

Appendix A – Conservation Study

Technical Memorandum



Merced Integrated Regional Water Management Plan

Subject: Conservation Study

Prepared For: Merced IRWMP Regional Water Management Group

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The IRWM Plan must consider Resource Management Strategies (RMS) that help achieve the Plan objectives and contribute to resolving the water issues described in the regional description. The California Water Plan defines a RMS as a project, program or policy that manages water and related resources to meet the water management objectives of the region. Minimizing water losses from the region through agricultural and urban water conservation can help maximize water use efficiency and correct groundwater overdraft conditions, two important regional objectives.

This technical memorandum (TM) summarizes agricultural and urban water demand trends for the Merced IRWM Region. This TM is organized in the following sections:

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Conservation Study

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1 Urban Conservation

This section summarizes urban water use and conservation in the Merced IRWM Region.

1.1 Urban Water Demands

The cities of Merced, Livingston, and Atwater are located in Merced County in the Central San Joaquin Valley of California. The local climate consists of cool, humid winters and hot, dry summers, with most of the rainfall occurring between November and April. All three agencies use groundwater as their primary source of water supply.

Figure 1 presents historic and projected water demands and **Figure 2** presents population and per capita water use for each city, based on the latest available Urban Water Management Plans (UWMPs).

Figure 1: Urban Water Demand Projection

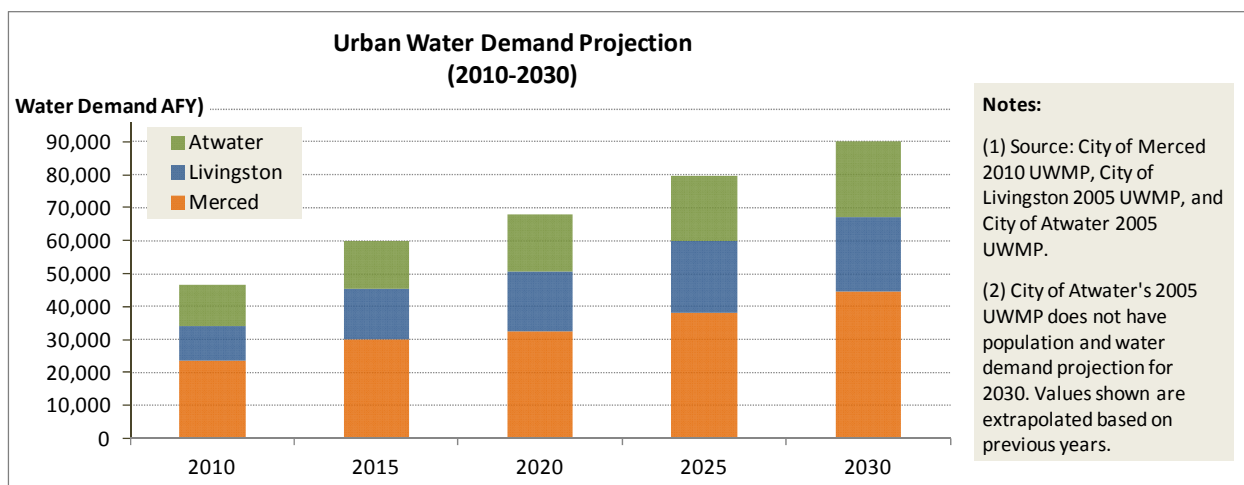
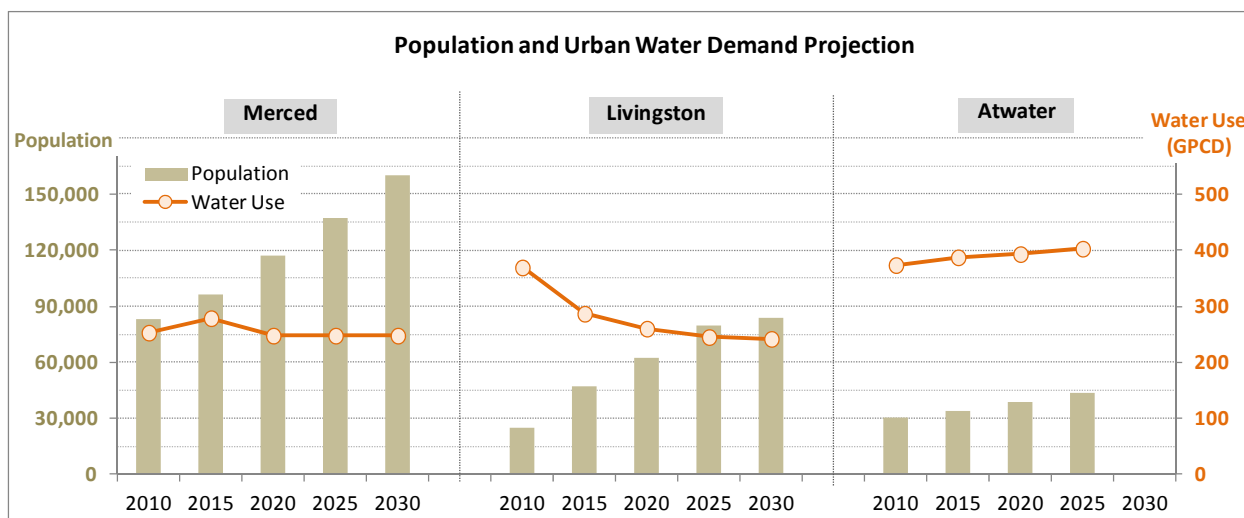


Figure 2: Population and Per Capita Urban Water Demand Projection



Based on the data provided in the UWMPs:

- All three cities are projected to experience considerable population growth and an increase in water demand in the next 20 years. Total combined population is projected to increase by 112 percent by 2030, while the total combined water demand is projected to increase by about 93 percent.
- Daily per capita water use (in gallons per capita per day, or gpcd) for each city was calculated based on population and water demand projections. Together the three cities average about 300 gpcd (compared to a statewide average of 192 gpcd and San Joaquin River hydrologic region average of 248 gpcd in 2005).
- The City of Merced has the highest population and water use of the three cities, but its current per capita water use is the lowest (about 253 gpcd in 2010 and expected to remain at about the same level through 2030 assuming conservation efforts are implemented). This could be attributed to many factors, such as higher number of multi-family residential units and a higher percentage of metered accounts than the other two cities.
- The City of Livingston has projected a rapid growth; its population is expected to triple in the next 20 years from less than 25,000 in 2010 to over 80,000 in 2030. Its water demand is expected to also double by 2030 from just over 10,000 acre-feet (AF) per year (AFY) to almost 23,000 AFY. The city's current per capita water use is almost 370 gpcd. According to the city's 2005 UWMP, this high water use is partially due to the presence of a large industry with high water demands. The city estimated that the per capita use rate between its residential and commercial customers is below 200 gpcd.
- The City of Atwater is expecting moderate population growth of about 45% by 2025 (the city's latest UWMP, which was developed in 2007, did not include 2030 in its planning horizon. Projections for 2010 through 2025 assumed a 3 percent annual growth rate). The city's water use is estimated to increase from about 13,000 AFY in 2010 to about 20,000 AFY in 2025. Daily per capita use is also estimated to increase from the current 370 gpcd to about 400 gpcd in 2025.

To better understand urban water demand and conservation opportunities in the region, water use patterns of each city's major customer classes was reviewed, including single-family residential (SFR); multi-family residential (MFR) and non-residential, which consists of commercial, institutional, and industrial customers, generally referred to as the "CII" sector. Of each sector, we also analyzed the water use between metered and unmetered accounts to evaluate any noticeable difference in water use trends.

1.1.1 City of Merced

Water demands in the City of Merced are primarily residential, accounting for almost two thirds of the city's water usage. However, as of 2009, over half of these accounts were not metered. **Table 1** summarizes the number of accounts in each sector and their water demands in 2009.

Table 1: City of Merced Water Accounts (2009)

Sector	Metered ⁽¹⁾				Unmetered ⁽¹⁾		
	No. of Accounts	Percent ⁽²⁾	Demand (AFY)	Demand (gpd/account) ⁽³⁾	No. of Accounts	% of Accounts ⁽²⁾	Demand (AFY)
SFR	6,797	34%	4,092	537	10,736	53%	n/a
MFR	1,519	7%	3,390	1,992	5	0.02%	n/a
CII	1,178	6%	3,303	2,503	34	0.2%	n/a
Total	9,494	47%	10,785	n/a	10,775	53%	11,342

Notes:

- (1) Data on the number of accounts (both metered and unmetered), the corresponding demand for each sector and the total demand for the unmetered accounts was obtained from the City's 2010 UWMP.
- (2) Calculated as a percentage of total number of accounts, including both metered and unmetered.
- (3) Demand in gallons per day (gpd) per account. For SFR accounts, this refers to the daily water demand per household. For MFR accounts, this refers to the daily water demand per building or apartment complex, depending on where the master meter is installed. Note that this is different from gpcd, which refers to the daily water demand per person.

As shown in Table 1:

- The majority of the City's water connections are SFR units, accounting for 87 percent of all accounts.
- The City has a significant number of MFR accounts, potentially contributing to its lower per capita water use rate, as MFR units typically have proportionately less outdoor area (and therefore lower irrigation demands) on a per capita basis, reducing the citywide per capita water use rate.
- It was not possible to distinguish water demand by sector for unmetered accounts. However, if we assume that the five unmetered MFR accounts and the 34 unmetered CII accounts use about the same amount of water as their unmetered counterparts (2,000-2,500 gpd/account, on average), the SFR unmetered accounts use about 930 gpd/account. This is significantly higher than that of metered accounts (537 gpd/account).

1.1.2 City of Livingston

Table 2 summarizes the number of accounts in each sector and associated water demands for the City of Livingston in 2005.

Table 2: City of Livingston Water Accounts (2005)

Sector	Metered Account ⁽¹⁾		Unmetered Account ⁽¹⁾		Total Demand (AFY)
	Number	Percent (%) ⁽²⁾	Number	Percent (%) ⁽²⁾	
SFR	1,732	68%	617	24%	n/a
MFR	49	2%	0	0%	n/a
CII	144	6%	0	0%	n/a
Total	1,925	76%	617	24%	8,070

Footnotes:

- (1) Data on the number of accounts and the total demand was obtained from the City's 2005 UWMP.
- (2) Calculated as a percentage of total number of accounts, including both metered and unmetered.

As shown in **Table 2**:

- Over 90% of the Livingston’s water accounts are SFR accounts, with more than one third of these accounts unmetered.
- SFR lot sizes average about 10,000 square feet in Livingston. This suggests that SFRs in Livingston may have relatively higher irrigation needs than in Merced. This, coupled with the relatively low number of MFR units (only 49 units, 2% of all accounts) and hot, dry summer weather (which further increases outdoor irrigation needs) likely contribute to the city’s relatively high per capita water demands (over 370 gpcd in 2010).

1.1.3 City of Atwater

Table 3 summarizes the number of accounts in each sector and associated water demands for the City of Atwater in 2010. As shown in **Table 3**:

- Similar to the other two cities, single family residences are the predominant residential housing type in Atwater, accounting for 88 percent of all accounts.
- A majority (97 percent) of water accounts are unmetered. Atwater’s 2005 UWMP indicated that the City tracks high consumption accounts and performs periodic surveys of the system as requested or as the accounts are flagged during the billing process due to high consumption. However, water savings from this effort might be limited since only 3 percent of the City is currently metered.
- The city’s SFR sector averages about 1,117 gpd/account for unmetered accounts, which is relatively close to the estimated use of Merced’s unmetered SFR accounts (930 gpd/account), but higher than that of Merced’s metered accounts (537 gpd/acc). This suggests that unmetered SFR accounts tend to use more water than metered accounts.

Table 3: City of Atwater Water Accounts (2010)

	Metered ⁽¹⁾				Unmetered ⁽¹⁾			
	No. of Accounts	% of Accounts ⁽²⁾	Demand (AFY) ⁽³⁾	Demand (gpd/account)	No. of Accounts	% of Accounts ⁽²⁾	Demand (AFY)	Demand (gpd/account)
SFR	12	0%	0	n/a	7,655	88%	9,579	1,117
MFR	17	0%	0	n/a	347	4%	1,967	5,061
CII	253	3%	0	n/a	385	4%	1,166	2,704
Total	282	3%	0	n/a	8,387	97%	12,712	n/a

Footnotes:

- (1) Data on the number of accounts and the total demand was obtained from the City’s 2005 UWMP.
- (2) Calculated as a percentage of total number of accounts, including both metered and unmetered.
- (3) Unclean why the UWMP stated that the demand was zero.

1.2 Urban Water Conservation Programs

Urban water conservation efforts are often influenced by factors such as supply availability and regulatory guidelines. This section reviews the water conservation measures that each city is currently implementing, as well as supply availability and regulatory constraints faced by each city when shaping its water conservation program.

1.2.1 Demand Management Measures

All three cities currently implement a number of water conservation measures. **Table 4** summarizes the implementation status of the 14 demand management measures (DMMs) listed in each of the cities' most recent UWMPs.

Table 4: Implementation Status of Common Water Conservation Measures

Demand Management Measure ⁽¹⁾	City of Merced	City of Livingston	City of Atwater
1 Water Survey Program	⊗	○	●
2 Residential Plumbing Retrofit	●	○	●
3 System Water Audits, Leak Detection and Repair	●	●	●
4 Metering with Commodity Rates	●	●	●
5 Large Landscape Conservation Programs	○	●	●
6 High-Efficiency Washing Machine Rebate Program	⊗	○	⊗
7 Public Information Programs	●	○	●
8 School Education Program	●	○	●
9 Conservation Programs for CII Accounts	⊗	○	●
10 Wholesale Agency Programs	n/a	n/a	n/a
11 Conservation Pricing	○	●	●
12 Water Conservation Coordinator	●	○	●
13 Water Waste Prohibition	●	●	●
14 Residential ULFT Replacement Programs ⁽²⁾	⊗	○	⊗

Footnotes:

(1) ● -Fully or Partially Implemented; ○ - Planned or in Evaluation; ⊗ - Not Implemented; N/A -Not applicable to agency

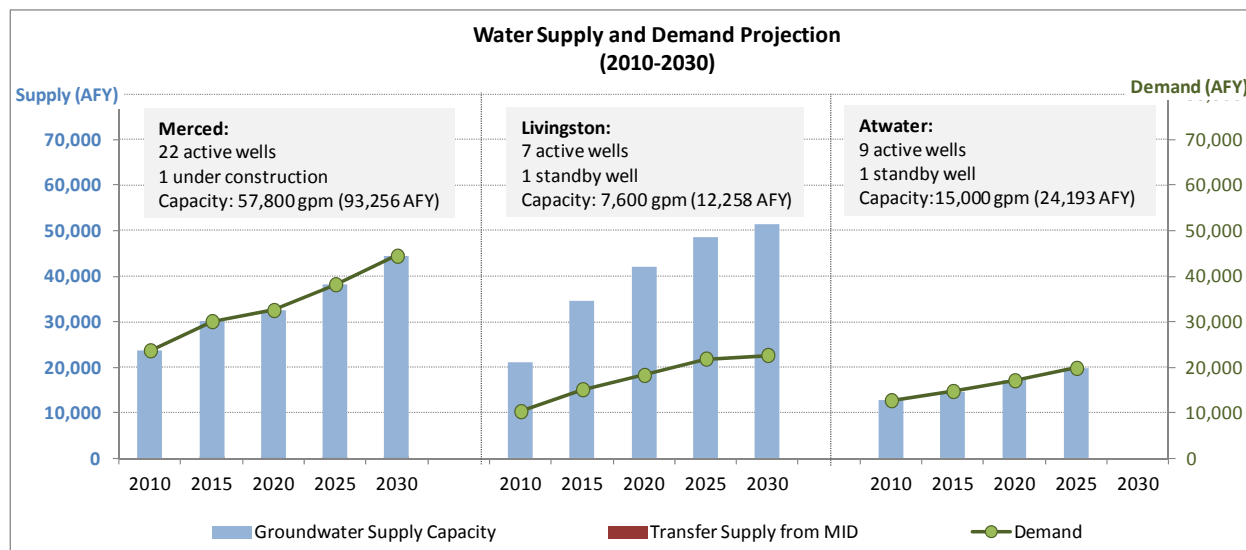
(2) ULFT: Ultra Low Flow Toilet

1.2.2 Supply Availability

Groundwater is the primary source of water supply for all three cities. Each city operates groundwater wells that pump from the Merced groundwater subbasin. The City of Merced and Merced Irrigation District (MID) are currently planning to introduce the use of surface water from MID for landscape irrigation. The Cities of Livingston and Atwater plan to continue to use groundwater as their sole source of water supply. **Figure 3** summarizes the number, total rated capacity, and projected available supply from each city's wells with respect to projected demand.

As shown in **Figure 3**, all cities are projected to be able to fully meet their urban water demands in 2030. However, water conservation is vital to prevent overdraft or other adverse impacts to the groundwater basin. For example, City of Merced started implementing a number of conservation measures in response to Merced subbasin overdraft conditions between 1990 and 1995.

Figure 3: Supply Projection (2010-2030)



1.2.3 Regulatory Frameworks

In addition to active water conservation measures, the following state and federal laws mandate conservation practices, helping to shape existing conservation programs.

Assembly Bill 1420 (AB 1420) amended the Urban Water Management Planning Act to require, effective January 1, 2009, that the terms of and eligibility for any water management grant or loan made to an urban water supplier and awarded or administered by the Department of Water Resources (DWR), State Water Resources Control Board (SWRCB), or California Bay-Delta Authority (CBDA) or its successor agency be conditioned on the implementation of the Water Demand Management Measures (DMMs) described in Water Code Section 10631 (f). As shown in Table 4, all cities are currently implementing a subset of the DMMs.

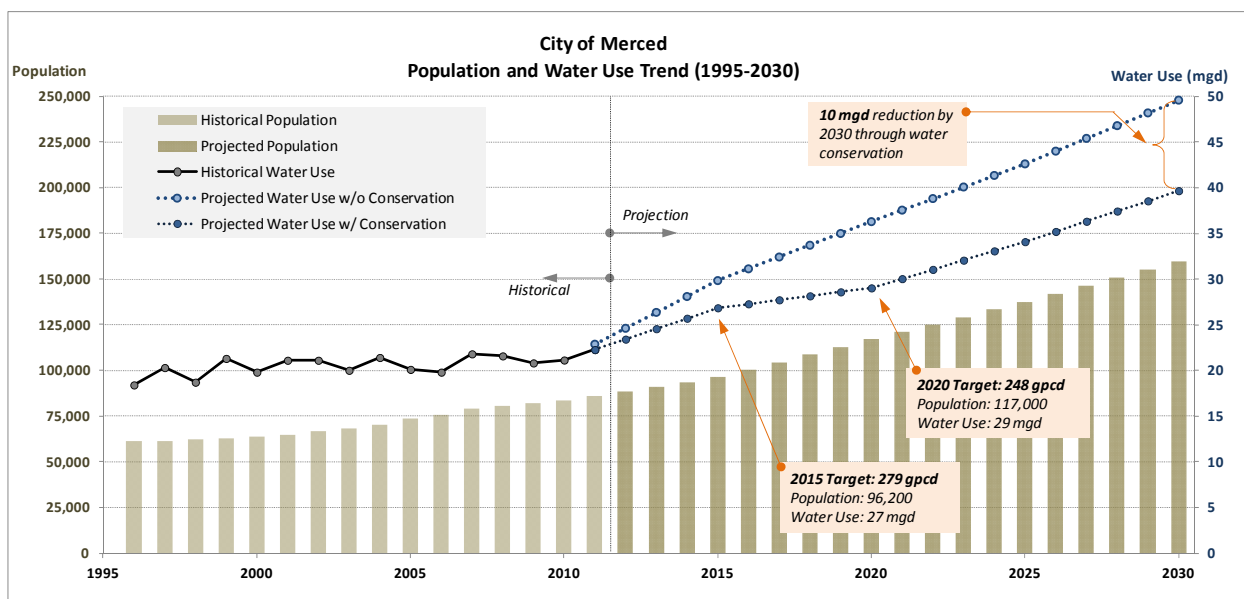
Assembly Bill 1881 (AB 1881), the Water Conservation in Landscaping Act of 2006, mandated increased water efficiency for both new and existing development statewide. The law required DWR to update the Model Water Efficient Landscape Ordinance (MWELo), which established water management practices and water waste prevention for landscape irrigation needs. Cities can elect to either adopt the DWR's MWELo or introduce its own local landscape ordinance. In addition to adopting the MWELo, each city has its own efforts in place to further reduce irrigation needs. For example, all of Atwater's city-maintained median strips and traffic islands that require plantings are landscaped with drought-tolerant plants. Atwater's five-year Capital Improvement Plan also calls for \$0.2M in parks water conservation improvements (City of Atwater Municipal Service Review, April 2010). The City of Merced is also currently enforcing a local Water Conservation Ordinance that restricts outdoor irrigation to three days a week and only between 7 p.m. and 11 a.m.

California Water Code Sections 525-529.5 requires that urban water suppliers install water meters on all municipal and industrial service connections on or before January 1, 2025 and charge customers based on the actual volume of deliveries as measured by the water meters. As discussed in the previous section, all three cities have a large number of unmetered accounts, primarily in the SFR sector. It is difficult to estimate the water savings that could be realized through metering, but it is generally accepted that metered accounts typically use less water than unmetered accounts.

According to Merced’s 2010 UWMP, the city will add over 17,000 new SFR accounts by 2030. Analysis in the previous section suggests that metered SFR accounts are likely to use less water than unmetered SFR accounts. With this assumption, Merced’s SFR sector could expect noticeable per capita water use reductions due to metering.

Senate Bill x7-7 (SB x7-7) was enacted in November 2009, requiring all water suppliers to increase water use efficiency. SBx7-7 also sets an overall goal of reducing per capita urban water use by 20 percent by 2020, with an interim goal of reducing per capita water use by at least 10 percent by December 31, 2015. Each urban water supplier shall also develop its water use target and interim target using one of the four methods established by DWR. According to City of Merced’s 2010 UWMP, the city’s baseline daily per capita water use is 310 gpcd. **Figure 4** illustrates City of Merced’s historical and projected population and water use, its interim target and 2020 target.

Figure 4: City of Merced Urban Water Conservation Trend



The City of Livingston’s and the City of Atwater’s 2010 UWMPs were not yet available at the time this document was prepared. As such, information regarding their baseline water use, 2015 interim targets, and 2020 final targets is not provided in this document.

1.3 Future Urban Conservation Opportunities

A successful conservation program is often implemented and managed in an adaptive fashion and in close coordination with the public and, at times, neighboring communities. This section discusses some conservation opportunities that could be considered in the future.

1.3.1 Regional Approach

A **Regional Public Outreach Program** could provide relatively easy and effective means of enhancing urban conservation region-wide. A successful outreach program would:

1. Ensure consistent messaging throughout the region
2. Promote coordination between agencies

3. Strengthen public interest in water conservation
4. Educate the public on water conservation issues and approaches
5. Generate long-term water savings.

Outreach programs can be implemented using traditional tools such as radio advertisements and bill inserts, as well as newer technologies such as social media networks and blogs. Such a program would be even more efficient if paired with a free audit program offered by each local agency.

1.3.2 Local Approach

In reviewing each city’s UWMP and related planning documents, a series of water conservation programs could be considered by each agency for future implementation. **Table 5** lists these projects and summarizes their estimated effectiveness in terms of water savings. These programs are summarized below.

Table 5: Potential Future Water Conservation Projects

Proposed Project/Measure	Effectiveness/Applicability ⁽¹⁾		
	City of Merced	City of Livingston	City of Atwater
1 Meter Installation	✓✓	✓✓	✓✓✓
2 Water Audit Program	✓✓	⊕	⊕
3 Residential Retrofit Rebate Program	✓	✓	✓
4 Non-Residential Retrofit Partnership Program	✓	✓	✓
5 Rainwater/Graywater Program	✓	✓	✓
6 Conservation Modeling	✓✓✓	✓✓	✓✓
7 Conservation Planning	✓✓✓	✓✓✓	✓✓✓

Footnote:

(1) ✓✓✓=Highly effective/applicable; ✓✓= Effective/Applicable; ✓ = Merits consideration, conduct pilot or evaluate cost-effectiveness before full-scale implementation; ⊕ = already implementing but can improve

Meter Installation is crucial to a successful water conservation program by providing enhanced understanding of water use patterns, both for city water departments and for end users. All three cities have a large number of unmetered accounts. By metering these accounts, the cities could better understand customer water use trends, identify large users, identify system leaks to reduce water waste, and conduct more accurate revenue forecasting. Without metering, it is difficult to estimate the city’s system water losses and to prioritize the city’s leak detection and repair activities. As discussed previously, CWC Sections 525-529.5 require that all new accounts be metered by 2025. The Cities could, however, accelerate the schedule by considering strategies such as free meter installation, meter rebate, or raising the flat rate charge for unmetered accounts. This is especially worth considering for the City of Atwater, which has 88 percent of its accounts unmetered (Merced has 53 percent, Livingston has 24 percent unmetered).

Water Audit Programs can provide enhanced understanding of customers’ water use patterns and can realize significant long-term water savings. An effective water audit program should include both indoor and outdoor evaluations and include free giveaways such as toilet leak detection kits, buckets (to collect pre-shower water), faucet aerators, low-flow showerheads, etc. Two of the most common outcomes of outdoor evaluations are landscape removal and installation of automated landscape irrigation systems.

The City of Merced indicated in its 2010 UWMP that a system-wide audit program may not be cost-effective. The City could consider focusing on a smaller portion of the city, such as the top one to five percent of large residential users to maximize return on investment. A similar approach was recommended in the Livingston's 2005 UWMP.

The City of Atwater is currently offering free water audit program, but participation rates are relatively low (about 30 residential audits performed per year). To improve participation, the City could consider an outreach campaign such as bill inserts to raise awareness of the program.

Residential Retrofit Rebate Program is the most direct way to reduce water use. Currently, all three cities rely on PG&E's washer rebate program to drive their high-efficiency washer markets. The city could consider leveraging PG&E's rebate program by offering a modest additional rebate for those who install an even higher efficiency washer than those rebated by PG&E to provide additional incentive to install conserving devices.

Non-Residential Retrofit Partnership Program: Water use in the non-residential sector typically depends on the type of business. Achieving significant water savings may require replacement of expensive devices or adjustments to manufacturing processes. The Cities could consider launching a program to encourage business owners to propose their own approaches to conserving water, and offer grants or loans to cost-share the capital investment. A similar grant/loan program could also be implemented to target large landscape users such as hospitals and schools. The effectiveness/applicability of such a program greatly depends on the number and type of businesses/industries operating within each city. For example, the City of Livingston may be a good candidate for this program, due to the large industry with high water demands identified in its UWMP.

Rainwater Harvesting and Gray Water Programs could complement water conservation programs. The Cities could consider providing rainwater barrels to homes at reduced cost, providing free consultation on gray water system installation, or hosting public workshops on how to install rainwater or graywater systems. The Cities could also encourage or require new developments to consider rainwater and graywater system installation as a permit approval condition. The Cities could also explore receiving deliveries for landscape or other compatible use from MID surface water in exchange for tertiary treated water applicable for agriculture use.

Conservation Modeling provides a tracking and forecasting mechanism. Conservation models can be developed as simple Excel spreadsheets that account for agency cost, device cost, and program implementation costs, as well as historical participation rates, population and employment projections, market saturation rates, etc. For example, the City of Atwater is not currently tracking each DMM as a separate line item in its budget planning documents, which makes evaluating the effectiveness of any DMM impossible. A conservation model could be used to track the investment and effectiveness of each measure and enable educated decisions on where and how to adjust these programs. When built and used correctly, a conservation model can effectively standardize the monitoring and projection of savings, help identify market saturation rates of conserving devices, provide guidelines for future resource investment, and justify grant or loan applications.

Conservation Plans are important documents that can assist in managing and forecasting water conservation needs and enable prioritization of financial and staff resources. Conservation plans should provide a review (both qualitative and quantitative) of current conservation measures, present an analysis of projected water savings for each measure, and identify recommended areas to focus

resources. Conservation plans should also provide guidance on different approaches to be implemented in wet and dry years. Such plans are typically updated periodically; often on a five-year cycle coinciding with UWMP update schedules.

2 Agricultural Conservation

This section summarizes agricultural water use and conservation in the Merced IRWM Region.

2.1 Introduction

Agricultural water conservation can be defined as reducing the amount of water applied to crops while maintaining or improving crop yield. Water can be conserved by reducing diversions while still meeting customer water orders and also by reducing water applied to a field with maintaining or improving production. When considering the benefits of agricultural water conservation, it is important to recognize that applied water that is not evaporated or transpired is often reused. This reuse may occur on the same farm, in the same region, or in another region. In addition to water savings, agricultural water conservation may provide water quality improvements, environmental benefits, and increased energy efficiency.

The Agricultural Water Management Planning Act of 2009, also referred to as Senate Bill x7-7 (SBx7-7), requires agricultural water suppliers providing water to more than 25,000 irrigated acres to implement Efficient Water Management Practices (EWMPs) and to prepare and adopt agricultural water management plans. Implementing these EWMPs can lead to water conservation that helps to maximize water use efficiency and to avoid or correct groundwater overdraft conditions. However, the water supply source (i.e., surface water or groundwater) and the existing water management conditions influence how and which EWMPs can be applied to help achieve regional objectives. The following sections describe the agricultural water management settings in the region, how the EWMPs apply to each setting, and conclusions and recommendations.

2.2 Agricultural Water Management “Settings” and Conservation Approaches

With respect to water supply, agriculture within the Merced IRWMP area can be grouped into three broad classes (Table 6). **First**, the irrigated area constituted from areas within the boundaries of MID, Stevinson Water District (SWD), and Turlock Irrigation District (TID), of which only a small portion is within the Merced Region, enjoys a reliable surface water supply in most years. MID and SWD apply waters mainly from the Merced River while TID supplies are primarily derived from the Tuolumne River. The MID service area covers about 164,000 acres, of which 133,000 acres are irrigable. SWD has 3,632 irrigable acres. Some groundwater is pumped within the MID and SWD service areas by both private landowners and by MID. **Second**, approximately 69,000 irrigated acres are served by other agricultural water suppliers that rarely, if ever, have adequate surface water supplies to meet agricultural demands. These areas rely on a blend of surface water and groundwater with groundwater being the primary source. **Finally**, irrigated areas outside of the service areas of MID and the other agricultural water suppliers rely solely on groundwater supplies for irrigation, with the exception of limited surface water purchases made in some years, subject to availability.

Table 6: Classes of Agricultural Water Suppliers in the Merced IRWMP

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total 2009 Irrigated Ag area, acres	Total 2009 Non-Ag area, acres	Total Area, acres
Organized Agricultural Water Suppliers Relying Mainly on Surface Water¹			
• Merced Irrigation District	133,000	31,000	164,000
• Stevinson Water District	3,600	2,600	6,200
Other Organized Agricultural Water Suppliers	68,000	29,400	97,400
No Organized Agricultural Water Suppliers	94,000	220,600	314,600
Total	298,600	283,600	582,200

1. Turlock Irrigation District also supplies surface water to a small portion of the Merced Region. However, because the irrigated area supplied is minimal, TID supplies have not been included in this analysis.

Seven smaller agricultural water suppliers (Table 7), located entirely or partially within the Merced IRWMP boundary, provide limited surface water supplies dependent upon availability. The irrigated areas served by these suppliers range from about 1,500 to 19,500 acres. The surface water supplies of these water districts are not adequate to fully irrigate the areas they serve; thus, groundwater is also used to meet crop water needs. With the exception of Chowchilla Water District, which includes additional area served outside of the Merced IRWMP boundaries, these water districts provide water to less than 25,000 acres and are thus not subject to SBx7-7 requirements to measure deliveries, price water based on volume and submit agricultural water management plans unless funding specifically is provided for that purpose.

Table 7: Other Organized Agricultural Water Suppliers

S. No.	Water Supplier Name¹	Total 2009 Irrigated Area, acres	Total Non-Ag Area, acres	Total Area, acres
1	Le Grand-Athlone W.D.	19,534	4,952	24,486
2	Chowchilla W.D.	16,040	12,737	28,777
3	Merquin County W.D. ²	13,661	6,439	20,100
4	Eastside W.D.	10,361	2,145	12,506
5	Turner Island W.D.	7,440	557	7,997
Total		72,097	29,548	101,645

1. Inactive Districts are not listed. These include Plainsburg Irrigation District (total area approximately 5,000 acres) and Sierra Water District (total area approximately 1,580 acres).

2. Personal communication with staff at Merquin County Water District indicates irrigated area in 2009 was 9,775 acres. The additional acres identified from the NASS data may be groundwater only acres.

Effective conjunctive use of surface water and groundwater requires different conservation approaches in areas with adequate surface water supplies compared to areas with inadequate or no

surface water supplies that rely mostly (or solely) on groundwater. Sustainable use of groundwater relies on surface water for recharge of the groundwater storage reservoir. Thus, continued use of surface water must be encouraged to the greatest extent possible. Use of surface water in place of groundwater, known as in lieu recharge, helps maintain groundwater storage by reducing groundwater demand. The analysis that follows estimates the effect on groundwater of agricultural irrigation and crop evapotranspiration (ET) in the three aforementioned areas. A recent year (2009), with crop acreage data and water balance information available was chosen for the analysis. This year is by no means representative of an average or typical year in the area. The year 2009 was selected because this is the most recent year for which a complete set of land and water use as well as water supply data was available for this analysis. It is worthy to note, however, that with reduced diversions from the Merced River, conjunctive use opportunities become limited due to the difficulty in maintaining a balance between recharge and extraction of groundwater. At a certain threshold, increasing distribution system efficiency mainly by lining the system combined with a program to introduce flood release flows (when they occur) to protected recharge areas would be a more effective way to ensure surface water reliability.

2.2.1 Analytical Approach

An analysis of the Merced IRWMP area was performed to define the exchanges between the surface layer (defined as the crop root zone) and underlying groundwater aquifers through groundwater pumping and deep percolation of applied water and precipitation. Understanding the relative magnitudes of these exchanges in the areas with differing surface water availability is important when considering the agricultural conservation actions (i.e., EWMPs) best suited for each area.

The net depth of ground water extracted from the groundwater system, or net extraction (NE), provides an indication of the net effect of irrigation on the groundwater system. This indicator does not include lateral groundwater flows and therefore does not provide a complete picture of the groundwater balance as can be obtained through more rigorous groundwater modeling. Determining the NE requires estimation of the volume of water withdrawn from and entering groundwater storage (withdrawals and recharge, respectively). These two parameters are generally not available through direct measurement.

Although the analysis described herein is not a complete water balance accounting for all inflows and outflows from the surface layer, the estimates of these exchanges for a recent year (2009) provide an important foundation for considering EWMPs to implement in the various areas. Development of a complete, multi-year water balance for the region is recommended for a more complete understanding of the regional hydrology, historical irrigation water management practices, and potential trends in water supply and demand.

Groundwater Withdrawals

The volume of water withdrawn can be estimated by determining water demands and estimating the volume of surface and groundwater supplied to meet those demands. The following sections describe how water demands were estimated and the corresponding water supplies available.

Water Demands

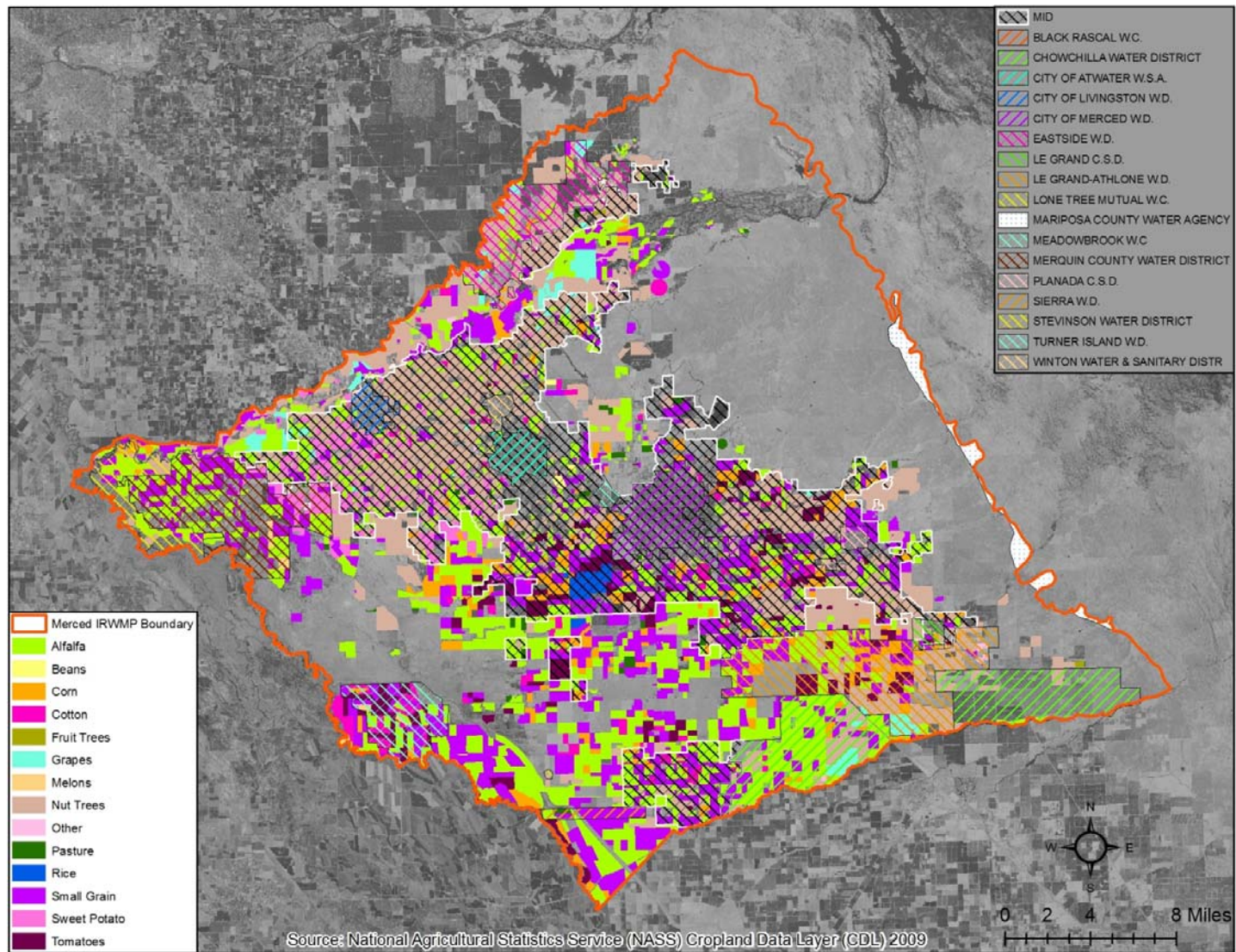
Land use for the Merced IRWMP area was estimated based on the National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) for California for 2009, which is provided as spatially-distributed digital data in raster format and is available from the USDA at <http://nassgeodata.gmu.edu/CropScape/>. The boundaries of individual fields were obtained from the 2002 DWR land use survey of Merced County. The NASS land use data were utilized to assign land use information to the individual fields delineated in the DWR land use dataset. A map showing the distribution of crop types within the Merced IRWMP area based on the available 2009 data is shown in Figure 5.

A root zone water balance simulation was available for 2009. The main inputs to the root zone water balance model include reference evapotranspiration (ET_o), precipitation, crop coefficients, rooting depths, and soil hydraulic parameters. The model performs a unique hydrologic simulation for each crop on a monthly time step. The simulation tracks depletion of soil moisture by crop ET, and accretions of soil moisture from precipitation and irrigation. Priority is given to use of precipitation, and irrigation is triggered only when precipitation is inadequate to meet crop water requirements. Crop use of precipitation and applied irrigation water are tracked separately. The results estimate the portions of total crop ET supplied from applied water (ET_{aw}) and from precipitation (ET_{pr}) for each crop by month. Estimated growing season ET_{aw} values generated by the model are presented in Table 3. Note that the ET values have been adjusted to account for decreases in vigor and bare spots that generally exist under actual growing conditions. Unit ET_{aw} values for each crop were multiplied by the corresponding cropped acres in 2009 to compute total applied water volumes consumed for agricultural purposes.

Table 8: Annual ET_{aw} for Major Crops in the Merced IRWMP Area

Crop	ET_{aw}, inches
Alfalfa	39.1
Beans	18.9
Corn	21.9
Cotton	27.5
Fruit Trees	32.5
Grain Corn	31.2
Grapes	20.7
Melons	18.1
Nut Trees	32.5
Other	12.9
Pasture	38.2
Rice	36.6
Small Grain	13.6
Sweet Potato	28.3
Tomatoes	20.5

Figure 5: Land Use within Merced IRWMP Area¹



1. Inactive Districts (Plainsburg Irrigation District and Sierra Water District) are not shown. TID is not shown because the estimated irrigated area served is negligible.

Surface Water Supplies

Surface water deliveries in the region totaled approximately 290,050 AF in 2009, which was a below normal water year (based on the San Joaquin River 60-20-20 index).

Groundwater Supplies

MID measures District groundwater pumping used to supplement surface water supplies in dry years and also to serve customers in high ground areas that cannot be served by surface water via gravity flow. Private groundwater pumping is not measured and has been estimated by assuming that 80 percent of the groundwater pumped is consumed by the crops as ET_{aw}. Deep percolation of applied groundwater is estimated by assuming that tailwater from lands served by groundwater averages three percent of the applied water volume.

Groundwater Recharge

The volume of water entering groundwater storage includes seepage from irrigation canals and water from precipitation, or in the case of irrigation, applied water leaving the root zone of irrigated or cropped land, called deep percolation of precipitation or applied water, respectively. The following sections describe how seepage from irrigation canals, deep percolation of precipitation, and deep percolation of applied water were estimated.

Seepage from Irrigation Canals

Seepage from irrigation canals was available for MID from the 2009 water balance reported in MID's Agricultural Water Management Plan. For the other water suppliers, estimates of seepage from irrigation canals were not available. Given the limited volume of surface water delivered by the other agricultural water suppliers and the lack of infrastructure in the groundwater only areas, seepage from irrigation canals in these areas was assumed to be negligible for this analysis.

Deep Percolation of Precipitation

The deep percolation of precipitation was determined for MID by totaling the volume determined for each crop from the root zone water balance simulation described earlier. For the other surface water suppliers and the groundwater-only areas, the unit depth of deep percolation of precipitation was assumed to be the same as estimated for the MID area.

Deep Percolation of Applied Water

Deep percolation of applied water was determined for MID as the closure term of the irrigated lands accounting center in the 2009 water balance. For the other surface water suppliers, 75 percent of the surface water applied was assumed to be consumed by the crop and the remaining 25 percent was split equally between surface runoff and deep percolation. For groundwater application in areas with limited surface water supplies and in areas with no surface water supplies, 80 percent of the applied groundwater was assumed to be consumed by the crop. Given that drip and micro irrigation systems tend to be more prevalent in groundwater supplied areas, 17 percent of the remaining 20 percent was assumed to percolate back to the groundwater system.

2.2.2 Analysis Results

The following subsections summarize the results of the analysis. As primary emphasis was placed on the interaction between the land surface layer (root zone) and the underlying groundwater system, the discussion centers on groundwater withdrawals and recharge.

Groundwater Withdrawals

The volume of water withdrawn was estimated by determining water demands and estimating the volume of surface and groundwater supplied to meet those demands. The following sections describe estimated water demands for 2009 and the corresponding estimated water supplies available.

Water Demands

The total water demand for agricultural use in 2009 was estimated to be 650,900 AF (Table 9). About 250,500 AF, or 38%, of the total agricultural water demand was from the irrigated area served by MID. Together the other organized agricultural water suppliers and groundwater-only areas accounted for about 400,400 AF, or 62% of the total agricultural demand.

Table 9: 2009 Estimated Annual Water Demands in the Merced IRWMP Area

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	ET_{aw}, AF	ET_{aw}, AF per acre
Organized Agricultural Water Suppliers	204,600	423,700	2.1
No Organized Agricultural Water Suppliers	94,000	227,200	2.4
Total	298,600	650,900	2.2

Surface Water Supplies

Total surface water deliveries in the region were estimated to be 289,850 AF (Table 10). Surface water deliveries by MID to water customers were about 246,600 AF in 2009, a below normal water year. The surface water delivered was less than the ET_{aw} in MID because surface water supplies were not adequate, and some growers supplemented their surface water deliveries by pumping groundwater. The seven other water suppliers within the Merced IRWMP area received about 43,450 AF of surface water supplies in 2009, and the area with no organized agricultural water suppliers was assumed to have not received surface water.

Table 10: 2009 Annual Surface Water Deliveries in the Merced IRWMP Area

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	Surface Water Delivered, AF	Surface Water Delivered, AF per acre
Organized Agricultural Water Suppliers	204,600	289,850	1.4
No Organized Agricultural Water Suppliers	94,000	0	0.0
Total	298,600	289,850	1.0

Groundwater Supplies

Total groundwater pumped in the region was estimated to be 583,300 AF (Table 11) in 2009. Combined groundwater pumping by MID for delivery to its customers and private groundwater pumping within MID was estimated to be about 126,600 AF in 2009, a below normal water year. In wet and above normal years, substantially less groundwater pumping occurs within the MID boundaries. Estimated groundwater pumping within the service areas of the seven other water suppliers within the Merced IRWMP was estimated to be about 172,700 AF in 2009. In areas with no organized agricultural water supplier, groundwater pumping was estimated to be 284,000 AF in 2009.

Table 11: 2009 Estimated Annual Groundwater Pumping for Irrigation in the Merced IRWMP Area

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	Estimated Groundwater Pumped, AF	Estimated Groundwater Pumped, AF per acre
Organized Agricultural Water Suppliers	204,600	299,300	1.5
No Organized Agricultural Water Suppliers	94,000	284,000	3.0
Total	298,600	583,300	2.0

Groundwater Recharge

The volume of water entering groundwater storage includes seepage from irrigation canals and water from precipitation, or in the case of irrigation, applied water leaving the root zone of irrigated or cropped land, called deep percolation of precipitation or applied water, respectively. The following sections describe the estimates of seepage from irrigation canals, deep percolation of precipitation, and deep percolation of applied water for 2009.

Seepage from Irrigation Canals

Seepage from irrigation canals was estimated to be 168,750 AF for the 2009 MID water balance reported in MID’s Agricultural Water Management Plan. Given the limited volume of surface water delivered by the other agricultural water suppliers and the lack of infrastructure in the groundwater only areas, seepage from irrigation canals in these areas was assumed to be negligible.

Deep Percolation of Precipitation

Total deep percolation of precipitation during the irrigation season in the agricultural production areas in the region was estimated to be 80,400 AF (Table 8). Deep percolation of precipitation from the MID irrigated area during the MID irrigation season was estimated to be about 32,600 AF in 2009, a below normal water year. Estimated deep percolation of precipitation in the seven other water suppliers within the Merced IRWMP was estimated to be about 20,800 AF. In the areas with no organized agricultural water suppliers, deep percolation of precipitation was estimated to be 27,000 AF. It is important to note that additional deep percolation of precipitation, not included in this analysis, occurred both outside the irrigation season and also on lands not in agricultural production.

Table 12: 2009 Estimated Annual Deep Percolation of Precipitation in the Merced IRWMP Agricultural Area

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	Estimated Deep Percolation of Precipitation, AF	Estimated Deep Percolation of Precipitation, AF per acre*
Organized Agricultural Water Suppliers	204,600	53,386	0.3
No Organized Agricultural Water Suppliers	94,000	26,982	0.3
Total	298,600	80,368	0.3

* It is assumed that the deep percolation of precipitation on a unit basis (AF per acre) is similar among areas.

Deep Percolation of Applied Water

Total deep percolation of applied water during the irrigation season in the agricultural production areas in the region was estimated to be 162,100 AF (Table 9). Deep percolation of applied water from the MID irrigated area was estimated to be about 74,700 AF, or 46 percent of the IRWMP area total in 2009, a below normal water year. Combined deep percolation of applied water in the seven other water suppliers within the Merced IRWMP area was estimated to be about 39,200 AF in 2009. In the areas with no organized agricultural water suppliers, deep percolation of applied water was estimated to be 48,300 AF in 2009.

Table 13: 2009 Estimated Deep Percolation of Applied Water in the Merced IRWMP Agricultural Area

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	Estimated Deep Percolation of Applied Water, AF	Estimated Deep Percolation of Applied Water, AF per acre
Organized Agricultural Water Suppliers	204,600	113,858	0.6
No Organized Agricultural Water Suppliers	94,000	48,281	0.5
Total	298,600	162,139	0.5

Net Extraction Results

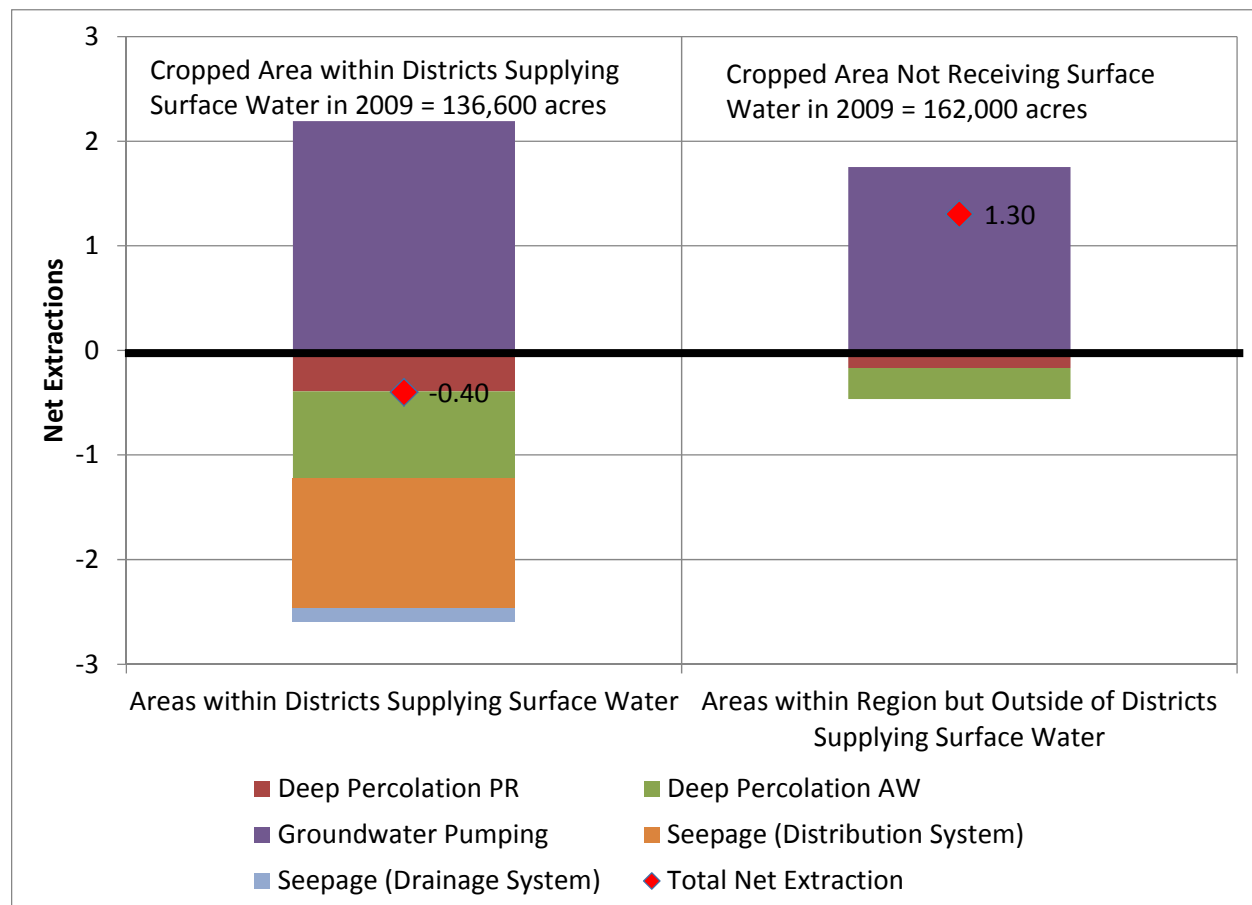
Total net extraction of groundwater in the agricultural production areas in the region for 2009 was estimated to be 158,300 AF (Table 14). Net extraction of groundwater from the MID irrigated area was estimated to be negative 167,400 AF. This means that MID added 167,400 AF to groundwater storage in 2009, a below normal water year. Estimated net extraction of groundwater per acre in the MID service area in 2009 was approximately -1.5, meaning that groundwater was replenished in the MID service area at a rate of approximately 1.5 AF per acre. Estimated net extraction of groundwater from the areas of the seven other water suppliers within the Merced IRWMP area was estimated to be about 117,000 AF in 2009, or 1.6 AF per acre. This means that in areas served by agricultural suppliers outside of MID’s service area, groundwater supplies were diminished at a rate of 1.6 AF/acre in 2009. In areas with no organized agricultural water suppliers, net extraction was approximately 208,700 AF in 2009. This translates to a net removal of 2.2 AF of groundwater per acre in areas with no organized agricultural water suppliers. This analysis indicates that the impact of agricultural production and irrigation on groundwater supply varies substantially depending on the adequacy of surface water supplies. Net extraction is depicted graphically in Figure 6.

Table 14: 2009 Estimated Net Extraction of Groundwater in the Merced IRWMP Agricultural Areas

Agricultural Water Suppliers within Merced IRWMP Boundaries	Total Irrigated area, acres	Estimated Total Net Extraction, AF	Estimated Total Net Extraction, AF per acre
Organized Agricultural Water Suppliers	204,600	-50,459	-0.2
No Organized Agricultural Water Suppliers	94,000	208,744	2.2
Total	298,600	158,285	0.5

*Positive net extraction indicates that withdrawals exceed inputs; negative net extraction indicates that inputs exceed withdrawals.

Figure 6: 2009 Estimated Groundwater Fluxes and Net Extraction of Groundwater per Acre in the Merced IRWMP Agricultural Areas by Water Supply Category



2.3 EWMPs Applicable to Merced IRWMP Conservation Settings

2.3.1 Introduction

This section describes the actions that MID and others have taken and are planning to take to improve water management with respect to relevant Merced Region IRWMP objectives.

Agricultural water conservation actions support progress toward maximizing water use efficiency and correcting groundwater overdraft conditions, two important Merced Region IRWMP objectives.

These water conservation actions are organized with respect to the Efficient Water Management Practices (EWMPs) described in California Water Code §10608.48. The Code lists two types of EWMPs: (1) critical EWMPs that are mandatory for all agricultural water suppliers subject to the Code and (2) additional EWMPs that are mandatory if found to be technically feasible and locally cost effective. Among agricultural water suppliers in the Merced IRWMP region, only MID and CWD serve areas greater than 25,000 acres, and are thus subject to the Code; however, many of the smaller agricultural water suppliers have also implemented some of the EWMPs.

The two mandatory EWMPs are measurement of the volume of water delivered to customers with sufficient accuracy for aggregate reporting and adoption of a pricing structure based at least in part on the quantity delivered. MID is actively implementing the delivery measurement accuracy EWMP and has utilized a pricing structure based partly on volume delivered for more than 10 years. MID has implemented and plans to continue implementing all additional (i.e., conditional) EWMPs that are technically feasible and locally cost effective (shown in Table 15).

2.3.2 EWMPs with Respect to Conservation “Settings”

The analysis described previously identified two conservation “settings” with respect to groundwater: (1) areas with adequate surface water supplies in most years and (2) areas with inadequate surface water supplies. Given the differences in water supply reliability between settings and overall implications to regional water supply reliability, EWMPs should be applied strategically to meet the Merced Region IRWMP water management objectives.

In areas with adequate surface water supplies, maximizing water use efficiency is important for drought preparedness so that available surface water supplies can provide the most benefit. However, the inevitable tradeoffs of this increased efficiency (primarily reduced recharge in wet years) must be recognized and actions taken to offset the reduced recharge. In other words, projects that reduce recharge in wet years should include a managed recharge component to replace the reduced recharge. A managed recharge component could include direct recharge of groundwater within the MID service area or other designated areas within the region, in-lieu recharge through surplus water sales to areas within the region with inadequate surface water supplies, or a combination of strategies.

This additional managed recharge component is necessary for sustainable resource management within the region. Due to the potential additional costs associated with managed recharge, particularly for constructing and operating facilities for direct groundwater recharge, EWMPs that maximize efficiency without reducing recharge in wet years could be considered first for areas with

adequate surface water supplies in most years. Once maximum utilization of these actions is achieved, the more expensive EWMPs requiring a managed recharge component could be considered.

Under managed in-lieu recharge, surplus surface water supplies, to the extent that they cannot be held in carryover storage for use in future years, could be made available to areas within the region with inadequate surface water supplies. This approach could potentially reduce the cost of improving groundwater storage in the region through increased revenue for the seller of surplus surface water and through reduced pumping costs for the buyer or buyers of available surface water. The net effect would be to increase overall regional water supplies and overall water supply reliability.

Areas with inadequate surface water supplies should maximize conservation within cost-effective limits. However, since most water pumped from groundwater above crop requirements returns to the groundwater through deep percolation, the main benefit of maximizing water conservation is energy conservation. Benefits of conservation are reaped in all years because surface water supplies are always inadequate. Table 15 describes the strategies for implementation of each EWMP with respect to adequacy of surface water supplies in the area.

Table 15: EWMP Strategies and Activities for Areas with Surface Water Resources and Groundwater Resources

EWMP	Strategies for implementing EWMPs in areas where surface water supplies are, in most years, adequate for customer demands (i.e. MID)	Strategies for implementing EWMPs in areas where surface water supplies are always inadequate for meeting customer demands
<p>Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement 10608.48.b(2). Adopt a pricing structure for water customers based at least in part on quantity delivered.</p>	<ul style="list-style-type: none"> • Entities subject to the Regulation implement as required to comply. • Entities subject to the Regulation to develop a volumetric pricing structure that encourages use of surface water instead of groundwater. 	<ul style="list-style-type: none"> • Entities subject to the Regulation implement as required to comply. • Entities subject to the Regulation to develop a volumetric pricing structure that encourages use of surface water instead of groundwater.
<p>Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.</p>	<ul style="list-style-type: none"> • Lands with exceptionally high water duties or whose irrigation contributes to significant problems are not found within the Merced IRWMP area. Furthermore, agricultural water supplier rules and regulations prohibit wasteful use of water, preventing exceptional water duties or significant problems from occurring. 	<ul style="list-style-type: none"> • Lands with exceptionally high water duties or whose irrigation contributes to significant problems are not found within the Merced IRWMP area. Furthermore, agricultural water supplier rules and regulations prohibit wasteful use of water, preventing exceptional water duties or significant problems from occurring.
<p>Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils</p>	<ul style="list-style-type: none"> • Recycle M&I wastewater not otherwise used beneficially within the Region to the maximum extent locally cost effective subject to applicable regulations. • Search for grant funding for projects recycling M&I wastewater not otherwise used beneficially within the Region that are not locally cost effective. 	<ul style="list-style-type: none"> • Recycle M&I wastewater not otherwise used beneficially within the Region to the maximum extent locally cost effective subject to applicable regulations. • Search for grant funding for projects recycling M&I wastewater not otherwise used beneficially within the Region that are not locally cost effective.
<p>Facilitate financing of capital improvements for on-farm irrigation systems</p>	<ul style="list-style-type: none"> • Encourage growers installing high efficiency irrigation systems to remain connected to and continue to utilize available surface water supplies. Include incentives and possibly payments for growers to remain connected to the surface system. 	<ul style="list-style-type: none"> • Encourage growers to install/convert to high efficiency irrigation systems, thereby reducing the volume of required groundwater pumping and potentially conserving energy. Water quality benefits may also be achieved.
<p>Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.</p>	<ul style="list-style-type: none"> • Utilize pricing structure that promotes use of surface water when available and encourages efficient use of surface water when supplies are limited, leading to conjunctive use of groundwater, appropriate increase of groundwater recharge, prevention of problem drainage, and effective management of all water sources throughout the year. 	<ul style="list-style-type: none"> • Where surface supplies are available, utilize pricing structure that promotes use of surface water when available and encourages efficient use of surface water when supplies are limited, leading to conjunctive use of groundwater, appropriate increase of groundwater recharge, prevention of problem drainage, and effective management of all water sources throughout the year.
<p>Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage</p>	<ul style="list-style-type: none"> • Line, or convert to pipelines, canals in high seepage areas only as new controlled groundwater recharge basins are constructed or in lieu recharge is implemented to offset groundwater recharge lost due to seepage reduction. • Construct regulating reservoirs, where cost effective, to improve delivery flexibility and service and to reduce operational spillage that would not otherwise be beneficially used. • Provide high levels of service to maintain surface water customer base. 	<ul style="list-style-type: none"> • Line or pipe all existing or new systems and constructed regulating reservoirs to minimize spills and provide high levels of service.
<p>Increase flexibility in water ordering by, and delivery to, water customers within operational limits</p>	<ul style="list-style-type: none"> • Implement projects to increase delivery flexibility and provide high levels of service to all users to maximize surface water use. 	<ul style="list-style-type: none"> • Increase delivery flexibility and provide high levels of service to all users in all existing or new systems to maximize surface water use and overall water use efficiency.
<p>Construct and operate supplier spill and tailwater recovery systems</p>	<ul style="list-style-type: none"> • Expand spillage recovery to conserve water otherwise lost from the region. • Expand tailwater recovery operations to conserve water otherwise lost from the region and to improve water quality. 	<ul style="list-style-type: none"> • Where surface water is available, expand spillage recovery to conserve water otherwise lost from the region. • Encourage growers to install/convert to high efficiency irrigation systems and manage the system to conserve water lost to the region, improve water quality, and potentially conserve energy.

EWMP	Strategies for implementing EWMPs in areas where surface water supplies are, in most years, adequate for customer demands (i.e. MID)	Strategies for implementing EWMPs in areas where surface water supplies are always inadequate for meeting customer demands
<p>Increase planned conjunctive use of surface water and groundwater within the supplier service area</p>	<ul style="list-style-type: none"> • Implement a comprehensive conjunctive management program through: <ul style="list-style-type: none"> ○ Investigation of ways to increase surface water sales when available through expansion of surface water deliveries to high ground areas and groundwater only areas within the Merced IRWMP area. ○ Investigation of ways to expand direct and in lieu recharge of groundwater. ○ Supplement available surface water supply with groundwater, when limited. ○ Implement a pricing structure that promotes the following conjunctive management goals: (1) encourages use of available surface water supplies, (2) encourages conservation of limited surface water supplies in dry years, and (3) provides revenue required to operate groundwater wells in dry years. ○ Through surplus water sales outside of service area, promote direct and in-lieu recharge within Merced IRWMP boundaries and generate funds to implement projects that enhance water management within the Merced IRWMP boundaries. ○ Development and adoption of a GMP, and participate in local groundwater management activities. ○ Implementation of groundwater monitoring as part of CASGEM. ○ Development of analytic tools to support long term planning and management. 	<ul style="list-style-type: none"> • Implement a comprehensive conjunctive management program. Since the groundwater pumping capacity exists, the main focus here is to enhance recharge through: <ul style="list-style-type: none"> ○ Investigation of ways to increase surface water use and availability through water transfers and other means. ○ Investigation of ways to expand recharge of groundwater through local streams and other means. ○ Encouragement of substitution of M&I wastewater not otherwise beneficially used for groundwater. ○ Implementation of groundwater monitoring as part of CASGEM. ○ Development of analytic tools to support long term planning and management.
<p>Automate canal control structures</p>	<ul style="list-style-type: none"> • Continue to automate canal control structures to facilitate increased delivery flexibility and steadiness in surface water deliveries while reducing spillage lost to the region. 	<ul style="list-style-type: none"> • Where surface water is available, continue to automate canal control structures to facilitate increased delivery flexibility and steadiness in surface water deliveries while reducing spillage lost to the region.
<p>Facilitate or promote customer pump testing and evaluation Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.</p>	<ul style="list-style-type: none"> • Promote and facilitate pump testing and evaluation. • Designate a Water Conservation Coordinator. 	<ul style="list-style-type: none"> • Promote and facilitate pump testing and evaluation. • Where applicable designate a Water Conservation Coordinator.
<p>Provide for the availability of water management services to water users.</p>	<ul style="list-style-type: none"> • Support CIMIS site and provide a link to CIMIS on agency web sites. • Provide links to other water management resources on agency web sites. • Develop framework for local agricultural surface water suppliers to cooperate and make the most efficient, cost-effective use of return flows. 	<ul style="list-style-type: none"> • Support mobile irrigation evaluation labs
<p>Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.</p>	<ul style="list-style-type: none"> • Develop framework for local agricultural surface water suppliers to cooperate and make the most efficient, cost-effective use of return flows. 	<ul style="list-style-type: none"> • Not Applicable
<p>Evaluate and improve the efficiencies of the supplier's pumps.</p>	<ul style="list-style-type: none"> • Test agricultural surface water supplier wells. • Established an ongoing capital improvement program to rehabilitate and replace pumps as necessary. 	<ul style="list-style-type: none"> • Develop a program to support pump testing of supplier pumps.

2.3.3 Conclusions

Based on the agricultural conservation analysis completed, the following conclusions have been identified.

1. Deep percolation of applied water in irrigated agricultural areas is a significant source of groundwater recharge in the Merced IRWMP area.
2. The impact of agricultural production and irrigation on groundwater varies substantially depending on the adequacy of surface water supplies:
 - a. Agricultural areas with adequate surface water supplies in most years have a net positive effect on groundwater supplies through recharge in below normal water years.
 - b. Agricultural areas with inadequate surface water supplies have a net effect of extracting water from groundwater storage.
3. Most irrigation return flows are reused within the region. Net outflows of applied irrigation water are unknown at this time. Any reduction in net outflows would represent conserved water for the region.
4. The main benefit of irrigation water conservation is reduced groundwater pumping resulting in:
 - a. Potential reductions in energy consumption
 - b. Water quality benefits
 - c. Increased supply to the Region, to the extent that net outflows are reduced

2.3.4 Recommendations

The following recommendations have been identified for future agricultural conservation in the Merced Region.

1. EWMPs improving irrigation efficiency should be implemented at the maximum cost effective level in areas with inadequate surface water supplies.
2. In areas with adequate surface water supplies, EWMPs that result in reduced recharge of applied surface water should be carefully evaluated to avoid unintended reductions in recharge to groundwater system. To the extent that groundwater system is jeopardized, offsetting artificial recharge should be considered. Artificial recharge may include direct recharge, in lieu recharge, or a combination of strategies.
3. Comprehensive flood management solutions that redirect flood waters into spreading basins in recharge areas should be investigated. Benefits include both reduced flooding and increased groundwater recharge.
4. Recharge opportunities by flooding agricultural lands during winter time should be investigated. The source of water could be spills from the reservoir and/or intentional releases during winter non-irrigation season, with the goal of spreading on farmland areas.

5. Detailed multi-year water balance analyses structured around water supplier and groundwater only areas should be developed to better understand water supply conditions, water conservation opportunities, and interactions between supply areas within the Region.