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2022 Water Supply Evaluation Update

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Executive Summary

Zone 7 periodically conducts Water Supply Evaluation Updates (WSE Updates) to evaluate water supply conditions in the Tri-Valley to support Zone 7's planning for long-term water supply reliability. Past WSE Updates utilized an Excel-based Water Supply Risk Model to simulate the risk of water supply shortages on an annual timestep. In June 2021, Zone 7 initiated the development of a new model to replace the old version. The New Risk Model runs on RiverWare, a water supply modeling platform, and operates at a finer monthly timestep to simulate monthly variations and constraints on supply and demand. The 2022 Water Supply Evaluation Update (2022 WSE Update) utilizes the New Risk Model to test its capabilities for long-term water supply planning. Additionally, the 2022 WSE Update supersedes the 2019 Water Supply Evaluation Update (2019 WSE Update) by capturing the latest assumptions for Zone 7's demands, Zone 7's system, State Water Project (SWP) reliability, and potential future water supply reliability projects. This evaluation is a high-level assessment, and the 2022 WSE Update is intended to communicate current reliability of Zone 7's water system to stakeholders and the general public, identify actions needed, and inform recommendations to the Zone 7 Board of Directors.

Prior WSE Updates concluded that Zone 7's Water Supply Reliability Policy is unlikely to be met by implementing a single water supply reliability project, and that implementing a portfolio of several water supply reliability projects would be required to meet the Water Supply Reliability Policy. Therefore, the 2022 WSE Update evaluates a range of portfolios, an approach that is consistent with State-level trends and is in-step with long-term water supply planning strategies being implemented by Zone 7's wholesale peer agencies. A Baseline portfolio was developed to represent Zone 7's existing system that includes the planned future addition of new wells. Next, eight multi-project portfolios were developed by layering combinations of water transfers and potential future projects on top of the Baseline. The potential future projects considered were Sites Reservoir Project (Sites), Los Vaqueros Reservoir Expansion (LVE), Bay Area Regional Desalination Project (BARDP or Desal), Potable Reuse, and Delta Conveyance Project (DCP). One single-project portfolio containing only DCP was developed to compare against multi-project portfolios that also contain DCP. Table ES-1-1 summarizes the projects included in the non-Baseline portfolios.

Table ES-1-1: Summary of Projects

Project	Average New Supply	New Storage	New Conveyance (Not Modeled)	Online Date
Sites	8,000 acre-feet per year (AFY)	62,340 acre-feet (AF)	-	2030
Desal	5,600 AFY	-	None, but can be paired with LVE and/or EBMUD Reliability Intertie (see Section 4.2.4) for conveyance	2030
Potable Reuse	8,800 - 9,600 AFY	-	-	2030 with expansion in 2040
Transfers	10,000 AFY	-	-	2023-2030
LVE	-	10,000 AF	Transfer-Bethany Pipeline with total capacity of 300 cubic feet per second (cfs)	2030
DCP	6,500 AFY of restored SWP supply	-	Single tunnel with total capacity of 6,000 cfs	2040

The New Risk Model does not simulate Delta outages (i.e., outages of SWP facilities in the Sacramento-San Joaquin Delta), which would prevent Zone 7 from importing water without alternative conveyance to circumvent the Delta. Therefore, the alternative conveyance component of DCP and LVE (i.e., direct deliveries via the Transfer-Bethany Pipeline), was not modeled. Instead, DCP was modeled as an increase in SWP reliability and LVE was modeled as new storage capacity.

The portfolios were evaluated for their ability to meet Zone 7's Water Supply Reliability Policy. The reliability goals are stated in terms of probability of water supply shortage below.

- **90% chance of shortage reliability goal:** 90% chance of no Municipal and Industrial (M&I) or treated water shortage (or 10% chance of any level of M&I or treated water shortage)

- **99% chance of shortage reliability goal:** 99% chance of a M&I or treated water shortage of up to 15% (or 1% chance of M&I or treated water shortage greater than 15%)

While the policy is directed towards M&I customers, total water shortages, which include treated (i.e., M&I), and untreated water shortages, were evaluated against the policy goals. In general, the effects of water supply reliability projects on reducing potential shortages are not fully realized until around 2045, given that the entire roster of projects is not fully operational until around 2040. Therefore, the portfolios were compared at 2045 conditions. Note that "buildout", which is when Tri-Valley development is expected to cease, is expected around 2040.

The New Risk Model runs 94 "traces" in which each forecasted demand year (2023-2081) is assigned a historical year of hydrology drawn from 1922 to 2015 that was adjusted to capture climate change conditions in 2040. The 94 traces were then used to determine the probability of shortage in each future year for each portfolio. Figures ES-1-1 and ES-1-2 summarize modeled shortage probability for the year 2045. Figure ES-1-1 presents, for each portfolio, the maximum level of shortage that occurred across 90% of model traces for that portfolio. Figure ES-1-2 presents, for each portfolio, the maximum level of shortage that occurred across 99% of model traces for that portfolio. Maximum shortages are higher at a 99% chance because the 99% chance captures 9% more traces with less likely but more unfavorable outcomes than the 90% chance.

For a portfolio to meet the 90% chance of shortage reliability goal, it must have a 90% chance of a 0% shortage in Figure ES-1-1. The Baseline has a 90% chance of a shortage up to 55% or 30,200 AF and does not meet the 90% chance of shortage reliability goal in 2045. The multi-project portfolios show significant improvements, with a 90% chance of shortages up to 2-4% or 900-2,200 AF. The 2-4% shortage levels are small enough that they likely could be mitigated through optimization of Zone 7's operations. Therefore, all eight multi-project portfolios are considered to meet the 90% chance of shortage reliability goal in 2045 because 90% of the time, shortage does not <u>*substantially*</u> exceed 0%. The only non-Baseline portfolio that does not meet the 90% chance of shortage reliability goal is DCP alone, which has a 90% chance of a shortage up to 30% or 16,600 AF. While DCP provides better reliability than the Baseline, DCP alone will not meet the reliability goal, underlining the finding that more than one project is required to meet Zone 7's Water Supply Reliability Policy.

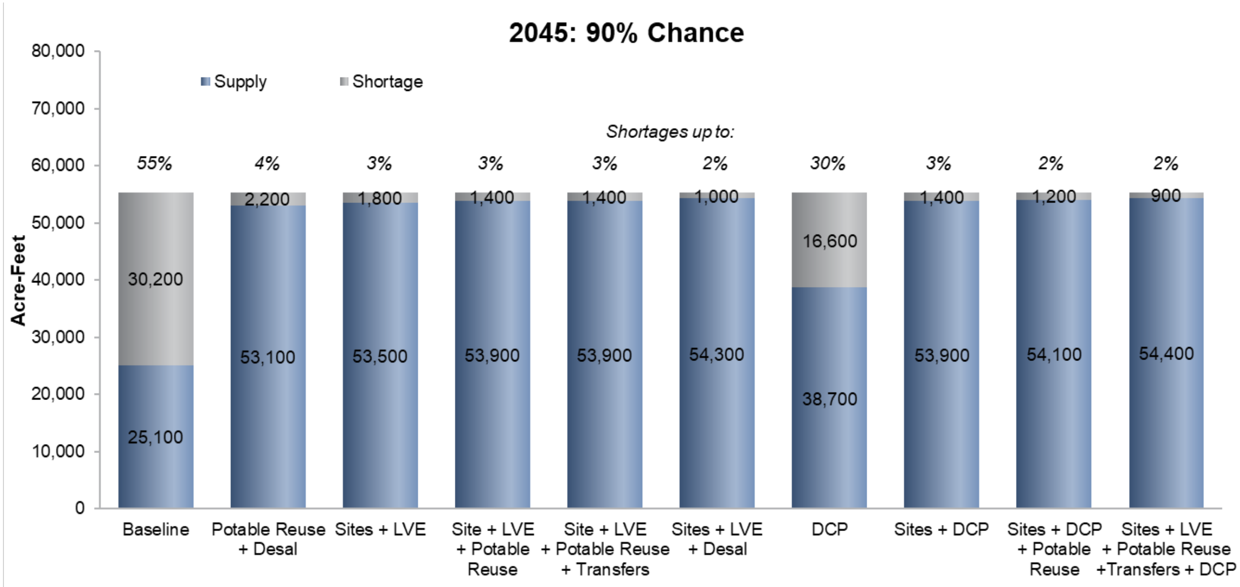

Figure ES-1-1: 90% Chance Conditions in 2045 for all Portfolios

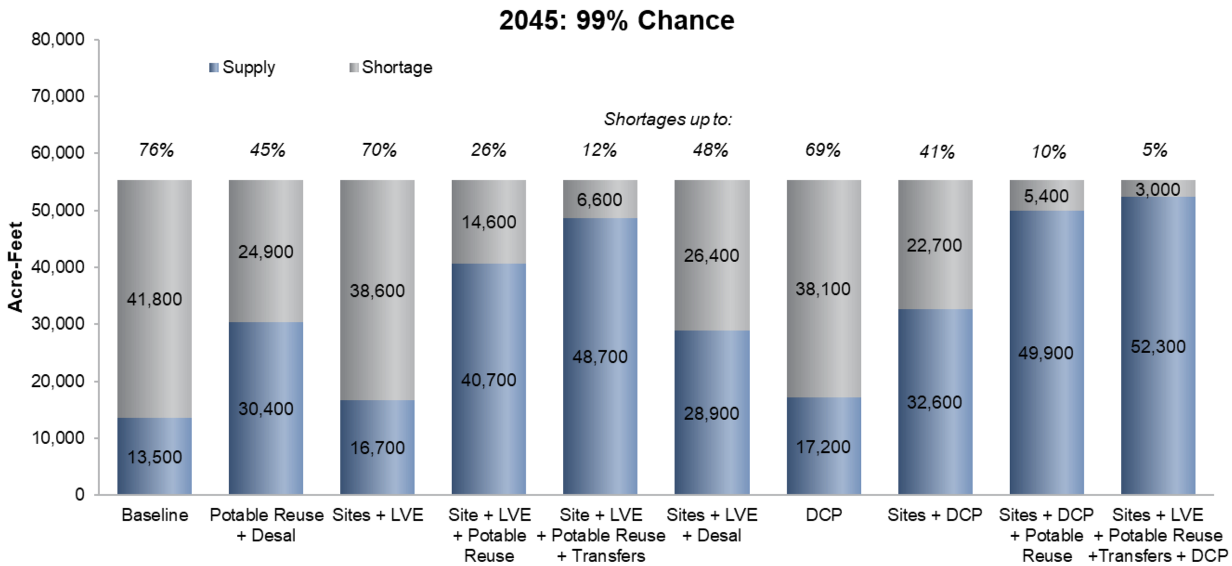

Figure ES-1-2: 99% Chance Conditions in 2045 for all Portfolios

For a portfolio to meet the 99% chance of shortage reliability goal, it must have a 99% chance of a shortage of up to 15% in Figure ES-1-2. The Baseline has a 99% chance of a shortage up to 76% or 41,800 AF and does not meet the 99% chance of shortage reliability goal in 2045. The other portfolios have a large range of maximum shortages at a 99% chance. Sites + LVE and DCP are two portfolios that offer minor improvements relative to the Baseline with shortages of 70% or 38,600 AF and 69% or 38,100 AF, respectively. The remaining portfolios perform significantly better than the Baseline with much smaller maximum shortage levels ranging from 5% to 48%. Generally, the portfolios with a larger number of projects perform better than those with a smaller number of projects. There are only three portfolios that meet the 99% chance of shortage reliability goal in 2045: Sites + LVE + Potable Reuse + Transfers has a 99% chance of a shortage up to 12% or 6,600 AF, Sites + DCP + Potable Reuse has a 99% chance of a shortage up to 10% or 5,400 AF, and Sites + LVE + Potable Reuse + Transfers + DCP has a 99% chance of a shortage up to 5% or 3,000 AF.

The range of shortages that could occur in 2045 for each portfolio, shown in Figure ES-1-3, provides further detail on portfolio performance.

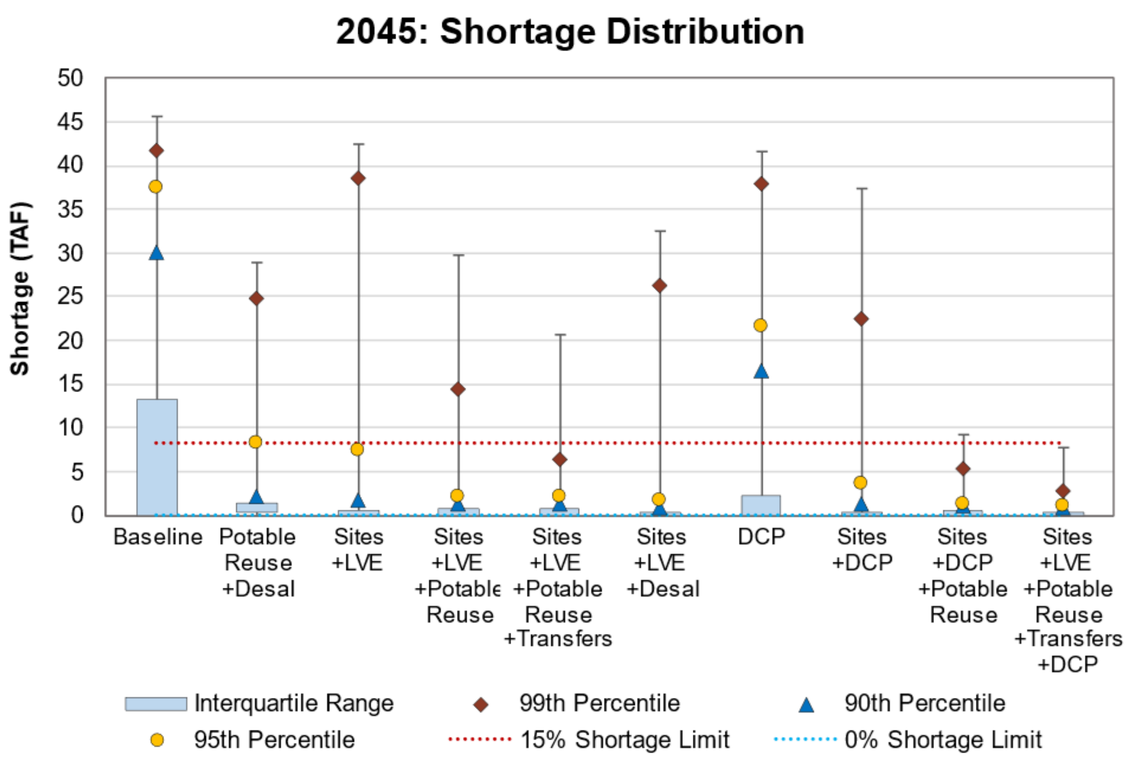

Figure ES-1-3: Distribution of Shortages in 2045 by Portfolio

The 99th percentile plotted in Figure ES-1-3 represents the shortage that is greater than 99% of all potential shortages in 2045 and is equivalent to shortages plotted in Figure ES-1-2. If a portfolio's shortage at the 99th percentile falls at or below the 15% shortage limit, then it will meet the 99% chance of shortage reliability goal. The 90th percentile plotted in Figure ES-1-3 represents the shortage that is greater than 90% of all potential shortage in 2045 and is equivalent to shortages plotted in Figure ES-1-1. If a portfolio's shortage at the 90th percentile falls at or below the 0% shortage limit, then it will meet the 90% chance of shortage reliability goal.

Most portfolios have a large difference between the shortage at the 99th and 90th percentile, indicating that there is a large range of shortages that could occur in the worst 1% to 10% of outcomes. To better visualize the distribution of shortages, the shortage at the 95th percentile (yellow circle) was plotted as a "midpoint" between the 99th and 90th percentiles. The shortage at the 95th percentile represents the shortage that is greater than 95% of all potential shortages (i.e., there is a 95% chance that shortages do not exceed this volume). For all non-Baseline portfolios, the shortage at the 95th percentile is much closer to the 90th percentile compared to the 99th percentile, indicating that risk of extreme shortage is concentrated above the 95th percentile. Additionally, all eight multi-project portfolios have shortages at the 95th percentile that fall at or below 15% (i.e., they have a 95% chance that shortages will not exceed 15%). If the 99% chance of shortage reliability goal was instead replaced by a goal allowing a 95% chance of shortages up to 15%, then eight out of nine non-Baseline portfolios would be considered to meet the goal.

The key findings and recommendations from the 2022 WSE Update are listed below in no particular order.

- The New Risk Model can be maintained and updated to support Zone 7's water supply planning. Therefore, Zone 7 should incorporate new information as it becomes available from the State Water Project, water supply reliability projects, Zone 7's groundwater investigations, etc.

- All eight multi-project portfolios meet the 90% chance of shortage reliability goal at 2045, assuming that the minor shortages can be remedied with optimized operations. The 99% chance of shortage reliability goal at 2045 is more difficult to meet. Portfolios containing a larger number of projects perform better; the only three portfolios to meet the 99% chance of shortage reliability goal at 2045 contain at least three projects. Therefore, Zone 7 should continue to evaluate new opportunities to diversify its water supply portfolio and:

    - Continue to pursue investigation of potable reuse

    - Continue to investigate brackish water desalination with other agencies

    - Continue participation in Sites Reservoir Project for average reservoir releases of 10,000 AFY

    - Continue participation in Los Vaqueros Reservoir Expansion and evaluate participation level for storage (Los Vaqueros Reservoir) and conveyance (Transfer-Bethany Pipeline)

    - Continue participation in the Delta Conveyance Project.

- At 2045, five multi-project portfolios have a 99% chance of maximum shortages much greater than 15% and a 95% chance of maximum shortages up to 15%. The current 99% chance of shortage reliability goal sets a maximum shortage limit associated with extreme and very rare conditions that may be unreasonably difficult or costly to achieve. Therefore, Zone 7 should consider revising the 99% chance of shortage reliability goal.

- Most new supply alternatives are not anticipated to be available until at least 2030. Transfers before 2030 help bolster storage, benefit long-term reliability, and result in reductions in the 99% chance shortages beyond 2030. Therefore, Zone 7 should pursue transfers (an average of 10,000 AFY) until additional long-term supply sources become available.

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Abbreviation	Definition
ACWD	Alameda County Water District
AF	Acre-Feet
AFY	Acre-Feet per Year
BARDP	Bay Area Regional Desalination Project
BAWSCA	Bay Area Water Supply and Conservation Agency
CA	California
CCWD	Contra Costa Water District
COL	Chain of Lakes
COL PL	Chain of Lakes Pipeline
CRSS	Colorado River Simulation System
CVP	Central Valley Project
DCP	Delta Conveyance Project
DCR	Delivery Capability Report
DSRSD	Dublin San Ramon Services District
DVWTP	Del Valle Water Treatment Plant
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
GW	Groundwater
HEC-RAS	Hydrologic Engineering Center River Analysis System
ISM	Index Sequential Method
LDV	Lake Del Valle
LVE	Los Vaqueros Reservoir Expansion
MCL	Maximum Contaminant Level
MWD	Metropolitan Water District of Southern California
M&I	Municipal and Industrial
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanoic Sulfonic Acid
PL	Pipeline
PPWTP	Patterson Pass Water Treatment Plant
SBA	South Bay Aqueduct
SWP	State Water Project
TBP	Transfer-Bethany Pipeline
TM	Trademark
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
CR (VI)	hexavalent chromium
WSE	Water Supply Evaluation
WTP	Water Treatment Plant

1. Introduction

1.1 Purpose of the 2022 Water Supply Evaluation Update

Zone 7 Water Agency (Zone 7) has a mission to deliver safe, reliable, efficient, and sustainable water and flood protection services. The 2022 Water Supply Evaluation Update (2022 WSE Update) supports Zone 7's mission by facilitating the development of a diversified water supply plan and by evaluating and developing appropriate new water supply and reliability opportunities.

Zone 7 is the water wholesaler for the Livermore-Amador Valley, also referred to as the Tri-Valley, and supplies treated water to four retail water supply agencies (retailers): California Water Service – Livermore District (Cal Water), Dublin San Ramon Services District (DSRSD), City of Livermore (Livermore), and City of Pleasanton (Pleasanton). These retailers deliver water for municipal and industrial (M&I) purposes within their individual service areas. Zone 7 also serves treated water directly to a small number of direct retail customers and serves untreated water to agricultural customers. The majority of Zone 7's water is supplied as treated water to the four retailers for M&I use.

Zone 7 last updated its evaluation of water supply conditions in the Tri-Valley area in the 2019 Water Supply Evaluation Update (2019 WSE Update) (Zone 7, 2019). The 2022 WSE Update incorporates new developments since the 2019 WSE Update such as:

- **New Water Supply Risk Model:** Zone 7 developed a new Water Supply Risk Model utilizing RiverWare, a water supply modeling software platform. Compared to the previous Excel-based risk model, the New Risk Model is better catered to supporting Zone 7's short- and long-term water supply planning. For example, the New Risk Model, with its monthly timestep, can better simulate monthly delivery and demand variation compared to the old model with its annual timestep.

- **New Demand Projections:** Zone 7 conducted the 2020 Tri-Valley Municipal and Industrial Water Demand Study (2020 Demand Study) (Zone 7, 2020), which involved building a land-use based demand model to project buildout M&I demand. The buildout demand from the 2020 Demand Study was similar to the demand used in the 2019 WSE Update.

- **Decreased Well Capacity:** Zone 7 is anticipating that some wells will require treatment for per- and polyfluoroalkyl substances (PFAS) and/or hexavalent chromium [Cr (VI)] to meet the pending new MCLs and other regulatory standards. The treatment will cause a reduction in well production capacity. The reduced production capacity was reflected in the New Risk Model. Well capacity was further reduced in the New Risk Model by building in expected well downtime based on input from Zone 7's Operations staff.

- **Updated State Water Project (SWP) Reliability Projections:** The California Department of Water Resources (DWR) released the State Water Project Final Delivery Capability Report 2021 (2021 DCR) (DWR, 2021a), which contains the latest projections for future SWP reliability.

- **Updated Water Supply Reliability Projects:** Updated information and assumptions for several water supply reliability projects were incorporated.

The 2022 WSE Update is a high-level assessment of Zone 7's long-term water supply reliability and is intended to inform recommendations to the Zone 7 Board of Directors. Additionally, the 2022 WSE Update provides Zone 7's water retailers (i.e., Cal Water, DSRSD, Livermore, and Pleasanton), Zone 7's other customers, and the general public with an outlook on the Tri-Valley's water supply conditions.

1.2 Overview of 2022 Water Supply Evaluation Update Process

The 2022 WSE Update consists of several technical elements, which include development of a new Water Supply Risk Model (New Risk Model), qualitative evaluation of different water supply and storage projects, quantitative evaluation of water supply reliability based on combinations of those projects into portfolios, and assessment of costs associated with the portfolios. The technical elements comprising the 2022 WSE Update are documented over eight sections in this report, outlined briefly below:

- Review of Zone 7's current and future water demand projections (Section 2).
- Overview of Zone 7's existing supply sources and storage facilities (Section 3).
- Overview of Zone 7's future potential water supply and storage projects, including a review of water supply portfolios evaluated in this 2022 WSE Update (Section 4).
- Discussion of the methodology and data sources used in developing the New Risk Model, including a review of key model assumptions, operating rules, and performance metrics (Section 5).
- Summary of the modeled performance of each water supply portfolio defined in Section 4, as well as discussion of selected sensitivity analyses to better quantify uncertainties in future system conditions and operations (Section 6).
- Analytical comparison of the reliability and costs associated with the water supply portfolios defined in Section 4 (Section 7).
- Review of the conclusions and next steps recommended by the 2022 WSE Update (Section 8).

The 2022 WSE Update was developed in consultation with Zone 7's retailers, Zone 7's Water Resources Committee, and the Zone 7 Board. The Committee and Board meetings were public meetings and provided an opportunity for the general public to be informed about Zone 7's water supply planning activities and provide feedback. Stakeholder comments and directions received were integrated at various stages of the process. The dates and subjects of the stakeholder meetings in support of this effort are identified in Table 1-1.

Table 1-1: Summary of Stakeholder Meetings in Support of the 2022 WSE Update

Meeting Date	Stakeholder Group	Subject
March 3, 2022	Zone 7 Retailers	Overview of 2022 WSE Update Strategy
August 30, 2022	Zone 7 Retailers	Review of 2022 WSE Update Draft Results
August 31, 2022	Zone 7 Board	Review of 2022 WSE Update Draft Results
March 21, 2023	Zone 7 Water Resources Committee	Review of the 2022 WSE Update Draft Report
March 30, 2023	Zone 7 Retailers	Review of the 2022 WSE Update Draft Report
April 19, 2023	Zone 7 Board	Review of the 2022 WSE Update Draft Report

1.3 Key Planning Goals Addressed

Zone 7 has a Water Supply Reliability Policy that sets goals for maintaining a reliable M&I water supply system throughout varying hydrologic conditions. The policy states:

Zone 7 will meet its treated water customers' water supply needs as follows:

- 100% of M&I water demands 90% of the time
- At least 85% of M&I water demands 99% of the time.

As written, the reliability goals are stated in terms of probability of meeting demand. The reliability goals can be re-stated in terms of probability of shortage (i.e., the probability of unmet demand):

- **90% chance of shortage reliability goal:** 90% chance of no M&I or treated water shortage (or 10% chance of any level of M&I or treated water shortage)
- **99% chance of shortage reliability goal:** 99% chance of a M&I or treated water shortage of up to 15% (or 1% chance of M&I or treated water shortage greater than 15%).

Although Zone 7 primarily delivers treated water to M&I customers, Zone 7 also delivers untreated water to agricultural customers. On average, approximately 87% of Zone 7's water deliveries are to treated water customers and 13% are to untreated water customers.[1] The Water Supply Reliability Policy sets targets for meeting treated water demands. Zone 7 does not currently have a policy that sets reliability targets for meeting untreated water demands, although the potential for shortages is addressed in the 'Rules and Regulations Governing Untreated Water Service'.[2] When evaluating the water supply portfolios against Zone 7's reliability goals, total shortages for the water supply system serving both treated and untreated water demands are presented. Shortages discussed in this report are total shortages (i.e., the sum of treated and untreated water shortages), unless otherwise stated.

[1] Statistic is based on water deliveries from 2019 to 2022.
[2] https://www.zone7water.com/sites/main/files/file-attachments/exhibit_a_-_rules_and_regulation_2021.pdf?1625093446

2. Summary of Projected Water Demands

Zone 7’s total water demand consists of treated water deliveries to Zone 7’s major retailers and direct customers, untreated water deliveries to agricultural customers, and system losses (i.e., unaccounted water). Historically, Zone 7’s total water demand has generally trended upwards until 2013. Demand decreased significantly from 2014 through 2015 due to conservation efforts during drought conditions. Demand increased between 2015 and 2020 and began decreasing in 2021 due to the return of dry conditions that began in 2020. On September 1, 2021, the Zone 7 Board of Directors passed a resolution to declare a Drought Emergency and Stage 2 Water Shortage Emergency. This declaration requires 15% mandatory conservation from Zone 7’s retailers in accordance with the 2020 Urban Water Management Plan (2020 UWMP) and Water Shortage Contingency Plan. Drought conditions have persisted in 2022 and demand is expected to remain at lower levels until water supply conditions significantly improve.

The 2022 WSE Update is intended to assess the long-term reliability of Zone 7’s water supply system. Although Zone 7 forecasts its near-term demand to be depressed due to current drought conditions, long-term demand is forecasted to grow until buildout, which is expected to occur in 2040. Since the 2019 WSE Update, Zone 7 has updated its demand projections with the 2020 Demand Study. The 2020 Demand Study involved developing a new regional, land-use based water demand forecasting model to project M&I demand at buildout. Six different demand scenarios were assessed and the baseline scenario, which reflects recent consumption patterns and expected growth, was used for the 2022 WSE Update. Based on the baseline demand scenario, Zone 7’s annual total water demand at buildout is projected at 55,300 acre-feet per year (AFY). This projection is essentially the same as the annual total water demand of 55,500 AFY used in the 2019 WSE Update. See Figure 2-1 for Zone 7’s historical demand and future demand projections.

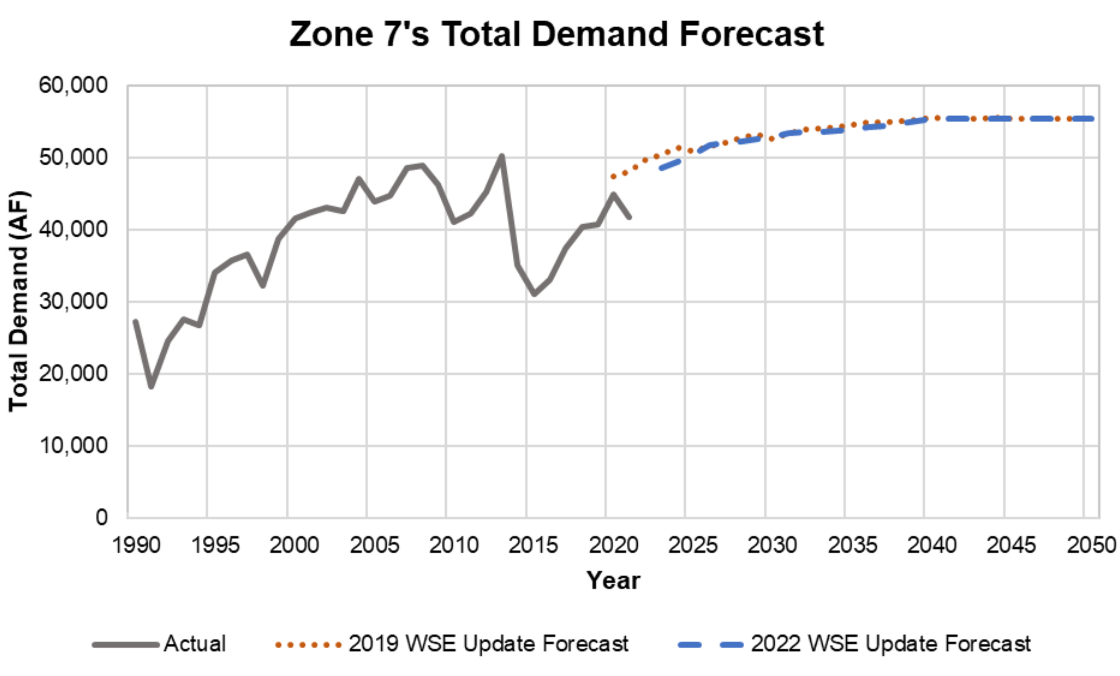

Figure 2-1: Comparison of Zone 7's Total Demand Forecasts

Figure 2-2 shows the breakdown of the Zone 7's total demand forecast at buildout. Treated, or M&I, demand is expected to account for 85% of the total demand and untreated demand is expected to account for the remaining 15%. M&I demands are further broken down in Figure 2-3. These buildout demands are used to calculate the modeled shortages in 2045.

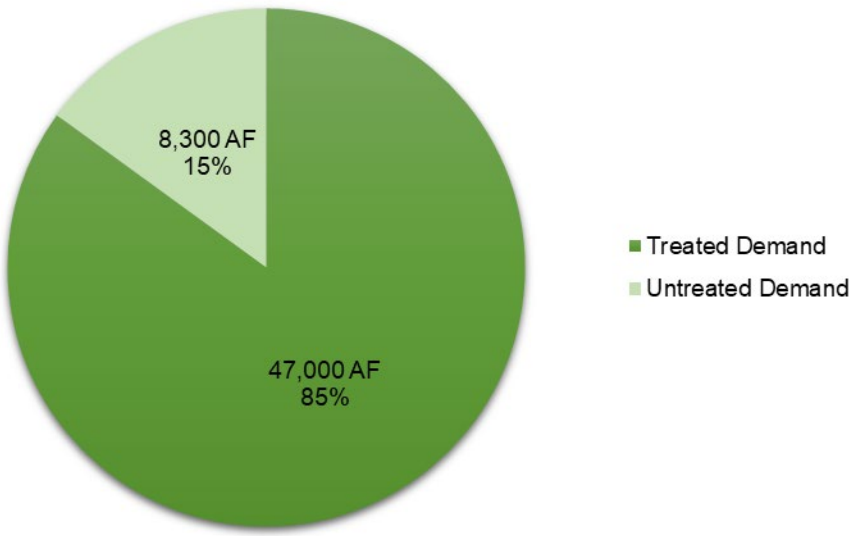

Figure 2-2: Breakdown of Zone 7's Total Demand Forecast at Buildout

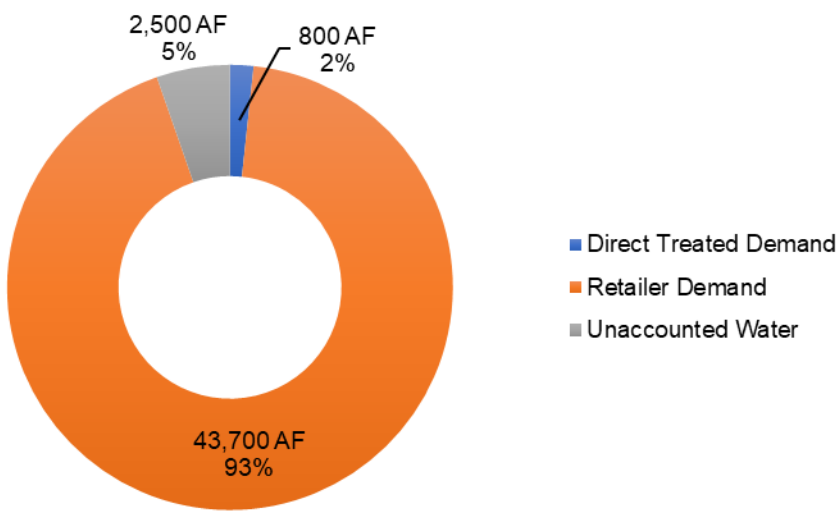

Figure 2-3: Breakdown of Zone 7's M&I Demand Forecast at Buildout

3. Summary of Existing Water Supply System

The Zone 7 service area includes the cities of Livermore, Pleasanton, Dublin, and the Dougherty Valley portion of the City of San Ramon. Significant growth through 2040 is anticipated in the service area, which would increase water demands. Decisions on community growth rest with local jurisdictions, not Zone 7. Customers include four retailers (i.e., Cal Water, DSRSD, Livermore, and Pleasanton), agricultural users in Alameda County, and a small number of other users. See Figure 3-1 for a location map of the Zone 7 service area.

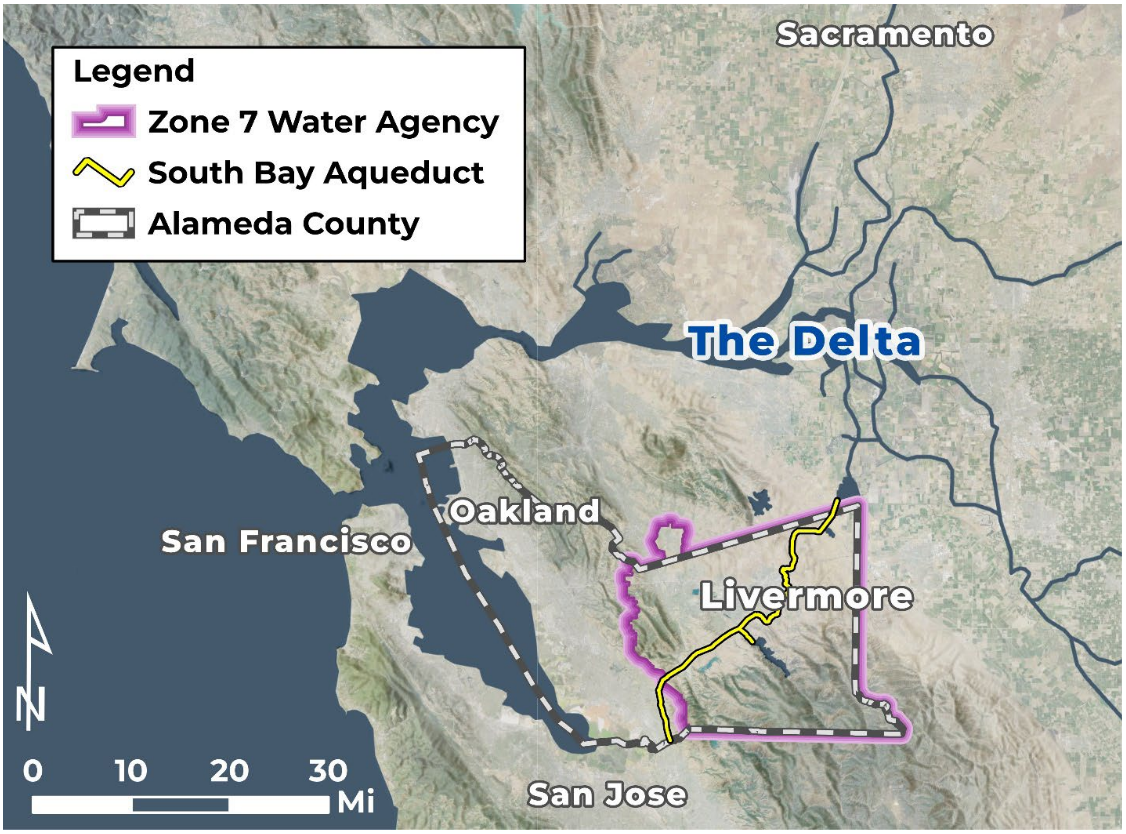

Figure 3-1: Zone 7 Location Map

3.1 Existing Supply Sources

This Section provides a brief overview of Zone 7’s current water supply sources, including the State Water Project (SWP), local surface water (Arroyo Valle), local groundwater, and transfers. For more information on these supplies, see also Zone 7’s 2020 UWMP (2021).

3.1.1 SWP Supplies

Zone 7 is a SWP Contractor, and thus receives SWP water through a long-term water supply contract with the Department of Water Resources (DWR). Imported water from the SWP, which is owned and operated by DWR, provides about 90% of Zone 7's water supply on an annual average basis. SWP water originates within the Feather River watershed, is captured in and released from Lake Oroville, and flows through the Sacramento–San Joaquin River Delta (Delta) before it is conveyed by the South Bay Aqueduct (SBA) to Zone 7. Untreated customers receive raw water deliveries directly from turnouts off the SBA. Water for M&I uses is delivered to the Zone 7 transmission system from the SBA and is treated at either the Del Valle Water Treatment Plant (DVWTP) or Patterson Pass Water Treatment Plant (PPWTP), which are both owned and operated by Zone 7. The types of water available to Zone 7 from the SWP include Table A allocations, carryover, and Article 21 water.

3.1.1.1 Table A Allocation and Carryover

Each SWP Contractor has a maximum annual contract amount referred to as "Table A." Zone 7's maximum Table A allocation is 80,619 acre-feet per year (AFY). In practice, the actual amount of SWP water available to Zone 7 under the Table A allocation process (presented as % of maximum Table A) varies from year to year due to hydrologic conditions, water demands of other contractors, existing SWP stored water, SWP facility capacity, and environmental/regulatory requirements. From 2017 to 2021, Zone 7's Table A allocations ranged from 5% to 85%, demonstrating the annual variability of supply. DWR has projected decreasing reliability of Table A supplies. In the 2021 DCR, DWR projects long-term average Table A allocations to be 55% under existing conditions and 51% under future conditions in 2040. The future conditions scenario incorporates impacts from climate change and sea level rise and is therefore more conservative than the existing conditions scenario. The New Risk Model uses the future conditions scenario to simulate the long-term reliability of Zone 7's SWP supplies.

As a SWP contractor, Zone 7 has the ability to store unused Table A water from one year to the next in the SWP's San Luis Reservoir (see Section 3.2), when there is storage capacity available. This "carryover" water is also called Article 56 water, in reference to the relevant contract terms. The maximum amount of Article 56 water that can be stored in a given year is dependent on the year's final Table A allocation. Once stored, Article 56 water may remain as carryover as long as San Luis Reservoir storage is available. In the event that the SWP can fill San Luis Reservoir during a wet year, a SWP contractor is required to promptly use their carryover water or it (or a portion thereof) will be converted to SWP water and lost to the SWP contractor; this event is called "carryover spill". From 2017 to 2021, Zone 7's carryover deliveries ranged from approximately 2,600 AFY to 15,700 AFY (approximately 8,800 AFY on average). Zone 7 has typically targeted about 10,000 AFY of carryover storage in San Luis Reservoir in preparation for the possibility of a coming dry year.

3.1.1.2 Article 21 Water

Article 21 of the SWP contract allows SWP contractors to take deliveries above their Table A allocations when surplus water is available from the SWP. DWR can only offer Article 21 deliveries if: 1) it does not interfere with SWP operations or Table A allocations, 2) excess water is available in the Delta, and 3) it will not be stored in the SWP system. As described in the 2021 DCR, Article 21 water deliveries are highly variable year-to-year, but also by month. This water becomes available during short time windows in the wet season when storms bring excess water that DWR cannot store in San Luis Reservoir. When Article 21 water becomes available, SWP contractors can request delivery, and the available water is distributed generally in proportion to the Table A contract amounts of those contractors requesting delivery. Delivery of Article 21 water requires the ability to store the water in a non-SWP facility during very wet conditions and/or the ability to use the water directly without impacting scheduled Table A deliveries to Zone 7 (i.e., Article 21 delivery cannot be used to substitute scheduled Table A deliveries). Historically, these conditions have been difficult to meet for Zone 7 and have resulted in infrequent and low yields. Zone 7 has not received any Article 21 deliveries since 2007 when it received 912 AF. Having access to additional storage in the future would increase Zone 7's access to Article 21 water.

3.1.1.3 Turnback Pool Water

Under Article 56d, SWP contractors with unused Table A water during a given year may sell that water to other SWP contractors via a "turnback pool" administered by DWR. Historically, only a few SWP contractors have been able to make turnback pool water available for purchase, particularly in normal or dry years. Zone 7 received approximately 100 AF, 820 AF, and 710 AF in 2015, 2016, and 2017, respectively, from the Turnback Pool Program. This program is largely obsolete now, as the SWP contract has recently been amended to allow for more flexible options for transfers/exchanges of water among SWP contractors.

3.1.2 Local Surface Water - Arroyo Valle

Zone 7, along with Alameda County Water District (ACWD), has a water right to divert flows from the local watershed named "Arroyo del Valle" or "Arroyo Valle." Runoff from local precipitation in the Arroyo Valle watershed above Lake Del Valle is stored in the lake. Lake Del Valle also stores imported surface water deliveries from the SWP and is owned and managed by DWR as part of the SWP. Water supply in Lake Del Valle is conveyed to Zone 7 via the SBA through operating agreements with DWR. Water delivered for M&I uses is treated at Zone 7's DVWTP. Local surface water inflows to Lake Del Valle, after accounting for permit conditions, are equally divided between ACWD and Zone 7 under their respective permits. From 2017 to 2021, deliveries from Arroyo Valle ranged from approximately 0 AFY to 8,100 AFY (approximately 4,900 AFY on average). The New Risk Model reflects Zone 7's long-term average local water yield of approximately 7,000 AFY from Arroyo Valle. Zone 7 also has access to flood releases from Lake Del Valle, but it currently lacks storage to capture these flood releases. Currently, Zone 7 uses flood release water directly at the DVWTP as much as possible. Enhanced local storage via the Chain of Lakes (discussed in Section 4.2.3) will allow for greater capture of local water, increasing the yield of Zone 7's water right.

3.1.3 Local Groundwater

Zone 7 produces groundwater supplies from the Livermore Valley Groundwater Basin (Main Basin). The Main Basin's sustainable yield is estimated to be 13,400 AFY and is allocated to Zone 7's retailers (i.e., Cal Water, DSRSD, and Pleasanton) and other groundwater users for drinking water supply and agriculture. Zone 7's pumping does not use the sustainable yield. Instead, Zone 7 only pumps what it has artificially recharged into the basin. Zone 7 releases water from the SBA (SWP and Arroyo Valle water) to Arroyo Valle and Arroyo Mocho to artificially recharge the basin. From 2017 to 2021, total retailer groundwater production (including groundwater pumped for DSRSD by Zone 7) ranged from 4,800 AFY to 7,100 AFY (approximately 5,800 AFY on average). Zone 7's groundwater production over the same time period (excluding Zone 7 pumping for DSRSD) ranged from approximately 3,900 AFY to 14,000 AFY (approximately 8,500 AFY on average). Zone 7's long-term average pumping (including Zone 7's pumping for DSRSD) is approximately 4,700 AFY.

A portion of Zone 7's groundwater production from the Mocho Wellfield is treated at the Mocho Groundwater Demineralization Plant (MGDP) to remove total dissolved solids (TDS) and hardness. Zone 7 plans to install additional demineralization facilities in the future if needed to meet its salt management goals. In recent years, Zone 7 has been monitoring for and has detected concentrations of PFAS and Cr (VI) in several production wells. Zone 7 is managing its production wells in anticipation of the establishment of federal and state MCLs and other regulatory standards.

3.1.4 Yuba Accord and Other Transfers

Zone 7 can receive water mostly during dry years through its participation in the Yuba Accord, which is set to expire in 2025. Zone 7 has also participated in other short-term transfers (e.g., Mojave Water Agency). In 2021, Zone 7 received 1,000 AF from the Yuba Accord and 8,100 AF from Mojave Water Agency. Zone 7 has also benefited from participating in the Dry-Year Transfer Program, facilitated by the State Water Contractors, and received a total of 190 AF in 2021.

3.2 Existing Storage Facilities

This Section provides a brief overview of Zone 7's existing storage facilities, including Lake Del Valle, the Main Basin, Kern County Storage and Recovery Program (or Kern Banks), and San Luis Reservoir.

3.2.1 Lake Del Valle

As described above in Section 3.1.2, runoff from Arroyo Valle is stored in Lake Del Valle (or Del Valle Reservoir). Zone 7 typically can capture up to 7,500 AF of Arroyo Valle water in Lake Del Valle and can store this water from one year to the next.

3.2.2 Livermore Valley Groundwater Basin

Zone 7 uses the Main Basin as a local storage facility and Zone 7 only pumps groundwater that it has artificially recharged using its surface water supplies. The Main Basin has an estimated storage capacity of 254,000 AF. To avoid significant depletion of groundwater storage, Zone 7 operates the Main Basin such that groundwater in storage remains between its full volume and the historical low storage volume of 128,000 AF. This 126,000 AF is considered the Main Basin's operational storage and the remaining 128,000 AF is considered reserve storage that is intended for use only during emergency conditions. Zone 7 artificially recharges the Basin by releasing water from turnouts along the SBA and the Del Valle Branch Pipeline into the Arroyo Mocho and Arroyo del Valle for percolation into the Basin.

3.2.3 Kern County Storage and Recovery Program

Zone 7 has invested in two groundwater storage banks in the Kern County Subbasin, collectively referred to as the "Kern County Storage and Recovery Program", or "Kern Banks". The Kern Banks are operated by Semitropic Water Storage District (1998) and Cawelo Water District (2006). Zone 7 recovers water from the Kern Banks during dry years in the form of imported surface water through pumpback or exchange via the SWP system. Delivery of this banked water supply requires the SWP's Banks Pumping Plant in the Delta and the SBA to be operational. Low levels of water flowing through the SWP system can limit the delivery of these banked supplies via exchange. Additional information on each bank is described below.

3.2.3.1 Semitropic Water Storage District

Zone 7 has a storage capacity of 78,000 AF in Semitropic Water Storage District (Semitropic Water Bank). Water put into Semitropic Water Bank is subject to a 10% loss. Under the contract terms, Zone 7 can request up to 9,100 AF of pumpback and up to 8,645 AF of exchange water. Pumpback is water that is pumped out of the Semitropic aquifer and into the SWP system. Exchange water is water that is transferred between Zone 7 and Semitropic by adjusting the amounts of Table A water delivered to Zone 7 and Semitropic; the availability of this type of water depends on the SWP allocation. Between 2017 and 2021, Zone 7 stored approximately 23,800 AF after losses and withdrew approximately 11,600 AF from Semitropic Water Bank.

3.2.3.2 Cawelo Water District

Zone 7 has a storage capacity of 120,000 AF in Cawelo Water District (Cawelo Water Bank). Water put into Cawelo Water Bank is subject to a 50% loss. Zone 7 can store up to 5,000 AFY in the bank (with additional up to 5,000 AFY water loss to Cawelo). Zone 7 can request up to 10,000 AFY of pumpback or SWP exchange water from the Cawelo Water Bank. Between 2017 and 2021, Zone 7 stored approximately 11,300 AF after losses and did not make withdrawals from Cawelo Water Bank.

3.2.4 San Luis Reservoir

As described in Section 3.1.1.1, Zone 7 can store unused Table A water in San Luis Reservoir from one year to the next (Article 56 or carryover) as long as storage in San Luis Reservoir is available. Zone 7 can lose water stored in San Luis Reservoir if the reservoir "spills" (i.e., DWR needs the storage capacity to store its SWP water) during a wet year. Zone 7 typically targets storing approximately 10,000 AFY of its Table A allocation as carryover in San Luis Reservoir.

4. Overview of Potential Water Supply Reliability Projects

This Section provides an overview of the potential water supply reliability projects that Zone 7 is considering. A portfolio of several of these projects is likely required to meet Zone 7's Water Supply Reliability policy. The projects are summarized with costs in Section 4.3. This section concludes with a discussion of the portfolio-based approach applied in this WSE Update in Section 4.4.

4.1 Potential Water Supply Projects

The reliability of the SWP, which provides the bulk of Zone 7's water supply, has been declining over the past years, and is projected to continue declining in the future. Consequently, Zone 7 will need to add new water supply in its water supply portfolio to meet future demand. Zone 7 is evaluating Sites Reservoir Project, Bay Area Regional Desalination Project, Potable Reuse, and water transfers as opportunities for new supply. Due to the evolving nature of these projects, the information presented below is subject to change over time as projects are better defined.

4.1.1 Sites Reservoir Project (Sites)

4.1.1.1 Overview

Sites is a proposed new off-stream reservoir located in Glenn and Colusa counties that would capture and store excess stormwater flows from the Sacramento River after all other water rights and regulatory requirements are met. The project's location is depicted in Figure 4-1. As an off-stream reservoir, Sites will not dam a major river system and will not block fish migration and/or spawning. It is widely recognized that California needs additional storage as climate change is expected to cause more precipitation to fall as rain rather than snow. With a proposed storage capacity of 1.5 million acre-feet, Sites will increase the resilience of statewide water supplies to the impacts of climate change. Sites can be operated in coordination with SWP and the federal Central Valley Project (CVP) reservoirs (e.g., Oroville, Shasta, and Folsom), thereby increasing the flexibility and reliability of statewide water supplies. In addition to water supply and storage benefits, Sites will also provide a dedicated allocation of water for the environment. Environmental benefits include releases from the reservoir to improve conditions for fish, migratory birds, and other native species. Because Sites provides both new water supply and storage, it adds flexibility to Zone 7's water supply system. For example, the timing of deliveries from Sites Reservoir could be modified to maximize yields from other water supplies and/or to accommodate delivery timing restrictions of other supplies.

Figure 4-1: Sites Reservoir Project Location Map

The Sites Project Authority was formed on August 26, 2010 as a Joint Powers Authority to pursue the development and construction of Sites Reservoir. The Sites Project Authority is governed by a 9-member Board of Directors representing public agencies within the Sacramento Valley. Zone 7 participates in Sites as a member of the Reservoir Committee. The Reservoir Committee consists of 22 water agencies across California who are investing in the project and provides recommendations to the Sites Project Authority to help advance the project.

At Zone 7's current level of participation, Sites is expected to provide Zone 7 an average of 10,000 AFY of annual releases from the reservoir. After accounting for losses as the released water travels through the

Delta ("carriage water" or "carriage losses"), the average annual water supply from Sites is estimated to be 8,000 AFY. This level of water supply is equivalent to Zone 7's share of storage in the reservoir at approximately 62,340 AF. Zone 7's share of storage in Sites is approximately 6% of the storage capacity allocated to participating water agencies. As currently envisioned, Sites would be utilized by Zone 7 as a water supply for all year types (i.e., wet, average, and dry years).

4.1.1.2 Schedule

In December 2016, the Zone 7 Board authorized participation in Phase 1 of the project. The project is now in Phase 2 and in January 2022, the Zone 7 Board authorized participation through the completion of Phase 2 at the end of December 2024. Phase 2 focuses on completing the environmental documentation, securing key permits, advancing design to a 30% level, and preparing for long-term financing. The next phases are as follows: Phase 3 – final design and right-of-way acquisition, Phase 4 – construction and commissioning, and Phase 5 – construction close-out and operations. Sites is planned to be fully operational in 2030.

4.1.2 Bay Area Regional Desalination Project (BARDP or Desal)

4.1.2.1 Overview

For this 2022 WSE Update, the terms "BARDP" and "desal" are used interchangeably.

BARDP is a regional project that seeks to desalinate brackish water from the Delta to provide water supply to the participating Bay Area water agencies. The project is currently a partnership among Contra Costa Water District (CCWD), East Bay Municipal Utility District (EBMUD), San Francisco Public Utilities Commission, Valley Water, and Zone 7. The project proposes constructing a desalination plant in eastern Contra Costa County. Brackish water would be diverted using CCWD's existing Mallard Slough Pump Station and the desalination plant would remove the salts from the source water to produce fresh water. The project facilities are shown in Figure 4-2. Diversions would occur in accordance with CCWD's existing water right license and permit. The proposed desalination plant has a planned production capacity of up to 20 million gallons per day (MGD). Zone 7's estimated yield is up to 5 MGD or 5,600 AFY. BARDP is expected to provide a reliable water supply to Zone 7 that would be available in most hydrologic conditions except for critically dry conditions. In critically dry conditions, the project may be unable to divert the source water due to potential water curtailments.

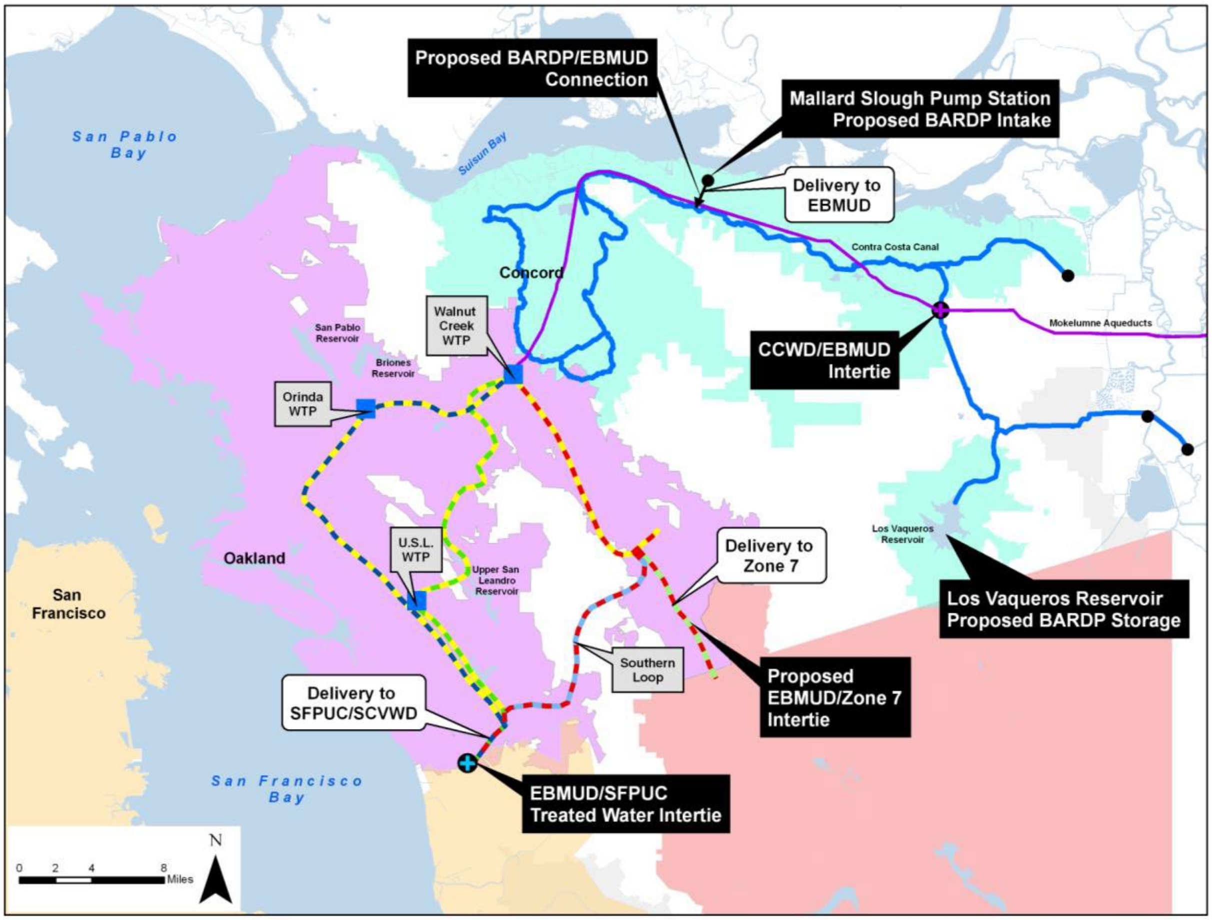

Figure 4-2: Bay Area Regional Desalination Project Facilities

BARDP provides operational flexibility because there are multiple conveyance routes for Zone 7 to receive this new water supply. Zone 7 could take delivery as:

- Raw water through the Delta and South Bay Aqueduct (SBA) by exchanging water with CCWD
- Treated water through a reliability intertie with EBMUD to supply the west side of Zone 7's transmission system
- Raw water through Los Vaqueros Reservoir Expansion (LVE) facilities, which could either be stored in the reservoir or conveyed via LVE facilities to Zone 7

The last two conveyance options provide resiliency against Delta outages as they are alternative conveyance routes that do not go through the Delta. Refer to Section 4.2.2.1 for discussion on the risk of Delta outages.

4.1.2.2 Schedule

There has been recent renewed interest in desalination as part of the Bay Area Regional Reliability Partnership, and there may be new developments in the near-term. The water yield of the project is being re-evaluated, and the participating agencies may change. BARDP is still in the planning phase, and there is no formally approved project at this time. If a project is approved over the next few years, it could be in service by 2030 although that would be under an expedited or aggressive timeline.

4.1.3 Potable Reuse

4.1.3.1 Overview

Potable reuse is the use of purified water derived from wastewater effluent to supplement potable water supplies. Its main benefits include local production and control, drought resistance, and use of an existing water resource. Potable reuse differs from recycled water, as recycled water is the use of treated wastewater for non-potable uses such as irrigation. Although Zone 7 does not supply recycled water, recycled water service has been available through DSRSD, Livermore, and Pleasanton for many years. Potable reuse in the Tri-Valley would involve a partnership between Zone 7 and its retailers to manage the wastewater collection and treatment, and purified water production and distribution/storage. Local wastewater resources would be collected by DSRSD and Livermore and treated to meet drinking water standards. Following treatment, potential purified water uses include:

- Indirect potable reuse
  - Groundwater recharge via injection wells
  - Groundwater recharge via surface spreading at Chain of Lakes (see Section 4.2.3)
- Direct potable reuse
  - Raw water augmentation to Zone 7's Del Valle Water Treatment Plant

For the purposes of the 2022 WSE Update, the New Risk Model reflects indirect potable reuse as groundwater recharge of purified water via injection wells. Average annual yield was estimated based on DSRSD's and Livermore's projected wastewater availability and assumed a two-phase project that initially produces a lower yield of 8,800 AFY from 2030 to 2039 and reaches a maximum yield of 9,600 AFY beginning in 2040. Potable reuse operations were assumed to occur year-round with Livermore providing year-round wastewater supplies and DSRSD providing seasonal wastewater supplies. The assumed yields do not account for the potential reduction of wastewater flows due to conservation regulations that have set statewide lower indoor water use targets. Zone 7 will work with DSRSD and Livermore to monitor future expected yields for potable reuse.

4.1.3.2 Schedule

In 2018, the Tri-Valley water agencies completed the Joint Tri-Valley Potable Reuse Technical Feasibility Study (Potable Reuse Study) to evaluate a wide range of potable reuse options and found that potable reuse is technically feasible for the Tri-Valley with benefits to water reliability and water quality. In 2021, Zone 7 began the Desktop Groundwater Contaminant Mobilization Study, which was identified as a next step in the Potable Reuse Study, to characterize the potential for contaminant mobilization in the groundwater basin under recharge of purified water. This study is expected to be completed by spring of 2023.

There is no formally approved Zone 7 potable reuse project at this time; however, DSRSD is currently leading an effort to develop the Regional Purified Water Pilot Project (Purified Water Pilot). In addition to DSRSD and Zone 7, the Purified Water Pilot involves Alameda County Water District, City of Livermore, Livermore-Amador Valley Water Management Agency, and Union Sanitary District. The effort will be focused on public outreach and monitoring of grant funding opportunities for the Purified Water Pilot through December 2023; construction of a 0.2 MGD purified water facility is envisioned after this phase.

4.1.4 Transfers

4.1.4.1 Overview

Transfer water can be used to supplement Zone 7's existing water supplies. Zone 7 has participated in water transfers in the past. For example, in 2021, Zone 7 received 8,100 AF from Mojave Water Agency. Zone 7 is currently participating in the Yuba Accord through 2025, which can provide transfer water mostly during dry years. Zone 7 is also participating in the Dry-Year Transfer Program, which is facilitated by the State Water Contractors. In 2021, Zone 7 received 1,000 AF from the Yuba Accord and 190 AF from the Dry-Year Transfer Program.

Zone 7 relies on SWP facilities to convey transfer water to the Tri-Valley. Restrictions related to water transfer include:

- SWP Capacity – SWP supplies have a higher priority for conveyance through the SWP system compared to other supplies. Therefore, the SWP must have sufficient excess capacity to facilitate the water transfer.
- Carriage water – Transfers of non-SWP water that are conveyed through the Delta incur losses, referred to as carriage water. Carriage water, expressed as a percentage of the water transfer amount, varies year-to-year and is determined based on Delta conditions.
- Transfer window – Transfers conveyed through the Delta must occur during the transfer window of July through November.

Annual water transfers are subject to water market conditions. Generally, water transfers are less expensive in wet years when extra water is available and more expensive in dry years when extra water is scarce. One strategy Zone 7 could utilize is purchasing more water during wet years at a lower cost to store for later use in dry years. The 2019 WSE Update found that Zone 7 would need steady annual transfers ranging from 5,000-10,000 AFY in the short-term to meet its reliability policy goals. In this 2022

WSE Update, portfolios that included transfers were modeled with 10,000 AFY of annual transfers occurring through 2030.

4.1.4.2 Schedule

Advantages of water transfers include: 1) they can be pursued as needed in any given year and 2) they do not require new infrastructure to be constructed. In current drought conditions, however, water transfer opportunities have been limited. Zone 7 continues to pursue and evaluate water transfer opportunities in the Bay Area and statewide. Through the Bay Area Regional Reliability Partnership, Zone 7 is participating in a Reclamation grant-funded project to develop a "Regional Water Market Program," which will identify transfer types and opportunities and develop a road map to facilitate transfers and exchanges in the Bay Area.

4.2 Potential Water Storage and Conveyance Projects

In addition to diversifying its water supply portfolio, Zone 7 can improve the benefit and use of various water supplies by investing in water storage and conveyance projects. Zone 7 relies heavily on the Delta to convey imported supplies to the Tri-Valley, and a Delta outage resulting in loss of access to water from the SBA would impact Zone 7. The Delta's ability to convey water has become increasingly unreliable due to aging levees, earthquake risk, climate change, and increasingly stringent regulations resulting from declining ecosystem conditions. If Zone 7 were to invest in local storage and alternative conveyance that circumvents the Delta, the agency would be better prepared to respond to a Delta outage. Zone 7 is evaluating the Los Vaqueros Reservoir Expansion, Delta Conveyance Project, Chain of Lakes Pipeline, and EBMUD Reliability Intertie as potential new water storage and conveyance projects. Due to the evolving nature of these projects, the information presented below is subject to change over time as the projects are better defined.

4.2.1 Los Vaqueros Reservoir Expansion (LVE)

4.2.1.1 Overview

Los Vaqueros Reservoir is an off-stream reservoir located in Contra Costa County and is owned and operated by CCWD. The reservoir was originally built in 1998 and was expanded in 2012 to a total capacity of 160,000 AF. LVE is the proposed expansion of the reservoir by an additional 115,000 AF, bringing the new total capacity to 275,000 AF. In addition to the expansion of Los Vaqueros Reservoir, LVE intends to construct the Transfer-Bethany Pipeline and other supporting facilities. The project is depicted in Figure 4-3. The Transfer-Bethany Pipeline provides alternative conveyance to Zone 7 by connecting LVE facilities to the SBA.

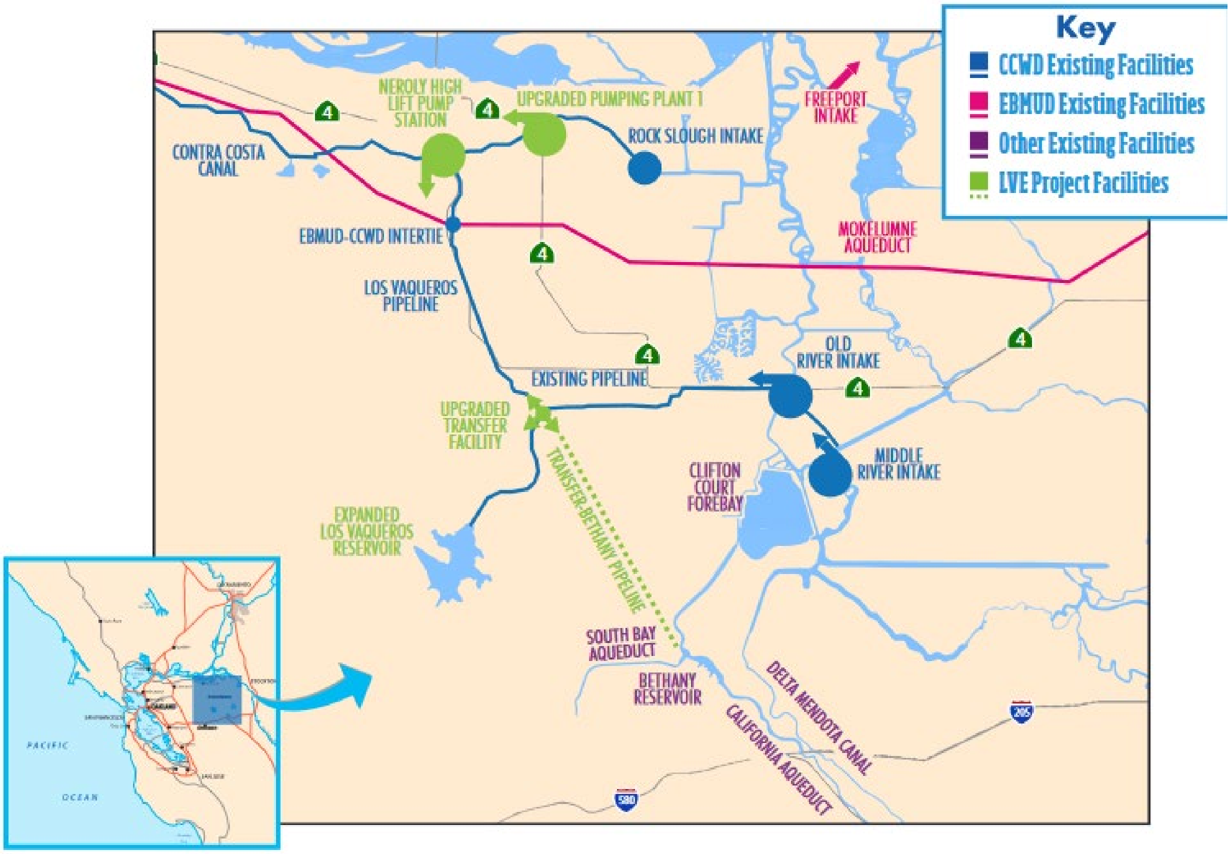

Figure 4-3: Los Vaqueros Reservoir Expansion Project Facilities

LVE's key objectives are to: 1) develop water supplies for environmental water management, 2) increase M&I water supply reliability, and 3) improve the quality of water deliveries. CCWD and local agency partners (LAPs) have partnered together to advance the project and fulfill these objectives. Zone 7 is one of the LAPs; LAPs are water agencies that serve urban areas, agricultural areas, and wildlife refuges in the Bay Area and Central Valley. In October 2021, CCWD and LAPs formed the Los Vaqueros Reservoir Joint Powers Authority (LV JPA) to govern the design, construction, operations, and maintenance of LVE. Zone 7 is a member of the LV JPA.

It is currently envisioned that Zone 7 could receive up to 10,000 AF of storage in the expanded reservoir. Since Los Vaqueros Reservoir is upstream of and near Zone 7, the project could provide local storage that is accessible to Zone 7 when needed. A key advantage of LVE is its location; Los Vaqueros Reservoir is located between the Delta and Zone 7, so Zone 7 would have access to its stored water in the reservoir even during a Delta outage. Other storage facilities located further downstream of Zone 7, such as the Kern Banks and San Luis Reservoir, depend on SWP pumping facilities in the Delta to convey recovered water to Zone 7, making downstream storage inaccessible during a Delta outage. LVE could protect Zone 7 against a Delta outage by providing alternative conveyance through Transfer-Bethany Pipeline. Zone 7 currently relies on Banks Pumping Plant (Banks), the SWP's Delta intake, to convey imported water from the Delta, to the SBA, and finally to Zone 7. Instead of relying solely on Banks, Zone 7 could use Transfer-Bethany Pipeline to take direct delivery from one of LVE's four Delta intakes.

Transfer-Bethany Pipeline provides protection against a Banks outage by opening up another route to deliver water to Zone 7.

4.2.1.2 Schedule

In September 2016, Zone 7's Board approved participation in LVE. Zone 7 is currently committed to LVE through the Multi-Party Agreement Amendment No. 4, which provides funding for the project through June 30, 2023. The project is currently in its development phase, with current work focusing on securing financing through the Water Infrastructure Finance and Innovation Act (WIFIA), developing project agreements, refining operations modeling, and refining cost estimates. Construction is planned to begin in 2024 and Transfer-Bethany Pipeline is expected to be constructed and ready for partial operations in 2027. Full operations of LVE are expected to begin around 2030, when the reservoir expansion is complete.

4.2.2 Delta Conveyance Project (DCP)

4.2.2.1 Overview

DWR's proposed DCP involves construction of two new intake facilities in the North Delta with a total capacity of 6,000 cubic feet per second (cfs) and a single below ground tunnel under the Delta to convey water from the new intakes to the existing Bethany Reservoir on the California Aqueduct. The project's potential tunnel alignments and intake alternatives are depicted in Figure 4-4. The purpose of DCP is to modernize the aging SWP infrastructure in the Delta to restore and protect the reliability of SWP water deliveries. The Delta is a critical conveyance component of SWP; the SWP diverts water in the South Delta for delivery to SWP Contractors south of the Delta, such as Zone 7.

The DCP supersedes the previously proposed conveyance project known as California WaterFix. California WaterFix was the proposed construction of two new diversion points and two new below ground tunnels under the Delta to convey water from the Sacramento River north of the Delta to the SWP and Central Valley Project facilities in the South Delta. DWR approved California WaterFix in July 2017, but rescinded its approval in May 2019 in response to Governor Newsom's announcement in the State-of-the-State speech on February 2019 that he did not support California WaterFix as configured, but that he did support a single tunnel conveyance project. In January 2020, DWR released a Notice of Preparation of an Environmental Impact Report (EIR) for the DCP pursuant to the California Environmental Quality Act (CEQA). In July 2022, DWR released the Draft EIR for the DCP.

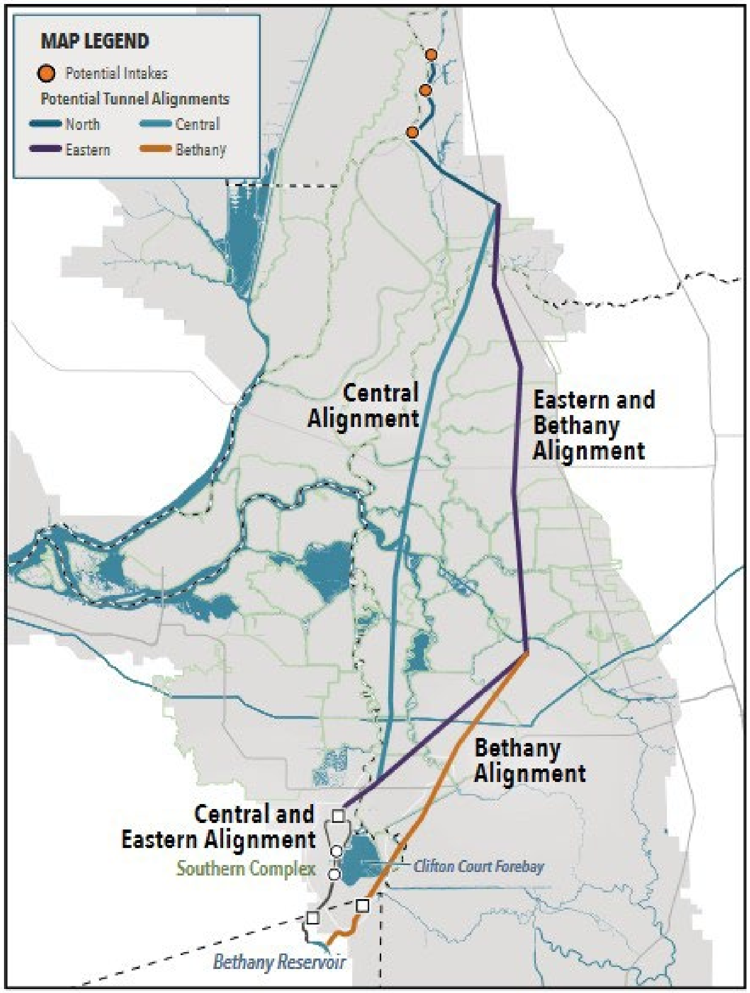

Figure 4-4: Delta Conveyance Project Alignment Alternatives

The DCP intends to address the risk of a Delta outage brought on by climate change/sea level rise and seismic events:

- Climate change is expected to raise sea levels, potentially causing saltwater to enter the interior Delta and compromise freshwater supplies. The South Delta is situated at a lower elevation than the North Delta, so sea level rise could render the South Delta unusable for water supply diversions during portions of the year due to saltwater intrusion. The DCP would provide an alternative conveyance for fresh water from North Delta to South Delta when the South Delta is too saline.
- A major Northern California earthquake could cause levee failures and subsequent flooding in the Delta. Experts suggest that fresh water supply through the Delta could be lost for months, if not a year or two. The DCP would provide an alternative conveyance of freshwater from North Delta to South Delta while levee repairs and other work are being completed.

Zone 7 relies on the Delta to convey approximately 90% of its existing incoming supplies under normal conditions. Currently, all of Zone 7's imported water supply (e.g., Table A, carryover, banked water from the Kern County Storage and Recovery Program, and transfers) is conveyed through the Delta. DCP could benefit Zone 7 by minimizing water supply disruptions due to poor Delta conditions. Additionally, DCP could provide South Delta flow pattern improvements to fisheries, water transfer capacity and carriage water savings, and water quality improvements for SWP deliveries.

Zone 7's current participation level is based on its maximum Table A amount of 80,619 AF, constituting 2.2% of the project's participation after accounting for SWP contractors not participating in DCP. DCP will not increase the maximum Table A amounts for participating SWP Contractors. However, DCP could help protect against declining SWP reliability. Based on the DCP's Draft EIR, the SWP's average long-term reliability in future conditions with DCP implemented is 59%. For comparison, based on the 2021 DCR, the SWP's average long-term reliability in future conditions without DCP implemented is 51%. Note that although the DCP's Draft EIR and the 2021 DCR were based on similar CalSim 3 models, San Luis Reservoir operations were modeled differently across the two models.

4.2.2.2 Schedule

The DCP's environmental planning phase is expected to span from 2020 through 2024. In November 2020, the Zone 7 Board approved participation in the first two years of DCP's environmental planning phase through December 2022. In April 2022, the Zone 7 Board approved continued participation in DCP through December 2024. The current project phase focuses on completing the environmental documents, permitting, and regulatory processes. The following phase is the construction of the project. The DCP is planned to be fully operational around 2040.

4.2.3 Chain of Lakes (COLs) and Chain of Lakes Pipeline (COL PL)

4.2.3.1 Overview

The future COLs, shown on Figure 4-5, is a series of former and active gravel quarry pits located in the Tri-Valley. The COLs will ultimately consist of ten lakes named Lakes A through I and Cope Lake, connected through a series of conduits. Zone 7 currently owns Lake I and Cope Lake and expects Lakes A and H to be transferred to Zone 7 within the next few years once reclamation is completed. The remaining lakes (B through G) will be transitioned to Zone 7 over the next decades, likely through 2060. The COLs will ultimately cover approximately 1,500 acres and have about 150,000 AF of total storage volume; 31,000 AF is estimated to be available for operational storage.

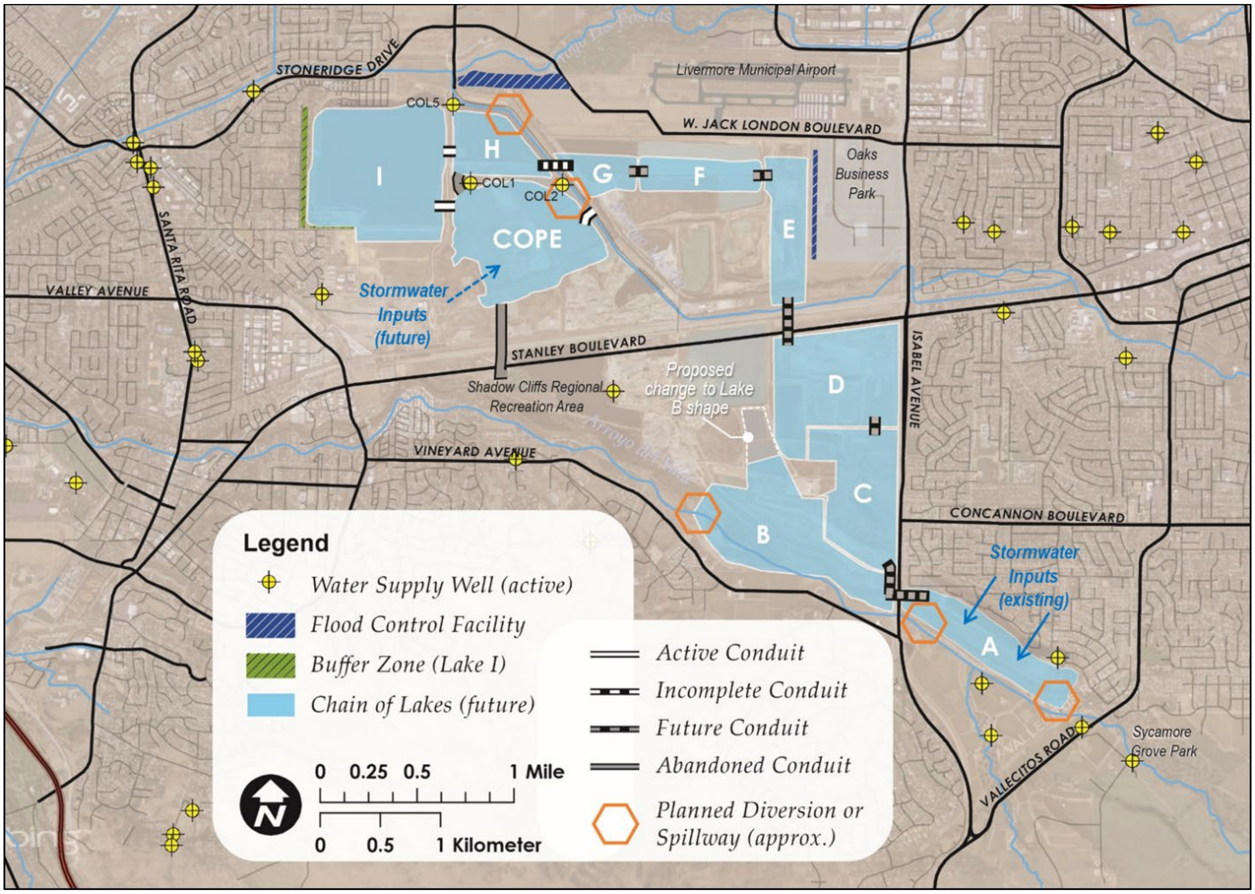

Figure 4-5: Chain of Lakes Existing and Planned Facilities

Zone 7 envisions using the COLs as a large facility for water management and related purposes, including surface storage of local runoff, SWP water, other potential future sources of surface water, stormwater, and possibly recycled water. This surface water storage capability allows Zone 7 to facilitate increased recharge of the Main Basin and perfect its water right on the Arroyo Valle, thereby increasing future yields from this local supply. Lake I is currently planned to be the key recharge lake. More details on the potential future use of the COLs can be found in the 2020 Update of the Preliminary Lake Use Evaluation for the Chain of Lakes.

Zone 7's water supply system is currently not connected to the lakes that Zone 7 currently owns in the northern COLs area. The COL Pipeline (COL PL) is a proposed a multi-use pipeline that would connect the northern COLs area with Lake A and the SBA/DVWTP and allow Zone 7 to access and utilize storage in the northern COLs area prior to the full COLs being in service. The COL PL can be utilized in several ways, including:

- The COL PL could convey excess surface water supply, including imported water and local water from the Arroyo Valle, to the COLs for storage and groundwater recharge. Zone 7 could capture an average of approximately 3,000 AFY of additional local water that could be stored in the COLs.

- The COL PL could supply raw water from the COLs to DVWTP for use under emergency and drought situations.
- The COL PL could be paired with potable reuse. Purified water could be stored in the COLs and the pipeline could be used to convey the purified water to DVWTP for raw water augmentation.

4.2.3.2 Schedule

Zone 7 is conducting a pipeline alignment study to evaluate the cost and benefits associated with potential pipeline alignments. Figure 4-6 depicts the potential alignments that are under evaluation. The study is scheduled for completion in early 2023. For this 2022 WSE Update, the COL PL's estimated cost is presented in Table 4-1 and the COL PL was defined in the New Risk Model as discussed in Section 5.1.2. However, the COL PL is not included in the portfolio-based analysis. The COL PL will continue to be evaluated over the coming months as the alignment study is completed.

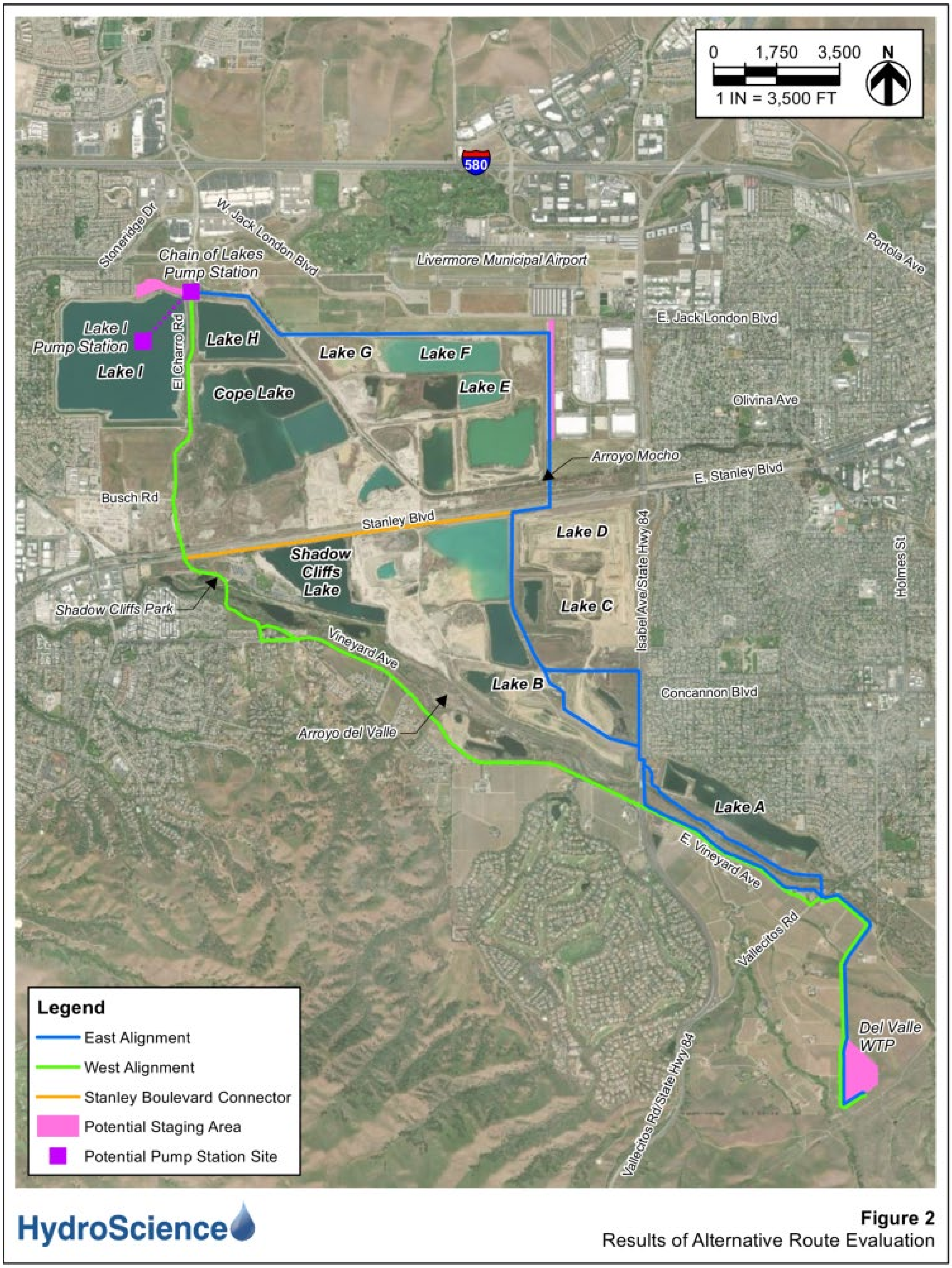

Figure 4-6: Chain of Lakes Pipeline Potential Alignments

4.2.4 East Bay Municipal Utility District (EBMUD) Reliability Intertie

4.2.4.1 Overview

The EBMUD reliability intertie is a proposed 30-inch diameter treated water pipeline to connect EBMUD and Zone 7's systems. The pipeline spans approximately seven miles and could be used to deliver up to 10 MGD of treated water from EBMUD to the west side of Zone 7's transmission system. Zone 7's water supply infrastructure is currently very isolated and Zone 7 is completely reliant on the Delta and SBA system for imported water. The reliability intertie provides alternative conveyance and could be used to deliver imported treated water to Zone 7 in case the Delta and/or SBA are experiencing an outage. See Section 4.2.2.1 for more discussion on Delta risks.

Potential water supply reliability projects to pair with the reliability intertie include:

- BARDP – Zone 7 could receive its yield from BARDP through the reliability intertie.
- LVE – Zone 7 could receive its delivery of stored water from Los Vaqueros Reservoir through the reliability intertie. Additionally, water diverted through the LVE intakes could also be delivered to Zone 7 through the reliability intertie.

The reliability intertie was not modeled as part of the 2022 WSE Update but will continue to be evaluated over the coming years as the BARDP and LVE projects are developed further.

4.2.4.2 Schedule

The reliability intertie was previously planned to be in service by 2030. Zone 7 will continue to evaluate the project's implementation and schedule.

4.3 Summary of Water Supply Reliability Projects

Table 4-1 summarizes the estimated water supply reliability benefits, various cost metrics, and online date of the projects. For the purposes of the 2022 WSE Update, the New Risk Model utilizes the average new supply, new storage, and online date assumptions from Table 4-1. Refer to Section 6 for the New Risk Model assumptions by portfolio. The price level of the costs presented in Table 4-1 were adjusted to 2022$ for the portfolio cost analysis in Section 7.2, but are shown in their original price level in this table. Due to the evolving nature of these projects, the assumptions/estimates presented below are subject to change.

Table 4-1: Summary of Projects

Project	Average New Supply	New Storage	New Conveyance	Total Capital Cost ($M)	Zone 7's Share of Capital Cost ($M)	Zone 7's Unit Cost When Operational[1]	Online Date
Sites[2]	8,000 AFY	62,340 AF	-	$3,934 (2021$)	$176 (2021$)	$1,100/AF (2021$)	2030
Desal[3]	5,600 AFY	-	None, but can be paired with LVE and/or EBMUD Reliability Intertie for conveyance	$191 (2022$)	$95 (2022$)	$3,500/AF (2022$)	2030
Potable Reuse[4]	8,800 - 9,600 AFY	-	-	$310 (2022$)	$310 (2022$)	$3,200/AF (2022$)	2030 with expansion in 2040
Transfers[5]	10,000 AFY	-	-	$80.2 (2022$)	$80.2 (2022$)	$1,000/AF (2022$)	2023-2030
LVE[6]	-	10,000 AF	Transfer-Bethany Pipeline with total capacity of 300 cfs	$1,376 (future$)	$48 (future$)	$2,700/AF (2031$)	2030
DCP[7]	6,500 AFY of restored SWP supply	-	Single tunnel with total capacity of 6,000 cfs	$15,900 (2020$)	$350 (2020$)	$3,100/AF (2020$)	2040
COLs & COL PL[8]	3,000 AFY	150,672 AF	Pipeline with total capacity of 20 MGD	$125 (2022$)	$125 (2022$)	$2,700/AF (2022$)	2027

Notes/assumptions:

1. Zone 7's unit cost when operational includes debt service and O&M, unless noted otherwise.

2. Sites: Zone 7's current participation in Sites is expected to provide 10,000 AFY of average annual releases from the reservoir. Based on the operations modeling provided by the Sites Project Authority in July 2022, the average delivery to Zone 7 after accounting for Delta carriage losses is 8,000 AFY. Costs are based on the Sites Draft Plan of Finance analyses from October 2021 assuming project financing at historical average rates with no WIFIA loan. Actual costs may change depending on factors such as final project design, Zone 7's participation amount, financing terms, and project operations.

3. Desal: Costs are based on a 10 MGD facility with Zone 7's share at 5 MGD and Zone 7 receiving its yield as treated water delivered using the EBMUD Reliability Intertie. Capital costs and O&M costs, excluding wheeling cost, are based on the 2019 WSE Update. Wheeling cost is based on the EBMUD Proposed Updated Usage Fees for Los Vaqueros report dated June 2021, which

utilizes a longer wheeling route than assumed in BARDP reports. Costs are escalated to 2022$. Actual costs may change depending on factors such as final project design, Zone 7's participation amount, financing terms, and project operations.

4. Potable Reuse: Costs are based on a single-phase project providing an average yield of 10,000 AFY through seasonal treatment of wastewater sourced from DSRSD and Livermore, as defined in the 2018 Joint Tri-Valley Potable Reuse Technical Feasibility Study. Refer to Section 4.1.3.1 for details on the two-phase potable reuse project reflected in the New Risk Model. Costs are from the 2019 WSE Update and are escalated to 2022$. Project yield is subject to substantial uncertainty, as it is both a function of project size and wastewater availability. This analysis does not consider any yield reductions that might occur from water conservation efforts associated with Senate Bill 606 and Assembly Bill 1668. Actual costs may change depending on factors such as final project design, financing terms, and project operations.

5. Transfers: Annual transfers of 10,000 AFY are assumed to occur over 2023-2030. Cost is based on a purchase price of $1,000/AF and $200k of administrative/legal/environmental costs that occur in year 1. Actual costs may change depending on factors such as water market conditions, transfer amount, and financing terms.

6. LVE: Costs are based on the LVE Proforma model dated August 2022, which assumed 9,000 AF of storage allocation, 4.3% of conveyance allocation, and 1,400 AFY of average deliveries for Zone 7. The capital costs are in future prices (future$), in which costs are escalated to their year of occurrence over the life of the project. The LVE Proforma model will be refined in the near future and values presented are subject to change based on factors such as final project design, Zone 7's participation amount, financing terms, and project operations.

7. DCP: Based on the DCP's Draft EIR, DCP may restore an average of approximately 6,500 AFY of Zone 7's SWP Table A supplies relative to future conditions without DCP. Costs are based on estimates provided by State Water Contractors to Zone 7 in August 2022. O&M costs were not available at the time of writing; Zone 7's unit cost when operational consists of only debt service and excludes O&M costs. Actual costs may change depending on factors such as final project design, financing terms, and project operations.

8. COLs & COL PL: The average yield of 3,000 AFY is based on hydrologic and hydraulic modeling of the COLs and COL PL performed by Stetson Engineers and HydroScience Engineers, assuming a pipeline configuration consisting of a 30" upper segment and 48" lower segment. The complete COLs is estimated to have a total storage capacity of 150,672 AF. The costs are based on a cost estimate by HydroScience Engineers in June 2022. O&M costs were not available at the time of writing; Zone 7's unit cost when operational consists of only debt service and excludes O&M costs. Actual costs may change depending on factors such as final project design, financing terms, and project operations.

4.4 Application of a Portfolio-Based Approach

Prior WSE Updates (Zone 7 2011, 2019) concluded that implementation of a single water supply reliability project is unlikely to meet Zone 7's Water Supply Reliability Policy (see Section 1.3). Rather, portfolios consisting of several water supply reliability projects implemented in parallel are more likely to provide the required yield and storage to meet the Water Supply Reliability Policy. Therefore, the 2022 WSE Update evaluates a range of portfolios, an approach that is consistent with State-level trends and is in-step with long-term water supply planning strategies being implemented by Zone 7's wholesale peer agencies, including Santa Clara Valley Water District (2019) and the Metropolitan Water District of Southern California (MWD) (2015, 2022).

A Baseline portfolio was developed to represent Zone 7's existing system, which includes Zone 7's current water supply and storage facilities identified in Section 3, with the addition of planned new wells identified in Table 5-6. Next, eight multi-project portfolios were developed by layering combinations of potential water supply reliability projects (i.e., Sites, Desal, Potable Reuse, Transfers, LVE, and DCP) identified in Sections 4.1 and 4.2 on top of the Baseline. One single-project portfolio containing only DCP was developed to compare against multi-project portfolios that also contain DCP. Table 4-2 provides a summary of the ten portfolios further analyzed in Section 6. Additional detail on the model assumptions associated with the representation of the projects are presented in Sections 5.1.2 and 6.

Table 4-2: Summary of Portfolios

Portfolio Name	New Wells	Transfers	*Potential Future Projects*				
			Sites	LVE	Desal	Potable Reuse	DCP
Baseline	✓						
Potable Reuse + Desal	✓				✓	✓	
Sites + LVE	✓		✓	✓			
Sites + LVE + Potable Reuse	✓		✓	✓		✓	
Sites + LVE + Potable Reuse + Transfers	✓	✓	✓	✓		✓	
Sites + LVE + Desal	✓		✓	✓	✓		
DCP	✓						✓
Sites + DCP	✓		✓				✓
Sites + Potable Reuse + DCP	✓		✓			✓	✓
Sites + LVE + Potable Reuse + Transfers + DCP	✓	✓	✓	✓		✓	✓

Outside of the portfolios identified in Table 4-2, sensitivity testing was performed to evaluate both the impact of DCP and alternate groundwater pumping/conjunctive use strategies. Sensitivity analyses are presented in Section 6.7.

5. Methodology for Evaluating the Water Supply System

This Section discusses the methodology and analytical framework used to perform quantitative analyses of Zone 7's water supply system with the Water Supply Risk Model in support of the WSE Update. This Section first describes the Water Supply Risk Model used to evaluate reliability of water supply projects and portfolios. The Section closes with a discussion of specific performance metrics that were used to measure the performance of projects, portfolios, and the overall system.

5.1 Water Supply Risk Model

The Water Supply Risk Model is a decision support tool developed to perform computer simulations of Zone 7's water supply system and evaluate overall system performance given varying hydrology, water demands, and investments in supply, storage, and conveyance projects. Prior to the 2022 WSE Update, Zone 7's Old Risk Model consisted of a customized spreadsheet model that allowed for probabilistic simulation of the water supply system on an annual time step. Under the 2022 WSE Update, the Water Supply Risk Model was migrated to the RiverWare platform to allow for more detailed simulation of system operations on a monthly time step while maintaining the probabilistic simulation approach. This Section provides a brief overview of the prior modeling framework and documents the development of the New Risk Model.

5.1.1 Overview of Prior Modeling Framework

Prior to the 2022 WSE Update, the Old Risk Model was built within Excel and leveraged the Frontline Analytic Solver® plug-in for probabilistic simulation. The Old Risk Model represented the raw water supply system for Zone 7, simulating the system behavior and estimating system reliability. The Old Risk Model solved for treated and untreated demands based on available system water, operating at the annual time step. The solution was achieved by using available supplies in a fixed, sequential order. The priority of supplies used was as follows: SWP carryover, Lake Del Valle, SWP transfers, SWP Table A, SWP Article 21, local groundwater, and exchanges from the Kern Banks.

To simulate future projected conditions, the Analytic Solver® tool utilized a Monte Carlo simulation to randomize hydrologic sequences to test system robustness. To create randomness, the hydrologic record (including set design drought reference years), as well as an earthquake caused Delta outage were randomly shuffled to different model simulation years within one model trace. Details of the randomization approach through the Monte Carlo method are further outlined below:

- The hydrologic record referenced included historical precipitation, Table A allocations, and Arroyo Valle runoff values from 1922-2002.
- The design drought was defined as the historical conditions from 1987-1992. Within a model simulation run, the order of these years was varied. Additionally, the design drought start year was randomly shuffled to different model simulation years.

- A simulated one-year earthquake was randomly assigned to different model simulation years within each trace. This caused an outage of Delta supplies, which would occur at different times throughout the model traces.

The Old Risk Model solved 10,000 traces with this method, generating a range of model output projected values to ultimately determine the probability, or likelihood, of meeting demands under variable future conditions.

The Old Risk Model was successfully leveraged for long-term planning support. However, as planning support needs evolved over time, limitations from the structure of the Old Risk Model were identified. The annual time step prohibited the preferred level of detail for understanding and testing operations and constraints. The default supply prioritization order was difficult to change or modify, which added difficulty when trying to update operating rules or add new supply sources. The model logic as coded in Excel formulas was complex and difficult to quickly understand, which complicated output transparency and analysis. Lastly, there was limited staff availability to train and understand this model. After these considerations, it was determined that developing the New Risk Model was preferred to support the 2022 WSE Update.

5.1.2 Development of a New Risk Model

This section provides an overview of the development of the New Risk Model, and includes discussion of the following topics:

- Model platform selection,
- Model representation of Zone 7's water supply system,
- Overview of key model inputs and operating rules,
- Summary of the New Risk Model's probabilistic representation of hydrology, and
- A summary of model validation.

5.1.2.1 Model Platform Selection

The new modeling technical requirements were collaboratively defined by Zone 7 staff within a workshop setting. These requirements included the following:

- Monthly operating time step,
- Dynamic representation of operations,
- Ability to support efficient testing of operating rules and preferences, and
- Ability to assess risk over varied hydrology scenarios.

Due to these technical constraints, three modeling platforms were shortlisted for further consideration: RiverWare, OASIS, and GoldSim. These three platforms support the necessary major technical requirements. OASIS and RiverWare are specifically tailored for water resources applications whereas GoldSim is a more general simulation software. A brief comparison of these platforms related to the modeling requirements is listed in Table 5-1. Other considerations included cost, ease of use, transparency, and resources.

Table 5-1: Model Requirement Platform Comparisons

Model Requirement	RiverWare	OASIS	GoldSim
Monthly time step	X[1]	X[1]	X[1]
Dynamic representation of operations			
Support efficient testing (e.g., "optimization") of operating rules or preferences			
Ability to assess risk over varied hydrology scenarios (e.g., Monte Carlo analysis)	X[2] May require external module	X[2] May require external module	X
Short-term planning/operations support	X[1] Apply different operating mode or ruleset	X[1] Apply different operating mode with same ruleset	X[2] Build sub-model within existing model to operate in short-term planning mode

X[1] – Indicates platform meets requirement
X[2] – Indicates platform can meet requirement, with additional effort

Ultimately, RiverWare was selected for the new modeling platform. Major benefits of RiverWare were that it was a water supply-specific platform and that it allowed for increased flexibility in how the groundwater system could be represented. RiverWare provides access to vendor training and support, including annual user group meetings and online help manuals. Lastly, there is a strong user base in the Western US (e.g., EBMUD, BAWSCA, Bureau of Reclamation, MWD) to better facilitate peer collaboration and support.

5.1.2.2 Water Supply System Representation

The Zone 7 Water Supply System is represented in RiverWare as a network diagram, consisting of "objects", "slots", and "links". In RiverWare, supply sources, storage, conveyance, and diversions are represented as specific "objects." Objects store data to represent physical processes. The data within an object are called "slots." Links are used to connect object's slots and identify flow paths between objects. Table 5-2 describes the objects used in the New Risk Model.

Table 5-2: Summary of RiverWare Objects Utilized in Water Supply System Representation

RiverWare Object(s)	Description	Examples from Zone 7 System
Reach, Confluence, Bifurcation, Inline Pump	• Represents a section of a river or other flow path with inflow and outflow • Optional functions include diversions, gains, losses, and return flows • Reaches have one inflow and one outflow. Confluences/bifurcations have two inflows/outflows respectively.	• Arroyo Mocho • Arroyo Valle • SBA
Storage Reservoir	• Storage is calculated using inflow(s), outflow(s) and an elevation volume table. • Optional processes include evaporation, seepage, and spills.	• Sites • Los Vaqueros • San Luis • Lake Del Valle
Diversion	• Directs water to be diverted from a reach or reservoir based on a requested diversion. • Sets constraints on minimum and maximum flows through the diversion.	• PPWTP SBA turnout • Lake Del Valle Diversion to SBA
Water User/Aggregate Water User	• Simulates the consumption of water based on diversion requests and incoming available water. • If demand is not met, shortages are calculated as the difference between the diversion requested and the diversion delivered.	• Oakland Scavenger • Wholesale customers
Groundwater Storage	• Tracks groundwater storage using seepage inflows and pumped outflows. • Options to define maximum storage capacity and aquifer dimensions.	• Semitropic • Cawelo • Main Basin

An overview of the Zone 7 Water Supply System is shown in Figure 5-1 as a simplified network diagram. The diagram shows key infrastructure and supply sources as represented in the RiverWare model network.

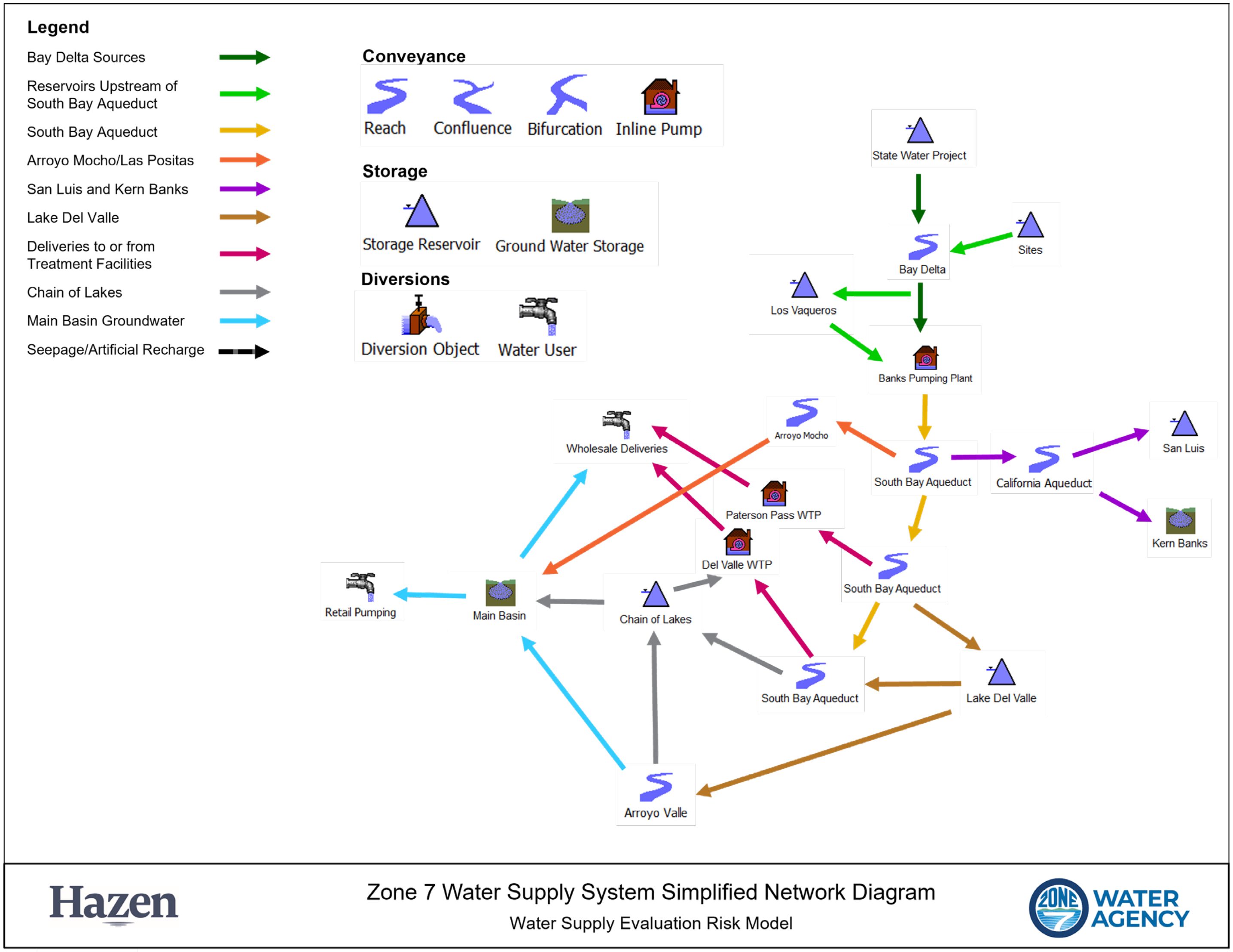

Figure 5-1: Simplified System Network Diagram

Table 5-3 provides a summary of the detailed model schematics for subsections of the New Risk Model that are presented in Figure 5-2 through Figure 5-7.

Table 5-3: Summary of Schematic Figures

Figure #	Title	Description
Figure 5-2	Delta Above the South Bay Aqueduct	• Delta supplies (i.e., supplies conveyed through the Delta) are represented independently and are upstream of the *Bay Delta* object. • Supplies from the *Los Vaqueros* storage reservoir object bypass the Delta and are routed to the *Bethany* object which flows to the South Bay Aqueduct (SBA)
Figure 5-3	San Luis and Kern Banks Schematic	• Delta supplies can be stored in San Luis reservoir and the Kern Banks (Cawelo Water Bank and Semitropic Water Bank). • Losses from storing water in the Kern Banks are accounted for in the reach objects *Delivery to Cawelo* and *Delivery to Semitropic*, so the groundwater storage objects *Cawelo* and *Semitropic* reflect water that is available to Zone 7. • Kern Banks water is delivered to Zone 7 for use via an exchange of Delta supply or via pumpback to San Luis. The *Cawelo to Exchange* and *Semitropic to Exchange* diversion objects in this figure request water from the Kern Banks to deliver to the *Semitropic_Delivery* and *Cawelo_Delivery* objects in Figure 5-2. • Supplies conveyed via the SBA can be delivered to the turnouts shown in this figure and/or continue down the SBA as shown in Figure 5-4.
Figure 5-4	Lake Del Valle and South Bay Aqueduct	• The Branch Pipeline is a bi-directional pipeline connecting Lake Del Valle and the SBA and is represented with two distinct flow paths. The path from *SBA_to_BranchPL* to *Lake_Del_Valle* represents flow from the SBA to Lake Del Valle. The path from *Lake_Del_Valle* to *BranchPL_to_SBA* represents flow from Lake Del Valle to SBA. • Water can be released from Lake Del Valle to Arroyo Valle • Supplies conveyed via the SBA can be delivered to the turnouts shown in this figure

Figure 5-5	Water Treatment Plants and Wholesale Deliveries	• Water can be diverted from the SBA for treatment at the DVWTP and PPWTP facilities. • Water can be diverted from SBA to the Arroyos for artificial recharge to the Main Basin • *Wholesale_Demands* is an aggregate water user object which represents each retail customer independently within the object. Demand for this object is fulfilled through deliveries from the treatment plants and Main Basin groundwater pumping. • *EBMUD_Intertie* represents the proposed EBMUD Reliability Intertie, which was not utilized in this 2022 WSE Update
Figure #	**Title**	**Description**
Figure 5-6	Chain of Lakes and Chain of Lakes Pipeline	• The COL pipeline is planned to be bi-directional, with gravity flow to the COLs and pressured flow from Lake I to DVWTP. The system is modeled with independent flow paths for each direction of flow. • Reservoir seepage to the Main Basin from Lakes A, B, C, D, H, and I is represented in Figure 5-7.
Figure 5-7	Groundwater Recharge and Pumping	• Bernal, Busch Valley 1 and COL 3 and 4 wells are proposed well facilities and not currently pumping from Main Basin. The wells are planned to begin operations in 2027, 2031, 2035 respectively. • *Total_WellfieldProduction* is an aggregate object that sums the total groundwater pumping by Zone 7. This object eventually flows to *Wholesale_Demands* object but passes through the *EBMUD_Intertie* object first due to modeling convention. Refer to Figure 5-5 for the flow path to *Wholesale_Demands.* • Retail pumping is represented independently from Zone 7's pumping.

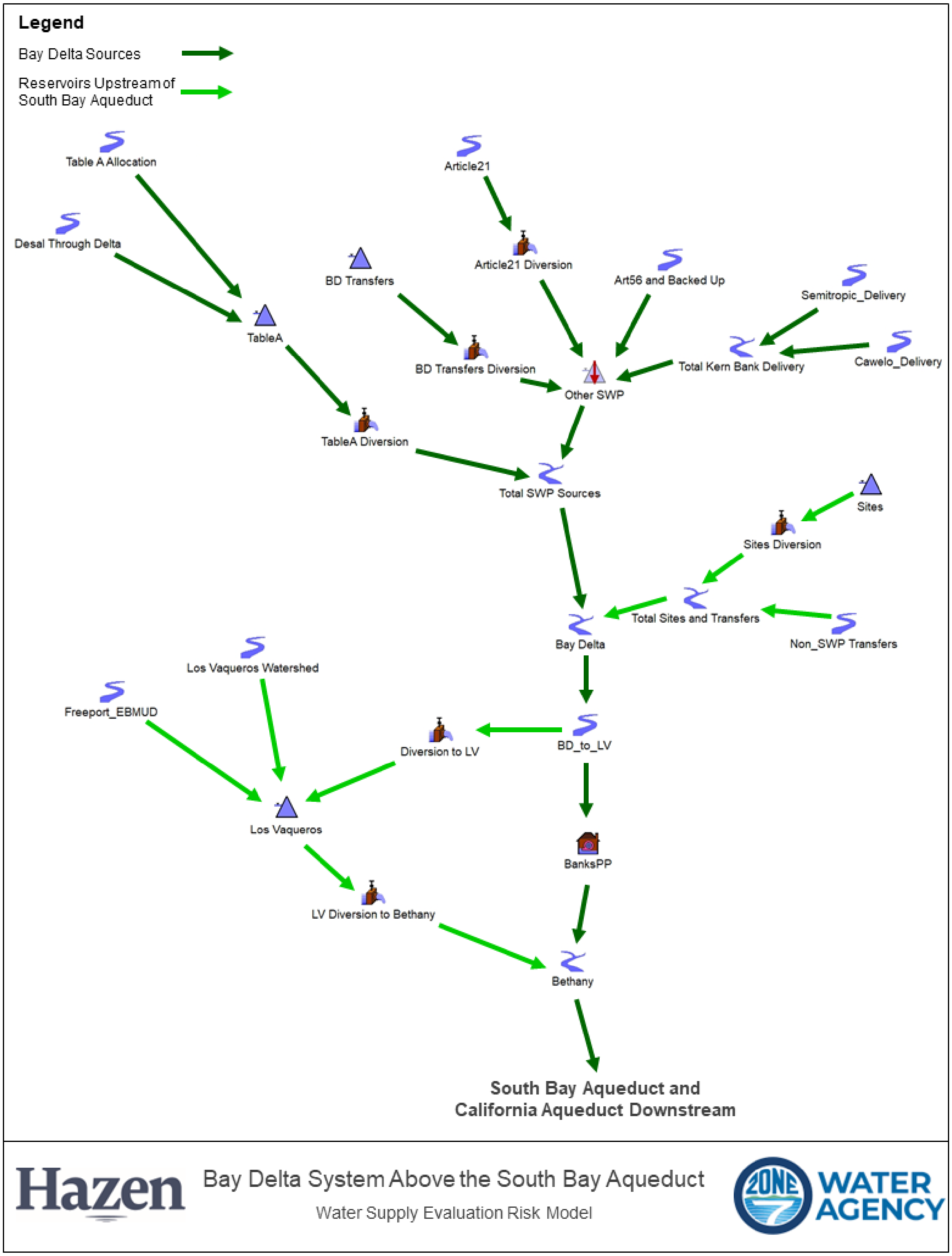

Figure 5-2: Delta Above the South Bay Aqueduct

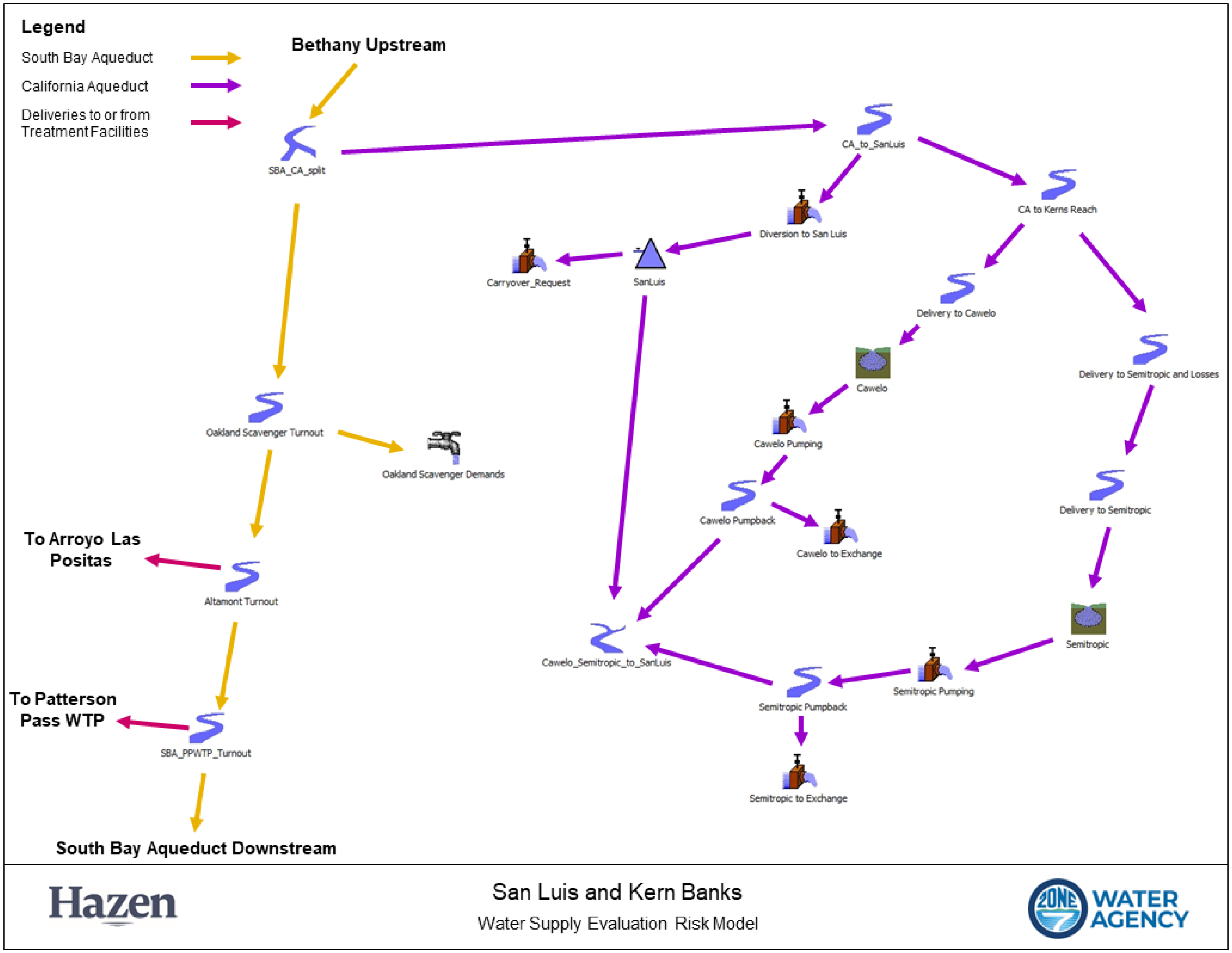

Figure 5-3: San Luis and Kern Banks Schematic

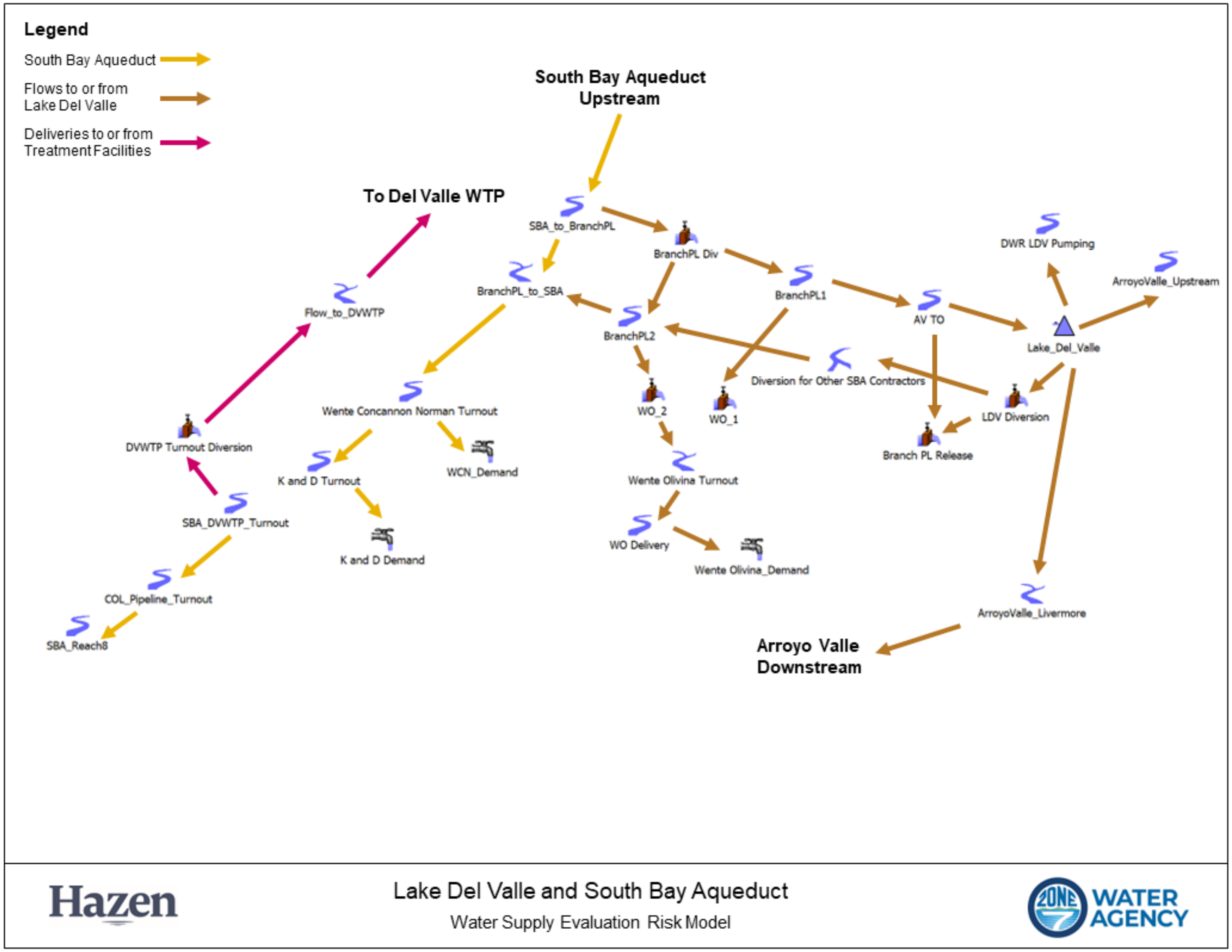

Figure 5-4: Lake Del Valle and South Bay Aqueduct

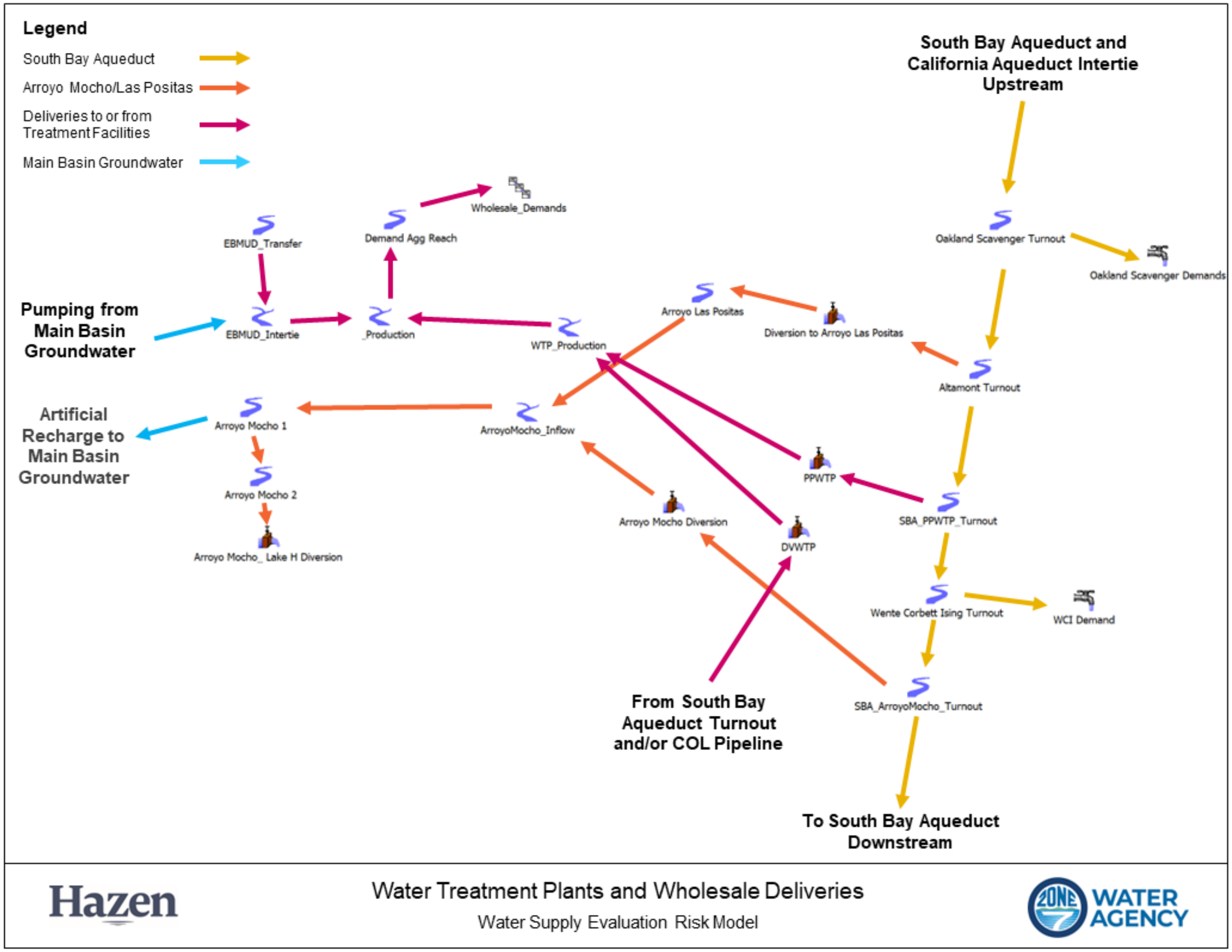

Figure 5-5: Water Treatment Plants and Wholesale Deliveries

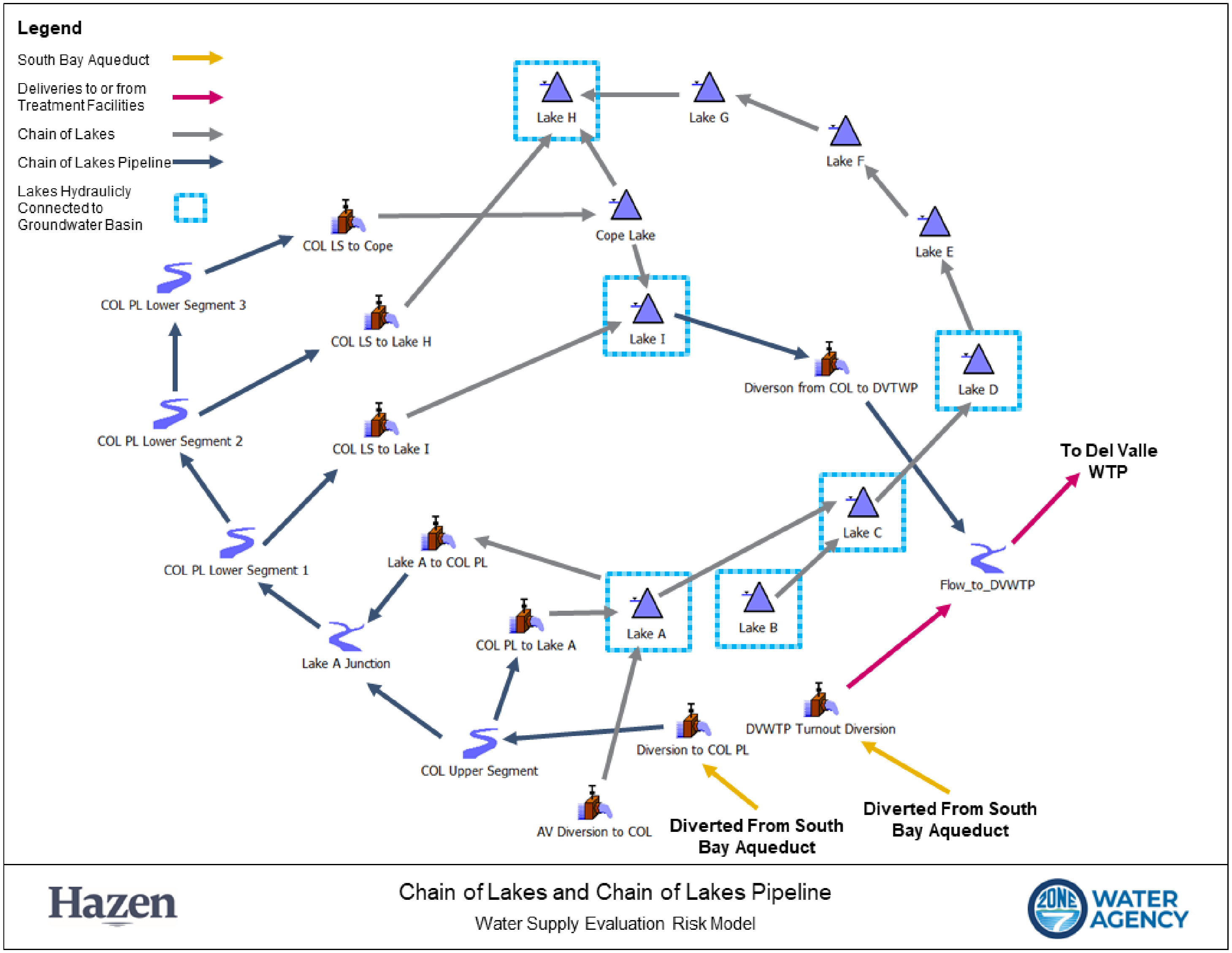

Figure 5-6: Chain of Lakes and Chain of Lakes Pipeline

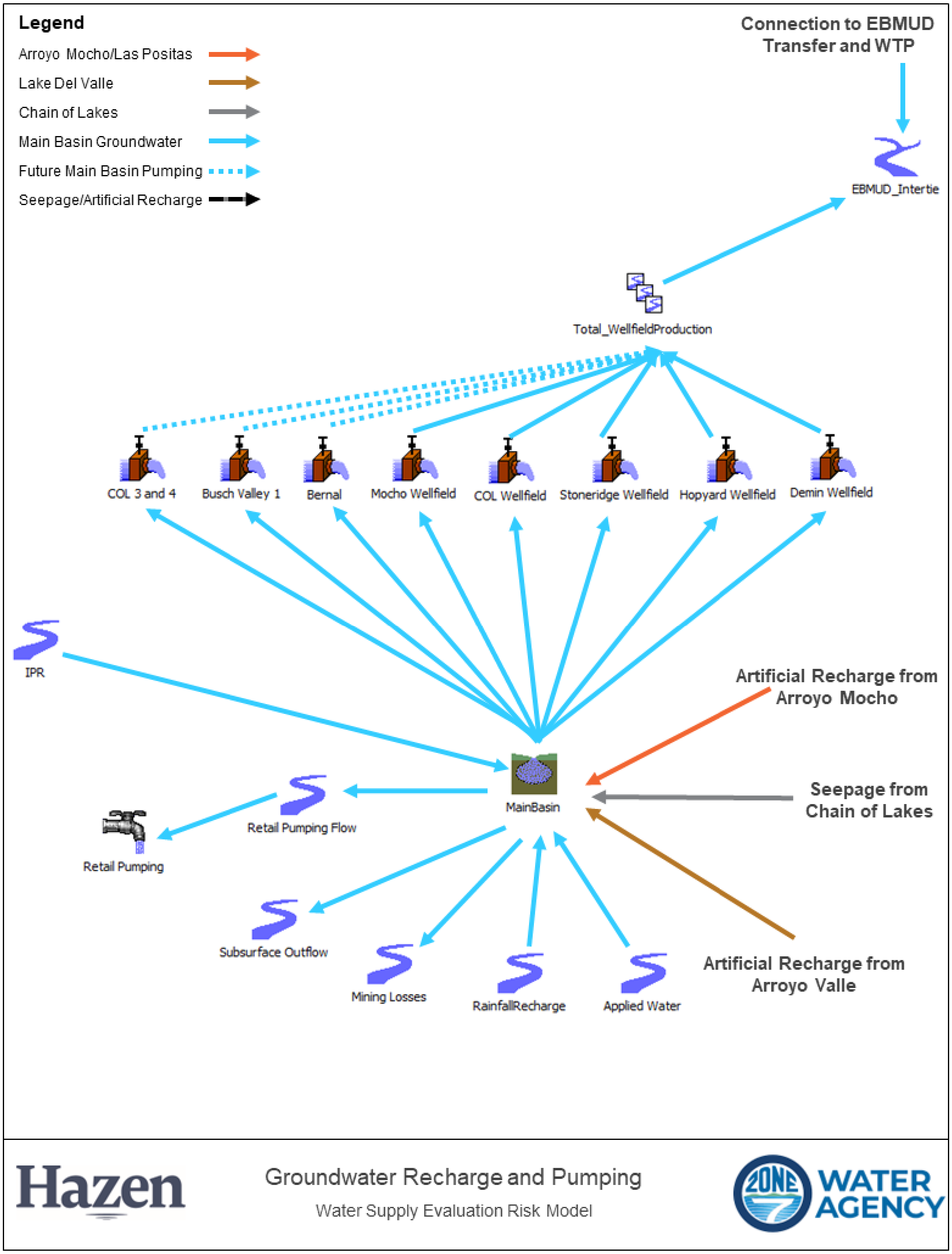

Figure 5-7: Groundwater Recharge and Pumping

5.1.2.3 Overview of Model Inputs

This Section provides an overview of model inputs, assumptions, and data sources. Key inputs to the New Risk Model consist of:

- Timeseries inputs reflecting hydrologic conditions and water demands,
- Storage facility capacities, and
- Transmission capacities associated with conveyance, treatment, and pumping facilities.

A summary of key time series inputs including their data source(s) and key assumptions is provided in Table 5-4. It includes hydrologic conditions, supply allocations and demands. System wide storage capacities for reservoirs, lakes and groundwater are defined in Table 5-5, which includes the assumed storage capacity in acre-feet and the data source. Table 5-6 summarizes conveyance, pumping, and treatment capacities, constraints, and assumptions.

Table 5-4: Summary of Key Input Timeseries

Model Input	Data Source(s)	Literature Reference(s)	Description/Key Assumptions
SWP Table A Allocation	• Table A availability from CalSim 3	• California Department of Water Resources. (2021a)	• DCR 2021 CalSim 3 annual allocation assumed available January 1st of each year
SWP Article 21	• Interruptible water availability from CalSim 3	• California Department of Water Resources (2021a)	• DCR 2021 CalSim 3 monthly allocation assumed only available in specified month
Sites Reservoir Availability	• Zone 7 Deliveries from Sites South of Delta Model Alternative 3B, 2035 CT climate hydrology	• Sites Reservoir Authority (2022)	• Assumed Zone 7 could request annual availability any time during transfer window • 1921 to 2003: Direct Sites model output • 2004 to 2012: Processed Sites model output assuming 1922 to 2003 hydrologic year type averages • 2013 to 2015: replicated drought with dry years 1987-1989
Lake Del Valle Inflow	• Monthly inflows 1912 – 2020 provided by Zone 7 • USGS 11176400 Arroyo Valle below Lang Canyon near Livermore, CA • USGS 11179000 Alameda Creek near Niles, CA	• USGS gage 11176400 • USGS gage 11179000	• Monthly inflows provided by Zone 7 were used whenever possible, but were missing 1931-1941, 1943, and 1956-1957 • Missing values were estimated based on a drainage area ratio between USGS 11176400 and USGS 11179000

Model Input	Data Source(s)	Literature Reference(s)	Description/Key Assumptions
Potable Reuse Availability	• DSRSD and Livermore	• N/A	• Projected wastewater availability between 2030-2040 and 2040 onward
Desal Availability	• Planning estimates from the Bay Area Regional Desalination Project	• N/A	• Assumed to be a constant 5,600 AF/year availability post-2030 except in critically dry years
Main Basin Natural Inflow	• Annual precipitation timeseries from 1922-2014 provided by Zone 7/Old Risk Model • Monthly Lake Del Valle inflows 1912 – 2020 provided by Zone 7	• N/A	• Main Basin natural recharge was calculated from a linear equation relating precipitation to recharge at annual level (equation provided by Zone 7/Old Risk Model) to calculate Annual Recharge Capacity • The Annual Recharge Capacity was disaggregated to monthly values. To disaggregate, the ratio of monthly to annual Lake Del Valle inflow for each month and year was multiplied to the Annual Recharge Capacity value
Applied Water	• 2021 Hydrologic Inventory • Monthly fraction of total annual demand	• N/A	• Median of applied water recharge for 2011-2021 Inventory values • Disaggregated annual recharge to monthly based on demand fractionation pattern
Treated Water Demands Raw Water Demands	• See Section 2 for discussion of demands • Historical consumption data	• N/A	• Demands disaggregated from an annual to monthly timestep based on historical consumption data

Table 5-5: Summary of Input Storage Capacities

Model Input	Data Source(s)	Reference(s)	Assumed Maximum Storage (AF)
Sites Reservoir	Amendment 2 Storage Allocation April 16, 2021 Reservoir Committee Agenda Item 2.2 Attachment A	Zone 7 Water Agency Reservoir Committee Meeting (2021)	62,343
Los Vaqueros	Zone 7 2020 UWMP	Zone 7 (2021)	10,000
San Luis [a]	Communication with Zone 7	N/A	10,000
Cawelo	Zone 7 2020 UWMP	Zone 7 (2021)	120,000
Semitropic			78,000
Lake Del Valle	Lake Del Valle Operations Manual	Zone 7	7,500 (Zone 7 storage) 77,000 (Total storage below spillway)
Main Basin	Zone 7 2020 UWMP	Zone 7 (2021).	254,000
COL Total	HEC-RAS 5.0.3 February 2022 Zone 7 Chain of Lakes P01.#0_LDV_Historical_Z7Cvt Size	Zone 7 (2022).	*150,672*
Lake A			3,411
Lake B			31,260
Lake C			23,769
Lake D			34,362
Lake E			6,232
Lake F			4,754
Lake G			2,989
Lake H			7,436
Lake I			27,605
Cope Lake			8,854

Notes:

[a] Zone 7's storage capacity in San Luis is greater than 10,000 AF. However, staff have determined 10,000 AF of storage minimizes spill risk while maximizing storage capacity.

Table 5-6: Summary of Key Input Conveyance/Pumping/Treatment Capacities and Constraints

Model Input	Modeled Capacity	Data Source(s)	Reference(s)
Zone 7 Wells [(a)]	*Total capacity (45 mgd)*	Communication with Zone 7	N/A
Mocho Wellfield [(b)]	6.3 mgd		
COL Wellfield	7.9 mgd		
Stoneridge Wellfield	5.1 mgd		
Hopyard Wellfield	6.0 mgd		
Demin Wellfield [(b)]	4.6 mgd		
Busch Valley 1 Wellfield [(c)]	2.9 mgd		
Bernal Wellfield [(c)]	3.6 mgd		
COL 3 and 4 Wellfield [(c)]	8.6 mgd		
Zone 7 Water Treatment Plants	*Total capacity (61.6 mgd)*	Zone 7 2020 UWMP	Zone 7 (2021)
Patterson Pass WTP	21.6 mgd		
Del Valle WTP	40.0 mgd		
Los Vaqueros			
Diversion to Los Vaqueros	Max 200 cfs (dependent on CCWD use, water quality and available water)	LVE Storage Exploration Tool Los Vaqueros Reservoir Expansion Project Operational Constraints and Capacity Sharing PPTX Draft LVE Operations Plan	CCWD (2022b) CCWD (2022a) CCWD (2021)
Los Vaqueros Diversion to Transfer-Bethany Pipeline	Max 300 cfs (depending upon buy-in capacity)	LVE Transfer-Bethany Pipeline (TBP) Exploration Tool Draft LVE Operations Plan	CCWD (2022c) CCWD (2021)
Kern Banks			
Cawelo Loss on Put	50%	Zone 7 2020 UWMP	Zone 7 (2021)
Semitropic Loss on Put	10%		
Cawelo Maximum Annual Delivery	10,000 AF/year		
Semitropic Maximum Annual Delivery	9,100 AF/year		
SBA/Lake Del Valle			
Arroyo Mocho SBA Turnout	50 cfs	Communication with Zone 7	N/A
Branch Pipeline SBA Turnout	120 cfs		
Lake Del Valle Diversion to SBA	120 cfs		
Lake Del Valle Release to Arroyo Valle	4,500 cfs		
COL			
Arroyo Valle Diversion Weir to Lake A	120 cfs [(d)]	HEC-RAS 5.0.3 February 2022 Zone 7 Chain of Lakes P01.#0_LDV_Historical_Z7CvtSize	Zone 7 Water Agency (2022d).
COL PL Upper Segment	150 cfs	Communication from Zone 7	N/A
COL PL Lower Segment	50 cfs		
Lake I to COL PL Pumps	35 cfs		
COL Inter-Lake Transfers	Varies based on Lake	HEC-RAS 5.0.3 February 2022 Zone 7 Chain of Lakes P01.#0_LDV_Historical_Z7CvtSize	Zone 7 Water Agency (2022d).
Reliability Intertie [(e)]	Not a supply source in current model, however it is planned to be added in future model development.	Zone 7 2020 UWMP	Zone 7 Water Agency. (2021).

Notes:

[(a)] Zone 7 well pumping capacities have been rounded to the nearest hundredth.

[(b)] Gross production from the Mocho Wellfield equals 11.0 MGD. An assumed 42%, or 4.6 mgd, is treated at the Mocho Groundwater Demineralization Plant, which is modeled as the Demin Wellfield.

[(c)] Planned new wells come online in the following order: Busch Valley 1 Wellfield in 2026, Bernal Wellfield in 2031, and COL 3 and 4 Wellfield in 2036.

[(d)] Actual planned capacity is 500 cfs; 120 cfs is a calibrated value adjusted to better reflect yield from sub-daily H&H modeling.

[(e)] The EBMUD Reliability Intertie is planned to be a 30" diameter pipeline.

The New Risk Model assumes groundwater pumping capacity follows the pumping capacity rating curve shown in Figure 5-8. This curve constrains the total pumping capacity across all of Zone 7's wells to a rate pertaining to the groundwater storage level. This curve was taken from the Old Risk Model and was modified based on input from Zone 7's Groundwater staff to better align with recent pumping operations observed during the current drought. Note that this curve will continue to be evaluated and updated as Zone 7 gains more experience with the groundwater basin's response to lower groundwater levels during drought conditions.

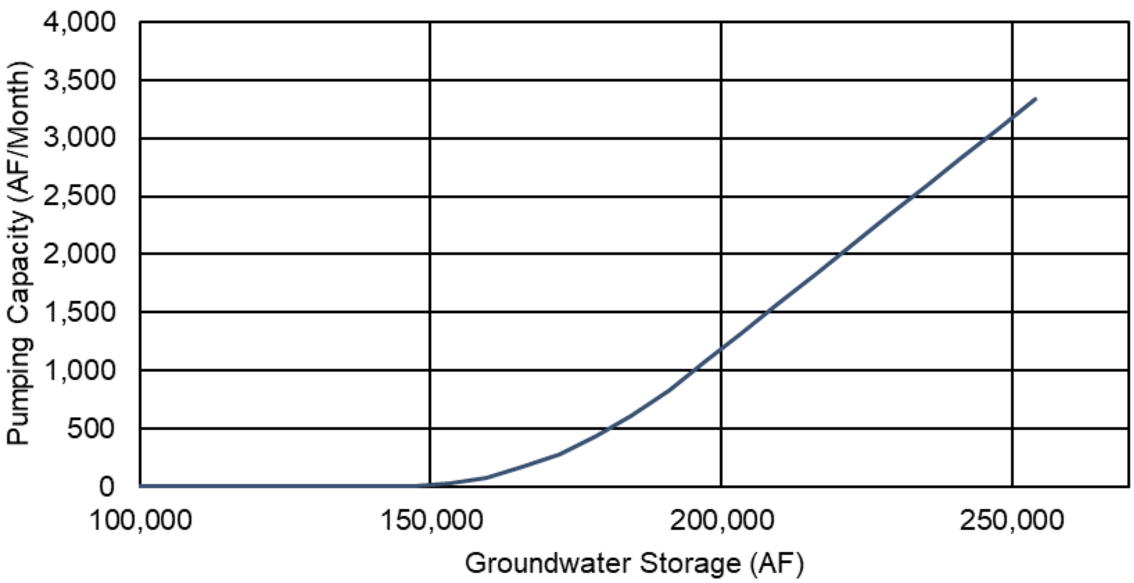

Figure 5-8: Groundwater Pumping Capacity

5.1.2.4 Overview of Model Operating Rules

In addition to the network diagram and model inputs, output from the New Risk Model is governed by procedural rules[3] (i.e., "operating rules") that simulate the decision-making process for prioritizing delivery of different supply sources and operating system infrastructure. This section provides an overview of the New Risk Model's key operating rules associated with:

- Supply delivery preferences,
- Storage and conjunctive use, and
- Integration/representation of new water supply projects.

[3] The Risk Model's procedural rules are coded in RiverWare's RiverWare Policy Language (RPL), which is a programming language that allows modelers to express conditional water supply system operating policy that are separate from physical processes.

Overall Supply Delivery Preferences

The New Risk Model is coded to make monthly decisions on the utilization of different supply sources based on supply availability and general preferences expressed by Zone 7 staff. Table 5-7 summarizes the New Risk Model's water supply delivery preferences and provides a brief description of key operational rules/assumptions.

Table 5-7: Summary of Water Supply Delivery Preferences Reflected in the New Risk Model

Priority	Supply Source	Description of Operational Assumptions/Rules
1	"Baseline" Groundwater Pumping	• Reflects a base level of groundwater pumping (100 AF/month) [a] for meeting wholesale demand. • Pumping is increased (see Priority 11) to meet demand after other available supply sources are utilized.
2	Carryover Storage in Lake Del Valle	• Reflects use of prior year storage of local water in Lake Del Valle (up to 7,500 AF). • Primarily allocated to meeting agricultural demands downstream of Lake Del Valle and treated water demands via Del Valle WTP.
3	Carryover Storage in San Luis Reservoir (Article 56)	• Reflects delivery of prior year storage of imported water in San Luis Reservoir. • Used to meet remaining agricultural and treated water demands and/or direct towards artificial groundwater recharge.
4	Sites Reservoir	• Reflects deliveries from Sites Reservoir, only available in portfolios where Sites Reservoir is included. • Deliveries restricted to transfer window (July-November). • Deliveries prioritized to meet unmet agricultural and treated water demands first, then as puts to other available storage. [b]
5	Article 21	• Reflects deliveries of Zone 7's share of SWP Article 21 supplies • Deliveries prioritized as puts to available storage.
6	Los Vaqueros	• Reflects deliveries of water stored in Los Vaqueros Reservoir, only available in portfolios where Los Vaqueros is included. • Deliveries restricted based on modeled available capacity in Transfer-Bethany Pipeline. [c] • Deliveries prioritized to meet unmet agricultural and treated water demands first, then as puts to available storage.
7	Table A Allocation	• Reflects use of annual allocation of SWP Table A allocation. • Deliveries prioritized to meet agricultural and treated water demands first, then as puts to available storage.
7	Desal	• Reflects use of the Bay Area Regional Desalination Project. • Implemented as the same priority as Table A water.
8	Bay Delta Transfers	• Transfers are prioritized for delivery provided volume is available and the transfer window (July-November) is open. • Used to meet remaining agricultural and treated water demands.
9	Semitropic Recovery via Exchange	• Reflects recovery of imported water stored in Semitropic Groundwater Bank. • Semitropic recovery is only called upon when there is unmet demand from higher priority supplies and Table A allocation is less than 35%. [d] • Recovery limited to maximum annual delivery specified in Table 5-6. • Used to meet remaining agricultural and treated water demands.
10	Cawelo Recovery via Exchange	• Reflects recovery of imported water stored in Cawelo Groundwater Bank. • Cawelo recovery is only called upon when there is unmet demand from higher priority supplies and Table A allocation is less than 35%. [d] • Recovery limited to maximum annual delivery specified in Table 5-6. • Used to meet remaining agricultural and treated water demands.

Priority	Supply Source	Description of Operational Assumptions/Rules
11	Supplemental Groundwater Pumping	• Reflects additional groundwater pumping to meet unmet demands from higher priority supplies. • Maximum pumping constrained by wellfield capacities and groundwater storage-pumping rating curve (see Table 5-6 and Figure 5-8). • Supplemental pumping prioritized ahead of Kern Bank recoveries when Table A allocation is greater than or equal to 35%.
12	COL PL	• Reflects direct deliveries from Lake I to Del Valle WTP via the COL PL. • Deliveries constrained by pumping capacity from Lake I, capacity in the COL PL lower segment (see Table 5-6), and a maximum blending ratio of 20% COL water with 80% other surface supply at Del Valle WTP.

Notes:
(a) Initial pumping rate of 100 AF/month based on a review of historical operations plans and communications with Zone 7 staff.
(b) Priorities associated with puts to other available storage are further elaborated in Table 5-8.
(c) Operational assumptions associated with Los Vaqueros are further discussed in Table 5-9.
(d) 35% Table A threshold based on review of historical deliveries from Kern Banks and discussion with Zone 7 staff.

Rules Associated with Storage and Conjunctive Use

As identified in Table 5-7, the New Risk Model allows several water supply sources to be utilized for replenishing available storage when not being delivered for consumptive use. Generally, the New Risk Model allocates excess supply available after meeting consumptive use based on the following priorities:

1. Meet a 10,000 AF annual carryover storage goal in San Luis Reservoir.
2. Maximize recharge to the Main Basin via SBA turnouts subject to natural constraints on reach seepage in the Arroyos.
3. Fill available void space in other storage facilities, including the Kern Banks, Los Vaqueros, and the COLs.

Modeled deliveries for storage vary based on supply source, available storage capacity, conveyance constraints, and future investments in new water supply infrastructure. Table 5-8 on the following page provides a more detailed summary of rules and priorities for storage of excess supply organized by modeled storage facility. The current representation of storage priorities is based on review of past annual operations plans and discussions with Zone 7 staff and reflects a “baseline” strategy for storing excess available water. Rules, priorities, and strategies for storage may be further optimized in future improvements to the New Risk Model. Sensitivity testing of alternate storage strategies were conducted under this 2022 WSE Update and are further discussed in Section 6.7.

Table 5-8: Summary of New Risk Model Rules Associated with Puts to Storage

Storage Facility	Supply Sources Utilized for Puts	Risk Model Conveyance Pathways	Description of Rules/Priorities
San Luis Reservoir	• Table A • Kern Bank Pumpback	• California Aqueduct	• Excess Table A water after meeting consumptive use up to annual storage target of 10,000 AF. • Pumpback from the Kern Banks are prioritized in years when Table A water is unavailable for Carryover, subject to annual delivery limits.
Main Basin	• Table A • Article 56 Carryover • Arroyo Valle • Sites • Article 21 • Potable Reuse • "Natural" recharge / applied water [(a)]	• Reach seepage from Arroyo Mocho (via diversions from the SBA) • Reach seepage from Arroyo Valle (via releases from Lake Del Valle or the SBA) • Reservoir seepage from the COLs • Potable Reuse	• Imported water [(b)] via SBA prioritized for consumptive use and meeting the 10,000 AF storage target in San Luis Reservoir. Remaining imported water preferentially released for reach seepage via Arroyo Mocho, constrained by seepage efficiency [(c)]. • Reach seepage from Arroyo Valle is mainly driven by downstream releases [(d)] from Lake Del Valle, constrained by seepage efficiency [(e)]. • Reservoir seepage from the COLs are governed by Darcy's Law, constrained by hydraulic conductance[(f)], wetted area[(f)], and hydraulic head[(g)]. The New Risk Model currently only allows flow from the COLs to the Main Basin. • Potable reuse is currently implemented as direct injection to the Main Basin.
Semitropic Groundwater Bank	• Table A • Sites	• California Aqueduct	• Excess water delivered from Table A after puts to San Luis Reservoir and the Main Basin. • Excess water delivered from Sites after puts to Los Vaqueros, COLs, and Main Basin. • Puts subject to 10% loss.
Cawelo Groundwater Bank	• Table A • Sites	• California Aqueduct	• Excess water delivered from Table A after puts to San Luis Reservoir, the Main Basin, and Semitropic. • Excess water delivered from Sites after puts to Los Vaqueros, COLs, the Main Basin, and Semitropic. • Puts subject to 50% loss.
Los Vaqueros Reservoir	• Article 21 • Sites • Table A • Desal [(h)]	• CCWD Transfer Facility	• Excess water delivered from Sites after meeting consumptive use. • First priority storage of Article 21 water. • Excess water delivered from Table A after puts to San Luis Reservoir, the Main Basin, and Kern Banks.
COLs	• Flood releases from Lake Del Valle • Sites • Article 21 • Table A	• Lake A Diversion Weir • COL PL	• Storage of flood releases from Lake Del Valle prioritized, constrained by Lake A Diversion Weir capacity and available storage in COLs. • Excess water delivered from Sites after puts to Los Vaqueros. • Excess water delivered from Article 21 after puts to Los Vaqueros. • Excess water delivered from Table A after puts to puts to San Luis Reservoir, the Main Basin, Kern Banks, and Los Vaqueros. • Evaporative losses explicitly accounted for in each Lake. • Deliveries from SBA via COL PL prioritized to fill Lakes I, H, and Cope prior to Lake A. • Deliveries from Arroyo Valle routed to Lakes I, H, and Cope via COL PL or allowed to "cascade" to Lake B and downstream.
Lake Del Valle	• Arroyo Valle • DWR pumping from SBA	• Reservoir inflow from Arroyo Valle • Branch Pipeline	• Half of local runoff inflow from Arroyo Valle allocated to Zone 7's storage account, constrained by storage limits defined in Table 5-5. • DWR pumping represented to reflect reasonable overall operations of Lake Del Valle (e.g., reservoir filling). DWR pumping is not co-mingled with Zone 7's local Arroyo Valle storage and is not diverted for meeting consumptive use or recharge purposes. • Total evaporative losses are modeled for Lake Del Valle, which affect and inform overall reservoir operations. Evaporative losses are not levied on Zone 7's storage account.

Notes:
[(a)] Natural recharge is driven by a timeseries of natural contributions to the Main Basin from natural streamflow (i.e., flows not originating from releases) and rainfall. Applied water consists of seepage from outdoor water consumption. Both natural recharge and applied water are considered static inputs to the Main Basin and do not have associated operating rules in the New Risk Model. See Table 5-4 for additional discussion.
[(b)] Excludes Kern Bank availability and transfers, which are prioritized for meeting consumptive use.
[(c)] Seepage efficiency for Arroyo Mocho is assumed to be 90% of SBA release up to 15 cfs. Reach seepage is generally observed to be largest in the summer; releases from the SBA are scaled commensurate with this.
[(d)] Most downstream releases from Lake Del Valle are conservation releases, which are assumed to be 3 cfs when Zone 7 has available storage and the reservoir is below the flood pool. Flood releases made when Lake Del Valle is above the flood pool also contribute to reach seepage but are constrained by seepage efficiency.
[(e)] Seepage efficiency in Arroyo Valle is assumed to be 90% of Lake Del Valle releases up to 9 cfs.
[(f)] Hydraulic conductance constants and permeable area curves to inform wetted areas were provided by the 2020 Stetson Development of Chain of Lakes Hydrologic/Hydraulic Model report.
[(g)] The hydraulic head is calculated at each model timestep execution, calculating the difference between each lake's water surface elevation and the Main Basin groundwater level
[(h)] Desal is conceptually a supply source for Los Vaqueros but is currently only implemented for meeting consumptive use.

Integration and Representation of New Water Supply Projects

The New Risk Model incorporates several new water supply projects being considered by Zone 7. Table 5-9 provides a summary of the key operational assumptions for the new supply projects implemented in the model.

Table 5-9: Summary of New Supply Projects Implemented in the New Risk Model

Supply Project	Key Operational Assumptions
Sites Reservoir	• Operation of reservoir not explicitly represented in the New Risk Model. • Yield is reflected by annual modeled deliveries to Zone 7. • New Risk Model makes decisions for monthly delivery requests within transfer window period, based on needs for consumptive use and storage.
Los Vaqueros Expansion	• The reservoir can only be filled when salinity at the intakes is less than 65 milligrams/liter. • Available water sources identified in Table 5-8. • The portion of the total intake capacity not used by CCWD available to Zone 7 is equal to the proportion of Zone 7's storage buy-in volume to the total expansion volume. • The full portion of the storage and TBP buy-in capacities are always available.
COLs and COL PL	• The New Risk Model allows the user to specify specific dates for each Lake to be made available to Zone 7 for storing water. • Certain scenarios have examined phased implementation of the Lakes, with Lakes A, I, H, and Cope available by 2030 and remaining Lakes available by 2060. • When only Lakes A, I, H, and Cope are available, the COL PL is used to balance storage between the Lakes. Lakes A and I are preferentially filled given physical position in the system (Lake A) and ability to supplement surface water diversions to Del Valle WTP (Lake I). • When all Lakes are available, water is preferentially delivered to Lake A and allowed to "cascade" downstream to Lake B and the other downstream Lakes subject to planned culvert/spillway capacities between each Lake.
Potable Reuse	• Currently implemented as direct injection to the Main Basin. • Yield based on projected wastewater availability from DSRSD and Livermore.
Desal	• Currently implemented as an additional supply through the Delta at the same delivery priority as Table A.

5.1.2.5 Probabilistic Representation of Hydrology (Summary of Index Sequential Approach)

The New Risk Model uses the Index Sequential Method (ISM) to represent the range of future hydrologic conditions of the system. ISM is a commonly used resampling technique used to generate alternate historical hydrologic sequences to represent long-term hydrologic variability. This approach cycles through historical years of hydrology to generate different outcomes for each demand forecast year. Several major California water suppliers implement an ISM approach in water supply planning modeling, including MWD, DWR, and the Bureau of Reclamation. MWD uses ISM to evaluate the future reliability of its water supply under a range of resource management strategies (MWD 2015). Similarly, the Bureau of Reclamation uses this approach for water supply scenario generation in the Colorado River Simulation System (CRSS) model (Bureau of Reclamation 2020). DWR also implements ISM through the Position Analysis functionality of CalSim to simulate SWP allocations (DWR 2021b).

The New Risk Model consists of 94 traces in which each forecasted demand year (2023-2081) is assigned a historical year of hydrology that was adjusted to capture climate change conditions in 2040. ISM "shifts" one hydrologic year at a time, such that each demand year experiences the full range of historical hydrology. In this study, the historical hydrologic record from 1922-2015 was used. Table 5-9 demonstrates how this method functions for the New Risk Model. In this table, traces can be read horizontally such that the forecasted demand year in the header of the column is assigned a historical year of hydrology for that trace. Each sequential trace begins with a "shifted" year of hydrology such that Trace 1 begins with hydrologic data for 1922, Trace 2 begins with 1923, and so on. Each forecasted demand year can therefore be evaluated by reading down the column to determine which historical year of hydrology is assigned to that year for each trace. In summary, a trace is a single iteration of the 2023-2081 modeling period that reflects one possible hydrologic time series. By running 94 traces, the results all possible hydrologic time series are considered over the modeling period.

Table 5-9: Demonstration of the Indexed Sequential Method for the New Risk Model

Year/Trace	2023	2024	2025	→	2081
Trace 1	1922	1923	1924	→	1979
Trace 2	1923	1924	1925	→	1980
Trace 3	1924	1925	1926	→	1981
Trace 4	1925	1926	1927	→	1982
Trace 5	1926	1927	1928	→	1983
↓	↓	↓	↓	→	↓
Trace 94	2015	1922	1923	→	1978

By sequentially ordering the historical hydrology, the ISM approach maintains the historical hydrologic sequence such that the New Risk Model (a) reflects the historical long-term probability of drought events and (b) faithfully captures the interannual variability associated with dry/wet sequences and year-to-year storage within the SWP system. Maintaining the historical hydrologic sequence is one of the key assumptions in DWR's modeling of the SWP. Therefore, the New Risk Model reflects the reasonable interannual variability of SWP storage and allocations using the ISM approach with DWR's CalSim data. All input hydrologic data defined in Table 5-4 excluding demands are varied using ISM.

Figure 5-9 and Figure 5-10 provide an example of Table A allocations associated with two example traces with unique hydrologic sequences. Comparing Table A allocations associated with Trace A and Trace B demonstrates that Trace B is shifted to begin at a later year of historical hydrology than Trace A. Therefore, the 1977 and 2014 dry years appear earlier in the hydrologic sequence for Trace B.

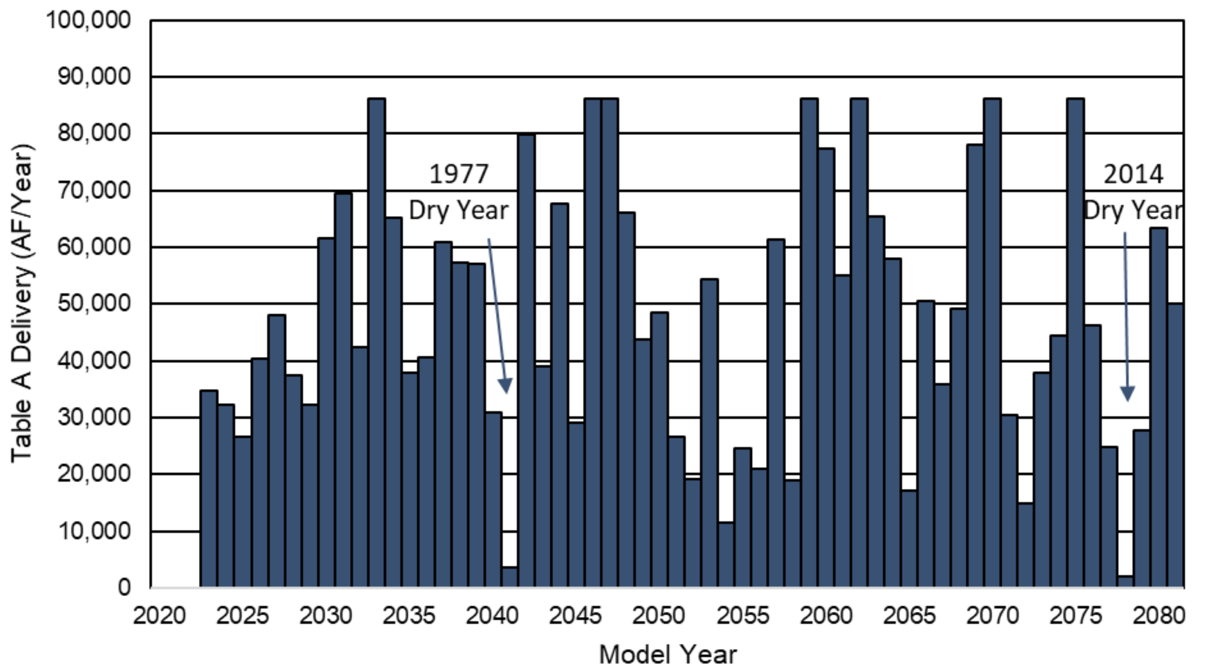

Figure 5-9: Annual Table A Allocation from Trace A

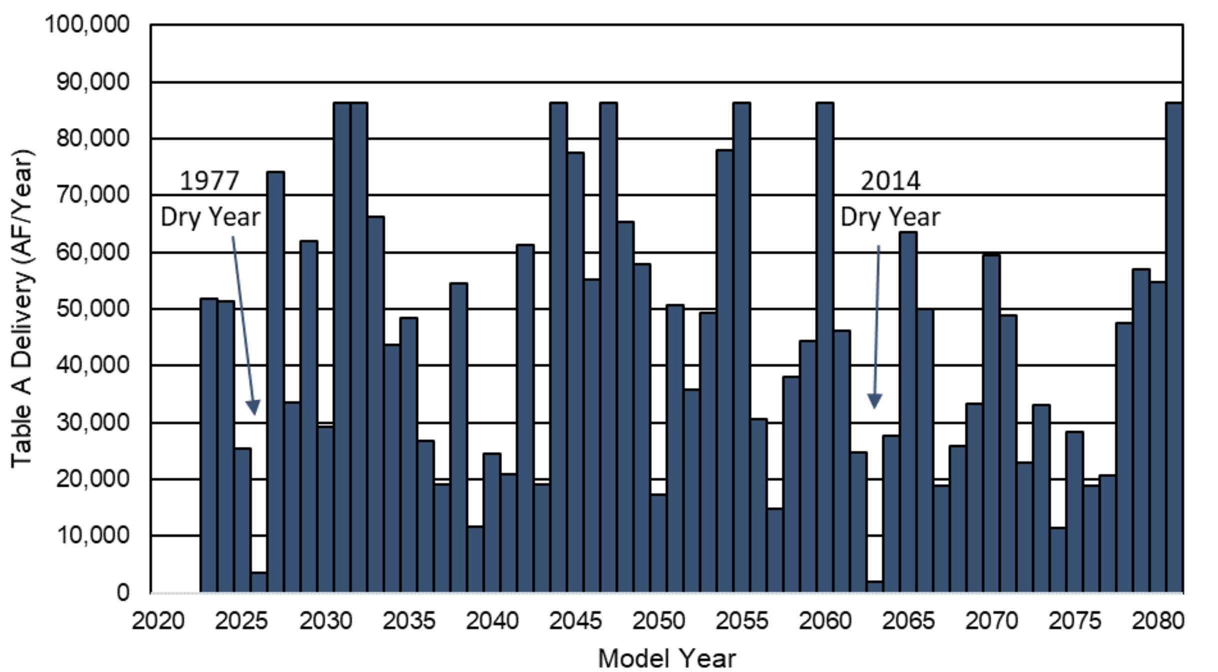

Figure 5-10: Annual Table A Allocation from Trace B

5.1.2.6 Model Validation

A validation approach was developed and implemented throughout the modeling process to test system performance. The identified models and datasets for comparative analysis were the Old Risk Model and the 2021 Hydrologic Inventory. The basis of comparison and common assumptions, including similar infrastructure assumptions and hydrologic periods were established. Common parameters and variables available across the comparative datasets were identified and then reviewed. Model inputs and outputs were then quantitatively compared across the three sources. The comparative analysis between the Inventory and Old Risk Model established a baseline for the new model parameterization. Data relationships from the Old Risk Model (i.e., future infrastructure modifications) were built into the New Risk Model and more granular specifics (i.e., groundwater mass balance parameters) from the Inventory were implemented where possible. This ensured that the New Risk Model aligns at a high-level with the inputs and outputs established in the comparative datasets and models.

The validation approach applied to groundwater mass balance components is exemplified in Figure 5-11. This figure displays the minimum, maximum, and average values for different gains and losses to the groundwater system, comparing a range of values from the 2021 Hydrologic Inventory, Old Risk Model, and New Risk Model. The new model gains and losses averages align between the comparative sources. These metrics were reviewed with Zone 7 within a workshop, and it was determined that the new model performance was acceptable for further testing and analysis.

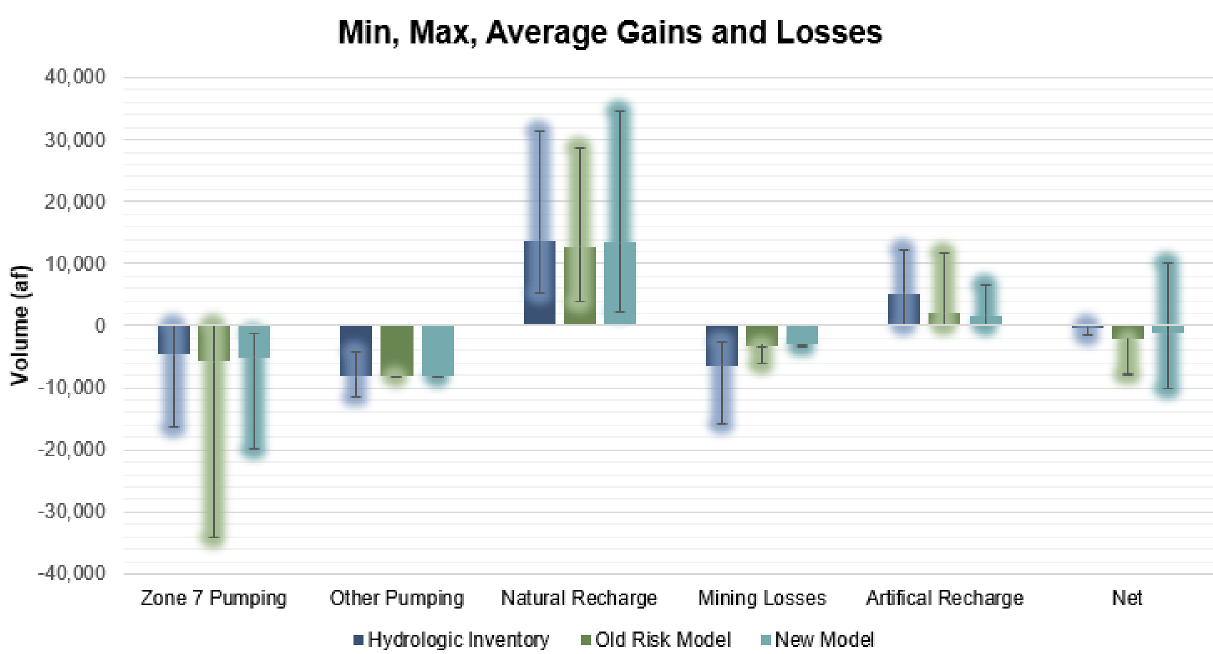

Figure 5-11: Validation – Groundwater Mass Balance Comparison

5.2 Performance Metrics for Measuring System Performance

This Section reviews the performance metrics used for measuring system performance with the New Risk Model.

5.2.1 Probabilistic Measures of Supply Reliability

As discussed in Section 5.1.2.5, the results generated by the ISM are 94 traces for each supply portfolio. These results cover the range of likely outcomes, and no single trace represents the most, or least, likely outcome. Rather than attempt to look at 94 traces at once, shortages are summarized by three metrics: average, 99% chance of shortage of up to 15%, and 90% chance of shortage of up to 0%. The 90% and 99% Chance of Shortage lines plot the shortage volume that would not be exceeded 90% or 99% of the time, respectively. Conversely, this shortage volume can be expected to be exceeded 10% or 1% of the time, respectively. Callouts in Figure 5-12 and Figure 5-13 provide tips for reading the shortage plots.

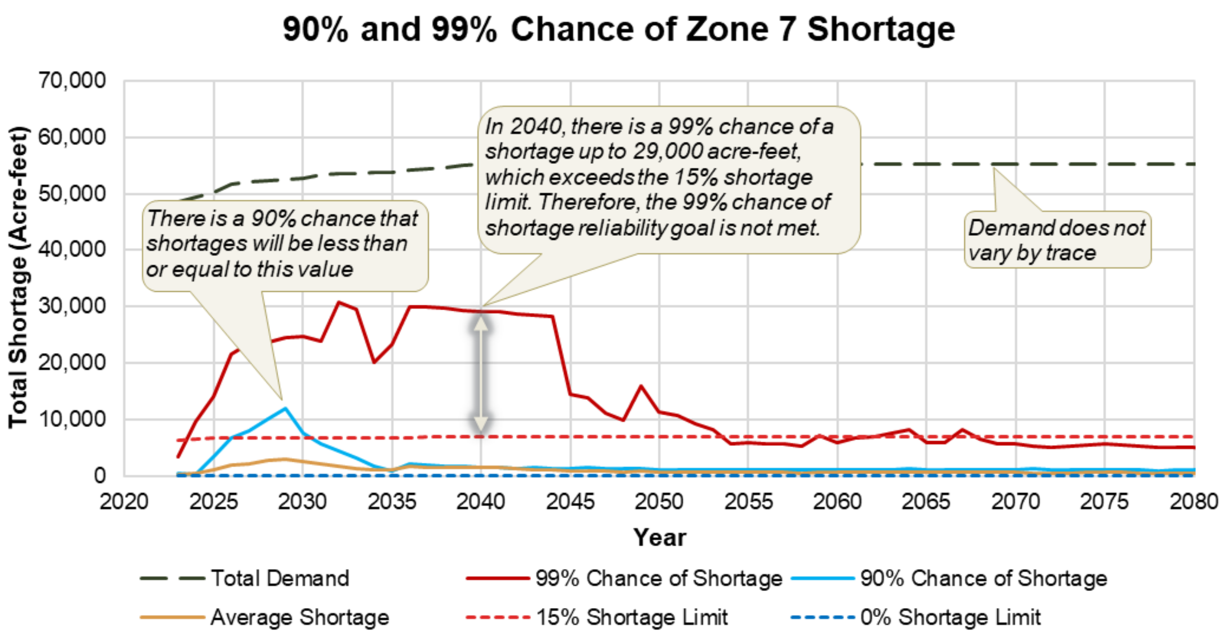

Figure 5-12: Example timeseries of demand, shortage, and reliability goals plot

In Figure 5-12, for a portfolio to meet the 99% chance of shortage reliability goal, the 99% Chance of Shortage (solid red line) must fall at or below the 15% Shortage Limit (dashed red line). For a portfolio to meet the 90% chance of shortage reliability goal, the 90% Chance of Shortage (solid blue line) must fall at or below the 0% Shortage Limit (dashed blue line). This figure is useful for determining long-term trends in a portfolio's effectiveness at meeting the reliability goals.

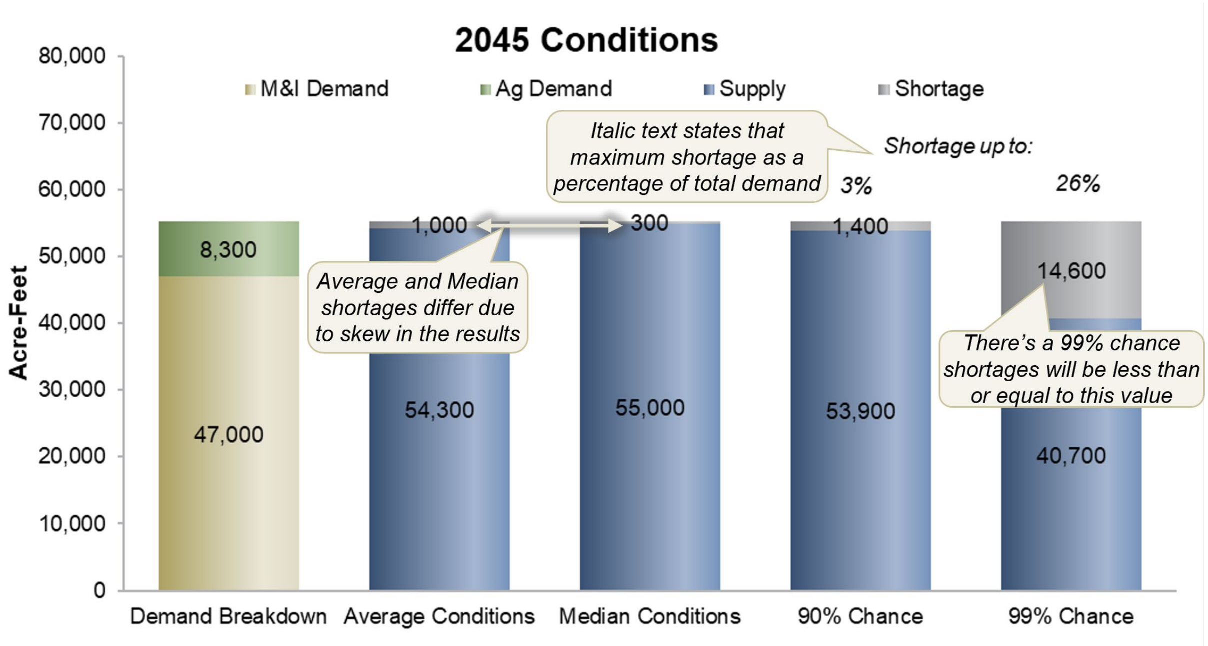

Figure 5-13: Example demand, supply, and shortage for 2045

In Figure 5-13, for a portfolio to meet the 99% chance of shortage reliability goal in 2045, shortages on the 99% Chance bar must not exceed 15%. For a portfolio to meet the 90% chance of shortage reliability goal in 2045, the 90% Chance bar must have 0% shortages. This figure is useful for determining if a portfolio would meet the reliability goals in 2045.

6. Summary of Risk Model Analyses

The New Risk Model was run for a total of ten portfolios, outlined in Table 4-2. Shortage results for each portfolio are summarized in the following sections; see Figure 5-12 and Figure 5-13 for examples of how to interpret the results plots.

6.1 Baseline

The Baseline portfolio does not include any additional water supply reliability projects outside of additional planned well facilities. Table 6-1 presents a summary of portfolio inputs and model assumptions.

Table 6-1: Baseline portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

As shown in Figure 6-1, shortages rise for the first portion of the study period through 2045. Average shortages continue to rise somewhat after 2045 and reach their maximum, around 9,500 AFY after 2055. The 90% chance of shortage (90th percentile) peaks around 2045 at approximately 31,000 AFY. The 99% chance of shortage (99th percentile) peaks around 42,000 AFY after 2041. The increase in demands coupled with lack of new supplies and/or projects mean that shortages progressively get worse until they plateau during the study period.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is not met throughout the study period. The 99% chance of 15% shortage reliability goal rises from 6,455 AFY in 2023 to a final value of 7,050 AFY in 2040. The goal is only met in 2023 and is not met for the remainder of the study period. In 2045, there's a 90% chance of shortage up to 55% and 99% chance of shortage up to 76% (see Figure 6-2).

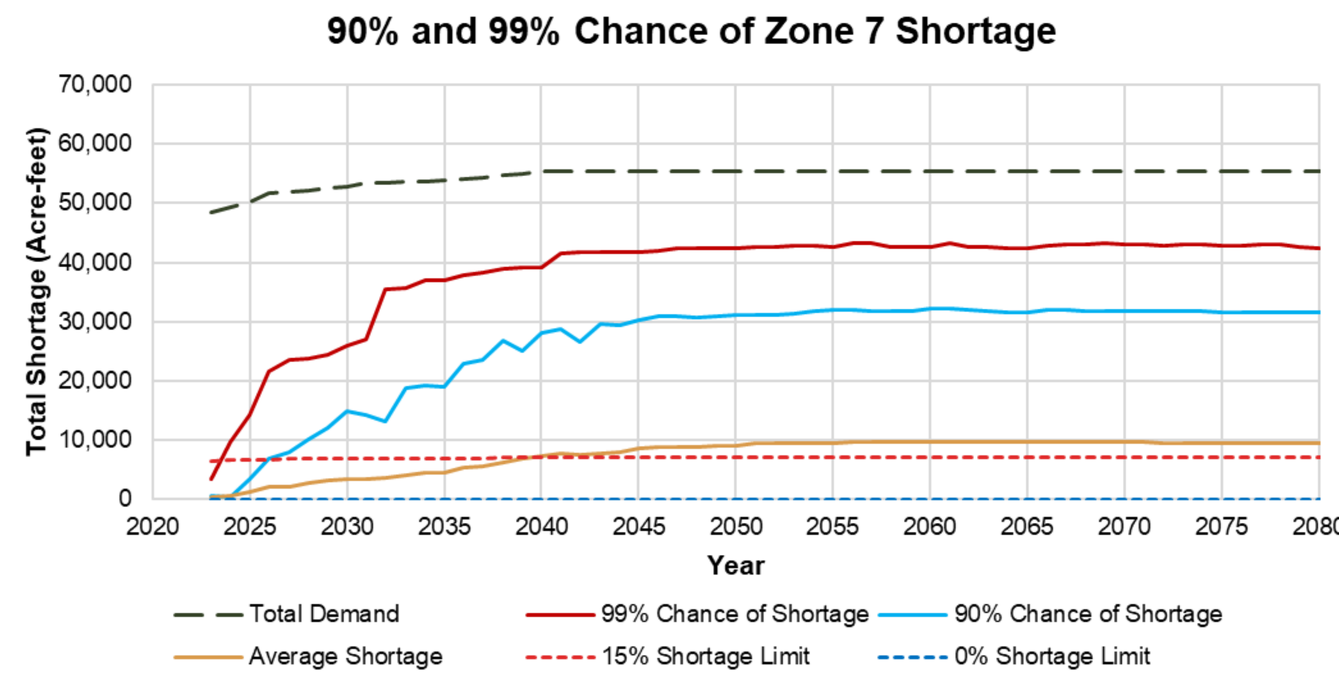

Figure 6-1: Timeseries of total baseline demand, shortage, and reliability goals

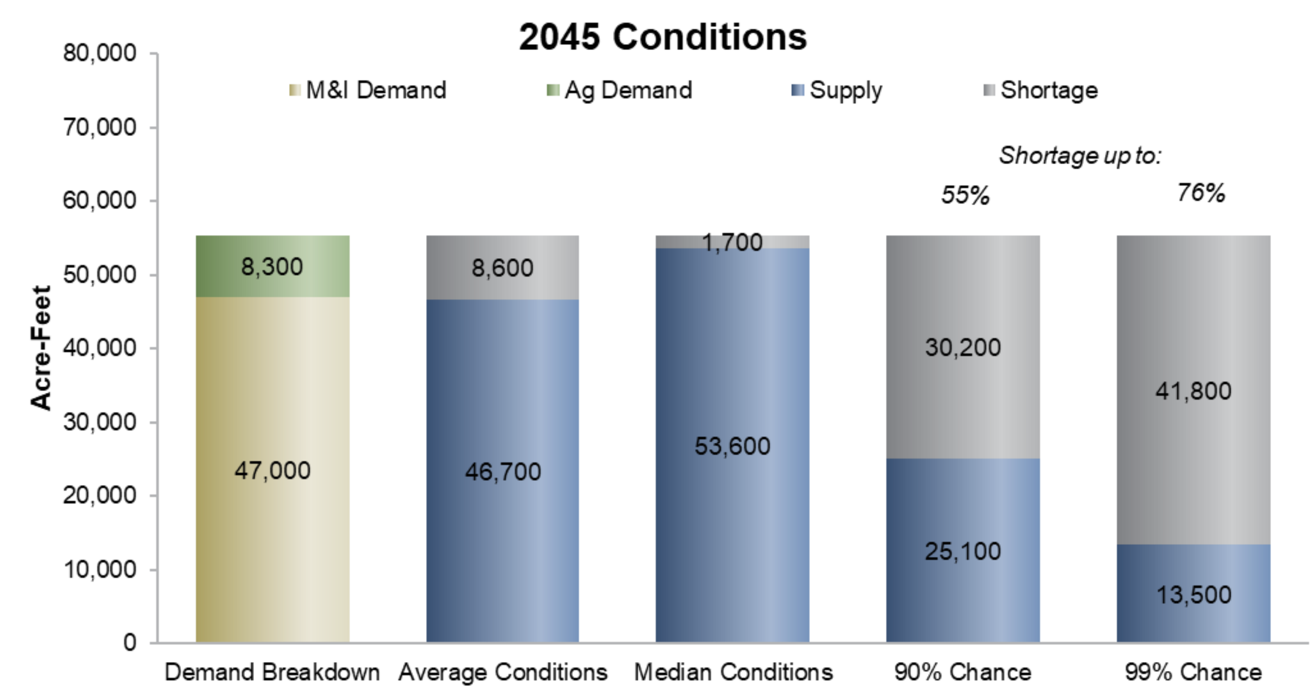

Figure 6-2: Baseline demand, supply, and shortage for 2045

6.2 Potable Reuse + Desal

This portfolio utilizes the same basic assumptions as the baseline scenario, with the addition of desalination and phased potable reuse. Phase 1 of potable reuse begins in 2030 with a max yield of 8,800 AFY and phase 2 begins in 2040 and increases max yield to 9,600 AFY. Desalination begins in 2030 with a max yield of 5,600 AFY (equivalent to 5 MGD). Desalination provides no supply during critically dry years, which occurs for a maximum of two years in any single trace. Table 6-2 presents a summary of portfolio inputs and model assumptions.

Table 6-2: Potable Reuse + Desal portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Potable Reuse	Phase 1 • Supply available 2030-2039 • Max Yield: 8,800 AFY Phase 2 • Supply available in 2040 • Max Yield: 9,600 AFY
Desal	• Supply available in 2030 • Max Yield: 5,600 AFY • Min Yield: 0 AFY in critically dry years
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Shortages follow the same trajectory as the Baseline until new supplies (i.e., phase 1 potable reuse and desalination) become available in 2030 (see Figure 6-3). After 2030, the average shortage decreases from over 3,000 AFY to about 1,500 AFY. The 90% chance of storage (90th percentile) peaks at approximately 12,000 AFY before 2030, then decreases to approximately 2,200 AFY by 2045, after which it remains relatively constant. The 99% chance of shortage (99th percentile) dips to 18,000 AFY in 2031 as a response to new supplies becoming available in 2030. Shortages rebound afterwards and remain around 24,000 AFY throughout the remainder of the study period.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. Although shortages decrease as a response to new supplies, the shortages generally hover at slightly above 4% after 2040 so only a handful of years meet the goal. The 99% chance of a 15% shortage reliability goal is not met throughout the study period. In 2045, there's a 90% chance of shortage up to 4% and 99% chance of shortage up to 45% (see Figure 6-4).

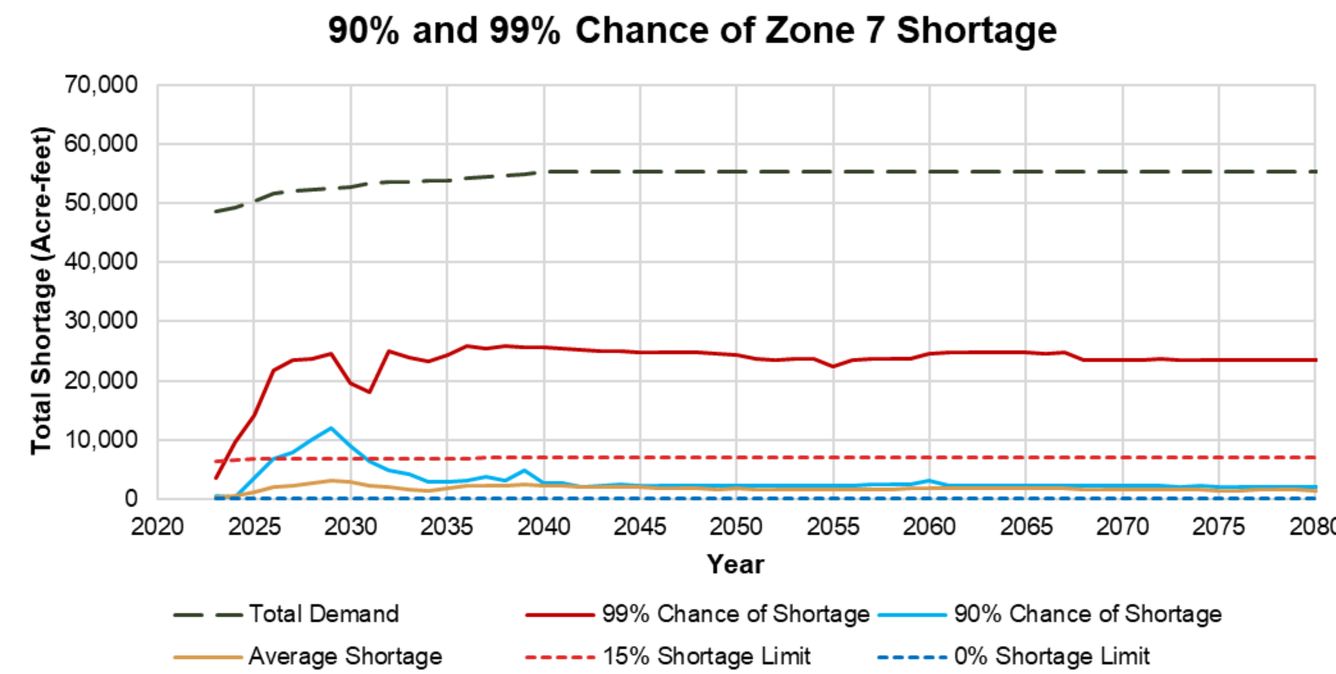

Figure 6-3: Timeseries of total demand, shortage, and reliability goals for the potable reuse + desalination portfolio

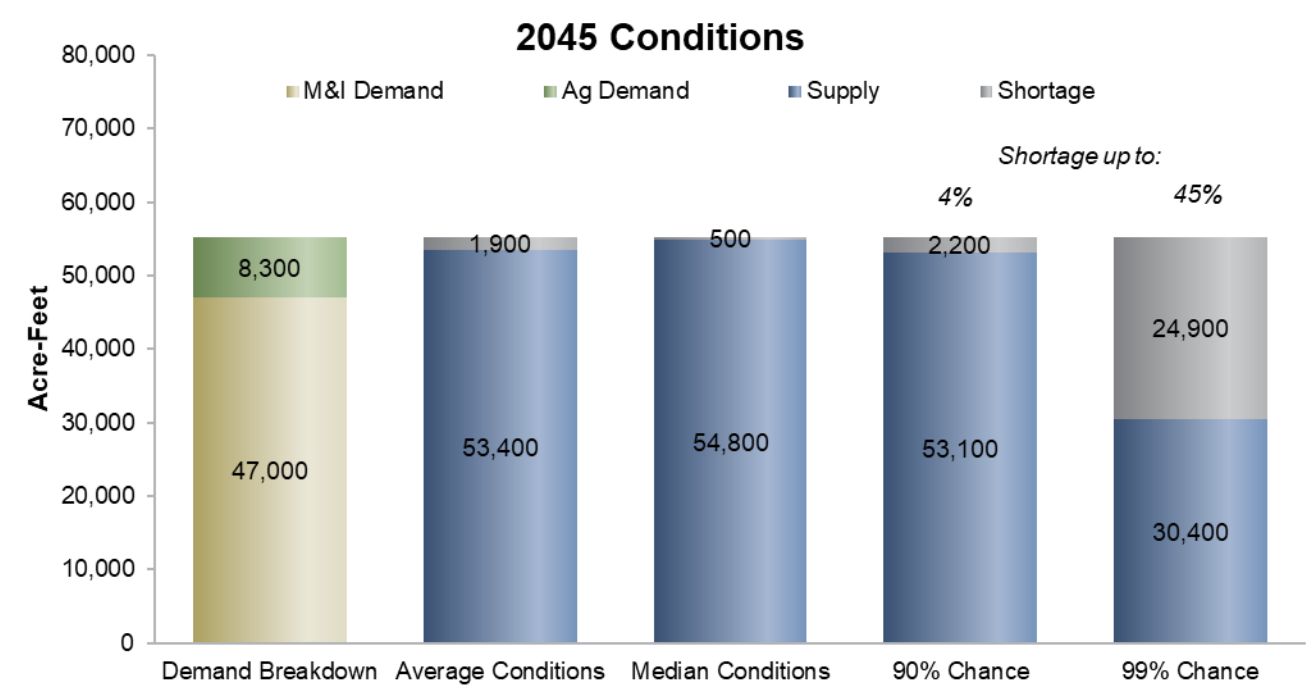

Figure 6-4: Demand, supply, and shortage for 2045 for the potable reuse + desalination portfolio

6.3 Sites + LVE

This portfolio utilizes the same basic assumptions as the Baseline, with the addition of Sites and LVE. Both projects become available in 2030. Average Sites deliveries are 8,000 AFY with 62,340 AF of storage capacity available to Zone 7. Meanwhile, 10,000 AF of storage capacity is available to Zone 7 in the expanded Los Vaqueros Reservoir. Table 6-3 presents a summary of portfolio inputs and model assumptions.

Table 6-3: Sites + LVE portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
LVE	• Storage capacity available in 2030 • Storage Capacity: 10,000 AF
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Shortages follow the same trajectory as the Baseline until new supplies become available in 2030 (see Figure 6-5). Average shortages peak at over 3,000 AFY prior to new supplies coming online in 2030. After 2030, the average shortage decreases somewhat and varies between about 2,000 and 3,000 AFY for the remainder of the study period. The 90% chance of storage (90th percentile) peaks at 12,000 AFY prior to 2030. After new supplies and storage come online in 2030, the 90% chance shortages decrease to a relatively constant 2,000 AFY until 2055. After 2055, the 90% chance of shortage increases to between 6,000 and 8,000 AFY. The 99% chance of shortage (99th percentile) rises to 25,000 AFY prior to 2030, then jumps to vary between 37,000 and 38,000 AFY for the remainder of the study period.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is most consistently met from 2044 to 2052. The 99% chance of a 15% shortage reliability goal is not consistently met throughout the study period. In 2045, there's a 90% chance of shortage up to 3% and 99% chance of shortage up to 70% (see Figure 6-6).

Deliveries from Sites are dependent on annual inflow to the reservoir and range from 0 to 30,600 AFY and are on average 8,000 AFY. Sites storage ranges from 0 to 33,300 AF (about half of Zone 7's storage capacity). Deliveries from Los Vaqueros range from 0 to 6,000 AFY and average less than 800 AFY. Storage and deliveries are dependent on the annual inflow to the reservoir.

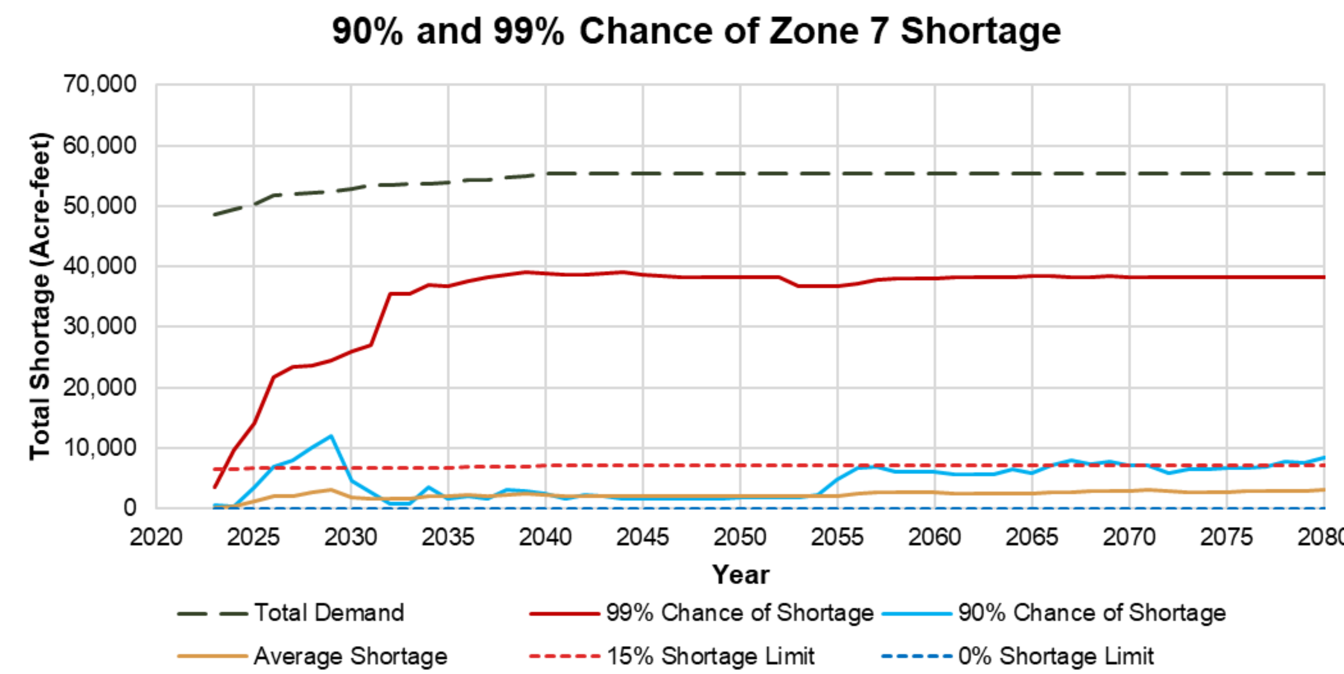

Figure 6-5: Timeseries of total demand, shortage, and reliability goals for the Sites + LVE portfolio

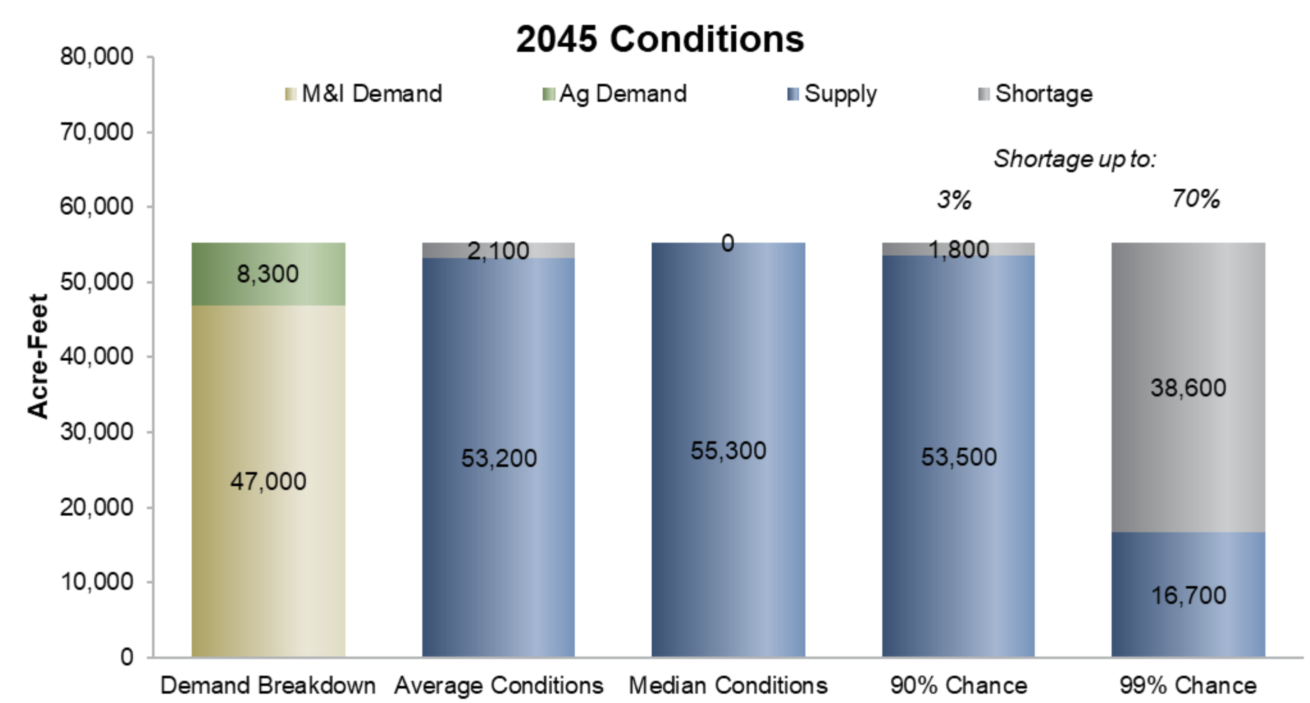

Figure 6-6: Demand, supply, and shortage for 2045 for the Sites + LVE portfolio

6.4 Sites + LVE + Potable Reuse

This portfolio utilizes the same basic assumptions as the Sites + LVE portfolio, with the addition of phased potable reuse. Table 6-4 presents a summary of portfolio inputs and model assumptions.

Table 6-4: Sites + LVE + Potable Reuse portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
LVE	• Storage capacity available in 2030 • Storage Capacity: 10,000 AF
Potable Reuse	Phase 1 • Supply available 2030-2039 • Max Yield: 8,800 AFY Phase 2 • Supply available in 2040 • Max Yield: 9,600 AFY
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Shortages follow the same trajectory as the Baseline until new supplies become available in 2030 (see Figure 6-7). The average shortage peaks at over 3,000 AFY prior to 2030. After 2030, the average shortage decreases to less than 1,000 AFY after 2045. The 90% chance of shortage (90th percentile) peaks at approximately 12,000 AFY prior to 2030, then decreases to below 2,000 AFY at 2034, after which it remains relatively constant. The 99% chance of shortage (99th percentile) plateaus around 30,000 AFY from 2032 to 2044 and sharply decreases in 2045. It reduces to around 6,000 AFY in 2054 and remains relatively constant for the remainder of the study period.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is not met for any year throughout the study period. The 99% chance of 15% shortage reliability goal is only met for one year prior to 2030. The 99% chance reliability goal is also met for 31 out of the 37 years between 2045 and the end of the study period in 2081. In 2045, there's a 90% chance of shortage up to 3% and 99% chance of shortage up to 26% (see Figure 6-8).

Deliveries from Sites are dependent on annual inflow to the reservoir and range from 0 to 30,600 AFY and are on average 8,000 AFY. Sites storage ranges from 0 to 29,700 AF (about half of Zone 7's storage capacity). Deliveries from Los Vaqueros range from 0 to 3,300 AFY and average less than 1,000 AFY. Storage and deliveries are dependent on the annual inflow to the reservoir.

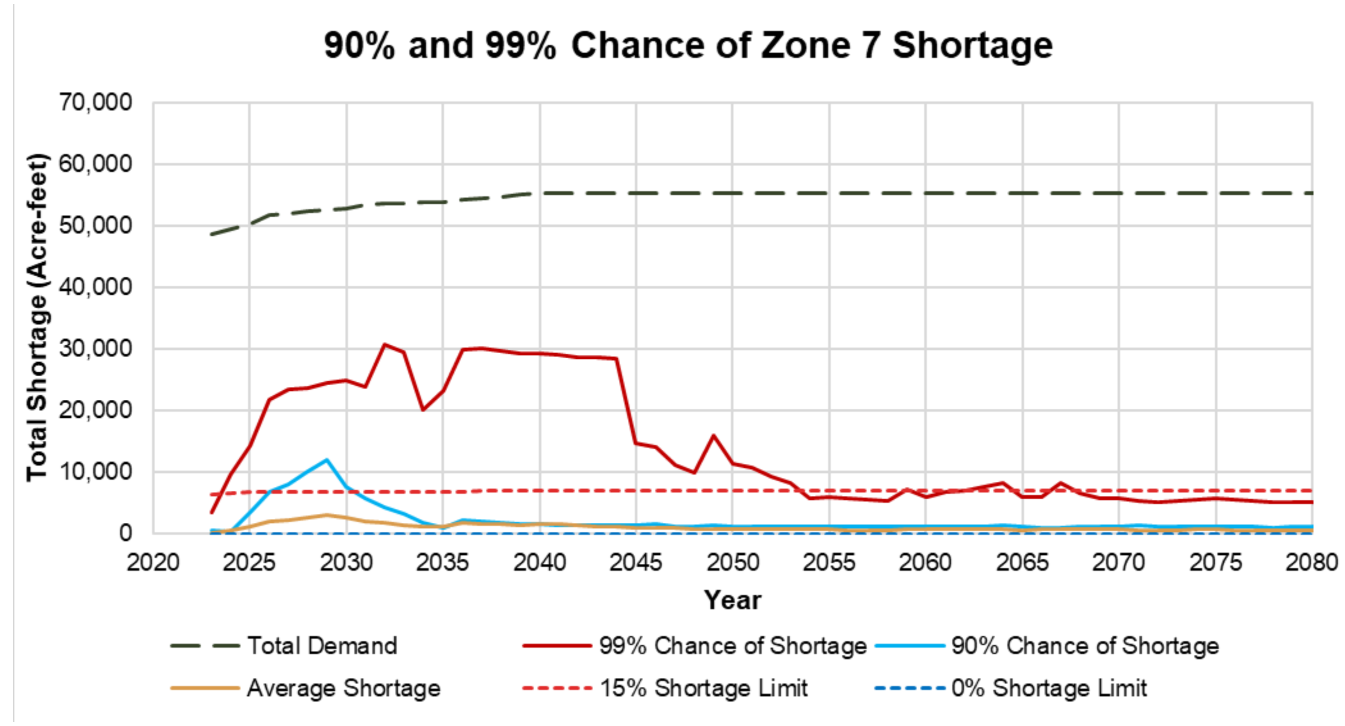

Figure 6-7: Timeseries of total demand, shortage, and reliability goals for the Sites + LVE + Potable Reuse portfolio

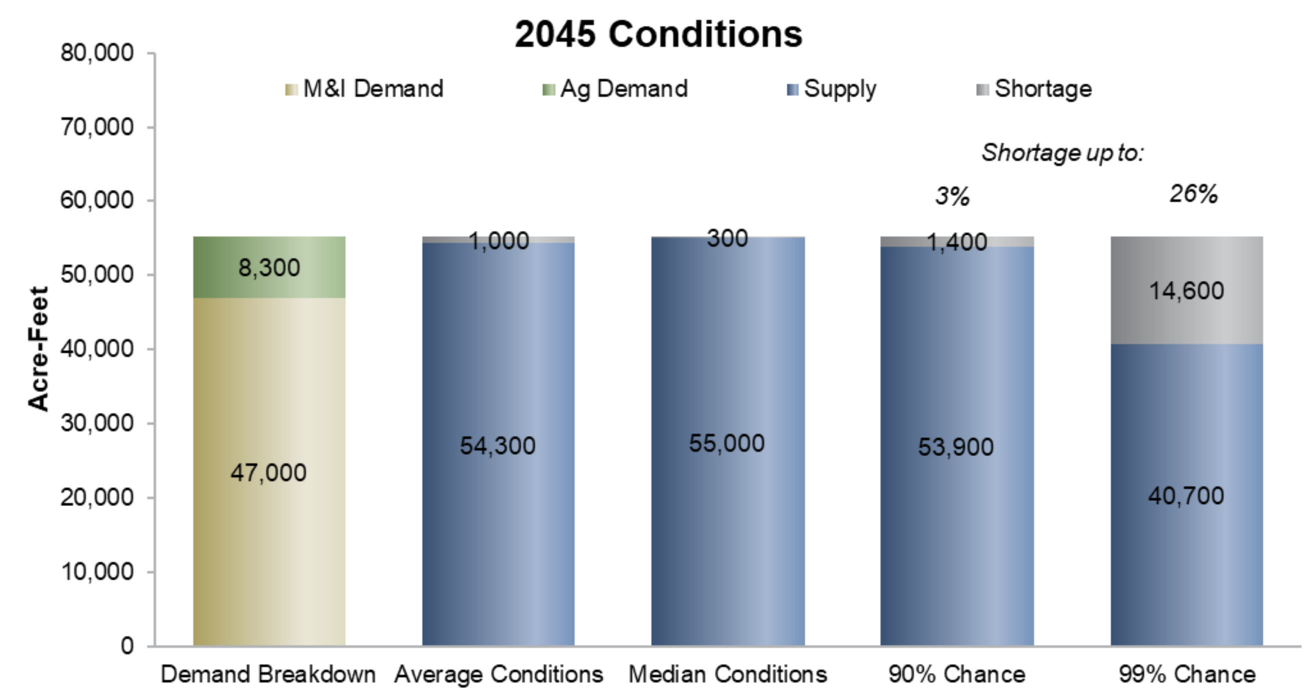

Figure 6-8: Demand, supply, and shortage for 2045 for the Sites + LVE + Potable Reuse portfolio

6.5 Sites + LVE + Potable Reuse + Transfers

This portfolio utilizes the same basic assumptions as the Sites + LVE + Potable Reuse portfolio, with the addition of transfers. Table 6-5 presents a summary of portfolio inputs and model assumptions.

Table 6-5: Sites + LVE + Potable Reuse + Transfers portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
LVE	• Storage capacity available in 2030 • Storage Capacity: 10,000 AF
Potable Reuse	Phase 1 • Supply available 2030-2039 • Max Yield: 8,800 AFY Phase 2 • Supply available in 2040 • Max Yield: 9,600 AFY
Transfers	• Supply available 2023-2030 • Max Yield: 10,000 AFY
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Shortages are noticeably smaller than Baseline portfolio before 2030 due to the additional supply from transfers (see Figure 6-9). Average shortages peak at just over 1,400 AFY in 2031, then decrease to below 1,000 AFY starting in 2044. The 90% chance of shortage (90th percentile) is less than 400 AFY prior to 2030, peaks at 5,300 AFY in 2030, and decreases to below 2,000 AFY beginning in 2037. The 99% chance of shortage (99th percentile) is highly variable until 2045, after which it ranges from approximately 5,000 to 8,000 AFY. Prior to 2045, the peak 99% chance of shortage is 26,500 AFY is 2037.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is met for 55 of the 59 years in the planning period. The 99% chance of 15% shortage reliability goal is met for five years prior to 2030 and for all years from 2045 through the end of the study period in 2081. When comparing this portfolio to Sites + LVE + Potable Reuse (see Figure 6-9 and Figure 6-7), the benefit of the transfers is noticeable even after the program ends in 2030; with transfers, there is an increased number of years the 99% chance of shortage reliability goal is met post-2030 and the reduction in peak 99% and 90% chance shortages. In 2045, there's a 90% chance of shortage up to 3% and 99% chance of shortage up to 12% (see Figure 6-10).

Deliveries from Sites range from 0 to 30,600 AFY and average 8,000 AFY. Deliveries are dependent on annual inflow to the reservoir. Sites storage ranges from 0 to 33,300 AF (about half of Zone 7's storage capacity). Diversions from Los Vaqueros range from 0 to 3,300 AFY and average less than 1,000 AFY. Storage and deliveries are dependent on the annual inflow to the reservoir.

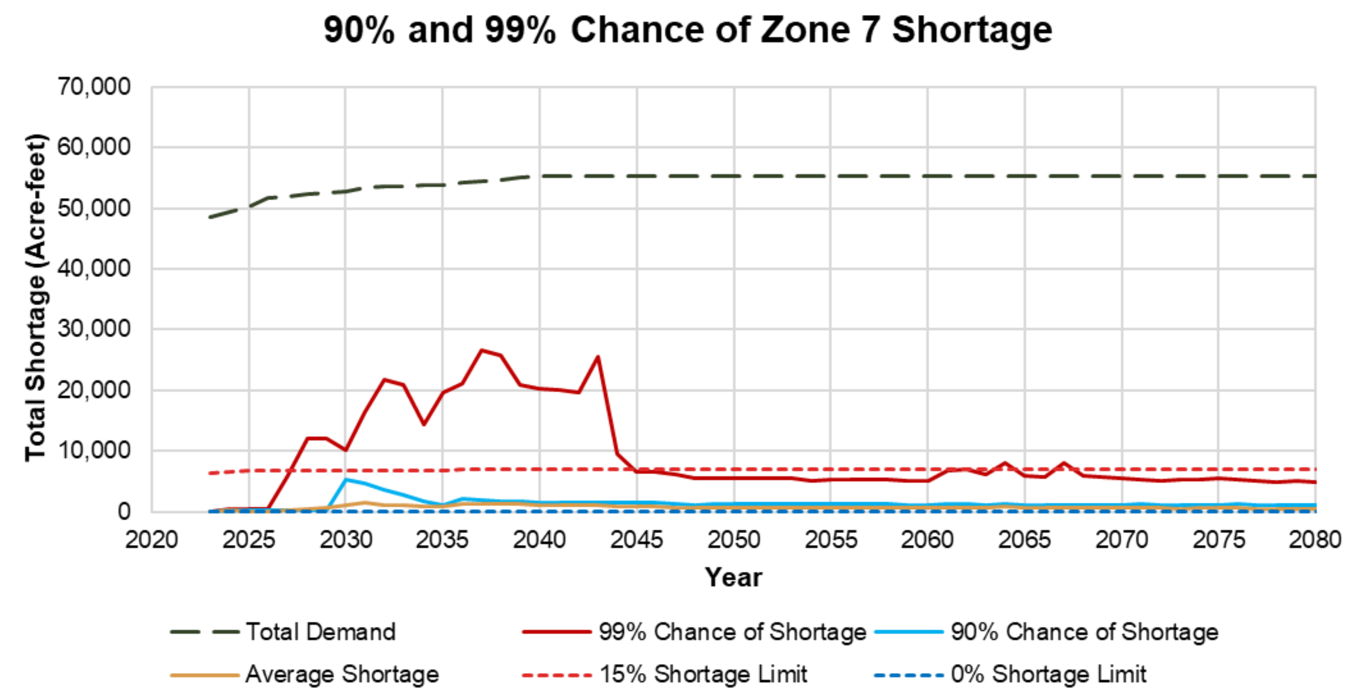

Figure 6-9: Timeseries of total demand, shortage, and reliability goals for the Sites + LVE + potable reuse + transfers portfolio

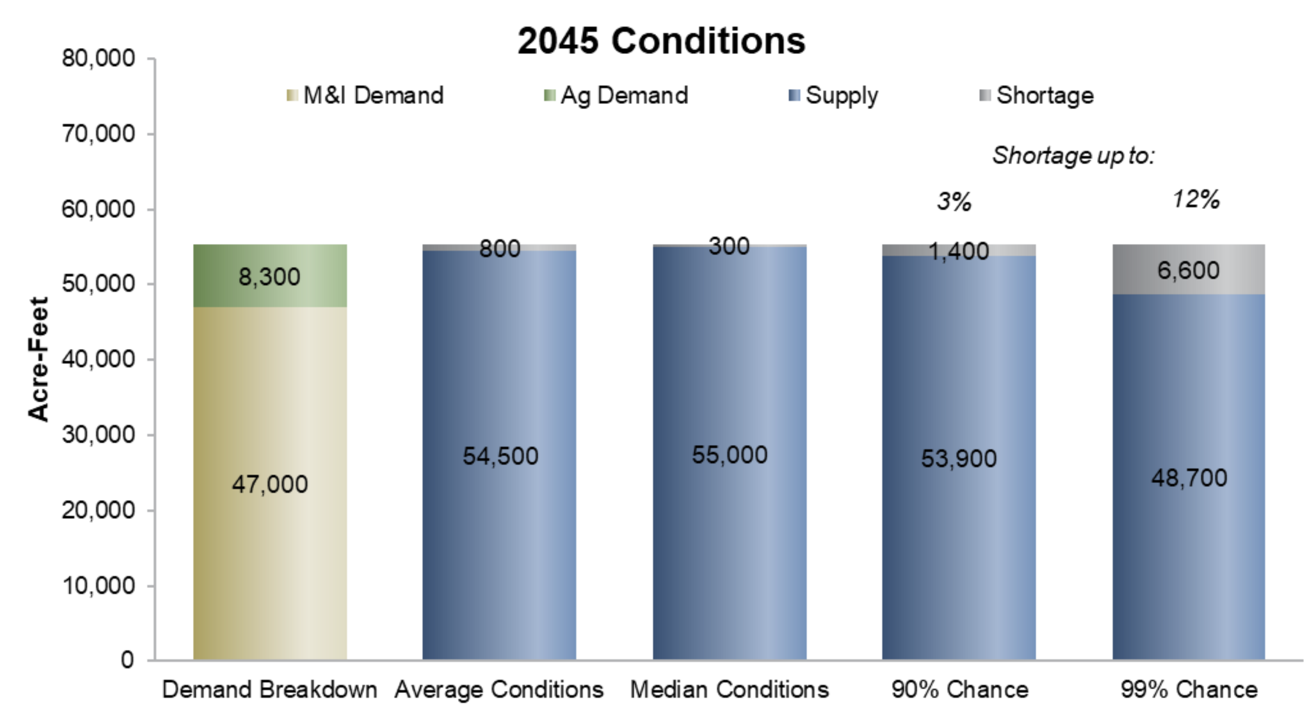

Figure 6-10: Demand, supply, and shortage for 2045 for the Sites + LVE + potable reuse + transfers portfolio

6.6 Sites + LVE + Desal

This portfolio utilizes the same basic assumptions as the Sites + LVE portfolio, with the addition of desalination. Table 6-6 presents a summary of portfolio inputs and model assumptions.

Table 6-6: Sites + LVE + Desal portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
LVE	• Storage capacity available in 2030 • Storage Capacity: 10,000 AF
Desal	• Supply available in 2030 • Max Yield: 5,600 AFY • Min Yield: 0 AFY in critically dry years
Model Assumptions	
SWP Reliability	• 51% from 2021 DCR Future Conditions • *No Delta Conveyance Project*
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Shortages follow the same trajectory as in the Baseline portfolio until new supplies become available in 2030 (see Figure 6-11). The average shortage peaks at over 3,000 AFY prior to 2030. After 2030, the average shortage decreases to less than 1,000 AFY after 2045. The 90% chance of storage (90th percentile) peaks at 12,000 AFY prior to 2030 and remains relatively constant around 1,000 AFY beginning in 2030. The 99% chance of shortage (99th percentile) generally increases until it roughly plateaus at a maximum of about 33,000 AFY from 2036 to 2044. After 2045, the 99% chance shortages decrease to a minimum of approximately 12,000 AFY before rising to plateaus of about 28,000 AFY in the 2060s and 20,000 AFY in the mid-2070s.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is met for 54 of the 59 years in the planning period. The 99% chance of 15% shortage reliability goal is not met throughout the study period except for in 2023. In 2045, there's a 90% chance of shortage up to 2% and 99% chance of shortage up to 48% (see Figure 6-12).

Deliveries from Sites range from 0 to 30,600 AFY and average 8,000 AFY. Deliveries are dependent on annual inflow to the reservoir. Sites storage ranges from 0 to 33,300 AF (about half of Zone 7's storage capacity in Sites Reservoir). Deliveries from Los Vaqueros range from 0 to 3,100 AFY and average less than 1,000 AFY. Storage and deliveries are dependent on the annual inflow to the reservoir.

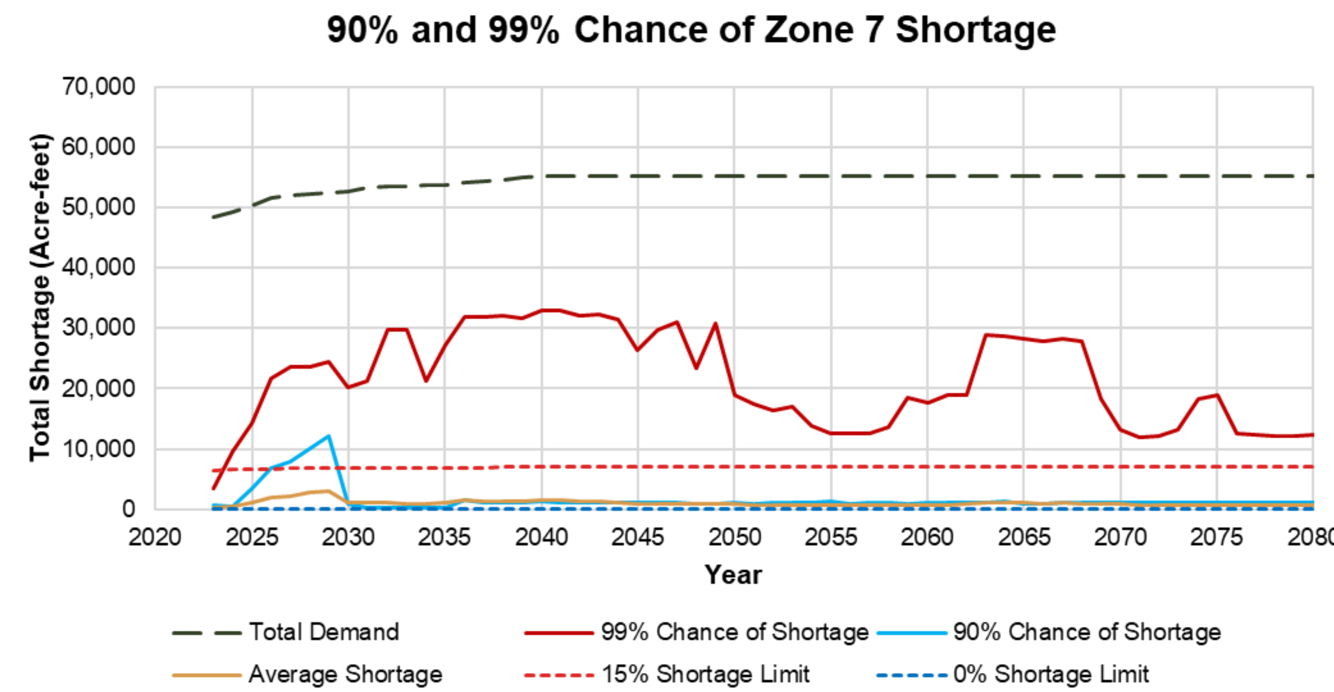

Figure 6-11: Timeseries of total demand, shortage, and reliability goals for the Sites + LVE + Desal portfolio

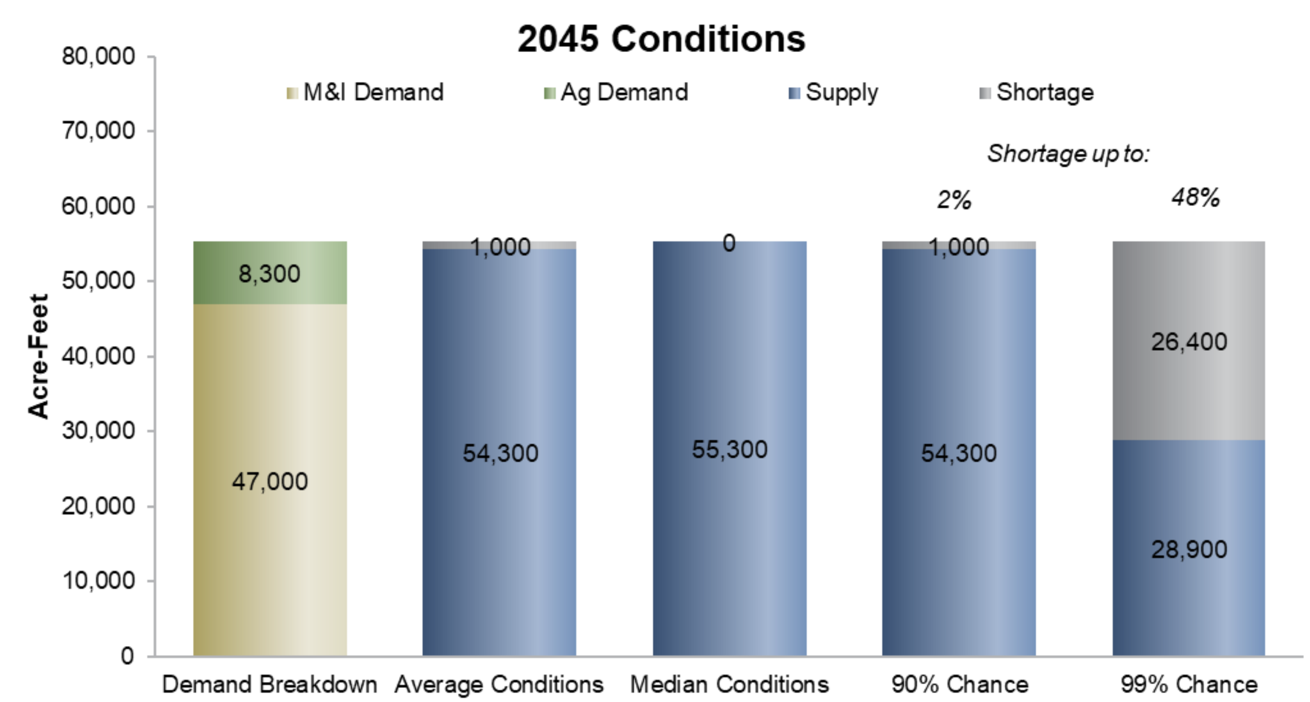

Figure 6-12: Demand, supply, and shortage for 2045 for the Sites + LVE + Desal portfolio

6.7 Sensitivity Analyses

This section reviews the sensitivity analyses conducted using the New Risk Model. Sensitivity analyses were conducted to evaluate the impact of DCP and alternate groundwater pumping/conjunctive use strategies. The following subsections review the sensitivity analysis assumptions and results.

6.7.1 DCP

DCP was evaluated using revised Table A and Article 21 availability from the most recent CalSim 3 scenarios executed by DWR (California Department of Water Resources, 2021a). Per discussion with DWR, there are slight differences in San Luis operations associated with DCP. DCP was incorporated in the following scenarios defined in Table 6-7.

Table 6-7: Summary of DCP Portfolios

Portfolio Name	New Wells	Transfers	*Potential Future Projects*				
			Sites	LVE	Desal	Potable Reuse	DCP
DCP	✓						✓
Sites + DCP	✓		✓				✓
Sites + Potable Reuse + DCP	✓		✓			✓	✓
Sites + LVE + Potable Reuse + Transfers	✓	✓	✓	✓		✓	✓

The addition of DCP, which increases SWP reliability, effectively reduces the 90% and 99% chance shortages, and in certain scenarios increases the number of years the 99% chance of 15% shortage reliability goal is met. For example, the addition of DCP to the Sites + LVE + Potable Reuse + Transfers scenario increases the number of years the 99% chance of 15% shortage reliability goal is met by two years. The addition of DCP to the Baseline portfolio decreases the 99% chance shortages by about 5,000 AFY for the last 40 years of the study period.

6.7.1.1 DCP

The DCP portfolio does not include any additional water supply projects outside of additional planned well facilities and the Delta Conveyance Project. The modeled benefits of DCP include only improvements in SWP reliability and do not account for any Delta outage scenarios. Table 6-8 presents a summary of portfolio inputs and model assumptions.

Table 6-8: Baseline scenario input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
DCP	*Delta Conveyance Project Included*
Model Assumptions	
SWP Reliability	• 59% from Draft DCP EIR
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

As shown in Figure 6-13, shortages rise for the first portion of the study period. Average shortages reach their maximum, around 6,700 AFY in 2039. The 90% chance of shortage (90th percentile) peaks at approximately 27,000 AFY at 2038 and decreases to stay consistently around 20,000 AFY beginning in 2041. The 99% chance of shortage (99th percentile) peaks around 39,000 AFY in 2039 and decreases to stay consistently around 38,000 AFY beginning in 2040. Compared to the Baseline portfolio without DCP (Figure 6-1), average shortages after 2040 are over 4,000 AFY less with DCP. The addition of the DCP decreases the 90% chance shortages by approximately 11,000 AFY after 2040 while the 99% chance shortages decrease by about 5,000 AFY.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is not met for any year after 2024. The 99% chance of 15% shortage reliability goal is not met for any year after 2023.

In 2045, DCP decreases the 90% chance of shortage of up to 55% for the Baseline (Figure 6-2) to up to 30% with the DCP portfolio (Figure 6-14). The 99% chance of shortage decreases from up to 76% for the Baseline to up to 69% with the DCP portfolio.

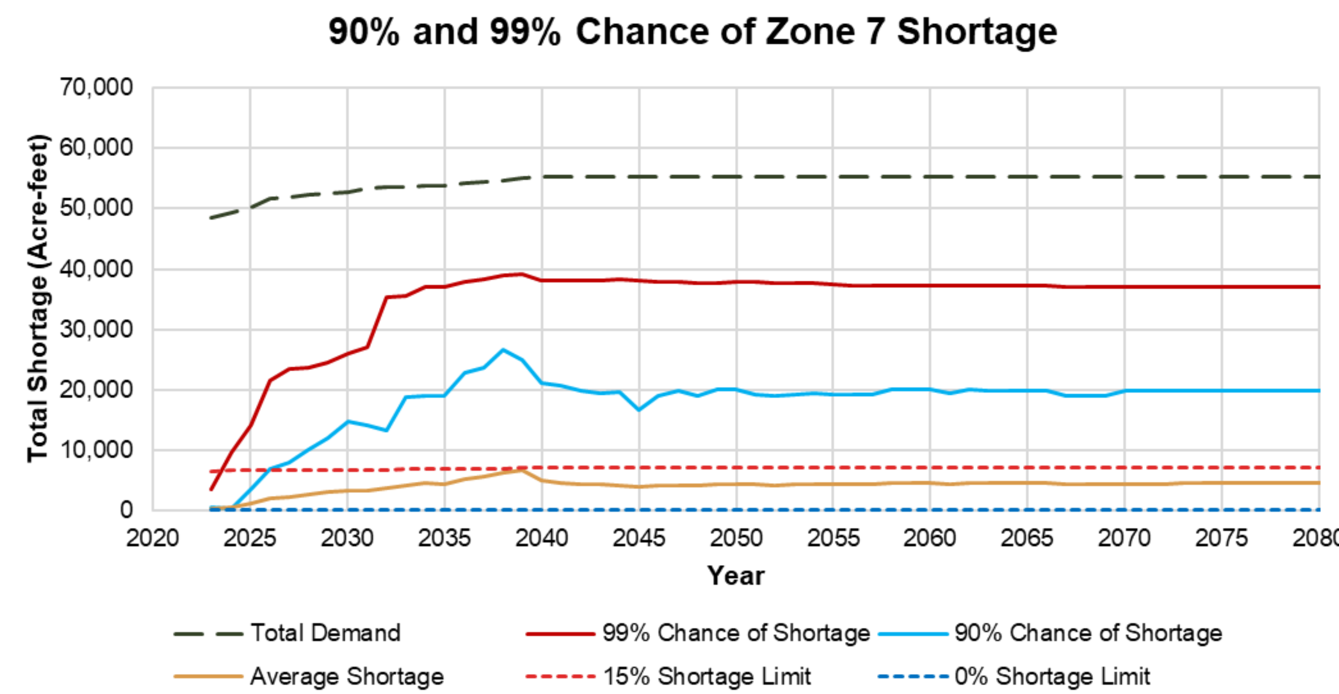

Figure 6-13: Timeseries of total demand, shortage, and reliability goals for the DCP portfolio

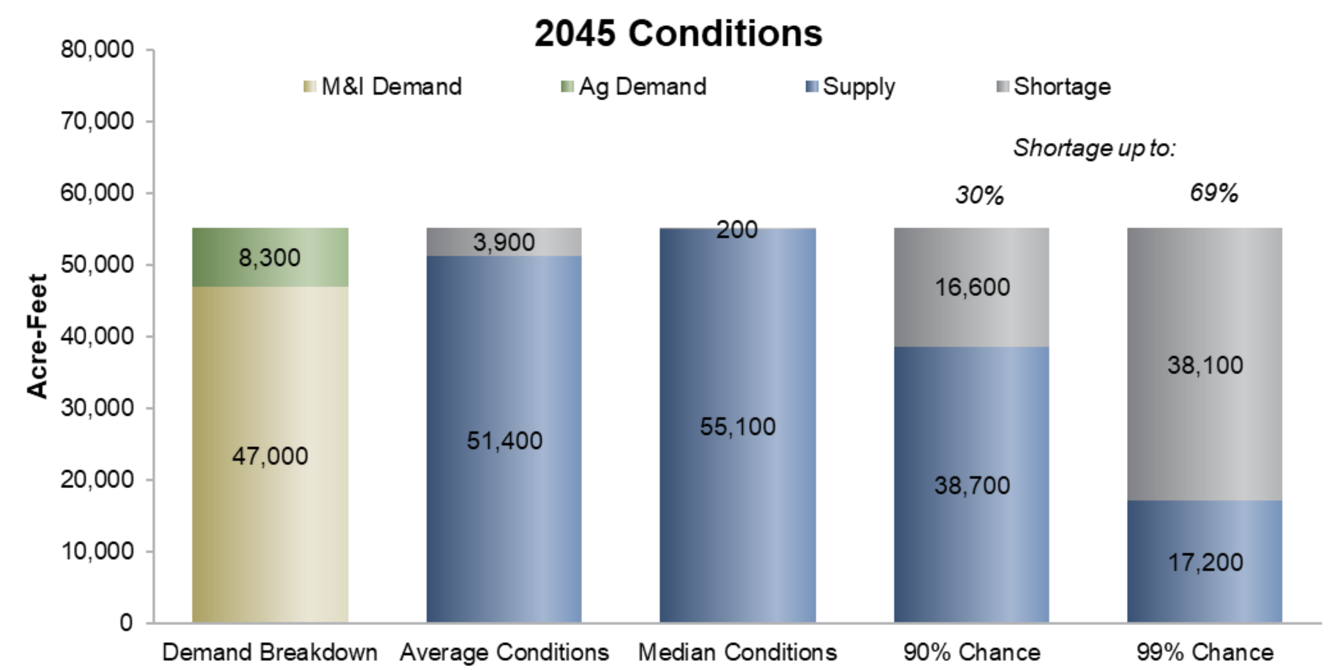

Figure 6-14: Demand, supply, and shortage for 2045 for the DCP portfolio

6.7.1.2 *Sites + DCP*

This portfolio utilizes the same basic assumptions as the DCP scenario, with the addition of the Sites Reservoir Project. Table 6-9 presents a summary of portfolio inputs and model assumptions.

Table 6-9: Sites + DCP portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
DCP	*Delta Conveyance Project Included*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
Model Assumptions	
SWP Reliability	• 59% from Draft DCP EIR
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

As shown in Figure 6-15, shortages rise for the first portion of the study period. Average shortages reach their maximum, around 2,500 AFY in 2039, after which they decrease to below 1,000 AFY after 2050. The 90% chance of shortage (90th percentile) peaks in 2029 at approximately 12,000 AFY and decreases to below 2,000 AFY after 2040. The 99% chance of shortage (99th percentile) peaks around 39,000 AFY in 2039 and decreases to approximately 10,000 AFY beginning in 2055. Compared to the DCP portfolio (Figure 6-13), the Sites + DCP portfolio's average shortages after 2030 are reduced by up to 3,900 AFY. The addition of Sites decreases the 90% chance of shortage by up to 22,000 AFY while the 99% chance of shortage decreases by about 27,000 AFY after 2055.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is not met consistently until 2040, when DCP comes online. The 99% chance of 15% shortage reliability goal is not met for any year after 2023.

In 2045, the addition of Sites decreases the 90% chance of shortage from up to 30% with the DCP portfolio (Figure 6-14) to up to 3% with the Sites + DCP portfolio (Figure 6-16). The 99% chance of shortage decreases from up to 69% with the DCP portfolio to up to 41% with the Sites + DCP portfolio. Additionally, the Sites + DCP portfolio further reduces the 99% chance shortages compared to the DCP portfolio after 2045.

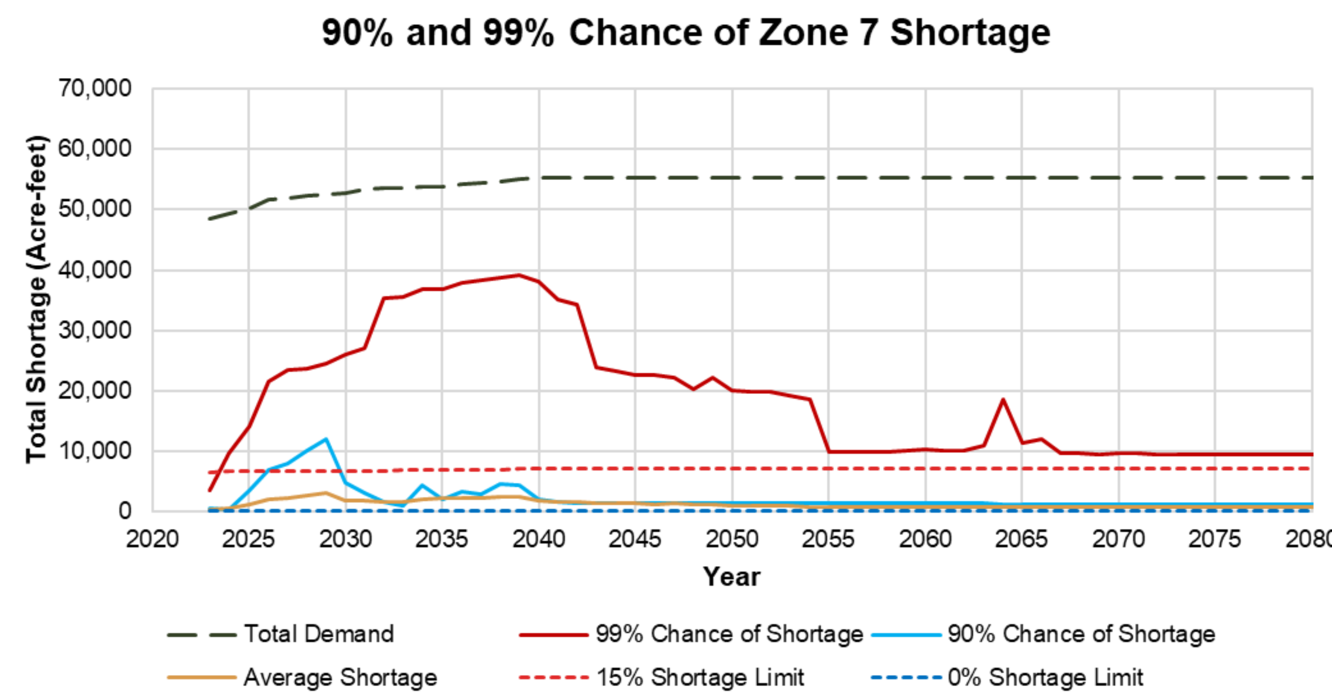

Figure 6-15: Timeseries of total demand, shortage, and reliability goals for the Sites + DCP portfolio

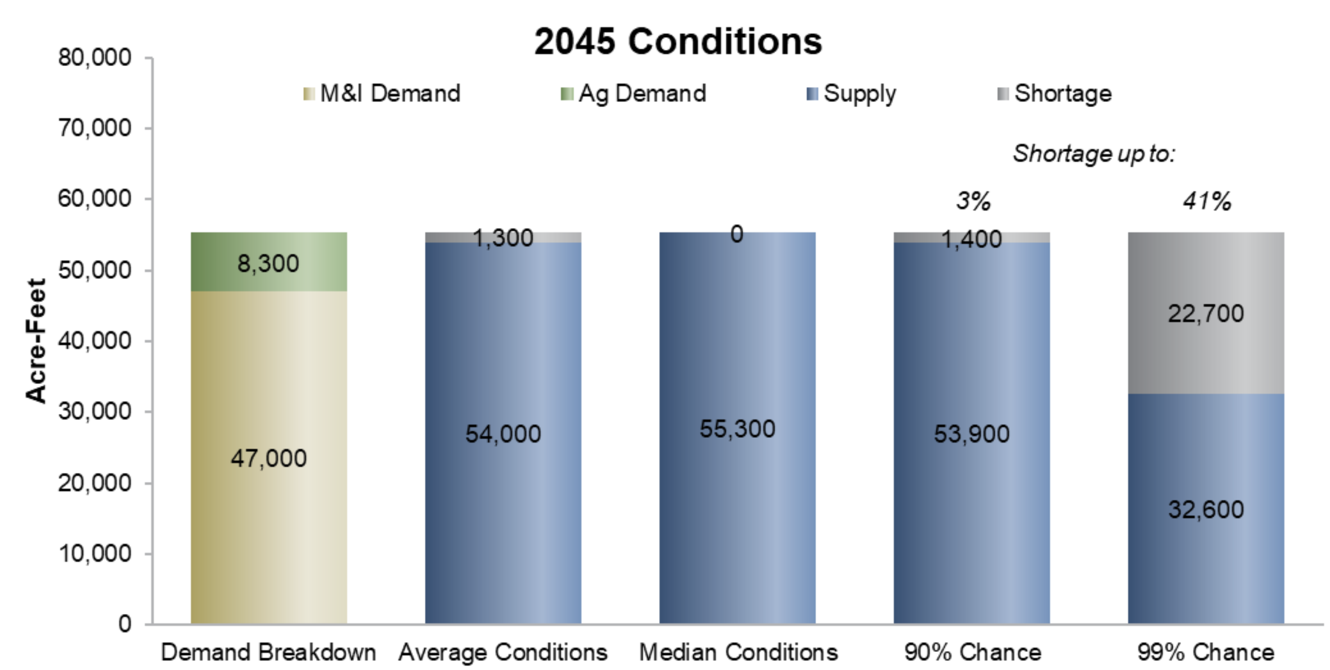

Figure 6-16: Demand, supply, and shortage for 2045 for the Sites + DCP portfolio

6.7.1.3 Sites + Potable Reuse + DCP

This portfolio utilizes the same basic assumptions as the Sites + DCP portfolio, with the addition of phased potable reuse. Table 6-10 presents a summary of portfolio inputs and model assumptions.

Table 6-10: Sites + Potable Reuse + DCP portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
DCP	*Delta Conveyance Project Included*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
Potable Reuse	Phase 1 • Supply available 2030-2039 • Max Yield: 8,800 AFY Phase 2 • Supply available in 2040 • Max Yield: 9,600 AFY
Model Assumptions	
SWP Reliability	• 59% from Draft DCP EIR
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

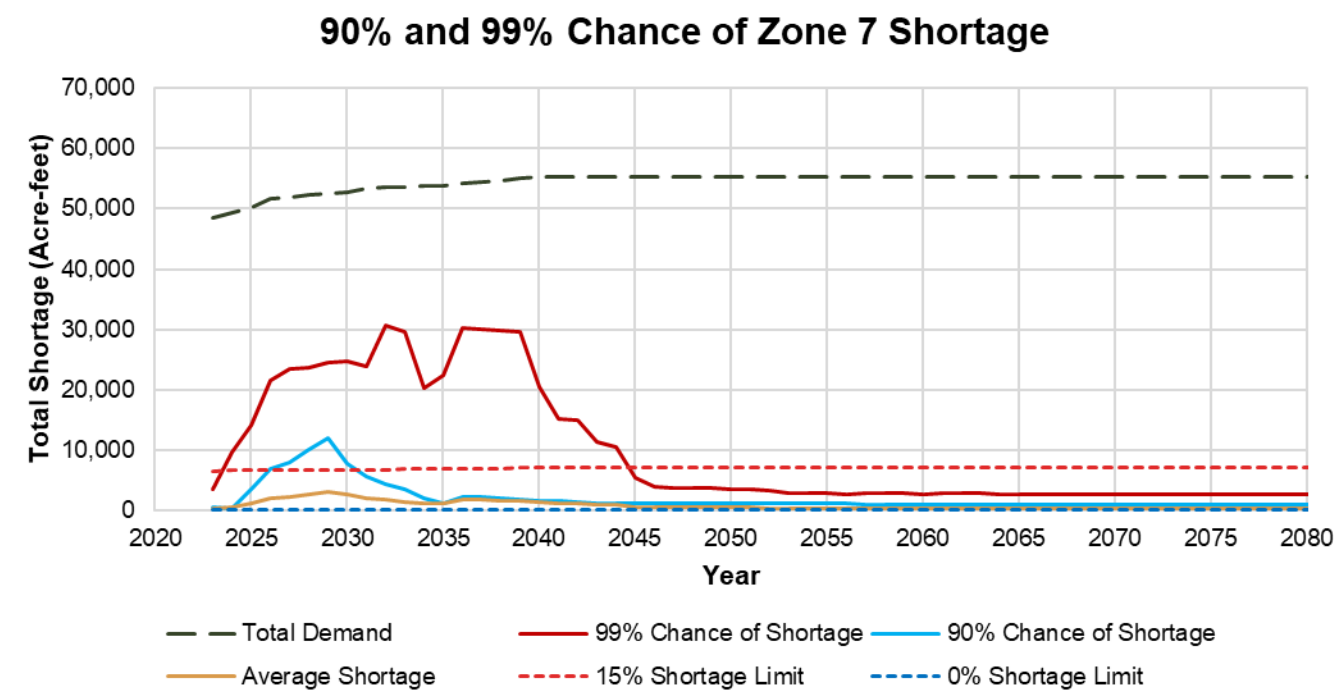

Figure 6-17: Timeseries of total demand, shortage, and reliability goals for the Sites + Potable Reuse + DCP portfolio

As shown in Figure 6-17, shortages rise for the first portion of the study period. Average shortages reach their maximum, around 3,100 AFY in 2029 and decrease to approximately 400 AFY after 2048. The 90% chance of shortage peaks in 2029 at approximately 12,000 AFY and decreases to below 2,000 AFY after 2038. The 99% chance of shortage peaks around 31,000 AFY in 2032 and decreases to below 3,000 AFY beginning in 2053.

Average shortages for the Sites + Potable Reuse + DCP portfolio follow similar trends to the Sites + DCP portfolio (Figure 6-15) throughout the study period. Sites + Potable Reuse + DCP has average shortages that are 300 AFY less than Sites + DCP beginning in 2055. The 90% chance of shortages are also similar for the two portfolios. Sites + Potable Reuse + DCP has 90% chance shortages that are 300 AFY less than Sites + DCP beginning in 2050. The 99% chance of shortages are similar for the two portfolios until 2030, when supply from Sites and Potable Reuse become available. The addition of potable reuse to the Sites + Potable Reuse + DCP portfolio results in 99% chance of shortages that are approximately 10,000 AFY less than Sites + DCP when shortages peak and plateau from 2032 to 2040. Sites + Potable Reuse + DCP has a drastic reduction in 90% chance shortages from 2039 through 2046 and stabilizes with shortages less than 3,000 AFY beginning in 2053, resulting in 90% shortages that are about 7,000 AFY smaller than the Sites + DCP portfolio in the mid-2050s throughout the rest of the study period.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is not met consistently until 2040, when DCP comes online. The 99% chance of 15% shortage reliability goal is met beginning in 2045. The same portfolio without potable reuse (i.e., Sites + DCP) is not able to meet the 99% chance of shortage reliability goal (Figure 6-15) after 2023. In 2045, the addition of potable reuse decreases the 90% chance of shortage from up to 3% with the Sites + DCP portfolio (Figure 6-16) to up to 2% with the Sites + Potable Reuse + DCP portfolio (Figure 6-18). The 99% chance of shortage decreases from up to 41% with the Sites + DCP portfolio to up to 10% with the Sites + Potable Reuse + DCP portfolio.

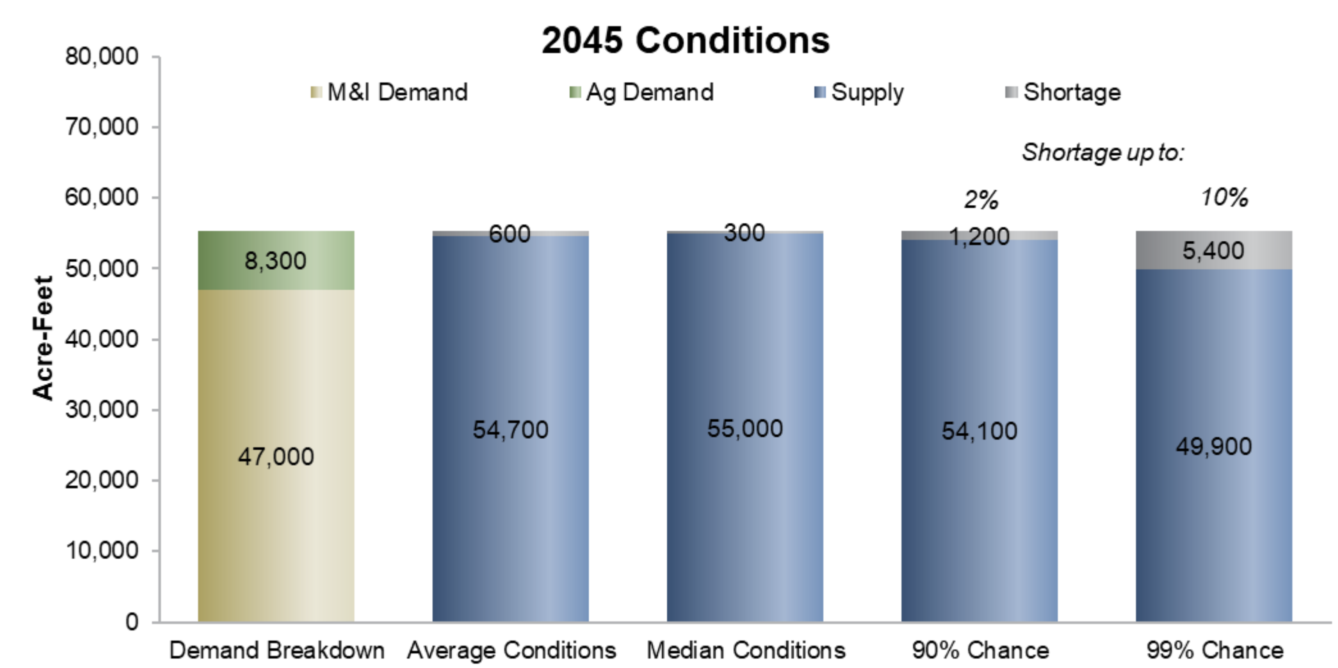

Figure 6-18: Demand, supply, and shortage for 2045 for the Sites + Potable Reuse + DCP portfolio

6.7.1.4 Sites + LVE + Potable Reuse + Transfers + DCP

This portfolio utilizes the same basic assumptions as the Sites + LVE + Potable Reuse + Transfers portfolio, with the addition of DCP. Table 6-11 presents a summary of portfolio inputs and model assumptions.

Table 6-11: Sites + LVE + potable reuse + transfers portfolio input and model assumptions

Portfolio Input	
COL PL	*No Chain of Lakes Pipeline*
DCP	*DCP Included*
Sites	• Supply available in 2030 • Average Yield: 8,000 AFY • Storage Capacity: 62,340 AF
LVE	• Storage capacity available in 2030 • Storage Capacity: 10,000 AF
Potable Reuse	Phase 1 • Supply available 2030-2039 • Max Yield: 8,800 AFY Phase 2 • Supply available in 2040 • Max Yield: 9,600 AFY
Transfers	• Supply available 2023-2030 • Max Yield: 10,000 AFY
Model Assumptions	
SWP Reliability	• 59% from Draft DCP EIR
Average Lake Del Valle Yield	7,000 AFY
Main Basin Initial Storage	208,000 AF
Kern Banks Initial Storage	86,000 AF

Since this portfolio includes transfers, shortages are smaller compared to the other portfolios that include DCP prior to 2030. Average shortages peak at about 1,400 AFY in 2036, then decrease to around 300 AFY beginning in 2045. The 90% chance of shortage is less than 300 AFY before 2030, peaks at 5,300 AFY in 2030, then decreases to below 700 AFY after 2050. The 99% chance of shortage rises to a peak of 26,400 AFY in 2037, then decreases to below 3,000 AFY beginning in 2045.

The 90% chance of 0% shortage reliability goal is assessed with the assumption that shortages of up to 4% can be mitigated with operational changes. The goal is met throughout the study period except from 2030 to 2033, indicating that there is a transitional period between when transfers cease and projects come online. During this period, the shortages associated with the 90th percentile (solid blue line) increase above the level necessary to meet the 90% chance of shortage reliability goal.

The 99% chance of 15% shortage reliability goal is met throughout the study period except from 2028 to 2044. The impact of DCP on the Sites + LVE + Potable Reuse + Transfers portfolio is an a) decrease in average, 90%, and 99% chance shortages, and b) increase in the number of years the 99% chance of 15% shortage reliability goal is met.

Deliveries from Sites range from 0 to 30,600 AFY and average 13,400 AFY. Deliveries are dependent on annual inflow to the reservoir. Sites storage ranges from 0 to 14,200 AF (about a quarter of Zone 7's storage capacity). Deliveries from Los Vaqueros range from 0 to 3,200 AFY and average between 500 and 1,900 AFY. Storage and diversions are dependent on the annual inflow to the reservoir.

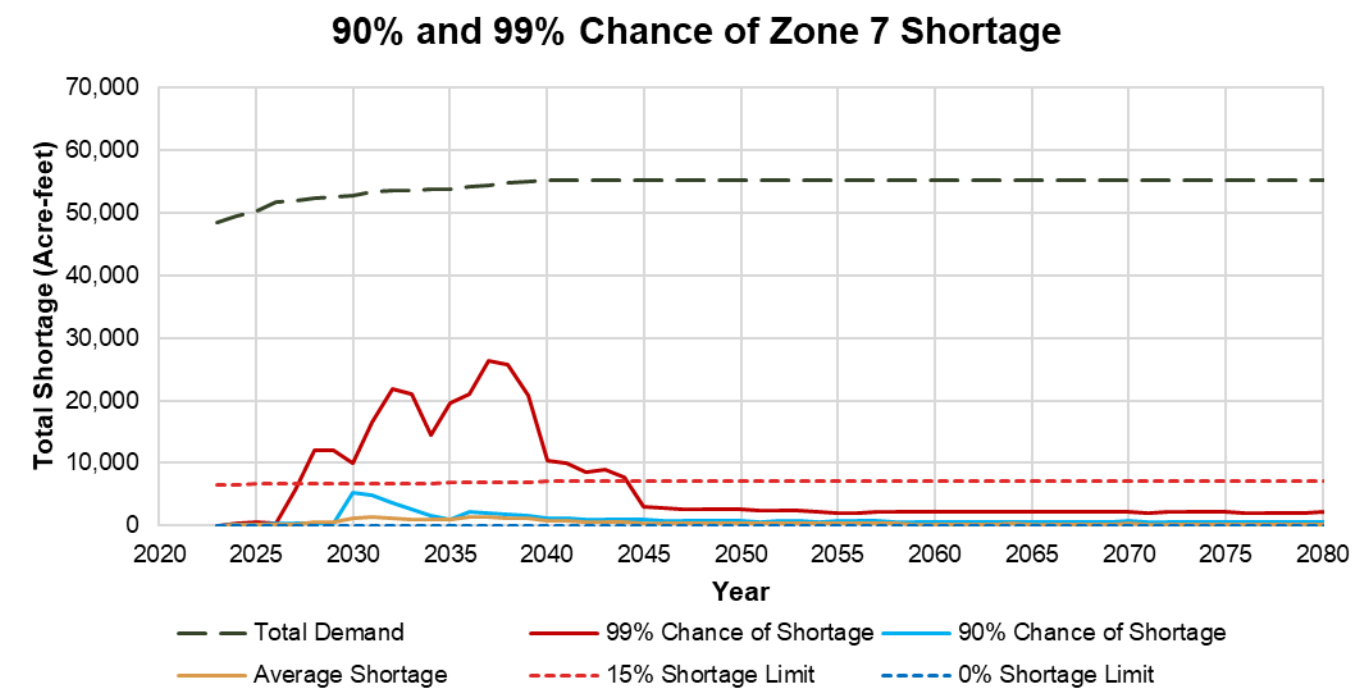

Figure 6-19: Timeseries of total demand, shortage, and reliability goals for the Sites + LVE + Potable Reuse + Transfers + DCP portfolio

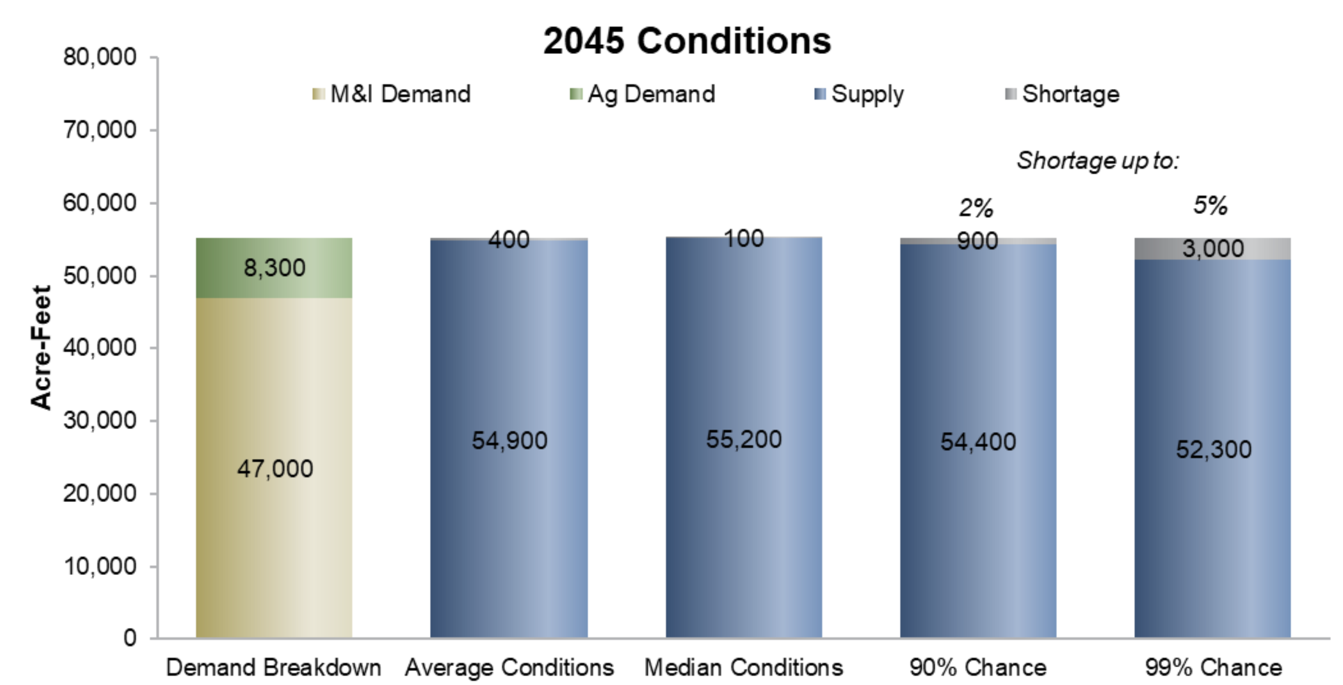

Figure 6-20: Demand, supply, and shortage for 2045 for the Sites + LVE + Potable Reuse + Transfers + DCP portfolio

6.7.2 Alternate Groundwater Pumping and Conjunctive Use Strategies

Alternate operations associated with groundwater pumping, storage, and conjunctive use were identified as a potential strategy that could reduce modeled shortages and increase water supply reliability. The following general strategies were tested in the New Risk Model:

- Decreasing the threshold of Table A allocation (in percent of maximum allocation) below which pumping is increased,
- Increasing pumping when the Table A allocation is less than the threshold,
- Decreasing pumping when the Table A allocation exceeds the threshold, and
- Adding a storage goal for the Main Basin, over which pumping is increased.

The goal of these strategies is to preserve storage in the Main Basin to allow for increased pumping in years with more limited surface water availability (i.e., years with low Table A allocation). To test the efficacy of the strategies, multiple combinations of strategies and threshold/goal values were run for a single trace. The two best performing combination of strategies and values, named "Run 1" and "Run 2", were selected for full ISM analysis with 94 traces. Run 1 limits baseline pumping to 50 AF/month except when annual Table A allocations are less than 25%. Run 2 also limits baseline pumping, but only to 75 AF/month. In addition, Run 2 increases pumping when Main Basin storage exceeds 95% of full. Both scenarios use Baseline assumptions for all other inputs (see Table 6-1 for Baseline model assumptions). See Table 6-12 for details on the tested groundwater management strategies.

Table 6-12: Groundwater model strategies

Run Name	Baseline Pumping (AF/mon)	Table A Threshold	Low Table A Pumping (AF/mon)	Main Basin Storage Goal	High Storage Pumping (AF/mon)
Baseline*	100	35%	1,500	NA	NA
Run 1	50	25%	1,500	NA	NA
Run 2	75	25%	2,000	95%	850

*See Section 6.1 for detailed results for the Baseline scenario

The average shortage, 90% chance of shortage, and 99% chance of shortage is plotted for the Baseline, Run 1 and Run 2 in Figure 6-21. Run 1 and Run 2 follow a similar trend in the 99% chance of shortage until after 2045; both have 99% chance of shortages that are approximately 5,000 AFY higher than the Baseline prior to 2032 and have 99% chance of shortages that are up to approximately 5,000 AFY lower than the Baseline prior to 2045. After 2045, Run 1 has a 99% chance of shortage that is consistently about 3,500 AFY lower than the Baseline. After 2045, Run 2 has a 99% chance of shortage that is similar to the Baseline. Run 1, Run 2, and Baseline follow similar trends throughout the study period for both the 90% chance of shortage and average shortage. Therefore, Run 1 and Run 2 are not effective at decreasing the 90% chance of shortage and average shortage level across the study period. However, Run 1 can provide long-term and consistent 99% chance shortage reductions after 2040 with compared to the Baseline.

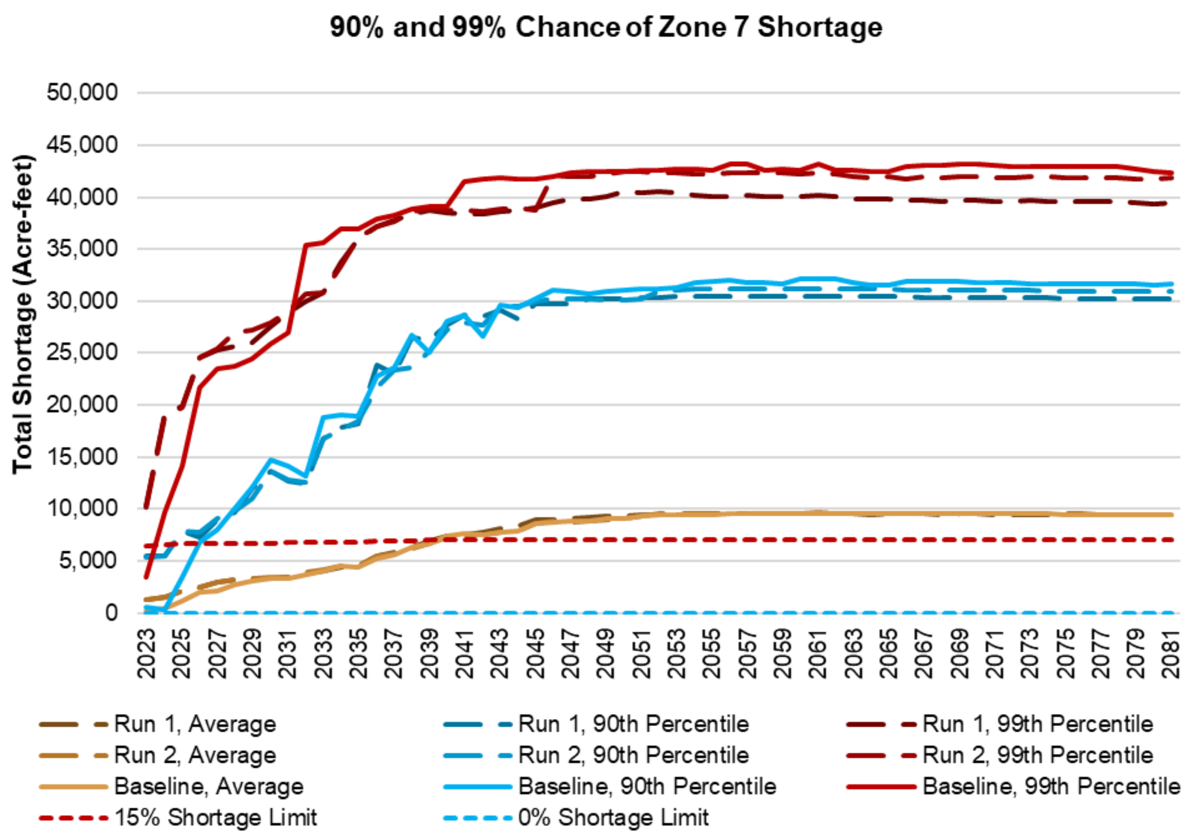

Figure 6-21: Shortage comparison for groundwater runs

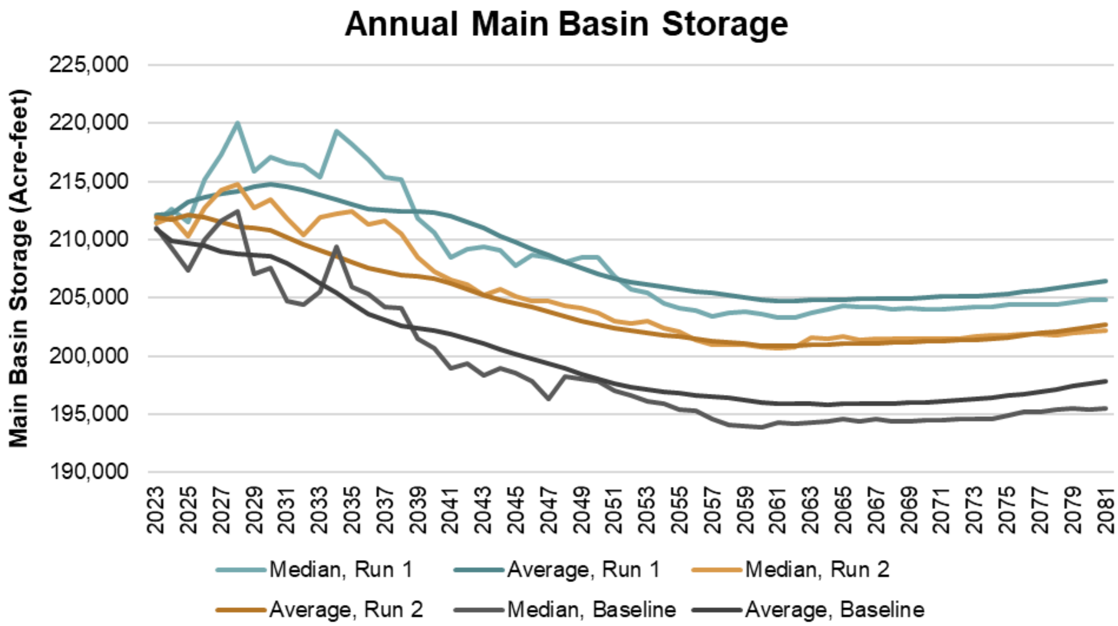

Figure 6-22: Main Basin storage

The average and median Main Basin storages for Run 1, Run 2, and the Baseline are shown in Figure 6-23. Run 1 is the most effective at maintaining Main Basin storage and has a median storage that is approximately 9,000 AF higher than the Baseline throughout the study period. Run 2 also maintains higher median storage compared to the Baseline; Run 2 has a median storage that is approximately 5,000 AF higher than the baseline throughout the study period. Although Run 1 and Run 2 do not have a pronounced effect on increasing water supply reliability in comparison to the Baseline, they are both effective strategies for maintaining Main Basin storage.

7. Comparison of Portfolio Performance

Portfolio performance is gaged by its ability to meet future demands. A well-performing portfolio minimizes future shortages, particularly in the most extreme cases represented by the 99% chance shortages.

7.1 Ability to Meet Reliability Policy

Zone 7 has two reliability goals, as identified in Section 1.3.

- The 90% chance of up to 0% shortage reliability goal is that for any given year, Zone 7 has a 90% chance of no Municipal and Industrial (M&I) or treated water shortage.
- The 99% chance of up to 15% shortage reliability goal is that for a given year, Zone 7 has a 99% chance of a M&I or treated water shortage of up to 15%.

While the policy is directed towards M&I customers, total water shortages, which include treated (i.e., M&I), and untreated water shortages, were evaluated against the policy goals. In general, the effects of water supply reliability projects on reducing potential shortages are not fully realized until around 2045, given that the entire roster of projects is not fully operational until around 2040. Therefore, the portfolios were compared at 2045 conditions. Note that "buildout", which is when Tri-Valley development is expected to cease, is expected around 2040.

The average shortage, maximum shortage at a 90% chance of shortage, and maximum shortage at a 99% chance of shortage for ten portfolios at the year 2045 are shown in Figure 7-1, Figure 7-2, and Figure 7-3, respectively. As can be expected, the Baseline is the least reliable: in 2045, average shortages equal 16% of total demand, or 8,600 AFY (Figure 7-1). Neither the 90% nor 99% chance of shortage reliability goals are met: the 90% chance shortage is 30,200 AFY while the 99% chance shortage is 41,800 AFY (Figure 7-2 and Figure 7-3).

All eight multi-project portfolios have a similar reliability for average and 90% chance conditions in 2045. Average shortages range from 1% to 4% of total demand, or 400 to 2,100 AFY (Figure 7-1). None of these portfolios technically meet the goal of a 90% chance of no shortage because they have a 90% chance of shortages up to 2-4% or 900-2,200 AF. However, the 2-4% shortage levels are small enough that they could be potentially avoided through optimization of Zone 7's operations. As such, these eight multi-project portfolios are considered to meet the 90% chance of shortage reliability goal because 90% of the time, shortage does not ***substantially*** exceed 0%. The only non-Baseline portfolio that does not meet the 90% chance of shortage reliability goal is DCP alone, which has a 90% chance of a shortage up to 30% or 16,600 AF. While DCP provides better reliability than the Baseline, DCP alone will not meet the reliability goal, underlining the finding that more than one project is required to meet Zone 7's Water Supply Reliability Policy.

The differences between non-Baseline portfolios at 2045 become more apparent when looking at the 99% chance conditions (Figure 7-3). The worst performing portfolio is the single-project portfolio with DCP alone, with a 99% chance of shortages up to 69% or 38,100 AF. DCP alone performs only slightly better than Baseline, which has a 99% chance of shortages up to 76% or 41,800 AF. The multi-project portfolios perform better and generally, the portfolios with more projects perform better than those with less projects. The worst performing multi-project portfolio is Sites + LVE, with a 99% chance of shortages up to 70% or 38,600 AF. Adding potable reuse to the Sites + LVE creates the Sites + LVE + Potable Reuse portfolio, which reduces the 99% chance of shortage to 26% or 14,600 AF. The further addition of transfers creates the Sites + LVE + Potable Reuse + Transfers, reduces the 99% chance of shortage to 12% or 6,600 AFY, which meets the 99% chance of shortage reliability goal. Although transfers end in 2030, adding transfers to a portfolio helps reduce shortages in future years. There are two other portfolios that meet the 90% chance of shortage reliability goal: Sites + DCP + Potable Reuse has a 99% chance of a shortage up to 10% or 5,400 AF, and Sites + LVE + Potable Reuse + Transfers + DCP has a 99% chance of a shortage up to 5% or 3,000 AF.

The Baseline portfolio is unable to meet both reliability goals in 2045, indicating that Zone 7 needs to invest in water supply reliability projects in order to improve long-term reliability. All the non-Baseline portfolios that contain at least two projects meet the 90% chance of shortage reliability goal in 2045. This indicates that a portfolio of multiple projects is effective at enhancing long-term reliability. Only three out of the nine non-Baseline portfolios are able to meet the 99% chance of shortage reliability goal in 2045. These three portfolios contain at least three projects each, indicating that more projects are needed to mitigate shortages in the driest years. Under average conditions, however, all portfolios perform similarly. This indicates that the makeup of the portfolios does not have a strong effect on average shortage levels and are more relevant to addressing the drier conditions that lead to shortages.

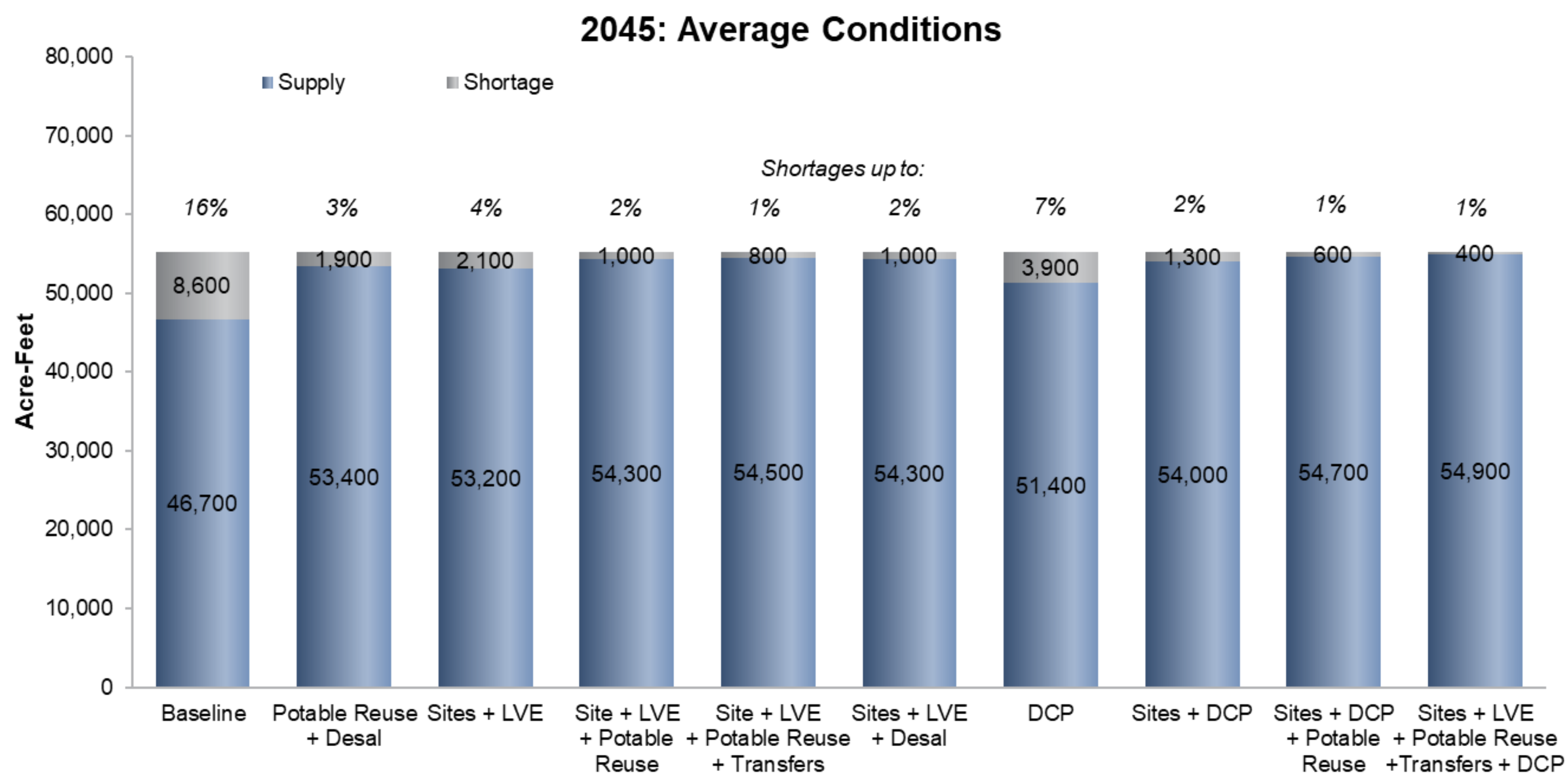

Figure 7-1: Average conditions in 2045 for all portfolios

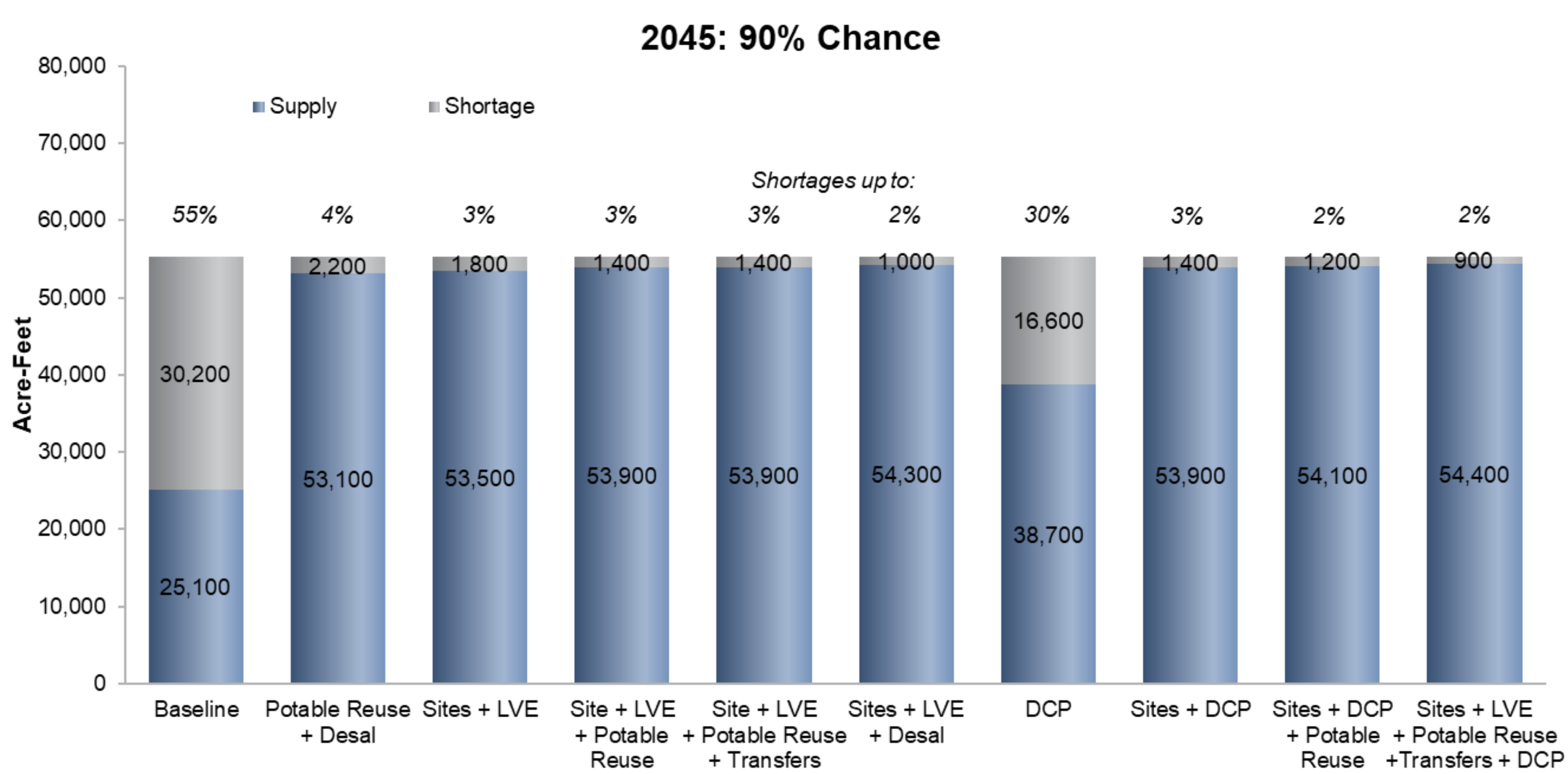

Figure 7-2: 90% chance conditions in 2045 for all portfolios

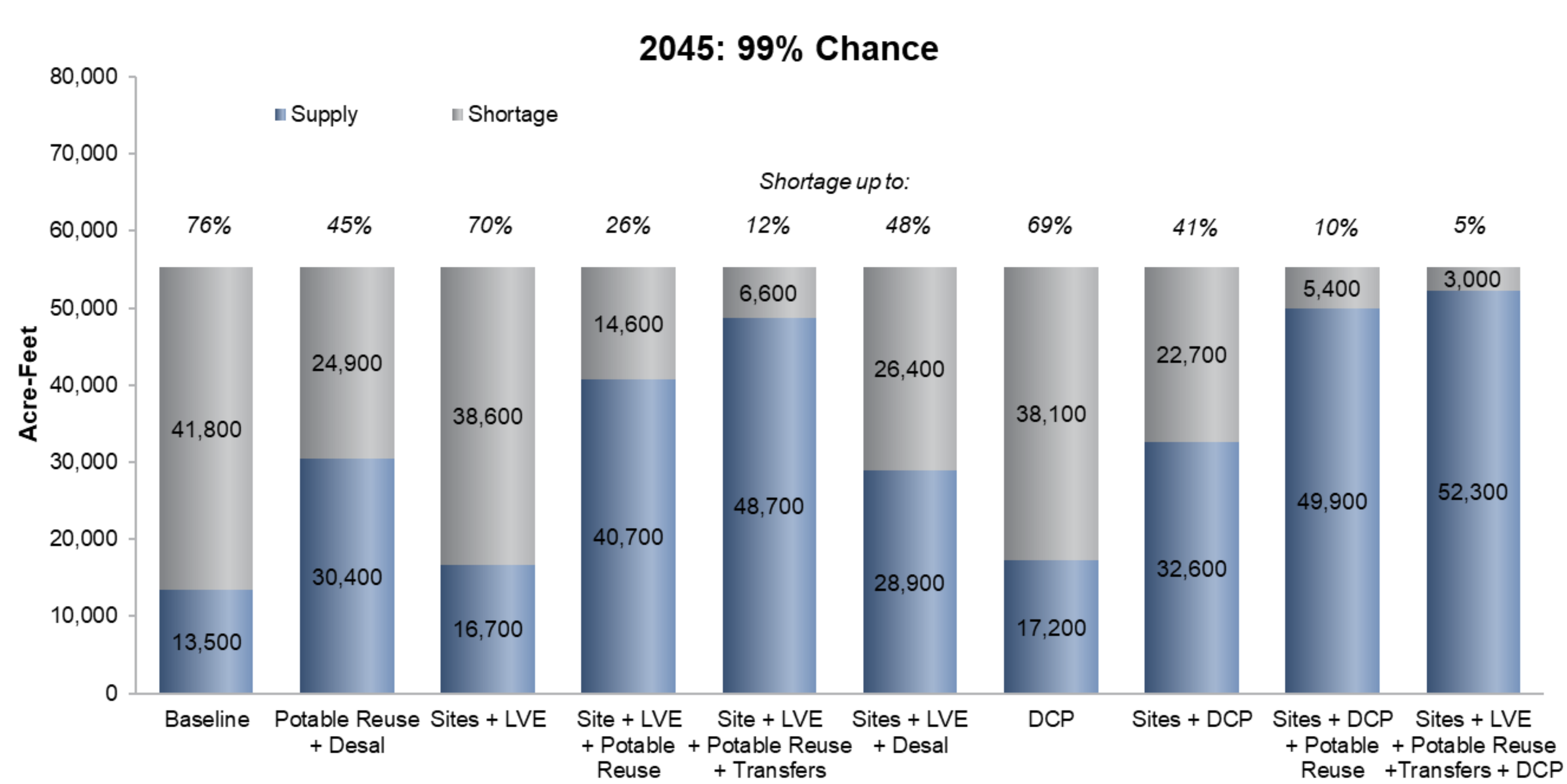

Figure 7-3: 99% chance conditions in 2045 for all portfolios

The range of shortages that could occur in 2045 for each portfolio, shown in Figure 7-4, provides further detail on portfolio performance. As described in Section 5.2.1, the New Risk Model simulations performed 94 traces for each portfolio (i.e., 94 different hydrologic time series) to estimate the distribution of potential shortages for each portfolio over time. Again focusing on the year 2045, the 99th percentile plotted in Figure 7-4 represents the shortage that is greater than 99% of all the potential shortages and is equivalent to the 99% chance of shortage shown in Figure 7-3. The 99th percentile also represents the shortage level that would be exceeded in the worst 1% of outcomes. The 90th percentile plotted in Figure 7-4 represents the shortage that is greater than 90% of all potential shortages and is equivalent to the 90% chance of shortage shown in Figure 7-2. The 90th percentile also represents the shortage level that would be exceeded in the worst 10% of outcomes. The interquartile range represents the range of the shortages between the 25th and 75th percentiles.

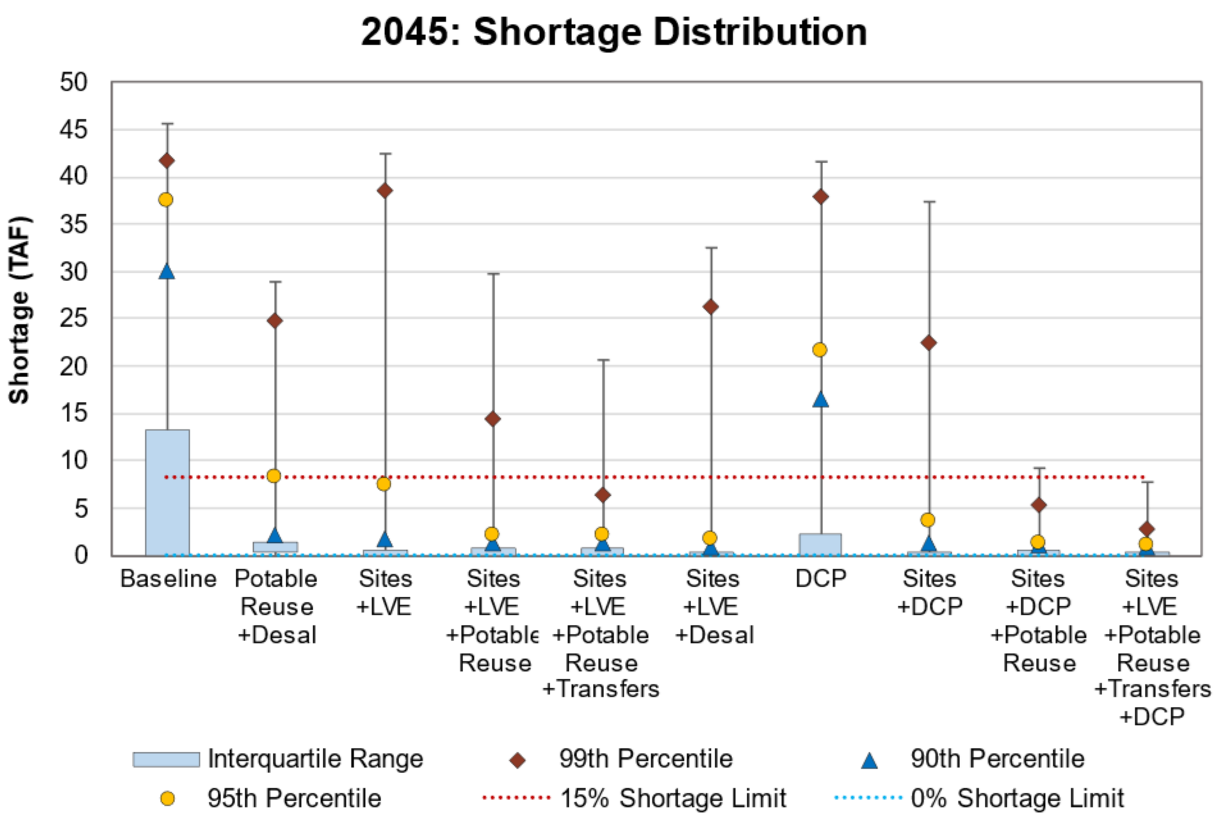

Figure 7-4: Distribution of Shortages in 2045 by Portfolio

In order for a portfolio to meet the reliability goals, the shortage at the 99th percentile (red diamond) needs to fall below the 15% shortage limit (red dotted line, equal to the 99% chance of shortage reliability goal) and the shortage at the 90th percentile (blue triangle) needs to reach the 0% shortage limit (blue dotted line, equal to the 90% chance of shortage reliability goal). As discussed earlier in this section, eight of the non-Baseline portfolios have small enough shortages at the 90th percentile to be considered to have met the goal of a 90% chance of no shortage, while only three of the non-Baseline portfolios have small enough shortages at the 99th percentile to meet the goal of a 99% chance of a shortage up to 15%. Therefore, there are five portfolios that are considered to meet the 90% chance of shortage reliability goal but do not meet the 99% chance of shortage reliability goal: Potable Reuse + Desal, Sites + LVE, Sites + LVE + Potable Reuse, Sites + LVE + Desal, and Sites + DCP.

Most portfolios have a large difference between the shortage at the 99th and 90th percentile, indicating that there is a large range of shortages that could occur in the worst 1% to 10% of outcomes. To better visualize the distribution of shortages, the shortage at the 95th percentile (yellow circle) was plotted as a "midpoint" between the 99th and 90th percentiles. The shortage at the 95th percentile represents the shortage that is greater than 95% of all potential shortages and is equivalent to a 5% chance of exceeding the shortage volume. For all non-Baseline portfolios, the shortage at the 95th percentile is much closer to the 90th percentile compared to the 99th percentile, indicating that the most extreme shortage events are rare and concentrated above the 95th percentile (i.e., the distribution of possible outcomes has a long tail).

These results may also be interpreted from a risk tolerance perspective. Risk tolerance generally refers to definition of an acceptable likelihood of adverse outcomes from a decision. In this case, tolerating more risk of shortage may lead to selection of smaller and lower cost portfolios, whereas minimizing tolerance for risk of shortage may lead to selection of larger and more costly portfolios. Selection of an appropriate risk tolerance will impact how Zone 7 makes investment decisions. The current 99% chance of shortage reliability goal indicates that investment decisions should be made such that in 99% of all cases, shortage would not exceed 15% of demand. This implies a low tolerance for shortage risk since this goal only allows a 1% chance of exceeding a 15% shortage. An increase in risk tolerance, such as allowing a 5% chance of exceeding a 15% shortage, would affect judgement of portfolio performance thus investment decision-making.

To further illustrate this concept, Sites + LVE's shortages in the worst 1% to 10% of outcomes are examined. Sites + LVE has the largest range of shortages that could occur between the 99th and 90th percentiles. This portfolio has a shortage of 38,600 AF (i.e., shortage of 70%) at the 99th percentile, a shortage of 7,600 AF (i.e., shortage of 14%) at the 95th percentile, and a shortage of 1,800 AF (i.e., shortage of 2%) at the 90th percentile. In other words, Sites + LVE has a 1% chance of exceeding a 70% shortage, a 5% chance of exceeding a 14% shortage, and a 10% chance of exceeding a 2% shortage. Therefore, if risk tolerance increases from *1% chance of exceeding a 15% shortage* to a tolerance for a *5% chance of exceeding a 15% shortage*¸ Sites + LVE would switch from failing to meet the goal to meeting the goal; Sites + LVE has a 1% chance of a shortage exceeding 70% (much higher than 15%), and a 5% chance of the shortage exceeding 14% (below the threshold of 15%). In this example, the probability of any shortage outcome for Sites + LVE is not changed, but the change in tolerance for shortage risk results in a different judgment of portfolio performance.

Given that only three of the eight non-Baseline portfolios meet the current reliability goals, Zone 7 may want to consider adjusting the risk tolerance for shortages. Doing so may provide a better understanding of the differences in performance between portfolios by reducing focus on extremely rare outcomes. Currently, the 99% chance of shortage reliability goal equates to planning for 99% of modeled outcomes. If the existing goal of a 99% chance of a shortage up to 15% was replaced with a new goal of a 95% chance of a shortage up to 15%, eight out of nine non-Baseline portfolios analyzed in this report would meet that goal.

7.2 Cost

As described in Section 4.4, eight multi-project portfolios were developed reflecting a mix of new supply, storage, and conveyance projects intended to support achievement of Zone 7's reliability goals. A single-project portfolio containing DCP only was developed for sensitivity testing against multi-project portfolios containing DCP, as described in Section 6.7.1. In total, nine portfolios are included in this cost analysis. This section discusses the relative performance of these portfolios with regard to cost and/or increased water supply reliability. The portfolio costs discussed in this section are estimated costs incurred by Zone 7 when the Tri-Valley reaches buildout, based on Zone 7's unit cost when operational from Table 4-1. All projects (excluding transfers) are expected to be operational. The portfolio costs were adjusted to a 2022 price level (2022$) in order to compare costs across portfolios.

7.2.1 Average Annual Cost and Average Annual Yield at Buildout

Figure 7-5 shows the estimated average annual cost incurred at buildout by portfolio in 2022$. Figure 7-6 shows the estimated average annual yield at buildout by portfolio. Average annual yield is based on the average new supply listed in Table 4-1. Since LVE does not provide new supply, average annual delivery of 1,400 AFY was used for its average annual yield. The impact of including transfers in a portfolio is not captured in Figure 7-5 and Figure 7-6 because transfers are assumed to occur from 2023 to 2030. For example, Sites + LVE + Potable Reuse has the same cost and yield at buildout as Sites + LVE + Potable Reuse + Transfers since transfers do not occur at buildout.

Sites + LVE + Potable Reuse + Transfers + DCP has the highest average annual cost of $67 million and the highest average annual yield of 26 TAF. Note that this portfolio contains transfers, which incurs no cost and provides no yield at buildout. This portfolio is the largest one out of all the portfolios evaluated, so it is reasonable for it to have the highest cost and yield.

Sites + LVE has the lowest average annual cost of $11 million and provides the second-lowest average annual yield of 9 TAF. This portfolio is one of the smaller portfolios in terms of number of projects (two projects) and has the lowest average annual cost at buildout.

DCP has the second-lowest annual cost of $23 million and provides the lowest average annual yield of 7 TAF. This portfolio is the smallest portfolio out of all the portfolios evaluated and is the only portfolio that contains a single project, so it is reasonable for it to have the lowest yield. DCP alone is less cost effective than Sites + LVE since it provides a smaller yield at a higher cost.

To determine the relative cost effectiveness of an individual project, the project's yield bar in Figure 7-6 can be compared against the project's cost bar in Figure 7-5. For most of the projects, the size of yield and cost bars are generally similar. However, for Sites, the size of its yield bar is much larger than its cost bar, indicating that Sites provides the most cost effective yield at buildout compared to the other projects. Therefore, it is advantageous to include Sites in a portfolio from a cost effectiveness perspective.

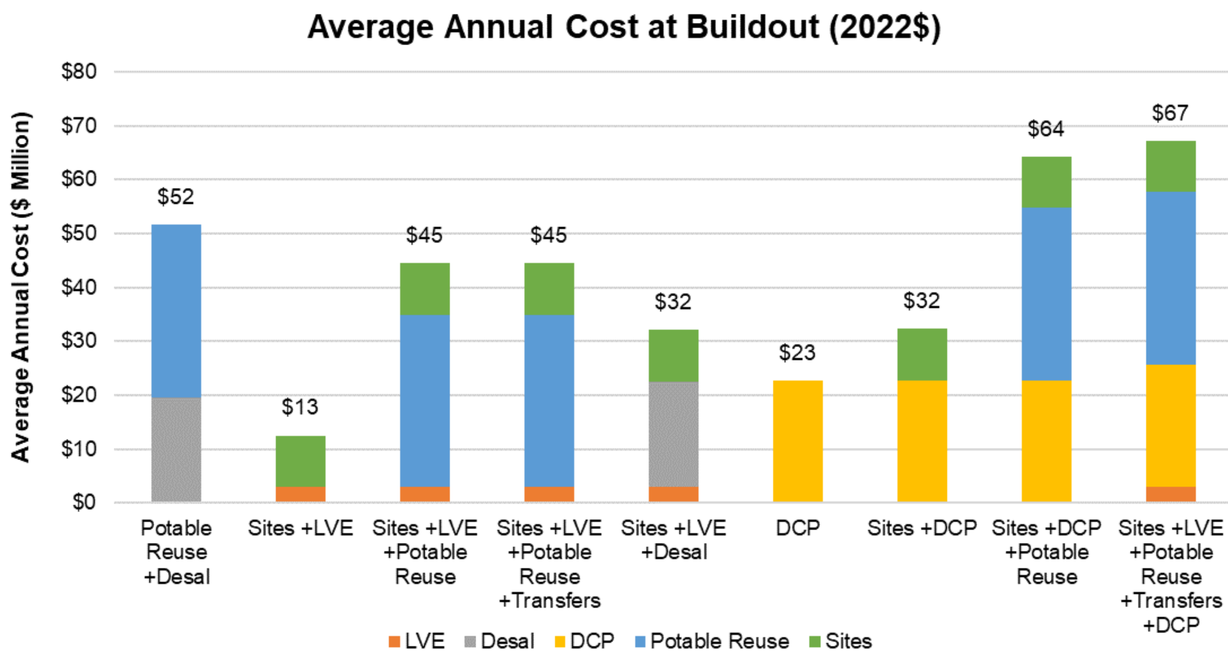

Figure 7-5: Average Annual Portfolio Costs at Buildout (2022$)

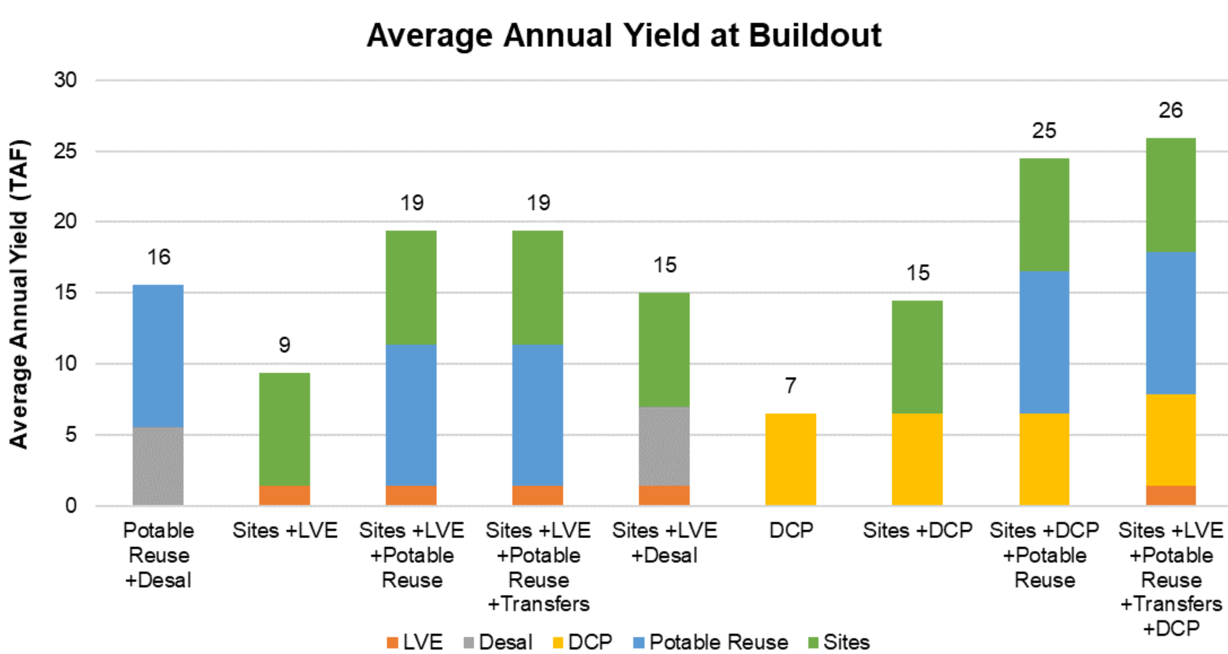

Figure 7-6: Average Annual Portfolio Yields at Buildout

7.2.2 Best Buy Analysis

The portfolios can be assessed for cost effectiveness with regard to Zone 7's Reliability Policy's goals. As discussed in Section 7.1, all eight multi-project portfolios have a 90% chance of shortages up to 2-4% in 2045. These minor shortages can likely be addressed by optimizing Zone 7's operations; therefore, all eight multi-project portfolios are considered to meet the 90% chance of up to 0% shortage reliability goal in 2045. However, most portfolios were unable to meet the 99% chance of up to 15% shortage reliability goal in 2045. Furthermore, at a 99% chance of shortage in 2045, the portfolios had a wide range of shortage levels. This analysis examines each portfolio's shortage level reduction compared to the Baseline at a 99% chance of shortage in 2045. The portfolio costs are based on Zone 7's share of the capital costs for the projects, as shown in Table 4-1. The portfolio costs were adjusted to 2022$.

Figure 7-7 plots each portfolio's shortage reduction compared to the Baseline at a 99% chance of shortage in 2045 on the x-axis, each portfolio's average annual cost on the y-axis, and categorizes each portfolio as either a *best buy*, *cost effective*, or *not cost effective*.

- Best buy portfolios are the array of most cost effective portfolios that minimize incremental cost at each successive level of shortage reduction. This array of portfolios constitutes an *efficient frontier* of investment options, illustrated by the dotted line between the best buy portfolios. The best buy portfolios are plotted as green circles.
- Cost effective portfolios are identified when no other portfolio provides the same shortage reduction at a lower cost, or greater shortage reduction at the same cost. For example, Sites + LVE + Desal is cost effective because the next portfolio with greater yield, Sites + DCP, has a higher cost. Cost effective portfolios are plotted as purple circles.
- Not cost effective portfolios are those that fail the above cost effectiveness test. For example, Potable Reuse + Desal is not cost effective because the next portfolio with greater yield, Sites + DCP, provides greater yield at a lower cost. Not cost effective portfolios are plotted as gray circles.

Figure 7-7 also indicates which reliability goal (if any) each portfolio is able to meet in 2045. Portfolios that have a blue square around their circle meet the only the 90% chance of shortage reliability goal in 2045. Portfolios that have a red diamond around their circle are able meet both the 90% and 99% chance of shortage reliability goals in 2045.

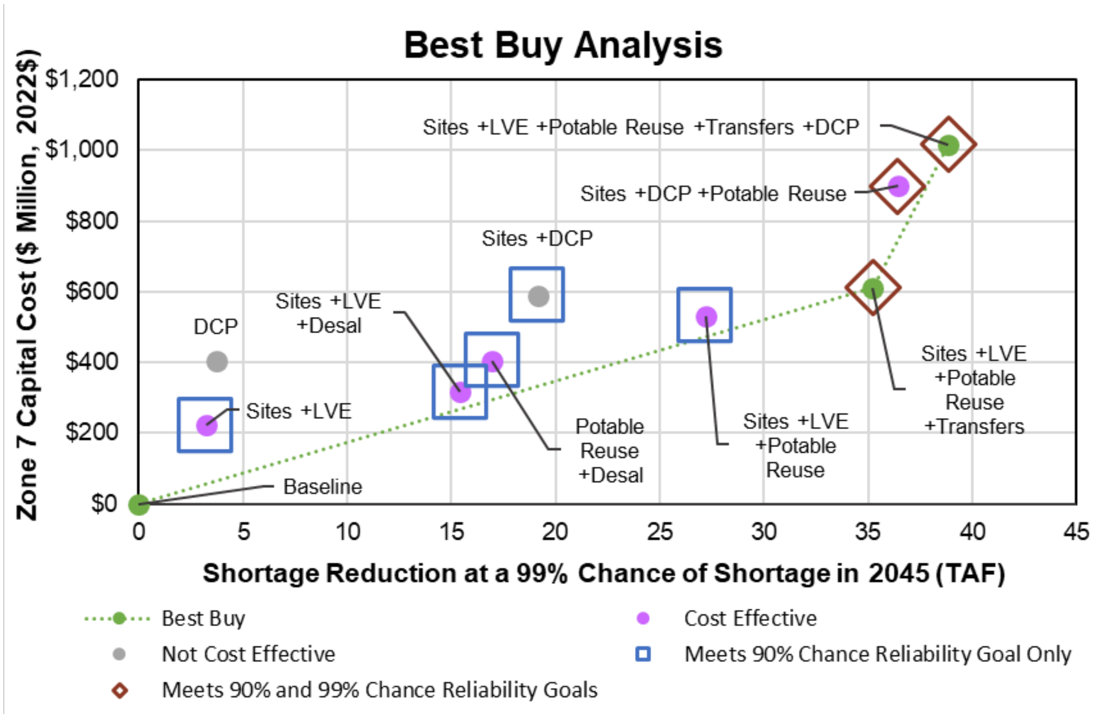

Figure 7-7: Best Buy Portfolio Analysis in 2045

This analysis does not examine cost in terms of Zone 7's required payments for each portfolio, which are dependent on financing terms. Due to the complexity of the projects' payment structure and payment periods, it was determined that comparing Zone 7's capital cost was the simplest way to compare the portfolios on the same cost basis. Therefore, Zone 7's capital cost was used as a measure of the relative size of investment required for each portfolio. For this analysis, if a portfolio were to be selected based on cost effectiveness, the array of best buy portfolios would be most preferred, followed by cost effective portfolios, with not cost effective portfolios being least preferred. If a different cost basis (e.g., total payments over a common time period for each portfolio) were used, this best buy analysis may yield different results.

As shown in Figure 7-7, Sites + LVE + Potable Reuse + Transfers is the first best buy, followed by Sites + LVE + Potable Reuse + Transfers + DCP. The following five portfolios are categorized as cost effective: Sites + LVE, Sites + LVE + Desal, Potable Reuse + Desal, Sites + LVE + Potable Reuse, and Sites + DCP + Potable Reuse. The portfolios that are categorized as not cost effective are DCP and Sites + DCP.

Portfolios categorized as best buy contain the largest number of projects and include transfers. Although annual transfers cease after 2030, the shortage reduction benefits of transfers in 2045 are clear when comparing Sites + LVE + Potable Reuse and Sites + LVE + Potable Reuse + Transfers. Without transfers, the shortage reduction compared to Baseline at 2045 is 27 TAF for a capital cost of $532 million and the Sites + LVE + Potable Reuse portfolio only meets the 90% chance of shortage reliability goal. With transfers, the shortage reduction compared to Baseline at 2045 is 35 TAF for a capital cost of $612 million and the Sites + LVE + Potable Reuse + Transfers portfolio meets both the 90% and 99% chance of shortage reliability goal. Therefore, the cost of transfers plays a significant role in whether or not a portfolio is considered a best buy. The cost of transfers was assumed at $1000/AF in this analysis; if the cost were to increase, then portfolios close to the efficient frontier (i.e., Sites + LVE + Desal and Sites + LVE + Potable Reuse) would become even more cost effective in comparison and become best buy portfolios. However, these two portfolios would still only meet the 90% chance of shortage reliability goal, and therefore not satisfy Zone 7's Reliability Policy.

7.2.3 Additional Monthly Cost per Household

The portfolios can be evaluated in terms of impact to a typical Tri-Valley household's monthly water cost. Figure 7-8 illustrates the estimated monthly cost per household at buildout in 2022$. A typical household's monthly water cost is estimated to be $76 based on the 2022 treated water rate and an estimated household use of 20 centum cubic feet per month. The additional cost from the portfolios is estimated to range from $9 - $49. This cost is based on the estimated annual cost of each portfolio at 2045, so the cost of transfers is not reflected since transfers occur prior to 2045. Note that the additional cost from portfolios is a simplified estimate and the actual cost impact on a household's monthly water bill will be based on future cost of service and water rate studies, actual water use, and additional retailer charges.

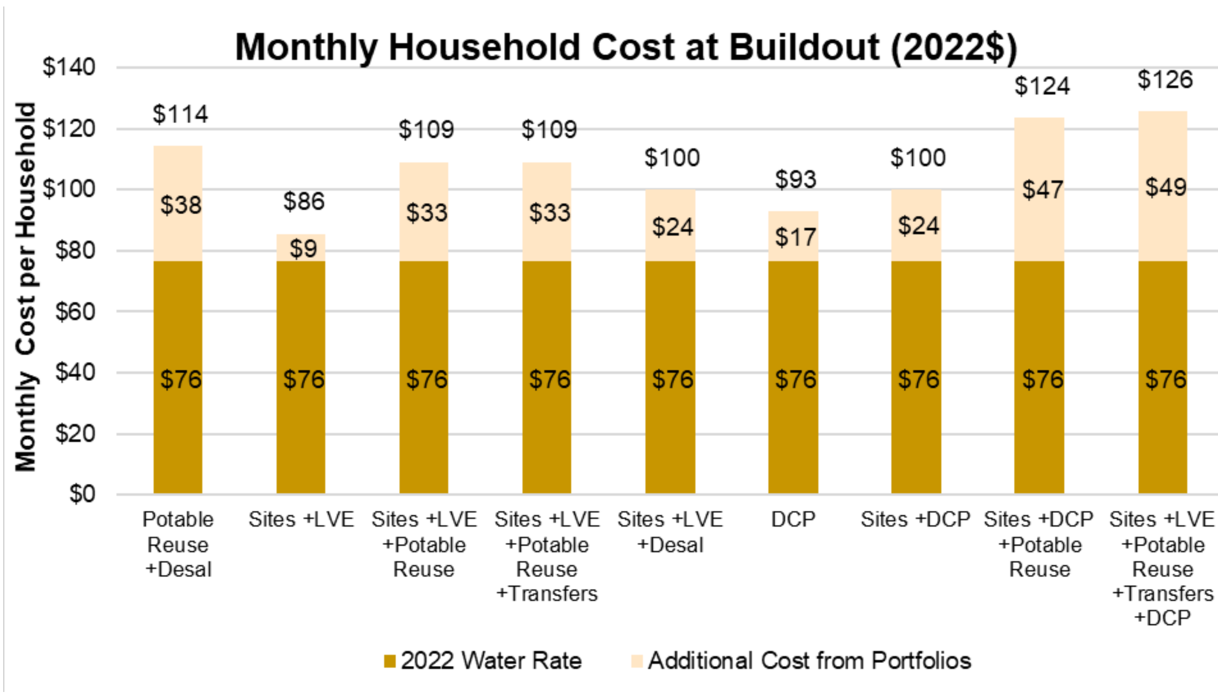

Figure 7-8: Monthly Cost per Household at Buildout by Portfolio (2022$)

8. Conclusions and Next Steps

The 2022 Water Supply Evaluation Update (2022 WSE Update) evaluates water supply conditions in the Tri-Valley to support Zone 7's planning for long-term water supply reliability. This evaluation is a high-level assessment and is intended to inform recommendations to the Zone 7 Board of Directors.

Key findings and recommendations from the 2022 WSE Update are listed below in particular order. Detailed conclusions and next steps are listed in Table 8-1.

- The New Risk Model can be maintained and updated to support Zone 7's water supply planning. Therefore, Zone 7 should incorporate new information as it becomes available from the State Water Project, water supply reliability projects, Zone 7's groundwater investigations, etc.

- All eight multi-project portfolios meet the 90% chance of shortage reliability goal at 2045, assuming that the minor shortages can be remedied with optimized operations. The 99% chance of shortage reliability goal at 2045 is more difficult to meet. Portfolios containing a larger number of projects perform better; the only three portfolios to meet the 99% chance of shortage reliability goal at 2045 contain at least three projects. Therefore, Zone 7 should continue to evaluate new opportunities to diversify its water supply portfolio and:

    - Continue to pursue investigation of potable reuse

    - Continue to investigate brackish water desalination with other agencies

    - Continue participation in Sites Reservoir Project for average reservoir releases of 10,000 AFY

    - Continue participation in Los Vaqueros Reservoir Expansion and evaluate participation level for storage (Los Vaqueros Reservoir) and conveyance (Transfer-Bethany Pipeline).

    - Continue participation in the Delta Conveyance Project

- At 2045, five multi-project portfolios have a 99% chance of maximum shortages much greater than 15% and a 95% chance of maximum shortages up to 15%. The current 99% chance of shortage reliability goal sets a maximum shortage limit associated with extreme and very rare conditions that may be unreasonably difficult or costly to achieve. Therefore, Zone 7 should consider revising the 99% chance of shortage reliability goal.

- Most new supply alternatives are not anticipated to be available until at least 2030. Transfers before 2030 help bolster storage, benefit long-term reliability, and result in reductions in the 99% chance shortages beyond 2030. Therefore, Zone 7 should pursue transfers (an average of 10,000 AFY) until additional long-term supply sources become available.

Table 8-1: Conclusions for Consideration

Category	Conclusions	Recommendations
New Risk Model Improvements	• Receive and incorporate information on evolving PFAS constraints and related operational/infrastructure solutions that affect overall groundwater production. • Incorporate findings from operations experience during the drought and recovery period and from updated groundwater modeling when available (e.g., elevation/pumping curves, recharge efficiencies, and surface water/groundwater interactions in the COLs)	• Monitor and incorporate operational experience and future groundwater modeling and studies
	• Climate change was explicitly represented in the assumed yield associated with the SWP. • Impacts associated with the seasonal cycle variability, extreme events, and average yield of Arroyo Valle and Main Basin should be considered. A downscaled climate change impact study on the local watershed could inform the model.	• Consider explicit incorporation of climate change impacts to local supplies
	• Operational decisions around priorities for "puts" and "takes" for different storage facilities can continue to be optimized to minimize shortages, particularly as new supply sources are added. • Consider developing storage targets to provide guidance on water supply decisions while allowing for adaptive decision-making as conditions evolve over time.	• Continue efforts to "optimize" operational decisions
Regulatory Considerations	• Changes to environmental regulations, such as implementation of the Bay Delta Water Quality Control Plan (Bay Delta Plan) and/or associated Voluntary Agreements (VAs), while not analyzed as part of this modeling effort, are likely to result in changes to the availability of SWP supplies. • DWR modeling of SWP availability under Bay Delta Plan/VA conditions is currently not available. Impacts to SWP availability should be considered when new modeling from DWR becomes available.	• Continue to monitor supply impacts due to changing environmental regulations
Reliability Policy Modifications	• All the multi-project portfolios meet the 90% reliability goal at 2045, assuming that minor shortages can be remedied with optimized operations. The single-project portfolio did not meet the 90% reliability goal at 2045. • Portfolios containing a larger number of projects perform better at meeting the 99% reliability goal at 2045. The only three non-Baseline portfolios to meet the 99% reliability goal at 2045 contain at least three projects. • At 2045, five multi-project portfolios have a 99% chance of maximum shortages much greater than 15% and a 95% chance of maximum shortages up to 15%. The current 99% reliability goal appears to set a maximum shortage limit associated with extreme and very rare conditions that may be unreasonably difficult or costly to achieve.	• Consider revising the 99% reliability policy
Projects	• Portfolios with at least three projects maintain total system storage better than portfolios with none or two projects (the Sites + LVE + Potable Reuse + Transfers portfolio not only maintains highest system storage but is best at meeting the 90% and 99% chance of shortage reliability goals).	• Prioritize projects and optimization which preserve storage • Continue coordination with COL PL project

Category	Conclusions	Recommendations
	• Maintaining storage in Kern Banks early in the simulation period helps meet 90% and 99% chance of shortage reliability goals in the future	• Prioritize projects which maintain the volume stored in Kern Banks
	• The best performing portfolios, particularly for meeting the 99% chance of shortage reliability goal, include both new supplies and new or expanded storage.	• Prioritize combinations of projects which add both new supply and storage
	• Modeled operation of the COL PL and controlled transfers between the Lakes should be updated in the New Risk Model as planning and design of the COL PL advances and more data is collected on the COL.	• Continue coordination with COL PL project
	• As planning and design of DCP advance, changes to anticipated reliability of the SWP should be monitored and incorporated into the New Risk Model. • DCP has smaller yield compared to CA Waterfix (6,500 versus 11,000 AFY, respectively)	• Continue to support and monitor the progress and anticipated future reliability of the SWP with DCP in place
	• As planning and design of Sites Reservoir advance, changes to anticipated yield should be monitored and incorporated into the New Risk Model. • Consider operational optimization of storage and delivery requests as the Sites Reservoir JPA team provides additional opportunities to collaborate with participating agencies on operational scenarios.	• Continue to support and monitor the progress and anticipated yield of Sites Reservoir
	• Desalination is expected to be a reliable supply source except in critically dry conditions. • The status of a regional desalination project alternative is uncertain and should continue to be monitored.	• Continue to monitor opportunities for desalination and other regional supply alternatives
	• Potable reuse provides a drought-resistant and locally-controlled water supply • Potable reuse is currently modeled as indirect potable reuse through groundwater augmentation. Other forms of potable reuse can be considered in future analysis as regulations are better defined and more information is derived from the Regional Purified Water Pilot Project.	• Continue to support the planning for potable reuse
	• Sensitivity testing indicates that LVE is most effective when paired with additional supply sources but must be balanced with storage operations in the Kern Storage and Recovery Program (Kern Banks) and Main Basin. • The physical location of LVE suggests there are resiliency benefits related to system outages. Scenarios explicitly examining outages in the Delta and/or other critical system infrastructure could be examined to better quantify these benefits.	• Continue to support LVE and explicitly quantify project benefits associated with supply resiliency
	• Most new supply alternatives are not anticipated to be available until at least 2030. • Transfers should continue to be prioritized as a short-term stop gap. • Transfers before 2030 help bolster storage, benefit long-term reliability, and result in reductions in the 99% chance shortages beyond 2030 (in 2045, the Sites + LVE + Potable Reuse + Transfers scenario meets the 99% chance of shortage reliability goal while the Sites + LVE + Potable Reuse scenario does not).	• Pursue transfers (an average of 10,000 AFY) until additional long-term supply sources become available
	• Optimizing groundwater operations may be an effective method for increasing resiliency • Groundwater optimization effectively maintains storage in the Main Basin	• Continue to support optimization of groundwater operations

References

Bureau of Reclamation. (2020). *Supply (Hydrology) Scenarios*. Presentation included as part of CRSS training. Presented March 2020.

California Department of Water Resources. (2021a). *State Water Project Draft Delivery Capability Report 2021*. December 2021.

California Department of Water Resources. (2021b). *2022 Position Analysis*. December 2021.

Contra Costa Water District. (2021). *DRAFT Operations Plan for Phase 2 Los Vaqueros Reservoir Expansion*. April 2021.

Contra Costa Water District. (2022a). *LVE Operational Constraints and Capacity Sharing - 2022.06.16 Presentation.* Presented May 2022.

Contra Costa Water District. (2022b). LVE Storage Exploration Tool. Received: July 2022

Contra Costa Water District. (2022c). LVE TBP Exploration Tool. Received: July 2022

The Metropolitan Water District of Southern California. (2015*). Integrated Water Resources Plan 2015 Update: Technical Appendices.*

The Metropolitan Water District of Southern California. (2022). *2020 IRP – Regional Needs Assessment.*

Tri-Valley Agencies. (2018). *Joint Tri-Valley Potable Reuse Technical Feasibility Study*.

Santa Clara Valley Water District. (2019). *Santa Clara Valley Water District Water Supply Master Plan 2040.*

Sites Reservoir Authority. (2022). Sites Reservoir Model Alternative 3B, 2035 CT climate hydrology. Model Date: April 4, 2022.

USGS. 11176400 Arroyo Valle below Lang Canyon near Livermore, CA. https://waterdata.usgs.gov/ca/nwis/uv/?site_no=11176400. Data Accessed: October 2022.

USGS. 11179000 Alameda Creek near Niles, CA. https://waterdata.usgs.gov/nwis/uv/?site_no=11179000. Data Accessed: October 2022.

Zone 7 Water Agency. (2011). *2011 Water Supply Evaluation*.

Zone 7 Water Agency. (2019). *2019 Water Supply Evaluation Update*.

Zone 7 Water Agency. (2020a). *Addendum 1 – 2020 Update to the Preliminary Lake Use Evaluation for the Chain of Lakes*.

Zone 7 Water Agency. (2020b). *Development of Chain of Lakes Hydrologic/Hydraulic Model.* November 2020.

Zone 7 Water Agency. (2020c). *Tri-Valley Municipal and Industrial Water Demand Study.*

Zone 7 Water Agency Reservoir Committee Meeting. (2021). Agenda Item 2.2 Attachment A. *Storage Allocation Based on Amended 2 Participation Levels.* April 16, 2021.

Zone 7 Water Agency. (2021). *Zone 7 Water Agency 2020 Urban Water Management Plan.* June 2021.

Zone 7 Water Agency. (2022a). *Chain of Lakes H&H Modeling to Provide the Bases for the COL Pipeline Design and Operations: Task 1 Tech Memo*. January 2022.

Zone 7 Water Agency. (2022b). *Chain of Lakes H&H Modeling to Provide the Bases for the COL Pipeline Design and Operations: Task 2 Tech Memo*. January 2022.

Zone 7 Water Agency. (2022c). *Chain of Lakes H&H Modeling to Provide the Bases for the COL Pipeline Design and Operations: Task 3 Tech Memo*. January 2022.

Zone 7 Water Agency (2022d). *Chain of Lakes Hydrologic/Hydraulic Model*. Plan: #0_LDV_Historical_Z7CvtSize. Received: February 2021.

Appendix A – Additional Los Vaqueros Reservoir Expansion Analysis

Background

Zone 7 has engaged with CCWD regarding Zone 7's participation in LVE. CCWD performs their own operations modeling of the LVE system which incorporates modeling outputs and operations assumptions from each LVE participant. CCWD has requested updated inputs from Zone 7 to inform the CCWD model and to provide Zone 7 updated results on LVE operations. Zone 7 decided to provide updated LVE modeling assumptions to CCWD based on additional analysis of LVE performance with the Risk Model. The findings from this analysis are described in this appendix.

Risk Model Approach

The 2022 WSE Update evaluates various portfolios' performance at enhancing Zone 7's long-term water supply reliability. LVE was included in several portfolios with the following operating rules and assumptions:

- The reservoir can only be filled when salinity at the intakes is less than 65 mg/L;
- Available water sources include Article 21, Sites, Table A and desalination (see Table 5-8);
- The portion of the total intake capacity not used by CCWD available to Zone 7 is equal to the proportion of Zone 7's storage buy-in volume to the total expansion volume;
- The full portion of Zone 7's storage and Transfer-Bethany Pipeline buy-in capacities are always available.

See Section 5.1.2.4 for more details on modeled LVE operations. For the portfolios analyzed in Section 6, excess water was stored preferentially in the Kern County Storage and Recovery Program (Kern Banks). To assess whether excess water should be stored locally in LVE, the model rules were altered to simulate more aggressive utilization of LVE by prioritizing storage of excess water in LVE over Kern Banks. Portfolios that are subject to these new operating rules have names ending in "(new rule)". Since LVE does not provide new supply, the portfolios used for this analysis include combinations of Sites, LVE, and DCP. Sites and LVE come online in 2030 while DCP comes online in 2040. Table A-1 summarizes the portfolios for this analysis.

Table A-1: Summary of Portfolios

Portfolio Name	New Wells	New LVE Operating Rules	*Potential Future Projects*		
			Sites	LVE	DCP
Sites + LVE	✓		✓	✓	
Sites + LVE (new rule)	✓	✓	✓	✓	
Sites + LVE + DCP	✓		✓	✓	✓
Sites + LVE + DCP (new rule)	✓	✓	✓	✓	✓

Findings

Los Vaqueros Expansion Storage

Storage in LVE was compared across the portfolios to assess the effect of the new rule. See Figure A-1 for the average storage in LVE over the study period.

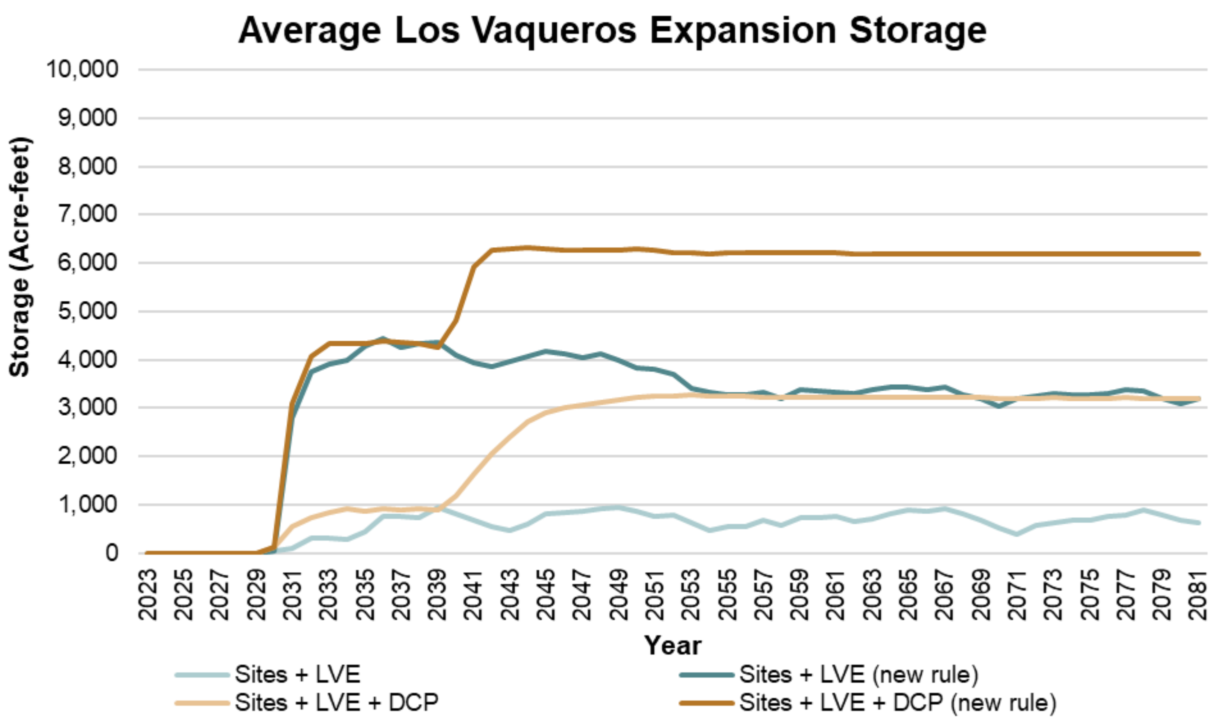

Figure A-1: Timeseries of Average Storage in LVE

For Sites + LVE, average annual storage in LVE hovers below 1,000 AF. With Sites + LVE (new rule), storage of excess water is prioritized in LVE instead of the Kern Banks, and the average annual storage in LVE increases to range from 3,000 to 4,500 AF. When not prioritizing storage in LVE, Zone 7's full storage capacity in the reservoir (10,000 AF) is not being utilized. However, prioritizing storage in LVE results in instances where the maximum 10,000 AF of storage capacity is utilized.

Combining DCP with Sites and LVE adds more supply to the system, thereby creating more opportunity to store excess water in LVE (Figure 0-1, dark blue and dark brown lines). With Sites + LVE + DCP, the average storage in LVE increases from 1,200 AF in 2040, when DCP comes online, to a steady 3,200 AF starting in 2050. Sites + LVE + DCP (new rule) results in greater storage in LVE due to the prioritizing storage of excess water in LVE: the average storage in LVE is around 6,200 AF after DCP comes online in 2040.

Kern Banks Storage

Storage in Kern Banks was compared across the portfolios to assess the effect of the new rule. See Figure A-2 for the average Kern Banks storage over the study period.

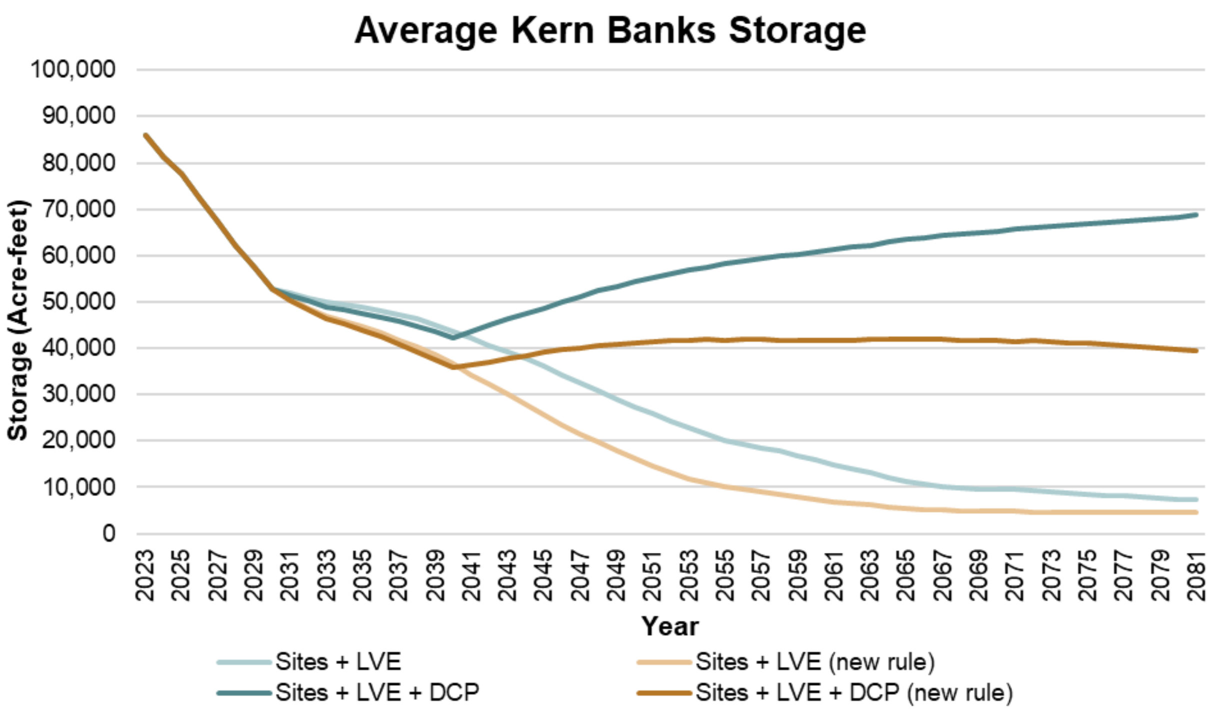

Figure A-2: Timeseries of Average Kern County Groundwater Banks Storage

The main trade-off in implementing the new rule for LVE is a reduction in water being sent to refill storage in the Kern Banks since excess water is stored in LVE first. Therefore, the portfolios with new rule implemented result in an accelerated drawdown of Kern Banks storage compared to the portfolios without the new rule. For example, for Sites + LVE + DCP, the average Kern Banks storage decreases from 2023 until 2040, then increases somewhat, reaching an average storage of about 69,000 AF at the end of the study period (Figure 0-2, dark blue line). In comparison, Sites + LVE + DCP (new rule) experiences a quicker drawdown and less rebound in average Kern Banks storage, reaching an average storage of about 40,000 AF at the end of the study period (Figure 0-2, dark brown line). The Sites + LVE and Sites + LVE (new rule) scenarios also show that the new rule result in a quicker drawdown of average Kern Banks storage: the average Kern Banks storage at the end of the study period is 7,500 AF for Sites + LVE and 4,500 AF for Sites + LVE (new rule). Since these two scenarios do not include additional supply from DCP, they do not experience a rebound in Kern Banks storage.

Modeled Losses

Both LVE and Kern Banks storage incur losses. Storage in LVE is subject to evaporation losses on the order of 8% annually, while puts to Semitropic and Cawelo are subject to one-time losses of 10% and

50%, respectively. For this analysis, full optimization was not performed to minimize losses associated with storage in LVE and Kern Banks. However, a simple calculation, shown in Table A-2, was performed to determine the losses incurred by LVE, Semitropic, and Cawelo over the course of 10 years if each storage received 10,000 AF in year 1 before losses. Since evaporation losses to LVE are modeled to occur on annual basis, LVE begins in year 1 with the full 10,000 AF. Since Semitropic and Cawelo are subject to one-time losses on puts, Semitropic begins year 1 with a storage of 9,000 AF and Cawelo begins year 1 with a storage of 5,000 AF. With no further inputs or withdrawals, evaporation losses from LVE exceeds put losses from Semitropic by year 3, while put losses from Cawelo aren't exceeded until year 10. These results indicate that using LVE as long-term storage with the intent of buffering extended, multi-year droughts will generate significantly more losses than storage in Kern Banks. However, short-term storage in LVE is more efficient in terms of losses than utilizing Kern Banks.

Table A-2: Hypothetical storage after losses for LVE and Kern Banks

Year	Annual Storage After Losses (AF)		
	LVE	Semitropic	Cawelo
1*	10,000	9,000	5,000
2	9,200	9,000	5,000
3**	8,464	9,000	5,000
4	7,787	9,000	5,000
5	7,164	9,000	5,000
6	6,591	9,000	5,000
7	6,064	9,000	5,000
8	5,578	9,000	5,000
9	5,132	9,000	5,000
10***	4,722	9,000	5,000

**In year 1, each storage receives 10,000 AF before losses*

***In year 3, evaporation from LVE exceeds put losses from Semitropic*

****In year 10, evaporation from LVE exceeds put losses from Cawelo*

Shortages

The effect of the new rule on the four portfolios' performance in relation to the 90% chance of shortage reliability goal (see Figure A-3) and the 99% chance of shortage reliability goal (see Figure A-4) were assessed.

The 90% chance shortages were similar between the Sites + LVE and Sites + LVE (new rule) until 2055, when they increase. The increase in shortages after 2055 is likely cause by the depletion of storage in Kern Banks (see the pale blue and pale brown line in Figure A-2). The 90% chance shortages are generally caused by extended droughts, which LVE, as modeled, is not effective at mitigating. Kern Banks is more effective than LVE at buffering extended droughts. Since Sites + LVE (new rule) puts less water in Kern Banks, it experiences a more rapid depletion of Kern Bank storage and therefore has higher shortages at a 90% chance than Sites + LVE after 2055. Sites + LVE + DCP and Sites + LVE + DCP (new rule) have almost identical results throughout the study period at a 90% chance of shortage. By adding DCP, these two portfolios have enough supply to result in low shortages at a 90% chance after 2040.

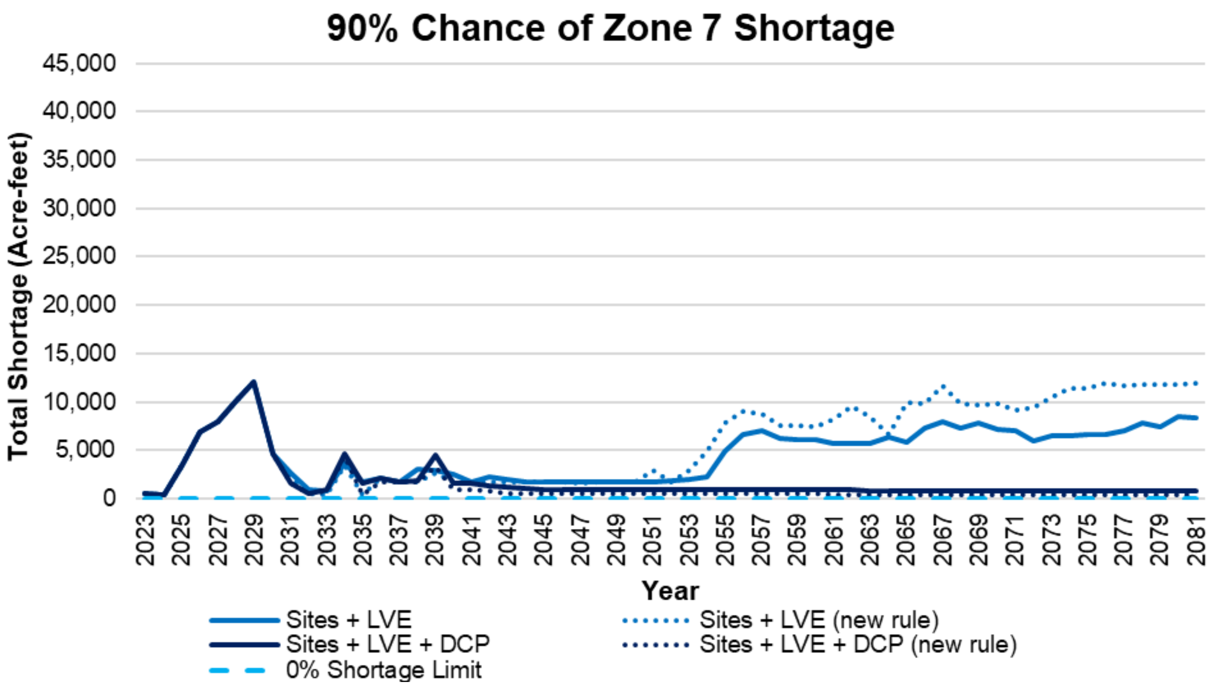

Figure A-3: Timeseries of 90% Chance of Shortages

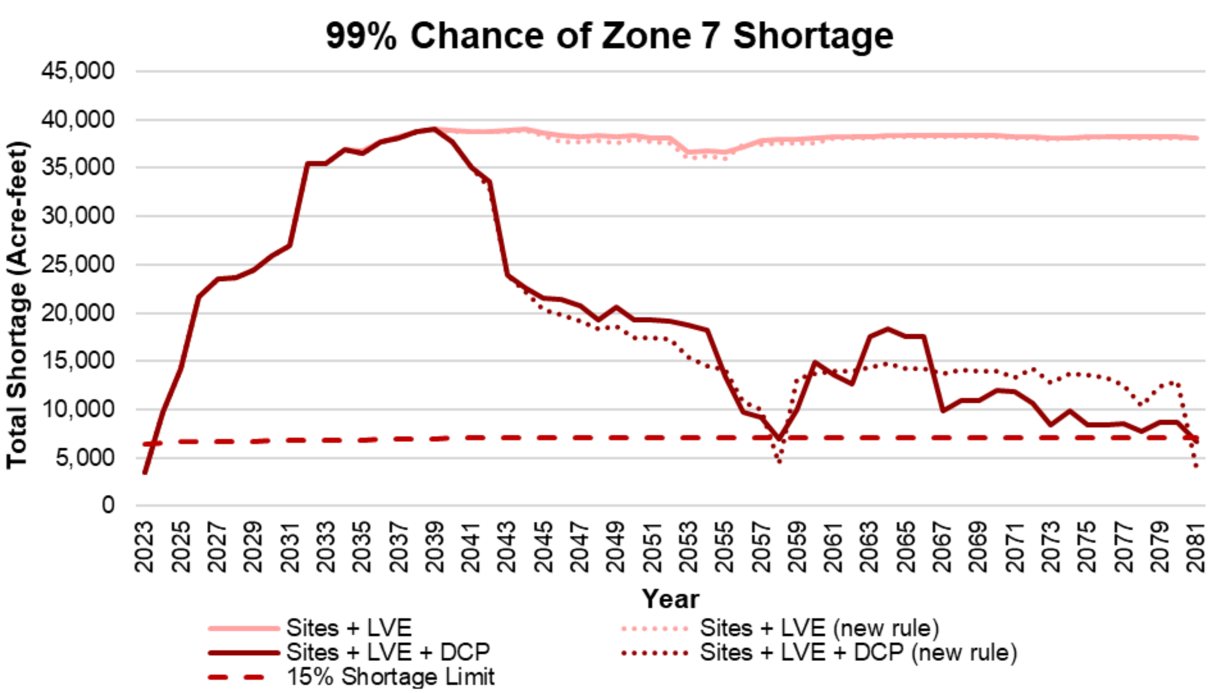

Figure A-4: Timeseries of 99% Chance of Shortages

At a 99% chance, Sites + LVE and Sites + LVE (new rule) have almost identical levels of shortage throughout the study period. Sites + LVE + DCP and Sites + LVE + DCP (new rule) have slightly different shortages, but the overall trend throughout the study period is the same. Similar to the 90% chance shortages, the new rule has a minimal effect on mitigating the 99% shortages since LVE is not as effective at mitigating extended droughts. The portfolios that include DCP have additional supply compared to the portfolios without DCP. As such, adding DCP has a significant effect on reducing shortages at a 99% chance due to the increase in SWP reliability. After DCP comes online in 2040, both Sites + LVE + DCP and Sites + LVE + DCP (new rule) experience a significant reduction in shortages.

Conclusions

The key results from this analysis are summarized below.

- The Zone 7 system is supply-limited: adding supply to a portfolio (here, adding DCP) is more effective at reducing shortages than the re-prioritization of excess water storage. This is particularly pronounced for rarer, more extreme shortages.

- Kern Banks provides an effective system buffer for withstanding extended/multi-year droughts and thus larger shortages. The initial storage in the Kern Banks successfully buffers against shortages early in the study period at the expense of reduced storage (and shortage buffering capacity) later in the study period.

- As evidenced by the similar performance between prioritizing storage between Kern Banks versus LVE at the 90% and 99% chance shortages, LVE is not as effective at mitigating the longer, more severe droughts that cause the 90% and 99% chance shortages.

- Evaporative losses from LVE are greater than put losses associated with Kern Banks when storing water for long periods of time.

- However, LVE still serves as an effective buffer against short-term droughts and provides operational flexibility.

This analysis highlights certain limitations with the Risk Model. First, the Risk Model is strictly limited to LVE operations and does not consider alternative conveyance via the Transfer-Bethany Pipeline. The Risk Model also does not consider the implications of local versus non-local storage. LVE, as well as direct deliveries via the Transfer-Bethany Pipeline, could act as countermeasures against catastrophic events that impede Zone 7’s ability to use SWP infrastructure. Additionally, the analysis simulated a LVE storage capacity of 10,000 AF, which may help buffer against shortages caused by single-year droughts but has a limited impact when considering the long-term ability of the project to store and deliver water.

Recommendations

As described above, the current analysis does not capture the potential additional benefits associated with the Transfer-Bethany Pipeline. For example, alternative conveyance through Transfer-Bethany Pipeline could serve as a counter measure against catastrophic events (e.g., natural disaster or terrorist attack) that could disconnect Zone 7 from SWP infrastructure.

Based on this analysis, the following recommendations are listed in no particular order.

- Consider additional LVE operations testing, such as modeling LVE with new Sites operations once the new Sites modeling is available from the Sites Project.
- Consider evaluating Transfer-Bethany Pipeline in addition to LVE storage.
- Consider evaluating Transfer-Bethany Pipeline on its own without storage. Note that Los Vaqueros reservoir is envisioned to provide emergency supply to those invested in storage.
- Consider testing LVE under outage conditions (e.g., Delta outage, Zone 7 infrastructure outage)
- Consider further optimization around prioritizing the distribution of storage between LVE and Kern Banks and identification of trigger points to better inform operational decisions regarding prioritization of supplies.
- Consider the potential benefits of local storage in LVE versus transfer-dependent storage in Kern Banks.

Ultimately, subsequent model modifications, including adding the capability to model direct diversions through the Transfer-Bethany Pipeline and further optimization around prioritizing storage between the Kern Banks and LVE, could help optimize LVE and Zone 7 operations to maximize LVE benefits and minimize Zone 7 shortages.