CHAPTER 2

DESCRIPTION OF THE SOURCE WATER SYSTEM

2.0 Description of the Source Water System

During the last 100 years, the CSD's water system has evolved into a very complex system. It is now estimated to serve a population of 1.4 million people spread out over 370 square miles (**Table 2.1**). The CSD treats imported raw water and local runoff water at three City WTPs which have a combined capacity of 378 MGD. The CSD treats water by conventional technologies using coagulation, flocculation, sedimentation, filtration and disinfection. Recently, all CSD water treatment plants have been modified to provide for the addition of fluoride to the potable water supply. To ensure safe and palatable water quality, the CSD collects water samples at its reservoirs, WTPs, and throughout the treated water storage and distribution system.

The CSD's use of local and imported water to meet water demand is affected by availability, cost, and water resource management policies**.** Imported water availability decreases the need to carry over local water for dry years in City reservoirs. CSD policy is to use local water first to reduce imported water purchases; this policy runs the risk of increased dependence on imported water during local droughts.

Table 2.1 - City of San Diego General Statistics

Population (2010)	1,301,621
Population (Estimated 2014)	1,381,069
Population percent change	6.1
Land Area Square Miles	370
Population Density per Square Mile	3733
Water Distribution Area Square Miles	403
Number of Service Connections (2015)	279,102

2.1 Water Sources (**Figure 2.1**)

Most of California's water development has been dictated by the multi-year wet/dry weather cycles. Records indicate that extremely dry periods frequently last several years both locally and throughout California. During wet years, excess runoff is impounded in surface water reservoirs. Runoff in dry years is generally insufficient to meet environmental requirements and riparian water rights in their natural water watersheds; therefore, during droughts all imported and local water comes from reservoir or groundwater storage (**Table 2.2)**. In 2016, a major new source of "drought proof" water will become available to the CSD with the completion of the Claude "Bud" Lewis Carlsbad Desalination Plant which will have a capacity of producing 56,000 AFY.

Figure 2.1 City of San Diego Source Water System

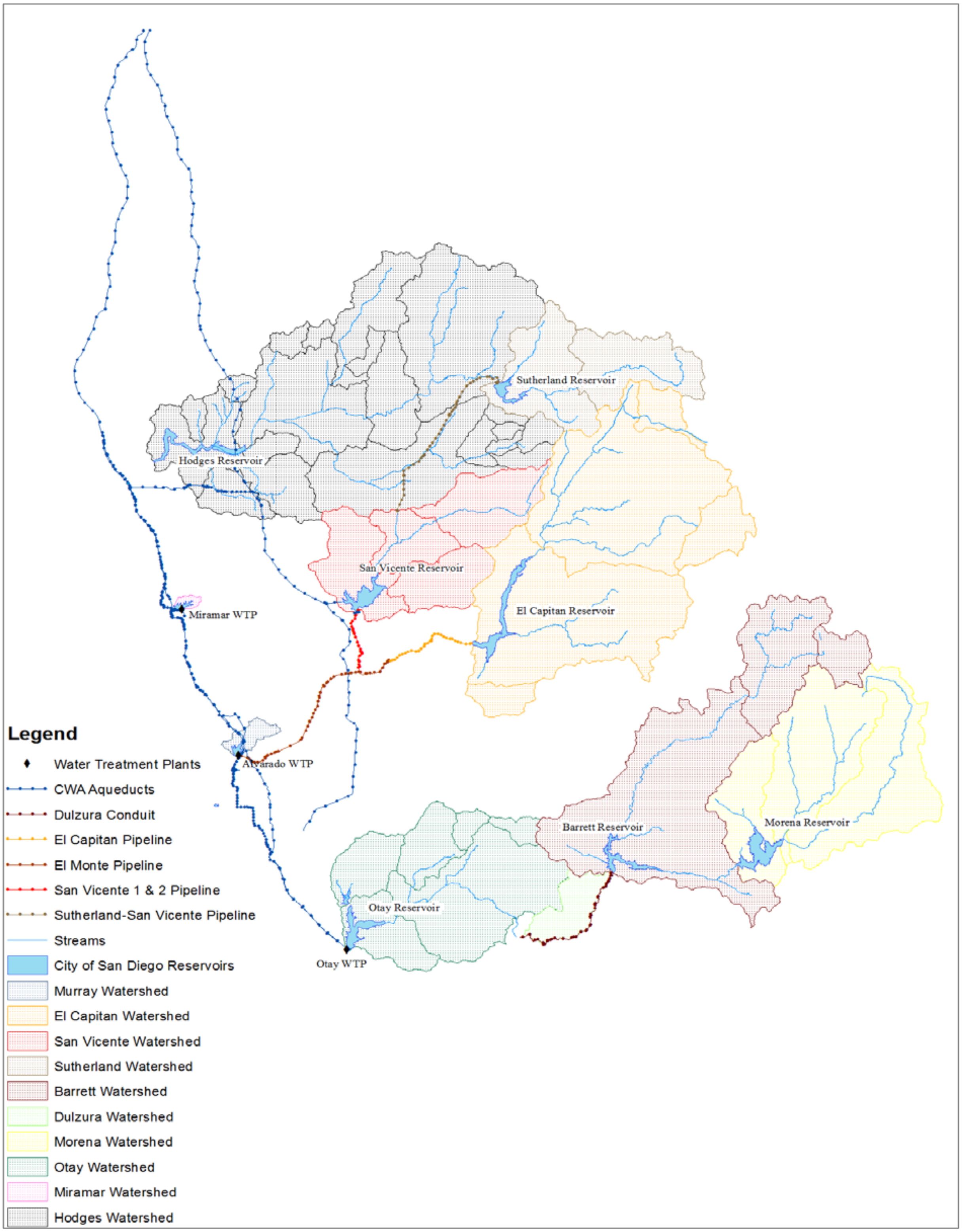

Table 2.2 - City of San Diego Local and Imported Water Use					
Fiscal Year	Local Volume (AF)	Percent	Imported Volume (AF)	Percent	Total Production (AF)
2015	6,279	3%	184,878	97%	191,157
2014	23,858	11%	186,228	89%	210,086
2013	15,958	8%	180,848	92%	196,806
2012	22,215	12%	165,497	88%	187,712
2011	21,870	12%	163,041	88%	184,911
Total	90,181	N/A	880,491	N/A	970,671
Average	18,036	9%	176,098	91%	194,134

Imported Water

Imported water has historically accounted on average for **80%** of the CSD's annual water use. Sources include:

- The Colorado River via 300 miles of canals and pipelines.
- The Sacramento River via more than 500 miles of canals and pipelines.
- MWD's Lake Skinner.

Imported water is delivered by federal, state and regional agencies; these agencies are the United States Bureau of Reclamation, the State of California Department of Water Resources (CDWR), MWD, and SDCWA.

Imported raw water originates either from the Colorado River or the Feather River in the Sacramento River Watershed. Precipitation on these watersheds has similar seasonal (winter/summer) and cyclical (wet/dry year) patterns to those of local watersheds. In most years, winter snowpack in the High-Sierras stores a significant amount of water until early summer. This "snow pack storage" in combination with reservoir storage helps CSD meet seasonal summer demand. To avoid water shortages during cyclical droughts, reservoirs are used to carry over (store) water from wet years to dry years.

Volumetric use of imported water peaked at 228,000 AF or 93 percent of total demand in fiscal year 1989 during the statewide drought of 1987-92. The maximum imported water purchase occurred in fiscal year 1990 when the City purchased 270,000 AF of imported water which was 11 percent more than the year's water demand of 243,000 AF. The additional water was purchased to replace evaporation losses on local reservoirs and to provide reserve in the event of continued drought.

Local Runoff

Local runoff has historically accounted on average for **20%** of CSD’s annual water use. Sources include Nine (9) major CSD reservoirs which collect local runoff from their respective watersheds collectively covering more than 900 square miles. The annual average rainfall exceeds fifteen (15) inches in these mostly hilly and mountainous watersheds located outside of the CSD boundaries.

Local water use varies greatly due to the variation of annual local runoff. The total annual CSD water demand may be served by local water in an average of one out of ten years. In dry years, runoff on local watersheds is generally less than loss due to evaporation from local reservoirs. The maximum local water use was about 97,000 AF in fiscal year 1984 after a wet winter filled all CSD reservoirs. The minimum local water use was less than 5,000 AF in fiscal years 1964 and 1965 during the local 1959-66 drought.

The rainfall and runoff information in this section was supplied by the CSD Public Utilities Department Production Engineering, National Oceanic and Atmospheric Association, and San Diego Geographical Information System (SanGIS). Rainfall data is collected at each reservoir by the CSD. Runoff data is calculated monthly by using the measured amount of rainfall, rain on the surface of the reservoir, evaporation, draft, storage, dam leaks, change in reservoir level, and other calculated inputs.

San Diego County's climate is classified as a Mediterranean dry summer type where the amount of runoff is highly variable from year to year due to wet and dry cycles. In their natural conditions, local streams and rivers feeding CSD reservoirs are ephemeral or intermittent. During the summer, seepage under dams and irrigation runoff are the major sources of water in many streambeds. On average, 90% of the annual rainfall occurs between the months of November and April (**Table 2.3**) and 93% of local runoff occurs during the months of December through May.

Table 2.3 - Climate Data for San Diego (Lindbergh Field)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high (°F)	65.8	66.3	66.3	68.7	69.3	72.2	75.8	77.5	77	74	69.9	66.3	70.8
Daily mean (°F)	57.8	58.9	60	62.6	64.6	67.4	70.9	72.5	71.6	67.6	61.8	57.6	64.4
Average low (°F)	49.7	51.5	53.6	56.4	59.8	62.6	65.9	67.4	66.1	61.2	53.6	48.9	58.1
Rainfall (in)	2.28	2.04	2.26	0.75	0.2	0.09	0.03	0.09	0.21	0.44	1.07	1.31	10.77
Avg. rainy days (≥ 0.01 in)	7.2	6.6	7.2	4.1	2	1.1	0.6	0.6	1.5	2.8	4	5.2	42.9

The region needs rainfall levels at about the annual average to sufficiently saturate the soils so that significant surface runoff can occur (**Table 2.4**). Consequently, most of the runoff to CSD reservoirs is produced in years with much greater than average rainfall. About one half of the total runoff into CSD reservoirs is produced during the wettest ten percent of the years. Conservation of runoff during these wet years requires large water storage capacity in comparison to the average annual water yield. CSD reservoir capacity is less than one half of the highest (maximum) annual runoff yield; as a result the excess local water is lost to the ocean and contributes to flooding below CSD reservoirs. Some flooding may occur even during years with average or below average rainfall levels if the annual rainfall volume is concentrated in a few intense storms.

Table 2.4 - 30 Year Average Rainfall within Local Source Water System Boundaries; SanGIS update 2008								
	San Diego River System		**Otay-Cottonwood System**		**Miramar System**		**Hodges System**	
Range	Acres	% Acres	Acres	% Acres	Acres	% Acres	Acres	% Acres
12 to 15	2,298	1.1	6,573	2.9	121	18.8	2,586	1.6
15 to 18	21,129	10.3	37,011	16.3	524	81.2	41,440	26.2
18 to 21	104,818	51.2	80,018	35.2	0	0.0	86,830	54.9
21 to 24	45,308	22.1	40,629	17.9	0	0.0	24,967	15.8
24 to 27	16,313	8.0	41,085	18.1	0	0.0	2,449	1.5
27 to 30	12,075	5.9	21,700	9.6	0	0.0	0	0.0
30 to 33	2,864	1.4	0	0.0	0	0.0	0	0.0
Total	204,805	100	227,016	100	645	100	158,272	100

Historically, on average approximately 12% of local precipitation results in surface runoff to CSD reservoirs (**Table 2.5**). While historical information on rainfall and the resulting runoff is available, accurate and sufficient information on the amount of local groundwater recharge is lacking. In some watersheds the lower coefficient of runoff may be explained by groundwater recharge, and in other watersheds the difference cannot be accounted for.

Table 2.5 - City of San Diego Reservoirs Historical Average Annual Precipitation & Runoff					
Reservoir	Watershed (Acres)	Precipitation (Inches)	Precipitation (AF)	Runoff (AF)	Precipitation as Runoff
Morena	72,960	19.81	120,469	10,986	9%
Barrett	85,760	16.63	118,866	11,411	10%
Lower Otay	62,720	11.25	58,796	6,796	12%
El Capitan	121,600	16.07	162,868	21,457	13%
San Vicente	47,360	15.11	59,644	6,668	11%
Murray	3,200	11.61	3,097	258	8%

Miramar	640	12.84	685	190	28%
Sutherland	34,560	21.83	62,875	7,604	12%
Hodges	159,360	14.36	190,738	6,668	3%
Total	588,160	139.53	778,038	72,037	NA
Average	65,351	15.50	86,449	8,004	12%

Since 1971, local water use by the CSD (including California-American Water Company) averaged nearly 30,000 AFY while HWD, SDWD and SFID used an average of 13,000 AFY (**Table 2.6**).

Table 2.6 - City of San Diego Reservoir 2011 - 2015 Average Annual Precipitation & Runoff

Reservoir	Watershed (Acres)	Precipitation (Inches)	Precipitation (AF)	Runoff (AF)	Precipitation as Runoff
Morena	72,960	13.39	81,408	1,218	1%
Barrett	85,760	12.22	87,361	5,833	7%
Lower Otay	62,720	8.24	43,057	3,056	7%
El Capitan	121,600	12.66	128,333	5,490	4%
San Vicente	47,360	10.90	43,034	3,291	8%
Murray	3,200	8.75	2,332	111	5%
Miramar	640	8.37	446	167	37%
Sutherland	34,560	15.97	45,988	2,756	6%
Hodges	159,360	10.14	134,686	10,958	8%
Total	588,160	100.65	566,645	32,880	NA
Average	65,351	11.18	62,961	3,653	6%

Historically, about 40% of the local runoff is used for the municipal water supply (**Tables 2.5** & **2.7**). Local water use is much less than the long term average annual runoff into CSD reservoirs due to losses which include:

- Limited reservoir capacity to conserve all local runoff during wet years resulting in loss over dams
- Limited pipeline capacity between CSD WTPs plants and reservoirs resulting in losses due to evaporation during prolonged storage in less efficient reservoirs and ground water recharge when water is transferred between reservoirs via streambeds.

Table 2.7 - Local Runoff Uses/Losses		
Description	Historical Average Annual (AFY)	2011-2015 Average Annual (AFY)
Use by City, including Cal American Water Company	29,500	18,000
Use by Helix, San Dieguito, & Santa Fe	12,950	12,600
Evaporation Loss	20,337	13,179
Transit Loss through Open Flumes & Channels	2,191	2,220
Spill to the Pacific Ocean in Wet Years	11,000	9,300
Total	75,978	55,298

2.2 Source Water Reservoirs

Reservoir storage is necessary to balance seasonal and cyclical variations in the water supply volume and variability of sources and demands. CSD total reservoir capacity is over double its average annual water production (**Table 2.2** & **2.8**).

Table 2.8 - Water Storage Statistics	
Combined Capacity of City Reservoirs	402,668 AF
Capacity below Lowest Usable Outlets / Dead Storage	15,563 AF
HWD Owned Storage Capacity in El Capitan Reservoir	10,000 AF
Net Usable City Owned Storage Capacity	387,106 AF
Minimum Usable Hodges Storage Required for SFID/SDWD	8,300 AF
Maximum Usable Hodges Storage Required for SFID/SDWD	15,800 AF

The conservation of local runoff with the least amount of loss requires coordinated management of CSD reservoirs involving a need to consider local weather patterns, watershed characteristics, storage capacity, and the efficiency of the reservoirs. Under ideal conditions, all water storage would occur in reservoirs with the lowest probability of spillage during the winter and with the lowest evaporation loss during the summer. Ninety-three percent (93%) of local runoff occurs during the months of December through May, and Ninety-four percent (94%) of the net evaporation occurs from June through December. This seasonal wet/dry cycle requires shifting priorities throughout the year between the need to maximize conservation of runoff and the need to minimize evaporative losses. To accomplish this, the CSD drafts water from its reservoirs as quickly as pipeline capacity, water quality, and CSD water demand allows until only the required emergency supply remains. While this type of operation saves no water in local reservoirs for dry years, it maximizes local water production by reducing loss due to evaporation and reservoir spills. It is not always possible to achieve this goal due to a lack of adequate transfer facilities, the need to distribute emergency supply to designated areas, and the need to access reservoirs for recreation purposes.

Average runoff produced in the watersheds is generally proportional to the relative size and elevation of the watersheds; however, rainfall and resulting runoff in a given year may vary significantly from the annual average causing unpredictable and significant variations. Consequently, optimization of the multiple reservoir system depends on whether the reservoirs are tributary or parallel; with the exception of Morena, Barrett, and Sutherland, all CSD reservoirs are considered to be parallel.

On parallel reservoirs the storage capacity available to impound runoff is allocated among the reservoirs in proportion to the average annual runoff patterns of their respective watersheds. The amount of storage capacity allocated to each reservoir is determined by its historical percent contribution of runoff to the system for a calendar year. This method will optimize local water production by providing the highest overall yield.

On tributary reservoirs the lower elevation reservoir may capture spills from the higher elevation reservoir, whereas spills from the lower reservoir will be a loss. Therefore, at the beginning of the rainy season most of the storage capacity available to impound runoff is allocated to the lower elevation reservoir. This practice will result in higher water yield as opposed to allocating the water storage between reservoirs in proportion to the average annual runoff patterns of their respective watersheds.

The location of storage capacity is also determined by the intended purpose:

- Emergency storage capacity is located as close to the point of use as possible. The purpose of emergency storage is to provide a minimum reserve of water for use during emergencies such as earthquakes, aqueduct failures, or aqueduct pump station outages. CSD Council Policy 400-4 "Emergency Storage of Water" requires the storage of 60% of the annual requirement of the CSD and its contractees as active available storage in Murray, San Vicente, El Capitan, Lower Otay, and Miramar reservoirs. Active, available storage is the portion of the water that is above the lowest usable outlet of each reservoir. Emergency storage is interpreted as fluctuating requirement from month to month, consequently, as water demand peaks in summer months the volume of emergency storage increases; this results in a difference of 37,000 AF or more between the April high and October low. To meet this requirement, the CSD reserves up to 175,000 AF (a seven month supply) of storage capacity for emergency storage.
- Seasonal storage capacity is located as close to the point of use as possible. Seasonal storage is the storage of surplus water in the wet winter season for use during the dry summer season. This type of operation increases imported water yield and reduces summer peaking on the imported water delivery system.
- Dry-year storage capacity, sometimes called carry-over storage, may be located anywhere along the water delivery system. Dry-year storage is the storage of surplus water in wet and normal years for use in dry years to produce a more dependable water supply. The water is stored for many years to provide water during the longest anticipated drought.
- Operational storage capacity is located as close to the point of use as possible. Operational storage is the storage of water intended to meet the variability in daily demand of the WTP.
- The remainder of the storage capacity is used as impounding storage to maximize local water yield.

The City owns and operates all of the reservoirs, water treatment plants, pipelines, pump stations, and associated facilities; unless otherwise noted.

San Diego River System (Fig.2.1, Tables 2.9 & 2.10)

The San Diego River System is comprised of:

- Reservoirs: Murray, San Vicente, El Capitan, Sutherland, and Cuyamaca owned by HWD.
- Their respective watersheds.
- Interconnecting pipelines and pump stations: Sutherland-San Vicente Pipeline, San Vicente Pipelines Nos.1 & 2, El Capitan Pipeline, El Monte Pipeline, El Monte Pump Station, and Lakeside Pump Station.
- Water treatment plants: Alvarado WTP, R.M. Levy Water Treatment Plant (Levy WTP) owned by HWD, and John C. Bargar Water Treatment Plant (Barger WTP) owned by the Ramona Municipal Water District (RMWD).

Table 2.9 - City of San Diego Dam & Outlet Structure Statistics

Reservoir	Year Built	Construction Type	Total Height(ft)	Crest Length (ft)	Spillway Capacity (MGD)	Transfer Capacity(MGD)-Receiving Facility
San Diego River System						
Murray	1918	Multiple Arch	117	870	1309	126-Alvarado WTP
San Vicente	1943 *2014	Concrete Gravity	337	1442	30312	76-Murray Reservoir/ Alvarado WTP
El Capitan	1934	Hydraulic Fill	242	1170	110303	61-Murray Reservoir/ Alvarado WTP
Sutherland	1954	Multiple Arch	174	1188	26651	65-San Vicente Reservoir
Otay-Cottonwood System						
Lower Otay	1919	Concrete Gravity	182	741	31940	48-Otay WTP
Barrett	1922	Concrete Gravity	205	746	56897	31-Otay Reservoir
Morena	1897	Rock Filled	284	550	16164	194-Barrett Reservoir
Miramar System						
Miramar	1960	Earth Embankment	155	1189	279	100-Miramar WTP
Hodges System						
Hodges	1919	Multiple Arch	157	729	43604	387-Hodges Reservoir-Olivenhain Reservoir

* Dam Raise

Table 2.10 - City of San Diego Reservoir Statistics						
Reservoir	Watershed Area (Mi^2)	Historical Average Annual Rainfall (in)	Historical Average Annual Evaporation (in)	Primary Storage Function*	CSD Storage Capacity (MG)	CSD Usable Storage (MG)
San Diego River System						
Murray	5	11.63	48.28	E,O	1570	1442
San Vicente	74	15.15	57.69	E,I,S	29879	29244
El Capitan	190	16.09	60.84	E,I,S	36758	35841
Sutherland	54	21.85	50.92	I	9673	9636
Total	323	64.73	217.73	NA	77880	76163
Otay-Cottonwood System						
Lower Otay	98	11.27	52.59	E,O,I,S	17610	15517
Barrett	134	16.66	52.4	I	13550	13355
Morena	114	19.84	61.24	I	16360	16140
Total	346	47.77	166.23	NA	49360	46852
Miramar System						
Miramar	1	12.75	50.13	E,O	2341	2045
Hodges System						
Hodges	248	14.41	56.43	E,I	1629	1078

*E: Emergency Storage, I: Impounding Storage, O: Operational Storage, S: Seasonal Storage

- The effective volume of this system comprises more than half of the emergency water storage requirement for the CSD.
- The San Diego River System covers a combined area of 204,813 acres, or approximately 320 square miles. The Alvarado WTP, located adjacent to Murray Reservoir is the terminus for this source water system and serves the central area of the CSD. The Alvarado WTP has a capacity of 200 MGD and is of conventional design using ozone for primary disinfection and chloramines for secondary disinfection in the distribution system.

Murray Reservoir

The function of Murray Reservoir is to serve as emergency and operational storage to meet Alvarado WTP and city-wide emergency storage needs. Operational storage is between reservoir gauges 88 and 92; the spillway is at reservoir gauge 95.

- Murray Reservoir is located on Chaparral Canyon Stream, a tributary to Alvarado Creek and the San Diego River. Murray Reservoir impounds water transferred from San Vicente, El Capitan, and Sutherland Reservoirs via the El Monte Pipeline, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir is surrounded by a "first-flush bypass system" with a capacity of 39 MGD which diverts runoff from the surrounding 5 square mile watershed; except during large storm events. The reservoir has a storage capacity of 1,570 MG and a surface area of 0.26 square miles at its spillway crest.

- Murray Dam is a multiple arch reinforced concrete structure with a 42-foot-wide uncontrolled over pour spillway at elevation 536 ft Mean Sea Level (ft. MSL). The spillway capacity is 1,309 MGD and discharges to the Pacific Ocean via the San Diego River. The dam crest has a length of 870 ft and stands roughly 112 ft above the streambed.
- The Murray Reservoir Outlet structure consists of an independent wet tower with eight 30-inch saucer valves for selective level draft control. Water is released from the tower through a 48-inch outlet pipe located at the base of the tower with a maximum draft rate of 126 MGD to the Alvarado WTP.

San Vicente Reservoir

The function of San Vicente Reservoir is to serve as emergency and impounding storage to meet Alvarado WTP and city-wide emergency storage needs with a minimum pool of 55,000 AF (inclusive of SDCWA owned water). Seasonal storage is incidental to emergency and impounding storage or as economically justified.

- San Vicente Reservoir is located on San Vicente Creek, a tributary to the San Diego River, and impounds runoff from the surrounding 74 square mile watershed, water transferred from Sutherland Reservoir located in the San Dieguito Watershed via the Sutherland-San Vicente Pipeline, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 79,408 MG and a surface area of 2.6 square miles at its spillway crest.
- San Vicente Dam is a straight concrete gravity structure with a 275-foot-wide uncontrolled over pour spillway at elevation 766 ft. MSL. The spillway capacity is 30,312 and discharges to the Pacific Ocean via the San Diego River. The dam crest has a length of 1,442 ft and stands roughly 317 ft. above the streambed.
- The San Vicente Dam outlet structure is a wet tower integrated into the upstream face of the dam and consists of six outlets for selective level draft control. Water is released from the tower through two gates located at its base. One gate delivers water to a 90-inch pipe which connects to CWA's water system. The second gate delivers water to a 66-inch pipe that connects to both San Vicente Pipeline No. 1 and San Vicente Pipeline No. 2; these two pipelines have a maximum combined draft rate of 76 MGD and transfer the water to the Lakeside Pump Station. From the Lakeside Pump Station, the El Monte Pipeline with a maximum draft rate of 95 MGD delivers the water to either Murray Reservoir for storage or to the Alvarado WTP for immediate use.

El Capitan Reservoir

The function of El Capitan Reservoir is to serve as emergency and impounding storage to meet Alvarado WTP and city-wide emergency storage needs with a minimum pool of 15,000 AF (inclusive of HWD owned water). Seasonal storage is incidental to impounding and emergency storage or as economically justified.

- El Capitan Reservoir is located on the San Diego River and impounds runoff from the surrounding 188 square mile watershed, water transferred from Cuyamaca Reservoir via Boulder Creek, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 36,758 MGD and a surface area of 2.44 square miles at its spillway crest.
- El Capitan Dam is a hydraulic fill rock embankment with an impervious clay core and a 510-foot-wide uncontrolled independent side channel spillway at elevation 750 ft. MSL. The spillway capacity is 110,303 MGD and discharges to the Pacific Ocean via the San Diego River. The dam crest has a length of 1,170 ft and stands roughly 217 ft. above the streambed.
- The El Capitan Reservoir Outlet Structure is an independent wet tower with six 30-inch saucer valves for selective level draft control. Water is released from the tower through two 42-inch and two 36-inch saucer valves located within the base of the tower to the El Capitan Pipeline. The El Capitan Pipeline extends from the tower through an outlet tunnel in the left abutment of dam to the El Monte Pump Station. The pipeline has a 30-inch and a 48-inch blow-off which has a maximum draft rate of 61 MGD to the El Monte Pump Station with a combined 345 MGD maximum draft rate to the pump station and blow-offs. Water from the El Monte Pump Station is transferred via the El Monte Pipeline to the Lakeside Pump Station. From the Lakeside Pump Station, the El Monte Pipeline maximum draft rate increases to 95 MGD and delivers water to either to Murray Reservoir for storage or to the Alvarado WTP for immediate use.

Cuyamaca Reservoir (owned by HWD)

Cuyamaca Reservoir is a tributary stream reservoir to El Capitan Reservoir. Cuyamaca Reservoir is located on Boulder Creek, a tributary to the San Diego River, and impounds runoff from the surrounding watershed. The reservoir has a storage capacity of 3,831 MG at its spillway crest.

- Cuyamaca Dam is an earth-fill embankment with a 30-foot-wide rectangular spillway at elevation 4,635 ft. MSL. The spillway capacity is approximately 2,935 MGD and discharges to El Capitan Reservoir via Boulder Creek. The dam crest has a length of 665 ft and stands approximately 33 ft above the streambed.
- Cuyamaca Reservoir Outlet comprises a 36-inch steel pipeline extending through an outlet tunnel in the dam and a concrete channel downstream of the dam. All water discharged from Cuyamaca Reservoir to El Capitan Reservoir belongs to HWD. In addition, HWD has a separate and exclusive right to 17 MGD of runoff from the Upper San Diego River. The water in El Capitan Reservoir owned by HWD is

transferred to their Levy WTP via the El Capitan Pipeline and El Monte Pump Station. HWD has a right to a minimum draft rate of 20 MGD.

Sutherland Reservoir

Sutherland Reservoir is a tributary system reservoir to San Vicente Reservoir and a tributary stream reservoir to Hodges. Sutherland Reservoir captures, stores, and transfers runoff from the San Dieguito Watershed Basin to the San Diego River Watershed Basin. The function of Sutherland Reservoir is to serve as impounding storage with a minimum pool of 2,680 AF (reservoir gauge 65); plus any additional water reserved for RMWD according to a water exchange agreement. Sutherland Reservoir is not a practical emergency, operational, or seasonal storage site due to its remote location, high elevation, and lack of connections to imported water aqueducts; consequently, runoff impounded in Sutherland Reservoir is transferred to San Vicente Reservoir via the Sutherland-San Vicente Pipeline provided storage capacity is available. Generally, all water above RMWD's contract pool is released.

- Sutherland Reservoir is located on Santa Ysabel Creek a tributary to the San Dieguito River and impounds runoff from the surrounding 54 square mile watershed. The reservoir has a storage capacity of 9,673 MG and a surface area of 0.87 square miles at its spillway crest.
- Sutherland Dam is a multiple-arch reinforced concrete structure with a 168-foot-long uncontrolled over pour spillway at elevation 2,057 ft.MSL. The spillway has a design capacity of 26,651 MGD and discharges to Hodges Reservoir via Santa Ysabel Creek. The dam crest has a length of 1,188 ft. and stands roughly 162 ft. above the streambed.
- The Sutherland Dam Outlet Structure is integrated into the upstream face of the dam and comprises a concrete box at 1940 MSL with two 36-inch outlet pipes each controlled by a 30-inch gate valve. In 1983, RMWD modified their 36-inch outlet with a floating flexible line to permit selective level draft control. Each outlet discharges to the 36-inch Sutherland-San Vicente Pipeline. A 24-inch bypass pipeline with a 20-inch plug valve at the end can be used as a blow off and to control water release into the creek channel below the dam. The maximum draft rate of the Sutherland-San Vicente Pipeline is 65 MGD to San Vicente Reservoir and a combined 225 MGD maximum draft rate to the reservoir and 20 inch blow-off. The RMWD, through a water use agreement with the CSD, transfers water from Sutherland Reservoir via a service connection off the Sutherland-San Vicente Pipeline to their Barger WTP.
- The Sutherland-San Vicente Pipeline discharges into San Vicente Creek at Daney Canyon; two miles north of the San Vicente Reservoir. Since the transfer of water from Sutherland Reservoir to San Vicente Reservoir utilizes a natural water course, the water is usually transferred to San Vicente Reservoir in the spring when the streambed is wet to minimize water loss during transport. Control of the volume and timing of the water transfer is important to minimize water loss, streambed erosion, and accommodate bass spawning (April 1 through May 15) in Sutherland Reservoir; and the federally endangered arroyo toad (*Bufo californicus*) breeding (March 15 through July 1) within the streambed. In coordination with the USFWS, the CSD

has agreed to conduct arroyo toad breeding activity surveys prior to, during, and after the water transfer.

The Otay-Cottonwood System

The Otay-Cottonwood System is comprised of:

- Reservoirs: Otay, Upper Otay, Barrett, and Morena.
- Their respective watersheds.
- Interconnecting pipeline: Dulzura Conduit.

- 11 square mile area of watershed upslope of the Dulzura Conduit that captures runoff into the conduit via a series of diverting structures.
- Water treatment plant: Otay WTP.
- This system captures, stores, and transfers runoff from the Cottonwood Watershed of Tijuana River Watershed Basin to the Otay River Watershed Basin for storage in Otay Reservoir and treatment at the Otay WTP.
- The Otay-Cottonwood System covers a combined area of 225,913 acres or about 353 square miles. The Otay WTP, located adjacent to Lower Otay Reservoir, is the terminus for this source water system and serves the South Bay area of the CSD and the California-American Water Company. The Otay WTP has a capacity of 34 MGD and is of conventional design using chlorine dioxide for primary disinfection and chloramines for secondary disinfection in the distribution system.

Otay Reservoir

The function of Otay Reservoir is to serve as emergency, operational, and impounding storage to meet Otay WTP and city-wide emergency storage needs with a minimum pool of 3,000 AF. Seasonal storage is incidental to emergency and impounding storage or as economically justified.

- Otay Reservoir is located on the Otay River and impounds runoff from the surrounding 97 square mile watershed, water transferred from Morena and Barrett Reservoirs located in the Cottonwood Watershed via the Dulzura Conduit, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 17,610 MG at the top of the central over pour spillway flash gates, 16,243 MG at the crest of the independent spillway, and 15,334 MG at the crest of the central over pour spillway with a surface area of 1.92, 1.78, and 1.61 square miles respectively.
- Savage Dam is a curved concrete gravity structure with a 225-foot-wide gated over pour spillway at elevation 484 ft.MSL and a 201-foot-wide gated independent spillway at elevation 487 ft.MSL. The combined spillway capacity is 31,940 MGD and discharges to the Pacific Ocean via the Otay River. The dam crest has a length of 741 ft. and stands roughly 145 ft. above the streambed. Spillway gates must be fully open during winter from November 1 to April 1.
- Otay Reservoir Outlet Structure is an independent wet tower with seven 30-inch saucer valves for selective level draft control. Water is released from the tower through a 48-inch outlet pipe located at the base of the tower with a maximum draft

rate of 48 MGD to the Otay WTP and a combined 248 MGD maximum draft rate to the treatment plant and blow-off.

Upper Otay Reservoir (no longer used for storage)

Upper Otay Reservoir is a tributary stream reservoir to the Otay Reservoir and is no longer used for storage. The reservoir is located on Proctor Valley Creek, a tributary to the Otay River. The reservoir has a storage capacity of 143 MG and a surface area of 0.06 square miles at the 16-inch outlet invert.

- The Upper Otay Reservoir Dam is a thin flat concrete arch reinforced with wire rope and steel plates with an independent uncontrolled spillway at elevation 550 ft. MSL. The dam crest has a length of 350 ft and stands approximately 68 ft above the streambed. From a seismic analysis of the dam completed by the California Division of Safety of Dams (DSOD), a mandate was issued requiring the maximum storage capacity to be lowered. The dam was reduced in size by creating an uncontrolled central over pour spillway at elevation 535 ft. MSL with a capacity of 6,789 MGD and discharges to Otay Reservoir.
- The Upper Otay Dam Outlet Structure is integrated into the upstream face of the dam and consists of a 16-inch conduit which passes through the right abutment of the dam at elevation 521 ft. MSL with a maximum draft rate of 22 MGD. The structure is passive, which effectively reduces the storage capacity of the reservoir from 921 MG to 143 MG and discharges to Otay Reservoir.

Barrett Reservoir

Barrett Reservoir is a tributary system reservoir to Otay Reservoir and tributary stream reservoir to the Tijuana River. The function of Barrett Reservoir is to serve as impounding storage with a minimum pool of 4,372 AF at its lowest available outlet. Barrett Reservoir is not a practical emergency, operational, or seasonal storage site due to its remote location, high elevation, and lack of connections to imported water aqueducts; consequently, runoff impounded in Barrett Reservoir is transferred via the Dulzura Conduit to Otay Reservoir provided storage capacity is available. Control of the volume and timing of the water transfer is important to minimize water loss and streambed erosion.

- Barrett Reservoir is located on Cottonwood Creek, a tributary to the Tijuana River, and impounds runoff from the surrounding 131 square mile watershed and water transferred from Morena Reservoir via Cottonwood Creek. The reservoir has a storage capacity of 13,550 MG at the top of the spillway flash gates and 11,332 MG at the crest of the spillway with a surface area of 1.4 square miles and 1.3 square miles respectively.
- Barrett Dam is a single curve gravity structure with a 336-foot-wide gated central over pour spillway at elevation 1,607 ft.MSL. The capacity of the spillway is 56,897 MGD and discharges to the Pacific Ocean via the Tijuana River. The dam crest has a length of 746 ft and stands approximately 171 ft above the streambed. Spillway gates must be fully open during winter from November 1 to April 1.
- The Barrett Reservoir Outlet Structure consists of an independent dry tower with three 30-inch saucer valves on the outside and 30-inch gate valves on the inside for

selective level draft control. Each valve is connected to a 30-inch conduit which passes through a tunnel in the right abutment of the dam with a maximum draft rate of 175 MGD and discharges to the Dulzura Conduit. The Dulzura Conduit has the ability to transport 31 MGD and discharges into Upper Dulzura Creek, a tributary to Jamul Creek and the Otay River.

Morena Reservoir

Morena Reservoir is a tributary stream reservoir to Barrett Reservoir. The function of Morena Reservoir is to serve as impounding storage with a minimum pool of 674 AF.

- Morena Reservoir is not a practical emergency, operational, or seasonal storage site due to its remote location, high elevation, and lack of connections to imported water aqueducts, and is considered an inefficient reservoir due to its high evaporative losses; consequently, runoff impounded in Morena Reservoir is transferred to Barrett Reservoir provided storage capacity is available.

- Morena Reservoir is located on Cottonwood Creek, a tributary to the Tijuana River, and impounds runoff from the surrounding 115 square mile watershed. The reservoir has a storage capacity of 16,360 MG and a surface area of 2.41 square miles at its spillway crest.
- Morena Dam is a rock-fill embankment with an impervious upstream face consisting of rubble masonry and concrete with an uncontrolled 312-foot-wide Ogee Crest spillway at elevation 3,039 ft. MSL. The spillway capacity is 16,164 MGD and discharges to Barrett Reservoir via Cottonwood Creek. The dam crest has a length of 550 ft and stands roughly 171 ft above the streambed.
- The Morena Reservoir Outlet Structure consists of an independent dry tower with three 24-inch sluice gate valves on the outside and 24-inch gate valves on the inside for selective level draft control. Each valve is connected to a 30-inch pipe with a maximum draft rate of 194 MGD and discharges through a tunnel in the left abutment of the dam into Cottonwood Creek.

Miramar System

The Miramar System is comprised of:

- Reservoir: Miramar.
- Its respective watershed.
- Water treatment plant: Miramar WTP.

The Miramar Watershed has an area of 645 acres or about one square mile. The Miramar WTP, located adjacent to Miramar Reservoir, is the terminus for this source water system and serves the northern section of the CSD. The Miramar WTP has a capacity of 144 MGD and is of conventional design, using ozone for primary disinfection and chloramines for secondary disinfection in the distribution system.

Miramar Reservoir

The function of Miramar Reservoir is to serve as emergency and operational storage for the Miramar WTP and city-wide emergency storage needs. Operational storage is between reservoir gauges 104 and 106; the spillway is at reservoir gauge 114.

- Miramar Reservoir is located on Big Surr Creek and impounds water from following sources: runoff from its one (1) square mile watershed, receives imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 2,341 MG and a surface area of 0.42 square miles at the spillway crest.
- Miramar Dam is a zoned earth embankment with a 10-foot-wide uncontrolled open channel spillway at elevation 714 ft. MSL. The spillway capacity is 279 MGD and discharges to the Pacific Ocean via Big Surr Creek. The dam crest has a length of 1,189 ft and stands roughly 150 ft above the streambed.

- The Miramar Reservoir Outlet Structure consists of an independent wet tower with seven 36-inch saucer inlet valves for selective level draft control. Water is released from the tower through a 48-inch conduit located at the base of the tower with a maximum draft rate of 100 MGD to the Miramar WTP and a total combined 178 MGD maximum draft rate to the WTP and 24-inch blow-off.

Hodges System

Hodges System is comprised of:

- Reservoirs: Hodges, San Dieguito jointly owned by SDWD and SFID, Olivenhain owned by the SDCWA.
- Their respective watersheds.
- Interconnecting pipelines: San Dieguito/Santa Fe Flume jointly owned by SDWD and SFID, Hodges-Olivenhain Pipline owned by SDCWA.

The Hodges System covers a combined area of 158,281 acres or about 247 square miles. The City has no direct treatment facilities for water impounded by this system. \

- Although the Hodges Watershed is a large watershed in the CSD system it had not been considered a major contributor to the CSD water supply system because from 1969 - 2012 Hodges Reservoir was not connected to the CSD's water system; consequently, the CSD has had no means of delivering the water impounded in Hodges Reservoir to its service area. During this time all impounded water was sold to SDWD and SFID. In 2012, construction of the Hodges-Olivenhain Pipeline and pump station connecting Hodges to Olivenhain was completed as part of the San Diego Water Authority's Emergency Storage Project. This connection provides the ability to transfer water between Hodges Reservoir and the SDCWA Aqueduct System via Olivenhain Reservoir. Subsequently, the CSD now has the ability to utilize the storage capacity of Hodges Reservoir to augment overall emergency and impound storage.

Hodges Reservoir

The function of Hodges Reservoir is to serve as emergency and impound storage with a minimum pool of 8,300 AF according to agreement with SDWD and SFID.

- Hodges Reservoir is located on the San Dieguito River and impounds runoff from the surrounding 247 square mile watershed, water that spills over Sutherland Dam via Santa Ysabel Creek, a tributary to the San Dieguito River, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 9,857 MG and a surface area of 1.74 square miles at the spillway crest.
- The Hodges Dam is a Multiple-arch Buttress Dam with a 342-foot-wide uncontrolled over pour spillway at elevation 315 ft. MSL. The spillway crest consists of 202-foot-wide Ogee weir section and 140-foot-wide broad-crested weir section with a capacity of 43,509 MGD that discharges to the Pacific Ocean via the San Dieguito River. The dam crest has a length of 729 ft. and stands roughly 130 ft. above the streambed.
- The Hodges Dam Outlet Structure is integrated into the upstream face of the dam and consists of four downspouts on the face of the dam for selective level draft control. The downspouts are 20-inch diameter cast iron pipes controlled by 20-inch gate valves with a maximum draft rate 117 MGD that discharge to San Dieguito Reservoir via the San Dieguito/Santa Fe Flume. The San Dieguito/Santa Fe Flume has a maximum draft rate of 13 MGD. The Badger WTP is the terminus of this source water system.
- The Hodges Reservoir Emergency Storage Project has the ability to transfer water between Hodges and Olivenhain reservoirs and consists of an inlet-outlet structure, pump station, and the Hodges-Olivenhain Pipeline.

2.3 Emergency Plans

Typically, the City manages its water supply system to restrict the purchase of imported water and to regulate the reservoir levels to maximize the use of local water. Under all conditions, an emergency supply is maintained in the reservoirs to be available if a failure occurs to the imported water supply system.

The DSOD has jurisdiction over 13 CSD dams. The Dams and Reservoir Team (DRT) in the CSD Public Utilities Department System Operations Division serves as the City's liaison with DSOD and coordinates all dam safety related issues.

One of the City’s most critical responsibilities is to keep CSD dams the safest possible. This requires continuous staff education and training, regular and thorough inspections, and evaluation of the collected data.

The CSD's Dam Instrumentation Program includes piezometer readings of water levels in earth-filled dams, micrometer readings of cracks on concrete dams, leakage readings, survey monument readings and recording of reservoir levels. These readings are taken by trained reservoir keepers on a weekly and monthly basis and by surveyors on annual and semi-annual basis. The data is then compiled, graphed and analyzed monthly by the DRT. On a yearly basis, this information is forwarded in the Annual Dam Instrumentation Report to DSOD for their review. The DRT, with DSOD, conducts annual dam inspections on all CSD Dams. The DRT formally documents and details each inspection through Dam Inspection Reports, which include required maintenance and work items. The reports and their findings are reviewed and discussed with each reservoir keeper. It is also part of the DRT's role to identify, plan check and inspect major capital facility improvements necessary to keep all dams and outlet work facilities in safe and operable condition. This practice ensures that DSOD and CSD comments and concerns are adequately addressed.

Runoff is conveyed through natural water courses in the rural and remote portions of the watershed to their respective storage reservoirs. These systems are not likely to fail due to age and deterioration. Structural conveyance facilities between storage reservoirs are subject to damage by vandalism and major events such as earthquakes, storms, and fires. For these reasons, CSD staff performs inspections of these facilities periodically and after major events. Other problems may be encountered in the pumping process between the reservoirs and the WTPs, and can be minimized through regular maintenance.

There are no written emergency plans addressing accidental or intentional disposal of contaminants to the raw water supply system for the CSD. However, the CSD does have two understood policies to follow if an emergency occurs relating to water quality:

- If a WTP cannot treat the water to an approved health standard level, due to upstream contaminants or treatment plant failure, the WTP shall be shut down. The CSD will then re-direct treated water to the downed service area through the distribution system served by other WTPs [or SDCWA].
- If any emergency exists, the CSD has a chain of communication procedure for notification of CSD staff.