WEST YOST ASSOCIATES
Consulting Engineers

TECHNICAL MEMORANDUM

DATE: October 7, 2009 Project No.: 418-02-07-22

TO: Jack Bond, City of Modesto

CC: Rich Ulm, City of Modesto
Jim Alves, City of Modesto
Glenn Prasad, City of Modesto

FROM: Charles Duncan
Amy Kwong

SUBJECT: City of Modesto's 2010 Water System Engineer's Report Comparison of Existing Water Supply and Projected Water Demands (Supply vs. Demand TM)

The primary purpose of this technical memorandum (TM) is to describe the City of Modesto's (City's) existing sources of water supply and then compare these existing supplies to projected water demands previously presented by West Yost Associates (WYA) in the Demand TM (Appendix B) to determine if an overall system supply shortage exists. This TM also provides a cursory overview of other supply alternatives to potentially meet identified supply shortages. Recommended actions the City should take to be able to operationally convey alternative supplies will be identified in subsequent TMs to be completed as part of the 2010 Water System Engineer's Report.

An outline of this TM is as follows:

- Description of the City's Service Area
- Projected Water Demands
- Existing Water Supplies
- Comparison of Existing Water Supplies to Projected Water Demands
- Overview of Additional Sources of Potential Water Supply
- Conclusions

1.0 DESCRIPTION OF THE CITY'S SERVICE AREA

In addition to the City of Modesto proper, the City's water system provides domestic water to several other areas previously served by the Del Este Water Company including the City of Waterford, portions of the cities of Ceres and Turlock, the communities of Salida, Empire, Del Rio, Grayson, and Hickman.

The City's service area consists of one large "contiguous" service area and several "outlying" non-contiguous service areas. The City's contiguous service area is primarily defined by the current sphere of influence (SOI), Salida, North Ceres and some unincorporated Stanislaus County "islands" within or adjacent to the SOI (Empire is in the SOI). The outlying service areas include Del Rio, Grayson, Hickman, Waterford, Ceres (Walnut Manor), and portions of Turlock. Figure 1 illustrates the location of the City's contiguous and outlying service areas.

The Riverdale Park Tract (approximately 40 acres located in the southwest portion of the contiguous service area) is physically connected to the City's water system to provide Riverdale with an emergency backup supply, and has only been used when the single well in the Riverdale area was inoperable or could not meet pressure requirements. A records check of the City's billing data over the last two years indicates the water consumption from this area is negligible; therefore, the existing water demands from the Riverdale area have not been included in this analysis.

2.0 PROJECTED WATER DEMANDS

Water demands were previously projected in the Demand TM. Table 1 presents the projected water demands[1] by service area, and will be used in subsequent sections to determine if a water supply shortage exists. As shown in Table 1, the City's total water demands are projected to increase by approximately 47 percent, from 78,755 acre-feet per year (af/yr) in 2006 to a buildout demand of approximately 116,055 af/yr in 2038.

Additionally, as discussed in the City's 2005 Urban Water Management Plan[2] (UWMP), the City has been in Stage 1 of its Water Shortage Contingency Plan since March of 2003; Stage 1 specifies a 10 to 20 percent reduction in customer water demands. The UWMP also assumed that customer water supplies would not be further reduced unless surface water supplies from the Modesto Irrigation District (MID) were cutback by 25 percent or more (see subsection 3.2.3 of this TM).

3.0 EXISTING WATER SUPPLIES

The City has two existing water supply sources: local groundwater and treated surface water purchased from MID. The reliability of both supplies is discussed below.

3.1 Reliability of Existing Groundwater Supplies

The City's service area is located within the San Joaquin Valley Groundwater Basin (SJV Basin), and the City's customers have relied on groundwater pumped from the following three subbasins defined within the SJV Basin:

[1] As discussed previously in the Demand TM, future projections of water demands ("demand" = customer water use + unaccounted for water) were assumed to equal the required production to meet those demands.

[2] RMC, May 2007. City of Modesto/Modesto Irrigation District Joint Urban Water Management Plan 2005 Update.

Table 1. Summary of Projected Water Demands by Service Area, af/yr[a,b]

Service Area		2006[e]	2010	2015	2020	2025	2030	2038[f]
Contiguous Service Area	North Modesto[c]	67,039	70,299	74,375	78,452	84,081	89,709	98,715
	South Modesto[d]	8,159	8,682	9,263	9,553	10,035	10,517	11,288
	Subtotal	*75,198*	*78,981*	*83,638*	*88,005*	*94,116*	*100,226*	*110,003*
Outlying Service Areas	Del Rio	694	841	1,026	1,210	1,395	1,579	1,874
	Waterford	2,111	2,224	2,366	2,508	2,649	2,791	3,018
	Ceres (Walnut Manor)	29	29	29	29	29	29	29
	Hickman	194	228	270	312	354	396	464
	Portions of Turlock	353	353	353	353	353	353	353
	Grayson	176	193	215	236	258	280	314
	Subtotal	*3,557*	*3,868*	*4,259*	*4,648*	*5,038*	*5,428*	*6,052*
Total		78,755	82,849	87,897	92,653	99,154	105,654	116,055

[a] Assumes normal hydrologic conditions.

[b] Projected demands in 2010, 2015, 2020, 2025, and 2030 were linearly interpolated using 2006 and projected buildout (2038) demands, and subsequently reduced by 10 percent to account for the expected reduction in water use as a result of the City's ongoing residential meter installation program.

[c] Includes portions of the City north of the Tuolumne River, Salida, and Empire.

[d] Includes portions of the City south of the Tuolumne River and North Ceres.

[e] Based on Table 5, Appendix B (Demand TM). Demands in South Modesto based on demands allocated in the existing system model.

[f] Based on Table 13, Appendix B (Demand TM). Buildout demands in South Modesto were calculated based on land uses south of the Tuolumne River.

- Modesto Subbasin,
- Turlock Subbasin, and
- Delta-Mendota Subbasin.

The City's contiguous service area and some outlying services areas span both the Modesto and Turlock Subbasins. North Modesto, Salida, Empire, Del Rio, and Waterford are located in the Modesto Subbasin. South Modesto, Turlock, North Ceres, Ceres (Walnut Manor), and Hickman are located in the Turlock Subbasin. Grayson is located in the Delta-Mendota Subbasin. Figure 2 illustrates the location of the City's service area in relation to the boundaries of these three subbasins.

The following subsections describe the preliminary groundwater operational yield developed by City staff and the corresponding planning level criteria used in this TM. Review of basin formations, groundwater levels, groundwater quality, or existing groundwater management plans for each subbasin is beyond the scope of this TM; however, this information is summarized and available in the City's UWMP.

3.1.1 Preliminary Operational Yield Developed by the City

As discussed in the UWMP, the City has estimated that their preliminary operational yield from the three groundwater subbasins underlying the City's service area is approximately 53,500 af/yr.[3] This preliminary operational yield is based on historic groundwater pumpage by the City from the Modesto, Turlock, and Delta-Mendota Subbasins, and was developed by City staff in order to maintain a minimum average groundwater elevation of 40 feet above mean sea level (ft msl) (Attachment A).

The general conclusion of the City's analysis is that if the total, long-term average groundwater pumpage quantity is held at or below 53,500 af/yr,[4] then stable groundwater levels will result at around 40 ft msl within and near the City's contiguous service area. If groundwater pumpage is significantly less than 53,500 af/yr, groundwater levels will probably rise; thereby, increasing the quantity of available groundwater stored within the basin for later use in dry periods and/or to meet future demands, via "in-lieu" groundwater banking. Alternatively, if more than 53,500 af/yr is extracted (e.g., during dry years), groundwater levels will probably decline. Actual annual groundwater pumpage is expected to be less during normal or wet years and higher during dry years.

3.1.2 Preliminary Operational Yield Assumed for Each Subbasin for this Planning Level Analysis

As stated above, the preliminary groundwater operational yield is assumed to be a long-term average, and that actual annual extractions will be higher or lower than 53,500 af/yr to meet demands (depending on actual hydrologic conditions, i.e., wet or dry rainfall year). Table 2

[3] Evaluating the City's existing preliminary operational yield estimate or the resulting water level rise and fall over the historical period is beyond the scope of this TM.

[4] Per discussion with City staff on 5/8/08.

summarizes the long-term average preliminary operational yield assumed for each subbasin for the planning level analysis used in this TM.

Table 2. Preliminary Operational Yield Assumed for Each Subbasin[(a)]

Groundwater Subbasin	Allocation, af/yr
Modesto	48,286
Turlock	4,900
Delta-Mendota	314
Total	53,500

(a) Provided to WYA by City staff.

The planning level analysis completed in this TM also assumes that the City will conduct the necessary activities[5] to ensure that it can continue to provide not only the long-term average preliminary operational yield of 53,500 af/yr, but also the capacity required to pump additional groundwater during dry periods. The additional annual groundwater pumping capacity required is discussed in subsequent sections of this TM.

3.1.3 Future Groundwater Available to the City

As will be discussed in the next section, the City purchases treated surface water from MID; thereby, allowing the City to supplement groundwater extractions with the use of treated surface water. This conjunctive use operational strategy assumes that when the need for groundwater pumping is below the preliminary operational yield (53,500 af/yr) due to the availability and use of MID treated surface water during normal or wetter years, the unused groundwater remains as groundwater storage for later use during dry periods, and/or to meet future demands, up to the amount previously banked (based on the preliminary operational yield estimate).

As discussed previously, the preliminary operational yield is a long-term average and therefore, was assumed available to the City during all hydrologic conditions (dry, normal, and wet years); consequently, the preliminary groundwater operational yield available to the City between 2006 and 2038 was assumed equal to the long-term average, or 53,500 af/yr.

3.2 Reliability of Existing Surface Water Supplies

MID has historic surface water rights on the Tuolumne River. Some of these water rights have been used to deliver raw water to the Modesto Regional Water Treatment Plant (MRWTP). The MRWTP is located at the Modesto Reservoir, approximately 14 miles east of the City; actual deliveries are made to the City via MID's terminal reservoir facilities [booster pump station and two storage tanks (5 million gallons each) located on the east side of the city (Figure 3)].

[5] Activities the City may need to conduct can include normal operation and maintenance, construction of new groundwater wells, or installation of new wellhead treatment.

Subsequent sections briefly describe the MRWTP, the City's water delivery agreement with MID, and the reliability of surface water supplies purchased by the City from MID.

3.2.1 Brief Description of the MRWTP

The original 30 million gallon per day (mgd) MRWTP (operational in January 1995) is a conventional treatment facility providing flocculation, sedimentation, and filtration, along with ozonation for primary disinfection. The MRWTP Phase Two Expansion (an additional 30 mgd in treatment capacity) will be a membrane treatment facility that is currently under construction and is anticipated to be operational by early 2010. The combined 60 mgd (67,204 af/yr) capacity is an annual average, and both the original and expanded facilities will have peaking capacities greater than the annual averages; the initial phase of the MRTWP has a maximum functional capacity of 42.5 mgd that helps meet the Maximum Day and Peak Hour demands of the City's contiguous service area north of the Tuolumne River (North Modesto, Salida, and Empire) but has been permitted by the State to produce up to 45 mgd for the last few years. Peaking capacity for the Phase Two Expansion will be determined after start-up operations and testing protocols are completed.

3.2.2 Amended and Restated Treatment and Delivery Agreement

The MRWTP, terminal reservoir facilities (booster pump station and tanks), and a portion of the transmission pipelines traversing the City are owned and operated by MID, and provide treated surface water to the City's contiguous service area (north of the Tuolumne River) via an existing *Amended and Restated Water Treatment and Delivery Agreement between Modesto Irrigation District and the City of Modesto* (AR TDA), dated October, 2005. Additionally, the State Water Resources Control Board (SWRCB) approved an order (see the UWMP) for a long-term transfer for up to 67,204 af/yr (60 mgd) of surface water from MID to the City through 2054.

The AR TDA is the document controlling the delivery of treated surface water to the City, and obligates MID to deliver 33,602.1 af/yr now and 67,204.2 af/yr after completion of the MRWTP Phase Two Expansion Project during normal or wetter years. The AR TDA also limits the use of MID surface water supplies to areas of the City located north of the Tuolumne River (the southern boundary of MID's service area).

A formula in the AR TDA governs supply reductions to the City in drier-than-average years, based on the number of inches of surface water the MID Board allocates to its agricultural customers. The formula is as follows:

$$\frac{Y}{42} \times 33{,}602.1 = X \text{ , where}$$

Y is the number of inches of water allocated to MID's agricultural customers, and

X is the amount of water delivered to the City.

As shown in the formula above, MID's delivery of surface water to the City may be reduced in equal proportions to deliveries to MID's agricultural customers during supply shortage (dry) years. The City, however, does have the option of making up these shortages by either purchasing additional supplies (at a higher rate) from MID, or delivering an equal amount of

groundwater to MID's irrigation canal system in exchange for a similar amount of treated surface water, which could lead to short-term increased pumpage from the groundwater basin.[6]

3.2.3 Reliability of Surface Water Supplies Purchased from MID

For consistency with the UWMP, it was assumed that critically dry year reductions were based on 1991 hydrologic conditions.[7] In 1991, the base supply for the City was defined as 33-inches (out of a potential total of 42-inches) of water; thereby, reducing the City's allocation of MID surface water by 9-inches or 21.4 percent (9/42*100). Also for consistency with the UWMP, MID surface water supplies assumed available during a 5-year drought are as follows:

- Year 1: 95.7 percent (40.2/42), or 64,324 acre-feet
- Year 2: 91.4 percent (38.4/42), or 61,444 acre-feet
- Year 3: 87.1 percent (36.6/42), or 58,563 acre-feet
- Year 4: 82.9 percent (34.8/42), or 55,683 acre-feet
- Year 5: 78.6 percent (33/42), or 52,803 acre-feet

The UWMP also assumed that 100 percent of the City's MID surface water supplies were available during normal or wetter hydrologic conditions. As previously discussed, groundwater not extracted during these hydrologic conditions is assumed to be banked for later use during dry years, and/or to meet future demands (up to the amount of groundwater stored based on the preliminary operational yield estimate); thereby, allowing the City to conjunctively use the groundwater basin to meet supply deficits.

It should also be noted that the largest MID supply reduction used in the UWMP is 21.4 percent (equivalent to a "Year 5" reduction); therefore, in theory, water supplies to the City's customers will not be reduced during drought periods because the MID reduction will always be less than the 25 percent threshold defined in the City's Water Shortage Contingency Plan (see section 2.0 of this TM).

3.3 Summary of Existing Water Supplies for the City

As discussed previously, the planning level analysis in this TM adopted the operational method presented in the UWMP, which assumed that during certain periods, the City could extract more than the preliminary operational yield to meet supply deficits because it had previously banked and stored excess groundwater during normal or wetter hydrologic conditions. Tables 3 and 4

[6] Evaluating infrastructure required to convey this water is beyond the scope of this TM.

[7] City staff provided WYA information on the amount of water allocated by MID to its agricultural customers between 1988 and 2007; this data corresponds with the conclusions in the UWMP. Typical planning level efforts, however, cover a much longer period of time to ensure that sufficient conservatism is built into the analysis (e.g., including the 1977 critical drought). This additional data was not readily available at the time this TM was completed; consequently, it is recommended that the City collect additional delivery data from MID to its agricultural customers to confirm the frequency of past reductions and to ensure the hydrologic conditions in 1991 truly represent critically dry years as defined by the City's AR TDA.

summarize the existing water supplies available to the City during normal or wetter hydrologic conditions and during a five-year drought, respectively.

Table 3. Total Existing Water Supplies During Normal or Wetter Hydrologic Conditions, af/yr

Supply	2006	2010	2015	2020	2025	(Buildout) 2038
Groundwater[(a)]	53,500	53,500	53,500	53,500	53,500	53,500
Surface Water[(b)]	33,602	67,204	67,204	67,204	67,204	67,204
Total	87,102	120,704	120,704	120,704	120,704	120,704

(a) Includes all groundwater from contiguous and outlying service areas.
(b) Based on the AR TDA.

Table 4. Total Existing Water Supplies During a 5-Year Drought at and near Buildout, af/yr

Supply	Year 1 (2034)	Year 2 (2035)	Year 3 (2036)	Year 4 (2037)	Year 5 (2038)
Groundwater[(a)]	53,500	53,500	53,500	53,500	53,500
Surface Water[(b)]	64,324	61,444	58,563	55,683	52,803
Total	117,824	114,944	112,063	109,183	106,303

(a) Includes all groundwater from contiguous and outlying service areas.
(b) Surface water reductions obtained from the UWMP.

4.0 COMPARISON OF EXISTING WATER SUPPLIES TO PROJECTED WATER DEMANDS

As previously illustrated on Figure 1, the City's total service area contains several outlying areas that must rely solely on groundwater. Portions of the contiguous service area located south of the Tuolumne River, in the Turlock Subbasin, must also rely solely on groundwater. Supply and demand comparisons presented in this TM consider these limitations.

Subsequent sections compare supply and demand for the outlying service areas, portions of the contiguous service area north of the Tuolumne River (North Modesto), and portions of the contiguous service area south of the Tuolumne River (South Modesto).

4.1 Supply Requirements for Outlying Service Areas

The City's outlying service areas are not connected via existing infrastructure to the contiguous service area and therefore, cannot physically receive the treated surface water supply from MID. Consequently, the planning level analysis in this TM assumed that the outlying service areas have priority use of the groundwater supplies from their respective subbasins (i.e. based on the preliminary operational yield) up to their projected demand at buildout.

Table 5 presents the portion of the preliminary operational yield used by each outlying service area and the remaining groundwater available for the contiguous service area. As shown, there is sufficient groundwater supply using the City's preliminary operational yield to meet projected water demands of the outlying service areas during all hydrologic conditions. Table 5 also shows that the current preliminary operational yield available to the contiguous service area decreases as the demands in the outlying areas increase.

4.2 Supply Requirements for North Modesto

Figure 4 compares projected water demands in North Modesto to existing water supplies under normal or wetter hydrologic conditions (i.e., with a full allotment of MID supplied surface water). As shown, North Modesto has sufficient water supplies during normal or wetter hydrologic conditions.

Figure 4 also indicates that the Modesto Subbasin has some available surplus groundwater supplies (within the preliminary operational yield definition), ranging from approximately 9,403 to 42,125 af/yr depending on the year (i.e., the availability of treated surface water from MID and demands). Discussions with City staff indicated that the City does have the authority and ability to move surplus groundwater supplies south to meet demands in South Modesto. For planning purposes in this TM, it was assumed that surplus groundwater from the Modesto Subbasin could be conveyed and used to meet supply requirements for South Modesto (areas located in the Turlock Subbasin).

Figure 5 compares projected water demands in North Modesto to available supplies during a 5-year drought scenario (buildout was assumed to occur at Year 5). As shown, additional groundwater extraction is required beyond the preliminary operational yield (from either existing or new wells) during the last year of the drought. However, as stated before, under normal or wetter hydrological conditions, when groundwater extraction is below the preliminary operational yield, groundwater recharge would occur; thereby, creating a net increase in the groundwater basin storage for use in future years. Therefore, the additional groundwater required to meet demands during the last two years of the drought would be made available through previously banked groundwater in the Modesto Subbasin; however, further studies should be developed by the City to determine the effects of short-term overpumping and to better define the operational yield of the subbasin.

Table 5. Preliminary Operational Yield Allocated to Outlying Service Areas and Available to the Contiguous Service Area, af/yr[a,b]

Subbasin	Outlying Service Area	2006[e]	2010	2015	2020	2025	2030	2038[f]
Modesto	Del Rio Demand	694	841	1,026	1,210	1,395	1,579	1,874
	Waterford Demand	2,111	2,224	2,366	2,508	2,649	2,791	3,018
	Subtotal	2,805	3,065	3,392	3,718	4,044	4,370	4,892
	Preliminary Operational Yield [c]	*48,286*	*48,286*	*48,286*	*48,286*	*48,286*	*48,286*	*48,286*
	Remaining Groundwater Yield	45,481	45,221	44,894	44,568	44,242	43,916	43,394
Turlock	Hickman Demand	194	228	270	312	354	396	464
	Turlock Demand	353	353	353	353	353	353	353
	Ceres (Walnut Manor) Demand	29	29	29	29	29	29	29
	Subtotal	576	610	652	694	736	778	846
	Preliminary Operational Yield [c]	*4,900*	*4,900*	*4,900*	*4,900*	*4,900*	*4,900*	*4,900*
	Remaining Groundwater Yield	4,324	4,290	4,248	4,206	4,164	4,122	4,054
Delta-Mendota	Grayson Demand	176	193	215	236	258	280	314
	Preliminary Operational Yield [c]	*314*	*314*	*314*	*314*	*314*	*314*	*314*
	Remaining Groundwater Yield	138	121	99	78	56	34	0
Total Preliminary Operational Yield for Contiguous Service Area [d]		49,804	49,510	49,141	48,773	48,405	48,037	47,448

[a] Assumes normal or wetter hydrologic conditions.

[b] Projected demands in 2010, 2015, 2020, 2025, and 2030 were linearly interpolated using 2006 and projected buildout (2038) demands, and subsequently reduced by 10 percent to account for the expected reduction in water use as a result of the City's ongoing residential meter installation program.

[c] Preliminary operational yield allocated based on Table 2.

[d] This is the remaining groundwater available for the contiguous service area. It does not include groundwater from the Delta-Mendota Subbasin because there is not a physical connection between the water systems of Grayson and the contiguous service area.

[e] Based on Table 5, Appendix B (Demand TM). Demands in South Modesto based on demands allocated in the existing system model.

[f] Based on Table 13, Appendix B (Demand TM). Buildout demands in South Modesto were calculated based on land uses south of the Tuolumne River.

4.3 Supply Requirements for South Modesto

Per the AR TDA that the City has with MID, the City cannot use MID surface water supplies to meet demands in South Modesto; consequently, the only existing water supply source for South Modesto is groundwater from the Turlock and Modesto Subbasins. Figure 6 compares projected water demands in South Modesto to the groundwater supplies available from the Turlock Subbasin and those remaining groundwater supplies available from the Modesto Subbasin under normal or wetter hydrologic conditions.

As shown in Figure 6, South Modesto has sufficient water supplies though buildout (2038) during normal or wetter hydrologic conditions, assuming that surplus groundwater from the Modesto Subbasin can be conveyed and used in South Modesto.

Figure 6 also shows that if the City transfers its surplus groundwater from the Modesto Subbasin to South Modesto, that over time, the annual surplus of groundwater from the Modesto Subbasin (within the defined preliminary operational yield) is drastically reduced from approximately 37,732 af in year 2010, to approximately 4,649 af by buildout (2038).

Figure 7 compares projected water demands in South Modesto to available supplies during a 5-year drought scenario (buildout was assumed to occur at Year 5). As shown, an additional supply is required during the last three years of the drought. However, under normal or wetter hydrological conditions, the quantity of groundwater recharge would be in excess of groundwater pumpage; thereby, creating a net increase in the groundwater basin storage for use in future years. Therefore, the additional supply required to meet demands during the last three years of the drought could be made available through previously banked groundwater in the Turlock and Modesto Subbasins; however, further studies should be developed by the City to determine the effects of short-term overpumping and to better define the operational yield of the subbasins.

Subsequent sections of this TM discuss other potential water supply options the City is considering.

5.0 OVERVIEW OF ADDITIONAL SOURCES OF POTENTIAL WATER SUPPLY

As shown in Figure 4, the City appears to have sufficient water supplies in North Modesto (within the limits of the defined preliminary groundwater operational yield) to meet projected demands through 2038 during normal or wetter hydrologic conditions. In South Modesto, the City has sufficient water supplies through 2038 if the annual surplus of groundwater from the Modesto Subbasin is transferred to South Modesto. As discussed in the previous sections, the preferred supply option assumes that during certain periods, the City could extract more than the preliminary operational yield to meet supply deficits because it had previously banked and stored excess groundwater during normal or wetter hydrologic conditions. However, this preferred supply option is highly dependent upon the preliminary operational yield estimate of 53,500 af/yr. Since further studies to verify and refine this preliminary operational yield have not been completed, the following potential supply options are briefly reviewed:

- More Refined Operational Yield Estimate,
- Regional Surface Water Supply Project (RSWSP) with the Turlock Irrigation District (TID),
- MRWTP Phase Three Expansion Project,
- Development of Recycled Water Options,
- Additional In-Lieu Groundwater Banking and Aquifer Storage Recovery (ASR),
- Conversion to Metered-Based Billing, and
- Additional Water Conservation and Revised Water Shortage Contingency Plan.

Each of these potential future water supply sources is described below.

5.1 More Refined Operational Yield Estimate

As previously discussed, during a 5-year drought condition (buildout was assumed to occur at Year 5), short-term overpumping of the Modesto and/or Turlock Subbasins would occur as needed to meet demands. The additional groundwater required to meet demands during the last several years of the drought would be made available through previously banked groundwater. Based on these findings, it is recommended that the City perform a more comprehensive hydrogeological groundwater yield study to verify the preliminary operational yield, and assess the impacts of short-term pumping that exceeds the preliminary operational yield. Subsequent analyses using the City's hydraulic model, to be completed as part of the 2010 Water System Engineer's Report, will determine if additional groundwater supplied from the Modesto and Turlock Subbasins can be physically distributed and sustain City-wide system pressures and system reliability. Other more costly water supply sources (e.g., TID's RSWSP or a MRWTP Phase Three Expansion Project) may be required to ensure service reliability.

5.2 Regional Surface Water Supply Project with the Turlock Irrigation District

A proposed RSWSP is currently being planned by the TID, along with the Cities of Ceres, Hughson, Modesto, and Turlock. Potential participants, such as the City, are evaluating the feasibility of such a project. The development of the RSWSP would initially provide the City with an additional 6 mgd (6,720 af/yr) (this amount would be the first phase of a multi-phase treatment plant, but the actual total quantity has not yet been determined) of treated surface water to South Modesto.

The City is currently working under the "First Drinking Water Agreement" executed between the TID and the participating cities (Ceres, Hughson, Modesto, and Turlock) that primarily encompasses the planning, environmental review, and design of the RSWSP, plus transmission facilities that, through a future Water Sales Agreement, will provide the treated surface water to South Modesto. The TID surface water supply deliveries could be available as early as 2013; however, it is recommended that the City review the reliability of TID water supplies before moving forward because these supplies are likely subject to the same dry year reductions as MID surface water rights, as they both come from the Tuolumne River.

5.3 MRWTP Phase Three Expansion Project

A MRWTP Phase Three Expansion Project may be possible if there is a sizeable future conversion of agricultural land to urban uses (requiring an accompanying change in water rights from agricultural to municipal and industrial (M&I) uses), which would allow for a corresponding redistribution of MID's existing surface water rights. In addition, the City may also be able to purchase an additional water supply from another wholesale water agency (e.g., Oakdale Irrigation District) that, through special arrangements, could be treated at the MRWTP with the Phase Three Expansion Project for transmission to the City. The City has engaged in very preliminary discussions with MID regarding the possibility of a MRWTP Phase Three Expansion Project, but at this time, this project is speculative.

5.4 Development of Recycled Water Options

The City completed a feasibility study entitled "Northern San Joaquin Valley Water Reclamation Project" dated June 2005 (scheduled to be updated in 2010), by Raines, Melton, & Carella that looked at the potential development of a regional wastewater treatment and recycling system to offset a portion of the City's potable water demand. Tier I of this project has the potential to develop an additional 6,720 to 11,200 af/yr (6 to 10 mgd) of potable water supply by using recycled water for irrigation at existing golf courses, parks, schools, industrial uses, and for landscape irrigation in future Comprehensive Planning Districts, in-lieu of using potable water supplies.

Much of this additional supply will not affect potable water supply needs because most of the golf courses and parks are currently irrigated with non-potable water supply sources. However, non-potable water supply sources may be subject to cut-backs during dry years and the City would need to use groundwater to make-up the difference. Consequently, recycled water supplies are not subject to cut-backs and therefore, could reduce groundwater extractions during dry years. This would help the City meet its long-term average groundwater pumping requirements.

The City anticipates that the Tier I system, if found to be economically feasible, could be developed and operational within 5 to 10 years.

5.5 Additional In-Lieu Groundwater Banking and ASR Program

This planning level analysis indicates that the City will need to use the entire 67,204 af/yr of treated surface water supply under the AR TDA with MID to fully implement the in-lieu groundwater banking program defined in the UWMP. Consequently, surplus surface water supplies would not be immediately available for additional in-lieu banking or an Aquifer Storage Recovery (ASR) program unless the City participates in the RSWSP with TID or a MRWTP Phase Three Expansion Project (a banking of surface water would require a close review of the water rights and permitting issues associated with such an activity).

The feasibility of an ASR program in the City's contiguous service area would need to be further evaluated in a separate, more comprehensive, study.

5.6 Conversion to Metered-Based Billing

The City requires installation of water meters with all new development and is currently converting all services to an Automated Meter Reading (AMR) system by either installing new AMR's where no meter existed or retrofitting existing meters to the AMR system. The City starts billing residential customers on metered usage soon after meters are installed (multi-family residential, industrial and commercial customers are already billed based on meter readings). In general, typical water use reductions in residential demands expected from the residential conversion to metered use billing is estimated to range from 7 to 20 percent, based on studies by the California Public Utilities Commission and California Urban Water Conservation Council. For the purposes of this TM and related TMs of the 2010 Engineer's Report, a reduction factor of 10 percent was used for projecting future demands; which also takes into account the planned meter installation schedule by the City's Operations Division over the next ten years. Another benefit of metering is that the City's water conservation effort can utilize direct system audits to identify significant water leaks (landscape irrigation pipe breaks, etc.).

5.7 Additional Water Conservation and Revised Water Shortage Contingency Plan

As discussed previously, the UWMP presents a water shortage contingency plan that only mandates rationing if MID surface water supplies are reduced by 25 percent or more. One option available to the City for reducing long-term average groundwater extractions is to reduce water demands by implementing additional water conservation and mandating rationing during cutbacks when MID surface water supplies are reduced by 10 to 20 percent, instead of 25 percent.

Evaluating the impacts of additional water conservation efforts is beyond the scope of this analysis; however, it is recommended that the City conduct an additional study to define applicable conservation methods to help prepare for compliance with the Executive Order recently issued by California's Governor concerning the statewide drought and the need to reduce demands by approximately 20 percent by 2020.

6.0 CONCLUSIONS

The planning level analysis completed for this TM indicates that the City's existing water supplies are sufficient to meet projected demands through buildout.

The analysis indicates that the City's existing water supplies for North Modesto appear to be adequate under normal or wetter hydrologic conditions. In South Modesto, supplies are also adequate, if the yearly surplus of groundwater from the Modesto Subbasin is provided to South Modesto during normal or wetter hydrologic conditions.

During a 5-year drought condition (buildout was assumed to occur at Year 5) in North and South Modesto, it was shown that short-term overpumping of the Modesto and/or Turlock Subbasins would occur as needed to meet demands. However, under normal or wetter hydrological conditions, unused groundwater is banked for use during dry years. Therefore, the additional groundwater required to meet demands during the last several years of the drought in North and South Modesto would be made available through previously banked groundwater; however,

further studies should be developed by the City to determine the effects of short-term overpumping and to better define the operational yield.

Since further studies to verify and refine the preliminary operational yield have not been completed, other potential supply options were reviewed to create additional supply reliability options for the City. However, the decision to participate or further investigate the other potential supply options should not be based solely on this planning level analysis. The City may have compelling reasons or unique opportunities to pursue one or more of the potential supply options, and additional transmission and distribution system constraints may also influence and justify the participation in the other potential supply options.

FIGURE 1

City of Modesto
MODESTO SERVICE AREAS

Del Rio
Salida
Modesto
Empire
Waterford
Hickman
Ceres (Walnut Manor)
North Ceres
(Portion Served by Modesto)
Grayson
Turlock
Stanislaus River
Dry Creek
Tuolumne River
San Joaquin River
132
99

N

0 0.5 1 2

Scale in Miles

NOTES:

LEGEND:

- Contiguous Service Area
- Outlying Service Area
- Street

CITY of MODESTO

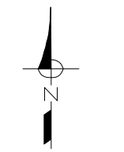
WEST YOST ASSOCIATES
Consulting Engineers

O\C418\020722\GIS\Figures\Water Supply\Fig 1_Modesto Service Area.mxd

FIGURE 2

City of Modesto

MODESTO SERVICE AREAS AND LOCATION OF GROUNDWATER SUBBASINS



NOTES:

Del Rio
Salida
Modesto
Empire
Waterford
Hickman
Stanislaus River
Dry Creek
Tuolumne River
Ceres (Walnut Manor)
North Ceres
(Portion Served by Modesto)
Grayson
San Joaquin River
Turlock
132
99

LEGEND:

- Modesto Subbasin
- Turlock Subbasin
- Delta-Mendota Subbasin
- Contiguous Service Area
- Outlying Service Area
- Street

CITY of MODESTO

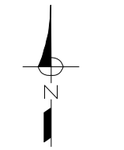
WEST YOST ASSOCIATES
Consulting Engineers

O\C418\020722\GIS\Figures\Water Supply\Fig 2_Modesto Service Area GW.mxd

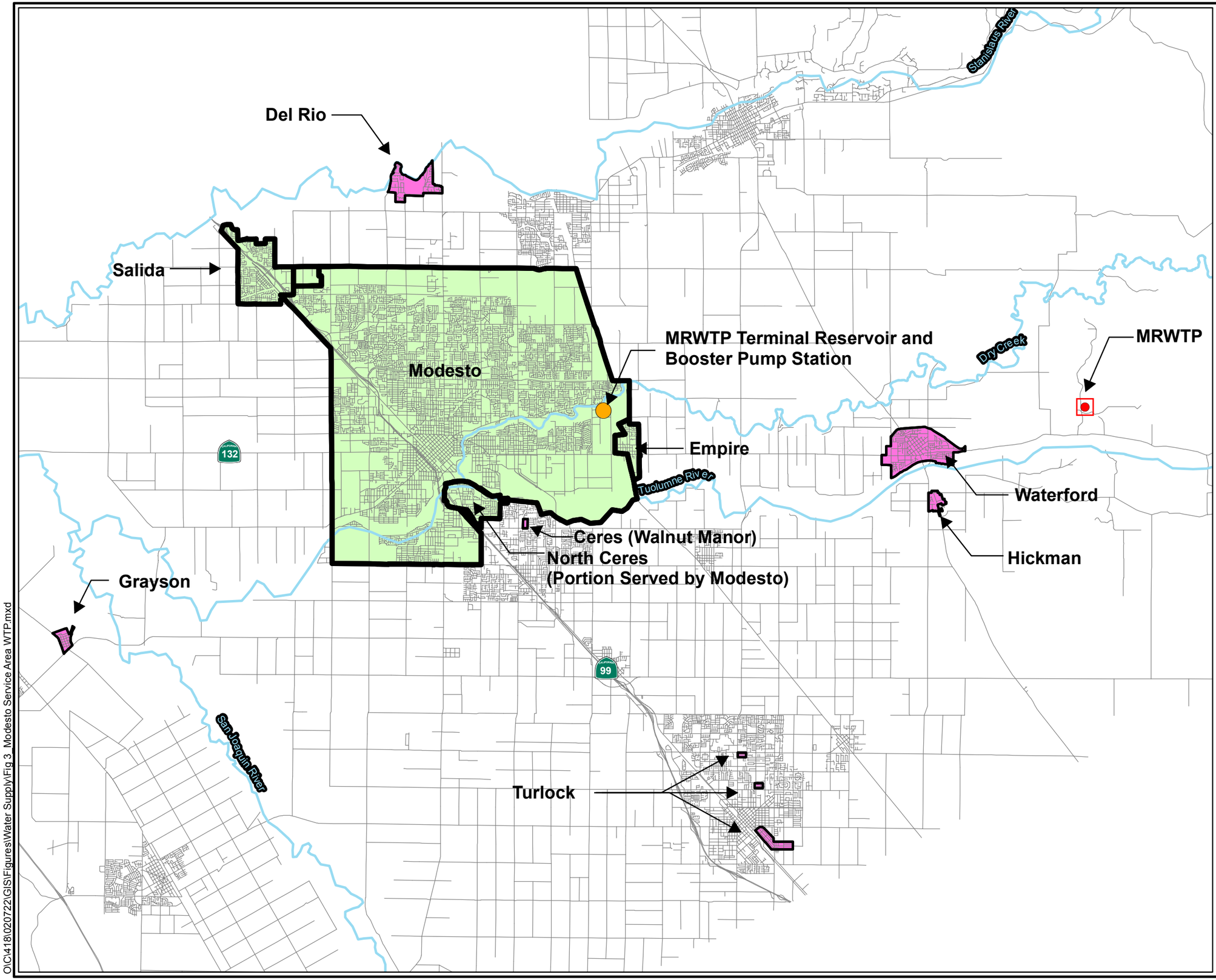
FIGURE 3

City of Modesto

MODESTO SERVICE AREAS AND MRWTP



NOTES:



LEGEND:

- MRWTP
- Location of MRWTP Terminal Facilities
- Contiguous Service Area
- Outlying Service Area
- Street

CITY of MODESTO

WEST YOST ASSOCIATES
Consulting Engineers

O\C418\020722\GIS\Figures\Water Supply\Fig 3_Modesto Service Area WTP.mxd

Figure 4. Comparison of Supply and Demand (Wet and Normal Conditions): North Modesto

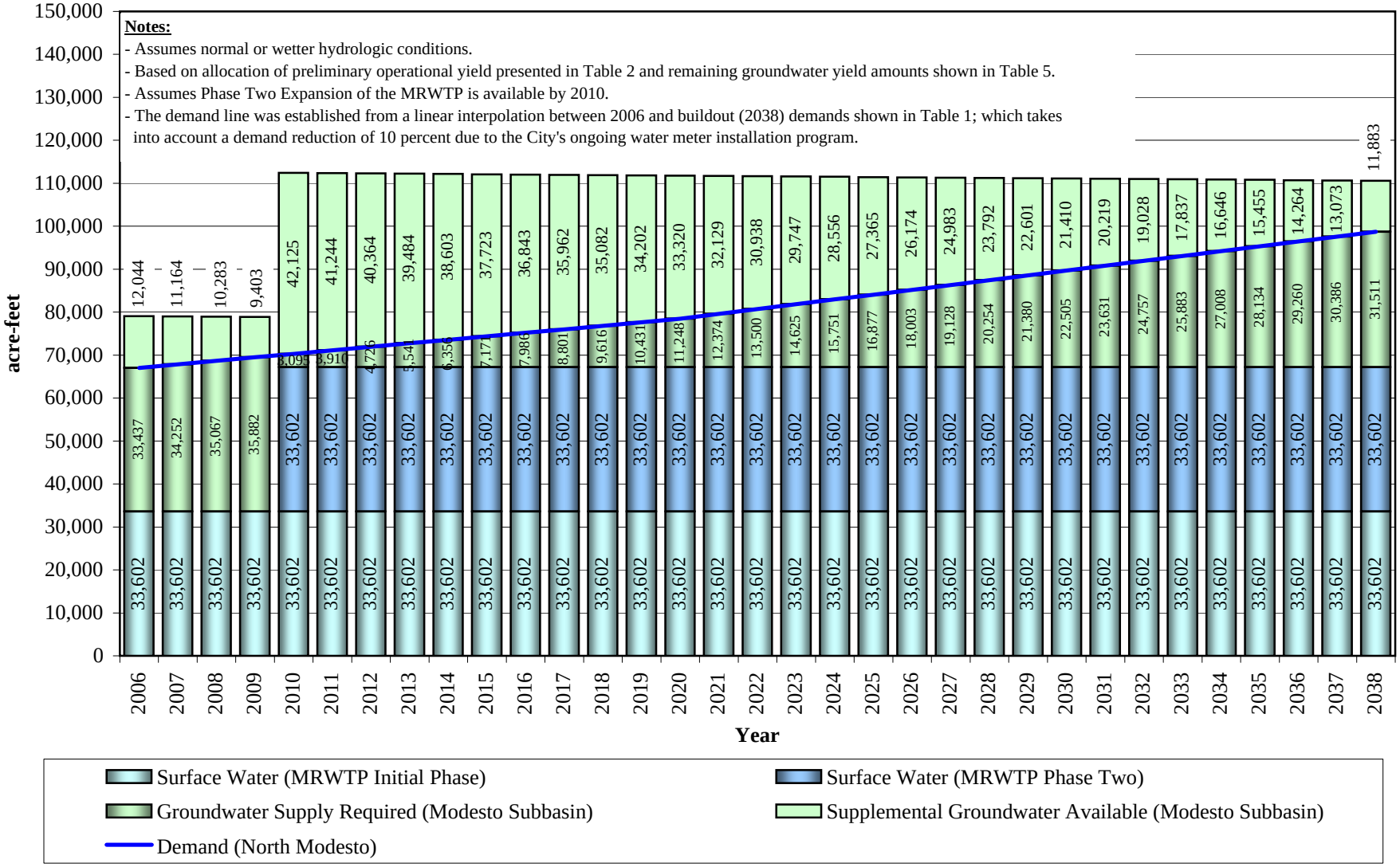


Figure 5. Comparison of Supply and Demand (Multiple Year Drought): North Modesto

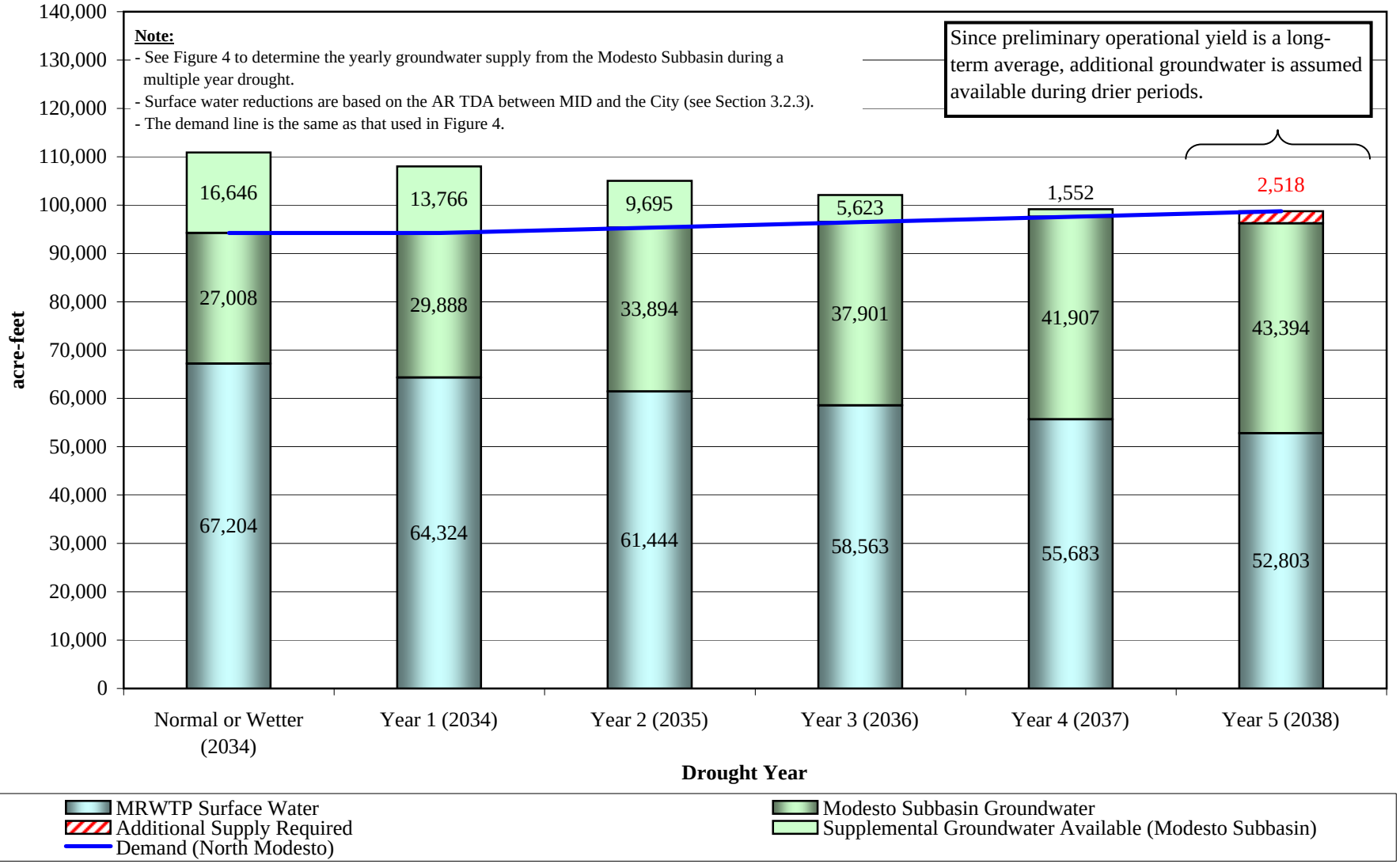


Figure 6. Comparison of Supply and Demand (Wet and Normal Conditions): South Modesto

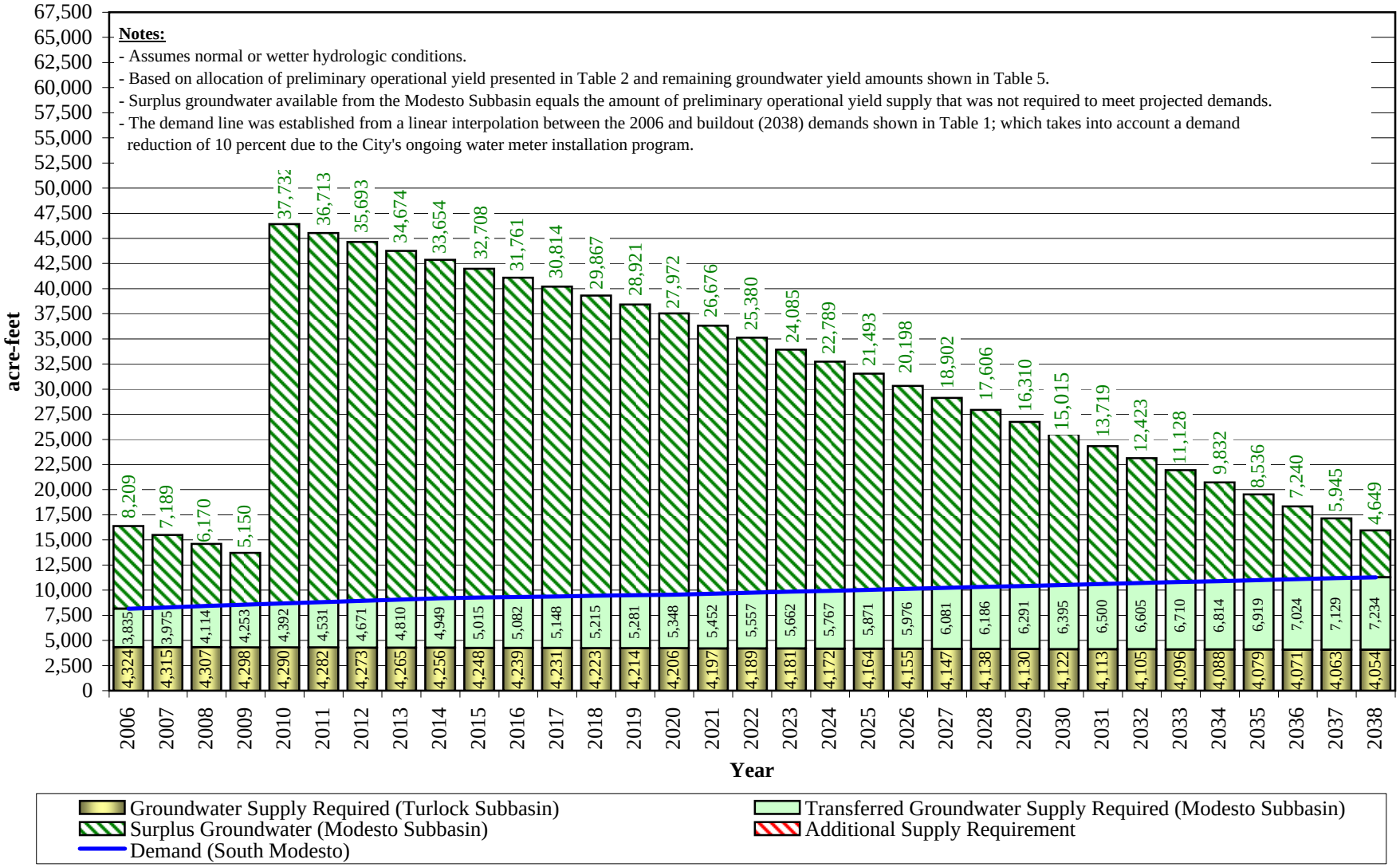
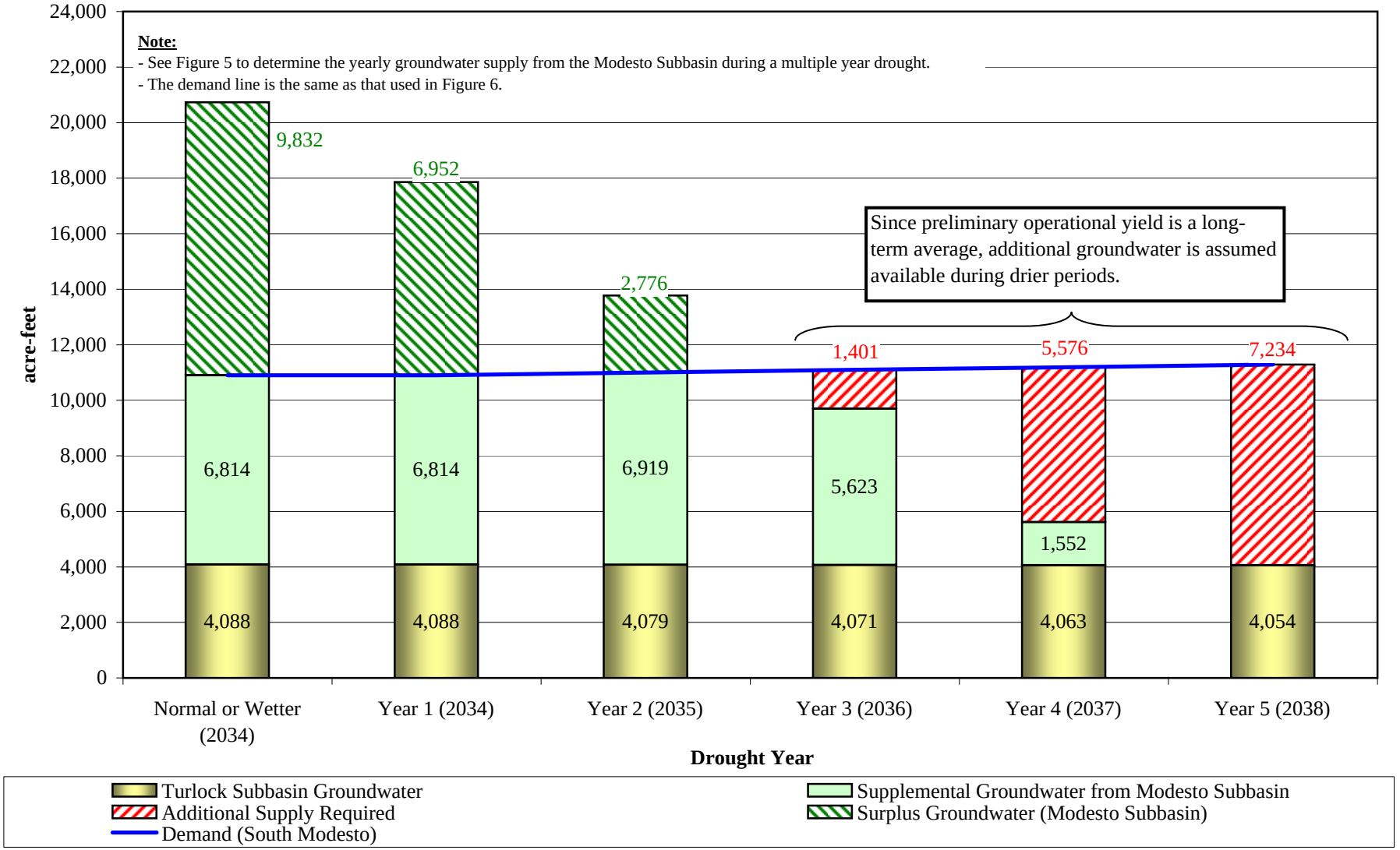


Figure 7. Comparison of Supply and Demand (Multiple Year Drought): South Modesto



ATTACHMENT A

Discussion on Operational Yield for the 2005 Urban Water Management Plan

City of Modesto

Memo

To: Nick Pinhey – Public Works Director
Rolly Stevens – Assistant City Attorney
Alison Barratt-Green – Senior Deputy City Attorney

From: William Wong – Associate Civil Engineer

CC: Rich Ulm, Jack Bond, Garner Reynolds, Jim Alves, Violet Jakab, Allen Lagarbo

Date:

Re: **FINAL** - Discussion on Operational Yield for the 2005 Urban Water Management Plan (UWMP)

This memorandum establishes an empirical basis for estimating the "operational yield" for the rate of groundwater pumping within the City's water service area that includes the Modesto, Turlock, and Delta-Mendota sub-basins. Information incorporated into this study includes water well pumping records, groundwater elevation data, and future demands based on land use densities at build-out.

For clarification, and as used in this report, the following terms are defined:

Operational Yield – is an amount (or rate in acre-feet per year) of localized groundwater withdrawn on an annual average basis by a given agency that does not exceed the long-term annual average recharge rate of the localized aquifer(s) from which the groundwater is being pumped.

Sustainable Yield – is similar to operational yield, but applies to an entire groundwater basin and all of the entities pumping from it as a whole, rather than just a localized area and a specific agency.

Safe Yield – is everything defined for sustainable yield, but also includes other considerations beyond just a quantity of water extracted or recharged, such as its quality and potential surface subsidence issues. Safe yield can be defined as the maximum amount of water that can be pumped without creating any long-term undesirable results. However, for the purposes of this report, safe yield is considered to be synonymous with sustainable yield.

Overdraft – is when the long-term annual average rate of extracted groundwater exceeds the annual average rate of recharge, as measured by groundwater levels (as measure of groundwater volume is difficult). Overdraft is also defined as the deficit between the water pumped from a groundwater basin and the long-term basin recharge.

The basis of previous estimates of the combined City's "safe yield" of 50,000 AFY repeated in various City documents is not clear through researching of available literature. Previous documents reference a historic water budget, using data that was not directly measured, but estimated. The uncertainty of this data and the

determination of the safe yield are currently considered questionable, and recent data suggests that this value may not be correct.

This memorandum attempts to use existing data from various sources to reconcile an estimate of the City's current groundwater operational yield, instead of "safe yield" for the entire City of Modesto's Water Service Area.

Establishing an Operational Yield:

It is envisioned that the City will undertake a more comprehensive, hydro-geological groundwater yield study in the upcoming fiscal year where more resources can be devoted to the task of quantifying the City's groundwater operational yield. Until then, it is believed that the rate of extraction established in this report accurately reflects the best data readily available to staff and will be incorporated into the 2005 Urban Water Management Plan.

Prior to 1995, the City's sole source of domestic water was from groundwater pumping. The effect of long-term groundwater extraction consequently resulted in a decline of groundwater elevation, which led to temporary overdraft conditions, primarily in the downtown Modesto area. However, once the City began to implement conjunctive use by supplementing its water supplies with 33,602 AFY of treated surface water from Phase 1 of the MID Modesto Regional Water Treatment Plant (MRWTP) in 1995, the City has been able to reduce its groundwater extraction. As a result, groundwater levels began to rise correcting the temporary overdraft conditions. **Figure 1** shows that recent groundwater levels have decreased slightly as groundwater pumping increased over the last six years (2000 – 2005); however, until additional hydrogeologic studies are completed, it appears that current groundwater extractions and water levels are, to some extent, in a steady state condition.

The current annual water demands for the entire City of Modesto water system, in the Modesto and Turlock sub-basins, are over 79,000 AFY. The City's current rate of groundwater extractions is about 70% of the historically high pumping levels of 1994, and is not causing an overdraft condition.

Table 1 – Current Annual Groundwater Extractions

Year	Annual GW Extractions from the Modesto Subbasin (AFY)[a]	Annual GW Extractions from the Turlock Subbasin (AFY) [a,b]	Average GW Extractions from the Delta-Mendota Subbasin (AFY) [a,c]	Totals
2000	37,495	4,958	261	42,714
2001	40,857	4,837	297	45,991
2002	43,535	5,445	324	49,304
2003	41,990	5,053	287	47,330
2004	41,681	4,194	261	46,136
2005	41,090	4,849	237	46,176
Average Annual Groundwater Extractions	**41,108**	**4,889**	**278**	**46,275**

a. Based on City of Modesto SCADA records
b. Includes South Modesto, Hickman, portions of North Ceres and Turlock.
c. The Community of Grayson is within the Delta-Mendota Subbasin

As shown in **Table 1**, current six-year average (between 2000 and 2005) of groundwater extractions for the entire City of Modesto water system is 46,275 AFY. These water demands also reflect some water conservation due to continuous implementation of Stage I restrictions from the City's Drought Contingency Plan in 2003.

The City maximizes its surface water allocation within the City's contiguous service area, and must rely on groundwater pumping to meet its maximum day and peak hour demands. To meet the demands of future development, the City will is currently working with the MID to double the capacity of the Modesto Regional Water Treatment Plant (MRWTP) to 67,204 AFY. However, the Phase 2 Expansion of the MRWTP is not anticipated to be on-line until mid- to late-2009, and therefore the City will need to increase its groundwater pumping to meet the demands for near-term development. This would be done by drilling new wells, rehabilitating currently out-of-service wells, or increasing the pumping from existing wells.

The movement of groundwater for both sub-basins is generally in a westward direction from the Sierra Nevada foothills. Recent analysis by the USGS and information from California's Groundwater Bulletin 118 has indicated that the geological characteristics of the Modesto and portions of Turlock sub-basins that are served by the City of Modesto appear to be similar. Although the Tuolumne River separates the Modesto and Turlock sub-basins, the USGS has determined that both groundwater and surface water systems are interconnected, and it can be reasonably assumed that groundwater flows between the two sub-basins. This has also been indirectly substantiated by analysis of the City's static well level data; the average groundwater elevations of the City's production wells between the Modesto and Turlock groundwater sub-basins are very comparable. Therefore, in this analysis, it is assumed that the cumulative groundwater extractions by the City apply to the entire City's water service area and no further distinctions are made between the two sub-basins (this does not apply to the Delta-Mendota sub-basin).

Based on California's Groundwater Bulletin 118 for the Modesto Sub-basin, as a result of long-term groundwater pumping, a cone of depression formed when the groundwater elevations reached around 30 feet above sea level (ASL) (see **Figure 2**). In order to extrapolate an operational yield using empirical data, a minimum groundwater elevation of 40 feet ASL was selected as the lowest elevation that the City will allow groundwater to reach. By establishing this minimum groundwater elevation allowable, the City can reasonably establish a conservative operational yield and be certain that the associated amount groundwater pumping should not result in an overdraft condition.

Based on a relative stabilization of groundwater elevations through the City's water service area, the City's current annual average groundwater pumping constitutes a non-overdraft condition, and therefore it can be assumed that the City is within its operational yield range. **Figure 3** plots the City's groundwater pumping and associated well levels between 1993 through 2006. It is apparent that there is not a linear relation between groundwater extractions to groundwater levels. Nevertheless, a linear factor rate was extrapolated from existing well information and can be considered a conservative representation of the effects of groundwater levels due to pumping. An empirical equation was extrapolated from these data points, which estimates that the groundwater levels will decline at a rate of approximately **0.685 feet/1,000 AFY** (or 1 foot per 1,430 AFY) of groundwater extracted over the entire water service area.

It is reasonable that, until hydrogeologic studies are complete, the City can use this estimated rate as the City's **"operational yield factor".** Using 40 ft ASL as the minimum allowable groundwater elevation, the associated **operational groundwater yield** is approximately **53,500 AFY**. This calculated operational yield is a projection of the City's water service area's groundwater pumping capacity (AFY) and is based on the following:

- Groundwater elevation data from 1993 to 2006 obtained from spring and fall field measurements by the City Water Department.
- Groundwater pumping data obtained from Water Department and from the City's SCADA from 2003 to current. Prior pumping records were obtained through Del Este and City of Modesto files.
- Assumes that Ag-to-Urban conversion accounted for in the calculated operational yield estimate.

The calculated operational yield does not account for:

- The City's ability to extract groundwater from the subbasins to meet demands.
- Seasonal peak water demands, and localized water distribution and pressure issues.

- Growth beyond the City's current water service area, either within the contiguous Modesto System or the outlying areas.
- Varying economic factors that could effect the projected growth assumptions.
- More stringent water quality standards would result in potential losses in well production from taking wells out-of-service due to contamination, such as from Arsenic, Nitrates and Uranium.

Additionally, once the City begins necessary groundwater studies to determine an actual operational yield (or specific yield) of the groundwater sub-basins, water budget and quality analyses for the groundwater sub-basins, the City would be able to develop procedures to optimize its groundwater extractions, and determine potential Aquifer Storage and Recovery (ASR) opportunities, where the City could potentially recharge the groundwater basins with surface water during seasonal low demand periods.

Conclusions:

Recent projections from MID anticipate that Phase 2 of the MRWTP expansion will be complete by mid- to late-2009. However, until the additional 33,602 AFY of surface water is available to meet demands, the City will need to increase its groundwater extractions to meet water demands until Phase 2 is on-line.

More extensive studies and modeling will be required to quantify the City's operational yield and water budget for both the Modesto and Turlock sub-basins. However, based on self-imposed groundwater level limits, the City's current Operational Yield is estimated at **53,500 AFY**.

Recent information has indicated that the City has gradually increased its groundwater pumping over the last few years to meet growth demands. It is not anticipated that the City will continue to increase its groundwater extractions for an extended period of time, since Phase 2 is expected to be online by mid- to late- 2009. It is not expected that this short term increase of pumping would cause an overdraft condition in the Modesto Subbasin, which is typically a result from a cumulative effect of long-term over-pumping.

Figure 1 - 1993-2006 Groundwater Elevation and Pumping Data

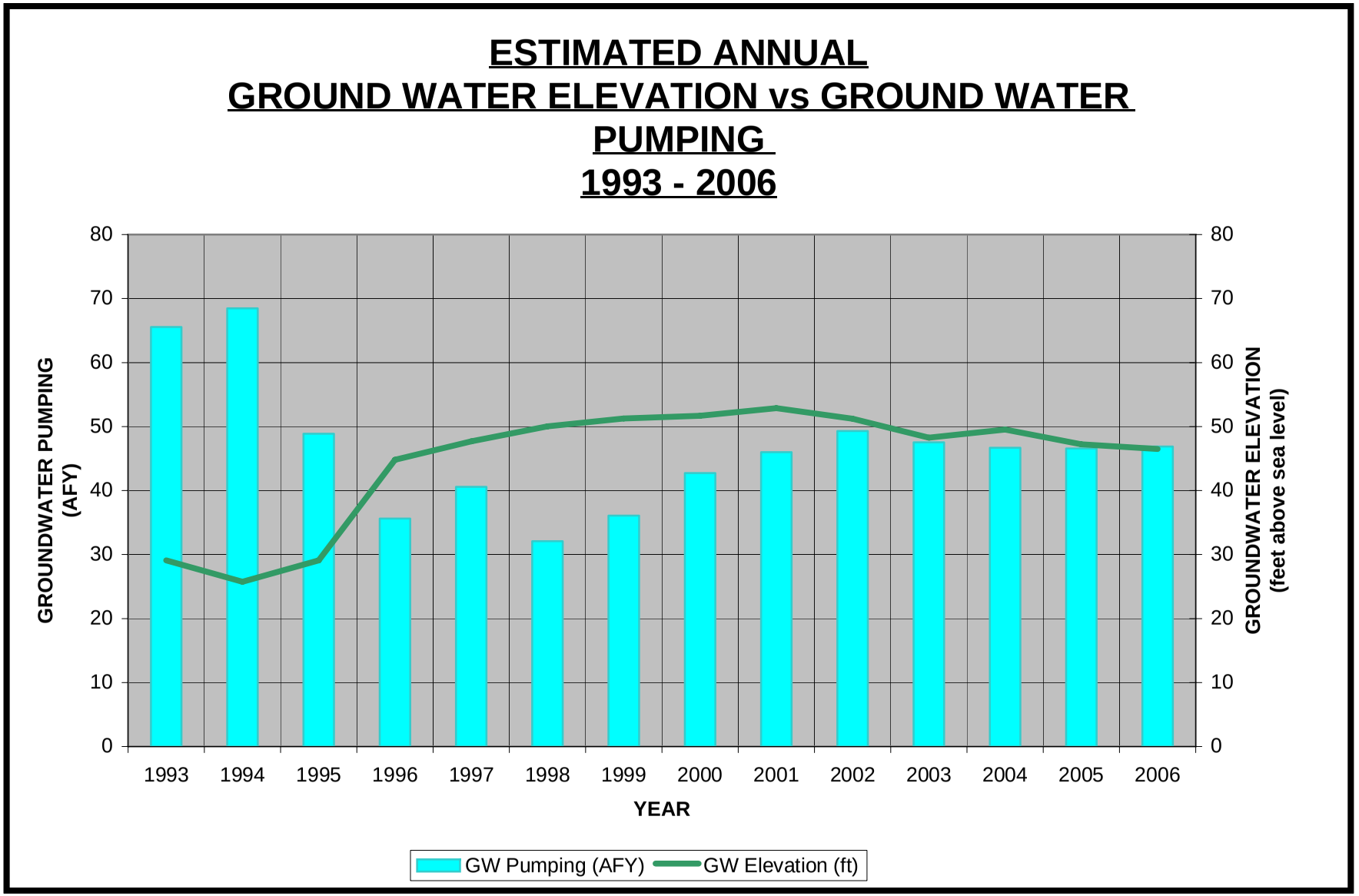
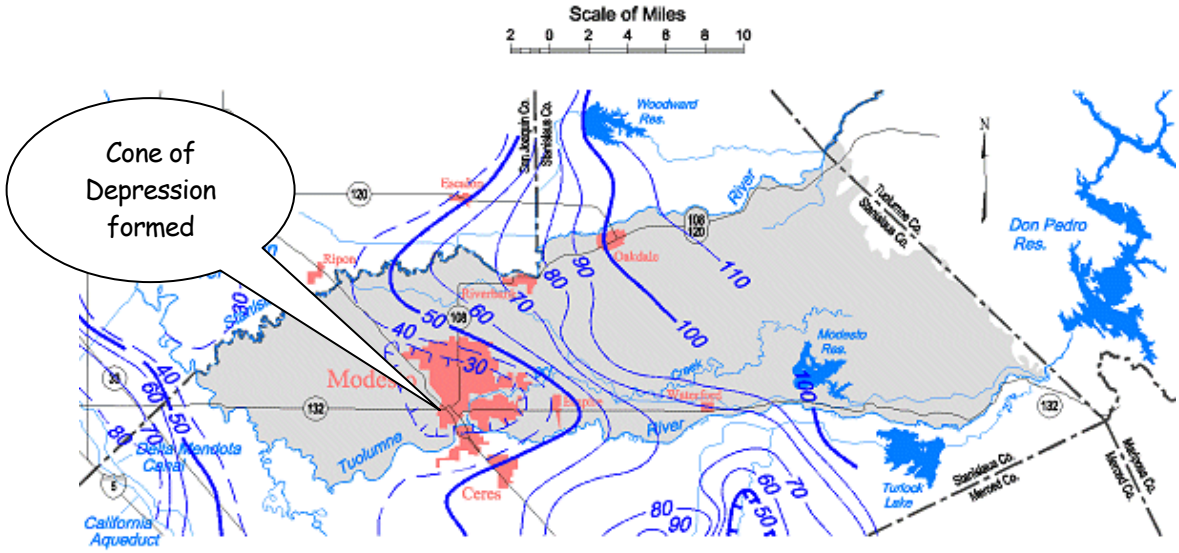


Figure 2 – 1993 and 1998 Groundwater Elevations (above sea level)

Source: Department of Water Resources (DWR) Website - http://www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm

Modesto Groundwater Basin

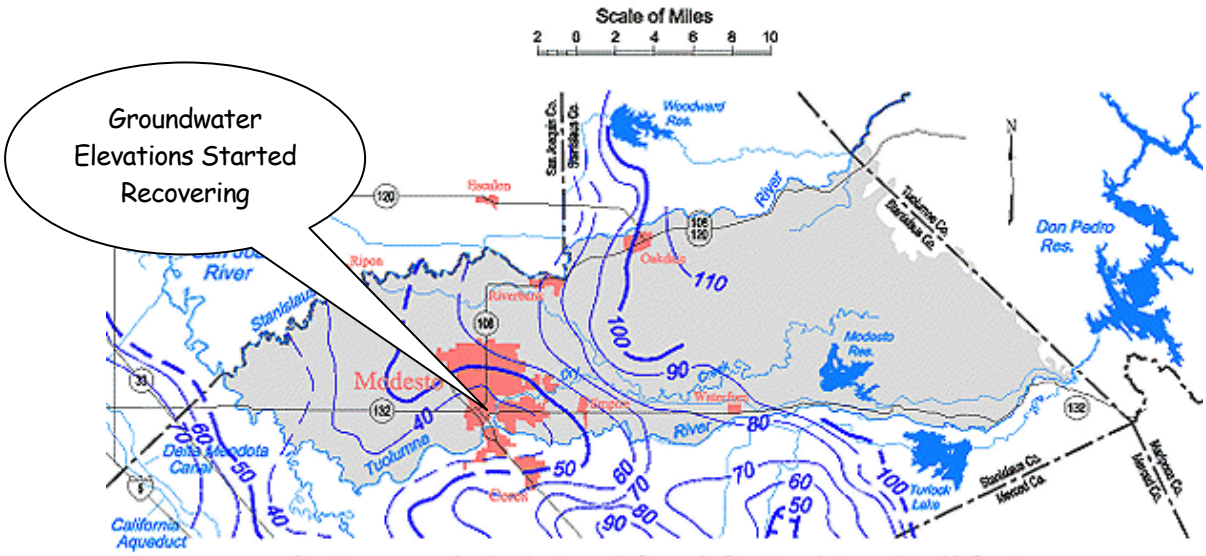
Spring 1993, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Modesto Groundwater Basin

Spring 1998, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Figure 3 - Annual Groundwater Pumping (AFY) vs. Groundwater Elevation (feet, above sea level)

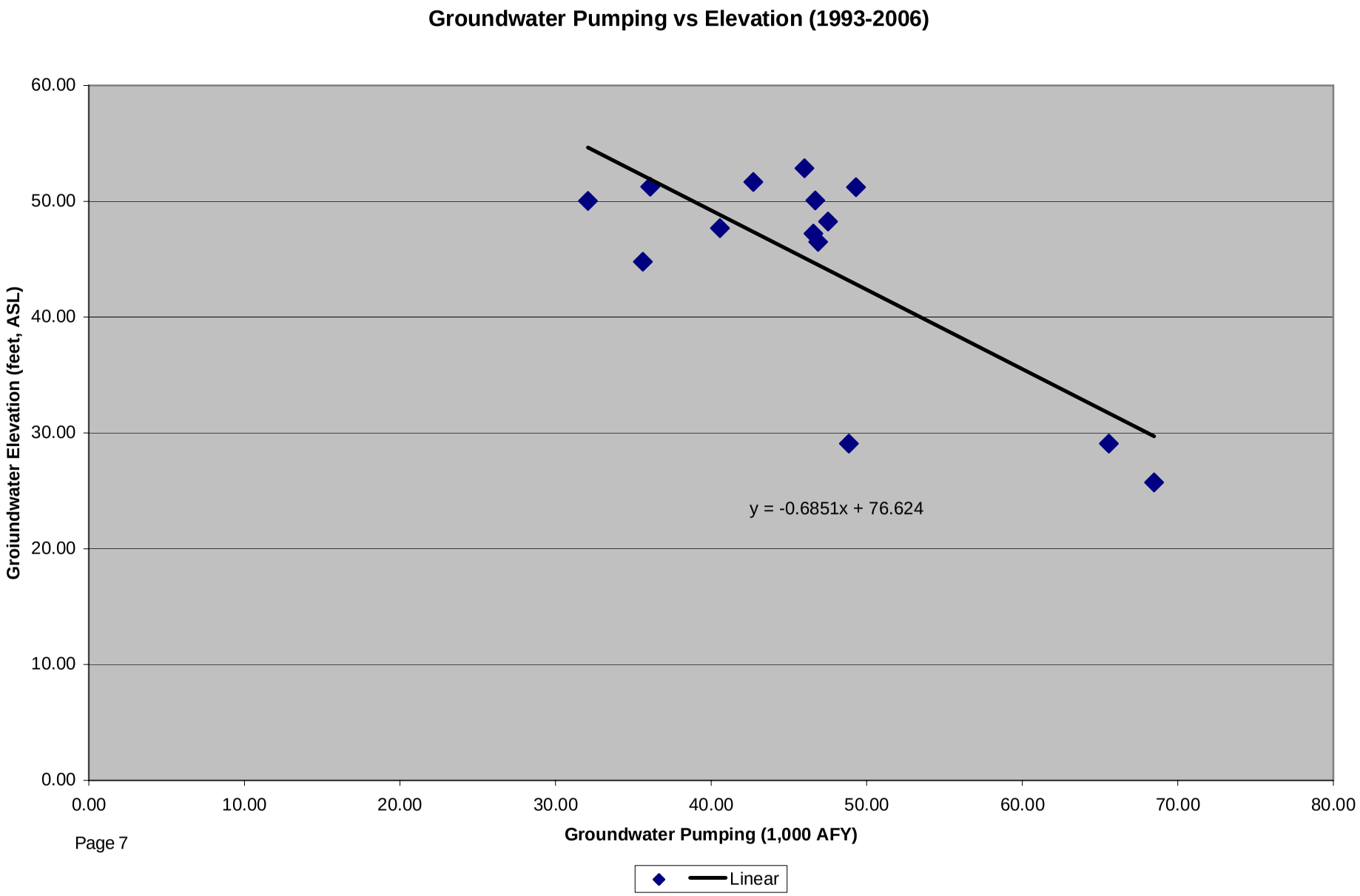


Figure 4 - Projected Near-Term Water Demands (to 2010)