2.0 ANALYSIS OF IMPORTING SURFACE WATER: DRINKING WATER AND WASTEWATER QUALITY BENEFITS/IMPACTS

2.1 INTRODUCTION

The City of El Paso de Robles currently relies on groundwater for 100% of its water supply, as described in Chapter 1 of this report. The City has been considering importing surface water from Lake Nacimiento to improve the quality of the City's treated wastewater for regulatory compliance. This would also increase the City's water supply reliability. This chapter discusses two key aspects of this potential addition to the City's source of water:

- Possible water quality impacts in the City's distribution system
- Expected treated wastewater quality improvements

The analyses presented in this report were performed by Malcolm Pirnie based on available reports and other documents provided by the City for review, as well as discussions with City staff. The evaluations herein are at the planning level; that is, they were conducted at a level of detail appropriate for understanding potential water quality impacts and wastewater quality benefits, and their relevance to developing an overall water and wastewater quality strategy for the City. The information herein is incorporated into Chapter 3 of this report, which discusses the development and ranking of water/wastewater alternatives.

2.2 POTENTIAL WATER QUALITY IMPACTS OF INTRODUCING SURFACE WATER TO CITY SYSTEMS

This section discusses the water quality considerations associated with introducing a new source of water (specifically, treated Lake Nacimiento water) into the City's distribution system, which has historically been supplied exclusively by groundwater. Section 3 of this chapter focuses on another key aspect of introducing a new water source, namely, the resulting effect on the City's treated wastewater quality and regulatory compliance.

2.2.1 Pertinent Existing Water Quality Parameters

Chapter 1 of this report provided a brief summary of the City's existing water system and water quality, and a more complete description is provided in Appendix A. This section discusses those parameters of particular importance to the consideration of a new water source. Each of these parameters directly relates to the possible water quality impacts of introducing a new water source, potential wastewater quality benefits of doing so, or both.

- Total Dissolved Solids (TDS): The TDS content of the City's water is fairly high, averaging about 510 mg/L in the system. This is the result of the generally high TDS content of the City's two groundwater sources, the Salinas River Underflow unit and the Paso Robles Formation.

- Hardness: The City's water is hard, with hardness values ranging from 250 to 300 mg/L (as $CaCO_3$). A "moderate" range for hardness is 75-150 mg/L, with water between 150 and 300 mg/L classified as “hard.” (AWWA, 1999). There is a corresponding widespread use of water softeners among City residents (pers. comm., Columbo, 2003).

- pH: The City’s water is neutral to slightly basic, with an average pH of about 7.5.
- Chlorine residual: The City chlorinates all of its well water to achieve a system free chlorine residual target of 0.8 to 1.1 mg/L. There have historically been no problems with loss of residual in the City system. Similarly, there have been no problems with high coliform counts, which are usually associated with insufficient chlorine residuals (pers. comm., Dunham, 2002).
- Total Trihalomethanes (TTHM): TTHMs are disinfection by-products (DBP) that are found at relatively low concentrations (10 to 25 µg/L) in the City’s system, as would be expected from chlorination of groundwater. Groundwater typically has low concentrations of DBP precursors, which can be measured as Total Organic Carbon (TOC). TOC data is not available for the City’s water, but the reported TTHM range suggests an average TOC content in the City’s groundwater sources of approximately 1 mg/L
- Lead and copper: The City has conducted monitoring at the tap per the federal Lead and Copper Rule and no action level exceedances for either parameter have been recorded based on the annual Water Quality Reports reviewed. The 90th percentile value for the 1998-2000 data sets for copper monitoring was 1.1 mg/L as compared to the corresponding action level of 1.3 mg/L. This suggests some corrosion of household copper plumbing, given the non-detect or otherwise very low copper results associated with the City’s source water per Water Quality Reports from the early 1990s.

2.2.2 Water Supply Scenario with Nacimiento Imports

As discussed in Chapter 1, the City is considering participating in the Nacimiento Project and receiving imported water deliveries of 4,000 acre-feet per year (AF/yr). (It is understood that this allocation may change depending on decisions made by the Nacimiento Participants Advisory Committee members and/or other agencies.) It is envisioned that the City will receive its full allocation of 4,000 AF/yr when the Project is implemented, and use its groundwater sources to meet its remaining demand. Initially, this scenario will represent a significant decrease in groundwater production as compared to current conditions. Over time, however, assuming the City’s Nacimiento allocation remains at 4,000 AF/yr, groundwater production will have to again steadily increase to meet the City’s growing population and associated water demand.

As noted in Chapter 1 and discussed more fully in Appendix A, previous authors have developed a number of estimates of future City population and water demand. For the purposes of investigating the expected proportions of City water sources over time, we used a current population of 26,000 (City of El Paso de Robles, 2003a) and estimated a current water demand of 7,300 AF/yr based on available 2001 and 2002 water production records (City of El Paso de Robles, 2002). An average annual increase in both of 3% was used (Todd, 2000), which brings the population in 20 years to approximately 47,000. This is a reasonable and conservative estimate of the City's build-out population, given the estimate of 42,000 as presented in Appendix A and the possibility of additional annexation. The water demand associated with a population of 47,000 in 2023 would be approximately 13,200 AF/yr, given current consumption rates. This is generally consistent with the 2020 demand estimates of 10,600 and 11,130 AF/yr presented in the 2000 Urban Water Management Plan (Todd, 2000).

Table 2-1 summarizes the growth in the City's water demand and expected reliance on surface water and groundwater sources from the present (2003) to 2023, based on the assumptions outlined above. This population, demand, and water supply analysis is also shown graphically in **Figure 2-1**.

The distribution of water between the East and West Zones indicated in the table reflects that most of the future growth is expected to take place in the East Zone, as discussed in the Water Master Plan (Boyle, 1995), and that the percentage of the City's population that resides in the East Zone will increase with time. As noted in the table, the distribution of groundwater and imported surface water between the West and East Zones was estimated based on (1) a faster rate of population growth in the East Zone over the coming decades and (2) equitable distribution of surface water between the two zones over time; that is, as the imported surface water amount stays fixed at 4,000 AF/yr while the demand grows, the surface water is assumed to be distributed between the West and East Zones according to their proportional population. The water quality and customer equity issues associated with this assumption are discussed later in this report.

As illustrated by **Figure 2-1**, the introduction of surface water in the near future (e.g., 2007) would reduce the use of City groundwater by roughly one-half. Under this scenario, in 2007, both imported surface water and groundwater would contribute approximately 4,000 AF/yr to meet the City's projected demand at that time of just over 8,000 AF/yr. As the population continues to grow, the City's groundwater production would steadily increase to make up the difference between the growing water demand and the 4,000 AF/yr surface water allocation.

As seen in **Figure 2-1**, under this scenario, by 2014, the City's wells will be producing 1.5 times the imported surface water amount (i.e., approximately 6,000 AF/yr), and by 2018, the City's wells will again be producing as much water per year as they are now. That is, for the first 10 years or so of importing water from Lake Nacimiento, the City's wells can be operated at lower production rates than they are now. After about 10 years (in 2018 in our scenario), however, the imported supply no longer offsets the expected growth in demand, and City groundwater production will have to increase over its current 7,000 to 8,000 AF/yr to meet the City demand.

A key consideration related to importing surface water and reducing groundwater production in the near-term is maintenance of the City's water rights to Salinas River Underflow water. City wells completed in the Underflow include the Thunderbird wells, the Borcherdt well, and the off-line Ronconi wells. As discussed in Appendix A, the City currently has water rights to produce either 4,600 or 5,800 AF/yr from the Underflow (according to two different sources). Following the introduction of surface water, City pumping from the Underflow will decrease significantly, as shown in the "Groundwater Supply to West Zone" column in **Table 2-1.**

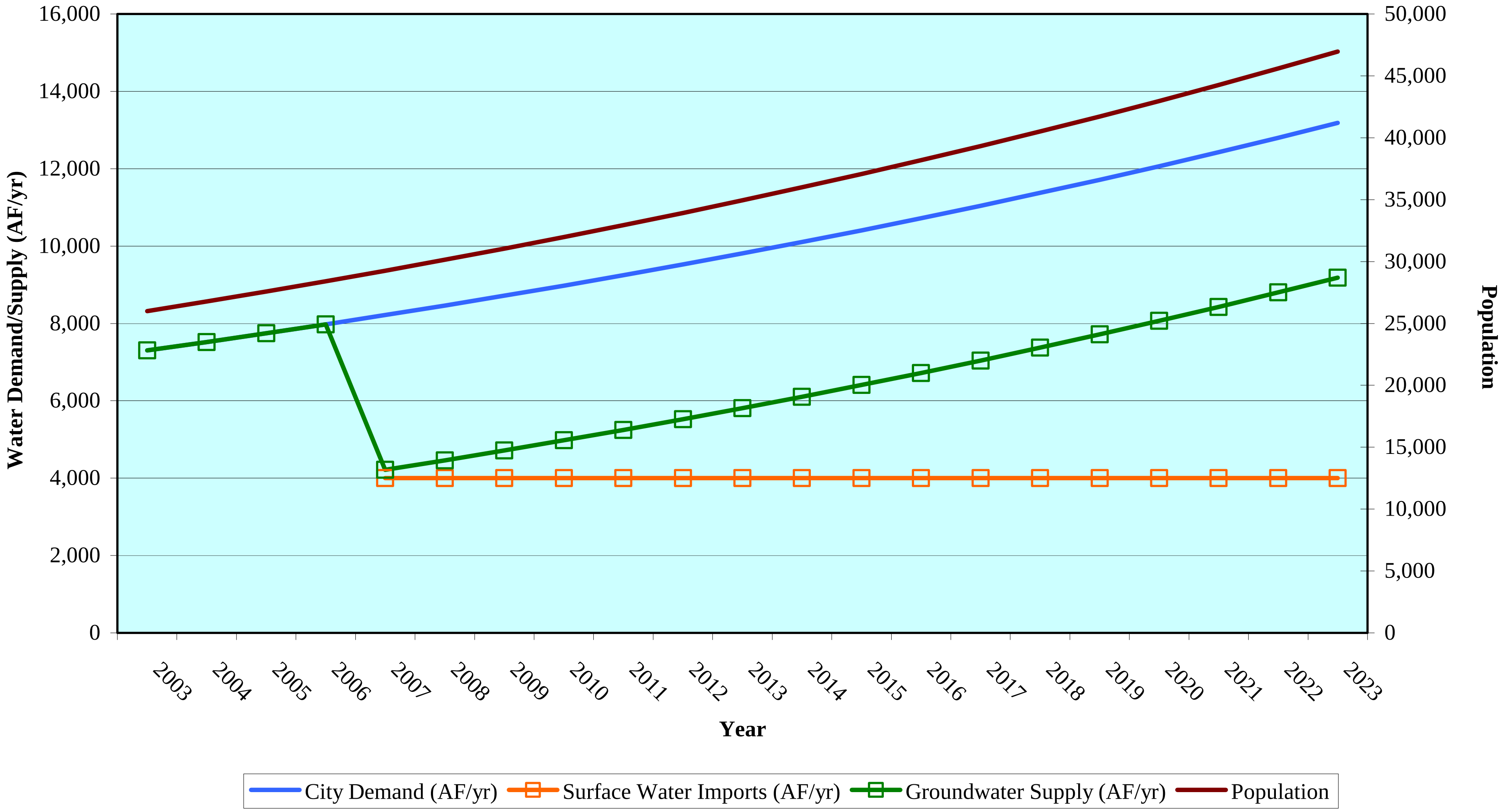
Table 2-1. Population, Water Demand, and Water Supply Sources Over Time

Year	**Population**	**City Demand (AF/yr)**	**West Zone Demand (AF/yr)**	**East Zone Demand (AF/yr)**	**Surface Water Imports (AF/yr)**	**Surface Water Imports to West Zone (AF/yr)**	**Surface Water Imports to East Zone (AF/yr)**	**Groundwater Supply (AF/yr)**	**Groundwater Supply to West Zone (AF/yr)**	**Groundwater Supply to East Zone (AF/yr)**
2003	26,000	7300	2920	4380	-	-	-	7300	2920	4380
2004	26,780	7519	2972	4547	-	-	-	7519	2972	4547
2005	27,583	7745	3024	4721	-	-	-	7745	3024	4721
2006	28,411	7977	3075	4902	-	-	-	7977	3075	4902
2007	29,263	8216	3127	5089	4000	1522	2478	4216	1605	2612
2008	30,141	8463	3179	5284	4000	1503	2497	4463	1676	2786
2009	31,045	8717	3231	5486	4000	1483	2517	4717	1748	2968
2010	31,977	8978	3282	5696	4000	1462	2538	4978	1820	3158
2011	32,936	9247	3334	5913	4000	1442	2558	5247	1892	3355
2012	33,924	9525	3386	6139	4000	1422	2578	5525	1964	3561
2013	34,942	9811	3438	6373	4000	1402	2598	5811	2036	3775
2014	35,990	10105	3489	6615	4000	1381	2619	6105	2108	3997
2015	37,070	10408	3541	6867	4000	1361	2639	6408	2180	4228
2016	38,182	10720	3593	7127	4000	1341	2659	6720	2252	4468
2017	39,327	11042	3645	7397	4000	1320	2680	7042	2324	4717
2018	40,507	11373	3697	7677	4000	1300	2700	7373	2396	4977
2019	41,722	11714	3748	7966	4000	1280	2720	7714	2468	5246
2020	42,974	12066	3800	8266	4000	1260	2740	8066	2540	5525
2021	44,263	12428	3852	8576	4000	1240	2760	8428	2612	5816
2022	45,591	12801	3904	8897	4000	1220	2780	8801	2684	6117
2023	46,959	13185	3955	9229	4000	1200	2800	9185	2755	6429

Notes and Assumptions

1. Current population of 26,000 is based on City website (City of El Paso de Robles, 2003a)
2. Growth in population is assumed to be 3% per year (Todd, 2000) to a build-out population of 47,000 (see population/build-out discussion in Appendix A).
3. City demand is assumed to grow commensurate with population (i.e., 3% per year).
4. The ratio of West Zone demand to East Zone demand is expected to decrease from 40:60 to 30:70 as the population grows (per Tables 4 and 6 of Boyle, 1995)
5. Surface water imports are assumed to be 4000 AF/yr according to the existing plan for City participation in the Nacimiento Project.
6. Surface water imports are assumed to begin in 2007 following design, construction, and startup of a new water treatment plant.
7. Groundwater used is calculated based on each year’s difference between surface water imports and City demand.

Figure 2-1. Population, Water Demand, and Water Supply Sources Over Time



As discussed in previous reports (e.g., Boyle, 1995 & Todd, 2000), the City typically does not use its full Underflow allocation each year. Under the surface water supply import scenario considered here, this would not change; however, the City would be using a lower percentage of its allocation than it has in recent years. There is a general concern that reducing pumping from wells completed in the Underflow (e.g., the Thunderbird wells) may reduce the magnitude of the City's water rights to pump from this zone. However, there is no information in available reports that indicates the City would jeopardize its Underflow water rights by reducing pumping from its Underflow wells in accordance with the introduction of surface water into the system. However, the City may wish to confirm this. One method to possibly help maintain the Underflow water rights if necessary following the introduction of surface water would be to preferentially pump from the Thunderbird well field to meet the 4,000 AF/yr or so not met by imported surface water. Reactivating the Ronconi wells could also be a strategy to ensure that pumping from the Underflow unit is maintained. (This would require the implementation of treatment, such as microfiltration, at these wells because they have been determined to be under the direct influence of surface water.) The Borcherdt well, although located on the City's east side, is also classified as an Underflow well. However, serving the East Zone by increasing the proportion of water produced by Underflow wells may be limited by the system's west-to-east hydraulic capacity. Also, because the wells supply the City's distribution system directly, doing so would likely lead to water quality/customer equity impacts as discussed in Chapter 3 of this report.

2.2.3 Imported Water Quality

This section discusses the quality of the water that will be introduced into the City's system if and when surface water imports are brought on-line. Specifically, this section discusses the quality of treated Lake Nacimiento water considering three possible water treatment plant locations and four candidate water treatment plant configurations and process trains.

The City importing raw water from the Nacimiento project is a possibility, but is not considered here in detail. Our understanding is that a "phased approach" to City participation in the Nacimiento Project was originally considered. The first phase of such an approach would consist of importing raw water for local recharge for approximately 10 years prior to the implementation of a water treatment plant.

Raw water would not be suitable for direct delivery to City customers or blending with existing groundwater supplies, but could be used to recharge the Salinas River Underflow groundwater supply. The potential benefits to this approach are that (1) City costs to help construct a water treatment plant are deferred while the City is only accepting raw water, and (2) water storage and water rights associated with the Salinas River Underflow supply are enhanced by the addition of the imported surface water.

Under this scenario, the City would still have to pay their share of the Nacimiento Project facilities to transmit raw water from the lake to the City. (Cost-sharing strategies are still being discussed among the Nacimiento Participants Advisory Committee members.) The most important drawback of raw water imports relative to the City's water quality strategy, however, is that the City would not realize the full benefit of the relatively low-TDS lake water – both in terms of drinking water quality and wastewater effluent quality. That is, if the low-TDS lake water is recharged into the Salinas River Underflow, it will mix with the existing high-TDS shallow groundwater and likely only partially be recovered in City wells completed in that zone.

In addition to the potential loss of the TDS benefit of importing water, the City may also not be able to recover the full quantity of the recharged water. It is Malcolm Pirnie's understanding that this Project participation option (importing raw water) was introduced a number of years ago, before City water and wastewater quality issues were considered as critical as they are today.

2.2.4 Nacimiento Project Water Treatment Alternatives

Documents reviewed for this project (Carollo, 2002 & Nacimiento Participants Advisory Committee, 2001) indicate that a regional water treatment plant would likely be sited approximately halfway between Lake Nacimiento and the City (i.e., roughly 10 miles from each). For the purposes of considering possible water quality characteristics of imported treated water, we considered two additional locations. These were: (1) at the Lake, and (2) just at the north end of the City, to represent "worst-case" and "best-case" scenarios relative to DBP formation. These scenarios are discussed later in this section with regards to water age and DBP formation.

An earlier study that evaluated a regional treatment plant for Lake Nacimiento water considered the following treatment technologies (Boyle, 2002):

- Conventional treatment that included coagulation, sedimentation, and flocculation processes with GAC as the filter media in filtration.

- The Actiflo⊇ process, which is a proprietary, ballasted, coagulation-flocculation process. In this process, microsand is used as ballast material to aid in the formation of floc. (Operation of the "hydrocyclone" centrifuge unit necessary for this process is generally energy-intensive.)

- Membrane treatment with or without GAC polishing treatment.

For all the above processes, Boyle (2002) suggested using either chloramines or ultraviolet (UV) light with chloramines for disinfection. The regional treatment plant considered had a capacity of 17 MGD. Boyle (2002) appears to have provided a well-developed discussion of regional water treatment plant options and treated water quality. For this exercise, we built on their work by focusing on (1) a local water treatment plant – discussed below – and (2) the considerations associated with introducing treated surface water into the City's distribution system – discussed later in this chapter.

A treatment plant dedicated to supplying water to the City of El Paso Robles would be approximately of 4-MGD (4000 AF/yr equals 3.6 MGD) capacity, roughly one-fourth the size of a regional treatment plant. This 4-MGD capacity is based on the City relying on surface water imports for its "base flow," or relatively constant production, and increasing or decreasing groundwater production to match City demand including peak demand. For a treatment plant as small as 4 MGD, it is economical to use automated, packaged treatment systems that are relatively easy to design, install, operate, and maintain as compared to a treatment plant the size of the proposed regional plant that is not available as a package and must be designed from the ground up. Giving due consideration to the water quality of Lake Nacimiento water as summarized in Appendix A, current/future drinking water regulations, and treatment plant size, the following four treatment scenarios were considered to be the most feasible alternatives for a City-dedicated 4-MGD water treatment plant:

∉# Conventional treatment with disinfection using chloramines (Scenario 1A).

∉# Conventional treatment coupled with granular activated carbon (GAC) post-filter adsorber and disinfection using free chlorine (Scenario 1B).

∉# Microfiltration (MF) with chloramines as the disinfectant (Scenario 2A).

∉# MF with GAC post-filter adsorbers and free chlorine as the disinfectant (Scenario 2B)

There are benefits and drawbacks and finished water quality differences associated with each of these water treatment scenarios. The treatment processes, chemicals, doses, detention times, and other parameters discussed in this section are planning-level estimates, and are indicated here for comparative purposes. More detailed analyses of the selected treatment processes will be necessary if a water treatment plant is to be implemented. A key concern for surface water treatment plant managers and operators nationwide is the need to achieve adequate microbial control while minimizing disinfection by-product formation. The Stage 1 Disinfectants/Disinfection By-Products (D/DBP) Rule limits for average TTHMs and haloacetic acids (HAA) in the distribution system are 80 µg/L and 60 µg/L, respectively. To limit the formation of TTHMs and HAAs, sufficient DBP precursor removal must occur in the treatment process. Using chloramines in place of free chlorine to maintain a distribution system residual can also help to control DBP formation.

Except for the proprietary Actiflo$^{\supseteq}$ treatment process, the treatment trains that are being considered in this study agree with what were considered for the regional treatment facility. The Actiflo$^{\supseteq}$ process is energy-intensive and also generates residuals that may be difficult to handle. Therefore, the Actiflo$^{\supseteq}$ process was not considered to be a viable alternative for the City-dedicated plant considered here. However, because both conventional and Actiflo$^{\supseteq}$ processes rely on coagulation for TOC removal, they are very similar in terms of DBP precursor removal performance.

A schematic of the Scenario 1A treatment train is shown as **Figure 2-2**. Treating the water conventionally using coagulation, flocculation, sedimentation, and filtration processes can achieve only a limited amount of total organic carbon (TOC) removal, and therefore may lead to problematic DBP concentrations. Therefore, for treatment Scenario 1A, chloramines were considered as the disinfectant to help ensure compliance with DBP regulations. The key conceptual design criteria for the Scenario 1A conventional treatment plant are summarized in **Table 2-2**. Ferric chloride was assumed as the coagulant for this evaluation for two main reasons. First, studies have shown that iron-based coagulants are generally superior to aluminum-based coagulants for TOC removal. This is a primary concern for treatment of Lake Nacimiento water because higher removal of TOC results in lower DBP concentrations. Second, ferric chloride generally removes iron and manganese better than alum. (As noted in Appendix A, available Lake Nacimiento data indicate possible problematic concentrations of iron and manganese.) Bench-scale studies such as jar tests will help in identifying the most appropriate coagulant among the available choices (e.g., aluminum sulfate, polyaluminum chloride, ferric chloride, and other proprietary coagulants) if and when a water treatment plant is moved forward in the planning and design process.

Figure 2-2. Schematic of Conventional Treatment (Scenario 1A)

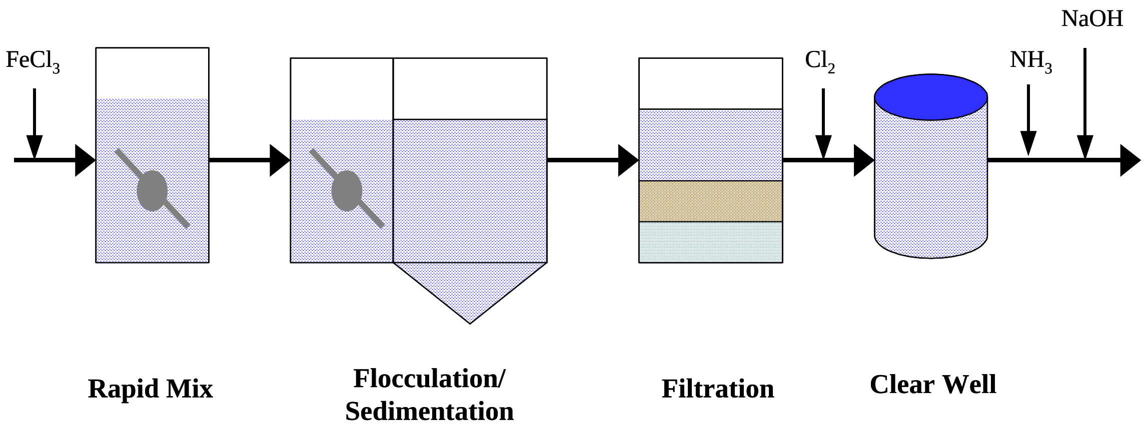


Table 2-2. Conceptual Design Criteria For Conventional Treatment Plant (Scenario 1A)

Parameter	Value
Rapid Mixing	
Coagulant ($FeCl_3$) Dose	15 mg/L
Detention Time	5 min
Flocculation	
Detention Time	30 min
Sedimentation	
Detention Time	2 hr
Overflow Rate	800 gpd/sf
Tank Depth	12 ft
Filtration	
Loading Rate	6 gpm/sf
Filter Type	Dual-media (anthracite/sand)
Detention Time	20 min
Chlorine Addition	
Chlorine Dose	2.8 mg/L
Finished Water Reservoir	
Detention Time	1 hr
Ammonia Addition	
Ammonia Dose	0.6 mg/L
pH Adjustment	
Target pH	7.5
Caustic Dose	2.5 mg/L

The conventional plant system will include a finished water reservoir to provide approximately one hour of detention time (after chlorine addition, before ammonia addition) to achieve the necessary free chlorine contact time prior to creation of the chloramine residual.

The unit process schematic for Scenario 1B is shown as **Figure 2-3**. The conceptual design criteria for Scenario 1B are shown in **Table 2-3**. Polishing treatment with GAC is the only additional treatment process or change in Scenario 1B compared to Scenario 1A. The assumed empty-bed contact time for the GAC filters is 15 min with a replacement frequency of 180 days. A pressure vessel is also possible for the GAC unit process at the treatment plant size considered. In this scenario also, the finished water is stored in a reservoir for about one hour after chlorination for contact time purposes.

Figure 2-3. Schematic of Conventional Treatment Coupled with Post-Filter Adsorber (Scenario 1B)

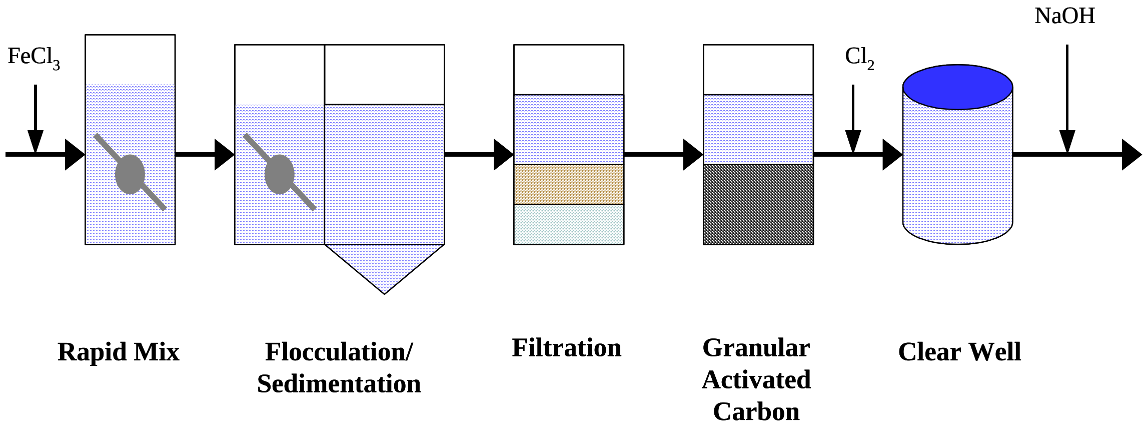


Table 2-3. Conceptual Design Criteria For Conventional Treatment Plant With Post-Filter Adsorbers (Scenario 1B)

Parameter	Value
Rapid Mixing	
Coagulant ($FeCl_3$) Dose	30 mg/L
Detention Time	5 min
Flocculation	
Detention Time	30 min
Sedimentation	
Detention Time	2 hr
Overflow Rate	800 gpd/sf
Tank Depth	12 ft
Filtration	
Loading Rate	6 gpm/sf
Filter Type	Dual-media (anthracite/sand)

Parameter	Value
Detention Time	20 min
Chlorine Addition	
Chlorine Dose	2 mg/L
GAC Adsorption	
Empty-Bed Contact Time	20 min
Replacement Frequency	180 days
Loading Rate	6 gpm/sf
Finished Water Reservoir	
Detention Time	1 hr
pH Adjustment	
Target pH	7.5
Caustic Dose	8.5 mg/L

The schematic for the MF plant of Scenario 2A is shown as **Figure 2-4**. As indicated, it may be necessary to add some coagulant prior to MF to achieve adequate turbidity removal. The conceptual design criteria for the MF system are shown in **Table 2-4**. Approximately 95 percent or more of the feed water that goes through the MF system will be product water (>95 percent recovery). The finished water reservoir after chlorine addition in Scenario 2A will be sized to yield a detention time of 5 min. Most of the disinfection credits are obtained by the MF treatment. MF treatment is capable of significant log removal of bacteria, *Giardia*, and *Cryptosporidium*; however, MF treatment alone is not effective for DBP precursor removal. Therefore, for Scenario 2A, to reduce formation of DBPs in the distribution system, chloramines were considered for disinfection.

Figure 2-4. Schematic of Microfiltration Treatment (Scenario 2A)

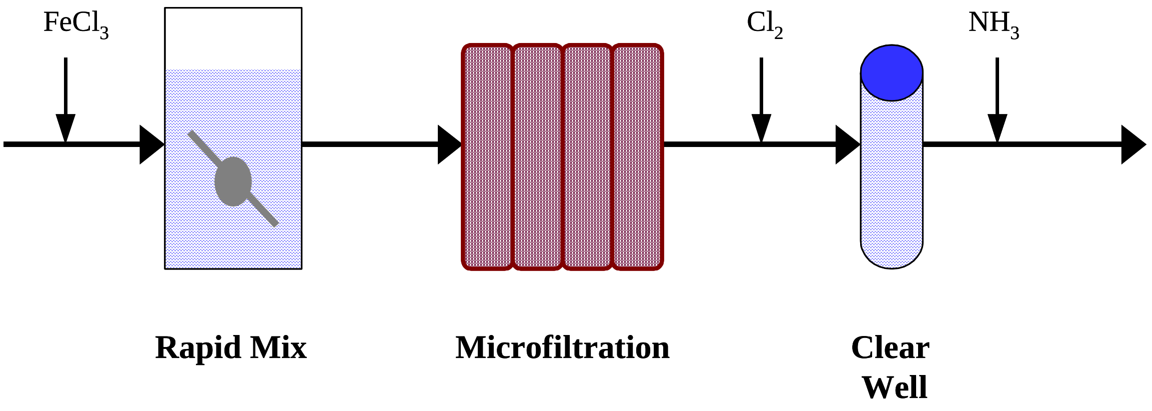


Table 2-4. Conceptual Design Criteria For Microfiltration Treatment Plant (Scenario 2A)

Parameter	Value
Rapid Mixing	
Coagulant ($FeCl_3$) Dose	5 mg/L
Detention Time	5 min
Microfiltration	
Recovery	>95%
Flux Rate	Depends on Membrane Type and Design (Pressurized or Submerged)
Operating Pressure	Depends on Membrane Type and Design
Chlorine Addition	
Chlorine Dose	2.5 mg/L
Finished Water Reservoir	
Detention Time	5 min
Ammonia Addition	
Ammonia Dose	0.6 mg/L

Illustrated as **Figure 2-5** is the schematic for MF treatment coupled with GAC polishing treatment (Scenario 2B). The GAC polishing treatment in Scenario 2B is expected to reduce TOC significantly. Therefore, free chlorine can be used for disinfecting the Scenario 2B water. The conceptual design criteria for Scenario 2B are shown in **Table 2-5**.

Figure 2-5. Schematic of Microfiltration with Post-Filter Adsorber (Scenario 2B)

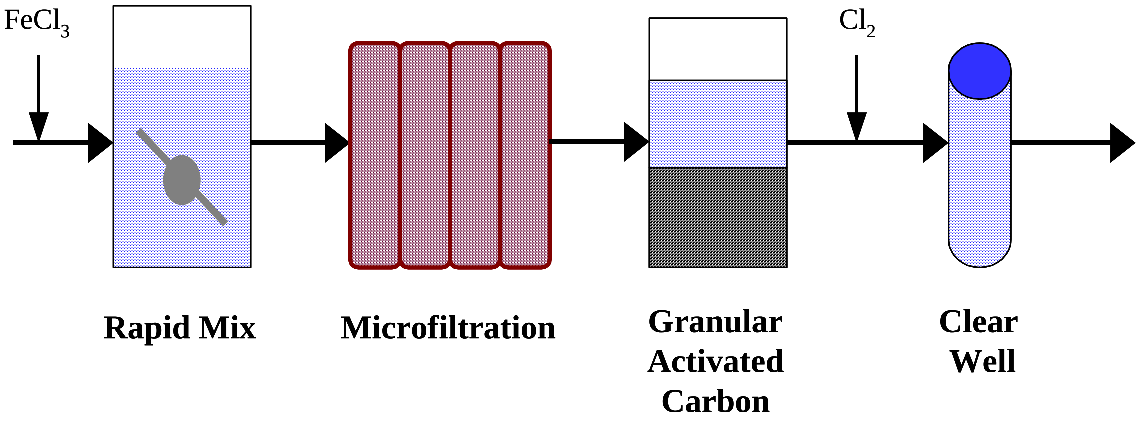


Table 2-5. Conceptual Design Criteria For Microfiltration Treatment Plant (Scenario 2B)

Parameter	Value
Rapid Mixing	
Coagulant ($FeCl_3$) Dose	5 mg/L
Detention Time	5 min
Microfiltration	
Recovery	95%
Flux Rate	Depends on Membrane Type and Design (Pressurized or Submerged)
Operating Pressure	Depends on Membrane Type and Design
GAC Adsorption	
Empty-Bed Contact Time	20 min
Replacement Frequency	180 days
Loading Rate	6 gpm/sf
Chlorine Addition	
Chlorine Dose	2.1 mg/L
Finished Water Reservoir	
Detention Time	5 min

Presently, the groundwater that is being supplied to the City's customers is being disinfected using free chlorine. If chloramines were considered to disinfect Lake Nacimiento water then due consideration must be given to potential issues of mixing of waters with different disinfectants in the distribution system. Specifically, if water with free chlorine is mixed with chloraminated water, the disinfectant residual may be lost, and taste-and-odor problems may result. There are utilities that have successfully used both chlorinated and chloraminated water in their distribution systems. However, careful planning including modeling and bench, pilot, and field experiments are necessary to ensure adverse impacts do not occur. Additionally, public relations/education (e.g., kidney dialysis centers, aquarium owners) must be conducted along with coordination with regulatory agencies (for Paso Robles, the California Department of Health Services). Generally, mixing residual disinfectants is risky and should be avoided if possible. Certainly, using GAC polishing treatment may enable the use of free chlorine as the disinfectant and thereby avoid the presence of variedly disinfected waters in the City's distribution system.

2.2.5 Water Treatment Plant Modeling Results/Treated Water Quality

Malcolm Pirnie's Water Treatment Plant (WTP) model was used to predict the treated water quality for the alternative treatment scenarios discussed above. The WTP model is an empirical model developed by Malcolm Pirnie in conjunction with the USEPA and the University of Colorado at Boulder, and simulates surface water treatment plant performance with a focus on disinfection and DBP formation. The WTP modeling approach includes estimation of organic removal by individual treatment processes, disinfectant decay based on the demands exerted by the organics in the water, and DBP formation based on the water quality at the treatment plant and in the distribution system.

The WTP model simulations were performed using the raw Lake Nacimiento water quality summarized in Appendix A. Other input parameters (specifically, ammonia, bromide, and UV_{254} absorbance) were estimated based on Lake Nacimiento data provided by the County of San Luis Obispo (County of San Luis Obispo, 2002). A conservative raw water quality scenario was generated, based on 90th percentile values of the ranges of water quality parameters shown in Tables 5-1 through 5-4 of Appendix A of this report.

Water age for our water quality modeling purposes is the total time that the treated water would spend in the transmission pipeline, City storage reservoirs, and in the distribution system. Water age is a significant parameter that governs the concentrations of DBPs in water reaching consumers. Assuming a typical water transmission velocity of 5-7 feet per second, it would take approximately 4-6 hours to transport water from Lake Nacimiento to the City. It is our understanding from review of available reports (e.g., Boyle, 1995) and conversations with Water Division staff (pers. comm., Dunham, 2003) that a range or average of water age in the City distribution system has not been previously estimated or calculated. Based on the system schematic and description in the Water Master Plan (Boyle, 1995) and the City's Water Atlas (City of El Paso de Robles, 1996), we estimated the system water age could range from zero to eight hours or more, with an average age at the low end (e.g., 1 to 2 hours). Because the wells (and the future Nacimiento turnouts) directly feed the distribution system, there is a high level of confidence associated with the low end of this range (essentially zero detention time). The upper end of the water age range is more difficult to estimate. This is because of the City's well and storage reservoir operations, which are typical of water utilities of its size. Specifically, water levels in the City's two 4.0 million gallon reservoirs and one 150,000-gallon reservoir activate or shut off the City's wells. Wells feed the system and customers directly, and feed the reservoirs when production exceeds demand. Wells shut off when the reservoirs are nearly full, at which time the reservoirs feed the system.

Total water age for our modeling purposes was conservatively estimated to be 2 days. This accounts for the estimated 4-6 hour transmission time, the estimated high end of the in-City detention time (8 hours), plus a significant factor of safety to account for the uncertainties associated with in-City operations. As discussed earlier, the greater the distance that the future treatment plant is from the City, the greater the travel time and DBP formation will be. If the water age in the City were known with greater accuracy, DBP concentrations could be modeled according to distance from the treatment plant to the City. However, the degree of uncertainty associated with the water age in the City system as described above exceeds the differences in travel time associated with the potential treatment plant sites. Therefore, it would not be meaningful at this conceptual planning stage to attempt to distinguish water quality characteristics according to travel distance, and a conservative 2-day water age is assumed for all model runs. However, depending on the City's future regional or local water treatment options, siting the plant as close to the City as possible is generally preferable from a water quality standpoint for disinfectant residual maintenance and to minimize DBP formation.

Summarized in **Tables 2-6** through **2-9** are the WTP simulation results for key water quality parameters for the four treatment scenarios. The surface water treatment processes considered do not remove hardness and TDS. Each table shows the results for water quality leaving the treatment plant ("finished water quality") and in the distribution system at the end of the 2-day period discussed above. Between Scenarios 1A (conventional treatment with chloramines) and 1B (conventional treatment with filter adsorbers and free chlorine for disinfection), Scenario 1B had lower TTHMs and HAAs leaving the plant because of the greater removal of organics by the GAC filter adsorber. At the end of two days, however, the levels of DBPs for Scenarios 1A and 1B are comparable (1B had more TTHMs and 1A had more HAAs) due to the greater degree of DBP formation associated with free chlorine disinfection. As expected, using chloramines for disinfection results in a lesser degree of DBP formation after finished water leaves the plant, and may be an economical alternative compared to post-filter adsorbers.

Table 2-6. WTP Model Predictions For Conventional Treatment Plant (Scenario 1A)

Parameter	Estimated Value
Finished Water Quality	
pH	7.5
Residual Total Chlorine (Chloramine)	2.0 mg/L
Average TOC	4.0 mg/L
TTHMs	25 µg/L
HAAs	20 µg/L
In Distribution System After 2 Days	
Residual Total Chlorine (Chloramine)	1.9 mg/L
TTHMs	35 µg/L
HAAs	25 µg/L

Table 2-7. WTP Model Predictions For Conventional Treatment Plant With Post-Filter Adsorbers (Scenario 1B)

Parameter	Estimated Value
<u>Finished Water Quality</u>	
pH	7.5
Residual Free Chlorine	1.5 mg/L
Average TOC	2.0 mg/L
TTHMs	10 µg/L
HAAs	10 µg/L
<u>In Distribution System After 2 Days</u>	
Residual Free Chlorine	0.5 mg/L
TTHMs	50 µg/L
HAAs	20 µg/L

Table 2-8. WTP Model Predictions For Microfiltration Treatment Plant (Scenario 2A)

Parameter	Estimated Value
<u>Finished Water Quality</u>	
pH	7.5
Residual Free Chlorine	0 mg/L
Residual Total Chlorine (Chloramine)	2.0 mg/L
Average TOC	4.0 mg/L
TTHMs	15 µg/L
HAAs	15 µg/L
<u>In Distribution System After 2 Days</u>	
Residual Free Chlorine	0 mg/L
Residual Total Chlorine (Chloramine)	1.8 mg/L
TTHMs	20 µg/L
HAAs	20 µg/L

Table 2-9. WTP Model Predictions For Microfiltration Treatment Plant With Post-Filter Adsorbers (Scenario 2B)

Parameter	Estimated Value
Finished Water Quality	
pH	7.5
Residual Free Chlorine	2.0 mg/L
Average TOC	2.0 mg/L
TTHMs	10 µg/L
HAAs	10 µg/L
In Distribution System After 2 Days	
Residual Free Chlorine	0.5 mg/L
TTHMs	30 µg/L
HAAs	30 µg/L

The TTHMs and HAAs in Scenarios 2A and 2B are somewhat lower than for Scenarios 1A and 1B. This is to be expected because of the superior removal of particulates and flocculated material by MF compared to conventional treatment, and the subsequent need for shorter chlorine contact time for primary disinfection. The 2-day TTHMs and HAAs for Scenario 2B treated water are higher than the 2-day TTHMs and HAAs for Scenario 2A treated water, again, due to the assumed use of free chlorine instead of chloramine in these scenarios. Among the four treatment scenarios, Scenario 2A had the lowest TTHMs and HAAs in the distribution system water due to the combination of microfiltration and residual disinfection with chloramines. All four treatment scenarios produced water that meets the Stage-2 DBP Rule limits for TTHMs (80 µg/L) and HAAs (60 µg/L).

These four treatment scenarios and model runs representing a potential future City-dedicated plant necessarily are conceptual-level only, limited by the extent of available raw water data, and do not provide an exhaustive or detailed analysis of all the treatment options or process combinations available to the City if such a plant is pursued. They do, however, represent the most practical and economic alternatives, given the quality of Lake Nacimiento water and the expected size of a City-dedicated plant. The model runs indicate that although GAC units can provide additional TOC removal beyond that provided by conventional treatment alone (and therefore lower DBPs in finished water leaving the plant), the benefits of doing so may not be as great as using chloramine instead of free chlorine as the residual disinfectant. This choice (for both the potential regional and City-dedicated treatment plant) is a function of several parameters, including the desires of other Project participants regarding disinfectant selection, the final distance from the plant to the City, and the various pros and cons – including cost – of converting the City's existing disinfectant to chloramine. These are discussed in Chapter 3 to the extent practical given the conceptual stage of this project. Much of the decisions regarding water quality and treatment will be dictated by still-undetermined variables – in particular, by what method, if any, the City will receive Lake Nacimiento water.

2.2.6 Blending Analysis

The analysis of potential blending impacts was conducted considering several factors. These include:

- The raw (Lake Nacimiento) water quality as discussed in Appendix A and noted above.

- The characteristics of the treated water from either a regional water treatment plant as discussed in Boyle (2002) or as described in the previous sections for a smaller City-dedicated water treatment plant.

- The characteristics of the City's existing groundwater and current operations regarding corrosion control and chlorination.

- The materials of construction of the City's existing water system.

When evaluating blending impacts from mixing two waters (in this case, treated surface water and groundwater) it is important to review the key parameters that define chemical compatibility between waters and can indicate potential problems. Waters from two or more sources can often be successfully mixed, but careful attention must be paid to avoid problems associated with corrosivity, disinfectant residual loss, taste-and-odor, color, and other system problems (e.g., excessive precipitation/scaling). The Langelier Saturation Index (LSI) and Calcium Carbonate Precipitation Potential (CCPP) are commonly used parameters that can indicate a water's tendency to either dissolve existing calcium carbonate scale (undesirable) or to deposit protective calcium carbonate scale (a mild degree of deposition is desirable). Each of the key parameters relative to blending treated Lake Nacimiento water with City groundwater is discussed below.

- **Hardness.** If a very soft water (e.g., 30-40 mg/L or less) is introduced into a system conditioned with water of moderate hardness or greater, adverse impacts may occur. Specifically, soft water is generally more "aggressive" or corrosive than hard water, and the relative lack of cations such as calcium or magnesium in it may lead to difficulties in forming a protective scale on the interior of a distribution system. City groundwater is on the high end of what is considered "hard" water (AWWA, 1999), ranging from 250 to 300 mg/L as $CaCO_3$. This is generally beneficial from a system corrosion perspective although it results in the widespread use of residential water softeners. Available data indicate that Lake Nacimiento water is moderately hard (AWWA, 1999), ranging from roughly 80 to 130 mg/L of hardness as $CaCO_3$. Surface water treatment would not affect the hardness of the lake water. Although there is some difference between the two waters in hardness, the expected blend of the two waters will still contain at least 150 to 175 mg/L of hardness, quite sufficient to provide beneficial scale material in drinking water distribution systems.

- **pH.** If waters of significantly different pH are blended, adverse effects can occur. In general, lower pH (more acidic) waters are more aggressive and may lead to dissolution of beneficial scale built up under more favorable pH conditions (slightly above the pH of saturation for calcium carbonate). The ambient pH of the City's existing system supplied by groundwater is approximately 7.5. Typically surface water treatment plants will control (raise) pH at the end of the treatment process because the addition of oxidants such as chlorine and coagulants such as ferric chloride tend to depress pH values through the treatment process. (This is especially true for utilities practicing enhanced coagulation, where pH is often depressed further to achieve maximum particulate and organic removal through the coagulation/flocculation/sedimentation process.) Typically a target pH will be set by a utility based on DBP and corrosion control concerns, and application of a chemical such as caustic soda will be used to achieve the target. Because of this flexibility, achieving pH compatibility between treated lake water and City groundwater is relatively straightforward. The water treatment plant modeling efforts described earlier in this chapter assumed a treated water target pH of 7.5 to match the City's groundwater. Therefore, no adverse blending impacts are indicated based on the pH values of the two waters.

⊄# **Alkalinity.** Alkalinity and pH are interdependent, but in general, low alkalinity in source water or in blended waters suggests potential problems. Alkalinity provides buffering capacity against changes in pH, so with insufficient alkalinity, undesirable pH swings can occur, potentially leading to DBP and/or corrosion problems. Alkalinity also provides carbonate for beneficial calcium carbonate scale formation, so without sufficient alkalinity, protective scale might not form, regardless of pH conditions or water hardness. Data from Lake Nacimiento indicate that its alkalinity ranges from roughly 90 to 130 mg/L as $CaCO_3$, and City groundwater is higher, averaging about 250 mg/L. Although determining blended water alkalinity cannot be performed by simple mass proportions as with TDS or hardness and alkalinity benchmarks, both these numbers indicate adequate buffer capacity as well as sufficient carbonate content to continue to form beneficial scale in the City's distribution system. For comparison purposes, the alkalinity categories for source water incorporated into the TOC removal requirements of the D/DBP Rule are as follows: low, 0-60 mg/L; medium, 60-120 mg/L; and high, >120 mg/L.

Summarized in **Table 2-10** are the values for these three key parameters and others for the raw and variously treated water scenarios. These are based on the WTP model runs described in Section 2.3, which provide these finished water quality parameters in addition to those indicated in **Tables 2-6** through **2-9**.

Table 2-10. Selected Additional Raw and Treated Water Quality Parameters for the Four Modeled WTP Scenarios

Parameter	Representative Raw Water Value	Treated Water			
		Scenario 1A	Scenario 1B	Scenario 2A	Scenario 2B
Total Hardness (mg/L as $CaCO_3$)	124	124	124	124	124
pH (units)	8.1	7.5[1]	7.5[1]	7.5[2]	7.5[2]
Alkalinity (mg/L as $CaCO_3$)	130	120[1]	122[1]	123	123
TOC (mg/L)	4.1	3.8	1.8	3.9	2.1
UV_{254} Absorbance (cm^{-1})	0.06	0.03	0.02	0.03	0.02
SUVA[3] (cm^{-1})	1.5	0.8	1.1	0.8	1.1

[1] After pH adjustment via caustic addition
[2] Without caustic addition
[3] SUVA = Specific UV absorbance (100 * UV_{254} absorbance)/TOC)

As indicated in the table, no change in hardness was observed between the raw and finished waters, as expected based on the treatment processes considered. The pH of the water exiting the treatment plant was adjusted to 7.5 (to match the average pH of the groundwater) using caustic for Scenarios 1A and 1B. If caustic were not used for these treatment scenarios, the pH would be significantly lower (more acidic). Adjustment of pH for the plant models using microfiltration (Scenarios 2A and 2B) was not necessary to match the City groundwater pH. Alkalinity in the finished waters is slightly lower than in the raw water. This is to be expected based on some consumption of alkalinity by the treatment process during the coagulation step. As expected, lower TOC values and UV_{254} absorbance values were predicted in finished waters that include the GAC polishing treatment step (Scenario 1B and Scenario 2B).

There are several points to be made based on our review of available water quality and City water system information regarding the potential impacts of blending:

1. From a water quality standpoint, it appears quite feasible to blend Lake Nacimiento water and City groundwater. The characteristics of each are similar enough that blending of the two should not be problematic, provided common treatment steps are taken to prevent adverse impacts. These are discussed below.

2. Design and operation of the water treatment plant that will treat Lake Nacimiento water, whether regional or dedicated to Paso Robles, must account for pH adjustment (raising pH) at the end of the process. This is typically achieved by

the addition of caustic soda, and is necessary to ensure a low-pH, aggressive water is not introduced into the City system. A specific corrosion control product (e.g., an orthophosphate or polyphosphate product) may also be warranted, but this cannot be determined without additional bench-scale or pilot-scale investigations of various water blends. Adjustment of pH is a very common surface water treatment process and will be a significant step to ensure that no adverse water quality effects result from blending the two waters.

3. It is advisable to match the disinfectant used for the City's groundwater and the treated surface water. The City currently disinfects its well water with free chlorine. If free chlorine is used as the residual disinfectant at either a regional or City water treatment plant, slightly faster/higher DBP formation can be expected after the finished water leaves the treatment plant, but the City will be able to continue the use of free chlorine as its groundwater disinfectant. However, if chloramines or selected at the regional or City treatment plant, the City is advised to chloraminate its well water to match residual disinfectants.

4. When treated surface water is available, it is advisable to phase it into the City system gradually, for example, from 0 to the full 3.6 MGD over a period of 6-12 months. This will provide an extra level of protection in addition to the steps noted above against potential adverse blending effects by ensuring that existing protective scale in the City's distribution system is not disturbed by a sudden change in ambient water chemistry.

5. As noted in Appendix A, the installation of steel water pipes in the City has been minimal, so the associated corrosion concerns are relatively low. However, galvanized steel household plumbing is subject to corrosion. As an additional protective measure, the City may want to promote the replacement of galvanized pipe with pipe of an alternative material by home and business owners.

6. Because of the general compatibility of the waters as indicated by available data, the selection of the treatment process (e.g., conventional, microfiltration, with or without GAC) can be conducted independently of blending considerations. That is, each of the processes that would be considered for treatment of Lake Nacimiento water would produce finished water feasible to blend with City groundwater. Any chemical dosage or other operational adjustments necessary to prevent possible blending impacts can be made with any of the candidate treatment trains. The choice between free chlorine and chloramine as the disinfectant used at a regional or City-dedicated water treatment plant, however, will have implications for City operations. Specifically, if chloramine were selected, it would be advisable for the City to switch its groundwater disinfectant to chloramine as well. In terms of selecting a process for the treatment of Lake Nacimiento water, blending impacts are secondary in importance to the considerations of adequate microbial control, disinfection by-product minimization, and cost. The City or appropriate agency can proceed with conceptual design based on these criteria, and possibly conduct jar tests, pipe loop

tests, or others, to verify the expected lack of blending problems and selected corrosion control approach.

A review of the various blending experiences some other water utilities have had supports the assertion that Lake Nacimiento water and City groundwater are similar enough that blending is quite feasible, and that any potential adverse effects can be mitigated with common treatment and operational actions. These case studies also highlight the need to study and identify these actions prior to full-scale implementation, and to phase in any new source of water gradually. These case studies are summarized briefly below.

- *Santa Clara Valley Water District (SCVWD), San Jose, California, and San Francisco Public Utilities Commission (SFPUC), San Francisco, California*. In 1999, these two agencies studied the water quality effects of potential blending of their two waters (SCVWD distribution system water and SFPUC Hetch Hetchy water) during planning and design activities for the "Intertie," a connection between the two systems to be used in case of emergency or service outage (e.g., prolonged plant shutdown) for either utility (CDM, 1999). The two waters were significantly different according to the three parameters discussed above. SFPUC's Hetch Hetchy water is extremely soft, with hardness measurements occasionally as low as 10 mg/L, while SCVWD's is moderately hard, similar to Lake Nacimiento's. SFPUC adjusts its pH to a relatively high level (above 9) for corrosion control, while SCVWD maintains a pH closer to 7.2 to 7.5. Alkalinity in Hetch Hetchy water, like hardness, is very low relative to SCVWD's and most other waters – as low as 10 to 15 mg/L. Additionally, at the time, SCVWD used chloramine as its residual disinfectant while SFPUC relied on free chlorine.

  All of these water quality differences prompted the agencies to properly investigate the potential water quality impacts of blending and develop appropriate mitigation strategies. As a result, the two agencies collectively developed blending treatment steps to be taken at the Intertie in the event of its operation to maintain high water quality in either system receiving water from the other, and the strategies have proven successful in Intertie operations to date (pers. comm., Cabral, 2003). Specifically, aqueous ammonia and a corrosion inhibitor similar to that used in SCVWD's system (an orthophosphate product) are added when water is delivered from SFPUC to SCVWD. Although SFPUC has not yet had a need to receive deliveries from SCVWD to date, pH adjustment (addition) will likely be provided in such an instance. These treatment options to maintain disinfectant residual and corrosion protection were developed first through paper studies, and then refined through bench-scale investigations of various water blends and treatment products. Although the Intertie is not a consistently operated facility, the importance of its limited operation and bench-scale results to date to the City of Paso Robles are that it demonstrates successful blending with two waters with much greater differences between their chemistries than between City groundwater and Lake Nacimiento water.

- *Tucson Water, Tucson, Arizona.* The mitigation of blending-related water quality problems experienced by the City of Tucson is fully described in the published literature (Pearthree and Davis, 2000; Swanson, Chowdhury, and Davis, 1998). In short, the City experienced significant color, taste-and-odor, and other adverse water quality impacts upon the introduction of treated surface water into its previously groundwater-only system. A main cause appears to have been the rapid introduction of a new source of water into a system conditioned over the long-term for different water source chemistry, as opposed to a gradual phase-in. Because the potential problems were not thoroughly studied beforehand, their causes could only be investigated in retrospect.

  The chief water chemistry problem appeared to be the pH fluctuation in the treated surface water, and subsequent iron release and aesthetic impacts in blended drinking water. Bench-scale investigations after the full-scale problems occurred pH adjustment to a consistent, higher level (roughly 8.5) was found to be beneficial, as well as a low dose of a corrosion inhibitor product (in Tucson's case, polyphosphate). The introduction of surface water, with a TDS of roughly 650 mg/L, also represented a salinity increase for the City, whose groundwater TDS averaged 200-300 mg/L. The increased ionic strength associated with this salinity increase may have contributed to the corrosion problems, although bench-scale and pilot-scale studies after the fact were too limited to conclusively identify the problem. The most important aspect of the Tucson blending experience for the City of Paso Robles to note is that water quality problems were experienced following a rapid introduction of a new water source, with incomplete planning and blending mitigation strategies identified beforehand.

- *City of Tampa Water Department, Tampa, Florida.* In the summer of 2000, severe drought conditions prompted Tampa to quickly introduce a groundwater supply into its surface water-supplied system. Resulting consumer complaints regarding the color and turbidity of their drinking water were attributed to significant chemical differences between the new groundwater and the City's historical surface water supply. Specifically, the introduction of the high-TDS (1500-2200 mg/L) groundwater resulted in a much higher salinity and ionic strength in the City's finished water. Finished drinking water TDS values jumped from 300-400 mg/L to as high as 940 mg/L upon the introduction of groundwater, accompanied by a ten-fold increase in chloride concentrations in the system (roughly an increase from 20 to 200 mg/L). At the same time, the City decreased its target pH to 7.0-7.3 to prevent calcium carbonate formation on plant equipment, which unfortunately may have exacerbated conditions for consumers. The quick introduction of a new water source led to "red water" incidents – discolored water due to iron leaching and scale dissolution and detachment from the City's distribution system pipes. Both the introduction of a higher-TDS water, and the rapid introduction of the water, are similar to the Tucson experience described above.

> A series of bench-scale tests was undertaken to determine the appropriate pH target for the blended water and other corrosion control strategies to prevent the adverse impacts of blending, and was successful. Specifically, various pH targets and different TDS blends were studied, and a higher pH (7.7-8.0) was found to mitigate the scale dissolution and iron release. If the City had had the time to properly study the blending issues in advance, as well as introduce the new source gradually, the "red water" occurrence may have been prevented. There are two points to be made from this case study relative to the potential blending scenario in the City of Paso Robles. First, because Paso Robles is anticipating introducing a source with lower TDS than its existing supply, lower ionic strength water can be expected, unlike Tampa's (and Tucson's) blending conditions. A decrease in TDS and ionic strength due to blending does not in itself guarantee that blending the waters will be problem-free, but the suspected primary cause of Tampa's problems does not appear to be an issue for Paso Robles. Second, even with the significantly different water qualities of the two Tampa sources, adverse effects were prevented once the problem was adequately investigated and appropriate treatment steps were implemented. This highlights the need to introduce new supplies gradually instead of suddenly, and generally to confirm corrosion control and other blending strategies with bench-scale or pilot-scale tests prior to full-scale implementation.

From these blending case studies it is important to note (1) the importance of phasing in new water sources gradually, (2) the success of utilities in blending waters of more disparate chemistry than the City of Paso Robles' two potential sources, and (3) the benefit of bench-scale and/or pilot-scale work in determining the effects of multiple interrelated water quality parameters on blending and identifying optimum mitigation strategies. In addition to the case studies noted above, many other cities (e.g., Phoenix, Arizona and neighboring communities) blend groundwater and surface water in their systems routinely with no adverse effects. Although individual water chemistries and treatment strategies (e.g., pH adjustment, corrosion inhibitor addition) vary based on specific conditions, the common feature of all successful blending projects is the gradual phase-in of new water (or the development of systems with both surface water and groundwater on-line over the long term). Both strategies avoid the "shock" of a rapidly introduced new water chemistry that can result in pre-existing scale dissolution, iron release, and consumer complaints.

2.3 EFFECT OF IMPORTING SURFACE WATER ON TREATED WASTEWATER QUALITY AND REGULATORY COMPLIANCE

As noted in Chapter 1 and discussed in Appendix A, the TDS content of the City's treated wastewater is the result of four main factors: (1) the TDS content of the City's source water, which is currently 100% local groundwater; (2) the increase in TDS that typically results from municipal water use; (3) the TDS load from residential water softeners; and (4) the TDS input from industrial/commercial sources. The City currently has compliance issues with respect to TDS (as well as the individual constituents of sodium, chloride, and sulfate) in its wastewater plant effluent.

Factor #2 above can be considered an unchangeable value for the purposes of salt management – TDS will always increase due to the inherent nature of water use, consumption, and disposal by a City's population. Also, the Salt Management Study (Carollo, 2001b) outlined a number of reasons why factor #3 above is difficult to control. Regulating or otherwise reducing the salt load from residential water softeners is not considered viable for the City to implement. There may be some opportunities regarding factor #4 (industrial/commercial sources); however, flow data to accompany the available salt concentration data would be necessary to quantify the potential benefits, as noted in Chapter 1.

This section focuses on the potential TDS benefit of introducing treated surface water to the City system. As a salt management alternative, it is unique in that it addresses all categories of potential salt sources in the City. Residential, commercial, industrial, and any other salt sources in the City area are essentially incremental additions to the salt already present in the City's source water. Therefore, reducing salt in the City's source water reduces the salt contribution across all potential categories of contributors.

Some of the previous studies reviewed alluded to the TDS benefits to be gained from introducing treated Lake Nacimiento water into the City's system. This section develops a quantitative estimate of that benefit, in terms of wastewater effluent TDS concentrations over time associated with the likely imported water scenario as developed in Section 2.2 of this report. The TDS benefit in the City's wastewater effluent is proportional to the ratio of treated surface water imported to City groundwater in the system. As discussed in Section 2.2, the City expects to import 4,000 AF/yr of Nacimiento water. When brought on-line, this will represent a decline in groundwater pumping, but groundwater production will have to increase with time to keep pace with City population. **Table 2-11** and **Figure 2-6** represent continuations of the water supply analysis presented earlier in this chapter, and focus on the TDS issue, showing the resultant wastewater plant effluent TDS based on the anticipated source water proportions over the coming decades. Coincident with groundwater production, effluent TDS is expected to decline sharply with the introduction of surface water, but climb steadily over the following years as the proportion of surface water to groundwater decreases. Surface water, groundwater, and incremental TDS values will of course vary somewhat from year to year, but the table uses consistent, representative values for illustrative purposes.

Table 2-11. Example WWTP Effluent Quality (TDS) Over Time With Surface Water Imports

Year	Surface Water Imports (AF/yr)	Groundwater Supply (AF/yr)	Average Surface Water TDS (mg/L)	Average Groundwater TDS (mg/L)	Combined Water Supply Average TDS (mg/L)	Example TDS Increase From City Use (mg/L)	Example WWTP Effluent TDS (mg/L)
2003	-	7300	190	510	510	470	980
2004	-	7519	190	510	510	470	980
2005	-	7745	190	510	510	470	980
2006	-	7977	190	510	510	470	980
2007	4000	4216	190	510	354	470	824
2008	4000	4463	190	510	359	470	829
2009	4000	4717	190	510	363	470	833
2010	4000	4978	190	510	367	470	837
2011	4000	5247	190	510	372	470	842
2012	4000	5525	190	510	376	470	846
2013	4000	5811	190	510	380	470	850
2014	4000	6105	190	510	383	470	853
2015	4000	6408	190	510	387	470	857
2016	4000	6720	190	510	391	470	861
2017	4000	7042	190	510	394	470	864
2018	4000	7373	190	510	397	470	867
2019	4000	7714	190	510	401	470	871
2020	4000	8066	190	510	404	470	874
2021	4000	8428	190	510	407	470	877
2022	4000	8801	190	510	410	470	880
2023	4000	9185	190	510	413	470	883

Notes and Assumptions (in addition to those indicated for Table 2-1)

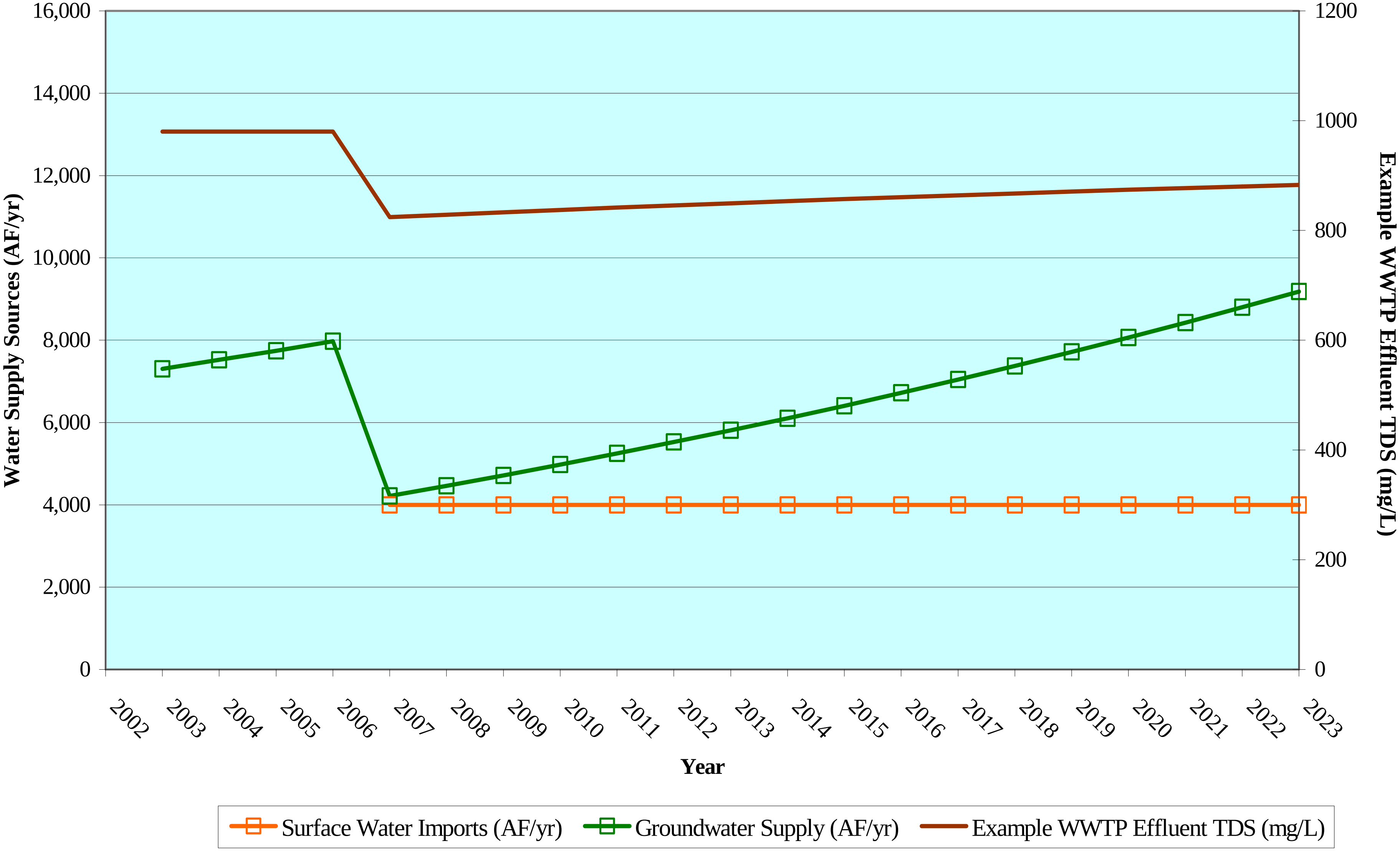
1. Surface water TDS value of 190 mg/L is based on average of Lake Nacimiento TDS results from 1993-2002 (County of SLO, 2002); other supporting information includes Boyle, 2002 and MCWRA/USACE, 2001.

2. Groundwater TDS value of 510 mg/L is based on City water quality reports from 1992-2001 (City of El Paso de Robles, 2002d) and the 2001 Salt Management Study (Carollo, 2001b).

3. Combined water supply TDS values are calculated based on expected proportions of surface water and groundwater for each year.

4. Example TDS increase from City use of 470 mg/L based on data compiled from Tables 2 and 3 of the 2001 Salt Management Study (Carollo, 2001b) and discussed in Section 2 of the draft Task 1 report.

Figure 2-6. Example WWTP Effluent Quality (TDS) Over Time With Surface Water Imports



As illustrated by the figure, the City can realize a significant wastewater regulatory benefit with respect to TDS if treated surface water is imported. The scenario shown features an approximately 1000 mg/L effluent TDS concentration, based on no surface water imports, an average City groundwater TDS concentration of 510 mg/L, and a incremental TDS increase through City residential, commercial, and industrial use of 470 mg/L. This is generally consistent with the current condition, and represents meeting the City's TDS discharge limit of 1100 mg/L with less than a 10% margin of safety. As available data indicate, TDS values in the City's effluent can vary greater than 10% from sampling period to sampling period. Therefore, the 2003 condition in **Figure 2-6** represents a fairly high-risk situation with respect to non-compliance for TDS. Upon the modeled introduction of surface water in 2007, the effluent TDS drops to approximately 820 mg/L[1]. This represents a value approximately 25% lower than the current discharge limit and a much greater factor of safety against discharge violations.

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[1] This assumes equal brine contribution from residential home softeners before and after the introduction of surface water into the City system. However, the brine contribution may actually decrease, providing an additional incremental TDS benefit. A decrease in the number of homes with softeners cannot be assumed, because the blended hardness value will be approximately 200 mg/L when surface water is first introduced – still above the 150-mg/L guideline above which many consumers prefer to soften their water (AWWA, 1999). Nevertheless, softer water on average in the City system should translate into reduced brine discharge from each unit into the City's wastewater collection system.