Appendix C.2

Water Quantity

C.2 Water Quantity

Movement of water through the Westside Region is a complex process, and the water balance tool was completed in order to illustrate the movement, storage, and use of water throughout the Region. An overview of the water balance prepared for the Westside Region is described in Section 3 of the IRWM Plan. The following provides supplemental information and technical analyses used to develop the conceptual order of magnitude scale water balance summary.

As noted in Section 3, the water balance is not complete. All the data necessary to complete the water balance is not available and the data included is of varying accuracy. The water balance was developed using an aggregation of existing, available hydrologic and water supply information and reports. This Appendix describes the approaches used to prepare the water balance as well as some of the inconsistencies and limitations of the data available for the Westside Region. This information could be used as a starting point for development of a complete water balance should the Regional stakeholders choose to conduct studies and/or data collection in the future to gain further insight into how water moves through the Region. Figure C.2-1 outlines the key processes that delineate how water moves through the Region.

The availability and movement of water through the Region is highly dependent on the hydrologic conditions for that year; therefore, two water year types were analyzed during this assessment:

- Average Water Year – Used to represent how water moves through the Region during an average hydrologic year. The average hydrologic data (including precipitation and measured flows) of the years 1980-2000 was considered representative of an average year.

- Dry Water Year – Used to represent how water moves through the Region during a dry hydrologic year. For hydrologic data, the year 1988 was used as a representative dry year.

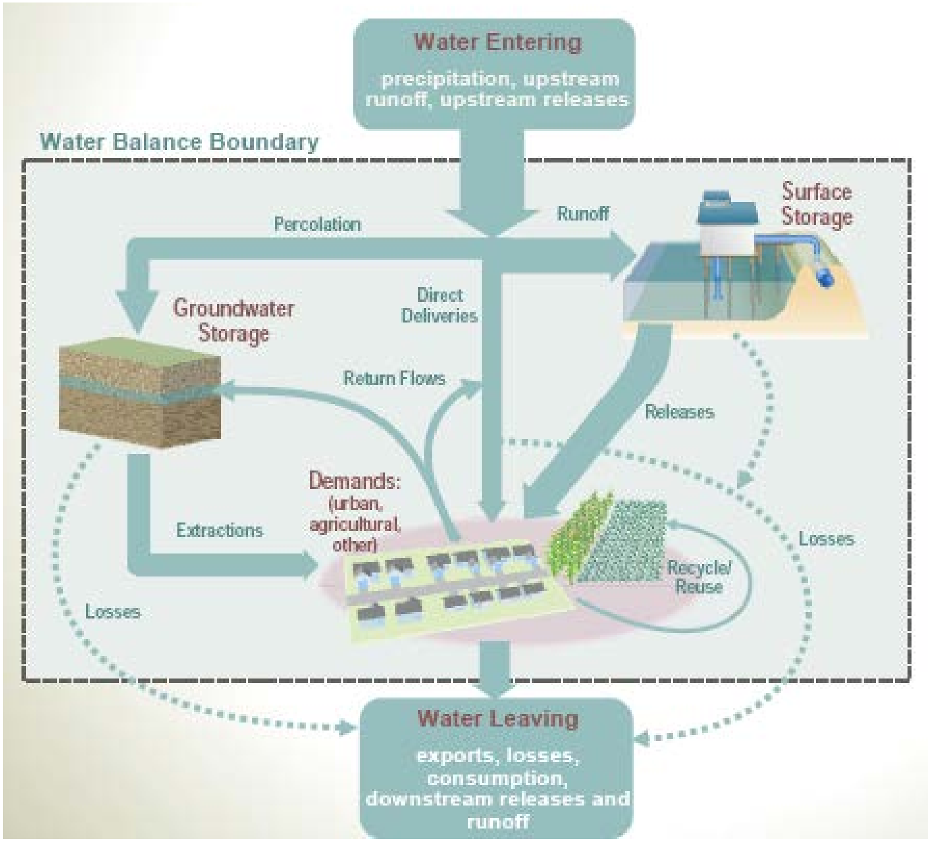

Figure C.2-1: Water Balance Schematic

C.2.1 Water Entering

Water enters each Planning Area of the Westside Region through multiple processes including precipitation, upstream runoff, upstream releases (regulated releases) and the import of water from outside the Region. Each of these is discussed in the following subsections.

C.2.2 Precipitation

Precipitation includes the water provided through rainfall or snow that falls on an area. Wherever possible, watershed level estimates of "unimpaired runoff" were used in the water balance as a surrogate for complex precipitation runoff analyses. Unimpaired runoff is a term referring to the full natural flow of a watershed that would have occurred prior to human influences, such as the construction of dams or diversions. Unimpaired runoff estimates were available for the Upper Cache Creek and Upper Putah Creek watersheds (Department of Water Resources, 2007).

Precipitation was not estimated for the Valley Floor due to a lack of published information that estimates annual rainfall for the entire Planning Area. Unimpaired runoff estimates prepared by the Department of Water Resources that include the Valley Floor PA include the entire Sacramento Valley watershed. The PA-specific data could not be readily extracted, therefore this information was not included.

C.2.3 Upstream Runoff

Upper Cache and Upper Putah Planning Areas are located at the upstream ends of each watershed, and therefore there is no upstream runoff into these Planning Areas. The Valley Floor PA upstream runoff was calculated as the sum of the measured flow from the Upper Putah and Upper Cache Creek watersheds minus the Upstream Releases (based on gage data).

C.2.4 Upstream Releases (Regulated Releases)

Upper Cache and Upper Putah Planning Areas have no upstream releases (regulated releases) because these watersheds are located at the top of the Region and there are no significant releases into the Planning Areas. Valley Floor upstream release inflows were calculated as the sum of the Solano Project direct deliveries, which includes releases from Lake Berryessa, and the Yolo County Flood Control & Water Conservation District (YCFCWCD) direct deliveries from Indian Valley Reservoir and Clear Lake.

C.2.5 Imported Water

Water supplies whose source water originated outside of the Westside Region boundary are categorized as imported surface water. Imported water supplies are used directly and not stored within the region. Upper Cache and Upper Putah Creek PAs do not receive any Imported Water. Valley Floor PA does use a significant amount of imported water. Many purveyors on the eastern side of Yolo County use riparian or appropriative water rights to divert water for agricultural and municipal uses from the Sacramento River, the state's largest river, or the Colusa Basin Drain. Some agencies within the Region also have contracts or agreements for deliveries from the Federal Central Valley Project (CVP) and California State Water Project (SWP) and their contractors.

Imported Water Infrastructure

Imported water infrastructure in the Region consists of many water intake facilities situated along the Sacramento River and in the Delta. In addition, the Tehama-Colusa Canal and Colusa Basin Drain are two prominent water canals that convey water into the Region across the Colusa/Yolo County Boundary.

a) North Bay Aqueduct

The North Bay Aqueduct (NBA) is a component of the SWP and provides water to several agencies in Solano County, including the City of Vacaville. The SWP supply originates in the Feather River watershed and is stored in Lake Oroville. Releases from Oroville flow into the Feather River until its confluence with the Sacramento River at the northeastern corner of the Region near Knight's Landing. The NBA was built by DWR in 1988 as part of the State Water Project to serve water users in Solano and Napa Counties. The NBA consists of an intake structure and pumping plant at Barker Slough in the Delta in the southeastern section of the Region. The 28 mile long NBA travels westerly through the region and terminates at the Cordelia Forebay, just outside the Westside Region. Water supply through the NBA is currently limited by pumping capacity and the water quality of Barker Slough. The North Bay Aqueduct has a design flow of 154 cfs; however pumping tests have shown that the maximum delivery is limited to 142 cfs. The SWP full contract amount that is to be served through the North Bay Aqueduct is 175 cfs. (SCWA, 2005)

b) Sacramento River Diversions,

There are several existing diversions along the Sacramento River that provide water for agricultural and M&I uses. One example of a diversion facility is the Reclamation District 2035 (RD 2035) diversion in eastern Yolo County. The Conaway Conservancy Group has appropriative rights on the Sacramento River, Willow Slough, and Cache Creek as well as CVP settlement water. RD 2035 currently diverts water from the Sacramento River via a large pumping plant near Vietnam Veterans Bridge on Interstate-5 (Water Resources Association of Yolo County, 2007) which is used to irrigate approximately 17,000 acres of agricultural lands, owned by the Conaway Conservancy Group.

c) Tehama-Colusa Canal

The Tehama-Colusa Canal is part of the United States Bureau of Reclamation CVP and serves users in Tehama, Glenn, Colusa and Yolo Counties. It begins north of the Region at the Red Bluff Diversion Dam and terminates in the northern portion of Yolo County. The Tehama-Colusa Canal provides agricultural water supplies for Colusa County Water District and Dunnigan Water District.

d) Colusa Basin Drain

The Colusa Basin Drain (Drain) runs southerly beginning in Glenn County and continues for 70 miles to Knights Landing in Yolo County, where there is a 7 mile extension of the drain that allows water to drain into the Yolo Bypass. The Drain consists of water from multiple sources including natural runoff, return flow from Sacramento River diversions, and other local sources. Water from the Drain is used for agricultural purposes by several Reclamation Districts.

e) Drinking Water Supplies

Drinking water supply is an important use of imported water; two of the three major surface water treatment plants in the Region (West Sacramento and Vacaville) treat water from imported sources, while the third draws water from Lake Berryessa (Vacaville). The City of West Sacramento's Bryte Bend Water Treatment Plant (WTP) treats Sacramento River water and has a design capacity of 58 million gallons per day (MGD). The permitted capacity of the Bryte Bend WTP is 40 mgd between November and March (City of West Sacramento 2010 UWMP). The North Bay Regional Water Treatment Plant (NBR WTP) is jointly owned by the Cities of Vacaville and Fairfield and treats water from both the Putah South Canal (Solano Project) as well as the North Bay Aqueduct (SWP). The NBR WTP has a capacity of 13.3 MGD designated for the City of Vacaville (Vacaville 2010 UWMP). The NBR WTP presents an example of interregional collaboration and the sharing of limited water resources to enhance supply reliability. The City of Vacaville also has a diatomaceous earth treatment plant that treats water from Lake Berryessa with a firm capacity of 10 MGD (Vacaville 2010 UWMP).

Reliability of Imported Supply

The amount of imported water available for a given application is highly variable and depends on hydrologic conditions in northern California, the season and timing of diversion, and a number of water rights and contractual factors specific to each water supply source. The actual amount of water diverted by each purveyor varies and depends on a number of conditions, such as applied water needs, climactic conditions, and mandated cutbacks. It is anticipated that the currently available water supply will continue to be available through the 2035 planning horizon under normal conditions, unless otherwise indicated.

a) Sacramento River Diversions

Most water diversions from the Sacramento River are appropriative or riparian water rights diversions approved through the State Water Resources Control Board (SWRCB) and are reliable sources under many conditions. Exceptions include potential Term 91 curtailments enacted by the SWRCB on appropriative water rights holders, which can require reductions in diversions starting with the most junior water rights holders on the river. For example, in 1991 and 1992, the City of West Sacramento was prohibited from diverting water from the Sacramento River using its appropriative water rights between the months of June and October (Carollo Engineers, 2011) Fortunately, the City of West Sacramento has access to multiple water rights sources and contracts, including pre-1914 water rights from the North Delta Water Agency (NDWA) and is therefore expected to be able to avoid supply shortages in most conditions.

b) State Water Project Supplies

State Water Project (SWP) supplies are shared by 29 water contractors throughout the State of California and therefore shortages affecting the SWP operations as a whole can also impact the North Bay Aqueduct diversions. Shortages experienced during dry years are proportional to their share of the overall contract with DWR. The City of Vacaville is also entitled to Settlement Water from DWR, which is made available in settlement of area-of origin water rights applications made by the cities of Fairfield, Benicia, and Vacaville. Settlement water is not considered SWP water (Nolte Associates, Inc., 2011).

The reliability of SWP deliveries is contingent upon a number of complex factors. The amount of SWP water supply delivered to contractors in a given year depends on the demand for the supply, amount of rainfall, snowpack, runoff, water in storage, Delta pumping capacity, and legal constraints on SWP operations. SWP delivery reliability depends on three general factors: 1) the availability of water at the source, 2) the ability to convey water from the source to the desired point of delivery and 3) the magnitude of demand for the water (Solano County Water Agency, 2011). Reliability projections are determined using DWR's State Water Project (SWP) Delivery Reliability Report, which was most recently updated in 2011.

c) Central Valley Project Supplies

The City of West Sacramento and Dunnigan Water District receive water from the USBR's Central Valley Project (CVP), which supplies water from the Sacramento River and storage in Lake Shasta. Water availability to CVP contractors is determined at the discretion of USBR, and is based on a combination of operational objectives, hydrologic conditions, reservoir storage conditions, and environmental needs. There is no limit on the shortage that USBR can impose on M&I or agricultural user's CVP water. In fact, USBR can reduce their CVP water delivery to zero. In 1992, the City of West Sacramento's CVP Diversions were reduced by 75 percent. Fortunately the City was able to use alternative water supplies to supplement these deficits. (Carollo Engineers, 2011)

d) Colusa Basin Drain

The Colusa Basin Drain (Drain) supply is dependent upon natural runoff and return flow from upstream Sacramento River diversions, therefore water is not assured or always available at the same time it is desired. Initially water users along the Drain had inadequate water rights to allow for the full use of water from the Drain so the 2047 Drain Water Users' Association was formed and negotiated a supplemental water supply contract with the U.S. Bureau of Reclamation. The contract became effective in 1988 and the Association became the Colusa Drain Mutual Water Company (MWC). The contract has a maximum project water quantity determined by the acreage irrigated on a year by year basis, which will not exceed 100,000 AFY (Water Resources Association of Yolo County, 2007). Much of the Colusa Drain MWC service area extends north of the Region along the Drain in Colusa County.

Summary of Imported Water

Table C.2-1 provides a summary of the imported water available in acre-feet per year (AFY) within the Region, categorized by supply source and purveyor. The table includes the current end uses of the supply diversions; whether it is for agriculture or municipal and industrial (M&I) purposes, as well as the average year and dry year supply projected in the water balance. The actual quantity of water diverted by each purveyor varies and depends on a number of conditions, such as applied water demands, contracts, climactic conditions, system operations, and regulations. It is anticipated that the currently available water supply will continue to be available through the 2035 planning horizon under normal conditions, unless otherwise stipulated.

Table C.2-1: Imported Surface Water Supplies

Imported Source/Purveyor	End Uses	Expected Available Supply[(a)] Average Year (AFY)	Potential Available Supply Dry Year (AFY)
Sacramento River [(c) (f)]			
Reclamation District 108	*Ag*	33,000	19,800
River Garden Farms	*Ag*	500	300
Colusa Basin Drain MWC	*Ag*	3,660	2,196
Conaway Conservancy Group	*Ag*	50,190	30,114
Reclamation District 108	*Ag*	199,000	119,400
Reclamation District 787 (River Garden Farms)	*Ag*	29,300	17,580
Woodland-Davis Clean Water Agency	*M&I*	45,000	27,000
City of West Sacramento[(d)]	*M&I*	28,600	18,350
Reclamation District 2068	*Ag*	75,000	45,000
Reclamation District 999	*Ag*	95,600	57,360
Subtotal – Sacramento River[(a)]		*549,600*	*329,760*
Colusa Basin Drain[(c) (f)]			
Colusa Basin Drain Mutual Water Company	*Ag*	Unknown	Unknown
Reclamation District 108	*Ag*	33,000	13,200
Reclamation District 787	*Ag*	1,090	436
Other	*Ag*	3,410	1,364
Subtotal – Colusa Basin Drain		*37,500*	*15,000*
Settlement Water (DWR)			
City of Vacaville[(d)]	*M&I*	9,320	9,320
State Water Project (SWP)[(d)]			
City of Vacaville	*M&I*	5,746	5,656
City of Dixon	*M&I*	960	945

Imported Source/Purveyor	End Uses	Expected Available Supply[(a)] Average Year (AFY)	Potential Available Supply Dry Year (AFY)
City of Rio Vista	*M&I*	960	945
Subtotal – State Water Project		*7,666*	*7,546*
Central Valley Project (CVP)[(c)]			
City of West Sacramento	M&I	(d)	(d)
River Garden Farms	*Ag*	500	500
Dunnigan Water District	*Ag*	19,000	4,750
Subtotal – Central Valley Project		*19,500*	*5,250*
Total Imported Supplies		***623,586***	***366,876***

(a) Available supply is the total reported water right, entitlement, or contract (may be reduced in dry years)
(b) TBD – to be determined
(c) WRA of Yolo County IRWMP – Appendix A
(d) City of Vacaville 2010 UWMP, City of West Sacramento 2010 UWMP. City of Vacaville DWR Settlement water includes Kern County Water Agency Settlement Agreement water. City of West Sacramento Sacramento River water supply includes CVP contracts and appropriative rights.
(e) All imported water sources are supplies within the Valley Floor PA water balance boundary.
(f) Dry Year assumes 60% reliability.

C.2.6 Water Within

The water within the balance boundary refers to movement and storage of water within each Planning Area. The available water versus the water demand within an area are estimated to highlight any deficiencies in water supply or highlight areas where improvements to conjunctive use or water conservation might be applied to improve water management within the Region. To describe this, the water within was simplified into two major categories: Water Supplies and Applied Water Demand.

C.2.6.1 Water Supplies

C.2.6.1.1 Direct Deliveries

Direct deliveries include upstream releases, imported water as well as water diverted under riparian and appropriative water rights and delivered to end users. Upper Putah and Cache Creek PAs do not have upstream releases or imported water, water supply is predominantly obtained from storage, and any appropriative or riparian water rights along streams were not quantified. Direct Deliveries to the Valley Floor PA are assumed equal to the sum of upstream releases from the Upper Cache and Putah Creek watersheds and imported water from outside the region. Water diverted from Cache and Putah Creek under riparian and appropriative water rights are unknown and therefore not quantified.

Cache Creek

Water from Cache Creek and Clear Lake is an important supply source and provides municipal and agricultural supply for users around Clear Lake in Lake County and agricultural supply in Yolo County. The Yolo County Flood Control and Water Conservation District (YCFCWCD) owns and operates the Cache Creek Dam consistent with the Gopcevic Decree, issued in 1920, which regulates how much water can be stored in Clear Lake during non-flood and flood conditions. YCFCWCD stores up to 150,000 AFY in Clear Lake for agricultural water use in Yolo County as allowed in the Solano Decree, which was approved in 1978. In 1975, YCFCWCD completed constructing the Indian Valley Reservoir, located on the North Fork of Cache Creek, to help meet agricultural water demands within Yolo County during dry years that could not be supplied by Clear Lake alone. Indian Valley Reservoir also provides 40,000 AF of reserve capacity for flood control out of its 300,600 AF total storage. (Water Resources Association of Yolo County, 2007)

Putah Creek

Runoff from the upper watershed of Putah Creek in Lake and Napa Counties is captured in Lake Berryessa. Lake Berryessa was created by the construction of Monticello Dam which provides a maximum storage capacity of 1,600,000 AF. Water stored in Lake Berryessa is part of the Solano Project, a federal project with the Bureau of Reclamation operated by Solano County Water Agency (SCWA) that supplies water to agencies in Solano County. Solano County agencies and USBR first conceived the project in the 1940s and 1950s to meet the increasing water demands of agriculture, municipalities and military facilities within Solano County.

The Solano Project provides water to agencies inside and outside the Westside Region. Solano Irrigation District, the City of Vacaville, UC Davis, and Main Prairie Water District all receive Solano Project water and are within the Westside Region; agencies outside the Region are the City of Vallejo, City of Fairfield, Suisun City, City of Benicia, and California State Prison – Solano. The contracted water supply (plus operational losses) for the Solano Project total 207,350 AFY, which is roughly consistent with USBR's estimation of "firm yield". Firm yield is the calculated amount of water supply available during the driest hydrologic period of record for the project. Approximately 154,873 AFY is allocated to water agencies within the Region, as summarized in Table C.2-2. (Solano County Water Agency, 2005)

Table C.2-2: Solano Project Water Supply Allocations within the Westside Region

Agency	Contract Amount
Maine Prairie Water District	15,000
California State Prison – Solano	1,200
Solano Irrigation District	141,000
City of Vacaville	5,750
UC Davis	4,000
Project Operating Losses[(b)]	(12,077)
Total – Solano Project (in Region)	***154,873***

(a) Source: Solano IRWMP, Appendix A, Page 12 – Table 2.
(b) Project operating losses are assumed at 15,000 AFY of total diversions and have been proportioned relative to the Solano county based contracts.

Other Local Supplies

Other surface water supplies in the Westside Region include riparian diversions from local streams and waterways. The Willow Slough and Willow Slough Bypass is located in between the Cache Creek and Putah Creek Watersheds and provides an intermittent water supply in Yolo County. Existing water rights diversions from the Willow Slough Bypass include 13,600 AFY by Conaway Ranch. Conaway Ranch water rights also include 10,000 AFY from Cache Creek.

C.2.6.2 Surface Water Storage

Surface water storage is a significant water resource for many users. Table C.2-3 summarizes the major reservoirs and dams in the Region, with their net usable capacity, as well as their average year and dry year estimated carryover storage. Carryover storage was estimated as the level in the reservoir as measured on October of the water year.

Table C.2-3: Major Lakes and Reservoirs

Reservoir	Planning Area	Dam	Net Usable Capacity (AF)	Average Year Carryover Storage (AF) [a]	Dry Year Carryover Storage (AF) [b]
Indian Valley Reservoir [c]	Upper Cache	Indian Valley Dam	300,600	153,600	50,600
Clear Lake [d]	Upper Cache	Cache Creek Dam	313,000	66,400	42,300
Lake Berryessa [e]	Upper Putah	Monticello Dam	1,602,000	1,103,000	965,300

(a) Average of water stored in October 1 of each water year between the period of 1980-2000.
(b) Water stored in October for water year 1988.
(c) (California Data Exchange Center, Sta. INV)
(d) (California Energy Commission, Sta. CLA)
(e) (California Data Exchange Center, Sta. BER)

Local Release Deliveries

Local release deliveries include deliveries within each PA that are directly released from water storage originating in that PA.

Local releases within the Cache Creek PA consists of releases from Clear Lake. YCFCWCD is contracted to provide up to approximately 23,700 AF of surface water to 16 purveyors around Clear Lake. Most of the water is used for municipal purposes. Users in Lake County reportedly have never used their full contractual amounts. About 7,950 AF of this amount is also allotted to the Geysers hydrothermal project outside the Region.

Local releases within the Upper Putah Creek PA consist of releases from Lake Beryessa; however, local release amounts are unknown and are therefore not quantified.

There are no large storage facilities in the Valley Floor PA, therefore local releases are shown as zero.

Reliability of Regional Surface Supplies

The reliability of water available from the Cache Creek, Putah Creek, and other local direct water supplies vary due to hydrologic conditions and various other constraints. As previously described, Cache Creek and Clear Lake diversions are dictated by the Solano Decree; for this reason the quantity of water available for diversion from this source can be as little as 0 AF under the driest of conditions. In most cases however, water is available to customers that depend on surface water supplies from the Cache Creek watershed. Similarly, the Solano Project supply from Lake Berryessa was determined based on the firm yield that the reservoir can provide which is up to several years' of storage, and is therefore expected to be highly reliable under most conditions (SCWA, 2011).

C.2.6.3 Groundwater Storage

Groundwater is also an essential water supply resource to the Region. The following descriptions of groundwater have been separated into Planning Area level discussions due to the unique aquifer characteristics in each area of the Westside Region. The groundwater basins are also briefly described and shown in Section 2.

Upper Cache Creek and Upper Putah Creek Planning Areas Groundwater Basins

Groundwater in the upper watersheds is extracted primarily from shallow alluvial deposits, the fractured sedimentary and metamorphic rock of the Franciscan Formation, and the Clear Lake volcanic deposits. Significant information is available for the major alluvial aquifers; however, there is very little information available for fractured bedrock and volcanic aquifers. The geologic and hydrologic characteristics of each groundwater basin differ with respect to many factors including the distribution of aquifer materials of varying permeability and material composition, sources of recharge, distribution over area and depth, and presence of boundaries or faults that limit groundwater flow.

Groundwater basins in the Upper Cache PA are the High Valley, Burns Valley, Lower Lake, Long Valley, Clear Lake Cache Formation, Middle Creek, Clear Lake Pleistocene, North Fork Cache Creek and Bear Valley. Limited information is available for these basins. It is known that groundwater levels in High Valley Basin has fluctuated significantly over the years; due to low recharge rates, groundwater levels are slow to recover following droughts. In the Upper Putah Creek Planning Area, the groundwater basins are composed primarily of alluvial deposits found in Coyote Valley, Collayomi Valley, Pope Valley and Berryessa Valley. The fractured metamorphic rock of the Clear Lake volcanic deposits which form the Clear Lake Pleistocene Basin are also found in the Planning Area.

Table C.2-4 provides a summary of the groundwater basins, formation type, approximate thickness, estimated storage capacity, and sustainable yield (if available).

Table C.2-4: Groundwater Basins in the Upper Cache Creek and Upper Putah Creek Planning Areas

Basin	Formation Type	Approximate Thickness (feet)	Usable Capacity (AF)[c]	Sustainable Yield
Upper Cache Creek Planning Area				
Upper Lake Valley Basin	Alluvium, terrace deposits, lake deposits	NKD[a]	5,000	NKD
Scotts Valley Basin	Alluvium, lake deposits, terrace deposits	40-105	4,500	NKD
Big Valley Basin	Alluvium, volcanic ash	30-430	60,000	NKD
High Valley Basin	Alluvium, volcanics	100	900	NKD
Burns Valley Basin	Alluvial, terrace depostis, lake deposits	250	1,400	NKD
Lower Lake Basin[b]	Alluvium, Lower Lake Formation	50-75	NKD	NKD
Long Valley	Alluvium	NKD	NKD	NKD
Clear Lake Cache Formation Basin	Cache Formation (alluvium and lake deposits)	13,000	NKD	NKD
Middle Creek Basin	Alluvium	NKD	NKD	NKD
Clear Lake Pleistocene Volcanics	Volcanics	1,600	NKD	NKD
North Fork Cache Creek Basin[c]	Alluvium	NKD	NKD	NKD
Bear Valley Basin	Alluvium	NKD	NKD	NKD
Upper Putah Creek Planning Area				

Basin	Formation Type	Approximate Thickness (feet)	Usable Capacity (AF)[c]	Sustainable Yield
Coyote Valley Basin	Alluvium, volcanics, Cache Formation	100-300	7,000	NKD
Collayomi Valley Basin	Alluvium	350-475	7,000	NKD
Pope Valley	Alluvium	25-30	7,000	NKD
Berryessa Valley	Alluvium	NKD	NKD	NKD

(a) NKD = No known data
(b) Thickness and storage capacity of the Lower Lake Formation are not included because the information is not known
(c) The North Fork Cache Creek Basin underlies Indian Valley Reservoir and is not used for water supply.
Sources: Lake County Groundwater Management Plan, DWR Bulletin 118

a) Percolation/Natural Recharge

Natural recharge can be variable and difficult to quantify for the multiple groundwater basins in the upper watersheds. The natural recharge is assumed to be equal to the estimated usable capacity developed for each of the groundwater basins. These values may be amended or updated in future iterations of the IRWM Plan as additional information becomes available.

b) Infrastructure

There are thousands of water supply wells in the Upper Cache and Putah Planning Areas. Many in Lake County rely on groundwater as a water source. Lake County has approximately 3,700 domestic/municipal wells, 800 irrigation wells and 800 other wells. Over 50 percent of domestic wells are shallow, less than 100 feet deep, and over 50 percent of irrigation wells are less than 125 feet deep (CDM, 2006c).

c) Reliability of Groundwater Supplies

Groundwater supply in the Upper Putah Creek Planning Area mainly comes from the Coyote Valley Basin and Collayomi Valley Basin. These basins rely on Putah Creek as their major groundwater recharge source. Historically the groundwater levels in these basins have remained fairly constant. Spring water levels in the Coyote Valley Basin are generally within 10 to 15 feet below ground surface; over the summer the water levels fluctuate between 5 to 10 in the eastern portion and 20 to 25 feet in the western portion of the basin. Spring water levels in the Collayomi Valley Basin are generally within 3 to 15 feet below ground surface and fluctuate between 5 and 20 feet through the summer. The Collayomi Valley Basin alluvium, which is the source of water for Middletown and nearby agricultural land, ranges from 350 to 475 feet.

The major groundwater supply basins in the upper watersheds are Big Valley, Scotts Valley, and Upper Lake Valley. Historically, the groundwater levels in these basins have remained fairly constant. The Big Valley Basin is composed of an alluvial portion in the north and volcanic ash in the south. In the northern portion, groundwater levels are typically shallow in the spring, within 5 feet of ground surface, and decrease from 10 to 50 feet through the summer. In the southern portion, spring groundwater levels begin around 70 to 90 feet below ground and drawdown 30 to 40 feet over the summer. Spring water levels in Scotts Valley Basin are generally within 10 feet of ground surface and fluctuate between 30 and 60 feet between spring and fall. Spring water levels in the Upper Lake Valley Basin are generally within 10 feet of the ground surface and fluctuates between 5 and 15 feet between spring and fall.

Groundwater levels appear to recover in most years in the primary groundwater basins, therefore it is assumed that groundwater supplies are reliable under most hydrologic conditions. There are some indications of temporary water level declines during drought periods, but the groundwater basins appear to recover fairly rapidly. There is no quantification that suggests placing a limit in groundwater pumping capacity that is more restrictive than the estimated sustainable yield for each basin.

In order to ensure a zero net change in groundwater levels, it is assumed that future extractions of groundwater will be limited to the available groundwater supplies (sum of the natural recharge and any artificial recharge).

Valley Floor Planning Area Groundwater Basins

The Valley Floor Planning Area is underlain by several subbasins of the Sacramento Valley Groundwater Basin, namely the Capay Valley Subbasin, Colusa Subbasin, Yolo Subbasin and Solano Subbasin. The water bearing formations of these basins are essentially contained within two stratigraphic units: (1) the older thick alluvial and river sediments of the Tehama formation, and (2) the younger sediments, floodplain deposits, and stream channel deposits that overlie the Tehama formation. Table C.2-5 provides a summary of the Valley Floor PA groundwater basins, formation type, approximate thickness, estimated storage capacity, and sustainable yield (if available).

Table C.2-5: Groundwater Basins in the Valley Floor PA

Basin	Formation Type	Approximate Thickness (feet)	Storage Capacity (AF)	Sustainable Yield
Colusa Subbasin	Alluvium, Tehama Formation	2,000	13,025,887	NKD[a]
Capay Valley Subbasin	Tehama Formation	1,000	99,800	NKD
Yolo Subbasin	Young alluvium, older alluvium, Tehama Formation	3,000	6,455,940	NKD
Solano Subbasin	Young alluvium, older alluvium, Tehama Formation	3,000	1,750,000	NKD

(a) NKD = No known data
Sources: Yolo County Integrated Regional Water Management Plan, DWR Bulletin 118

In Yolo County, studies of the groundwater subbasins have been divided into vertical zones of shallow, intermediate and deep. While there are no regionally continuous barriers to vertical flow, clay and silt layers act as impediments to vertical flow and the zone designations roughly correlate to geologic units and water well completion depths. The shallow zone, which extends to about 220 feet below ground surface, is the zone in which most domestic wells and many irrigation wells are located. The intermediate zone, which extends from 220 to 600 feet below ground surface, is the zone in which most public supply and irrigation wells exist. The deep zone, which extends from 600 to 1,500 feet below ground surface, contains relatively softer water and a few municipal wells for the City of Davis and UC Davis.

In Solano County, the Solano Subbasin can be divided smaller subareas. The Putah Creek Fan represents the most productive groundwater area. The Putah Creek Fan lies on the eastern edge of Solano County and consists of alluvium deposited by Putah Creek after the creek leaves the Vaca Mountains and enters the Valley Floor. The alluvial deposits range from 50 to 130 feet in depth. Beneath the young alluvium the Tehama Formation extends for roughly

3,000 feet. The Los Putos Foothills area lies between Vacaville and Lake Solano. This region is not a significant source of groundwater as it consists of disparate pockets of shallow alluvium and few gravel layers are found in the upper 1,000 feet of the Tehama Formation. The Southwest Putah Plain area lies to the south and west of the Putah Creek Fan. The alluvial deposits in this area are not as productive as the Putah Creek Fan as they consist of shallower clay deposits. The underlying Tehama Formation is the major water bearing unit in this area with wells for the City of Vacaville completed at depths up to 1,200 feet.

a) Percolation/Natural Recharge

The percolation is assumed to be equal to the estimated usable capacity developed for each of the groundwater basins. The Yolo County Integrated Groundwater/Surface Water Model was developed in 2006 and includes a full model of the hydrologic system in Yolo County. The natural recharge of the basins underlying Yolo County, and including a recharge buffer zone along Putah Creek which includes a portion of Solano County was estimated at 483,751 AFY (Water Resources & Information Management Engineering, Inc., 2006). The estimated natural recharge in Solano County is 40,000 AFY (Summers Engineering, Inc., 2003).

b) Artificial Recharge

Artificial recharge includes aquifer storage and recovery activities. Some agencies in the Westside Region, including YCFCWCD have explored and currently practice active groundwater recharge operations by maintaining flows in Cache Creek, which eventually percolates into and recharge the aquifer. YCFCWCD is able to accomplish this through operation of Indian Valley Reservoir and releases from Clear Lake. YCFCWCD is also exploring the potential for enhancing conjunctive use through percolation of water in their unlined canals during the non-growing season. (Water Resources & Information Management Engineering, Inc., 2006)

c) Groundwater Infrastructure

Groundwater infrastructure represents a significant investment of many water purveyors, farmers, and domestic self-suppliers in both Yolo and Solano Counties. There are more than 7,500 wells in Yolo County (Ludorff and Scalmanini, 2004). Many of the communities, including Woodland, Davis, Rio Vista, Winters, and Dixon rely wholly on groundwater to meet expected water demands. Some suppliers including Davis and UC Davis have begun to construct wells in the deeper portion of the Tehama formation in order to obtain improved water quality. Information on the number of wells specific to the portion of Solano County within the Region was not available.

C.2.6.4 Return Flows

Return flows include runoff from agricultural irrigation or outside landscape irrigation in developed areas that either reenter the surface water system, or percolate into the aquifers and are later recoverable. The term return flows refers to the part of applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface water body. For purposes of this IRWM Plan return flows were determined by the following equations:

Return Flows = Water applied – Water required

*Water required = Irrigation Efficiency (IE) * Water applied*

Substituting the second equation into the first,

Return Flows = Water applied – IE Water applied = (1- IE) * Water applied*

There are three types of return flows: agricultural, urban, and recycle/reuse. Actual return flows are a function of actual water applied within the study area. In certain year types, especially drier conditions there may not be enough water available to supply the total projected applied water need. Typically row and field crops in the Region have been fallowed, which would in turn reduce the total available return flows. Since the crop acreage that will be required to be fallowed in the future is not currently well understood, therefore return flows for agriculture were shown as constant for the dry and average year.

Agricultural Return Flows

Agricultural return flow rates were determined using the projected range of supply available for agricultural use and an irrigation efficiency of 75 percent. Assuming an irrigation efficiency of 75 percent and the equation above, agricultural return flows would be 25 percent (1-0.75 = 0.25) of the water applied to crops. The agricultural water applied was assumed to be equal to the water available for agricultural use and was estimated by applying the projected percentages of agricultural demand to the total projected water deliveries (sum of the surface deliveries, imported water deliveries, recycled water, natural and artificial recharge, and return flows). Basing the return flows on the available supply, as opposed to demand, allows for a better representation of future supplies. Estimates based on demand can overestimate supply since they include return flows on future demands which may not be met if there is not sufficient supply. Table C.2-6 provides the projected agricultural return flows.

Previous studies have indicated that there is some time-delay between when the water is applied to when it actually reaches the aquifer, however these estimates have varied from 1 to 2 years to as much as 10 years (USGS 2003). Time delays are extremely difficult to estimate and may vary by geographic location. However, for the purposes of this IRWM Plan, no time-delay is included since the water budget comparison is for long-term averages over the entire basin (or steady-state conditions), which absorb the variations from the time-delay.

Table C.2-6: Estimated Agricultural Return Flows, AF

Planning Area	Year Type	2010	2015	2020	2025	2030	2035
Valley Floor PA	Average	362,498	362,498	362,498	362,498	362,498	362,498
	Dry	388,654	388,654	388,654	388,654	388,654	388,654
Upper Cache PA	Average	7,680	7,680	7,680	7,680	7,680	7,680
	Dry	10,211	10,211	10,211	10,211	10,211	10,211
Upper Putah PA	Average	2,412	2,412	2,412	2,412	2,412	2,412
	Dry	2,796	2,796	2,796	2,796	2,796	2,796

a) Municipal and Industrial Return Flows

The ratio of indoor to outdoor water use for the Westside Region was used to estimate the return flows to the surface water system or deep groundwater percolation resulting from municipal and industrial water use. The statewide average for outdoor water use is approximately 50 percent of total residential demand. Summer water demand is then assumed to be equivalent to the total indoor and outdoor water use, while it is assumed that winter urban water use includes the indoor component only (as there is very little outdoor watering during this season). Thus, subtracting the winter M&I water use from the summer water demand would yield an estimate of outdoor water use for the Westside Region. The outdoor water use is then compared to the total water demand to get a percentage of outdoor water usage.

As with agricultural use, an irrigation efficiency of 75 percent is assumed, and thus M&I return flows are 25 percent of outdoor M&I applied water. Outdoor urban applied water was assumed to be 70 percent of total urban applied water. As with agricultural use, the total urban applied water was assumed to be the water available for urban use and was determined by applying the projected percentages of urban to the total projected water deliveries. Table C.2-7 provides a summary of anticipated urban return flows.

Table C.2-7: Municipal and Industrial Return Flow Estimates, AF

Planning Area	Year Type	2010	2015	2020	2025	2030	2035
Valley Floor PA	Average	10,416	11,938	12,208	13,182	14,160	15,389
	Dry	10,416	11,938	12,208	13,182	14,160	15,389
Upper Cache PA	Average	1,596	1,729	1,874	2,033	2,207	2,396
	Dry	1,596	1,729	1,874	2,033	2,207	2,396
Upper Putah PA	Average	276	314	359	412	475	549
	Dry	276	314	359	412	475	549

C.2.6.5 Recycled/Reused Water

b) Recycled Water Sources

Community wastewater collection, treatment, and disposal systems serve larger, more urbanized populations. The majority of domestic wastewater in the Westside Region is treated by community wastewater systems. Community wastewater systems influence how water moves within the Region and the availability of recycled water. Wastewater which is disposed of within the Region and is not currently consumptively used represents a source of water that could be captured for reuse. Table C.2-8 summarizes the current disposal methods for the Region’s wastewater treatment plants.

Table C.2-8: Wastewater Treatment Plants and Disposal Methods

Planning Area/Facility	Disposal Method
Upper Putah Creek Planning Area	
Hidden Valley Lake WWTP	Land application - golf course
Middletown WWTP	Geothermal injection
Upper Cache Creek Planning Area	
Lakeport WWTF	Land application – pasture
Kelseyville WWTP	Land application – vineyards
Northwest Regional WWTP	Geothermal injection
Southeast Regional WWTP	Geothermal injection
Clearlake Oaks WWTP	Geothermal injection
Valley Floor	
Davis WWTP	Willow Slough Bypass and Conaway Toe Drain (tributaries to or part of Yolo Bypass)
Easterly WWTP (Vacaville)	Alamo Creek (to Cache Slough)
Winters WWTF	Land application - native grasslands
UC Davis WWTP	Putah Creek
Dixon WWTP	Land application - percolation/evaporation basins

Planning Area/Facility	Disposal Method
Woodland WWTP	Unimproved channel to Tule Canal (Yolo Bypass)
Rio Vista - Beach Drive	Sacramento River
Rio Vista - Northwest	Sacramento River
West Sacramento WWTP	Export to Sacramento Regional County Sanitation District

Sources: Lake County Inventory & Analysis, City of Davis Urban Water Management Plan, City of Vacaville Urban Water Management Plan, Winters Municipal Service Review, UC Davis NPDES No. CA0077895, City of Woodland Urban Water Management Plan, City of Rio Vista Urban Water Management Plan, City of West Sacramento Urban Water Management Plan

Wastewater systems also serve an important function in protecting water bodies from degradation. Understanding the available capacity of wastewater treatment plants in the Lake County area could be beneficial in assessing opportunities to treat additional flows and reduce septic system impacts in the area; additional research on this topic is necessary.

Wastewater discharges from the nine wastewater treatment plants in the Valley Floor Planning Area provide multiple reuse and water recycling opportunities. Some of the wastewater is discharged to managed wetlands to provide habitat and aquifer recharge benefits (City of Davis), while other wastewater effluent is discharged into local creeks for later reclamation for agricultural use (City of Vacaville Easterly WWTP).

Most of the wastewater effluent in the Upper Cache PA is exported and reused at the Geysers project, which is located in Sonoma County to the west of the planning area boundary. A summary of the wastewater treatment facilities and discharge/reuse locations for the Upper Cache PA is provided in Table C.2-11.

a) Recycled Water Infrastructure

A summary of the wastewater treatment facilities, projected annual discharges (if available) and discharge/reuse locations for each PA is provided in Table C.2-9 through Table C.2-11.

Table C.2-9: Valley Floor Planning Area Projected Treated Wastewater Discharges

Wastewater Treatment Plant	Discharges to	Projected Annual Discharge (AFY)					
		2010	2015	2020	2025	2030	2035
City of Davis	Wetlands (to Conaway Toe Drain)	3,093	2,120	2,120	2,120	2,120	2,120
	Willow Slough Bypass	2,322	3,480	3,480	3,680	3,980	4,280
Easterly WWTP (Vacaville)	Recycled water for customers south of I-80	0	0	880	880	880	880
	Alamo Creek (to Cache Slough); Solano and Maine Prairie Irrig./const. firms for dust control	16,690	19,042	18,946	19,394	19,730	20,178
Winters WWTF	Native grasslands	672	1,243	1,814	1,814	1,814	1,814
UC Davis	UC Davis Arboretum (to Putah Creek)	1,709	1,796	1,888	1,984	2,086	2,192
Dixon	Percolation/evaporation basins (no discharge)	851	871	891	912	934	957
Woodland	Unimproved channel to Tule Canal (Yolo Bypass)	6,271	7,391	7,055	7,495	7,951	7,951
Rio Vista - Beach Drive	Sacramento River	722					
Rio Vista - Northwest	Sacramento River						
West Sacramento	N/A						

Table C.2-10: Upper Putah Creek Planning Area Projected Treated Wastewater Discharges

Wastewater Treatment Plant	Discharges to	2010	2015	2020	2025	2030	2035
Hidden Valley Lake WWTP	Golf Course	420	420	420	420	420	420
Middletown WWTP	Geysers	143	143	143	143	143	143

Table C.2-11: Upper Cache Creek Planning Area Projected Treated Wastewater Discharges

Wastewater Treatment Plant	Discharges to:	2010	2015	2020	2025	2030	2035
Lakeport WWTP	Pasture Irrigation	1,177	1,177	1,177	1,177	1,177	1,177
Kelseyville WWTP	Agricultural Land	291	291	291	291	291	291
Northwest Regional WWTP	Geysers	1,793	1,793	1,793	1,793	1,793	1,793
Southeast Regional WWTP	Geysers	2,130	2,130	2,130	2,130	2,130	2,130
Clearlake Oaks WWTP	Geysers						

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b) Reliability

Recycled water is assumed to be 100 percent reliable since it is based on a consistent water supply and is not expected to change for average, single-dry, or multi-dry year water conditions. Usefulness of recycled water as a supply is limited more by recycled water infrastructure and demand for recycled water than reliability of such water as a supply.

C.2.7 Applied Water (Demand)

The term “demand” is used in this Plan to represent the quantity of water various water users are willing to pay to use for one or more beneficial uses. While economists have demonstrated that demand for water can most accurately be described as a function that relates the quantity of water a user would purchase and the unit cost of water, there is not sufficient information for this Region to estimate those specific economic functions of demand. Instead, this Plan presents approximations of water demand using estimates of applied water quantities based on historic information in lieu of economic demand functions. Water is applied within the Westside Region to meet consumptive and nonconsumptive uses. Consumptive water uses within the Region are Municipal and Industrial (M&I) and agricultural applied water. Nonconsumptive water uses within the Region included hydropower, environmental and recreational flows.

Consumptive Applied Water Definitions

M&I Applied Water – includes residential, commercial, industrial, landscaping, as well as non-revenue water lost during distribution. This water is used primarily in urban areas such as Davis, Dixon, Woodland, West Sacramento, Vacaville, Rio Vista, Clearlake, and Lakeport; however, some of this water is used by rural populations throughout the region.

Agricultural Applied Water – Agriculture is the predominant use of applied water in the Westside Region. Yolo and Solano Counties in the Valley Floor PA are known for high quality agricultural lands where crops varying from orchards to alfalfa and rice are grown.

The Upper Putah Creek and Upper Cache Creek PA's also have considerable agricultural acreages, with primary crops consisting of vineyards, walnuts and pears.

Nonconsumptive Applied Water Definitions

Environmental Applied Water – Although this could have a variety of definitions, for the purposes of this plan, it is being defined as required environmental flows dictated under governing documents such as Federal Energy Regulatory Commission (FERC) hydropower licenses or a decree.

Recreational Applied Water – Recreational applied water within the Region includes flows discharged into Cache Creek during the summer months to support recreational activities such as river rafting and kayaking.

Hydropower Applied Water – There are three (3) existing hydropower plants within the Region, although the plant at Clearlake does not currently function. The other two plants are located at Indian Valley Reservoir and Monticello Dam. Flows are often released from these dams in order to optimize energy production at these plants, as well as to meet other applied water demands. These flows are not further detailed below.

Consumptive applied water estimates for the region were developed considering numerous factors including agricultural acreages, crop types, population, historical applied water data, and hydrologic conditions (water year type). Wherever possible, existing documents and studies documenting current and projected applied water were used. Applied water was calculated at the Planning Area, County, and Urban/Community levels where appropriate and grouped into classifications as the data allowed (residential, commercial, agricultural, etc.). Limited agricultural crop projection data were available for the Region, therefore agricultural applied water estimates were held constant through 2040.

Hydrologic variability is one of the key components in estimating applied water. The estimates were developed within the region by assuming representative dry and average water years to evaluate the variability in water demands from year to year. For example, a dry water year will require larger amounts of irrigation water for crops and M&I landscaping to make up for reduced precipitation and increased evapotranspiration. Although some variability will occur in M&I water use in a dry versus average year, the water estimates presented in this do not show this variation.

a) Environmental Applied Water

Maintaining minimum flows in streams is beneficial for fisheries and many other aquatic species. It is important to realize that environmental benefits to aquatic and riparian habitats occur from various other water source contributions throughout the Region, such as return flows from municipal and agricultural use, flow discharges above the required environmental flows, and recreational flows. Historical required environmental flows within the Region have not always been sufficient to support aquatic habitat, as was seen in Putah Creek prior to the Putah Creek Accord. Agencies and environmental organizations continue to study Putah and Cache Creeks to determine the flows and timing of releases that are most suitable to maintaining the diverse aquatic and riparian habitat throughout the Region, while supporting M&I and agricultural water demands.

Required flows in Cache Creek include releases from Indian Valley Reservoir, in Lake County, and at the Putah Creek Diversion Dam in Yolo County. Indian Valley Dam is owned and operated by YCFCWCD. Flows are used for power production and for agricultural demand within Solano County. The FERC license requires certain environmental flows, although greater flows than this are often released. These flows allow for increased flow in Cache Creek throughout the summer months for improved aquatic habitat for fish and recreational use within a naturally intermittent creek.

Putah Creek flow requirements at Monticello Dam are dictated by required instream flows for Lower Putah Creek established in the Putah Creek Accord (2000). The Putah Creek Accord established minimum releases and instream flows for Putah Creek downstream of the Putah Diversion Dam to maintain rearing and spawning flows and to provide supplemental flows for the protection of aquatic resources. The Putah Creek Accord equates to an environmental water demand in average years of roughly 22,000 AFY. In dry years the environmental demand increases with lower natural flows in the creek and the settlement does provide for reduced releases and instream requirements in years when total storage in Lake Berryessa is less than 750,000 AF. Instream flow requirements downstream of the diversion dam require increased releases from Monticello Dam to ensure sufficient water for diversion at the Putah Diversion Dam and flows in Lower Putah Creek.

b) M&I Applied Water

Urban and rural domestic (M&I) applied water in the Westside Region was estimated using recent, publically approved planning documents with water use projections through the planning horizon (2040). The methodology for each planning area required a slightly different approach due to the availability of planning documents.

Urban water suppliers (with more than 3,000 service connections or delivering more than 3,000 AFY) are required by DWR to prepare UWMP's and are now also required to develop gallon per capita day water use reduction targets in accordance with SBX7-7, the Water Conservation Act of 2009. Table C.2-12 below presents the baseline GPCD, 2015 Interim Target, and 2020 Compliance Targets that were included in the UWMP's. Please refer to each UWMP for a discussion of the data and calculation methods used to select each GPCD target. Water conservation necessary to meet these GPCD targets is key in the Region since these urban water suppliers represent a significant percentage of the overall M&I water demand.

Table C.2-12: UWMP Baseline GPCD Factors

Urban Water Supplier	Baseline (gpcd)	2015 Interim Target	2020 Compliance Target
Vacaville	188	176	164
Rio Vista	310	279	248
Davis	215	194	172
Dixon	170	165	161
West Sacramento	293	264	234
Woodland	290	261	232

Valley Floor Planning Area

The Municipal and Industrial (M&I) applied water rates for the Valley Floor PA are shown in Table C.2-13. These values were compiled using Urban Water Management Plans (UWMPs) and other local planning documents developed within the area in coordination with current population data from the U.S. Census Bureau and estimated gpcd for rural populations. The various assumptions and sources used in these calculations are described below.

M&I applied water for urban areas was estimated using the 2015 UWMP for Davis, Dixon, Rio Vista, Vacaville, West Sacramento and Woodland. The values presented in each UWMP were grouped to fit into the following applied water classifications: Residential Demand, Commercial and Industrial (CII) Demand, Landscape Demand, and Unaccounted for Water Loss/Other. The M&I projections in the UWMPs include projections for reduced water use through increased conservation measures and incorporate meeting the new gallons per capita day (gpcd) targets as required by SBX7-7. M&I applied water for UC Davis was determined by extrapolating projections presented in the "Evaluation of Hydrologic Effects of Regional Surface Water Supply Project & Cache Creek Groundwater Recharge and Recovery Project", 2011.

Water demand projections for rural areas were not provided in planning documents, therefore the demands had to be estimated. The rural M&I applied water for areas in Yolo County and Solano County were calculated using estimated rural populations and applying a rural gpcd factor. The City of Dixon's average water use (170 gpcd) was selected as a representative gpcd for rural populations in Yolo and Solano Counties.

Table C.2-13: M&I Projected Applied Water - Valley Floor

Applied Water Category	2015 (AFY)	2020 (AFY)	2025 (AFY)	2030 (AFY)	2035 (AFY)	2040 (AFY)
Residential	23,975	35,204	36,656	37,937	39,518	41249
CII	6,682	9,038	9,812	10,267	10,808	11374
Landscape	3,093	3,574	3,900	4,068	4,258	4457
Unaccounted for Water Loss/Other	2,502	3,858	4,039	4,121	4,251	4397
Total	**36,251**	**51,674**	**54,407**	**56,392**	**58,835**	**61,477**

Source: Vacaville 2015 UWMP Table 16, Davis 2015 UWMP Table 3-7 to 3-10 and 3-13 to 3-14, Dixon District 2015 UWMP, Table 3.3-2 to 3.3-6; 3.4-1, West Sacramento 2015 UWMP, Tables 9-15, Woodland 2015 UWMP, Tables 4-4 to 4-7, Rio Vista 2015 UWMP, Tables 4 to 11, Appendix E; Assumed 2040 had the same growth as 2025 to 2030; 2010 US Census by Census Blocks; DOF projections for Solano and Yolo Counties; YCFCWCD IGSM Study, 2011 4.3.2.

Upper Putah Creek Planning Area

M&I applied water projections for the Upper Putah Creek Planning Area is shown in Table C.2-14.Unlike the Valley Floor PA, there are no urban water suppliers in the Upper Putah Creek PA. Therefore, demands were estimated using the Lake County Water Demand Forecast (2006) in conjunction with current population data from the 2010 Census for areas in Lake County, and by a custom method for areas in Napa County as discussed in Section C.1. M&I applied water for urban and rural areas within Lake County was estimated using the Lake County Water Demand Forecast to determine current and projected residential, commercial/industrial/institutional (CII) and landscape water use. These estimates assumed a linear growth rate from 2000 to 2040. A rural applied water factor of 131 gpcd based on a weighted average of the rural gpcd factors assigned to other Upper Putah Creek rural communities in the Lake County Water Demand Forecast was applied to the estimated population projections.

Table C.2-14: M&I Projected Applied Water – Upper Putah Creek

Applied Water Category	2015 (AFY)	2020 (AFY)	2025 (AFY)	2030 (AFY)	2035 (AFY)	2040 (AFY)
Residential	1,947	2,236	2,578	2,984	3,465	3,777
CII	71	77	83	89	96	102
Landscape	75	81	87	94	101	107
Total	**2,094**	**2,394**	**2,748**	**3,167**	**3,663**	**3,986**

Source: Lake County Water Demand Forecast, assumed linear growth rate between 2000-2040; 2010 US Census by Census Blocks.
Note: Unaccounted for Water Loss included in Residential/CII/Landscape Demands

Upper Cache Creek Planning Area

The Municipal and Industrial (M&I) applied water for the Upper Cache Creek Planning Area is shown in Table C.2-15. These values were calculated using the Lake County Water Demand Forecast in coordination with current population estimates. The various assumptions and sources used in these calculations are described below. M&I applied water for urban and rural areas within Lake County was estimated using the Lake County Water Demand Forecast (2006) to determine current and projected residential, commercial/industrial/institutional (CII) and landscape water use. These estimates assumed a linear growth rate from 2000 to 2040.

The rural applied water for Colusa and Yolo Counties was calculated by applying an estimated rural applied water factor of 150 gpcd (based on a weighted average of the rural gpcd factors assigned to similar rural communities in the Lake County Water Demand Forecast) to the rural population projections for Colusa and Yolo Counties.

Table C.2-15: M&I Applied Water – Upper Cache Creek

	2015 (AFY)	2020 (AFY)	2025 (AFY)	2030 (AFY)	2035 (AFY)	2040 (AFY)
Residential Demand [a]	9,400	10,202	11,082	12,047	13,104	14,100
CII Demand [a]	1,415	1,525	1,644	1,772	1,910	2,041
Landscape Demand [a]	714	769	828	893	961	1,027
Total	**11,529**	**12,496**	**13,554**	**14,712**	**15,975**	**17,168**

(a) Lake County Water Demand Forecast, assumed linear growth rate between 2000-2040; 2010 US Census by Census Blocks.
Note: Unaccounted for Water Loss included in Residential/CII/Landscape Demands

Agricultural Applied Water

The same method was used for estimating agricultural applied water for each planning area; therefore, the discussion is not separated by planning area. Agricultural applied water calculations were developed using a number of sources and grouped according to planning area and county. The method used to calculate the agricultural water use included the following steps:

- Estimated irrigated acreages of each crop type for each county and planning area based on the most recently available Department of Water Resources (DWR) land use surveys.
- Selected applied water factors for each crop type based on DWR applied water factors for a dry and wet year. A representative dry and average year was selected for each county based on available DWR applied water factors, provided for the years 1998-2005.
- Compared results to agricultural applied water estimates from the Yolo IRWM Plan and Lake County Inventory Analysis and County Crop Reports.

The DWR land use surveys are a comprehensive accounting of the land uses by urban/agricultural land uses and crop types. The land use surveys are completed in an ongoing basis for each County with differing year of compilation. For this reason, there may have been changes in cropping patterns since the land use surveys were compiled that would not be reflected in the applied water estimates. These land use surveys were used to estimate the current acreage of irrigated and non-irrigated crop types within each planning area:

Colusa County 2003

Lake County 2006
Napa County 1999
Solano County 2003
Yolo County 2008

Applied water factors were selected based on the DWR applied water (AW) factors, which are available for the period of 1999-2005. Agricultural applied water incorporates multiple factors including (evapotranspiration, crop coefficient, and irrigation efficiency factors). A dry and average year were selected from this period by analyzing precipitation data for the period between 1999-2005. It was determined that the year 1999 was representative of a dry year and that the year 2000 was representative of an average year. If a crop type was not available, a similar crop was used as an approximation. Table C.2-16 through Table C.2-18 contain the major crop types by planning area, along with their irrigated acreages and applied water factors. If a particular county was not available for a specific crop type, the applied water factor from a neighboring county was used.

Table C.2-16: Irrigated Acreages and Applied Water Factors – Valley Floor PA

	Acres			Applied Water Factors Average Year (Acre-feet/Acre)		Applied Water Factors Dry Year (Acre-feet/Acre)	
Crop Type	**Yolo County**	**Solano County**	**Total**	**Yolo AW**	**Solano AW**	**Yolo AW**	**Solano AW**
Almonds	13,614	2,123	15,737	4.2	4.06	4.48	4.49
Walnuts	13,244	8,775	22,019	4.23	3.89	4.65	4.43
Safflower	12,166	6,639	18,805	0.56	0.71	0.71	0.77
Corn (field & sweet)	8,005	8,331	16,336	2.79	3.01	3.07	3.38
Sunflowers	11,866	2,511	14,377	2.36	2.52	2.62	2.79
Wheat		11,537	11,537	1.27	1.74	1.47	1.34
Alfalfa & alfalfa mixtures	51,406	35,027	86,433	5.27	5.47	5.61	5.81
Tomatoes	38,548	9,509	48,057	3.04	3.18	3.34	3.65
Vineyards	13,526	1,887	15,413	1.69	1.42	1.94	2.23
Other Grain and Hay Crops	54,744	20,331	75,075	1.27	1.28	1.47	1.34
Other Pasture	14,094	28,070	42,164	5.67	6.01	5.83	6.11
Rice	35,822	0	35,822	5.26	5.26	5.42	5.42
Other Crops	16,801	11,579	28,380	varies	varies	varies	varies
Subtotal	**283,836**	**146,319**	**430,155**				
Idle	11,136	1,521	12,657				
Semi agricultural	16,888	3,655	20,543				
Total	**311,859**	**151,495**	**463,354**				

Source: DWR Land Use Survey (Solano 2003; Yolo 2008); DWR Applied Water Use Factors 1999, 2000.

Table C.2-17: Irrigated Acreages and Applied Water Factors – Upper Putah Creek PA

	Acres			Average Year (Acre-feet/Acre)		Dry Year (Acre-feet/Acre)	
Crop Type	**Lake**	**Napa**	**Total**	**Lake AW**	**Napa AW**	**Lake AW**	**Napa AW**
Pasture	1,448	77	1,525	3.63	4.63	3.71	4.56
Vineyard	810	3,424	4,233	0.59	1.11	1.88	1.24
Other Crops	0	34	34	varies	varies	varies	varies
Subtotal	**2,258**	**3,534**	**5,792**				
Idle	0	617	617				
Semi agricultural	44	73	117				
Total	**2,302**	**4,225**	**6,527**				

Source: DWR Land Use Survey (Lake 2001; Napa 1999); DWR Applied Water Use Factors 1999, 2000.

Table C.2-18: Irrigated Acreages and Applied Water Factors – Upper Cache Creek PA

	Acres				Average Year (Acre-feet/Acre)	Dry Year (Acre-feet/Acre)
Crop Type	**Lake**	**Colusa**	**Yolo**	**Total**	**Lake AW**	**Lake AW**
Walnuts	869	0	47	916	2.82	2.95
Pears	2,729	0	0	2,729	2.82	2.95
Pasture	2,696	436	0	3,131	3.63	3.71
Vineyards	8,141	0	0	8,141	0.59	1.88
Other Crops	1,337	0	64	1,401	varies	varies
Subtotal	**15,772**	**436**	**111**	**16,319**		
Idle	1,557	293	35	1,885		
Semi agricultural	518	23	19	560		
Total	**17,847**	**752**	**164**	**18,763**		

Source: DWR Land Use Survey (Lake 2001; Colusa 2003; Yolo 2008); DWR Applied Water Use Factors 1999, 2000.

Groundwater Extractions

a) Upper Cache & Upper Putah

Groundwater for the Upper Cache and Upper Putah PAs is extracted from the multiple groundwater basins as described above. Historically, groundwater is the primary supply for agricultural users, domestic self-supplied residents, and municipalities that do not obtain supply from Clear Lake. Groundwater also provides supplemental capacity for many municipalities that primarily rely upon surface water.

It was estimated that approximately 80% of M&I applied water and 20% of agricultural applied water in the Upper Cache and Upper Putah PAs is groundwater based on water use estimates presented in the Lake County Water Demand Forecast.

b) Valley Floor

Groundwater provides about 40% of the total water supply in the Valley Floor PA on an average annual basis. However, because most agricultural pumping activities are not regularly measured, it is difficult to compile an accurate estimate of actual historical pumping rates. As a result, groundwater extraction volumes are typically estimated by taking the total estimated water demand less recorded surface water diversions; however, this analysis used somewhat different assumptions as described below due to a deficiency of complete surface water diversion data.

Approximately 65% of M&I water use is groundwater (based on UWMPs and assumption that rural populations are served by groundwater wells). It was assumed that 32% of agricultural applied water is supplied by groundwater in an average year and that 42% of agricultural applied water is supplied by groundwater in a dry year. These values were based on the distribution of groundwater to surface water applies presented in the Yolo IRWM Plan.

There have been historical overdraft conditions in the shallow and intermediate aquifers, but conjunctive use programs including the Solano Project (Lake Berryessa) and Indian Valley Reservoir have provided for significant recovery of groundwater elevations in the valley, which today remain high and stable in most conditions.

There are areas in the region that are still reliant upon groundwater as the only water supply source where ground subsidence due to groundwater pumping has been detected, including the northern Yolo-Zamora area of Yolo County between Zamora and Knights Landing, where subsidence is reported to be on the order of 5 feet and in the vicinity of Davis and Woodland, where subsidence is estimated at 2 to 3 feet.

C.2.8 Water Leaving

The Westside Region is an open watershed, interconnected with the overall Sacramento River watershed, and as a result water leaves the Region and the Planning Areas through multiple avenues. Methods for water leaving include losses to consumption, evaporation and transpiration, streamflow into the Sacramento River and Delta, wastewater discharges and to a lesser extent, subsurface conveyance through groundwater aquifers. In the process of developing a complete water balance for each planning area, these components must be fully understood and estimated. This initial water balance process does not intend to quantify each of these components, but rather identify opportunities for additional data collection activities to improve the understanding of these important factors.

Water leaves the Region through multiple courses including:

- Consumption of Applied Water – Consumption of applied water is the portion of water that is applied for agricultural or M&I uses, but does not return to the Planning Area. This may be through production of food, or other losses. Consumption of Applied Water was calculated as Applied water minus recycled water and return flows.

- Exports – Exported water is water that is exported outside of the Region. This includes the water exported to the geysers in Lake County and water leaving the Valley Floor through the Sacramento River, Willow Slough, Colusa Basin Drain, the Yolo Bypass, Sacramento Deep Water Ship Channel, and Sacramento-San Joaquin River Delta. Most of the water leaving the Region is not directly monitored at these locations and therefore exports for the Valley Floor PA are not fully understood.

- Downstream Releases– includes those flows that are released from Putah Creek and Cache Creek for M&I and agricultural purposes.

- Downstream Runoff – includes those flows that are released for environmental, recreational, or flooding purposes.

- Wastewater Discharges – includes wastewater flows that are discharged outside of the Planning Area or Region.

- Surface Evaporation – Surface evaporation is especially important in the Upper Cache and Upper Putah PAs due to the large lakes and reservoirs present in these areas. Surface evaporation from Clear Lake has been estimated at 135-158 TAFY (CDM, 2006b). This evaporation was not included in the exports for Upper Cache Creek PA because the unimpaired flow calculations used for the precipitation values used in the analysis included evaporation as a water loss already. The evaporation for Indian Valley Reservoir (IVR) and Lake Beryessa are shown in the exports for Upper Cache and Upper Putah Creek PAs. IVR and Lake Beryessa evaporation was estimating using a pan coefficient method.

- Subsurface Flow – Subsurface aquifer losses for the Upper Putah and Cache Creek aquifers have not been quantified and therefore a value of NQ was reported in the Water Balance. The Valley Floor aquifers groundwater flow is generally from west to east. The 2006 Yolo County Integrated Groundwater/Surface Water Model Report (2006 WRIME) discusses assumed groundwater boundary conditions at the eastern side of Yolo and Solano Counties. In development of the model, it was assumed there was interaction between the aquifer and the Sacramento River, but the nature and extent of this interaction is unknown. Therefore, the net subsurface outflow from the Valley Floor Planning Area is assumed to be zero and is represented as NQ, until these conditions are better understood.

C.2.9 Missing Information

There are a number of areas where the Region does not currently have sufficient data or sufficient compiled data to provide full understanding of how water moves through the Region. Providing this type of analysis was beyond the scope of this plan; however, Table C.2-19 describes the data gaps identified from the water balance analysis conducted for this Plan.

Table C.2-19: Water Balance Missing Information

Category	Valley Floor PA	Upper Putah Creek PA	Upper Cache Creek PA
Water Entering			
Precipitation	Estimate of annual rainfall/unimpaired runoff for Planning Area		
Upstream Runoff (upper watershed)			
Upstream Flow (regulated releases)			
Imported Water (outside watershed)	(1) Direct Deliveries for Colusa Basin Drain MWC & West Sacramento CVP Diversions.		
Water Balance Boundary			
Direct Deliveries	(1) data for the Direct Deliveries for Colusa Basin Drain MWC (3) Water diverted from Cache and Putah Creek under riparian and appropriative water rights have not been quantified. Unclear if sufficient data exists to quantify.	(1) Water diverted from Putah Creek under riparian and appropriative water rights have not been quantified. Unclear if sufficient data exists to quantify.	(1) Water diverted from Cache Creek under riparian and appropriative water rights have not been quantified. Unclear if sufficient data exists to quantify.
Surface Water Storage			
Surface Storage			
Local Release Deliveries		data for direct deliveries	
Downstream Releases (see Water Leaving)			
Groundwater Storage			
Groundwater Percolation (Recharge)	No data for the Sustainable Yield or existing groundwater storage is available	Using Usable Capacity in place of GW Percolation Data. No data for sustainable yield or existing groundwater storage.	Using Usable Capacity in place of GW Percolation Data. No data for sustainable yield or existing groundwater storage.

Category	Valley Floor PA	Upper Putah Creek PA	Upper Cache Creek PA
Water Entering			
Return Flows	Broad estimate of RFs in all categories (ag, urban, and wastewater).	Broad estimate of RFs in all categories (ag, urban, and wastewater).	Broad estimate of RFs in all categories (ag, urban, and wastewater).
Recycle/Reuse			
Applied Water Demand			
Applied Surface Water Demand			
M&I	Dry year estimate of use.		
Agricultural	(1) Crop forecasting for this area. (2) Analysis of change in groundwater vs. surface water use in dry vs. average year.	(1) Crop forecasting for this area.	(1) Crop forecasting for this area.
Applied Groundwater Extractions			
M&I	Dry year estimate of use.		
Agricultural	(1) Crop forecasting for this area. (2) Understanding in change in groundwater vs. surface water use in dry vs. average year. (3) total groundwater pumping capacity and measured groundwater extractions.	(1) Crop forecasting not available for this area that allowed for consistent analysis throughout the region. (2) total groundwater pumping capacity and measured groundwater extractions.	(1) Crop forecasting not available for this area that allowed for consistent analysis throughout the region. (2) total groundwater pumping capacity and measured groundwater extractions.
Water Leaving			
Consumption of Applied Water			
Exports			
Downstream Releases			
Downstream Runoff	flow data for water leaving the Planning Area.		

Category	Valley Floor PA	Upper Putah Creek PA	Upper Cache Creek PA
Water Entering			
Wastewater Discharges	Some missing information for WWTP flows.		Some missing information for WWTP flows.
Losses			
Surface Evaporation/Seepage	Assumed to be negligible, as no calculated data available for losses in conveyance to evaporation or groundwater percolation etc. throughout the region.	(1) Estimated surface evaporation of Lake Berryessa; however, no dry vs. average year available. (2) No seepage estimates available.	(1) Estimated surface evaporation for Indian Valley Reservoir; however, no dry vs. average year available. (2) No seepage estimates available.
Subsurface Aquifer	No data available.	No data available.	No data available.
Other Unrecoverable Losses	No data available.	No data available.	No data available.