Appendix B

Appendix B

Supplemental Water Supply Project: Proposed Diversion Scenarios

Introduction

The following Technical Report is a supplement to the information provided as Attachment A to Appendix B, "Alternatives Screening Report," in the 1997 DEIR/EIS. Attachment A provided an overview of key water quality issues and concerns, as well as a summary of the general water qualities of the American River, Sacramento River, and Delta.

This Technical Report was prepared at the request of the Sacramento Parties and provides additional information regarding those issues covered in Attachment A, but does so for specific non-American River alternatives for water diversion location, water transmission piping, and specific pre-treatment and treatment process scenarios.

Supplemental Water Supply Project - Proposed Diversion Scenarios

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DATE: September 26, 2000

Introduction

In response to comments on the East Bay Municipal Utility District's (EBMUD's) Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS), and requests from the City of Sacramento, the County of Sacramento and other Sacramento-area interests, the recirculated EIR/EIS discusses additional project alternatives which include new points of diversion from the Sacramento River and the Delta as follows:

Alternative 5: SRWTP. Diversion from the Sacramento River at the Sacramento WTP.

Alternative 6: Freeport East. Diversion from the Sacramento River at Freeport.

Alternative 7: Freeport South. Diversion from the Sacramento River at Freeport.

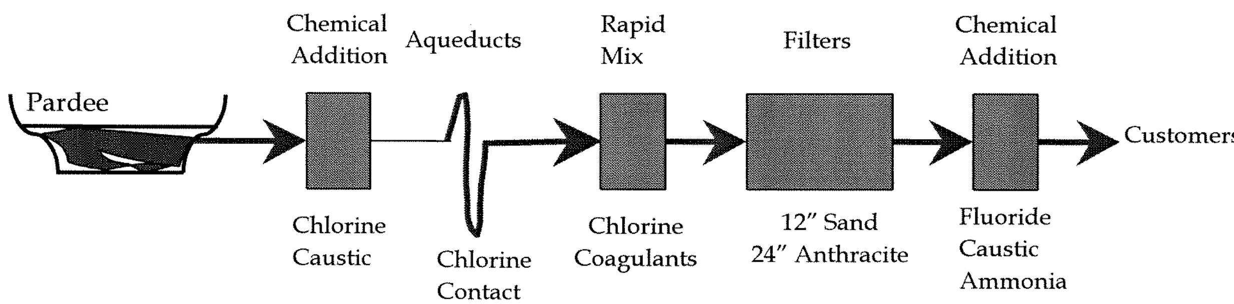
Alternative 8: Delta. Indian Slough at Bixler.

Alternatives 6 and 7 use the same diversion site. The major differences between these alternatives are the route of conveyance from Freeport, the location of treatment facilities, and the location of blending facilities with EBMUD's current raw water supply.

The objective of the memorandum is to evaluate the feasibility of each of the alternative diversion locations to meet specific water quality objectives. Cost estimates to convey the water from the diversion site to EBMUD's Bay Area system and to treat the diverted water to specific levels of quality were used to differentiate the feasibility of the alternative diversions. It should be noted that the estimated costs are not intended as definitive values. They are planning estimates, and are within an order of magnitude of what the actual costs may be. This document briefly describes all the treatment options considered and the basis for selecting or not selecting them. It presents the processes selected to treat the alternative sources, technical justifications of these treatment processes, and the limitations and uncertainties associated with the conveyance and treatment options.

EBMUD's drinking water is primarily taken from the Pardee Reservoir on the Mokelumne River and is transmitted using the three Mokelumne Aqueducts to three in-line filtration plants at Walnut Creek, Orinda, and Lafayette. This raw water can also be transmitted to three terminal reservoirs, Briones, San Pablo, and Upper San Leandro. The reservoirs provide water for EBMUD's full-treatment plants, Sobrante and Upper San Leandro, that have limited capacity and serve small portions of the distribution system. Briones Reservoir can also return water to the in-line treatment plants for treatment. Before entering the Mokelumne Aqueducts, the water is chlorinated for the inactivation of pathogens and lime is added for corrosion control. Additional chlorination occurs at an intermittent point during the conveyance of the raw water through the Aqueducts. At the in-line filtration plants, the water is filtered, the pH is adjusted for corrosion control and a residual disinfectant is added. At the full-treatment plants, the water is coagulated, flocculated, settled, filtered, and a residual disinfectant is added. Additionally, at the Sobrante and Upper San Leandro plants, the settled water is contacted with ozone for additional disinfection and taste and odor control.

In-line filtration is not considered an "approved" technology in California and the in-line filtration plants are operated under a permit that is specific for the high quality Mokelumne River source water. For example, the Orinda plant uses the following treatment train:



Any deleterious alteration of the water quality to be treated at the in-line filtration plants will result in a California Department of Health Services (DoHS) reevaluation of the operating permit for these plants. A reevaluation could result in the need to significantly modify the existing plants to treatment designs (direct filtration or conventional filtration) that are equivalent to those processes used by other drinking water agencies that treat Sacramento River and Delta source water. EBMUD's existing plants cannot simply be upgraded, but must be rebuilt to these more rigorous design standards. However, rebuilding at existing plant sites, particularly at the Orinda Treatment Plant would be impractical due to interference with critical on-going operations, site size limitations for new facilities, and neighborhood impacts. For these reasons upgrading/rebuilding of existing in-line plants was not considered feasible.

To evaluate the potential source alternatives, two levels of treatment have been proposed for each alternative source:

1. To comply with all drinking water regulations.
2. To comply with all drinking water regulations and reasonably match EBMUD's current finished water quality.

Treatment processes to comply with all drinking water regulations were designed to ensure that:

- The operational performance standards of EBMUD's existing plants were not degraded by the treated diversion water, and

- Water quality in EBMUD's terminal reservoirs was not degraded if treated diversion water were input.

The major difference between the level of treatment intended to simply comply with all drinking water regulations, and the level intended to also reasonably match current finished water quality is the control of aesthetic parameters, primarily salinity and objectionable taste and odor. For the purposes of this evaluation these aesthetic water quality parameters were not considered a regulatory compliance issue, although DoHS has developed secondary maximum contaminant levels (SMCLs) for both odor-threshold and total dissolved solids. Under DoHS regulations, exceeding SMCLs carries regulatory consequences and must be reported in the annual Consumer Confidence Report, which for EBMUD will have significant customer confidence and satisfaction implications.

For the Sacramento River diversions, pretreatment processes (sedimentation/disinfection) followed by blending with Mokelumne River water and treatment at EBMUD's in-line plants will both comply with drinking water regulations, and reasonably match EBMUD's current finished water quality. On the other hand, far more extensive pretreatment for the Delta diversion will be needed simply to meet drinking water regulations. Additionally, several deleterious impacts of introducing this pretreated alternative source into the EBMUD system can be foreseen. Pretreatment of the Delta diversion water alone (followed by blending and treatment at EBMUD's facilities) is insufficient in meeting current aesthetic expectations. To reasonably match current finished water quality as well as complying with drinking water regulations will require advanced levels of treatment to reduce salinity levels in water diverted from the Delta.

Comparison of Water Quality

The three alternative sources being considered by EBMUD, the American River, Sacramento River and the Delta, have lower water quality than the Mokelumne River due to agricultural and urban runoff and wastewater discharges into these water bodies. Table 1 shows the 90th percentile values for some key water quality parameters at the three diversion sites and at Pardee Reservoir. The 90th percentile values were used as the basis for treatment process design to ensure adequate treatment during drought years. There was insufficient water quality data for the Freeport diversion location on the Sacramento River to include this diversion location in Table 1. However, inspection of water quality data at Greene's Landing, downstream from Freeport indicated that water quality at both the Sacramento River WTP and Freeport sites were generally equivalent and could be used to design the pretreatment process needed for either diversion. The following observations can be made based on the available data:

1. Turbidity values at the river sites are higher than in the Mokelumne River, as measured in Pardee Reservoir. This is to be expected since reservoir water is well-settled and river water is not.

2. Total organic carbon is higher at the Delta site. This site can be expected to produce more disinfection by-products during chlorination. Also, ozonating the water from this site to meet *Cryptosporidium* inactivation requirements will require higher ozone dosages and will produce more biodegradable organic matter, raising concerns of bio-

film control in the finished water distribution system. Furthermore, EBMUD's distribution system has extremely long detention times, and is dependent on stable water with low TOC levels for its integrity. Any increase in TOC could create serious water quality degradation within the distribution system.

TABLE 1

Water Quality Data Comparison (Using 90th percentile values)

Parameter	Mokelumne River – Pardee Reservoir	American River at E.A. Fairbairn Water Treatment Plant	Sacramento River at Sacramento River Water Treatment Plant*	Delta – Indian Slough at Bixler
Turbidity, NTU	1.0	4.4	15	24
Total Organic Carbon, mg/L	3.2	2.1	3.3	7.6
Total Dissolved Solids, mg/L	38	55	102	550
Bromide, µg/L	38	NA	NA	665
Hardness, mg/L	17	27	53	140
Phosphate as P, mg/L	0.001	0.15	0.11	0.12
Nitrate as N, mg/L	0.001	0.16	0.6	0.86
Total Coliforms, cfu/100 mL	68	2400	2400	1300
Fecal Coliforms, cfu/100 mL	4	230	230	118

* Water quality at both the Sacramento River WTP and Freeport sites were generally equivalent and could be used to design the pretreatment process needed for either diversion site.

3. Total dissolved solids is slightly increased at the Sacramento River sites and substantially increased at the Delta site. This parameter is generally considered to be aesthetic, but has economic impacts for both residential and commercial/industrial customers. The SMCL for total dissolved solids (TDS) is 500 mg/L.

4. Bromide data for the Sacramento River diversion sites was not available, but data from downstream on the Sacramento River at Greene's Landing suggests that bromide levels would be similar to those of the Mokelumne River. Conversely, bromide levels are substantially increased at the Delta. This is especially important from the perspective of disinfection. If ozone is used as a disinfectant, it will react with the bromide in this water to form bromate, which has a current MCL of 10 µg/L. If free chlorine is used as a disinfectant, it will react with the bromide and the organic matter present to form brominated trihalomethanes and haloacetic acids. These brominated species are considered to be higher risk carcinogens than their chlorinated counterparts.

5. Hardness is higher in the Sacramento River and increases downstream. This is probably insignificant for residential use, although some industrial and commercial customers may have to begin treating their water or modify their current treatment process as a result of this higher hardness. In addition, EBMUD's in-line plants use eductors for chemical feed, which use low-hardness Mokelumne water as process water. Water softening systems would be needed to treat higher hardness source water used for chemical feed systems.

6. The phosphate and nitrate concentrations are higher in the American River, Sacramento River and Delta at Indian Slough than in the Mokelumne River. Elevated phosphorus and nitrate levels will increase the nutrient loading into EBMUD's terminal reservoirs, which will likely increase the frequency and the intensity of algal blooms. This could have an impact on the taste and odor of the water and would require increased ozone dosages at EBMUD's full treatment plants, thereby increasing the operating costs at those plants treating the terminal reservoir water. If the increase in algal blooms results in a more intensified taste and odor rather than more frequent episodes, modifications to EBMUD's existing plants would increase the capital costs of American River, Sacramento River and Delta diversion alternatives. Furthermore, increased algal growth will result in higher TOC levels and elevated THM formation potential, which will compound the problems discussed above.

7. Total Coliforms and Fecal Coliform levels are significantly higher in the American River, Sacramento River and Delta diversion sites than the Mokelumne River. This will require a higher level of pathogen protection via disinfection and/or physical removal for these source waters.

The chief water quality concern with the American River, Sacramento River and the Delta is the vulnerability of these sources to *Cryptosporidium* and other pathogens. This is of particular concern since the focus of such upcoming drinking water regulations as the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), will be

> "...on identifying 'vulnerable' systems with high levels of *Cryptosporidium* in source water. Analysis of the ICR data to determine 'vulnerable' has been problematic as 93% of the ICR *Cryptosporidium* samples have been non-detects".[1]

Limited data on *Cryptosporidium* and *Giardia* levels have been collected from the Sacramento River and the Mokelumne River using both the ICR method and the more recent EPA 1623 method. Although there was little or no detection of these pathogens in either set of data, the fecal coliform levels in the American River, Sacramento River and Delta indicate that other pathogen contamination, including *Cryptosporidium* and/or *Giardia*, is a concern. This concern is supported by the Federal Advisory Committee's (FACA) current recommended option in the LT2ESWTR for small surface water systems to use E. coli levels as a surrogate for *Cryptosporidium* monitoring. It is assumed that the American River, Sacramento River and Delta sources, due to influences of urban and agricultural runoff and wastewater discharges, have significantly higher levels of *Cryptosporidium* and *Giardia* than the Mokelumne River.

[1] Roberson, Alan, "M/DBP Update," American Water Works Association, Denver, CO, June 6, 2000.

Source Water Quality Selection

In attempting to match Mokelumne source water quality for EBMUD customers, it is incorrect to conclude that treatment technologies provide the same level of long-term public health protection as a protected watershed. Similarly, it is incorrect to conclude that the American and Sacramento Rivers have similar water quality, based solely on comparing the limited number of parameters presented in Table 1.

The American River receives input from a watershed that is less than one-tenth the size (1,900 square miles) of the Sacramento River's watershed (27,000 square miles). More importantly, the American River's upper watershed is significantly less developed than the Sacramento River's upper watershed. The waters in each basin have been impaired by similar activities including urban runoff, storm sewers, agriculture, and resource extraction.[2] However, the greater scale of development in the Sacramento River watershed and its greater comparative size would predict that the loading of chemical and biological contaminants that degrade drinking water quality is greater for the Sacramento River than the American River. Similarly, Delta supplies are more vulnerable to chemical and biological contaminant loading than the Sacramento River due to the number and magnitude of potentially polluting activities. Table 2 provides a best professional judgement, qualitative comparison of each diversion site's vulnerability to be used in conjunction with measured water quality in judging the suitability of each alternative.

Because of these watershed characteristics, the American River is preferable to the proposed Sacramento River or Delta diversions as a source of drinking water because it is less vulnerable to contaminants that are currently regulated and those that will be regulated in the near-future.

Water quality cannot be measured solely by the levels of currently regulated contaminants, but must consider the vulnerability of source water to emerging and/or unknown contaminants. In addition to the 91 chemicals currently regulated by MCLs and SMCLs (15) and the 5 pathogens regulated by treatment techniques, there are many other microbiological and chemical contaminants that pose health impacts that are currently unregulated. The 1996 revision to the Safe Drinking Water Act required EPA to develop the Contaminant Candidate List (CCL) from which to develop drinking water standards. The current CCL has 50 chemical and 10 microbiological drinking water contaminants that pose a potential risk to drinking water supplies.

Historically, a multi-barrier approach to protect drinking water quality that integrates source water selection/protection with treatment and distribution system management has been strongly supported by the drinking water industry. Source water protection is an inherently better approach to deliver safe drinking water, than relying on a single treatment barrier to remove contaminants, especially when treatment is subject to process upset and human error. In its "Statement of Policy on Water Supply Matters, Drinking Water Quality," the American Water Works Association underscores the importance of source water quality.

[2] US Environmental Protection Agency. 1998. California List of Impaired Waters. Total Maximum Daily Load Program.

All water utilities should deliver to the consumer an adequate supply of high quality drinking water at a cost commensurate with the needs of each individual water system. To achieve this objective, the water should come from the highest quality source of supply available and be appropriately treated to meet regulatory and water supply industry criteria.

TABLE 2

Supplemental Supply Source Water/Treatment Alternative Qualitative Comparison

Alternative	Impacts to Customers[1]	Vulnerability[2]	New & Existing D/DBP Precursors	Nutrients	New - Emerging Contaminants[3]	New - Emerging Pathogens[4]
2-3	Low	Low	Low	Low	Low	Low
4	Low	Low	Low	Low	Low	Low
5	Mod	Mod	Low	Mod	High	High
6	Mod	Mod	High	High	High	High
7	Mod	Mod	High	High	High	High
8	High	High	High	High	High	High

1 Increased taste and odor, increased salinity impacts.
2 Risk and susceptibility to urban and agricultural runoff, permitted discharges, and spills.
3 Level of activity in watershed that could be the source of new contaminants posing acute or chronic public health risk.
4 Level of activity in watershed that could be the source of new pathogens posing acute or chronic public health risk.

The vulnerability of drinking water sources to both regulated and unknown and/or emerging contaminants has also prompted the US Environmental Protection Agency (EPA) to make source water protection a priority. In its "Environmental Goals for America with Milestones for 2005", EPA has set the goal of having 60 percent of the population served by community water systems that have source water protection programs in place. To achieve this goal EPA has implemented a Source Water Assessment and Protection Program to supplement its sanitary survey program that was initiated in 1989.

A more elaborate presentation of drinking water industry and regulatory agency prioritization for source water selection/protection and EBMUD's interpretation of this approach is presented in Volume II Technical Appendices, Chapter 5, Attachment A of EBMUD's 1997 Supplemental Water Supply Project Draft EIR/EIS.

Goals of Treatment

The primary goal of all drinking water treatment is to protect the health of the drinking water consumer by providing the highest quality finished water that meets all current and anticipated regulatory requirements, and that uses accepted treatment technologies. Therefore, the goal of treating Sacramento River water or Delta water as a supplemental source is first to protect human health, and second, to maintain an aesthetically high quality drinking water. Aesthetic water quality is important because it is the principal measure used by consumers to judge the "acceptability" of the water. If consumers consider the water aesthetically unacceptable, they are likely to find another source of drinking water, such as bottled water.

In drinking water treatment, the primary element in protecting public health is to control pathogens. To illustrate the regulatory approach that is being developed by the FACA regarding pathogens, Roberson says the following:

> "The FACA has agreed to another round of microbial monitoring (2 years of monthly *Cryptosporidium* [using EPA Method 1623] and E. coli monitoring for surface water systems serving > 10,000 people) that will be used to place systems in different "bins" based on the average *Cryptosporidium* level. Systems in the different "bins" will go to a "toolbox" of options for additional removal and/or inactivation credits." [3]

Although the terms "bins" and "toolboxes are new to the drinking water regulatory environment, these concepts have long been established. At one end of the spectrum, pristine waters in protected watersheds have been permitted to be distributed without being filtered, while at the other end, water taken from highly industrialized cities has been required to receive several barriers of treatment. The Surface Water Treatment Rule (SWTR), which required a minimum combined level of pathogen removal and inactivation, granted different levels of removal credit for different filtration technologies. Under the SWTR, conventional plants received the highest credit for physical removal and direct, slow sand and diatomaceous earth filtration received lower levels of credit. Under the impending Long Term 2 Enhanced Surface Water Treatment Rule, this concept will be expanded to compensate for source water quality. Different water sources will be ranked according to the risk associated with their watershed, and each will be placed in one of four "bins." All of the sources in any bin will be required to achieve some combined level of pathogen removal and inactivation using any or all of the technologies and source water protection actions in the "toolbox." For example, to achieve the log removal credit required for a higher risk watershed, a utility may not be able to achieve required log-reductions through source water protection and may have to use more than one type of treatment (chemical inactivation and physical barriers). The agency may choose to focus on physical removal of pathogens by installing membrane filtration, and may then only be required to provide some minimum amount of inactivation after filtration, or they may find a high level of inactivation to be more attractive, and, thereby, be able to maintain a less robust physical removal process.

As stated in a previous section, the water quality of the American and Sacramento Rivers and the Delta is under the influence of wastewater discharges and urban and agricultural

[3] Roberson, Alan, "M/DBP Update," American Water Works Association, Denver, CO. July 31, 2000.

runoff and is in a different bin than the Mokelumne River. These influences result in water that is higher in fecal contaminants and also more vulnerable to contamination by *Cryptosporidium* and other pathogens than EBMUD's protected source of drinking water, the Mokelumne River. In order to meet the primary goal of protecting health, the health risk of using the American and Sacramento Rivers or Delta water needs to be reduced to the same level of pathogenic risk as EBMUD's current drinking water source. This can be done either by:

1) pretreating the raw American River, Sacramento River or Delta water using the "toolbox" to change their "bin" to the lower risk "bin" of the Mokelumne River and then treating all of the lower risk water at the existing in-line treatment plants, or
2) rebuilding the current treatment plants to treat water from a source with higher pathogenic health risk.

The first method was chosen to reduce pathogenic health risk because rebuilding existing plants is impractical (see discussion pages 2 and 15 and cost in Table 9).

Blending of the American River, Sacramento River or Delta water with Mokelumne River water cannot achieve the desired risk reduction because the difference between "bins" is measured in orders of magnitude. For example, the fecal coliform densities given in Table 1 show that the 90th percentile fecal coliform densities for Mokelumne and Sacramento River are 4 and 230 cfu/100 mL, respectively. Blending would provide less than a factor of two dilution, which falls far short of the order of magnitude (>10 factor) reduction needed to achieve any significant control of pathogens.

Table 3 shows the resulting fecal coliform densities for several blends of Mokelumne and Sacramento River water. The only blends of these two water sources that are within the same order of magnitude as the Mokelumne River are those that use more than 90% Mokelumne River water. This level of blending cannot be achieved because the supplemental water supply is most needed during drought years when such high percentages of Mokelumne River would not be available.

More importantly, blending does nothing to remove or inactivate pathogens it simply reduces their concentration and is not considered a means to reduce pathogen risk.

Similarly, turbidity reduction is not linear with respect to dilution, and blending is not expected to reduce turbidity levels by significantly more than a factor of two. Again this reduction falls far short of the reduction (a factor of 5-8) needed to achieve any significant control of turbidity in water diverted from the American River, Sacramento River or Delta. Although other water quality parameters can be reduced by blending they did not dictate treatment design decisions.

Another key factor in protecting public health is the control of disinfection by-products (DBPs). Recent regulations have focussed on two classes of compounds, trihalomethanes (THMs) and haloacetic acids (HAAs) that are produced by the reaction between chlorine and naturally occurring organic matter. The concentration of bromide in the water plays a determining role in the mixture of chlorinated and brominated trihalomethanes and haloacetic acids. If ozone is used, it will react with any bromide present to form bromate, another disinfection by-product. Stage I of the Disinfectants and Disinfection By-Products (D/DBP) Rule regulates these disinfection by-products in this way:

- THMs have a MCL of 80 µg/L based on the running annual average of quarterly samples at four distribution system sampling points.
- HAAs have a MCL of 60 µg/L based on the running annual average of quarterly samples at four distribution system sampling points.

Bromate has a MCL of 10 µg/L based on the running annual average, calculated quarterly, of monthly samples taken at the distribution system entry point.

TABLE 3

Fecal Coliform Density Resulting from Blending Mokelumne and Sacramento River Water

Mokelumne River water, percent	Sacramento River water, percent	Blended Fecal Coliform Density, cfu/100 mL
40	60	140
50	50	117
60	40	94
70	30	72
80	20	49
90	10	27
95	5	15
99	1	6.3

Although Stage 2 of the D/DBP Rule will not regulate specific DBP compounds, there is a growing body of information that suggests brominated THMs and HAAs carry a higher health risk than their chlorinated counterparts. Any shift toward forming more brominated organic compounds is considered to carry an additional health risk to the public. In order to maintain the same level of public health protection as is currently being provided, the treatment of the alternative water supplies must not:

1. increase the level of disinfection by-products over the levels that are currently being produced, or
2. increase the ratio of brominated to chlorinated disinfection by-product species.

In order to accomplish these goals, concentrations of total organic carbon and bromide must not increase in the water that is being chlorinated, or disinfection practices must be altered.

Finally, drinking water treatment must be sufficiently robust to protect the health of consumers from new and/or currently unregulated biological or chemical contaminants. For instance, there is growing international concern that such pharmaceutically active chemicals as 17B-estradiol (hormone), sulfonamides and tetracyclines (antibiotics) and analgesics may pose public health risk at the levels they have been detected in surface waters. Such concern has prompted EPA to recently propose testing a wide variety of chemicals for their ability to disrupt endocrine function. The increased vulnerability of

Sacramento River and Delta source waters to wastewater discharges, as mentioned previously, increases the likelihood that pharmaceutically active chemicals may also be present. In addition, other contaminants such as pesticides are more likely to occur in the Sacramento River and Delta watersheds than in the Mokelumne since they are subject to urban and agricultural point and non-point source discharges.

Besides health-related concerns, aesthetic water quality is among the chief determinants of drinking water consumer acceptance, and an important issue for EBMUD's customers. A research report from the American Water Works Association Research Foundation states the following:

> "The occurrence of periodic episodes of objectionable tastes and odors has plagued the water supply industry throughout time. Organoleptic problems are associated with unsafe water by the public regardless of the actual toxicological quality of the water. This leads to customer dissatisfaction, and bad public relations. It may result in economic losses to a public water utility if a contractual agreement between a bulk water producer and a redistributor (e.g. a town purchasing water from a large utility) stipulates organoleptic quality limits with cost penalties. Such clauses have been proposed by bulk customers in France. In addition, customers may choose alternate untreated water sources which may be hazardous to their health."[4]

Taste and odor is regulated by a SMCL threshold odor number of 3. The DoHS set a SMCL for the rice herbicide, thiobencarb, (Bolero) of 1 μg/L in 1987 based upon taste and odor.[5] In 1999 they adopted a SMCL for the gasoline additive, methyl tert-butyl ether, of 5 μg/L based upon taste and odor[6], for which EBMUD has implemented an aggressive source control program to greatly reduce MTBE levels in its reservoirs. In California, secondary standards are enforceable, reflecting the State's high priority on aesthetic water quality.

The Mokelumne River is a high quality source with little or no vulnerability to compounds causing objectionable taste and odor. The Sacramento River and Delta sources, because of the agricultural and urban runoff and wastewater discharges, are higher in nitrogen and phosphorus than the Mokelumne River. This increase in nutrient levels causes increased algal growth and elevated levels of such algal metabolites as geosmin and 2-methyl isoborneol, known to cause objectionable taste and odor. For the Sacramento River and the Delta, taste and odor control should be incorporated into the treatment scheme to meet the water consumers' expectations.

Total dissolved solids (TDS), which can also affect the palatability of the water, carry a SMCL of 500 mg/L. The TDS in the finished water will increase as the result of augmenting the EBMUD supply with water from these alternative sources. Table 4 shows the finished TDS concentrations that could be expected using water from the three diversion points if treatment to reduce TDS is not included. A similar comparison was not performed for

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[4] "Taste and Odor in Drinking Water Supplies - Phases I & II," AWWA Research Foundation, Denver, CO, 1989.

[5] State of California, Proposed Maximum Contaminant Level for Thiobencarb, Bolero, Regulatory Package, 1987.

[6] California Register, "Final Statement of Reason Secondary Maximum Contaminant Level for Methyl Tert-Butyl Ether and Revisions to the Unregulated Chemical Monitoring List." R-44-97. Title 22 CCR 64449, January 1999.

blending with diversion from the American River because TDS levels are far more similar to levels found in the Mokelumne River.

The increase in TDS levels resulting from blending Mokelumne River water with Sacramento River water are not expected to have a great impact on the aesthetics of the water. However, the much greater increase on TDS attributable to diverting water from the

TABLE 4

Comparison of Total Dissolved Solids Levels Using Alternative Source Waters Blended with Mokelumne River Water

	Total Dissolved Solids, mg/L		
Diversion Point	Yearly Average*	Winter Conditions**	Summer Conditions***
Mokelumne River	32	32	32
Sacramento River WTP	62	67	59
Sacramento River at Freeport	74	82	69
Indian Slough at Bixler	204	234	183

* Yearly Average is assumed to be 58% Alternative Source and 42% Mokelumne River water.
** Winter Condition is assumed to be 68% Alternative Source and 32% Mokelumne River water.
*** Summer Condition is assumed to be 51% Alternative Source and 49% Mokelumne River water.

Delta will produce a noticeable change in taste and customer uses. For example, the use of the Delta water source could have an impact on the reuse of wastewater as cooling water.

Currently, EBMUD's North Richmond Water Reclamation Plant (NRWRP) provides 3.4 million gallons per day of cooling water to the Chevron refinery in Richmond. The chloride limit in the contract is 175 mg/L. Chloride concentrations are currently averaging approximately 170 mg/L. Therefore, any increase in chloride would result in the inability of NRWRP to sell its effluent. To reduce chloride levels to those specified in the contract will require adding microfiltration followed by reverse osmosis. EBMUD staff has estimated the additional annual cost of treating NRWRP water (capital costs amortized over 30 years and O&M cost) to lower elevated TDS levels to be between $380,000 and $494,000.

Also, the use of the Delta water source could have an impact on the reuse of wastewater for irrigation due to high levels of salinity (TDS). According to a report prepared for Metropolitan Water District of Southern California and the United States Department of the Interior, Bureau of Reclamation in June 1999, TDS levels above 1000 mg/L could significantly limit the reuse of wastewater. Additionally, *Guidelines for Reuse* and *Water Quality for Agriculture* (United Nations, Report 29, Rev.1, 1989) recommend a level of TDS not to exceed 500 mg/L for landscape irrigation. Increases in the TDS of the finished water will make the wastewater less desirable for agricultural uses, especially for landscaping plants that are highly sensitive to high salinity waters.

General Treatment Design Approach for Diversion Alternatives

The various treatment designs that were considered for each diversion location alternative are described. The description includes treatment processes and costs to meet specific drinking water quality objectives. The rationale for not selecting each of these treatment design options is also provided.

This is followed by a presentation of the selected treatment design process using two water quality objectives:

1. To comply with all drinking water regulations (Treatment Scenario A).
2. To comply with all drinking water regulations, and reasonably match current finished water quality (Treatment Scenario B).

For each Treatment Scenario a description of the unit processes (and alternative unit processes) is provided, and rationalized. In addition, process concerns and achievable water quality are presented for each Scenario.

Current and Impending Drinking Water Regulations used in Screening Treatment Process Options

During the screening of treatment process options for each of the alternative diversions, a major decision criterion was meeting existing drinking water quality requirements as set forth in federal and state regulations. This includes the Stage 1 Disinfectant/Disinfection By-products (D/DBP) rule and the Interim Enhanced Surface Water Treatment Rule (IESWTR) collectively referred to as the Stage 1 Microbial/Disinfection By-Product (M/DBP) rule. EPA adopted the Stage 1 M/DBP Rule in 1998, with compliance of large systems required by January 2002.

The Stage 1 M/DBP Rule's turbidity requirements were used to select the treatment design that most effectively achieved the water quality objective of meeting current drinking water regulations. Treatment designs for pathogen control reflect not only the 2-log *Cryptosporidium* removal requirement of the IESWTR, but also the more stringent requirements anticipated under the impending Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) to be proposed by EPA in early 2001. Using both current and impending rules to select the treatment design most appropriate for controlling pathogens is warranted based on the need to meet all drinking water regulations over the planned life of the facility, and the small percentage (~10%) that the addition of UV or ozone disinfection contribute to the overall cost of the diversion alternatives.

It should also be emphasized that new more stringent pathogen control requirements will soon be required by the impending regulation based on the following:

1. The promulgation date for the Long Term-2 Surface Water Treatment Rule and the Stage 2 D/DBP rule is mandated by Federal Law. Below is a quote from the Safe Drinking Water Amendments of 1996 - PL 104-182, Section 300g-1 (b) (2):

> "(C) – Disinfectants and disinfection byproducts. – The Administrator shall promulgate an Interim Enhanced Surface Water Treatment Rule, a Stage I Disinfectants and Disinfection Byproducts Rule, and a Stage II Disinfectants and Disinfection Byproducts Rule in accordance with the schedule published in volume 59, Federal Register, page 6361 (February 10, 1994), in table III.13 of the proposed Information Collection Rule."

The legal deadlines translate to a May 2002 promulgation date, with compliance required by 2010. EPA is expected to propose new rules, now called the LT2ESWTR and the Stage II D/DBP Rule by early 2001.

2. The requirements of the new rules are fairly well established at the present time, due to the negotiated rulemaking process that was used by EPA to develop them. EPA empowered a Federal Advisory Committee convened for this purpose. The Committee consisted of water purveyors, federal, state and local government representatives, environmentalists and consumer interest groups. On September 12, 2000 the Committee members signed an Agreement in Principal which fully detailed the regulatory standards to be contained in the Stage II rules.
3. It is unlikely that the final Stage II rules will change significantly before the Rules are finalized unless changes make those requirements more stringent.

Alternatives 2, 3 and 4: Pretreatment of American River Water

Treatment Designs Considered

The treatment alternatives considered for an American River diversion are identical to those considered for the Sacramento River. The justification and selection of processes are also identical. For a discussion of the alternatives, see the next section.

Selected Process

Since the draft EIR/EIS was published in 1997, EPA adopted the Stage 1 M/DBP Rule and the expected requirements of the soon-to-be adopted Stage 2 M/DBP Rule have become better defined. Based on the measured American River water quality, and the pathogenic risk posed by municipal wastewater discharges and agricultural runoff, treatment of American River diversions will now need to include clarification and disinfection. The same level of pretreatment described in detail for the Sacramento River diversions (Alternatives 5, 6 and 7) in the next section needs to occur before the American River water can be blended with the higher quality Mokelumne River water. The same treatment was selected for both Treatment Scenario A and B. Taste and odor potential are considered low in the American River because of the low nutrient and organic levels in this water body. The footprint for the design is included in Appendix A.

Alternatives 5, 6 and 7: Pretreatment of Sacramento River Water

Pretreatment process trains for Sacramento River water are being proposed based on the two water quality objectives as described above.

Treatment Designs Considered

Treatment Scenario A: Complying with all Drinking Water Regulations. (For cost comparisons of these alternatives, please see Table 9, page 29.)

- Blending with Mokelumne source water and treatment at upgraded EBMUD facilities. Due to its higher turbidity and fecal coliform content, blending of the American River water with the Mokelumne will result in the need to modify EBMUD's in-line filtration facilities. This alternative was not selected due to the high cost associated with modifying the in-line plants.

- Conventional clarification and rapid sand filtration at Brandt and blending with Mokelumne source water. This alternative would use the same barrier against *Cryptosporidium* as used in EBMUD's in-line filtration plants downstream. A failure in the pretreatment filtration step would likely be accompanied by a failure at the in-line plants, because both rely on the same type of treatment process. The desirability of different treatment types (physical removal and inactivation) is consistent with a multiple barrier approach. A treatment process, which includes physical removal and inactivation, is reinforced in the U.S. EPA's "M/DBP Agreement in Principal" which requires at least 1 log of *Cryptosporidium* inactivation for water classified in the two higher-level action bins. This alternative was not selected because it lacks an inactivation barrier for *Cryptosporidium*.

- High-rate clarification, rapid sand filtration and chlorination at Brandt and new treated water pipeline to the EBMUD service area. This alternative would create a full treatment plant at Brandt actually having a lower barrier to *Cryptosporidium* than the previous alternative and the finished water would need to be conveyed to the distribution system. The cost of finished water conveyance alone would be extremely high, as shown for Alternative 8B. Unit cost for a 155-cfs-capacity pipeline is approximately $5 million/mile. From the Brandt site to Walnut Creek WTP is some 70 miles resulting in a pipeline cost of about $350 million. For these reasons, this alternative was not selected.

- High rate clarification and ozonation at Brandt, and blending with Mokelumne source water. This alternative would provide an inactivation barrier to *Cryptosporidium* as encouraged by USEPA. Because the cost of ozone is higher than UV and the effectiveness of ozone is lower than UV, this alternative would be selected only if UV would not be acceptable to the DoHS. See more detailed description of treatment process beginning on page 16.

- High rate clarification and UV disinfection at Brandt, and blending with Mokelumne source water. This alternative is the most cost-effective option for providing an inactivation barrier to *Cryptosporidium*. See more detailed description of treatment process beginning on page 16.

Treatment Scenario B: Complying with all Drinking Water Regulations, and reasonably matching current finished water quality.

- Conventional clarification and rapid sand filtration with activated carbon, and blending with Mokelumne source water. As in the second process alternative listed above, this would not provide an inactivation barrier to *Cryptosporidium*. Also, local and national experience with granular activated carbon (GAC) for the control of geosmin and methyl isoborneol indicates that GAC does not reliably control these odor-causing compounds. For these reasons this alternative was not selected.

- High rate clarification, UV disinfection and ozonation for T&O control at Brandt, and blending with Mokelumne source water. This selected alternative combines the most cost-effective option for inactivation of *Cryptosporidium with* the most reliable method for controlling geosmin and methyl isoborneol. See more detailed description of treatment process beginning on page 18.

Selected Process

Based on the measured Sacramento River water quality, advanced treatment in conjunction with EBMUD's current treatment processes is not required to achieve either level of water quality. However, the higher turbidity and increased risk from pathogens attributable to wastewater discharges and agricultural runoff dictates the need for pretreatment prior to blending the Sacramento River water with the higher quality Mokelumne River water.

The proposed pretreatment processes are based on the assumption that both diversion points (Sacramento River WTP and Freeport) have similar water quality. Therefore, the pretreatment processes for the Sacramento River alternatives are the same for both diversion sites.

Alternative 5 consists of diverting raw Sacramento River water at the Sacramento River WTP and conveying it to the Folsom South Canal where it will flow to a new 100 MGD pretreatment WTP at Brandt. Alternative 6 consists of diverting the Sacramento River water at Freeport and conveying it to the Folsom South Canal as in Alternative 5. Alternative 7 consists of diverting the Sacramento River water at Freeport and conveying it south, parallel to Interstate 5 to the Mokelumne Aqueducts and flowing it through the Aqueducts to a new 100 MGD pretreatment WTP at Bixler. In each case, the pretreated Sacramento River water will then be pumped from the pretreatment WTP to a new 100 MGD blending facility where it will be mixed with Mokelumne River water. The mixed waters will then flow via the Aqueducts to EBMUD's existing in-line filtration plants.

Treatment Scenario A: Complying with all Drinking Water Regulations

Treating the Sacramento River water to meet current drinking water regulations, as defined by DoHS, will require:

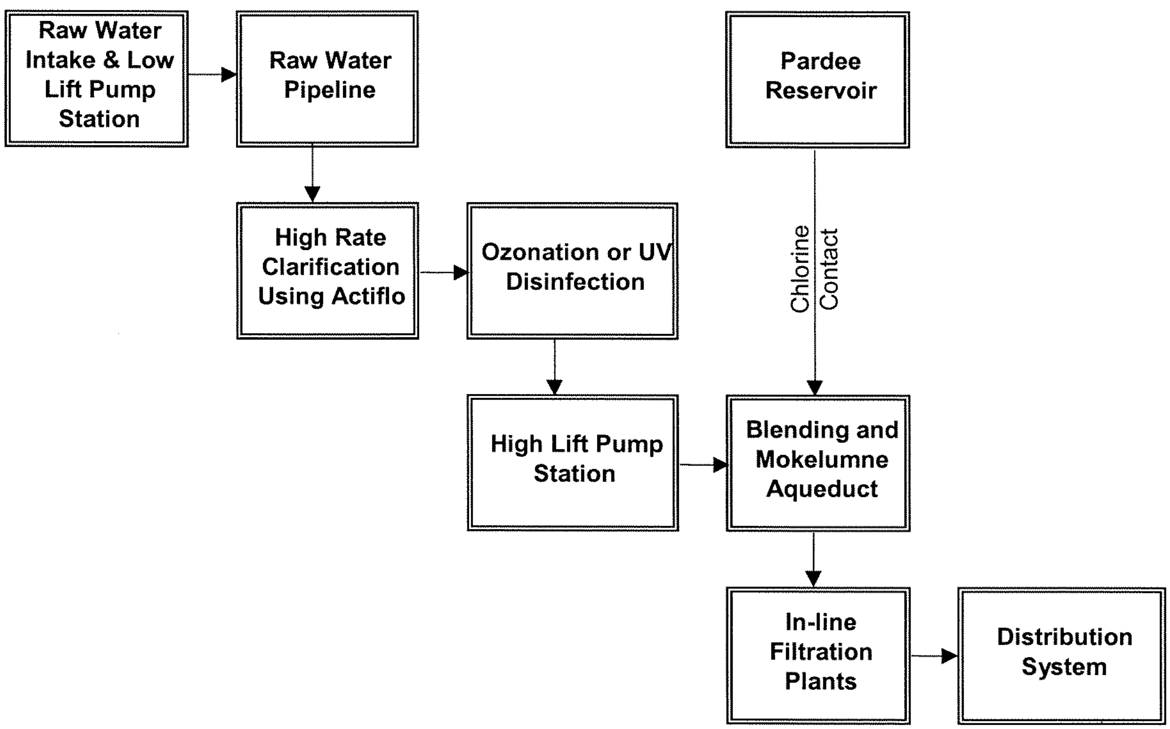
- a clarification step to reduce turbidity to levels that can be treated by EBMUD's in-line plants, and
- a disinfection step to achieve at least a 2-log inactivation of pathogens.

The proposed pretreatment scenario includes the processes of high rate clarification using Actiflo® and either ozone or UV disinfection. However, the proposed treatment process does not control for compounds that cause objectionable taste and odor. Equally important, a system designed to meet these regulatory requirements may not have sufficient capability to meet more stringent pathogen removal requirements or to control the levels of new pathogens or chemicals which may be required under future regulations. Figure 1 shows the pretreatment process diagram for treating Sacramento River water to achieve a water quality that complies with drinking water regulations. Appendix A shows the footprint for the design.

High Rate Clarification Using Actiflo

Actiflo is a proprietary ballasted flocculation process that is used to reduce the turbidity, TOC and pathogens in the water. Alum is used in the beginning of the process to form

Figure 1: Pretreatment Process Diagram for Sacramento River Water to Comply with all Drinking Water Regulations.



flocs, and then polymer and sand are introduced to the system to provide the "ballast" to which the flocs adhere. The purpose of a "ballast" is to allow for a more rapid clarification process. Settling of these "ballasted" flocs occurs within a small fraction of the time (<1/10) of a conventional clarification process.

Disinfection

Alternative 1: Ozonation

Ozone has been shown to inactivate *Giardia*, *Cryptosporidium*, and viruses. However, inactivation of *Cryptosporidium* requires ozone contact which, measured as the product of concentration and time, is between 10 and 20 times the ozone contact needed to inactivate

Giardia. It is assumed that ozone dosages on the order of 12 mg/L and contact chambers with 20 minutes residence time will be needed to inactivate two logs of *Cryptosporidium* in the clarified Sacramento River water. Pilot testing will be necessary to verify this dosage. Rapid sand filtration was not included in the design for the reasons presented on page 13.

Alternative 2: UV Disinfection

UV disinfection uses ultraviolet (UV) irradiation to inactivate pathogens. Low dosages of UV light have been shown to inactivate four logs (99.99%) of *Cryptosporidium* and *Giardia*. The effectiveness of UV for inactivating pathogens at a low cost makes UV disinfection an attractive process. Rapid sand filtration was not included in the design for the reasons presented on page 13. UV disinfection is effective in waters with turbidities of $\leq$ 2 NTU.

It should be noted that no drinking water UV disinfection installations have received an operation permit from the DoHS, to date, nor is UV used as the sole process to achieve pathogenic inactivation in any existing plant of the capacity proposed in this report. Also, UV disinfection of drinking water typically follows filtration, which produces water that is very transmissive to ultraviolet light. The proposed installation in this alternative would follow clarification, not filtration. In order to receive an operating permit to practice UV disinfection on this water, pilot testing to prove system reliability and performance will be required.

Treatment Scenario B: Complying with all Drinking Water Regulations and reasonably matching current finished water quality

Achieving a finished water quality similar to treating Mokelumne River source water requires adding taste and odor control to the processes in Treatment Scenario A. As stated above, the Sacramento River has a higher nutrient loading than the Mokelumne and the American Rivers due to urban and agricultural runoff and wastewater discharges. The higher nutrient levels will cause increased algal growth that in turn will produce compounds that impart objectionable taste and odor to the water. Therefore, to achieve a drinking water quality reasonably similar to that produced with Mokelumne River source water, compounds causing objectionable taste and odor need to be controlled. A 100 MGD pretreatment WTP consisting of high rate clarification using Actiflo, ozonation and UV disinfection will achieve a water quality similar to treated Mokelumne River source water. The ozonation process provides taste and odor control along with additional disinfection of *Giardia* and viruses. Figure 2 shows the pretreatment process diagram for treating Sacramento River water to achieve a water quality similar to Mokelumne River water. The footprint for the design is included in Appendix A.

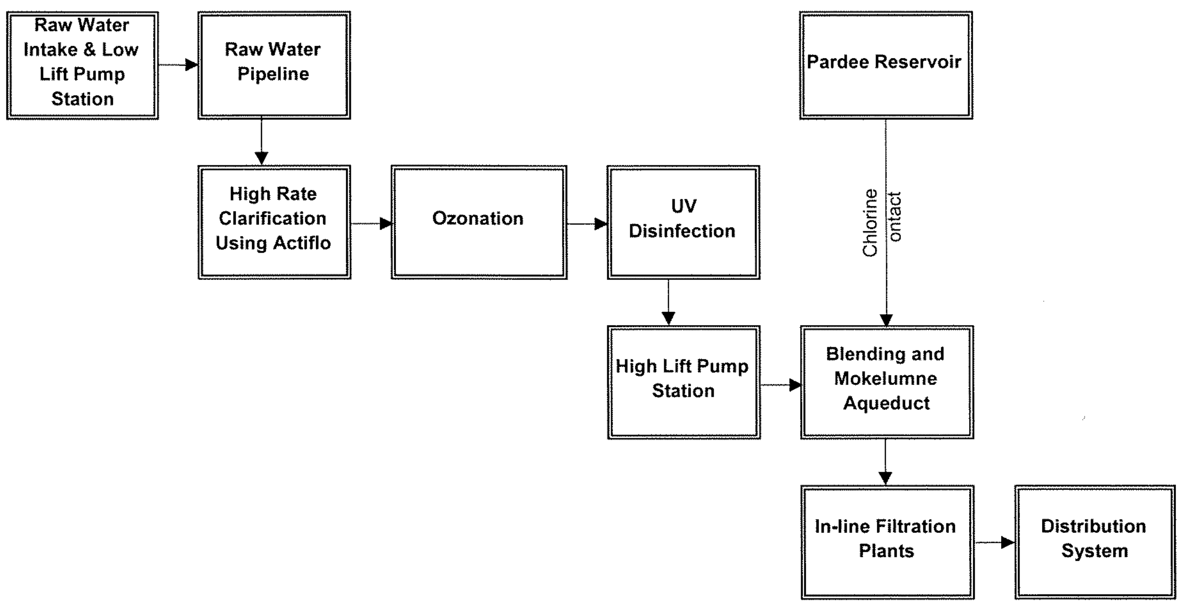
High Rate Clarification Using Actiflo

Actiflo is a proprietary ballasted flocculation process that is used to reduce the turbidity, TOC and pathogens in the water. Alum is used in the beginning of the process to form flocs, and then polymer and sand are introduced to the system to provide the "ballast" to which the flocs adhere. The purpose of a "ballast" is to allow for a more rapid clarification process. Settling of these "ballasted" flocs occurs within a small fraction of the time (<1/10) of a conventional clarification process.

UV Disinfection

UV disinfection uses ultraviolet (UV) irradiation to inactivate pathogens. Low dosages of UV light have been shown to inactivate four logs (99.99%) of *Cryptosporidium* and *Giardia*. UV disinfection is effective in waters with turbidities of $\leq$ 2 NTU. To date, no drinking water UV disinfection installations have received an operation permit from the DoHS, nor has UV been used as the sole process to achieve pathogen inactivation in any plant of the capacity (100 MGD) proposed in this document. Also, UV disinfection of drinking water typically follows filtration, to maximize the effectiveness of UV disinfection in very transmissive water. In this proposed design, however, UV disinfection would follow clarification and not filtration. In order to receive an operating permit for such a design, pilot testing to prove system reliability and performance will be required.

Figure 2: Pretreatment Process Diagram for Sacramento River Water to Reasonably Match Current Finished Water Quality.



Ozonation

Ozonation, in this alternative, will control compounds (particularly geosmin and 2-methyl isoborneol) that cause objectionable taste and odor, by oxidizing these compounds. The dosages required to control taste and odor are similar to those required for virus and *Giardia* inactivation. Since ozone is not being relied upon for disinfection credit, a much smaller contact structure is required. It is assumed that ozone dosages on the order of 6 mg/L will be needed to address taste and odor concerns in the clarified Sacramento River water. Pilot testing will be necessary to verify this dosage.

Process Concerns

A concern to using a chemical flocculation process during pretreatment (Treatment Scenarios A and B) is the reduced effectiveness of chemical coagulation using a similar process in subsequent treatment at EBMUD's existing facilities. The chemical coagulants alter the charge on the surface of the solids promoting the formation of flocs. In this altered state, it is unknown if adding a chemical coagulant a second time would be successful in forming flocs. This problem, however, may be resolved by blending the pretreated Sacramento River water with the Mokelumne River water and with travel time in the Aqueduct. During these processes, normal (negative) surface charge will be returned to the solids and addition of alum will properly condition them for removal in the in-line filtration process. Bench or pilot scale testing prior to full design of the pretreatment system will be needed to determine with certainty if it is possible to treat Sacramento River water twice with a chemical coagulant. Coagulation with alum is expected to increase sulfate and total dissolved solids concentrations by less than 10 mg/L.

The very high ozone dosages needed to achieve *Cryptosporidium* inactivation in Sacramento River water, can also have deleterious effects on treated water quality. These include reacting with naturally occurring organic material to form biodegradable organic carbon, which can result in biologically unstable water in the distribution system, as well as causing objectionable tastes and odors to develop in the water.

Finally, it should be noted that neither treatment scenario may provide the necessary power or flexibility to control contaminants if their current MCLs/SMCLs are made more stringent, or to control emerging chemical and biological contaminants.

Achievable Water Quality

The expected removal efficiencies for the proposed treatment processes for Alternatives 5, 6 and 7 are provided in Table 5. These removal efficiencies are only to be considered as estimates. Accurate predictions of removal efficiencies would need to be determined through bench and pilot testing.

Alternative 8A: Pretreatment of Delta Water from Indian Slough

The objective of pretreating water diverted from the Delta in proximity to Bixler is to reduce turbidity, TOC, and pathogens to levels that can be effectively treated by existing EBMUD facilities in compliance with drinking water regulatory requirements.

Treatment Designs Considered

- High-rate clarification using Superpulsators, rapid sand filtration, UV disinfection at Bixler, and new treated water pipeline. This alternative was not selected due to the extremely high cost of conveying the finished water to the distribution system.

- High-rate clarification using Superpulsators, rapid sand filtration, UV disinfection at Bixler, and blending with Mokelumne source water. This selected alternative combines a low cost physical removal process (clarification and rapid sand filtration) with the low cost inactivation process (UV disinfection) for control of *Cryptosporidium.*

- High-rate clarification using Superpulsators, ultrafiltration, UV disinfection at Bixler, and blending with Mokelumne source water. This selected alternative combines a higher cost physical removal process (membrane filtration) with a low cost inactivation process (UV disinfection) for control of *Cryptosporidium.*

Selected Process

- High-rate clarification using Superpulsators, rapid sand filtration, UV disinfection at Bixler, and blending with Mokelumne source water
- High-rate clarification using Superpulsators, ultrafiltration, UV disinfection at Bixler, and blending with Mokelumne source water

The proposed pretreatment scenario consists of diverting raw Delta water from Indian Slough and pumping it to a new 100 MGD pretreatment WTP located at Bixler. The 100 MGD pretreatment WTP would consist of high rate clarification using the Superpulsator®

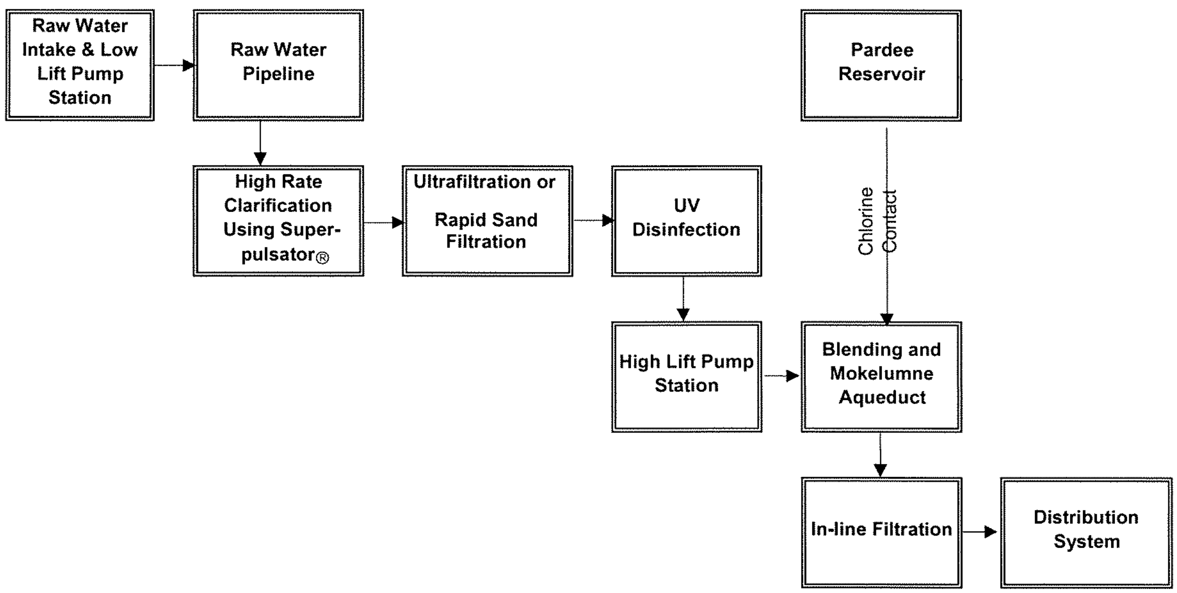
TABLE 5
Purpose and Achievable Water Quality with Proposed Pretreatment Processes

Diversion Option	Treatment Process	Achievable Water Quality	Rationale
Diversion from the Sacramento River to meet all drinking water regulations (see Figure 1)	High-rate clarification	Turbidity: 1-2 NTU TOC: 25-50% reduction Pathogens: 2 log reduction of *Giardia*, *Cryptosporidium*, and viruses	Pretreatment required because in-line EBMUD plants cannot effectively treat water with turbidity > 2 NTU. Lower THM formation potential will be achieved by pretreatment.
- 5A at Sacramento Water Treatment Plant - 6A at Freeport (East Conveyance) - 7A at Freeport (South Conveyance)	Ozone Or	Pathogens: 2 log reduction of *Cryptosporidium,* 3 log reduction of *Giardia* and viruses	Elevated pathogen levels require additional disinfection step to meet pathogen inactivation requirements.
	UV	Pathogens: 4 log reduction of *Giardia* and *Cryptosporidium*	
Diversion from Sacramento River to match current finished water quality (see Figure 2)	High-rate clarification	Turbidity: 1-2 NTU TOC: 25-50% reduction Pathogens: 2 log reduction of *Giardia*, *Cryptosporidium*, and viruses	Pretreatment required because in-line EBMUD plants cannot effectively treat water with turbidity > 2 NTU. Lower THM formation potential will be achieved by pretreatment.
- 5B at Sacramento Water Treatment Plant	UV	Pathogens: 4 log reduction of *Giardia* and *Cryptosporidium*	Elevated pathogen levels require additional disinfection step to meet pathogen inactivation requirements.
- 6B at Freeport (East Conveyance) - 7B at Freeport (South Conveyance)	Ozone	Oxidation of Geosmin and Methyl-isoborneol	Elevated algal levels require pretreatment to control objectionable T&O.

process with powdered activated carbon, followed by ultrafiltration and UV disinfection. The pretreated Delta water will then be pumped to a new 100 MGD blending facility where it will be mixed with Mokelumne River water in the Mokelumne Aqueduct. Figure 3 shows the process diagram for the pretreatment scenario for the Delta. The footprint for the design is included in Appendix A.

Currently, the Mokelumne River source water is chlorinated at Pardee Reservoir and again at Bixler, and disinfection is achieved within the Aqueducts. The water in the Delta is considerably higher in total organic carbon and bromide levels than in the Sacramento or the Mokelumne River. Blending insufficiently treated Delta water with the chlorinated Mokelumne River water, followed by chlorination at Bixler will result in an increase in THM and HAA concentrations that may exceed regulatory standards. In addition, the high bromide concentrations in the Delta water would cause the ratio of brominated to chlorinated DBP species to increase, elevating the public health risk from these DBPs. To reduce the health risk from chlorinated and brominated organic compounds, the pretreatment process needs to significantly reduce total organic carbon levels in the Delta

Figure 3: Pretreatment Process Diagram for Delta Water to Comply with all Drinking Water Regulations



diversion water prior to blending with the Mokelumne River source water. In addition, the chlorine residual in the Mokelumne River water at the blending point needs to be minimized to also reduce the formation potential of DBPs.

High Rate Clarification Using Superpulsator with PAC

Although blending with Mokelumne River water will reduce TOC levels by approximately 40%, this would not lower TOC to levels needed to ensure that existing in-line plant performance would not be compromised.

The Superpulsator is included in this treatment scenario to reduce TOC and turbidity. It is a proprietary up-flow clarification process that forms a floc blanket. A pulse flow allows for better mixing and solids separation of the blanket. Plate settlers are also used above the floc blanket to catch any flocs that escape the blanket. One advantage of the floc blanket is that it optimizes contact of powdered activated carbon for removal of total organic carbon. The Superpulsator with powdered activated carbon is expected to remove approximately 35 to 50 percent of the total organic carbon in the Delta water. Actiflo can not be used in this treatment train due to its reliance on polymers, which will clog the membranes in the ultrafiltration process, and its incompatibility with powdered activated carbon.

Ultrafiltration

Ultrafiltration is included in this treatment scenario primarily to remove pathogens, and to reduce turbidity further to enhance the effectiveness of UV disinfection. Ultrafiltration is a low-pressure membrane process that removes particulate matter larger than about 0.02 μm. As a pathogen barrier, ultrafiltration has been shown to remove up to 5 logs (99.999%) of *Giardia* cysts, *Cryptosporidium* oocysts and viruses. Ultrafiltration will produce a water quality with a turbidity of $\leq$ 0.05 NTU, however, it will not remove dissolved material such as total organic carbon. Ultrafiltration is preferred over microfiltration because ultrafiltration removes viruses. The capital and O&M costs for the two membrane processes are comparable.

Rapid Sand Filtration

Rapid sand filtration is included as a low-cost alternative to ultrafiltration in this treatment scenario to remove pathogens, and to reduce turbidity further to enhance the effectiveness of UV disinfection. As a pathogen barrier, rapid sand filtration has been shown to remove 1 or more logs of *Giardia* cysts, *Cryptosporidium* oocysts and viruses. Rapid sand filtration will produce a water quality with a turbidity of < 0.3 NTU.

UV Disinfection

To protect the public from pathogenic risk, DoHS strongly promotes a multi-barrier approach to disinfection. This approach typically includes an inactivation step, such as chlorination, ozonation or UV to follow a physical pathogen barrier. UV has been selected to inactivate pathogens, as a complement to physical removal by membrane filtration because it is a cost-effective method to inactivate four logs (99.99%) of *Cryptosporidium* and *Giardia*.

Process Concerns

The water produced using this treatment scenario will be substantially higher in TDS, chloride and bromide than the current finished water (see Table 4). From September 1977 to January 1978 EBMUD pumped Delta water from the Middle River. During this period, the Delta water was blended with Mokelumne River water to an average of 13 percent and then treated at the in-line filtration plants. Even with this minor input of Delta water, TDS in the finished water increased to 81 mg/L versus 40 mg/L before Delta pumping and brominated THM species increased from < 5% to between 10 and 30% during Delta use. The largest impact of the high TDS water was felt at the terminal reservoirs, however. At the Upper San Leandro Reservoir, the chloride levels increased from 8 to 40 mg/L from 1976 to 1978 due to Delta pumping. After an 8-year period they finally returned to their normal level (9 mg/L) in 1985. During the entire period of elevated chloride (and TDS), the Upper San Leandro WTP experienced increased percentage of brominated THM species. If Delta water is introduced to the system without removal of TDS, chloride, and bromide, at the frequency (~ once every three years) anticipated under EBMUD's Drought Planning Sequence, the terminal reservoirs may continually experience elevated levels of these contaminants.

The finished water is likely to have increased objectionable taste and odor from elevated algal metabolite levels in the raw water. It is not feasible to use ozone to control the compounds causing this taste and odor because of high bromide concentration and a high bromate formation potential. However, the use of powdered activated carbon may be effective at partially controlling compounds causing objectionable taste and odor.

This alternative does not reduce nutrient levels. Increased algal growth will occur at terminal reservoirs. In turn this will increase TOC levels and elevate THM formation potentials, as well as increasing the frequency and magnitude of compounds causing objectionable taste and odor at the Upper San Leandro and Sobrante WTPs. Increased bromide levels may also cause exceedance of the 10 ug/L bromate MCL in the finished water of these plants. The levels of brominated THMs and HAAs would also increase in the finished water of these plants.

Coagulation with alum is expected to increase sulfate and total dissolved solids concentrations by less than 20 mg/L.

Achievable Water Quality

The expected removal efficiencies for the proposed treatment processes for this pretreatment scenario are provided in Table 6.

Alternative 8B: Advanced Treatment of Delta Water from Indian Slough

The second alternative for treating Delta water is to provide advanced treatment. The objective of this alternative would be to produce a finished water quality similar to that which is achieved by treating Mokelumne River source water at existing EBMUD in-line treatment facilities.

Treatment Designs Considered

- Presedimentation, microfiltration, reverse osmosis, ozonation, corrosion control, chloramination, at Bixler and a new treated water pipeline

Selected Process

The advance treatment scenario consists of diverting raw Delta water from Indian Slough and pumping it to the 100 MGD Advanced WTP. Advanced treatment would include the presedimentation, microfiltration, reverse osmosis, ozonation, corrosion control and chloramination processes. The finished water would then be pumped and conveyed to a point where it can be blended with finished water from the existing EBMUD plants and put into the distribution system. Figure 4 shows the process diagram for the advance treatment scenario. The footprint for the design is included in Appendix A.

TABLE 6

Purpose and Achievable Water Quality with Proposed Pretreatment Process

Diversion Option	Treatment Process	Achievable Water Quality	Rationale
Diversion from Delta at Bixler to meet all drinking water regulations (see Figure 3) - 8A	High-rate clarification PAC addition	Turbidity: 2 - 4 NTU TOC: 50% reduction	Pretreatment required because in-line EBMUD plants cannot effectively treat water with turbidity > 2 NTU. Elevated TOC level requires pretreatment to lower THM formation potential.
	Ultrafiltration	Turbidity: 0.05 NTU Pathogens: 4 log reduction of *Giardia, Cryptosporidium* and viruses	Filtration required because in-line EBMUD plants cannot effectively treat water with turbidity > 2 NTU. Physical pathogen removal is preferable to chemical inactivation because elevated levels of bromide and TOC increase the formation potential of bromate and DBPs.
	Rapid Sand Filtration	Turbidity: 0.3 NTU Pathogens: 1 log reduction of *Giardia, Cryptosporidium* and viruses	Filtration required because in-line EBMUD plants cannot effectively treat water with turbidity > 2 NTU. Physical pathogen removal is preferable to chemical inactivation because elevated levels of bromide and TOC increase the formation potential of bromate and DBPs.
	UV	Pathogens: 4 log reduction of *Cryptosporidium* and *Giardia*	Low dosage pathogen inactivation to comply with DoHS disinfection requirements

Presedimentation

Presedimentation is a necessary process prior to microfiltration in order to remove large particles that could cause expensive damage to the membranes.

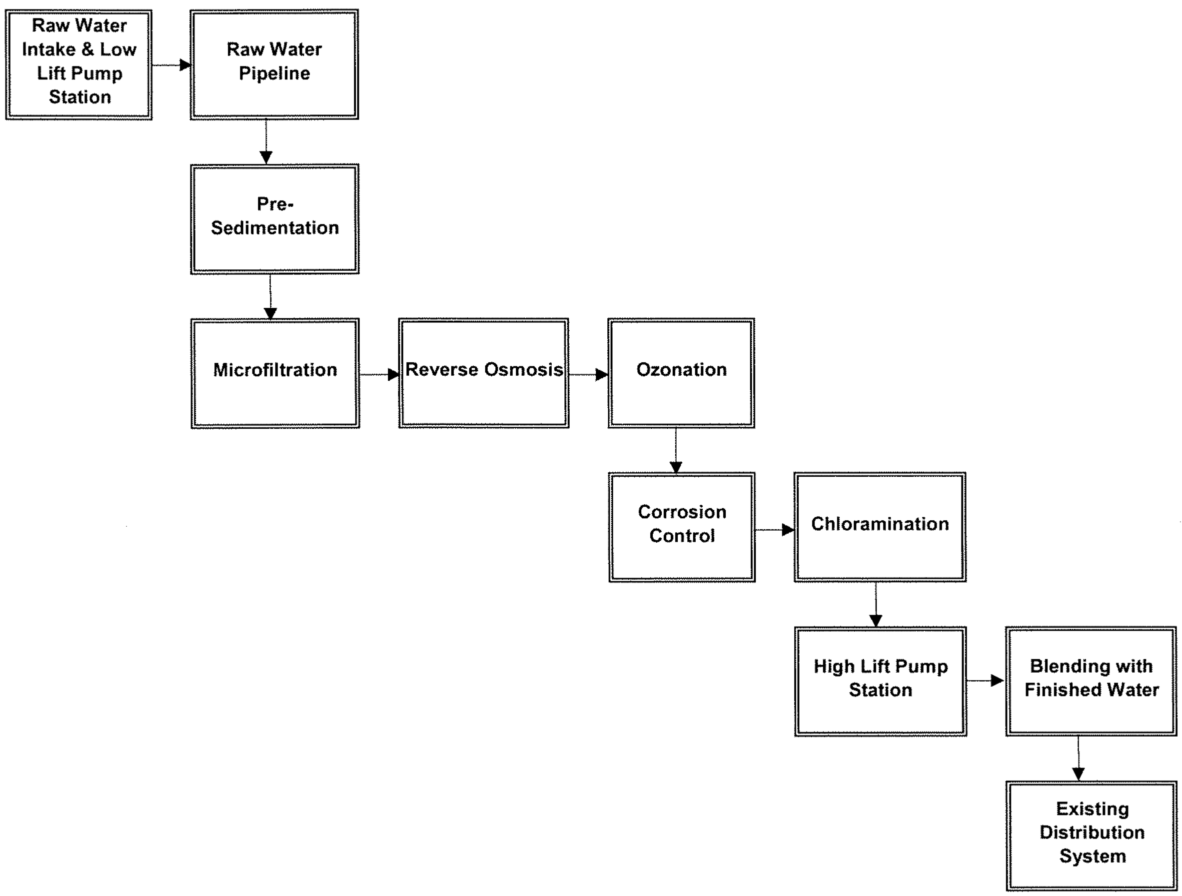
Microfiltration

Microfiltration is a low-pressure membrane process that removes particulate matter larger than about 0.2 μm. The resultant water from the microfiltration process will have turbidity of $\leq$ 0.1 NTU. Microfiltration has also been shown to remove 4 or more logs (99.99%) of *Giardia* cysts and *Cryptosporidium* oocysts. Microfiltration will not, however, remove dissolved material such as total organic carbon. The main reason for using microfiltration in this process is its ability to produce water that is suitable for reverse osmosis.

Reverse Osmosis

Reverse osmosis is a high-pressure membrane process that removes much of the dissolved material in water, such as total organic carbon, calcium, magnesium, sodium, bromide, etc. Reverse osmosis has also been shown to remove up to 7 logs (99.99999%) of enteric viruses, *Giardia* cysts, and *Cryptosporidium* oocysts. The two major reasons for using reverse osmosis in this process are the removal of bromide and total dissolved solids.

Figure 4: Treatment Process Diagram for Delta Water to Match Current Finished Water Quality



Corrosion Control

Because reverse osmosis removes nearly all of the hardness, the product water is highly corrosive. In order to make this water less corrosive, chemicals must be added to adjust the pH and increase the hardness and alkalinity.

Chloramination

Chloramination is the current process used at EBMUD's in-line filtration facilities to provide a residual disinfectant for the distribution system. Since the water from this plant will be pumped directly to the distribution system, chloramination must be provided at this facility. Chloramines are formed by the addition of chlorine and ammonia to the finished water.

Process Concerns

A potential concern with the proposed treatment train is that ozonation modifies organic matter making it more biologically available. This may cause re-growth of microorganisms in the distribution system. On the other hand, reverse osmosis will remove most of the organic matter, so there would not be a sufficient amount left in the water for ozone to activate re-growth problems. Reverse osmosis also removes much of the bromide in the water, thereby resolving the complications of forming bromate during ozonation and brominated disinfection by-products during chlorination.

In this alternative, a new finished water aqueduct would need to be constructed, at high cost, to connect the advanced treatment plant to the distribution system. Another alternative would be to blend the water from the advanced treatment plant into the existing aqueducts with the Mokelumne River water. This would have the disadvantage of mixing fully treated finished water with raw water, and thus, require the water to be retreated. However, it has a substantial cost advantage in eliminating the need for a new finished water aqueduct. There is uncertainty whether shifting the Aqueducts between treated and untreated Mokelumne River water would be permitted by DoHS. There is some concern over the ability of the existing in-line plants to treat this new blend of reverse osmosis water and Mokelumne River water.

Achievable Water Quality

The expected removal efficiencies for the proposed treatment processes for this advanced treatment scenario are provided in Table 7.

TABLE 7

Purpose and Achievable Water Quality with Proposed Treatment Process

Diversion Option	Treatment Process	Achievable Water Quality	Rationale
Diversion from Delta at Bixler to match current finished water quality (see Figure 4) - 8B	Microfiltration	Turbidity: 0.1 NTU Pathogens: 5 log reduction of *Cryptosporidium* and *Giardia*	Treatment required to reduce turbidity to meet finished water MCL of 0.3 NTU and as pretreatment for reverse osmosis.
	Reverse Osmosis	TDS: 95% reduction TOC: 95% reduction Bromide: 80% reduction Pathogens: 7 log reduction of *Cryptosporidium*, *Giardia*, and viruses	Treatment required for removal of TDS to match palatability of Mokelumne River finished water. Bromide and TOC removal will reduce formation of brominated DBPs.
	Ozonation	Oxidation of Geosmin and Methyl-isoborneol	Elevated algal levels require treatment to control objectionable T&O. Low dosage pathogen inactivation to comply with DoHS disinfection requirements

Costs

Individual process costs for Alternatives 3 through 8 are based on a plant flow of 100 MGD, except for the microfiltration process in Alternative 8B, which is based on 120 MGD. Costs for processes that use chemicals were also based on the dosage of the applied chemicals. Table 8 provides the chemicals and dosages assumed in the costing of these processes.

Costs for site work were estimated as 28 percent of the summation of all of the capital process costs. The site work is broken down into the following categories:

- Civil (5%)
- Yard Piping (10%)
- Electrical (5%)
- Instrumentation & Control (8%)

TABLE 8
Chemical Dosages used to Estimate Process Costs

Alternative	Chemical Feed Systems	Ozone	UV Disinfection
Alternatives 5A1, 6A1 and 7A1	Coagulants: Alum (30 mg/L) Polymer (3 mg/L)	12 mg/L for Cryptosporidium Inactivation	N/A
Alternatives 5A2, 6A2 and 7A2	Coagulants: Alum (30 mg/L) Polymer (3 mg/L)	N/A	40 mWs/cm^2
Alternatives 5B, 6B and 7B	Coagulants: Alum (30 mg/L) Polymer (3 mg/L)	6 mg/L for Taste and Odor Control	40 mWs/cm^2
Alternative 8A	Coagulants: Alum (30 mg/L) Polymer (3 mg/L) Powdered Activated Carbon (25 mg/L)	N/A	40 mWs/cm^2 after Ultrafiltration
Alternative 8B	Antiscalant, Acid, Lime and Calcium Carbonate	2 mg/L (after RO) for Taste and Odor Control	N/A

Additional costs for site work are included for the Alternatives located at Bixler (Alternatives 7 and 8), because the instability of the soils in this area required the installation of support piles.

Table 9 shows a cost comparison for treatment processes considered for Alternative 6 – Freeport East, Treatment Scenario A – meets all regulations. Table 10 shows a breakdown of chemical and power costs for the unit processes selected for use in this study.

Conveyance Sizing

Table 11 displays cost estimates for Alternatives 2, 4, 5, 6, 7 and 8 based on conveyance sizing and treatment at 155 cfs (100 MGD). For comparative purposes, cost estimates have been developed and displayed in Table 12 for Alternatives 2, 3, 5, 6 & 7 based on conveyance sizing at 350cfs (226 MGD). This conveyance sizing would enable these alternatives to provide the same benefit as the original joint project (Alternative #3) including providing for periodic planned outages of the Mokelumne River system. Treatment capacity for alternatives in Table11 is 350 cfs for wet-year-take alternatives and 155 cfs for dry-year-take alternatives. The environmental effects of these options are not analyzed in the supplemental environmental documentation and the cost data are provided to facilitate comparison of alternatives that provide equivalent benefits. Figures that diagram the conveyance and treatment locations for each of the Diversion Alternatives at both 155 and 350 cfs are provided in Appendix B.

TABLE 9

Cost Comparison for Options Considered[a]

Option	Conveyance[b]		Treatment[c]		Total	
	Capital	O&M	Capital	O&M	Capital	O&M
I. Blending with Mokelumne source water and treatment at upgraded EBMUD facilities (no pretreatment)	$247	$3.2	$228	$5.4	$475	$8.6
II. Conventional clarification - rapid sand filtration pretreatment at Brandt, blending with Mokelumne source water	$247	$3.2	$109	$3.1	$356	$6.3
II High-rate clarification - rapid sand filtration - chlorination at Brandt, new treated water pipeline	$597	$4.1	$100	$2.9	$697	$7.0
I High-rate clarification - ozonation pretreatment at Brandt, blending with Mokelumne source water	$247	$3.2	$113	$3.7	$360	$6.9
V High-rate clarification - UV pretreatment at Brandt, blending with Mokelumne source water	$247	$3.2	$65	$2.4	$312	$5.6

All costs expressed in August 2000 dollars. Capital costs are million dollars. O&M costs are million dollars per year.

a. Comparison is made for a representative alternative (Alternative 6 - Freeport East, Treatment Scenario A) 155 cfs conveyance and treatment capacity, 21.3 TAF/yr average delivery.

b. Conveyance from Freeport to Folsom South Canal to Mokelumne Aqueduct at Brandt

c. See Table 10 for treatment chemical and power unit cost assumptions

TABLE 10

Chemical and Power Unit Costs for Treatment Processes

Process	Unit Cost, $/million gallons	
	Chemicals[a]	Power[b]
Conventional clarification	$18	$0
High-rate clarification with Actiflo	$18	$0
High-rate clarification with Superpulsator	$245	$0
Rapid sand filtration	$0	$0
Chlorination	$12	$0
Ozonation (disinfection)	$0	$50
Ozonation (taste and odor)	$0	$25
UV	$0	$10

Costs expressed in August 2000 dollars.

a. Chemical cost based on: Alum @ $140/tn
Sodium Hypochlorite @ $900/tn
PAC @ $2000/tn

b. Power cost based on: Electricity @ $0.10/kwh

TABLE 11

Cost Estimates for Alternatives (155 cfs capacity)

Alternatives	Conveyance		Treatment		Total		Present Value[a]	
	Capital	O&M	Capital	O&M	Capital	O&M	Total	$/AF diverted
Alternative 2: American River at Nimbus								
Canal Terminus, Alignment 2								
1: Actiflo and Ozone Disinfection	$135	$2.0	$113	$2.6	$248	$4.6	$298	$658
2: Actiflo and UV Disinfection	$135	$2.0	$65	$1.6	$200	$3.6	$237	$523
Contract Turnout, Alignment 4								
1: Actiflo and Ozone Disinfection	$218	$2.3	$113	$2.6	$331	$4.9	$371	$819
2: Actiflo and UV Disinfection	$218	$2.3	$65	$1.6	$283	$3.9	$310	$684
Alternative 4: American River, Modified Project								
Site 5 Intake								
1: Actiflo and Ozone Disinfection	$254	$2.7	$113	$2.6	$367	$5.3	$409	$903
2: Actiflo and UV Disinfection	$254	$2.7	$65	$1.6	$319	$4.3	$348	$768
Fairbairn Intake								
1: Actiflo and Ozone Disinfection	$224	$2.7	$113	$2.6	$337	$5.3	$384	$849
2: Actiflo and UV Disinfection	$224	$2.7	$65	$1.6	$289	$4.3	$323	$714
Alternative 5: Sacramento River at Sacramento WTP								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$270	$3.2	$113	$3.0	$383	$6.2	$441	$689
2: Actiflo and UV Disinfection	$270	$3.2	$65	$1.9	$335	$5.1	$378	$591
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$270	$3.2	$99	$2.6	$369	$5.8	$421	$658
Alternative 6: Sacramento River at Freeport - East Conveyance								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$247	$3.2	$113	$3.0	$360	$6.2	$421	$659
2: Actiflo and UV Disinfection	$247	$3.2	$65	$1.9	$312	$5.1	$358	$560
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$247	$3.2	$99	$2.6	$346	$5.8	$401	$628
Alternative 7: Sacramento River at Freeport - South Conveyance								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$254	$3.2	$122	$3.0	$376	$6.2	$435	$681
2: Actiflo and UV Disinfection	$254	$3.2	$69	$1.9	$323	$5.1	$368	$576
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$254	$3.2	$107	$2.6	$361	$5.8	$415	$649
Alternative 8: Delta at Indian Slough.								
A: Meet Regulatory Requirements.								
1: Superpulsator w/ PAC, Ultrafiltration, and UV Disinfection	$42	$1.4	$211	$7.5	$253	$8.9	$392	$613
2: Superpulsator w /PAC, Rapid Sand Filtration, and UV Disinfection	$42	$1.4	$129	$4.6	$171	$6.0	$264	$414
B: Similar to Current Finished Water Quality								
Microfiltration, Reverse Osmosis, Ozone and Corrosion Control	$329	$2.1	$404	$14.4	$733	$16.5	$941	$1,472

All costs expressed in August 2000 dollars. Capital costs and total present value are million dollars. O&M costs are million dollars per year.

Operation and unit cost estimates were based on the following average annual deliveries:
15.1 TAF/yr for Alternatives 2 and 4. 21.3 TAF/yr for all other alternatives

Cost of water not included

a. Present value based upon assumptions used for the EBMUD Water Supply Management Program EIR:
30-year project period, 8% discount rate, 5%/yr escalation of O&M costs
Salvage value computed assuming 4%/yr capital escalation and straight-line depreciation over useful life of the facilities.

TABLE 12

Cost Estimates for Alternatives (350 cfs capacity)

Alternatives	Conveyance		Treatment[a]		Total		Present Value[b]	
	Capital	O&M	Capital	O&M	Capital	O&M	Total	$/AF diverted
Alternative 2: American River at Nimbus								
Canal terminus, Alignment 2								
1: Actiflo and Ozone Disinfection	$185	$2.3	$221	$4.9	$406	$7.2	$484	$598
2: Actiflo and UV Disinfection	$185	$2.3	$124	$2.9	$309	$5.2	$362	$446
Contract turnout, Alignment 4								
1: Actiflo and Ozone Disinfection	$300	$2.5	$221	$4.9	$521	$7.4	$581	$718
2: Actiflo and UV Disinfection	$300	$2.5	$124	$2.9	$424	$5.4	$459	$566
Alternative 3: American River, Joint Project[c]								
1: Actiflo and Ozone Disinfection	$344	$3.2	$113	$2.6	$457	$5.8	$493	$771
2: Actiflo and UV Disinfection	$344	$3.2	$65	$1.6	$409	$4.8	$432	$675
Alternative 5: Sacramento River at the Sacramento WTP								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$379	$2.7	$113	$3.0	$492	$5.7	$520	$813
2: Actiflo and UV Disinfection	$379	$2.7	$65	$1.9	$444	$4.6	$457	$715
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$379	$2.7	$99	$2.6	$478	$5.3	$500	$782
Alternative 6: Sacramento River at Freeport - East Conveyance								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$347	$2.7	$113	$3.0	$460	$5.7	$493	$772
2: Actiflo and UV Disinfection	$347	$2.7	$65	$1.9	$412	$4.6	$430	$673
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$347	$2.7	$99	$2.6	$446	$5.3	$473	$741
Alternative 7: Sacramento River at Freeport - South Conveyance								
A: Meet Regulatory Requirements.								
1: Actiflo and Ozone Disinfection	$369	$2.4	$122	$3.0	$491	$5.4	$513	$802
2: Actiflo and UV Disinfection	$369	$2.4	$69	$1.9	$438	$4.3	$446	$697
B: Similar to Current Finished Water Quality								
Actiflo, Ozone and UV Disinfection	$369	$2.4	$107	$2.6	$476	$5.0	$492	$770

All costs expressed in August 2000 dollars. Capital costs and total present value are million dollars. O&M costs are million dollars per year.

Operation and unit cost estimates were based on the following average annual deliveries:
27.0 TAF/yr for Alternative 2. 21.3 TAF/yr for all other alternatives

Cost of water is not included.

a. Treatment capacity is 350 cfs for wet-year-take projects (Alternative 2) and 155 cfs for dry-year-take projects (all other alternatives)

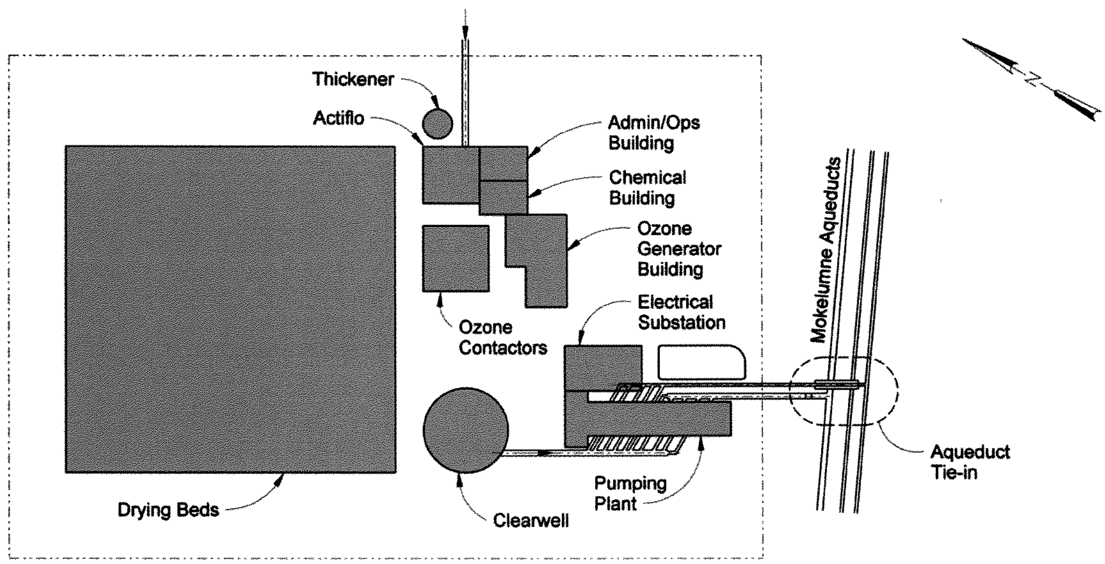
b. Present value based upon assumptions used for the EBMUD Water Supply Management Program EIR:
30-year project period, 8% discount rate, 5%/yr escalation of O&M costs
Salvage value computed assuming 4%/yr capital escalation and straight-line depreciation over useful life of the facilities

c. EBMUD share of costs shown for Alternative 3 (Joint Project)

Appendix A

Treatment and Pumping Facility Footprints

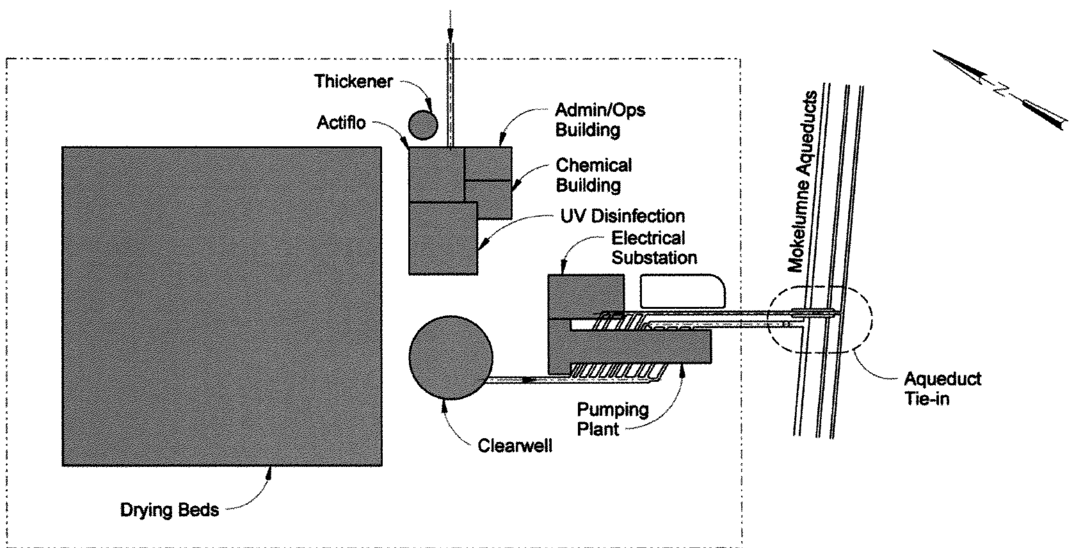
The figures in this appendix show the general layout of treatment and pumping facilities for the 155-cfs-capacity diversion alternatives addressed in this technical memorandum.



Site Plan
Scale 1"=200'

Alternatives 2-1, 3-1, 4-1, 5A-1, 6A-1, and 7A-1

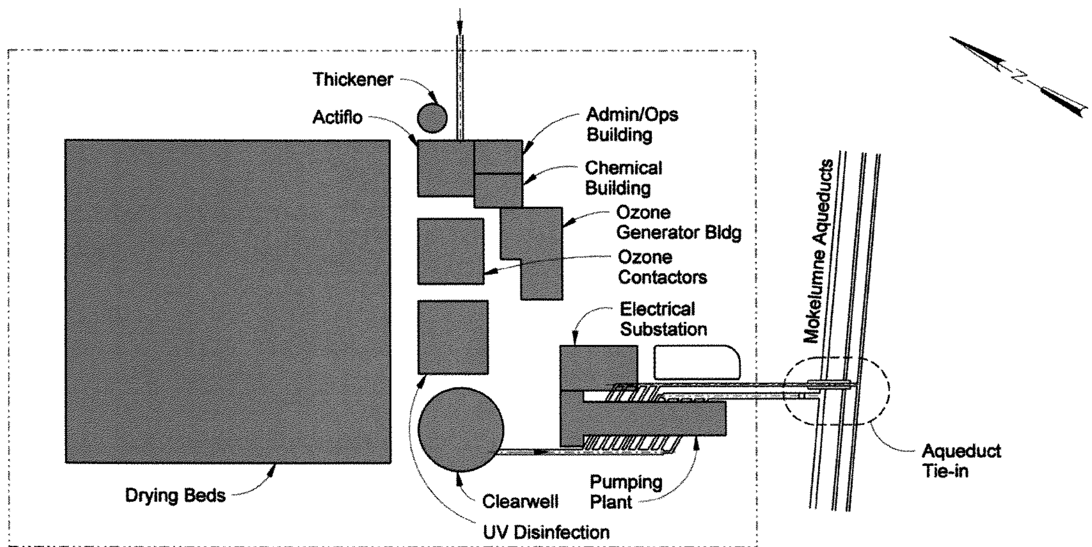
Pretreatment and Pumping Facilities for the American River and Sacramento River Diversion Alternatives.



Site Plan
Scale 1"=200'

Alternatives 2-2, 3-2, 4-2, 5A-2, 6A-2, and 7A-2

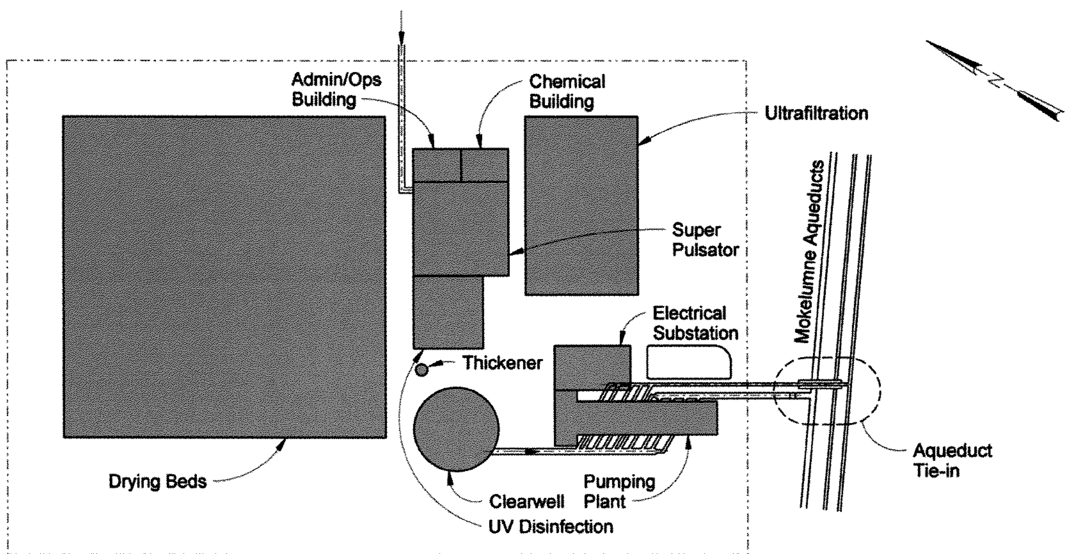
Pretreatment and Pumping Facilities for the American River and Sacramento River Diversion Alternatives.



Site Plan
Scale 1"=200'

Alternatives 5B-1, 6B-1, and 7B-1

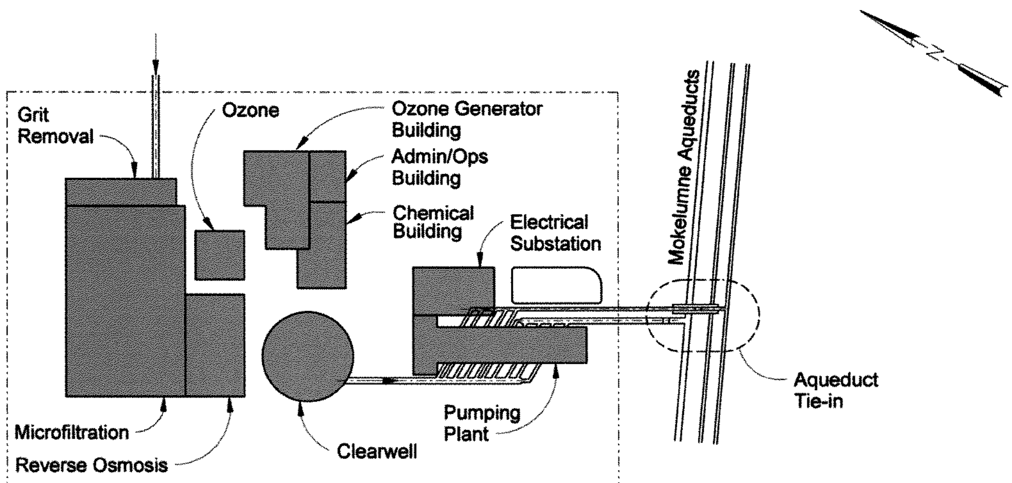
Pretreatment and Pumping Facilities for the Sacramento River Diversion Alternatives.



Site Plan
Scale 1"=200'

Alternative 8A

Pretreatment and Pumping Facilities for the Indian Slough Diversion Alternative.



Site Plan
Scale 1"=200'

Alternative 8B

Pretreatment and Pumping Facilities for the Indian Slough Diversion Alternative.

Appendix B

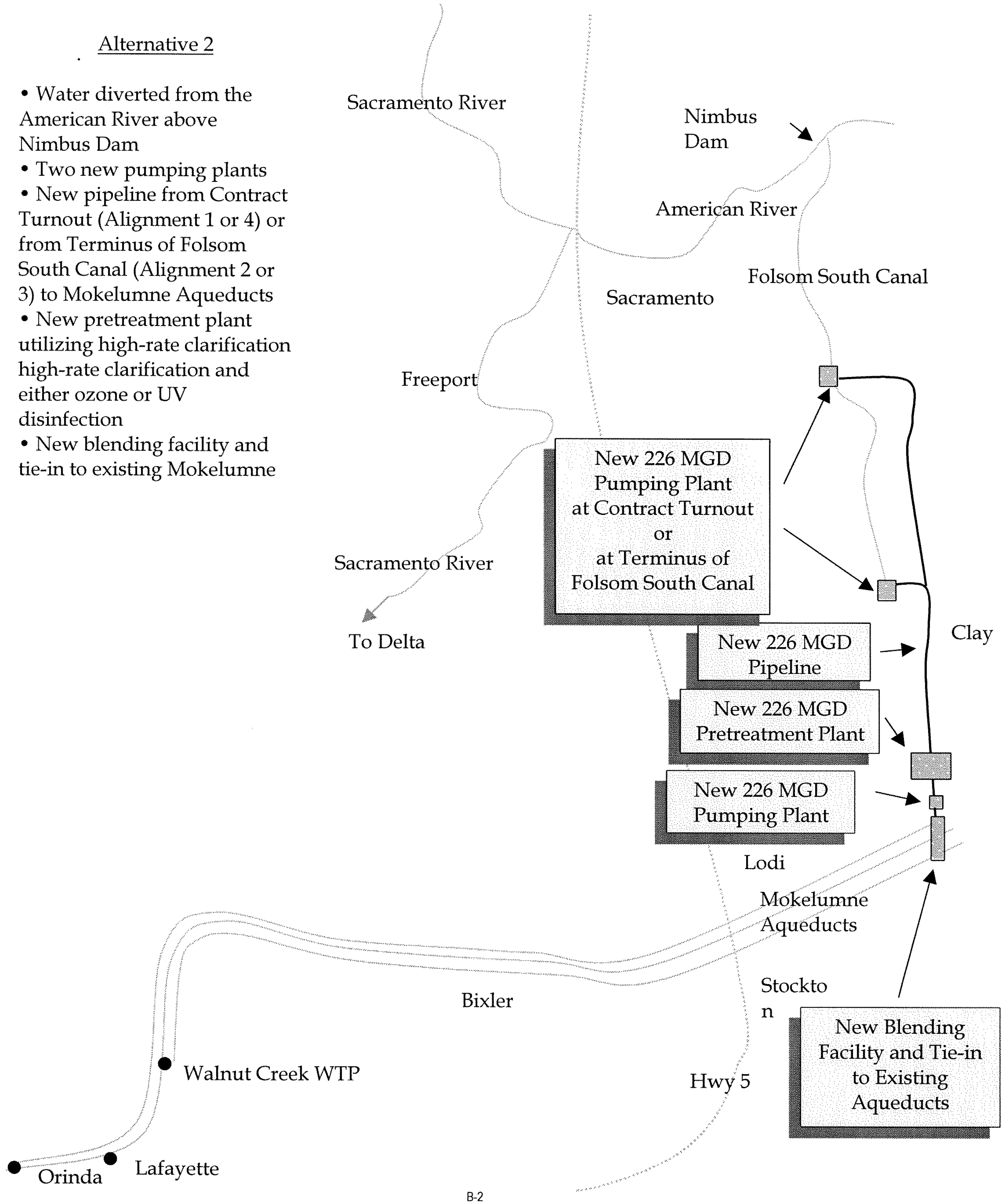
Alternative Diagrams

The figures in this appendix summarize the location, capacity, and general characteristics of facilities included of each of the seven diversion alternatives addressed in this technical memorandum.

Treatment and Conveyance for Water Diverted from the American River at Nimbus Dam

<u>Alternative 2</u>

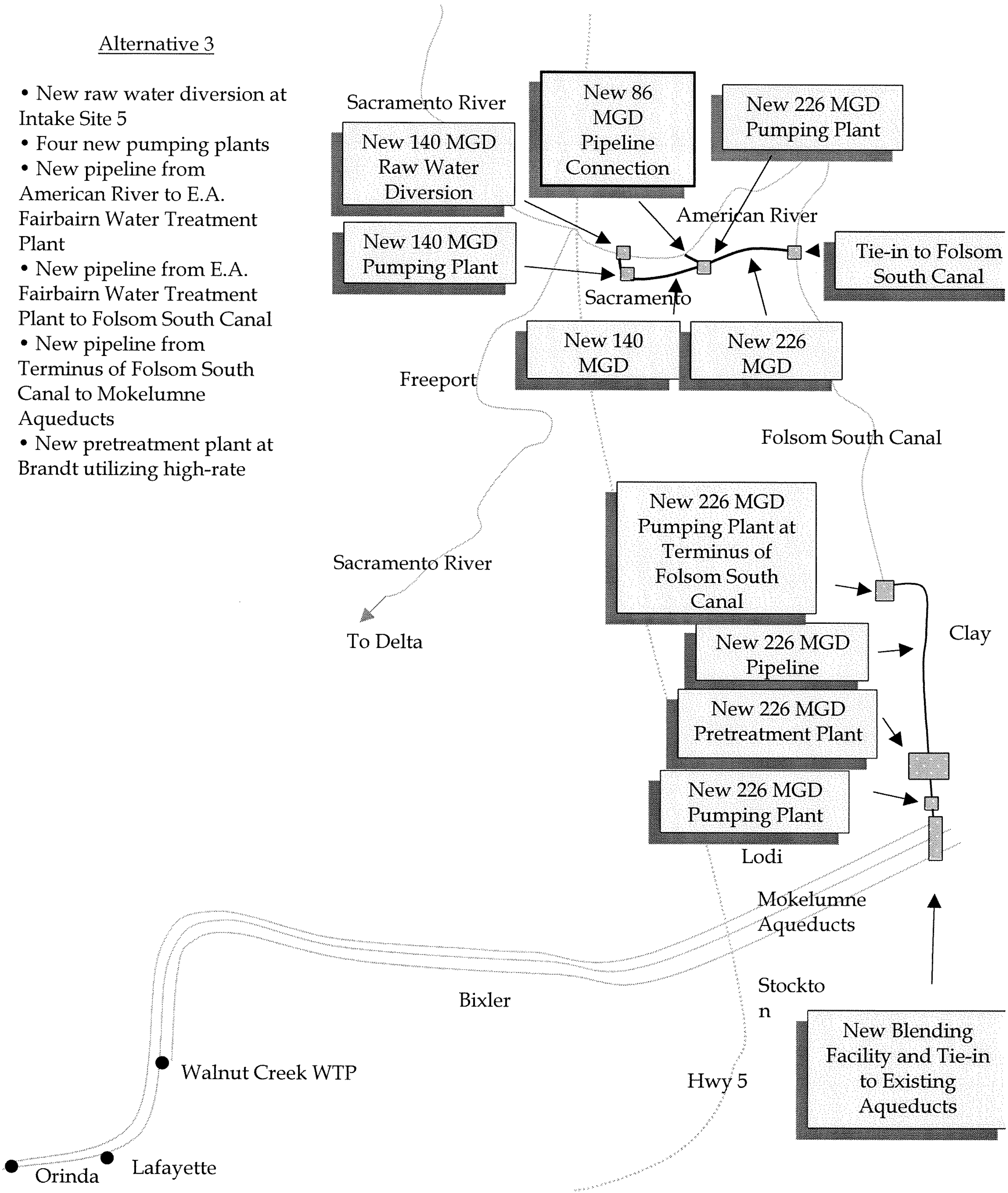
- Water diverted from the American River above Nimbus Dam
- Two new pumping plants
- New pipeline from Contract Turnout (Alignment 1 or 4) or from Terminus of Folsom South Canal (Alignment 2 or 3) to Mokelumne Aqueducts
- New pretreatment plant utilizing high-rate clarification high-rate clarification and either ozone or UV disinfection
- New blending facility and tie-in to existing Mokelumne



Treatment and Conveyance for Water Diverted from the American River at Intake Site 5 (Joint Project)

<u>Alternative 3</u>

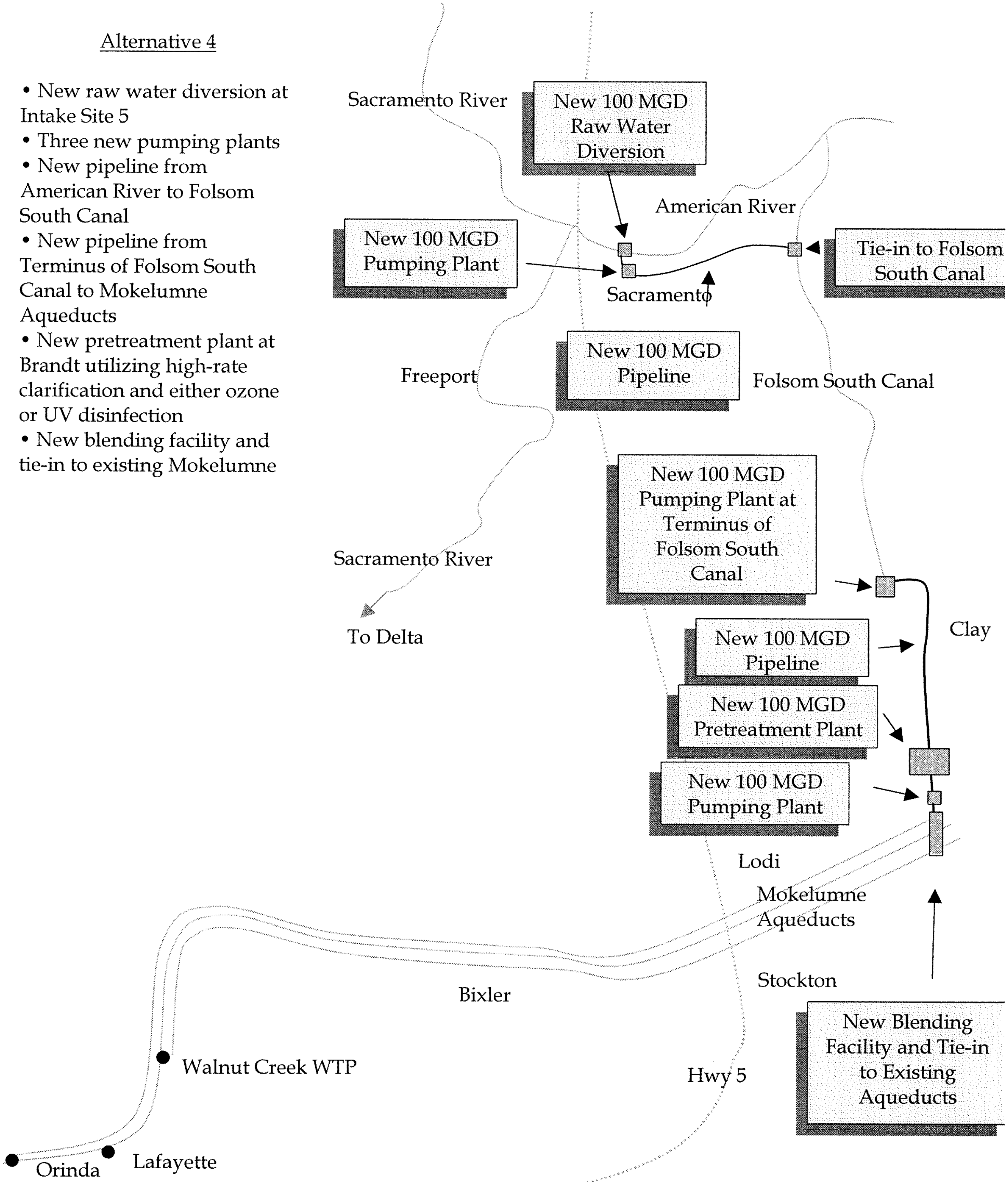
- New raw water diversion at Intake Site 5
- Four new pumping plants
- New pipeline from American River to E.A. Fairbairn Water Treatment Plant
- New pipeline from E.A. Fairbairn Water Treatment Plant to Folsom South Canal
- New pipeline from Terminus of Folsom South Canal to Mokelumne Aqueducts
- New pretreatment plant at Brandt utilizing high-rate



Treatment and Conveyance for Water Diverted from the American River at Intake Site 5 (Modified Project Proposal)

<u>Alternative 4</u>

- New raw water diversion at Intake Site 5
- Three new pumping plants
- New pipeline from American River to Folsom South Canal
- New pipeline from Terminus of Folsom South Canal to Mokelumne Aqueducts
- New pretreatment plant at Brandt utilizing high-rate clarification and either ozone or UV disinfection
- New blending facility and tie-in to existing Mokelumne

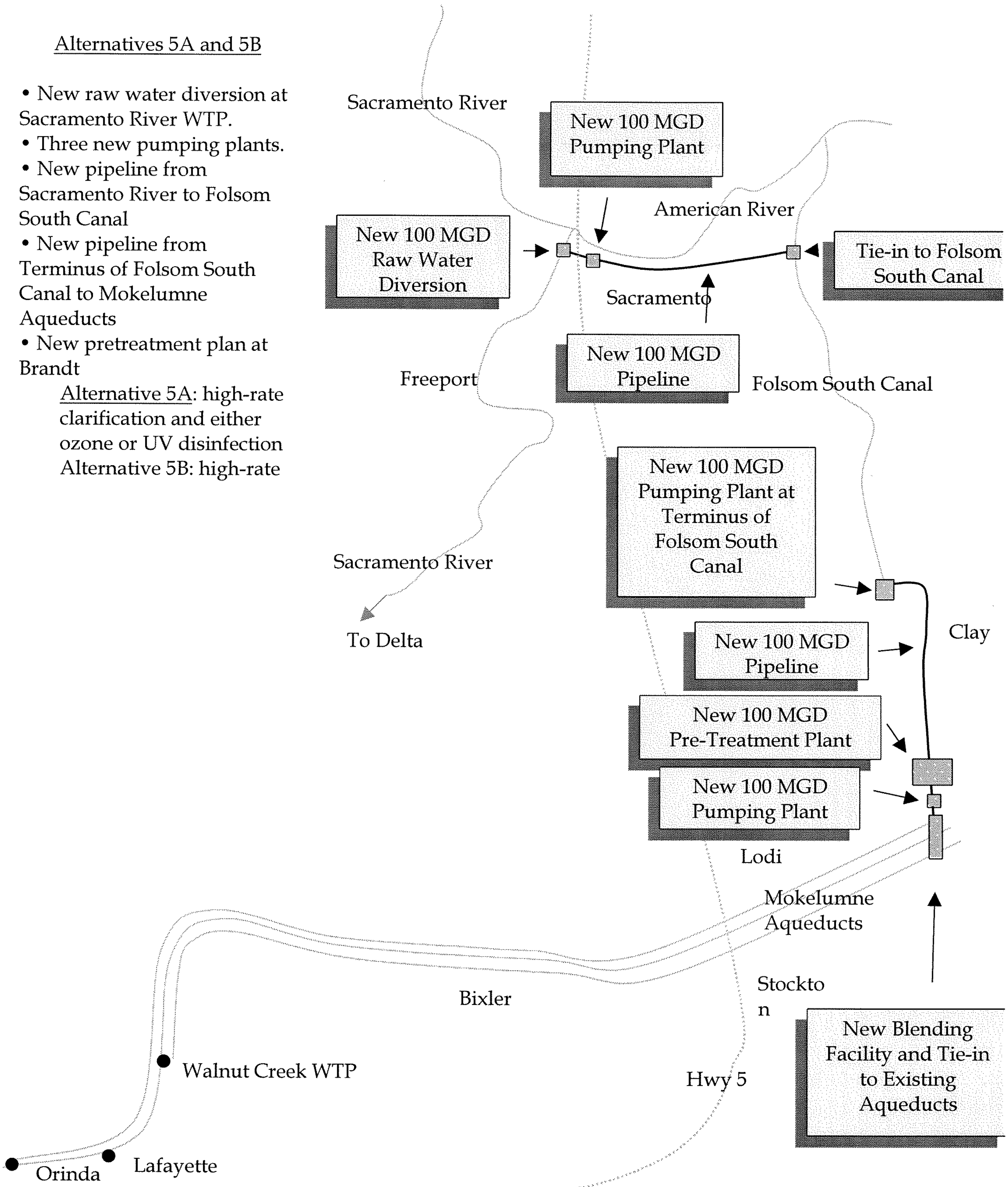


Treatment and Conveyance for Water Diverted from the Sacramento River at Sacramento River WTP

<u>Alternatives 5A and 5B</u>

- New raw water diversion at Sacramento River WTP.
- Three new pumping plants.
- New pipeline from Sacramento River to Folsom South Canal
- New pipeline from Terminus of Folsom South Canal to Mokelumne Aqueducts
- New pretreatment plan at Brandt

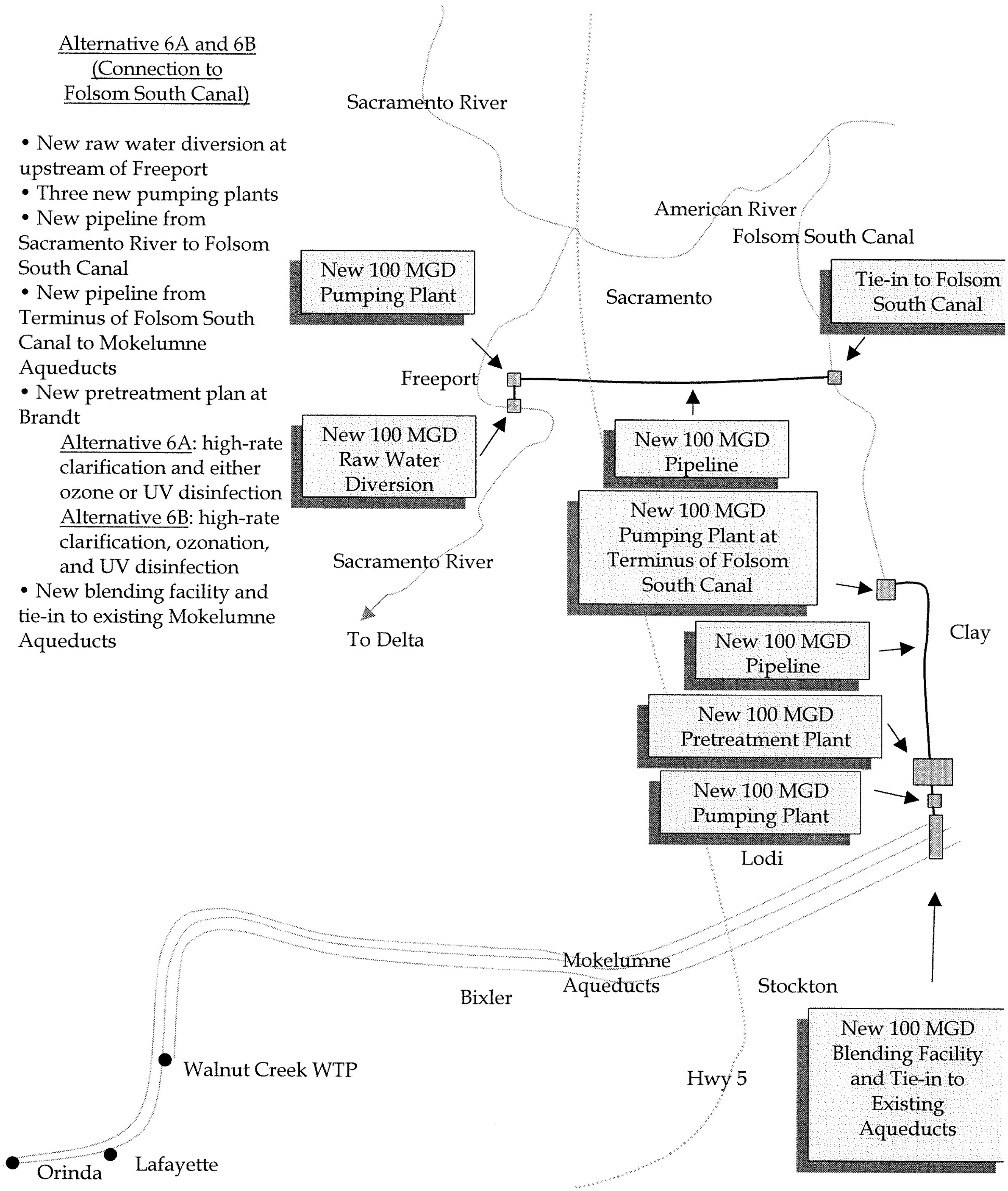
  <u>Alternative 5A</u>: high-rate clarification and either ozone or UV disinfection
  Alternative 5B: high-rate



Treatment and Conveyance for Water Diverted from the Sacramento River at Freeport (Freeport East)

Alternative 6A and 6B (Connection to Folsom South Canal)

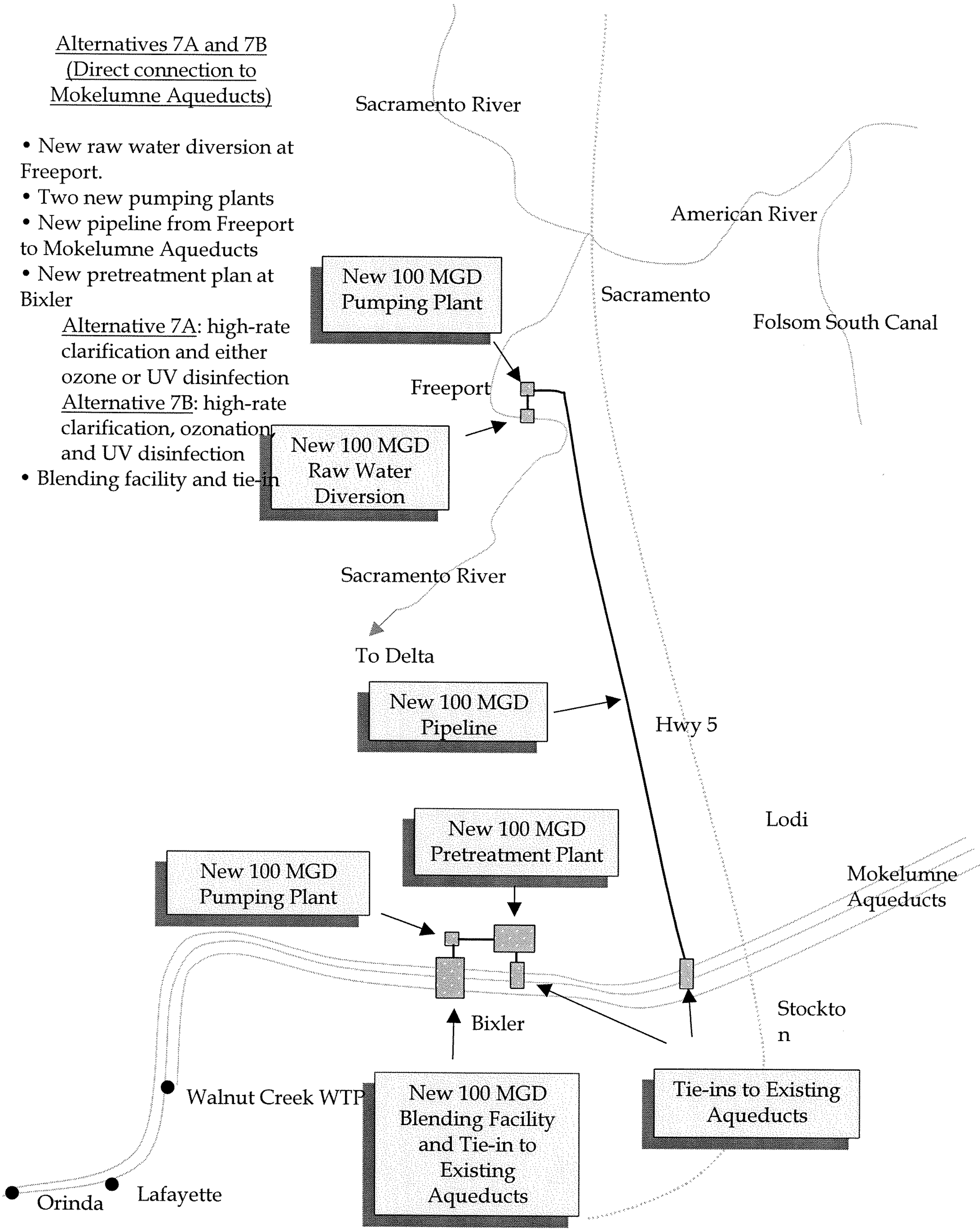
- New raw water diversion at upstream of Freeport
- Three new pumping plants
- New pipeline from Sacramento River to Folsom South Canal
- New pipeline from Terminus of Folsom South Canal to Mokelumne Aqueducts
- New pretreatment plan at Brandt
  - Alternative 6A: high-rate clarification and either ozone or UV disinfection
  - Alternative 6B: high-rate clarification, ozonation, and UV disinfection
- New blending facility and tie-in to existing Mokelumne Aqueducts



Treatment and Conveyance for Water Diverted from the Sacramento River at Freeport (Freeport South)

<u>Alternatives 7A and 7B (Direct connection to Mokelumne Aqueducts)</u>

- New raw water diversion at Freeport.
- Two new pumping plants
- New pipeline from Freeport to Mokelumne Aqueducts
- New pretreatment plan at Bixler
  - <u>Alternative 7A</u>: high-rate clarification and either ozone or UV disinfection
  - <u>Alternative 7B</u>: high-rate clarification, ozonation, and UV disinfection
- Blending facility and tie-in



Treatment and Conveyance for Water Diverted from the Delta at Bixler