ANGELES LINK PHASE 1

WATER RESOURCES EVALUATION

FINAL REPORT - DECEMBER 2024

SoCalGas commissioned this Water Resources Evaluation study from Rincon Consultants and Jacobs Engineering Group. The analysis was conducted, and this report was prepared, collaboratively.

December 2024

Angeles Link: Summary of Water Resources Evaluation – Final Report

Southern California Gas Company (SoCalGas) is proposing to develop a clean renewable hydrogen[1] pipeline system to facilitate transportation of clean renewable hydrogen from multiple regional third-party production sources and storage sites to various delivery points and end users in Central and Southern California, including in the Los Angeles Basin. SoCalGas commissioned Rincon Consultants, Inc. (Rincon) with subconsultant Jacobs Engineering Group to assist in the preparation of this Water Resources Evaluation (WRE or Study). This Study is being prepared pursuant to the California Public Utilities Commission's (CPUC) Angeles Link Memorandum Account Decision D.22-12-055, Ordering Paragraph (OP) 6 (b), which states SoCalGas shall provide the findings from Phase 1 feasibility studies for "identification of the potential sources of hydrogen generation and water and estimating the costs of the hydrogen."

The objective of this WRE is to evaluate potential water availability for third-party hydrogen production; the water quality requirements for water treatment to meet the technical requirements of electrolyzers; a high-level cost estimate for key aspects of water management; and potential challenges and opportunities for the development of water supply sources that may support third-party clean renewable hydrogen production within SoCalGas's service territory. The WRE is a compilation of six separate chapters: (1) Chapter 1: Water Availability Study; (2) Chapter 2: Water Quality Requirements; (3) Chapter 3: Acquisition and Purification Costs; (4) Chapter 4: Challenges and Opportunities; (5) Chapter 5: Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance; (6) Stakeholder Input.

Key Findings

The key findings are presented below and are discussed further within this WRE.

- Water required for the portion of third-party clean renewable hydrogen production to meet the projected 2045 demand across SoCalGas's service territory comprises a

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[1] In the California Public Utilities Commission (CPUC) Angeles Link Decision (D).22-12-055 (Phase 1 Decision), clean renewable hydrogen refers to hydrogen that does not exceed 4 kilograms of carbon dioxide equivalent (CO2e) produced on a lifecycle basis per kilogram of hydrogen produced and does not use fossil fuels in the hydrogen production process, where fossil fuels are defined as a mixture of hydrocarbons including coal, petroleum, or natural gas, occurring in and extracted from underground deposits.

small percentage (approximately 0.02 to 0.10 percent) of California's total applied water usage each year.

- Multiple water supply sources can be identified to meet water demand for the clean renewable hydrogen production that Angeles Link could transport, including existing water supplies and new water supplies that could be developed.
- Examples of potential water sources include surface water, treated wastewater, groundwater, agricultural industry water, brine line flows, advanced water treatment concentrate, oil & gas industry water, inland brackish water, dry weather flows, and urban storm water capture and reuse.
- Third-party producers may use different mechanisms to acquire water supplies to meet production needs, including exchange agreements, local water agencies, and water markets, or through acquisition of land purchase with water rights.
- Shifting water demands and obligations may present opportunities for development of new water supplies.
- The menu of water sources that feed specific production projects can be further evaluated on a case-by-case basis as more details on specific production projects develop.

Stakeholder Input

The input and feedback from stakeholders including the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) have been helpful to the development of the Angeles Link Phase 1 studies. SoCalGas presented opportunities for the PAG and CBOSG to provide feedback at four key milestones in the course of conducting this study: (1) the draft description of the Scope of Work, (2) the draft Technical Approach, (3) Preliminary Findings and Data, and (4) the Draft Report. SoCalGas also conducted a series of meetings and presentations to PAG and CBOSG members, that included presentations on this study. On February 15, 2024, SoCalGas presented an overview of the study and key initial findings for the Water Resources Evaluation.

Feedback was incorporated as applicable at each milestone throughout the progression of the study. Some feedback was not incorporated for various reasons, including because feedback was outside of the scope of the Phase 1 Decision or study and feedback raised issues better suited for third parties to address. A summary of the feedback windows for each milestone and the stakeholder input that was incorporated into the study is provided in Chapter 6: Stakeholder Input. SoCalGas's full responses to all feedback received on this study are provided in the quarterly reports submitted to the CPUC and published on SoCalGas's website.[2]

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[2] Each Quarterly Report can be accessed at https://www.socalgas.com/sustainability/hydrogen/angeles-link.

Study Introduction, Background, and Overview of Chapters

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Tables

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Introduction

This report provides the Water Resources Evaluation (WRE) prepared for Southern California Gas Company's (SoCalGas) proposed Angeles Link project (Angeles Link). The WRE is part of a larger feasibility investigation (Phase 1) being conducted for the development of a system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. On December 15, 2022, the California Public Utilities Commission (CPUC) adopted Decision 22-12-055 (Decision) authorizing the establishment of SoCalGas's Angeles Link Memorandum Account (Memorandum Account) to track costs for advancing Phase 1 of Angeles Link. The Decision states SoCalGas shall provide findings from its Phase 1 feasibility studies, including studies that identify the potential sources of clean renewable hydrogen generation and water and estimate the costs of the clean renewable hydrogen production that could support Angeles Link (Decision, Ordering Paragraph (6)(b)).

Angeles Link would transport clean renewable hydrogen anticipated to be produced by future third-party producers to end users in Central and Southern California. The responsibility to secure sufficient water quantity and quality for future clean renewable hydrogen production projects will be held by third-party producers.[1]

An analysis of potential demand for clean renewable hydrogen through 2045 was prepared as a separate Phase 1 feasibility analysis, referred to herein as the "Demand Study," which assessed potential hydrogen demand throughout SoCalGas's service territory by 2045. The portion of that demand that would Angeles Link proposes to transport, also referred to as the "Angeles Link potential throughput," includes approximately 0.5 million metric tonnes per year (MMT/Y) in a low case scenario and up to 1.5 MMT/Y in a high case scenario. The Demand Study's estimated range of potential scenarios of overall demand for clean renewable hydrogen for SoCalGas's service territory and Angeles Link's proposed throughput scenarios are summarized in Table INTRO-1, below.[2]

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[1] Please also refer to SoCalGas's Production Planning and Assessment Study (Production Study).

[2] The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1,9-5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5-1.5 MMT/Y).

Table INTRO-1 Demand Study Projections, Angeles Link Potential Throughput, and Associated Water Needs

Scenario	Clean Renewable Hydrogen Demand (MMT/Year)[1]	Water Needs (AFY)[1,2]	Water Needs (MGD)[1,2]
SoCalGas Service Territory			
Low Demand	1.9	20,900	19
High Demand	5.9	64,700	59
Angeles Link Potential Throughput			
Low Case	0.5	5,500	5
High Case	1.5	16,500	15

[1] MMT/Year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

The magnitude of total water needs associated with anticipated demands for clean renewable hydrogen was used to inform the technical analyses summarized herein, and to facilitate identification of Study findings.

Background

The Water Resources Evaluation is a compilation of six separate chapters which can be reviewed independently or as a part of this larger WRE. The six chapters are presented below and summarized in the next section, *Overview of Chapters*.

- **Chapter 1: Water Availability Study.** A feasibility-level analysis of water supply for clean renewable hydrogen development was conducted to identify a variety of water supply source types based upon anticipated availability and potential for sustainable management,[3] among other factors.
- **Chapter 2: Water Quality Requirements.** An analysis of water quality required for clean renewable hydrogen production was conducted based on technical requirements of the electrolyzer(s) that may be used to produce clean renewable hydrogen.
- **Chapter 3: Acquisition and Purification Costs.** High-level cost estimates were developed for key aspects of water supplies that could support third-party clean renewable hydrogen production (including water conveyance, treatment, and waste management).
- **Chapter 4: Challenges and Opportunities.** Challenges and opportunities were identified at a high level for the development of water supply sources that may support clean renewable hydrogen production in the study area.
- **Chapter 5: Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance.** In direct response to stakeholder feedback, a supplemental desktop analysis of potential greenhouse gas emissions associated with water treatment and conveyance was prepared.
- **Chapter 6: Stakeholder Input.** Input is provided from the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG), as received during four feedback windows, including: 1) Scope of Work; 2) Technical Approach; 3) Preliminary Findings and Data; and 4) Draft Report.

For consistency across chapters, the parameters presented above in Table INTRO-1 for the anticipated demand for clean renewable hydrogen and associated water needs, were used to inform the analyses presented in each chapter of the Water Resources Evaluation.

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[3] See, e.g., https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf

Overview of Chapters

Chapter 1: Water Availability Study

Scope of Work/Technical Approach

Pursuant to the Decision, the Water Resources Evaluation included preparation of a Water Availability Study, the purpose of which was to identify and characterize potential water supply sources that could support future third-party production of clean renewable hydrogen. While SoCalGas would not produce clean renewable hydrogen as part of Angeles Link, the purpose of the Water Availability Study was to provide potential water supply sources for third-party clean renewable hydrogen producers to pursue, to the extent that those resources have not already been acquired by hydrogen producers or other projects.

A key factor applied to the identification of potential water supply sources for clean renewable hydrogen production was a lack of interference with existing and planned uses of the respective water supply source. Therefore, treated wastewater streams were considered to be unavailable to clean renewable hydrogen production if they were part of an existing or planned water recycling or water reuse project. Similarly, groundwater was assumed to be unavailable unless the respective basin was not affected by overdraft and was sustainably managed, including under an adjudication judgment facilitating water market activity.

To avoid potential competition for water supply, the approach applied for the Water Availability Study involved the collection and review of applicable state-required land use and water supply planning documents, including: Urban Water Management Plans (UWMPs) which are required of supply providers with 3,000 or more service connections or delivering 3,000 AFY or more of water; Groundwater Sustainability Plans (GSPs) addressing individual groundwater basins for compliance with the Sustainable Groundwater Management Act (SGMA); and the California Water Plan maintained by the California Department of Water Resources (DWR) to plan for and provide for the sustainable management of water resources throughout the state. In addition, initial input from water agencies and managers was collected through agency outreach efforts.

Initial outreach with relevant water agencies was conducted to facilitate meaningful collaboration between future hydrogen producers and agencies involved in the development and distribution of water supply within SoCalGas's service territory. The agency outreach effort involved identifying agencies based upon ownership and operation of existing water supply projects and infrastructure, size, and location. Virtual meetings were conducted with water agencies, for discussion of the respective agencies' water supply sources, programs, and facilities, as well as potential opportunities for the development of water supply for clean renewable hydrogen production through partnership with future hydrogen producers. Input from water agencies and managers helped to inform consideration of creative or alternative means of developing potential water supply sources for clean renewable hydrogen production, such as treatment of flows currently managed as waste.

The Water Availability Study provides a thorough characterization of existing water supply management in Southern California, with descriptions of existing water supply sources, water supply development projects, and water demands in key sectors including urban (municipal and industrial), agricultural, and environmental uses. As discussed above, potential water supply sources were eliminated from consideration if they were (1) fully allocated or planned for use in meeting existing or anticipated water needs for a given area, (2) part of existing or planned water recycling or reuse projects, (3) part of the sustainable management of local groundwater resources for SGMA compliance, or (4) if use would conflict with existing or anticipated water needs. Potential supply source types were not eliminated based upon cost, quality, complexity, or acquisition or development.

Overview and Findings

The Water Availability Study produced a menu of 10 potential water supply sources determined to be feasible for future acquisition or development by third-party clean renewable hydrogen producers to support their respective projects, as presented in Table INTRO-2, below.

Table INTRO-2 Potential Water Supply Sources

Source Type	Overview*
Imported Surface Water	Imported surface water from the SWP, Colorado River, and CVP may be purchased from a contractor to the respective project from within the contractor’s existing allocations.
Treated Wastewater	Treated wastewater is highly treated and disinfected at wastewater treatment facilities where it is available for purchase if not already planned for beneficial reuse; this water would be purchased from the treatment provider.
Groundwater	Local groundwater being sustainably managed by local agencies under SGMA or by Court-ordered adjudication may be available in DWR-designated Low Priority basins, adjudicated areas, or groundwater storage banks.
Agricultural Industry Water	Agricultural industry water includes agricultural field drainage, surface water runoff, subsurface drainage, and used wash water that may be captured or diverted for treatment and reuse.
Brine Line Flows	Brine line flows are highly concentrated with salts and other contaminants that could be diverted at the point of origin, or from the brine line directly, for further treatment and reuse.

Source Type	Overview*
Advanced Water Treatment Concentrate	Advanced water treatment concentrate is wastewater from treatment processes that may be diverted at the point of origin for further treatment and reuse.
Oil & Gas (O&G) Industry Water	O&G industry water includes refinery offset water from reduced or halted refinery operations and produced water that may be treated for reuse.
Inland Brackish Groundwater	Inland brackish groundwater arises from natural and manmade sources, and may be extracted for treatment and reuse.
Dry Weather Flows	Dry weather flows are on-precipitation flows accumulating in municipal storm sewer systems during dry weather conditions that may be collected and treated for reuse.
Urban Stormwater Capture and Reuse	Urban stormwater capture and reuse refers to stormwater runoff that is captured for storage, treatment, and reuse before reaching discharge outlets during precipitation events.

* CVP = Central Valley Project; DWR = Department of Water Resources; O&G = oil and gas; SGMA = Sustainable Groundwater Management Act; SWP = State Water Project

Table INTRO-3, below, provides an overview of existing mechanisms that can be used to acquire or develop water supply, to assist future clean renewable hydrogen producers in securing sufficient water quantity and quality for their respective projects.

Table INTRO-3 Potential Water Supply Acquisition Mechanisms

Acquisition Mechanism	Overview*
Exchange Agreements	Exchange agreements may be developed between future clean renewable hydrogen producers and water agencies with sufficient surplus supply or supply development potential.
Local Water Agencies	Agencies may have supply available for purchase or may partner with future producers to develop a supply source for mutual benefit. Agencies may also consider the inclusion of future production projects in UWMP projections of water needs and availability.
Water Markets	Water markets may be used, including for adjudicated groundwater resources and surplus surface flows, as available.

Acquisition Mechanism	Overview*
Land Purchase with Water Rights	Land purchase with water rights may be available, depending upon the physical availability of water, population growth projections, land use planning and zoning, and project proposals submitted to the local land use agency.

* SWP = State Water Project; UWMP = Urban Water Management Plan

The Water Availability Study did not develop estimates of water needs for individual clean renewable hydrogen production projects. However, as described above, water needs associated with clean renewable hydrogen development potential were estimated based upon the projected demands for clean renewable hydrogen throughout SoCalGas's service territory (as described in the Angeles Link Phase 1 Demand Study) as well as upon the estimated volume of clean renewable hydrogen Angeles Link is expected to transport in the long term.

To provide context to the scale of anticipated water needs for clean renewable hydrogen production, the Water Availability Study presented overall rates of applied water use in California, where "applied water" refers to the amount of water provided for use in the urban and agricultural sectors and dedicated for environmental uses and obligations on an annual basis. Table INTRO-4, below, shows average annual applied water rates in California.

Table INTRO-4 Average Annual Statewide Applied Water[1]

Sector	Dry Year (AFY)[3]	Wet Year (AFY)[3]
Urban[2]	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	**62,000,000**	**103,000,000**

[1] "Applied water" refers to the volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions.

[2] The urban sector, also referred to as "Municipal and Industrial" (M&I) includes commercial, industrial, and residential uses.

[3] The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023

Applied water for the urban sector tends to increase during wet years, when water conservation requirements are less stringent, while applied water for the agricultural sector decreases during wet years, when increased precipitation reduces needs for irrigation. Applied water for environmental uses and obligations increases during wet years due to increased precipitation replenishing natural systems and environmental needs. Table INTRO-5, below, compares applied water rates to the water needs of service territory-wide demands and Angeles Link expected throughput, as previously presented in Table INTRO-1, in the this introduction.

Table INTRO-5 Water for Clean Renewable Hydrogen vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY)[1,2]	Dry Year Applied Water (62 MAFY)[1]	Wet Year Applied Water (103 MAFY)[1]
SoCalGas Service Territory			
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%
Angeles Link Throughput			
Low Case	5,500	0.01%	< 0.01%
High Case	16,500	0.03%	0.02%

[1] AFY = acre-feet per year; MAFY = million acre-feet per year

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

Source: PPIC 2023

The comparisons provided above between applied water rates and water needs for clean renewable hydrogen production demonstrate that the water needed by third-party producers to meet demands for clean renewable hydrogen represents a small percentage of total applied water in California. The amount of water needed to meet the portion of demand that would be served by Angeles Link would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

Overall findings of the Water Availability Study are summarized below.

- A substantial portion of water demands for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition.
- The quantity of water needed by third-party producers of clean renewable hydrogen to meet the projected demands across SoCalGas's service territory by 2045, including the portion that would be transported by Angeles Link, comprises a small percentage of the total amount of water used in California each year.
- Third-party producers of clean renewable hydrogen may draw from a number of water supply sources to meet the water needs of their respective projects producing clean renewable hydrogen throughout SoCalGas's service territory, including for Angeles Link's expected throughput.
- Water needs of clean renewable hydrogen projects could be refined in the future, as projects are developed, and proposed projects are submitted to the appropriate agencies for approvals.

- As water supply planning documents including UWMPs continue to be updated in the future, and clean renewable hydrogen projects are proposed via applications submitted to the respective land use agencies, associated water needs of such projects may be incorporated into agency projections and planning documents.

Chapter 2: Water Quality Requirements

Scope of Work/Technical Approach

An analysis of water quality requirements for clean renewable hydrogen production was conducted. The scope of work for assessment of water quality included collecting water quality specifications for the electrolyzers that could be used to generate clean renewable hydrogen and conducting a desktop review to evaluate the efficiency of these systems. Pretreatment requirements for potential water supply sources were assessed, including consideration of electrolyzer efficiencies. Water quality requirements were established based on electrolyzer type (e.g., alkaline, polymer electrolyte membrane or solid oxide).

Overview and Findings

The two main technologies available for use in large-scale hydrogen generation include alkaline electrolysis and polymer electrolyte membrane (PEM) electrolysis. Solid oxide electrolysis cell (SOEC) is another electrolyzer technology that is not as widely commercialized but may be an efficient option, and membraneless technologies were also considered as an emerging technology in large-scale hydrogen production. Electrolyzer water quality requirements depend upon the type of electrolysis technology used. Table INTRO-6, below, provides an overview of typical requirements.

Table INTRO-6 Water Quality Requirements by Electrolyzer Type

Electrolyzer Technology	Typical Water Quality Requirements
Alkaline Electrolyzer	Ultrapure water is typically required. Recommended higher water conductivity of <5 μS/cm.[1]
Polymer Electrolyte Membrane (PEM) Electrolyzer	Ultrapure water is required. Suggested water conductivity of <0.2 for PEM electrolyzers.
Solid oxide electrolysis cell (SOEC)	Some manufacturers suggest using deionized or boiler feed water but most typically do not require high quality water.
Membraneless electrolyzers	Some systems use untreated seawater or potable water, while others require demineralized or deionized water with a specific pH.

[1] μS/cm = microsiemens per centimeter (unit of measurement of electric conductivity)

As shown above, alkaline and PEM electrolysis technologies involve the use of ultrapure water.[4] Ultrapure waste has been highly treated and purified, including with respect to electric resistivity and other characteristics. Treating and purification to ultrapure standards requires pretreatment of raw water as well as polishing of treated water. The final pretreatment step typically uses reverse osmosis (RO). Table INTRO-7, below, provides an overview of the water quality treatment stages to produce ultrapure water, based upon initial treatment equivalent to tertiary-treated recycled water.

Table INTRO-7 Target Contaminants for Water Quality Treatment by Inflow Type

Inflow Water Quality	Treatment Stage	Target Contaminants
Tertiary-treated,[1] potable water	Pretreatment for RO[2]	Suspended solids, oil and grease, organics, microorganisms, nuisance compounds (e.g. iron, manganese, hardness)
Demineralized water, boiler feeder water	RO	TDS,[2] conductivity, total and dissolved organic compounds, and other dissolved contaminants, e.g. boron
Deionized, ultrapure water	Post-RO Polishing	Gas, silica, conductivity, and TOC[2]

[1] Tertiary treatment of water eliminates non-biodegradable pollutants, phosphorus, and nitrogen in the water, and follows primary treatment (removal of solids) and secondary treatment (removal of dissolved and suspended organic compounds).

[2] RO = reverse osmosis; TDS = total dissolved solids; TOC = total organic compounds

It was determined that for alkaline and PEM electrolysis technologies, between approximately 950 and 1,100 gallons of ultrapure water would be required per day per megawatt (MW) of electrolyzer capacity. The amount of source water required to produce sufficient ultrapure water would vary depending upon the quality of the supply source type and the extent of required water quality treatment. The extent of water quality treatment required was used to inform calculation of the amount of water that would be lost to treatment and cooling, and the total amount of source water required to produce clean renewable hydrogen using the available electrolysis technologies.

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[4] Please also refer to SoCalGas's Production Study.

Chapter 3: Acquisition and Purification Costs

Scope of Work/Technical Approach

High-level cost estimates of the main cost components of water supply were developed, including for water acquisition, treatment, concentrate management, and conveyance. Costs were expressed in unit costs (i.e., costs per unit hydrogen produced or costs per unit volume of water). This approach supported the calculation of rough estimates of potential costs associated with respective water supply sources identified in the Water Availability Study. The cost outputs were presented in life cycle and unit cost formats to facilitate the comparison of costs across potential water supply sources and to support the development of costs for specific water supply projects or water supply portfolios that may be defined in the future.

Overview and Findings

An analysis of potential costs associated with water supply acquisition and development was conducted for supply source types identified in the menu of options from the Water Availability Study described in Chapter 1. This analysis was informed by the water quality requirements of the electrolysis technology types available and the extent of water quality treatment required for each potential source type, as well as management of waste materials generated during treatment processes. Total dissolved solids (TDS) concentration was identified as a key determining factor of cost, as water quality polishing systems typically require TDS concentration of less than 350 milligrams per Liter (mg/L), and most of the supply source types identified in the Water Availability Study have TDS concentrations above this level. Location of the potential source types and extent of conveyance required were also found to be key determining factors of cost.

The acquisition and purification costs analysis considered the location of water supply sources and treatment facilities relative to clean renewable hydrogen production projects, and assessed how transportation needs would affect cost. Factors considered included the length of pipelines, and future production sites, as well as the energy needs of conveyance, which would increase in relation to topographic relief.

Conceptual supply projects were developed to assess costs and create cost estimates. Assuming the average total project cost of the conceptual projects, the water supply costs for 0.5 MMT/Y to 1.5 MMT/Y of clean renewable hydrogen would range from $445 million to $1,335 million, including construction and net present value operation and maintenance for 30 years of operation.

Chapter 4: Challenges and Opportunities

Scope of Work/Technical Approach

Challenges and opportunities related to water supply and treatment were assessed for three key topics, including: (1) potential water supply sources, (2) geographic location, setting, and distance to clean renewable hydrogen production, and (3) requirements for conveyance, including methods and distance. Challenges considered included those factors that could have significant impacts on water availability, or that could jeopardize access to water for clean renewable hydrogen production. Challenges associated with advancing pipelines through developed areas, potentially introducing infrastructure relocation and disturbances to traffic and businesses, as well as through undeveloped areas, could result in environmental impacts that require mitigation.

Opportunities included identification of potential source types and transportation methods that could streamline the provision of water supply at the locations of clean renewable hydrogen production, and could improve cost as well as reliability of hydrogen supply. Technology improvements may also be available to support the electrolysis process, as discussed in SoCalGas's Production Study. The analysis also considered cost-streamlining options, such as prioritizing water supply sources close to hydrogen production areas. Acquiring surface water through an exchange would provide another opportunity to address conveyance challenges. One of the primary benefits of an exchange project is that it provides a potential approach to avoid the need to construct pipelines from coastal and urban areas to the potential areas for hydrogen production.

Overview and Findings

Table INTRO-8 provides an overview of potential challenges, mitigation strategies, and opportunities associated with the supply source types identified in the Water Availability Study.

Table INTRO-8 Challenges and Opportunities of Potential Supply Source Types

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Imported Surface Water	Long-term reliability and drought-year availability, and regulatory permitting issues of exchange projects.	Explore water banking options to store excess water when available for use as needed.	Partnerships in distribution and conveyance of surface water, and development of exchange supply in areas where there is a need for diversification.

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Treated Wastewater	Reliability of supply (conservation efforts reducing water use can also reduce wastewater flows) and management of concentrate.	Contribute funds for the expansion of wastewater treatment facilities in growing areas; identify other sources for a diverse supply portfolio.	Partnerships to facilitate gathering effluent from multiple facilities and conveying it to hydrogen production areas for treatment and use.
Groundwater	Concentrate management, including potential cost and operation of large evaporation basins or pipelines for disposal. Source reliability may pose an additional challenge.	Coordinate with Groundwater Sustainability Agencies (GSAs) for possible partnership on supply improvement and mutual benefit projects such as banking.	Partnerships to support sustainable groundwater management such as through mutually beneficial groundwater banking projects.
Agricultural Industry Water	Treatment of agricultural drainage water is expected to be challenging due to very high TDS concentrations.	Target source water where the removal of agricultural discharge would be particularly beneficial to receiving waterways.	Partnerships to enhance access to agricultural industry water, and partnerships for the implementation of salinity management projects.
Brine Line Flows	Cost and implementation of concentrate disposal pipelines or evaporation basins.	Locate the project treatment facility close to the source concentrate pipeline and use that existing pipeline to dispose the concentrate generated from water treatment processes.	Partnerships between brine line flow contributors and hydrogen producers.

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Advanced Water Treatment Concentrate	Water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, scaling of treatment equipment and concentrate pipelines.	Use or expand the existing concentrate disposal system; locate the project treatment plant at or near the advanced water treatment facility for direct delivery of treated water to the production site.	Partnerships to enhance access to concentrate supply and partnerships related to the distribution and conveyance of concentrate for hydrogen production.
O&G Industry Water	Long-term reliability; concentrate management, treatment, and operational issues.	Further treatment of the residuals/ concentrate to reduce the potential need for handling as hazardous wastes.	Partnerships to use or repurpose existing oilfield waste disposal systems; partnerships related to the distribution and conveyance of O&G production water from multiple oil fields or refineries for hydrogen production.

Supply Source Type	Challenges	Mitigation Strategies	Opportunities
Inland Brackish Groundwater	Concentrate management; source reliability due to a finite volume of brackish groundwater available; potential connection between brackish groundwater and drinking water aquifers.	Develop projects to comply with regulatory requirements of salt and nutrient management or to address brackish groundwater caused by previous land uses.	Partnerships to fund or assume operation of desalination systems, which may enhance access to brackish groundwater sources while allowing water agencies to shift funding and resources to projects that provide a more cost-effective supply for their ratepayers.
Dry Weather Flows	Reliability; concentrate management; treatment complexity; operational issues.	Gather dry weather flows from multiple watersheds and convey that water to hydrogen production areas for treatment and use.	Partnerships related to the distribution and conveyance of dry weather flows; collaboration with agencies with interests related to the benefits of capturing and treating dry weather flows.
Urban Stormwater Capture	Reliability; flow fluctuations.	Divert stormwater from multiple stormwater basins within a watershed to allow for diversion of stormwater flows for a longer duration between storm events.	Partnerships with agencies that need to improve or repair existing flood control or stormwater systems.

Chapter 5: Supplemental Desktop Analysis

Scope of Work/Technical Approach

This supplemental desktop analysis provides information related to potential GHG emissions associated with the treatment and conveyance of water supply in California, to address comments received from the PAG and CBOSG members. This report does not include quantification of GHG emissions associated with the potential supply source types identified in the Water Resources Evaluation; rather, it provides information, including data and methodology, to provide additional context at this stage of potential future GHG emissions associated with future water supply development. This supplemental analysis is informed by review of available literature and resources.

Overview and Findings

This supplemental analysis finds the extent of GHG emissions associated with water supply management depends on many factors, including, but not limited to, the type and amount of electricity used for a given activity (i.e., for pumping needs depending on local topography or whether gravity is available for conveyance or for treatment needs depending on the quality of the water). Water quality treatment and water conveyance are the most energy-intensive aspects of water supply management.

Chapter 6: Stakeholder Input

Chapter 6 provides a summary of the PAG and CBOSG input that was incorporated into the Water Resources Evaluation through the four feedback milestones including: 1) Scope of Work; 2) Technical Approach; 3) Preliminary Findings and Data; and 4) Draft Report. SoCalGas's responses to PAG/CBOSG feedback are provided in the quarterly reports submitted to the CPUC and published on SoCalGas's website.[5]

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[5] Each Quarterly Report can be accessed at https://www.socalgas.com/sustainability/hydrogen/angeles-link.

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PPIC (Public Policy Institute of California). 2023. Fact Sheet - Water Use in California. April. https://www.ppic.org/wp-content/uploads/jtf-water-use.pdf (June 2023).

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Chapter 1: Water Availability Study

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Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
ASR	Aquifer Store and Recovery
AVEK	Antelope Valley-East Kern
AWMP	Agricultural Water Management Plan
AWPF	Advanced Water Purification Facility
AWTF	Advanced Water Treatment Facility
BAP	Base Annual Production
BLM	Bureau of Land Management
CalEPA	California Environmental Protection Agency
CalGEM	California's Geologic Energy Management Division
CARB	California Air Resources Board
CBP	Chino Basin Program
CCC	California Coastal Commission
CCR	California Code of Regulations
CCST	California Council on Science and Technology
CDA	Chino Desalter Authority
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CNRA	California Natural Resources Agency
CPUC	California Public Utilities Commission
CNRA	California Natural Resources Agency
CR	Colorado River
CRB	Colorado River Board
CRS	Congressional Research Service
CTP	Coastal Treatment Plant
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CVP	Central Valley Project
CVSC	Central Valley Salinity Coalition
CVWD	Coachella Valley Water District

CWC	California Water Code
CWC	California Water Commission
Delta	Sacramento-San Joaquin River Delta
DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	direct potable reuse
DWR	Department of Water Resources
EMWD	Eastern Municipal Water District
EO	Executive Order
EWA	Encina Wastewater Authority
EWMP	Efficient Water Management Practices
FPA	Free Production Allowance
FWA	Friant Water Authority
GHC	Green Hydrogen Coalition
GRF	Groundwater Recovery Facility
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IEUA	Inland Empire Utilities Agency
IID	Imperial Irrigation District
JCSD	Jurupa Community Services District
JPA	Joint Powers Authority
LACSD	Los Angeles County Sanitation Districts
LADWP	Los Angeles Department of Water and Power
LASAN	Los Angeles Sanitation and Environment
LCWSP	Lower Colorado Water Supply Project
MAFY	millions of acre-feet per year
Metropolitan	Metropolitan Water District of Southern California
MGD	millions of gallons per day
M&I	municipal and industrial
MOU	Memorandum of Understanding
MPN	most probable number
MS4	municipal separate storm sewer system
MMT	million metric tons
MWD	Municipal Water District

NCWA	Northern California Water Association
NPDES	National Pollutant Discharge Elimination System
NTC	Notice to Contractors; Notice to SWP Long-Term Water Supply Contractors
OC-San	Orange County Sanitation District
O&G	oil and gas
PFAS	per- and polyfluoroalkyl substances
PHWA	Port Hueneme Water Agency
PNNL	Pacific Northwest National Laboratory
PPIC	Public Policy Institute of California
PPR	Present Perfected Rate
PVID	Palo Verde Irrigation District
QSA	Quantification Settlement Agreement
RRF	Resource Recovery Facility
RTP	Regional Treatment Plant
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Protection Authority
SCE	Southern California Edison
SCWD	South Coast Water District
SD	Sanitation District
SD	Secondary Disinfected
SGMA	Sustainable Groundwater Management Act
SJRWA	San Joaquin River Exchange Contractors Water Authority
SJV	San Joaquin Valley
SJVGB	San Joaquin Valley Groundwater Basin
SJRRP	San Joaquin River Restoration Program
SLC	San Luis Canal
SNMP	Salt and Nutrient Management Plan
SoCalGas	Southern California Gas Company
SOCWA	South Orange County Wastewater Authority
SU	Secondary Undisinfected
SWMP	Stormwater Management Program
SWP	State Water Project

SWRCB	State Water Resources Control Board
T	Tertiary
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USCB	U.S. Census Bureau
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Society
UV	ultraviolet
UWCD	United Water Conservation District
UWMP	Urban Water Management Plan
WBMWD	West Basin Municipal Water District
WDR	Waste Discharge Requirements
WEF	Water Education Foundation
WMWD	Western Municipal Water District
WPCF	Water Pollution Control Facility
WQCP	Water Quality Control Plant
WRE	Water Resources Evaluation
WRC	Water Resource Center
WRD	Water Replenishment District of Southern California
WRP	Water Reclamation Plant
WRP	Water Resilience Portfolio
WRRF	Water Resource Recovery Facility
WSCP	Water Shortage Contingency Plan
WSS	California Water Supply Strategy
WWD	Westlands Water District
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

Glossary of Key Terms

- **Adjudication** occurs when water users within a basin are in dispute over legal rights to the water, and a court issues a ruling known as an adjudication; an adjudication judgment defines the area of adjudication (which may include an entire basin, a portion of a basin, or a group of basins), and defines the following: 1) who the water rights owners are ("parties" to the adjudication), 2) how much groundwater each water rights owner can extract, and 3) who the Watermaster will be for the administration and enforcement of the adjudication judgement (see "Watermaster" definition below).
- **Advanced water treatment** is a tertiary-level process that reduces impurities in wastewater to levels below those attainable through conventional secondary or biological treatment. The process typically involves membrane filtration, reverse osmosis, and oxidation (see below).
- **Agricultural wash water** refers to water that is applied to produce to remove soil and debris prior to the produce being received by produce buyers and distributors. Spent wash water is referred to as "process wastewater."
- **Applied water** refers to the volume of water provided for use in the urban (M&I) and agricultural sectors, and dedicated to environmental uses and obligations; applied water rates vary annually depending upon demands and climatic conditions.
- **Basin Priority** is a ranking assigned by the Department of Water Resources (DWR) to individual groundwater basins to reflect the current condition of each basin, with High Priority basins being affected by long-term overdraft.
- **Beneficial use** refers to the uses of water necessary for the survival or wellbeing of humans, plants, and wildlife. Beneficial use designations are assigned to surface water and groundwater resources by the RWQCB for waters in their respective regions. Water quality objectives and management actions and programs are included in each Basin Plan and are designed to support the designated beneficial uses.
- **Brackish groundwater.** Brackish groundwater is water that occurs below the ground surface and is characterized by salinity levels between freshwater and seawater. In coastal areas, brackish groundwater is commonly caused by seawater intrusion. In inland areas, brackish groundwater typically occurs from soil conditions and discharges from water quality treatment facilities. It can be treated to reduce total dissolved solids (TDS) concentrations for reuse for non-potable purposes like irrigation or industrial processes, providing an alternative water source in regions with limited freshwater availability.
- **Brackish water** has high salinity content that is higher than freshwater and lower than seawater.
- **Brine** is a solution of highly concentrated salts, with TDS concentrations higher than seawater. Brine is a byproduct of water treatment processes and can be repurposed for specific industrial applications or resource recovery purposes.

- **Brine lines** are conveyance systems dedicated to brine, which collect brine flow from multiple dischargers and convey it to a treatment facility where it is treated for disposal in compliance with regulatory discharge requirements.
- **California Aqueduct.** The California Aqueduct is the key feature of the State Water Project (SWP), owned and operated by the DWR. The California Aqueduct specifically serves as conveyance for the SWP; flows contained within the aqueduct belong to contractors and customers of the SWP who hold contracted allocations to the water.
- **Central Valley Project (CVP).** The CVP is a federal power and water project that consists of reservoirs, canals, aqueducts, and pumping plants to convey surface water from the Sacramento River, where it collects behind Shasta Dam and Trinity Dam, and delivers it to irrigation and municipal water customers in the San Joaquin Valley.
- **Colorado River.** Water from the Colorado River is managed through a joint federal/state project that imports water from the Lower Basin of the Colorado River watershed and conveys that water through the Colorado River Aqueduct to municipal and agricultural demands in Southern California.
- **Concentrate** refers to the brine stream that is produced as a byproduct of advanced water treatment processes, specifically membrane filtration and reverse osmosis.
- **Conjunctive Use Management.** Conjunctive use of water resources refers to the coordinated use of surface water and groundwater resources to maximize each resource. Conjunctive use management involves actively recharging groundwater with surface water supplies and monitoring to assess and control for water quality implications, among other types of management techniques. An important consideration in conjunctive use management is the presence of water rights held by tribal communities.
- **Decision 22-12-055 (Decision)** was adopted by the California Public Utilities Commission (CPUC) on December 15, 2022, authorizing the establishment of SoCalGas's Angeles Link Memorandum Account to track costs for advancing the first phase of Angeles Link.
- **Demand Study** is part of a separate Phase 1 feasibility study for Angeles Link, prepared to define a range of potential scenarios of demand for clean renewable hydrogen that could occur by 2045 across SoCalGas's service territory, spanning from a low demand or conservative scenario to a high demand or ambitious scenario.
- **Desalter.** A desalter is a facility designed to remove salts and other water quality constituents from water, lowering TDS concentrations and converting previously unusable brackish groundwater into high-quality drinking water.
- **Developed water** refers to water supply that is controlled and managed such as through treatment, conveyance, storage, or trade, to be available for specific purposes.

- **Dry weather flow** occurs in the absence of precipitation due to surface discharges from activities such as watering lawns, operating car washes, and discharge of treated wastewater from wastewater treatment plants.
- **Effluent** is treated flow discharged from a wastewater treatment facility.
- **Exchange Water.** Under an agreement for exchange water, a water seller provides its excess supplies to a water buyer and in exchange, the buyer provides a replacement water supply to the seller. The replacement water supply is provided in amounts equal to the amount of water purchased and must be made available to the seller within its service area.
- **Fracking/fracturing** is an oil and gas (O&G) production process that involves injecting liquid at high pressure into the ground to force open existing fissures and extract O&G. Fracking permits are no longer issued in the State of California; existing fracking operations are allowed to continue but will be phased out as they reach their useful operational lifetime.
- **Groundwater** is defined by the state as "all water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water but does not include water that flows in known and definite channels." Cal. Water Code Section 10752.
- **Injection wells** are used to place fluids in the subsurface for disposal, dilution, storage, or reuse. Injection wells are regulated and permitted by California's Geologic Energy Management Division (CalGEM), formerly the Division of Oil, Gas, and Geothermal Resources (DOGGR).
- **Membrane filtration** removes solids, bacteria, protozoa, and some viruses by pumping recycled water (treated wastewater) through tubes filled with tiny membranes made up of hollow fibers.
- **Municipal Separate Storm Sewer Systems (MS4s)** are stormwater conveyance and discharge systems that are separate from the local sanitary sewer systems, and do not route flows through a treatment facility prior to discharge.
- **O&G Industry** refers generally to activities associated with the production of oil and gas resources from below the ground surface.
- **Offset water** refers to water that was used in O&G production or refinery operations that becomes available for other uses once the respective activities cease.
- **Outfall** is the point where treated or reclaimed water is intentionally released from a water treatment facility or distribution system, either into a water body or for specific environmental/agricultural purposes, marking the endpoint of the water reuse process.
- **Overdraft** occurs when the amount of water entering a groundwater basin is consistently less than the amount of water leaving the basin. The effects of overdraft over time can include seawater intrusion (an ongoing issue along the coast), land subsidence (a long-standing issue in the San Joaquin Valley), and overall groundwater depletion (an issue throughout the state).

- **Oxidation** destroys any organisms remaining after reverse osmosis by using ultraviolet (UV) light and hydrogen peroxide (H2O2) to disinfect the flow of trace organic compounds.
- **PFAS (per- and polyfluoroalkyl substances).** PFAS are a large group of manufactured substances that do not occur naturally and are resistant to heat, water, and oil. PFAS originate from four sources including: fire foams used in fire training/fire response sites, industrial and manufacturing sites, landfills, and wastewater treatment plants.
- **Plumes.** A plume is a concentrated area of groundwater contamination occurring near the source of the contamination, such as the discharge point for effluent from a wastewater treatment facility.
- **Potable Reuse.** Water Code Section 13561 defines potable recycled water use as including:
    - *Indirect Potable Reuse for groundwater recharge* = recycled water that replenishes groundwater designated as a source of water supply for a public water system
    - *Reservoir water augmentation* = recycled water that replenishes surface water reservoir designated as a source of water supply for a public water system
    - *Direct Potable Reuse (DPR)* = recycled water that contributes directly to a public water system or raw water supply immediately upstream of a water treatment plant
- **Potable water** is water that is suitable for human consumption based upon state and federal regulations for drinking water.
- **Produced water** is water that underlies oil and gas fields and is brought to the surface along with oil and gas as a result of pumping activities. Produced water is typically high in salt content and contains salts and minerals from the subsurface.
- **Reclaimed water** refers to recycled water that is applied to beneficial use. Reclamation requirements include “fit-for-purpose” specifications, which define the treatment requirements to bring water from a particular source to the quality needed for a given use while ensuring public health, environmental protection, or specific user needs (USEPA 2023).
- **Recycled water** is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility.
- **Refinery** is an industrial process plant where crude oil is transformed into products such as gasoline, diesel fuel, asphalt base, fuel oils, heating oil, kerosene, and liquefied petroleum gas. Refining breaks crude oil down into its various components, which are then selectively reconfigured into new products. All refineries involve three basic steps, including separation, conversion, and treatment. Most of the water used in a petroleum refinery is used for cooling purposes; water can be used for boiler feed water, fire protection, sanitary services, and processing (Sensorex 2022).

- **Reverse Osmosis** removes salts, viruses, pharmaceuticals, and pesticides from the filtered recycled water by using high pressure to force it through membranes with microscopic holes.
- **Secondary Undisinfected (SU)** water is oxidized wastewater. This water is typically suitable for surface irrigation of limited crop types and flushing of sanitary sewers.
- **Secondary Disinfected-23 (SD-23) water** is wastewater that has been oxidized and disinfected with total coliform bacteria not exceeding a most probable number (MPN) of 23 per 100 milliliters. This water is typically used for surface irrigation of limited crop types, landscape impoundments, and other industrial or commercial processes.
- **Secondary Disinfected-2.2 (SD-2.2) water** is wastewater that has been oxidized and disinfected with total coliform bacteria not exceeding MPN of 2.2 per 100 milliliters. This water is typically used for similar applications as SD-23 water with some additions.
- **State Water Project (SWP).** The SWP conveys surface water from the Sierra Nevada Mountains, where it originates as snowmelt, to SWP contractors in Southern California via a system of canals, tunnels, and pipelines, for distribution to individual customers.
- **Surface Water** is defined by the State of California as water in a “stream, lake, or other body of water” and “subterranean streams flowing through known and definite channels.” (California Water Code Section 1200)
- **Table A** water refers to the maximum amount of water each SWP contractor can receive each year. DWR uses Table A to allocate SWP supplies and costs among the contractors.
- **Tertiary (T) water** is wastewater that has been filtered and disinfected with median coliform bacteria not exceeding MPN of 2.2 per 100 milliliters. This water has the widest applications, including landscape irrigation, food crops, recreational impoundments, dual plumbed facilities, and industrial and commercial processes.
- **Transfer Water.** A water transfer is a means of providing water to areas of critical need from other areas that have surplus for the given year. Transfers are designed for use as short-term solutions to water supply challenges. A transfer differs from an “exchange” in that it does not involve the provision of a replacement water supply.
- **Wastewater** refers to untreated municipal sewage unless specified otherwise.
- **Water Source** refers to both the origin of water (surface water or groundwater) and the place where water is obtained for use (ex., water recycling facility, desalter facility, reservoir, low-elevation collection area, discharge pipe, etc.)
- **Water supply** refers to water that is procured or developed to meet the water needs of a particular use, in this case the development of clean renewable hydrogen.

- **Watermaster** refers to the court-appointed parties responsible for overseeing the day-to-day administration of water rights within an adjudicated groundwater basin and, when necessary, for taking enforcement action related to compliance of water users with the adjudication judgment.

Executive Summary

This Water Availability Study summarizes one chapter of the larger Water Resources Evaluation (WRE) being prepared as part of the Phase 1 feasibility studies conducted in support of Angeles Link. Pursuant to the California Public Utilities Commission (CPUC)'s Decision 22-12-055 (Decision), the purpose of this Water Availability Study is to identify and characterize potential water supply sources that could support future third-party production of the clean renewable hydrogen that Angeles Link could transport to end users in Central and Southern California, including the Los Angeles Basin (inclusive of the Ports of Los Angeles and Long Beach).[1]

The study area considered for this Water Availability Study is generally defined by the boundaries of SoCalGas's service territory; certain potential water sources located outside SoCalGas's service territory were also included based on resource-specific features and potential to contribute to water supply availability. The approach to this Water Availability Study included conducting initial inquiries to select water agencies and regional water suppliers to inform identification of potential supply sources. To provide context for the potential water supply sources, identified herein, this Water Availability Study includes background information on water supply management in California, with descriptions of key regulatory agencies, laws and regulations, and major water supply sources including the State Water Project, the Central Valley Project, and the Colorado River.

Under separate Phase 1 feasibility analyses for Angeles Link, a Demand Study was prepared, which identified a range of potential demand scenarios for clean renewable hydrogen across SoCalGas's service territory by 2045. The overall projected demand spans from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year.[2] The Angeles Link system would transport a portion of the overall projected demand for clean renewable hydrogen, with a proposed throughput of approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/year

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[1] Other chapters of the WRE include an evaluation of water quality requirements for clean renewable hydrogen production (Chapter 2), an evaluation of estimated acquisition, conveyance, and purification costs (Chapter 3), a summary analysis of potential risks and opportunities related to water resources (Chapter 4), and a high level analysis of potential greenhouse gas emissions associated with water conveyance and treatment (Chapter 5).

[2] The Demand Study also identifies a potential mid-range or moderate demand scenario for clean renewable hydrogen by 2045. To evaluate the potential water resources third-party clean renewable hydrogen producers may draw upon, this Water Availability Study focuses on the low and high demand levels at each end of the potential demand range.

under a high case scenario.[3] The following tables quantify water needs for each projected demand scenario:

- Table 1.ES-1 presents water needs for the production of clean renewable hydrogen in amounts meeting projected demands throughout SoCalGas's service territory, and
- Table 1.ES-2 presents water needs for the expected Angeles Link throughput, or the portion of the overall demand for clean renewable hydrogen that would be transported by Angeles Link.

SoCalGas would not produce clean renewable hydrogen as part of Angeles Link; rather, SoCalGas would implement the Angeles Link system to transport clean renewable hydrogen produced by third parties. Additional details on the water needs for clean renewable hydrogen production are provided in Chapter 3, *Acquisition and Purification Costs*, of the WRE.[4]

Table 1.ES-1 Water Needs: SoCalGas Service Territory Projected Demands

Demand Scenario	Clean Renewable Hydrogen Demand (MMT/Year)[1]	Water Needs (AFY)[1,2]	Water Needs (MGD)[1]
Low Demand	1.9	20,900	18.7
High Demand	5.9	64,700	57.8

[1] MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

As mentioned above, while Table 1.ES-1 above presents overall projected demand for clean renewable hydrogen across SoCalGas's service territory, Table 1.ES-2, below, presents the portion of that overall expected demand that would be served by the Angeles Link system.

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[3] The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1,9-5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5-1.5 MMT/Y).

[4] Additional details on the water demand estimates required for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion of the WRE (Chapter 3). Water needs calculations assume all clean renewable hydrogen assessed herein would be electrolytic hydrogen, i.e. produced using electrolyzers. Water needs would decrease if other sources of clean renewable hydrogen are produced and conveyed to meet demand.

Table 1.ES-2 Water Needs: Angeles Link Throughput

Throughput Scenario	Clean Renewable Hydrogen Throughput (MMT/Year)[1]	Water Needs (AFY)[1,2]	Water Needs (MGD)[1]
Low Case	0.5	5,500	4.9
High Case	1.5	16,500	14.7

[1] MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

This Water Availability Study provides a high-level overview of potential water supply sources that third-party clean renewable hydrogen producers may draw upon for their respective projects. The potential water supply sources identified herein may be used to produce clean renewable hydrogen for the overall service territory demand, as well as the portion of clean renewable hydrogen that would be transported by Angeles Link.

Water supply management throughout California is conducted on state, regional, and local levels, with the availability of water sources varying by location and climatic conditions. Agencies must manage their respective supply sources throughout seasonal and annual fluctuations to accommodate existing demands and obligations in key sectors including municipal and industrial (“M&I” or “urban”), agricultural, and environmental sectors. The volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, is referred to as “applied water” and varies depending upon demand and climatic conditions. For example, during wet years characterized by higher-than-average precipitation, less applied water is typically used by the agricultural sector because precipitation reduces the need for irrigation, while more water is used by the urban sector due to reduced conservation requirements, and more water is dedicated to environmental uses, as the increased precipitation would increase flows in waterways and habitat areas.

Table 1.ES-3, below, provides an overview of the total amount of applied water throughout California for each of the three key sectors: urban, agricultural, and environmental. These totals were determined through consideration of applied water usage reported to the State by numerous agencies throughout California between 1998 and 2018 (PPIC 2023a). This 20-year timeframe included periods of varying drought intensity, and is considered representative of typical climatic conditions throughout the state; totals are provided for dry year (drought) conditions and wet year (surplus) conditions, representing climatic variations over the 20-year timeframe.

Table 1.ES-3 Average Annual Applied Water1 in California

Sector	Dry Year (AFY)[3]	Wet Year (AFY) [3]
Urban[2]	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	**62,000,000**	**103,000,000**

[1] "Applied water" refers to the volume of water provided for use in the urban and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions.

[2] The Urban sector, also referred to as "Municipal and Industrial" (M&I) includes commercial, industrial, and residential uses.

[3] The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023a

The table above shows that under both dry year and wet year conditions, the urban sector receives the least amount of applied water, while the agricultural sector receives the most applied water under dry year conditions, when more irrigation is needed due to reduced precipitation. The highest volume of applied water is dedicated to environment uses during wet year conditions, when higher-than-average precipitation results in surplus water supply availability. Table 1.ES-4, below, provides comparison between the total amount of applied water use in California (Table 1.ES-3) and the amount of water needed to meet the total demand for clean renewable hydrogen throughout SoCalGas's service territory (Table 1.ES-1).

Table 1.ES-4 Water for SoCalGas Service Territory Demand vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY)[1,2]	Dry Year Applied Water (62 MAFY)[3]	Wet Year Applied Water (103 MAFY)[3]
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%

[1] AFY = acre-feet per year

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

[3] MAFY = million acre-feet per year; Source: PPIC 2023a

The table above shows that water needs for the High Demand scenario for clean renewable hydrogen would represent a maximum of 0.10 percent of total applied water in California, while the Low Demand scenario would represent a maximum of 0.03 percent of total applied water. Table 1.ES-5, below, provides comparison between the total amount of applied water use in California (Table 1.ES-3) and the amount of water needed for the expected Angeles Link throughput portion of clean renewable hydrogen demand (Table 1.ES-2).

Table 1.ES-5 Water for Angeles Link Throughput vs Statewide Applied Water

Angeles Link Throughput Scenarios	Water Needs for Throughput (AFY)[1,2]	Dry Year Applied Water (62 MAFY)[3]	Wet Year Applied Water (103 MAFY)[3]
Low Case	5,500	0.01%	< 0.01%
High Case	16,500	0.03%	0.02%

[1] AFY = acre-feet per year

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

[3] MAFY = million acre-feet per year; Source: PPIC 2023a

The table above shows that for the Angeles Link portion of total clean renewable hydrogen demand, water needs for the High Case scenario would represent a maximum of 0.03 percent of total applied water in California, while the Low Case scenario would represent a maximum of 0.01 percent of total applied water. The comparisons provided in Table 1.ES-4 and Table 1.ES-5 demonstrate that the volumes of water needed by third-party producers to meet demands for clean renewable hydrogen across the SoCalGas service territory by 2045 represents a small percentage of total applied water in California. The volumes of water needed to meet the portion demand that would be served by Angeles Link would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

Considering the size of existing water needs and obligations throughout the state Table 1.ES-3), the representative portions of those quantities needed to meet clean renewable hydrogen demands (Table 1.ES-4) and Angeles Link throughput (Table 1.ES-5), and the extensive systems in place to make water supply available throughout the state (Part 2, *Supply Management in California*), third-party clean renewable hydrogen producers may draw upon a number of water supply sources for their respective development projects. This Water Availability Study identifies some of the different water source types that could potentially provide water supply for future production projects, as well as the mechanisms through which third-party producers may acquire various water sources.[5]

Table 1.ES-6, below, gives an overview of the water source types identified in this Water Availability Study as having potential to provide water supply for future clean renewable hydrogen projects developed by third-party producers. These source types are generally presented in descending order of anticipated size and potential

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[5] The water resources described in this study have been identified as potential resources for third-party clean renewable hydrogen producers to pursue to the extent that those resources have not already been acquired by hydrogen producers or other potential users that have projects further developed in the planning process.

for development. The various water supply sources for clean renewable hydrogen production include but are not necessarily limited to the source types presented below and detailed in Part 3, *Potential Water Supply Sources*.

Table 1.ES-6 Potential Water Supply Sources

Source Type	Overview
Imported Surface Water	Surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans (UWMPs), which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act (SGMA), to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater "banks," or aquifer storage and recovery (ASR) projects, may be used to facilitate a water supply exchange (see description provided in Table ES-7, *Potential Water Supply Acquisition Mechanisms*, for "Exchange Agreements").

Source Type	Overview
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: (i) agricultural field drainage; and (ii) wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to produce to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production. Water quality treatment of brine line flows would be needed to remove high concentrations of total dissolved solids (TDS) and other constituents.
Advanced Water Treatment Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine, or “concentrate.” This waste flow can be either recycled for reuse or treated for disposal. Concentrate from advanced water treatment that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.
Oil & Gas (O&G) Industry Water	O&G industry water from refinery offset water and/or produced water could be developed as a water supply source. Refinery offset water includes the water gained from the reduction or cessation of refinery operations, and could be developed as O&G operations are phased out in accordance with state goals and objectives. The amount of water per barrel of oil produced is expected to vary by refinery location, depending upon multiple factors including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately, produced water includes water brought to the surface along with oil and gas as a result of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.

Source Type	Overview
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans for management for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, as a result of low volume and velocity, these flows accumulate within the MS4 causing water quality concerns and potential violation of the MS4 operating permit (NPDES). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Table 1.ES-7, below, provides a summary of some potential water supply acquisition mechanisms for clean renewable hydrogen producers.

Table 1.ES-7 Potential Water Supply Acquisition Mechanisms

Acquisition Mechanism	Overview
Exchange Agreements	A water "exchange" is an agreement under which a water seller provides an amount of surplus water to a buyer and the buyer provides a replacement water supply in the same amount to the seller within the seller's service area or territory. An exchange agreement for clean renewable hydrogen production in Southern California would likely involve the SWP because imported surface water supplies comprise a substantial portion of Southern California's water supply portfolio and most water agency supplies are comprised at least in part of imported surface water. Groundwater banking using ASR (aquifer storage and recovery) techniques may be used to support an exchange agreement by providing necessary storage, particularly in desert areas.
Local Water Agencies (e.g., purchase available supply, develop partnerships for mutual benefit)	Water supply may be purchased from local water agencies drawing upon their locally available supplies such as imported surface water, sustainably managed groundwater, developed water such as treated wastewater, and surplus water from previous wet weather years that has been stored in water banks for future use. In addition, there may be opportunities for future clean renewable hydrogen producers to partner with local water agencies for mutual benefit, to develop new water supply source(s) for producers while relieving existing management challenges for agencies. For example, future supply source development could involve the collection and treatment of existing waste streams, removing the agency's burden of managing them. Local water agencies plan for and provide the amount of water they anticipate being needed within their respective service areas based upon population growth projections, land use planning and zoning, and project proposals submitted to the local land use agency. Urban Water Management Plans (UWMPs) are updated every five years with supply and demand projections. As future applications for clean renewable hydrogen projects are submitted to applicable planning departments, water agencies may consider them for inclusion in UWMP projections.

Acquisition Mechanism	Overview
Water Markets (e.g., adjudicated groundwater rights, wet weather surplus flows)	Water supplies could be accessed by contracts in water markets. For example, certain adjudicated groundwater basins have water markets that cover yearly or permanent water rights that can be purchased. Adjudicated groundwater basins are subject to the management direction of a court-ordered basin adjudication, administered by a court-designated Watermaster. In some adjudicated areas, unused allocations or surplus water supply is available for purchase through existing water markets, subject to review and approval of the Watermaster. In addition, wet weather surplus flows may be available for purchase from SWP contractors through existing water markets. Wet weather flows consist of surface water runoff that occurs during years of above-average precipitation, including snowpack. Wet weather flows can result in surplus flows, which consist of any supply available in excess of local demands.
Land Purchase with Water Rights	The purchase of land with certain attached water rights could allow the new landowner to use water associated with the attached rights for "reasonable and beneficial purposes." The availability of water rights associated with specific properties can be determined through review of property ownership records to confirm the type of right(s) associated with the subject property and that such rights were not previously severed from the subject property. Use of such water for clean renewable hydrogen production would be subject to other potential constraints, such as compliance with the Sustainable Groundwater Management Act (SGMA), which may require water rights holders to reduce their rates of groundwater production towards the common purpose of achieving and maintaining sustainable groundwater conditions while supporting existing uses (see Section 3.3, *Groundwater*).

Based on the review of the identified water sources and the potential supply acquisition mechanisms, this Water Availability Study makes the following key findings.

Key Findings

- The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean renewable hydrogen to meet 2045 demand across SoCalGas's service territory comprises a small percentage (0.02 to 0.10 percent) of total annual applied water in California for urban (M&I), agricultural, and environmental purposes.

- Third-party clean renewable hydrogen producers may draw from a number of water supply sources to meet the water needs to produce the clean renewable hydrogen to meet the overall expected SoCalGas service territory demand and the portion of that demand that would be transported by Angeles Link.
- The water supply sources identified in Part 3 of this chapter may be considered by third- party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects to produce the clean renewable hydrogen to meet the overall service territory demand, including expected Angeles Link throughput.
- A substantial portion of water needs for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. New supply sources may also be developed to support clean renewable hydrogen production projects.
- Shifting water needs and obligations may change over time as uses for water in the state evolve and may present opportunities for new water supply development, such as but not limited to water offset from reduced oil and gas operations, additional storage and banking, expanded wastewater treatment, and increased desalination. These shifts will be documented in water supply providers' UWMP updates, which occur every five years and include projections of the water needs and supply availability within the respective UWMP area over a 20-year planning horizon.
- The potential water supply sources available to feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details on specific clean renewable hydrogen production projects are developed.

Part 1: Introduction and Background

1.1 Angeles Link

This Water Availability Study has been prepared as part of the WRE being prepared in support of Angeles Link proposed by Southern California Gas Company (SoCalGas).

1.1.1 Overview

Angeles Link is envisioned as a non-discriminatory pipeline system that is dedicated to public use and aims to facilitate transportation of clean renewable hydrogen from multiple regional third-party production sources and storage sites to various end users in Central and Southern California, including the Los Angeles Basin. Angeles Link is intended to serve difficult-to-electrify sectors, including power generation, mobility, and industrial uses.

1.2 Water Needs for Clean Renewable Hydrogen

This section identifies water needs to produce clean renewable hydrogen in amounts sufficient to meet demand throughout SoCalGas's service territory, as well as to meet the portion of expected demand that would be served by Angeles Link, also referred to as "throughput." While SoCalGas would not produce clean renewable hydrogen as part of Angeles Link, SoCalGas would implement Angeles Link to transport clean renewable hydrogen produced by third parties. Under separate Phase 1 feasibility analyses for Angeles Link, a Demand Study was prepared to define potential demand scenarios for clean renewable hydrogen by 2045 in SoCalGas's service territory.

The Demand Study identified a range of scenarios from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year. Within this overall demand, throughput for the Angeles Link system would be approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/Year under a high case scenario.[6] The following tables quantify water needs for each scenario defined in the Demand Study, as follows:

- Table 1-1 provides an overview of water needs for clean renewable hydrogen demand throughout SoCalGas's service territory, and

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[6] The Demand Study also identified a moderate demand scenario of 3.2 MMT/Year in SoCalGas's service territory by 2045. Angeles Link also has a medium case scenario of throughput of 1.00 MMT/Y. For purposes of the feasibility analysis in this Study, this Study analyzes potential water demands for the low and high ranges of the Demand Study (1.9 to 5.9 MMT/Y) and low and high ranges of the proposed Angeles Link throughput (0.5 to 1.5 MMT/Y).

- Table 1-2 provides an overview of water needs for the Angeles Link throughput portion of clean renewable hydrogen demand.

Additional details on the water needs for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion (Chapter 3) of the WRE.[7]

Table 1-1 Water Needs: SoCalGas Service Territory Demands

Demand Scenario	Clean Renewable Hydrogen Demand (MMT/Year)[1]	Water Needs (AFY)[1,2]	Water Needs (MGD)[1, 2]
Low Demand	1.9	20,900	18.7
High Demand	5.9	64,700	57.8

[1] MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

While the table above shows water needs for clean renewable hydrogen demand throughout SoCalGas's service territory, Table 1-2, below, shows water needs for the Angeles Link throughput portion of that overall demand.

Table 1-2 Water Needs: Angeles Link Throughput

Throughput Scenario	Clean Renewable Hydrogen Throughput (MMT/Year)[1]	Water Needs (AFY)[1,2]	Water Needs (MGD)[1, 2]
Low Case	0.5	5,500	4.9
High Case	1.5	16,500	14.7

[1] MMT/year = million metric of tons per year; AFY = acre-feet per year; MGD = million gallons per day.

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

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[7] Additional details on the water demand estimates required for clean renewable hydrogen production are provided in the acquisition and purification cost estimate portion (Chapter 3) of the WRE. Water needs calculations assume all clean renewable hydrogen assessed herein would be electrolytic hydrogen, i.e. produced using electrolyzers. Water needs would decrease if other sources of clean renewable hydrogen are produced and conveyed to meet demand.

As added context for the volumes of water needed to produce clean renewable hydrogen for the identified expected demand, Table 1-3 quantifies applied water use rates throughout California, which are compared to clean renewable hydrogen water needs in the SoCalGas service area. Table 1-4 presents this information in comparison to the Angeles Link expected throughput. “Applied water” refers to the volume of water provided for use in the urban (municipal and industrial, or “M&I”) and agricultural sectors, and dedicated for use in the environmental sector, and varies annually depending upon demand and climatic conditions. Applied water totals were determined through research and consideration of usage reported to the State by numerous agencies throughout California between 1998 and 2018 (PPIC 2023c). This 20-year timeframe included periods of varying drought intensity, and is therefore considered representative of typical climatic conditions; totals are provided for dry year (drought) conditions and wet year (surplus) conditions, representing climatic variations over the 20-year timeframe.

Table 1-3 Average Annual Applied Water in California

Sector	Dry Year (AFY)[2]	Wet Year (AFY)[2]
Urban[1]	7,000,000 (12%)	8,000,000 (8%)
Agriculture	33,000,000 (53%)	30,000,000 (29%)
Environment	22,000,000 (35%)	65,000,000 (62%)
Total	**62,000,000**	**103,000,000**

[1] The Urban sector, also referred to as “Municipal and Industrial” (M&I) includes commercial, industrial, and residential uses.

[2] The values shown in parentheses indicate the percentage of total applied water use represented by the respective sector.

Source: PPIC 2023a

The table above shows that under both dry year and wet year conditions, the Urban sector receives the least amount of applied water, while the Agriculture sector receives the most applied water under dry year conditions, and the Environment sector receives the most under wet year conditions.

Table 1-4 Water for SoCalGas Service Territory Demand vs Statewide Applied Water

Demand Scenarios	Water Needs for Production (AFY)[1,2]	Dry Year Applied Water (62 MAFY)[3]	Wet Year Applied Water (103 MAFY)[3]
Low Demand	20,900	0.03%	0.02%
High Demand	64,700	0.10%	0.06%

[1] AFY = acre-feet per year

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

[3] MAFY = million acre-feet per year; Source: PPIC 2023a

As shown in the table above, total applied water in California averaged 62 MAFY under dry year conditions, invlusive of all three sectors (urban, agricultural, and environmental), and 103 MAFY under wet year conditions. In comparison, water needs for the High Demand scenario for clean renewable hydrogen throughout SoCalGas's service territory represent a maximum of 0.10 percent of total applied water in California, while the Low Demand scenario represents a maximum of 0.03 percent of total applied water. The table below provides comparison between applied water use rates and water needs for the expected Angeles Link throughput portion of overall demand.

Table 1-5 Water for Angeles Link Throughput vs Statewide Applied Water

Angeles Link Throughput Scenarios	Water Needs for Throughput (AFY)[1,2]	Dry Year Applied Water (62 MAFY)[3]	Wet Year Applied Water (103 MAFY)[3]
Low case scenario	5,500	0.01%	< 0.01%
High case scenario	16,500	0.03%	0.02%

[1] AFY = acre-feet per year

[2] Includes the water needs for hydrogen production electrolyzers, electrolyzer cooling, and water treatment.

[3] MAFY = million acre-feet per year; Source: PPIC 2023a

Table 1-5, above, shows that for the Angeles Link throughput portion of total clean renewable hydrogen demand, water needs for the High Case scenario would represent a maximum of 0.03 percent of total applied water in California, while the Low Case scenario would represent a maximum of 0.01 percent of total applied water. The comparisons provided in Table 1-4 and Table 1-5 demonstrate that the volumes of water needed by third-party producers to meet demands for clean renewable hydrogen across the SoCalGas service territory by 2045 represent small percentages of total applied water in California. The volumes of water needed for the Angeles Link throughput scenarios would be even smaller, with the Low Case scenario needs under wet year conditions representing less than 0.01 percent of total applied water.

1.3 Approach to Analysis for this Water Availability Study

1.3.1 Study Areas

This study area was selected to provide a reasonable basis to evaluate potential water resource availability for the clean renewable hydrogen production that could utilize Angeles Link. The study area for this Water Availability Study includes SoCalGas's service territory as well as other geographic areas to include opportunities third-party producers may pursue to develop and wheel water to areas where it is needed. Figure 1-1, below, provides an overview of SoCalGas' service territory, which represents the primary extent of the study area for this Water

Availability Study, as well as select resources located outside SoCalGas's service territory based upon resource-specific features.[8]

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[8] The separate Angeles Link Phase 1 feasibility analysis Production Planning & Assessment (Production Study) identified the San Joaquin Valley, areas around the City of Lancaster, and areas around the City of Blythe as potential areas for third-party clean renewable hydrogen production projects within SoCalGas's service territory. The Water Resources Evaluation, including this Chapter encompassing the Water Availability Study, does not evaluate water availability in those specific geographic areas. The Water Resources Evaluation instead identifies potential sources of water for clean renewable hydrogen generation that third-party producers may draw upon to evaluate on a case-by-case basis when details of specific production projects develop further.

Figure 1-1 SoCalGas Service Territory

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22-13179 EPS
Fig X SCG Service Territory Map

The resources located outside of SoCalGas's service territory that are included in this Water Availability Study consist of the following:

- Existing wastewater treatment facilities in the San Joaquin Valley just north of SoCalGas's service territory are considered for the potential for treated effluent to be acquired as a water supply source (see Section 3.2, *Treated Wastewater*).
- The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program, also located in the San Joaquin Valley, is considered in this study as relevant to brackish groundwater as a potential supply source (see Section 3.8.1, *Brackish Plumes*).
- Treated effluent from Encina Wastewater Authority's (EWA) facilities in San Diego County, along the southern boundary of SoCalGas's service territory, is considered for potential acquisition through an exchange agreement (see Part 4, *Mechanisms of Supply Acquisition*).

Considerations associated with water supply conveyance and treatment are addressed in separate chapters of the WRE, including Chapter 2, *Water Quality Requirements*, Chapter 3, *Acquisition and Purification Costs,* and Chapter 4, *Challenges and Opportunities.* In addition, Chapter 5, *Supplemental Desktop Analysis*, is provided to address GHG emissions associated with water treatment and conveyance.

1.3.2 Review of Previous Feasibility Analysis

In 2021, SoCalGas commissioned SPEC Services (SPEC) to prepare a series of pre-feasibility studies to assess the potential for large-scale development of hydrogen infrastructure in California. As part of the 2021 SPEC studies, Rincon Consultants, Inc. prepared a preliminary evaluation of potential water supply sources, referred to as the "2021 SPEC water study." The Water Availability Study presented herein was informed by the 2021 SPEC water study, and expands upon that study's approach, content, and findings as applicable for the purposes of Angeles Link Phase 1.

This Water Availability Study builds upon the 2021 SPEC water study through use of an expanded study area, and through outreach with public water agencies. First, the study area used in the 2021 SPEC water study focused on certain identified production hub regions within SoCalGas's service territory where it was anticipated that clean renewable hydrogen production projects would be concentrated. In comparison, this Water Availability Study did not limit potential water sources to anticipated hub regions; rather, as noted in Section 1.4.1, *Study Area*, this Water Availability Study considers SoCalGas's entire service territory as well as select potential sources that are located outside the service territory but may have potential to provide water supply for clean renewable hydrogen production. As a result, this Water Availability Study identifies a different range of potential water supply sources than were previously considered in the pre-feasibility analyses including the 2021 SPEC water study.

Second, preparation of the 2021 SPEC water study did not involve direct inquiries to public agencies or water providers. In comparison, this Water Availability Study involved direct inquiries to certain water managers and agencies throughout the study area to inform characterization of the types and extent of water source(s) that could be available for clean renewable hydrogen development (see Section 1.4.5, *Agency Outreach*).

1.3.3 Review of Planning Documents and Other Studies

To support the Water Availability Study, applicable state-required land use and water supply planning documents were collected and reviewed, including: Urban Water Management Plans (UWMPs) which are required of supply providers with 3,000 or more service connections or delivering 3,000 AFY or more of water; Groundwater Sustainability Plans (GSPs) addressing individual groundwater basins for compliance with the Sustainable Groundwater Management Act (SGMA) (see Section 3.3, *Groundwater*); and the California Water Plan maintained by the California Department of Water Resources (DWR) to plan for and provide for the sustainable management of water resources throughout the state.

Future clean renewable hydrogen projects that would utilize Angeles Link have not yet been developed, and associated water needs are therefore not considered in the aforementioned water supply planning documents. However, as future clean renewable hydrogen projects are proposed via applications submitted to the respective land use agencies, associated water needs will be incorporated into the applicable water supply planning and management documents, including through coordination between future producers and water managers.

Other existing studies and literature related to water resources and hydrogen production in California were reviewed for the purposes of this Water Availability Study. One study included the HyBuild Los Angeles Phase 2 Report (“HyBuild LA Report”) prepared by the Green Hydrogen Coalition (GHC) for its proposed HyBuild Los Angeles (HyBuild LA) initiative. The GHC is an educational non-profit organization established in 2019 that operates under a mission to “facilitate policies to advance the production and use of green hydrogen at scale in all sectors where it will accelerate the transition to a carbon free energy system” (GHC 2023a). The HyBuild LA initiative is part of GHC’s HyBuild North America platform, which it created to launch green hydrogen ecosystems across North America (GHC 2023b).

The GHC partnered with the Pacific Northwest National Laboratory (PNNL) to evaluate water needs and supply availability for the HyBuild LA initiative and to develop the HyBuild LA Report. The PNNL evaluated water for the proposed scale of the HyBuild LA green hydrogen system plan, as well as potential for green ammonia due to stakeholder feedback seeking to understand the process requirements of a potential green ammonia industry. The HyBuild LA Report determined that water needs for green hydrogen and green ammonia production could be met using recycled or repurposed water sources, including wastewater recycled from other sectors and repurposed water currently used in the local oil and gas sectors. (GHC 2023a)

Another study reviewed was a 2019 market briefing from IHS Markit Ltd, which merged with S&P Global in 2022, entitled, “Hydrogen in the Golden State – Implications for Water.” The market briefing stated that “local water deliveries” are the largest source of water supply in California; “local water deliveries” is water provided by local water agencies, typically sourced from precipitation stored in reservoirs for use throughout the year (IHS Markit 2019). The IHS Markit briefing further stated that groundwater is “the swing source” of water supply during dry years, but acknowledges that groundwater is also “difficult to replenish relative to the historical rate of withdrawals” and, with implementation of SGMA, “less groundwater may be available during dry years than what has historically been used” (IHS Markit 2019).

In addition, IHS Markit discussed water consumption declines anticipated to occur in other industries as California moves to decarbonized conditions and suggests that those declines in other industries could create water availability for clean renewable hydrogen production. The specific activities that are anticipated to decline by 2050, thereby freeing up water supply, include: refining gasoline and diesel, oil production, and thermal power generation, all of which are anticipated to cease in a “deeply decarbonized California” (IHS Markit 2019).

1.3.4 Agency Outreach

The approach to this Water Availability Study involved conducting initial outreach with water agencies and regional water suppliers within the study area. Agencies for initial outreach were identified based upon location, size, and existing facility ownership and operations. Facilities were identified through review of regulatory permit records for facilities that treat municipal and industrial wastewater within the study area. Agency contact was first made electronically via introductory emails containing an overview of Angeles Link and the Phase 1 feasibility studies.

Virtual meetings were conducted with responding parties including the Metropolitan Water District of Southern California (“Metropolitan”), which serves 26 member agencies including cities, municipal water districts, and one county water authority. Metropolitan member agencies deliver water supply to 19 million people throughout the study area including within Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. Virtual meetings were also held with Encina Wastewater Authority (EWA), Los Angeles Department of Water and Power (LADWP), Orange County Sanitation District (OC-San), and Santa Ana Watershed Protection Authority (SAWPA). The virtual meetings included discussion of the respective parties’ water supply sources, programs, and facilities, as well as potential opportunities for the development of water supply sources for clean renewable hydrogen production.

In response to outreach efforts, on October 17, 2023, Metropolitan provided a letter to SoCalGas expressing concerns about climate change and willingness to partner on the production of green energy. The letter included the following statements (Metropolitan 2023e):

- Metropolitan has historically been open to collaboration and negotiations with other water agencies and stakeholders within California to manage water resources effectively. Metropolitan has participated in water transfers, exchanges, and agreements with other agencies and regions to address water supply challenges, especially during periods of drought or when water demand is high.
- Out-of-region water exchanges can involve Metropolitan obtaining water from sources outside of its immediate service area in California. The specifics of these exchanges can vary depending on the agreements and arrangements in place at any given time.
- Metropolitan is willing to work with SoCalGas on exchanges either on the Colorado River or the State Water Project.[9] In these arrangements, SoCalGas would pay into or directly produce new supplies of water that directly benefit Metropolitan's service area, and then exchange the new supplies for out-of-region imported water supplies. Quantification of a proposed exchange would depend upon case-by-case evaluation of the potential benefit of the proposed exchange to the Southern California region's well-being and water supply security.

Input received from water agencies and managers informed the identification of potential supply sources presented in Part 3, *Potential Water Supply Sources*.

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[9] The letter from Metropolitan refers to SoCalGas as the party potentially pursuing water supply development. As noted earlier in this Water Availability Study, SoCalGas would not be developing water supplies for Angeles Link, as third-party producers would produce the clean renewable hydrogen that Angeles Link would convey. SoCalGas conducted agency outreach for informational purposes to support the analysis in this study.

Part 2: Supply Management in California

Water supply management in California involves oversight by multiple regulatory agencies, as well as numerous applicable laws and regulations, with federal, state, and local agencies responsible for various permits and authorizations. This background section is provided to inform discussion of potential water supply sources for clean renewable hydrogen production.

2.1 Regulatory Agencies

Key agencies and entities involved in the management and regulation of water supply in California are identified in Table 1-6, below, and include entities on the federal, state, and local levels.

Table 1-6 Key Agencies & Entities – California Water Supply

Name	Overview
Federal	
U.S. Army Corps of Engineers (USACE)	The USACE regulates discharge of dredge or fill material into waters of the United States under Section 404 of the Clean Water Act (CWA). "Waters of the United States" is used as a threshold term in the CWA to define the geographic scope of federal jurisdiction of waterways. The U.S. Environmental Protection Agency (USEPA) and the USACE have authority to define the limits of navigable waters in regulations.
U.S. Bureau of Reclamation (USBR)	The USBR is part of the U.S. Department of Interior and operates federal water projects including dams and canals. In California, the USBR manages the Central Valley Project (CVP), which was constructed in the 1930s to transport water from Northern California to Central California. The California Department of Water Resources (DWR) administers long-term water supply contracts to CVP contractors. The USBR also manages most of the Colorado River's water supply allocations to California and issues water contracts to Colorado River Entitlement Holders. The CVP and Colorado River are discussed in Section 2.3, *Key Water Supply Projects.*

Name	Overview
State	
California Coastal Commission (CCC)	The CCC regulates the use of land and water in the coastal zone through implementation of the Coastal Act. A coastal permit is generally required from the CCC for development activities including construction of buildings, divisions of land, and activities that change the intensity of use of land or public access to coastal waters.
California Department of Water Resources (DWR)	The DWR oversees water resources planning, regulates groundwater, reviews water agency groundwater and water supply planning documents, and operates the state's water storage and supply systems. The DWR operates the State Water Project (SWP), which supplies water from the Sacramento-San Joaquin River Delta in Northern California to SWP contractors in Central and Southern California. The State Water Resources Control Board (SWRCB) reports that two-thirds of Californians receive water supply from the SWP; as discussed below, whereas DWR is responsible for water supply, the SWRCB is responsible for water rights and quality.
California Environmental Protection Agency (CalEPA)	CalEPA is the state's regulatory agency that enforces pollution control laws, including water pollution, and oversees six other state agencies, including the State Water Resources Control Board (SWRCB). CalEPA is one of the three agencies tasked with developing California's Water Resilience Portfolio.
California Natural Resources Agency (CNRA)	The CNRA oversees several state entities including DWR and the California Water Commission and is one of the three agencies tasked with developing California's Water Resilience Portfolio. The purpose of the CNRA is to support regional water resilience, including through drought and flood conditions.
California Water Commission	The California Water Commission advises DWR on water planning and management priority, approves all DWR rules and regulations, and advises DWR on SWP operations based upon annual reviews. It also administers the *Water Storage Investment Program* to fund water storage projects. In 2022, the California Water Commission developed a white paper on how the state can support the development of well-managed groundwater trading programs with appropriate safeguards for vulnerable water users (CWC 2022). The California Water Commission is currently assessing the state's role in financing conveyance projects in support of the Water Resilience Portfolio.

Name	Overview
Colorado River Board (CRB) of California	The CRB of California was established in 1937 to protect California's rights and interests in the resources provided by the Colorado River and to represent California in discussions and negotiations regarding the Colorado River and its management. Seven counties in Southern California receive water and hydroelectric energy from the Colorado River. Colorado River water is used for drinking water by over 19 million people in Southern California and irrigates over 600,000 acres of agricultural lands that produce fruits, vegetables, and other crops that help feed our nation's families (CRBC 2023a).
Geologic Energy Management Division (CalGEM)	CalGEM, formerly the Division of Oil, Gas, and Geothermal Resources (DOGGR), oversees the drilling, operation, maintenance, and plugging and abandonment of oil, natural gas, and geothermal energy wells in California.
SWRCB and Regional Water Quality Control Boards (RWQCBs)	Under the federal CWA and the state's *Porter-Cologne Water Quality Control Act,* the SWRCB and its nine RWQCBs have regulatory authority over surface water rights and water quality in California. Each RWQCB maintains a Water Quality Control Plan (Basin Plan) and is responsible for issuing discharge permits and enforcing water quality regulations. The SWRCB Division of Water Rights oversees water transfers in California under the Water Transfers Program, which covers both temporary (less than one year, Water Code Section 1725) and long-term exchanges (more than one year, Water Code Section 1735).
Local	
Groundwater Sustainability Agencies (GSAs)	A GSA may be a single agency, a group of agencies operating under a Memorandum of Understanding (MOU), or a Joint Powers Authority (JPA) comprised of multiple agencies which form a separate legal entity. The Sustainable Groundwater Management Act (SGMA) requires that GSAs are formed by local public agencies; private water companies are only represented in a GSA when partnered with a public agency. SGMA further mandates that each delineated groundwater basin that is subject to SGMA has a DWR-approved GSA for management.

Name	Overview
Metropolitan Water District of Southern California (Metropolitan)	Metropolitan serves 26 public water agencies including cities, municipal water districts and one county water authority that deliver supplies directly or indirectly to 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura counties. Metropolitan has imported water from the Colorado River since 1941 and from Northern California via the State Water Project (SWP) since the early 1970s. Metropolitan is the largest single contractor of the SWP and a major supporter of Southern California water conservation and water recycling programs, along with other local water management activities (Metropolitan 2023d).
Watermasters	A Watermaster is responsible for overseeing the administration of water rights within an adjudicated groundwater basin and, when necessary, for taking enforcement action related to compliance of water users with the adjudication judgment for the respective groundwater basin.
Other local entities	Other local entities include water agencies, irrigation districts, sanitation districts, wastewater treatment providers, water rights holders, and others.

Sources: USBR 2023a; DWR 2022a; WEF 2023a, 2023b

The federal, state, and local entities identified above reflect those which are specifically involved in California water supply planning and management, as relevant to this Water Availability Study.

2.2 Laws and Regulations

Laws and regulations addressing the management and regulation of water supply in California, including related plans, programs and policies where relevant, are presented in Table 1-7, below.

Table 1-7 Water Supply Laws, Regulations, Policies, and Associated Plans and Programs

Name	Overview
California Code of Regulations (CCR)	CCR Title 22 includes the state guidelines for how treated/recycled water is used and discharged. Title 22 defines approved uses for recycled water by treatment level including: ▪ 40 uses for disinfected tertiary recycled water (ex., irrigating parks), ▪ 24 uses for disinfected secondary recycled water (ex., irrigating animal feed), and ▪ Seven uses for undisinfected secondary recycled water (ex., industrial uses). The SWRCB is responsible for permitting recycled water projects and approving Title 22 engineering reports for proposed uses, ensuring consistency with the Title 22 approved uses.
California Water Code (CWC)	The CWC determines the limits of waters of the state and regulates discharges to state waters. CWC Division 2 (Water) requires a water right for any water taken from a lake, river, stream, or creek, or from groundwater; the SWRCB is the only agency with authority to administer water rights. New uses of existing surface water resources require approval of a water right license from the SWRCB. Groundwater rights do not specially require a license; groundwater is regulated by local entities such as local water agencies, districts, and GSAs.
California Water Plan ("Water Plan")	The Water Plan is a strategic plan designed to manage and develop water resources in a manner that is both sustainable and equitable. The Water Plan is maintained by the DWR in accordance with CWC Section 10005(a). It is updated every 5 years and has most recently been updated for 2023 (DWR 2023e). Key information included in the Water Plan includes: ▪ Status and trends for water-dependent natural resources, water supplies, and agricultural, urban, and environmental demands (see Section 2.6, *Existing Demands & Regulations*). ▪ Recommended actions, funding sources, and an investment strategy for responding to water supply challenges including declining groundwater levels and unreliable water supplies. ▪ Assessment of challenges and opportunities related to climate change including droughts and floods, rising temperatures, declining fish populations, and groundwater overdraft.

Name	Overview
California Water Resilience Portfolio (WRP)	The California WRP is prepared and updated by the CNRA, CalEPA, and California Department of Food and Agriculture (CDFA) in response to Executive Order (EO) N-10-19. This EO requires state agencies to plan response actions for effects of climate change while ensuring the availability of clean and reliable water supplies to meet demands. The WRP directly informs the California Water Plan, described above. It identifies goals and management actions associated with water supply diversification, supply reliability, and infrastructure needs for storage, conveyance, flood protection, and recharge, among other related factors.
California Water Supply Strategy (WSS)	The WSS was prepared in 2022 By the State of California, including the state's Natural Resources Agency, DWR, Water Boards, Environmental Protection Agency (EPA), and Department of Food & Agriculture. The purpose of the WSS was to update the WRP (see above) based on new data and accelerating climate change, which is projected to reduce California's water supplies by 10 percent over the next 20 years, or approximately 450,000 acre-feet per year (AFY), for a total of up to nine million acre-feet (MAF). The WSS (and WRP, as updated) identify the following strategies to respond to this anticipated water loss (CNRA et al 2022): 1) Create 4.0 MAF of new storage space, 500,000 AFY of additional groundwater recharge, 250,000 AFY of new stormwater capture by 2030 and 500,000 AFY by 2040. 2) Recycle and reuse at least 800,000 AFY by 2030 and 1.8 MAF by 2040. 3) Reduce water use by at least 500,000 AFY through efficiency and conservation. 4) Increase brackish groundwater desalination by 28,000 AFY by 2030 and 84,000 AFY by 2040.
California Recycled Water Policy/ Water Recycling Policy	The SWRCB's Water Recycling Policy was established in 2019 and requires local water and wastewater stakeholders to develop Salt and Nutrient Management Plans (SNMPs) to promote basin-wide management of salts and nutrients in groundwater. Many groundwater basins contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the Basin Plans. The purpose of the SNMPs is to identify all sources of salts and nutrients in groundwater basins and manage them in a manner that preserves, enhances, and restores the quality of groundwater for drinking and other beneficial uses (SWRCB 2023a, SWRCB 2023b). Many SNMPs identify use of recycled water for groundwater recharge to manage salt and nutrient levels.

Name	Overview
CARB 2022 Scoping Plan	In 2006, the Legislature passed the California Global Warming Solutions Act of 2006 (Assembly Bill 32), which created a multi-year program to reduce greenhouse gas emissions in California. The CARB 2022 Scoping Plan lays out a path to achieve targets for carbon neutrality and reduce anthropogenic greenhouse gas emissions by 85 percent below 1990 levels no later than 2045, as directed by Assembly Bill 1279 (CARB 2022). The CARB 2022 Scoping Plan targets phaseout of fossil fuel production to meet the state's carbon neutrality goals.
California Senate Bill (SB) 100	SB 100, officially titled the "100 Percent Clean Energy Act of 2018," mandates the state of California to achieve 100 percent clean, carbon-free electricity by 2045. SB 100 sets interim targets of 50 percent renewable energy by 2026 and 60 percent by 2030. SB 100 builds on previous legislation, including the Renewables Portfolio Standard (RPS), presented above, to accelerate the transition to renewable energy sources like wind, solar, and geothermal. SB 100 aims to reduce GHG emissions, combat climate change, and promote public health and environmental sustainability. It also encourages innovation and investment in clean energy technologies and infrastructure.

Name	Overview
Sustainable Groundwater Management Act (SGMA)	Established in September 2014 as part of California Water Code, SGMA provides a framework for local groundwater management. The purpose of SGMA is for local agencies and stakeholders to coordinate groundwater management. Many of California's groundwater basins are in overdraft, which occurs when groundwater extraction exceeds recharge which leads to a decline in groundwater levels. SGMA requires local agencies to reverse groundwater overdraft and sustainably manage groundwater resources by ensuring groundwater extraction no longer exceeds recharge (DWR 2023d). SGMA requires local agencies to form Groundwater Sustainability Agencies (GSAs), who are responsible for management of local groundwater. GSAs are required to adopt and implement Groundwater Sustainability Plans (GSPs), and bring overdrafted basins into balanced levels of pumping and recharge within the timelines established by SGMA. GSPs include an assessment of existing groundwater conditions, identify existing uses of groundwater, and identify management actions and water projects needed to achieve sustainable groundwater conditions (DWR 2023d). Successful management requires DWR approval of a GSP for each basin, and proven accomplishment of specific sustainability goals to reverse overdraft and create sustainable groundwater conditions by 2040. The purpose of this is to facilitate local groundwater management and sustainable groundwater conditions throughout the state.
Urban Water Management Planning Act	This Act requires preparation of an Urban Water Management Plan (UWMP) by every water supplier that serves more than 3,000 urban connections or delivers 3,000 AFY or more of water. Each UWMP characterizes existing and anticipated water needs and available supplies and identifies projects to improve supply reliability.

Name	Overview
Waste Discharge Requirements (WDR) Program	The WDR program regulates wastewater that is discharged to land, with core program areas including but not limited to: agricultural uses, Aquifer Storage and Recovery (ASR), treated groundwater from cleanup operations, and recycled water. WDRs protect surface water by prescribing requirements for discharge to waters that are not federally jurisdictional waters of the U.S., which are addressed under the National Pollutant Discharge Elimination System (NPDES) Program. WDRs also protect groundwater by prescribing waste containment, treatment, and control requirements. The NPDES program regulates wastewater that is discharged from point sources to navigable water, which refers to federally jurisdictional waters of the U.S. "Waters of the United States" is used as a threshold term in the federal CWA to define the geographic scope of federal jurisdiction of waterways and give authority to the U.S. Environmental Protection Agency (USEPA) and the USACE to define the limits of these waters in regulations.

2.3 Key Water Supply Projects

There are three projects in California that provide imported surface water supplies throughout the state, including the SWP, the Colorado River, and the Central Valley Project (CVP). Each of these projects is described in respective sections below. This information is presented to inform discussion of potential exchange agreements which are a mechanism to supply water within SoCalGas's service territory. Exchange agreements are discussed further in Part 4, *Mechanisms for Supply Acquisition,* in Section 4.1, *Exchange Agreements.* In addition, Part 3, *Potential Water Supply Sources,* describes how each of the imported surface water projects described herein provide water within SoCalGas's service territory; see Section 3.1, *Imported Surface Water in the Study Area*.

2.3.1 State Water Project

The SWP is a conveyance system that provides surface water from the Feather River watershed and Central Valley runoff to SWP contractors in Southern California. Specifically, the SWP diverts water from the Feather River in Sacramento County. There are four main tributaries to the Feather River, including the South Fork, Middle Fork, North Fork, and West Branch, which converge approximately one mile upstream of Lake Oroville to form the main stem of Feather River (DWR 2023b). Lake Oroville is located in the foothills of the western Sierra Nevada, and receives snowmelt from the Sierra Nevada via the four tributaries of Feather River north of Oroville Dam. Figure 1-2, below, provides an overview of the SWP system.

Figure 1-2 State Water Project Overview

Source: DWR 2023d

The SWP conveys water from the Feather River watershed through the Sacramento-San Joaquin River Delta (Delta) to SWP contractors in Central and Southern California. The Delta is formed by the Sacramento River flowing south to meet the north-flowing San Joaquin River just south of Sacramento, where the rivers mingle with smaller tributaries and tidal flows (WEF 2023c). Freshwater from the rivers flows through the Carquinez Strait, a narrow break in the Coast Range, into San Francisco Bay's northern arm to form the Bay Delta (WEF 2023c). Brackish water forms a marshy transition area between the freshwater of the rivers and the salt water of the ocean. The extent of the brackish transition area depends upon climatic conditions and is annually variable.

The figure below shows that south of the Delta, SWP water is conveyed via pipelines, aqueducts, and reservoirs; specifically, this figure shows a SWP aqueduct/pipeline (the California Aqueduct) extending south from the Delta to San Luis Reservoir, where a “joint-use” aqueduct referred to as the San Luis Canal (SLC) continues south. The SLC conveys water for both the California SWP and the federal CVP, transitioning back to the state-only California Aqueduct in the southern portion of the San Joaquin Valley. The 444-mile-long California Aqueduct (including the joint-use SLC portion) conveys SWP water into Southern California, with several branches of the California Aqueduct conveying SWP water throughout SoCalGas’s service territory.

Section 3.1, *Imported Surface Water in the Study Area*, provided in Part 3, *Potential Water Supply Sources,* discusses SWP water as a potential water supply source throughout SoCalGas’s service territory; see Section 3.1.1, *SWP Water*, for detailed discussion of SWP conditions within SoCalGas’s service territory.

SWP Contractors and Allocations

Water in the SWP system is fully allocated to 29 contractors, which are public agencies that distribute SWP water to other agencies and individual connections in their service territories. The maximum amount of SWP water that each SWP contractor may receive in a given year is referred to as “Table A” water; Table 1-8, below, provides an overview of Table A allocations per contractor.

Table 1-8 SWP Contractors and Table A Allocations[1]

SWP Water Contractor	Table A Allocation (AFY)
Feather River Region	
County of Butte	27,500
Plumas County FC&WCD	2,700
City of Yuba City	9,650
Subtotal	**39,850**
North Bay Region	
Napa County FC&WCD	29,025
Solano County WA	47,756
Subtotal	**76,781**
South Bay Region	
Alameda County FC&WCD	80,619
Alameda County WD	42,000
Santa Clara Valley WD	100,000
Subtotal	**222,619**

SWP Water Contractor	Table A Allocation (AFY)
San Joaquin Valley Region	
Oak Flat WD	5,700
County of Kings	9,305
Dudley Ridge WD	41,350
Empire West Side ID	3,000
Kern County WA	982,730
Tulare Lake Basin WSD	87,471
Subtotal	**1,129,556**
Central Coastal Region	
San Luis Obispo County FC&WCD	25,000
Santa Barbara County FC&WCD	45,486
Subtotal	**70,486**
Southern California Region	
Antelope Valley-East Kern WA	144,844
Santa Clarita Valley WA	95,200
Coachella Valley WD	138,350
Crestline-Lake Arrowhead WA	5,800
Desert WA	55,750
Littlerock Creek ID	2,300
Metropolitan	1,911,500
Mojave WA	89,800
Palmdale WD	21,300
San Bernardino Valley MWD	102,600
San Gabriel Valley MWD	28,800
San Gorgonio Pass WA	17,300
Ventura County WPD	20,000
Subtotal	**2,633,544**
Total	**4,172,836**

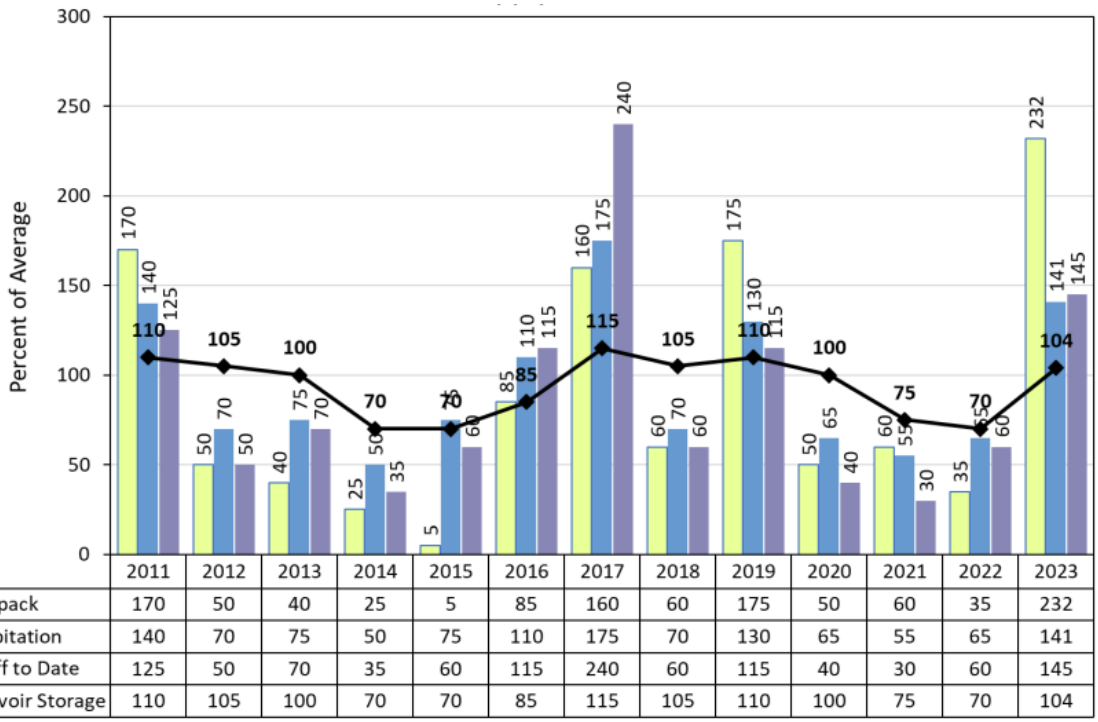
[1] AFY = Acre-Feet per Year; FC&WCD = Flood Control and Water Conservation District; ID = Irrigation District; MWD = Mutual Water District; WA = Water Agency; WD = Water District; WDSC = Water District of Southern California; WPD = Watershed Protection District

Source: DWR 2023c

The table above shows that Table A allocations total 4,172,836 AFY for all 29 SWP contractors; this is the maximum amount of water each contractor may receive through the SWP system each year. The amount of water that is physically available in the SWP system depends upon climatic and drought conditions, which affect rates of precipitation, size of the Sierra Nevada snowpack, and the rate and timing of snowmelt runoff to Lake Oroville. The DWR, which is responsible for operation of the SWP, notifies SWP contractors of the availability of SWP water throughout the year by issuing “Notices to SWP Long-Term Water Supply Contractors,” or “Notices to Contractors” (NTCs).

Each NTC provides timely updates on SWP operations, hydrologic conditions, water supply programs, fees and funding information, among other key information. Select NTCs also announce the portion of Table A allocations DWR is able to fulfill based on current hydrologic conditions, as a percentage of total Table A contracts. Drought conditions that affect the amount of water in storage or the amount of runoff anticipated as snowmelt result in contractors receiving a smaller portion of their Table A allocations, while normal water year conditions and wet-weather conditions result in full distribution of Table A allocations. Figure 1-3, *Statewide Hydrologic Conditions, 2011-2023*, below, portrays statewide hydrologic conditions for a 13-year period, 2011 through 2023, using the key indicators of precipitation, snowpack, runoff, and reservoir storage; this data is displayed as a percentage of average conditions, such that values below 100 are below average and those above 100 are above average (DWR 2023a, pg. 19).

Figure 1-3 Statewide Hydrologic Conditions, 2011-2023



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
🟨 Snowpack	170	50	40	25	5	85	160	60	175	50	60	35	232
🟦 Precipitation	140	70	75	50	75	110	175	70	130	65	55	65	141
🟪 Runoff to Date	125	50	70	35	60	115	240	60	115	40	30	60	145
◆ Reservoir Storage	110	105	100	70	70	85	115	105	110	100	75	70	104

Source: DWR 2023a, pg. 19

The figure above shows that between 2011 and 2023, the lowest and highest hydrologic conditions occurred in 2014 and 2017, respectively. During both water year 2014 and water year 2017, four NTCs were issued by DWR to SWP contractors with updated Table A fulfillment amounts, presented as percentages of total Table A contracted allocations.

The figure above also shows that water year 2022/2023 was characterized by unusually wet conditions compared to average; this resulted in a surplus of water supply available through the SWP system, which is discussed further in Part 4, *Mechanisms of Supply Acquisition*, Section 4.3.2, *Wet Weather Surplus Flows*. However, the amount of water in storage and being conveyed through the SWP system changes throughout the year, depending upon existing and projected hydrologic conditions in combination with infrastructure capacity. Despite the unusually wet 2022/2023 conditions, DWR projected that initial Table A contract fulfillments in 2024 would be just 10 percent of Table A allocations (DWR 2023l). This was due to precipitation in October/November of 2023 being only about half of average, which indicated a dry pattern through the end of 2023 and the beginning of 2024.

Table 1-9, below, provides an overview of NTCs issued during 2014, 2017, and 2023, representing the lowest hydrologic year, the highest hydrologic year, and the most recent complete water year from the historical period represented in Figure 1-3, above. This table is informed by 12 separate NTCs, consisting of four from each of the years 2014 (DWR 2014), 2017 (DWR 2017), 2023 (DWR 2023f, 2023g, 2023h), and 2024 (DWR 2023l). These NTCs announced Table A fulfillment amounts as percentages of total Table A contracted amounts under dry year conditions (2014), wet year conditions (2017), and current Conditions (2023).

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Table 1-9 Table A Fulfillment (AFY)[1] – Dry Year (2014), Wet Year (2017), and Current (2023)

		2014:[2]				2017:				2023:			
Note SWP Contractor	**Table A**	**5%**	**0%**	**5%**	**10%**	**20%**	**45%**	**60%**	**85%**	**30%**	**35%**	**75%**	**100%**
County of Butte	27,500	1,375	0	1,375	2,750	5,500	12,375	16,500	23,375	8,250	9,625	20,625	27,500
Plumas County FCWCD	2,700	135	0	135	270	540	1,215	1,620	2,295	810	945	2,025	2,700
City of Yuba City	9,650	483	0	483	965	1,930	4,343	5,790	8,203	2,895	3,378	7,238	9,650
Napa County FC&WCD	29,025	1,451	0	1,451	2,903	5,805	13,061	17,415	24,671	8,708	10,159	21,769	29,025
Solano County WA	47,756	2,388	0	2,388	4,776	9,551	21,490	28,654	40,593	14,327	16,715	35,817	47,756
Alameda County FCWCD	80,619	4,031	0	4,031	8,062	16,124	36,279	48,371	68,526	24,186	28,217	60,464	80,619
Alameda County WD	42,000	2,100	0	2,100	4,200	8,400	18,900	25,200	35,700	12,600	14,700	31,500	42,000
Santa Clara Valley WD	100,000	5,000	0	5,000	10,000	20,000	45,000	60,000	85,000	30,000	35,000	75,000	100,000
Oak Flat WD	5,700	285	0	285	570	1,140	2,565	3,420	4,845	1,710	1,995	4,275	5,700
County of Kings	9,305	465	0	465	931	1,861	4,187	5,583	7,909	2,792	3,257	6,979	9,305
Dudley Ridge WD	41,350	2,068	0	2,068	4,135	8,270	18,608	24,810	35,148	12,405	14,473	31,013	41,350
Empire West Side ID	3,000	150	0	150	300	600	1,350	1,800	2,550	900	1,050	2,250	3,000
Kern County WA	982,730	49,137	0	49,137	98,273	196,546	442,229	589,638	835,321	294,819	343,956	737,048	982,730
Tulare Lake Basin WSD	87,471	4,374	0	4,374	8,747	17,494	39,362	52,483	74,350	26,241	30,615	65,603	87,471
San Luis Obispo County FCWCD	25,000	1,250	0	1,250	2,500	5,000	11,250	15,000	21,250	7,500	8,750	18,750	25,000
Santa Barbara County FCWCD	45,486	2,274	0	2,274	4,549	9,097	20,469	27,292	38,663	13,646	15,920	34,115	45,486
Antelope Valley-East Kern WA	144,844	7,242	0	7,242	14,484	28,969	65,180	86,906	123,117	43,453	50,695	108,633	144,844
Santa Clarita Valley WA	95,200	4,760	0	4,760	9,520	19,040	42,840	57,120	80,920	28,560	33,320	71,400	95,200
Coachella Valley WD	138,350	6,918	0	6,918	13,835	27,670	62,258	83,010	117,598	41,505	48,423	103,763	138,350
Crestline-Lake Arrowhead WA	5,800	290	0	290	580	1,160	2,610	3,480	4,930	1,740	2,030	4,350	5,800
Desert WA	55,750	2,788	0	2,788	5,575	11,150	25,088	33,450	47,388	16,725	19,513	41,813	55,750
Littlerock Creek ID	2,300	115	0	115	230	460	1,035	1,380	1,955	690	805	1,725	2,300
Metropolitan	1,911,500	95,575	0	95,575	191,150	382,300	860,175	1,146,900	1,624,775	573,450	669,025	1,433,625	1,911,500
Mojave WA	89,800	4,490	0	4,490	8,980	17,960	40,410	53,880	76,330	26,940	31,430	67,350	89,800
Palmdale WD	21,300	1,065	0	1,065	2,130	4,260	9,585	12,780	18,105	6,390	7,455	15,975	21,300
San Bernardino Valley MWD	102,600	5,130	0	5,130	10,260	20,520	46,170	61,560	87,210	30,780	35,910	76,950	102,600
San Gabriel Valley MWD	28,800	1,440	0	1,440	2,880	5,760	12,960	17,280	24,480	8,640	10,080	21,600	28,800

		2014:[2]				2017:				2023:			
Note SWP Contractor	**Table A**	**5%**	**0%**	**5%**	**10%**	**20%**	**45%**	**60%**	**85%**	**30%**	**35%**	**75%**	**100%**
San Gorgonio Pass WA	17,300	865	0	865	1,730	3,460	7,785	10,380	14,705	5,190	6,055	12,975	17,300
Ventura County WPD	20,000	1,000	0	1,000	2,000	4,000	9,000	12,000	17,000	6,000	7,000	15,000	20,000
Total:	**4,172,836**	**208,642**	**0**	**208,642**	**417,284**	**834,567**	**1,877,776**	**2,503,702**	**3,546,911**	**1,251,851**	**1,460,493**	**3,129,627**	**4,172,836**

[1] AFY = acre-feet per year. Table A allocations are the amounts of State Water Project (SWP) water promised to each SWP contractor in contracts with the state through the Department of Water Resources (DWR); Table A allocations are contracted amounts that do not change in response to hydrologic conditions or the actual amount of water that is physically available. Table A fulfillment refers to the amount of SWP water that is physically available at a given time, represented as a percentage of Table A allocations. The ability of the State (DWR) to fulfill its Table A contracts with SWP contractors fluctuates throughout the year, depending upon hydrologic conditions and the amount of water currently stored in and being conveyed through the SWP. The DWR notifies SWP contractors of fulfillment amounts through Notices to Contractors (NTCs) which are issued as fulfillment ability changes, and are therefore issued multiple times throughout a year.

[2] During water year 2014, two NTCs were issued announcing 5 percent fulfillment of Table A allocations; as described for footnote (1), fulfillment of Table A allocations changes throughout the year depending upon hydrologic conditions and the physical availability of water within the SWP system. A 5 percent fulfillment indicates the state is able to deliver 5% of each contractor’s Table A allocation of the SWP.

Source: DWR 2014; DWR 2017; DWR 2023f, 2023g, 2023h, 2023l

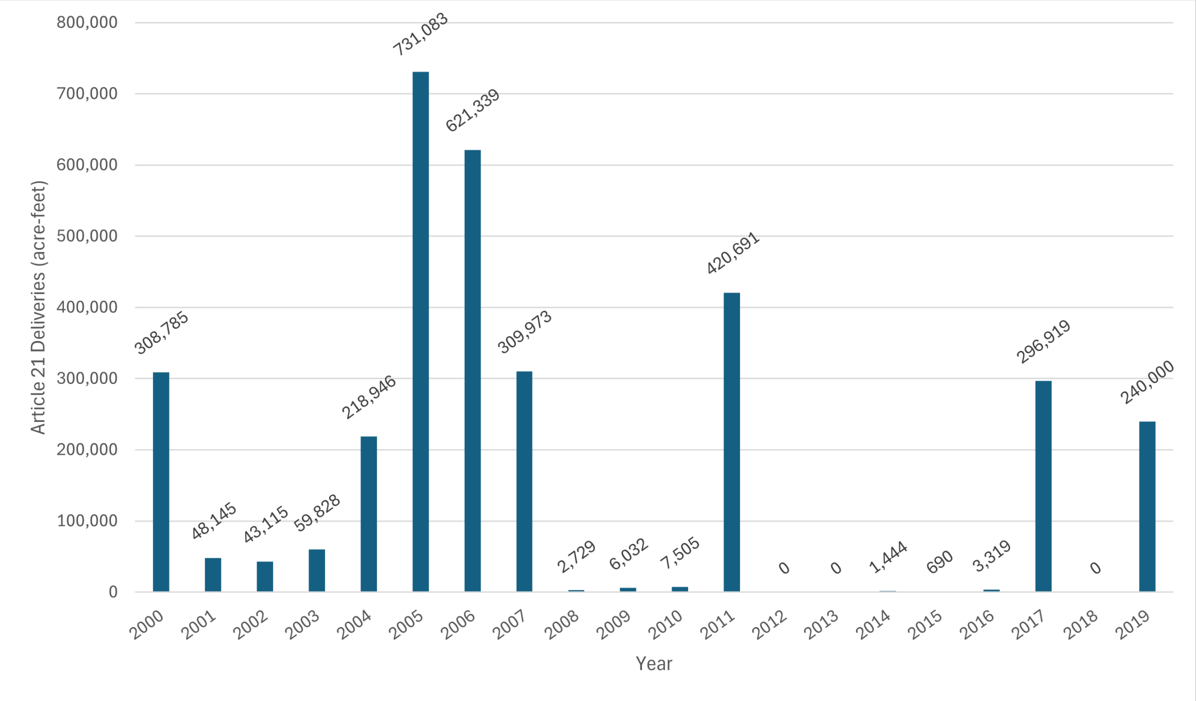
The table above shows that at the end of 2023, the SWP was operating at full capactiy, with 100 percent of all SWP contractors' Table A allocations being fulfilled.

Section 3.1.1, *SWP Water*, includes discussion of DWR's Delta Conveyance Project which, as proposed, would provide a dual conveyance system for SWP water through the Delta, thereby increasing capabilities to capture wet weather flows for use during dry year conditions. This expansion of SWP facilities would increase the reliability of SWP water deliveries to south-of-Delta SWP contractors and improve the fulfillment allocations shown in the table below. The Delta Conveyance Project would not alter existing water rights or Table A contract amounts. As discussed in Section 3.1.1, the DWR is currently conducting Tribal engagement and regulatory compliance for the Delta Conveyance Project. A new cost estimate and a benefit-cost analysis for the project are expected to be provided by the Delta Construction Authority in mid-2024 (DWR 2023n).

Article 21 Water

During some "wet weather" years, SWP contractors may have access to additional flows provided through the SWP conveyance system, but which are separate and in addition to Table A allocations. These surplus flows are authorized under Article 21 of the SWP Long-Term Water Supply Contracts, and are referred to as "Article 21 water." The mechanisms for how Article 21 can be used to procure additional supply are discussed in Part 4, Mechanisms of Supply Acquisition, in Section 4.3.2, Wet Weather Surplus Flows. The following graphics are provided to demonstrate the volume of Article 21 flows that have been obtained by SWP contractors both cumulatively Figure 1-4 and per contractor Figure 1-5. Between 2000 and 2017, a total of 3,080,543 acre-feet of Article 21 water was provided by DWR to individual SWP contractors. Article 21 water was also distributed in 2019, in the amount of 242,000 acre-feet (DWR 2023m).

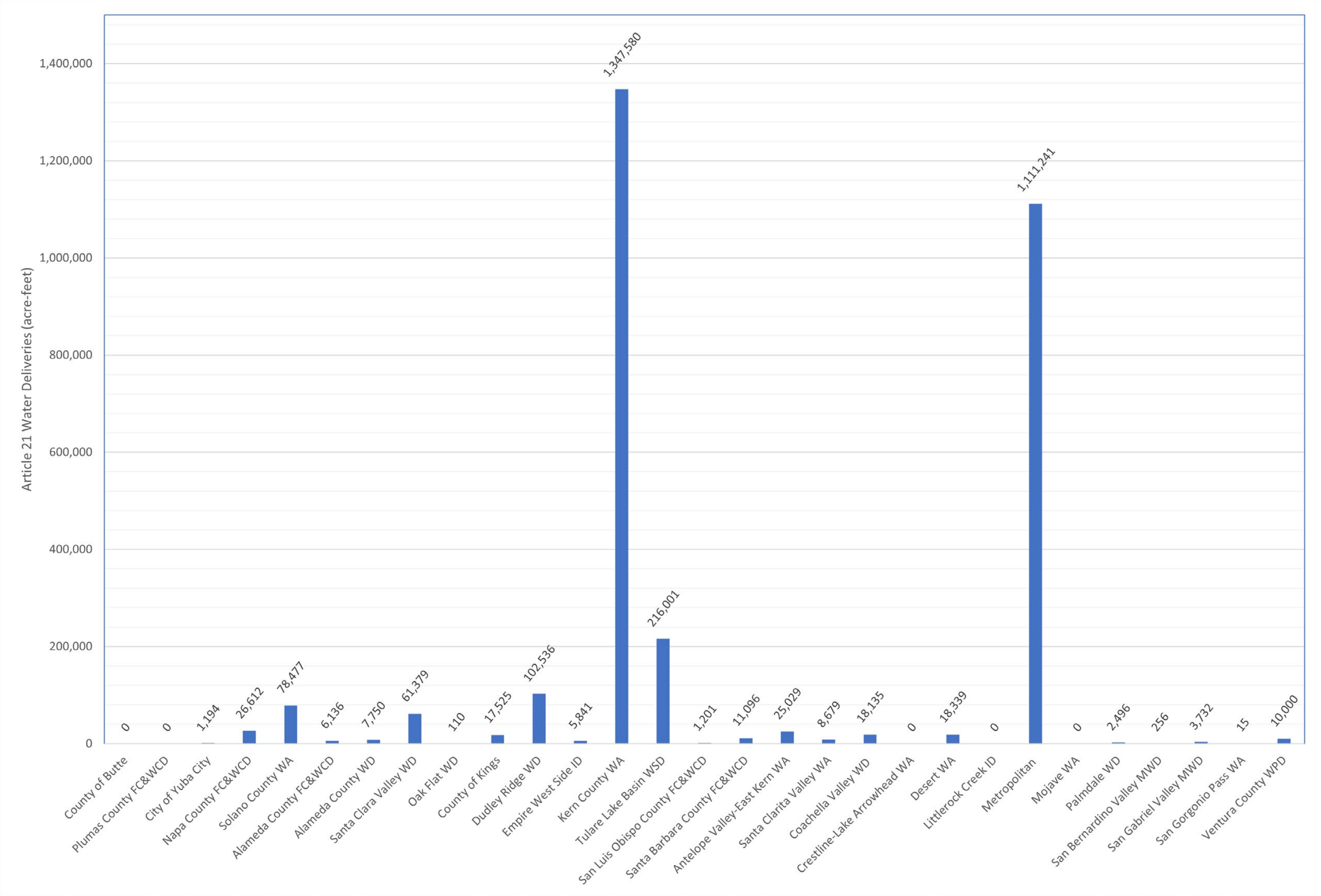
Figure 1-4 Annual Article 21 Deliveries to SWP Contractors, 2000-2019



Source: Austin 2018; DWR 2023m

In addition to the Article 21 deliveries shown above, the State also released Article 21 water in 2023; as of April 2023, approximately 265,000 acre-feet of Article 21 water had been made availabel to SWP contractors (DWR 2023). Figure 1-5, below, shows how the Article 21 water was distributed among the 29 SWP contractors during the historical period of 2000 through 2017.

Figure 1-5 Total Article 21 Water Deliveries (acre-feet) per SWP Contractor, 2000-2017



Source: Austin 2018

California Aqueduct

A series of figures is presented on the following pages to show the alignment for each branch of the California Aqueduct, and to identify the facilities, communities, and other features existing along the branch alignments. These figures include the following:

- Figure 1-6, shows that the Coastal Branch conveys SWP water into San Luis Obispo County and Santa Barabara County;
- Figure 1-7, shows the West Branch conveys SWP water into Los Angeles County, ending at Castaic Lake, and the East Branch conveys water into San Bernardino County and Riverside County, ending at Lake Perris (which is also the southern-most SWP facility);
- Figure 1-8, shows the East Branch serves the Inland Empire and conveys SWP water from Silverwood Lake to Lake Perris, with an East Branch Extension conveying SWP water farther southeast into San Bernardino County;
- Figure 1-9, shows the East Branch Extension of the California Aqueduct conveys SWP water to Low Desert Contractors that otherwise would have no connection to SWP facilities, including the Coachella Valley Water District, Desert Water Agency, San Bernardino Valley Municipal Water District, and San Gorgonio Pass Water Agency.

These figures are provided to inform consideration of where SWP water could potentially be available as a supply source for clean renewable hydrogen production, based on where existing facilities are located. Future clean renewable hydrogen production facilities may be located near or along existing SWP facilities. See Part 4, *Mechanisms of Supply Acquisition*, for a general discussion of water supply acquisition mechanisms and Section 4.1, *Exchange Agreements*, for discussion of exchange as a mechanism to acquire water supply for clean renewable hydrogen development.

Section 3.1, *Imported Surface Water in the Study Area,* further discusses SWP supplies and facilities.

Figure 1-6 SWP Facilities – CA Aqueduct Coastal Branch

Source: SWC 2023a

Figure 1-7 SWP Facilities – CA Aqueduct West Branch and East Branch

Source: SWC 2023b

Figure 1-8 SWP Facilities – CA Aqueduct East Branch, Inland Empire

Source: SWC 2023c

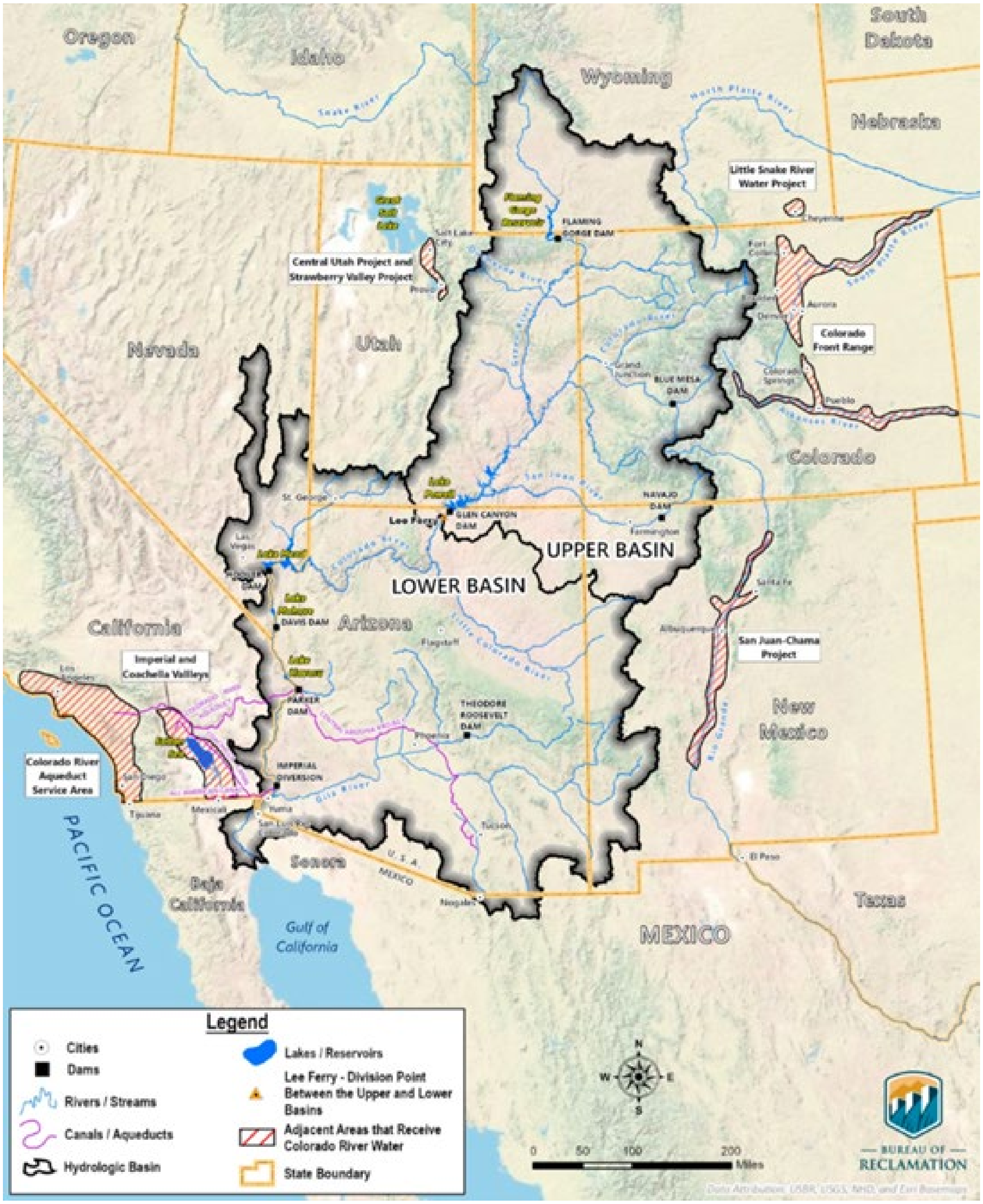
Figure 1-9 SWP Facilities – High and Low Desert Regions

Source: SWC 2023d

2.3.2 Colorado River

Colorado River water is conveyed into Southern California via the Colorado River Aqueduct, which is owned and operated by Metropolitan. Figure 1-10, below, provides an overview of the Colorado River and its Upper and Lower Basins.

Figure 1-10 Colorado River Basin and Facilities



Source: USBR 2021a

Section 3.1, *Imported Surface Water in the Study Area*, details Colorado River entitlements for Southern California contractors in Table 1-16, *Colorado River Water Entitlements in California.* Similar to the SWP, Colorado River water is fully allocated to existing contractors, which may sell or authorize use of portions of their existing allocations and as supplies are available.

The Upper Basin and Lower Basin of the Colorado River were defined in the 1922 Colorado River Compact, which also allocated 7.5 MAFY to each basin. In the Lower Basin, California is authorized 4.4 MAFY, nearly 59 percent, of the Lower Basin's total allocations. Conflicts between signatories to the Colorado River Compact are long-standing, particularly regarding California's agricultural and municipal interests, and priority uses over Colorado River water. A contract called the Seven-Party Agreement was established in 1931 to help settle these conflicts. Claimants of the Seven-Party Agreement who were able to reach consensus in the Seven-Party Agreement on the amounts of water to be allocated to each entity include the following: Palo Verde Irrigation District (PVID), Yuma Project, Imperial Irrigation District (IID), Coachella Valley Irrigation District, Metropolitan, City of San Diego, and County of San Diego.

In 2007, in response to six years of severe drought in the Colorado River Basin, federal officials and representatives of the seven basin states adopted a framework to better respond to drought and coordinate the operations of Lake Powell and Lake Mead, two key reservoirs on the Colorado River. The Interim Guidelines were adopted because in addition to water supply, there was concern that if Lake Mead's elevation dropped to 1,050 feet above sea level, hydroelectric-generation capacity at Hoover Dam would be compromised (WEF 2023c).

The following sections, *Near-Term Colorado River Operations,* and *Lower Colorado Conservation and Efficiency Program*, describe decisions and management direction for the Colorado River that developed in 2023. The efforts described below build off the 2007 Interim Guidelines (valid through December 2025) and update management guidance and requirements to account for the effects of climate change and drought, as well as population increases.

Near-Term Colorado River Operations

In 2023, USBR developed revisions to the 2007 Interim Guidelines in response to the potential for continued low-runoff conditions in the Colorado River. These revisions represent *Near-Term Colorado River Operations*, which address the operation of Glen Canyon and Hoover Dams beginning on October 1, 2023, for the 2024 operating year. The *Near-Term Colorado River Operations* were developed in response to USBR's determination that potential impacts of low-runoff conditions (during winter of 2022/2023 and the remainder of the interim period through 2026) pose risks to routine operations of Glen Canyon and Hoover Dams, which necessitate modified operating guidelines (USBR 2023a). Also in October 2023, the USBR determined ongoing cutbacks were sufficient to avoid critically low reservoir levels through October 2025 (USBR 2023c).

The modification of operating guidelines put forward in the *Near-Term Colorado River Operations* adjusts management practices in response to drought conditions and disputes over water rights and allocations. The proposed *Near-Term Colorado River Operations* were analyzed in a 2023 Draft Supplemental Environmental Impact Statement (EIS) to the 2007 EIS for the Lower Basin Interim Guidelines (USBR 2023a). However, the 2023 Supplemental EIS was temporarily withdrawn from public review in May 2023, when the U.S. Department of the Interior (USDOI) announced the *Lower Colorado Conservation and Efficiency Program*, discussed below. USBR developed new analyses, adding in the Conservation Program as an additional alternative, as part of an updated Draft Supplemental EIS published in October 2023 (USBR 2023a).

Lower Colorado River Basin System Conservation and Efficiency Program

The *Lower Colorado River Basin System Conservation and Efficiency Program* ("Conservation Program") is a consensus-based funding program which commits to conserving Colorado River water through 2026, when the current operating guidelines are set to expire (USDOI 2023). The Conservation Program is funded through the Inflation Reduction Act, and through an existing Intentionally Created Surplus extraordinary conservation water storage program, to provide resources for water management and conservation efforts in the Colorado River Basin and other basins experiencing comparable levels of long-term drought (CRBC 2023b). Through this program, the USBR is accepting proposals describing lower Colorado River Basin conservation projects that would reduce consumptive use of Colorado River water having a recent history of use (USBR 2023b).

California's Colorado River contractors and entitlement holders have collaborated with the USBR to develop proposals that will conserve up to 1.6 million acre-feet of water through 2026 for the benefit of the Colorado River System as part the Conservation Program (CRBC 2023b). To date, the USDOI has announced investments in the following Conservation Program projects (USDOI 2023):

- 127,000 AFY conserved through 21 water recycling projects ($281 million);
- 125,000 AFY in 2024 and 2025, and multiple other savings, through water conservation funding for the Gila River Indian Community ($233 million);
- 140,000 AF in Lake Mead in 2023 and up to 393,000 AF through 2025, through eight new agreements that commit water entities in Tucson and Phoenix areas to conserve use;
- $73 million for infrastructure repairs on water delivery systems, including $19.3 million in fiscal year 2022 and another $54 million announced in April 2023;
- $71 million for 32 drought resiliency projects to expand access to water through groundwater storage, rainwater harvesting, aquifer recharge and water treatment;
- $50 million over the next five years to improve key water infrastructure and enhance drought-related data collection across the Upper Colorado River Basin; and

- $20 million in new, small surface and groundwater storage investments.

Each of California's Colorado River contractors and entitlement holders, including Metropolitan, IID, PVID, CVWD, Bard Water District, and the Fort Yuma Quechan Indian Tribe, will conserve water by leaving it in the Colorado River as part of the Conservation Program (CRBC 2023b).

2.3.3 Central Valley Project

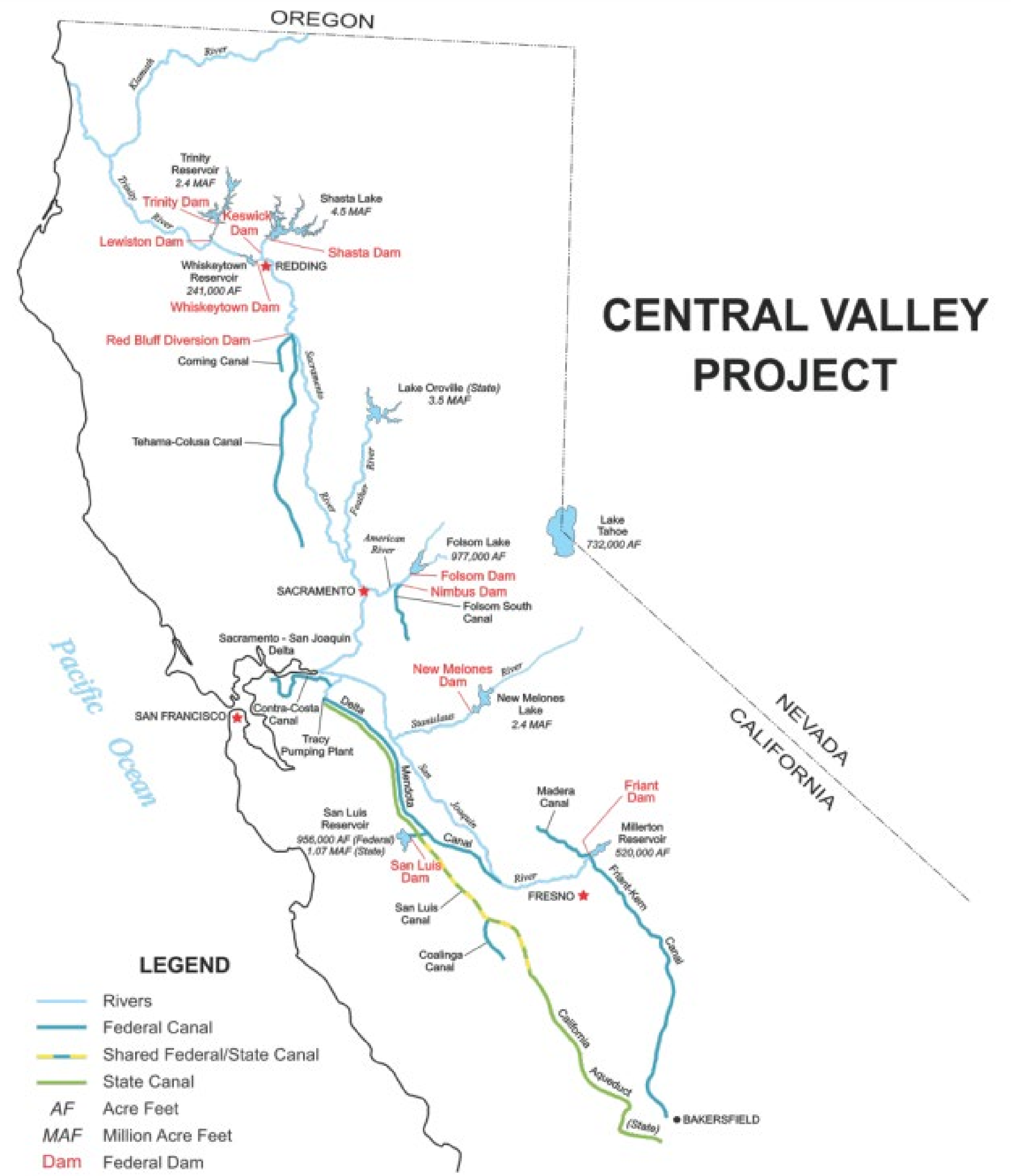
The CVP is a federal public works project, constructed and operated by U.S. Bureau of Reclamation (USBR). The CVP is a complex, multi-purpose network of dams, reservoirs, canals, hydroelectric powerplants and other facilities that extend over 400 miles between Northern and Central California. It also reduces flood risk for the Central Valley, and supplies water to major urban centers in the Greater Sacramento and San Francisco Bay areas, as well as producing electrical power (USBR 2023d). CVP facilities extend from Shasta Dam on the Sacramento River near Redding to as far south as Bakersfield, in the southern San Joaquin Valley portion of Central California (USBR 2023d). Figure 1-11, below, provides an overview of the CVP service area and primary features.

The Sacramento River carries water to the Sacramento-San Joaquin River Delta; once water reaches the southern end of the Delta, CVP facilities include pump stations and other infrastructure to lift CVP water out of the Delta and into conveyance and storage facilities for delivery to south-of-Delta contractors. At the southern end of the CVP system, water is stored in the New Melones Reservoir for distribution to water rights holders in the Stanislaus River watershed and CVP contractors in the northern San Joaquin Valley. This portion of the CVP consists of the Friant Division, one of eight management divisions on the CVP, and is located within the northern-most portion of SoCalGas's service territory; see detailed discussion in Section 3.1, *Imported Surface Water in the Study Area.*

CVP facilities have a total cumulative capacity of approximately 12 million acre-feet. The CVP has long-term agreements to supply water to more than 250 contractors in 29 counties. During an average water year, CVP water deliveries include the following (CRS 2017):

- 5 million acre-feet of system-wide water deliveries to farms for agricultural (irrigation) uses;
- 600,000 acre-feet to municipal and industrial (M&I) users;
- 410,000 acre-feet to wildlife refuges (statutory requirements with agencies); and
- 800,000 acre-feet for other fish and wildlife needs (statutory requirements with agencies).

Figure 1-11 Central Valley Project Infrastructure and Storage



Source: USBR 2023f

The quantities above reflect deliveries for the CVP system as a whole, including for contractors located both north and south of the Delta. The discussion provided below, under "CVP Contractors and Allocations," identifies the south-of-Delta contractors and their respective allocations, as well as historical data on fulfillment rates. North-of-Delta contractors are not detailed herein, due to their substantial geographic distance outside the study area used for this Water Availability Study (see Section 1.4.1, *Study Area*).

CVP Contractors and Allocations

Water in the CVP system is fully allocated to more than 250 contractors throughout Northern and Central California, both north and south of the Delta. As noted above, for the purposes of this Water Availability Study, information is provided for south-of Delta contractors. Table 1-10, below, identifies all south-of-Delta CVP contractors by water supply unit, and provides the maximum CVP water delivery amount per water supply unit, as well as the amount designated for agricultural uses and non-agricultural uses, including the amount historically used for M&I uses (USBR 2016).

Table 1-10 CVP Water Allocations (AFY)[1] – South of Delta

Water Supply Unit	CVP Contractors	Max Contract Amount	Contract Amount for Ag	Contract Amount non-Ag	M&I Historical Use[2]
Delta-Mendota Canal	▪ Banta-Carbona Irrigation District ▪ Byron-Bethany Irrigation District 1 ▪ Del Puerto Water District ▪ Eagle Field Water District ▪ Mercy Springs Water District ▪ Oro Loma Water District ▪ Pajaro Valley WMA ▪ Patterson Irrigation District ▪ The West Side Irrigation District ▪ Tracy, City of ▪ U.S. Department of Veteran Affairs ▪ West Stanislaus Irrigation District ▪ Westlands Water District	330,100	318,396	11,704	10,986

Water Supply Unit	CVP Contractors	Max Contract Amount	Contract Amount for Ag	Contract Amount non-Ag	M&I Historical Use[2]
Mendota Pool	▪ Coelho Family Trust ▪ Fresno Slough Water District ▪ James Irrigation District ▪ Laguna Water District ▪ USBR District No. 1606 ▪ Tranquility Irrigation District ▪ Westlands Water District (assigned from Oro Loma)	60,278	60,278	0	0
Cross Valley Canal	▪ Fresno, County of ▪ Hills Valley Irrigation District ▪ Kern-Tulare Water District ▪ Lower Tule River Irrigation District ▪ Pixley Irrigation District ▪ Tri-Valley Water District ▪ Tulare, County of	128,300	127,406	894	0
San Felipe	▪ San Benito County Water District ▪ Santa Clara Valley Water District	196,300	60,744	135,556	135,556
San Luis Unit	▪ Avenal, City of ▪ California, State of ▪ Coalinga, City of ▪ Huron, City of ▪ Pacheco Water District ▪ Panoche Water District ▪ San Luis Water District ▪ Westlands Water District	1,397,920	1,375,253	22,667	14,254
Total		**2,112,898**	**1,942,077**	**170,821**	**160,796**

[1] CVP water allocations are shown in acre-feet per year (AFY).

[2] M&I Historical Use was calculated based upon the past three years of unconstrained CVP delivery for all contractors except Contra Costa Water District, Santa Clara, and Byron Bethany, where historical use figure represents an amount agreed upon in contract renewal or other agreements with USBR.

Source: USBR 2016

The table above shows that a total of 2,112,898 AFY of CVP water is allocated to south-of-Delta contractors. Of this total, approximately 92 percent (1,942,077 AFY) is dedicated for agricultural uses and approximately 170,821 AFY for non-agricultural uses, of which approximately 160,796 AFY has historically been used for M&I uses.

Similar to the SWP, the reliability of delivery of water supply allocated under the CVP is variable and depends upon factors including weather and drought conditions, contractual obligations, and other demands on water in the CVP system. Table 1-11, below, provides an overview of historical fulfillments of CVP allocations to south-of-Delta contractors, shown as a percentage of total contracted allocations. The use types presented below include those defined by the 2006 *San Joaquin River Restoration Settlement*, including Wildlife Refuges, Settlement Contractors, Eastside Division Contractors, and Friant Class 1 and Class 2 contractors. The 2006 Settlement was between the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, and the Friant Water Users Authority, and resolved an 18-year lawsuit. The 2006 Settlement resulted in the federal San Joaquin River Restoration Settlement Act, which was passed in March 2009 with 32 contractors (districts and cities) party to the Settlement (SJRRP 2024).

Table 1-11 CVP South of Delta Allocations – Historical Fulfillment (%) by Use Type[1]

Year	Agriculture	Urban (M&I)	Wildlife Refuges	Settlement Contractors	Eastside Division Contractors	Friant Class 1	Friant Class 2
2023	100	100	100	100	100	100	70
2022	0	PHS[2]	SC[2]	SC[2]	0	30	0
2021	5	55	75	75	100	20	0
2020	15	65	100	100	100	20	0
2019	35	75	100	100	100	100	100
2018	20	70	100	100	100	30	9
2017	65	90	100	100	100	100	100
2016	5	55	100	100	0	30	6
2015	0	25	75	75	0	0	0
2014	0	50	40	40	55	0	0
2013	25	75	100	100	100	65	0
2012	30	75	75	75	100	35	0
2011	50	75	100	100	100	100	20
2010	5	55	100	100	100	100	0
2009	10	60	100	100	12	77	18
2008	40	75	100	100	23	100	5
2007	50	75	100	100	29	65	0

Year	Agriculture	Urban (M&I)	Wildlife Refuges	Settlement Contractors	Eastside Division Contractors	Friant Class 1	Friant Class 2
2006	100	100	100	100	100	100	100
2005	85	100	100	100	28	100	100
2004	70	95	100	100	0	100	8
2003	75	100	100	100	0	100	5
2002	70	95	100	100	0	100	8
2001	49	77	100	100	22	100	5

[1] The use types presented above include those defined by the 2006 San Joaquin River Restoration Settlement, including Wildlife Refuges, Settlement Contractors, Eastside Division Contractors, and Friant Class 1 and Class 2 contractors. At the Friant Division, a two-class system is used to determine water rights under the Settlement, where Class 1 consists of the first 800,000 acre-feet developed and accessible for delivery (usually for M&I use or for districts without access to groundwater supply); and Class 2 consists of the next 1.4 million acre-feet developed, primarily for groundwater recharge projects (WEF 2014).

[2] PHS = public health and safety needs; SC = Shasta Critical (as defined in their contract)

Source: USBR 2023e

The table above demonstrates that the amount of fulfillment of contracted CVP allocations vary substantially, similar to the other key water supply projects. CVP facilities within SoCalGas's service territory are detailed in Section 3.1, *Imported Surface Water in the Study Area*.

2.4 Urban Water Management Planning

California law (CWC Sections 10610-10656 and Section 10608) requires urban water supply providers within the state of California to prepare a UWMP if they have at least 3,000 service connections or deliver more than 3,000 AFY of water within their service territory. Each UWMP quantifies the anticipated water needs and available supply sources within service territory being addressed. UWMPs include supply and availability projections over a minimum 20-year planning horizon and with consideration to drought conditions. The purpose of a UWMP is to support the water suppliers' long-term resources planning so that there are sufficient reliable water supply sources available to support existing and anticipated water needs. UWMPs are required to be updated every five years, with calculations adjusted to account for any changes in population projections, land use plans, climatic conditions, water supply development projects, and other factors affecting water supply availability to the respective planning area. As such, UWMPs provide a "snapshot" of existing conditions within the planning area, and projected conditions which are updated based upon the best available data as reviewed every five years.

Demand and supply projections in a UWMP typically do not reflect substantial amounts of surplus supply availability. This is because UWMPs are designed to provide the water supplies needed to satisfy anticipated water needs within a specific area, based upon known and anticipated land uses. UWMP projections are required to address a minimum 20-year planning horizon. Some agencies project farther into the future, depending upon funding, data availability, and other factors. UWMPs estimate and account for water needs of future development projects based upon project applications that have been submitted to applicable land use planning agencies and are available for public review. UWMPs identify water supply development projects as needed to supplement existing supplies and meet projected demands; such projects may include but are not limited to conservation, water recycling and water reuse, treatment of waste streams, stormwater capture and reuse, and purchase of surplus supplies when available.

Based on the review of UWMPs throughout SoCalGas's service territory conducted to support this Water Availability Study, clean renewable hydrogen projects were not accounted for in the 2020 UWMP supply availability projections. As future applications for clean renewable hydrogen projects are submitted to local county planning departments for consideration of approval, water agencies may consider those projects for incorporation into their UWMP projections of demand and supply. For example, when clean renewable hydrogen projects are formally proposed for consideration by local planning agencies, UWMPs would account for the water needs of those projects. UWMPs are required to be updated every five years; therefore, the 2020 UWMPs that were used to inform this analysis contain the most current data available until UWMPs are updated in 2025.

Below is an overview of some of the required contents of a UWMP, demonstrating how UWMPs are used to plan for and provide sufficient water supply to meet demands within their service areas.

- **System Water Use:** Presents water use data for the past five years and projects water needs for the next 20 years, accounting for population growth, land use changes, and conservation measures. These projections are updated with every UWMP five-year update, accounting for changes including population growth and land use changes.
- **System Supplies:** Describes the current and planned sources of water supply for the UWMP area including surface water, groundwater, imported water, recycled water, desalinated water, and transfers and exchanges, and quantifies the amount of water available from each source for the next 20 years under normal, single dry year, and multiple dry year scenarios.
- **Water Supply Reliability Assessment:** Evaluates the reliability of the water supply sources and compares the total water supply with the total water needs over the next 20 years under normal, single dry year, and multiple dry year scenarios. It also discusses how climate change may affect the water supply reliability.

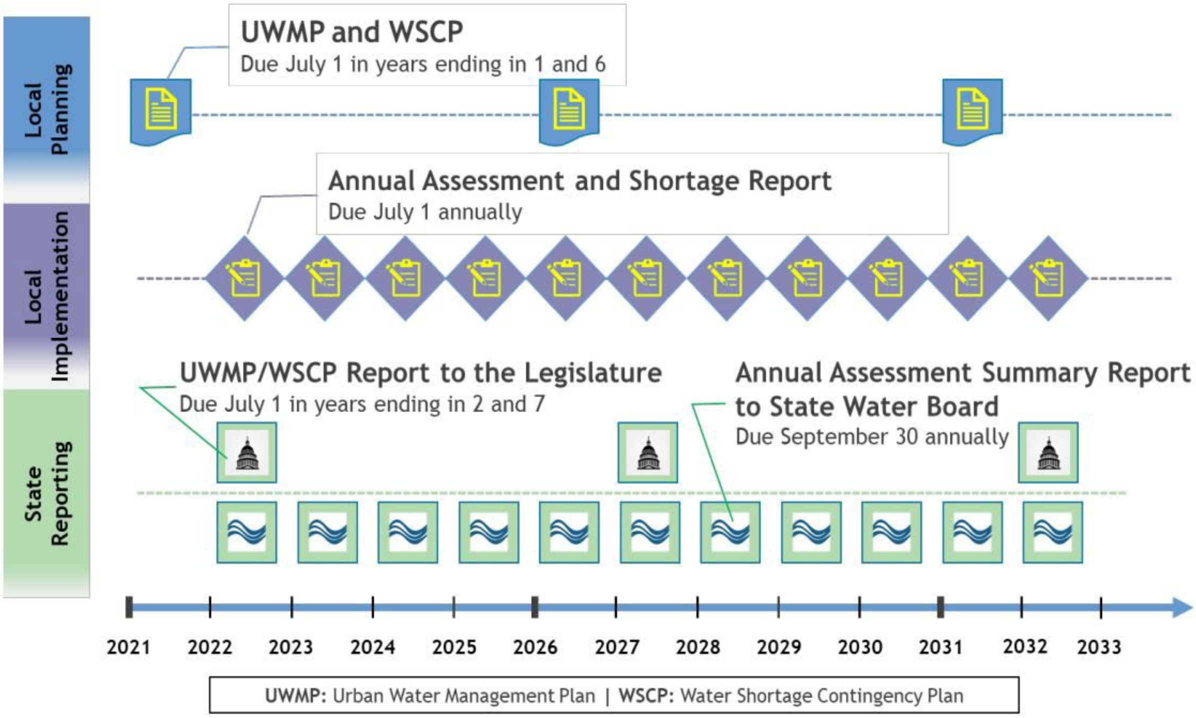
- **Water Shortage Contingency Plan (WSCP):** Describes response actions the water supplier will take during water shortages of varying levels of severity, including a drought risk assessment, a six-stage shortage response plan, a communication strategy, a compliance and enforcement strategy, a legal authority statement, a financial plan, a monitoring and reporting plan, and a plan update schedule.
- **Demand Management Measures:** Describes the demand management measures the urban water supplier has implemented or plans to implement to achieve water use efficiency. Includes a description of each measure, its implementation status, its estimated water savings, its costs and benefits, and its funding sources.

In addition to five-year updates of UWMPs, agencies responsible for preparing UWMPs are also required to prepare and maintain the following reports:

- **Annual Water Supply and Demand Assessment** (Annual Assessment) – evaluates the anticipated water supply and demand for the current year and the next three years under normal, single dry year, and multiple dry year scenarios. This is similar to a UWMP except the Annual Assessment is prepared every year and projects for three years, whereas the UWMP is prepared every five years and projects for five years.
- **Annual Water Shortage Assessment Report** (Annual Shortage Report) – summarizes the results of the Annual Assessment and any response actions from the UWMP triggered by water shortage conditions.

The Annual Assessment and Annual Shortage Report are important tools for drought response as they help to proactively prepare for water shortages and implement strategies to increase water availability and efficiency. Figure 1-12, below, provides an overview of the timeline and reporting frequency of UWMPs and WSCPs, as well as Annual Assessments and Annual Shortage Reports.

Figure 1-12 Water Shortage Contingency Planning and Implementation Timeline



Source: DWR 2022b

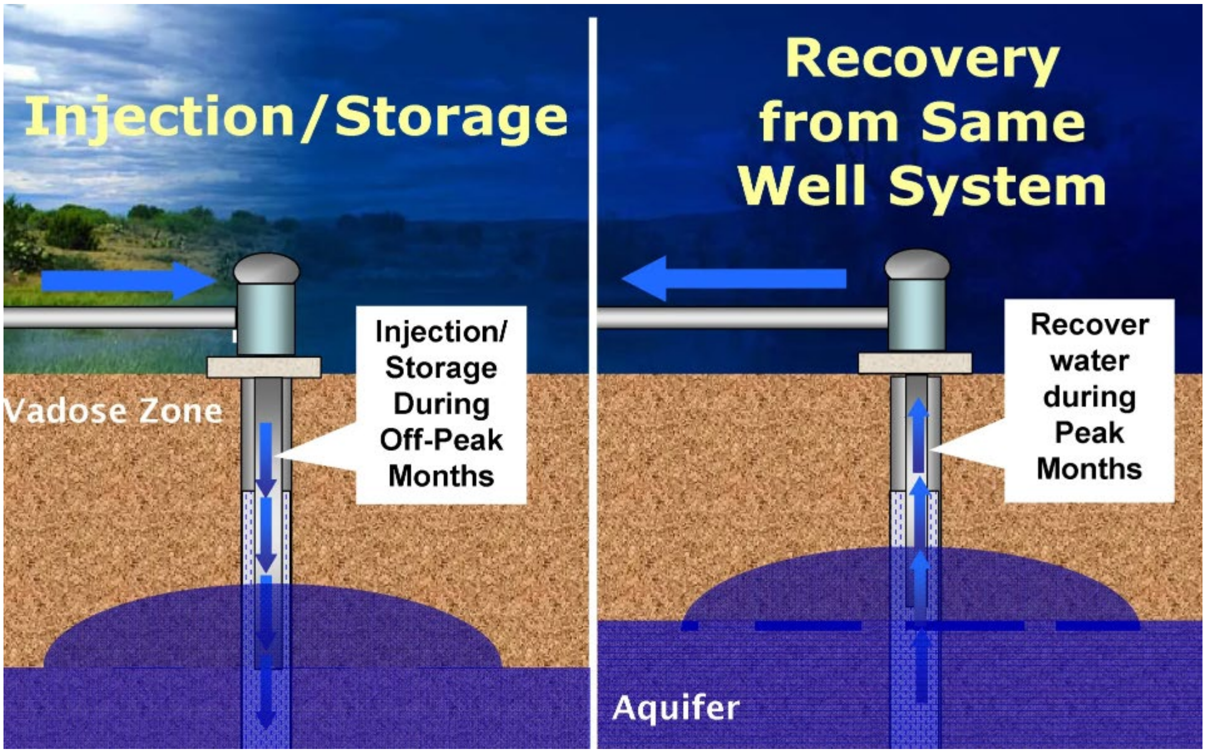
As shown above, the first year of reporting under the Water Conservation and Drought Planning Act was 2022; therefore, long-term data is not currently available. However, data will continue to be collected and reported annually, building valuable information that will help water managers address water availability and predict and respond to drought and shortage conditions.

2.5 Conjunctive Use Management

Conjunctive use refers to the coordinated management of surface water and groundwater supplies, to maximize opportunities for beneficial use of the overall water supply. It is anticipated that water supply for clean renewable hydrogen development will come from multiple sources, depending upon the point of use and available supply sources and supply acquisition mechanisms available. Conjunctive use management could contribute to supply development for clean renewable hydrogen by providing storage of acquired supplies as they become available, for use as needed to produce clean renewable hydrogen. Hydrogen producers may partner with local water agencies to participate in or develop conjunctive use projects, towards the purpose of securing sufficient water supply for clean renewable hydrogen development. See Section 4.2, *Local Water Agencies,* for discussion of how water supply may be acquired from local agencies through purchase or through partnership on the development of new water supply.

A common method of conducting conjunctive use management is through aquifer storage and recovery (ASR), which involves storing surplus water in the ground during wet periods of high availability, and withdrawing these stored supplies for use during dry periods of low or restricted surface water availability. Figure 1-13, below, provides an overview of typical ASR processes.

Figure 1-13 Schematic of Aquifer Storage and Recovery



Source: Coyote Gulch 2018

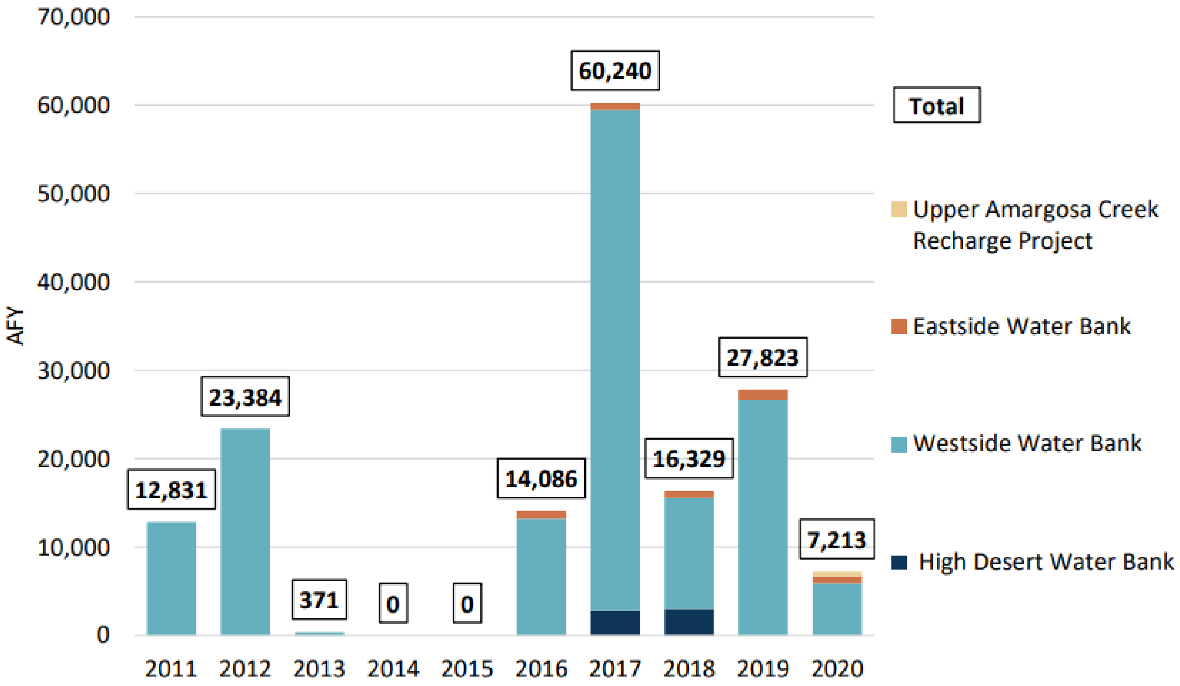
ASR is conducted both actively, where surface water is intentionally injected or percolated into the ground for later use, and passively, where surface water is relied on during wet years and groundwater is relied on during dry years. ASR may also be used to facilitate exchange agreement(s) as a mechanism to acquire water supply for clean renewable hydrogen; see Section 4.1, *Exchange Agreements,* for further discussion. ASR is conducted throughout SoCalGas's service territory to support conjunctive use management efforts and provide supply reliability, particularly through drought conditions. As an example of the scale of water storage that can be conducted through ASR programs, the Antelope Valley-East Kern (AVEK) water agency uses extensive groundwater banks in the Antelope Valley region of Southern California to store SWP water during times of surplus, and recover the supplies during dry periods. Active AVEK groundwater banks include:

- Westside Water Bank, operational since 2010;
- Eastside Water Bank, operational since 2016;

- Upper Amargosa Creek Recharge Project, operational since 2019 (AVEK, City of Palmdale, Palmdale Water District, and Los Angeles County Waterworks District 40); and
- High Desert Water Bank, planned operational in 2024 (AVEK 2021).

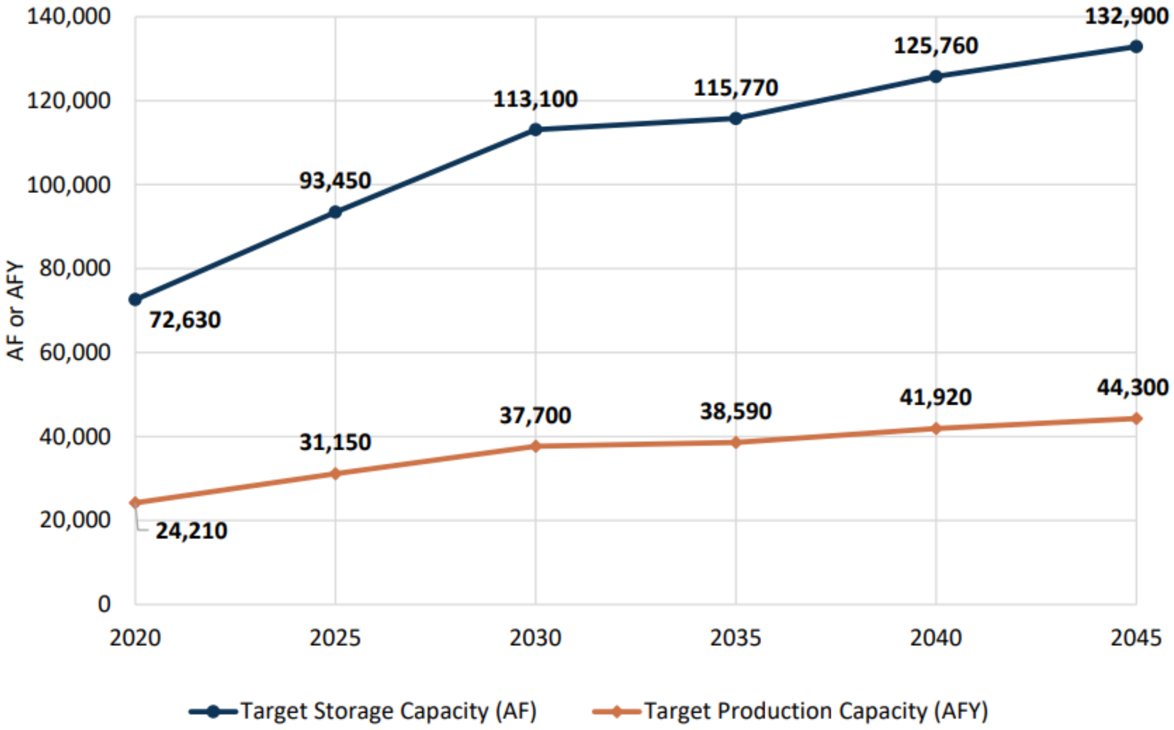
Figure 1-14 and Figure 1-15, below, portray the amounts of water contributed to AVEK banks each year, and AVEK's target amounts for storage and recovery capacities from its banking program. There are additional active ASR projects in SoCalGas's service territory. This information is provided as an illustrative example to demonstrate the scale of water quantities that are actively being managed through ASR within SoCalGas's service territory. As mentioned above, AVEK's projects are presented as an example of ASR occurring in the region; ASR is actively used throughout SoCalGas's service territory, beyond AVEK's management area.

Figure 1-14 AVEK Imported Water Deliveries to Groundwater Banking Sites, 2011-2020



Source: AVEK 2021

Figure 1-15 AVEK Groundwater Banking Target Storage and Production Capacities



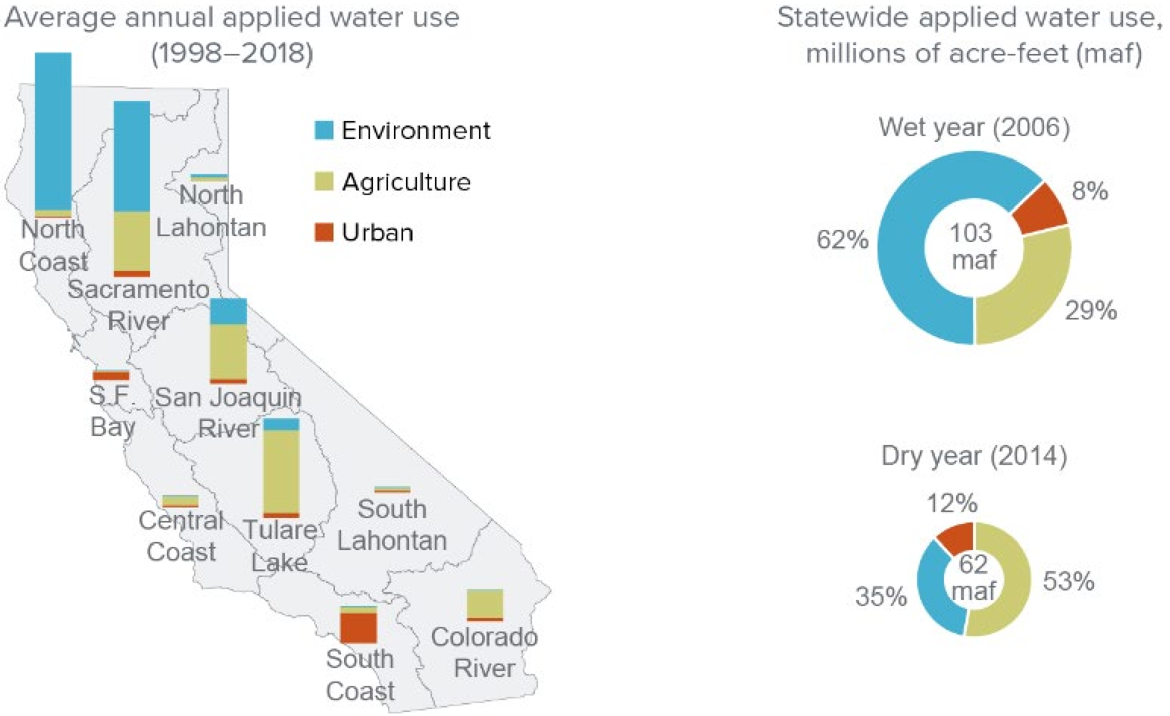
Source: AVEK 2021

Figure 1-14 demonstrates that the amount of imported surface water contributed to AVEK banks can vary substantially from year to year, reflecting variabilities in deliveries of imported surface water supplies. Figure 1-15 demonstrates how AVEK is developing its banks to provide sufficient storage and recovery capacity to compensate for SWP deliveries that are reduced to 10 percent of contracted allocations for three consecutive years. Figure 1-15 further demonstrates how reliability could be built even when contributions to the program are variable.

2.6 Existing Demands and Obligations

This section provides an overview of existing water needs and water supply obligations within SoCalGas's service territory. As discussed in Section 2.4, *Urban Water Management Planning*, existing water needs and obligations are accounted for in local agencies' UWMPs, as part of water supply reliability planning to meet all demands within the respective service area. Water use varies substantially across regions and between wet and dry years. Shifting water needs and obligations may change over time as uses for water in the state evolve. Figure 1-16, below, portrays the average applied water use rates for 1998 through 2018 for uses including urban and municipal, agricultural, and environmental.

Figure 1-16 Average Annual Applied Water Use, 1998-2018



Source: PPIC 2023a

The figure above shows that between 1998 and 2018, the total amount of applied water use for urban, agricultural, and environmental uses averaged 103 MAFY during wet year conditions (representative year 2006) and 62 MAFY during dry year conditions (representative year 2014). Commercial, industrial, and residential uses are included in the urban category. Table 1-12, below, provides a breakdown of applied water use rates by use type.

Table 1-12 Average Annual Applied Water Use, 1998-2018

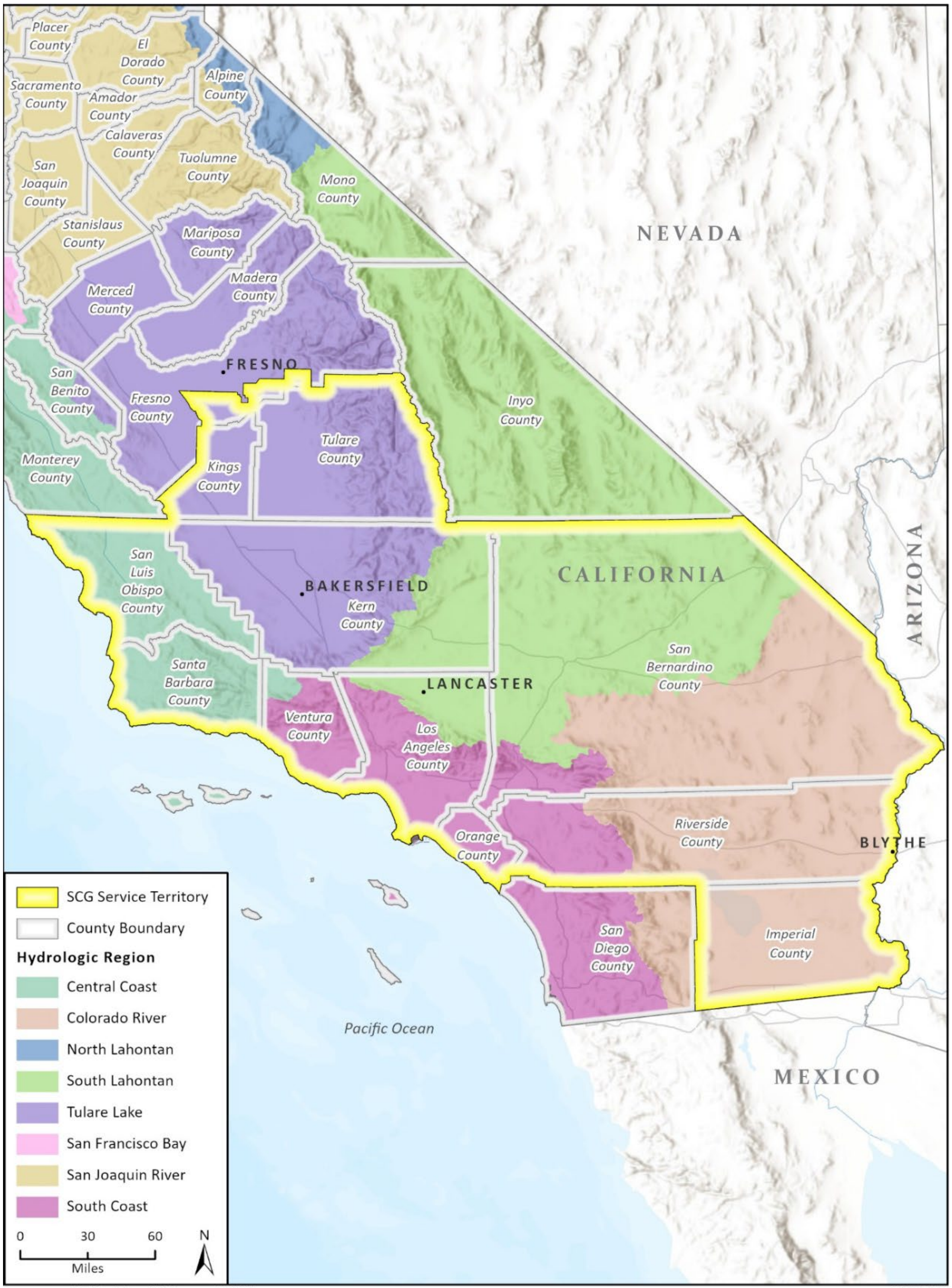
Use Type	Dry Year (AFY)	Wet Year (AFY)
Urban	7,000,000	8,000,000
Agriculture	33,000,000	30,000,000
Environment	22,000,000	65,000,000
Total	**62,000,000**	**103,000,000**

Source: PPIC 2023a

The use types characterized in the figure and table above are discussed in the following sections to anticipate how applied use rates may occur in the future, including: Section 2.6.1, *Urban and Municipal Demands,* Section 2.6.2, *Agricultural Demands,* and Section 2.6.3, *Environmental Obligations.*

Figure 1-17, below, portrays the county and hydrologic regions within SoCalGas's service territory, which are discussed in the following sections addressing existing demands and obligations.

Figure 1-17 Counties and Hydrologic Regions in SoCalGas's Service Area



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22-13179 EPS
Fig X RWQCB Regions

2.6.1 Urban and Municipal Demands

Urban and municipal water needs are estimated based upon population growth rates. Table 1-13, below, provides population projections for counties within SoCalGas's service territory.

Table 1-13 Population Projections for Counties within SoCalGas's Service Area

County	2020	2030	2040	2050	2060	Percent Change 2020-2060
Fresno[1]	1,008,966	1,096,638	1,170,525	1,226,158	1,272,559	20.7
Imperial	179,489	206,486	222,307	235,339	246,235	27.1
Kern	909,997	1,019,221	1,127,781	1,217,086	1,295,502	29.8
Kings	152,627	165,752	176,940	185,868	192,955	20.9
Los Angeles	9,989,165	10,322,678	10,286,350	10,061,774	9,697,634	-3.0
Orange	3,184,101	3,291,863	3,315,726	3,268,048	3,166,309	-0.6
Riverside	2,422,764	2,728,068	2,933,038	3,059,095	3,129,833	22.6
San Bernardino	2,182,740	2,368,002	2,536,592	2,681,796	2,818,707	22.6
San Luis Obispo	282,231	284,729	284,346	274,677	263,650	-7.0
Santa Barbara	448,096	469,717	479,622	479,532	473,067	5.3
Tulare	473,736	516,810	551,563	575,525	591,539	19.9
Ventura	842,921	872,856	885,628	873,594	849,091	0.7
Total	**22,076,833**	**23,342,820**	**23,970,418**	**24,138,492**	**23,997,081**	**8.0**

[1] This table reflects county-wide data; however, only a small portion of Fresno County is within SoCalGas's service territory.

Sources: DOF 2023; USCB 2023

The table above shows that in July 2020, the total population of counties in SoCalGas's service territory was approximately 22 million people (USCB 2023). This table also indicates:

- Fresno, Imperial, Kern, Kings, Riverside, San Bernardino, and Tulare County populations increase by approximately 20 to 30 percent by 2060;
- Santa Barbara and Ventura county populations increase by less than six percent by 2060; and

- Los Angeles, Orange, and San Luis Obispo county populations reduce by three to seven percent through 2060.

The total population of counties within SoCalGas's service territory is anticipated to increase by approximately eight percent by 2060. With an existing population of approximately 22 million, an eight percent increase would add approximately 1.76 million individuals to the service territory, such that total population in 2060 would be approximately 23.76 million individuals.[10]

Per capita water use in California has been steadily decreasing since before the drought of 2012-2016 (PPIC 2023a). Total urban water use has plateaued, even as California's population grew by 5.5 million between 2000 and 2020 (PPIC 2023a). This trend indicates that although urban populations have been growing, per-capita demands have been reducing, such that the same amount of water can serve the needs of more individuals. The DWR and SWRCB have recommended that urban water suppliers achieve an indoor water use efficiency standard of 47 gallons per day by 2025 and 42 gallons by 2030 and beyond, noting that the current statewide median indoor residential water use is 48 gallons per capita per day, and that a quarter of California households already use less than 42 gallons per capita per day (SWRCB 2021).

The SWRCB has also been adopting increased efficiency standards for indoor and outdoor use, and has proposed regulations to mandate conservation measures at over 400 cities and water agencies and could save about 413,000 AFY by 2030 (SWRCB 2023c).

2.6.2 Agricultural Demands

Agricultural water use in California accounts for approximately 40 percent of all water use in the state, while urban uses account for 10 percent and environmental obligations account for approximately 50 percent; on average, farms use approximately 80 percent of all water used by homes and businesses (PPIC 2023a, 2023d). The San Joaquin Valley produces more than half of the state's total agricultural output; in 2018, about 4.5 million acres of cropland were irrigated in the San Joaquin Valley, using a total of approximately 16.1 million acre-feet per year (MAFY) of water (PPIC 2023b). Throughout the state in an average year, approximately 9.6 million acres are irrigated with roughly 34 MAFY of water (DWR 2023j).

There is ongoing pressure on the agricultural industry to reduce water use rates, such as through conservation, use of improved technologies, shifting patterns in the location and type of irrigated crops, and fallowing actively irrigated lands to relieve water needs, particularly in areas dependent on overdrafted groundwater basins. The Public Policy Institute of California (PPIC) estimates that by 2040, approximately 3.2 MAFY or 20 percent of existing water supplies in the San Joaquin

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[10] These totals include Fresno County; however, only a small portion of southern Fresno County is within SoCalGas's service territory. Therefore, these estimates are highly conservative.

Valley will be unavailable due to the combined impacts of SGMA and bringing groundwater basins into balanced conditions, as well as the effects of climate change and environmental regulations (PPIC 2023b). However, PPIC research also suggests that changes in land use and agricultural operations could create increased opportunities for water markets and trading (PPIC 2023c); see Section 3.4, *Agricultural Industry Water*, and Section 4.3, *Water Markets*. The PPIC concluded that with the right incentives, and with cooperative planning and implementation, land use transitions could occur in ways that would allow agriculture to thrive while minimizing the downsides of fallowing, and potentially creating water availability through markets and trading (PPIC 2023c).

Reporting conducted under the Water Conservation Act of 2009 (SB X7-7) helps to identify and monitor trends in agricultural water uses and efficiency practices. SB X7-7 requires agricultural water suppliers serving more than 25,000 irrigated acres to adopt and submit to DWR an Agricultural Water Management Plan (AWMP), which must include reports on the implementation status of specific Efficient Water Management Practices (EWMPs) (DWR 2023j). Agricultural water suppliers that provide water for the irrigation of 10,000 to 25,000 acres are not required to prepare or submit AWMPs, unless state funds are made available to do so (DWR 2023j). The use of recycled water for irrigation is exempted from SB X7-7 requirements for AWMPs, as the use of recycled water supports the same purpose of AWMPs, to reduce water needs and improve efficient uses.

Table 1-14 on the following page presents the total acreage of harvested crops within the counties in SoCalGas's service territory. The purpose of this table is to convey trends in agricultural production which correlate with water needs for agriculture and to use these trends to inform consideration of water availability in agricultural areas. This table shows that with the exception of the COVID-19 pandemic years of 2020-2021, annual crop production in SoCalGas's service territory has been relatively stable over the past decade. If annual production of harvested crops continues to remain steady, agricultural demands are also likely to remain similar to existing conditions.

Table 1-14 Harvested Acreage of Crops Within SoCalGas's Service Territory, 2011-2021

County	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[2]	2021[2]
Fresno[1]	1,981,209	1,960,450	1,750,000	1,73,0959	1,740,689	1,805,920	1,827,828	1,853,795	1,950,505	1,104,301	1,721,307
Imperial	579,717	604,117	550,011	482281	514,718	515,343	512,164	513,468	572,349	540,751	1,008,081
Kern	2,288,600	2,273,999	2,250,996	2261285	2,166,523	2,252,354	2,252,715	2,234,001	2,236,204	675,229	4,151,893
Kings	825,131	832,883	820,142	721896	750,274	746,677	791,216	815,343	832,247	789,794	1,458,571
Los Angeles	17,384	15,524	13,907	16,088	27,111	27,111	0	172	0	0	0
Orange	1,007	1,035	908	787	676	543	386	1,252	879	554	862
Riverside	197,841	212,737	210,452	202,516	198,536	194,027	188,597	189,819	198,258	206,977	417,152
San Bernardino	1,407,348	1,404,316	1,385,202	1,384,955	1,385,313	1,385,763	1,428,069	1,384,055	1,368,626	1,368,577	1,370,845
San Luis Obispo	1,141,588	1,135,433	1,118,327	1,115,318	1,122,220	1,131,373	1,121,563	1,126,355	1,125,001	1,133,915	210,848
Santa Barbara	708,982	707,036	710,006	711,585	708,207	705,397	692,730	663,676	661,801	658,770	1,313,091
Tulare	1,667,812	1,677,908	1,693,245	1,456,951	1,780,288	1,802,587	1,742,002	1,664,712	1,624,808	1,657,491	3,396,675
Ventura	186,173	190,792	197,108	195,930	297,085	293,146	293559	313,461	294,127	293,500	548,536
Total	**11,002,792**	**11,016,230**	**10,700,304**	**10,280,551**	**10,691,640**	**10,860,241**	**10,850,829**	**10,760,109**	**10,864,805**	**8,429,859**	**15,597,861**

[1] This table reflects county-wide data; however, only a small portion of Fresno County is within SoCalGas's service territory.

[2] Variations in the 2020 and 2021 crop productions were a result of the COVID-19 pandemic.

Source: USDA 2012, 2013, 2015a, 2015b, 2016, 2018a, 2018b, 2020, 2021, 2022, 2023

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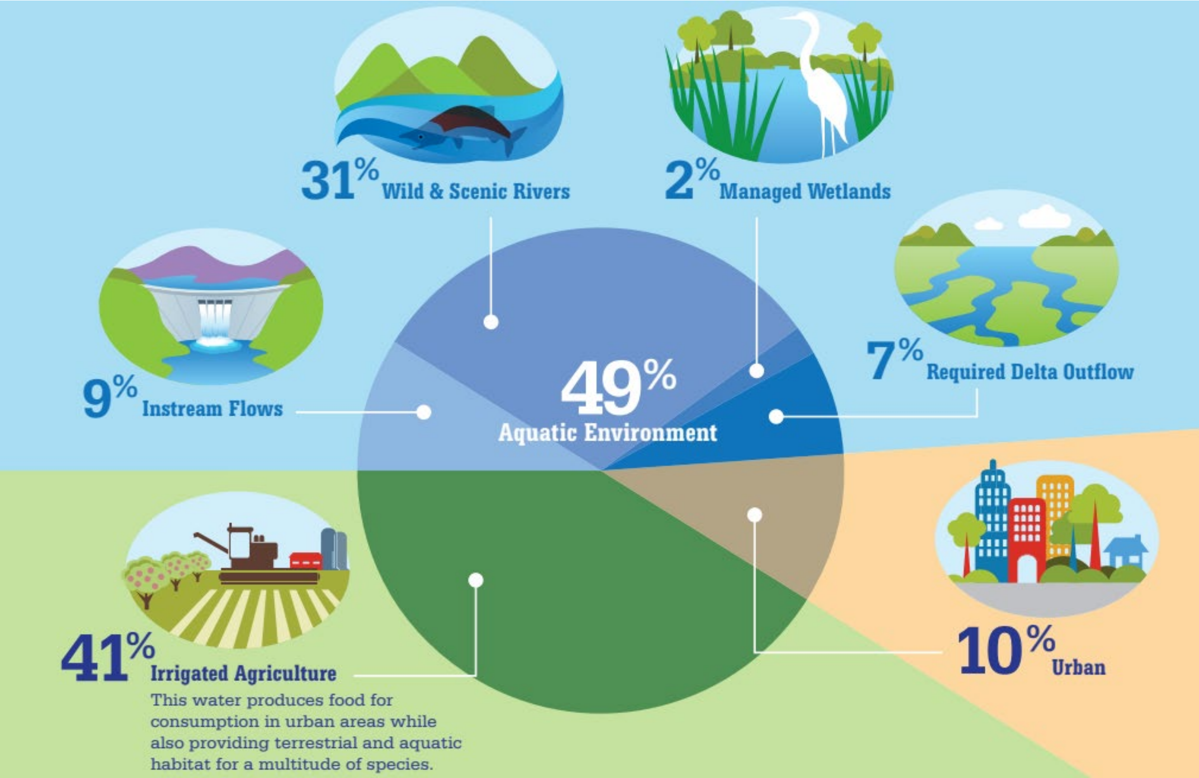
2.6.3 Environmental Obligations

Environmental obligations are water needs associated with the health and balance of rivers and wetlands, and the habitats and species supported by these resources. As shown in Table 1-12, *Average Annual Applied Water Use, 1998-2018*, in the introduction to this section, average annual applied water use for environmental obligations between 1998 and 2018 ranged between 22 MAFY for dry year conditions and 65 MAFY for wet year conditions. Environmental water obligations fall under four categories:

- **Wild and Scenic Rivers**–- waters protected under federal and state laws;
- **Instream flows**–- required for maintaining habitat within streams;
- **Required Delta Outflow**–- water quality improvements for agricultural and urban uses; and
- **Managed wetlands**–- wetlands within wildlife preserves (PPIC 2019).

Figure 1-18, below, provides an overview of applied water use for each of the environmental obligation categories listed above, as well as the portion of state-wide water supply applied to irrigated agriculture and urban uses.

Figure 1-18 Distribution of Environmental Water Obligations



Source: NCWA 2015

Within the CVP and SWP systems, introduced in Section 2.3, *Key Water Supply Projects*, environmental obligations are given the first priority for water deliveries from each system; only after these priorities are met is water supplied to the SWP and CVP (DWR 2022a). Although environmental obligations are treated as priority demands under the CVP and SWP, at the height of the 2012-2016 drought, the state reduced water allocations for environmental uses in order to reserve critical supplies for farms and cities. This indicates that during extended drought periods, all water use sectors are affected, and urban and agricultural demands can be prioritized above environmental obligations when critical.

For purposes of this study, water used for environmental obligations is presumed to be not available as a potential water supply source for clean renewable hydrogen production.

2.7 Climatic Variability

Climatic variation refers to changes in climate that affect temperature and precipitation as well as water supply and demand. The following sections discuss climate variability with consideration to water supply and demands.

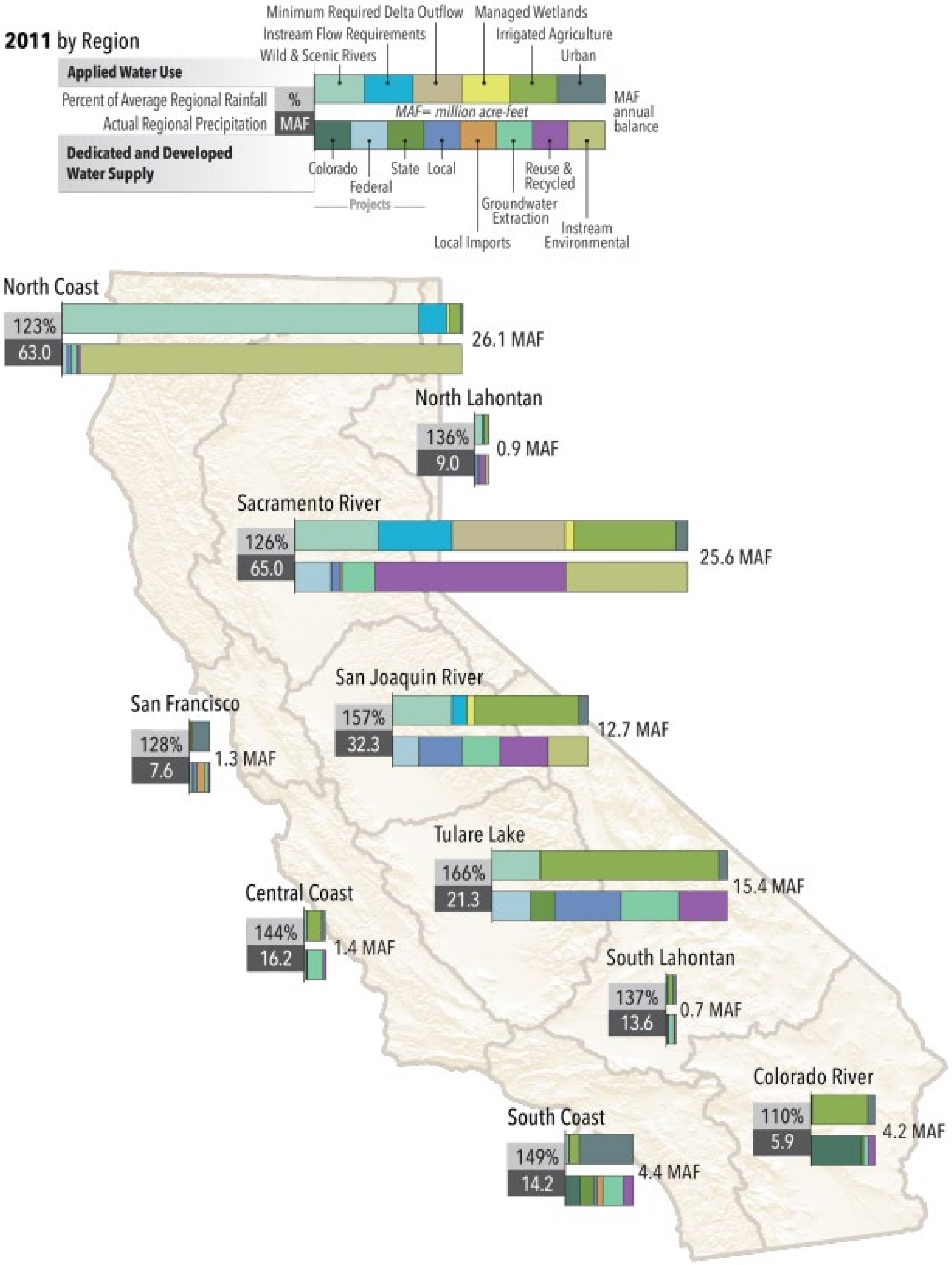
2.7.1 Supply and Demand in Wet and Critically Dry Years

This section discusses trends in water supply availability and demands under “wet year” conditions and “dry year” conditions, where the former represents a water year with above-average rainfall and the latter represents a water year with below-average rainfall. The purpose of this section is to convey how climatic variations can affect water supplies and uses, and to inform consideration of water supply availability for clean renewable hydrogen production.

Figure 1-19, below, reflects wet year conditions, using 2011 as the representative year, and Figure 1-20 reflects critically dry year conditions, using 2014 as the representative year. While these figures portray state-wide trends, SoCalGas’s service territory includes five DWR-defined hydrologic regions in the central and southern portions of the state, including the Tulare Lake, Central Coast, South Lahontan, South Coast, and Colorado River Hydrologic Regions.

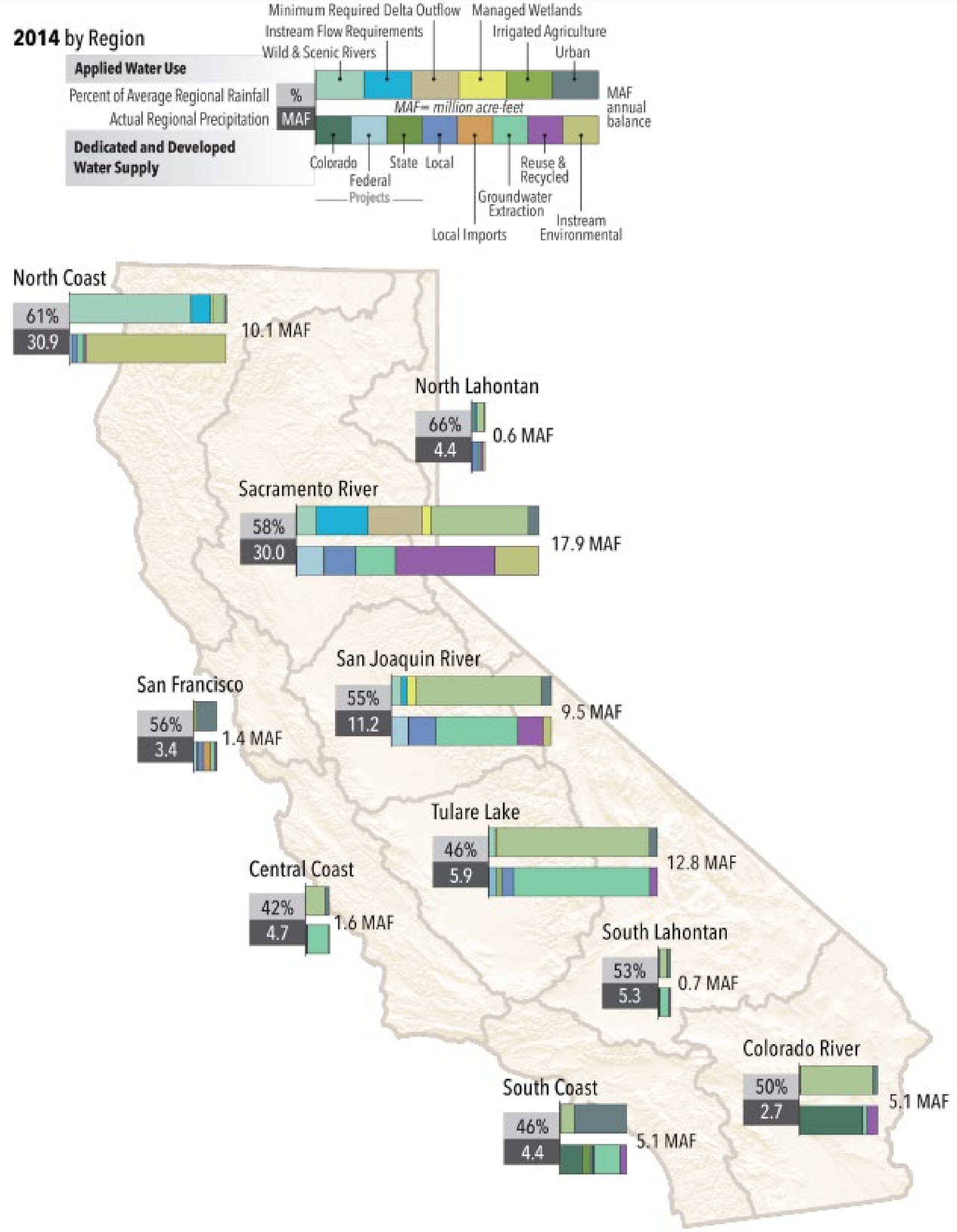
These figures indicate that during dry years, the distribution of water use is adjusted in each hydrologic region to meet priority needs first. During wet years, agricultural and environmental uses are supported through multiple water supply sources, whereas dry year uses are limited to agriculture and rely entirely on groundwater resources.

Figure 1-19 Wet Year (2011) Water Uses and Supplies



Source: DWR 2019

Figure 1-20 Critical Dry Year (2014) Water Uses and Supplies



Source: DWR 2019

2.7.2 Drought Response & Climate Change

Climate change affects California's water supply availability through multiple means, particularly reduced snowpack in the Sierra Nevada Mountains, which results in reduced flows in the SWP and CVP and deliveries of water that are smaller than contracted amount for most years. Rising temperatures are predicted to reduce snowpack by more than one third in 2050 and by more than half in 2100, even if precipitation levels remain stable (State of California 2023). Rising temperatures also affect California's precipitation cycles, with multi-year wet and dry periods making it difficult to predict future average precipitation rates. However, climate change predictions agree that even if precipitation remains stable or increases, drought severity and number of dry years will continue to increase, and more extreme precipitation events will occur.

Figure 1-21, below, includes two photos of Lake Oroville that were taken three months apart, one in December 2022 which shows dramatically low water levels in the lake, and one in March 2023 which shows the reservoir at near-full capacity. As discussed in Section 2.3.1, *State Water Project*, the SWP (California Aqueduct) initiates at Lake Oroville, conveying the captured Sierra Nevada snowmelt through the Delta to SWP Contractors and connections in Southern California.

Figure 1-21 Lake Oroville Storage, December 2022 and March 2023

Source: Metropolitan 2023c

The dramatic difference between these conditions, just three months apart, demonstrates that local water supply reliability is a critical aspect of water supply management in the face of climate change, as there are water needs in Southern California regardless of whether there is SWP water in Lake Oroville. In addition to variable and hard-to-predict precipitation, climate change is also projected to result in sea level rise, potentially causing more frequent periods of water quality degradation in the Delta, which could require increased Delta outflow to maintain water quality objectives (DWR 2022a). As discussed in Section 2.3.1, *State Water Project,* the Delta is formed by the Sacramento River flowing south to meet the north-flowing San Joaquin River; the Delta supports important environmental habitat and endangered species, as well as key water supply projects. The effects of climate change on the Delta will increase the importance of Delta management to protect supply quantity and quality for both human and environmental needs.

While effects on the Delta influence availability of both CVP water and SWP water, the effects of climate change also exacerbate long-standing issues with water supply entitlements to Colorado River water; see Section 2.3.2, *Colorado River*. Southern California relies on the Colorado River for about 25 percent of its water supply; however, the system is in the midst of a 23-year drought, the most serious in 1,200 years, and the system's reservoirs were threatening to drop to catastrophic levels (Metropolitan 2023b). Please see Section 2.3.2, *Colorado River,* for discussion of the decisions and management direction for the Colorado River that have developed through 2023, which build off the 2007 Interim Guidelines (valid through December 2025) and update management guidance and requirements to account for the effects of climate change and drought, as well as population increases.

The pressures introduced by climate change on all three of the major water supply projects in California, including the SWP (see Section 2.3.1, *State Water Project*), the Colorado River (see Section 2.3.2, Colorado River), and the CVP (see Section 2.3.3, *Central Valley Project*), indicate that local water supply resiliency and reduced dependence on imported water supplies are critical aspects to climate change response and water supply reliability throughout the state. As discussed throughout this report, any supply sources that are currently or planned for use to recharge local groundwater basins and improve local water supply reliability are considered unavailable as a supply source for clean renewable hydrogen development for purposes of this study. The development of any local supply source that would help to reduce an area's dependence on imported water supply is also considered a priority, and such sources are not considered available to clean renewable hydrogen production for purposes of this study.

Part 3: Potential Water Supply Sources

For the purposes of this analysis, “water source” refers to both the origin of water (surface water or groundwater) and the place where water is obtained for use (ex., water recycling facility, desalter facility, reservoir, low-elevation collection area, discharge pipe, etc.), and “water supply” refers to water that is procured or developed to meet the water needs of a particular use, in this case the development of clean renewable hydrogen.

Water supply for clean renewable hydrogen development is anticipated to come from multiple sources. Naturally occurring sources consist of groundwater and surface water, including rainfall and snowpack, which are used in accordance with state regulations and designated water rights. Other sources are anthropogenically developed and consist of water and wastewater that has been treated for reuse. Developed supply sources are made available for use or made available in a certain area through treatment, conveyance, storage, and/or agreements with water supply providers or public agencies responsible for delivering water supply for beneficial uses within their respective service areas.

Given the complexity of water supply sources and management in California, and considering the existing systems available to move water supply throughout the state, there is a variety of potential water supply sources that could be acquired or developed for clean renewable hydrogen production. Third-party producers of clean renewable hydrogen may draw upon these options of water supply sources to produce quantities of clean renewable hydrogen to meet the projected demands across the SoCalGas service territory and the portion of the demand that Angeles Link would transport. The water supply sources summarized in this Part have been identified as having potential for third-party producers to pursue for acquisition or development to support respective future projects.

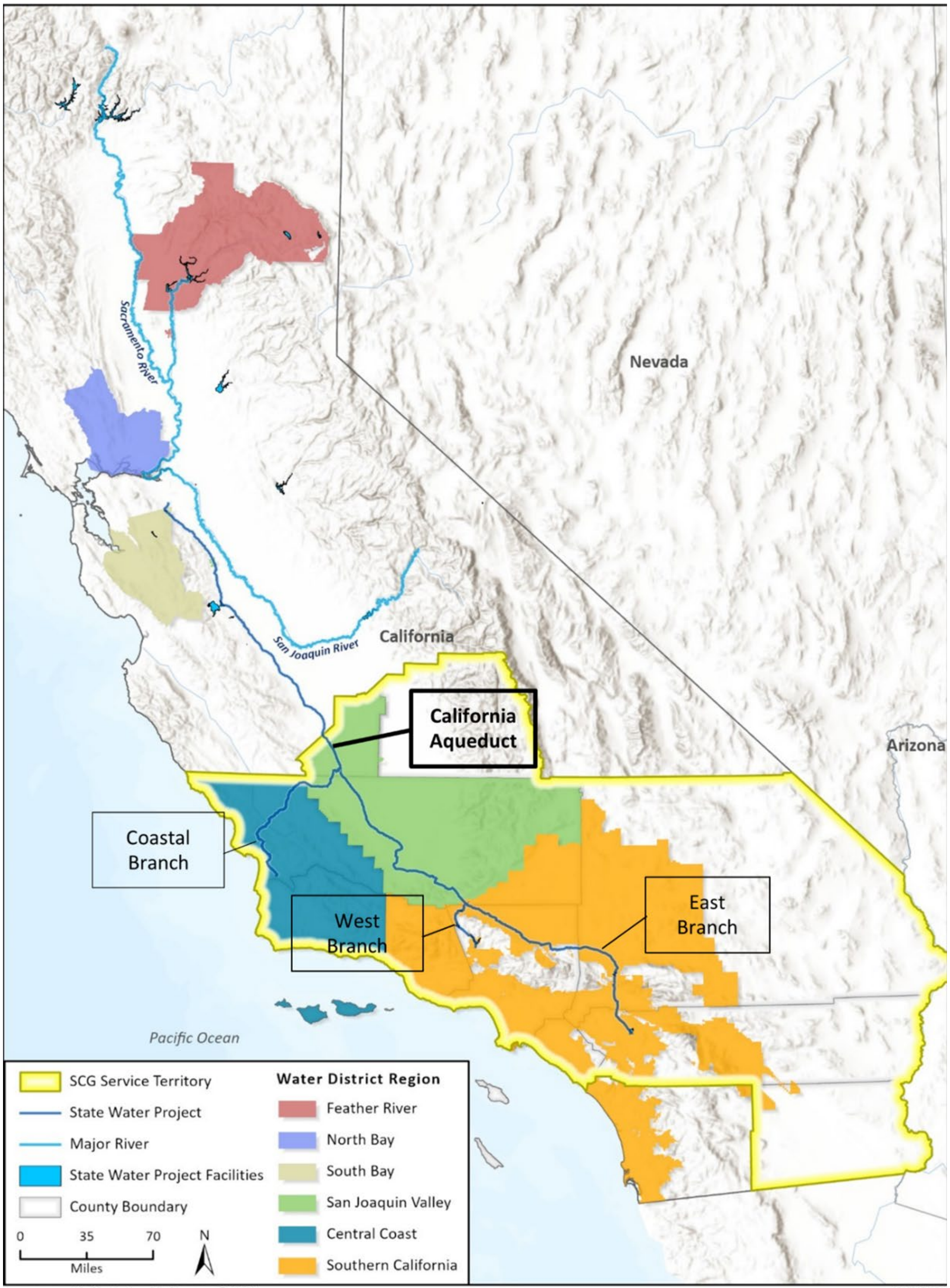
3.1 Imported Surface Water in the Study Area

Imported surface water supply sources include the State Water Project (SWP), the Colorado River (CR), and the Central Valley Project (CVP), as introduced in Section 2.3, *Key Water Supply Projects*, of Part 2, *Supply Management In California.* As described therein, each of these projects allocates water supply to contract holders of the respective project. To acquire water supply from the SWP, CR, or CVP, the water must be purchased from a contractor to the respective project from within the contractor’s existing allocations. This section provides an overview of imported surface water supplies and facilities within SoCalGas’s service territory.

3.1.1 SWP Water

The SWP is introduced in Section 2.3.1, *State Water Project*, which provides an overview of the state-wide storage and conveyance system, contractors and allocations, hydrologic conditions, fulfillment quantities and trends, and key infrastructure and facilities. Figure 1-22, below, provides an overview of the SWP system and management regions, as well as the California Aqueduct branches in Southern California. SoCalGas's service territory in Southern California encompasses three branches of the California Aqueduct, including the Coastal Branch, West Branch, and East Branch, as discussed further below.

Figure 1-22 SWP Management Regions and SoCalGas's Service Area



Imagery provided by Esri and its licensors © 2023.

As shown in the figure above, the California Aqueduct branches off its main stem at several locations within SoCalGas's service territory. These begin in the northern portion of the service territory, just south of Kettleman City in Kings County, where the Coastal Branch diverges to deliver SWP water to Kern, Santa Barbara, and San Luis Obispo counties. The main stem of the Aqueduct splits again on the south side of the Tehachapi Mountains in southern Kern County, where the West Branch diverges to store SWP water in Pyramid Lake and Castaic Lake in Los Angeles County, and the East Branch diverges to store SWP water in Silverwood Lake in San Bernardino County and Lake Perris in Riverside County (WEF 2023a).

Table 1-15, below, details the Table A SWP allocations held by contractors within SoCalGas's service territory. As discussed in Section 2.3.1, *State Water Project*, under "SWP Contractors and Allocations," "Table A" refers to the contracted amount of SWP water each contractor is promised to receive under its respective SWP contract with the DWR. Table A allocations are the maximum amount of SWP water contractors are promised. The actual amount of SWP water delivered is commonly less than Table A, due to hydrologic and climatic conditions that reduce the physical presence and availability of SWP water in the system; less often, the amount delivered may also be more than a contractor's Table A allocations, such as in response to wet weather conditions that create surplus supply availability (see discussion in Section 2.3.1 under "Article 21 Water").

Table 1-15 SWP Water Contracted Allocations (Table A) within SoCalGas Service Territory

SWP Contractor	Contracted Allocation (AFY)[1]
San Joaquin Valley Region	
Oak Flat Water District	5,700
County of Kings	9,305
Dudley Ridge Water District	41,350
Empire West Side Irrigation District	3,000
Kern County Water Agency	982,730
Tulare Lake Basin Water Storage District	87,471
Subtotal	1,129,556
Central Coastal Region	
San Luis Obispo County Flood Control & Water Conservation District	25,000
Santa Barbara County Flood Control & Water Conservation District	45,486
Subtotal	70,486

SWP Contractor	Contracted Allocation (AFY)[1]
Southern California Region	
Antelope Valley-East Kern Water Agency (AVEK)	144,844
Santa Clarita Valley Water Agency	95,200
Coachella Valley Water District	138,350
Crestline-Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California (Metropolitan)[2]	1,911,500
Mojave Water Agency	89,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600
San Gabriel Valley Municipal Water District	28,800
San Gorgonio Pass Water Agency	17,300
Ventura County Watershed Protection District	20,000
Subtotal	**2,633,544**
TOTAL SWP Allocations within SoCalGas's Service Area	**3,833,586**

[1] AFY = acre-feet per year; SWP contracted allocations refer to Table A contract amounts; see Section 2.3.1, State Water Project, under "SWP Contractors and Allocations" for further discussion.

[2] A portion of Metropolitan's service area is within a portion of San Diego County located outside of SoCalGas's service territory.

Source: DWR 2023c

The table above indicates that within SoCalGas's service territory, SWP allocations total 3,833,586 AFY. The SWP was designed to deliver 4,172,786 AFY of water, indicating, 91 percent of all SWP water is delivered within SoCalGas's service territory. The three largest SWP contractors are: AVEK (144,844 AFY), Kern County Water Agency (982,730 AFY), and Metropolitan (1,911,500 AFY).

The actual amount of SWP water available for delivery varies each year, depending on drought and rainfall conditions and impacts on endangered species. DWR changes the amount of water allocated to the water contractors multiple times per year based on the actual water availability. Between 1996 and 2023, the amount of SWP water that was physically delivered to SWP contractors represented between zero and 75 percent of the contracted allocations (DWR 2023c). Water deliveries have averaged approximately 2.8 million acre-feet per year (MAFY) over the last decade (WEF 2023a), representing approximately 35 percent of total SWP allocations.

Efforts to improve the reliability of SWP deliveries to south-of-Delta contractors include DWR’s development of the proposed Delta Conveyance Project, which would expand existing SWP facilities through the Sacramento-San Joaquin Delta. The Delta Conveyance Project would implement new water intake facilities on the Sacramento River in the north Delta, and a tunnel to divert and move water entering the north Delta from the Sacramento Valley watershed to existing SWP facilities in the south Delta. These improvements would result in a dual conveyance system for SWP water through the Delta, facilitating the capture and storage of more water during wet seasons to improve water availability during dry seasons, while also protecting against earthquake disruptions to the existing system. The Delta Conveyance Project would not alter Table A contract amounts; rather, it would increase the reliability of contract fulfillment for Table A contractors south of the Delta.

The DWR initiated planning for the Delta Conveyance Project in response to an April 2019 Executive Order directing the assessment of a single-tunnel project, compared to the dual-tunnel design of the previously approved All California WaterFix project, which was not implemented due to environmental and regulatory issues. The DWR has completed its California Environmental Quality Act (CEQA) review processes for the Delta Conveyance Project, and certified its Environmental Impact Report (EIR) for the project in December 2022. As of the time of this study, tribal engagement and regulatory compliance efforts are ongoing for the Delta Conveyance Project, as the DWR pursues numerous state and federal permits or authorizations required by the State Water Resources Control Board (SWRCB), the Delta Stewardship Council, and the state and federal Endangered Species Acts (ESAs). A new cost estimate and a benefit-cost analysis for the Delta Conveyance Project are expected to be provided by the Delta Construction Authority in mid-2024 (DWR 2023n).

3.1.2 Colorado River Water

Colorado River water enters California in the southeastern portion of the state, where the Colorado River Aqueduct initiates at Lake Havasu, formed by Parker Dam at the California border with Arizona. Figure 1-23, below, provides an overview of the Colorado River Aqueduct alignment through Southern California and the agencies which hold entitlements to Colorado River water.

Figure 1-23 California Entities Using Colorado River Water

Source: Metropolitan 2021

Table 1-16, below, lists the Southern California entitlements to Colorado River water, presented in order of priority ranking.

Table 1-16 Colorado River Water Entitlements in California

Contractor or Decree Name	Diversion (AFY)
Federal	
Chemehuevi Indian Reservation	11,340
Fort Yuma Indian Reservation	71,616
Colorado River Indian Reservation (Nov 22, 1873)	10,745
Colorado River Indian Reservation (Nov 16, 1874)	40,241
Colorado River Indian Reservation (May 15, 1876)	5,860
Fort Mojave Indian Reservation	16,720

Contractor or Decree Name	Diversion (AFY)
Present Perfected Rates (PPRs)[a]	
PPRs consist of 59 agencies and private entities listed in Article II(B)(3) of the 1964 Supreme Court Decree (*Arizona v. California*) that settled disputes raised in 1952 over claims to Colorado River water in the Lower Basin (USBR 2023). Under this decree, during any year when less than 7.5 MAF are available to fulfill the Lower Basin states' (California, Nevada, Arizona) total allocations, the Secretary of the Interior must provide supply to the PPRs in order of priority, regardless of state lines. The remaining amount of Lower Basin states' allocation is distributed to the Lower Basin states only after PPR water supplies are met. Finally, surplus water contracts are fulfilled only after the Lower Basin states' allocations are delivered.	3,824
Seven-Party Agreement[b]	
1. Palo Verde Irrigation District (104,500 acres)[c]	3,850,000
2. Yuma Project (25,000 acres)[c]	
3(a). IID and lands in Imperial and Coachella Valleys to be served by the All American Canal (AAC)	
3(b). Palo Verde Irrigation District (16,000 acres of mesa lands)[c]	
4. Metropolitan and/or City of Los Angeles and/or others on coastal plain	**550,000**
5(a). Metropolitan and/or City of Los Angeles and/or others on coastal plain	**550,000**
5(b). City and/or County of San Diego	112,000
6(a). IID and lands in Imperial and Coachella Valleys to be served by the AAC	300,000
6(b). Palo Verde Irrigation District (16,000 acres of mesa lands)[c]	
7. All remaining water available for use in California for agricultural uses	-
TOTAL acre-feet of the 1931 Seven Party Agreement (USBR 2021b)[d]	**5,362,000**
Surplus Water Contracts	
Bureau of Land Management (BLM)	1,000
BLM (in lieu of water pumped from Lower Colorado Water Supply Project [LCWSP] facilities or in the event the LCWSP is non-functional)	1,150

Contractor or Decree Name	Diversion (AFY)
Coachella Valley Water District	100,000
Department of the Navy	25
Needles, City of	10,000
Metropolitan Water District of Southern California	**180,000**

Notes:

a. PPRs include the following 59 agencies and entities, listed in order of priority ranking: Yuma Associates Ltd. And Winterhaven Water District; Wavers; Stephenson (PPR No. 30); Campbell, Terry E. and Carol J.; Maureen E. and Robert M. Buncati; Bruncati Family Trust 12/19/02; Sunrise Management LLC; Gary J. George; Robert L. & Christine M.; Lake enterprises of California, LLC; Gowan, Sonny (Grannis); Morgan; Milpitas (PPR No. 34); Simons; Colorado River Sportsmen's League; Milpitas (PPR No. 37); Andrade (PPR No. 38); Reynolds; Cooper; Chagnon; Lawrence; Needles, City of (PPR No. 43); Needles, City of (PPR No. 44); Conger; G. Draper; McDonough; Faubion; Dudley; Douglas; Beauchamp; Clark; Lawrence; J. Graham; Geiger; Schneider; Martinez; Earle; Diehl; Reid; Graham; Cate; McGee; Stallard (PPR No. 64); Randolph; Stallard (PPR No. 66); Keefe; C. Ferguson; W. Ferguson; Vaulin; Salisbury; Hadlock; Streeter; J. Draper; Fitz; Williams; Estrada; Whittle; Corrington; Tolliver.

b. The Seven-Party Agreement of 1931 (Metropolitan et al. 1931) details these original allocations of Colorado River water. California later reduced its use of Colorado River water to 4.4 MAFY under the 2003 Quantification Settlement Agreement (USDOI 2003), which set aside decades-old disputes and facilitated water transfers from farms to cities, funded linking the All-American and Coachella Canals, and led to new agricultural conservation in California and partnership with Metropolitan (Metropolitan 2023d).

c. Uniquely, the PVID's Colorado River rights are not quantified by volume; rather, their water rights allow for irrigation and potable water to serve 104,500 acres in the Palo Verde Valley (overlying the Palo Verde Valley Groundwater Basin; see Section 3.3, Groundwater) and 16,000 acres on the Palo Verde Mesa (overlying the Palo Verde Mesa Groundwater Basin; see Section 3.3, Groundwater) each year. In addition, the U.S. Bureau of Land Management (BLM)'s Yuma Project receives Colorado River water from the All American Canal to irrigate the California portion of the project, which consists of 25,000 acres in Imperial County; the remainder of the Yuma Project's total 68,000 acres is located in Yuma County, Arizona.

d. During the term that the Colorado River Water Delivery Agreement (Federal Quantification Settlement Agreement) dated October 10, 2003, remains in effect, the delivery of Colorado River water will be in accordance with the terms as set forth in that agreement, including Exhibit B which identifies specific entitlements during the time the agreement is in effect (USDOI 2003).

Source: USBR 2021b; USDOI 2003

As shown in the table above, Colorado River water users in California include Metropolitan, Coachella Valley Water District (CVWD), Imperial Irrigation District (IID), and Palo Verde Irrigation District (PVID); these agencies receive and distribute Colorado River water to customers within their respective service territories, including within SoCalGas's service territory. Metropolitan holds a fourth-priority right to 550,000 AFY of California's apportionment of 4.4 MAFY, which is 59 percent of the Lower Basin states' total apportionment of 7.5 MAFY. Metropolitan also holds Surplus Water Contracts amounting to 180,000 AFY.

3.1.3 CVP Water

The majority of the CVP occurs outside of SoCalGas's service territory; however, the southern-most portion of the CVP consists of the Friant Division, which extends CVP water conveyance into SoCalGas's service territory via the Friant-Kern Canal. The Friant-Kern Canal supplies San Joaquin River water stored at Millerton Lake to more than 30 irrigation districts and cities, as well as 15,000 family farms (FWA 2023). The Friant Water Authority (FWA) represents the majority of Friant Division water users and maintains and operates the Friant-Kern Canal. There are 32 CVP contractors within the Friant Division, of which 19 are located within SoCalGas's service territory.

Table 1-17, below, identifies the Friant Division contractors within SoCalGas's service territory, and the contracted allocation of CVP water held by each, followed by Figure 1-24, which provides an overview of the CVP system and facilities, including within SoCalGas's service territory.

Table 1-17 CVP Contracted Allocations to Friant Division Contractors

Region	Contracted Allocation (AFY)
Arvin-Edison Water Storage District	351,675
Delano-Earlimart Irrigation District	183,300
Exeter Irrigation District	30,100
Ivanhoe Irrigation District	7,000
Kaweah Delta Water Conservation District	8,600
Kern-Tulare Water District	5,000
Lewis Creek Water District	1,200
Lindmore Irrigation District	55,000
Lindsay, City of	2,500
Lindsay-Strathmore Irrigation District	27,500
Lower Tule River Irrigation District	299,200
Porterville Irrigation District	45,000
Saucelito Irrigation District	54,300

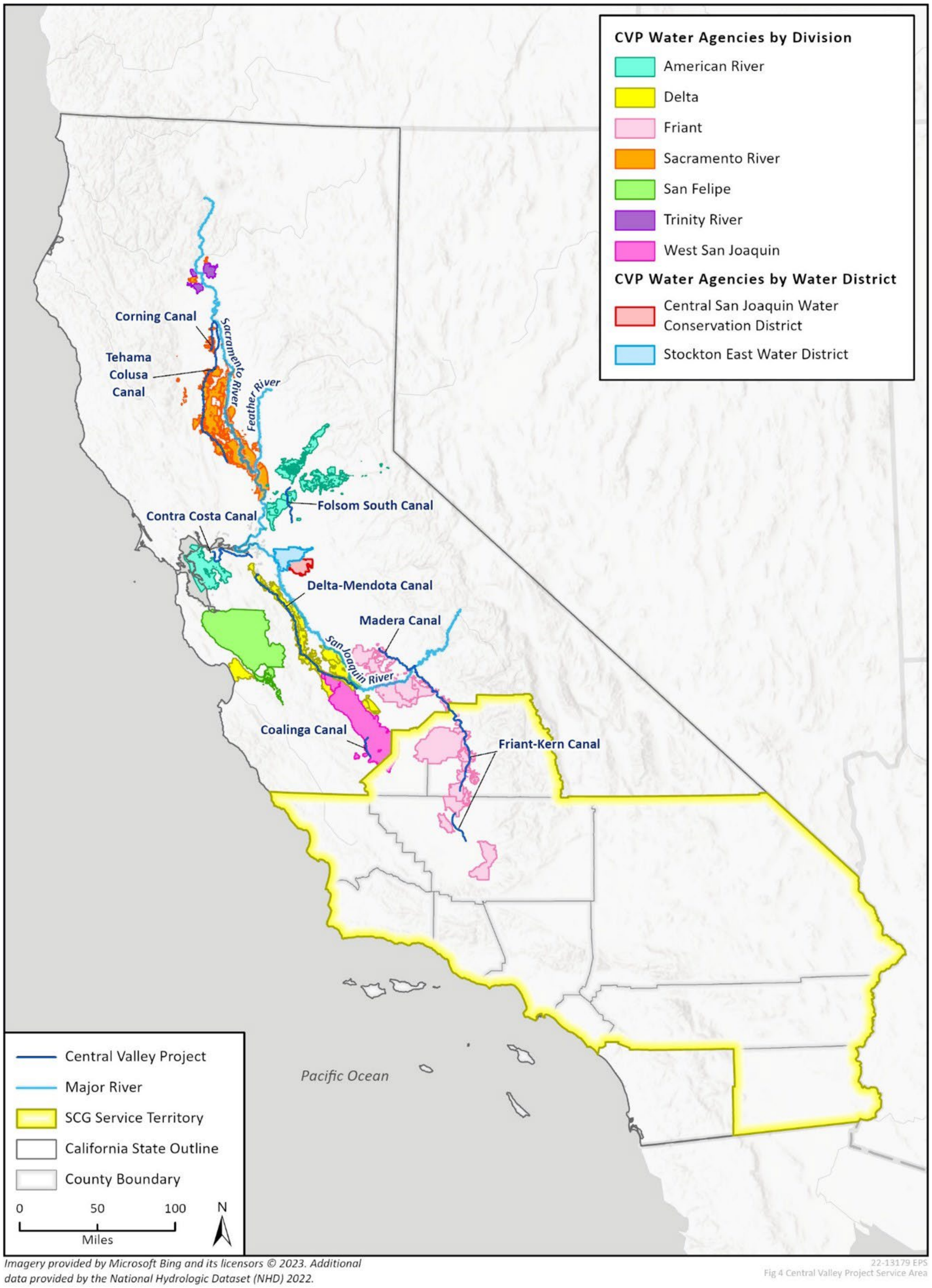
Region	Contracted Allocation (AFY)
Shafter-Wasco Irrigation District	89,600
Southern San Joaquin Municipal Utility District	142,000
Stone Corral Irrigation District	10,000
Tea Pot Dome Water District	7,200
Terra Bella Irrigation District	29,000
Tulare Irrigation District	171,000
Total Allocations with SoCalGas's Service Area	**1,519,175**

Source: USBR 2016

The table above indicates that of the 19 Friant Division contractors within SoCalGas's service territory, five have CVP allocations of more than 100,000 acre-feet per year (AFY), all of which are irrigation districts which primarily provide water for agricultural irrigation. These allocations are contracted amounts but do not represent the physical amount of water received each year, which is dependent upon climatic conditions and supply availability in the source waters. The USBR changes the amount of water annually delivered to contractors based on the actual water availability, including for enviornmental needs.

Section 2.3.3, *Central Valley Project,* discusses the physical deliveries of CVP water and provides quantification of annual fulfillment amounts in Table 1-11. Similar to SWP deliveries discussed above, deliveries of CVP water vary depending upon climatic conditions and drought, and can range between 0 and 100 percent fulfillment of contracted allocations to CVP water. Figure 1-24, below, provides an overview of the CVP system and facilities, including within SoCalGas's service territory.

Figure 1-24 CVP Divisions and SoCalGas's Service Territory



Source: USBR 2021a

3.2 Treated Wastewater

Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. For the purposes of this analysis, treated wastewater that is currently being discharged from treatment facilities without further reuse or plans for future reuse[11] is considered available as a potential water supply source for clean renewable hydrogen production.

Wastewater Treatment Facilities

Table 1-18, below, provides an overview of estimated discharges of treated wastewater from each facility shown in the following Figure 1-25. These estimates are informed by data provided to DWR for the 2020 UWMP cycle, and therefore reflect 2020 conditions. To isolate those discharges of treated wastewater from discharges that would be reused through other projects and activities, individual UWMPs were reviewed and quantities of treated wastewater planned for reuse were subtracted from total discharges of treated wastewater from respective facilities. The purpose of this approach was to differentiate to the extent feasible between discharges for disposal versus discharges for reuse; discharges conducted for disposal are considered potentially available as a supply source for clean renewable hydrogen production, while discharges planned for reuse are not available as a potential supply source. Further investigation and evaluation of site-specific conditions will help to determine how much treated wastewater could be made available for clean renewable hydrogen from the identified facilities, and whether additional facilities should be included as potential supply sources. As discussed in Section 2.4, *Urban Water Management Planning*, UWMPs are updated by water providers every five years; the next round of UWMP updates will occur in 2025.

Table 1-18 Recycled Water Facilities Discharging Treated Effluent (2016-2020)[1]

Facility[2]	Agency (owner/operator, if different)[3]	Discharge (MGD)	Treatment Level[4]
Reedley WWTP	Reedley, City of	0.57	SU
Dinuba WWRF	Dinuba, City of	0.59	SU
Coalinga Domestic WWTP	Coalinga, City of	0.28	SU
City of San Luis Obispo WRRF	San Luis Obispo, City of	1.07	T
Bakersfield WWTP No. 3	Bakersfield, City of	10.86	SU

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[11] Recycled water that is currently reused or is planned for reuse is based on information in 2020 UWMPs and considered unavailable to future hydrogen development for purposes of this study.

Facility[2]	Agency (owner/operator, if different)[3]	Discharge (MGD)	Treatment Level[4]
Lancaster WRP	LACWD 40, Antelope Valley (LACSD)	11.74	T
Palmdale WRP	LACWD 40, Antelope Valley (LACSD 20)	7.69	T
Adelanto WWTF	Adelanto, City of	2.68	SU
Goleta WWTP	Goleta Water District (Goleta SD)	3.62	SD-2.2
El Estero WWTP	Montecito Water District (Montecito SD)	5.19	SU
El Estero WRC	Santa Barbara, City of	4.91	SD-23
Montecito WWTP	Montecito Water District (Montecito SD)	0.64	SU
Oxnard WWTP	Oxnard, City of	8.40	SD-2.2
Simi Valley WQCP	Ventura County Waterworks District No 08	7.07	T
San Jose Creek WRP	San Gabriel Valley Water Company (LASAN)	5.82	T
Rialto WWTP	Rialto, City of	7.24	T
Banning WWTP	Banning, City of	1.95	SU
Long Beach WRP	Long Beach, City of	3.13	T
OC-San Plant No. 2	Huntington Beach, City of (OC-San)	66.96	SD-2.2
Laguna Niguel RTP	Moulton Niguel Water District (SOCWA)	3.57	T
MNWD Plant 3A	Moulton Niguel Water District (SOCWA)	0.85	T
San Clemente WRP	San Clemente, City of (SOCWA)	2.86	SU
J.B. Latham Plant	Moulton Niguel Water District (MNWD)	11.15	SU
JB Latham Plant and CTP	South Coast Water District (SOCWA)	1.96	SD-2.2
CVWD WRP-10	CVWD	1.53	T
CVWD WRP-7	CVWD	1.16	T

Facility[2]	Agency (owner/operator, if different)[3]	Discharge (MGD)	Treatment Level[4]
CVWD Avenue 54 WWTP	Coachella, City of (Coachella SD)	2.77	SU
CVWD WRP-4	CVWD	5.85	SD-23
Blythe WWTP	Blythe, City of	1.39	SD-23
Encina WPCF (to San Elijo)	Carlsbad MWD	23.18	SU
Encina WPCF	San Dieguito Water District	10.12	SU
Hale Avenue RRF (to San Elijo)	Escondido, City of	11.36	T
San Elijo WRF	San Dieguito Water District	1.47	T
South Bay WRP	San Diego, City of	4.41	SU
Brawley WWTP	Brawley, City of	0.92	SD-2.2
City of Imperial WWTP	Imperial, City of	1.20	SD-2.2
Calexico WWTP	Calexico, City of	2.57	SD-2.2
El Centro WWTP	El Centro, City of	3.16	SD-23
Total		**241.90**	

[1] Facility information was sourced from 2020 Urban Water Management Plans (UWMPs), which updated 2015 UWMPs and reflect observed conditions for years 2016-2020 as well as projected conditions through 2040; the next UWMP update cycle will occur in 2025, and will account for changed supplies and demands occurring since the 2020 update cycle.

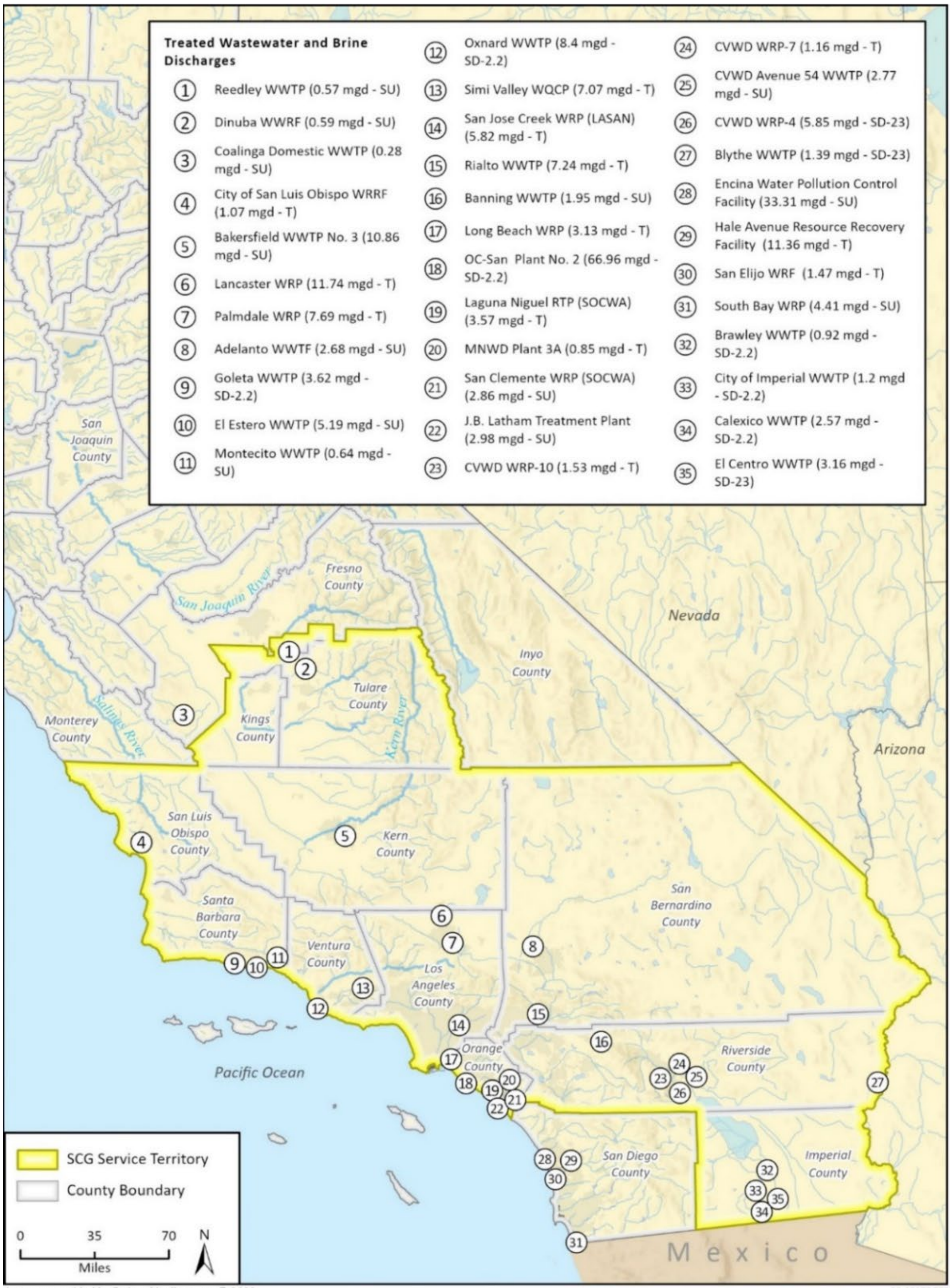
[2] CTP = Coastal Treatment Plant; RRF = Resource Recovery Facility;
RTP = Regional Treatment Plant; WPCF = Water Pollution Control Facility;
WQCP = Water Quality Control Plant; WRC = Water Resource Center;
WRP = Water Reclamation Plant; WRRF = Water Resource Recovery Facility;
WWTF = Wastewater Treatment Facility; WWTP = Wastewater Treatment Plant

[3] CVWD = Coachella Valley Water District; LACSD = Los Angeles County Sanitation Districts; LASAN = City of Los Angeles Sanitation & Environment; SD = Sanitary District; SOCWA = South Orange County Wastewater Authority

[4] SU = Secondary, Undisinfected; SD-23 = Secondary, Disinfected-23;
SD-2.2 = Secondary, Disinfected-2.2; T = Tertiary

Figure 1-25, below, provides an overview of the locations of recycled water facilities within SoCalGas's service territory, as well as several adjacent facilities that are currently discharging treated wastewater without further reuse. The select adjacent facilities are included due to site-specific considerations, such as, but not limited to, the regional importance of the facility and the amount of recycled water produced.

Figure 1-25 Wastewater Treatment Facilities Discharging Treated Flows (2016-2020)[1]



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[1] Facility information was sourced from 2020 Urban Water Management Plans (UWMPs), which updated 2015 UWMPs and reflect observed conditions for years 2016-2020 as well as projected conditions through 2040; the next UWMP update cycle will occur in 2025, and will account for changed supplies and demands occurring since the 2020 update cycle.

3.3 Groundwater

Groundwater is an important supply source in California, with about 83 Percent of Californians depending on groundwater for some portion of their supplies and many communities entirely dependent upon their local groundwater resources (DWR 2023k). There are 515 defined groundwater basins throughout the state. In 2014, the Sustainable Groundwater Management Act (SGMA) was passed, requiring all groundwater basins to be ranked by DWR in order of priority, as either Very Low, Low, Medium, or High Priority. All High and Medium Priority basins are required to be managed in accordance with a Groundwater Sustainability Plan (GSP) administered by a Groundwater Sustainability Agency (GSA) for compliance with SGMA. An overview of SGMA is provided in Table 1-7, presented in Section 2.2, *Laws and Regulations*; SGMA is also discussed as relevant in the basin prioritization sections below.

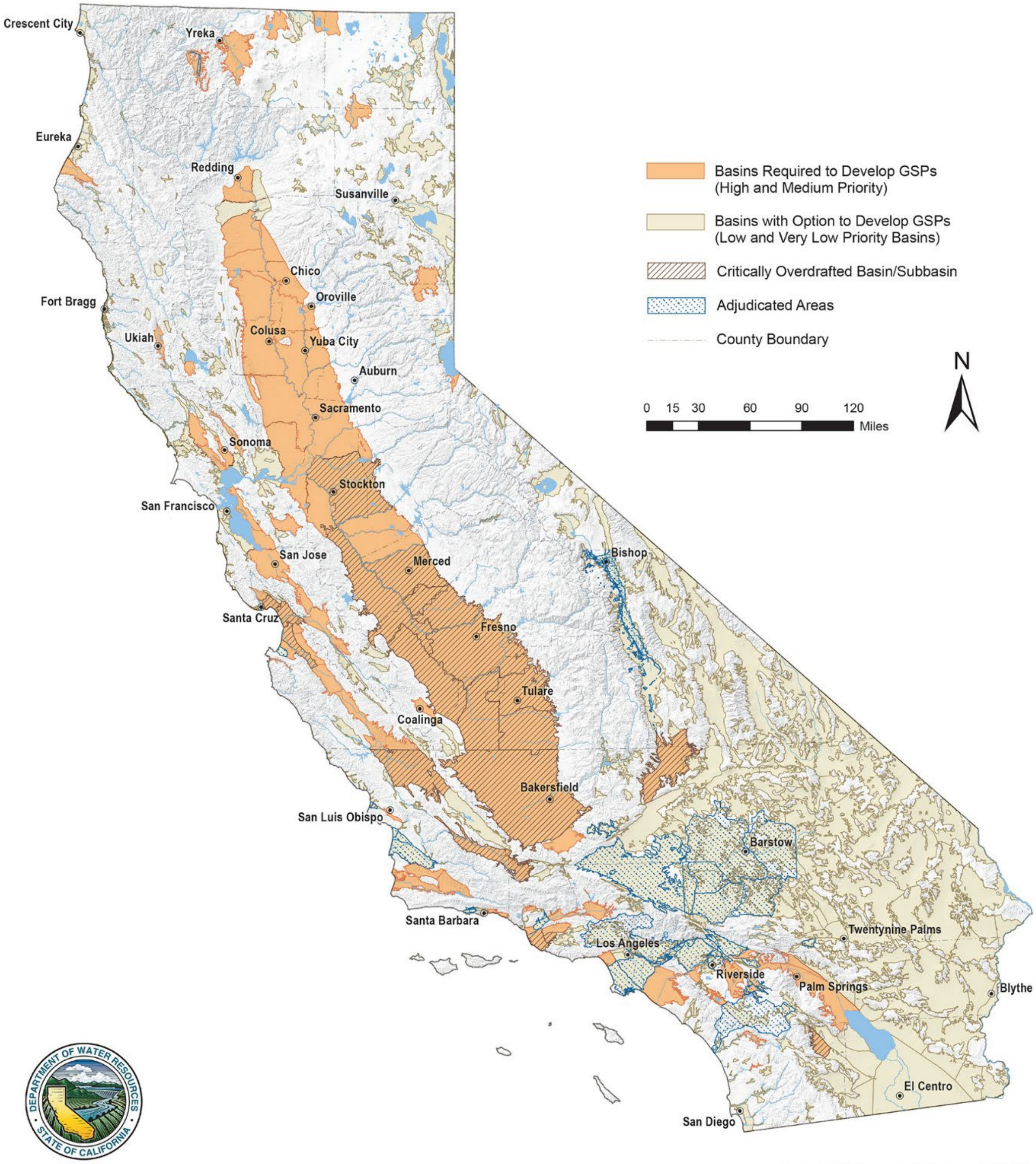
3.3.1 Basin Prioritization and Availability

In accordance with SGMA, the DWR has ranked each of California's 515 defined groundwater basins into one of four categories: Very Low Priority; Low Priority; Medium Priority; and High Priority. Prioritization rankings are based upon consideration of eight components identified in California Water Code Section 10933(b) as follows:

1) The population overlying the basin or subbasin;
2) The rate of current and projected growth of the population overlying the basin or subbasin;
3) The number of public supply wells that draw from the basin or subbasin;
4) The total number of wells that draw from the basin or subbasin;
5) The irrigated acreage overlying the basin or subbasin;
6) The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water;
7) Any documented impacts on the groundwater within the basin or subbasin, including overdraft, subsidence, saline intrusion, and other water quality degradation; and
8) Any other information determined to be relevant by the department, including adverse impacts on local habitat and local streamflow (DWR 2023i).

Based on consideration of the above components, DWR has identified California's 515 defined groundwater basins as consisting of 46 High Priority basins, 48 Medium Priority basins, 11 Low Priority basins, and 410 Very Low Priority basins (DWR and CNRA 2020). The 94 Medium and High Priority basins, in combination with adjudicated areas which have existing governance and oversight in place, account for 98 percent (20 MAFY) of all groundwater pumping in California (DWR 2023i). The 421 Low and Very Low Priority basins account for two percent (0.408 MAFY) of all groundwater pumping in the state (DWR 2023i). Figure 1-26, below, provides an overview of groundwater basin prioritization, followed by discussion of rankings under respective headings.

Figure 1-26 California Groundwater Basin Prioritization



Department of Water Resources, Public Affairs Office April 28, 2020

Source: DWR 2023i

Figure 1-26 above shows that High and Medium Priority basins are concentrated in California’s Central Valley, while Low and Very Low Priority basins are concentrated in the High Desert region of Southern California, extending through Blythe in eastern Riverside County. Discussion of groundwater as a potential supply source for clean renewable hydrogen is provided below, by priority ranking. Adjudicated basins, which are primarily located within Low and Very Low Priority basins, are discussed in Section 3.3.2, *Adjudicated Groundwater Basins*.

High Priority Basins

As shown in Figure 1-26 above, High and Medium Priority basins are concentrated in California’s Central Valley, where critically overdrafted basins are also concentrated. As defined by SGMA, “A basin is subject to critical overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts.” Therefore, critically overdrafted groundwater basins are not considered a potential supply source for clean renewable hydrogen for purposes of this study. However, not all High Priority basins are critically overdrafted.

High Priority basins are persistently overdrafted, meaning that more water leaves the basin than recharges to it. The purpose of a GSP is to reverse overdraft conditions, create sustainable conditions, and maintain sustainable conditions. As such, a High Priority basin may be currently overdrafted but may be managed with progress towards sustainable conditions. Use of groundwater from an overdrafted basin could exacerbate the overdraft conditions, assuming existing reliance on the basin continues unabated. To avoid contributing to existing adverse conditions, groundwater basins that are currently overdrafted and not managed towards sustainability are not a potential supply source for clean renewable hydrogen production for purposes of this study. However, depending upon the management approach and physical conditions in a High Priority groundwater basin, it is possible that a supply source could be developed within the guidelines of the basin’s GSP.

For example, in the High Priority-designated Westside Subbasin of the San Joaquin Valley Groundwater Basin (SJVGB), the Darden Clean Energy Project (“Darden”) was proposed in application documents submitted to the California Energy Commission (CEC) in November 2023 to use groundwater from the High Priority basin to meet a portion of its water needs, in compliance with SGMA.[12] As stated in the application, the Darden project as proposed would construct and operate a 1,150-megawatt (MW) solar photovoltaic (PV) facility and an up to 1,150-MW green hydrogen generator, as well as a battery energy storage system (BESS),

[12] The Darden Clean Energy Project is cited to provide an example of the potential water sources third-party producers may pursue and how those producers may acquire those water sources. Before finalizing this report, an update on the Darden Project was posted on the CEC' website on October 3, 2024, stating the "800-megawatt green hydrogen facility is no longer part of the project." (See https://www.energy.ca.gov/powerplant/solar-photovoltaic-pv/darden-clean-energy-project)

transmission and conveyance facilities, and appurtenances (IP Darden I LLC 2023b, pg. 2-1). The application further states that the Darden project facilities would be capable of producing up to 220 tonnes[13] per day of pure, gaseous hydrogen (CEC 2024). For the proposed hydrogen production, the project's total water needs would be up to approximately 21,990 AF for the combined construction and operational water needs over a future projection of 20 years, with the operational demands each year estimated to be 1,039 AFY (IP Darden I LLC 2023a, pg. 5.13-43).

The application also states that the Darden project proposes to obtain the water supply for the solar facility component through the acquisition of property and use of landowner groundwater rights in the Westside Subbasin (IP Darden I LLC 2023a, pgs. 5.13-41, 5.13-42). Based upon the terms of an Option Agreement between Westlands Water District (WWD) and the Applicant, the Darden project would receive 2 AFY for every 320 acres of land acquired within the project site for solar energy development. As the primary GSA for the Westside Subbasin, WWD's groundwater allocations (as specified in the Option Agreement with the Applicant) are assumed to be consistent with the objectives of SGMA and the Westside Subbasin GSP. In total, approximately 9,000 acres of land would be acquired under the Darden project proposal and landowner rights would provide 56 AFY of water (or a total of up to 1,120 AF over 20 years) produced from onsite wells for the solar facility component of the project (IP Darden I LLC 2023a, pg. 5.13-42). See Section 4.4, *Land Purchase with Water Rights,* for further discussion of this supply acquisition method.[14]

Medium Priority Basins

As noted above, Medium Priority basins are required by SGMA to be managed under a GSP implemented by a DWR-approved GSA, as are High Priority basins. The difference between a High Priority basin and Medium Priority basin is the score assigned by DWR based upon consideration of the eight components listed in the

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[13] A tonne is a metric measurement of weight equivalent to 1,000 kilograms; 220 tonnes per day is equivalent to 220,000 kilograms per day, for a total annual production rate, assuming consistent daily production, of up to 80,300 tonnes (80.3 million kilograms).

[14] As stated in its application, the Darden project proposes to obtain water supply for the green hydrogen production component of the project through surplus surface water flows that occurred during the 2022/2023 water year and would be purchased as Article 21 water from WWD; see Section 4.3.2, Wet Weather Surplus Flows, for discussion of this mechanism for supply acquisition (IP Darden I LLC 2023a, pg. 5.13-53). Under the Darden project, the purchased Article 21 water would be stored via aquifer storage and recovery (ASR), also referred to as "groundwater banking," for use as needed over the life of the project (IP Darden I LLC 2023a, pg. 5.13-53). As of October 2023, approximately 43,000 AF of this supply source was available through WWD. Operation of the electrolyzer for the green hydrogen component of the project would require approximately 1,000 AFY, or approximately 20,000 AF in total (IP Darden I LLC 2023a, pg. 5.13-53). Project details may change.

introduction to this section, from California Water Code Section 10933(b). High and Medium Priority Basins are generally grouped together in DWR maps and analyzed as basins that require GSPs. Depending upon the physical conditions and management approach of a given basin, Medium Priority basins could potentially provide water supply for future clean renewable hydrogen projects. As with High Priority basins, availability should be assessed by potential third-party clean renewable hydrogen producers on a case-by-case basis, in coordination with the respective GSA(s).

Low and Very Low Priority Basins

Groundwater basins that are designated as Low or Very Low Priority, which are not considered by the state to be at risk of overdraft, and which are not restricted by water rights requirements, may present an opportunity to supply water to future clean renewable hydrogen projects. A Low or Very Low Priority basin is not impacted by overdraft conditions, and in some cases may be characterized by surplus conditions. Low and Very Low Priority basins are commonly managed through compliance with water rights requirements.

For example, in eastern Riverside County, the city of Blythe overlies two Very Low Priority groundwater basins, the Palo Verde Valley Groundwater Basin (PVVGB) and the Palo Verde Mesa Groundwater Basin (PVMGB), as shown in Figure 1-27, below. The PVVGB is hydrologically connected to the Colorado River and receives most of its recharge as infiltration from the overlying Colorado River. Most discharge (outflow) of water from this basin occurs via municipal and agricultural wells, evapotranspiration, and as underflow returning to the Colorado River (USGS 2013). Contracted allocations of Colorado River water do not change when the water infiltrates into underlying groundwater basins from the river channel. As such, some Colorado River water rights holders obtain their allocations by pumping Colorado River water from hydrologically connected groundwater, such as the PVVGB.

The PVVGB and PVMGB are located within the service territory of the Palo Verde Irrigation District (PVID) and as noted above, the PVVGB is hydrologically connected to the Colorado River. The PVID holds some of the highest priority rights to Colorado River water, including the State of California's Priority 1 rights, as well as a shared portion of the state's Priority 3 rights; see Table 1-16, *Colorado River Water Entitlements in California* (see Section 3.1.2, *Colorado River Water*). Uniquely, the PVID's Colorado River rights are not quantified by volume; rather, their water rights allow for irrigation and potable water to serve 104,500 acres in the Palo Verde Valley (overlying the PVVGB), and 16,000 acres on the Palo Verde Mesa (overlying the PVMGB) each year.

In addition to the PVID's rights to water in the PVVGB and PVMGB, water supply is also managed through agricultural fallowing. Under a 35-year agreement (initiated in 2005) between Metropolitan and PVID, farmers in the Palo Verde Valley are paid to refrain from irrigating up to 28 percent of their farmland at Metropolitan's call, making water available for the communities served by Metropolitan (Metropolitan 2022b). The water saved from fallowing remains in the Colorado River Aqueduct and connected groundwater as it passes through the Palo Verde Valley, continuing into Metropolitan's service territory to the west.

Figure 1-27 Palo Verde Groundwater Basins

Source: USGS 2013

Metropolitan also owns about 22,000 acres of irrigable farmland in the Palo Verde Valley, and participates in the fallowing program (Metropolitan 2022b).

It is possible, as in the PVVGB and PVMGB, that water may be procured from Low and Very Low Priority basins through multiple mechanisms, depending upon physical conditions and management of the basin. Please see Part 4, *Mechanisms of Supply Acquisition*, for further discussion.

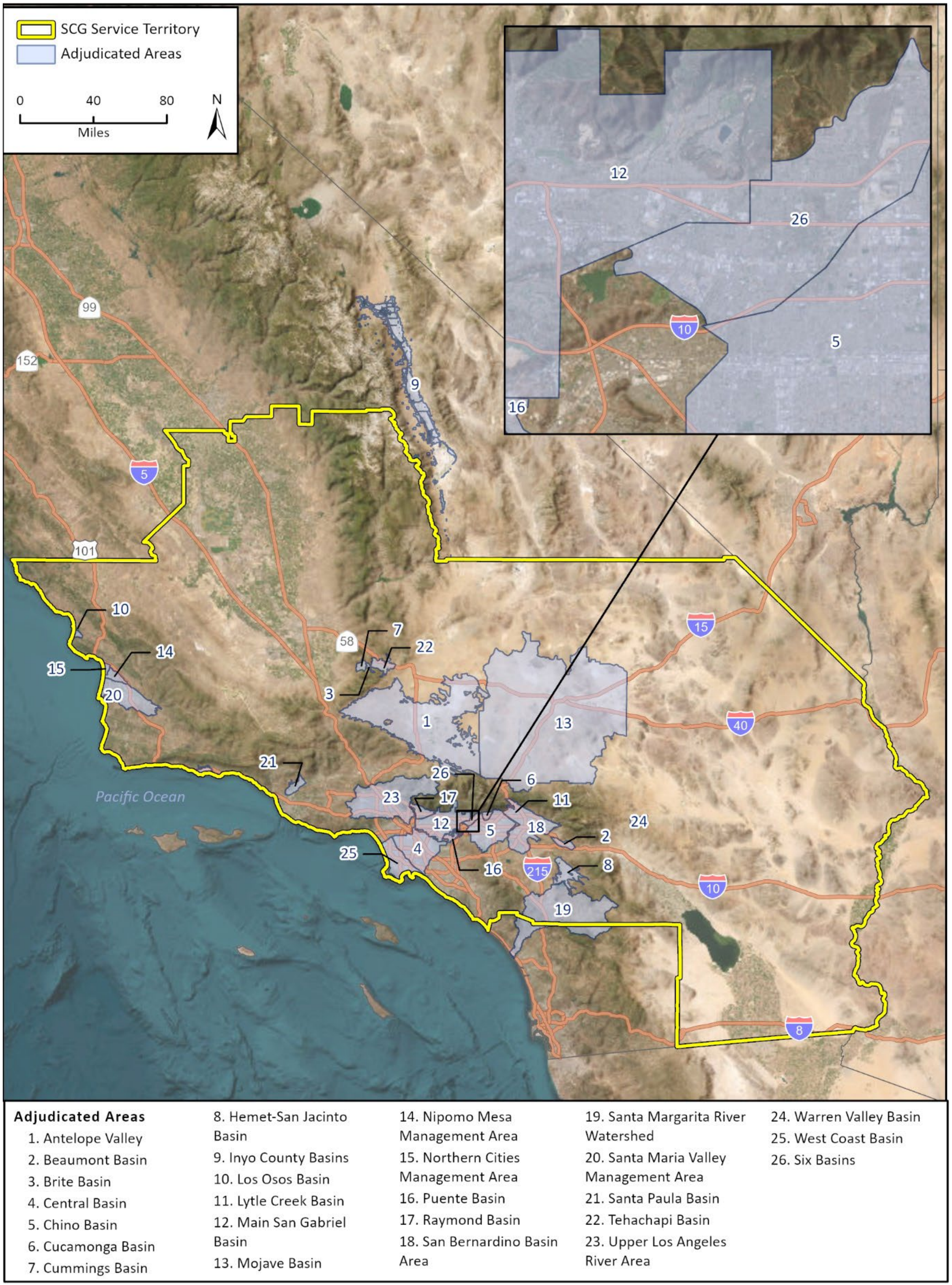
3.3.2 Adjudicated Groundwater Basins

Groundwater adjudication occurs when a legal dispute over the uses of groundwater in a given area results in a court-ordered Adjudication Judgement, which identifies all parties to the judgement (water rights holders within the adjudication area) and quantifies the rights of each party to the judgement. The court also designates a Watermaster responsible for administration of the judgment, with the Watermaster typically consisting of a Board of Directors comprised of agencies and other stakeholders within the adjudication area. An adjudication judgement generally assigns base annual production (BAP) rights to each party, which is the total amount of water each party is allowed to produce annually. Some Watermasters also assign a variable free production allowance (FPA) each year, with the FPA being the portion of the BAP that each party is allowed to pump for the respective year; the FPA may be adjusted throughout the year as needed to support sustainable management of the basin.

An adjudication judgment may address an entire groundwater basin, a portion of a groundwater basin, or portions of multiple basins. Figure 1-26, presented above in Section 3.8.1, indicates that most adjudicated areas are located in Southern California; Figure 1-28, below, identifies adjudicated areas within and adjacent to SoCalGas's service territory. The largest adjudicated area shown below is identified as number 13, the Mojave Basin adjudication area; this area consists of multiple groundwater basins including: Coyote Lake Valley (Basin No. 6-037), Caves Canyon Valley (Basin No. 6-038), Lower Mojave River Valley (Basin No. 6-040), and Antelope Valley (Basin No. 6-044). All four of these basins are managed under the adjudication judgment for the Mojave Basin Area (MBA), administered by the Mojave Water Agency (MWA) as the designated Watermaster.

Please see Section 4.3.1, *Adjudicated Groundwater Rights,* for discussion of adjudicated areas, as allowed by the respective adjudication judgment and Watermaster.

Figure 1-28 Adjudicated Groundwater Basins in SoCalGas's Service Territory



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Additional data provided California Department of Water Resources, 2023.

22-13179 EPS
Fig X Adjudicated GW Basins

3.4 Agricultural Industry Water

This category for “agricultural industry water” includes two potential water supply sources associated with ongoing agricultural operations throughout the study area: agricultural field drainage, and wastewater from produce washing operations, each of which is described below.

3.4.1 Agricultural Drainage

Agricultural drainage refers to surface water runoff and shallow subsurface drainage of irrigation water and precipitation. Some agricultural operations conduct drainage water recycling, which is the practice of capturing excess water from fields, storing the collected water, and using it to irrigate crops when there is a supply deficit. The use of systems to capture and reuse agricultural drainage could also potentially facilitate supply development for clean renewable hydrogen. Agricultural drainage collection is typically accomplished by two means: surface drainage features such as ditches and channels that use gravity to move flows to a storage area, and subsurface drainage consisting of pipes that facilitate the movement of excess water away from the target area to a storage area. The latter, involving subsurface drainage, is typically referred to as “tile drainage.”

The quantification of potential agricultural drainage capture from a specific area depends upon site-specific conditions, including but not limited to the following: size and topography of the subject site; geologic and soil conditions; intensity of agricultural water application; rates and patterns of precipitation and evapotranspiration; existing and planned land cover; underlying groundwater conditions; and presence of shallow groundwater. Water quality constituents of concern that are commonly present in agricultural drainage include total dissolved solids (TDS), selenium (Se), boron (B), and chlorine (Cl), as well as pesticides, metals, or contaminants of emerging concern (CECs) including per- and polyfluoroalkyl substances (PFAS). In the San Joaquin Valley, agricultural drainage can have TDS concentrations of up to 20,000 mg/L (ACS ESTE 2022).

In 2018, approximately 24.5 MAFY of irrigation water was applied to approximately 8.4 million acres of land across California (ACS ESTE 2022). It has been estimated based upon irrigation volumes, irrigation consumptive use volumes, and area of farmland currently managed with tile drainage that approximately 419 MGD of drainage could be potentially captured and reused from existing agricultural operations throughout the state (ACS ESTE 2022). Approximately eight percent of the tile drainage considered in these estimates are associated with San Joaquin Valley farming operations (33.52 MGD), while nearly 90 percent of the estimated tile drainage occurred in the Imperial Valley (377.1 MGD) within Riverside and Imperial counties (ACS ESTE 2022). As noted above, there are multiple site-specific considerations that contribute to the amount of tile drainage that can be captured for potential reuse; coordination by potential third-party clean renewable hydrogen producers with individual landowners and agricultural producers is needed to quantify drainage capture potential on a site-specific basis.

3.4.2 Agricultural Wash Water (Process Wastewater)

Agricultural wash water refers to water that is applied to produce to remove soil and debris prior to the produce being received by produce buyers and distributors. After produce is washed and the process wastewater (spent wash water) is reused to the extent feasible, the process wastewater is disposed of via discharge to an existing municipal sewer system, which conveys the process wastewater to a wastewater treatment facility for treatment to acceptable constituent levels prior to discharge, or it is disposed of via discharge to land in accordance with waste discharge requirements (WDRs) or conditional waivers of WDRs (Orders) issued by the SWRCB. The SWRCB regulates water quality from point-source and nonpoint-source agricultural drainage under the Irrigated Lands Regulatory Program, through which the SWRCB issues WDRs and Orders to growers (SWRCB 2023d). These WDRs and Orders contain conditions requiring water quality monitoring of receiving waters and corrective actions when impairments are found.

As a potential supply source for clean renewable hydrogen, process wastewater would be diverted prior to disposal, for treatment and reuse by hydrogen producers. The amount of process wastewater available from a given facility depends upon the size of facility operations and the permitted discharge limits, which vary by facility as determined by the SWRCB. For the purposes of this analysis, a case study is used to characterize process wastewater as a potential supply source for clean renewable hydrogen development. This case study is the Shafter Carrot Packing Plant, which is owned and operated by Grimmway Enterprises, Inc. in Shafter, California, and operates under WDR Order R5-2021-0029 (Central Valley Region RWQCB 2021). Below is an overview of agricultural wash water processes and process wastewater reuse and disposal for this facility:

- Trailers loaded with carrots are parked in soaker sheds where the carrots are rinsed with groundwater produced from an on-site well;
- Carrots are flushed from the trailers using recycled process wastewater;
- Carrots pass through a cleaning station and hydro-cooling process for rinsing with chlorinated water;
- Process wastewater is either recirculated through the wash system or discharged to settling ponds (Central Valley Region RWQCB 2021).

Process wastewater that is not reused is discharged to a Land Application Area at the Shafter Airport Wastewater Treatment Facility (WWTF) under WDR Order R5-2015-0057, which authorizes an average monthly discharge (of process wastewater) of 0.700 MGD and maximum annual discharge of 182 million gallons (MG). Table 1-19, below, provides an overview of process wastewater discharges from the Shafter facility for years 2017 through 2019, indicating discharges for this facility were consistent with the WDR limitations of 0.700 MGD or 182 MG/year.

Table 1-19 Wash Water Case Study – Discharge Rates, 2017-2019

Year	Gallons per Year	MGD	Acre-feet per year
2017	121,827,000	0.33	373.87
2018	149,105,400	0.41	457.59
2019	171,900,600	0.47	527.54

Source: Central Valley Region RWQCB 2021

As noted above, as a potential supply source for clean renewable hydrogen development, process wastewater would be diverted from agricultural wash facilities prior to discharge for disposal, and conveyed for treatment and use in clean renewable hydrogen production. The amount of process wastewater associated with a given operation depends upon factors such as the commodity processed, the process unit operations used, the daily-production performance level, and the seasonal variation, e.g., growing condition and crop age at harvest. Coordination by potential third-party clean renewable hydrogen producers with individual facility owners and operators would be needed to quantify supply source potential from process wastewater on a site-specific basis.

3.5 Brine Line Flows

Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Use of this supply source could involve diverting the brine flows at the point of origin, or diverting collective flows from the brine line directly; either way, brine flows could be removed from the local watershed which would be beneficial to local water quality, and could relieve local water managers from water quality treatment processes, including as related to brine. It is anticipated that the use of this supply source would not compete with the needs of other water users because the brine is a waste stream, and is not planned for any use other than disposal at this time.

3.5.1 Brine Line Dischargers

Table 1-20, below, provides an overview of two brine lines within SoCalGas's service territory, including the Inland Empire Brine Line in Riverside County (SAWPA), which is fully developed and operational, and the Salinity Management Pipeline in Ventura County (Calleguas MWD), which is partially implemented with final phases undergoing planning and design.

Table 1-20 Brine Line Dischargers

Brine Line	Dischargers/Connections
Inland Empire Brine Line ▪ SAWPA, Riverside County ▪ 30 MGD maximum flow ▪ ~12 MGD average flow	Trucked Disposal Collection Stations: ▪ IEUA Collection Station ▪ San Bernardino Collection Station ▪ Western Municipal Water District (WMWD) Collection Station ▪ Eastern Municipal Water District (EMWD) Collection Station
	Desalters: ▪ Arlington (WMWD) ▪ Chino I (Chino Desalter Authority (CDA) / IEUA) ▪ Chino II (CDA / Jurupa Community Services District (JCSD)) ▪ Menifee (EMWD) ▪ Perris (EMWD) ▪ Perris II (EMWD) ▪ Temescal (Corona)
	Direct Dischargers (Industrial): ▪ Mission Linen Supply ▪ OLS Energy ▪ Repet, Inc. ▪ Del Real, LLC ▪ Magnolia Foods, LLC ▪ Metal Container Corporation ▪ Southern California Edison (SCE) Mira Loma Peaker Plant ▪ City of Colton – Aqua Mansa Power Plant ▪ Mountainview Generating Station ▪ Rialto Bioenergy Facility LLC ▪ Aramark Uniform & Career Apparel LLC ▪ Dart Container Corporation ▪ Frutarom USA Inc. ▪ Wellington Foods Inc.
	Wastewater RO Concentrate Dischargers: ▪ Yucaipa Valley WD Wohholz Regional Water Recycling Facility ▪ City of Beaumont WWTP

Brine Line	Dischargers/Connections
Salinity Management Pipeline ▪ Calleguas MWD, Ventura County ▪ 19.1 MGD maximum flow ▪ ~10 MGD average flow	▪ Ventura WaterPure ▪ Port Hueneme Water Agency (PHWA) Brackish Water Demonstration Facility ▪ Oxnard Advanced Water Purification Facility ▪ United Water Conservation District (UWCD) Brackish Groundwater Desalter ▪ Camrosa Water District Water Reclamation Facility ▪ Round Mountain Water Treatment Plant ▪ Pleasant Valley Mutual Desalter ▪ North Pleasant Valley Desalter ▪ Las Posas Ag Desalter ▪ Moorpark Desalter ▪ Santa Rosa Ag Desalter ▪ Camrosa Desalter ▪ Conejo Valley Desalter ▪ Triunfo-Las Virgenes Pure Water ▪ West Simi Desalter

Sources: SAWPA 2023, 2019; Calleguas MWD 2023

The table above shows that SAWPA's Inand Empire Brine Line has a maximum capacity of 30 MGD and Calleguas MWD's Salinity Management Pipeline has a maximum capacity of 19.1 MGD. These maximum capacities are determined by outfall requirements for each project. In 2020, approximately 12 MGD of brine were removed from the Santa Ana River Watershed through disposal to the Inland Brine Line (SAWPA 2021). As a potential supply source for clean renewable hydrogen production, the target of this source is any brine flows that are currently or planned for discharge to a brine line for disposal, without further treatment and reuse. The 12-MGD average flows in the Inland Empire Brine Line are not planned for further treatment and reuse, and are therefore potentially available to support clean renewable hydrogen production.

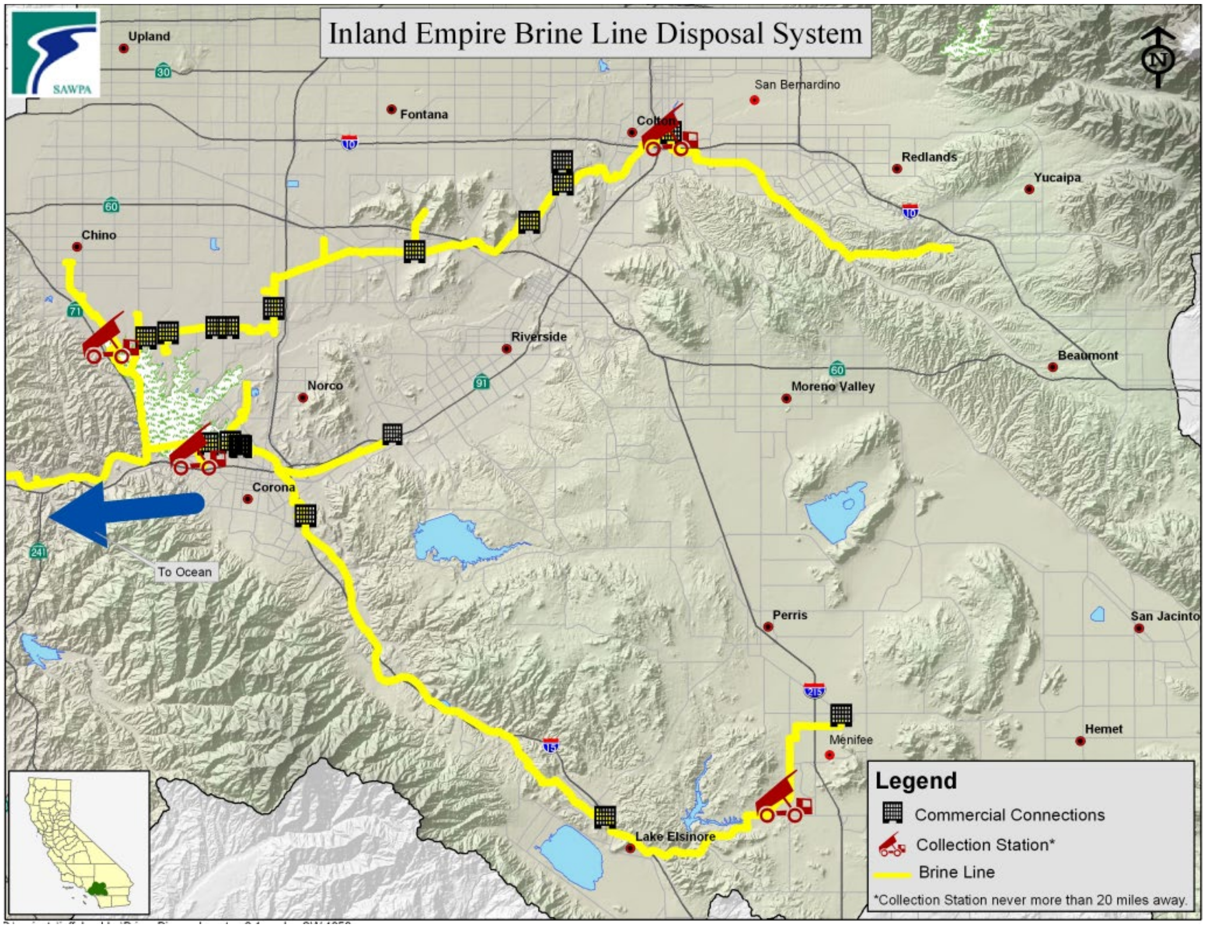
As a potential supply source for clean renewable hydrogen production, brine line flows could be diverted from the point of origin or from a connection or discharge point along the brine line. For example, SAWPA's Inland Empire Brine Line has existing connection points where it receives flows collected from respective origin points. Trucked disposal is conducted at four separate collection stations, identified on Figure 1-29, below. The collection stations include:

- Inland Empire Utilities Agency (IEUA) Collection Station (16400 El Prado Road, Chino CA 91718);
- San Bernardino Valley Municipal Water District (MWD) Collection Station (Water Reclamation Plant, 399 Chandler Place, San Bernardino CA 92408);

- Western MWD Collection Station (City of Corona Wastewater Treatment Plant No. 1, 2205 Railroad Street, Corona CA 92880); and
- Eastern MWD Collection Station (Menifee Valley Truck Waste Disposal Facility, 29541 Murrieta Rd, Murrieta, CA 92586) (SAWPA 2023).

Figure 1-29, below, provides an overview of the Collection Station locations and Commercial Connections, which reflect the Inland Empire Brine Line's direct connections.

Figure 1-29 Inland Empire Brine Line



Source: San Bernardino Valley MWD 2023

The figure above shows there are currently 14 direct connections to the Inland Empire Brine Line for industrial dischargers. The brine line provides disposal of brine for seven desalter facilities, which remove salts and other water quality constituents from water.

The diversion of brine for clean renewable hydrogen production could transfer the costs of waste stream treatment and connection to the discharge line (Brine Line) from existing brine dischargers to future hydrogen producers. The treatment of brine as a supply source would result in its own waste stream, which would likely have more concentrated brine and contaminants of concern.

3.6 Advanced Water Treatment Concentrate

Advanced Water Purification Facilities (AWPF) processes use secondary-treated wastewater to conduct further water quality treatment and produce tertiary-level treated water. This involves several processes including membrane filtration, reverse osmosis, and oxidation, as shown in Figure 1-30, below. Concentrated wastewater is created during Stages 1 and 2, as both stages involve removing impurities from the secondary-treated wastewater, which creates a concentrate consisting of highly saline brine that can be either recycled for reuse or treated for disposal.

Figure 1-30 Overview of AWPF Treatment

Microorganisms remove and transform nitrogen compounds, while membranes filter out tiny particles smaller than 1/100 of a grain of sand.

Pressurized membranes further remove microscopic materials, such as bacteria, pharmaceuticals, and salts, eliminating more than 99% of all impurities.

Ultraviolet light and a powerful oxidant destroy any remaining viruses and remove trace chemical compounds.

Source: Metropolitan 2022a

Use of this supply source would not compete with the needs of other water users because it is a waste stream, and is not planned for any use other than disposal. Use of this supply source could potentially relieve operators of advanced water purification facilities from the cost of disposing of concentrate, while also removing salts and contaminants from the basin.

3.6.1 Advanced Water Treatment Projects

Table 1-21, below, identifies existing and planned recycled water projects within SoCalGas's service territory that use advanced water treatment processes at this time. The concentrate amounts shown below reflect the total amount of concentrate produced under respective projects, using an assumed recovery rate of 80 percent in the treatment processes. The actual efficiency rate of each project will depend upon concentration of TDS in the associated flow. As noted above, the target of this supply source is the concentrate produced as a by-product of treatment processes.

Table 1-21 Potable Reuse Projects in SoCalGas's Service Territory

Project[1]	Agency[2]	Operational	Project Size (AFY)	Concentrate (MGD)
Alamitos Barrier	LADPW	existing	6,000	1.07
ARC Project	WRD	existing	10,000	1.79
Burbank Recycled Water	BWP	existing	1,814	0.32
Central Coast Blue	SLO CSD	2025	3,566	0.64
Chino Basin Program	IEUA	existing	15,000	2.68
City of Oxnard	Oxnard, City of	2030	7,000	1.25
City of Santa Monica	Santa Monica, City of	2023	1,650	0.29
D.C. Tillman WRP AWPF	LASAN	2026	21,283	3.80
		2025	17,000	3.04
Dominguez Gap Barrier	LADPW	existing	4,700	0.84
		2024	8,500	1.52
East County AWP Project	East County AWP JPA	construction	12,882	2.30
GWR Plus	Eastern MWD	existing	30,000	5.36
GWRS	OCWD & OCSD	existing	134,000	23.93
Montebello Forebay GWRP	LADPW	existing	51,000	9.11
Operation NEXT	LASAN & LADWP	2046	158,000	28.21
		2035	190,000	33.92
		2035	85,000	15.18
Pure Water Oceanside	Oceanside, City of	construction	5,601	1.00
Pure Water Las Virgenes-Triunfo	Las Virgenes-Triunfo JPA	2029	3,000	0.54
Pure Water San Diego - Phase One	San Diego, City of	planning	33,604	6.00
Pure Water San Diego - Phase 2	San Diego, City of	planning	59,368	10.60

Project[1]	Agency[2]	Operational	Project Size (AFY)	Concentrate (MGD)
Pure Water Southern California	Metropolitan & LACSD	2028	33,600	6.00
		2032	112,000	20.00
		2036	155,000	27.68
		planning	168,022	30.00
RWAP - AWPF	Palmdale Water District	planning	5,325	0.95
Ventura Pure Water	Ventura, City of	2030	4,000	0.71
West Coast Basin Barrier	LADPW	existing	17,000	3.04
Total			**1,353,915**	**241.77**

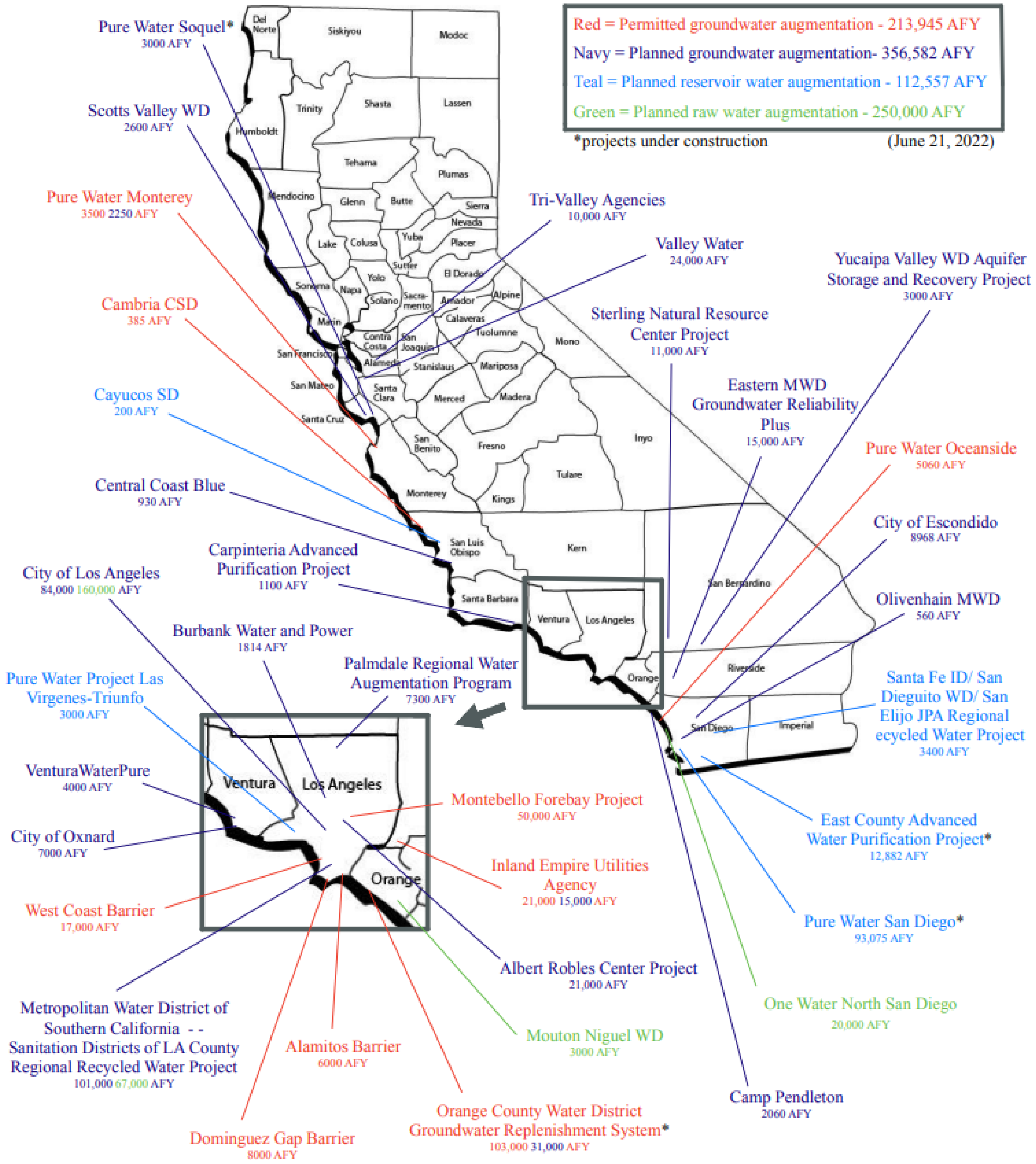
[1] ARC Project = Albert Robles Center Project; AWPF = Advanced Water Purification Facility; DCT WRP = Donald C. Tillman Water Reclamation Plant; GWR Plus = Groundwater Reliability Plus; GWRP = Groundwater Recharge Project; GWRS = Groundwater Replenishment System

[2] BWP = Burbank Water and Power; East County AWP JPA = East County Advanced Water Purification Joint Powers Authority; Eastern MWD = Eastern Municipal Water District; IEUA = Inland Empire Utilities Agency; LADPW = Los Angeles County Department of Public Works; LASAN = City of Los Angeles Sanitation Districts; Metropolitan = Metropolitan Water District of Southern California; OCSD = Orange County Sanitation District; OCWD = Orange County Water District; RWAP = Regional Water Augmentation Program; SLO CSD = San Luis Obispo County Sanitation District; WRD = Water Replenishment District of Southern California

Source: WateReuse California 2023a, 2023b

The table above indicates that there are 22 projects at this time within SoCalGas's service territory that employ the use of advanced water treatment techniques and create a concentrated brine stream. Figure 1-31, below, provides a map of potable reuse projects throughout the state, including those listed above.

Figure 1-31 Potable Reuse Projects in California



Source: WateReuse 2023b

Figure 1-31 above indicates at this time the majority of potable reuse projects throughout the state are located in Southern California, including both planned and permitted projects consisting of groundwater augmentation projects, reservoir augmentation projects, and raw water augmentation projects. Each of these projects is a type of potable reuse; these projects use advanced water treatment processes to create potable water.

3.7 Oil & Gas Industry Water

As a potential supply source for clean renewable hydrogen, the target of O&G industry water includes "offset" water that becomes available due to the reduction and cessation of water use at refineries, and "produced" water that is currently discharged without reuse.

- **Refinery Offset water** from the cessation of O&G refinery operations could become available if the refinery owner does not transition the site to other industrial use(s) that would rely on the same water supply and if future developers of clean hydrogen projects are able to secure access to this potential source. Water sources for O&G refineries in Southern California include treated wastewater and groundwater; offset water may not be available if it is needed to reverse overdraft conditions in the groundwater basin for compliance with SGMA.
- **Produced water** is brought to the surface along with oil and gas as a result of pumping conducted to produce oil and gas materials. If produced water is not reused in the O&G production process, it may be disposed of by discharge to land, which requires water quality treatment for compliance with a National Pollutant Discharge Elimination System (NPDES) discharge permit. As a potential supply source, the treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.

In addition to the above, the O&G industry also uses "process water" for some methods of extraction and production including hydraulic fracturing, or "fracking," which involves injecting liquid at high pressure into the ground to force open existing fissures and extract O&G. Fracking permits are no longer issued in the State of California; existing fracking operations are allowed to continue, but will be phased out as they reach their useful operational lifetime. Process water is not included as a potential water supply source for clean renewable hydrogen production because its use is being phased out in California; through compliance with state law, process water from fracking will no longer be part of the O&G industry and therefore is not available as a potential supply source for clean renewable hydrogen.

Since 2021, California's Geologic Energy Management Division (CalGEM, previously DOGGR) has been directed via California Governor Executive Order (EO) to cease the issuance of new fracking permits by January 2024. The EO does not ban existing fracking, but it does direct the California Air Resources Board (CARB) to analyze pathways to phase out oil extraction across the state by no later than 2045. CARB is evaluating this phase-out under the 2022 Climate Change

Scoping Plan, which was developed to achieve state-wide reductions in greenhouse gas emissions and economy-wide carbon neutrality by 2045 (CARB 2022).

3.7.1 Refinery Offset Water

CARB has evaluated pathways to phase out oil extraction across the state under the CARB 2022 Scoping Plan (see Table 1-7). It was determined by CARB that complete cessation of fossil fuel production by 2045 would not be feasible; however, crude oil production has been steadily decreasing even without the CARB 2022 Scoping Plan (CARB 2022). Specifically, CARB noted that crude oil production peaked in 1986 at 402 million barrels, and has been decreasing by an average of six million barrels per year to about 200 million barrels in 2020 (CARB 2022). Under business-as-usual conditions, CARB has projected that crude oil production in California will decrease by an additional 52 percent to 97 million barrels in 2045 (CARB 2022).

Table 1-22, below, provides an overview of existing oil refineries in California. Under current state law, O&G refineries are not required to report water usage. The amount of water per barrel of oil produced is expected to vary by refinery location, depending upon multiple factors including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Further investigation by third-party clean renewable hydrogen producers could include coordination with O&G companies to characterize water use at respective facilities and explore whether offset water could be developed for clean renewable hydrogen production. Direct coordination between hydrogen producers and O&G companies may also help to develop offset water as a supply source.

Table 1-22 Current California Oil Refinery Locations and Capacities[1]

Refinery Name	Barrels/Day	% of State Production	Location (County)
Phillips 66, Wilmington Refinery	139,000	8.00%	Los Angeles
Phillips 66, Rodeo San Francisco Refinery[2]	120,200	6.90%	Los Angeles
Valero Energy, Wilmington Refinery	85,000	4.90%	Los Angeles
Kern Energy, Bakersfield Refinery	26,000	1.50%	Los Angeles
San Joaquin Refining Company Inc., Bakersfield Refinery	15,000	0.90%	Los Angeles
Lunday Thagard, South Gate Refinery	8,500	0.50%	Los Angeles
Valero Wilmington Asphalt Refinery	6,300	0.40%	Los Angeles
PBF Energy, Torrance Refinery	160,000	9.20%	Kern

Refinery Name	Barrels/Day	% of State Production	Location (County)
PBF Energy, Martinez Refinery	156,400	9.00%	Kern
Valero Energy, Benicia Refinery	145,000	8.30%	Kern
Marathon Petroleum Corp., Carson Refinery[3]	363,000	20.90%	Contra Costa
Chevron U.S.A. Inc., El Segundo Refinery	269,000	15.50%	Contra Costa
Chevron U.S.A. Inc., Richmond Refinery	245,271	14.10%	Contra Costa
Talley Asphalt Inc., Kern Refinery	1,700	0.10%	San Francisco
Marathon Martinez, Golden Eagle Refinery[4]	0	0%	Solano
Total	**1,740,371**	**100%**	

[1] Data in this table represents total crude oil capacity, not gasoline, distillate production, diesel fuel production or production of other products. Capacity numbers do not change or often vary year to year. Production potential varies depending on time of year and status of the refinery. A rule of thumb is that roughly 50 percent of total capacity is gasoline production (about 1.0 million barrels of gasoline - 42 million gallons - is produced per day).

[2] Phillips 66 Rodeo and Santa Maria began reporting as one entity as of 2017.

[3] Marathon Carson and Wilmington began reporting as one entity as of 2019.

[4] Marathon Martinez, Golden Eagle Refinery's status is idle as of August 2020 with approved plans to convert to a Renewable Fuels Facility, which would repurpose the existing Refinery to discontinue refining of crude oil and switch to production of fuels from renewable feedstock sources including rendered fats, soybean and corn oil, and potentially other cooking and vegetable oils, but excluding palm oil.

Source: CEC 2023

As noted in the table above, the amount of offset water that may become available from oil refineries phasing out prodution activities in accordance with the CARB 2022 Scoping Plan depends in part on the source(s) of water that is used at the subject O&G facility. This is due to other existing and anticipated uses that are anticipated to rely on the given source, and whether such needs take priority over other needs, including clean renewable hydrogen production. Table 1-23, below, provides an overview of water supply sources that are typically used in refineries and identifies considerations associated with each source's availability as offset water.

Table 1-23 Water Sources for California Refineries

Source	Availability as Offset Water
Municipal Wastewater	Municipal wastewater will continue to be generated once O&G operations cease. In addition, as discussed in Section 3.2, *Treated Wastewater*, there are regional water recycling programs being developed and implemented throughout SoCalGas's service territory. This is a potentially reliable source of offset water that could be used for clean renewable hydrogen production.
Surface Water	In SoCalGas's service territory, surface water is primarily imported SWP water. As discussed in Section 2.3, *Key Water Supply Projects*, deliveries of SWP water are regularly less than contracted allocations; surface water would therefore be an inconsistent source of offset water, unless storage during surplus is used to provide consistency.
Groundwater	As O&G operations cease, groundwater previously used as a supply source could become available as offset water, if the affected basin is being managed in accordance with SGMA and rights to the groundwater are not owned by the refinery. Oil refineries may sell or lease water rights to other users, as available. Section 3.3, *Groundwater*, provides discussion of groundwater management and potential availability based upon priority rankings and SGMA compliance, also discussed in Section 4.4.2, *SGMA and Water Rights*.

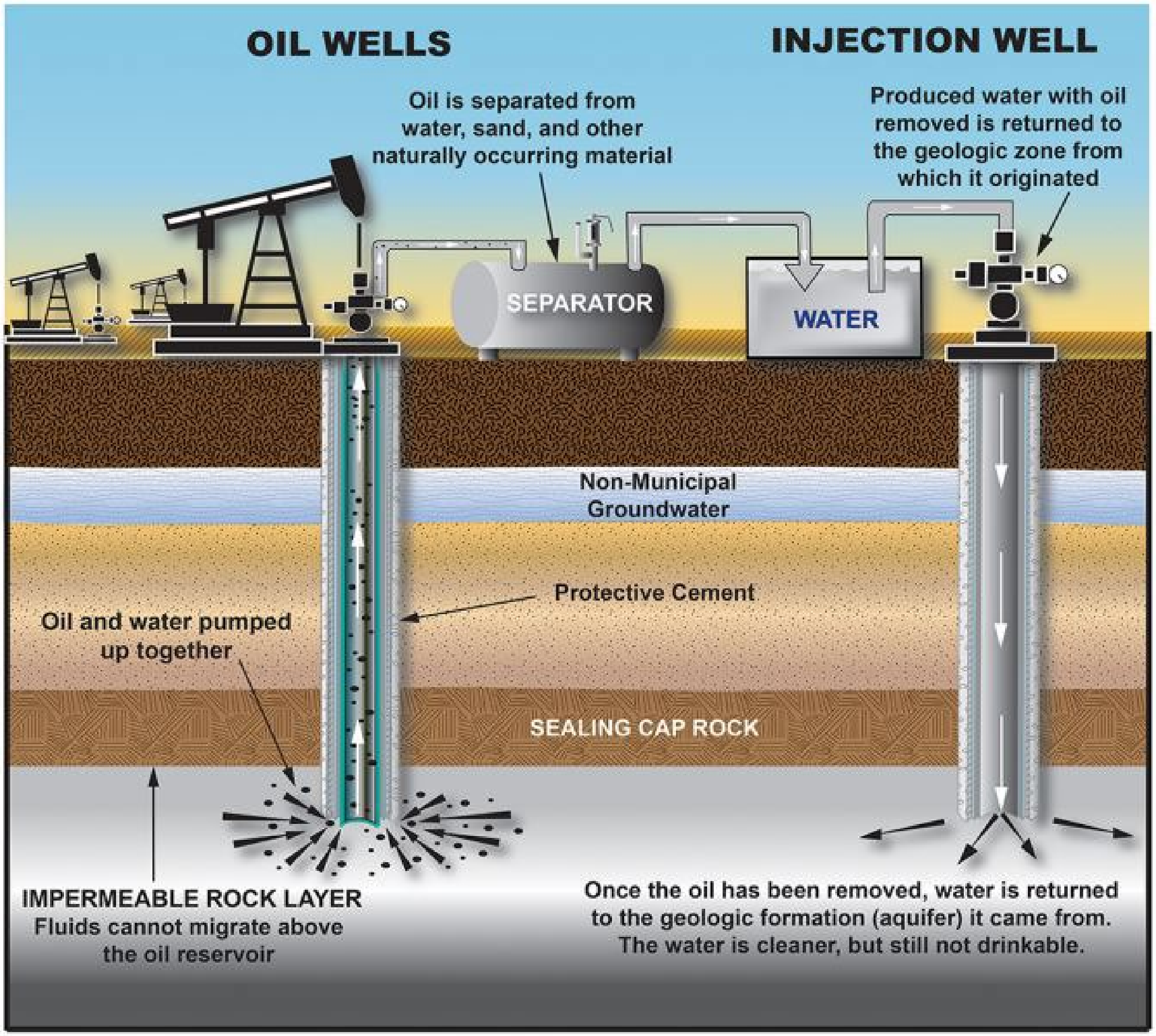
In summary, the availability of offset water from refinery operations will depend upon the timing of phasing out of refinery operations, whether the facility would be repurposed to other uses relying on the same water, and the source of water.

3.7.2 O&G Produced Water

As described in the introduction to this section, produced water is water that is incidentally brought to the surface along with oil and gas as a result of pumping conducted to produce oil and gas materials. Produced water typically has elevated TDS concentrations because while in the subsurface, the minerals in soils can leach into the water. If contaminants are present, they can also leach into the groundwater that becomes produced water during O&G production.

Figure 1-32, below, provides an overview of how produced water is separated from minerals and other constituents at the surface. The target of this potential supply source is any produced water that is not reused in the O&G production processes or for a beneficial use such as groundwater recharge or irrigation.

Figure 1-32 Produced Water from Oil and Gas Operations



Source: CalGEM 2023

To determine the amount of produced water that may be available from a given O&G operation, this study considered the amount of produced water that is reused in the O&G production processes; for any produced water that is reused in ongoing O&G operations, this study presumed that such water is not available as a potential supply source for clean renewable hydrogen production. Table 1-24, below, details the sources of water used in O&G operations, including produced water, for four major oil-producing areas in California, including the Los Angeles Basin, San Joaquin Valley, Santa Barbara-Ventura, and Santa Maria Basin.

Table 1-24 Breakdown of Water Sources for O&G Operations (AFY)

	Los Angeles Basin		San Joaquin Valley		Santa Barbara/Ventura		Santa Maria Basin	
Source Water	**Saline**	**Fresh/Brackish**	**Saline**	**Fresh/Brackish**	**Saline**	**Fresh/Brackish**	**Saline**	**Fresh/Brackish**
Drilling and Other Oilfield Waste	71.72		25.72	44.28	21.24			
Municipal Wastewater		2,108.72						
Other	573.12	0.44		27.08	74.04	0.28		
Produced Water	120,772.64	86.08	197,490.16	843.80	11,080.20		9,899.16	
Surface Water	1,202.52							
Water Supplier (not operator-owned)	12.24	57.92	758.84	1,677.44		12.96		
Groundwater Well (operator-owned)	875.96			3,352.44	212.12	0.12		65.56
Well Stimulation Recovered Fluids				2,928.28				
Total (all sources)	123,508.20	2,253.16	198,274.72	8,873.32	11,387.60	13.36	9,899.16	65.56
Produced Water (portion of total)	98.21%	1.79%	95.72%	4.28%	99.88%	0.12%	99.34%	0.66%

Source: CCST 2019

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The table above shows that for each of the oil-producing areas reflected, produced water comprises a substantial portion of saline water sources. The amount of produced water available from a given operation depends upon site-specific conditions and other existing or planned uses for the produced water. Produced water that is disposed of without being reused is considered available as a potential supply source for clean renewable hydrogen production. Table 1-25, below, details how produced water is reused or disposed of for each of the oil-producing areas presented above.

Table 1-25 Breakdown of Destinations for Produced Water (AFY)

	Los Angeles Basin		San Joaquin Valley		Santa Barbara/ Ventura		Santa Maria Basin	
Source Water	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**
DISPOSAL:								
Discharge to Land	1.96	n/a	469.60	27.48	n/a	n/a	n/a	n/a
Discharge to Lined Pond	0.16	0.04	0.08	n/a	n/a	n/a	36.28	n/a
Discharge to Unlined Pond	380.80	34.16	4,088.56	95.80	8.12	n/a	n/a	n/a
Public Wastewater System	1,568.52	4.76	n/a	n/a	0.72	n/a	n/a	n/a
Discharge to Surface Water[1]	n/a	n/a	70.40	n/a	n/a	n/a	400.16	n/a
Subtotal (Disposed):	**1,949.48**	**38.96**	**4,628.64**	**123.28**	**8.84**	**0.00**	**436.44**	**0.00**
REUSE:								
Subsurface Injection (UIC)	112,950.92	76.36	190,466.16	3,412.52	4,770.84	5,776.36	6,592.68	n/a
Reuse- Operator Facilities	75.20	n/a	2,090.52	n/a	103.16	n/a	75.12	n/a
Reuse - Other Operator or Oil Field	7,967.96	n/a	5,147.08	827.76	41.28	n/a	n/a	n/a
Reuse - Agriculture or Recharge	n/a	n/a	34,329.44	1,437.68	n/a	n/a	n/a	n/a

	Los Angeles Basin		San Joaquin Valley		Santa Barbara/ Ventura		Santa Maria Basin	
Source Water	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**	**Saline**	**Fresh/ Brackish**
Reuse - Well Stimulation	n/a	n/a	5,172.84	3.28	n/a	n/a	n/a	n/a
Reuse - Well Work	16.80	n/a	685.28	n/a	9.56	n/a	n/a	n/a
Reuse - Other	565.76	0.04	7,265.80	n/a	22.32	n/a	n/a	n/a
Subtotal (Reused):	**123,528.08**	**115.36**	**249,785.76**	**5,804.52**	**4,956.00**	**5,776.36**	**7,104.24**	**0.00**
Total Produced Water[2]	125,477.56	154.32	254,414.40	5,927.80	4,964.84	5,776.36	7,540.68	0.00

[1] Discharge to surface water is listed under disposal methods, but depending upon the receiving water affected, there may be environmental requirements to maintain certain flow levels, which would make the water unavailable as a supply source for clean renewable hydrogen production.

[2] “Total Produced Water” shown in Table 1-25 is higher than the “Total (all sources)” amount shown in Table 1-24 because more produced water is generated than is reused as a supply source for the respective O&G operations.

Source: CCST 2019

Table 1-26, below, summarizes produced water (saline and fresh/brackish) that is currently disposed of without beneficial reuse.

Table 1-26 Produced Water Currently Disposed without Reuse

O&G Production Area	Disposal of Produced Water (AFY)	Disposal of Produced Water (MGD)
Los Angeles Basin	1,988.44	1.78
San Joaquin Valley	4,751.92	4.24
Santa Barbara/Ventura	8.84	0.01
Santa Maria Basin	436.44	0.39
Total	**7,185.64**	**6.41**

Source: CCST 2019

The table above shows that a cumulative total of 7,185.64 AFY (6.41 MGD) of produced water is disposed of in the Los Angeles Basin, San Joaquin Valley, Santa Barbara/Ventura, and Santa Maria Basins. Coordination by third-party clean renewable hydrogen producers with O&G field operators is recommended to assess the amount of produced water potentially available from respective fields, based upon the constraints noted above.

3.8 Inland Brackish Groundwater

Brackish groundwater has TDS concentrations of approximately 1,000 to 10,000 mg/L (versus brine which has TDS concentrations of up to 35,000 mg/L). As a potential supply source for clean renewable hydrogen production, the target of this supply source is brackish groundwater located in inland areas where it does not have a natural drainage outlet, and is not currently managed or planned to be managed for beneficial reuse. For the purposes of this study, it is presumed that use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and potentially threatens the viability of local land uses. In some cases, use of this water could relieve local water and land use managers from the cost of conducting water quality remediation for brackish groundwater plumes. In overdrafted groundwater basins, the local GSP should be consulted regarding SGMA compliance. In the San Joaquin Valley, a potential supply includes priority management areas identified by the Central Valley Salinity Coalition (CVSC) through the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program.

Brackish groundwater also occurs in coastal areas as a result of seawater intrusion, which is commonly managed with a “seawater intrusion barrier” involving the injection of water into the subsurface to create a buffer between groundwater wells and seawater. The use of inland brackish water as a supply source could have the greatest potential for mutual benefit to the local area.

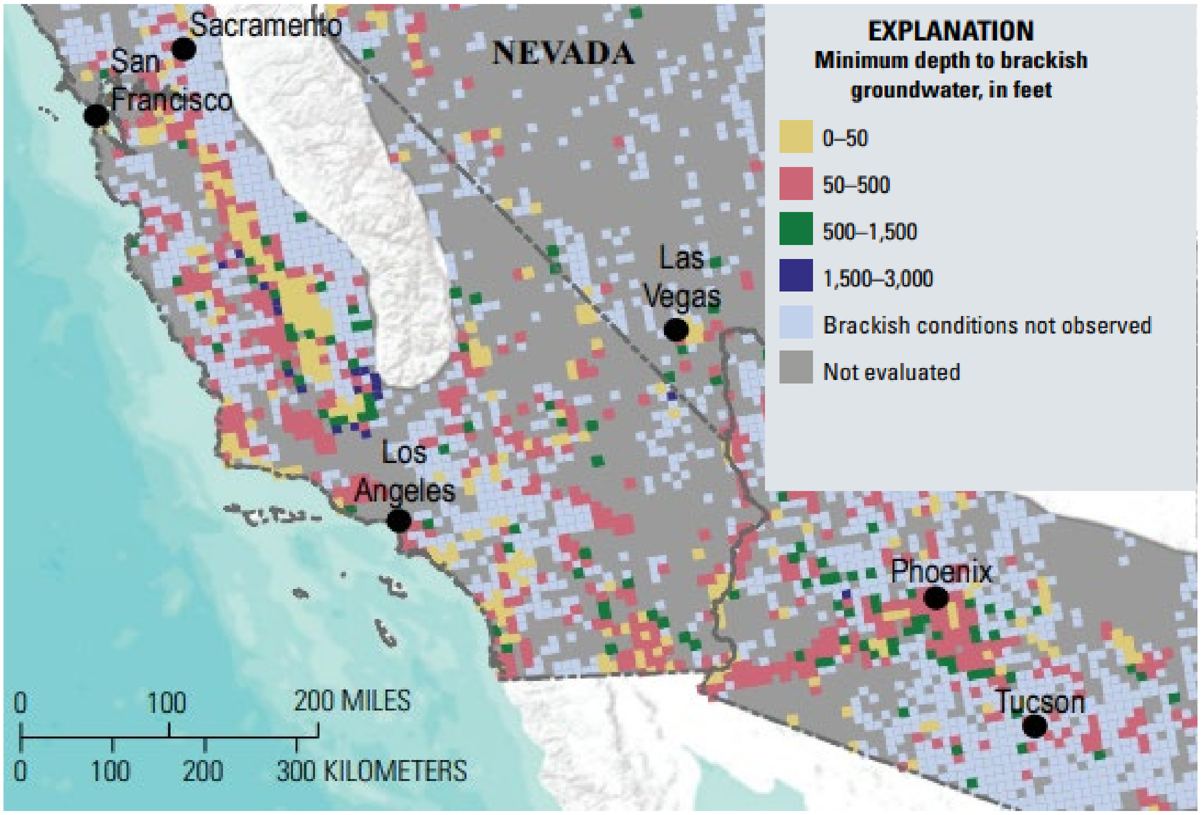
3.8.1 Brackish Plumes

Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (such as discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater can be managed as both a supply source, by pumping and treating it to water quality standards that facilitate reuse, as well as for remediation purposes, reducing salt concentrations that have adverse effects on land uses that rely on groundwater.

In inland areas, affected land uses commonly include agricultural irrigation, and municipal uses for communities that are not connected to a major surface water project (i.e., the SWP, CVP, or Colorado River; see Section 4.1, *Exchange Agreements*). In inland areas, including throughout the Inland Empire, brackish groundwater does not have an outlet to the ocean and is not caused by seawater intrusion. This brackish groundwater tends to accumulate into “plumes” which are volumes of contaminated groundwater (such as high salts creating brackish conditions) that extend away from the original source of contamination. The size and shape of a contaminated plume can be determined by collecting measurements from multiple wells in the vicinity of the plume.

Figure 1-33, below, portrays the depth to brackish groundwater for areas with available data, to demonstrate the extent of known shallow brackish plumes (within 50 feet and between 50 and 500 feet), and to portray the extent of brackish conditions that have either not been evaluated or where brackish conditions have not been observed. Areas of brackish groundwater shown in Figure 1-33 could be targeted for treatment, in collaboration with local water managers, towards the purpose of creating a new water supply source for clean renewable hydrogen production while also relieving local water managers of the cost and effort associated with remediating brackish groundwater.

Figure 1-33 Minimum Depth to Brackish Groundwater



Source: USGS 2018

Figure 1-33 above shows that there are known shallow brackish plumes in portions of Southern California, particularly in inland areas, as well as in the San Joaquin Valley where brackish groundwater more commonly occurs within the first 50 feet. The list below, while not exhaustive of all groundwater desalination projects, highlights large-scale brackish groundwater desalination projects that have been implemented throughout SoCalGas's service territory (CalDesal 2022):

- In Ontario, the Chino Basin Desalter Authority produces 14 MGD of fresh water by desalinating brackish water pumped from wells throughout the Chino area.
- In Orange County, the South Coast Water District (SCWD) operates the Groundwater Recovery Facility (GRF), which provides approximately 15 percent of SCWD's water supply portfolio by conducting reverse osmosis to remove salts from local brackish groundwater; other supply sources include imported water from northern California (SWP) and the Colorado River.
- Eastern Municipal Water District (EMUD) in Perris is currently constructing its third Desalter as part of its Groundwater Reliability Plus Program, which cumulatively will produce 14 MGD of fresh water from brackish groundwater.
- In Torrance, the Water Replenishment District of Southern California (WRD) operates the Goldsworthy Groundwater Desalter, which creates five MGD of fresh water through desalting local brackish groundwater.

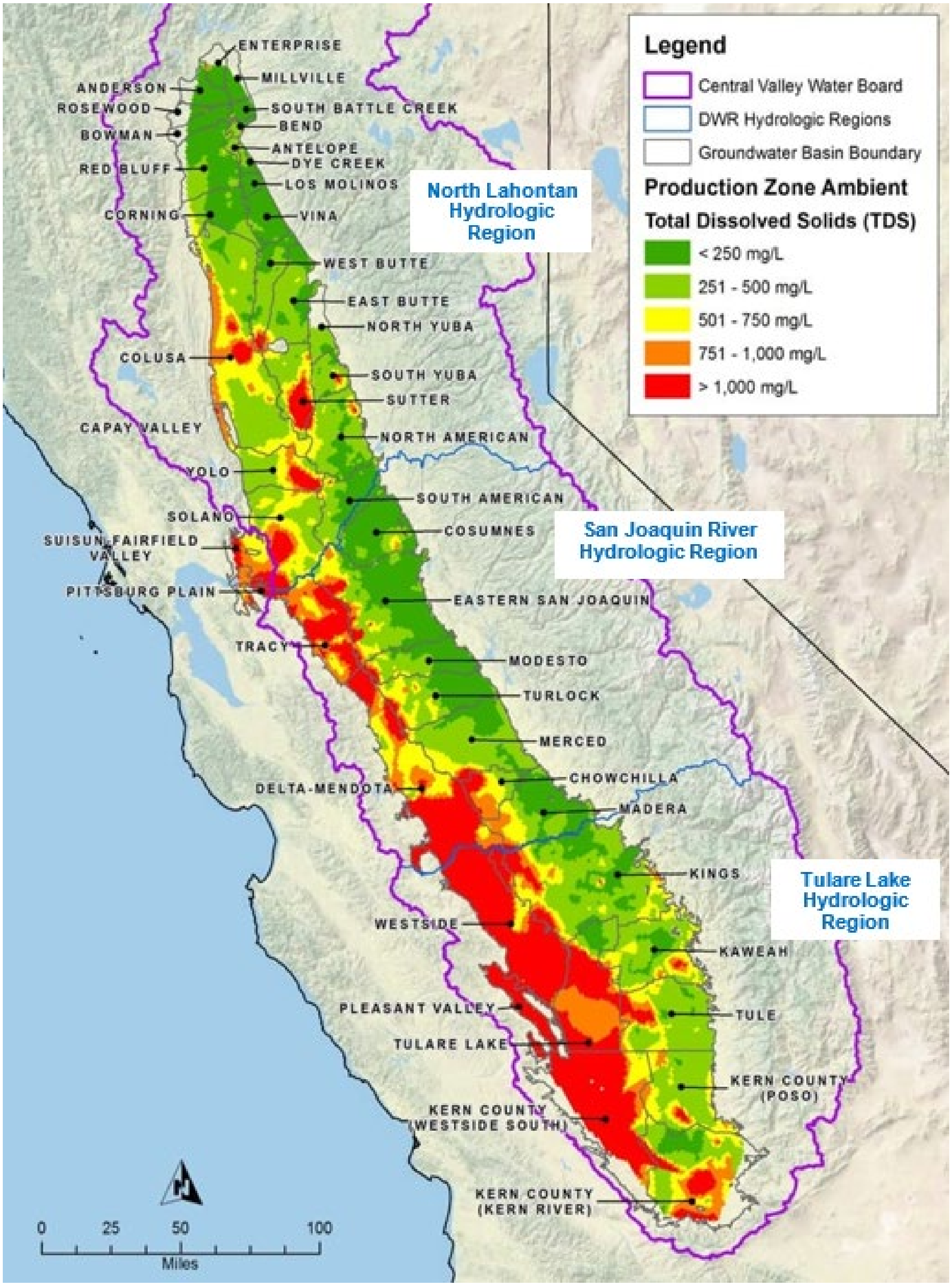
- In Carson, West Basin Municipal Water District (WBMWD) operates the C. Marvin Brewer Desalter Treatment Facility, which purifies one MGD of brackish groundwater for potable use.

The list above demonstrates there are different types of groundwater desalination projects occurring in SoCalGas's service territory. In addition to point source discharges such as those noted above, contaminated plumes also occur from non-point sources. In the Central Valley and the San Joaquin Valley (which comprises the southern portion of the Central Valley), regional drainage issues have resulted in substantial salt accumulation in the soils, and subsequently the groundwater. Regional planning for salts management in this area is being conducted by the Central Valley Salinity Coalition (CVSC) through the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program. CV-SALTS is designed to address regional salinity issues from brackish groundwater in the Central Valley, which includes the San Joaquin Valley portion of SoCalGas's service territory.

One of the management strategies being pursued through the CV-SALTS program is desalination and reuse of brackish groundwater. Figure 1-34, below, provides an overview of TDS concentrations in the Central Valley; as shown, the highest TDS concentrations occur in the Tulare Lake Hydrologic Region, which encompasses the San Joaquin Valley and the northern portion of SoCalGas's service area. The figure below indicates that the western portion of the San Joaquin Valley is most affected by brackish groundwater; this is likely due to the natural characteristics of soils from the Coast Range which create water quality issues from irrigation and leaching to the groundwater. These high-TDS areas would most benefit from brackish groundwater management through proposals under the CVSC's CV-SALTS program.

Coordination with CVSC and local GSAs by potential third-[arty clean renewable hydrogen producers would be needed to identify local opportunities for the creation of a new water supply from brackish groundwater. There may be opportunities for mutual benefit through the CV-SALTS program, by advancing the CVSC's purpose to reduce regional brackish groundwater contamination, while also creating a new water supply for clean renewable hydrogen production.

Figure 1-34 Salt Accumulation in the Central Valley



Source: CVSC 2023

3.9 Dry Weather Flows

Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, as a result of low volume and velocity of flows during dry-weather conditions, these flows accumulate within the MS4 causing water quality concerns and potential violation of the MS4 operating permit (NPDES). Dry weather flows also commingle with other native water that, without human intervention, may provide replenishment to any given source, and includes rainfall, stream channel infiltration, and tributary runoff.

Dry weather flows that pose management challenges due to water quality considerations and retention within the drainage system could be ideal as a supply source for clean renewable hydrogen production. The collection and reuse of dry weather flows could present a solution to local flood control districts with insufficient funding to effectively manage dry weather flows. Assuming the use of dry weather flows would not injure existing water users, use off this supply source could relieve local agencies from the cost of disposing dry weather flow issues, while also removing contaminants contained therein from the basin.

3.9.1 Accumulation Areas

An MS4 is a stormwater conveyance and discharge system that is separate from the local sanitary sewer systems, and does not route flows through a treatment facility prior to discharge. MS4s use a series of structures such as roadside culverts, pipes, ditches, and retention basins designed to guide stormwater through developed areas for discharge without treatment to outfalls permitted under the NPDES program. These NPDES permits are commonly called “MS4 permits” or “Stormwater Permits,” and are issued by the SWRCB through its nine RWQCBs; these permits require implementation of a Stormwater Management Program (SWMP) for permit compliance. The SWMP must include pollution prevention measures, treatment or removal techniques, monitoring, use of legal authority, and other appropriate measures to control the quality of stormwater discharged to storm drains and eventually to waters of the United States.

During wet weather conditions, there is sufficient flow volume and velocity within an MS4 system that the flow travels through the system and discharges without accumulating within the system.

During dry weather conditions, runoff that occurs from non-weather events such as car washing and other wastewater discharges also enters the MS4, but due to the lower volume and velocity of dry weather conditions, these flows accumulate within the system, causing water quality concerns and risking violation of the MS4 permit conditions. Dry weather flows contain high bacteria that may be as high as wastewater, including heavy metals, pet waste, trash, and petroleum products. This can be particularly challenging for flood control districts that do not have funding to collect and treat dry weather flow, but also are obligated to water quality discharge requirements for their MS4 permits. Efforts to manage dry weather runoff include collection and disposal to an existing brine line, collection and diversion to a wastewater treatment facility, diversion to a detention pond for infiltration and evaporation, and other potential methods.

In inland areas, the quantity of dry weather flow depends largely on weather conditions and water conservation practices among other factors. Coordination by third-party clean renewable hydrogen producers with individual flood control districts and MS4 operators should be conducted to characterize dry weather flow as a potential supply source.

3.10 Urban Stormwater Capture and Reuse

Water supply derived from urban stormwater capture can create a water supply from runoff that would otherwise be discharged across the ground surface or through the local stormwater conveyance system. Some water agencies such as the Los Angeles Department of Water and Power (LADWP) are undertaking large-scale stormwater capture and reuse programs, which allow the agency to collect flows during wet periods and store that water for later use during dry periods.

Stormwater capture and reuse may be conducted on various scales, and could be scaled to project-specific sizes. Supply generation can be seasonally limited and may not provide a constant supply source. Urban capture and reuse programs are also typically developed to provide local water supply resiliency, and decrease the area’s reliance on imported supply. Future clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects or could help develop stormwater capture projects as a potential water source for hydrogen development.

Part 4: Mechanisms of Supply Acquisition

Water supply for clean renewable hydrogen development may be acquired through several different mechanisms, including through exchange agreements, working with local water agencies (purchase available supplies or develop partnerships for mutual benefit), participation in water markets, or through purchase of land with water rights. Each of these mechanisms is described in the sections below.

4.1 Exchange Agreements

A water "exchange" is an agreement under which a water seller provides an amount of surplus water to a buyer and the buyer provides a replacement water supply in the same amount to the seller, within the seller's service area or territory. A replacement water supply could consist of a new facility or participation in existing supply development projects or programs.

Exchange agreements are anticipated to have the greatest potential to provide water supply for clean renewable hydrogen development, compared to the other supply acquisition mechanisms discussed herein and the water supply sources discussed in Part 3, *Potential Water Supply Sources.* This is due to the potential for exchange agreements to provide large quantities of water, and to provide such water in areas where naturally occurring sources may be limited.

4.1.1 Water Sources for Exchange Agreements

The specific water sources used in an exchange agreement are determined by the parties involved in the exchange, based upon their location and available supply source(s). However, any exchange agreement to support clean renewable hydrogen production is anticipated to involve one or more of the imported surface water supply projects in California, because imported surface water supplies comprise a substantial portion of Southern California's water supply portfolio and most water agency supplies are comprised at least in part of imported surface water.

Imported surface water in Southern California is provided through the SWP, the Colorado River, and the CVP; see Section 2.3, *Key Water Supply Projects*. For each of these projects, water is distributed to contractors that hold water allocations to the respective projects; contractors distribute their portion of the project to individual connections and water agency customers to meet water needs projected in their respective UWMPs (see Section 2.4.1, *Urban Water Management Plans*). Water from the SWP, Colorado River, or CVP, can be obtained through purchase or transfer of rights from an existing contractor, or through exchange for a replacement supply.

Section 3.1, *Imported Surface Water in the Study Area,* provides an overview of the facilities and allocations associated with the SWP, CR, and CVP that are present within SoCalGas's service territory.

4.1.2 Examples of Scale and Source

Exchange agreements have historically been used in California to facilitate land uses and maximum beneficial use of available water supply sources. This section provides brief summaries of several different types of existing exchange agreements used to provide water supply in areas that would not otherwise have access to the subject supply source(s).

Coachella Valley Water District and Metropolitan

CVWD receives its allocation of SWP through Metropolitan, allowing CVWD to access SWP water despite not having an infrastructure connection to the SWP system or California Aqueduct. CVWD does have a direct connection to the Colorado River Aqueduct, which continues west past CVWD's service area into Metropolitan's service area and Metropolitan, in turn, has direct connections to the SWP system.

CVWD has entitlements for both SWP water and Colorado River water; therefore, to collect its portion of SWP water, CVWD has an exchange agreement with Metropolitan. Under this agreement, CVWD withholds a portion of Metropolitan's Colorado River water from the Colorado River Aqueduct in an amount equal to CVWD's allocation of SWP water for the given year; in exchange, Metropolitan keeps the same amount of water from the SWP's California Aqueduct, effectively completing the exchange of SWP water for Colorado River water, allowing CVWD to utilize its full allocations (as available) from both projects.

San Joaquin River Exchange Contractors

Exchange agreements have been used throughout the history of California's development. In the early 1870's in the Central Valley, irrigation canals began to be constructed to divert water from the San Joaquin River and the Kings River to allow for irrigation in the western portion of Fresno, Madera, Merced, and Stanislaus counties. As the need for more irrigation and farmable land in the Central Valley increased, the USBR began construction of the CVP in 1933 (see Section 2.3.3, *Central Valley Project*). One of the dams constructed was the Friant Dam, located north of Fresno, which was needed to provide water the San Joaquin River to agricultural uses on the east side of the Central Valley (SJRWA 2023). This would impact water supply from the San Joaquin River that farmers on the west side of the valley depend on. Therefore, the San Joaquin River Exchange Contractors ("Exchange Contractors") and the "Friant Division Contractors" were formed.

- Exchange Contractors are the original water rights holders for use of San Joaquin River water on the west site of the Central Valley. USBR acquired water rights for the Friant Division in 1939 through purchase and exchange agreements with these original water rights holders. USBR delivers CVP water to the Exchange Contractors in amounts equal to each Exchange Contractor's original rights to San Joaquin River water (FWA 2018).

- Friant Division Contractors include 32 water districts and agencies that receive water supply from Lake Millerton, which is formed by Friant Dam and entrains water from the San Joaquin River. Friant Division Contractors pay for the operation and maintenance of facilities used to provide CVP water to the Exchange Contractors (FWA 2018), without which the Friant Division Contractors would not have access to San Joaquin River water.

As summarized above, the Exchange Contractors retained their rights to the San Joaquin River water through the exchange agreement. In normal water years, the Exchange Contractors are guaranteed 100 percent of their contractual water allotment (840,000 AFY) and in critical years the amount is 75 percent (650,000 AFY) (SJRWA 2018).

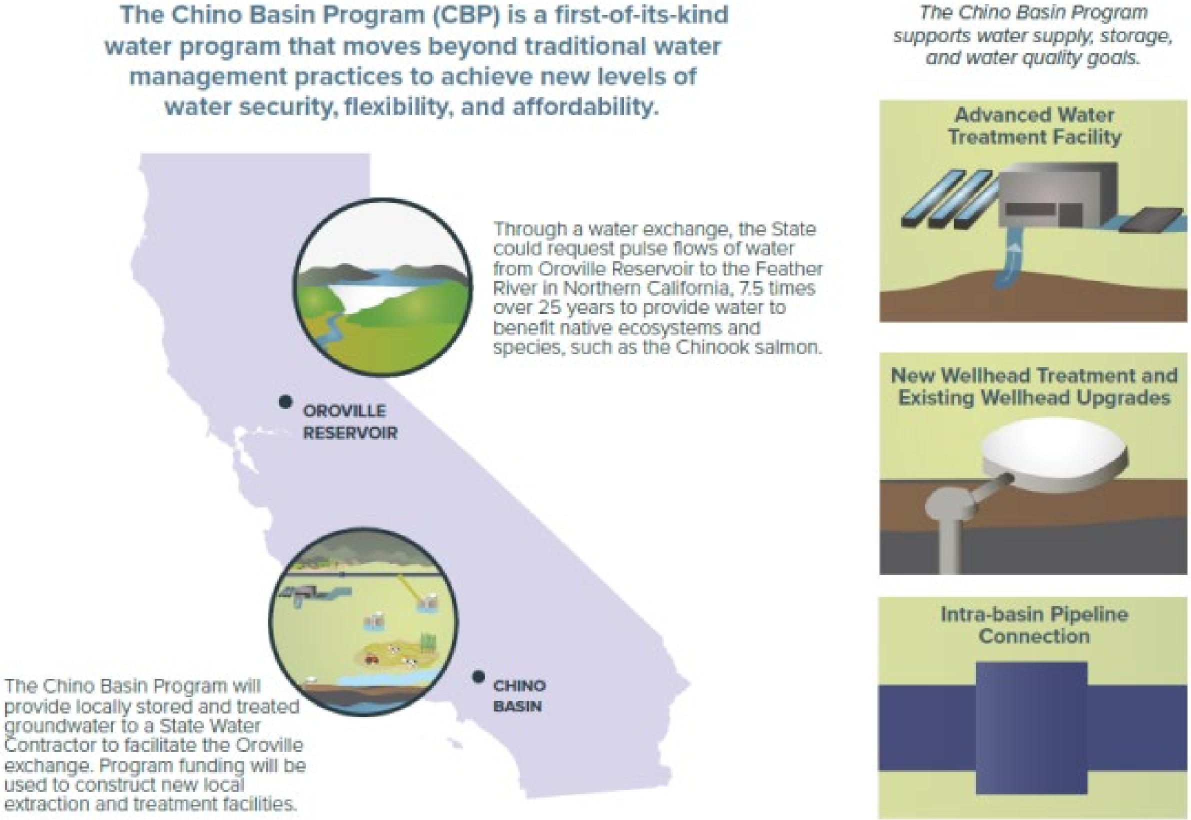
Chino Basin Program

The CBP is a 25-year conjunctive use project, under which Inland Empire Utilities Agency (IEUA) uses a new advanced water purification facility (AWPF) to create a new recycled water supply amounting to 15,000 AFY. Over the program's 25-year lifetime, creating 15,000 AFY of recycled water will generate 375,000 acre-feet of total new supply. Under the exchange agreement between IEUA and DWR, new supply from the AWPF will be stored in the Chino Groundwater Basin ("Chino Basin"), and will be provided to DWR incrementally over the project's 25-year lifetime. DWR may request portions of this new supply in "call years" which occur once every 7.5 years, for a maximum request of 50,000 acre-feet in one call year.

DWR receives its share of the new supply in Northern California, at the headwaters of the SWP, not at the location of the AWPF and Chino Basin. This is accomplished through exchange, using IEUA's SWP Contractor partner for this project to facilitate the physical exchange of water; IEUA's SWP Contractor partner for the CBP is Metropolitan. DWR accesses the exchange water by withholding it in Lake Oroville rather than releasing the flows into the Feather River for conveyance to SWP contractors in Southern California (as discussed in Section 2.3.1, *State Water Project*, the Feather River provides the headwaters for the SWP as snowmelt from the Sierra Nevada Mountains). Metropolitan, as IEUA's SWP Contractor partner in Southern California, will then receive up to 50,000 acre-feet less from the SWP system for the given call year, and Metropolitan will in turn withhold this amount from deliveries of SWP water to IEUA during the respective call year, effectively completing the exchange between DWR and IEUA (Metropolitan 2021).

Figure 1-35, below, provides an overview of the CBP.

Figure 1-35 Location and Features of the Chino Basin Program



Source: CWC 2022

4.2 Local Water Agencies

Water agencies provide water for various potable (drinkable) and non-potable (not drinkable) purposes, referred to collectively as “Municipal and Industrial” or “M&I” water. M&I water use includes all residential, commercial, institutional, and industrial uses. Developers of clean renewable hydrogen projects may reach out to water agencies for exploring several alternatives of securing water supply, described below.

4.2.1 Purchase Available Supply

Water supply may be purchased from local water agencies drawing upon their locally available supplies, which may include imported surface water, sustainably managed groundwater, developed water such as treated wastewater, and surplus water from previous wet weather years that has been stored in water banks for future use. As discussed in Section 2.4, *Urban Water Management Planning*, water needs associated with anticipated M&I uses and associated water supply availability are documented in agency-specific UWMPs. Clean renewable hydrogen production projects are not documented in the current UWMPs reviewed from water agencies within SoCalGas’s territory. However, future clean renewable hydrogen producers can work closely with water agencies with specific project proposals. Water agencies that are interested in supporting hydrogen development may start to include water needs for those projects in their supply planning and UWMPs or commit to serve specific projects.

4.2.2 Partnership for Mutual Benefit

Water supply may be developed through partnerships between future hydrogen producers and water agencies. Such partnerships could be designed for mutual benefit, by providing a water supply source for clean renewable hydrogen development, while also supporting local development of supplemental supply sources, or removing a nuisance for the local agency. For example, as discussed in Part 3, *Potential Water Supply Sources*, supply sources that could potentially be developed for clean renewable hydrogen include existing waste streams (brine line flows) and dry weather flows, which commonly pose a management challenge to local agencies that do not have the resources to proactively manage such issues.

4.3 Water Markets

A “water market” refers to the transfer or sale of water or water rights from one user to another, typically from an agricultural to an urban water agency (WEF 2023b).

4.3.1 Adjudicated Groundwater Rights

Please see Section 3.3.2, *Adjudicated Groundwater Basins*, for discussion of adjudicated basins with respect to basin prioritization rankings.

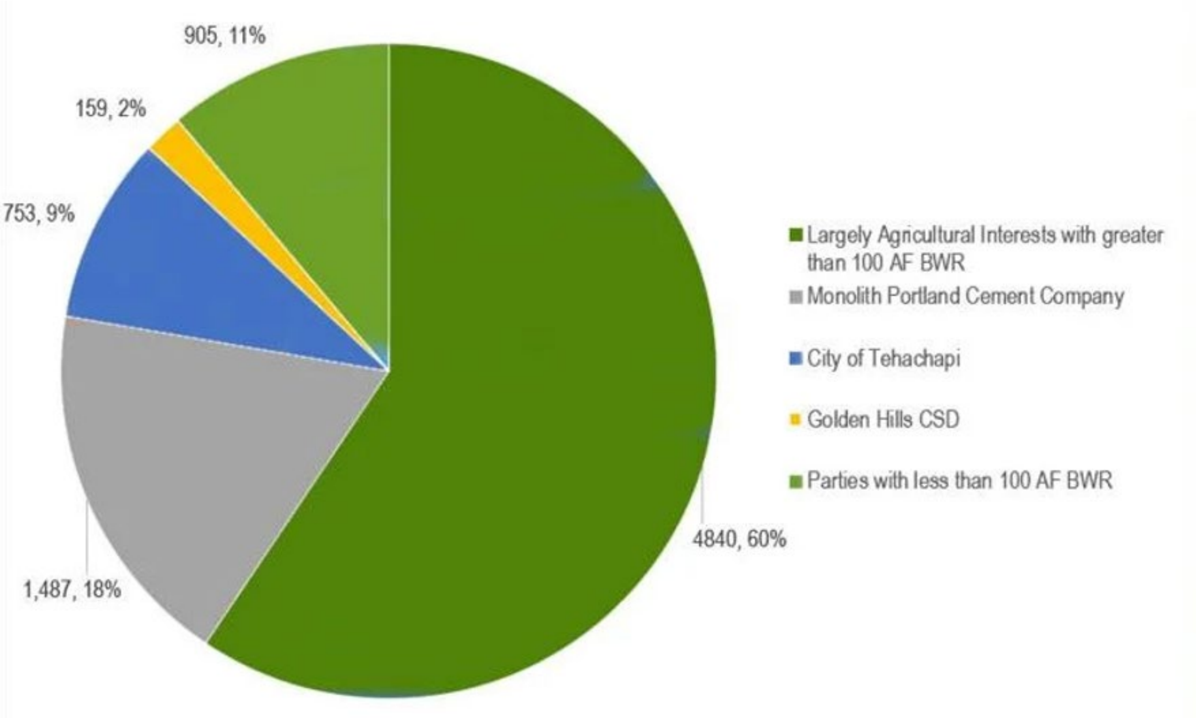
In some adjudicated areas, unused allocations or surplus water supply is available for purchase through existing water markets, subject to approval of the Watermaster. The conditions placed on water rights transfers or sales within adjudicated areas vary depending upon the specific Adjudication Judgement and Watermaster. In many adjudicated areas, groundwater is required to be used within the same basin, while in other areas it is possible to convey or exchange adjudicated groundwater to locations outside the basin. Amendments to an adjudication judgment may also be issued as needed to revise water rights information, including but not limited to ownership.

The Tehachapi Basin, identified as adjudicated basin number 22 in Figure 1-28, *Adjudicated Groundwater Basins in SoCalGas’s Service Territory* (see Section 3.3.2, *Adjudicated Groundwater Basins*), provides an example of how water rights in an adjudicated basin can shift between water rights holders, including changes of ownership. The Tehachapi Basin is managed by the Tehachapi-Cummings County Water District (TCCWD) as the court-designated Watermaster responsible for compliance with the adjudication judgment. As stipulated by the court in the adjudication judgment, the average annual safe yield for the Tehachapi Basin is 5,500 AFY (TCCWD 2022).

Since adjudication of the Tehachapi Basin in 1971, the City of Tehachapi has systematically increased its share of base annual production (BAP) water rights in the basin from approximately nine percent in 1971 to approximately 36 percent in

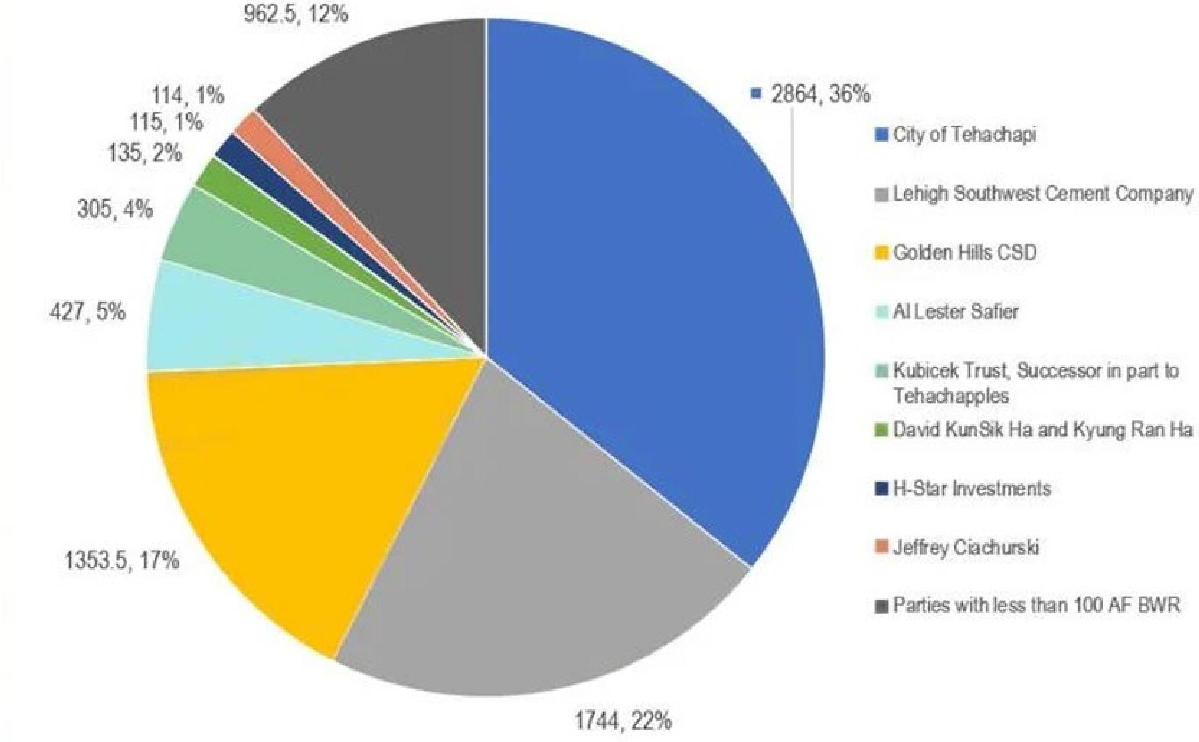
2018 (TCCWD 2022). This effort has been in response to land use and economic changes, as agriculture has diminished in importance to the local economy and population continues to increase (TCCWD 2022). Figure 1-36 and Figure 1-37, below, provide an overview of these base water rights in 1971 and in 2018, for comparison.

Figure 1-36 Base Water Rights Ownership (AFY) – Tehachapi Basin, 1971



Source: Elliot 2023; TCCWD 2022

Figure 1-37 Base Water Rights Ownership (AFY) – Tehachapi Basin, 2022



Source: Elliot 2023; TCCWD 2022

Figure 1-36 and Figure 1-37 above demonstrate that a water market can be used to change the distribution and ownership of water rights in an adjudicated area. These figures also show that a substantial portion of base water rights in the Tehachapi Basin are owned by a cement company; in 1971 the Monolith Portland Cement Company held rights to 1,487 AFY of water from the Tehachapi Basin, then changed ownership over the years, becoming the Lehigh Southwest Cement Company by 2018 with rights to 1,744 AFY (Elliot 2023). Cement manufacturing comprises a substantial portion of base water rights in the Tehachapi Basin because the 1971 adjudication judgement determined Base Water Rights by the "doctrine of mutual prescription," which does not consider priority of uses, but rather defines Base Water Rights as the "highest continuous extractions of water by a party from the basin for beneficial use in any period of five consecutive years after the commencement of overdraft in Tehachapi Basin" (Elliot 2023).

The acquisition of base water rights is conducted through purchase, annexation, and consolidation. If base water rights may be purchased or leased from existing rights holders within an adjudicated Tehachapi Basin, and if that water may be used outside the Tehachapi Basin, it could potentially be developed as a water supply source for clean renewable hydrogen development. Other adjudicated basins present similar opportunities. Third-party clean renewable hydrogen producers should consider the potential to acquire water supply through an adjudication judgment on a case-by-case basis including through coordination with respective Watermasters.

4.3.2 Wet Weather Surplus Flows

Wet weather flows consist of surface water runoff that occurs during years of above-average precipitation, including snowpack. Wet weather flows can result in surplus flows, which consist of any supply available in excess of local demands. This is water that is available after all existing demands and contractual obligations are met for the respective water year. Wet weather surplus flows may be available for purchase from SWP contractors through existing water markets.

As discussed in Section 2.3.1, *State Water Project*, under “Article 21 Water,” during some wet weather years (as determined by DWR), SWP contractors may have access to additional flows provided through the SWP conveyance system, separate and in addition to Table A allocations. The availability of Article 21 water, also referred to as “interruptible water,” may not be carried over for delivery in a subsequent year, and may not affect approved deliveries of Table A water to SWP contractors. There is no storage for Article 21 water in the SWP system; it must be taken from the system as available (Austin 2018). If an eligible SWP contractor does not have the ability to receive or store Article 21 water when it is available to them, the contractor may enter an agreement with DWR to provide storage through a “change in point of deliveries” agreement. (Austin 2018)

As an example of how surplus water may be procured through existing markets, the Darden Clean Energy Project (see Section 3.3.1, *Basin Prioritization and Availability*), located in Fresno County, proposed in November 2023 application documents to the CEC to procure the majority of its operational water from surplus supplies purchased through WWD. The targeted surplus occurred in response to unusually high precipitation during water year 2022-2023; as proposed, this water would be purchased from WWD as Article 21 water, then stored for the Darden project through groundwater banking conducted in collaboration with WWD. The water would be accessed as needed throughout the lifetime of the project, with its entire operational demands of 1,039 AFY met using surplus flows acquired from WWD during and since the wet water year of 2022/2023. (IP Darden I LLC 2023)

4.4 Land Purchase with Water Rights

In California, water rights permits typically specify the allowed uses for the subject water. There are certain water rights associated with land ownership that may provide a potential mechanism to acquire water supply for the production of clean renewable hydrogen. The availability of water rights associated with specific properties can be determined through review of property ownership records to confirm the type of right(s) associated with the subject property, and to confirm that such rights were not previously severed from the subject property.

The purchase of land with attached water rights would allow the new landowner to use water associated with the attached rights for “reasonable and beneficial” purposes. As such, the purchase of land with water rights could provide a potential water supply source for the production of clean renewable hydrogen.

4.4.1 Water Rights Attached to Real Estate

California has a complex legal framework for water rights attached to real estate. This section provides an overview of the types of water rights applicable to the potential possibility of acquiring water supply through the purchase of land with attached water rights.

Overlying Groundwater Rights

Landowners in California are entitled to pump and use a “reasonable amount” of groundwater from beneath their land, as long as it is put to a “beneficial, non-wasteful” use. The concepts of “safe yield,” “surplus,” and “overdraft” are key to assessing how much water can reasonably be withdrawn from a basin, and are determined on a basin-specific basis by the local management agencies (WEF 2023d).

An overlying groundwater right is the right of a landowner to extract groundwater from beneath their property, for use on land overlying the subject groundwater basin. Overlying rights:

- Are contingent upon the produced water being put to “reasonable and beneficial use;”
- Are correlative (related to each other), meaning the rights are held in common with all real property-based users of the same water source;
- In the event of a water shortage, responsibility for the shortage is shared by all users regardless of their location within the basin, and landowners are expected to collectively reduce their pumping rates as needed for alignment with the safe yield of the basin;
- Are not lost due to nonuse; and
- Cannot be used outside the subject groundwater basin (BBK 2021).

Riparian Water Rights

Riparian rights are held by landowners with property bordering streams, and entitle the landowner to use a correlative share (see above) of the water flowing past his or her property. Riparian rights:

- Do not require permits, licenses, or government approval;
- Apply only to the water which would naturally flow in the stream;
- Do not entitle a water use that diverts water to storage for use in the dry season;
- Do not entitle use of the water on land outside of the watershed; and
- Remain with the property when it changes hands unless the subject parcel(s) have been severed from the adjacent water source (SWRCB 2020).

Under California law, a riparian water right arises by virtue of ownership of riparian land, which is defined as the smallest parcel of land contiguous to a watercourse, in a single chain of title from the original private owner, that is within the watershed of the subject watercourse (BBK 2021). Riparian rights have a higher priority than appropriative rights (see below); the priorities of riparian right holders of a common resource generally carry equal weight, such that during drought conditions, all common riparian rights holders share the shortage among themselves.

Appropriative Rights

In contrast with riparian and overlying water rights, water transported away from its source for use on land that is not adjacent to the surface water source or at a location outside the watershed or groundwater basin generally falls under a different category of water rights, and thus is subject to a distinct set of rules and regulations. In California, this use is categorized as an “appropriative” water right. Appropriative water rights:

- Are generally junior to riparian and overlying rights, which means that appropriative rights can only be exercised when there is surplus water after overlying and riparian uses are met;
- Are subject to the doctrine of prior appropriation, which means that priority is determined based upon the date the use began or the date a permit was obtained;
- Can be used at locations separate from where they originate;
- Can be lost through nonuse; and
- May be subject to the state permitting authority (BBK 2021).

4.4.2 SGMA and Water Rights

The Sustainable Groundwater Management Act (SGMA) requires land use plans to consider groundwater sustainability plans and to assess the impact of land use on groundwater. SGMA prioritizes local management of groundwater resources; if local entities are unable to manage the local resources, the SWRCB may intervene to develop and implement a GSP for the respective basin. State intervention would generally be an undesirable outcome for most local agencies. Table 1-7, presented in Section 2.2, *Laws and Regulations,* describes that the purpose of SGMA is for local agencies and stakeholders to conduct groundwater management towards the purpose of reversing overdraft conditions and achieving sustainable conditions according to a SGMA-established timeline.

SGMA does not alter water rights, including overlying groundwater rights, riparian water rights, and appropriative rights, as discussed above in Section 4.4.1, *Water Rights Attached to Real Estate*. However, due to the correlative nature of the types of water rights associated with land ownership, water rights holders may be expected to reduce their use of water rights as needed to achieve the goals of SGMA. Compliance with SGMA requires DWR approval of a GSP for the basin, and proven accomplishment of specific sustainability goals to reverse overdraft and create sustainable groundwater conditions. The GSP typically quantifies the groundwater budget and safe yield of a subject basin, and may set limits to the amounts of groundwater that can be produced while supporting sustainable conditions in the basin.

Therefore, although SGMA does not alter water rights, compliance with SGMA may require water rights holders to reduce their rates of groundwater production towards the common purpose of achieving and maintaining sustainable groundwater conditions while supporting existing uses. There is incentive for landowners with attached water rights to comply with the respective GSP because non-compliance with SGMA could result in state intervention. Although GSPs may result in reduced pumping rates, GSPs may also allow for specific water uses that were either not previously documented, were unclear, or were previously not available.

As discussed in Section 3.3.1, *Basin Prioritization and Availability*, the Darden Clean Energy Project, as proposed in November 2023 application documents to the CEC, would acquire part of its water supply through the acquisition of land with attached water rights. Based upon the terms of a confidential Option Agreement between WWD and the Applicant, the Darden project companies would receive 2 AFY for every 320 acres of land acquired within the project site and developed for solar energy. WWD is also the primary GSA for the Westside Subbasin, and is responsible for SGMA compliance and the development of sustainable groundwater conditions. Therefore, WWD’s approval of these water rights is consistent with the Westside Subbasin GSP and SGMA objectives.

Part 5: Conclusions

Water supply for future clean renewable hydrogen projects may be sourced from existing supply sources (see Part 3) including: (i) imported surface water; (ii) treated wastewater; (iii) groundwater; (iv) agricultural industry water; (v) brine line flows; (vi) advanced water treatment concentrate; (vii) oil and gas industry water; (viii) inland brackish groundwater; (ix) dry weather flows; and (x) urban stormwater capture and resource. Water supply may be acquired by future clean renewable hydrogen producers through various mechanisms (see Part 4) including: (i) exchange agreements; (ii) purchase from or partnership with local water agencies; (iii) participation in water markets; and (iv) land purchase with water rights. In addition to these existing supply sources and mechanisms of acquisition, new supply opportunities may also be developed between future hydrogen producers and local water agencies.

Below is an overview of key conclusions of this Water Availability Study, prepared under the Water Supply Evaluation of the Angeles Link Phase 1 feasibility investigations.

- The volume of water needed for third-party clean renewable hydrogen producers to produce the quantity of clean renewable hydrogen to meet 2045 demand across SoCalGas's service territory comprises a small percentage (0.02 to 0.10 percent) of total annual applied water in California for urban (M&I), agricultural, and environmental purposes.
- Third-party clean renewable hydrogen producers may draw from a number of water supply sources to meet the water needs to produce the clean renewable hydrogen to meet the overall expected SoCalGas service territory demand and the portion of that demand that would be transported by Angeles Link.
- The water supply sources identified in Part 3 of this chapter may be considered by third- party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects to produce the clean renewable hydrogen to meet the overall service territory demand, including expected Angeles Link throughput.
- A substantial portion of water needs for clean renewable hydrogen production may be met using existing water supply sources and mechanisms of acquisition. New supply sources may also be developed to support clean renewable hydrogen production projects.
- Shifting water needs and obligations may change over time as uses for water in the state evolve and may present opportunities for new water supply development, such as but not limited to water offset from reduced oil and gas operations, additional storage and banking, expanded wastewater treatment, and increased desalination. These shifts will be documented in water supply providers' UWMP updates, which occur every five years and include projections of the water needs and supply availability within the respective UWMP area over a 20-year planning horizon.

- The potential water supply sources available to feed specific clean renewable production projects can be further evaluated and developed on a case-by-case basis as more details on specific clean renewable hydrogen production projects are developed.

Part 6: References

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Chapter 2: Water Quality Requirements for Hydrogen Generation

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Executive Summary

This technical memorandum (TM) provides findings based on a desktop level review of water quality requirements for the production of clean renewable hydrogen as part of the Water Resources Evaluation to support the Phase 1 feasibility studies for Angeles Link proposed by Southern California Gas Company (SoCalGas). This technical memorandum provides an overview of the water requirements for hydrogen generation via electrolysis. While SoCalGas would not produce clean renewable hydrogen as part of Angeles Link, the purpose of this memorandum is to summarize the water quality and quantity requirements for the electrolyzers that third-parties may use to produce clean renewable hydrogen.

First, this technical memorandum considers electrolysis technologies involved in hydrogen production and details three primary commercialized electrolysis technologies: alkaline, polymer electrolyte membrane (PEM), and solid oxide electrolysis cell (SOEC) electrolyzers.

Second, the memorandum summarizes water quality specifications for electrolyzers. Water quality is critical to the lifespan and efficiency of electrolyzers, with impurities potentially causing damage or repairs. The memorandum specifies that treatment of feed water is necessary for current technologies like PEM and alkaline electrolyzers, with Reverse Osmosis (RO) being a common pretreatment method. The memorandum also summarizes the expected water quality, treatment stages, and target contaminants for various source waters, emphasizing the need for ultrapure water to prevent electrolyzer damage.

Finally, the memorandum discusses the overall water quantity requirements for hydrogen generation, which includes water consumed in the pretreatment process, the electrolysis process itself, and cooling of electrolyzer equipment. It explains that water quantity consumed in electrolysis is directly proportional to the amount of hydrogen produced, with specific figures provided for the water required per kilogram of hydrogen and per day per MW of electrolyzer capacity. Additionally, this memorandum outlines the cooling water quantity requirements, comparing closed-loop air cooling and open-loop cooling towers in terms of water usage and efficiency.[1]

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[1] For additional analysis of estimated water quantities, see further analysis in Chapter 3, Technical Memorandum for Water Acquisition and Purification Costs.

1 Electrolysis Technologies for Hydrogen Production

Electrolysis of water to produce hydrogen involves using electricity to decompose water (H_2O) into oxygen (O_2) and hydrogen (H_2) gas (Rodriguez, 2020) by providing electricity as summarized in the following chemical equation:

$$2\ H_2O_{(l)} + \text{electrical energy} \rightarrow 2\ H_{2(g)} + O_{2(g)}$$

The above chemical reaction shows that energy is a required input for generating hydrogen in addition to water. Electrolyzers used for clean renewable hydrogen generation typically contain anodes and cathodes submerged in electrolyte. The types of electrolyzers differ by the type of electrolytes and electrodes used.

There are two water electrolysis technologies that have been commercialized and used in large-scale hydrogen generation projects (Schmidt et al., 2017), namely alkaline electrolyzers and polymer electrolyte membrane (PEM) Electrolyzers. Solid oxide electrolysis cell (SOEC) electrolyzer technology is not as widely commercialized but has drawn great attention in the past few decades as an efficient electrolyzer technology (Schmidt et al., 2017).

2 Electrolyzer Water Quality Specifications

Water quality used for water electrolysis can impact the life span of an electrolyzer because certain ions, molecules, and compounds present in the water can cause irreversible damage to electrolyzers. Hence, treatment of feed water for electrolyzers are required using the current electrolyzer technologies, such as PEM and alkaline electrolyzers (Schmidt et al., 2017). The water quality requirements for an electrolyzer vary depending on the type of electrolyzer technology and the manufacturer. Reverse osmosis is commonly used as the main pretreatment technology for electrolyzers (Simoes et al., 2021). Table 2-1 summarizes the expected water quality, treatment stage, and target contaminants removed.

Table 2-1 Treated Water Quality, Treatment Stage, and Target Contaminants

Potential Source Water	Treatment Stage	Expected Treated Water Quality	Treatment Stage	Target Contaminants
Water sources of lower quality than recycled water or potable water[1]	Pretreatment for RO	Recycled water and potable water	Pretreatment for RO, processes vary depending on water quality	Suspended solids, oil and grease, organics, microorganisms, nuisance compounds (e.g., iron, manganese, hardness) (MWH, 2012)
Recycled water and potable water	Reverse Osmosis	Demineralized water, boiler feed water	Reverse Osmosis	Total dissolved solids, conductivity, total and dissolved organic compounds, and other dissolved contaminants, e.g., boron (MWH, 2012)
Demineralized water	Post-RO Polishing	Deionized, ultrapure water	Post-RO Polishing	Gas, silica, conductivity, and TOC (MWH, 2012)

Note: [1] Chapter 1 (Water Availability Study) considered imported surface water, treated wastewater, groundwater, agricultural industry water, brine line flows, advanced treatment concentrate, inland brackish groundwater, dry weather flows, and urban stormwater capture and reuse.

Treatment of source water to ultrapure water has two main steps: pretreatment of raw water and polishing to ultrapure water. The pretreatment process is designed to remove the bulk of the constituents, such as suspended solids, salts, organics, and microorganisms, from a selected source water supply, such as municipal potable water, seawater, and groundwater. The number of pretreatment steps required can vary depending on the source water quality; and the use of RO is commonly used as the final pretreatment step. For example, groundwater contains dissolved redox-active species such as iron and manganese, which can precipitate and damage RO and require removal of these constituents. Pretreatment steps required could involve oxidation and sand filtration prior to RO. Seawater requires the removal of suspended solids, organics, and microorganisms before RO. The polishing step is typically used to remove constituents that are present in low concentrations and are difficult to be removed to levels meeting the electrolyzer feed water requirements using RO alone. These constituents include conductivity (ions contents), hardness, total organic carbon (TOC), and silica.

The water quality after RO is usually of high purity already. Water resistivity, water conductivity, total organic carbons (TOC), are commonly used to indicate the level of water purity instead of measuring individual ions or organic species that still be present in the water. Certain difficult-to-remove contaminants that have high potential to cause damages to electrolyzers, such as silica, are the exceptions and they usually have separate water quality requirements specified by manufacturers. Table 2-2 shows the water quality specifications for ultrapure water defined by American Society for Testing and Materials (ASTM).

Table 2-2 Water Quality Specifications for Ultrapure Water (ASTM, 2023)

	Value	
Water Quality Parameter	**Type I Ultrapure Water Defined by ASTM**	**Type II Ultrapure Water Defined by ASTM**
Water resistivity (MΩ/cm)	>18	>1
Water conductivity (µS/cm)	<0.056	<1.0
TOC (ppb)	<50	<50
Silica (µg/L)	<3	<3

The two main electrolyzer technologies, PEM and alkaline electrolyzers, require ultrapure water. Ultrapure water for alkaline electrolyzer can be obtained by advanced water treatment processes, such as double-pass reverse osmosis (RO) followed by electrodeionization (EDI) as the polishing step. In contrast, PEM requires advanced water treatment and continuous internal water polishing in the electrolyzer cells. Most PEM electrolyzer manufacturers suggest ASTM D1193-06 Type I or II water; however, there are exceptions. For example, Eurowater, an electrolyzer supplier, only requires water conductivity of <0.2 µS/cm and <5 µS/cm for PEM and alkaline electrolyzers, respectively (Eurowater ,2023).

Unlike PEM and alkaline electrolyzers that require ultrapure feed water, SOECs usually has lower water quality requirements because it operates at very high temperature (650 to 1,000 °C) where steam is fed into the electrolyzer (Schmidt et al., 2017). As noted above, different membraneless electrolyzers require different water quality depending on their materials and/or operation conditions. Some of membraneless electrolyzer technologies can use seawater as feed water directly without any pretreatment necessary, such as sHYp. Other membraneless technologies such as CPH2 electrolyzer only require potable water quality, while others such as Hydrox electrolyzer require demineralized or deionized water with a specific pH. Table 2-3 summarizes the water quality requirements for these electrolyzer technologies.

Table 2-3 Typical Water Quality Summary Table

Electrolyzer Technologies	Typical Water Quality Requirements
Alkaline Electrolyzer	Alkaline electrolyzers typically require ultrapure water. Higher water conductivity of <5 µS/cm for Alkaline electrolyzers has also been recommended.
PEM Electrolyzer	PEM electrolyzers require ultrapure water. Various sources such as Eurowater suggests water conductivity of <0.2 for PEM electrolyzers.
SOEC	Some SOEC manufacturers such as Sunfire suggest using deionized or boiler feed water but most of the SOECs such as Nexceris' SOEC usually do not require high quality water (Sunfire and Nexceris).
Membraneless electrolyzers	Some membraneless electrolyzers such as sHYp electrolyzer use untreated seawater. Some such as CPH2 electrolyzer work with potable water, while others such as Hydrox electrolyzer require demineralized or deionized water with a specific pH.

3 Water Quantity Requirements

Water quantity requirements consists of three main components:

- Water consumed in pretreatment process
- Water quantity consumed in electrolysis process
- Water utilized in cooling of electrolyzer equipment

This section discusses water demands for the electrolysis process and cooling for PEM technology. Water demands for pretreatment processes and estimates of the combined water demands for pretreatment, electrolysis, and cooling for the production of clean renewable hydrogen are discussed in Chapter 3, Technical Memorandum for Water Purification and Acquisition Costs.

3.1 Water Quantity Requirements for Hydrogen Generation

Water quantity consumed in water electrolysis process is directly proportional to the amount of hydrogen produced because of the conservation of mass. The chemical reaction for water electrolysis summarized in the equation below.

$$2H2O(l) \rightarrow 2H2(g) + O2(g)$$

The molecular mass of water (H2O) is 18.015 g/mol, while the molecular mass of hydrogen (H2) is 2.016 g/mol and the molecular mass of oxygen (O2) is 31.998 g/mol.

Therefore, for every 36.030 g of water that is electrolyzed, 4.032 g of hydrogen and 31.998 g of oxygen are produced. More simply, for every 1 kg of H2 produced, 9 kg of H20 is required from a stoichiometric point of view (Shi et al, 2020). One kilogram of water is equivalent to one liter of water, so therefore 9 liters (2.378 gallons) of ultrapure water is needed to produce 1 kg of hydrogen (Shi et al, 2020).

3.2 Water Quantity per Size of Electrolyzer

The amount of water required is proportional to the electrical load of the electrolyzers and electrical efficiency of electrolyzers. The electrical efficiency of an electrolyzer is a measure of how effectively it converts electrical energy into the chemical energy stored in hydrogen gas. It is typically expressed in terms of the amount of electrical energy required to produce one kilogram of hydrogen (kWh/kg). The energy stored in one kilogram of hydrogen is 39.4 kWh (higher heating value). Therefore, a 100% efficient liquid water electrolyzer would consume 39.4 kWh/kg.

The electrical efficiency of an electrolyzer depends on various factors, such as the design of the electrolyzer, the type of electrode materials used, the temperature and pressure of the electrolyte, and the purity of the water. Generally, modern electrolyzers have electrical efficiencies ranging from 70% to 80%, meaning that it takes between 50 and 60 kWh of electrical energy to produce one kilogram of hydrogen gas (O. Schmidt et al, 2027).

Based on the rate of 50 to 60 kWh/kg, the amount of hydrogen produced per MW electrolyzer size is between 480 and 400 kg/day, respectively. Therefore, the water quantity required in the electrolysis process using technologies such as alkaline electrolyzers and PEM, is between 1,100 and 950 gallons of ultrapure water per day per MW of electrolyzer capacity. The source water quantity required to produce ultrapure water is larger because of treatment losses and will vary depending on the quality of the source water.

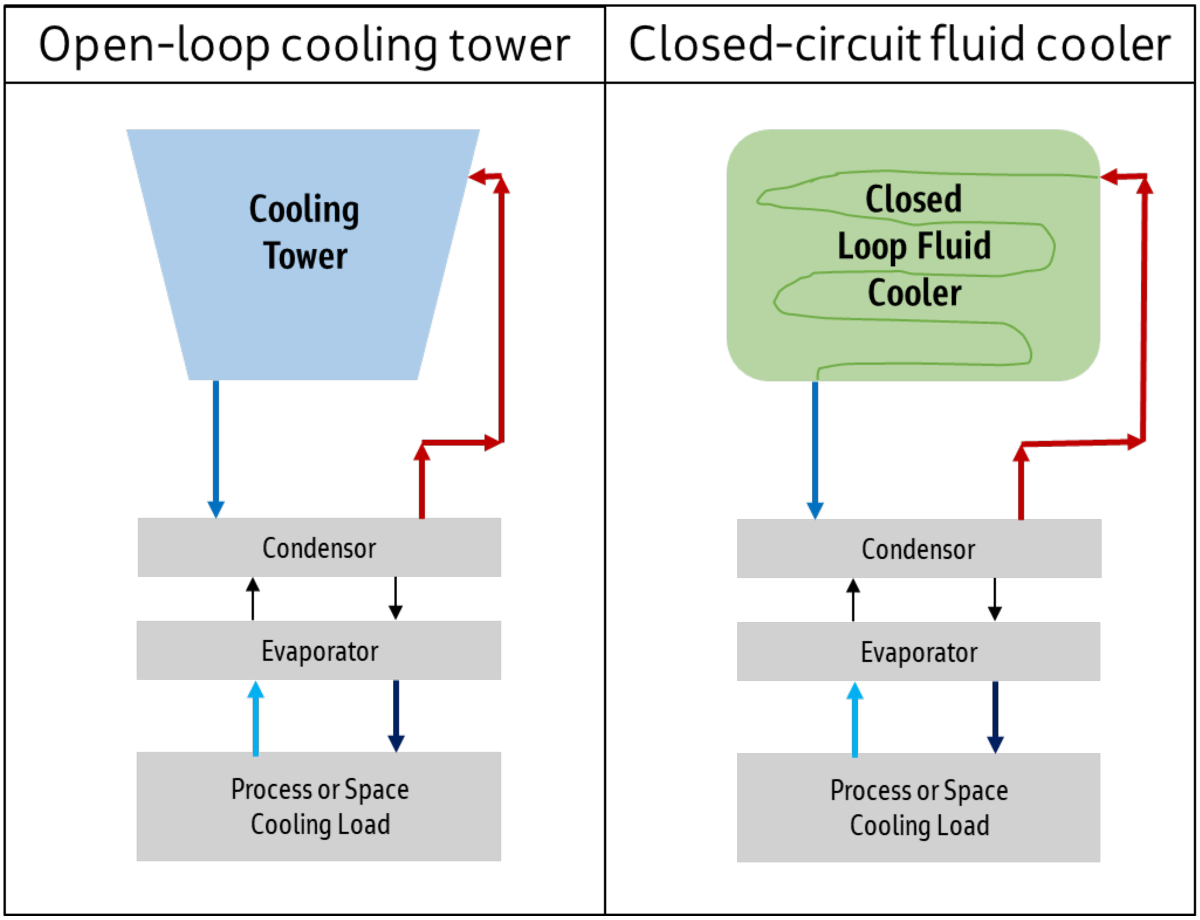
3.3 Electrolyzer Cooling Water Quantity Requirements

The cooling requirements of an electrolyzer depend on the amount of heat generated during the electrolysis process, which can be influenced by factors such as the current density, the operating voltage, and the flow rate of the electrolyte. In general, the higher the current density and the operating voltage, the greater the heat generated by the electrolyzer. SOEC usually does not have large cooling demands since the thermal energy from the high temperature outlet gases of SOEC is utilized to preheat the inlet gases via a heat exchanger network.

There are two main methods of cooling for an electrolyzer: closed-loop air cooling and open-loop cooling towers as shown in Figure 2-1. Cooling methods should be selected based on environmental, location, water availability, and electrolyzer manufacturer recommendations.

- Closed-loop air cooling involves using a cooling system that circulates air through a heat exchanger to remove the heat generated by the electrolyzer. The heated air is then discharged outside the facility. This method is typically used for smaller electrolyzers and in situations where water is not readily available or is expensive. Closed-loop air cooling typically requires between 0 and 100 gallons of water per day per MW of electrolyzer capacity (R. Niekerk and R. Manita, 2022) .
- Open-loop cooling towers use water as the cooling medium. The hot water from the electrolyzer is circulated through a cooling tower, which is cooled by evaporation and then returned to the electrolyzer. Open-loop cooling towers typically require between 2,000 and 4,000 gallons of water per day per MW of electrolyzer capacity (R. Niekerk and R. Manita, 2022; Eurowater ,2023).

Figure 2-1 Main Cooling Technologies used for PEM and Alkaline Electrolyzers (modified from Michaels Energy, 2023.)



4 Summary

Electrolysis of water uses electricity to break down water into oxygen (O_2) and hydrogen (H_2) gas. When coupled with renewable energy, electrolysis is a pathway to producing clean renewable hydrogen. Currently, the most readily available electrolyzer technology includes alkaline and PEM electrolyzers. However, SOEC and other advanced technologies are rapidly gaining interest and availability.

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Chapter 3: Water Acquisition and Purification Costs

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Acronyms and Abbreviations

$M	million dollars
AF	acre-foot
AFC	air fin cooling
AFY	acre-foot per year
ASTM	ASTM International
AWT	advanced water treatment
AWTF	Advanced water treatment facilities
BAC	biological activated carbon
CVP	Central Valley Project
DWR	California Department of Water Resources
EDI	electrodialysis
EMWD	Eastern Municipal Water District
EPA	United States Environmental Protection Agency
GPD/MW	gallons per day per megawatt of electrolyzer capacity
GSA	Groundwater Sustainability Agencies
HDD	horizontal directional drilling
HDPE	high-density polyethylene
kg	kilogram(s)
kWh	kilowatt(s) per hour
mg/L	milligram(s) per liter
MG	million gallon(s)
MGD	million gallons per day
MMTY	million metric tons per year
MS4	Municipal Separate Storm Sewer System
NPV	net present value
NSQD	National Stormwater Quality Database
O&G	oil and gas
O&M	operations and maintenance
PVC	polyvinyl chloride
RO	reverse osmosis

RPD	Replica™ Parametric Design
SAWPA	Santa Ana Watershed Project Authority
SoCalGas	Southern California Gas Company
SWP	State Water Project
TDS	total dissolved solids
TM	technical memorandum
TOC	total organic carbon
UF	ultrafiltration

1 Introduction

This chapter documenting Water Acquisition and Purification Costs has been prepared as part of the Water Resources Evaluation being prepared for Angeles Link proposed by Southern California Gas Company (SoCalGas). The Water Resources Evaluation is part of a larger feasibility study being conducted by SoCalGas in support of SoCalGas's proposed development of a pipeline system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. The purpose of the Water Resources Evaluation is to identify and characterize water supply sources and identify costs associated with those sources that third-party producers may pursue to produce clean renewable hydrogen.

This chapter relies on and incorporates analysis from the following two studies that were prepared separately as part of the Water Resources Evaluation for the Angeles Link Phase 1 feasibility analyses:

1. Chapter 1: Water Availability Study: identifies and characterizes potential water supply sources that could support future third-party clean renewable hydrogen production.
2. Chapter 2: Water Quality Requirements for Hydrogen Generation: identifies water quality requirements for the production of clean renewable hydrogen.

1.1 Scope of Work

The scope of work for this chapter includes:

- Conducting a high-level engineering evaluation to identify water treatment and conveyance needs for the water supply types that have been identified in the Water Availability Study.
- Developing rough order-of-magnitude cost estimates for treatment, concentrate management, water acquisition, and conveyance for the water supply types that have been identified in the Water Availability Study.

The Water Availability Study (refer to Chapter 1) identified the following potential supply types:

- Source 1: Imported Surface Water
- Source 2: Treated Wastewater
- Source 3: Groundwater
- Source 4: Agricultural Industry Water
- Source 5: Brine Line Flows
- Source 6: Advanced Water Treatment Concentrate
- Source 7: Oil & Gas (O&G) Industry Water
- Source 8: Inland Brackish Groundwater

- Source 9: Dry Weather Flows
- Source 10: Urban Stormwater Capture and Reuse

Section 3 of this chapter describes each of these source types and summarizes their water quality characteristics.

1.2 Technical Approach

The technical approach used for this chapter is to develop high-level cost estimates of the main cost components of water supply (water acquisition, treatment, concentrate management, and conveyance) to support clean renewable hydrogen production for the potential identified source types in the Water Availability Study. Since specific water supply projects have not yet been identified, these costs are expressed in unit costs (i.e., costs per unit volume of water). This will support calculating rough estimates of the potential costs for third-party producers developing specific water sources for clean renewable hydrogen production.

1.3 Chapter Organization

The following is the organization of this chapter:

- Section 1: Introduction, presents the objective and approach for this task of the Water Resources Evaluation.
- Section 2: Cost Estimate Approach, describes the approach used to develop cost estimates for water supply and treatment for each of the potential sources that have been identified.
- Section 3: Water Source Types and Water Quality Characteristics, describes the potential supply types that were identified and their water quality characteristics.
- Section 4: Water Quality Requirements for Electrolyzers and Cooling, presents an overview of the water quality requirements for hydrogen production electrolyzers and cooling systems.
- Section 5: Treatment Processes and Costs, presents an evaluation of the processes and costs for pretreatment of the identified water supply sources.
- Section 6: Concentrate Management Costs, presents cost estimates for two potential concentrate management options.
- Section 7: Conveyance Costs, presents cost estimates for two potential conveyance construction methods.
- Section 8: Water Acquisition Costs, presents costs estimates for acquisition of the water supplies for the potential sources that have been identified.
- Section 9: Cost Summary, overall cost estimates for the conceptual water supply scenarios developed for this chapter.
- Section 10: Estimates of Overall Water Demands and Water Supply Costs, presents estimates of the overall water demands for Angeles Link inclusive of treatment and production demands and associated water supply costs.
- Section 11: References, lists the references cited in this chapter.

1.4 Key Terms

- **Advanced Water Treatment (AWT).** Advanced water treatment is pursued after water/wastewater treatment to further remove trace constituents still present in the water.
- **Antiscalant.** A polymer used to inhibit crystalized mineral salts from forming on surfaces (i.e., scale).
- **Air Fin Cooling (AFC).** A cooling process that uses ambient air to cool the system and extended surfaces (fins) to increase heat transfer from the closed-loop air system.
- **Backwash.** A process used to clean filtration tanks where water is pumped backward through the media filters to clean.
- **Biological Activated Carbon (BAC).** A process used in water purification that utilizes both adsorption onto activated carbon and degradation of pollutants through biofilms.
- **Biological Treatment.** Biological treatment refers to microorganisms used to consume organic waste present in the water being treated.
- **Blow Down.** Water used in a cooling tower is drained to prevent/minimize build-up on the system from mineral scale and total dissolved solids.
- **Brackish Groundwater.** Groundwater with elevated dissolved solids (salt content). For this assessment, groundwater with Total Dissolved Solids (TDS) concentration (a measure of salt content) exceeding 1,000 milligrams per liter (mg/L) is considered brackish.
- **Brine.** A solution with a higher amount dissolved solids (salt content) than brackish water.
- **California Code of Regulations Title 22.** Set forth by the State Water Resources Control Board, Title 22 details water quality requirements and treatment standards dependent on the end use of the water being treated.
- **California Code of Regulations Title 27*.*** Title 27 of the California Code of Regulations is a set of regulations pertaining to waste disposal on land. It is a joint effort of the California Department of Resources Recycling and Recovery and the State Water Resources Control Board. The regulations cover the criteria for all waste management units, facilities, and disposal sites, including landfills.
- **Clarification.** A treatment process that removes gravity-settled suspended solids and scum floating on the water's surface.
- **Concentrate**. A liquid waste stream generated during reverse osmosis treatment that contains elevated concentrations of dissolved solids (salts).
- **Conveyance.** Pipelines, pump stations, and other associated equipment needed to move water from the source location to the hydrogen production facility.
- **Desalination/Desalinated (Water).** A treatment process that removes salt from seawater.
- **Dewatering.** (Used in conjunction with thickening) A process done to minimize the volume of waste being disposed of.

- **Dissolved Air Flotation.** A treatment process that dissolves air into the water under pressure and then releases the water into a separate tank at atmospheric pressure. This causes contaminants to float to the surface of the water.
- **Divalent Ions.** Of an atom that has a valency of two.
- **Dry Weather Flow**. Dry weather flow occurs in the absence of precipitation, typically from surface discharges.
- **Effluent.** Water discharged from a system/process.
- **Electrodialysis (EDI).** A process where ions are moved across a semipermeable membrane with the help of an electric field.
- **Electrolyzer.** A technology that employs electrolysis. The process that separates the hydrogen atoms from the oxygen atom in water to produce hydrogen and oxygen gas.
- **Equalization.** Buffering or equalizing characteristics, such as flowrate, of wastewater before it enters a treatment facility.
- **Exchange mechanism (including imported surface water).** Water acquired through an exchange agreement with existing water rights holders by developing a replacement water source.
- **Flocculation.** Flocculation is a treatment process in which solids cluster, or floc, together to create heavier particles that can be extracted more easily from the water.
- **Freeboard.** In the context of evaporation ponds, freeboard refers to an additional amount of depth added onto the calculated depth to prevent the concentrate from overflowing.
- **Greenfield Project.** A project without any previous infrastructure.
- **Influent.** Water entering a system/process.
- **Lime.** Lime is used in water/wastewater treatment to soften water by removing magnesium and calcium ions from the water. Additionally, lime can be used as a coagulant to aid in the removal of solids from water.
- **Microfiltration.** Microfiltration is a filtration process with a pore-sized membrane filter that contaminated water is pushed through.
- **Oil and gas (O&G) production wastewater (produced water).** Water that is pumped to the surface during the extraction of O&G.
- **Ozone.** An oxidizer that neutralizes biological matter instantly.
- **Pretreatment.** Pretreatment is integral to the success of the following treatment processes as each process of wastewater treatment targets the removal of specific contaminants. Without the required pretreatment, the processes to follow would not be as effective.
- **Residuals.** For this study, solid or liquid wastes produced during treatment of water source for hydrogen supply.

- **Reverse Osmosis (RO).** A tertiary treatment process where water is pushed through a semipermeable membrane in order to separate water molecules from other contaminants in the water. This assessment discusses both a single-pass system and a double-pass system. A single-pass RO system only passes water through the system once, and a double-pass system has the permeate from the first pass go through a second stage of RO.
- **Scalant.** Crystalized mineral salts that form on surfaces.
- **State Water Project (SWP).** The California State Water Project allocates water from Northern California rivers to water scarce areas across the state.
- **Surface Water.** Surface water refers to any body of water on the earth's surface such as streams, rivers, lakes, and reservoirs.
- **Surfactants.** A substance that reduces the surface tension of the liquid it is dissolved in.
- **Suspended Solids.** Small solid particles in water that remain in suspension.
- **Tertiary-Treated Recycled Water.** Reclaimed wastewater that has undergone preliminary, primary, secondary, and tertiary treatment.
- **Total Dissolved Solids (TDS).** A measure of the dissolved salt content in a liquid.
- **Total Organic Carbon (TOC).** A measure of organic compounds that contain carbon.
- **Thickening.** (Used in conjunction with dewatering) A process that increases the concentration of solids and decreases the volume of sludge present.
- **Ultrafiltration (UF).** A filtration process where water is pushed through multiple semi permeable membranes to remove suspended solids.
- **Ultrapure Water.** Ultrapure water is required for the success of an electrolyzer. It is as close to H_2O as possible, meaning it is purified according to stringent requirements.

2 Cost Estimate Approach

This section describes the approach used to develop cost estimates for water supply and treatment for each of the water sources identified in the Water Availability Study (Chapter), including an overview of the conceptual framework for cost development, tools used to develop the cost estimates, key assumptions, and a discussion of cost outputs.

2.1 Conceptual Framework

The conceptual framework for the cost estimates is as follows:

- The source (raw) water flow for treatment is 10 million gallons per day (MGD).
- The water quality varies among the source types (refer to Section 3).
- The water treatment plant is co-located with the hydrogen production facility.
- Concentrate produced during treatment is discharged to new evaporation ponds that are co-located with the treatment facility or conveyed to an existing brine disposal facility.

The 10 MGD for source water flows corresponds to approximately 1.0 million metric tons per year (MMTY) of clean renewable hydrogen production (refer to Section 10). For purposes of the Angeles Link Phase 1 feasibility analysis, this is assumed to be reasonable source water flow for developing water supply and treatment costs for third-party producers given the scale of the production projects expected to produce clean renewable hydrogen for use in Central and Southern California by 2045, including the volume Angeles Link proposes to transport (approximately 0.5-1.5MMTY).

2.2 Cost Estimating Tools

The following tools were used to develop the cost estimates:

- Replica™ Parametric Design (RPD), Internal Jacobs cost database for conveyance system components
- A hydraulic model (Applied Flow Technology's Fathom™ software), used to estimate pumping horsepower power consumption for source water conveyance

RPD is a proprietary Jacobs' model used to design and estimate costs for water and wastewater facilities. This tool generates conceptual designs based on standard facility arrangements resulting in quantity take-offs for cost estimates. RPD is a parametric estimating system based on standardized infrastructure models and uses actual cost data from existing facilities designed or constructed by Jacobs. The internal costs database is augmented with cost data from RSMeans® and is updated frequently. The capital cost includes the labor, materials and equipment for all unit process construction. Operations and maintenance (O&M) costs include equipment maintenance, electricity, chemical consumption, labor, and residuals management.

2.3 Common Assumptions for Construction Cost Development

Common assumptions used to develop the construction cost estimates are as follows.

- All costs presented are in 2023 dollars.[1]
- Facilities would be developed on greenfield sites.
- An installation cost of 20% is added to equipment cost.
- Approximately 55% of the material cost before markup is taxable material.
- A sales tax of 8.25% was added to the taxable component of the material cost.
- Cost allowances were assumed for select cost components.
    - Finishes – 2% of material costs
    - Instrumentation and controls – 2% of material costs
    - Mechanical – 2% of material costs
    - Electrical – 2% of material costs

- The applied contractor markups include overhead profit, mobilization/bonds/insurance, and contingency.
    - Overhead – 12% of the project cost
    - Profit – 10% of the project cost and overhead
    - Mobilization/bonds/insurance – 3% of project costs, overhead, and profit
    - Contingency – 30% of project costs, overhead, profit, and mobilization/bonds/insurance

The estimates are for construction only and exclude costs for land acquisition and non-construction elements sometimes included in capital cost estimates (e.g., permitting, engineering, services during construction, and commissioning).

2.4 Common Assumptions for Operations and Maintenance Costs

The following are common assumptions used to develop the O&M cost estimates.

- Energy consumption for treatment is estimated based on the amount of water treated and treatment processes used. The detailed assumptions are presented in Section 5.

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[1] 2023 dollars were used as this analysis was initiated in late 2023.

- Energy consumption for conveyance is estimated based on the amount of water conveyed, the assumed distance, and the elevation increase. The detailed assumptions are presented in Section 7.
- The cost of power is $0.185 per kilowatt hour (kWh) based on long term average cost data for California available from U.S. Energy Information Administration (1990 to 2017).
- Chemical costs are based on cost data incorporated into the RPD database.
- The average hourly rate for O&M labor is $35 per hour.
- Labor requirements are similar to those required for municipal water or wastewater treatment plants.
- Maintenance and replacement cost for treatment process equipment.
- Residuals management and disposal.
- 10% additional O&M cost was included to count for the use of vehicles, laboratories, office equipment and other required miscellaneous expenses.
- 10% additional O&M cost was included for O&M cost contingency.

2.5 Cost Outputs

The cost outputs are presented in life cycle and unit cost formats to allow for comparison of costs among the water sources and to support the development of costs for specific water supply projects or water supply portfolios that might be defined by third-party producers for future production projects. For life cycle costs, the inflation and discount rates used to establish net present value (NPV) were assumed to be 2% and 8%, respectively, and the project duration was assumed to be 30 years. Table 3-1 summarizes the unit cost formats that were developed.

The cost estimates that were developed are for the concept screening, or Class 5 estimates (AACE 2000). Given the conceptual nature of these estimates and the limited project definition, the accuracy of these estimates is considered to be-50% to +100%.

Table 3-1 Unit Cost Formats

Cost Component	Unit Cost Format	Cost Bookend Range
Conveyance Cost	$/mile	Trenching vs HDD
Water Treatment Cost	$/MG	Source Specific
Concentrate Management Cost	$/MG	Brine Line vs Evaporation Ponds
Source Water Acquisition	$/MG	Source Specific

HDD = horizontal directional drilling (a type of trenchless construction method)
MG = million gallon(s)

3 Water Source Types and Water Quality Characteristics

This section describes the potential supply types that were identified in the Water Availability Study and their water quality characteristics.

3.1 Description of Potential Water Sources

The Water Availability Study (Chapter 1) focused on identifying potential water sources that third-party producers could pursue to produce clean renewable hydrogen (Rincon 2024). Table 3-2 presents an overview of the supply sources that were identified.

Table 3-2 Identified Potential Water Sources for Clean Renewable Hydrogen Production

Supply Source	Description
Imported Surface Water	Generally, surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans, which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.

Supply Source	Description
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act, to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate local groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater banks, or aquifer storage and recovery projects, may be used to facilitate a water supply exchange.
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production.
Advanced Water Treatment (AWT) Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine or concentrate. This waste flow can be either recycled for reuse or treated for disposal. Concentrate from AWT that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.

Supply Source	Description
O&G Industry Water	O&G industry water from refinery offset water and/or produced water could be developed as a water supply source. Refinery offset water includes the water gained from the reduction or cessation of refinery operations and could be developed as O&G operations are phased out in accordance with state goals and objectives. The amount of water per barrel of oil produced is expected to vary by refinery location, depending on multiple factors, including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately, produced water includes water brought to the surface along with O&G because of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans to be managed for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, because of low volume and velocity, these flows accumulate within the MS4, causing water quality concerns and potential violation of the MS4 operating permit (National Pollutant Discharge Elimination System). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.

Supply Source	Description
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple Southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Source: modified from Table ES-6 Potential Supply Sources in the Chapter 1: Water Availability Study (Rincon 2024)

3.2 Water Quality Characteristics

The water quality characteristics of the source water will influence the treatment required to produce water for hydrogen production. The total dissolved solids (TDS) concentration of the source water has the most impact on treatment costs and treated water recovery. Reverse osmosis (RO) treatment will be needed for most source types to produce water with the TDS concentrations required for electrolyzer feed and cooling (refer to Section 4). Table 3-3 presents examples of TDS concentrations for the supply sources that have been identified.

Table 3-3 Total Dissolved Solids Concentrations for Identified Water Sources

Source	Unit	Value
Source 1: Imported surface water	mg/L	320[a]
Source 2: Treated wastewater	mg/L	890[b]
Source 3: Groundwater	mg/L	485[c]
Source 4: Agricultural industry water	mg/L	15,000[d]
Source 5: Brine line flows	mg/L	5,210[e]
Source 6. Advanced water treatment concentrate	mg/L	2,950[b]
Source 7: Oil and gas industry water	mg/L	22,500[f]
Source 8: Inland brackish groundwater	mg/L	1,810[g]
Source 9: Dry weather flows	mg/L	2,470[h]
Source 10: Urban stormwater capture and reuse	mg/L	168[i]

mg/L = milligram(s) per liter

[a] SWP Water – Lake Perris Outlet (average of 2022 samples): wdl.water.ca.gov/WaterDataLibrary. Given that third-party producers would be responsible for acquiring and treating the water for clean renewable hydrogen production and the precise source of water is unknown at this time, this cost analysis assumes a TDS concentration from SWP to evaluate one TDS value for this water source for purposes of this analysis. Other imported surface water sources, such as water from the Colorado River, may have a higher TDS value.

[b] Municipal recycled water and concentrate data from West Basin Municipal Water District Recycled Water Master Plan (HDR 2022). This cost analysis assumes a TDS concentration from one recycled water treatment facility to evaluate one TDS value for this water source for purposes of this analysis. Other sources of treated wastewater may have higher or lower TDS values.

[c] Average of TDS concentrations of produced groundwater for the groundwater basins relevant for the *Water Supply Study: Southern San Joaquin, Antelope Valley, Coachella, and Palo Verde Groundwater Basin* (DWR 2010).

[d] Arias-Paic et al (2022). Agricultural industry water includes agricultural drainage and agricultural wash water (discharge). To provide a conservative estimate of treatment costs, this study assumes TDS concentrations are representative of agricultural drainage for this source.

[e] Santa Ana Watershed Project Authority (January-March 2023 data) (SAWPA 2023).

[f] Lester et al (2015). O&G industry water includes water produced during O&G extraction and water used for refining or production. To provide a conservative estimate of treatment costs, this study assumes TDS concentrations are representative of produced water for this source.

[g] Well bend for Eastern Municipal Water District (EMWD) Perris II Desalter (CH2M 2008). This cost analysis assumes a TDS concentration from one water district to evaluate one TDS value for this water source for purposes of this analysis. Other sources of inland brackish groundwater may have higher or lower TDS values.

[h] Jacobs internal data (2023, unpublished).

[i] Average of TDS concentrations for stormwater from Los Angeles, Orange, Riverside, San Bernardino and San Diego Counties (https://bmpdatabase.org/national-stormwater-quality-database).

Other water source-specific water quality characteristics that influence the pretreatment steps for RO (e.g., removal of suspended solids or organics) or other membrane processes are summarized in Section 5. These pretreatment processes will affect overall treatment costs.

4 Water Quality Requirements for Electrolyzers and Cooling

This section presents an overview of the water quality requirements for hydrogen production electrolyzers and cooling systems. The Water Quality Requirements for Hydrogen Generation (see Chapter 2 of this Water Resources Evaluation) provides additional information regarding the requirements for hydrogen production electrolyzers and cooling systems.

4.1 Requirements for Hydrogen Production Electrolyzers

The water quality required for hydrogen production depends on the type of electrolyzer technology employed, see also the separate SoCalGas Angeles Link Phase 1 feasibility study, the *Production and Planning Assessment* (Production Study). The technologies currently available at large scales typically require the deionized water (or ultrapure quality, meeting the ASTM International (ASTM)[2] D1193-06 Type II or Type I water quality standards) as feed water. The larger electrolyzer systems typically incorporate RO and electrodialysis (EDI) treatment to polish the feed water to meet the ASTM Type II or Type I standards. RO is a treatment process where water is pushed through a semipermeable membrane in order to separate water molecules from dissolved solids and other constituents in the water. EDI is a treatment process where ions are moved across a semipermeable membrane with the help of an electric field.

Based on the input provided by Nel Hydrogen (2023), these polishing systems require TDS concentrations less than 350 mg/L and total organic carbon (TOC) concentrations less than 5 mg/L (Table 3-4). The anticipated TDS and TOC concentrations for all potential supply types identified in Chapter 1: Water Availability Study (Rincon 2024) exceed these limits, with the exception of surface water sources and urban stormwater capture and reuse (refer to Table 3-3). Consequently, pretreatment by RO will be required for those remaining eight supply sources.

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[2] ASTM stands for the American Society for Testing and Materials. It is an internationally recognized organization that develops and delivers voluntary consensus standards for improving product quality across various industries and applications. www.astm.org

Table 3-4 Water Quality Requirements for Electrolyzer Supplier's Polishing Treatment System

Parameter	Value (mg/L)
TDS	<350
TOC	<5
Total suspended solids	<1
Total Silica (as SiO2)	<30

4.2 Cooling Water Requirements for Electrolyzers

Water quality requirements for electrolyzer cooling vary depending on the cooling technology employed. More water efficient cooling technology tends to require cooling water with higher water quality. There are two main types of cooling technologies commonly used in the market: water-cooled system (cooling towers) and air-cooled system.

Cooling towers use water evaporation to cool the fluid. They can be configured into an open-loop system, which will expose the water to be cooled directly to the air, or a closed-loop system, which will use an intermediate fluid to transfer heat from the warm fluid via heat exchangers and cool the intermediate fluid via a cooling tower or air cooling.

For cooling towers, water is lost through evaporation, and the loss is replenished by providing makeup water. The overall process increases the TDS in the recirculated water. TDS levels in cooling water are controlled by water discharges through blow down when TDS reaches specified thresholds, and any water lost is replenished. A typical TDS concentration threshold for blowdown water is approximately 5,000 mg/L. To maintain a reasonable cycle of concentration (5 or higher), the cooling makeup water TDS concentration needs to be less than 1,000 mg/L to maintain a TDS threshold of 5,000 mg/L for blowdown water.

An air-cooled cooling system, such as air fin cooling (AFC) systems, can be operated without water—where ambient temperature is lower than the temperature of the fluid—but it will lose the efficiency as the air temperature approaches the fluid temperature. The AFC may use water to lower the temperature of air entering the system with spray or adiabatic pads utilizing the latent heat of vaporization, and it is used commonly for the installations in warm climatic conditions. The AFC with spray does not generate a blowdown stream because water is sprayed into the air in fine mist right at the air intake, and all water will be evaporated as intake air is cooled down. To avoid scaling of the cooling fins, water with a low TDS concentration should be used. Based on information from AFC system suppliers, a TDS level of 10 mg/L is recommended to minimize scaling on the fins, which can reduce the cooling efficiency. Water with higher TDS concentrations, however, can be used with descaling agents to remove the mineral scale that has accumulated on the cooling system (Menze, pers. comm. 2023). For many of the supply sources that have been identified, RO pretreatment will be needed to achieve the water quality necessary for AFC with a spray system.

5 Treatment Processes and Costs

This section presents an evaluation of the processes and costs for pretreatment of the identified water supply sources to levels required for hydrogen production electrolyzers and cooling (refer to Section 4 of this chapter). The treatment process for each source type was developed using the TDS concentrations presented in Table 2-2 and other assumed source water quality characteristics. Figures 3-1 through 3-10 are conceptual process flow diagrams that illustrate the expected pretreatment process required for each supply source. Appendix A includes summary RPD costs outputs.

5.1 Source 1 - Imported Surface Water

Imported surface water includes water from the SWP, the CVP, and the Colorado River. Without additional details on the particular water sources third-party producers may pursue for clean renewable hydrogen production at this feasibility stage, the surface water source for this scenario is assumed to be the SWP to evaluate one potential imported surface water source for purposes of the cost estimates at this stage. As shown in Table 3-3, SWP water is expected to have one of the lowest TDS of the water supply sources that have been identified. RO treatment prior to the electrolyzer's polishing treatment system is not included for this source because its TDS (315 mg/L) is less than required for electrolyzer (350 mg/L). The SWP water, however, is expected to have total suspended solids and organics that will need to be removed to meet the water quality requirements shown in Table 3-4.

The treatment requirements for imported water sourced from CVP are expected to be similar to those for the SWP water, but imported Colorado River would require additional treatment. The TDS concentrations of imported Colorado River water have ranged from approximately 500 to 800 mg/L (MWD and BOR, 1999). Consequently, RO treatment would be required for imported Colorado River water to produce acceptable water quality for electrolyzer feed and cooling.

5.1.1 Treatment Processes

The treatment process for Source 1 is shown on Figure 3-1. The major unit processes and equipment that are included in the cost estimate are as follows.

- Plant feed water storage/equalization tank
- Plant feed pump station
- Membrane separation of solids (ultrafiltration [UF])
- Solids thickening with flocculation tanks and solids settling
- Solids dewatering including thickened solids storage
- Treated water equalization/storage tank

For this source, a UF system will be required to provide feed water of acceptable quality for the polishing treatment systems that are included with electrolyzers, but RO will not be required because the TDS concentration of SWP water is less than 350 mg/L (Table 3-3). Solids in the UF backwash will be thickened and dewatered and disposed of separately. Based on the consultant's experience, a water recovery of 98% is estimated to be achievable for SWP using these processes.

5.1.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year) and following the cost estimate approach described in Section 2. A summary of the cost estimate is provided in Table 3-23.

Table 3-5 Planning-Level Cost Estimate, Imported Surface Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$98.5M	$197M	$49.2M
Treatment Annual O&M, $M/year	$8.1M	$16.2M	$4.0M
NPV of Total Project Cost over 30 years, $M	$210M	$420M	$105M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$1,916	$3,833	$958
Energy Consumption, kWh/year	14.0M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.2 Source 2 - Treated Wastewater

Treated wastewater is the effluent from a water reclamation facility effluent that has been treated to meet the water quality criteria specified in the California Code of Regulations Title 22 for disinfected tertiary recycled water.

5.2.1 Treatment Processes

Treated wastewater will need to be treated further to meet the requirements for the electrolyzer feed and cooling. Treated wastewater typically contains TDS concentrations that exceed the water quality requirements specified by electrolyzer vendors (e.g., greater than 350 mg/L [Table 3-3]), so RO treatment will be needed to meet the water quality requirements as described in Section 4.1. In addition, particulate and colloidal organic particles as well as total suspended solids will need to be removed prior to RO to avoid RO membrane fouling that degrades RO performance. Microfiltration or UF is commonly used as the pretreatment for RO for this source water type. In this chapter, UF is assumed for RO feed water pretreatment. Additionally, membrane systems require inflow to be relatively stable. To buffer the flow variation, equalization is also provided upstream of the membrane processes. In addition, pH adjustment is also added to meet the pH range specified by electrolyzer vendors.

The treatment process for Source 2 is shown on Figure 3-2. The major unit processes and equipment that are included in the cost estimate are as follows:

- Feed water storage/equalization tank
- Plant feed pump station
- Membrane separation of solids (UF)
- UF backwash water clarification and return flow pumps
- UF backwash solids holding
- UF backwash dewatering and return flow pumps
- RO, single-pass system to lower the TDS level
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalitzation/storage tank

The treated water recovery rate for the UF was assumed to be 95%; however, assuming that the clarified backwash water return will be transferred back to the UF feed, which increases the water recovery, the net recovery for the UF system was estimated to be 98% (used for cooling). Overall recovery for UF-RO treatment of 85% (used for electrolyzer feed) is achievable based on the consultant’s experience. The estimated water recovery rates for cooling and electrolyzer feed are 98% and 85%, respectively.

5.2.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-6 Planning-Level Cost Estimate, Treated Wastewater

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$207M	$414M	$103M
Treatment Annual O&M, $M/year	$16.0M	$32.0M	$8.0M
NPV of Total Project Cost over 30 years, $M	$426M	$853M	$213M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$3,895	$7,790	$1,947
Energy Consumption, kWh/year	13.9M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.3 Source 3 - Groundwater

The use of groundwater as a supply requires extraction wells and a pipeline system to convey the groundwater to the treatment facility.

5.3.1 Treatment Processes

Groundwater is expected have a TDS concentration that slightly exceeds the acceptable limits for electrolyzer feed and cooling (e.g., 485 mg/L vs. 350 mg/L, respectively). In this case, a portion of the process flow (50%) can be treated with RO, and the permeate can be blended with groundwater to produce treated water that has a TDS concentration less than 350 mg/L. The treatment process for Source 3 is shown on Figure 3-3. The major unit processes and equipment that are included in the cost estimate are as follows.

- Groundwater extraction wells
- Feed water storage/equalization
- Membrane separation of solids (UF)
- UF backwash water clarification and return flow pumps
- UF backwash solids holding
- UF backwash dewatering and return flow pumps
- RO, single-pass system to lower the TDS level for 50% of the process flow (5 MGD)
- Post-RO treatment to adjust pH (5 MGD) (decarbonator)
- Bypass line from the UF discharge to the treated water tank for blending
- Treated water equalization/storage tank

Based on the consultant’s experience, an overall treated water recovery of approximately 95% is achievable for groundwater using these processes.

5.3.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-7 Planning-Level Cost Estimate, Groundwater

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$156M	$312M	$78M
Treatment Annual O&M, $M/year	$11.7M	$23.4M	$5.9M
NPV of Total Project Cost over 30 years, $M	$314M	$628M	$157M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$2,868	$5,735	$1,434
Energy Consumption, kWh/year	17.1M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.4 Source 4 - Agricultural Industry Water

Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. The water quality characteristics of these sources are very different. The consultant assumed that potable quality water with relatively low TDS concentration would be needed for washing operations. Agricultural field drainage, however, can have elevated TDS concentrations (e.g., 15,000 mg/L [Table 3-3]). Other constituents of concern for the treatment of agricultural drainage include high levels of calcium sulphate originated from the soil conditioning gypsum application and selenium, which is prevalent in the soil naturally in the Central Valley and other regions in California. To provide a conservative estimate of the treatment costs for agricultural industry water, this chapter assumes the water quality characteristics of agriculture drainage for this source.

5.4.1 Treatment Processes

The treatment process for Source 4 is shown on Figure 3-4. The major unit processes and equipment that are included in the cost estimate are as follows.

- Drainage water intake structure with screens
- Feed water storage/equalization
- Feed water softening
- Softening process residuals dewatering
- Decarbonization process of the softened feed water
- Membrane separation of solids (UF)
- RO, double-pass system to lower the TDS level
- Treated water equalization/storage tank

Based on the consultant’s experience, a treated water recovery of 75% is achievable for agriculture industry water (drainage) using these processes.

5.4.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-8 Planning-Level Cost Estimate, Agricultural Industry Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$308M	$617M	$154M
Treatment Annual O&M, $M/year	$32M	$64M	$16M
NPV of Total Project Cost over 30 years, $M	$741M	$1,482M	$370M
Annual Source Water Usage, MG/year	3650	3650	3650
Treatment Cost, $/MG	$6,767	$13,533	$3,383
Energy Consumption, kWh/year	60.2M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.5 Source 5 - Brine Line Flows

In Southern California, RO concentrate from inland brackish groundwater desalination facilities is typically discharged into inland brine lines, such as Inland Empire Brine Line, for ocean discharge (SAWPA 2010). To use this source for clean renewable hydrogen generation, the brine line flows would be intercepted and diverted for treatment.

5.5.1 Treatment Processes

Brine line flows typically contain concentrated level of ions, organics, nutrients, and other chemicals added to the RO treatment process (Greenlee et al 2010; WRF 2006). Treatment will be required to remove these constitutes to levels acceptable for electrolyzer feed and cooling. The treatment process for Source 5 is shown on Figure 3-5. The major unit processes and equipment that are included in the cost estimate are as follows.

- Feed concentrate storage/equalization
- Treatment facility feed pump station
- Antiscalant removal process (ozone treatment)
- Magnesium-enriched lime softening process for softening and silica removal
- Carbon dioxide removal process
- Microfiltration/UF for remaining precipitate removal
- Weak acid ion exchange for removal of scaling divalent ions
- RO, single-pass system to lower the TDS level below the required quality
- Treated water equalization/storage tank

Based on the consultant's experience, a treated water recovery of 85% is achievable for brine line flows using these processes.

5.5.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-9 Planning-Level Cost Estimate, Brine Line Flows

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$319M	$638M	$159M
Treatment Annual O&M, $M/year	$37.0M	$74.1M	$18.5M
NPV of Total Project Cost over 30 years, $M	$829M	$1,657M	$414M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$7,567	$15,134	$3,784
Energy Consumption, kWh/year	22.9M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.6 Source 6 - Advanced Water Treatment Concentrate

In Southern California, an increasing number of agencies are implementing potable water reuse that requires the use of RO to meet regulatory water quality requirements. RO concentrate generated from these treatment facilities is typically disposed of (SWRCB 2023). For this source, the chapter assumes that concentrate would be diverted prior to disposal and conveyed to a treatment plant.

5.6.1 Treatment Processes

RO concentrate generated from AWTF typically contains concentrated level of ions, organics, nutrients, and other chemicals added to the RO treatment process (WRF 2006). Treatment will be required to remove these constitutes to levels acceptable for electrolyzer feed and cooling. The treatment process for Source 6 is shown on Figure 3-6. The major unit processes and equipment included in the cost estimate are as follows:

- Feed concentrate storage/equalization
- Treatment facility feed pump station
- Antiscalant removal process (ozone treatment)
- Biological activated carbon (BAC)
- Magnesium-enriched lime softening process for softening and silica removal
- Carbon dioxide removal process

- Microfiltration/UF for remaining precipitate removal
- Weak acid ion exchange for removal of scaling divalent ions
- RO, single-pass system to lower the TDS level below the required quality
- Treated water equalization/storage tank

Based on the constituents commonly present in concentrate, constituents that require treatment include antiscalant used at the AWTF, organic constituents of wastewater origin, and reactive silica (WRF 2006). Ozone treatment can reduce the antiscalant and break down some of the recalcitrant organic constituents. BAC is included to further reduce organic constituents. Ozone-BAC treatment is followed by a magnesium-enriched lime softening process to reduce hardness and reactive silica. UF is used to remove silica precipitation products, and weak acid ion exchange is used to reduce the residual magnesium to minimize the scaling potential for the RO process. As the typical TDS level in the AWT concentrate is expected to be approximately 5,000 mg/L (Table 3-3), a single-pass RO should reduce the TDS level below the required 350 mg/L for the polishing treatment included with the electrolyzer systems. Concentrate from the treatment process would be treated with evaporation or disposed of via existing brine disposal infrastructure. It was assumed that the residuals generated from the softening and filtration process would be dewatered within the facility and disposed of offsite. Based on the consultant’s experience, a treated water recovery of 85% is achievable for AWT concentrate using these processes.

5.6.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-10 Planning-Level Cost Estimate, Advanced Water Treatment Concentrate

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$351M	$702M	$175M
Treatment Annual O&M, $M/year	$37.5M	$75.0M	$18.8M
NPV of Total Project Cost over 30 years, $M	$867M	$1,734M	$433M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$7,917	$15,833	$3,958
Energy Consumption, kWh/year	23.1M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.7 Source 7 - Oil and Gas Industry Water

O&G industry water includes water from produced water and/or refinery offset water that could be developed as a water supply source. During O&G production, water is also extracted. This water typically contains high salinity and soluble and insoluble oil/organics, suspended solids, and chemicals used for O&G production (e.g., surfactants and biocides) (Lester et al. 2015). Offset water includes groundwater or surface water currently used for refining and may become available for supply in the future. Offset water is expected to have substantially lower TDS concentrations than water generated during O&G production. To provide a conservative estimate of the treatment costs, this chapter assumes the water quality characteristics of produced water for this source.

5.7.1 Treatment Processes

The treatment process for Source 7 is shown on Figure 3-7. The major unit processes and equipment that are included in the cost estimate are as follows.

- Inlet screens
- Oil/grease separator
- Dissolved air flotation for solids removal
- Pretreated water transfer pump station
- Feed water storage/equalization tank
- Biological treatment feed pump station
- Biological treatment for biodegradable organics and nutrient removal with membrane separation of solids (membrane bioreactor)
- Biosolids thickening and dewatering
- RO, consisting of a double-pass system to reduce the TDS level below the required quality
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalization/storage tank

The pretreatment processes include screens, oil separator, and solids removal. Given the high TDS concentration for this source, a double-pass RO system will be required to provide feed water that meets the requirements for electrolyzer systems. Based on the consultant’s experience, a treated water recovery of 75% is achievable for this source.

5.7.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-11.

Table 3-11 Planning-Level Cost Estimate, Oil and Gas Industry Water

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$387M	$773M	$193M
Treatment Annual O&M, $M/year	$48.8M	$97.6M	$24.4M
NPV of Total Project Cost over 30 years, $M	$1,058M	$2,116M	$529M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$9,661	$19,323	$4,831
Energy Consumption, kWh/year	69.9M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.8 Source 8 - Inland Brackish Groundwater

Brackish groundwater has been identified as a potential supply for clean renewable hydrogen production (Rincon 2024). The use of brackish groundwater for supply will require extraction wells and a pipeline system to convey the brackish groundwater to the treatment facility.

5.8.1 Treatment Processes

Brackish groundwater has elevated TDS concentrations (1,800 mg/L, [Table 3-3]), and RO treatment will be required to reduce TDS to levels acceptable for electrolyzer feed and cooling. The treatment process for Source 8 is shown on Figure 3-8. The major unit processes and equipment that are included in the cost estimate are as follows.

- Brackish groundwater extraction wells
- Plant feed pump station
- Feed water storage/equalization
- Media filtration for solids removal
- Backwash solids clarification and clarified return flow pumps
- Backwash solids holding
- Backwash solids dewatering and filtrate return pumps
- RO, single-pass system to lower the TDS level below the required quality
- Post-RO treatment to adjust pH (decarbonator)
- Treated water equalization/storage tank

The media filtration process was included to remove suspended solids. If iron and manganese removal were required, specialty media filters, such as green sand filters, with the addition of oxidants upstream, such as chlorine might be used in place of regular media filters. Based on the TDS concentrations presented in Section 3, a single-pass RO system will be sufficient to meet the water quality requirements for the polishing treatment systems included with electrolyzers (Table 3-4). Based on the consultant's experience, a treated water recovery of 85% is achievable for brackish groundwater using these processes.

5.8.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-12 Planning-Level Cost Estimate, Inland Brackish Groundwater

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$207M	$414M	$104M
Treatment Annual O&M, $M/year	$13.7M	$27.3M	$6.8M
NPV of Total Project Cost over 30 years, $M	$395M	$790M	$198M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$3,607	$7,215	$1,804
Energy Consumption, kWh/year	19.8M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.9 Source 9 - Dry Weather Flows

Dry weather flows are flows that are collected into stormwater collection systems during dry weather. The flows could be generated from runoff that originates from landscape irrigation, car washing, and other activities producing runoff from pavements, groundwater infiltration, and illegal discharge of water/liquid into stormwater drains. In urban areas, dry weather flows contain constituents both from road surfaces and of unknown origins, and their characteristics are not well documented and are highly variable. Dry weather flow is assumed to be diverted from a storm drain system at an appropriate location and conveyed to the hydrogen production facility for treatment.

5.9.1 Treatment Processes

Dry weather flows commonly contain oil and grease, large debris, suspended solids, organics, elevated TDS concentrations, and other regulated constituents (Stein and Ackerman 2007). RO treatment will be needed because the TDS concentrations are elevated for this source (2,460 mg/L, Table 3-3). The treatment process for Source 9 is shown on Figure 3-9. The major unit processes and equipment that are included in the cost estimate are as follows:

- Influent screen
- Oil/grease separator

- Dissolved air flotation
- Pretreated water transfer pump station
- Feed water storage/equalization tank
- UF feed pump station
- Membrane separation of solids (UF)
- RO, single-pass system to lower the TDS level below the required quality
- Post-RO treatment for pH adjustment (decarbonator)
- Treated water storage/equalization tank

Given the water quality expected for dry weather flows, pretreatment to remove oil/grease and particulate matter will be required before UF and RO treatment. Solids in the pretreatment and UF backwash will be thickened and dewatered and disposed of separately. Based on the consultant's experience, a treated water recovery of 85% is achievable for dry weather flows using these processes.

5.9.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-13 Planning-Level Cost Estimate, Dry Weather Flows

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$304M	$608M	$152M
Treatment Annual O&M, $M/year	$21.2M	$42.4M	$10.6M
NPV of Total Project Cost over 30 years, $M	$596M	$1,191M	$298M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$5,439	$10,878	$2,720
Energy Consumption, kWh/year	21.6M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.10 Source 10 - Urban Stormwater Capture and Reuse

Urban stormwater flows are flows that are collected into stormwater collection systems during wet weather. The flows are primarily the runoff from paved surface in urban areas. The US EPA has compiled stormwater quality data across the US in the National Stormwater Quality Database (NSQD). Stormwater quality data for Southern California was obtained from the NSQD, and this information was used to develop the treatment processes for urban stormwater capture and reuse. Based on this data, the TDS concentration of this source is expected to be relatively low (approximately 168 mg/L [Table 3-3]). Although RO treatment is not required, suspended solids concentrations are expected to be elevated (e.g., 155 mg/L [NSQD]) and will require treatment. For this source, stormwater flow is assumed to be diverted from a retention basin at an appropriate location and conveyed to the hydrogen production facility for treatment.

5.10.1 Treatment Processes

The treatment process for Source 10 is shown on Figure 3-10. The major unit processes and equipment that are included in the cost estimate are as follows.

- Influent screens
- High-rate solids removal
- Solids holding tank, solids dewatering process, and the dewatering return flow pumps
- Feed water storage/equalization tank
- Ultrafiltration for solids removal
- Treated water storage/equalization tank

Based on the consultant's experience, an overall treated water recovery of 98% is achievable for urban stormwater capture and reuse using these processes, assuming the solids processing return flows and UF backwash flow to be returned to the feed to the treatment system.

5.10.2 Cost Estimate

A planning-level cost estimate was developed for the treatment system to produce water for cooling water and electrolyzer feed based on 10MGD source availability (3,650 MG/year). A summary of the cost estimate is provided in Table 3-23.

Table 3-14 Planning-Level Cost Estimate, Urban Stormwater Capture and Reuse

Item	Estimate	+100%	-50%
Treatment Construction Cost, $M	$134	$268	$67
Treatment Annual O&M, $M/year	$9.8M	$19.7M	$4.9M
NPV of Total Project Cost over 30 years, $M	$267M	$533M	$133M
Annual Source Water Usage, MG/year	3,650	3,650	3,650
Treatment Cost, $/MG	$2,436	$4,872	$1,218
Energy Consumption, kWh/year	8.7M	NA	NA

$M = million dollars
M = million kilowatt hours per year
NA = not applicable

5.11 Treatment Cost Summary

An overall summary of treatment costs based on 10-MGD source flows is as follows.

- Total treatment costs in the NPV over the 30-year project period for the source types range from $210M for the imported surface water to $1,058M for the O&G production wastewater, with corresponding unit costs of $1,916/MG and $9,661/MG, respectively.
- The energy consumption associated with treatment ranges from 8.7M to 69.9M kWh/year.

Table 3-23 provides a more detailed summary of the treatment costs and associated energy consumption.

Table 3-15 Treatment Cost Summary [a,b]

Source	Treated Water Yield (MGD[c])	O&M ($/year)	Total Project Cost[d] ($)	Unit Cost ($/MG)	Energy Consumption (kWh/year)
Source 1: Imported surface water	9.8	$8.1M	$210M	$1,916	14.0M
Source 2: Treated wastewater	8.6	$16.0M	$426M	$3,895	13.9M
Source 3: Groundwater	9.5	$11.7M	$314M	$2,868	17.1M
Source 4: Agricultural industry water	7.5	$32.1M	$741M	$6,767	60.2M
Source 5: Brine line flows	8.5	$37.0M	$829M	$7,567	22.9M
Source 6: Advanced water treatment concentrate	8.5	$37.5M	$867M	$7,917	23.1M
Source 7: O&G industry water	7.5	$48.8M	$1,058M	$9,661	69.9M
Source 8: Inland brackish groundwater	8.5	$13.7M	$395M	$3,607	19.8M
Source 9: Dry weather flows	8.5	$21.2M	$596M	$5,439	21.6M
Source 10: Urban stormwater capture and reuse	9.8	$9.8M	$267M	$2,436	8.7M

[a] All costs are based on 10 MGD of source water flow.

[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

[c] The treated water yield is the flow rate of treated water (in MGD) produced from 10 MGD of source water flow.

[d] Construction costs plus NPV O&M costs for 30 years of operation.

6 Concentrate Management Costs

With the exception of SWP water and urban stormwater capture and reuse, the remaining source types that have been identified will require RO pretreatment to achieve the water quality required for hydrogen production electrolyzers and cooling, which will produce a concentrate, or high-salinity waste liquid, that will need to be managed. The cost and implementation challenges associated with concentrate management can be significant. The management approaches depend on the composition and volume of the concentrate, land availability, proximity to existing concentrate disposal facilities, and other factors.

This section presents planning-level cost estimates for two options for concentrate management to provide a range of potential costs for potential third-party production projects

1. Discharge to existing brine disposal facilities
2. Evaporation ponds

Appendix B includes cost summary outputs for the concentrate management options.

6.1 Existing Brine Disposal Facilities

Concentrate disposal via an existing brine disposal facility will be the least cost concentrate management approach if the existing disposal facility (e.g., a brine line) is located near the source water treatment plant. The Inland Empire Brine Line managed by the Santa Ana Watershed Project Authority (SAWPA) is an example of an existing brine disposal facility. The Inland Empire Brine Line conveys high salt content wastewater generated from the inland facilities to the wastewater treatment plant operated by the Orange County Sanitation District for discharge to the Pacific Ocean.

6.1.1 Assumptions

As described above, the use of an existing brine line for concentrate management will be the least costly approach if the treatment plant is located close to a brine line. Assumptions regarding the distance to the brine line connection point and other key inputs needed for costing this alterative are as follows.

- The distance between the treatment facility and the closest brine line connection point is 5 miles. This is consistent with the assumption that the use of a brine line for disposal would be an appropriate option for facilities located near an existing brine line.
- There is no elevation difference between the treatment facility and the brine line connection, consistent with the nearby connection point assumed for this option.

- Given that the assumed distance to the connection point is nearby and the elevation gain is negligible, residual pressure from the RO process is sufficient to convey brine to the brine line. Therefore, an additional pump station is not required.
- The concentrate pipeline is constructed of polyvinyl chloride (PVC), which is more compatible with the brine than steel pipe, and is installed using cut-and-fill construction methods.
- Based on treated water recovery rates for the water source, the concentrate flow rate is 2.5 MGD for O&G industry water and agricultural industry water, 0.5 MGD for non-brackish groundwater, and 1.5 MGD for the other supply sources that produce concentrate.
- Corresponding pipe diameters are 10 inches, 14 inches, and 6 inches, respectively, to maintain approximately 5.5 feet per second of velocity.
- O&M costs include discharge fees; discharge fees for SAWPA's Inland Empire Brine Line were assumed for costing ($0.00184 per gallon) (Mosher 2021).
- The maintenance and replacement cost of valves along the pipeline is not considered for this analysis.

6.1.2 Estimated Costs

For the supply sources evaluated that require RO treatment, the brine yields for 10-MGD source flows range from approximately 0.5 MGD to 2.5 MGD. Table 3-23 summarizes the capital, annual O&M, and lifecycle costs for the water sources that have been identified.

Table 3-16 Planning-level Costs Estimates for Concentrate Management, Existing Brine Disposal Facilities[a,b]

Source	Construction Costs ($)	Annual O&M Costs ($/YR)	Total NPV Cost[c] ($)	Unit Cost Cost($/MG)
Source 1: Imported Surface Water	$0	$0	$0	$0
Source 2: Treated Wastewater	$6.4M	$1.0M	$20.5M	$187
Source 3: Groundwater	$2.3M	$0.3M	$7.0M	$85
Source 4: Agricultural Industry Water	$9.9M	$1.7M	$33.3M	$304
Source 5: Brine Line Flows	$6.4M	$1.0M	$20.5M	$187
Source 6: Advanced Water Treatment Concentrate	$6.4M	$1.0M	$20.5M	$187

Source	Construction Costs ($)	Annual O&M Costs ($/YR)	Total NPV Cost[c] ($)	Unit Cost Cost($/MG)
Source 7: O&G Industry Water	$9.9M	$1.7M	$33.3M	$304
Source 8: Inland Brackish Groundwater	$6.4M	$1.0M	$20.5M	$187
Source 9: Dry Weather Flows	$6.4M	$1.0M	$20.5M	$187
Source 10: Urban Stormwater Capture and Reuse	$0	$0	$0	$0

[a] All costs are based on 10 MGD of source water flow.

[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

[c] Construction costs plus NPV O&M costs for 30 years of operation.

6.2 Evaporation Ponds

For projects that do not have access to an existing brine disposal pipeline or when constructing a new pipeline is infeasible, evaporation ponds can be used for disposal of RO concentrate. The evaporation ponds rely on the solar energy to evaporate water. Evaporation ponds are land intensive, and their effectiveness depends on the climatic conditions of the site.

6.2.1 Assumptions

Key assumptions for developing costs for concentrate management with evaporation basins are as follows.

- Approximate concentrate flow rates for the respective water sources were determined based on the assumed overall recovery and the source water intake of 10 MGD.
- Approximate concentrate salinity was estimated based on the source water TDS used to develop the treatment facility concept and the assumed UF-RO recovery.
- The approximate size of the evaporation basins is based on the concentrate flow rates, salinity, and climate conditions, which are based on the average conditions for San Joaquin Valley, Blythe, and Lancaster, California. Those areas are identified for potential production facilities by third-party clean renewable hydrogen producers in the SoCalGas Phase 1 feasibility Production Study prepared separately as part of the Angeles Link Phase1 feasibility analyses.
- Consistent with standard design practices for evaporation basins, two evaporation ponds are assumed, each with 4 to 5 feet of pond depth depending on the evaporation rate at the assumed salinity; an additional 3 feet of freeboard.
- Ponds are lined with high-density polyethylene (HDPE) liners to align with regulatory requirements (*California Code of Regulations* Title 27).

- O&M costs include the transport and disposal of accumulated salt.
- Evaporation ponds were assumed to be located next to the water treatment facility.
- Land acquisition costs for the evaporation pond site is not included in the estimate because these costs can vary widely based on project location and therefore are difficult to generalize.

6.2.2 Estimated Costs

The evaporation pond cost estimate was developed using the RPD tool. For the sources evaluated that require RO treatment, the brine yields for 10-MGD source flows range from approximately 0.7 MGD to 2.5 MGD. Table 3-23 summarizes the capital, annual O&M, and lifecycle costs for the water sources that have been identified.

Table 3-17 Planning-level Costs Estimates for Concentrate Management, Evaporation Ponds[a,b]

Source	Construction Costs ($)	Annual O&M Costs ($/year)	Total NPV Cost[c] ($)	Unit Cost ($/MG)
Source 1: Imported Surface Water	$0	$0	$0	$0
Source 2: Treated Wastewater	$132M	$1.3M	$151M	$1,376
Source 3: Groundwater	$71M	$1.9M	$97.4M	$889
Source 4: Agricultural Industry Water	$291M	$25.8M	$318M	$2,900
Source 5: Brine Line Flows	$152M	$7.8M	$259M	$2,365
Source 6: Advanced Water Treatment Concentrate	$152M	$4.4M	$213M	$1,944
Source 7: O&G Industry Water	$229M	$33.6M	$691M	$6,313
Source 8: Inland Brackish Groundwater	$152M	$11.5M	$310M	$2,830
Source 9: Dry Weather Flows	$152M	$3.7M	$203M	$1,849
Source 10: Urban Stormwater Capture and Reuse	$0	$0	$0	$0

[a] All costs are based on 10 MGD of source water flow.

[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

[c] Construction costs plus NPV O&M costs for 30 years of operation.

6.3 Summary of Concentrate Management Costs

For the eight source types that are expected to require RO treatment and will produce concentrate, the planning-level costs for concentrate management range from $889/MG to $6,313/MG for evaporation basins and from $100/MG to $311/MG for discharge to existing brine disposal facilities. Imported surface water (SWP water) and urban stormwater capture and reuse do not have associated concentrate management costs because these sources do not require RO treatment.

Although land acquisition and other cost factors would need to be considered, locating the treatment near existing brine disposal facilities may be an opportunity to reduce overall project costs. In this case, treated rather than untreated source water would be conveyed to the hydrogen production facility. This may be more feasible for the concentrate source types because these sources are essentially diversions of flows that would be discharged to existing brine lines

7 Conveyance Costs

This section presents planning-level cost estimates for pipelines and related infrastructure to convey water from the potential source location to the water treatment facility. Costs were developed for two construction techniques to provide a range of potential costs for conveyance.

- Cut and fill
- Horizontal direction drilling (a type of trenchless construction methods)

Appendix C includes summary cost outputs for conveyance.

7.1 Key Assumptions

Key assumptions used for developing costs for conveyance are as follows.

- Source water flows are 10 MGD. 10 MGD for source water flows corresponds to approximately 1.0 MMTY of clean renewable hydrogen production (refer to Section 10). For purposes of the Angeles Link Phase 1 feasibility analysis, this is assumed to be reasonable source water flow for developing conveyance costs for third-party producers given the scale of the production projects expected to produce clean renewable hydrogen for use in Central and Southern California by 2045, including the volume Angeles Link proposes to transport (approximately 0.5-1.5MMTY).
- The distance between the source and treatment facility is 25 miles. Potential conveyance distances could range from less than 5 miles to greater than 100 miles. A distance of 25 miles is a reasonable conveyance distance to develop unit costs for the scale of projects expected.
- The elevation difference between the source and treatment facility is 100 feet. Although the actual elevation differences between the source and treatment plant will vary based site-specific conditions, this provides a reasonable estimate of pumping lift to support the development of unit costs.
- The conceptual pipeline design incorporates a single pump station (housed within a building), isolation valves, and combination air-relief valves. Costs for a surge system were incorporated with an allowance (10% of costs of the pump station building).
- Piping is 30-inch DR17 PVC, which provides acceptable flow velocities of up to 6 feet per second, is compatible with the water sources that have been identified, and can accommodate the anticipated pipeline pressures.
- The O&M cost estimates include power costs for pumping water from the source to the treatment plant and maintenance and replacement for pump station equipment.

7.2 Estimated Costs

The estimated conveyance costs of 10-MGD source flows are the same for all identified water source types. The estimated energy consumption for conveyance (pumping source water) is 5.7M kWh/year. Table 3-23 summarizes the capital, annual O&M, and lifecycle costs for cut-and-fill and HDD construction methods.

Table 3-18 Planning-level Costs Estimates for Conveyance[a,b]

Source	Distance (Miles)	Construction Costs ($)	Annual O&M Costs ($/year)	Total NPV Cost[c] ($)	Unit Cost ($/Mile)
Cut-and-Fill Construction	25	$115M	$1.1M	$131M	$5.2M
HDD Construction	25	$125M	$1.1M	$141M	$5.6M

[a] All costs are based on 10 MGD of source water flow.

[b] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

[c] Construction costs plus NPV O&M costs for 30 years of operation.

8 Water Acquisition Costs

This section presents costs estimates for acquisition of the water supplies for the supply sources that have been identified.

8.1 Key Assumptions

Water acquisition costs were estimated based on published estimates if available.

- For surface water (Source 1), the acquisition mechanism is assumed to be an exchange. The cost for surface water exchange is based on the difference in cost of water associated with the exchange project and the costs of untreated surface water that is provided in exchange.
  - The cost of water for the exchange project was assumed to be equivalent to the total costs of water for inland brackish groundwater developed for this chapter (Source 8) including treatment, conveyance, acquisition, and concentrate management (brine line disposal) ($1,663 per acre-foot [AF]).
  - The cost for untreated surface water was assumed to be equivalent to published costs for untreated surface water provided by the Metropolitan Water District ($855/AF for 2023) (MWD 2022).
  - The resulting acquisition cost is $1,259/AF.
- Acquisition cost for treated wastewater (Source 2) was assumed to be the average of the published retail rates for treated wastewater for the Inland Empire Utility District (IEUA 2022), EMWD (2024), and the Coachella Valley Water District (CVWD 2024a).
  - The resulting acquisition cost is $440/AF.
- For groundwater (Source 3), acquisition is assumed to occur via a combination of groundwater pumped by the project developer and water purchased (assumed to be groundwater) from a water purveyor. Two acquisition mechanisms were assumed because project developers may not be able to meet the full water demand with site-produced groundwater, so they may need to purchase groundwater from a purveyor to meet the overall water demand for their project. For this chapter, 75% of the water demand (7.5 MGD) was assumed to be groundwater pumped by the project developer, and 25% (2.5 MGD) was assumed to be groundwater purchased from a water purveyor.
  - The acquisition cost for pumping is assumed to be similar to the fees levied by Groundwater Sustainability Agencies (GSAs) and the California Department of Water Resources (DWR) for groundwater basin management. The published management fees for DWR are $10, $25, $40, and $55 per AF of groundwater pumped, depending on the status of the groundwater basin (DWR 2024); the GSA for the Indian Wells Valley Groundwater Basin levies a pumping fee $105/AF (IWVGA 2020); and the Mid Kings River GSA has

  - proposed a pumping fee $95/AF (MKRGSA 2024). The average of these fees ($55/AF) was assumed as the acquisition cost for pumped groundwater.
  - The acquisition cost for retail water is assumed to be the average of industrial water rates for the Coachella Valley Water District, City of Blythe, City of Bakersfield, and Los Angeles County Water Works in Palmdale (CVWD 2024b; City of Blyth 2024; City of Bakersfield 2024; LACWD 2024). These are water purveyors with service areas near the areas that have been identified for potential hydrogen production as part of the Angeles Link Phase 1 feasibility analyses. The average water cost for these purveyors is $571/AF.
  - The overall acquisition cost is $184/AF.
- For inland brackish groundwater (Source 8), the acquisition costs are assumed to be the same as that for pumped groundwater, $55/AF.
- Published estimates of the acquisition costs for the remaining sources were not available. These sources are waste streams or are sources without existing demands. They are not expected to have significant acquisition costs, but the agencies involved may require administrative or infrastructure fees to use these sources. A nominal cost of $100/AF was assumed to provide a conservative estimate of the acquisition cost for these sources.

8.2 Estimated Costs

Table 3-23 summarizes the estimated for source water acquisition.

Table 3-19 Planning-level Costs Estimates for Source Water Acquisition[a]

Source	Unit Cost ($/AF)	Annual Costs[b] ($/YR)	Total NPV Cost[c] ($)	Cost/ Volume ($/MG)
Source 1: Imported Surface Water	$1,259	$14.1M	$423M	$3,863
Source 2: Treated Wastewater	$440	$4.9M	$68.7M	$628
Source 3: Groundwater	$184	$2.1M	$29.3M	$267
Source 4: Agricultural Industry Water	$100	$1.1M	$15.6M	$143
Source 5: Brine Line Flows	$100	$1.1M	$15.6M	$143
Source 6: Advanced Water Treatment Concentrate	$100	$1.1M	$15.6M	$143
Source 7: O&G Industry Water	$100	$1.1M	$15.6M	$143
Source 8: Inland Brackish Groundwater	$55	$0.6M	$8.6M	$78
Source 9: Dry Weather Flows	$100	$1.1M	$15.6M	$143
Source 10: Urban Stormwater Capture and Reuse	$100	$1.1M	$15.6M	$143

[a] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

[b] Assuming 10 MGD (11,200 AF per year) source water flows.

[c] Total NPV acquisition costs for 30 years of operation.

9 Cost Summary

This section presents a summary of the overall cost estimates for the conceptual water supply scenarios developed for this chapter and the associated unit cost outputs for the following project elements:

- Water treatment
- Concentrate management
- Conveyance
- Water acquisition

9.1 Combined Project Cost Estimates

Combined project costs that incorporate the costs for water treatment, concentrate management, conveyance, and water acquisition were developed for each supply source assuming 10-MGD source water flows and 25 miles of conveyance (Table 3-23). The combined project costs range from $414M to $1,906M. The costs per unit volume of water supplied range from $3,655/MG to $17,403/MG, with an overall average of $8,124/MG. For these scenarios, the overall cost for Source 10 (urban stormwater), is the lowest, and the overall cost for Source 7 (O&G industry water) is the highest of the sources that were evaluated.

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Table 3-20 Combined Project Costs for 10 MGD Source Flows[a,b]

Total Project Cost[c]	Source 1: Imported Surface Water	Source 2: Treated Wastewater	Source 3: Groundwater	Source 4: Agricultural Industry Water	Source 5. Brine Line Flows	Source 6: Advanced Water Treatment Concentrate	Source 7. O&G Industry Water	Source 8. Brackish Groundwater	Source 9: Dry Weather Flows	Source 10: Urban Stormwater Capture and Reuse
Treatment ($)	$210M	$426M	$314M	$741M	$829M	$867M	$1,058M	$395M	$596M	$267M
Concentrate ($) Evaporation Basins Existing Brine Line	$0 $0	$151M $20.5M	$97.4M $7.0M	$318M $33.3M	$259M $20.5M	$213M $20.5M	$691M $33.3M	$310M $20.5M	$203M $20.5M	$0 $0
Conveyance ($) Cut-and-Fill HDD	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M	$131M $141M
Acquisition ($)	$423M	$68.7M	$29.3M	$15.6M	$15.6M	$15.6M	$15.6M	$8.6M	$15.6M	$15.6M
Combined Costs ($) High-Cost Options Low-Cost Options	$774M $764M	$787M $646M	$582M $481M	$1,216M $921M	$1,245M $996M	$1,237M $1,034M	$1,906M $1,238M	$855M $555M	$956M $763M	$424M $414M
Unit Cost, Flow ($/MG) High-Cost Options Low-Cost Options	$7,068 $6,977	$7,184 $5,901	$5,312 $4,395	$11,101 $8,410	$11,366 $9,097	$11,293 $9,444	$17,403 $11,305	$7,805 $5,069	$8,727 $6,969	$3,868 $3,777

[a] Costs are presented in 2023 dollars, cost accuracy is +100%, -50%.

[b] Assuming 10-MGD source water flows.

[c] Total project costs are sum of construction and MPV O&M costs for 30 years of operation.

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9.2 Unit Cost Summary

As described in Section 2 of this chapter, the major cost elements associated with water supply and treatment have been presented as unit costs to support the development of cost estimates for third-party clean renewable production projects as those details projects develop in the future. Table 3-23 summarizes the costs for the major project elements in unit costs format.

Table 3-21 Summary of Unit Cost Outputs[a]

Cost Component	Units	Estimate[b,c]	+100%	-50%
Conveyance Cost				
Cut-and-Fill Construction	$/mile	$5.2M	$10.4M	$2.6M
HDD Construction		$5.6M	$11.3M	$2.8M
Water Treatment Cost				
Source 1: Imported Surface Water	$/MG	$1,916	$3,883	$958
Source 2: Treated Wastewater		$3,894	$7,789	$1,947
Source 3: Groundwater		$2,868	$5,735	$1,434
Source 4: Agricultural Industry Water		$6,767	$13,533	$3,383
Source 5: Brine Line Flows		$7,567	$15,134	$3,784
Source 6: Advanced Water Treatment		$7,917	$15,833	$3,958
Concentrate		$9,661	$19,323	$4,831
Source 7: O&G Industry Water		$3,067	$7,215	$1,804
Source 8: Inland Brackish Groundwater		$5,439	$10,878	$2,720
Source 9: Dry Weather Flows		$2,436	$4,872	$1,218
Source 10: Urban Stormwater Capture and Reuse				
Concentrate Management Cost- Evaporation Ponds				
Source 1: Imported Surface Water	$/MG	$0	$0	$0
Source 2: Treated Wastewater		$1,376	$2,751	$688
Source 3: Groundwater		$889	$1,779	$445
Source 4: Agricultural Industry Water		$2,900	$5,800	$1,450
Source 5: Brine Line Flows		$2,365	$4,729	$1,182
Source 6: Advanced Water Treatment		$1,944	$3,888	$972
Concentrate		$6,313	$12,627	$3,157
Source 7: O&G Industry Water		$2,830	$5,611	$1,415
Source 8: Inland Brackish Groundwater		$1,849	$3,699	$925
Source 9: Dry Weather Flows		$0	$0	$0
Source 10: Urban Stormwater Capture and Reuse				

Cost Component	Units	Estimate[b,c]	+100%	-50%
Concentrate Management Cost- Brine Line				
Source 1: Imported Surface Water	$/MG	$0	$0	$0
Source 2: Treated Wastewater		$187	$374	$94
Source 3: Groundwater		$85	$171	$43
Source 4: Agricultural Industry Water		$304	$608	$152
Source 5: Brine Line Flows		$187	$374	$94
Source 6: Advanced Water Treatment Concentrate		$187	$374	$94
Source 7: O&G Industry Water		$304	$608	$152
Source 8: Inland Brackish Groundwater		$187	$374	$94
Source 9: Dry Weather Flows		$187	$374	$94
Source 10: Urban Stormwater Capture and Reuse		$0	$0	$0
Source Water Acquisition				
Source 1: Imported Surface Water	$/MG	$3,863	$7,726	$1,932
Source 2: Treated Wastewater		$628	$1,256	$314
Source 3: Groundwater		$267	$534	$134
Source 4: Agricultural Industry Water		$143	$286	$72
Source 5: Brine Line Flows		$143	$286	$72
Source 6: Advanced Water Treatment Concentrate		$143	$286	$72
Source 7: O&G Industry Water		$143	$286	$72
Source 8: Inland Brackish Groundwater		$78	$156	$39
Source 9: Dry Weather Flows		$143	$286	$72
Source 10: Urban Stormwater Capture and Reuse		$143	$286	$72

[a] All costs are based on 10 MGD of source water flow.

[b] Costs are presented in 2023 dollars; cost accuracy is +100%, -50%.

[c] Unit costs include construction costs plus NPV O&M costs for 30 years of operation.

10 Estimates of Overall Water Demands and Water Supply Costs

Under separate Phase 1 feasibility analyses for Angeles Link, a clean renewable hydrogen Angeles Link Demand Report (Demand Study) was prepared, which identified a range of potential demand scenarios for clean renewable hydrogen across SoCalGas's service territory by 2045 (SoCalGas 2024). The overall projected demand spans from a low demand (conservative scenario) of 1.9 million metric tons per year (MMT/Year) to a high demand (ambitious scenario) of 5.9 MMT/Year. The Angeles Link system would transport a portion of the overall projected demand for clean renewable hydrogen, with a proposed throughput of approximately 0.5 MMT/Year under a low case scenario and up to 1.5 MMT/year under a high case scenario. This section presents estimates of the corresponding water demands and the associated water supply costs for the overall projected demand for clean renewable hydrogen within SoCalGas's service territory by 2045, as well as the water demands for the portion of that clean renewable hydrogen that Angeles Link proposes to transport.

10.1 Water Demands

The overall source water demand associated with the production of clean renewable hydrogen consists of three main components:

- Electrolyzer demands, water consumed by electrolyzer systems to produce clean renewable hydrogen
- Electrolyzer cooling demands, water consumed during cooling of the electrolyzer systems
- Pretreatment demands, water consumed during pretreatment of source water to levels needed for electrolyzer feed and cooling

10.1.1 Electrolyzer Demands

Water demand required for the electrolysis process is discussed in Chapter 2 ,Water Quality Requirements for Hydrogen Generation. The estimated demand ranges from approximately 950 to 1,100 gallons per day of ultrapure water per megawatt of electrolyzer capacity (GPD/MW). Refining this estimate to account for losses within the electrolyzer process due to evaporation and leaks, the estimated ultrapure water demand of 1,200 GPD/MW was used as a planning-level estimate for this chapter.

As mentioned in Section 4.1.1, typical large electrolyzer systems include RO and EDI polishing of the feed water for the electrolyzer. Treatment losses associated with these processes increase the overall water demand for electrolyzer systems. The water recovery rate of the RO-EDI processes depends on the treated water quality and site-specific conditions. Based on the consultant's experience, however, a treated water recovery of 85% is achievable for the RO-EDI treatment included with electrolyzer systems. The corresponding electrolyzer water demand including treatment losses for the RO-EDI system is 1,413 GPD/MW capacity.

10.1.2 Electrolyzer Cooling Demands

The water cooling demands for electrolyzers will vary depending on the technology employed.

- For open-loop system cooling, the cooling demands depend on the amount of water evaporated for cooling and the cycle of concentration for the recirculating water to maintain the operational TDS. A typical water demand of 3,790 GPD/MW for open cooling systems has been reported by Niekerk and Manita (2022).
- Typical treated water demands for closed-loop cooling (AFC) with spray systems range from 46 to 79 GPD/MW (Niekerk and Manita 2022).

For the purposes of this chapter, AFC with a spray system is assumed to be the option third-party producers may pursue for cooling because it has lower water demands than open-loop system cooling systems. For this chapter, 79 GPD/MW was used as a planning-level estimate for cooling water demands.

10.1.3 Pretreatment Demands

Based on the treated water yield that was estimated for each of the supply sources, the water lost during pretreatment for electrolyzer feed (feed to the RO-EDI polishing) and cooling ranges from approximately 2% to 25% of the source water flow, depending on source type (refer to Section 5.11). The average water losses for pretreatment for this portfolio of water sources is approximately 13%. The combined demand for electrolyzer feed and electrolyzer cooling is approximately 1,492 GPD/MW. Assuming this combined demand estimate and the average water loss for pretreatment for the supply portfolio, the average source water demand would be approximately 1,722 GPD/MW.

10.1.4 Total Source Water Demands

A typical 1 MW electrolyzer facility will produce approximately 175 metric tons of hydrogen per year, based on the stoichiometric water demand and the electrolyzer energy efficiency. Based on 0.000175 MMTY production per 1 MW, and the average water demand of 1,722 GPD/MW for the supply sources that were evaluated, the total source water demand for the production of 1 MMTY of clean renewable hydrogen is approximately 9.8 MGD for this water portfolio. Table 3-23 summarizes the estimated average water demands for the range of clean renewable hydrogen supply that Angeles Link anticipates conveying over time.

Table 3-22 Estimated Water Demands for Angeles Link Estimated Throughput[a]

Hydrogen Supply (MMTY)	Electrolyzer Demand (MGD | AFY)	Electrolyzer Cooling Demand (MGD | AFY)	Source Water Pretreatment Demand [b] (MGD | AFY)	Total Source Water Demand (MGD | AFY)
0.5	4.0 | 4,500	0.2 | 200	0.7 | 800	**4.9 | 5,500**
1	8.1 | 9,100	0.5 | 600	1.3 | 1,500	**9.8 | 11,000**
1.5	12.1 | 13,600	0.7 | 800	2.0 | 2,200	**14.7 | 16,500**

[a] Note the sum of the individual components and totals may differ because of rounding

[b] Based on the average water recovery efficiency for pretreatment for the supply sources that have been identified

MGD | AFY = million gallons per day | acre-feet per year; the AFY value that is shown is rounded to the nearest 100 AFY

Table 3-23 summarizes the estimated water demands for the overall range of demand for clean renewable hydrogen in SoCalGas’ service territory.

Table 3-23 Estimated Water Demands for Clean Renewable Hydrogen in SoCalGas’ Service Territory [a]

Hydrogen Supply (MMTY)	Electrolyzer Demand (MGD | AFY)	Electrolyzer Cooling Demand (MGD | AFY)	Source Water Pretreatment Demand [b] (MGD | AFY)	Total Source Water Demand (MGD | AFY)
1.9	15.4 | 17,00	1.0 | 1,100	2.3 | 2,600	**18.7 | 20,900**
5.9	47.8 | 53,500	3.0 | 3,400	7.1 | 8,000	**57.8 | 64,700**

[a] Note the sum of the individual components and totals may differ because of rounding

[b] Based on the average water recovery efficiency for pretreatment for the supply sources that have been identified

MGD | AFY = million gallons per day | acre-feet per year; the AFY value that is shown is rounded to the nearest 100 AFY

10.2 Overall Water Supply Costs

Assuming the average total project cost for the conceptual supply projects developed for this chapter ($8,124 per MG) and the estimated total source water demands summarized in Table 3-22, the water supply costs corresponding to 0.5 MMTY to 1.5 MMTY of clean renewable hydrogen supply would range from $436M to $1,308M, inclusive of construction costs and NPV O&M costs for 30 years of operation.

11 References

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Figures

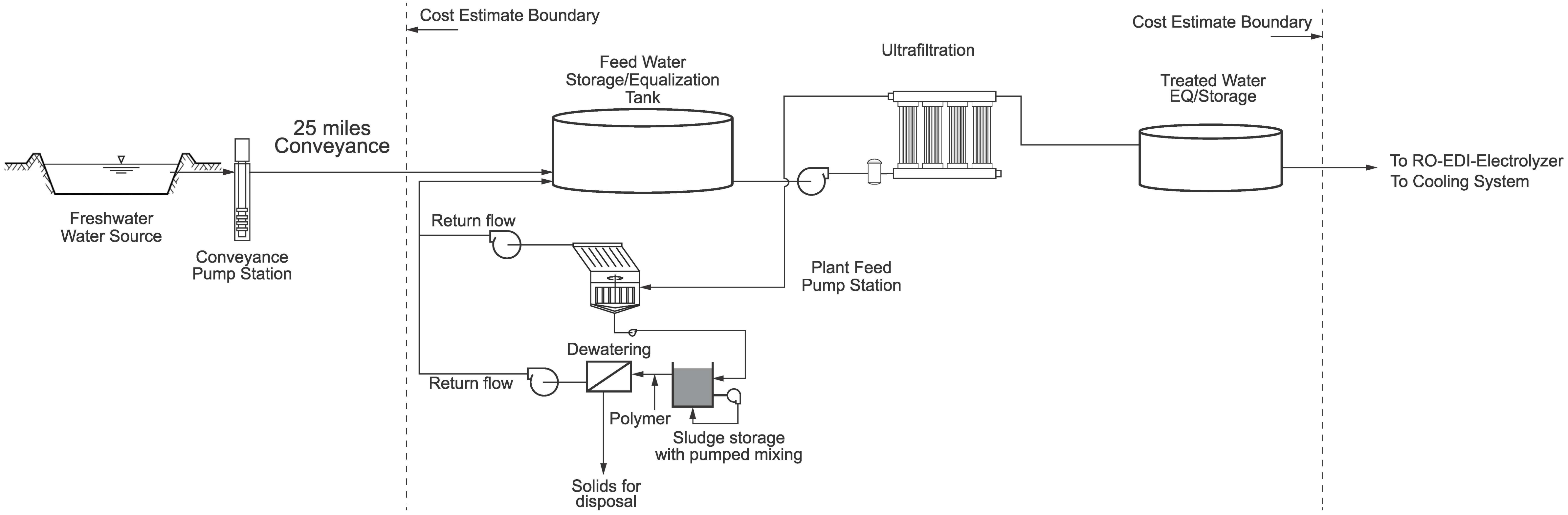
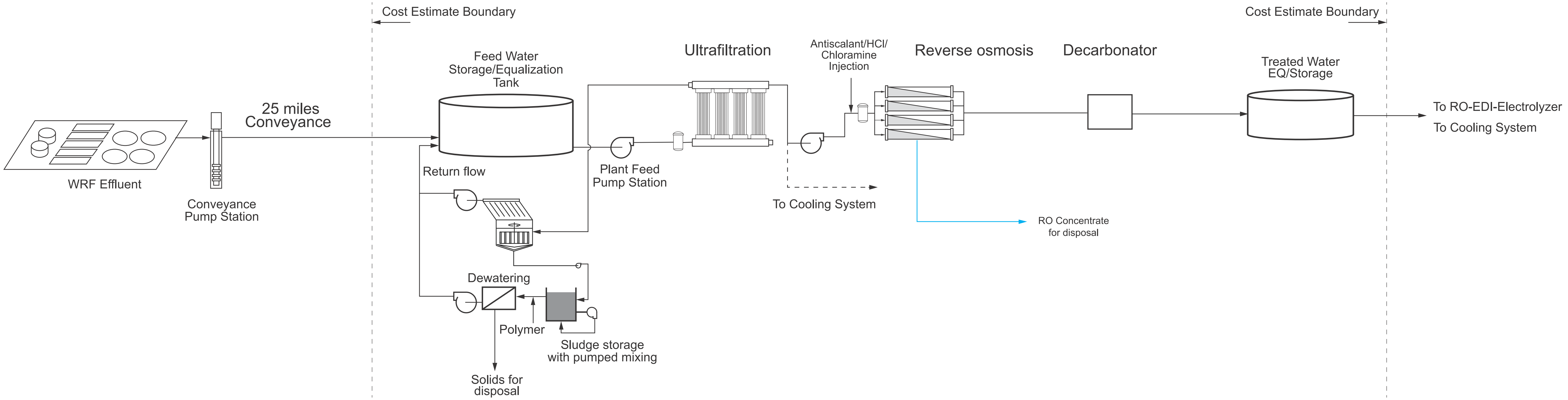


Figure 3-1

Process Flow Diagram for Treatment of Source 1: Imported Surface Water

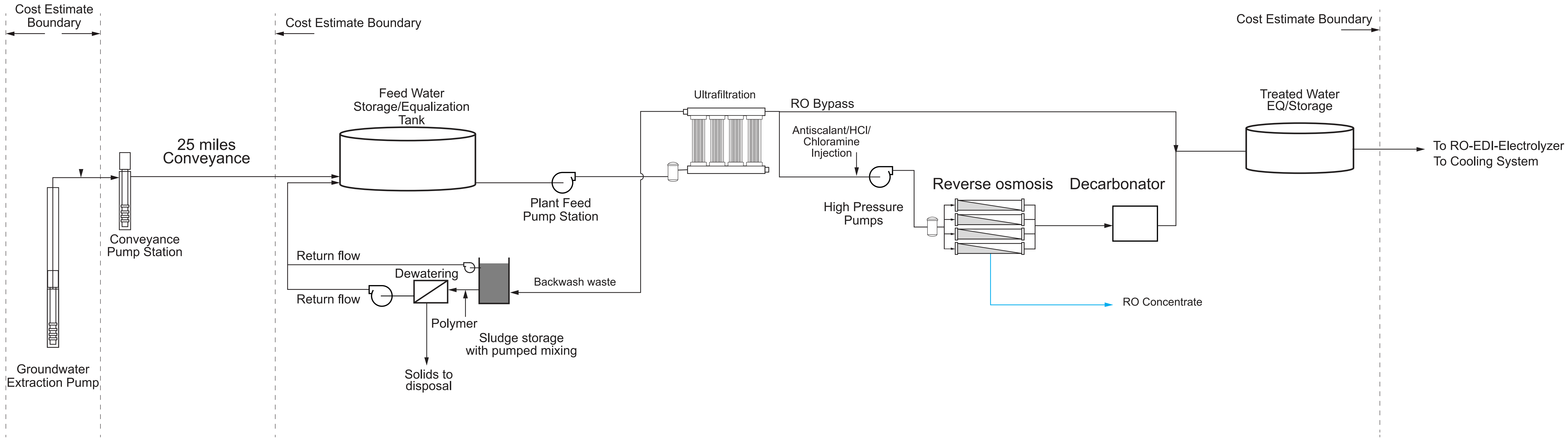
Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-2

Process Flow Diagram for Treatment of Source 2: Treated Wastewater



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-3

Process Flow Diagram for Treatment of Source 3: Groundwater

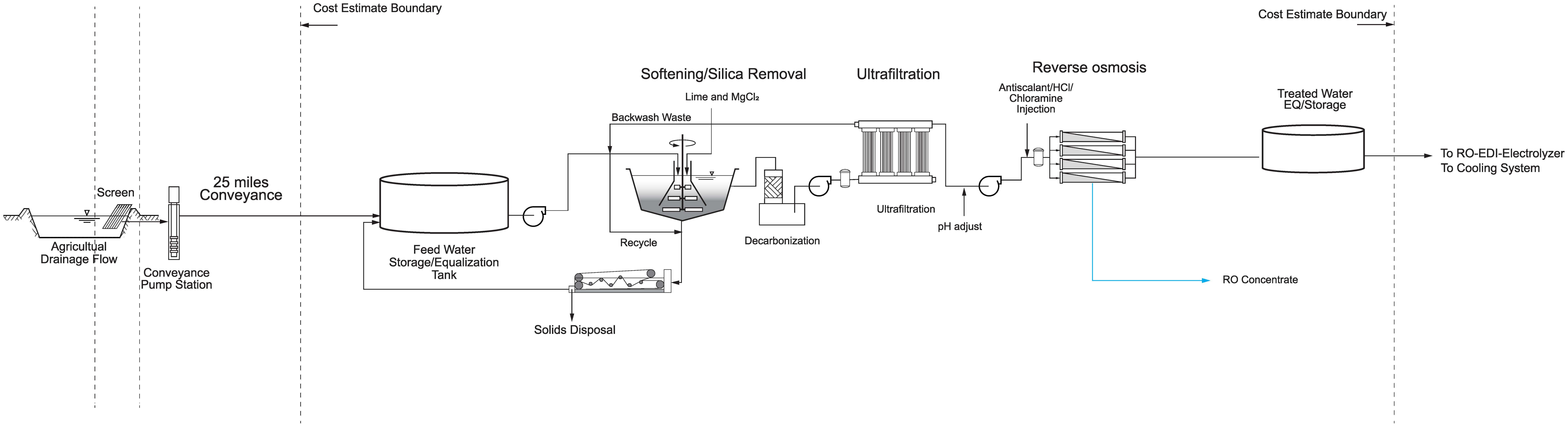
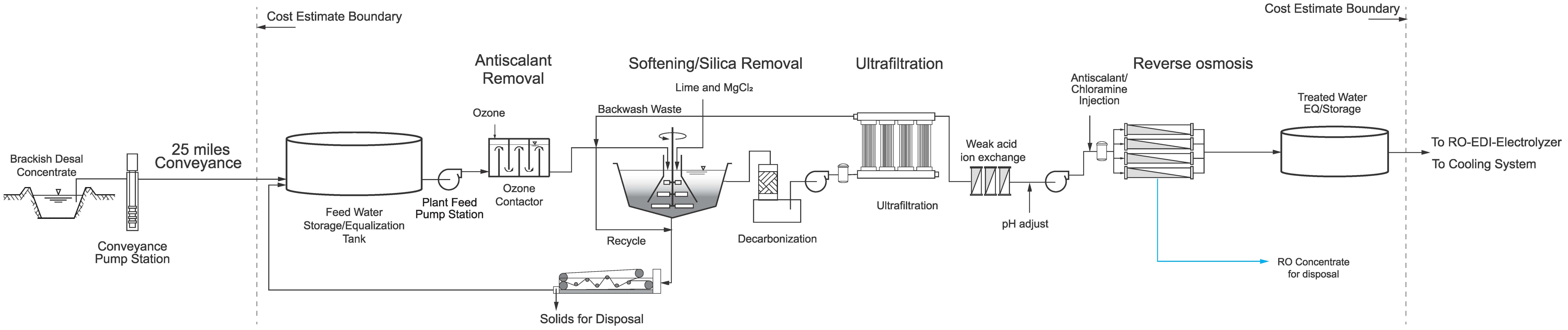


Figure 3-4

Process Flow Diagram for Treatment of Source 4: Agricultural Industry Water

Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-5

Process Flow Diagram for Treatment of Source 5: Brine Line Flows

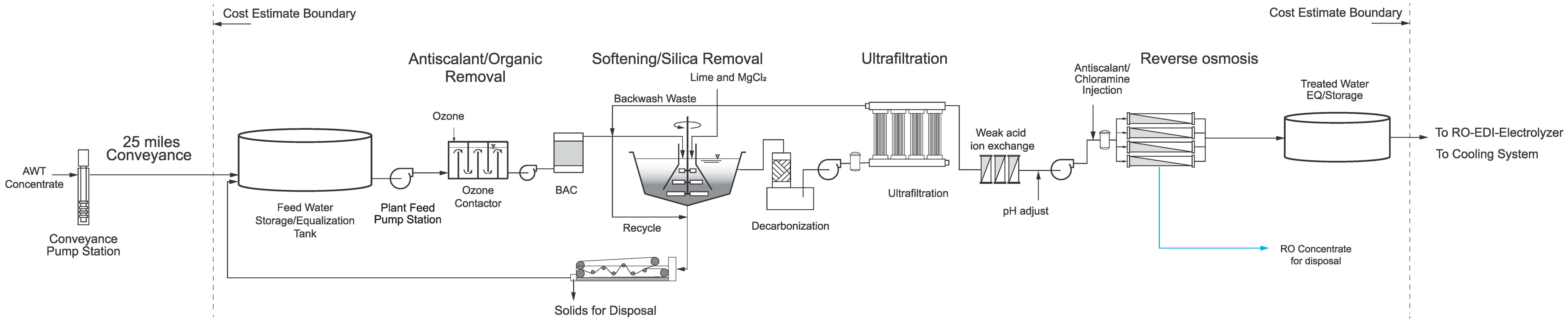
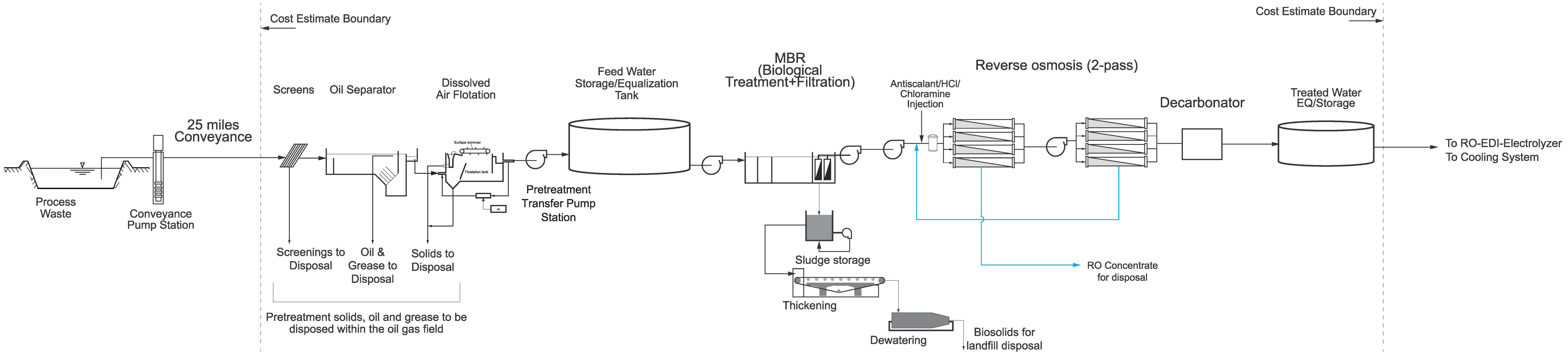


Figure 3-6

Process Flow Diagram for Treatment of Source 6: Advanced Water Treatment Concentrate

Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

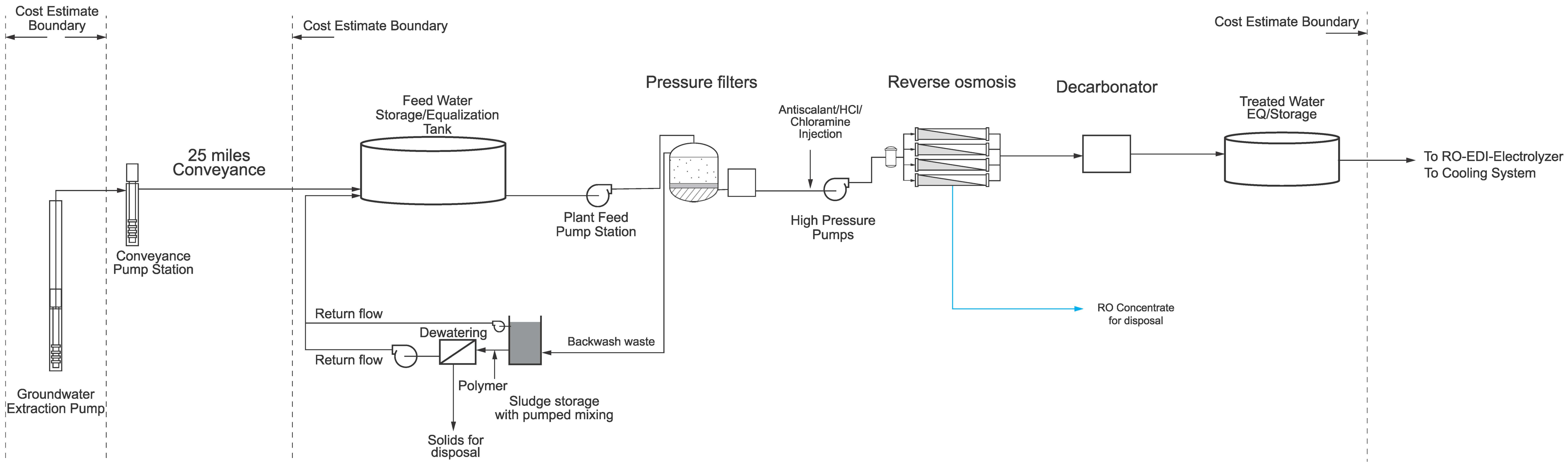
Jacobs



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-7

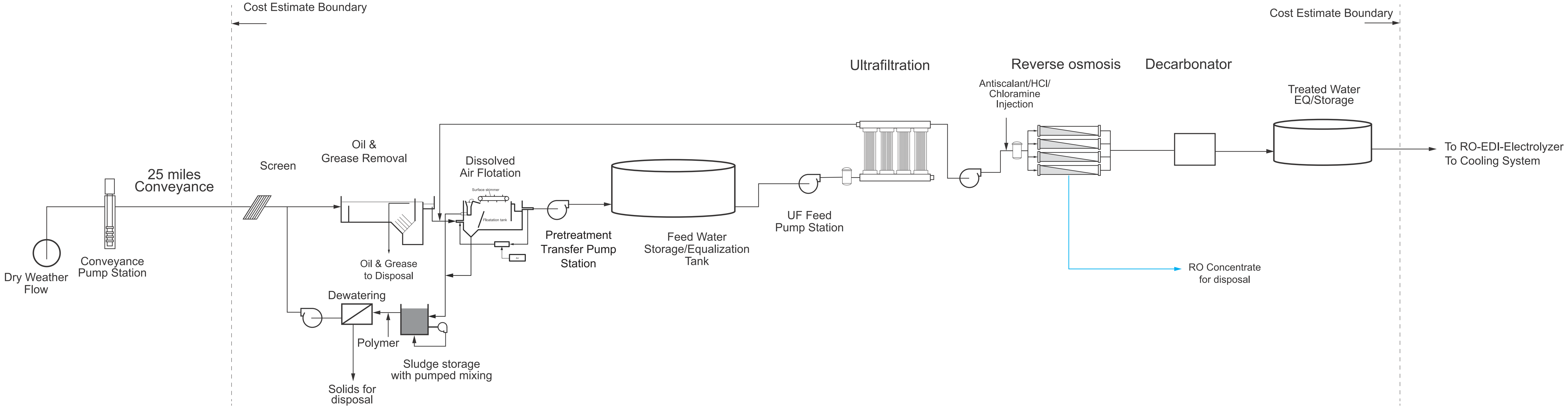
Process Flow Diagram for Treatment of Source 7: O&G Industry Water



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-8

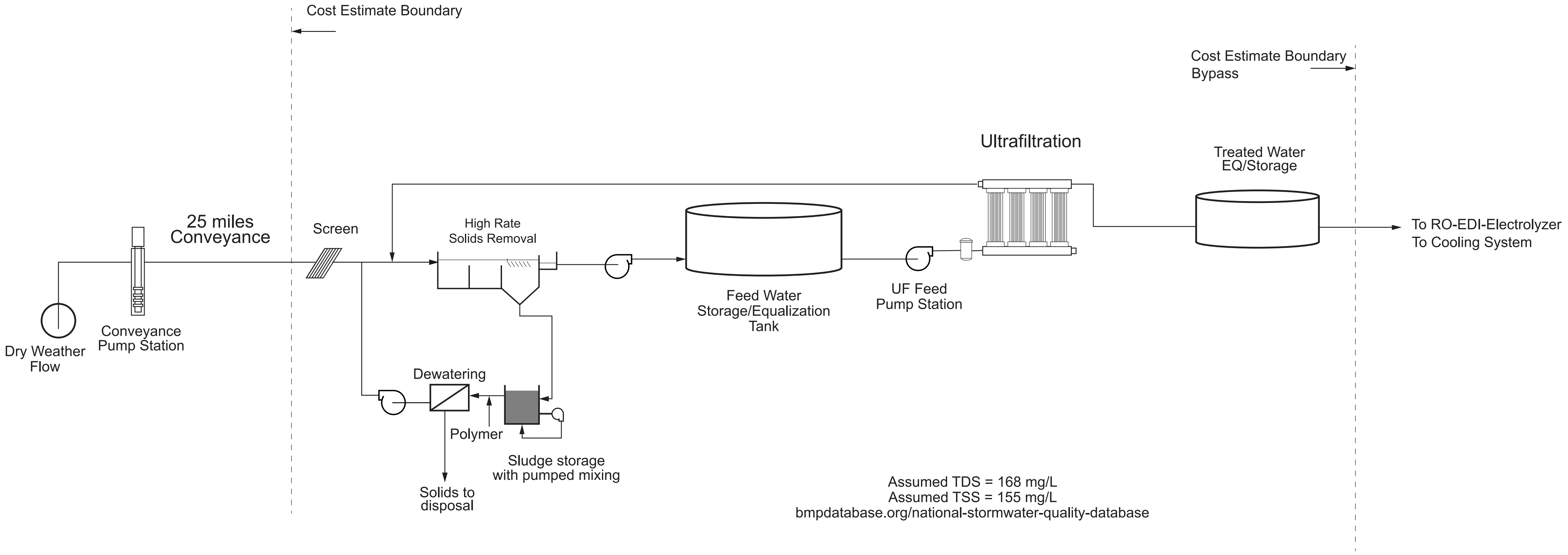
Process Flow Diagram for Treatment of Source 8: Inland Brackish Groundwater



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-9

Process Flow Diagram for Treatment of Source 9: Dry Weather Flows



Note: The cost estimate boundary shows the components that are included in the treatment costs. Cost estimates for conveyance and concentrate management were developed separately from treatment costs.

Figure 3-10

Process Flow Diagram for Treatment of Source 10: Urban Stormwater Capture and Reuse

Appendix A

Treatment Cost Summary Outputs

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*
Project Number:
Project Manager:
Estimator:
Project Description: *Source 1: Imported Surface Water*
Project Location (City): *Los Angeles*
Project Location (State): *CALIFORNIA*
Project Location (Country): *USA*
Cost Basis (Month/Year): *December/2023*

Roundup to the nearest: ***$1,000***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	$733,000
	Yes	Horizontal PS: PlantFeed	$5,937,000
	Yes	Lamella Clarifier: New	$3,420,000
	Yes	In-Plant PS: Return	$407,000
	Yes	Small Surge Basin: New	$516,000
	Yes	WTP Belt FP: New	$3,787,000
	Yes	In-Plant PS: Filtrate	$413,000
	Yes	Pall - Large: New	$17,414,000
	Yes	Steel Clearwell: Treated	$1,465,000
	Yes	Vertical Turbine PS: Dist	$5,105,000

SUBTOTAL - PROJECT COST			$39,197,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$2,352,000
Plant Computer System:	6.00%		$2,352,000
Yard Electrical:	9.00%		$3,528,000
Yard Piping:	8.00%		$3,136,000
UD #1 Default Description	0.00%	$19,694,000	$0
UD #2 Default Description	0.00%		$0
UD #3 Default Description	0.00%		$0
SUBTOTAL with Additional Project Costs			$50,565,000

RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			

4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$50,565,000**
TAX:		**8.25%**	**$27,810,750**	**$2,294,387**
SUBTOTAL with Tax				**$52,859,387**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$52,859,387**	**$6,344,000**
Subtotal				**$59,203,387**
Profit		**10.00%**	**$59,203,387**	**$5,921,000**
Subtotal				**$65,124,387**
Mob/Bonds/Insurance		**3.00%**	**$65,124,387**	**$1,954,000**
Subtotal				**$67,078,387**
Contingency		**30.00%**	**$67,078,387**	**$20,124,000**
SUBTOTAL with Markups				**$87,202,387**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$87,202,387**	**$98,452,000**
SUBTOTAL - with Local Adjustment Factor				**$98,452,000**
MARKET ADJUSTMENT FACTOR			**$98,452,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$98,452,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	

Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$98,452,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*

Project Number:

Project Manager:

Estimator:

Project Description: *Source 1: Imported Surface Water*

Project Location (City): *Los Angeles*

Project Location (State): *CALIFORNIA*

Project Location (Country): *USA*

Cost Basis (Month/Year): *December/2023*

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	Yes	Steel Clearwell: Feed	$0
	Yes	Horizontal PS: PlantFeed	$145,000
	Yes	Lamella Clarifier: New	$290,000
	Yes	In-Plant PS: Return	$13,000
	Yes	Small Surge Basin: New	$62,000
	Yes	WTP Belt FP: New	$281,000
	Yes	In-Plant PS: Filtrate	$13,000
	Yes	Pall - Large: New	$4,129,000
	Yes	Steel Clearwell: Treated	$0
	Yes	Vertical Turbine PS: Dist	$1,440,000

Additional Project Costs:

Biosolids Disposal	$36,000
Standard Items	$638,000
User Defined Items	$0

Plant O&M Labor	$1,049,000

TOTAL - ANNUAL O&M COST	**$8,096,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*
Project Number: [redacted]
Project Manager:
Estimator:
Project Description: *Source 2: Treated Wastewater*

Roundup to the nearest: ***$1,000***

Project Location (City): *Los Angeles*
Project Location (State): *CALIFORNIA*
Project Location (Country): *USA*
Cost Basis (Month/Year): *December/2023*

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Cost*
	Yes	Steel Clearwell: Feed EQ	$1,544,000
	Yes	Steel Clearwell: RO EQ	$1,544,000
	Yes	BWRO: New	$27,613,000
	Yes	Pall - Large: New	$28,001,000
	Yes	Air Stripper: New	$5,378,000
	Yes	Horizontal PS: PlantFeed	$9,413,000
	Yes	Lamella Clarifier: New	$3,473,000
	Yes	In-Plant PS: Return	$526,000
	Yes	Small Surge Basin: New	$516,000
	Yes	WTP Belt FP: New	$3,787,000
	Yes	In-Plant PS: Filtrate	$545,000

SUBTOTAL - PROJECT COST				**$82,340,000**
ADDITIONAL PROJECT COSTS:				
Demolition:		**0.00%**		**$0**
Overall Sitework:		**6.00%**		**$4,941,000**
Plant Computer System:		**6.00%**		**$4,941,000**
Yard Electrical:		**9.00%**		**$7,411,000**
Yard Piping:		**8.00%**		**$6,588,000**
UD #1 Default Description		**0.00%**	$41,364,000	**$0**
UD #2 Default Description		**0.00%**		**$0**
UD #3 Default Description		**0.00%**		**$0**
SUBTOTAL with Additional Project Costs				**$106,221,000**
RED FLAGS:				
1	***Rock Excavation***			
2	***Pile Foundations***			

3	***Seismic Foundations***			
4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$106,221,000**
TAX:		**8.25%**	**$58,421,550**	**$4,819,778**
SUBTOTAL with Tax				**$111,040,778**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$111,040,778**	**$13,325,000**
Subtotal				**$124,365,778**
Profit		**10.00%**	**$124,365,778**	**$12,437,000**
Subtotal				**$136,802,778**
Mob/Bonds/Insurance		**3.00%**	**$136,802,778**	**$4,105,000**
Subtotal				**$140,907,778**
Contingency		**30.00%**	**$140,907,778**	**$42,273,000**
SUBTOTAL with Markups				**$183,180,778**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$183,180,778**	**$206,812,000**
SUBTOTAL - with Local Adjustment Factor				**$206,812,000**
MARKET ADJUSTMENT FACTOR			**$206,812,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$206,812,000**

Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$206,812,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*

Project Number:

Project Manager: [redacted]

Estimator:

Project Description: *Source 2: Treated Wastewater*

Project Location (City): *Los Angeles*

Project Location (State): *CALIFORNIA*

Project Location (Country): *USA*

Cost Basis (Month/Year): *December/2023*

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	Yes	Steel Clearwell: Feed EQ	$0
	Yes	Steel Clearwell: RO EQ	$0
	Yes	Pall - Large: New	$4,569,000
	Yes	BWRO: New	$7,782,000
	Yes	Air Stripper: New	$449,000
	No	Mech Evaporation: New	$0
	No	Evap Ponds: New	$0
	No	Vertical Turbine PS: DistPS	$0
	Yes	Horizontal PS: PlantFeed	$47,000
	No	Horizontal PS: SourceFeed	$0
	Yes	Lamella Clarifier: New	$304,000
	Yes	In-Plant PS: Return	$20,000
	Yes	Small Surge Basin: New	$62,000
	Yes	WTP Belt FP: New	$281,000
	Yes	In-Plant PS: Filtrate	$21,000

Additional Project Costs:

Biosolids Disposal	$36,000
Standard Items	$1,339,000
User Defined Items	$0

	A	B	C	E
38				
39			Plant O&M Labor	**$1,049,000**
40				
41	***TOTAL - ANNUAL O&M COST***			**$15,959,000**

Replica - Parametric Design

REPLICA

Jacobs

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: Source 3: Groundwater

Roundup to the nearest: $1,000

Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Vertical Turbine PS: New	$3,337,000
	Yes	Horizontal PS: PlantFeed	$11,658,000
	Yes	Pall - Large: New	$16,431,000
	Yes	BWRO: New	$16,296,000
	Yes	Air Stripper: New	$5,535,000
	Yes	Steel Clearwell: New	$1,405,000
	Yes	Steel Clearwell: Treated	$1,405,000
	Yes	WTP Belt FP: New	$5,063,000
	Yes	Small Surge Basin: New	$510,000
	Yes	In-Plant PS: Filtrate	$408,000

SUBTOTAL - PROJECT COST			$62,048,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$3,723,000
Plant Computer System:	6.00%		$3,723,000
Yard Electrical:	9.00%		$5,585,000
Yard Piping:	8.00%		$4,964,000
UD #1 Default Description	0.00%	$31,170,000	$0

UD #2 Default Description		0.00%		$0
UD #3 Default Description		0.00%		$0
SUBTOTAL with Additional Project Costs				$80,043,000
RED FLAGS:				
1	***Rock Excavation***			
2	***Pile Foundations***			
3	***Seismic Foundations***			
4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$80,043,000
TAX:		8.25%	$44,023,650	$3,631,951
SUBTOTAL with Tax				$83,674,951
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$83,674,951	$10,041,000
Subtotal				$93,715,951
Profit		10.00%	$93,715,951	$9,372,000
Subtotal				$103,087,951
Mob/Bonds/Insurance		3.00%	$103,087,951	$3,093,000
Subtotal				$106,180,951
Contingency		30.00%	$106,180,951	$31,855,000

SUBTOTAL with Markups				**$138,035,951**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$138,035,951**	**$155,843,000**
SUBTOTAL - with Local Adjustment Factor				**$155,843,000**
MARKET ADJUSTMENT FACTOR			**$155,843,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$155,843,000**
MAXIMUM CONSTRUCTION COST				**$155,843,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: *Source 3: Groundwater*
Project Location (City): *Los Angeles*
Project Location (State): *CALIFORNIA*
Project Location (Country): *USA*
Cost Basis (Month/Year): *December/2023*

Life Cycle Anal
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Annual Inflation:

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Annual O&M Cost (Year 1)*
	Yes	Vertical Turbine PS: New	$890,000
	Yes	Horizontal PS: PlantFeed	$61,000
	Yes	Pall - Large: New	$3,973,000
	Yes	BWRO: New	$3,762,000
	Yes	Air Stripper: New	$566,000
	Yes	Steel Clearwell: New	$0
	Yes	Steel Clearwell: Treated	$0
	Yes	WTP Belt FP: New	$298,000
	Yes	Small Surge Basin: New	$62,000
	Yes	In-Plant PS: Filtrate	$13,000

Additional Project Costs:

Biosolids Disposal	$0
Standard Items	$1,029,000
User Defined Items	$0
Plant O&M Labor	$1,070,000

	A	B	C	E
39	***TOTAL - ANNUAL O&M COST***			**$11,724,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
Project Number:	[redacted]	
Project Manager:		
Estimator:		
Project Description:	Source: 4 Agricultural Industry Water	**Roundup to the nearest:**
Project Location (City):	Los Angeles	**$1,000**
Project Location (State):	CALIFORNIA	
Project Location (Country):	USA	
Cost Basis (Month/Year):	December/2023	

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Submersible IPS: New	$2,901,000
	No	Screening and Grit: New	$0
	Yes	Concrete Clearwell: FeedEQ	$1,733,000
	Yes	Lamella Clarifier: New	$16,505,000
	Yes	Air Stripper: New	$8,699,000
	Yes	Pall - Large: New	$27,845,000
	Yes	1st Pass SWRO: New	$36,493,000
	Yes	2nd Pass SWRO: New	$15,433,000
	No	Concrete Clearwell: PureWater	$0
	Yes	WTP Belt FP: New	$10,075,000
	Yes	RW Screening PS: New	$1,655,000
	Yes	Steel Clearwell: TreatedEQ	$1,405,000

SUBTOTAL - PROJECT COST			$122,744,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$7,365,000
Plant Computer System:	6.00%		$7,365,000
Yard Electrical:	9.00%		$11,047,000
Yard Piping:	8.00%		$9,820,000
UD #1 Default Description	0.00%	$61,658,000	$0
UD #2 Default Description	0.00%		$0
UD #3 Default Description	0.00%		$0
SUBTOTAL with Additional Project Costs			$158,341,000

RED FLAGS:				
1	***Rock Excavation***			
2	***Pile Foundations***			
3	***Seismic Foundations***			
4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$158,341,000**
TAX:		**8.25%**	**$87,087,550**	**$7,184,723**
SUBTOTAL with Tax				**$165,525,723**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$165,525,723**	**$19,864,000**
Subtotal				**$185,389,723**
Profit		**10.00%**	**$185,389,723**	**$18,539,000**
Subtotal				**$203,928,723**
Mob/Bonds/Insurance		**3.00%**	**$203,928,723**	**$6,118,000**
Subtotal				**$210,046,723**
Contingency		**30.00%**	**$210,046,723**	**$63,015,000**
SUBTOTAL with Markups				**$273,061,723**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$273,061,723**	**$308,287,000**
SUBTOTAL - with Local Adjustment Factor				**$308,287,000**
MARKET ADJUSTMENT FACTOR			**$308,287,000**	**$0**

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			**$308,287,000**
MAXIMUM CONSTRUCTION COST			**$308,287,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	[redacted]
Project Description:	***Source: 4 Agricultural Industry Water***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Life Cycle Anal

i =

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Annual Inflation:

Item	***Include? (Yes or No)***	***SCOPE OF PROJECT***	***Annual O&M Cost (Year 1)***
	Yes	**Submersible IPS: New**	**$869,000**
	Yes	**Concrete Clearwell: FeedEQ**	**$3,000**
	Yes	**Lamella Clarifier: New**	**$1,609,000**
	Yes	**Air Stripper: New**	**$455,000**
	Yes	**Pall - Large: New**	**$7,063,000**
	Yes	**1st Pass SWRO: New**	**$12,400,000**
	Yes	**2nd Pass SWRO: New**	**$3,175,000**
	Yes	**WTP Belt FP: New**	**$2,511,000**
	Yes	**RW Screening PS: New**	**$882,000**
	Yes	**Steel Clearwell: TreatedEQ**	**$0**

Additional Project Costs:

Biosolids Disposal	**$0**
Standard Items	**$2,036,000**
User Defined Items	**$0**
Plant O&M Labor	**$1,070,000**

	A	B	C	E
38	***TOTAL - ANNUAL O&M COST***			**$32,073,000**

Replica - Parametric Design

REPLICA™

Jacobs

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	
Estimator:	
Project Description:	***Source 5: Brine Line Flows***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Roundup to the nearest: ***$1,000***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	$1,544,000
	Yes	Horizontal PS: Feed	$12,171,000
	Yes	Ozone O-U: New	$11,342,000
	Yes	Circular Clarifier: Soften	$4,498,000
	Yes	Dry Chemical: Lime	$7,278,000
	Yes	Air Stripper: New	$11,421,000
	Yes	Pall - Large: New	$29,202,000
	Yes	Ion Exchange: WAC	$10,211,000
	Yes	Liquid Chemical: WACRO	$367,000
	Yes	1st Pass SWRO: New	$27,167,000
	Yes	Steel Clearwell: Store	$1,544,000
	Yes	WTP Belt FP: Res	$9,230,000
	Yes	Dry Chemical: MgO	$992,000

SUBTOTAL - PROJECT COST			**$126,967,000**
ADDITIONAL PROJECT COSTS:			
Demolition:	**0.00%**		**$0**
Overall Sitework:	**6.00%**		**$7,619,000**
Plant Computer System:	**6.00%**		**$7,619,000**
Yard Electrical:	**9.00%**		**$11,428,000**
Yard Piping:	**8.00%**		**$10,158,000**
UD #1 Default Description	**0.00%**	$63,780,000	**$0**
UD #2 Default Description	**0.00%**		**$0**
UD #3 Default Description	**0.00%**		**$0**
SUBTOTAL with Additional Project Costs			**$163,791,000**
RED FLAGS:			

1	*Rock Excavation*			
2	*Pile Foundations*			
3	*Seismic Foundations*			
4	*Dewatering Conditions*			
5	*Wetlands Mitigation*			
6	*Weather Impacts*			
7	*Depth of Structures*			
8	*Local Building Code Restrictions*			
9	*Coatings or Finishes*			
10	*Building or Architectural Considerations*			
11	*Client Material Preferences*			
12	*Client Equipment Preferences*			
13	*Piping Galleries, Piping Trenches, Piping Racks*			
14	*Yard Piping Complexity*			
15	*Existing Site Utilities (New, Retrofit, and Complexity)*			
16	*I & C Automation (New or Retrofit)*			
17	*Electrical Feed (New or Retrofit)*			
18	*Electrical Distribution*			
19	*Shoring*			
20	*Contamination*			
21	*User Defined Red Flag 1*			
22	*User Defined Red Flag 2*			
23	*User Defined Red Flag 3*			
24	*User Defined Red Flag 4*			
25	*User Defined Red Flag 5*			
26	*User Defined Red Flag 6*			
27	*User Defined Red Flag 7*			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$163,791,000
TAX:		8.25%	$90,085,050	$7,432,017
SUBTOTAL with Tax				$171,223,017
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$171,223,017	$20,547,000
Subtotal				$191,770,017
Profit		10.00%	$191,770,017	$19,178,000
Subtotal				$210,948,017
Mob/Bonds/Insurance		3.00%	$210,948,017	$6,329,000
Subtotal				$217,277,017
Contingency		30.00%	$217,277,017	$65,184,000
SUBTOTAL with Markups				$282,461,017
LOCATION ADJUSTMENT FACTOR		112.9	$282,461,017	$318,899,000
SUBTOTAL - with Local Adjustment Factor				$318,899,000
MARKET ADJUSTMENT FACTOR			$318,899,000	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				$318,899,000

Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$318,899,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: ***Clean Renewable Hydrogen Water Treatment Cost Estimate***

Project Number:

Project Manager: [redacted]

Estimator:

Project Description: ***Source 5: Brine Line Flow***

Project Location (City): ***Los Angeles***

Project Location (State): ***CALIFORNIA***

Project Location (Country): ***USA***

Cost Basis (Month/Year): ***December/2023***

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
18		Yes	Steel Clearwell: Feed	$0
19		Yes	Horizontal PS: Feed	$53,000
20		Yes	Ozone O-U: New	$1,426,000
22		Yes	Circular Clarifier: Soften	$208,000
23		Yes	Dry Chemical: Lime	$2,706,000
24		Yes	Air Stripper: New	$294,000
25		Yes	Pall - Large: New	$5,980,000
26		Yes	Ion Exchange: WAC	$7,637,000
27		Yes	Liquid Chemical: WACRO	$101,000
28		Yes	1st Pass SWRO: New	$6,915,000
30		Yes	Steel Clearwell: Store	$0
32		Yes	WTP Belt FP: Res	$2,468,000
33		Yes	Dry Chemical: MgO	$118,000

Additional Project Costs:

Biosolids Disposal	$6,023,000
Standard Items	$2,065,000
User Defined Items	$0

	A	B	C	E
41			Plant O&M Labor	**$1,049,000**
42				
43	***TOTAL - ANNUAL O&M COST***			**$37,043,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***	
Project Number:		
Project Manager:	[redacted]	
Estimator:		
Project Description:	***Source 6: Advanced Water Treatment Concentrate***	***Roundup to the nearest:***
Project Location (City):	***Los Angeles***	***$1,000***
Project Location (State):	***CALIFORNIA***	
Project Location (Country):	***USA***	
Cost Basis (Month/Year):	***December/2023***	

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Steel Clearwell: Feed	$1,544,000
	Yes	Horizontal PS: Feed	$12,171,000
	Yes	Ozone O-U: New	$11,342,000
	Yes	Filters: BAC	$12,700,000
	Yes	Circular Clarifier: Soften	$4,498,000
	Yes	Dry Chemical: Lime	$7,278,000
	Yes	Air Stripper: New	$11,421,000
	Yes	Pall - Large: New	$29,202,000
	Yes	Ion Exchange: WAC	$10,211,000
	Yes	Liquid Chemical: WACRO	$367,000
	Yes	1st Pass SWRO: New	$27,167,000
	Yes	Steel Clearwell: Store	$1,544,000
	Yes	WTP Belt FP: Res	$9,230,000
	Yes	Dry Chemical: MgO	$992,000

SUBTOTAL - PROJECT COST			**$139,667,000**
ADDITIONAL PROJECT COSTS:			
Demolition:	**0.00%**		**$0**

Overall Sitework:		**6.00%**		**$8,381,000**
Plant Computer System:		**6.00%**		**$8,381,000**
Yard Electrical:		**9.00%**		**$12,571,000**
Yard Piping:		**8.00%**		**$11,174,000**
UD #1 Default Description		**0.00%**	$70,160,000	**$0**
UD #2 Default Description		**0.00%**		**$0**
UD #3 Default Description		**0.00%**		**$0**
SUBTOTAL with Additional Project Costs				**$180,174,000**
RED FLAGS:				
1	***Rock Excavation***			
2	***Pile Foundations***			
3	***Seismic Foundations***			
4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$180,174,000**
TAX:		**8.25%**	**$99,095,700**	**$8,175,395**
SUBTOTAL with Tax				**$188,349,395**

CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$188,349,395**	**$22,602,000**
Subtotal				**$210,951,395**
Profit		**10.00%**	**$210,951,395**	**$21,096,000**
Subtotal				**$232,047,395**
Mob/Bonds/Insurance		**3.00%**	**$232,047,395**	**$6,962,000**
Subtotal				**$239,009,395**
Contingency		**30.00%**	**$239,009,395**	**$71,703,000**
SUBTOTAL with Markups				**$310,712,395**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$310,712,395**	**$350,795,000**
SUBTOTAL - with Local Adjustment Factor				**$350,795,000**
MARKET ADJUSTMENT FACTOR			**$350,795,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$350,795,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer			**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST				**$350,795,000**

REPLICA™

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 6: Advanced Water Treatment Concentrate***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Annual O&M Cost*
	Yes	Steel Clearwell: Feed	$0
	Yes	Horizontal PS: Feed	$53,000
	Yes	Ozone O-U: New	$1,426,000
	Yes	Filters: BAC	$813,000
	Yes	Circular Clarifier: Soften	$208,000
	Yes	Dry Chemical: Lime	$2,706,000
	Yes	Air Stripper: New	$294,000
	Yes	Pall - Large: New	$5,666,000
	Yes	Ion Exchange: WAC	$7,637,000
	Yes	Liquid Chemical: WACRO	$101,000
	Yes	1st Pass SWRO: New	$6,672,000
	Yes	Steel Clearwell: Store	$0
	Yes	WTP Belt FP: Res	$2,468,000
	Yes	Dry Chemical: MgO	$118,000

Additional Project Costs:

Biosolids Disposal	$6,023,000
Standard Items	$2,271,000
User Defined Items	$0

	A	B	C	E
40				
41			Plant O&M Labor	**$1,049,000**
42				
43	***TOTAL - ANNUAL O&M COST***			**$37,505,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name:	**Clean Renewable Hydrogen Water Treatment Cost Estimate**
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	**Source 7: Oil and Gas Industry Water**
Project Location (City):	**Los Angeles**
Project Location (State):	**CALIFORNIA**
Project Location (Country):	**USA**
Cost Basis (Month/Year):	**December/2023**

Roundup to the nearest: **$1,000**

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Submersible IPS: New	$3,073,000
	Yes	Screening and Grit: New	$12,031,000
	Yes	Aeration Basin: Main	$13,679,000
	Yes	Blowers: Main	$6,630,000
	Yes	MBR: Main	$17,540,000
	Yes	GBT: GBT	$4,931,000
	Yes	WWTP BFP: BFP	$3,530,000
	Yes	IWP Oil Water Sep: New	$7,131,000
	Yes	DAF: New	$4,489,000
	Yes	Steel Clearwell: Feed EQ	$1,465,000
	Yes	Steel Clearwell: RO EQ	$1,465,000
	Yes	1st Pass SWRO: New	$36,084,000
	Yes	2nd Pass SWRO: New	$14,803,000
	Yes	Air Stripper: New	$3,324,000
	Yes	WAS Storage: MBR	$5,784,000
	Yes	Horizontal PS: ToFeedEQ	$17,951,000

SUBTOTAL - PROJECT COST			**$153,910,000**
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$9,235,000
Plant Computer System:	6.00%		$9,235,000
Yard Electrical:	9.00%		$13,852,000
Yard Piping:	8.00%		$12,313,000
UD #1 Default Description	0.00%	$77,316,000	$0
UD #2 Default Description	0.00%		$0

UD #3 Default Description		0.00%		$0
SUBTOTAL with Additional Project Costs				$198,545,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$198,545,000
TAX:		8.25%	$109,199,750	$9,008,979
SUBTOTAL with Tax				$207,553,979
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$207,553,979	$24,907,000
Subtotal				$232,460,979
Profit		10.00%	$232,460,979	$23,247,000
Subtotal				$255,707,979
Mob/Bonds/Insurance		3.00%	$255,707,979	$7,672,000
Subtotal				$263,379,979
Contingency		30.00%	$263,379,979	$79,014,000
SUBTOTAL with Markups				$342,393,979
LOCATION ADJUSTMENT FACTOR		112.9	$342,393,979	$386,563,000

SUBTOTAL - with Local Adjustment Factor			**$386,563,000**
MARKET ADJUSTMENT FACTOR		**$386,563,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			**$386,563,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$386,563,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	
Estimator:	
Project Description:	***Source 7: Oil and Gas Industry Water***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	Yes	Submersible IPS: New	$1,051,000
	Yes	Screening and Grit: New	$1,759,000
	Yes	Aeration Basin: Main	$308,000
	Yes	Blowers: Main	$1,668,000
	Yes	MBR: Main	$5,257,000
	Yes	GBT: GBT	$363,000
	Yes	WWTP BFP: BFP	$195,000
	Yes	IWP Oil Water Sep: New	$627,000
	Yes	DAF: New	$347,000
	Yes	Steel Clearwell: Feed EQ	$0
	Yes	Steel Clearwell: RO EQ	$0
	Yes	1st Pass SWRO: New	$12,379,000
	Yes	2nd Pass SWRO: New	$3,112,000
	Yes	Air Stripper: New	$288,000
	Yes	WAS Storage: MBR	$597,000
	Yes	Horizontal PS: ToFeedEQ	$771,000

Additional Project Costs:

Biosolids Disposal	$1,536,000
Standard Items	$2,502,000

	A	B	C	E
42			User Defined Items	**$0**
43				
44		Plant O&M Labor		**$16,016,000**
45				
46	***TOTAL - ANNUAL O&M COST***			**$48,776,000**

Replica - Parametric Design

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	
Estimator:	
Project Description:	***Source 8: Inland Brackish Groundwater***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Roundup to the nearest: ***$1,000***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Vertical Turbine PS: Intake	$12,034,000
	Yes	Steel Clearwell: Feed	$1,557,000
	Yes	BWRO: New	$22,962,000
	Yes	Air Stripper: New	$7,901,000
	Yes	Horizontal PS: Feed	$11,751,000
	Yes	Steel Clearwell: Treated	$1,557,000
	Yes	WTP Belt FP: New	$3,787,000
	Yes	Small Surge Basin: New	$1,534,000
	Yes	In-Plant PS: Return	$526,000
	Yes	In-Plant PS: Filtrate	$545,000
	Yes	VP Filter: New	$17,979,000
	Yes	Steel Clearwell: Backwash	$91,000
	Yes	Filter BW PS: New	$216,000

SUBTOTAL - PROJECT COST			$82,440,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$4,947,000
Plant Computer System:	6.00%		$4,947,000
Yard Electrical:	9.00%		$7,420,000
Yard Piping:	8.00%		$6,596,000
UD #1 Default Description	0.00%	$41,416,000	$0
UD #2 Default Description	0.00%		$0
UD #3 Default Description	0.00%		$0
SUBTOTAL with Additional Project Costs			$106,350,000

RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$106,350,000**
TAX:		**8.25%**	**$58,492,500**	**$4,825,631**
SUBTOTAL with Tax				**$111,175,631**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$111,175,631**	**$13,342,000**
Subtotal				**$124,517,631**
Profit		**10.00%**	**$124,517,631**	**$12,452,000**
Subtotal				**$136,969,631**
Mob/Bonds/Insurance		**3.00%**	**$136,969,631**	**$4,110,000**
Subtotal				**$141,079,631**
Contingency		**30.00%**	**$141,079,631**	**$42,324,000**
SUBTOTAL with Markups				**$183,403,631**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$183,403,631**	**$207,063,000**
SUBTOTAL - with Local Adjustment Factor				**$207,063,000**
MARKET ADJUSTMENT FACTOR			**$207,063,000**	**$0**

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			**$207,063,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$207,063,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name: ***Clean Renewable Hydrogen Water Treatment Cost Estimate***

Project Number:

Project Manager: [redacted]

Estimator:

Project Description: ***Source 8: Inland Brackish Groundwater***

Project Location (City): ***Los Angeles***

Project Location (State): ***CALIFORNIA***

Project Location (Country): ***USA***

Cost Basis (Month/Year): ***December/2023***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	Yes	Vertical Turbine PS: Intake	$1,699,000
	Yes	Steel Clearwell: Feed	$0
	Yes	BWRO: New	$6,699,000
	Yes	Air Stripper: New	$798,000
	Yes	Horizontal PS: Feed	$60,000
	Yes	Steel Clearwell: Treated	$0
	Yes	WTP Belt FP: New	$281,000
	Yes	Small Surge Basin: New	$106,000
	Yes	In-Plant PS: Return	$20,000
	Yes	In-Plant PS: Filtrate	$21,000
	Yes	VP Filter: New	$1,573,000
	Yes	Steel Clearwell: Backwash	$0
	Yes	Filter BW PS: New	$2,000

Additional Project Costs:

Biosolids Disposal	$10,000
Standard Items	$1,341,000
User Defined Items	$0

	A	B	C	E
41			Plant O&M Labor	**$1,049,000**
42				
43	***TOTAL - ANNUAL O&M COST***			**$13,659,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/16/2023

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 9: Dry Weather Flows***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Roundup to the nearest: ***$1,000***

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Cost*
	Yes	**Screening and Grit: New**	**$2,782,000**
	Yes	**IWP Oil Water Sep: New**	**$7,414,000**
	Yes	**WAS Storage: New**	**$11,163,000**
	Yes	**Centrifuge Dew: New**	**$29,642,000**
	Yes	**In-Plant PS: Cent**	**$286,000**
	Yes	**Horizontal PS: PrimEff**	**$4,229,000**
	Yes	**Steel Clearwell: New**	**$1,465,000**
	Yes	**Horizontal PS: Feed**	**$3,641,000**
	Yes	**Pall - Large: New**	**$27,901,000**
	Yes	**BWRO: New**	**$22,331,000**
	Yes	**Air Stripper: New**	**$4,500,000**
	Yes	**Steel Clearwell: ROEff**	**$1,465,000**
	Yes	**DAF: DAFalt**	**$4,301,000**

SUBTOTAL - PROJECT COST			**$121,120,000**
ADDITIONAL PROJECT COSTS:			
Demolition:	**0.00%**		**$0**
Overall Sitework:	**6.00%**		**$7,268,000**
Plant Computer System:	**6.00%**		**$7,268,000**
Yard Electrical:	**9.00%**		**$10,901,000**
Yard Piping:	**8.00%**		**$9,690,000**
UD #1 Default Description	**0.00%**	$60,844,000	**$0**
UD #2 Default Description	**0.00%**		**$0**
UD #3 Default Description	**0.00%**		**$0**
SUBTOTAL with Additional Project Costs			**$156,247,000**

RED FLAGS:				
1	**Rock Excavation**			
2	**Pile Foundations**			
3	**Seismic Foundations**			
4	**Dewatering Conditions**			
5	**Wetlands Mitigation**			
6	**Weather Impacts**			
7	**Depth of Structures**			
8	**Local Building Code Restrictions**			
9	**Coatings or Finishes**			
10	**Building or Architectural Considerations**			
11	**Client Material Preferences**			
12	**Client Equipment Preferences**			
13	**Piping Galleries, Piping Trenches, Piping Racks**			
14	**Yard Piping Complexity**			
15	**Existing Site Utilities (New, Retrofit, and Complexity)**			
16	**I & C Automation (New or Retrofit)**			
17	**Electrical Feed (New or Retrofit)**			
18	**Electrical Distribution**			
19	**Shoring**			
20	**Contamination**			
21	**User Defined Red Flag 1**			
22	**User Defined Red Flag 2**			
23	**User Defined Red Flag 3**			
24	**User Defined Red Flag 4**			
25	**User Defined Red Flag 5**			
26	**User Defined Red Flag 6**			
27	**User Defined Red Flag 7**			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$156,247,000**
TAX:		**8.25%**	**$85,935,850**	**$7,089,708**
SUBTOTAL with Tax				**$163,336,708**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$163,336,708**	**$19,601,000**
Subtotal				**$182,937,708**
Profit		**10.00%**	**$182,937,708**	**$18,294,000**
Subtotal				**$201,231,708**
Mob/Bonds/Insurance		**3.00%**	**$201,231,708**	**$6,037,000**
Subtotal				**$207,268,708**
Contingency		**30.00%**	**$207,268,708**	**$62,181,000**
SUBTOTAL with Markups				**$269,449,708**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$269,449,708**	**$304,209,000**
SUBTOTAL - with Local Adjustment Factor				**$304,209,000**
MARKET ADJUSTMENT FACTOR			**$304,209,000**	**$0**

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			**$304,209,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer		**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST			**$304,209,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 9: Dry Weather Flow***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
	No	Trench Style IPS: New	$0
	Yes	Screening and Grit: New	$361,000
	Yes	IWP Oil Water Sep: New	$715,000
	No	IWP DAF: New	$0
	Yes	WAS Storage: New	$1,221,000
	Yes	Centrifuge Dew: New	$4,561,000
	Yes	In-Plant PS: Cent	$10,000
	Yes	Horizontal PS: PrimEff	$129,000
	Yes	Steel Clearwell: New	$0
	Yes	Horizontal PS: Feed	$60,000
	Yes	Pall - Large: New	$4,559,000
	Yes	BWRO: New	$5,648,000
	Yes	Air Stripper: New	$390,000
	Yes	Steel Clearwell: ROEff	$0
	No	Vertical Turbine PS: Dist	$0
	Yes	DAF: DAFalt	$347,000
	No	Evap Ponds: New	$0

Additional Project Costs:	
Biosolids Disposal	**$159,000**

	A	B	C	E
38			Standard Items	**$1,969,000**
39			User Defined Items	**$0**
40				
41		Plant O&M Labor		**$1,049,000**
42				
43	***TOTAL - ANNUAL O&M COST***			**$21,178,000**

Replica - Parametric Design

REPLICA™ Jacobs

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM...)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: Source 10: Urban Stormwater Capture and Reuse
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: $1,000

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Screening and Grit: Screen	$2,755,000
	Yes	Lamella Clarifier: New	$5,665,000
	Yes	Small Surge Basin: New	$860,000
	Yes	WTP Belt FP: New	$5,305,000
	Yes	In-Plant PS: Filtrate	$531,000
	Yes	In-Plant PS: FeedTank	$6,734,000
	Yes	Steel Clearwell: Feed	$1,405,000
	Yes	Pall - Large: New	$28,677,000
	Yes	Steel Clearwell: Treated	$1,405,000

SUBTOTAL - PROJECT COST			$53,337,000
ADDITIONAL PROJECT COSTS:			
Demolition:	0.00%		$0
Overall Sitework:	6.00%		$3,201,000
Plant Computer System:	6.00%		$3,201,000
Yard Electrical:	9.00%		$4,801,000
Yard Piping:	8.00%		$4,267,000
UD #1 Default Description	0.00%	$26,796,000	$0
UD #2 Default Description	0.00%		$0
UD #3 Default Description	0.00%		$0
SUBTOTAL with Additional Project Costs			$68,807,000

RED FLAGS:				
1	***Rock Excavation***			
2	***Pile Foundations***			
3	***Seismic Foundations***			
4	***Dewatering Conditions***			
5	***Wetlands Mitigation***			
6	***Weather Impacts***			
7	***Depth of Structures***			
8	***Local Building Code Restrictions***			
9	***Coatings or Finishes***			
10	***Building or Architectural Considerations***			
11	***Client Material Preferences***			
12	***Client Equipment Preferences***			
13	***Piping Galleries, Piping Trenches, Piping Racks***			
14	***Yard Piping Complexity***			
15	***Existing Site Utilities (New, Retrofit, and Complexity)***			
16	***I & C Automation (New or Retrofit)***			
17	***Electrical Feed (New or Retrofit)***			
18	***Electrical Distribution***			
19	***Shoring***			
20	***Contamination***			
21	***User Defined Red Flag 1***			
22	***User Defined Red Flag 2***			
23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$68,807,000**
TAX:		**8.25%**	**$37,843,850**	**$3,122,118**
SUBTOTAL with Tax				**$71,929,118**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$71,929,118**	**$8,632,000**
Subtotal				**$80,561,118**
Profit		**10.00%**	**$80,561,118**	**$8,057,000**
Subtotal				**$88,618,118**
Mob/Bonds/Insurance		**3.00%**	**$88,618,118**	**$2,659,000**
Subtotal				**$91,277,118**
Contingency		**30.00%**	**$91,277,118**	**$27,384,000**
SUBTOTAL with Markups				**$118,661,118**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$118,661,118**	**$133,969,000**
SUBTOTAL - with Local Adjustment Factor				**$133,969,000**
MARKET ADJUSTMENT FACTOR			**$133,969,000**	**$0**

SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			**$133,969,000**
MAXIMUM CONSTRUCTION COST			**$133,969,000**

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

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Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: *Source 10: Urban Stormwater Capture and Reuse*
Project Location (City): *Los Angeles*
Project Location (State): *CALIFORNIA*
Project Location (Country): *USA*
Cost Basis (Month/Year): *December/2023*

Life Cycle Anal
i =
n =
Annual Inflation:

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Annual O&M Cost (Year 1)*
	Yes	**Screening and Grit: Screen**	**$365,000**
	Yes	**Lamella Clarifier: New**	**$741,000**
	Yes	**Small Surge Basin: New**	**$64,000**
	Yes	**WTP Belt FP: New**	**$329,000**
	Yes	**In-Plant PS: Filtrate**	**$21,000**
	Yes	**In-Plant PS: FeedTank**	**$407,000**
	Yes	**Steel Clearwell: Feed**	**$0**
	Yes	**Pall - Large: New**	**$5,960,000**
	Yes	**Steel Clearwell: Treated**	**$0**
		Additional Project Costs:	
		Biosolids Disposal	**$0**
		Standard Items	**$885,000**
		User Defined Items	**$0**
		Plant O&M Labor	**$1,070,000**
TOTAL - ANNUAL O&M COST			**$9,842,000**

Appendix B

Concentrate Management Cost Summary Outputs

Capital and O&M Estimates
Evaporation Basins

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Name:	**Clean Renewable Hydrogen Water Treatment Cost Estimate**	
Project Number:		
Project Manager:	[redacted]	
Estimator:		
Project Description:	**Source 2: Treated Wastewater**	**Roundup to the nearest:**
Project Location (City):	**Los Angeles**	**$1,000**
Project Location (State):	**CALIFORNIA**	
Project Location (Country):	**USA**	
Cost Basis (Month/Year):	**December/2023**	

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$67,924,000
SUBTOTAL - PROJECT COST				$67,924,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$67,924,000

TAX:		**8.25%**	**$37,358,200**	**$3,082,052**
SUBTOTAL with Tax				**$71,006,052**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$71,006,052**	**$8,521,000**
Subtotal				**$79,527,052**
Profit		**10.00%**	**$79,527,052**	**$7,953,000**
Subtotal				**$87,480,052**
Mob/Bonds/Insurance		**3.00%**	**$87,480,052**	**$2,625,000**
Subtotal				**$90,105,052**
Contingency		**30.00%**	**$90,105,052**	**$27,032,000**
SUBTOTAL with Markups				**$117,137,052**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$117,137,052**	**$132,248,000**
SUBTOTAL - with Local Adjustment Factor				**$132,248,000**
MARKET ADJUSTMENT FACTOR			**$132,248,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$132,248,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer			**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST				**$132,248,000**

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

4 **File Version: 3/17/2023**

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7 ***Project Name:*** ***Clean Renewable Hydrogen Water Treatment Cost Estimate***

8 ***Project Number:***

9 ***Project Manager:*** [redacted]

10 ***Estimator:***

11 ***Project Description:*** ***Source 2: Treated Wastewater***

12 ***Project Location (City):*** ***Los Angeles***

13 ***Project Location (State):*** ***CALIFORNIA***

14 ***Project Location (Country):*** ***USA***

15 ***Cost Basis (Month/Year):*** ***December/2023***

16

	Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost
17				
24		Yes	Evap Ponds: New	$1,336,000
33				
40				
41	**TOTAL - ANNUAL O&M COST**			**$1,336,000**

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager:
Estimator:
Project Description: Source 3. Groundwater Evap Pond
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: **$1,000**

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$28,401,000
SUBTOTAL - PROJECT COST				$28,401,000
ADDITIONAL PROJECT COSTS:				
Demolition:		0.00%		$0
Overall Sitework:		6.00%		$1,705,000
Plant Computer System:		6.00%		$1,705,000
Yard Electrical:		9.00%		$2,557,000
Yard Piping:		8.00%		$2,273,000
UD #1 Default Description		0.00%	$14,270,000	$0
UD #2 Default Description		0.00%		$0
UD #3 Default Description		0.00%		$0
SUBTOTAL with Additional Project Costs				$36,641,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			

11	*Client Material Preferences*			
12	*Client Equipment Preferences*			
13	*Piping Galleries, Piping Trenches, Piping Racks*			
14	*Yard Piping Complexity*			
15	*Existing Site Utilities (New, Retrofit, and Complexity)*			
16	*I & C Automation (New or Retrofit)*			
17	*Electrical Feed (New or Retrofit)*			
18	*Electrical Distribution*			
19	*Shoring*			
20	*Contamination*			
21	*User Defined Red Flag 1*			
22	*User Defined Red Flag 2*			
23	*User Defined Red Flag 3*			
24	*User Defined Red Flag 4*			
25	*User Defined Red Flag 5*			
26	*User Defined Red Flag 6*			
27	*User Defined Red Flag 7*			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$36,641,000
TAX:		8.25%	$20,152,550	$1,662,585
SUBTOTAL with Tax				$38,303,585
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$38,303,585	$4,597,000
Subtotal				$42,900,585
Profit		10.00%	$42,900,585	$4,291,000
Subtotal				$47,191,585
Mob/Bonds/Insurance		3.00%	$47,191,585	$1,416,000
Subtotal				$48,607,585
Contingency		30.00%	$48,607,585	$14,583,000
SUBTOTAL with Markups				$63,190,585
LOCATION ADJUSTMENT FACTOR		112.9	$63,190,585	$71,343,000
SUBTOTAL - with Local Adjustment Factor				$71,343,000
MARKET ADJUSTMENT FACTOR			$71,343,000	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				$71,343,000
MAXIMUM CONSTRUCTION COST				$71,343,000

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

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Project Name:	**Clean Renewable Hydrogen Water Treatment Cost Estimate**	**Life Cycle Analysis:**	
Project Number:		**i =**	
Project Manager:	[redacted]	**n =**	
Estimator:		**Annual Inflation:**	
Project Description:	**Source 3. Groundwater Evap Pond**		
Project Location (City):	**Los Angeles**		
Project Location (State):	**CALIFORNIA**		
Project Location (Country):	**USA**		
Cost Basis (Month/Year):	**December/2023**		

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
	Yes	Evap Ponds: New	$370,000
		Additional Project Costs:	
		Biosolids Disposal	$0
		Standard Items	$472,000
		User Defined Items	$0
		Plant O&M Labor	$1,070,000
TOTAL - ANNUAL O&M COST			**$1,912,000**

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: Source 4.Agricultural Industry Water Evap Pond
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: $1,000

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$115,958,000
SUBTOTAL - PROJECT COST				$115,958,000
ADDITIONAL PROJECT COSTS:				
Demolition:		0.00%		$0
Overall Sitework:		6.00%		$6,958,000
Plant Computer System:		6.00%		$6,958,000
Yard Electrical:		9.00%		$10,437,000
Yard Piping:		8.00%		$9,277,000
UD #1 Default Description		0.00%	$58,250,000	$0
UD #2 Default Description		0.00%		$0
UD #3 Default Description		0.00%		$0
SUBTOTAL with Additional Project Costs				$149,588,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			

11	*Client Material Preferences*			
12	*Client Equipment Preferences*			
13	*Piping Galleries, Piping Trenches, Piping Racks*			
14	*Yard Piping Complexity*			
15	*Existing Site Utilities (New, Retrofit, and Complexity)*			
16	*I & C Automation (New or Retrofit)*			
17	*Electrical Feed (New or Retrofit)*			
18	*Electrical Distribution*			
19	*Shoring*			
20	*Contamination*			
21	*User Defined Red Flag 1*			
22	*User Defined Red Flag 2*			
23	*User Defined Red Flag 3*			
24	*User Defined Red Flag 4*			
25	*User Defined Red Flag 5*			
26	*User Defined Red Flag 6*			
27	*User Defined Red Flag 7*			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$149,588,000
TAX:		8.25%	$82,273,400	$6,787,556
SUBTOTAL with Tax				$156,375,556
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$156,375,556	$18,766,000
Subtotal				$175,141,556
Profit		10.00%	$175,141,556	$17,515,000
Subtotal				$192,656,556
Mob/Bonds/Insurance		3.00%	$192,656,556	$5,780,000
Subtotal				$198,436,556
Contingency		30.00%	$198,436,556	$59,531,000
SUBTOTAL with Markups				$257,967,556
LOCATION ADJUSTMENT FACTOR		112.9	$257,967,556	$291,246,000
SUBTOTAL - with Local Adjustment Factor				$291,246,000
MARKET ADJUSTMENT FACTOR			$291,246,000	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				$291,246,000
MAXIMUM CONSTRUCTION COST				$291,246,000

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

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Project Name: *Clean Renewable Hydrogen Water Treatment Cost Estimate*

Project Number:

Project Manager: [redacted]

Estimator:

Project Description: *Source 4. Agricultural Industry Water Evap Pond*

Project Location (City): *Los Angeles*

Project Location (State): *CALIFORNIA*

Project Location (Country): *USA*

Cost Basis (Month/Year): *December/2023*

Life Cycle Analysis:

i =

n =

Annual Inflation:

Item	Include? (Yes or No)	SCOPE OF PROJECT	Annual O&M Cost (Year 1)
	Yes	Evap Ponds: New	$22,851,000
		Additional Project Costs:	
		Biosolids Disposal	$0
		Standard Items	$1,923,000
		User Defined Items	$0
		Plant O&M Labor	$1,070,000
TOTAL - ANNUAL O&M COST			**$25,844,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		***Project Unit: >>>***		*(For example: MGD, HP, GPM…)*

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: Source 5: Brine Line Flows

Roundup to the nearest: **$1,000**

Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$77,969,000
SUBTOTAL - PROJECT COST				$77,969,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			

23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$77,969,000
TAX:		8.25%	$42,882,950	$3,537,843
SUBTOTAL with Tax				$81,506,843
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$81,506,843	$9,781,000
Subtotal				$91,287,843
Profit		10.00%	$91,287,843	$9,129,000
Subtotal				$100,416,843
Mob/Bonds/Insurance		3.00%	$100,416,843	$3,013,000
Subtotal				$103,429,843
Contingency		30.00%	$103,429,843	$31,029,000
SUBTOTAL with Markups				$134,458,843
LOCATION ADJUSTMENT FACTOR		112.9	$134,458,843	$151,805,000
SUBTOTAL - with Local Adjustment Factor				$151,805,000
MARKET ADJUSTMENT FACTOR			$151,805,000	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				$151,805,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				$151,805,000

Replica - Parametric Design

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

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Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	
Estimator:	
Project Description:	***Source 5: Brine Line Flows***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	***Include? (Yes or No)***	***SCOPE OF PROJECT***	***Annual O&M Cost***
	Yes	Evap Ponds: New	**$7,786,000**
TOTAL - ANNUAL O&M COST			**$7,786,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: Zita Yu, Richard Sturn
Estimator: Ryujiro Tsuchihashi
Project Description: Source 6: Advanced Water Treatment Concentrate
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: $1,000

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$78,207,000
SUBTOTAL - PROJECT COST				$78,207,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			

23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$78,207,000**
TAX:		**8.25%**	**$43,013,850**	**$3,548,643**
SUBTOTAL with Tax				**$81,755,643**

CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$81,755,643**	**$9,811,000**
Subtotal				**$91,566,643**
Profit		**10.00%**	**$91,566,643**	**$9,157,000**
Subtotal				**$100,723,643**
Mob/Bonds/Insurance		**3.00%**	**$100,723,643**	**$3,022,000**
Subtotal				**$103,745,643**
Contingency		**30.00%**	**$103,745,643**	**$31,124,000**
SUBTOTAL with Markups				**$134,869,643**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$134,869,643**	**$152,268,000**
SUBTOTAL - with Local Adjustment Factor				**$152,268,000**
MARKET ADJUSTMENT FACTOR			**$152,268,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$152,268,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer			**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST				**$152,268,000**

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

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Project Name:	***Clean Renewable Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 6: Advanced Water Treatment Concentrate***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	***Include? (Yes or No)***	***SCOPE OF PROJECT***	***Annual O&M Cost***
	Yes	**Evap Ponds: New**	**$4,406,000**
TOTAL - ANNUAL O&M COST			**$4,406,000**

Replica - Parametric Design

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		Project Unit: >>>		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager:
Estimator:
Project Description: Source 7: Oil and Gas Industry Water
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: $1,000

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	$117,578,000

SUBTOTAL - PROJECT COST		$117,578,000
RED FLAGS:		
1	Rock Excavation	
2	Pile Foundations	
3	Seismic Foundations	
4	Dewatering Conditions	
5	Wetlands Mitigation	
6	Weather Impacts	
7	Depth of Structures	
8	Local Building Code Restrictions	
9	Coatings or Finishes	
10	Building or Architectural Considerations	
11	Client Material Preferences	
12	Client Equipment Preferences	
13	Piping Galleries, Piping Trenches, Piping Racks	
14	Yard Piping Complexity	
15	Existing Site Utilities (New, Retrofit, and Complexity)	
16	I & C Automation (New or Retrofit)	
17	Electrical Feed (New or Retrofit)	
18	Electrical Distribution	
19	Shoring	
20	Contamination	
21	User Defined Red Flag 1	
22	User Defined Red Flag 2	

23	User Defined Red Flag 3			
24	User Defined Red Flag 4			
25	User Defined Red Flag 5			
26	User Defined Red Flag 6			
27	User Defined Red Flag 7			
TOTAL - RED FLAGS				$0
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				$117,578,000
TAX:		8.25%	$64,667,900	$5,335,102
SUBTOTAL with Tax				$122,913,102
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		12.00%	$122,913,102	$14,750,000
Subtotal				$137,663,102
Profit		10.00%	$137,663,102	$13,767,000
Subtotal				$151,430,102
Mob/Bonds/Insurance		3.00%	$151,430,102	$4,543,000
Subtotal				$155,973,102
Contingency		30.00%	$155,973,102	$46,792,000
SUBTOTAL with Markups				$202,765,102
LOCATION ADJUSTMENT FACTOR		112.9	$202,765,102	$228,922,000
SUBTOTAL - with Local Adjustment Factor				$228,922,000
MARKET ADJUSTMENT FACTOR			$228,922,000	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				$228,922,000
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			Garcia-Aleman, Jesus	
Name of Estimator Reviewer			Meyer, Ed	
MAXIMUM CONSTRUCTION COST				$228,922,000

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

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Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 7: Oil and Gas Industry Water***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	***Include? (Yes or No)***	***SCOPE OF PROJECT***	***Annual O&M Cost***
	Yes	**Evap Ponds: New**	**$33,604,000**
TOTAL - ANNUAL O&M COST			**$33,604,000**

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/17/2023

Project Capacity: >>>		**Project Unit: >>>**		(For example: MGD, HP, GPM…)

Project Name: Clean Renewable Hydrogen Water Treatment Cost Estimate
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: Source 8: Inland Brackish Groundwater
Project Location (City): Los Angeles
Project Location (State): CALIFORNIA
Project Location (Country): USA
Cost Basis (Month/Year): December/2023

Roundup to the nearest: $1,000

Item	Include? (Yes or No)	SCOPE OF PROJECT		Cost
	Yes	Evap Ponds: New		$77,969,000
SUBTOTAL - PROJECT COST				$77,969,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			

23	***User Defined Red Flag 3***			
24	***User Defined Red Flag 4***			
25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$77,969,000**
TAX:		**8.25%**	**$42,882,950**	**$3,537,843**
SUBTOTAL with Tax				**$81,506,843**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$81,506,843**	**$9,781,000**
Subtotal				**$91,287,843**
Profit		**10.00%**	**$91,287,843**	**$9,129,000**
Subtotal				**$100,416,843**
Mob/Bonds/Insurance		**3.00%**	**$100,416,843**	**$3,013,000**
Subtotal				**$103,429,843**
Contingency		**30.00%**	**$103,429,843**	**$31,029,000**
SUBTOTAL with Markups				**$134,458,843**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$134,458,843**	**$151,805,000**
SUBTOTAL - with Local Adjustment Factor				**$151,805,000**
MARKET ADJUSTMENT FACTOR			**$151,805,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$151,805,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer			**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST				**$151,805,000**

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ACILITIES LIFE CYCLE COST ANALYSIS MODULE

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Project Name: ***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:
Project Manager: [redacted]
Estimator:
Project Description: ***Source 8: Inland Brackish Groundwater***
Project Location (City): ***Los Angeles***
Project Location (State): ***CALIFORNIA***
Project Location (Country): ***USA***
Cost Basis (Month/Year): ***December/2023***

Item	*Include? (Yes or No)*	*SCOPE OF PROJECT*	*Annual O&M Cost*
	Yes	Evap Ponds: New	$11,491,000
TOTAL - ANNUAL O&M COST			**$11,491,000**

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FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 3/16/2023

Project Name:	Clean Renewable Hydrogen Water Treatment Cost Estimate	
Project Number:		
Project Manager:	[redacted]	
Estimator:		
Project Description:	Source 9: Dry Weather Flows	**Roundup to the nearest:**
Project Location (City):	Los Angeles	**$1,000**
Project Location (State):	CALIFORNIA	
Project Location (Country):	USA	
Cost Basis (Month/Year):	December/2023	

Item	Include? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	Evap Ponds: New	$77,969,000

SUBTOTAL - PROJECT COST				$77,969,000
RED FLAGS:				
1	Rock Excavation			
2	Pile Foundations			
3	Seismic Foundations			
4	Dewatering Conditions			
5	Wetlands Mitigation			
6	Weather Impacts			
7	Depth of Structures			
8	Local Building Code Restrictions			
9	Coatings or Finishes			
10	Building or Architectural Considerations			
11	Client Material Preferences			
12	Client Equipment Preferences			
13	Piping Galleries, Piping Trenches, Piping Racks			
14	Yard Piping Complexity			
15	Existing Site Utilities (New, Retrofit, and Complexity)			
16	I & C Automation (New or Retrofit)			
17	Electrical Feed (New or Retrofit)			
18	Electrical Distribution			
19	Shoring			
20	Contamination			
21	User Defined Red Flag 1			
22	User Defined Red Flag 2			
23	User Defined Red Flag 3			
24	User Defined Red Flag 4			

25	***User Defined Red Flag 5***			
26	***User Defined Red Flag 6***			
27	***User Defined Red Flag 7***			
TOTAL - RED FLAGS				**$0**
SUBTOTAL - PROJECT COST with Additional Project Costs and Red Flag Costs				**$77,969,000**
TAX:		**8.25%**	**$42,882,950**	**$3,537,843**
SUBTOTAL with Tax				**$81,506,843**
CONTRACTOR MARKUPS:				
Overhead (includes General Conditions and General Administrative Costs)		**12.00%**	**$81,506,843**	**$9,781,000**
Subtotal				**$91,287,843**
Profit		**10.00%**	**$91,287,843**	**$9,129,000**
Subtotal				**$100,416,843**
Mob/Bonds/Insurance		**3.00%**	**$100,416,843**	**$3,013,000**
Subtotal				**$103,429,843**
Contingency		**30.00%**	**$103,429,843**	**$31,029,000**
SUBTOTAL with Markups				**$134,458,843**
LOCATION ADJUSTMENT FACTOR		**112.9**	**$134,458,843**	**$151,805,000**
SUBTOTAL - with Local Adjustment Factor				**$151,805,000**
MARKET ADJUSTMENT FACTOR			**$151,805,000**	**$0**
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor				**$151,805,000**
Replica PD Estimate MUST be reviewed by a Process person AND an Estimator:				
Name of Process Reviewer			**Garcia-Aleman, Jesus**	
Name of Estimator Reviewer			**Meyer, Ed**	
MAXIMUM CONSTRUCTION COST				**$151,805,000**

Replica - Parametric Design

ACILITIES LIFE CYCLE COST ANALYSIS MODULE

File Version: 3/17/2023

Linked to Replica - Parametric Design Facilities File: https://jacobsengineering-my.sharepoint.com/personal/ryujiro_tsuchihashi_jacobs_com/Docum

Project Name:	***Clean Renewable Hydrogen Water Treatment Cost Estimate***
Project Number:	
Project Manager:	[redacted]
Estimator:	
Project Description:	***Source 9: Dry Weather Flows***
Project Location (City):	***Los Angeles***
Project Location (State):	***CALIFORNIA***
Project Location (Country):	***USA***
Cost Basis (Month/Year):	***December/2023***

Item	***Include? (Yes or No)***	***SCOPE OF PROJECT***	***Annual O&M Cost***
	Yes	**Evap Ponds: New**	**$3,685,000**
TOTAL - ANNUAL O&M COST			**$3,685,000**

Capital and O&M Estimates for Existing Brine Disposal Facilities

Source 3. Groundwater Concentrate conveyance pipeline cost estimate - 0.75 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	**$ 1,826,137**
Sales tax on material @ 8.25%	$ 79,305
Sub total w/General conditions	**$ 1,905,443**
Contractor overhead @ 12%	$ 228,653
Contractor profit @ 10%	$ 190,544
Mobilization/Bonds and Insurance @ 3%	$ 57,163
Subtotal W/O Contingency	**$ 2,381,803**
Owner Contingency @ 30%	$ 714,541
Total Conveyance construction cost w/o escalation	**$ 3,097,000**
Total Converyance Construction Cost with location factor adjustment (12.9%)	**$ 3,497,000**

Source 2: Treated Wastewater; Source 5: Brine Line Flows; Source 6: Advanced Water Treatment Concentrate; Source 8: Inland Brackish Groundwater; Source 9: Dry Weather Flows Concentrate conveyance pipeline cost estimate - 1.5 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	**$ 3,361,954**
Sales tax on material @ 8.25%	$ 146,003
Sub total w/General conditions	**$ 3,507,957**
Contractor overhead @ 12%	$ 420,955
Contractor profit @ 10%	$ 350,796
Mobilization/Bonds and Insurance @ 3%	$ 105,239
Subtotal W/O Contingency	**$ 4,384,946**
Owner Contingency @ 30%	$ 1,315,484
Total Conveyance construction cost w/o escalation	**$ 5,701,000**
Total Converyance Construction Cost with location factor adjustment (12.9%)	**$ 6,436,000**

Source 4. Agricultural Industry Water Source 7. O&G Industry Water Concentrate conveyance pipeline cost estimate - 2.5 mgd	Cost
Project Construction cost estimates	
Point A SS reservoir to Point B SS reservoir	
Direct costs subtotal	**$ 5,158,031**
Sales tax on material @ 8.25%	$ 224,003
Sub total w/General conditions	**$ 5,382,034**
Contractor overhead @ 12%	$ 645,844
Contractor profit @ 10%	$ 538,203
Mobilization/Bonds and Insurance @ 3%	$ 161,461
Subtotal W/O Contingency	**$ 6,727,542**
Owner Contingency @ 30%	$ 2,018,263
Total Conveyance construction cost w/o escalation	**$ 8,746,000**
Total Converyance Construction Cost with location factor adjustment (12.9%)	**$ 9,874,000**

Brine Conveyance O&M

Brine Line O&M - $0.00184/gal for disposal fee			0.00184
	MGD		$/yr
	0.75	$	503,700
	1.5	$	1,007,400
	2.5	$	1,679,000

Estimated Concentrate Flow Rates

0.75 mgd	Source 3: Groundwater
1.5 mgd	Source 2: Treated Wastewater
1.5 mgd	Source 5: Brine Line Flows
1.5 mgd	Source 6: Advanced Water Treatment Concentrate
1.5 mgd	Source 8: Inland Brackish Groundwater
1.5 mgd	Source 9: Dry Weather Flows
2.5 mgd	Source 4. Agricultural Industry Water
2.5 mgd	Source 7. Oil and Gas Industry Water

Appendix C

Conveyance Cost Summary Outputs

Conveyance Alternative 1 - Point A - Surface storage reservoir at source to Point B - Surface storage reservoir at H2 plant, 25 miles Open Cut Construction	Cost
Project Construction cost estimates	
Direct costs subtotal	**$ 59,549,470**
Sales tax on material @ 8.25%	$ 2,860,738
Sub total w/General conditions	**$ 62,410,208**
Contractor overhead @ 12%	$ 7,489,225
Contractor profit @ 10%	$ 6,241,021
Mobilization/Bonds and Insurance @ 3%	$ 2,284,214
Subtotal W/O Contingency	**$ 78,424,667**
Owner Contingency @ 30%	$ 23,527,400
Total Conveyance construction cost w/o escalation	**$ 101,953,000**
Total Conveyance Construction Cost with Location Factor (12.9%)	**$ 115,105,000**

Conveyance Alternative 2 - Point A - Surface storage reservoir at source to Point B - Surface storage reservoir at H2 plant, 25 miles HDD Construction	Cost
Project Construction cost estimates	
Direct costs subtotal	**$ 65,095,634**
Sales tax on material @ 8.25%	$ 2,860,738
Sub total w/General conditions	**$ 67,956,372**
Contractor overhead @ 12%	$ 8,154,765
Contractor profit @ 10%	$ 6,795,637
Mobilization/Bonds and Insurance @ 3%	$ 2,487,203
Subtotal W/O Contingency	**$ 85,393,978**
Owner Contingency @ 30%	$ 25,618,193
Total Conveyance construction cost w/o escalation	**$ 111,013,000**
Total Conveyance Construction Cost with Location Factor (12.9%)	**$ 125,333,677**

Conveyance System O&M Cost Estimate	Cost
Material Cost	$ 598,723
Sales tax on material @ 8.25%	$ 49,395
Sub total w/General conditions	$ 678,008
Contractor overhead @ 12%	$ 81,361
Contractor profit @ 10%	$ 67,801
Mobilization/Bonds and Insurance @ 3%	$ 24,815
Subtotal W/O Contingency	$ 851,985
Owner Contingency @ 30%	$ 255,596
Total equipment construction cost w/o escalation	$ 1,107,581
Maintenance cost at 3.05% of equipment cost	**$ 33,781**
Replacement cost at 3.3% of equipment cost	**$ 36,550**
Pump Power Cost	**$ 1,056,077**
O&M Cost Subtotal	**$1,126,409**

Chapter 4: Challenges and Opportunities Related to Water Supply and Treatment

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Table of Contents

Tables

Appendices

Appendix A Challenge and Opportunity Tables

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Acronyms and Abbreviations

AWT	Advanced Water Treatment
CVP	Central Valley Project
mg/L	milligram(s) per liter
MGD	million gallons per day
O&G	oil and gas
O&M	operations and maintenance
RO	reverse osmosis
ROW	right-of-way
SoCalGas	Southern California Gas Company
SWP	State Water Project
TDS	total dissolved solids
TM	technical memorandum

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1 Introduction

This technical memorandum (TM) addressing the challenges and opportunities related to water supply and treatment has been prepared as part of the Water Resources Evaluation prepared for Angeles Link proposed by Southern California Gas Company (SoCalGas). The Water Resources Evaluation is part of a larger feasibility study being conducted by SoCalGas to support the development of a pipeline system that will transport clean renewable hydrogen for use in Central and Southern California, including the Los Angeles Basin. The purpose of the Water Resources Evaluation is to identify and characterize water supply sources and identify costs associated with those sources that third-party producers may pursue to produce clean renewable hydrogen.

This chapter relies on and incorporates analysis from the following three technical studies that were prepared separately and incorporated as chapters of the Water Resources Evaluation for the Angeles Link Phase One feasibility analyses:

- Chapter 1: Water Availability Study
- Chapter 2: Technical Memorandum for Water Quality Requirements for Hydrogen Generation
- Chapter 3: Technical Memorandum for Water Acquisition and Purification Costs

1.1 Objectives

The objective of this chapter is to identify and characterize potential challenges and opportunities third-party developers may face when developing water supplies for clean renewable hydrogen production, including the portion of clean renewable hydrogen production that Angeles Link may transport.

Specifically, this evaluation considers challenges and opportunities for the following potential supply sources that were identified as part of the Water Availability Study (Chapter 1):

- Imported Surface Water
- Treated Wastewater
- Groundwater
- Agricultural Industry Water
- Brine Line Flows
- Advanced Water Treatment Concentrate
- Oil & Gas (O&G) Industry Water
- Inland Brackish Groundwater
- Dry Weather Flows
- Urban Stormwater Capture and Reuse

Section 2 of this chapter summarizes each of these source types.

1.2 Technical Approach

This chapter provides a qualitative analysis of the potential challenges and opportunities for third-party clean renewable hydrogen producers associated with the water supply and treatment that may support future production by considering the following three separate assessment areas:

1. The qualities of the potential water supply sources identified for production
2. Conveyance
3. Geographic setting of the identified potential water supply sources

The qualitative analysis in this chapter is based on the professional opinion of the consultant team based on the evaluation of potential water supply sources as identified in Chapter 1 (Water Availability Study) and the team's professional experience in developing potential water supply sources for different projects. This analysis is intended to be preliminary for purposes of the Angeles Link Phase 1 feasibility analyses. Third-party producers would likely conduct additional analysis of the challenges and opportunities associated with water supply and treatment as more details on specific production projects are developed.

1.2.1 Identified Water Supply Sources

For the assessment area related to the identified water supply sources, the following approach was used:

- Identify evaluation categories for specific supply sources (e.g., supply reliability, stakeholder considerations, etc.).
- Identify challenges and opportunities specific to each supply source.
- Identify and develop potential strategies to mitigate potential challenges and to capture opportunities that have been identified, where applicable.

1.2.2 Conveyance

Some of the sources that have been identified are located in costal or urban areas of Central and Southern California. Pipelines may be needed to convey water from the coastal and urban areas to the production areas. However, as discussed further in Chapter 1 (Water Availability Study), significant conveyance may not be necessary for all potential water supply sources, as sources could be developed through a water exchange mechanism. In some instances, conveyance of water from source locations to a site for hydrogen production may be necessary and may pose challenges for certain supply types. For this assessment area, the common challenges related to conveyance were identified and discussed.

1.2.3 Geographic Setting

For the assessment area related to geographic setting, the following assessment approach was used:

- Identify general categories of challenges and opportunities related to the geographic setting of the water sources.
- Group the source locations into broad geographic categories with different challenges and opportunities.

1.3 Chapter Organization

The following is the organization of this chapter:

- Section 1: Introduction - presents the objective and approach for this chapter.
- Section 2: Description - summarizes potential water sources for hydrogen production.
- Section 3: Water Supply Challenges and Opportunities - presents an evaluation of challenges and opportunities related to identified water source types.
- Section 4: Conveyance Challenges - summarizes challenges related to conveyance that are common to all supply types.
- Section 5: Geographic Challenges and Opportunities - presents a summary of the challenges and opportunities related to geographic settings.
- Section 6: Summary – summarizes the findings of this assessment.
- Section 7: References - lists the references cited in this chapter.

1.4 Key Terms

- **Conveyance.** Pipelines, pump stations, and other associated equipment needed to move water from the source location to the hydrogen production facility.
- **Brackish Groundwater.** Groundwater with elevated dissolved solids (salt content). For this assessment, groundwater with total dissolved solids concentration (a measure of slat content) exceeding 1,000 milligrams per liter is considered brackish.
- **Brine minimization.** Process modifications that increase the efficiency of reverse osmosis treatment resulting in lower volumes of concentrate (brine) and higher volumes of treated water.
- **Challenge.** For this study, a challenge is defined as a barrier (e.g., cost, permitting, reliability) to implementing a water supply project for hydrogen production.
- **Concentrate**. A liquid waste stream generated during reverse osmosis treatment that contains elevated concentrations of dissolved solids (salts).
- **Coastal (geography)**. For this study, areas within the jurisdiction of the California Coastal Commission.

- **Dry Weather Flow**. Dry weather flow occurs in the absence of precipitation, typically from surface discharges.
- **Ecological Flows.** Regulatorily required discharges from wastewater treatment plants to support ecological water demands.
- **Opportunity.** For this study, an opportunity is an action that can be taken to mitigate barriers (e.g., cost, permitting, reliability) to implementing a water supply project for hydrogen production.
- **Other (geography).** For this study, areas located outside of city limits and the jurisdiction of the California Coastal Commission.
- **Process Upset**. An operating condition for a treatment plant that results in non-compliance or taking the system offline unexpectedly, reducing the volume treated water produced for hydrogen production.
- **Recycled Water/Wastewater Effluent**. Recycled water is highly treated wastewater effluent that has been filtered to remove solids and other impurities and disinfected (depending on treatment level).
- **Residuals.** For this study, solid or liquid wastes produced during treatment of water source for hydrogen production.
- **Total Dissolved Solids (TDS).** A measure of the dissolved salt content in a liquid.
- **Urban (geography).** For this study, areas within the jurisdictional boundaries of a city (city limits).
- **Water Exchange.** Water exchange involves delivery of water by one water user to another water user. The receiving water user will be required to return the water at a specified time or when the conditions of the parties’ agreement are met.
- **Water Banking**. A project that stores excess surface water, when available, in the subsurface, and recovers the stored water when surface water is unavailable for a project’s demands.

2 Description of Potential Water Sources

Chapter 1, Water Supply Availability, focused on identifying water sources that could be used for the production of clean renewable hydrogen that do not have existing demands or otherwise would not compete with existing and planned land uses (Rincon 2024). In addition, several of the proposed sources involve the treatment and reuse of waste streams and thus could be considered a new supply source. Table 4-1 presents an overview of the ten supply sources that were identified.

Table 4-1 Identified Water Sources for Clean Renewable Hydrogen Production

Supply Source	Description
Imported Surface Water	Surface water in California is available through three major water projects, including the Central Valley Project (CVP), the State Water Project (SWP), and the Colorado River. Accessing surface water from existing water rights holders could provide a large source of supply for future clean renewable hydrogen production.
Treated Wastewater	Recycled water is highly treated wastewater (municipal sewage) that has been filtered and disinfected at a wastewater treatment facility. There are numerous recycled water facilities in Southern California. Facility capacity, inflows, and outflows are documented in water quality permits and Urban Water Management Plans, which were used to identify and quantify flows of treated wastewater that are currently discharged without being reused. Treated wastewater that is being discharged from treatment facilities without further reuse or plans for future reuse could supply clean renewable hydrogen production projects.
Groundwater	Groundwater in California is managed by local agencies under the Sustainable Groundwater Management Act, to reverse overdraft and create long-term sustainable conditions. As groundwater basins recover from overdraft conditions, local resources may become more available. Depending on site-specific conditions at the time of future project development, individual clean renewable hydrogen producers can further evaluate local groundwater as a potential supply source. There may be opportunities to develop groundwater as a supply source in Low Priority basins and in adjudicated areas, depending upon site-specific conditions and other demands. In addition, groundwater banks, or aquifer storage and recovery projects, may be used to facilitate a water supply exchange.

Supply Source	Description
Agricultural Industry Water	Agricultural industry water includes two potential water supply sources associated with ongoing agricultural operations: agricultural field drainage and wastewater from produce washing operations. Agricultural field drainage refers to surface water runoff and shallow subsurface drainage of irrigation and water precipitation. Agricultural wash water or process water refers to water that is applied to remove soil and debris prior to distribution to buyers and customers. As a potential supply source, systems could be used to capture and reuse field drainage water and process wastewater could be diverted prior to disposal for treatment and reuse by hydrogen producers.
Brine Line Flows	Brine lines are used to remove salts and other contaminants from a given watershed area to protect the quality of local surface water and groundwater resources. Brine flows that are currently planned for discharge to a brine line for disposal could be diverted for use in clean renewable hydrogen production.
Advanced Water Treatment (AWT) Concentrate	An advanced water treatment facility (AWTF) uses secondary-treated recycled water to conduct further water quality treatment and produce tertiary-level treated water. This process creates waste flow consisting of highly saline brine or concentrate. This waste flow can be either recycled for reuse or treated for disposal. Concentrate from AWT that is not currently reused or planned for beneficial reuse could supply clean renewable hydrogen production.
O&G Industry Water	O&G industry water from produced water and/or refinery offset water could be developed as a water supply source, as O&G operations are phased out in accordance with state goals and objectives. Refinery offset water includes the water gained from the reduction or cessation of refinery operations. The amount of water per barrel of oil produced is expected to vary by refinery location, depending on multiple factors, including the source water, other refinery operations and processes, and requirements of the facility-specific discharge permit. Separately, produced water includes water brought to the surface along with O&G because of pumping. Treated produced water could be acquired by a hydrogen producer from the oil field operator prior to its discharge to land.

Supply Source	Description
Inland Brackish Groundwater	Brackish groundwater can occur from both natural sources (geology and soils) and from manmade sources (discharges from wastewater treatment plants and agricultural runoff). Brackish groundwater located in inland areas without natural drainage outlets and that is not currently managed or does not have plans to be managed for beneficial use could provide a supply source for clean renewable hydrogen production. Use of inland brackish water as a supply source would not compete with the needs of other water users because it would provide beneficial use to brackish water that otherwise poses water quality concerns and management issues.
Dry Weather Flows	Dry weather flows are discharges of flows that enter a Municipal Separate Storm Sewer System (MS4) during dry weather conditions and, because of low volume and velocity, these flows accumulate within the MS4, causing water quality concerns and potential violation of the MS4 operating permit (National Pollutant Discharge Elimination System). Dry weather flows are known to be problematic for local flood control agencies with insufficient resources to remove and dispose of them. Dry weather flows that are not reused or planned for beneficial use could provide a potential source for clean renewable hydrogen production projects.
Urban Stormwater Capture and Reuse	Stormwater runoff occurs in direct response to precipitation events. Stormwater runoff that can be captured before reaching a discharge outlet can be stored and treated for future use. Multiple Southern California water agencies have existing stormwater capture and reuse programs; however, these are generally not considered currently available because the respective agencies have developed such programs to improve their own water supply portfolios. Clean renewable hydrogen producers could work with agencies overseeing stormwater capture projects to evaluate sources that may become available in the future or may develop new stormwater capture projects as a potential new source for clean renewable hydrogen production.

Source: modified from Table ES-6 Potential Supply Sources in the Chapter 1: Water Availability Study (Rincon 2024)

Chapter 1 also identified potential mechanisms that may be available to acquire these supply sources (Rincon 2024):

- Exchange agreements
- Direct purchase or partnership with local agencies
- Water markets
- Purchase of land with water rights

Although more than one acquisition mechanism may be possible for each supply source, specific mechanisms were assumed to develop cost estimates for water supplies to support hydrogen production, as summarized in Chapter 3:

- Surface water: SWP water acquired using an exchange agreement
- Groundwater: acquired by a combination of water rights associated with purchased land (pumping of groundwater) and direct purchase from a local agency
- Inland brackish groundwater: acquired by water rights associated with purchased land (pumping of brackish groundwater)
- All other supply sources: acquired by direct purchase

The same acquisition mechanisms were assumed for this chapter when evaluating challenges and opportunities for the identified supply sources.

3 Water Supply Challenges and Opportunities

This section presents an evaluation of challenges and opportunities for the water sources that were identified as part the Chapter 1: Water Availability Study.

3.1 Evaluation Categories

As described in Section 1 of this chapter, the Chapter 1 of the Water Availability Study identified a portfolio of potential water supply types that could support clean renewable hydrogen production. Third-party clean renewable hydrogen producers may draw from those potential water supply sources to produce hydrogen, and the menu of specific water sources would be developed on a case-by-case basis as details of specific production projects develop. Note that project-level analysis for specific proposed clean renewable hydrogen production projects would be speculative if conducted at this time, given the unknown variables associated with a project-level analysis (e.g., specific menu of water supply sources, specific size of production facilities). For purposes of this analysis in this feasibility phase, this chapter focused on evaluation categories that may be common to most of the supply sources third-party producers may draw upon. The following evaluation categories were considered:

- **Concentrate management:** refers to issues related to the management of reverse osmosis (RO) concentrate generated during treatment of source water to produce high-purity water for hydrogen production
- **O&M:** refers to issues related to operating the treatment facilities
- **Partnerships:** refers to issues related to partnerships, and mutual benefits that may ease access to water supply sources, enhance reliability, or simplify operations
- **Regulatory compliance:** refers to issues related to regulatory compliance for supply or residual management
- **Supply reliability:** refers to long-term supply reliability for the water source
- **Stakeholder considerations:** refers to stakeholder benefits and concerns for accessing the water supply
- **Treatment**: refers to issues related to treating water that meets quality requirements for hydrogen production

Category-specific challenges and opportunities were identified for each of the water sources that have been identified. A summary of these findings is presented in the following sections. **Table A-1 in Appendix A** summarizes the challenges and opportunities for the supply sources that have been identified.

3.2 Imported Surface Water

Imported surface water exchange using a new water supply developed elsewhere could potentially be used as an important mechanism to facilitate water access in remote inland areas where large-scale renewable energy production projects and may be more favorable without the need to construct long conveyance pipelines. Another advantage of treating surface water sources for hydrogen production is that it is expected to be less energy intensive than other sources because the concentration of total dissolved solids (TDS) is relatively low (e.g., 320 milligrams per liter [mg/L] for SWP water); refer to Chapter 3). The following are important considerations regarding the use of imported surface water, acquired though exchange, as a source for hydrogen production.

- The principal challenge for the imported surface water exchange source is providing a long-term reliable supply of imported surface water for a production project. A surface water exchange project would involve the development of a new water source (e.g., recycled water reuse or desalination) to offset the amount of imported surface water diverted for hydrogen production. Even when coupled with development of a new supply source to offset the exchange of surface water, the amount of surface water available year-over-year may vary based on hydrologic conditions and existing demands, especially during droughts. For example, the SWP, which conveys water from the Bay Delta Area in Northern California to Southern California, received the lowest initial allocation of zero percent on December 1, 2021, with limited water designated only for any unmet human health and safety needs (CDWR 2022).
- A potential mitigation strategy for this supply variability challenge is for project developers to explore water banking options (surface or subsurface storage) to store excess surface water during wet years and to recover the stored water when surface water supply is less or not available to meet a particular production project’s need.
- Other challenges are related to potential regulatory issues associated with the permitting of the related exchange projects (e.g., a desalinization or reuse project) and the management of concentrate generated during water treatment for the related exchange projects.
- Important opportunities include partnerships related to the distribution and conveyance of surface water and partnerships related to the development of an exchange supply in areas where there is a need to diversify supplies. Partnerships of this nature may support a reliable exchange supply for hydrogen production.

3.3 Treated Wastewater

The use of treated wastewater as a water source would involve diversion, and treatment of wastewater effluent to produce high-purity water for hydrogen production. The following are important considerations for the use of treated wastewater as a source for hydrogen production.

- The primary challenges for the use of treated wastewater as a source are related to the reliability of supply and concentrate management.
- Conservation efforts that reduce water use can result in lower wastewater flows over time, or there may be future plans for indirect or direct potable reuse of the wastewater effluent, which may result in less effluent available as a source of water for hydrogen production. For example, the State Water Resource Control Board is implementing conservation standards for water use that may reduce wastewater flows (SWRCB 2024). A potential mitigation approach for reliability challenges would be to identify other sources of water and to maintain a diverse portfolio of sources.
- The primary challenges associated with concentrate management are related to potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- Opportunities related to recycled water/wastewater effluent include partnerships that ease access to this supply source. In areas experiencing population growth, wastewater agencies may need to expand their wastewater treatment plant to accommodate the additional wastewater flows. Contributing funding for plant expansion may provide access to a reliable supply of wastewater effluent for hydrogen production.
- Coordinating partnerships that facilitate gathering of wastewater effluent from multiple facilities and conveying that water to hydrogen production areas may facilitate the supply of treated wastewater for production projects. Partnership strategies like these may enhance access to treated wastewater sources.
- Further treatment of treated wastewater will be needed to produce high-purity water for hydrogen production, but treatment is expected to be less challenging than for other of the potential supply sources (e.g., concentrate sources, O&G industry water, and agriculture industry water, and dry weather flows) because TDS concentrations are lower for this source (approximately 890 mg/L) (refer to Chapter 3.

3.4 Groundwater

The use of groundwater as a source for hydrogen production would involve the extraction and treatment of groundwater to produce high-purity water for hydrogen production. The following are important considerations for the use of groundwater as a source for hydrogen production.

- The primary challenge for the use of groundwater water as source is related to concentrate management. This includes the potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- The source reliability may pose an additional challenge because groundwater pumping may need to be reduced if it adversely impacts the sustainability of the groundwater basin.

- Treatment is expected to be less challenging than for many of the other identified sources because groundwater is expected to have relatively low TDS concentrations (e.g., 485 mg/L) and would only require partial RO treatment (refer to Chapter 3).

3.5 Agricultural Industry Water

Agricultural industry water includes agricultural field drainage and wastewater from produce washing operations. The use agricultural industry water would involve the diversion and treatment of these source flows to produce high-purity water for hydrogen production. The following are important considerations for the use of agricultural industry water as a source for hydrogen production.

- The primary challenges for the use of agricultural industry water as source are related to concentrate management and treatment.
- The challenges associated with concentrate management are related to potential cost and implementation issues associated with the need to construct large concentrate evaporation basins or long pipelines for concentrate disposal.
- Treatment of agricultural industry water is expected to be challenging, at least for the agricultural drainage component of this source. Agricultural drainage can have very high TDS concentrations (e.g., 15,000 mg/L) and other scale-forming minerals (refer to Chapter Part 3). These water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, and scaling of treatment equipment and concentrate pipelines. In addition, the potential exists for treatment residuals and concentrate to require management as hazardous wastes because of elevated concentrations of metals.
- Potential opportunities include partnerships to enhance access to agricultural industry water and partnerships related to the distribution and conveyance of agricultural industry water for hydrogen production. In addition, the salt content of agricultural drainage and wastewater used in food processing can be challenging to manage, sometimes requiring specific treatment, infrastructure, or management approaches to comply with discharge limits. Diverting these flows for hydrogen production may be beneficial to agricultural producers, irrigation districts, and regulatory agencies involved with agricultural industry water. Partnerships with these entities to develop infrastructure to divert agricultural industry water may increase access to this supply source.

3.6 Brine Line Flows

The use of brine line flows as a water source would involve harvesting RO concentrate from turnouts on inland concentrate pipelines that convey concentrate to coastal outfalls for disposal and treating the harvested concentrate to produce high-purity water for hydrogen production. The following are important considerations for the use of brine line flows as a water source for hydrogen production.

- The primary challenges associated with the use of brine line flows for hydrogen production are related to the cost and implementation challenges associated with construction of concentrate disposal pipelines or evaporation basins.
- Treatment of brine line flows is expected to be more challenging than surface water, groundwater or treated wastewater because the concentrate will have relatively high TDS concentrations (e.g., 5,120 mg/L, refer to Chapter 3). In addition, this concentrate source will also contain dissolved constituents that can foul RO membranes, similar to concentrate from advanced water treatment facilities.
- Potential opportunities exist to avoid costs for construction of evaporation basins or long conveyance pipelines for concentrate disposal by locating the project treatment facility close to the source concentrate pipeline and to use that existing pipeline to dispose the concentrate generated from water treatment processes to generate water for hydrogen production. For this source water, it would be more advantageous to convey product water to the hydrogen production facility so that concentrate generated could be discharged back into the existing brine line for disposal.

3.7 Advanced Water Treatment Concentrate

RO is commonly used during the advanced treatment of wastewater effluent, which produces concentrate (brine) as a waste stream. The use of this concentrate as a water source would involve diverting the advanced water treatment plant concentrate for further treatment to produce high-purity water for hydrogen production. The following are important considerations for the use of advanced water treatment concentrate as a water source for hydrogen production.

- The primary challenges associated with the advanced recycled water treatment concentrate for hydrogen production are cost and implementation challenges associated with construction of disposal pipelines or evaporation basins. Like brine line flows, the additional treatment of advanced water treatment concentrate will produce a concentrate waste stream that will contain even higher concentrations of dissolved salts, which can lead to scaling and plugging of concentrate pipelines. In addition, the required areas for evaporation ponds can be large, resulting in increased land acquisition costs for the project or otherwise competing with land needed for renewable energy generation.
- All advanced water treatment plants have an existing concentrate disposal system. A potential mitigation approach related to concentrate management for this water source would be to use or expand the existing concentrate disposal systems for these facilities. This would likely require the project treatment plant for hydrogen production to be located at or near the advanced water treatment facility, and in this case, treated water would be conveyed to the hydrogen production site.
- Potential opportunities also include partnerships to enhance access to concentrate supply and partnerships related to the distribution and conveyance of concentrate for hydrogen production. In addition, for water agencies planning

to construct advanced recycled water treatment facilities, identifying cost-effective approaches for the management and disposal of RO concentrate is a critical factor for planning and design of the advanced water treatment facility. These agencies may view partnerships with entities that would acquire and take responsibility for their RO concentrate as beneficial because this would reduce capital and operating costs for the advanced water treatment facility, especially for facilities that do not have close access to concentrate disposal pipelines or outfalls.

- Treatment of concentrate from advanced water treatment facilities is expected to be more challenging than surface water, groundwater, or municipal wastewater because the concentrate will have relatively high TDS concentrations (approximately 2,950 mg/L), foulants of RO membranes, such as organics and other scale-forming minerals, such as calcium and phosphate (refer to Chapter 3). All of these water quality characteristics would pose additional operational challenges and costs, such as higher energy costs, more frequent backwash of processes, scaling of treatment equipment and concentrate pipelines.

3.8 Oil and Gas Industry Water

The use of O&G industry water as a source would involve diverting production water after separating O&G components and treating production water to produce high-purity water for hydrogen production. In addition, this source also includes water currently used for O&G production and refining that would become available for use as a source for hydrogen production as these industries contract over time. The following are important considerations regarding the use of O&G industry water as a source for hydrogen production.

- The long-term reliability of O&G production water is a potential challenge. Conceptually, less produced water may be available for hydrogen production if oil fields become less productive or oil production becomes less favorable over time. If this occurs, however, other water sources (e.g., groundwater or surface water) used for oil production and refining could be available to offset the loss of produced water supply.
- Concentrate management, treatment, and O&M issues related to the characteristics of oilfield production water would also pose challenges. Oilfield production water is considered to be the most challenging of the potential sources to treat for hydrogen production (refer to Chapter 3). For example, the TDS concentrations of this source are expected to be elevated (e.g., 22,500 mg/L, refer to Chapter 3). In addition, O&G production water can contain organic substances, toxic metals, and naturally occurring radioactive constituents that may become concentrated during treatment (Lester et al. 2015).
- If the concentrations of hazardous constituents in the treatment residuals or concentrate exceed regulatory thresholds, they would need to be handled as hazardous wastes, which would increase the costs and complexity of residuals management for this source. A potential mitigation strategy for this challenge would be further treatment of the residuals/concentrate to reduce the volumes of

these waste streams that would require special handling and disposal requirements.

- Potential opportunities include using or repurposing existing oilfield waste disposal systems and partnerships related to the distribution and conveyance of O&G production water from multiple oil fields or refineries for hydrogen production. If the source water treatment facility for hydrogen production is located near existing O&G production centers, purchasing or repurposing existing waste injection wells and conveyance used for disposal of O&G production wastes may be an opportunity to reduce the overall costs for concentrate management.

3.9 Inland Brackish Groundwater Desalination

The use of inland brackish groundwater as a source for hydrogen production would involve the extraction and treatment (desalinization) of brackish groundwater to produce high-purity water for hydrogen production. The following are important considerations for the use of inland brackish groundwater as a source for hydrogen production.

- Like concentrate from advanced water treatment facilities and bine lines, the primary challenges associated with the desalination of inland brackish groundwater as a source of water for hydrogen production are related to concentrate management.
- The source reliability may pose an additional challenge. In general, a finite volume of brackish groundwater may be available for hydrogen production, and in some cases, the brackish aquifer zones are not entirely separated from drinking water aquifers. In these cases, brackish groundwater pumping may need to be reduced if it adversely impacts the sustainability of the groundwater basin.
- In some cases, brackish groundwater projects have been implemented to comply with regulatory requirements related to salt and nutrient management of the groundwater basin (e.g., Chino Basin Desalter) or to address brackish groundwater caused by previous land use practices (e.g., the CV-Salts program). Partnership opportunities may exist to fund or assume operation of these obligatory desalination systems, which may enhance access to brackish groundwater sources, while allowing water agencies to shift funding and resources to projects that provide a more cost-effective supply for their ratepayers.
- Treatment is expected to be more challenging than surface water, urban stormwater, groundwater, and municipal wastewater because brackish groundwater can have relatively high TDS concentrations (e.g., 1,800 mg/L; refer to Chapter 3). In addition, this concentrate source will also contain dissolved constituents that can foul RO membranes, similar to concentrate from advanced water treatment facilities.

3.10 Dry Weather Flows

The use of dry weather flows as a water source would involve diverting and treating dry weather flows to produce high-purity water for hydrogen production. The following are important considerations regarding the use of dry weather flows as a source for hydrogen production.

- The primary challenges associated with the use of dry weather flow are related to reliability, concentrate management, treatment complexity, and O&M issues.
- In general, treatment of dry weather flow is expected to be more complex than most of the other potential sources because of the additional pretreatment needed to remove oil/grease and particulates from dry weather flows before treatment via ultrafiltration and RO (refer to Chapter 3). Also, given the contaminants sometimes found in dry weather flows (e.g., metals [Stein et al, 2008]), the potential exists for treatment residuals and concentrate to require management as hazardous wastes.
- Potential opportunities include partnership related to the distribution and conveyance of dry weather flows for hydrogen production and collaboration with agencies with interests related to the benefits of capturing and treating dry weather flows. Given the distributed nature of dry weather flows, coordinating partnerships that facilitate the gathering of dry weather flows from multiple watersheds and conveying that water to hydrogen production areas may facilitate the large-scale use of dry weather flows for hydrogen production. In addition, given the broad environmental benefits (e.g., reduced contaminant loading to receiving waters) of diverting dry weather flows, partnering with municipalities, regulatory agencies, flood control districts, and non-governmental agencies to divert these flows may enhance access to this supply source.

3.11 Urban Stormwater Capture and Reuse

The use of urban stormwater capture and reuse as a water source would involve diverting stormwater from a flood control or stormwater retention basin and treating these flows to produce high-purity water for hydrogen production. The following are important considerations regarding the use urban stormwater capture and reuse as a source for hydrogen production.

- The primary challenges associated with the use of use urban stormwater capture are related to the reliability and flow fluctuations.
- Urban stormwater flows are dependent on the occurrence of storm events and therefore, are not available continuously. In addition, available flows are expected to fluctuate over a broad range. One mitigation approach for these challenges is to divert stormwater from multiple stormwater basins within a watershed. This combined storage may allow for diversion of stormwater flows for a longer duration between storm events.

- In general, treatment of urban stormwater is expected to be less complex than most of the other potential sources because the TDS concentrations of this source are expected to be relatively low (e.g., 168 mg/L, refer to Chapter 3).
- Potential opportunities include partnerships with agencies to that need to improve or repair existing flood control or stormwater systems. Partnering with these agencies to make needed improvements or repairs may increase access to this source.
- In addition, combining the collection and treatment systems for dry weather flows and urban stormwater capture and reuse is a potential opportunity to reduce costs and improve the reliability of supply.

4 Conveyance Challenges

Conveyance of source water, treated water, and concentrate may pose potential challenges for each of the potential supply sources third parties may pursue for clean renewable hydrogen production as identified in the Chapter 1: Water Availability Study. As described in Section 5 of this chapter, some potential sources identified may be located in coastal or urban areas throughout Southern California. Clean renewable hydrogen production areas, however, are expected to be located farther inland in areas that are favorable for renewable energy, as described in the Production and Planning Assessment (Production Study) prepared as a separate Angeles Link Phase 1 feasibility study. Long pipelines may be needed to convey water from the coastal and urban areas to the production areas.

Required conveyance may add to the associated cost and implementation challenges for the water sources that have been identified. In addition, the topographic relief between the coastal and urban areas of Southern California and the intervening mountainous terrain between the coast and the expected areas for hydrogen production can exceed thousands of feet, which could lead to energy needs and energy costs associated with pumping water supplies or concentrate. Other implementation challenges associated with conveyance may also apply. For example, advancing pipelines through developed areas may require the relocation of existing infrastructure and traffic and business disturbances, even with the use of tunneling methods. In addition, the construction of pipelines through undeveloped areas may have environmental impacts that require mitigation (e.g., for pipeline alignments that traverse surface water features or otherwise impact critical habitats). In addition, securing easements for this conveyance is also expensive and can lead to delays. These challenges and associated permitting requirements may pose additional barriers for conveyance projects.

Potential opportunities exist to minimize challenges associated with conveyance. Prioritizing sources close to the hydrogen production areas would mitigate construction and cost challenges associated with long conveyance requirements. Acquiring surface water through an exchange provides another opportunity to mitigate challenges associated with conveyance. One of the primary benefits of an exchange project is that it provides a potential approach to avoid the need to construct pipelines from coastal and urban areas to the areas for hydrogen production. As described in Chapter 1 (Water Availability Study [Rincon 2024]), several regional surface water conveyance systems, the State Water Project for example, may provide an opportunity for surface water exchange that could reduce the need to construct and operate long pipeline systems to convey water for hydrogen production.

5 Geographic Challenges and Opportunities

This section presents an evaluation of potential implementation challenges related to the geographic setting of the potential water sources.

5.1 Geographic Categories

Considering the locations of the potential water supply sources, and the different characteristics of those locations, the source locations were grouped into the following broad geographic categories with different project implementation challenges.

- Coastal – water sources located within the jurisdiction of the California Coastal Commission
- Urban – water sources located within the incorporated limits of a city
- Other – water sources located outside costal and urban zones

For the purpose of this evaluation, the following implementation challenges were evaluated to assess challenges and opportunities associated with the geography of potential supply sources.

- Land availability – land availability for project development and right-of-way (ROW) for conveyance
- Construction challenges – level of existing development that can interfere with constructing treatment facilities and conveyance
- O&M challenges – degree of constraints on implementing repairs and coordination to implement intrusive O&M activities, potentially resulting in more downtime
- Conveyance challenges – potential long conveyance distance from geographic areas and renewables areas for hydrogen production
- Permitting complexity – geographic permitting complexities that pose challenges for project development across multiple public agencies

5.2 Geographic Challenges

In general, the potential project impacts for the area are similar for many of the geographic implementation challenges for each of the three geographic categories. **Table A-2 in Appendix A** presents the category-specific challenges and opportunities for the geographic settings. The following summarizes important considerations regarding potential project geographies.

- Project implementation in coastal geographies may be more challenging than urban and other settings. Permitting, in particular, is expected to be complex because of the need to comply with coastal development permitting requirements. In addition, sources in coastal settings are expected to require longer pipelines to convey source water to hydrogen production areas.

- Many of the implementation challenges for urban settings are similar to those for coastal settings. Land availability and conveyance, however, are expected to be significant challenges for projects in urban settings.
- Some of the potential sources are located outside of coastal and urban settings. Many of potential implementation challenges for projects in other settings may apply. However, land availability and conveyance may pose less of a challenge for water supply sources in other settings.

6 Summary

Supply reliability, concentrate management, and conveyance are the primary challenges for each of the identified supply source types. Challenges related to treatment vary among the source types based on differences in the water quality and may result in increased treatment and operational costs for some sources (e.g., produced water and dry weather flows). In general, water supply projects located in non-coastal, non-urban settings would have fewer implementation challenges. Accommodating for supply reliability long term is another concern for each of the supply types.

Concentrate management may also pose a challenge for all supply types. If access to an existing concentration disposal pipeline is unavailable for the project, or it is located too far away to economically convey concentrate to that location, alternative concentrate management methods, such as evaporation ponds or mechanical evaporative methods, might need to be used. Potential opportunities exist to mitigate these challenges for several source types. For produced water, project developers may be able to utilize existing oilfield wastewater disposal wells for concentrate disposal. For advanced recycled water treatment, brackish groundwater, and desalter sources, project developers may be able to utilize or expand existing brine disposal systems. In this case, the project treatment plant would likely need to be located near the source water diversion location, and product water would be conveyed to the hydrogen production site.

Conveyance may also pose challenges for all supply types. As discussed in Section 5 of this chapter, the principal challenge for conveyance is related to the cost to construct and operate conveyance systems. These concerns could be mitigated in part by prioritizing water sources located near the hydrogen production site. Acquiring imported surface water through an exchange could provide another potential strategy to avoid the challenge associated with long conveyance distances.

Third-party producers may need to acquire supply from multiple sources and supply for certain clean renewable hydrogen production projects. The locations of potential sources are distributed throughout Central and Southern California. Opportunities may exist for coordinating entities/partnerships to facilitate the gathering and conveyance of water supplies from distributed sources throughout Central and Southern California to potential hydrogen production sites. This may help accommodate supply reliability for future production projects. These coordinating entities could include a consortium of hydrogen producers, an independent joint powers agency tasked with gathering and conveying water supplies to hydrogen producers, or other partnerships among the parties involved in clean renewable hydrogen production.

7 References

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Appendix A

Challenge and Opportunity Tables

Table A-1 Challenges and Opportunities – Supply Sources

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Concentrate Management	Concentrate Disposal Conveyance	A long conveyance run for concentrate disposal and/or construction of a new outfall may be required .	Challenge	Locating treatment near an existing disposal conveyance/outfall would reduce the need for long conveyance runs or construction of a dedicated outfall.
Concentrate Management	Land Requirements for Concentrate Evaporation Ponds	Large areas of land may be required for construction of concentrate evaporation ponds, which may increase overall costs and compete with land needed for renewable systems (electricity generation).	Challenge	Implement brine minimization to reduce volume of brine to be disposed of (additional energy demands).
Concentrate Management	Existing Concentrate Disposal Conveyance/ Outfalls	Instead of constructing a new concentrate management system, connect to an existing concentrate disposal pipeline or outfall.	Opportunity	▪ Use of existing concentrate disposal conveyance/outfall would avoid the need to construct a new disposal pipeline/outfall, concentrate evaporation basin, or other concentrate management systems. ▪ Specifically for O&G industry water, purchasing or repurposing existing waste injection wells and conveyance used for disposal of O&G production wastes may be an opportunity to reduce the overall costs for concentrate management for O&G production water.
O&M	Concentrate plugging - Pipelines	Concentrate chemistry leads to scaling and plugging of the concentrate pipeline, impacting recovery.	Challenge	▪ Expected to be more challenging for O&G industry water, agricultural industry water, and the concentrate sources ▪ Plan for additional O&M of the concentrate pipeline. ▪ Incorporate redundancy in the design of the concentrate pipeline.
O&M	Process Upset	For example, treatment system outage caused by mechanical or performance issues, impacting recovery and system uptime.	Challenge	▪ Process upset is expected to be more likely for O&G industry water, agricultural industry water, dry weather flows, and the concentrate sources. ▪ Conduct additional pretreatment to mitigate scaling. ▪ Incorporate treatment redundancy to ensure supply.
O&M	Waste Classification - Concentrate	Due to concentration of hazardous chemicals, the RO concentrate may be classified as hazardous waste.	Challenge	▪ More likely for O&G industry water, agricultural industry water, and the concentrate sources. ▪ Implement brine minimization to reduce volume of brine to be disposed of (additional energy demands). ▪ Conduct treatment to remove hazardous constituents from the concentrate (additional treatment costs).
O&M	Waste Classification - Residuals	Due to concentration of hazardous chemicals, solid residuals from the treatment may be classified as hazardous waste.	Challenge	Dispose of wastes in hazardous waste landfill (additional costs).

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Partnerships	Coordinating Partnerships	Acquiring and conveying water supplies from many distributed sources may be needed for third-party hydrogen production projects. Given the dispersed nature of these sources, coordinating entities/partnerships may be needed for such a system to be implementable. These coordinating entities could include a consortium of hydrogen producers, an independent joint powers agency tasked with gathering and conveying water supplies to hydrogen producers, or other partnerships among other parties involved in hydrogen production.	Opportunity	As the details for specific clean renewable hydrogen production projects evolve, facilitate the development of partnerships among the parties involved to coordinate the acquisition and conveyance of source water supplies for hydrogen production.
Partnerships	Surface Water Exchange	Potential synergies exist for supply projects that would provide water supply diversification for areas that only have access to one source of imported water (e.g., areas that are 100% dependent on State Water Project water). Partnerships could involve constructing, partnering, or funding local water supply projects (e.g., brackish desalinization and recycled water projects) for potable supply within the imported water service areas. The treated water would be distributed within the local service area in lieu of imported surface water deliveries.	Opportunity	Coordinate with agencies involved with the conveyance and supply of imported surface water, as well as local agencies reliant on imported surface water to identify mutually beneficial partnership opportunities for surface water exchange.
Partnerships	Private-Public Partnerships, Treated Wastewater - Wastewater Treatment Plant Expansions	Availability of recycled municipal wastewater may be greater for new plants or plants undergoing expansion because those discharges may not have yet been allocated to other uses (e.g., further treatment for potable uses or use for environmental flows). Thus, partnership opportunities with agencies undertaking or planning to expand their wastewater treatment plants may increase access to this source. Potential partnerships mechanisms may include the purchase of municipal wastewater and/or contributing funding for wastewater treatment plant construction or expansion.	Opportunity	Identify regions experiencing or projecting population growth, coordinate with agencies in these areas to identify those constructing or expanding wastewater treatment plants, and explore partnerships to gain access to the wastewater from those plants.
Partnerships	Concentrate Harvesting	Identifying cost-effective approaches for the management and disposal of RO concentrate from advanced water treatment plants may be critical for agencies operating or planning to construct advanced water treatment plants. Thus, these agencies may view partnerships with entities that would acquire and take responsibility for their RO concentrate as beneficial, especially for advanced water treatment plants where traditional disposal approaches for RO concentrate is challenging.	Opportunity	Coordinate with agencies operating discharging concentrate sources to identify mutually beneficial partnership opportunities for diverting their concentrate streams for hydrogen production.

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Partnerships	Private-Public Partnerships, Brackish Water Desalters	In some cases, the agencies have implemented inland brackish water desalter systems to comply with regulatory requirements to improve or maintain the salt balance in a groundwater basin. In this context, the brackish groundwater systems are analogous to groundwater remediation projects. These agencies may view private partnerships that operate or fund these types of projects as beneficial because this would allow the agencies to divert funding allocated for desalter construction and operation to less costly supply sources. Such partnerships may ease access to brackish groundwater supplies for hydrogen production.	Opportunity	Identify those agencies conducting brackish groundwater desalination as a regulatory obligation, and coordinate with these agencies to identify partnership opportunities for groundwater desalters.
Partnerships	Multiple -Benefit Projects, Dry Weather Flow	Dry weather flows in storm water systems can pose compliance challenges for municipal agencies and can be a source of contaminant loading to receiving waters and associated aquatic habitats. Thus, diverting dry weather flows for hydrogen production my provide multiple benefits (e.g., source water for hydrogen production, improved municipal compliance, and benefits to the environment). Given the broad benefits of diverting dry weather flows, partnering with municipalities, regulatory agencies, flood control districts, and non-governmental agencies to divert these flows may increase access to this supply source for hydrogen production.	Opportunity	Identify those agencies/receiving waters that would benefit most from dry weather flow diversion and coordinate with the appropriate agencies, regulators, and non-government entities in these watersheds to identify partnership opportunities for dry weather flow diversion
Partnerships	Agricultural Salt Management, Agricultural Industry Water	The salt content of agricultural drainage and wastewater used in food processing can be challenging to manage, sometimes requiring specific treatment, infrastructure, or management approaches to comply with discharge limits. Diverting these flows for hydrogen production may be beneficial to agricultural producers, irrigation districts, and regulatory agencies involved. Partnerships with these entities to develop infrastructure to divert agricultural industry water may increase access to this supply source.	Opportunity	Identify those entities that would benefit most from diversion of agricultural industry water and coordinate with these entities to identify partnership opportunities for diversion of this source.
Partnerships	Stormwater Infrastructure Improvements, Urban Stormwater Capture and Reuse	In some cases, agencies may need to improve or repair their flood control or stormwater systems (e.g., channel repairs, levee repairs, or the construction of retention basin). Partnerships with agencies that need to improve their flood control or stormwater systems may increase access to this source. Potential partnership mechanisms may include contributing funding for flood control/stormwater system repairs or expansions.	Opportunity	Identify those agencies/receiving waters that need to implement flood control/stormwater system improvements or repairs and identify partnership opportunities for stormwater capture and reuse.

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Regulatory	Regulatory Compliance	Regulatory compliance issues that impact supply or concentrate disposal.	Challenge	▪ For surface water exchange, permitting of new exchange projects (e.g., ocean desalinization, brackish groundwater, or reuse) may be difficult because impacts or mitigation may be too costly or difficult to make the projects feasible; target investments in existing desalinization, reuse or brackish groundwater projects (expansion of those existing projects) or new projects that have already been identified with mitigable permitting challenges; look for muti-benefit opportunities; add value to local communities ▪ For treated wastewater, diverting wastewater discharge for hydrogen generation may decrease ecological flows; develop mitigations for reduced flows; engage with parties to understand potential concerns related to the change in discharge ▪ For dry weather flows and stormwater capture and reuse, regulatory changes may reduce diversions to support other demands (e.g., to ensure ecological purposes); diversify supply.
Stakeholder	External Stakeholders	External stakeholder involvement in development of water supply source.	Opportunity	▪ Address potential impacts related to water supply (e.g., supply available, water prices) from development of water supplies that will support hydrogen production. ▪ Develop robust stakeholder engagement plan during the planning phase that includes early identification, assessment, mapping, and engagement planning for external stakeholders; conduct early and active engagement.
Supply Reliability	Long-Term Reliability, Surface Water	For surface water, required volume of produced water may not be available long term because of competing demands for surface water, climatic conditions, or other constraints.	Challenge	▪ Contribute (invest) in water banking operations and recover banked storage when needed to maintain reliable supply ▪ Identify alternative local water sources to diversify supply
Supply Reliability	Long-Term Reliability, Treated Wastewater	For treated wastewater, required volume of recycled water may not be available long term because of conservation efforts or other actions that can reduced wastewater flows.	Challenge	Identify alternative water sources to diversify supply
Supply Reliability	Long-Term Reliability, Groundwater Sources	For groundwater and inland brackish groundwater, required volume of produced water may not be available long term because pumping may impact groundwater sustainability.	Challenge	Identify alternative water sources to diversify supply
Supply Reliability	Long-Term Reliability, Urban Stormwater Capture and Reuse	For stormwater capture and reuse, stormwater will not be available continuously as a supply for hydrogen production (only available during storm events).	Challenge	Identify alternative water sources to diversify supply
Supply Reliability	Long-Term Reliability, O&G Production Water	O&G production water, required volume of produced water may not be available long term because of a decline in oil production over time.	Challenge	▪ Shift to using water sources previously used for O&G production and refining (e.g., surface water or groundwater) that become available as O&G production declines. ▪ Identify alternative water sources (other water sources) to diversify supply

Category	Title	Challenge/ Opportunity Description	Challenge/ Opportunity	Notes/Mitigation/Opportunity Capture Actions
Treatment	Treatment Complexity	The more complex the treatment system, the more operational downtime is expected to be needed for maintenance.	Challenge	▪ Treatment for surface water, groundwater, and dry weather flows may be less complicated. ▪ Treatment for concentrate sources and brackish groundwater may be moderately complicated. ▪ Treatment for O&G industry water, agricultural industry water, and dry weather flows is expected be the most complicated of the sources that have been identified. ▪ For mitigation, plan for additional O&M, and incorporate redundancy in the treatment system.
Treatment	Supply Volume Fluctuation	Quantity of water supply fluctuates substantially, impacting recovery.	Challenge	▪ General mitigations include Incorporating flow equilibration and adding treatment capacity to accommodate higher flows. ▪ For stormwater capture and reuse, flows may fluctuate significantly based on the availability of stormwater. This source will require significant equilibration storage to accommodate these fluctuations. This may be mitigated in part by diverting water from multiple existing stormwater retention basins.
Treatment	Water Quality Fluctuations	Quality of the produced water fluctuates substantially, impacting recovery.	Challenge	▪ Plan for additional O&M. ▪ Add treatment capacity to accommodate higher flow.

O&M = operations and maintenance

RO = reverse osmosis

Table A-2 Implementation Challenges and Opportunities – Geographic Settings

Title	Challenge/Opportunity Description	Notes/Mitigation/Opportunity Capture Actions
Land Availability	Land availability for project development and ROW for conveyance	▪ In general, land may be unavailable in coastal areas for development, and ROW access can be difficult to obtain. ▪ In general, less land is available in urban areas for development, and ROW access can be difficult to obtain. ▪ In general, more land is available in non-urban/non-coastal areas for development, and ROW may be more attainable.
Construction Challenges	Level of existing development that can interfere with the construction of treatment facilities and conveyance	▪ In generally dense, urban and costal settings, significant existing infrastructure can interfere with the construction of treatment facilities and conveyance. ▪ A lower-density setting and fewer construction interferences are expected for non-urban/non-costal settings.
O&M Challenges	Degree of constraints on implementing repairs and coordination to implement intrusive O&M activities, potentially resulting in more downtime	▪ Constraints on implementing repairs are likely for coastal settings; public coordination and approval may be needed from multiple agencies to implement intrusive O&M activities. ▪ Some constraints on implementing repairs are expected for urban settings; public coordination and agency approval may be needed. ▪ Few constraints on implementing repairs are expected in lower-density, non-urban/non-costal settings.
Conveyance Challenges	Long conveyance distance from geographic area to hydrogen production locations	▪ For all geographies, one opportunity to reduce costs and to avoid potential challenges associated with conveyance is prioritizing source types that are located near the hydrogen production facility because the associated conveyance distances would be shorter. ▪ Shorter pipeline runs may be needed to convey water supply from sources located in non-coastal/non-urban regions.
Permitting Complexity	Geographic permitting complexities that pose challenges for project development	▪ For all geographies, one opportunity to mitigate potential challenges related to permitting is early and proactive engagement with applicable agencies and stakeholders in order to understand their permitting requirements, concerns, and preferred approaches for mitigation. ▪ In general, project permitting is expected to be complex for costal settings, potentially requiring permits from multiple agencies, as well as compliance with Costal Commission permitting, and associated analyses and impact mitigation requirements (e.g., sea level rise). ▪ Project permitting is also expected to be complex for urban settings and for non-urban/non-coastal, potentially requiring permits from multiple agencies.

ROW = right-of-way

Chapter 5: Supplemental Desktop Analysis - Greenhouse Gas Emissions Associated with Water Treatment and Conveyance

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Appendices

Appendix A Delta Conveyance Project Mitigation Measure to Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

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Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
AQ	air quality
CAP	Climate Action Plan
CBOSG	Community Based Organization Stakeholder Group
CEQA	California Environmental Quality Act
CH4	methane
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
CVP	Central Valley Project
EIR	Environmental Impact Report
GHG	greenhouse gas
GWP	global warming potential
HFC	hydrofluorocarbons
IEUA	Inland Empire Utilities Agency
kWh	kilowatt hour
LADWP	Los Angeles Department of Water and Power
m3	cubic meter
Metropolitan	Metropolitan Water District of Southern California
MG	million gallons
MGD	million gallons per day
MT	million tons
MWh	megawatt hours
N2O	nitrous oxide
NEPA	National Environmental Policy Act
NOx	nitrogen oxide
PAG	Planning Advisory Group
PCS	pressure control structure
PFC	perfluorocarbons
RRWP	Regional Recycled Water Program

SCE	Southern California Edison
SF6	sulfur hexafluoride
SWP	State Water Project
T&D	transmission and distribution
UWMP	Urban Water Management Plan
WESim	Water-Energy Simulator
WRE	Water Resources Evaluation

Executive Summary

This supplemental desktop analysis was prepared in direct response to stakeholder feedback during Phase 1 of Angeles Link, including in response to comments received verbally during meetings with the Angeles Link Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) members and in response to written comments received on the preliminary findings provided for the Water Resources Evaluation (WRE). Specifically, PAG and CBOSG members expressed concerns about the potential greenhouse gas (GHG) emissions associated with the development of water supplies for clean renewable hydrogen production, including emissions associated with conveyance and treatment of different water supply sources.

SoCalGas does not propose to directly develop water supplies or produce clean renewable hydrogen as part of Angeles Link, as described in the Production and Planning Assessment (Production Study). A detailed, quantified analysis of potential GHG emissions associated with water conveyance and treatment is outside the scope of the WRE. In addition, a quantified analysis would not be feasible during this feasibility stage without more information on the specific options for water supply sources third-party producers may develop to produce clean renewable hydrogen. However, to understand more about the potential GHG emissions associated with water supply development more generally, this supplemental analysis was prepared to provide a high-level overview of existing published data and studies regarding potential GHG emissions associated with the energy required to conduct water supply treatment and conveyance.

This supplemental analysis is informed by review of available literature and resources. Finding the extent of GHG emissions associated with water supply management depends on many factors, including, but not limited to, the potential distance required for conveyance, the initial water quality of the source water, and type and amount of electricity used for a given activity (i.e., for pumping needs depending on local topography or whether gravity is available for conveyance or for treatment needs depending on the quality of the water). As more details on specific clean renewable hydrogen production projects emerge, potential GHG emissions associated with water supply development could be further evaluated on a case-by-case basis. SoCalGas anticipates clean renewable production projects would undergo a thorough environmental review under the California Environmental Quality Act (CEQA) and/or the National environmental Policy Act (NEPA), as applicable, when such projects apply for discretionary permits from federal, state, and/or local agencies as applicable. That environmental review would likely include an analysis of potential GHG emissions associated with development of those projects.

1 Scope

This report has been prepared as part of the WRE for the Phase 1 feasibility studies conducted for SoCalGas's Angeles Link. As noted in Chapter 1, *Water Availability Study*, of the WRE, water supply sources that may be considered by third-party clean renewable hydrogen producers to pursue quantities sufficient to meet the water needs for their respective projects were identified. The ultimate location, capacity and design of those production projects will be determined by the clean hydrogen producers.

The purpose of this report is to provide a high-level overview of information related to potential GHGs associated with the treatment and conveyance of water supply in California and to address comments received from the PAG/CBOSG stakeholders. This report does not include quantification of GHG emissions associated with the potential supply source types identified in the WRE; rather, it provides information, including data and methodology, to offer additional context at this stage regarding potential future GHG emissions associated with water supply development. Potential GHG emissions from combustion associated with Angeles Link infrastructure, including from third-party production and storage activities, as well as potential GHG combustion emissions reductions from displacing fossil fuels with hydrogen in various sectors are evaluated in the Greenhouse Gas Emissions Evaluation Report (GHG Study) being prepared as a separate Phase 1 analysis. Given the scope of the feasibility analyses, the GHG Study's evaluation of potential GHG emissions associated with third-party production does not include an assessment of emissions associated with conveyance and treatment of water sources that may feed specific third-party production projects.

The type and extent of GHG emissions associated with water supply management are related to treatment and conveyance, and depend upon numerous factors such as, but not limited to, the potential distance required for conveyance, the initial water quality of the source water, and the type and amount of electricity used for a given activity. Water quality treatment and water conveyance are the most energy-intensive aspects of water supply management. The GHG emissions associated with a given activity are calculated based upon the activity's energy usage.

The principal anthropogenic (human-made) GHGs are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated compounds, including sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Those that are associated with combustion include CO2, CH4, and N2O. To quantify GHG emissions, a carbon dioxide equivalent (CO2e) is calculated, where CO2e is a metric measure used to compare the emissions from various GHGs based on their global warming potential (GWP). This is done by converting quantities of other gases to the equivalent amount of CO2 that would result in the same GWP, where CO2 has a GWP value of one. CO2e is typically expressed in weight of CO2e per unit of energy used.

2 Literature Review

Published resources included in this literature review were identified because they contain data and methodology that may be helpful to informing analysis of potential GHG emissions associated with use of water supplies, including emissions associated with water treatment and conveyance. Table 5-1, below, provides an overview of the published resources discussed herein.

Table 5-1 Overview of Published Resources

Resources	Information/Findings
Implications of Future Water Supply Sources for Energy Demands (WRF 2012)	The Water-Energy Simulator (WESim) analytical tool is used to evaluate the energy and greenhouse gas implications of water management. The tool is suitable for individual water utilities and groups of water utilities, as well as policy and decision makers.
Energy Demands on Water Resources: Report to Congress of the Interdependency of Energy and Water (USDOE 2006)	This report is a response to a Congressional directive within a letter to the Secretary of Energy from the chairmen and ranking members of the House and Senate Subcommittees on Energy and Water Development Appropriations, dated December 9, 2004, wherein they asked for “a report on energy and water interdependencies, focusing on threats to national energy production that might result from limited water supplies.”
Metropolitan Water District of Southern California (Metropolitan), Climate Action Plan (Metropolitan 2022)	This Climate Action Plan (CAP) sets targets for reducing GHG emissions from Metropolitan’s operations, including conveyance, storage, treatment, and delivery of water to its 26 member water agencies. The CAP also complements Metropolitan’s existing long-range planning efforts, including the Integrated Water Resources Plan, Energy Sustainability Plan, and Capital Investment Plan.

Resources	Information/Findings
Delta Conveyance Project, Environmental Impact Report (EIR), Chapter 23: Air Quality (DWR 2023)	The Delta Conveyance Project is a proposed project to modernize State Water Project (SWP) infrastructure in the network of waterways comprising the Sacramento-San Joaquin Delta that collects and moves water to homes, farms, and businesses to major regions in California from the Bay Area to Southern California. The Air Quality and Greenhouse Gases (GHG) chapter of the Final EIR (DWR 2023, Chapter 23) describes the environmental setting and study area for air quality and GHG emissions; analyzes impacts that could result from construction, operation, and maintenance of the project; and provides mitigation measures to reduce the effects of potentially significant impacts. Analysis includes detailed mitigation to provide net zero emissions.
Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board (CARB 2023)	Under California's *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions*, industrial sources (i.e. emitters of GHG emissions), fuel suppliers, and electricity importers must report their annual GHG emissions to the California Air Resources Board (CARB). Certain water supply providers are subject to CARB reporting, with emissions resulting from water treatment, conveyance, and other activities conducted to support water supply-related operations.

The discussions below present key information and findings from the resources identified above, as relevant to the analysis of potential GHG emissions associated with water treatment and conveyance.

Implications of Future Water Supply Sources for Energy Demands (WRF 2012)

Capturing and treating surface water requires an average of around 1,400 kWh/MG, or 0.37 kWh per cubic meter (kWh/m3). Groundwater supplies require slightly more energy, around 1,800 kWh/MG (0.48 kWh/m3). Energy requirements for wastewater treatment vary depending on the type of treatment conducted, ranging from less than 1,000 kWh/MG (0.26 kWh/m3) for basic treatment to more than 1,900 kWh/MG (0.50 kWh/m3) for advanced treatment. (WRF 2012)

The median energy intensity for imported water is around 3,000 kWh/MG (0.79 kWh/m3), with low and high values ranging from 1,900 kWh/MG (0.50 kWh/m3) to 5,300 kWh/MG (1.4 kWh/m3). Imported water energy demands are particularly high due to the use of extensive pumping, where gravity flow is not available to provide conveyance. (WRF 2012)

For example, water from the Hetch Hetchy system, which is owned and operated by the City of San Francisco, extends more than 100 miles largely by the force of gravity, with energy requirements of two kWh/MG (5.3 × 10-4 kWh/m3) (WRF 2012); as such, water from the Hetch Hetchy system would have lower associated GHG emissions, with reduced energy needs due to the use of gravity flow. In contrast, SWP water and Colorado River water is imported to Southern California over hundreds of miles and steep terrain, with energy needs of up to approximately 7,500 kWh/MG (2.0 kWh/m3) (WRF 2012); as such, these imported water sources have higher rates of GHG emissions than gravity-driven systems.

Energy Demands on Water Resources: Report to Congress of the Interdependency of Energy and Water (USDOE 2006)

Table 5-2, below, provides an overview of statewide energy requirements for water supply and treatment (USDOE 2006, pg. 25).

Table 5-2 California Statewide Energy Requirements for Water Supply and Treatment

Water Cycle Phase	kWh/MG[1] – Low	kWh/MG[1] - High
Supply and Conveyance	0	16,000
Treatment	100	1,500
Distribution	700	1,200
Wastewater Collection and Treatment	1,100	4,600
Wastewater Discharge	0	400
Total	**1,900**	**23,700**
Recycled Water Treatment and Distribution for Non-Potable Uses[2]	400	1,200

[1] kWh = kilowatt hours; MG = million gallons.

[2] Recycled water is presented separately as a non-potable supply, versus the potable water cycle phases presented above.

Source: USDOE 2006, pg. 25

The study found that the biggest difference among regions in rates of energy use is the amount of energy used to supply water for agriculture. In general, per capita non-agricultural use of energy for water is similar from region to region. However, within regions, there can be substantial variation in energy requirements for water supply and treatment, depending on the source, the distance water is conveyed, and the local topography. (USDOE 2006, pg. 25)

The report also concluded that local, alternative water sources have relatively high treatment energy requirements compared to traditional water sources; however, in regions like the South Coast, they are still typically lower than the energy requirements for the conveyance of imported water (except for the most energy-intensive source, seawater desalination). (USDOE 2006, pg. 25)

Metropolitan Water District of Southern California, Climate Action Plan (2022)

Most GHG emissions from Metropolitan's operations are associated with electricity for importing water; therefore, Metropolitan emissions are highly dependent on where water is sourced. Metropolitan's 2020 Urban Water Management Plan (UWMP) provided historical data on water delivery from 1990 to 2020, which was used as a proxy to develop an emission factor for future deliveries. Metropolitan projected that in 2020, it would deliver a total of 1,794,625 acre-feet of water with associated GHG emissions totaling 234,329 MT CO_2e, for an emission factor of 0.17054 MT CO_2e per AF of water delivered. (Metropolitan 2022)

Table 5-3, below, provides an overview of Metropolitan's estimates of GHG emissions associated with their respective facilities and operational activities. These estimates include direct emissions from fuel uses (gasoline, diesel, propane, and natural gas), and indirect emissions from the purchase and consumption of electricity used for the transmission, treatment, and distribution of water.

Table 5-3 Water Infrastructure – Energy Use and GHG Emissions (2017)

Consumption Source[1]	Electricity Consumption (MWh)[1]	GHG Emissions (MT CO2e)[1]
Treatment Plants	48,789	11,727
Pumping Plants – Wholesale Power	1,313,240	176,080
Pumping Plants – Retail Power	4,875	1,172
Reservoirs	2,539	610
Power Plants & PCS	2,125	511
Older Facilities	8,074	1,941
Misc. Energy Usage	1,960	471
T&D Losses	14,687	1,969

[1] GHG = greenhouse gas; MT CO_2e = million tons of carbon dioxide equivalent; MWh = megawatt hours (1 MWh = 1,000 kilowatt hours); PCS = pressure control structure; T&D = transmission and distribution.

Source: Metropolitan 2022, pgs. 78, 79

Metropolitan's CAP also included projections of GHG emissions from its planned Regional Recycled Water Program (RRWP), anticipated operational in 2031. The RRWP would produce up to 150 million gallons per day (MGD) of purified water and the conveyance of purified water via approximately 60 miles of pipelines (Metropolitan 2021). Table 5-4 provides an overview of the calculated energy needs and associated GHG emissions for the RRWP.

Table 5-4 Regional Recycled Water Program – Projected Operational Emissions

Year	Electricity Consumption (MWh)[1]	GHG Emissions (MT CO2e)[1]
2035	594,675	87,675
2040	594,675	57,643
2045	594,675	27,611

[1] 264,988 MWh per year for operations at the AWTP and an additional 329,687 MWh per year to operate the pump stations; 1 Megawatt hour = 1,000 kilowatt hours

[2] GHG = greenhouse gas; MT CO_2e = million tons of carbon dioxide equivalent; MWh = megawatt hours (1 MWh = 1,000 kilowatt hours)

Source: Metropolitan 2022, pg. 256

Operational electricity demand was estimated to be 264,988 MWh per year for operations at the AWTP and an additional 329,687 MWh per year to operate the pump stations which will move water from the AWTP to the spreading grounds and injection wells (Metropolitan 2022, pg. 256). The total estimated emissions associated with this electricity demand are anticipated to decrease annually. With the implementation of California Senate Bill (SB) 100, which established a policy requiring renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045, GHG emissions from electricity consumed at the AWTP would be reduced to zero MT of CO_2e by 2045. (Metropolitan 20222, pg. 256)

Delta Conveyance Project EIR (2023)

The Delta Conveyance Project is a proposed project to modernize State Water Project (SWP) infrastructure in the network of waterways comprising the Sacramento-San Joaquin Delta that collects and moves water to homes, farms, and businesses to major regions in California from the Bay Area to Southern California. The California Department of Water Resources (DWR) certified a Final Environmental Impact Report (EIR) for the Delta Conveyance Project (DWR 2023) that includes calculations of GHG emissions associated with the facility, including CO_2, CH_4, N_2O, SF_6, and HFCs. Emissions were estimated for the EIR based on consideration project-specific activity data, relevant agency guidance and published literature, and emissions factors and methodologies from models including

CalEEMod (https://www.caleemod.com/), EMFAC (https://arb.ca.gov/emfac/), and AP-42, the U.S. Environmental Protection Agency's Compilation of Air Emissions Factors from Stationary Sources (https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors-stationary-sources).

Total net additional emissions generated by construction of the Delta Conveyance Project and displaced purchases of CVP electricity are estimated to be approximately 629,356 metric tons CO_2e. These emissions exceed the net zero threshold adopted by DWR; however, Mitigation Measure AQ-9, *Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero*, outlines a menu of feasible GHG reduction strategies that could be individually or collectively implemented to achieve the magnitude of GHG reductions required to meet the project's maximum total mitigation commitment (DWR 2023, pg. 178). Mitigation Measure AQ-9 is presented in full in Appendix A to this report, as an example of potential mitigation to address GHG emissions from water infrastructure projects.

Annual Summary of Greenhouse Gas Emissions Data Reported to the California Air Resources Board (CARB 2023)

Reporting of GHG emissions by major sources is required by the California Global Warming Solutions Act of 2006 (AB 32). The *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions* applies to emitters including electricity generators, industrial facilities, fuel suppliers, and electricity importers. Some of these emitters include major water purveyors that own and operate water supply facilities including for conveyance, storage, treatment, and distribution, as well as other types of facilities such as for power generation. Table 5-5, below, provides an overview of data reported by such parties to CARB for 2022; this is the most recent data available at the time of preparation of this supplemental analysis.

Table 5-5 GHG Emissions Data Reported to CARB by Water Purveyors

Water Purveyor	Facility	City (County)	Total CO2e[1]
Central Contra Costa Sanitary District	All facilities	Martinez (Contra Costa)	70,753
City of San Diego Public Utilities Dept.	North City Water Reclamation Plant	San Diego (San Diego)	3,815
	Point Loma Treatment Plant	San Diego (San Diego)	15,072
East Bay Municipal Utility District	All facilities	Oakland (Alameda)	37,292
Encina Wastewater Authority	Encina Water Pollution Control Facility	Carlsbad (San Diego)	97,058
Los Angeles County Sanitation Districts	Hyperion Water Reclamation Plant	Playa del Rey (Los Angeles)	101,872
	Joint Water Pollution Control Plant	Carson (Los Angeles)	25,496
Orange County Sanitation District	Plant 1	Fountain Valley (Orange)	29,186
	Plant 2	Huntington Beach (Orange)	6,325
San Francisco Water, Power, Sewer	San Francisco Southeast Treatment Plant	San Francisco (San Francisco)	35,918
City of San Jose, City of Santa Clara	San Jose-Santa Clara Regional Wastewater Facility	San Jose (Santa Clara)	10,238
City of Tulare	Tulare Water Pollution Control Facility	Tulare (Tulare)	3,815

[1] Carbon dioxide equivalent (CO_2e) is a metric measure used to compare the emissions from various GHGs based on their global warming potential; see Section 1, *Scope*.

Source: CARB 2023

Data reported under the *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions*, including as presented in the table above, is used by the State's Cap-and-Trade Program and included in California Greenhouse Gas Inventory.

3 Summary Findings

This section provides the Summary Findings identified as part of this report, the purpose of which is to provide a high-level overview of information related to potential GHGs associated with the treatment and conveyance of water supply in California and to address comments received from the PAG/CBOSG stakeholders. The Summary Findings include the following:

- Land use changes and technological advancements will influence emissions from water treatment and conveyance. Irrigation pump energy use produced 12.6 million metric tonnes of CO_2e in the US in 2018, predominantly attributable to groundwater pumping. Groundwater reliance, irrigated area extent, water demand, fuel choice, and electrical grid emissions intensity drove spatial heterogeneity in emissions. (Driscoll et al. 2024)
- Local, alternative water sources have relatively high treatment energy requirements compared to traditional water sources; however, in regions like the South Coast, they are still typically lower than the energy requirements for conveyance of imported water (except for the most energy-intensive source, seawater desalination). (WRF 2012)
- Third parties constructing and operating water infrastructure projects may implement mitigation measures for emissions; for example, the Final EIR for the Delta Conveyance Project identifies Mitigation Measures AQ-9, which requires implementation of a GHG Reduction Plan to minimize emissions from project construction and operation (DWR 2023, pg. 178).

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Appendix A

Delta Conveyance Project Mitigation Measure to Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

Mitigation Measure AQ-9: Develop and Implement a GHG Reduction Plan to Reduce GHG Emissions from Construction and Net CVP Operational Pumping to Net Zero

Prior to issuance of the first construction or grading permit for the project, DWR will retain a qualified consultant to develop a GHG Reduction Plan (Plan) to mitigate GHG emissions resulting from construction and displaced purchases of CVP electricity to net zero. Net additional GHG emissions from construction and displaced purchases of CVP electricity have been quantified as part of this Draft EIR and total between 453,412 and 794,180 metric tons CO_2e, depending on the alternative. Construction of the compensatory mitigation restoration sites is predicted to generate an additional 3,570 metric tons CO_2e. This yields a reduction commitment of up to 797,750 metric tons CO_2e needed to meet the net zero performance standard. The net zero performance standard may be achieved based on actual emissions calculations, as described below. The reduction commitment may therefore change based on project activities and adoption of new state regulations. Notably, if CARB's amendments to the Regulation for Reducing Sulfur Hexafluoride Emissions from Gas Insulated Switchgear (SF_6 Switchgear Regulation) are not adopted, DWR must reduce annual ongoing SF_6 from electrical transmission beyond 2045. This is further discussed below.

Required content for the Plan is identified in Section A below, including potential GHG reduction strategies to achieve the net zero performance standard. Monitoring, reporting, and enforcement requirements for future implementation of the Plan are outlined in Section B.

A. Required Plan Contents

1) *Emissions Quantities and Reduction Commitments:* GHG emissions from construction and displaced purchases of CVP electricity must be mitigated to net zero on a continual basis throughout construction and operations. This will require DWR to constantly "stay ahead" of the estimated emissions through early investment in GHG reduction efforts prior to construction (to ensure mitigation of unavoidable initial construction GHG emissions) and advanced planning for GHG reductions so that throughout the construction and operational period, the net effect of project emissions and this mitigation is that the project will not result in any increase in GHG emissions over baseline conditions. Since some of the planning will rely on the estimated GHG reduction value of future actions during construction and operation, there may be some need for "catch up" GHG reductions if emissions are higher than expected or reduction results are lower than expected. Conversely, if emissions are lower than expected or reduction results are higher than expected, there may be some building up of "forward credits" for the next phase of construction and/or operations.

2) *Plan Development:* Developing a fixed and rigid implementation strategy up-front to cover 12 to 14 years of construction, depending on the alternative, followed by project operation will be restrictive and will potentially preclude DWR from pursing future reduction technologies that could be economically or environmentally superior to options that are currently available.

   Given the constraints associated with developing a fixed and rigid reduction plan to cover all project emissions, the Plan may be developed and implemented over multiple phases. A phased approach provides increased implementation and management flexibility. It also enhances Plan quality as lessons learned during initial phases are applied to future reduction efforts. The first phase of the Plan must address no fewer than the first 5 years of construction. The Plan will be amended to provide implementation details for subsequent phases according to the requirements in Section B below.

The Plan will identify the amount of GHG emissions anticipated in the covered phase, as well as emissions from prior phases (if applicable) and the projected total net emissions of the project. This Draft EIR presents an estimate of annual GHG emissions generated by project construction and displaced purchases of CVP electricity. Although this inventory could be used exclusively to inform the required mitigation commitment, the methods used to quantify emissions in the Draft EIR were conservative. They also do not account for any GHG reduction strategies that may be implemented by DWR pursuant to this measure. Accordingly, this Draft EIR likely overestimates actual GHG emissions that would be generated by the project. DWR may therefore reanalyze GHG emissions for any phase of the project to update the required reduction commitment to achieve net zero.

An updated emissions analysis conducted for the Plan will be performed using approved emissions models and methods available at the time of the reanalysis. The analysis must use the latest available engineering data for the project, inclusive of any required environmental commitments or GHG emissions reduction strategies. Consistent with the methodology used in this Draft EIR, emissions factors may account for enacted regulations that will influence future year emissions intensities (e.g., fuel efficiency standards for on-road vehicles). Emissions from displaced purchases of CVP electricity will be derived by subtracting the project total energy consumption from what would have been generated by the system without implementation of the project, and then multiplying the net change in energy consumption by the statewide grid average emissions intensity.

3) *GHG Reduction Strategies*: Each phase of the Plan will identify the GHG reduction strategies that will be implemented during that phase to achieve the net zero performance standard. Strategies that could be used in formulating the Plan are summarized below. GHG reduction strategies must be verifiable and feasible to implement. The Plan will identify the entity responsible for implementing each strategy (if not DWR) and the estimated GHG reduction that will be achieved by implementation of the strategy. If the selected strategies are shown to exceed total net emissions of that phase, the estimated surplus can be applied as a credit in future phase(s), as explained in Section B.1.

Environmental commitments (Section A.3a) are required project design features that must be incorporated into the Plan. Following environmental commitments, DWR will prioritize selected strategies as: (1) on-site construction strategies (Section A.3b); (2) off-site strategies (Section A.3c); and (3) GHG credits (Section A.3d). The order of priority for the location of selected strategies will be: (1) within the project right-of-way; (2) within communities surrounding the water conveyance alignment (e.g., Hood); (3) throughout California's Central Valley and Northern California; (4) in the State of California; (5) in the United States; and (6) outside of the United States. If the Plan proposes GHG reduction strategies that do not conform to the priorities outlined above, it must present substantial evidence to justify the deviation or explain why higher priority strategies were deemed infeasible as defined under CEQA.

It is possible that some of the strategies could independently achieve the net zero performance standard for the project. Various combinations of strategies could also be pursued to optimize total costs or community co-benefits. DWR will be responsible for determining the overall mix of strategies necessary to ensure the performance standard to mitigate the significant GHG impact is met.

The list of strategies presented in this section is not exclusive. DWR may include additional or new strategies to reduce GHG emissions to the extent that they become commercially available and cost effective and earn a track-record for reliability in real-world conditions. This may include new equipment and vehicle systems (e.g., autonomous construction equipment, fuel-cells), new energy systems (e.g., battery storage), or other technologies (e.g., carbon capture and storage).

a. Environmental Commitments: All phases of the Plan must incorporate the following environmental commitments. Refer to Appendix 3B, *Environmental Commitments and Best Management Practice*, for measure descriptions.

   i. EC-7: *Off-Road Heavy-Duty Engines*

   ii. EC-8: *On-Road Haul Trucks*

   iii. EC-9: *On-Site Locomotives*

   iv. EC-10: *Marine Vessels*

   v. EC-13: *DWR Best Management Practices to Reduce GHG Emissions*

b. On-Site Construction Strategies: Strategies to reduce on-site construction emissions may include but are not limited to the following.

   i. *Purchase Zero-Carbon Electricity:* Enter into a power purchase agreement, where feasible, with utilities that provide electricity service to the study area to purchase construction electricity from renewable sources. Renewable sources must be zero-carbon energy sources (e.g., wind, solar, hydro) and may not be accounted to utility RPS goals.

   ii. *Install Electric Vehicle (EV) Charging Stations at Park-and-Ride Lots:* Install EV charging stations at employee park-and-ride lots.

   iii. *Use Electric Shuttles and Buses:* Require electric shuttles and buses to transport employees from the park-and-ride lots to construction sites.

   iv. *Optimize Delivery Logistics:* Utilize freight instead of on-road haul trucks to deliver construction materials and equipment, if feasible.

c. Off-Site Strategies: Off-site strategies to reduce emissions may include but are not limited to the following.

   i. *Support Community Building Energy Efficiency Improvements:* In coordination with local utilities, fund or contribute to an energy efficiency improvement program to achieve reductions in residential and commercial natural gas and electricity usage. Potential building improvements may include energy efficient appliances, energy efficient boilers, installation of alternative water heaters in place of natural gas storage tank heaters, installation of induction cooktops in place of gas ranges, or installation of cool roofs or green roofs.

ii. *Support Community Renewable Energy Projects:* In coordination with local utilities, fund or contribute to community solar, wind, or other renewable energy projects or programs. This could include providing funding to support utility programs that will allow homeowners to install solar photovoltaic systems at zero or minimal up-front cost. All projects installed under this measure must be designed for high performance (e.g., optimal full-sun location, solar orientation) and additive to utility RPS goals.

iii. *Support Energy Decarbonization Projects:* In coordination with local utilities, fund or contribute to community infrastructure projects (e.g., retirement of natural gas facilities) to support decarbonization of the electric power sector.

iv. *Support Community Transit Programs:* In coordination with local transit providers, fund or contribute to programs to increase the use of public transit (e.g., increased transit frequency, reduced transit fares).

v. *Support Community Pedestrian Network Improvements:* In coordination with local authorities, fund or contribute to programs to increase sidewalk coverage to improve pedestrian access and interconnectivity of the pedestrian network.

vi. *Support Community Bicycle Network Improvements:* In coordination with local authorities, fund or contribute to programs to construct or improve bicycle lane facilities (Class I, II, or IV) or bicycle boulevards.

vii. *Support Community Carshare or Bikeshare Programs:* In coordination with local authorities, fund or contribute to the deployment of neighborhood/city conventional or electric carshare or bikeshare programs.

viii. *Support Transportation Decarbonization Projects:* In coordination with local authorities, utilities, or transit providers, fund or contribute to community infrastructure projects (e.g., electric-transit buses, EV infrastructure) to support decarbonization of the transportation sector.

ix. *Support Biomass Waste Digestion and Conversion Facilities:* Fund or contribute financing to facility development either through long-term power purchase agreements or up-front project financing. Projects should be awarded through a competitive bidding process and chosen for GHG reduction and other environmental benefits to the project area. Projects could provide a range of final products: electricity generation, compressed natural gas for transportation fuels, and pipeline quality biomethane.

x. *Support Agriculture Waste Conversion Development:* Fund or contribute financing to the re-commissioning of thermal chemical conversion facilities to process collected agricultural biomass residues**.** Project funding should provide incentives to farmers in the project area to deliver agricultural wastes to existing facilities.

xi. *Increase Renewable Energy Purchases for Operations:* Increase renewable energy purchases under DWR's REPP) to reduce project emissions. The REPP identifies the quantity of renewable electricity resources that DWR will purchase each year to achieve the GHG emissions reduction goals laid out in its Update 2020.

xii. *Support Tidal Wetland Inundation Projects:* Expand the number of subsidence reversal and/or carbon sequestration projects currently being undertaken by DWR on Sherman and Twitchell Islands. Existing research at the Twitchell Wetlands Research Facility demonstrates that wetland restoration can sequester 25 tons of carbon per acre per year. Measure funding could be used to finance permanent wetlands for waterfowl or rice cultivation, creating co-benefits for wildlife and local farmers.

xiii. *Support Urban Tree Planting:* In coordination with local authorities, fund, contribute to, or implement a program to expand urban tree planting. The program should prioritize native tree species that require minimal water and maintenance, low-biogenic VOC emitting tree species, and low-allergen tree species. All trees should be appropriately distanced from buildings, especially in high fire areas.

xiv. *Conserve Agricultural Lands:* In coordination with local authorities, fund a program to protect agricultural lands from conversion to urban or rural residential development.

d. GHG Credits: A GHG credit enables development projects to compensate for their GHG emissions and associated environmental impacts by financing reductions in GHG emissions elsewhere. GHG credits derived from completed prior actions are referred to as “GHG offsets” or “carbon offsets.” GHG credits derived from future contracted actions are referred to as “GHG future credits” or “GHG future mitigation units” (FMUs). GHG credits (including offsets) are classified as either compliance credits or voluntary credits. Compliance offsets can be purchased by covered entities subject to the cap-and-trade regulation to meet predetermined regulatory targets (to date, the cap-and-trade regulation only allows the use of GHG offsets, not GHG future credits). Voluntary offsets or voluntary GHG future credits are not associated with the cap-and-trade regulation and are purchased with the intent to voluntarily meet carbon neutral or other environmental obligations.

As of June 2021, DWR has 59,552 credits registered with the American Carbon Registry (ACR). One credit is equal to a GHG reduction or GHG removal enhancement of 1 metric ton of CO_2e. All GHG credits must be created through a CARB-approved registry. These registries are currently the ACR, Climate Action Reserve, and Verra, although additional registries may be accredited by CARB in the future. These registries use robust accounting protocols for all GHG credits created for their exchange, including the six currently approved CARB protocols. This mitigation measure specifically requires GHG credits created for the project to originate from a CARB-approved protocol or a protocol that is equal to or more rigorous than CARB requirements under 17 Cal. Code Regs. Section 95972. The selected protocol must demonstrate that the reduction of GHG emissions are real, permanent, quantifiable, verifiable, enforceable, and additional. Definitions of these terms from 17 Cal. Code Regs. Section 95802(a) are provided below (the original text used the term *offset*, which has been replaced in the text below with the generic term *GHG credit,* as this measure allows for use of both offsets and FMUs).

- **Real:** GHG reductions or GHG enhancements result from a demonstrable action or set of actions, and are quantified using appropriate, accurate, and conservative methodologies that account for all GHG emissions sources, GHG sinks, and GHG reservoirs within the [GHG credit] project boundary and account for uncertainty and the potential for activity-shifting leakage and market-shifting leakage.
- **Additional:** GHG reductions or removals that exceed any GHG reduction or removals otherwise required by law, regulation, or legally binding mandate, and that exceed any GHG reductions or removals that would otherwise occur in a conservative business-as-usual scenario.
- **Permanent:** GHG reductions and GHG removal enhancements are not reversible, or when GHG reductions and GHG removal enhancements may be reversible, mechanisms are in place to replace any reversed GHG emissions reductions and GHG removal enhancements to ensure that all credited reductions endure for at least 100 years.
- **Quantifiable:** The ability to accurately measure and calculate GHG reductions or GHG removal enhancements relative to a project baseline in a reliable and replicable manner for all GHG emissions sources, GHG sinks, or GHG reservoirs included within the [GHG credit] project boundary, while accounting for uncertainty and activity-shifting leakage and market-shifting leakage.
- **Verified:** A [GHG credit] project report assertion is well documented and transparent such that it lends itself to an objective review by an accredited verification body.
- **Enforceable:** The authority for CARB to hold a particular party liable and to take appropriate action if any of the provisions of this article are violated.

  Note that this definition of enforceability is specific to the cap-and-trade regulation, where CARB holds enforcement authority, but this measure will employ GHG credits from the voluntary market, where CARB has no enforcement authority. Applying the definition to this mitigation measure means that GHG reductions must be owned by a single entity and be backed by a legal instrument or contract that defines exclusive ownership.

GHG credits may be in the form of GHG offsets for prior reductions of GHG emissions verified through protocols or FMUs for future committed GHG emissions meeting protocols. Because emissions reductions from GHG offsets have already occurred, their benefits are immediate and can be used to compensate for an equivalent quantity of project-generated emissions at any time. GHG credits from FMUs must be funded and implemented within 5 years of project GHG emissions to qualify as a GHG credit under this measure (i.e., there can only be a maximum of 5 years lag between project emissions and their real-world reductions through funding an FMU in advance and implementing the FMU on the ground). Any use of FMUs that result in a time lag between project emissions and their reduction by GHG credits from FMUs must be compensated through a pro-rated surcharge of additional FMUs proportional to the effect of the delay. Since emissions of CO_2 in the atmosphere reach their peak radiative forcing within 10 years, a surcharge of 10% for every year of lag between project emissions and their reduction through an FMU will be added to the GHG credit requirement (i.e., 1.10 FMUs will be required to mitigate 1 metric ton of project GHG emissions generated in the year prior to funding and implementation of the FMU).

Consistent with the priorities outlined above in Section A.2, GHG credits from reduction projects in geographies closest to the water conveyance alignment (i.e., Sacramento and Central Valley) will be prioritized before projects in larger geographies (i.e., Southern California, California, United States, internationally). DWR will inform brokers of the required geographic prioritization for the procurement of GHG credits. GHG credits from reduction projects identified in the Sacramento and Central Valley that are of equal or lesser cost compared to the settlement price of the latest cap-and-trade auction must be included in the transaction. GHG credits from reduction projects in larger geographies may be purchased if adequate credits cannot be found in the Sacramento and Central Valley or they exceed the price maximum identified above. The economic and geographic analysis undertaken to inform the selection of GHG credits must be provided as part of the required documentation discussed below in Section B.3.

All GHG credits will be verified by an independent verifier accredited by the ANSI National Accreditation Board (ANAB) or CARB, or an expert with equivalent qualifications to the extent necessary to assist with the verification. Following the standards and requirements established by the accreditation board (ANAB or CARB), the verifier will certify the following.

- GHG credits conform to a CARB-approved protocol or a protocol that is equal to or more rigorous than CARB requirements under 17 Cal. Code Regs. Section 95972. Verification of the latter requires certification that the credits meet or exceed the standards in 17 Cal. Code Regs. Section 95972.
- GHG credits are real, permanent, quantifiable, verifiable, enforceable, and additional, as defined in this measure.
- GHG credits were purchased according to the geographic prioritization standard defined in this measure.

Verification of GHG offsets must occur as part of the certification process for compliance with the accounting protocol. Because FMUs are GHG credits that will result from future projects, additional verification must occur beyond initial certification. Verification for FMUs must include initial certification and independent verification every 5 years over the duration of the FMU generating the GHG credits. The verification will examine both the GHG credit realization on the ground and its progress toward delivering future GHG credits. DWR will retain an independent verifier meeting the qualifications described above to certify reductions achieved by FMUs are achieved following completion of the future reduction project.

B. Implementation and Enforcement

1) *Phased Analysis and Plan Amendments:* As described above in Section A.1, the Plan may be developed and implemented over multiple phases. Prior to the start of each phase, DWR will update the Plan to calculate the amount of GHG emissions anticipated in the

covered phase, as well as emissions from prior phases (if applicable) and the projected total net emissions of the project. The Plan will identify the specific GHG reduction strategies that will be implemented to meet the net zero performance standard for the covered phase and quantify the expected reductions that will be achieved by each strategy. All emissions and reductions will be quantified in accordance with the requirements outlined in Section A.1.

DWR will retain a qualified professional firm where the supervising staff has at least 10 years of experience performing air quality and GHG analysis to assist with its review and approval of the Plan. Subsequent amendments to the Plan will identify reductions that have been achieved during prior phases and determine if those reductions exceed emissions generated by the project. If the GHG reduction strategies implemented by DWR result in a surplus of reductions above the net zero performance standard, the balance of those reductions may be credited to subsequent phases.

The final phase of the Plan must address operational emissions following construction, accounting for regulations adopted at that time that will reduce project emissions. Specifically, DWR will confirm statewide emissions from electricity transmission will achieve carbon neutrality no later than December 31, 2045, pursuant to SB 100 and the SF_6 Switchgear Regulation (or subsequent regulations). If GHG emissions from displaced purchases of CVP electricity are expected to persist beyond 2045, DWR will calculate the amount of GHG emissions anticipated until the industry achieves carbon neutrality. The final Plan will identify GHG reduction strategies that will be implemented by DWR to meet the net zero performance standard for these emissions.

2) *Timing and Execution:* DWR will prepare the Plan (or first phase of the Plan) prior to issuance of the first construction or grading permit for the project. If DWR elects to use a phased approach, the first phase of the Plan must identify the expected future phases and schedule for amending the Plan to cover future phases.

   Environmental Commitments and selected on-site construction strategies will be included in construction permits (as appliable) and contractor bid packages/agreements. Selected off-site strategies will be completed or operational before completion of the applicable phase. If GHG credits are pursued, DWR will enter the necessary contract(s) to purchase credits prior to the start of each phase. All credits must be retired before completion of the applicable phase.

3) *Reporting:* DWR will conduct annual reporting to verify and document that selected strategies achieve sufficient emissions reductions to mitigate project emissions to net zero. Each report should describe the GHG reduction strategies that were implemented over the prior year, summarize past, current, and anticipated project phasing, document compliance with Plan requirements, and identify corrective actions (if any) needed to ensure the Plan achieves the net zero performance standard. If GHG credits have been purchased to reduce emissions for the reporting year, the annual report must include copies of the offset retirement verification.

   DWR will retain a qualified professional firm where the supervising staff has at least 10 years of experience performing air quality and GHG analysis to assist with its review and approval of the annual reports. Annual reports will be finalized and posted on DWR's website by December 31 of the following year.

Chapter 6: Stakeholder Feedback

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1 Stakeholder Feedback

Southern California Gas Company (SoCalGas) presented opportunities for the Planning Advisory Group (PAG) and Community Based Organization Stakeholder Group (CBOSG) to provide feedback on the Water Resources Evaluation (WRE) at four key milestones including: (1) the draft description of the Scope of Work, (2) the draft Technical Approach, (3) Preliminary Findings and Data, and (4) the Draft Report. These milestones were selected because they are critical points at which relevant feedback can meaningfully influence the study. Table 6-1, below, presented an overview of the four key milestones for the WRE.

Table 6-1 Four Key Milestone Dates for the WRE

Milestone	Date Provided to PAG/CBOSG	Comment Due Date	Responses to Comments in Quarterly Report
1. Scope of Work	July 6, 2023	July 31, 2023	Q3 2023
2. Technical Approach	September 7, 2023	October 20, 2023	Q4 2023
3. Preliminary Findings and Data	February 27, 2024	March 29, 2024	Q1 2024
4. Draft Report	July 5, 2024	August 2, 2024	Q3 2024

Feedback provided at the PAG/CBOSG meetings is memorialized in the transcripts of the meetings. Written feedback received, and responses from SoCalGas, are included in quarterly reports which are provided by SoCalGas to the California Public Utilities Commission (CPUC). Meeting transcripts are also included in the quarterly reports, which are published on SoCalGas's website.[1]

Feedback was incorporated as applicable at each milestone throughout the progression of the study. Some feedback was not incorporated for various reasons including because feedback was outside the scope of the Phase 1 Decision or study or feedback raised issues better suited for third parties to address.

Table 6-2, below, provides a summary of the stakeholder feedback received through the development of the Water Resources Evaluation that was incorporated into the final study. Additionally, some administrative and other minor corrections were made to the final report for the Water Resources Evaluation for clarity.

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[1] Each Quarterly Report can be accessed at https://www.socalgas.com/sustainability/hydrogen/angeles-link.

Table 6-2 Summary of Incorporated Stakeholder Feedback

Thematic Comments from PAG/CBOSG Members	Incorporation of and Response to Feedback
Water Demands for Third-Party Production Stakeholders stated it was not clear whether estimates for water demands needed for third-party clean renewable hydrogen electrolytic production as presented in the study referred to raw water or ultrapure water needs of electrolyzers.	The water demands presented in the Water Resources Evaluation (Table INTRO-1, *Demand Study Projections, Angeles Link Potential Throughput, and Associated Water Needs*) are estimates of the total water demands needed for (i) water pretreatment; (ii) electrolyzer production, and (iii) electrolyzer cooling. The water pretreatment demands (i) encompass the average recovery rate through water pretreatment across the ten potential water sources identified. The electrolyzer production demand (ii) component also encompasses a degree of treatment that occurs for treated water to be fed into the electrolyzer. For clarification, explanatory footnotes have been added to the final Water Resources Evaluation, where applicable, stating that the water demands encompass water demands for electrolyzers, electrolyzer cooling, and water pretreatment (refer to footnotes added to Tables INTRO-1, INTRO-2, INTRO-4, and INTRO-5, as well as Tables 1-1, 1-2, 1-4, and 1-5).
Geographic Scope of Analysis Stakeholders expressed concerns that the Water Resources Evaluation did not account for the potential variability of water sources in different geographic areas, and specifically the three potential production areas of Blythe, Lancaster, and San Joaquin valley.	The Water Resources Evaluation does not evaluate water availability in those specific geographic areas. Third parties will ultimately produce the clean renewable hydrogen and would evaluate specific water supply sources and acquisition mechanisms on a case-by-case basis as details for those production projects develop. In response to this feedback, a new footnote has been added to Section 1.3.1, *Study Areas,* in Chapter 1, *Water Availability Study*, clarifying the limitations of the geographic scope of analysis for this feasibility study.

Thematic Comments from PAG/CBOSG Members	Incorporation of and Response to Feedback
Greenhouse Gas (GHG) Emissions related to Water Development Stakeholders commented on the presentation of the preliminary findings and data for this study that the evaluation should address potential GHG emissions associated with water supply development for clean renewable hydrogen production.	In response to this feedback, additional analysis was added to the original scope of the Water Resources Evaluation and was included in the draft report as Chapter 5, *Supplemental Desktop Analysis – Greenhouse Gas Emissions Associated with Water Treatment and Conveyance*. Chapter 5 includes a literature review of existing publications, and a high-level overview of information related to potential GHGs associated with the treatment and conveyance of water supply in California.

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