Final Draft Lake Alternative Evaluation

for the

Bear Valley Water Sustainability Project

Prepared for:

Big Bear Area Regional Wastewater Agency

Big Bear City Community Services District

Big Bear Lake Department of Water and Power

Big Bear Municipal Water District

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12/19/2018

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1 EXECUTIVE SUMMARY

Natural precipitation provides the sole source of water supply for the Big Bear Valley (Valley), and is relied on for potable groundwater supplies, replenishing Big Bear Lake and Stanfield Marsh, and supporting the rare and diverse habitat and species in the Valley. Drought conditions and a long-term decline in precipitation trends have led the local water management agencies to investigate opportunities for supplemental water supplies, which are extremely limited due to its isolated location at the top of the watershed. Currently, wastewater generated within the Valley undergoes preliminary and secondary treatment and is discharged outside of the watershed to irrigate alfalfa fields in the Lucerne Valley, located approximately 20 miles north of the Valley.

The Big Bear Area Regional Wastewater Agency (BBARWA), Big Bear City Community Services District (BBCCSD), Big Bear Lake Department of Water and Power (BBLDWP), and Big Bear Municipal Water District (BBMWD) (collectively, the Project Team) recognize that retaining recycled water in the watershed for beneficial use would significantly increase the sustainability of local water supplies. The Project Team has partnered to develop a project that will recover this lost water resource and keep the water in the Valley for beneficial reuse.

In 2016, the Bear Valley Water Sustainability Study evaluated four (4) alternatives for reuse, including distribution of tertiary treated recycled water for landscape irrigation and several groundwater recharge alternatives using advanced purified water. However, these alternatives address only the potable water supply component of the Valley's water needs and do not provide sufficient benefits to warrant the local investment so they have not been pursued.

The Project Team is currently evaluating an additional water reuse alternative that provides more widespread benefits to the Valley, known as the Lake Alternative. The Lake Alternative includes the following uses and benefits:

- High quality water will be discharged to the Stanfield Marsh Wildlife and Waterfowl Preserve, providing a consistent water source to sustain habitat and increase education opportunities for the community and visitors
- Water from the Marsh provides new inflow to Big Bear Lake to augment lake levels, enhance recreational opportunities and aquatic habitat and support water quality improvements
- High quality water will be discharged to Shay Pond to sustain habitat for the federally listed Unarmored Threespined Stickleback fish, which is currently sustained using potable water
- During extended dry periods, water from Big Bear Lake will be pumped to Sand Canyon to recharge the groundwater basin to strengthen the sustainability of the groundwater basin
- During wet periods, excess water could be stored locally as snow, providing flexibility to further enhance winter recreation, reduce spills from Big Bear Lake, augment spring runoff and increase groundwater recharge. Water could also be used to irrigate the local golf course in the summer, if desired.

- Additional inflow may enable BBMWD to modify their current Big Bear Lake management strategy to minimize spills and optimize releases to enable additional water to be captured downstream for recharge of the San Bernardino Basin, rather than discharged to the ocean.

Implementation of the Lake Alternative will require significant upgrades to BBARWA's wastewater treatment plant (WWTP) to produce high quality water that meets stringent discharge requirements for Big Bear Lake, particularly for nutrients (specifically phosphorus and total inorganic nitrogen) and total dissolved solids (TDS). To achieve the anticipated effluent limits, it is anticipated that BBARWA will need to implement a series of upgrades to existing unit processes and integrate new unit processes:

- Upgrade the extended aeration process through retrofit of the existing oxidation ditches to optimize biological nitrification-denitrification (NDN) and phosphorus removal.
- If needed, incorporate chemical precipitation of soluble phosphorus through addition of a metal salt within the activated sludge tankage, upstream of clarification.
- New NDN process to reduce inorganic nitrogen concentrations. This process may consist of a biologically active filter with sand or synthetic media, or biological reactors designed specifically for nitrogen and phosphorus removal.
- New low pressure filtration, such as microfiltration (MF) or ultrafiltration (UF), to reduce flocculated or colloidal solids upstream of the reverse osmosis (RO) process.
- New RO to reduce TDS concentration and nutrient concentrations.
- Disposal of brine stream generated from the RO process, such evaporation ponds, with or without brine minimization.

The preliminary design capacity of the treatment upgrades is 2.2 mgd, which corresponds with the 10-year average annual flow to the WWTP. It is assumed that any flows in excess of 2.2 mgd would be treated to a secondary level and discharged to Lucerne Valley, similar to the existing discharge method. Accounting for seasonal and annual flow variations and the volume disposed of as brine, the preliminary estimate of yield from the Lake Alternative is 1,950 AFY.

The Lake Alternative is a multi-component project that achieves the Project Team's goal of recovering a lost water supply to increase the sustainability of local water supplies to benefit the entire Valley. It is also the most cost-effective alternative that has been identified, in terms of unit cost of water recovered for various beneficial uses. The Project Team is continuing to collaborate with regulators and other stakeholders to refine these benefits, identify potential additional benefits and identify a path toward a cost effective and multi benefit for sustainable water in the Big Bear Valley.

2 INTRODUCTION

2.1 BACKGROUND

The Big Bear Valley (Valley) is located in the San Bernardino Mountains of San Bernardino County, California. The area includes approximately 135 square miles within a 12-mile long valley surrounded by mountain ridges and rugged slopes. Land surface elevations range from 6,000 to 9,900 ft and the area is entirely surrounded by the San Bernardino National Forest. Big Bear Lake (Lake) lies within the Valley and has a surface area of approximately 10 square miles and 23 miles of shoreline and is connected to the Stanfield Marsh Wildlife and Waterfowl Preserve. The Valley is home to approximately 23,000 full time residents. The area is primarily residential with some commercial uses, and experiences an influx of part-time population and vacationers enjoying the four season recreational facilities within the valley. In 2016, it is estimated that 8.3 million people visited the Valley. Due to the recreational nature of the Valley economies, occupancy within the valley fluctuates seasonally, typically peaking in July and at the lowest level during the winter. Based on the United States Census American Community Survey 2010-2014 data, all of the developed areas of the Valley are considered Disadvantaged or Severely Disadvantages Communities due to Median Household Incomes (MHI) less than 80% or 60%, respectively, of the statewide MHI, as defined in the California Public Resources Code Section 75005.

Natural precipitation provides the sole source of water supply for the Valley, and is relied on for potable groundwater supplies, replenishing the Lake, and supporting the rare and diverse habitat and species in the Valley. Drought conditions and a long-term decline in precipitation trends have led the local water management agencies to investigate opportunities for supplemental water supplies, which are extremely limited due to its isolated location at the top of the watershed. Currently, wastewater generated within the Valley undergoes preliminary and secondary treatment and is discharged outside of the watershed to irrigate alfalfa fields in the Lucerne Valley, located approximately 20 miles north of the Valley.

2.2 PROJECT TEAM

The Project Team is comprised of the Big Bear Area Regional Wastewater Agency (BBARWA), Big Bear City Community Services District (BBCCSD), Big Bear Lake Department of Water and Power (BBLDWP), and Big Bear Municipal Water District (BBMWD). The Project Team recognizes that retaining recycled water in the watershed for beneficial use would significantly increase the sustainability of local water supplies to benefit the entire Valley and has partnered to jointly fund and prepare this report. The following sections provide a brief introduction to each agency.

2.2.1 BBARWA

BBARWA was formed in March 1974 to conduct a study to develop a plan for wastewater management within the greater Valley region. A subsequent 1975 Wastewater Facilities Plan was prepared which identified the need to provide centralized, environmentally friendly wastewater conveyance, treatment and disposal for the BBARWA service area.

The BBARWA service area includes the entire Valley (79,000 acres) and is served by three separate collection systems: City of Big Bear Lake, representing approximately 47% of the connections, and BBCCSD, representing approximately 48% of the connections, and County of San Bernardino Service Area 53B (CSA 53), representing approximately 5% of the connections. Each of these member agencies maintains and operates its own wastewater collection system, and delivers wastewater to BBARWA's interceptor system for transport to the BBARWA Regional Wastewater Treatment Plant (WWTP).

2.2.2 BBCCSD

BBCCSD was created in 1966 by a formation and consolidation election and initially provided solid waste collection, fire protection and street lighting services. In 1967, the former Big Bear Mutual Service Company voted to relinquish ownership and operation of their water system to BBCCSD. Currently BBBCSD's services include water, wastewater collection, fire protection & emergency medical services, solid waste collection, and street lighting services. BBCCSD's water service area includes Big Bear City and portions of San Bernardino County. BBCCSD's wastewater collection area includes Big Bear City and portions unincorporated communities such as Sugarloaf, Erwin Lake, Whispering Forest, and Moonridge.

2.2.3 BBLDWP

BBLDWP was formed in 1989 with the purchase of the retail water system from Southern California Water Company and currently provides water service to the City of Big Bear Lake, located along the south side of Big Bear Lake, as well as the unincorporated communities of Fawnskin, which lies to the north of the lake, and Sugarloaf, Erwin Lake and Lake William areas, which lie on the east side of the Valley.

The City of Big Bear Lake provides wastewater collection services within the city, while BBCCSD and CSA 53B provide wastewater collection services within BBLDWP's water service area that lies outside the city limits.

2.2.4 BBMWD

BBMWD, formed in 1964, is an independent special district that is responsible for the overall management of Big Bear Lake. The primary responsibilities of BBMWD are:

- Stabilization of the level of Big Bear Lake by managing the amount of water released to Bear Valley Mutual
- Watershed/water quality management
- Recreation management
- Wildlife habitat preservation and enhancement
- Bear Valley Dam and Reservoir maintenance

2.3 PRIOR STUDIES & PURPOSE

There is a long legacy of exploring water reuse opportunities in the Big Bear Valley for a variety of beneficial uses including wildlife habitat, landscape irrigation, surface water discharge, and groundwater recharge. Water reuse opportunities in the Valley were first investigated in 1964 and evaluations have continued intermittently since BBARWA was formed in 1974.

Most recently, in 2016, the Bear Valley Water Sustainability Study (2016 Study) evaluated four (4) alternatives for reuse, including distribution of tertiary treated recycled water for landscape irrigation and several groundwater recharge alternatives using advanced purified water. The 2016 Study concluded that groundwater recharge at two different recharge sites (Greenspot and Sand Canyon) was the highest ranked alternative due to a lower unit cost relative to the other alternatives and higher volume of water retained in the Valley.

Due to stringent water quality requirements and the challenge of disposing of the brine waste generated from the treatment process upgrades, full-scale groundwater recharge in the Valley is still a costly option. Although local potable groundwater water supplies are impacted by drought, conservation efforts in the past few years have maintained the total potable consumption below the safe yield of the groundwater basin. While the availability of high quality recharge water would benefit the water agencies by providing a supplemental drought proof source of supply when needed during future extended drought periods, continuous large volumes of recharge water are not needed to sustain local groundwater supplies at this time. A full-scale groundwater recharge project addresses only the potable water supply component of the Valley's water needs and does not provide sufficient benefits to warrant the high cost. For these reasons, full scale groundwater recharge in the Valley is not being pursued at this time.

The purpose of this report is to evaluate an additional water reuse alternative that more widespread benefits to the Valley; the subject alternative is presented in Section 2.5. This report repeats some relevant background information contained in the 2016 Study for context. Additional background information and detail on the prior alternatives evaluated can be found in the 2016 Study. Appendix C to the 2016 Study includes a timeline summarizing the evolution of wastewater management in the Valley from 1935 to 2003 as well as a partial list of documents related to water reuse in the Valley, as of April 2005.

2.4 PROJECT GOALS AND OBJECTIVES

The goal of the Project Team is to partner to recover a lost water resource, close the water loop, and keep the water in the Valley for beneficial reuse. This goal will be achieved through development of a multi-benefit water reuse project that:

1. Augments natural recharge for water supply sustainability
2. Protects the rare and diverse habitat and species in the Valley
3. Promotes a thriving community through enhanced recreation

2.5 THE LAKE ALTERNATIVE

The project alternative evaluated in this report is referred to as the Lake Alternative and includes upgrades to the WWTP to produce high quality water for the following uses and benefits:

- High quality water will be discharged to the Stanfield Marsh Wildlife and Waterfowl Preserve (Marsh), providing a consistent water source to sustain habitat and increase education opportunities for the community and visitors

- Water from the Marsh provides new inflow to the Lake to augment Lake levels, enhance recreational opportunities and aquatic habitat and support water quality improvements
- High quality water will be discharged to Shay Pond to sustain habitat for the federally listed Unarmored Threespined Stickleback (Stickleback) fish, which is currently sustained using potable groundwater
- During dry periods, Lake water will be pumped to Sand Canyon to recharge the groundwater basin to strengthen the sustainability of the groundwater basin during extended droughts
- During wet periods, excess water could be stored locally as snow using existing snow making infrastructure. This provides flexibility to further enhance winter recreation, reduce spills from the Lake, augment spring runoff and increase groundwater recharge. The existing snow making pump and pipeline can also be used to deliver irrigation water to the Bear Mountain Golf Course in the summer, if desired. The water demand for the Bear Mountain Golf Course is estimated to be 120 AFY (1).
- Additional inflow into the Lake may enable BBMWD to modify the current Lake management strategy to minimize spills and flood control releases and optimize releases to enable additional water to be captured for recharge of the San Bernardino Basin, rather than discharged to the ocean.

The Project Team is conducting ongoing outreach to a variety of potential stakeholders within the Valley and the greater Santa Ana River watershed to collaboratively refine these benefits and identify potential additional benefits that could be achieved through implementation and management of the Lake Alternative.

The Lake Alternative will require significant upgrades to the treatment process at the WWTP to meet stringent discharge requirements for the Lake, as discussed in subsequent sections of this report.

3 WATER SUPPLIES AND MANAGEMENT

This section provides a brief overview of current water supplies and water management practices in the Big Bear Valley to provide context for the development of recycled water supplies. Currently, the sole source of water supply in the Valley is groundwater from the Big Bear Valley Groundwater Management Zone (Basin). BBMWD manages Big Bear Lake but the water agencies do not have surface water rights and imported water is not available in the Valley due to lack of infrastructure to the isolated location. Additional information about potable water supplies can be found in the BBCCSD 2015 Urban Water Management Plan (UWMP) and BBLDWP 2015 UWMP.

3.1 BIG BEAR VALLEY GROUNDWATER MANAGEMENT ZONE

The Basin lies in the northeastern portion of the Santa Ana River Watershed and is currently not adjudicated. The Basin is roughly 14 miles long from east to west and 7 miles wide from north to south. Big Bear Lake and Baldwin Lake are located in the middle of the Basin. Surface drainage within the Basin flows to one of the two lakes, mostly Big Bear Lake. Big Bear Lake empties on the west into Bear Creek, which is a tributary to the Santa Ana River. Additional information on the management of surface water in Big Bear Lake is discussed in Section 3.3.

The Basin is primarily composed of unconsolidated alluvium and is divided into upper, middle and lower aquifers; where the upper and middle aquifers are the primary producers. Based on the drainage system, the Basin is divided into 16 hydrologic subunits with the main tributaries including Grout Creek, Van Dusen Canyon, Sawmill Canyon, Sand Canyon, Knickerbocker Creek, Metcalf Creek, and North Creek. The Basin and subunits are presented in Figure 3-1.

The Basin is naturally recharged from percolation of precipitation, runoff and underflow from fracture rock formations; with groundwater levels that generally correlate with annual fluctuations of precipitation. Storage capacity of the Basin is estimated by DWR at 42,000 AFY with the maximum perennial yield estimated at 4,800 AFY (7). In addition to the municipal water purveyors, there are numerous private wells throughout the Basin serving properties that are not connected to a public water system.

BBLDWP and BBCCSD manage and monitor the Basin. Through the Groundwater Monitoring and Management Plan, BBLDWP contributes to Basin management by conducting monthly monitoring of 18 non-pumping monitoring wells and approximately 40 production wells, bi-annual Technical Review Team meetings, and has established conservation levels based on groundwater levels and trends in key wells. BBCCSD also manages the groundwater level and water quality by conducting monthly monitoring in 11 non-pumping monitoring wells and 13 production wells, monthly monitoring of surface flow in Van Dusen Creek, Shay Creek and Green Canyon Creek, and has established action criteria for average groundwater levels across the BBCCSD service area that are tied to conservation stages and measures. Conservation efforts have helped to keep annual groundwater production less than the perennial yield of the Basin. The Basin is not currently identified by DWR to be in overdraft condition. (4) (8)

3.1.1 Sustainable Groundwater Management Act

In 2014, California passed the Sustainable Groundwater Management Act (SGMA), which established a framework for sustainable, local groundwater management. The California Department of Water Resources (DWR) is responsible for implementing the law and supporting local agencies to achieve sustainable groundwater management. DWR identified the Basin as a Medium Priority Basin and SGMA requires Medium Priority Basins that are not in critical overdraft to be managed under a Groundwater Sustainability Plan (GSP) by January 21, 2022. The GSP will be developed and implemented through formation of the Bear Valley Basin Groundwater Sustainability Agency (BVBGSA), which is a Joint Powers Authority (JPA) comprised of the four agencies on the Project Team.

In December 2017, the BVBGSA applied for a Sustainable Groundwater Planning Grant to fund the preparation of the GSP. The GSP is anticipated to be completed by 2020 and will leverage existing data sources and management actions that have been utilized by BBLDWP and BBCCSD in the past. The workshops held throughout the development of the GSP will provide a venue to engage relevant stakeholders in a dialogue to build on this foundation and develop similar management actions to meet sustainability goals for the Basin as a whole.

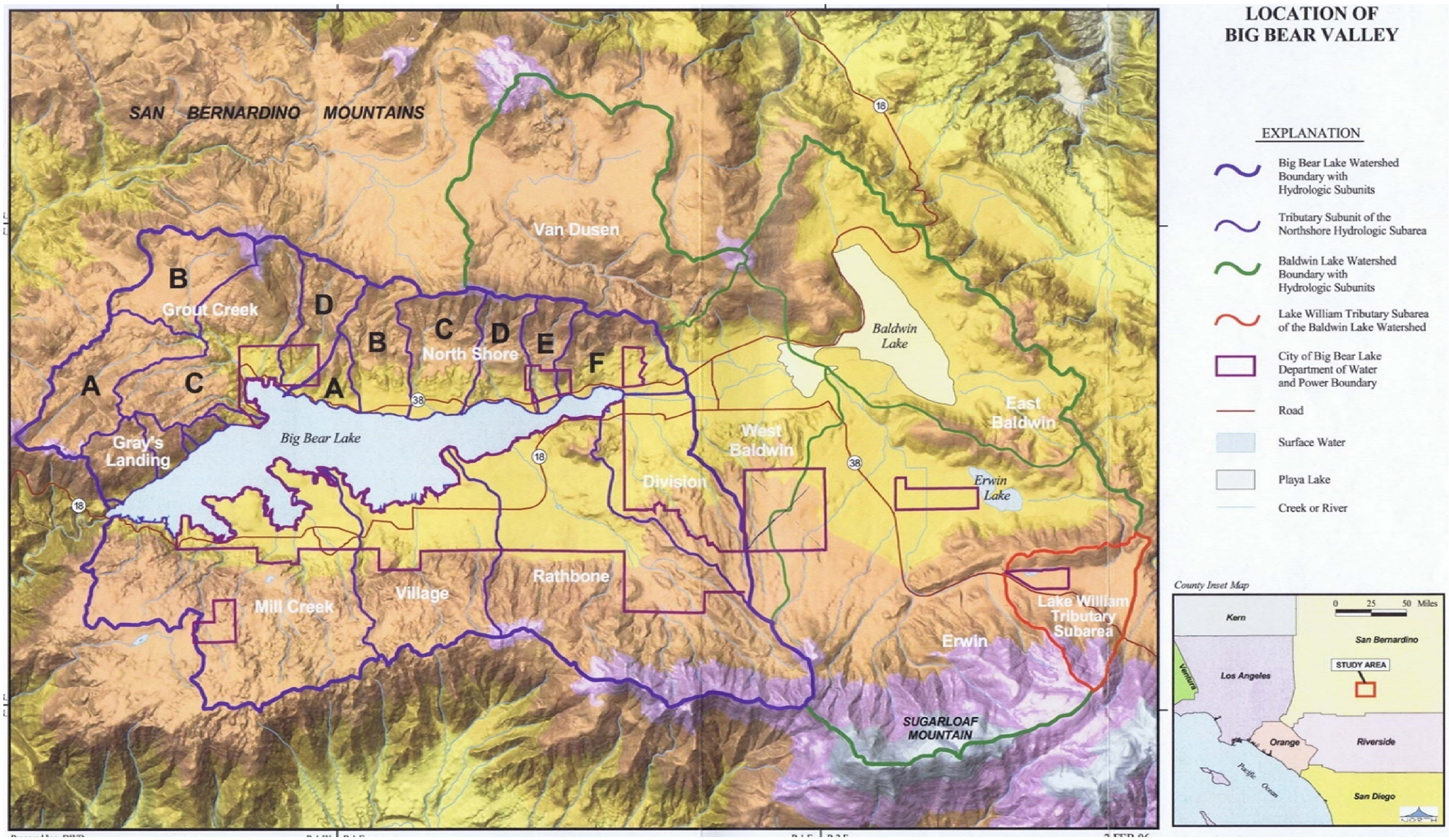


Figure 3-1. Big Bear Valley Groundwater Basin and Subunits (9)

3.2 WATER DEMAND

The BBLDWP service area is primarily residential with commercial accounts making up 5% and industrial making up less than 1% of the total accounts. BBCCSD serves only residential accounts. The projected water demands for BBLDWP and BBCCSD area are presented in Table 3-1. The historical and projected water demands for each water agency along with the total demands for the agencies are presented in Figure 3-2. These estimates do not include water used from private wells, which was estimated to be approximately 169 AFY in the BBLWDP 2006 Water Master Plan (7).

Table 3-1. Water Demand Projections for Bear Valley Water Agencies (AFY)

Water Agency	2015	2020	2025	2030	2035
BBLDWP[1]	2,095	2,169	2,246	2,326	2,408
BBCCSD[2]	940	1,163	1,220	1,281	1,344
Total	3,035	3,332	3,466	3,607	3,752

Note:
1. BBLDWP 2015 UWMP
2. BBCCSD 2015 UWMP

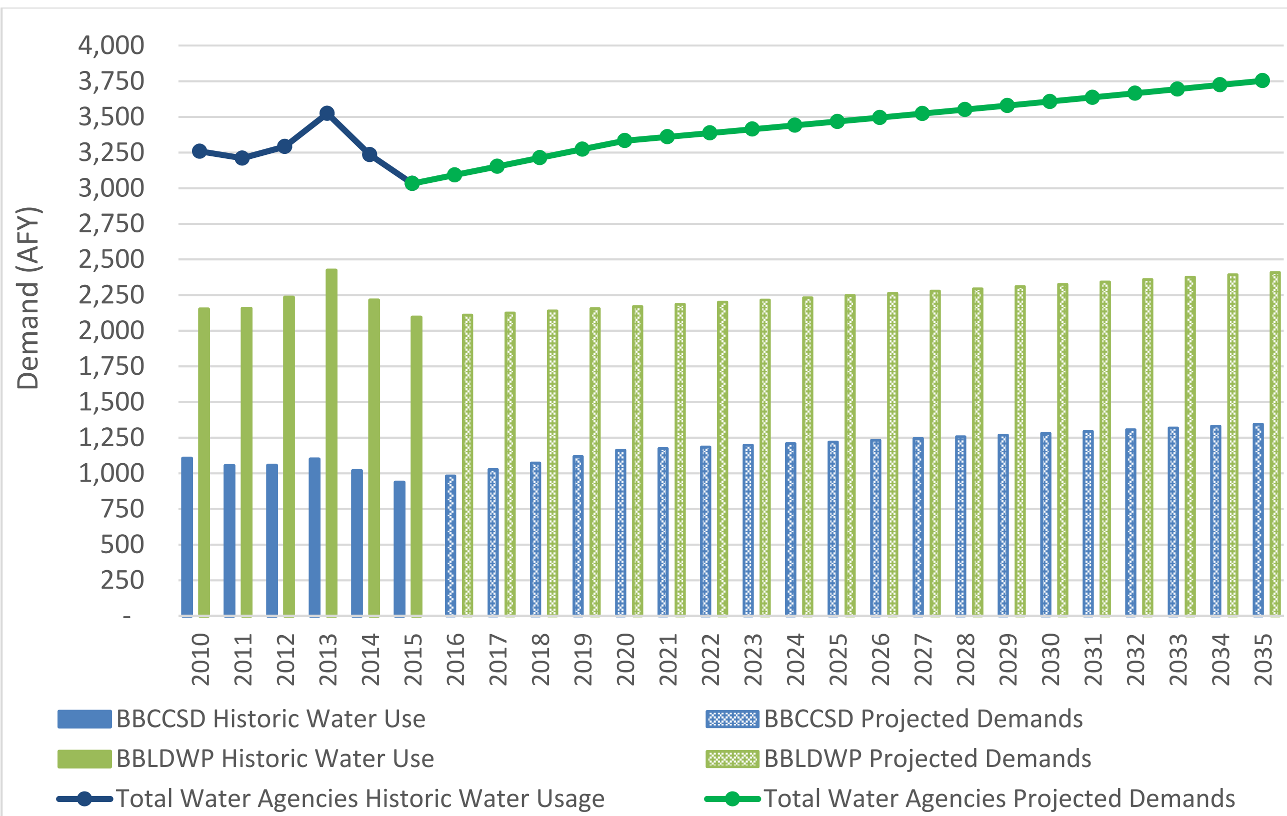


Figure 3-2. Historic and Projected Water Demands

3.3 BIG BEAR LAKE WATER MANAGEMENT

This section describes the key management practices and documents that govern the management of the water in Big Bear Lake. This information is also presented graphically in Figure 3-4.

3.3.1 The 1977 Judgement

The Big Bear Dam was originally constructed to provide water storage for Bear Valley Mutual Water Company (Mutual), which was formed in 1903 by the citrus growers of the Redlands/Highland area to ensure water supply for irrigation needs. The historic operation of the Big Bear Lake (Lake) as an irrigation reservoir resulted in drastic fluctuations in lake levels, which conflicted with the goals of BBMWD and the community of Big Bear Valley. A legal conflict over the water rights and management of the lake was ultimately settled out of court through the 1977 Judgement. Under the terms of this judgement, BBMWD purchased the lake bottom, Bear Valley Dam, and the right to utilize and manage the surface of Big Bear Lake from Bear Valley Mutual. Bear Valley Mutual retained a storage right and ownership of all water inflow into the Lake (1). Mutual has the right to request Lake releases as may be reasonably necessary to meet the requirements of Mutual's stockholders, not exceeding 65,000 AF in any ten (10) year period.

3.3.2 In-Lieu Water and Lake Release Policy

The 1977 Judgment allows BBMWD to maintain a higher water level in the lake by delivering water to Mutual from an alternate source of water. This alternate source of water, referred to as In-Lieu Water, comes mainly from the State Water Project through a contract executed in 1996 with San Bernardino Valley Municipal Water District (Valley District), a State Water Contractor. This In-Lieu Agreement provides that:

- BBMWD shall make Lake releases to meet the demands of Mutual when such releases are consistent with BBMWD's Lake Release Policy (described below)
- Whenever Lake releases under the Lake Release Policy are not sufficient to meet Mutual's demands, Valley District shall provide In-Lieu Water to Mutual to meet the remainder of their demands
- BBMWD shall pay Valley District a fixed annual fee, which is escalated annually based on BBMWD's assessed value. In 2017, BBMWD's In-Lieu payment to Valley District was approximately $1,400,000.

BBMWD's current Lake Release Policy was adopted in 2006 provides guidance on how Mutual demands will be met depending on the Lake level.

- When the Lake is in the top 4 feet, Mutual's demands will be met with Lake releases
- When the Lake is between 4 and 6 feet below full, Lake releases will be made in the months of November through April and In-Lieu Water will be obtained from May to October
- When the Lake is more than 6 feet below full, In-Lieu Water will be obtained

3.3.3 Snow Making Withdrawals

BBMWD currently has a contract with the Big Bear Mountain Resorts, allowing the withdrawal of an allocated amount of water from the Lake to use for snow making purposes. Currently, Big Bear Mountain Resort is authorized to withdraw a maximum of 11,000 acre-feet (AF) of water from the Lake over a 10-year rolling period, not exceeding 1,300 AF in any single year. It is calculated that half of the water withdrawn from the lake is returned as runoff (1).

3.3.4 Net Wastewater Exports

The 1977 Judgement required that, beginning in 1986, any net export of water to an area of the Upper Bear Creek Watershed that is not tributary to the Santa Ana Watershed would be transferred from BBMWD's Lake Account to Mutual's Lake Account, as discussed in Section 3.3.6. Because water reclamation was not implemented by 1986, a net wastewater export occurs annually and is calculated as the difference between the wastewater that leaves the Big Bear Lake watershed and the water that is imported into the Big Bear Lake Watershed from the Baldwin Lake Watershed. Groundwater that is produced within the Big Bear Lake Watershed and returned to the sewer after use is treated at the BBARWA WWTP (located in the Baldwin Lake Watershed), then discharged to Lucerne Valley; this water is exported from the Big Bear Lake Watershed. Groundwater that is produced in the Baldwin Lake Watershed by BBLDWP and BBCCSD and served to customers within the Big Bear Lake Watershed is imported into the Big Bear Lake Watershed. In 2016, the net wastewater exported from the Big Bear Lake Watershed was 848 AF.

3.3.5 Fish Protection Releases

In 1995, the State Water Resources Control Board (SWRCB) issued Order No. 95-4, which requires BBMWD and Mutual to release water from the Lake for fishery protection in Bear Creek. Sufficient water must be released from the Lake to maintain a seven-day average flow of 1.2 cubic feet per second (cfs) and minimum average daily flow of 1.0 cfs in Bear Creek no more than 500 feet downstream of its confluence with West Cub Creek, referred to as Station A. SWRCB Order No. 95-4 also requires sufficient releases to maintain a minimum flow of 0.3 cfs approximately 300 feet downstream of the toe of the dam, referred to as Station B. The dam releases required to maintain these minimum flows vary by month and by hydrologic year type (normal, above normal or below normal precipitation).

3.3.6 Watermaster Accounting

The 1977 Judgment requires the establishment of a Watermaster to maintain three basic accounts:

BBMWD's Lake Account. A detailed account to reflect actual operation of the Lake by BBMWD.

Mutual' s Lake Account. A corollary account that simulates the effect of Mutual's operation if Mutual had owned the Lake, the In-Lieu Program was not in place, and there was no net wastewater export from the Big Bear Lake Watershed.

Basin Make-up Account. An account of BBMWD's annual and cumulative obligation for Basin Make-up Water in the San Bernardino Groundwater Basin to offset any deficiencies in recharge as a result of BBMWD's Lake operation. In 2016, the Basin Make-up Account had an ending balance of 27,120 AF. This positive amount means that there has been an increase in groundwater recharge in the San Bernardino Basin as a result of the BBMWD operation of the Lake.

Figure 3-3 depicts the actual Lake levels under BBMWD's operation compared to the simulated Lake operation by Mutual as shown by the balance of Mutual's Lake Account. In 2016, BBMWD's operation of the Lake resulted in a Lake level 14.43 feet higher than it would have been under Mutual's operation.

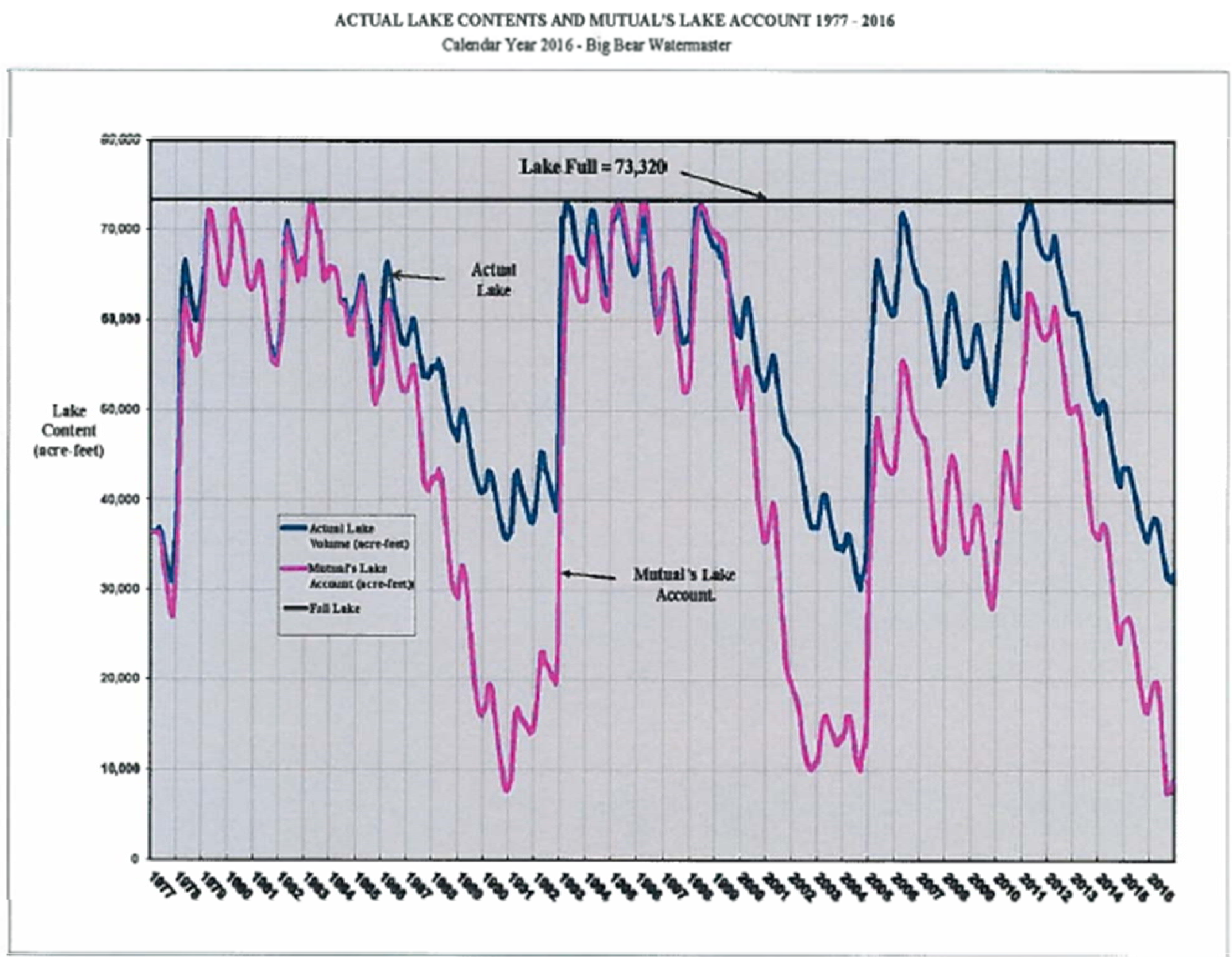


Figure 3-3. Actual Lake Levels and Mutual's Lake Account Comparison, 1977 - 2016 (5)

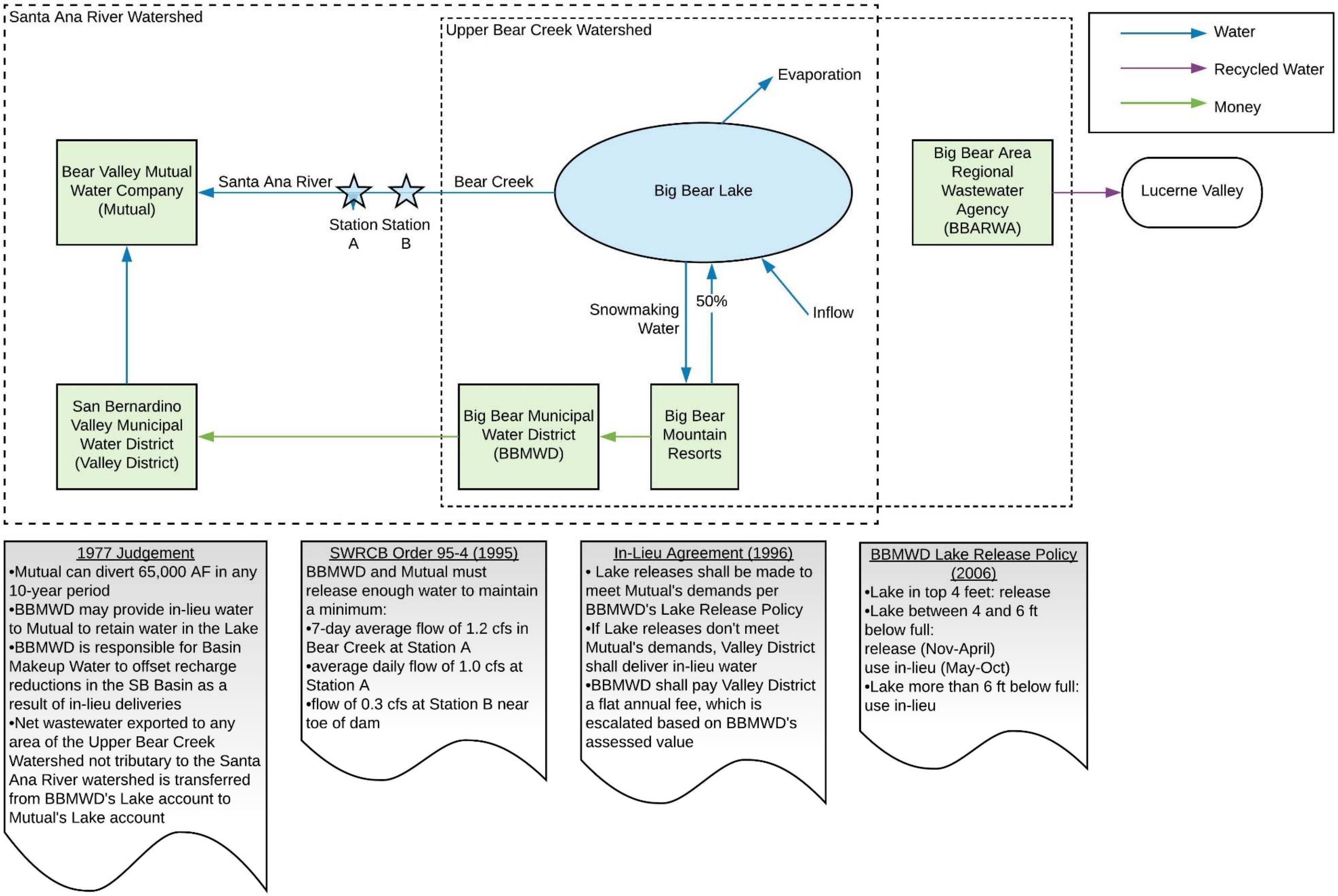


Figure 3-4. Big Bear Lake Management Framework

4 WASTEWATER CHARACTERISTICS AND FACILITIES

BBARWA owns and operates a 4.9 million gallon per day (MGD) capacity WWTP located just south of Baldwin Lake on the east side of the Valley. In 2016, the WWTP treated approximately 1.9 MGD of municipal wastewater collected from BBCCSD, the City of Big Bear Lake and CSA 53 in Fawnskin.

4.1 EXISTING AND PROJECTED WASTEWATER FLOWS

The influent flows to BBARWA's WWTP are comprised of three components:

- Flow from full-time residential homes
- Flows due to tourism, commercial activities and part-time residential homes
- Flows from Infiltration and Inflow (I/I) due to precipitation

These components create a seasonal variation in the wastewater flows treated at the plant. Based on full-time residency rates from BBCCSD and BBLDWP and the number of full-time dwelling units reported by Bear Valley Electric, BBARWA's 2010 Sewer Master Plan (2010 SMP) estimated that the full-time residential rate is 38% (2).

The tourism season is largely concentrated in the months of December through April due the local ski resorts; this period also corresponds with higher precipitation and increased flows due to I/I. The months of June and July also see a slight rise in tourism due to Lake recreation activities. Average daily flows and the seasonal variation during the 10-year period from 2007 to 2016 (which included a wet and dry cycle) are shown in Figure 4-1. The average daily flow for this 10-year period is approximately 2.2 MGD and the maximum month flow is 5.5 MGD.

The 2010 SMP estimated the future sewer flows based on future population and equivalent dwelling unit (EDU) projections utilizing the constant sewer load index of 172 gallons per day (gpd) for full time residential EDUs. The 2010 SMP assumes the full-time EDUs will increase at an annual rate of 0.8% over a 20-year period based on a long-term average. Assuming the full-time residence rate remains at 38% and that I/I will be consistent with the previous average, the 2010 SMP projects that the average annual sewer flows will increase to 2.7 MGD by 2030. However, the 2010 SMP flow projections did not account for reduced sewer loads due to recent water conservation so future flows will likely be significantly lower than projected.

If the Lake Alternative is implemented, it is recommended that the future flow projections be updated as part of the preliminary design phase to inform the design capacity for treatment upgrades based on realistic flows based on current water use trends.

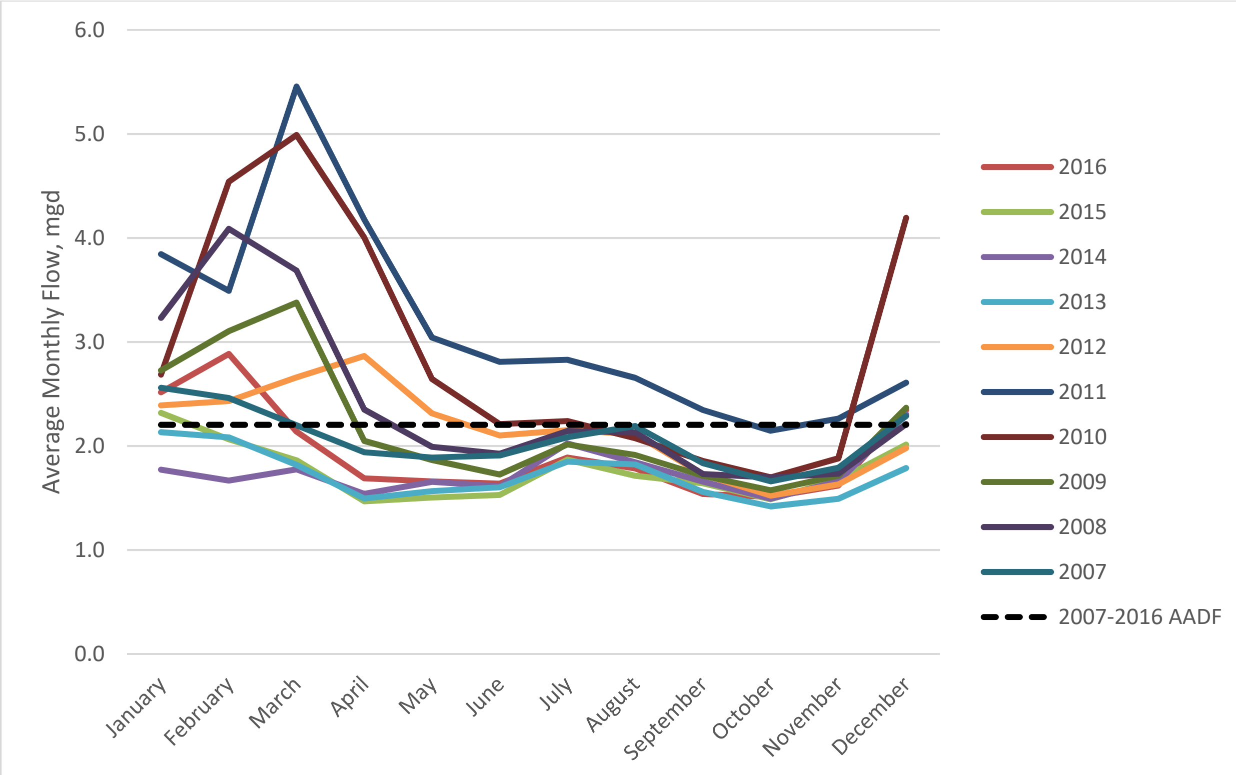


Figure 4-1. 10-Year Average Daily Flows by Month (2007-2016)

4.2 EXISTING FACILITIES AND DISCHARGE REQUIREMENTS

BBARWA's WWTP is located on a 93.5-acre lot. The WWTP process components occupy 11.2 acres and the remaining 82.3 acres include storage ponds and evaporation ponds. Influent flows are conveyed through three BBARWA operated sewer mains and lift stations to the plant. The WWTP currently provides preliminary and secondary treatment. Table 4-1 summarizes the WWTP's treatment processes and the process flow diagram is depicted in Figure 4-2.

BBARWA recently completed several upgrades to the sludge dewatering process. Heat exchangers were installed on the existing generator to capture waste heat; hot water from the heat exchangers is used to heat the floor of the lined drying bed. A 315 foot by 60 foot metal building was also constructed to cover the lined drying bed so that the dewatering process could operate year round.

BBARWA's WWTP generates its own electricity using three natural gas generators that can be run in parallel: two 250 KW Cummins generators and one Waukesha generator with a rating of 600 kilowatts for a total generating capacity of 1100 kilowatts. BBARWA only generates the energy needed to operate the WWTP and Administration Building and typical generation is in the range of 225,000 - 350,000 kilowatt-hours (kW-hr) per month. In 2015, total energy generation was 3,100,216 kW-hr. Natural gas consumption was 43,544 million British Thermal Units (MMBTU) or 435,440 therms. BBARWA also has a connection to the Bear Valley Electric utility system that is used to run its pumping stations and can serve as an emergency backup power supply for the WWTP.

Table 4-1. BBARWA's WWTP Treatment Process

Treatment Process[1]	Description
Preliminary Treatment	Consists of bar screens, grit removal and disposal of solids
Secondary Biological Treatment	Consists of oxidation ditches which use mechanical aeration to achieve organic material stabilization, nutrient removal and pathogen reduction. Solids production is minimized by the Cannibal® Solids Reduction System, through use of a side-stream interchange bioreactor with aeration controlled by the ORP level.
Secondary Sedimentation Treatment	Consists of clarifiers to settle solids. Waste activated sludge (WAS) is pumped to a dissolved air floatation (DAF) system
WAS Thickening	Consists of a DAF system that skims sludge for sludge dewatering. Filtrate is returned to oxidation ditches.
Sludge Dewatering[2]	Sludge is dewatered using a belt press and dried in a building with heated floors that utilize waste heat from a generator. The building allows sludge to be dried year-round. The dry solids are hauled to a composting facility in Redlands.

Notes:
1. Descriptions obtained from the 2005 BBARWA Recycled Water Master Plan unless otherwise noted.
2. Obtained from BBARWA's website - http://bbarwa.org

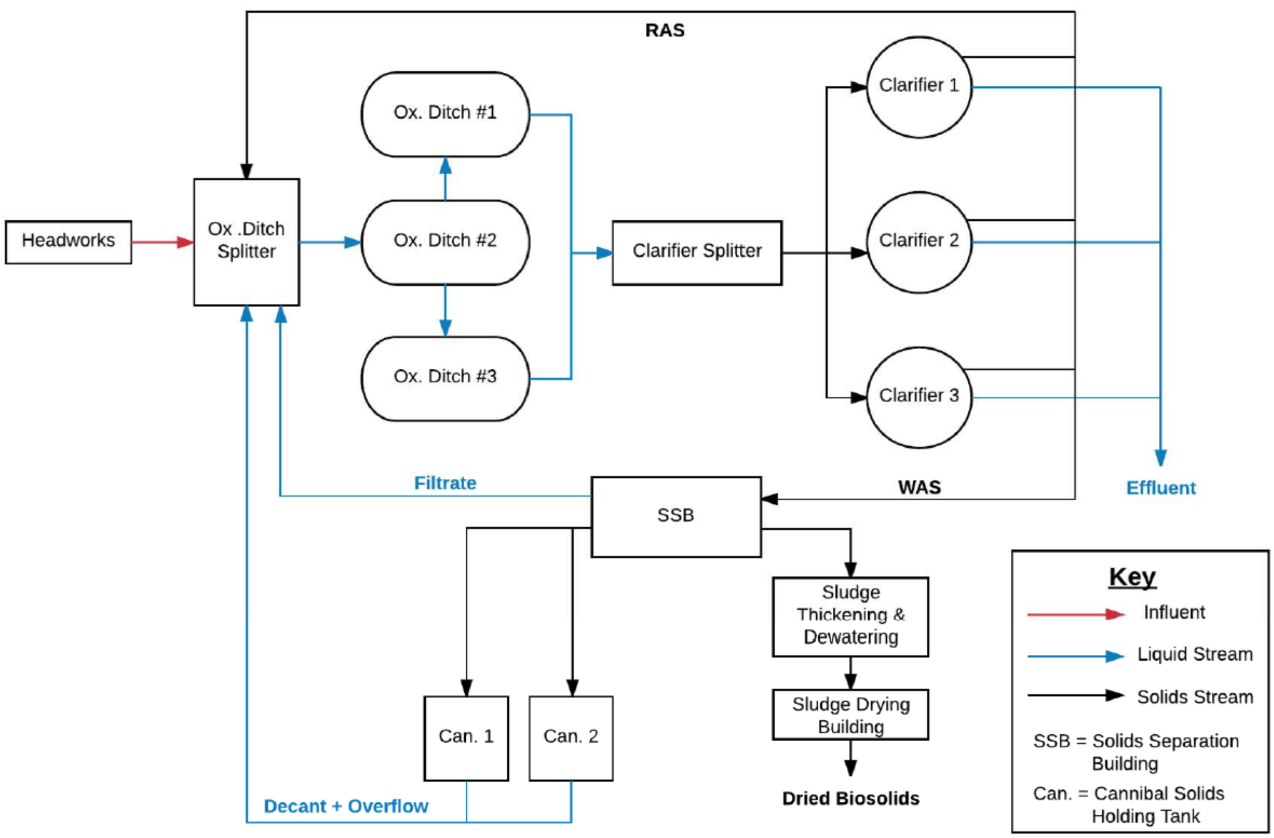


Figure 4-2. BBARWA WWTP Process Flow Diagram

4.2.1 Existing Discharge Requirements

The wastewater stream that is treated by the WWTP consists of sewage generated from urban land uses. There are no significant sources of major industrial waste or processing water treated by the facility (2). The WWTP discharge is currently regulated by the Santa Ana Regional Water Quality Control Board (RWQCB) under Waste Discharge and Producer/User Water Recycling Requirement (WDR) Order No. R8-2005-0044 (Santa Ana WDR) issued on June 24, 2005. There are three permitted discharge locations, summarized in Table 4-2. Discharge Point 001 for irrigation in Lucerne Valley, is located within the Colorado River Basin Region and is regulated by Colorado River Basin RWQCB WDR Order No. R7-2016-0026 (Colorado WDR), issued on June 30, 2016.

Treated secondary effluent is discharged to a 480-acre site in Lucerne Valley (LV Site) for irrigation of fodder and fiber crops that are used as feed for livestock. Use of recycled water for crop irrigation at the LV Site began in 1980 and 100% of the WWTP effluent is currently discharged to the LV Site. Figure 4-3 depicts the location of BBARWA's existing recycled water distribution facilities and the LV Site, approximately 20 miles north of the Valley. Discharge Points 002 and 003 are not currently used.

Table 4-2. WDR Order No. R8-2016-0044 Discharge Points

Discharge Point	Effluent Description	Receiving Water/Disposal Site	Recycling Reuse
001[1]	Secondary effluent w/o disinfection	Storage Ponds in Lucerne Valley	Irrigation in Lucerne Valley
002	Secondary effluent with disinfection	State surface water (Storage pond in Baldwin Lake) and Big Bear Valley Groundwater Management Zone	Construction and wildlife habitat
003	Tertiary effluent with disinfection	Big Bear Valley Groundwater Management Zone	Irrigation

Notes:
1. The Colorado River Basin Regional Water Quality Control Board (Region 7) regulated the use of the recycled water in the Lucerne Valley (WDR Order No. R7-2016-0026).

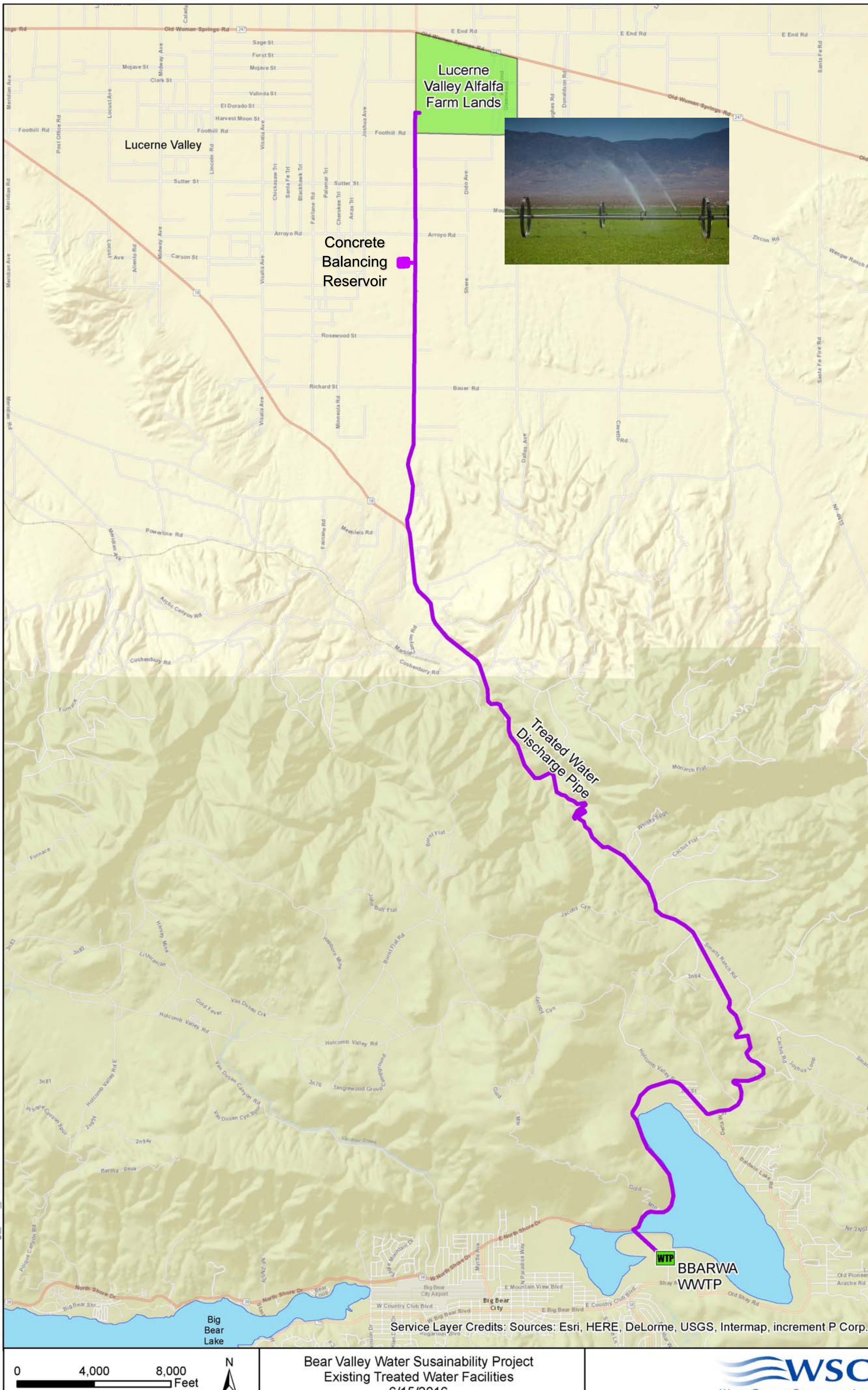


Figure 4-3. Existing Recycled Water Facilities

The effluent requirements for conventional pollutants for recycled water discharged to the LV Site contained within the Colorado WDR are presented in Table 4-3 and a summary of the actual effluent quality in 2015 is presented in **Table 4-4**.

The previous Colorado WDR that regulated this discharge (Board Order 01-156) included a Total Dissolved Solids (TDS) limit of a maximum of 400 mg/L above the domestic source water. The WWTP discharge was always well within compliance with this requirement. The recently updated WDR requires BBARWA to provide a technical report in the form of a study that analyzes the impacts to groundwater in the vicinity of the LV Site by the discharge and an evaluation of water quality trends. The results of the study will be used to establish an appropriate effluent limitation for TDS. BBARWA submitted this report to the Colorado River Basin RWQCB in December 2017 with a recommendation that the prior TDS limit remain unchanged. The Colorado River Region RWQCB has not yet provided feedback on the report or an indication of whether the TDS effluent limitation will be changed. At this time, a substantive change in the TDS limit is not anticipated and treatment upgrades are not anticipated to be required to remain in compliance with this WDR. A copy of BBARWA's two WDR permits are attached in Appendix A.

Table 4-3. Discharge Limits for LV Site

Parameter	Units	30-Day Mean	7-Day Mean	Maximum Daily
Biochemical Oxygen Demand (BOD_5)	mg/L	30	45	-
Total Suspended Solids (TSS)	mg/L	30	45	-
Chloride	mg/L	60	-	80
Sulfate	mg/L	60	-	80
Boron	mg/L	-	-	0.75
Total Nitrogen	mg/L	10	-	-
pH	pH units	Between 6.0 - 9.0 at all times		

Table 4-4. 2015 BBARWA WWTP Effluent Quality – Annual Average

Parameter	Value	Units
TDS	453	mg/L
BOD_5	6	mg/L
TSS	13	mg/L
Chloride	56	mg/L
Sulfate	43	mg/L
Phosphorus	2.3	mg/L
Total Inorganic Nitrogen (TIN)	4.6	mg/L
pH	7.12 – 8.09	pH units

5 RECYCLED WATER MARKET ANALYSIS UPDATE

A brief description of previous alternatives evaluated in the 2016 Study was discussed in Section 2.3. This section provides additional details on the recycled water uses envisioned for the Lake Alternative only.

In 2017, the Project Team collaborated to identify a new Lake Alternative that maximizes the use of existing infrastructure to reduce project costs while keeping most or all of the treated water in the Valley for a variety of beneficial uses. The following uses are anticipated to be included in the Lake Alternative and are discussed in more detail in subsequent sections.

- Continuous water supply to Stanfield Marsh Wildlife and Waterfowl Preserve
- Continuous water supply to Big Bear Lake
- Continuous water supply to Shay Pond Unarmored Threespined Stickleback habitat
- Periodic groundwater recharge in Sand Canyon during dry periods
- Periodic storage in the watershed as snow during wet winter periods
- Irrigation water for Big Bear Golf Course
- Potential water supply for downstream users when water exceeds needs in the Valley

5.1 STANFIELD MARSH AND BIG BEAR LAKE

Discharge to Stanfield Marsh was considered in the 2016 Study as a potential groundwater recharge location; however, it was not pursued because a prior study stated that the bottom of the Marsh contains a clay layer that would prevent sufficient percolation into the surrounding groundwater basin. Discharge to the Marsh is being re-evaluated as part of this study due to the benefits that a new consistent water source would provide to the wildlife in the Marsh, and because it provides a means to supplement inflow in the Lake as well.

The Stanfield Marsh Wildlife and Waterfowl Preserve began a transformation in 1982 when BBMWD, working with the California Department of Fish and Wildlife, dredged basins, laid culvert pipes to connect to the Lake, and planted the shoreline, followed by numerous other enhancements in subsequent years. The Marsh is now a scenic 145-acre nature park that includes a gazebo, walking paths, and two boardwalks that extend out into the Marsh so that visitors can observe the wildlife in, under and around the water. The Marsh is home to rare and diverse species of birds, fish, amphibians, and mammals. In the center of the Marsh, there is an island that was constructed to provide a safe haven for waterfowl, including a moat-like barrier to make it difficult for predators to reach it, even when water levels are low. Informational placards installed at the Marsh educate visitors on the diverse wildlife and BBMWD has plans to install several additional placards, such as those as shown in Figure 5-1, to increase educational opportunities and awareness of the value of the Marsh to the local ecosystem.

Figure 5-1. Informational Placards at the Marsh Provide Educational Opportunities for Visitors

Rainfall and snowmelt are the only sources of water for the Marsh so the water level varies from season to season and throughout longer hydrologic cycles. During wet periods, the Marsh is a thriving wildlife preserve. During extended drought conditions, the water level recedes dramatically, the boardwalks extend over dry soil, and the wildlife become scarce. This condition is shown in Figure 5-2, which was taken in September 2016 following the recent multi-year drought.

Figure 5-2. Aerial View of the Dry Marsh, September 2016

High quality recycled water would provide a new, drought proof source of inflow to stabilize the water levels and sustain habitat in the Marsh even during dry periods.

Water from the Marsh will also provide new inflow into the Lake to augment Lake levels. Preliminary model analysis performed by BBMWD indicates that new inflow into the Lake could increase Lake levels by as much as 7 feet in 10 years, depending on the volume of new inflow. As discussed in Section 3.3.2, in-lieu water is obtained to meet Mutual's Lake demands when Lake levels are below 4 and 6 feet from full, depending on the month. With the additional inflow, Lake levels will be in the top 4 feet more often, which will reduce in-lieu water needs.

Increased Lake levels will also enhance recreational opportunities by enabling BBMWD to reduce closures of boat ramps due to low water levels during dry periods. More wetted shoreline is anticipated to improve aquatic habitat and the additional inflow will provide BBMWD with additional flexibility in managing Lake releases, creating an opportunity to improve water quality in the Lake.

The California Code of Regulations Title 22 (Title 22) establishes acceptable uses of recycled water and provides that disinfected tertiary recycled water may be used as a source of supply for nonrestricted recreational impoundments, which are water bodies where no limitations are imposed on body-contact water recreational activities.

In 2000, BBARWA was issued a National Pollutant Discharge Elimination System (NPDES) permit (Santa Ana Region Board Order No. 00-12), which included the Marsh and a proposed new Stickleback habitat in Baldwin Lake as authorized discharge points, subject to construction of tertiary treatment and disinfection upgrades. The NPDES permit limited discharges to the Marsh to periods of lower water levels when the Marsh was not hydraulically connected to the Lake. The tertiary treatment upgrades were not completed and the discharge point was never used so the NPDES permit was not renewed when it expired in 2005. In 2005, the Santa Ana Regional Board issued Order No. R8-2005-0044, as discussed in Section 4.2.1, which does not allow discharge to the Marsh. A new NPDES permit would be required for the Lake Alternative to address discharges into the Marsh, the Lake, and the Shay Pond Stickleback habitat.

5.2 STICKLEBACK FISH HABITAT

5.2.1 History

The Unarmored Threespine Stickleback (*Gasterosteus aculeatus williamsoni*), also known as UTS (referred to as "Stickleback" in this study), is listed as both a Federal and State of California Endangered Species under the respective Endangered Species Acts (1). On the California list, the Stickleback is also given the title of Fully Protected Species (2). The Stickleback lives in California and have been on the Federal list since 1970 and on the State list since 1971 (2) (3). There has been a population of Stickleback in the Shay Creek area on the east side of the Valley, as shown in Figure 5-3, which includes Shay Pond, Sugarloaf Pond, Juniper Springs, Motorcycle Pond, Shay Creek, Wiebe Pond, and Baldwin Lake (10). By the summer of 1990, it was thought that the Stickleback remained in only Shay Pond; however, several years of above-average precipitation in the mid-1990s resulted in the establishment of a pool of water in Baldwin Lake (10). This study focusses primarily on Stickleback in Shay Pond.

There is a long history of study and group effort regarding the Stickleback in the Shay Creek area. The main stakeholders include the United States Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), the San Bernardino National Forest (SBNF), BBCCSD, BBLDWP, and BBARWA. Additionally, the Shay Creek Working Group, which includes representatives from the USFWS, CDFW, SBNF, BBCCSD, DWP, and BBARWA, was formed during the process of preparing the USFWS' 2002 Biological Opinion (BO) for the area (4).

The Shay Creek Working Group has been meeting since 1999 to address and resolve issues related to the Stickleback in the Shay Creek area, including re-initiation of Section 7 consultation resulting in a 2007 Draft revised BO (1). The 2007 Draft BO has not been finalized so the 2002 BO is still in effect. The primary issue that requires resolution is the impact on the Stickleback habitat from three Special Use Permits issued by the SBNF to BBCCSD (for groundwater extraction and spring diversion), BBLDWP (for groundwater extraction), and BBARWA (for wastewater effluent outfall line) (1). Studies and discussions indicate that the actions these permits allow may be adversely impacting the Stickleback in Shay Creek (4).

In 2009, the USFWS conducted a 5-Year Review Summary and Evaluation of the Stickleback, which stated that the Stickleback spend all of their life in freshwater and the ideal habitat for Stickleback is a small, clean pond in the stream with a constant flow of water through it. The Stickleback tend to gather in areas of slower-moving or standing water (10 p. 12).

One of the Conservation Measures for the Stickleback in the Description of the Proposed Action in the 2002 BO is "Shay Pond Land Acquisition", which includes acquisition of the land on which Shay Pond lies, as well as some additional area immediately around the pond to adequately maintain and manage the aquatic habitat(4 p. 4). This has been completed with involvement from BBCCSD, DWP, and BBARWA (5).

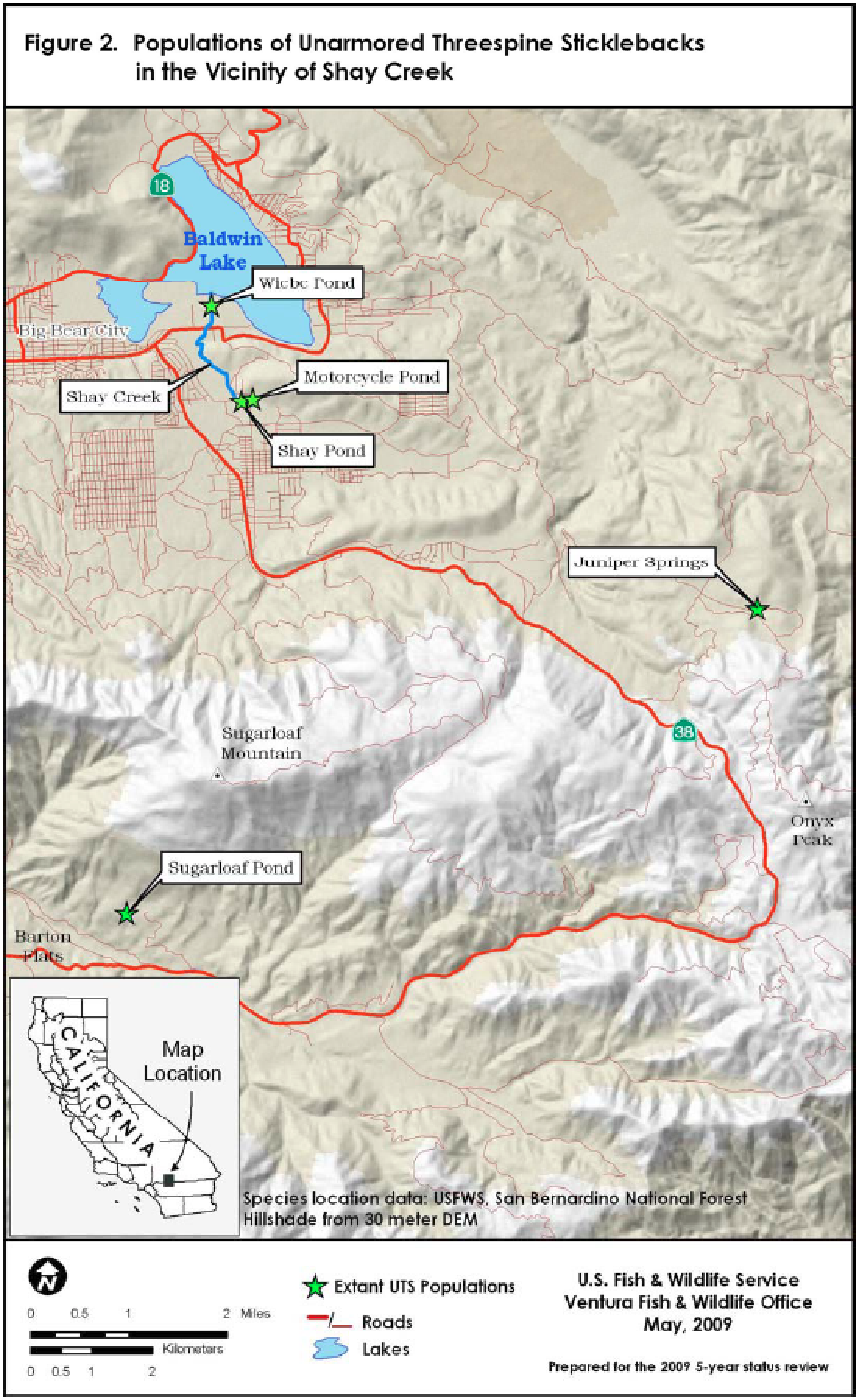


Figure 5-3. Populations of Stickleback in the Shay Creek Area (3 p. 11)

Per the 5-Year Review, there are habitat threats that are specific to the Shay Creek area, including wetland vegetation growth and encroachment, pollution or eutrophication from contamination from horse manure, and loss of flow in the creek due to property development in the area (3 p. 20). To mitigate wetland vegetation growth and encroachment, Shay Pond was dredged by BBCCSD in 2011 (5), and again most recently in 2017. Figure 5-4 and Figure 5-5 show the pond before and after the 2011 dredging, respectively.

Figure 5-4. Shay Pond Before Dredging (5)

Figure 5-5. Shay Pond After Dredging (5)

5.2.2 Shay Pond Water Supply

The requirements of the 2002 BO state that BBCCSD will continue to provide water to Shay Pond to maintain a minimum 20-gallon-per-minute outflow from Shay Pond. To meet this outflow requirement, BBCCSD discharges 50 gpm of potable water into the pond. This equates to 80 AFY, which is significant for BBCCSD because it represents approximately 9% of BBCCSD's customer water demand. The objective is to maintain a minimum pond water level that will support suitable habitat conditions for the fish. BBCCSD currently meets this requirement by discharging potable water into Shay Pond, but the 2002 BO also states that, should a suitable alternative supply of water be found to be appropriate for the stickleback in the future, BBCCSD may use an 'in-lieu' water supply, which could include the use of tertiary-treated water. Prior to use as an in-lieu supply, tertiary-treated water must be studied to confirm suitability to support long-term Stickleback survival, see Section 4.1.3.1 for details. The Lake Alternative would provide an in-lieu water supply for Shay Pond to meet the requirements of the 2002 BO, which would enable BBCCSD to recover this potable supply to serve their customers.

5.2.3 Next Steps for Implementation

Implementation of the Lake Alternative will require further investigation into the suitability of the proposed recycled water quality for discharge into Shay Pond. The concept of providing recycled water to Shay Pond has been evaluated by BBARWA previously. In the Mitigation Monitoring and Reporting Program (MMRP) of the *Final Program Environmental Impact Report for the Big Bear Area Regional Wastewater Agency's Recycled Water Master Plan* (Final EIR), Biological Resources Mitigation Measure 4.5-8 states that: "BBARWA shall initiate a long-term study of Stickleback survival in recycled water if this component of the [Recycled Water Master Plan] program is implemented. The following steps will be implemented: (1) obtain submittals outlining a proposed study program to answer the question of whether the Stickleback can survive and breed over several generations without any measurable damage to individuals or the population; (2) consult with the [USFWS] and [CDFW] to obtain concurrence and approval to implement the study program; (3) fund the study implementation and compile a report of results and recommendations; and (4) submit the report and recommendation to the [USFWS] and [CDFW] with the objective of obtaining an incidental take permit to use recycled water to supplement the habitat in Shay Creek and replace potable water currently being used for this purpose," (6 p. 12). Specific issues that are anticipated to be addressed through these studies include contaminants of emerging concern (CECs), endocrine disrupting compounds (EDCs), and temperature.

Another parallel path could include seeking outside partnerships to develop and implement this beneficial use alternative. For instance, in the late 1990s, the National Heritage Foundation (NHF) sought a partnership with BBARWA to upgrade the WWTP to tertiary treatment to provide water for creation of a new Stickleback habitat in Baldwin Lake. The NHF obtained grant funding to support the construction of treatment upgrades and the pipeline to the new habitat, although this work was not ultimately completed. Additionally, The Nature Conservancy (TNC) played a role in developing a plan in the Santa Clara River watershed addressing important Stickleback habitat (3). The Project Team could coordinate with the NHF, TNC, and/or other similar organizations focused on habitat restoration to evaluate partnership opportunities to further study and enhance the Stickleback habitat.

A new NPDES permit would be required for the proposed discharge into Shay Pond.

5.3 GROUNDWATER RECHARGE AT SAND CANYON

Groundwater recharge at Sand Canyon was evaluated by Thomas Harder & Co. (Harder) to assess the feasibility of recharging the groundwater aquifer at Sand Canyon using surface water from Big Bear Lake and estimate the annual recharge capacity. Harder found that the recharge potential at Sand Canyon is approximately 380 AFY over a 6-month period, based on a recharge area of approximately 4.2 acres and a recharge rate of 2.1 ft/day. The primary limit to recharge rates in the Sand Canyon area appears to be available subsurface storage space to accommodate the groundwater mound. The target maximum groundwater level relative to the land surface was 20 ft below ground surface because previous studies in the Big Bear area have shown that this depth is protective of liquefaction. The full technical memorandum presenting Harder's analysis is attached as Appendix A.

The Sand Canyon recharge concept involves extracting water from the Lake (a blend of surface water and recycled water) and discharging it into Sand Canyon, which serves as a flood control channel. The recharge operation would only occur during dry periods when needed to supplement groundwater supply and would be operated intermittently as needed to avoid interference with flood flows. Prior studies evaluating potential recharge operations in Sand Canyon considered constructing a series of small berms along the streambed to create a percolation area or modifying stream channel to create a meandering stream with small natural ponds to slow the water down and enhance percolation. An additional concept that could be considered is the use of inflatable rubber dams in the channel which could be inflated to create percolation ponds during the recharge operation only and deflated at all other times so as not to impact the natural function of the channel. All of these concepts would need to be coordinated with the flood control agency to ensure that the capacity of the flood control channel remains sufficient to meet the primary purpose of providing flood protection. If these improvements resulted in a decrease in surface flow entering the Lake, the impact to surface water rights under the 1977 Judgment would need to be evaluated.

When water is needed for recharge in Sand Canyon during dry periods, it is assumed that the existing lake pump station owned by Big Bear Mountain Resort (Ski Resort) could be used to transfer water through an existing pipeline into the existing storage pond located at Bear Mountain Ski Resort. These facilities are used primarily for snow making in the winter and are expected to be available for the proposed recharge operation, which would only occur in April – October when the resorts are not making snow. The Project Team has conducted preliminary discussions with the Resort about the Lake Alternative and potential joint use of their snowmaking facilities. The Resort is interested in the Lake Alternative because low Lake levels significantly complicate their snow making operation so they would benefit from an increase in Lake levels. The Project Team will continue discussions with the Resort and work to develop a mutually agreeable arrangement for joint use of the snowmaking facilities. This study assumes joint use of the snowmaking facilities will be viable and that a new pump station would be constructed near the Resort pond to convey water through a new pipeline to discharge into Sand Canyon, as shown in Figure 7-3. If a joint use arrangement for the snowmaking facilities cannot be negotiated, constructing new pumping and conveyance facilities to reach Sand Canyon would substantially increase the project cost.

5.4 SNOW STORAGE

During wet periods, excess water could be stored as snow at the Resorts using their existing snowmaking infrastructure. This would reduce spills from the Lake, keep more of the water in the Valley and enhance winter recreation by providing additional snowmaking water to the Resorts beyond their current allotment from the Lake. When the snow melts in the spring, runoff would be augmented, which is expected to increase natural groundwater recharge and may improve fish spawning habitat in streams tributary to the Lake. A hydrologic analysis would be required to assess the potential benefits of this component, but this is a flexible strategy to enable to Project Team to further expand the benefits of the Lake Alternative.

Title 22 provides that disinfected tertiary recycled water may be used for artificial snowmaking for commercial outdoor use.

5.5 GOLF COURSE IRRIGATION

As another potential option to keep additional water in the Valley, the existing snowmaking facilities could also be used to deliver irrigation water to the Bear Mountain Golf Course (also owned by the Ski Resort) in the summer, if desired. The water demand for the Bear Mountain Golf Course is estimated to be 120 AFY (1). This option would allow the Resort to rest their groundwater irrigation wells and reduce pumping from the Basin.

Title 22 provides that disinfected tertiary recycled water may be used for irrigation of unrestricted access golf courses, subject to the restriction that irrigation shall not take place within 50 feet of an unshielded domestic water supply well and that recycled water impoundment may not occur within 100 feet of a domestic water supply well. Additionally, some adjustments to irrigation practices may be needed to comply with the use site requirements in Title 22. This option would need to be coordinated with the Resort.

5.6 DOWNSTREAM RECHARGE

Additional inflows into the Lake will provide BBMWD with more flexibility in managing Lake releases, while still maintaining higher Lake levels than are possible without the Lake Alternative. In particular, during wet periods, additional flood control releases are anticipated that will flow down the Santa Ana River to the Seven Oaks Dam, which is upstream of the San Bernardino Groundwater Basin area. BBMWD intends to coordinate with Valley District in an effort to optimize the volume of releases from the Lake that can be captured for recharge of the San Bernardino Basin, rather than flow past to the ocean. A Seven Oaks Dam capture project is underway that will enable Valley District to vastly increase their capacity to recharge water released from the Seven Oaks Dam. To further assess the potential benefits to recharge in the San Bernardino Basin, a hydrology study is needed to estimate the volume and timing of additional flows under a range of hydrologic conditions. That information can then be input into Valley District's model to assess their ability to capture these flows for recharge.

6 TREATMENT UPGRADE REQUIREMENTS

A key consideration in the development of any recycled water project is the required quality and treatment level of the recycled water as established by various permitting agencies and State Regulations. The key drivers for treatment upgrades for the Lake Alternative are described in this section.

6.1 BASIN PLAN WATER QUALITY OBJECTIVES

In order to recharge the Basin or discharge recycled water to the Lake, the recycled water must meet the water quality objectives set by the Santa Ana River Basin Water Quality Control Plan (Basin Plan). The Basin Plan establishes beneficial uses and water quality objectives (WQO) for the ground and surface waters of the region and includes an implementation plan describing the actions by the RWQCB and others that are necessary to achieve and protect the water quality standards. The Basin Plan provides a general narrative regarding the WQO for each water body type and specific numeric objectives for total dissolved solids (TDS), hardness, sodium, chloride, total inorganic nitrogen (TIN), total phosphorus (TP), sulfate, and chemical oxygen demand (COD). Additional information about the Basin plan is provided in Appendix B of the 2016 Study. The WQO for the Big Bear Valley are summarized in Table 6-1. As shown, the WQOs for Big Bear Lake are the most stringent of the proposed discharge points and will therefore govern the treatment upgrades required for the Lake Alternative.

Table 6-1. Basin Plan Water Quality Objectives

Water Body	TDS	Hardness	Sodium	Chloride	TIN	Sulfate	COD
Inland Surface Streams							
Rathbone Creek (downstream of Sand Canyon)	300	-	-	-	-	-	-
Shay Creek (Narrative Objectives)	-	-	-	-	-	-	-
Lakes and Reservoirs							
Big Bear Lake	175	125	20	10	0.15	10	-
Wetlands (Inland)							
Stanfield Marsh (Narrative Objectives)	-	-	-	-	-	-	-
Groundwater Management Zones							
Big Bear Valley	300	225	20	10	5	20	-

6.1.1 Big Bear Lake Nutrient Limits

In addition to the numeric and narrative WQOs, Big Bear Lake is subject to a Total Maximum Daily Load (TMDL) numeric target of 35 µg/L-P for total phosphorus during dry hydrologic conditions, per Resolution No. R8-2006-0023. By 2020, the total phosphorus numeric target must be achieved at all times. A causal target was established for phosphorus because it was determined to be the limiting nutrient in the lake; however, nitrogen may be the limiting nutrient under certain conditions and as a result, a nitrogen TMDL may be established in the future. Data collected in accordance with the Big Bear Lake Watershed-wide Nutrient Monitoring Plan is currently used to assess compliance with the lake's water quality objectives, and can also assist in determining nutrient TMDL waste-load allocations (WLAs) and numeric targets for nitrogen in the future. Response targets for macrophyte coverage, percentage of nuisance aquatic-vascular plant species and chlorophyll a concentration have also been implemented under the nutrient TMDL to further assess water quality improvements in the lake.

The nutrient limits for an NPDES permit to Big Bear Lake are expected to align with the Basin Plan WQOs and the TMDL numeric targets to protect the beneficial uses of the lake. The anticipated effluent nutrient limits of 35 µg/L-P for total phosphorus and 0.15 mg/L-N for total inorganic nitrogen would require multiple process steps and consistent treatment through seasonality. For a cold climate like Big Bear's, compliance with stringent nutrient limits through the winter season would be the greatest challenge due to decreased biological nutrient removal when wastewater temperatures drop below 10-degrees Celsius. Some California wastewater facilities that operate in cold climates have separate summer and winter nutrient limits in consideration of this seasonal affect – the winter limits being less stringent – although it is unknown at this point if BBARWA's future discharge permit would be considered for seasonal limits. The treatment required to meet the expected phosphorus and nitrogen limits includes enhanced nutrient removal processes and technologies, as further described in Section 7.1 of the report.

Note that the RWQCB may consider permitting increased nutrient limits for the discharge if an approved nutrient offset program is implemented as well. A nutrient offset program would reduce nutrient loads elsewhere in the watershed by an amount at least equal to the amount discharged in excess of the WQO. Coordination with the RWQCB staff is needed to explore potential opportunities for a nutrient offset program in the Valley.

6.2 SURFACE WATER DISCHARGE

Based on initial discussions with the SWRCB Division of Drinking Water (DDW), this project would not likely be considered a Surface Water Augmentation project because the Lake is not used directly as a drinking water source and the environmental buffer between the discharge point and downstream uses is extremely large. Additional coordination with DDW is needed to verify the permitting strategy and technical analysis may be required to support DDW's determination.

6.3 GROUNDWATER RECHARGE REQUIREMENTS

Several key regulatory requirements for groundwater recharge are described in the following subsections.

6.3.1 Recycled Water Concentration

The groundwater replenishment regulations in Title 22 require that the initial concentration of filtered and disinfected tertiary recycled water (Recycled Water Concentration or RWC) not exceed 20% of the total recharge water, which requires 80% of the total recharge water to come from other high-quality water sources for blending. Blend water can be a combination of imported SWP water, captured surface water, or natural underflow. If sufficient dilution water is not available from these sources, advanced purified recycled water using reverse osmosis (RO) and advanced oxidation can serve as a dilution source. As discussed previously, SWP water is not available in the Valley. The Groundwater Recharge Regulations assess a project's compliance with the RWC requirement using a 120-month running monthly average.

The Lake Alternative proposes to discharge treated water to the Marsh, which will flow through to the Lake and blend with surface water captured in the Lake, which is expected to be a qualified dilution water source. Based on annual Lake inflows from 1977 to 2016 (5), the lowest 10-year rolling average of Lake inflows over this period was 10,389 AF, which occurred in 2016. Based on effluent flows from 2007-2016, the anticipated 10-year average recycled water flow into the Lake is approximately 1,950 AF, which would equate to approximately 16% RWC in the Lake on a 10-year rolling average.

In addition, natural underflow beneath the Sand Canyon recharge area is expected to qualify as a dilution source. A preliminary estimate of underflow volume was developed by Thomas Harder & Co. in the Sand Canyon Recharge Evaluation Technical Memorandum, dated November 29, 2017 and attached as Appendix A. Depending on the interpretation of the data by the SWRCB Department of Drinking Water (DDW), the underflow dilution credit is estimated to range from 58 AFY to 247 AFY, which would further reduce the RWC of 16% from the blended Lake water. Based on this preliminary assessment of available diluent water, groundwater recharge at Sand Canyon with blended water from the Lake is expected to meet the initial RWC requirement of 20%.

Because the Lake WQO are much more stringent than the Basin WQO, it is anticipated that the blended water from the Lake will meet the WQOs for groundwater recharge in the Basin.

At the planning level, there is some uncertainty in the treatment requirements because the qualifying dilution water has not been fully quantified. If needed, project proponents have an opportunity to perform additional analysis to demonstrate to the RWQCB and DDW that tertiary treatment and dilution water will meet the Title 22 and Basin Plan requirements. The RWQCB and DDW will make the final decisions on the required treatment levels after review and evaluation of technical information presented by the project proponent during the permitting process.

6.3.2 Minimum Travel Time

The Groundwater Recharge Regulations require a minimum “response retention time” or minimum groundwater travel time of two months between the point of surface application or injection, and the point of extraction. Harder’s preliminary analysis shows that the recharge water will reach the nearest production well (Sheephorn Well) in a little more than approximately 13 months. For preliminary recharge siting purposes, the Groundwater Recharge Regulations allow a “credit” of 0.25 for travel time calculations using an analytical model, as was done for this analysis. Thus, the credited retention time is interpreted to be 3.25 months (13 x 0.25). This credited retention time is less than the minimum retention time of 2 months, indicating that the simulated recharge operation is feasible based on the data assumptions in the analysis.

6.3.3 Pathogen Control

Pathogen controls include specific provisions for log reduction of microorganisms and treatment process requirements. The treatment process used to treat recharge water for a GRRP must provide treatment that achieves at least 12-log enteric virus reduction, 10-log Giardia cyst reduction, and 10-log Cryptosporidium oocyst reduction from raw sewage to usable groundwater. The treatment train shall consist of at least three separate treatment processes. For each pathogen (i.e., virus, Giardia cyst, or Cryptosporidium oocyst), a separate treatment process may be credited with no more than 6-log reduction, with at least three processes each being credited with no less than 1.0-log reduction. If the treatment process itself does not achieve the required pathogen control credits, additional credit can be gained through underground retention time prior to extraction. The pathogen control credit requirement and underground retention time should be considered as part of the treatment process selection during preliminary design.

7 LAKE ALTERNATIVE ANALYSIS

The following subsections provide additional information about the Lake Alternative, including treatment upgrades, yield, brine disposal alternatives, treated water distribution, and a summary of capital and operating costs.

7.1 TREATMENT UPGRADES

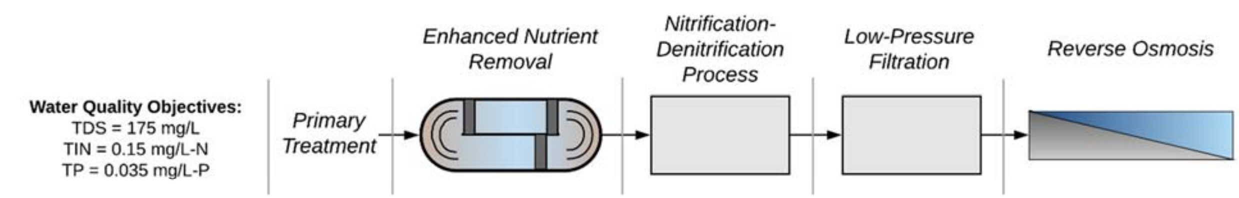
For the Lake Alternative, BBARWA's existing wastewater facility will be upgraded to meet the water quality objectives identified for Big Bear Lake in the Santa Ana Basin Plan (Table 6-1). Inorganic nitrogen and phosphorus must be removed through multiple in-series processes because a single process cannot reliably reduce effluent TIN and TP concentrations to the levels required for Big Bear Lake's WQOs. To achieve these strict effluent limits, it is anticipated that BBARWA will need to implement a series of upgrades to existing unit processes and integrate new unit processes, specifically:

- Upgrade the extended aeration process through retrofit of the existing oxidation ditches to optimize biological nitrification-denitrification (NDN) and phosphorus removal. Phosphorus removal occurs in anaerobic conditions and denitrification occurs in anoxic conditions, both of which could be incorporated into the existing infrastructure with modifications to aeration patterns or with dedicated tanks. If needed, chemical precipitation of soluble phosphorus can be performed through addition of a metal salt within the activated sludge tankage, upstream of clarification.
- Nutrient-laden liquid sidestreams, which are produced during solids handling processes, may require management or treatment due to the potential negative impacts of returning high nutrient loads to other unit processes. The need for sidestream treatment will be determined during subsequent phases of the project when a plant-wide mass balance and/or process model can be developed to identify sidestream characteristics.
- Retrofit or operational modifications to secondary clarifiers for settling of phosphorus precipitates. It is important to note that chemical precipitation of phosphorus within the existing clarifiers requires an evaluation of effects on sludge production and handling. Removal of phosphorus through chemical precipitation is expected to increase solids production and impact operation of the current solids handling process.
- Addition of an NDN process to reduce inorganic nitrogen concentrations. This process may consist of a biologically active filter with sand or synthetic media, or biological reactors designed specifically for nitrogen and phosphorus removal. The denitrification process will likely require an external carbon source to facilitate the reduction of nitrate.
- Low pressure filtration, such as microfiltration (MF) or ultrafiltration (UF), to reduce flocculated or colloidal solids upstream of the reverse osmosis (RO) process.

- RO to reduce TDS concentration and nutrient concentrations. The assumed operational recovery for the RO system is 90% of the design flow. While it may be challenging for conventional RO systems to achieve this recovery rate, emerging RO technologies that are configured for brine recirculation, multiple pass, or in-series operation to achieve high recoveries (such as closed-circuit reverse osmosis), have been demonstrated to achieve high recovery rates with reduced energy consumption at comparable capital costs to conventional RO (15). Such technologies would need to be piloted with BBARWA's specific water quality characteristics to verify expected performance for this application.

  The low-pressure filtration and RO unit processes are expected to provide the physical filtration for reduction of the 1 to 2 mg/L of TIN and TP coming from upstream processes. RO is the only unit process capable of removing TDS, making it a critical unit process for compliance with WQOs. It is assumed that 100% of the design flow will need to receive RO treatment to meet the WQOs. RO offers the advantage of removing organics, inorganics and nutrients to a sufficient level for meeting nutrient WQOs; however, the RO process also presents the challenge of managing brine stream disposal in an inland location, as further discussed in Section 7.3.

A representative process flow diagram (PFD) for this alternative is shown in Figure 7-1. Potential water quality performance for TIN, TP and TDS constituents are estimated for each unit process; however, it is important to note that the performance of each of these unit processes is highly site specific based on the water quality composition being treated. A pilot test of each unit process is recommended to refine performance estimates and establish design criteria.



		Primary Treatment	Enhanced Nutrient Removal	Nitrification-Denitrification Process	Low-Pressure Filtration	Reverse Osmosis
Potential Water Quality Performance	TIN (mg/L-N)	--	5	1	1	0.1
	TP (mg/L-P)	8	2	2	0.1	0.02
	TDS (mg/L)	430	430	430	430	50*

Figure 7-1. Representative Treatment Process Flow Diagram for the Lake Alternative

7.1.1 Effluent Temperature

It should be noted that Lake water temperatures and WWTP effluent temperatures vary seasonally. While they are relatively similar in the summer months, the WWTP effluent temperature is considerably higher than the Lake temperature in the winter, as shown in Figure 7-2. It is expected that the discharge permit for this alternative would include limits for effluent temperature, and/or the allowable temperature change in the Lake caused by the discharge to avoid adverse thermal impacts to aquatic habitat. As a result, the treatment upgrades may need to include a provision for effluent cooling during winter.

Temperature reduction of the effluent may be achieved through a variety of methods or a combination of methods (16). Potential methods that may be applicable to BBARWA's WWTP include:

- Selecting a disinfection process with lower relative heat addition than other alternatives (i.e. chlorine contactor or UV) and by covering the disinfection facility to reduce solar energy addition
- Use of a multiple port diffuser system at the discharge location to facilitate more rapid mixing with the receiving water
- Discharge into a constructed wetland with long detention times through shaded, deep narrow channels
- Discharge into shallow reservoir to act as a cooling pond to achieve evaporative and radiative heat loss prior to surface water discharge. Depending on the configuration of the treatment process, the existing secondary effluent storage ponds may be able to provide some cooling benefit
- Spray cooling, which uses evaporative cooling to remove heat from treated wastewater by spraying it into the air from a lined pond when the ambient temperature is significantly lower than the effluent temperature. Spray cooling could potentially be implemented in the secondary effluent storage ponds and would require the installation of a pump, manifold and nozzles.
- Cooling towers or chillers could be considered, although they are expensive to install and operate so this equipment is not desirable

The need for effluent cooling should be assessed during the preliminary engineering phase once discharge temperature criteria are more well defined. The costs for the Lake Alternative presented in Table 7-5 do not include the cost of effluent cooling, if required.

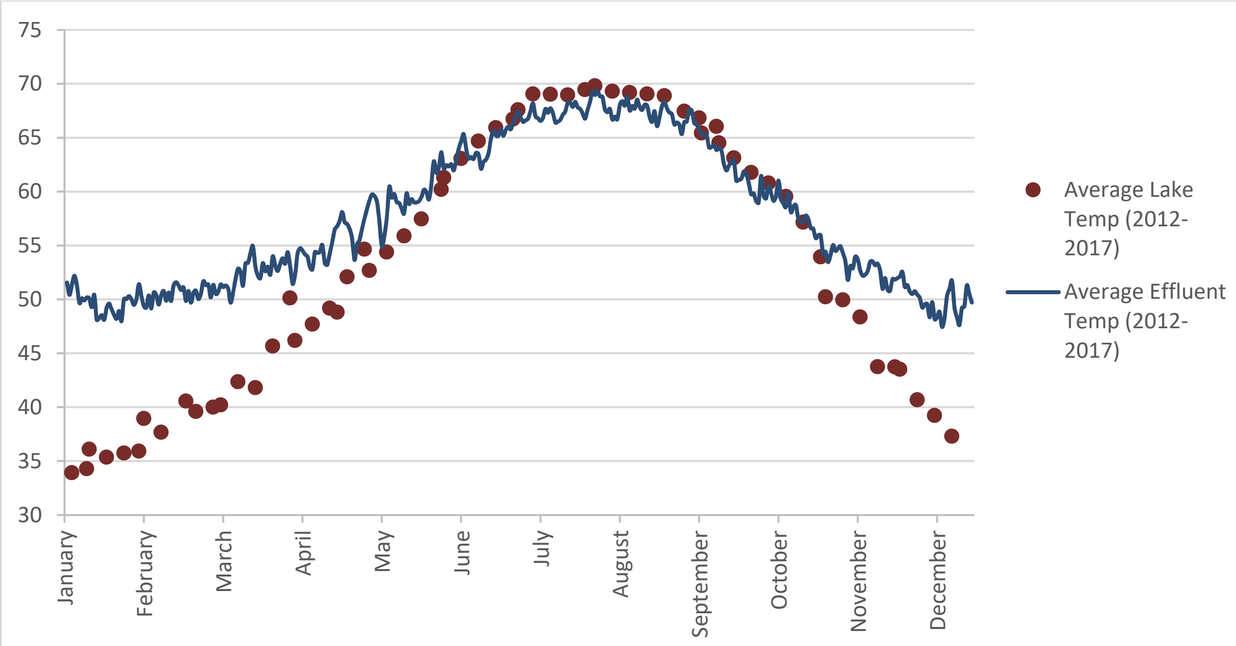


Figure 7-2. Comparison of Average Lake and BBARWA Effluent Temperatures (2012-2017)

7.2 DESIGN CAPACITY AND ANNUAL YIELD

The design capacity of the treatment upgrades is assumed to be 2.2 mgd, which corresponds with the 10-year average annual flow. Based on a preliminary sizing analysis, increased treatment capacity results in only a marginal increase in yield and does not provide an appreciable increase in economic or environmental benefit. It is assumed that any flows in excess of 2.2 mgd would be treated to a secondary level and discharged to Lucerne Valley, similar to the existing discharge method.

However, due to daily and seasonal variations in flow, the actual yield will be less than 2.2 mgd. It is assumed that the secondary effluent storage volume will offset some daily variations in flow, but the capacity is not sufficient to offset seasonal variations, particularly in dry years when summer flows have been as low as 1.6 mgd. A preliminary analysis based on monthly flows for the 10-year period from 2007-2016 indicates that the average secondary effluent available will be approximately 1.93 mgd, or 2,160 AF. Based on a 90% recovery rate, the average recycled water production would be 1.74 mgd, or approximately 1,950 AFY.

Note that recycled water production may increase in the future as average dry weather flows increase due to growth; however, continued conservation may offset some increases. Additionally, reduced design capacities could be evaluated to determine the optimal cost to yield ratio. It is recommended that the design capacity and RW production estimates be refined during the preliminary and final design phases based on more detailed flow data and actual MF and RO recovery rates.

7.3 BRINE DISPOSAL - SOLAR EVAPORATION PONDS

A key challenge with implementation of RO treatment, particularly in inland communities, is effective management of the brine concentrate. The most common brine concentrate disposal options include deep well injection (where permitted), surface water discharge (including the ocean), discharge to a wastewater treatment plant (such as via the Inland Empire Brine Line), land disposal, and solar evaporation or Zero Liquid Discharge (ZLD) with disposal of solids to a landfill. Deep well injection, surface water discharge, and land application are not feasible due to regulatory and geologic constraints (14). Discharge to the Inland Empire Brine Line is assumed to be infeasible because the nearest discharge point is over 20 miles away in straight line distance and the capacity is fully subscribed. ZLD, a combined evaporation and crystallization process that produces a dry waste, has relatively high capital and O&M costs and operational complexity compared to other disposal alternatives, and is typically only considered for disposal of municipal brine when no other disposal option is available (17). Therefore, ZLD is not evaluated in this study.

The focus of this section is a preliminary evaluation of several solar evaporation pond alternatives. Evaporation ponds rely on solar energy to evaporate water from the brine concentrate stream, leaving behind precipitated salts, which ultimately are disposed of in a landfill. Evaporation ponds for brine concentrate disposal are most appropriate for smaller volume flows and for regions having a relatively warm, dry climate with high evaporation rates, level terrain, and low land costs. Evaporation ponds are relatively easy to construct, are low maintenance and have no mechanical equipment except for pumps to convey brine to the ponds. However, pond size requirements can be quite high depending on the brine flow and evaporation rates and the regulatory requirement for impervious liners of clay or synthetic membranes substantially increases the cost of construction. Monitoring wells will be required to verify that seepage from the ponds is not contaminating underlying groundwater.

A comparative analysis of evaporation ponds located in either the Big Bear Valley on the WWTP site or in the Lucerne Valley on BBARWA's 480-acre site is presented in this section.

7.3.1 Brine Volume & Reduction

As discussed in Section 7.2, the actual treated flow may be lower than the design capacity of 2.2 mgd; however, the full capacity of 2.2 mgd is used for this brine disposal analysis to ensure sufficient disposal capacity if higher recovery rates area achieved or flows increase in the future due to growth.

As discussed in Section 7.1, the estimated recovery of the RO process is 90%, so 10% of the treated flow, or 220,000 gallons per day (gpd), will be brine concentrate. If recovery of additional water is desired or if it is necessary to reduce the size of the evaporation pond, an additional treatment process can be added to further concentrate the brine volume. Potential brine concentration processes include electrodialysis reversal (EDR), Vibratory Shear Enhanced Process (VSEP) and Enhanced Membrane Systems (EMS), which were previously evaluated for BBARWA (14). Although these processes recover additional water for beneficial use, they are relatively high in capital and O&M cost and increase operational complexity.

For the purposes of this analysis, a brine concentrator is assumed to have a 90% recovery rate, so 10% of the original brine concentrate, or 22,000 gpd, will be discharged to an evaporation pond. Brine concentrator recovery rates greater than 90% may be achievable and would further reduce the brine volume discharged to the evaporation pond. The water recovered from a brine concentrator is expected to be relatively low in TDS (less than 500 mg/l), so it expected that the product water could be blended with the RO permeate and still meet the TDS WQO for the proposed uses.

7.3.2 Evaporation Rates and Pond Size

Due to a higher evaporation rate and lower precipitation, ponds located in Lucerne Valley could be smaller than ponds located in Big Bear Valley. The estimated evaporation rate in Lucerne Valley is 63 inches per year (14) and average annual precipitation is 8.4 inches per year (15). The estimated evaporation rate in the Big Bear Valley is 45 inches/year (14) and the average annual precipitation at the BBCCSD station is 14.4 inches per year (5). Although the average annual evaporation rate calculated for the Lake in the Big Bear Watermaster Annual Reports is higher at 51.2 inches per year (previous 12-year average), the lower value of 45 inches per year is used in this comparative analysis to be consistent with the evaporation data available for the Lucerne Valley region.

Evaporation efficiency of brine is significantly lower than fresh water; while complex site-specific variables impact the actual evaporation rate, an evaporation ratio of 0.70 is considered a reasonable allowance in absence of site specific data (16). Subtracting the annual precipitation from the annual evaporation and adjusting for brine evaporation efficiency yields a net evaporation rate of 38.2 inches per year in Lucerne Valley and 21.4 inches per year in Big Bear Valley.

The required evaporative area of an evaporation pond is based on the flow rate of brine and the evaporation rate but the actual pond area constructed should be at least 20% larger to allow for operational contingency and space for dikes and service roads (16). Total evaporation pond areas for the two location and brine volume options were calculated using an evaporation pond regression model (17) and are presented in Table 7-1.

Table 7-1. Evaporation Pond Areas

	Evaporation Pond Total Area, acres	
Brine Flow Rate	**Big Bear Valley**	**Lucerne Valley**
RO Concentrate (220,000 gpd)	138	78
Reduced Brine (22,000 gpd)	13.8	7.7

As shown, the evaporation pond areas are greatly reduced when the brine is concentrated; however, brine concentrators add a significant capital and O&M cost that may offset the cost savings and benefits of the reduced pond size. The BBARWA WWTP site is 80 acres and the adjacent land is primarily in the flood plain and/or National Forest System Land so a 138-acre evaporation pond near the WWTP site in Big Bear Valley is not likely feasible.

7.3.3 Brine Storage and Conveyance

7.3.3.1 Big Bear Valley

If the evaporation ponds are located at the BBARWA WWTP site, the brine is assumed to be conveyed directly from the treatment process to the evaporation ponds so brine storage and brine pumps would not be required. A new pipeline from the RO process to the evaporation ponds would be needed. An allowance of 2,000 feet is included in this analysis, assuming that the evaporation ponds are located within the current WWTP site.

7.3.3.2 Lucerne Valley

If evaporation ponds are located in the Lucerne Valley, BBARWA desires to use the existing effluent pipeline for brine conveyance as it is not financially feasible to construct a second pipeline to Lucerne Valley. Because this pipeline will also need to be used to convey peak flows to the Lucerne Valley site, the operational strategy to maintain dual use of this pipeline will be an important consideration to ensure that BBARWA is able to remain in compliance with discharge permit requirements at all times.

The key constraint on the use of the pipeline is anticipated to occur during winter periods with sustained higher flows. During these periods, the availability of the pipeline to convey brine to Lucerne Valley will be limited and brine discharges will need to occur in a series of relatively short windows during which the effluent storage provides a buffer to discharge brine. The maximum month effluent flow from the WWTP in the 10-year period from 2007-2016 occurred in March 2011 and was 169 million gallons (MG), or an average monthly flow of 5.6 mgd. The maximum daily flow in March 2011 was 7.6 mgd, but the maximum day flow in the 10-year period was 9.6 mgd on December 22, 2010, which is equal to the maximum capacity of the effluent pump station. The WWTP has 10 MG of emergency storage that provides sufficient capacity to manage peak hour flows (18) so 9.6 mgd is the maximum expected effluent flow, limited by the capacity of the auxiliary effluent pump station.

The design capacity of the proposed tertiary treatment upgrades is 2.2 mgd, so the secondary effluent discharged to Lucerne Valley will be reduced by that amount during high flow periods. The WWTP has 2 secondary effluent storage ponds with a combined storage of 5 MG. Table 7-2 shows the duration of time that the effluent pumps can be turned off during peak flow periods and the duration of time they will need to run to empty the storage ponds once they are filled. At a minimum, 13 hours of brine storage volume must be provided at the WWTP to allow for the secondary effluent pumps to empty the ponds. During a peak day event, the secondary effluent storage will refill in only 15 hours so additional brine storage is recommended to provide operational flexibility so that operators do not have to transition from effluent to brine discharge during a peak day while also managing peak hour flows using the emergency storage pond. For this analysis, 3 days of brine storage is assumed, but this could be increased if additional operational flexibility is needed. The brine pump station is sized to empty the brine storage tank in 35 hours so that it can be emptied within the effluent storage window of the 1-Year max month flow condition in Table 7-2. The resulting brine storage and pumping capacities are shown in Table 7-3.

Table 7-2. Secondary Effluent Storage and Pumping Durations in Peak Flow Periods

Wet Weather Flow Condition	Total Flow, mgd	Secondary Effluent Flow, mgd[1]	Hours of Secondary Effluent Storage[2]	Minimum Time to Empty Secondary Effluent Storage[3]
10-Year Maximum Month Flow (2007-2016)[4]	3.3	1.1	109 hours	13 hours
1-Year Maximum Month Flow (2011)	5.6	3.4	35 hours	13 hours
Peak Daily Wet Weather Flow	9.6	7.6	15 hours	13 hours

Notes:
1. Total Flow minus 2.2 mgd which is diverted to the tertiary treatment system
2. Time to fill 5MG secondary effluent storage when effluent pumps are off, assuming that it is emptied by a prior pumping cycle. This is the available window for brine discharge.
3. Assumes auxiliary pumps are operated at maximum capacity of 9.6 mgd until the ponds are emptied
4. Average of maximum month flows for the 10 year period 2007-2016

Table 7-3. Brine Storage and Pumping Capacity for Lucerne Valley Evaporation Ponds

Brine Flow Rate	Brine Storage Volume, gallons	Brine Pumping Capacity, gpm
RO Concentrate (220,000 gpd)	660,000	470
Reduced Brine (22,000 gpd)	66,000	50

Under this operational scenario, the discharge pipeline to Lucerne Valley would be used for brine discharge for up to 35 hours, then would be available for secondary effluent discharge for up to 3 days while to brine storage tank is refilled. Each time the pipeline use switches from brine to secondary effluent, the brine remaining in the pipeline would need to be flushed into the evaporation pond before the effluent could be applied to the fields. This mode of operation would limit the amount of time the pipeline is filled with brine and may help reduce corrosion potential; however, further evaluation is needed during the preliminary design phase to assess the suitability of the existing cement lined ductile iron pipe to convey brine. A condition assessment and corrosion testing of the pipeline material is recommended to determine whether the existing pipeline would be degraded by this operation. If the pipeline needs to be lined to protect it from corrosion, this would significantly increase the capital cost. A flushing and monitoring protocol would need to be established to ensure that the discharge to the fields remains in compliance with BBARWA's WDR permit which regulates this discharge. The existing WDR permit would need to be modified to include the proposed evaporation pond, subject to approval by the Colorado River RWQCB.

The existing discharge pipeline fills a concrete lined balancing reservoir located approximately 1.25 miles south of BBARWA's LV Site then flows by gravity to the LV site to irrigate the fields. Because the concrete balancing reservoir was not likely constructed with an impervious liner and it would be difficult to flush frequently, it is assumed that brine flows will not enter the balancing reservoir, but be conveyed to the LV site through a new dedicated brine pipeline from the balancing reservoir site, approximately 10,000 feet long. Automatic control valves could be installed at the balancing reservoir site to enable BBARWA to conduct the pipeline flushing remotely before switching to effluent discharge. Note that BBARWA's 2010 Sewer Master Plan indicates that there are 2 parallel pipelines from the balancing reservoir to the LV Site so the configuration and operation of these pipelines should be investigated to evaluate whether one could be repurposed to convey brine to the LV site and eliminate the need to construct a new pipeline.

7.3.4 Brine Disposal Comparative Costs

Comparative capital and O&M costs for each scenario are presented in Table 7-4.

Table 7-4. Brine Concentration and Evaporation Comparative Costs

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Cost Component[1]	Big Bear Valley RO Concentrate 138 Acre Pond[2]	Big Bear Valley Reduced Brine 13.8 Acre Pond	Lucerne Valley RO Concentrate 78 Acre Pond	Lucerne Valley Reduced Brine 7.7 Acre Pond
Capital Costs				
Evaporation Pond	$13,394,000	$1,339,000	$7,507,000	$750,000
Brine Concentrator	-	$8,522,000	-	$8,522,000
Brine Storage	-	-	$1,432,000	$143,000
Brine Pump Station	-	-	$584,000	$93,000
Brine Pipeline	$290,000	$219,000	$1,837,000	$1,452,000
Total Capital Cost	**$ 13,684,000**	**$ 10,080,000**	**$ 11,360,000**	**$ 10,960,000**
O&M Cost				
Evaporation Pond	$67,000	$7,000	$38,000	$4,000
Brine Concentrator	-	$539,000	-	$539,000
Brine Storage	-	-	$14,000	$1,000
Brine Pump Station	-	-	$52,000	$5,000
Brine Pipeline	$3,000	$2,000	$18,000	$15,000
Total O&M Cost	**$ 70,000**	**$ 548,000**	**$ 122,000**	**$ 564,000**

Notes:

1. Capital costs include 25% markup for construction contingency and 30% markup for implementation. See Appendix B for a summary of capital cost methodology and assumptions.
2. Sufficient space on the existing WWTP site is not available and adjacent lands are primarily in the flood plain and/or National Forest System Lands so this alternative is likely not feasible, or the capital cost will be much higher due to the need for land acquisition.

7.3.5 Representative Evaporation Pond Alternative

As shown in Table 7-4, the capital cost of Alternative 1 is significantly higher than that of Alternatives 2, 3 and 4 and is likely not feasible due to the size of the land required. The remaining alternatives are relatively comparable in capital cost, but the O&M cost of Alternative 3 is substantially lower because it does not include a brine concentrator. Although Alternatives 2 and 4 recover more water for beneficial use due to the additional recovery through the brine concentrator, the unit cost of Alternative 3 is still lower due to the substantially lower O&M costs. Therefore, Alternative 3, which includes disposal of the full RO brine concentrate stream to evaporation ponds at the LV site, is used as the representative brine disposal alternative in this study. If an RO system at the WWTP can achieve greater than 90% recovery, the size of the evaporation ponds can be reduced, which will result in lower costs for all evaporation pond alternatives.

7.4 TREATED WATER STORAGE & DISTRIBUTION

The treated water is planned to be discharged continuously to Shay Pond and Stanfield Marsh; therefore, treated water storage at the WWTP is not included.

A single effluent pump station is assumed to pump purified water to both Shay Pond and Stanfield Marsh; the variation in elevation of the two discharge points is approximately 15 feet. The pump station capacity will match the capacity of the tertiary treatment system, which is 2.2 mgd, or approximately 1,530 gpm. A new effluent pump station is included in the cost estimate in this study, but if the existing effluent auxiliary pumps could be used as the primary secondary effluent pump station, the existing secondary effluent pump station may be able to be repurposed to avoid the need for a new effluent pump station. If this modification is feasible, the cost of effluent pump station improvements could potentially be reduced, but additional evaluation of the existing pump stations and the WWTP operation would be needed to determine if this is a viable option.

There is an existing 6-inch C-900 PVC pipeline that begins at the intersection of Shay Road and Palomino Drive and terminates near Shay pond that can be used to convey purified water to Shay Pond, with an extension of approximately 710 feet to reach Shay Pond. This pipeline was constructed in 1986 for future use, but has never been put into service.

A new 12-inch pipe will need to be installed from the WWTP to the proposed discharge point in Stanfield Marsh, as shown in Figure 7-3. BBARWA identified an existing pipeline that is believed to extend from near the Marsh to the WWTP, however, BBARWA located a valve on this line and found that the number of turns was consistent with a 6-inch pipeline, which is too small to accommodate the proposed flows. Additionally, the year of construction and condition of the pipeline are unknown.

When water is needed for recharge in Sand Canyon, it is assumed that the Resort's existing snowmaking facilities will be used to transfer water into the existing storage pond located at Bear Mountain Ski Resort and a new pump station would be constructed near the pond to convey water through a new pipeline to discharge into Sand Canyon, as shown in Figure 7-3. The pump station and pipeline are sized to convey 380 AF of recharge water over a 6-month period, which equates to approximately 470 gpm. If a joint use arrangement for the Resort's snowmaking facilities cannot be negotiated, constructing new pumping and conveyance facilities to reach Sand Canyon would substantially increase the project cost.

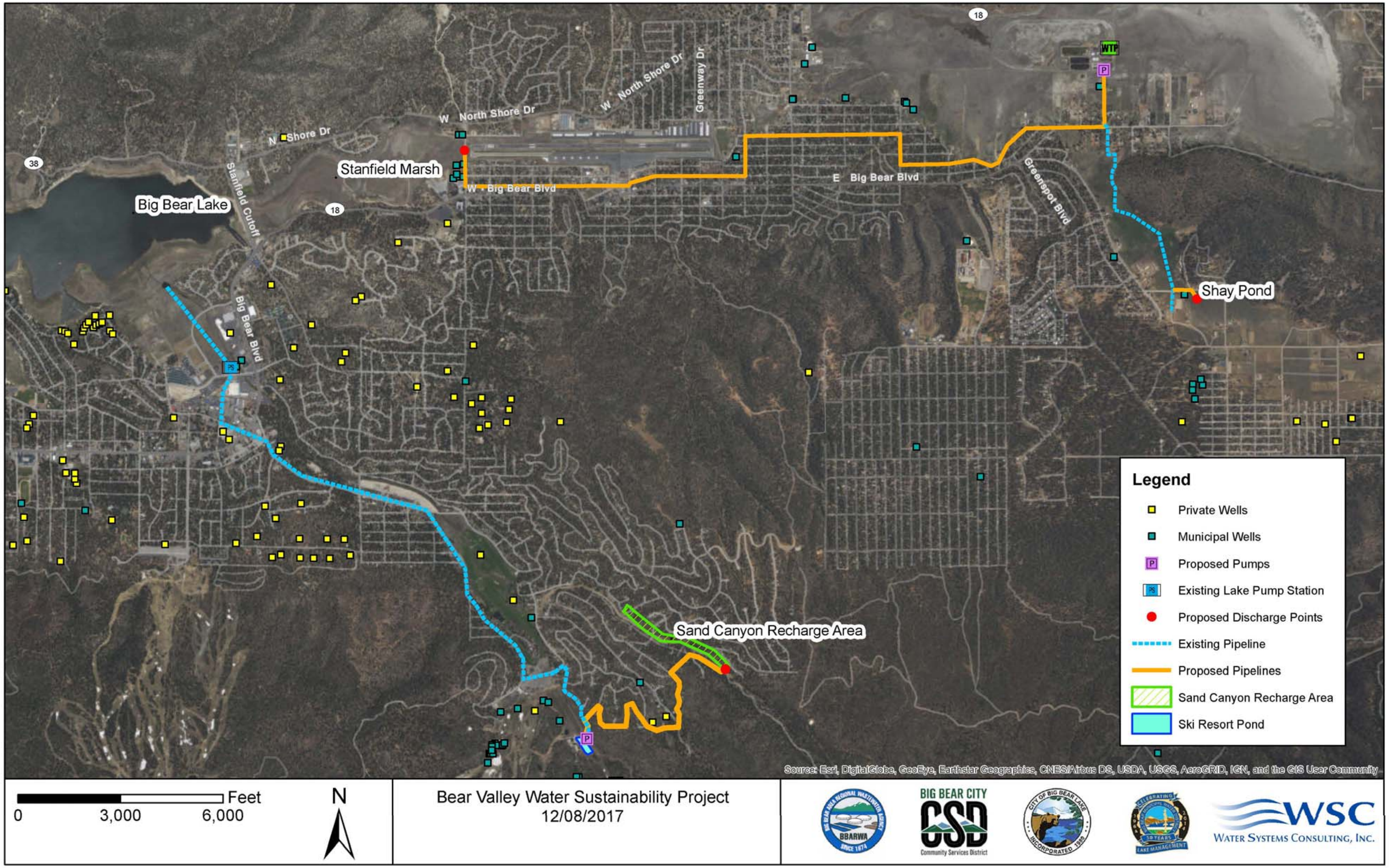


Figure 7-3: Proposed Infrastructure for Bear Valley Lake Alternative

7.5 UNIT COST

The unit cost for the Bear Valley Lake Alternative is shown in Table 7-5. Itemized cost estimates are included in Appendix C.

Table 7-5: Unit Cost for Bear Valley Lake Alternative

Total Capital Cost	Annual O&M	Annual Yield (AF)[1]	30-year Net Present Value (NPV)	Unit Cost ($/AF)[2]
$43,715,000	$2,397,000	1,950	$116,549,000	$1,920

Notes:
1. Based on 10-year average flows. See discussion of yield in Section 7.2, actual yield will vary annually.
2. Unit costs for various alternatives are calculated by dividing the 30-year NPV by the total yield in the 30-year period. See Appendix B for more detail.

7.6 BENEFITS

Implementation of the Lake Alternative provides numerous benefits as described in Section 5, including:

- A consistent high-quality water source to the Marsh to sustain habitat and increase education opportunities for the community and visitors through wildlife observation
- A new source of inflow to the Lake to augment Lake levels, enhance recreational opportunities and aquatic habitat and support water quality improvements. Preliminary models indicate that the implementation of the Lake Alternative will increase Lake levels by nearly 7 feet in 10 years.
- A new and consistent high-quality water source to Shay Pond to sustain habitat for the Unarmored Threespined Stickleback fish, so that the current potable water source can be redirected to serve the community
- A drought proof source of recharge water during dry periods, which will allow blended Lake water to be pumped to Sand Canyon to recharge the groundwater basin to strengthen the sustainability of the groundwater basin during extended droughts
- Flexibility during wet periods to store excess water locally as snow using existing snow making infrastructure. This provides an opportunity to further enhance winter recreation, reduce spills from the Lake, augment spring runoff and increase groundwater recharge. The existing snow making pump and pipeline can also be used to deliver irrigation water to the Bear Mountain Golf Course in the summer, if desired.
- Additional inflow into the Lake may enable BBMWD to modify the current Lake management strategy to minimize spills and flood control releases and optimize releases to ensure that the water can be captured for recharge of the San Bernardino Basin rather than discharged to the ocean.

7.7 ALTERNATIVES COMPARISON

Table 7-6 compares the Lake Alternative to Alternatives 1 through 4 evaluated in the 2016 Study. Capital and O&M Cost estimates from the 2016 Study were escalated to October 2017 and financing assumptions were revised to align with the estimates in this report to provide an even comparison. Note that the unit costs are based on funding 100% the project with loans at a rate of 5% and are expected to be conservative. The project is pursuing multiple grant programs as well as low interest loans which could reduce both the capital payment and interest rate, resulting in a lower unit cost than presented here.

As shown, the Lake Alternative retains more water in the Valley at a lower unit cost than other alternatives, and provides several additional benefits, as discussed in Section 7.6.

Table 7-6. Alternative Comparison

Alternative	Alternative 1 Irrigation (Segment 1.1 Only)	Alternative 2 Greenspot	Alternative 3 Sand Canyon (Low Range)	Alternative 4 Greenspot & Sand Canyon	Lake Alternative
Total Capital Cost	$3,510,000	$47,984,000	$25,057,000	$75,102,000	**$43,715,000**
Annual O&M Cost	$68,000	$1,614,000	$1,232,000	$2,860,000	**$2,397,000**
Recycled Water Yield (AFY)	54	1,000	520	1,750	**1,950**
Unit Cost ($/AF)	$3,950	$3,510	$4,180	$3,310	**$2,110**
Net Present Value	$6,406,000	$105,351,000	$65,226,000	$173,711,000	**$123,309,000**

8 NEXT STEPS

The Lake Alternative is a multi-component project that achieves the Project Team's goal of recovering a lost water supply to increase the sustainability of local water supplies to benefit the entire Valley. As shown in Table 7-6, it is also the most cost-effective alternative that has been identified, in terms of unit cost of water recovered for various beneficial uses.

To move the Lake Alternative into implementation, the following next steps toward several key milestones will need to be pursued in parallel.

8.1 FUNDING APPLICATIONS

Outside funding from various sources will be critical to moving this project forward. Additional outreach to funding agencies and development of a funding and financing strategy is recommended to prioritize funding program pursuits. Potential funding programs that have been identified for the Lake Alternative include:

- $15 million in federal grant funding previously authorized in the Water Resources Development Act of 2007 for water reclamation and distribution by BBARWA. The Project Team is currently pursuing an extension of this authorization, which is set to expire. If the authorization is extended, the project will remain eligible for funding, subject to allocation by the federal government
- California Department of Water Resources Integrated Regional Water Management Implementation Grants, implemented through the Santa Ana Watershed Project Authority
- US Bureau of Reclamation (USBR) WaterSMART Title XVI Water Reclamation and Reuse Program
- United States Department of Agriculture (USDA) Water and Wastewater Disposal Loan and Grant Program
- SWRCB Water Recycling Funding Program Grant and Loan Program
- SWRCB Clean Water State Revolving Fund Loan Program
- US Bureau of Reclamation WaterSMART Water & Energy Efficiency Grant Program (Note: Cannot apply for both USBR Title XVI and WaterSMART programs)
- iBank

8.2 ENVIRONMENTAL IMPACT REPORT

To comply with the California Environmental Quality Act (CEQA), it is anticipated the Project Team will prepare an Initial Study (IS) followed by an Environmental Impact Report (EIR) for the recommended project. In anticipation of applying for federal funding sources, the Project Team may also prepare an Environmental Assessment (EA) and an Environmental Impact Statement (EIS) to comply with the National Environmental Policy Act (NEPA).

Some funding programs require a completed EIR/EIS before a funding application can be considered complete so the schedule.

8.3 PERMIT APPLICATIONS

Ongoing coordination with the permitting agencies will be needed to refine permitting strategies and identify supporting technical studies that will be required. Some specific coordination requirements are expected to include:

- Coordinate with the RWQCB to explore the feasibility of developing a nutrient offset program in exchange for increased nutrient discharge limits for the Marsh/Lake (See Section 6.1.1)
- Continue coordination with DDW to verify the permitting strategy for the Marsh/Lake discharge and the Sand Canyon Recharge Component. Identify technical analysis required to support a determination that the project will not be regulated as Surface Water Discharge (See Section 6.2). Identify technical analysis required to justify recycled water dilution credit from surface water and underflow (See Section 6.3).
- Initiate a long-term study of Stickleback survival in recycled water (See Section 5.2.3)

To obtain an NPDES permit, BBARWA will need to submit a Report of Waste Discharge (ROWD) to the Santa Ana RWQCB, along with an Engineering Report describing the treatment upgrades, effluent characteristics, and proposed uses. The Engineering Report must also be submitted to DDW for review in parallel and DDW will issues findings and conditions for the Sand Canyon recharge component of the project to be incorporated into the discharge permit issued by the RWQCB. The ROWD should be submitted as soon as the Engineering Report is available but no later than six months before the project becomes online, as it typically takes six months for the Regional Board and EPA to review and issue a new permit.

8.4 PRELIMINARY ENGINEERING

A preliminary engineering report is needed to support the development of funding applications, the EIR and the permit applications and can be prepared in parallel with these activities to expedite the implementation schedule. As noted in prior sections of this report, key issues that will need to be evaluated during the preliminary engineering phase include:

- Update WWTP flow projections based on current water use trends to inform appropriate sizing of treatment and disposal facilities (See Section 4.1)
- Update estimates of Lake water level impacts based on anticipated project yield, which may consider the effects of evaporation in the Marsh (See Section 5.1)
- Quantify potential Lake water quality improvements resulting from the implementation of the Lake Alternative (See Section 5.1)
- Refine the estimated recharge potential in Sand Canyon through performance of a pilot infiltration test (See Section 5.3)
- Coordinate with flood control agency to identify technical studies and management practices needed to enable effective joint use of Sand Canyon for flood control and recharge (See Section 5.3)
- Perform a hydrology study to estimate the volume and timing of additional Lake releases under a range of hydrologic conditions so this information can be used in Valley District's model to assess their ability to capture these flows for recharge. (See Section 5.6)

- For Sand Canyon recharge, verify the pathogen control credit that can be achieved by the selected treatment process and identify whether additional underground retention time is needed to achieve the required total credit. (See Section 6.3.3)
- Perform a treatment process alternatives analysis and conduct a pilot study using potential equipment to refine design criteria and validate treatment performance estimates, including nutrient removal capability and RO recovery rates (See Section 7.1)
- Evaluate whether effluent temperature reduction will be required in cooler months (See Section 7.1.1)
- Refine design capacity and RW production estimates based on more detailed flow data, updated future flow projections, and actual MF and RO recovery rates (See Section 7.2)
- Perform a condition assessment and corrosion testing of the exisitng discharge pipeline to Lucerne Valley to determine whether the existing pipeline could accommodate brine conveyance without resulting in significant corrosion. Evaluate whether one of the parallel lines from the concrete balancing main to the LS site could be repurposed for brine conveyance. (See Section 7.3.3)
- Evaluate whether the existing secondary effluent pump station could be repurposed for the new tertiary effluent discharge (See Section 7.4)
- Initiate a water quality sampling program for nutrients, metals, COD, etc. throughout the existing treatment process to support modeling and design of the potential process upgrades needed at the WWTP.

8.5 PUBLIC OUTREACH

A public information program for the Lake Alternative is recommended to engage the community in the development of the project and educate them about the features and benefits. A public information program could take many forms and it is recommended that the Project Team engage in a proactive public outreach program in coordination with other existing or planned outreach programs.

A demonstration project can also be a key feature of a public outreach program because it provides an opportunity to engage and educate the community and improve confidence in the ability of the treatment processes to provide high quality water.

8.6 STAKEHOLDER COORDINATION AND GOVERNANCE

The Project Team should continue the ongoing stakeholder outreach activities they are currently engaged in, including:

- Coordination with each other regarding funding, cost sharing, and ongoing operation and management for the various project components
- Outreach to the Ski Resort to negotiate joint use of their snowmaking facilities for Sand Canyon Recharge and potentially additional snow storage, as well as use of Lake water for irrigation of the Bear Mountain Golf Course
- Collaboration with Valley District to further assess benefits to recharge in the San Bernardino Basin and the potential for a partnership

In addition, an effort should be made to identify potential additional stakeholders that should be engaged early in the project, such as organizations focused on habitat restoration to identify partnership opportunities to further study and enhance the Stickleback habitat

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APPENDIX A. SAND CANYON RECHARGE EVALUATION

Technical Memorandum

To: Ms. Laine Carlson
Water Systems Consulting, Inc.

From: Thomas Harder, P.G., C.HG.
Thomas Harder & Co.

Date: 29-Nov-17

Re: Sand Canyon Recharge Evaluation

This Technical Memorandum (TM) presents an evaluation of groundwater recharge potential within Sand Canyon near the City of Big Bear Lake, California (see Figure 1). The evaluation is being conducted as part of a larger study to assess the feasibility of delivering surface water from Big Bear Lake to Sand Canyon using a combination of existing and new pumps and pipeline infrastructure. The water from Big Bear Lake would include treated water stored in the lake from a Big Bear Area Regional Wastewater Agency (BBARWA) treatment plant. Given the source of water, it will be necessary to consider California Division of Drinking Water (DDW) regulations for indirect potable reuse in evaluating the location of recharge within Sand Canyon.

The specific purpose of this evaluation was to consider the following:

1. Given the surface configuration of the Sand Canyon channel and the hydrogeology of the area, how much water can be recharged in Sand Canyon?
2. Where in Sand Canyon would the recharge facilities need to be located in order to meet DDW regulations for subsurface residence time of recharge water prior to extraction?
3. As there is a diluent requirement for recharge of recycled water in surface basins and given that regulations allow for consideration of subsurface underflow as a diluent source, how much natural underflow can be applied to the diluent requirement in Sand Canyon?

Thomas Harder & Co.
1260 N. Hancock St., Suite 109
Anaheim, California 92807
(714) 779-3875

Sources of Data

A number of hydrogeological studies have already been conducted in Sand Canyon. These include:

- Geoscience, 1990. Geohydrologic Characteristics and Artificial Recharge Potential of the Sand Canyon Area. Dated December 1990.
- Geoscience, 2002. Results of Drilling, Construction, Testing and Pump Design for the Sheephorn Well. Dated February 1, 2002.

Analysis Methodology

Geoscience (1990) had previously conducted a travel time analysis for the Sand Canyon area using a numerical groundwater flow model. The downgradient extent of recharge ponds was identified as the point where Teton Road crosses the channel (see Figure 2). Based on this analysis, the travel time to the proposed downgradient extraction wells (proposed to be near TH-5) was more than six months. However, the analysis was based on a range of assumed hydraulic conductivity of 13 ft/day to 40 ft/day. Further, the range of effective porosity was 0.15 to 0.2. These values are relatively high and estimated based on the lithology of sediments encountered during drilling of test boreholes in the area. Subsequent pumping tests from the City of Big Bear Lake Department of Water's (the City's) Sheephorn Well (see Figure 2) indicate that the hydraulic conductivity of the aquifer is less than 1 ft/day. Further, other pumping tests in the area have shown that the effective porosity (which is equivalent to the specific yield in an unconfined aquifer) is on the order of 0.04.

In order to reevaluate the potential travel time and mounding from recharge basins upstream of Teton Road using updated aquifer properties, TH&Co developed a two-dimensional analytical flow model of the Sand Canyon area (see Figure 3 for model area). The analysis was conducted for steady state conditions using the model code WinFlow[1]. All travel time analyses were conducted using the particle tracking feature which allows for the estimation of groundwater travel time between two points from advective groundwater flow. The analysis incorporated the following assumptions:

- The area of the Sand Canyon channel identified for recharge is shown on Figure 3 and is equivalent to approximately 4.2 acres.
- The volume of water applied to the Sand Canyon recharge area was based on an assumed recharge rate of 0.5 ft/day, applied to the recharge basins over a 6-month period. Thus, the total volume of managed recharge for the simulation was 384 acre-ft.

[1] WinFlow Version 3, Environmental Simulations Inc., 2003.

- The analysis was conducted with the Sheephorn Well pumping at a rate of 125 gallons per minute (gpm) for 7 hours per day and the Sand Canyon Well pumping at a rate of 115 gpm for 9 hours per day.
- The initial groundwater levels were conditioned to a groundwater level contour map published by Geoscience (1990)[2] (see Figure 3). This contour map was generated based on data collected during a relatively dry hydrologic period.
- The hydraulic conductivity of the aquifer beneath the basins is assumed to be 1 ft/day.
- The porosity of the aquifer sediments is assumed to be 0.04.
- The sediments in the vadose zone and aquifer are homogeneous.

Findings

Recharge Potential

The primary limit to recharge rates in the Sand Canyon area appears to be available subsurface storage space to accommodate the groundwater mound. The target maximum groundwater level relative to the land surface was 20 ft below ground surface. Previous studies in the Big Bear area have shown that this depth is protective of liquefaction. This groundwater level was achieved at a recharge rate of 2.1 acre-ft/day in the recharge area, with the shallowest groundwater levels occurring beneath the furthest downgradient recharge basins. At a recharge rate of 2.1 acre-ft/day, the maximum predicted recharge for this study was approximately 380 acre-ft/yr, based on a six-month recharge period.

Recharge Water Subsurface Travel Time to the Nearest Downgradient Well

The particle tracking analysis shows that the recharge water will reach the nearest production well (Sheephorn Well) in a little more than approximately 13 months (see Figure 4). Assuming the Sand Canyon recharge project would fall under the definition of a Groundwater Replenishment Reuse Project (GRRP), per DDW regulations, the required subsurface retention time for the recharge water is 2 months. For preliminary recharge siting purposes, a “credit” of 0.25 is applied for travel time calculations using an analytical model, as was done for this analysis. Thus, the credited retention time is interpreted to be 9.75 months (39 x 0.25). This credited retention time is less than the retention time simulated for this analysis (13 months), indicating that the sites simulated are feasible based on the data assumptions in the analysis.

The limiting factors for recharge capacity, as identified by this analysis, were infiltration rate and groundwater mounding in proximity to the land surface. Further data collection will be necessary to determine the total recharge potential of the Sand Canyon area of interest. The most

[2] Geoscience, 1990. Geohydrologic Characteristics and Artificial Recharge Potential of the Sand Canyon Area.

representative infiltration rates can be obtained through a pilot infiltration test. The test would consist of a controlled release of water into a portion of the channel where the water can be dammed up and temporarily ponded. The water level stage in the ponded area can be measured using a staff gage. Once the depth of the ponded area was sufficient (1 to 2 ft deep), the discharge into the channel would be discontinued and the rate of infiltration measured using the staff gage. Optimally, a succession of multiple wetting and drying cycles would be conducted to obtain an average infiltration rate. If possible, the test should also be conducted at multiple locations along the channel, to determine differences in infiltration rate with location.

Native Subsurface Underflow to the Recharge Area

As the aquifer beneath the Sand Canyon area is conceptualized as being unconfined, native subsurface underflow contribution to the portion of the aquifer beneath the recharge area was estimated based on the Dupuit Equation[3], which is expressed as:

$$Q = 0.5K\left(\frac{(h_1 - h_2)^2}{L}\right)$$

Where:

Q	=	Subsurface flow, (acre-ft)
K	=	Hydraulic Conductivity, (ft/day)
h_1	=	Initial Hydraulic head, (ft amsl)
h_2	=	Ending Hydraulic head, (ft amsl)
L	=	Flow Length (ft)

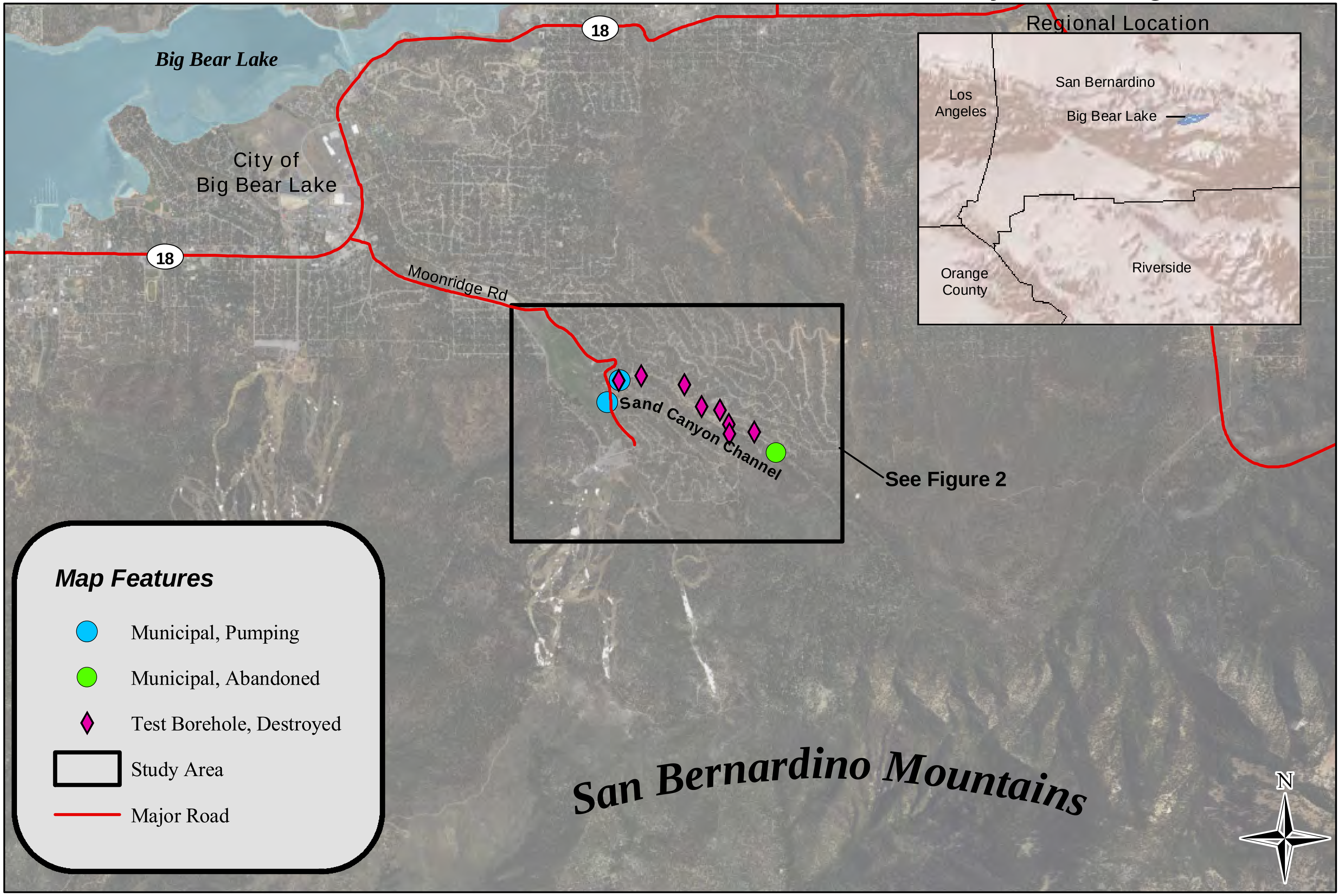
The change in hydraulic head was determined based on the contour map published in Geoscience (1990). The hydraulic conductivity was assumed to be 1 ft/day based on a pumping test conducted in the Sheephorn Well. A summary of the underflow analysis is provided in Table 1. The volume of underflow that may be applied toward the diluent requirement will likely depend on DDW review and interpretation of the data. A range of potential diluent credit was developed such that the low end of the range represents the underflow directly beneath the Sand Canyon channel and the high end of the range represents the entire flow net that ultimately contributes

[3] Fetter, 1994. Applied Hydrogeology, 3rd Edition. MacMillan College Publishing Co.

underflow to the Sand Canyon area, as shown on Figure 1. The range is approximately 58 acre-ft/yr to 247 acre-ft/yr (see Table 1).

WSC
Water Systems Consulting, Inc.

Sand Canyon Recharge Evaluation



29-Nov-17

Thomas Harder & Co.
Groundwater Consulting

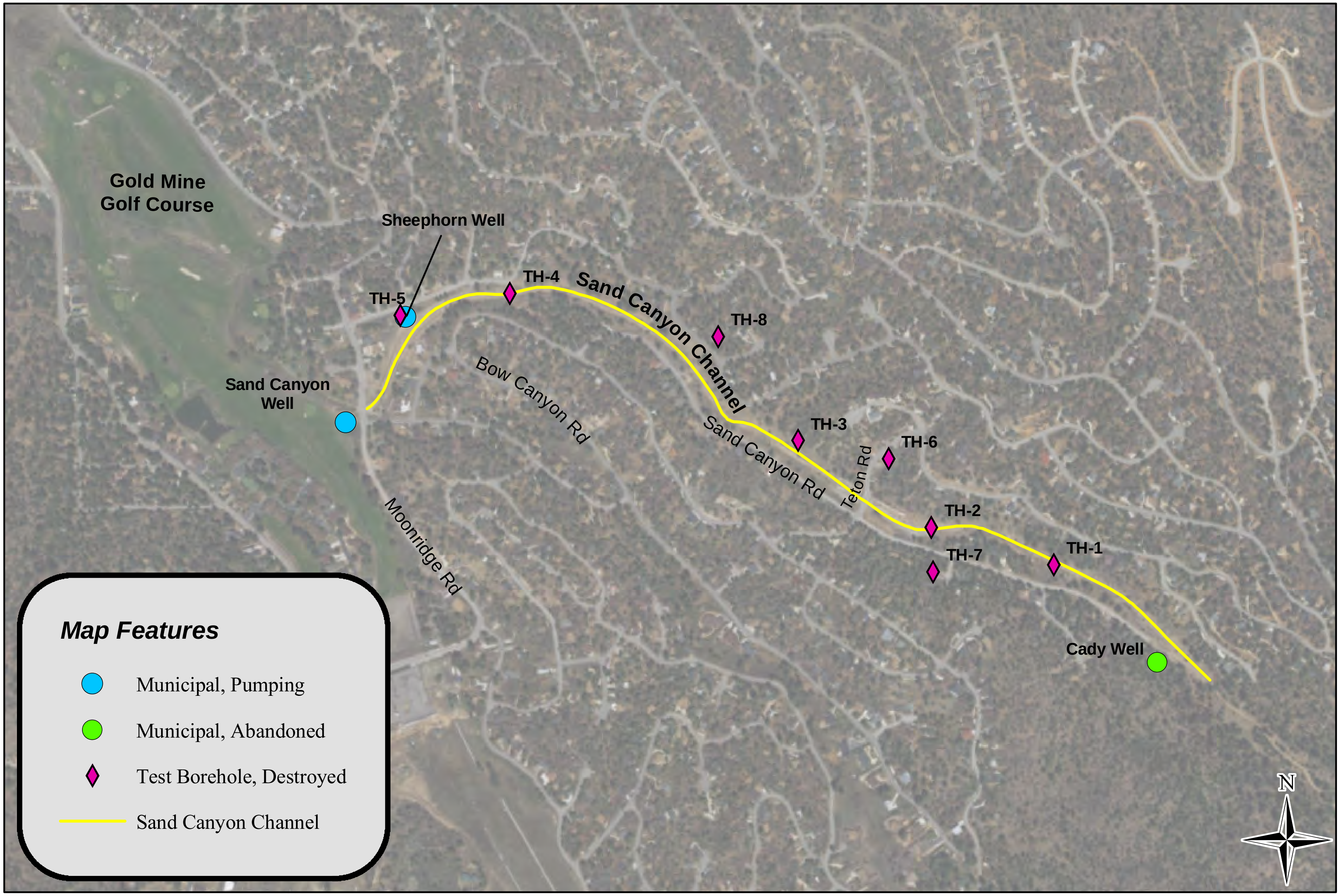
0 0.25 0.5 1 Mile

NAD 83 UTM Zone 11

Area Map

Figure 1

Sand Canyon Recharge Evaluation



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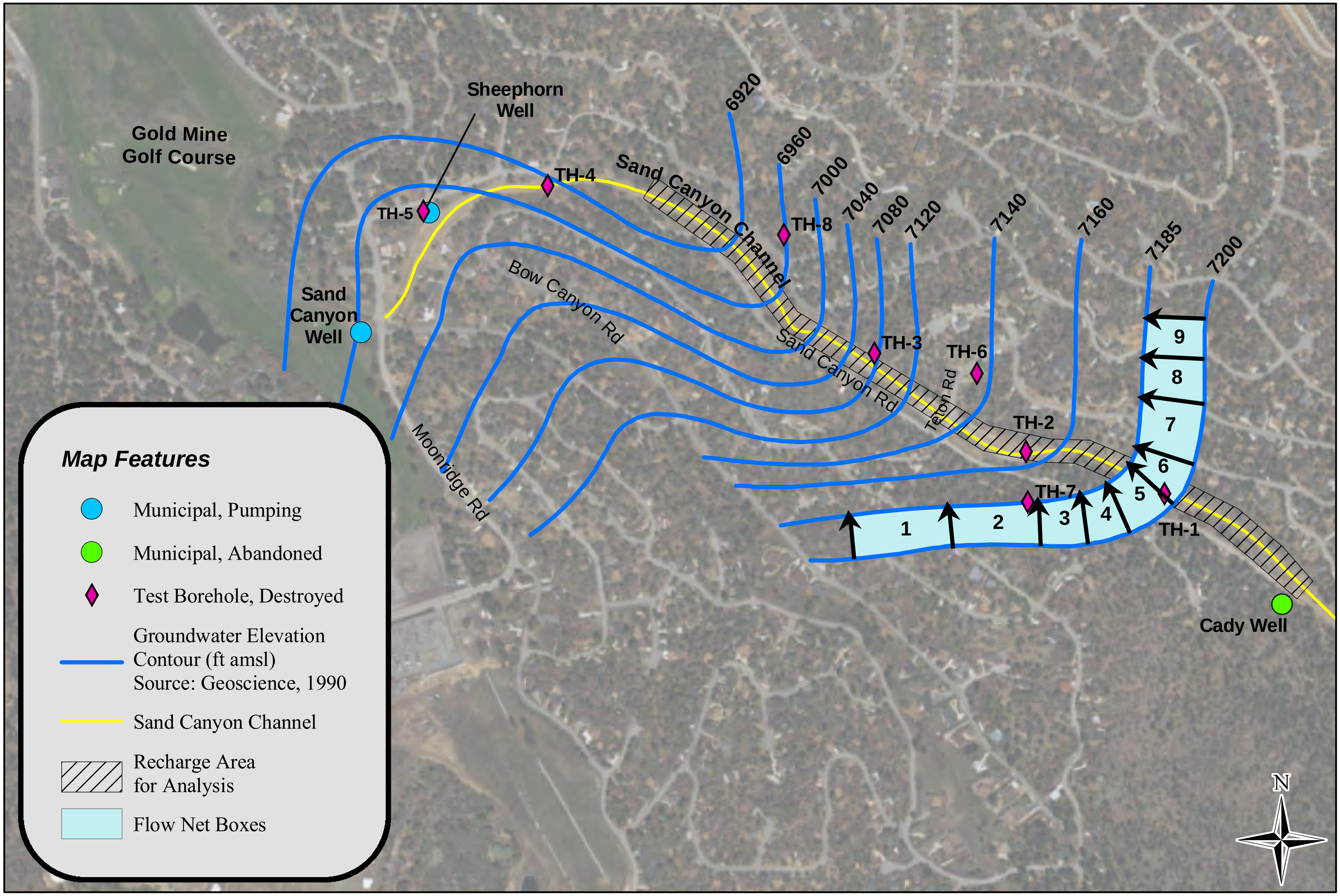
0 250 500 1,000 Feet

NAD 83 UTM Zone 11

Site Location

Figure 2



29-Nov-17

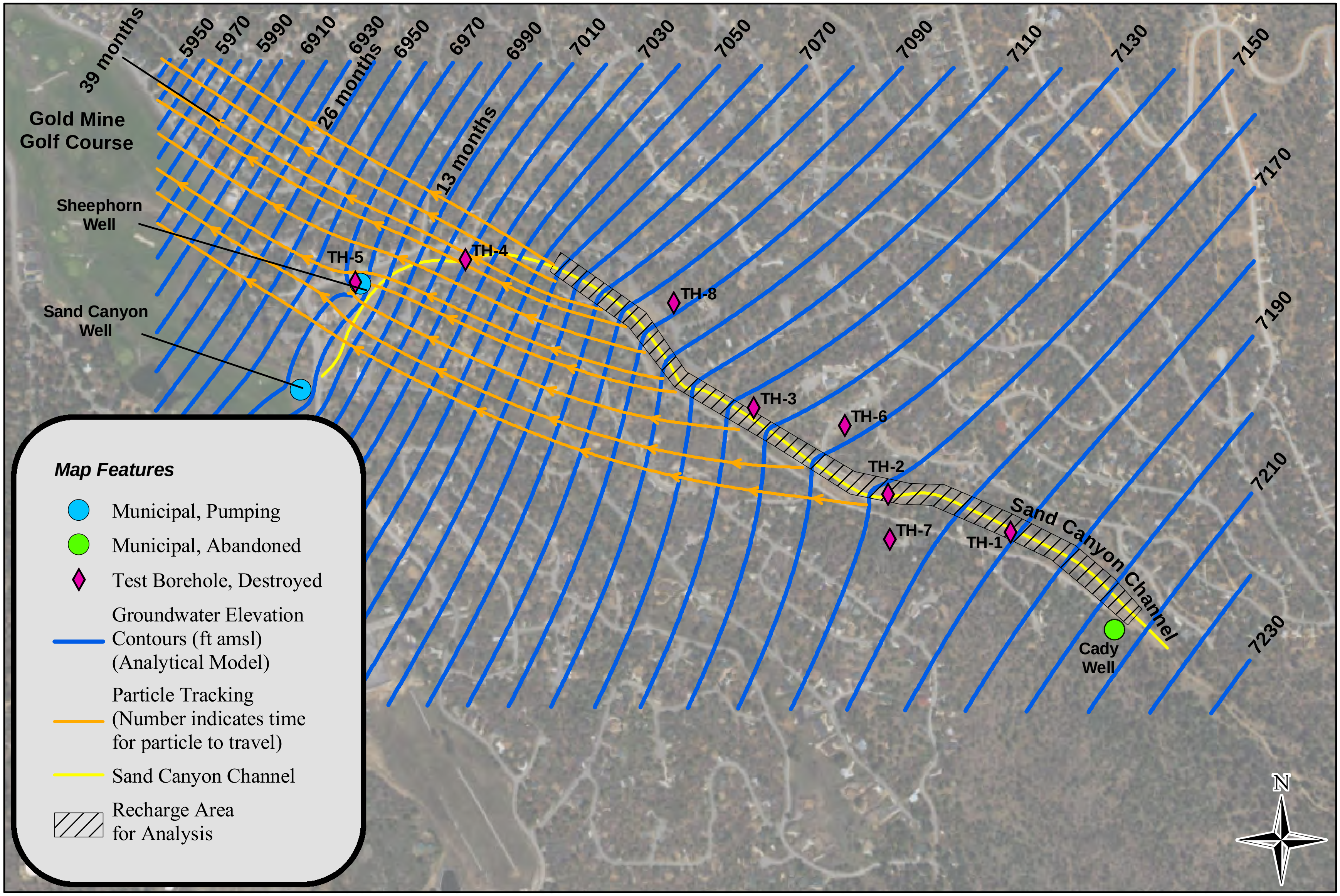
0 250 500 1,000 Feet

NAD 83 UTM Zone 11

Sand Canyon Underflow Analysis

Figure 3

Sand Canyon Recharge Evaluation



29-Nov-17

Thomas Harder & Co. Groundwater Consulting

0 250 500 1,000 Feet

NAD 83 UTM Zone 11

Recharge Travel Time Analysis

Figure 4

Sand Canyon Underflow Analysis

Cell Name	Hydraulic Conductivity [K] (ft/day)	Flow Cell Width (ft)	Initial Hydraulic Head [h_1] (ft)	Ending Hydraulic Head [h_2] (ft)	Length of Flow Cell [L] (ft)	Flow Rate [Q] (ft^3/day)	Flow Rate [Q] (acre-ft/yr)
1	1	490	145	130	213	4,745	40
2	1	439	145	130	205	4,417	37
3	1	296	145	130	223	2,738	23
4	1	307	145	130	177	3,577	30
5	1	305	145	130	200	3,145	26
6	1	296	145	130	161	3,792	32
7	1	281	145	130	275	2,108	18
8	1	254	145	130	210	2,495	21
9	1	235	145	130	197	2,460	21
					Total Flow	**29,476**	**247**

Range in potential diluent credit = 58 - 247 acre-ft/yr

Notes:

Initial and ending hydraulic heads relative to assumed aquifer bottom.

Yellow highlighted values represent underflow directly beneath the Sand Canyon channel.

APPENDIX B. FINANCIAL ASSUMPTIONS

Planning Level Cost Estimates

The cost opinions (estimates) included in this Study are prepared in conformance with industry practice and, as planning level cost opinions, will be ranked as a Class 4 Conceptual Opinion of Probable Construction Cost as developed by the Association for the Advancement of Cost Engineering (AACE) Cost Estimate Classification System (19). The AACE classification system is intended to classify the expected accuracy of planning level cost opinions, and is not a reflection on the effort or accuracy of the actual cost opinions prepared for the study. According to AACE, a Class 4 Estimate is intended to provide a planning level conceptual effort with an accuracy that will range from -30% to +50% and includes an appropriate contingency for planning and feasibility studies. The conceptual nature of the design concepts and associated costs presented in this Study are based upon limited design information available at this stage of the projects. These cost estimates have been developed using a combination of data from RS Means CostWorks®, recent bids, vendor supplied data, experience with similar projects, current and foreseeable regulatory requirements and an understanding of the necessary project components. As specific projects progress, the design and associated costs could vary significantly from the project components identified in this Study. Cost opinions are planning level and may not fully account for site-specific conditions that will affect the actual costs, such as soils conditions and utility conflicts.

For projects components where applicable cost data is available in RS Means CostWorks® (e.g. pipeline installation), cost data released in Quarter 3 of 2017, adjusted for San Bernardino, California, is used. Material prices were adjusted in some cases to provide estimates that align closer with actual local bid results. For projects where RS Means CostWorks® data is not available, cost opinions are generally derived from bid prices from similar projects, vendor quotes, material prices, and labor estimates, with adjustments for inflation, size, complexity and location.

Cost opinions are in 2017 dollars (ENR 20 City Average Construction Cost Index of: 10,817 for October 2017).

Markups and Contingencies

For the development of the planning level cost estimates, several markups and contingencies are applied to the estimated construction costs to obtain the total estimated project costs. The markups are intended to account for costs of engineering, design, administration, and legal efforts associated with implementing the project (collectively, Implementation Markup). Contingency accounts for additional construction costs that could not be anticipated at the time of this analysis. A summary of the markups and contingencies applied are presented in the table below.

	Markups and Contingencies
	Construction Subtotal
+	20% of Construction Subtotal for Contingency
+	40% of Construction Subtotal for Implementation
=	**Total Capital Cost**

Unit Cost and Net Present Value

To comply with federal funding program requirements, the net present values (NPV) are calculated for each alternative and treatment option. The NPVs account for capital costs (one-time costs associated with each alternative) and operation and maintenance (O&M) costs (i.e. electrical and maintenance) over a 30-year period. O&M costs are subdivided into Conveyance Pumping Energy costs and Non-Energy costs to enable these costs to be escalated at different rates in the future, recognizing that energy costs are anticipated to rise faster than non-energy costs.

The assumptions used to calculate the costs for each alternative are summarized in the table below.

Assumption	Current Value	Annual Escalation Rate	Description
Loan Terms	100% loan for 30-year loan term with a 5% capital financing rate		Loan term based on CWSRF loan term. Capital financing rate of 5% is expected to be conservative as the project may be eligible for low interest loans.
Discount Rate			A Discount Rate of 3% is used for the NPV
O&M – Conveyance Pumping Energy	$ 0.14/ KW-hr	3.0 %	Energy escalation based on US Energy Information Administration (USEIA) previous 5-year average electricity rate data for California Commercial rates.
O&M – Non Energy	Varies by facility type, based on capacity or capital cost	2.4%	Non-energy escalation based on California CCI previous 5-year average

APPENDIX C. DETAILED COST ESTIMATE

WATER SYSTEMS CONSULTING, INC.

Alternative Information					
Treatment					
Secondary Effluent Available for Treatment	2.20	MGD	2509	AFY	
Recycled Water Produced	1.98	MGD	2220	AFY	
Capital Cost					
	Capacity/Size		Length		
Pipeline to Lake	12	in	19940	LF	$ 4,276,000
Pipeline to Stickleback Pond	4	in	710	LF	$ 67,000
Pipeline from Snow Making Pond to Sand Canyon	8	in	7210	LF	$ 855,000
Recycled Water Storage	0.00	MG			$ -
Effluent Pump Station @ WWTP	1528	gpm			$ 988,000
Pump Station @ Snow Making Pond	471	gpm			$ 377,000
Enhanced Biological Nutrient Removal	2.20	MGD			$ 1,918,000
Nitrification-Denitrification Process	2.20	MGD			$ 2,758,000
MF/UF and RO	2.20	MGD			$ 9,364,000
UV Disinfection	1.98	MGD			$ 1,480,000
Brine Concentrator	0	gpd			$ -
Evaporation Ponds	77	acres			$ 4,843,000
Brine Storage	0.66	MG			$ 924,000
Brine Pump Station	470	gpm			$ 377,000
Brine Pipeline	8	in	10000	LF	$ 1,185,000
Monitoring Well for GWR	2	EA			$ 215,000
Construction Subtotal					**$ 29,627,000**
Construction Contingency	20%				$ 5,925,000
Implementation Costs	40%				$ 11,851,000
Total Capital Cost					**$ 47,403,000**
O&M Cost Estimates					
	Capacity/Size		Length		
Pipeline			37860	LF	$ 102,000
Storage	0.66	MG			$ 15,000
Pump Station	2469	gpm			
Maintenance					$ 139,000
Power					$ 51,000
Enhanced Biological Nutrient Removal	2.20	MGD			$ 150,000
Nitrification-Denitrification Process	2.20	MGD			$ 211,000
UF/RO/UV	2.20	MGD			$ 1,598,000
Evaporation Ponds	77.46	acres			$ 38,000
Compliance Activities for Discharge Permits					$ 126,000
Total Annual O&M Cost					**$ 2,430,000**