site but requires significant modifications to the existing Warren Facility site and unit processes. Comparatively, an HPOLE expansion maximizes the use of existing assets, including the recently installed vapor pressure swing adsorption oxygen generators, but comes with the disadvantage of larger land requirements. The HPOLE approach also relies on continued utilization of pure oxygen, which can be considered a benefit from the view of managing industrial loads but requires continued maintenance of the oxygen generation systems. As planning progresses, the operational cost of HPOLE compared to the SMBR or a replacement conventional activated sludge process utilizing diffused air could be considered.

Whole plant equalization was considered with the Phase 2 SMBR concept to stabilize flows through the AWP Facility. In a whole plant SMBR, equalization provides the added benefit of reducing the peak flows to be treated through the membranes, reducing membrane system and associated costs. The baseline equalization concept incorporated offsite equalization as described in the JTAP 1 report, Task 2 Report – Analysis of Train 4 (Secondary BNR + Single-Pass RO) and Train 5 (Tertiary BNR + Single-Pass RO) (Hazen, 2021). **Figure 7-10** includes an alternate equalization location within the footprint of the abandoned HPOAS reactors.

Figure 7-10. Whole-Plant Flex MBR – Secondary Operation

Figure 7-11. Whole-Plant Flex MBR + HPOLE

7.7 Key Issues to Be Resolved

As the project moves forward, remaining key issues will be resolved. The program manager for Metropolitan recently began their work, and project design is not yet underway. Thus, these key issues are typical for this type of project and this stage of the project, and there are plans to address and resolve each issue as the project implementation moves forward. No significant outstanding issues, beyond the typical issues, have been identified. Moving forward, the following will be addressed and resolved:

- The future Joint Plant Site is being remediated at this time, and remediation is expected to be completed within 5 years.
- Further demonstration testing will continue to be performed at the Demonstration Plant to support the project.
- Metropolitan and the Sanitation Districts are negotiating an agreement for the O&M of Pure Water.
- Metropolitan will develop agreements with recycled water customers.

8
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Appendix B.2

OPC for NdN tMBR Train
Draft Final TM (2022)

Updated Opinion of Probable Cost for the NdN Tertiary MBR based Advanced Water Treatment Facility

Draft Final Technical Memorandum

Date: 8th July, 2022

Prepared for:

Metropolitan Water District of Southern California

Prepared by:

Stantec

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Abbreviations

Abbreviation	Definition
ADD	Average Day Demand
AFY	Acre Feet per Year
APC	Advanced Purification Center
AWT	Advanced Water Treatment
AWTF	Advanced Water Treatment Facility
AWTP	Advanced Water Treatment Plant
BAC	Biological Activated Carbon
BIM	Building Information Modeling
DAFT	Dissolved Air Floatation Treatment
DDW	Division of Drinking Water
DPR	Direct Potable Reuse
EBCT	Empty Bed Contact Time
FAT	Full Advanced Treatment
FORCO	Fletcher Oil and Refinery Company
FTE	Full-time Equivalents
GWRS	Groundwater Replenishment System
HGL	Hydraulic Grade Line
HPOAS	High-purity Oxygen Activated Sludge
HRT	Hydraulic Retention Time
I&C	Instrumentation and Controls
IPR	Indirect Potable Reuse
JTAP	JWPCP Technical Analysis Project
JWPCP	Joint Water Pollution Control Plant
LACSD	Los Angeles County Sanitation Districts
LOX	Liquid Oxygen
MDD	Maximum Day Demand
MF	Membrane Filtration (Micro or Ultrafiltration)
MGD	Million Gallons per Day
MBR	Membrane Bioreactor
Metropolitan	Metropolitan Water District of Southern California
MWD	Metropolitan Water District of Southern California
NdN (also NDN)	Nitrification-Denitrification
NRCY	Nitrified Mixed Liquor Recycle
O&M	Operations and Maintenance

OPC	Opinion of Probable Cost
OPCC	Opinion of Probable Construction Cost
PHD	Peak Hour Demand
PWSC	Pure Water Southern California (formerly the Regional Recycled Water Program)
QTO	Quantity Take-off
RAS	Return Activated Sludge
RO	Reverse Osmosis
SCE	Southern California Edison
sMBR	Secondary MBR
TDH	Total Dynamic Head
TM	Technical Memorandum
T&M	Testing and Monitoring
tMBR	Tertiary MBR
TOC	Total Organic Carbon
UV/AOP	Ultraviolet Advanced Oxidation Process
VFD	Variable Frequency Drive
WAS	Waste Activated Sludge
WBMWD	West Basin Municipal Water District

1.0 INTRODUCTION

In accordance with the scope of work in Task Order No. 1, Task 6 – "Cost of Service Analysis", this technical memorandum (TM) has been prepared to summarize this task's approach and findings. This includes updated cost estimates for the full-scale advanced water treatment (AWT) facility.

1.1 PROGRAM BACKGROUND AND DRIVERS

Imported sources make up a large portion of Metropolitan Water District of Southern California's (Metropolitan) customers water supplies. The reliability of imported supplies is in question due to both water availability with the imposition of restrictions due to ongoing drought conditions as well as the potential impacts to conveyance infrastructure functionality after a major seismic event. The potential for procuring new supplies to import are very limited. Within this context, the reuse of water from the municipal wastewater facilities, including the Los Angeles County Sanitation Districts' (LACSD) Joint Water Pollution Control Plant (JWPCP), is a critical supply component necessary to provide long-term sustainable water supply sources to Metropolitan's customers.

Metropolitan and LACSD are developing Pure Water Southern California (PWSC), a large-scale regional recycled water program, to beneficially reuse water currently discharged to the Pacific Ocean. The overall program involves construction of an Advanced Water Treatment (AWT) facility to treat effluent from the LACSD's Joint Water Pollution Control Plant (JWPCP) located in the City of Carson, California, as well as a new regional conveyance system and associated infrastructure to utilize the purified water to augment regional water supplies.

PWSC is planned to purify primary or secondary wastewater effluent from LACSD's JWPCP through AWT processes for potable reuse in Southern California. Water from the program will be used to recharge groundwater basins. This system will also have the flexibility to accommodate industrial users whose needs are consistent with the quality of water produced by the advanced water treatment facility (AWTF). Finally, future use of this system for direct potable reuse (DPR) applications appears feasible once applicable regulations are established. As currently envisioned PWSC will be constructed in a phased approach with the ultimate capacity of the program considering both the availability of source water at the JWPCP and the anticipated water demands of member agencies for groundwater replenishment and raw water augmentation.

1.2 PROJECT BACKGROUND AND OBJECTIVES

Various studies have been performed by Metropolitan and LACSD on viability and cost of implementing an advanced water treatment facility (AWTF). In 2016, Metropolitan completed a feasibility study (Metropolitan Report No. 1530, 2016) that included a Class 4 opinion of probable cost (OPC) prepared by Stantec (Stantec, 2016) and used as part of an assessment of PWSC's economic viability. Stantec performed a nitrogen management evaluation (Stantec, 2018), prepared site layouts and developed cost estimates for various AWTF phasing alternatives; findings from these studies were summarized in a conceptual planning studies report (Metropolitan Report No. 1618, 2019). Stantec updated the OPC in 2018 (Stantec, 2018) to reflect then current market conditions. Later in 2020, LACSD retained Jacobs and Hazen separately, each to conduct specific tasks for the JWPCP Technical Analysis Project (JTAP), which included preparation of Class 4 cost estimates for multiple process trains (LACSD, 2021). This TM incorporates information from the JTAP reports and provides an updated cost estimate after analyzing the differences between previous OPCs and the equivalent process train OPC in the JTAP reports (Train 1C, by Jacobs). The resulting OPC is a Class 4 estimate. The class of estimates referred to herein are based on criteria established by the Association for the Advancement of Cost Engineering International (AACEI). Class 4 cost estimates have typical expected accuracy ranges of -15% to -30% on the low side, and +20% to +50% on the high side. The timeline in **Figure 1-1** depicts the flow of work leading up to this report.

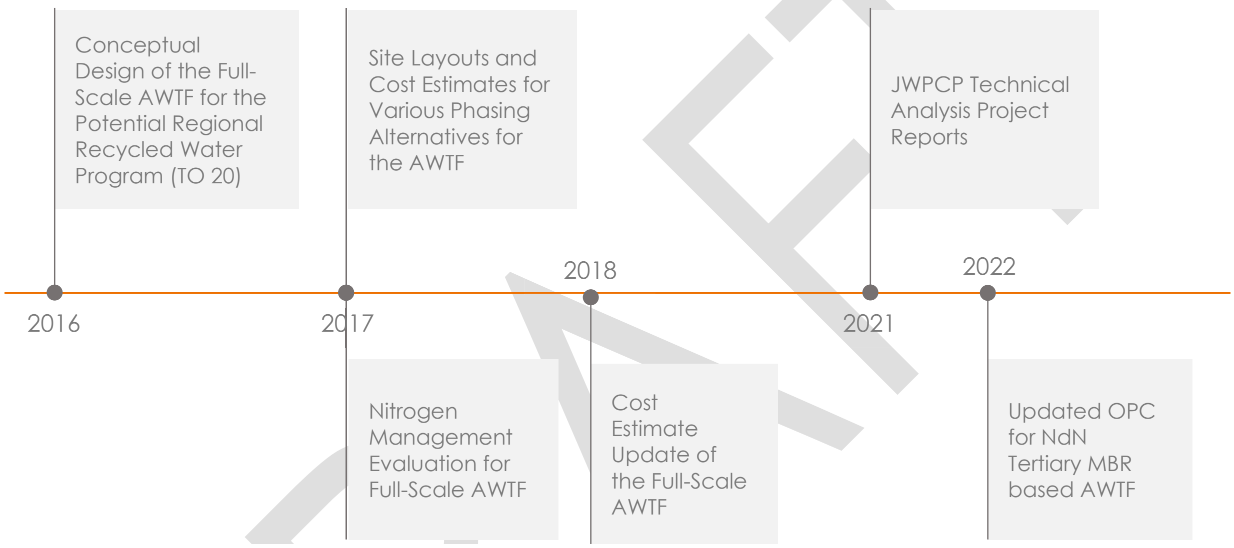

Figure 1-1: Timeline of Cost Estimates for the AWTF to Date

The objectives of this TM are to:

1. Review the differences between the 150-MGD IPR-only AWTF estimates prepared by Stantec (for Metropolitan) and Jacobs (for LACSD) and develop an updated 2021 estimate.
2. Update the 2021 150-MGD IPR-only AWTF estimate to 2022 dollars and include additional ancillary facilities identified by the Metropolitan staff.
3. Develop estimates for DPR facilities for each phase based on Metropolitan's program phasing plan.
4. Develop cost estimates for each phase including ancillary and DPR facilities.

The construction and annual O&M costs presented in this TM are costs at year zero with an assumption that Metropolitan will make appropriate adjustments based on program's construction schedule.

1.3 STUDY APPROACH

The general approach for updating the OPC is shown in **Figure 1-2** and summarized as follows:

- Stantec's previous estimates from 2016 and 2018 for a 150-MGD IPR-only AWTF were escalated to 2021 dollars so that they can be compared to Jacobs' 2021 estimates from JTAP studies.
- Each line item from these two 2021 estimates was reviewed to understand the differences and an updated estimate was developed for the overall AWTF cost.
- The 2021 updated estimate was then escalated to 2022 dollars at Metropolitan's request.
- Several new ancillary facilities were identified by Metropolitan staff to be included in the site plan and cost estimates were developed for those facilities in 2022 dollars.
- The estimates for the ancillary facilities were added to the 2022 AWTF estimate to produce the overall facility cost for a 150-MGD IPR-only facility at the Joint Site.
- Phasing plan developed by Metropolitan was used to estimate costs for each phase:
  - Phase 1: 100 MGD IPR at Joint Site + 10 MGD DPR at Weymouth WTP
  - Phase 2: Additional 50 MGD IPR at Joint Site + 150 MGD DPR at Joint Site
- Using the cost estimates for DPR facilities and applying phasing factor for additional mobilization/demobilization costs, cost estimates were developed for Phases 1 and 2.

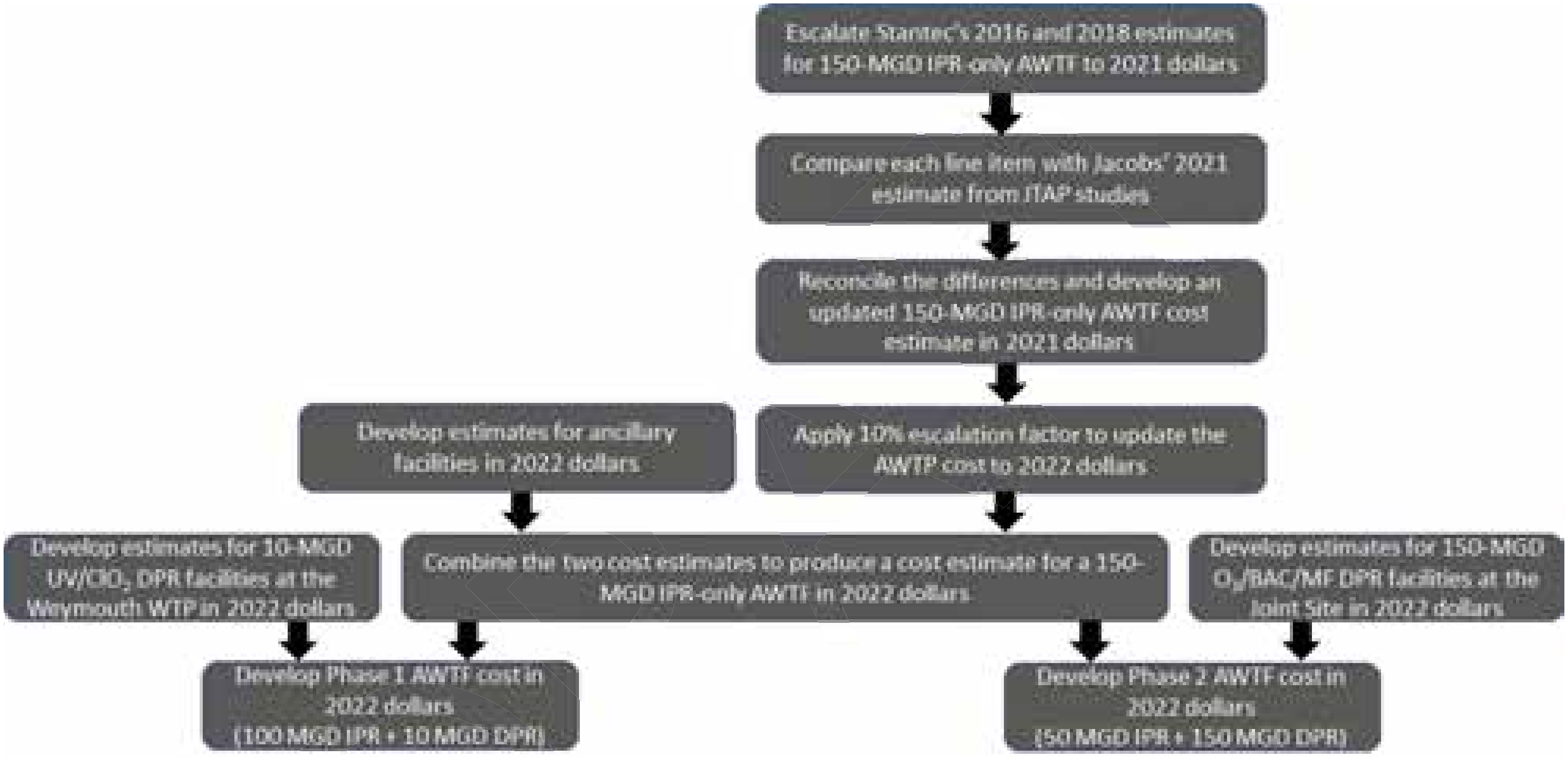

Figure 1-2: Approach to Develop the Cost Estimates for IPR and DPR Facilities

1.4 TM STRUCTURE AND CONTENT

This TM consists of five sections:

- **Section 1 – Introduction**: Provides background, drivers, and approach to developing the OPC.
- **Section 2 – Update of Cost Estimates**: Provides assumptions and key parameter values used to develop the capital and O&M cost estimates along with the estimates in 2021 dollars. Line by line comparison between Stantec and Jacobs' estimates is provided in Appendices B and C; those estimates are shown in 2021 dollars since Jacobs estimates were developed in 2021.
- **Section 3 – Ancillary Facilities**: Provides a brief description of facilities and a summary of the cost estimate for ancillary facilities.
- **Section 4 – DPR Facilities**: Provides a brief description of facilities and a summary of the cost estimate for DPR facilities.
- **Section 5** – **Cost Estimates for Individual Phases based on Current Program Phasing Plan**: Describes the methodology to derive cost estimates for the two program phases and resulting estimates.
- **Section 5 – Summary**: Summarizes the updated cost estimates in 2022 dollars.

2.0 UPDATE OF COST ESTIMATES

The cost estimates for each unit process/component of the full-scale AWT facility from Stantec and Jacobs were compared and the differences analyzed to develop the updated estimates for the full-scale AWTF. This section describes the key project markups and assumptions used in developing the capital and O&M costs along with the summary of these estimates. Details on differences between the estimates and the justifications for new estimates are included in **Appendices B and C** for the construction and O&M costs, respectively. The costs for the clearwell, effluent conveyance pumps and surge tanks are not included in these estimates since those will be covered by PWSC's conveyance team.

2.1 DESCRIPTION OF PROCESS TRAIN

The treatment process presented in Stantec's reports is equivalent to the Train 1C process in the JTAP reports. The process configuration (**Figure 2-1**) consists of a NdN tMBR, single pass RO, UV/AOP and stabilization. The sidestream centrate treatment has also been included in the overall treatment cost. The design criteria for the process train are included in **Appendix A**.

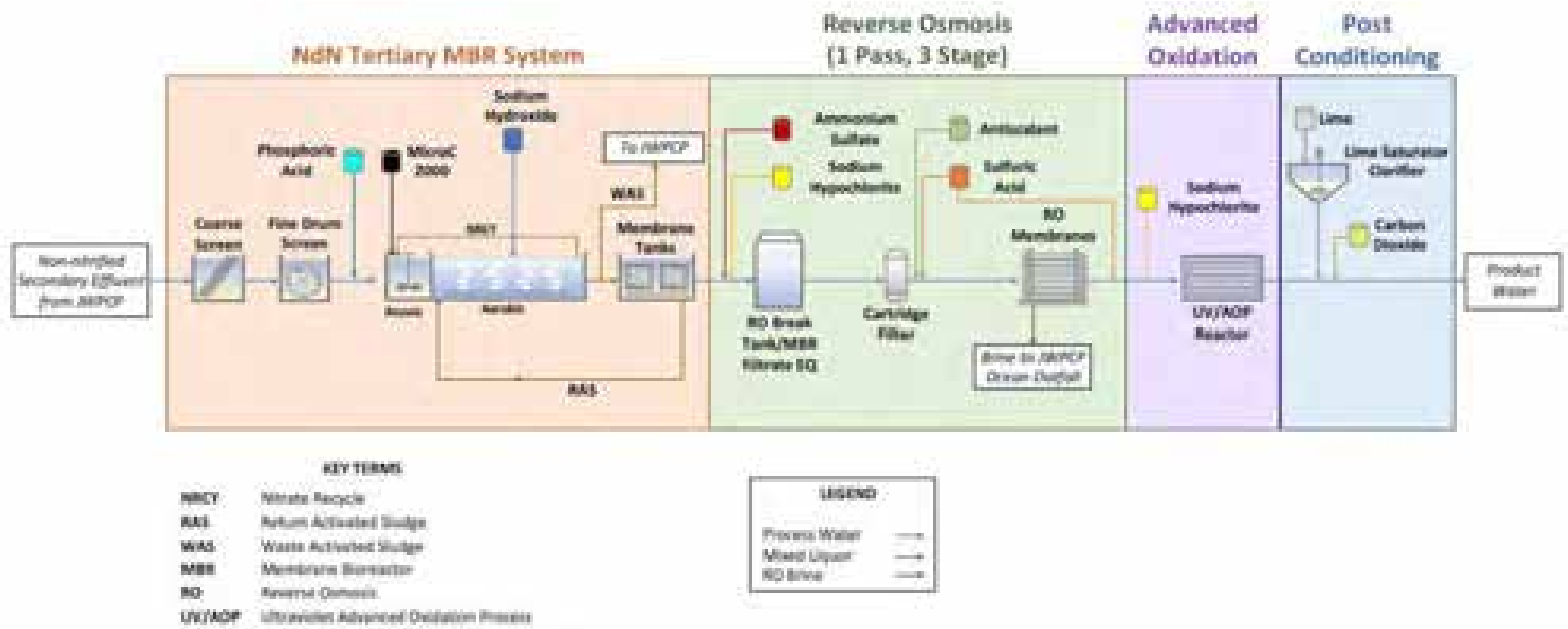

Figure 2-1: Process Flow Diagram for the NdN tMBR based Advanced Water Treatment Facility

2.2 COST ESCALATION

Stantec estimates developed in 2016 (and updated in 2018) were first escalated to 2021 dollars to allow comparison with Jacobs' estimates developed in 2021. Stantec's cost estimation team utilizes the TBD Consultants Bid Index, based on actual construction costs in San Francisco, CA, to provide OPCs with reasonable accuracy. Though based in San Francisco, we have found this bid index to be reliable. According to TBD Consultants bid index, an escalation of 33% on construction costs was required to update the May 2016 estimates to May 2021 dollars. A comparison of the TBD index to ENR's California Construction Cost Index is shown in **Table 2-1**. To compare the operations and maintenance (O&M) costs, Stantec used escalated equipment costs as a basis to develop the equipment replacement and maintenance costs.

Table 2-1: Construction Index Factor Comparison

	ENR CCCI[1]	TBD Consultants Bid Index[2]
May 2016	10315.44	193.1
May 2018	11012.77	219.06
May 2021	11989.91	257.12
Escalation Factor	16.2%	32.8%

1. ENR California Construction Cost Index (CCCI) is provided in the JTAP reports.
2. TBD Consultants uses a construction bid index based off of actual bids in San Francisco, CA. http://www.tbdconsultants.com/mobi/TBDBidIndex.htm

2.3 CONSTRUCTION AND PROJECT MARKUPS

The markups that differ between Stantec's estimates prepared for Metropolitan and Jacobs' estimates prepared for LACSD include:

- Construction markups (e.g. contractor overhead and profit)
- Project markups (e.g. engineering and administrative services, contingency)

Construction markups are summarized in **Table 2-2**. Based on current market conditions, the markups from Jacobs' estimates are more consistent with recent experience from Stantec's cost estimators and are recommended to be used for the updated costs.

Table 2-2: Construction Markups

	Stantec's Estimate from 2016 TO20	Jacobs' Estimate	Recommendation
Sales Tax	9.5% applied to 40% of subtotal, separate from Contractor markups	9.5% applied to 40% of subtotal, prior to Contractor markups	9.5% applied to 40% of subtotal, prior to Contractor markups
Contractor Overhead	Combined with Contractor Profit	7.5%	7.5%
General Conditions	5% at 4 years	7.5%	7.5%
Subcontractor General Conditions	6%	not stated	included in general conditions percentage
Contractor Profit	10% on self-perform, 4% on subs	10%	10%
Mobilization/Bonds/Insurance	2.50%	5%	5%
Total	19%[1]	30%	30%

1. This is a blended percentage based on taking the contractor markups total divided by the cost subtotal

Project markups are summarized in **Table 2-3**. The recommended markups were obtained from Metropolitan and were applied on top of construction costs for an estimated project cost.

Table 2-3: Project Markups

	Metropolitan Conceptual Design Report	Jacobs' Estimate	Recommendation
Engineering	25%	12%	17%
Services During Construction/Startup		6%	6%
Construction Management (CM)		12%	12%
Permitting/Legal Fees		Lump sum of $10M	Lump sum of $10M
Administrative Fees		Lump sum of $5M	5%
Engineering and Admin Total	25%	30% + $15M	40% + $10M
Contingency	35%	35% applied prior to Engineering and Administrative Costs	35% applied prior to Engineering and Administrative Costs

2.4 LIMITATIONS OF THE APPROACH

The updated OPCs presented in this TM combine two cost estimates with different underlying assumptions and basis of design at different points in time. While the basis of design for each OPC was evaluated, the unit costs the OPCs are built from were not evaluated or updated. The updated OPC considered these assumptions and generally used the more conservative estimate.

Stantec strongly recommends updating this OPC using the quantity take-offs from a BIM model prepared on the basis of a well-developed conceptual design for the selected final process train with up-to-date unit costs. With this recommendation in mind, decisions regarding economic feasibility and costs of service should recognize the limitations and potential inaccuracies of this approach.

2.5 O&M COST PARAMETERS

The approach to developing the O&M costs between Stantec's and Jacobs' estimates was similar. The parameters used in the development of the O&M costs are shown in **Table 2-4** and then discussed by category in following paragraphs.

Table 2-4: O&M Cost Parameters

	Updated/Escalated Stantec's Estimate	Jacobs' Estimate	Recommendation
Maintenance	3% of equipment cost	3% of equipment cost	3% of equipment cost
Major equipment overhaul	Not included	5% of mechanical equipment cost, at year 10	5% of mechanical equipment cost each year
Local sales tax on replacement components	9.5%	9%	9.5%
Contingency	15%	15%	15%
Labor Costs, $/hr	$150/hr for 2,080 hrs	$150/hr for 1,800 hrs	$150/hr for 2,080 hrs
Biosolids Disposal, $/DT	Not used	190	190
Pure Oxygen feed, $/lb-$O_2$	Not used	0.015	Not used
Replacement frequency, years			
MBR modules	10	10	10
MF modules	10	10	10
Cartridge filters	0.5	0.5	0.5
RO elements	5	5	5
UV lamps	1.6	1.6	1.6
UV ballasts	10	5	5
UV-AOP sleeves, sensors	Not included	per vendor quotes	per vendor quotes
Blowers	>20	>20	>20
Major pumping systems	>20	>20	>20
Net Present Value			
Net Present Value period, years	Not used	20	Not used
Net Present Value interest rate, %	Not used	5	Not used
Electricity			
JWPCP produced, $/kWh	Not used	0.06 [1]	Not used
Purchased electricity, $/kWh	0.15	0.15	0.15
Chemicals			

	Updated/Escalated Stantec's Estimate	Jacobs' Estimate	Recommendation
Ammonium sulfate (40%), $/gal	2.25	3.54	2.25
Antiscalant (100%), $/gal	13.00	8.63	13.00
Carbon dioxide, $/lb	0.085	0.08	0.09
MicroC 2000 (100%), $/gal	3.05	3.35	3.05
Caustic soda (25%), $/gal	1.42	1.39	1.42
Citric acid (50%), $/gal	13.50	5.05	13.50
Hydrated lime, $/lb	0.19	0.25	0.19
Hydrochloric acid (33%), $/gal	Not used	1.80	Not used
Sodium bisulfite (25%), $/gal	1.49	1.10	1.49
Sodium hypochlorite (12.5%), $/gal	0.84	0.82	0.84
Sulfuric acid (93%), $/gal	2.08	1.84	2.08
Sodium dodecylbenzylsulfonate, $/lb	Not used	1.5	Not used

[1] The energy savings from energy produced at JWPCP was not factored into Jacobs' estimates. All alternatives projected using more energy than production capacity at JWPCP.

The categories of O&M parameters and how they compare between the estimates are described as follows:

- **Maintenance**: Both estimates used the same basis of 3% of equipment costs for maintenance.
- **Major equipment replacement**: Both estimates assumed major equipment such as pumps and blowers would have a useful life of greater than 20 years and therefore full replacement costs were not included. Jacobs' estimate included a 5% allowance for the cost of major equipment overhaul at year 10.
- **Contingency**: A contingency of 15% was applied in addition to all O&M costs, except for labor.
- **Labor**: Both estimates used the same hourly rate, though Stantec's estimate assumed this rate was applied at 40 hrs per week for 52 weeks (equal to 2,080 hours per year) compared to an average yearly total hours of 1,800 assumed for Jacobs' estimate.
- **Biosolids disposal and pure oxygen feed**: Specific unit cost parameters based on JWPCP operational costs were used by Jacobs in their estimate of costs associated with processes at the JWPCP. Stantec's estimate in 2018 was based on approximate percentages of total treatment cost for secondary treatment at JWPCP. Jacobs' estimate is based on greater specificity and more recent cost data.
- **Assets requiring scheduled replacement**: Both estimates included replacement costs for assets requiring schedule replacement with less than a 20-year life, such as membranes and UV lamps and ballasts. Stantec's estimate was based on the 2021 unit cost quotes per replacement part obtained by Jacobs. Sales tax was applied to the replacement costs.
- **Electricity**: Both estimates were based on $0.15/kWh.
- **Chemicals**: Unit costs used in Jacobs' estimate were the same as from Stantec's 2018 estimate except for updated costs for MicroC 2000 (carbon) and sodium hypochlorite. Stantec

received updated costs for all chemicals in early 2022 as part of this effort except for sodium bisulfite and sodium hypochlorite, which were escalated based on the overall average increase in chemical unit costs from the quotes received.

2.6 UPDATED CAPITAL COST ESTIMATE FOR A 150-MGD IPR FACILITY AT THE JOINT SITE

The cost estimates developed in 2021 dollars to compare with Jacobs' estimates were escalated to 2022 dollars per Metropolitan's request. Escalation from Q2 2021 dollars (included in Section 2) to Q2 2022 dollars was based on a 10% escalation factor since the TBD price index has not yet been updated for 2022 at the time of this report.

The total capital cost in 2022 dollars (**Table 2-5**) is estimated to be **$2.5 billion** based on an assumption that the entire facility will be built in a single phase. This estimate also includes additional ancillary facilities per Metropolitan's request that were not part of the previous estimates developed by Stantec; details on those facilities can be found in **Section 3**. An additional Title 22 Facility for 1.0 mgd of non-potable reuse consisting of UV disinfection and storage is included based on recent planning efforts with Metropolitan. This estimate does not include any DPR facilities and is meant to provide comparison to previous (2016 and 2018) estimates for a 150-MGD IPR-only AWTF.

Table 2-5: Updated Capital Cost Estimate for a 150-MGD IPR Facility at the Joint Site

Area	Capital Cost
Site Improvements	$16,330,000
Drum Screen and Influent Pump Station	$20,630,000
Biological Treatment	$289,600,000
RO	$209,800,000
UV-AOP	$33,960,000
Chemicals	$8,174,000
Lime System	$16,930,000
Electrical and I&C	$82,270,000
Yard Piping	$10,460,000
Sidestream Centrate Treatment	$75,680,000
Title 22 Facility[1]	$7,000,000
O&M Buildings and Ancillary Facilities[2]	$126,600,000
Estimating Allowance	$73,470,000
Subtotal	**$971,000,000**
Construction Markups [3]	$339,200,000
Subtotal Construction Cost	**$1,310,200,000**
Construction Cost Contingency [4]	$458,600,000
Engineering, Startup, Admin, Const. Mgmt.[5]	$707,400,000
Permitting	$10,000,000
Capital Cost ($)	**$2,487,000,000**

[1] Title 22 Facility consists of 1.0 mgd UV disinfection and a 400,000 gallon storage tank

[2] The buildings and the ancillary facilities costs from Section 3 are combined in one line item here. This excludes electrical buildings which are included within process line items

[3] Construction markups include sales tax of 9.5% on 40% of equipment cost, contractor overhead of 15%, contractor profit of 10%, and mobilization/bonds/insurance of 5%.

[4] Contingency is 35% of subtotal construction cost

[5] Project markups include engineering at 17%, startup at 6%, CM at 12%, admin at 5%, applied on top of the sum of the subtotal construction cost and contingency.

2.7 UPDATED O&M COST ESTIMATE FOR THE 150-MGD IPR FACILITY AT THE JOINT SITE

A summary of the updated O&M costs is presented in **Table 2-6.** The annual O&M cost is estimated to be **$156M** excluding biogas credit**.**

Table 2-6: Updated O&M Cost Estimate for a 150-MGD IPR Facility at the Joint Site

Area	Annual O&M Cost
Influent and MBR	$49,836,000
RO	$43,809,000
UV AOP	$6,258,000
Stabilization	$6,198,000
Effluent Chlorination	$3,120,000
Balance of Chemicals, Buildings, Electrical	$3,150,000
Major Equipment Replacement Cost	$4,859,000
Labor	$37,128,000
JWPCP Secondary Treatment and Biosolids[1]	$996,000
Title 22 Facility[2]	$10,000
Ancillary Facilities	$500,000
O&M Cost ($)	**$155,864,000**
Annual Biogas Credit[1]	$1,243,000
Annual O&M with Biogas Credit	**$154,621,000**

[1] JWPCP Secondary Treatment and Biosolids, and Biogas Credit O&M cost reflect only the differences between the tMBR train and current JWPCP operations

[2] Title 22 facility O&M is based on power, maintenance, and replacement parts for UV disinfection facility

3.0 ANCILLARY FACILITIES

3.1 DESCRIPTION OF FACILITIES

The ancillary facilities include facilities that assist with operating the plant as well as others that provide a space for education and demonstration to the public. A list of the facilities and their basic descriptions can be found below in **Table 3-1**.

Table 3-1: Description of Potential Ancillary Facilities

Facility	Basic Facility Description
Operations Building	Offices, central control room, locker rooms, and full kitchen/lunchroom. Includes training room.
Laboratory	Laboratory with additional space for pilot facilities with available connections to process waters. Adjacent to Operations Building.
MWD Warehouse	Large warehouse with size split and shared with LACSD
MWD Maintenance	Includes equipment and space for any necessary maintenance for mechanical, electrical, I&C, or painting at the facility.
Electrical Buildings	Buildings housing the electrical controls for the facility.
Electrical Substation	Electrical Substation
Fueling Facilities	Gasoline and Diesel refueling station, as well as EV charging stations for fleet vehicles.
Demonstration Garden	Garden to showcase native and low water needs plants that would do best to reduce water usage.
Amphitheater	Large outdoor amphitheater to give talks or hold activities out with seating.
Innovation Center	A center to demonstrate technologies used within the facility.
Tour Galleries	Area to lead tours on to showcase the facility and both the history and future of the facility.
Stormwater capture (LID), and multiple PS	Bioswales for stormwater capture throughout the facility and a pond or potentially another water feature to showcase captured stormwater.
Battery Storage	Battery storage facilities.
Solar Power	Solar panels for energy generation
Generators	Generators for emergency power to run essential equipment in case of power outage.
Parking	Parking for both staff and public.

3.2 CONSTRUCTION COSTS

Class 5 cost estimates, as defined by AACEI, for the construction of ancillary facilities were developed by Stantec. The estimates are parametric, based on unit costs per square foot and developed with reference to Metropolitan's Lake Matthews Reservoir Rehabilitation Storage Facility project bid. **Table 3-2** summarizes the ancillary facilities, anticipated footprints, and Class 5 costs for each. Sections of the facility that have already been priced in other sections are noted accordingly in the cost estimate columns and their values are not repeated. Class 5 cost estimates have typical expected accuracy ranges of -20% to -50% on the low side, and +30% to +100% on the high side.

Table 3-2: Ancillary Facility Capital Cost Summary

Facility	Gross Footprint (sf)[1]	Building Area (sf)	Cost Estimate	Cost Estimate Assumptions
Operations Building	15,000	N/A	Included elsewhere	Assuming 75 operators, and 50 on any given day. May need expansion for training rooms. Two story building.
Laboratory	47,000	50,000	$60,500,000	Lab staff of 40 employees. Need an additional 2000 sf for pilot facilities. Separate but adjacent to the Ops building.
Warehouse	50,000	23,000	$12,850,000	LACSD needs 13,000 sf for their part of the warehouse.
Maintenance Building	75,000	N/A	Included elsewhere	Includes parking. Indoor space is 20,000 -30,000 sf
Electrical Buildings	13,260	N/A	Included elsewhere	N/A
Electrical Substation	N/A	N/A	Included elsewhere	N/A
Fueling Facilities	10,000	N/A	$2,000,000	Installation of underground petroleum storage tanks
Demonstration Garden	10,000	N/A	$350,000	Meandering sidewalks, some CA native planting potential smaller bioswales. Maybe 1/2 acre landscaped.
Amphitheater	5,000	5,000	$625,000	Outdoor, open, seating (benches), maybe electronics for presentation, no real cover
Innovation Center	1,200	N/A	Included elsewhere	Likely retain existing APC learning center. Triple-wide trailer
Tour Galleries	N/A	N/A	$250,000	Outdoor sidewalks (4' width) and placards
Stormwater capture (LID), and multiple PS	N/A	N/A	Included elsewhere	Bioswales around parking lot. Sewer that runs under the disposal pit. Set up grading that water can go through bioswales to a sump and pump into sewer.
Battery Storage	3,830	N/A	$12,000,000	Assumed to be 2 MW, based off of previous MWD battery storage average of $6 million per MW

Solar Power	10 acres	N/A	$4,500,000	1.5 MW estimated at $3/watt, based on recent costs with conservatism for unknowns of mounting and electrical infrastructure
Generators	13,150	N/A	Included elsewhere	N/A
Parking	139,368	N/A	$3,484,000	Next to innovation center. Canopies over with Solar, EV, etc.
Subtotal Ancillary Facility Construction Cost			$96,600,000	Includes Contractor Markups
Construction Cost Contingency (35%)			$33,800,000	
Engineering, Startup, Admin, Const. Mgmt. (40%)			$52,200,000	
Total			**$182,600,000**	

[1] Gross footprint includes parking, landscaping, and facility

3.3 OPERATION & MAINTENANCE COSTS

The O&M cost estimate is based on the total ancillary facilities estimated costs. It uses an estimate of 0.5% of the total cost of the facility of $96,600,000, leaving O&M estimated costs at about $500,000 dollars per year.

4.0 DIRECT POTABLE REUSE FACILITIES

4.1 BASIS OF COST ESTIMATE

The location of DPR processes within the process train for PWSC is still under evaluation. Metropolitan's planned potential approaches to implement DPR and research needs associated with each approach are discussed in the two TMs generated by the Stantec Team (Stantec, 2022a and b).

Amongst the proposed DPR implementation approaches, those that place ozone/BAC processes upstream of RO have been stipulated in the draft DPR regulations. The process design criteria for ozone/BAC processes for such implementation are well defined and therefore, process sizing and cost estimation can be completed. For the DPR implementation approaches that place ozone/BAC processes downstream of RO, several treatment questions have yet to be addressed and Metropolitan plans to do so over the next few years.

For the Phase 1 of the program, Metropolitan plans to install UV and chlorine dioxide processes at the Weymouth WTP to further treat 10 MGD of advanced treated water (ATW). Adding these processes to the treatment train and limiting the ATW's contribution as a percentage of the total feed water supply to Weymouth WTP to less than 10% during Phase 1 allows Metropolitan to meet the draft DPR regulatory requirements. The preliminary estimate for such treatment concept is provided in **Table 4-1**.

For the Phase 2, Metropolitan plans to produce up to 60 MGD of DPR quality water. Since that flow would result in ATW making up more than 10% of the total feed water supply to the Weymouth WTP, ozone, BAC and UV (or MF) processes will have to be included in the process train and will likely be located at a satellite facility somewhere between the Joint site and the Weymouth WTP. The Stantec Team has been tasked to develop the design basis, site layout and cost estimates for such treatment concept, which will be included in a separate TM.

Another DPR treatment approach under consideration places ozone, BAC and MF processes at the Joint site upstream of the RO. Under this treatment concept, the entire plant flow (150 MGD product water) will be treated to DPR standards. Although this approach is less likely to be implemented, it provides the most conservative cost estimate for DPR implementation and is included in this TM (**Table 4-2**).

4.2 CONSTRUCTION COSTS

The cost estimate for the DPR treatment is a Class 5 Opinion of Probable Construction Cost based on criteria established by AACEI. The costs are based on the following assumptions:

- Design criteria as shown in **Appendix A**
- **For the 10 MGD of DPR treatment at the Weymouth WTP**:
  - Costs are based on vendor quotes, with parametric estimates for balance of plant construction

- Costs for chlorine facilities are not included; this estimate assumes existing on-site chlorine systems at Weymouth WTP will be utilized
- No other ancillary facilities are included in the estimate based on an assumption that the existing Weymouth facilities will be used for maintenance and storage

- **For the 150 MGD of DPR treatment at the Joint site**:
  - Liquid oxygen (LOX) storage and supply for the ozone process will be required and is included in this estimate
  - Ozone & BAC costs are based on a scaled bid price for the 34-MGD Pure Water San Diego, North City Pure Water Facility (NCPWF), which has the same design criteria as PWSC
  - NCPWF bid was in Oct 2020 and was escalated to Q2 2021 dollars using TBD index, with an additional 10% escalation between Q2 2021 and Q2 2022 (TBD index is not yet updated for 2022). The estimate to account for capacity scaling to 150-mgd was done using power factor scaling equation with coefficient of 0.75 (Dysert, 2003):

    $\$B = \$A * (\text{Capacity B} / \text{Capacity A})^e$, where:

    $B = cost of construction for Project B, unknown
    $A = cost of construction for Project A, known
    Capacity B = capacity of Project B (in our case, flow rate of facility in mgd)
    Capacity A = capacity of Project A (in our case, flow rate of facility in mgd)
    e = power factor exponent (in our case, 0.75 based on comparison to other facility costs)

  - MF cost is based on JTAP Train 4 estimate, escalated from Q2 2021 to Q2 2022 dollars by using 10% escalation factor
  - The DPR line items for ozone, BAC and MF include proportional adders for contractor mobilization, electrical and I&C, site work, yard piping, testing, building enclosure for equipment, sales tax on equipment, and associated support facilities (LOX storage and feed system, BAC backwash tank/MF feed tank, CIP system)
  - No additional ancillary facilities were included assuming use of IPR facilities for operations, maintenance, and storage

Table 4-1: Capital Cost Summary for the 10-MGD DPR Facility at the Weymouth WTP

Area/Item	Cost
UV [1]	$1,103,000
ClO_2 [1]	$500,000
Chemical Storage [1]	$76,000
Tank for Contact Time [1]	$7,573,000
Building and Pad [1]	$3,360,000

Subtotal	**$12,612,000**
Contractor Markups	$3,800,000
Construction Subtotal	**$16,412,000**
Construction Cost Contingency (35%)	$7,100,000
Engineering, Startup, Admin, Const. Mgmt. (40%)	$9,400,000
Capital Cost ($)	**$33,000,000**

[1]Each item includes electrical, I&C, civil site work, and installation costs

Table 4-2: Capital Cost Summary for the 150-MGD DPR Facilities at the Joint Site

Area/Item	Cost
Ozone [1]	$166,540,000
BAC[1]	$123,420,000
MF [1]	$236,800,000
Subtotal	**$526,760,000**
Contractor Markups	$158,000,000
Construction Subtotal	**$684,760,000**
Construction Cost Contingency (35%)	$239,666,000
Engineering, Startup, Admin, Const. Mgmt. (40%)	$369,800,000
Capital Cost ($)	**$1,294,000,000**
Capital Cost ($M)	**$1,294**

[1]Each item includes electrical, I&C, civil site work, building, tanks, LOX system, and installation costs

4.3 OPERATION & MAINTENANCE COSTS

O&M costs were developed using the same unit costs as in Section 2.5, where applicable (e.g. electricity unit cost of $0.15/kWh) and are based on the following assumptions:

- **For the 10-MGD of DPR treatment at the Weymouth WTP (Table 4-3)**:
  - O&M costs for UV and ClO_2 processes include power, maintenance, replacement, and chemicals (ClO_2).
  - Additional maintenance and replacement costs are included for the chlorine contact tank and building, labeled in **Table** as "Other".

- Unit cost for chlorine gas is $0.93/lb and sodium chlorite is $1.00/lb.
- Labor – 0.5 FTEs, assuming $150/hr, 2090 hr/FTE, no contingency.

- **For the 150 MGD of DPR treatment at the Joint site (Table 4-4)**:
  - Ozone & BAC costs are based on quantities scaled from the 34-MGD Pure Water San Diego, North City Pure Water Facility which has the same design criteria as PWSC. Unit costs for energy and chemical are then applied to these quantities. No activated carbon replacement is assumed to be needed for the analysis period.
  - Liquid oxygen (LOX) storage and supply for the ozone process is included in this estimate
  - MF cost is based on JTAP Train 4 estimate, escalated from Q2 2021 to Q2 2022 dollars by using 10% escalation factor.
  - Labor – additional 10 FTEs in addition to IPR staff, assuming $150/hr, 2080 hr/FTE, no contingency.

Table 4-3: O&M Costs for 10 MGD DPR Facilities at the Weymouth WTP

Area	Annual O&M Cost
UV	$100,000
ClO_2	$147,000
Other	$299,000
Labor	$156,000
O&M Cost ($)	$700,000

Table 4-4: O&M Costs for 150 MGD DPR Facilities at the Joint Site

Area	Annual O&M Cost
Ozone	$14,850,000
BAC	$1,890,000
MF	$11,000,000
Labor	$3,120,000
O&M Cost ($)	$30,900,000

5.0 COST ESTIMATES FOR INDIVIDUAL PROGRAM PHASES BASED ON CURRENT PHASING PLAN

The program implementation plan developed by the Metropolitan includes two phases:

- Phase 1 – 100 mgd of IPR treatment (MBR, RO, UV-AOP, Stabilization) at the Joint Site, 10 mgd of UV and chlorine dioxide treatment at the Weymouth WTP
- Phase 2 – Add 150 MGD of DPR treatment (Ozone, BAC, MF) and expand IPR capacity to 150 mgd total

The proposed DPR treatment concept for Phase 2 is conservative and Metropolitan may choose to implement DPR at a satellite facility, which will require treating only 60 MGD of water to DPR standards. Such concept may result in lower capital and O&M costs for Phase 2.

During Phase 1, a majority of the infrastructure for the ultimate capacity of 150 mgd would be constructed including all buildings and the ancillary facilities and most of the treatment process piping and structural infrastructure (buildings/canopies, basins, etc.). During Phase 2, the IPR treatment process equipment and remaining necessary infrastructure for an additional 50 mgd capacity would be added, along with all facilities associated with the DPR treatment processes as described in Section 4. The phased costs were developed based on following assumptions:

- Phase 1 costs were estimated per-line item based on an assumed percentage of the 150 mgd construction cost for the infrastructure that would be built during Phase 1. The total cost of Phase 1 is approximately 84% of the 150 mgd IPR construction cost.
- A phasing factor of 10 % was applied to Phase 2 costs to account for additional contractor mobilization/demobilization activities and inefficiencies of constructing the facility in two phases.
- The DPR line items for ozone, BAC and MF include proportional adders for contractor mobilization, electrical and I&C, site work, yard piping, testing, building enclosure for equipment, sales tax on equipment, and associated support facilities (LOX storage and feed system, BAC backwash tank/MF feed tank, CIP system).
- All costs are in 2022 dollars and do not account for the time-value of money based on when the construction of Phase 1 and Phase 2 occur.

The capital and O&M costs for each phase are summarized in **Table 5-1** and **Table 5-2**, respectively.

Table 5-1: Capital Costs for Individual Phases in 2022 Dollars

	Phase 1	Phase 2	Phase 1 + 2
	100 mgd IPR at Joint Site and 10 mgd DPR at Weymouth WTP	Additional 50 mgd IPR and 150 mgd DPR at Joint Site	
Area	Capital Cost	Capital Cost	Capital Cost
Site Improvements	$16,330,000	$0	$16,330,000
Drum Screen and Influent Pump Station	$15,472,500	$5,157,000	$20,630,000
Biological Treatment (including Carbon Addition)	$231,680,000	$57,920,000	$289,600,000
Ozone	$0	$166,540,000	$166,540,000
BAC	$0	$123,420,000	$123,420,000
MF	$0	$236,800,000	$236,800,000
RO	$157,350,000	$52,450,000	$209,800,000
UV-AOP	$25,470,000	$8,490,000	$33,960,000
Chemicals	$6,130,500	$2,043,500	$8,174,000
Lime System	$12,697,500	$4,232,500	$16,930,000
Title 22 Facility	$7,000,000	$0	$7,000,000
Electrical and I&C	$74,043,000	$8,227,000	$82,270,000
Yard Piping	$10,460,000	$0	$10,460,000
Sidestream Centrate Treatment	$75,680,000	$0	$75,680,000
O&M Buildings and Ancillary Facilities	$126,600,000	$0	$126,600,000
Estimating Allowance	$55,102,500	$18,367,500	$73,470,000
10-MGD UV and ClO_2 at Weymouth WTP	$12,612,000	$0	$12,612,000
Phasing Factor (additional mob/de-mob)	$0	$15,690,000	$15,690,000
Subtotal	**$826,700,000**	**$699,400,000**	**$1,526,000,000**
Sales Tax[1]	$31,420,000	$6,570,000	$37,980,000
Contractor Markups[1]	$257,450,000	$211,800,000	$469,194,000
Subtotal Construction Cost	**$1,115,600,000**	**$917,800,000**	**$2,033,200,000**
Construction Cost Contingency[2]	$390,460,000	$321,230,000	$711,620,000
Engineering, Startup, Admin, Const. Mgmt.[3]	$602,424,000	$495,612,000	$1,097,928,000
Permitting	$5,000,000	$5,000,000	$10,000,000
Capital Cost ($)	**$2,114,000,000**	**$1,740,000,000**	**$3,854,000,000**
Capital Cost ($M)	**$2,114**	**$1,740**	**$3,854**
Capital Cost per gpd ($/gpd)	**$21.1**	**n/a**	**$25.7**

[1] Construction markups include sales tax of 9.5% on 40% of equipment cost; contractor markups consist of contractor overhead of 15%, contractor profit of 10%, and mobilization/bonds/insurance of 5%.

[2] Contingency is 35% of subtotal construction cost

[3] Project markups include engineering at 17%, startup at 6%, CM at 12%, admin at 5%, applied on top of the sum of the subtotal construction cost and contingency.

Table 5-2: O&M Costs for Individual Phases in 2022 Dollars

	Phase 1	Phase 2	Phase 1 +2
Annual O&M Costs	**100 mgd IPR at Joint Site + 10 MGD DPR at Weymouth WTP**	**Additional 50 mgd IPR and 150 mgd DPR at Joint Site**	
Area	**O&M Cost**	**O&M Cost**	**O&M Cost**
Influent and MBR [1]	$33,224,000	$16,612,000	$49,836,000
Ozone	$0	$14,850,000	$14,850,000
BAC	$0	$1,890,000	$1,890,000
MF	$0	$11,000,000	$11,000,000
RO	$29,206,000	$14,603,000	$43,809,000
UV AOP	$4,172,000	$2,086,000	$6,258,000
Stabilization	$4,132,000	$2,066,000	$6,198,000
Effluent Chlorination	$2,080,000	$1,040,000	$3,120,000
10-MGD UV and ClO_2 at Weymouth WTP	$700,000	$0	$700,000
Balance of Chemicals, Buildings, Electrical	$2,100,000	$1,050,000	$3,150,000
Major Equipment Replacement Cost	$3,239,333	$1,619,667	$4,859,000
Labor	$35,568,000	$4,680,000	$40,248,000
JWPCP Secondary Treatment and Biosolids	$664,000	$332,000	$996,000
Ancillary Facilities	$500,000	$0	$500,000
Total	**$115,700,000**	**$71,900,000**	**$187,600,000**
Annual Biogas Credit	$828,667	$414,333	$1,243,000
Annual O&M with Biogas Credit	$114,900,000	$71,500,000	$186,400,000

[1] Influent and MBR O&M cost includes sidestream treatment, odor control, equalization, biological process chemicals, influent pumps/screens and MBR costs.

6.0 SUMMARY

Stantec was tasked by Metropolitan to update the full-scale AWTF cost estimates to 2022 dollars and include additional ancillary and DPR facilities in these estimates. Using Metropolitan's program phasing plan, Stantec also developed estimates for each phase of the Program. **Table 6-1** summarizes the 2022 estimates. The Phase 2 estimates were developed based on an assumption that all 150 MGD of product water will meet DPR water quality requirements. However, Metropolitan is considering use of a satellite DPR facility that will allow Metropolitan to treat only 60 MGD of water to DPR standards – the flow that is expected to be used for DPR application. Therefore, the Phase 2 estimates presented in this TM are expected to be conservative. Stantec Team is in the process of developing the estimates for a satellite DPR facility, which will be included in a separated TM.

Table 6-1: Summary of Cost Estimates

Program Treatment Components	Capital Costs ($M)	Annual O&M Costs ($M/yr)
150-MGD IPR-only AWTF[1]	$2,487	$156
Additional Ancillary Facilities	$183	$0.5
10-MGD DPR Facilities at Weymouth WTP	$33	$0.7
150-MGD DPR Facilities at Joint Site	$1,294	$30.9
Program Phases	**Capital Costs ($M)**	**Annual O&M Costs ($M/yr)**
Phase 1 (100 MGD IPR + 10 MGD DPR)	$2,114	$116
Phase 2 (50 MGD IPR + 150 MGD DPR)	$1,740	$72
Phase 1 + 2	$3,854	$188

[1] Assumes the whole facility is built in a single phase and includes essential ancillary facilities as indicated in Table 3-2

7.0 REFERENCES

Los Angeles County Sanitation Districts (2021). Technical Analysis of Biological and Advanced Water Treatment Processes at the Joint Water Pollution Control Plant - Analysis of Train 1C-1F: Nitrification and Denitrification Tertiary Membrane Bioreactor + Reverse Osmosis.

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Stantec, Carollo Engineers and Trussell Technologies Inc. (2022b). Roadmap to Address the Direct Potable Reuse Research Needs for the Regional Recycled Water Program.

TBD Consultants Price Index, http://www.tbdconsultants.com/mobi/TBDBidIndex.htm

8.0 APPENDICES

Appendix A DESIGN CRITERIA

Table 8-1 Influent Pump Station Design Criteria

Parameter	Unit	Value
General		
JWPCP Secondary Effluent Required	MGD	180
Influent Pump Station		
Number of Pumps (Duty + Standby)	-	3+1
Design Capacity, Each	**MGD**	**86**
Motor Power, Each	HP	770
Influent Fine Screens		
Type	-	Center-Fed Drum Screen
Size of Perforations	mm	2
Number of Screens (Duty + Standby)	-	5+1
Capacity, Each	MGD	50
Power, Each	HP	3.0
Washer/compactor (Duty + Standby)	--	1+1

Table 8-2 Biological Process Design Criteria for MBR

Parameter	Unit	Value
General		
MBR Average Flow	mgd	180
MBR Peak Flow	mgd	234
MCRT	days	>10
Waste Activated Sludge (WAS)		
MBR WAS Flow	% of Influent	1.83%
WAS Flow Rate	MGD	3.30
WAS Solids Content	%	3.4 to 3.8
WAS Pumps (Duty + Standby)	--	1 + 1
WAS Pump Capacity, Each	gpm	2,300
WAS Pump Power, Each	HP	40
Return Activated Sludge (RAS)		
RAS Flow Setpoint	% of Q	150%
RAS Flow Rate, Total	MGD	351
RAS Flow Pumps, (Duty + Standby)	-	5 + 1
RAS Flow Pump Capacity, Each	MGD	80
RAS Flow Pump Power, Each	HP	300
Nitrified Mixed Liquor Recycle (NRCY)		
NRCY Flow Setpoint	% of Q	150%
NRCY Flow Rate, Total	MGD	351
NRCY Flow Pumps, (Duty + Standby)	-	12 + 0

NRCY Flow Pump Capacity, Each	MGD	33.3
NRCY Flow Pump Power, Each	HP	40
Bioreactor		
Number of Trains	-	6
Anoxic Basins		
Number of Basins per Train	-	2
Number of Basins Total	-	8
Wet Volume, Each Basin	gal	1,670,000
Total Volume	gal	13,360,000
HRT (Excluding Recycle Flow)	hours	1.8
Mixer Type	--	Top mounted
Mixer Motor	HP	30
Number of Mixers	--	16
Mixing Power, Total	HP	480
Aeration Basins		
Number of Basins per Train	-	3
Number of Basins Total	-	12
Wet Volume, Each Basin	gal	1,380,000
Total Volume	gal	16,560,000
HRT (Excluding Recycle Flow)	hours	2.2
Process Air Capacity	cfm	72,000
Process Air Blowers, (Duty + Standby)	-	3 + 1
Process Air Blower Capacity, Each	cfm	24,000
Process Air Blower Power, Each	HP	1,430

Table 8-3 Membrane System Design Criteria for MBR

Parameter	Unit	Value
General		
Membrane System Influent	MGD	180
Number of Membrane Basins Total	-	18
Maximum MLSS Concentration	mg/L	3,820
Design Permeate Flux	gfd	17
Number of Cassettes Per Basin (Duty + Standby)	-	26 + 4
Membrane Area per Cassette	ft^2	22,360
Membrane Air Scour		
Membrane Air Scour Rate per Cassette	cfm	208
Membrane Air Scour Rate, Total	cfm	97,200
Membrane Air Blowers, (Duty + Standby)	-	7+1
Membrane Air Blowers Capacity, Each	cfm	17,500
Membrane Air Blower Power, Each	HP	800
Filtrate Pumping		
Filtrate Pumps, Total	-	17+1
Filtrate Pump Flow, Each	MGD	14

Filtrate Pump Power, Each	HP	285
MBR Air Compressor System		
Type	-	Rotary screw
Number of Compressors (Duty + Standby)		1 + 1
Motor Power for Compressor, Each	HP	75
Air Flow, Each	cfm	360
Design Pressure, Each	psi	125

Table 8-4 Ozonation System Design Criteria

Parameter	Unit	Value
General		
Process Influent Flow	mgd	180
Number of Trains	--	5
Ozone Contactors		
Maximum Applied Dose[b]	mg/L	14
CxT Value	mg-min/L	3.9
Contact Time (T_{10})	min	6
Contactor Baffling Factor	--	0.6
Total Contactor Residence Time	min	10
Number of Ozone Contactors	--	5
Volume per Contactor	gal	259,000
Injection System		
Injection Type	--	Side Stream
Number of Injectors (Duty)	--	10
Number of Injectors (Standby)	--	5
Ozone Transfer Efficiency, Minimum	%	95%
Ozone Generators		
Minimum Generator Capacity at 10% (each)	lb/day	2,287
Total Ozone Production	lb/day	22,870
Number of Ozone Generators (Duty)	--	10
Number of Ozone Generators (Standby)	--	2
Power Supply Unit per Generator	--	1
Power per Generator	kWh/day	10,292
Ozone Destruct System		
Number of Destruct Units (Duty)	--	10
Number of Destruct Units (Standby)	--	5
LOX System		
LOX Usage (pounds per day)	lb/day	228,697
LOX Usage (standard cubic ft per hour)	scfh	115,111
LOX Usage (gallons per day)	gpd	24,013
Oxygen Supply		LOX System
LOX Tank Orientation	--	Horizontal
LOX Tank Volume (each)	gal	80,000

Parameter	Unit	Value
Number of LOX Tanks	--	2
LOX Storage at Peak Flow and Dose	days	5
Minimum Vaporizer Capacity	scfh	115,200
Number of Vaporizers	--	5

Table 8-5 Biologically Activated Carbon Design Criteria

Parameter	Unit	Value
General		
Process Influent Flow	mgd	180
Number of Trains	--	5
BAC Filters		
Type of Filter	--	Gravity
Surface Area, Each Filter	ft^2	700
Filter Length, Each	ft	35
Filter Width, Each	ft	20
Media Bed Depth	ft	10
Number of Filters (Duty)	--	35
Number of Filters (Standby)	--	5
Flow per Filter (Duty)	mgd	5.31
Flow per Filter (Duty + Standby)	mgd	4.65
Filter Loading Rate (Duty)	gpm/ft^2	5.3
Filter Loading Rate (Duty + Standby)	gpm/ft^2	4.6
EBCT (Duty)	min	14.2
EBCT (Duty + Standby)	min	16.2
L/d Ratio	--	2,345
Feed Pumps (Duty + Standby)	--	4 + 1
Feed Pump Flow, each	mgd	46.5
Feed Pump Power, each	HP	200
Activated Carbon Media		
Mesh Size	--	8x16 or 8x20
Effective Size	mm	1.3
Uniformity Coefficient	--	1.4 to 1.5
Iodine Number	mg/g	900
Trace Capacity Number, Min	mg/cm^3	9
Abrasion Number, Min	--	75
Density, Apparent	g/cm^3	0.56
Specific Gravity, Wetted	--	1.4
Backwash System		
Backwashes per Week, Each Filter	--	1
Total Backwash Loss	%	0.5%
Backwash Supply Source	--	MBR Filtrate

Parameter	Unit	Value
Design Backwash Velocity	gpm/ft^2	23
Design Backwash Flow Rate	gpm	16,100
Backwash Time	min	10
Backwash Volume	gal	161,000
Backwash Pumps (Duty + Standby)	--	1 + 1
Backwash Pump Flow, each	mgd	23.2
Backwash Pump Power, each	HP	150
Design Air Scour Velocity	cfm/ft^2	4
Design Air Scour Flow Rate	scfm	2,800
Air Scour Blower (Duty + Standby)	--	1+1
Air Scour Blower Capacity, each	cfm	2,800
Air Scour Blower Power, each	HP	150

Table 8-6 Microfiltration Membranes Design Criteria

Parameter	Unit	Value
General		
Influent Flow	MGD	186
Filtrate Flow	MGD	177
Membrane System Sizing		
Recovery	%	95%
Number of Sub-Systems	--	4
Cells per Sub-system	--	5
Cells in Operation	--	18
Cells in Standby/Available	--	2
Cells, Total	--	20
Membrane Type	--	PVDF Hollow Fiber
Modules per Cell		1,000
Available Module Space per Cell		1,100
Total Number of Modules		20,000
Membrane Surface Area per Module	ft^2	375
Membrane Surface Area per Cell		375,000
Instantaneous Flux (18 cells operating)	gfd	33
Average Flux (18 cells operating)	gfd	26
Net Filtrate Flow, per train	MGD	9.8
Backwash Requirements		
Backwash Frequency	mins	22
Backwashes per Cell per Day	--	60
Backwash Filtrate Volume per Cell	gal	15,210
Backwash Waste per Day	MG	13.5
Maintenance Wash Requirements		
Chlorine Maintenance Wash Frequency	hrs	24
Acid Maintenance Wash Interval	hrs	72

Volume of Chemical Waste per Wash	gal	56,000
Full CIP Interval	days	30.0
Volume of Chemical Waste per CIP	gal	120,000
Total Volume of CIP Waste per Day	gal	80,000

Table 8-7 Reverse Osmosis System Design Criteria

Parameter	Unit	Value
RO Break Tank		
Total Volume	MG	10
Number	--	1
Length	feet	683
Width	feet	108
Sidewater Depth	feet	19
Freeboard	feet	2
Hydraulic Residence Time	min	81.49
RO Feed Transfer Pump Station		
Flow, Total	MGD	177
RO Feed Pumps, (Duty + Standby)	-	7 (6+1)
RO Feed Pump Flow, Each	MGD	29.5
Power, Each	HP	2,500
Total dynamic head	feet	381
Type	--	vertical turbine
Efficiency	%	82%
Drive	--	variable frequency
Wetted end material	--	316 SS
Cartridge Filters		
Total flow	mgd	177
Maximum Design Loading Rate (per cartridge)	gpm	20 (5 per 10-inch length)
Average Design Loading Rate (per cartridge)	gpm	16 (5 per 10-inch length)
Maximum Design Capacity (per housing)	gpm / mgd	5,660 / 8.2
Average Design Capacity (per housing)	gpm / mgd	4,528 / 6.5
Number of Housing	--	29 (28+1)
Cartridge filters per housing	--	283
Pressure rating	psi	150
Flange size	inches	20
Element filter pore size	microns	5
Element length	inches	40
Element diameter	inches	2.5
Element type	--	string-wound
RO Feed Booster Pump Station		
Flow, Total	MGD	177
RO Feed Pumps, (Duty + Standby)	-	7 (6+1)

Parameter	Unit	Value
RO Feed Pump Flow, Each	MGD	29.5
Power, Each	HP	1,250
Total dynamic head	feet	196
Type	--	vertical turbine
Efficiency	%	82%
Drive	--	constant speed
Wetted end material	--	316 SS
General		
Total Feed Flow	MGD	177
Total Permeate Flow	MGD	150
Total Concentrate Flow	MGD	27
System Recovery	%	85%
RO Skids		
Number of Skids (Duty + Standby)	--	30 + 3
Skid feed capacity	MGD	5.9
Skid permeate capacity	MGD	5.0
Vessels per skid	--	147
Total Elements per Vessel	--	7
Membrane Area per Module / Element Area	ft^2	400
Element area per skid	ft^2	411,600
Vessel configuration	--	11 high, 14 wide
Spacer	mil	34
Average design flux	gfd	12.1
Pressure Vessel Array, Each Skid (Stage 1 : Stage 2 : Stage 3)	-	84:42:21
Second Stage Booster Pumps		
Flow, Total	MGD	88.5
Pumps, (Duty + Standby)	-	30 + 3
Pump Flow, Each	MGD	3.0
Power, Each	HP	50
Third Stage Booster Pumps		
Flow, Total	MGD	44.3
Pumps, (Duty + Standby)	-	30 + 3
Pump Flow, Each	MGD	1.5
Power, Each	HP	20

Table 8-8 UV/AOP System Design Criteria

Parameter	Unit	Value
General		
Total Flow	MGD	150
Type of UV System	--	Low Pressure High Output
Minimum UV Transmittance	%	95%
UV Reactor		

Parameter	Unit	Value
Reactor Make	--	Trojan/Xylem-Wedeco
Reactor Model	--	UVFlex 200 / K143 12-40 600W
UV Dose	mJ/cm2	>1600 / 1,680
Flow Per Reactor Train	MGD	25 / 15
Number of Reactor Trains	--	7 (6+1) / 11 (10+1)
Ballasts per Reactor	--	192 / 240
Lamps per Reactor	--	384 / 480
Lamp Power	kWh/kgal	1 / 0.6
Reactor Power, Each	kWh/kgal	310
Total Connected Load	kWh/kgal	3,024/3,413
Advanced Oxidation		
Oxidant	--	NaOCl
Maximum Oxidant Dose	mg/L	5
Minimum Removal of 1,4-dioxane	log	0.5
Minimum Removal of NDMA	log	1.2
Minimum Removal of Cryptosporidium/Giardia/Virus	log	6

Table 8-9 Post-treatment Stabilization Design Criteria

Parameter	Unit	Value
General		
Target Finished Water pH Range	pH units	7.5 to 8.5
Target Finished Water LSI	-	0 to +0.5
Alkalinity	mg/L as $CaCO_3$	>50
Stabilization Process	-	Lime Addition
Lime Stabilization		
Lime Dose	mg/L as $Ca(OH)_2$	30 to 50
Lime Clarifiers	-	3
Lime Clarifier Drive Power, each	HP	10
Lime System Solution Water Pumps	-	5 (4+1)
Lime Silos	--	8
Storage Time	days	14
Total Storage Volume	ton	350
Carbon Dioxide Stabilization		
CO_2 dose	mg/L	4 to 5
Carbon Dioxide Storage, Total	ton	90
Number of Tanks	--	1.0
Storage Time	days	30.0
Carbon Dioxide Storage Tank, Each	ton	90

Table 8-10 Chemical System Design Criteria

Parameter	Unit	Value
Phosphoric Acid		
Injection Location/Purpose	--	Secondary Effluent (Biomass Uptake)
Strength	%	85%
Target Residual	mg-P/L	0.2
Target Dose	mg/L	
Total Storage Volume	gal	12,000.0
Storage Volume, Each Tank	gal	6,000
Number of Tanks	--	2
Carbon Source (Micro C 2000)		
Injection Location/Purpose	--	MBR Anoxic Tank (Denitrification)
Strength	%	100%
Target Dose - Anoxic Basin	mg/L COD	130.1
Total Storage Volume	gal	360,000.0
Storage Volume, Each Tank	gal	20,000
Number of Tanks	--	18
Sodium Hypochlorite		
Injection Locations/Purpose	--	RO feed (for biofouling control), UV-AOP feed (oxidant), Final Effluent (Disinfection)
Strength	%	12.5%
Target Dose	mg/L	1 to 5
Storage Time	days	30
Storage Unit	--	Tanks
Number of Units (ALL NaOCl)	--	16
Unit Volume	gal	15,400
Unit Volume	cu ft	2,059
Total Storage Volume	cu ft	33,000
Unit Diameter	ft	14
Unit Height	ft	16
Liquid Ammonium Sulfate		
Injection Location/Purpose	--	RO feed (for chloramine formation / biofouling control)
Strength	%	40%
Target Dose	mg/L	1 to 6
Storage Time	days	30
Storage Unit	--	Tanks
Number of Units	--	4
Unit Volume	gal	13,500
Unit Volume	cu ft	1,805
Unit Diameter	ft	14
Unit Height	ft	14

UPDATED OPINION OF PROBABLE COST FOR THE NDN TERTIARY MBR BASED ADVANCED WATER TREATMENT FACILITY

Parameter	Unit	Value
Sulfuric Acid		
Injection Location/Purpose	--	RO feed (for scaling control)
Strength	%	93%
Target Dose	mg/L	7 to 70
Storage Time	days	10
Storage Unit	--	Tanks
Number of Units	--	3
Unit Volume	gal	10,600
Unit Volume	cu ft	1,417
Unit Diameter	ft	14
Unit Height	ft	11
Antiscalant		
Injection Location/Purpose	--	RO feed (for scaling control)
Strength	%	100%
Target Dose	mg/L	2 to 4
Storage Time	--	30
Storage Unit	--	Tanks
Number of Units	--	1
Unit Volume	gal	13,500
Unit Volume	cu ft	1,805
Unit Diameter	ft	14
Unit Height	ft	14
Sodium Hypochlorite		
Strength	%	12.5%
Dose, Maintenance Clean	gal/tank/clean	50
MBR CIP		
Injection Location/Purpose	--	MBR Backwash (Membrane Cleaning)
Frequency, Maintenance Clean	frequency/tank	2 times per week
Dose, Recovery Clean	gal/tank/clean	972
Frequency, Recovery Clean	frequency/tank	2 times per year
Storage Time	days	47/10
MF CIP		
Injection Location/Purpose	--	MF Backwash (Membrane Cleaning)
Dose, Recovery Clean	gal/tank/clean	972
Frequency, Recovery Clean	frequency/tank	1 time per month
Storage Time	days	30
Total Storage		
Storage Unit	--	Tanks
Number of Units	--	5, FRP
Unit Volume	gal	6,000
Total Storage Volume	gal	30,000
Citric Acid		

Parameter	Unit	Value
Strength	%	50%
MBR CIP		
Injection Location/Purpose	--	MBR Backwash (Membrane Cleaning)
Dose, Maintenance Clean	gal/tank/clean	97
Frequency, Maintenance Clean	frequency/tank	1 time per week
Dose, Recovery Clean	gal/tank/clean	377
Frequency, Recovery Clean	frequency/tank	2 times per year
Storage Time	days	48/20
MF CIP		
Injection Location/Purpose	--	MF Backwash (Membrane Cleaning)
Dose, Recovery Clean	gal/tank/clean	377
Frequency, Recovery Clean	frequency/tank	1 time per month
Storage Time	days	30
Total Storage		
Storage Unit	--	Tanks
Number of Units	--	4
Unit Volume	gal	4,700
Total Storage Volume	gal	18,800
Citric Acid		
Injection Location/Purpose	--	RO feed (for CIP)
Strength	%	50%
Target Dose	%	0.1%
Storage Criteria	--	1 CIP event
Storage Unit	--	Silo
Number of Units	--	6
Unit Volume	gal	8,600
Sodium Hydroxide		
Injection Location/Purpose	--	RO feed (for CIP and neutralization)
Strength	%	25%
Target Dose	%	0.2%
Storage Criteria	--	1 CIP event
Storage Unit	--	Tanks
Number of Units	--	1
Unit Volume	gal	7,700
Unit Volume	cu ft	1,029
Unit Diameter	ft	14.0
Unit Height	ft	8.0
Sodium Tripolyphosphate		
Injection Locations	--	RO feed (for CIP)
Strength	%	85%
Target Dose	%	1.0%

Parameter	Unit	Value
Storage Criteria	--	1 CIP event
Storage Unit	--	Silo
Number of Units	--	4
Unit Volume	gal	6,100
Unit Volume	cu ft	816
Unit Diameter	ft	12.0
Unit Height	ft	8.6
Sodium Dodecilsulphonate		
Injection Locations	--	RO feed (for CIP)
Strength	%	80%
Target Dose	%	0.5%
Storage Criteria	--	1 CIP event
Storage Unit	--	Silo
Number of Units	--	4
Unit Volume	gal	3,600
Unit Volume	cu ft	481
Unit Diameter	ft	10.0
Unit Height	ft	5.0

Table 8-11 Odor Control System Design Criteria

Parameter	Unit	Value
General		
Service	--	Primary Effluent Pump Station, Fine Screen Facility, Bioreactors
Carbon Adsorbers		
Type	--	Dual-Bed Carbon
Capacity, each	cfm	40,000
Quantity	--	3 (2+1)
Fans		
Type	--	FRP Centrifugal
Capacity, each	--	40,000
Quantity	--	3 (2+1)

Table 8-12 Sidestream Centrate Treatment System Design Criteria

Parameter	Unit	Value
Number of Basins	--	4
Basin Sidewater Depth	ft	21
Basin Dimensions	ft x ft	86 x 73
Total Volume per Basin	MG	0.98
Total Volume	MG	3.9
Design SARR	NH_3-N/m^2/d	2.1
Design Fill	%	50%

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Appendix B CONSTRUCTION COST SUMMARY

The escalated OPC from Task Order 20 (herein referred to as Stantec's estimate) is approximately $51.1M less than the Train 1C OPC in the JTAP report (herein referred to as Jacobs' estimate). Jacobs' estimate included additional items such as odor control, larger filtrate flow equalization basin, and MBR building instead of a canopy, a higher assumption for building unit costs, a different approach to yard piping costs, and other key differences that are explained in the following sections. Another reason for the cost difference is in the differing underlying assumptions for a certain process area. Stantec compared the line items in each OPC to identify the reason for cost differences. The major areas identified with significant capital cost differences were the biological treatment equipment and facilities, reverse osmosis equipment and facilities, and the buildings on site. The cost estimates were examined to understand the differences and to provide Metropolitan an updated OPC for budgeting purposes. The following principles were employed in the adjustment of costs when comparing the two OPCs:

- For line items with a difference of less than 10% or less than $1 million, the higher cost was selected to be conservative. For the others, a revised cost was developed with justification provided.
- If a greater level of detail or precision could be determined based on the information used for one of the estimates compared to the other, that estimate was used

Revised cost estimates and associated justifications are discussed in the following sections.

B.1 SITE IMPROVEMENTS

For the general site development costs, Jacobs used 3% of the construction cost for sitework and 1% of the construction cost for demolition. Stantec's estimate used QTOs from the full-scale AWT facility BIM model. Since the general site development cost from Stantec's estimate was developed with greater detail in the BIM model, it is expected to be more precise than a blanket percentage (4%) cost applied to the total construction cost and therefore, Stantec's estimate was used in the updated cost. Stantec included costs for the Joint Site improvements, but this was not included in Jacobs' scope. The Stantec cost consisted of relocation of 10" gas line, 72" sewer line, 10'x12' storm drain culvert, and other utilities. It is not included in this analysis and assumed to be outside of the program scope. A summary of the costs, differences, and updated cost is shown in **Table 8-13**.

Table 8-13: Site Improvements Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
General Site Development	$14,840,000	$18,010,000	$3,170,000	21%	$14,840,000
Improvements at the Joint Site	$10,510,000	n/a-	n/a	n/a	n/a

Subtotal for Site Improvements	$25,340,000	$24,010,000	($1,340,000)	-5%	$14,840,000

B.2 DRUM SCREEN & INFLUENT PUMP STATION

The overall OPCs for screening and the influent pump station were similar between the two estimates. Jacobs' estimate used a horizontal, rotating center-fed drum screen with 2-mm opening while Stantec's estimate used a perforated in-channel rotary drum screen. The influent pump station in Jacobs' estimate applied a 1.3 peak flow factor resulting in larger pumps and a higher cost. The updated cost (**Table 8-14**) uses Jacobs' estimate because it accounted for the drum screen and larger influent pump station.

Table 8-14: Drum Screen & Influent Pump Station Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Drum Screen and Influent Pump Station	$15,940,000	$18,750,000	$2,810,000	18%	$18,750,000
Subtotal for Drum Screen and Influent Pump Station	$15,940,000	$18,750,000	$2,810,000	18%	$18,750,000

B.3 BIOLOGICAL TREATMENT

Stantec's estimate for the MBR included the MBR membrane tanks, blower structure, and carbon addition facilities. Jacobs' estimate included enclosing the MBR equipment within a building, while Stantec assumed the equipment is housed under a canopy. An odor control system (concrete covers and carbon vessels) was included in Jacobs' estimate. Due to the updated quotes Jacobs received from vendors as well as the inclusion of a building and odor control, the updated cost (**Table 8-15**) uses the costs from Jacobs' estimate. The cost estimates from Stantec and Jacobs for the carbon addition facility were very close in terms of cost and associated assumptions. Stantec's estimate used 14 tanks with 18,000-gallon volume each, while Jacobs' estimate used 12 tanks with 20,000-gallon volume. Since the difference in cost was less than $1 million, the greater cost was used in the updated cost.

Table 8-15: Biological Treatment Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Aeration, Anoxic, and Membrane Tanks for MBR & Blowers Structure	$164,820,000	$218,970,000	$54,160,000	33%	$218,970,000
MBR Equipment Building	n/a	$35,950,000	n/a	n/a	$35,950,000
Odor Control for Bioreactors	n/a	$4,690,000	n/a	n/a	$4,690,000

MicroC 2000 Storage & Dosing [1]	$2,700,000	$3,640,000	$940,000	35%	$3,640,000
Subtotal for Biological Treatment	$167,510,000	$263,260,000	$95,750,000	57%	$263,260,000

B.4 REVERSE OSMOSIS

The RO process area includes the RO feed tank, RO cartridge filters, RO facility, and RO flush tank. This process train utilizes single-pass RO. Stantec's estimate included a building for RO, while Jacobs' used a canopy. Jacobs' estimate also includes a filtrate equalization tank (10 MG), RO pretreatment and cleaning chemicals, and applies a safety factor on the high-pressure pump size. Jacobs' estimate also used fewer number of larger pieces of equipment, reflecting updated vendor configurations. Due to the updated RO equipment sizes and more conservative equalization tank volume used in Jacobs' estimates, the updated cost (**Table 8-16**) used Jacobs' estimates.

Table 8-16: Reverse Osmosis Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
RO Feed Tank	$4,780,000	$13,030,000	$8,250,000	173%	$13,030,000
RO Cartridge Filters	$17,370,000	$12,050,000	($5,330,000)	-31%	$12,050,000
RO Facility	$136,470,000	$165,580,000	$29,110,000	21%	$165,580,000
RO Flush Tank	$4,090,000	n/a	n/a	n/a	n/a
Subtotal for RO	$162,720,000	$190,660,000	$27,940,000	17%	$190,660,000

B.5 ULTRAVIOLET ADVANCED OXIDATION PROCESS

Stantec and Jacobs estimates were within 10% of each other. The vendor equipment utilized was similar and includes a pre-engineered building. The higher estimate was used in the updated cost (**Table 8-17**) to be conservative.

Table 8-17: UV Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
UV AOP Facility	$29,120,000	$30,870,000	$1,750,000	6%	$30,870,000
Subtotal for UV AOP Facility	$29,120,000	$30,870,000	$1,750,000	6%	$30,870,000

B.6 CHEMICALS

Jacobs' estimate uses a canopy in the chemical storage line instead of a full chemical facility. In terms of chemical storage, Jacobs used lower chemical dosages but longer storage durations;

the end result was a lower estimate than Stantec's. Jacobs' chemical storage & dosing cost was used because it was based on updated modeling. Since Jacobs' chemical storage & dosing cost was used, the chemical facility was not included (**Table 8-18**).

Table 8-18: Carbon Addition and Chemicals Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Chemical Facility	$3,890,000	n/a	n/a	n/a	n/a
Chemical Storage & Dosing	$10,510,000	$7,430,000	($3,080,000)	-29%	$7,430,000
Subtotal for Chemicals	$17,100,000	$7,4300,000	($6,969,000)	-48%	$7,430,000

B.7 LIME SYSTEM

The lime system includes lime storage, pumping, and clarifiers. One key difference in assumptions between Stantec's and Jacobs' estimates was the storage volume provided for chemicals and lime. Volumes were based on dosages and the duration between chemical deliveries. For the lime system, Stantec's estimate used a 7-day storage while Jacobs' estimate used a 14-day storage; both estimates use the same lime dose. Stantec used three transfer pumps while Jacobs used five transfer pumps. The updated cost (**Table 8-19**) was based on 14-day storage and five transfer pumps, coupled with the higher lime system clarifier cost.

Table 8-19: Lime System Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Lime System	$4,760,000	$12,020,000	$7,260,000	153%	$12,020,000
Lime System Clarifiers	$3,370,000	$1,680,000	($1,700,000)	-50%	$3,370,000
Subtotal for Lime System	$8,130,000	$13,690,000	$5,560,000	68%	$15,390,000

B.8 SIDESTREAM CENTRATE TREATMENT

Sidestream centrate treatment cost estimates appeared to be based on the same vendor for Annamox treatment with other applicable equipment and facilities included. Stantec's estimate applied an escalation factor. Hazen's estimate is based on more recent vendor information and is therefore used in the updated cost (**Table 8-20**).

Table 8-20: Sidestream Centrate Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate[1]	Difference ($)	Difference (%)	Updated Cost
Sidestream Annamox	$90,320,000	$68,800,000	($21,520,000)	-24%	$68,800,000
Subtotal for Sidestream Annamox	$90,320,000	$68,800,000	($21,520,000)	-24%	$68,800,000

[1]This cost was developed by Hazen

B.9 BUILDINGS

The buildings anticipated at the future facility are subject to significant additional refinement. Both estimates utilized similar building footprints, but the probable unit costs assumed significant differences in building types. Stantec's estimate applied a unit cost for a basic warehouse type building, whereas Jacobs' estimate applied a unit cost for a building with substantial architectural features. Jacobs' estimate did not include an electrical building. The design assumptions for the buildings are shown in **Table 8-21**.

Table 8-21: Footprint and Cost Assumptions for the Buildings

	Stantec's Estimate		Jacobs' Estimate		Updated Estimate	
	Footprint (sq ft)	Unit Cost	Footprint (sq ft)	Unit Cost	Footprint (sq ft)	Unit Cost
Maintenance Building	225 x 85	$93/sf	230 x 88	$1,005/sf	230 x 88	$400/sf
Electrical Building	233 x 72	$115/sf	n/a	n/a	n/a	n/a
Administrative Building	225 x 85	$373/sf	200 x 75	$1,017/sf	225 x 85	$1,000/sf

A summary of the OPCs for each building is provided in **Table 8-22**. To reconcile the building costs, the larger footprint for each is used along with unit costs of $400/sf for the maintenance building (higher than a basic warehouse) and $1,000/sf for the administrative building to account for a laboratory and other features. The electrical building cost is not included since Jacobs' costs for process areas are used and those included electrical buildings per information provided by Jacobs.

Table 8-22: Buildings Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Maintenance Building	$1,970,000	$20,340,000	$18,380,000	935%	$8,100,000
Electrical Building	$1,940,000	n/a	n/a	n/a	n/a
Administrative Building	$7,730,000	$15,260,000	$7,530,000	97%	$19,130,000
Subtotal for Buildings	$11,640,000	$39,800,000	$28,160,000	242%	$33,930,000

B.10 ELECTRICAL AND I&C

The electrical and I&C items included the onsite electrical substation, the electrical substation for SCE, emergency generators, slabs for a generator building, and overall electrical and I&C costs. The difference in the site electrical substation and the electrical substation for SCE was the escalation factor. Jacobs' estimate for substations was the same as Stantec's 2018 estimate whereas Stantec's estimate included escalation to 2021 dollars. Stantec's estimate for emergency generators was based on five generators, each costing $250,000. Jacobs' estimate was not specific to generator sizing, it used a factor applied to a demand with a conservative factor of safety. Stantec's estimate was used in the updated cost due to greater degree of precision. The significant difference between Stantec's and Jacobs estimated "Electrical & I&C" line item resulted from a difference in approach to cost allocation. Stantec's Electrical and I&C line item included all anticipated electrical & I&C costs at the AWPF. Jacobs' estimate incorporated these electrical & I&C costs for each process into the process area line items not the Electrical and I&C line item. Since Jacobs' estimates were used in the process area updated costs (**Table 8-23**), they were also used for the Electrical & I&C line item to avoid double counting of those costs. The slabs for the generator building were included in the updated cost.

Table 8-23: Electrical and I&C Costs Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Electrical Substation	$2,960,000	$2,460,000	($500,000)	-17%	$2,960,000
Electrical Substation for SCE	$26,570,000	$22,360,000	($4,210,000)	-16%	$26,570,000
Emergency Generator	$1,760,000	$10,940,000	$9,180,000	521%	$10,940,000
Generator Building (slabs only)	$200,000	n/a	n/a	n/a	$200,000
Electrical & I&C	$104,940,000	$34,110,000	($70,820,000)	-67%	$34,110,000
Subtotal for Electrical & I&C	$136,420,000	$69,870,000	($66,550,000)	-49%	$74,780,000

B.11 YARD PIPING

Stantec's and Jacobs' approach to estimating the yard piping costs were substantially different. Stantec's BIM model included the yard piping and QTOs were used to develop the OPC. Jacobs applied a blanket percentage at 10% of the construction cost to calculate the yard piping costs. This cost includes drainage and is a parametric estimate based on a recent facility designed by Jacobs. The updated cost (**Table 8-24**) uses Stantec's estimate with an update on the mechanical installation crew (increase from 31 to 400 days). At $4,500/day with the escalation factor applied, the increase is approximately $2.2 million.

Table 8-24: Yard Piping Capital Cost Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Yard Piping	$7,300,000	$60,020,000	$52,720,000	722%	$9,500,000
Subtotal for Yard Piping	$7,300,000	$60,020,000	$52,720,000	722%	$9,500,000

B.12 ESTIMATING ALLOWANCES

Stantec's estimate included an allowance for startup, commissioning, and owner training as well as for estimating accuracy and unlisted items. This line item is not a contingency; it covers known items that may not be estimated accurately and small items that may be left out and therefore, this allowance is included in the updated cost (**Table 8-25**). Examples of unlisted items include details, finishes, and amenities.

Table 8-25: Estimating Allowances Comparison

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Startup/Commissioning/Owner Training	$460,000	n/a	n/a	n/a	$460,000
Estimating Accuracy, Unlisted Items Allowance	$66,790,000	n/a	n/a	n/a	$66,790,000
Subtotal for Estimating Allowances	$67,250,000	n/a	n/a	n/a	$67,250,000

Appendix C O&M COST SUMMARY

The escalated and updated annual operation and maintenance (O&M) OPC from the 2018 studies by Stantec is approximately $22M per year more than the Train 1C O&M OPC in the JTAP report. This amounts to an approximate difference of ~16% as compared to the total annual estimated O&M cost of $136M per year, excluding costs for existing JWPCP processes. Stantec compared the line items in each OPC to identify and assess significant cost differences. The major areas identified with substantive O&M cost differences are the influent and biological treatment equipment, biological process chemicals, chloramine addition, treated water chlorination, buildings on site, and labor. Additionally, labor was reevaluated and updated based on planning discussions with Metropolitan. The following principles were used when deciding which cost between the two OPCs should be recommended:

- For line items with a difference less than 10% or less than $1 million annual O&M cost, the higher cost was selected to be conservative.
- For line items with a difference greater than 10% or more than $1 million annual O&M cost, a revised recommended cost was developed with an explanation.
- If a greater level of detail or precision could be determined based on the information used for one of the estimates compared to the other, that estimate was used

Cost differences and reconciliation are discussed in the sections that follow.

C.1 INFLUENT AND MBR

Stantec's estimate for influent and MBR equipment consisted of costs for power, maintenance, and replacement of consumables (membranes). The power cost was based on equipment capacity instead of an operational average for the blowers and pumps and therefore is more conservative. The Jacobs' estimate for influent and MBR equipment did not detail quantities between power, maintenance, and replacement of consumables but likely was lower for power costs, given similar basis for maintenance and consumables. Jacobs' estimate was used for the updated cost for the influent and MBR equipment since Stantec's estimate overestimated power consumption.

Biological process chemical costs included carbon addition for Stantec's whereas carbon and phosphoric acid addition for Jacobs'. Stantec's estimate was used for carbon as it was based on a higher dose (more conservative). The cost of phosphorus acid was based upon the demand experienced at the APC testing program.

The O&M costs for sidestream centrate treatment differed by 36% but the difference was less than $1M/year. The costs in Jacobs' estimate were prepared by Hazen and were recommended since they were more recent and was prepared after research done by LACSD on sidestream centrate treatment.

The following additional costs were included in Jacobs' estimate:

- Odor control: odor control is required at the future facility and is included in the updated cost.
- Equalization: This is a minor cost based on the maintenance of valves and gates associated with the equalization tank in Jacobs' process design for this train; this cost was included in the updated cost.

A summary of costs, differences, and updated cost is shown in **Table 8-26**.

Table 8-26: Influent and MBR O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Influent and MBR Facilities	$20,150,000	$14,380,000	($5,770,000)	-29%	$14,380,000
Biological Process Chemicals	$31,780,000	$28,650,000	($3,130,000)	-10%	$32,580,000
Sidestream Centrate	$1,870,000	$2,540,000	$670,000	36%	$2,540,000
Odor Control	n/a	$330,000	$330,000	n/a	$330,000
Equalization	n/a	$8,000	$8,000	n/a	$8,000
Subtotal for Influent & MBR	$53,790,000	$45,910,000	($7,880,000)	-15%	$49,840,000

C.2 REVERSE OSMOSIS

Stantec's estimate for chloramine addition was based on a conservative chloramine dose of approximately 4 mg/L as chlorine. Jacobs' estimate was slightly lower and was recommended since testing at the APC has typically required a lower dose than in Stantec's estimate. The RO equipment costs including power, chemicals (antiscalant and sulfuric acid), maintenance, and replacement parts were similar and within $1 million total cost difference. Therefore, Stantec's cost was used in the updated cost (**Table 8-27**).

Table 8-27: RO O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Chloramine Addition	$6,240,000	$4,460,000	($1,780,000)	-29%	$4,460,000
RO System	$39,350,000	$38,390,000	($960,000)	-2%	$39,350,000
Subtotal for RO	$45,590,000	$42,850,000	($2,740,000)	-6%	$43,810,000

C.3 ULTRAVIOLET ADVANCED OXIDATION PROCESS

Stantec's and Jacobs' estimates were based on similar assumptions for equipment, chemical dose and unit cost, and replacement of consumables. Jacobs' used the latest reactor types and considered multiple products (Wedeco K, Trojan Flex) that have fewer lamps and other components, while Stantec used the Wedeco K reactor since the Trojan Flex was yet not available at the time. The costs were within 10% and $1 million total difference. Stantec's cost was used as the updated cost (**Table 8-28**) as it was slightly more conservative.

Table 8-28: UV AOP O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
UV AOP System	$6,260,000	$5,770,000	($490,000)	-8%	$6,260,000
Subtotal for UVAOP	$6,260,000	$5,770,000	($490,000)	-8%	$6,260,000

C.4 STABILIZATION

Stantec's and Jacobs' estimates were based on similar assumptions for equipment, chemical dose and unit cost for lime and carbon dioxide addition for water quality stabilization. The costs were within $1 million of each other. Stantec's cost was used as the updated cost to be conservative. An additional cost was included by Jacobs' and added to the updated cost (**Table 8-29**), for hauling of residual sludge from lime clarifiers, a cost not included in the Stantec estimate.

Table 8-29: Stabilization (Lime and Carbon Dioxide) O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Stabilization	$6,160,000	$5,450,000	($710,000)	-12%	$6,160,000
AWT residuals handling	n/a	$34,000	$34,000	n/a	$34,000
Subtotal for Stabilization	$6,160,000	$5,480,000	($680,000)	-11%	$6,200,000

C.5 EFFLUENT CHLORINATION

Stantec's estimate in 2016 included chemical costs for additional chlorination downstream of UV AOP. Stantec's estimate in 2018 and Jacobs' estimates did not include effluent chlorination. There will be some free chlorine and chloramine residual downstream of UV AOP since it uses chlorine as an oxidant. However, it is conservative to assume some additional chlorine dosing or formation of chloramines prior to product water conveyance. To be conservative, it is recommended effluent chlorination be included in the updated cost (**Table 8-30**) and that any residual chlorine from the UV AOP process is assumed to be zero.

Table 8-30: Effluent Chlorination O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Effluent Chlorination	$3,260,000	n/a	($3,260,000)	n/a	$3,120,000
Subtotal for Effluent Chlorination	$3,260,000	n/a	($3,260,000)	n/a	$3,120,000

C.6 BALANCE OF CHEMICALS, BUILDINGS, ELECTRICAL

The balance of AWT plant O&M costs includes the following components and corresponding recommendations:

- **Chemical systems power & maintenance**: Stantec's estimate included a separate chemical pump power cost and an equipment maintenance cost. Jacobs' estimate included this within each process line item. Stantec's cost is included in the updated cost since many of Stantec's process line-item costs are used.
- **Administration and maintenance buildings**: Stantec's estimate was based on HVAC power costs on similar AWT process building design estimates. Jacobs' estimate used a percentage applied to the building costs. Stantec's estimate was included in the updated cost since it is based on similar facilities.
- **Electrical maintenance**: Stantec's estimate includes only general electrical maintenance. Jacobs' estimate was based on an emergency generator. Jacobs' estimate was included for the updated cost to account for emergency generator cost and because it is more conservative.

A summary of costs, differences, and updated cost is shown in **Table 8-31**.

Table 8-31: Balance of Chemicals, Buildings, Electrical O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Chemical Systems Power & Maintenance	$240,000	n/a	($240,000)	n/a	$240,000

Administration and Maintenance Buildings	$2,470,000	$93,000	($2,380,000)	-96%	$2,470,000
Electrical Maintenance	$50,000	$440,000	$400,000	869%	$440,000
Subtotal for Balance of Chemicals, Buildings, Electrical	$2,750,000	$540,000	($2,210,000)	-80%	$3,150,000

C.7 MAJOR EQUIPMENT REPLACEMENT COST

Major equipment replacement cost was not included in either estimates for equipment such as influent screens, blowers, and pumps. To account for the eventual replacement of this equipment over time, an average annual cost of 5% of equipment was included in the updated cost (**Table 8-32**) estimate; this assumes that equipment will be replaced every 20 years on an average. This cost excludes major process equipment replacements, such MBR and RO equipment.

Table 8-32: Major Equipment Replacement O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Major Equipment Replacement	Not included	Not included	n/a	n/a	$4,860,000
Subtotal Major Equipment Replacement	n/a	n/a	n/a	n/a	$4,860,000

C.8 LABOR

Stantec's estimate for labor was based on costs for the AWT only (i.e. excluded costs for JWPCP labor) and 52 full-time equivalents (FTEs), $150 per hour, and 2,080 hours per FTE per year, with 15% contingency. Jacobs' estimate was based on staffing estimate of 52 FTEs, $150 per hour and 1,800 hours per FTE per year without a contingency. An updated estimate for the updated cost was developed using the information from Orange County Water District's (OCWD's) Groundwater Replenishment System (GWRS) with additional factors considered to be more accurate. OCWD's GWRS staff (64 FTEs) was scaled to 79 FTEs to account for additional plant size and complexity for PWSC (100 mgd for GWRS vs 150 mgd for PWSC), plus an additional 40 FTEs for laboratory staffing, assuming $150 per hour, 2,080 hours per FTE per year without contingency. This results in a total of 119 FTEs for 150 mgd IPR facility. A summary of costs, differences, and updated cost is shown in **Table 8-33**.

Table 8-33: Labor O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Labor	$18,660,000	$14,040,000	($4,620,000)	-25%	$37,128,000
Subtotal Labor	$18,660,000	$14,040,000	($4,620,000)	-25%	$37,128,000

C.9 JWPCP SECONDARY TREATMENT AND BIOSOLIDS PROCESSING

The cost of O&M associated with JWPCP secondary treatment and biosolids was included in both Stantec's and Jacobs' estimates to account for differences between AWT process trains that impact the treatment at JWPCP. For the updated estimate, the JWPCP costs were revised to reflect only the differences between the tMBR train and current JWPCP operations. The components and recommendations are as follows:

- **High purity oxygen activated sludge (HPOAS) treatment**: Stantec's estimate in 2018 was based on approximate percentages of total treatment cost for secondary treatment at JWPCP. Jacobs' estimate was based on greater detail and more recent cost data. For the updated estimate, neither is included since current HPAOS treatment is not impacted by the tMBR AWT train. If sMBR was to be implemented instead, a portion of the HPOAS flow will be treated with sMBR and therefore, a portion of the current HPOAS O&M cost should be credited.

- **Biosolids disposal**: Stantec's estimate in 2018 was based on approximate percentages of total treatment cost for secondary treatment at JWPCP and was escalated to 2021 dollars. Jacobs' estimate was based on more recent cost data although both estimates are similar. Both estimates are shown in **Table 8-34** as tMBR biosolids only (excludes biosolids from HPOAS). Jacobs' estimate for the increase in biosolids disposal from the tMBR process is included in the updated cost.

- **Dissolved air flotation treatment (DAFT) and dewatering energy costs**: Stantec's estimate in 2018 was based on approximate percentages of total treatment cost for secondary treatment at JWPCP. Jacobs' estimate was based on greater detail and more recent cost data. For the updated estimate, neither is included since current treatment is not substantially impacted by the tMBR.

- **Biogas credit**: Jacobs' estimate included a biogas energy credit based on biosolids production and cogeneration of methane produced from anaerobic digesters. The basis for this credit includes biosolids production from existing HPOAS processes to compare with other trains such as sMBR. For the updated estimate, Jacobs' estimate was used for the biogas credit for solids from tMBR process only.

A summary of costs, differences, and updated cost is shown in **Table 8-34**.

Table 8-34: JWPCP Secondary Treatment and Biosolids Processing O&M Cost Summary

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
HPOAS Treatment	$17,110,000	$11,680,000	($5,430,000)	-32%	$0
Biosolids Disposal (tMBR solids only)	$790,000	$1,000,000	$200,000	25%	$1,000,000
DAFT Energy Cost	n/a	$240,000	$240,000	n/a	$0

UPDATED OPINION OF PROBABLE COST FOR THE NDN TERTIARY MBR BASED ADVANCED WATER TREATMENT FACILITY

	Stantec's Estimate	Jacobs' Estimate	Difference ($)	Difference (%)	Updated Cost
Dewatering Energy Cost	n/a	$350,000	$350,000	n/a	$0
Subtotal for JWPCP	$17,900,000	$13,270,000	($4,840,000)	-27%	$1,000,000
Biogas credit	n/a	$8,440,000	n/a	n/a	$1,240,000
Subtotal for JWPCP with biogas credit	n/a	$4,820,000	n/a	n/a	($250,000)

DRAFT

Appendix B.3

Final Feasibility Design Report Backbone Conveyance (2020)

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

FINAL

REGIONAL RECYCLED WATER PROGRAM

Backbone Conveyance System | Feasibility Level Design Report

Volume I of III

June 2020

Black & Veatch
Project No. 191628

BLACK & VEATCH

IN ASSOCIATION WITH CDM Smith

FINAL

REGIONAL RECYCLED WATER PROGRAM

Backbone Conveyance System
Feasibility-Level Design Report
Volume 1

BLACK & VEATCH PROJECT NO. 191628

PREPARED FOR

Metropolitan Water District of Southern California

30 JUNE 2020

BLACK & VEATCH

In association with CDM Smith

Regional Recycled Water Program
Black & Veatch Project 191628

Backbone Conveyance System Feasibility-Level Design Report
June 2020

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ACRONYM AND ABBREVIATIONS LIST

The following abbreviations or acronyms are used in this document.

AACE	Association for the Advancement of Cost Engineering
ARVV	air-release and vacuum valve
AWT	advanced water treatment
Black & Veatch	Black & Veatch Corporation
BEP	best-efficiency point
CalOSHA	California Occupational Safety and Health Administration
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
cf	cubic feet
CGS	California Geologic Survey
CM	construction method
CNDDB	California Natural Diversity Database
DPR	direct potable reuse
EPBM	earth pressure balance tunnel boring machine
FEWWTP	F.E. Weymouth Water Treatment Plant
ft	feet
FLDR	Feasibility-Level Design Report
fps	feet per second
GAC	granular activated carbon
GeoPentech	GeoPentech Inc
GIS	geographic information system
gpm	gallons per minute
HDD	horizontal directional drilling
HGL	hydraulic grade line
HI	Hydraulic Institute
HP	horsepower
ID	inside diameter
in	inches
IPR	indirect potable reuse
IRRP	Indirect Reuse Replenishment Project
IPR	indirect potable reuse
JWPCP	Joint Water Pollution Control Plant
kWh	kilowatt hour
LA	Los Angeles
LACDPW	Los Angeles County Department of Public Works

LACFCD	Los Angeles County Flood Control District
LACSD	Sanitation Districts of Los Angeles County
LADWP	Los Angeles Department of Water and Power
LUFT	leaking underground storage tank
MCAA	Mechanical Contractors Association of America
MCCs	motor control centers
Metropolitan	Metropolitan Water District of Southern California
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
Minagar	Minagar & Associates, Inc.
MJA	McMillan Jacobs Associates
MT	microtunneling
M_W	moment magnitude scale
NECA	National Electrical Contractors Association
OC	Orange County
OC Reach	optional branch to the Orange County Spreading Grounds
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
OD	outside diameter
O&M	operations and maintenance
OPCC	opinion of probable construction cost
Project	design of the conveyance facilities of the Regional Recycled Water Program
PS	pump station
PS-1	Pump Station 1
PS-2	Pump Station 2
PS-3	Pump Station 3
RPM	revolutions per minute
RRWP	Regional Recycled Water Program
RVs	recreational vehicles
SCE	Southern California Edison
SFSG	Santa Fe Spreading Grounds
SG	San Gabriel
SWRCB	State Water Resources Control Board
TBM	tunnel boring machine
TCE	trichloroethylene
USGMWD	Upper San Gabriel Municipal Water District
VFD	variable frequency drive

WBS	work breakdown structures
WRD	Water Replenishment District of Southern California
WSE	water surface elevation

Executive Summary

PROJECT OVERVIEW

In order to improve water supply reliability in Southern California, the Metropolitan Water District of Southern California (Metropolitan) is studying the feasibility of a Regional Recycled Water Program (RRWP). The RRWP would utilize advanced water treatment (AWT) processes to purify secondary treated effluent from the Sanitation Districts of Los Angeles County's (LACSD) Joint Water Pollution Control Plant (JWPCP) in Carson, California, and then pump the advanced treated water to select locations within Metropolitan's service area for beneficial reuse. The full implementation of the RRWP system would include construction of a 150 million gallons per day (mgd) AWT plant next to the JWPCP, a new regional conveyance system, pump stations, and various additional appurtenant facilities as required to convey advanced treated water to the delivery points. Additional smaller diameter piping would be required for laterals and connections to discharge locations, which could include the Santa Fe Spreading Grounds (SFSG), the West Coast Basin Injection Wells, Long Beach Injection Wells, Rio Hondo Spreading Grounds, Montebello Forebay Injection Wells, Orange County (OC) Spreading Grounds, and harbor area industrial users.

The primary objective of the RRWP is to develop a local and sustainable water supply for the region, with an initial focus on providing water to replenish groundwater basins for indirect potable reuse (IPR). In the future as appropriate regulations are promulgated, the RRWP water may transition to direct potable reuse (DPR).

Metropolitan, in conjunction with LACSD, has been conducting planning level studies for the RRWP for more than ten years, which provided the basis for conducting more detailed, feasibility level analyses. Metropolitan separated the feasibility level planning of the RRWP into two components:

- The AWT plant, which in addition to feasibility level analyses for a full-scale treatment plant, included the design and construction of a 0.5 mgd demonstration and piloting project at the JWPCP.
- The conveyance system, which includes the pipeline, pump stations, and associated appurtenant facilities.

The feasibility level study of the conveyance system is the focus of this report. Metropolitan retained the team of Black & Veatch Corporation (Black & Veatch) and CDM Smith to provide the feasibility-level professional engineering services for the alternatives analysis of the conveyance system. The services performed included feasibility-level engineering evaluations to identify, compare, and rank alternatives that best meet the overall project objectives.

This Feasibility-Level Design Report (FLDR) comprehensively documents the conveyance system evaluations completed by the Black & Veatch/CDM Smith team and Metropolitan to date. It also provides the planning basis for the next phases of the RRWP. These next phases of work are expected to include the following studies, which will be used to support final alignment selection:

- Conducting environmental studies and permitting processes to comply with the California Environmental Quality Act (CEQA) and, if necessary, the National Environmental Policy Act.

While this FLDR typically references CEQA, the information in this report can also be used to support the National Environmental Policy Act processes, if required.

- Performing more detailed technical analyses, including field subsurface geotechnical and hydrogeologic investigations, river scour analyses, utility location investigations, and trenchless installation technical studies to advance the pipeline alignment and construction techniques definition and selection.
- Continuing right-of-way acquisition efforts and financial analyses.

PROJECT BACKGROUND

This FLDR is the culmination of several years of effort on the part of Metropolitan's staff, on-going input from and collaboration with stakeholders, and contribution from Metropolitan's consultants, including the Black & Veatch and CDM Smith team. These efforts resulted in several study reports, all of which are embodied in this FLDR and its appendices.

Figure ES-1 presents a timeline summarizing the efforts and reports contributing to the development of this FLDR. Details are summarized below.

Figure ES-1 Timeline of Major Events Pertaining to the Development of this FLDR

Conveyance System Feasibility Assessment. In April 2016, Metropolitan completed a planning study for the RRWP conveyance system, which was documented in the report entitled "Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment." At the time, the RRWP was envisioned to convey the advanced treated water from the AWT plant to various spreading basins and injection wells sites within Metropolitan's service area for groundwater recharge. Upon reaching the discharge locations, the advanced treated water would be recharged into the ground, either through surface infiltration at existing spreading basins or through injection wells. After being stored in the groundwater basin for at least the minimum required retention time, the water would be available for extraction by partnering member agencies, treated, and sold for potable water distribution.

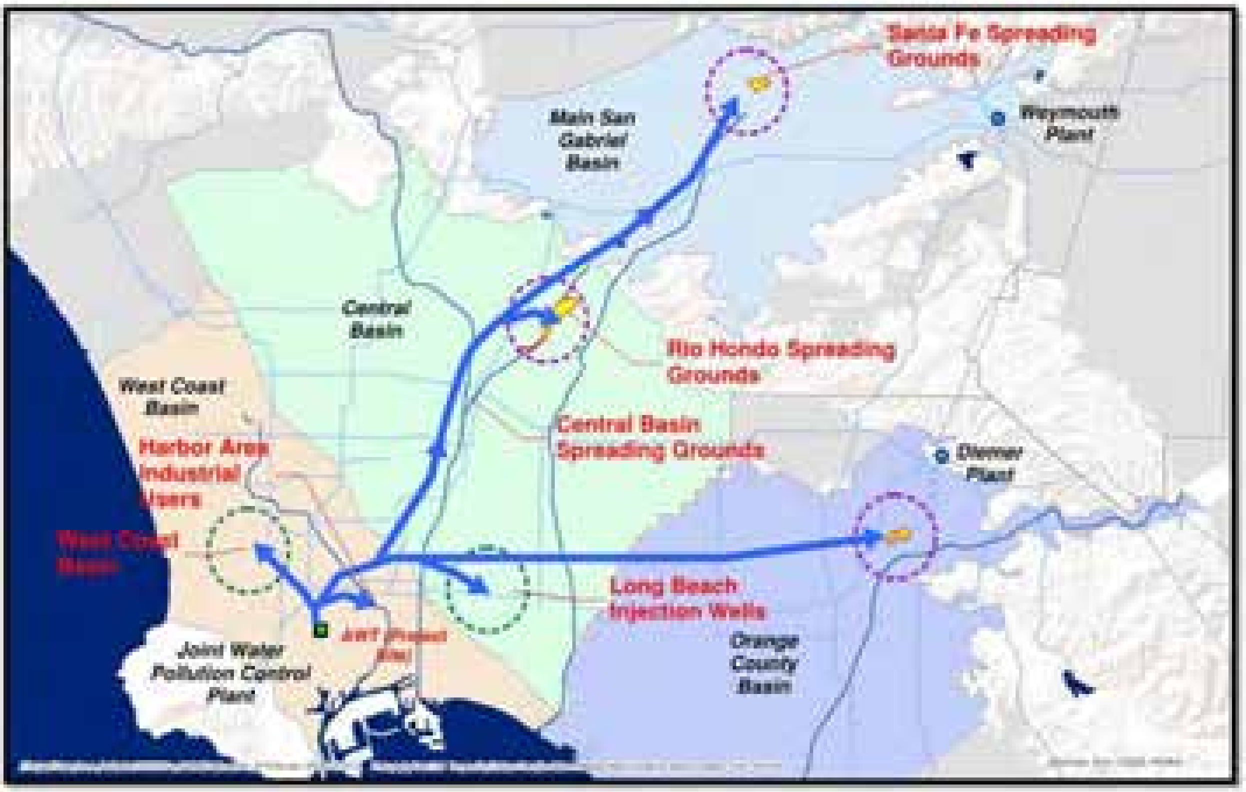

Figure ES-2 RRWP Conceptual Plan as Presented in Metropolitan's April 2016 Assessment

2018 Draft FLDR. In April 2016, Metropolitan initiated the Black & Veatch and CDM Smith team to further refine and evaluate the conveyance system alternatives described in Metropolitan's April 2016 report to help Metropolitan select a preferred alignment and system configuration. Toward that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible alignment alternatives to construct a large diameter conveyance pipeline system to deliver advanced treated water under the same system configuration described in Metropolitan's April 2016 Report. A thorough review of the study area resulted in the assessment of 89 separate pipeline segments, collectively covering nearly 200 miles of potential pipeline routes.

An extensive evaluation process was developed to score and rank the various alternatives and sub-alternatives. The evaluation process considered a host of factors to address the feasibility of construction, as well as minimization of potential community and biological impacts. The evaluation process, including the scoring system, application of weighting/importance factors, and sensitivity analyses, were all developed collaboratively with stakeholders across the Metropolitan organization.

The evaluation and screening process resulted in three overall alignment alternatives for more detailed consideration. One alternative generally follows the San Gabriel (SG) River, one alternative generally follows the Los Angeles (LA) River, and the third alternative utilizes a combination of existing public streets rights-of-way. These three alternatives were subsequently assessed, compared, and ranked based on the project configuration at that time. The results of this analysis were documented in a draft FLDR in October 2018 (referred to as "2018 Draft Report" in this

FLDR). The 2018 Draft Report presented the findings and conclusions of the preliminary technical investigations completed to date, including the recommendations of a preferred conveyance system that would deliver the advanced treated water to multiple spreading grounds and injection well locations, the farthest of which were the SFSG and the OC Spreading Grounds. At that time, the conveyance system was envisioned to split the flows with up to 80 mgd being conveyed to the SFSG and up to 60 mgd being conveyed to the OC Spreading Grounds. The remaining flows would be taken by potential customers along the way, such as the West Coast Basin, the City of Long Beach at injection wells, harbor area industrial users, and the Central Basin (at the Rio Hondo Spreading Grounds).

Conceptual Planning Studies Report. In February of 2019, Metropolitan issued the Conceptual Planning Studies Report presenting the results of further technical studies related to the RRWP conducted by Metropolitan and their consultants, which incorporated the results of the 2018 Draft Report. The studies presented in the Conceptual Planning Studies Report evaluate, among other things, program phasing and the potential for the program to accommodate raw water augmentation for DPR. The report recommended that Metropolitan should "proceed with the environmental review process" for the RRWP.

RRWP White Paper No. 1. In July of 2019, Metropolitan issued the RRWP White Paper No. 1 – Program Implementation and Delivery. In this document, Metropolitan examines two items in detail: 1) what are the implementation options to accelerate the program to construct conveyance facilities and/or make initial deliveries of purified water and 2) how would Metropolitan proceed in developing raw water augmentation opportunities if DPR regulations become promulgated.

Through the studies mentioned above, a proposed implementation strategy emerged that would provide the flexibility to adapt the initial system for future DPR, allow phasing opportunities to accelerate some, or all, of the program, and facilitate phasing of treatment capacity at the AWT plant. The proposed approach included an AWT plant sized to meet existing near-term and planned future demands and a "backbone conveyance system" (Backbone System) that is sized to convey the full 150 mgd from the AWT plant in Carson to the SFSG through an 84-inch pipeline. Under this scenario, a pipeline and pumping stations could be installed to convey the water from the SFSG to the existing F.E. Weymouth Water Treatment Plant (FEWWTP) for additional treatment and incorporation into Metropolitan's existing treated water distribution system for DPR.

Figure ES-3 presents a schematic of the Backbone Alignment conveyance system.

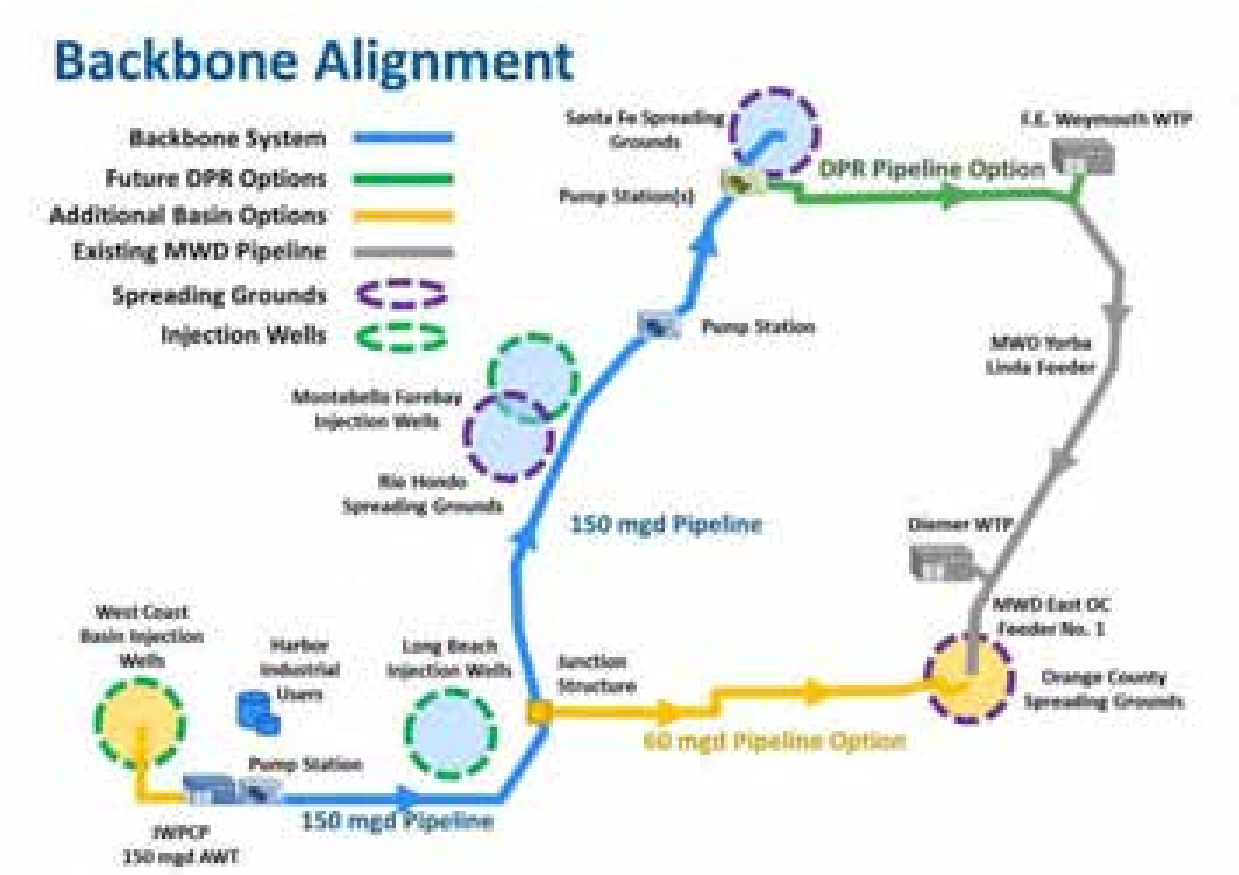

Figure ES-3 Proposed Regional Recycled Water Program Backbone System

2020 Final FLDR. As noted above, this FLDR is the culmination of the above described efforts, as well as additional studies conducted since that time. This FLDR and its appendices include all the studies and research conducted to date related to the RRWP conveyance system. It is an update of the 2018 Draft FLDR. Whereas the 2018 Draft FLDR was developed based on the system configuration described in Metropolitan's Conveyance System Feasibility Report, which was focused on delivering advanced treated water exclusively for groundwater augmentation, the 2020 Final FLDR includes the subsequent evaluations completed to assess the system configuration derived from Metropolitan's Conceptual Planning Studies Report and RRWP White Paper No. 1. Specifically, both documents recommend a Backbone System configured to allow for future implementation of DPR, as shown on Figure ES-3.

The 2020 Final FLDR included two key additional studies:

- ***Impact on Alignment Selection of OC Reach Removal.*** As shown in Figure ES-3, the pipeline reach extending to the OC Spreading Grounds in Anaheim is shown as optional. This is because 1) the current focus of the RRWP is to implement the Backbone System (which provides the flexibility to most easily incorporate raw water augmentation for DPR should regulations get promulgated), and 2) there is uncertainty as to whether the OC Spreading Grounds will ultimately be a key delivery point for IPR use. Since the 2018 Draft

Report included the branch to the OC Spreading Grounds as a critical point of delivery and not an optional future phase, a revisit of the detailed alignment evaluation was warranted to determine what impacts removing this branch would have on the selection of a “preferred” alignment for the Backbone System. Metropolitan authorized Black & Veatch to revisit the alignment study to determine what impact removing the OC Reach would have on the selection of a preferred alignment for the Backbone System. This follow up task was primarily focused between the intersection of the LA River with Sepulveda Boulevard and near the Whittier Narrows Dam, as the alternatives share a common alignment before and after these points.

- ***High Level Evaluation of DPR Alignment Options***. The 2018 Draft Report also ended with a delivery point at the SFSG, with no connection to the FEWWTP having been identified at that point. Towards that end, Metropolitan tasked Black & Veatch with conducting a high-level alignment evaluation for the potential pipeline that would connect the SFSG to the FEWWTP for the purposes of raw water augmentation for DPR.

FLDR PURPOSE

The purpose of this FLDR is to 1) document the robust evaluation process completed to compare and assess an extensive list of alignment alternatives in order to identify the preferred conveyance system, 2) provide detailed descriptions of proposed facilities to support the initiation of subsequent environmental studies and permitting processes to comply with CEQA, and 3) establish the basis for pre-design of the proposed facilities.

An evaluation process was followed to identify the preferred alignments and pump station configurations and locations such that they provide the following attributes:

- Most cost effective to construct
- Optimized operation and maintenance costs
- Minimized impacts on community
- Minimized impacts to the environment

The FLDR considered factors associated with the conveyance system including: potential alignments, feasibility-level pipe design, feasibility-level pump station design, system hydraulics, desktop geologic and seismic hazard analyses, geotechnical considerations, environmental concerns, traffic impacts, Project stakeholder requirements, construction duration, and estimated construction cost to be used as the basis for establishing construction budgets. Extensive review and input from stakeholders across the Metropolitan organizations, including Real Property Group, External Affairs Group, Environmental Planning Section, Engineering Services Group (specifically Design Section and Infrastructure Reliability Section), and Water System Operations was included in the assessments throughout the study.

BACKBONE SYSTEM ALIGNMENT ALTERNATIVES

As a result of the analyses completed, two alternatives appeared favorable as compared to their peers: the SG River Alignment and the LA River Alignment. These two alternatives are recommended to be carried forward into the environmental studies necessary to comply with

CEQA and are described in greater detail herein. Subsurface investigations and detailed environmental studies were not performed as part of this Project and will be completed during subsequent phases of work and will be used to help refine and differentiate between the two options.

While these two alternatives appear most favorable based on the analysis completed to date, the third "street right-of-way" alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan. By virtue of the compiled information presented within the main FLDR report and its appendices, this FLDR also identifies and describes additional feasible alignments and subalignment alternatives that could be carried forward if obstacles are encountered during future phases of work that impact the viability of any part of an alternative, such as unforeseen environmental impacts, technical infeasibility found via future detailed subsurface geotechnical and utility investigations, community or municipal objections, or the inability to acquire right-of-way.

This section describes the two alignment alternatives that are recommended for more detailed technical and environmental study: the SG River Alignment and the LA River Alignment.

San Gabriel River Alignment

The SG River Alignment is comprised of three reaches (Reach 1, Reach 3, and Reach 4), as described below, and is presented on Figure ES-4. The SG River Alignment is similar in concept to the "Initial Base Case" identified in an earlier phase of the RRWP, which was the route selected by Metropolitan as the most promising prior to the start of this Project.

The "Initial Base Case" was split into four reaches, with each reach beginning at a proposed pump station or control structure and ending at the wet well of the next pump station, a discharge basin, or control structure. While the Backbone System that is currently proposed does not include the branch to the OC Spreading Grounds (Reach 2) in the initial implementation phases, this FLDR has maintained the same breakdown of reaches for the SG River Alignment in the event that the branch to the OC Spreading Grounds moves forward at a later date. It may be warranted to revise the breakdown of reaches for the Backbone System during the next phase of work.

- Reach 1 – Reach 1 would be approximately 13 miles in length and would begin at the AWT plant and terminate at the former junction to the OC Spreading Grounds adjacent to the SG River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of Los Angeles, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within existing public street right-of-way with a short stretch along the San Gabriel River. This pipeline section would convey up to 150 mgd.
- Reach 2 – Reach 2 consists of the alignments proposed to reach the OC Spreading Grounds from the Initial Base Case and would, if further considered in the future, convey up to 60 mgd. It is not part of the Backbone System.

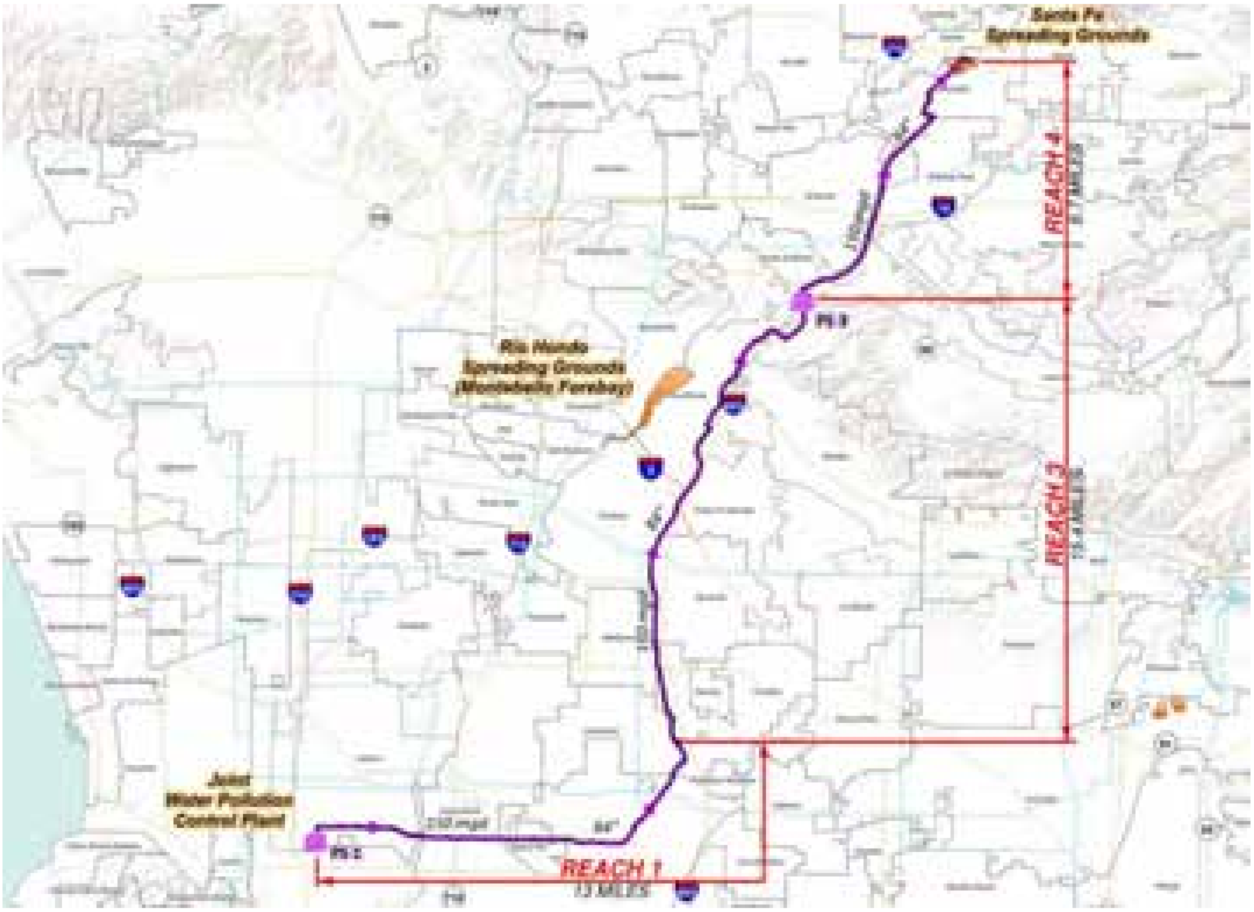

Figure ES-4 SG River Alignment Overview and Reach Extents

- Reach 3 – Reach 3 would be approximately 15.4 miles in length and begin at the former junction to the OC Spreading Grounds and terminate at the proposed site of Pump Station 3 (PS-3), north of Whittier Narrows Dam. From south to north, the alignment would pass through the Cities of Cerritos, Bellflower, Downey, and Pico Rivera. The majority of the alignment would fall within Southern California Edison (SCE) right-of-way paralleling the San Gabriel River. Due to the narrow SCE corridor and environmentally-sensitive nature areas along the San Gabriel River, the pipeline may have to be placed alternatively within the river bed itself, as well as within public street rights-of-way for portions of the alignment. It is anticipated that the pipeline would convey up to 150 mgd.
- Reach 4 – Reach 4 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG in the City of Irwindale. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LA County Flood Control District (LACFCD) right-of-way with a small stretch in public street rights-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

Table ES-1 summarizes key information about each reach.

Table ES-1 Key Characteristics of SG River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FEET)
1	Pump Station 1 (PS-1) to optional connection for Reach 2	0.0 – 14.0	350
2	Reach1 to OC Spreading Grounds (optional) (Note 2)	N/A	N/A
3	End of Reach 1 to PS-3	14.0 – 28.4	Note 1
4	PS-3 to SFSG	28.4 – 38.1	336

Notes:
1. PS-1 provides the lift for Reach 3, as well as for Reach 2 with a flow control structure should it be further evaluated.
2. Pump Station 2 (PS-2) was eliminated as part of the Backbone System.

Los Angeles River Alignment

The LA River Alignment is comprised of two reaches (Reach 1 and Reach 2), as presented on Figure ES-5. The LA River Alignment generally aligns with the Los Angeles River. The LA River Alignment is slightly shorter than the SG River Alignment and is located further west, which affords a shorter connection to any potential partnership opportunities with the City of LA. It should be noted that Reach 2 is the same as Reach 4 for the SG River Alignment.

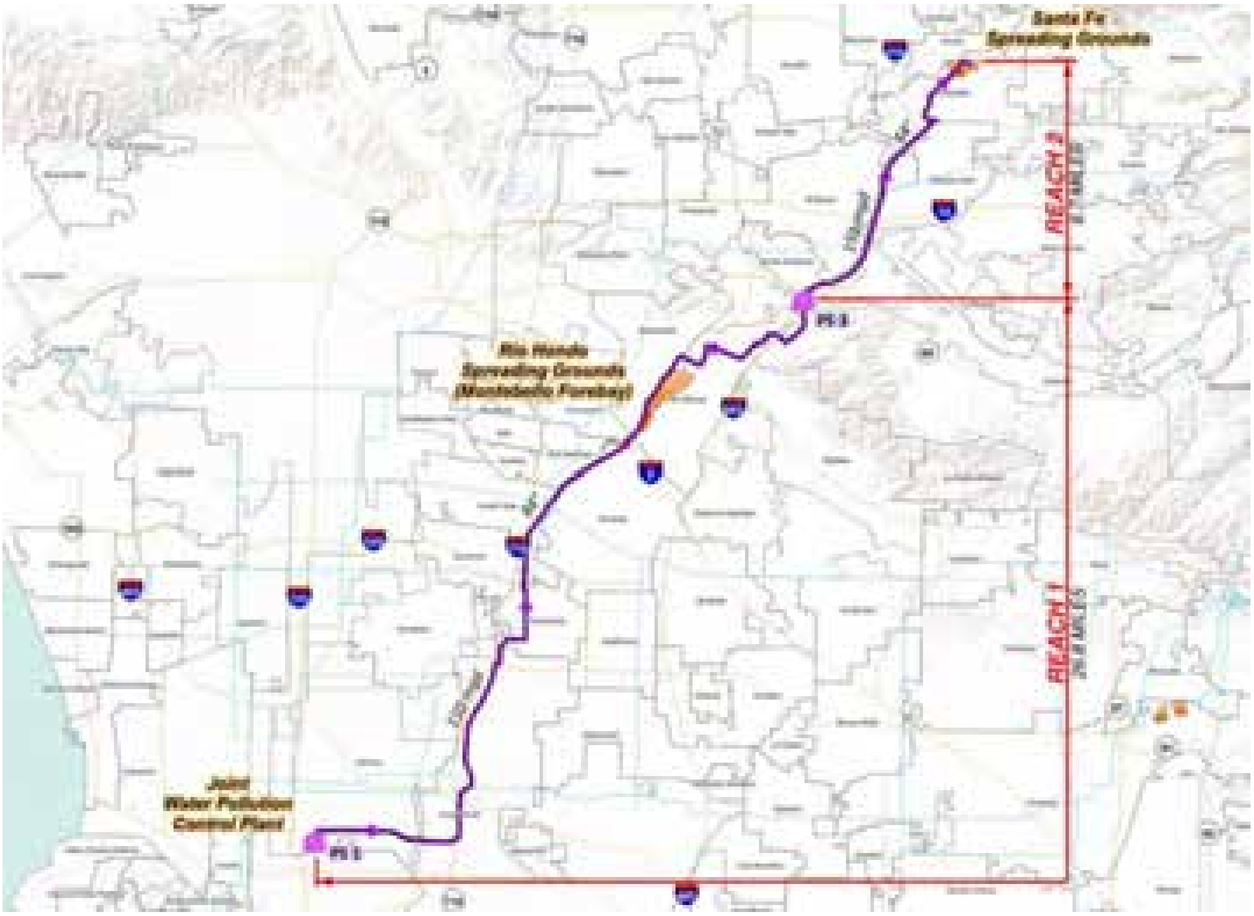

Figure ES-5 LA River Alignment Overview and Reach Extents

The LA River Alignment was developed and evaluated for the Backbone System and does not include the OC Reach, as the analysis completed shows that the SG River Alignment would be the preferred conveyance system with the OC Reach. Therefore, the LA River Alignment was separated into two reaches.

- Reach 1 – Reach 1 would be approximately 26.8 miles in length and would begin at the AWT plant and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, this reach would pass through unincorporated L.A. County and the Cities of Long Beach, Paramount, South Gate, Downey, Commerce, Pico Rivera, Montebello, and Industry. A majority of this reach would be within SCE and LACFCD right-of-way paralleling the LA River and then the Rio Hondo Channel. To avoid locations where a sufficient corridor does not exist, the pipeline would leave the river to be within public street rights-of-way for portions of the alignment. At Whittier Boulevard, the alignment would leave the Rio Hondo Channel and head east in existing public rights-of-way to the SG River. From here, the alignment would be mostly within SCE right-of-way parallel to the SG River. This pipeline section would convey up to 150 mgd.
- Reach 2 – Reach 2 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A

majority of the alignment would fall within SCE and LACFCD right-of-way with a small stretch in public street rigs-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

Table ES-2 summarizes key information about each reach.

Table ES-2 Key Characteristics of LA River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FET)
1	PS-1 to PS-3	0.0 – 26.8	341
2	PS-3 to SFSG	26.8 – 36.5	336
Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.			

PUMP STATIONS

The preferred pump station configuration for the Backbone System includes two pump stations to overcome the changes in elevation and system head losses along the alignment: The first pump station would be at the AWT plant, known as PS-1, and the second, known as PS-3, would be at the end of Reach 3 for the SG River Alignment and Reach 1 for the LA River Alignment. Prior to the identification of the Backbone System as the preferred implementation strategy, another pump station, known as PS-2, was considered where the branch to the OC Spreading Grounds would have been located. While the Backbone System that is currently proposed does not include the branch to the OC Spreading Grounds, nor PS-2, the FLDR retained the naming convention for consistency. It may be warranted to rename the proposed pump stations during the next phase of work.

Table ES-3 presents key design criteria for each of the pump stations being considered for the Backbone System. These pump stations form the basis for the cost opinions prepared for the Project. PS-1 is currently envisioned to have two separate discharge pipelines operating at different hydraulic grades. Therefore, to provide the most efficient system, two sets of pumps (Set A and Set B) would be provided: Set A would pump to injections wells for West Basin and Set B would pump to PS-3. PS-3 would only have one set of pumps pumping to the SFSG.

Under the concept outlined in Table ES-3, PS-1 would pump directly to the wet well of PS-3 and PS-3 would pump to the SFSG. Flow control would be achieved by modulating the variable frequency drive (VFD) driven pumps or flow control valves to meet the flow set point. The flow set point would be modified, or trimmed, based on the level in the upstream storage tank/forebay. The pump stations would be interlocked to keep the stations operating within designated parameters.

At this stage of study, it was determined that the hydraulics of the SG and LA River Alignments were similar enough that a common layout and general siting could be assumed as equally applicable for both alternatives.

Table ES-3 Summary of Key Pump Station Design Characteristics

ITEM	PUMP STATION 1	PUMP STATION 3
Pumps to	Set A: West Basin Injection Wells Set B: PS-3 Forebay	SFSG
Number of Pumps	Set A: 2 duty, 1 standby Set B: 4 duty, 1 standby	4 duty, 1 standby
Pump Type	Vertical turbine, VFDs	Vertical turbine, VFDs
Firm Capacity, per station	Set A: 15 mgd Set B: 150 mgd	150 mgd (SFSG)
Rated Point for Pump Selection, per pump	Set A: 7.5 mgd at 165 ft Set B: 37.5 mgd at 352 ft	37.5 mgd at 352 ft
Rated Horsepower (hp), each pump	Set A: 300 to 350 hp Set B: 4,500 to 5,000 hp	4,500 to 5,000 hp
Site Layout	Within AWT plant site	Approximately 350 ft by 450 ft
Approximate Ground Elevation, feet above mean sea level	42 ft	220 ft
General Location	Located on the northeast corner of the AWT plant	Near Whittier Narrows Dam
Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.		

FEASIBILITY-LEVEL DESIGN OF THE PIPELINES

Black & Veatch completed the feasibility-level design of the pipelines associated with the Backbone System for the SG and LA River Alignments. Based on a constant design flow rate of 150 mgd and the operating pressures resulting from the lifts provided at each pump station, the design team optimized the pipeline's characteristics. Higher design velocities translate to higher hydraulic losses in the pipeline and, subsequently, higher pumping costs. Higher velocities in the pipeline would also increase the surge potential and intensity during any unplanned stoppage of the pumps (i.e., a pump trip), which would lead to larger footprints required for surge mitigation as compared to lower velocities in the pipelines. Higher velocities can also require more expensive lining methods and could lead to higher maintenance costs. Conversely, lower design velocities require larger pipe diameters which correlates to higher capital costs to construct. The optimization compared these factors and recommended a pipe diameter of 84 inches. As the capacity required for the Backbone System is constant from the AWT plant to the SFSG, the recommended pipe size is unchanged throughout. The pipe material would be welded steel pipe in accordance with Metropolitan standards.

Preliminary steel plate thickness calculations were completed for the SG River Alignment based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a reach by reach analysis to support cost estimating. It is assumed that more detailed, site specific calculations will be completed during preliminary design. The required steel plate thickness was 0.5 inches for all reaches. Since the LA River Alignment has the same, or slightly less, lift required at each pump station (since the alignment is slightly shorter), the plate thicknesses calculated for the SG River Alignment were also used for the LA River Alignment for purposes of planning and cost estimating.

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings would be used to develop typical details for these appurtenances.

As part of the preliminary design, a study should be performed to determine potential locations of blow-offs and ARVVs along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design. In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points. Since the pipeline would convey advanced treated water, care in planning and design would be needed to assure compliance with regulatory requirements. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

POTENTIAL CONNECTION FROM THE SFSG TO THE FEWWTP FOR DPR

An evaluation was performed to determine the preferred conveyance alignment for the future connection from the SFSG to the FEWWTP. While the flow rate for the conveyance system connection to the FEWWTP has not yet been determined, it is currently envisioned to be up to the full 150 mgd. The evaluation compared alignment alternatives for the purposes of achieving a ranking to recommend a preferred alignment; the evaluation did not include scope for additional facility descriptions or hydraulic evaluations. Additional evaluations would be required to determine the details of the pump station, or stations.

The preferred conveyance alignment connecting the SFSG to the FEWWTP would consist of a new pipeline connecting to Metropolitan's existing Glendora Tunnel (15'6" tunnel per as-built records) and then pumping water east to the FEWWTP, reverse of its current operation. The Glendora Tunnel is currently used to convey raw water from the Rialto Pipeline and / or the Upper Feeder to the USG-3 service connection for discharge to San Gabriel Canyon and ultimately to spreading basins for groundwater recharge. With the implementation of the RRWP, the Upper San Gabriel Municipal Water District (USGMWD) could receive their replenishment water via the RRWP at the SFSG in lieu of from USG-3. Therefore, the Glendora Tunnel could be available for this new use.

To reach the Glendora Tunnel, the pipeline alignment would follow Arrow Highway and then turn north at Irwindale Avenue. At Gladstone Street, the alignment would turn east before turning north in Azusa Avenue / SR 39. From there, the corridor would traverse north in Azusa Avenue and then north on Ranch Road. From Ranch Road, a new tunnel connecting to the terminus of the Glendora Tunnel would be constructed.

The alignment then follows the Glendora Tunnel east to the La Verne Pipeline. The La Verne Pipeline connects the east portal of the Glendora Tunnel to the Upper Feeder Junction Structure, approximately two miles to the south. The Upper Feeder Junction Structure has the ability to blend the advanced treated water with Colorado River water and State Water Project water before discharging into the FEWWTP's inlet conduit. The Upper Feeder Junction Structure allows for flow to be diverted to the Diemer Water Treatment Plant via the Yorba Linda Feeder.

Metropolitan conducted a preliminary hydraulic analysis and determined that the hydraulic grade line required to pump water east through the Glendora Tunnel is less than the design hydraulic grade for the tunnel. Therefore, this FLDR assumes that no structural improvements to the tunnel are required. This assumption should be confirmed during subsequent evaluations.

Since Metropolitan currently provides replenishment water to the USGMWD via USG-3, which is located at the westerly end of the Glendora Tunnel, approximately 14,000 feet (ft) of the Backbone Alignment associated with discharging to the SFSG could be substituted. Instead, the advanced treated water could be discharged to the San Gabriel River at, or near, USG-3 (or at another location north of the SFSG) which the Los Angeles County Department of Public Works (LACDPW) has indicated is preferred to the SFSG.

This FLDR recognizes that construction of a large diameter pipeline within Azusa Avenue would have significant impacts on the community. Azusa Avenue is one of the most heavily traveled surface streets in the area and is a popular through street from the 10 Freeway in the south to the 210 Freeway in the north. North of the 210 Freeway, Azusa Avenue is home to downtown Azusa, an improved, walkable downtown district with shops, wide sidewalks, and narrow streets.

Towards that end, this Project identified, but did not fully evaluate, two alternate alignments from Arrow Highway to the Glendora Tunnel, as shown on Figure ES-6. These alternatives should be further evaluated should the SFSG to FEWWTP concept move forward.

Hydraulic Considerations

Although a detailed hydraulic evaluation and pump station siting study for the connection from the SFSG to the FEWWTP was outside the scope of this evaluation, a quick review of the topography shows that there is a ~550-ft difference in grade (480 ft at the SFSG compared to 1,030 ft invert elevation at the terminus of the Glendora Tunnel) plus hydraulic losses along the way. Metropolitan prefers to limit the lift at any single pump station to between 300 and 400 ft when possible. Therefore, it appears that at least two additional pump stations would be required.

Figure ES-6 Preferred Connection from SFSG to the FEWWTP and Alternatives

EVALUATION OF LONG TUNNELS TO AVOID AREAS OF CONCERN

A preliminary review was performed comparing and assessing two long tunnels to avoid areas of particular concern for the Project.

The first area of concern was the approximately 4.5-mile-long portion of the alignment within the City of Carson. To avoid anticipated City of Carson concerns on traffic and community impact, Metropolitan considered tunneling within the City of Carson. This section has many active and abandoned utilities already in the same corridor due to the historic oil refineries in the area, as well as large sewer trunk lines flowing to the JWPCP. By tunneling this section, the Project could avoid both of these potential obstacles.

The second area of concern was the approximately 4.6-mile-long section of the SG River Alignment that is proposed within the earthen bottom of the SG River. This section extends from Imperial Highway to Washington Boulevard, where available corridors adjacent to the river channel are temporarily unavailable.

After conversations with Metropolitan's project management team, the FLDR incorporated the following approach:

- Further evaluations are required to determine the preferred construction method for these sections during the next phase of work.
- For the purposes of this FLDR, it was assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed was developed using the cost of a tunnel such that this section would have a conservative budget. This assumption was considered in evaluation scoring and did not change the outcomes.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Table ES-4 provides the Engineer's opinion of probable construction cost (OPCC) for the conveyance portion of the RRWP Backbone System. This includes the pipelines and pump stations from the AWT plant to the SFSG.

The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars.
- The Engineer's OPCC is Class 4 from the Association for the Advancement of Cost Engineering (AACE) with an accuracy range of -30% to +50%.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.
- Prices include 22% to cover contractor overhead, profit, bonding, and insurance.
- The following costs are not included in the Engineer's OPCC:
    - Injection wells
    - Laterals to Project customers, including service connections and injection wells
    - Improvements to spreading basins
    - Permits
    - Right of way or easement acquisition
    - Property acquisition
    - Professional services, including engineering
    - Metropolitan staff time, including construction management
    - Design fieldwork, including potholing, geotechnical or environmental fieldwork
    - Contingency for potential tariffs
    - Removal, remediation, and/or disposal of potentially contaminated soils identified as a result of future environmental fieldwork

Table ES-4 Summary of Construction Costs for the Conveyance Facilities (Backbone System)

ITEM	SG RIVER ALIGNMENT TOTAL CONSTRUCTION COST	LA RIVER ALIGNMENT TOTAL CONSTRUCTION COST
Pipeline	$796,300,000	$727,600,000
Pump Stations		
PS-1	$51,200,000	$51,200,000
PS-3	$51,200,000	$51,200,000
RRWP Conveyance System Total	**$898,700,000**	**$830,000,000**

Per Table ES-4, the cost opinions for the SG and LA River Alignments are within ten percent of each other. At this feasibility level of study and estimating, this is within the level of accuracy of the estimates. Other factors outside of the construction cost opinion impact the overall feasibility and cost of each alignment, such as the property acquisition costs, design costs, and environmental mitigation costs. These are not included in the numbers presented in Table ES-4.

A cost opinion was also prepared for the pipelines associated with the connection from the SFSG to the FEWWTP. The cost opinion was based upon Alignment 4 connecting to the Glendora Tunnel, as described previously. The pump stations and any modifications, improvements, or repairs to Metropolitan's existing facilities – such as the Glendora Tunnel, La Verne Pipeline, or Upper Feeder Junction Structure – that would be required to form a complete and functioning system, are outside of the scope of this Project and are not included in this cost opinion. The OPCC for the pipelines that would be required to connect the SFSG to the FEWWTP for DPR would be:

- $214,600,000

As noted above, a cost opinion has not been prepared for the pump stations necessary to convey water from the SFSG to the Glendora Tunnel, and ultimately on to the FEWWTP. However, for budgeting purposes until these facilities can be further evaluated, Metropolitan has indicated that two pump stations of similar size and cost as PS-3 should be used as a place holder. The combined cost for two PS-3's would be:

- $102,400,000

The OPCC for the connection from the SFSG to the FEWWTP for DPR was based upon the quantities presented in Table ES-5

Table ES-5 Quantity Take Off – Connection from SFSG to FEWWTP for DPR

ITEM	QUANTITY
84-inch welded steel pipe in roadways, feet	40,200
Tunnel, feet	10,500
Pump Stations, each	2

CONCLUSION AND RECOMMENDATIONS

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of impacts and risks based on the information available for this Project. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies and technical analysis. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

While these two alternatives appear most favorable based on the analysis completed to date, the third "street right-of-way" alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan.

It is recommended that the future connection from the Backbone System to the FEWWTP utilize the Glendora Tunnel. Additional evaluations that include coordination with the local jurisdictions should be completed during the next phase of work to determine the preferred alignment to reach the terminus of the Glendora Tunnel, as well as the number and location of the pump stations required. This evaluation should also consider if any improvements are required to Metropolitan's existing facilities to utilize the Glendora Tunnel in this manner, such as repairs to the Glendora Tunnel's lining, service connections (i.e., PM-26 or USG-3), or the functionality of the Upper Feeder Junction Structure.

This FLDR documents technical analysis completed to date supporting the development of the RRWP conveyance system and provides a basis as the RRWP transitions to the next phase of design. The next phase of design will continue to refine the RRWP conveyance system and will consist of more detailed engineering studies, as well as the initiation of more detailed environmental studies to comply with CEQA.

1.0 Introduction

In order to improve water supply reliability in Southern California, the Metropolitan Water District of Southern California (Metropolitan) is studying the feasibility of a Regional Recycled Water Program (RRWP). The RRWP would utilize advanced water treatment (AWT) processes to purify secondary treated effluent from the Sanitation Districts of Los Angeles County's (LACSD) Joint Water Pollution Control Plant (JWPCP) in Carson, California and then pump the advanced treated water to select locations in Metropolitan's service area for beneficial reuse.

In March 2016, Metropolitan retained the Black & Veatch Corporation (Black & Veatch) and CDM Smith team to complete feasibility level engineering and technical investigations to support the feasibility-level design of the conveyance system facilities for the RRWP. At the time, the RRWP was envisioned to provide advanced treated water to select locations within Metropolitan's service area for groundwater recharge, including the Santa Fe Spreading Grounds (SFSG). Towards that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible corridors in which to construct a large diameter conveyance pipeline system. A thorough review of the study area resulted in 89 separate pipeline segments, covering nearly 200 miles collectively, being considered. The results of this analysis was documented in a draft Feasibility-Level Design Report (FLDR) in October 2018 (referred to as "2018 Draft Report" in this FLDR), which presented the findings and conclusions of the preliminary technical investigations, including the recommendations of a preferred conveyance system focusing on indirect potable reuse (IPR) based on the best information available at the time. Throughout the process, workshops were held with Metropolitan stakeholders to gain feedback at every step of the evaluation.

As expected during the planning stages of a large-scale program that would provide regional benefits, the RRWP has continued to evolve since that time due to ongoing collaboration amongst interested potential partners and additional technical investigations, including the following key elements:

- How could the program accommodate future direct potable reuse (DPR) opportunities?
- Are there beneficial partnerships with other regional entities the program could leverage?
- What happens if an optional delivery point is removed from the analysis?

Based on the evolution of the Project, the technical evaluations completed prior to October 2018 were revisited. However, due to additional funding for this Project being reserved for future phases of work, a limit on time, and the uncertainties with the future regulations regarding DPR, some of the technical evaluations were performed only at a high level or were deferred to future phases.

This FLDR presents the revised findings and conclusions supporting the upcoming design and construction of the RRWP. In this FLDR, it is noted where technical evaluations need to be revisited for confirmation during the next phase of work.

1.1 PROJECT OVERVIEW

The RRWP would include construction of an AWT plant and a new regional conveyance system, including pump stations, pipelines, and various additional appurtenant facilities to convey the advanced treated water to select locations in Metropolitan's service area for beneficial reuse, including groundwater recharge. Additional smaller diameter distribution piping would be required for the laterals and connections to discharge points. It is anticipated that the program would consist of multiple implementation phases with an ultimate build-out system capacity of 150 million gallons per day (mgd) of highly treated recycled water. This new water supply would reduce dependency on imported water, while increasing overall flexibility and reliability for the region. Metropolitan separated the planning of the RRWP into two components.

- The AWT plant, which includes the full-scale treatment plant, as well as the design and construction of a 0.5 mgd demonstration project at the JWPCP. The purpose of the demonstration project is to:
  - Demonstrate proof of concept while identifying viable treatment technologies
  - Establish performance parameters for preliminary and final design
  - Provide information for projecting capital, operation and maintenance costs
- The conveyance system, which includes the pipeline, pump stations, and associated appurtenant facilities.

This FLDR documents the feasibility-level design for the conveyance system facilities of the RRWP (known as the "Project"). Work associated with the AWT plant is outside the scope of this report.

1.2 PROJECT BACKGROUND

This FLDR is the culmination of several years of effort on the part of Metropolitan's staff, on-going input from and collaboration with stakeholders, and contribution from Metropolitan's consultants, including the Black & Veatch and CDM Smith team. These efforts resulted in several study reports, all of which are embodied in this FLDR and its appendices.

Figure 1-1 presents a timeline summarizing the efforts and reports contributing to the development of this FLDR. Details are summarized below.

Figure 1-1 Timeline of Major Events Pertaining to the Development of this FLDR

Conveyance System Feasibility Assessment. In April 2016, Metropolitan completed a planning study for the RRWP conveyance system, which was documented in the report entitled "Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment". At the time, the RRWP was envisioned to convey the advanced treated water from the AWT plant to various spreading basins and injection wells sites within Metropolitan's service area for groundwater recharge. Upon reaching the discharge locations, the advanced treated water would be recharged into the ground, either through surface infiltration at existing spreading basins or through injection wells. After being stored in the groundwater basin for at least the minimum required retention time, the water would be available for extraction by partnering member agencies, treated, and sold for potable water distribution.

Figure 1-2, prepared by Metropolitan in 2016, presents a conceptual plan of the RRWP conveyance system including potential discharge locations as envisioned at the time.

Figure 1-2 RRWP Conceptual Plan as Presented in Metropolitan's April 2016 Assessment

2018 Draft FLDR. In April 2016, Metropolitan initiated the Black & Veatch and CDM Smith team to further refine and evaluate the conveyance system alternatives described in Metropolitan's April 2016 report in an effort to help Metropolitan select a preferred alignment and system configuration. Toward that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible alignment alternatives to construct a large diameter conveyance pipeline system to deliver advanced treated water under the same system configuration described in Metropolitan's April 2016 Report. A thorough review of the study area resulted in the assessment of 89 separate pipeline segments, covering nearly 200 miles of potential pipeline routes, collectively.

An extensive evaluation process was developed to score and rank the various alternatives and sub-alternatives. The evaluation process considered a host of factors to address the feasibility of construction as well as minimization of potential community and biological impacts. The evaluation process, including the scoring system, application of weighting/importance factors, and sensitivity analyses were all developed collaboratively with stakeholders across the Metropolitan organization.

The evaluation and screening process resulted in three overall alignment alternatives for more detailed consideration. One alternative generally follows the San Gabriel (SG) River, one alternative generally follows the Los Angeles (LA) River, and the third alternative utilizes a combination of existing public streets rights-of-way. These three alternatives were subsequently assessed, compared, and ranked based on the project configuration at that time. The results of this analysis were documented in a draft FLDR in October 2018 (referred to as "2018 Draft Report" in this FLDR). The 2018 Draft Report presented the findings and conclusions of the preliminary technical investigations completed to date, including the recommendations of a preferred conveyance system that would deliver the advanced treated water to multiple spreading grounds and injection well locations, the farthest of which were the SFSG and the OC Spreading Grounds. At that time, the conveyance system was envisioned to split the flow with up to 80 mgd being conveyed to the SFSG and up to 60 mgd being conveyed to the OC Spreading Grounds. The remaining flows would be taken by potential customers along the way, such as the West Coast Basin, the City of Long Beach at injection wells, harbor area industrial users, and the Central Basin (at the Rio Hondo Spreading Grounds).

Conceptual Planning Studies Report. In February of 2019, Metropolitan issued the Conceptual Planning Studies Report presenting the results of further technical studies related to the RRWP conducted by Metropolitan and their consultants, which incorporated the results of the 2018 Draft Report. The studies presented in the Conceptual Planning Studies Report evaluate, among other things, program phasing and the potential for the program to accommodate raw water augmentation for DPR. The report recommended that Metropolitan should "proceed with the environmental review process" for the RRWP.

RRWP White Paper No. 1. In July of 2019, Metropolitan issued the RRWP White Paper No. 1 – Program Implementation and Delivery. In this document, Metropolitan examines two items in detail: 1) what are the implementation options to accelerate the program to construct conveyance facilities and/or make initial deliveries of purified water and 2) how would Metropolitan proceed in developing raw water augmentation opportunities if DPR regulations become promulgated.

Through the studies mentioned above, a proposed implementation strategy emerged that would provide the flexibility to adapt the initial system for future DPR, allow phasing opportunities to accelerate some, or all, of the program, and facilitate phasing of treatment capacity at the AWT plant. The proposed approach included an AWT plant sized to meet existing near-term and planned future demands and a "backbone conveyance system" (Backbone System) that is sized to convey the full 150 mgd from the AWT plant in Carson to the SFSG through an 84-inch pipeline. Under this scenario, a pipeline and pumping stations could be installed to convey the water from the SFSG to the existing F.E. Weymouth Water Treatment Plant (FEWWTP) for additional treatment and incorporation into Metropolitan's existing treated water distribution system for DPR.

Another benefit of the Backbone System is that it would allow for a potential interconnection to other purified water reuse programs. Note that the details of other water reuse programs remain uncertain. So, while the Backbone System concept may provide the aforementioned potential benefit, the Backbone System concept has not been developed to accommodate any interconnecting systems nor has the alignment selection analysis attempted to take potential points of connection into account. Additional coordination and studies will be necessary should such partnerships become better defined.

Figure 1-3 presents a schematic of the Backbone Alignment conveyance system.

2020 Final FLDR. As noted above, this FLDR is the culmination of the above described efforts, as well as additional studies conducted since that time. This FLDR and its appendices include all the studies and research conducted to date related to the RRWP conveyance system. It is an update of the 2018 Draft FLDR. Whereas the 2018 Draft FLDR was developed based on the system configuration described in Metropolitan's Conveyance System Feasibility Report which was focused on delivering advanced treated water exclusively for groundwater augmentation, the 2020 Final FLDR includes the subsequent evaluations completed considering the system configuration derived from Metropolitan's Conceptual Planning Studies Report and RRWP White Paper No. 1. Specifically, both documents recommend a Backbone System configured to allow for future implementation of DPR, as shown in Figure 1-3.

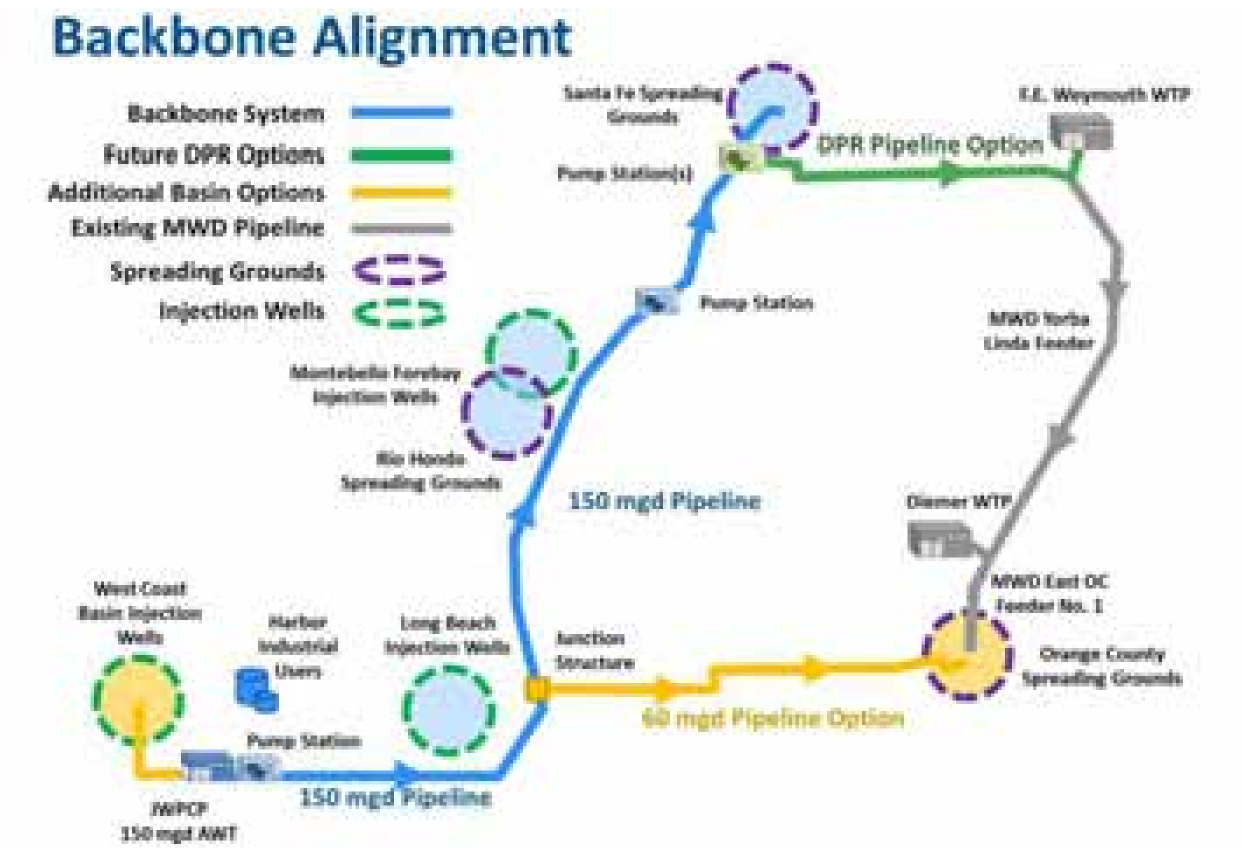

Figure 1-3 **Proposed Regional Recycled Water Program Backbone System**

The 2020 Final FLDR therefore included two key studies:

- ***Impact on Alignment Selection of OC Reach Removal.*** As shown in Figure 1-3, the pipeline reach extending to the Orange County Spreading Grounds in Anaheim is shown as optional. This is because 1) the current focus of the RRWP is to implement the Backbone System (which provides the flexibility to most easily incorporate raw water augmentation for DPR should regulations get promulgated) and 2) there is uncertainty as to whether the OC Spreading Grounds will ultimately be a key delivery point for IPR use. Since the 2018 Draft Report included the branch to the OC Spreading Grounds as a critical point of delivery and not an optional future phase, it was warranted to revisit the detailed alignment evaluation to determine what impacts removing this branch would have on the selection of a "preferred" alignment for the Backbone System. Metropolitan authorized Black & Veatch to revisit the alignment study to determine what impact removing the OC Reach would have on the selection of a preferred alignment for the Backbone System. This follow up task was primarily focused between the intersection of the LA River with Sepulveda Boulevard and near the Whittier Narrows Dam, as the alternatives share a common alignment before and after these points.
- ***High Level Evaluation of DPR Alignment Options***. The 2018 Draft Report also ended with a delivery point at the SFSG, with no connection to the FEWWTP having been identified at that point. Towards that end, Metropolitan tasked Black & Veatch with conducting a high-level alignment evaluation for the potential pipeline that would connect the SFSG to the FEWWTP for the purposes of raw water augmentation for DPR.

This FLDR documents the efforts described above and the resulting descriptions, including:

- The technical investigations evaluating a potential conveyance system intended for IPR
- The re-evaluation of pipeline alignments for the Backbone System
- The evaluation of pipeline alignments from the Backbone System to FEWWTP
- The resulting Project alternatives recommended for further evaluation

1.3 FLDR PURPOSE

The purpose of this FLDR is to 1) document the robust evaluation process completed to compare and assess an extensive list of alignment alternatives in order to identify the preferred conveyance system, 2) provide detailed descriptions of proposed facilities to support the initiation of subsequent environmental studies to comply with the California Environmental Quality Act (CEQA), and 3) establish the basis for pre-design of the proposed facilities. While this FLDR typically references CEQA, the information in this report can also be used to support the National Environmental Policy Act processes, if required.

An evaluation process was followed to identify the preferred alignments and pump station configurations and locations such that they provide the following attributes:

- Most cost effective to construct
- Optimized operation and maintenance costs

- Minimized impacts on community
- Minimized impacts to the environment

The FLDR considered factors associated with the conveyance system including: potential alignments, feasibility-level pipe design, feasibility-level pump station design, system hydraulics, geologic and seismic hazards analysis, desktop geotechnical considerations, environmental concerns, traffic impacts, Project stakeholder requirements, construction duration, and estimated construction cost to be used as the basis for establishing construction budgets. Extensive review and input from stakeholders across the Metropolitan organization, including Public Affairs, Environmental, Geotechnical, Water System Operations, Engineering, and so on was included in the assessments throughout the FLDR development. Subsurface investigations and detailed environmental studies were not performed as part of this Project and should be completed during subsequent phases of work.

By virtue of the compiled information presented within the main FLDR report and its appendices, this FLDR also identifies and describes additional feasible alignments and subalignment alternatives that could be carried forward if obstacles are encountered during future phases of work that impact the viability of any part of an alternative, such as unforeseen environmental impacts, technical infeasibility found via future detailed subsurface geotechnical and utility investigations, community or municipal objections, or the inability to acquire right-of-way.

1.4 PRIOR STUDIES

This section discusses other studies completed on the RRWP and provides additional background information on the Project.

1.4.1 Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment

Prior to retaining Black & Veatch and CDM Smith, Metropolitan performed an initial identification of potential alignments for the RRWP conveyance system intended to deliver water to the SFSG and the OC Spreading Grounds – along with other points along the way – in the report entitled "Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment," dated April 2016. In the study, Metropolitan evaluated multiple alignments and identified the most promising to serve as the starting point for this FLDR.

The assessment separated the alternatives into 59 separate pipeline segments. Each segment started and ended at a junction with another segment and could be combined to form various alignments from the AWT plant to the discharge locations. These segments, numbered numerically (i.e., Segment 1, 2, etc.), could then be evaluated to determine which combination of segments form the alignment that meets the Project's goals.

Figure 1-4 was obtained from Metropolitan's April 2016 assessment and presents the 59 pipeline segments identified by Metropolitan.

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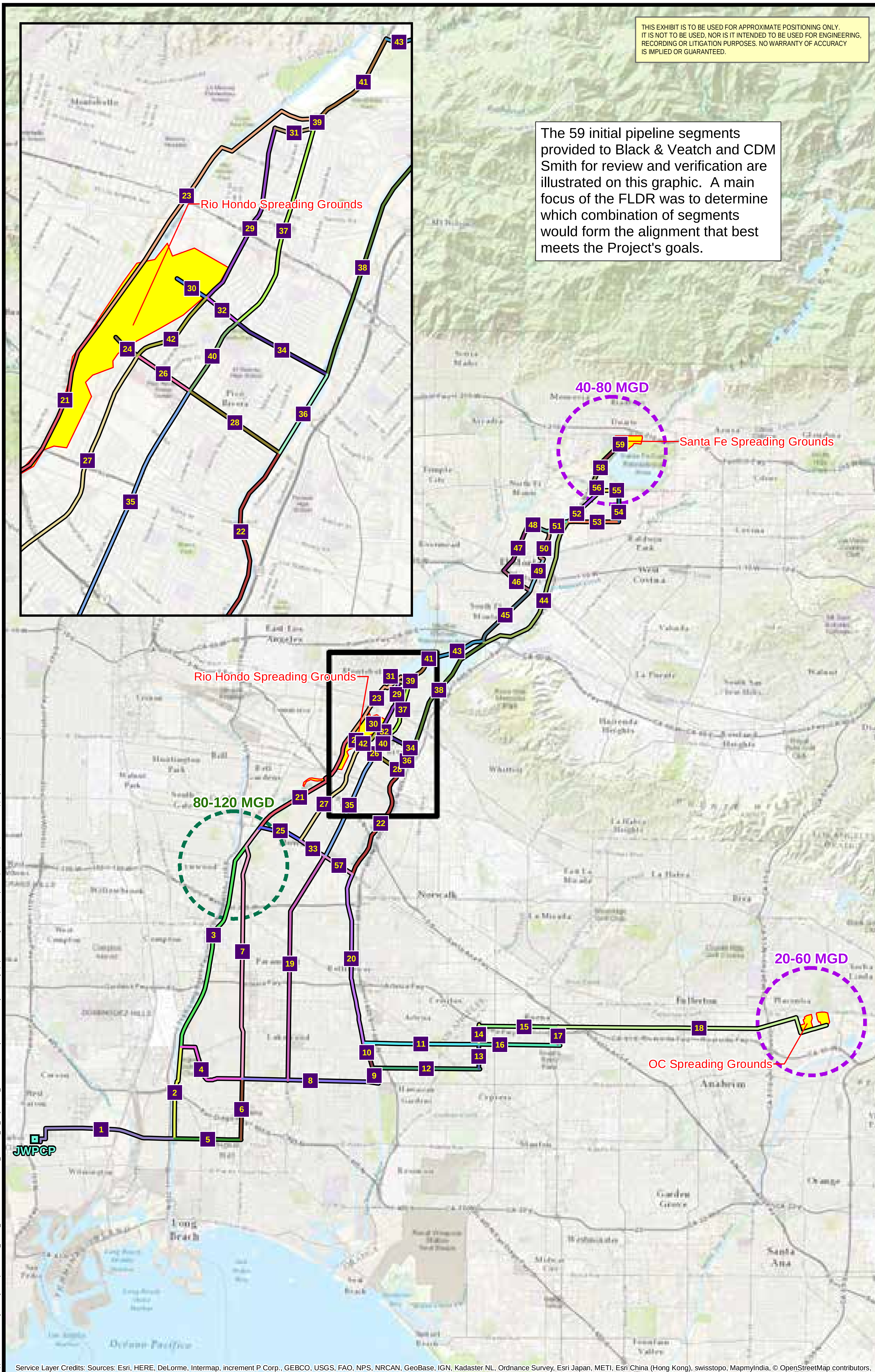

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Figure 1-4: 59 Initial Pipeline Segments Identified in Metropolitan's April 2016 Assessment

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1.4.1.1 Initial Base Case

Metropolitan's April 2016 assessment discussed all the alignment segments, and an initial identification of the most feasible alignment was made (Initial Base Case). For simplicity, the Initial Base Case alignment was broken into four reaches (Reach 1-4). Each reach would consist of pipeline sections beginning at a pump station or diversion structure and ending at the wet well of the next pump station, discharge basin, or diversion structure, as described below:

- Reach 1 – Reach 1 would be approximately 16 miles in length and begin at the AWT plant and terminate at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of LA, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within public street right-of-way with stretches along both the Los Angeles River and the San Gabriel River.
- Reach 2 – Reach 2 would be approximately 16 miles in length and begin at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River in the City of Cerritos and terminate at the OC Spreading Basins at Anaheim Lakes in the City of Anaheim. From west to east, the alignment would pass through the Cities of Cerritos, La Palma, Buena Park, Fullerton, Placentia, and Anaheim. Approximately six miles of the alignment would lie within Southern California Edison (SCE) right-of-way while the remaining 10 miles would fall within public street right-of-way.
- Reach 3 – Reach 3 would be approximately 14 miles in length and begin at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River in the City of Cerritos and terminate near Whittier Narrows Dam. From south to north, the alignment would pass through the cities of Cerritos, Bellflower, Downey, and Pico Rivera. Most of the alignment would fall within SCE right-of-way paralleling the San Gabriel River. Due to the narrow SCE corridor and environmentally-sensitive areas along the San Gabriel River, the pipeline may have to be placed alternatively within the river bed itself and within public street rights-of-way for portions of the alignment.
- Reach 4 – Reach 4 would be approximately 10 miles in length and start near Whittier Narrows Dam and end at the Santa Fe Spreading Basins in the City of Irwindale. The alignment would fall within both public street right-of-way and SCE and Los Angeles County Flood Control District (LACFCD) right-of-way.

The Initial Base Case alignment segments are presented in Table 1-1 and shown on Figure 1-5. Figure 1-5 was obtained from Metropolitan's April 2016 assessment.

Table 1-1 Initial Base Case Segments

REACH	SEGMENT NOS.
1	1, 2, 4, 8, 9, 10
2	11, 16, 17, 18
3	20, 22, 28, 26, 24, 36, 38
4	44, 52, 56, 58, 59

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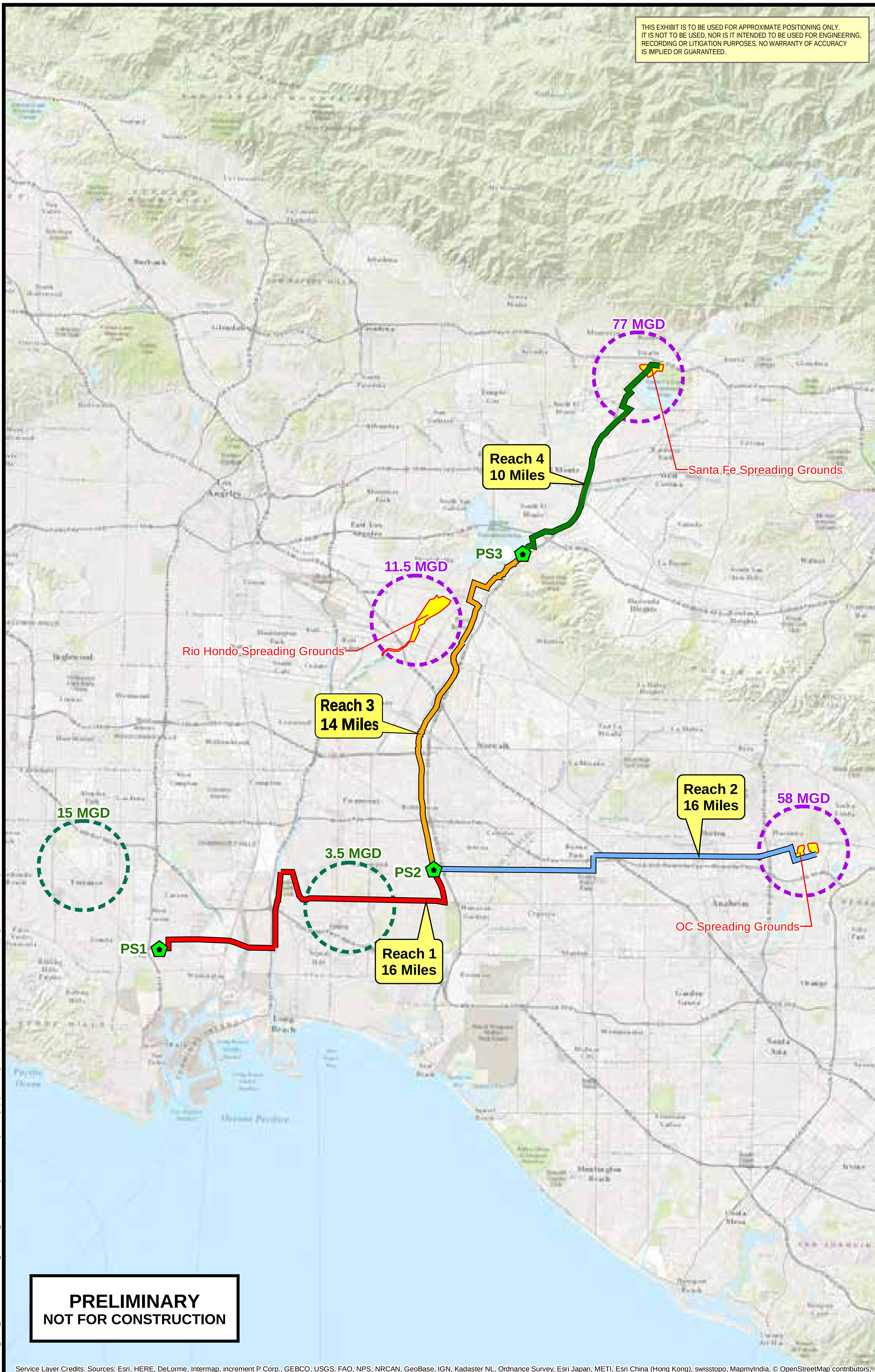

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Figure 1-5: Initial Base Case Conveyance Map

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1.4.1.1 Pump Stations

At the time, Metropolitan envisioned the RRWP would require three pump stations based on hydraulic effects, pipeline elevations, required pipe diameters, pumping costs, and pump station construction and maintenance costs.

Table 1-2 lists the pump stations identified by Metropolitan and provided to Black & Veatch and CDM Smith. Their general locations are shown on Figure 1-5. The number and location of pump stations was further evaluated during the preparation of this FLDR, as described in Chapter 5. Specific details on the pump stations, including siting, are provided in Chapter 8.

Table 1-2 Initial RRWP Pump Stations

PUMP STATION	GENERAL LOCATION	PUMPS TO
Pump Station 1 (PS-1)	JWPCP, Carson	Set A: Potential Future User Set B: PS-2 Forebay
Pump Station 2 (PS-2)	Adjacent to San Gabriel River near Del Amo Street	Set A: OC Spreading Basin Set B: PS-3 Forebay
Pump Station 3 (PS-3)	Near Whittier Narrows Dam	Santa Fe Spreading Basin

PS-1 and PS-2 would have two separate discharge pipelines operating at different hydraulic grades. Therefore, to provide the most efficient system, two sets of pumps (Set A and Set B) would be provided at PS-1 and PS-2. PS-3 only has one discharge location so only one set of pumps would be provided.

1.4.2 Business Case Report

In parallel with the initial efforts of this FLDR, Metropolitan developed a Business Case report that was presented to the Board of Directors in October of 2016. With support from data developed for this FLDR, the Business Case report included preliminary capital and operating cost estimates for the Base Case conveyance system. Those costs were combined with costs for the RRWP treatment system and other associated RRWP costs to support an evaluation of the potential economic viability of the overall RRWP.

1.5 FEASIBILITY-LEVEL ENGINEERING DEVELOPMENT APPROACH

The approach used to develop this FLDR consisted of five phases, as shown on Figure 1-6. Throughout the process, workshops were held with Metropolitan and, as appropriate, with other stakeholders to ensure consensus.

Additional discussion on each phase of FLDR development is discussed in the subsections that follow.

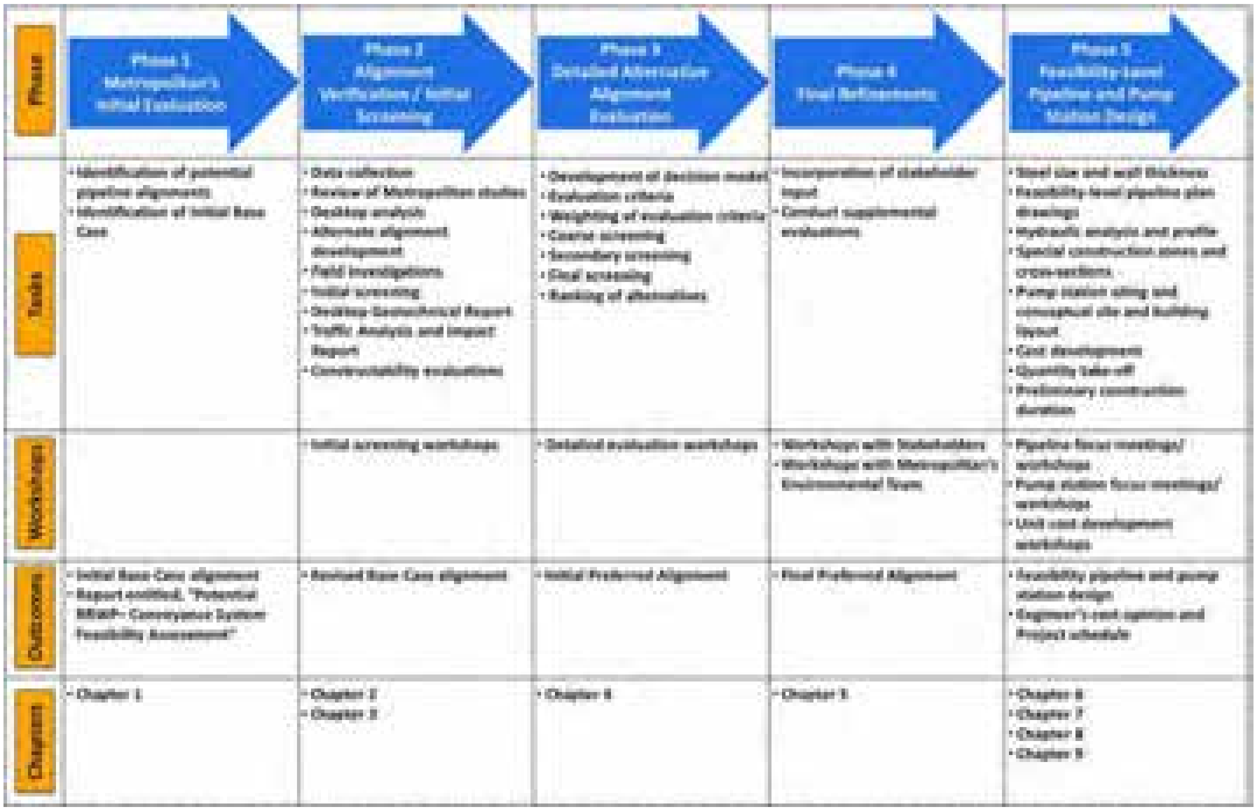


Figure 1-6 Feasibility-Level Engineering Development Approach

1.5.1 Metropolitan's Initial Evaluation

Black & Veatch reviewed Metropolitan's April 2016 assessment, which serves as the basis of this FLDR.

1.5.2 Alignment Verification and Initial Screening

Building upon the previous evaluations completed by Metropolitan, Black & Veatch performed an independent assessment of potential pipeline alternatives.

Goals associated with the assessment of alignment and segment alternatives included:

- Identifying additional feasible alignments that could be carried forward for further review if obstacles are encountered later during Project planning and design. Obstacles could include physical obstacles that would impact constructability and Project cost, leading to the selection of a better alternative route. Obstacles could also include unforeseen community or municipal objections, inability to acquire rights-of-way from entities such as SCE or LACFCD, or environmental / regulatory constraints yet to be identified.
- Providing full consideration of alignment alternatives such that the FLDR documentation and alignment analyses would support the next stages of CEQA compliance, Project planning, and preliminary and final design.
- Performing independent data gathering that supported an initial screening of the identified alignments, including those in the Metropolitan report, others identified and considered by

Metropolitan, and additional alternatives identified by Black & Veatch by the following methods:

- Compiling and reviewing record information about potential pipeline alignments in the Project area, using a combination of printed information and data available from Geographic Information Systems (GIS) records.
- Completing a desktop-level analysis of potential pipeline alignments using the aforementioned printed and GIS record information and internet-based mapping tools.
- Performing field reconnaissance of potential pipeline alignments.
- Conducting alignment-focused workshops with Metropolitan to review the results of the records review, desktop analyses, and field reconnaissance.

- Concluding the initial screening by identifying the set of alignment alternatives to be carried forward for additional analysis.

Using the information provided by Metropolitan and additional data obtained by Black & Veatch, an initial screening was performed to eliminate alignments not meeting Metropolitan's Project goals. At the end of the initial screening, a Revised Base Case alignment was identified which was used as the basis for Metropolitan's development of the Business Case Report and the development of a detailed Engineer's Opinion of Probable Construction Cost (OPCC) for the Business Case Report. Additionally, the initial screening identified the alignments to be carried forward to the detailed alternative alignment evaluation.

1.5.3 Detailed Alternative Alignment Evaluation

The alignments carried forward from the initial screening underwent a detailed alternative alignment evaluation to achieve a ranking of alternative alignments. The highest ranked alignment from this evaluation was known as the Initial Preferred Alignment. This evaluation was focused on a conveyance system for IPR and included alignments to reach the SFSG and the OC Spreading Grounds, along with other delivery points to potential customers such as refineries, etc. along the way.

1.5.4 Final Refinements

Additional technical evaluations were conducted to build upon and further refine the analysis completed. These technical evaluations covered two main areas. The first covered a more in depth evaluation to address specific areas of concern. As a result of the technical analysis completed, revisions were made to the Initial Preferred Alignment towards refining its constructability, financial feasibility, and social and environmental acceptability.

Second, several major changes to Project goals occurred that warranted being reflected in the alignment evaluation, including 1) the potential for DPR to become regulated, 2) the potential for partnership opportunities with other regional entities, and 3) the potential change in delivery points. As a result of these changes, two alignment alternatives emerged as favored and warranting of more detailed analysis in order to select a preferred alignment. Both alignments are recommended for further environmental studies. As noted previously, while two alternatives appear favorable, the third street right-of-way alternative has been described and evaluated in sufficient detail to be considered for CEQA, if so desired by Metropolitan.

1.5.5 Feasibility-Level Pipeline and Pump Station Design

Feasibility-level designs were completed on the two alignment alternatives resulting from the Final Refinements, including pump stations. These feasibility-level descriptions of facilities serve as the basis for the development of an Engineer's OPCC and feasibility-level construction duration. This FLDR was prepared documenting the work that had been completed.

1.6 REPORT ORGANIZATION

The FLDR documents the development of a preferred alignment and pump station configuration and recommended design decisions for the Project elements in support of environmental studies, permitting processes, and pre-design. Table 1-3 summarizes the organization of the FLDR.

Table 1-3 Organization of Report

CHAPTER/TITLE	DESCRIPTION
Executive Summary	Provides a general description of the RRWP conveyance system and summarizes the overall FLDR organization.
1.0 Introduction	Presents an overview of the RRWP and the background on the Project's evolution, discusses previous related studies, outlines the purpose of the FLDR, summarizes the feasibility-level engineering development approach and describes the organization of the FLDR.
2.0 Alignment Verification and Initial Screening	Briefly describes the data collection and initial screening process, including desktop evaluations of possible pipeline alignments, field verification of desktop evaluation findings, and results of workshops with Metropolitan's staff. Summarizes the initial screening process and identifies pipeline segments carried forward for additional analysis.
3.0 Supporting Technical Evaluations	Summarizes three supporting technical evaluations completed during FLDR development: traffic analysis and impacts evaluation, desktop geotechnical evaluation, and construction evaluation. The latter discussion incudes a preliminary description of trenchless and cut-and-cover construction methods.
4.0 Detailed Alternative Alignment Evaluations	Focuses on the pipeline segments identified in Chapter 2 to achieve a ranking of alignment alternatives. Describes evaluation goals, decision model, evaluation criteria, weighting of evaluation factors, and the evaluation screening. The results of this evaluation, as well as the Initial Preferred Alignment that was identified, was based on the inclusion of the reach to the OC Spreading Grounds.
5.0 Final Refinements	Describes the evolution of the Project after the initial alignment evaluation including the subsequent evaluations that resulted from changes in the Project's objectives. Included in this chapter are 1) progressive refinements to the Initial Preferred Alignment, 2) further alignment evaluations on the Backbone System, and 3) evaluation of alignments connecting the Backbone System to the FEWWTP.

CHAPTER/TITLE	DESCRIPTION
6.0 Feasibility-Level Design of the San Gabriel (SG) River Alignment	Documents the development of a feasibility-level design for the SG River Alignment with a focus on providing information to support the next phase of technical analysis, environmental studies and permitting processes. Additionally, develops feasibility-level engineering details for the pipeline to provide the basis for pre-design of the proposed facilities.
7.0 Feasibility-Level Design of the LA River Alignment	Documents the development of a feasibility-level design for the LA River Alignment with a focus on providing information to support the next phase of technical analysis, environmental studies and permitting processes. Additionally, develops feasibility-level engineering details for the pipeline to provide the basis for pre-design of the proposed facilities.
8.0 Pump Station Analysis	Focuses on developing a feasibility-level design for the pump stations required for the RRWP. Pump stations were developed for the IPR conveyance system originally envisioned that included the OC Reach. Changes that would be required for the Backbone System were noted, where applicable. The additional pump stations that would be required to convey water from the Backbone System to FEWWTP were not evaluated as part of this Project and need to be defined in subsequent phases of work. This chapter describes the following: pump station overview, conceptual operating strategy, pump station hydraulics, building requirements, surge control strategies, storage facilities, yard piping, power supply and electrical requirements, site investigations, and architectural theme.
9.0 Project Duration and Cost Opinion	Describes the development of the construction duration and the engineer's opinion of probable construction cost for the LA and SG River Alignments' conveyance system, including unit cost development and quantity take-off.
10.0 Conclusions and Recommendations	Summarizes the conclusions resulting from the technical analysis documented in this report, including the recommendation to complete more detailed analysis on the SG and LA River Alignments and the summarization of the additional studies required in the next phases of work, as identified elsewhere in the report.

CHAPTER/TITLE	DESCRIPTION
Appendices	A. Field Investigation Notes B. Preliminary Traffic Control Assessment for the Metropolitan Water District of Southern California's Potential Regional Recycled Water Supply Program Feasibility Study C. Preliminary Geotechnical/Geologic Evaluation, Proposed Regional Recycled Water Supply Program D. Raw Data Tables of Segments and Subsegments E. Decision Model Results F. Additional Details on Secondary and Fine Screening G. Feasibility-Level Pipeline Plan Drawings H. Optimization of Pipe Sizes and Pumping Costs I. Steel Cylinder Design Calculations J. Preliminary Calculations and Equipment Selection for Pump Stations K. Concept Pump Performance Curves L. Concept Pump Station Site Layouts M. Unit Cost Development for Construction Methods and Adders N. Quantity Take-Off O. Pipeline Engineer's Opinion of Probable Construction Cost P. Pump Station Engineer's Opinion of Probable Construction Cost Q. Hydraulic High Point Memo R. Alignment Verification Analysis S. Backbone Alignment Decision Model Details T. Santa Fe to Weymouth WTP Alignment Evaluation Memo U. Orange County Reach Evaluation V. 2018 Draft Report Pump Station Analysis W. Conceptual Review of Three New Tunnel Alignments Draft Report

2.0 Alignment Verification and Initial Screening

As described in Chapter 1 and highlighted in Figure 2-1 below, the initial focus of this study was to build upon the extensive research and evaluations performed by Metropolitan, verify the alignment alternatives previously identified, and complete an initial screening. This chapter documents the completion of the following tasks:

- **Data Collection and Initial Screening.** Data was collected for the study area relevant to identifying risk factors for the construction of a large conveyance system. Data was collected in paper and electronic forms and was confirmed via field visits. Workshops were held with Metropolitan to validate the data collected.
- **Summary of Pipeline Segments.** This section documents the 89 potential pipeline segments that were identified after an exhaustive review of the study area. These segments could be combined to form full alignment alternatives. Workshops were held with Metropolitan to review the pipeline segments identified.
- **Initial Screening Results and Revised Base Case.** During collaborative workshops with Metropolitan, the potential pipeline segments identified were screened to remove high risk alternatives. To support Metropolitan's development of the Business Case Report, revisions to the Initial Base Case that were preferable based on the level of evaluation completed were reviewed and agreed to with Metropolitan. The refined alignment was known as the Revised Base Case. An Engineer's OPCC was developed on the Revised Base Case to support the Business Case Report.

At the completion of this chapter, 89 potential pipeline segments were identified for further evaluation and screening. Additionally, the Revised Base Case had been established and an Engineer's OPCC developed to support Metropolitan's Business Case Report.

The alignment alternatives identified by Metropolitan and verified / screened in this Chapter were focused on the delivery of water to the SFSG and the OC Spreading Grounds, as well as other locations along the way, for the purpose of groundwater recharge as that was the Project concept at the time. Although the Project concept has evolved, the analyses provided in this Chapter were sufficiently robust to provide the foundation for additional alignment analyses that resulted in the two alternatives for the Backbone System which are presented later in this FLDR: the LA River and SG River Alignments.

See Chapter 5 for the subsequent alignment alternatives connecting the Backbone System to the FEWWTP. Figure 2-1 summarizes the Project methodology as it applies to this chapter.

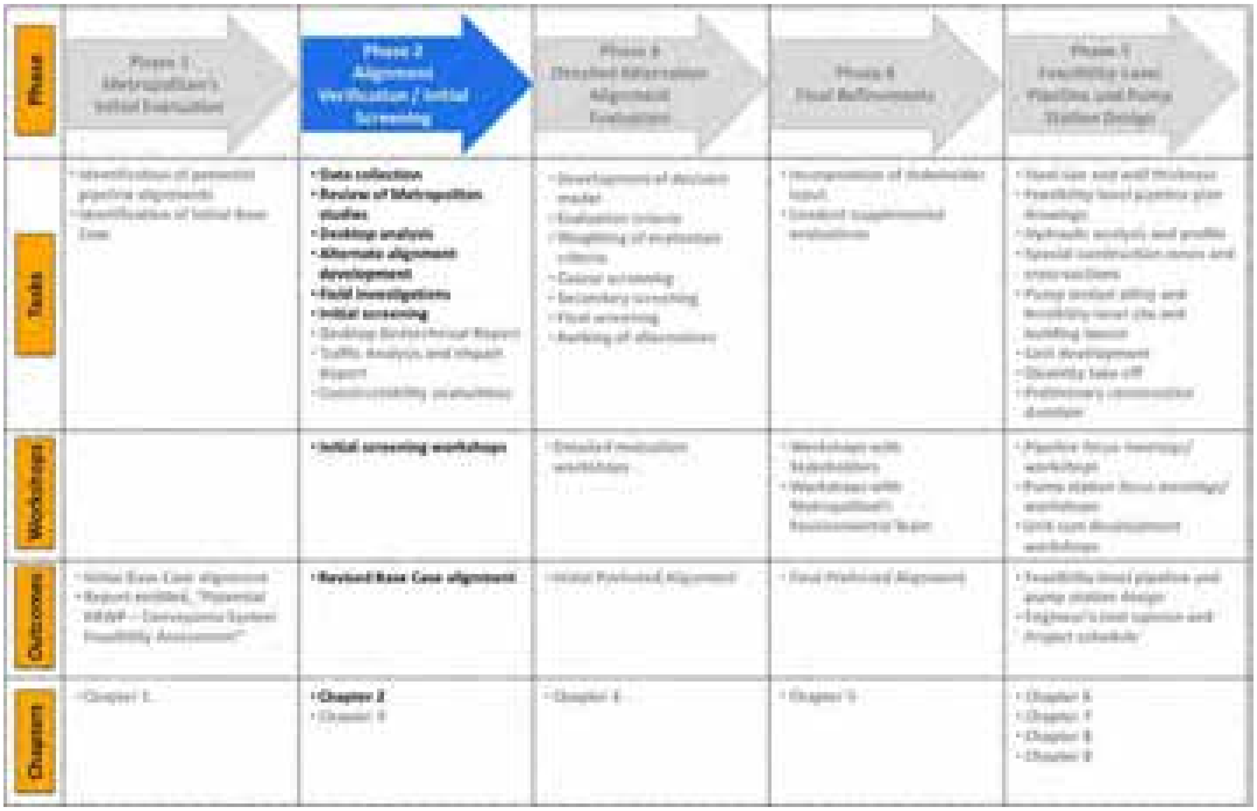


Figure 2-1 Chapter 2 Methodology

2.1 DATA COLLECTION AND INITIAL SCREENING

2.1.1 Desktop Analysis and Review of Metropolitan Studies

For the April 2016 assessment, Metropolitan collected data in both electronic and paper format from the agencies, municipalities, and utilities potentially impacted by construction of the distribution system. The available data was provided to Black & Veatch and logged into a GIS database. The GIS information was layered over aerial imagery to support the initial evaluations of existing and proposed pipeline segments.

The type of GIS information received and the agencies that provided the GIS data are listed in Table 2-1.

A map book of the segments with GIS utility layers was also prepared to assist with the field investigations.

Table 2-1 GIS Information

GIS INFORMATION RECEIVED	AGENCIES PROVIDING GIS INFORMATION	
Contour mapping	Cities	Districts
Contaminated sites	Anaheim	Metropolitan
Environmental constraints mapping	Arcadia	LACSD
Historical landfills	Bellflower	LACFCD
Jurisdictional boundaries	Buena Park	
Land use	Carson	
Park boundaries	Cypress	
Property/parcel lines	El Monte	
Rights of way/easements	Fullerton	
Streets	La Palma	
Traffic signals	Lakewood	
Utility records (includes storm drains, water, sewer, oil/gas, franchise mains, abandoned pipes)	Long Beach	
Watersheds	Los Angeles – Department of Public Works	
	Paramount	
	Placentia	
	Signal Hill	
	South Gate	

The desktop evaluations allowed for an expedited review and comparison of possible pipeline alignments, confirming that linkable corridors were available. They also allowed Black & Veatch to identify potential obstacles and screen alignments that included high risk construction areas, such as utility-congested streets and difficult freeway and utility crossing locations. Also, readily discernible were areas that presented potential community related concerns, such as schools, hospitals, regional shopping centers, and auto malls.

2.1.1.1 Existing Utilities

The existing utility information collected by Metropolitan included water, sewer, gas, storm drain, and telecommunications. Telecommunications and electrical utilities were not evaluated for the FLDR but were provided in the GIS database to be referenced in future design phases.

Table 2-2 lists the utility owners along the alternative Project alignments.

Table 2-2 List of Utility Owners

AGENCY/COMPANY	WATER	SEWER	GAS	STORM DRAIN	OIL
City of Anaheim		✓		✓	
City of Buena Park	✓	✓		✓	
City of Carson		✓			✓(1)
Dominguez Water(2)	✓				
City of Fullerton	✓	✓		✓	
LACFCD				✓	
LACSD		✓			
City of Lakewood	✓	✓		✓	✓(1)
City of Long Beach	✓	✓	✓(5)	✓	
OC Sanitation District (OCSD)(3)		✓			
Pico Co. Water District	✓				
City of Pico Rivera		✓		✓	
City of Placentia		✓		✓	
So Cal Gas(4)			✓		
City of Industry(6)					
City of Baldwin Park(6)					
City of Irwindale(6)					
Los Angeles County(6)					

Notes:
1. Existing oil utility information within the Cities of Carson and Lakewood was obtained from the Los Angeles County Road Department Permit Drawings.
2. Existing Dominguez Water utility information within the City of Carson was obtained from the Los Angeles County Road Department Permit Drawings.
3. Existing OCSD utility information within the Cities of Buena Park and Fullerton was obtained via City GIS and Sewer Atlas'.
4. Existing So Cal Gas utility information within the Cities of Carson, Lakewood, and Pico Rivera was obtained from the Los Angeles County Road Department Permit Drawings.
5. Existing gas utility information within the City of Long Beach was obtained from the City's GIS. The owners are unknown.
6. Utility information should be collected during future Project phases.

2.1.2 Alternate Alignment Development

During the desktop evaluation of Metropolitan's conceptual alignments, Black & Veatch identified 42 additional potential alignment segments that warranted consideration. These additional segments were identified to address constructability issues, property/right-of-way constraints, or municipality feedback regarding the segments already identified by Metropolitan. The additional segments are designated with a letter identifier after the segment number of the segment for which they are an alternative (i.e., 1A, 1B, etc.). The additional segments identified are shown on Figure 2-2, Figure 2-3, and Figure 2-4.

2.1.3 Field Investigations

Black & Veatch performed field reconnaissance to confirm the findings of the desktop evaluation. The reconnaissance was limited to visible at or above grade features. During the visits, actual field conditions and constructability concerns were further identified and evaluated. Attention was given to identifying high risk construction areas and finding viable solutions that could be compared based on cost and impacts to the surrounding community and environment. Visible utilities, land use restrictions, traffic flow, and environmental concerns were documented in field notes and are included in Appendix A.

2.1.4 Workshops with Metropolitan

Three separate workshops were held to discuss and compare Metropolitan's and Black & Veatch's findings about the alignments, including the initial results of the desktop evaluations, field investigations, and feasibility-level analyses. The focus of each workshop was to determine the suitability of existing and newly proposed pipeline segments. Workshop outcomes resulted in several new segments being introduced into the evaluation.

The workshops also resulted in the identification of 19 segments that were deemed unsuitable and removed from further consideration. Table 2-3 lists the segments not considered in further analyses and provides the reasons for their elimination. The locations of the eliminated segments are illustrated as the green dashed lines on Figure 2-2, Figure 2-3, and Figure 2-4.

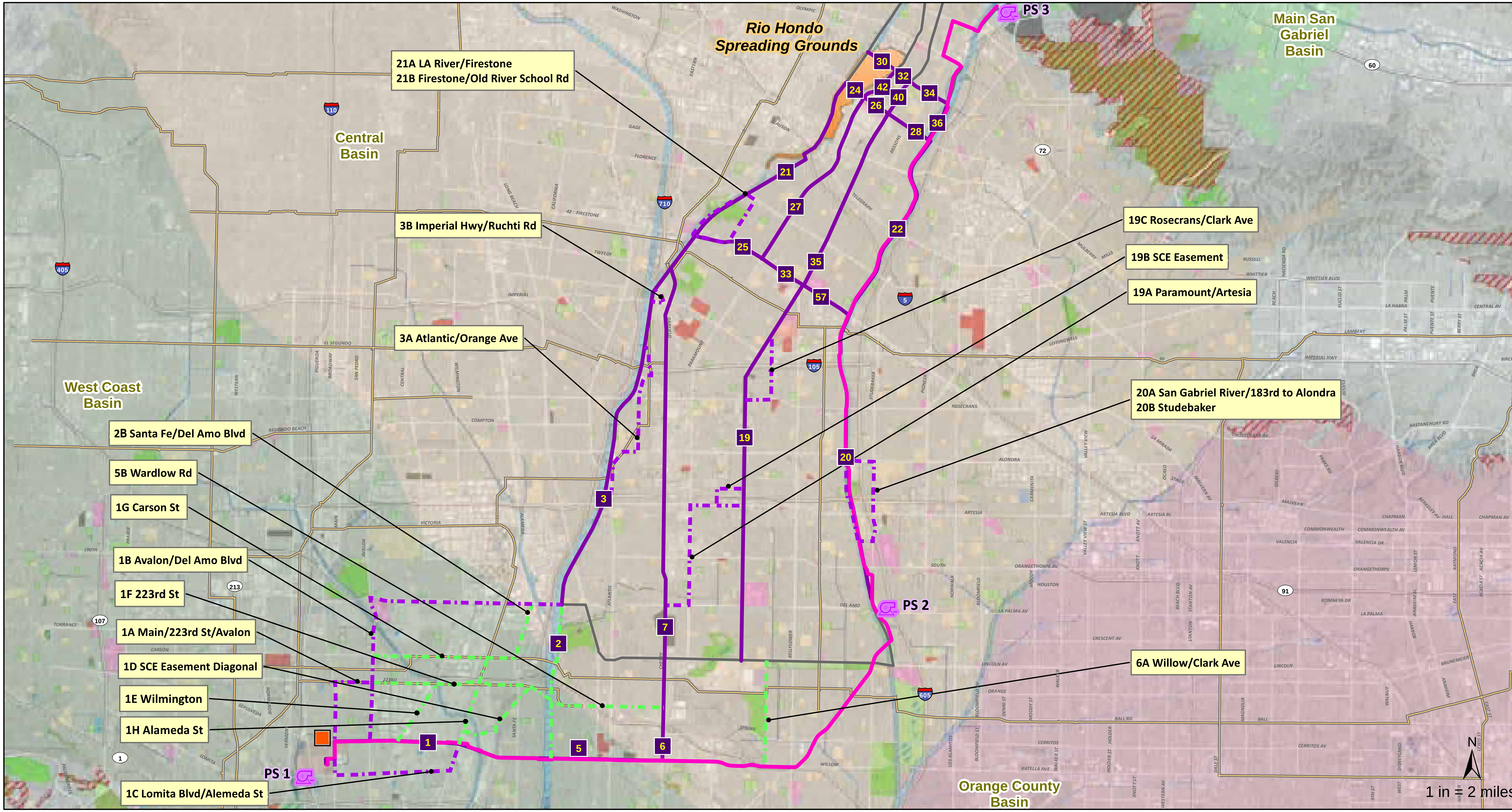
Table 2-3 Segments Eliminated

SEGMENT(S)	REASON ELIMINATED FROM FUTURE ANALYSES
1D, 1G	The proposed segments would be located in sections of Carson Street that the City of Carson indicated would not be feasible.
1E, 1F, 5B	The City of Carson stated this routing would have significant traffic and utility concerns.
1H	The proposed segment would be within a state highway which causes constructability concerns.
2B	The proposed segment would be located in streets that the City of Carson indicated would not be feasible.
6A	The proposed segment was eliminated due to community impact concerns (Long Beach City College, Long Beach Fire Station, Golf Course, Embry-Riddle Aeronautical University, and Long Beach Airport).

SEGMENT(S)	REASON ELIMINATED FROM FUTURE ANALYSES
13B	The proposed segment was eliminated to avoid Coyote Creek.
49, 50	The proposed segment would be in narrow streets that would require a full road closure. Residences would not have alternate access routes and the impact on residential community was deemed to be too great.
52D	The proposed segment was determined to not be constructible due to its location interfering with the Santa Fe Dam.

2.2 SUMMARY OF PIPELINE SEGMENTS

Following the workshops, 89 pipeline segments (57 identified by Metropolitan and 32 subsequently proposed by Black & Veatch) were carried forward for additional analysis. Figure 2-2, Figure 2-3, and Figure 2-4 illustrate the alignments carried forward for additional analyses with purple, pink and grey lines. Figure 2-2 focuses on Reaches 1 and 3, Figure 2-3 focuses on Reach 2, and Figure 2-4 focuses on Reach 4. References to critical habitats refer to California Natural Diversity Database (CNDDB) habitats. The results of the data collection for the 89 pipeline segments carried forward for detailed evaluation are presented in Appendix D.



- Pump Stations
- Base Case Alignment
- Additional Alignments/Segments for Consideration
- Eliminated Alignments/Segments
- Alternative Alignments/Segments Reviewed By MWD
- Other Alignments/Segments Reviewed By MWD
- Waterways
- CNDDB Habitat
- LA County Flood Control District

Land Types

- Other
- Sports Complexes
- Golf Courses
- Historical Parks, Museums, Aquariums
- Recreation Centers and Sports Venues
- Arts & Recreation, Recreation Centers,
- Natural Areas and Wildlife Sanctuaries
- Parks and Gardens
- Colleges and Universities
- Schools
- Government
- Municipal Services
- Hospitals
- Cemeteries
- Shopping Centers
- TV and Movie Studios
- Social Services
- Airports

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-2: Alternative Alignments Carried Forward - Reach 1 and Reach 3

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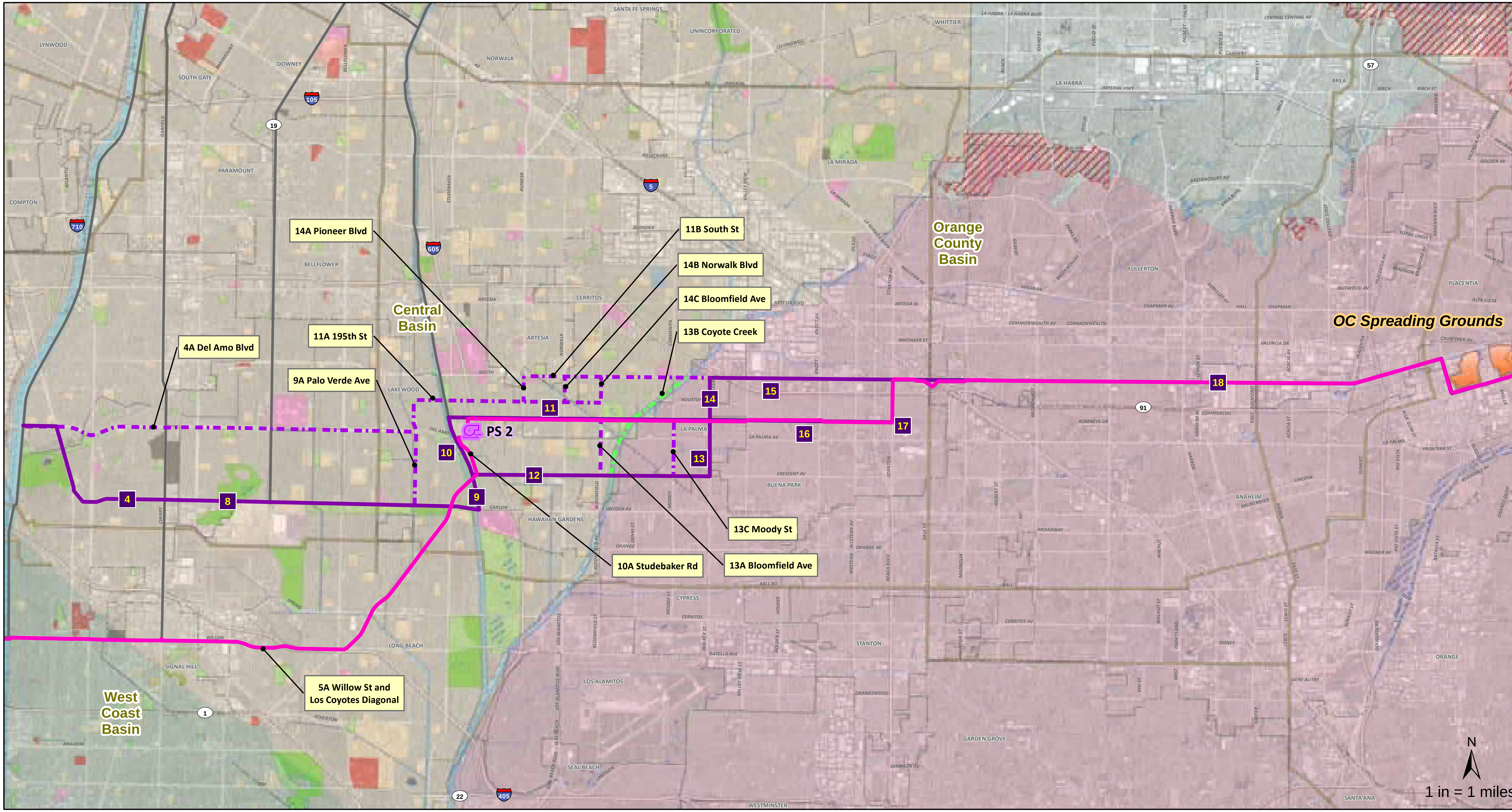

Pump Stations
Base Case Alignment
Additional Alignments/Segments for Consideration
Eliminated Alignments/Segments
Alternative Alignments/Segments Reviewed By MWD
Other Alignments/Segments Reviewed By MWD

Waterways
CNDDB Habitat
LA County Flood Control District

Land Types

Other
Sports Complexes
Golf Courses
Historical Parks, Museums, Aquariums
Recreation Centers and Sports Venues
Natural Areas and Wildlife Sanctuaries
Parks and Gardens
Colleges and Universities
Schools
Government
Municipal Services
Hospitals
Cemeteries
Shopping Centers
TV and Movie Studios
Airports

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-3: Alternative Alignments Carried Forward - Reach 2

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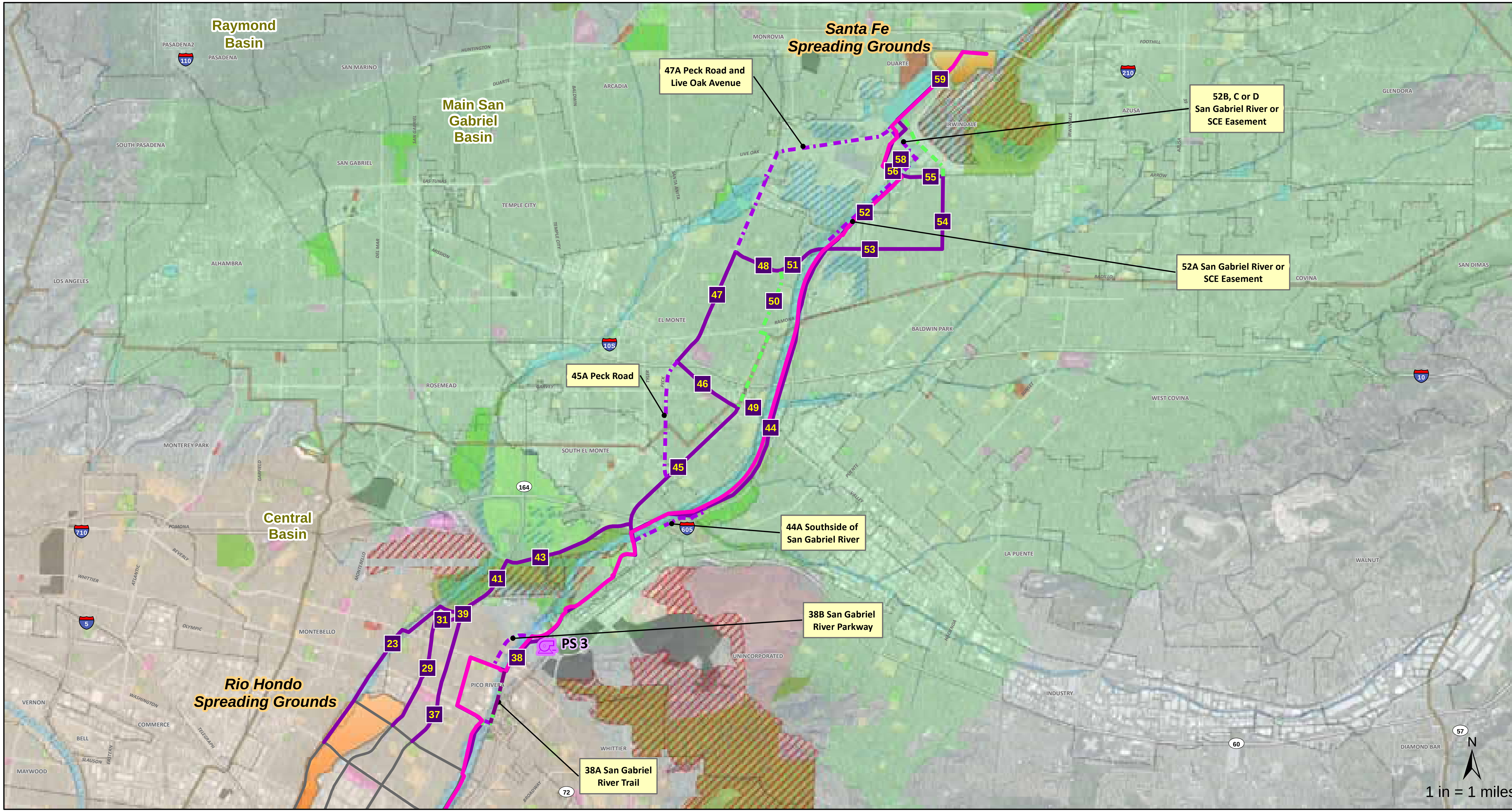

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-4: Alternative Alignments Carried Forward - Reach 4

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2.3 INITIAL SCREENING RESULTS AND REVISED BASE CASE

To support Metropolitan's development of the Business Case Report, the alternative alignment verification and initial screening process identified revisions to the Initial Base Case that were preferable based on the level of evaluation completed. The refined alignment was known as the Revised Base Case. An Engineer's OPCC was developed on the Revised Base Case to support the Business Case Report. This section of the report describes the Revised Base Case.

The revisions made to the Initial Base Case are summarized in Table 2-4.

Table 2-4 Summary of Initial Base Case Revisions

DESCRIPTION OF INITIAL BASE CASE REVISION	JUSTIFICATION FOR REVISION
• Added Segment 5 (Willow Rd). • Added a new segment (Segment 5A) to extend the alignment along Willow Rd to Los Coyotes Diagonal, and along Los Coyotes Diagonal to Carson St. • Removed Segments 4 and 8 and part of Segment 2.	• Provides a more direct route to the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. • Avoids the Dominguez Gap restored wetlands and bike path constructed along the Los Angeles River.
• Added a new segment (Segment 10A) along Los Coyotes Diagonal between Carson St and the San Gabriel River/Centralia St., extending along Studebaker Rd between Centralia St and Del Amo Blvd. • Removed Segments 9 and 10.	• Provides a more direct route to junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. • Avoids impacts to the Lakewood Equestrian Center and Rynerson Park facilities.

Table 2-5 lists the segments included in the Revised Base Case while Figure 2-5 presents the Revised Base Case alignment.

Table 2-5 Revised Base Case Segments

REACH	REVISED BASE CASE SEGMENT NOS.
1	1, 5, 5A, 10A
2	11, 16, 17, 18
3	20, 22, 36, 38
4	44, 52, 56, 58, 59

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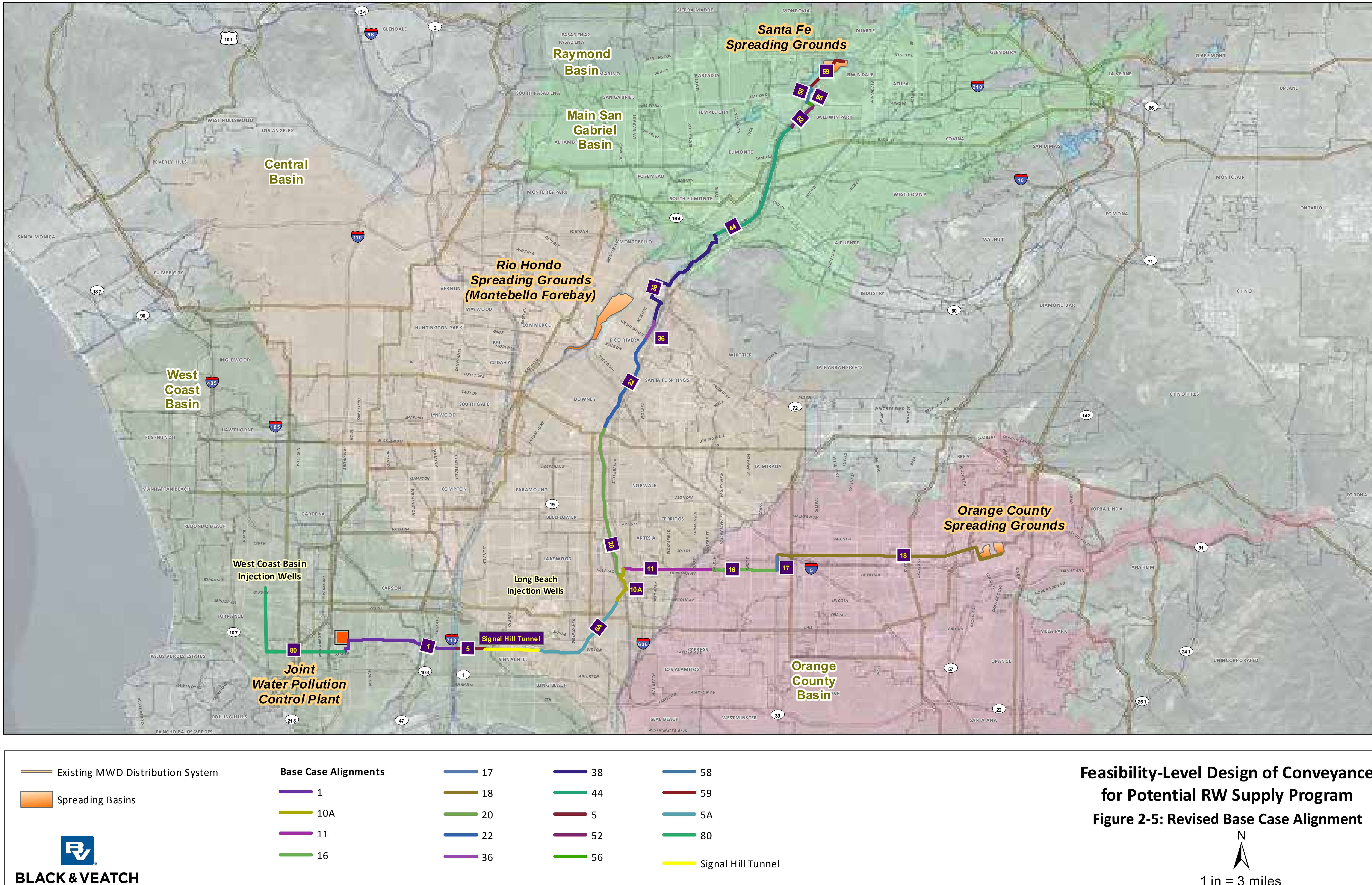

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-5: Revised Base Case Alignment

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3.0 Supporting Technical Evaluations

This chapter summarizes the three supporting technical evaluations completed during the development of the FLDR: a traffic analysis and impacts evaluation, a desktop geotechnical evaluation, and a constructability evaluation. A brief overview of the analysis documented in this chapter is as follows:

- **Traffic Analysis and Impacts Evaluation.** This section summarizes the preliminary traffic control assessment that was completed on all of the potential pipeline segments that had been identified. Covered in this assessment was Metropolitan's preliminary outreach efforts, the establishment of four conceptual traffic control configurations for pipeline construction of the RRWP in roadways, two conceptual traffic control configurations for pipeline construction through intersections, traffic control assessments for each pipeline segment, and cost opinions for traffic control. The full traffic control assessment is provided in Appendix B.
- **Desktop Geotechnical Evaluation.** A desktop geotechnical evaluation was completed on the study area using information from published literature, government agency websites, and in-house records. The evaluation summarized the mapped surficial geologic units, soil types, shallowest historic depths to groundwater, location of oil and gas fields, seismic hazards, earthquake fault zones, soil reuse, trenchless excavations, and pipeline construction in earthen river beds. The intent of the evaluation was to provide preliminary geotechnical recommendations as supporting information for Project planning and CEQA documentation. The full desktop geotechnical evaluation is provided in Appendix C.
- **Constructability Evaluations.** This section describes the trenchless and cut-and-cover construction methods that are anticipated to be required for the construction of the RRWP conveyance system. Included in the descriptions are anticipated key design criteria that serve as the basis for the cost opinion. The three trenchless construction methods evaluated were jack & bore, microtunneling (MT), and traditional tunneling. Cut-and-cover construction methods are expected for the majority of the alignment alternatives. The desktop geotechnical evaluation indicated that the soil conditions would allow for the use of either temporary shoring or temporary sloped excavation throughout the proposed alignments. Temporary shoring would likely be necessary for most of the alignment, as well as portal excavations, and has been assumed everywhere except where noted to minimize impacts to surface features, traffic flow, and adjacent utilities. Where the pipeline would be in areas with adequate space to accommodate temporary sloped excavation methods, it could be considered during future design phases.

This Chapter also summarizes the development of typical construction methods. The potential pipeline segments would generally be constructed within four different situations: roadways, SCE easements, LACFCD easements, and trenchless (tunnels). A typical construction method was developed for each alignment type for the purpose of establishing a conservative budget and determining the approximate impact area for environmental analysis.

Figure 3-1 summarizes the Project methodology as it applies to this chapter. The traffic analysis and impacts evaluation and the desktop geotechnical evaluation were both completed for the development of the October 2018 Draft Report and focused on the alternatives identified to deliver water to the SFSG and the OC Spreading Grounds. While these evaluations were not updated after October 2018, they considered the entire Project study area and generally encompass the revisions that have occurred since then, including the LA River and SG River Alignments described later in this FLDR. The exception is that they do not include the alignment alternatives that would connect the SFSG to the FEWWTP.

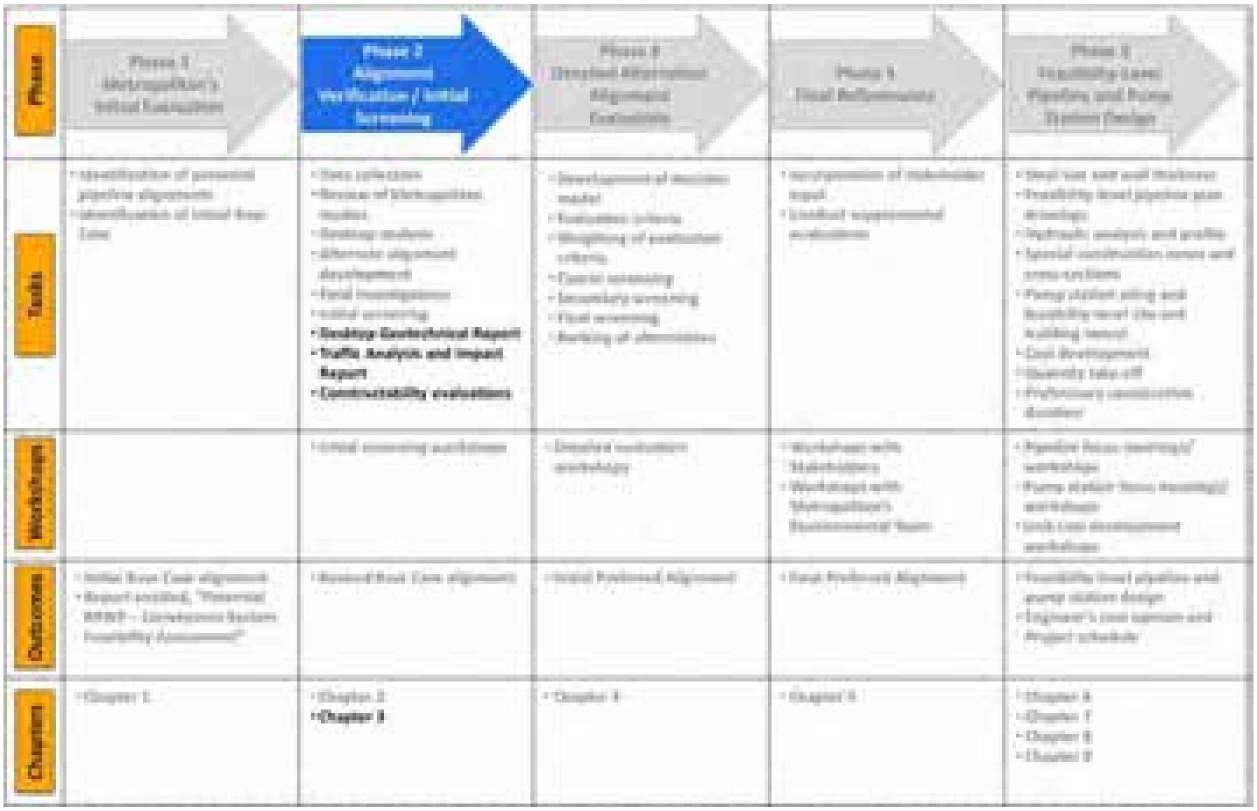


Figure 3-1 Chapter 3 Methodology

3.1 TRAFFIC ANALYSIS AND IMPACTS EVALUATION

A preliminary evaluation of construction-related traffic control, community impact, and production considerations was performed by Minagar & Associates, Inc. (Minagar) and is presented in "Preliminary Traffic Control Assessment for The Metropolitan Water District of Southern California's Potential Regional Recycled Water Supply Program Feasibilities Studies", (Traffic Impact Analysis) which is provided in Appendix B. The evaluation identified construction impact to each street segment and intersection along potential alignments and recommended typical traffic control measures to mitigate these impacts.

The evaluation included the following:

- A summary of Metropolitan's preliminary outreach efforts
- Jurisdictional requirements for each agency included in Metropolitan's preliminary outreach, including:
    - City of Carson

  - City of Cypress
  - City of Fullerton
  - City of La Palma
  - City of Long Beach
  - Los Angeles County
- Roadway traffic analysis and impacts
  - Four basic traffic control configurations which were conceptually developed for pipeline construction of the RRWP
  - Cost estimates for the four basic traffic control configurations
- Intersection traffic analysis and impacts
  - Two basic traffic control configurations which were conceptually developed for pipeline construction at roadway intersections of the RRWP
  - Cost estimates for the two basic traffic control configurations at intersections
- Traffic control assessments for each alternative segment
- Traffic control cost estimates at signalized intersections for all alternative segments

It should be noted that further outreach with agencies along the LA and SG River Alignments will be required during future phases of work.

3.1.1 Intersections

The Traffic Impact Analysis identified, listed, and described the signalized intersections through which the proposed pipeline alignments, segments, and alternatives would cross. A designation of either Major Intersection or Minor Intersection was then established for each intersection. In general, an intersection is defined as Major or Minor by meeting one or all the criteria defined in Table 3-1.

Table 3-1 Designation of Intersections

DESIGNATION	DEFINITION
Major Intersection	Any intersection meeting one of the following criteria: • Contains a multi-lane arterial highway or major collector roadway • Provides protected left-turn signal phasing on all four intersection approaches • Serves a designated regional truck route • Serves multiple municipal fixed bus routes
Minor Intersection	Any intersection not designated as a Major intersection

Two construction methods were considered to cross signalized (Major and Minor) intersections: shored excavation or trenchless. At this feasibility level of planning, insufficient information was available to specifically determine the preferred construction method for each location. Factors that affect the selection of the appropriate construction method include:

- Geotechnical and groundwater conditions
- Traffic impacts
- Jurisdictional requirements
- Utilities within the intersection, including their size, quantity, depth, and criticality
- Other community or environmental impacts
- Overall constructability and cost

Determination of construction methodology for each location will be evaluated during Preliminary Design.

For planning purposes, this FLDR assumed that all intersections would be crossed using shored construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing rail road tracks, rivers, bridges, and California Department of Transportation (Caltrans) roads or highways). It is recognized that shored construction across signalized intersections would have a slower production rate and higher unit construction costs than shored methods elsewhere. Further, at some intersections, trenchless construction may be warranted or preferred, depending on the factors described earlier. Therefore, the FLDR has assumed a premium is applied to account for the higher cost of construction at all intersections that the Traffic Impact Analysis considered to be a Major Intersection. Additional details on the cost of intersection crossings are provided in Chapter 8.

3.1.1.1 Traffic Control at Intersections

Various traffic control approaches could be implemented for construction across the signalized intersections along the alignment. With shored excavations, three traffic control approaches were considered:

- **Full Closure of Cross Street** - With the concurrence of local jurisdictions, the work zone would continue through the intersection blocking both the upstream and downstream traffic during construction.
- **Phased Traffic Control** - Construction across larger intersections could be completed in phases such that traffic control would be established to detour the upstream and downstream traffic around the work.
- **Non-Peak Construction Hours** - Construction would be completed during non-peak traffic hours, such as at night, and the trench could be plated during the day to minimize the construction impacts.

For trenchless construction methods, the intersection would be kept clear for traffic to pass in each direction. On the primary street where the pipeline is being constructed, the work zone would extend around the launching and receiving portals and taper off on one side as it approaches the crosswalk to provide the needed space for left turns. Additional coordination should occur with the local agencies during Preliminary Design. Section 6.3.6 presents a list of the signalized intersections along the SG River Alignment that would require temporary traffic control, while Section 7.3.6 presents the same information for the LA River Alignment. See Appendix B for additional details and figures for traffic control at signalized intersections.

3.2 DESKTOP GEOTECHNICAL EVALUATION

A "desktop" geotechnical evaluation was conducted as part of the FLDR: "Preliminary Geotechnical/Geologic Evaluation, Proposed Regional Recycled Water Supply Program" (Desktop Geotechnical Evaluation). The report was prepared by GeoPentech Inc. (GeoPentech) and is included in its entirety in Appendix C. Key information is summarized below.

The purpose of the Desktop Geotechnical Evaluation was to assess the general geotechnical/geological conditions along Metropolitan's proposed conveyance alignment alternatives for the RRWP. The information used in the evaluation was from published literature, government agency websites, and in-house records. Specifically, the evaluation summarized the mapped surficial geologic units, soil types reported for borings up to 100 feet (ft) in depth, shallowest historic depths to groundwater, location of oil and gas fields, seismic hazards, earthquake fault zones, and Quaternary faults mapped along the Project area. The intent of the evaluation was to provide preliminary geotechnical recommendations as supporting information for Project planning and CEQA documentation.

3.2.1 Regional Geology

The majority of the RRWP conveyance alignment alternatives would be located within Quaternary-age alluvial and fluvial sediments that were deposited in the Los Angeles, San Gabriel, and OC basins from the foot of the San Gabriel and San Bernardino mountains to the Pacific Ocean along the Los Angeles, San Gabriel, Rio Hondo, and Santa Ana rivers and their associated tributaries. The Quaternary-age alluvial and fluvial sediments along the proposed alternatives are composed mainly of sand, gravel, and cobble at the northern end of the alignment with fine-grained sediments present at a depth less than about 20 ft; sand, silty sand and silt in the central and eastern alignment areas; and silty sand, silt, and clay in the south and southwestern portion of the conveyance Project area.

Outcrops of Pleistocene-age and older bedrock units occur in the Puente, Montebello, and Signal hills. Bedrock units in the Puente and Montebello hills are composed of shale, siltstone, sandstone, pebbly sandstone, and conglomerate of the Sespe, Topanga, Puente, and Fernando formations. Bedrock units exposed in the Signal Hill area are composed of sandy silt, sandstone, and pebbly sandstone of the Lakewood Formation, Palos Verdes Sand, and San Pedro Formation. Within the Los Angeles coastal plain, shallow groundwater less than 50 ft below the ground surface occurs perched on fine-grained alluvial deposits that range in depth from about 60 to 100 ft. See Figure 2 in Appendix C for details.

3.2.2 Quaternary Faults

The conveyance alignment alternatives would cross the Newport-Inglewood Fault Zone, the Los Alamitos Fault, and possible, though not shown, a buried fault trace that connects the Whittier and East Montebello faults. The Newport Inglewood and Los Alamitos faults have experienced surface rupture in the late Quaternary (<130,000 years before present). A summary of fault geometry and deformation characteristics is provided in the Desktop Geotechnical Evaluation in Appendix C.

The Newport Inglewood Fault is Holocene active and estimated to have probable earthquake magnitudes in the range of 6.0 to 7.4 on the moment magnitude scale (M_W) with surface rupture likely to occur above M_W 6.0. The Newport-Inglewood Fault has right-lateral displacement with an estimate of 2 meters (6.5 ft) average displacement. The Los Alamitos Fault is not known to be active in the Holocene (<11,700 years before present).

In the Puente Hills, southeast of the proposed alignment alternatives, the Whittier Fault is Holocene active and estimated to have probable earthquake magnitudes in the range of M_W 6.0 to 7.2 with surface rupture likely to occur above M_W 6.0. The Whittier Fault has right-lateral displacement with an estimate of 1.9 meters (6 ft) average displacement. See Figure 2 in Appendix C for details.

3.2.2.1 Alquist-Priolo Act Earthquake Fault Zones

The Alquist-Priolo Act established a program to produce maps of earthquake fault zones that delineate the surface trace of active faults as well as buffer zones where special studies are required to ensure structures for human occupancy do not cross the fault. It should be noted that the act does not directly address structures without human occupancy or infrastructure facilities, such as pipelines or tunnels. However, this information has been included for reference purposes.

As shown on Figure 4 in Appendix C, the Newport-Inglewood Fault Zone crosses the study area. Other identified Alquist-Priolo earthquake fault zones that are near the proposed alignment alternatives include the Whittier-Elsinore Fault Zone, East Montebello Fault Zone, and the Sierra Madre Fault Zone. The other fault that is crossed is the Los Alamitos Fault, though this fault has not been identified as a possible Holocene-active fault and, therefore, is not designated as an Alquist-Priolo Earthquake Fault Zone.

3.2.3 Groundwater Occurrence

Shallow groundwater with depths of 20 ft or less is found primarily within alluvial sediments throughout most of the proposed conveyance Project area with exceptions including the area east of the intersection of the 91 and 5 freeways in OC and north of Ramona Boulevard in the San Gabriel Valley. The shallow groundwater generally coincides with California Geologic Survey (CGS) mapped liquefaction Hazard Zones. See Figure 5 in Appendix C for details.

3.2.4 Oil and Gas Fields

The conveyance alignment alternatives would overlie oil and gas fields in the Cities of Wilmington, Long Beach, Signal Hill, Montebello, Whittier, Santa Fe Springs, Buena Park, and Placentia. Issues associated with pipeline and undercrossing tunnel construction in areas overlying oil and gas field include the potential accumulation of hazardous gasses, such as methane and hydrogen sulfide in underground excavations and tunnels, oil residuals in soil, legacy contamination associated with oil and gas production activities, and abandoned well casings.

In areas where occurrences of explosive and hazardous gases are possible, positive ventilation along with intrinsically safe and explosion-proof equipment should be used. In addition, pre-design hazardous chemical assessments should be completed to identify if legacy soil contamination exists in the Project area. A review of California's Division of Oil and Gas records should be completed in these areas to identify the possible presence of abandoned well casings, and prior to construction geophysical means should be used to clear the planned extent of excavations of buried objects. As this impacts Project cost due to utilization of specialized equipment, for the purpose of the FLDR all alignments in these areas were considered as gassy. See Figure 6 in Appendix C for details.

3.2.5 Soil Characteristics

In general, shallow (less than 20 ft depth) soils throughout the proposed conveyance Project area are composed of sandy silt and clay while the deeper (greater than 20 ft) soils tend to be coarse grained (sand, gravel, cobbles and boulders) in the northern portion of the alignment alternatives and finer grained to the south consistent with alluvial and fluvial deposition that is sourced from the mountains to the north of the Project. Deep soils within the eastern portion of the conveyance Project area (i.e., within OC) tend to be predominantly sand with some fine-grained silts and clays in the shallow zone. See Figures 7a and 7b in Appendix C for details.

3.2.6 Excavation and Soil Reuse

In general, excavation of the alluvial or fluvial materials present along most of the proposed alternative alignments would not require special equipment. Where the alignment would enter the Signal Hill area where outcropping bedrock is present heavy ripping equipment, such as a Caterpillar D-9 or D-10 dozer equipped with a ripper shank, may be necessary. Based on GeoPentech's experience, blasting would not be necessary for excavation sites in Signal Hill.

Reuse of excavated material for backfill would be evaluated on a case-by-case basis depending on the soil type present at the proposed excavation sites and the possible occurrence of contamination / hazardous substances, specifically in the areas near oil and gas fields. However, generally, non-contaminated alluvial or fluvial materials would be acceptable for reuse provided that oversized material is removed and the material is appropriately moisture conditioned and compacted.

The requirements for backfill material would depend on the anticipated use of the site and any conditions imposed by the design or the local jurisdiction. As general guidance, material with a liquid limit less than 40 and a plastic limit less than 12, or alternatively, with a sand equivalent less than 30, would likely be acceptable. Generally, this excludes clays with moderate to high plasticity, but may allow reuse of some low plasticity clays and silts. Actual requirements would depend on the soil properties, design criteria, and local jurisdictional restrictions.

In some portions of the proposed conveyance Project area, soil boring logs reviewed identified some material that would not likely be acceptable for reuse. This included particular references to material characterized as "Gumbo silt," which was noted in logs from specification No. 722 for Metropolitan's Second Lower Feeder project in the Los Alamitos area. It is not clear whether this material is only present locally and therefore was not noted in other logs, or if the particular description is a unique expression from the person(s) who documented these boreholes. GeoPentech's experience at other projects in this area suggests that fine-grained sediments would be appropriate for reuse.

3.2.7 Liquefaction

A significant portion of the proposed conveyance Project area would be located within mapped liquefaction hazard zones. Due to the deeper depth of groundwater in the portions of the conveyance alignment alternatives proposed in Signal Hill, north of Arrow Highway in the San Gabriel Valley, and between Euclid Street and Kraemer Boulevard in OC, liquefaction hazards in these sections is considered relatively low and not likely. However, liquefaction hazards are moderate to high on a regional basis for the remaining portions of the proposed conveyance alignment alternatives. Sections that would pass through mapped liquefaction hazard zones should be prioritized for evaluation, and the remaining areas should be screened to establish whether there is relatively high groundwater present and potentially susceptible soils (i.e. loose granular soils with low plasticity). Areas where these hazards are known to exist should be evaluated to estimate potential settlements or deformation for design or whether flotation of the pipeline could be a risk. See Figure 3 in Appendix C for details.

3.2.8 Seismically Induced Land Sliding

Most of the proposed alternative alignments would cross relatively flat terrain through the Los Angeles, San Gabriel and OC basins and are not near areas where seismically induced landslide zones are mapped but would be within one mile of these zones in the Montebello/Pico Rivera area.

3.2.9 Pipeline Undercrossing Excavation

The Desktop Geotechnical Evaluation evaluated the preliminary trenchless crossings required for the Project and presented four trenchless construction methods that would be feasible based on assumptions of the undercrossing design and inferred ground conditions: jack & bore, MT, traditional tunneling, and horizontal direction drilling (HDD). While HDD was initially considered, it was deemed to be unsuitable for the Project based on the diameter of the pipeline being proposed and the nature of the materials being considered (welded steel pipe). As such, HDD was not considered for any trenchless crossing for this Project.

The geotechnical criteria used to evaluate the feasibility of the alternative excavation methods considered the following:

- Pipeline design (i.e. diameter, depth and length) and applicability considering engineering constraints.
- Construction access, such as launching and receiving portals.
- Anticipated soil conditions along undercrossing such as mixed face with cobbles and boulders and potential running ground.
- Ability to control groundwater along undercrossing.

Additional discussion on each trenchless construction method is provided in Section 3.3.1.

3.2.10 Pipeline Construction in Earthen Riverbed

One of the alignment alternatives proposes constructing the pipeline linearly within the unlined portion (earthen) of the SG River bed. Construction within the unlined river bed poses many challenges, with the particular areas of concern including:

- **Scour Potential.** The depth of excavation and construction methods required to mitigate scour potential could add to the cost to construct this section. This also needs to be looked at in conjunction with any risk for flotation of the existing pipeline.
- **High probability of cobbles and boulders within the river bottom.** Cobbles and boulders slow down production rates for excavation and can impact the trenchless construction that may be required either to cross existing levees or to cross beneath existing rubber dams. They can also create challenges for the drilling and groundwater

dewatering wells. During excavation, specialized equipment may be required by the earthwork contractor.

- **Dewatering.** The river bottom is anticipated to have larger dewatering volumes, particularly if the depth of excavation is required to be deeper to avoid scour potential. Based on recharge activities conducted by LA County Public Works and the Water Replenishment District, most of the SG River is anticipated to be fully saturated most of the year. Additionally, the river bottom is anticipated to be gravelly with silt and clay lenses due to seasonal storms, which could add to dewatering difficulties.
- **Seasonal Construction Constraints.** Due to the seasonality of rainfall in Southern California, construction would likely be limited to the dry season. Off season rain events would require preventative measures, such as cofferdams, as well as the removal of construction equipment and potentially even the damage of facilities at the worksite (i.e., previously installed pipe, dewatering equipment, etc.).

No subsurface investigations or scour analysis was completed as part of this study. These tasks are recommended during future phases of work to better define the areas of concern described above.

3.3 CONSTRUCTABILITY EVALUATIONS

Installation of the RRWP conveyance system would require either trenchless or cut-and-cover construction methods. This section discusses these construction methods.

3.3.1 Trenchless Construction Method Evaluation

This section describes each trenchless method identified by GeoPentech in the Desktop Geotechnical Evaluation as being geotechnically feasible methods for the Project. Included in the descriptions are anticipated key design criteria that serve as the basis of the cost opinion.

The four trenchless construction methods evaluated were jack & bore, HDD, MT, and traditional tunneling. As described above, while HDD was initially considered, it was deemed to be unsuitable for the Project based on the diameter of the pipeline being proposed and the nature of the materials being considered and was therefore not considered for any trenchless crossing for this Project. Evaluation criteria included length, diameter, crossing type (interstate, intersection, river, etc.), groundwater levels, and anticipated geotechnical conditions. Groundwater levels and anticipated geotechnical conditions reflect the results of the Desktop Geotechnical Evaluation.

3.3.1.1 Jack & Bore (Pipe Jacking)

The primary trenchless solution considered was jack & bore, also known as pipe jacking. It provides favorable construction cost due to a less complicated technical installation, thereby allowing a larger contractor pool. Jack & bore is considered an open excavation as there is no pressurization. Jack & bore allows access to the face of the excavation facilitating removal of obstructions (boulders, cobbles, man-made structures, tree limbs, etc.). Excavation can be accomplished from within the jacked pipe with a rotating cutter head (tunnel boring machine), rotating cutter boom, backacter (digger arm), or even hand mining.

Jack & bore is generally appropriate under the following conditions:

- Less than or equal to 96 inches diameter, although larger diameters are possible
- Less than 300 ft in length if hand mining, up to 1,000 ft with mechanical methods
- Not passing beneath structures that are sensitive to dewatering (dams)
- Not a river crossing
- Not in a known oil field requiring dewatering or in other contaminated soils
- Not excavated in loose ground prone to raveling or flowing

To protect the cement mortar coating on Metropolitan's steel carrier pipes, a larger diameter casing pipe would be installed first with the steel carrier pipe inserted within. The annular space would be filled with low density cellular grout. For an 84-inch carrier pipe, the casing is assumed to be a 108" permalok pipe. For a 60-inch carrier pipe, the casing is assumed to be an 84-inch permalok pipe. For a 54-inch carrier pipe, the casing is assumed to be a 78-inch permalok pipe.

Figure 3-2 and Figure 3-3 depict examples of equipment used for large diameter jack & bore installations.

Figure 3-2 Jack & Bore Excavation Methods, Pipe Jacking Association

Figure 3-3 Boring/Digger Shield and Cutting Head, Akkerman

3.3.1.2 Horizontal Directional Drilling

As mentioned previously, while initially considered, HDD has since been deemed unsuitable for the Project. HDD can be a cost-effective solution for long drive lengths as it can be driven from the surface without shafts. However, HDD is not generally installed in diameters exceeding 54 inches and is most common for small diameter pipe less than 48 inches. Figure 3-4 depicts examples of equipment used for HDD installations.

HDD with steel pipe requires a bend radius of 100 times the pipe diameter due to the properties of the steel pipe. Due to the Project requirement of steel pipe and the relatively large diameter for trenchless crossings, HDD is not suitable for crossings less than 1,800 ft in length. Gravel, cobbles, and boulders cause problems with maintaining line and grade for HDD crossings. Due to the size of the pipeline being proposed and the material being considered, HDD was eliminated from consideration for the Backbone System but may be applicable for smaller diameter distribution pipelines, such as to potential injection well sites.

Figure 3-4 Large Diameter HDD Reaming Tool and Drilling Equipment

3.3.1.3 Microtunneling

MT was considered for all crossings not suitable for jack & bore. MT is more expensive than jack & bore but is a robust construction method capable of handling complex and challenging ground more effectively. In addition, MT can be done below the groundwater table without dewatering along the alignment, making it well suited for river crossings and other crossings that are difficult or expensive to dewater or where contaminated soil may be encountered (i.e. oil fields). MT does not allow access to the cutterhead from within the excavating machine. Therefore, obstructions including boulders, cobbles, or man-made structures, such as abandoned oil wells, pose a higher risk than they would for jack & bore, where the face of the excavation can be more readily accessed. MT cutter heads can be designed to crush cobbles and boulders of a certain size and frequency. However, if more frequent or larger cobbles and boulders are encountered, the tunneling excavation rate may be reduced or stopped.

Trenchless sections not using jack & bore were identified for MT unless the trenchless sections exceeded 2,000 ft, therefore require multiple jacking portals or interjack stations. Additional jacking portals or interjack stations are necessary when the jacking load on the pipe reaches a level at which damage to the pipe could occur. The maximum jacking load is a function of pipe type, thickness, pipe diameter, and ground conditions and would vary between tunnel alignments. Generally, 1,500 - 2,000 ft is considered a reasonable distance between jacking locations.

Interjack stations are installed within the tunnel between segments of pipe. They allow the jacking forces to be distributed along the pipe string allowing longer drive lengths between jacking portals.

Figure 3-5 depicts a typical jacking portal and interjack station relationship.

Figure 3-5 Interjack Stations and Jacking Portal, Pipe Jacking Association

In order to protect the lining, coating, and structural integrity of the carrier pipe during the mining and installation process, a larger diameter casing pipe would be installed into the ground first. Similar to jack and bore, the annular space would be filled with low density cellular grout. For an 84-inch carrier pipe, the casing is assumed to be 108" permalok pipe. For a 60-inch carrier pipe, the casing is assumed to be 84-inch permalok pipe. For a 54-inch carrier pipe, the casing is assumed to be 78-inch permalok pipe.

Figure 3-6 depicts a typical MT installation.

Figure 3-6 72-inch diameter Microtunneling Machine – East Chicago, Indiana

To protect the cement mortar coating on Metropolitan's steel carrier pipes, a larger diameter casing pipe would be installed first with the steel carrier pipe inserted within. The annular space would be filled with low density cellular grout.

3.3.1.4 Traditional Tunneling

Traditional tunneling allows long distances between shafts but requires an excavated diameter large enough for the man operated equipment to function. Crossings of significant length would also be large enough in diameter for conventional tunneling to be considered. Multiple methods of traditional tunneling are available, two of which are potentially applicable to portions of the Project: open shielded tunnel boring machine (TBM) and earth pressure balance tunnel boring machine (EPBM).

3.3.1.4.1 Shielded Tunnel Boring Machine

A Shielded TBM protects workers from ground falls into the tunnel until initial support or tunnel lining can be safely installed. As shown on Figure 3-7, the body of the machine is enclosed in a shield marginally smaller than the excavated diameter of the tunnel. The front of the Shielded TBM is a rotating cutterhead that matches the diameter of the tunnel. As the cutterhead rotates, a ring of hydraulic cylinders provides forward thrust through "shoes" that push against the initial support or final tunnel lining. The cutterhead may be dressed with carbide picks and teeth and/or disc cutters evenly spaced across the cutterhead depending on the ground being excavated. Excavation and installation of initial support or final lining are performed sequentially. To steer, cylinders orient the articulated cutterhead in the required direction.

Figure 3-7 Open Mode Shielded TBM used on Cady Marsh Stormwater Tunnel, Griffith, Indiana

Shielded TBMs are feasible in a wide variety of ground conditions including less competent rock and soft ground. Shielded TBMs have multiple variants typically subdivided based on how the material is removed from the face of the excavation [belt conveyor (open), screw conveyor (EPBM) or pipe (slurry)]. For the purpose of the FLDR, "Shielded TBM" refers to a machine operating in open mode that removes material from the face of the excavation by belt conveyor and installs an initial support system behind the TBM. Once the tunneling is completed with the Shielded TBM, the final steel pipe would be installed and grouted in place inside the initial support system.

If groundwater is anticipated to flow into the excavation at a rate above that which can be handled with sumping, additional groundwater controls potentially including pre-excavation grouting, dewatering, permeation grouting, and/or jet grouting would be required. Pre-excavation grouting can be performed through ports in the TBM and cutterhead to reduce hydraulic conductivity ahead of the excavation. However, it is important to note that the TBM must be designed with ports for pre-excavation grouting; therefore, if anticipated, pre-excavation grouting should be specified in the contract documents.

Dewatering, permeation grouting and jet grouting all must be completed from the surface. Groundwater control through grouting is generally only cost effective if it is isolated to small portions of the alignment. If groundwater inflow is anticipated to impact large portions of the alignment tunneling, an EPBM should be considered.

3.3.1.4.2 Earth Pressure Balance Machine

EPBMs are a type of Shielded TBM specially designed for operation in soft or raveling ground conditions containing water under pressure. Figure 3-8 depicts typical EPBM equipment. EPBMs have an articulated shield that can be sealed against the pressure of ground and water inflows. EPBMs control the stability of the tunnel face and subsidence of the ground surface by monitoring and adjusting the pressure inside the cutterhead chamber to achieve a balance with the pressure in front of the cutterhead. EPBMs work best in soils with cohesion or soils that can be preconditioned to exhibit cohesion characteristics.

The working area inside the EPBM is completely sealed against the groundwater pressure outside the machine. A screw conveyor as shown in Figure 3-8 removes the fluidized muck behind the cutterhead and in front of the pressurized bulkhead. The screw conveyor's speed and discharge rate are controlled by the operator and used to control the pressure at the working face and match the muck discharge rate to the advance rate of the EPBM. Controlling inflow of water and muck through the screw can be difficult in rock and non-cohesive material, making EPBMs suited for soft ground and cohesive soils.

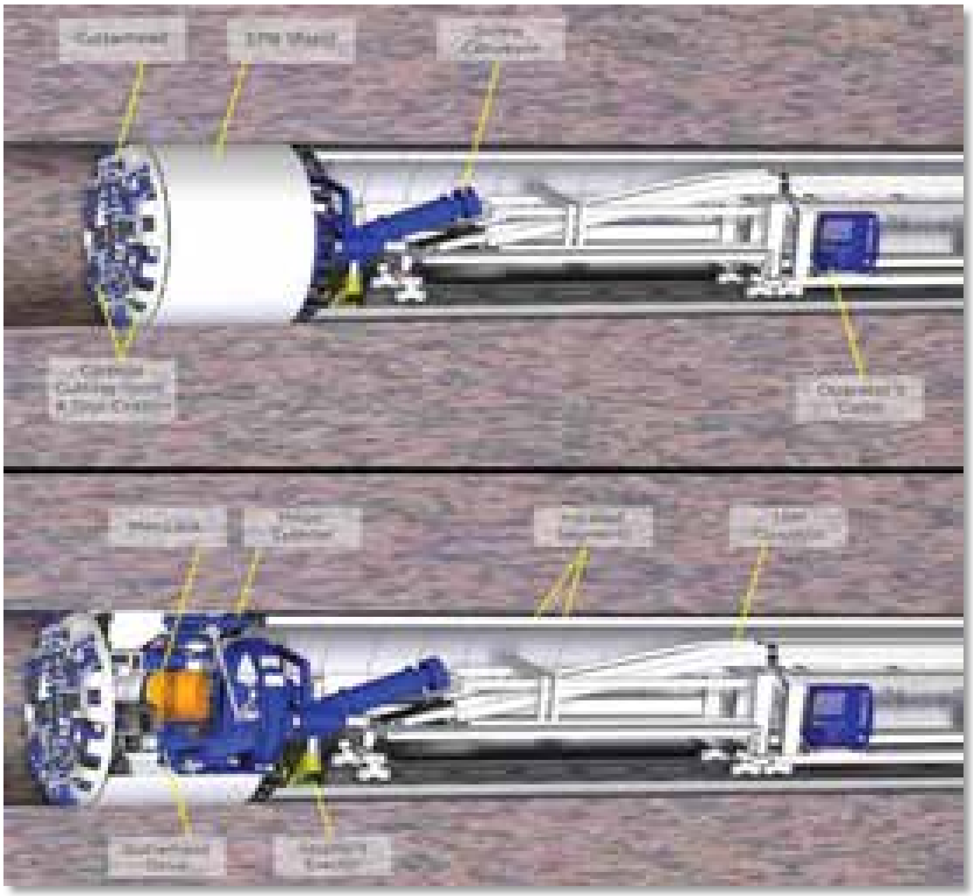


Figure 3-8 EPBM, The Robbins Company

An EPBM erects a pre-cast concrete segment tunnel final lining sequentially after each push. Specially designed high-pressure seals in the tail shield effectively seal the machine to the outside of the tunnel lining and create a barrier against groundwater. When it becomes necessary to enter the cutterhead chamber to inspect the cutterhead or change cutting tools, workers can enter through an airlock while compressed air is used to maintain a pressure balance to support the working face.

Due to equipment limitations and man access requirements into the EPBM, the minimum finished diameter possible for an EPBM is 7.5 ft, although at this diameter, machines are not readily available and would have to be special ordered. Machines are more common when at least 2.5-meter diameter (8.2 ft), and even more common when 3 meters (9.84 ft), and larger. The finished diameter consists of precast concrete segments, which are generally adequate for stormwater or wastewater conveyance. For this application, a steel pipe would be installed and grouted in place within the precast concrete segmental liner. This double liner system would allow a less robust concrete segment design as the segments are only required for initial support but would increase overall Project cost compared with a single liner system.

3.3.1.4.3 Traditional Tunneling Excavation Method Recommendation

For the FLDR, the traditional tunnel sections identified were assumed to be EPBM excavated with precast concrete segment initial support and steel pipe final lining. This is a reasonable approach given the feasibility level of analysis and lack of geotechnical field investigations. If, following a geotechnical investigation, it is determined that the soils along the alignment have low permeability that could allow shielded TBM, the tunnel cost would be lower than currently estimated. Additionally, if implementing EPBM tunneling with a secondary steel lining is cost prohibitive, the alignments could be excavated with MT equipment with intermediate jacking pits every 1,500 to 2,000 ft.

3.3.1.5 Minimum Working Spaces

In general, the larger the working space that can be provided the installation contractor, the more efficient the construction would be. Provided herein is a guideline for the minimum space that would be required at the launching and receiving shaft sites. This minimum space would provide enough area for a two to three-day supply of casing segments.

The minimum workspace for jack and bore and MG shaft sites would be as follows:

- Launching shaft minimum 105’ x 60’ or 6,300 ft^2 or 0.14 acres
- Reception shaft minimum 65’ x 60’ or 3,800 ft^2 or 0.09 acres

The minimum workspace for traditional tunneling shaft sites would be as follows:

- Launching shaft minimum 180’ x 126’ or 22,680 ft^2 or 0.52 acres
- Reception shaft minimum 108’ x 108’ or 11,664 ft^2 or 0.27 acres

For a more efficient site with a better supply of casing segments on hand, a workspace in the range of 3-5 acres is recommended.

3.3.1.6 Portals and Shafts

All trenchless methods with the exception of HDD would require portals and/or shafts to launch and retrieve the trenchless excavation equipment. In some cases, even HDD would require a launch excavation if the curve radius required is incompatible with the length of the alignment.

The pipeline alignment is relatively shallow, which would minimize the dewatering and water tight excavation methods required. In all cases, the excavation necessary for launch and retrieval would be a temporary excavation. Any permanent structure required for access or venting would have a much smaller footprint.

3.3.1.6.1 Ground Support Methods

The most common types of ground support for portals and shafts of this depth are sheet piles, soldier piles and hardwood lagging or plates, and steel ribs and hardwood lagging or steel liner plate.

Figure 3-9 depicts a typical sheet pile excavation support system.

Figure 3-9 Sheet Pile Excavation Support System, Black & Veatch

Generally, all these methods are not considered water tight although gasketed sheet piles can be installed to minimize seepage between piles. Depending on local ground conditions, dewatering could be accomplished with a sump at the bottom of the portal/shaft and a trash pump or through well point dewatering surrounding the shaft. Figure 3-10 depicts a typical steel rib with steel liner plate and hardwood lagging excavation support system.

Figure 3-10 Steel Ribs with Steel Liner Plate (Top) and Hardwood Lagging (Bottom), Black & Veatch

Local geotechnical information would help develop the most appropriate support method. However, unless a certain method is required to mitigate risk, the ground support method would generally be left up to the Contractor. The Contractor would submit a work plan prior to proceeding with the activity outlining a proposed approach for the Owner's approval.

When the trenchless crossing would be below the groundwater table, water tight shaft construction methods would be anticipated. Water tight ground stabilization would likely be accomplished with secant piles, as driven sheeting may be problematic due to cobbles and boulders.

More advanced and expensive excavation support systems also would be possible, but unlikely due to the planned depths. Other excavation systems include diaphragm walls and caissons.

Figure 3-11 depicts a typical soldier pile and steel plate excavation support system.

Figure 3-11 Soldier Piles and Steel Plates, Black & Veatch

3.3.1.6.2 Portal/Shaft Sizing

Due to the depth required, rectangular portals would likely be utilized, but circular shafts would be possible for deeper sections. For circular shafts, the launch shaft diameter would generally be two to two and a half times the excavated diameter of the pipe jacking or MT machine. The retrieval shaft would generally be one and half to two times the excavated diameter. The larger diameter necessary for the launch shaft would allow space for the jacking equipment and pipe segments. For example for an 84 inch diameter steel pipe MT drive with 108 inch steel casing, the launch shaft would be between 18 and 23 ft in diameter, and the retrieval shaft would be 14 to 18 ft diameter.

Figure 3-12 depicts a circular pipe jacking shaft site.

Figure 3-12 Pipe Jacking from a Circular Shaft, Pipe Jacking Association

A circular shaft affords plenty of space around the jacking frame and inserted pipe segments, but the extra space is not efficiently utilized. Due to the linear nature of trenchless installations, a rectangular shaft would be more appropriate when possible. Circular shafts are often the only feasible geometry for deep shafts due to the efficient management of ground forces. However, for shallow installations, rectangular shafts/portals would be possible.

For the same example of an 84-inch diameter steel pipe MT drive with 108 inch casing, the rectangular launch portal would need to be at least 16 ft wide. Although a wider portal would provide more work space, a 16 ft width would be possible. Generally, a width of slightly less than two times the excavated diameter would be possible. Portal length should consider the Contractor's means and methods and the site constraints. Technically, a portal length of two to two and half times the excavated diameter would be possible, but a longer portal can improve productivity. A 36 ft long portal would allow the Contractor to place 20 ft lengths of steel pipe minimizing the time for welding between each pipe segment. The receiving shaft for the same MT boring machine would be 25 ft long by 13 ft wide.

Figure 3-13 depicts a rectangular pipe jacking shaft site.

Figure 3-13 Pipe Jacking from a Rectangular Shaft, ConstructionEquipmentGuide.com

3.3.1.6.3 Conventional Tunnel/EPBM Shaft Sizing

Shaft size guidance for conventional tunneling and EPBM tunneling would be consistent with the other trenchless technology discussed with a few exceptions.

Since conventional tunneling and EPBM tunneling could require steel pipe installed within the precast concrete segment lined EPBM tunnel or initially supported conventionally lined tunnel, the excavated diameter would be much larger than the 84-inch diameter steel pipe. The excavated diameter would consist of an outer 8 to 12-inch-thick concrete segment, followed by a 6 to 12-inch annular space filled with low density cellular concrete or structural grout, and finally the steel pipe with cement coating and lining. Therefore, for an 84-inch diameter steel pipe, the excavated diameter would likely be between 118 and 132 inches. The minimum excavated diameter required to build precast segments is generally also between 118 and 132 inches due to tunnel boring machine limitations. Therefore, smaller diameter pipes would be installed in a larger excavated tunnel. Figure 3-14 shows an example of a carrier pipe installed within a larger excavated tunnel. The finished pipe shown is approximately 48 inches; therefore, the smallest TBM available was considerably larger, resulting in additional annular space.

Figure 3-14 Carrier Pipe (Fiberglass) Installed in a Larger Excavated Tunnel, Black & Veatch

The launch and retrieval shaft sizes would need to account for this larger diameter. Due to the larger excavated diameter, the minimum width for a rectangular shaft would probably be at least 20 ft and between 20 and 25 ft for a circular shaft.

Conventional tunneling and EPBM tunneling do not require jacking of pipe so longer shaft lengths would not be required for staging pipe segments. However, conventional tunneling machines and EPBMs are considerably longer than MT and pipe jacking equipment. This equipment could be assembled segmentally in a circular shaft, but a longer rectangular portal would allow this process to proceed much quicker. A portal length exceeding 50 ft would reduce the duration of machine assembly and allow mining to commence sooner.

3.3.2 Cut-and-Cover Construction Methods

A majority of the Preferred Alignment would be expected to be constructed using cut-and-cover construction methods. The Desktop Geotechnical Evaluation indicated that the soil conditions allow the use of temporary shoring or sloped-back trenches for excavation throughout the proposed alignment. Temporary shoring would likely be necessary for most of the alignment as well as portal excavations to minimize impacts to surface features, traffic flow, and adjacent utilities. Where the pipeline would be in areas with adequate space to accommodate temporary sloped excavation methods, the excavation could be sloped back. For the purposes of this FLDR, all excavations were assumed to require temporary shoring with the exception of CM3B, as described in Section 3.4.3.

Temporary shoring such as speed shores, slide rails, trench boxes, cantilever sheet piles, soldier piles with lagging, and internal bracing could be used throughout the alignment combined with adequate dewatering where necessary. An exception is that the use of cantilever sheet piles would likely not be appropriate in areas where outcropping rock or bedrock occurs close to the ground surface as the necessary embedment may be difficult to achieve. Non-interlocking shoring would not be appropriate in areas where shallow groundwater and sandy materials are not adequately dewatered ahead of the excavation as windows between shoring may allow soil and groundwater intrusion into the excavation, potentially destabilizing it. Temporary shoring should be designed and provided based on California Division of Occupational Safety and Health Administration (CalOSHA) requirements and specified soil types.

Most of the proposed Project area appears to have relatively shallow groundwater with depths ranging from 8 ft to 20 ft below ground surface. Groundwater that is less than 20 ft below ground surface would likely require dewatering for pipeline trench construction. In areas where the groundwater level is high, cut-and-cover excavations would be difficult without adequate dewatering. Dewatering would be a viable means for controlling groundwater flow into open excavations along the majority of the alignment. In general, the sandy to cobbley deposits that occur at the northern end of the proposed Project area and the sands on the eastern end would require higher pumping rates with more wells than the finer grained deposits that occur in the south and southwestern areas of the Preferred Alignment.

3.3.3 Pipeline Separation Requirements

The proposed conveyance pipeline would be designed in accordance with the requirements of the State of California Department of Health Services, Section 64572, Title 22 of the California Administrative Code and Metropolitan's design guidelines and standards for the construction of a new pipeline conveying advanced treated recycled water. These requirements lay out the minimum separation requirements for new construction of a pipeline from existing parallel and crossing infrastructure.

Further coordination and review will be required with the California Department of Health Services and other applicable jurisdictions during design to review and approve the design documents. In locations where the basic separation standards cannot be met due to congested utility corridors, approvals will be required for alternative construction criteria from the Department of Health Services and potentially from the County of Riverside. The alternative construction criteria include specific material and design requirements.

Preliminary and final design efforts would include field verification (potholing) of existing utilities to finalize the proposed pipeline alignment and to verify separation clearances.

3.3.4 Major Utility Crossings

The proposed conveyance pipeline would cross many large diameter (major) utilities, including several of Metropolitan's existing Feeders. All major utility crossings would be in accordance with Metropolitan's design standards and follow the guidelines of Metropolitan's Substructures team.

Details would be further evaluated and defined during preliminary and final design.

3.4 DEVELOPMENT OF TYPICAL CONSTRUCTION METHODS

The routes traversed by the proposed advanced treated water pipeline were classified into four general alignment types: roadways, SCE easements, LACFCD easements, and trenchless (tunnels). A typical construction method was developed for each alignment type for the purpose of establishing a conservative budget and determining the approximate impact area for environmental analysis. These methods were intended to cover the materials and work consistently utilized for pipe installation along that alignment type. The four standard construction methods and locations where they are applied are discussed in more detail below.

3.4.1 Construction Method 1 - Roadways

Construction Method 1 (CM1) was the standard method applied in all roadway/street locations. CM1 would utilize shored construction and would be used along local, collector, or arterial roadways where the curb to curb distance is 60 ft or greater. Figure 3-15 shows the typical manner in which CM1 would be applied to construction along roadways utilizing vertical shoring.

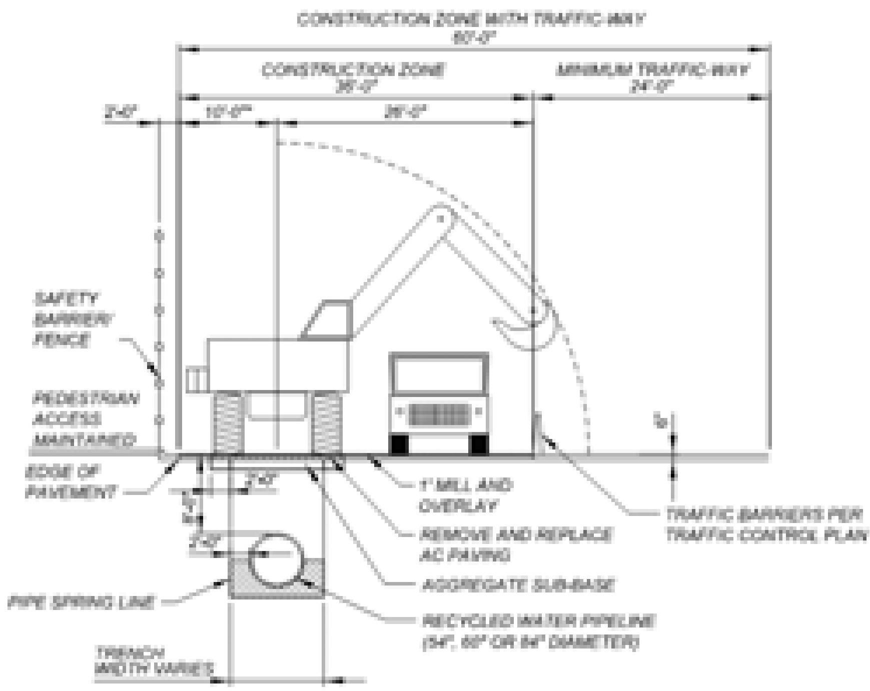


Figure 3-15 Construction Method 1 – Roadways (Shored Construction)

The minimum street width required for a 36 ft wide construction zone and two 12 ft lanes is 60 ft, in order to maintain two-way traffic and leaving the sidewalks free for pedestrian traffic and store-front access. The 36 ft wide construction zone is governed by the clearances required for operation of construction equipment of the type and size envisioned. For this feasibility-level analysis, it was assumed that the construction zone width does not vary as the trench width or pipe diameter / depth varies. Additional curb to curb width beyond 60 ft would not invalidate the configuration shown for CM1 but would permit an even wider construction zone and/or additional traffic lanes beyond the minimum. Instances with less than 60 ft curb to curb width were special cases which would require utilizing either one lane with a flagman or full closure to traffic with a detour.

3.4.2 Construction Method 2 – SCE Easements

Construction Method 2 (CM2) was the standard method applied along all SCE Easements. CM2 would utilize vertically shored excavation and a 36 ft wide construction zone plus additional clearance from transmission towers and energized lines as shown on Figure 3-16. The clearance from the towers would provide a corridor of travel for SCE to use during construction and the clearance from the energized lines (conductors) would be required to comply with the National Electric Safety Code.

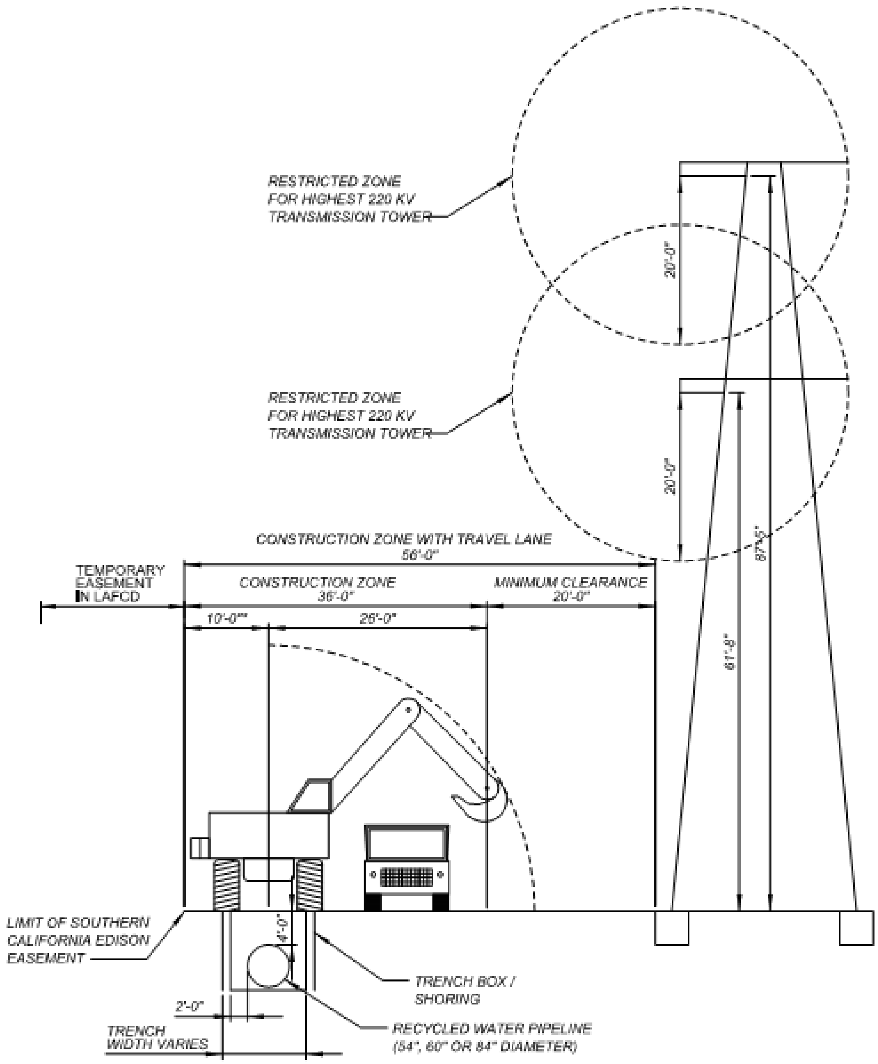


Figure 3-16 Construction Method 2 – SCE Easement (Shored Construction)

The width of the construction zone would not vary based on the diameter of the pipe because the equipment used to build the pipeline would require the 36 ft width regardless of the diameter of the pipe being installed. In certain cases, where the full 36 ft width would not be available within the interior of the SCE easement, the pipeline could still be installed within the SCE easement if a temporary easement were obtained to permit a portion of the construction zone to extend into an adjacent LACFCD corridor. Additional width available for construction activities beyond the 36 ft minimum would allow a wider construction zone and would potentially lower construction costs by increasing the speed of construction.

3.4.3 Construction Method 3 – LACFCD Easements

Construction Method 3 (CM3) would utilize cut-and-cover construction and would be the standard method applied within LACFCD easements. Figure 3-17, Figure 3-18, and Figure 3-19 show the possible variations for use depending on the pipeline location in relation to the river channel. The three CM3 construction variations are:

- **<u>CM3A – River Bank</u>:** This method would use shored construction where there is sufficient space outside of the river channel to install the pipeline either at the top of the bank or adjacent to the toe of the levee.
- **<u>CM3B – River Channel (Unlined)</u>:** This method would be for temporary sloped construction where a concrete encased pipe is installed in an earthen river bottom.
- **<u>CM3C – River Channel (Lined)</u>:** This method would be for shored construction where a concrete encased pipe is installed in a concrete lined river bottom.

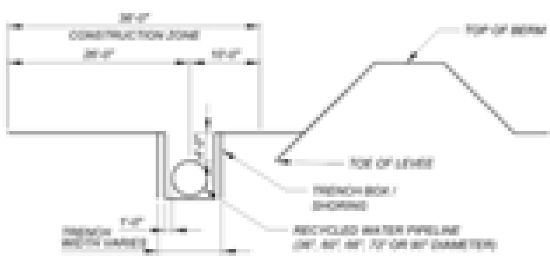


Figure 3-17 Construction Method 3A – River Bank (Shored Construction)

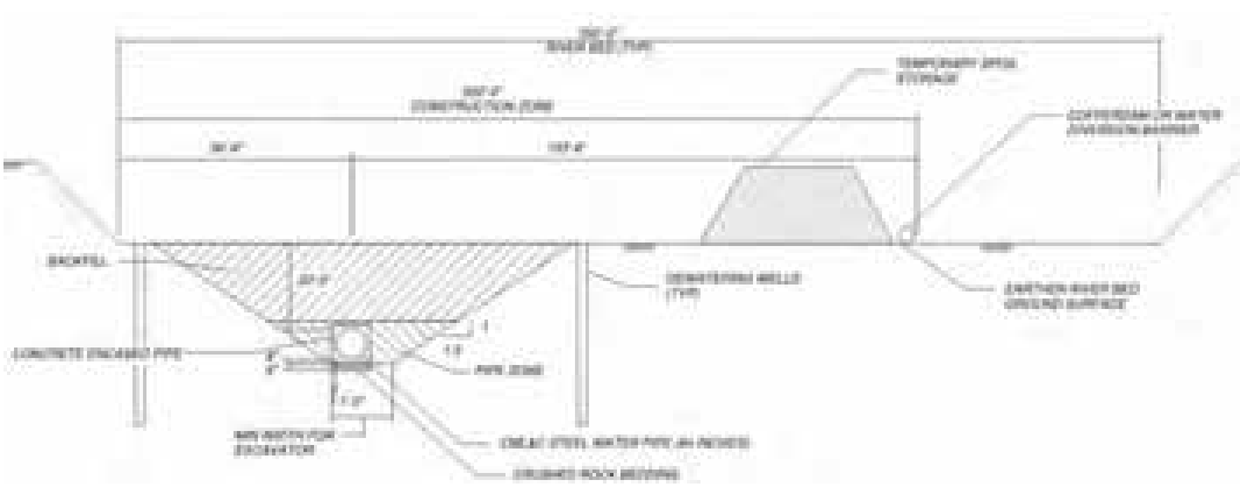


Figure 3-18 Construction Method 3B – River Channel (Unlined) (Temporary Sloped Excavation)

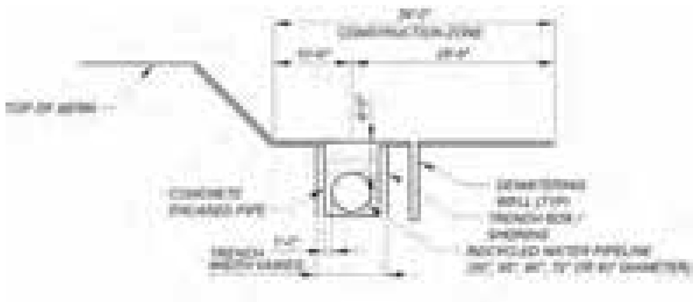


Figure 3-19 Construction Method 3C – River Channel (Lined) (Shored Construction)

As shown on the figures above, 36 ft would provide the minimum required width for pipeline installation and clearances for construction activities for CM3A and CM3C. The FLDR evaluation assumed that CM3A and CM3C would utilize a vertically shored excavation in order to stay within the construction zone and to minimize impacts to the river bank, river bed, or its lining. In certain cases, where the full 36 ft width would not be available within the interior of the LACFCD easement, the pipeline could still be installed within the easement if a temporary easement were obtained to permit a portion of the construction zone to overlay the adjacent SCE corridor. Conversely, additional width available for construction activities beyond the 36 ft minimum would permit a wider construction zone and could potentially lower construction costs.

CM3B applies if the pipeline were to be installed using temporary sloped excavation methods within an unlined river channel. As shown in Figure 3-18, this FLDR has assumed that 20 ft of cover over the pipeline and a minimum of 1 ft of concrete encasement would be required to protect the pipe from scour and prevent flotation. Pending a more detailed evaluation of scour potential, this is considered to be a reasonable planning-level assumption.

To control against groundwater, it was assumed that dewatering wells would be required at 25 ft on center for the purposes of establishing a conservative budget. Field investigations to estimate the groundwater depths and volumes have not been completed at this time and would be required prior to design. While the dewatering strategy utilized would ultimately be the responsibility of the contractor, it is anticipated that the frequency and depth of dewatering wells required would be refined for future cost estimates once this information is known.

Due to the depth of the excavation, it was assumed that the pipe trench would be laid back at a 1.5 to 1 slope instead of shoring the sides as assumed for the other construction methods. Further investigations into LACFCD's requirements on pipes installed in earthen channels and evaluations on scour and pipe flotation should be completed during subsequent design phases to confirm these planning-level assumptions.

3.4.3.1 Construction Method 4 – Trenchless

Construction Method 4 (CM4) was applied for the sections of RRWP alignment that were identified as requiring trenchless construction methods. In general, these would include crossing of rivers, major drainage channels, freeways, and railroad tracks. The Desktop Geotechnical Evaluation identified four conservative trenchless installation methods as feasible for the Project's crossings, as discussed in Section 3.2.9. After reviewing the segments of the RRWP alignment preliminarily identified for trenchless installation, the FLDR determined that HDD was not applicable for any of the Project's crossings.

The three feasible, conservative trenchless installation methods assumed for the Project's crossings were as follows:

- CM4A – Jack & Bore: This method would use a jacking system to push casing pipe (or carrier pipe) into place. A cutting head would mine the face of the excavation and a conveyor or muck car would remove spoils from inside the casing pipe. Jack & bore was selected for tunnel lengths up to 2,000 ft under appropriate conditions.
- CM4B – Microtunneling: MT also would use a jacking system to push the casing pipe (or carrier pipe) into place, but with a TBM mounted at the head of the pipe string instead of a cutter head. MT was generally selected for tunnel lengths up to 2,000 ft where the tunneling conditions were beyond those readily handled by a jack & bore system. CM4B assumed utilization of an EPBM unless more challenging conditions required the use of a slurry-faced TBM.
- CM4C – Traditional Tunneling: Traditional tunneling would be utilized for longer trenchless applications where the friction from pipe jacking would become too great. This method does not require a pipe jacking system, but instead constructs the tunnel from segmental liners using a self-advancing TBM. The recycled water carrier pipe would be then skidded into the tunnel after completion. Traditional tunneling was generally selected for tunnel lengths of 2,000 ft or greater and assumed an EPBM unless more challenging conditions require use of a slurry-faced TBM.

Figure 3-20 shows the typical set-up schematically for each of the three conservative trenchless construction methods considered.

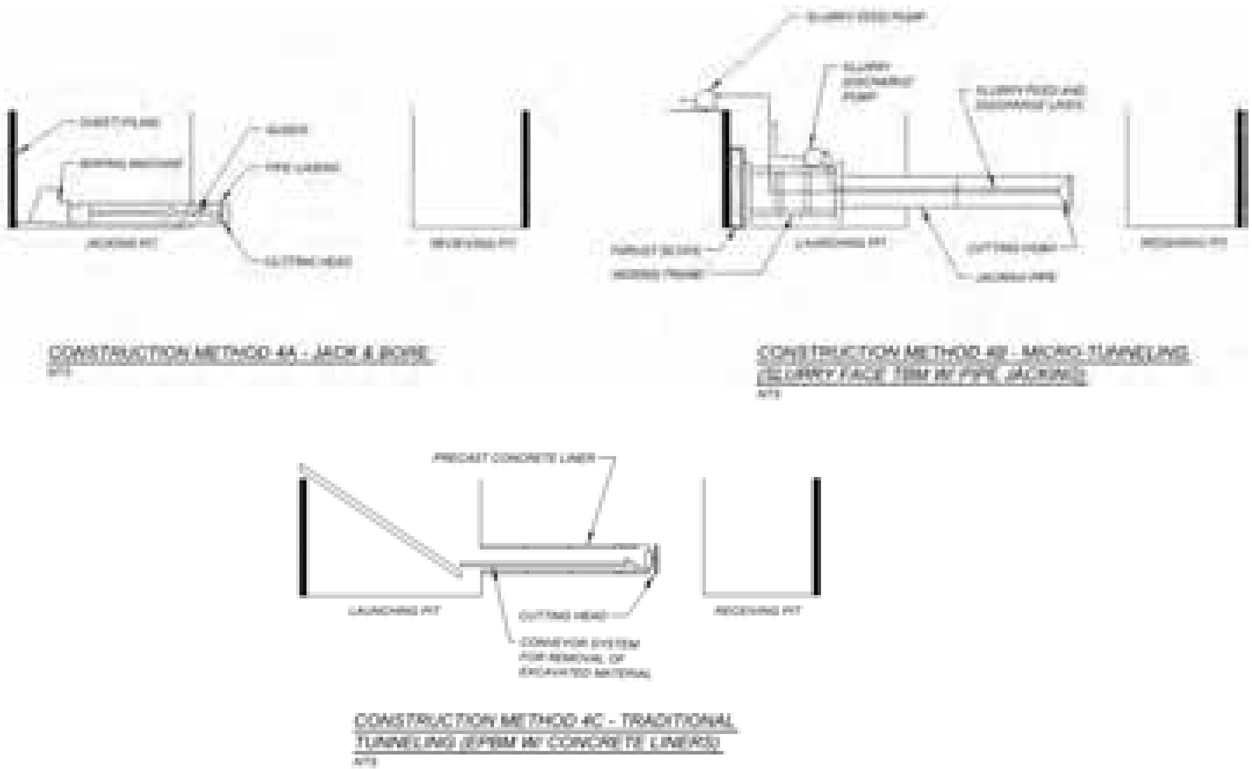


Figure 3-20 Construction Method 4 - Trenchless

4.0 Detailed Alternative Alignment Evaluation

This chapter documents two primary topics. The first is the evaluation process used to compare and assess alignments to achieve a ranking of alternatives. This evaluation process was used to assess all alignment alternatives throughout the Project and is comprised of a decision model that scores the alternatives based on a set of screening criteria and weighting factors.

The second topic documented in this chapter is the initial alignment evaluation that was completed up through the 2018 Draft Report in October 2018. At that time, the Project still envisioned delivering water to both the SFSG and the OC Spreading Grounds. The results of the evaluation, including the identification of the Initial Preferred Alignment which would deliver water to both the SFSG and the OC Spreading Grounds, are presented herein. A brief overview of the analysis documented in this chapter is as follows:

- **Goals of Detailed Alternative Alignment Evaluation.** This section presents the goals of the alignment evaluation, which includes establishing a defensible and objective process that supports upcoming environmental evaluations to comply with CEQA.
- **Decision Model.** A spreadsheet-based decision model was developed to document the alignment evaluation process. The spreadsheet-based decision model utilized the evaluation screening criteria, weighting factors, and scoring methodology established in this section to compare and rank pipeline segments. A listing of all segments and sub-segments and the corresponding raw data collected for each are presented in Appendix D. Detailed descriptions of the screening criteria are provided in Appendix F.
- **Evaluation.** This section documents the results of the alignment evaluation completed for the 2018 Draft Report. Covered in this section are the coarse, secondary, and fine screening steps. Each step evaluated progressively longer combinations of pipeline segments, until, at the fine screening step, full alignment alternatives starting at the AWT plant and ending at the SFSG and the OC Spreading Grounds were compared. Three full alignment alternatives were considered during fine screening: the SG River Alignment, the LA River Alignment, and an "All Streets" Alignment. The results of the screening evaluations are documented in Appendix D.
- **Results and Conclusions.** This section documents the results of the initial alignment evaluation completed for the 2018 Draft Report. The SG River Alignment (Route A) scored most favorably in the initial alignment evaluation, which included the reach to the OC Spreading Grounds, and is known as the "Initial Preferred Alignment".

Chapter 5 presents the subsequent investigations that considered only the Backbone System. Within those subsequent investigations, additional Metropolitan stakeholders provided input to the scoring and weighting methodology described in this chapter. The details of that input are described in Chapter 5 and were applied to the alignment evaluations described in that chapter. That feedback to this evaluation process was ultimately used to arrive at the SG River and LA River Alignments presented later in this FLDR.

Figure 4-1 summarizes the Project methodology as it applies to this chapter including many of the factors listed above.

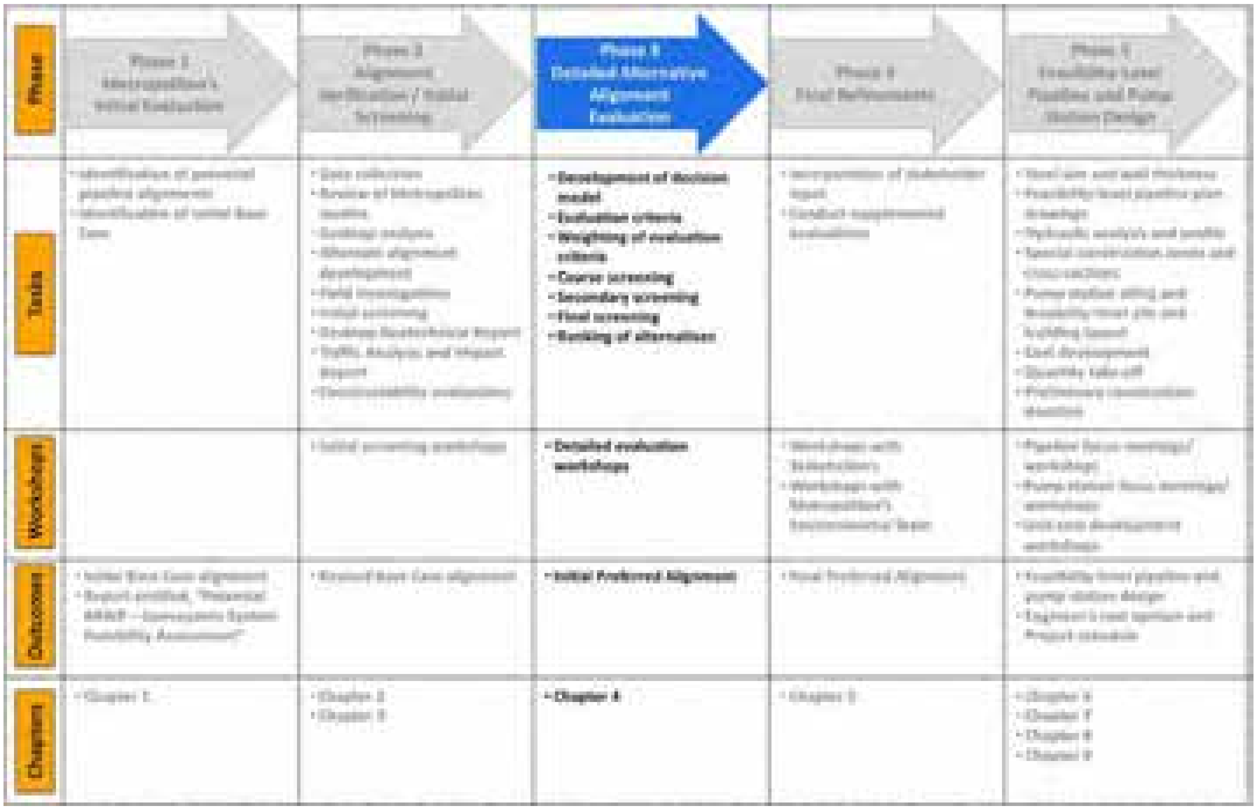


Figure 4-1 Chapter 4 Methodology

4.1 GOALS OF DETAILED ALTERNATIVE ALIGNMENT EVALUATION

The goals of the analyses were to:

- Establish a defensible evaluation process that objectively determines a preferred conveyance system.
- Providing full consideration of alignment alternatives such that the FLDR documentation and alignment analyses would support the next stages of CEQA compliance, Project planning, and preliminary final design. Identify and rank viable alternative segments and/or overall alignments so that adjustments could be made should impediments be encountered during subsequent phases of the Project (such as the inability to acquire right-of-way, identification of fatal flaws during more detailed technical analyses, objections from regulatory agencies during permitting, etc.).
- Provide support to upcoming environmental evaluations through identification of viable segments and/or overall alignment alternatives, including a documented rationale for how the recommended alignment was selected.

As discussed previously, this process was used not only to identify the Initial Preferred Alignment in 2018 but also to evaluate the Backbone System during the later stages of the Project, as discussed in Chapter 5.

4.2 DECISION MODEL

To achieve a ranking of viable alternatives and identify a preferred alignment, a spreadsheet-based decision model was developed. The decision model was linked to the ArcGIS database to use the data compiled from record information, desktop analyses, and field observations to compare the quantitative and qualitative characteristics of individual pipe segments or combinations of pipe segments.

In the decision model, evaluation criteria, established to assess and compare the relative feasibility of each pipe segment, was scored based upon its ability to satisfy the Project objectives. A weighting factor, reflecting Metropolitan's priorities for the RRWP, was then assigned to the evaluation criteria to assess the relative contribution of each on the ranking and selection of a preferred alignment.

In certain cases, to provide sufficient resolution to make distinctions about the features and attributes of each segment (i.e., varying construction methods required for installation) within the decision model, the pipeline segments described in Chapter 2.0 were divided into new sub-segments. This was also necessary to facilitate the evaluation of alignment combinations that intersected at segment midpoints. As a result, nearly 200 separate sub-segments were included in the decision model. A listing of all segments and sub-segments and the corresponding raw data collected for each are presented in Appendix D.

The sections below describe in detail the components of the decision model, including:

- Scoring
- Evaluation criteria
- Weighting

4.2.1 Scoring

This section describes the rating system developed to compare each pipeline segment and sub-segment. Each combination of alignments or pipe segments was assigned a rating score for each criterion based upon its ability to satisfy the Project objectives using a scale of 1 to 5, as shown in Table 4-1.

Table 4-1 Screening Criteria Rating System

RATING SCORE	DEFINITION
1	Pipe segment or alignment alternative satisfies Project objectives with little to no impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally be less than the average occurrence across all segments. Significant advantages may be noted.
2	Not used.
3	Pipe segment or alignment alternative satisfies the Project objectives, but with an increasing level or degree of impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally fall within a range of average occurrences across all segments.

RATING SCORE	DEFINITION
4	Pipe segment or alignment alternative satisfies the Project objectives, but with a level or degree of impacts between a 3 and 5 score related to the evaluation criterion. (Used only for the ease of operations and accessibility evaluation criterion due to the four different types and/or methods of construction for the pipeline requiring different rating scores).
5	Satisfies Project objectives, but with a higher level or degree of impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally be greater than the average occurrence across all segments. Significant disadvantages may be noted.

In this rating system, lower scores were favorable and higher scores were unfavorable. A low rating score (i.e., a score at or near to 1) signaled the segment, or combination of segments, compared favorably to the evaluation criteria, indicating that impacts related to the evaluation criterion either do not exist or would occur at a rate that is generally less than the average occurrence across all alternatives. Conversely, a rating score of 5 indicated the alignment alternative would not compare favorably to the evaluation criteria and the impacts related to the criterion would occur at a rate that is generally higher than average. The rating scores as applied to each of the evaluation factors are described in Section 4.2.2.

It should be noted that the evaluation was originally developed utilizing three rating scores (1, 3, and 5). However, as evaluation screening criteria were developed (as described in Section 4.2.2) it became warranted to add a fourth rating score to differentiate between alternatives. For this reason, the rating score of 4 was added strictly for the ease of operations and accessibility evaluation criterion. For all other evaluation screening criteria, the three rating scores original developed were all that were used.

4.2.2 Evaluation Criteria

This section describes the evaluation criteria used to assess and compare the various alignment and segment alternatives. The evaluation criteria were organized into three major categories: factors that would add construction risk, factors that would result in social and community impacts, and factors that would have biological impacts. The screening criteria were generally consistent with the Project description information required for preparation of CEQA review. The individual evaluation factors within each category are described in detail in Subsections 4.2.2.1 through 4.2.2.3.

4.2.2.1 Construction Risk

The construction risk category comprised factors that increase the inherent risk associated with below grade pipeline construction in urban areas. Each of the seven evaluation factors included in this category were considered to potentially affect the success of the Project by impacting the Project budget, the rate of construction progress, or the safety of working conditions. Details of the scoring for each construction risk category are presented in Table 4-2 with descriptions provided in Appendix F.

Table 4-2 Evaluation Criteria: Construction Risk

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Major Utility Crossings	Number of major utility crossings, including: • Storm Drains >30 in. • Sewer Lines/Force Mains > 24 in. • Water Transmission Mains >24 in. • Oil/Gas Pipelines >18 in.	<1 crossing per 1000 ft of trench construction	Between 1 and 2 crossings per 1,000 ft of trench construction	>2 crossings per 1,000 ft of trench construction
Trenchless Construction	Percent of pipe length that would be constructed using trenchless construction methods, such as crossing freeways, railroads, river channels, major intersections, and environmental areas	<5% of pipe length requires trenchless crossings	Between 5% and 15% of pipe length requires trenchless crossings	>15% of pipe length requires trenchless crossings
High Groundwater Conditions	Percent of pipe length that would be constructed in areas with high groundwater conditions and permeable/sandy type soils	<10% of pipe length encounters a groundwater depth <10 ft.	Between 10% and 30% of pipe length encounters a groundwater depth <10 ft	≥30% of pipe length encounters a groundwater depth <10 ft
Alignment Length[1]	Proposed pipe length compared to the shortest alignment	Shortest proposed alignment; or within 10% of the shortest alignment	Between 10 and 20% of the shortest alignment	Greater than 20% of the shortest alignment
Seismic Hazard	Presence of known active seismic fault crossing proposed pipe	Pipe segment does not cross a known active fault	---	Pipe segment crosses a known active fault
Soil Contamination	Number of reported contaminated soil sites within 75 ft of proposed pipe	<0.15 “hits” per 1000 ft	Between 0.15 and 0.40 “hits” per 1000 ft	>0.40 “hits” per 1000 ft

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE			
		(1)	(3)	(4)	(5)
Ease of Operations and Accessibility[2]	Weighted score based upon land use of the proposed segment	Utility easement	Roadway	Tunnel	River bed

Notes:
1. Additional details on the scoring of Alignment Length are provided in Appendix F.
2. Additional details on the weighted scoring of Ease of Operations and Accessibility are provided in Appendix F.

4.2.2.2 Social and Community Impacts

The evaluation factors included in the social and community impact category were used to identify and assess at a feasibility-level the potential impacts construction would have on residences and businesses located along or near to construction activities, at construction staging areas, and along designated haul routes. The Project would generate both temporary and permanent impacts on traffic circulation, the use of parks and recreation areas, and access to public facilities. Selecting pipeline routes minimizing social and community impacts would result in fewer controls and restrictions being imposed on construction activities by jurisdictional and regulatory agencies. The selection of pipeline routes minimizing these social and community impacts were also anticipated to yield less community, municipality, or regulatory body resistance, reducing the risk of delay.

Details of the scoring for each social and community impact category are presented in Table 4-3 descriptions provided in Appendix F.

Table 4-3 Evaluation Criteria: Social and Community Impacts

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Parks and Recreation Areas[1]	Would have a direct impact from construction activities within parks and recreation areas with differentiation between parks inside SCE easements	Not constructed in a park	Constructed in a park and SCE easement	Constructed in a park, no SCE easement
Public Facilities	Number of high use public facilities that would be encountered along the pipe segment, including hospitals, schools, airports, civic centers, cemeteries, and regional shopping centers	<0.35 public facilities per mile of pipe length	Between 0.35 and 0.45 public facilities per mile of pipe length	>0.45 public facilities per mile of pipe length
Traffic Impacts[2]	Length of pipe that would impact the traveled roadway during construction activities as well as the volume of traffic impacted	Not constructed in traveled roadways	Constructed in a roadway designated as a collector or local street	Constructed in a roadway designated as a minor arterial street or requiring a road closure
Street and Median Improvements	Would have a direct impact from construction activities on improved/landscaped center medians (parallel construction)	<20% of segment length	Between 20% and 30% of pipe length	≥30% of pipe length
Major Intersections	Number of major intersections that would be crossed using cut-and-cover construction (based on the Traffic Impact Analysis)	<1 major intersections per mile of pipe	Between 1 and 2 major intersections per mile of pipe	>2 major intersections per mile of pipe

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Residential and Minor Commercial	Length of pipe alignment that would impact access, traffic, and safety of residential and minor commercial areas during construction activities	<10% of segment length	Between 10% and 60% of pipe length	>60% of pipe length

Notes:
1. Additional details on the weighted scoring of Parks and Recreation Areas are provided in Appendix F.
2. Additional details on the weighted scoring of Traffic Impacts are provided in Appendix F.

4.2.2.3 Biological Impacts

Details of the scoring for each biological impact category are presented in Table 4-4 with descriptions provided in Appendix F.

Table 4-4 Evaluation Criteria: Biological Impacts

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Waters of the US or State	Length of pipe alignment that would cross through Waters of the US or State	<2.5% of pipeline length	Between 2.5% and 5% of pipeline length	>5% of pipeline length
CNDDB Habitats	Pipe alignment would cross through areas of known CNDDB habitats	Pipe segment does not cross a known CNDDB habitat	---	Pipe segment crosses a known CNDDB habitat

4.2.3 Weighting of Evaluation Criteria

Weighting factors reflecting Metropolitan's priorities for the RRWP were assigned to the evaluation factors to assess the relative contribution of each criterion on the ranking and selection of preferred alternative alignments. Weighting factors were also assigned to the three evaluation categories to test the relative importance of each category and its sensitivity to adjustments of the weighting.

Workshops were held with representatives from across Metropolitan's organization to discuss the criteria and weighting to assure they reflect Metropolitan's concerns and priorities for the Project. Two weighting scenarios were developed during these workshops, presented in Table 4-5 below. Weight A placed an increased emphasis on evaluation factors related to the assessment of construction risk. Weight B emphasized evaluation factors for social and community and biological impacts.

As noted in the introduction to this chapter, stakeholder input provided after the completion of the October 2018 Draft Report resulted in a variety of different weighting scenarios which were used during evaluation and refinement of the alignment alternatives presented later in this FLDR. See Chapter 5 for details about that input.

Table 4-5 Evaluation Criteria: Weighting Factors Matrix

	WEIGHT A: EMPHASIS ON CONSTRUCTION RISK FACTORS	WEIGHT B: EMPHASIS ON COMMUNITY AND ENVIRONMENTAL FACTORS
Construction Risk	**Category Weight: 60%**	**Category Weight: 30%**
Major Utility Crossings	20%	20%
Trenchless Construction	20%	20%
High Groundwater Conditions	5%	5%
Alignment Length	25%	25%
Seismic Hazard	5%	5%
Soil Contamination	5%	5%
Ease of Operation and Accessibility	20%	20%
Subtotal	**100%**	**100%**
Social and Community	**Category Weight: 30%**	**Category Weight: 55%**
Parks and Recreation Areas	5%	5%
Public Facilities	20%	20%
Traffic Impacts	20%	20%
Street and Median Improvements	20%	20%
Major Intersections	15%	15%
Residential and Minor Commercial	20%	20%
Subtotal	**100%**	**100%**
Biological	**Category Weight: 10%**	**Category Weight: 15%**
Waters of the US and State	20%	20%
CNDDB Habitats	80%	80%
Subtotal	**100%**	**100%**

4.3 EVALUATION

This section documents the initial alignment evaluation that was completed prior to October 2018 and includes the reach to the OC Spreading Grounds.

Due to the large number of segments and sub-segments, an almost endless number of alignment iterations were possible. To make this evaluation more manageable, the following methodology was employed:

- A coarse screening focusing on relatively short, individual segments where two or more pipeline route options were available was performed to reduce the total number of alignment combinations.
- A secondary screening comparing longer combinations of segments was completed, further reducing the number of possible alignments.
- Fine screening built upon the results from the coarse and secondary screening and focused on developing and evaluating segment combinations for three basic conveyance alignments as options for the RRWP conveyance system, hereafter referred to as follows:
  - San Gabriel River Alignment – Route A
  - All Street Alignment – Route B
  - Los Angeles River Alignment – Route C

Workshops were held with Metropolitan staff during the evaluation to review the procedure, develop the evaluation criteria and weighting, and verify the results accurately represented Metropolitan's goals for the Project.

The Initial Preferred Alignment was the best scoring alignment from Routes A, B, and C and included the reach to the OC Spreading Grounds.

The focus of the evaluation process that was established was to be able identify a "preferred" alignment for the overall conveyance system that would serve as the basis for future technical/pre-design, right-of-way acquisition, and environmental, regulatory, and municipal permitting. The evaluation process was set up such that, as new information emerged during subsequent efforts, the analysis tools provided herein could be readily revisited to help identify alternatives to accommodate new or unforeseen issues with the recommended alignment. When the Project evolved as described in Chapter 5.0, these same processes, using the weighting scenarios provided by Metropolitan stakeholders, were applied to recommend a revised conveyance system. The revised weighting factors were applied to the analysis described in this chapter. and the results were unchanged.

4.3.1 Coarse Screening

The coarse screening process evaluated relatively short segments, or combination of segments, where two or more pipeline route options were available to determine the preferred route. A "path" refers to these individual evaluations of two or more pipeline routes with common starting and finishing locations, consisting of one or more combinations of segments and sub-segments. In many cases, "paths" compare routes along parallel and adjoining streets to address potential community impacts or to avoid high risk crossing areas. These paths, numbered numerically (i.e., Path 1, 2, etc.), were then evaluated to determine which segment or combination of segments met the Project's goals.

The data for each path, consistent with the evaluation criteria, was entered into the decision model spreadsheet. The coarse screening paths are presented on Figure 4-2.

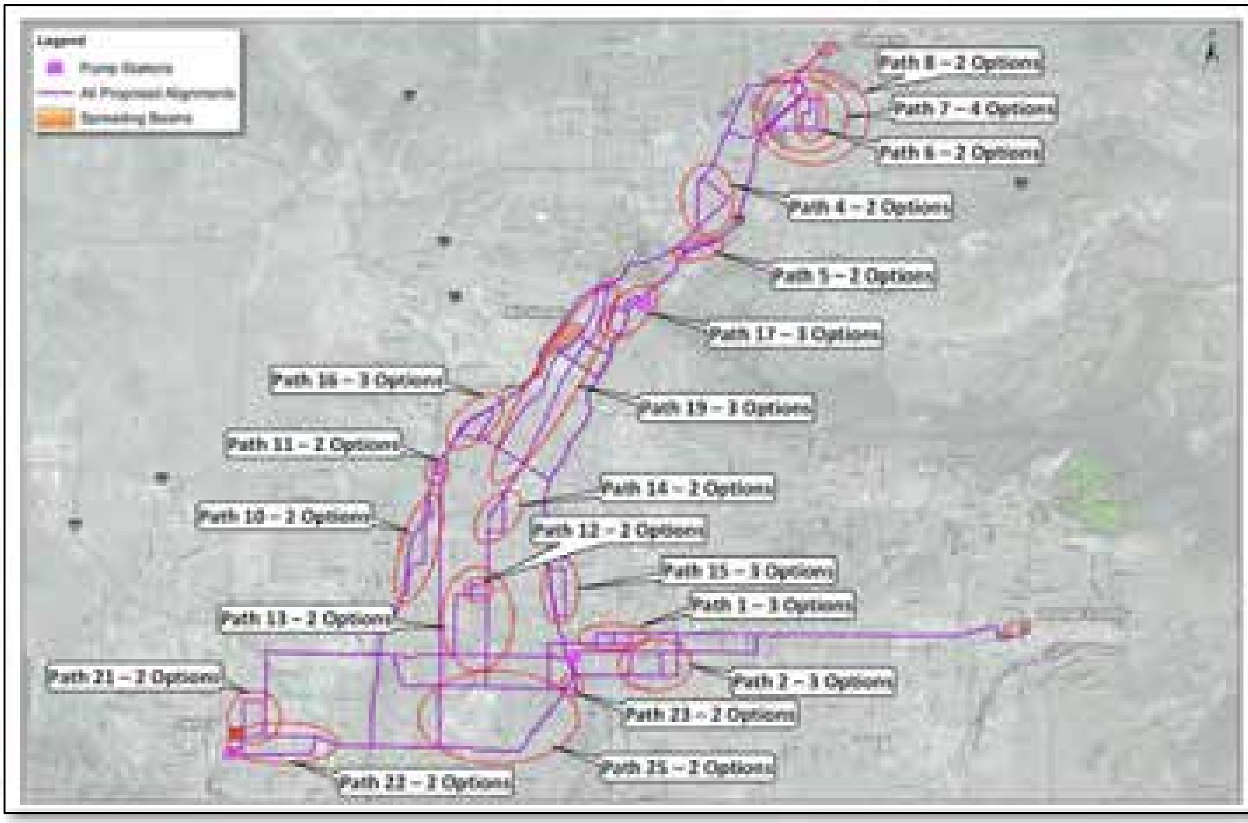


Figure 4-2 Paths Evaluated During the Coarse Screening

As described previously, outcomes from the decision model were dependent upon the evaluation criteria rating scores and category weights. To provide a more intuitive final scoring system, each total weighted score was summed for each path and then converted to a percentage (out of 100) so that the highest final score out of 100 percent was considered the preferred path for each comparison. Path scores are only applicable to the other options considered in the comparison. For instance, scores for Path 1 are only comparable to the three alignment options included in this comparison and not directly comparable to the scores for Path 2 or others.

Decision model results for the coarse screening are provided in Appendix E. The bolder black lines shown on Figure 4-3 depict the favored route for each path of the coarse screening. By performing a coarse screening, many less advantageous, localized alignments were eliminated, thereby removing these segments from further consideration. The results from the coarse screening were subsequently used to develop the longer paths and routes used for secondary screening.

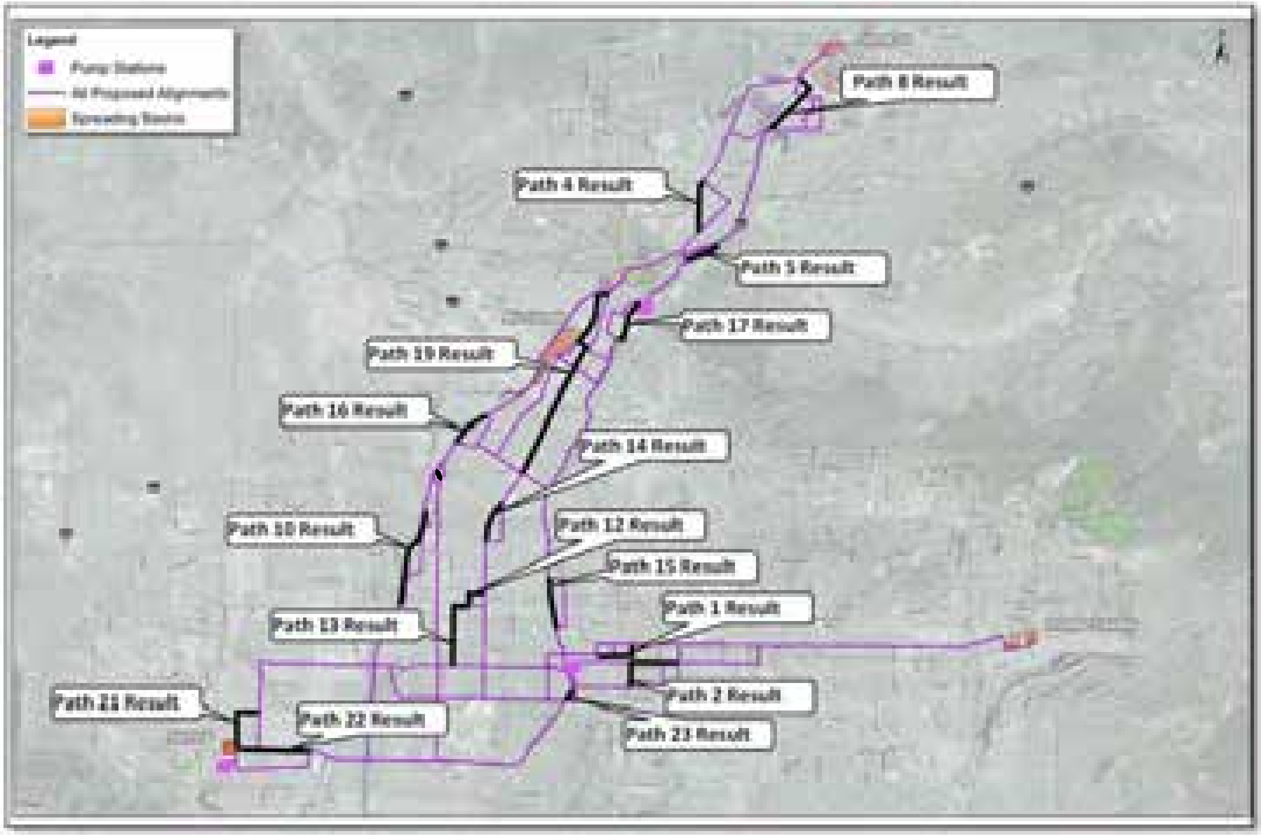


Figure 4-3 Coarse Screening Results for Weighting A

4.3.2 Secondary Screening

Secondary screening entailed developing longer segment combinations beginning at the AWT plant and ending at each of the system delivery points.

Secondary screening was divided into three areas with the goal of determining the favored alignment through each. The areas generally align with Reaches 2 thru 4 identified in Chapter 1.0 and are as follows:

- From the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River to the OC Spreading Grounds
- From the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River to PS-3/Rio Hondo Spreading Grounds
- From PS-3/Rio Hondo Spreading Grounds to the Santa Fe Spreading Grounds

Secondary screening resulted in longer alignments that were pieced together to build the "Ultimate Routes" evaluated in the fine screening.

See Appendix F for detailed discussion on the secondary screening process and key maps with paths identified.

4.3.3 Fine Screening

The three basic conveyance alignments evaluated in the fine screening are described in this section. These three "Routes" were assessed to determine the Initial Preferred Alignment for the conveyance system. Additional details on the fine screening process, including decision model results and schematics to help illustrate how the paths from the coarse and secondary screening combine to form longer alignments, is provided in Appendix F.

4.3.3.1 Route A – San Gabriel River

Route A would travel from the AWT plant to the San Gabriel River by following Sepulveda Boulevard and Willow Street to the Los Angeles River. From the Los Angeles River, the alignment would travel north and tunnel to Carson Street. The alignment would then head east on Carson Street to the Los Coyotes Diagonal before traveling along the San Gabriel River in easements to PS-2.

Continuing from PS-2, Route A would break into two branches: one branch would continue out to the OC Spreading Grounds and the other would travel north to the Santa Fe Spreading Grounds. The latter would generally follow the San Gabriel River. Also, from PS-2 Route A would head east in the SCE easement until jogging north to Orangethorpe Avenue. This would be the shortest route. Route A can be seen on Figure 4-4 in the bolder black linework.

4.3.3.2 Route B – Street Alternative

In the event that easements from SCE and/or LACFCD prove to be unavailable, Route B represents a system that would be located entirely within existing public rights-of-way to provide an optional corridor.

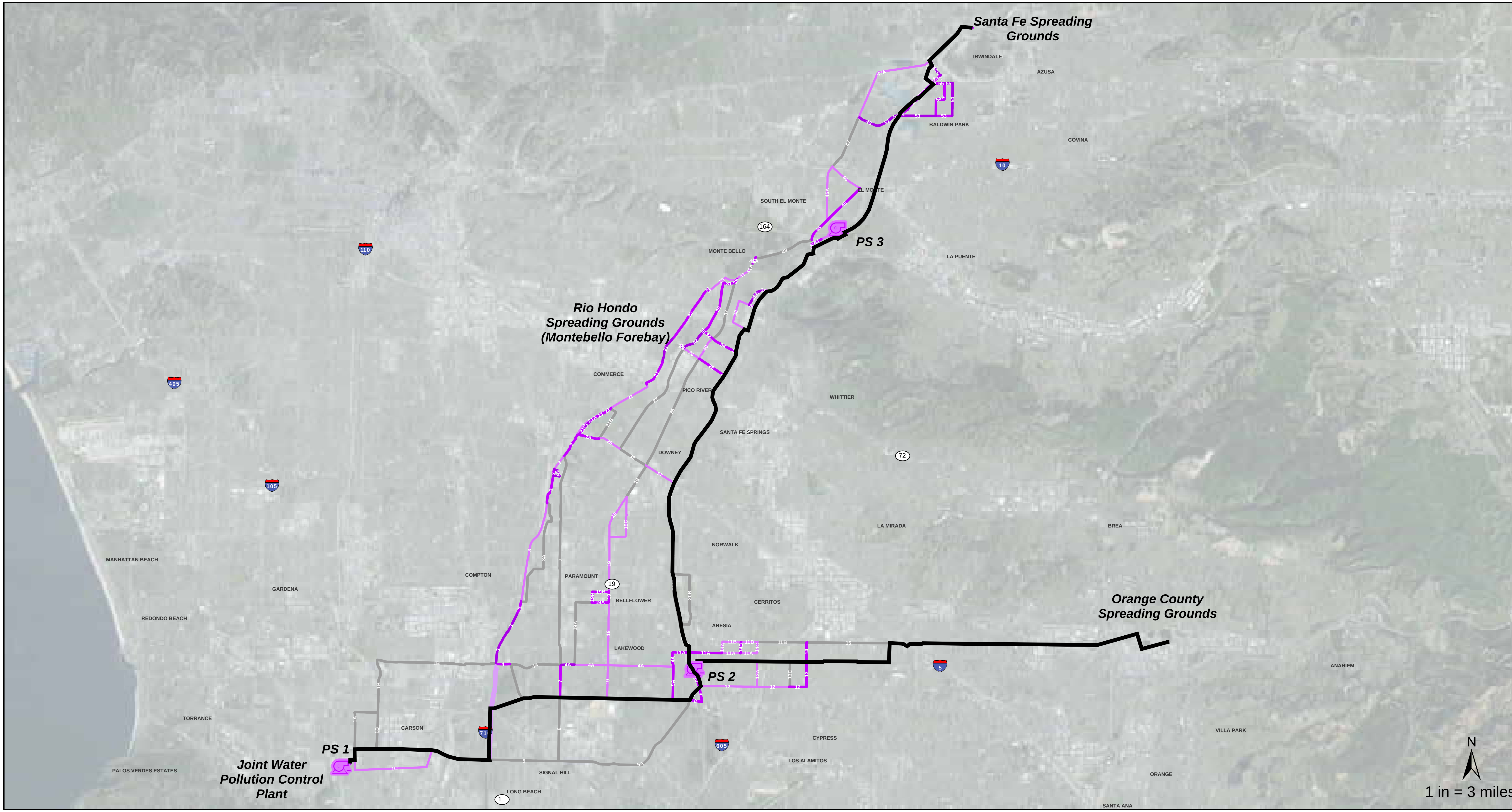
Route B would exit the AWT plant and travel north to Del Amo, then east to Paramount Boulevard before traveling north using a combination of Paramount and Lakewood Boulevards. This alignment would continue following streets from there to the Santa Fe Spreading Grounds.

To reach the OC Spreading Grounds, the alignment would travel east on Del Amo Boulevard until the San Gabriel River and would then turn south to Centralia Street and Crescent Avenue, then east before jogging north to Orangethorpe Avenue. The circuitous routing would avoid creating an expensive additional freeway crossing, would avoid Knotts Berry Farm area, and scores well in other aspects. Route B can be seen on Figure 4-5 in the bolder black linework.

4.3.3.3 Route C – Los Angeles River

Route C would require traveling from the AWT plant to the east side of the Los Angeles River and then traverse north using the best combination of streets and/or Los Angeles River easements. Similar to Route A, the alignment would follow Sepulveda/Willow Street east to the Los Angeles River, then turn north along the Los Angeles River easements. At the intersection of Durfee Avenue and Peck Avenue, the alignment would switch to follow the San Gabriel River in easements.

Again, similar to Route A, Route C would tunnel to Carson Street from the Los Angeles River, then head east to the Los Coyotes Diagonal and along the San Gabriel River in easements to PS-2, then easterly in the SCE easement until jogging north to Orangethorpe Avenue. Route C can be seen on Figure 4-6 in the bolder black linework.



Pump Stations

Figure 4-4: Route A - San Gabriel River Weighting A

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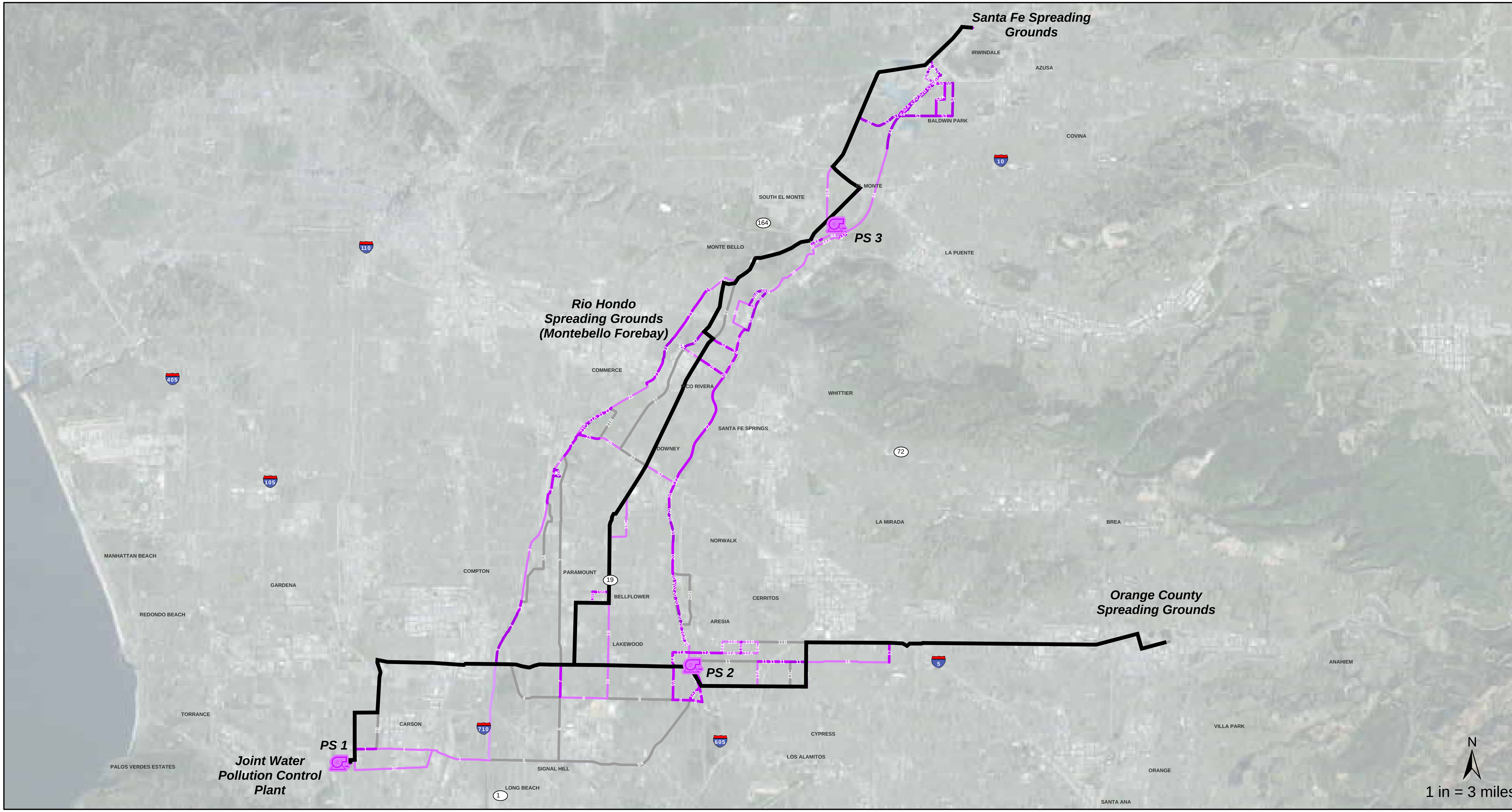

Pump Stations

Figure 4-5: Route B - Street Alternative Weighting A

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Building a world of difference.

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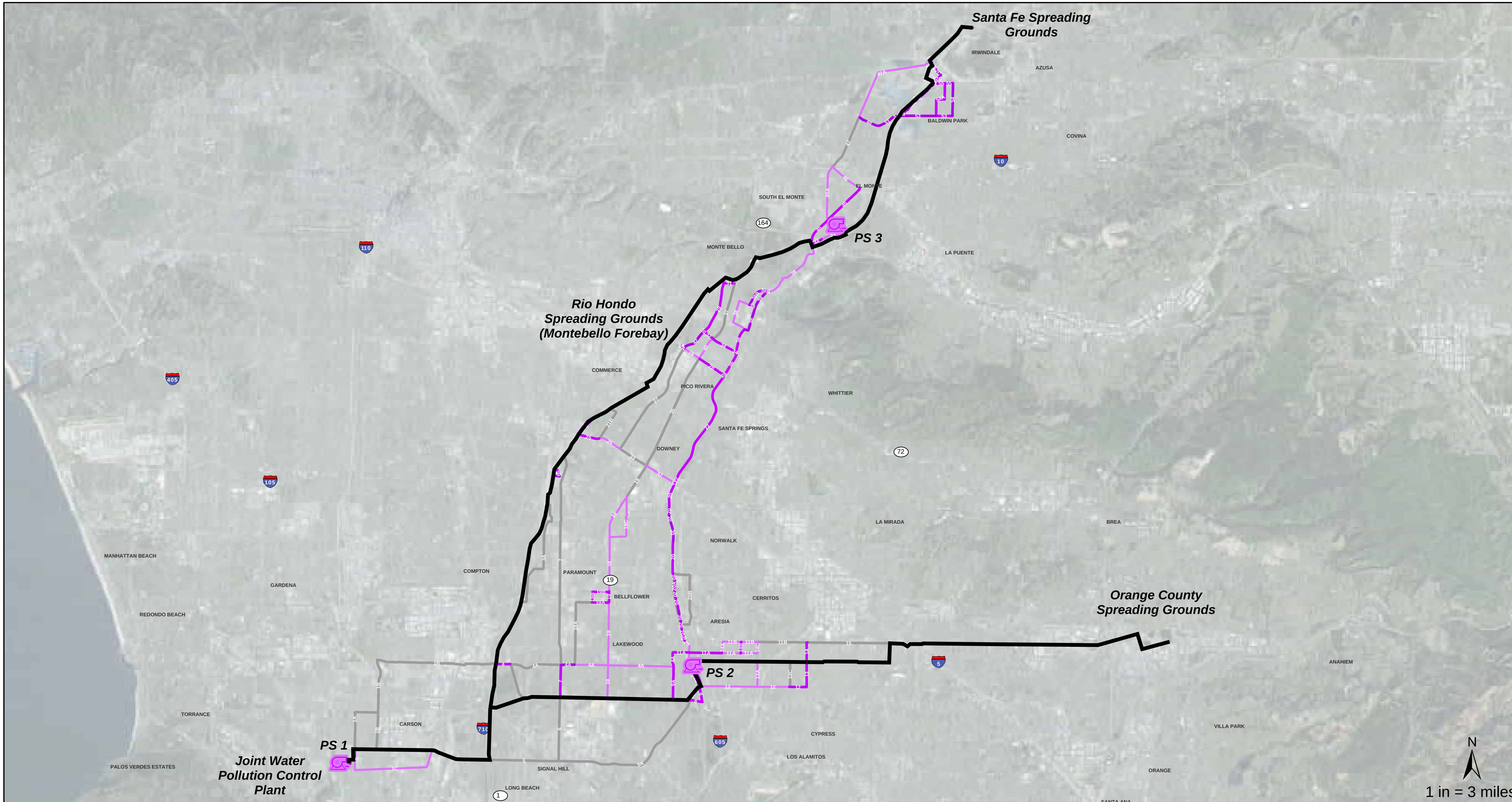

Pump Stations

Figure 4-6: Route C - LA River Weighting A

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4.4 RESULTS AND CONCLUSIONS

4.4.1 Results

The overall results of the detailed evaluation are summarized as follows:

- **Route A** was considered the most favorable alignment because it would have:
  - The fewest major utility crossings
  - The lowest contaminated soils risk
  - The fewest public facility crossings
  - The fewest major intersection crossings
  - The shortest total alignment length
  - The fewest residential and minor commercial impacts
  - High risk of groundwater impacts
  - Most impact on waters of the US and state
- **Route C** was rated as the second most favorable alignment because it would have:
  - The most favorable ease of operations and accessibility
  - The fewest traffic impacts
  - The fewest center median impacts
  - The highest risk of groundwater impacts
  - The longest total alignment length
- **Route B** was rated as the third most favorable alignment because it would have:
  - The shortest trenchless construction length and the least impacts to parks
  - The most public facility crossings
  - The most length in streets and traffic impacts
  - The most impact to center medians
  - The most major intersection crossings
  - The most contaminated soils risk

A detailed summary of the fine screening criteria and results is presented in Table 4-7.

4.4.2 Initial Preferred Alignment

Route A scored most favorably in the initial alignment evaluation, which included the reach to the OC Spreading Grounds, and is hereafter known as the “Initial Preferred Alignment”. Table 4-6 lists the segments comprising the Initial Preferred Alignment, organized based on the four reaches described in Chapter 1.0.

Table 4-6 Initial Preferred Alignment Segments by Reach

REACH	SEGMENTS
1	1, 2, 2A, 4, 8, 10A
2	11, 16, 17, 18
3	20, 22, 36, 38, 38A
4	44, 44A, 52A, 52, 56, 58, 59

Figure 4-7 presents the Initial Preferred Alignment.

As noted previously, the revised weighting factors provided by Metropolitan's internal stakeholder described in Chapter 5 were applied to the analysis described in this chapter. It was found that the new weighting factors did not affect the conclusion of the analysis.

It should be noted that some of the screening criteria were compared utilizing percentages. For example, trenchless construction was compared based upon a percentage of the alignment that was anticipated to require trenchless construction. Detailed descriptions of each screening criteria, including scoring methods, are provided in Appendix F.

Table 4-7 Summary of Overall Route Results

	MAJOR UTILITIES (EA)	TRENCHLESS CONSTRUCTION (FT)	DEPTH TO WATER (FT)	SEISMIC HAZARD (Y/N)	CONTAMINATED SOILS RISK (# HITS)	EASE OF OPERATION SUB-SCORE (WEIGHTED)	PARKS (WEIGHTED)	NON- SCE PARKS & REC AREAS (FT)	SCE PARKS & REC AREAS (FT)	PUBLIC FACILITIES (EA)	LENGTH IN STREETS (FT)	ROAD CATEGORY & TRAFFIC IMPACT (WEIGHTED)	CENTER MEDIANS (FT)	MAJOR INTERSECTIONS (EA)	RESIDENTIAL/ MINOR COMMERCIAL (FT)	TOTAL ALIGNMENT LENGTH (FT)	WATERS OF THE US AND STATE (FT)	PIPE LENGTH (FT)	TOTALS
Route A																			
Raw Count	258	29,879	102,238	Y	34.00	2.56		395	18,921	17	124,384	2.09	42,080	22	57,174	283,929	39,083	283,929	
Evaluation Criteria	0.91	10.5%	36%	Y	0.12	2.56	1.14			0.32		2.09	14.8%	0.41	20%	0%	14%		
Rating Factor	1	3	5	5	1	2.56	1.14			1		2.09	1	1	3	1	5		35
Weighted Score	12.00	36.00	15.00	15.00	3.00	30.71	1.71			6.00		12.56	6.00	4.50	18.00	15.00	10.00		193.47
																		Route A - Total “Comparable” Score	**61.31%**
Route B (Road Route)																			
Raw Count	260	23,743	72,059	N	82.00	3.01		-	-	33	262,433	3.60	127,357	74.5	113,489	296,695	6,192	296,695	
Evaluation Criteria	0.88	8.0%	24%	N	0.28	3.01	1.00			0.59		3.60	42.9%	1.33	38%	4%	2%		
Rating Factor	1	3	3	1	3	3.01	1.00			5		3.60	3	3	3	1	1		39
Weighted Score	12.00	36.00	9.00	3.00	9.00	36.11	1.50			30.00		21.60	18.00	13.50	18.00	15.00	2.00		232.71
																		Route B - Total “Comparable” Score	**53.46%**
Route C																			
Raw Count	313	40,711	111,195	Y	42.00	2.26		4,130	19,377	18	122,255	1.97	41,894	29	57,750	300,878	25,648	300,878	
Evaluation Criteria	1.04	13.5%	37%	Y	0.14	2.26	1.18			0.32		1.97	13.9%	0.51	19%	6%	9%		
Rating Factor	3	3	5	5	1	2.26	1.18			1		1.97	1	1	3	1	5		37
Weighted Score	36.00	36.00	15.00	15.00	3.00	27.11	1.78			6.00		11.81	6.00	4.50	18.00	15.00	10.00		213.19
																		Route C - Total “Comparable” Score	**57.36%**

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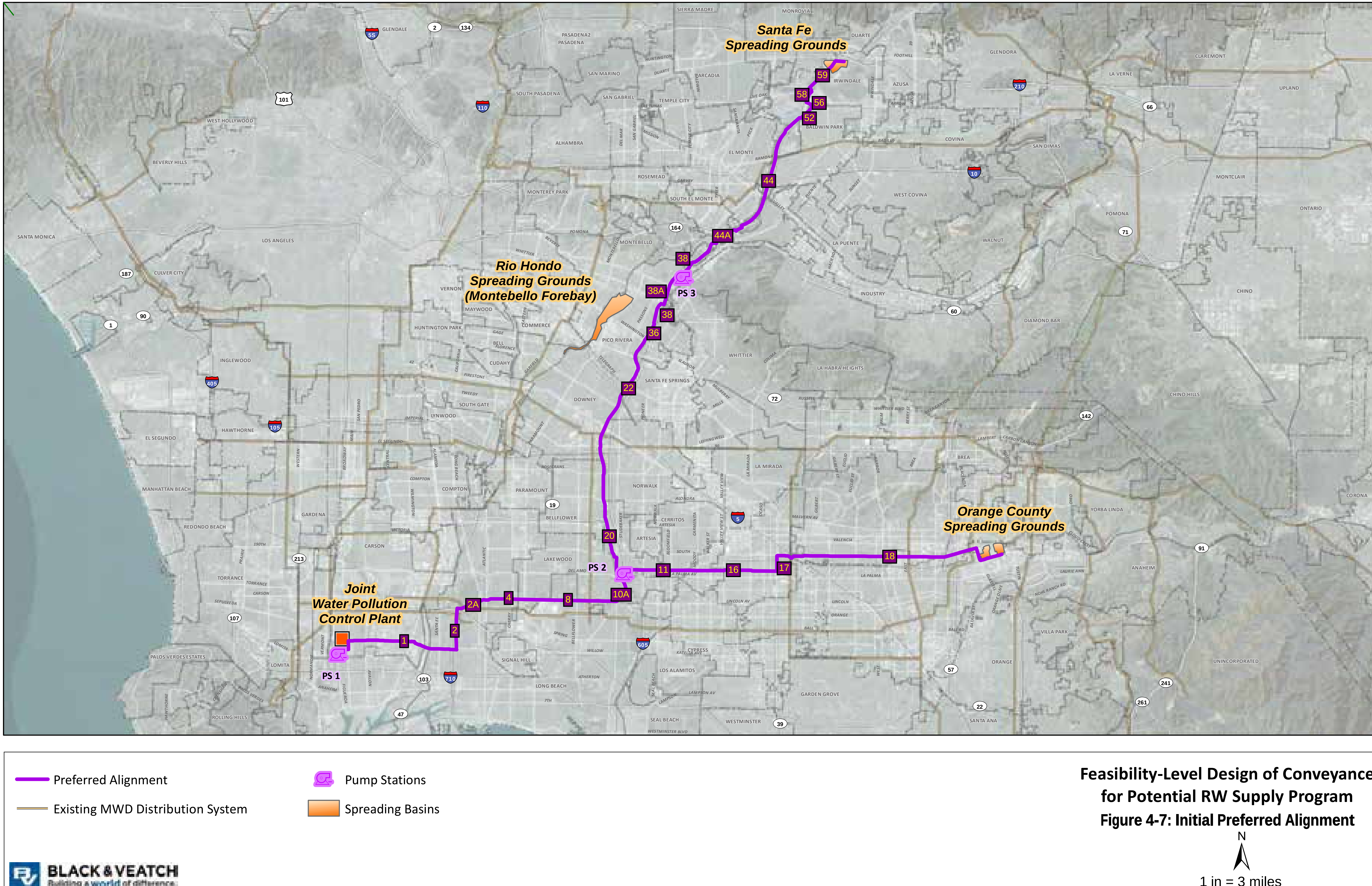

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 4-7: Initial Preferred Alignment

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5.0 Final Refinements

This chapter describes the additional technical studies that were completed after the identification of an Initial Preferred Alignment, as documented in Chapter 4.0. These subsequent technical studies were completed to ensure that the alignment would be constructible, financially feasible, and socially and environmentally acceptable. A brief overview of the analysis documented in this chapter is as follows:

- **Refinements Prior to the 2018 Draft Report.** The first part of this chapter describes the refinements occurring prior to the 2018 Draft Report and any refinements to the Initial Preferred Alignment that resulted from those evaluations. Additionally, it documents the analysis of the Signal Hill high point for the SG River Alignment.
- **Refinements Occurring after the 2018 Draft Report.** The second part of this chapter describes the evolution of the Project, and its goals, that occurred after the evaluations that comprised the 2018 Draft Report. Three topics were evaluated:
    - <u>Backbone System Alignment Evaluation.</u> As a result of the Conceptual Planning Studies Report completed by Metropolitan in February 2019 and the RRWP White Paper No. 1 completed by Metropolitan in July 2019, Metropolitan recommended the Backbone System as an implementation strategy that would provide the flexibility to adapt the initial RRWP system for DPR and allow phasing opportunities to accelerate the program. Since the Backbone System forgoes the OC Reach, Metropolitan asked Black & Veatch to re-visit the alignment evaluation to see how removing the OC reach impacts the selection of a preferred alignment for the Backbone System.
    - <u>DPR System Alignment Evaluation.</u> To incorporate raw water augmentation into the RRWP, a new pipeline and at least one pump station, but likely multiple, would be required to connect the Backbone System to the FEWWTP. This section documents the high-level evaluation of alignments for this connection.
    - <u>Evaluation of Long Tunnels to Avoid Areas of Concern.</u> McMillan Jacobs Associates (MJA) reviewed available information to determine the feasibility of tunneling select areas of concern and developed an opinion of probable construction cost for those tunnels. This was documented in a report which has been included in its entirety as Appendix W. These areas were compared to the current cut-and-cover methods to determine the preferred construction method. Further evaluations, including a subsurface geotechnical investigation, are ultimately required during the next phase of work to determine the preferred construction method for these sections. For the purposes of this FLDR, it is assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed is developed using the costs prepared by MJA, such that a conservative budget is established for this section.

The additional studies and evolution of the Project implementation strategy resulted in both the LA River and SG River Alignments being recommended for more detailed environmental studies and technical analysis in the next phases of the Project.

Figure 5-1 summarizes the Project methodology as it applies to this chapter.

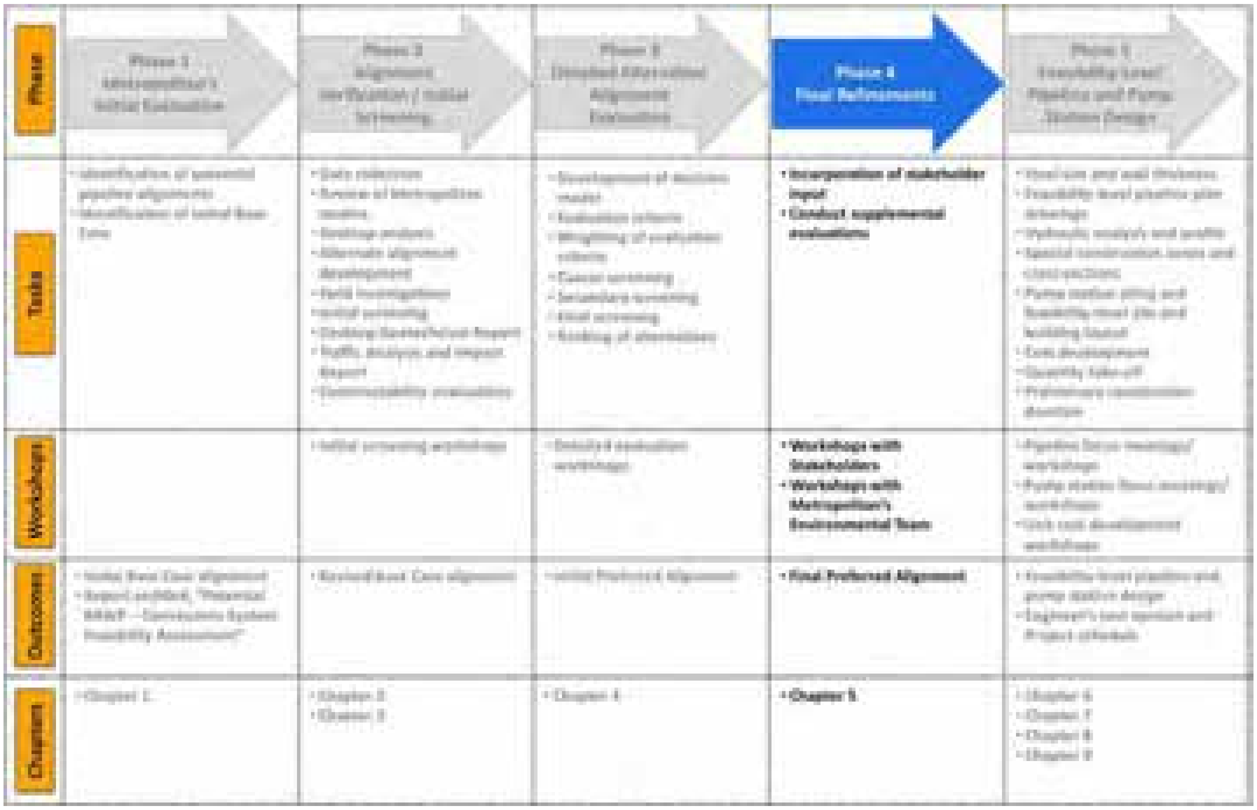


Figure 5-1 Chapter 5 Methodology

5.1 REFINEMENTS PRIOR TO THE 2018 DRAFT REPORT

This section presents the refinements that occurred to the Initial Preferred Alignment prior to the completion of the 2018 Draft Report. These refinements include a more detailed evaluation of specific areas along the Initial Preferred Alignment as well as an evaluation of the system hydraulics to account for the high point in the alignment located at Signal Hill.

5.1.1 Detailed Evaluation of the Initial Preferred Alignment

This section discusses the areas of concern identified during workshops with Metropolitan staff and summarizes the response to each concern.

5.1.1.1 Alignment Verification Workshops

A series of workshops were held with Metropolitan staff to review the Initial Preferred Alignment and gather input from the Project team, which included the Real Property Group, External Affairs Group, Environmental Planning Section, Engineering Services Group (specifically the Design Section and Infrastructure Reliability Section), and Water System Operations. The goal of the workshops was to receive feedback from the Project team, to confirm that the rights-of-way for the alignment could be obtained and that the costs would be financially feasible, and to identify areas requiring further investigation to alleviate concerns from the initial investigation. As shown in Table 5-1, four areas of concern were identified during the workshops. The table also summarizes the responses, which are more fully described in the following subsections.

Table 5-1 Summary of Internal Stakeholder Input

CONCERN	DESCRIPTION
Whittier Narrows Revision	Metropolitan's staff had concerns with the Initial Preferred Alignment alongside the San Gabriel River from LACSD's San Jose Creek Water Reclamation Plant north due to the increased risk of environmental hazards and the proximity to the Upper San Gabriel Valley Municipal Water District's future Indirect Reuse Replenishment Project (IRRP) pipeline. Additional alignments were identified as alternatives for this section. After further evaluation, it was agreed that the preferred route was still adjacent to the San Gabriel River.
Alternative Alignments to San Gabriel River Bed	Additional alignments were identified as an alternative to constructing pipe in the San Gabriel River bed and were evaluated against the Initial Preferred Alignment. No revision to the Initial Preferred Alignment was recommended.
Santa Fe Dam Alternatives	Alternatives were identified and evaluated to avoid crossing the Santa Fe Dam. No revision to the Initial Preferred Alignment was recommended.
Alameda Corridor/Dominguez Channel Crossing	Three methods of crossing the Alameda Corridor and Dominguez Channel were identified and presented to Metropolitan. One alternative was selected as the basis of the FLDR.

Whittier Narrows Revision. After the selection of the Initial Preferred Alignment, Metropolitan's staff became aware of the Upper San Gabriel Valley Municipal Water District's plans to construct their IRRP pipeline through the same corridor as the RRWP pipeline northward from LACSD's San Jose Creek Water Reclamation Plant. Metropolitan's staff identified an alternative route using public rights-of-way in city streets to avoid the area of concern. The revised route would be in wide streets and scored highly in many of the evaluation criteria from the detailed alignment evaluation. Black & Veatch further investigated the revised route and prepared detailed maps in GIS to document its feasibility.

Black & Veatch reviewed the revised route with Metropolitan in a series of workshops. Black & Veatch and Metropolitan agreed to leave the alignment adjacent to the San Gabriel River in a similar corridor as the IRRP pipeline. The alternative alignment using city streets would be a viable alternative to this stretch of the Revised Preferred Alignment should it become infeasible during subsequent design phases due to the construction of the IRRP pipeline or other factors.

Alternative Alignments to San Gabriel River Bed. The Initial Preferred Alignment proposed constructing pipe in the San Gabriel River bed from approximately Imperial Highway to Whittier Boulevard. Since constructing pipe in the San Gabriel River bed would introduce risk to the Project schedule and budget due to potential permitting issues and the additional interagency coordination required, Metropolitan's staff asked Black & Veatch to identify alternatives to constructing in the San Gabriel River bed as a backup plan should this concept prove to be unfeasible.

Working together, Black & Veatch and Metropolitan staff identified multiple routes that utilize public rights-of-way in city streets to avoid the San Gabriel River bed. The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the different alternatives to the Initial Preferred Alignment. The Initial Preferred Alignment, utilizing the San Gabriel River bed, remained the favored alternative through the additional analysis. However, should an alternative route be needed, the other routes identified would be viable. The results of the analysis were presented to Metropolitan staff at a workshop on August 31, 2017, and it was agreed that no changes to the Initial Preferred Alignment should be made.

Details of the analysis, including the results of the spreadsheet-based decision model and figures, are provided in Appendix R.

Santa Fe Dam Alternatives. The Initial Preferred Alignment proposed a route on the west side of Interstate 605 to reach the Santa Fe Spreading Grounds that would require crossing a dam. Although feasible, dam crossings require additional, potentially onerous permits and engineering work, in addition to coordination with various jurisdictions. Metropolitan asked Black & Veatch to investigate alternatives that would eliminate the dam crossing.

Black & Veatch identified a route on the east side of the Santa Fe Dam to reach the Santa Fe Spreading Grounds. However, the route would be significantly longer, require difficult freeway, river, and/or dam crossings, and have greater social and community impacts. Black & Veatch presented the results of the analysis, to Metropolitan staff at the August 31 workshop. It was agreed with Metropolitan's staff to leave the Initial Preferred Alignment unaltered in this area. Details of the analysis, including figures, are provided in Appendix R.

Alameda Corridor/Dominguez Channel Crossing. The Initial Preferred Alignment would require crossing the Alameda Corridor at Sepulveda Boulevard and then, approximately 1,700 ft later, crossing the Dominguez Channel. The Alameda Corridor includes multiple railroad tracks and a state highway (Alameda Street), and trenchless construction methods would be required to cross. Crossing the Dominguez Channel also would require trenchless construction methods. However, the land adjacent to Sepulveda Boulevard at these crossings is used by oil and gas refineries and is congested with tanks, below and above grade utilities, and other manufacturing facilities. Therefore, very limited space would be available for the launching and receiving portals required for any trenchless construction method and no clear-cut route between the two crossings exists.

After discussions with Metropolitan staff, Black & Veatch developed three alternatives to construct these crossings and presented them during the August 31 workshop. All three alternatives were viable ways to construct the crossings. However, Metropolitan directed Black & Veatch to use the crossing displayed on Figure 5-2 as the basis of this FLDR as it was the most conservative alternative from a planning perspective. Further evaluation should be completed during the preliminary design phase of the Project to verify this crossing is preferred. Additional details of this crossing are discussed in Chapter 6.

Details of the analysis, including figures, are provided in Appendix R.

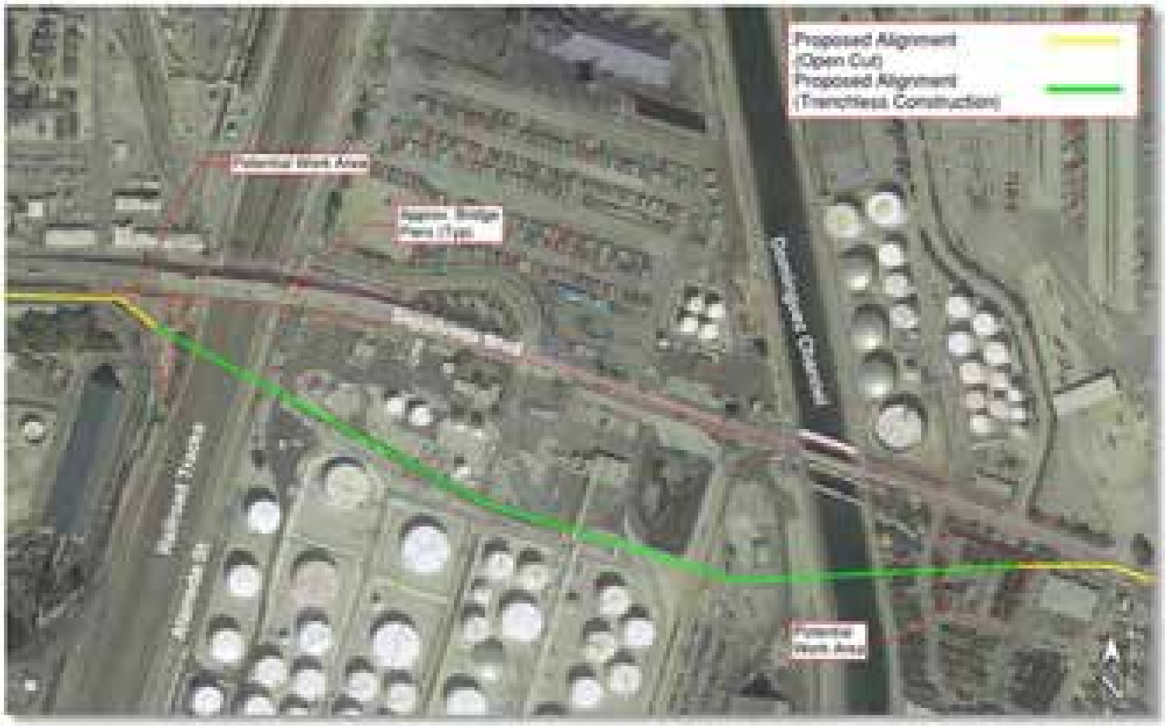


Figure 5-2 Alameda Corridor and Dominguez Channel Crossing

5.1.2 Evaluation of System Hydraulics Due to Signal Hill

This section describes the supplemental evaluations completed after the selection of the Initial Preferred Alignment to address any operational concerns with the selected alignment.

The Initial Preferred Alignment was selected based on minimizing construction risk, social and community impacts, and biological impacts during the detailed alignment evaluation completed in Chapter 4. A quick comparison of the elevation profile of the Initial Preferred Alignment's Reach 1 with the hydraulic grade line (HGL) reveals that a high point would be between PS-1 and PS-2. When the system is operated at its full 150 mgd capacity, the HGL would be above the top of the pipeline. However, the HGL would fall below the top of pipe elevation for flowrates less than approximately 140 mgd, resulting in a partially filled pipe. Since the Project could be phased in its implementation, additional analysis was conducted.

Supplemental evaluations were conducted to address the high point issue and were documented in a memorandum, entitled "Hydraulic High Point Memo", provided in its entirety in Appendix Q. The purpose of the Hydraulic High Point Memo was to provide Metropolitan with sufficient information to select a preferred method of conveying water through Reach 1.

Six concept-level alternatives were identified and evaluated by Black & Veatch and CDM Smith for conveying flows over (or around) the high point and were presented to Metropolitan staff at a coarse screening workshop on June 14th, 2017.

- Concept 1 – Initial Preferred Alignment: Pressurized and Gravity Flow
- Concept 2 – Initial Preferred Alignment: Pressurized Flow

- Concept 3 – Reroute the Preferred Alignment to Del Amo Boulevard
- Concept 4 – Relocate PS-2's Wet Well and Use Can Pumps at PS-2
- Concept 5 – Tunnel Below HGL
- Concept 6 – Eliminate PS-2

At the workshop, Metropolitan eliminated Concepts 2, 3, and 4 and requested additional analysis on the remaining three concepts. The additional analysis compared the benefits of each concept, including a feasibility-level cost estimate, and Concept 6 emerged as the preferred concept from Metropolitan's engineering perspective. Subsequently, one of the concepts originally eliminated, Concept 4, was reconsidered due to increased interest from potential Project customers located near the Carson Plant and proposed AWT plant (i.e., Los Angeles Department of Water and Power [LADWP], West Basin, and the City of Long Beach). Concept 4 adds flexibility to the Project by allowing delivery of advanced treated water to additional customers and facilitating the ability to phase the Project.

Another workshop was held with Metropolitan to present the results of the reintroduction of Concept 4. At the workshop, it was agreed that both Concept 4 and Concept 6 were viable strategies for the RRWP but that Concept 6 remained the preferred concept.

Table 5-2 summarizes the analysis of the six concept-level alternatives.

Table 5-2 Summary of Hydraulic High Point Concept-Level Alternatives

CONCEPT	PRELIMINARY REVIEW	ADDITIONAL ANALYSIS
1) Initial Preferred Alignment: Pressurized and Gravity Flow	Additional analysis requested	Eliminated
2) Initial Preferred Alignment: Pressurized Flow	Eliminated after preliminary review	N/A
3) Reroute the Initial Preferred Alignment to Del Amo Boulevard	Eliminated after preliminary review	N/A
4) Relocate PS-2's Wet Well and Use Can Pumps at PS-2	Eliminated after preliminary review	Reintroduced to analysis to provide flexibility
5) Tunnel Below HGL	Additional analysis requested	Eliminated
6) Eliminate PS-2	Additional analysis requested	Preferred concept

Concept 6 is henceforth known as Alternative A and Concept 4 is henceforth known as Alternative B. Alternatives A and B are discussed in detail below.

5.1.2.1 Alternative A - Eliminate PS-2 (Concept 6)

Under this alternative, PS-1 would be used to pump flow directly to the OC Spreading Basins and PS-3, eliminating the need for PS-2. The pumping head requirement from PS-1 would significantly increase due to the additional friction loss resulting from the longer pumping distance, and because of the higher discharge elevations of the OC Spreading Basins and PS-3. The resulting HGL of Reach 1 would be significantly over the high point.

Flow Control. To allow Metropolitan operational flexibility to adjust flow delivery to each end point, based upon the different downstream groundwater recharge needs, the Project would require one or more flow control facilities, comprising control valves and flow meters to control the splitting of flow between the two discharge locations. Flow regulation could be accomplished in one combined control facility, located at the proposed PS-2 location, or could be accomplished in a facility at any point along the alignments to at least one or both points of delivery. The flow control facilities could be located along the alignment to the points of delivery, allowing greater flexibility in site selection.

If it were certain that Metropolitan would need to deliver flows to each end user at a consistent flow rate, it would be possible to optimize such a control facility to minimize inefficiencies. However, should the flow rates vary, it would be necessary to throttle flow in one, or both, of the pipelines. For example, to reduce the water sent to OC while maintaining the amount of water to PS-3, the control facility on the OC line would need to dissipate head. This throttling operation could reduce overall system efficiency depending on the extent and duration of throttling and whether any energy recovery is included.

PS-1 Size. As mentioned earlier, eliminating PS-2 would increase the pumping head requirement at PS-1. If PS-2 were eliminated, the size of pumping equipment at PS-1 would increase significantly in order to pump to the terminal discharge points at PS-3 and OC. Essentially, the pumping power previously placed at PS-2 would be relocated and incorporated into PS-1. Although pumping head would be increased at PS-1, the overall system pumping and energy use could actually be reduced due to the associated elimination of pumping equipment at PS-2 (actual overall energy use would depend on how flow control is achieved).

Potential Reach 1 Discharge Locations. With PS-2 eliminated, the pressure in Reach 1 from PS-1 to PS-2 would increase by approximately 150 psi. If discharge locations were ultimately included in the Project along Reach 1, such as those being considered in Long Beach, this additional excess pressure would need to be dissipated, reducing the overall system efficiency.

Site Selection. If PS-2 were eliminated, it would likely be replaced with a flow control station to provide Metropolitan the ability to control the amount of flow going to both the OC Spreading Basins and PS-3. Although still of some size and complexity depending on the ultimate design criteria, it would likely have a much smaller footprint than PS-2. Additionally, and as noted above, the control facility could be located at any point along the alignments or at the points of delivery and have less stringent site criteria, allowing for greater flexibility in site selection and property acquisition. Overall, the siting challenges for a flow control station(s) are expected to be significantly reduced compared to a pump station with a large wet well or storage tank.

Additionally, with the elimination of PS-2, PS-3 would be located to minimize hydraulic inefficiencies between pumping from PS-1 to PS-3 and to the OC Spreading Grounds. Initial hydraulic calculations have been performed to optimize the location of PS-3, which is between the Whittier Narrows Dam and the San Jose Creek Water Reclamation Plant. Several potentially viable sites for PS-3 were identified in this general vicinity and are discussed in greater detail in Chapter 7. These sites are in the same general location identified as part of the Base Case system.

Alignment. The Revised Base Case alignment between PS-1 and PS-2, identified by Metropolitan and Black & Veatch as part of the development of the Business Case Report presented to Metropolitan's Board of Directors in October of 2016, was routed through Signal Hill on Willow Street (instead of Carson Street). As background, the Revised Base Case alignment was not selected as the Initial Preferred Alignment during the detailed evaluation phase of the Project in large part due to the length and depth of the tunnel required under Signal Hill to remain under the HGL. Since eliminating PS-2 would cause the pumping head requirement of PS-1 to increase so that the HGL of this reach would be significantly over the high point in Signal Hill, it was logical to consider the Revised Base Case alignment through Signal Hill. The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the Revised Base Case alignment through Signal Hill to the Initial Preferred Alignment without PS-2 in the Project.

The results of the new model run show that the Revised Base Case alignment through Signal Hill would be superior to the Initial Preferred Alignment on Carson Street without PS-2.

Figure 5-3 presents the revisions to the Initial Preferred Alignment through Signal Hill.

Figure 5-3 Signal Hill Revision without PS-2

5.1.2.2 Alternative B - Relocate PS-2 Wet Well and Use Can Pumps at PS-2 (Concept 4)

PS-2 would remain in the Project at its previously discussed location, but the wet well/storage tank would be relocated to the highest point of Reach 1 at a location near the alignment. Additionally, PS-

2 would be revised to an in-line pump station utilizing can pumps. PS-2 would then retain the pressure head resulting from passing over the high point to maximize system energy efficiency.

The tank at the high point would improve surge control and provide a hydraulic break in the system to aid in flow control and balancing, consistent with the original design concept. By pumping to a storage tank located at the high point of Reach 1, potential Project customers located near the Carson Plant (i.e. LADWP, West Basin, and City of Long Beach) could receive advanced treated water at a constant pressure head during all phases of the Project and not have to address the complications of receiving lower head water during the initial phases of the Project and higher head water at the ultimate Project build out.

By locating the storage tank at the top of Reach 1, the RRWP would be able to provide benefits to the entire region, regardless of individual agreements with LADWP, West Basin, City of Long Beach, or other discharge locations. Additionally, the relocated storage tank would provide benefits to the RRWP Project by improving overall system energy efficiency, increasing surge control by maintaining positive pressure, and providing balancing and control functions.

Alignment. Since relocating PS-2's wet well to the high point in Reach 1 and revising PS-2 to use can pumps would allow the pipeline to be installed through the high point without the use of trenchless construction methods (a tunnel), it was logical to re-introduce the Revised Base Case alignment through Signal Hill to the analysis as well.

The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the Revised Base Case alignment through Signal Hill to the Initial Preferred Alignment without tunnels required to remain under the HGL. The results of the new model run show that the Revised Base Case alignment through Signal Hill, following Willow Street and Los Coyotes Diagonal, would be superior to the Initial Preferred Alignment following the Los Angeles River easements and Carson Street.

Figure 5-4 presents the revisions to the Initial Preferred Alignment through Signal Hill.

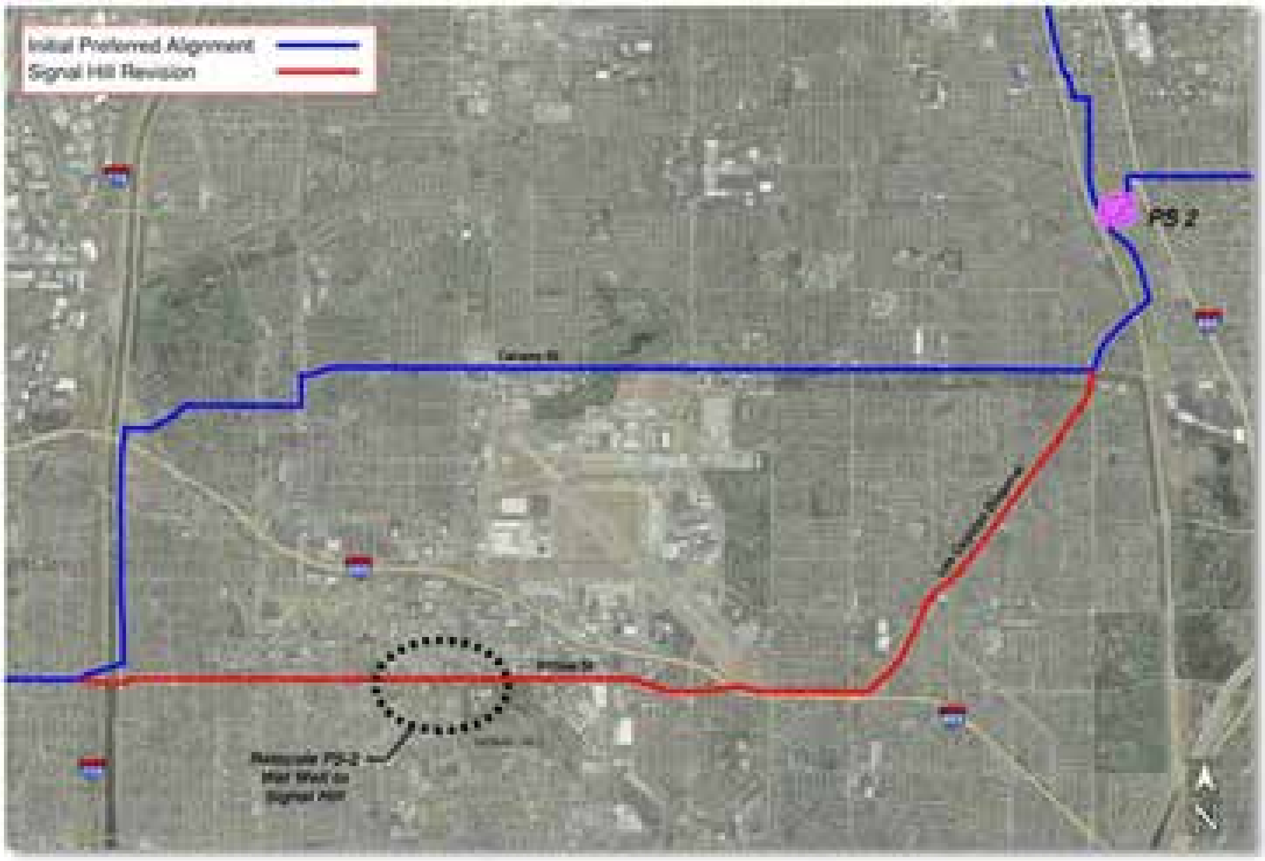


Figure 5-4 Signal Hill Revision

Storage Tank Size. The storage volume of the PS-2 wet well would be sized to improve operational control, allow coordinated and synchronized controls between stations to limit imbalances, and to minimize risk if a pump station fails to shut off. Additionally, it would be sized to provide limited surge control benefits. By moving the wet well at PS-2 to the high point of Signal Hill, the size of the storage tank could conceivably remain the same as it would have been at the same site as PS-2. However, if off-takers of the Project's advanced treated water in Reach 1, between PS-1 and PS-2, have diurnal flow demands, then the size of the storage tank would need to be revaluated and could potentially increase. Additional evaluations to determine the storage volume size should be completed once agreements with Project customers have been reached and the diurnal curves of their demands have been obtained. Details of the storage tank sizing are discussed in Chapter 7.

Storage Tank Site Identification. Several locations near the alignment at the highest point of Signal Hill were identified as potential sites for the storage tank. These sites were selected based on their proximity to the Signal Hill alignment, site access, and land use/availability. Property ownership was not evaluated during site identification. Site selection assumed 2.0 MG for the tank volume and 20 ft side water depth, resulting in a tank diameter of approximately 135 ft.

Figure 5-5 depicts potentially viable sites for the storage tank at the high point of Signal Hill. Site Nos. 2, 5, and 6, as identified on Figure 5-5, are potentially not large enough to feature a single above grade circular tank; however, other tank configurations are possible at these locations.

Figure 5-5 Signal Hill Tank Location Map

5.1.2.3 Hydraulic High Point Evaluation Results

The preferred hydraulic operating scenario selected was to eliminate PS-2 (Alternative A).

Alternative A includes the revised route through Signal Hill to match the Revised Base Case.

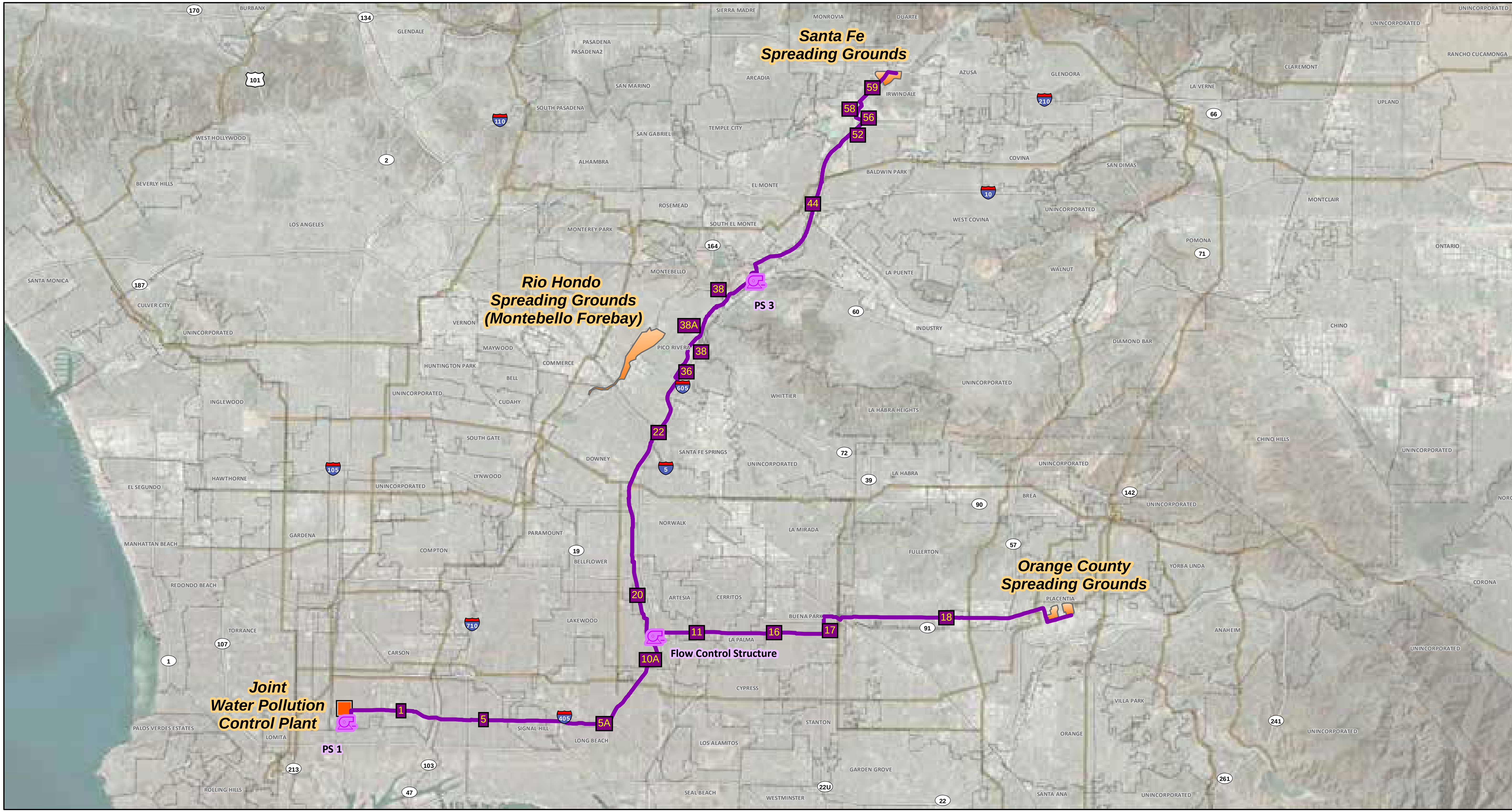
It is recognized that the Project is still at the feasibility-level planning stage. Additional planning, negotiations with potential customers, and collaboration with other Project stakeholders occurring during subsequent design phases could result in Metropolitan choosing to enact a different hydraulic operating scenario. It is recommended that the facilities required for both Alternative A and B should be included as a part of the Project for CEQA permitting purposes to provide Metropolitan flexibility to adapt the Project as it progresses.

5.1.2.4 Revised Preferred Alignment

The Revised Preferred Alignment incorporated the input received from internal and external stakeholders and was based on the information available during the preparation of the 2018 Draft Report, including:

- Input from the Metropolitan organizations for the selection and refinement of the Revised Preferred Alignment.
- Establishment, with a high degree of confidence, that the rights-of-way for the Revised Preferred Alignment can be obtained and that the costs are financially feasible.
- Results from further investigation of areas of concern from the initial investigation to determine the constructability and feasibility of the alignment.
- Additional input from municipalities and regulatory agencies.

The Revised Preferred Alignment is depicted on Figure 5-6 and is described in greater detail in Chapter 6.



Existing MWD Distribution System
Preferred Alignment
Pump Station or Flow Control Structure
Spreading Basins

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 5-6: Revised Preferred Alignment

N

1 in = 3 miles

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5.2 REFINEMENTS OCCURING AFTER THE 2018 DRAFT REPORT

In the February 2019 Conceptual Planning Studies Report and the July 2019 RRWP White Paper No. 1, Metropolitan determined that a Backbone System would be the best implementation strategy for the RRWP, as it would facilitate phasing opportunities to accelerate the program and provide the flexibility to incorporate raw water augmentation opportunities if DPR regulations get promulgated. DPR occurs when purified, recycled water is introduced directly into a potable water supply distribution system or into the raw water supply immediately upstream of a water treatment plant. At the time of this report, DPR is not permitted by the California State Water Resources Control Board's (SWRCB) regulations. Currently, the SWRCB is working to develop regulations permitting DPR. The timeline for their final approval remains uncertain but appears to be gaining traction. Two analyses were enacted specifically as a result of this latest Project concept:

- **Backbone System Alignment Evaluation**. Since the Backbone System forgoes the OC Reach, Metropolitan asked Black & Veatch to re-visit the alignment evaluation to see how removing the OC reach impacts the selection of a preferred alignment for the Backbone System.
- **DPR System Alignment Evaluation.** To incorporate raw water augmentation into the RRWP, a new pipeline and at least one pump station, but likely multiple, would be required to connect the Backbone System to the FEWWTP. Metropolitan retained Black & Veatch to complete an alignment evaluation for this proposed pipeline.

Figure 5-7 presents a schematic of the Backbone System with future options to incorporate raw water augmentation at FEWWTP. The OC Reach is shown as optional was removed from further consideration in the initial phases of the Project.

In addition to the above studies, Metropolitan also enacted a more detailed study for the potential use of long tunnels to avoid constructability risks identified for portions of the Project. The engineering evaluations that comprised these tunnels were completed by MJA.

This section documents these three evaluations: 1) the re-evaluation of the preferred alignment for the Backbone System, 2) the evaluation of alignments connecting the Backbone system to the FEWWTP, and 3) the consideration of using long tunnels to avoid areas of concern.

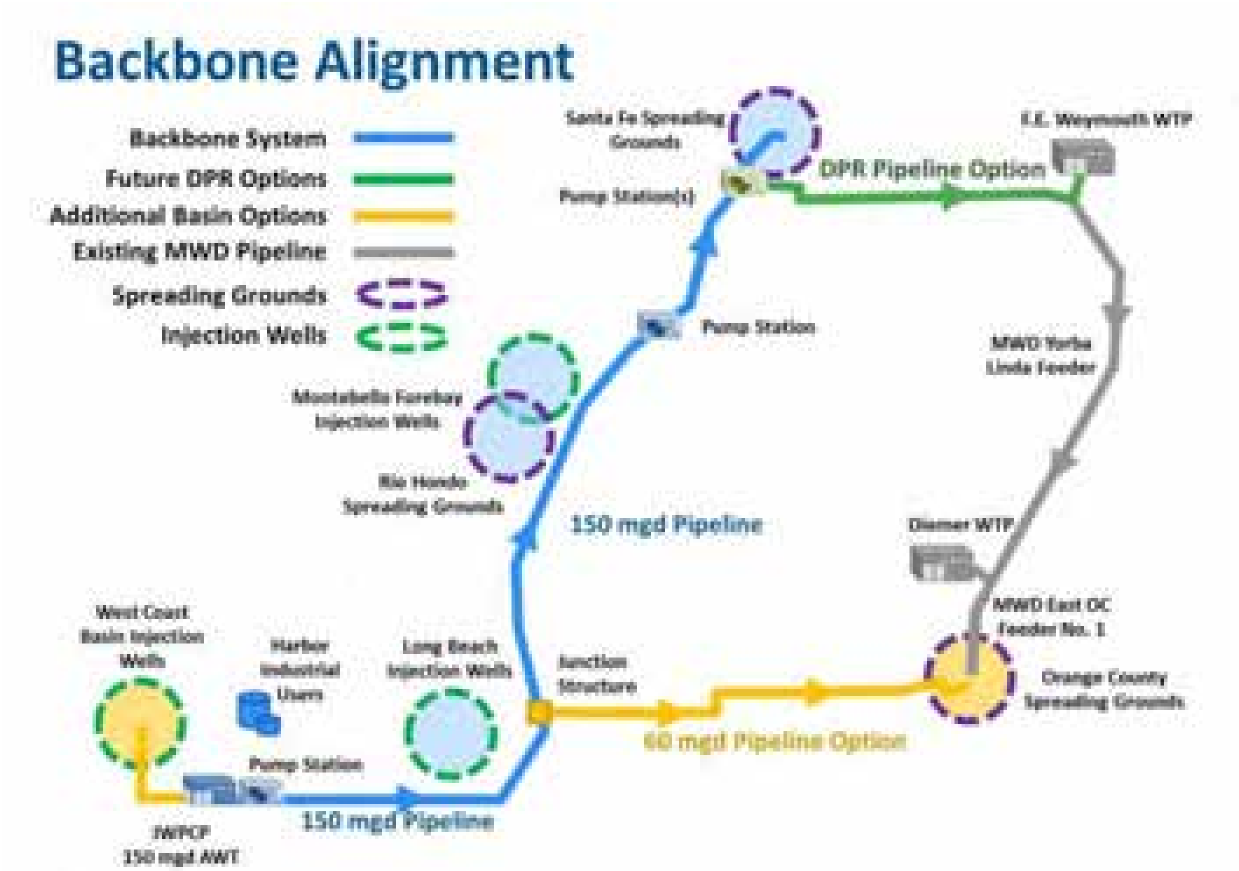


Figure 5-7 Proposed Regional Recycled Water Program Backbone System

5.2.1 Backbone System Alignment Evaluation

Through the analysis completed in Chapter 4, three full alignment alternatives were identified: the SG River Alignment, the All Street Alignment, and the LA River Alignment. Using the evaluation process established in Chapter 4, Black & Veatch was asked to rerun the analysis based on the Backbone System, with the OC Reach eliminated. As part of this effort, Black & Veatch and Metropolitan held a number of workshops with Metropolitan internal stakeholders to validate the prior evaluation process and to ensure the ongoing input from internal stakeholders was incorporated. First, the revisions to the LA River Alignment that resulted from these workshops are presented, and then following that, the evaluation itself is documented.

5.2.1.1 Revisions to the LA River Alignment

Based on the feedback from workshops with Metropolitan, the LA River Alignment was revised as follows. The alignment remains unchanged through the City of Carson and would be located within the existing public rights of way of Main Street and Sepulveda Boulevard / Willow Street. Upon crossing the LA River, the alignment would turn north and follow LACFCD's existing easement outside of the embankment adjacent to the LA River. At the 405 Freeway, the alignment would traverse to the northeast using trenchless construction methods to perpendicularly cross the Newport-Inglewood Fault Zone. The alignment would continue using trenchless methods north mostly within the existing public rights-of-way in Country Club Drive and then through the Virginia

Country Club until it is back to being adjacent to the LA River in LACFCD's existing rights-of-way / easement.

The alignment would continue parallel to the LA River until it reaches the SCE easement immediately north of the 91 Freeway where it would shift to be within the existing public rights-of-way of Atlantic Place, Hunsaker Avenue, and finally Alondra Boulevard. When Alondra Boulevard crosses the SCE easement between Garfield Avenue and Orange Avenue, the alignment would turn north again and be located within the SCE rights-of-way / easement. Initially within SCE's easement, the pipeline is envisioned to be located east of the two western transmission line towers, which is the opposite side from Metropolitan's existing Middle Feeder South. After continuing north in SCE's easement, the pipeline would shift its location as necessary to avoid obstructions.

North of Burns Avenue, the SCE easement crosses to the west side of the Rio Hondo Channel. At this point, the alignment would leave the SCE easement to continue parallel to the Rio Hondo Channel on the east side. Just south of the 5 Freeway, the alignment would cross to the north and west side of the Rio Hondo Channel and would continue adjacent to the river channel along the perimeter of the spreading basins within the LACFCD's existing rights-of-way / easements.

At Whittier Boulevard, the alignment would turn east and be located within the existing public rights-of-way. The alignment would then turn north at Paramount Boulevard and east at Beverly Boulevard until it reached the SG River. From here, the LA River Alignment would share the same route as the SG River Alignment.

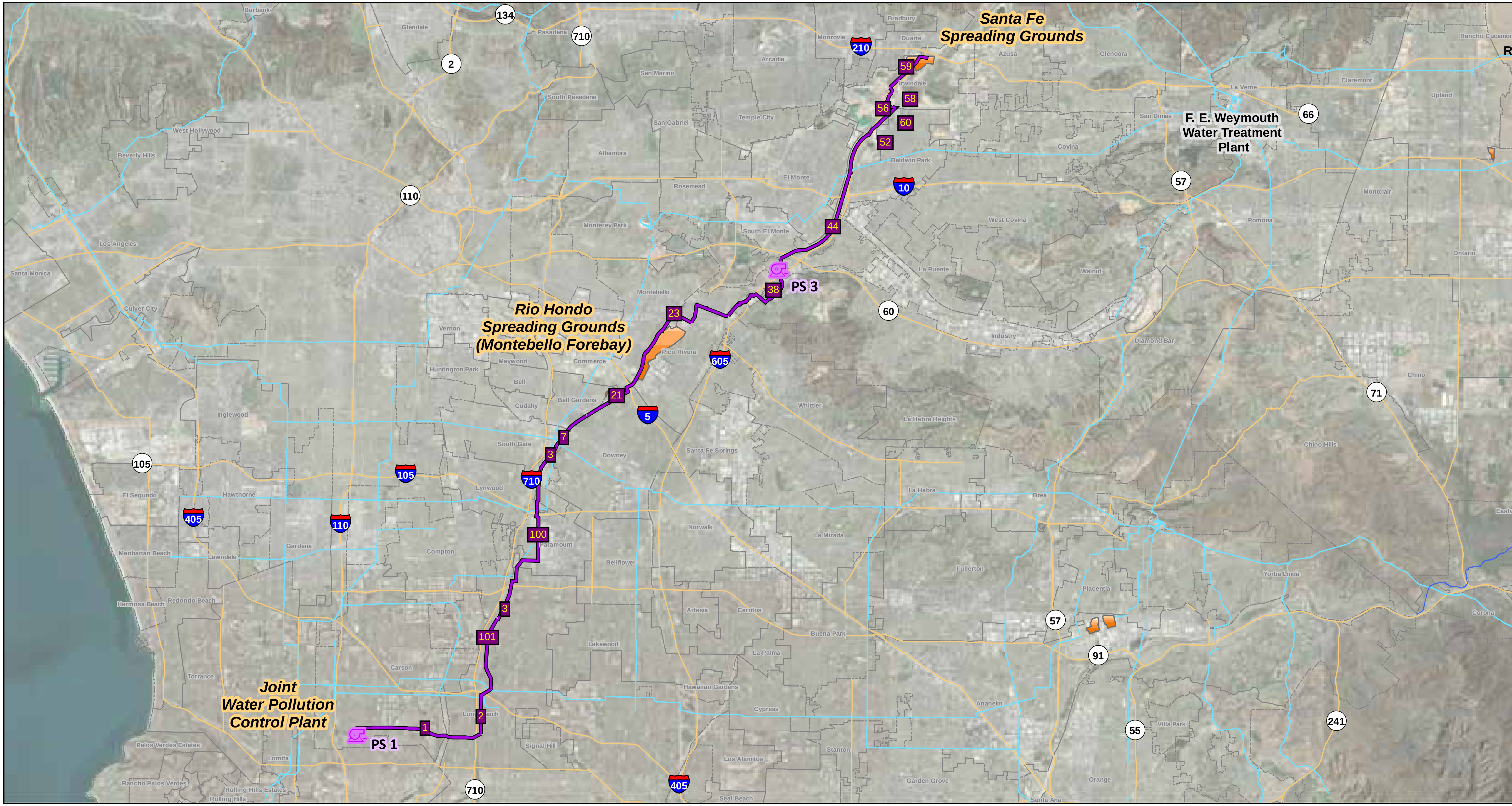
Segments 100 and 101 were added to the evaluation to document the details of the sections that were added to the evaluation per the revisions described. Details are provided in Appendix S.

Figure 5-8 presents the revised LA River Alignment.

5.2.1.2 Revisions to the Project in the Vicinity of Whittier Narrows Dam

During the workshops with Metropolitan, the crossing of the Whittier Narrows Dam, which is common to both the SG River and LA River Alignments, was evaluated further. Previously, the alignment was shown as crossing the dam itself. The United States Army Corps of Engineers (USACE) is in the planning phase for their Whittier Narrows Dam upgrade, which presents significant challenges for an alignment crossing beneath the dam. A more suitable corridor exists on the east side of the 605 Freeway that avoids crossing the dam. To some extent, the topography in this vicinity limits the availability of feasible alignments as the Puente Hills are located just to the east and the Montebello Hills and oil refineries are located to the west. Metropolitan agreed to revise the alignment as shown on Figure 5-9. Segment 60 was added to the evaluation to document the details of the new section along Workman Mill Road. Details are provided in Appendix S.

It should be noted that the revised alignment includes a high point ground elevation on Workman Mill Road of approximately 253 ft. Of the five sites identified for PS-3 during the preparation of the 2018 Draft Report, as described in Chapter 8, only Site 1 is located prior to (south of) this high point. The remaining four sites are located approximately one mile north of the high point at around elevation 230 ft. The evaluations that occurred after the preparation of the 2018 Draft Report only included scope to revise the pipeline alignments, as Metropolitan is reserving additional funding for the next phases of work which are anticipated in the near future. As such, the siting and design of PS-3 requires further evaluation during the subsequent phases of design to optimize its location and size. For planning purposes of this phase of the Project, the sites identified are sufficient for the feasibility-level Project definition and cost estimating.



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MWD Pipelines

Rialto Pipeline

Interstate / State Highway

Date: 4/27/2020

0 0.75 1.5 3 4.5 Miles

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 5-8: Revised LA River Alignment

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Figure 5-9 Revised Project in the Vicinity of Whittier Narrows Dam

Figure 5-10 presents the revised SG River Alignment.

5.2.1.3 Evaluation Process

A similar evaluation process to that documented in Chapter 4 was used to compare the Backbone System alignment alternatives, with modifications as follows:

- As one of the major unknowns regarding the SG River Alignment is the depth and design required to ensure the pipeline constructed within the earthen portion of the SG River bed remains safely buried, a new evaluation criterion was added to assess scour potential. The criterion assessed the risk associated with the design and construction of a pipeline within an earthen river bottom to protect against scour, as well as pipe flotation, and was applied for portions of the alignment within an earthen river bottom. As a new evaluation criterion was added, the weighting factors had to be adjusted to account for the new criterion. See Table 5-3 below for details on the revised weighting factors.

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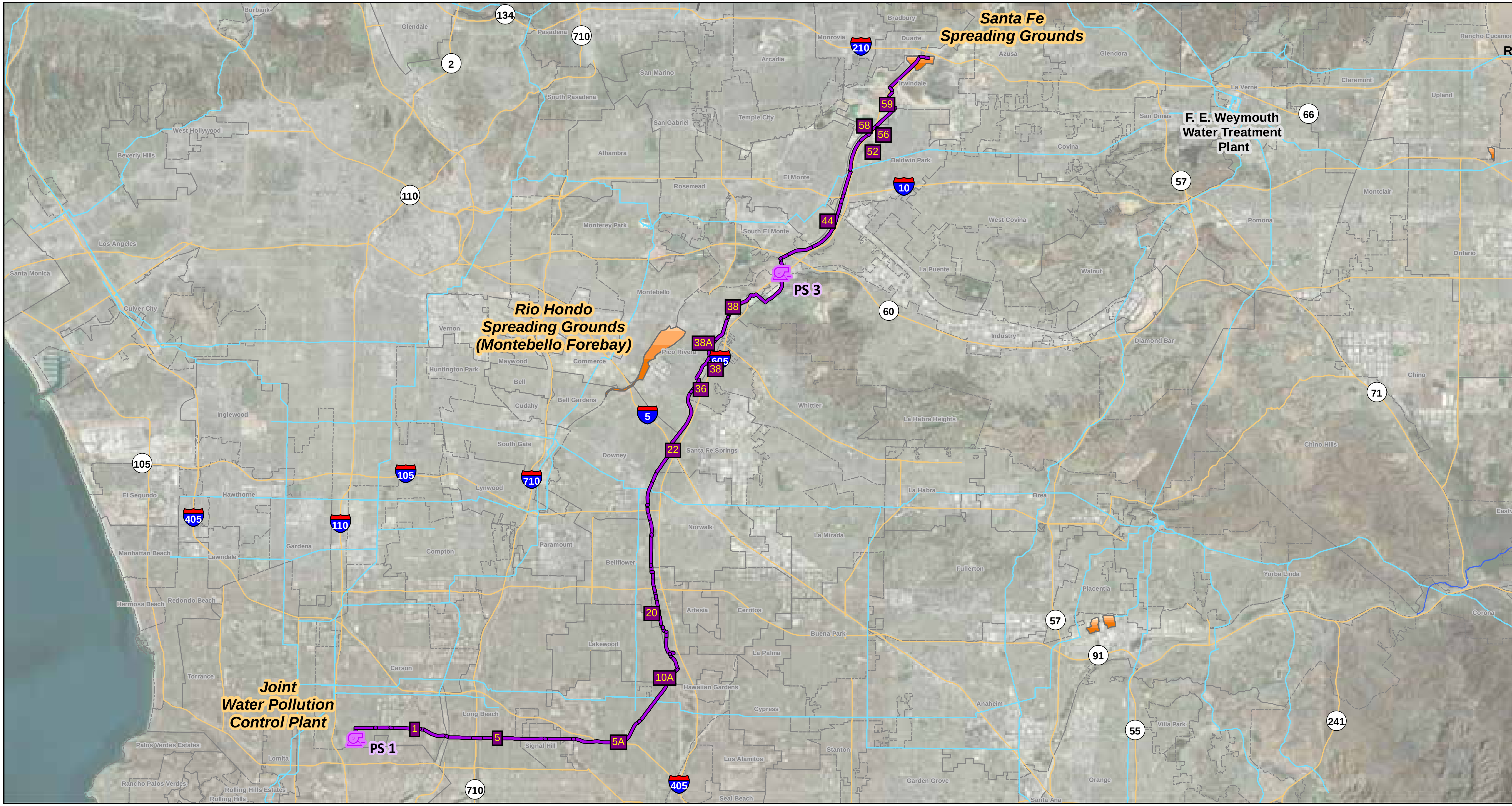

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MWD Pipelines

Rialto Pipeline

Interstate / State Highway

Date: 4/28/2020

0 0.75 1.5 3 4.5 Miles

N W E S

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 5-10: Revised SG River Alignment

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- Since the Project had been ongoing for nearly four years, it was warranted to review the scoring and weighting system for validation. The Project team (Environmental Planning Section, Real Property Group, and External Affairs Section) provided additional weighting scenarios to consider. The feedback was generally within the range of the two weighting scenarios developed in Chapter 4: Weighting A favoring construction risk criteria and Weighting B emphasizing the social, community, and biological criteria. Due to this, it was agreed that weighting scenarios provided by Metropolitan's internal stakeholders be used as a sensitivity analysis to check the impact the changes in weights would have on the result. Table 5-4 below presents the weighting scenarios provided by Metropolitan's internal stakeholders.

Table 5-3 Evaluation Criteria: Weighting Factors Matrix

Evaluation Factor	Scenario A (Emphasis on Construction Risk)		Scenario B (Emphasis on Community and Biological)	
Construction Risk	**Category Weight:**	**60%**	**Category Weight:**	**30%**
	Factor Weight	**Factor Score**	**Factor Weight**	**Factor Score**
Major Utility Crossings	20.0%	12.00	20.0%	6.00
Trenchless Construction	20.0%	12.00	20.0%	6.00
Groundwater Conditions	5.0%	3.00	5.0%	1.50
Alignment Length	25.0%	15.00	25.0%	7.50
Seismic Hazard	5.0%	3.00	5.0%	1.50
Soil Contamination Risk	5.0%	3.00	5.0%	1.50
Ease of Operations/ Accessibility	15.0%	9.00	15.0%	9.00
Scour	5.0%	3.00	5.0%	1.50
Social and Community	**Category Weight:**	**30%**	**Category Weight:**	**55%**
Parks/Recreation Areas	5.0%	1.50	5.0%	2.75
Public Facilities	20.0%	6.00	20.0%	11.00
Traffic Impacts	20.0%	6.00	20.0%	11.00
Street/Median Improvements	20.0%	6.00	20.0%	11.00
Major Intersections	15.0%	4.50	15.0%	8.25
Residential/Minor Commercial	20.0%	6.00	20.0%	11.00
Biological	**Category Weight:**	**10%**	**Category Weight:**	**15%**
Waters of the US and State	20.0%	2.00	20.0%	3.00
CNDDB Habitats	40.0%	4.00	40.0%	6.00

Table 5-4 Additional Weighting Scenarios Provided from Metropolitan's Project Team

Criteria	Internal Stakeholder Input					
	Environmental Planning		Real Property		External Affairs	
	A	B	A	B	A	B
Construction Risk		**30%**	**60%**	**30%**	**55%**	**30%**
Major Utilities	N/A	5%	25%	25%	20%	20%
Trenchless Construction	N/A	10%	20%	20%	20%	20%
Depth to Groundwater	N/A	25%	5%	5%	5%	5%
Total Alignment Length	N/A	0%	20%	20%	25%	25%
Seismic Hazard	N/A	5%	5%	5%	5%	5%
Contaminated Soils Risk	N/A	25%	5%	5%	5%	5%
Ease of O&M	N/A	15%	15%	15%	15%	15%
Scour Potential	N/A	15%	5%	5%	5%	5%
Social and Community		**20%**	**30%**	**60%**	**35%**	**55%**
Parks & Rec Areas	N/A	29%	5%	5%	5%	5%
Public Facilities	N/A	29%	20%	20%	15%	15%
Road Category & Traffic Impact	N/A	7%	20%	20%	30%	30%
Center Medians	N/A	7%	10%	10%	10%	10%
Major Intersections	N/A	6%	15%	15%	15%	15%
Residential/ Minor Commercial	N/A	22%	30%	30%	25%	25%
Biological		**50%**	**10%**	**10%**	**10%**	**15%**
Waters of the US and State	N/A	20%	20%	20%	20%	20%
CNDDB Habitats	N/A	80%	80%	80%	80%	80%

The spreadsheet-based decision model used during the detailed alternative alignment evaluation described in Chapter 4 was rerun to compare the three alignment alternatives, the SG River Alignment, the All Streets Alignment, and the LA River Alignment, without the OC Reach. Details on the decision model inputs and results for the Backbone System are provided in Appendix S.

5.2.1.4 Backbone System Evaluation Results

The result of the Backbone System alignment evaluation is that the LA River and the SG River Alignments both score very similarly, while the Streets Only Alignment scored poorly. Table 5-5 presents a summary of the scoring results for the LA River and the SG River Alignments.

Table 5-5 Summary of LA River and SG River Alignments Scoring

ROUTES	SAN GABRIEL RIVER ALIGNMENT				LA RIVER ALIGNMENT			
	SUM (#)	RAW SCORE	WEIGHT "A"	WEIGHT "B"	SUM (#)	RAW SCORE	WEIGHT "A"	WEIGHT "B"
Major Utilities	223	3	36	18	211	3	36	18
Trenchless Constr.	21K	3	36	18	36K	5	60	30
Depth to Water	78K	5	15	8	67K	5	15	8
Seismic Hazard	Y	5	15	8	Y	5	15	8
Contam. Soils Risk	24	3	9	5	22	3	9	5
Ease of Operation Sub-Score	3	3	23	11	2	2	17	8
Parks	1	1	2	3	1	1	2	3
Public Facilities	7	3	18	33	7	3	18	33
Road Category & Traffic Impact	2	2	12	22	2	2	11	20
Center Medians	36K	3	18	33	30K	3	18	33
Major Crossings	16	3	14	25	14	3	14	25
Residential/ Minor Commercial	30K	3	18	33	31K	3	18	33
Total Alignment Length	201K	1	15	8	193K	1	15	8
Waters of the US and State	36K	5	10	15	19K	3	6	9
CNDDB Habitats	N	1	8	12	N	1	8	12
Scour	Y	5	15	8	N	1	3	2
Weighted Score			**59%**	**61%**			**59%**	**62%**

Per Table 5-5, the LA River Alignment is anticipated to have more trenchless construction while being slightly shorter overall. The SG River Alignment would have a larger impact on biological resources and scour potential due to the length proposed in the SG River bed. Overall, the results of the analysis are that both alignments are feasible and have similar levels of impacts over the course of nearly 40 miles.

It should be noted that some of the screening criteria are scored using a weighted percentage. This is described in detail in Appendix F.

5.2.1.5 Backbone System Evaluation Conclusions

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of risk and impacts based on the information available for this Project. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies, technical analysis, and collaboration with Project stakeholders, such as regulatory agencies, municipalities, and right-of-way owners. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

Additional studies that should be completed in order to identify the preferred Backbone System alignment include, but are not limited to, the following:

- Right-of-way and ownership evaluations
- Additional evaluation of the permitting and jurisdictional requirements
- Evaluation of impacts to environmental resources and regulatory requirements.
- Geotechnical evaluations, including dewatering testing/studies and a scour analysis

5.2.2 DPR System Alignment Evaluation

Metropolitan retained Black & Veatch to conduct an alignment evaluation on the alternatives connecting the Backbone System to the FEWWTP. The evaluation used the same approach as described in Chapter 4 and is documented in its entirety in the technical memorandum titled "Santa Fe to Weymouth WTP Alignment Evaluation" which is included as Appendix T.

The evaluation only compared alignment alternatives for the purposes of achieving a ranking to recommend a preferred alignment. Evaluations required to describe the additional facilities that would be necessary for a functioning system – such as pump stations and/or modifications to Metropolitan's existing facilities – have not been completed and are recommended during the next phase of work.

While the flow rate for the conveyance system connection to the FEWWTP has not been determined yet, it is currently envisioned to be up to the full 150 mgd.

The results of this evaluation are summarized in the following subsections.

5.2.2.1 Pipeline Corridors

Metropolitan identified various alignment alternatives to convey water from the Backbone System near the SFSG to the FEWWTP. These alignment alternatives were provided to Black & Veatch and served as the basis of this alignment evaluation.

The alignments identified by Metropolitan generally follow four east-west corridors between the SFSG and the FEWWTP. Three of these east-west corridors are generally within existing public street rights-of-way. In addition to these roadways, a potential alignment utilizing Metropolitan's existing Glendora Tunnel was considered. This corridor allows for the construction of a new transmission pipeline north in roads to the westerly end of the Glendora Tunnel. The Glendora Tunnel would be re-purposed to convey water east to the FEWWTP.

These four main east-west corridors form the basis for the pipeline segments.

- Gladstone Street
- Arrow Highway
- Cypress Street
- Glendora Tunnel

Figure 5-11 presents the segments assessed in this evaluation. Descriptions of the four main east-west corridors are provided in the sections that follow.

Figure 5-11 DPR Pipeline Segments

After the completion of a coarse screening to reduce the number of alternatives, the remaining segments were combined to form full alignments starting at the Backbone System and ending at the FEWWTP. The alignments within the four pipeline corridors are described as follows:

Alignment 1 – Gladstone Street. Alignment 1 would generally be located within Gladstone Street and would start in Arrow Highway heading east. At Azusa Avenue / SR 39, Alignment 1 would turn north and then east at Gladstone Street. From there, Alignment 1 is within Gladstone Street for 4.5 miles before turning south in Lone Hill Avenue, west in Arrow Highway and finally north in Wheeler Avenue. Alignment 1 is comprised of the following segments: 1, 6, 10, 13, 19, 20, 21, and 22.

Gladstone Street is a mix of industrial and residential with most residential driveways located off frontage roads or side streets with only an occasional driveway directly on Gladstone Street.

Gladstone Street is considered a collector road and is one of the primary continuous east-west roadways in the area.

Alignment 2 – Arrow Highway. Alignment 2 would generally be located within Arrow Highway and would travel east all of the way to Wheeler Avenue. Alignment 2 is comprised of the following segments: 1, 7, 11, 13, 19, 20, 21, and 22.

Alignment 2 is the most direct route from the SFSG to the FEWWTP.

Arrow Highway is mostly comprised of minor commercial and industrial land uses. Residential areas off of Arrow Highway utilize frontage roads for driveway access. Arrow Highway is considered an arterial road and is one of the primary east-west roadways in the area.

Alignment 3 – Cypress Street. Alignment 3 would generally be located within Cypress Street and would begin in a parking lot/ existing utility easement traveling east to get from the Backbone System on Rivergrade Road to Olive Street. The utility easement has existing LACFCD pipes and overhead SCE transmission lines within it and would likely require tunneling to avoid impacts to existing facilities. The alignment would then follow Olive Street to Azusa Canyon Road before turning east in Cypress Street. Alignment 3 would follow Cypress Street for 6.5 miles before turning north in Lone Hill Avenue, then East in Covina Boulevard, east again in Arrow Highway and finally north in Wheeler Avenue. Alignment 3 is comprised of the following segments: 2, 3, 4, 5, 12, 17, 21, and 22.

Cypress Street is heavily residential with driveways commonly directly on the street. Due to the residential nature of the area, overhead power lines cross the street more frequently than the other alternatives considered.

Alignment 4 – Azusa Avenue / SR 39 to Glendora Tunnel. Alignment 4 would consist of a new pipeline connecting to Metropolitan's existing Glendora Tunnel to pump water east to the FEWWTP, reverse of its current operation. The Glendora Tunnel is currently used to convey raw water from the Rialto Pipeline and / or the Upper Feeder to the USG-3 service connection for discharge to the San Gabriel Canyon and ultimately to spreading basins for groundwater recharge. With the implementation of the RRWP, the Upper San Gabriel Municipal Water District (USGMWD) would receive their replenishment water via the RRWP at the SFSG, just downstream of the USG-3 service connection, in lieu of from USG-3. Therefore, the Glendora Tunnel could be available for this new use.

To reach the Glendora Tunnel, the corridor would follow Arrow Highway and then turn north at Irwindale Avenue. At Gladstone Street the alignment would turn east before turning north in Azusa Avenue / SR 39. From there, the corridor would traverse north on Azusa Avenue and then north on Ranch Road. San Gabriel Canyon Road is another potential north-south corridor available as an alternative to Azusa Avenue, should objections to the use of Azusa Avenue arise during subsequent phases of work. Metropolitan, and their consultant McMillan Jacobs and Associates, evaluated three options to construct the pipeline from Ranch Road to the terminus of the Glendora Tunnel. The first option was to use shored excavation methods to construct the pipeline within San Gabriel Canyon Road and Old San Gabriel Canyon Road and then tunnel the final 4,400-ft. The second option involved two tunnels with 2,000-ft of shored excavation on Old San Gabriel Canyon Road between them. The third option was a single tunnel for the entire stretch.

For the purposes of this analysis, the third option, a single tunnel, was assumed for this section due to its lower overall community impact as compared to the other options. San Gabriel Canyon Road is also a portion of State Route 39 and is the primary point of access for the Mountain Cover residential development located along this corridor. Further, Old San Gabriel Road serves as access to the Azusa River Wilderness Park, a popular hiking and pedestrian trail. By tunneling this section, it minimizes the impacts to the community.

The corridor then follows the Glendora Tunnel east to the La Verne Pipeline. The La Verne Pipeline connects the east portal of the Glendora Tunnel to the Upper Feeder Junction Structure, approximately 2 miles to the south. The Upper Feeder Junction Structure has the ability to blend the advanced treated water with Colorado River water and State Water Project water before discharging into the FEWWTP's inlet conduit.

Metropolitan conducted a preliminary hydraulic analysis and determined that the hydraulic grade line required to pump water east through the Glendora Tunnel is less than the design hydraulic grade for the tunnel. Therefore, this Project assumed that no structural improvements to the tunnel are required. This assumption should be confirmed during subsequent evaluations.

Alignment 4 is comprised of the following segments: 1, 6, 23, 24, 25, and the Glendora Tunnel (known as Segment 26).

South of the 210 Freeway, Azusa Avenue is considered a primary arterial road and is one of the principal north-south trafficways with large on and off ramps to the 210 Freeway in the north and the 10 Freeway to south.

North of the 210 Freeway, Azusa Avenue transitions into heavily residential areas. Between the 210 Freeway and Fifth Street, most of the driveways in the residential areas are off frontage roads and not directly on the street. However, north of Fifth Street, Azusa Avenue travels through an improved downtown district with many driveways and commercial businesses having access directly from Azusa Avenue. Significant impacts would be anticipated for shored excavation pipeline construction through this area. Therefore, it was assumed that this section would need to be tunneled for the purposes of this evaluation. Alternate routes that avoid this localized issue, such as San Gabriel Avenue may warrant consideration in subsequent design phases.

Since Metropolitan currently provides replenishment water to the USGMWD via USG-3, which is located at the westerly end of the Glendora Tunnel, approximately 14,000 ft of the Backbone Alignment associated with discharging to the SFSG could be eliminated. Instead, the advanced treated water could be discharged to the San Gabriel River at, or near, USG-3 (or at another location north of the SFSG) which the Los Angeles County Department of Public Works (LACDPW) has indicated is preferred to the discharge location shown in the FLDR.

Figure 5-12 illustrates the eliminated section of the Backbone Alignment and the connection to USG-3 for Alignment 4 schematically. The line in red represents Alignment 4, which connects the Backbone Alignment to the Glendora Tunnel and USG-3. The blue line represents the Backbone

Alignment and the dashed blue line represents the 14,000 ft of alignment that could be eliminated if a new discharge location along Alignment 4 was implemented. The Backbone Alignment currently proposes crossing the Santa Fe Dam spillway. By eliminating this section of the Backbone Alignment, it would also eliminate the difficulty relating to the design, construction, and permitting associated with going through the spillway.

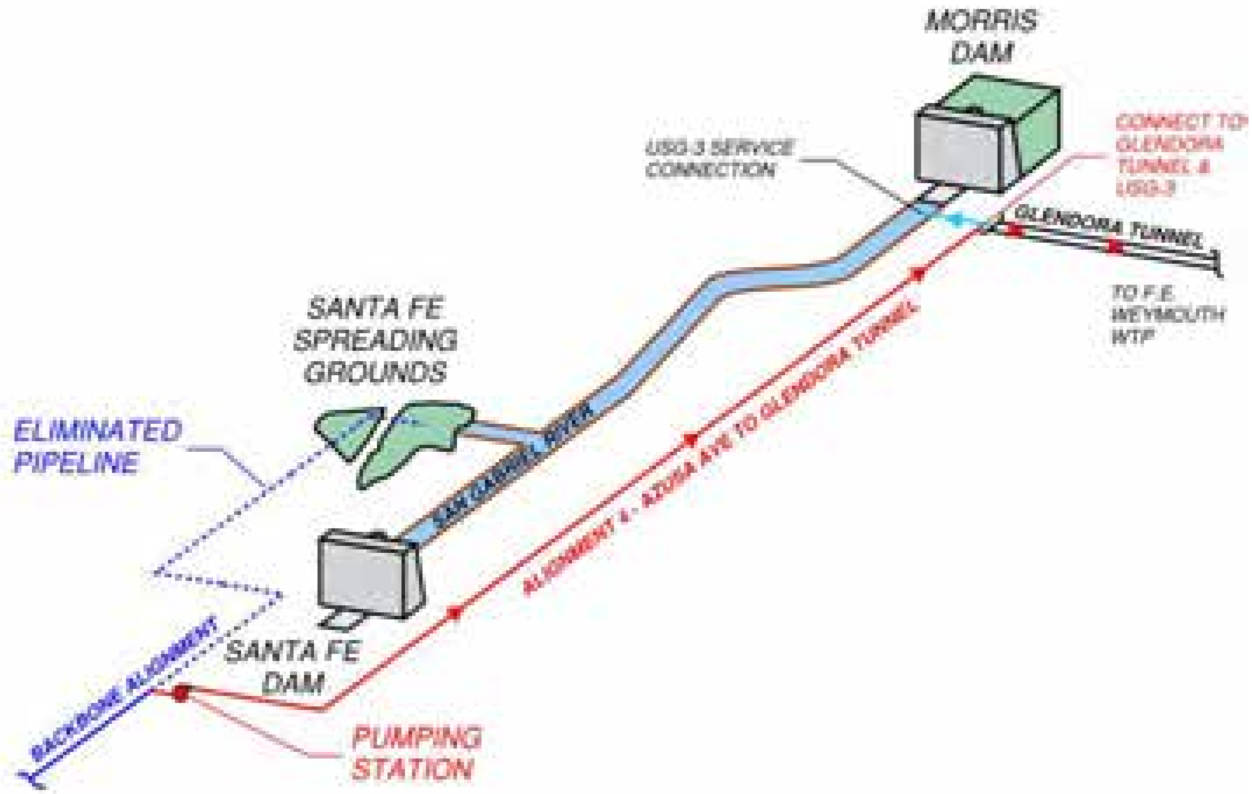

Figure 5-12 Alternative Discharge Location for Alignment 4 – Schematic View

5.2.2.2 Evaluation Results

Table 5-6 summarizes the results of the alignment evaluation.

Table 5-6 Summary of DPR System Alignment Evaluation Results

ALIGNMENT	SEGMENTS	WEIGHTING A SCORE	WEIGHTING B SCORE
Alignment 1 – Gladstone Street	1, 6, 10, 13, 19, 20, 21, and 22	51%	53%
Alignment 2 – Arrow Highway	1, 7, 11, 13, 19, 20, 21, and 22	51%	53%
Alignment 3 – Cypress Street	2, 3, 4, 5, 12, 17, 21, and 22	45%	49%
Alignment 4 – Azusa Ave / SR 39 to Glendora Tunnel	1, 6, 23, 24, 25, and 26	68%	72%

As can be seen in Table 5-6, **Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel** was the best scoring and most favorable alignment.

Alignment 4 offers many potential benefits, including:

- Requiring the shortest length of new pipe due to repurposing the Glendora Tunnel
- Having the fewest number of major utility crossings
- Having the fewest public facility impacts
- Having the fewest major intersection crossings

Outside of the scoring system, Alignment 4 also offers other benefits to the RRWP, such as being able to eliminate 14,000 ft of pipe associated with the Backbone Alignment and providing a more preferred discharge location for the replenishment water being supplied to the USGMWD.

Details of the decision model inputs, scoring, weighting, and results can be found in Appendix T. Figure 5-13 presents **Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel**.

5.2.2.3 Refinement of DPR Alignment 4

This Project recognizes that construction of a large diameter pipeline within Azusa Avenue would have significant impacts on the community. Azusa Avenue is one of the most heavily traveled surface streets in the area and is a popular through street from the 10 Freeway in the south to the 210 Freeway in the north. North of the 210 Freeway, Azusa Avenue is home to downtown Azusa, an improved, walkable downtown district with shops, wide sidewalks, and narrow streets.

Towards that end, this FLDR identified two alternate alignments to Azusa Avenue to get from Arrow Highway to the Glendora Tunnel. Both alternative alignments follow Alignment 4 from the Backbone Alignment to the intersection of Irwindale Avenue and Gladstone Street. When Alignment 4 turns east in Gladstone Street, both alternatives would continue north in Irwindale Avenue. Upon reaching Foothill Boulevard, Alternative 4A would turn west for approximately one-half mile and then head north in the open land adjacent to the San Gabriel River multi-purpose trail. The pipe would be constructed parallel to the trail outside of the influence of the levee. North of the San Gabriel Canyon Spreading Grounds, Alternative 4B would turn east. As of the time of this writing, there is a vacant parcel north of the City of Azusa's Filtration Plant that could serve as the portal for a tunnel. Alternatively, the tunnel portal could be located west of San Gabriel Canyon Road. The alignment would then tunnel east and connect back with Alignment 4.

Alternative 4A has several "pinch points" where the distance between the San Gabriel River and the adjacent railroad tracks narrows. At the time this FLDR was prepared, information was not available on the levee to determine if there would be enough space to construct a large diameter pipeline. Additional evaluations are required to confirm the feasibility of this alignment.

Alternative 4B would be located entirely within existing public rights-of-way. From Irwindale Avenue Alternative 4B would turn east in Foothill Boulevard, north in Todd Avenue, and then east in Sierra Madre Avenue back to Alignment 4. While still entirely located within existing public rights-of-way, Alternative 4B avoids Azusa Avenue and would be located on much less impactful streets.

Figure 5-13 presents Alternatives 4A and 4B. Both alternatives carry the same benefits as the base Alignment 4 located in Azusa Avenue but were developed to try to avoid the more challenging sections of the alignment.

Figure 5-13 Alignment 4 – Azusa Avenue / SR 39 to Glendora Tunnel and Alternatives

5.2.2.4 Conclusions

In addition to being the preferred alignment for the DPR system in the assessment completed, Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel offers other qualitative benefits to the RRWP outside of those strictly considered in the screening criteria. Among these benefits are the ability to eliminate 14,000 ft of the Backbone Alignment and provide replenishment water at a more preferred location.

The use of the Glendora Tunnel is the preferred alignment to get from the SFSG to the FEWWTP. Several alternatives appear feasible to get from the Backbone Alignment near the SFSG to the Glendora Tunnel. These alternatives are recommended to be carried forward for additional evaluation in subsequent design phases to confirm their feasibility and to select the preferred route.

5.2.2.5 Hydraulic Considerations

Although a detailed hydraulic evaluation and pump station siting study was not completed, a quick review of the topography shows that there is a ~550- ft difference in grade (480 ft at the SFSG compared to 1,030 ft invert elevation at the terminus of the Glendora Tunnel) plus hydraulic losses along the way. Metropolitan prefers to limit the lift at any single pump station to between 300 and 400 ft when possible. Therefore, it appears that at least two additional pump stations would be required. FEWWTP is located at approximately elevation 1080 ft, slightly higher than Glendora Tunnel's invert elevation. A quick review of the hydraulics shows there would be minimal head loss within Glendora Tunnel for the RRWP flows. Pumping would be required to lift water from Santa Fe Spreading Grounds to the Glendora Tunnel connection and ultimately on to FEWWTP. System hydraulics should be further evaluated during subsequent evaluations.

5.2.3 Evaluation of Long Tunnels to Avoid Areas of Concern

Metropolitan retained the services of MJA, outside of the scope of this Project, to evaluate long tunnels to avoid two areas of concern. As part of their evaluation, MJA reviewed available information to determine the feasibility of tunneling these areas and developed an opinion of probable construction cost. These areas could then be compared to the current cut-and-cover methods to determine the preferred construction method.

5.2.3.1 Carson to Long Beach

The first area of concern was the beginning of the proposed conveyance system within the City of Carson. To mitigate anticipated City of Carson concerns on traffic and community impact, Metropolitan considered tunneling within the City of Carson. Further, this section of the conveyance system is proposed within the existing rights of way of Sepulveda Boulevard, which turns into Willow Street. This street has many active and abandoned utilities already in the same corridor due to the historic oil refineries in the area, in addition to the large sewer trunk lines going to the JWPCP. By tunneling this section, the Project could avoid both of these potential obstacles.

This tunnel would begin at the AWT plant and head east below an existing railroad spur line. After crossing beneath Avalon Boulevard and Wilmington Avenue, the tunnel would cross various private properties before aligning with Willow Street. The tunnel would end after crossing the 710 Interstate and the LA River.

5.2.3.2 San Gabriel River Bed

The second area of concern was the section of the SG River Alignment that is proposed within the earthen bottom of the SG River. This section extends from Imperial Highway to Washington Boulevard, where available corridors adjacent to the river channel are temporarily unavailable. While Metropolitan has had conversations with the various jurisdictions that would regulate construction within the river bottom regarding its feasibility, no scour analysis had been completed at the time of this writing. Therefore, it is uncertain how much cover the pipeline would require in order to protect against scour or flotation.

Metropolitan tasked Black & Veatch with revalidating the assumptions used to prepare costs for cut-and-cover construction of the pipeline within the earthen river bottom and then comparing that to the costs prepared by MJA. The revised assumptions within the earthen river bottom included 1) the pipe would require 20 ft of cover, 2) dewatering wells would be required at 25 ft on center, 3) a flow diverting rubber dam would be required to protect the open excavation, 4) 30% of dewatering wells would encounter cobbles and need to be re-drilled, and 5) the trench would have slopes laid back at 1.5 to 1.

Figure 5-14 presents the revised typical construction cross section for the river bed.

Black & Veatch then prepared a new opinion of probable construction cost with the revised assumptions to compare to MJA's tunnel costs.

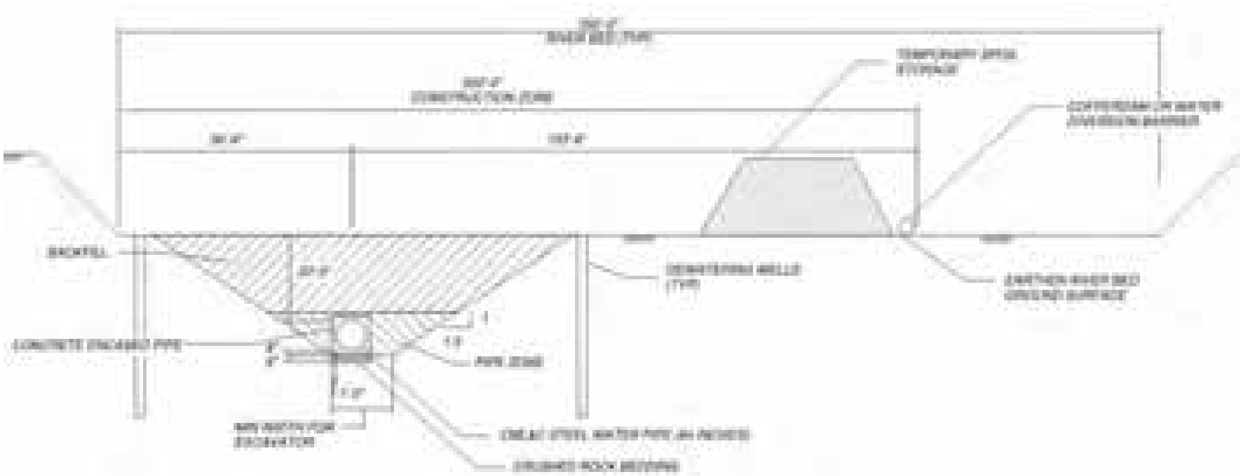

Figure 5-14 Typical Construction Cross Section in Earthen River Beds

5.2.3.3 Summary

Black & Veatch reviewed the costs prepared for tunneling these two areas of concern with the costs for constructing them with cut-and-cover methods and presented the comparison to Metropolitan. Due to uncertainties in subsurface ground conditions, a higher contingency was used for tunneling.

Table 5-7 presents this cost comparison. Black & Veatch, MJA, and Metropolitan met to discuss the cost opinions prepared. During this meeting, it was contingencies were determined for the cut and cover construction, as well as for the tunnels. In general, the level of uncertainty for the construction of tunnels is greater at this planning level and therefore warranted a higher contingency.

Table 5-7 Tunnel Costs Compared to Cut-and-Cover Costs

ITEM	CUT-AND-COVER COSTS	CUT-AND-COVER COST W/ CONTINGENCY (35%)	TUNNEL COST (MJA)	TUNNEL COST W/ CONTINGENCY (40%)	COST DELTA W/ CONTINGENCY
Carson to Long Beach	$120,200,000	$162,300,000	$168,365,200	$235,700,000	$73,400,000
SG River Bed	$139,300,000	$188,100,000	$182,844,900	$256,000,000	$67,900,000

Metropolitan reviewed the costs, along with other factors, and provided the following feedback:

- Further evaluations, including a subsurface geotechnical investigation, are required to determine the preferred construction method for these sections during the next phase of work.
- For the purposes of this FLDR, it is assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed is developed using the costs prepared by MJA, such that a conservative budget is established for this section. The construction methodology for this reach is described in Chapter 3. The cost opinion for the Project is described in Chapter 9.

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6.0 San Gabriel River Alignment Feasibility-Level Design

This chapter describes the key facility components for the SG River Alignment required for the conveyance of advanced treated water from the AWT plant in Carson to the SFSG. Chapter 7 provides similar information for the LA River Alignment.

When this chapter was originally prepared for the 2018 Draft Report, it contained information pertaining to the OC Reach. Since the OC Reach is no longer part of the base Project description, this information has been moved to Appendix U. Table 6-1 summarizes key Project components and characteristics associated with this alignment.

Table 6-1 SG River Alignment Characteristics

CHARACTERISTIC	SG RIVER ALIGNMENT
Minimum Ground Elevation, ft above mean sea level (MSL)	5
Maximum Ground Elevation, ft above MSL	525
Total Pumping Head, ft	686
Overall Alignment Length, miles	38.1
Pump Stations, each	2

Figure 6-1 summarizes the Project methodology as it applies to this chapter.

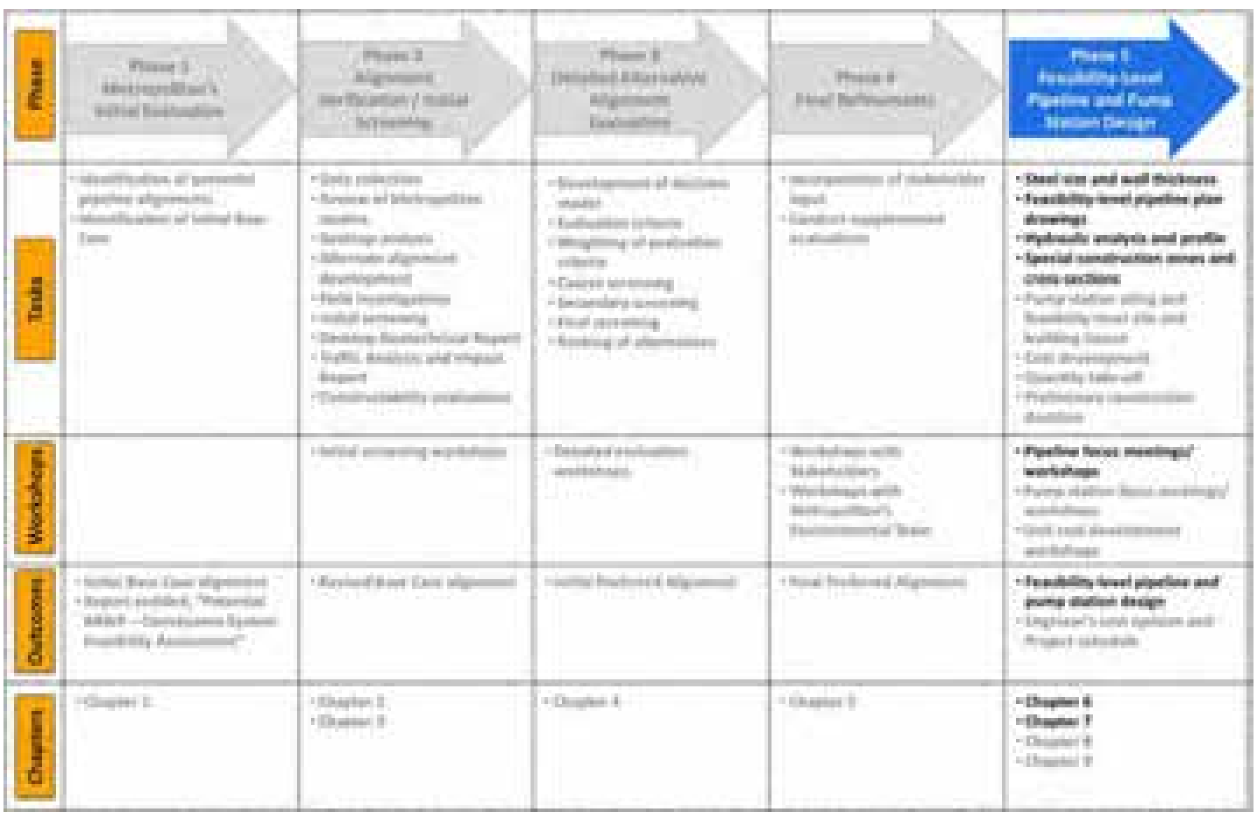

Figure 6-1 Chapter 6 Methodology

6.1 CHAPTER ORGANIZATION

Key operating parameters and Project components affecting alignment decisions for the RRWP are summarized below and discussed in the following sections:

- **SG River Alignment Overview** – This section describes the development of the SG River Alignment and presents a summary of the key attributes of the alignment, as well as areas that require further evaluation during subsequent phases of work.
- **Feasibility-Level Pipeline Plan Drawings** – This section presents the pipeline plan drawings that were developed to show the alignment at a scale large enough to display relevant surface features.
- **Feasibility-Level Pipeline Design** – This section describes the system of pressurized pipelines and tunnels for the SG River Alignment, including design criteria applicable to pipeline sizing and the development of a cost opinion. This section also describes locations that are anticipated to require trenchless construction methods to avoid surface or below grade features or obstructions and presents typical cross-sections for the alignment.

6.2 SAN GABRIEL RIVER ALIGNMENT OVERVIEW

The SG River Alignment, established in Chapter 5, was the result of feasibility-level engineering development, input from internal and external stakeholders, and the ability to procure rights-of-way and easements. Details of construction activities, including but not limited to construction sequencing, contractor access and storage area, and traffic control and road closures, would be assessed during the preliminary design phase.

Figure 6-2 presents an overview of the SG River Alignment and the three reaches it is comprised of. Table 6-2 summarizes key information about each reach.

Table 6-2 Key Characteristics of SG River Alignment Reaches

REACH	BEGINNING /ENDING LOCATION	STATIONING (MILES)	LIFT (FT)
1	PS-1 to optional connection for Reach 2	0.0 – 14.0	350
2 (optional OC Reach)	Reach 1 to OC Spreading Grounds (optional)	Not included in current Project	Not included in current Project
3	End of Reach 1 to PS-3	14.0 – 28.4	Note 1
4	PS-3 to SFSG	28.4 – 38.1	336

Note 1: PS-1 provides the lift for Reach 3.

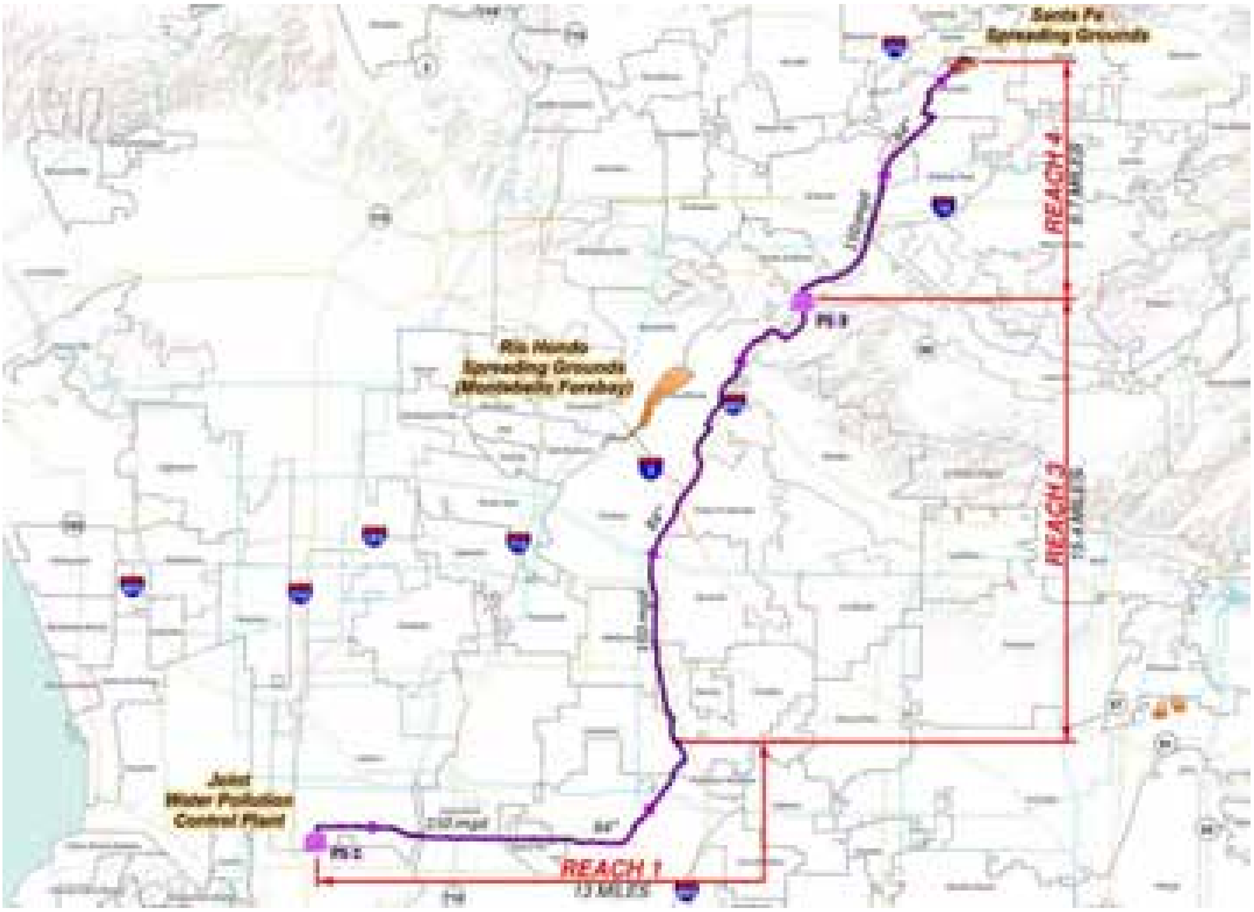

Figure 6-2 SG River Alignment Overview and Reach Extents

A description of each reach is as follows:

- Reach 1 – Reach 1 would be approximately 13 miles in length and would begin at the AWT and terminate at the former junction to the OC Spreading Grounds adjacent to the SG River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of Los Angeles, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within existing public street right-of-way with a short stretch along the SG River. This pipeline section would convey up to 150 mgd.
- Reach 3 – Reach 3 would be approximately 15.4 miles in length and begin at the former junction to the OC Spreading Grounds and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, the alignment would pass through the Cities of Cerritos, Bellflower, Downey, and Pico Rivera. The majority of the alignment would fall within SCE right-of-way paralleling the SG River. Due to the narrow SCE corridor and environmentally-sensitive nature areas along the SG River, the pipeline may have to be placed alternatively within the river bed itself, as well as within public street rights-of-way for portions of the alignment. It is anticipated that the pipeline would convey up to 150 mgd.

- Reach 4 – Reach 4 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG in the City of Irwindale. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LACFCD right-of-way with a small stretch in public street rights-of-way. It is anticipated that the pipeline would convey up to 150 mgd. It should be noted that much of Reach 4 parallels USGMWD's proposed IRRP Pipeline Project.

For details on Reach 2 (OC Reach), see Appendix U.

A summary of the key attributes of the SG River Alignment is presented in Table 6-3. Additionally, areas requiring specific considerations during subsequent design phases are described in Table 6-4.

6.3 FEASIBILITY-LEVEL PIPELINE PLAN DRAWINGS

Feasibility-level plan drawings depicting the SG River Alignment were developed in GIS. These plans depict the SG River Alignment at a scale large enough to display surface features that would prevent or restrict cut-and-cover construction and/or require trenchless construction methods.

The feasibility-level plan sheets are provided in Appendix G.

Table 6-3 Summary of SG River Alignment

SEGMENT	PIPE DIAMETER (IN.)	TOTAL LENGTH (FT)	TRENCHLESS CONSTRUCTION (FT)	CITIES	DESCRIPTION	STREET	STREET WIDTH (FT)	TRAFFIC LANES (NO.)	TYPICAL CONSTRUCTION METHOD ASSUMED[1]
1	84	23,957	4,948	Carson, Los Angeles, Long Beach	Roadway	Main St.	80	4 + median	CM1
						Sepulveda Blvd. (turns into Willow St)	80	4,6 + median	
5	84	11,004	222	Long Beach, Signal Hill	Roadway	Willow St.	80	6 + median	CM1
5A	84	26,649	366	Long Beach, Signal Hill	Roadway	Willow St.	80	6 + median	CM1
						Los Coyotes Diagonal	75 to 80	4 + median	
10A	84	6,871	1,006	Lakewood, Cerritos	Roadway/SCE/Private	Los Coyotes Diagonal	75	4 + center lane	CM1/CM2
						Studebaker Rd	80	4 + center lane	
						Del Amo Blvd.	80	4 + median	
20	84	32,140	2,527	Cerritos, Bellflower, Downey	SCE/LACFCD	Studebaker Rd.	75	4 + median	CM2/CM3A
22	84	20,094	422	Downey, Pico Rivera	LACFCD/River	-	-	-	CM3B/CM3C
36	84	4,651	-	Pico Rivera	LACFCD	-	-	-	CM3A
38	84	21,745	1,921	Pico Rivera, Industry, Unincorporated	SCE/LACFCD/Roadway	SG River Pkwy	100	4 + median	CM1/CM2
						Rose Hills Rd.	60	4	
						Workman Mill Rd	85	4 + median	
						Peck Rd	75	4 + median	
38A	84	4,592	3,734	Pico Rivera	LACFCD	-	-	-	CM3A/CM4C
44	84	28,748	4,575	South El Monte, Industry, Baldwin Park, Irwindale, Unincorporated	SCE/LACFCD	-	-	-	CM2/CM3A
52	84	2,292	-	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	22 to 60	2, 4 + center lane	CM1
60	84	4,884	528	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	60 to 80	4 + center lane	CM1
56	84	1,166	-	Irwindale	Roadway	Live Oak Ave.	80	4 + median	CM1
58	84	3,339	517	Irwindale	SCE/Private	-	-	-	CM2
59	84	9,028	1,723	Irwindale	LACFCD	-	-	-	CM3A
TOTALS		201,160	22,489						

Note 1: See Section 3.4 for details on typical construction methods, including definitions of abbreviations.

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Table 6-4 Areas Requiring Specific Consideration During Subsequent Design Phases

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
General	Where the SG River Alignment would cross a seismic hazard/ fault, a detailed seismic assessment which may include finite element analysis would be required in subsequent design phases to design for seismic resiliency (Segments 5, 5A, and 22).
	At this feasibility level of planning, sufficient information is not available to determine the preferred construction method, cut-and-cover or trenchless construction, at intersections crossing the Preferred Alignment. For planning purposes, this FLDR assumed that all intersections would be crossed using cut-and-cover construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing railroad tracks, rivers, bridges, and Caltrans roads or highways). The FLDR applies a premium to account for the higher cost of construction at all intersections that the traffic analysis report considered to be a Major Intersection. Further evaluation will be completed during the Preliminary Design when a comprehensive investigation and mapping of buried utilities, additional traffic control analysis, and coordination with local jurisdictions would be completed.
	This FLDR assumed that when the pipeline alignment would cross beneath freeway overpasses with adequate clearance from the bridge structure to the ground for construction equipment, and no on or off-ramp access, the pipeline would be constructed using cut-and-cover methods. Based on prior experience with Caltrans District 7, this would be feasible as long as the edge of pipe is at least 10 ft from the bridge footings and abutment. Additionally, a casing is typically required, even with cut-and-cover construction methods. These crossings would be evaluated on a case by case basis. Additional coordination should be conducted with Caltrans during subsequent design phases to better understand their design requirements. No discussions with Caltrans were held at this stage of the project.
	Further investigation into designated wetlands and sensitive wildlife areas along the SG River and associated spreading grounds would be required in subsequent design phases.
1	Assumptions made for the crossing of Alameda Corridor and Dominguez Channel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59 should be verified. Should any issues be encountered with the proposed crossing during subsequent design phases, two other viable crossings were identified and are presented in Appendix R.[1]
	Numerous underground utilities were identified along Sepulveda Boulevard and Willow Street. Additional utility research and potholing should be completed to confirm the alignment.[2]
5	None.
5A	This FLDR assumed that the crossing at Interstate 405 would be constructed using trenched construction methods due to freeway's overpass having adequate clearance from the ground to the bridge structure and no on or off-ramp access from Stanton Ave.
10A	This FLDR assumed that trenchless construction would be required to cross the LADWP transmission corridor, SG River, multi-use trails, linear parks, SCE transmission corridor, and concrete drainage channel continuously. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders and construction staff to determine if the crossing could be made with two shorter tunnels and cut-and-cover construction through the remaining area.[1]

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
20	The proposed alignment would be constructed in equestrian areas, crowded storage yards, open space, and Ironwood Nine Golf Course from 183rd Street to Alondra Boulevard within the SCE and LACFCD easements.
22	This FLDR assumed a typical construction method to protect against scour and pipe flotation in an earthen channel. Further investigations into LACFCD's requirements on pipes installed in earthen channels and evaluations on scour and pipe flotation should be completed in subsequent design phases. [3] However, the FLDR conservatively assumed the cost for tunneling this section.
	This FLDR assumed that construction of the pipeline would be possible under the four LACDPW's rubber dam locations in the river bed. Coordination with LACDPW would need to be completed in subsequent design phases.
36	This FLDR assumed the alignment would be constructed around the perimeter of the LACFCD spreading basins from Reach 3, Sta. 1207+00 to Reach 3, Sta. 1253+80 (end of Segment 36). Additional evaluations into the impacts the pipeline construction could have on the spreading basins recharge capacities should be completed in subsequent design phases. If pipeline construction is determined not to impact the recharge capacities, a straighter alignment may be possible through the basins with LACDPW's consent.
38	This FLDR assumed that the crossing of a drainage channel that crosses SG River Parkway, just west of Interstate 605, could be constructed using trenched construction methods. During subsequent phases of design, this assumption should be further evaluated.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
38A	This FLDR assumed traditional tunneling methods would be used to construct the segment crossing the SG River and running alongside the railroad tracks from Reach 3, Sta. 1291+00 to Reach 3, Sta. 1328+79 in one continuous span. The crossing would consist of an oversized excavated tunnel with an 84-inch carrier pipe inside. The additional annular space created by the EPBM tunnel (minimum excavated diameter of 118-132 inches) would be filled with grout. Additional geotechnical information should be obtained during preliminary design to determine if other trenchless technologies would be more appropriate for the anticipated ground conditions. [1]
44	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
52	A general corridor was selected that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. However, utility information has not been received from the Cities of Baldwin Park and Irwindale. Future utility investigation should be completed during subsequent design phases and the alignment should be adjusted accordingly.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
	Due to the narrow width of Rivergrade Road (approx. 32 ft) from Reach 4, Sta. 1804+50 to Reach 4, Sta. 1825+00, a full road closure may be required.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
60	None.
56	None.
58	Construction is required on private property from approximately Reach 4, Sta. 1888+00 to Reach 4, Sta. 1912+00.
59	The corridor selected involves crossing the Santa Fe Dam from approximately Reach 2, Sta. 1966+50 to Reach 2, Sta. 1978+50. Additional evaluations would need to be completed to determine the preferred crossing method.

Notes:
1. See Section 6.4.7 for additional details.
2. See Section 6.4.8 for typical cross-sections.
3. See Section 3.4.3 for typical section.
4. See Figure 5-10~~Figure 5-10~~ for identification of segments comprising the SG River Alignment.

6.4 FEASIBILITY-LEVEL PIPELINE DESIGN

The following section establishes the pipeline design basis, including the pipeline flow rate, hydraulic profile, diameter, material, and governing design standards.

6.4.1 Design Flow

Pipeline diameters were sized for the full program build out of 150 mgd.

6.4.2 Optimization of Pipe Sizes and Pumping Costs

A feasibility-level analysis optimizing the pipe size for the SG River Alignment to balance pumping power cost with capital construction cost was performed. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. A more detailed evaluation should be conducted during preliminary design to validate the results. The pipe size optimization calculation is presented in Appendix H.

The pipeline diameters selected for each reach are presented in Table 6-5. The stated diameter shall be the clear inside diameter after application of linings and the velocity shall be in feet per second (fps).

Table 6-5 Pipe Sizes

REACH	PIPE DIAMETER (IN.)	DESIGN FLOW (MGD)	PIPE VELOCITY (FPS)
1	84	150	6.0
3	84	150	6.0
4	84	150	6.0

Note: Reach 2 refers to the OC Reach, which has been excluded from the initial implementation of the Project.

6.4.3 Hydraulic Profile

Preliminary hydraulic profiles were developed for the SG River Alignment (Backbone System) and are presented on Figure 6-3 through Figure 6-5. It should be noted that tunneling under a dam is technically feasible but could lead to permitting challenges.

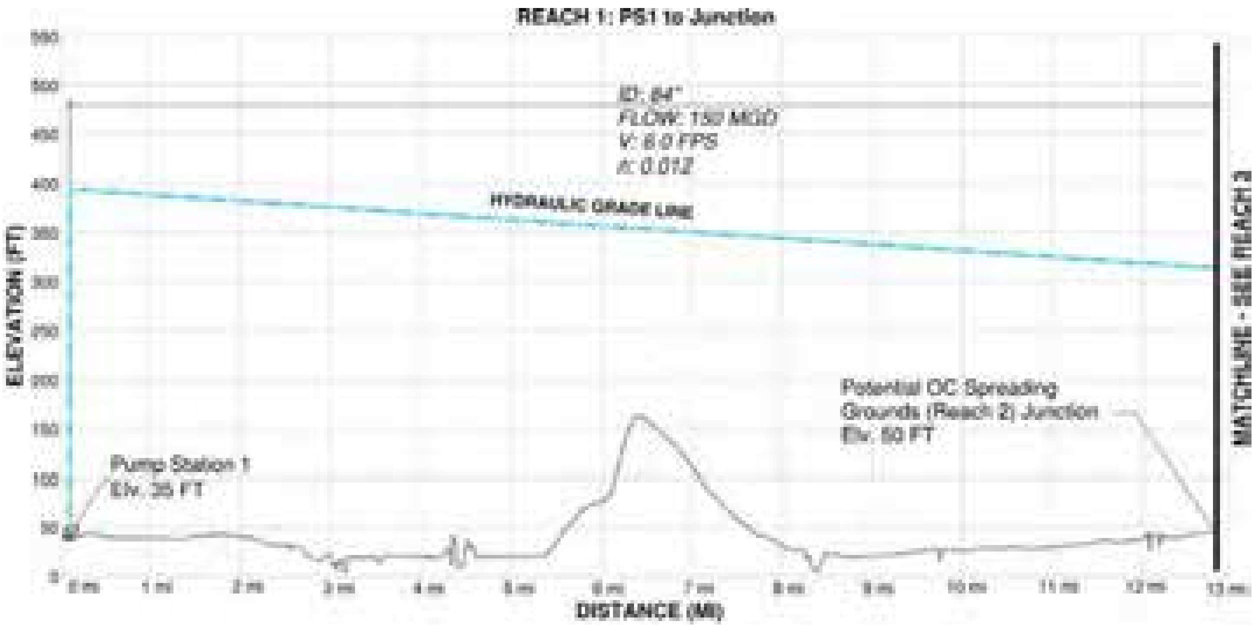

Figure 6-3 Reach 1 Hydraulic Profile (SG River Alignment)

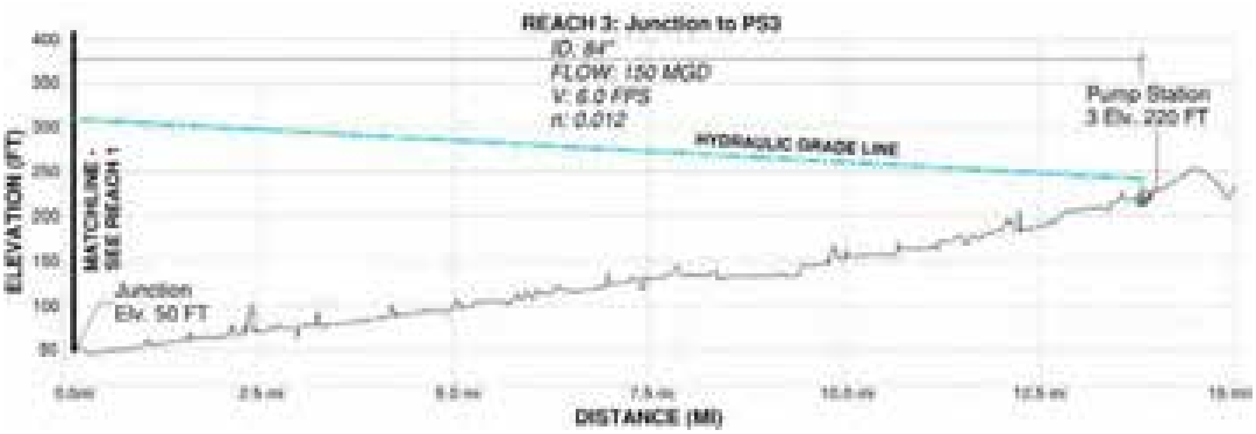

Figure 6-4 Reach 3 Hydraulic Profile (SG River Alignment)

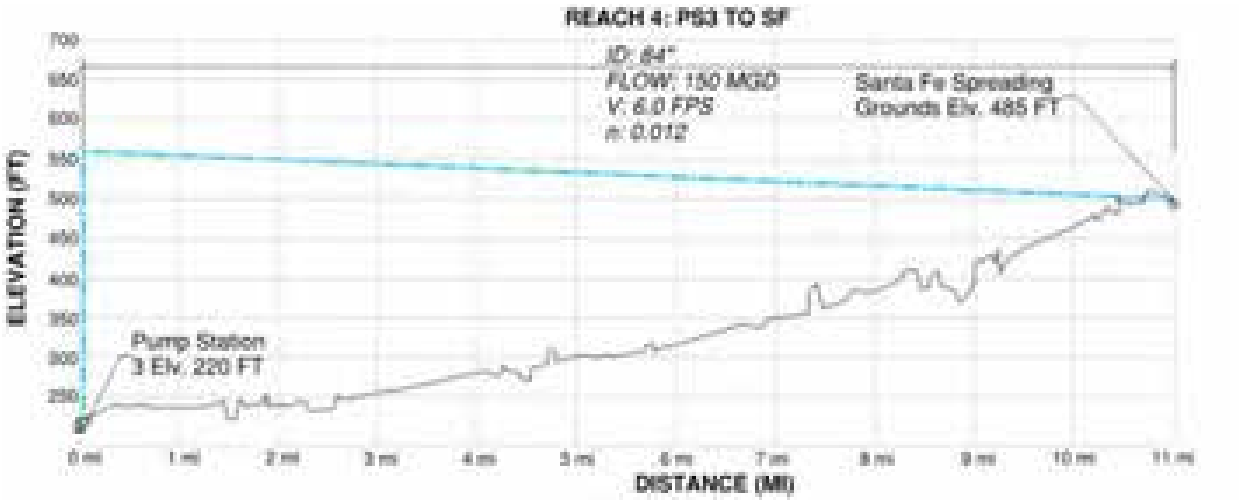

Figure 6-5 Reach 4 Hydraulic Profile (SG River Alignment)

As can be seen on Figure 6-5 above, the proposed alignment crosses the Santa Fe Dam spillway to reach the SFSG. It is currently envisioned that the alignment would cross under the dam using trenchless construction methods, which is technically feasible but could lead to permitting challenges. Additional coordination with the governing jurisdictions would be required during future phases of work to determine the preferred construction method.

6.4.4 Pipe Materials

Pipeline materials would be welded steel pipe in accordance with Metropolitan standards. Lining material selection was not evaluated as part of the study but was assumed to be cement mortar for purposes of establishing a budgetary cost. Metropolitan's design standards will be followed with evaluating and selecting lining material during future phases of work, in conjunction with water quality data from the demonstration plant.

6.4.4.1 Steel Cylinder Design Calculations

Initial pipeline plate thickness calculations were completed for the SG River Alignment. The steel plate thickness was determined based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a basic segment by segment analysis to support cost estimating and provide an initial basis for preliminary design development. Site specific calculations should be completed during preliminary design.

The recommended steel plate thicknesses for each pipe segment are summarized in Table 6-6. Details of the initial pipeline plate thickness calculations are presented in Appendix I.

Table 6-6 Steel Cylinder Thicknesses

REACH	PLATE THICKNESS (IN.)
1	0.500
3	0.500
4	0.500
Note: Steel cylinder thickness calculations assume 42 kips per square inch steel and a minimum plate thickness of 0.375 inches per Metropolitan's standard specification Section 02662.	

6.4.5 Pipeline Appurtenances

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings should be used to develop typical details for these appurtenances. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

As part of the preliminary design, a study should be performed to determine potential blow-off and ARVV locations along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design.

In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points.

6.4.6 Intersections

A list of Major and Minor Intersections, as designated by the Traffic Impact Analysis, for each Segment of the SG River Alignment is provided in Table 6-7.

Table 6-7 Summary of Intersection Designations

SEGMENT	INTERSECTION	CLASSIFICATION
1	Sepulveda Blvd. @ Dolores St.	Minor
	Sepulveda Blvd. @ Marbella Ave.	Minor
	Sepulveda Blvd. @ Panama Ave.	Minor
	Sepulveda Blvd. @ Avalon Blvd.	Major
	Sepulveda Blvd. @ Banning Blvd.	Minor
	Sepulveda Blvd. @ Wilmington Ave.	Major
	Sepulveda Blvd. @ Tesoro/Phillips 66	Minor
	Sepulveda Blvd. @ Alameda Connector	Minor
	Sepulveda Blvd. @ Intermodal Wy.	Minor
	Sepulveda Blvd. @ R/R Xing	Major
	Sepulveda Blvd. @ ICTF	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Sepulveda Blvd. @ Middle Rd.	Minor
	Sepulveda Blvd. @ CA-103 terminus	Minor
	Sepulveda Blvd. @ Regway Ave.	Minor
	Sepulveda Blvd. @ Santa Fe Ave.	Major
	Sepulveda Blvd. @ Easy Ave.	Minor
5	Willow @ Golden Ave.	Minor
	Willow @ Magnolia Ave.	Minor
	Willow @ Pacific Ave.	Minor
	Willow @ Earl Ave.	Minor
	Willow @ Long Beach Blvd.	Major
	Willow @ Atlantic Ave.	Major
	Willow @ California Ave.	Minor
	Willow @ Orange Ave.	Minor
	Willow @ Walnut Ave.	Minor
	Willow @ Town Center	Minor
	Willow @ Cherry Ave. (alignment turn)	Major
5A	E. Willow @ Cherry Ave. — continued from 5	Major
	E. Willow @ Dawson Ave. / Town Center E.	Minor
	E. Willow @ Junipero Avenue	Minor
	E. Willow @ Temple Avenue	Minor
	E. Willow @ Redondo Avenue	Major
	E. Willow @ Grand Avenue	Minor
	E. Willow @ Lakewood Boulevard	Major
	E. Willow @ Clark Avenue	Major
	E. Willow @ Bellflower Boulevard	Major
	E. Willow @ N. Los Coyotes Diagonal (alignment turn)	Minor
	Los Coyotes Dia. @ Spring St.	Minor
	Los Coyotes Dia. @ Woodruff Ave.	Minor
	Los Coyotes Dia. @ Wardlow Rd.	Minor
	Los Coyotes Dia. @ Palo Verde Ave.	Minor
	Los Coyotes Dia. @ Studebaker Rd. / Parkcrest St.	Major
	Los Coyotes Dia. @ Carson St. — continues to 10A	Minor
10A	Los Coyotes Diagonal @ Carson — continued from 5A	Minor
	Studebaker @ Del Amo — continued from 10A	Major
20	Studebaker @ 195th Street	Minor
22	None	N/A

SEGMENT	INTERSECTION	CLASSIFICATION
36	None	N/A
38	Shepherd St. @ Rose Hills Rd.	Minor
	Rose Hills Rd. @ Workman Mill Rd.	Minor
	Workman Mill Rd. @ E Mission Mill Rd.	Minor
	Workman Mill Rd. @ Rose Hills Gate 1	Minor
	Workman Mill Rd. @ College Dr.	Minor
	Workman Mill Rd. @ Peck Rd.	Minor
	Peck Rd. @ Pellissier Rd.	Minor
	Peck Rd. @ Rooks Rd.	Major
38A	None.	N/A
44	None	N/A
52	Rivergrade @ Brooks Dr.	Minor
60	Rivergrade @ Live Oak Ave.	Minor
56	Live Oak @ Graham	Minor
58	None	N/A
59	None	N/A

6.4.7 Trenchless Construction Recommendations

In order to establish a conservative budgetary construction cost for the portions of the alignment preliminarily identified for trenchless installation, it was necessary to select a feasible trenchless construction method for each location. To do this, the engineering team reviewed the trenchless methods that were identified as applicable in the Desktop Geotechnical Evaluation and selected a feasible method for each trenchless installation site based on its location, length, pipeline size, and the foreseeable subsurface geotechnical and hydrogeologic conditions available from the desktop studies.

The next phase of the Project is expected to include site specific subsurface geotechnical explorations, comprehensive investigations, and mapping. These site-specific analyses will allow for a final selection of trenchless installation methods to be used at each location and may warrant that the trenchless methods described herein be revised.

The selected trenchless methods provided the basis for development of the feasibility level Engineer's OPCC for the Project. Figure 6-6 correlates the trenchless identification number listed in Table 6-8 (shown below) with the location of each trenchless sub-segment along the SG River Alignment. Table 6-8 summarizes the assumptions used to select the trenchless methods. The geotechnical information presented in Table 6-8 was based on the provided in the Desktop Geotechnical Evaluation.

It should be noted that a conservative depth of cover was assumed generally equal to three times the excavated diameter for the purposes of establishing a conservative budget for each trenchless crossing. Section 6.4.8 evaluates nine trenchless crossings in greater detail. At these locations, the depth of cover that was assumed to be required were further refined, which, in some cases, led to them being reduced to less than three times the excavated diameter based upon the trenchless construction method assumed, the anticipated ground conditions, and the sensitivity of facilities for which it would cross beneath.

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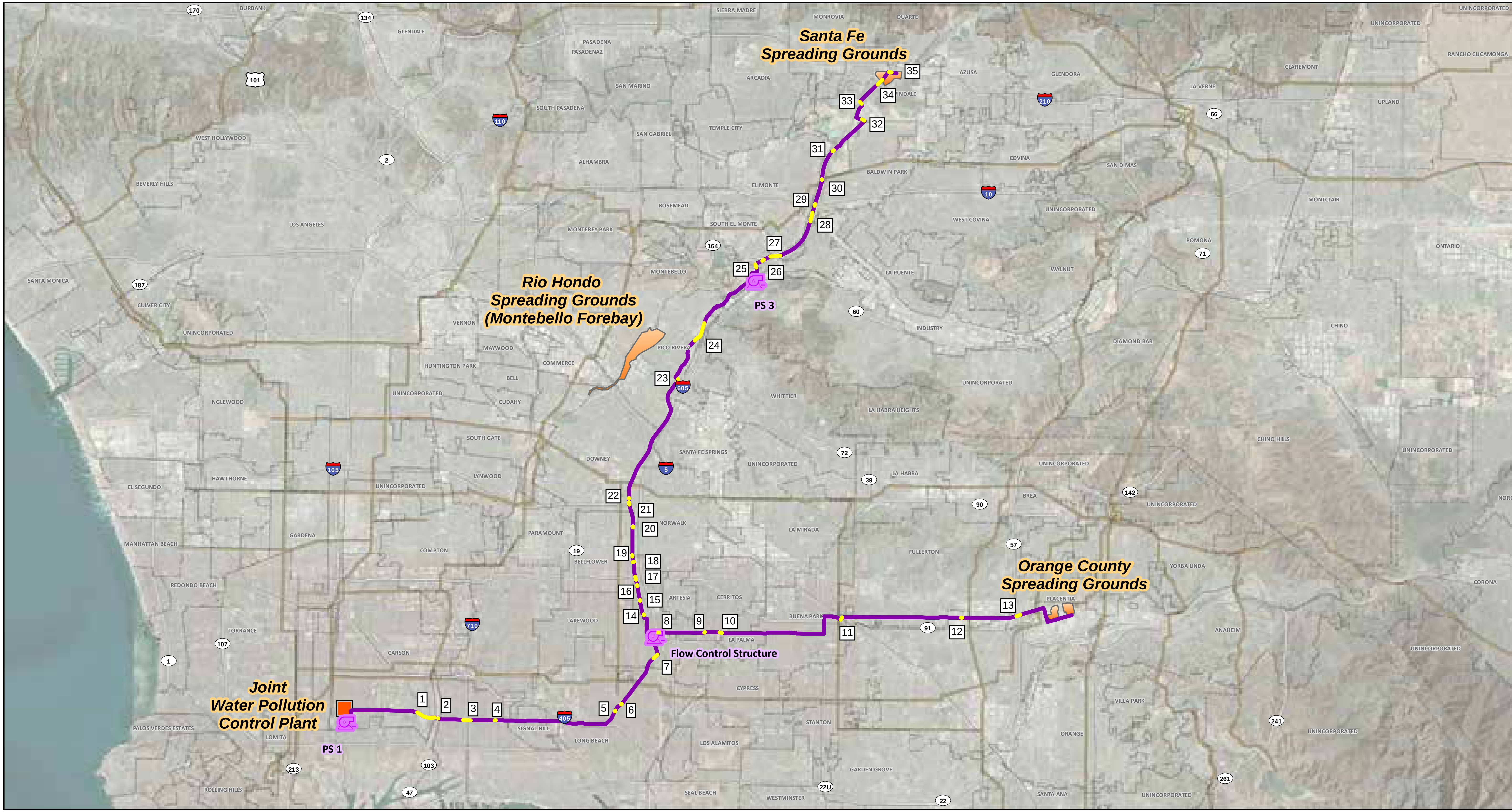

Existing MWD Distribution System

Preferred Alignment

Trenchless / Tunnel Undercrossing with ID #

Pump Station or Flow Control Structure

Spreading Basins

BLACK & VEATCH
Building a world of difference.

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 6-6: Final Preferred Alignment Trenchless/Tunnel ID

N

1 in = 3 miles

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Table 6-8 Assumed Trenchless Construction Methods (SG River Alignment)

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
1	3,442	Intersection / railroad / river	7	11	33	Yes	Traditional Tunneling (EPBM)	-	-	Yes	Length and curves would make MT difficult but not impossible, recommend EPBM at this time.
2	88	Railroad	7	9	27	Yes	Microtunneling	-	-	-	MT would be best suited to manage risk under railroad.
3	1,418	River	7	9	27	Yes	Microtunneling	Yes	-	-	Too large diameter for HDD, too short for conventional tunneling. Not possible to dewater and use jack & bore.
4	222	Intersection / Railroad	7	9	27	Yes	Jack & Bore	-	-	Yes	Presence of clay and short drive length make jack & bore feasible with dewatering.
5	166	River	7	9	27	Yes	Jack & Bore	-	-	-	Crossing is under a concrete lined channel which appears to generally only have minimal flow. Jack & Bore acceptable.
6	200	River	7	9	27	Yes	Jack & Bore	-	-	-	Crossing is under a concrete lined channel which appears to generally only have minimal flow. Jack & Bore acceptable.
7	1,006	River	7	9	18	Yes	Microtunneling	-	-	-	Crossing would not suitable for jack & bore as a river crossing.
8	206	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
9	167	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
10	249	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
11	580	Freeway	7	9	11	Yes	Microtunneling	-	-	-	Drive length too long for Jack & Bore.
12	270	River	7	9	11	Yes	Microtunneling	-	-	-	Drive length too long for Jack & Bore.
13	280	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	
14	205	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
15	468	Freeway	7	9	27	Yes	Microtunneling	-	-	-	Drive length long enough to assume MT, particularly with fine grained soils and sands and crossing critical infrastructure.
16	102	Dam	7	9	27	Yes	Jack & Bore	-	-	-	Crossing under levee. Into drainage area. Jack & Bore acceptable due to length.
17	422	River	7	9	27	Yes	Microtunneling	-	-	-	Length and lack of clay lend it to MT.
18	3,734	River/Railroad	7	11	22	Yes	Traditional Tunneling (EPBM)	-	-	-	Length and curves would make MT difficult but not impossible. However, EPBM is recommended for budgeting at this time. Further analysis would be recommended to confirm in later design stages.
19	325	Freeway	7	9	27	Yes	Jack & Bore	-	-	-	Short drive length favors jack & bore.

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
20	88	Railroad	7	9	27	Yes	Microtunneling	-	-	-	MT would be best suited to manage risk under railroad.
21	842	Freeway	7	9	27	Yes	Microtunneling	-	-	-	Length and lack of clay lend it to MT.
22	666	River	7	9	27	Yes	Microtunneling	Yes	-	-	Crossing would not be suitable for jack & bore as a river crossing.
23	381	Freeway	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
24	1,825	River	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
25	1,631	Railroad / River	7	9	18	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
26	325	Freeway	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
27	128	Road	7	9	27	Yes	Jack & Bore	Yes	-	-	Short drive length favors jack & bore.
28	285	Road	7	9	27	No	Jack & Bore	Yes	-	-	Short drive length favors jack & bore.
29	528	River	7	9	11	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT
30	517	Freeway	7	9	18	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
31	1,215	Dam	7	9	27	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
32	508	Freeway	7	9	27	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.

Notes:
1. Tunnel identification number corresponds with Figure 6-6.
2. Depth below ground surface or river channel to top of pipe or crown of tunnel; generally equal to 3 diameters of the excavated hole.

6.4.8 Feasibility-Level Technical/Construction Details

This section discusses segments of the SG River Alignment where the typical construction methods would not be sufficient to construct the pipeline due to terrain, such as rivers, and/or physical barriers, such as freeways or railroads, or to avoid impacts to the community. A preliminary review of the SG River Alignment identified nine locations warranting feasibility-level technical / construction details. The nine feasibility-level technical / construction detail locations are identified in Table 6-9 and presented on Figure 6-7.

Descriptions for each of the nine feasibility-level technical / construction detail locations are provided in the following subsections, including details on site conditions, existing utilities, easements, and trenchless methodology. Additionally, plan and profiles have been developed for each of the nine locations. All ground elevations shown were obtained through Google Earth and are approximate. Ground surveys were not completed for this FLDR.

Table 6-9 Feasibility-Level Technical/Construction Detail Locations

NO.	STATION	DESCRIPTION
1	Reach 1, Sta. 139+17 – Reach 1, Sta. 173+59	Trenchless crossing of Alameda Street/railroad corridor and the Dominguez Chanel along Sepulveda Boulevard.
2	Reach 1, Sta. 225+38 – Reach 1, Sta. 239+57	Trenchless crossing of 710 Freeway and Los Angeles River along Sepulveda Boulevard.
3	Reach 1, Sta. 635+90 – Reach 1, Sta. 645+96	Trenchless crossing of SG River at Los Coyotes Diagonal.
4	Reach 3, Sta. 808+30 – Reach 3, Sta. 814+10	Trenchless crossing of 91 Freeway along the SG River easements.
5	Reach 3, Sta. 841+37 – Reach 3, Sta. 844+07	Trenchless crossing of the SG River south of Alondra Boulevard.
6	Reach 3, Sta. 1291+00 – Reach 3, Sta. 1328+34	Trenchless crossing of the SG River and parallel to the railroad tracks from Whittier Boulevard to Beverly Boulevard.
7	Reach 4, Sta. 1652+73 – Reach 4, Sta. 1669+04	Trenchless crossing of the Walnut Creek Wash along the SG River
8	Reach 4, Sta. 1871+00 – Reach 4, Sta. 1876+28	Trenchless crossing of the SG River along Live Oak Avenue.
9	Reach 4, Sta. 1997+81 – Reach 4, Sta. 2002+89	Trenchless crossing of the 605 Freeway.

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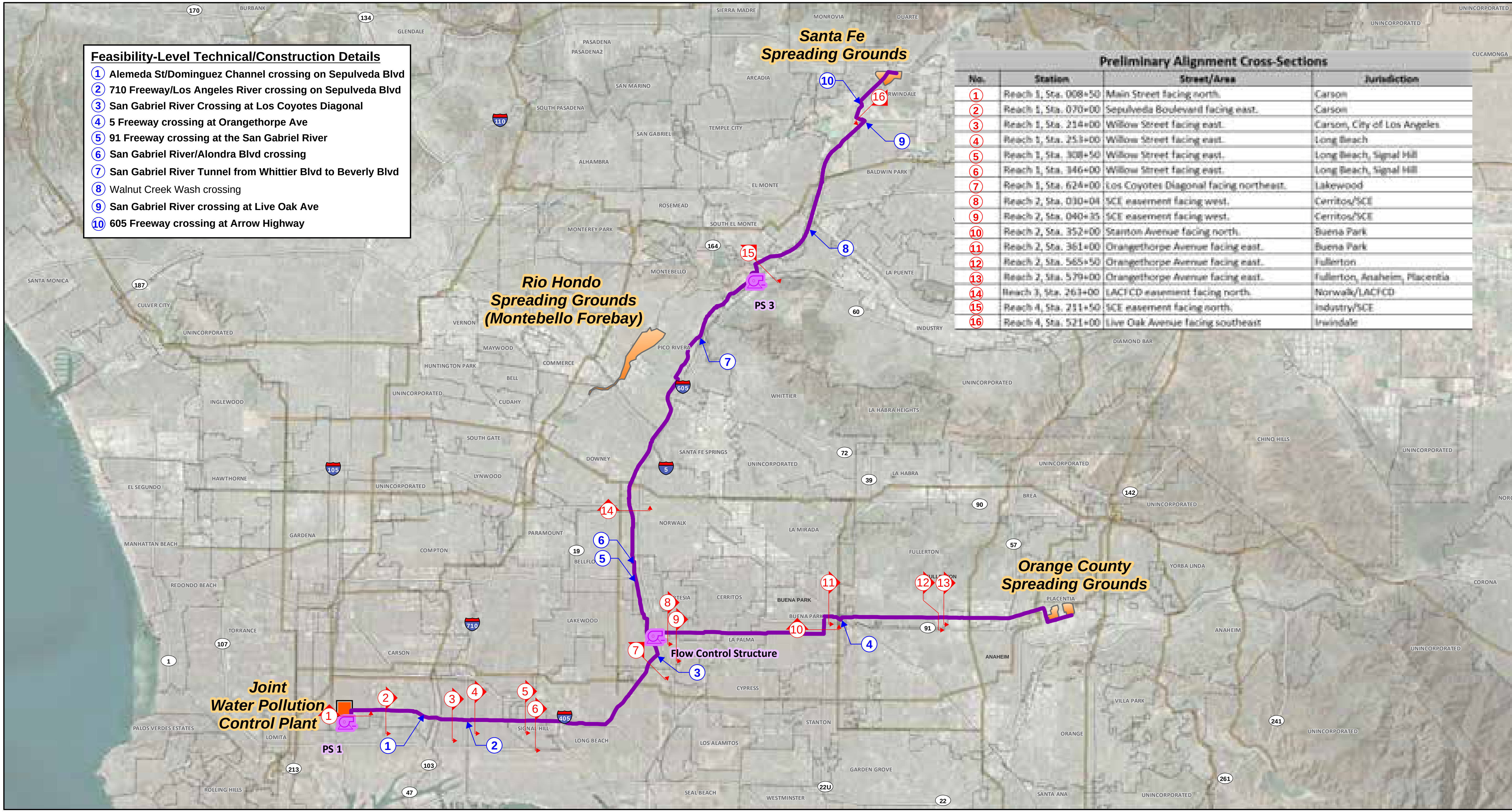

Preliminary Alignment Cross-Sections

No.	Station	Street/Area	Jurisdiction
1	Reach 1, Sta. 008+50	Main Street facing north.	Carson
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.	Carson
3	Reach 1, Sta. 214+00	Willow Street facing east.	Carson, City of Los Angeles
4	Reach 1, Sta. 253+00	Willow Street facing east.	Long Beach
5	Reach 1, Sta. 308+50	Willow Street facing east.	Long Beach, Signal Hill
6	Reach 1, Sta. 346+00	Willow Street facing east.	Long Beach, Signal Hill
7	Reach 1, Sta. 624+00	Los Coyotes Diagonal facing northeast.	Lakewood
8	Reach 2, Sta. 030+04	SCE easement facing west.	Cerritos/SCE
9	Reach 2, Sta. 040+35	SCE easement facing west.	Cerritos/SCE
10	Reach 2, Sta. 352+00	Stanton Avenue facing north.	Buena Park
11	Reach 2, Sta. 361+00	Orangethorpe Avenue facing east.	Buena Park
12	Reach 2, Sta. 565+50	Orangethorpe Avenue facing east.	Fullerton
13	Reach 2, Sta. 579+00	Orangethorpe Avenue facing east.	Fullerton, Anaheim, Placentia
14	Reach 3, Sta. 263+00	LACFCD easement facing north.	Norwalk/LACFCD
15	Reach 4, Sta. 211+50	SCE easement facing north.	Industry/SCE
16	Reach 4, Sta. 521+00	Live Oak Avenue facing southeast	Irwindale

Existing MWD Distribution System
Preferred Alignment
Pump Station or Flow Control Structure
Spreading Basins
1 Preliminary Alignment Cross-Section
1 Location of Concept Construction Details

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Building a world of difference.

Feasibility-Level Design of Conveyance for Potential RW Supply Program
Figure 6-7: Feasibility-Level Technical/ Construction Detail and Cross Section Locations

N
1 in = 3 miles

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6.4.8.1 Alameda Corridor and the Dominguez Channel Crossing (Detail Location 1)

The SG River Alignment proposes crossing the Alameda Corridor at Sepulveda Boulevard and then, approximately 1,700 ft later, crossing the Dominguez Channel. Trenchless construction methods would be required to cross either of these obstructions. Additionally, the land adjacent to Sepulveda Boulevard is used for oil and gas refineries and is congested with tanks, below and above grade utilities, and other manufacturing facilities leaving very limited space for the launching and receiving portals required for any trenchless construction method.

As discussed in Chapter 5, three alternatives were identified to construct these crossings and presented to Metropolitan during a workshop on August 31, 2017. All three alternatives are viable options for constructing through this segment. The most conservative alternative was selected for use in this FLDR. Key details of this crossing are provided in Table 6-10.

Table 6-10 Summary of Alameda Corridor / Dominguez Channel Crossing (Detail Location 1)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
3,442	Intersection / Railroad / River	7	33	Yes	EPBM Tunnel	Y	N	N	N	Y

The selected crossing, displayed on Figure 6-8, Figure 6-9, and Figure 6-10, would use EPBM tunneling methods to cross both the Alameda Corridor and the Dominguez Channel in a single tunnel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59. Further evaluation should be completed during the preliminary design phase of the Project to verify this is the preferred crossing. The profile of the proposed crossing is shown on Figure 6-11.

Receiving is recommended from the property west of the Alameda Corridor and south of Sepulveda Boulevard based on available, undeveloped space for portal excavation and contractor staging. Access to the site would be available via the access road on the south side of Sepulveda Boulevard and from the north side of Sepulveda Boulevard via the private parking lot located under the bridge for Sepulveda Boulevard. The potential receiving location is presented on Figure 6-8. Further investigation of the property would be required to finalize portal location and availability.

The proposed pipeline would cross existing railroad tracks twice as the alignment leaves Sepulveda Boulevard to reach the proposed launching site. However, the railroad tracks are fenced off as they cross the driveway to Sepulveda Boulevard and grass has grown over the tracks indicating that the tracks may not be active. Therefore, this FLDR assumed that the pipeline would be constructed across these tracks using cut-and-cover construction methods and that the tracks would be replaced in kind afterwards. Additional investigation into the status of the tracks should be conducted during preliminary design.

The lot east of the Dominguez Channel is recommended for the launching portal. This lot has potentially available space for excavation and contractor staging. The area is currently used as storage. Further investigation of the property would be required to finalize portal location and availability. Construction and easements would have a significant impact on the property, and early real property acquisition is recommended to confirm the alignment.

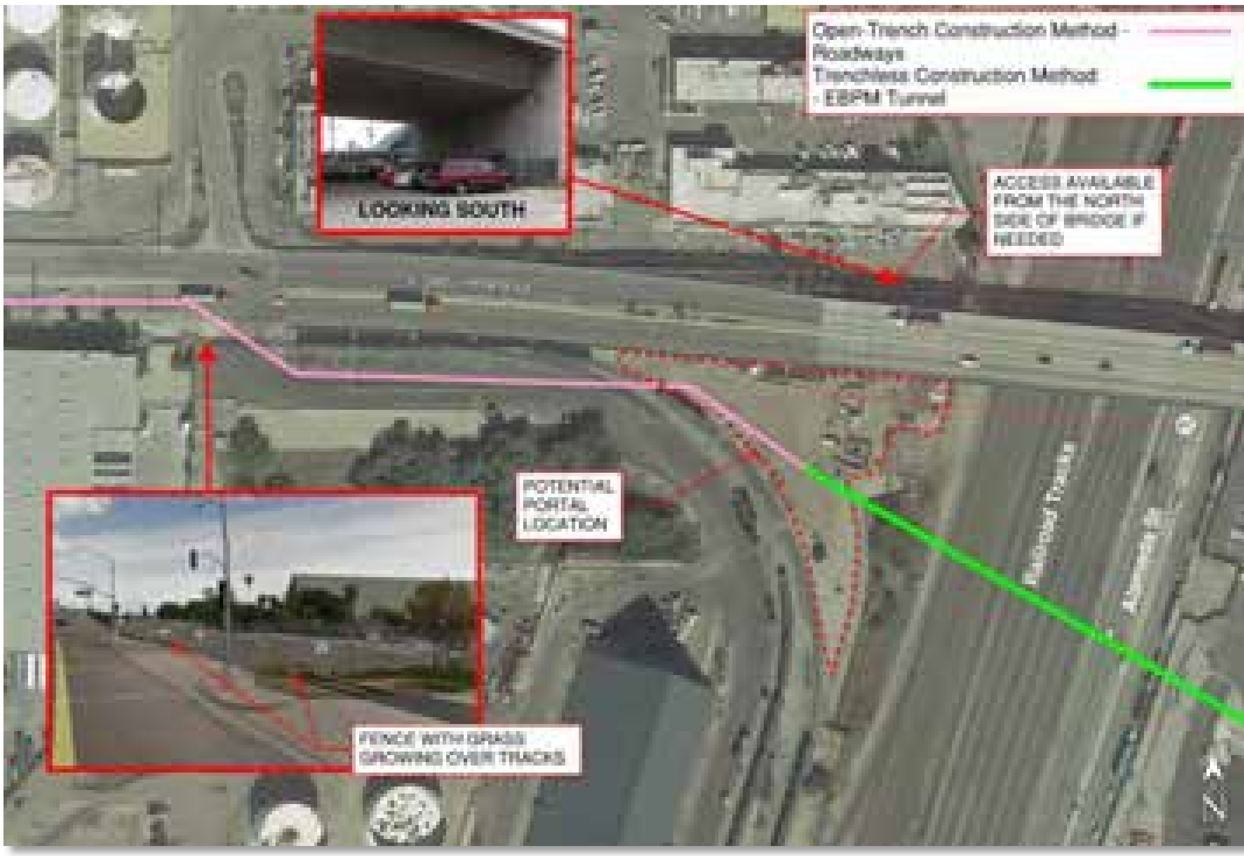
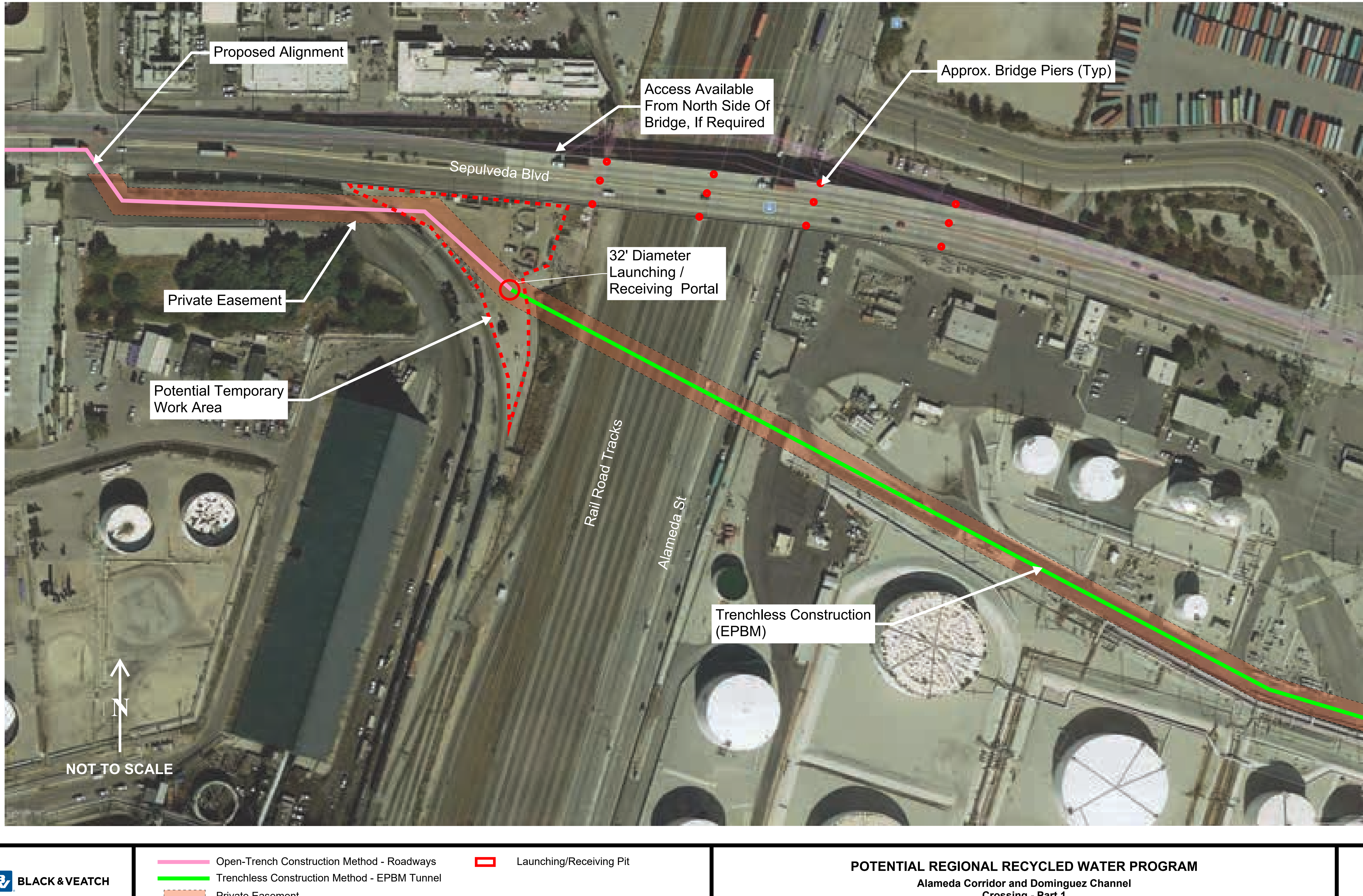


Figure 6-8 **Potential Launching Portal Site for the Alameda Corridor/Dominguez Channel Crossing (Detail Location 1)**

Due to the depth, both the launching and receiving portals are assumed to be circular.

The proposed receiving site is on the corner of an oil refinery that is congested with existing utilities. Potholing would be required to finalize portal location and feasibility. Additionally, Sepulveda Boulevard has many existing utilities that would need to be crossed as the pipe leaves the street to reach the launching and receiving portal locations. The excavation for the pipeline would need to be deep to avoid interferences at these crossings. Utilities anticipated include storm drain, water, telecommunications, sewer, oil, and gas pipes. Potholing to locate the utilities is recommended. Acquisition of temporary and permanent easements would be required.



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POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Alameda Corridor and Dominguez Channel Crossing - Part 1

FIGURE 6-9

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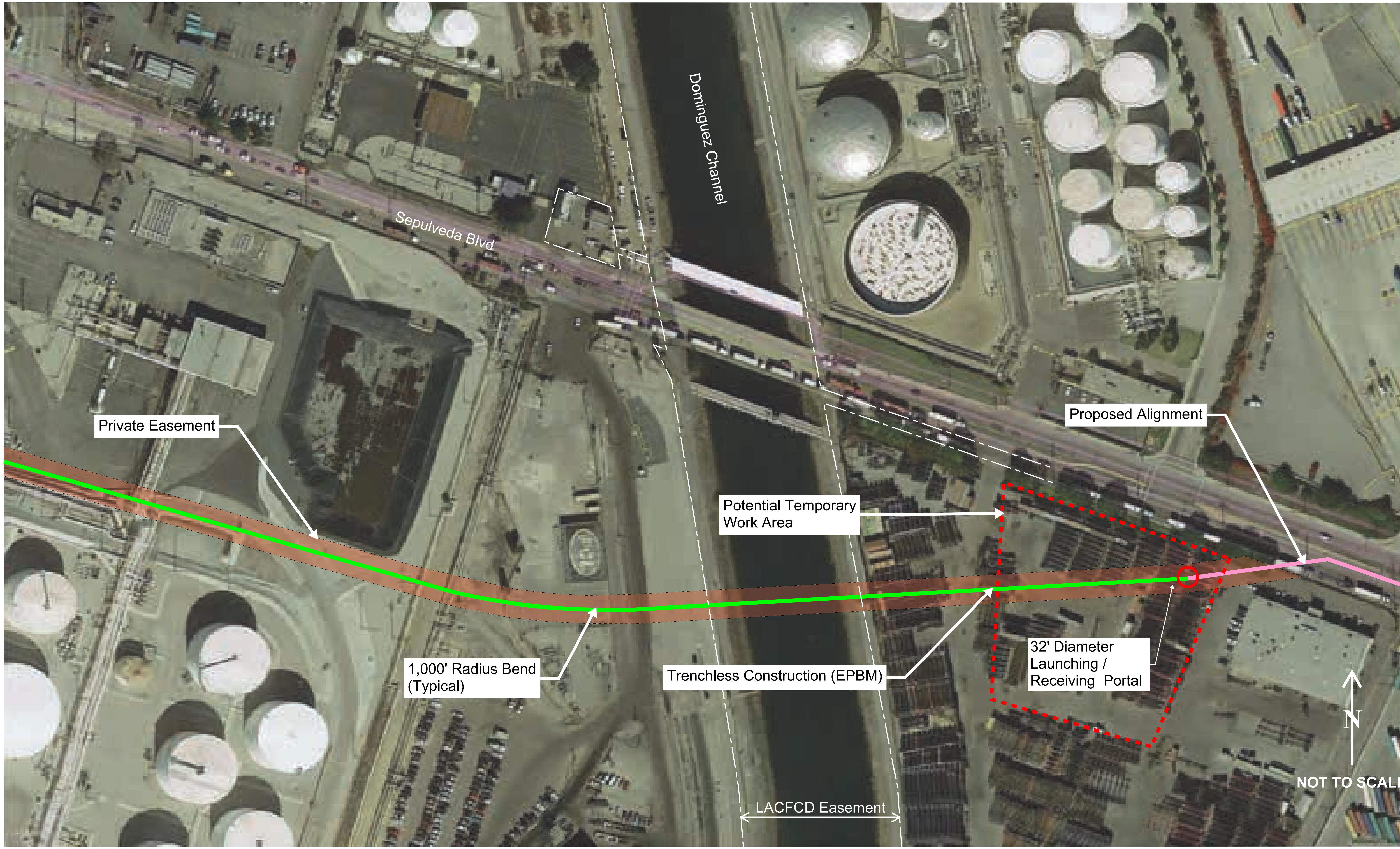

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - EBPM Tunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Alameda Corridor and Dominguez Channel Crossing - Part 2

FIGURE 6-10

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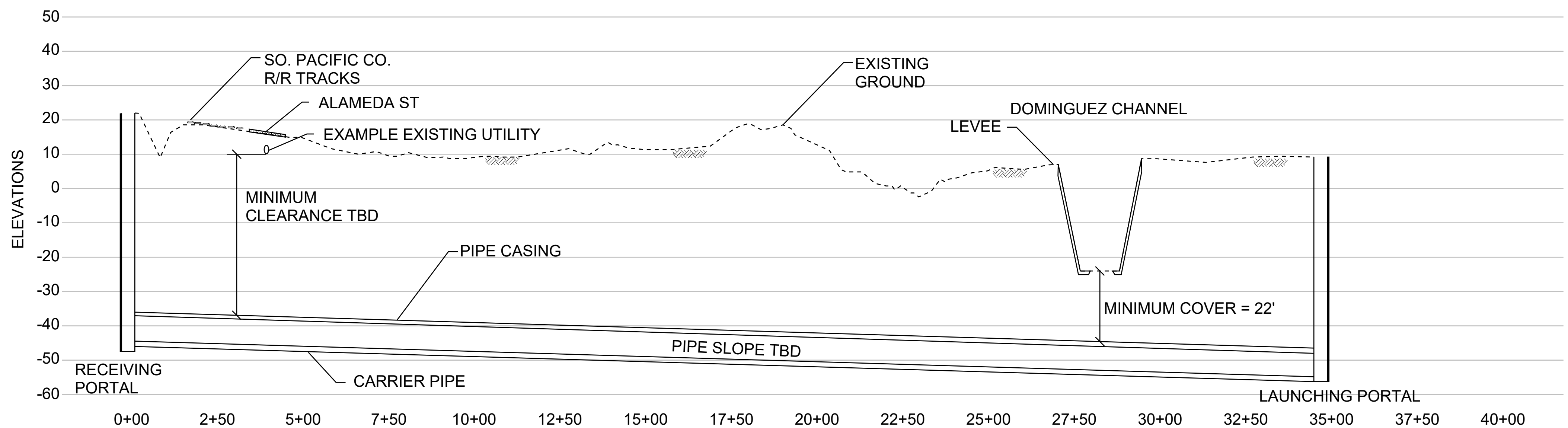

CONVENTIONAL TUNNEL (EPBM) OF ALAMEDA ST AND DOMINGUEZ CHANNEL (1)

HORZ: 1" = 400'
VERT: 1" = 40'

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1" = 200' 0 200' 400' 600' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Alameda Corridor and Dominguez Channel Crossing

FIGURE 6-11

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6.4.8.2 710 Freeway and Los Angeles River Crossing (Detail Location 2)

The SG River Alignment proposes crossing below the 710 Freeway and the Los Angeles River on the south side of Willow St from Reach 1, Sta. 225+38 to Reach 1, Sta. 239+57. Key details of the crossing are provided in Table 6-11. The proposed crossing is shown in plan on Figure 6-12 and in profile on Figure 6-13.

Table 6-11 Summary of the 710 Freeway and Los Angeles River Crossing (Detail Location 2)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,418	River / Freeway	7	11	Yes	MT	Y	N	Y	N	N

Launching is recommended from the west side of the 710 Freeway based upon potentially available space for portal excavation and contractor staging in the vacant lot on the corner of the on/off ramp to the 710 Freeway. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended from the east side of the Los Angeles River in the area between Willow Street and W 25th Way. The property is recommended for the receiving portal due to limited available space and potential impacts to existing trees. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

This drive length may require an intermediate jacking station. Although with good continuously replenished overcut lubrication, it may be possible without one. The MT boring machine is assumed to need disc cutters to fracture any boulders encountered and the shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. While the cover under the LA River is not known at this time, it is assumed that a minimum of 11 ft would be required below the lowest point, with more cover provided along the rest of the route.

Willow Street is congested with existing utilities and the SG River Alignment may require deeper excavation to avoid interferences as it leaves the street to reach the launching and receiving site locations. These utilities include existing storm drains, water, sanitary sewer, oil and gas piping, and telecommunications. Potholing of these utilities is recommended. The vertical profile of the pipeline would rise after reaching its alignment in Willow Street. Additionally, a corridor of existing oil and gas pipes runs parallel to the Los Angeles River on the east side. Potholing of these utilities is also recommended to confirm the location of the receiving portal.

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

710 Freeway and Los Angeles River Crossing

FIGURE 6-12

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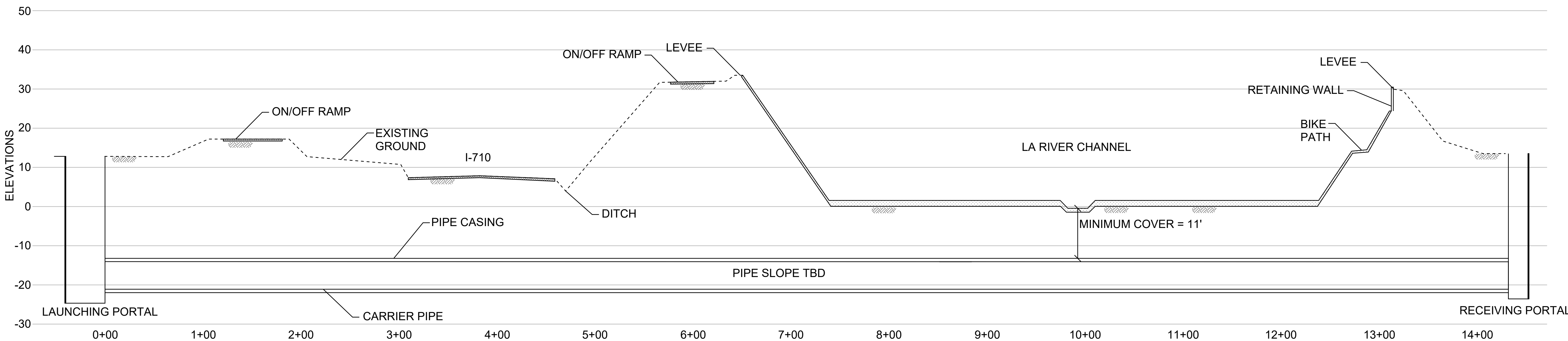

MICROTUNNEL CROSSING OF I-710 AND THE LA RIVER (2)
HORZ: 1" = 50'
VERT: 1" = 12.5'

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1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Profile of 710 Freeway and Los Angeles River Crossing

FIGURE 6-13

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6.4.8.3 SG River Crossing – Los Coyotes Diagonal (Detail Location 3)

The SG River Alignment proposes crossing the SG River at the Los Coyotes Diagonal from Reach 1, Sta. 635+90 to Reach 1, Sta. 645+96 using trenchless construction methods. Key details of the crossing are provided in Table 6-12. The proposed crossing is shown in plan on Figure 6-14 and in profile on Figure 6-15.

Table 6-12 Summary of SG River Crossing at Los Coyotes Diagonal (Detail Location 3)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,006	River	7	18	Yes	MT	Y	N	N	N	N

Launching is recommended from the west side of the river and LADWP easement in the vacant lot at the end of the Los Coyotes Diagonal based upon available, undeveloped space for portal excavation and contractor staging. The Los Coyotes Diagonal dead-ends into the vacant lot with no driveways or other street entrances in the vicinity. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended from the east side of the river in the vacant space between the drainage channel and Centralia Street due to limited available space. Early real property acquisition is recommended to confirm the alignment and acquire access. Temporary and permanent easements are anticipated to be required.

An existing LACSD sewer line follows this same alignment to cross the SG River. Additionally, overhead LADWP and SCE transmission line corridors run parallel to the SG River. No other utilities are anticipated. Potholing of the LACSD sewer is recommended to confirm the alignment.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

This FLDR assumed that this crossing would span across the LADWP transmission corridor, SG River, multi-use trails, linear parks, SCE transmission corridor, and concrete drainage channel in one continuous trenchless segment with a launching and receiving portal on either end. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders and construction staff, to determine if the crossing could be made with two shorter tunnels and cut-and-cover construction through the remaining green space.

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Los Coyotes Diagonal

FIGURE 6-14

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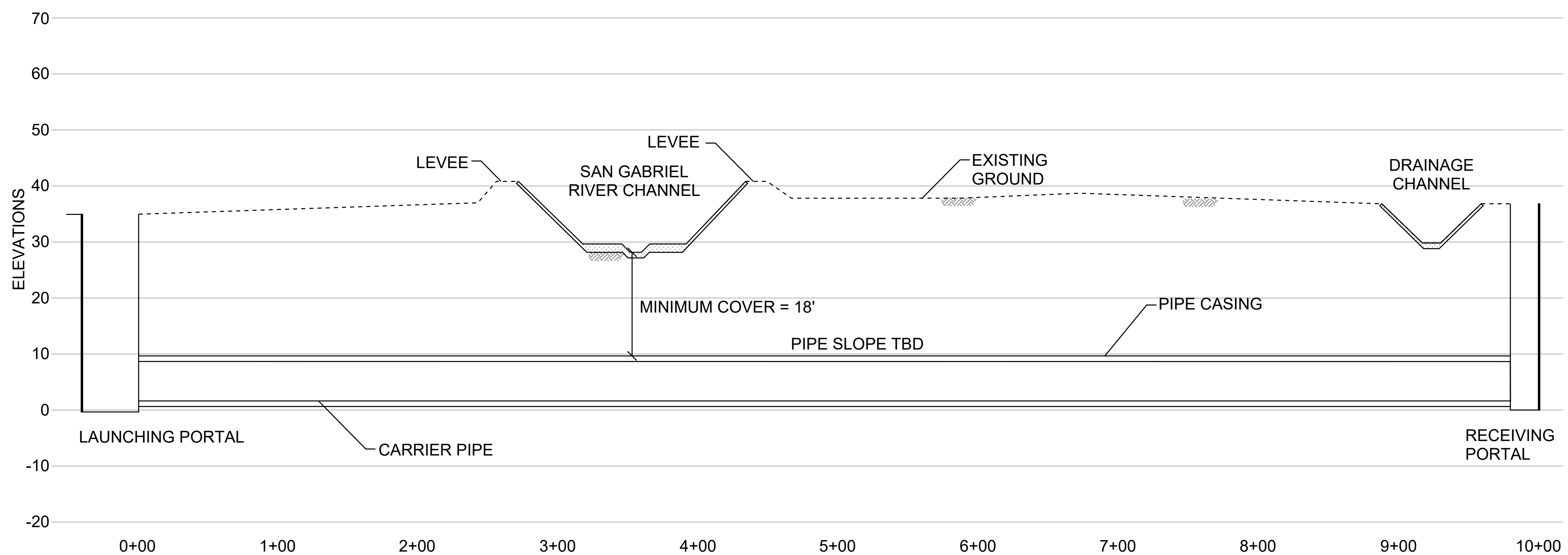

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT LOS COYOTES DIAGONAL 3

HORZ: 1" = 50'
VERT: 1" = 12.5'

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1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Los Coyotes Diagonal

FIGURE 6-15

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6.4.8.4 91 Freeway Crossing (Detail Location 4)

While traveling in the SCE and LACFCD easements parallel to the east side of the SG River, the SG River Alignment proposes crossing the 91 Freeway from Reach 3, Sta. 808+30 to Reach 3, Sta. 814+10 using trenchless construction methods. Key details are provided in Table 6-13. The proposed crossing is shown in plan on Figure 6-16 and in profile on Figure 6-17.

Table 6-13 Summary of 91 Freeway Crossing (Detail Location 4)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
580	Freeway	7	11	Yes	MT	Y	N	N	N	N

Launching is recommended from the north side of the freeway based upon potentially available space for portal excavation and contractor staging in the corner of the golf course located within SCE and LACFCD's easements. Construction would directly impact a minimum of one hole on the golf course and construction access could impact additional holes. Further investigation of the property would be required to finalize portal location and availability.

The receiving portal is recommended on the south side of the freeway due to limited available space between an existing long-term storage unit facility and the overhead SCE transmission lines. The recommended receiving portal location is currently used as long-term storage for recreational vehicles (RVs), trucks, and boats in the SCE easement and is directly adjacent to an existing long-term storage unit facility in the LACFCD easement. Construction and easements would have a significant impact on both the launching and receiving properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

No underground utilities would be anticipated to impact this crossing. However, the alignment is located parallel to a SCE transmission line corridor and overhead utilities could impact construction activities.

An inactive railroad corridor is located immediately south of the proposed trenchless construction segment. Additional investigations and coordination with the owner of the railroad corridor would be required in subsequent design phases to confirm this crossing.

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

91 Freeway Crossing

FIGURE 6-16

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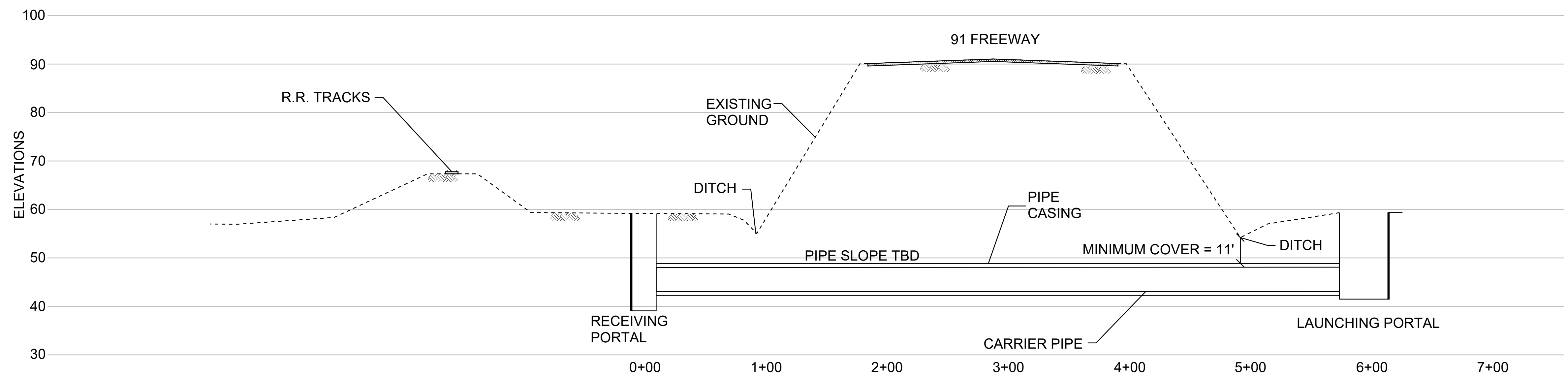

MICROTUNNEL CROSSING OF 91 FREEWAY

4

HORZ: 1" = 50'
VERT: 1" = 12.5'

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1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 91 Freeway Crossing

FIGURE 6-17

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6.4.8.5 SG River Crossing - Alondra Boulevard (Detail Location 5)

Traveling parallel to the SG River, the SG River Alignment proposes crossing from the SCE easement on the east side of the SG River to the west side from Reach 3, Sta. 841+37 to Reach 3, Sta. 844+07 using trenchless construction methods. The alignment would then cross under Alondra Boulevard in the SCE easement. Key details of the crossing are provided in Table 6-14. The proposed crossing is shown in plan on Figure 6-18 and in profile on Figure 6-19.

Table 6-14 Summary of SG River Crossing (Detail Location 5)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
270	River	7	11	Yes	MT	Y	N	N	N	N

Launching for the trenchless construction is recommended from the east side of the river based upon potentially available space for portal excavation and contractor staging. The land is used to store transportable property such as RVs, trucks, and boats. Further investigation of the property would be required to finalize portal location and availability. The receiving portal is recommended on the west side of the river due to limited available space between the SG River, a LACSD sewer pipe, and a concrete drainage channel. The area also contains a short, multi-use trail. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

An existing LACSD sewer pipe runs parallel to the SG River and the proposed alignment and crosses under Alondra Boulevard. The alignment would cross the LACSD sewer pipe just prior to crossing under Alondra. Additionally, a LACFCD storm drain connects to the drainage channel in the vicinity of the proposed receiving portal location. Potholing would be required to finalize portal and alignment locations and feasibility.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

In subsequent phases of design, should the land west of the SG River and south of Alondra Boulevard prove to be infeasible for the construction of the alignment for any reason (from property acquisition or otherwise), it would be feasible to cross under the SG River and Alondra Boulevard in one continuous tunnel. Additional details on the bridge abutment for Alondra would need to be collected.

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit
Trenchless Construction Method - Jack & Bore w/ Dewatering

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Alondra Boulevard

FIGURE 6-18

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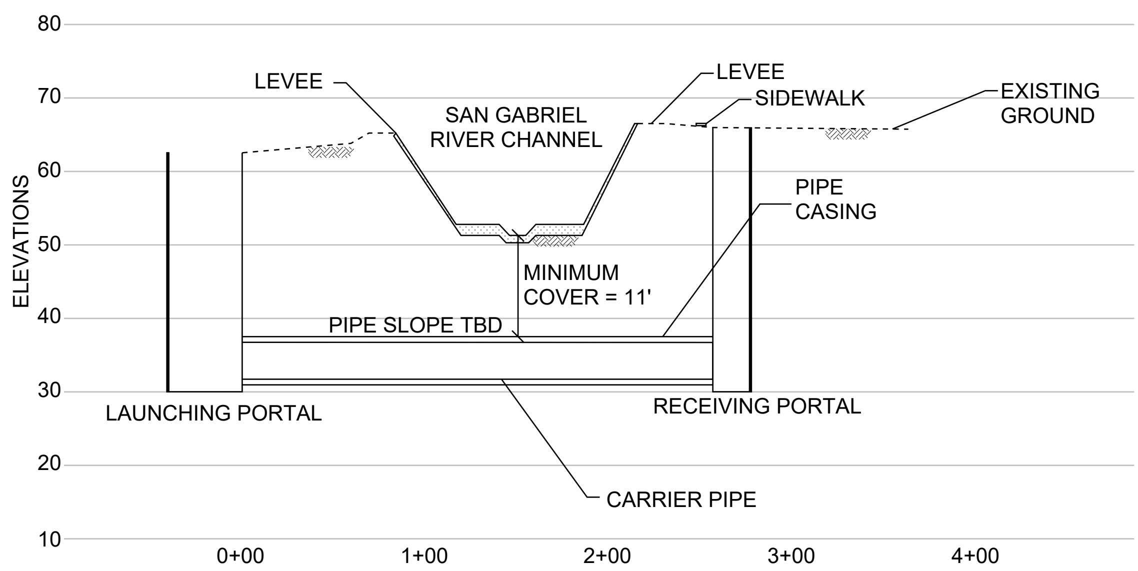

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT ALONDRA BOULEVARD 5

HORZ: 1" = 50'
VERT: 1" = 12.5'

1" = 50' 0 50' 100' 150' FEET

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Alondra Boulevard

FIGURE 6-19

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6.4.8.6 SG River Crossing - Whittier Boulevard (Detail Location 6)

The SG River Alignment proposes using trenchless construction methods from Reach 3, Sta. 1291+00 to Reach 3, Sta. 1328+34 during which the pipeline would cross Whittier Boulevard, the SG River, railroad tracks, and travel parallel to the SG River in the space between the river levee and the adjacent railroad tracks. The FLDR conservatively assumed that this section would be constructed using trenchless methods due to the narrow space between the river levee and the railroad corridor for construction activities. Additionally, overhead utility poles are present for part of this segment to further limit the available construction space. Key details of the crossing are provided in Table 6-15. The proposed crossing is shown in plan on Figure 6-20 and Figure 6-21 and in profile on Figure 6-22 through Figure 6-24.

Table 6-15 Summary of SG River Tunnel and 605 Freeway Crossing (Detail Location 6)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
3,734	River / Railroad	7	22	Yes	EPBM	Y	N	N	N	N

Launching is recommended from north of the railroad tracks east of the river due to potentially available space for portal excavation and contractor staging. The area is undeveloped and appears unused in LACFCD's easement. Additional space is potentially available for contractor staging in the existing storage lot for transportable property such as RVs, trucks, and boats in SCE's easement adjacent to the site. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended on the west side of the river, south of Whittier Boulevard due to limited available space next to LACFCD's recharge basins. Construction and easements could impact LACFCD operations on the west property and early real property acquisition is recommended to confirm the alignment and acquire access.

Due to the depth, the receiving portal is assumed to be circular. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

The west side of the SG River has several existing LACFCD storm drains and a LACSD sewer pipe that the alignment would cross. An existing LACSD sewer pipe travels parallel to the alignment near the proposed launching site on the north end and would be crossed by the alignment twice. Potholing is recommended to confirm the alignment and portal location. Acquisition of temporary and permanent easements would be required

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Open-Trench Construction Method - LACFCD Easement (River Bank)

Trenchless Construction Method - EPBM

Launching/Receiving Pit

Private Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Whittier Boulevard – Part 1

FIGURE 6-20

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - EPBM
Launching/Receiving Pit
Private Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
San Gabriel River Crossing at Whittier Boulevard – Part 2

FIGURE 6-21

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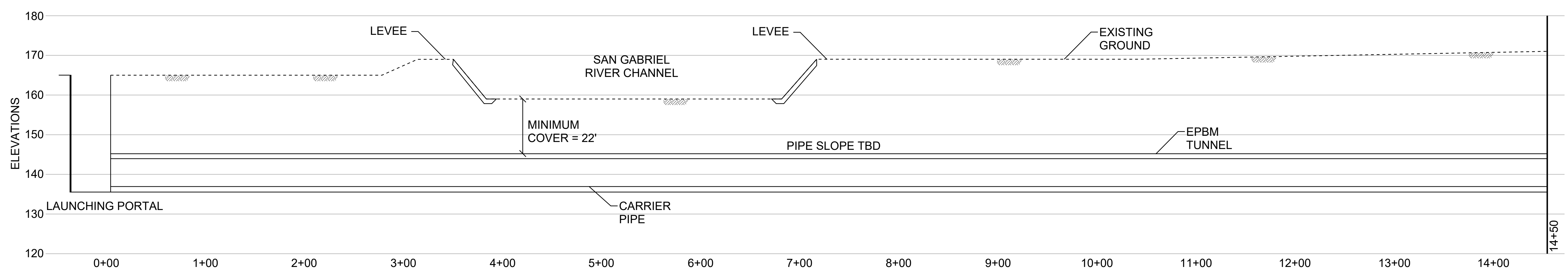

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD 6.1

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Whittier Boulevard – Part 1

FIGURE 6-22

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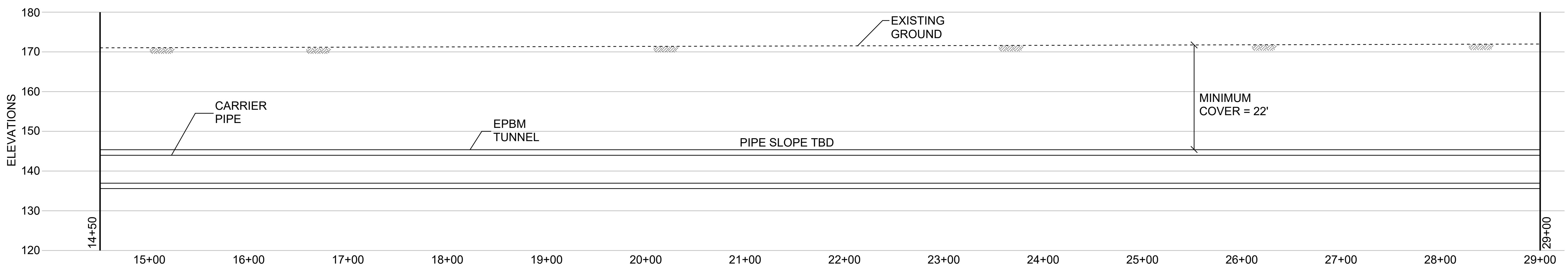

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD 6.2
HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Whittier Boulevard – Part 2

FIGURE 6-23

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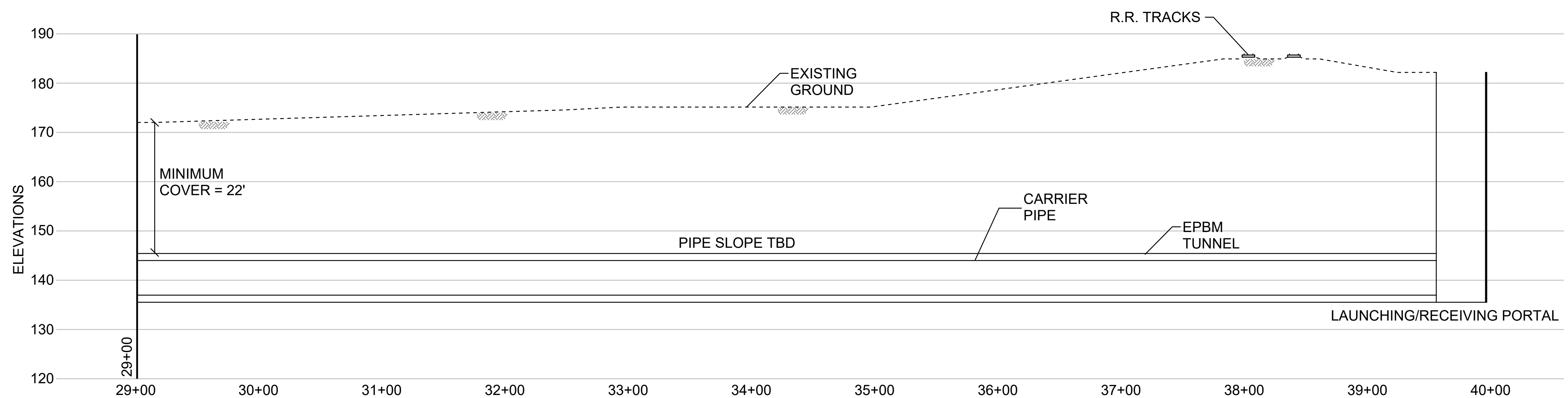

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD 6.3
HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Profile of San Gabriel River Crossing at Whittier Boulevard – Part 3

FIGURE 6-24

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6.4.8.7 Walnut Creek Wash Crossing (Detail Location 7)

The SG River Alignment proposes crossing below the Walnut Creek Wash north of Valley Blvd from Reach 4, Sta. 1652+73 to Reach 4, Sta. 1669+04 using trenchless construction methods. Key details of the crossing are provided in Table 6-16. The proposed crossing is shown in plan on Figure 6-25 and in profile on Figure 6-26.

Table 6-16 Summary of Walnut Creek Wash Crossing (Detail Location 7)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,631	River	7	18	Yes	MT	Y	N	Y	N	N

Launching is recommended south of railroad tracks due to potentially available space for portal excavation and contractor staging. The trenchless construction segment would cross under Union Pacific Rail Road and Southern California Regional Rail Authority property, which would require tunnel easements. Further investigation of the property would be required to finalize portal location and availability. The receiving portal is recommended on the northern side of the river due to the proximity of over-head powerlines and transmission towers.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

Potholing is recommended to confirm the portal and alignment locations. Additional utility information should be gathered in this area during subsequent phases of design. Acquisition of temporary and permanent easements would be required.

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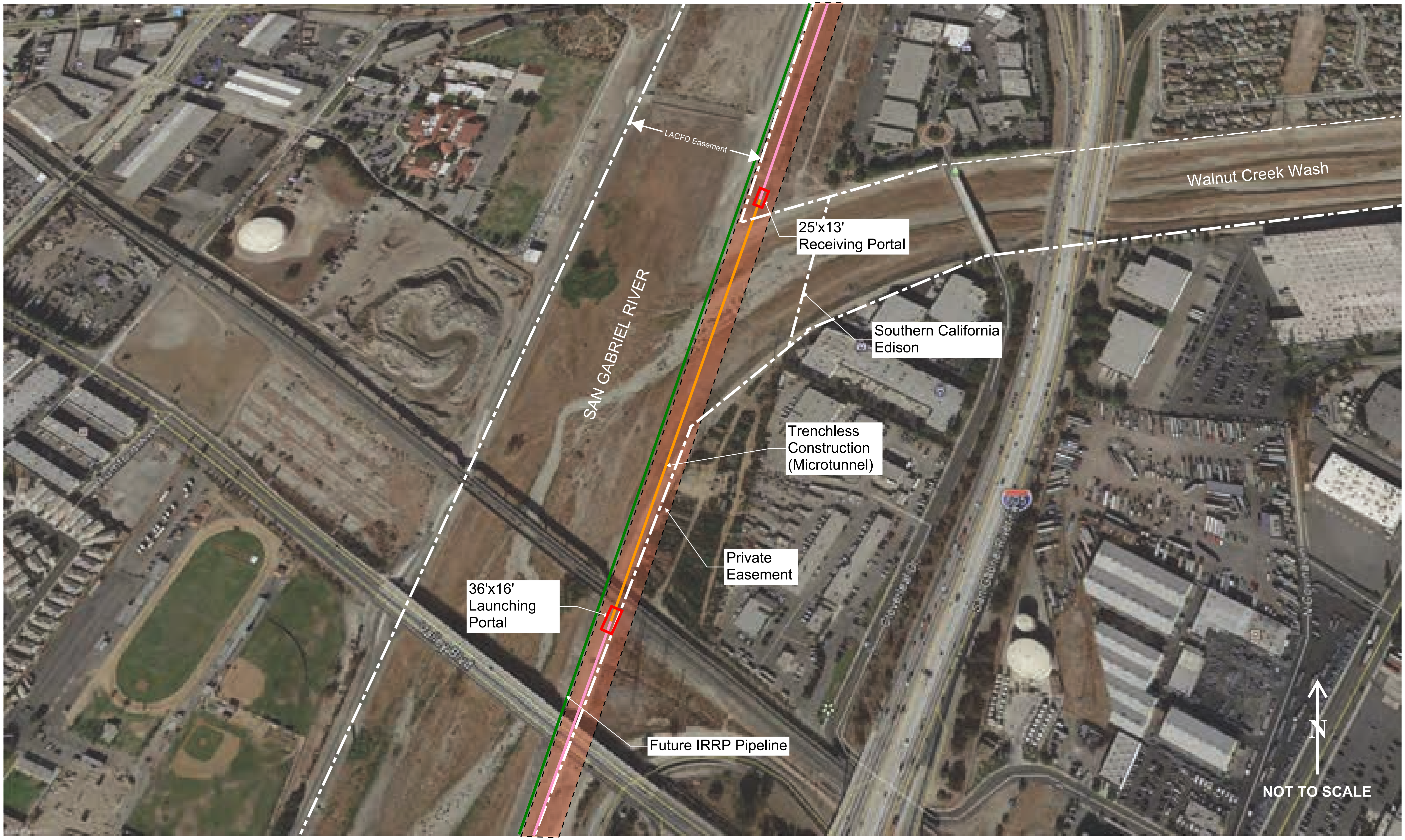

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Walnut Creek Wash Crossing

FIGURE 6-25

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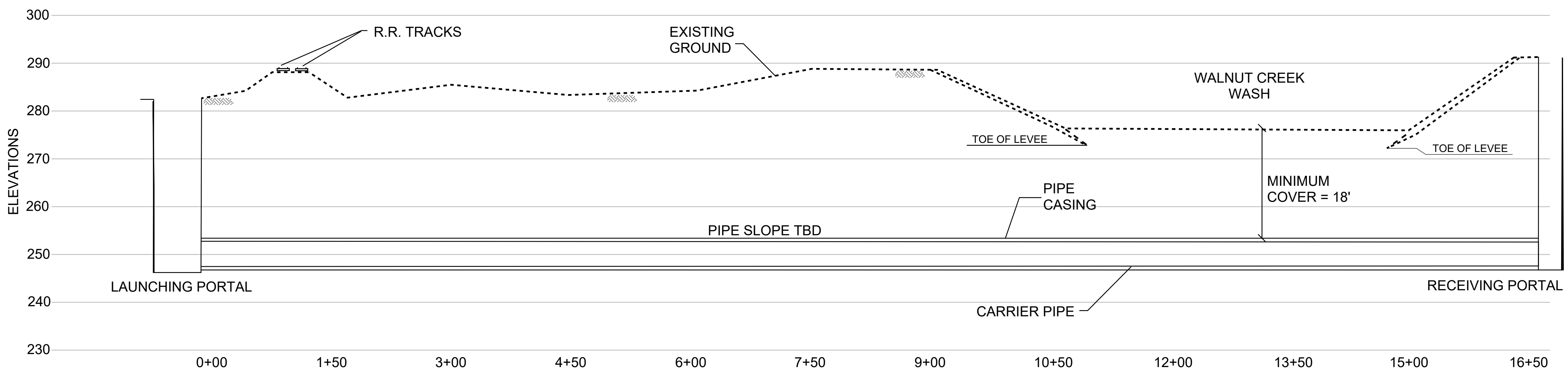

MICROTUNNEL CROSSING OF WALNUT CREEK WASH

HORZ: 1" = 50'

VERT: 1" = 12.5'

7

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Walnut Creek Wash Crossing

FIGURE 6-26

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6.4.8.8 SG River Crossing – Live Oak Ave (Detail Location 8)

The SG River Alignment proposes crossing below the SG River north of Live Oak Avenue from Reach 4, Sta. 1871+00 to Reach 4, Sta. 1876+28 using trenchless construction methods. Key details of the crossing are provided in Table 6-17. The proposed crossing is shown in plan on Figure 6-27 and in profile on Figure 6-28.

Table 6-17 Summary of SG River Crossing at Live Oak Ave (Detail Location 8)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
528	River	7	11	Yes	MT	Y	N	Y	N	N

This FLDR assumed launching would be accomplished from the east side of the creek due to potentially available space for portal excavation and contractor staging in the west lanes of Rivergrade Road. Should the impact to the property on the west side of the river be determined to be less during preliminary design, then the launching portal could be moved to the west side of the river. Further investigation of the property would be required to finalize portal location and availability. The receiving portal and subsequent alignment on the west side of the river would be located in the corner of the facility to reduce the impact to the property. Even with mitigation, construction and easements would still have significant impacts on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Utility information has not been collected along the alignment in this area. During subsequent phases of design additional utility information should be collected and the location of the alignment and excavation portals verified. Utilities anticipated in roads the size of Live Oak Avenue and Rivergrade Road include storm drain, water, telecommunications, sewer, and oil and gas pipes, and potholing is recommended to verify the alignment and excavation portals. However, on the east side of the crossing, the alignment would pass near visible storm drain outlets in the SG River. The underground alignment of the storm drain piping is unknown at this time and may require relocation or deeper excavation to avoid. Potholing would be required to finalize portal location and feasibility.

Acquisition of temporary and permanent easements would be required.

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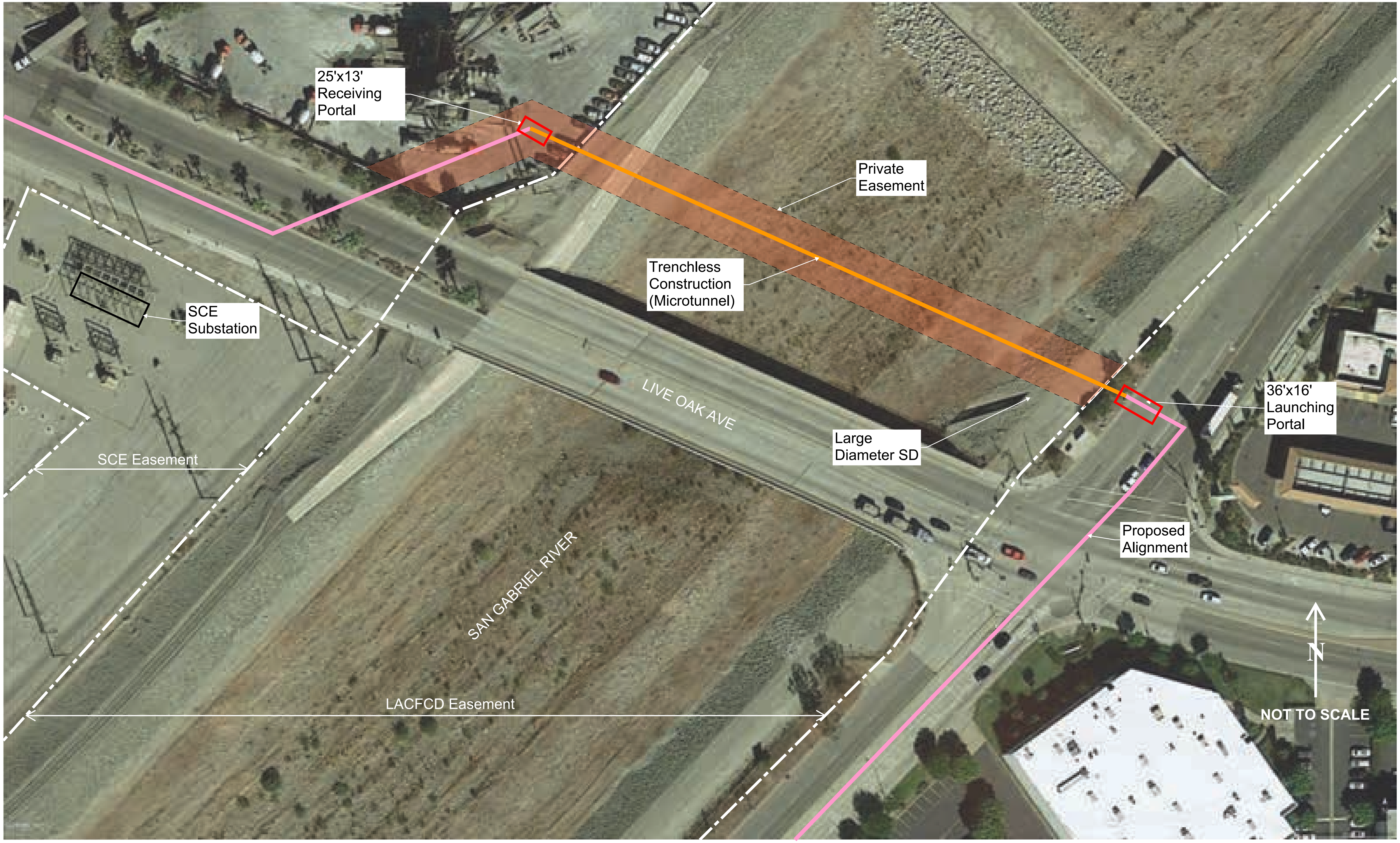

BLACK & VEATCH

Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
San Gabriel River Crossing at Live Oak Ave

FIGURE 6-27

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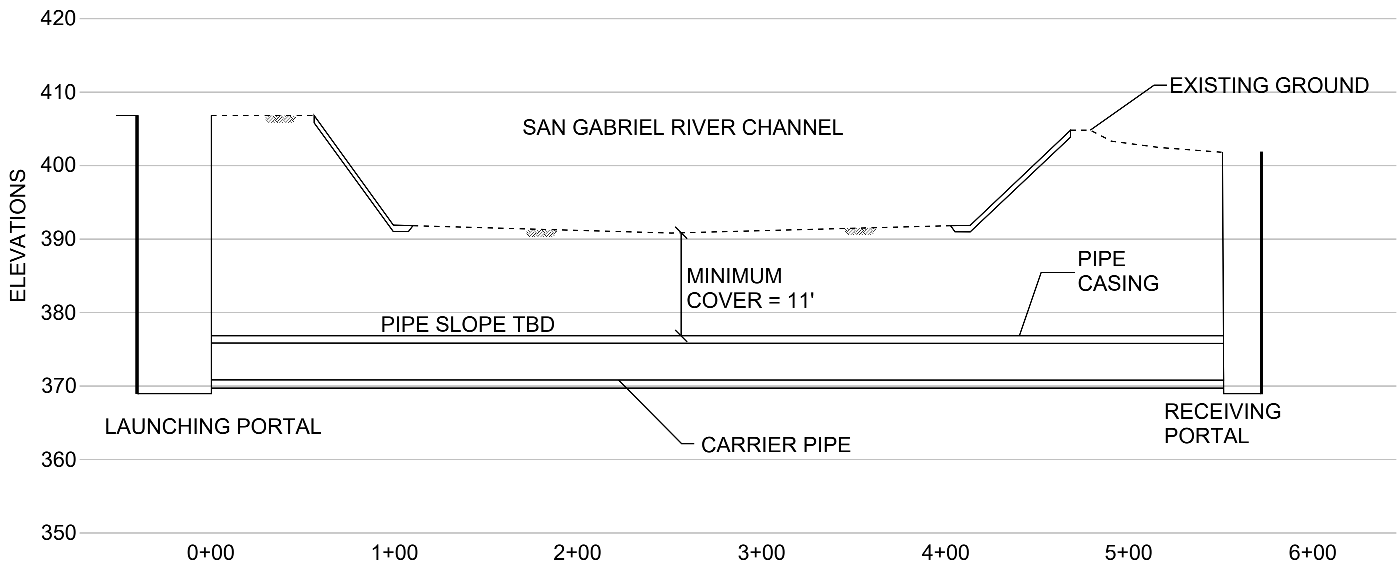

MICROTUNNEL CROSSING OF SAN GABRIEL RIVER

8

HORZ: 1" = 50'
VERT: 1" = 12.5'

1" = 50' 0 50' 100' 150' FEET

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Live Oak Ave

FIGURE 6-28

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6.4.8.9 Arrow Highway and 605 Freeway Crossing (Detail Location 9)

The SG River Alignment would cross below the 605 Freeway. Key details of the crossing are provided in Table 6-18. The proposed crossing is shown in plan on Figure 6-29 and in profile on Figure 6-30.

Table 6-18 Summary of Arrow Highway and 605 Freeway Crossing (Detail Location 9)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
508	Freeway	7	18	No	MT	Y	N	Y	N	N

Launching is recommended from the north side of the freeway based upon available, undeveloped space for portal excavation and contractor staging. The portal is proposed on the access road on the bank of the Santa Fe Diversion Channel. Early real property acquisition is recommended to confirm the alignment and acquire access.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

The alignment would cross Arrow Highway parallel to five LACFCD culverts and cross the 605 Freeway parallel to a single large diameter culvert/tunnel in the Santa Fe Diversion Channel. No other utilities are anticipated at this crossing. Potholing would be required to finalize the alignment and portal location and feasibility. Acquisition of temporary and permanent easements would be required.

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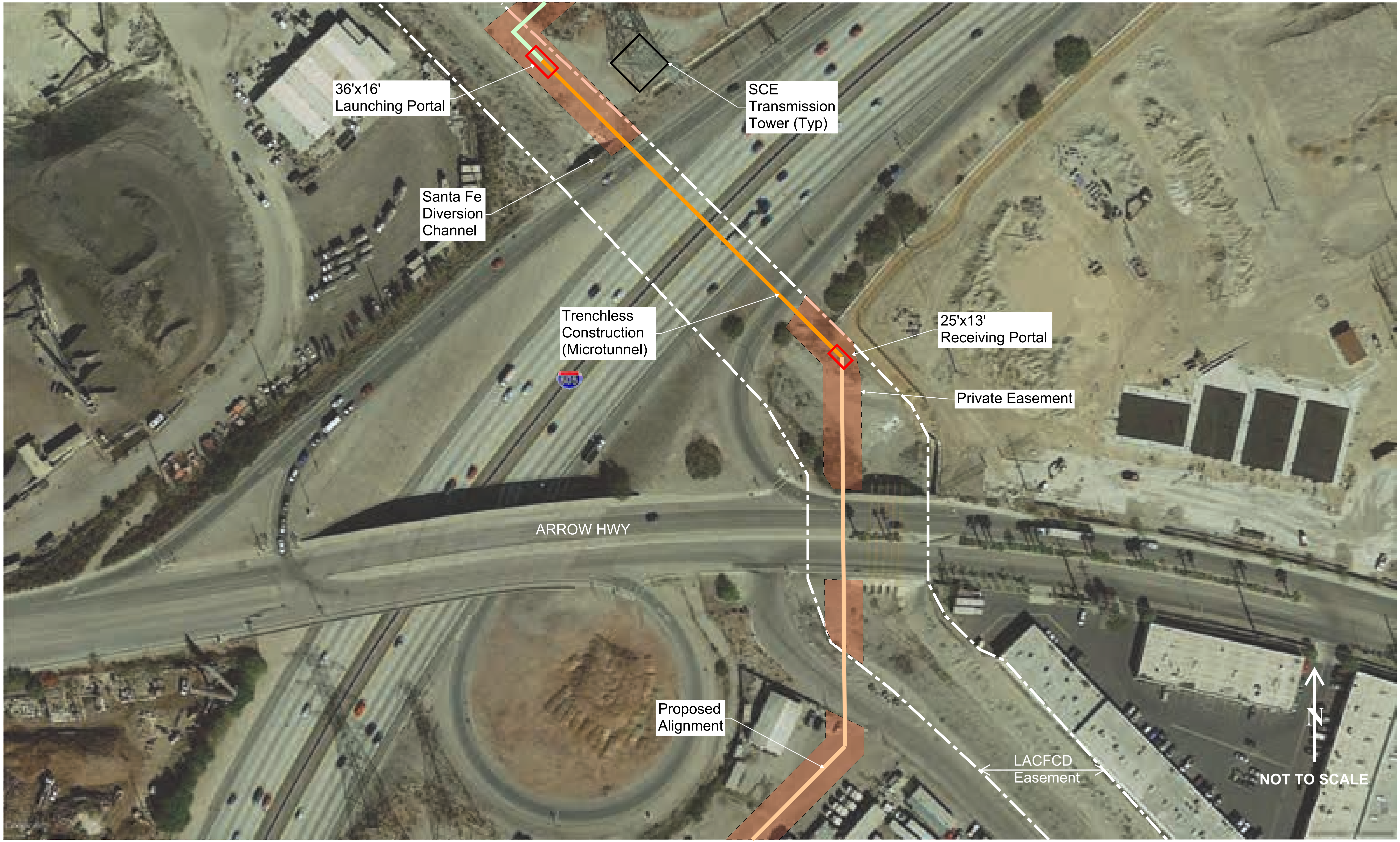

BLACK & VEATCH

Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit
Open-Trench Construction Method - LACFCD Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Arrow Highway and 605 Freeway Crossing

FIGURE 6-29

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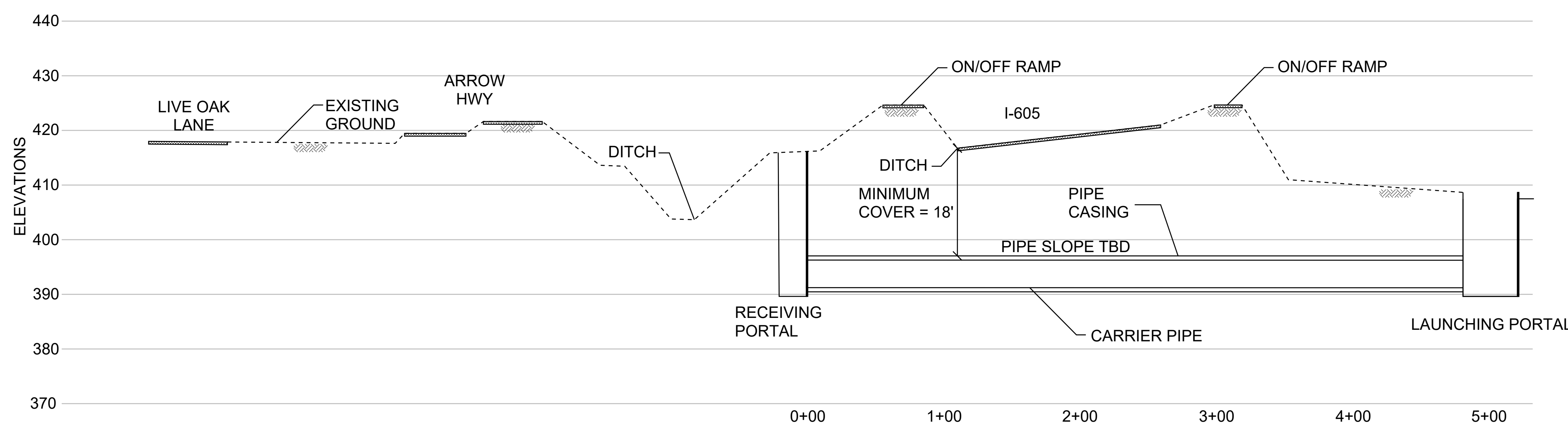

MICROTUNNEL CROSSING OF ARROW HWY AND I-605

HORZ: 1" = 50'
VERT: 1" = 12.5'

9

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Arrow Hwy and 605 Freeway Crossing

FIGURE 6-30

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6.4.9 Preliminary Alignment Cross-Sections

Utilizing GIS mapping and right-of-way information, feasibility-level alignment cross-sections were developed to depict the approximate location of the SG River Alignment relative to known major utilities and key surface features. The proposed location of the SG River Alignment was developed based on extensive research of existing utilities based on above grade features and available utility maps. The cross-sections are graphical in nature and are not intended to represent design-level detail. However, the alignment does reflect a general corridor that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. Additional utility investigations, including subsurface investigations, will be completed during subsequent design phases and the alignment is anticipated to be adjusted accordingly.

Since the SG River Alignment would traverse long stretches of existing streets with utilities varying in location, no “typical” section is provided to represent the location of the pipeline along the entire alignment. Instead, the alignment attempts to account for the presence of existing utilities and constructability concerns at each specific location. The representative cross-sections at key corridors are identified in Table 6-19 and presented on Figure 6-31 thru Figure 6-40. Figure 6-7 presents the location of each representative cross-section.

Table 6-19 Preliminary Alignment Cross-Section Locations

NO.	STATION	DESCRIPTION
1	Reach 1, Sta. 008+50	Main Street facing north.
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.
3	Reach 1, Sta. 214+00	Willow Street facing east.
4	Reach 1, Sta. 253+00	Willow Street facing east.
5	Reach 1, Sta. 308+50	Willow Street facing east.
6	Reach 1, Sta. 346+00	Willow Street facing east.
7	Reach 1, Sta. 624+00	Los Coyotes Diagonal facing northeast.
8	Reach 3, Sta. 946+00	LACFCD easement facing north.
9	Reach 4, Sta. 1523+00	SCE easement facing north.
10	Reach 4, Sta. 1883+00	Live Oak Avenue facing southeast.

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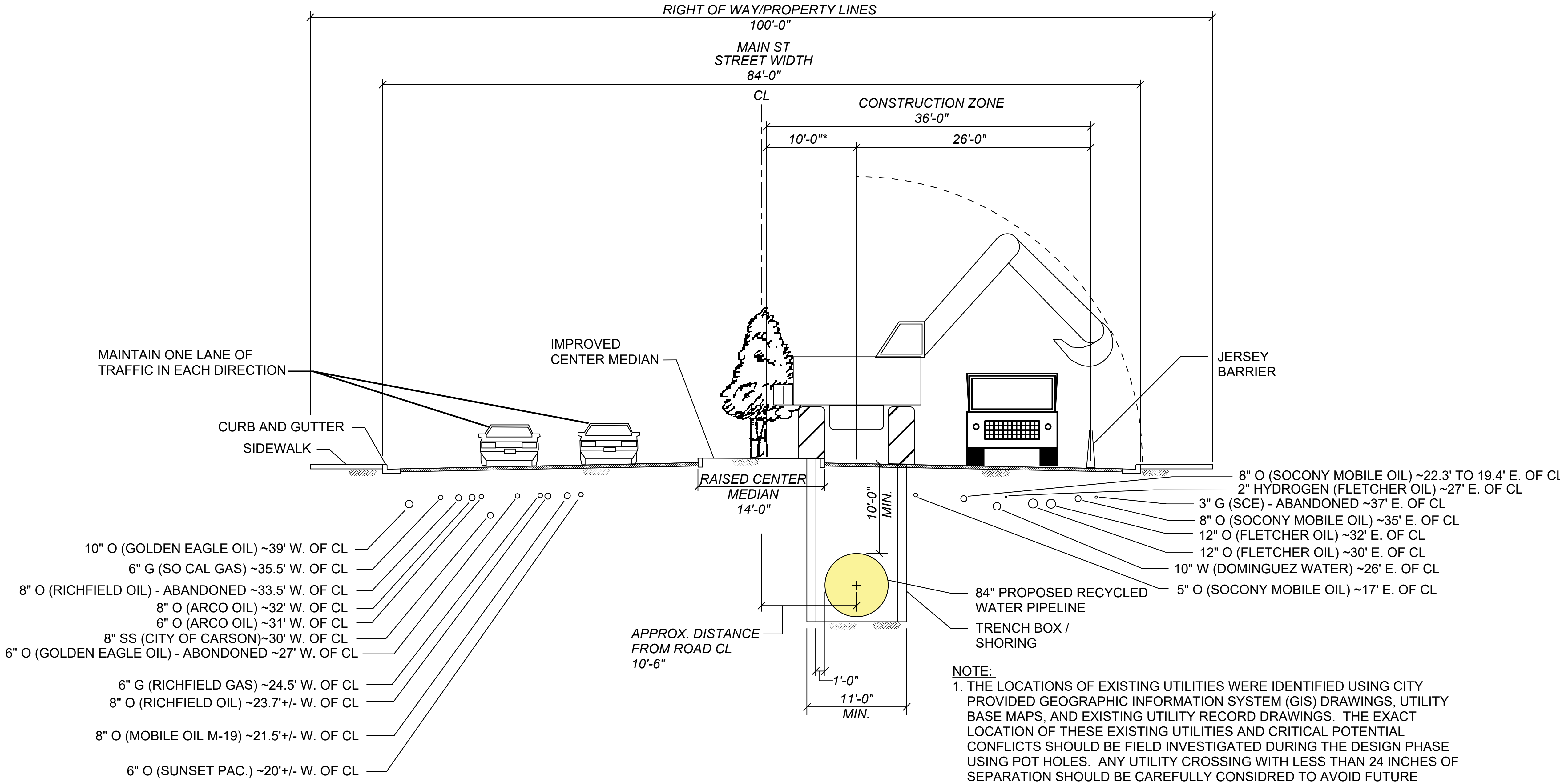

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 1 / -

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-300

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 1 – MAIN STREET FACING NORTH (REACH 1, STA 008+50)

FIGURE 6-31

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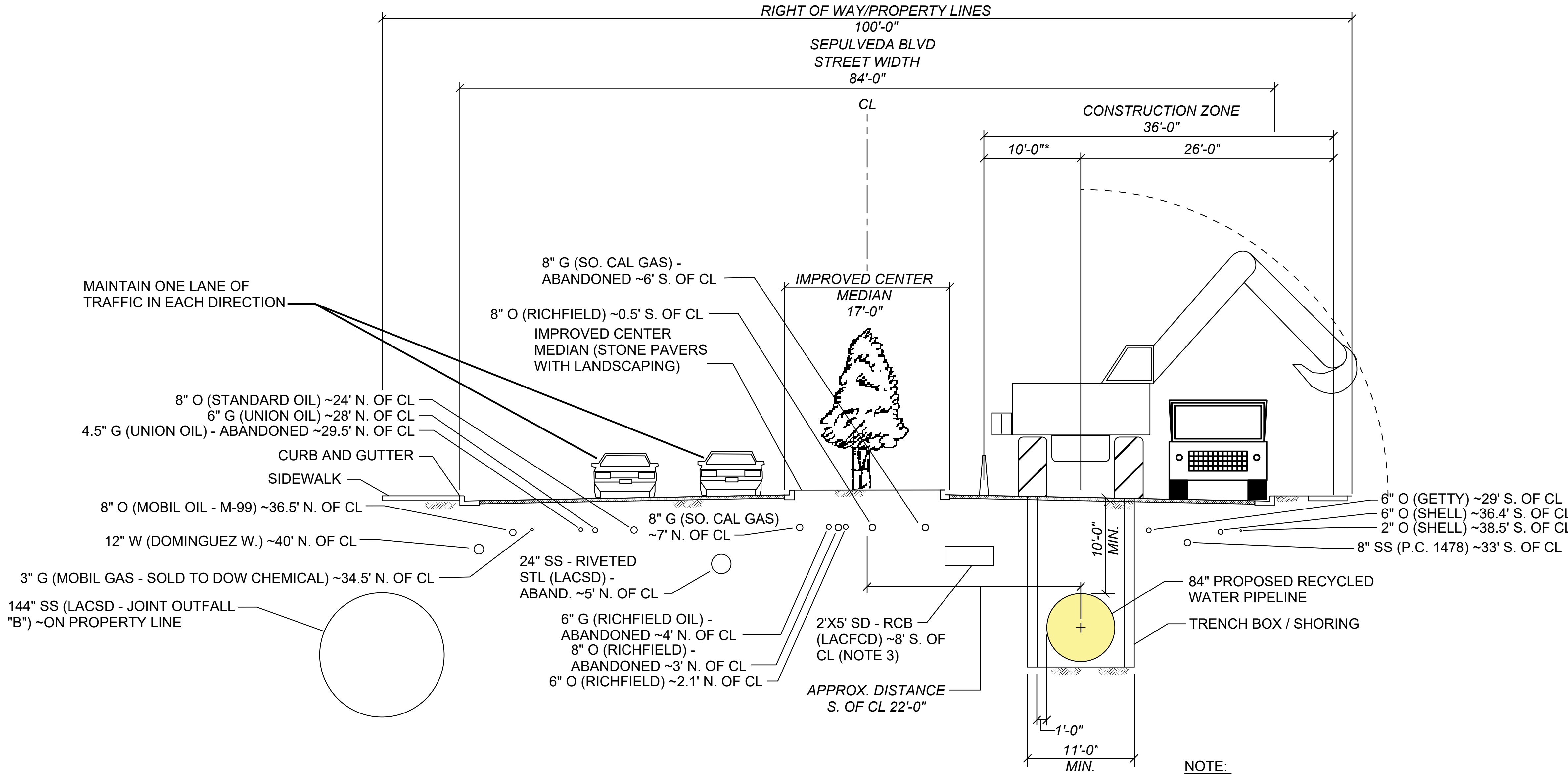

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. LOCATED IN STREET FOR APPROXIMATELY 550'.

CROSS SECTION 2 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-291

NOTE:
** WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH	0 5 10 15 FEET	**POTENTIAL REGIONAL RECYCLED WATER PROGRAM** **PRELIMINARY ALIGNMENT CROSS-SECTION 2 –** **SEPULVEDA BLVD FACING EAST (REACH 1, STA 070+00)**	**FIGURE 6-32**

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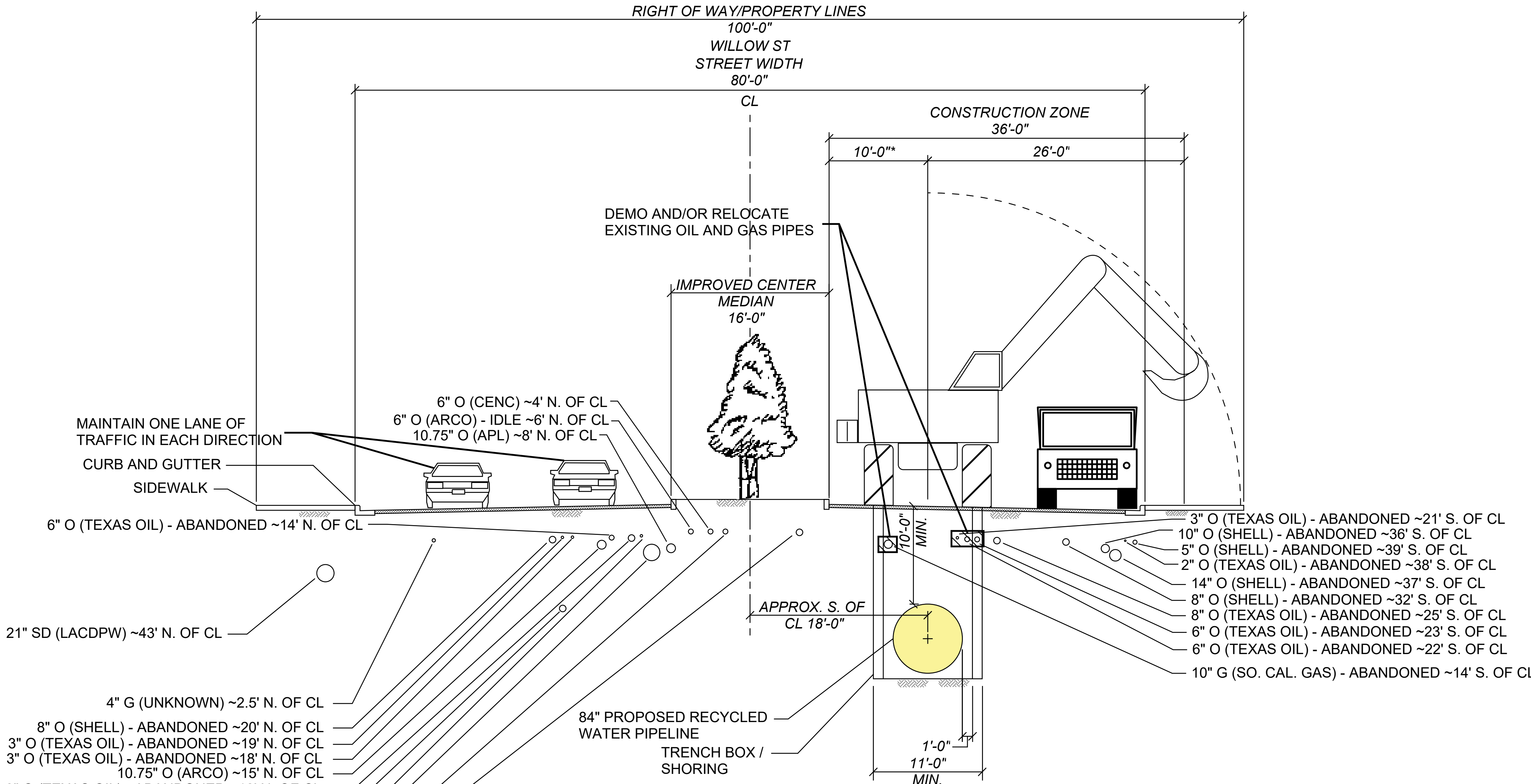

CROSS SECTION 3
NO SCALE -

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-307
- CITY OF LONG BEACH GIS DATA

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 3 – WILLOW ST FACING EAST (REACH 1, STA 214+00)

FIGURE 6-33

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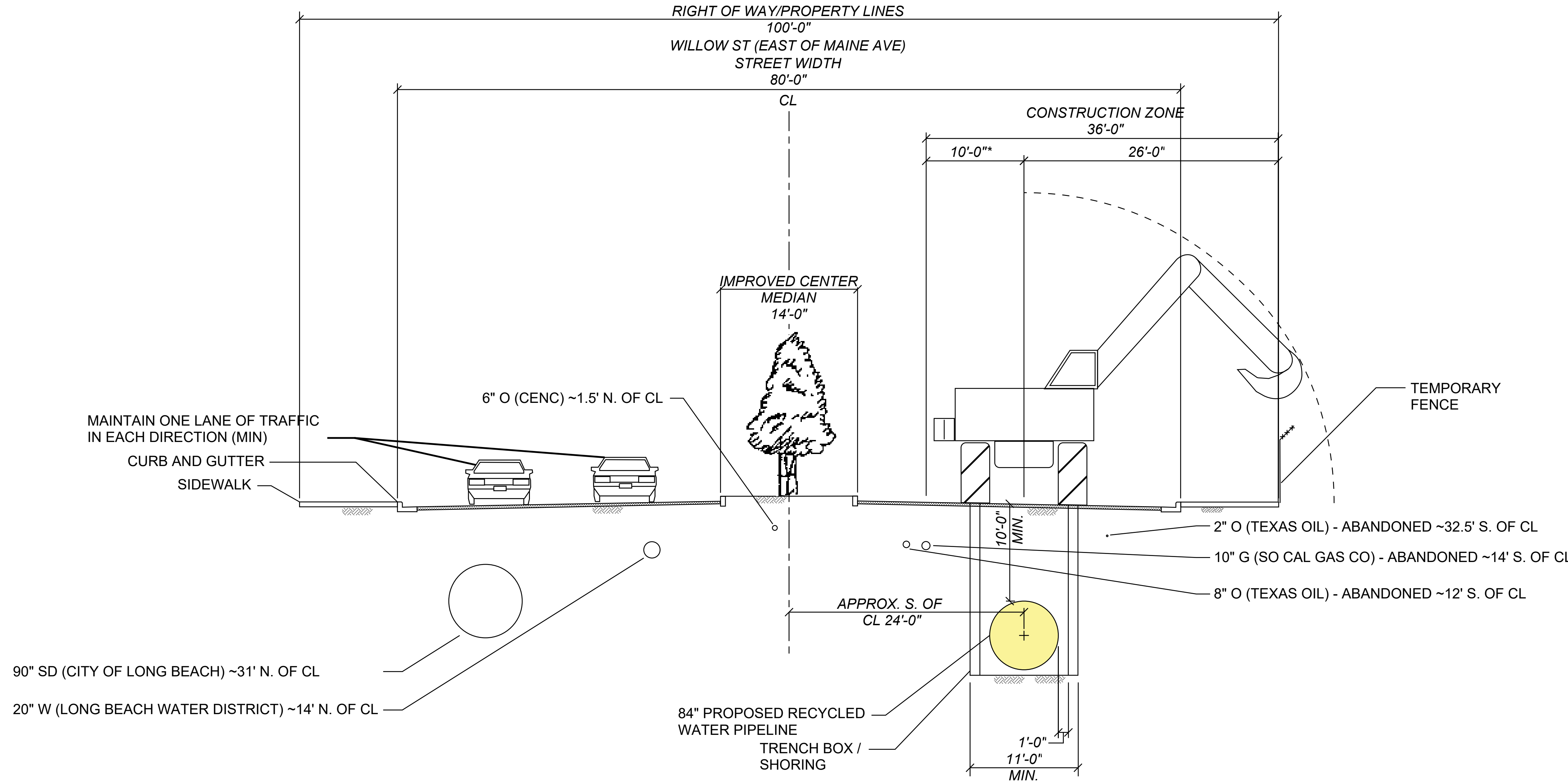

CROSS SECTION 4 -

NO SCALE

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-307
- CITY OF LONG BEACH GIS DATA

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 4 – WILLOW ST FACING EAST (REACH 1, STA 253+00)

FIGURE 6-34

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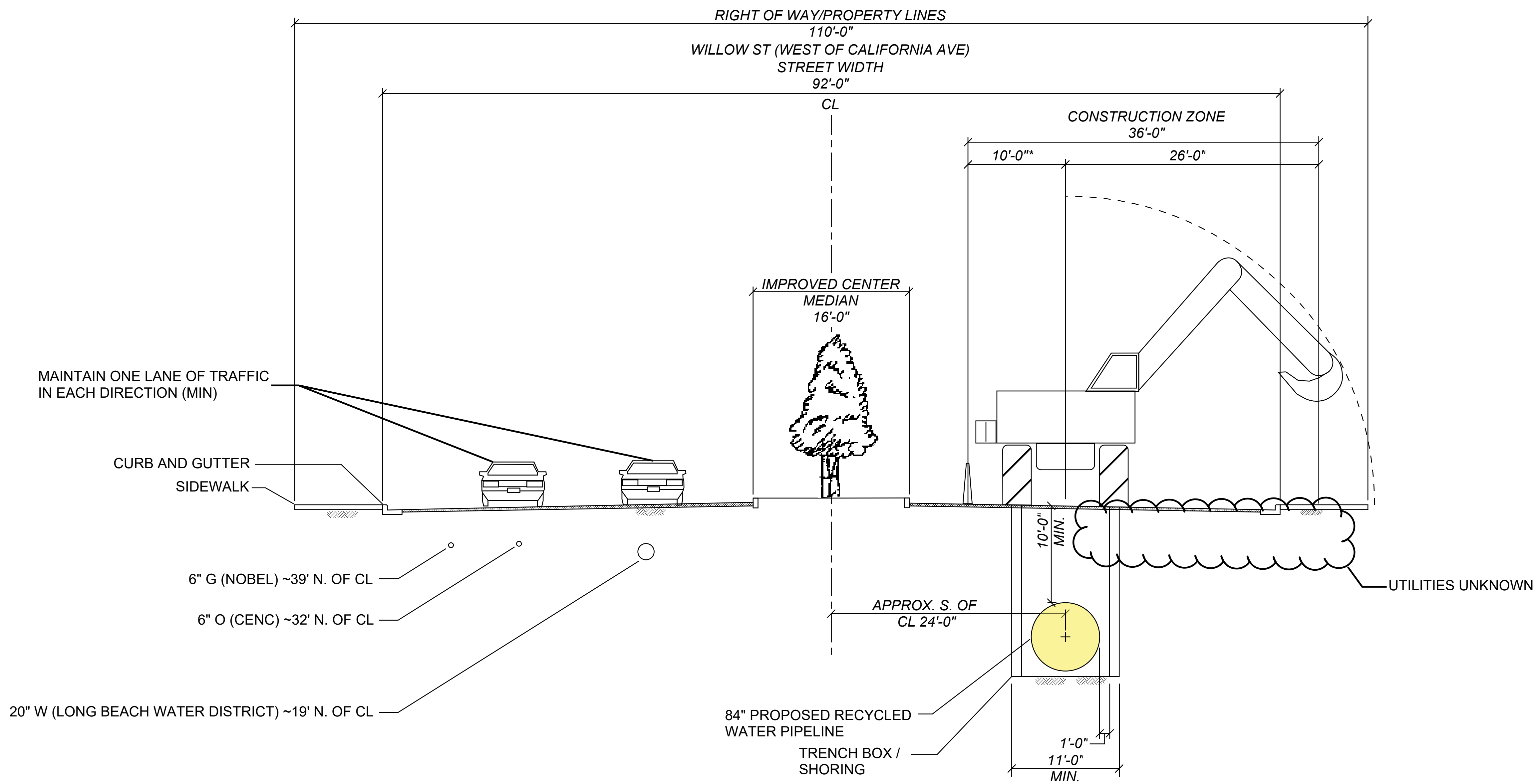

CROSS SECTION 5 / -

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

- CITY OF LONG BEACH GIS DATA

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 5 – WILLOW ST FACING EAST (REACH 1, STA 308+50)

FIGURE 6-35

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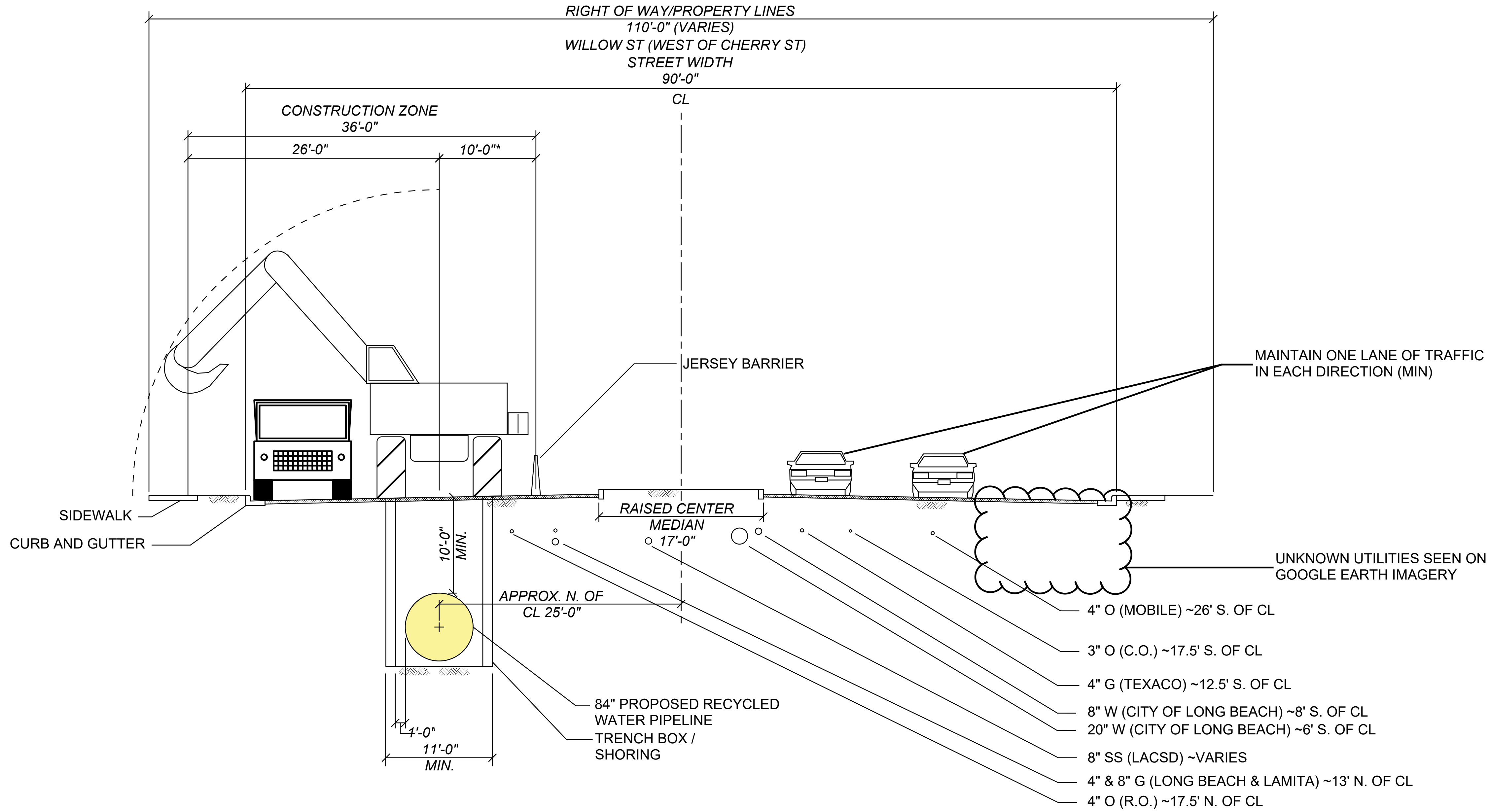

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 6 / -

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- CITY OF SIGNAL HILL STREET IMPROVEMENT PLAN DWG R-1147-A (WILLOW STREET STA. 46+40.99 TO STA. 50+50.00
- CITY OF SIGNAL HILL STREET IMPROVEMENT PLAN DWG R-1148-A (WILLOW STREET STA. 50+50.00 TO STA. 56+23.69
- CITY OF LONG BEACH GIS DATA

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 6 – WILLOW ST FACING EAST (REACH 1, STA 346+00)

FIGURE 6-36

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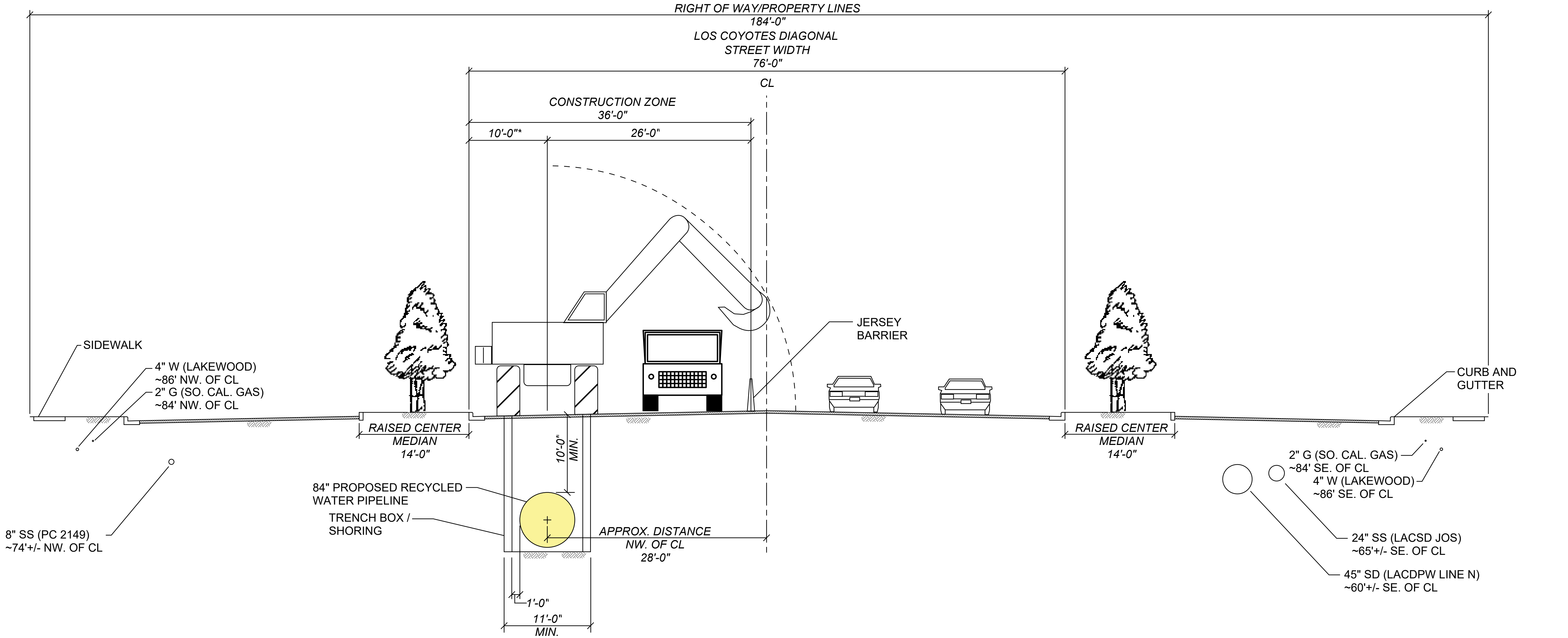

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 7 / -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-420
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-433
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-434

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 7 – LOS COYOTES DIAGONAL FACING NORTHEAST (REACH 1, STA 624+00)

FIGURE 6-37

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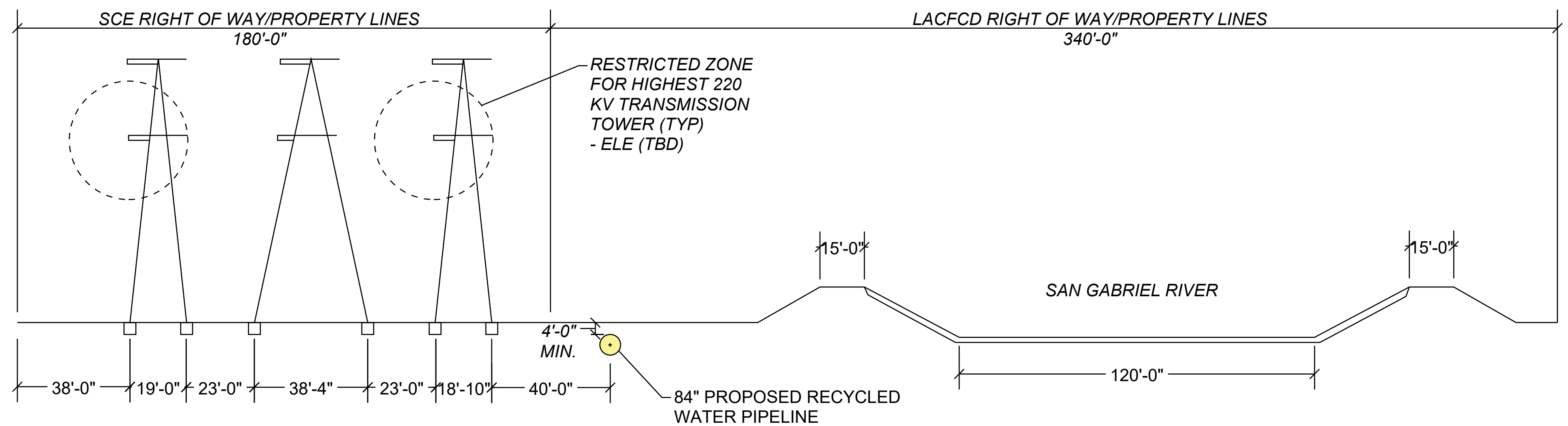

CROSS SECTION 8 / -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 8 – LACFCD EASEMENT FACING NORTH (REACH 3, STA 946+00)

FIGURE 6-38

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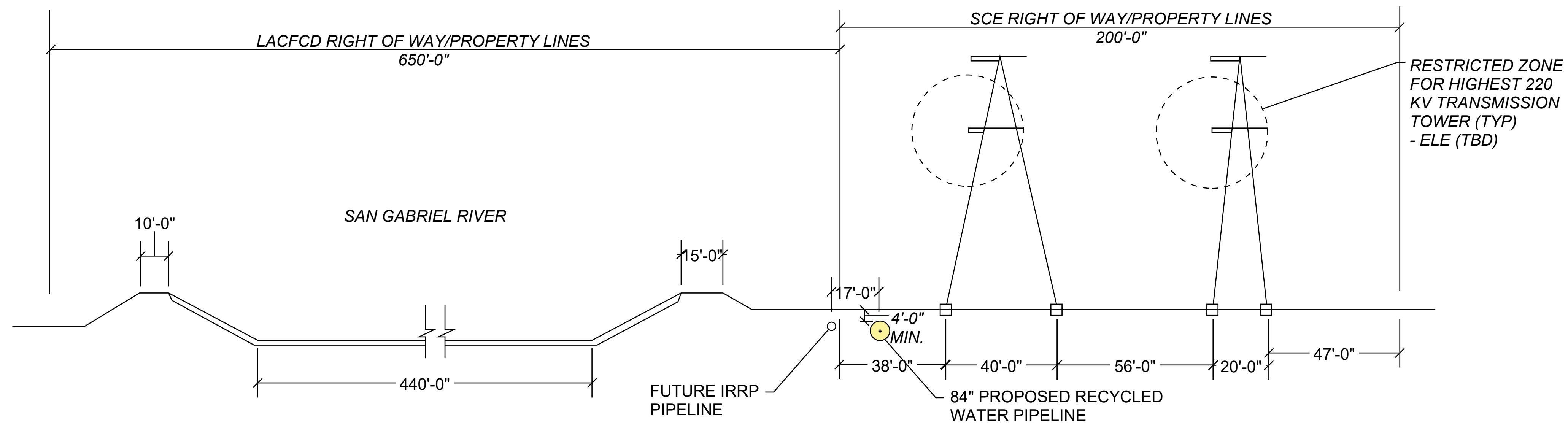

CROSS SECTION 9 / -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 9 – SCE EASEMENT FACING NORTH (REACH 4, STA 1253+00)

FIGURE 6-39

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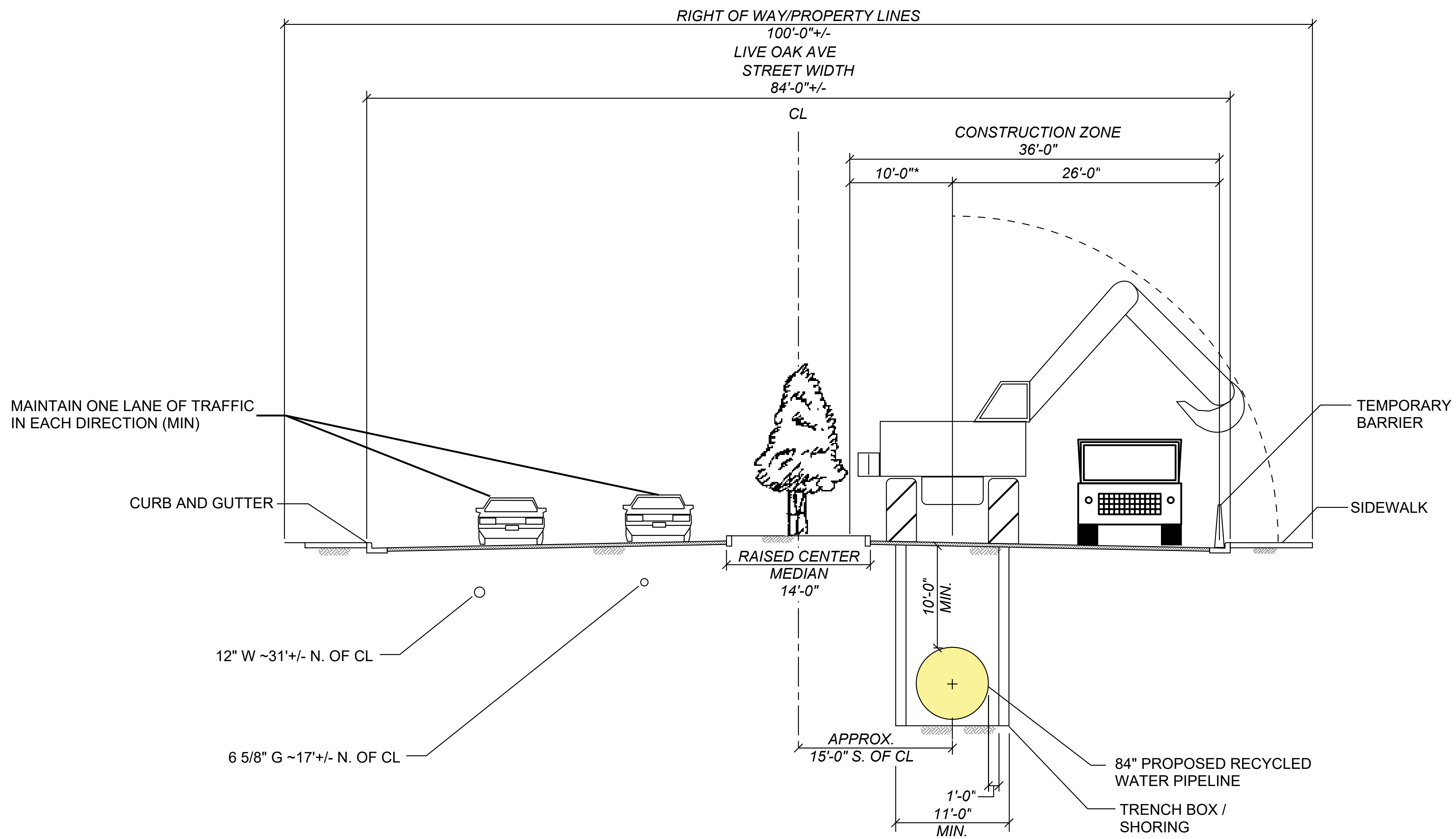

CROSS SECTION 10 / -
NO SCALE

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- CITY OF IRWINDALE STORM DRAIN IMPROVEMENT PLANS FOR TENT. PARCEL MAP NO 22505, JOB NO 89140.27, SHEET 7

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 10 – LIVE OAK AVE FACING SOUTHEAST (REACH 4, STA 1883+00)

FIGURE 6-40

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7.0 Los Angeles River Alignment Feasibility-Level Design

This chapter describes the key facility components for the LA River Alignment required for the conveyance of advanced treated water from the AWT plant in Carson to the SFSG.

If the LA River alignment is selected as the preferred alignment during future phases of work and a pipeline to OC were ultimately required, this study identified alignments to OC as described in Chapter 4. Table 7-1 summarizes key Project components and characteristics associated with this alignment.

Table 7-1 LA River Alignment Characteristics

CHARACTERISTIC	LA RIVER ALIGNMENT
Minimum Ground Elevation, ft above MSL	7
Maximum Ground Elevation, ft above MSL	525
Total Pumping Head, ft	677
Overall Alignment Length, miles	36.5
Pump Stations, each	2

Figure 7-1 summarizes the Project methodology as it applies to this chapter.

Figure 7-1 Chapter 7 Methodology

7.1 CHAPTER ORGANIZATION

Key operating parameters and Project components affecting alignment decisions for the RRWP are summarized below and discussed in the following sections:

- **LA River Alignment Overview** – This section describes the development of the LA River Alignment and presents a summary of the key attributes of the alignment, as well as areas that require further evaluation during subsequent phases of work.
- **Feasibility-Level Pipeline Plan Drawings** – This section presents the pipeline plan drawings that were developed to show the alignment at a scale large enough to display relevant surface features.
- **Feasibility-Level Pipeline Design** – This section describes the system of pressurized pipelines and tunnels for the LA River Alignment, including design criteria applicable to pipeline sizing and the development of a cost opinion. This section also describes locations that are anticipated to require trenchless construction methods to avoid surface or below grade features or obstructions and presents typical cross-sections for the alignment. Similar descriptions for the LA River Alignment are provided in Chapter 6.

7.2 LOS ANGELES RIVER ALIGNMENT OVERVIEW

The LA River Alignment, established in Chapter 5, was the result of feasibility-level engineering development, input from internal and external stakeholders, and the ability to procure rights-of-way and easements. Details of construction activities, including but not limited to construction sequencing, contractor access and storage area, and traffic control and road closures, would be assessed during the preliminary design phase.

Figure 7-2 presents an overview of the LA River Alignment and the two reaches it is comprised of. Table 7-2 summarizes key information about each reach.

Table 7-2 Key Characteristics of LA River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FT)
1	PS-1 to PS-3	0.0 – 26.8	341
2	PS-3 to SFSG	26.8 – 36.5	336
Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.			

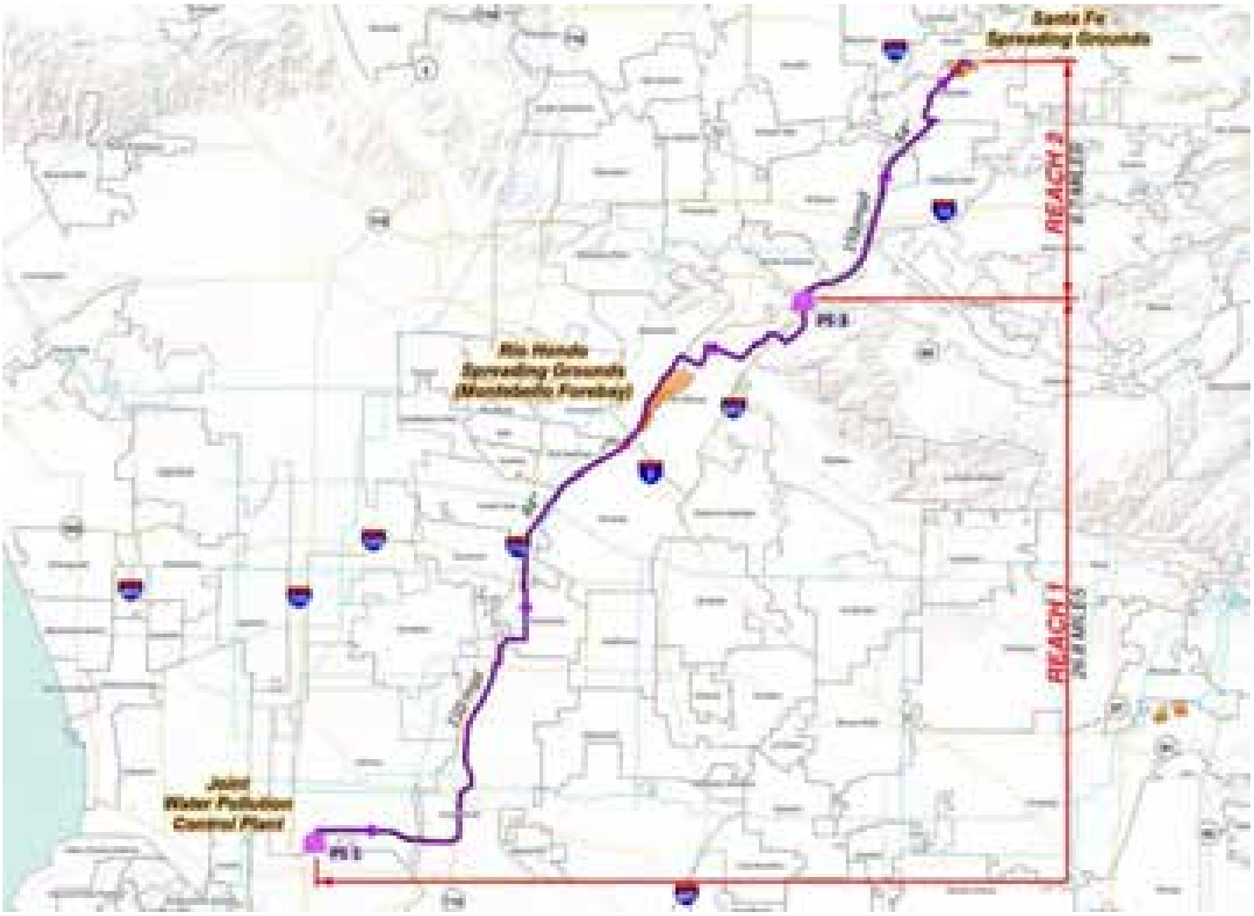

Figure 7-2 LA River Alignment Overview and Reach Extents

A description of each reach is as follows:

- Reach 1 – Reach 1 would be approximately 26.8 miles in length and would begin at the AWT plant and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, this reach would pass through unincorporated L.A. County and the Cities of Long Beach, Paramount, South Gate, Downey, Commerce, Pico Rivera, Montebello, and Industry. A majority of this reach would be within SCE and LACFCD right-of-way paralleling the LA River and then the Rio Hondo Channel. To avoid locations where a sufficient corridor does not exist, the pipeline would leave the river to be within public street rights-of-way for portions of the alignment. At Whittier Boulevard, the alignment would leave the Rio Hondo Channel and head east in existing public rights-of-way to the SG River. From here, the alignment would be mostly within SCE right-of-way parallel to the SG River. This pipeline section would convey up to 150 million gallons per day (mgd).
- Reach 2 – Reach 2 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LACFCD right-of-way with a small

stretch in public street rigs-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

A summary of the key attributes of the LA River Alignment is presented in Table 7-3. Additionally, areas requiring specific considerations during subsequent design phases are described in Table 7-4.

7.3 FEASIBILITY-LEVEL PIPELINE PLAN DRAWINGS

Feasibility-level plan drawings depicting the LA River Alignment were developed in GIS. These plans depict the LA River Alignment at a scale large enough to display surface features that would prevent or restrict open-cut construction and/or require trenchless construction methods. The feasibility-level plan sheets are provided in Appendix G.

Table 7-3 Summary of LA River Alignment

SEGMENT	PIPE DIAMETER (IN.)	TOTAL LENGTH (FT)	TRENCHLESS CONSTRUCTION (FT)	CITIES	DESCRIPTION	STREET	STREET WIDTH (FT)	TRAFFIC LANES (NO.)	TYPICAL CONSTRUCTION METHOD ASSUMED[1]
1	84	24,083	5,074	Carson, Los Angeles, Long Beach	Roadway	Main St.	80	4 + median	CM1
						Sepulveda Blvd. (turns into Willow St)	80	4,6 + median	
2	84	12,826	6,365	Long Beach	LACFCD/Roadway	Country Club Rd.	40	2	CM3A/CM4C
101	84	8,635	8,635	Long Beach	LACFCD	-	-	-	CM4C
3	84	9,206	2,531	Long Beach, South Gate	Roadway/SCE	De Forest Ave.	40	2	CM1/CM2
100	84	24,418	1,396	Long beach, Paramount, South Gate	LACFCD/SCE/Roadway	N Atlantic Pl.	70	4 + bike lanes	CM1/CM2
						Hunsaker Ave.	80	4 + center lane	
						Alondra Blvd	82	4 + median	
7	84	3,700	180	South Gate	SCE	-	-	-	CM2
21	84	23,415	7,745	South Gate, Downey, Commerce, Pico Rivera, Montebello	SCE/LACFCD	-	-	-	CM2/CM3A
23	84	19,433	1,497	Montebello, Pico Rivera	LACFCD/Roadway	El Camino Real	55 to 85	4 + median	CM1/CM3A
						Paramount Blvd	85	4 + median	
						Beverly Blvd	80	4 + median	
38	84	17,937	1,921	Pico Rivera, Industry, Unincorporated	SCE/Roadway	SG River Pkwy	100	4 + median	CM1/CM2
						Rose Hills Rd.	60	4	
						Workman Mill Rd	85	4 + median	
						Peck Rd	75	4 + median	
44	84	28,748	4,575	South El Monte, Industry, Baldwin Park, Irwindale, Unincorporated	SCE/LACFCD	-	-	-	CM2/CM3A
52	84	2,292	-	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	22 to 60	2, 4 + center lane	CM1
60	84	4,884	528	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	60 to 80	4 + center lane	CM1
56	84	1,166	-	Irwindale	Roadway	Live Oak Ave.	80	4 + median	CM1
58	84	3,339	517	Irwindale	SCE/Private	-	-	-	CM2
59	84	9,028	1,723	Irwindale	LACFCD	-	-	-	CM3A
TOTALS		**193,110**	**42,687**						

Note 1: See Section 3.4 for details on typical construction methods, including definitions of abbreviations.

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Table 7-4 Areas Requiring Specific Consideration During Subsequent Design Phases

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
General	Where the LA River Alignment would cross a seismic hazard/ fault, a detailed seismic assessment which may include finite element analysis would be required in subsequent design phases to design for seismic resiliency (Segments 2 and 101).
	At this feasibility level of planning, sufficient information is not available to determine the preferred construction method, cut-and-cover or trenchless construction, at intersections crossing the Preferred Alignment. For planning purposes, this FLDR assumed that all intersections would be crossed using cut-and-cover construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing railroad tracks, rivers, bridges, and Caltrans roads or highways). The FLDR applies a premium to account for the higher cost of construction at all intersections that the traffic analysis report considered to be a Major Intersection. Further evaluation will be completed during Preliminary Design when a comprehensive investigation and mapping of buried utilities, additional traffic control analysis, and coordination with local jurisdictions would be completed.
	This FLDR assumed that when the pipeline alignment would cross beneath freeway overpasses with adequate clearance from the bridge structure to the ground for construction equipment, and no on or off-ramp access, the pipeline would be constructed using cut-and-cover methods. Based on prior experience with Caltrans District 7, this would be feasible as long as the edge of pipe is at least 10 ft from the bridge footings and abutment. Additionally, a casing is typically required, even with cut-and-cover construction methods. These crossings would be evaluated on a case by case basis. Additional coordination should be conducted with Caltrans during subsequent design phases to better understand their design requirements. No discussions with Caltrans were held at this stage of the project.
	Further investigation into designated wetlands and sensitive wildlife areas along the Los Angeles and SG Rivers and associated spreading grounds would be required in subsequent design phases.
1	Assumptions made for the crossing of Alameda Corridor and Dominguez Channel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59 should be verified. Should any issues be encountered with the proposed crossing during subsequent design phases, two other viable crossings were identified and are presented in Appendix R.[1]
	Numerous underground utilities were identified along Sepulveda Boulevard and Willow Street. Additional utility research and potholing should be completed to confirm the alignment.[2]
2/101	The proposed alignment crosses Interstate 405, the Newport-Inglewood Fault Zone, a historic environmental storage clean up site, and MCTA railroad tracks all in the same vicinity. This FLDR assumed that trenchless construction would be used to cross the fault zone perpendicularly. Due to the estimated width of the fault zone, the alignment would be in Los Cerritos Park before it reached the edge. To minimize the impact on the residential neighborhood and Virginia Country Club, the FLDR proposes to continue tunneling to avoid these features. The alignment would follow the existing public right-of-way of Country Club Drive and then cross beneath private properties before rejoining the LA River. The alignment shown was chosen to establish a conservative budget for the Project with the understanding that further evaluation is required to verify.[1]
3/100	The proposed alignment would impact various above grade features that are currently located on SCE's existing rights-of-way. These features are generally constructed to be temporary and include nurseries, equestrian areas (i.e. stables and pens), storage units, RV and boat storage, and community parks between Alondra Boulevard and Garfield Avenue.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
100	This FLDR assumed that trenchless construction would be required to cross East Artesia Blvd and the mobile home community directly south. Alternative alignments, such as taking 63rd Street to Atlantic Avenue, were identified but were deemed to have a larger impact on the community. The alignment shown was chosen to establish a conservative budget for the Project with the understanding that further evaluation is required to verify.[1]
7	None.
21	This FLDR assumed that trenchless construction would be required to cross Firestone Blvd, railroad tracks, and the Rio Honda Golf Club. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders to determine if the golf course can be constructed with cut-and-cover methods.[1]
	From Reach 1, Sta. 885+00 to Reach 1, Sta. 969+00, the workspace available for construction would be limited due to congestion in the LADWP transmission line corridor and the speed of construction may be impacted.
	This FLDR assumed that trenchless construction would be required to cross Interstate 5 along the Rio Honda Bike Path. However, it may be possible to use cut-and-cover methods, along with a casing pipe, for this crossing.
23	This FLDR assumed the alignment would be constructed around the perimeter of the LACFCD spreading basins. Additional evaluations into the impacts the pipeline construction could have on the spreading basins recharge capacities should be completed in subsequent design phases. If pipeline construction is determined not to impact the recharge capacities, a straighter alignment may be possible through the basins with LACDPW's consent.
38	This FLDR assumed that the crossing of a drainage channel that crosses SG River Parkway, just west of Interstate 605, would be constructed using trenched construction methods. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project Stakeholders and construction staff to determine if the crossing would be required to be made with trenchless construction methods.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
44	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
52	A general corridor was selected that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. However, utility information has not been received from the Cities of Baldwin Park and Irwindale. Future utility investigation should be completed during subsequent design phases and the alignment should be adjusted accordingly.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
	Due to the narrow width of Rivergrade Road (approx. 32 ft) from Reach 2, Sta. 1724+00 to Reach 2, Sta. 1744+50, a full road closure may be required.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
60	None.
56	None.
58	Construction is required on private property from approximately Reach 2, Sta. 1807+80 to Reach 2, Sta. 1831+50.
59	The corridor selected involves crossing the Santa Fe Dam from approximately Reach 2, Sta. 1885+90 to Reach 2, Sta. 1898+00. Additional evaluations would need to be completed to determine the preferred crossing method.

Notes:
1. See Section 7.4.7 for additional details.
2. See Section 7.4.8 for typical cross-sections.
3. See Section 3.4.3 for typical section.
4. See Figure 5-8 for identification of segments comprising the LA River Alignment.

7.4 FEASIBILITY-LEVEL PIPELINE DESIGN

The following section establishes the pipeline design basis, including the pipeline flow rate, hydraulic profile, diameter, material, and governing design standards.

7.4.1 Design Flow

Pipeline diameters were sized for the full program build out of 150 mgd.

7.4.2 Optimization of Pipe Sizes and Pumping Costs

Since the LA River Alignment is so similar to the SG River Alignment hydraulically, it is anticipated that the feasibility-level analysis optimizing the pipe size for the SG River Alignment to balance pumping power cost with capital construction cost would be the same for the LA River Alignment. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. A more detailed evaluation should be conducted during preliminary design to validate the results. The pipe size optimization calculation is presented in Appendix H. The pipeline diameters selected for each reach are presented in Table 7-5. The stated diameter shall be the clear inside diameter after application of linings.

Table 7-5 Pipe Sizes

REACH	PIPE DIAMETER (IN.)	DESIGN FLOW (MGD)	PIPE VELOCITY (FPS)
1	84	150	6.0
2	84	150	6.0

7.4.3 Hydraulic Profile

Preliminary hydraulic profiles were developed for the LA River Alignment and are presented on Figure 7-3 thru Figure 7-5.

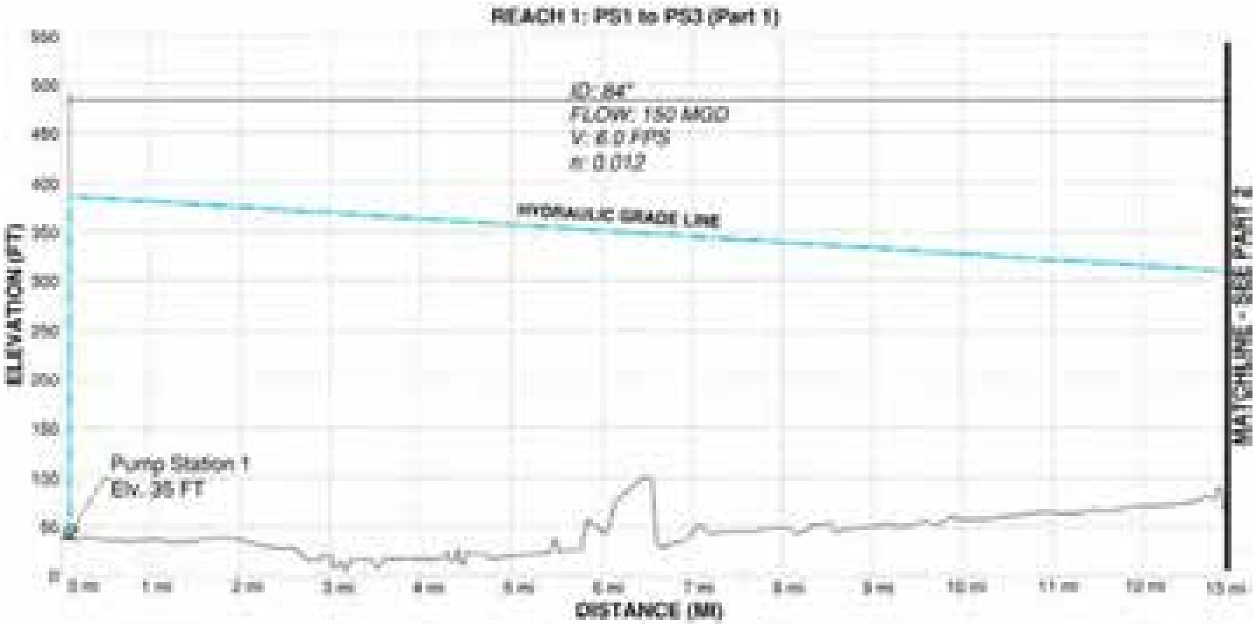


Figure 7-3 Reach 1, Part 1 Hydraulic Profile (LA River Alignment)

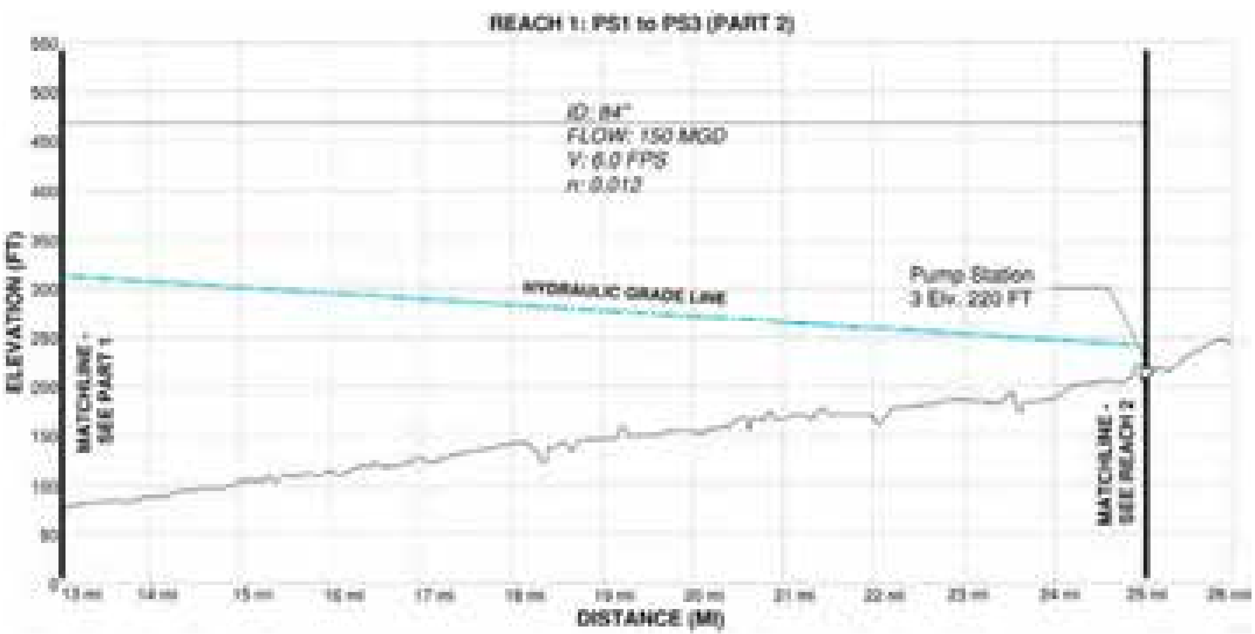


Figure 7-4 Reach 1, Part 2 Hydraulic Profile (LA River Alignment)

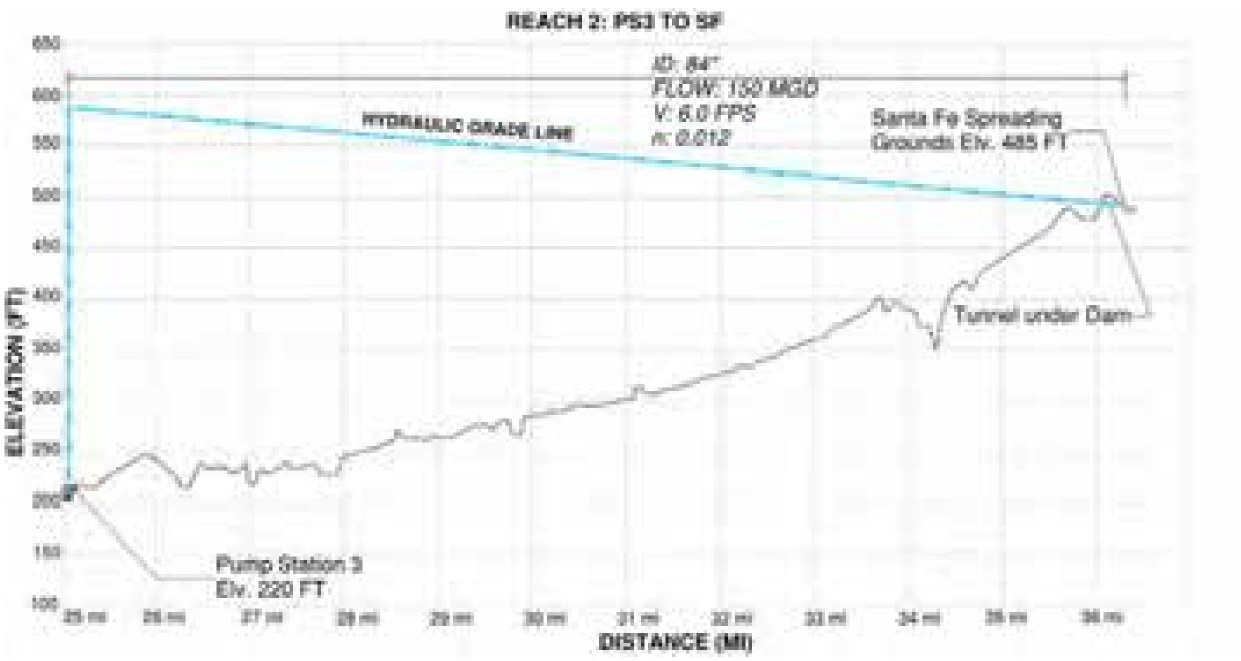


Figure 7-5 Reach 2 Hydraulic Profile (LA River Alignment)

As can be seen on Figure 7-5 above, the proposed alignment crosses the Santa Fe Dam spillway to reach the SFSG. It is currently envisioned that the alignment would cross under the dam using trenchless construction methods, which is technically feasible but could lead to permitting challenges. Additional coordination with the governing jurisdictions would be required during future phases of work to determine the preferred construction method.

7.4.4 Pipe Materials

Pipeline materials would be welded steel pipe in accordance with Metropolitan standards. Lining material selection was not evaluated as part of the study but was assumed to be cement mortar for purposes of establishing a budgetary cost. Metropolitan's design standards will be followed with evaluating and selecting lining material during future phases of work, in conjunction with water quality data from the demonstration plant.

7.4.4.1 Steel Cylinder Design Calculations

Initial pipeline plate thickness calculations were completed for the SG River Alignment. Since the LA River Alignment has the same, or slightly less, lift required at each pump station (since the alignment is slightly shorter), the plate thicknesses calculated for the SG River Alignment were used for the LA River Alignment.

The steel plate thickness was determined based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a basic segment by segment analysis to support cost estimating and provide an initial basis for preliminary design development. Site specific calculations should be completed during preliminary design.

The recommended steel plate thicknesses for each pipe segment are summarized in Table 7-6. Details of the initial pipeline plate thickness calculations are presented in Appendix I.

Table 7-6 Steel Cylinder Thicknesses

REACH	PLATE THICKNESS (IN.)
1	0.500
2	0.500
Note: Steel cylinder thickness calculations assume 42 kips per square inch steel and a minimum plate thickness of 0.375 inches per Metropolitan's standard specification Section 02662.	

7.4.5 Pipeline Appurtenances

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings should be used to develop typical details for these appurtenances. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

As part of the preliminary design, a study should be performed to determine potential blow-off and ARVV locations along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design.

In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points.

7.4.6 Intersections

A list of Major and Minor Intersections, as designated by the Traffic Impact Analysis, for each Segment of the LA River Alignment is provided in Table 7-7.

Table 7-7 Summary of Intersection Designations

SEGMENT	INTERSECTION	CLASSIFICATION
1	Sepulveda Blvd. @ Dolores St.	Minor
	Sepulveda Blvd. @ Marbella Ave.	Minor
	Sepulveda Blvd. @ Panama Ave.	Minor
	Sepulveda Blvd. @ Avalon Blvd.	Major
	Sepulveda Blvd. @ Banning Blvd.	Minor
	Sepulveda Blvd. @ Wilmington Ave.	Major
	Sepulveda Blvd. @ Tesoro/Phillips 66	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Sepulveda Blvd. @ Alameda Connector	Minor
	Sepulveda Blvd. @ Intermodal Wy.	Minor
	Sepulveda Blvd. @ R/R Xing	Major
	Sepulveda Blvd. @ ICTF	Minor
	Sepulveda Blvd. @ Middle Rd.	Minor
	Sepulveda Blvd. @ CA-103 terminus	Minor
	Sepulveda Blvd. @ Regway Ave.	Minor
	Sepulveda Blvd. @ Santa Fe Ave.	Major
	Sepulveda Blvd. @ Easy Ave.	Minor
2	None.	N/A
101	None.	N/A
3	None.	N/A
100	Hunsaker Ave. @ Alondra Blvd.	Major
	Alondra Blvd. @ Orange Ave.	Major
	Alondra Blvd. @ Gundry Ave.	Minor
7	None.	N/A
21	None.	N/A
23	Whittier Blvd. @ Myrtle St.	Minor
	Whittier Blvd. @ Paramount Blvd.	Major
	Paramount Blvd. @ Beverly Rd.	Major
	Paramount Blvd. @ Beverly Blvd.	Major
	Beverly Blvd. @ Acacia Ave.	Minor
	E Beverly Blvd. @ Rosemead Blvd.	Major
	E Beverly Blvd. @ Durfee Ave.	Minor
	E Beverly Blvd @ Sandoval Ave.	Minor
	E Beverly Blvd @ SG River Pkwy.	Minor
38	Shepherd St. @ Rose Hills Rd.	Minor
	Rose Hills Rd. @ Workman Mill Rd.	Minor
	Workman Mill Rd. @ E Mission Mill Rd.	Minor
	Workman Mill Rd. @ Rose Hills Gate 1	Minor
	Workman Mill Rd. @ College Dr.	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Workman Mill Rd. @ Peck Rd.	Minor
	Peck Rd. @ Pellissier Rd.	Minor
	Peck Rd. @ Rooks Rd.	Major
44	None	N/A
52	Rivergrade @ Brooks Dr.	Minor
60	Rivergrade @ Live Oak Ave.	Minor
56	Live Oak @ Graham	Minor
58	None	N/A
59	None	N/A

7.4.7 Trenchless Construction Recommendations

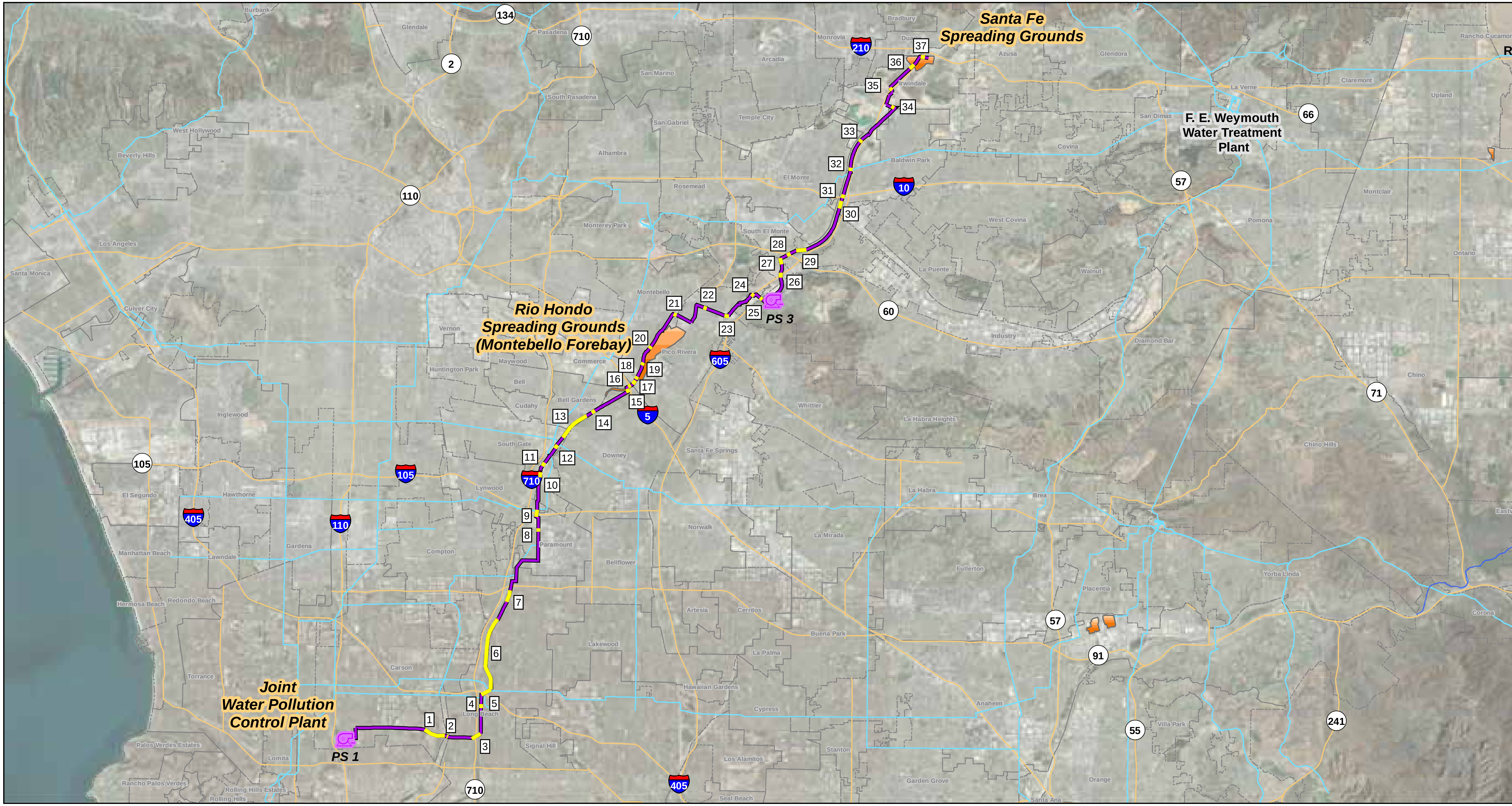
Similar to the SG River Alignment, feasible trenchless installation methods were selected for each location identified as potentially necessitating it for the purposes of establishing a conservative budget.

The next phase of the Project is expected to include site specific subsurface geotechnical explorations, comprehensive investigations, and mapping. These site-specific analyses will allow for a final selection of trenchless installation methods to be used at each location and may warrant that the trenchless methods described herein be revised.

The selected trenchless methods provided the basis for development of the feasibility-level Engineer's OPCC for the Project. Figure 7-6 correlates the trenchless identification number listed in Table 7-8 (shown below) with the location of each trenchless sub-segment along the LA River Alignment.

Table 7-8 summarizes the assumptions used to select the trenchless methods. The geotechnical information presented in Table 7-8 was based on the provided in the Desktop Geotechnical Evaluation.

It should be noted that a conservative depth of cover was assumed generally equal to three times the excavated diameter for the purposes of establishing a conservative budget for each trenchless crossing. Section 7.4.8 evaluates eleven trenchless crossings in greater detail. At these locations, the depth of cover that was assumed to be required were further refined, which, in some cases, led to them being reduced to less than three times the excavated diameter based upon the trenchless construction method assumed, the anticipated ground conditions, and the sensitivity of facilities for which it would cross beneath.



Existing MWD Distribution System

Los Angeles River Alignment

Trenchless / Tunnel Undercrossing with ID #

Pump Station or Flow Control Structure

Spreading Basins

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 7-6: Los Angeles River Alignment Trenchless/Tunnel ID

0 0.75 1.5 3 4.5 Miles

N W E S

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Table 7-8 Assumed Trenchless Construction Methods (LA River Alignment)

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
1	3,442	Intersection / railroad / river	7	11	33	Yes	Traditional Tunneling (EPBM)	No	No	Yes	Length and curves would make microtunneling (MT) difficult but not impossible. This FLDR assumed EPBM at this time.
2	88	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk when crossing a railroad.
3	1,544	Freeway / River	7	9	11	Yes	Microtunneling	Yes	No	No	Length is too short to warrant conventional tunneling and it would be difficult to dewater and use jack & bore.
4	315	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
5	1,845	Freeway / Railroad	7	9	11	Yes	Microtunneling	Yes	Yes	No	Length is too long to reliably complete with jack & bore. Tunnel 5 is assumed to share a launching/receiving portal with Tunnel 6.
6	12,841	Steep Terrain / railroad / Road	7	11	22	Yes	Traditional Tunneling (EPBM)	Yes	Yes	No	EPBM is recommended for budgeting purposes due to the length.
7	2,326	Intersection / Community Crossing	7	9	22	Yes	Microtunneling	Yes	No	No	Length and curves would make MT difficult but not impossible. EPBM is recommended for budgeting at this time. Further analysis would be recommended to confirm in later design stages.
8	209	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
9	1,031	Freeway	7	9	11	Yes	Microtunneling	Yes	No	No	MT would be best suited to manage risk under freeway and flood control basin.
10	156	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
11	205	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
12	180	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
13	5,699	Road / railroad	7	11	22	Yes	Traditional Tunneling (EPBM)	Yes	No	No	EPBM is recommended for budgeting at this time due to length. Further analysis would be recommended to confirm in later design stages.
14	282	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
15	422	River	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under river.
16	222	Freeway	7	9	27	Yes	Jack & Bore	No	No	No	Could be installed with cut-and-cover and a carrier pipe due to the freeway crossing above via a bridge. Assumed to be installed by jack and bore for budgeting. Further anlaysis would be recommended to confirm later in design.
17	382	Railroad / road	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
18	148	Road	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
19	432	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
20	157	Road	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
21	526	River	7	9	27	Yes	Microtunneling	No	No	No	Crossing is not suitable for jack & bore as a river crossing.
22	283	Intersection	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
23	688	River	7	9	27	Yes	Microtunneling	No	No	No	Crossing is not suitable for jack & bore as a river crossing.
24	325	Freeway	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
25	88	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
26	842	Freeway	7	9	27	Yes	Microtunneling	No	No	No	Length lends it to MT.
27	666	River	7	9	27	Yes	Microtunneling	Yes	No	No	Crossing is not suitable for jack & bore as a river crossing.
28	381	Freeway	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
29	1,825	River	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
30	1,631	Railroad / River	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
31	325	Freeway	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
32	128	Road	7	9	27	Yes	Jack & Bore	Yes	No	No	Short drive length favors jack & bore.
33	285	Road	7	9	27	No	Jack & Bore	Yes	No	No	Short drive length favors jack & bore.
34	528	River	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT
35	517	Freeway	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
36	1,215	Dam	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
37	508	Freeway	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.

Notes:
1. Tunnel identification number corresponds with Figure 7-6.
2. Depth below ground surface or river channel to top of pipe or crown of tunnel; generally equal to 3 times the excavated diameter.

7.4.8 Feasibility-Level Technical/Construction Details

This section discusses segments of the LA River Alignment where the typical construction methods would not be sufficient to construct the pipeline due to terrain, such as rivers, and/or physical barriers, such as freeways or railroads, or to avoid impacts to the community.

A preliminary review of the LA River Alignment identified eleven locations warranting feasibility-level technical / construction details. The eleven feasibility-level technical / construction detail locations are identified in Table 7-9 and presented on Table 7-9. Where a location is identified for the LA River Alignment that is common to the SG River Alignment, the description was not repeated. Instead, in Table 7-9 it was noted and a reference to the description in Chapter 6 was provided. Descriptions for each location include details on site conditions, existing utilities, easements, and trenchless methodology. Additionally, plan and profiles have been developed for each location. Ground elevations shown were obtained through Google Earth and are approximate. Ground surveys were not completed for this FLDR.

Table 7-9 Feasibility-Level Technical/Construction Detail Locations

NO.	STATION	DESCRIPTION	COMMENT
1	Reach 1, Sta. 139+17 – Reach 1, Sta. 173+59	Trenchless crossing of Alameda Street/railroad corridor and the Dominguez Chanel along Sepulveda Boulevard.	See Section 6.4.8.
2	Reach 1, Sta. 225+38 – Reach 1, Sta. 240+82	Trenchless crossing of 710 Freeway and Los Angeles River along Sepulveda Boulevard.	Described below.
3	Reach 1, Sta. 308+55 – Reach 1, Sta. 327+00	Trenchless crossing of 405 Freeway	Described below.
4	Reach 1, Sta. 327+05 – Reach 1, Sta. 455+46	Trenchless crossing of Los Cerritos / Los Angeles River bank.	Described below.
5	Reach 1, Sta. 488+80 – Reach 1, Sta. 512+06	Trenchless crossing of East Artesia Blvd and mobile home community.	Described below.
6	Reach 1, Sta. 678+62 – Reach 1, Sta. 688+93	Trenchless crossing of the 105 Freeway	Described below.
7	Reach 1, Sta. 828+68 – Reach 1, Sta. 885+67	Trenchless crossing of Firestone Blvd and Rio Hondo Golf Course.	Described below.
8	Reach 1, Sta. 1250+25 – Reach 1, Sta. 1257+13	Trenchless crossing of SG River along Beverly Blvd.	Described below.
9	Reach 2, Sta. 1467+00 – Reach 2, Sta. 1485+25	Trenchless crossing of the Walnut Creek Wash along the SG River.	See Section 6.4.8.
10	Reach 1, Sta. 1790+45 – Reach 1, Sta. 1795+73	Trenchless crossing of the SG River along Live Oak Avenue.	See Section 6.4.8.
11	Reach 1, Sta. 1917+30 – Reach 1, Sta. 1922+38	Trenchless crossing of the 605 Freeway.	See Section 6.4.8.

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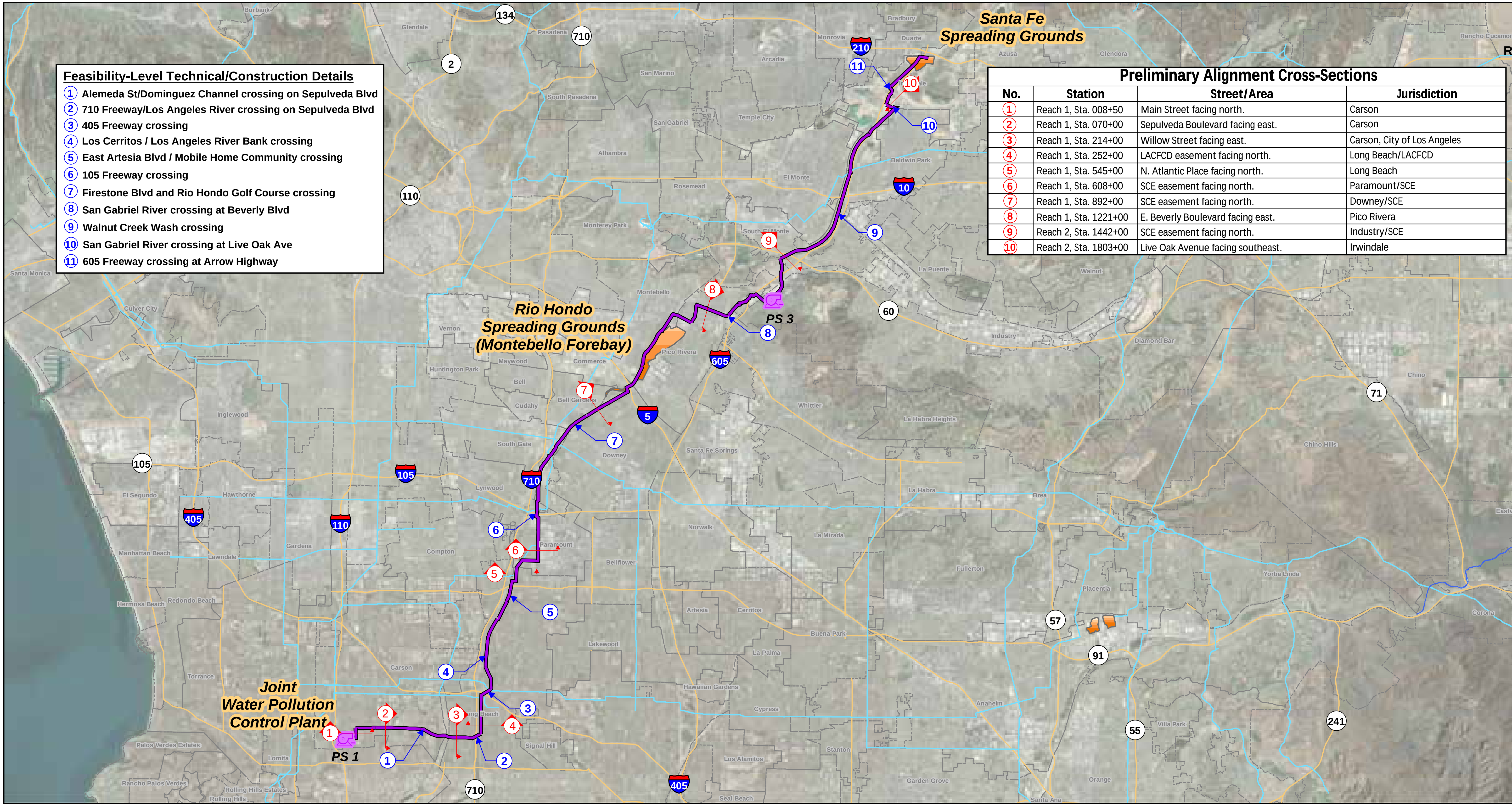

Preliminary Alignment Cross-Sections

No.	Station	Street/Area	Jurisdiction
1	Reach 1, Sta. 008+50	Main Street facing north.	Carson
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.	Carson
3	Reach 1, Sta. 214+00	Willow Street facing east.	Carson, City of Los Angeles
4	Reach 1, Sta. 252+00	LACFCD easement facing north.	Long Beach/LACFCD
5	Reach 1, Sta. 545+00	N. Atlantic Place facing north.	Long Beach
6	Reach 1, Sta. 608+00	SCE easement facing north.	Paramount/SCE
7	Reach 1, Sta. 892+00	SCE easement facing north.	Downey/SCE
8	Reach 1, Sta. 1221+00	E. Beverly Boulevard facing east.	Pico Rivera
9	Reach 2, Sta. 1442+00	SCE easement facing north.	Industry/SCE
10	Reach 2, Sta. 1803+00	Live Oak Avenue facing southeast.	Irwindale

Existing MWD Distribution System

Los Angeles River Alignment

Trenchless / Tunnel Undercrossing with ID #

Pump Station or Flow Control Structure

Spreading Basins

Preliminary Alignment Cross-Section

Location of Concept Construction Details

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 7-7: Los Angeles River Alignment Feasibility-Level Technical/ Construction Detail and Cross Section Locations

0 0.75 1.5 3 4.5 Miles

N W E S

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7.4.8.1 710 Freeway and Los Angeles River Crossing

The LA River Alignment proposes crossing below the 710 Freeway and the LA River from Reach 1, Sta. 225+38 to Reach 1, Sta. 240+82. The proposed crossing is shown in plan on Figure 7-8 and in profile on Figure 7-9. Key details of the crossing are provided in Table 7-10.

Table 7-10 Trenchless Method Summary of the 710 Freeway and Los Angeles River Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,544	River / Freeway	7	11	Yes	MT	Y	N	Y	N	N

Launching is recommended from the west side of the 710 Freeway based upon potentially available space for portal excavation and contractor staging in the vacant lot on the corner of the on/off ramp to the 710 Freeway. Further investigation of the property would be required to finalize portal location and availability. Other locations could include a portal within Fashion Avenue or in the open space between the 710 Freeway and the on/off ramp. Receiving is recommended from the east side of the Los Angeles River in the LACFCD ROW adjacent to De Forest Avenue. This property is recommended for the receiving portal due to limited available space. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

This drive length may require an intermediate jacking station. Although with good continuously replenished overcut lubrication, it may be possible without one. The MT boring machine is assumed to need disc cutters to fracture any boulders encountered and the shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. While the cover under the LA River is not known at this time, it is assumed that a minimum of 11 ft would be required below the lowest point, with more cover provided along the rest of the route.

Willow Street is congested with existing utilities. These utilities include existing storm drains, water, sanitary sewer, oil and gas piping, and telecommunications. Potholing of these utilities is recommended. Additionally, a corridor of existing oil and gas pipes runs parallel to the Los Angeles River on the east side. Potholing of these utilities is also recommended to confirm the location of the receiving portal.

It is recognized that this is a challenging crossing. Towards that end, other locations to cross the 710 Freeway and the LA River have been identified and include a crossing using the cul-de-sac at the end of Spring Street. Further evaluation is recommended during the next phase of design.

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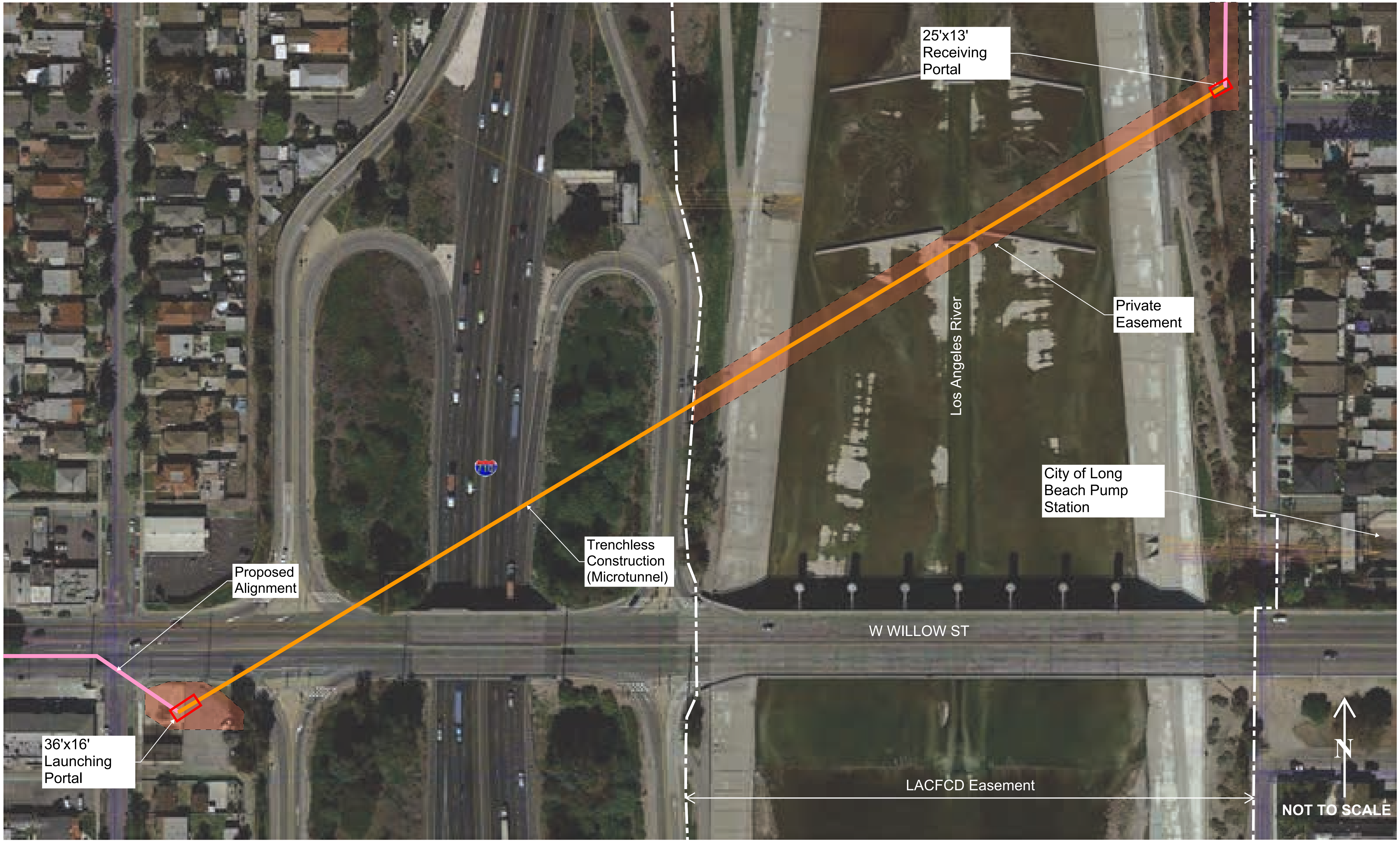

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
710 Freeway and Los Angeles River Crossing

FIGURE 7-8

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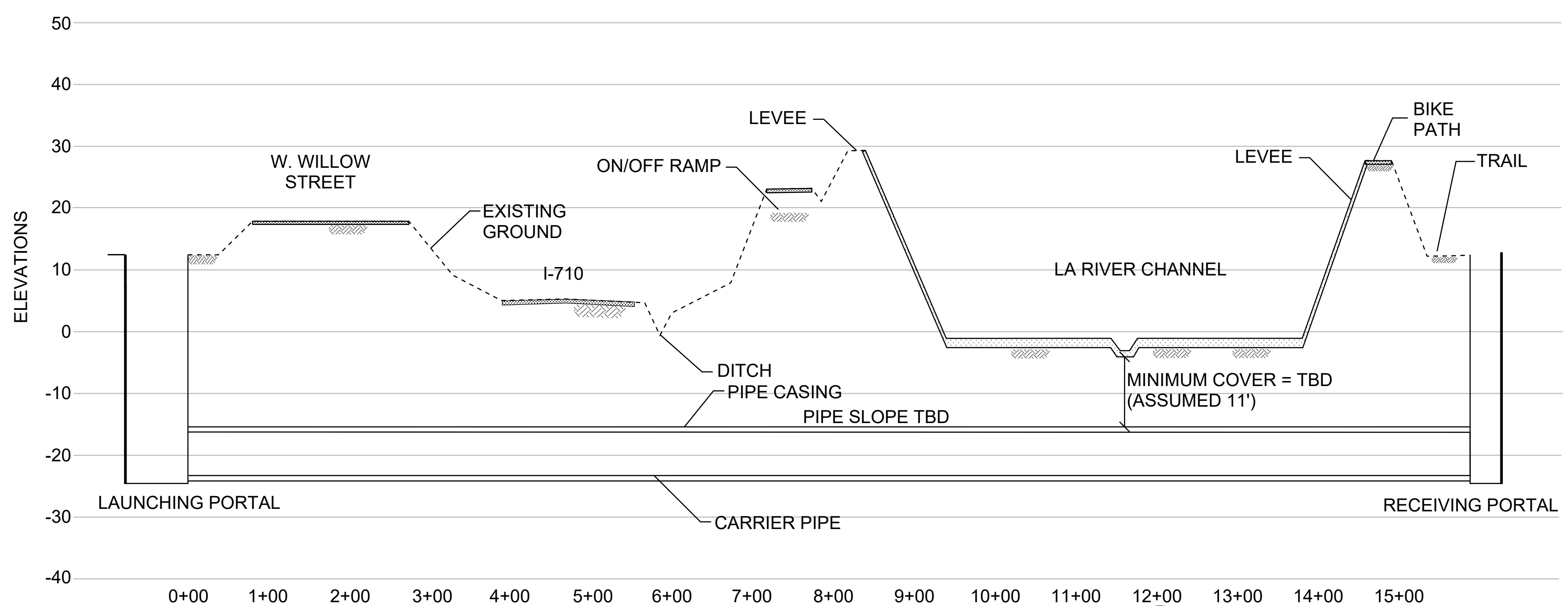

MICROTUNNEL CROSSING OF 710 FREEWAY AND THE LA RIVER 1

HORZ: 1" = 200'

VERT: 1" = 25'

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1" = 200' 0 100' 200' 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 710 Freeway and Los Angeles River Crossing

FIGURE 7-9

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7.4.8.2 405 Freeway Crossing

The LA River Alignment proposes crossing the 405 Freeway, railroad tracks, and an existing environmental storage cleanup site from Reach 1, Sta. 308+55 to Reach 1, Sta. 327+00 using trenchless construction methods.

The proposed crossing is shown in plan on Figure 7-10 and in profile on Figure 7-11. Key details of the crossing are provided in Table 7-11.

Table 7-11 Trenchless Method Summary of 405 Freeway Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,845	Freeway/ Railroad	7	11	Yes	MT	Y	N	Y	Y	N

Launching is recommended from the southwest side of the freeway based upon potentially available space for portal excavation and contractor staging. This area is primarily in the LACFCD ROW and is undeveloped. The receiving portal is recommended on the northeast side of the freeway and railroad tracks in Los Cerritos Park.

Acquisition of temporary and permanent easements would be required.

Due to the length of the drive, it is assumed that an intermediate jacking station would be required along with continuously replenished overcut lubrication to reduce side friction and minimize the risk of getting stuck. The intermediate jacking station is recommended on the north side of the 405 Freeway.

Due to the depth of the receiving portal, a circular shaft has been assumed.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

The end of the trenchless crossing is proposed to be the beginning of the next trenchless crossing, as described in the following section. Site use coordination between the two drives would be required. It is recommended that the use of a common shaft between the two drives or two separate shafts be evaluated during subsequent design phases as the logistical challenges may outweigh the benefits.

The Newport-Inglewood Fault Zone crosses through this area roughly parallel and adjacent to the existing rail road tracks. This fault zone is estimated to be 865 ft wide in this vicinity and the best estimate of the right-lateral displacement is 6.5 ft average displacement according to the Desktop Geotech Report. The proposed alignment was selected to cross the fault zone perpendicularly. If Metropolitan requires the conveyance system to remain functional after a major earthquake, special design and construction measures would be required.

Special considerations would be required by the tunneling contractor when tunneling through faults and fault zones. These considerations could include slowing the tunnel advance rate, monitoring of groundwater inflow, and/or modifying the initial and final tunnel ground support and/or final lining. This is because the weakened state in the fault zone could lead to increased ground support requirements, which slows the overall tunnel advance rate, in addition to the increased potential for groundwater inflow.

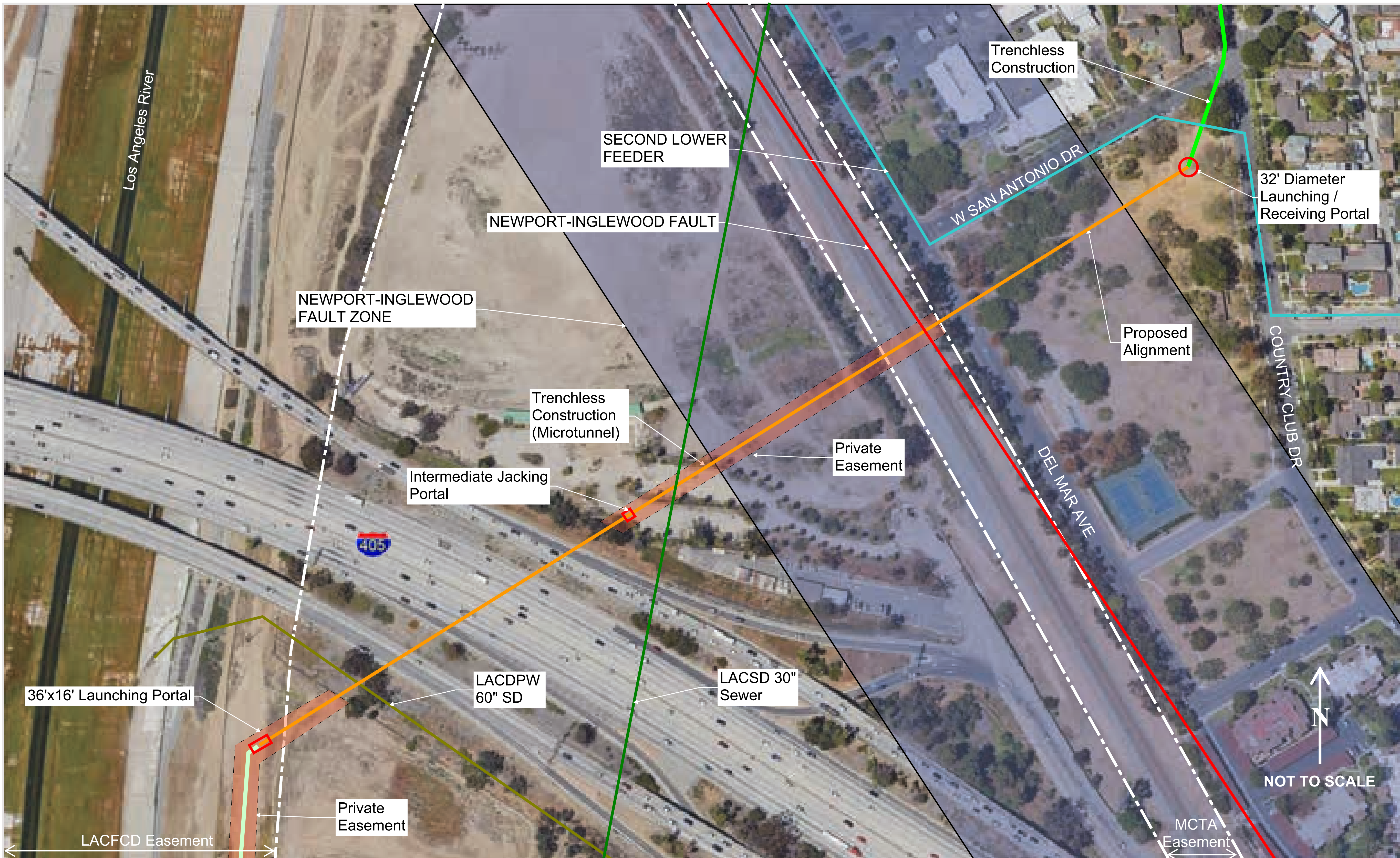
Specialized designs would be required for fault crossings. These designs could include, but are not limited to: 1) over-excavation or enlargement of the tunnel to provide for future movement of the fault where the tunnel crosses; 2) filling of the annular space between the initial tunnel excavation and the exterior of the tunnel final lining with low strength material such as cellular concrete; 3) grouting the faulted ground to increase the strength and ductility of the faulted ground; and/or 4) using flexible joints to increase the longitudinal flexibility of the tunnel final lining.

No seismic design criteria have been established at this stage but will be critical as the RRWP progresses to future phases of work.

The former sedimentation basin, a portion of which is currently being used as a golf center / driving range, that this alignment would cross near is the home of a historic environmental storage cleanup site. The selected alignment made efforts to minimize the length of the crossing in the potentially contaminated zone. By the time the fault zone is crossed, the alignment would be in Los Cerritos Park.

The receiving portal is assumed to be circular due to its depth to account for the change in ground elevation from the launching portal to the receiving.

An existing LACDPW storm drain parallels the 405 Freeway close to the LA River Alignment. Additionally, an existing LACSD sewer also crosses the 405 Freeway in the vicinity and intersects with the proposed alignment just north of the 405 Freeway. Potholing these utilities is recommended to confirm the alignment. No other utilities are anticipated.



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Legend	
Open-Trench Construction Method - LACFCD Easement (River Bank)	Launching/Receiving Pit
Trenchless Construction Method - Microtunnel	Private Easement
Trenchless Construction Method - EPBM Tunnel	Second Lower Feeder
LACDPW Storm Drain	Fault Zone
Active Fault	LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

405 Freeway Crossing

FIGURE 7-10

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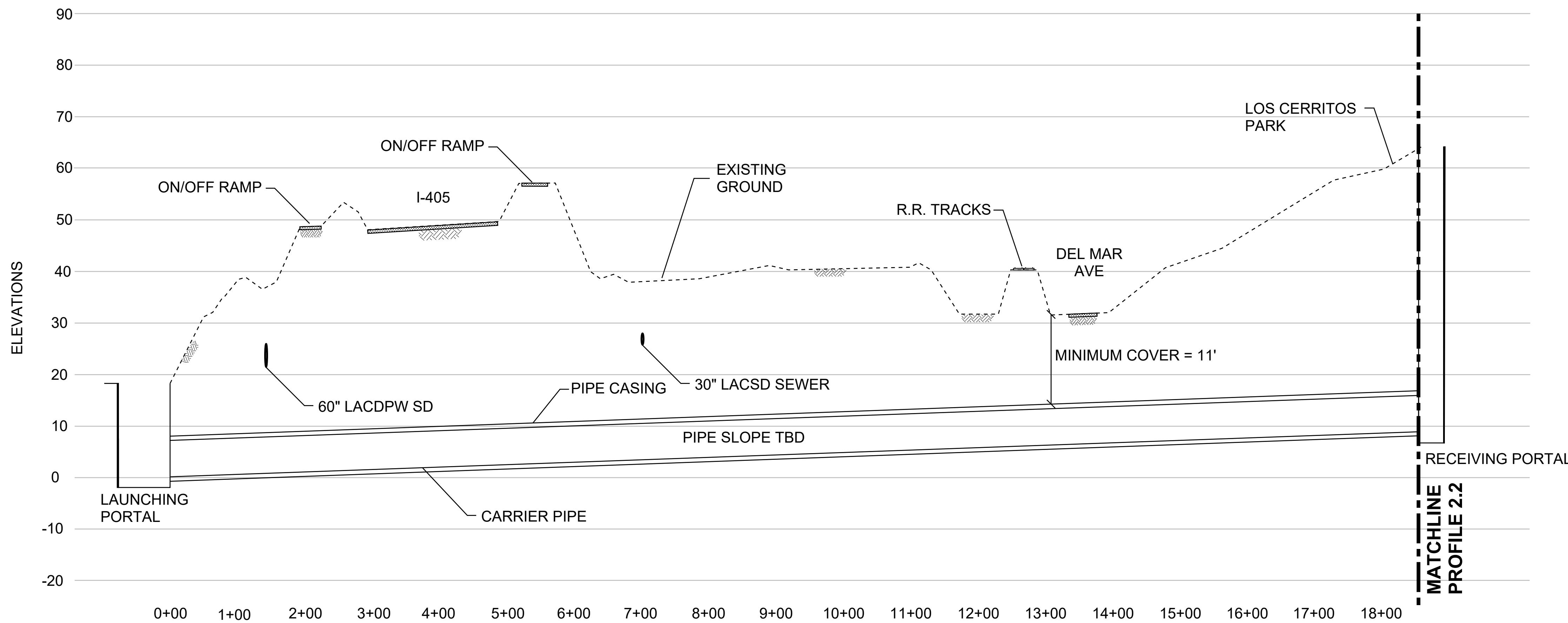

MICROTUNNEL CROSSING OF 405 FREEWAY

HORZ: 1" = 200'
VERT: 1" = 25'

2.1

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1" = 200' 0 100' 200' 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 405 Freeway Crossing

FIGURE 7-11

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7.4.8.3 Los Cerritos / Los Angeles River Bank Tunnel Crossing

The LA River Alignment proposes crossing the Los Cerritos community and a portion of the LA River bank from Reach 1, Sta. 327+05 to Reach 1, Sta. 455+46 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-12 and Figure 7-13 and in profile on Figure 7-14 and Figure 7-15. Key details of the crossing are provided in Table 7-12.

Table 7-12 Trenchless Method Summary of Los Cerritos / LA River Bank Tunnel Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
12,841	Steep Terrain, Railroad	7	22	Yes	EPBM	Y	N	Y	Y	N

The trenchless crossing of the 405 Freeway and the Newport-Inglewood Fault Zone ended in the Los Cerritos Park by the time it was out of the fault zone, as described in Section 7.4.8.2. The Los Cerritos Park is surrounded by a residential neighborhood. To minimize the impact on the residents, this FLDR proposed a traditional tunnel that follows the existing public rights-of-way of Country Club Drive then traverses beneath private property, including the Virginia Country Club before returning to adjacent to the LA River within LACFCD right-of-way. From here, the tunnel would continue to avoid impacts to the newly completed improved wetland and spreading basins alongside the LA River.

It is assumed that this would be constructed in one continuous span with a launching portal at Los Cerritos Park. The receiving portal is assumed to be located in the LACFCD easement adjacent to De Forest Avenue, north of Long Beach Boulevard.

It is assumed that a minimum of two excavated diameters, or 22 ft, of cover would be required along the tunnel. The depth of the tunnel would be driven by the elevations within the golf course or along the spreading basins adjacent to the LA River. The launching portal is assumed to be circular due to its depth required from the change in ground elevation between the launching portal and the alignment low points.

The use of a shielded TBM would help prevent explosion risk and toxic gas risk if any gas is present in ground or groundwater.

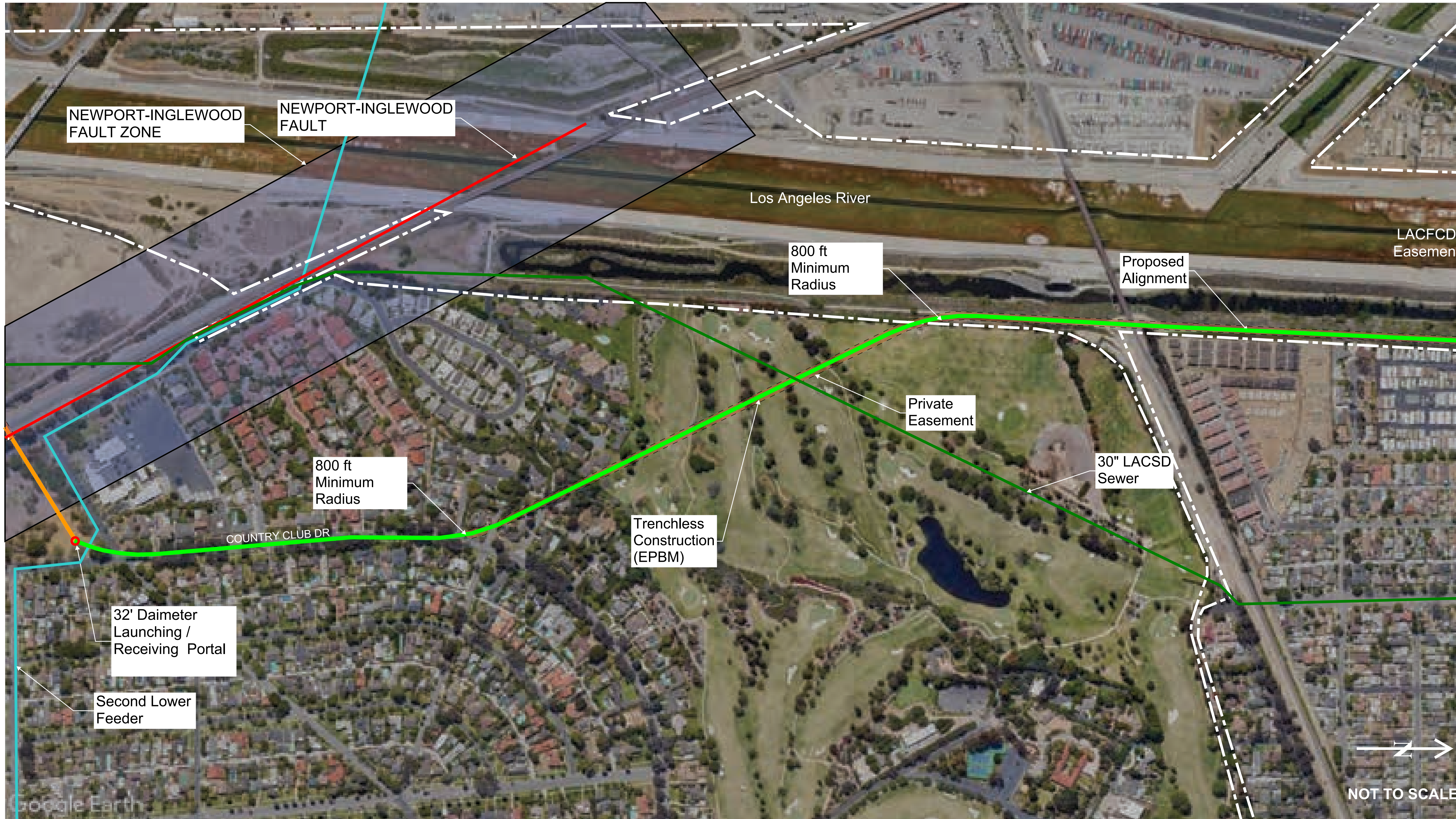
The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

Generally, a minimum tunnel radius of 800 ft is recommended for EPBM tunneling with segments and was the minimum radius assumed herein. This radius provides for efficient installation of the 20 ft long steel carrier pipe segments and allows for a wider pool of TBMs. Smaller radii can be considered but require careful curve evaluation. Tighter curves can result in a larger excavation / casing diameter to account for carrier pipe placement and grouting. For these reasons, among others, tighter curves are more expensive.

This tunnel alignment crosses Metropolitan's Second Lower Feeder when exiting the Los Cerritos Park. Additionally, it crosses LACSD's North Long Beach Trunk in the golf course and is parallel to the Joint Outfall A – Unit 6 Trunk sewer from south of Long Beach Boulevard to the end of the tunnel. It also crosses multiple storm drain lines discharging into the spreading basins adjacent to the LA River. Potholing these utilities is recommended to confirm the alignment. Other utilities, such as potable water and sewer connections for the neighborhood and recycled water for irrigation of the golf course, would be anticipated.

Acquisition of temporary and permanent easements would be required.



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Trenchless Construction Method - Microtunnel
Trenchless Construction Method - EPBM Tunnel
Private Easement
LACSD Sewer Pipe
Launching/Receiving Pit
Second Lower Feeder
Fault Zone
Active Fault

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Los Cerritos / Los Angeles River Bank Tunnel - Part 1

FIGURE 7-12

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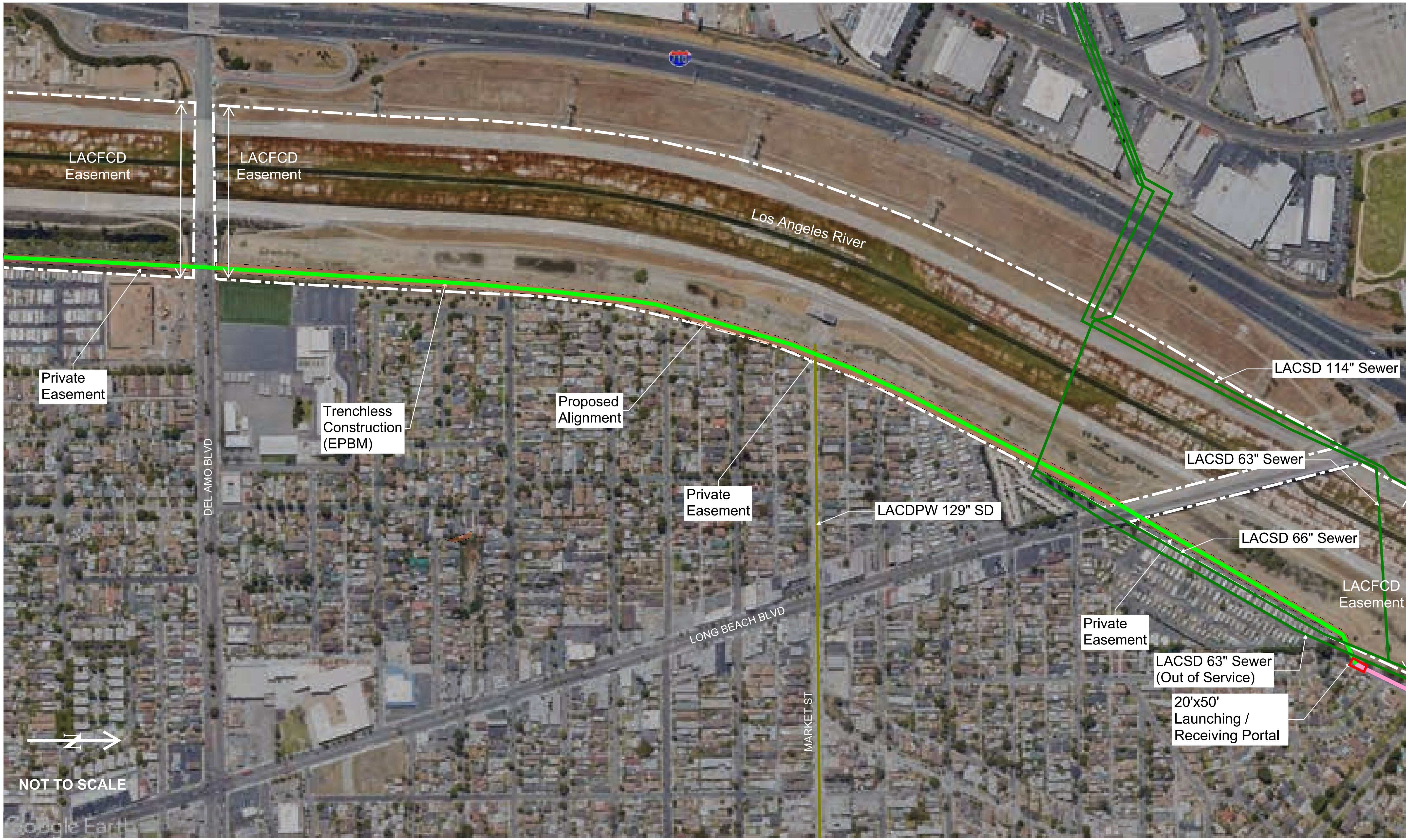

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- Open-Trench Construction Method - Roadways
- Trenchless Construction Method - EPBM Tunnel
- Private Easement
- Launching/Receiving Pit
- LACDPW Storm Drain
- LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Los Cerritos / Los Angeles River Bank Tunnel - Part 2

FIGURE 7-13

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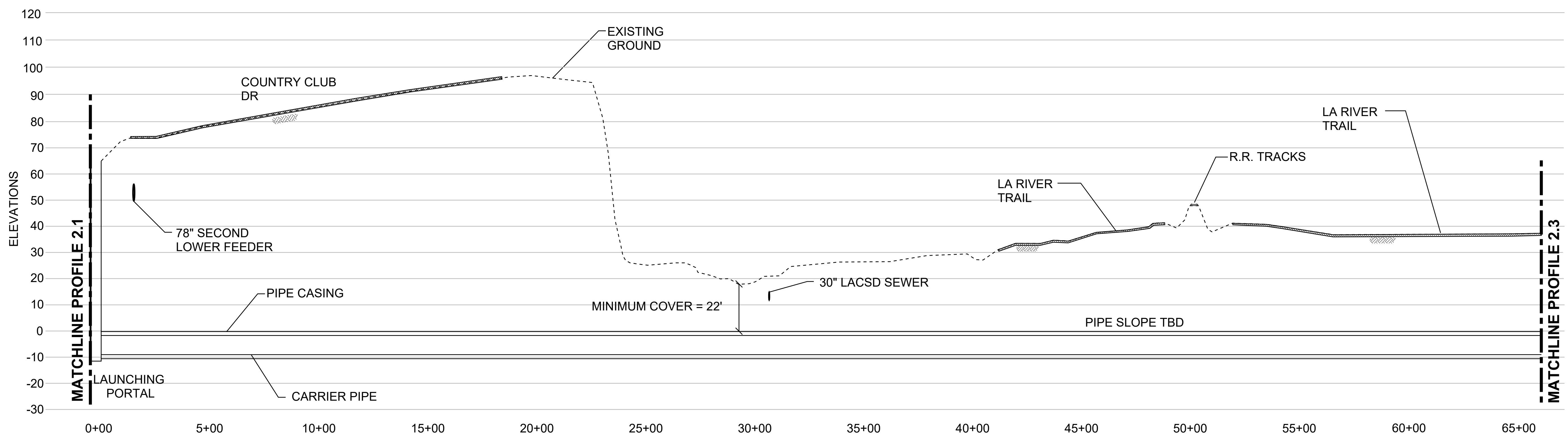

CONVENTIONAL TUNNEL (EPBM) LOS CERRITOS AND LA RIVER BANK (2.2)

HORZ: 1" = 500'
VERT: 1" = 40'

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1" = 1000' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Los Cerritos / Los Angeles River Bank Tunnel - Part 1

FIGURE 7-14

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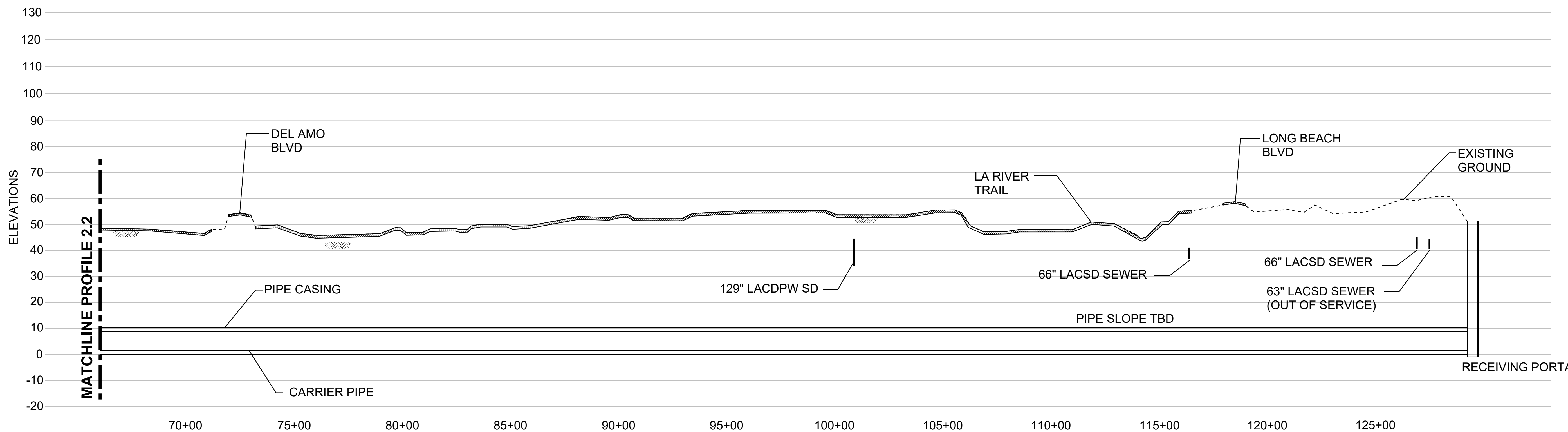

CONVENTIONAL TUNNEL (EPBM) LOS CERRITOS AND LA RIVER BANK 2.3

HORZ: 1" = 500'
VERT: 1" = 40'

BLACK & VEATCH

1" = 1000' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Los Cerritos / Los Angeles River Bank Tunnel - Part 2

FIGURE 7-15

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7.4.8.4 East Artesia Boulevard Crossing

The LA River Alignment proposes crossing East Artesia Boulevard and a mobile home community from Reach 1, Sta. 488+80 to Reach 1, Sta. 512+06 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-16 and in profile on Figure 7-17. Key details of the crossing are provided in Table 7-13.

Table 7-13 Trenchless Method Summary of East Artesia Boulevard Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
2,326	Road/ Community	7	22	Yes	MT	Y	N	Y	N	N

This proposed crossing would run parallel to, and between, three existing LACSD sewers (two active and one out of service) that also have the same crossing. Like the existing sewer lines, the proposed crossing would pass beneath the mobile home community in LACFCD's existing easement (quitclaim). To minimize the impacts on the community, it is assumed that this crossing would be completed with trenchless construction methods.

Launching for the trenchless construction is recommended from the north side of Artesia Boulevard and the LACDPW storm pump station in the LACFCD easement based upon potentially available space for portal excavation and contractor staging. The receiving portal is recommended on the south side of the mobile home community. The recommended receiving portal is located in the LACFCD easement. Acquisition of temporary and permanent easements would be required.

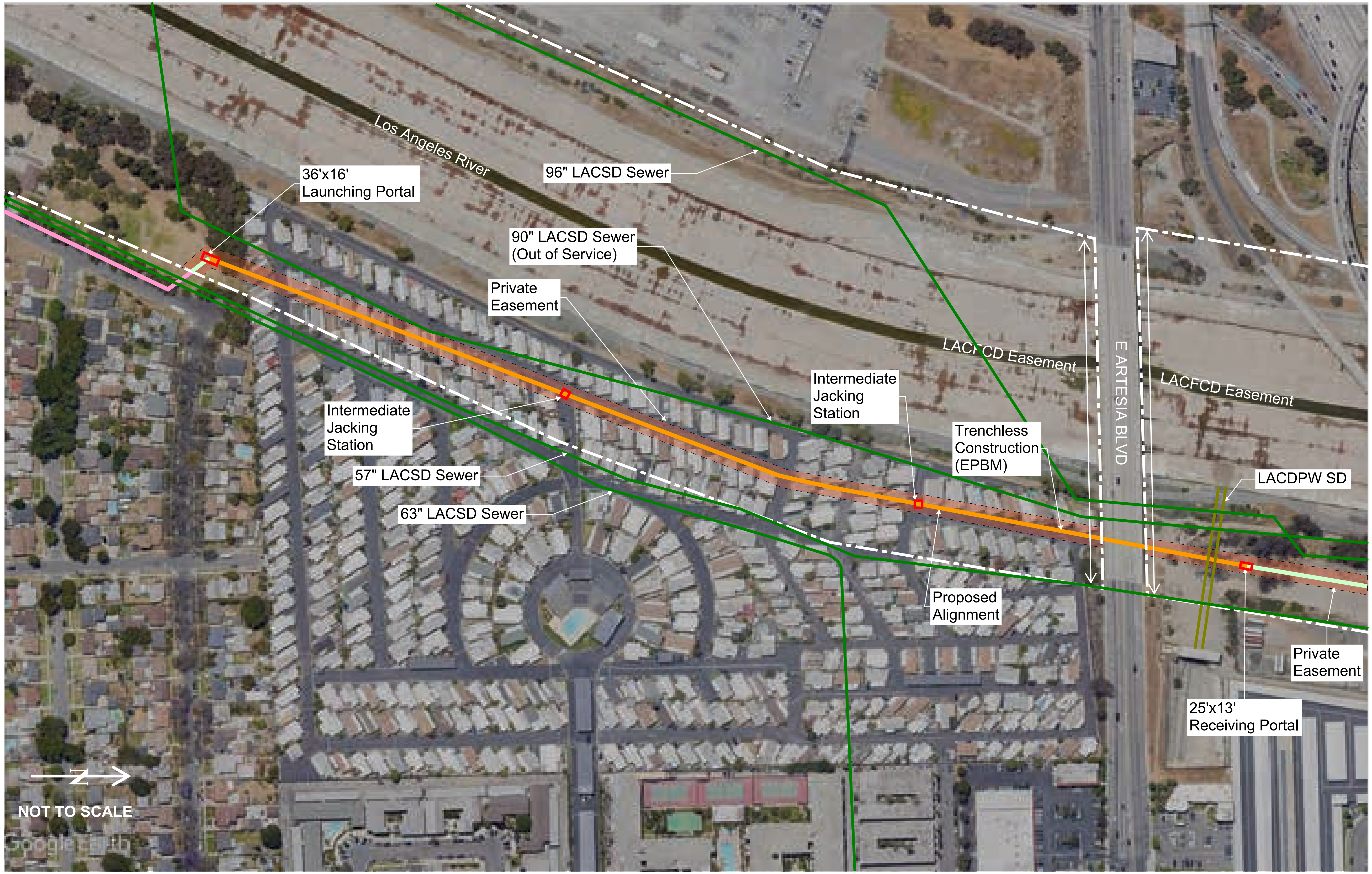
Due to the length and the curve radius, two intermediate jacking stations with continuously replenished overcut lubrication would work to reduce the side friction and minimize the risk of getting stuck. Since the proposed crossing would cross beneath trailer homes, the tunnel should be deep enough to provide at least 22 feet of cover below the ground surface.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Due to their depth, circular shafts should be considered.

The proposed alignment would pass close to the bridge for Artesia Blvd. The bridge abutment and piers are likely supported by piles or drilled shaft foundations. Detailed stress change and ground movement analysis is recommended at these locations. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required.

Existing LACFCD storm pipes run perpendicular to the Los Angeles River and the proposed alignment just north of East Artesia Boulevard. The alignment would cross the LACDPW storm pipes near the launching portal. As mentioned previously, the alignment is parallel to, and between, three existing LACSD sewer lines, with a fourth joining near Artesia Boulevard. Potholing would be required to finalize portal and alignment locations and feasibility.

Alternative routes to crossing beneath the mobile home community, such as following 63rd Street to Atlantic Avenue, were considered. However, these alternative routes were anticipated to have a greater impact on the community. Further coordination is required with property owners in subsequent phases of work to confirm this alignment. The alignment shown provides a conservative budget should an alternative be required.



BLACK & VEATCH

Open-Trench Construction Method - Roadways	Launching/Receiving Pit
Trenchless Construction Method - Microtunnel	Private Easement
Open-Trench Construction Method - LACFCD Easement (River Bank)	LACDPW Storm Drain
	LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

East Artesia Boulevard Crossing

FIGURE 7-16

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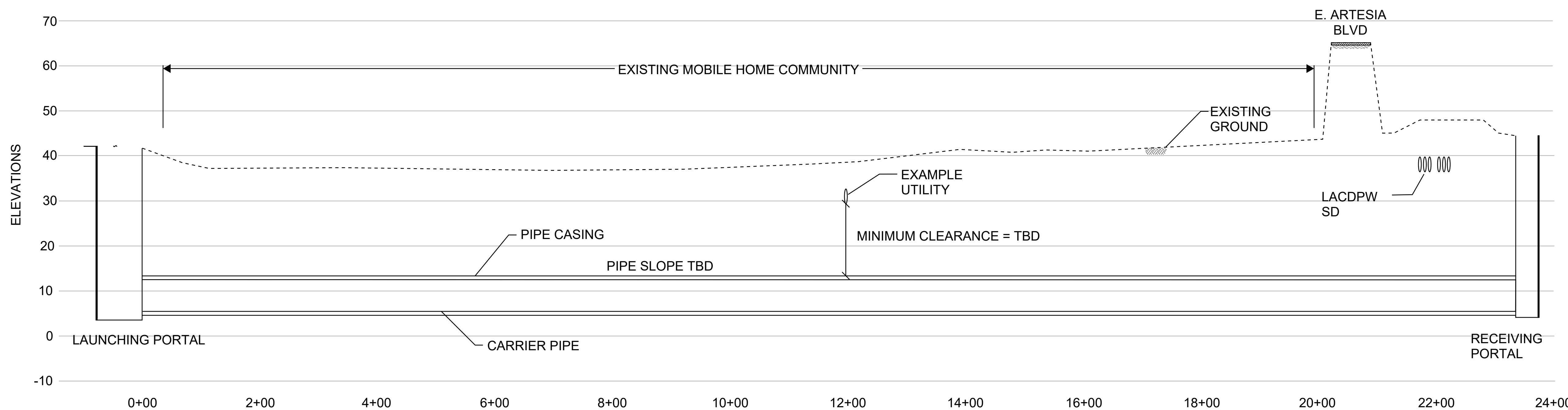

MICROTUNNEL CROSSING OF EAST ARTESIA BOULEVARD (4)
HORZ: 1" = 200'
VERT: 1" = 25'

BLACK & VEATCH

1" = 200' — 0, 100', 200', 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of East Artesia Boulevard Crossing

FIGURE 7-17

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7.4.8.6 105 Freeway Crossing

The LA River Alignment proposes crossing the 105 Freeway from Reach 1, Sta. 678+62 to Reach 1, Sta. 688+93 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-18 and in profile on Figure 7-19. Key details of the crossing are provided in Table 7-14.

Table 7-14 Trenchless Method Summary of 105 Freeway Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,031	Freeway	7	11	Yes	MT	Y	N	Y	N	N

The crossing would a feature trenchless construction segment crossing the railroad tracks, the 105 Freeway, a LACDPW stormwater retention basin, and Metropolitan's West Coast Feeder. Launching for the trenchless construction is recommended from near the dead end of railroad tracks in the MTA easement. Additional investigations and coordination with the owner of the railroad corridor would be required in subsequent design phases to confirm this portal location.

The receiving portal is recommended on the north side of the LACDPW retention basin and Metropolitan West Coast Feeder in SCE's easement. The area is currently being leased by a nursery and the plants would require temporary relocation during construction. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

No intermediate jacking stations would be anticipated to accomplish this drive length. Continuous replenishing of the overcut with lubrication should reduce the side friction sufficiently to manage the risk of getting stuck.

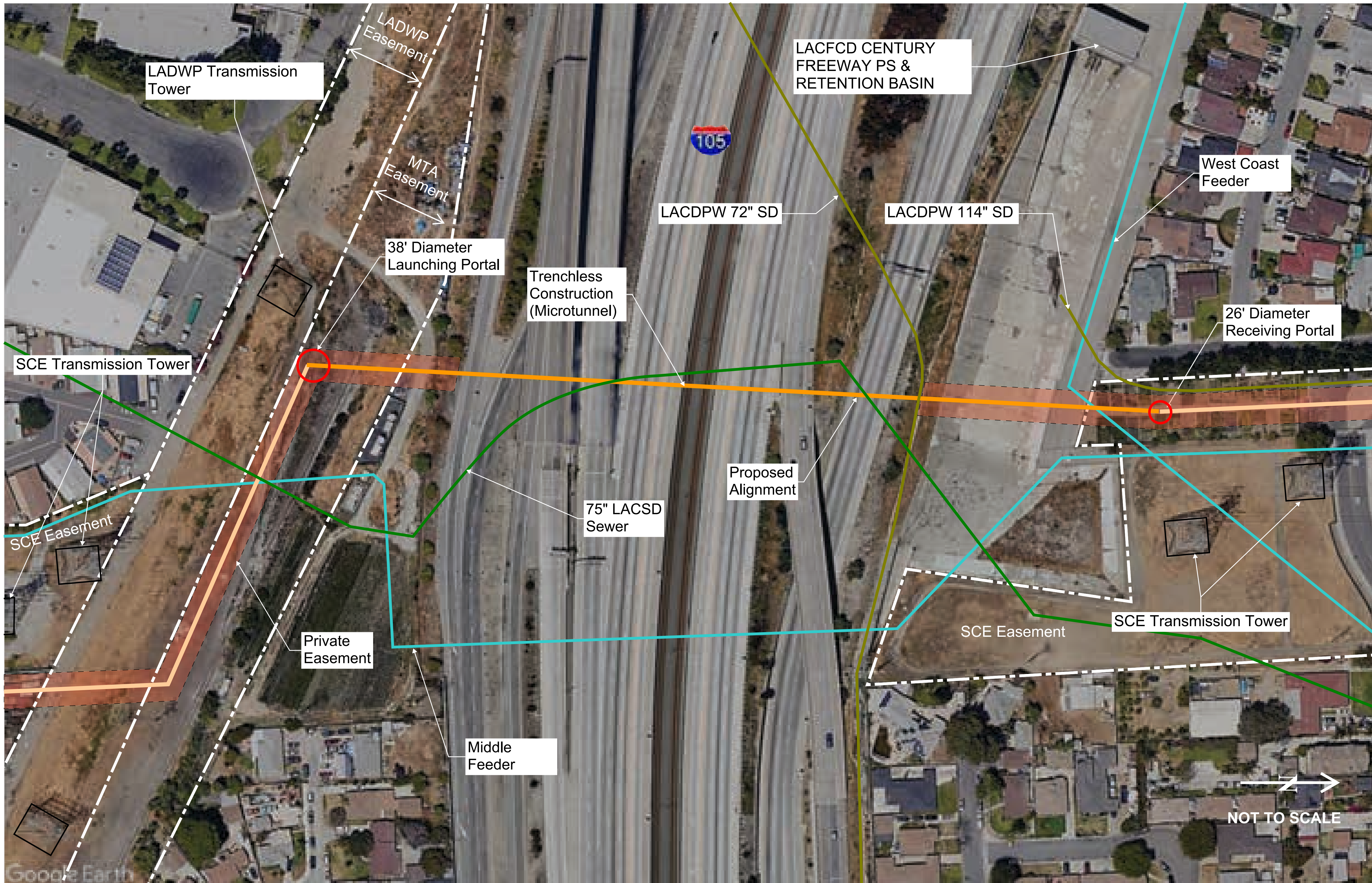
The proposed alignment passes beneath Interstate 105, along with two bridges, so the excavation would need to be deep enough to provide at least 11 ft of cover at the deepest point. Due to the depth required to accomplish this, the launching and receiving portals are recommended to be circular.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Metropolitan's Middle Feeder South and LACSD's Joint Outfall B – Unit 1C Trunk line cross the freeway in a similar location, with the sewer crossing the proposed tunnel alignment. On the north side of the 105 Freeway, LACDPW owns a storm drain detention basin and two storm drain pipes, one crossing the proposed alignment and the other parallel to the alignment. Additionally, Metropolitan West Coast Feeder crosses the proposed tunnel alignment near the receiving portal.

Due to the number of large utility / significant infrastructure crossings for the proposed tunnel, early coordination with stakeholders is recommended to determine feasibility of crossing and launching/receiving portal locations. Potholing would also be required to finalize portal and alignment locations and feasibility.

The on and off ramps associated with the freeway interchange occurring in this area are supported by piers and abutments. The bridge piers and abutments are likely supported by piles or drilled shaft foundations, which are not known at the time of this FLDR. Detailed stress change and ground movement analysis is recommended at these locations. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required. It is anticipated that the proposed trenchless alignment would be modified once the bridge supports are known.



Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
MET Pipelines
Launching/Receiving Pit
Private Easement
LACDPW Storm Drain
LACSD Sewer Pipe

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

105 Freeway Crossing

FIGURE 7-18

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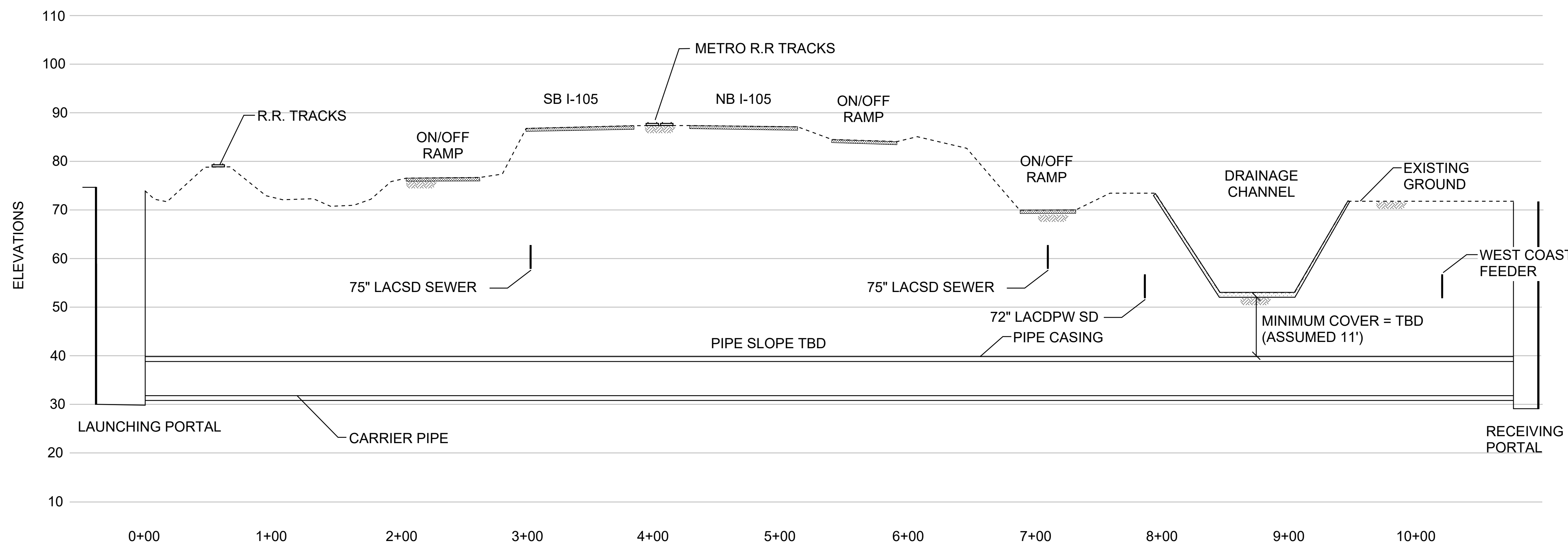

MICROTUNNEL CROSSING OF 105 FREEWAY (5)
HORZ: 1" = 100'
VERT: 1" = 25'

BLACK & VEATCH

1" = 100' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 105 Freeway Crossing

FIGURE 7-19

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7.4.8.7 Firestone Boulevard / Rio Hondo Golf Course Crossing

The LA River Alignment proposes using trenchless construction methods from Reach 1, Sta. 828+68 to Reach 1, Sta. 885+67 during which the pipeline would cross Firestone Boulevard, railroad tracks, a community park, and the Rio Hondo Golf Course. The proposed crossing is shown in plan on Figure 7-20 and in profile on Figure 7-21. Key details of the crossing are provided in Table 7-15.

Table 7-15 Trenchless Method Summary of Firestone Boulevard / Rio Hondo Golf Course Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
5,699	Road / Railroad	7	22	Yes	EPBM	Y	N	Y	N	N

This FLDR proposed trenchless construction beneath the storage facility located south of the railroad tracks and the park, neighborhood and the Rio Hondo Golf Course on the north side of the tracks to minimize the impact of the Project to the community. It may be warranted to complete an economic analysis comparing cut-and-cover construction through the golf course with the currently proposed trenchless construction during the next phase of work. However, this FLDR conservatively assumed that trenchless construction would be required.

This crossing is assumed to be constructed in one continuous span with launching and receiving portals both located in SCE easements. Both ends of the proposed tunnel appear to have enough available open space for portal excavation and contractor staging. The launching portal is recommended southwest of Firestone Boulevard and the receiving portal is recommended northeast of the Rio Hondo Golf Course.

A minimum cover of 22 ft is assumed at the lowest point, which appears to be along Rio Honda Dr. While the slope of the tunnel has not yet been determined, for this Project the receiving portal was assumed to be 3 ft higher than the launching portal. Due to the depth required, it is recommended that the receiving portal be circular. The launching portal is assumed to be rectangular. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. The proposed tunnel alignment is parallel to LACSD's existing JOA-1A Los Coyotes WRP Interceptor Trunk line for the first 2,000 ft. The alignment would also cross multiple LACDPW storm drain lines. Potholing would be required to finalize portal and alignment locations and feasibility. Additional utilities that would be anticipated are local utilities (water, sewer, recycled water, and dry utilities) in Firestone Boulevard and Rio Hondo Drive, as well as irrigation lines in the Rio Hondo Golf Course.Acquisition of temporary and permanent easements would be required.

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - EPBM Tunnel
Private Easement
Launching/Receiving Pit
LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Firestone Blvd / Rio Honda Golf Course Crossing

FIGURE 7-20

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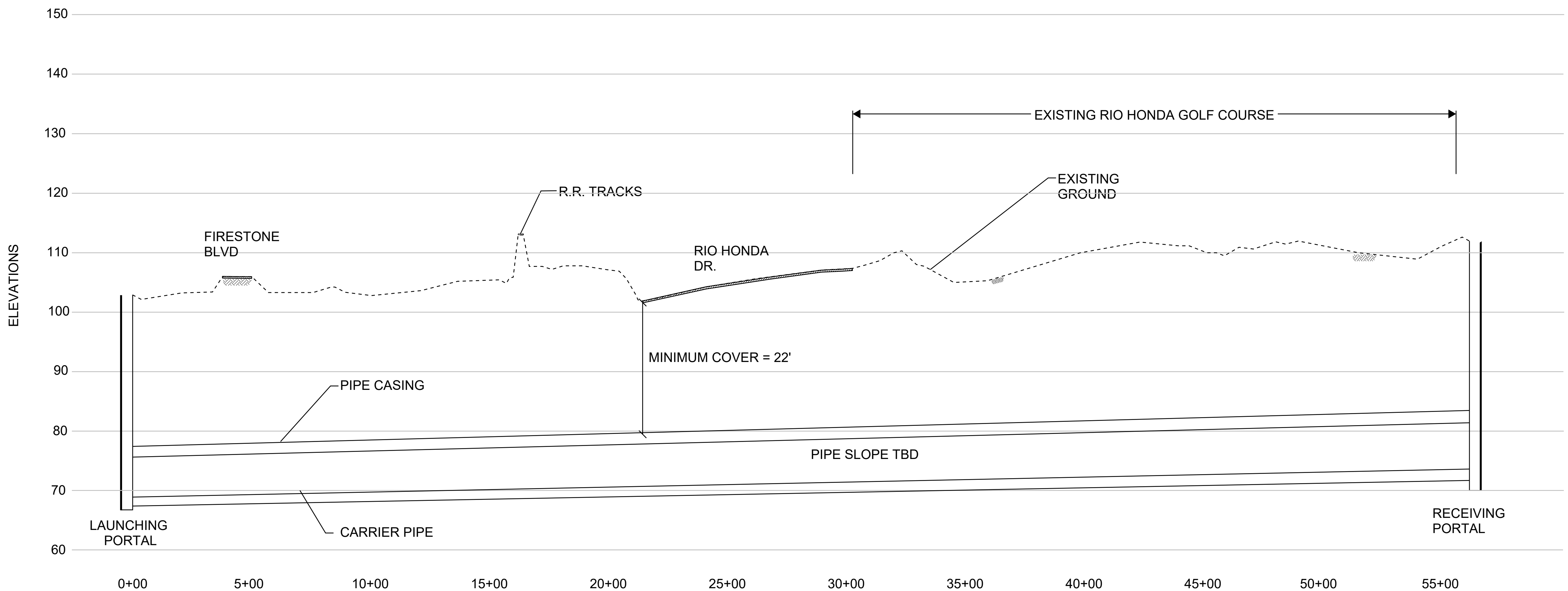

CONVENTIONAL TUNNEL (EPBM) FIRESTONE BLVD AND RIO HONDA GOLF COURSE 6

HORZ: 1" = 500'
VERT: 1" = 20'

BLACK & VEATCH

1" = 500' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Firestone Blvd / Rio Honda Golf Course Crossing

FIGURE 7-21

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7.4.8.8 SG River Crossing – Beverly Boulevard

The LA River Alignment proposes crossing the SG River near Beverly Blvd from Reach 1, Sta. 1250+25 to Reach 1, Sta. 1257+13 using trenchless construction methods.

Key details of the crossing are provided in Table 7-16.

Table 7-16 Trenchless Method Summary of SG River Crossing at Beverly Boulevard

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
688	River	7	11	Yes	MT	Y	N	Y	N	N

The proposed crossing is shown in plan on Figure 7-22 and in profile on Figure 7-23.

Launching is recommended in the SCE easement on the east side of the river due to available space in the area. The receiving portal is recommended on the eastern side of the river in the public right-of-way. Further investigation of the surrounding area and the traffic control requirements would be required to finalize portal location and availability.

No intermediate jacking stations are anticipated to accomplish this drive length. Continuous replenishing of the overcut with lubrication should reduce the side friction sufficiently to manage the risk of getting stuck.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Due to their depth, circular shafts should be considered.

The proposed alignment would pass close to a building that may have shallow spread footings and a bridge abutment. The bridge abutment is likely supported by piles or drilled shaft foundations. A settlement trough evaluation should be completed to determine the potential impacts on the foundations and if any ground improvement is needed to minimize the risk. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required.

The proposed trenchless crossing would intersect three LACSD sewer lines and one LACDPW storm drain line. It is also anticipated that other local utilities would be located within Beverly Boulevard. Potholing is recommended to confirm the portal and alignment locations. Additional utility information should be gathered in this area during subsequent phases of design.

Acquisition of temporary and permanent easements would be required.

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- Open-Trench Construction Method - Roadways
- Trenchless Construction Method - Microtunnel
- Open-Trench Construction Method - SCE Easement
- Launching/Receiving Pit
- Private Easement
- LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Beverly Blvd

FIGURE 7-22

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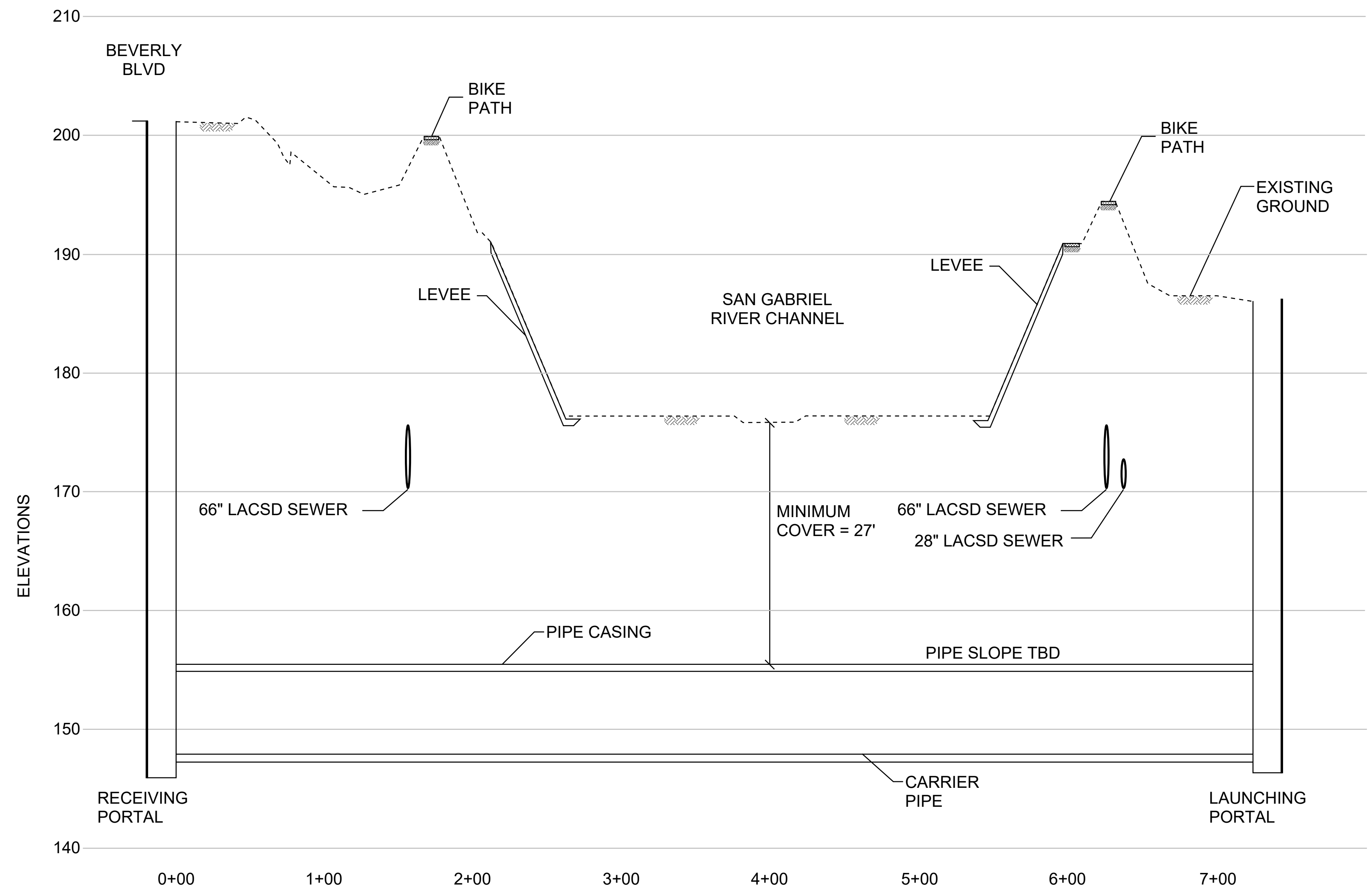

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT BEVERLY BLVD 7

HORZ: 1" = 100'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Beverly Blvd

FIGURE 7-23

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7.4.9 Preliminary Alignment Cross-Sections

Utilizing GIS mapping and right-of-way information, feasibilitiy-level alignment cross-sections were developed to depict the approximate location of the LA River Alignment relative to known major utilities and key surface features. The proposed location of the LA River Alignment was developed based on extensive research of existing utilities based on above grade features and available utility maps. The cross-sections are graphical in nature and are not intended to represent design-level detail. However, the alignment does reflect a general corridor that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. Additional utility investigations, including subsurface investigations, will be completed during subsequent design phases and the alignment is anticipated to be adjusted accordingly.

Since the LA River Alignment would traverse long stretches of existing streets with utilities varying in location, no "typical" section is provided to represent the location of the pipeline along the entire alignment. Instead, the alignment attempts to account for the presence of existing utilities and constructability concerns at each specific location. The representative cross-sections at key corridors are identified in Table 7-17 and presented on Figure 7-24 thru Figure 7-28. Figure 7-7 presents the location of each representative cross-section.

Where a location is identified for the LA River Alignment that is common to the SG River Alignment, the figure was not repeated. Instead, in Table 7-17 it was noted and a reference to the figure in Chapter 6 was provided.

Table 7-17 Preliminary Alignment Cross-Section Locations

NO.	STATION	DESCRIPTION	LOCATION OF DESCRIPTION
1	Reach 1, Sta. 8+50	Main Street facing north.	See Section 6.4.9.
2	Reach 1, Sta. 70+00	Sepulveda Boulevard facing east.	See Section 6.4.9.
3	Reach 1, Sta. 214+00	Willow Street facing east.	See Section 6.4.9.
4	Reach 1, Sta. 252+00	LACFCD Easement facing north.	
5	Reach 1, Sta. 545+00	N. Atlantic Place facing north.	
6	Reach 1, Sta. 608+00	SCE Easement facing north.	
7	Reach 1, Sta. 892+00	SCE Easement facing north.	
8	Reach 1, Sta. 1221+00	E. Beverly Boulevard facing east.	
9	Reach 2, Sta. 1442+00	SCE easement facing north.	See Section 6.4.9.
10	Reach 2, Sta. 1803+00	Live Oak Avenue facing southeast.	See Section 6.4.9.

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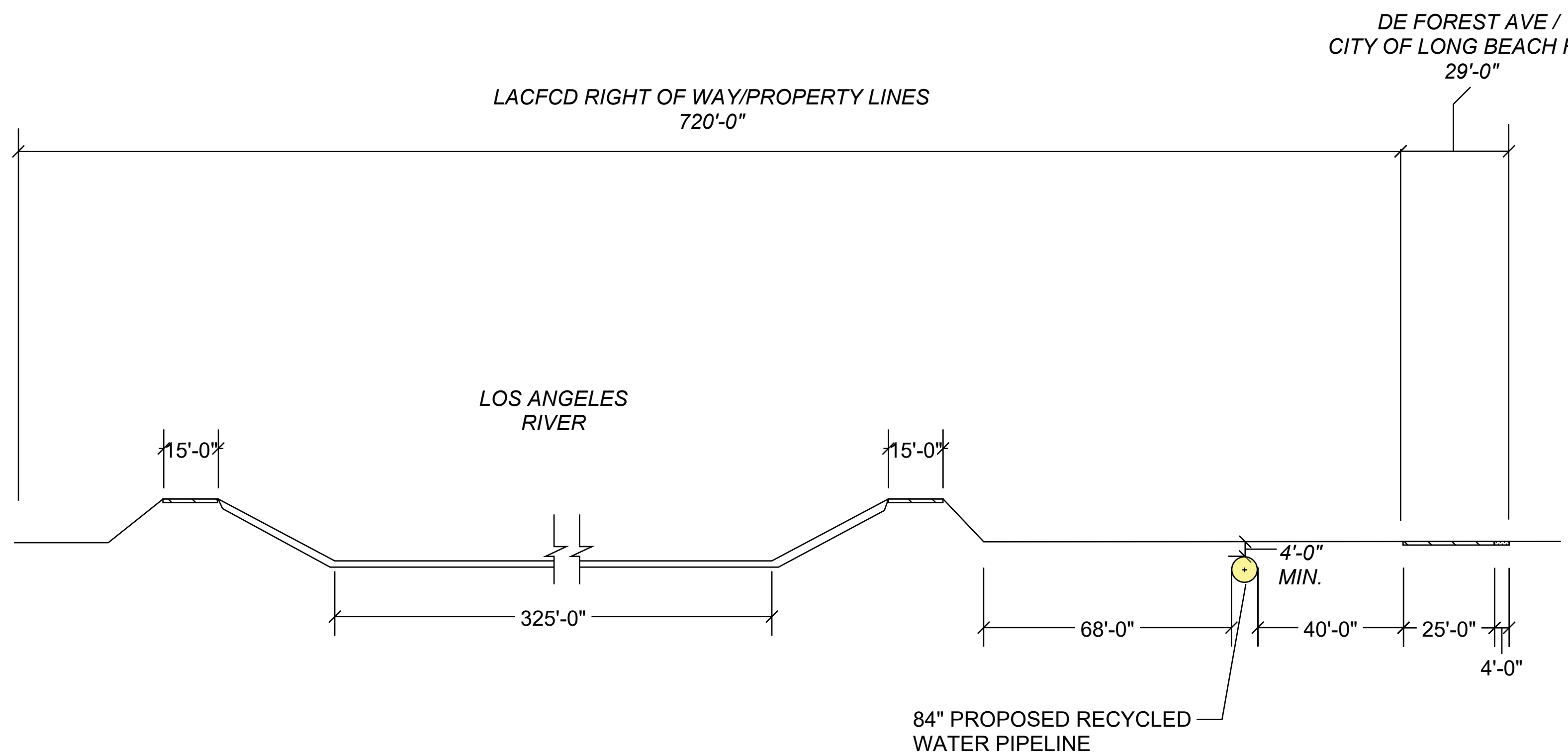

CROSS SECTION 4 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDERED TO AVOID FUTURE EXPOSURE OR CONFLICT.
2. ALL DEPTHS OF EXISTING UTILITIES ARE ASSUMED.

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 4 – LACFCD EASEMENT FACING NORTH (REACH 1, STA 252+00)

FIGURE 7-24

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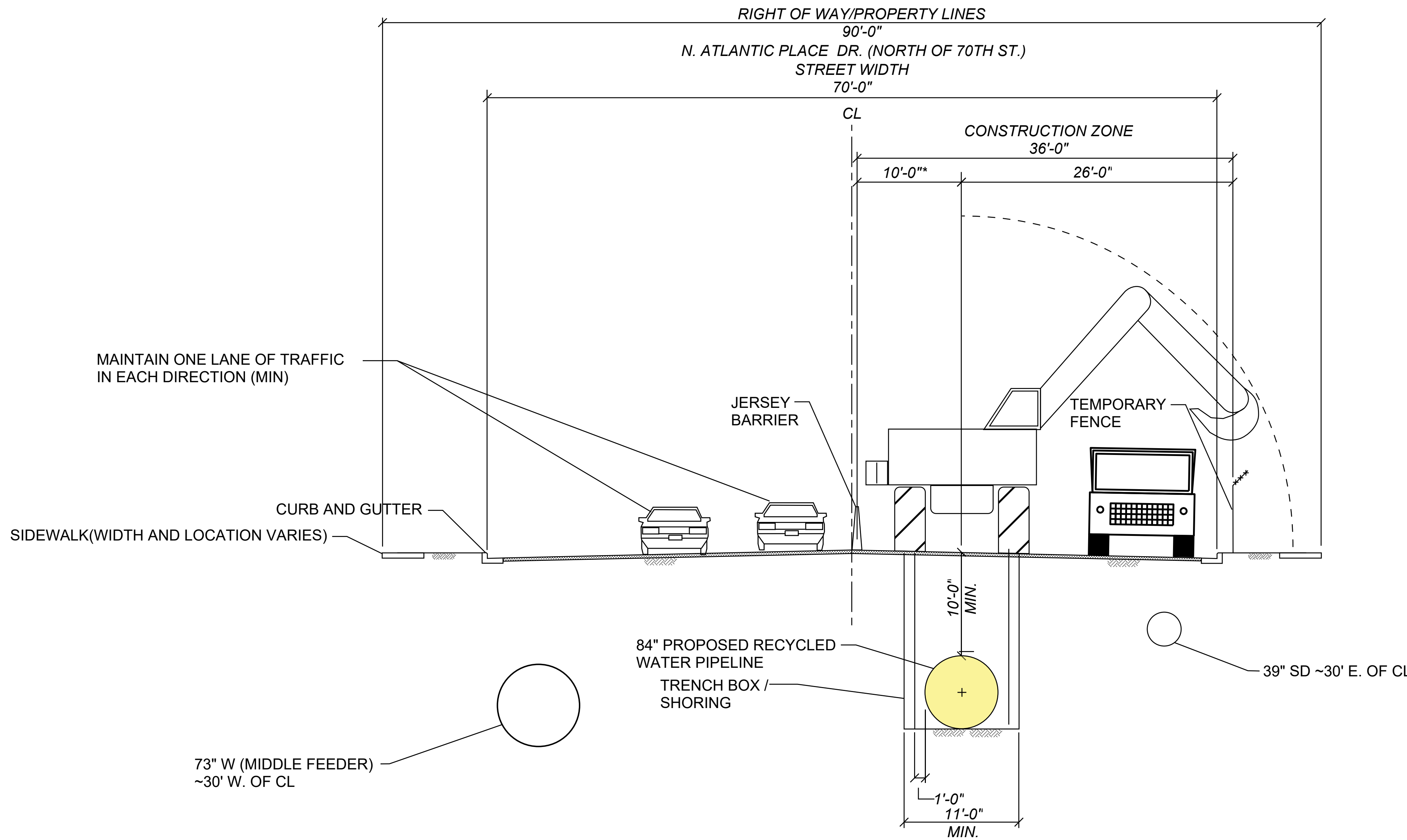

CROSS SECTION 5
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- LA COUNTY DEPT OF PUBLIC WORKS GIS RECORDS
- METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA GIS RECORDS

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 5 – NORTH ATLANTIC PLACE FACING NORTH (REACH 1, STA 545+00)

FIGURE 7-25

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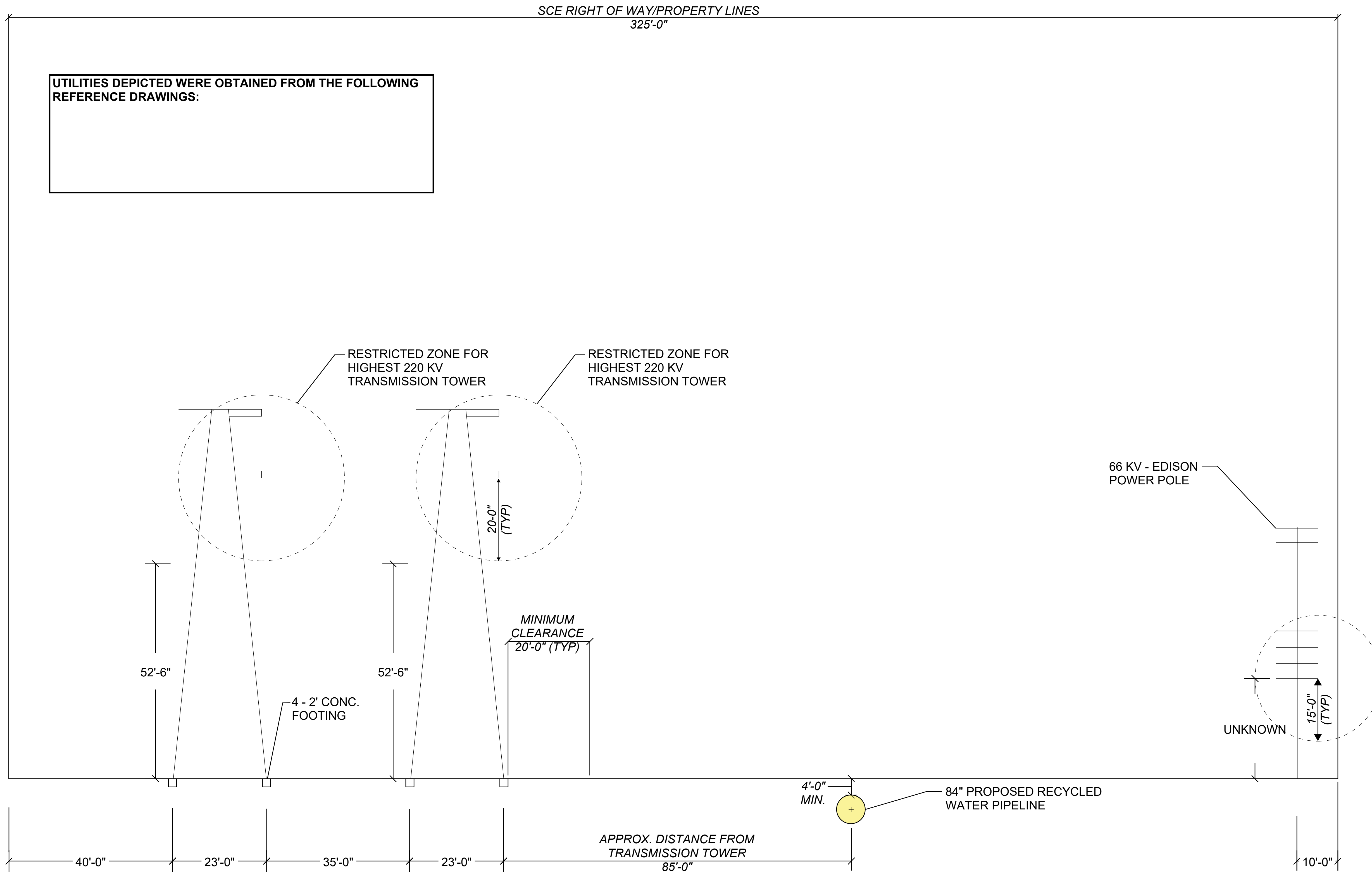

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

CROSS SECTION 6 -

NO SCALE

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH	0 10 20 30 FEET	**POTENTIAL REGIONAL RECYCLED WATER PROGRAM** **PRELIMINARY ALIGNMENT CROSS-SECTION 6 – SCE EASEMENT FACING NORTH (REACH 1, STA 608+00)**	**FIGURE 7-26**

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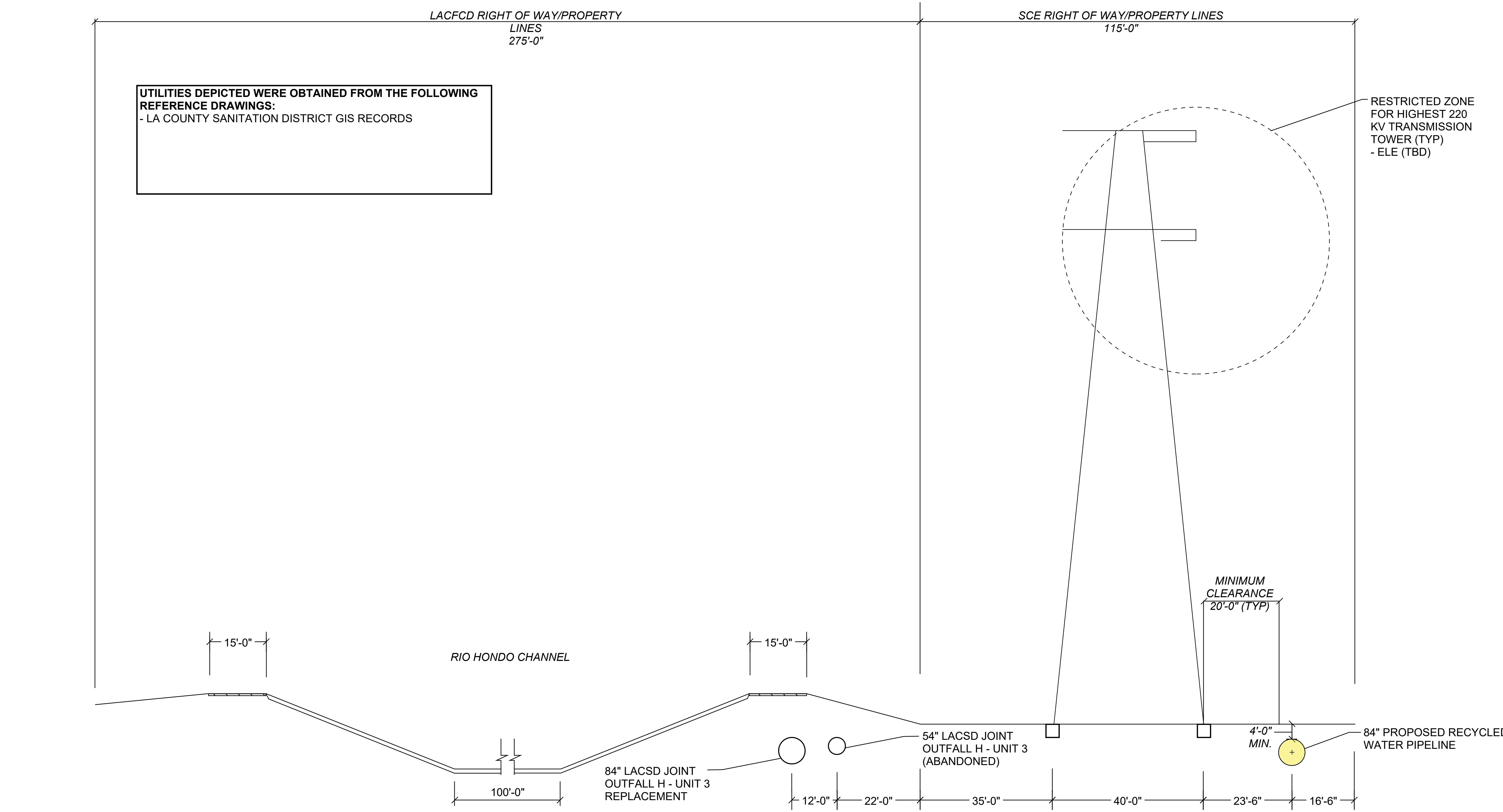

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

CROSS SECTION 7 -

NO SCALE

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFLICT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH

0 10 20 30 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 7 – SCE EASEMENT FACING NORTH (REACH 1, STA 892+00)

FIGURE 7-27

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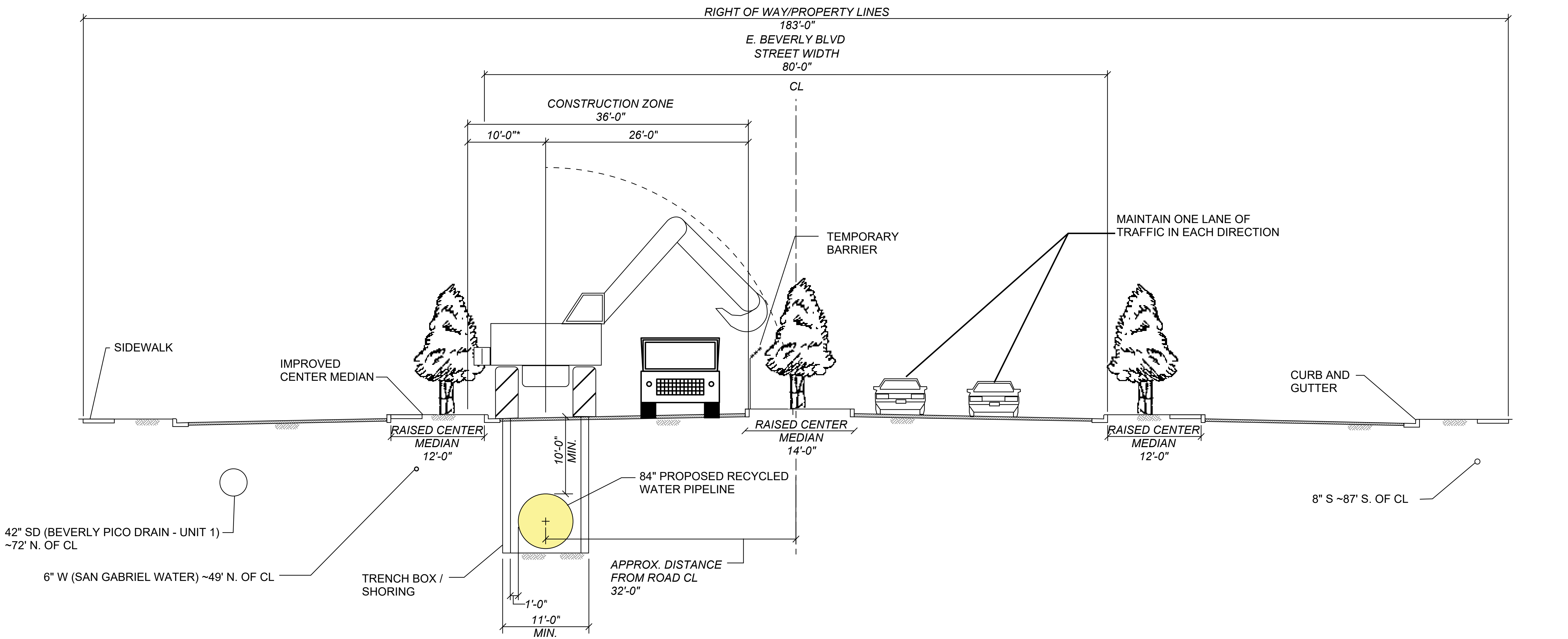

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 8
-
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG PR-16
- LA COUNTY DEPT OF PUBLIC WORKS GIS RECORDS

NOTE:
* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 8 – EAST
BEVERLY BOULEVARD FACING EAST (REACH 1, STA 1221+00)

FIGURE 7-28

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8.0 Pump Station Analysis

This chapter provides feasibility-level design information for the pump stations that would be necessary to convey water from the AWT plant to the various groundwater recharge locations. The section begins with an overview of the pump station system and continues through more detailed discussions of key feasibility-level design criteria and features that would serve as a basis for subsequent design activities.

A brief overview of the analysis documented in this chapter is as follows:

- **Pump Station Overview.** Two pumps in series would be required for the Backbone System: PS-1 and PS-3. This section includes a description of the system, the components that are anticipated at each station, and the approach utilized to size the stations.
- **Conceptual Operating Strategy.** This section describes the planning level control strategy for the pump system that was developed to guide the subsequent operation of the pump stations. There are alternate control strategies which should be further investigated during subsequent phases of work.
- **Pump Station Hydraulic Analysis and Pump Evaluation.** A planning level hydraulic analysis was performed to determine preliminary sizing of the pumping equipment at each station, including system curve development, pumping equipment characteristics, and preliminary pump selections.
- **Planning Level Pump Station Design and Sizing.** This section documents the feasibility-level design of the pump station components for the purposes of feasibility-level station configuration, cost estimating, and site planning, including 1) pump station building, 2) hydraulic surge control facilities, 3) storage facilities, 4) yard piping, dichlorination, and metering, and 5) power supply and electrical requirements.
- **Pump Station Site Investigations.** This section documents the identification and comparison of potential pump station sites. PS-1 is anticipated to be located at the AWT plant site. While not a part of the Backbone System, potential sites were identified for PS-2 or the flow control facility if needed in the future and are presented in Appendix V. Five potential sites were considered for PS-3.
- **Site and Yard Piping Development.** Preliminary site plans were developed for each pump station site. Specific site plans were developed for PS-1 at the AWT plant, while a typical site plan was developed for PS-3 that is applicable to the five potential sites that were identified. The preliminary site plans are presented in Appendix L.

This chapter was originally prepared for the 2018 Draft Report, focusing on a conveyance system intended only for IPR and included the reach to the OC Spreading Grounds. At the time, this chapter also went on to note what revisions would be anticipated to the pump stations should Metropolitan elect to implement what is now known as the Backbone System. This effort was not developed to the same level of detail. Metropolitan has made the decision as an organization to reserve additional funding for the upcoming phases of work. As such, the analysis completed on the pump stations has not been updated since the 2018 Draft Report, except that the material was reviewed relative to changes to the Project concept since that time.

Based on that review, it was determined that:

- The general location for PS-3 shown herein remains applicable to the Backbone System. Other sites besides those identified herein may also warrant consideration during the next phase of planning and design.
- The general location for PS-3 shown herein is applicable to both the SG and LA River Alignments, as the hydraulics are similar.
- For cost estimating, the planning level cost of PS-1 and PS-3 are similar.

Additional evaluations will be required in the next phase of design to further refine the size and location of the pump stations for the Backbone System, as well as the control strategy. The size and location of the pump stations required for the future connection to the FEWWTP will also need to be determined.

Figure 8-1 summarizes the Project methodology as it applies to this chapter.

Figure 8-1 Chapter 8 Methodology

8.1 PUMP STATION OVERVIEW

This section describes the pump station system, the associated pump station components, and the analysis approach for developing the feasibility-level design information.

8.1.1 System Description

As described in Chapter 5, multiple pump stations would be required to convey recycled water from the AWT plant to the anticipated discharge locations, which are located several miles away and at higher elevations than the AWT plant. Table 8-1 summarizes the approximate ground elevations of these discharge points. The ground elevation at the AWT plant is approximately 42 ft. Elevations are relative to MSL.

Table 8-1 Groundwater Recharge Location Elevations

RECHARGE LOCATION	APPROXIMATE GROUND ELEVATION (FT)
Potential Future (West Coast Basin) Injection Wells	90
Potential Future (Central Basin/Long Beach) Injection Wells	60
OC Spreading Grounds	230
Rio Hondo Spreading Grounds (Montebello Forebay)	145
Santa Fe Spreading Grounds	485-500

As described previously, the analysis in this chapter has not been revised since the preparation of the 2018 Draft Report, as Metropolitan is reserving additional funding to complete those efforts as part of upcoming phases of work, coincident with additional decision making on Project concepts and potential partnerships. At the time of the 2018 Draft Report, three pumping concepts were being considered. However, two of those concepts were based upon delivering flow to the OC Spreading Grounds, which has since been removed from the initial implementation phases envisioned for the Project. Therefore, those two pumping concepts have been removed from this chapter and are provided in Appendix V for future reference, if needed. The remaining pumping configuration for the Backbone System is described herein. This concept was evaluated based upon the SG River Alignment, which is the more conservative of the two alignments due to longer length.

- **Alternative A-Backbone System – Potential for DPR.** This concept includes two pump stations where PS-1 pumps directly to PS-3. This concept does not include PS-2 nor a junction structure at the original proposed location of PS-2. Thus, pumping to the OC Spreading Grounds is not included.

While PS-2 is no longer a part of this Project, the numbering of the pump stations has remained unchanged in the event that deliveries to the OC Spreading Grounds become desirable in the future. It may be warranted to rename facilities during subsequent phases of work.

Table 8-2 summarizes the proposed pump stations, including their general locations, capacities, and configuration. PS-1 would have two sets of pumps and discharge pipelines to deliver recycled water to two separate discharge locations. PS-3 would have one set of pumps to send recycled water to the Santa Fe Spreading Grounds, with the Rio Hondo Spreading Grounds being served by gravity from the storage tank at PS-3.

Table 8-2 Summary of Pump Station Attributes (Backbone System)

PUMP STATION	GENERAL LOCATION (WITH APPROXIMATE GROUND ELEVATION)	PRELIMINARY FIRM CAPACITY	PUMPS TO
PS-1	AWT plant/JWPCP, Carson (42 ft)	Set A: 15 mgd Set B: 150 mgd	Set A: West Basin Set B: PS-3 Forebay
PS-3	Near Whittier Narrows, Pico Rivera (220 ft)	Set A: 150 mgd	Set A: Santa Fe Spreading Grounds

8.1.2 Station Components

Each pump station would have similar components that would be adjusted to account for the station's specific location and capacity. The components reflected in the feasibility-level design include, but are not limited to, the following:

- Main pump area: This area would include the pumps and motors, surge tank air compressors, and administration area. At PS-1, the pumping equipment itself would be outdoors with a building sized just for administration, storage, and air compressors. Since PS-1 will be located at the AWT plant site, ultimately the design of PS-1 will need to be coordinated with that of the AWT plant. At PS-3, all the equipment associated with this area would be located within a building.
- Surge control area: This area would include above-grade, air-over-water hydropneumatic surge tanks and associated piping. The tanks would be located outdoors and would be shielded by a curtain wall.
- Pump station forebay/suction storage facility: At PS-1 and PS-3, this was assumed to be an above grade circular tank. The pump station forebay at PS-1 will need to be coordinated with the hydraulic grade line coming out of the AWT plant, which may necessitate it to be below grade. Additionally, to reduce the site requirements for PS-3, a buried forebay could also be considered. Pump station forebay configurations should be further studied during the next phase of work and should be coordinated with design of the AWT plant.
- Dechlorination facility on storage tank overflow: This structure, mostly located below-grade, would use granular activated carbon to dechlorinate any overflow before entering offsite drainage channels. This component would be required at PS-1 and PS-3.
- Electrical room/building: This building would house the main electrical equipment for the station, including variable frequency drives (VFDs) and switchgear.
- Electrical transformer area: This area would house the electrical transformers that feed the electrical room/building.
- Miscellaneous facilities, including valve and meter vaults.

8.1.3 Analysis Approach

The feasibility-level design of the pump stations is based on first establishing a conceptual operating strategy describing how the multiple pump stations would be controlled. This was followed by determining the preliminary size of the pumping equipment (flow, head, and power) based on the conveyance system configuration described in the previous sections. With basic control and equipment sizing established, the ancillary facilities were sized. The information provided is at the feasibility level and will be refined and detailed in subsequent design phases. Preliminary calculations and equipment selections supporting the feasibility-level design are included in Appendix J.

8.2 CONCEPTUAL OPERATING STRATEGY

The pump stations must operate and be controlled in a carefully coordinated manner to deliver flow at the required rates to the various discharge points. The method of control will dictate design of the pump stations, including the size of storage facilities and size and speed ranges of pumping equipment. This section describes a conceptual control strategy for the system that was developed to guide the subsequent conceptual operation of the pump stations. There are alternate control strategies which should be further investigated during subsequent phases of work.

8.2.1 Overall Conceptual Control Strategy

In general, the proposed primary control strategy is based on coordinated flow set points calculated for each set of pumps/flow control stations based on AWT plant production and desired delivery points. These set points would be communicated to each set of pumps/flow control stations and associated flow meters so that the flow rate entering a pump station would be equal to the flow rate leaving a pump station. The control strategy for the Project is shown on Figure 8-2. The control strategy is anticipated to be further refined during subsequent phases of work.

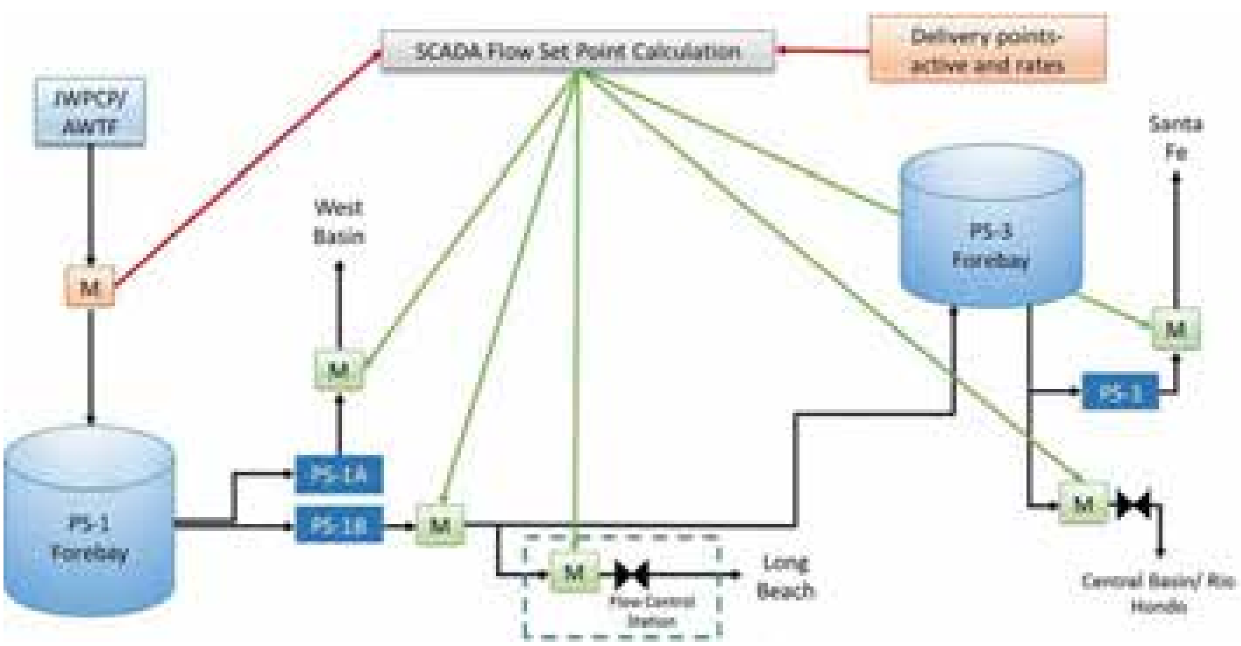

Figure 8-2 Overall Control Strategy Concept

The flow set points would be achieved by modulating the VFD-driven pumps or flow control valves to meet the flow set point. The flow set point would be modified, or trimmed, based on the level in the upstream storage tank. For example, if the level in the tank were rising above a desired level set point, the flow set point of the downstream pumps would be increased until stable tank levels are achieved. The control approach for PS-1 is illustrated on Figure 8-3. This general control framework would be supplemented by a range of control interlocks to keep the stations operating within designated parameters, which will reduce the risk of unanticipated operating scenarios. These interlocks are discussed in greater detail below.

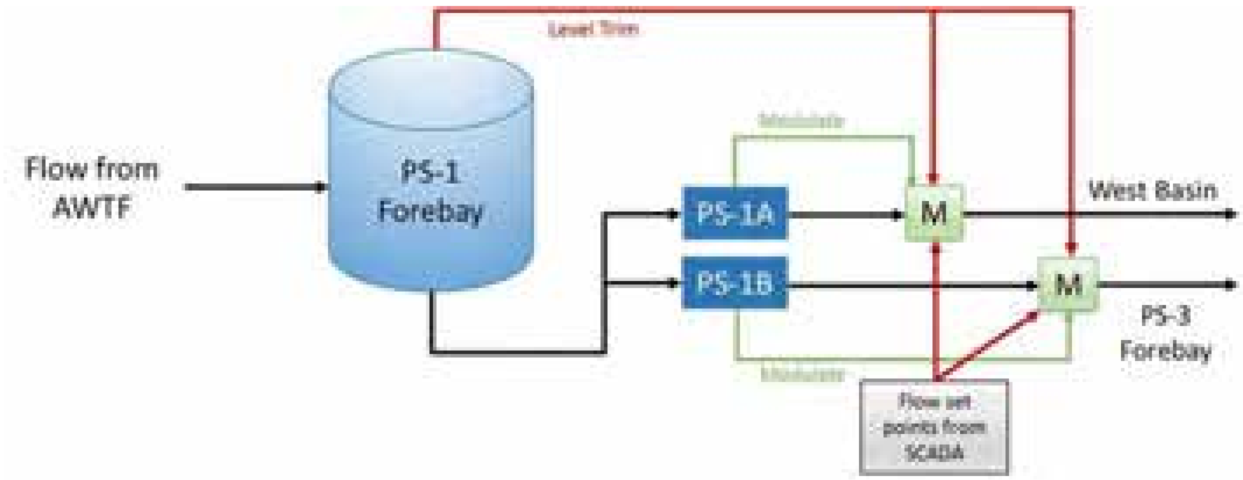

Figure 8-3 Flow Control with Level Trim and PS-1

The goal of the conceptual control strategy described above is to achieve stable tank levels, typically at around 50 percent of the forebay tank depth. When the system is stable, tank level should not change, and the need for storage would be minimal. However, there would be instances, especially during normal starting and stopping of the system, when flow imbalances would be expected to occur and the level in the forebay storage tank would either go up or down.

To estimate the volume associated with a flow imbalance during normal starting and stopping operations, a conceptual starting and stopping sequence was developed as depicted on Figure 8-4 and Figure 8-5. The ramp-up times for the system to start (time for pump to accelerate from OFF to the preset speed) were estimated at 2 minutes, which is expected to exceed the critical period for the longest length of pipe to reduce pressure surges. The "critical period" is the time required for an acoustic wave to travel from the pump station to the end of the pipe and back.

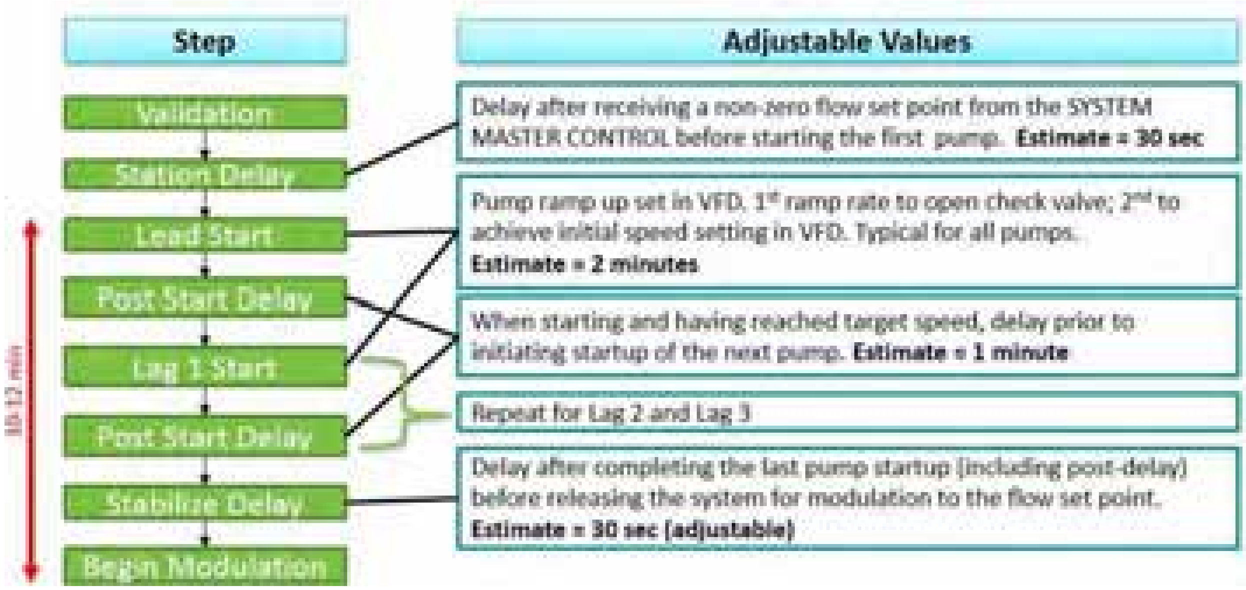

Figure 8-4 Conceptual Starting Sequence

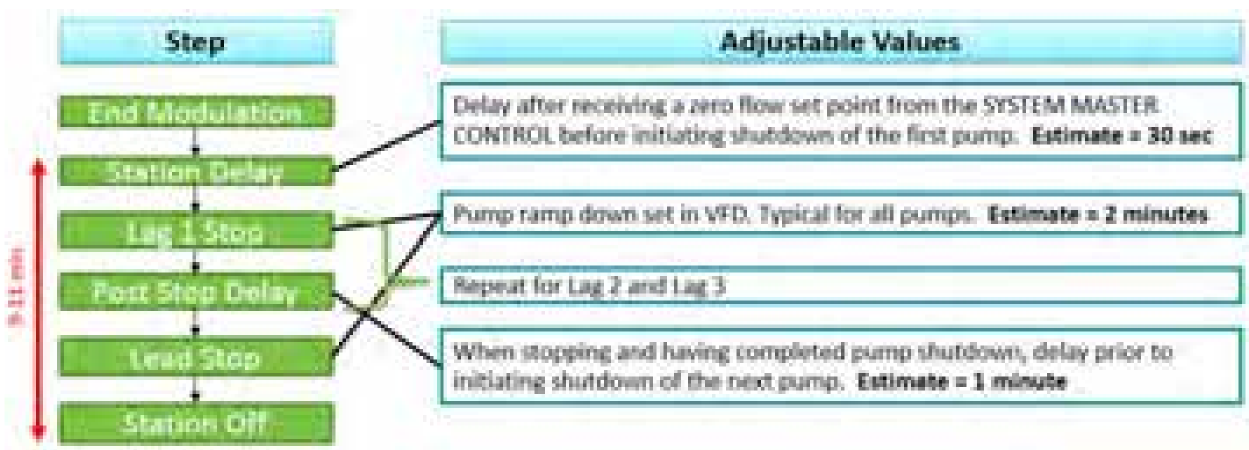

Figure 8-5 Conceptual Stopping Sequence

The estimated time for a controlled startup would range from 10-12 minutes based on the initial estimated ramping rates and control delays. The time for a controlled ramp down would range from 9-11 minutes. An emergency stop would happen essentially instantaneously as power is cut to the pumps and they decelerate (i.e., spin down) according to the system inertial characteristics. In an emergency stop scenario, the stored energy in the hydro-pneumatic surge control tanks would help to gradually reduce the flow and protect the system from damaging hydraulic surge conditions.

The operating and control philosophy presented was developed collaboratively with Metropolitan and presents one feasible approach that takes into account the size of the pumps. Pump operating and control philosophy, as well as forebay sizing will be further refined during the next stage of the project.

8.2.2 Control System Interlocks and Backup Systems

The control system for the conveyance system would be designed with various features to prevent the system from operating outside of design parameters. These features would include software and hardwired interlocks as well as backup control systems. Examples of interlocks that would be implemented include:

- Level transmitters – high or low tank level shuts down upstream/downstream of pump station.
- Redundant high and low float switches in tanks, hardwired to pumps - high or low tank level would shut down upstream/downstream of a pump station.
- Pressure transmitter/switches – out of range would shut down pump stations.
- If one station were to shut down, then all stations would shut down.
- Peer-to-peer heartbeat: if pump stations were to lose communication, all pump stations would shut down after a set delay.
- Loss of communication time-out: if a pump station would be unable to communicate, it would shut down.
- Flow coordination check routines in software to make sure flow rates at each station would match.
- Redundant operator verifications to modify automatic controls and interlocks.

Examples of backup control systems include switching to local level control if communication is lost. In this scenario, the pump station would operate to maintain the level in its associated upstream storage tank. This would prevent overflow of the local storage tank; however, it would not prevent overflow of the downstream storage tank if that facility was shut down. Thus, loss of communication is likely a scenario that would require a shutdown.

8.3 PUMP STATION HYDRAULIC ANALYSIS AND PUMP EVALUATION

This section describes the hydraulic analysis performed to determine preliminary sizing of the pumping equipment at each station. Specifically, this section describes system curve development, pumping equipment characteristics, and preliminary pump selections.

8.3.1 System Curve Development

System curves were developed for each set of pumps to document the required total dynamic head at the pump stations from the static condition to the maximum capacity. These curves were then used to select candidate pumping equipment. Detailed preliminary system curve calculations are provided in Appendix J. The following system curves were developed for each station to provide an envelope of operating points:

- High Manning's: This system curve assumes low suction tank level, high discharge tank level, and calculation of friction losses using the Manning's equation with n=0.012, as prescribed by Metropolitan's Hydraulic Design Manual. This results in the highest head condition and was the basis for the rated point on pump selections. Since this was considered to likely be a conservative condition, this point was selected left of best-efficiency point (BEP) when selecting pumps, which would provide additional runout capacity for lower head conditions when fewer pumps are operating.

- Low Manning's: This system curve assumes high suction tank level, low discharge tank level, and calculation of friction losses using the Manning's equation with n=0.012, as prescribed by Metropolitan's Hydraulic Design Manual.
- High Darcy: This system curve assumes low suction tank level, high discharge tank level, and calculation of friction losses using the Darcy-Weisbach equation with a surface roughness of 0.000225 ft, which is considered at the upper range for cement mortar lined steel pipe. The value of 0.000225 ft is 1.5 times 0.00015 ft, the surface roughness used in the Low Darcy scenario.
- Low Darcy: This system curve assumes high suction tank level, low discharge tank level, and calculation of friction losses using the Darcy-Weisbach equation with a surface roughness of 0.000015 ft, which is considered at the lower range for cement mortar lined steel pipe. This curve was the lowest estimated system curve. If possible, pumps were selected to also intercept this curve to prevent runout of a single pump at 100 percent speed. However, in some cases this would not be possible due to the relatively high friction head for some of the pump sets and would require limiting pump operating speeds for single pump operation, which is readily achievable with VFD operation and control.

8.3.1.1 PS-1 System Curves

Table 8-3 summarizes the key inputs used to develop the system curve for PS-1 and the resulting rated design point used for subsequent pump selection. The key inputs include suction tank water surface elevation (WSE) range, discharge elevation, discharge pipe length and diameter, and the rated point for pump selection.

Table 8-3 PS-1 System Curve Inputs (Backbone System)

PARAMETER	SET A	SET B
Suction Tank (PS-1) WSE Range (ft)	44 - 74[1]	44 - 74
Discharge Elevation (ft)	136	222
Discharge Pipe Length (ft)	26,400	141,478
Discharge Pipe Diameter (in)	30	84
Rated Point for Pump Selection	**7.5 mgd at 165 ft**	**37.5 mgd at 352 ft**

Note:
1. Assuming ground elevation of 42 ft with a tank level range of 2 ft to 32 ft.

Figure 8-6 and Figure 8-7 present the associated system curves developed for PS-1 Set A and Set B, respectively. The curves include an overlay from one of the candidate pump selections (see Section 8.3.3).

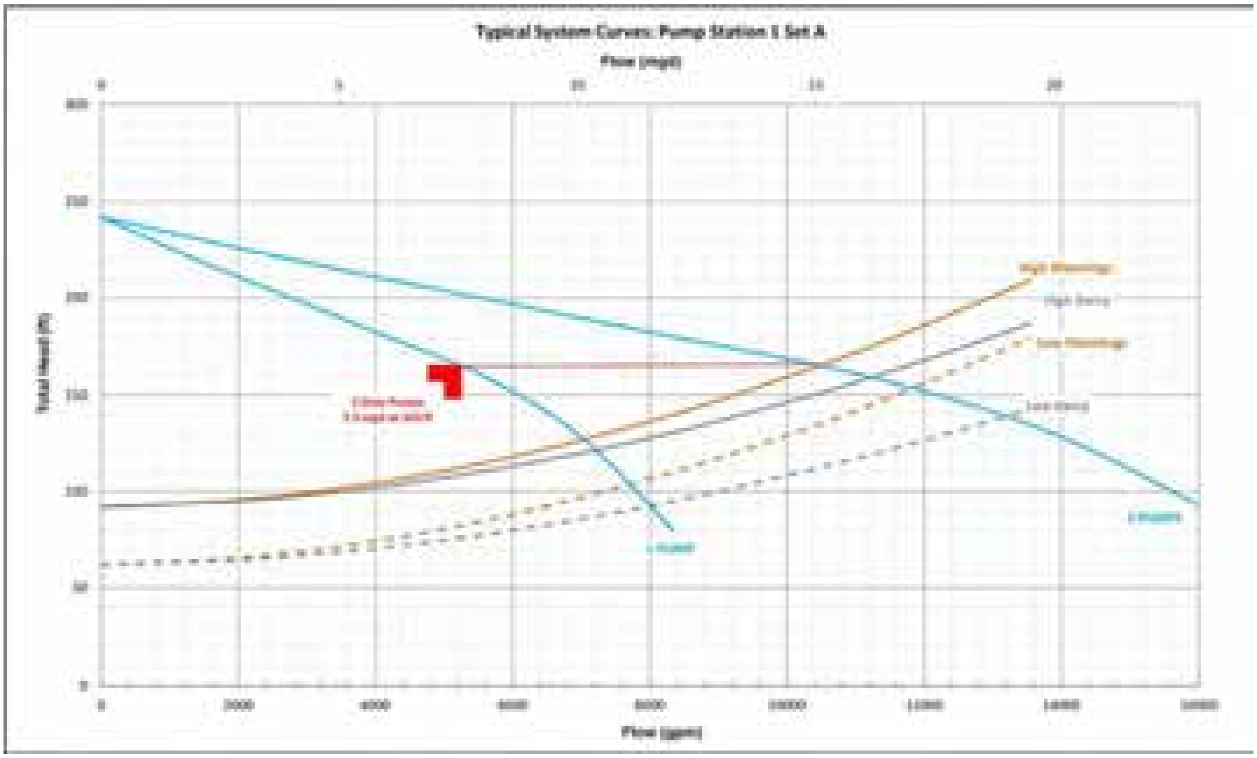

Figure 8-6 PS-1 Set A System Curves

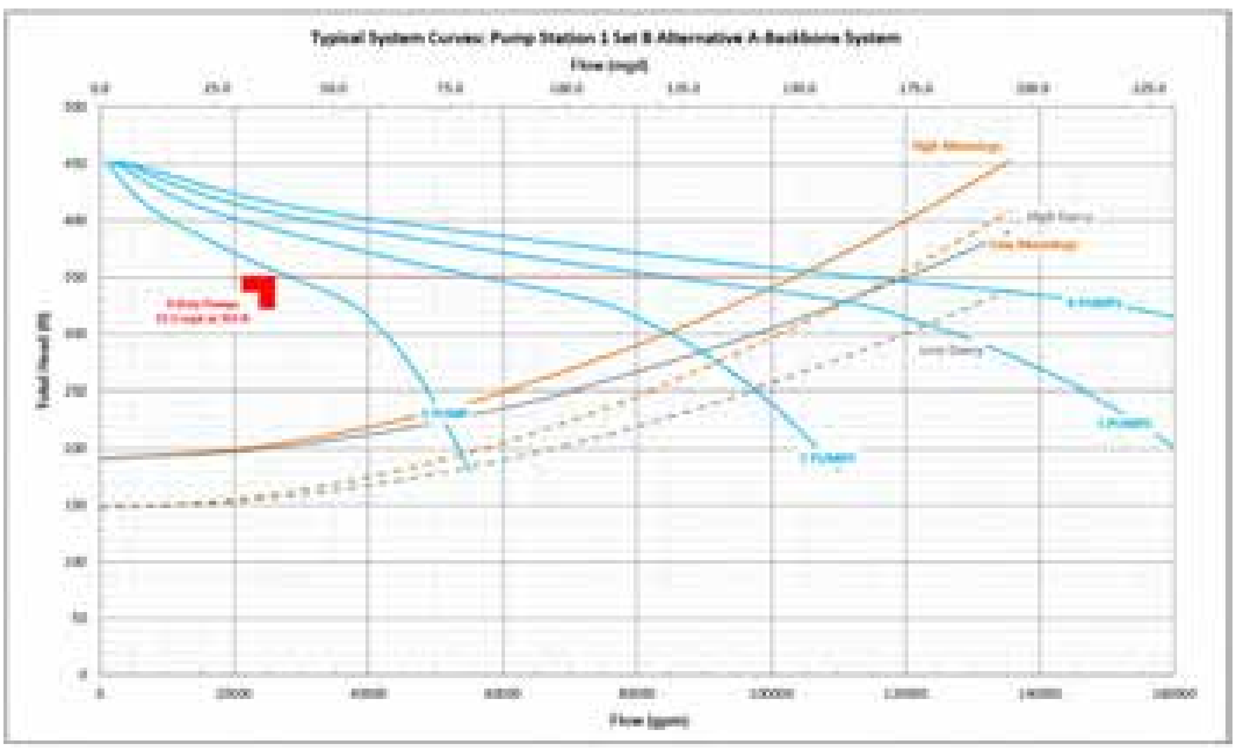

Figure 8-7 PS-1 Set B System Curves – Backbone System

8.3.1.2 PS-3 System Curves

Table 8-4 summarizes the key inputs used for both Alternative A and B to develop the system curve for PS-3 and the resulting rated design point used as the basis for subsequent pump selection.

Table 8-4 PS-3 System Curve Inputs (Backbone System)

PARAMETER	SET A
Suction Tank (PS-3) WSE Range (ft)	222 - 236[1]
Discharge (Santa Fe Spreading Grounds) Water Surface Elevation with 20 ft Distribution Head (ft)	505
Discharge Pipe Length (ft)	58,800
Discharge Pipe Diameter (in)	**84**
Rated Point for Pump Selection	**37.5 mgd at 352 ft**

Note:
1. Assuming ground elevation of 220 ft with a tank level range of 2 ft to 16 ft.

Figure 8-8 presents the associated system curves developed for PS-3. The curves include an overlay from one of the candidate pump selections (see Section 8.3.3).

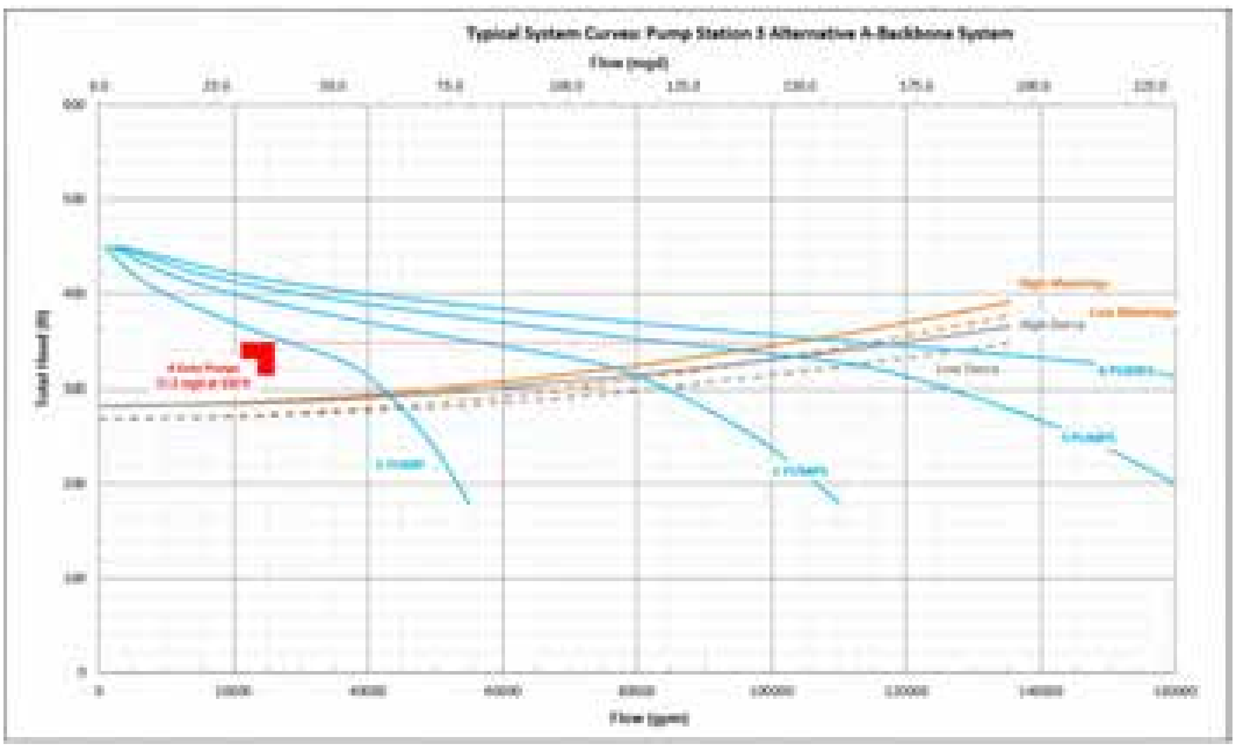

Figure 8-8 PS-3 System Curves (Backbone System)

8.3.2 Pumping Equipment

The recommended pumping equipment for the Project is vertical turbine pumps. These pumps have a smaller footprint than horizontal pumps, are familiar to Metropolitan staff, and offer efficient operation across the range of flows and heads that are being contemplated. It is proposed that the vertical turbine pumps would be installed in cans/barrels and separated from the water storage tank.

8.3.3 Feasibility-Level Pump Selection

The hydraulic conditions described in Section 8.3.1 were used to identify candidate pumping equipment that meets the preliminary performance requirements. Initial curves were selected from three typical manufacturers: Fairbanks, Ebara, and Sulzer. These preliminary selections are summarized in Table 8-5, and the associated performance curves are included in Appendix K. The purpose of these selections was to demonstrate the availability of equipment in these sizes from multiple manufacturers and to verify motor sizes to develop the feasibility-level electrical system design (see Section 8.8.1). In subsequent design phases, the following additional analyses are recommended to optimize the pump selections:

- Refine system hydraulic calculations to include station specific losses, final pipeline alignments and hydraulic properties, and final pump station locations.
- Identify the relative frequency of various operating conditions and optimize selections to minimize power consumption.
- Investigate selections from other acceptable manufacturers to identify optimal selections and increase procurement competition.
- Develop detailed technical specifications based on Metropolitan's requirements for pumping equipment with modifications specific to the proposed service of the equipment.

Table 8-5 Summary of Feasibility-Level Pump Selection (Backbone System)

STATION	RATED DESIGN POINT	FAIRBANKS NIJHUIS	EBARA	SULZER
PS-1 Set A	7.5 mgd at 165 ft	27ML-BRZ 890 RPM, 300 horsepower (HP)	600X400VYBM 890 RPM, 350 HP	SJT-28GMC 885 RPM, 350 HP
PS-1 Set B	37.5 mgd at 352 ft	63HRO 7000 592 RPM, 4,500 HP	1500X1000VYB2M 710 RPM, 5,000 HP	SJT-56TMC 595 RPM, 4,000 HP
PS-3	37.5 mgd at 352 ft	63HRO 7000 592 RPM, 4,500 HP	1500X1000VYB2M 710 RPM, 5,000 HP	SJT-56TMC 595 RPM, 4,000 HP

8.3.4 Suction and Discharge Piping Sizing

As mentioned in Section 8.3.2, the vertical turbine pumps are proposed to be installed in cans/barrels. Recycled water would be supplied from the storage tanks via a suction header pipe with suction laterals feeding each pump can.

Per Hydraulic Institute (HI) Standard 9.8 - Intake Design for Rotodynamic Pumps, the maximum flow velocity recommended for a suction lateral entering a closed-bottom can below the elevation of the discharge lateral is 4 fps. Table 8-6 provides a summary of the flow velocities that can be anticipated in the suction laterals for the corresponding pump sets. The pipe sizes have capacity to accommodate a maximum flow rate of 150 percent of the design flow rate. The maximum flow rates were determined based on the can sizing, as discussed in Section 8.3.5, and also to provide flexibility to operate individual pumps across a wider range of flows. It was assumed that the pump VFDs would limit maximum runout conditions to maintain flow velocities below 4 fps. Detailed suction lateral sizing calculations are provided in Appendix J.

Table 8-6 Preliminary Suction Lateral Sizing (Backbone System)

PUMPS	PIPE SIZE (IN.)	DESIGN FLOW RATE (MGD)	FLOW VELOCITIES (FPS)[1]
PS-1 Set A	30	7.5	2.4 – 3.6
PS-1 Set B	66	37.5	2.4 – 3.7
PS-3	66	37.5	2.4 – 3.7

Note:
1. Velocity range: lower limit at design flow rate, upper limit at 150% of design flow rate.

HI Standard 9.6.6 - Rotodynamic Pumps for Pump Piping, recommends that pipe sizes for pump discharge laterals be designed to limit flow velocities to 15 fps. For the purposes of this evaluation, the maximum allowable flow velocity is assumed to be 10 fps in order to reduce both friction losses and life-cycle costs for each station. Table 8-7 provides a summary of the flow velocities that can be anticipated in the discharge laterals for the corresponding pump sets. Detailed discharge lateral sizing calculations are provided in Appendix J.

Table 8-7 Preliminary Discharge Lateral Sizing (Backbone System)

PUMPS	PIPE SIZE (IN.)	DESIGN FLOW RATE (MGD)	FLOW VELOCITY (FPS)
PS-1 Set A	16	7.5	8.2
PS-1 Set B	36	37.5	8.2
PS-3	36	37.5	8.2

8.3.5 Pump Can Sizing

As part of the initial pump sizing described in Section 8.3.3, the manufacturers provided estimated sizing for the pump cans. HI Standard 9.8 provides maximum velocities to guide the sizing of various aspects of the pump cans/barrels. The maximum velocity through the barrel at both the bowl and the bell is 5 fps. Figure 8-9 shows the standard configuration of a pump can and the acceptable dimensions and velocities per HI Standard 9.8.

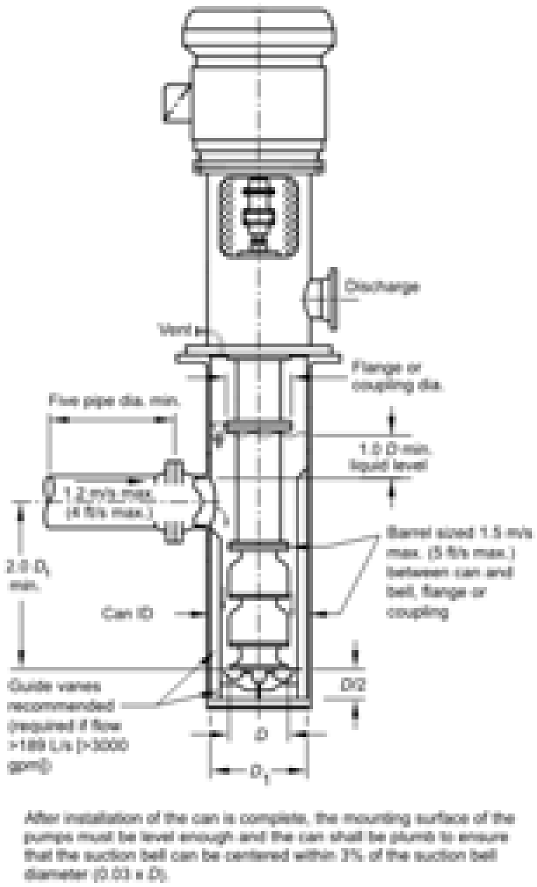

Figure 8-9 Closed Bottom Can Standard Configuration

The can sizing provided by Fairbanks Nijhuis, including the inside diameter (ID) of the barrel, outside diameter (OD) of the bowl, and OD of the bell, were used to estimate the maximum allowable flow rate through the pump can by limiting the velocity through the barrel to 5 fps. The desired maximum flow rate is 125 to 150 percent of the design flow rate. The pump can dimensions and maximum flow rates are presented in Table 8-8 and Table 8-9. Detailed can sizing calculations are provided in Appendix J.

Table 8-8 Preliminary Pump Can/Barrel Sizing – Fairbanks Nijhuis (Backbone System)

PUMPS	ID OF BARREL (IN.)	OD OF BOWL (IN.)	OD OF BELL (IN.)
PS-1 Set A	36.75	26.60	22.50
PS-1 Set B	96	64	64
PS-3	96	64	64

Table 8-9 Preliminary Pump Can/Barrel Maximum Flow Rates (Backbone System)

PUMPS	DESIGN FLOW RATE (GALLONS PER MINUTE [GPM])	MAXIMUM FLOW RATE (GPM)(1)	MAXIMUM VELOCITY IN BARREL AT BOWL (FPS)	MAXIMUM VELOCITY IN BARREL AT BELL (FPS)
PS-1 Set A	5,208	7,813	4.98	3.63
PS-1 Set B	26,042	39,063	3.13	3.13
PS-3	26,042	39,063	3.13	3.13

Note:
1. 150% of design flow rate.

8.4 PUMP STATION BUILDING

The pumping equipment, discharge piping and valves, and surge tank air compressors would be housed in a building at PS-3, along with areas for maintenance and administrative functions (control room, storage, etc.). Since PS-1 would be located at a treatment plant facility, the pumping equipment at that site would be outdoors, and the building would only include the air compressors and administrative facilities.

The pump building at PS-3 would be of sufficient height to allow for installation of a bridge crane for servicing the pumps and valves. Above-grade discharge laterals would include check and isolation valves for each pump before the piping extends below grade. The pumping area would also include sufficient room to assemble and disassemble a pump and perform applicable onsite maintenance. The approximate pump building/space footprint for each station is presented in Table 8-10.

Table 8-10 Preliminary Pump Building/Pad Size Estimates (Backbone System)

PUMP STATION FACILITY	LOCATION	APPROXIMATE ROOM/ PAD SIZE
PS-1	Outdoor pad	145-ft x 50-ft
PS-3	Building[1]	165-ft x 50-ft

Note:
1. Includes administration/control room.

8.5 HYDRAULIC SURGE CONTROL AND FACILITIES

Metropolitan's preferred method of surge control is to use air-over-water hydro-pneumatic tanks (also known as "air chambers"). On downsurges, as when a pump fails, the pressurized air in the tank forces fluid out into the pipeline to make up for the reduction in pipeline flow caused by the pump shutdown. As the pressure in the tank decreases from the expansion, the flow out of the tank decreases. Thus, flow changes are gradual rather than abrupt, and surge pressures are reduced. On reverse flow and upsurge, the surge chamber acts as a cushion and storage device. For a conveyance system of this size, the surge control system usually consists of several tanks, connecting pipelines with isolation valves, air compressors, liquid level sensors, and controls. The tanks themselves would be located outdoors on a pad (with appropriate curtain walls for shielding at PS-3), with the air compressors, add-air and vent-air solenoids, and controls panels located in the adjacent pump and/or control building.

Final sizing of the surge tanks would require detailed hydraulic transient analysis to investigate potential surge conditions and the required system performance under each of these conditions. This level of analysis would be completed during the detailed design phase of the Project. However, for the purposes of the feasibility-level station configuration and site planning included in this report, surge tank sizes were estimated based on pipeline lengths, estimated flows, and typical surge performance requirements. The procedure used is described by Stephenson (2002) and the associated calculations are included in Appendix J. Table 8-11 summarizes the estimated surge tank sizes and associated footprints.

Table 8-11 Preliminary Surge Tank Size Estimates (Backbone System)

PUMP STATION FACILITY	SURGE TANK SIZE	APPROXIMATE PAD SIZE
PS-1	6 tanks at 6,000 cu-ft	202-ft x 100-ft
PS-3	4 tanks at 6,000 cu-ft	141-ft x 100-ft

8.6 STORAGE FACILITIES

8.6.1 Overall Considerations

There are several features to consider when determining the optimal storage volume for a water transmission system such as the RRWP. Table 8-12 summarizes these design considerations and how they apply to this Project based on the current concept for the system.

Table 8-12 Storage Design Considerations

ITEM	STORAGE FUNCTION	APPLIES TO RRWP?	REMARKS
Diurnal Equalization	Necessary if there is a need to smooth the diurnal flow from the treatment plant so the conveyance system can pump a steady flow and not be sized for peak periods.	No	The AWT plant is expected to operate at a fairly constant rate (i.e. equalization occurs upstream at the advanced treatment plant), so this storage function is not required.
Off-Peak Power Operation	Necessary if there is a desire to only operate the conveyance system during off-peak power periods.	No	The advanced treatment plant is expected to operate continuously at a near constant flow, which would require a prohibitively large storage reservoir to avoid off-peak pumping. Thus, this storage function is not being considered. If pumps at JWPCP are shut-down during off-peak periods, or for O&M, the treatment plant flows can be diverted to the existing plant outfall.

ITEM	STORAGE FUNCTION	APPLIES TO RRWP?	REMARKS
Continuous Delivery	Necessary if there is a need for the system to supply demands/customers even if the pump stations are shut down.	No	The only customers planned on the system are spreading basins and potential future injection wells, so the temporary disruption of flow will not have critical impacts. If future customers require continuous delivery they can be required to provide their own on-site storage.
Pump Cycling	If constant speed pumps are used and incoming flow does not match pumping rate enough storage must be provided to limit pump starts and stops.	No	All pumps on the RRWP will be equipped with variable frequency drives to match flow rates with adjacent stations.
Surge	Different surge control approaches require different amounts of storage to supply or accept water during a surge event.	Limited	The concept of using pressurized hydro-pneumatic tanks on the discharge side of pump stations means most of the volume is contained in pressure tanks. Currently the most volume for surge tanks is expected at PS-1, with a total volume of less than 0.7 MG; therefore, this volume would need to be available in the downstream storage facility.
Control	Storage between pump stations provides a hydraulic break and facilitates controlled ramping up and down of pumps.	Yes	The RRWP includes multiple pumps stations all with multiple pumping units as well as long transmission mains. Thus, storage facilities are necessary for improved operational control, especially during starting and stopping.
Balancing	Provides storage for short duration, low-magnitude imbalances between upstream and downstream pump stations.	Yes	Coordinated and synchronized controls between stations will limit the magnitude and duration of the imbalances.
Risk Mitigation	If a pump station fails to shut off due to upstream low reservoir level or downstream high reservoir level, pumps could be damaged or tank overflow could damage adjacent property or the environment.	Yes	The risk of such a failure can be reduced by implementation of robust control systems (as noted elsewhere in this document). If the control system fails, the facility can be located in an area that can safely convey an overflow to a drainage way.

As noted in Table 8-12, the feasibility-level storage sizing approach for the RRWP Pump Stations was based primarily on considerations of controls, balancing, and risk management. The following sections provide additional detail on the minimum volume recommended for each of these considerations.

8.6.2 Control and Balancing Volume

Storage upstream of the pump stations provide an atmospheric break between the pump stations which simplifies the controls and allows for short-duration flow imbalances between facilities, especially during starting and stopping of pumps. To determine the volume necessary for these control and balancing functions, the Project team developed a conceptual control strategy for the RRWP, which was presented in Section 8.2.

Based on the discussion in Section 8.2, the estimated duration of a flow imbalance during starting or stopping would be on the order of 12 minutes before the flow set point – level trim control algorithm engages and stabilizes tank levels. Since each station would have a slightly different size and/or number of pumps, a small flow imbalance would be likely. It is difficult to quantify the exact flow imbalance at this stage of the feasibility-level design, but it is believed it would be on the order of 5 mgd during the duration of the starting or stopping sequence. At a flow rate of 5 mgd, twelve minutes of flow imbalance would result in a total balancing storage volume of approximately 0.02 million gallons (MG), which is a relatively small volume.

8.6.3 Risk Mitigation Volume

As noted in Section 8.6.2, it is anticipated that a relatively small storage volume would be needed for pump station control. However, this assumes the station controls and interlocks are operating correctly. In the event of a control system/interlock failure, flow imbalances at a storage tank could be much higher than the controlled scenario investigated above. If a large flow imbalance occurs and is not corrected, the storage tank could either fully drain, potentially damaging the downstream pumping equipment, or it could overflow, releasing recycled water from the conveyance system. Thus, providing additional storage at each pump station would provide an increased level of risk mitigation by providing time for the control system to recover and/or for the system to shut down either automatically or via operator intervention.

8.6.4 Reaction Times

The volume of storage that should be provided for risk mitigation ultimately is a decision based on the estimated likelihood of a control failure and the potential consequences of a tank drain or overflow scenario. The probability of control failure is difficult to quantify at the feasibility-level level, but modern control and communication systems can be designed with high levels of reliability. The consequences of an overflow can also be managed in the design of the stations. The feasibility-level design presented in this report includes facilities to discharge to the nearest drainage way, including a system to dechlorinate the recycled water before discharge off-site.

Table 8-13 summarizes the required storage volumes in MG for a range of flow imbalances and reaction times.

Table 8-13 Required Storage Volumes in MG as a Function of Reaction Time and Flow Rate

CONDITION DESCRIPTION	FLOW RATE		REACTION TIME (MINUTES)									
	MGD	GPM	5	10	15	20	25	30	35	40	50	60
PS-1 to PS-3	150	104,167	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	10.4	12.5
PS-1 Single Pump Capacity	37.5	26,042	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.6	3.1
PS-3 Peak Capacity	150	104,167	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	10.4	12.5
PS-3 Single Pump Capacity	37.5	26,042	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.6	3.1
Estimated Ramp Up/Down Imbalance	5.0	3,472	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4

The volumes reported in Table 8-13 are total operational volumes based on the assumption that the tank would start at 50 percent full, as shown on Figure 8-10. The storage tank would also need a freeboard from the maximum level to the overflow and a minimum level to maintain pump submergence. These are estimated at 3 ft and 2 ft respectively, as shown on Figure 8-10.

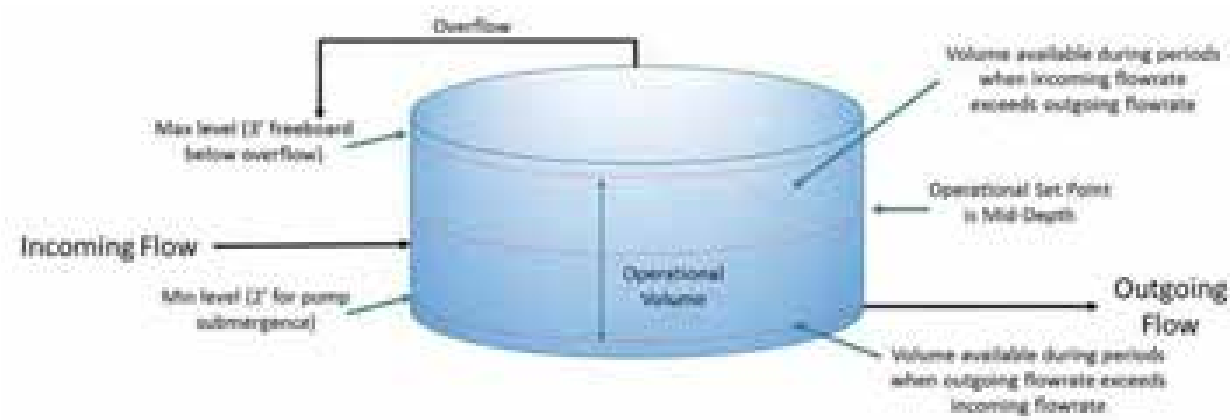

Figure 8-10 Typical Tank Level Configuration

Based on discussions with Metropolitan staff, it was determined that the AWT plant would require between 35 and 40 minutes to react to an unexpected shutdown of the conveyance system since PS-3 is anticipated to be unmanned. At PS-3, it was determined that ten minutes of reaction time would be required to trigger a shutdown of the system if communication and control were lost. Using these criteria, the following storage volumes were recommended for this feasibility-level design.

- PS-1: 7.5 MG
- PS-3: 2.5 MG (Backbone System)

Table 8-14 presents the recommended sizes and the associated storage times in minutes at the range of possible flow rates from low to high.

Table 8-14 Storage Times in Minutes at Various Flow Rates Based on Recommended Storage Volumes

CONDITION DESCRIPTION	FLOW RATE (MGD)	FLOW RATE (GPM)	STORAGE TIME (MINUTES)	
			PS-1 7.5 MG	PS-3 (BACKBONE) 2.5 MG
Estimated Ramp Imbalance	5	3,472	1,080	360
PS-1 to PS-3 and PS-3 Single Pump Capacity	26.7	18,542	202	40
PS-1 Single Pump Capacity	37.5	26,042	144	29
PS-3 Single Pump Capacity (Backbone)	37.5	26,042	N/A	48
PS-3 Peak Capacity (Backbone)	150	104,167	36	12

Several layers of control system failure would be required for a pump station's local storage volume to reach an empty tank or overflow scenario, including:

- Failure of one or more pumps at pump station and inability of station to recover to specified flow set point.
- Failure of interlocks to trigger shut-down due to out-of-range operation.
- Failure of communication between stations to trigger shut-down if one station fails.

8.6.5 Storage Configuration

The proposed storage volume would be provided in above-ground circular tanks at PS-1 and PS-3. Selection of the construction material for the storage tanks (i.e. steel vs. concrete) will be determined in subsequent design phases.

8.7 YARD PIPING, DECHLORINATION, AND MISCELLANEOUS FACILITIES

8.7.1 Discharge Piping and Meter Vault

Individual discharge laterals from each pump would feed a discharge header downstream of the pumps. A meter vault would be provided following the connection to the surge tanks to house and provide operator access to a flow meter and isolation vault installed in each discharge header. The approximate dimensions of the meter vaults are shown below in Table 8-15. It should be noted that the meters do not need to be located in a vault. Meter location and design should be further evaluated during future phases of work.

Table 8-15 Preliminary Meter Vault Size Estimates (Backbone System)

PUMP STATION FACILITY	NO. OF FLOWMETERS	APPROXIMATE VAULT SIZE
PS-1	2	42-ft x 28-ft
PS-3	1	17-ft x 28-ft

8.7.2 Dechlorination

In case of pump station failure, there may be emergency or unplanned discharges of recycled water that would ultimately reach the SG River. In order to discharge recycled water to a waterbody, it is currently anticipated that Metropolitan will need to apply for an Individual National Pollutant Discharge Elimination System Permit from the Los Angeles Recycled Water Quality Control Board, which may require additional water treatment to meet the water quality objectives for the SG River. Due to its nature as advanced treated water, it is likely that the recycled water quality would already meet basin plan requirements, with the possible exception of chlorine.

If required, dechlorination could be provided at the pump station sites to treat emergency overflows before discharging to flood control channels. This is traditionally addressed in one of two ways:

- Option 1: Using a liquid chemical injection system (e.g., sodium bisulfate) mixed into the overflowing volume to neutralize the chlorine during an overflow event. The benefit of this option is that its initial capital costs and overall footprint are typically less than that of a passive flow-through system. However, because the success of this approach relies on the performance of locally stored chemicals which can degrade over time, the cost of maintaining such a system and replacing these chemicals (on at least an annual basis) is viewed as excessive to most utilities- especially if an overflow event does not occur for several years.
- Option 2: Using a passive flow-through system containing media which can neutralize the chlorine during an overflow event. This approach is more likely to require a higher footprint and initial capital costs, as compared to a liquid chemical treatment system. However, because the chlorine-neutralizing capabilities of some media, such as granular activated carbon (GAC), are not exhausted with time or contact with chlorine, the need and frequency of replacement is greatly reduced. Another benefit of the passive system is that it is already ‘ready’ for its intended purpose; it requires no startup time, dosage metering or monitoring, and very little to no annual maintenance.

At the current feasibility-level stage of the Project, it was assumed that Metropolitan would select the flow-through system for overflow dechlorination, if required. Assuming that GAC would be utilized as the flow-through media, it is estimated that approximately 56,000 cubic ft (cf) of GAC media would be required to dechlorinate an overflow event of 150 mgd containing up to 5 milligrams per liter (mg/L) chlorine. This volume of media would correspond roughly to a facility

150-ft (long) by 40-ft (wide) by 10-ft (deep). For smaller overflow rates, the size of the facility would be reduced proportionally.

A flow-through dechlorination system is assumed for PS-1 and PS-3, both of which have on-site storage tanks. The design of the dechlorination system should be further evaluated during future phases of work in conjunction with coordination with applicable regulatory agencies.

8.8 POWER SUPPLY AND ELECTRICAL REQUIREMENTS

8.8.1 Major Load Estimation

The major use of electricity at the pump stations would be associated with operating pump motors. The pump selections discussed in Section 8.3.3 and shown in Table 8-5 were used to develop the feasibility-level electrical system design. As shown in Table 8-16, a representative manufacturer's selection for each pump station was used to estimate the amount of power that would need to be supplied to the site and to determine the required sizes of the electrical facilities.

Table 8-16 Summary of Design Motor Size (Backbone System)

STATION	RATED DESIGN POINT	MOTOR SIZE FOR DESIGN
PS-1 Set A	7.5 mgd at 165 ft	3 pumps (2 duty + 1 standby) at 350 HP each
PS-1 Set B	37.5 mgd at 352 ft	5 pumps (4 duty + 1 standby) at 5,000 HP each
PS-3	37.5 mgd at 352 ft	5 pumps (4 duty + 1 standby) at 5,000 HP each

8.8.2 Electrical Facilities and Space Requirements

Each pump station would include an electrical building/room, which is anticipated to be located immediately adjacent to the pump building/pad. This building/room would house electrical equipment that cannot be located outdoors, including motor control centers (MCCs), VFD controllers, and uninterruptable power supply system. In addition to the electrical building/room, an outdoor transformer farm would be included at each pump station for medium and high voltage electrical equipment.

There are two possible electrical service options that are likely to serve the pump stations: Option 1 assumed that the medium voltage (4,160 volts) is supplied by the power utility; Option 2 assumed that higher voltage (above 4,160 volts) is supplied. The power utility would dictate which option needs to be implemented at each site. For this Project, the feasibility-level layouts shown in Appendix L are based on Option 2. The power utility may require additional space either at or near the pump station sites for a switchyard, which is not currently shown on the feasibility-level layouts.

Table 8-17 summarizes the estimated footprint of the electrical facility at each pump station. Coordination with the power utility will be required in future phases of the Project.

Table 8-17 Preliminary Electrical Facility Dimensions (Backbone System)

PUMP STATION	ELECTRICAL BUILDING/ROOM	OPTION 1 TRANSFORMER FARM	OPTION 2 TRANSFORMER FARM
PS-1	68' x 44'	36'-0" x 50'-2"	99' x 68'
PS-3	68' x 44'	36'-0" x 50'-2"	99' x 66'-3"

8.9 PUMP STATION SITE INVESTIGATIONS

8.9.1 Methodology

The site for PS-1 was identified by Metropolitan to be located at the northeast corner of the AWT plant site. It was determined that there would be enough space at the existing site for the pump station and its associated facilities.

While not part of the Backbone System, potential sites for PS-2 or the flow control facility were identified if needed in the future and are presented in Appendix V.

Potential sites for PS-3 were identified during the preparation of the 2018 Draft Report. As discussed in Chapter 5, the revised route around the Whittier Narrows Dam resulted in a high point in the alignment located just upstream of four of the five sites that were identified. Further evaluation will be required to determine the optimal pump station location, as well as the pump station layout and site requirements. The sites identified for PS-3 during the preparation of the 2018 Draft Report were evaluated based on the following criteria: 1) Current Site Uses, 2) Existing Major Utilities, 3) Site Access, 4) Overall Constructability, 5) Environmental Risks, 6) Hazardous Materials Risks, 7) Proximity to Overflow Discharge Locations, and 8) Proximity to Recycled Water Pipeline Alignment. These criteria are explained in further detail below:

- Current Site Uses: Potential sites were evaluated based on existing land use in an effort to minimize impacts to communities. Potentially sensitive sites such as religious facilities, public institutions, and community facilities were eliminated from consideration. It was assumed that Metropolitan would obtain any existing, non-Metropolitan owned properties using eminent domain.
- Existing Major Utilities: The presence of existing major utilities was investigated by performing a desktop review of the available GIS data obtained from Metropolitan and Los Angeles County, the United States Department of Transportation (DOT) National Pipeline Mapping System and a review of aerial maps available online. Utilities analyzed included sanitary sewers, storm drains, overhead electrical lines, oil and gas transmission lines, and railroads.
- Site Access: The potential sites were evaluated for ease of construction and operational access.
- Overall Constructability: Potential sites were evaluated for ease of construction, e.g. topographic constraints of the site, demolition requirements of any existing structures, and trenchless construction requirements for the suction, discharge, and overflow pipelines.

- Environmental Risks: The presence of endangered species habitats was studied using the California Natural Resources Diversity Database.
- Hazardous Materials Risks: The presence of environmental hazard sites was analyzed using the California State Water Resources Control Board (Water Boards) Geotracker database. Sites with active environmental remediation activities were not considered viable (e,g,. environmental hazards include leaking underground storage tanks, or the presence of trichloroethylene (TCE) plumes at former dry cleaner locations).
- Proximity to Overflow Discharge Locations: Potential sites were evaluated based on their ability to gravity flow to existing storm water facilities.
- Proximity to Recycled Water Pipeline Alignment: Potential sites were evaluated based on their proximity to the Recycled Water Pipeline Preferred Alignment to minimize capital costs and pipeline construction impacts.

8.9.2 Feasibility-Level Site Identification

Potential sites have been identified for PS-3, based on a desktop review of locations along the Recycled Water Pipeline Preferred Alignment. Further analysis will have to be conducted including onsite surveys and geotechnical studies to select the preferred pump station location.

8.9.2.1 PS-3: Potential Siting

Five potential sites for PS-3 have been identified in a commercial area near the 605 Freeway between Beverly Boulevard and Whittier Boulevard as shown in Figure 8-11. This general vicinity for PS-3 was originally selected based on balancing flows between PS-3 and the OC Spreading Grounds. However, since flows are no longer anticipated to be delivered to the OC Spreading Grounds, at least initially, the location of PS-3 should be re-evaluated during subsequent phases of work. The PS-3 site, regardless of its final location, was originally anticipated to have a footprint measuring approximately 300’ x 400’, although the Backbone System would likely require a slightly larger footprint (approximately 350’ x 450’).

Figure 8-11 Potential PS-3 Locations Key Map

PS-3 Site No. 1 is located near the intersection of Rose Hills Drive and Capitol Avenue. Site No. 2 is located at the intersection of Rooks Road and Sports Arena Drive. Site No. 3 is located at the intersection of Rooks Road and Peck Road. Site No. 4 is located at the intersection of Rooks Road and Kella Avenue. Lastly, Site No. 5 is located west of the intersection of Rooks Road and Peck Road.

8.9.3 Site Attribute Investigation

This section describes the attributes for each potential site according to the criteria described in Section 8.9.1.

8.9.3.1 Potential PS-3 Site Attributes

This section describes the site attributes for the potential PS-3 sites identified during the preparation of this FLDR. A summary of the site attributes is presented in Table 8-18.

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Table 8-18 Attributes of Potential PS-3 Sites

SITE	APPROXIMATE SITE ADDRESS	CURRENT SITE USES	EXISTING MAJOR UTILITIES	SITE ACCESS	CONSTRUCTABILITY	ENVIRONMENTAL RISKS	HAZARDOUS MATERIALS RISKS	PROXIMITY TO OVERFLOW DISCHARGE LOCATION (FT)	PROXIMITY TO PIPELINE ALIGNMENT (FT)	NOTES
1	10015 Rose Hills Road, City of Industry, Ca	Carpenter's Union Training Facility	An existing 54-inch sanitary sewer is located between the site and drainage channel that feeds the SG River. Suction and discharge pipelines would have to cross the existing 54-inch sanitary sewer and 605 Freeway to reach the Preferred Alignment.	The site is fronted by the four-lane Rose Hills Drive and two-lane Capitol Avenue.	The site is level and would require demolition of a commercial facility. Suction and discharge pipelines would require trenchless construction to cross the 605 Freeway.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	700	1,200	This site is close to an overflow location. However, the site is further away from the Preferred Alignment and would require trenchless pipeline crossing of the 605 Freeway. Alternative A-Backbone for this pump station would require acquisition of an additional parcel to the northeast (Industrial Bakery) to accommodate the larger site footprint.
2	11003 Sports Arena Dr, Whittier, CA	Los Angeles County Mounted Assistance Unit Training Site	An existing sanitary sewer crosses the parcel. Overflow pipeline would cross the sanitary sewer and two separate vacant parcels to reach the SG River.	The site is accessible from the four-lane Rooks Road.	The site is level and is currently open space for vehicular parking. The pump station footprint may overlap with an existing training facility.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	1,300	140	The site does not require the demolition of a major building and also appears viable for the larger footprint of the Alternative A-Backbone option.
3	2429 Peck Road, Whittier, CA	Velocity Truck Centers	An existing sanitary sewer and 42-inch storm drain are both in the vicinity of the parcel. The overflow pipeline would cross the sanitary sewer in order to reach the SG River. Overhead powerlines are observed to the north of the parcel.	The site is accessible from the four-lane Rooks Road.	The site is accessible by the two-lane Rooks Road. The overflow pipeline would cross an adjacent parcel that is currently occupied by a parking lot before discharging to the SG River.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	600	150	There is little additional space near this site for the larger footprint of the Alternative A-Backbone option.
4	2450 Kella Ave, Whittier, CA	Rush Truck Center	No major utilities are present on the site. The overflow pipeline would cross an existing sanitary sewer to reach the SG River.	The site can be accessed from the four-lane Rooks Road, and the 605 Freeway.	The site is level and would require demolition of a commercial facility.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	1,400	450	There is little additional space near this site for the larger footprint of the Alternative A-Backbone option.
5	10149 Rooks Road Whittier, CA 9066	Blackwill Equestrian Center (Los Angeles County Parks & Recreation)	There is an existing sanitary sewer and an overhead power line at the south part of the site.	Site is accessible from the four-lane Rooks Road.	The site is level and would not require the demolition of buildings. Pump station footprint would have to avoid an existing power transmission tower on the parcel.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	150	250	The site would occupy an open space currently used for equestrian activities There is potentially enough space in the area for the larger footprint of the Alternative A-Backbone option.

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8.9.3.1.1 Potential PS-3 Site 1 Attributes

Potential PS-3 Site 1 is located approximately 1,200 ft away from the Preferred Alignment and is approximately 700 ft away from a nearby drainage channel (see Figure 8-12). The existing drainage channel appears to have enough capacity to receive the overflow from the pump station. The site is currently occupied by Carpenter's Union Training Facility. The site is level but would require demolition of the commercial facility for the construction of the pump station. Suction, discharge, and overflow piping may be constructed via cut-and-cover construction except for the 605 Freeway crossing. Suction and discharge piping may cross the 605 Freeway via trenchless technologies, which would require a Caltrans permit. There appears to be an approximate 20-ft drop in elevation between the pump station site and the drainage channel and may allow the overflow to drain by gravity. Hazardous materials requiring remediation do not appear to be present at this site. The implementation of Backbone System would require the acquisition of an additional parcel to the northeast (Industrial Bakery) to accommodate the larger site footprint.

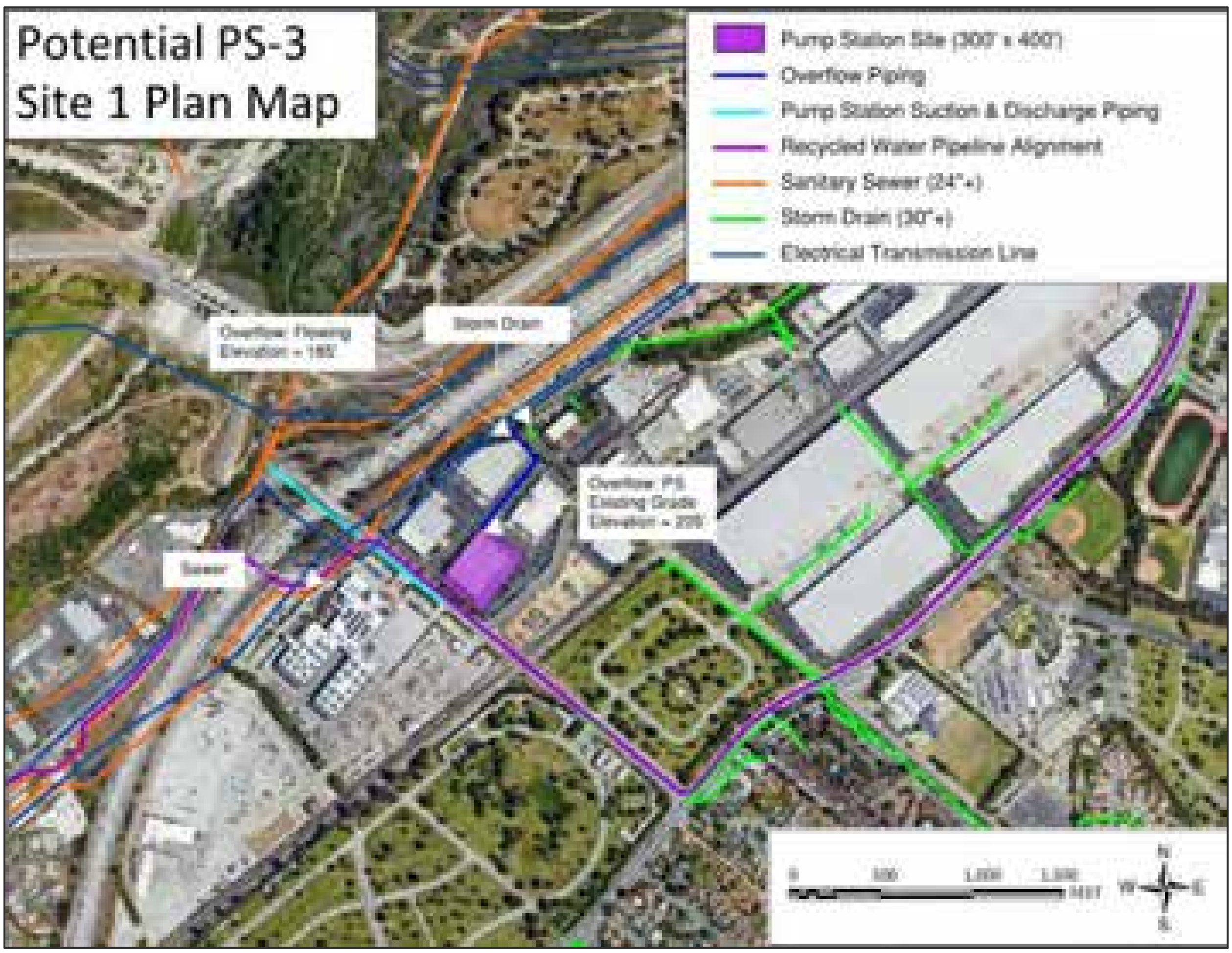


Figure 8-12 Potential PS-3 Site 1 Plan Map

8.9.3.1.2 Potential PS-3 Site 2 Attributes

Potential PS-3 Site 2 is located adjacent to the Preferred Alignment and approximately 1,300 ft away from the SG River (see Figure 8-13). The site is currently occupied by the Los Angeles County

Mounted Assistance Unit. Overflow, suction, and discharge pipelines may be constructed via cut-and-cover construction. The overflow pipeline would have to cross an existing sanitary sewer pipeline and two vacant parcels to the discharge point at the SG River. There appears to be an approximate 26-ft drop in elevation between the pump station site and the river and may allow the overflow to drain by gravity. The site is level and would require minimal demolition of the existing facilities. Hazardous materials requiring remediation do not appear to be present at this site. The site appears to be viable for the larger footprint required for the Backbone System.

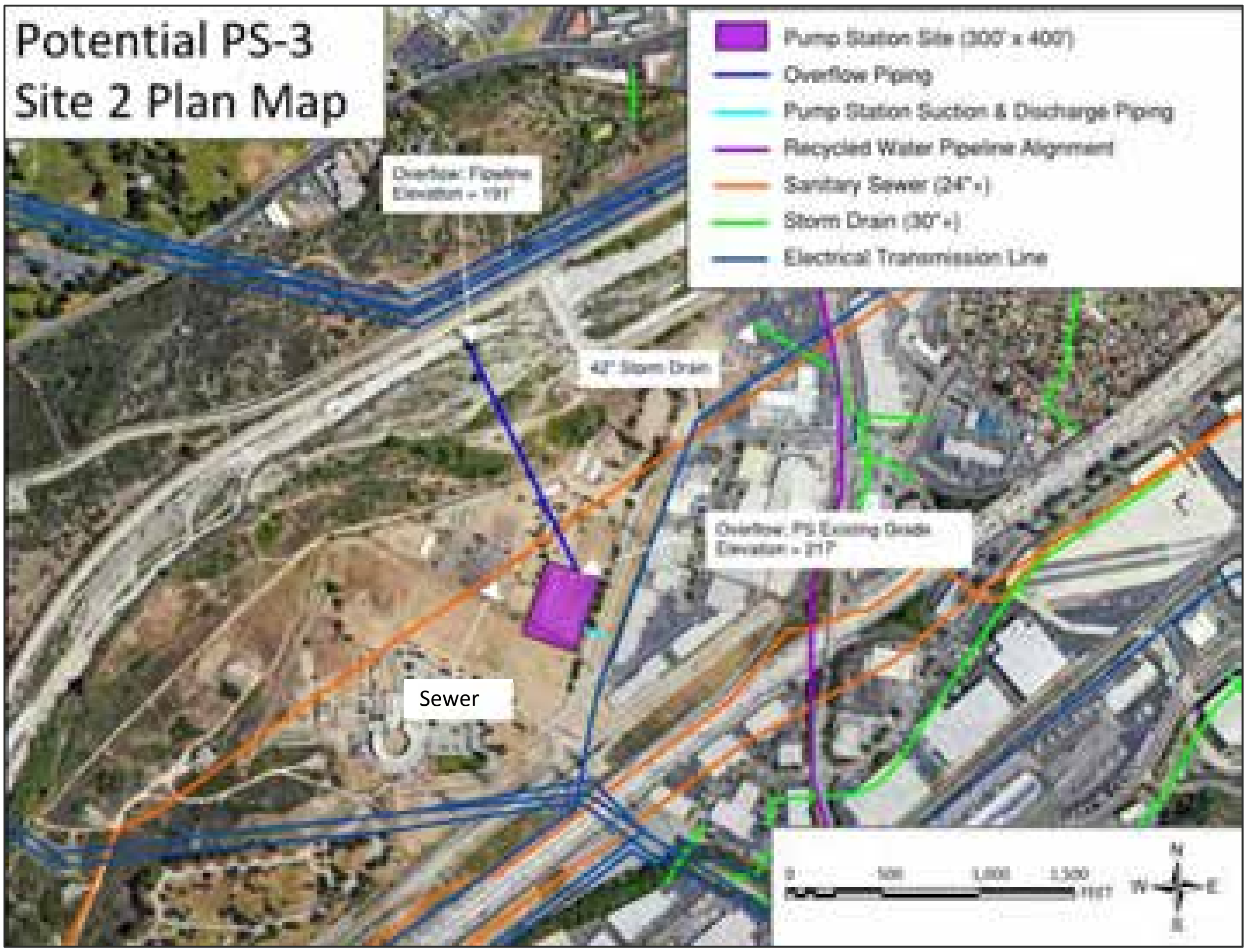


Figure 8-13 Potential PS-3 Site 2 Plan Map

8.9.3.1.3 Potential PS-3 Site 3 Attributes

Potential PS-3 Site 3 is located adjacent to the Preferred Alignment on a parcel by the intersection of Peck Road and Rooks Road (see Figure 8-14). The site is currently occupied by Velocity Truck Center. The site is level and would require the demolition of the existing building. Suction, discharge, and overflow piping may be constructed via cut-and-cover construction. The overflow pipeline would cross an existing sanitary sewer and the adjacent parcel to the north that currently contains a parking lot. There appears to be an approximate 28-ft drop in elevation between the pump station site and the SG River and may allow the overflow to drain by gravity. Hazardous materials requiring remediation do not appear to be present at this site. This site might not have sufficient space for the Backbone System.

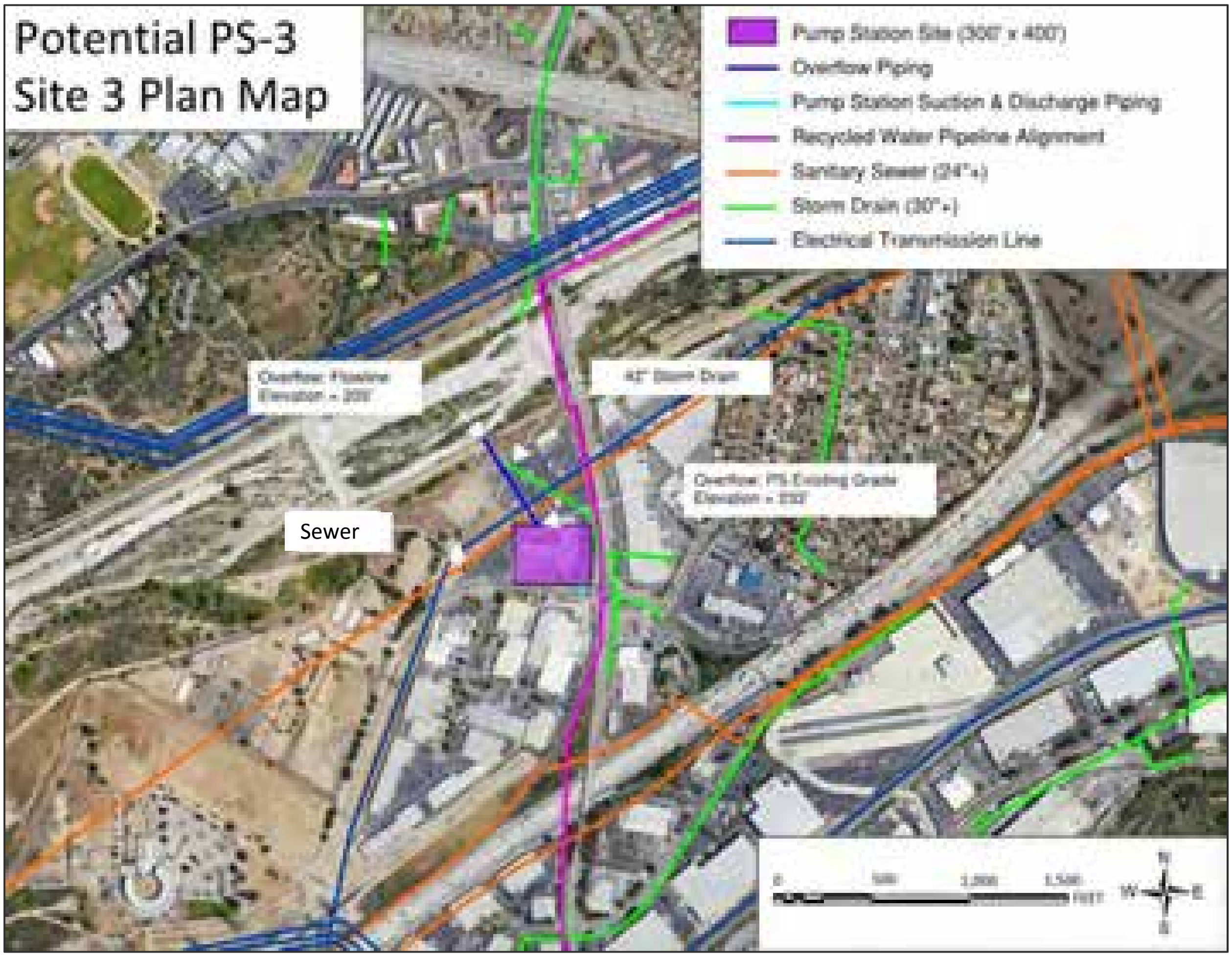


Figure 8-14 Potential PS-3 Site 3 Plan Map

8.9.3.1.4 Potential PS-3 Site 4 Attributes

Potential PS-3 Site 4 is located at a commercial facility at the intersection of Kella Avenue and Rooks Road on the west side of the 605 Freeway (see Figure 8-15). The commercial facility is occupied by Rush Truck Center. The suction and discharge piping would extend approximately 450 ft to the Preferred Alignment at the intersection of Rooks Road and Peck Road. Overflow piping may be routed north along Peck Road towards the SG River and would cross an existing sanitary sewer. There appears to be an approximate 10-ft drop in elevation between the pump station site and the river which may not allow the overflow to completely drain by gravity during periods of discharge. The site is built on level ground and construction would require the demolition of the existing facilities. Hazardous materials requiring remediation do not appear to be present at this site. This site may not have sufficient space for the Backbone System.

Figure 8-15 Potential PS-3 Site 4 Plan Map

8.9.3.1.5 Potential PS-3 Site 5 Attributes

Potential PS-3 Site 5 is located on an open space parcel currently occupied by the Backwill Equestrian Center (see Figure 8-16). Of the five potential sites, this site would have the shortest suction, discharge, and overflow piping. There is an existing sanitary sewer and an overhead power transmission line of the site. The overflow pipeline would run north and discharge into the SG River. There appears to be an approximate 10-ft drop in elevation between the pump station site and the river which may not allow the overflow to completely drain by gravity during periods of discharge. The site is level and would not require demolition of existing buildings. Hazardous materials requiring remediation do not appear to be present at this site. The area appears to be viable for the larger footprint required for the Backbone System.

Figure 8-16 Potential PS-3 Site 5 Plan Map

8.10 SITE AND YARD PIPING DEVELOPMENT

Preliminary site plans were developed for each pump station site, as presented in Appendix L. The following sections provide details on each site. For details on PS-2, see Appendix V.

8.10.1 PS-1 Site and Yard Piping Development

PS-1 would be located on the northeast corner of the AWT plant site, as shown on Sheet C-1 in Appendix L. The circular 7.5-MG storage tank and optional dechlorination facility would be on the southern end of the pump station site. The pump pad, electrical room, transformer farm, surge tanks, and meter vault would be located on the northern portion of the site, with a parking lot between the pump facilities and the storage tank. Access to the electrical room would be provided from the east via South Main Street.

Treated recycled water would enter the storage tank from the east through a 102-inch inlet. An overflow pipeline would be provided on the southeast part of the tank and travel through the dechlorination facility, if required. From there, the overflow pipe would travel north to the drainage system. A 102-inch suction header would extend from the northwestern part of the storage tank to the pump pad. The pumps would connect to two discharge headers, which would travel north through the meter vault before exiting the site. The pumps for PS-1 Set A would use a 30-inch discharge pipeline to send water to the potential future injection wells. The pumps for PS-1 Set B would use an 84-inch discharge pipeline to send water to PS-3.

Sheets M-1 and M-2 in Appendix L contain more detailed plan views for PS-1, and Sheet M-3 contains sections of a PS-1 surge tank and valve vault.

8.10.2 PS-3 Site and Yard Piping Development

The site for PS-3 has not yet been selected, but preliminary section and plan drawings are presented on Sheets M-6 and M-7 in Appendix L. The plan drawings were developed assuming that PS-3 would convey 80 mgd. Since the Backbone System would convey 150 mgd, the layout would be the same as shown but the site is anticipated to include a 2.5-MG storage tank, 84-inch inflow pipeline, and 102-inch suction header. The circular 2.5-MG storage tank would be located on the southeast portion of the site. The 84-inch inflow pipeline would enter the storage tank from the south. The pump room would be located to the northwest of the storage tank, fed by a 102-inch suction header. An 84-inch discharge header would exit the site through a meter vault to the east and continue to the Santa Fe Spreading Grounds.

9.0 Project Duration and Cost Opinion

This chapter documents the development of the Engineer's OPCC and estimated construction duration for the conveyance facilities associated with the SG and LA River Alignments. The OPCC was prepared for the Backbone System and is Class 4 as defined by the Association for the Advancement of Cost Engineering (AACE) with an accuracy range of -30% to +50%.

Development of the Engineer's OPCC is broken down into a discussion of the following tasks:

- **Unit Cost Development** – This section describes the development of the unit costs for each facility. The unit cost includes two components: 1) a typical cost that covers the work generally anticipated for each construction method being used and 2) cost "adders" that address non-typical features or features that are not uniformly encountered, such as major utility crossings.
- **Quality Take-Off** – This section documents the quantity of each component being proposed for which a cost is being considered, known as a quantity take-off. This quantity take-off corresponds to the data and information available at the feasibility study level.
- **Engineer's OPCC** – This section applies the unit costs to the quantity of facilities being proposed for the SG and LA River Alignment alternatives to develop the OPCC. The OPCC for the RRWP conveyance system without contingency is as follows:
  - SG River Alignment - $898,700,000 (total project without contingency)
  - LA River Alignment - $830,000,000 (total project without contingency)
- **Preliminary Construction Duration Estimate** – This section presents an estimate of the construction duration for the individual pipeline segments for both the SG and LA River Alignments. This estimate was prepared to provide Metropolitan with information necessary to determine the implementation strategy for the program and is not intended to represent the actual implementation approach. The Metropolitan program management team will determine an implementation schedule which will consider other factors beyond the scope of this Project.

Figure 5-8 and Figure 5-10 depicts the LA River and the SG River Alignments, respectively, and shows the segment numbers comprising each alignment. These segment numbers are referred to in various tables in this chapter.

While not studied in the same level of detail as the Backbone System, a cost opinion was also prepared for the pipelines associated with the preferred connection from the SFSG to the FEWWTP. The OPCC for the pipelines only would be $214,600,000 without contingency. Details are provided following the OPCC for the Backbone System.

Figure 9-1 summarizes the Project methodology as it applies to this chapter.

Figure 9-1 Chapter 9 Methodology

9.1 UNIT COST DEVELOPMENT

Unit costs were developed for the pipeline and pump stations. This section presents those unit costs.

9.1.1 Pipeline

9.1.1.1 Pipeline Cost Development Methodology

The methodology used to develop the Engineer's OPCC for the pipelines was based on the data available at the feasibility-level study phase. The approach included development of typical construction methodologies that were consistently applied along each of the four major alignment types, as well as identification and development of the non-standard features required along the various segments. The key steps are further defined as follows.

- **Typical Construction Methods**: As discussed in Chapter 4, four typical construction methods were developed to cover the materials and work that would be consistently utilized for pipe installation along that alignment type. These methods, and the locations where they would be applied, include:
  - Construction Method 1 – Roadways
  - Construction Method 2 – SCE Easements
  - Construction Method 3 – LACFCD Easements
  - Construction Method 4 – Trenchless (Tunnels)

- **Cost Adders**: Variations from the standard construction methods which would be encountered along each alignment were designated as "Adders". Adders cover features and work methods which were not included in the typical construction method as described above because they were not consistently required or uniformly found along each segment. Consistent with a feasibility- level study, adders are items which are readily discernable and measurable from the desktop analysis, visual observations made in the field, review of utility information, analysis of traffic control requirements, desktop study of geotechnical and groundwater conditions, and so on.
- **Unit Prices:** Standard unit prices were developed for each construction method. Details about this effort are described later in this chapter.
- **Quantity Take-Off:** A quantity take-off was performed along the alignment alternatives as described above, and a count was made of the lengths and quantity of each alignment type and the related "Adders".
- **Engineer's OPCC:** The Engineer's OPCC was produced from the unit costs and the quantity take-off.

The development of costs for the standard construction methods and associated adders for each of the four construction types described in Section 4.3.3 are described herein.

9.1.1.2 Construction Method 1 - Roadways

As discussed in Section 3.4, CM1 was the standard method applied in all roadway/street locations. Figure 3-15 shows the typical manner in which CM1 would be applied to construction along roadways. CM1 is intended to cover all materials and work needed for construction of a finished and functional pipeline along a typical roadway section. The following were included in the standard unit cost.

- Sitework, including surveying, dust/erosion control, etc.
- Pavement removal and restoration
- Standard vehicular traffic control and pedestrian safety measures
- Earthwork, such as excavation, shoring, hauling, and compaction of all bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs and cathodic protection
- Utility protection, repair, and relocation

Adders for roadway work included the special features and additional work items not listed above, but which would be counted separately and added to the overall cost of the relevant segment. Adders associated with roadway work included the following:

- Intersection Traffic Control: Applied to signalized intersections and included the cost of all barriers, cones, signage, lighting, re-striping, and re-signalizing required. Intersections requiring traffic control were identified in the Traffic Control Study (provided in Appendix B) along with the type of traffic control to be applied.

- Construction through Major Intersections: Applied to signalized intersections identified in the Traffic Control Study (provided in Appendix B) as a Major Intersection, and not identified as being constructed with trenchless methods. Addresses the additional cost associated with the slower construction production rates that would occur due to construction staging, traffic control, and presence of numerous crossing utilities, or need to utilize trenchless construction methods, as discussed in Section 3.1.1. The cost included for these intersections is the same as to using trenchless installation methods.
- Median Removal and Replacement: Applied to roadways with an improved center median (other than a striped center turning lane) whenever the outer curb to median distance measured less than 36 ft. All street alignments were measured and locations with less than 36-ft curb to median were recorded in the quantity take-off.
- Major Utility Crossings: The added cost for crossing a major utility using trenchless installation methods (see Section 4.3.1 for major utility definition).
- Trench Dewatering: A standard dewatering cost adder was applied at all locations where the trench bottom would be below the groundwater level as described in the Desktop Geotechnical Evaluation (provided in Appendix C). A cost premium was added if permeable soils such as sand were also present.

Additional details regarding CM1 - Roadways and related adders can be found in Appendix M.

9.1.1.3 Construction Method 2 – SCE Easements

As discussed in Section 3.4, CM2 was the standard method applied along all SCE easements. Figure 3-16 shows the typical manner in which CM2 would be applied to SCE easements. CM2 was intended to cover all work and materials needed for construction of a finished and functional pipeline along a typical SCE easement. The following were included in the standard unit cost.

- Sitework, including surveying, clearing and grubbing, dust / erosion control, etc.
- Earthwork, such as excavation, shoring, hauling, and compaction of bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs, cathodic protection, etc.
- Site restoration

Adders for pipeline installation in an SCE easement included the special features and additional work items not listed above. SCE Adders included the following:

- Major Utility Crossings: (see Major Utility Crossings in Section 4.3.1.1)
- Trench Dewatering: (see Trench Dewatering in Appendix C and Appendix F)

Additional details regarding CM2 – SCE easements and related adders can be found in Appendix M.

9.1.1.4 Construction Method 3 – LACFCD Easements

As discussed in Section 3.4, CM3 was the standard method applied along all LACFCD easements. Figure 3-17 shows the typical manner in which CM3 would be applied to LACFCD easements. CM3A, 3B, and 3C, described in Section 3.4.3, was intended to cover all work and materials needed for construction of a finished and functional pipeline along a typical LACFCD easement. The following were included in the standard unit cost.

- Sitework, including surveying, clearing and grubbing, dust / erosion control, etc.
- Earthwork, such as excavation, shoring hauling and compaction of bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs, and cathodic protection, etc.
- Site restoration

Adders for pipeline installation in an LACFCD easement cover the special features and additional work items are not included in the list of standard items above. LACFCD Adders include the following:

- Major Utility Crossings: (see Major Utility Crossings in Section 4.3.1.1)
- Trench Dewatering: (see Trench Dewatering in Appendix C and Appendix F)

It should be noted that the entire section shown being installed with cut-and-cover methods within the SG River bed was budgeted using the cost for a tunnel prepared by MJA in their report titled, "Conceptual Review of Three New Tunnel Alignments." This report has been included in its entirety as Appendix W. Additional details regarding CM3 – LACFCD easements and related adders can be found in Appendix M.

9.1.1.5 Construction Method 4 – Trenchless

As discussed in Section 3.4, CM4 covered all of the trenchless construction applications on this Project. Figure 3-20 shows the typical setup for each of the three trenchless construction methods considered. The standard unit cost for CM4A, 4B, and 4C, described in Section 3.4.3, was intended to cover all materials and work needed for construction of a finished and functional pipeline along those segments identified for trenchless construction including the following:

- Demolition, site work, earthwork, and site restoration for launching and receiving portals
- Tunneling equipment, such as pipe jacking system, TBM, spoils removal, etc.
- Casing pipe or segmental tunnel liners, grouting, and annular spacers/fill
- Pipe material and installation (carrier pipe or direct jack pipe)

Adders for trenchless work included the special features and additional work items which were not listed above. CM4 – Trenchless adders include the following:

- MT and Traditional Tunneling Dewatering: A cost adder was applied at all locations where the bottom of the tunnel launching and receiving portals would be below the groundwater level. A cost premium was added if permeable soils were also present.
- Jack & Bore Dewatering: Dewatering of the tunnel alignment, from the launching portal to receiving portal, would be provided when the jack & bore method (CM4A) is utilized for an intersection crossing and the tunnel invert is below the water level. A premium was added to the dewatering cost to account for the additional work associated with slant drilling

and/or permeation grouting to reach out and dewater and/or stabilize the soils below the intersection.

- Seismic hazards/fault zones.

Additional details regarding CM4 – Trenchless construction and related adders can be found in Appendix M.

9.1.1.6 Pipeline Unit Cost Summary

The standard unit costs associated with each construction method and related adders are presented in Table 9-1 and Table 9-2 below. Cost data was obtained from the following primary sources. Additional sources and the details of unit cost development are provided in Appendix M.

- R.S. Means 2nd Quarter of 2016 for Los Angeles, California
- Preliminary Design Report, Prepared by IEM for AECOM, October 2015
- Northwest Pipe Company Budgetary Quote dated July 19, 2018
- Preliminary Traffic Control Assessment, Prepared by Minagar, August 2018
- Black & Veatch, Heavy Civil Cost Data Base
- Desktop Geotechnical Evaluation for RRWP, Prepared by GeoPentech, August 2018

The direct unit costs are direct costs presented in April 2020 dollars and do not include indirect costs or contingency. The total construction unit costs are presented in April 2020 dollars as well, but include 15 percent for general requirements, 15 percent for general contractor overhead and profit, 3.6 percent for bonds and insurance, and 0 percent contingency. All costs were escalated to April 2020 dollars using the Construction Cost Indexes from Engineering News Report for Los Angeles, California.

All construction unit costs were developed using the budgetary quote received from Northwest Pipe Company on July 19, 2018. This quote is in line with historical prices for steel and does not include contingency for future fluctuations in steel prices due to potential tariffs or commodity price fluctuation.

Table 9-1 Construction Method Unit Costs

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
CM1 – Roadways			
84”	LF	$1,880	$2,530
60”	LF	$1,340	$1,780
54”	LF	$1,270	$1,700
CM2 – SCE Easements			
84”	LF	$1,400	$1,890
60”	LF	$870	$1,170
54”	LF	$780	$1,050
CM3A – River Bank			

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
84”	LF	$1,410	$1,900
60”	LF	$860	$1,160
54”	LF	$770	$1,040
CM3B – Cut-and-cover Earthen Channel			
84”	LF	$3,480	$4,680
60”	LF	$2,610	$3,510
54”	LF	$2,440	$3,280
CM3C – Cut-and-cover Concrete Lined Channel			
84”	LF	$2,350	$3,160
60”	LF	$1,630	$2,200
54”	LF	$1,500	$2,010
CM4A – Jack & Bore			
84”			
<200 ft length	LF	$10,510	$14,150
200-2000 ft length	LF	$5,000	$6,740
60”			
<200 ft length	LF	$9,400	$12,660
200-2000 ft length	LF	$4,100	$5,520
54”			
<200 ft length	LF	$9,200	$12,400
200-2000 ft length	LF	$3,900	$5,260
CM4B – Microtunnel			
84”			
<200 ft length, No Boulders	LF	$11,860	$15,970
<200 ft length, With Boulders	LF	$12,560	$16,910
200-2000 ft length, No Boulders	LF	$5,300	$7,140
200-2000 ft length, With Boulders	LF	$5,450	$7,340
60”			

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
<200 ft length, No Boulders	LF	$10,760	$14,490
<200 ft length, With Boulders	LF	$11,500	$15,500
200-2000 ft length, No Boulders	LF	$4,400	$5,930
200-2000 ft length, With Boulders	LF	$4,550	$6,130
54”			
<200 ft length, No Boulders	LF	$10,500	$14,150
<200 ft length, With Boulders	LF	$11,250	$15,150
200-2000 ft length, No Boulders	LF	$4,200	$5,660
200-2000 ft length, With Boulders	LF	$4,350	$5,860
CM4C – Traditional Tunnel			
84”			
EPBM (>2000 ft)	LF	$4,980	$6,700
60”			
EPBM (>2000 ft)	LF	$4,760	$6,410
54”			
EPBM (>2000 ft)	LF	$4,750	$6,395

Notes:
1. The unit costs are direct costs presented in April 2020 dollars and do not include general requirements, general contractor overhead and profit, contingencies, bonds, and insurance.
2. The total construction costs are presented in April 2020 dollars and include 15% for general requirements, 15% for general contractor overhead and profit, 3.6% for bonds and insurance, and 0% contingency.
3. Unit costs for CM4A and CM4B include a larger casing pipe or segmental tunnel liners, grouting, and annular spacers/fill.

Table 9-2 Construction Unit Costs for Adders

ADDED CONSTRUCTION COSTS DESCRIPTION	UNIT	DIRECT UNIT COST	TOTAL CONSTRUCTION UNIT COST[2]
Intersection Traffic Control (Cut-and-cover)	EA	$78,500	$105,700
Intersection Traffic Control (Trenchless)	EA	$12,500	$16,830
Landscaped Median (demo & replace)	LF	$192	$258
Raised Median (demo & replace)	LF	$181	$244
Major Utility Crossings			
84”	EA	$315,232	$424,475
60”	EA	$282,170	$379,950
54”	EA	$276,150	$371,850
Major Intersection Construction Crossing			
84”	EA	$1,000,210	$1,346,830
60”	EA	$820,050	$1,104,240
54”	EA	$780,160	$1,050,520
Seismic Hazards/Fault Zones			
84”	EA	$1,012,100	$1,362,830
60”	EA	$442,170	$595,410
54”	EA	$339,750	$457,500
Dewatering			
CM1 – Roadway	LF	$31	$41
CM2 – SCE Easement	LF	$6	$8
CM3A – River Bank	LF	$6	$8
CM3B & C – River Channel	LF	$9	$11
CM4A – Jack & Bore	LF	$50	$67
CM4B – Microtunnel	LF	$35	$48
CM4C – Traditional Tunneling	LF	$44	$59
Permeable Soils			
CM1 – Roadway	LF	$15	$21
CM2 – SCE Easement	LF	$3	$4
CM3A – River Bank	LF	$3	$4
CM3B & C – River Channel	LF	$4	$6
CM4A – Jack & Bore	LF	$25	$33
CM4B – Microtunnel	LF	$18	$24

ADDED CONSTRUCTION COSTS DESCRIPTION	UNIT	DIRECT UNIT COST	TOTAL CONSTRUCTION UNIT COST[2]
CM4C – Traditional Tunneling	LF	$22	$30

Notes:
1. The unit costs are direct costs presented in April 2020 dollars and do not include general requirements, general contractor overhead and profit, contingencies, bonds, and insurance.
2. The total construction costs are presented in April 2020 dollars and include 15% for general requirements, 15% for general contractor overhead and profit, 3.6% for bonds and insurance, and 0% contingency.

The following observations apply:

- CM2 and CM3A, construction along SCE and LACFCD easements would have the lowest cost per linear ft of the construction methods considered. This is primarily due to the shallower pipe installation, fewer potential utility impacts, and the lack of need for traffic control and pavement removal/replacement.
- Costs would increase significantly if the pipeline were located within the river channel (CM3B and CM3C) due to increased depth required to protect the pipeline from scour and provide concrete encasement of the pipeline in unlined portions of the river, concrete lining removal/replacement in lined portions of the channel, cost of installing and maintaining well point dewatering systems, the need to protect the work area from rainfall events, and reduced available working period during rainy seasons.
- CM1, construction along roadways, would have a high cost per linear ft. Elements contributing to the higher pipeline installation cost along roadways would include depth of the pipe, higher density of crossing and parallel utilities, removal and replacement of paving, and other surface improvements and the need to provide traffic control.
- CM4, trenchless construction methods, would have the highest cost per linear ft. Longer trenchless installations have a lower unit cost than short installations using the same method due to economies of scale coming into play with fixed costs (launching and receiving portals) and variable costs associated with the length of tunnel.
- Due to equipment limitations and man access requirements, CM4C, EPBM tunnels would have a minimum finished diameter of 7.5 ft, although at this diameter, machines are not readily available and would have to be special ordered. This FLDR assumed that all EPBM tunnels would have a minimum finished outer diameter of 118 to 132 inches so that a wider pool of contractors and tunnel boring machines would be available. The excess annular space was assumed to be filled with grout. Therefore, the cost difference for EPBM between pipe sizes would be minimal.

9.1.2 Pump Stations

The cost estimate for the pump stations has been prepared based on the contents of this report in combination with the feasibility-level drawings contained in Appendix L. In general, the following three methods for estimating costs were applied:

- Where sufficient detail is included on the drawings, a deterministic method for quantification of scope and assembly of costs has been utilized. Quantity takeoff was performed and transcribed into individual line item entries based on historical cost data for pricing and productivity. The historical cost archive is maintained primarily in the Sage Timberline Office Estimating application. This estimating system consists of a custom database (over 130,000 items) with assemblies that group items into definable cost systems and a spreadsheet to display results grouped according to user defined Work Breakdown Structures (WBS).
- The equipment pricing for vertical turbine pumps was obtained directly from pump vendors. The cost estimate reflects the most conservative costs obtained from two different vendors for pumps with equivalent design/service conditions.
- Scope items where the level of Project definition is conceptual in nature have been parametrically estimated utilizing cost data from similar projects in scope and size and adjusted to suit the specific requirements of this Project. For example, this approach was used to estimate the cost of the electrical room and transformer farm at each pump station.

Labor costs are adjusted in the OPCC to the Project location based on published prevailing wage rates, R.S. Means Location Adjustments and payroll tax information. The rates used are computed into averages based on a mixture of resources required for a given crew. Multiple crews are utilized in the cost as required for the different disciplines and activities involved in the work. Detailed line items throughout the OPCC are calculated using a production rate that has been established through a combination of estimating guides, historical data and specific experience with the disciplines and trades required to perform the work. Estimating guides that are utilized in the estimate include Richardson's Cost Data, R.S. Means, Mechanical Contractors Association of America (MCAA) and National Electrical Contractors Association (NECA).

Material pricing is maintained in the Sage Timberline Office Estimating database utilizing quoted pricing, vendor updates and multipliers on published list pricing. Pricing used in the OPCC has been reviewed by the estimators and adjusted based on the most current information available that is retained from recent bids on competitive priced projects.

Construction equipment costs are regularly updated based on the National Equipment Rental Blue Book publication. Cost for construction equipment is stored as an hourly rate that is then computed into averages based on a mixture of types of equipment required for a given crew. Multiple crews are utilized in the cost in the same manner as labor crews, with most crews containing both labor and equipment resources and having total amounts displayed in different cost categories. Individual line items are calculated using a production rate that has been established through a combination of estimating guides, historical data and specific experience with the disciplines and trades required to perform the work.

9.2 QUANTITY TAKE-OFF

A quantity take-off was completed for the SG and LA River Alignments. The quantity take-off has been separated into pipelines and pump stations, as presented in the following sections.

9.2.1 Pipeline

A quantity take-off was performed for the pipelines associated with the SG and LA River Alignments. The quantity take-off includes the quantity of each CM utilized and the number of adders found along the alignments.

Table 9-3 compares the total length of each construction method proposed for the SG and LA River Alignments. The complete and detailed quantity take-off is provided in Appendix N.

Table 9-3 Summary of Construction Methods for the SG and LA River Alignments

CONSTRUCTION METHOD	SG RIVER ALIGNMENT (FT)	LA RIVER ALIGNMENT (FT)
CM1 - Roadways	93,220	61,880
CM2 – SCE Easements	42,350	57,540
CM3 – LACFCD Easements	43,100	31,010
CM3A – River Bank	19,110	31,010
CM3B – River Bed (unlined)[1]	19,670	0
CM3C – River Bed (lined) [1]	4,320	0
CM4 – Trenchless	22,490	42,690
CM4A – Jack & Bore	2,540	2,370
CM4B – Microtunneling	12,770	16,010
CM4C – Traditional	7,180	24,310
Total	**201,150**	**193,120**

Note 1: This FLDR has assumed the portion of the SG River Alignment constructed within the SG River bottom would be constructed with cut-and-cover methods. However, for the purposes of establishing a conservative budget, this FLDR used a cost equivalent to tunneling this section.

The following observations were noted when comparing the construction methods between the SG and LA River Alignments:

- The SG River alignment is roughly 4 percent longer than the LA River Alignment. However, the LA River Alignment requires nearly doubles the length of trenchless construction.
- The LA River Alignment does not include any cut-and-cover construction within a LACFCD riverbed while the SG River Alignment has roughly 25,000 feet.
- The LA River alignment has several long traditional tunnels. This construction method typically results in longer construction durations.

9.2.2 Pump Station

As currently envisioned, the Backbone System for the SG and LA River Alignments would each have two pump stations, PS-1 and PS-3. At this level of study, the hydraulics between the two alignments are similar enough that the pump station feasibility-level design described in Chapter 8 is applicable to either alignment with respect to arrangement, preliminary sizing, and planning level cost. A quantity take-off was performed on the proposed pumping plants.

In general, the following two methods for determining pump station quantities was applied:

- Where sufficient detail is included on the drawings, a deterministic method for quantification of scope and assembly of costs has been utilized.
- Scope items where the level of Project definition is conceptual in nature have been parametrically estimated utilizing data from similar projects in scope and size and adjusted to suit the specific requirements of this Project. For example, this approach was used to estimate the cost of the electrical room and transformer farm at each pump station.

In addition to containing the material quantities shown on the drawings in Appendix L, the pump station estimates also include additional lengths of discharge and suction/inlet piping where necessary to connect to the Backbone System, and an assumed length of overflow piping when this feature is present. These additional pipeline lengths are summarized below in Table 9-4.

Table 9-4 Summary of Additional Pipe Lengths Included with Pump Station Cost Estimates

PUMP STATIONS AND PIPING	PIPE LENGTH (FT)		
	PAVED	UNPAVED	TRENCHLESS
PS-1: 102" Suction Pipe	0	0	0
PS-1: 84" Discharge Pipe	100	120	200 (railroad crossing)
PS-1: 30" Discharge Pipe	100	120	200 (railroad crossing)
PS-1: 102" Overflow Pipe	500	500	0
PS-2[1]: 84" Suction Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-2[1]: 54" Discharge Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-2[1]: 60" Discharge Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-3[2]: 84" Suction Pipe	1,900	0	0
PS-3[2]: 84" Discharge Pipe	1,900	0	0
PS-3[2]: 102" Overflow Pipe	2,000	0	0

Notes:
1. PS-2 was not included as part of the Backbone System.
2. The PS-3 Site 2 location was used for estimating purposes because it has the most conservative lengths of additional piping as compared to the other potential sites for PS-3.

9.3 ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

An Engineer's OPCC was prepared from the unit costs and quantity take-off for the SG and LA River Alignments. The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars.
- The Engineer's OPCC is Class 4 from the AACE with an accuracy range of -30% to +50%.

- The Engineer's OPCC includes indirect costs of 22 percent for overhead, profit, bonding, and insurance.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.
- The following costs are not included in the Engineer's OPCC:
  - Injection wells
  - Laterals to Project customers, including injection wells
  - Improvements to spreading basins
  - Permits
  - Right of way or easement acquisition
  - Property acquisition
  - Professional services, including engineering
  - Metropolitan staff time, including construction management
  - Design fieldwork, including potholing, geotechnical investigations, environmental fieldwork
  - Contingency for potential tariffs
  - Removal, remediation, and/or disposal of potentially contaminated soils identified as a result of future environmental fieldwork

9.3.1 Pipeline

A summary of the Engineer's OPCC for the SG and LA River Alignments is presented in Table 9-5 and Table 9-6, respectively. Figure 5-8 and Figure 5-10 identify the locations of the segments listed. A detailed breakdown of the costs associated with all the segments included in the SG and LA River Alignments can be found in Appendix O.

Table 9-5 Summary of Construction Costs for the SG River Alignment

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
1	23,957	84	$112,900,000
5	11,004	84	$37,900,000
5A	26,649	84	$91,600,000
10A	6,871	84	$29,400,000
20	32,140	84	$127,600,000
22	20,094	84	$140,100,000
36	4,651	84	$9,300,000
38	21,745	84	$68,900,000
38A	4,592	84	$27,800,000
44	28,748	84	$85,100,000

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
52	2,292	84	$6,800,000
56	1,166	84	$4,600,000
58	3,339	84	$11,300,000
59	9,028	84	$27,400,000
60	4,884	84	$15,600,000
		SG River Alignment Total	**$796,300,000**

Table 9-6 Summary of Construction Costs for the Los Angeles River Alignment

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
1	24,083	84	$113,800,000
2	12,826	84	$61,500,000
101	8,635	84	$62,600,000
3	9,206	84	$35,300,000
100	24,418	84	$72,100,000
7	3,700	84	$9,600,000
21	23,415	84	$90,800,000
23	19,433	84	$67,700,000
38	17,937	84	$63,400,000
44	28,748	84	$85,100,000
52	2,292	84	$6,800,000
56	1,166	84	$4,600,000
58	3,339	84	$11,300,000
59	9,028	84	$27,400,000
60	4,884	84	$15,600,000
		Los Angeles River Alignment Total	**$727,600,000**

9.3.2 Pump Station

A summary of the Engineer's OPCC for the pump stations included in the Backbone System is presented in Table 9-7. At this level of study, the hydraulics between the SG and LA River Alignments are similar enough that the pump station feasibility-level design described in Chapter 8 is applicable to either alignment with respect to arrangement, preliminary sizing, and planning level cost. A detailed breakdown of the line items and costs associated with the elements included in the Pump Stations can be found in Appendix P.

Table 9-7 Summary of Construction Costs for the Pump Stations

PUMP STATIONS	CONSTRUCTION COST ($)
PS-1[1]	$51,200,000
PS-3[2]	$51,000,000
Pump Stations Total	**$102,400,000**

Notes:
1. The PS-1 layout and sizing associated with Alternative A was used for cost estimating purposes.
2. As described in Chapter 8, the hydraulics for PS-1 and PS-3 are similar enough at this planning level as to warrant the use of a common arrangement, preliminary layout, and planning level cost.

9.3.3 Summary of Construction Costs for the RRWP Conveyance Facilities

A summary of the Engineer's OPCC for the entire RRWP Backbone System, including pipelines and pump stations, for the SG and LA River Alignments is presented in Table 9-8. As before, a detailed breakdown of the line items and costs can be found in Appendix O and Appendix P.

Table 9-8 Comparison of Construction Costs for the Backbone System

ITEM	SG RIVER ALIGNMENT TOTAL CONSTRUCTION COST	LA RIVER ALIGNMENT TOTAL CONSTRUCTION COST
Pipeline	$796,300,000	$727,600,000
Pump Stations		
PS-1	$51,200,000	$51,200,000
PS-3	$51,200,000	$51,200,000
RRWP Conveyance System Total	**$898,700,000**	**$830,000,000**

As discussed in Chapter 5, at one time this Project envisioned delivering flow to the OC Spreading Grounds with PS-2 included (Alternative B). For planning purposes, the total cost of the RRWP conveyance system for Alternative B would be $840,400,000.

As stated previously, the Engineer's OPCC is AACE Class 4, which carries an accuracy range of -30% to +50%. The values presented up until this point do not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team. For reference, Table 9-9 presents what the Engineer's OPCC for the Backbone System is using a -30% to +50% contingency.

Table 9-9 Example of Construction Costs with AACE Class 4 Contingency Applied (Backbone)

CONTINGENCY RANGE	SG RIVER ALIGNMENT	LA RIVER ALIGNMENT
Accuracy Range -30%	**$629,000,000**	**$581,000,000**
Accuracy Range +50%	**$1,348,000,000**	**$1,245,000,000**

9.3.4 Conclusion

Per Table 9-8, the cost opinions for the SG and LA River Alignments are within ten percent of each other. At this feasibility level of study and estimating, this is within the level of accuracy of the estimates. Other factors outside of the construction cost opinion impact the overall feasibility and cost of each alignment, such as the property acquisition costs, design costs, and environmental mitigation costs. These are not included in the numbers presented in Table 9-8.

9.4 PUMP STATION OPERATION AND MAINTENANCE COSTS

An estimate of the power, material, and labor operation and maintenance (O&M) costs was developed for the Project's pump stations under the Backbone System. This section describes the O&M costs developed for the pump stations. O&M costs for the pipeline are not included in this FLDR.

9.4.1 Power O&M Costs

The following assumptions were made in the development of the power costs for operation of the pump stations. A comparison of the power costs for operation of the pump stations is presented in Table 9-10.

- The pump efficiency was assumed to be 75 percent. This is a conservative assumption.
- For frictional hydraulic losses, the Manning's equation was used per Metropolitan's Hydraulic Design Manual. A Manning's Coefficient "n" of 0.012 was used for steel pipe.
- At Metropolitan's direction, an assumed cost per kWhr of $0.15/kWhr was used.
- Power usage assumed 150 mgd of flow.

Table 9-10 Preliminary Pump Station Power Operating Costs (Backbone System)

PUMP STATION	SG RIVER ALIGNMENT		LA RIVER ALIGNMENT	
	ANNUAL POWER CONSUMPTION (KWHR)	ANNUAL COST ($)	ANNUAL POWER CONSUMPTION (KWHR)	ANNUAL COST ($)
PS-1	80,282,000	$12,040,000	78,127,000	$11,720,000
PS-3	76,951,000	$11,540,000	76,951,000	$11,540,000

9.4.2 Material O&M Costs

An analysis was conducted to provide a general order-of-magnitude for the material costs, including pumps, motors, and other mechanical equipment, for the operation of the pump stations. During the analysis, the following assumptions were made:

- Material costs were generated in August 2016 and escalated to April 2020 dollars using the Construction Cost Indexes from Engineering News Report for Los Angeles, California.
- Costs are estimated for materials only for pumps, motors, and other mechanical equipment.
- Costs are not included for ancillary system (e.g. structures, software, etc.).
- Costs do not include tax, supplier markup, labor, tools, engineering, or material disposal.

- Costs do not include additional contingency.
- Frequency of component replacement depends heavily on operating conditions, operating frequency, and specific equipment supplied. It is assumed all equipment will have 24 hours per day, 365 days per year operation (8,760 hours per year).
- Values below are estimated capital costs for the pumping equipment based on input received from a typical manufacturer in 2017. These are provided to show a comparison to the estimated material costs for routine O&M. These are equipment costs only with no additional markup.

Table 9-11 presents the annual material costs for maintenance for PS-1 and PS-3 each.

Table 9-11 Annual Material Costs for Maintenance of PS-1 and PS-3 (Backbone System)

MAINTENANCE DESCRIPTION	FREQUENCY / REMARKS	COST PER UNIT ($)	ANNUAL PERCENT	QUANTITY	UNIT	TOTAL ANNUAL COST
Replace motor bearing oil	Every 8,760 hours of operating time	1,105	100%	8	per pump	$8,800
Mechanical seal	Inspect annually; assume replacement every 5 years	5,424	20%	8	per pump	$8,700
Submerged bearings and shaft sleeves	Assume replacement of 6 bearings per pump every 20 years. $5k/bearing	32,343	5%	8	per pump	$12,900
Impeller ring and casing ring	Assume replacement every 20 years; $2.5k per stage; 4 stage	10,748	5%	8	per pump	$4,300
Shaft	Assume replacement every 25 years	107,877	4%	8	per pump	$34,500
Impeller	Assume replacement every 25 years; 4 stages/ $10k/stage	43,191	4%	8	per pump	$13,800
Compressor motor air filters	Inspect annually; assume replacement every 2 years	2,712	50%	1	per pump station	$1,400
Valve seals at PS1	Replace valve seals (at 5% of initial valve material cost of $720k) every 10 years	42,186	10%	1	per pump station	$4,200
HVAC	Inspect and replace air filters, lubricate, minor maintenance twice per year	2,712	100%	1	per pump station	$2,700

MAINTENANCE DESCRIPTION	FREQUENCY / REMARKS	COST PER UNIT ($)	ANNUAL PERCENT	QUANTITY	UNIT	TOTAL ANNUAL COST
Generator	Fuel for annual testing; minor annual repairs	552	100%	1	per generator	$600
Instruments	Inspect annually; assume replacement every 10 years	213,745	10%	1	per pump station	$21,400
Miscellaneous	10% of sum of individual costs above	N/A	10%	1	per pump station	$11,300
Total estimated annual material cost for each pump station's maintenance						**$124,600**

Based on Table 9-11, the estimated annual material cost for both PS-1 and PS-3 is $249,200. For CIP budgeting purposes, this FLDR recommends that Metropolitan consider the potential for more costly, unanticipated, replacements (e.g., upgrade SCADA to new technology, replace electrical gear or components thereto, other structural or piping rehabs) above and beyond the costs provided. For example, if Metropolitan assumed 10 percent of all non-structural materials are replaced every 20 years, the annual amortized cost would be $85,000/year for PS-1 (0.5% of $17M for materials) and $70,000/year for PS-3 (0.5% of $14M for materials). Additional analysis would need to be completed to determine more accurately what that cost would be.

9.4.3 Labor O&M Costs

At this time, it is not known whether new distribution staff specific to the operation of the RRWP will be needed or if Metropolitan's existing potable water distribution staff will be able to maintain operations themselves. For planning purposes, Metropolitan has budgeted for the labor costs of 12 full time equivalents (2,080 hours per year) at $75 per hour. Table 9-12 shows the assumed annual labor O&M costs.

Table 9-12 Assumed Annual Labor O&M Costs

ITEM	COST
Labor O&M	$1,872,000

9.4.4 Summary of O&M Costs

A comparison of the estimated annual power, material, and labor O&M costs developed for the Project's pump stations (Backbone System) is provided in Table 9-13. O&M costs for the pipeline are not included in this FLDR.

Table 9-13 Summary of Annual O&M Costs

ITEM	SG RIVER ALIGNMENT ANNUAL COST	LA RIVER ALIGNMENT ANNUAL COST
Power	$23,580,000	$23,260,000
Material	$249,200	$249,200
Labor	$1,872,000	$1,872,000
Total O&M	**$25,701,200**	**$25,381,200**

9.5 CONNECTION FROM SFSG TO FEWWTP: ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

An Engineer's OPCC for the pipeline that would be required to connect the SFSG to the Glendora Tunnel, which would be used to convey water on to FEWWTP in the future, was developed upon Metropolitan's request. The pump stations and any modifications, improvements, or repairs to Metropolitan's existing facilities, such as the Glendora Tunnel, La Verne Pipeline, or Upper Feeder Junction Structure, that would be required to form a complete and functioning system, are not included in this cost opinion and should be further evaluated during the next phase of work.

The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars using the Construction Cost Indexes from Engineering News Report 2020 for Los Angeles, California.
- The Engineer's OPCC is AACE Class 4 with an accuracy range of -30% to +50%.
- The Engineer's OPCC includes indirect costs of 22 percent for overhead, profit, bonding, and insurance.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.

Table 9-14 the Engineer's OPCC for the connection from the SFSG to the FEWWTP. A detailed breakdown of the costs can be found in Appendix O and a feasibility-level quantity takeoff can be found in Appendix N.

Table 9-14 Engineer's OPCC for the Connection from the SFSG to the FEWWTP (Pipeline Only)

ITEM	CONSTRUCTION COST
Pipeline	$214,600,000

As noted above, a cost opinion has not been prepared for the pump stations necessary to convey water from the SFSG to the Glendora Tunnel, and ultimately on to the FEWWTP. However, for budgeting purposes until these facilities can be further evaluated, Metropolitan has indicated that two pump stations of similar size and cost as PS-3 should be used as a place holder. The combined cost for two PS-3's would be:

- $102,400,000

The OPCC for the connection from the SFSG to the FEWWTP for DPR was based upon the quantities presented in Table 9-17.

Table 9-15 Quantity Take Off – Connection from SFSG to FEWWTP for DPR

ITEM	QUANTITY
84-inch Pipeline in Roadways, feet	40,200
Tunnel, feet	10,500
Pump Stations, each	2

9.6 PRELIMINARY CONSTRUCTION DURATION AND CONTRACT PACKAGING

To establish a feasibility-level construction schedule, preliminary construction durations were determined for the conveyance facilities of the RRWP. Installation rates were developed and contract packages were identified to determine a feasibility-level construction schedule to assist Metropolitan with their capital improvement planning and budgeting. While a specific breakdown of construction packages is shown, it should be noted that there are numerous factors that play into the final breakdown of construction packages which are not known at the time of this FLDR, such as annual limits on capital expenditures and implementation strategies. Further evaluation of contract packaging is expected during subsequent planning and design phases of the Project and would be expected to refine the size, number, and duration of each potential contract package.

9.6.1 Purpose of Contract Packaging

The overall size of the conveyance portion of the RRWP, as well as the number of different jurisdictions that it encompasses, makes it prudent to consider splitting the construction of the program into individual contract packages. The strategy used to develop the potential contract packages in this FLDR aimed to satisfy four objectives: 1) reduce overall schedule, 2) obtain competitive pricing, 3) optimize construction management costs, and 4) minimize risk associated with multiple construction contract interfaces.

9.6.2 Installation Rates

An estimate of the installation rate for each construction method was developed as follows:

- A total of six months would be required for pipe procurement and mobilization of each contract package.
- A total of three months would be required for the testing, commissioning, and demobilization of each contract package.
- The rate of construction progress would be expected to vary between a high production rate when experiencing ideal conditions and a low production rate when faced with less than ideal conditions.
  - CM1 would range between 40 ft/day and 80 ft/day
  - CM2 and CM3A would range between 180 ft/day and 200 ft/day
  - CM3B and CM3C would range between 100 ft/day and 140 ft/day

- CM4 work would be performed by a separate tunneling contractor in parallel with cut-and-cover construction being completed by the general contractor. In most cases, the CM4 work is not anticipated to add to the overall duration of work for contract packages, as the longer cut-and-cover sections would dictate the critical path. However, in contract packages with long tunnels proposed, CM4C would set the contract duration. Traditional tunneling assumed the following production rates:
  - Mining / excavation – 20 to 40 ft/shift
  - Carrier pipe install – 80 ft/shift
  - Grouting – 200 ft/shift
  - Launching shaft assumed 5 days mobilization, 2 ft of excavation depth / shift at 45 ft depth, and 5 days to pour the slab, install utilities, and support breakout
  - Assembly of EPBM machine – 1 to 2 months
  - EPBM procurement and delivery would require 6 to 12 months
  - Working days are assumed to be one 10-12 hour shift
  - The overall production range, including all factors of work, would be between 11 and 18 ft/day for CM4C
- The installation rates described above account for "typical" conditions that would be anticipated and do not account non-typical constraints, such as:
  - Environmental constraints, such as nesting birds or mating seasons
  - Jurisdictional constraints, such as restrictions on working hours or working days per week
  - Labor disputes
  - Material delays
  - Forces of nature, such as floods, pandemics, or above average rainfall

9.6.3 Contract Packaging

This section describes the potential contract packages developed for the conveyance facilities of the RRWP.

9.6.3.1 Pump Stations

Pump stations can be grouped into their own contract package, which could be a single contract package encompassing both pump station sites or could be split into individual contracts for each facility. Construction of the pump stations could happen in parallel with the construction of the pipeline.

9.6.3.2 Pipeline

To meet the stated objectives for contract packaging, the SG and LA River Alignments were evaluated to identify potential contract packages of similar size or duration. Other factors considered included municipal/jurisdictional boundaries, the type of construction activity, and location.

The resulting potential contract packages for the SG and LA River Alignments are shown on Figure 9-2 and Figure 9-3 and summarized in Table 9-16 and Table 9-17.

Table 9-16 Potential Contract Packages for the SG River Alignment Pipeline

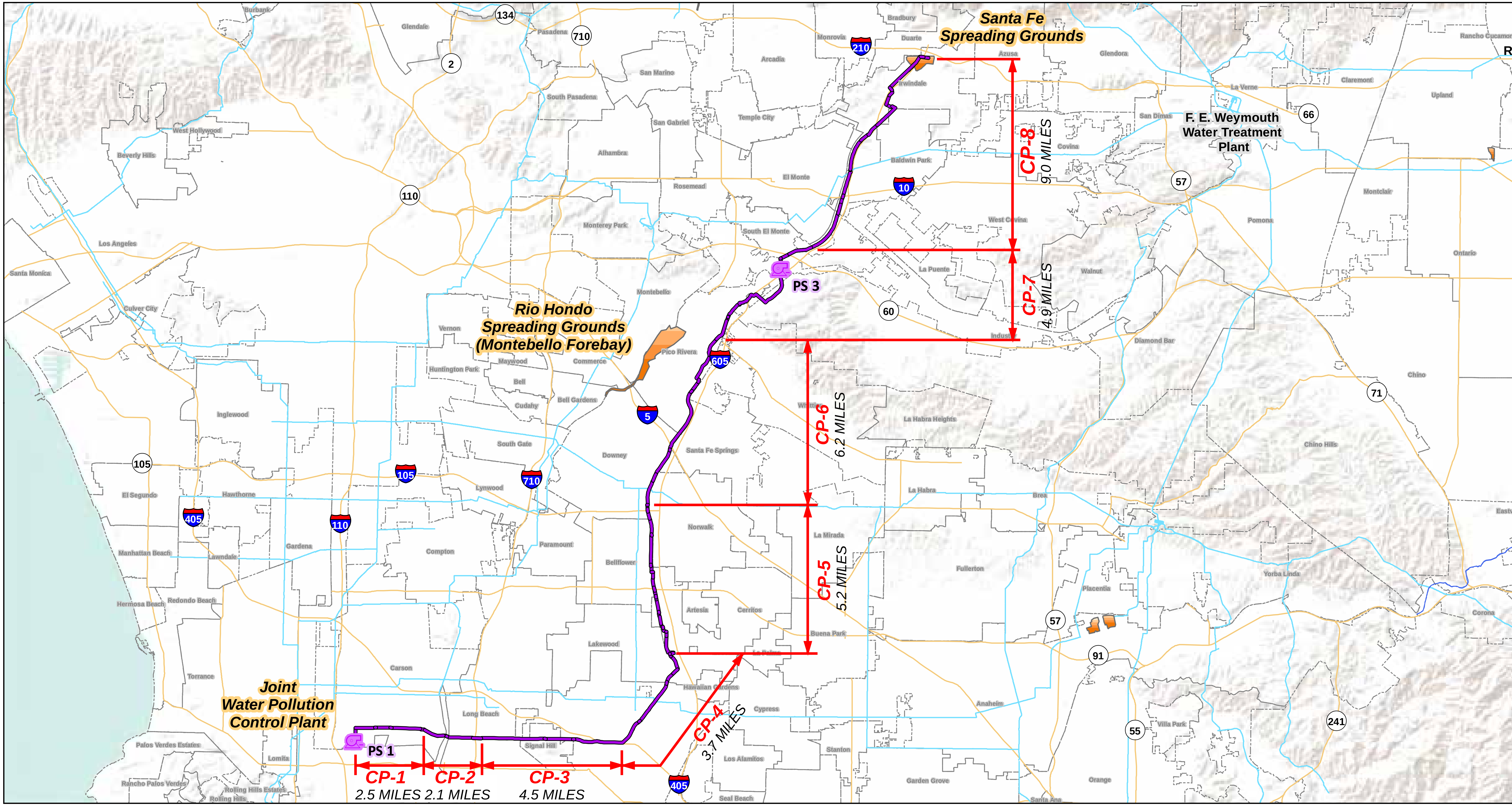
PIPELINE CONTRACT	DESCRIPTION	STATION START	STATION END	CM-1 STREETS	CM2, CM3A EASEMENTS	CM4 TUNNELING	CONTRACT DURATION - AVG[1] (MONTHS)
1	First Contract to Alameda Corridor	0	13,100	13,100			21
2	Alameda to East Bank of LAR	13,100	24,100	7,570			21
3	LAR to Bellflower Blvd	24,100	48,000	23,900			30
4	Bellflower Blvd to JS	48,000	67,700	19,390		310	26.5
5	JS to Transition to River Bed	67,700	95,400	4,685		23,015	19.5
6	River Transition to Whittier Blvd	95,400	128,300		24,100	8,800	21
7	Whitter Blvd to SJ Creek	128,300	154,100	12,970		6,340	27
8	SJ Creek to Santa Fe	154,100	201,400	8,700		32,300	25

Notes:
1. Average contract duration using the high and low production rates. This duration is recommended for use in high level planning.
2. Minor trenchless crossings for Contracts 1, 3, 4, 5, and 6 would not impact the overall schedule estimate and were therefore not itemized in this schedule estimate.
3. Contract 2 and Contract 7 each include traditional tunnels of 3,430 ft and 3,700 ft, respectively.
4. Contract 8 includes multiple trenchless installations of significant length, which were itemized in this schedule estimate. These trenchless installations would not all occur consecutively and therefore would not add to the duration of the work.
5. Due to construction restrictions, Contract 5 may be required to be constructed using tunneling construction methods within the riverbed. If tunneling is required, the mid-range contract duration for contract 5 is roughly 88 months.

Table 9-17 Potential Contract Packages for the Los Angeles River Alignment Pipeline

PIPELINE CONTRACT	DESCRIPTION	STATION START	STATION END	CM-1 STREETS	CM2, CM3A EASEMENTS	CM4 TUNNELING	CONTRACT DURATION -AVG[1] (MONTHS)
1	First Contract to Alameda Corridor	0	13,100	13,100			21
2	Alameda to East Bank of LAR	13,100	24,100	7,570		3,430	21
3	LAR to Chestnut Ave	24,100	45,300		6,570	14,630	59
4	Chestnut Ave to Somerset Blvd	45,300	62,310	10,500	4,190	2,320	20
5	Somerset Blvd to Century Blvd	62,310	69,800		6,490	1,000	13
6	Century Blvd to Whittier Blvd	69,800	112,600		37,100	5,700	28.5
7	Whittier Blvd to SJ Creek	112,600	145,840	24,210	6,320	2,710	32
8	SJ Creek to Santa Fe	145,840	193,140	8,700	32,300	6,300	27

Notes:
1. Average contract duration using the high and low production rates. This duration is recommended for use in high level planning.
2. Minor trenchless crossings for Contracts 1, 5, and 6 would not impact the overall schedule estimate and were therefore not itemized in this schedule estimate.
3. Contract 2, 3, 4, and 6 each include traditional tunnels.
4. Contract 8 includes multiple trenchless installations of significant length, which were itemized in this schedule estimate. These trenchless installations would not all occur consecutively and therefore would not add to the duration of the work.



Legend

- Alignment
- Spreading Basins
- MWD Pipelines
- Interstate / State Highway

Date: 5/1/2020

0 0.75 1.5 3 4.5 Miles

N W E S

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Feasibility-Level Design of the Conveyance for the Potential Regional RW Program
Figure 9-2: SG River Alignment Contract Packaging

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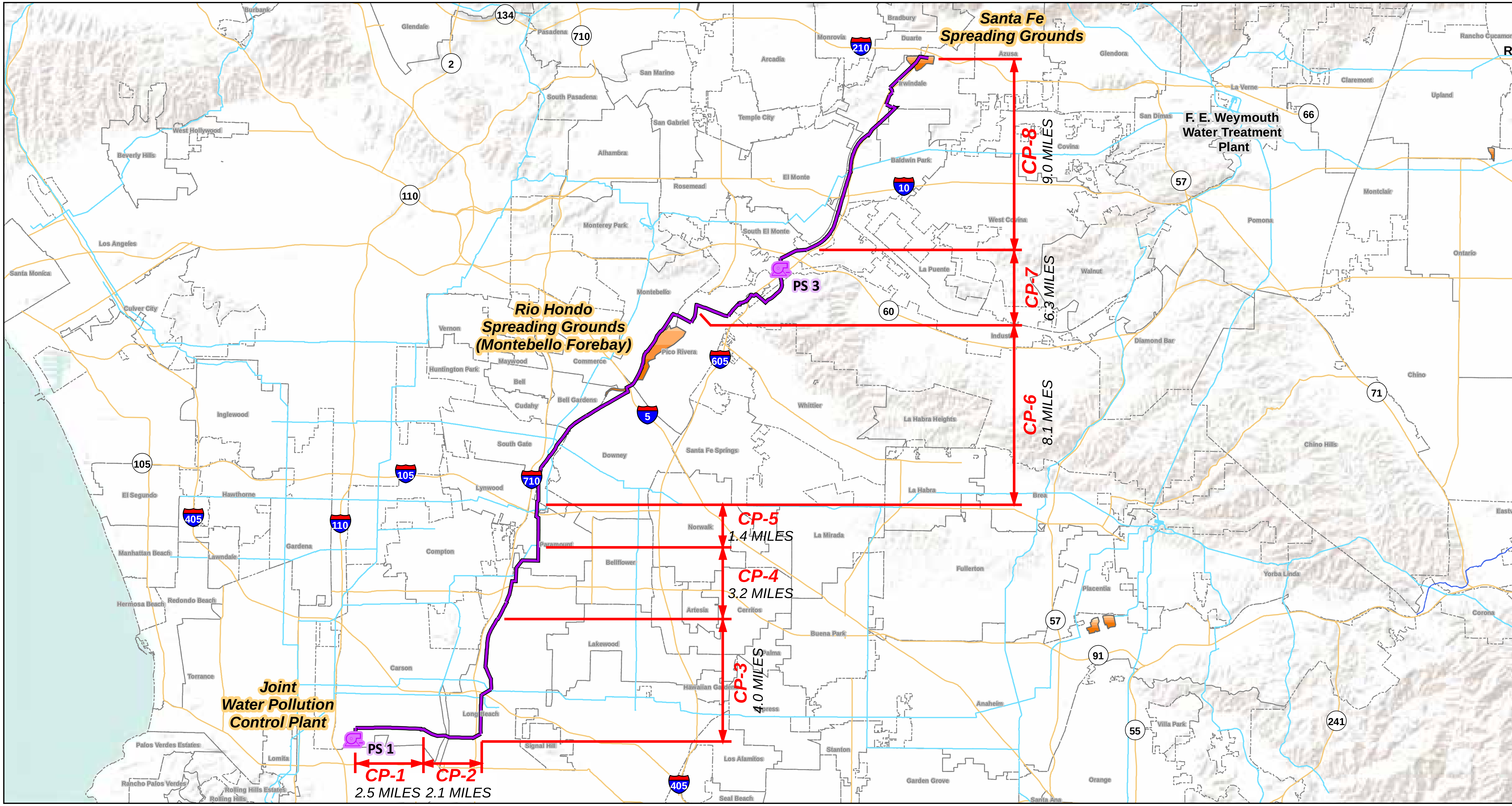

Legend

- Alignment
- Spreading Basins
- MWD Pipelines
- Interstate / State Highway

Date: 5/1/2020

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program
Figure 9-3: LA River Alignment Contract Packaging

N W E S

0 0.75 1.5 3 4.5 Miles

BLACK & VEATCH
Building a world of difference.

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9.6.3.3 Contract Packaging Observations

Contract packaging observations include:

- The longest potential pipeline contracts shown for the SG River Alignment would be Contracts 3 and 7. Contract 3 contains a long reach of roadway construction and Contract 7 contains a large traditional tunnel section that would be critical path.
- The longest potential pipeline contract shown for the LA River Alignment would be contract 3, with an anticipated duration of 59 months. Contract 3 contains a traditional tunnel that is roughly 13,000 feet in length.
- Metropolitan is considering various implementation strategies for the RRWP, which were not considered by this contract packaging evaluation. Contract packaging should be further evaluated during subsequent design phases to support the implementation strategies.

  A more detailed evaluation of construction rates and contract packaging is recommended during subsequent design phases and could result in revisions to contract packages to better align with jurisdictional boundaries.

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10.0 Conclusions and Recommendations

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of impacts based on the information available for this FLDR. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies and analysis. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

While these two alternatives appear most favorable based on the analysis completed to date, the third "street right-of-way" alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan.

It is recommended that the future connection from the Backbone System to the FEWWTP utilize the Glendora Tunnel. Additional evaluations, including coordination with the local jurisdictions, should be completed during the next phase of work to determine the preferred alignment to reach the terminus of the Glendora Tunnel, as well as the number and location of the pump stations required. This evaluation should also consider if any improvements are required to Metropolitan's existing facilities to utilize the Glendora Tunnel in this manner, such as repairs to the Glendora Tunnel's lining, service connections (such as PM-26 and USG-3), or the functionality of the Upper Feeder Junction Structure.

This FLDR documents technical analysis completed to date supporting the development of the RRWP conveyance system and provides a basis as the RRWP transitions to the next phase of design. The next phase of design will continue to refine the RRWP conveyance system and will consist of more detailed engineering studies including, but not limited to, those listed below as described in various places throughout the report:

- Continued alignment evaluations to further optimize the alternatives and determine the preferred method of construction throughout
- While it is anticipated that the alignments proposed would continue to be refined throughout as jurisdictional coordination progresses and subsurface investigations are completed, the following locations in particular are highlighted as requiring addition analysis:
  - Crossing of the Newport-Inglewood Fault Zone
  - Alameda Corridor / Dominguez Channel crossing
  - Tunneling verses cut-and-cover methods within existing public rights-of-way associated with streets
  - Tunneling verse cut-and-cover methods within the SG River bed
  - Discharge location at the SFSG and crossing of the Santa Fe Dam
  - Alignment crossing beneath or going around the Whittier Narrows Dam
  - Alignment adjacent to the Upper SG Valley Municipal Water District's Indirect Reuse Replenishment Project (IRRP) pipeline

    - Alignment connecting the Backbone Alignment to the Glendora Tunnel, include the portion in Azusa Avenue, north of Fifth Street (for the potential connection to FEWWTP)
    - Tunnel portal size and locations
- Further refinement of cost opinions, contract packaging, and implementation strategy
- Location and design of appurtenances (blow offs, including discharge locations and dewatering plan, air release and vacuum valves, and sectionalizing valves, if needed)
- Continued coordination with local jurisdictions
- Further refinement of initial traffic control concepts and evaluation of impacts
- Refinement of feasibility-level pump station design, including:
    - Coordination of PS-1 and wet well layout into the overall AWT plant site
    - Further refinement of system curves and pump selection
    - Further refinement of pump station siting, including more detailed siting studies for PS-3
    - Evaluation of infrastructure requirements (incoming power supply and communications)
    - Further investigation and risk assessment for the dechlorination system for off-site facilities, including coordination with applicable regulatory jurisdictions
- Refinement of system hydraulics, including:
    - More detailed surge and transient analysis
    - Further evaluation of the Signal Hill storage tank concept to determine if its required
    - More detailed hydraulic analysis for the connection to FEWWTP, including confirmation of flow capacity
    - More detailed system optimization analysis to validate the planning level balancing of capital costs with annual operating costs
- More detailed evaluations of the connection to FEWWTP, including:
    - Selection of a preferred alignment connecting the Backbone System to the Glendora Tunnel
    - More detailed hydraulic analysis and confirmation of flow capacity
    - Evaluation of pump station requirements, including a more detailed siting study
    - Evaluation to determine if any improvements to Metropolitan's existing system would be required
- Further refinement of pipe structural design to account for 1) the results of a surge analysis, 2) refinements to the alignment, and 3) the results of a seismic hazard assessment
- Design field-work program:

    - Geotechnical evaluations, including dewatering testing/studies, a seismic hazard analysis, and an analysis of trenchless and cut-and-cover construction throughout
    - Desktop environmental program to determine the need for a field program to identify possible hazardous soils and groundwater
    - Utility research and potholing
    - Survey
- Scour analysis of the SG River
- Additional data collection and review of existing records for the following:
    - Existing river and levee design
    - Foundations of LACFCD's in-river rubber dams
    - Foundations of existing facilities, including bridges, abutments, tanks, and buildings
    - Existing utilities
    - More detailed understanding of designated wetlands and sensitive wildlife areas
    - Existing spreading facility design to determine requirements for tie-in
- Further refinement of right of way and ownership evaluations and identification of construction laydown and staging areas
- Development of distribution laterals connecting the Backbone System to proposed injection well sites and identification of improvements at spreading basins to accommodate the program
- Continued coordination with other regional entities regarding partnership opportunities, including the City of LA, the Upper SG Valley Municipal Water District, and the Southern Nevada Water Authority
- Further refinement of Project risks and development of a quantitative risk register
- Additional evaluation of permitting and jurisdictional requirements

Appendix B.4

Final Distributed Treatment TM (2022)

Assessment of Distributed Recycled Water Treatment Plants

Final Technical Memorandum

September 16, 2022

Prepared for:

Metropolitan Water District of Southern California

Prepared by:

Stantec

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1.0 INTRODUCTION

In accordance with the scope of work in Task Order No. 2, Task 6 – "Assessment of Distributed Recycled Water Treatment Plants Study", this technical memorandum (TM) has been prepared to summarize this task effort's approach and findings. This includes providing preliminary planning for the assessment of an alternative approach to the siting of treatment systems that differ from a centralized approach.

1.1 PROGRAM BACKGROUND AND DRIVERS

Imported sources make up a large portion of Metropolitan Water District of Southern California's (Metropolitan) customers water supplies. The reliability of imported supplies is in question due to both water availability with the imposition of restrictions due to ongoing drought conditions as well as the potential impacts to conveyance infrastructure functionality after a major seismic event. The potential for procuring new supplies to import is very limited. Within this context, the reuse of water from the municipal wastewater facilities, including the Los Angeles County Sanitation Districts' (LACSD) Joint Water Pollution Control Plant (JWPCP), is a critical supply component necessary to provide long-term sustainable water supply sources to Metropolitan's customers.

The Metropolitan and LACSD are developing a large-scale Regional Recycled Water Program (RRWP) to beneficially reuse water currently discharged to the Pacific Ocean. The overall program involves construction of an Advanced Water Treatment (AWT) facility to treat effluent from the LACSD's JWPCP located in the City of Carson, California, as well as a new regional conveyance system and associated infrastructure to utilize the purified water to augment regional water supplies.

The RRWP is planned to purify primary or secondary wastewater effluent from LACSD's JWPCP through AWT processes for potable reuse in Southern California. Water from the program will be used to recharge groundwater basins. This system will also have the flexibility to accommodate industrial users whose needs are consistent with the quality of water produced by the AWT facility. Finally, future use of this system for direct potable reuse (DPR) applications appears feasible once applicable regulations are established. As currently envisioned the RRWP will be constructed in a phased approach with the ultimate capacity of the program dependent on both the availability of source water at the JWPCP and the anticipated water demands of member agencies for groundwater replenishment and raw water augmentation.

1.2 STUDY BACKGROUND AND OBJECTIVES

This study was undertaken to provide a comparison of two siting approaches for new treatment facilities associated with this program. The alternatives under consideration are (1) a centralized siting approach versus (2) a distributed/decentralized siting approach. On the basis of this comparison, a recommendation will be made for a preferred strategy. The potential benefits of a distributed approach over that of a centralized approach include:

- Potential energy saving by reduced pumping (costs and greenhouse gas (GHG) emissions)

- Production risk reduction with multiple, process independent plants (reliability)

In addition to the benefits cited, there are challenges and potential cost ramifications related to the distributed approach. These will be discussed and incorporated into the analysis, ultimately leading to a recommended approach.

The primary objectives of this study were as follows:

1. **Locate Candidate Sites**: Develop a cross-section of candidate locations for flow interception and wastewater treatment as well as identification of associated rights-of-way
2. **Evaluate Locations:** Assess the viability of each identified distributed treatment scenario, including qualitative and quantitative (costs) information
3. **Comparative Assessment:** Based upon the analysis and comparison to the centralized approach, recommend a path forward for this program

1.3 TM STRUCTURE AND CONTENT

This TM consists of five sections:

- **Section 1 – Introduction**: Provides program background and drivers as well as study objectives and approach.
- **Section 2 – Study Approach**: Delineates the overall approach to achieve project objectives.
- **Section 3 – Identification and Selection of Collection System Flow Interception/Diversion Locations**: Describes the means to analyze the collection system and determine candidate locations for the diversion of sewage to a distributed treatment plant.
- **Section 4 - Treatment Plant Siting**: Delineates the methodology employed for locating candidate treatment plant sites and selecting suitable sites.
- **Section 5 – Conveyance Facilities**: Layout the facilities required to transport product water to the main distribution pipeline.
- **Section 6 – Evaluation of Distributed and Centralized Treatment Approaches**: Compare approaches in terms of facilities and costs.
- **Section 7 – Findings and Recommendations**: Describes the preferred alternative and recommended approach.
- **Section 8 – References**: Shows references used in the study.
- **Appendices**: A compilation of reference materials supporting this TM's findings including the cost model and the property acquisition costs.

Although this study examines alternative approaches to treatment plant siting, it is not reviewing any potential new applications for the use of recycled water produced (e.g. new purple pipe reuse customers). The analysis is limited to treatment location alternatives with all planned reuse applications remaining as those identified for the RRWP, namely the Santa Fe Spreading Grounds (SFSG) and augmentation of Weymouth Water Treatment Plant's raw water supply. Product water flow from any alternative site will be piped directly to the backbone conveyance distribution system and treated to a level consistent with that within the backbone system.

2.0 STUDY APPROACH

The study hypothesis was that diversion and treatment of flows via distributed treatment plants will reduce the required capacity of the centralized plant, and the associated costs, accordingly. **Figure 2-1** shows the overall study approach to determine the suitability of adapting distributed treatment over centralized treatment. In the development of distributed sites options, the facilities required to implement such an approach can be categorized as follows:

- **Wastewater Interception / Diversion**: Those physical improvements needed to intercept raw wastewater flows within the existing conveyance system, divert a portion of it from the existing conveyance network, and transport the diverted raw wastewater to the new distributed treatment plant site.
- **Treatment**: Procurement of a parcel of land with sufficient area and geometry to construct and operate the treatment systems required to provide full secondary treatment and AWT, achieving indirect potable reuse (IPR) standards.
- **Product Water Conveyance**: Facilities to convey treated product water to the "backbone" product water distribution system.
- **RO Concentrate Conveyance**: Facilities to convey RO concentrate to JWPCP. Solids residuals will also be disposed of or conveyed to sewer in accordance with LACSD sewer requirements.

The analysis was carried out for two candidate diversion locations within the Joint Outfall System's (JOS) collection network and three potential sites for treatment.

There are a significant number of approvals that would be required from different parties for implementing the distributed treatment approach including:

- **LACSD**: Permits/approvals for flow diversion including connection to existing sewers for discharge of solids waste streams from the treatment plant and new RO concentrate line to JWPCP
- **Division of Drinking Water (DDW):** Treatment process approval
- **Regional Water Quality Control Board (RWQCB):** Water recycling discharge permit
- **Various Jurisdictions**: Rights-of-way for conveyance to the treatment site and conveyance to the backbone product water distribution pipeline and conveyance of residual waste to sewer and RO concentrate to JWPCP
- **Private Party:** Procurement of treatment site
- **Other Regulatory Agencies:** Other permits such as South Coast Air Quality Management District (SCAQMD), building department(s) with jurisdiction, zoning approval.

For the purposes of this analysis, it is assumed the approvals and procurements required can all be obtained and thereby not impact the feasibility of the distributed treatment approach.

The following paragraphs briefly describes each step in the overall study approach.

Figure 2-1 – Overall Study Approach

2.1 IDENTIFY AND SELECT COLLECTION SYSTEM FLOW INTERCEPTION / DIVERSION LOCATIONS

To narrow down the selection of potential wastewater flow interception / diversion locations, guidelines, requirements and preferences from LACSD were used. The two primary considerations used to select appropriate interception / diversion locations included their proximity to reuse applications and amount of wastewater that can be extracted. The determination of suitable locations in the wastewater collection system was closely coordinated with LACSD; primary criteria included:

1. Wastewater must be tributary to JWPCP – there is no excess flow available upstream of existing water reclamation plants (WRPs)

Additionally, there must be no impact to JOS collection system's functioning as a result of lower flows. Adherence to LACSD's limitations related to residual solids discharge is also required. These criteria, primarily the requirement of finding excess flows tributary to JWPCP, substantively reduced the potential locations for intercepting and diverting raw sewage to distributed treatment sites. Additional details on the methodology and corresponding results from this step are described in **Section 3**.

2.2 SITE THE DISTRIBUTED TREATMENT PLANTS

Once the interception / diversion locations were identified, suitable locations to site treatment (wastewater plus advanced water treatment) plants were determined. The guiding principles to assess the suitability of potential sites included size of available land as well as its proximity to the interception / diversion site and backbone conveyance line.

Additional details on the methodology and corresponding results from this step are described in **Section 4**.

2.3 DETERMINE CONVEYANCE COSTS / ENERGY SAVINGS

The primary benefit anticipated from the distributed treatment approach is lower energy consumption from not having to pump the treated water a longer distance. To quantify the costs / energy savings, distances between the diversion location and treatment site as well as from the treatment site to backbone conveyance line were quantified for each treatment site. The distance and elevation difference were then used to calculate the energy and cost savings; results from which are described in **Section 5**.

2.4 ASSESS DISTRIBUTED VS CENTRALIZED APPROACHES QUALITATIVELY AND QUANTITATIVELY

The qualitative comparison of distributed vs centralized treatment approach included non-monetary factors such as community impact, ability to procure, zoning, etc. To compare the approaches quantitatively, capital costs, operations and maintenance (O&M) costs and net present values were used. Results from this assessment were used to make a recommendation for the preferred approach.

3.0 IDENTIFICATION AND SELECTION OF COLLECTION SYSTEM FLOW INTERCEPTION/DIVERSION LOCATIONS

The purpose of this section is to outline the steps in identifying suitable locations within the JOS's collection network for diversion of a portion of the raw wastewater flow to be treated at a distributed treatment plant site.

3.1 LACSD'S GUIDELINES AND REQUIREMENTS

Occasionally, the LACSD are approached by parties interested in water recycling by treatment of wastewater extracted from the JOS collection system upstream of the JWPCP. The treatment plants for this purpose are referred to as "scalping plants" or "satellite plants". Over the course of time, the LACSD have developed a number of guiding principles relative to extracting and treating raw wastewater from their collection system. Diversion locations for the distributed treatment plant option should be in compliance with these guidelines, which are stipulated below:

- Conditions for the Baseline Collection System:
  - Wastewater is tributary to JWPCP or a WRP with tributary flow exceeding its treatment capacity (i.e., do not take water from any existing or planned recycled water projects)
  - No negative impact to downstream collection system as result of lower flows
- Conditions for Residual Solids Return:
  - Mass of solids in scalped sewage roughly equals mass in discharge
  - No impact to downstream sewers from solids
  - No impact to downstream wastewater plants (including JWPCP) operation from discharge
  - Only solids residual from treatment of sewage, residuals from onsite treatment of other wastewater per industrial waste (IW) permit
  - No grit/screenings should be disposed

In order to identify acceptable locations for diverting flow, information was obtained directly from the LACSD and candidate sites vetted with their staff.

3.2 DIVERSION LOCATION PREFERENCES

In the determination of candidate locations to site flow diversion facilities, there are two primary considerations that factor into the analysis:

- Proximity to reuse application
- Volume of wastewater that can be extracted or treated / product water generated

The closer the diversion structure is to the reuse application, in this case the San Gabriel Spreading Grounds (SFSG), the higher the elevation and shorter the distance to pump product water. This translates to less static head (elevation differential) and lower dynamic head (friction losses), resulting in reduced power requirements for pumping. Therefore, the greater the volume being pumped at the lower head conditions, the larger the reduction in power for conveyance overall.

3.3 IDENTIFYING POTENTIAL DIVERSION LOCATIONS

This basic analysis aimed at reducing pumping power requirements surfaces two conflicting realities. While the preference is to site diversion structures as close to the SFSG as possible, there are, however, no excess flows in the immediate proximity of the spreading basins. Flows to divert are only available closer to the JWPCP (i.e., farther from the SFSG). **Figure 3-1** shows LACSD's service area, depicting area with limited to no excess flow available (blue) and the area with potential locations where excess flow could be diverted (red hatch). The RRWP's product water backbone conveyance system's San Gabriel River alignment is also shown on the figure. The black triangles depict locations with available flows and for the most part, are within a four mile radius of the JWPCP. For perspective, the length of backbone product water conveyance system is 40 miles from the JWPCP to the SFSG. A request was made to the LACSD to identify the northern most location where flows of at least 10 mgd could be diverted to a distributed treatment plant; this location is shown in **Figure 3-1** as the northernmost black triangle.

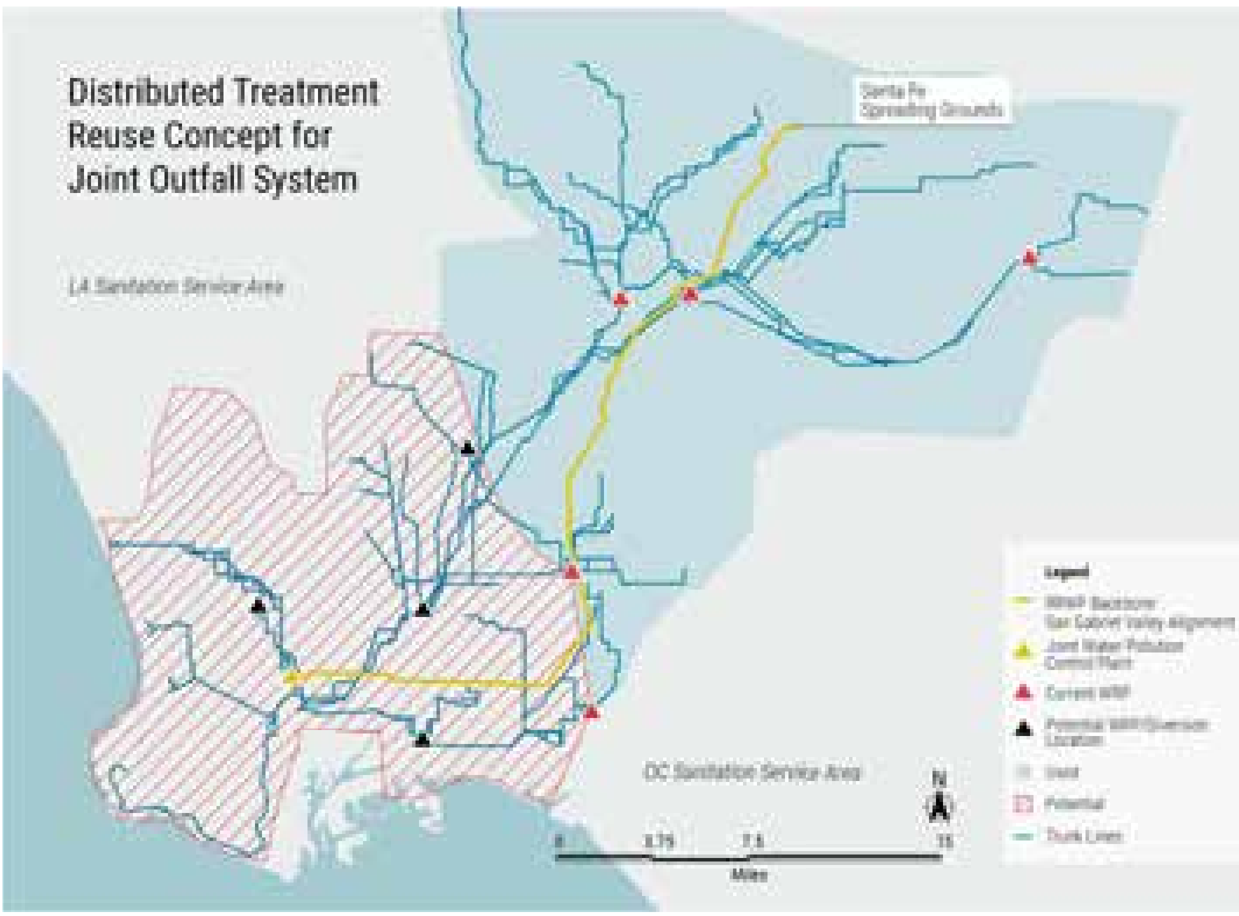

Figure 3-1 – LACSD's service area

3.4 SELECTING DIVERSION LOCATION

On the basis of the stated location preferences and actual availability of flows, two potential diversion sites were identified, which are shown in **Figure 3-2** along with the available flows at each. A third potential site was screened out due to the proximity to the JWPCP negating any real cost savings from pumping. Subsequent analysis, as described in the following section, was undertaken to locate suitable lots where the treatment plants can be sited.

Figure 3-2 – Wastewater diversion locations

4.0 TREATMENT PLANT SITING

This section outlines the methodology employed to locate and select candidate properties for siting of distributed treatment plants and summarizes the approach used to the distributed treatment plant's viability.

4.1 SITE SELECTION PROCESS

Locating and selecting suitable properties for siting distributed treatment plants involved six steps (**Figure 4-1**):

- **Step 1 – Establish Desired Perimeter from the Diversion Location and Backbone Conveyance System**: Flow must be conveyed (1) from the diversion structure to the plant and (2) from the plant to the backbone product water conveyance system; the preferred lot location is a property that minimizes the sum of these two distances, thereby minimizing conveyance costs.
- **Step 2 – Determine Lot Size Needed and Identify Potential Sites:** The size of the parcels was chosen to allow for enough area to build a treatment facility capable of processing a majority of the available flow from a diversion. With the information on size and general location, the County Assessor's property database was used to identify available sites with sufficient area. Refer to 4.4.2 for sizing of the treatment plant.
- **Step 3 - Further Investigation**: Confirmation of property attributes (**Section 4.2**) was undertaken using a variety of information sources to validate or correct records within the database.
- **Step 4 - Assess Suitability**: Potential sites were comparatively evaluated using defined attributes and ranked accordingly.
- **Step 5 - Select Sites**: Select the preferred sites.

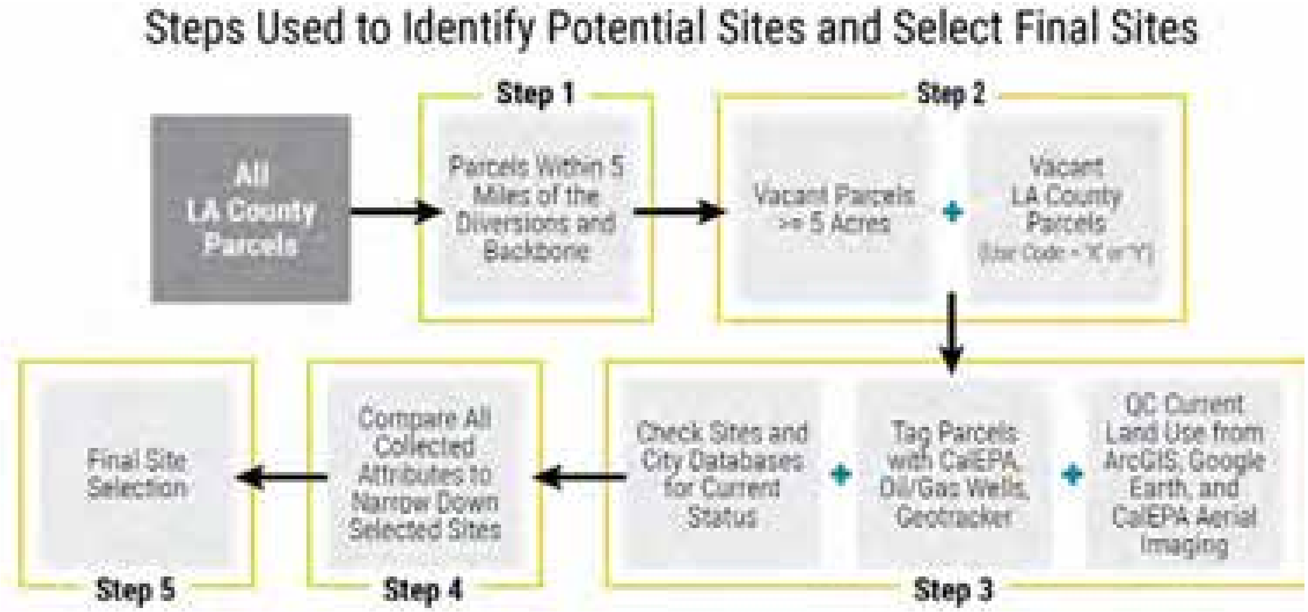

Figure 4-1 Potential site identification flowchart

4.2 PROPERTY ATTRIBUTES

The investigation of the comparative suitability of properties involves evaluating a variety of attributes associated with each parcel. General property attributes include:

- **Size**: The useable area must meet or exceed that required for the plant capacity and the geometry of the parcel must also be conducive to efficiently laying out processes and systems.
- **Availability**: The parcel is preferred to be vacant or limited current usage and listed or soon to be listed for purchase; there should be no conflicting current uses.
- **Community Impact**: There should be very limited to no displacement of commerce or people related to the treatment plant's construction and operations.
- **Ability to Procure**: The parcel should be for sale or formerly on the market for sale with no deed restrictions relative to usage.
- **Zoning**: The site must be zoned for uses compatible with treatment facilities or be eligible to change the zoning as needed.
- **Acceptability**: Relative to the neighborhood and immediate neighbors, there should be no discernable significant opposition to the siting of treatment works (e.g. proximity to schools, recreation parks). Surrounding land uses should be compatible with treatment facilities.
- **Access**: Treatment plant construction and long-term operation will require access of large vehicles/equipment/deliveries.
- **Suitability**: Among the many considerations, one of particular relevance is to locate the plant on a site that has no contamination legacy issues.

With respect to the technical aspects of a property specifically related to the treatment facilities, attributes include:

- **Proximity to Raw Wastewater Diversion**: The closer the treatment plant site is to the wastewater diversion location, the shorter the conveyance distance and associated costs.
- **Proximity to Backbone Pipeline**: The closer the treatment plant is to the backbone recycled water pipeline, the shorter the conveyance distance and associated costs.
- **Residuals**: The plant will generate three categories of residual to be disposed of: (1) screenings, (2) sludges and (3) RO concentrate. The location of the plant relative to processing and disposal of these materials will impact the site's attractiveness for use.

4.3 RESOURCES USED FOR SITE ANALYSIS

This section lists the resources used to gather information on the property attributes and the information that they provide.

- **California Environmental Protection Agency (CalEPA) Regulated Site Portal**: This is a publicly available combined database and interactive map that provides information on all environmentally regulated sites in the State of California for things such as hazardous waste, cleanup sites, and toxic releases. This also had what appeared to be the most up to date aerial imagery of the site locations, and was used to help compare to other aerial photos on current land status.
- **California Geologic Energy Management Division (CalGEM) Well Finder**: This is also a publicly available combined database and interactive map to track the locations of both active and closed oil and gas wells.
- **Los Angeles City Geohub GIS Los Angeles County Assessor Parcel Data**: This publicly available data is updated from the data provided by the LA County Assessor Database. This lists significant amounts of data from nearly 2.4 million parcels found in Los Angeles County. The relevant data used included zoning types, use codes, area, and address.
- **ESRI ArcMap (ArcGIS)**: This software was used in conjunction with the GIS from the LA County Assessor database to access the data in a usable form, but also to allow for filtering. This allowed selection of sites that met desired criteria such as all sites greater than 5 acres.
- **Google Maps and Google Earth**: These two databases were used in combination with the images from CalEPA aerial images to help narrow down the current site development and up to date land construction status. Additionally, the Google Earth terrain map layer was used for obtaining the elevation at each site.

4.4 RESULTS FROM THE SITE SELECTION PROCESS

The two diversion locations Diversion North (20 MGD available wastewater flow) and Diversion South (30 MGD available wastewater flow) are shown in **Figure 3-2**. These locations provided the basis for identifying potential properties within a reasonable proximity. The following paragraphs describe the findings from each step of the site selection process.

4.4.1 Setting the Perimeter for General Location of Treatment Sites

The initial location screening criteria were 5 mile buffers around potential wastewater sources, and the entire backbone pipeline. A distance of 5 miles was chosen to limit the total amount of pipeline that would need to be installed for these sites. This criterion narrowed the number of potential sites from over 2.5 million to about 10,500 as shown in red in **Figure 4-2**.

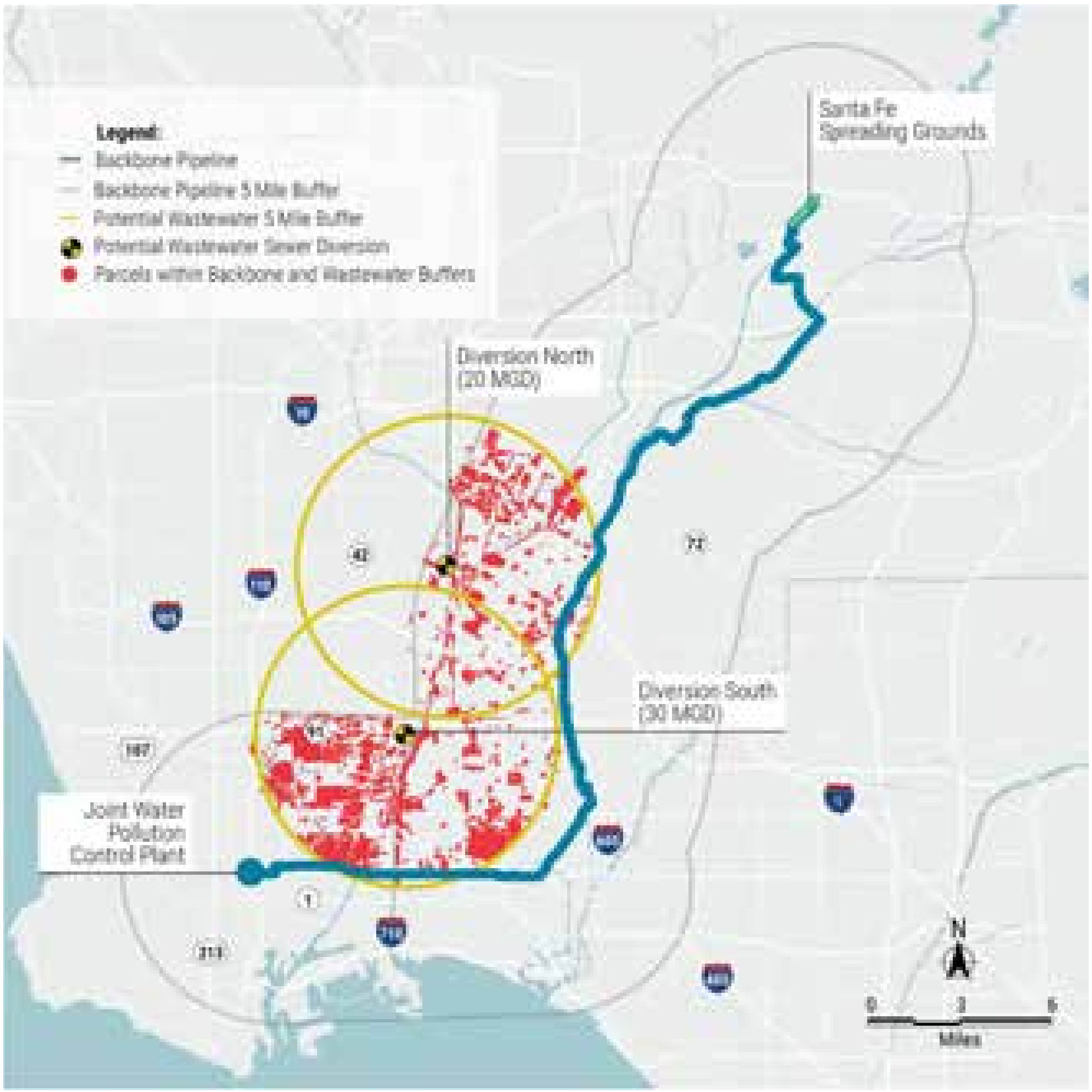

Figure 4-2 – Sites within desired perimeter

4.4.2 Calculating the Required Lot Size for Treatment Facilities

Assuming a preliminary estimate of 0.45 acres required for every million gallons per day (MGD) of treatment capacity, the minimum desired lot size was determined to be five acres. This was based on comparison to constructed or planned facilities of similar size, accounting for all treatment processes, parking lots, access roads, operation and maintenance buildings, and electrical buildings. This five acre minimum was established in order to maintain a manageable number of candidate sites examined within the context of a reasonable minimum sized treatment facility, in this case 10 mgd. Although the initial estimates for available diversion capacities were at 20 MGD and 30 MGD (requiring 9 and 13.5 acres respectively), this smaller sizing of 5 acres allowed for identifying smaller sites that would be able to process a minimum of 10 MGD in the case that larger sites are not feasible or preferred due to other factors.

Within the 0.45 acres per mgd footpint are screening (coarse and fine) facilities, MBR (secondary and pre-RO treatment), UV-AOP and product water conditioning. Basically, the processes and support infrastructure to achieve an IPR level of treatment. Space is also allocated for operations/control and maintenance buildings. Facilities for DPR levels of treatment (O_3-BAC-MF) were not provided for in the area allocations.

Space was not specifically set aside for plant expansion. The capacity is limited by the available flow within the collection system and is not expected to increase to any significant degree. Conservation could reduce available flows. Also, considering the nature of this study (conceptual), the availability of support utilities, specifically electric power, was not assessed. If the determination is made as to the initial feasibility of the distributed/decentralized approach to treatment, further in-depth analysis would be warranted.

4.4.3 Identifying Vacant Lots

Using categories available in the GIS parcel database from the Los Angeles County Assessor website, site use codes designating sites that were vacant (code V) or had only minor development (code X) were chosen for the next filter. These site use codes were combined with the five acre sizing criterion to further narrow down potential sites to 166, shown as dark yellow in **Figure 4-3**.

Figure 4-3 – Sites selected by size and site use codes

4.4.4 Further Investigations

The next step in filtering was the use of aerial photography to verify whether sites had large amounts of development or were actually undeveloped/vacant. Photos from Google Earth, CalEPA, and Google Maps were compared and any sites that showed extensive development or active construction on the site, or were part of a school or park, were removed from the list of potential sites. Further verification included reviewing the parcel status from different databases, looking at street views from Google Earth and Maps, and contacting the city planning departments to verify whether sites were still vacant, or had any current permitted construction or modification. A few of these sites were visited to confirm vacancy and this further narrowed the sites down to 17 as shown in green in **Figure 4-4**.

Figure 4-4 – Sites selected based on further investigations

4.4.5 Assessing Suitability and Selecting Final Sites

The suitability of the shortlisted sites for a treatment plant was assessed by using criteria including elevation, distances (to JWPCP, closest diversion, and backbone), area, level of development and current listed status. Records from CalEPA and CALGEM were also used to track any hazardous waste, cleanup sites, toxic release, presence of oil or water wells and the previous status of the land (such as a previous landfill, recycling facility, or a superfund site). These investigations narrowed down the final number of potential sites to three as shown in red stars on **Figure 4-5**.

The aerial photos of the three final sites are shown in **Figure 4-6** and the characteristics of all three candidate sites are shown in **Table 4-1**. With respect to Site 2 Commerce East, the primary limitations are that the size is slightly smaller than needed to use the full amount of water from the wastewater diversion, and that the land is owned by the cemetery directly adjacent to the property. With respect to Site 3 Long Beach, a significant drawback is that the site is at a lower elevation than the JWPCP, adding more than 100 ft of pumping head when compared with the other two sites.

Figure 4-5 – Final three sites selected for detailed evaluation

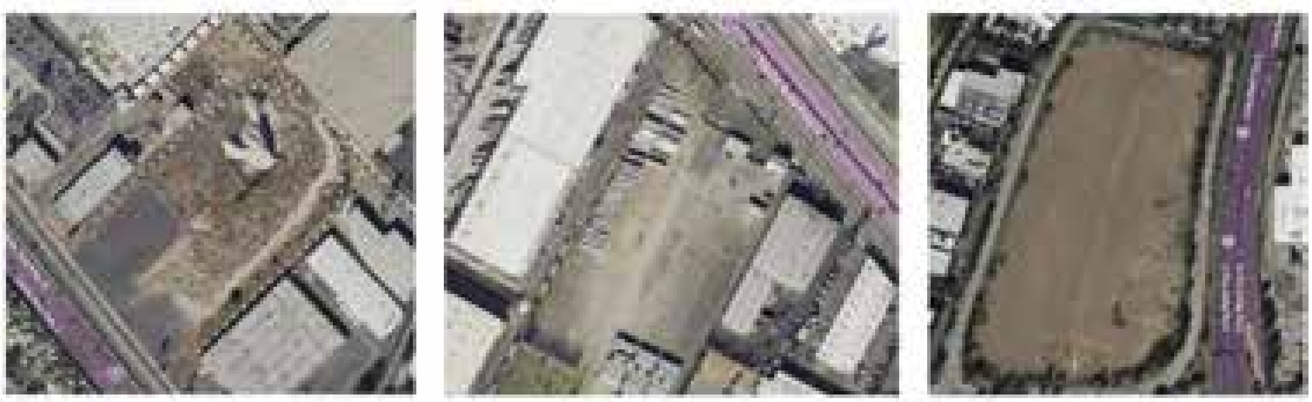

Figure 4-6 – Aerial photos of the final three sites 1, 2 and 3 shown in sequence

Table 4-1 – Properties of final three candidate sites

	Diversion North Candidate Site 1 Commerce West	Diversion North Candidate Site 2 Commerce East	Diversion South - Candidate Site 3 Long Beach
Location	Commerce, CA	Commerce, CA	Long Beach, CA
Area (acres)	14.39	5.03	24.95
Current Status	Partially Paved	Paved with a small trailer building	No Development
Closest Diversion	Diversion North	Diversion North	Diversion South
Distances (miles) a. From Diversion b. To Pipeline c. Total	a. 5.78 b. 4.22 c. 10.00	a. 4.22 b. 3.00 c. 7.22	a. 2.10 b. 2.12 c. 4.22
Elevation	150 ft	156 ft	30 ft
List other info	Listed as a Leaky Underground Storage Tank cleanup site by CalEPA	Owned by cemetery adjacent to the property. Unclear if they will have any objections to building at this location.	Technically multiple parcels on the same plot of land. Elevation lower than JWPCP

5.0 CONVEYANCE FACILITIES

In addition to the treatment plant, the distributed treatment approach also requires three sets of conveyance facilities for each plant; these facilities are:

- **Raw Wastewater**: Convey raw wastewater from the diversion point to the plant
- **Product Water**: Convey treated potable recycle water from the plant to the backbone recycled water distribution pipeline
- **RO Concentrate**: Convey RO concentrate from the treatment plant to JWPCP

The purpose of this section is to describe the conveyance systems for each of the identified diversions and corresponding treatment plant site. **Figure 5-1** shows a schematic of the proposed pumping and conveyance components included in this analysis.

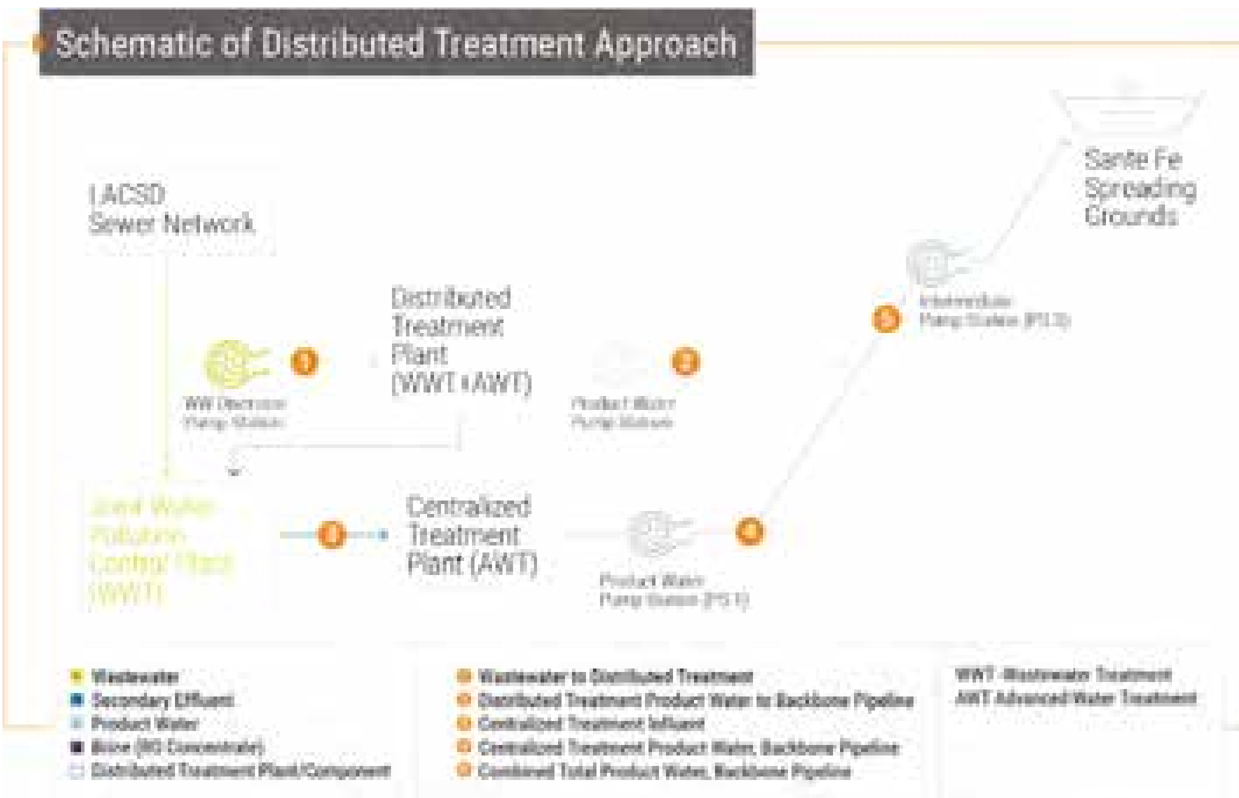

Figure 5-1 – Distributed treatment approach schematic

5.1 COMPONENTS

The existing wastewater collection system for the JOS does not have flexibility to allow for any significant adjustments to the diversion locations, or the maximum amount of wastewater intercepted at each identified diversion. Similarly, the product water backbone conveyance system alignment between the JWPCP and the SFSG is fixed. Therefore, the recycled water produced at the distributed treatment plants must be conveyed to the backbone system using the lowest cost alignment. For the purposes of this study, the San Gabriel River alignment and associated pump stations were used to define the backbone system as described in the Regional Recycled Water Program Backbone Conveyance System Feasibility Level Design Report (RRWP Backbone Conveyance Report, Black and Veatch and CDM Smith, 2020).

The one component of the system, that has a degree of flexibility, is the location of the treatment plant. The process for siting the plant is described in the previous section. Once the treatment plant location is identified, the pumping and conveyance facilities are defined. For each of the three candidate treatment plant sites, the associated pumping and conveyance facilities are described in the following sections.

5.2 SIZING ASSUMPTIONS

The following assumptions apply to the sizing of pumping and conveyance components for all alternatives. Additional information is provided in the calculations in **Appendix A**.

- Flow rate assumptions: WAS = 3% of influent, RO Recovery = 85% of RO Feed
- Wastewater conveyance velocity range of 2.5 to 6 ft/s
- Centralized facility only option, which has 150 MGD in the backbone pipeline sized at 6 ft/s. This study keeps product water conveyance pipelines sized for 6 ft/s or less. Conveyance Backbone Report (Black and Veatch and CDM Smith, 2020)
- ROconcentrate conveyance velocity target of 2 to 6 ft/s. RO concentrate pipelines were sized in order to allow flow by gravity to avoid pumping energy costs, where possible.
- Product water discharge elevation at distributed treatment facilities is estimated to be 25 feet above grade assuming treatment facilities are constructed above grade
- Pumping power calculation assumed 75% overall efficiency (pump and motor) for product water and concentrate, and 70% for wastewater
- Static lift is based on approximate elevations. Pipeline elevation profiles were investigated and high points were not present in the alignments of more than 5 feet from the uphill end point and therefore, were not part of this analysis. Product water pump station assumes the static lift is to an intermediate pump station based on RRWP Conveyance Backbone Report (Black and Veatch and CDM Smith, 2020) to compare pump station size and account for centralized facility pump station savings.
- The cost of concentrate management could be reduced if a regional concentrate line is constructed along the same alignment as the backbone conveyance system.

5.3 SITE 1 PUMPING AND CONVEYANCE

The three locations that define the required conveyance facilities for treatment Site 1 Commerce West are:

- **Diversion Location**: Exact address unclear, closest address is 5114 Firestone Blvd, Commerce CA. GPS coordinates used are 33°56'58.49"N, 118°10'40.17"W
- **Treatment Plant Location**: 5933 TELEGRAPH RD E COMMERCE CA , GPS Coordinates 33°58'56.55"N, 118° 8'2.85"W
- **Connection to Backbone Conveyance Pipeline**: 81140 Slauson Ave, GPS coordinates 33°58'0.09"N, 118° 5'23.44"W

Figure 5-2 shows the potential alignment of the raw wastewater and finished product water pipelines for Site 1.

Table 5-1 provides a summary of design criteria for this system.

Figure 5-2 – Site 1 and associated conveyance lines

Table 5-1 – Site 1 conveyance design criteria

Parameter	Unit	Value
Conveyance of Raw Wastewater to Distributed Treatment Site		
Flow Rate	mgd	20
Total Dynamic Head	ft	125
Pumping Power, Duty	hp	622
Pipeline Diameter	in	36
Velocity, Approximate	ft/s	4.4
Pipeline Length	mi	5.8
Conveyance of Product Water to Backbone Pipeline		
Flow Rate	mgd	16.4
Total Dynamic Head	ft	201
Pumping Power, Duty	hp	770
Pipeline Diameter	in	30
Velocity, Approximate	ft/s	5.2
Pipeline Length	mi	4.53
Conveyance of RO Concentrate to JWPCP		
Flow Rate	mgd	3
Pipeline Diameter	in	20
Velocity, Approximate	ft/s	2.1
Pipeline Length	mi	19.7

5.4 SITE 2 PUMPING AND CONVEYANCE

The three locations that define the required conveyance facilities for Site 2 Commerce East are:

- **Diversion Location**: Exact address unclear, closest address is 5114 Firestone Blvd, Commerce CA. GPS coordinates used are 33°56'58.49"N, 118°10'40.17"W
- **Treatment Plant Location**: *6608 EAST 26TH STREET. COMMERCE, CA , GPS Coordinates 33°58'56.55"N, 118° 8'2.85"W*
- **Connection to Backbone Conveyance Pipeline**: 81140 Slauson Ave, GPS coordinates 33°58'0.09"N, 118° 5'23.44"W

Figure 5-3 shows the potential alignment of the raw wastewater and finished product water pipelines for Site 2.

Table 5-2 provides a summary of design criteria for this system.

Figure 5-3 – Site 2 and associated conveyance lines

Table 5-2 – Site 2 conveyance design criteria

Parameter	Unit	Value
Conveyance of Raw Wastewater to Distributed Treatment Site		
Flow Rate	mgd	13
Total Dynamic Head	ft	121
Pumping Power, Duty	hp	392
Pipeline Diameter	in	30
Velocity, Approximate	ft/s	4.1
Pipeline Length	mi	4.2
Conveyance of Product Water to Backbone Pipeline		
Flow Rate	mgd	10.7
Total Dynamic Head	ft	187
Pumping Power, Duty	hp	467
Pipeline Diameter	in	24
Velocity, Approximate	ft/s	5.3
Pipeline Length	mi	3
Conveyance of RO Concentrate to JWPCP		
Flow Rate	mgd	1.95
Pipeline Diameter	in	16
Velocity, Approximate	ft/s	2.2
Pipeline Length	mi	19.9

5.5 SITE 3 PUMPING AND CONVEYANCE

The three locations that define the required conveyance facilities for Site 3 Long Beach are:

- **Diversion Location**: Closest address 5759 Long Beach Blvd, GPS Coordinates 33°51'36.70"N, 118°11'58.42"W
- **Treatment Plant Location**: Closest address 4001 Via Oro Ave, GPS Coordinates 33°50'0.56"N, 118°12'38.38"W
- **Connection to Backbone Conveyance Pipeline**: Closest address W Willow St and the 710 Freeway , GPS coordinates 33°48'15.21"N, 118°12'27.21"W

Figure 5-4 shows the potential alignment of the raw wastewater and finished product water pipelines for Site 3.

Table 5-3 provides a summary of design criteria for this system. Since this site is at a lower elevation than JWPCP, a RO concentrate pump station is required.

Figure 5-4 – Site 3 and associated conveyance lines

Table 5-3 – Site 3 conveyance design criteria

Parameter	Unit	Value
Conveyance of Raw Wastewater to Distributed Treatment Site		
Flow Rate	mgd	30
Total Dynamic Head	ft	19
Pumping Power, Duty	hp	142
Pipeline Diameter	in	42
Velocity, Approximate	ft/s	4.8
Pipeline Length	mi	2.1
Conveyance of Product Water to Backbone Pipeline		
Flow Rate	mgd	24.6
Total Dynamic Head	ft	358
Pumping Power, Duty	hp	2061
Pipeline Diameter	in	36
Velocity, Approximate	ft/s	5.4
Pipeline Length	mi	2.12
Conveyance of RO Concentrate to JWPCP		
Flow Rate	mgd	4.5
Total Dynamic Head	ft	52
Pumping Power, Duty	hp	55
Pipeline Diameter	in	22
Velocity, Approximate	ft/s	2.6
Pipeline Length	mi	6.48

5.6 CENTRALIZED AWT FACILITY REDUCED PUMPING AND CONVEYANCE

Flows diverted to distributed treatment plants would result in reduced treatment capacity required at the centralized AWT facility. The reduction in energy for the pumping from the centralized AWT facility is based on the following factors:

- Reduced product water flow rate from the centralized AWT facility
- Reduced friction losses in the backbone system from the centralized AWT facility to the point of connection with the product water from the distributed AWT facility

The reduction in size of the product water backbone pipeline was based on the following criteria:

- If the velocity reduction in the pipeline allowed for the reduction of the pipeline diameter to a standard size and still maintained the design criteria of velocity less than 6 ft/s, the pipeline size was reduced
- If reduced, the length of the reduced pipeline was for the segment of backbone pipeline from the JWPCP to the point of connection with distributed treatment product water downstream of which the pipeline is conveying the combined 150 mgd flow rate

Table 5-4 provides a summary of design criteria for the centralized facility reduced pumping and conveyance in comparison to the project alternative of centralized treatment only. The design criteria from the RRWP Conveyance Backbone Report was used as the basis for the centralized treatment facilities. As defined in the RRWP Conveyance Backbone Report, the product water pump station at the centralized facility is referred to as Pump Station 1 (PS-1) and it pumps to an intermediate Pump Station 3 (PS-3), which then pumps to the SFGR (Black and Veatch and CDM Smith, 2020). The total discharge head (TDH) requirements are all based on pumping from PS-1 to PS-3 in order to allow for comparison to the centralized treatment only option.

Table 5-4 – Centralized facility conveyance design criteria

Parameter	Unit	Centralized Treatment Only	Diversion North Site 1 Commerce West	Diversion North Site 2 Commerce East	Diversion South Site 3 Long Beach
Conveyance of Product Water from Centralized Treatment					
Flow Rate	mgd	150	133.6	139.3	125.4
Total Dynamic Head	ft	352	330	337	353
Total Dynamic Head, Difference from Original	ft	-	-22	-15	+1
Pumping Power, Duty	hp	12350	10,325	11,000	10,370
Pumping Power, Duty, Difference from Original	hp	-	-2,020	-1,340	-1,980
Pipeline Diameter	in	84	84	84	78
Velocity, Approximate	ft/s	6.0	5.4	5.6	5.9
Pipeline Length, Smaller Diameter Segment	mi	-	not applicable	not applicable	6.5

5.7 PUMPING ENERGY SAVINGS

For each candidate site alternative, there is a savings of pumping energy due to the reduced centralized pump station and an addition of pumping energy due to the required conveyance of wastewater and product to and from the distributed treatment plant sites. **Table 5-5** shows a summary of the net energy savings for each candidate site alternative. The calculations assume a 97% online factor when calculating the approximate energy use in kilowatt-hours per year (kWh/yr).

Table 5-5 – Net energy savings for each candidate site

Parameter	Unit	Diversion North Site 1 Commerce West	Diversion North Site 2 Commerce East	Diversion South Site 3 Long Beach
Wastewater Diversion Pump Station	kWh/yr	3,680,000	2,320,000	840,000
Distributed Treatment Pump Station	kWh/yr	4,870,000	2,170,000	13,050,000
RO Concentrate Pump Station	kWh/yr	-	-	350,000
Centralized Treatment Product Water Pump Station				
without Distributed Treatment	kWh/yr	78,250,000	78,250,000	78,250,000
with Distributed Treatment	kWh/yr	65,450,000	69,770,000	65,720,000
Savings	kWh/yr	-12,800,000	-8,480,000	-12,530,000
Net Pumping Energy Savings	kWh/yr	-3,980,000	-3,040,000	1,780,000
Total Pumping Energy, Product Water Conveyance for Centralized Only Option[1]	kWh/yr	156,520,000	156,520,000	156,520,000
Total Net Pumping Energy Use, Increase (+), Savings (-)	%	-2.5%	-1.9%	+1.1%

Table footnotes:

1. Estimated from RRWP Backbone Conveyance Report using 150 mgd, 704 feet TDH, 75% efficiency, 97% online factor (Black and Veatch and CDM Smith, 2020)

6.0 EVALUATION OF DISTRIBUTED AND CENTRALIZED TREATMENT APPROACHES

Distributed and centralized treatment approaches were evaluated for qualitatively (non-monetary factors) and quantitatively (monetary factors) as described in the following paragraphs.

6.1 QUALITATIVE ANALYSIS

Qualitative evaluation of the alternatives was conducted for two categories – (1) the assessment of a distributed treatment approach compared to a centralized-only treatment approach and (2) the comparison of the candidate sites.

6.1.1 Distributed vs Centralized Treatment Assessment

The primary qualitative difference between centralized treatment and distributed treatment approaches lies in the difference between a single site with consolidated infrastructure and multiple sites with distributed infrastructure.

Reliability: The advantage of multiple, distributed facilities is increasing product water reliability by introducing redundancy to the system as a whole; for example, if major maintenance or disruption occurs at one facility the entire system recycled water production is not lost but only reduced. However, the feasible options of distributed treatment considered in this study are limited to a maximum production between 7 and 16% of the total system capacity and therefore the benefit of redundancy is not significant. Additionally, municipal facilities are built with redundancy designed into the facility itself on a process-by-process and equipment-by-equipment basis, significantly reducing the likelihood of major failure or loss of the entire facility's production capabilities. Electrical power failure is one conceivable means of entire facility failure; however, the closer the distributed facilities are to one another increases the likelihood they rely on the same or similar power grids and it is possible that power failure could simultaneously occur for multiple facilities.

Additionally, loss of a major conveyance pipeline is another conceivable means of loss of production capacity, though the benefit of multiple facilities and their production pipelines is limited by how near they are to one another since a failure could occur in the pipeline downstream of where the two combine. Nevertheless, there are some advantages of redundancy to distributed treatment facilities, though it would be greater if the facilities could be further apart and larger size than this study has concluded is feasible.

Operational Efficiency: The disadvantage of multiple, distributed facilities is the additional infrastructure to operate and maintain. Having multiple facilities introduces inefficiencies that lead to the need for additional staffing. The additional facilities that are introduced by multiple treatment plants include the need for either two laboratories or transportation of water samples from one site to the central laboratory, two treatment facilities and associated buildings, and new addition distributed assets of wastewater pump stations and wastewater, product water, and RO concentrate conveyance lines. All of these additional assets and multiple facilities introduce increased resource requirements on the part of Metropolitan and/or LACSD to operate and maintain, and to manage the associated staff and coordination of operations.

Summary: In conclusion, assessing the qualitative aspects of these alternatives, the centralized treatment approach appears to be more advantageous since the potential benefits of distributed treatment are limited due to the location (facilities are near to each other), size (small relative to total production capacity), and the need in this case for additional assets outside of just the treatment facility (pump stations, pipelines) that require operation, maintenance, and management.

6.1.2 Candidate Site Assessment

Once the potential distributed treatment plant sites were narrowed down to three, these sites were compared to one another using the qualitative attributes listed in **Section 4.2**. Inasmuch as the goal of this study was to assess the relative feasibility of distributed treatment as compared to centralized and did not include the selection of a specific site, the analysis of candidate distributed treatment sites used a strictly qualitative assessment approach. This information is summarized and compared side by side below in **Table 6-1**.

Table 6-1 – Candidate qualitative site attributes

Attributes	Diversion North Candidate Site 1 Commerce West	Diversion North Candidate Site 2 Commerce East	Diversion South Candidate Site 3 Long Beach
Size	Not the largest site, but sufficient size for available diversion flow	Smallest site, limits plant capacity	Largest site, most available land
Availability	Very Minor Development. Unclear if the site is for sale.	Very Minor Development. Unclear if the site is for sale.	Vacant, no development, and for sale
Community Impact	Surrounded by industrial area. Unlikely to displace any commerce or people.	Surrounded by industrial area. Unlikely to displace people, though commerce may be displaced.	Surrounded by industrial area. Unlikely to displace any commerce or people.
Ability to Procure	Not listed on the market, though appears there is nothing there.	Not on the market, and currently a truck trailer business on site.	For sale and no evident restrictions.
Zoning	Zoned for industrial	Zoned for industrial	Zoned for industrial
Acceptability	Unlikely to have any significant opposition from neighbors.	May have opposition from the adjacent cemetery who also owns the property.	Unlikely to have any significant opposition from neighbors.
Access	Easily accessible to even large vehicles.	Easily accessible to even large vehicles.	Easily accessible to even large vehicles.
Suitability	Previous site of Leaky Underground Storage Tank Cleanup.	No environmental or hazardous waste information on site.	No environmental or hazardous waste information on site.
Proximity to Nearest Diversion	5.78 Miles	4.22 Miles	2.10 Miles
Proximity to Backbone Pipeline	4.53 Miles	3.00 Miles	2.12 Miles

6.2 QUANTITATIVE ANALYSIS

A comprehensive cost evaluation was undertaken for this analysis to compare the economics of distributed and centralized treatment approaches. Class 5 estimates were developed given the degree of definition for the project alternatives. Assumptions that have been made are described herein. Where possible, assumptions, cost estimates, and unit costs have been derived from the most recent studies by Metropolitan and LACSD related to the RRWP to provide consistency and accuracy.

6.2.1 Capital Costs

The estimates were prepared in accordance with the criteria established by the Association for the Advancement of Cost Engineering International (AACEI) for a Class 5 cost estimate and include an additional project markup for engineering and administration (25% or 30%) as well as project contingency (35%) consistent with recent studies for the RRWP. According to AACEI, Class 5 estimates are "prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc." Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination". The basis for the capital cost estimation is further discussed by cost component. All costs were compared on the basis of an estimate for 2021 dollars.

Land Acquisition – A market analysis (**Appendix B**) was completed and costs of properties were estimated for each candidate site based on recent comparable pricing.

Distributed Treatment Facility – Facility costs are based on two major reference sources:

1. Influent coarse and fine screening: Reference facility construction cost, escalated to 2021 dollars, scaled for distributed treatment flow rate with economy of scale formula described below, plus engineering, admin, and project contingency consistent with JTAP estimates.
2. AWT facility: Cost estimate for RRWP using the JTAP Train 3 report (Jacobs, 2021a), scaled by a power factor of 0.75 based on comparison to similar facility estimates for unit process costs and found to be within 10-20%.

Influent coarse and fine screening includes duty and standby redundant screens located inside a building with odor control; there are no primary clarifiers. AWT facility cost includes greenfield secondary MBR (sMBR), reverse osmosis (RO), ultraviolet advanced oxidation process (UV-AOP), and associated facilities for a fully operational treatment plant. See **Appendix C** for process flow diagram. The formula used for scaling facility costs is the following, and is used industry-wide to account for an economy of scale for construction of industrial-type equipment and facilities (Dysert, 2003):

$\$B = \$A * (\text{Capacity B} / \text{Capacity A})^{e}$, where:

$B = cost of construction for Project B, unknown
$A = cost of construction for Project A, known
Capacity B = capacity of Project B (in our case, flow rate of facility in mgd)
Capacity A = capacity of Project A (in our case, flow rate of facility in mgd)
e = power factor exponent (in our case, 0.75 based on comparison to other facility costs)

Centralized Treatment Facility – The cost of the centralized treatment facility was based on the JWPCP Technical Analysis Project (JTAP) nitrifying-denitrifying Tertiary MBR (NdN tMBR) Train 1E

(Jacobs, 2021b). A process flow diagram is included in **Appendix C** for reference. This train is one of the lowest net present value cost options being considered for the centralized treatment facility therefore providing the distributed treatment alternatives a more favorable comparison. The reduction in the facility cost was calculated using the same power factor of 0.75 as was used to scale the distributed facility cost since this was found to be within 10-20% cost range of other similar facility unit process costs when scaled down.

Conveyance Pipelines – A unit cost of dollars per inch diameter per linear foot ($/in-dia/ft) was calculated from RRWP Backbone Conveyance Report; with 25% adder for engineering, construction management, and engineering services during construction, and 35% adder for contingency, and escalated to 2021 dollars. An adjusted unit cost was estimated based on similar project experience for a reduced cost of constructing pipelines of smaller diameter.

Pump Stations – For all pump stations, a unit cost of dollars per pumping power was calculated from RRWP Backbone Conveyance Report. The derived pumping cost was then increased by using a 25% adder for engineering, construction management, and engineering services during construction, and a 35% adder for contingency; the dollar amount was then escalated to 2021 dollars.

The following cost components are included as denoted compared to the centralized treatment only option:

- New costs:
    - Land acquisition
    - Distributed treatment facility
    - Wastewater pump station for pumping from the sewer diversion to distributed treatment site
    - Product water pump station for pumping from the distributed treatment facility to the backbone pipeline
    - Product water conveyance pipeline from distributed treatment facility to the backbone conveyance pipeline
    - Wastewater conveyance pipeline from the sewer diversion to AWT
    - RO concentrate conveyance pipeline from distributed treatment site to the JWPCP
    - RO concentrate pump station for pumping from distributed treatment site to the JWPCP (if required)
- Cost reductions:
    - Centralized treatment facility decreased capacity/cost
    - Product water pump station decreased pumping cost from the centralized site
    - Product water conveyance pipeline reduction in size, if applicable, from the centralized site to the point of connection with distributed treatment product water

A summary of the capital cost analysis is presented in **Table 6-2**.

Table 6-2 – Capital cost summary

Facility/Component	Distributed AWT Alternatives (Distributed AWT + Reduced-Size Centralized Facility)			Centralized AWT Project
	Diversion North Site 1 Commerce West	*Diversion North Site 2 Commerce East*	*Diversion South Site 3 Long Beach*	
Treatment Plant Product Flow	**16.4**	**10.66**	**24.6**	**150**
Distributed Treatment Facility Capital Costs				
Land Cost	$26,330,000	$9,610,000	$45,350,000	
Treatment Facility Cost	$500,900,000	$362,600,000	$678,800,000	$1,871,000,000
Subtotal - Treatment Facility Land and Construction	**$527,200,000**	**$372,200,000**	**$724,100,000**	**$1,871,000,000**
Treatment Facility Capital Cost per gpd	$32.1	$34.9	$29.4	$12.5
Conveyance and Pumping - Distributed Treatment New Components				
Raw Wastewater Conveyance Cost	$66,740,000	$40,610,000	$28,290,000	
Raw Wastewater Pump Station Cost	$4,860,000	$3,060,000	$1,110,000	
Product Water Conveyance (to Backbone)	$43,590,000	$23,090,000	$24,480,000	
RO Concentrate Line Conveyance Cost (to JWPCP)	$126,380,000	$102,130,000	$45,730,000	
RO Concentrate Line Pump Station Cost	$0	$0	$450,000	
Subtotal Conveyance and Pumping - New Components	**$242,100,000**	**$169,200,000**	**$100,160,000**	
Conveyance/Pumping Cost per gpd	**14.8**	**15.9**	**4.1**	**N/A**
Total Distributed Treatment Capital Costs				
Total Capital Cost (Treatment + Conveyance/Pumping)	**$769,000,000**	**$541,000,000**	**$824,000,000**	**$1,871,000,000**
Unit Cost – Treatment Facility/Conveyance Cost per gpd	**$46.9**	**$50.8**	**$33.5**	**$12.5**
Cost Reductions to Centralized Facility w/ Distributed Approach				
Treatment Facility Capital Cost Reduction	**-$199,000,000**	**-$129,000,000**	**-$301,000,000**	
Conveyance/Pumping - Product Water Reductions				
• Product Water PS Cost at Distributed - Increase	$6,350,000	$3,850,000	$16,990,000	
• Product Water PS Cost at Centralized-Reduction	-$15,490,000	-$25,410,000	-$15,190,000	
Product Water Conveyance Pipeline Savings (Backbone)	$0	$0	-$16,920,000	
Subtotal Product Water Conveyance and Pumping Reduction	**-$9,140,000**	**-$21,560,000**	**-$15,130,000**	
Total Capital Cost Reduction to Centralized Facility (Trt + Convey)	**-$208,140,000**	**-$150,560,000**	**-$316,130,000**	
Net Increase to Capital Cost (cost increases minus reductions)	**$561,000,000**	**$390,000,000**	**$5088,000,000**	
Net Increase as a % of Centralized AWT Cost	**30%**	**21%**	**27%**	
Distributed Product Water Flow as a % of Centralized AWT Flow	**11%**	**7%**	**16%**	

6.3 OPERATION AND MAINTENANCE COSTS

The main components of the O&M costs that differ for the distributed approach from the centralized treatment approach include the following:

- Operation and maintenance of coarse and fine screens at distributed treatment
- Washing, compacting, and disposal of coarse screenings at distributed treatment
- Additional labor for distributed treatment
- Reduced labor for centralized treatment
- Pumping energy – wastewater diversion to distributed treatment
- Pumping energy – product water from distributed treatment
- Pumping energy – reduced product water from centralized treatment

To provide an equivalent comparison between the cost to produce water from the centralized treatment facility and the cost to produce water from a decentralized treatment facility, accounting for economic impact of the O&M costs is required. The O&M cost basis and criteria used in the cost analysis are described in the following paragraphs. Where possible, unit costs and assumptions used are the same as recent studies for the RRWP.

Treatment Facility O&M – The annual O&M cost for various treatment trains was developed recently within the JTAP reports prepared in conjunction with LACSD and which also used information from previous Stantec/Metropolitan studies. For the distributed treatment facility, the greenfield sMBR Train 3 O&M costs from JTAP were used and scaled linearly based on flow rate of the facility (Jacobs, 2021a). For the centralized treatment facility, the tMBR Train 1E O&M costs were used and scaled linearly based on flow rate of the facility (Jacobs, 2021a). Linear scaling was used since most of the components of the O&M cost analysis scale based on production (e.g. energy, chemical usage, maintenance of equipment), with the one exception, labor, which is discussed as follows.

Labor Costs – The base labor costs are included in the treatment facility O&M described above. However, there is additional labor that will be needed for operation of two facilities compared to one. In order to account for this difference, it is assumed that the O&M staff will not be shared between facilities. An additional six full-time staff was assumed to be needed for a second distributed treatment facility, regardless of the size, to account for a plant operations manager, plant maintenance manager, a chief operator, two lead operation shift supervisors. In addition, staffing was estimated to include approximately two instrumentation and electrical technicians, and six operators/maintenance technicians for the first 15 mgd, and one instrumentation and electrical technician, and four operators/maintenance technicians per additional 15 mgd of capacity. Staffing of Orange County Water District's GWRS was reviewed as part of this process and as a reference for these assumptions. A labor cost of $150/hour, 2,080 hours per year per full time equivalent was used.

Energy – Energy costs associated with the treatment facilities are captured within the treatment facility O&M described above. The pumping energy due to conveyance of wastewater and product water are where the main differences are for these alternatives and these are enumerated for each component of these alternatives. A summary of pumping energy use and savings was presented in the previous section. The unit cost of electricity used was $0.15/kWh, and an online factor of 97% was used to calculate energy costs.

Maintenance of Pipeline and Pump Stations – The annual cost of maintaining these additional facilities is included at a rate of 0.5% of the capital costs per year.

Table 6-3 presents a summary of the O&M cost analysis.

Table 6-3 – O&M cost summary

Facility/Component	Unit	Distributed AWT Alternatives (Distributed AWT + Reduced-Size Centralized Facility)			Centralized AWT Project
		Diversion North Site 1 Commerce West	Diversion North Site 2 Commerce East	Diversion South Site 3 Long Beach	
Conveyance and Pumping Costs/Conveyance Savings					
Pumping Energy Cost (Increases/Reductions)					
WW Diversion Lift Station (Increase)	$/year	$590,000	$370,000	$140,000	
RO Concentrate Pump Station (Increase)		$0	$0	$50,000	
Product Water Pumping from Distributed AWT (Increase)	$/year	$730,000	$440,000	$1,960,000	
Product Water Pumping from Centralized AWT (Reduction)	$/year	-$1,920,000	-$1,270,000	-$1,880,000	
Subtotal – Annual Net Energy Cost (Increase/Reduction)	$/year	-$600,000 (Reduction)	-$460,000 (Reduction)	$270,000 (Increase)	
Annual Pumping Energy Use (Increase/Reduction)	kWh/yr	-3,980,000 (Reduction)	-3,040,000 (Reduction)	1,780,000 (Increase)	156,520,000 (Baseline)
Percent of Product Water Pumping for Centralized Project	%	-2.5%	-1.9%	1.1%	
Annual Maintenance Cost Increase	$/year	$230,000	$40,000	$60,000	
Subtotal – Conveyance/Pumping Annual O&M Cost Adjustment	**$/year**	**-$370,000** (Reduction)	**-$410,000** (Reduction)	**+$330,000** **(**Increase**)**	
Treatment Facility O&M Costs Increases					
WW Treatment at Distributed AWT (Energy, Labor, Maintenance)	$/year	$270,000	$180,000	$410,000	
SMBR train at Distributed AWT (Energy, Labor, Maintenance)	$/year	$11,040,000	$7,180,000	$16,560,000	
Centralized AWT - Adjusted (Energy, Labor, Maintenance)	$/year	$96,190,000	$100,320,000	$90,290,000	
Additional Net Labor Cost for Distributed Treatment	$/year	$2,810,000	$2,810,000	$2,810,000	
Total Scenario O&M: Centralized + Distributed Treatment	$/year	$110,310,000	$110,490,000	$110,070,000	$108,000,000
Subtotal - Treatment O&M Cost Increase	**$/year**	**$2,310,000**	**$2,490,000**	**$2,070,000**	
Total O&M Net Cost Increase (Conveyance/Pumping + Treatment)	**$/year**	**$1,940,000**	**$2,080,000**	**$2,400,000**	

6.4 NET PRESENT VALUE AND UNIT COSTS

Net present value estimates are presented in **Table 6-4**. The net present values were then divided by the product water flow rate associated with the subject facility to obtain a unit cost of water. The assumptions that define estimates are the following:

- Discount rate of 5%
- Time period of 20 years
- Capital cost is treated as a year zero present value cost and is not annualized

Table 6-4 – Net present value cost summary

Facility/Component	Unit	Distributed AWT Alternatives: Diversion North Site 1 Commerce West	Diversion North Site 2 Commerce East	Diversion South Site 3 Long Beach	Centralized AWT Project
Distributed Treatment Facilities					
O&M for Treatment Facility, NPV	$	$176,000,000	$126,600,000	$246,500,000	$1,346,000,000
O&M for Treatment Facility Conveyance and Pumping, New Components, NPV	$	$10,200,000	$5,170,000	$3,080,000	
Capital Cost for Treatment Facility	$	$527,200,000	$372,200,000	$724,100,000	$1,871,000,000
Capital Cost Conveyance/Pumping, New Components	$	$242,100,000	$169,200,000	$100,2-0,000	
Subtotal Distributed Treatment Facility and New Conveyance and Pumping Components	**$**	**$955,600,000**	**$673,200,000**	**$1,054,000,000**	**$3,217,000,000**
Unit Cost, $/gpd, treatment, per facility	**$/gpd**	**$58.3**	**$63.2**	**$43.7**	**$21.4**
Unit Cost, $/acre-ft, treatment, per facility	**$/acre-ft**	**$2,600/AF**	**$2,818/AF**	**$1,948/AF**	**$957/AF**
Centralized Treatment Cost Reductions					
Centralized Treatment O&M Reductions, NPV	$	-$147,160,000	-$95,650,000	-$220,740,000	
Capital Cost Savings for Centralized Treatment Facility	$	-$199,000,000	-$129,000,000	-$301,000,000	
Subtotal Centralized Treatment Facility Savings, NPV	**$**	**-$346,200,000**	**-$224,700,000**	**-$521,800,000**	
Product Water Conveyance and Pumping					
O&M Product Water Pumping, NPV Reduction (-) or Increase (+)	$	-$14,810,000	-$10,330,000	+$1,000,000	
Capital Cost Savings Product Water Conveyance and Pumping	$	-$9,140,000	-$21,560,000	-$15,130,000	
Subtotal Product Water Conveyance/Pumping Reduction	**$**	**-$24,000,000**	**-$31,900,000**	**-$14,100,000**	
Total Net Present Value Cost Increase for Distributed Approach (Treatment + Conveyance)	**$**	**$585,000,000**	**$416,000,000**	**$538,000,000**	

7.0 FINDINGS AND RECOMMENDATIONS

The distributed vs centralized treatment approaches were analyzed for the RRWP in this study. Sewer interception/diversion sites were identified with the help of LACSD with estimated flow rates between 20 and 30 mgd, and candidate properties for locating distributed treatment were identified within five miles of the diversion sites and product water backbone pipeline. However, the diversion locations and treatment sites are limited to being relatively near to the JWPCP in elevation and proximity. Such proximity limits the benefit of redundancy and energy savings, the latter being an estimated maximum of 2.5% pumping energy savings or even an additional energy cost and no savings.

7.1 COST

The comparison of potentially feasible options shows that distributed treatment is significantly more expensive to implement compared to centralized treatment only, exemplified by treatment unit costs per acre-foot of 2 to 3 times for distributed treatment compared to centralized treatment and an additional $420M to $590M net present value cost. An overall cost summary for the centralized vs distributed treatment approaches is presented in **Table 7-1**.

Table 7-1 – Overall cost summary

Parameter	Distributed AWT Alternatives			Centralized AWT Facility
	Diversion North Site 1 Commerce West	***Diversion North Site 2 Commerce East***	***Diversion South Site 3 Long Beach***	
Influent Flow (MGD)	20	13	30	186
Incremental Increase of Capital Costs ($)	+ $560M	+ $390M	+ $510M	-
Incremental Pumping Energy, Increase (+) or Reduction (-)	- 2.5% (Reduction)	- 1.9% (Reduction)	+ 1.1% (Increase)	-
Incremental Increase of O&M Cost for Distributed ($/year)	+ $1,900,000	+$2,100,000	+$2,400,000	-
Unit Treatment Cost ($/ac-ft)[1]	$2,601	$2,819	$1,948	$957
Incremental Increase Net Present Value ($)	+ $590M	+ $420M	+ $540M	

Table footnotes:

1. Unit treatment cost based on NPV, and includes additional costs required for the distributed facilities including additional conveyance line and pump station for wastewater and additional conveyance lines for product water and RO concentrate

7.2 NON-COST

From the qualitative standpoint, when the two approaches are compared, the centralized treatment offers more advantages and fewer drawbacks. These are summarized for each in the tabulations that follow.

Table 7-2 Overall qualitative analysis summary

Distributed/Decentralized Treatment	
Advantages	**Drawbacks**
• Potential energy savings – reduced pumping • Increase product water production reliability	• Purchase and permitting could extend implementation schedule and certainty of procurement not assured • Likely to face some type of stakeholder opposition • Construction disruptions/environmental impacts at more locations • Greater number of facilities to operate and maintain at separate locations • Separate RO concentrate management facilities • Critical support utilities may be challenging to obtain • Costly – capital and O&M – in comparison to centralized approach (20 to 30% capital increase per unit produced) • Limited energy savings (max 2.5% pumping)
Centralized Treatment	
Advantages	**Drawbacks**
• Certainty of property procurement (FORCO) • Less construction related disruptions (fewer locations) • Fewer systems to operate and maintain • Lower impacts to community • RO concentrate management cost minimal • Certainty in support infrastructure and utilities (power, etc.) • Reduced risk of externally caused schedule delays • Significantly lower costs – capital and O&M	• Single treatment plant – potentially lower reliability for uninterrupted recycled water production • Existing site requires environmental mitigation measures • Distance to reuse applications

Assessment of the approach to procure and improve alternative sites (locations other than FORCO) to allow for distributed/decentralized treatment was performed at a conceptual study level. If this approach is to be taken forward with respect to feasibility of the approach and the associated schedule and cost, there are many questions to address and challenges to be attenuated. Issues include the ability to actually procure a site and obtain the approvals relative to planned use. The ability of local utilities to provide service (electrical power, water, large vehicular access, etc.) was assumed but would need confirmation prior to moving forward. Community perceptions and reaction to the type of planned facilities could result in project opposition across a wide spectrum of stakeholders. There are a large number of concerns that will require further assessment to demonstrate the approach viability.

While the distributed treatment spreads the risk of failure to multiple facilities however, appropriate design of the centralized facility with sufficient equipment and systems redundancy could mitigate such risk. The management inefficiencies that come with operating multiple distributed facilities make the distributed treatment approach less attractive. Also, the feasibility of procuring the necessary permits and land for these facilities is uncertain. The main benefit of diversification comes with a large cost increase as well as some additional qualitative complexities.

As a result, the recommendation from this study is to proceed with a single centralized treatment facility. The basis for this approach being the preferred is:

- Management and operation of multiple plants at different sites increases complexity; greater efficiency with a single, large-scale facility
- Reduction in energy usage for distributed RWTPs is minimal
- Uncertainties exist relative to procurement of new sites beyond current centralized:
    - Potential opposition
    - Schedule impacts
- The centralized approach is significantly more cost-effective

The findings are influenced by the quantity and location of the potential flow diversions.

8.0 REFERENCES

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Appendix A CALCULATIONS FOR DISTRIBUTED TREATMENT FACILITY COMPONENTS

Appendix B LAND ACQUISITION MARKET COST ANALYSIS

Appendix C TREATMENT PROCESS FLOW DIAGRAMS