City of Fresno

Metropolitan Water Resources Management Plan Update
Phase 1 Baseline System Characterization

December 2007

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City of Fresno Metropolitan Water Resources Management Plan Update

Phase 1 Report: Baseline System Characterization

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Chapter 3. Urban Water Demands

Page 3-5, Table 3-2. Existing and Projected Land Use for the City of Fresno

Footnote (b) should be revised as follows:

(b) GIS data provided by the City included only polygons for parcels and did not include additional polygons for streets, highways, or major water ways; ~~hence,~~ the data presented is total acres for parcels included in the City's GIS database. ~~net acreage.~~

See revised Table 3-2 attached.

Table 3-2. Existing and Projected Land Use for the City of Fresno [a,b]

Customer Class[c]	Low Demand Area, acres[d]			High Demand Area, acres[e]		
	2005[f]	2010[f,g]	2025[f]	2005[f]	2010[f,g]	2025[f]
Single Family Residential	21,948	25,619	36,244	22,777	26,688	37,414
Multiple Family Residential	3,475	3,757	4,639	3,852	4,133	4,981
Commercial/Institutional	12,449	12,771	19,339	14,084	14,563	21,273
Industrial	1,994	1,994	4,098	1,994	1,994	4,098
Landscape Irrigation	2,304	2,376	2,675	2,310	2,391	2,705
South East Growth Area	0	2,094	8,376	0	2,094	8,376
Subtotal	**42,172**	**48,610**	**75,370**	**45,017**	**51,863**	**78,847**
Open Space or Vacant	28,958	24,614	4,136	30,286	25,533	4,832
Rural Residential in South East Growth Area	8,376	6,282	0	8,376	6,282	0
Total	**79,506**	**79,506**	**79,506**	**83,679**	**83,679**	**83,679**

[a] All acreage estimates include areas served by private groundwater users because they could not be removed from the geospatial data; however, including private users in the water demands additional planning conservatism that will allow existing private groundwater users the flexibility to connect to the City's water system in the future should water quality or other extenuating circumstances require them to abandon their groundwater well.

[b] GIS data provided by the City included only polygons for parcels and did not include additional polygons for streets, highways, or major water ways; the data presented is total acres for parcels included in the City's GIS database.

[c] Customer Classes correspond to water use records provided by the City.

[d] Low demand area does not include Bakman, Pinedale, or CSUF.

[e] High Demand area does include Bakman, Pinedale, and CSUF.

[f] Acreage obtained from GIS shapefiles provided by the City; General Plan land use categories were assigned to Customer Classes per Appendix 3-A.

[g] Acreage added from 2005 to 2010 is based on discussions with City staff and tentative map boundaries provided by the City.

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EXECUTIVE SUMMARY

INTRODUCTION

This report presents the findings of Phase 1 of the Fresno Metropolitan Water Resources Management Plan Update (Metro Plan Update). The purpose of this Metro Plan Update is to update and refine the 1996 Fresno Metropolitan Water Resources Management Plan (1996 Metro Plan), considering available new data and incorporating physical and institutional changes which have occurred since the 1996 Metro Plan was prepared.

The Metro Plan Update will include three key deliverables:

- An update to the Fresno Metropolitan Water Resource Management Plan (to be completed in a series of four phases),
- An environmental document, meeting the requirements of the California Environmental Quality Act (CEQA), covering near-term improvements and actions at a "project" level and long-term improvements and actions at a "program" level, and
- An Urban Water Management Plan (UWMP) and an accompanying updated Water Shortage Contingency Plan, both adopted by City Council.

The completed Metro Plan Update will facilitate future water resources decisions and facilities improvement planning through the years 2025 and 2060, and satisfy eligibility requirements for State funding, including potential grants and loans for special projects and infrastructure improvements.

The process for the Metro Plan Update is depicted in Figure ES-1. As shown, this Phase 1 Report presents the findings of Phase 1 of the Metro Plan Update.

OVERVIEW OF 1996 METRO PLAN FINDINGS AND RECOMMENDATIONS

The 1996 Metro Plan recommended a water supply plan to serve the Fresno-Clovis Metropolitan Area through the year 2050. The 1996 Metro Plan, developed in the early 1990's projected that City of Fresno demands (with conservation) would increase to 121,000 acre-feet per year (af/yr) by the year 2000 and 248,000 af/yr by the year 2050.

Proposed future supplies to meet these demands included untreated canal water for landscaping, treated surface water at two new surface water treatment plants (a northeast plant and a southeast plant), and groundwater from existing and new wells. Intentional groundwater recharge was proposed to be expanded to gradually restore groundwater levels and provide some drought contingency storage. Based on the 1996 Metro Plan, by 2010, the net recharge to the groundwater basin would be +10,000 af/yr (to help restore groundwater levels) and by 2050, the net recharge to the groundwater basin would be 0 af/yr, indicating a long-term balanced plan for City groundwater pumpage and recharge.

Table ES-1 provides a summary of the supply plan recommended in the 1996 Metro Plan.

Table ES-1. 1996 Metro Plan Supply Plan for City of Fresno

Demand/Supply Component	Future Demand and Supply, 1,000 af		
	2000	2010	2050
DEMAND			
Demand (without conservation)	129	163	321
Conservation	8	35	73
Total Demand (with conservation)	**121**	**128**	**248**
SUPPLY			
Untreated Canal Water for Landscaping	3	7	13
Treated Surface Water			
Northeast Treatment Plant	10	10	25
Southeast Treatment Plant	0	15	25
Total Treated Surface Water	10	25	50
Groundwater	108	96	185
Total Supply	**121**	**128**	**248**
GROUNDWATER RECHARGE			
Natural Groundwater Recharge	43	43	43
Urban Intentional Recharge	63	63	142
Total Groundwater Recharge	**106**	**106**	**185**
Net Groundwater Recharge (Recharge – Pumpage)	**-2**	**+10**	**0**

CURRENT SUPPLY AND DEMAND CONDITIONS

In 2006, the City's total water production (demand) was 155,750 af/yr. This water production is significantly higher that what was projected in the 1996 Metro Plan. As shown in Table ES-1 above, the 1996 Metro Plan projected that the demand in 2006 would be about 125,000 af/yr (interpolated based on 2000 and 2010 projections). Therefore, the 2006 actual demand is about 30,000 af/yr, or about 24 percent, higher than what was previously projected. This increase is likely due to the large amount of growth which has occurred since the late 1990s, for which the extent of said growth was not anticipated in the early 1990s when the 1996 Metro Plan was prepared.

In order to meet these larger than previously anticipated demands, in 2006 the City used its Surface Water Treatment Facility (completed in 2004) and groundwater. Approximately 13 percent of demands were met using treated surface water (19,701 af/yr). However, because demands were so high, groundwater pumpage (about 136,050 af/yr), exceeded groundwater recharge such that the net groundwater recharge was -59,000 af/yr. Also contributing to this negative groundwater recharge is the fact that natural groundwater recharge is now estimated to be only 37,000 af/yr (reduced from the previously estimated 43,000 af/yr). As discussed in Chapter 5, this natural groundwater recharge is expected to continue to decrease as urbanization increases. Table ES-2 summarizes the City's 2006 supply and demands.

Table ES-2. City of Fresno 2006 Supply and Demand

Demand/Supply Component	2006 Demand and Supply, 1,000 af
DEMAND	
Demand (without conservation)	--
Conservation	--
Total Demand (with conservation)	**156**
SUPPLY	
Untreated Canal Water for Landscaping	--
Treated Surface Water	
Northeast Treatment Plant	20
Southeast Treatment Plant	0
Total Treated Surface Water	20
Groundwater	136
Total Supply	**156**
GROUNDWATER RECHARGE	
Natural Groundwater Recharge	37
Urban Intentional Recharge	40
Total Groundwater Recharge	**77**
Net Groundwater Recharge (Recharge – Pumpage)	**-59**

As described in Chapter 3 of this Phase 1 Report, the City's water demands are projected to continue to grow. By 2060, the projected water demand is 381,400 af/yr. This is about 130,000 af/yr, or approximately 54 percent, higher than the 2050 demand projected in the 1996 Metro Plan. As such, this Metro Plan Update must take into account these increases in projected water demands as well as other changed conditions related to the City's water supply options.

PURPOSE OF PHASE 1 STUDY

The purpose of Phase 1 is to describe the City's water system background and existing conditions, as well as to evaluate the potential impacts of continuing to operate under "status quo", or "Future Without Project" conditions. For this Phase 1 Report, the "status quo" or "Future Without Project" is defined as use of the City's existing water supply sources (including existing and future groundwater wells and the existing 30-million gallon per day (mgd) Surface

Water Treatment Facility (SWTF)) to meet existing and future water demands through the year 2060.

SUMMARY OF PHASE 1 FINDINGS

Existing and Projected Water Demands

The City's existing and projected future water demands are described in Chapter 3 of this Phase 1 Report. Existing water demands were estimated based on water production records and metered water use data. Because the City currently does not meter single-family residential customers, single-family water use was estimated by subtracting metered water use for the City's other customers and the estimated unaccounted-for water (UAFW) from the total water production. In 2006, the total water production was 155,750 af/yr. UAFW was estimated to be approximately 10 percent of total production, or about 15,575 af/yr. 2006 water use by customer type is summarized in Table ES-3. As shown, most of the water use in the City, approximately 66 percent of the City's total water use, is by single-family and multi-family residential customers.

Table ES-3. City of Fresno 2006 Water Use by Customer Type[(a)]

Customer Type	2006 Water Use, af/yr	Percent of Total Water Use
Single-Family Residential[(b)]	81,398	52%
Multi-Family Residential	22,471	14%
Commercial/Institutional	24,928	16%
Industrial	3,865	2%
Landscape Irrigation	7,514	5%
Unaccounted-For Water[(c)]	15,575	10%
Total	**155,750**	**100%**

(a) Data from City of Fresno Water Division Customers and Net Sales Amounts by Class Calendar Year 2006 "HTE Revenue Report—2006.xls."
(b) Estimated single-family residential water use = Total water production – unaccounted for water – metered water use by all other users.
(c) Unaccounted-for water estimated to be 10 percent of total water production per City Water Department staff.

Over the last 18 years, per capita water use in the City has averaged about 300 gallons per capita per day (gpcd), and has ranged from a low of 269 gpcd in 1993 to a high of 332 gpcd in 2001. Since 2001, per capita water use has decreased significantly. In 2006, the per capita water use was 287 gpcd. This decrease in overall per capita water use may be attributed to a number of potential factors including wetter than normal conditions, regulations mandating low water use fixtures and appliances, general public awareness to conserve water resources, and the City's water conservation program, which has implemented and/or expanded several new conservation programs over the last several years, including a residential toilet retrofit program and an extensive public education program. A complete description of the City's current water conservation program is provided in Chapter 4 of this Phase 1 Report.

Estimates of future water demand were developed using both a per capita based projection based on future population projections and a land use based projection based on the City's General Plan land use plan. Key assumptions for each methodology are summarized as follows:

- Per Capita Based Projection:
  - Assumed a 1.9 percent population growth rate (as requested by the City), and
  - Reduced the current per capita per day water use from about 285 gpcd to 270 gpcd to account for the upcoming installation of residential water meters (reducing the residential per capita demand by 10 percent over five years).
- Land Use Based Projection:
  - Developed unit water use factors for different land use types and adjusted the residential unit water use factors to account for upcoming installation of residential water meters (reducing the residential unit demand by 10 percent over 5 years),
  - Used future land use projections for 2010 and 2025, as obtained from the City,
  - Interpolated future land use projections for 2015, 2020 and 2030 based on straight-line methodology, and
  - Used an aggregate unit demand factor and an estimated development boundary for 2060.

For both methodologies, high and low estimates were developed based on varying assumptions of population growth and rate of development. As described in Chapter 3, the two methodologies yielded similar results. To be consistent with the methodology used in the 1996 Metro Plan, future water demand projections based on the land use based methodology have been adopted for use in this Metro Plan Update. For planning purposes, it was assumed that future water demands would follow the low land use based demand estimate until 2013 (after residential water metering is scheduled to be completed), and then incrementally transition to the high land use based estimated by 2025. These recommended future water demand projections are summarized in Table ES-4.

These recommended future water demand projections are significantly higher than projections provided in the previous Metro Plan. This is primarily due to the extensive growth experienced over the last several years in the City, which was not foreseen in the previous Metro Plan. This is demonstrated by the fact that the City's current water demand of approximately 155,000 af/yr was not projected to occur until about 2020 in the 1996 Metro Plan.

Table ES-4. Recommended Future Water Demand Projections

Year	Per Capita Based Projection		Land Use Based Projection		Recommended Future Water Demand Projection, af/yr
	Low Estimate, af/yr[(a)]	High Estimate, af/yr[(b)]	Low Estimate, af/yr[(c)]	High Estimate, af/yr[(d)]	
2010	163,200	180,500	171,900	182,300	171,900[(e)]
2015	173,500	192,700	197,500	208,000	199,300[(f)]
2020	190,600	212,700	223,200	233,600	229,300[(f)]
2025	209,400	234,800	248,800	259,300	259,300[(g)]
2030	Not Estimated		266,200	276,700	276,700[(g)]
2060	Not Estimated		370,900	381,400	381,400[(g)]

(a) Based on City Water Division service area populations.
(b) Based on City General Plan population estimates.
(c) Does not include service to other areas (Pinedale, Bakman, etc.)
(d) Includes service to other areas (Pinedale, Bakman, etc.)
(e) Corresponds with low land use based estimate.
(f) Represents transition from low land use based estimate to high land use based estimate.
(g) Corresponds with high land use based estimate.

Existing and Projected Water Supplies

Surface Water Supplies

In 2004, the City completed construction of its 30 million gallon per day (mgd) Surface Water Treatment Facility (SWTF) located in the northeastern corner of the City's water service area, and began using treated surface water supplies to supplement its groundwater supplies. In 2006, approximately 13 percent of the City's total water demands were met using treated surface water supplies.

The City currently has contracts with the Fresno Irrigation District (FID) and the United States Bureau of Reclamation (USBR) to provide surface water for groundwater recharge and/or direct treatment and usage. The FID contract provides for increased amounts of surface water from FID as the City grows and annexes in lands served by FID. The USBR contract provides up to 60,000 af/yr of water to the City. Effluent discharge from the Regional Water Reclamation Facility (RWRF) is also sent to evaporation/percolation basins. This percolated treated effluent is then subsequently extracted from the groundwater basin and delivered into FID canals. Consequently, the City's percolation of treated wastewater helps supplement regional surface water supplies. The City and FID have an agreement to exchange this recycled water for surface water, but the exchange aspect of the agreement has never been exercised.

Chapter 5 of this Phase 1 Report discusses each of the City's available surface water supplies, and their reliability during various hydrologic conditions. Table ES-5 presents a summary of the total projected surface water available to the City in 2025 and 2060, based on various hydrologic conditions, as defined by the 2006 Settlement Agreement.

Table ES-5. Surface Water Supply Available to the City, af/yr

	Source	Wet	Normal-wet	Normal	Normal-dry	Dry	Critical-high	Critical-low
2025	FID Kings River	151,800	138,400	126,500	115,800	104,000	75,400	65,600
	USBR Class 1	60,000	60,000	58,200	56,200	39,800	25,200	13,900
	Recharge Water[a]	13,800	13,800	13,800	13,800	13,800	13,800	13,800
	Total	**225,600**	**212,200**	**198,500**	**185,800**	**157,600**	**114,400**	**93,300**
2060	FID Kings River	208,600	190,100	173,800	159,100	142,900	103,500	90,100
	USBR Class 1	60,000	60,000	58,200	56,200	39,800	25,200	13,900
	Recharge Water[a]	13,800	13,800	13,800	13,800	13,800	13,800	13,800
	Total	**282,400**	**263,900**	**245,800**	**229,100**	**196,500**	**142,500**	**117,800**

(a) Based on an agreement between FID and the City of Fresno.

However, although significant amounts of surface water supplies are available now and in the future under all hydrologic conditions, based on the "Future Without Project" alternative discussed in this Phase 1 Report, the City is currently only able to use up to 30,800 af of surface water supplies per year for direct treatment and use. This is due to the current treatment capacity of 30 mgd at the SWTF, assuming that the SWTF is down one month of the year for maintenance. Currently, most of the balance of these available supplies is used for groundwater recharge, but some supplies are also not being fully utilized. As such, significant amounts of surface water supplies which are available during even the driest of hydrologic conditions under the "Future Without Project" alternative, will go unused.

Groundwater Supplies

The City has historically used groundwater to meet its water demands. Prior to 2004, it was the City's only potable water supply. The City currently has approximately 250 wells located throughout the City. In 2006, approximately 87 percent of the City's water demands were met using groundwater.

Over the years, groundwater pumping has resulting in decreasing groundwater levels throughout the Fresno area. Groundwater quality has also emerged as a major factor, with several identified contaminant plumes in the Fresno area involving organic compounds, inorganic compounds, solvents, pesticides, and other contaminants. Thirty of the City's active wells currently have wellhead treatment systems for the removal of various compounds. Ten of the City's wells have blending plans, two wells are currently being blended, and two wells have blending plans under review. In addition, the Department of Health Services (DHS) has identified twenty-nine wells which have concentrations of 1,2,3-trichloropropane (1,2,3-TCP) which exceed the action level of 0.005 parts per billion (ppb). It is recommended in Chapter 5 of this Phase 1 Report that wellhead treatment systems also be planned and provided for these wells.

Groundwater recharge in the Fresno area consists of natural recharge and intentional recharge. Previously, for the 1996 Metro Plan, natural recharge was estimated to be 43,000 af/yr (see Appendix I). With the recent completion of the groundwater model (see discussion below), existing 2005 average natural recharge is currently estimated to be about 37,000 af/yr, and decreasing to about 27,000 af/yr by 2025 due to increased urbanization. These recently developed estimates of natural recharge are used in this Phase 1 Report and will be used in subsequent phases of this Metro Plan Update to assess potential future groundwater basin impacts.

In addition to natural groundwater recharge, there are a number of groundwater recharge facilities located in and around the City's service area which are used to intentionally recharge the groundwater basin. These facilities include the following:

- Several Fresno Metropolitan Flood Control District (FMFCD) flood control basins, many of which are dual use (recreation and recharge) facilities,
- FID basins (Kearney and North-Central),
- Leaky Acres, owned and operated by the City of Fresno,
- Chestnut Basin, owned and operated by the City of Fresno,
- Alluvial Groundwater Recharge Site (AGRS), owned and operated by the City of Clovis,
- Woodward Park ponds in the City of Fresno, and
- Numerous creeks and rivers.

The City estimates that intentional groundwater recharge by the City in 2006 was about 40,000 af/yr. The average intentional groundwater recharge by the City since 2000 has been about 51,200 af/yr, and represents recent hydrologic conditions and recent operational constraints. This average intentional recharge will be used for the Phase 1 analysis described in this report (see additional discussion in Chapter 5, Table 5-3).

Under the "Future Without Project" alternative evaluated in this Phase 1 Report, groundwater and the City's existing SWTF are the only supplies proposed for the future to meet future projected demands. As described in Chapter 5, up to 157 new wells (assuming average production rates of 800 gpm (east of Highway 99) and 2,000 gpm (west of Highway 99) per the City) would be required to meet the projected 2025 peak hour water demands (30 new wells by 2010 and an additional 127 new wells by 2035). However, as described in Chapters 5 and 7, the impact of pumping these new wells, in addition to the City's existing 250 wells, on the groundwater basin both in terms of increased groundwater level declines and possible water quality impacts would likely be significant.

As described in Chapter 5 of this Phase 1 Report, it is estimated that the City will use approximately 150,000 af/yr of stored groundwater by 2025 (assuming normal hydrologic water years) if it continues to meet increasing demands from the groundwater basin. Chapter 5 describes the cumulative stored groundwater that would be used, and the available surface water supplies which would not be used, during normal hydrologic water years, assuming the City continues its current operational practices. It should be noted that the analysis presented in

Chapter 5 does not consider annual variations in hydrologic conditions, and is presented only to demonstrate the potential future effects of groundwater use under normal year hydrologic supply conditions under "status quo" operations. Under the aforementioned conditions, it is estimated that the City would use approximately 1.83 million acre-feet (MAF) of stored groundwater by the year 2025 if it operates at "status quo." Removing 1.83 MAF of groundwater from this portion of the Kings subbasin would not be practical, as this would essentially "mine" the groundwater basin beneath the City's water service area. Additionally, the groundwater level decrease associated with mining 1.83 MAF of groundwater would likely further degrade water quality and could possibly cause subsidence.

Chapter 7 of this Phase 1 Report describes the baseline groundwater response developed using an Integrated Groundwater and Surface Water Model (IGSM) developed by Water Resources & Information Management Engineering (WRIME). This is the predicted groundwater response if the City's current water system is maintained at "status quo", with no additional new supplies or surface water treatment facilities to help meet future projected water demands.

As Chapter 7 describes, the use of the groundwater basin to meet the City's projected future water demands under the "Future Without Project" alternative has a significant impact on future groundwater levels and groundwater storage. Table ES-6 provides a summary of the estimated declines in groundwater levels and groundwater storage at the end of a 41-year hydrologic period under existing and future baseline conditions under the "Future Without Project" alternative. The declines in groundwater level and storage represent the changes that would occur if the last 41-years of hydrologic conditions (1964 to 2004) repeated themselves in the future, and land use conditions and demands are constant as projected for 2005, 2010, 2015, 2025, and 2060 respectively. Although this methodology does not provide for actual estimates of groundwater level and storage declines, it does provide for a relative comparison of impacts under the various demand conditions.

Table ES-6. Estimated Declines in Groundwater Levels and Groundwater Storage Under the "Future Without Project" Alternative

Condition	Estimated Average Change in Groundwater Levels at End of 41-Year Hydrologic Period, feet	Estimated Average Change in Groundwater Storage at End of 41-Year Hydrologic Period, thousand acre-feet (TAF)
1964-2004 Historical	-20[a]	-277[a]
2005 Existing Conditions	-8[b]	-122[b]
2010 Baseline Conditions	-7[b]	-105[b]
2025 Baseline Conditions	-20[b]	-347[b]
2060 Baseline Conditions	-23[b]	-482[b]

[a] Based on 41 years of historical hydrologic data from 1964 to 2004.
[b] Represents average change in groundwater level and groundwater storage at end of a 41-year period if the last 41-years of hydrologic conditions (1964 to 2004) repeated themselves in the future, and land use conditions and demands are constant as projected for 2005, 2010, 2015, 2025, and 2060 respectively.

As shown the estimated average change in groundwater storage shown in Table ES-6 is significantly less that the 1.83 MAF estimate described above and in Chapter 5. This is because, the estimates presented in Table ES-6 take into consideration differing hydrologic conditions from year to year, including both wet and dry year conditions, but hold the demand constant for each case evaluated. Nevertheless, the findings presented in both Chapters 5 and 7 indicate that the "Future Without Project" alternative would result in significant and continued overdraft of the groundwater basin, with no indications of future recovery, even in wet years. Furthermore, these declines in groundwater levels and storage would likely impact groundwater quality, an issue which is already of great concern in the City.

Existing Water Resources Systems

Chapter 6 of this Phase 1 Report describes the City's existing water resources systems including:

- Drinking water supply, treatment, transmission, and distribution facilities,
- Wastewater collection, treatment, and disposal/reuse facilities, and
- Flood control and groundwater recharge facilities.

Findings for each of these systems are described below.

<u>Water System Findings</u>

The City's existing water system is shown on Figure ES-2. Key water system components are listed in Table ES-7.

WYA's evaluation of the City's existing water system under future demand conditions under the "Future Without Project" alternative indicated that in addition to providing wellhead treatment on a number of existing wells (as described above and in Chapter 5), 157 new groundwater wells and new pipelines would be required to deliver sufficient groundwater supplies to meet the projected water demands of future customers. The costs for these new facilities would be substantial, as shown in Table ES-8.

Table ES-7. Existing City of Fresno Water System Components

Water System Component	Description/Capacity
Groundwater Wells	Number of Wells: 250 operational Total Production Capacity: 419 mgd
Surface Water Treatment Facility (SWTF)	Nominal Treatment Capacity: 30 mgd
Pressure Zones	Four quasi-pressure zones dividing higher topographic areas of the City from lower areas of the City to help regulate minimum and maximum system pressures
SCADA Zones	Number of SCADA Control Zones: 26
Transmission and Distribution Pipelines	Pipelines: About 1,740 miles ranging from 6-inch to 48-inch in diameter Materials: Asbestos-cement, cast iron, ductile iron, steel, and polyvinyl chloride
Treated Water Storage Facilities	Number of Storage Facilities: 2 Total Combined Capacity: 3.5 million gallons (MG) One 1.5 MG tank at the SWTF One 2 MG tank at the intersection of Clovis Avenue and California Avenue in the southeast portion of the City
Booster Pump Stations	Number of Booster Pump Stations: 3 Booster Pump 1 (BP01) boosts water from SCADA Zone 8 to SCADA Zone 4. Booster Pump 2 (BP02) boosts water from SCADA Zone 8 to SCADA Zone 4. Booster Pump 4 (BP04) boosts water from SCADA Zone 11 to SCADA Zone 14

Table ES-8. Estimated Costs to Maintain "Status Quo" Operations and Meet Future Demands in 2025 under "Future Without Project" Alternative

Cost Component	Quantity	Unit Cost	Total Cost
Wellhead Treatment for Existing Wells to Maintain Current Groundwater Production Capacity	35 existing wells @ 800 gpm	$1.4 million/mgd of production[(a)]	$56 million
Additional New Wells Required to Meet 2025 Peak Hour Demands	157 new wells (30 new wells by 2020 (800 gpm), and an additional 127 new wells by 2025) (90 @ 800 gpm and 37 @ 2,000 gpm	$675,000/well[(b)]	$106 million
Pipelines to Deliver Groundwater Supplies to Customers	1.1 million lf (211 miles) of 16-inch diameter pipeline	$350/lf[(c)]	$390 million
Total Cost			**$552 million**

(a) Per Carollo Engineers TM 1.4 Groundwater Contaminants and Treatment Alternatives (see Appendix H).

(b) Per City, already includes markup for construction contingencies, engineering, construction management, and project implementation

(c) Includes 50 percent markup for construction contingencies, engineering, construction management, and project implementation.

Although some of these costs could be attributed to new development and thus be paid by developers through Urban Growth Management (UGM) fees, this analysis indicates that considering the extremely high cost of wellhead treatment, the cost associated with new wells and new pipelines, and the City's available surface water resources (described above and in Chapter 5), expansion of the City's limited surface and groundwater conjunctive use program appears to be warranted. The City could better utilize available surface water supplies and provide additional supply reliability and system operational flexibility if additional surface water treatment facilities are constructed. This will be explored further in Phase 2 of this Metro Plan Update.

Wastewater System Findings

The City's existing wastewater system is shown on Figure ES-3. Key wastewater system components are listed in Table ES-9.

Table ES-9. Existing City of Fresno Wastewater System Components

Wastewater System Component	Description/Capacity
Collection System	Gravity Sewers convey wastewater from the City of Fresno, City of Clovis, Pinedale Public Utility District, and the Pinedale County Water District Pipelines: Range from 4-inch to 84-inch in diameter Gravity Sewer: 1,470 miles Sewer Force Mains: 1.7 miles Lift Stations: 14 Materials: Vitrified clay pipe, PVC, reinforced concrete pipe, and standard concrete pipe
Unsewered Areas	Approximately 830 acres within the City Sphere of Influence (SOI) remains unsewered: Sunnyside area Fort Washington area
Regional Wastewater Reclamation Facility (RWRF)	Treatment Capacity: 80 mgd (annual monthly average daily discharge flow); 88 mgd (maximum monthly average daily discharge flow) Treatment Level: Secondary Effluent Disposal: Percolation ponds and irrigation reuse

For this Phase 1 Study, existing RWRF plant flow, quantities of treated effluent available for direct reuse on crops near the RWRF, and quantities of extracted treated effluent available for recycling by FID (and in exchange for FID surface water supplies), were evaluated. Future quantities were also projected based on projected wastewater flows to the RWRF and future planned expansion of the RWRF. Table ES-10 provides a summary of the existing and future quantities. As shown, there are no current plans to expand current reuse or groundwater extraction operations at the RWRF. Therefore, the estimates for the future through 2030 remain the same as the 2005 values. However, at a future point in time when additional beneficial use can be secured, the extraction operations will be expanded. Also, although the RWRF can accommodate the potential future addition of tertiary treatment facilities, there are no current plans for tertiary treatment. It should be noted, however, that the City has indicated that it may pursue future opportunities to increase the use of treated wastewater effluent and the extraction of previously recharged groundwater.

Table ES-10. Projected Future RWRF Flows and Water Recycling Quantities

	2005	2010	2015	2020	2025	2030
Total Plant Flow (Undisinfected Secondary Treatment), af/yr	78,400	94,500	105,100	109,000	120,300	127,700
Quantity Available for Direct Reuse on Crops near the RWRF (Undisinfected Secondary Treatment), af/yr	8,500	8,500	8,500	8,500	8,500	8,500
Quantity Available for Recycling by FID (Extracted treated effluent that was previously percolated), af/yr	24,600	24,600	24,600	24,600	24,600	24,600
Quantity Available for New, Direct Recycling (Tertiary Treated), af/yr	0	0	0	0	0	0
Percent of Total Plant Flow Recycled	43%	35%	32%	31%	28%	26%

<u>Flood Control and Groundwater Recharge System Findings</u>

The City's existing flood control and groundwater recharge system is shown on Figure ES-4. Key flood control and groundwater recharge system components are listed in Table ES-11.

As discussed above, intentional groundwater recharge by the City of Fresno is currently estimated to be about 40,000 af/yr (2006). And since 2000, intentional recharge by the City of Fresno has averaged 51,200 af/yr. Groundwater recharge at the City of Clovis' AGRS, which also contributes to the groundwater basin underlying Fresno, has averaged about 2,100 af/yr since its inception; however, in 2004 the facility was expanded and recharge has averaged 4,300 af/yr since the expansion.

Table ES-11. Existing City of Fresno Flood Control and Groundwater Recharge System Components

Flood Control and Groundwater Recharge System Component	Description/Capacity
Conveyance Facilities	Open Channels and Pipelines: Approximately 1,100 miles Flow Control and Equalization Basins: 39 basins
FMFCD Basins	Number of Basins: 158 Number of Basins Used for Groundwater Recharge: 74 Recharge Operations: Typically March through September Owned and operated by Fresno Metropolitan Flood Control District (FMFCD)
FID Basins	Kearney and North-Central Basins Owned and operated by FID
Leaky Acres Groundwater Recharge Facility	Total Area: 245 acres Recharge Operations: 8 to 10 months per year Owned and operated by the City of Fresno
Chestnut Basins	Owned and operated by the City of Fresno
Alluvial Groundwater Recharge Site (AGRS)	Total Area: 85 acres Recharge Operations: 8 to 10 months per year Owned and operated by the City of Clovis

Existing Institutional Arrangements

Chapter 8 of this Phase 1 Report describes existing institutional arrangements governing water supply availability and distribution in and around the City, including agreements, settlements, judgments, permits, understandings, and joint planning efforts. Table ES-12 provides an overview of existing institutional arrangements.

Phase 2 of the Metro Plan Update will identify physical, institutional, and management actions needed to secure a sustainable and cost-effective future water supply for the City. Phase 3 of the Metro Plan Update will include the development of an institutional plan which may include recommendations for new arrangements or modifications to existing arrangements and agreements.

Table ES-12. Overview of Existing Institutional Arrangements

Water Supply Component	Involved Agencies	Purpose of Arrangement/Agreement
Water Supply		
Area Drinking Water Purveyors	City of Fresno Pinedale County Water District Bakman Water Company Herndon Water Company Park Van Ness Mutual Water Company California State University, Fresno	These water purveyors serve the Metro Plan Update study area[(a)].
Regional Water Supply Interconnections	City of Fresno City of Clovis	Draft agreement prepared between Fresno and Clovis for provision of two interconnections to provide service during emergencies and other times of hardship.
Surface Water Supply	FID/Kings River Water Association: Kings River Supply USBR CVP: San Joaquin River Supply Fresno Stream Group: Local surface water for irrigation and recharge use	Provides for surface water supplies for City of Fresno (approximately 13 percent of total supplies in 2006).
Groundwater Supply	Fresno Area Regional Groundwater Management Plan (FARGMP) Fresno County (Groundwater Export Ordinance) Settlement Agreement with various manufacturers to address groundwater contamination	Groundwater supplies for City of Fresno (approximately 87 percent of total supplies in 2006).
Integrated Regional Water Management Plan (IRWMP)	Kings River Conservation District (KRCD) Upper Kings Water Forum (Water Forum)	Development of Kings Integrated Groundwater and Surface Water Model (Kings IGSM).
Wastewater & Wastewater Recycling		
Wastewater Recycling	City of Fresno City of Clovis	Fresno-Clovis Regional Wastewater Reclamation Facility (RWRF) treats wastewater from the Fresno-Clovis area and produces treated effluent which is percolated into the groundwater basin. Percolated treated effluent is then pumped by FID in exchange for additional FID surface water for City.
Flood Control & Storm Drainage		
Flood Control and Storm Drainage	Fresno Metropolitan Flood Control District (FMFCD)	Fresno utilizes the FMFCD basins to recharge the groundwater basin with a portion of the City's surface water entitlements.
Land Use Planning		
Regional Land Use Planning	City of Fresno City of Clovis Fresno County	Preparation of General Plans

[(a)] For this Metro Plan Update, the City of Clovis was not part of the study area.

PHASE 1 CONCLUSIONS AND RECOMMENDATIONS

During Phase 1 of this Metro Plan Update, it has been assumed that the City will continue to operate at "status quo" (i.e., meeting future demands from groundwater basin storage and using the existing 30 mgd SWTF), assuming no modifications to its existing water system which would allow more use of available surface water supplies. With already declining groundwater levels, each year the City continues to operate in this mode will continue to accelerate groundwater level declines in the basin, possibly affecting groundwater quality, and further impacting available groundwater resources.

Clearly, Phase 2 of the Metro Plan Update will need to address this issue by identifying alternative and/or new system or operational changes that will allow the City to better use its available water supplies. Specific issues that will be evaluated in Phase 2 of the Metro Plan Update include:

- Water supply diversification to enhance overall water supply reliability;
- Conjunctive use of available water supplies to make maximum use of available surface water supplies and use the groundwater basin in a sustainable manner which minimizes or eliminates groundwater overdraft and groundwater quality degradation;
- Potential implementation of new water conservation measures to further reduce existing and projected water demands;
- Potential incorporation of new water management elements such as water recycling and desalting (potential for desalination of seawater or brackish groundwater as defined in the Urban Water Management Planning Act) to add to the City's water supply portfolio;
- Marketing of extracted percolated effluent from the RWRF to create a potential new revenue source for the City; and
- Further evaluation of potential future water treatment plant sites, including expansion of the City's existing SWTF and a potential new water treatment plant in the southeast portion of the City, to add to the City's surface water treatment capacity to take greater advantage of available surface water supplies.

FIGURE ES-1

City of Fresno Metropolitan Water Resources Management Plan Update

METRO PLAN UPDATE PROCESS

Phase 1: Baseline System Characterization

- Launch planning process
- Establish planning goals and objectives
- Estimate baseline demands and supplies
- Identify physical, regulatory and legal challenges and opportunities
- Document "Future without Project" alternative

Phase 1 Work Products:

- *This Phase 1 Report (Draft and Final) describing existing conditions and the "Future without Project" alternative*

Phase 2: Alternatives Development and Evaluation

- Develop strategies to meet water management challenges identified in Phase 1
- Revisit and refine the alternatives from the 1996 Metro Plan
- Recommend a preferred plan
- Prepare and adopt Urban Water Management Plan and Water Shortage Contingency Plan

Phase 2 Work Products:

- *A Phase 2 Report (Draft and Final) describing development and evaluation of alternatives and recommending a preferred alternative*
- *Urban Water Management Plan and Water Shortage Contingency Plan (Administrative Draft, Draft and Final)*

Phase 2 Public Involvement:

- *Public review and hearing to be held for Urban Water Management Plan*
- *Preparation of a Fact Sheet describing Metro Plan Update*

Phase 3: Implementation Plan

- Final refinements to preferred plan
- Development of an institutional plan, funding plan, and implementation schedule

Phase 3 Work Products:

- *A Phase 3 Report (Draft and Final) describing the final recommended preferred alternative, the institutional and funding plans, and the implementation schedule*

Phase 3 Public Involvement:

- *Preparation of a Summary Report describing the Metro Plan Update*

Phase 4: Project/Programmatic Environmental Impact Report (EIR)

- Near-term facility improvements and actions will be evaluated at a "project" level and long-term improvements and actions will be evaluated at a "program level"

Phase 4 Work Products:

- *Initial Study / Notice of Preparation (NOP)*
- *Administrative Draft, Draft and Final Program EIR*
- *Mitigation Monitoring Program*

Phase 4 Public Involvement:

- *Public review and hearing for Draft EIR*
- *Preparation of a Fact Sheet describing Metro Plan Update*

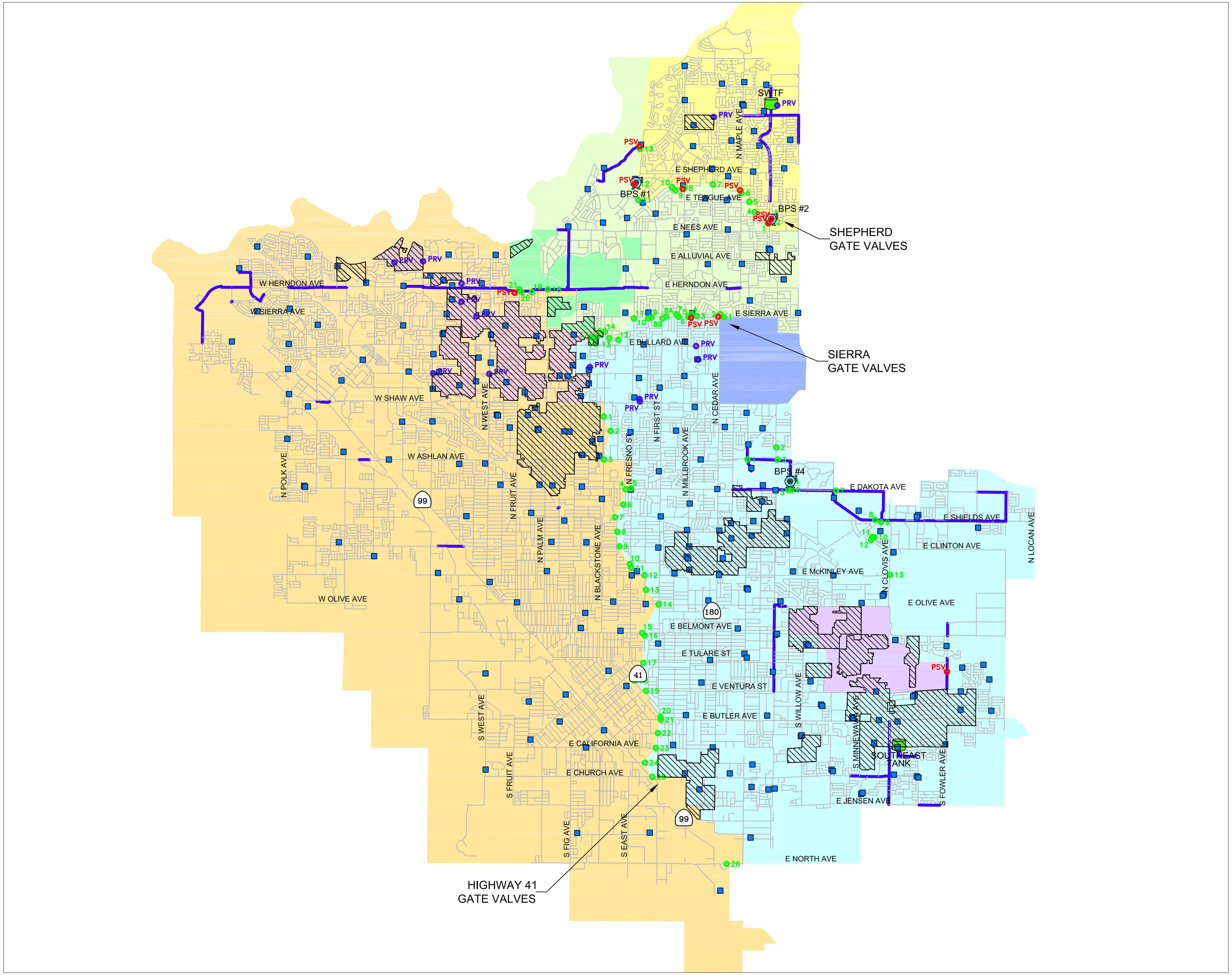
Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

FIGURE ES-2

City of Fresno
Metropolitan Water Resources Management Plan Update

EXISTING WATER DISTRIBUTION SYSTEM



N

0 4600 9200
SCALE IN FEET

NOTES:

A. Boundaries are approximated based on gate valve locations shown by GIS information provided by City Staff.

LEGEND:

- Existing City Wells
- Existing Storage Facility
- Booster Pump Station
- Existing 14-inch and Smaller Pipeline
- Existing 16-inch and Larger Pipeline
- Shepherd
- Sierra A
- Sierra B (Pinedale County Water District)
- Highway 41
- Highway 41B (CA State University, Fresno)
- Highway 41C (Bakman Water Company)
- Westside
- Fluoride Districts
- County Islands
- Closed or Partially Closed Gate Valve Location
- PSV Location
- Fluoride District PRV Location

Fresno All-America City 2000

WEST YOST ASSOCIATES
Consulting Engineers

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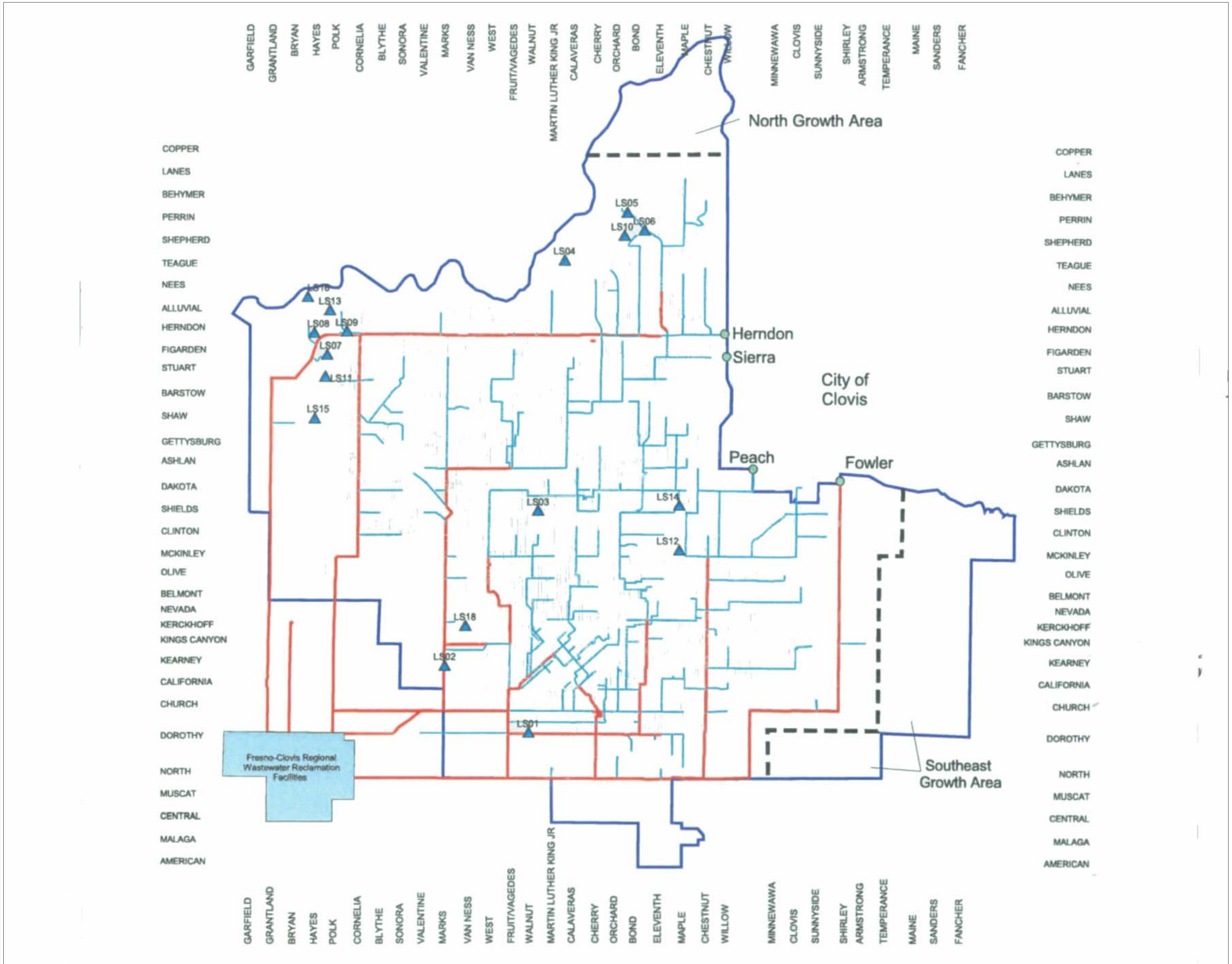


FIGURE ES-3

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING WASTEWATER SYSTEM

N

0 NOT TO SCALE

NOTES:

A. Source: Technical Memorandum 1.7 Existing Water Supply Systems dated October 2006

LEGEND:

- Lift Station
- General Plan Boundary
- Growth Area Boundary
- Smaller than 12" Diameter Sewer Line
- 12" - 33" Diameter Sewer Line
- Larger than 33" Diameter Sewer Line
- City of Clovis Connection

Fresno All-America City 2000

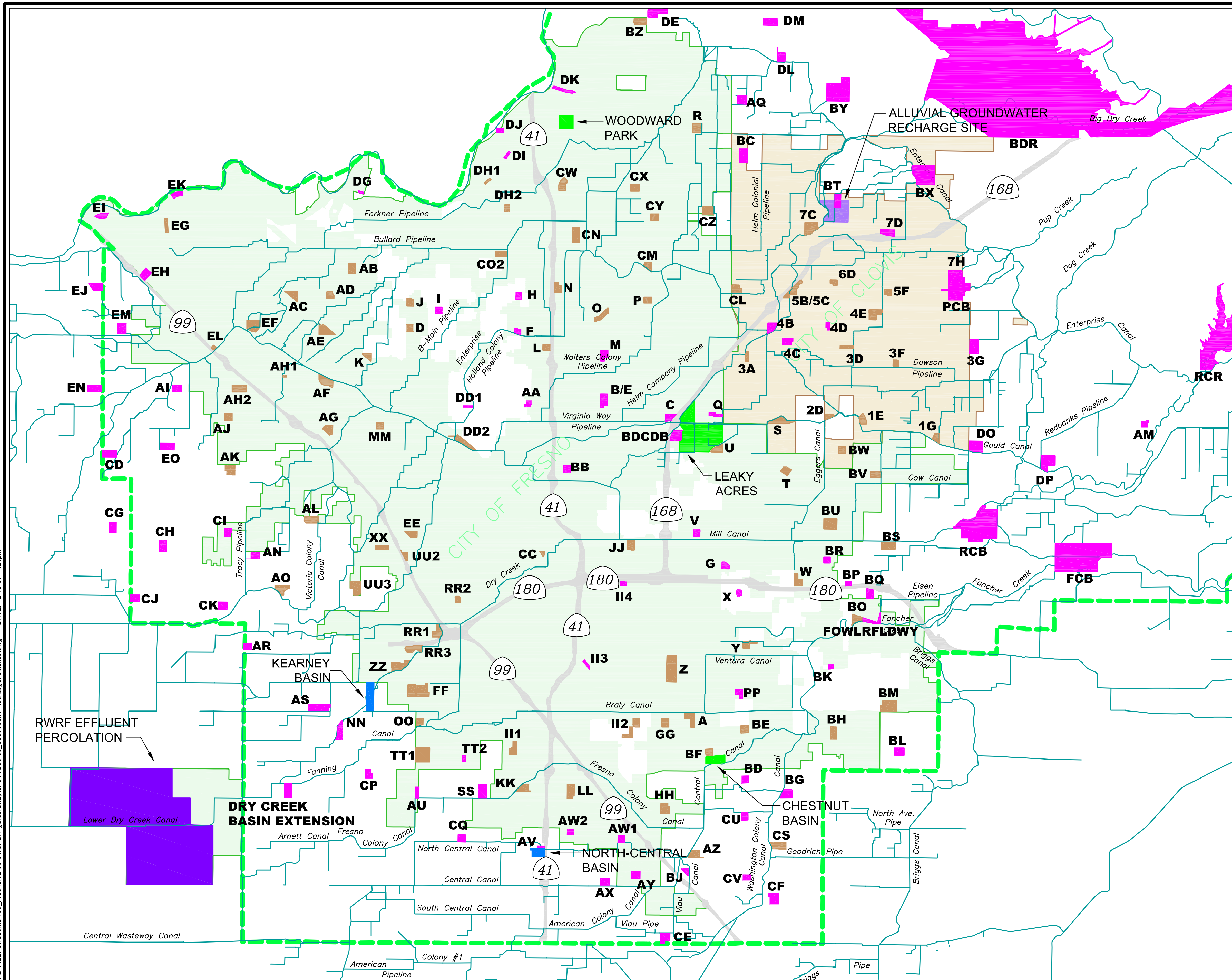
WEST YOST ASSOCIATES Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Executive Summary\439020501-FIGES-03-cn1.dwg DATE: 07-03-07 3:23pm

FIGURE ES-4

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING GROUNDWATER RECHARGE BASINS AND FLOOD CONTROL FACILITIES



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SCALE IN FEET

N

NOTES:

A. Recharge locations based on data provided by City Staff.

LEGEND:

- FID Water Course
- FMFCD Boundary
- City of Fresno Basins
- FMFCD Basins Used for Flood Control Only
- FMFCD Basins Used for Groundwater Recharge
- FID Basins for Groundwater Recharge
- City of Clovis Alluvial Groundwater Recharge Site
- RWRF Effluent Percolation

Fresno All-America City 2000

WEST YOST ASSOCIATES
Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Chapter 6\FIG06-05_083006cn1 RechargeFacilities.dwg DATE: 12-19-07 4:24pm

CHAPTER 1. INTRODUCTION

INTRODUCTION

This report presents the findings of Phase 1 of the Fresno Metropolitan Water Resources Management Plan Update (Metro Plan Update). The purpose of this Metro Plan Update is to update and refine the 1996 Fresno Metropolitan Water Resources Management Plan (1996 Metro Plan) taking into consideration available new data and accommodating physical and institutional changes which have occurred since the 1996 Metro Plan was prepared. These changes are discussed in detail in Chapter 2. The completed Metro Plan Update will facilitate future water resources decisions and improvement planning and satisfy requirements for State funding.

STUDY PROCESS

The Metro Plan Update includes three key deliverables:

- An update to the Fresno Metropolitan Water Resource Management Plan,
- An environmental document, meeting the requirements of the California Environmental Quality Act (CEQA), covering near-term improvements and actions at a “project” level and long-term improvements and actions at a “program” level, and
- An Urban Water Management Plan (UWMP) adopted by City Council.

The Metro Plan Update is being performed in four phases.

Phase 1: Baseline System Characterization

The purpose of Phase 1 is to describe the City’s water system background and existing conditions, as well as to evaluate the potential impacts of continuing to operate under “status quo”, or “Future Without Project” conditions. For this Phase 1 Report, the “status quo” or “Future Without Project” is defined as use of the City’s existing water supply sources (including existing and future groundwater wells and the existing 30-million gallon per day (mgd) Surface Water Treatment Facility (SWTF)) to meet existing and future water demands through the year 2060.

The focus of Phase 1 is to:

- Launch the planning process,
- Establish planning goals and objectives,
- Estimate baseline demands, supplies and water budget (essentially the “Future Without Project” scenario for the CEQA document), and
- Identify physical, regulatory, and legal challenges and opportunities.

This report presents the findings of Phase 1.

Phase 2: Development and Evaluation of Alternatives

Phase 2 is intended to evaluate alternatives and develop strategies to meet the water management challenges identified in Phase 1. Phase 2 will revisit and refine the alternatives from the 1996 Metro Plan and develop the "Future With Project" supply alternative, which will consist of a combination of existing and alternative future supplies to meet existing and future demands. The objective for the "Future With Project" alternative will be to optimize the use of available supplies to meet the City's existing and future demands.

An updated UWMP will be also completed and adopted at the close of Phase 2, which will incorporate the "Future With Project" supply alternative.

Phase 3: Implementation Plan

Phase 3 includes final refinements of the "Future With Project" supply alternative and development of an institutional plan, funding plan, and implementation schedule.

Phase 4: Project/Programmatic Environmental Impact Report (EIR)

Prior to City Council adoption of the Metro Plan Update, a CEQA document will be prepared for the "Future With Project" supply alternative. Near-term facility improvements and actions will be evaluated at a "project" level, and long-term improvements and actions will be evaluated at a "program level."

PROJECT CONTRIBUTORS AND ROLES

The Metro Plan Update was conducted by West Yost Associates (WYA), along with a number of subcontractors with specific expertise related to water supply issues in the Fresno area. Table 1-1 lists the project team and their roles.

Table 1-1. Metro Plan Update Project Team and Roles

Firm	Metro Plan Update Role
West Yost Associates (WYA)	Project management Water demands Water supply Urban Water Management Plan
Peterson, Brustad, and Pivetti, Inc.	Project management
Carollo Engineers	Water treatment technologies Wastewater regulatory issues
Blair, Church & Flynn	Fresno Irrigation District (FID), Clovis and Fresno Metropolitan Flood Control District (FMFCD) facilities planning and operations
Quad Consultants	Environmental compliance
Water Resources & Information Management Engineering (WRIME)	Groundwater modeling
Kenneth D. Schmidt & Associates	Hydrogeology
Astone, Inc.	Public involvement

CONTENTS AND ORGANIZATION OF THIS PHASE 1 REPORT

This report details the findings of the work prepared by the project team during Phase 1 of the Metro Plan Update. The chapter organization is listed below.

- Chapter 1: Introduction
- Chapter 2: Background
- Chapter 3: Urban Water Demands
- Chapter 4: Water Conservation & Demand Management Measures
- Chapter 5: Urban Water Supply
- Chapter 6: Existing Water Resources Systems
- Chapter 7: Future Without Project (Baseline) Groundwater Response
- Chapter 8: Institutional Arrangements

Appendices to this Metro Plan Update are listed below.

- Appendix A: Non-Fresno Water Demands
- Appendix B: Refinement of Existing Land Use Designation
- Appendix C: City of Fresno Municipal Code Water Conservation Provisions
- Appendix D: City of Fresno Water Conservation Plan (May 2005) Section 4: Best Management Practices (BMPs) for Urban Water Suppliers
- Appendix E: City of Fresno Water Meter Plan
- Appendix F: Non-Fresno Water Supplies
- Appendix G: Update on Hydrogeologic Conditions in the Fresno Metropolitan Area by Kenneth D. Schmidt and Associates
- Appendix H: Groundwater Contaminants and Treatment Alternatives Technical Memorandum 1.4 by Carollo Engineers
- Appendix I: Water Supply Summary for City of Fresno from Previous Metro Plan
- Appendix J: City of Fresno Water Supply Contracts with Fresno Irrigation District (FID) and United States Bureau of Reclamation (USBR)
- Appendix K: 83-Year Hydrologic Evaluation
- Appendix L: Fresno Water System Hydraulic Model Development
- Appendix M: Wastewater System Figures
- Appendix N: Existing Institutional Arrangements Technical Memorandum 1.9 by Carollo Engineers

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations have been used throughout this report for clarity and readability:

AB	Assembly Bill
ADAF	Average Day Annual Flow
Af	Acre-feet
af/ac/yr	Acre-feet per acre per year
AF/yr, afa	Acre-feet per year
AGRS	Alluvial Groundwater Recharge Site
AWWA	American Water Works Association
Bakman	Bakman Water Company
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
CEQA	California Environmental Quality Act
CII	Commercial, Industrial and Institutional
City	City of Fresno
COG	Fresno County Council of Governments
Council	City Council
CSUF	California State University at Fresno
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
CVWAC	Central Valley Water Awareness Committee
DBCP	1,2-Dibromo-3-Chloropropane
DMMs	Demand Management Measures
DOF	California Department of Finance
DWR	California Department of Water Resources
EDB	Ethylene dibromide
EEI	Environmental Education Initiative
EIR	Environmental Impact Report
FARGMP	Fresno Area Regional Groundwater Management Plan
FCMA	Fresno-Clovis Metropolitan Area
FID	Fresno Irrigation District
FMFCD	Fresno Metropolitan Flood Control District
Fps	Feet per second
Ft	Foot, feet
FYP	Flex Your Power

GAC	Granular Activated Carbon
General Plan	City of Fresno General Plan
GIS	Geographical Information System
GMP	Groundwater Management Plan
Gpcd	Gallons per capita per day
Gpd	Gallons per day
Gpm	Gallons per minute
HCF	Hundred cubic feet
IGSM	Integrated Groundwater and Surface Water Model
IRWMP	Integrated Regional Water Management Plan
Kgpm	Thousands of gallons per minute
Kings IGSM	Kings Basin Integrated Groundwater and Surface Water Model
KRWA	Kings River Water Association
LAFCO	Local Agency Formation Commission
MAF	Million acre-feet
MCL	Maximum Contaminant Level
MEF	Modified Energy Factor
Metro Plan	Fresno Metropolitan Water Resources Management Plan
mg/L	Milligrams per liter
Mgd	Million gallons per day
MOU	Memorandum of Understanding
NGA	North Growth Area
NRDC	National Resource Defense Council
PCE	Tetrachloroethylene
PG&E	Pacific Gas and Electric Company
Pinedale	Pinedale County Water District
psi	Pounds per square inch
PSV	Pressure sustaining valve
PVC	Polyvinyl Chloride
RWRF	Regional Wastewater Reclamation Facility
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SEGA	Southeast Growth Area
SJV Basin	San Joaquin Valley Groundwater Basin
SOI	Sphere of Influence
SWTF	Surface Water Treatment Facility
TAC	Technical Advisory Committee

TAF	Thousand acre-feet
TCE	Trichloroethylene
TCP	1,2,3-Trichloropropane
TDS	Total dissolved solids
TGMs	Transmission Grid Mains
TSS	Total Suspended Solids
UAFW	Unaccounted-for Water
UGM	Urban Growth Management
USBR	United States Bureau of Reclamation
UWMP	Urban Water Management Plan
VCA	Vitrified clay pipe
VFD	Variable frequency drive
VOCs	Volatile organic compounds
Water Forum	Upper Kings Basin Water Forum
WF	Water Factor
WSA	Water Supply Assessment
WWTP	Wastewater Treatment Plant
WYA	West Yost Associates

CHAPTER 2. BACKGROUND

DEVELOPMENT OF PREVIOUS METRO PLAN

Prior to 1980, the City of Fresno (City) enjoyed an extremely cost-effective and reliable drinking water system based on dispersed groundwater wells, transmission grid mains, and groundwater recharge facilities. Beginning in the late 1970s, discovery of widespread groundwater contamination began to adversely impact the system.

During the 1980s, drinking water regulations became more stringent, further complicating groundwater contamination problems. The City filed a lawsuit regarding agricultural contaminant sources and began working aggressively with parties responsible for industrial contamination. The City was successful in most of these actions, but the physical reality of groundwater contamination is that it takes decades or centuries to correct the problem, and impacted production wells must be retrofitted with wellhead treatment facilities or replaced. Further complicating long-term system viability, the water table in the regional unconfined aquifer was falling at a steady rate, indicating that groundwater extractions were exceeding annual recharge rates (an imbalanced water budget). Clearly, court actions were not enough to fully address the physical problems with the groundwater-based system.

During the late 1980s and early 1990s, the City invited the City of Clovis, Fresno County, FID, and the FMFCD to assist in preparation of a comprehensive Metropolitan Water Resources Management Plan (Metro Plan). The Metro Plan sought to balance the regional water budget, proactively address groundwater contamination plumes, and restore service reliability and sustainability in the Fresno-Clovis Metropolitan Area (FCMA) through 2050. The Metro Plan was guided by a Technical Advisory Committee (TAC) consisting of the five agencies plus several advisory members. Phases 1 and 2 of the Metro Plan were completed under the guidance of the TAC. However, due to disagreements between the agencies regarding implementation responsibilities and authorities, Phase 3 and the Programmatic EIR were completed under the guidance of the City of Fresno alone. Phase 3 was completed in 1994.

In 1995, the City reached a comprehensive settlement with the defendants in the 1,2-Dibromo-3-Chloropropane (DBCP) groundwater contamination lawsuit. The terms of the settlement necessitated an update of the Metro Plan to further refine the financing plan and rate impacts. That update was conducted and the results presented to the City Council (Council) in February 1996. The Council then accepted the Metro Plan and certified the Programmatic EIR. The Preferred Alternative that was adopted included two new surface water treatment plants, expanded use of wells with and without wellhead treatment, groundwater contaminant plume management, untreated water for large lot landscaping, water conservation, and groundwater recharge.

Following acceptance of the Metro Plan, the City began implementing the facility elements of the Plan. The most significant short-term element was the Surface Water Treatment Facility (SWTF) in Northeast Fresno. Prior to proceeding with design and construction of the new plant, the City felt it was appropriate to revisit the “All Groundwater Alternative” from Phase 2 of the Metro Plan to the same level of detail which was afforded the Preferred Alternative in Phase 3 of the Metro Plan, and in the 1996 Metro Plan Update. The result was the Fresno Metropolitan

Water Resources Management Plan Alternatives Comparison Update in October 1997. The conclusion of this 1997 Metro Plan Update confirmed that the Preferred Alternative was clearly the best option available for the City. Design began on the SWTF.

Other key elements recommended in the previous Metro Plan included conservation, untreated surface water for landscaping, a new SWTF in Southeast Fresno, groundwater contaminant plume management, wells with and without wellhead treatment, additional large-diameter transmission grid mains (TGMs) to move water from the major production sources further into the system, new water storage tanks, and intentional groundwater recharge through flood control basins and dedicated basins.

All of these strategies were implemented to varying degrees.

MOTIVATION FOR THIS METRO PLAN UPDATE

A number of physical realities and regulatory actions are driving the need to update the previously prepared Metro Plan. Although nitrate concentrations have improved in the Old Figarden area, groundwater contamination continues to be a problem in some areas. Nitrate contamination identified in the original Metro Plan has worsened in the South-Southeast Fresno and Fort Washington areas. Iron and manganese is an issue in many of the same wells. In addition, as described in Chapter 5, a new contaminant, trichloropropane (TCP), has been detected in 29 City wells where DBCP contamination also occurred. TCP is not regulated at the time of this writing, but indications are that it soon may be at concentrations potentially as low as 0.005 µg/L.

While it may be possible to deepen wells to avoid contamination or add wellhead treatment to remove contaminants, it is appropriate to examine other water supply strategies to identify the most cost-effective and reliable solution. The 1996 Metro Plan identified the need for a new SWTF in Southeast Fresno as a means to mitigate groundwater problems in that area. This recommendation must be revisited and refined as a priority in this Metro Plan Update. New regulations for naturally occurring contaminants like arsenic and radon are also still looming as well, which may tend to tip the economic scales to favor more treated surface water.

Groundwater contamination is not the only driver for the Metro Plan Update. Other factors include:

- Growth projections in the FCMA, as defined in the current General Plans of the City, Fresno County, the City of Clovis, go beyond the reach of the previous Metro Plan. The City now wishes to consider long-range growth and water supply planning at a programmatic level to the year 2060. The City's 2025 General Plan redirects growth patterns to the southeast. The City also initiated focused efforts to attract 25,000 new jobs over the next five years (Regional Jobs Initiative). Those factors, combined with a robust real estate market in the first part of the decade, resulted in entitlement of approximately 4,500 new residential lots approved for development in Southeast Fresno.

- State funding sources such as Proposition 50 require an agency to have participated in and be operating under three water plans: an UWMP, Groundwater Management Plan (GMP), and an Integrated Regional Water Management Plan (IRWMP). This Metro Plan Update will include an UWMP. The City is participating in multi-agency planning efforts for the other two requirements: the Fresno Area Regional GMP and the Upper Kings IRWMP. This planning effort will coordinate with and provide key input to those plans.
- State law requires an UWMP update every five years (years ending in 0 and 5). In the past, the City relied on the Metro Plan to cover the function of the UWMP and GMP, and had therefore not updated its UWMP since 1991. Between then and the time of this Metro Plan Update, a number of new requirements have been put in place, so the UWMP will be a new effort rather than a simple update.
- The growing groundwater mound beneath the Fresno-Clovis Regional Wastewater Reclamation Facility (RWRF) presents an opportunity for water recycling and/or water exchanges with other agencies. The City currently percolates 58,000 acre-feet per year (AF/yr) of treated effluent into the ground, and then recycles an average of 21,400 AF/yr by pumping percolated treated effluent to FID canals, leaving 36,600 AF/yr of excess percolated treated effluent at the RWRF. Going forward, effluent volume will increase, but the recycling agreement with FID is already maximized. Much of the excess percolated treated effluent flows to the southwest beyond FID boundaries, but the groundwater mound beneath the RWRF is also growing.
- The Central Valley Regional Water Quality Control Board has indicated that the RWRF discharge permit will be more stringent in the future. Wastewater collection system limitations, primarily in the North Avenue trunk system, and groundwater mounding at the RWRF have caused the City to consider a new satellite wastewater plant in Southeast Fresno.
- Water management strategies in the City of Clovis have changed and now include a new dedicated recharge facility, water treatment plant, and a planned wastewater treatment and recycling plant. These actions will positively impact the regional groundwater budget and may alter localized groundwater levels and flow directions, which are particularly important in plume management activities.
- The Waldron Pond groundwater bank west of Fresno and north of the RWRF, scheduled to be completed in the near future, is planned to yield 10,000 AF/yr. However, the service area of the Waldron Pond facility overlaps the recycled water service area for the RWRF, thereby reducing recycling demand potential in the future.
- Ongoing court and legislative actions related to restoration of the San Joaquin River will most likely negatively impact USBR Central Valley Project (CVP) deliveries to Friant Unit contractors, including the City.
- Incremental water meter retrofit projects are planned by the City between 2008 and 2013, in accordance with the stipulated schedule in the USBR CVP contract renewal.
- The City has renewed its CVP contract, which now includes "take or pay" provisions.
- There are planned interim, back-up, and permanent drinking water interconnections between Fresno and Clovis.

- Groundwater overdrafting in and around the FCMA is continuing, causing groundwater levels to decrease, rendering some shallow wells in some eastern and northern rural residential areas inoperable. Coincidently, much of the growth in the FCMA has been targeted toward the east and north.
- Risk of contamination of the Enterprise Canal serving the SWTP has necessitated a new look at a raw water pipeline directly from the Friant Kern Canal.
- There needs to be a plan to beneficially use the Fresno Stream Group water right filing (see Chapter 8 for additional discussion).
- Non-export policies of FID and the County need to be considered.
- New requirements for Senate Bill (SB) 610 Water Supply Assessments require identification of a 20-year water supply for developments or development plans generally serving more than 500 dwelling units. SB 221 requires written verification of water supply adequacy before approval of these major subdivisions.

As in the 1980s, the City is choosing to proactively address these issues, rather than taking a reactive posture. The Metro Plan Update, UWMP, IRWMP, and GMP will lay the groundwork for water management and infrastructure decisions, and will also position the City for possible state funding.

The City has joined FID and the City of Clovis in the preparation of a joint Assembly Bill (AB) 3030/SB1938 GMP. The joint plan focuses on setting up a framework for groundwater management, agency responsibilities, data management, and fundamental policies. The Metro Plan Update will provide the physical operating parameters, groundwater budgets, extraction rates, recharge rates, plume management, groundwater quality management strategies, and infrastructure plan that will be incorporated into the GMP by reference.

STUDY AREA AND PLANNING HORIZONS

The primary study area for this project is within the growth boundary (2060 Growth Fringe) of the City of Fresno (see Figure 2-1). Facilities and management actions will be primarily focused on the City. However, to understand the impacts of actions by the City and its neighbors, a much larger study area is being used to assess groundwater impacts in the greater regional context (see Figure 2-2). The Kings Basin Integrated Groundwater and Surface Water Model (Kings IGSM) is being developed as part of the IRWMP, and the Metro Plan Update is supplementing that effort to densify the analysis grid within the City (see Figure 2-3).

Planning horizons for the Metro Plan Update are as follows:

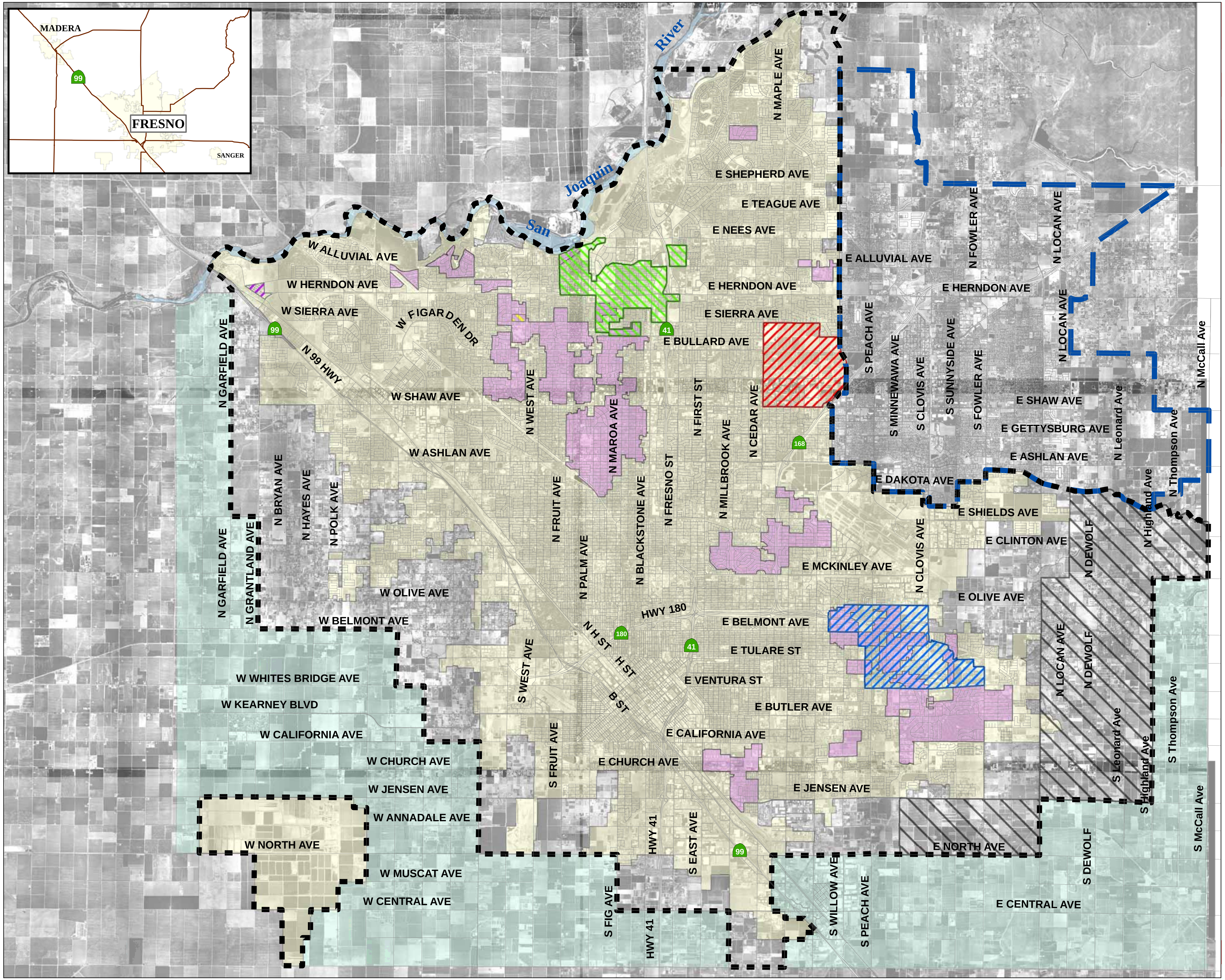
- 2010: corresponding with near-term actions
- 2025: corresponding with the City General Plan buildout, and
- 2060: representing a long-term, roughly 50-year planning horizon.

The UWMP will also include 5-year increments between present and 2030, as required by the UWMP Act.

FIGURE 2-1

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING AND FUTURE STUDY AREA



N

0 1 2 4

Scale in Miles

NOTES:

A. 2060 Growth Fringe is provided for discussional purposes only, and is not to be taken as representing any land use planning goals or objectives for City Growth

B. 2060 Growth Fringe adds approximately 37,000 acres.

- Fresno Sphere of Influence
- Clovis Sphere of Influence
- Pinedale County Water Dist.
- Bakman Water Company
- California State Univ., Fresno
- Herndon
- Park Van Ness
- Southeast Growth Area
- 2060 Growth Fringe
- County Island
- City Limit

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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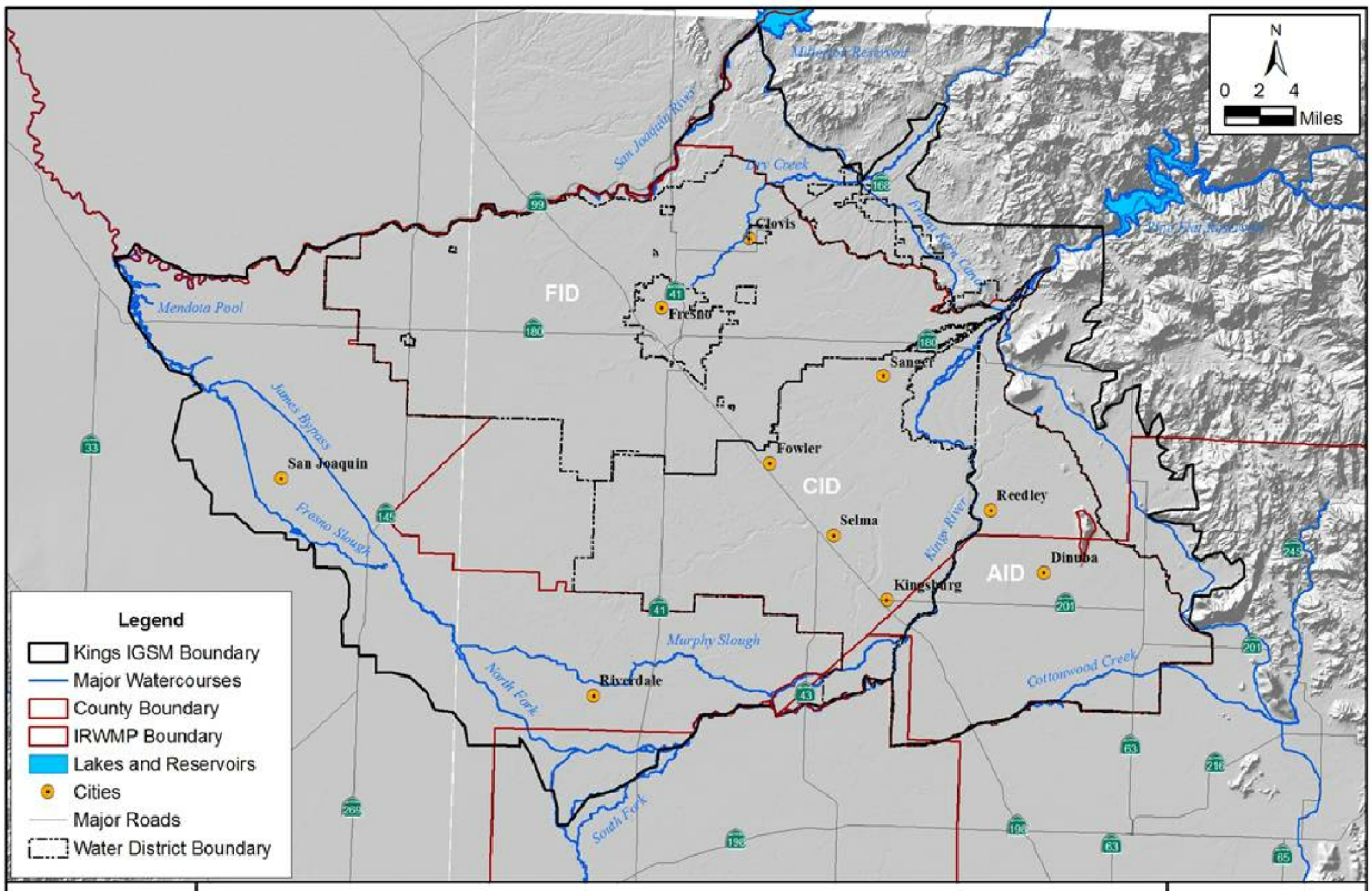
FIGURE 2-2

City of Fresno
Metropolitan Water Resources
Management Plan Update

FRESNO REGIONAL AREA PLANNING BOUNDARIES



Fresno All-America City 2000

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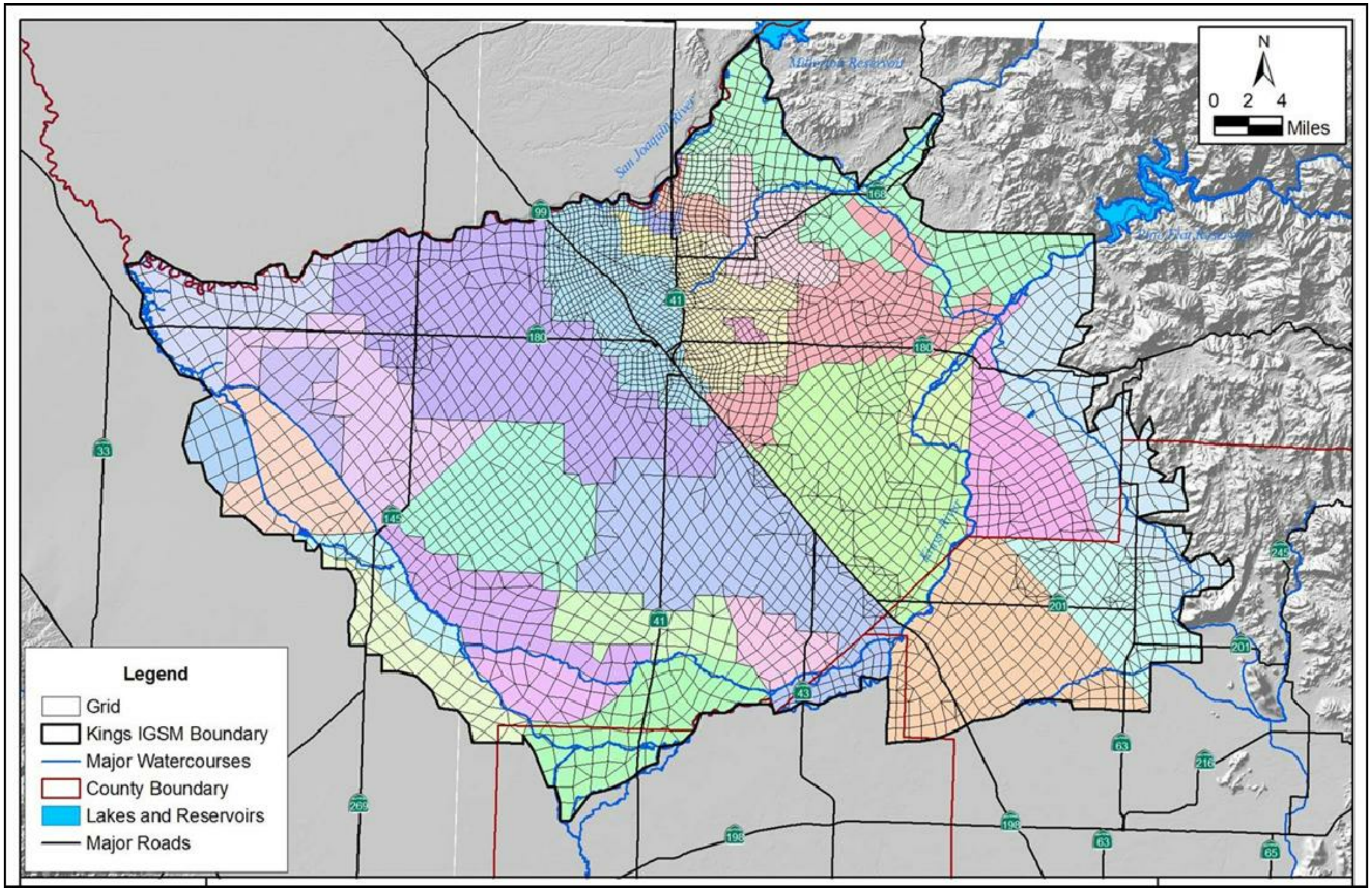

FIGURE 2-3

City of Fresno
Metropolitan Water Resources
Management Plan Update

KINGS BASIN INTEGRATED GROUNDWATER AND SURFACE WATER MODEL (IGSM) STUDY AREA AND ANALYSIS GRID

Fresno All-America City 2000

WEST YOST ASSOCIATES
Consulting Engineers

CHAPTER 3. URBAN WATER DEMANDS

Accurate and detailed potable water demand estimates are required to evaluate the City's existing and future water supplies, and identify potential future water system infrastructure requirements. Although Phase 1 of this Fresno Metropolitan Water Resources Management Plan Update (Metro Plan Update) is focused on the potential impact of the City continuing to manage and operate its available water resources as it historically has, which will be defined as the "Future Without Project" or the "status-quo" condition (i.e., continuing to rely on groundwater pumping and the existing 30 mgd Surface Water Treatment Facility to meet future demands), the water demands presented in this chapter will be used throughout this Metro Plan Update.

The purpose of this chapter is to present the current and projected potable water demands served by the City of Fresno (City). The following sections of this chapter describe the data and methodology utilized:

- The City's water service area
- Historical Water Production and Consumption
- Historical Peaking Factors
- Per Capita Based Potable Demand Projections
- Land Use Based Potable Demand Projections
- Recommended Urban Demand Projections
- Historical and Projected Wastewater Flows

Growth outside the City's Sphere of Influence (SOI) may also impact the availability of water supplies in the Fresno metropolitan area. Therefore, existing and future water demands for areas outside the City SOI, herein referred to as "Non-Fresno" water demands, have also been evaluated. A separate technical memorandum discussing these "Non-Fresno" water demands was prepared by WRIME and is included in this Metro Plan Update as Appendix A.

THE CITY'S WATER SERVICE AREA

The City currently provides retail potable water service to approximately 42,000 acres[1] located in Fresno County along Highway 99. With the exception of the Bakman Water Company (Bakman), Pinedale County Water District (Pinedale), California State University at Fresno (CSUF), and private groundwater users located within county islands, the City serves the entire area encompassed by its City Limits and SOI. The SOI is coincident with the General Plan Boundary and, therefore, includes all lands planned to be annexed by the City by 2025.

Discussions with City staff indicated that the City has expanded its SOI to include the Southeast Growth area. Figure 3-1 presents the study area used to develop the City's Urban Water Demands and Wastewater Flows.

Subsequent sections discuss population, existing land use, and projected land use for the City's General Plan Water Service Area, and assumed future growth fringe areas in 2060.

Historical and Projected Population

Historical and projected population was developed using data collected from the City and the California Department of Finance (DOF), and was compared to historical water production to develop a per capita demand factor. The actual methodology used to develop existing and future population estimates is described in more detail below.

<u>Comparison to 1996 Metro Plan Populations</u>

The original study area for the Fresno Metropolitan Water Resources Management Plan, Phase I Report (1992 Phase I Report) included both the cities of Fresno and Clovis. This Metro Plan Update includes only the City of Fresno's water service area, which encompasses the City Limits and Sphere of Influence areas, with the exception of some privately served areas within the City Limits (including Bakman, Pinedale, CSUF and some individual and/or industrial groundwater users located in these County islands). Thus, the historic and projected populations presented in this Metro Plan Update are significantly lower than the projections in the 1992 Phase 1 Report due to this reduction in evaluated study area.

<u>Historical Water Service Area Population</u>

The City of Fresno has historically experienced rapid growth, with the population increasing from 10,818 persons in 1900 to 60,685 in 1940, and 218,202 in 1980 (Census data)[2]. According to the U.S. Census, in 1990, the City population was 354,282, and in 2000, it was 427,652[3].

In the 1986 City of Fresno UWMP, it was estimated that the population served by the City Water Division was 269,824; 15,176 less than the City population of 285,000[4], accounting for areas within the City Limits served by private water companies, special districts, or their own wells. In 1989, the City Water Division acquired numerous County water facilities and began serving customers previously served by the County. This added a significant number of customers to the City's water service area; however, the exact number of customers added is unknown.

In 2000, the City Water Division developed a methodology for calculating the population of the City's water service area. The methodology involved summing all of the Census tract data for the April 2000 Census for the City's overall service area, and subtracting out tracts not served by the City. These tracts included areas served by Bakman, Pinedale and the City of Clovis, as well as areas outside the City service area, unserved areas within County areas, unserved areas within City areas and areas with only partial service (i.e., straddling City service areas). This population was then adjusted based on a 1.9 percent annual growth rate (based on the Fresno County Council of Government's (COG) growth rate for the City of Fresno from 1990 to 2000[5]) to determine the January 2001 water service area population.

For subsequent years, the City Water Division has used an annual increase of 1.9 percent, based on the COG annual growth rate to account for growth within the water service area. The calculated populations for the City water service area are summarized in Table 3-1.

Table 3-1. City of Fresno Water Service Area Population (2001-2006)[a,b]

Year	Estimated Service Area Population
2001	440,608
2002	448,980
2003	457,511
2004	466,203
2005	475,061
2006	484,087

(a) As calculated by the City Water Division ("census pop.xls")
(b) All estimated population numbers are as of January 1 of the given year

For purposes of this Metro Plan Update, and to establish long-term trends in population growth and resulting per capita water production, WYA has estimated the water service area population from 1989 to 2000 by using the DOF population estimates for the City of Fresno (Report E-4), adjusted to account for additional population served by the City as a result of the acquisition of County service areas and facilities in 1989. The DOF population estimates also provide populations for January 1 of a given year; both sets of population estimates (the City's and DOF's) are comparable.

The adjustment was based on the average difference between the City of Fresno DOF population and the City Water Division water service area population for 2001 through 2006. The resulting estimated historic water service area population is shown on Figure 3-2, indicating that the City's water service area population is somewhat higher than the City of Fresno population.

Projected Future Water Service Area Population

In the future, the population of the City's water service area is anticipated to continue to grow. Figure 3-3 shows the projected population to be served by the City Water Division. A range of projections has been made based on different projection methodologies. The first methodology involved projecting the actual population served (as calculated by the City Water Division) using the 1.9 percent COG annual growth rate. This results in a service area population of approximately 692,202 in 2025 and 760,508 in 2030.

The City of Fresno General Plan (General Plan) has somewhat different projections, and assumes a higher starting population in 2000 for the Community Plan Area (482,495 as compared to the City Water Division estimate of 435,814 for April 2000). According to the General Plan, the population of the Community Plan Area will increase to 790,955 by 2025, representing an approximately 2 percent annual growth rate[6]. As shown on Figure 3-3, if the General Plan Community Plan Area grows at only a 1.9 percent annual rate (per the COG growth rate), buildout of the General Plan Community Plan Area would not occur until about 2026.

The City has not completed any formal planning to grow beyond the year 2025 or the boundaries adopted in its General Plan; hence, no population projections were developed for years beyond 2025. However, as will be discussed in subsequent sections, this Metro Plan Update does estimate a potential water demand for the year 2060 using an aggregate unit demand factor and an assumed "growth fringe" area. Water demands estimated in this report for year 2060 are strictly for long-term water supply planning purposes, and the City does not currently have any formal plans to move beyond its current General Plan planning boundaries.

Existing and Projected Land Use

WYA obtained existing and future land use data from the City's Geographical Information System (GIS), which used land use designations adopted as part of the City's General Plan. The approximately 140 different land use designations developed for use in the City's General Plan were consolidated into one of the City Water Division's five existing customer classes (Single Family Residential, Multiple Family Residential, Commercial/Institutional, Industrial, and Landscape Irrigation) to facilitate development of unit demand factors. Appendix B presents a table illustrating how each land use designation was assigned to a customer class.

In addition to the five existing customer classes, WYA also added a sixth category (Southeast Growth Area) to account for an area located in the southeast area that the City recently added to the SOI. Spatially distributed land use information for the Southeast Growth Area was not available in the form of either AutoCAD files or GIS shapefiles; consequently, as will be discussed in more detail below, an aggregate unit demand factor was developed for this area. The City does not currently provide, or plan to provide in the future, water to Bakman, CSUF, or private groundwater users, any only provides minimal water supplies to Pinedale in the portion of their service area east of Highway 41.

However, it is the City's desire to provide a contingency in this Metro Plan Update for the Bakman, CSUF, Pinedale, and existing private groundwater well owners in case the City is required to serve these areas sometime in the future. For planning contingency purposes only, and if requested, the Metro Plan Update assumed that these areas would be served by the City sometime between 2013 and 2025 (buildout of the General Plan). Therefore, ranges of water demands were considered; the low demand estimate excluding these areas, and the high demand estimate including them.

Insufficient data was available to determine the quantity in acres or location of private groundwater users. The location of the acreage associated with private groundwater users is embedded within the geospatial information provided by the City, and no information regarding their population, size, or consumption history was available. The acreage for these users could not be removed from the analysis.

Consequently, the water demand projections in this Metro Plan Update include private groundwater users. This assumption provides additional planning conservatism that will allow existing private groundwater users the flexibility to connect to the City's water system in the future should water quality or other extenuating circumstances require them to abandon their groundwater wells.

Table 3-2 presents existing and future acreage served, by customer class, between 2005 and 2025 (buildout of the General Plan). Figures 3-4 and 3-5 illustrate the City's existing and future land use, respectively. Development for year 2010 is based on discussions with City staff and currently active tentative maps. No land use information was available for the 2060 planning

Table 3-2. Existing and Projected Land Use for the City of Fresno [a,b]

Customer Class[c]	Low Demand Area, acres[d]			High Demand Area, acres[e]		
	2005[f]	2010[f,g]	2025[f]	2005[f]	2010[f,g]	2025[f]
Single Family Residential	21,948	25,619	36,244	22,777	26,688	37,414
Multiple Family Residential	3,475	3,757	4,639	3,852	4,133	4,981
Commercial/Institutional	12,449	12,771	19,339	14,084	14,563	21,273
Industrial	1,994	1,994	4,098	1,994	1,994	4,098
Landscape Irrigation	2,304	2,376	2,675	2,310	2,391	2,705
South East Growth Area	0	2,094	8,376	0	2,094	8,376
Subtotal	**42,172**	**48,610**	**75,370**	**45,017**	**51,863**	**78,847**
Open Space or Vacant	28,958	24,614	4,136	30,286	25,533	4,832
Rural Residential in South East Growth Area	8,376	6,282	0	8,376	6,282	0
Total	**79,506**	**79,506**	**79,506**	**83,679**	**83,679**	**83,679**

[a] All acreage estimates include areas served by private groundwater users because they could not be removed from the geospatial data; however, including private users in the water demands additional planning conservatism that will allow existing private groundwater users the flexibility to connect to the City's water system in the future should water quality or other extenuating circumstances require them to abandon their groundwater well.

[b] GIS data provided by the City did not include polygons for streets, highways, or major water ways; hence, the data presented is net acreage.

[c] Customer Classes correspond to water use records provided by the City.

[d] Low demand area does not include Bakman, Pinedale, or CSUF.

[e] High Demand area does include Bakman, Pinedale, and CSUF.

[f] Acreage obtained from GIS shapefiles provided by the City; General Plan land use categories were assigned to Customer Classes per Appendix 3-A.

[g] Acreage added from 2005 to 2010 is based on discussions with City staff and tentative map boundaries provided by the City.

horizon, so a blended urban land use mix was assumed for planning purposes, similar to the Southeast Growth Area.

As shown in Table 3-2, under the high demand area projection, approximately 45,000 acres of the potential 83,700 acres within the City's Water Service Area (i.e., approximately 54 percent) are currently developed and receive water from either the City, Bakman, CSUF, Pinedale, or private groundwater wells. Table 3-2 also indicates that the developed area served by the City may grow from approximately 42,200 acres to 78,900 acres between now and 2025 (i.e., 87 percent over the next 20 years).

A review of Table 3-2 and Figures 3-4 and 3-5 also indicates that the developed area served by the City is 52 percent Single Family Residential, 30 percent Commercial/Institutional, 8 percent Multiple Family Residential, 3 percent Industrial, and 3 percent Landscape Irrigation. This mix does not change significantly in the future.

HISTORICAL WATER PRODUCTION AND CONSUMPTION

Water production is the combined quantity of water produced by the City's groundwater wells and surface water treatment plant, while water consumption is the quantity of water actually consumed or used. As will be discussed later, the difference between production and consumption is unaccounted-for water (UAFW).

The City currently tracks all of the water produced by its wells and surface water treatment plant. Although the City does not meter Single Family Residences, it does meter the consumption for a vast majority of its customers: Multiple Family Residential, Commercial/Institutional, Industrial, and Landscape Irrigation. As will be discussed in Chapter 4, the City will be implementing a metering program for its single-family customers.

Consequently, the City tracks water use in two ways: production records and meter (consumption) records. Both are discussed in more detail below, along with a discussion on UAFW.

Historical Water Production Records

The City currently meets its water demands using a combination of City owned groundwater wells and surface water supplied from one existing surface water treatment plant. Table 3-3 presents the City's historical water production between 1989 and 2005 from all of its water supply sources.

As shown in Table 3-3, the City's water production increased from approximately 114,230 acre-feet (af) in 1989 to 155,750 af in 2006, representing a 36 percent increase over the last 17 years. The City's surface water treatment plant came online in late 2004, and in 2006, the City was able to offset its groundwater use by approximately 13 percent by using the new surface water treatment plant throughout the year.

Table 3-3. Historical Water Production[a,b]

Calendar Year	SWTF, afa[c]	Total Groundwater, afa	Total Production, afa	% Surface Water	% Groundwater
1989	0	114,229	114,229	0%	100%
1990	0	118,808	118,808	0%	100%
1991	0	117,562	117,562	0%	100%
1992	0	118,303	118,303	0%	100%
1993	0	119,521	119,521	0%	100%
1994	0	128,992	128,992	0%	100%
1995	0	130,389	130,389	0%	100%
1996	0	138,389	138,389	0%	100%
1997	0	148,670	148,670	0%	100%
1998	0	135,546	135,546	0%	100%
1999	0	151,806	151,806	0%	100%
2000	0	156,487	156,487	0%	100%
2001	0	164,049	164,049	0%	100%
2002	0	165,542	165,542	0%	100%
2003	0	165,177	165,177	0%	100%
2004	4,060	160,047	164,108	2%	98%
2005	15,807	141,471	157,278	10%	90%
2006	19,701	136,050	155,750	13%	87%

[a] Surface water and groundwater data before 1995 obtained from "Production Statistics - Monthly Production for Years 1983 to 2006 (in Mgal)" provided by the City

[b] Surface water and groundwater data after 1994 obtained from "PumpingStats.xls" provided by the City

[c] Surface Water Treatment Facility (SWTF) began operation in June 2004 (majority of production beginning in October 2004)

afa = acre-feet annually

Additionally, Table 3-3 shows that the City's overall water use has decreased since 2002. This decrease is possibly a result of the City's water conservation efforts over the last several years (a check of the annual rainfall indicates that the City received about its historic annual average rainfall quantities over the past few years).

Figure 3-6 illustrates monthly water production by the City over the past six years. As shown on Figure 3-6, the City's water use in the summer is approximately three times the winter use due to exterior landscape irrigation demands, usually peaking in either July or August.

Historic Indoor and Outdoor Water Use

Figure 3-7 presents the average monthly water use from 2001 to 2006 for all users (including residential, commercial/industrial, institutional, and landscape irrigation). Assuming that very little irrigation occurs during either January or February, then water use during these months can be used as an overall estimate of indoor water use; all other water use above the average of February could be considered as exterior water use.

As shown in Figure 3-7, the City's annual average historic mix of indoor and exterior water use is nearly 50 percent indoor and 50 percent exterior. Figure 3-7 also indicates that exterior water use can be as much as 70 percent of total water use during the summer months due to summer time peak demands from irrigation customers (see July and August monthly averages).

Historic Per Capita Water Use

Based on the estimated historical population served by the City from 1989 to 2006, historical per capita water production has been estimated and is illustrated on Figure 3-8. As shown in Figure 3-8, from 1989 to 2006, total per capita water production has varied from a low of 269 gallons per capita per day (gpcd) in 1993 to a high of 332 gpcd in 2001. In 2006, the total per capita water production was 287 gpcd, reflecting annual decreases since 2001. The average total per capita water production was 300 gpcd from 1989 to 2006. As a comparison, per capita water use from the City of Clovis was also reviewed (see Appendix A). The City of Clovis' 2005 per capita water demand was 248 gpcd. This per capita water demand for Clovis is approximately 17 percent lower than Fresno's average per capita water demand.

The City does not currently meter single-family residential water use. However, water uses by other customer classes are metered. Therefore, the total water use by single-family residential can be estimated by subtracting all metered water use and estimated unaccounted for water (assumed to be 10 percent, see below) from the total water production. Using this methodology for single-family residential and the metered water use for multi-family residential, it was determined that, single-family and multi-family residential water use made up about 67 percent of the City's total water use. Based on this actual water use, the residential per capita water consumption in 2006 was 192 gpcd. Figure 3-8 shows the estimated residential per capita water consumption from 1995 to 2006, based on historic water consumption.

Figure 3-8 also shows the single-family residential per capita consumption for 1995 to 2006, calculated as described above (single-family residential water use = total production-unaccounted for water-all metered water uses) based on actual annual water use. As shown, single-family residential per capita consumption ranged from a low of 148 gpcd in 1998 to a high of 183 gpcd in 2001 and 2003. Since 2003, single-family residential per capita consumption has decreased significantly to 150 gpcd in 2006.

Figure 3-9 shows historic per capita water use for each user type from 1995 to 2006 (as well as for the future, see discussion below), based on actual metered water use (except for single-family residential).

Projected Future Per Capita Water Use

For projecting future demands, WYA has assumed that the baseline per capita water use (before recent water conservation and future metering is considered) will be equal to the average per capita water demand for the last eighteen years (1989 to 2006), or 300 gpcd. From this baseline, 5 percent has been deducted to account for recently implemented water conservation programs, for a per capita water use of 285 gpcd. The 2006 per capita use of 287 gpcd reflects this assumed reduction in per capita water use and the results of recent water conservation efforts.

For purposes of projecting future water demands based on per capita water use, consistent with the City's water conservation and demand management plans, we have assumed that the baseline total per capita water use will decrease as follows:

- All users have already achieved a water conservation savings of about 5 percent based on recently implemented water conservation measures, and
- Beginning in 2009, single-family residential per capita water use will decrease by 2 percent per year for five years, for a total reduction of 10 percent by 2013, to reflect the City's single-family residential water metering program.

Based on these assumptions, the current total per capita water consumption will be reduced by about 10 percent by 2013, to a total per capita water use of 270 gpcd. This projected reduction in per capita water use is summarized in Table 3-4 and shown on Figure 3-10.

Table 3-4. Projected Future Per Capita Water Consumption

	Calculation of Reduction	Reduction in Total Per Capita Water Consumption, gpcd	Resulting Future Total Per Capita Water Consumption, gpcd
Baseline Total Per Capita Water Consumption (average for 1989 to 2006)	--	--	300
Reduction Due to Recent Water Conservation by All Users	5% of 300 gpcd[(a)]	(15)	285
Estimated Reduction due to Single-Family Residential Metering Program (10% of Single-Family Per Capita Use)(2% per year starting in 2009; 10% total by 2013)	10% of 150 gpcd[(b)]	(15)	270

(a) Based on average Total Per Capita Water Consumption for the last eighteen years (1989-2006), see Figure 3-8.
(b) Based on 2006 Estimated Single-Family Residential Per Capita Consumption, see Figure 3-9.

Unaccounted-For Water

The City's UAFW is the difference between the recorded production and metered consumption; however, because the City does not meter its Single Family Residential customer class, the UAFW could not be specifically determined.

UAFW includes many uses, such as hydrant testing, construction, fires, system flushing, system leaks, and water main breaks. A city with the infrastructure age of Fresno likely has an UAFW rate of 10 percent or higher, depending on the condition of older pipelines in the system. For planning purposes in this Metro Plan Update, UAFW for the City's water system was assumed equal to 10 percent.

Historical Water Consumption

Historical water consumption for the City's water service area for 1995 through 2006 is shown on Table 3-5. As discussed above, the City does not meter single-family residential customers. However, the City does meter other customer classes, including multi-family residential, commercial/institutional, industrial, and landscape irrigation. Therefore, historical water consumption by single-family residential customers was estimated by WYA by subtracting all metered water use and estimated UAFW (assumed to be 10 percent of total water production) from the City's total water production.

In 2006, water use by single-family residential customers was estimated to be approximately 81,398 af, accounting for about 52 percent of the City's total water use, while multi-family residential was 22,471 af (14 percent), commercial/institutional was 24,928 af (16 percent), industrial was 3,865 af (2 percent), and landscape irrigation was 7,514 af (5 percent). Unaccounted for water was assumed to be 10 percent of total water production, or 15,575 af.

As shown in Table 3-5, single-family residential water use has decreased in the last three years from 93,845 af in 2003 to 81,398 af in 2006. This decrease may be a result of the City's water conservation efforts over the last several years (a check of the annual rainfall indicates that the City received about its historic annual average rainfall quantities over the past few years). Multi-family residential water use has decreased slightly over the last few years, commercial/institutional use has increased somewhat, industrial water use has decreased, and landscape irrigation has increased. Overall, water use in the City service area has decreased since 2002, again, possibly as a result of the City's water conservation efforts and/or the influence of an increased number of residential customers which dilutes the influence of industrial and commercial users. Additional discussion of this decrease in water use over the last several years is provided in the "Per Capita Water Use" section of this chapter.

Table 3-5. Calculated Water Use by User Class, acre-feet

User Type	Calendar Year 1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Estimated Single-Family Residential (Unmetered)[a], af	70,151	77,949	81,452	70,267	78,793	85,867	90,297	90,301	93,845	87,080	82,747	81,398
Single-Family Residential (Metered)[b], af	2,142	2,578	3	-	-	-	-	-	0	0	0	-
Multi-Family Residential (Metered)[b], af	20,207	17,086	21,715	21,453	23,987	21,792	22,649	23,342	22,902	23,587	22,651	22,471
Commercial/Institutional (Metered)[b,c], af	17,041	18,165	21,239	21,996	24,594	24,242	23,940	23,984	20,781	26,143	25,731	24,928
Industrial (Metered)[b], af	4,187	4,551	4,651	5,160	5,769	4,131	5,019	5,041	4,742	3,829	3,528	3,865
Landscape Irrigation (Metered)[b], af	2,679	3,049	3,460	3,123	3,492	4,607	5,563	6,043	6,400	7,057	6,894	7,514
Other (Metered)[b,d], af	951	1,179	1,292	-	-	208	186	287	-	-	-	-
Estimated Unaccounted For Water (10% of Total Production), af	13,040	13,840	14,868	13,555	15,182	15,650	16,406	16,555	16,519	16,411	15,728	15,575
Total Production (from Gold Book)[e], af	130,398	138,398	148,680	135,555	151,816	156,498	164,060	165,554	165,189	164,108	157,278	155,750
Total Unmetered, af	70,151	77,949	81,452	70,267	78,793	85,867	90,297	90,301	93,845	87,080	82,747	81,398
Total Metered, af	47,207	46,609	52,360	51,732	57,842	54,981	57,357	58,697	54,825	60,617	58,804	58,777
Unaccounted For Water, af	13,040	13,840	14,868	13,555	15,182	15,650	16,406	16,555	16,519	16,411	15,728	15,575
Total, af	130,398	138,398	148,680	135,555	151,816	156,498	164,060	165,554	165,189	164,108	157,278	155,750

(a) Unmetered single-family residential water use = Total Production - 10% Unaccounted For Water - Metered Water Use.

(b) Source: DWR Public Water System Statistics Reports (1995-2005) and 2006 HTE Revenue Report.

(c) "Institutional" includes schools and municipal uses. Except for 1995-1997, when municipal was included in "Other".

(d) "Other" consists of municipal uses for 1995-1997. "Other" in 2000-2002 was not specified on the DWR Public Water System Statistics Reports.

(e) Source: Gold Book "pumping stats.xls"

HISTORICAL PEAKING FACTORS

Peaking factors are used to calculate water demands expected under high demand conditions (i.e., Maximum Day and Peak Hour Demand). The resulting demand conditions for maximum day and peak hour periods are then used to evaluate and size transmission/distribution pipelines and storage facilities, and to define water supply needs and capacity requirements. This section describes the methodology used to develop the peaking factors for the maximum day and peak hour demand conditions within the City's water service area.

Maximum Day Peaking Factor

The maximum day demand peaking factor is determined by dividing the maximum day demand by the annual average day demand. Table 3-6 presents the City's maximum day demand and annual average day demands between 1995 and 2006; maximum day demand data prior to 1995 was not available for this analysis. As shown in Table 3-6, the City's maximum day demand peaking factor ranged from a low of 1.5 in 2002 to a high of 2.1 in 1995, and averaged approximately 1.7 over the entire period.

The 1992 Phase 1 Report used a maximum day peaking factor of 2.1 times the annual average day, which corresponds with the largest value observed between 1995 and 2006. Around 1996, as part of the City's water conservation efforts, a City Ordinance was passed that restricted exterior landscape irrigation to every other day (even and odd days), and does not allow exterior watering on Mondays. In March 1996, the Water Transmission Grid Main Hydraulic Model Report prepared by Montgomery Watson, calculated a max day peaking factor of 1.81 for the City system, but recommended use of a factor of 2.0 to allow for additional system flexibility.

In addition to conserving water, this Ordinance also appears to have slightly reduced the City's maximum day peaking factor. However, because there were also several wet years which have occurred within the last 10 years that could have also had an influence on reducing the City's maximum day peaking factor, this Metro Plan Update recommends use of an annual average day to maximum day peaking factor of 2.0 to size infrastructure. Using a peaking factor of 2.0 will ensure that the City's infrastructure can manage the largest maximum day peak observed over the past 10 years should such a peak occur again in the future.

Peak Hour Peaking Factor

The peak hour peaking factor is determined by dividing the peak hour demand by the annual average day demand. Table 3-7 presents the City's peak hour demand and annual average day demands between 1997 and 2006; peak hour data was not available for years prior to 1997. As shown in Table 3-7, the City's peak hour demand peaking factor ranged from a low of 2.2 in 2004 to a high of 2.6 in 1998 and 2006, and averaged approximately 2.4 over the entire period.

The peak hour demand factors presented in Table 3-7 are very low, compared to other typical metropolitan areas. More typical peak hour demand factors range from 3 to 5 times the annual average day demand. In fact, the 1992 Phase 1 Report used hourly telemetry data, not available for this Metro Plan Update, to justify a peak hour factor of 3.6. The 1996 Water Transmission Grid Main Hydraulic Model Report calculated a peak hour factor of 2.61, but also thought this value was low, and recommended use of an average day to peak hour factor of 2.90. To provide

Table 3-6. Maximum Day Peaking Factor[a,b]

Calendar Year	Average Day Demand, mgd[a]	Max Day Demand, mgd[b]	Day	Max Day Peaking Factor
1995	116	245.51	August 3	2.1
1996	124	222.00	August 15	1.8
1997	133	216.41	July 15	1.6
1998	121	217.07	July 19	1.8
1999	136	219.02	July 14	1.6
2000	140	213.76	June 27	1.5
2001	146	234.29	July 3	1.6
2002	148	223.07	July 9	1.5
2003	147	229.61	July 22	1.6
2004	146	224.37	August 18	1.5
2005	140	245.51	July 28	1.7
2006	139	252.79	July 27	1.8
Average				1.7
5-Year Average				1.6
Minimum				1.5
Maximum				2.1
Recommended Value				**2.0**

[a] Average Day Demand obtained by converting annual production from Table 3-1.

[b] Max Day obtained from "PumpingStats.xls" provided by the City in the Gold Book.

Table 3-7. Peak Hour Peaking Factor[a,b]

Calendar Year	Average Day Demand[a]		Peak Hour Demand[b]		Day	Peak Hour Peaking Factor
	Kgpm	mgd	Kgpm	mgd		
1997	133	191	321	463		2.4
1998	121	174	313	450		2.6
1999	136	195	307	442		2.3
2000	140	201	317	457		2.3
2001	146	211	342	492		2.3
2002	148	213	341	491		2.3
2003	147	212	343	494	July 17	2.3
2004	146	211	320	461	July 21	2.2
2005	140	202	357	514	July 12	2.5
2006	139	200	362	522	July 27	2.6
Average						2.4
5-Year Average						2.4
Minimum						2.2
Maximum						2.6
Recommended Value						**2.9**

[a] Average Day Demand obtained by converting annual production from Table 3-1.

[b] Peak Hour obtained from "PumpingStats.xls" provided by the City in the Gold Book.

Kgpm = Thousands of gallons per minute

mgd = million gallons per day

consistency with this previous work, for use in this Metro Plan Update, an annual average day to peak hour factor of 2.9 will also be used.

PER CAPITA BASED POTABLE DEMAND PROJECTIONS

Based on the projected population of the City's water service area and the projected future per capita water use (assuming additional water conservation savings by all customers, and the metering of all single-family residential customers), per capita based potable water demand projections have been made for the City's water service area. Using the City Water Division service area population estimates with a 1.9 percent annual population increase (considered to be the "Low Population" estimate), the projected potable water demand in 2025 is estimated to be approximately 209,400 af. Using the population estimates from the City's 2025 General Plan (considered to be the "High Population" estimate), the projected potable water demand in 2025 is 239,200 af.

However, as will be discussed in Chapter 5 (supplies), a portion of the demand estimate will be met with recycled water supplies. The per capita based water use projections are shown in Figure 3-11.

LAND USE BASED POTABLE DEMAND PROJECTIONS

In addition to per capita based potable demand projections, future water demands for the City were also calculated using land use acreage and unit demand factors to develop future water demand projections by customer class. Subsequent sections describe the methodology used to develop unit demand factors by customer type, project water demands, and then compare the land use based demand projections to the per capita based demand projections.

Development of Unit Demand Factors

Unit demand factors by customer type were developed by dividing existing water consumption by existing land use. Existing land use data was previously presented in Table 3-2, and existing water consumption was previously presented in Table 3-5.

Table 3-8 presents the unit demand factors calculated using 2005 water consumption and the average water consumption for the three years, 2003, 2004, and 2005; and the range used in the 1992 Phase 1 Report. Table 3-8 also presents the unit demand factors recommended for adoption in this report.

As shown in Table 3-8, both sets of calculated unit demand factors are very close and with the exception of Single Family Residential, fall within the range previously used in the 1992 Phase 1 Report. The unit demand factor for Single Family Residential is only slightly outside the range previously presented in the 1992 Metro Plan, and using this slightly higher, calculated unit demand factor will provide the City with additional conservatism.

As previously shown in Table 3-2, the Southeast Growth Area does not currently have specifically defined land uses; consequently, an aggregate unit demand factor was also developed. An aggregate unit demand factor using 2005 consumption data and the three-year average is also presented in Table 3-8. These aggregate unit demand factors are nearly identical;

Table 3-8. Calculated Unit Demand Factors[(a,b,c)]

Customer Class	2005 Existing Land Use, acres	2005		Three-Year Average		Range of Unit Factors Presented in the 1992 Metro Plan, af/ac/yr	Recommended Unit Demand Factor Before Conservation, af/ac/yr
		2005 Water Use, af	2005 Unit Factor, af/ac/yr	Average Water Use in 2003, 2004, 2005, af	Average Unit Factor, af/ac/yr		
Single Family Residential	21,948	82,747	3.8	87,891	4.0	2.7 to 3.7	3.8
Multi-Family Residential	3,475	22,651	6.5	23,047	6.6	3.1 to 6.8	6.5
Commercial/Institutional	12,449	25,731	2.1	24,218	1.9	1.9 to 3.2	2.0
Industrial	1,994	3,528	1.8	4,033	2.0	1.9 to 4.5	2.0
Landscape Irrigation	2,304	6,894	3.0	6,784	2.9	3.0 to 3.5	3.0
Total	42,172	141,550	3.4	145,972	3.5	--	3.4[(d)]

(a) Acreage obtained from Table 3-2.

(b) Water use (consumption) obtained from Table 3-5.

(c) Does not include water conservation.

(d) An aggregate unit demand factor of 3.4 was used to project water demands for the Southeast Growth Area because this area did not have specifically identified land use; the aggregate factor was determined by dividing total water use by total development.

therefore, the adopted aggregate unit demand factor was calculated by taking the weighted average (by 2005 area) of the adopted unit demand factors by land use class.

Adjusted Unit Demand Factors for Conservation and Metering

The unit demand factors were adjusted for overall conservation and Single Family Residential metering using the same methodology previously presented for the per capita demand factors: 5 percent conservation savings for all customer classes already achieved by 2006, plus reducing Single Family Residential for metering by 2 percent per year starting in 2009 until 2013 for a total savings of 10 percent. Table 3-9 presents the unit demand factors used to project water demands after accounting for additional conservation and metering.

Table 3-9. Unit Demand Factors Adjusted for Conservation & Metering

Customer Class	2005 Unit Factor, af/ac/yr	2010 Unit Factor, af/ac/yr[(a)]	2025 Unit Factor, af/ac/yr[(b)]
Single Family Residential	3.8	3.5	3.2
Multiple Family Residential	6.5	6.2	6.2
Commercial/Institutional	2.0	1.9	1.9
Industrial	2.0	1.9	1.9
Landscape Irrigation	3.0	2.9	2.9
Southeast Growth Area	3.4	3.2	3.2

(a) Assumes all customer classes have already achieved a water conservation savings of 5 percent due to recently implemented water conservation measures, and Single Family achieves an additional 4 percent by 2010 due to metering.

(b) Assumes that Single Family achieves an additional 10 percent savings due to metering by 2013.

Projected Potable Demands by Customer Class

Potable water demands were projected for the City by multiplying the unit demand factors presented in Table 3-9 by the acreages in Table 3-2. Table 3-10 presents the projected water demands, by customer class, for years 2005, 2010, and 2025 using land use based unit demand factors. Projected water use or consumption presented in Table 3-10 accounts for conservation and metering of Single Family Residential, while projected water production includes UAFW at 10 percent.

As shown in Table 3-10, the City's projected water production in 2005 was approximately 157,600 af, while the actual production was 157,278 af (see Table 3-3), verifying the validity and accuracy of this methodology.

Table 3-10 also indicates that the City's lower water production needs (corresponding to the lower service population estimate) will increase from approximately 157,600 af in 2005 to 248,800 af in 2025 (buildout of the General Plan), or approximately 58 percent over the next 20 years. However, the City's water production need could also increase by approximately 55 percent (from 167,400 to 259,300 af) should the contingency set aside for the Bakman, CSUF,

Table 3-10. Land Use Based Demand Projections by Customer Class (with conservation and future metering)[a]

				Low Demand Estimate						High Demand Estimate					
	Unit Factors, af/ac/yr			2005 (estimated)		2010		2025 (GP Buildout)		2005		2010		2025 (GP Buildout)	
Customer Class	2005	2010	2025	Area, acres	Water Demand, af/yr	Area, acres	Water Demand, af/yr	Area, acres	Water Demand, af/yr	Area, acres	Water Demand, af/yr	Area, acres	Water Demand, af/yr	Area, acres	Water Demand, af/yr
Single Family Residential	3.8	3.5	3.2	21,948	83,400	25,619	89,700	36,244	116,000	22,777	86,600	26,688	93,400	37,414	119,700
Multi-Family Residential	6.5	6.2	6.2	3,475	22,600	3,757	23,300	4,639	28,800	3,852	25,000	4,133	25,600	4,981	30,900
Commercial/Institutional	2.0	1.9	1.9	12,449	24,900	12,771	24,300	19,339	36,700	14,084	28,200	14,563	27,700	21,273	40,400
Industrial	2.0	1.9	1.9	1,994	4,000	1,994	3,800	4,098	7,800	1,994	4,000	1,994	3,800	4,098	7,800
Landscape Irrigation	3.0	2.9	2.9	2,304	6,900	2,376	6,900	2,675	7,800	2,310	6,900	2,391	6,900	2,705	7,800
South East Growth Area	3.4	3.2	3.2	0	0	2,094	6,700	8,376	26,800	0	0	2,094	6,700	8,376	26,800
Total Projected Consumption					141,800		154,700		223,900		150,700		164,100		233,400
UAFW (10%)					15,800		17,200		24,900		16,700		18,200		25,900
Total Projected Production					157,600		171,900		248,800		167,400		182,300		259,300

[a] Demands do not account for recycled water supplies, as recycled water supplies are discussed in Chapter 5.

Pinedale, and private groundwater users be requested (i.e., Bakman, CSUF, Pinedale, and private groundwater users request City service).

Figure 3-12 illustrates the City's low and high water production needs over the next 20 years using interpolation between 2005 and 2010, and between 2010 and 2025. As shown in Figure 3-12, the City's projected water demands can vary by approximately 10,000 af, depending on whether portions of the SOI currently served by others are served by the City in the future. The water demand projections presented in Figure 3-12 do not include raw surface water or recycled water supplies; these water supplies are discussed in Chapter 5.

Comparison of Per Capita and Land Use Based Demand Projections

Figure 3-13 compares per capita demand projections to land use based demand projections. The low per capita based demand estimate in 2025 is likely the result of assumed growth rates associated with future population projections, and not exercising the contingency set aside for Pinedale, Bakman, CSUF, and other private users to the City system. However, the per capita and land use based demand projections are sufficiently close for planning purposes in this Metro Plan Update.

Typically, per capita based water demand projections uniformly distribute water use over the entire service area and, therefore, do not account for specific land uses and locations. Additionally, per capita based water demand projections do not accurately account for changes in type of water demand over time (e.g., residential and commercial). Consequently, this Metro Plan Update will use land use based demand projections for planning future water supply needs.

RECOMMENDED URBAN WATER DEMANDS

As discussed above, this Metro Plan Update will use land use based demand projections. For planning purposes, it was assumed that future water demands would follow the low land use based demand estimate until 2013 (after conservation measures are completed), then incrementally transition to the high land use based estimate by 2025.

Figure 3-14 presents the recommended water demand projection for the City. As shown in Figure 3-14, the City's demands are projected to increase from 157,600 af in 2005 to 259,300 af by the year 2025; representing a 65 percent increase in water demands over the next 20 years.

Projected 2060 Demand Projections

Water demands for the Fresno Metropolitan area were also approximated for the year 2060. This water demand projection was developed using an estimated 2060 development boundary and an aggregate unit demand factor. The 2060 development area was estimated based on discussions with City staff, and is illustrated on Figure 3-1; the 2025 to 2060 incremental area is approximately 37,000 acres.

The aggregate unit demand factor developed for the 2060 planning horizon was approximated by dividing the adopted demand in 2025 (259,300 af) by the total developed acres in 2025 (78,847 acres) or approximately 3.3 af/acre. This aggregate unit demand factor already includes UAFW, and is lower than the unit demand factor (3.5 af/acre)[7] previously developed in the 1992 Phase 1

Report for Agriculture; as urban demands replace agricultural demand, total water consumption will decrease within FID's water service area.

Consequently, the incremental water demand in Year 2060 is approximately 122,100 af larger than the 2025 demand, for a total demand in Year 2060 of approximately 381,400 af. Table 3-11 and Figure 3-15 present the adopted demand projections through 2060 for this Metro Plan Update.

Table 3-11. Projected Water Demands through the Year 2060

Year	2005	2010	2015	2020	2025	2030[(a)]	2060
Demand, af	157,600[(b)]	171,900	199,300	229,300	259,300	276,700	381,400

(a) Year 2030 water demand projection based on interpolation of demand projections in 2025 and 2060.

(b) Actual demand in 2005 was 157,278 af/yr.

Comparison of Recommended Demand Projections to the 1996 Metro Plan

Table 3-12 compares the recommended demand projections to the demands from the 1996 Metro Plan. As shown in Table 3-12, the new demand projections are, on average, approximately 39 percent higher than the demand projections adopted for the City in the 1996 Metro Plan. Table 3-12 also indicates that the actual demand experienced by the City in 2005 was not projected to occur until 2020. The difference between actual demands recorded in 2005 and projected demands in the 1996 Metro Plan Update are likely the result of more aggressive growth taking place than was previously anticipated.

Table 3-12. Comparison to 1996 Metro Plan Water Demand Projections

Year	Adopted Demand Projection, af[(a)]	1996 Metro Plan Projection, af[(b)]	% Increase
2005	157,600	124,500	27
2010	171,900	128,000	34
2015	199,300	143,000	39
2020	229,300	158,000	45
2025	259,300	173,000	50
Average			39

(a) Data obtained from Figure 3-15.

(b) The 1996 Metro Plan Update only provided projections for years 2000, 2010, and 2050; consequently, demands for years 2005, 2015, and 2020, and 2025 are based on interpolation. Source: Table 2-1, 1996 Metro Plan Phase III Report.

HISTORICAL AND PROJECTED WASTEWATER/RECYCLED WATER FLOWS

The City currently operates a Regional Water Reclamation Facility (RWRF) that treats wastewater, to secondary levels, from the City of Fresno and the City of Clovis. The City of Clovis will also be initiating operation of a separate 2.76 mgd satellite wastewater treatment plant that intercepts a portion of the City of Clovis' wastewater flows, and then treated to tertiary levels for non-potable use. The City of Clovis' recycled water will be used to meet landscaping water demands within portions of the City of Clovis and CSUF.

Table 3-13 summarizes the total wastewater flows generated by the City of Fresno and City of Clovis, and the portion intercepted by the City of Clovis, through 2030. As shown in Table 3-13, the total quantity of wastewater is projected to increase from 78,400 afa in 2005 to 137,100 afa in 2030, representing approximately a 75 percent increase over the next 25 years.

Table 3-13. Summary of Total Generated Wastewater, afa

Destination	Level of Treatment	2005	2010	2015	2020	2025	2030
Clovis-Satellite Treatment Plant	Tertiary	0	2,900	2,900	6,200	6,200	9,400
RWRF	Secondary	78,400	95,400	105,100	112,900	120,300	127,700
Total Wastewater Generated		78,400	98,300	108,000	119,100	126,500	137,100

[a] All data provided by Carollo Engineers
afa = acre-feet annually

The total wastewater treated at the RWRF is then used to directly irrigate City of Fresno and privately owned farmland, and sent to percolation basins. No effluent from this treatment plant is currently discharged to surface water. A portion of the percolated effluent is pumped from the groundwater basin and discharged into the FID Canal system. Evaporation from the surface of these percolation ponds accounts for the balance of the water.

Table 3-14 summarizes the post-treatment uses of wastewater generated by the RWRF. As shown in Table 3-14, all of the wastewater generated is recycled through use as irrigation water or sent to percolation basins. Table 3-14 also estimates that the City contributes approximately 89 percent of the total wastewater generated at the RWRF.

Table 3-14. Summary of Wastewater Flows Generated at the RWRF, afa

Source	Component	2005	2010	2015	2020	2025	2030
Fresno (89%)	Farmland Irrigation	7,400	7,600	7,600	7,600	7,600	7,600
	Recharge Activities	60,840	77,540	86,060	93,070	99,690	106,320
	Pumped Groundwater	*21,400*	*21,400*	*21,400*	*21,400*	*21,400*	*21,400*
	Net Recharge	*36,500*	*52,000*	*60,100*	*66,600*	*72,700*	*78,900*
	Evaporation	*2,940*	*4,140*	*4,560*	*5,070*	*5,590*	*6,020*
	Subtotal	68,240	85,140	93,660	100,670	107,290	113,920
Clovis (11%)	Farmland Irrigation	1,100	900	900	900	900	900
	Recharge Activities	9,060	9,360	10,540	11,330	12,110	12,880
	Pumped Groundwater	*3,200*	*3,200*	*3,200*	*3,200*	*3,200*	*3,200*
	Net Recharge	*5,400*	*5,700*	*6,800*	*7,500*	*8,200*	*8,900*
	Evaporation	*460*	*460*	*540*	*630*	*710*	*780*
	Subtotal	10,160	10,260	11,440	12,230	13,010	13,780
Total RWRF Outflow (100%)	Farmland Irrigation	8,500	8,500	8,500	8,500	8,500	8,500
	Recharge Activities	69,900	86,900	96,600	104,400	111,800	119,200
	Pumped Groundwater	*24,600*	*24,600*	*24,600*	*24,600*	*24,600*	*24,600*
	Net Recharge	*41,900*	*57,700*	*66,900*	*74,100*	*80,900*	*87,800*
	Evaporation	*3,400*	*4,600*	*5,100*	*5,700*	*6,300*	*6,800*
	Total	78,400	95,400	105,100	112,900	120,300	127,700

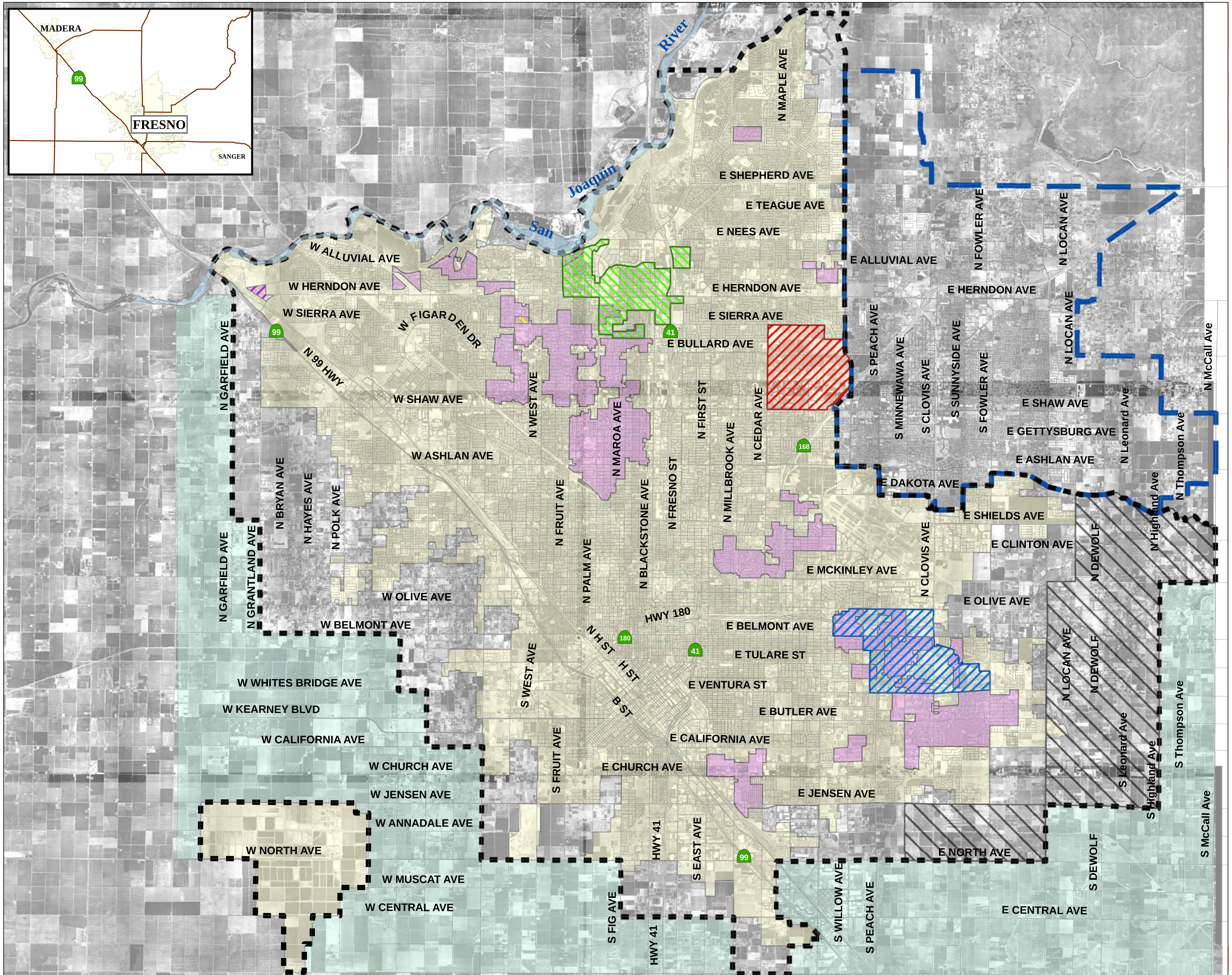

FIGURE 3-1

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING AND FUTURE STUDY AREA

N

0 1 2 4
Scale in Miles

NOTES:

A. 2060 Growth Fringe is provided for discussional purposes only, and is not to be taken as representing any land use planning goals or objectives for City Growth

B. 2060 Growth Fringe adds approximately 37,000 acres.

- Fresno Sphere of Influence
- Clovis Sphere of Influence
- Pinedale County Water Dist.
- Bakman Water Company
- California State Univ., Fresno
- Herndon
- Park Van Ness
- Southeast Growth Area
- 2060 Growth Fringe
- County Island
- City Limit

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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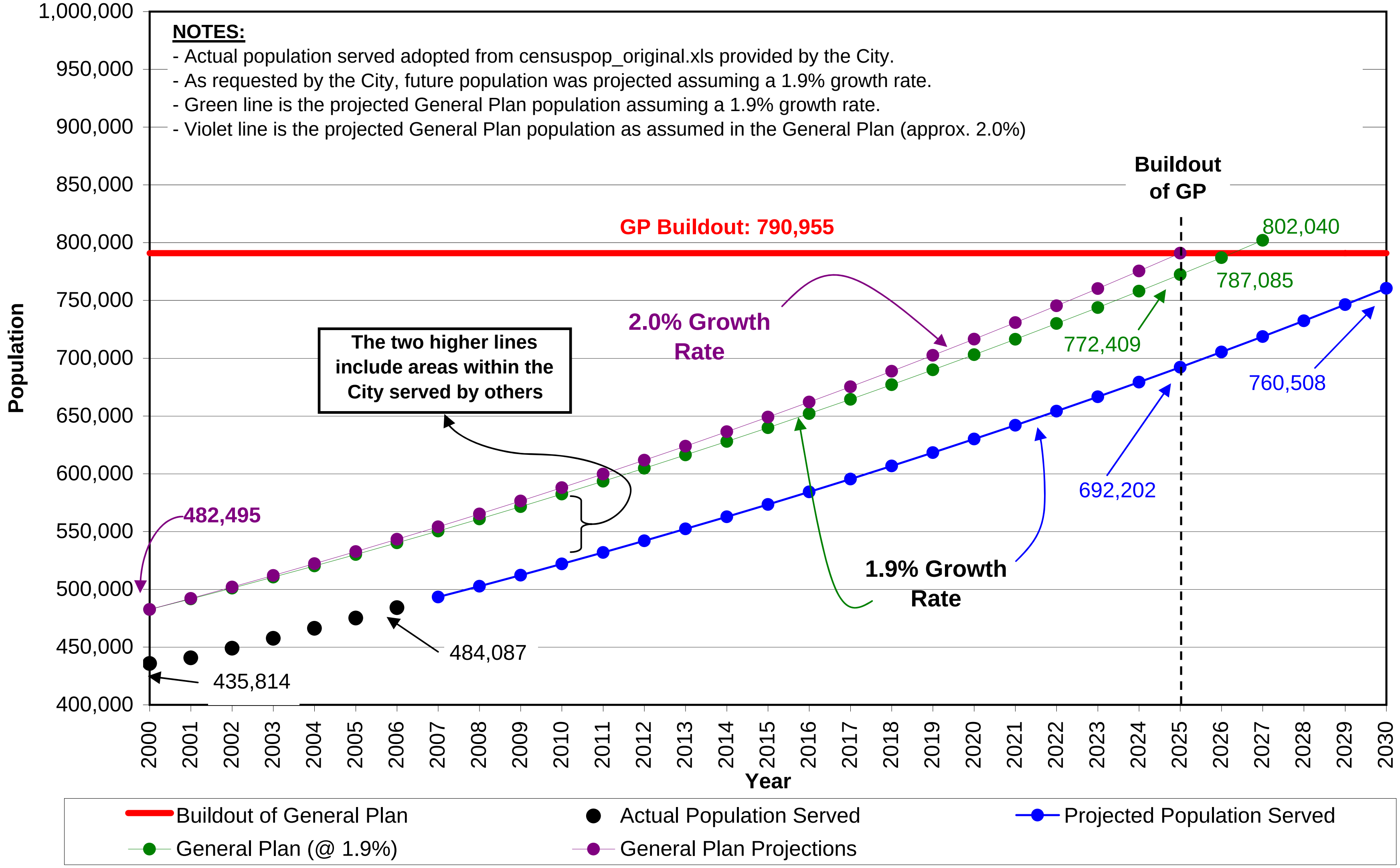
Figure 3-2. City of Fresno Water Service Area Estimated Historical Population

Last Revised: 10/30/07
o:\c\439\02-05-01\e\1\101\pop\6_26_07_WYA Population Analysis
Fig 3A-2.Est Historical Pop

Figure 3-3. Projected Population Served by the City



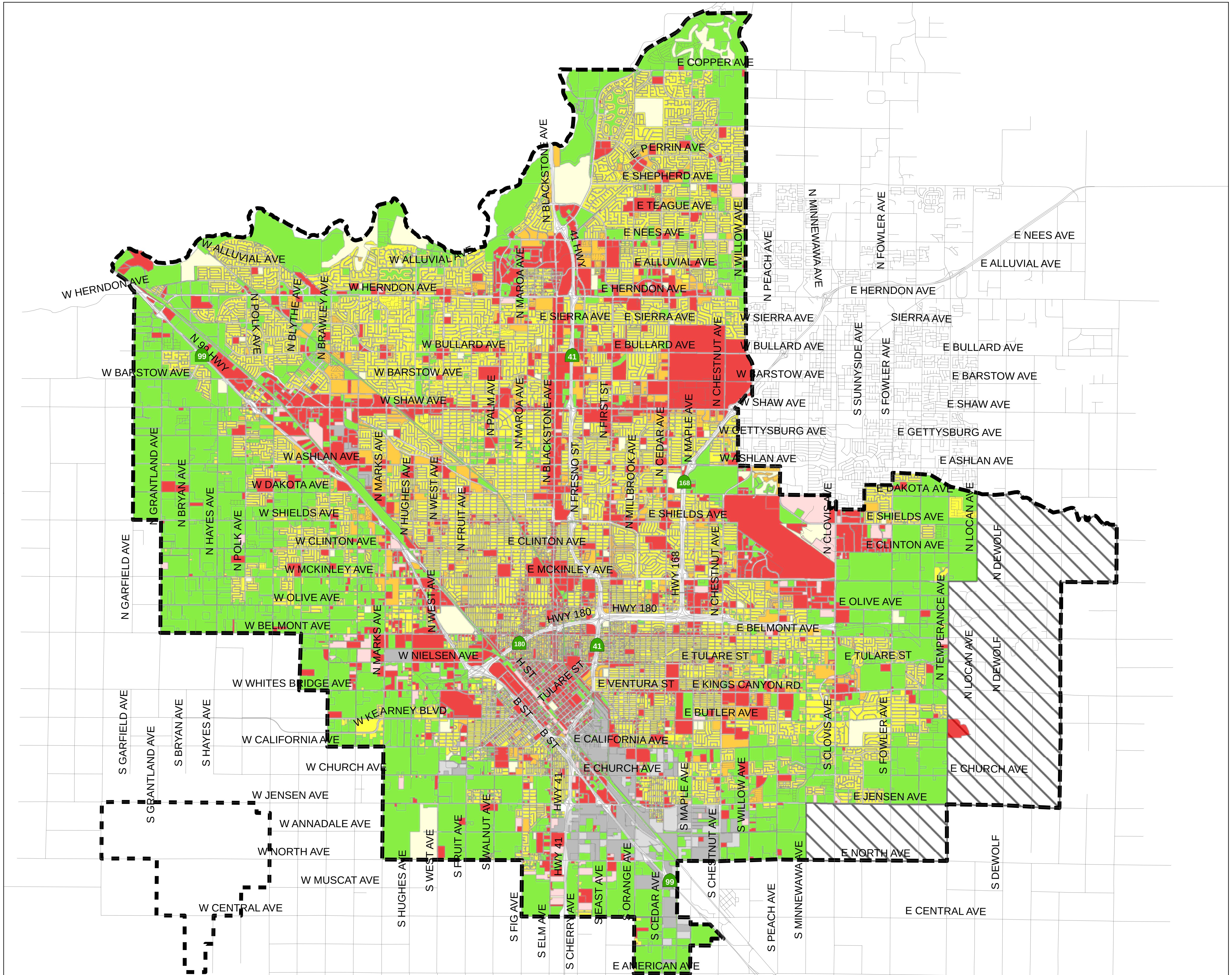


FIGURE 3-4

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING LAND USE

0 1 2 4
Scale in Miles

NOTES:

A. 50% of partial areas were assumed developed. The remaining area was assumed open space or vacant.

LEGEND:

Existing Land Use

- Commercial/Institutional
- Commercial/Institutional - Partial(A)
- Industrial
- Industrial - Partial(A)
- Landscape Irrigation
- Multi-Family Residential
- Multi-Family Residential - Partial(A)
- Single Family Residential
- Single Family Residential - Partial(A)
- Open Space / Vacant
- Southeast Growth Area
- Fresno Sphere of Influence

Fresno All-America City 2000

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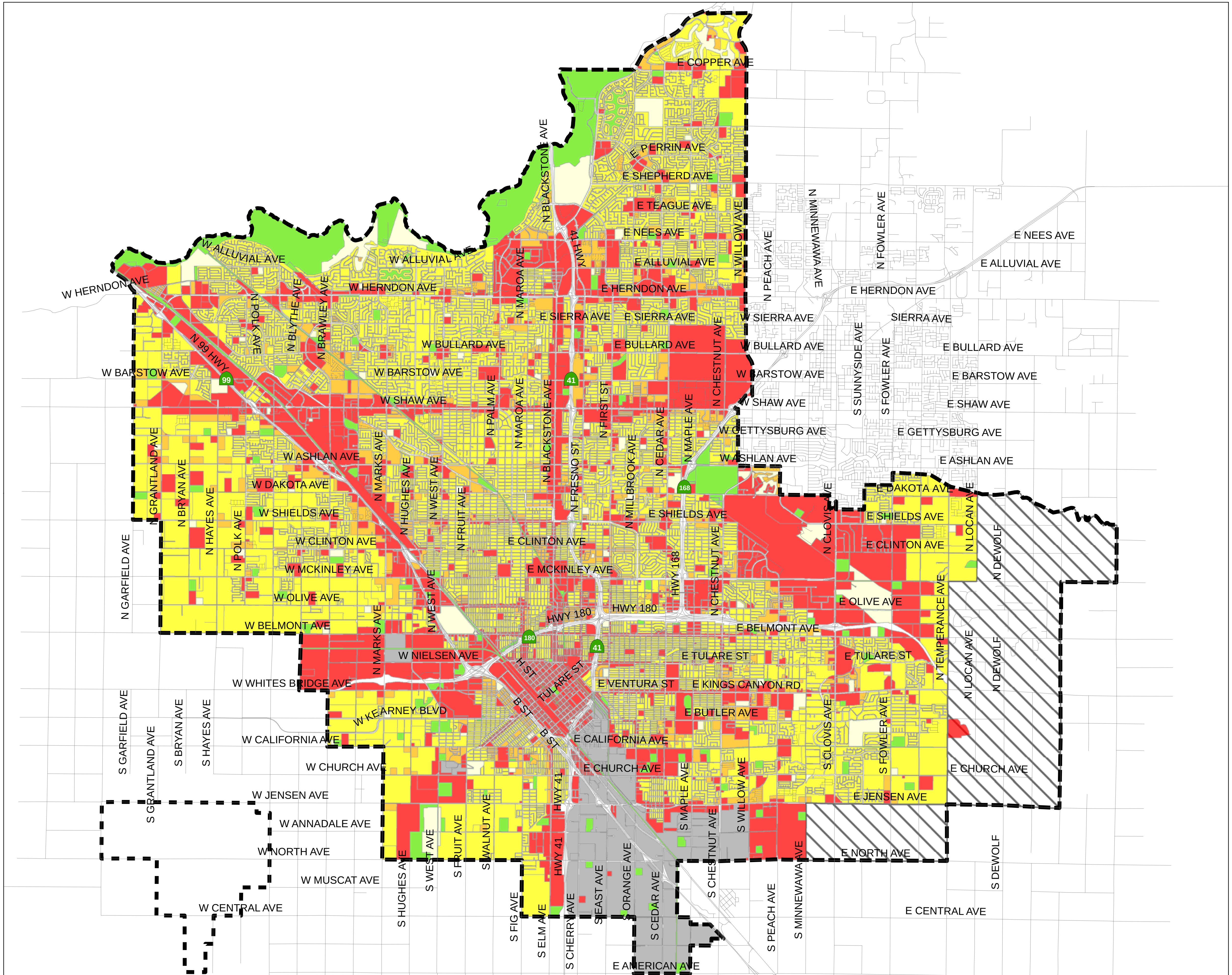

FIGURE 3-5

City of Fresno Metropolitan Water Resources Management Plan Update

FUTURE LAND USE

0 1 2 4

Scale in Miles

NOTES:

LEGEND:

Future Land Use

- Commercial/Institutional
- Industrial
- Landscape Irrigation
- Multi-Family Residential
- Single Family Residential
- Open Space
- South East Growth Area
- 2060 Growth Fringe
- Fresno Sphere of Influence

Fresno All-America City 2000

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Figure 3-6. Historic Monthly Water Production

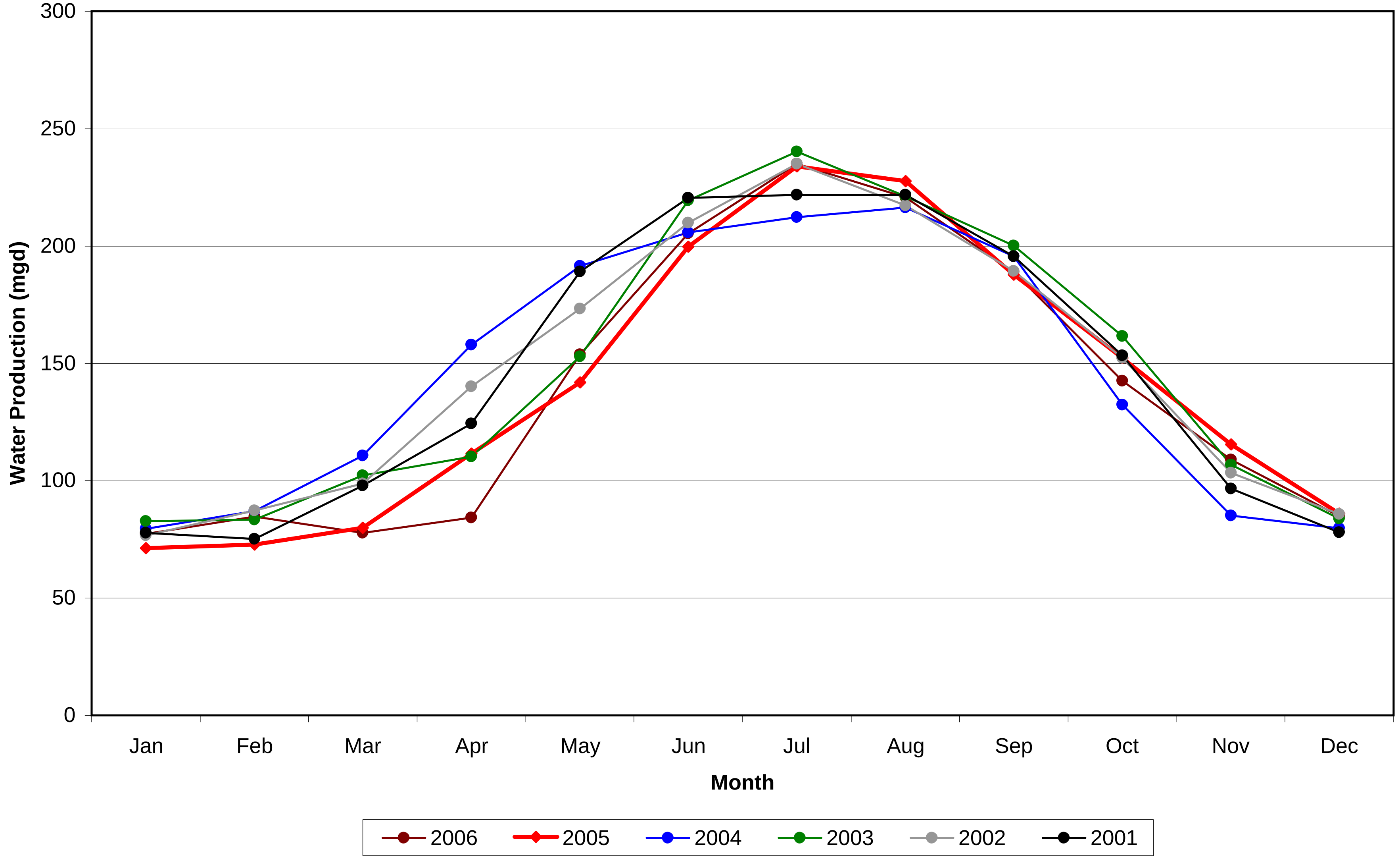

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Fig 3A-6 Monthly

Figure 3-7. Average Indoor and Outdoor Water Use from 2001 to 2006

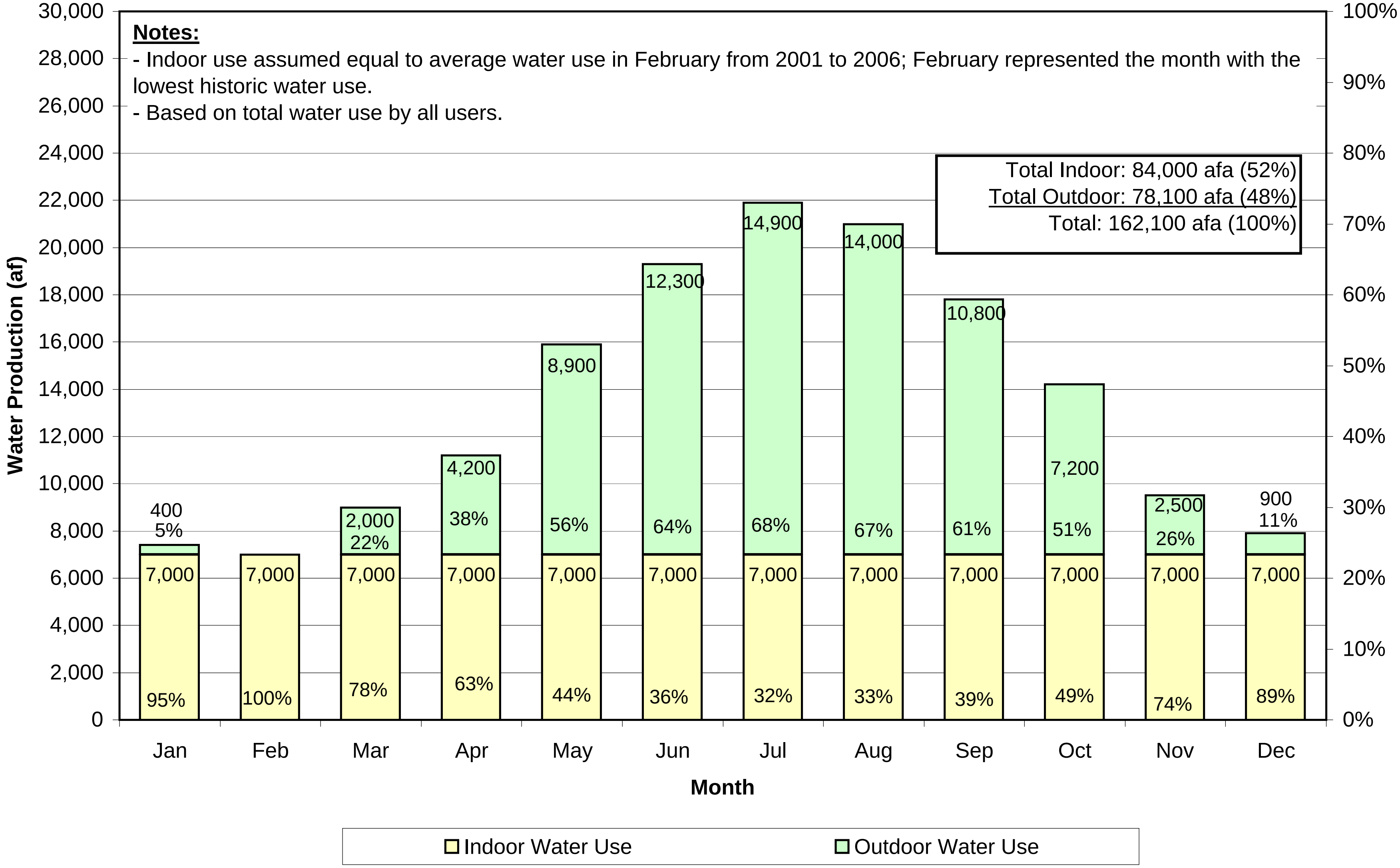

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Fig 3A-7 Indoor

Figure 3-8. City of Fresno Historic Per Capita Water Production and Consumption, gpcd

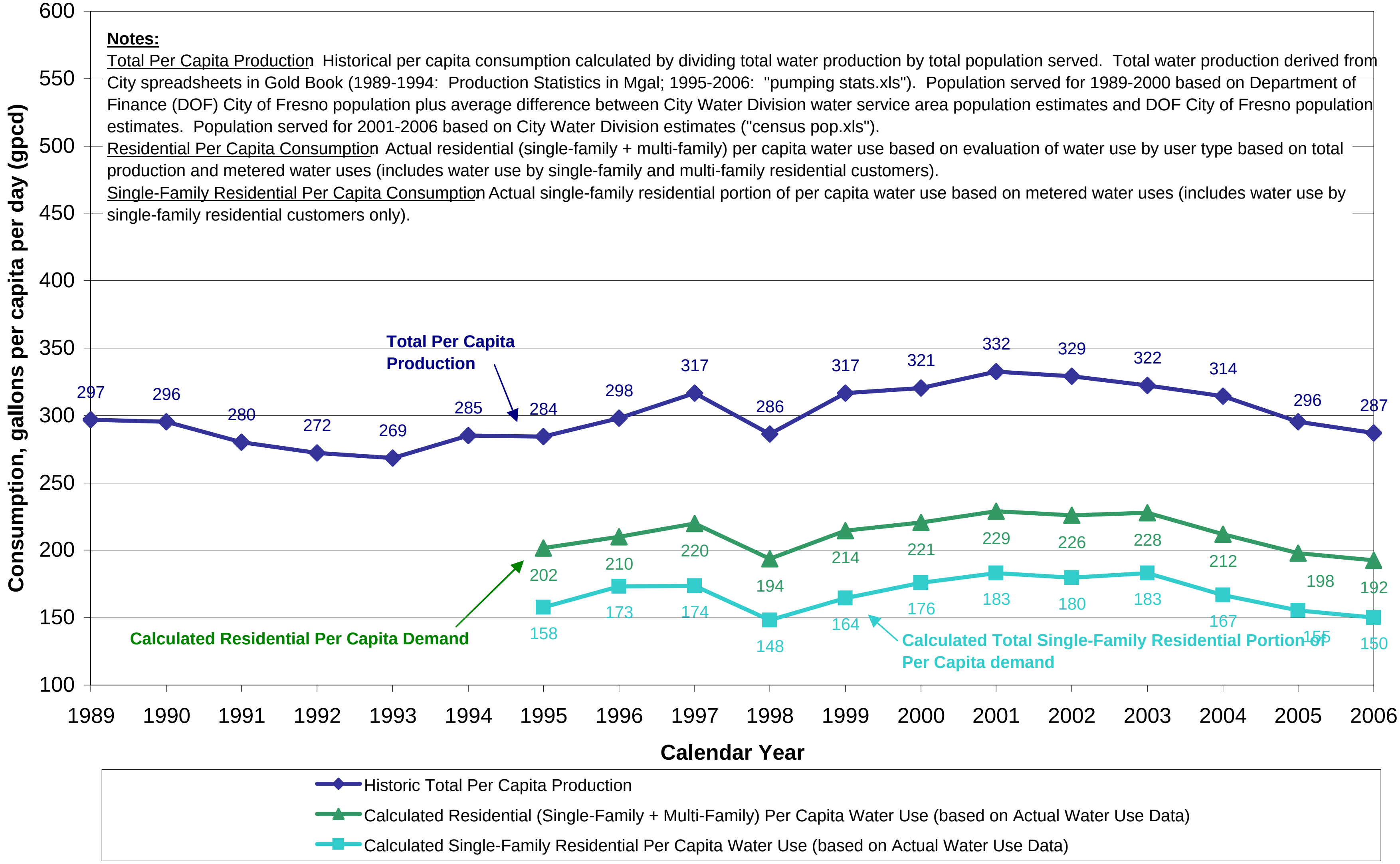

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Fig 3A-8. Per Capita Chart

Figure 3-9. City of Fresno Per Capita Water Use by User Class

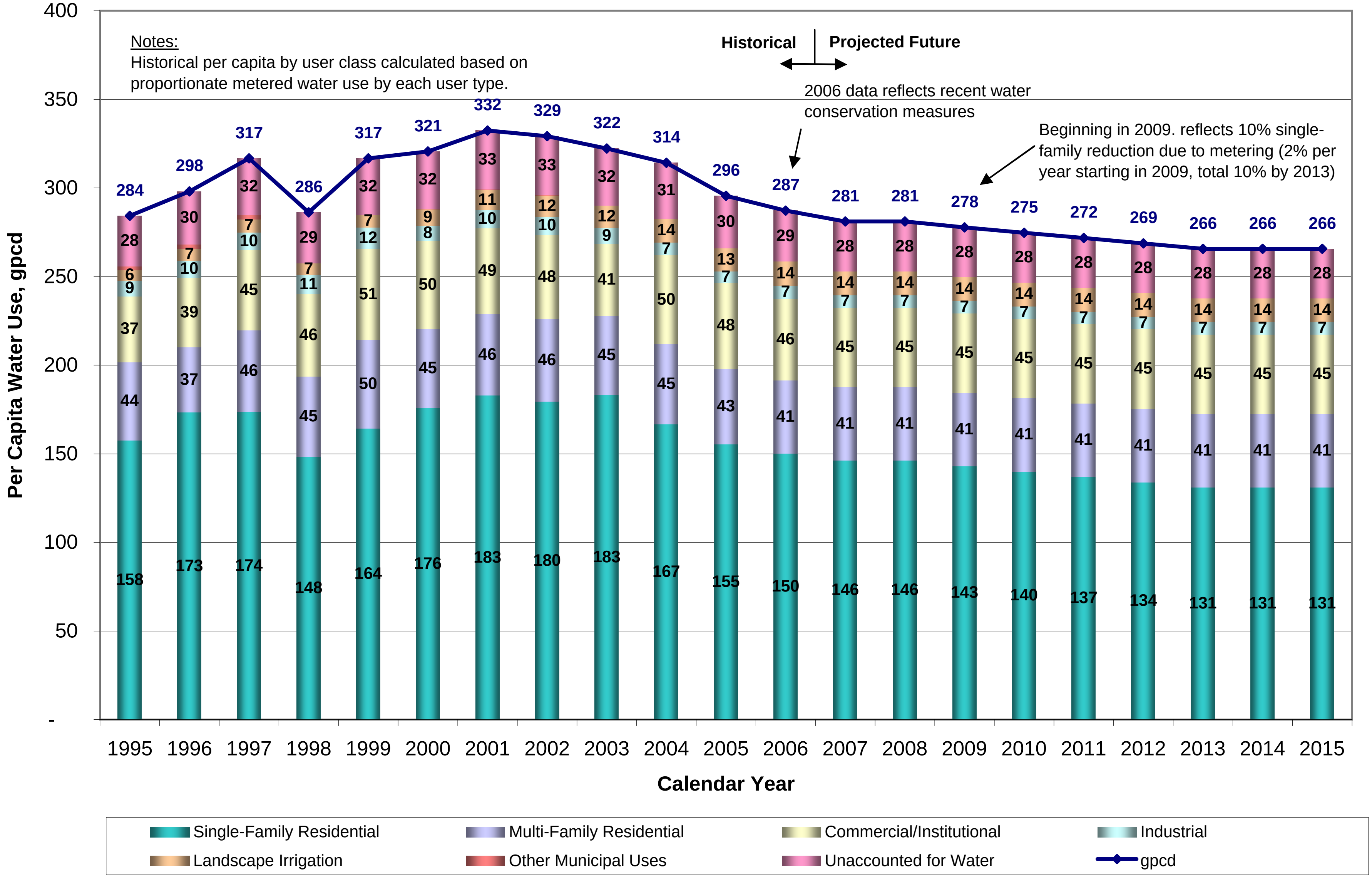

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Fig 3A-9.Per Capita by User

Figure 3-10. City of Fresno Future Per Capita Water Production

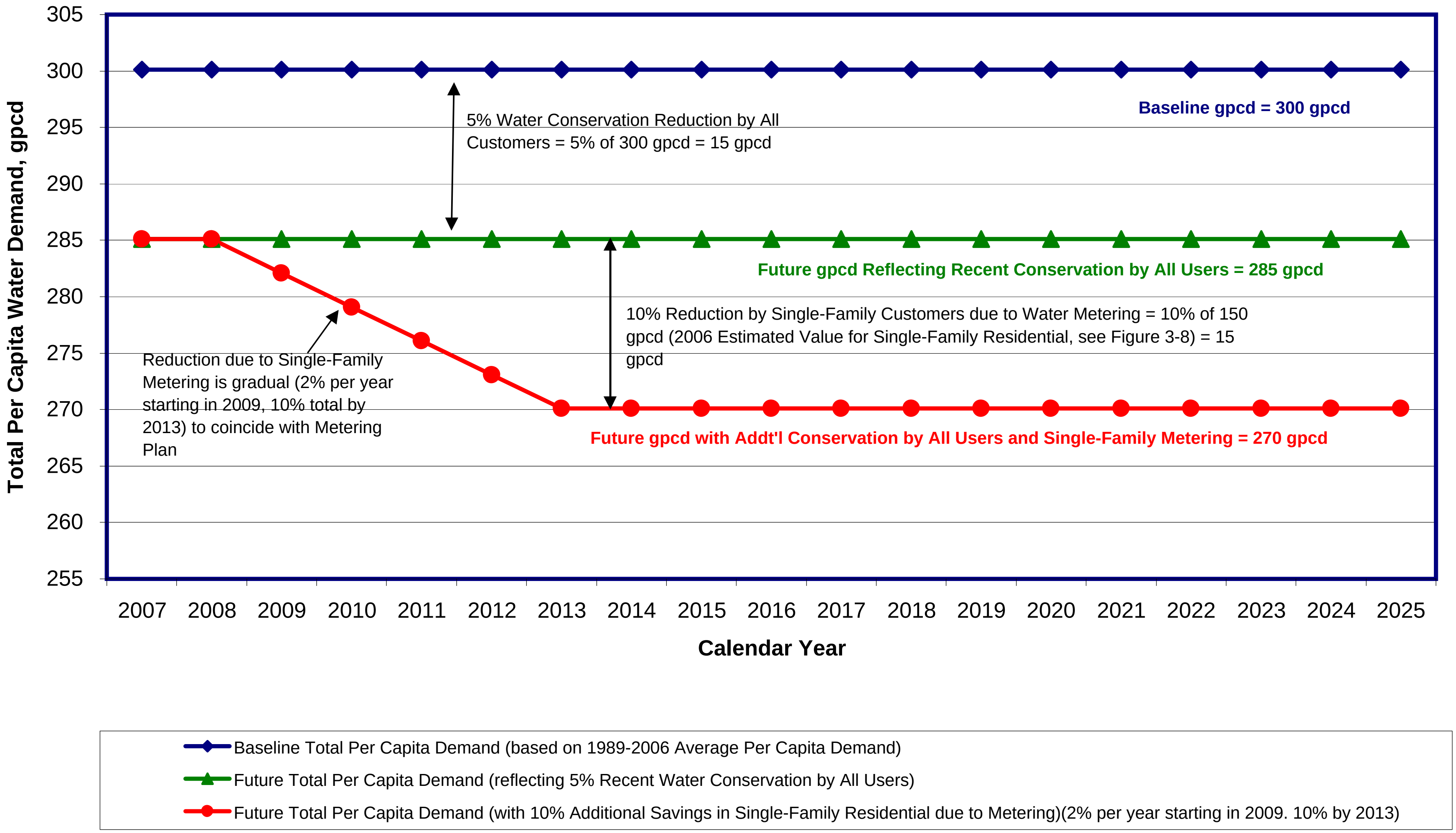


Figure 3-11. Per Capita Based Demand Projections

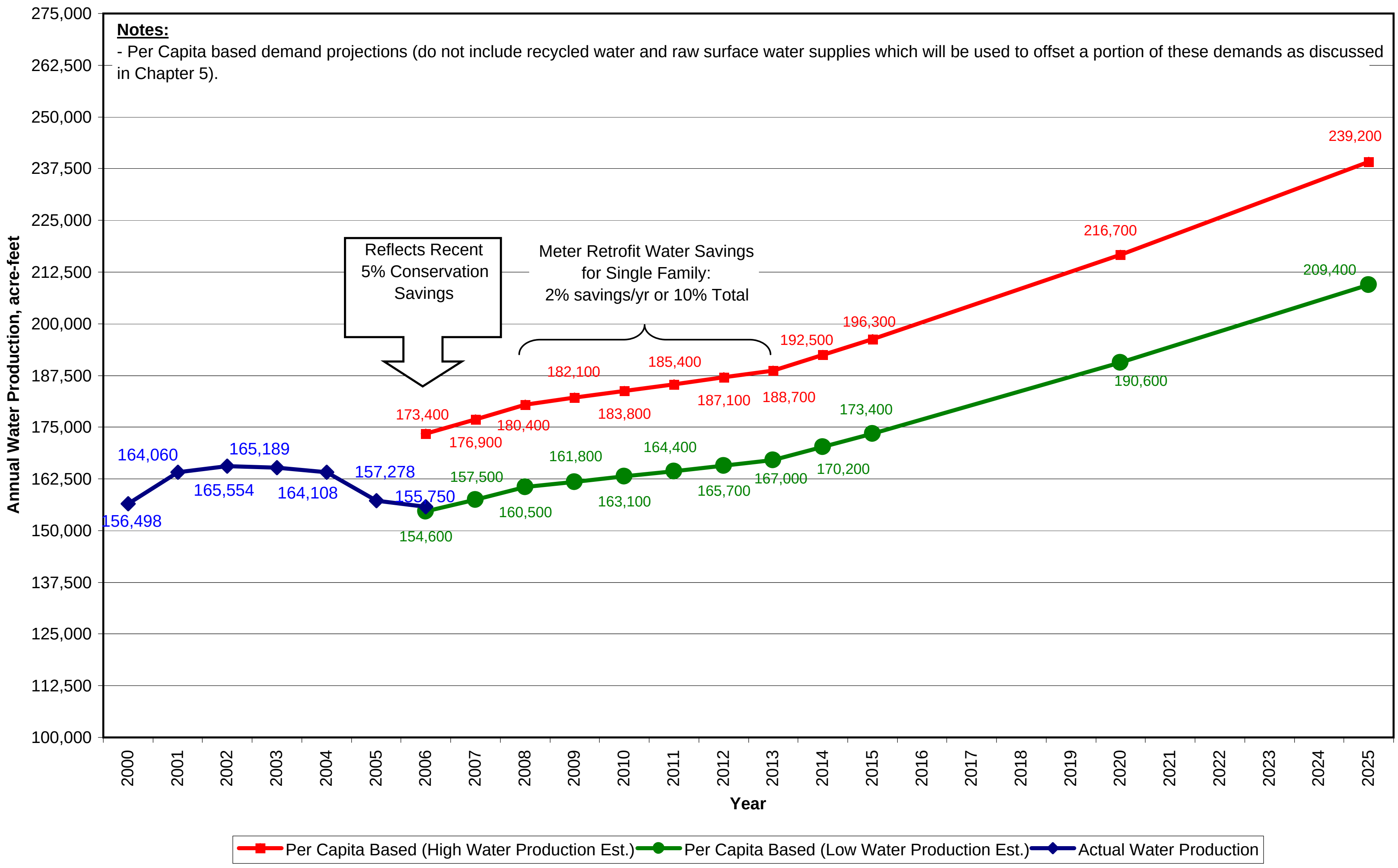
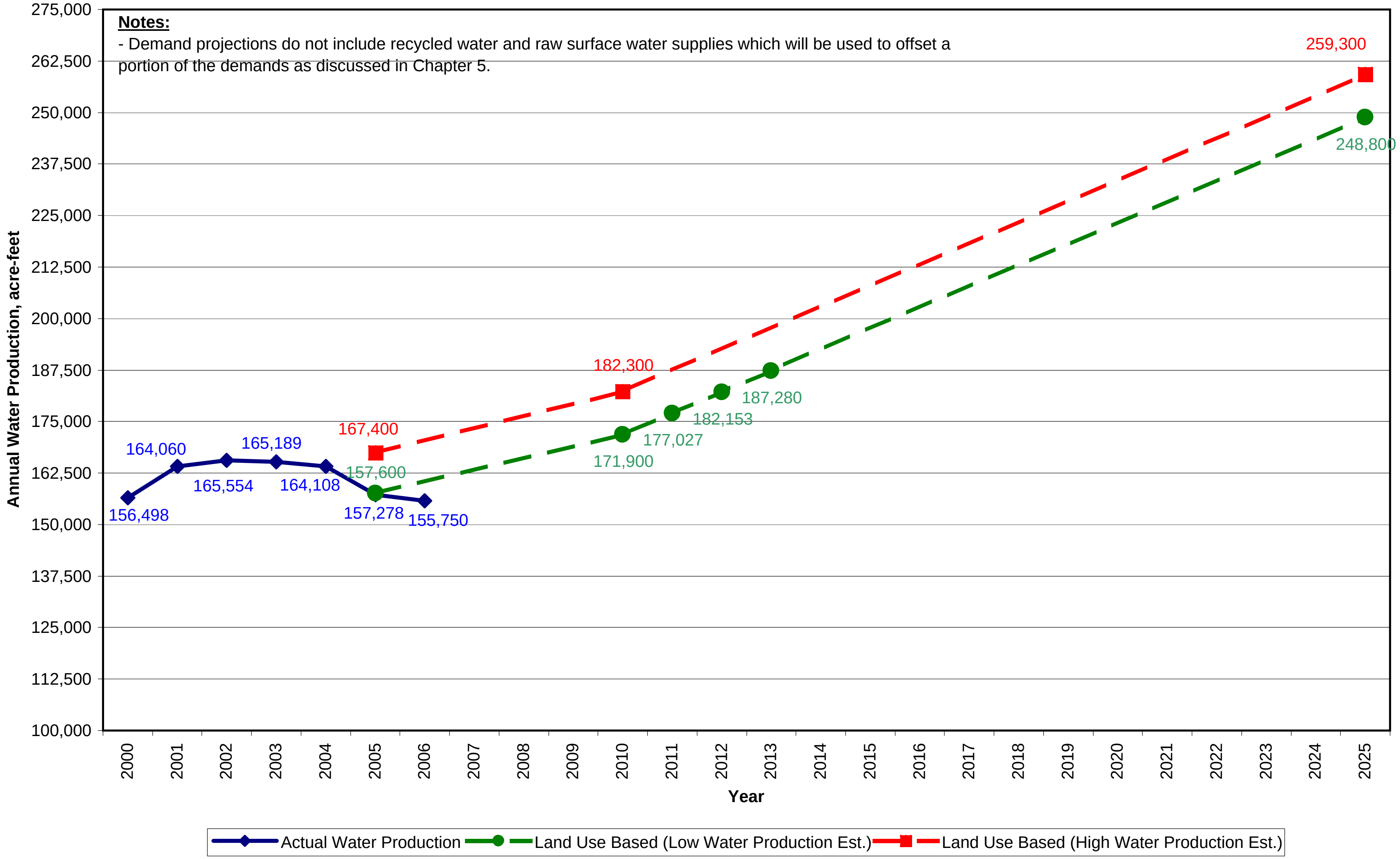


Figure 3-12. Land Use Based Demand Projections



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o:\c\439\02-05-01\e\1\101\unitfactorsprojections\ET_bmlRvsd_Metered Water Use Data
Figure 3-12_Fut LU

Figure 3-13. Comparison of Per Capita and Land Use Based Demand Projections

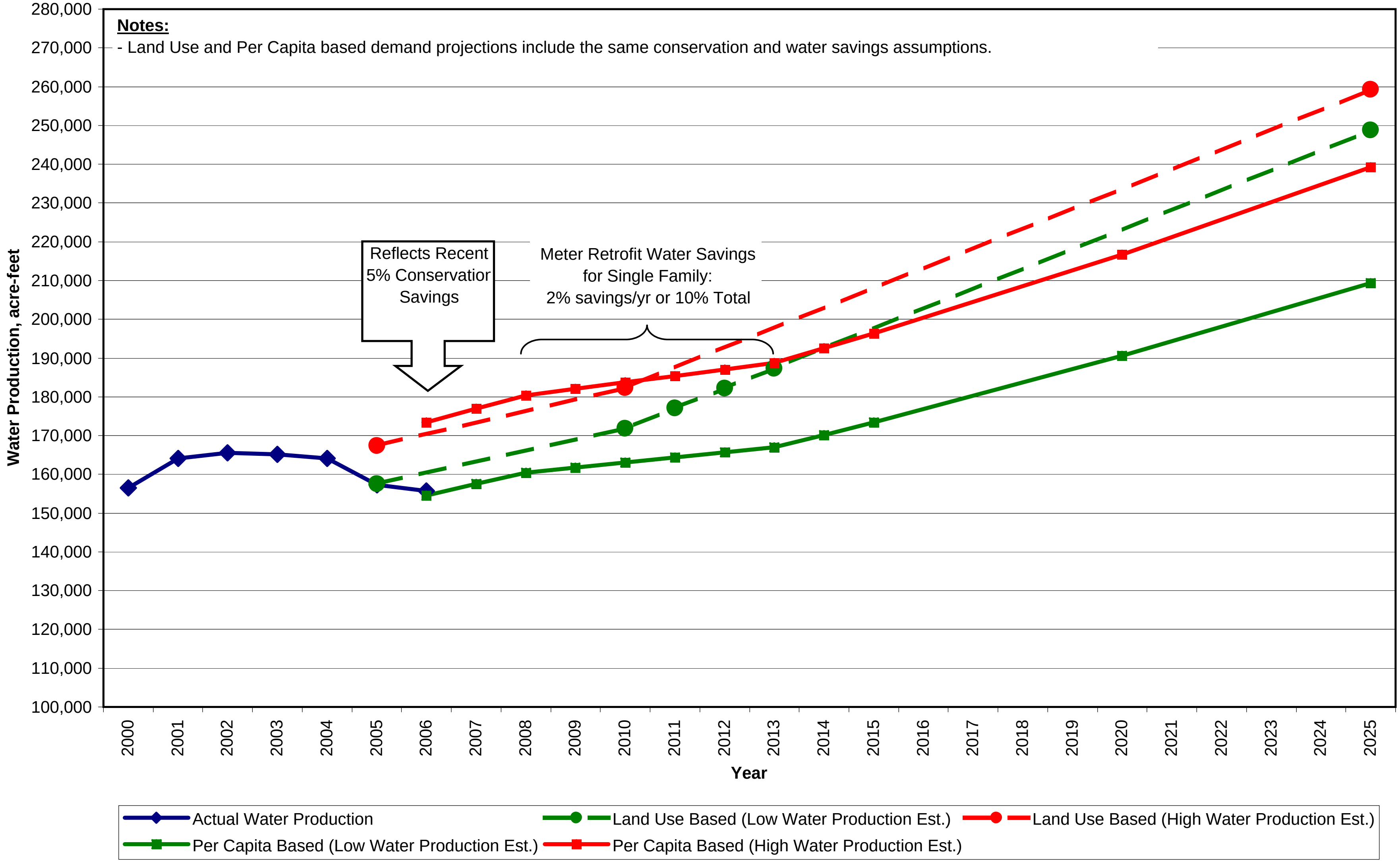
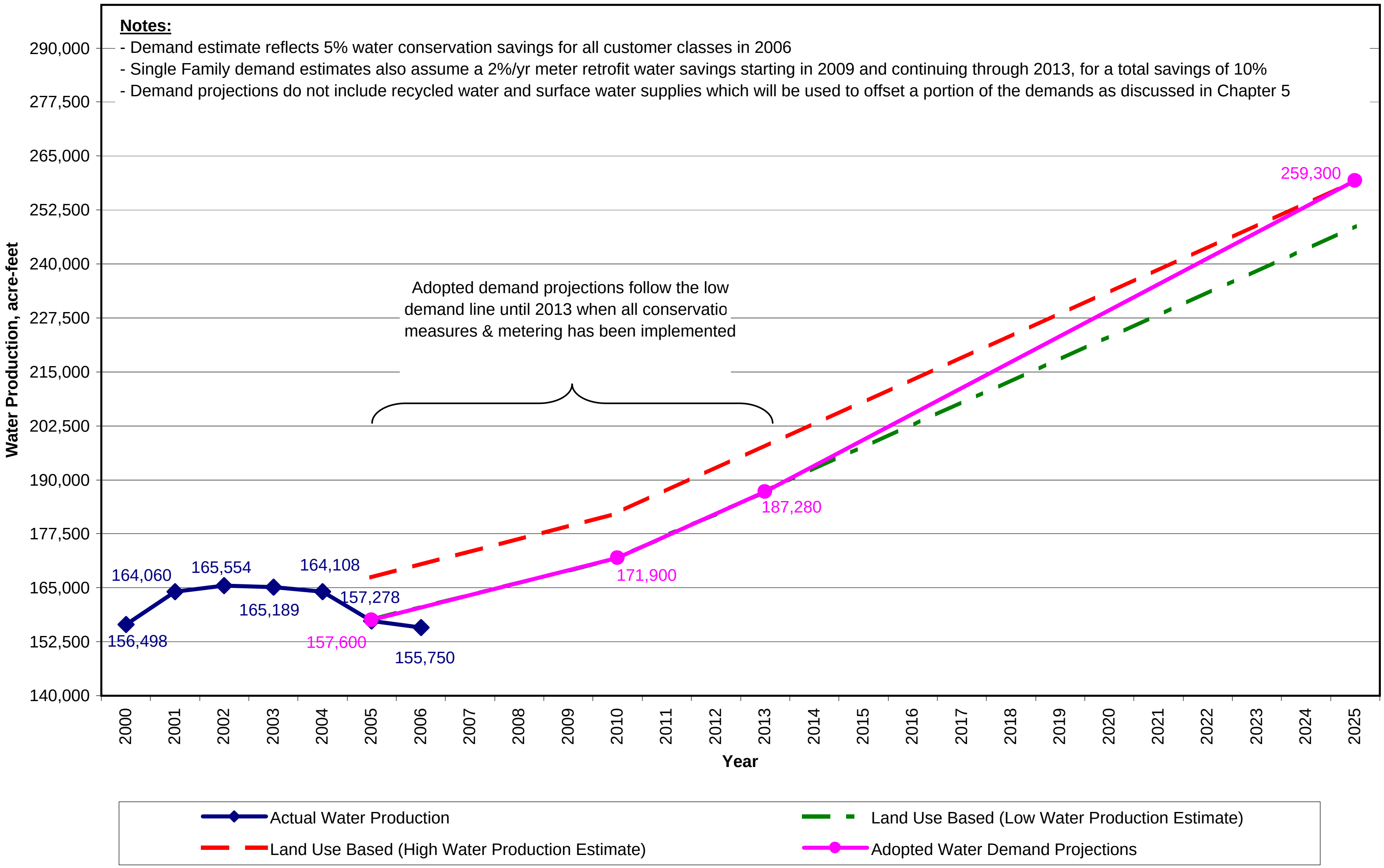
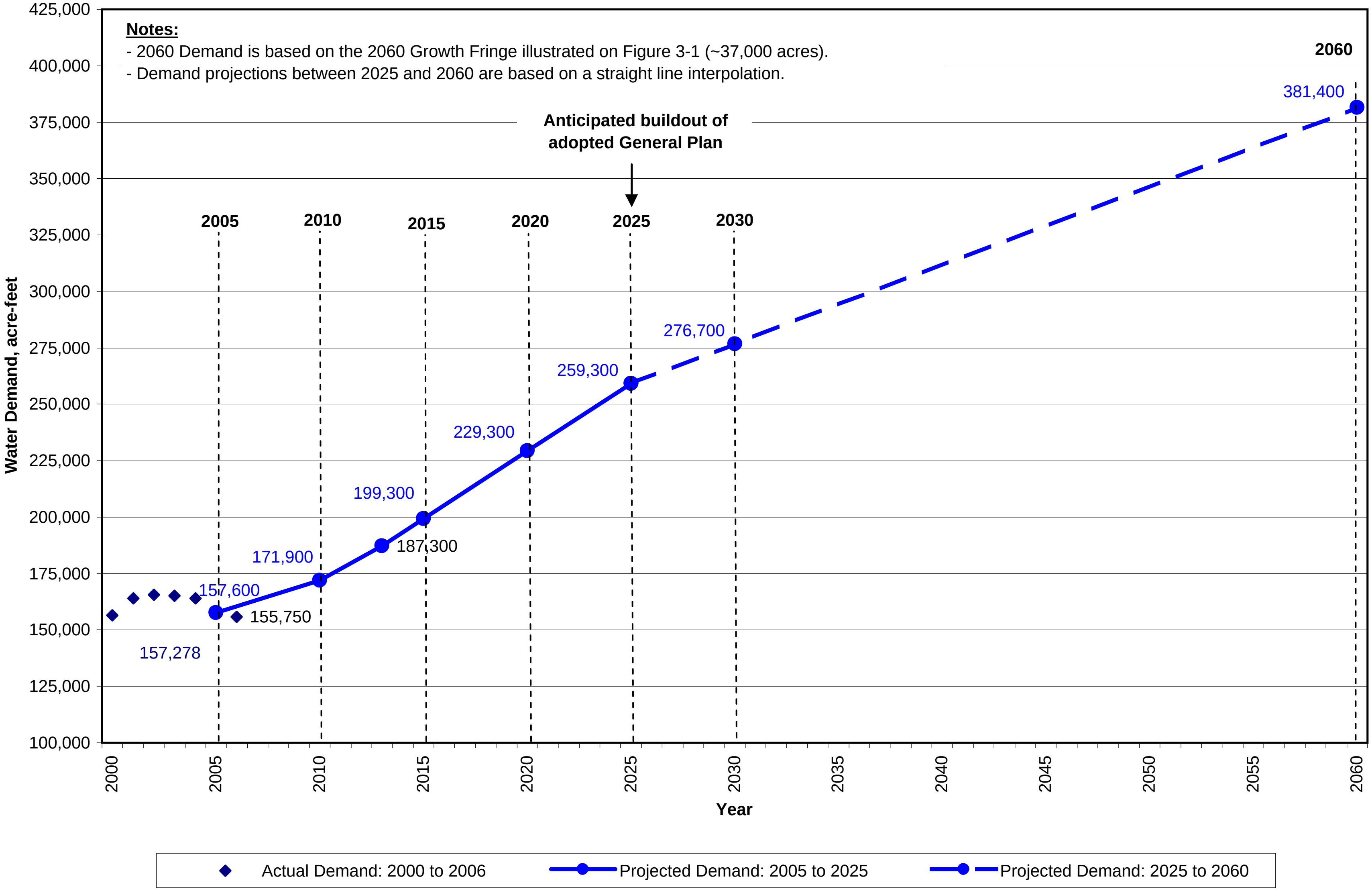


Figure 3-14. Recommended Water Demand Projections



Last Revised: 07/03/07
o:\c\439\02-05-01\e\1\101\unitfactorsprojections\ET_bmlRvsd_Metered Water Use Data
Figure 3-14_Adopted

Figure 3-15. Projected Water Demand to 2060



Last Revised: 07/03/07
o:\c\439\02-05-01\e\1\101\unitfactorsprojections\ET_bmlRvsd_Metered Water Use Data
Figure 3-15_Dmd 2060

REFERENCES

[1] This acreage estimate is larger than the estimate provided in the 2005 Water Conservation report (55,780 acres) because it includes existing open space/vacant land in the Southeast Growth Area and the Sphere of Influence.

[2] City of Fresno Urban Water Management Plan 1986-1995, page 28.

[3] U.S. Census website www.factfinder.census.gov, 1990 and 2000 Census data for City of Fresno.

[4] City of Fresno Urban Water Management Plan 1986-1995, page 29 footnote.

[5] Fresno County Council of Government website www.fresnocog.org "Census 1990-Census 2000 Population Growth Fresno County and its Jurisdictions."

[6] 2025 City of Fresno General Plan, Table 1, Population Projection by Community Plan Area.

[7] Future urban demands were compared to the Agricultural unit demand from the 1992 Phase 1 Report because actual applied water demands for Agriculture within FID's water service area will be revised once the IGSM is completed. However, preliminary estimates indicate that the applied water demands are similar to the value reported 1992 Phase 1 Report (3.5 af/acre).

CHAPTER 4. WATER CONSERVATION & DEMAND MANAGEMENT MEASURES

This chapter describes the following:

- The Urban Water Management Planning Act Demand Management Measures (DMMs) and relationship to the California Urban Water Conservation Council (CUWCC) BMPs
- The City's past and on-going water conservation programs and measures
- A description of the City's current and planned activities and budget allocations for each BMP/DMM
- Determination of DMM implementation
- Evaluation of any DMMs not being implemented

DEMAND MANAGEMENT MEASURES

The Urban Water Management Planning Act includes fourteen DMMs for urban water conservation. These fourteen measures include the following:

1. Water Survey Programs for Single-Family Residential and Multi-Family Residential Customers
2. Residential Plumbing Retrofit
3. System Water Audits, Leak Detection and Repair
4. Metering With Commodity Rates for All New Connections and Retrofit of Existing Connections
5. Large Landscape Conservation Programs and Incentives
6. High-Efficiency Washing Machine Rebate Programs
7. Public Information Programs
8. School Education Programs
9. Conservation Programs for Commercial, Industrial and Institutional Accounts
10. Wholesale Agency Programs
11. Conservation Pricing
12. Water Conservation Coordinator
13. Water Waste Prohibition
14. Residential Ultra-Low-Flush Toilet Replacement Program

These fourteen DMMs are the same as the fourteen BMPs listed in the CUWCC Memorandum of Understanding (MOU) Regarding Urban Water Conservation in California. The 1991 MOU originally listed sixteen BMPs for water conservation. In 1999, the MOU was revised to include fourteen BMPs, as listed above.

OVERVIEW OF PAST AND CURRENT WATER CONSERVATION PROGRAMS AND MEASURES

The City has a long history of water conservation. A letter dated June 20, 1917 from A.G. Wishon, General Manager of the Fresno City Water Company, to water customers stated that employees would patrol neighborhoods and take action against customers who wasted water. A copy of that letter is provided as Figure 4-1.

On January 1, 1956, the City adopted an ordinance prohibiting the wastage of water. This was one of the first such ordinances passed in California on a permanent basis. The ordinance included the following provisions:

Section 6-520. Use of Open Hose or Faucet; Wastage of Water[1]

(a) *The use of water by means of an open hose or open faucet for irrigation purposes is prohibited. All hose used for irrigation purposes shall have attached thereto a spray nozzle or sprinkling device.*

(b) *Each consumer of water shall keep all connections, faucets, hydrants, pipes, outlets and plumbing fixtures tight and free from leakage, dripping or waste of water.*

(c) *The willful waste of water supplied by the City Water Division is prohibited.*

(d) *The Water Division shall turn off the water connection to any property where any provision of this section is being violated and shall not turn it on again until a fee of five dollars ($5) for reconnection shall have been paid at the Water Division office in the City Hall.*

Water conservation in Fresno gained renewed emphasis during the 1976-77 drought. Conservation programs that were started then have continued and since 1981 have been supplemented with additional and expanded programs, as described in this chapter.

On December 11, 1991, the City became a signatory agency to the CUWCC's MOU Regarding Urban Water Conservation in California. The purpose of the MOU was to expedite implementation of reasonable water conservation measures in urban areas and to establish appropriate assumptions for use in calculating estimates of reliable future water conservation savings.

The City, as a USBR CVP contractor, was required to prepare a Water Conservation Plan as part of their USBR water supply contract renewal in 2005. In May 2005, the City completed its Water Conservation Plan, outlining its current and planned water conservation programs. The Water

[1] This Section of the City Municipal Code has been updated since it was first adopted in 1956. The latest version of Section 6-520. Wastage of Water is provided in Appendix C.

Conservation Plan was approved by USBR in May 2005 and adopted by the Fresno City Council on July 19, 2005. The fourteen BMPs required by USBR, and outlined in the City's Water Conservation Plan, are the same as the fourteen CUWCC BMPs and Urban Water Management Planning Act DMMs described above.

The information provided in this chapter is largely derived from the information provided in Section 4 of the City's 2005 Water Conservation Plan, with updates on recent City water conservation activities based on discussions with the City's Water Conservation Supervisor. A copy of Section 4 of the City's 2005 Water Conservation Plan is provided in Appendix D.

Table 4-1 lists the DMMs/BMPs and provides a brief description of the City's current activities related to each DMM/BMP and current implementation status. Detailed descriptions of the City's DMM/BMP implementation are provided in the next section of this chapter.

DESCRIPTION OF DMM IMPLEMENTATION

A description of the City's activities with respect to each DMM is provided below. Information was obtained from the City's 2005 Water Conservation Plan and the City's Water Conservation Supervisor.

In the past, the City has not filed annual reports with the CUWCC regarding water conservation activities. Specific reporting requirements for each DMM/BMP are outlined in Section 4 of the City's Water Conservation Plan, a copy of which is provided in Appendix D.

DMM 1: Water Survey Programs for Single Family and Multi-Family Residential Customers

Corresponding BMP

- CUWCC BMP 01: Water Survey Programs for Single-Family and Multi-Family Residential Customers

Description

The City currently performs few single-family or multi-family interior water surveys. While the City does not have an aggressive media campaign for marketing surveys, it does include the information in outreach literature, website and through direct contact with customers at outreach events, tours and speakers bureau. If a request for an interior survey is received, staff is available to respond. There has been little interest in this service by single-family consumers probably because of low, flat-rate water charges. Multi-family residential customers have also shown little interest, probably due to low water rates. The City has staff available to provide interior water surveys to customers.

Table 4-1. Overview of City's Current Water Conservation Activities

Urban Water Management Planning Act & CUWCC MOU DMM/BMP Number	DMM & BMP Description	Implementation Status	City Water Conservation Activities
1	Water survey programs for single-family residential and multi-family residential customers	Full program currently in place	• Interior and exterior water surveys are offered to and performed for single-family and multi-family residential customers upon request
2	Residential plumbing retrofit	Full program currently in place	• Low-flow showerheads and faucet aerators are provided to City customers upon request and at public outreach events
3	System water audits, leak detection and repair	Full program to be implemented when City is fully metered (anticipated by 2013)	• Leak detection pilot programs were conducted in 1998 and 2004 • Reported leaks are responded to and repaired as quickly as possible • A complete system audit will be performed once all customers are metered (by 2013)
4	Metering with commodity rates for all new connections and retrofit of existing connections	Full program to be in place by 2013	• Multi-family Residential, Commercial, Institutional, Industrial and Irrigation connections are metered and billed based on consumption (uniform rate) • Single-family Residential customers are currently not metered and are billed based on a flat rate. However, in accordance with SB229 and AB2572, and the conditions of the CVP contract renewal, all connections, including single-family residential, are required to be metered and be billed at a metered rate by 2013. • The City has developed a residential water meter installation plan (installation to start in 2008, complete by 2013).
5	Large landscape conservation programs and incentives	Full program currently in place	• Landscape water conservation surveys are offered to and performed for residential and business customers • Permits are required for watering of large landscapes • Water Conserving Landscape Requirements are included in the City Municipal Code • The City is developing a rebate program for installation of efficient irrigation timers
6	High-efficiency washing machine rebate programs	Full program to be in place by 2007	• A PG&E rebate program is available to City residents • The City will start a rebate program in late 2007 to supplement PG&E rebate program
7	Public information programs	Full program currently in place	• The City has an extensive public information program which uses various media to inform customers about the importance of water conservation. The various media include: Television and Radio Advertisements, Newsletters, Customer Billing Inserts, Community Outreach Events, Speakers Bureau and Water Education Tours
8	School education programs	Full program currently in place	• The City has an extensive Water Education Program for K-12 and college students
9	Conservation programs for commercial, industrial and institutional (CII) accounts	Program currently in place	• Interior water conservation surveys are offered and provided to business customers upon request • Requirements for water conservation devices are included in the City Municipal Code
10	Wholesale agency programs	Not applicable	• The City is not considered to be a wholesale water purveyor, as the City only serves about 60 connections on a wholesale basis (10 connections within Pinedale service area and 50 connections within Berans Tract area).
11	Conservation pricing	Full program to be in place by 2013	• Until the passage of AB2572 in 2004 (that requires urban suppliers to install meters and charge metered rates), the City Charter prohibited the installation of water meters and reading of water meters for billing purposes for single-family residential uses. • SB229 and AB2572, and the CVP contract renewal requires that the City install meters on all connections and meter all water deliveries to customers by 2013 • Multi-family Residential, Commercial, Institutional, Industrial, and Irrigation Customers are metered and are billed based on metered consumption (uniform rate); in 2010, the City will implement a metered rate for residential customers with metered installed • A billing rate schedule for all metered connections will be developed in accordance with the metering plan (development scheduled for 2007)
12	Water conservation coordinator	Full program currently in place	• The City has a full-time Water Conservation Program Coordinator and support staff
13	Water waste prohibition	Full program currently in place	• The City has a Water Waste Hotline and Reporting Form on City Website • Water waste prohibition is included in the City Municipal Code
14	Residential ultra-low-flush toilet replacement program	Full program currently in place	• The City implemented an ultra-low-flow toilet rebate program in March 2006

A single-family and multi-family pilot project has been initiated through the toilet rebate program (see DMM 14). When old 3.5 and 5.0 gallon toilets are replaced, an interior water use survey takes place. Water efficient hardware is left for the resident, along with hose nozzles for the exterior and an offer to perform an exterior survey.

The City does, however, aggressively market and perform single-family and multi-family residential exterior water surveys, which has the highest water usage. This program is staffed with two Landscape Water Conservation Representatives. Surveys are offered and cost-effective measures are recommended. The program is marketed through media, billing inserts, promotional materials, public outreach events, speaker's bureau, and the City's web site. During the exterior survey, City staff provide the following services:

- Landscape water-use surveys include consultation, irrigation system efficiency rating using "catch can" distribution uniformity method, measurement of turf and other landscaped area.
- Offer plant material tips.
- Irrigation controller setting and water budgeting recommendations.
- Offer to customer to perform interior survey.

To further enhance the exterior landscape program, staff has proposed that the City implement a pilot program in the future to offer rebates to rate payers to purchase updated and more efficient automatic irrigation timers.

<u>Implementation Schedule</u>

- Program Status:
  - On-going.
  - Offers for interior and exterior surveys made on an on-going basis to single-family and multi-family residential customers. Current focus is on exterior surveys.
  - The program is marketed through media, billing inserts, promotional materials, public outreach events, speaker's bureau, and the City's web site.
  - Interior and exterior surveys also being offered in conjunction with on-going toilet rebate program.
- Rebates for efficient automatic irrigation timers: Proposed for the future.

<u>Annual Budget/Expenditures</u>

FY2005: Actual Budget: $0

FY2006: Proposed Budget: $6,000

FY2007: Proposed Budget: $24,000

FY2008: Proposed Budget: $43,000

DMM 2: Residential Plumbing Retrofit

Corresponding BMP

- CUWCC BMP 02: Residential Plumbing Retrofit

Description

The City provides free low-flow showerheads and faucet aerators to the City's rate payers. These items are distributed based on customer request and are also available during public outreach events. Recently, fewer requests for showerheads have been received from customers. This is due to the efficiency standards requiring that only low-flow showerheads be sold in this country. Since 1993, the City has provided more than 120,000 showerheads to pre-1992 homes and currently more than 75 percent of pre-1992 homes have low-flow showerheads.

Implementation Schedule

- Program Status: Distribution of plumbing retrofit kits are on-going, and provided upon customer request and at public outreach events

Annual Budget/Expenditures

FY2005: Actual Budget: $0

FY2006: Proposed Budget: $0

FY2007: Proposed Budget: $0

FY2008: Proposed Budget: $0

DMM 3: System Water Audits, Leak Detection and Repair

Corresponding BMP

- CUWCC BMP 03: System Water Audits, Leak Detection and Repair

Description

Because the City is not entirely metered, a complete system water audit is not possible at this time. However, the City routinely compiles and compares its water distribution system data to identify any major leaks in the system. In 1998, approximately 60 miles of water mains were tested through a pilot leak detection program. At that time, few leaks were found. Staff is available for the timely repair of all reported leaks.

The City is currently reviewing new leak detection technology. A limited study was conducted in 2004 in a small area of an older section of Fresno using Permalog. No leaks were detected at that time. A full water system audit will be conducted as soon as the City is fully metered, with older neighborhoods being a priority. The City's leak detection program will be enhanced with the onset of the meter installation program, which will begin in 2008, and will be completed by 2013 (see DMM No. 4).

Implementation Schedule

- Pilot leak detection programs: Conducted in 1998 and 2004
- System audit: To be conducted as soon as the City is fully metered
- Leak detection program: To become a priority once meter installation begins in 2008 (see DMM No. 4)

Annual Budget/Expenditures

Funding for this DMM is not included in the City's Water Conservation budget. The budget for this DMM is included in the City's Water Operations budget; however, the specific budget for the leak detection program is not available.

DMM 4: Metering with Commodity Rates for all New Connections and Retrofit of Existing Connections

Corresponding BMP

- CUWCC BMP 04: Metering with Commodity Rates for all New Connections and Retrofit of Existing

Description

The City's multi-family residential, commercial, industrial, institutional, and irrigation water customers (17,930 accounts in 2006, excluding fire protection connections) are metered and billed based on a standby charge plus a quantity charge based on water usage (see DMM No. 11).

The City's single-family residential customers (105,216 accounts in 2006), however, are not metered, and are billed based on a flat rate based on lot size. Table 4-2 provides a summary of the City's total water service accounts in 2006.

Until recently, Article XII, Section 1225 of the City's Charter has prohibited the installation or required installation of water meters at single-family residential connections, and the billing of single-family residential water consumption at a metered rate. All new single-family residential connections (installed after January 1, 1992) have been provided with a meter box and/or meter in accordance with State Water Code Section 525 (adopted by Senate Bill 229 (SB 229) in 1991); however, based on the City Charter, all single-family residential customers are currently billed based on a monthly flat rate according to lot size. A discounted flat rate is also provided for single-family residential customers who are senior citizens.

However, in 2004, Assembly Bill 2572 (AB 2572) was signed into law. Among other provisions, AB 2572 enacted Water Code Section 527 that requires an urban water supplier to: (1) install water meters on all service connections located within its service area; and (2) charge metered rates to customers that have water service connections for which meters have been installed. Compliance with this statute is also one of the conditions of the City's USBR Water Supply Agreement renewal.

Table 4-2. Summary of City Water Accounts in 2006[a]

Customer Type	Inside City Limits		Outside City Limits		Total		Total Accounts
	Metered	Unmetered	Metered	Unmetered	Metered	Unmetered	
Single-Family Residential	0	94,629	1	10,586	1	105,215	105,216
Multi-Family Residential	7,059	0	457	0	7,516	0	7,516
Commercial/ Institutional[b]	7,746	0	218	0	7,964	0	7,964
Industrial	80	0	15	0	95	0	95
Landscape Irrigation	2,344	0	10	0	2,354	0	2,354
Fire Protection[c]	0	2,467	0	148	0	2,615	2,615
Total	17,229	97,096	701	10,734	17,930	107,830	125,760
% of Total					14.3%	85.7%	100%

[a] Source: City of Fresno HTE Revenue Report-2006.
[b] Institutional includes schools and municipal connections.
[c] Includes fire protection connections for multi-family residential, commercial/institutional and industrial customers.

The requirements of SB 229 and AB 2572 have superseded Article XII, Section 1225 of the City's Charter, because these state laws address a subject matter of statewide concern. Also, the State Legislature has declared that these requirements supersede and preempt all conflicting enactments of charter cities, including charter provisions.

The City has developed a meter installation plan and schedule to install meters on all existing customer properties without meters on or before 2013. The City will commence billing at a metered rate in 2010 for residential meters already in place. Meter retrofit installations are scheduled to start in 2008. A copy of the meter installation plan and schedule is provided in Appendix E.

Implementation Schedule

- Metering and Billing at Commodity Rates: On-going for multi-family residential, commercial, industrial, institutional and landscape irrigation customers. Scheduled to begin in 2010 for residential customers with meters in place.
- Single-Family Residential Metering Program: Scheduled to begin in 2008 and be completed by 2013.

Annual Budget/Expenditures

Funding for this DMM is not included in the City's Water Conservation budget. The budget for this DMM is included in the City's Water Operations budget; however, the specific budget for the metering with commodity rates program is not available.

DMM 5: Large Landscape Conservation Programs and Incentives

Corresponding BMP

- CUWCC BMP 05: Large Landscape Conservation Programs and Incentives

Description

The City has a Large Landscape Conservation Program which is staffed with two Landscape Water Conservation Representatives. Landscape surveys are offered and cost-effective repair or enhancement measures are recommended. The City primarily reaches its customers through advertising in billing inserts, conservation literature, speakers bureau, tours, web site, and public outreach events. The City has identified landscape meter accounts which serve one acre or more of landscape area. These identified large accounts receive annual water budgets in conjunction with the Large Landscape Water Permit Program.

To further enhance the exterior landscape program, staff has proposed that the City begin a pilot program to offer rebates to rate payers to purchase updated and more efficient automatic irrigation timers.

The City has also adopted water conserving landscape requirements which are specified in the City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-522. Water Efficient Landscape Standards). These requirements define standards and procedures for the design, installation and management of landscapes in order to utilize available plant, water, land and human resources to the greatest benefit of the people of the City. A copy of the water conserving landscape requirements is provided in Appendix C.

Implementation Schedule

- Landscape Surveys: On-going
- Water budgets for large landscape accounts: on-going
- Rebate program for efficient automatic irrigation controllers: Proposed for the future.
- Water Conserving Landscape Requirements: On-going per City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-522. Water Efficient Landscape Standards)

Annual Budget/Expenditures

FY2005: Actual Budget: $70,205

FY2006: Proposed Budget: $70,000

FY2007: Proposed Budget: $70,000

FY2008: Proposed Budget: $70,000

DMM 6: High-Efficiency Washing Machine Rebate Programs

Corresponding BMP

- CUWCC BMP 06: High-Efficiency Washing Machine Rebate Programs

Description

The City does not currently have a formal high-efficiency washing machine rebate program. However, Pacific Gas & Electric (PG&E) does have a rebate program which the City's water customers may be eligible for, depending on what type of washing machine they purchase. For a $35 rebate (Level 1), the clothes washer must have a Modified Energy Factor (MEF) of 1.42-1.59 and a Water Factor (WF) of 9.5 or lower. For a $75 rebate (Level 2), the clothes washer must have a MEF of 1.60 or greater and a WF of 8.5 or lower. The City is considering a rebate program of its own, which would supplement the PG&E program. The City is planning to begin its program in late 2007.

The City's current meter water rates are $0.606 per l,000 gallons of water used. An individual ratepayer washing two loads per week in a 50 gallon per load standard top loading washing machine, will use approximately 5,200 gallons per year at a cost of approximately $4.21 per year for water used. Therefore, incentives to purchase high-efficiency washing machines based on water cost savings may not be effective at this time. Water rates are currently under study by the City.

The City also participates in the State of California's Flex Your Power (FYP) program. A letter of support for the FYP program was sent by the City at the request of the California Urban Water Conservation Council. In April 2004, the California Water Awareness Campaign and the Flex Your Power energy efficiency program joined together to promote water and energy efficient appliances. Centered around Earth Day, over 40 water agencies, including the City of Fresno, participated in the project by choosing local non-profit organizations to receive new ENERGY STAR clothes washers and dryers.

Implementation Schedule

- PG&E Rebate Program: On-going
- City Pilot Rebate Program: Planned to start in late 2007
- City support of California's Flex Your Power Program: On-going

Annual Budget/Expenditures

FY2005: Actual Budget: $0

FY2006: Proposed Budget: $0

FY2007: Proposed Budget: $0

FY2008: Proposed Budget: $0

DMM 7: Public Information Programs

Corresponding BMP

- CUWCC BMP 07: Public Information Programs

Description

The City's water conservation public information program is managed in-house with the assistance of a contracted public relations firm. The firm's services include strategic planning, creative concepts, public relations, marketing, promotion, research, advertising, media placement, production and design, copy writing, event production and marketing and online services.

The City's public information program has many components including multi-media campaigns (paid and public service advertising); customer billing inserts; literature; public outreach activities, speakers bureau and inter-agency partnerships. Many of the City's water conservation materials are provided in three languages: English, Hmong and Spanish.

The City is a member of the Central Valley Water Awareness Committee (CVWAC), which is comprised of several cities, water utilities, irrigation districts and other groups in the Central Valley. The CVWAC was created to increase the public's understanding of how water is treated, managed and delivered to customers. The City participates in Water Awareness Month activities through its affiliation with the CVWAC.

In the past, the City has informally kept records of these related public information activities. In 2005, the City began keeping formal and accurate records of these activities for submittal to the CUWCC.

Implementation Schedule

- Paid Advertising: On-going
- Public Service Announcements: On-going
- Water Bill Inserts, Newsletters and Brochures: On-going
- Special Events, Media Events: On-going
- Speaker's Bureau: On-going

Annual Budget/Expenditures

FY2005: Actual Budget: $200,000

FY2006: Proposed Budget: $200,000

FY2007: Proposed Budget: $200,000

FY2008: Proposed Budget: $200,000

DMM 8: School Education Programs

Corresponding BMP

- CUWCC BMP 08: School Education Programs

Description

The City works with schools in the Fresno customer service area through its School Education Program. The Water Education Coordinator is a certified teacher on contract with the City, who has developed the program and is available for presentations to students, teachers and community groups. Some of these education programs are recorded for future use.

In the 2003/04 school year, 23 school presentations were made, reaching 659 students. One teacher workshop was also conducted.

The Water Education Coordinator is also attending Environmental Education Initiative (EEI) workshops in regard to the statewide curriculum. The first three of four phases have been completed, designing and pilot testing grade-level curricula aligned with state teaching standards.

Implementation Schedule

- School Outreach Program: On-going

Annual Budget/Expenditures

FY2005: Actual Budget: $45,811

FY2006: Proposed Budget: $45,600

FY2007: Proposed Budget: $45,600

FY2008: Proposed Budget: $45,600

DMM 9: Conservation Programs for Commercial, Industrial and Institutional Accounts

Corresponding BMP

- CUWCC BMP 09: Conservation Programs for Commercial, Industrial and Institutional Accounts

Description

Although the City does not currently aggressively market CII surveys to its customers, should a request for a survey be received, staff is available to respond. Customers are notified of the availability of this program through public outreach events, literature, speaker's bureau, and the City's web site. The City does identify customers according to classification and does rank the highest water users.

The City does have an ordinance which requires water conservation devices on water-cooled refrigeration units and evaporative coolers, which are primarily associated with CII accounts. The provisions of the ordinance have been incorporated into the City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-519. Water Conservation Device Required). A copy of the pertinent sections of the Municipal Code is provided in Appendix C.

Implementation Schedule

- Commercial, Industrial and Institutional Water Use Surveys: On-going upon request
- Requirements for Water Conservation Devices: On-going per City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-519. Water Conservation Device Required)

Annual Budget/Expenditures

FY2005: Actual Budget: $16,384

FY2006: Proposed Budget: $8,000

FY2007: Proposed Budget: $15,000

FY2008: Proposed Budget: $15,000

DMM 10: Wholesale Agency Programs

Corresponding BMPs

- CUWCC BMP 10: Wholesale Agency Programs

Description

The City functions primarily as a retail water purveyor for the City of Fresno water service area. The City does provide water on a wholesale basis to two limited areas within the City's water service area:

- Portion of Pinedale County Water District east of Highway 41, and
- Berans Tract area.

The City provides water on a wholesale basis to a small number of connections located within the portion of the Pinedale County Water District which lies east of Highway 41. This area of Pinedale east of Highway 41 consists of approximately 10 service connections which are essentially cut off from the remaining Pinedale system by Highway 41 and have no other water supply. These service connections are billed by Pinedale, which in turn pays the City for providing the water supply.

The City also provides water on a wholesale basis to the Berans Tract area, a County island consisting of about 50 service connections. The Berans Tract area is served by the City via two master meters.

These wholesale water service arrangements are considered to be a relatively minor part of the City's overall water system operations. Therefore, for purposes of DMM 10, the City is not considered to be a water wholesaler. As such, wholesale agency programs are not considered applicable to the City.

Implementation

Not applicable.

Annual Budget/Expenditures

Not applicable.

DMM 11: Conservation Pricing

Corresponding BMP

- CUWCC BMP 11: Conservation Pricing

Description

As described for DMM 4, only about 14 percent of the City's customer accounts are metered and billed based on usage. This is primarily because the City Charter has, until recently, prohibited the metering of single-family residential accounts. For the City's unmetered single-family residential customers, the City currently bills a flat monthly water rate based on lot size as shown in Table 4-3.

Table 4-3. City of Fresno Water Rates for Unmetered Services (Single-Family Residential Only)[a]

Customer Type	Water Service Charge (Flat Rate, per month)
Single-Family Residential	
First 6,000 square feet or less of lot size	$18.59
Each additional 100 square feet	$0.185
Single-Family Residential (Senior Citizen)	
First 6,000 square feet or less of lot size	$16.72
Each additional 100 square feet	$0.166

(a) Source: City of Fresno Master Fee Schedule (effective 09/01/07).

For the City's metered customers (including multi-family residential, commercial, industrial, institutional and irrigation), the City has a water rate structure which includes a monthly standby charge based on water meter size, and a uniform monthly quantity use charge based on actual monthly water use (see Table 4-4).

Table 4-4. City of Fresno Water Rates for Metered Services[a,b]

Water Meter Size	Water Service Charge = Standby Charge + Quantity Charge	
	Monthly Standby Charge, $	Quantity Charge
¾ inch or smaller	8.16	• Each 100 cubic feet (HCF) = $0.606 • Each 1,000 gallons = $0.809
1-inch	10.99	
1 ½ inch	15.36	
2-inch	22.03	
3-inch	36.65	
4-inch	51.24	
6-inch	80.50	
8-inch	124.36	
10-inch	146.21	

(a) Source: City of Fresno Master Fee Schedule (effective 09/01/07).
(b) Includes multi-family residential, commercial, institutional, industrial, and landscape irrigation customers.

The City is currently preparing a rate study, and will prepare future rate studies, which will consider the need for future rate increases, future conversion from flat rates to metered rates for single-family connections, and future conversion from uniform metered rates to increasing block rates for all metered connections in accordance with the requirements of AB2572.

The City's sewer service rates have varying structures based on customer type as summarized in Table 4-5.

Implementation

- Single-Family Residential Accounts: Until recently, metering of single-family residential accounts has been prohibited by the City Charter; all single-family residential accounts are currently billed based on a flat monthly rate. In accordance with the City's Metering Plan (see DMM No. 4), all single-family residential accounts will be metered by 2013, and will be billed based on actual water consumption.
- All Other Accounts: Currently billed based on actual water consumption based on uniform rate structure.
- Metered Billing Rate Structure for All Service Connections with Meters: Will be developed in accordance with Metering Plan (see DMM No. 4); rate structure currently planned for development in 2007.

Annual Budget/Expenditures

None.

Table 4-5. City of Fresno Wastewater Rate Structures by Customer Type[(a)]

Customer Type	Sewer Service Charge Structure/Rate
Single-Family Residential Single-Family Residential (Senior Citizen)	Flat Rate/Month: $17.67/month Flat Rate/Month: $15.90/month
Multi-Family Residential	Flat Rate/Month Per Unit: $17.67/month for first unit $11.87/month for each additional unit
Schools Kindergarten/Elementary Middle Senior High Parochial College	Flat Rate Per Student Per Year (based on average daily attendance): $10.948/student/year $16.989/student/year $20.491/student/year $5.923/student/year $7.305/student/year
Industrial High Industrial (Sewage effluent of 25,000 gpd or higher or Biochemical Oxygen Demand (BOD) greater than 265 mg/L or Total Suspended Solids (TSS) greater than 300 mg/L) Low Industrial	Uniform Rate per HCF of: Metered Potable Water Used (per HCF) or Metered Sewage Effluent (per HCF) + BOD/pound (for High Industrial Customers only) + Total Suspended Solids (TSS/pound) (for High Industrial Customers only) Rates vary for High and Low Industrial Customers A minimum monthly charge applied to Low Industrial Customers
Commercial High Commercial (BOD or TSS greater or equal to 501 mg/L) Medium Commercial (BOD or TSS from 201 to 500 mg/L) Low Commercial (BOD or TSS from 0 to 200 mg/L)	Uniform Rate per HCF of: Metered Potable Water Used (per HCF) or Metered Sewage Effluent (per HCF) Rates vary for High, Medium and Low Commercial Customers A minimum monthly charge applied to All Commercial Customers

[(a)] Source: City of Fresno Master Fee Schedule (April 2007).

DMM 12: Water Conservation Coordinator

Corresponding BMP

- CUWCC BMP 12: Water Conservation Coordinator

Description

The City has a full-time Water Conservation Supervisor and eight permanent support staff. The water conservation coordinator and conservation staff address the water conservation needs for the City of Fresno.

Water Conservation Supervisor (Position created August 1988): Ms. Nora Laikam

Support Staff:

- One Staff Assistant
- Two Water Conservation Representatives
- Two Landscape Conservation Representatives
- One Administrative Clerk
- One Education Coordinator (contracted)
- One Industrial Commercial Water Conservation Representative (currently vacant)
- Four seasonal temporary employees hired from April to November

Implementation Schedule

- Water Conservation Coordinator and Support Staff: On-going

Annual Budget/Expenditures

FY2004: Water Conservation Staffing Budget: $373,416

DMM 13: Water Waste Prohibitions

Corresponding BMP

- CUWCC BMP 13: Water Waste Prohibition

Description

The City prohibits water waste through ordinances found in the City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-520. Wastage of Water) (see Appendix C). The City has a water waste hotline and a reporting form on the City website, and keeps records of water waste violations. The ordinance prohibits gutter flooding and single-pass cooling systems in new connections.

Two Water Conservation Representatives monitor customer water waste through field operations. Communication to the City's diverse customer base is always taken into consideration, so representatives are bilingual, speaking English and either Hmong or Spanish. During the hot season, temporary Water Conservation Representatives are hired to monitor late night and early morning over watering. A seasonal temporary Administrative Clerk is also hired to keep up with the additional paperwork generated.

The program is marketed through media, billing inserts, promotional materials, public outreach events, speaker's bureau, and the City's web site.

Implementation Schedule

- Water waste prohibitions: On-going per City Municipal Code (Chapter 6, Article 5 Water Regulations, Section 6-520. Wastage of Water))
- Additional drought restrictions: Would be enacted by the City if water supply conditions required additional conservation measures (see Water Shortage Contingency Plan to be provided in UWMP).

Annual Budget/Expenditures

FY2005: Actual Budget: $145,039

FY2006: Proposed Budget: $145,000

FY2007: Proposed Budget: $145,000

FY2008: Proposed Budget: $145,000

DMM 14: Residential Ultra-Low Flush Toilet Replacement Programs

Corresponding BMP

- CUWCC BMP 14: Residential Ultra-Low-Flush Toilet Replacement Program

Description

In March 2006, the City implemented a residential ultra-low-flush toilet replacement rebate program. This program encourages the installation of ultra-low-flush toilets in older homes by offering a rebate for each replaced toilet. Up to a $75 rebate is available from the City. The program requires a pre-inspection and may require a post-inspection. As of June 2007, the City has received over 300 applications and replaced over 500 toilets.

Implementation Schedule

- Residential Ultra-Low Flush Toilet Retrofit Program: On-going

Annual Budget/Expenditures

FY2005: Actual Budget: $0

FY2006: Proposed Budget: $17,400

FY2007: Proposed Budget: $87,000

FY2008: Proposed Budget: $180,000

DETERMINATION OF DMM IMPLEMENTATION

As discussed above, the City has been actively implementing the DMMs to the extent permissible by the City Charter and as staffing and financial resources allow. In FY2005, the total budget for water conservation programs was $540,465. This budget is projected to increase over the next few years as the City expands its water conservation programs.

Because the City's single-family residential water customers are not metered, individual water savings by single-family residential customer are not possible to determine. However, based on the City's annual water production, the City calculates its water conservation savings each month, by comparing current per capita water use to the previous year's per capita water use and 1985 per capita water use (a pre-drought year). Figure 4-2 shows the estimated annual per capita water use for the last 18 years (1989 through 2006) indicating that per capita water consumption has varied somewhat over the last 18 years, but has averaged about 300 gallons per capita per day (gpcd). Figure 4-2 also shows that over the last five years per capita water use has decreased from 332 gpcd to 287 gpcd, which may be largely due to the City's expanded water conservation program over the last several years. Per capita water use may decrease even more in the future as the City implements its residential water meter program and customers become more aware of the water they actually use.

EVALUATION OF DMMS NOT IMPLEMENTED

As shown above in Table 4-1, the City has full programs in place for most of the DMMs. The only DMMs which are not fully implemented are DMM 3, DMM 4, DMM 6, and DMM 11. Also, DMM 10 has not been implemented as the City is not considered to be a wholesale water supplier (with the exception of about 10 connections in the portion of the Pinedale County Water District service area east of Highway 41 and about 50 connections in the Berans Tract area).

Because the City is not fully metered, full implementation of DMM 3 (System Water Audits, Leak Detection and Repair) is not possible at this time. The City's distribution system operations staff, including permanent shift employees (weekends and after hours), respond to and repair any reported leaks as quickly as possible. The City has performed some leak detection pilot studies in small areas of the City and very few leaks have been found. A full water system audit and a more extensive leak detection program will be implemented once the City is fully metered.

Full implementation of DMM 4 (Metering With Commodity Rates For All New Connections And Retrofit Of Existing Connections) and DMM 11 (Conservation Pricing) has, until recently, been restricted by the City Charter, which prohibited metering of single-family residential connections. However, as discussed in DMM 4 above, SB 229 and AB2572, and the renewal of the City's CVP Water Supply Contract, requires that all connections be metered and billed a metered rate by 2013. The City has developed a metering plan to install meters on all single-family residential connections. Implementation is scheduled to begin in 2008, with completion in 2013. Implementation of this metering plan will meet the conditions of the CVP Contract renewal, meet the requirements of SB 229 and AB 2572, and fulfill the requirements of DMM 4 and DMM 11.

The City is currently working on implementation of DMM 6 (High-Efficiency Washing Machine Rebate Programs), and plans to implement a pilot program in late 2007 to supplement PG&E's rebate program.

FRESNO CITY WATER COMPANY

CORNER H AND TULARE STREETS

W. G. KERCKHOFF, PREST.
A. C. BALCH, VICE PREST.
A. G. WISHON, GEN'L. MGR.

FRESNO, CAL.
June 20, 1917

Water Consumers:

In order that we may have ample pressure during the critical months of June, July and August for fire purposes and also for domestic use, all irrigation must be done with a sprinkler only, and not with an open butt hose, that has the effect of reducing the pressure in the locality where used. Use a sprinkler under pressure in any use of water through a hose.

We have Inspectors out, checking up all water waste, and those who persist in the waste of water or persist in an offense against the Company's rules will be served through a meter only. We urgently ask for the kindly co-operation of the Company's consumers. The Fresno City Water Company is serving more water per capita than is served to any other city in America. We have at all times tried to be liberal with our service, but there is a limit beyond which we cannot and should not go in such service.

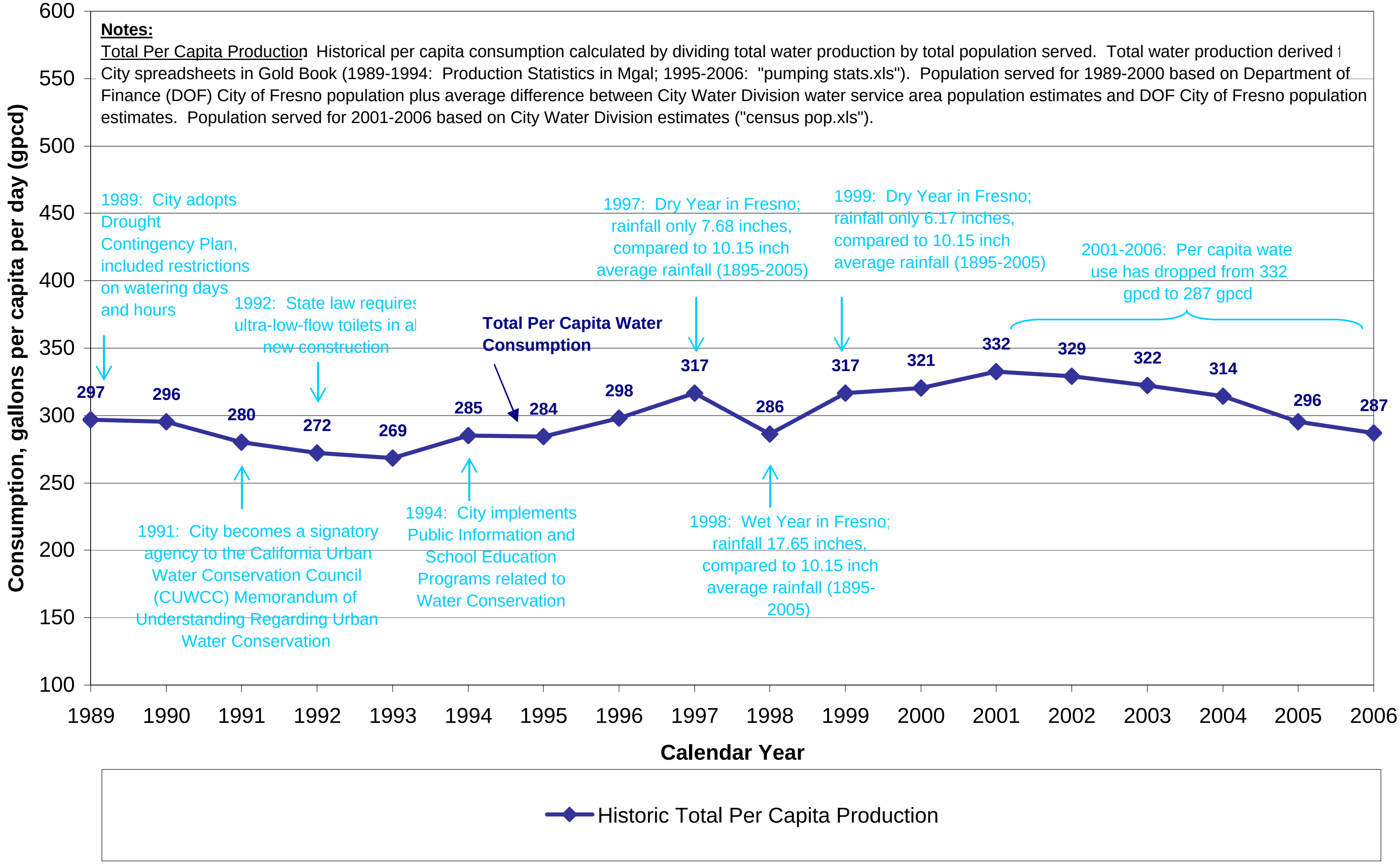
FRESNO CITY WATER COMPANY,

A G Wishon

General Manager

AGW:EPE

Figure 4-2. City of Fresno Historic Per Capita Water Consumption, gpcd



Last Revised: 10/30/07
o:\c\439\02-05-01\e\1\101\pop\6_26_07_WYA Population Analysis
Fig 4-2. Per Capita Chart

CHAPTER 5. URBAN WATER SUPPLY

The City currently uses a combination of groundwater and surface water to meet the water demands of its customers. The purpose of this chapter is to characterize the quantity and quality of each of these water supplies, then compare the City's existing water supplies to projected water demands through 2060 during normal, single dry, and multiple dry year conditions.

This Chapter then describes the potential impact of the City continuing to manage and operate its available water resources as it historically has, which will be defined as the "Future Without Project", or the "status-quo" condition (i.e., continuing to rely on groundwater pumping and the City's existing 30 mgd surface water treatment plant to meet future demands). Alternative water supply strategies for meeting future demands will be addressed in the Phase 2 Report.

The following sections summarize the City's existing water supplies:

- Existing Groundwater Supply
- Existing Surface Water Supply
- Long-Term Water Supply Yield (Normal Year)
- Comparison of Water Supply and Demand
- Potential Impacts of Climate Change
- Water Resource Impacts of City's "Status Quo" Water Supply Strategy

As discussed in Chapter 3, supplies available to areas outside the City's SOI may impact the availability and reliability of the City's supplies. Therefore, existing and future water supplies for areas outside the City SOI, herein referred to as "Non-Fresno" water supplies, have also been evaluated. A separate technical memorandum discussing these "Non-Fresno" water supplies was prepared by WRIME and is included in this Metro Plan Update as Appendix F.

EXISTING GROUNDWATER SUPPLY

The City overlies the Kings groundwater subbasin, which is part of the greater San Joaquin Valley Groundwater Basin (SJV Basin), and is one of many water purveyors that use groundwater from the Kings subbasin.[1] The City currently operates approximately 250 municipal supply wells within the Kings subbasin, and until late 2004, relied solely on pumped groundwater to meet the water demands within its service area. The City's desire is to continue to use groundwater within a larger conjunctive use program that maximizes its existing water rights and surface water supply sources.

The purpose of this section is to summarize hydrogeologic information available for the Kings subbasin near the City, including location, area geology, aquifer characteristics, water levels, groundwater quality, regional contamination, estimates of groundwater recharge and discharge, estimated groundwater yield beneath the City, and to provide a summary of available groundwater supply during all hydrologic conditions.

A detailed evaluation of the Kings subbasin underlying the City was previously conducted as part of the 1992 Fresno/Clovis Metropolitan Water Resources Management Plan Phase I Report (1992 Phase I Report), and an update to that evaluation was completed for this study (see Appendix G). Subsequent sections summarize the information collected in this update, along with supplemental data obtained from publications of the California Department of Water Resources (DWR).

Basin Location

The SJV Basin comprises the southern portion of the Great Central Valley of California, and is bounded to the north by the Sacramento-San Joaquin Delta and Sacramento Valley, to the east by the Sierra Nevadas, to the south by the San Emigdio and Tehachapi Mountains, and to the west by the Coast Ranges.[2]

The Kings subbasin, located within the southern half of the SJV Basin, is bounded to the north by the San Joaquin River, to the east by the alluvium-granite rock interface of the Sierra Nevada foothills, and to the west by the Delta-Mendota and Westside subbasins.[3] The Kings subbasin is bounded to the south by the northern boundary of the Empire West Side Irrigation District, the southern fork of the Kings River, the southern boundary of the Laguna Irrigation District, the northern boundary of the Kings County Water District, and the western boundary of Stone Corral Irrigation District.[4] Figure 5-1 illustrates the location of the City relative to the boundaries of the Kings subbasin.

Area Geology

The upper several hundred feet within the Kings subbasin generally consists of highly permeable, coarse-grained deposits, which are termed older alluvium.[5] Coarse-grained stream channel deposits, associated with deposits by the ancestral San Joaquin and Kings Rivers, underlie much of northwest Fresno.[6] Additionally, a recent study completed in 2004 indicated the presence of a laterally extensive clay layer, at an average depth of approximately 250 feet below the ground surface, beneath most of the south and southeastern portions of the City.[7]

Below the older alluvium to depths ranging from about 600 to 1,200 feet below ground surface, the finer-grained sediments of the Tertiary-Quaternary continental deposits are typically encountered.[8] Substantial groundwater has been produced and utilized from these depths by the City; however, deeper deposits located in the southeastern and northern portions of the City have produced less groundwater.[9]

There are also reduced deposits in the northern and eastern portions of the City, at depths generally below 700 or 800 feet, which are associated with high concentrations of iron, manganese, arsenic, hydrogen sulfide, and methane gas.[10] Groundwater at these depths does not generally provide a significant source for municipal supply wells.[11]

Figure 5-2 presents an idealized hydrogeologic cross-section that illustrates the general depth of various lithologic features within the Kings subbasin, near the City; additional cross-sections illustrating more detail are provided in Appendix G.

Aquifer Characteristics

Transmissivity indicates the ability of an aquifer to transmit groundwater, while the specific capacity indicates the ability of a particular well to produce that water; hence, any future groundwater wells should be located in areas of higher transmissivity. As part of updating the detailed hydrogeologic evaluation, aquifer test data (pump tests) were reviewed to update the hydrogeologic analysis and evaluate available transmissivity and specific capacity data.

Table 5-1 summarizes the pump test data by general geographic location within the City (i.e., North, South, East, and West Fresno). As shown in Table 5-1, the northwestern and southwestern portions of the City have wells with higher transmissivities and higher specific capacities. More detail for each pump test evaluated is provided in Appendix G.

Table 5-1. Summary of Pump Tests within the City[(a)]

Area of the City	Date Range	Range of Pumping Rates, gpm	Range of Transmissivities, gpd/ft	Range of Specific Capacities, gpm/ft
North Fresno	1979 to 2005	500 to 2,450	10,000 to 179,000	6 to 57
Northwest Fresno	1969 to 1995	570 to 2,735	66,000 to 298,000	43 to 134
Southwest Fresno	1995 to 2006	1,510 to 2,515	57,000 to 369,000	26 to 92
Southeast Fresno	1987 to 2005	340 to 1,790	15,000 to 135,000	4 to 54
East Fresno	1987 to 2005	450 to 1,740	3,500 to 109,000	2 to 38

(a) All data provided by Kenneth D. Schmidt and Associates, see Appendix G for a more detailed evaluation.

Current Water Level Elevation and Flow Direction

As discussed in Chapter 7, WRIME has recently completed a groundwater model for the Fresno region to evaluate current groundwater conditions and projected future groundwater response under various future water supply scenarios. As part of the development of the model, WRIME evaluated existing groundwater levels throughout the region. Figure 5-3 shows the regional groundwater levels for spring 2004 as compiled by WRIME for the Kings IGSM Model Development and Calibration.[12]

As part of the update to the detailed hydrogeologic evaluation, the City measured water levels in available nested monitoring wells from April 5 through April 18, 2006.[13] These more recent water level measurements, in conjunction with other data from 2001, were used to develop water surface level elevation and direction of groundwater flow maps for the shallow aquifer zone (~ 140 to 250 feet below ground surface) and the deeper aquifer zone (~ 450 to 600 feet below ground surface).[14] Figures 5-4 and 5-5 illustrate Spring 2006 water surface elevations and groundwater flow direction for both the shallow and deep aquifer zone, respectively.[15]

As shown in Figure 5-4, water surface elevations for the shallow groundwater zone range from less than 190 to more than 300 feet above mean sea level, and a large cone of depression extends from Herndon Avenue to Jensen Avenue in the north-south direction, and from Maple Avenue and Brawley Avenue in the east-west direction.[16] Figure 5-4 also indicates the presence of a large mound of groundwater near the wastewater treatment plant (WWTP), which is due to the City's effluent percolation activities (see additional discussion below).[17]

As shown in Figure 5-5, water surface elevations for the deeper groundwater zone ranged from 185 to 230 feet above mean sea level, with a larger cone of depression extending to the northeast to a greater extent than the cone of depression observed for the shallow groundwater zone.[18] The cone of depression within the deep groundwater bearing zone is likely associated with the development of new "moderately" deep groundwater wells constructed since the late 1980's in the northern portion of the City.[19] Figure 5-5 does not indicate the presence of a groundwater recharge mound, near the wastewater treatment plant, in the deeper aquifer zone.

Historic Water Level Trends

Appendix G includes updated water level hydrographs for the City's wells; these hydrographs were previously developed as part of the 1992 Phase I Report, and then updated as part of this planning effort. Average annual rates of groundwater elevation decline for the City wells over the last 30 years were developed from these hydrographs and are presented on Figure 5-6.[20] Water level data since 1965 was available for most of the wells evaluated.[21]

As shown in Figure 5-6, the slowest groundwater-level declines (less than 0.5 feet per year) were generally observed in the southwestern portion of the City's downtown area, while groundwater-level declines increased to 1.0 foot per year further northeast of the downtown area.[22] Figure 5-6 also indicates that average groundwater-level declines as high as 1.5 feet per year were primarily observed in the northern and southeastern (near the Fresno Air Terminal) portions of the City.[23] The largest average annual groundwater-level declines (3.0 feet per year) were observed in the northeastern area of the City, near Clovis.[24]

Figures 5 and 6 of Appendix G present updated long-term hydrographs for six City-owned groundwater wells. These hydrographs indicate that groundwater levels have somewhat stabilized (or at least slowed in decline) in areas with intentional groundwater recharge (e.g., Leaky Acres).[25]

The hydrographs also indicate that, in general, groundwater levels have declined by an average of about 1.5 feet per year since 1990. However, more recently, groundwater levels have begun to recover somewhat (or at least slow in decline), as City groundwater pumpage has been reduced, as the new SWTF has been brought online.[26]

Figure 5-7 shows water level hydrographs for six of the City's wells. As shown, hydrographs are shown for wells located in different parts of the City (South, North, West and East) and wells located near leaky acres and the RWRF. These wells were selected to demonstrate different groundwater level trends in different parts of the City. All of the wells indicated decreasing groundwater levels since 1990. However, all of the wells, except for the South Fresno well, have shown increases in water levels in the last one or two years, perhaps as a result of the introduction of treated surface water and/or groundwater recharge activities in the vicinity of these wells and treated wastewater percolation near the RWRF.

Groundwater Quality

Groundwater within the Kings subbasin generally meets primary and secondary drinking water standards for municipal water use, and is described as being bicarbonate type water, including calcium, magnesium, and sodium as the dominant ions.[27] Generally, total dissolved solids (TDS) concentrations rarely exceed 600 mg/L, and typically range from 200 to 700 mg/L.[28]

However, the groundwater basin is threatened by chemical contaminants that affect the City's ability to fully use the groundwater basin resources without some type of wellhead treatment in certain areas. Two detailed reports outlining regional contamination are provided in Appendices G and H.

A review of both reports indicates that many different types of chemical pollutants have contaminated portions of the Kings subbasin underlying the City's water service area. Some of the major contaminant plumes include 1,2-Dibromo-3-Chloropropane (DBCP), ethylene dibromide (EDB), Trichloropropane (TCP), other volatile organic compounds (VOCs) like trichloroethylene (TCE) and tetrachloroethylene (PCE), nitrate, manganese, radon, chloride, and iron.[29] There are also several known major contaminant point sources, which are summarized in Table 5-2. The City has received settlements in a number of lawsuits related to these contaminants. These settlements are discussed in Chapter 8 of this Phase 1 Report.

Figure 5-8 presents the general location of regional plumes and major point sources within the City. As shown in Figure 5-8, extensive groundwater contamination nearly covers the City's entire water service area; only areas located in the northwest appear to be relatively unaffected by regional groundwater contamination. Figure 5-8 also shows that many of the City's wells are impacted by one or more of the contaminant plumes (indicated by the presence of overlapping plumes on Figure 5-8). Of the City's currently active wells, 96 wells are impacted by one contaminant plume, 33 wells are impacted by two contaminant plumes, and 5 wells are impacted by three contaminant plumes. Figure 5-8 also indicates which of the City's wells have wellhead treatment systems (also discussed later in this chapter and in Table 5-19).

The largest plumes (unrelated to nitrates) include both DBCP and TCP in the southeastern portion of the City. Figure 5-8 also indicates that Nitrate (as NO_3) concentrations greater than 20 mg/L encompass large portions of the City. There is also a large nitrate plume located in the southwest (around but not under the wastewater treatment plant), this plume may be in the process of remediation, and might be associated with meat packing activities currently in the area or with the handling of winery wastes previously located in the area.

Any future groundwater wells should be located in areas that minimize the need for special design or wellhead treatment due to costs; however, wells could be designed so that groundwater in these areas can be used. These wells would need to be monitored closely, with special attention paid to established Maximum Contaminant Levels (MCLs).

Based on the generalized plume locations illustrated on Figure 5-8, most new wells will need to be constructed outside of the City's existing core area. If sufficient pumping capacity is available at any given well site, the City could also refurbish existing wells with wellhead treatment in-lieu of constructing new wells.

Table 5-2. Summary of Major Point Sources of Contamination[a]

Point Source	Approximate Location	Type of Contaminants
Fresno Railroad Yard	Along Hwy 99, between Clinton and Dakota Avenue	Salinity and Chloride
Fresno Meat Co	South of W. North Avenue, along S. Fig Street	Salinity, Chloride, Nitrate
Pinedale Groundwater Site	Near Sierra and Palm Avenue	VOCs
Thompson-Hayward Agricultural and Nutrition Co.	Southeast of Temperance and McKinley Avenue	Chloroform, 1,2-DCE, DBCP, Dieldrin, 1,2,3-TCP
Purity Oil Sales (Superfund)	Northwest of Maple and Muscat Avenue	VOCs, Manganese, Iron
Fresno Air Terminal	Near the intersection of E. McKinley and N. Clovis Avenue	VOCs, including TCE and PCE
FMC Superfund Site	Southeast of S. Walnut and E. Annandale Avenue	Numerous VOCs and Pesticides
Former Dow Brands Facility	South-central Fresno	PCE and 1,1-DCE
Wilbur-Ellis	Northwest of Maple and Muscat Avenue	Pesticides
Fruit and Church Junkyard	Near the intersection of S. Fruit and E. Church Avenue	No data available on extent of Groundwater Contamination
Fresno County Credit Union	Near the intersection of E. Kings Canyon Road and Hwy 41	No data available on extent of Groundwater Contamination
Commercial Electroplaters	Near W. North Avenue and Hwy 41	No data available on extent of Groundwater Contamination
ACE Trans State Tires	W. Kearney Boulevard and Hwy 41	Petroleum
ARCO Gas Station	N. Millbrook and W. Gettysburg Avenue	Petroleum
Beacon Gas Station	N. Clovis and E. Belmont Avenue	Petroleum
Chevron #1	Near the intersection of Hwy 99 and 41	Petroleum
Chevron #2	Near N. Maple and E. Kings Canyon Avenue	Petroleum
Fast Gas	Near N. West and E. Clinton Avenue	Petroleum

[a] List of point sources and data obtained from: CH2M Hill, 1992. Fresno/Clovis Metropolitan Water Resources Management Plan, Phase 1 Report, Existing Water Supply System Assessment, Volume 1 and 2. January 1992.

Estimated Groundwater Yield for the City

As previously discussed, Phase 1 of this project focuses on the consequences of continuing to operate the water system under "status-quo" conditions (i.e., pumping groundwater and using the existing 30 mgd surface water treatment plant to meet future water demands). In Phase 2 the possible construction of an expanded, or new surface water treatment facility and construction of additional groundwater recharge facilities will be evaluated. As described in Chapter 7, a model for the portion of the Kings subbasin underlying the City has been developed for this project. This IGSM has been used to evaluate groundwater levels and basin storage consequences of the City's "status-quo" operation on the City's groundwater resources (see Chapter 7).

Natural Groundwater Recharge

With the recent completion of the IGSM model, as described in Chapter 7, average natural recharge for the existing (2005) conditions has been estimated to be approximately 37,000 af/yr for the City SOI area, which includes the Pinedale, Bakman, and CSUF areas. In the future, as additional urbanization is assumed to occur, the IGSM model projects that the average natural recharge will decrease to about 27,000 af/yr by 2025. These recently developed estimates of average natural recharge are used in this Phase 1 Report and will be used in subsequent phases of this Metro Plan Update.

Intentional Groundwater Recharge with Surface Water

There are a number of groundwater recharge basins operated by FMFCD, FID, the City of Fresno, and the City of Clovis. The City is currently recharging the groundwater basin with surface water using several recharge facilities within its service area, and recharge via rivers in the area is naturally occurring. Figure 5-9 illustrates the location of these key recharge facilities. As shown on Figure 5-9, a majority of these facilities are located in the north-central portion of the City, away from future expansion areas, such as the Southeast growth area. It should be noted that some of the FMFCD basins are actually dual use (recharge and recreation) basins.

Table 5-3 presents historical recharge, by the City, from 1985 to 2006. As shown in Table 5-3, the current annual intentional recharge by the City is about 40,000 af/yr. Since 1985, the City has recharged a maximum of 61,700 af, and an average of approximately 44,100 af of surface water per year, with the majority of the recharge occurring at the Leaky Acres and the FMFCD facilities. The variability within the facilities is likely due to a number of factors, which could include pond availability, water delivery season, pond maintenance, or length of wet seasons. The average annual intentional recharge over the last seven years (2000 to 2006) has been 51,200 af/yr; as this average is representative of recent hydrologic variability and recent operational constraints, this value has been used in the analysis described in this Phase 1 Report.

It should be noted that the City of Clovis also owns and operates a groundwater recharge facility called the Alluvial Groundwater Recharge Site (AGRS). AGRS encompasses approximately 80

Table 5-3. Historical Groundwater Recharge with Surface Water Supplies, af [a]

Year	Leaky Acres	Woodward Park (WWP)	Flood Control Basins	Big Dry Creek	Fan/Red/ Dog/Pup	Copper Riv	Northeast	Fancher Basin	Misc[b]	Total
1985	12,907	300	12,133	2,294	1,322	0	0	0	0	28,956
1986	17,326	122	16,838	3,080	1,969	0	0	0	0	39,335
1987	8,418	105	6,184	847	186	0	0	0	0	15,740
1988	8,980	101	9,450	812	772	0	0	0	0	20,115
1989	19,637	246	23,376	1,102	439	0	0	0	0	44,800
1990	15,316	608	25,446	1,949	60	0	0	0	0	43,379
1991	18,162	511	20,294	1,830	2,797	0	0	0	0	43,594
1992	30,373	298	18,681	3,736	2,909	0	0	0	0	55,997
1993	18,305	365	25,604	4,748	722	0	0	0	0	49,744
1994	19,154	288	21,366	2,243	1,428	30	0	0	0	44,509
1995	11,895	311	21,885	5,079	478	886	0	339	540	41,413
1996	10,108	564	34,434	4,595	0	1,569	188	596	125	52,179
1997	11,078	435	29,147	5,120	76	1,225	507	234	0	47,822
1998	8,757	415	23,608	5,331	308	1,034	196	0	260	39,909
1999	12,124	521	26,230	5,369	0	506	16	0	253	45,019
2000	15,404	649	34,983	5,966	0	596	0	0	2,841	60,439
2001	13,210	601	24,052	4,457	0	1,094	0	0	8,134	51,548
2002	17,080	578	21,156	5,156	0	953	0	0	6,794	51,717
2003	18,208	379	27,623	5,160	0	688	0	0	9,659	61,717
2004	14,073	675	20,114	4,298	0	575	0	0	10,248	49,983
2005	12,559	676	18,004	3,728	0	196	0	0	7,970	43,133
2006	8,021	345	21,906	3,091	0	323	0	0	6,196	39,882
Average	14,595	413	21,932	3,636	612	440	41	53	2,410	44,133
Average 2000-2006	14,079	558	23,977	4,551	0	632	0	0	7,406	51,203

(a) Data obtained from the City's Gold Book, Recharge Statistics table

(b) Estimated recharge in creeks/canals. Includes Alluvial Drain Basin, Fresno State, Big Dry Creek Detention Basin, North-Central Basin, Delivery System Recharge, Chestnut Avenue Basin, and Kearney Basin.

acres and is typically in operation 8 to 10 months of the year. As further discussed in Chapter 6, groundwater recharge at the AGRS site has averaged about 2,100 af/yr from 1997 to 2005 (see Table 6-11), which contributes to the overall groundwater recharge of the basin underlying the City of Fresno. It should be noted that the AGRS was expanded in 2004, and recharge rates since then have averaged about 4,300 af/yr[30].

Existing Groundwater Production Capacity

Figure 5-10 illustrates the historical number of active wells (i.e., wells that can be operated) and corresponding production capacity between 1980 and 2005. As shown on Figure 5-10, the City's total number of operational wells and corresponding pumping capacity increased significantly in 1989 as a result of the City taking over County water service areas and wells at that time (no City data was available for years 1981, 1982 and 2000).

Figure 5-10 also indicates that between 1996 and 2005, while the number of active wells remained nearly constant (232 wells compared to 244 wells), the corresponding pumping capacity decreased from 474 mgd to 419 mgd, as calculated by the City. Another way of looking at this decline is to compare the total groundwater production capacity to the population served. In 1989, the City had a groundwater production capacity of 460 mgd serving a population of 343,362 people. This equates to 1,340 gallons per day of groundwater production capacity per person. In 2005, the City had a groundwater production capacity of 419 mgd serving a population of 435,814 people. This equates to 960 gallons per day of groundwater production capacity per person, representing a decline of 380 gallons per day per person (about 28 percent) since 1989. This significant decrease in production capacity is likely the result of a few concerns:

- Reduced well production capacity as a result of declining groundwater levels.
- The City is losing key, large producing groundwater wells due to groundwater contamination and/or regulatory issues, and only being able to replace this lost production capacity, with wells with lower yields.
- The City is replacing older wells with an open bottom, with newer wells that are gravel pack; new and replacement gravel pack wells have lower yields than open bottom wells.

If this trend continues, the City would lose approximately 5.3 wells per year, assuming each well produces 800 gpm.

In the future, the City will continue to rely on groundwater to meet a portion of its future water demands. Therefore, this decreasing trend in groundwater production capacity needs to be stabilized and then reversed, to allow the City to maintain its existing groundwater production capacity of approximately 419 mgd or 469,400 af per year, meet peak hour demands, and minimize loss of redundancy. It should be noted that the City has recently constructed wellhead treatment systems and blending facilities on a number of existing wells (see Table 5-19) and is constructing a number of new wells. These treatment facilities and new wells could help to offset the recent loss of groundwater production capacity. This phase of the project also assumes that the City will meet future water demands (above those met with the existing SWTF) using groundwater; hence, additional wells will also be required to meet the future projected demands. These are discussed later in this chapter under **Effects of Status Quo Water Supply Strategy**.

EXISTING SURFACE WATER SUPPLY

The City of Fresno currently has contracts with FID and USBR to provide surface water for groundwater recharge and/or direct treatment and usage. The City also sends treated effluent from the RWRF to percolation basins. This percolated effluent is then subsequently extracted from the groundwater basin and delivered into FID canals. Consequently, the City's groundwater recharge of treated wastewater helps supplement regional surface water supplies. The City and FID have an agreement to exchange this recycled water for surface water, but the exchange aspect of the agreement has never been exercised. Subsequent sections discuss each of the City's available surface water supplies, and their reliability during various hydrologic conditions.

Surface Water Supplies (Non-Recycled) Available through the City's FID Contract

On May 25, 1976, the City signed a contract with FID for delivery of the City's pro rata share of FID's water entitlements on the Kings River (see Appendix J). The contract specifically excludes any of FID's Class 2 USBR entitlement and any water stored in Pine Flat Reservoir by FID (see Chapter 8 for additional discussion of this specific contract). The quality and reliability of the surface water that the City purchases from FID is discussed below.

<u>Water Quality of Surface Water Supplies from the City's FID Contract</u>

Water quality along the Kings River below North Fork, near Trimmer Road, was summarized as part of the 1992 Phase I Report; however, this upstream water quality monitoring station was closed in 1993 and more recent data was not available.[31] Consequently, water quality data in 2005 from the Fresno Weir was obtained from the Kings River Conservation District.

Table 5-4 compares water quality reported in the 1992 Phase I Report to the 2005 water quality data collected at the Fresno Weir, south of Pine Flat Reservoir. As shown in Table 5-4, water delivered from the Kings River is of extremely good quality; these waters originate from snowmelt in the high sierras that has not been subjected to detrimental influences.[32]

Table 5-4. Water Quality on the Kings River

	Constituent	Unit	Standard(a)	1992 Metro Plan(b)	2005 at Fresno Weir(c)
Physical	Color	ACU	15	--	--
	Odor	TON	3	--	--
	pH	--	6.5 to 8.5	8.4	7.6
	Specific Conductance	umhos/cm	900	47	129
General Mineral	Alkalinity	Mg/L	--	20	55.1
	Hardness	Mg/L	--	16	52.09
	Sodium	Mg/L	--	3	--
	Sulfate	Mg/L	250	--	6.5
	Chloride	Mg/L	250	--	6.3
	TDS	Mg/L	500	30	88
Inorganic	Arsenic	Mg/L	.01	--	ND
	Barium	Mg/L	1	--	.030
	Cadmium	Mg/L	.005	--	ND
	Chromium	Mg/L	.05	--	ND
	Lead	Mg/L	.015	--	ND
	Mercury	Mg/L	.002	--	ND
	Selenium	Mg/L	.05	--	ND
	Silver	Mg/L	0.1	--	ND

(a) Standards downloaded from the California Department of Health Services website (www.dhs.ca.gov) on June 29, 2006.
(b) Obtained from Table 3-6 of the 1992 Metro Plan study.
(c) Data obtained from the Kings River Conservation District. All samples were taken in February 2005 at the Fresno Weir.
ND – non-detect

Reliability of Surface Water Supplies from the City's FID Contract

The reliability of surface water purchased by the City from FID was evaluated by reviewing historical diversions, calibrating the data to the water year types adopted in the 9/16 Expert Settlement Report (2006 Settlement Agreement)[33], calculating the City's portion of FID's entitlement, and then determining the City's available water supply from its FID contract during each hydrologic water year type. Each step is discussed below in more detail.

Water Year Types Adopted from the 9/16 Expert Settlement Report

In September 2006, the 2006 Settlement Agreement was filed in the U.S. District Court in Sacramento that ended an 18-year legal dispute over the operation of Friant Dam. The 2006 Settlement Agreement resolved legal claims brought by a coalition of conservation and fishing groups, which were led by the National Resource Defense Council (NRDC).

The 2006 Settlement Agreement provides for substantial river channel improvements and sufficient water flow to sustain a salmon fishery upstream from the confluence of the Merced River tributary, while still providing water supply to the Friant Division of the CVP.

As part of the 2006 Settlement Agreement, water year types were developed and simulated for the contracts in the Friant Division of the CVP. The water year types used in the 2006 Settlement Agreement, and adopted for this analysis included:

- Wet
- Normal-wet
- Normal-dry
- Dry
- Critical-high, and
- Critical-low

A normal year was assumed equal to the average of a Normal-wet and Normal-dry year for supply comparison purposes in the later phases of this project (e.g., the UWMP). For consistency with the City's other surface water supplies, these same hydrologic year types were used to analyze FID's water supplies.

FID's Historical Diversions from the Kings River Applicable to the City's Agreements

The Kings River Water Association (KRWA) allocates entitlements to Kings River contractors on a daily basis; these entitlements are allocated among the contractors using a methodology that estimates the flow in the Kings River before construction of Pine Flat Reservoir (i.e., the project) and depend on timing within each year. Once KRWA calculates the "pre-project" entitlement, FID has the option of releasing the entire entitlement for diversion, or storing a portion of the entitlement within Pine Flat Reservoir. As discussed previously, the City's portion of FID's Kings River water does not include water stored in Pine Flat Reservoir.

FID's historical annual "pre-project" water entitlement on the Kings River from 1964 to 2002 were obtained from Kings River Water Association (KRWA), and presented in column 2 of Table 5-5. The KRWA did not have data available after 2002. This data was used by WYA to estimate future deliveries for various hydrologic conditions for the purposes of this Metro Plan Update.

Although the entitlement numbers presented in Table 5-5 do not include any of FID's Class 2 USBR supplies, they <u>do</u> include water that may have been stored by FID in Pine Flat Reservoir. Consequently, the difference between the entitlement and actual FID releases was used to determine the portion of FID's Kings River supply that is applicable to the City's agreements.

The actual diversions were calculated by subtracting the sum of flows at the Kings River turnout and within Lone Tree from the sum of flows in the Gould and Fresno canals; data was provided by WRIME. The actual releases from Pine Flat Reservoir for FID are presented in column 7 of Table 5-5.

Table 5-5. FID Kings River Water Supply Applicable to the City's Agreements

[1]	[2]	[3]	[4]	[5]	[6]	[7] = [3]+[4]+[5]+[6]	[8] = [2]-[7]	[9] = see notes	[10] = see notes	[11] = see notes
		Actual Diversions[c]								
Year[a]	Pre-Project Entitlement[b]	Gould	Fresno	Lone Tree	Kings River Turnout	FID Supply	Difference	Applicable Diversion [d,e]	Calculated FID Pine Flat Storage[f]	Spill Water Available to Others
1964	342,611	93,435	297,716	(29,332)	(9,507)	352,312	(9,701)	342,611	109,299	0
1965	539,579	114,325	477,925	(28,783)	0	563,467	(23,888)	539,579	95,112	0
1966	407,538	96,334	382,030	(29,185)	(126,216)	322,963	84,575	322,963	119,000	0
1967	653,736	144,319	535,695	(35,490)	(273,244)	371,280	282,456	371,280	119,000	163,456
1968	347,123	99,126	337,098	(28,385)	(78,199)	329,640	17,483	329,640	119,000	0
1969	716,535	136,448	493,312	(27,210)	(24,517)	578,033	138,502	578,033	119,000	19,502
1970	450,050	107,267	426,493	(40,463)	(101,414)	391,883	58,167	391,883	119,000	0
1971	424,858	131,156	414,570	(24,644)	(112,813)	408,269	16,589	408,269	119,000	0
1972	371,633	103,229	300,907	(26,904)	(59,026)	318,206	53,427	318,206	119,000	0
1973	523,188	133,586	456,126	(23,528)	(255,590)	310,594	212,594	310,594	119,000	93,594
1974	526,572	129,185	457,690	(39,667)	(198,707)	348,501	178,071	348,501	119,000	59,071
1975	463,331	127,297	442,809	(34,655)	(63,009)	472,442	(9,111)	463,331	109,889	0
1976	232,257	71,716	193,907	(13,894)	(16,257)	235,472	(3,215)	232,257	115,785	0
1977	204,694	60,618	171,725	(15,617)	(14,426)	202,300	2,394	202,300	119,000	0
1978	660,883	149,470	458,078	(35,483)	(125,177)	446,888	213,995	446,888	119,000	94,995
1979	486,175	141,849	412,520	(40,473)	(147,973)	365,923	120,252	365,923	119,000	1,252
1980	609,463	154,402	461,641	(48,305)	(66,953)	500,785	108,678	500,785	119,000	0
1981	357,435	115,008	345,364	(26,674)	(72,749)	360,949	(3,514)	357,435	115,486	0
1982	673,906	130,545	425,988	(15,547)	(74,379)	466,607	207,299	466,607	119,000	88,299
1983	728,071	132,709	372,134	(21,085)	(16,927)	466,831	261,240	466,831	119,000	142,240
1984	528,641	147,229	496,292	(23,265)	(124,455)	495,801	32,840	495,801	119,000	0
1985	419,923	122,759	470,591	(25,989)	(56,740)	510,621	(90,698)	419,923	28,302	0
1986	618,996	139,390	455,392	(29,433)	(62,385)	502,964	116,032	502,964	119,000	0
1987	311,228	78,900	283,784	(16,423)	(34,560)	311,701	(473)	311,228	118,527	0
1988	357,786	94,224	331,023	(19,967)	(45,113)	360,167	(2,381)	357,786	116,619	0
1989	356,434	113,821	342,639	(23,618)	(70,772)	362,070	(5,636)	356,434	113,364	0
1990	314,025	78,919	226,079	(18,964)	(4,350)	281,684	32,341	281,684	119,000	0
1991	382,060	114,305	316,033	(19,470)	(66,098)	344,770	37,290	344,770	119,000	0
1992	282,849	113,715	274,971	(17,374)	(29,615)	341,697	(58,848)	282,849	60,152	0
1993	563,546	134,517	539,341	(32,015)	(169,220)	472,623	90,923	472,623	119,000	0
1994	338,731	110,833	289,135	(17,166)	(35,612)	347,190	(8,459)	338,731	110,541	0
1995	651,929	108,645	449,556	(29,386)	(60,074)	468,741	183,188	468,741	119,000	64,188
1996	538,552	130,304	457,156	(28,204)	(82,122)	477,134	61,418	477,134	119,000	0
1997	550,326	129,906	457,028	(32,568)	(71,879)	482,487	67,839	482,487	119,000	0
1998	634,477	104,779	374,043	(26,172)	(60,673)	391,977	242,500	391,977	119,000	123,500
1999	411,485	109,702	434,026	(25,536)	(107,627)	410,565	920	410,565	119,000	0
2000	430,945	119,073	422,498	(27,555)	(85,926)	428,090	2,855	428,090	119,000	0
2001	336,599	96,005	256,642	(17,131)	(56,139)	279,377	57,222	279,377	119,000	0
2002	372,040	93,679	385,117	0	(59,678)	419,118	(47,078)	372,040	71,922	0

[a] Calendar year.

[b] Data provided by the Kings River Water Association.

[c] Data provided by WRIME.

[d] If the difference between the "pre-project" entitlement and the actual diversion (i.e., [2] - [7]) is less than zero, then it implies that FID released stored water and therefore, the quantity of FID's Kings River water applicable to the City's agreements is equal to the entitlement, not the actual diversion.

[e] If the difference between the "pre-project" entitlement and the actual diversion (i.e., [2] - [7]) is greater than zero, then it implies that FID stored some if its entitlement within Pine Flat Reservoir and therefore, the quantity of FID's Kings River water applicable to the City's agreements is equal to the actual diversion, not the entitlement.

[f] FID's website indicates that max storage available in Pine Flat is 11.9% of 1 million AF, or 119,000 af.

[g] Any year in which the entitlement exceeds the actual diversion, and FID's storage in Pine Flat is full, will result in excess entitlement (spill water) being released.

The difference between the "pre-project" entitlement and the actual diversion (see column 8 of Table 5-5) indicates the quantity of FID's Kings River water applicable to the City's agreements.

If the difference between the "pre-project" entitlement and the actual diversion is less than zero, then it implies that FID released stored water and therefore, the quantity of FID's Kings River water applicable to the City's agreement is equal to the entitlement, not the actual diversion.

If the difference between the "pre-project" entitlement and the actual diversion is greater than zero, then it implies that FID stored some if its entitlement within Pine Flat Reservoir and therefore, the quantity of FID's Kings River water applicable to the City's agreements is equal to the actual diversion, not the entitlement.

Table 5-5 also indicates that in some years (e.g., 1967, see column 11 of Table 5-5), FID receives more Kings River water supply than it diverts or can store within Pine Flat Reservoir. This "spill" water is released and used by whoever diverts the water.

Figure 5-11 illustrates FID's historical water deliveries from 1964 to 2002, in relation to the adopted hydrologic year type, that are applicable to the City's agreement. Data for years after 2002 was not available. Figure 5-11 clearly indicates the critical-low, hydrologic conditions present in 1977, and also the 6-year continuous drought period that occurred from 1987 to 1992.

For planning purposes, it was assumed that a multiple dry year would consist of three consecutive years (consistent with UWMP requirements). The supply available during the first two years would be equal to the available supplies during "Dry" hydrologic conditions (e.g,. 1987 to 1992), while the third year would only provide supplies available during a Critical-low year (1977).

Calibration of Historical FID Diversions from the Kings River

Water year classification was used during this water supply analysis to help estimate the water supply expected to be available during various hydrologic conditions. As discussed previously, the hydrologic year types used in the 2006 Settlement Agreement were adopted for this analysis.

Table 5-6 summarizes the average and proposed "applicable" diversions for FID, by hydrologic year classification; data used to develop Table 5-6 was previously presented in Figure 5-11. Because a Normal year was not defined in the 2006 Settlement Agreement, the Normal year diversion is estimated to be approximately 390,000 af (based on the weighted average of Normal-wet and Normal-dry years).

Table 5-6. Available FID Diversion Quantity based on the 2006 Settlement Agreement

Water Year Classification	Total Diversion between 1964 and 2002 by Water Year Classification, af [1]	Number of Years within Water Year Classification [2]	Average Diversion by Water Year Classification, af[(a)] [3] = [1]/[2]	Proposed Diversion Quantity, for Water Supply Planning, af [4]
Wet	5,149,216	11	468,111	468,100
Normal-wet	3,839,518	9	426,613	426,600
Normal[(b)]	Normal years not defined in the 2006 Settlement Agreement			390,000
Normal-dry	3,571,299	10	357,130	357,100
Dry	2,244,530	7	320,647	320,600
Critical-high	232,257	1	232,257	232,200
Critical-low	202,300	1	202,300	202,300

(a) Average entitlement calculated by dividing the total entitlement by the number of years.
(b) Normal year assumed equal to the weighted average of Normal-wet and Normal-dry for this analysis.

Percent Allocation of FID Supply to the City

In accordance with the City's 1976 agreement with FID, the actual water supply available to the City is a percentage of FID's diversion from the Kings River. The percentage is based on the ratio of the total area annexed by the City, compared to the total area within FID's water service area, including the area served by the City. Hence, the water available to the City through its contract with FID will increase over time as the City annexes additional lands within FID's water service area.

The City's percentage allocation for 2005 was provided by FID, while the allocations for 2010, 2025, and 2060 were calculated by WYA. Allocations for other, intermediate years, were based on a straight-line interpolation.

Table 5-7 presents the City's estimated allocation percentages. As shown, the percentage of FID's total Kings River diversion available to the City increases over time. The actual quantities are presented in subsequent sections.

Table 5-7. Projected Allocation of FID Kings River Diversion to the City[(a)]

Year	Percentage Allocation
2005	23.63%
2010	24.30%
2015	27.01%
2020	29.73%
2025	32.44%
2060	44.60%

(a) Allocation in 2005 was provided by FID, allocation for 2010, 2025, and 2060 are based on WYA's GIS, and the allocation for other years is based on interpolation.

FID Surface Water Supply Available to the City for Each Water Year Classification

The surface water available for the City to purchase, based on its 1976 agreement with FID, was determined by multiplying the percentage allocation in Table 5-7 by the adopted “applicable” diversion quantities available in Table 5-6. Table 5-8 presents the Kings River water available to the City, based on hydrologic water year classification defined by the 2006 Settlement Agreement.

Table 5-8. FID Kings River Diversions Available to the City, af

Classification	2005	2010	2015	2020	2025	2060
Wet	110,600	113,800	126,400	139,100	151,800	208,600
Normal-wet	100,800	103,700	115,200	126,800	138,400	190,100
Normal	92,200	94,800	105,400	115,900	126,500	173,800
Normal-dry	84,400	86,800	96,500	106,200	115,800	159,100
Dry	75,800	77,900	86,600	95,300	104,000	142,900
Critical-high	54,900	56,500	62,800	69,100	75,400	103,500
Critical-low	47,800	49,200	54,600	60,100	65,600	90,100

Surface Water Available Under the City’s USBR Contract

The City recently renewed its contract with the USBR, through the year 2045. USBR oversees diversions from the San Joaquin River through the Friant-Kern Canal of the Central Valley Project (CVP). The Friant Water Users Authority owns and operates the Friant-Kern Canal and manages everyday operations of the canal. The City’s total entitlement from the USBR is 60,000 acre-feet per year of Class 1 water (see Appendix J).

USBR Class 1 water is generally water available from Millerton Lake, and is a very dependable water supply, regardless of the type of hydrologic water year. Class 2 water is generally any excess water available as determined by USBR, and is not considered as dependable as Class 1 water.[34]

The quality and reliability of the surface water diverted under the City’s USBR contract is discussed below.

Water Quality of Surface Water Supplies from the City’s USBR Contract

Water quality along the San Joaquin River at Millerton Lake, was summarized as part of the 1992 Phase I Report; however, more recent data at these water quality monitoring stations was not available. Consequently, water quality data collected in 2005 at a sampling location below the Friant Dam, in the Friant-Kern Canal was obtained from the USBR.

Table 5-9 compares water quality reported in the 1992 Phase I Report at Millerton Lake to 2005 water quality data provided by the USBR. As shown in Table 5-9, the quality of water from the San Joaquin River is of extremely good quality; these waters also originate from snowmelt in the high sierras that have not been subjected to detrimental influences.

Reliability of Surface Water Supplies from the City's USBR Contract

As discussed previously, the 2006 Settlement Agreement was filed in the U.S. District Court in Sacramento that ended an 18-year legal dispute over the operation of Friant Dam. The 2006 Settlement Agreement resolved legal claims brought by a coalition of conservation and fishing groups, which were led by NRDC. As part of the 2006 Settlement Agreement, the City's Class 1 deliveries, by hydrologic year type were developed and simulated. The quantities of USBR Class 1 water developed in the 2006 Settlement Agreement were also adopted for this analysis.

The following subsections first examine the historical USBR Class 1 deliveries to the City to help ensure that the Critical-low and Multiple-dry year scenarios in the 2006 Settlement Agreement are consistent with the historical record, then examine the reliability of USBR Class 1 supplies in the future.

Historical Deliveries from the USBR

Historical deliveries of Class 1 water under the City's USBR contract included both water delivered to the City, and water used by FID. From 1966 to 1994, a portion of the City's Class 1 USBR water supply (up to 60,000 af annually) was provided to FID. The Class 1 water provided to FID was proportioned based on a decreasing scale that started at 55,000 af in 1966 and then decreased to zero by 1994. For example, in 1966, the City was entitled to 5,000 af of its total Class 1 entitlement (60,000 af) and FID was provided up to 55,000 af.

Historical USBR deliveries of Class 1 water under the City's contract from 1974 to 2005 were obtained from the USBR; data before 1974 was not available. Historical data defining the delivery of the City's Class 1 water to FID were not available, however, USBR deliveries to FID were available. For planning purposes, it was assumed that the difference between the delivery to the City and its entitlement, up to the quantity delivered to FID, was the City's Class 1 water delivered to FID.

For example, in 1974, the USBR delivered 21,000 af to the City and 56,982 af to FID. Consequently, it was assumed that 21,000 af of the City's Class 1 water went to the City, and that 39,000 af (60,000–21,000 af) of the USBR water delivered to FID was the City's Class 1 water. Figure 5-10 illustrates USBR deliveries to the City from 1974 to 2005

Figure 5-12 indicates that FID may have been using a portion of the City's Class 1 water beyond 1994. Figure 5-12 also indicates that 1977 deliveries are consistent with the Critical-low year identified in the settlement agreement; however, historically, the City received a majority of its Class 1 USBR water during the multiple dry-year period from 1987 to 1992.

Table 5-9. Water Quality on the San Joaquin River

	Constituent	Unit	Standard[a]	1992 Millerton Lake[b]	1992 Mile Post 201	1992 Terra Bella ID	2005 at Friant-Kern Canal[c]
Physical	Color	ACU	15	8	--	< 5	--
	Odor	TON	3	2	--	1	--
	pH	--	6.5 to 8.5	6.7	7.6	7.7	7.82
	Specific Conductance	umhos/cm	900	110	29	61	38.4[d]
General Mineral	Alkalinity	mg/L	--	14	--	15	8
	Hardness	mg/L	--	18	--	21	--
	Iron	mg/L	0.3	< 0.3	0.14	0.1	< 0.1
	Manganese	mg/L	0.05	< 0.02	< 0.02	< 0.03	0.0015
	Sodium	mg/L	--	5	--	3	1.0
	Sulfate	mg/L	250	--	--	--	0.44
	Chloride	mg/L	250	6	< 10	--	0.560
	TDS	mg/L	500	70	46	27	24
Inorganic	Arsenic	mg/L	.01	--	< 0.001	< 0.03	0.001
	Barium	mg/L	1	--	< 0.015	< 0.5	0.0042
	Cadmium	mg/L	.005	--	< 0.002	< 0.005	< 0.0005
	Chromium	mg/L	.05	--	< 0.002	< 0.03	< 0.0005
	Lead	mg/L	.015	--	< 0.003	< 0.03	< 0.0005
	Mercury	mg/L	.002	--	< 0.0002	< 0.0001	< 0.000002
	Selenium	mg/L	.05	--	< 0.001	< 0.005	< 0.0004
	Silver	mg/L	0.1	--	< 0.001	< 0.03	< 0.0005

(a) Standards downloaded from the California Department of Health Services website (www.dhs.ca.gov) on June 29, 2006.
(b) Obtained from Table 3-7 of the 1992 Metro Plan study.
(c) Data obtained from the USBR, and all samples were taken in 2005.
(d) Data for specific conductance is equal to the annual average obtained from the California Data Exchange Center (CDEC) for the San Joaquin River, below Friant Dam (Station SJF), downloaded on 07/02/06.

ND – non-detect

Figure 5-12 also shows that historically, the average delivery the City received from the USBR was approximately 53,160 af (i.e., approximately an 89 percent delivery), and that generally, Class 1 deliveries from the USBR only receive minimal, if any, cut backs during dry periods (see data on Figure 5-12 from 1996 through 2005).

For planning purposes, it was assumed that a multiple dry year would consist of three consecutive years (consistent with UWMP requirements). The supply available during the first two years would be equal to the available supplies during "Dry" hydrologic conditions (e.g,. 1987 to 1992), while the third year would only provide supplies available during a Critical-low year (1977).

Deliveries of USBR Class 1 Water Adopted from the 2006 Settlement Agreement

Figure 5-13 illustrates the City's USBR Class 1 deliveries developed in the 2006 Settlement Agreement and adopted for this analysis. Comparing Figure 5-13 to Figure 5-12 clearly shows that the 2006 Settlement Agreement significantly reduced the City's USBR Class 1 deliveries during dry periods. For example, historically, the City received approximately 18,000 af in 1977, while the 2006 Settlement Agreement only assumes the City receives 13,900 af. The deliveries during the historical multiple dry-year period from 1987 to 1992 are reduced by half.

Table 5-10 summarizes the water deliveries allocated to the City in the 2006 Settlement Agreement by hydrologic year classification. As mentioned previously, a Normal year was not defined in the 2006 Settlement Agreement; therefore, Normal year supplies were assumed equal to the weighted average supply during a Normal-wet and Normal-dry years.

Table 5-10. Available USBR Entitlement Adopted from the 2006 Settlement Agreement

Classification	Total Delivery between 1922 and 2003, af [1]	Number of Years within Classification [2]	Average Delivery, af[a] [3] = [1]/[2]	Adopted Diversion Quantity, for Water Supply Planning, af
Wet	959,600	16	60,000	60,000
Normal-wet	1,499,700	25	60,000	60,000
Normal	Normal years not defined in the 2006 Settlement Agreement			58,200
Normal-dry	1,349,700	24	56,200	56,200
Dry	477,900	12	39,800	39,200
Critical-high	100,700	4	25,200	25,200
Critical-low	13,900	1	13,900	13,900

(a) Data obtained from the 2006 Settlement Agreement.

(b) The entitlement available during a critical-low year was assumed equal to the entitlement delivered in 1977 to provide additional conservatism for planning purposes.

USBR Surface Water Supply Available to the City for Each Water Year Classification

The projected surface water available for the City to purchase from the USBR during each hydrologic year defined by the 2006 Settlement Agreement is summarized in Table 5-11. As shown in Table 5-11, the projected water supply from the USBR, during each hydrologic year type, does not change over time. Unlike the City's contract with FID, the entitlement the City has with the USBR is not tied to growth of the City's water service area.

Table 5-11. USBR Entitlement Available to the City for Each Hydrologic Year Type, af

Classification	2005	2010	2015	2020	2025	2060
Wet	60,000	60,000	60,000	60,000	60,000	60,000
Normal-wet	60,000	60,000	60,000	60,000	60,000	60,000
Normal	58,200	58,200	58,200	58,200	58,200	58,200
Normal-dry	56,200	56,200	56,200	56,200	56,200	56,200
Dry	39,200	39,200	39,200	39,200	39,200	39,200
Critical-high	25,200	25,200	25,200	25,200	25,200	25,200
Critical-low	13,900	13,900	13,900	13,900	13,900	13,900

Surface Water Supply Available through the City's Wastewater Recycle Exchange

In addition to contracts with FID for a portion of its Kings River entitlement, the City also has a contract with FID that allows the City to pump groundwater developed through the percolation of previously treated wastewater. This percolated water is then extracted and then pumped into FID canals for delivery to downstream customers.

In return, the agreement states that FID will provide the City with surface water from either its Kings River entitlement or its Class 2 USBR water "insofar as is feasible and practical." The quantity of surface water that FID is required to provide is limited to 46 percent of the groundwater that the City pumps into FID's delivery canal, and the contract limits the annual quantity that can be pumped into FID's canals to 30,000 afa, or 100,000 af over a 10-year period.

Figure 5-14 compares the historical quantity of treated wastewater sent by the City to the percolation ponds to recharge the groundwater basin, to the quantity of water pumped by the City into FID's canals. For planning purposes, the total quantity of water sent to the percolation ponds was limited to the City's portion of wastewater (estimated at 89 percent, see Table 3-14 of Chapter 3), and evaporative losses were assumed equal to 4.9 percent of the total water sent to the percolation ponds (see Table 3-14 of Chapter 3).

As shown on Figure 5-14, the City has sent up to 65,100 af of treated wastewater effluent to the percolation basins, and pumped as much as 32,300 af per year into FID canals. Over the maximum 10-year period from 1996 to 2005, the City pumped 230,327 af into FID canals, exceeding the 100,000 af limit. Discussions with City staff indicate that, to date, the City has not requested that FID supply surface water to the City to replace the groundwater pumped into the FID delivery canals.

The quality of the surface water that the City would receive through this FID contract is identical to the water quality it receives from either the Kings River or the USBR. The quality of surface water delivered from the Kings River and the USBR was previously presented in Tables 5-4 and 5-9, respectively.

Reliability of Surface Water Available through Recycled Water Activities

Although total flow might be reduced slightly, wastewater flows are essentially 100 percent reliable even during drought events; consequently, under all hydrologic conditions, the City should be able to continue to continue to send treated effluent to percolation basins near the wastewater treatment plant. Based on the 16-year record graphically presented on Figure 5-14, the average annual quantity of treated effluent sent to percolation basins by the City is approximately 57,200 af per year. Therefore, there appears to be sufficient treated effluent percolation to allow the City to continue to pump 30,000 af of groundwater (maximum annual pumpage allowed) into the FID canals (assumes 10-year maximum of 100,000 af will be overlooked, as in the past).

Based on an agreement between the City of Fresno and FID, and based on a 46 percent return from FID, the City should be able to obtain 13,800 af of Kings River water from FID. For planning purposes, it was assumed that “insofar as is feasible and practical” implied that FID could supply up to 13,800 af of surface water supply during all hydrologic conditions.

Reliability of All Surface Water Supplies under Various Hydrologic Conditions

The City has water supply contracts with FID and the USBR, allowing it to use surface water from the Kings and San Joaquin Rivers. Table 5-12 presents an estimate of the total projected surface water available to the City in 2025 and 2060, based on possible hydrologic condition, as defined by the 2006 Settlement Agreement.

Table 5-12. Surface Water Supply Available to the City, af

Source		Wet	Normal-wet	Normal	Normal-dry	Dry	Critical-high	Critical-low
2025	FID Kings River	151,800	138,400	126,500	115,800	104,000	75,400	65,600
	USBR Class 1	60,000	60,000	58,200	56,200	39,800	25,200	13,900
	Recharge Water	13,800	13,800	13,800	13,800	13,800	13,800	13,800
	Total	225,600	212,200	198,500	185,800	157,600	114,400	93,300
2060	FID Kings River	208,600	190,100	173,800	159,100	142,900	103,500	90,100
	USBR Class 1	60,000	60,000	58,200	56,200	39,800	25,200	13,900
	Recharge Water	13,800	13,800	13,800	13,800	13,800	13,800	13,800
	Total	282,400	263,900	245,800	229,100	196,500	142,500	117,800

LONG-TERM WATER SUPPLY YIELD (NORMAL YEAR)

The hydrologic year type classifications adopted from the 2006 Settlement Agreement were used to estimate the future, long-term average surplus surface water supply not being used by the City, between 1922 and 2003. The long-term groundwater yield required was then used to compare to the City's available surface water supplies that are not being used due to treatment capacity or location of recharge ponds and wells.

In the analysis, water demands were assumed to be served first with surface water (FID, USBR, and recycling exchange), and then groundwater. It was assumed that during drought or other water shortage periods, that the City would implement mandatory demand management measures that would reduce demands by up to 10 percent in dry years and 15 percent in critically dry years.

By comparing the 2025 demands to the 81-year hydrologic period of record, the variability of supply availability can be analyzed, and used to calculate the average groundwater pumpage required over a long, historic hydrologic period, which can then be used to compare water demands and supply. This process was independently completed for years 2005, 2010, 2015, 2020, 2025, and 2060 demands (see Appendix K).

Figure 5-15 shows predicted City water supplies for the year 2025 level of development, assuming a repeat of the 1922 to 2003 historic hydrologic years. As shown on Figure 5-13, the City has 11,300 af of surplus surface water in critical-low years (i.e., 1977) and up to 143,600 af of surplus surface water in wet years that it cannot currently use due to facility and operational constraints.

Table 5-13 presents the projected water supplies available during a Normal water year for years 2005, 2010, 2015, 2020, 2025, and 2060. As shown in Table 5-13, natural groundwater inflow for 2005 was estimated to be 37,000 af, declining gradually to 27,000 af by 2025 due to increased urbanization within the Fresno SOI area.

Table 5-13. Estimated Water Supply Availability during a Normal Year, af

Source	2005	2010	2015	2020	2025	2060
FID (Kings River)	92,200	94,800	105,400	115,900	126,500	173,800
USBR (Class 1)	58,200	58,200	58,200	58,200	58,200	58,200
Recharge (Recycled)[a]	13,800	13,800	13,800	13,800	13,800	13,800
Natural Groundwater Inflow[b]	37,000	35,000	32,000	30,000	27,000	27,000
Total	201,200	201,800	209,400	217,900	225,500	272,800

(a) Per City of Fresno agreement with FID, based on 46% of 30,000 af/yr, City groundwater pumpage and delivery to FID canals of previously recharged, treated wastewater.
(b) Natural groundwater inflow was estimated based on recent work by WRIME (see Chapter 7).

COMPARISON OF WATER SUPPLY AND DEMAND

The purpose of this section is to compare the City's available water supply under various hydrologic conditions, to the City's projected water demands. This section begins with a discussion of the City's historical supply and demand, and then compares current supply and demand, and future supply and demand.

Comparison of Historical Water Supply and Demand

As described previously in Chapter 3, the City relied solely on groundwater until 2004 to meet the water demands within its water service area. In 2006, the City used a mixture of 13 percent treated surface water and 87 percent groundwater to meet its water demands. The City's reliance on groundwater, which is typically more drought resistant than surface water, has allowed the City to meet its customer demands without mandatory rationing, even during the prolonged drought period that occurred between 1987 and 1992.

Comparison of Supply and Demand in the Current Year

Table 5-14 compares current water demands to water supplies available during a normal year and single dry year for 2006. As shown in Table 5-14, the City has more surface water supplies than it can currently treat or deliver during a normal year, but uses all of its surface water supply during a Critical-low (i.e., Single Dry year, or 1977 conditions).

Surface water supplies are limited by the treatment capacity of its SWTF and its recharge facilities, while the use of percolated treated wastewater is limited by the location of the wastewater treatment plant (major conveyance facilities would need to be constructed to allow the City to extract additional groundwater near the wastewater treatment plant and distribute it within the City), and the use of percolated wastewater outside the FID boundary is subject to approval by the FID Board of Directors. Consequently, the City must pump additional groundwater that it would not otherwise need to pump because it cannot use all of its surface water.

The total quantity of groundwater historically pumped by the City (129,400 af in a normal year and 105,400 af in a Critical-low year) is below the historical average (140,000 af, see Chapter 3); although, as previously shown on Figure 5-5, historical average annual groundwater pumping has resulted in City-wide average water-level declines of approximately 1.5 feet per year over the past 30 years (i.e., 45 foot decrease in water levels over the past 30 years).

Hence, any water demands that cannot be met with surface water, groundwater inflow, or recharged recycled water, have been historically met with groundwater extracted from basin storage (up to 41,200 af in a normal year and 23,420 af in a Critical-low year). More groundwater basin storage is required during a normal year than in a Critical-low year because mandatory conservation (15 percent) is in place during a Critical-low year.

Comparison of Projected Supply and Demand

A comparison was made between projected supply and demand during three hydrologic conditions. The first hydrologic condition assumed that years 2006, 2010, 2015, 2020, 2025, and 2060 were all normal years. The second supply condition assumed that those same years were all

Table 5-14. Current Water Supply and Demand in Normal and Critical-Low Years

	Type	Source	Normal Year (2006), af	Critical-low Year (2006), af
Available	Surface Water	FID (Kings River)	92,720	48,080
		USBR (CVP)	58,200	13,900
		Recharge (Recycled)[a]	13,800	13,800
		Total Surface Water	*164,720*	*75,780*
	Groundwater Inflow[b]		37,000	37,000
	Subtotal		*201,720*	*112,780*
Usable	Surface Water	SWTF[c]	30,800	30,800
		Recharged & Extracted[d]	51,200	44,980
		Total Surface Water	*82,000*	*75,780*
	Groundwater Inflow		37,000	37,000
	Subtotal		*119,000*	*112,780*
Total Water Demand[e]			160,200	136,200
Additional Groundwater Pumped[f]			41,200	23,420
Estimated Actual Change in Groundwater Basin Storage[d]			(41,200)	(23,420)
Estimated Surface Water Supply Not Used by City			82,720	0
Recharged Recycled Water Not Used[a]			35,100	35,100

[a] For planning purposes, it was assumed that the City can recharge up to 65,100 af of recycled water per year (assumes 4.9% evaporative losses and that only 89% of total wastewater production is the City's), and that it provides up to 30,000 af as extracted groundwater to FID. In exchange, FID provides up to 13,800 of up stream surface water (near the City's demands). The remaining supply (65,100 af – 30,000 af = 35,100 af) is not available to the City because it's existing system does not have the structural ability to move this water to where its water demands are located.

[b] Based on recent estimates by WRIME (see Chapter 7).

[c] For planning purposes, it was assumed that the SWTF is down for one month out of the year for "canal" maintenance.

[d] As discussed previously, this phase of the project assumes the City operates status-quo, which limits the City's ability to recharge the groundwater basin with surface water to the average recharge over the last seven years (2000 to 2006) of 51,200 af. Consequently, any additional groundwater pumped beyond estimated inflow and intentional recharge is assumed to come from basin storage. Phase 2 of this project will consider additional facilities that will enable the City to utilize more surface water and eliminate the need to use groundwater basin storage.

[e] Demands during a Critical-low year were reduced by 15% due to mandatory rationing.

[f] Under existing conditions, total groundwater pumpage must come from basin storage.

Critical-low years. The third condition assumed that a multiple year drought period, consisting of three consecutive dry years (first two years are Dry followed by a third year which is Critical-low), occurs at the end of each five year increment until 2025.

Normal Year

Table 5-15 compares the City's projected water supply and demand for normal hydrologic years occurring in 2006, 2010, 2015, 2020, 2025, and 2060. As shown in Table 5-15, if all of these available supplies could be effectively used, the City does have sufficient water supply available until 2015, and needs additional supplies sometime between 2015 and 2020. However, existing system infrastructure limitations currently prevent the City from using all of its water supplies. These existing system limitations would force the City to use up to 150,000 afa of stored groundwater by the year 2025 under the "status quo" condition.

Critical-Low Year

Table 5-16 compares the City's projected water supply and demand for Critical-low years in 2006, 2010, 2015, 2020, 2025, and 2060. As shown in Table 5-16, the City does not have sufficient water supplies, even if it could use all available supplies, during Critical-low year hydrologic conditions without continuing to exceed the estimated perennial yield from the groundwater basin, and extracting groundwater from basin storage. Operating under status quo conditions (i.e., meeting future demands with groundwater basin storage), the City will use up to 111,200 afa of groundwater in storage for year 2025 conditions. The amount of groundwater in storage used in a Critical-low year is less than the storage used in a normal year due to mandatory conservation (15 percent) in place during a Critical-low year.

Multiple Dry Years

For planning purposes, it was assumed that a multiple dry year would consist of three consecutive years (consistent with UWMP requirements). The supply available during the first two years would be equal to Dry year conditions, while the third year would be equal to Critical-low conditions (i.e., 1977).

Table 5-17 compares the City's projected water supply and demand for multiple (3) dry hydrologic years ending in 2010, in 2015, 2020, and 2025. As shown in Table 5-17, the City has sufficient water supplies (with surplus surface water and recharged recycled water) through 2013 during all water year types except in the Critical-low year, if the City were able to effectively use all of its available water resources. From 2013 to 2020, the City has insufficient supplies in all years except normal years. After 2021, the City has insufficient supplies in all years.

POTENTIAL IMPACTS OF CLIMATE CHANGE

A variety of studies by numerous worldwide organizations, including extensive analysis of decades of data, indicate that the Earth is undergoing significant temperature increases. Many scientists fear that the increased concentrations of greenhouse gases have prevented additional thermal radiation from leaving the Earth, have enhanced the heat-trapping capability of the earth's atmosphere, and are believed to be the cause of global warming. A great deal of climate research, coupled with extensive data gathering and analysis, has led to development of

Table 5-15. Comparison of Projected Water Supply and Demand in Normal Years, af

	Type	Source	2006	2010	2015	2020	2025	2060
Available	Surface Water	FID (Kings River)[a]	92,720	94,800	105,400	115,900	126,500	173,800
		USBR (CVP)[a]	58,200	58,200	58,200	58,200	58,200	58,200
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*164,720*	*166,800*	*177,400*	*187,900*	*198,500*	*245,800*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*201,720*	*201,800*	*209,400*	*217,900*	*225,500*	*272,800*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[e]	51,200	51,200	51,200	51,200	51,200	51,200
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*119,000*	*117,000*	*114,000*	*112,000*	*109,000*	*109,000*
Total Water Demand[f]			160,200	171,900	199,200	229,100	259,000	381,400
Additional Groundwater Pumped[g]			41,200	54,900	85,200	117,100	150,000	272,400
Annual Change in Groundwater Basin Storage[e]			(41,200)	(54,900)	(85,200)	(117,100)	(150,000)	(272,400)
Estimated Surface Water Supply Not Used by City			82,720	84,800	95,400	105,900	116,500	163,800
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100	35,100

(a) Data obtained from Table 5-13.

(b) For planning purposes, it was assumed that the City can recharge up to 65,100 af of recycled water per year and that it provides up to 30,000 af as extracted groundwater to FID. In exchange, FID provides up to 13,800 of up stream surface water (near the City's demand areas). The remaining supply (65,100 af – 30,000 af = 35,100 af) is not available to the City because it's existing system does not have the structural ability to move this water to where its water demands are located.

(c) Based on recent estimates from WRIME (see Chapter 7).

(d) For planning purposes, it was assumed that the SWTF is down for one month out of the year for canal maintenance.

(e) As discussed previously, this phase of the project assumes the City operates status-quo, which limits the City's ability to recharge the groundwater basin with surface water to the average recharge over the last seven years (2000 to 2006) of 51,200 af. Consequently, any additional groundwater pumped beyond estimated inflow and intentional recharge is assumed to come from basin storage. Phase 2 of this project will consider additional facilities that will enable the City to utilize more surface water and eliminate the need to use groundwater basin storage.

(f) Demands during a Critical-low year were reduced by 15% due to mandatory rationing.

(g) Under existing conditions, total groundwater pumpage must come from basin storage.

Table 5-16. Comparison of Projected Water Supply and Demand in Critical-low Years, af

	Type	Source	2006	2010	2015	2020	2025	2060
Available	Surface Water	FID (Kings River)[a]	48,080	49,200	54,600	60,100	65,600	90,100
		USBR (CVP)[a]	13,900	13,900	13,900	13,900	13,900	13,900
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*75,780*	*76,900*	*82,300*	*87,800*	*93,300*	*117,800*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*112,780*	*111,900*	*114,300*	*117,800*	*120,300*	*144,800*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[e]	44,980	46,100	51,200	51,200	51,200	51,200
		Total Surface Water	*75,780*	*76,900*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*112,780*	*111,900*	*114,000*	*112,000*	*109,000*	*109,000*
Total Water Demand[f]			136,200	146,100	169,300	194,700	220,200	324,200
Additional Groundwater Pumped[g]			23,420	34,200	55,300	82,700	111,200	215,200
Change in Groundwater Basin Storage[e]			(23,420)	(34,200)	(55,300)	(82,700)	(111,200)	(215,200)
Estimated Surface Water Supply Not Used by City			0	0	300	5,800	11,300	35,800
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100	35,100

(a) Data obtained from Table 5-13.

(b) For planning purposes, it was assumed that the City can recharge up to 65,100 af of recycled water per year and that it provides up to 30,000 af as extracted groundwater to FID. In exchange, FID provides up to 13,800 of up stream surface water (near the City's demand areas). The remaining supply (65,100 af – 30,000 af = 35,100 af) is not available to the City because it's existing system does not have the structural ability to move this water to where its water demands are located.

(c) Based on recent estimates from WRIME (see Chapter 7).

(d) For planning purposes, it was assumed that the SWTF is down for one month out of the year for canal maintenance.

(e) As discussed previously, this phase of the project assumes the City operates status-quo, which limits the City's ability to recharge the groundwater basin with surface water to the average recharge over the last seven years (2000 to 2006) of 51,200 af. Consequently, any additional groundwater pumped beyond estimated inflow and intentional recharge is assumed to come from basin storage. Phase 2 of this project will consider additional facilities that will enable the City to utilize more surface water and eliminate the need to use groundwater basin storage.

(f) Demands during a Critical-low year were reduced by 15% due to mandatory rationing.

(g) Under existing conditions, total groundwater pumpage must come from basin storage.

Table 5-17. Comparison of Projected Water Supply and Demand in Multiple Dry Years, af

	Type	Source	2006 (Normal)	2007 (ND)	2008 (D: 1987-1992)	2009 (D: 1987-1992)	2010 (CL)
Available	Surface Water	FID (Kings River)[a]	92,700	85,360	77,060	77,480	49,200
		USBR (CVP)[a]	58,200	56,200	39,800	39,800	13,900
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*164,700*	*155,360*	*130,660*	*131,080*	*76,900*
	Groundwater Inflow[e]		36,600	36,200	35,800	35,400	35,000
	Subtotal		*201,300*	*191,560*	*166,460*	*166,480*	*111,900*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[d]	51,200	51,200	51,200	51,200	46,100
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*76,900*
	Groundwater Inflow		36,600	36,200	35,800	35,400	35,000
	Subtotal		*118,600*	*118,200*	*117,800*	*117,400*	*111,900*
Total Water Demand[f]			160,200	163,100	149,400	152,100	146,100
Additional Groundwater Pumped[g]			41,600	44,900	31,600	34,700	34,200
Change in Groundwater Basin Storage[c]			(41,600)	(44,900)	(31,600)	(34,700)	(34,200)
Estimated Surface Water Supply Not Used by City			82,700	73,360	48,660	49,080	0
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100

	Type	Source	2011 (Normal)	2012 (ND)	2013 (D: 1987-1992)	2014 (D: 1987-1992)	2015 (CL)
Available	Surface Water	FID (Kings River)[a]	96,900	90,680	83,120	84,860	54,600
		USBR (CVP)[a]	58,200	56,200	39,800	39,800	13,900
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*168,900*	*160,680*	*136,720*	*138,460*	*82,300*
	Groundwater Inflow[e]		34,400	33,800	33,200	32,600	32,000
	Subtotal		*203,300*	*194,480*	*169,920*	*171,060*	*114,300*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[c]	51,200	51,200	51,200	51,200	51,200
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[e]		34,400	33,800	33,200	32,600	32,000
	Subtotal		*116,400*	*115,800*	*115,200*	*114,600*	*114,000*
Total Water Demand[f]			177,000	182,200	168,600	173,900	169,300
Total Groundwater Pumped			60,600	66,400	53,400	59,300	55,300
Change in Groundwater Basin Storage[c]			(60,600)	(66,400)	(53,400)	(59,300)	(55,300)
Estimated Surface Water Supply Not Used by City			86,900	78,680	54,720	56,460	300
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100

	Type	Source	2016 (Normal)	2017 (ND)	2018 (D: 1987-1992)	2019 (D: 1987-1992)	2020 (CL)
Available	Surface Water	FID (Kings River)[a]	107,500	100,380	91,820	93,560	60,100
		USBR (CVP)[a]	58,200	56,200	39,800	39,800	13,900
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*179,500*	*170,380*	*145,420*	*147,160*	*87,800*
	Groundwater Inflow[e]		31,600	31,200	30,800	30,400	30,000
	Subtotal		*211,100*	*201,580*	*176,220*	*177,560*	*117,800*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[c]	51,200	51,200	51,200	51,200	51,200
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[e]		31,600	31,200	30,800	30,400	30,000
	Subtotal		*113,600*	*113,200*	*112,800*	*112,400*	*112,000*
Total Water Demand[f]			205,200	211,200	195,400	200,800	194,700
Total Groundwater Pumped			91,600	98,000	82,600	88,400	82,700
Change in Groundwater Basin Storage[c]			(91,600)	(98,000)	(82,600)	(88,400)	(82,700)
Estimated Surface Water Supply Not Used by City			97,500	88,380	63,420	65,160	5,800
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100

	Type	Source	2021 (Normal)	2022 (ND)	2023 (D: 1987-1992)	2024 (D: 1987-1992)	2025 (CL)
Available	Surface Water	FID (Kings River)[a]	118,000	110,040	100,520	102,260	65,600
		USBR (CVP)[a]	58,200	56,200	39,800	39,800	13,900
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*190,000*	*180,040*	*154,120*	*155,860*	*93,300*
	Groundwater Inflow[e]		29,400	28,800	28,200	27,600	27,000
	Subtotal		*219,400*	*208,840*	*182,320*	*183,460*	*120,300*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[c]	51,200	51,200	51,200	51,200	51,200
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[e]		29,400	28,800	28,200	27,600	27,000
	Subtotal		*111,400*	*110,800*	*110,200*	*109,600*	*109,000*
Total Water Demand[f]			235,100	241,100	222,300	227,700	220,200
Total Groundwater Pumped			123,700	130,300	112,100	118,100	111,200
Change in Ground Water Basin Storage[c]			(123,700)	(130,300)	(112,100)	(118,100)	(111,200)
Estimated Surface Water Supply Not Used by City			108,000	98,040	72,120	73,860	11,300
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100

(a) Data obtained from Table 5-14.

(b) For planning purposes, it was assumed that the City can recharge up to 65,100 af of recycled water per year and that it provides up to 30,000 af as extracted groundwater to FID. In exchange, FID provides up to 13,800 of up stream surface water (near the City's demands). The remaining supply (65,100 af – 30,000 af = 35,100 af) is not available to the City because its existing system does not have the structural ability to move this water to where its water demands are located.

(c) As discussed previously, this phase of the project assumes the City operates status-quo, which limits the City's ability to recharge the groundwater basin with surface water to the average recharge over the last seven years (2000 to 2006) of 51,200 af. Consequently, any additional groundwater pumped beyond estimated inflow and intentional recharge is assumed to come from basin storage. Phase 2 of this project will consider additional facilities that will enable the City to utilize more surface water and eliminate the need to use groundwater basin storage.

(d) For planning purposes, it was assumed that the SWTF is down for one month out of the year for maintenance.

(e) Based on recent estimates by WRIME (see Chapter 7).

(f) Demands during a dry and critically low year were reduced by 10% and 15%, respectively

(g) Under existing conditions, total groundwater pumpage must come from basin storage.

sophisticated climate models by leading governmental and academic researchers. On the whole, these models indicate that climate change is forecasted to continue and in some cases accelerate. Most global circulation model runs predict global warming of more than 3°F by 2050 or earlier. Furthermore, warming closer to the poles and at high elevations could be even greater, with increased inter- and intra-season variability. This could have enormous implications over time to water resources management. DWR is beginning development of CAL SIM III, a computer simulation model used to evaluate State Water Project (SWP) and CVP operations, deliveries and reliability. CAL SIM III will include the impacts of climate change.

According to John Pierre Stephens of DWR, due to the area and elevation characteristics of the Kings and Upper San Joaquin watersheds, they are not as vulnerable to rising snow levels as most Sierra Nevada basins. Assuming that a 3°F increase in temperature results in a 1,000 foot rise the snow level, the snow covered area of the Kings watershed above Pine Flat would decrease from 76 percent to 69 percent if the snow level rose from 5,500 feet to 6,500 feet. Likewise, the snow covered area of the San Joaquin watershed above Millerton Lake would decrease from 72 percent to 62 percent with the same warming. These changes to the snowpack would shift some of the annual runoff volume from late spring and early summer snowmelt to direct runoff during winter storms and early spring snowmelt, and increase the frequency of high runoff events during winter.

The effect of these runoff pattern changes on water supply to the City will depend on several factors, including reservoir operations, which will also be affected by the increased need for flood control space. These competing demands for winter reservoir storage space will be even more of an issue for Millerton than for Pine Flat due to the low ratio of active storage space to annual mean runoff in Millerton. The net result will likely be to decrease the reliable yield of the existing reservoirs, however, at this time the exact amount of the decrease is uncertain.

Therefore, for purposes of this Phase 1 report, a decrease of 10 percent has been assumed for FID (Kings River) and USBR (CVP) supply availability to Fresno as a result of future climate change. Table 5-18 shows the impact of these potential reductions in future surface water supply availability during normal years. Although the future availability of surface water supplies is potentially impacted, under the assumptions of this Phase 1 Report, assuming that future demands will be met from groundwater basin storage, the potential impacts of climate change do not impact the results previously presented in Table 5-15; this is because the currently available surface water supplies exceed the City's surface water treatment capacity. However, the potential impacts of climate change may be more of an issue to the City in the future if the City decides to rely more on surface water (by increasing surface water treatment capacity) and less on groundwater in the future.

Table 5-18. Comparison of Projected Water Supply and Demand in Normal Years Considering Future Climate Change, af

	Type	Source	2006	2010	2015	2020	2025	2060
Available	Surface Water	FID (Kings River)[a]	83,400	85,300	94,900	104,300	113,800	156,400
		USBR (CVP)[a]	52,400	52,400	52,400	52,400	52,400	52,400
		Recharge (Recycled)[a,b]	13,800	13,800	13,800	13,800	13,800	13,800
		Total Surface Water	*149,600*	*151,500*	*161,100*	*170,500*	*180,000*	*222,600*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*186,600*	*186,500*	*193,100*	*200,500*	*207,000*	*249,600*
Usable	Surface Water	SWTF[d]	30,800	30,800	30,800	30,800	30,800	30,800
		Recharged & Extracted[e]	51,200	51,200	51,200	51,200	51,200	51,200
		Total Surface Water	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*	*82,000*
	Groundwater Inflow[c]		37,000	35,000	32,000	30,000	27,000	27,000
	Subtotal		*119,000*	*117,000*	*114,000*	*112,000*	*109,000*	*109,000*
Total Water Demand			160,200	171,900	199,200	229,100	259,000	381,400
Additional Groundwater Pumped[f]			41,200	54,900	85,200	117,100	150,000	272,400
Annual Change in Groundwater Basin Storage[e]			(41,200)	(54,900)	(85,200)	(117,100)	(150,000)	(272,400)
Estimated Surface Water Supply Not Used by City			82,720	84,800	95,400	105,900	116,500	163,800
Recharged Recycled Water Not Used[b]			35,100	35,100	35,100	35,100	35,100	35,100

(a) Data obtained from Table 5-13. Available surface water supplies from FID (Kings River) and USBR (CVP) are assumed to be reduced by 10 percent due to the impacts of future climate change.

(b) For planning purposes, it was assumed that the City can recharge up to 65,100 af of recycled water per year and that it provides up to 30,000 af as extracted groundwater to FID. In exchange, FID provides up to 13,800 of up stream surface water (near the City's demand areas). The remaining supply (65,100 af – 30,000 af = 35,100 af) is not available to the City because it's existing system does not have the structural ability to move this water to where its water demands are located.

(c) Based on recent estimates from WRIME (see Chapter 7).

(d) For planning purposes, it was assumed that the SWTF is down for one month out of the year for canal maintenance.

(e) As discussed previously, this phase of the project assumes the City operates status-quo, which limits the City's ability to recharge the groundwater basin with surface water to the average recharge over the last seven years (2000 to 2006) of 51,200 af. Consequently, any additional groundwater pumped beyond estimated inflow and intentional recharge is assumed to come from basin storage. Phase 2 of this project will consider additional facilities that will enable the City to utilize more surface water and eliminate the need to use groundwater basin storage.

(f) Under existing conditions, total groundwater pumpage must come from basin storage.

EFFECTS OF "STATUS QUO" WATER SUPPLY STRATEGY

During Phase 1 of this study, it has been assumed that the City would continue to operate at "status quo" (i.e., meeting future demands from groundwater basin storage and the existing 30 mgd SWTF), assuming no modifications to its existing water system to use more of its available water supply. Future modifications and/or operational changes will be discussed and evaluated in Phase 2. Consequently, the purpose of this section is to briefly evaluate the long-term implications and costs to the City of continuing to operate at "status quo."

Long-term Implications of Operating at "Status Quo"

As shown previously in Table 5-15, the City would will use approximately 150,000 af per year of stored groundwater by 2025 during a normal hydrologic water year if it continues to meet increasing demands from the groundwater basin. With already declining groundwater levels, each year the City continues to operate in this mode would continue to accelerate groundwater level declines in the basin, and further impact available groundwater resources in the region.

Figure 5-16 illustrates the cumulative stored groundwater that would be used, and surface water supplies not used, during normal hydrologic water years assuming the City continues its current operational practices. It should be noted that the analysis presented in Figure 5-16 does not consider annual variations in hydrologic conditions, and as such is presented only to demonstrate the potential future effects of groundwater use under normal year hydrologic supply conditions under "status quo" operations. Chapter 7 presents an evaluation of potential future impacts on the groundwater basin under varying land use and hydrologic conditions. As shown in Figure 5-16, under the aforementioned conditions, the City would use approximately 1.83 million acre-feet (MAF) of stored groundwater by the year 2025 if it operates at "status quo". However, if all available surface water is effectively used to meet projected City demands, then approximately 195,000 af of net positive groundwater storage could be added to the basin by 2025. Figure 5-16 also indicates that beyond 2025, the City has insufficient water supplies and therefore, net groundwater storage eventually becomes negative.

Removing 1.83 MAF of groundwater from this portion of the Kings subbasin would not be practical, as this would essentially "mine" the groundwater basin beneath the City's water service area. Additionally, the groundwater level decrease associated with mining 1.83 MAF of groundwater would likely further degrade water quality and could possibly cause subsidence either locally or regionally. Clearly, Phase 2 will need to address this issue by identifying alternative and/or new system or operational changes that will allow the City to better use its available water supplies.

Estimated Capital Costs of Operating at "Status Quo"

Under existing conditions ("status quo"), the City has very limited above-ground storage, and must meet peak hour demand almost entirely from its groundwater supplies. For planning purposes, it was assumed that the City must meet any portion of its peak hour demand, not met with supply from the existing SWTF or existing above-ground storage, with its groundwater wells. Since the City's peak hour demand condition is larger than the maximum day demand condition, the water system infrastructure and supplies must be designed to enable the system to meet these peak hour demand. Therefore, the number of operational and available City wells needs to be sufficient to meet the City's peak hour demands, now and in the future. Peak hour is the controlling condition since the maximum day condition has a lower demand.

The total projected annual demand at buildout of the City's existing general plan (2025) is approximately 259,000 af. The projected peak hour demand in 2025 would be approximately 670 mgd (230 mgd average day demand times 2.9, see Chapter 3). To be able to serve this anticipated future peak hour demand, assuming the City's existing SWTF (30 mgd) is not expanded and that the City's existing limited storage is utilized, the City will require approximately 640 mgd of groundwater pumping capacity.

The City's current groundwater pumping capacity is only 419 mgd, which is decreasing at a rate of approximately 6.1 mgd per year (i.e., 5.3 wells per year, see Figure 5-10). Consequently, the capital cost of operating at "status quo" must include a combination of wellhead treatment and. replacement of wells in contaminated areas to maintain the existing groundwater production capacity of 419 mgd, and new wells to reliably increase the total groundwater production capacity from 419 mgd to 640 mgd.

Cost of Maintaining Existing Pumping Capacity

As listed in Table 5-19, a number of the City's wells are currently being treated or blended to address various contaminants. Thirty (30) active wells and eight (8) inactive wells have current wellhead treatment (either granular activated carbon (GAC) or packed tower aeration (PTA)) to remove either DBCP or TCE. Also, two (2) wells are being blended, ten (10) wells have blending plans, and two (2) wells have blending plans under review to address high nitrate concentrations. For purposes of this study, it has been assumed that budgeting for these "blending" facilities has already been accounted for in the City's capital improvement program.

However, there are also a number of additional wells which will require wellhead treatment to treat high TCP concentrations. It should be noted that while no current MCL exists for TCP, DHS is concerned and has identified twenty-nine (29) existing City wells with TCP concentrations that exceed the action level of 0.005 ppb (see Table 5-20).

Therefore, for purposes of this study, it was assumed that a total of 35 additional, existing wells will require wellhead treatment between now and 2025 (the 29 wells identified by DHS plus 6 additional wells to be determined based on additional identified contaminants or migrating plumes). Based on the estimated average well production of these wells of about 800 gpm, and a wellhead treatment cost of approximately $1.4 million per 700 gpm (1 mgd) of production capacity (see Appendix H), the cost to provide wellhead treatment on these 35 additional wells between now and 2025 is estimated to be $56 million. It should be noted that this cost does not include costs to treat for other additional contaminants or other additional wells (beyond the 35 wells assumed above).

Table 5-19. City Wells with Current Wellhead Treatment or Blending Plans[(a)]

Well Number	Contaminant of Concern			Treatment Method	Well Status
	DBCP	TCE	Nitrate		
8A	✔			GAC	Active
55-1	✔		✔	GAC; has blending plan	Active
55-2			✔	Has blending plan	Active
70		✔		PTA/GAC	Active
82-1[(b)]	✔			GAC	Active
85[(b)]	✔			GAC	Active
89A	✔			GAC	Active
110[(b)]	✔			GAC	Inactive due to sand and nitrates
135A[(b)]	✔			GAC	Active
137[(b)]	✔			GAC	Active
152	✔			GAC	Active
153-1			✔	Has blending plan	Active
153-2	✔		✔	GAC; Has blending plan	Active
159		✔		GAC	Active
164-2[(b)]	✔			GAC	Active
168-2	✔			GAC	Inactive (unknown reason)
175-2	✔			GAC	Active
176	✔			GAC	Active
180-1			✔	Has blending plan	Active
180-2	✔		✔	GAC; Has blending plan	Active
182-1			✔	Has blending plan	Active
182-2	✔		✔	GAC; has blending plan	Active
184[(b)]	✔		✔	GAC; has blending plan	Active
185	✔			GAC	Inactive due to nitrates
186	✔			GAC	Active
201	✔			GAC	Inactive due to nitrates
202	✔			GAC	Active
205	✔			GAC	Active
224	✔			GAC	Active
225	✔		✔	GAC; has blending plan	Active
253-2A	✔			GAC	Inactive due to nitrates
274[(b)]	✔			GAC; being actively blended with Well 275	Inactive due to nitrates
275[(b)]	✔			GAC; being actively blended with Well 274	Active
276	✔			GAC	Inactive due to nitrates
277[(b)]	✔			GAC	Active
279		✔		PTA	Active
283		✔		GAC	Active
286		✔		GAC	Active
289-2[(b)]	✔			GAC	Active
297-1	✔			GAC; blending plan under review by DPHS (DHS)	Inactive due to sand and nitrates
297-2	✔			GAC; blending plan under review by DPHS (DHS)	Active
308	✔			GAC	Active
Total Number of Wells	25 active 8 inactive	5 active	10		

(a) Source: City spreadsheet listed City of Fresno Production Wells with Wellhead Treatment dated October 19, 2006 and October 26, 2006 e-mail from Brock Buche listing sites with nitrate blending plans.
(b) These wells also have been identified by DHS as having TCP concentrations which exceed the action level of 0.005 ppb (see Table 5-20).

Table 5-20. City Wells with TCP Concentrations Exceeding the Current Action Level of 0.005 ppb[(a)]

City Wells with TCP Concentrations Exceeding the Current Action Levels of 0.005 ppb				
014A	059	101	184	274
018A	063	110	219	275
021A	065	135A	220	277
039A	070	137	230	289-2
040A	082	164-1	231	298
048	085	165-2	240	

(a) Source: March 1, 2004 letter from DHS to Lon Martin, City of Fresno. It should be noted that the DHS letter listed 35 wells. Only 29 wells are listed in Table 5-20, as the DHS letter listed a few wells twice.

Cost of Increasing the City's Groundwater Capacity

The costs presented above only include the cost to maintain the City's current capacity at 419 mgd; however, the actual reliable capacity required (for peak hour) in 2025 is 640 mgd. Therefore, the City needs to reliably increase its groundwater production capacity by approximately 220 mgd. Assuming that 10 percent of the City's wells are out of service for maintenance or other periodic modifications, an additional 157 wells (assuming each new well in the east produces about 800 gpm and each new well in the west produces 2,000 gpm) are required to reliably produce 640 mgd (see additional discussion in Chapter 6).

As discussed in Chapter 6, the average cost of a new well is estimated by the City to be about $675,000, fully equipped, including a 50 percent markup to account for construction contingencies, engineering, construction management, and implementation costs. Consequently, it will cost an additional $106 million (157 wells at $675,000 each) to reliably increase the City's existing groundwater production capacity to 640 mgd. This cost does not include the funding necessary to secure property for the wells. In addition, as described in Chapter 6, additional distribution pipelines would be required to deliver the water supplies from the new wells to customers. The estimated costs for these facilities are $390 million.

Total Cost of Operating at "Status Quo"

The total "capital" cost of operating under "status quo" conditions for the City of Fresno is estimated to be at $56 million for maintaining the City's existing groundwater production capacity, another $106 million to increase the groundwater production capacity to 640 mgd, and $390 million for new pipelines, or approximately $553 million. This cost does not include the environmental impacts (water quality, possible subsidence, loss of resource) associated with mining 1.83 MAF from the Kings subbasin in the vicinity of the City's water service area, or potential costs associated with providing wellhead treatment on any of the proposed new wells.

It should be noted that costs for improvements required to serve new development will be paid by developers through the City's Urban Growth Management (UGM) fees.

Additional discussion of these issues is provided in Chapter 6.

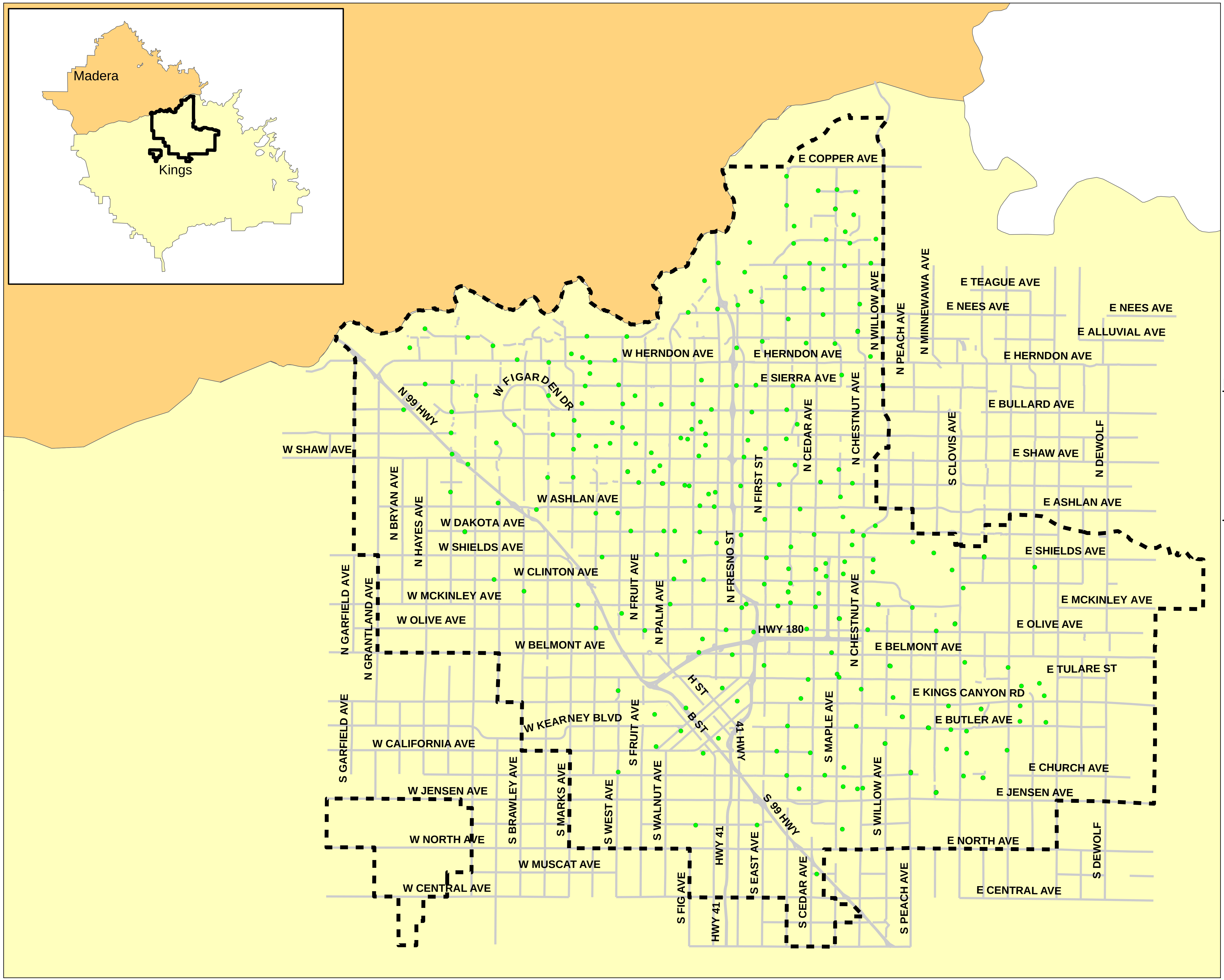


FIGURE 5-1

City of Fresno Metropolitan Water Resources Management Plan Update

KINGS GROUNDWATER SUBBASIN

N

0 1 2 4

Scale in Miles

NOTES:

LEGEND:

- City of Fresno Sphere of Influence
- Active City of Fresno Well
- Kings Groundwater Subbasin
- Madera Groundwater Subbasin

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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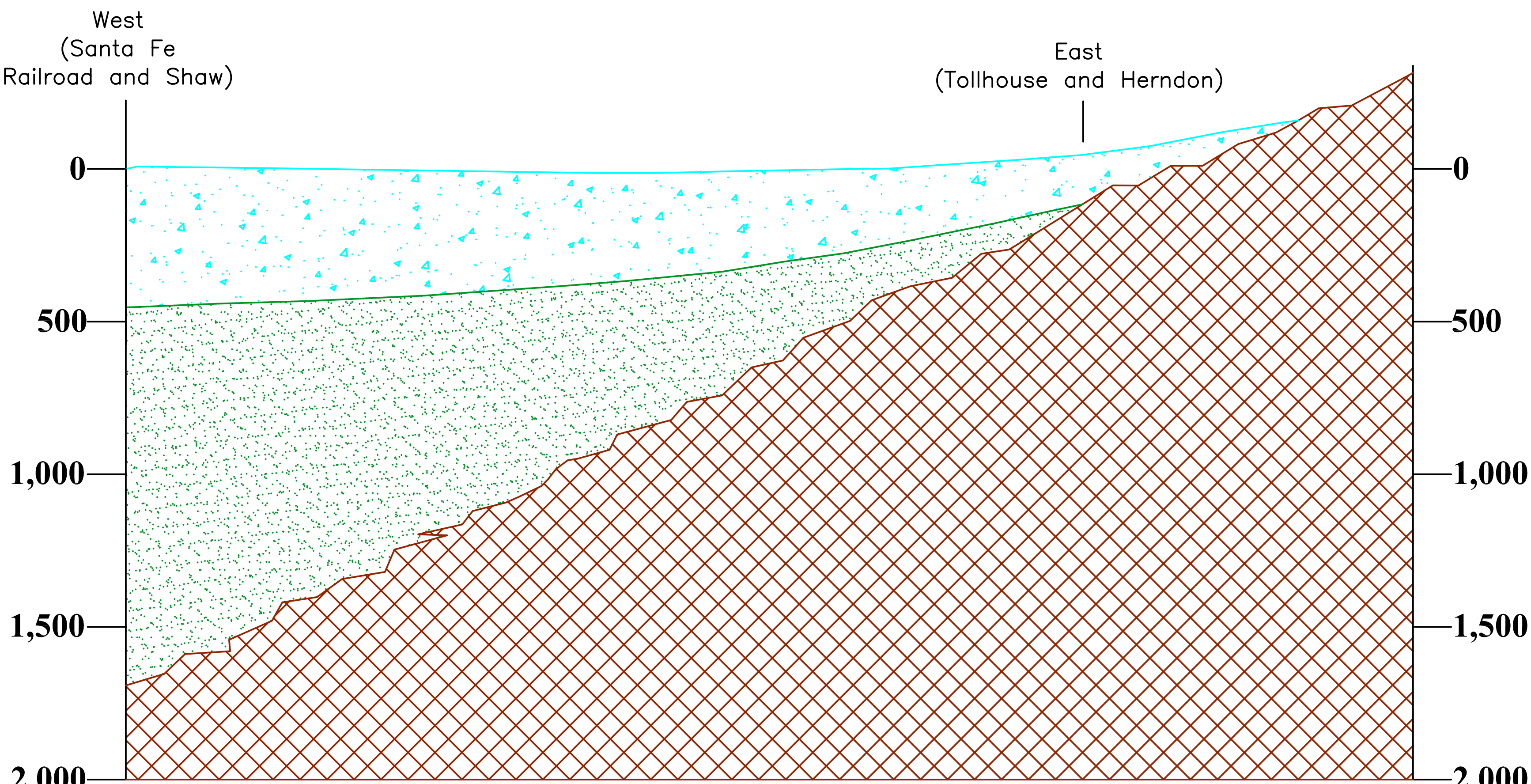

*Reference: Fresno/Clovis Metropolitan Water Resources Management Plan, Phase I Report: Figure 3–1

Vertical Scale: 1–inch = 500 feet

No Horizontal Scale

LEGEND

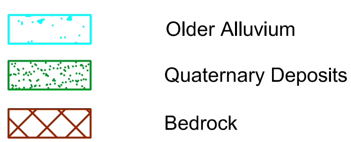

FIGURE 5-2

City of Fresno
Metropolitan Water Resources
Management Plan Update
IDEALIZED EAST-WEST
CROSS-SECTION

WEST YOST ASSOCIATES
Consulting Engineers

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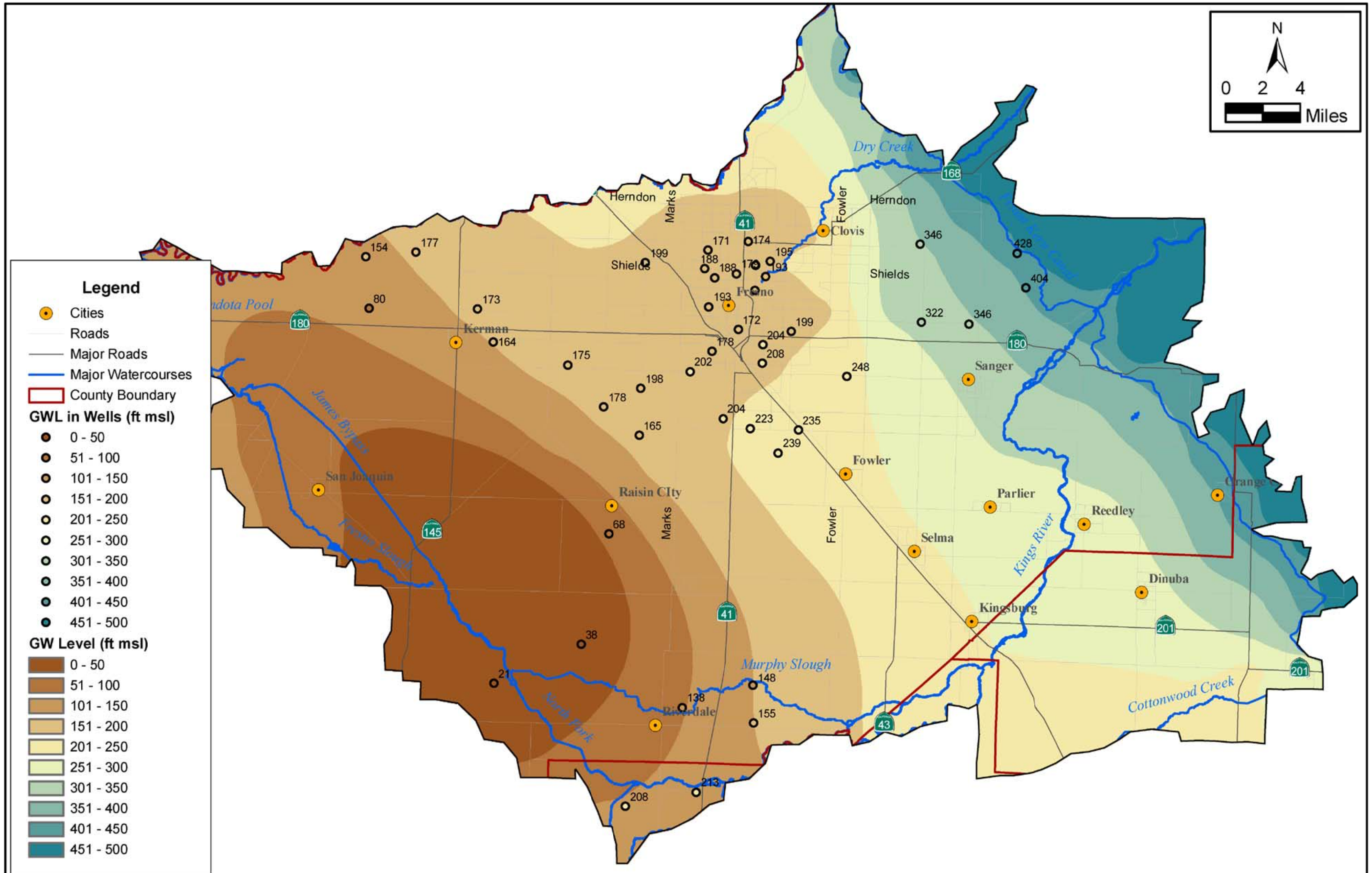
FIGURE 5-3

City of Fresno Metropolitan Water Resources Management Plan Update

REGIONAL GROUNDWATER LEVELS



Simulated Groundwater Levels (Spring 2004)

Kings IGSM Model Development and Calibration

July 2007

Figure 6-16

WRIME

NOTES:

Source: WRIME, July 2007

LEGEND:

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Chapter 5\FIG05-03_110807cn1 GWLevels.dwg DATE: 11-08-07 4:26pm

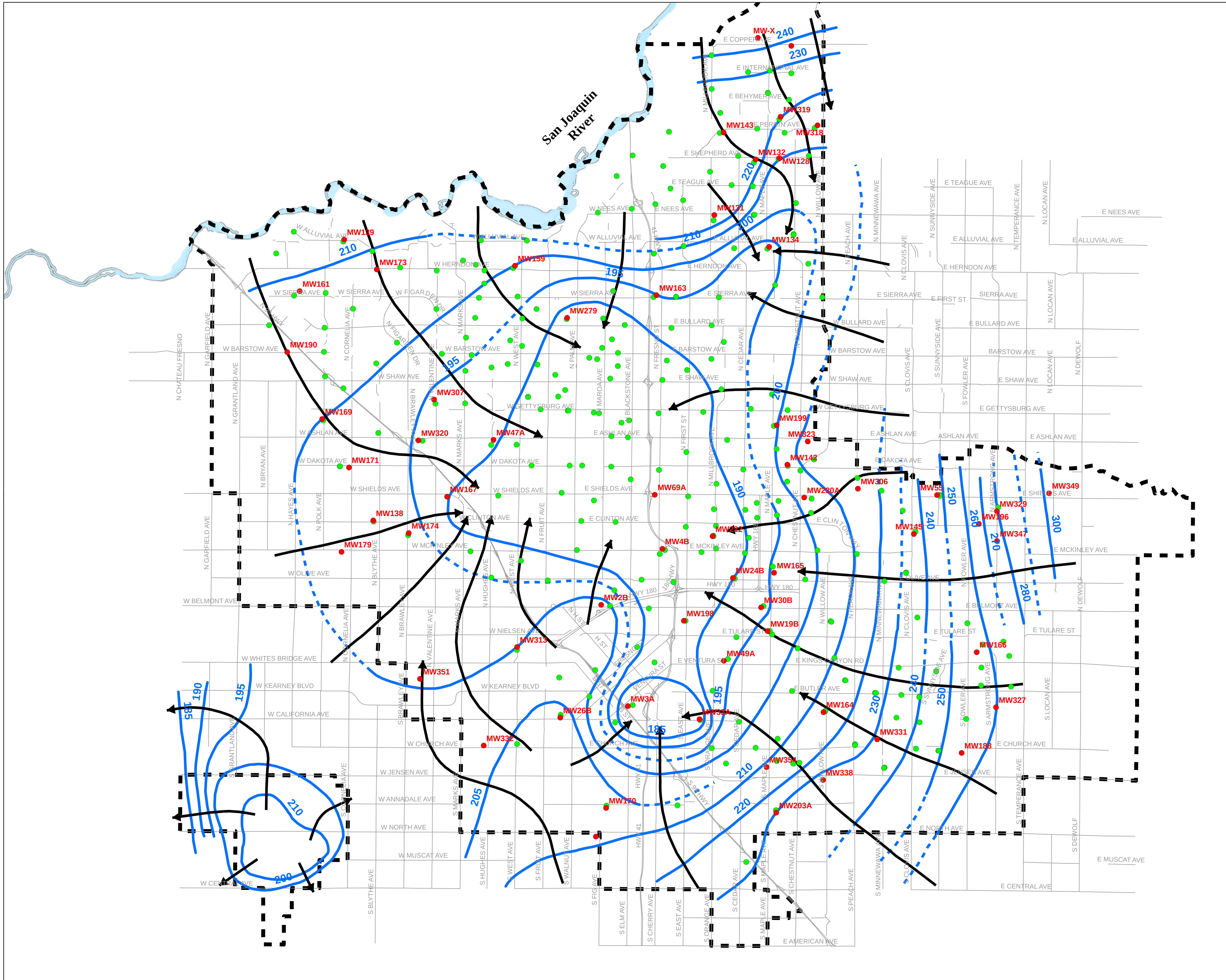


FIGURE 5-4

City of Fresno Metropolitan Water Resources Management Plan Update

SPRING 2006 GROUNDWATER ELEVATIONS IN THE UPPER AQUIFER ZONE (elevation above mean sea level)

0 0.5 1 2
Scale in Miles

NOTES:

- All data, including interpretation of groundwater elevation iso-contour lines provided by Schmidt & Associates (see Appendix G)

LEGEND:

- City of Fresno Sphere of Influence
- Active City Well
- Monitoring Well
- Estimated Upper Zone Groundwater Elevation
- Upper Zone Groundwater Elevations
- Generalized Direction of Groundwater Flow

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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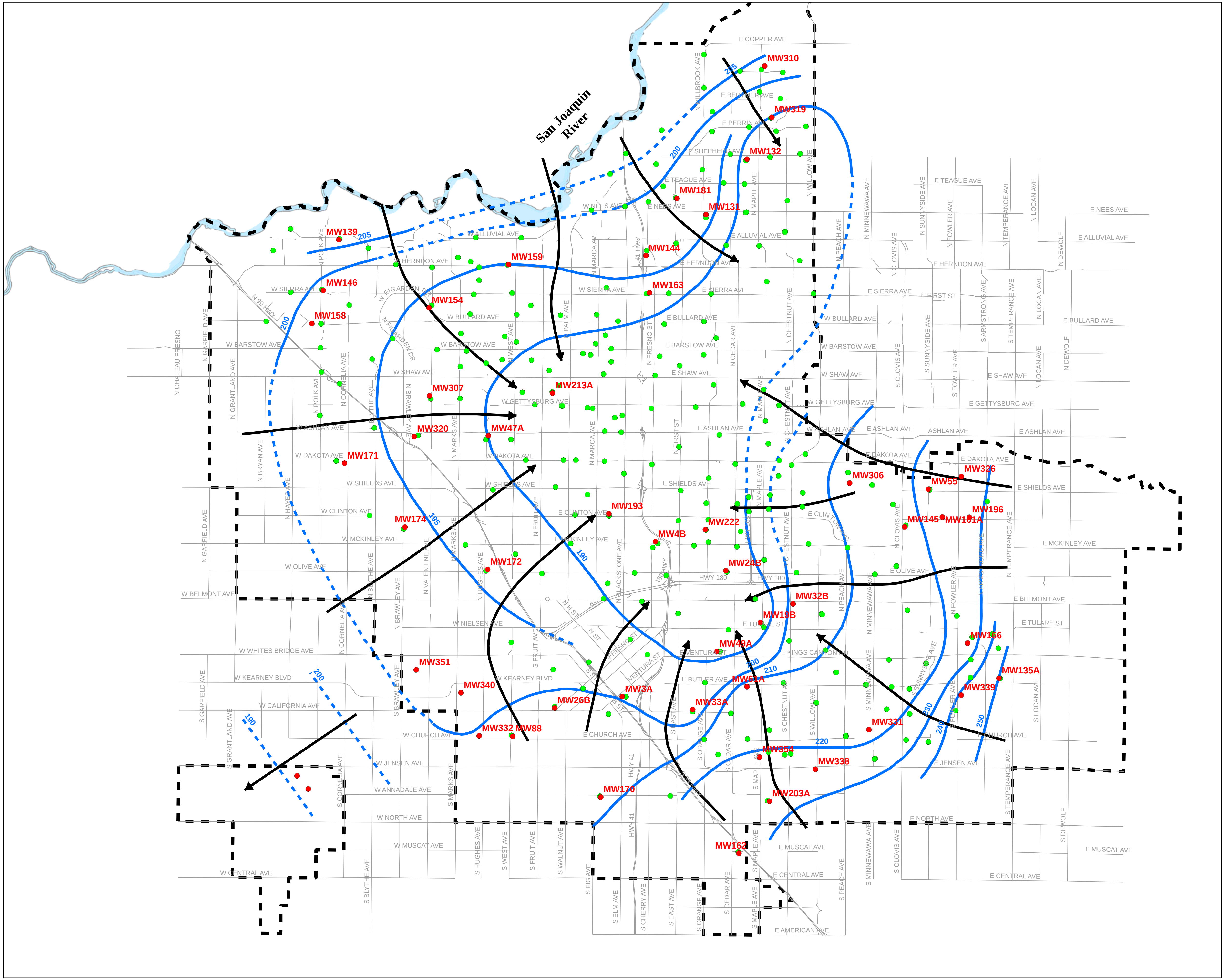

FIGURE 5-5

City of Fresno Metropolitan Water Resources Management Plan Update

SPRING 2006 GROUNDWATER ELEVATIONS IN THE LOWER AQUIFER ZONE (elevation above mean sea level)

N

0 0.5 1 2
Scale in Miles

NOTES:

- All data, including interpretation of groundwater elevation iso-contour lines provided by Schmidt & Associates (see Appendix G)

LEGEND:

- City of Fresno Sphere of Influence
- Active City Well
- Monitoring Well
- Estimated Lower Zone Groundwater Elevation
- Lower Zone Groundwater Elevation
- Generalized Direction of Groundwater Flow

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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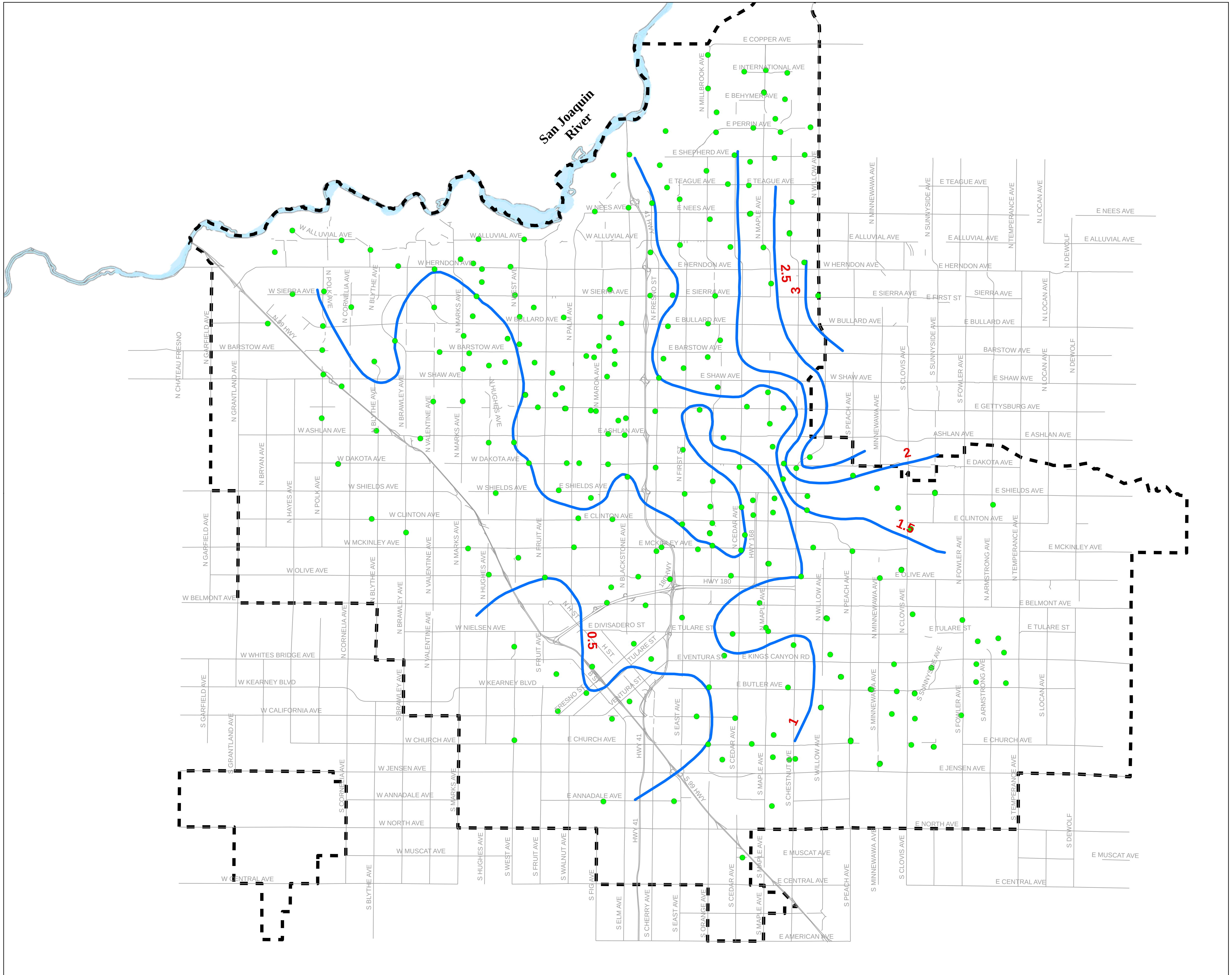


FIGURE 5-6

City of Fresno Metropolitan Water Resources Management Plan Update

AVERAGE ANNUAL WATER LEVEL DECLINE (Past 30 Years)

N

0 0.5 1 2

Scale in Miles

NOTES:

- All data, including interpretation of groundwater elevation iso-contour lines provided by Schmidt & Associates (see Appendix G)

LEGEND:

City of Fresno Sphere of Influence

Active City Well

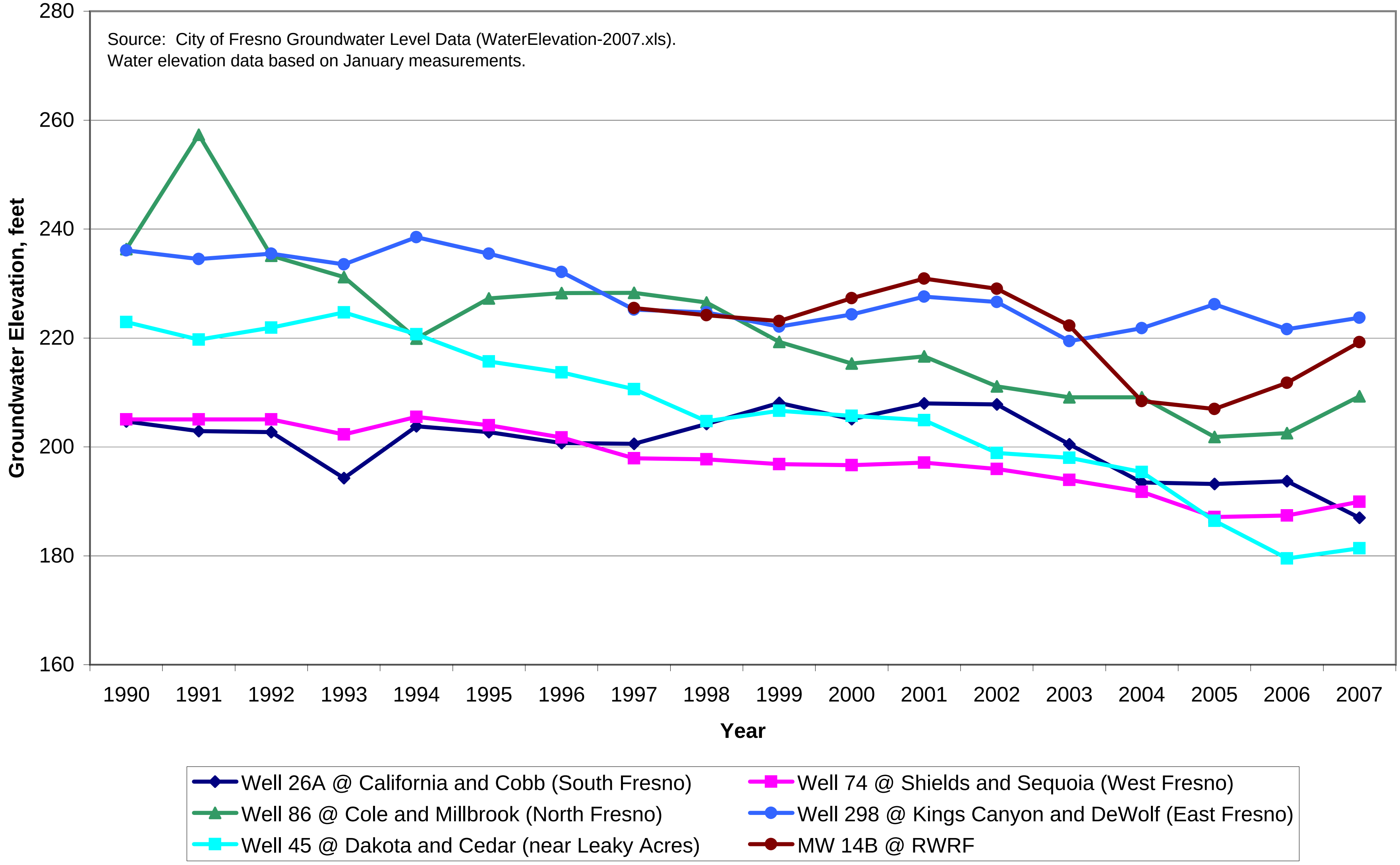
Average Annual Water Level Decline (in ft/year)

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

O:\C\439\020501\GIS\Phase1\Ch05\439020501-FIG0506cn1.mxd

Figure 5-7. Groundwater Elevation Hydrographs for Selected City of Fresno Wells



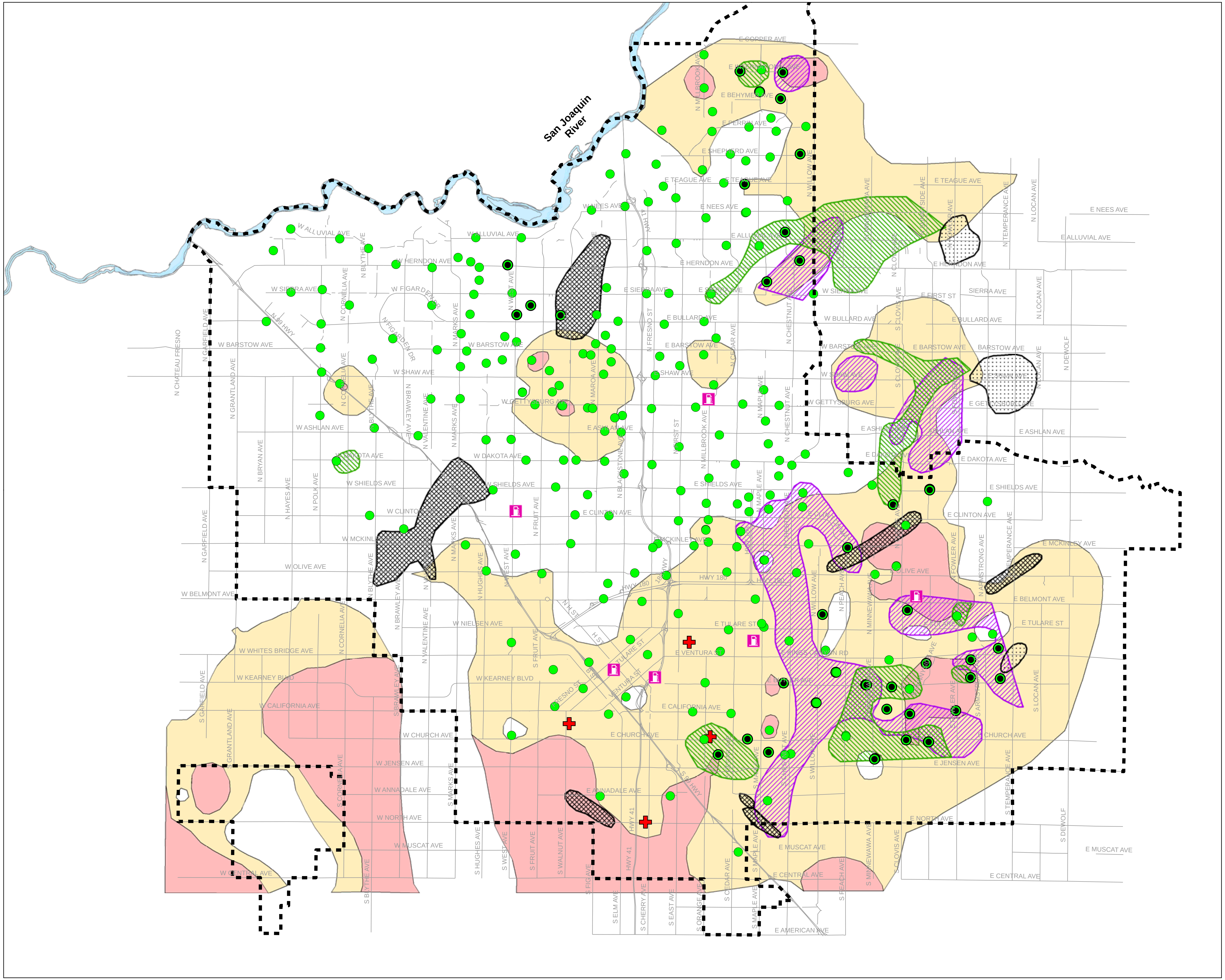


FIGURE 5-8

City of Fresno Metropolitan Water Resources Management Plan Update

REGIONAL GROUNDWATER CONTAMINATION

N

0 0.5 1 2

Scale in Miles

NOTES:

LEGEND:

- City of Fresno Sphere of Influence
- Active City Well
- Well with Wellhead Treatment and/or Blending Plan (See Table 5-19)
- Superfund Site (Old)
- Gasoline Case (Old)
- EDB Plume (Old)
- Point Source Plume (Old)
- DBCP Plume (> 0.1 ppb)
- TCP Plume (> 0.01 ppb)

Nitrates

- Nitrate > 20 mg/L
- Nitrate > 40 mg/L

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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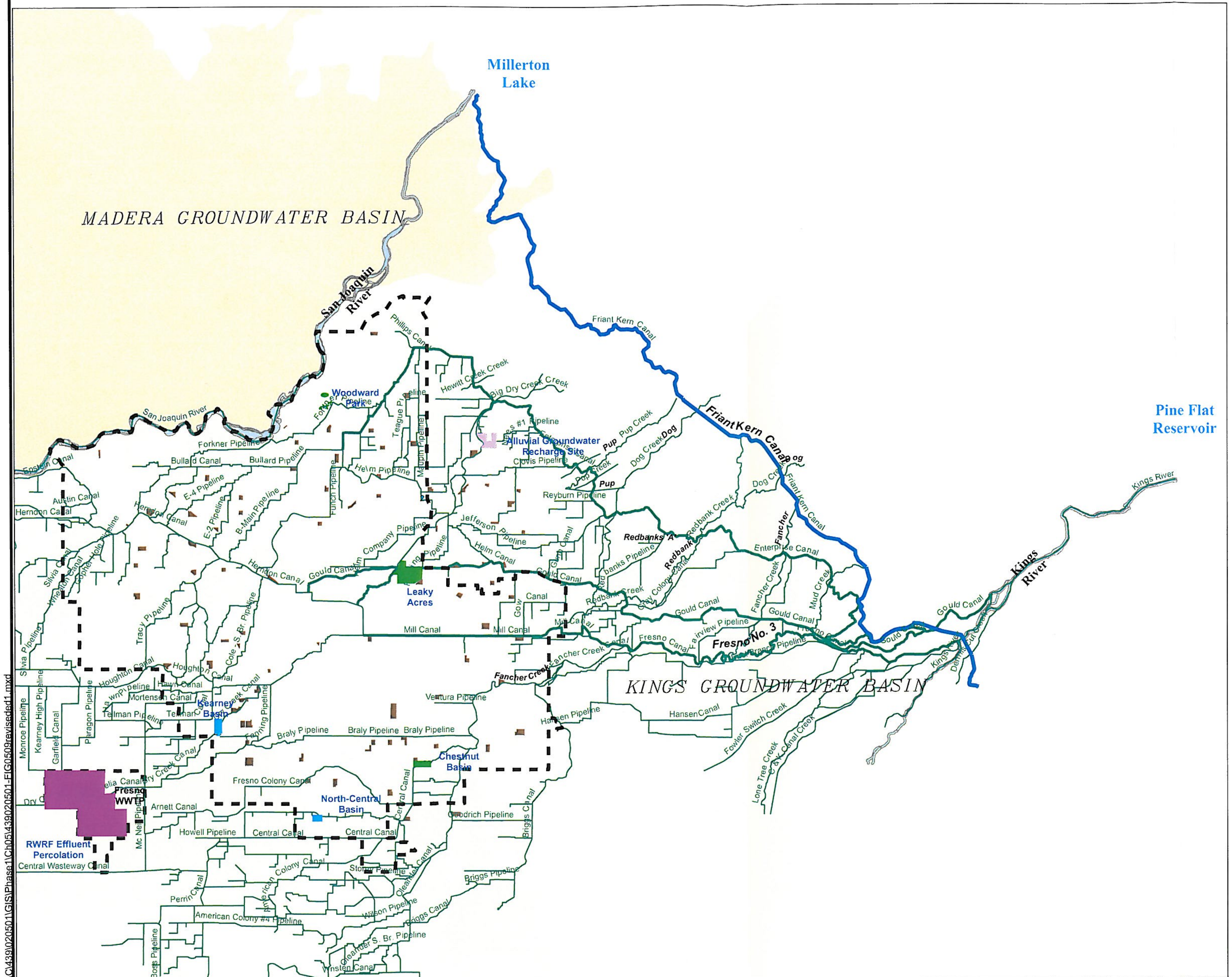

FIGURE 5-9

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING RECHARGE FACILITIES

N

0 1 2 4

Scale in Miles

NOTES:

1. Shows only basins used for groundwater recharge. Some of these FMFCD basins are dual use. FMFCD basin locations based on data provided by City (December 2007).

LEGEND:

- City of Fresno Sphere of Influence
- Friant Kern Canal
- Major FID Canals
- Other FID Canals
- City of Fresno Basins
- FMFCD Basins Used for GW Recharge
- FID Basins
- City of Clovis Basin
- RWRF Effluent Percolation
- Kings Groundwater Subbasin
- Madera Groundwater Subbasin

Fresno All-America City 2000

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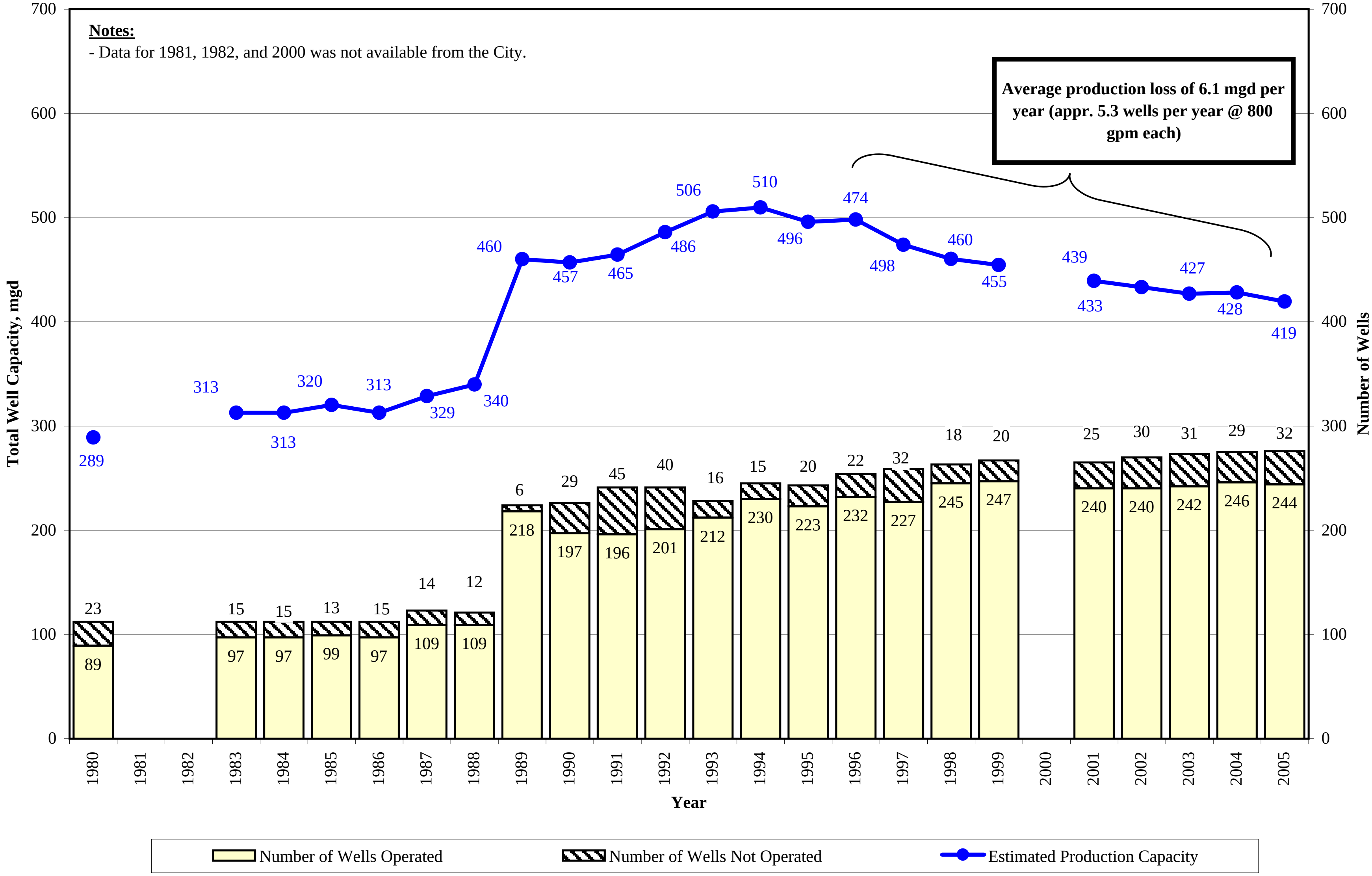
Figure 5-10. Historical Groundwater Production Capacity



Last Revised: 11/06/07

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City of Fresno

Phase 1 Report

Figure 5-11. FID Kings River Water Applicable to City's Agreement

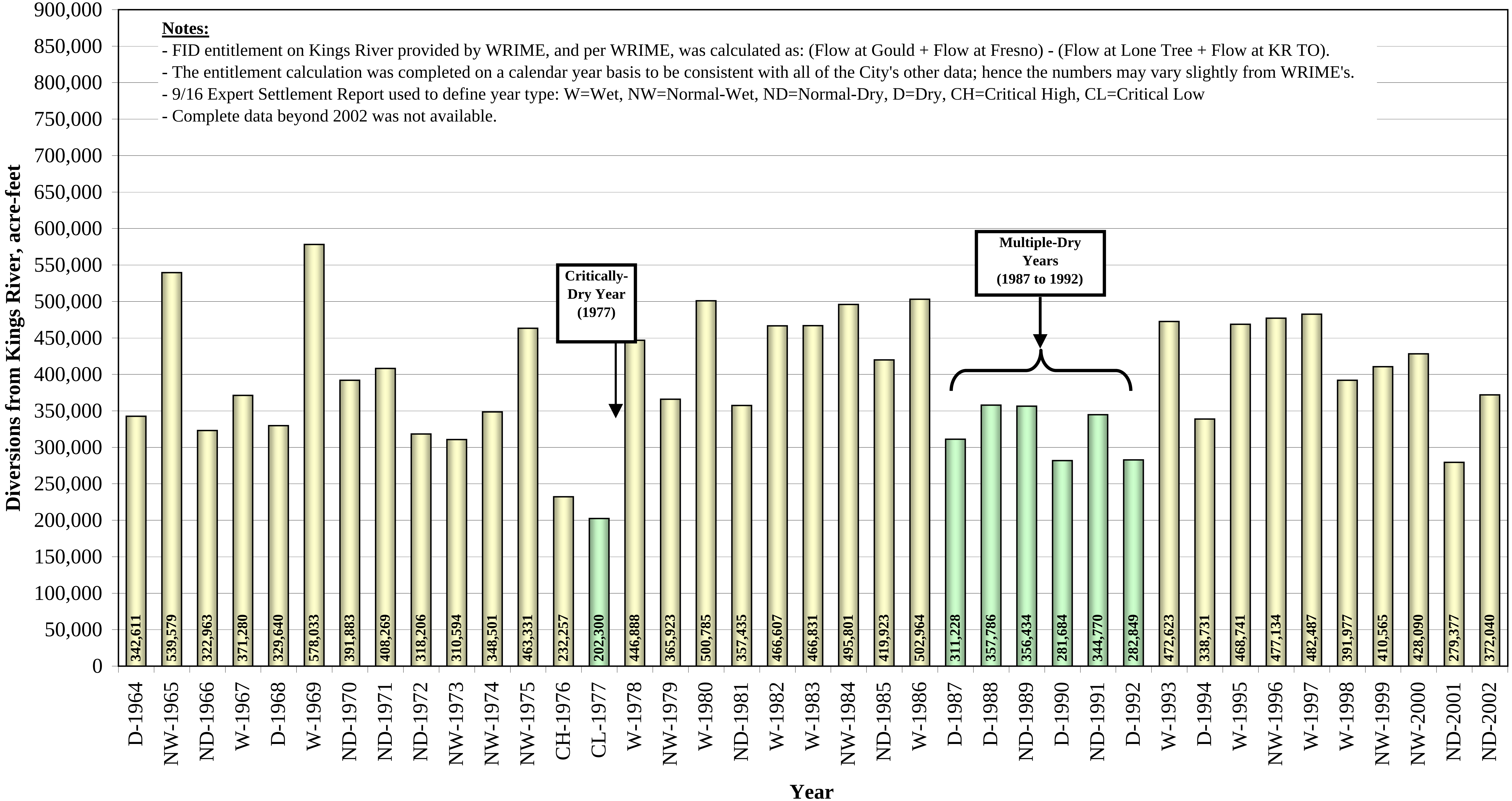


Figure 5-12. Bureau Deliveries to the City of Fresno: 32-Year History

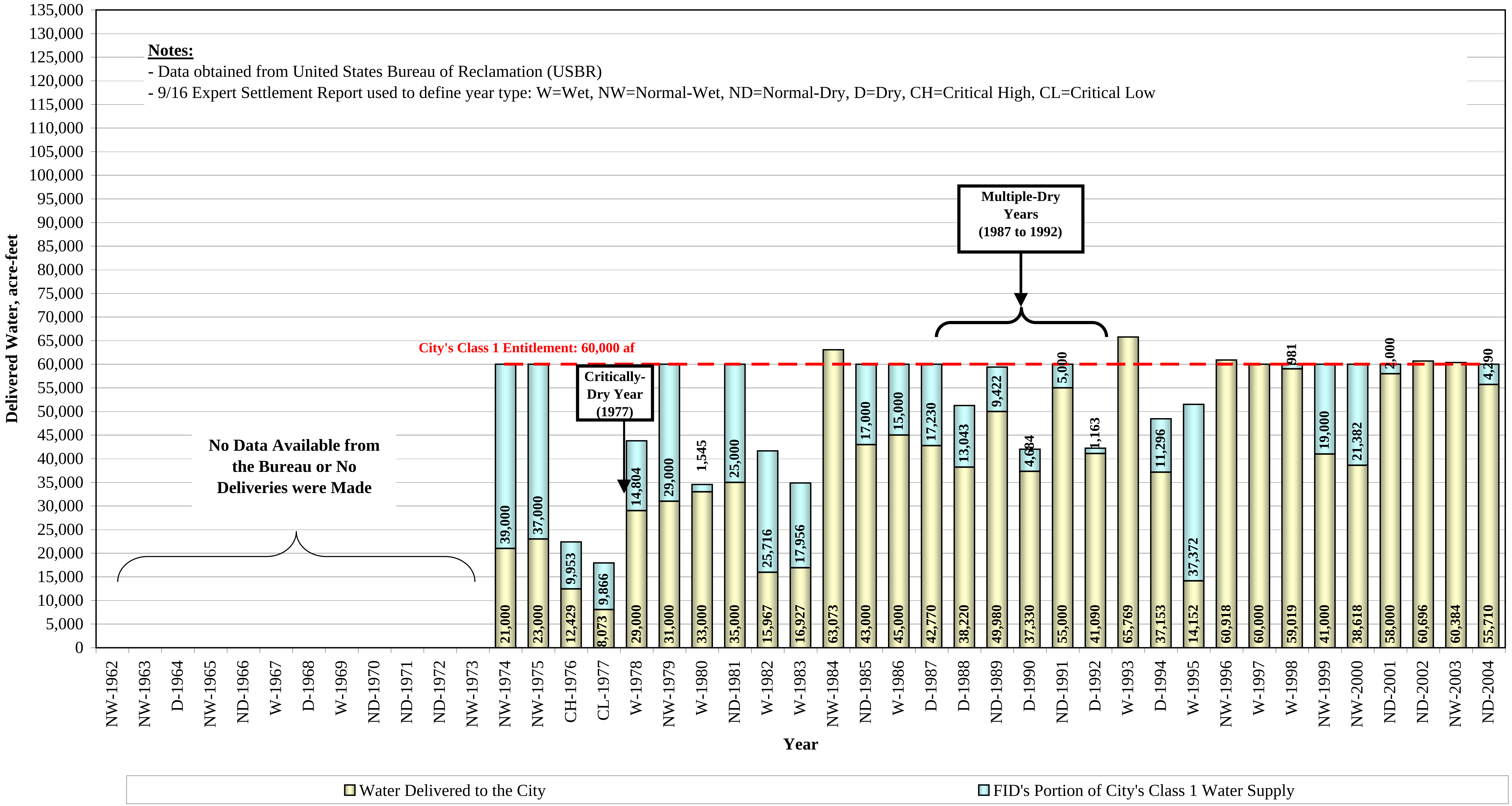


Figure 5-13. Bureau Deliveries to the City of Fresno Adopted from the 2006 Settlement Agreement

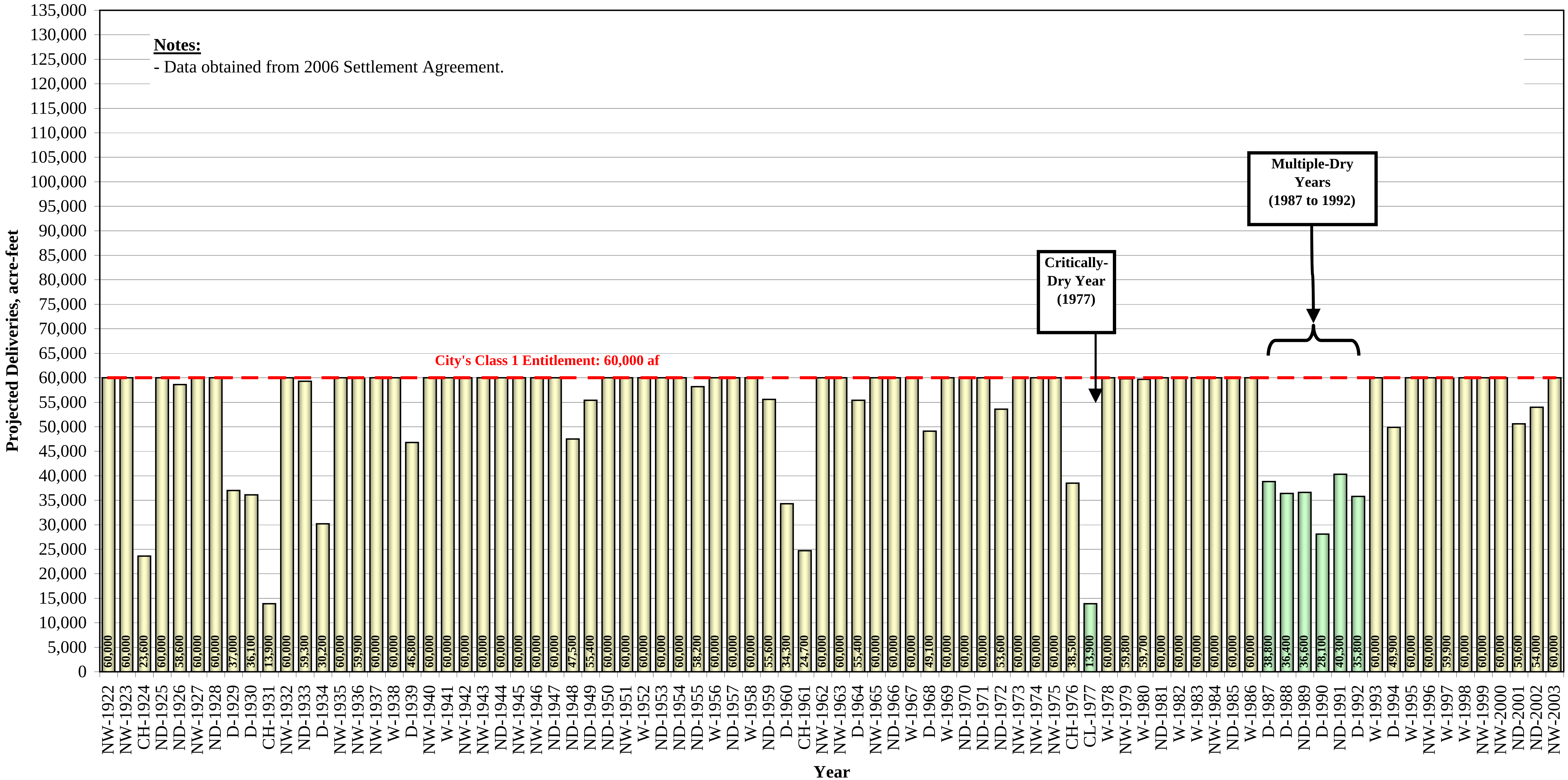


Figure 5-14. Historical Quantity of Treated Effluent Sent to Ponds for Percolation

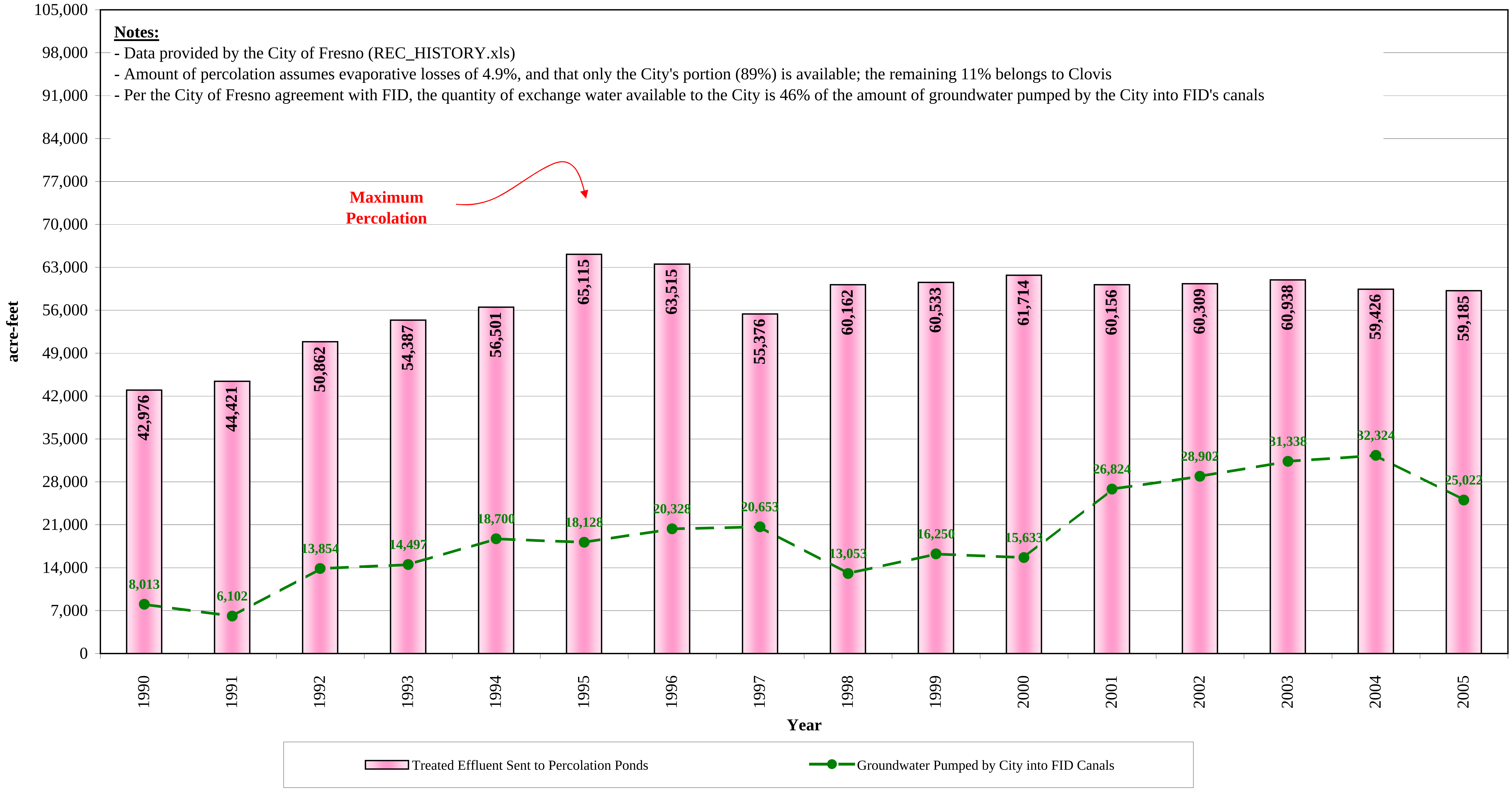


Figure 5-15. 2025 Estimated Annual Long-Term Groundwater Pumpage: Existing Conditions

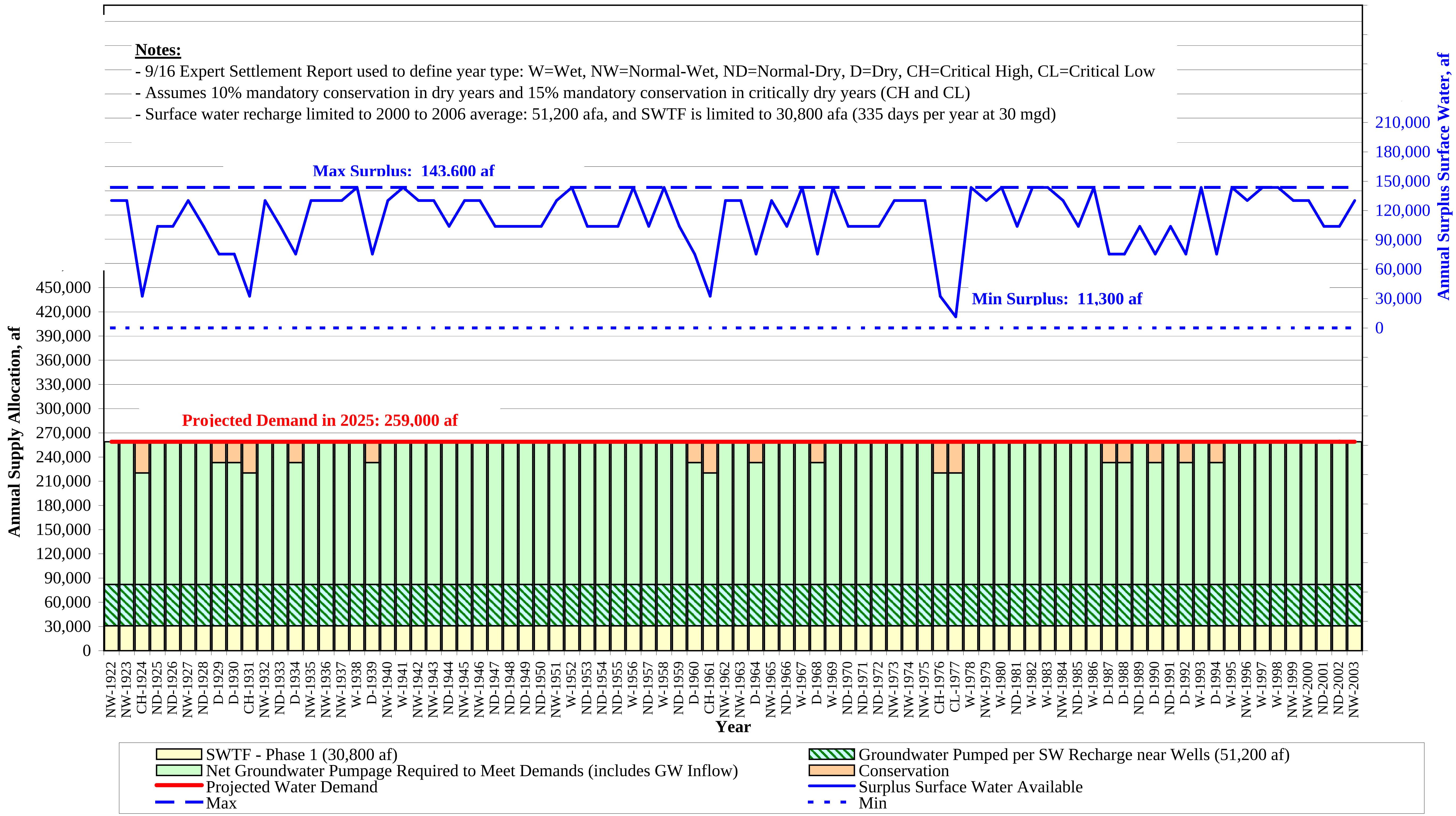
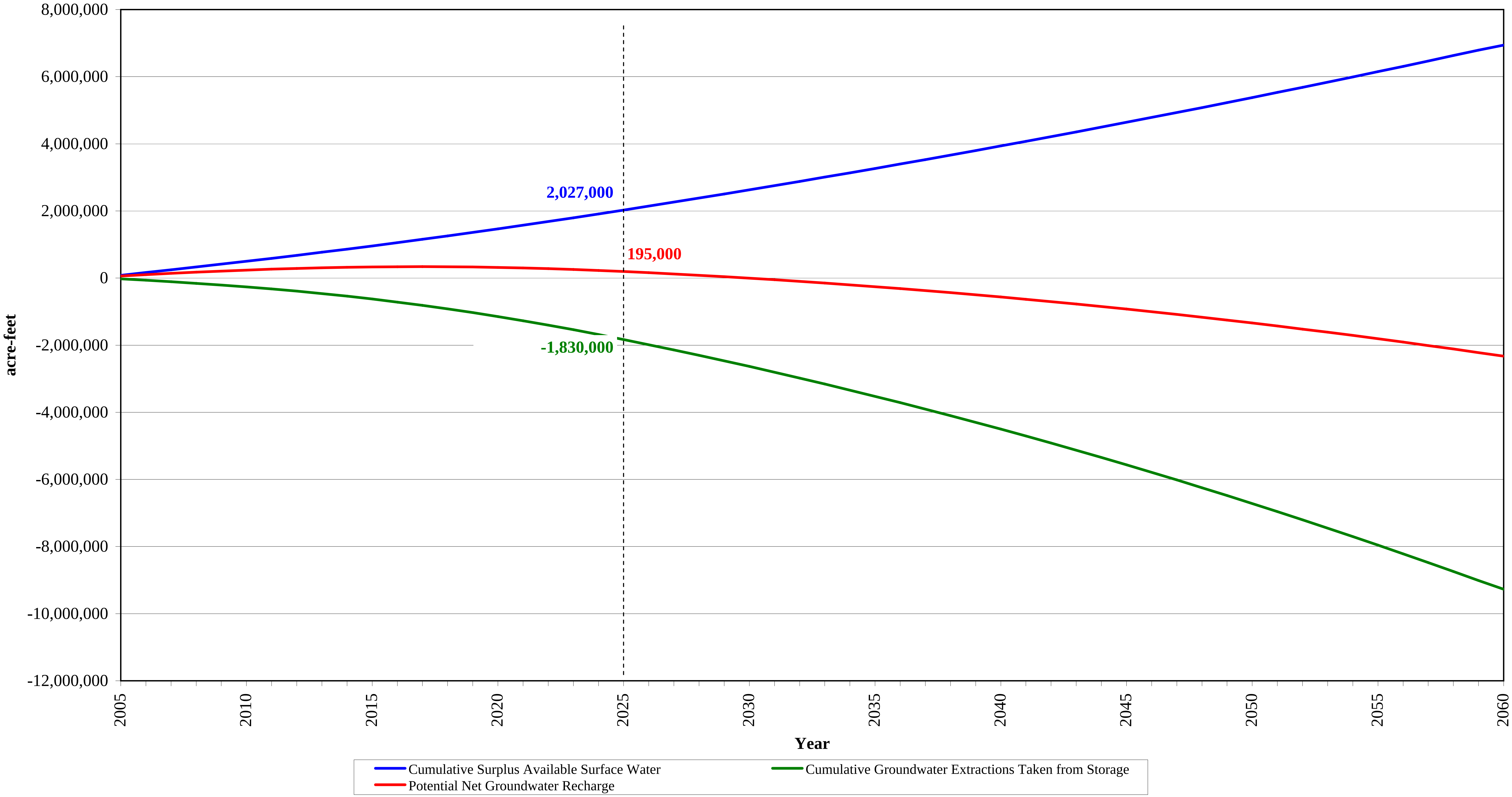


Figure 5-16. Cumulative Groundwater Pumpage and Surplus Surface Water: Existing Conditions



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CHAPTER 6. EXISTING WATER RESOURCES SYSTEMS

This chapter describes the following Fresno Metropolitan Area water resources systems:

- Drinking Water Supply, Treatment, Transmission and Distribution Facilities
- Wastewater Collection, Treatment and Disposal/Reuse Facilities
- Flood Control & Groundwater Recharge Facilities

DRINKING WATER SYSTEM

This section presents a description of the City of Fresno's (City) existing water service area, existing water supplies, treatment, distribution and storage facilities. It also presents an evaluation of the potential, future water system for 2010 and 2025, if the City were to continue to operate at "status quo" (continued use of groundwater to meet unmet demands, no new surface water treatment facility would be constructed).

Existing Service Area

The City's water service area is shown in Figure 6-1. There are numerous County islands that are served by the City's water system. There are also a few County islands that have chosen to be provided with fluoridated water. These fluoride districts are isolated from the City's water system by a system of closed valves, check valves and pressure reducing valves. The City's water system provides back-up supplies to supplement these fluoridated County districts in the event that low pressures occur within them. There are also five independent water systems within the City. They are the Bakman Water Company, Pinedale County Water District, California State University Fresno (CSUF), Herndon Water Company, and Park Van Ness Mutual Water Company. These water systems are not served by the City with the exception of a small portion of the Pinedale County Water Company system that lies to the east of Highway 41 and south of Herndon Avenue.

Existing Water Supply Sources

The City currently supplies water to its customers from groundwater wells and a surface water treatment facility.

<u>Groundwater Wells</u>

There are approximately 250 operational wells, with a total production capacity of 419 mgd, scattered throughout the City. Because the wells are so widely distributed, water never has to be conveyed far from a well to a demand location. The City has installed a Transmission Grid Main (TGM) system consisting of large diameter distribution main constructed on a half-mile grid. Most wells discharge to the TGM system running in front of the production well site. There are a few dozen wells that do not discharge directly into the distribution system.

Some of these well sites have pipelines that convey groundwater containing 1,2-dibromo-3-chloropropane (DBCP) to another well site for treatment by granular activated carbon (GAC), and then this treated groundwater is discharged to the nearest TGM. Twelve well sites have deaeration facilities. At these sites the well pump delivers water to a tank so deaeration can occur. The water is then drawn out by a booster pump and discharged to the TGM, or run through GAC treatment and then discharged to the system. Typically, the booster pump runs on a variable frequency drive (VFD) to maintain a set level in the tank. Some well sites have two on-site wells that may require blending to reduce nitrate levels.

<u>Water Treatment Plant</u>

In addition to the groundwater wells, the City has a Surface Water Treatment Facility (SWTF) which was completed in late 2004, and is used to supplement the groundwater supply. The SWTF currently has a nominal capacity of 30 mgd which is approximately 30 percent of the City's average day demand. The SWTF is located in the northeastern portion of the City's water service area.

Water Distribution System & Storage Facilities

<u>Pressure Zones</u>

The City's water distribution system network is divided into four quasi-pressure zones, created to prevent water from flowing freely from higher areas of the City to lower areas of the City. The zones are separated by "gates" which consist of a series of closed or partially closed valves that prevent or severely impede flow from one quasi-pressure zone to another. The three gates are named after the street alignment that they most closely follow. They are the Shepherd Gate, Sierra Gate, and Highway 41 Gate. Figure 6-1 shows the existing water distribution system.

There are seven pressure sustaining valves (PSV) incorporated into the Shepherd and Sierra Gates. There is an additional PSV at Fowler Avenue, which was installed in connection with the construction and operation of the Southeast tank facility. The location of these PSVs are also shown in Figure 6-1.

In addition to the PSV locations, there are 13 pressure reducing valves (PRVs) associated with the City's fluoride districts. The pressure of the water delivered to these districts is reduced slightly to prevent fluoridated water from re-entering the main water distribution system. The fluoride district PRV locations are shown in Figure 6-1.

The SWTF directly feeds the zone above the Shepherd Gate, then cascades through the Shepherd Gate and Sierra Gate, to the remainder of the system as pressures allow. The Highway 41 Gate is not entirely an isolating gate. The northern boundary of this gate inhibits flow across the boundary, but does not completely stop flow (i.e. there are several small mains north of the terminus that allow water to flow from east to west). There is also a series of valves along the 24-inch line used by Booster Pump 4 (BP04) to isolate this line from the distribution system. Additionally, there are more valves downstream of the 24-inch line which further restrict the direction of water flow. Wells 322 and 323 feed the 24-inch dedicated line. Well 199 also partially feeds this line and the immediate area around this well site.

SCADA Zones

The water distribution system is currently monitored and controlled using a Supervisory Control and Data Acquisition (SCADA) system. The water service area is divided into sub-areas defining boundaries for the SCADA control zones. These zones are numbered 1 to 26 as shown on Figure 6-2. The SCADA system defines the operational controls, such as the "on" and "off" pressure settings of wells within each control zone. All the wells are equipped with kilowatt transmitters so the water system costs can be controlled by operating wells with lower operational costs at any given time.

Water Pipelines

The City has approximately 9.2 million linear feet (or about 1,740 miles) of water system pipelines. These pipelines generally range from 6 to 48 inches in diameter, and are made up of a variety of materials, consisting primarily of asbestos-cement, cast iron, ductile iron, steel and polyvinyl chloride (PVC).

Treated Water Storage

There are currently two water storage tanks within the City's water system. One is located at the SWTF site and the other within the distribution system at the intersection of Clovis Avenue and California Avenue (in southeastern Fresno).

The 1.5 MG tank at the SWTF site stores treated surface water. Water flows by gravity from the treatment process into this tank. This water is then pumped into the distribution system by a 30 mgd booster pump station.

The 2 MG tank at the intersection of Clovis Avenue and California Avenue is called the Southeast Tank. In addition to storing water from the distribution system, it is a blending site for Wells 184 and 225. Well 152 also feeds into the tank, but is not part of the blending system. Operational staff have indicated that an additional 2 MG tank is planned for this same site in the future.

Booster Pump Stations

There are three booster pump stations located within the water distribution system. These are Booster Pump 1 (BP01), Booster Pump 2 (BP02) and Booster Pump 4 (BP04). Booster Pump 3 was budgeted but never built. BP01 and BP02 boost water from SCADA Zone 8 to Zone 4. BP04 boosts water from Zone 11 to Zone 14 through a dedicated 24-inch diameter pipeline and subsequent 12-, 14-, and 16-inch diameter pipelines.

Water Distribution System Performance Criteria

Standard operational and design criteria are required to evaluate the capabilities of a water distribution system and to guide the planning and design of overall system improvements. A set of criteria were developed for the City's water distribution system based on industry standards (AWWA Standards) and discussions with City staff. These criteria are summarized in Table 6-1 and described below. It should be noted that specific system characteristics and conditions in certain areas of the City's system may warrant modification of these criteria. These criteria are

Table 6-1. Water System Operational/Design Criteria Goals for City[a]

Component	Criteria[b]
Water Transmission Line	
Typical Diameter	18-inches in diameter or larger
Average Day Demand Condition	
Recommended Minimum Pressure [psi]	50
Maximum Head loss [ft/1000 ft] (transmission lines)	2
Maximum Velocity [ft/sec] [c]	3
Maximum Day Conditions	
Recommended Minimum Pressure [psi]	50
Maximum Head loss [ft/1000 ft]	5
Maximum Velocity [ft/sec] [c]	5
Peak Hour Demand Condition	
Recommended Minimum Pressure [psi]	40
Maximum Head loss [ft/1000 ft]	8
Maximum Velocity [ft/sec] [c]	7
Water Distribution and TGM Line	
Typical Diameter	16-inches in diameter or smaller
Average Day Demand Condition	
Typical Pressure Range, psi	40-80
Recommended Minimum Pressure [psi]	50
Maximum Head loss [ft/1000 ft] (distribution lines)	5
Maximum Velocity [ft/sec] [c]	5
Maximum Day w/ Fire Flow Demand Conditions	
Minimum Pressure [psi] (at fire hydrant)	20
Maximum Head loss [ft/1000 ft]	20
Maximum Velocity [ft/sec] [c]	10
Peak Hour Demand Condition	
Recommended Minimum Pressure [psi]	40
Maximum Head loss [ft/1000 ft]	10
Maximum Velocity [ft/sec] [c]	7

[a] From demand analysis, the maximum day and peak hour factors are 2.0 and 2.9, respectively, as multiples of the average day demand.

[b] Criteria proposed based on WYA's experience with similar cities and AWWA standards.

[c] Lower velocities may be required to minimize head loss and optimize system performance.

intended for overall system design and operations and are not intended for the design of on-site fire flow facilities.

Criteria differ between regional transmission mains and distribution mains. Regional transmission mains typically consist of large diameter pipe that have relatively few turnouts to the distribution system and do not include service taps. Distribution mains are typically smaller diameter pipes that serve local demands and fire hydrants. According to these common definitions, the TGM system is technically part of the distribution system, and not part of the regional transmission main system. These distinctions are discussed further below.

Regional Water Transmission System Sizing

Transmission pipelines are generally 18-inches in diameter or larger and shall be designed based on the criteria described below for average day, maximum day, and peak hour demand conditions.

Average Day Demand

- Service pressures shall be maintained at a minimum of 50 pounds per square inch (psi). These limits represent design criteria that will provide sufficient system performance with economy.
- Maximum velocity within transmission pipelines shall be 3 feet per second (fps).

Maximum Day Demand

- The minimum allowable service pressure in the water transmission main shall be 50 psi.
- The maximum velocity within the transmission system pipelines shall be 5 fps.

Peak Hour Demand

- The minimum residual pressure during a peak hour demand shall be 40 psi.
- The maximum pipeline velocity shall be 7 fps.

Water Distribution and TGM System Sizing

Distribution pipelines, including the TGM system, are generally 16 inches in diameter or smaller, and shall be sized based on the criteria described below for average day, maximum day plus fire flow, and peak hour demand conditions.

Average Day Demand

- Service pressures shall be maintained at a minimum of 50 psi. These limits represent design criteria that will protect the integrity of the system and improve system reliability.
- Maximum velocity within distribution system pipelines shall be 5 fps.

Maximum Day Demand plus Concurrent Fire Flow

- The minimum service pressure of 20 psi at the flowing fire hydrant shall be maintained by the water distribution system.
- The maximum velocity within the distribution system pipelines shall be 10 fps.

Peak Hour Demand

- Service pressures shall be maintained at a minimum of 40 psi during peak hour demand periods to ensure system reliability.
- The maximum pipeline velocity shall be 7 fps.

Fresno Water System - Future Without Project Evaluation

This section presents an evaluation of the City's water system under 2010 and 2025 water demand conditions without new water treatment facilities or major changes to the transmission grid system. Subsequent sections of this chapter present the water demands of the City and the water distribution system hydraulic network analysis. Neither water storage requirements nor system pumping capacity were evaluated as part of this analysis.

Water Demands

A summary of existing and future demands by planning year is presented in Table 6-2. These demands were used as the basis for the water distribution system evaluation in the subsequent section.

Table 6-2. Existing and Future City of Fresno Demands, gpm[(a)]

Demand Component	2005 (Actual)[(b)]	2010[(c)]	2025[(c)]
Average Day Demand	97,500	106,600	160,800
Maximum Day Demand[(d)]	195,000	213,200	321,600
Peak Hour Demand[(e)]	282,750	309,140	466,320

(a) Includes 10% unaccounted-for water.
(b) Based on actual 2005 water production of 157,278 af/yr.
(c) Based on projected future water demand (see Table 3-11).
(d) Maximum day demand equals 2.0 times the average day demand.
(e) Peak hour demand equals 2.9 times the average day demand.

As shown in Table 6-2, the demands of the City are anticipated to increase by approximately 10 percent from 2005 to 2010. From 2010 to 2025, the demands are anticipated to increase by an additional 50 percent. Part of this increase in demand is due to the potential future absorption of private water companies (see additional discussion in Chapter 3). These demand increases have great implications for the City's water distribution system in terms of infrastructure needs.

Water Distribution System Evaluation

This water distribution system evaluation was conducted using a hydraulic model of the City's existing water system. The development of the hydraulic model is documented in Appendix L. The focus of this evaluation is to identify areas within the City's water service area that could not be provided with adequate service due to the inadequacy of the existing water system infrastructure. Once these problem areas were identified, additional model simulations were conducted to evaluate potential water system improvements, including, new wells, new pipelines, parallel pipelines or replacement mains.

Steady state hydraulic simulations of the water system during peak hour demand conditions were used to evaluate the system. The peak hour demand was selected because it represents the most stressed condition (highest demand condition) under which the water system must deliver high flows and maintain a minimum system pressure. Peak hour demand simulations were run for 2010 and 2025 conditions and the results are discussed below.

2010 Peak Hour Demand Analysis

The 2010 water distribution system model was created by extending the existing water distribution system model (using new TGMs) in the new development (future demand) areas. New wells were assumed to be the source of supply to meet these demands. The total demand in 2010 was assumed to be met from existing groundwater wells (those wells which are currently providing supply to the City's system), existing storage reservoirs, and new wells.

The hydraulic model was run iteratively and the results compared with the previously discussed operational and design criteria. New wells were added to the water system model to provide supply for the new demand areas.

As shown in Figure 6-3, 30 additional wells with an assumed production capacity of 800 gpm each would be required to be added to southeast portion of the City's existing 2005 water system to be able to provide the system with a minimum service pressure of 40 psi. Sixteen-inch diameter TGMs would also be required to convey flows to the new development areas. Velocities were kept below the 7 fps design criterion when sizing the TGMs.

2025 Peak Hour Demand Analysis

The 2025 water distribution model was created by adding new pipelines to the 2010 water distribution system model. The same general assumptions used for the 2010 analysis were also used to locate new pipelines and wells to serve the 2025 demands.

As shown in Figure 6-4, 127 additional wells (beyond the 30 new wells required to meet the 2010 needs) (90 additional wells in the eastern portion of the City's system with an assumed production capacity of 800 gpm each) (37 additional wells in the western portion of the City's system with an assumed production capacity of 2,000 gpm each) would be required to be added to the City's existing 2005 water system to be able to meet the additional peak hour demand in 2025, and provide the system with a minimum service pressure of 40 psi. Sixteen-inch diameter TGM pipelines would also be required to convey flows to the new development areas.

Water System Improvement Capital Costs

The previous sections identified the need for additional facilities for the City's water distribution system to meet future demands without the construction of a new water treatment plant or expansion of the existing SWTF. Figures 6-3 and 6-4 show the additional facilities required for 2010 and 2025, respectively. Tables 6-3 and 6-4 show the associated capital costs for the improvements.

As shown in Table 6-3, the capital cost of improvements that must be completed by 2010 for the City's water system to continue serving its customers adequately is approximately $301 million. Approximately 19 percent of these costs are associated with the wellhead treatment anticipated to be required for existing wells with water quality issues (see additional discussion in Chapter 5). Costs for improvements required to serve new development will be paid by developers via Urban Growth Management (UGM) fees.

Table 6-3. Estimated Capital Costs for 2010 Water System Improvements (Operating Under Status Quo Conditions)

Item Description	Unit of Measure	Estimated Quantity	Unit Cost, dollars/unit	Estimated Cost, million dollars[(a)]
New Wells	each	30	450,000[(b)]	14
16-Inch Diameter Mains	lf	640,000	233	149
Subtotal				163
Additional Program Costs[(c)]				82
Wellhead Treatment for 35 Existing Wells[(d)]	Lump Sum	1	NA	56
Total				301

(a) Based on June 2006 ENR index of 7700 (20 Cities Average).

(b) Unit price currently used by City for budgeting purposes. Equates to $675,000 per well when additional program costs (construction contingency, engineering, construction management and program implementation costs) are included at 50%.

(c) Comprised of construction contingency, engineering, construction management and program implementation costs, estimated to be 50%.

(d) Based on cost developed in Chapter 5 (includes Additional Program Costs). Assumes existing wells produce 800 gpm, and that treatment costs are $1.4 million per mgd.

Table 6-4. Estimated Capital Costs for 2025 Water System Improvements (Operating Under Status Quo Conditions)

Item Description	Unit of Measure	Estimated Quantity	Unit Cost, dollars/unit	Estimated Cost, million dollars[(a)]
New Wells	Each	127	450,000[(b)]	57
16-Inch Diameter Mains	lf	475,000	$233	111
Subtotal				168
Additional Program Costs[(c)]				84
Total				252

(a) Based on June 2006 ENR index of 7700 (20 Cities Average).

(b) Unit price currently used by City for budgeting purposes. Equates to $675,000 per well when additional program costs (construction contingency, engineering, construction management and program implementation costs) are included at 50%.

(c) Comprised of construction contingency, engineering, construction management and program implementation costs, estimated to be 50%.

As shown in Table 6-4, the capital cost of additional improvements beyond those required to provide adequate service for the projected 2010 demands that must be completed by 2025 is approximately $252 million. The total capital cost required by 2025 for the improvement to the City's water system without consideration of a new surface water treatment plant is therefore approximately $553 million. The recommended cost split between existing customers and future development (through UGM fees) will be determined in later phases of this study. The $553 million cost does not include the cost of wellhead treatment for the proposed new wells (157 wells), which are assumed to tap the clean water strata below the groundwater contaminant plume areas. However, with the heavy draw on the groundwater basin, existing contaminant plumes will likely move and migrate, possibly affecting these new wells. If it were assumed that each of the 157 new wells would require wellhead treatment, an additional $343 million dollars (245 mgd x $1.4 million/mgd) would be needed.

Considering the extremely high cost associated with wellhead treatment, and the City's available surface water resources (see previous supply discussion in Chapter 5), additional surface water treatment will likely be a viable water supply strategy. This will be explored further in Phase 2 of this study.

WASTEWATER SYSTEM

This section summarizes the City's existing wastewater collection and treatment systems, along with projected wastewater flows and projected recycled water use estimates in the Clovis area. Effluent quality is also addressed as it relates to key irrigation use parameters.

Collection System

The City of Fresno wastewater collection system conveys wastewater by gravity sewers to the Fresno/Clovis Regional Wastewater Reclamation Facility (RWRF) located southwest of the City. This collection system also conveys wastewater from the City of Clovis, Pinedale Public Utility District, and the Pinedale County Water District. Clovis currently has four collection system connections which flow to the RWRF.

Existing Collection System

The existing collection system has about 7.8 million linear feet of gravity sewer pipelines ranging from 4 to 84 inches in diameter, with about 70 percent of the pipelines falling into the 4- to 8-inch diameter size range. About 24 percent of the pipelines are over fifty years old. Pipeline materials include primarily vitrified clay pipe (VCP), PVC, reinforced concrete pipe (RCP), and standard concrete pipe (SCP). There are 14 lift stations, and 1.7 miles of sewer force mains. The existing collection system is shown in Figure 1-2 located in Appendix M.

Unsewered City Areas

There are several large, formerly unsewered areas within the City's SOI that have slowly been connected to the RWRF collection system. These areas are shown in Figure 2-1 (Appendix M) from the City of Fresno Nitrate Management Plan (Boyle, 2006). These areas include Old Figarden, Mayfair, and Sunnyside (much of which still remains unsewered), and an area on Clovis Avenue between Belmont and McKinley. The Fort Washington Area in the northern portion of the City remains unsewered. The area of remaining unsewered land included in the Sunnyside and Fort Washington Area totals approximately 830 acres.

Proposed System Improvements and Growth

The Draft 2004 Wastewater Collection System Master Plan (2004 Plan) summarizes the planned collection system facilities and improvements to the existing system. The City is projecting new growth to occur in two areas, the North Growth Area (NGA) and the Southeast Growth Area (SEGA).

The NGA will be served by constructing a small satellite wastewater treatment plant (WWTP). This satellite plant will have a capacity of 0.8 million gallons per day (mgd). Solids from this new WWTP will be discharged into the City's collection system via a new lift station and force main (Figure 5-1, Appendix M). The treated wastewater will be used to meet non-potable landscape irrigation demand in the local area. The new satellite plant is anticipated to be operational by early 2008.

For the SEGA, a satellite treatment plant has also been discussed, but it has been shown to be cost prohibitive in recent studies. This area will be served by constructing new sewer trunks that would convey flows to be intercepted by the North Trunk sewer. Due to the increased flow, relief trunks would need to be constructed to mitigate potential surcharging in the North Trunk. These improvements are shown in Figure 5-8 in Appendix M.

According to the City of Fresno Wastewater Collection System Master Plan, Downtown Fresno has direct storm drain connections to the wastewater collection system. These connections include roof downspouts; parking lot drains, loading docks, or other illicit tie-ins. These connections account for high volumes of rainfall dependent infiltration and inflow (RDI/I). Based on statistical analysis, RDI/I could account for a peak flow of 136 mgd for a 10-year storm. The average daily flow at the RWRF from the 2004 Plan is approximately 73 mgd, therefore the peaking factor at the plant could be approximately 1.86 for the 10-year storm

The 2004 Plan also identified several areas where existing system deficiencies exist during wet weather flow scenarios. These deficiencies are shown in Figure 5-3 in Appendix M.

The City of Clovis has built a satellite treatment plant that treats 2.8 mgd of wastewater that was formerly discharged to the Fowler Trunk Sewer Main. The City of Clovis is planning to expand the capacity of this new treatment facility to 8.4 mgd in the future. Because the North Trunk intercepts the Fowler Trunk, this will reduce the City of Clovis' flow to the RWRF. Solids from this plant will be handled on-site.

Regional Wastewater Reclamation Facility

<u>Treatment Plant</u>

Current Plant

The Fresno-Clovis RWRF has a treatment capacity of approximately 80 mgd, based on annual monthly average daily discharge flow. The maximum monthly average daily discharge flow is 88 mgd. It provides secondary wastewater treatment with effluent disposal to a combination of percolation ponds (main disposal method) and irrigation re-use. The solids handling facility is capable of treating solids to Class B.

The RWRF facility consists of headworks followed by primary settling and secondary activated sludge biological treatment processes. The facility also has the capability of incorporating the old trickling filter plant into the treatment process to augment the activated sludge process.

Secondary effluent is discharged into a canal system feeding a series of percolation ponds. Local farmers use a portion of the effluent for direct re-use on agricultural land. The City also reclaims a significant portion of this percolated treated effluent by extracting groundwater and delivering it to the Fresno Irrigation District (FID). FID then delivers this water downstream to customers during the irrigation season (see Chapter 5 for an additional, more detailed discussion)

The solids handling facility consists of secondary sludge thickening and co-digestion with primary sludge. Digested sludge is dewatered and hauled off-site where a private company treats and land applies it, although the City is investigating co-composting it with their green waste for re-use.

Future Expansion

The City is currently in the process of upgrading the organic treatment capacity of the RWRF. The upgrades will be completed in mid-2009 and will provide greater flexibility in responding to the treatment challenges specific to the Fresno-Clovis wastewater composition. Challenges pertain to the fact that the Fresno-Clovis wastewater composition comprises a high component of industrial effluent. This, in turn, requires a treatment facility with the capability of responding with a variety of treatment alternatives to deal with this impact, which forms part of the upgrades currently being implemented. The City's water conservation efforts play an important role also. Flows from Copper River Ranch will be low (about 1 mgd) and insignificant. The design of the RWRF upgrade accounted for the separate 8 mgd facilities to be built in Clovis, with solids to be discharged to the RWRF. No significant impact is expected.

The RWRF Master Plan also allows for possible addition of future tertiary treatment facilities, namely filtration and disinfection. Although no such facilities are currently required or being constructed, the infrastructure and piping layout plan makes provision for such possible new facilities, in case of regulation or demand from an end-user. These future treatment facilities would be modular in case only a portion of the effluent needs to undergo tertiary treatment.

The RWRF Master Plan includes a schedule of additional infrastructure required to the year 2025 based on the projected wastewater flows and load increases. These projections are presented in the following section.

Current and Projected RWRF Flows

Current and projected RWRF flows were developed based on the RWRF Master Plan Update by Carollo Engineers in 2005 and are based on population projections provided by the cities of Fresno and Clovis. The average day annual flow (ADAF) to the RWRF was approximately 72.4 mgd in 2006. The projected ADAF for 2015 and 2025 are:

- 2015 = 96.0 mgd
- 2025 = 112.5 mgd

Table 6-5 provides projected total plant flows in acre-feet per year minus the projected Clovis wastewater treatment plant projected flows. The flow projections for the Clovis WWTP were provided by Blair, Church, & Flynn Consulting Engineers and are included in Table A of Appendix M. These flows will be "scalped" from the RWRF flows beginning in 2008. The treated effluent from the Clovis WWTP will be used for irrigation and other reuse in the Clovis/East Fresno Area, such as for agricultural irrigation at the California State University Fresno.

Table 6-5 provides the amount of available undisinfected secondary effluent and extracted groundwater that the City is currently recycling. Since the City currently does not have any specific plans for future water recycling, for the purposes of this Phase 1 Study, the values in Table 6-5 will remain the same until the year 2030. Although there are no current plans, the City is pursuing opportunities to increase the use of treated wastewater effluent.

Table 6-5. RWRF Flow Projection & Water Recycling

	Treatment	2005	2010	2015	2020	2025	2030
Total Plant Flow[a], ac-ft/year	Undisinfected Secondary	78,400	94,500	105,100	109,000	120,300	127,700
Quantity Available for Direct Recycling on Crops near the RWRF, ac-ft/year	Undisinfected Secondary[b,c]	8,500	8,500	8,500	8,500	8,500	8,500
Quantity Available for Recycling by FID, ac-ft/year	Extracted Groundwater[d,e]	24,600	24,600	24,600	24,600	24,600	24,600
Quantity Available for New, Direct Recycling, ac-ft/year	Tertiary[f]	0	0	0	0	0	0
% of Total Used for Recycled Water		42.86%	35.22%	31.97%	30.83%	27.93%	26.31%

(a) Projected ADAF to Clovis WWTP has been deducted
(b) Quantities presented include recycled water currently used by the other parties on City-owned farmland or farmlands owned by others.
(c) The City of Fresno does not have specific plans for increasing future recycling flows at this time, therefore future flows are shown to be the same as current flows. The City does plan to continue to pursue opportunities to increase the use of effluent and extracted well water to irrigate farmland. When additional beneficial use can be secured, extraction operations will be expanded.
(d) The City of Fresno and California Department of Health Services still need to resolve whether this water meets Title 22 criteria for tertiary recycled water for unrestricted use on crops per Sections 60301.230 (disinfected tertiary recycled water), 60301.320 (filtered wastewater) and 60304 (use of recycled water for irrigation).
(e) Based on current contract between the City of Fresno and the Fresno Irrigation District.
(f) Disinfected tertiary recycled water per Title 22 Section 60301.230

Flow projections and recycled water quantities for the entire Fresno-Clovis Metropolitan Area are shown in Table 6-6.

<u>Effluent Quality</u>

Effluent data collected by the RWRF was compiled and a comparison of the effluent to water quality guidelines for irrigation is presented in Table 6-7. Table 6-8 summarizes the probable reuse restrictions of the RWRF effluent for irrigation. As shown in Table 6-7, and 6-8, it can be seen that salinity, permeability, sodium, and bicarbonate levels fall within the slight to moderate degree of restricted use category, indicating that an increased level of recycled water management may be required for some irrigation. Other parameters tested should pose minimal to no problems to water use.

The solids to be received from the Clovis plant are not expected to impact the quality or reuse of the RWRF effluent.

Table 6-6 . Flow Projections and Water Recycling for Fresno Clovis Metro Area

	2005	2010	2015	2020	2025	2030
FCMA wastewater inflow (ac-ft/yr)	78,400	98,300	108,000	119,800	126,500	137,100
Inflow to Clovis WWTP	0	2,900	2,900	6,200	6,200	9,400
Inflow to RWRF	78,400	95,400	105,100	112,900	120,300	127,700
Outflow from RWRF(ac-ft/yr)						
Combined Outflow	78,400	95,400	105,100	112,900	120,300	127,700
Recycled on RWRF-owned farmland (direct)	8,500	8,500	8,500	8,500	8,500	8,500
Percolated to groundwater	66,500	82,300	91,500	98,700	105,500	112,400
Net Evaporation	3,400	4,600	5,100	5,700	6,300	6,800
Discharge to surface water	0	0	0	0	0	0
Recycled within FID (Pumped Groundwater)	24,600	24,600	24,600	24,600	24,600	24,600
Net Addition to Groundwater	41,900	57,700	66,900	74,100	80,900	87,800
Clovis Portion[a]	10,200	10,300	11,400	12,200	13,000	13,800
Recycled on Fresno or private farmland (direct)	1,100	900	900	900	900	900
Percolated to groundwater	8,500	8,800	9,800	10,500	11,200	11,900
Evaporation	460	460	540	630	710	780
Discharge to surface water	0	0	0	0	0	0
Recycled within FID (Pumped Groundwater)	0	0	0	0	0	0
Net Addition to Groundwater	8,500	8,800	9,800	10,500	11,200	11,900
Fresno Portion	68,200	85,100	93,700	100,700	107,300	113,900
Recycled on Fresno or private farmland (direct)	7,400	7,600	7,600	7,600	7,600	7,600
Percolated to groundwater	58,000	73,500	81,700	88,200	94,300	100,500
Evaporation	2,940	4,140	4,560	5,070	5,590	6,020
Discharge to surface water	0	0	0	0	0	0
Recycled within FID (Pumped Groundwater)	24,600	24,600	24,600	24,600	24,600	24,600
Net Addition to Groundwater	33,400	48,900	57,100	63,600	69,700	75,900

[a] Estimates of the proportion of Clovis flows changes from 13% in 2005 to 10.7% in 2030 based on population projections in the RWRF Master Plan (Carollo, 2005) and the City of Clovis Draft Recycled Water Master Plan (Blair, Church, & Flynn, 2006).

Table 6-7. Comparison of RWRF Effluent to Water Quality Guidelines for Irrigation[a]

Irrigation Water Key Quality Parameter	Units	Established Criteria Degree of Use Restriction[b,c,d] None	Slight to Moderate	Severe	RWRF Effluent Typical Value[e]
Salinity EC	dS/m	<0.7	0.7-3.0	>3.0	0.84
TDS	mg/l	<450	450-2000	>2000	462
Permeability[f]			EC		
SAR = 0 - 3 and E_w=		>0.7	0.7-0.2	<0.2	SAR = 3.02
= 3 - 6 and Ed_w=		>1.2	1.2-0.3	<0.3	EC_w = 0.84
Sodium (Na)					
Surface	SAR	<3	3-9	>9	3.02
Sprinkler	mg/l	<70	>70		76
Chloride (Cl)					
Surface	mg/l	<140	140-350	>350	76.8
Sprinkler	mg/l	<100	>100		76.8
Boron (B)	mg/l	<0.7	0.7-3.0	>3.0	0.18
Bicarbonate	mg/l	<90	90-500	>500	220
pH	--		6.5-8.4 (normal range)		7.6
Nitrate (NO_3 - N)	mg/l	<5	5-30	>30	0.83

[a] Adapted from University of California Committee of Consultants (1974), and Ayers and Westcot (1984)

[b] Method and Timing of Irrigation: Assumes normal surface and sprinkler irrigation methods are used. Water is applied as needed, and plants use a considerable portion of the available stored water (50% or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] > 15%).

[c] Site Conditions: Assumes soil texture ranges from sandy loam to clay with good internal drainage with no uncontrolled shallow water table present.

[d] Definition of Degree of Use Restriction terms:

None = Reclaimed water can be used similar to the best available irrigation water.

Slight = Some additional management will be required above that with the best available irrigation water in terms of leaching salts from the root zone and/or choice of plants

Moderate = Increased level of management required and choice of plants limited to those which are tolerant of the specific parameters.

Severe = Typically cannot be used due to limitations imposed by the specific parameters.

[e] "RWRF Effluent Values" are average values based on data collected from January 2003 to July 2004 for all except SAR, and bicarbonate which were determined from averages from data collected between January and March 2006.

[f] Permeability is evaluated based on the combination of sodium adsorption ratio (SAR) and electroconductivity (EC_w) values

Table 6-8. Reuse Restrictions for RWRF Effluent

Water Quality Parameter	Degree of Restriction
Salinity	Slight to Moderate
Permeability	Slight to Moderate
Sodium (Na)	Slight to Moderate (Sprinkler)
Chloride (Cl)	None
Boron (B)	None
Bicarbonate	Slight to Moderate
Nitrate (NO_3 - N)	None

The quality of the effluent is expected to improve as best practicable treatment and control (BPTC) practices are implemented and as industrial pretreatment practices continue to improve. Specifics about the overall quality of the future effluent cannot be detailed at this time.

Extracted Groundwater

Extracted groundwater quality data was provided by the City and compared with the same irrigation water parameters used to evaluate RWRF effluent for use as irrigation water. It can be seen from Tables 6-9 and 6-10 that salinity, sodium, and bicarbonate levels fall within the slight to moderate degree of restricted use category, indicating an increased level of water management may be required for some irrigation.

Table 6-9. Comparison of RWRF Extracted Groundwater to Water Quality Guidelines for Irrigation [a]

Irrigation Water Key Quality Parameter	Units	Established Criteria Degree of Use Restriction[b,c,d] None	Slight to Moderate	Severe	Extracted Groundwater Typical Value[e]
Salinity EC	dS/m	<0.7	0.7-3.0	>3.0	0.84
TDS	mg/l	<450	450-2000	>2000	509
Permeability[f]			EC		
SAR = 0 - 3 and Ec_w=		>0.7	0.7-0.2	<0.2	SAR = 2.37
= 3 - 6 and Ec_w=		>1.2	1.2-0.3	<0.3	EC_w = 0.84
Sodium (Na)					
Surface	SAR	<3	3-9	>9	2.37
Sprinkler	mg/l	<70	>70		83.4
Chloride (Cl)					
Surface	mg/l	<140	140-350	>350	83.7
Sprinkler	mg/l	<100	>100		83.7
Boron (B)	mg/l	<0.7	0.7-3.0	>3.0	0.21
Bicarbonate	mg/l	<90	90-500	>500	268
pH	--		6.5-8.4 (normal range)		7.2
Nitrate (NO_3 - N)	mg/l	<5	5-30	>30	1.41

[a] Adapted from University of California Committee of Consultants (1974), and Ayers and Westcot (1984)

[b] Method and Timing of Irrigation: Assumes normal surface and sprinkler irrigation methods are used. Water is applied as needed, and plants use a considerable portion of the available stored water (50% or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] > 15%).

[c] Site Conditions: Assumes soil texture ranges from sandy loam to clay with good internal drainage with no uncontrolled shallow water table present.

[d] Definition of Degree of Use Restriction terms:

None = Reclaimed water can be used similar to the best available irrigation water.

Slight = Some additional management will be required above that with the best available irrigation water in terms of leaching salts from the root zone and/or choice of plants

Moderate = Increased level of management required and choice of plants limited to those which are tolerant of the specific parameters.

Severe = Typically cannot be used due to limitations imposed by the specific parameters.

[e] "Extracted Groundwater Values" are average values based on data collected from all 14 groundwater extraction wells during October of 2005.

[f] Permeability is evaluated based on the combination of sodium adsorption ratio (SAR) and electroconductivity (EC_w) values

Table 6-10. Reuse Restrictions for Extracted Groundwater

Water Quality Parameter	Degree of Restriction
Salinity	Slight to Moderate
Permeability	None
Sodium (Na)	Slight to Moderate (Sprinkler)
Chloride (Cl)	None
Boron (B)	None
Bicarbonate	Slight to Moderate
Nitrate (NO_3 - N)	None

FLOOD CONTROL & GROUNDWATER RECHARGE SYSTEM

This section summarizes the operational data collected and evaluated by Blair, Church, & Flynn Consulting Engineers for groundwater recharge facilities, in support of the Fresno Metropolitan Water Resources Management Plan Update. The data were received from Fresno Metropolitan Flood Control District (FMFCD), Fresno Irrigation District (FID), the City of Fresno, and the City of Clovis.

Flood Control and Recharge Facilities

FMFCD currently owns and operates 158 flood control basins, of which 74 are routinely used for groundwater recharge of CVP and Kings River water. For FMFCD, the groundwater recharge season typically begins in March and ends in September. The Cities of Fresno and Clovis have agreements to pay FMFCD for the use of their basins for recharge, and the cities use their CVP entitlements and FID contractual supplies for the recharge activities.

The City of Fresno owns and operates the Leaky Acres Groundwater Recharge Facility (Leaky Acres), which is located east of State Route 168 at Ashlan Avenue. Leaky Acres encompasses approximately 245 acres and typically is in operation 8 to 10 months per year, based on historical data. The City also operates the Chestnut Basins located at Chestnut Avenue, north of Jensen Avenue. In addition, the City uses surface water from canals instead of pumping groundwater to fill the ponds at Woodward Park. The City of Fresno also owns and operates the Chestnut Basins (although the underlying land is owned by FID).

The City of Clovis owns and operates the Alluvial Groundwater Recharge Site (AGRS), which is located near the intersection of Clovis and Alluvial Avenues. AGRS encompasses approximately 85 acres and typically is in operation for 8 to 10 months per year, based on historical data.

Water is conveyed to the FMFCD, City of Fresno and City of Clovis recharge facilities via FID conveyance facilities (open channels and pipelines). FID owns and operates approximately 700 miles of these conveyance facilities. FID also operates 39 basins for flow control and equalization purposes. FID's Kearney and North-Central basins are used for groundwater recharge operations.

FMFCD, FID, City of Fresno and City of Clovis groundwater recharge facilities are shown on Figure 6-5.

Water Rights

The City of Fresno reports that it has a contractual agreement to water from FID and entitlements to USBR water. Currently, the City of Fresno encompasses 23.63 percent of the total land area within the Fresno Irrigation District, and as such has a contractual agreement to 23.63 percent of FID's water entitlement. For the 2005 irrigation season, Fresno's contracted water was approximately 121,900 acre-feet from the FID. Additionally, Fresno has a contract with USBR for 60,000 acre-feet of water per year.

The City of Clovis has an agreement with FID which provides them with a percentage of the Class 2 water that FID receives from the CVP. According to Blair, Church, & Flynn Consulting Engineers, the City of Clovis currently encompasses 4.76 percent of the total land area within the Fresno Irrigation District, and as such is entitled to 4.76 percent of FID's water entitlement. For the 2005 irrigation season, FID's water entitlement was approximately 515,870 acre-feet. For the 2005 irrigation season, Clovis was entitled to approximately 24,560 acre-feet of water from FID.

Data Acquisition

Operational data relative to intentional groundwater recharge for the last 10 years was obtained and evaluated by Blair, Church, & Flynn Consulting Engineers from FMFCD, FID, the City of Fresno, and the City of Clovis.

Data provided by FMFCD included a list of FMFCD drainage basins used by Fresno and Clovis for groundwater recharge, basin locations, basin size and storage capacity, water deliveries to each basin and basin infiltration rates. Data provided by FID included information for monthly water deliveries to Leaky Acres and AGRS and data for FID waterways and their water carrying capacities.

The City of Fresno provided information regarding the City's water rights and infiltration rates for Leaky Acres. The City of Clovis also provided information regarding their water rights.

Groundwater Recharge

The primary purpose of the FMFCD storm water retention and detention basins is for the control and storage of storm water. Generally, between March and September, FMFCD allows cities to use their basins for recognized groundwater recharge operations.

The average groundwater recharge rate for each basin was calculated. For each month, the average FID water delivery to each basin was estimated based on the data provided by FMFCD. The average monthly recharge rate for each basin is the average monthly FID water delivery less the water evaporation for that month. Table 6-11 includes the average monthly groundwater recharge rates for each basin.

FMFCD provided infiltration data for most of their basins. These basin infiltration rates are also included in Table 6-11. For basins with no infiltration rate, no value was entered for that basin. For Leaky Acres, City of Fresno staff estimated the infiltration rate at approximately 0.3 feet per day. The City of Clovis has no infiltration data for AGRS.

As shown in Table 6-11, based on a 10-year average from 1996 to 2005, the total combined intentional groundwater recharge rate for FMFCD basins, Leaky Acres, AGRS, Chestnut Basin, North-Central Basin, and Kearney Basin is 45,277 acre-feet per year[1]. Additional intentional

[1] It should be noted that improvements were made to the City of Clovis' AGRS facility in 2004 which increased the intentional groundwater recharge capacity. The City of Clovis has indicated that the groundwater recharge capacity since the improvements have been completed averages about 4,300 af/yr (reference: City of Clovis letter dated September 28, 2007).

Table 6-11. Average Monthly Groundwater Recharge for FMFCD, Fresno and Clovis Recharge Sites 1996-2005 (ac-ft)

Basin Name	Storage Capacity (ac-ft)	Percolation Rate (ft/d)	Basin Area (ft2)	January Recharge	February Recharge	March Recharge	April Recharge	May Recharge	June Recharge	July Recharge	August Recharge	September Recharge	October Recharge	November Recharge	December Recharge	Yearly Recharge
1G	114		401,109	-	-	-	-	20	16	24	14	-	-	-	-	74
2D	81	0.1	289,501	-	-	-	12	44	63	55	57	9	-	-	-	239
3A	43	0.0	276,985	-	-	-	8	18	25	31	25	-	-	-	-	107
3D	96	0.1	375,132	-	-	-	2	17	14	24	20	3	-	-	-	79
3F	83	0.1	298,474	-	-	-	1	27	35	27	25	4	1	-	-	120
4E	118	0.1	869,392	-	-	-	-	2	2	4	8	-	-	-	-	16
5B/5C	147		848,289	-	-	-	-	-	-	-	-	-	-	-	-	-
5F	80	0.2	334,710	-	-	-	-	3	7	12	12	3	-	-	-	36
6D	56	0.1	276,393	-	-	-	1	16	30	29	18	3	-	-	-	97
7C	224	0.1	1,106,305	-	-	-	23	33	21	16	47	3	-	-	-	143
A	83	0.2	675,736	-	-	-	14	37	42	99	82	52	4	-	-	329
AB	171	0.2	609,955	-	-	-	3	2	4	0	4	-	-	-	-	13
AC	128	0.1	553,352	-	-	-	15	37	66	56	43	8	-	-	-	224
AD	61	0.2	395,533	-	-	-	-	7	10	12	19	13	-	-	-	61
AE	160	0.3	876,867	-	-	-	9	50	67	63	72	22	-	-	-	282
AF	229	0.2	869,343	-	-	-	19	96	68	66	44	7	1	-	-	302
AG	216	0.3	600,662	-	-	-	-	1	10	14	62	54	0	-	-	142
AH2	255	0.2	816,873	-	-	-	-	57	85	79	83	55	0	-	-	359
AJ	88	0.2	442,271	-	-	2	25	61	116	156	187	102	7	-	-	656
AL	214	0.1	873,676	-	-	35	35	55	102	119	142	118	17	-	-	622
AO	167	0.8	762,907	-	-	8	20	30	33	32	21	24	6	-	-	174
AZ	263	0.3	604,363	-	-	5	11	40	63	56	34	12	-	-	-	222
BO	93	0.2	586,353	-	-	-	22	54	80	96	88	79	11	-	-	429
BU	243	0.1	1,109,124	-	-	-	-	-	4	19	16	-	-	-	-	38
BV	126	0.0	528,433	-	-	18	30	42	43	46	38	26	8	-	-	250
BW	113	0.2	437,489	-	-	-	12	18	28	31	29	11	-	-	-	127
CC	47	0.0	137,052	-	-	-	-	5	25	40	46	3	-	-	-	118
CL	172	0.2	626,975	-	-	-	17	58	55	62	73	40	1	-	-	307
CM	140	0.2	442,982	-	-	-	11	26	38	46	31	9	-	-	-	161
CN	261	0.3	888,109	-	-	-	-	-	93	85	95	76	17	-	-	366
CO2	127	0.8	566,820	-	-	16	216	304	288	226	180	116	20	-	-	1,367
CW	180	0.3	647,885	-	-	-	15	91	271	307	249	115	6	-	-	1,054
CX	178	0.1	486,018	-	-	-	2	80	47	46	54	4	-	-	-	233
CY	116	0.2	435,112	-	-	-	-	24	26	34	40	-	-	-	-	123
CZ	226	0.2	784,160	-	-	-	27	71	133	134	105	64	11	-	-	545
DD2	166	0.5	763,820	-	-	4	72	172	240	283	246	66	-	-	-	1,084
DH1	112		116,107	-	-	-	-	-	-	-	-	-	-	-	-	-
EE	213	0.2	509,438	-	-	-	-	33	79	104	142	46	-	-	-	404
EF	184	0.4	1,126,020	-	-	-	7	29	42	26	28	76	2	-	-	210
EL	21	0.2	113,343	-	-	-	7	51	57	61	66	31	0	-	-	273
FF	525	0.2	1,851,615	-	-	-	-	5	-	-	2	-	3	-	-	9
GG	150	0.1	522,722	-	-	-	14	34	43	41	37	18	-	-	-	188
HH	314	0.3	697,436	-	-	10	36	27	32	68	118	24	-	-	-	314
II1	176	0.2	612,881	-	-	-	-	5	25	23	50	38	-	-	-	141
II2	132	0.3	949,175	-	-	-	-	6	17	15	16	37	-	-	-	90
J	77	0.3	425,424	-	-	-	8	38	102	113	102	65	2	-	-	430
JJ	194	0.2	527,401	-	-	-	8	54	64	69	43	7	-	-	-	245
K	72	0.3	348,228	-	-	-	1	8	7	13	13	-	-	-	-	41
KK	144	0.3	642,796	-	-	28	54	53	62	86	133	91	4	-	-	511
LL	253	0.5	792,987	-	-	13	5	62	110	122	157	123	14	-	-	606
MM	81	0.4	393,446	-	-	8	44	118	110	178	195	25	-	-	-	678

Table 6-11. Average Monthly Groundwater Recharge for FMFCD, Fresno and Clovis Recharge Sites 1996-2005 (ac-ft)

Basin Name	Storage Capacity (ac-ft)	Percolation Rate (ft/d)	Basin Area (ft2)	January Recharge	February Recharge	March Recharge	April Recharge	May Recharge	June Recharge	July Recharge	August Recharge	September Recharge	October Recharge	November Recharge	December Recharge	Yearly Recharge
N	144	0.2	489,492	-	-	-	60	68	142	233	184	99	45	-	-	830
O	89	0.3	582,840	-	-	-	-	-	-	-	-	-	-	-	-	-
OO	55	0.5	373,860	-	-	-	17	92	114	147	176	125	64	-	-	735
P	90	0.1	386,395	-	-	-	2	13	5	4	7	-	-	-	-	31
R	174	0.1	705,178	-	-	18	12	62	52	68	115	67	3	-	-	397
RR1	233	0.3	746,570	-	-	42	83	199	177	192	205	144	15	-	-	1,057
S	183	0.1	996,345	-	-	-	12	40	41	60	64	29	-	-	-	246
TT1	601	0.5	1,658,588	-	-	45	94	124	170	114	112	150	60	-	-	868
U	89	0.1	544,511	-	-	-	22	38	71	91	117	52	6	-	-	398
UU2	102	0.5	260,916	-	-	-	4	24	28	38	21	13	4	-	-	131
UU3	348	0.4	991,974	-	-	72	265	377	405	490	453	361	154	-	-	2,576
Y	111	0.1	540,508	-	-	-	-	-	-	-	3	5	-	-	-	9
Z	193	0.2	2,158,214	-	-	-	-	-	-	-	-	-	-	-	-	-
ZZ	176	0.3	1,055,146	-	-	19	45	53	113	138	79	49	2	-	-	498
1E	95		467,651	-	-	-	11	19	35	37	35	12	-	-	-	150
BE	127	0.3	482,952	-	-	-	-	32	122	162	139	92	10	-	-	558
BF	101		403,333	-	-	-	25	84	102	99	111	78	19	-	-	518
BZ	104		587,097	-	-	-	10	26	24	25	23	16	-	-	-	125
EG		0.1	319,201	-	-	8	53	67	64	59	103	65	8	-	-	427
L	132	0.1	387,583	-	-	-	4	12	7	16	8	4	-	-	-	52
RR2	78		247,601	-	-	-	-	-	48	46	52	13	-	-	-	159
RR3	318		767,057	-	-	-	23	46	88	162	129	160	4	-	-	611
W	174	0.1	596,635	-	-	-	-	11	11	11	25	-	-	-	-	59
Leaky Acres (Fresno 1996-2004)			10,688,296	455	647	1,154	1,092	1,319	1,353	1,506	1,473	1,342	872	361	540	12,114
AGRS (Clovis 1997-2005)			3,719,500	77	98	169	175	276	266	321	294	289	125	-	22	2,113
Chestnut Basin (Fresno 1999-2006)			1,046,469	79	72	247	376	324	313	273	280	224	123	87	75	2,473
North-Central Basin (Fresno 2002-2006)			737,746	54	12	304	230	233	226	170	293	335	265	197	115	2,434
Kearney Basin (Fresno 2002-2006)			1,605,968	-	18	52	154	181	100	131	176	121	84	-	-	1,016
GRAND TOTAL																**45,227**

Source: Blair, Church and Flynn.

groundwater recharge in the Fresno area also results from the Woodward Park ponds and flows in several area creeks. As discussed in Chapter 5, the City of Fresno estimates that current intentional groundwater recharge by the City is about 40,000 af/yr, and that the average groundwater recharge since 2000 has been about 51,200 af/yr (see Table 5-3). This City of Fresno estimate does not include the recharge at the City of Clovis AGRS.

As described in Chapter 5, the average natural groundwater recharge beneath the City has been recently estimated by WRIME, through use of the calibrated IGSM model. For existing (2005) conditions, average natural recharge was estimated to be approximately 37,000 af/yr for the City SOI area, which includes the Pinedale, Bakman, and CSUF areas. In the future, as urbanization is assumed to occur, the IGSM model projects that the average natural recharge will decrease to about 27,000 af/yr by 2025. The recently developed estimates of average natural recharge have been used in this Phase 1 Report and will be used in subsequent phases of this Metro Plan Update.

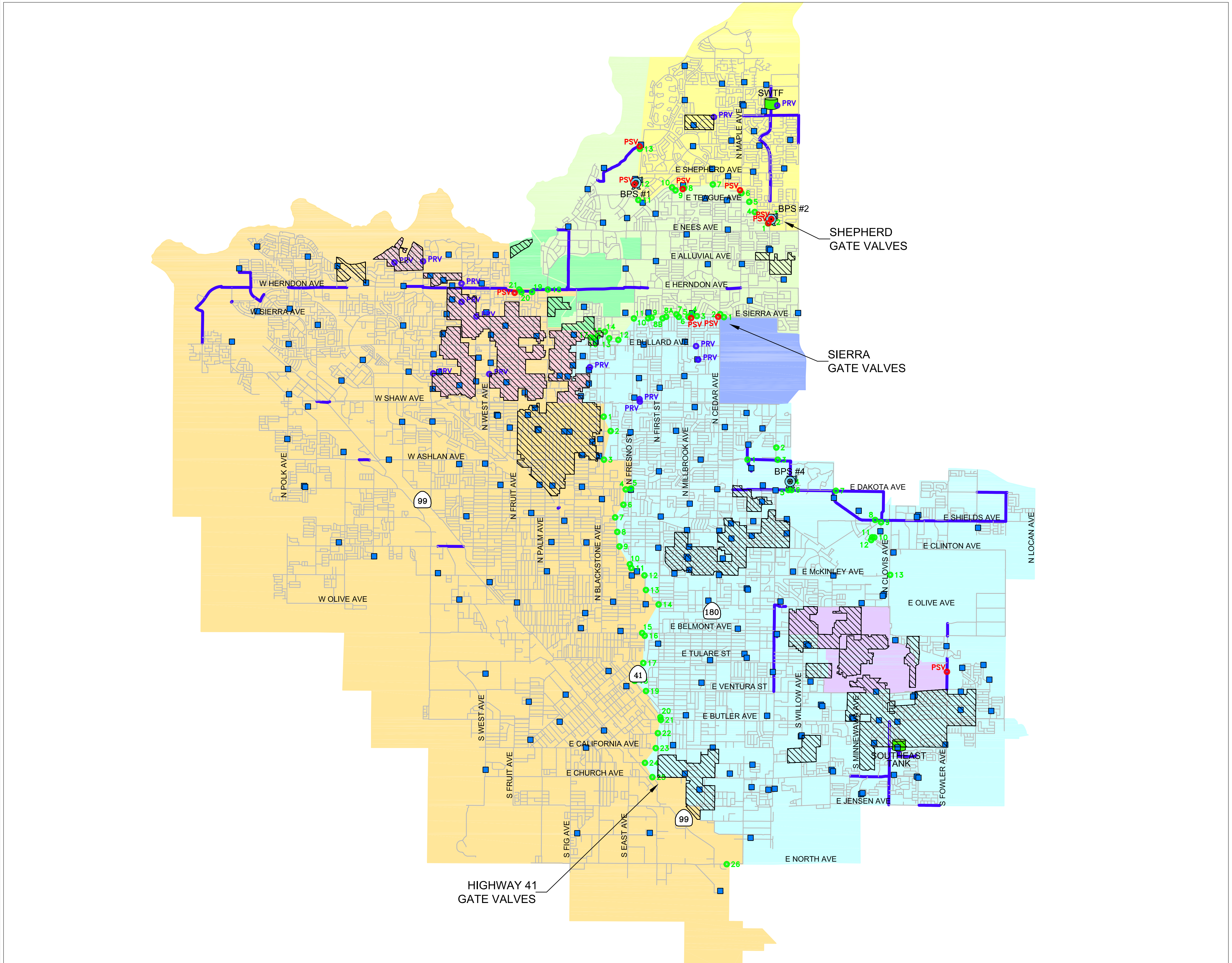


FIGURE 6-1

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING WATER DISTRIBUTION SYSTEM

N

0 4600 9200
SCALE IN FEET

NOTES:

A. Boundaries are approximated based on gate valve locations shown by GIS information provided by City Staff.

LEGEND:

- Existing City Wells
- Existing Storage Facility
- Booster Pump Station
- Existing 14-inch and Smaller Pipeline
- Existing 16-inch and Larger Pipeline
- Shepherd
- Sierra A
- Sierra B (Pinedale County Water District)
- Highway 41
- Highway 41B (CA State University, Fresno)
- Highway 41C (Bakman Water Company)
- Westside
- Fluoride Districts
- County Islands
- 1 Closed or Partially Closed Gate Valve Location
- 1 PSV Location
- 1 Fluoride District PRV Location

Fresno All-America City 2000

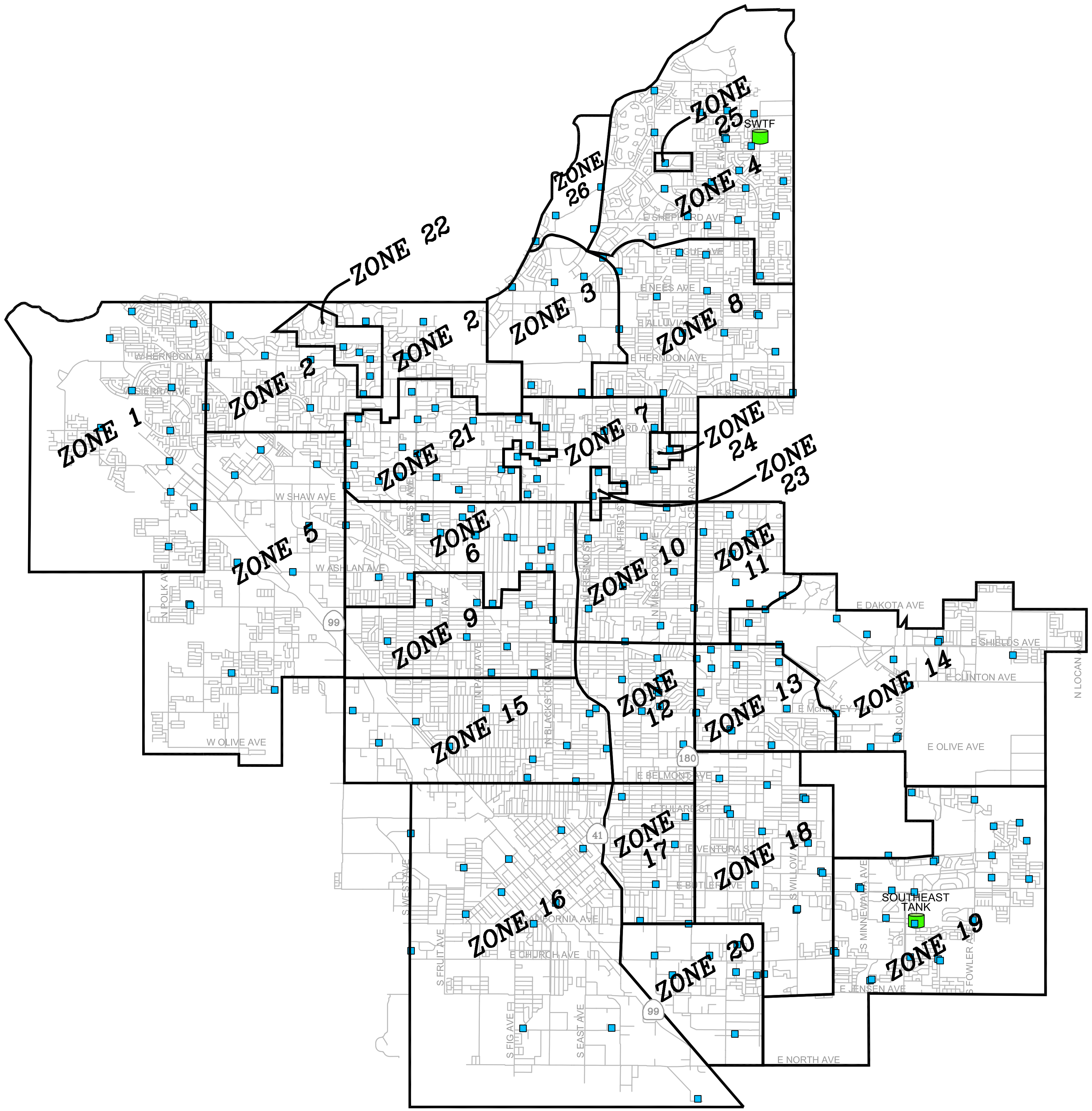
WEST YOST ASSOCIATES Consulting Engineers

CAD FILE: O:/Clients/439_Fresno/02-05-01/CAD/Figures/Chapter 6/FIG06-01_083006cn1 ExistingSystem.dwg DATE: 07-20-07 3:11pm

FIGURE 6-2

City of Fresno
Metropolitan Water Resources Management Plan Update

EXISTING SCADA ZONES



0 4600 9200
SCALE IN FEET

N

NOTES:

A. Boundaries are approximated based on data provided by City.

LEGEND:

- Existing City Wells
- Existing Storage Facility
- Existing Pipeline
- SCADA Zone Boundary

Fresno All-America City 2000

WEST YOST ASSOCIATES *Consulting Engineers*

CAD FILE: O:/Clients/439_Fresno/02-05-01/CAD/Figures/Chapter 6/FIG06-02_083006cn1 SCADAZones.dwg DATE: 09-01-06 3:59pm

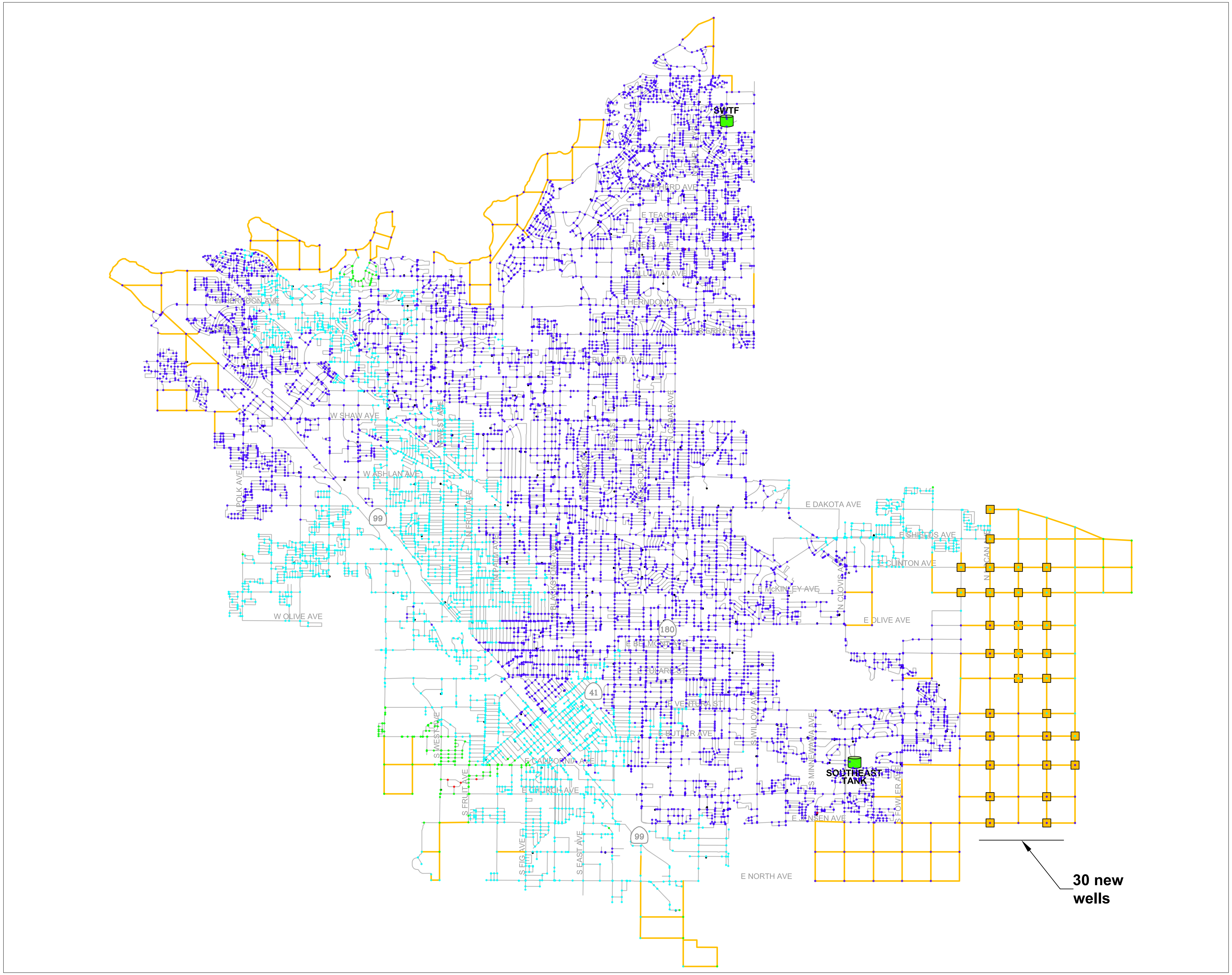


FIGURE 6-3

City of Fresno
Metropolitan Water Resources Management Plan Update

PROPOSED 2010 SYSTEM PEAK HOUR PRESSURES

N

0 4600 9200
SCALE IN FEET

NOTES:

A. Location and configuration of proposed facilities are approximated based on existing system information.

LEGEND:

- Existing Storage Facility
- Existing Pipeline
- Proposed 2010 Well Site
- Proposed 2010 Pipeline
- Pressure Below 40 psi
- Pressure Between 40 and 50 psi
- Pressure Between 50 and 60 psi
- Pressure Between 60 and 75 psi

Fresno All-America City 2000

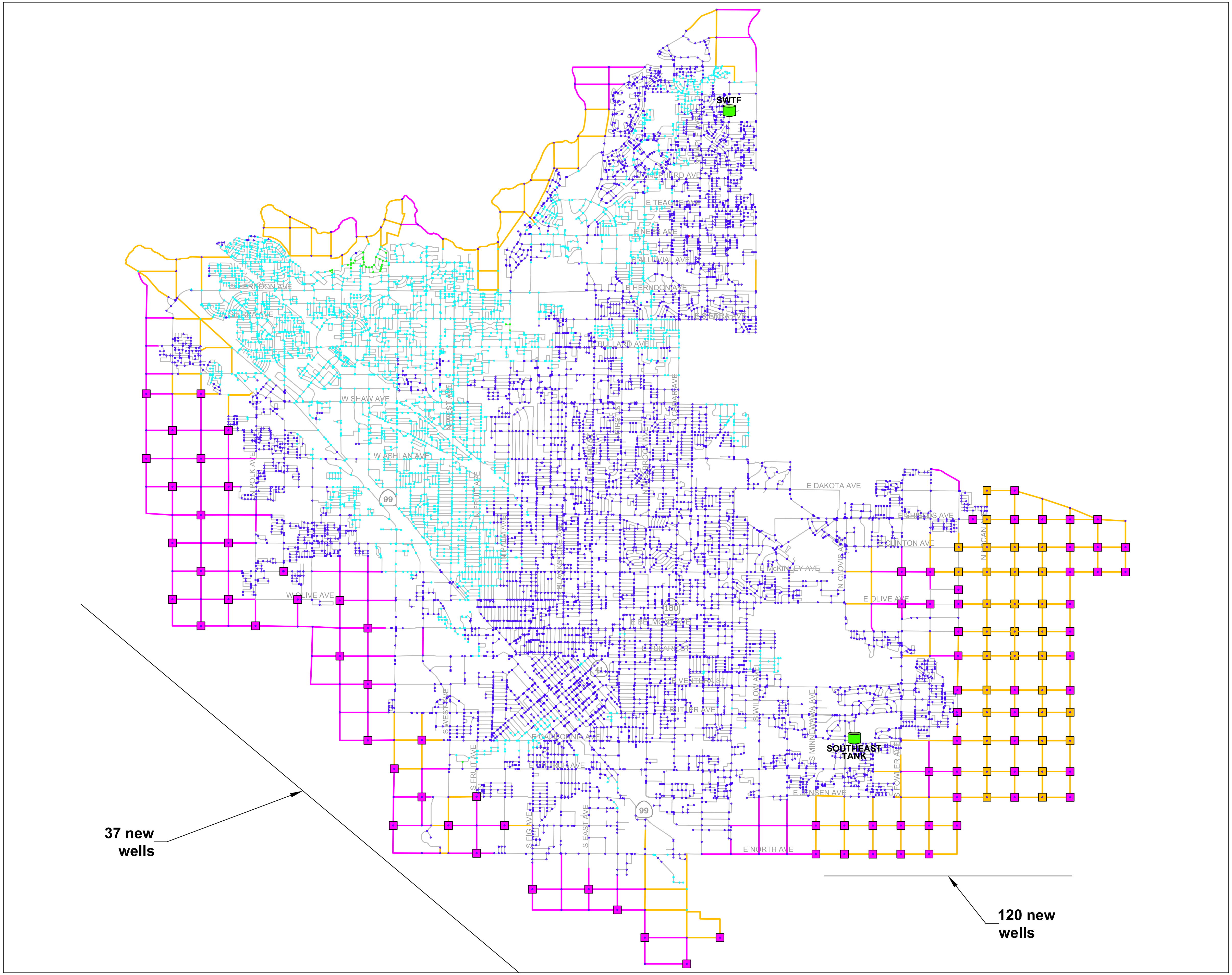
WEST YOST ASSOCIATES
Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Chapter 6\FIG06-03_083006cn1 2010PH.dwg DATE: 09-01-06 4:36pm

FIGURE 6-4

City of Fresno
Metropolitan Water Resources Management Plan Update

PROPOSED 2025 SYSTEM PEAK HOUR PRESSURES



N

0 4600 9200
SCALE IN FEET

NOTES:

A. Location and configuration of proposed facilities are approximated based on existing system information.

B. Wells east of Highway 99 assumed to produce 800 gpm. Wells west of Highway 99 assumed to produce 2000 gpm.

C. Some well sites assumed to have more than one well.

LEGEND:

- Existing Storage Facility
- Existing Pipeline
- Proposed 2010 Well Site
- Proposed 2010 Pipeline
- Proposed 2025 Well Site
- Proposed 2025 Pipeline
- Pressure Below 40 psi
- Pressure Between 40 and 50 psi
- Pressure Between 50 and 60 psi
- Pressure Between 60 and 75 psi

Fresno All-America City 2000

WEST YOST ASSOCIATES
Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Chapter 6\FIG06-04_083006cn1 2025PH.dwg DATE: 07-20-07 4:31pm

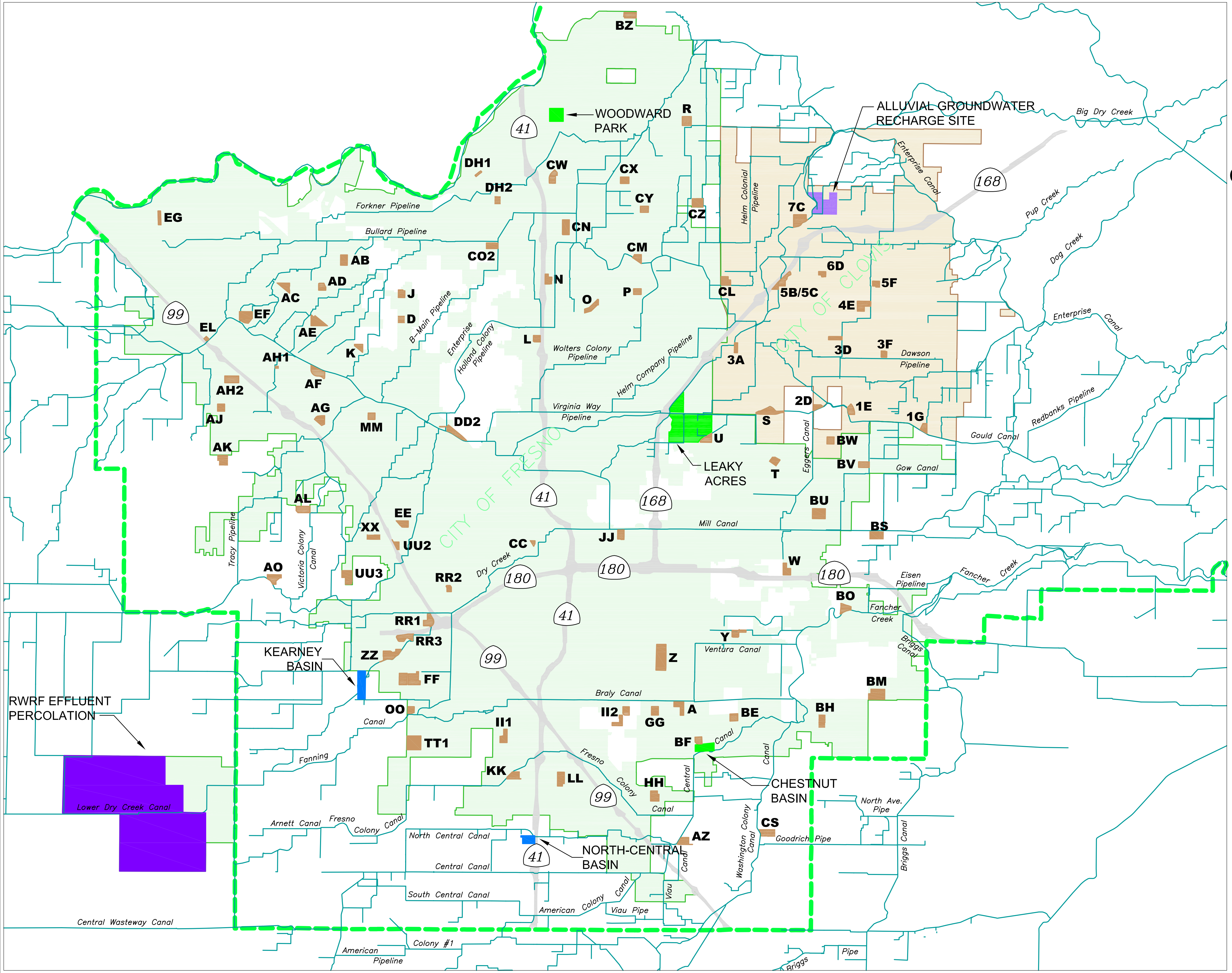


FIGURE 6-5

City of Fresno Metropolitan Water Resources Management Plan Update

GROUNDWATER RECHARGE BASIN LOCATIONS

N

0 4600 9200
SCALE IN FEET

NOTES:

A. Recharge locations based on data provided by City Staff.
B. FMFCD basins not used for groundwater recharge not shown.

LEGEND:

- FID Water Course
- FMFCD Boundary
- City of Fresno Basins
- FMFCD Basins
- FID Basins
- City of Clovis Basin
- RWRF Effluent Percolation

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

CAD FILE: O:\Clients\439_Fresno\02-05-01\CAD\Figures\Chapter 6\FIG06-05_083006cn1 RechargeFacilities.dwg DATE: 12-19-07 4:24pm

CHAPTER 7. FUTURE WITHOUT PROJECT GROUNDWATER RESPONSE

This chapter discusses the approach and assumptions used by WRIME in the technical analysis of the "Future Without Project" baseline conditions for the four different City of Fresno (City) development scenarios, including the 2005 Existing Conditions, and 2010, 2025 and 2060 Baseline Conditions. The Kings Basin Integrated Groundwater Surface Water Model (Kings IGSM) was used to evaluate "Future Without Project" conditions and the groundwater impacts of the land use changes that would occur under each set of growth assumptions. In this chapter, information on the Kings IGSM model is provided, the assumptions for areas outside the City are documented, and the results of the modeling are described. This chapter also explains the development, water demand, and water supply assumptions used for those areas outside the City.

APPROACH AND METHOD OF ANALYSIS-KINGS IGSM

The City overlies only a portion of the Kings Groundwater Basin (Kings Basin). The geographic extent of the Kings IGSM is the entire Kings Basin. The groundwater basin is interconnected and activities within the Kings Basin can affect the City. The land use and growth within the City may also affect the surrounding area. It is thus important to define the assumptions for land use, water demand and water supplies for both the City and the areas surrounding the City.

The Kings IGSM model was developed to support both the City and the Upper Kings Basin Water Forum (Water Forum) with financial support from DWR, the City, Kings River Conservation District and other Water Forum members. The Water Forum includes representatives from the overlying water districts, counties, incorporated cities, and environmental and other community interest groups. The Water Forum is developing an Integrated Regional Water Management Plan (IRWMP) for the Upper Kings Region defined as the IRWMP Area in Figure 7-1. The Water Forum's Technical Analysis and Data Work Group provided oversight and direction during the development and calibration of the Kings IGSM. A separate report has been prepared by WRIME discussing the development and calibration of the Kings IGSM.

The model was used to evaluate the effects on groundwater of future land uses for the City and surrounding area. This is important because under current City water supply conditions, when land is converted from agricultural uses to urban uses, the water supply generally shifts from agricultural irrigation with Kings River or Central Valley Project surface water, to pumping of groundwater. This shift to exclusive use of groundwater occurs in all developing urban areas except those areas that are to be provided treated surface water from the existing drinking water treatment plants. For each of the four planning horizons, the Kings IGSM model represents the land use and water supplies, the existing surface water treatment plants, the existing or approved groundwater recharge facilities (Leaky Acres, Waldron Ponds, Fresno/Fresno Metropolitan Flood Control District ponds); and the increased volumes of wastewater that are treated and sent to percolation basins at the City's wastewater treatment plant.

The demand conditions in the City are defined by the four development scenarios of 2005, 2010, 2025, and 2060 conditions. The water supply conditions and the impact of the future development conditions on groundwater in Kings Basin are dependent on future hydrologic conditions. Because future rainfall and streamflow conditions are not known, a surrogate hydrologic condition has been selected to represent likely future hydrologic and water supply conditions. Usually the surrogate hydrologic condition is a hydrologic period of several years (e.g., 30 or 40 years) selected from historical hydrologic records. The selected hydrologic period should include wet and dry conditions and represent the year-to-year variability. However, it is not reasonable to assume that year-to-year variability will be repeated in the order it occurred previously. For instance, the drought that occurred at the beginning of the selected period may occur near the end of the period. There are two main methods for analysis of future conditions:

- **Increasing Growth and Demands with Variable Hydrologic Conditions:** This method increases the future demand according to the desired planning and runs the demand scenario against the selected surrogate hydrologic period. However, the future hydrologic events may be different than the events in the surrogate hydrologic period. For instance, if the major drought sequence of the surrogate hydrologic period is at the beginning of the period, this analysis would not be stressed as much if the drought were at the end of the period. The drought would line up with lower demands rather than higher demands.
- **Constant Growth and Demands with Variable Hydrologic Conditions:** Similar to testing hypothetical design storms against a physical system, running the selected surrogate hydrologic period against each of several constant growth levels allows for comparison of the relative impact of the growth levels. This method is commonly used for simulating the future conditions, and has been used for this evaluation.

The Kings IGSM model uses the hydrology and surface water deliveries that occurred during the calibration period, from 1964 to 2004, to represent future conditions. In other words, it is assumed that the hydrologic conditions observed over the past 41 years for Kings River and San Joaquin streamflows and diversions would occur over the next 41 years. The 1964 to 2004 period contained both wet and dry periods and appropriate hydrologic variability to represent a range of potential future conditions. Global warming or changed climatic conditions were not evaluated.

MODELING ASSUMPTIONS AND INPUT SUMMARY

The Kings IGSM model was used to evaluate four "Future Without Project" conditions based on 2005 Existing Conditions, and 2010, 2025 and 2060 Baseline land use and water use conditions. The model input files for the four conditions were developed using projected data from the cities or water purveyors, and based on assumptions listed in Tables 7-1, 7-2, and 7-3. The model assumptions cover the City, the districts within City's SOI, the immediate area outside the City which includes the 2060 Growth Fringe, and the City of Clovis. Figure 7-1 defines the subregions of the Kings IGSM model for the Fresno Area. The Kings IGSM model can vary the model inputs for each subregion, allowing for varying land use and water supply assumptions within specific geographic areas. The model also produces analysis results for each subregion, helping to evaluate and explain the dynamics of the groundwater response to varying conditions. Some of the pertinent data inputs to the model that may have an influence on the groundwater budget are: hydrology, surface water deliveries, land use, water use, groundwater pumping, and groundwater recharge.

Table 7-1. City of Fresno Assumptions Summary

	2005 Existing Conditions	2010	2025/2030	2060
Land Use	2005 Land Use by West Yost	2010 Land Use by West Yost	2025 Land Use by West Yost	2060 Land Use by West Yost
Agricultural Water Demand	Based on: - 2004 Land Use and Crop Acreage - 1964-2004 Hydrology	Based on: - 2010 Land Use and Crop Acreage - 1964-2004 Hydrology	Based on: - 2025 Land Use and Crop Acreage - 1964-2004 Hydrology	Based on: - 2060 Land Use and Crop Acreage - 1964-2004 Hydrology
Crop Acreage	2004 Crop Acreage	2010 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)	2025 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)	2060 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)
Urban Water Demand	2005 Urban Demand Estimate by West Yost	2010 Urban Demand Estimate by West Yost (14.3 TAF/yr Increase over 2005 urban demand)	2025 Urban Demand Estimate by West Yost (77 TAF/yr increase over 2010 urban demand)	2060 Urban Demand Estimate by West Yost (121 TAF/yr increase over 2025 urban demand)
Recharge @ Leaky Acres	- For 1973-2004 use historical recharge rates - For 1964-1972 use 1973-2004 recharge rates based on San Joaquin Hydrology Index	Same as 2005/Existing Conditions	Same as 2005/Existing Conditions	Same as 2005/Existing Conditions
Recharge @ FMFCD Ponds	- For 1994-2004 use historical recharge rates - For 1964-1993 use 1994-2004 recharge rates based on San Joaquin Hydrology Index - Use ponds that are active in 2004 - Use 2000-2004 average recharge ratios for distribution of total recharge to individual ponds	Same as 2005/Existing Conditions	Same as 2005/Existing Conditions plus 2,734 AF/yr additional recharge at growth areas.	Same as 2005/Existing Conditions plus 14,853 AF/yr additional recharge at growth areas.
Recharge @ creeks and streams	2004 conditions	2004 conditions	2004 conditions	2004 conditions
Surface Water Treatment Plant	Full Capacity (32.5 TAF/yr with no production in November for maintenance)	Full Capacity (32.5 TAF/yr with no production in November for maintenance)	Full Capacity (32.5 TAF/yr with no production in November for maintenance)	Full Capacity (32.5 TAF/yr with no production in November for maintenance)
Wastewater Treatment Plant Total Flows and Flows to: Percolation Ponds; FID Canals; On-site irrigation (See Table 3-13 of Metro Plan)	78,400 AF	95,400 AF; increase of 17,000 AF over 2005	127,700 AF; increase of 43,900 AF over 2005	127,700 AF; increase of 43,900 AF over 2005
San Joaquin Settlement Flow Assumptions	No	No	No	No
Municipal Wells Pumping	- Use wells that are active in 2005 - Use 2005 Pumping Rates minus Surface Water Plant's 2005 Flows - Proportionally reduce pumping rate of each well	- Use wells that are active in 2005 - Use 2005 Pumping Rates minus Surface Water Plant's 2010 Flows - Proportionally reduce pumping rate of each well	- Use wells that are active in 2005 - Use 2005 Pumping Rates minus Surface Water Plant's 2025 Flows - Proportionally reduce pumping rate of each well	- Use wells that are active in 2005 - Use 2005 Pumping Rates minus Surface Water Plant's 2060 Flows - Proportionally reduce pumping rate of each well
Surface Water Deliveries - Kings River	Historical deliveries and diversions - Adjust for SWTP flows	Historical deliveries and diversions - Adjust for SWTP flows	Historical deliveries and diversions revised for capture of flood flows at Waldron/Harter ponds - Adjust for SWTP flows	Historical deliveries and diversions revised for capture of flood flows at Waldron/Harter ponds - Adjust for SWTP flows
Surface Water Deliveries - Friant-Kern	West Yost estimates of deliveries to FID & Fresno (60 TAF/yr, 17.9 TAF/yr for critically dry years) - Adjust for SWTP flows	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions
Land Use, Demand, Supply for Backman, Pinedale, and CSUF areas	2004 conditions	2004 conditions	2004 conditions	2004 conditions
Initial Conditions	- Use End of Sep 2004 values for GW levels, soil moisture, unsaturated soil moisture, and small watershed soil moisture	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions

Table 7-2. City of Clovis Assumptions Summary

	2005 Existing Conditions	2010	2025/2030	2060
Land Use	2004 Land Use	2004 Land Use	2030 Land Use	2030 Land Use
Agricultural Water Demand	Based on: - 2004 Land Use and Crop Acreage - 1964-2004 Hydrology	Same as 2005 conditions	Based on: - 2030 Land Use and Crop Acreage - 1964-2004 Hydrology	Based on: - 2030 Land Use and Crop Acreage - 1964-2004 Hydrology
Crop Acreage	2004 Crop Acreage	Same as 2005 conditions	2030 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)	2030 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)
Urban Water Demand	2004 Urban Demand	2010 Urban Demand	2030 Urban Demand	2030 Urban Demand
Recharge @ creeks and streams	Use 2004 conditions	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions
Surface Water Treatment Plant	- Use 2005 Calendar Year Rates (6.7 TAF/yr) - Use 2005 Monthly Rates	- Use 2005 Calendar Year Rates (6.7 TAF/yr) - Use 2005 Monthly Rates	- Use 2030 Rates (30 MGD) - Use 2005 Monthly Flow Ratios	- Use 2030 Rates (30 MGD) - Use 2005 Monthly Flow Ratios
Wastewater Treatment Plant Flows (RWRF)	see Fresno Table 7-1	see Fresno Table 7-1	see Fresno Table 7-1	see Fresno Table 7-1
Wastewater Treatment Plant Flows (Clovis Satelite Treatment Plant (tertiary treatment)	None	- 2,900 AF/yr - Plant outflow to be used for landscape irrigation in Clovis and CSUF	- 7,600 AF/yr - Plant outflow to be used for landscape irrigation in Clovis and CSUF	- 7,600 AF/yr - Plant outflow to be used for landscape irrigation in Clovis and CSUF
Municipal Wells Pumping	- Use wells that are active in 2004 - Use 2004 Pumping Rates minus Surface Water Plant's 2005 Flows - Proportionally reduce pumping rate of each well	Same as 2005 conditions	- Use wells that are active in 2004 - Use 2004 Pumping Rates minus Surface Water Plant's 2030 Flows - Proportionally reduce pumping rate of each well	- Use wells that are active in 2004 - Use 2004 Pumping Rates minus Surface Water Plant's 2030 Flows - Proportionally reduce pumping rate of each well
Initial Conditions	- Use End of Sep 2004 values for GW levels, soil moisture, unsaturated soil moisture, and small watershed soil moisture	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions

Table 7-3. Other Areas Assumptions Summary

	2005 Existing Conditions	2010	2025/2030	2060
Land Use	2004 Land Use	2004 Land Use	2030 Land Use	2030 Land Use
Agricultural Water Demand	Based on: - 2004 Land Use and Crop Acreage - 1964-2004 Hydrology	Same as 2005 conditions	Based on: - 2030 Land Use and Crop Acreage - 1964-2004 Hydrology	Same as 2025/2030 conditions
Crop Acreage	- 2004 Crop Acreage	- 2004 Crop Acreage	- 2030 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)	- 2030 Crop Acreage (2004 crop acreage minus agricultural areas converted to urban)
Recharge Ponds	2004 Conditions	2004 Conditions	2004 Conditions plus - Waldron Ponds (FID) - Harter Ponds (CID)	2004 Conditions plus - Waldron Ponds (FID) - Harter Ponds (CID)
Urban Water Demand	2004 Urban Demand	2010 Urban Demand	2030 Urban Demand	2030 Urban Demand
Wastewater Treatment Plants Flows	Use 2004 conditions for: - SKF WWTP - Other non-Fresno/Clovis WWTP	Use 2004 conditions for: - SKF WWTP - Other non-Fresno/Clovis WWTP	Use 2004 conditions for: - SKF WWTP - Other non-Fresno/Clovis WWTP	Use 2004 conditions for: - SKF WWTP - Other non-Fresno/Clovis WWTP
San Joaquin Settlement Flow Assumptions	No	No	No	No
Pine Flat Reservoir Operations	Historical releases and flows	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions
Surface Water Deliveries - Kings River	Historical deliveries and diversions	Same as 2005 conditions	Historical deliveries and diversions revised for capture of flood flows at Waldron/Harter ponds	Historical deliveries and diversions revised for capture of flood flows at Waldron/Harter ponds
Surface Water Deliveries - F-K & CVP to Non-Fresno/Clovis Areas	Historical deliveries and diversions	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions
Initial Conditions	- Use End of Sep 2004 values for GW levels, soil moisture, unsaturated soil moisture, and small watershed soil moisture	Same as 2005 conditions	Same as 2005 conditions	Same as 2005 conditions

Land Use

Growth in the City results in land use conversion from open space or agriculture to urban. The City land use information used in the Kings IGSM model was provided by West Yost Associates (WYA) in GIS format. Four alternative future scenarios were developed. The 2005 Existing Conditions establishes the land use as of 2005 with the assumption that there will be no further conversion of agricultural land to urban use (see Figure 7-2). This essentially "freezes" urbanization, population growth, water use, and other factors that may ultimately change with time. The 2005 Existing Conditions input files were then evaluated with the Kings IGSM model using the 41-year hydrologic period discussed above. For this scenario, it was assumed that there are no new water resources projects or supplies.

The additional baseline alternatives were developed for 2010, 2025, and 2060 Baseline land uses and are depicted in Figures 7-3, 7-4, and 7-5, respectively. The changes in land use are shown in Table 7-4 which presents the agriculture to urban conversion for each of the future development conditions for each subregion.

The City lies within subregions 7, 8, 10, 11, and 12. Other water producing agencies within the City SOI, located in subregions 9, 13, and 14, are Pinedale Water District (Pinedale), Bakman Water Company (Bakman), and California State University Fresno (CSUF), respectively. Little or no growth is expected within these areas. The City is assumed to develop outside of its current SOI into the Southeast Growth Area and the 2060 Growth Fringe, as shown in Table 7-4 under the Fresno Growth Area. The 2060 Growth Fringe overlies portions of other subregions in the Kings IGSM model; subregions 6 and 16 within Fresno Irrigation District, and subregion 27 within the Consolidated Irrigation District. Only agricultural and urban land uses are identified in Table 7-4. Urban development is not solely due to conversion of agricultural land, but may also be due to urbanization of riparian, native, or other vacant land, identified in Table 7-4 as "other land uses."

Water Use

The model calculates the water demand based on water duty factors assigned to each land use. The urban land use water duties, defined in acre-feet of water per acre, are contained in Chapter 3. Table 7-5 shows the total water demand for agricultural and urban uses within each subregion within the City, the Southeast Growth Area, and the 2060 Growth Fringe. The sources of the water for the subregions that make up the City (7, 8, 10, 11, and 12) are from groundwater or surface water diverted from the Kings River through FID facilities, and/or San Joaquin River via the Friant-Kern Canal. Groundwater is used to meet the agricultural and urban water demands that are not met by surface water. The assumptions for the 2005 Existing Conditions and the 2010, 2025, and 2060 Baseline Conditions are that the existing Surface Water Treatment Facility is producing at its maximum rate of 32,500 af/yr, and that this uniformly reduces groundwater extraction within the City of Fresno subregions.

Flood Control and Recharge Ponds for the Growth Area

The City, in cooperation with the Fresno Metropolitan Flood Control District (FMFCD), jointly operates recharge and flood control ponds. The Kings IGSM reflected the likely future operations of these ponds since they are an important part of the water budget in the Fresno Area.

Table 7-4. Fresno Area Land Use (Acres)

Area		Urban Land Use (Acres)				Agricultural Land Use (Acres)				Other Land Use (Acres)				Total Land Use (Acres)			
City of Fresno	SR	2005	2010	2025	2060	2005	2010	2025	2060	2005	2010	2025	2060	2005	2010	2025	2060
Westside	7	32,424	34,759	44,252	44,252	9,232	7,378	0	0	2,742	2,261	146	146	44,398	44,398	44,398	44,398
Fluoride	8	3,024	3,029	3,069	3,069	9	9	0	0	36	31	0	0	3,069	3,069	3,069	3,069
Shepherd	10	3,363	4,165	5,201	5,201	17	17	0	0	1,822	1,020	1	1	5,202	5,202	5,202	5,202
Sierra	11	4,960	4,990	5,952	5,952	1,047	419	0	0	222	820	277	277	6,229	6,229	6,229	6,229
Highway 41	12	21,958	23,720	27,867	27,867	326	310	0	0	5,584	3,838	1	1	27,868	27,868	27,868	27,868
Subtotal		**65,729**	**70,663**	**86,341**	**86,341**	**10,631**	**8,133**	**0**	**0**	**10,406**	**7,970**	**425**	**425**	**86,766**	**86,766**	**86,766**	**86,766**
Fresno Growth Area																	
SE Growth Area in FID East	16	1,455	2,630	8,143	8,143	5,895	5,001	0	0	793	512	0	0	8,143	8,143	8,143	8,143
SE Growth Area in CID East	27	3	3	549	549	546	546	0	0	0	0	0	0	549	549	549	549
2060 Fringe Area in FID West	6	1,358	1,358	1,393	22,935	20,825	20,825	20,800	0	751	751	741	0	22,935	22,935	22,935	22,935
2060 Fringe Area in FID East	16	1,512	1,512	1,530	6,985	5,062	5,062	5,047	0	411	411	407	0	6,985	6,985	6,985	6,985
2060 Fringe Area in CID East	27	89	89	89	6,872	6,744	6,744	6,744	0	39	39	39	0	6,872	6,872	6,872	6,872
Subtotal		**4,418**	**5,593**	**11,705**	**45,484**	**39,071**	**38,177**	**32,591**	**0**	**1,995**	**1,713**	**1,188**	**0**	**45,484**	**45,484**	**45,484**	**45,484**
Total Fresno		**70,147**	**76,256**	**98,046**	**131,825**	**49,702**	**46,310**	**32,591**	**0**	**12,401**	**9,683**	**1,613**	**425**	**132,250**	**132,250**	**132,250**	**132,250**

Table 7-5. Fresno Area Water Use (Acre-Feet)

Area		Urban Water Use (Acre-Feet)				Ag Water Use (Acre-Feet)				Total Water Use (Acre-Feet)			
City of Fresno	SR	2005	2010	2025	2060	2005	2010	2025	2060	2005	2010	2025	2060
Westside	7	67,727	71,500	111,894	111,869	29,185	23,519	0	0	96,912	95,019	111,894	111,869
Fluoride	8	10,371	9,666	9,941	9,941	35	35	0	0	10,406	9,701	9,941	9,941
Shepherd	10	11,384	12,572	14,377	14,377	3,297	1,259	0	0	14,681	13,831	14,377	14,377
Sierra	11	12,962	12,406	17,271	13,039	1,482	1,425	0	0	14,444	13,831	17,271	13,039
Highway 41	12	55,135	58,330	65,714	69,946	14,744	10,155	0	0	69,879	68,485	65,714	69,946
Subtotal		**157,579**	**164,474**	**219,197**	**219,172**	**48,743**	**36,393**	**0**	**0**	**206,322**	**200,867**	**219,197**	**219,172**
Fresno Growth Areas													
SE Growth Area in FID East	16	0	7,405	27,999	27,999	18,335	15,114	0	0	18,335	22,519	27,999	27,999
SE Growth Area in CID East	27	0	0	1,905	1,905	1,749	1,749	0	0	1,749	1,749	1,905	1,905
2060 Fringe Area in FID West	6	0	0	0	76,329	65,433	65,433	65,433	0	65,433	65,433	65,433	76,329
2060 Fringe Area in FID East	16	0	0	0	19,886	17,107	17,107	17,107	0	17,107	17,107	17,107	19,886
2060 Fringe Area in CID East	27	0	0	0	24,669	22,400	22,400	22,400	0	22,400	22,400	22,400	24,669
Subtotal		**0**	**7,405**	**29,904**	**150,788**	**125,024**	**121,803**	**104,940**	**0**	**125,024**	**129,208**	**134,844**	**150,788**
Total Fresno		**157,579**	**171,879**	**249,101**	**369,960**	**173,767**	**158,196**	**104,940**	**0**	**331,346**	**330,075**	**354,041**	**369,960**

Operational data for the existing ponds was limited to recent years, with the most detailed data available from 1999 to 2004. Partial records were available from the FMFCD for the period from 1980 to 2004.

To evaluate potential future conditions, a synthetic recharge schedule was developed using the historical data, average monthly recharge distribution for the years where data was available, and the San Joaquin River hydrologic index. Figure 7-6 shows the observed data for the total annual recharge water delivered into the FMFCD ponds from 1980 to 2004. The figure also shows the synthetic recharge schedule that was created for use in the Kings IGSM to represent future years 1 through 41. Figure 7-6 shows that the synthetic schedule would include more recharge than the historical period since it is assumed that additional ponds would be built in the growth areas. The synthetic schedule was used to approximate the total recharge within the existing subregions that will occur in the future baseline scenarios.

To validate the assumptions used to develop the synthetic schedule, the average monthly distribution of the synthetic recharge schedule was compared to the more detailed historical recharge data observed over the five years of actual operations from 1999 to 2004, as shown in Figure 7-7. The monthly distribution shows only a slight variation between the historical data and synthetic schedule.

An estimate of future recharge acreage in areas to be developed was also prepared to evaluate future conditions. Monthly and annual estimates of water intentionally recharged within the 2060 Growth Fringe were also developed. The 2060 Growth Fringe was divided into eleven subgroups. Each subgroup assumed a percolation rate ranging from 0.2 to 0.5 feet per day and the recharge acreage required to support mixed urban development as provided by WYA. Impacts on total recharge for low water years, maintenance, excavation and other unknowns were taken into account in the estimated average annual recharge. The future recharge schedule was used as part of the input files for 2025 and 2060 Baseline Conditions.

Natural Groundwater Recharge

Natural groundwater recharge was included in the IGSM as the "deep percolation" component of groundwater inflow. "Deep percolation" includes irrigation applied water and rainfall, but does not include subsurface inflow. For the Fresno SOI, average natural groundwater recharge ("deep percolation") for 1964 to 2004 was estimated to be 42,700 af/yr[1], and has been decreasing over time as urbanization has occurred. This natural groundwater recharge was recalculated for the 2005 Existing Conditions and 2010, 2025, and 2060 Baseline Conditions, based on estimated areas available for natural recharge within the Fresno SOI. For 2005, the natural groundwater recharge for the Fresno SOI was estimated to be about 37,000 af/yr. Due to projected future increased urbanization within the Fresno SOI, the areas available for "deep percolation," or natural groundwater recharge, are estimated to decrease over time. Thus, the annual quantity of natural groundwater recharge is estimated to decrease over time. For 2010, the natural groundwater recharge for the Fresno SOI is estimated to be reduced to about 33,600 af/yr; and

[1] Table 6-8, Kings Basin Integrated Groundwater and Surface Water Model (Kings IGSM) Model Development and Calibration, prepared by WRIME, November 2007.

for 2025 and 2060, the natural groundwater recharge for the Fresno SOI is estimated to be about 27,000 af/yr[2].

MODEL RESULTS

This section provides the summary of the Kings IGSM modeling results for the 41-year hydrologic period for the Fresno Area for 2005 Existing Conditions, and 2010, 2025, and 2060 Baseline Conditions. The results show the groundwater response and the water budgets based on the four development levels. The groundwater response is depicted by the change in groundwater level contour maps and changes in groundwater storage for the Fresno Area.

Table 7-6 shows the changes in groundwater elevation and groundwater storage in City SOI at the end of the 41-year hydrologic period under the existing and assumed baseline conditions. For the analysis of future land use conditions, the model runs hold annual growth rates constant for the entire 41-year period for each growth level. This allows for comparison of the relative effects of the four growth levels. The model indicates that if the 2005 existing land use conditions were in place over the next 41-year modeling period, the water table would decline an additional 8 feet, and 122 TAF would have been removed from groundwater storage at the end of the 41-year period. The 2010 Baseline Conditions shows a change in groundwater storage of 105 TAF, which is less than the 2005 Existing Conditions. The difference in change in groundwater storage between 2005 and 2010 Baseline Conditions is primarily due to the additional 17 TAF of percolation assumed from the wastewater treatment plant in 2010 (see Table 7-1). For the 2025 and 2060 conditions, water level would decline an additional 20 feet and 23 feet, respectively, and 347 TAF and 482 TAF would be removed from groundwater storage. The declines in 2025 and 2060 Baseline Conditions in water level and depletion of groundwater storage are associated with the resultant increased urban development and the increased urban reliance on groundwater.

Table 7-6. Groundwater Response Results for 41-Year Hydrologic Period[a]

	2005 Existing Conditions	2010 Baseline Conditions	2025 Baseline Conditions	2060 Baseline Conditions
End of 41-Year Period Change in Observed Groundwater Elevation in the Fall, Feet	-8	-7	-20	-23
End of 41-Year Period Change in Groundwater Storage, TAF	-122	-105	-347	-482

(a) Each model run is based on holding the demand constant over the 41-year period; thus the results (change in observed groundwater elevation and change in groundwater storage) represent a relative comparison of the impacts of different demand conditions over a 41-year period.

2 Source: Groundwater Budget Files for Existing and Baseline IGSM model runs, provided to WYA by WRIME on July 24, 2007.

Groundwater Elevation

The change in groundwater elevation associated with each of these four conditions can be shown using six Kings IGSM representative well hydrographs and a series of contour maps. The well locations follow the number format found in the Kings IGSM model and are not the City's well identification number. The well locations are shown in Figure 7-8 along with the current groundwater levels. To show the effects of variable hydrologic conditions, the 1964-2004 hydrologic period was evaluated to identify dry, multiple dry, wet and multiple wet years for the region. The hydrologic periods were selected as follows: 1976 Dry; 1983 Wet; 1987-1992 Multiple Dry; and 1995-1998 Multiple Wet years. These hydrologic water years are highlighted on the well hydrograph charts, Figures 7-9 through 7-14. The figures show the change in groundwater elevation within the City and its immediate surrounding area.

Figure 7-9 shows Well 35 which is in the southwest, in the 2060 Growth Fringe, near the regional wastewater treatment plant. The historical data shows a decline in groundwater elevation of approximately 5 feet. The 2005 Existing Conditions shows an additional 20 feet decline over the next 41-year period. The 2010 Baseline Condition shows a decline of groundwater elevation of 16 feet. The reduction of groundwater decline from the 2005 Existing Condition and the 2010 Baseline Conditions may be attributed to the percolation of treated effluent at the wastewater treatment plant. The impact on groundwater decreases as the well location distance increases from the wastewater treatment plant. Well 60 (Figure 7-13) and, to a lesser degree, Well 45 (Figure 7-10) also show a slower decline in groundwater elevation for the 2010 Baseline Conditions than the 2005 Existing Conditions.

Figure 7-11 shows Well 47 in the northeast near the southwest corner of Clovis. The historical change in groundwater elevation shows a drop of approximately 17 feet with a continuing decrease in levels from 3 feet with 2005 Existing Conditions, to 33 feet in the 2060 Baseline Conditions over the 41-year period. Located in the southeast, Well 58 (Figure 7-12) shows a more dramatic drop in groundwater elevation ranging from 12 feet (2005) to 52 feet (2060). The effects of development in the 2060 Baseline Conditions are reflected by a sharp decline in the first 14 years of the 41-year period compared to the 2005 and 2010 Baseline Conditions. The groundwater elevation shown for Well 70 (Figure 7-14) is higher due to its location in the foothills and distance from the recharge sources. The impacts on the groundwater elevation due to hydrologic cycle are shown by more pronounced peaks and valleys in the hydrograph. This is attributed to the reduced water storage capacity in the foothills compared to the area where Well 35 is located.

A series of contours showing the change in elevation between the 2005 Existing Conditions, 2010, 2025, and 2060 Baseline Conditions, are shown in Figures 7-15, 7-16, 7-17 and 7-18, respectively. Figure 7-15 represents the groundwater elevation at the end of the 41-year period under the 2005 Existing Conditions as compared to existing groundwater levels as shown on Figure 7-8. Following is a comparative summary of the baseline conditions to the 2005 Existing Conditions:

- 2010 Baseline Conditions:
  - Drop in groundwater elevation in the northeast Fresno and Clovis area of 0 to 4 feet.
  - Rise in groundwater elevation of 1 to 5 feet in all other areas.
  - Rise in groundwater elevation of 6-10 feet in the southwest Growth Fringe Area due to percolation of treated effluent at the wastewater treatment plant.
- 2025 Baseline Conditions:
  - Drop in groundwater elevation in southeast Fresno of 30 to 34 feet.
  - Drop in groundwater elevation in northern Fresno of 25 to 29 feet.
  - Rise in groundwater elevation of 1 to 5 feet in the southwest Growth Fringe Area.
- 2060 Baseline Conditions:
  - Drop in groundwater elevation in southeast Fresno of 50 to 54 feet.
  - Drop in groundwater elevation of 15 feet or greater in most of the Fresno Area.
  - Drop in groundwater elevation of 25 to 34 feet in the southeast Growth Fringe area.
  - Drop in groundwater elevation of 0 to 29 feet in the southwest Growth Fringe area.

Groundwater Storage

Changes in groundwater elevation are directly proportional to the changes in groundwater storage. Figure 7-19 shows the historical annual change in groundwater level (bars) and the cumulative change in storage (line graph). When the bar is above zero, this means that more water is put into storage than is removed. When it is below zero, more water is removed for that year than is recharged. The line on the graph adds together the annual change to show how groundwater storage may be increasing or decreasing over time. Note that there was a decrease in groundwater storage of 277 TAF at the end of the 1964 to 2004 period. The groundwater storage significantly declined over the multiple dry years between 1987 and 1992. It may also be observed that the storage did not recover even after the wet period from 1995 to 1998.

The historical period is used to establish the Fresno Area initial groundwater conditions. The cumulative changes in groundwater storage for the 2005 Existing Conditions and the 2010, 2025, and 2060 Baseline Conditions are presented on Figure 7-20. The figure shows the historic 41-year hydrologic period repeated as Years 1 to 41. The end of the line graph shows a drop in groundwater storage when compared to the initial storage in 1964.

The average annual change in groundwater elevation and storage for the historical and the four baseline conditions are summarized in Table 7-7. The table shows the “long-term” average change in groundwater levels and storage for the historical and future baseline conditions for the 41-year hydrologic period modeled. The long-term annual average change in groundwater storage is -7 TAF per year. The 2005 Existing Conditions long-term average annual change in storage is -3 TAF per year. This represents a decrease in the rate of depletion of groundwater storage under the existing conditions. Table 7-7 shows the 2010 Baseline Conditions long-term

Table 7-7. Groundwater Response by Hydrologic Year Type

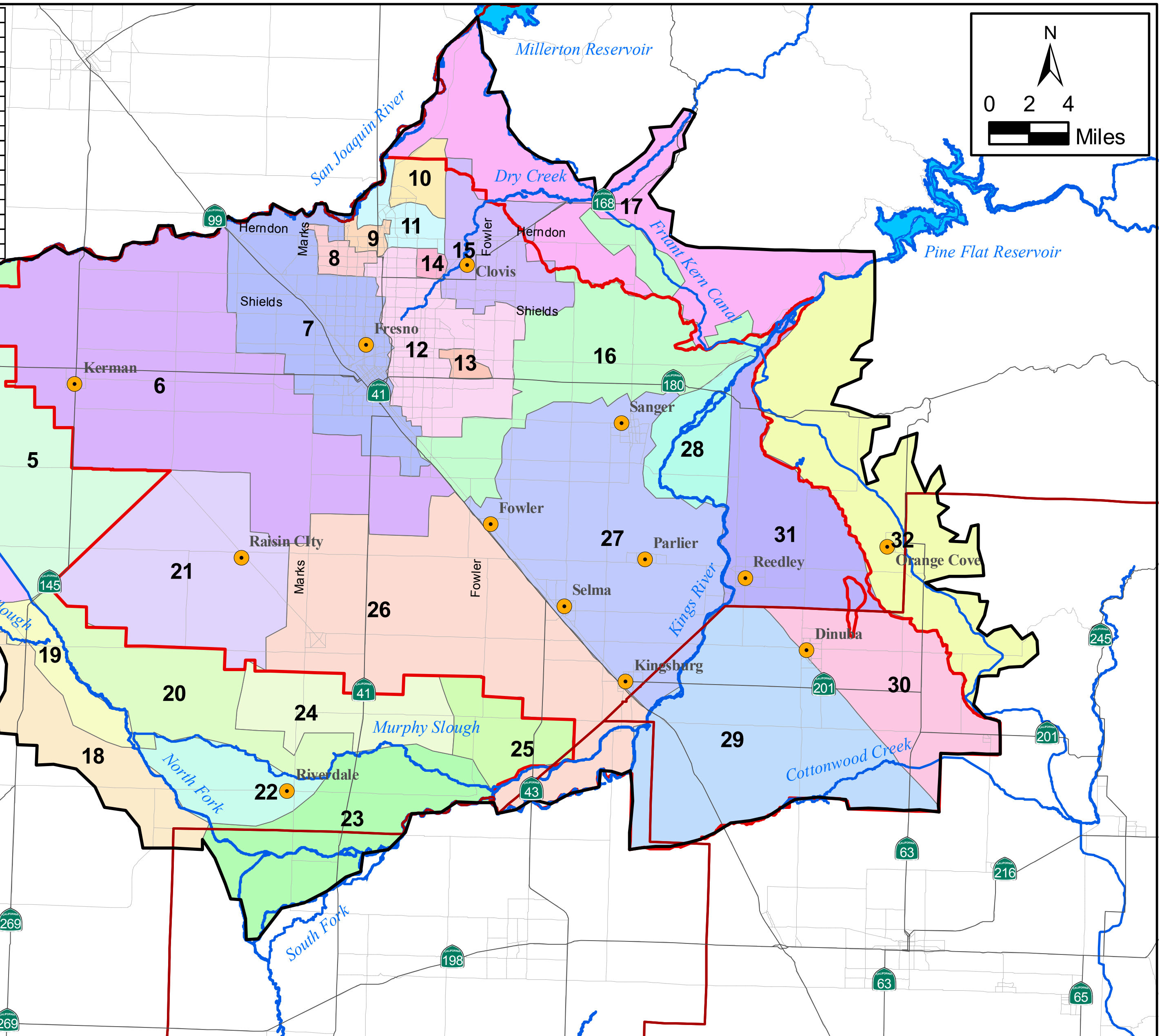
Average Annual Change Groundwater Elevation in the Fall (Feet per Year)	Dry Year 13 (1976)	Multiple Dry Years 24-29 (1987-1992)	Wet Year 20 (1983)	Multiple Wet Years 31-34 (1995-1998)
1964-2004 Historical	-4.2	-2.9	3.4	0.2
2005 Existing Conditions	-3.4	-2.5	3.0	1.0
2010 Baseline Conditions	-3.1	-2.4	3.0	1.2
2025 Baseline Conditions	-2.8	-1.9	2.9	1.3
2060 Baseline Conditions	-5.0	-1.7	4.1	0.8
Average Annual Change in Groundwater Storage (Thousand Acre-Feet)	**Dry Year 13 (1976)**	**Multiple Dry Years 24-29 (1987-1992)**	**Wet Year 20 (1983)**	**Multiple Wet Years 31-34 (1995-1998)**
1964-2004 Historical	-63	-40	32	8
2005 Existing Conditions	-64	-30	31	20
2010 Baseline Conditions	-61	-29	32	21
2025 Baseline Conditions	-60	-25	31	23
2060 Baseline Conditions	-59	-25	25	18

average as the same as 2005 Existing Conditions and a slight improvement in the change in water storage graph on Figure 7-20. This is due to percolation of treated effluent at the wastewater treatment plant, as explained previously. The 2025 Baseline Conditions shows a decrease in water storage of 347 TAF (Table 7-6) or a long-term average annual change of -8 TAF. The City SOI footprint is completely converted to urban land use under the 2025 Baseline Conditions (refer to Figure 7-4) but the City Growth Fringe area is still providing surface water recharge benefits from agricultural applied water. However, through continuing development in the Growth Fringe (Figure 7-5), the benefits of surface water recharge being applied adjacent to the City SOI was gradually removed due to urbanization. This is reflected in the long-term average of 2060 Baseline Conditions (Table 7-7); the rate of depletion of the groundwater storage is 12 TAF per year.

CONCLUSIONS

The “Future Without Project” alternatives would have a significant effect on groundwater levels and storage. Under each of the alternative land use scenarios evaluated, the dependence on groundwater to meet the urban demands would lead to continued declines in groundwater levels, overdraft of the groundwater basin, expansion of the trough in the water table (regional cone of depression) under the City, and result in a reduced potential for recovery of the groundwater levels even after wetter than average periods. The change in demand from agricultural uses reliant on both surface water deliveries and groundwater pumping, to urban demands reliant on groundwater exclusively will also change the rate and direction of flow. This change in the rate and direction of groundwater flow could also cause existing contamination plumes to migrate.

ID	Subregion	ID	Subregion
1	Mendota Pool Area	17	Foothills North
2	Tranquility	18	Crescent Canal Service Area
3	James	19	Stinson
4	Mid-Valley	20	Murphy Slough
5	East Side Well Field	21	Raisin City
6	FID West	22	Riverdale
7	Fresno - SOI - Westside	23	Laguna
8	Fresno - SOI - Fluoride	24	Liberty
9	Fresno - SOI - Pinedale	25	Private Pumpers East of Liberty
10	Fresno - SOI - Shepherd	26	CID West
11	Fresno - SOI - Sierra	27	CID East
12	Fresno - SOI - Highway 41	28	Kings River
13	Fresno - SOI - Bakman	29	AID West
14	Fresno - SOI - CSFU	30	AID East
15	Clovis - SOI	31	AID North
16	FID East	32	Foothills South



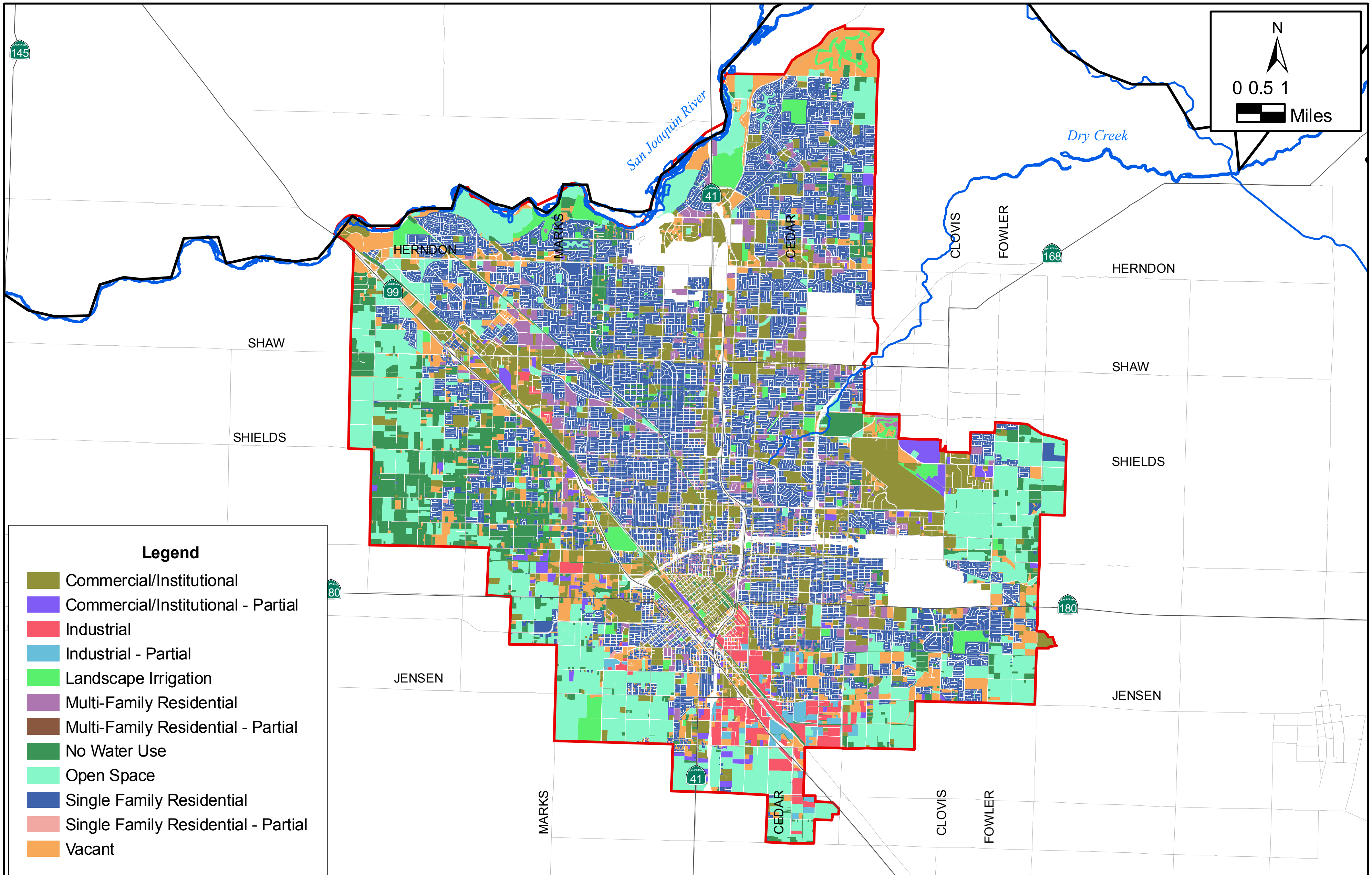
WRIME

Kings IGSM Subregions

Kings Basin Integrated Groundwater and Surface water Model (KingsIGSM)

May 2007

Figure 7.1



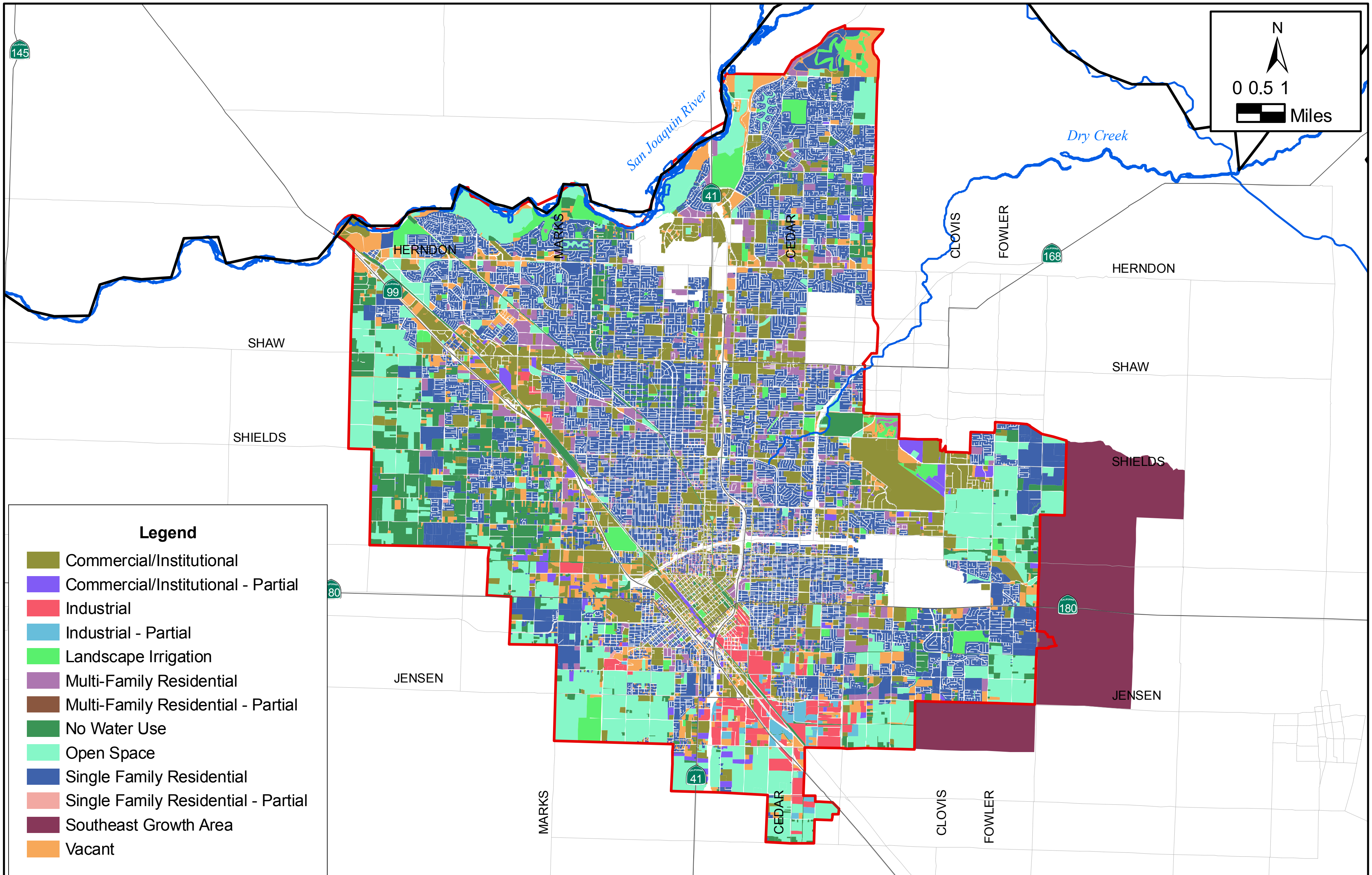
WRIME

City of Fresno Existing Land Use

Kings Basin Integrated Groundwater and Surface water Model (KingsIGSM)

May 2007

Figure 7.2

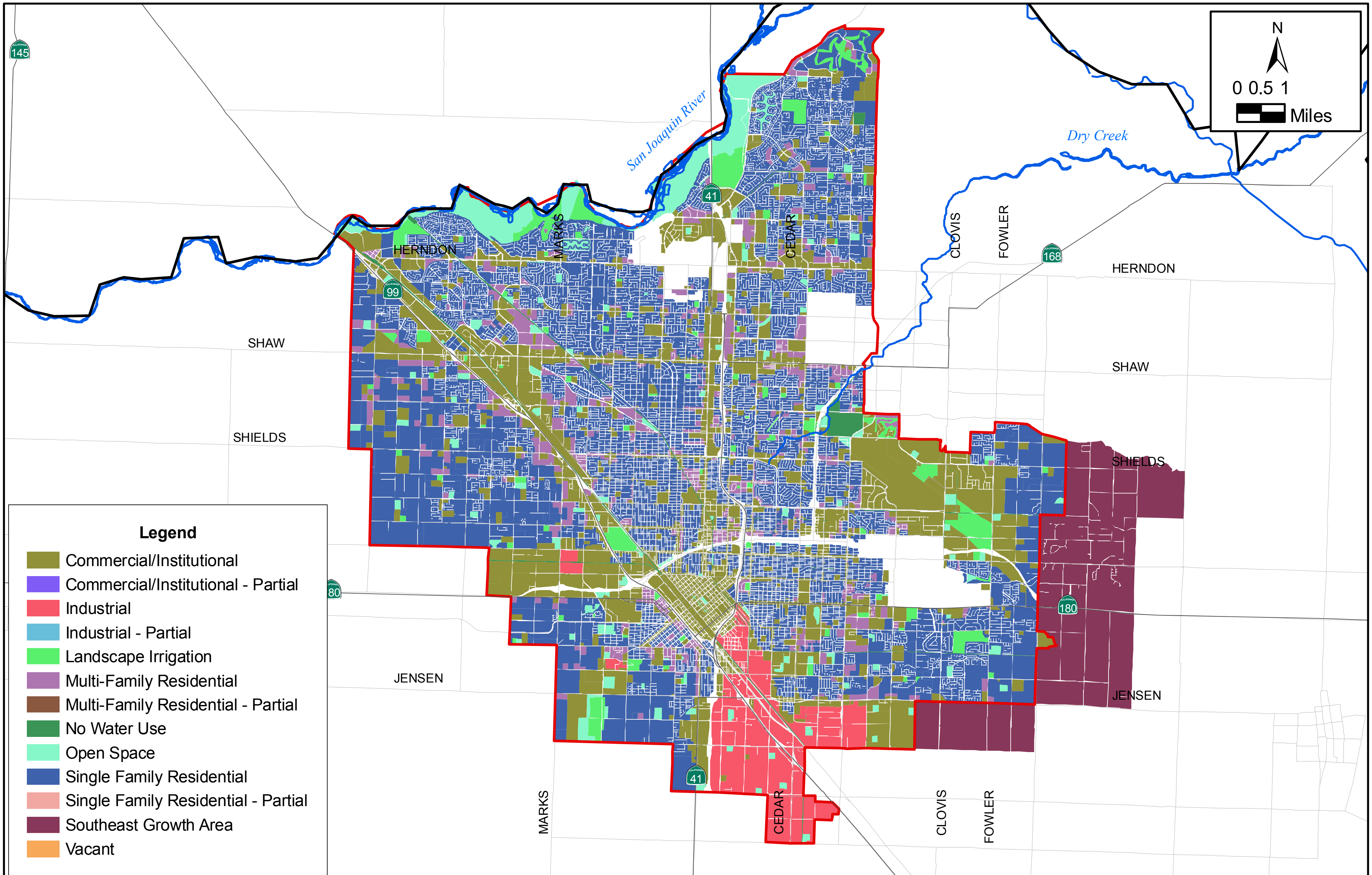


City of Fresno 2010 Land Use

Kings Basin Integrated Groundwater and Surface water Model (KingsIGSM)

May 2007

Figure 7.3

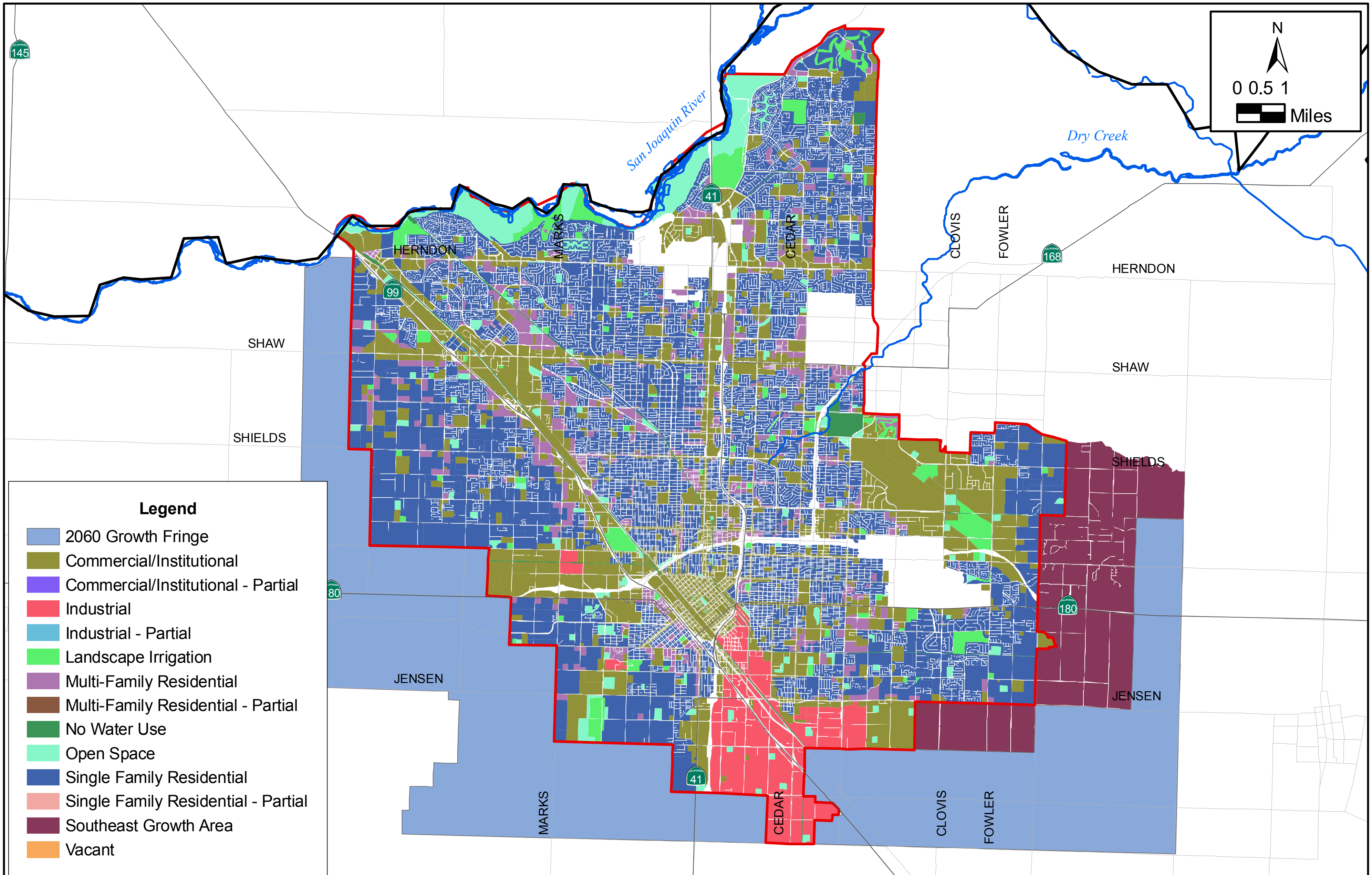


City of Fresno 2025 Land Use

Kings Basin Integrated Groundwater and Surface water Model (KingsIGSM)

May 2007

Figure 7.4



RIME

City of Fresno 2060 Land Use

Kings Basin Integrated Groundwater and Surface water Model (KingsIGSM)

May 2007

Figure 7.5

Figure 7-6. Annual Recharge Rate for FMFCD Basins Used for Recharge

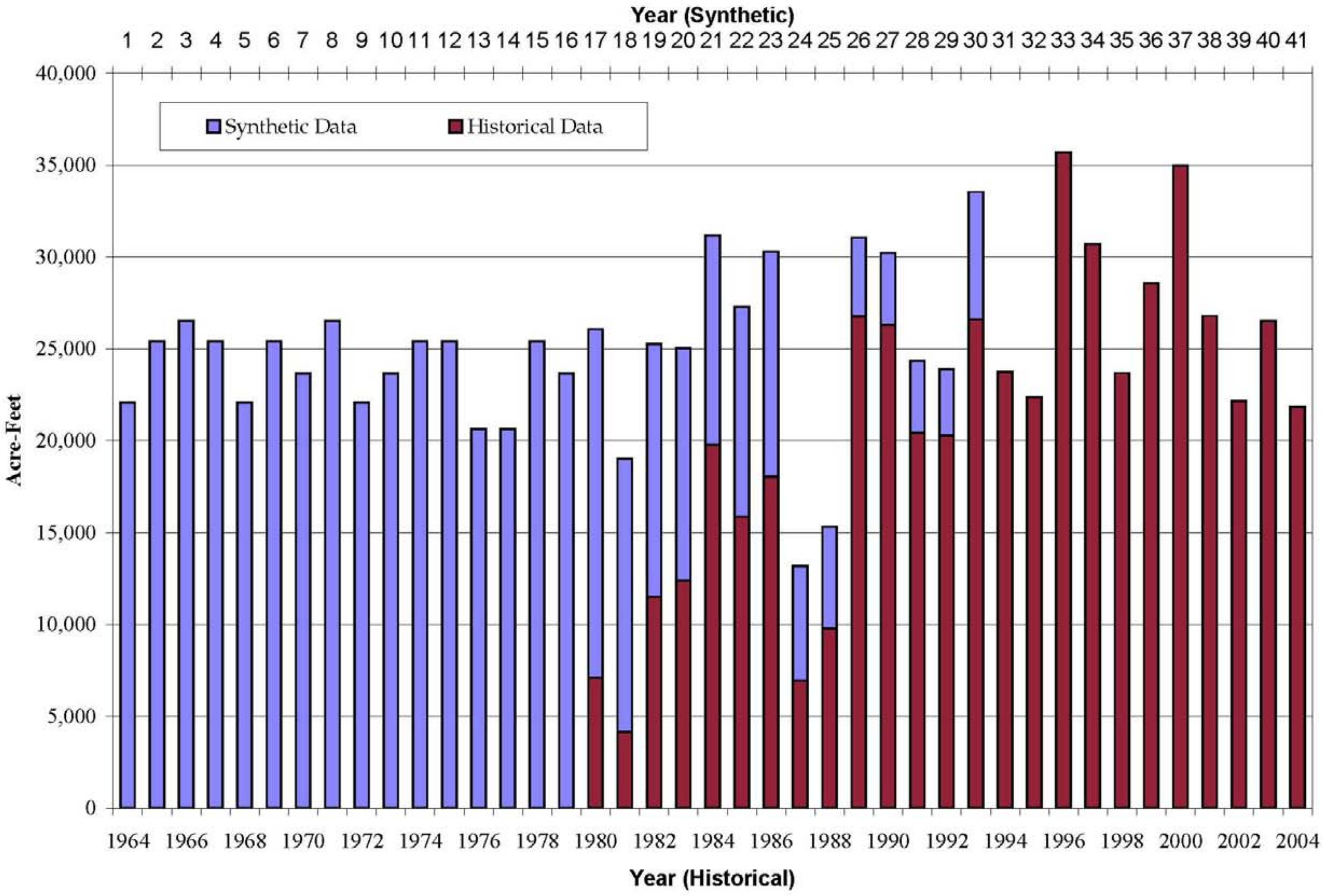
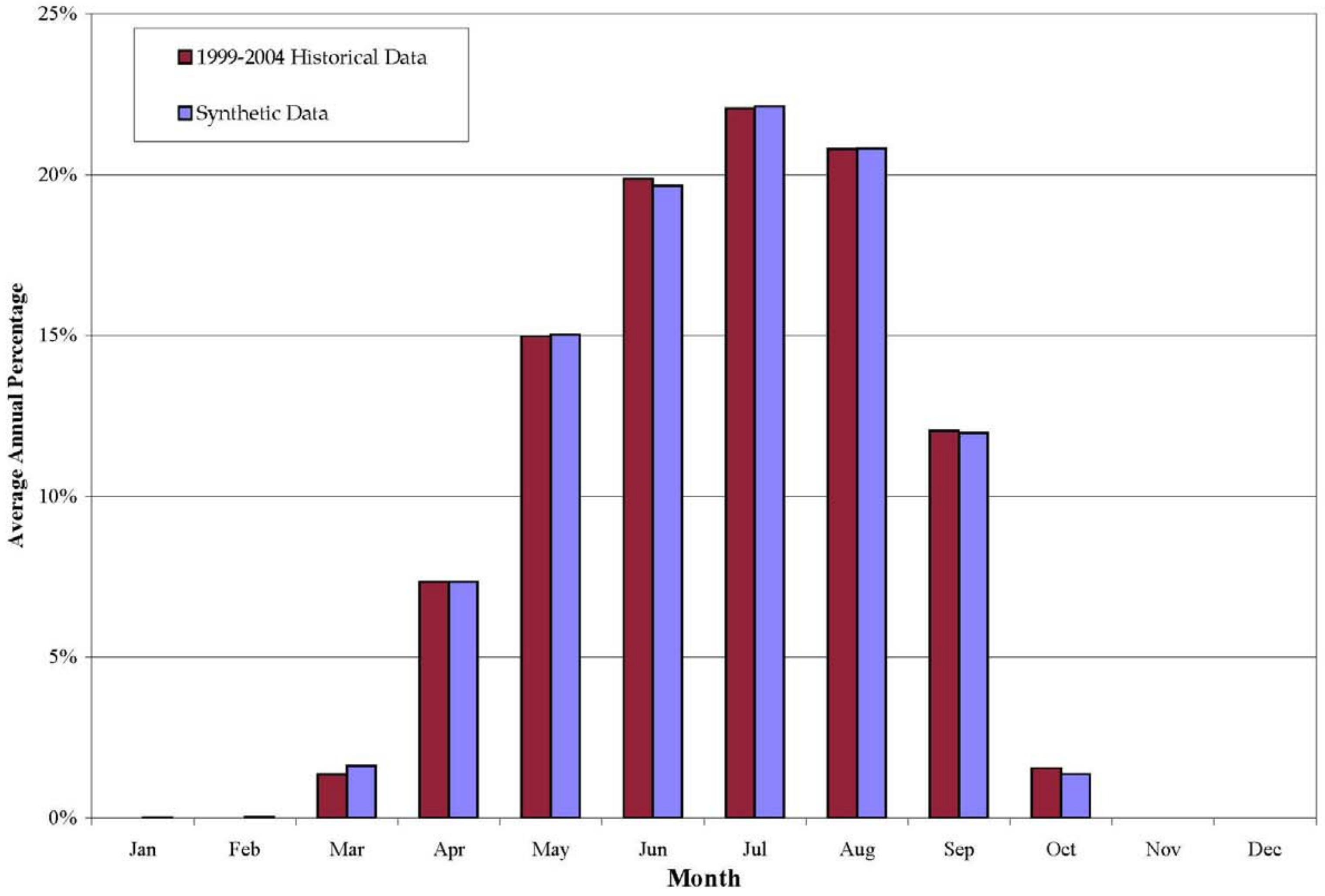
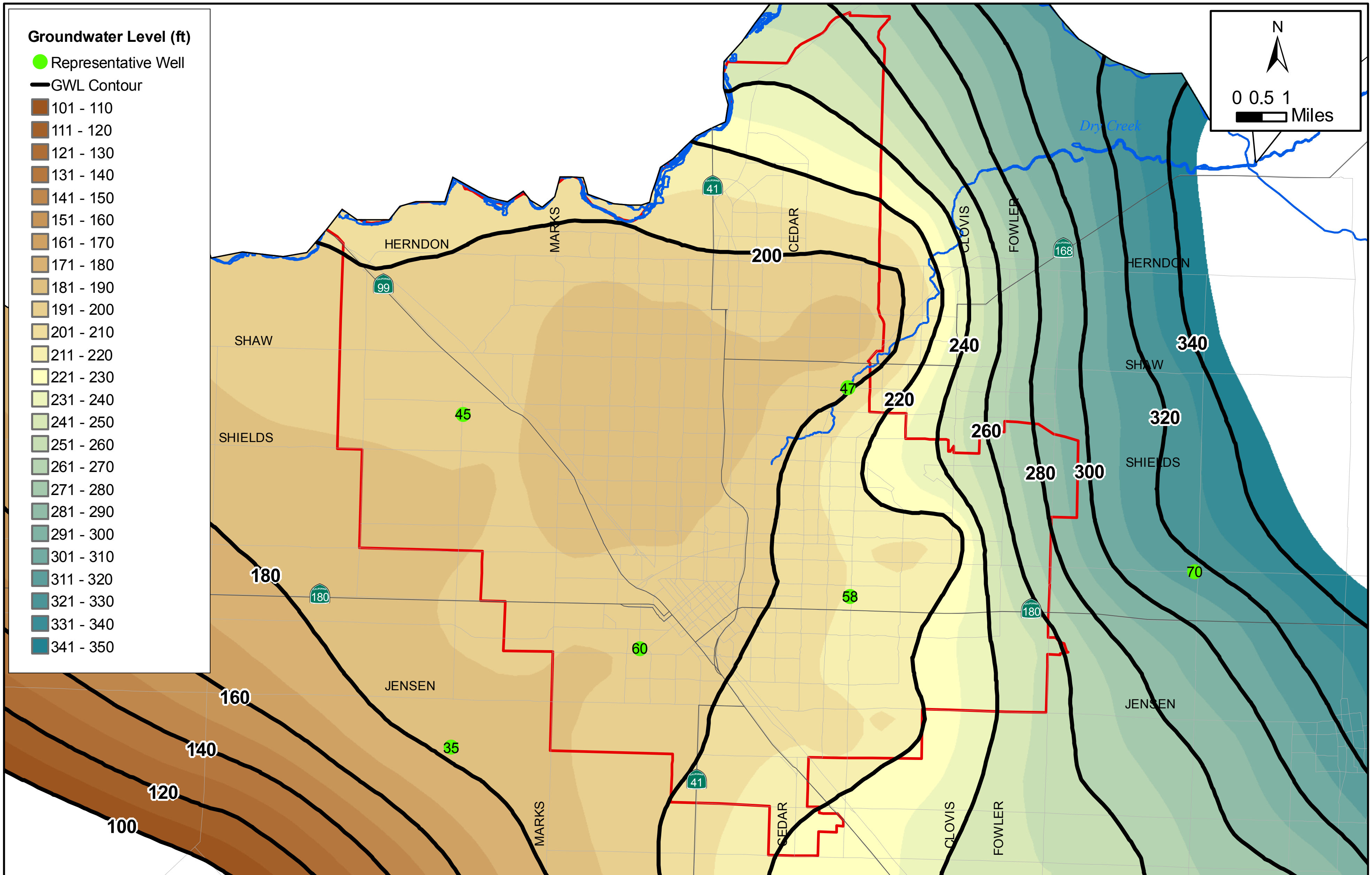


Figure 7-7. Monthly Recharge Distribution of FMFCD Basins Used for Recharge





Current Groundwater Levels and Location of Representative Wells

Groundwater levels represent Fall of 2004 at the end of simulation of the Kings IGSM model

May 2007

Figure 7.8

Figure 7-9. Annual Groundwater Levels in the Fall for Well 35

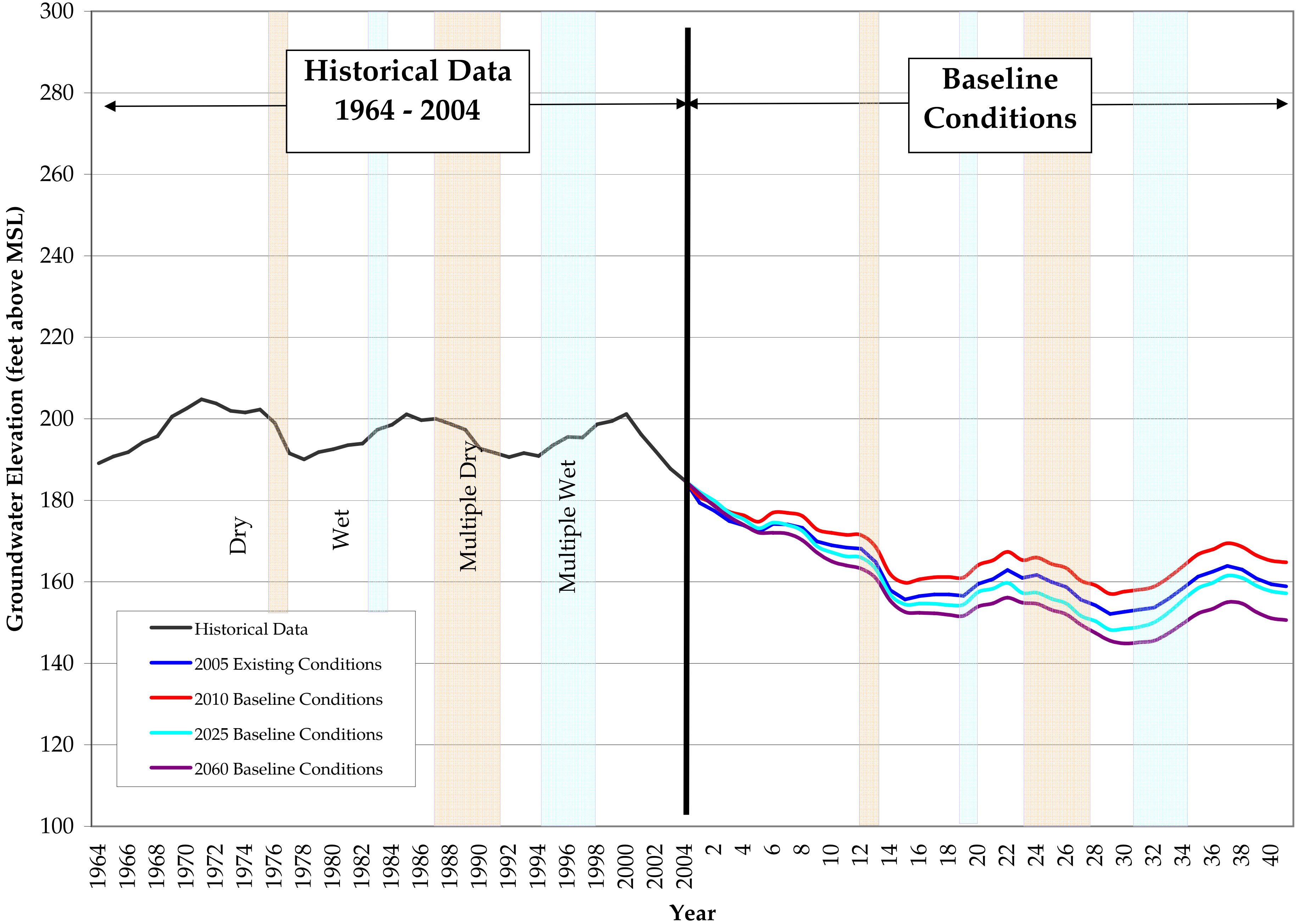


Figure 7-10. Annual Groundwater Levels in the Fall for Well 45

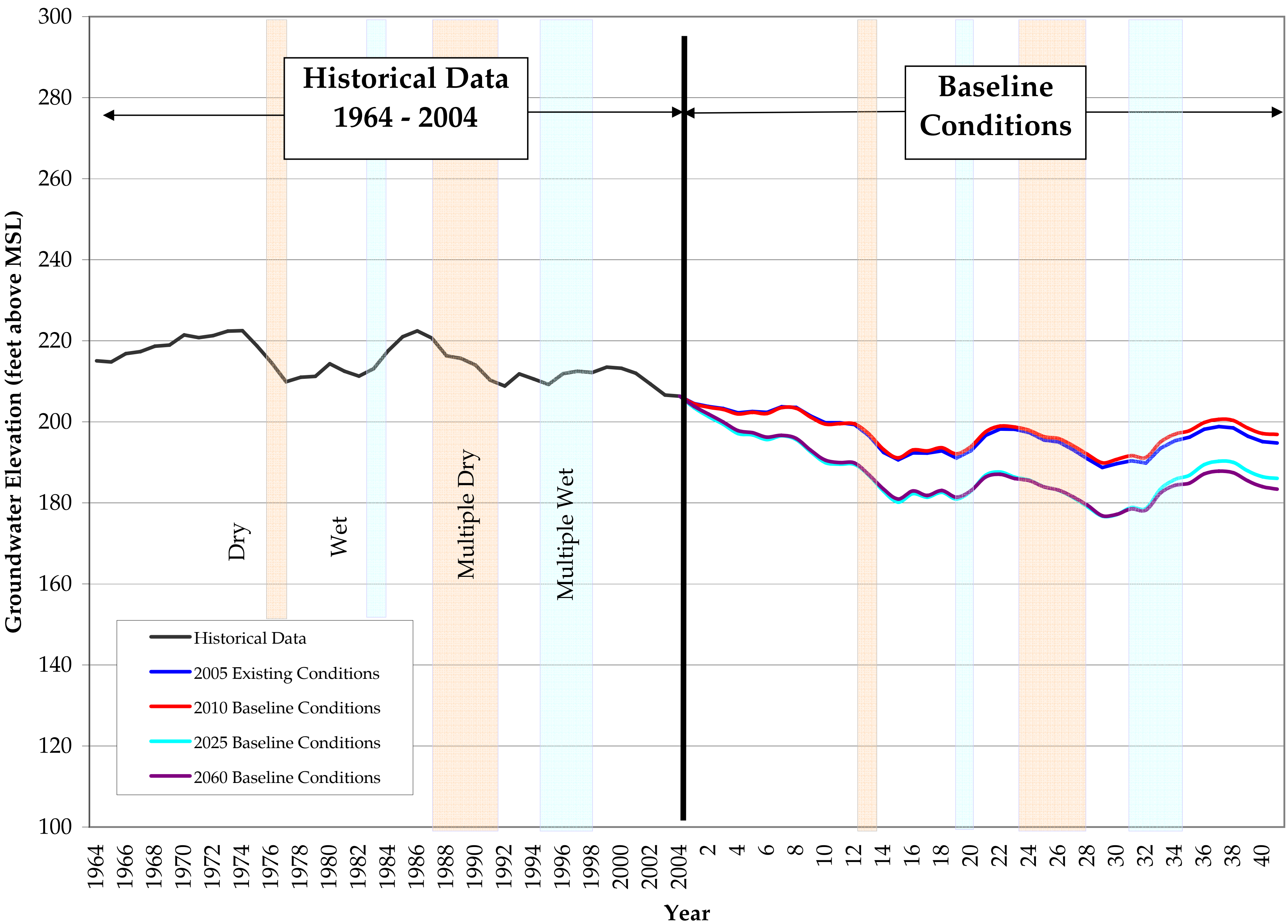


Figure 7-11. Annual Groundwater Levels in the Fall for Well 47

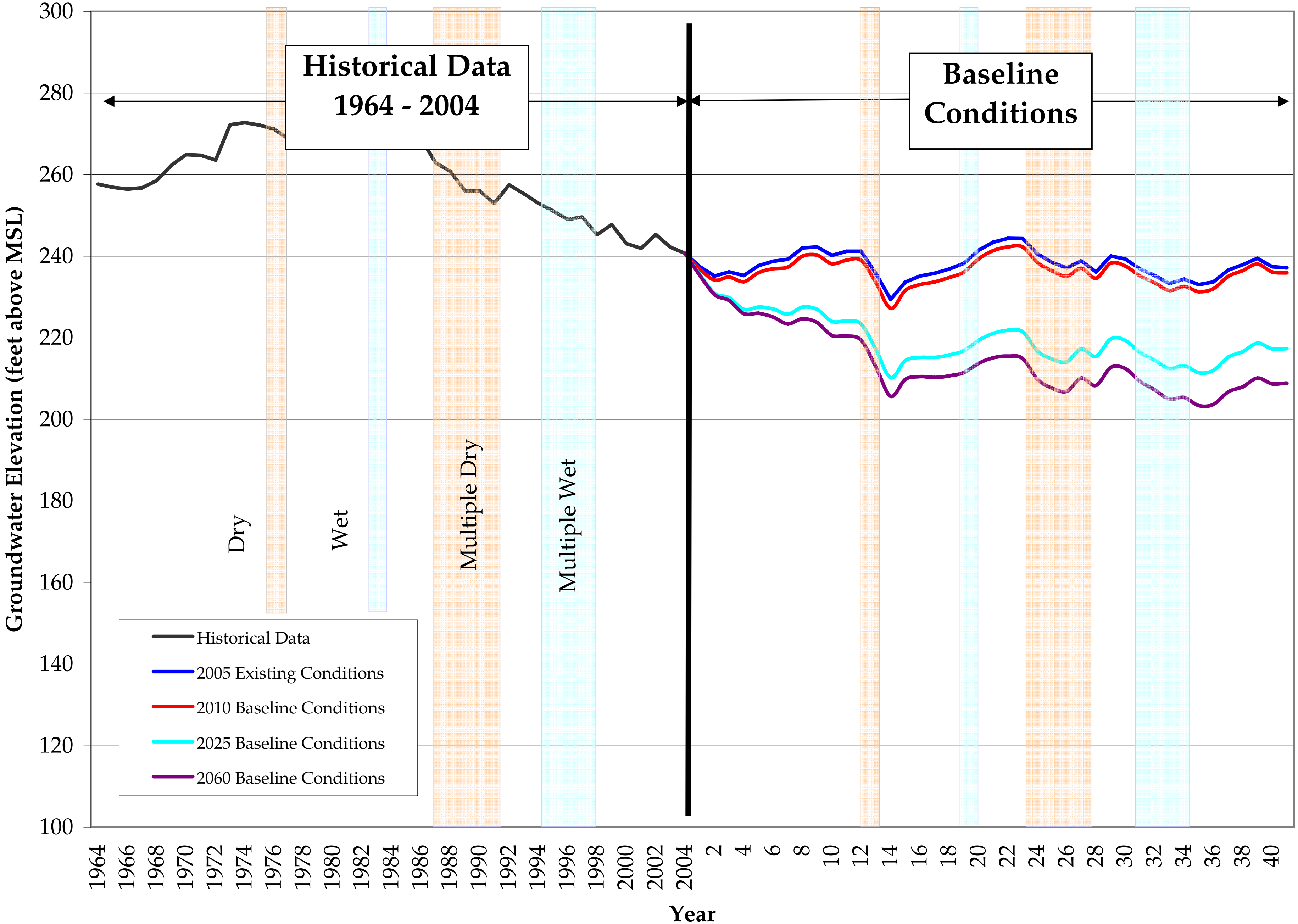


Figure 7-12. Annual Groundwater Levels in the Fall for Well 58

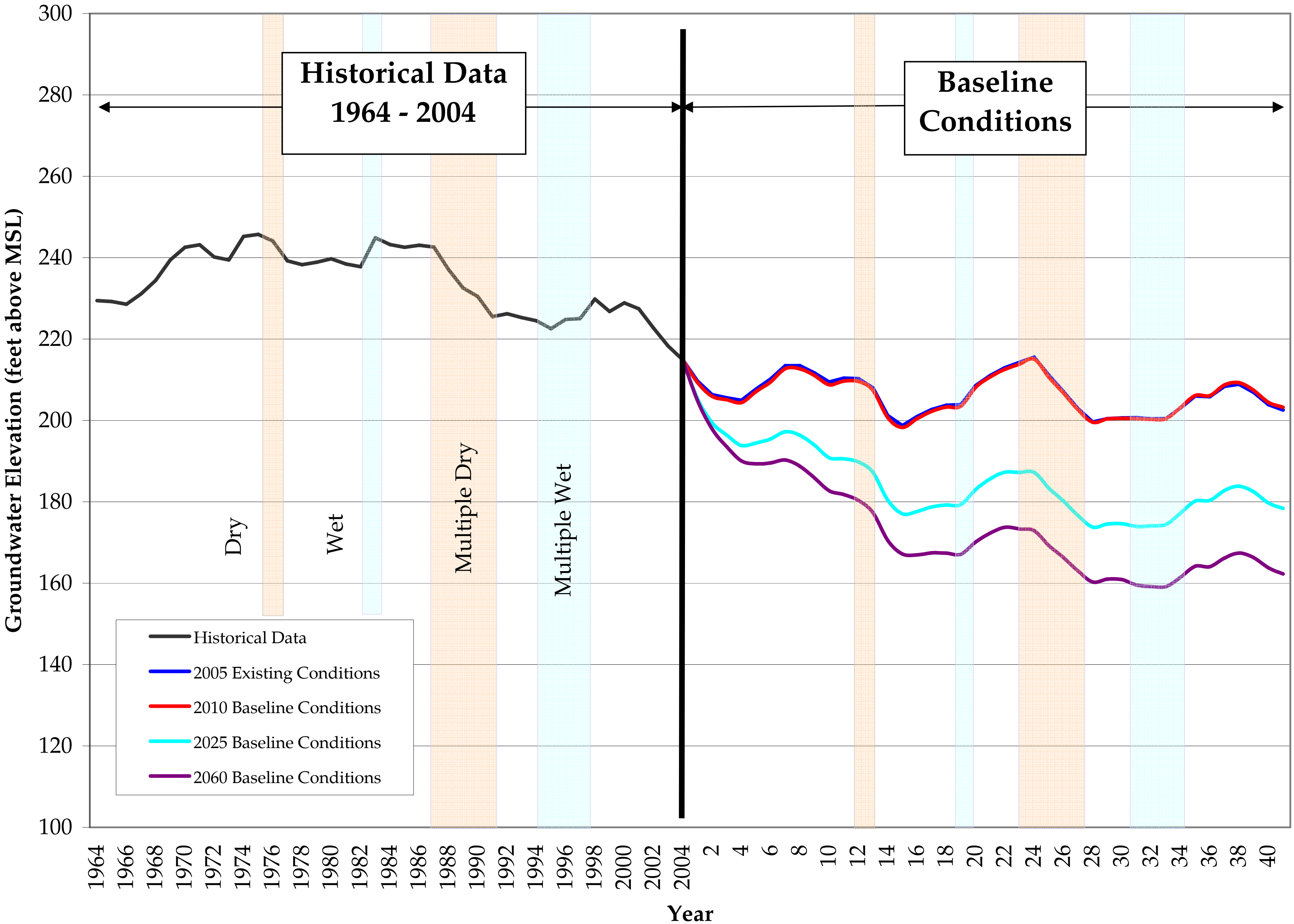


Figure 7-13. Annual Groundwater Levels in the Fall for Well 60

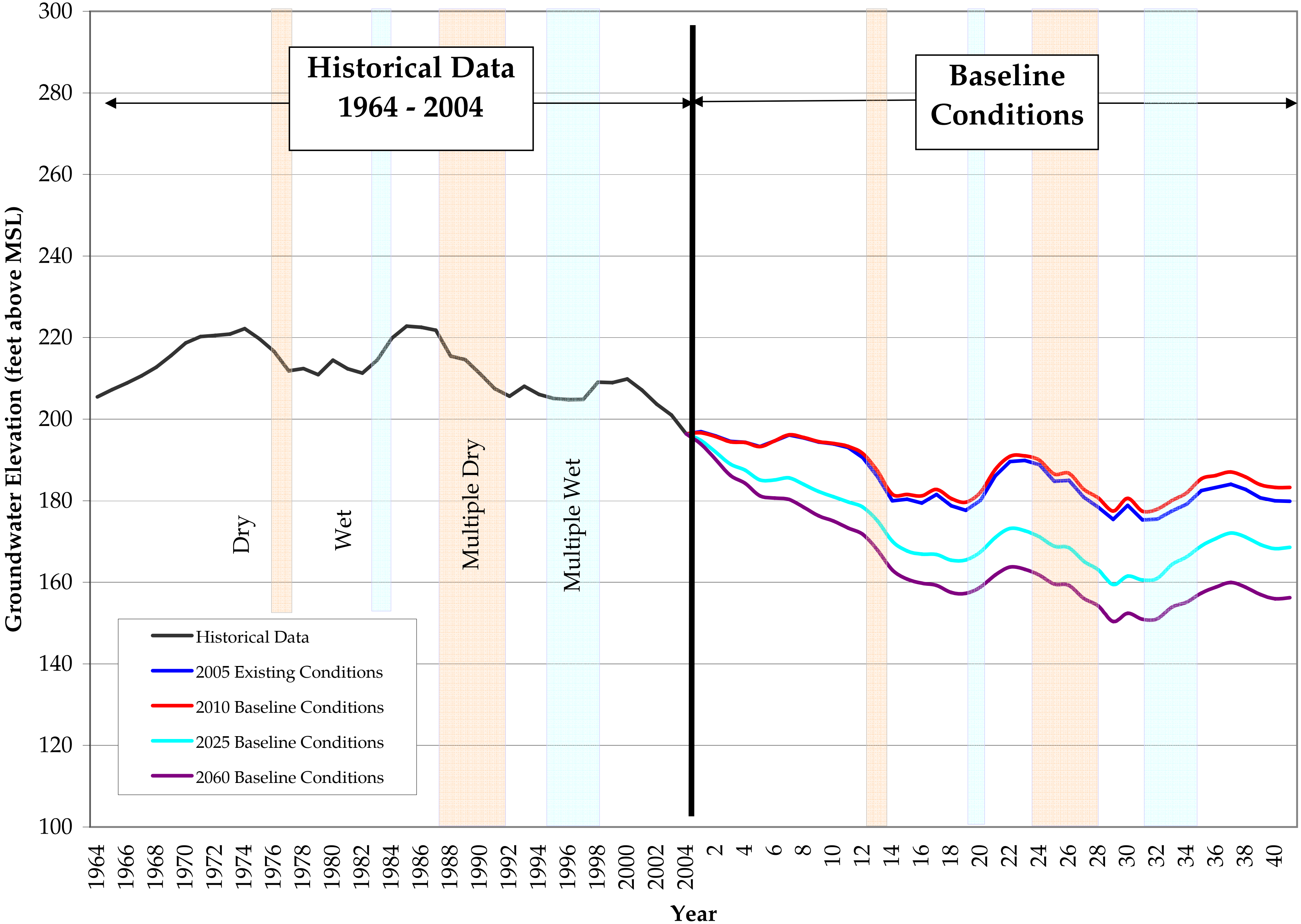
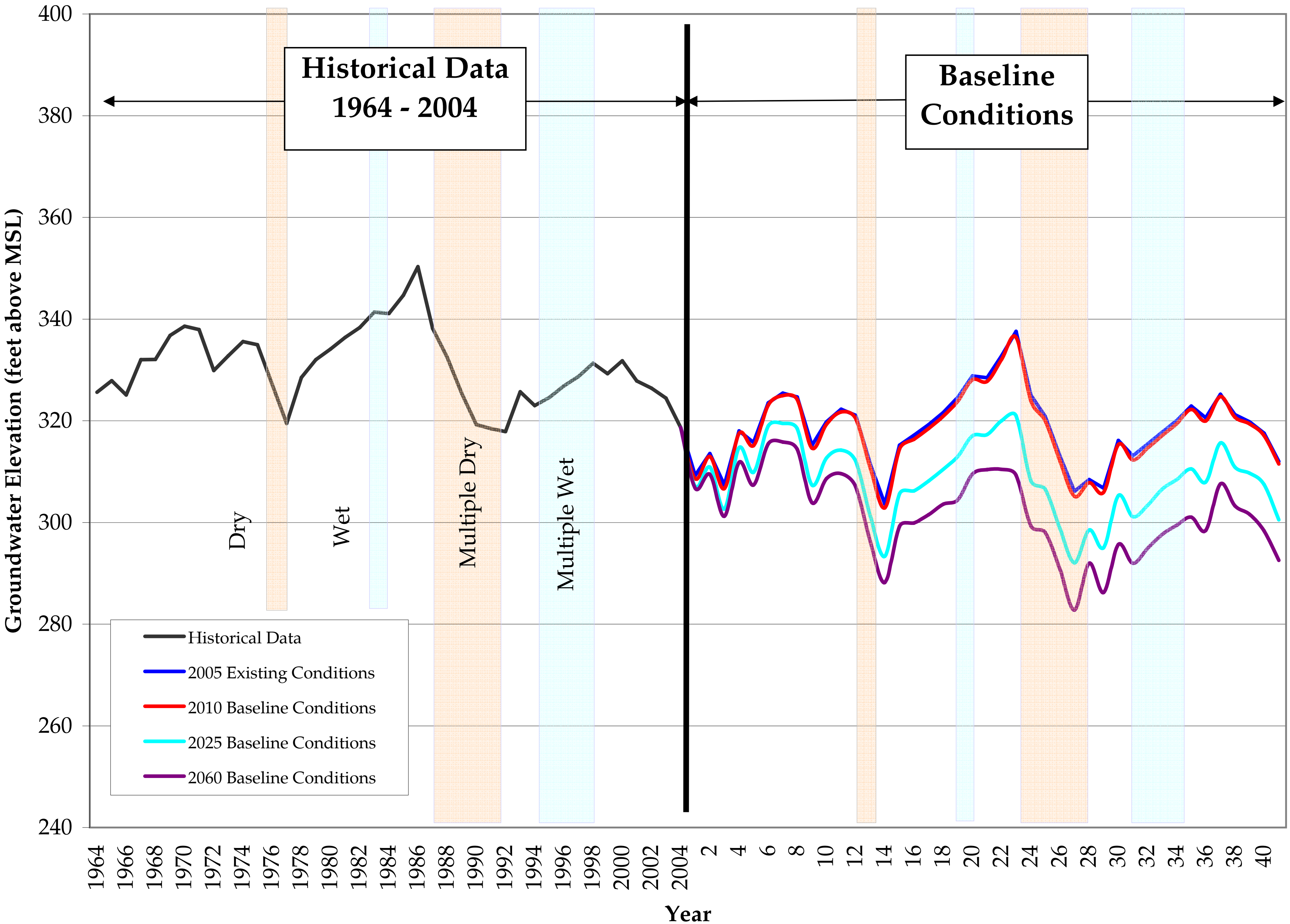
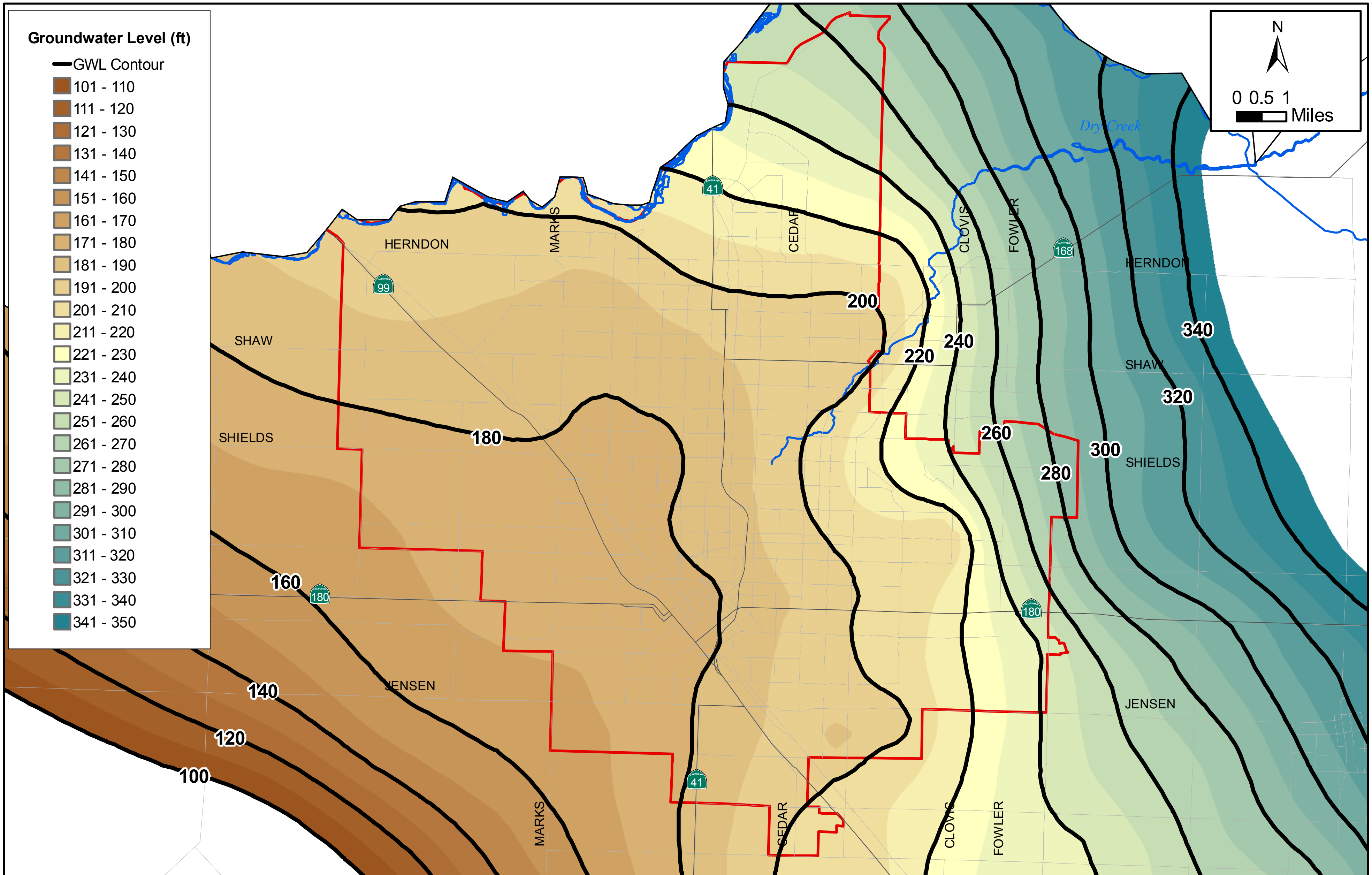


Figure 7-14. Annual Groundwater Levels in the Fall for Well 70





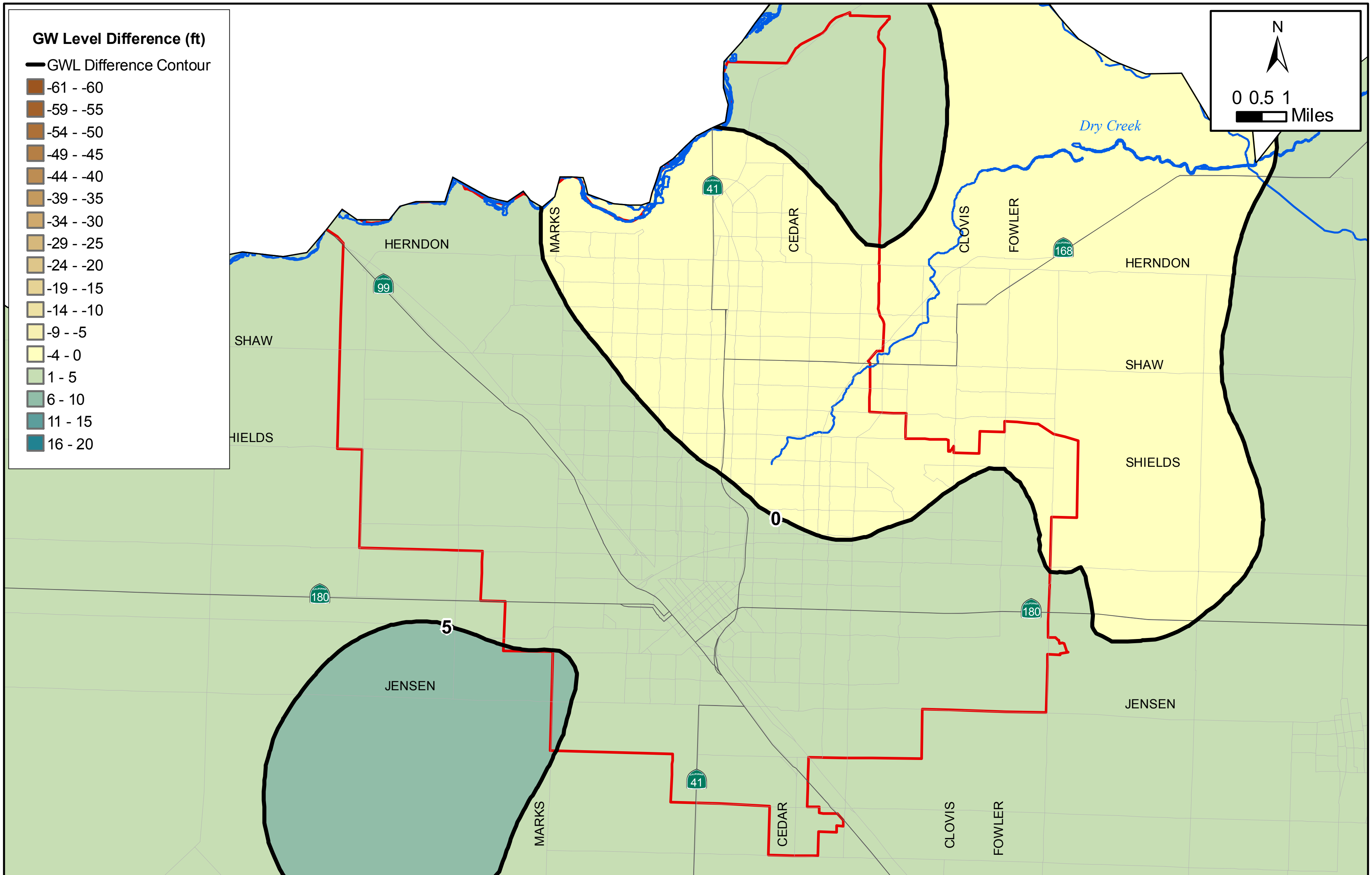
WRIME

40 Year Groundwater Level Projection Under Existing Conditions

Groundwater levels represent fall levels at the end of simulation of the Kings IGSM model using existing conditions

May 2007

Figure 7.15



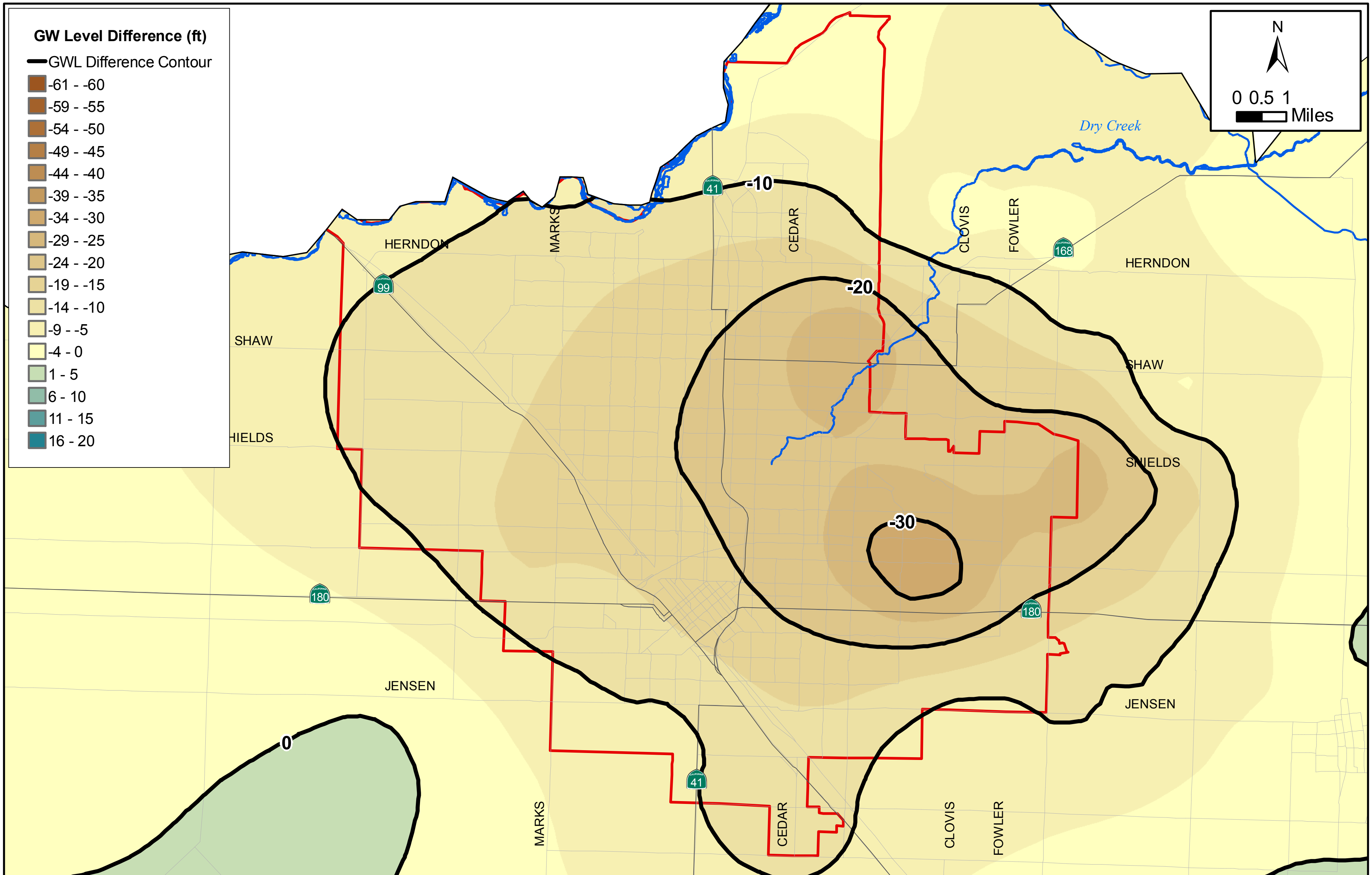
WRIME

Change in GW Levels between 2010 Conditions and Existing Conditions

Contours represent change in groundwater level between the 2010 Conditions and the Existing Conditions at the end of the 40-year period

May 2007

Figure 7.16



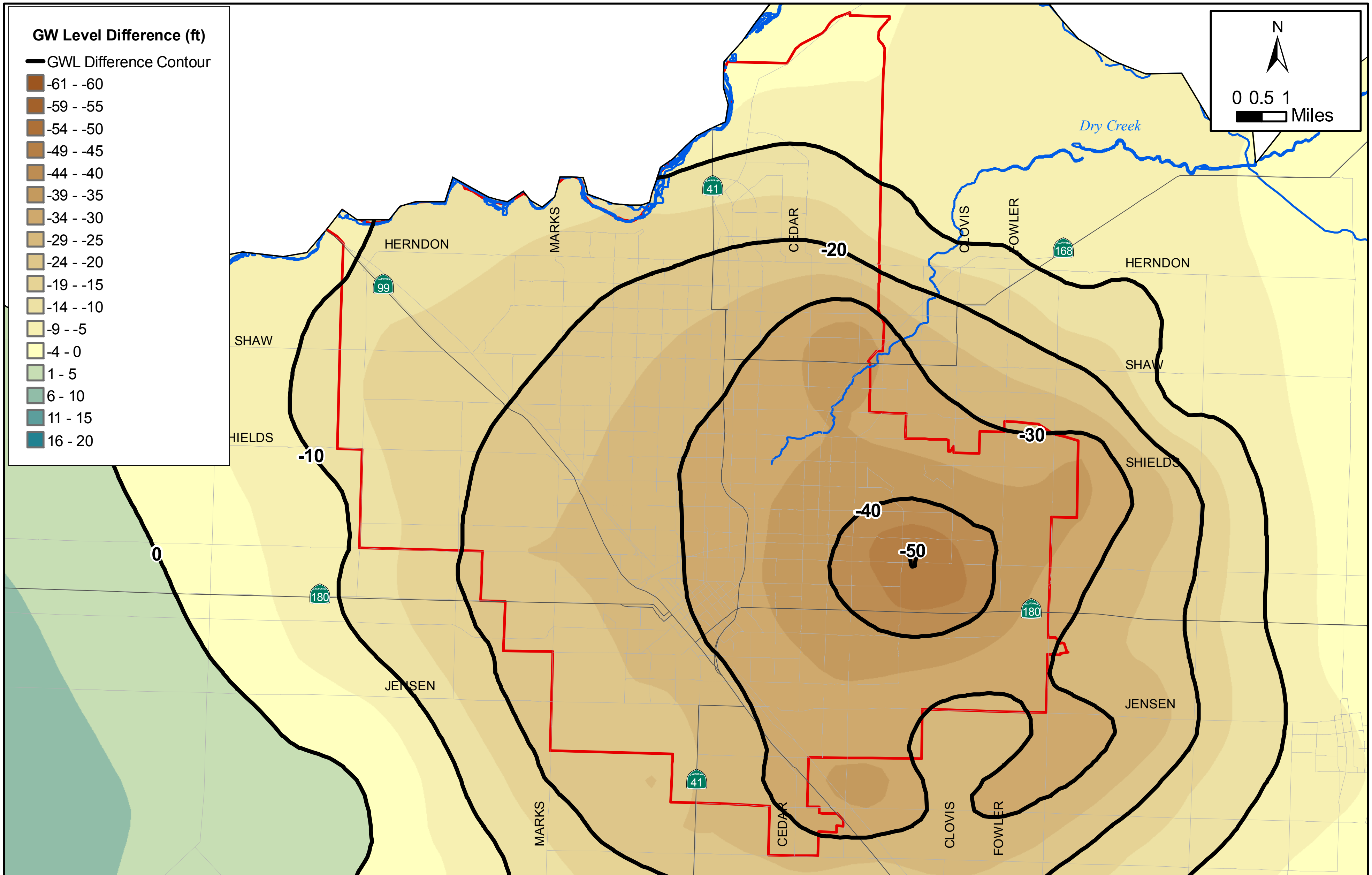
RIME

Change in GW Levels between 2030 Conditions and Existing Conditions

Contours represent change in groundwater level between the 2030 Conditions and the Existing Conditions at the end of the 40-year period

May 2007

Figure 7.17



RIME

Change in GW Levels between 2060 Conditions and Existing Conditions

Contours represent change in groundwater level between the 2060 Conditions and the Existing Conditions at the end of the 40-year period

May 2007

Figure 7.18

Figure 7-19. Historical Change in Storage in City of Fresno, 1964-2004

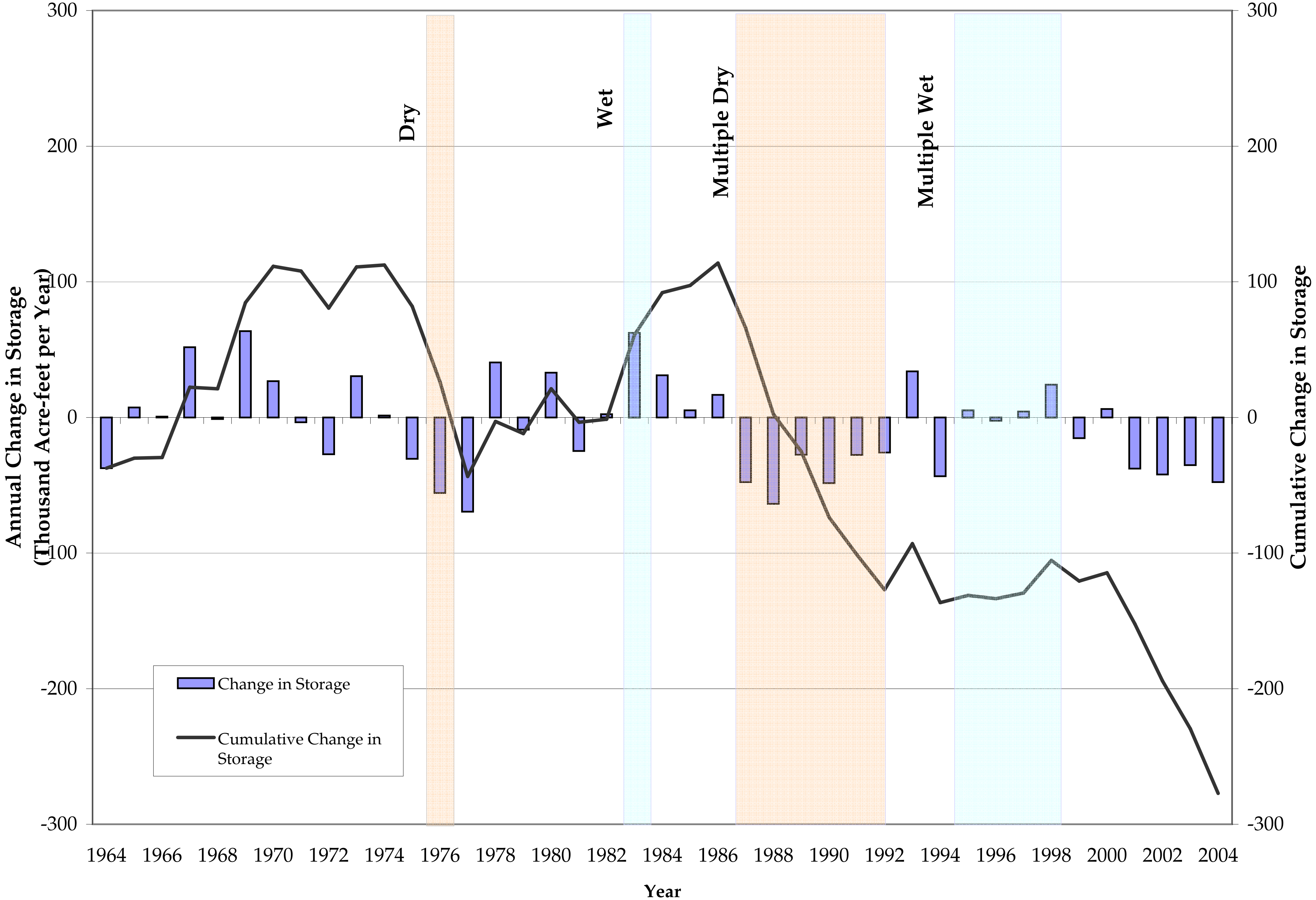
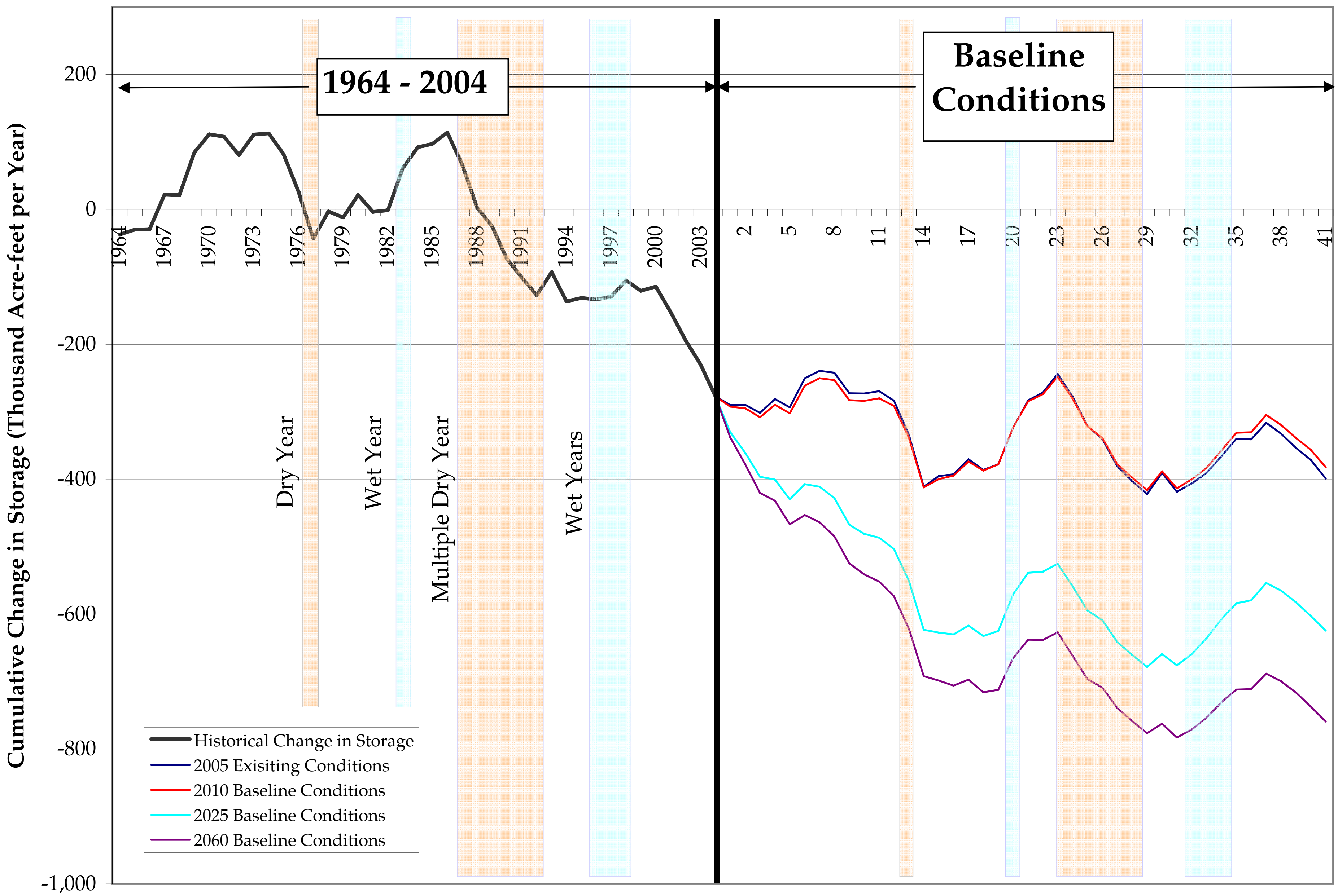


Figure 7-20. Cumulative Change in GW Storage in City of Fresno



REFERENCES

WRIME, 2006. Kings Basin Integrated Hydrologic Modeling – Modeling Objectives and Strategy. Prepared for the Upper Kings Basin Water Forum, California Department of Water Resources and the Kings River Conservation District.

WRIME, 2007. Kings Basin Integrated Groundwater and Surface Water Model (Kings IGSM) Model Development and Calibration. Prepared for the Upper Kings Basin Water Forum, the Kings River Conservation District, and the City of Fresno. November.

CHAPTER 8. INSTITUTIONAL ARRANGEMENTS

This chapter provides a summary of existing institutional arrangements governing water supply availability and distribution in and around the City of Fresno, including agreements, settlements, judgments, permits, understandings, and joint planning efforts. This chapter is intended to provide a consolidated understanding of the fundamentals and key concepts of the institutional arrangements, and is therefore provided in summary form. The reader is referred to the supporting documents for the full detail of the arrangements.

The Metro Plan Update process will identify physical, institutional and management actions needed to secure a sustainable and cost effective water supply future for the City of Fresno. Recommended actions will be developed in Phases 2 through 4 of the Metro Plan, which will include recommendations for new arrangements or modifications to existing arrangements.

WATER SYSTEMS

Water Suppliers

As shown on Figure 8-1, the study area is served by several drinking water suppliers: the City of Fresno, Pinedale County Water District (Pinedale), Bakman Water Company (Bakman), California State University Fresno, Malaga County Water District, Herndon Water Company, and Park Van Ness Mutual Water Company. A brief summary of the City of Fresno, Pinedale and Bakman is provided below. Fresno, Bakman, Malaga, and Pinedale are participants in the Fresno Area Regional Groundwater Management Plan (FARGMP), which is discussed later in this chapter.

<u>City of Fresno</u>

The City provides drinking water service to the bulk of the study area, including a number of unincorporated Fresno County islands. The City also provides wastewater collection and treatment service to the City and most of the County islands, with the exception of the Sunnyside and Fort Washington areas (see Figure 8-2). The City of Fresno also provides wastewater treatment service to the City of Clovis. In 2006, approximately 87 percent of the City’s drinking water came from groundwater, and 13 percent came from treated surface water. More detailed technical information about the City of Fresno water system is included in Chapter 6. The City has a number of agreements affecting various aspects of its water supply and management, which are described later in this chapter.

The City has begun investigating alternatives for future governance for its Utilities Department. On November 1, 2006, the City Council appointed Utility Commission issued its Report and Recommendations. The Utility Commission recommended that the City begin formation of a special district to provide water, wastewater, and solid waste service within the City limits. However, City Council had not yet made a decision on the Commission’s recommendation as of this writing.

Pinedale County Water District

Pinedale, a public utility, serves approximately 2,200 residential and commercial connections in a 1,090 acre partially built out section of the incorporated City of Fresno. The portion of Pinedale lying west of Highway 41 is supplied by groundwater, and the small portions to the east of Highway (totaling less than 10 connections) are supplied by wholesale connections to the City of Fresno system. Pinedale has no agreement for groundwater recharge. Several wells in the Pinedale area have been closed due to trichloroethylene (TCE) contamination, but the district has been able to continue service to its customers. Pinedale is a co-sponsor of the FARGMP.

Bakman Water Company

Bakman, a privately-owned utility, serves approximately 1,850 residential and commercial connections in a 1,660 acre section of the incorporated City of Fresno. Bakman's supply is entirely from groundwater. Bakman has no agreements for water supply or groundwater recharge, but negotiations are currently underway for a water service and groundwater recharge contract with FID. As with Pinedale, Bakman is a co-sponsor of the FARGMP. Three of Bakman's 13 active wells have been placed on standby due to DBCP and/or nitrate contamination.

Water System Interconnections

Fresno/Clovis

A draft agreement has been prepared between the Cities of Fresno and Clovis for interconnection of their potable water systems, to provide service during emergencies and other times of hardship in either community. The agreement covers interconnections, including apportionment of capital costs, at two locations:

1. Leonard Avenue at the Gould Canal alignment
2. Behymer Avenue at Willow Avenue

The agreement will provide for temporary deliveries from Clovis to southeast Fresno through the Leonard connection through 2013. Water delivered to Fresno in this manner will be charged against Fresno's surface water entitlements.

The agreement will also provide for temporary deliveries from Fresno to northern Clovis through the Behymer connection through 2015. Water delivered to Clovis in this manner will be charged against Clovis' surface water entitlements.

Beyond 2013 and 2015, localized supply deficiencies in the two areas should be remedied, and the interconnections will be reserved for emergency use only.

The agreement includes a formula for full reimbursement of costs to the providing agency.

Bakman and Pinedale

There are no emergency interconnections to serve either Bakman or the portion of Pinedale west of Highway 41 from the City of Fresno.

Surface Water Supply

The City receives surface water from three sources: the Kings River, San Joaquin River, and Fresno Stream Group. Some surface water is treated and then pumped into the drinking water system, and some is used directly without treatment for irrigation of large turf areas (schools, golf courses, cemeteries, parks, etc.). The remainder is used for groundwater recharge in City and FMFCD percolation basins. The FID conveys the water to the City and FMFCD facilities. Water rights and agreements for each source are described below.

Kings River

The KRWA holds water rights in trust for the twenty-eight member agencies of the KRWA. These water right licenses include four for direct diversion, and six for storage in Courtwright, Wishon, and Pine Flat Reservoirs, and Tulare Lake. FID is one of the larger members of KRWA. FID's place of use for Kings River water is the original FID boundary (see Figure 8-3). The 247,500 acres of FID served by Kings River water are each entitled to receive a pro-rata share of the available Kings supply available each year. As shown on Figure 8-3, much of the City of Fresno urban area is located within the FID. Exceptions include portions of the City that were de-annexed from FID at one time, and portions of the City which lie outside FID's external boundary. The City of Fresno and FID executed a Cooperative Agreement in 1976 which allows the FID to assume responsibility for delivering water and collecting assessments on behalf of City lands within FID. The City thus acts as a single consolidated customer of FID. To the extent the City expands its urban land uses within the FID service area, its pro-rata share of the FID entitlements also increases. Of the City of Fresno's 72,500 acre total service area, 57,100 acres are within FID, which constituted 23.6 percent of the FID service area as of January 2006. Chapter 5 provides an analysis of the availability of Kings River water to the City under this agreement with FID.

Under the Cooperative Agreement, the City does not have access to FID's stored water in the Kings River system. The Agreement states that the City will be served generally on the same schedule as FID's agricultural customers, and is subject to normal canal maintenance outages. However, FID has made special accommodations to serve the City's Surface Water Treatment Facility (SWTF) from the Enterprise Canal on a year-round schedule. The City can use the water for municipal and industrial uses, and groundwater recharge. In the future, it may be desirable to modify the Cooperative Agreement to formalize priority service to the City's SWTFs.

The City's assessments must be paid to FID, regardless of the quantity of water delivered to the City. FID charges on a per-acre-per-year basis, rather than a per-acre-foot basis. The City of Fresno's assessment in 2007 was $1,394,121.

San Joaquin River

The City receives water under contract with the USBR CVP. The City's initial 40-year contract was originally signed in 1961, but was not activated until 1965. It was renewed for a second 40 years in 2005. The contract provides for delivery of Millerton Lake water via the Friant-Kern Canal through 3 turnouts into FID's canals near the Kings River siphon. The City is planning a new dedicated turnout which will directly serve the Northeast Surface Water Treatment Facility via a new pipeline.

The City's CVP contract is for 60,000 acre-feet of Class 1 water, which receives priority service. The Friant Unit of the CVP also serves Class 2 water and Section 215 (flood) water to contractors on a lower priority basis. Class 1 water is considered dependable, and is available at least in part in all years (see Chapter 5 for data on historic water availability). The City can use the water for municipal and industrial uses, and groundwater recharge. The City's CVP assessments for Class 1 water must be paid to the USBR, regardless of whether the City uses the water ("take or pay" provision). Assessments for the Class 1 water (not including conveyance) were $6.6 million or $110 per acre-foot for 2005. Of this total, $22.87 per acre-foot was a restoration surcharge mandated by PL102-575 (more commonly known as the Central Valley Project Improvement Act), which was intended to compensate for San Joaquin River ecosystem damage caused by the Friant Unit of the CVP. In the future, the availability of Class 1 CVP water may be impacted by a recent settlement of a long-running dispute between the NRDC, Friant Water Users Authority (FWUA) and U.S. Departments of the Interior and Commerce over restoration of the San Joaquin River. Chapter 5 provides estimates of projected shortages resulting from the settlement.

Because the Friant-Kern Canal operation, maintenance, and replacement activities were transferred to FWUA in 1998, FWUA bills the City separately for CVP conveyance costs. In 2006, conveyance of the City's Class 1 contract totaled $750,780, or $12.51 per acre-foot.

FID also has a 40-year contract for 75,000 acre-feet of CVP Class 2 water, originally signed in 1964, and renewed in 2001. However, the City of Fresno is precluded in the Cooperative Agreement from receiving any of this water.

Fresno Stream Group

In 2000, the Cities of Fresno and Clovis, FID, and FMFCD submitted a joint water right application for all waters of Dry, Dog, Fancher, Mud, Redbank and Pup Creeks, and the Alluvial Drain; together these are referred to as the Fresno Stream Group. The streams are all intermittent, rain-fed drainages, but average yield is estimated to be between 40,000 and 65,000 acre-feet per year, depending on antecedent soil moisture. Flows from these streams have historically been used by the four agencies for irrigation and recharge. The objective of the water right application is to formalize this use, and allow for expansion of use. Once the water right application has been approved by the state, the four applicants must execute an agreement addressing water use and cost/revenue apportionment. The water right application was still pending as of this writing.

WASTEWATER

Wastewater Recycling

The City operates the Fresno-Clovis RWRF in southwest Fresno, which treats all wastewater collected within the Fresno-Clovis Metropolitan Area. Approximately 11 to 12 percent of the flows entering the plant are generated in Clovis, the remainder in Fresno. Treated effluent from the facility is used for direct reuse on a fodder cropland adjacent to the plant, with the remainder sent to percolation basins. A portion of the percolated treated effluent is extracted and pumped to FID canals in exchange for additional FID surface water under a 1974 Recycled Water Agreement between the City and FID. Under the Agreement, the City is to deliver a minimum of 100,000 acre-feet of recycled water to FID in each ten-year period, with a maximum of 30,000 acre-feet in any one year, unless approved by FID. Historically, the City has delivered between 15,000 and 34,000 acre-feet per year of extracted groundwater to FID. The schedule for delivery is subject to negotiation between the two agencies each year.

Under the Agreement, the City is entitled to receive additional surface water in the amount of 46 percent of the delivered recycled water. To date, this provision of the agreement has not been exercised.

This water exchange is revenue neutral between Fresno and FID, with each agency covering its own expenses in fulfilling the agreement.

Maintenance of stable groundwater levels is addressed in the FID/City of Fresno agreements. Under Section 13 of the 1976 Cooperative Agreement between FID and the City, the City is to retain the use of its sewage effluent within the boundaries of FID unless written consent from FID is obtained.

Additional detail regarding wastewater agreements is contained in Appendix N.

FLOOD CONTROL AND STORM DRAINAGE

Storm Water Basins

The FMFCD provides storm water management services to the study area. Most of the storm water runoff is captured in approximately 140 local retention basins. Because the basins generally lack gravity outlets, basin overflow must be pumped to prevent local flooding and make room for subsequent rainfall events. The basins discharge to streams, irrigation canals, other basins down slope, or the San Joaquin River. When not in use for storm water, many of the basins are used by the Cities of Fresno and Clovis for intentional recharge of their surface water supplies under cooperative agreements with FMFCD.

FMFCD also owns and operates a number of major regional detention facilities which capture and detain runoff from the Fresno Stream Group, which traverses the Metropolitan Area. These detention facilities could be used to make controlled releases for down slope recharge in the various Metro Area recharge basins.

The City of Fresno recharge operations are facilitated by a 1991 agreement, and subsequent amendments, with FMFCD, in which FMFCD receives $2.50 per acre-foot of water delivered for recharge. Recharge of storm water is covered through property tax assessments. Annual recharge quantities are summarized in Chapter 5, Table 5-3.

GROUNDWATER MANAGEMENT

Groundwater Management Plan

The FARGMP is a regional groundwater management plan prepared in 2006 to comply with AB 3030 and SB 1938. Participating agencies and adoption dates are listed in Table 8-1.

Table 8-1. Groundwater Management Plan Participants

Agency	Adoption Date
Fresno Irrigation District	01/25/2006
City of Clovis	02/13/2006
Bakman Water Company	03/13/2006
County of Fresno	07/18/2006
City of Fresno	04/18/2006
Pinedale County Water District	09/20/2006
Fresno Metropolitan Flood Control District	02/08/2006
City of Kerman	03/01/2006
Malaga County Water District	02/14/2006
Garfield Water District	11/01/2006

The plan boundaries generally coincide with FID, but also include a small area northeast of FID. The objectives of the FARGMP include:

1. Preserve and enhance the existing quality of the area's groundwater.
2. Correct the overdraft and stabilize groundwater levels at the highest practical beneficial levels.
3. Preserve untreated groundwater as the primary source of domestic water.
4. Maximize the available water supply, including conjunctive use of surface water and groundwater.
5. Conserve the water resource for long-term beneficial use and to assure an adequate supply for the future.

6. Manage groundwater resources to the extent necessary to ensure reasonable, beneficial, and continued use of the resource.
7. Monitor groundwater quality and quantity to provide the requisite information for establishing groundwater policies, goals, and recommended actions.
8. Improve coordination and consistency among agencies responsible for the monitoring and management of groundwater in the Plan Area.

Although FID led the development of the FARGMP, the October 2005 Memorandum of Understanding between the member agencies makes it clear that each member agency will retain authority and responsibility for groundwater management within its own jurisdiction.

Kings IGSM Integrated Groundwater and Surface Water Model

The Kings River Conservation District (KRCD) and Upper Kings Water Forum (Water Forum) participants (listed in Table 8-2) are currently working together to develop an IRWMP. The California Department of Water Resources (DWR) is providing water management and technical support, as well as facilitation services to the Water Forum to develop its water management strategies and conjunctive use programs. As part of this cooperative effort, the Water Forum has decided to develop an integrated hydrologic model for the following purposes:

1. To develop for the Kings Basin area an analytical tool that can represent the groundwater and surface water flow systems and their interactions.
2. To develop a planning level analytical tool that can provide quantitative information on a comparative basis to help answer different questions on the groundwater and surface water system characteristics and to evaluate alternative conjunctive water management strategies.
3. To develop a tool that can be used in assessing management strategies consistent with the IRWMP goals and objectives.

The development of the Kings IGSM is supported by a series of Technical Studies:

1. Modeling Objectives and Strategy
2. Hydrogeologic Investigation
3. Analysis of Water Demand Conditions
4. Analysis of Water Supplies
5. State of Groundwater Quality in the Basin

Table 8-2. Upper Kings Water Forum Participants

Kings River Conservation District	Regional Water Quality Control Board
Alta Irrigation District	City of Clovis
Consolidated Irrigation District	City of Kingsburg
Fresno Irrigation District	City of Reedley
Kings River Water Association	City of Sanger
Raisin City Water District	City of Selma
Fresno Audubon Society	City of Kerman
California Native Plant Society	City of Parlier
Kings River Fisheries Management Program Public Advisory Group	City of Fowler
California Water Institute	City of Fresno
Department of Water Resources	City of Dinuba
Center for Collaborative Policy	County of Fresno
California Department of Fish & Game	County of Kings

These Technical Studies were conducted to provide sufficient detail on the respective data to be used in the model. The Technical Memoranda for the first four studies have been published, and the fourth is in-process. As part of the Kings IGSM development, the following tasks are being conducted:

1. Conceptual Model Formulation
2. Model Development
3. Model Calibration
4. Sensitivity Analysis
5. Baseline Analysis
6. Alternatives Analysis

The conceptual model formulation, development and calibration tasks are complete. The remaining tasks will be performed subsequent to completion of model calibration.

In conjunction with development of the Kings IGSM, the City of Fresno requested that the model be intensified within the City sphere of influence to facilitate development of this Metro Plan update and subsequent groundwater management. Model development is discussed in a separate report issued by WRIME in July 2007, the Kings IGSM Model Development and Calibration Draft Report. The “future without project” results obtained from the model are discussed in

Chapter 7. The "future with project" analyses will be conducted in Phase 2 of the Metro Plan Update.

Fresno County Export Ordinance

Fresno County Ordinance No. 00-013 (included in the Fresno County Ordinance Code Chapter 14.03 Groundwater Management) requires that a permit be obtained from the County to extract, on a long-term basis, groundwater for transfer outside the County, including groundwater extracted to replace a surface water supply that has been, is being, or will be transferred for long-term use outside of Fresno County. However, it is the City Water Division's position that this ordinance is not applicable to the City.

Groundwater Contamination

As discussed in Chapter 5, a number of wells in the study area are impacted by groundwater contaminants, necessitating wellhead treatment (see also Appendices G and H). As a result of settlement of several lawsuits, the City now receives partial reimbursement of the capital, and operation and maintenance (O&M) costs of treatment from the defendants in those suits.

<u>DBCP, EDB</u>

In May of 1995, the City of Fresno entered into a 40-year Settlement Agreement with the manufacturer defendants of the pesticide DBCP, in which these defendants agreed to pay for the capital and operation and maintenance costs of treatment for wells which exceed the State MCL for DBCP. The manufacturers are the Dow Chemical Company, Shell Oil Company and Occidental Chemical Company. At that time, the defendants paid to the City a lump sum of $21 million, to reimburse the City for the capital costs of treatment facilities already in place or then under design and construction.

In June of 1995, the City of Fresno entered into a Settlement Agreement with the Dow Chemical Company, a manufacturer of the pesticide EDB. In this EDB Agreement Dow agreed to pay a lump sum of $2.5 million to cover the City of Fresno's current and future costs for treatment of wells which exceed the state MCL for EDB. Under the DBCP Agreement, however, two of the EDB wells receive a partial reimbursement for annual O&M costs incurred by the City.

Beginning with calendar year 1997, defendants began to reimburse the City, on an annual basis, for costs associated with the O&M of these DBCP (and two EDB) treatment facilities on the City's wells. The manufacturers have, to date, paid nearly $9 million in O&M reimbursement. The Agreement allows for the reimbursement for treatment of DBCP contaminated groundwater from a total of 60 wells at the current State MCL (and 80 wells if the state should lower the MCL). The City has treatment facilities installed on a total of 38 wells (including the two wells with EDB treatment facilities). The Agreement, and any future reimbursements, terminates on June 26, 2035.

The Agreement places wells in several categories. The breakdown, in terms of reimbursement potential, is referred to as "100 Percent Wells," "90 Percent Wells," and "50 Percent Wells."

For purposes of capital cost reimbursement, treatment facilities on most of the "100 Percent Wells" and both of the (EDB) "50 Percent Wells" have been constructed and the City reimbursed. Therefore, nearly all future reimbursements for DBCP wellhead treatment construction fall into the "90 Percent Wells" category. The Agreement provides for reimbursement according to the pumping rate of a well, and the total number of GAC vessels required to treat water from that well. Table 8-3 shows the one-time reimbursement amounts the City will receive from defendants: 1) before and after a cost-of-inflation adjustment, and 2) after payment of attorneys' fees.

Table 8-3. Capital Costs Reimbursement Breakdown (90 Percent Wells)

No. Vessels	1995 Dollars	After Attorneys' Fee	2006 Dollars	After Attorneys' Fee
One	$337,500	$253,125	$425,956	$319,467
Two	$450,000	$337,500	$567,941	$425,956
Three	$540,000	$405,000	$681,529	$511,147
Each over three	$90,000	$67,500	$113,588	$85,191

Note: The reuse of a vessel from a previous DBCP treatment facility will reduce the amount of the reimbursement claim by $95,000 but increase the claim to include the cost to relocate the vessel.

For annual O&M reimbursements, the City continues to be paid for wells within each well category (100 Percent, 90 Percent, and 50 Percent). The City's annual O&M claims have continued to grow as additional wells require treatment for DBCP and in response to inflation. The current, 2006 annual O&M claim requests reimbursement in the amount of $860,177. The City receives reimbursement for O&M on a per well/well site basis. Provided a well is in use, Table 8-4 shows the annual reimbursement amounts the City will receive from defendants: 1) before and after a cost-of-inflation adjustment, and 2) after payment of attorneys' fees.

Table 8-4. Annual Operation and Maintenance Reimbursement Breakdown

Well Category	1995 Dollars	After Attorneys' Fee	2006 Dollars	After Attorneys' Fee
100 Percent	$31,000	$23,250	$39,125	$29,344
90 Percent	$27,900	$20,925	$35,212	$26,409
50 Percent	$15,500	$11,625	$19,562	$14,672

In November of 1994, the City of Fresno entered into an Agreement with FMC to cover the costs for treatment of two City wells, should these wells ever exceed the State MCL for DBCP. One of these two wells exceeded the MCL for DBCP in 2004 and the City is currently seeking reimbursement for the construction of a treatment facility. It is anticipated that the City will be reimbursed by FMC for capital costs and O&M costs in amounts similar to those discussed above.

TCE

TCE groundwater contamination in the Pinedale area is the responsibility of Vendo, a company which produced vending machines. Per the Agreement between the City and Vendo dated May 12, 1998, the City loaned Vendo $2,250,000 to facilitate the construction of the PS 283 & PS 286 treatment system and raw water pipeline. Additionally, Vendo agreed to repay the City $399,920.07, previously "expended to remediate and mitigate the groundwater contamination emanating from the Pinedale Industrial Area." Repayment of the loan and previous expenditures included interest. Vendo also is responsible to pay for O&M costs directly attributed to the wellhead treatment systems. This includes power to overcome head losses in the pipeline from PS 286 to PS 283 and across the GAC bed; sampling analysis; carbon change-outs; and city labor to perform site operations. Although not specifically stated, it would appear the $399,920 covers the capital costs for the treatment system at PS 279 and other associated costs incurred by the Water Division due to the contaminant plume.

REGIONAL LAND USE PLANNING

Regional land use planning is conducted under the authority of the Cities of Fresno and Clovis within their corporate limits, and Fresno County outside of the cities. Each land use authority is required by California law to prepare a General Plan to guide future growth within its sphere of influence. The City of Fresno's General Plan was adopted in November 2002, and serves a planning horizon of 2025. This is the primary source of land use planning data used in this study to estimate future water demands. The City sphere of influence is determined by the Local Agency Formation Commission (LAFCO).

An important component of recent and future General Plans is a Water Supply Assessment (WSA), prepared in conformance with SB 610. Phase 2 of this Metro Plan Update will include an update to the Urban Water Management Plan. All subsequent development will be contingent on a finding of adequate water supply as defined by the UWMP.

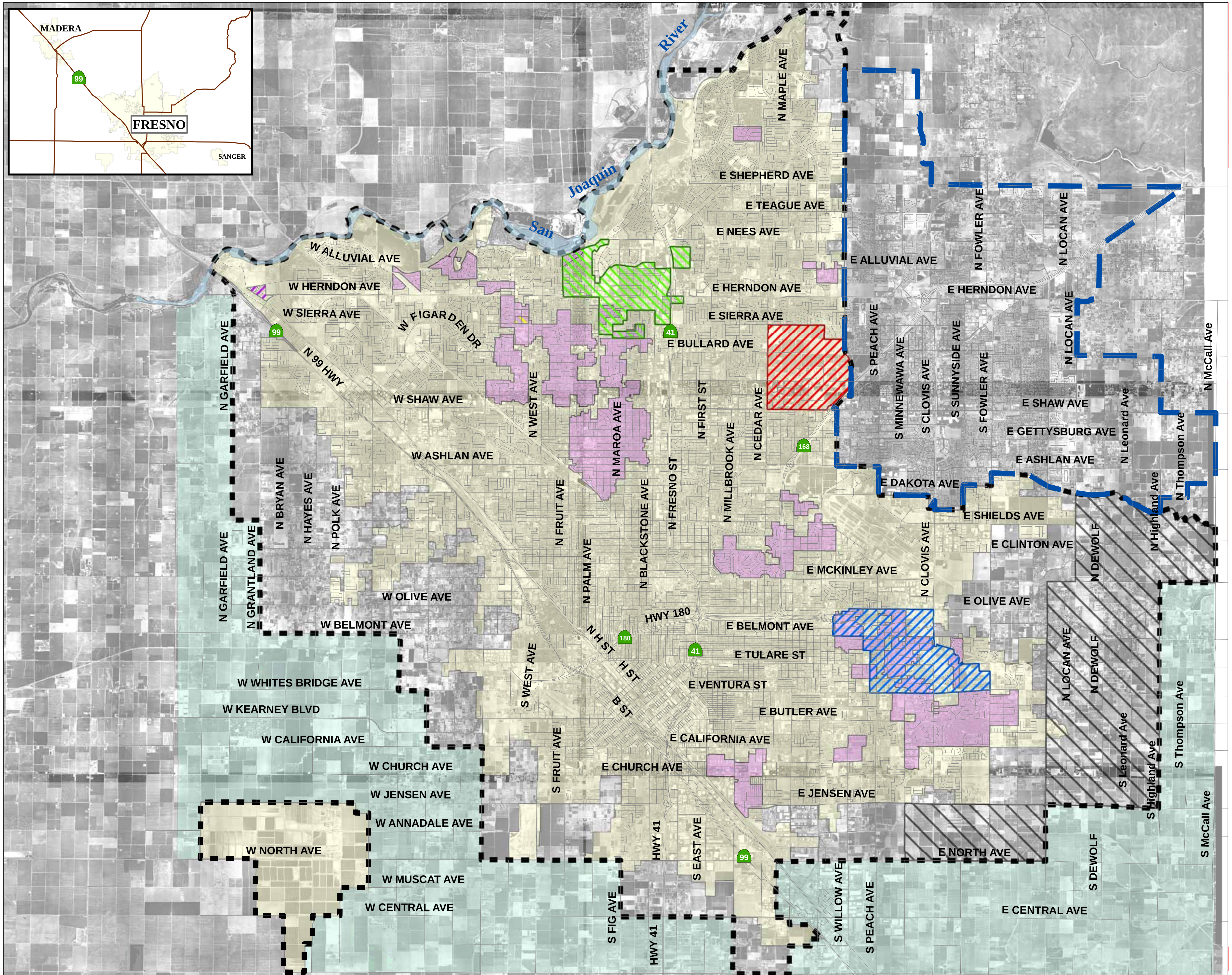


FIGURE 8-1

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING AND FUTURE STUDY AREA

N

0 1 2 4

Scale in Miles

NOTES:

A. 2060 Growth Fringe is provided for discussional purposes only, and is not to be taken as representing any land use planning goals or objectives for City Growth

B. 2060 Growth Fringe adds approximately 37,000 acres.

- Clovis Sphere of Influence
- Fresno Sphere of Influence
- Pinedale County Water Dist.
- Bakman Water Company
- California State Univ., Fresno
- Herndon
- Park Van Ness
- Southeast Growth Area
- 2060 Growth Fringe
- County Island
- City Limit

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

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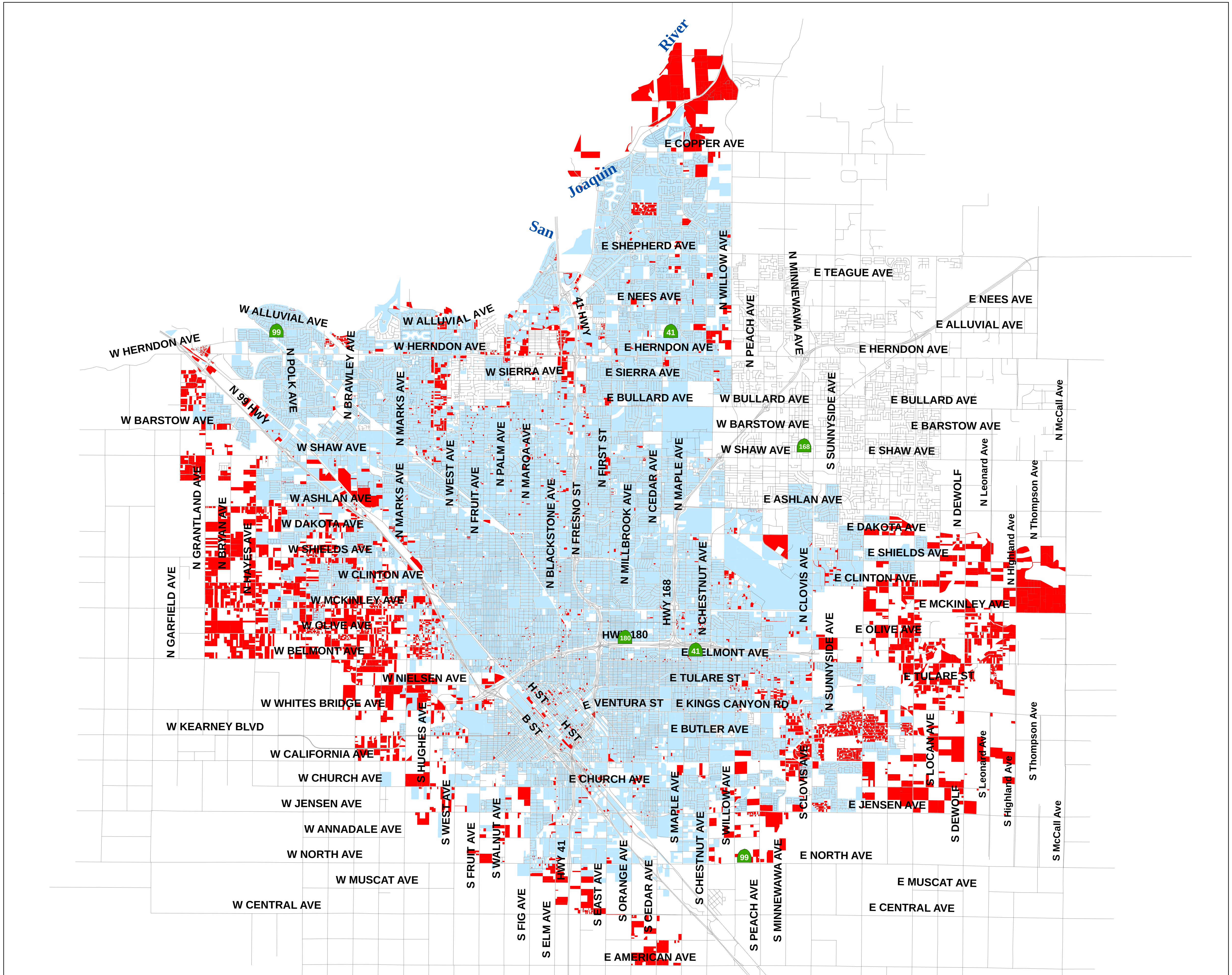

FIGURE 8-2

City of Fresno Metropolitan Water Resources Management Plan Update

EXISTING WASTEWATER SERVICE AREA

N

0 1 2 4

Scale in Miles

NOTES:

A. Sewered and unsewered areas based on GIS parcel information provided by City Staff.

LEGEND:

- Existing Sewered Area
- Unsewered Area

Fresno All-America City 2000

WEST YOST ASSOCIATES Consulting Engineers

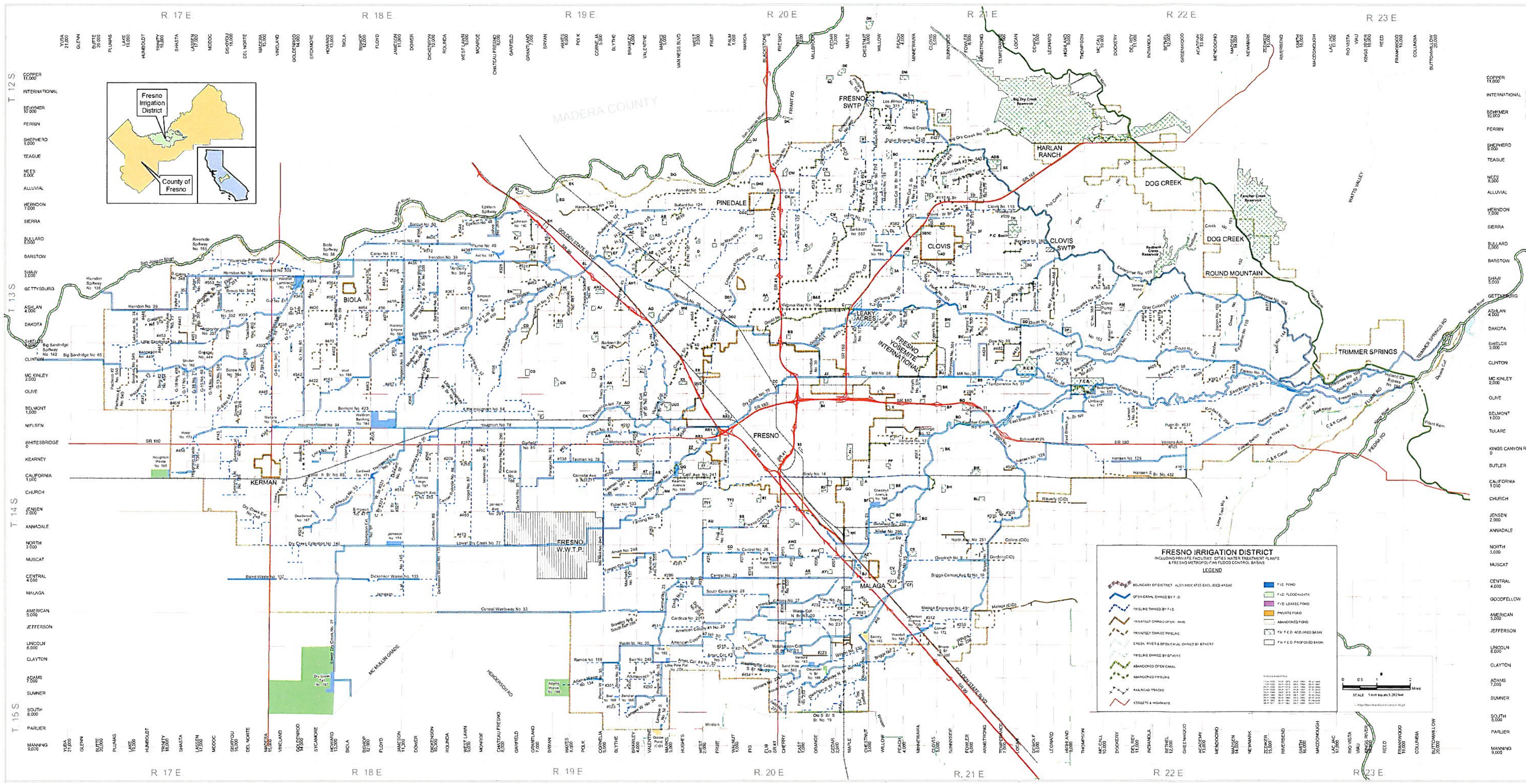

FIGURE 8-3

Fresno All-America City 2000

City of Fresno Metropolitan Water Resources Management Plan Update

FRESNO IRRIGATION DISTRICT BOUNDARY

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Consulting Engineers

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