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Testimony of Environmental Defense

Assembly Committee on Water, Parks & Wildlife

RESTORATION OF HETCH HETCHY VALLEY

October 10, 2006

Summary

Chairwoman Wolk and Honorable Committee Members:

I am Spreck Rosekrans, Senior Analyst for Environmental Defense. Thank you for the opportunity to testify today about the potential restoration of Hetch Hetchy Valley in Yosemite National Park.

For more than 35 years, Environmental Defense has been heavily involved in water issues in California. Meeting the water supply needs of the cities and farms in our great State is vital. In many cases, however, it has been deemed necessary to sacrifice important parts of our environmental and natural heritage to meet those needs. In more recent times, on the other hand, it has become evident that even as we continue to meet our growing need for water supply, we can undertake important restoration efforts, such as those at Mono Lake, on the Trinity and San Joaquin Rivers and in the San Francisco Bay-Delta. We believe that Hetch Hetchy Valley is also a place that we can restore for our children and grandchildren, and that we can do so without diminishing the Tuolumne River water supplies that the reservoir currently helps to provide.

Hetch Hetchy Valley was once one of California's most magnificent places. Like Yosemite Valley, 15 miles to the south, it was formed over tens of thousands of years as glaciers descended the Sierra Nevada mountains. Both valleys are surrounded by towering granite cliffs and are endowed with spectacular waterfalls. And peaceful Sierra rivers once meandered through meadows and grasslands on both valley floors, providing rich habitat for a wide variety of wildlife.

In 1890, Yosemite National Park was created, protecting and preserving almost 750,000 acres of California's Sierra Nevada, including Hetch Hetchy Valley. In the wake of the 1906 San Francisco earthquake and fire, however, a sympathetic Congress allowed a reservoir to be constructed in Hetch Hetchy Valley. Despite public outcry over the unprecedented act, park visitors would no longer be able to appreciate Hetch Hetchy Valley. No such project has since been allowed in a National Park.

Since 1923, Hetch Hetchy Reservoir has played an important role in providing water and power supplies to San Francisco and other communities. Any restoration plan must replace the vital services currently provided by the dam and reservoir. Further, replacement must be fully assured *before* restoration can begin.

Were it not possible to replace these services, Environmental Defense would not advocate for restoration. The State Report, *Hetch Hetchy Restoration Study*, confirms what Environmental Defense and others have found: that water and power replacement is possible and therefore restoration is indeed feasible.

We contend that restoration is not only feasible – it is in the public interest and should be pursued. Water supply modeling has shown that with straightforward changes to the conveyance system, more than 95% of the water and 60-80% of the hydropower provided by the present system can be retained. What would be lost can be replaced and there are ample ways to do so. There is only one Hetch Hetchy Valley, and its restoration would make Yosemite National Park whole once again. Moreover, California would be able once again to demonstrate to the world that great economies and great environments can coexist.

A few specific comments on the State Report:

The State Report found "no fatal flaws in the restoration concept".

> Environmental Defense agrees and made a similar finding in our own report, *Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley*.

The State Report includes a total cost estimate ranging from $3 billion to $10 billion, based on its "broad assumptions on a mix of facilities that may be required for water and power replacement."

> Environmental Defense has significant concerns with the methodology used to arrive at the cost estimates in the State Report and believes that the assumptions made in the State Report have greatly inflated the potential costs of restoration. For example, the alternatives analyzed by the State go far beyond the mere replacement of water and power. The State Report's low-end cost estimate includes new facilities and programs that would provide almost **three times** as much water as Hetch Hetchy Reservoir currently provides. The State Report's high-end cost estimate would provide more than **four times as much water supply**, and includes unreasonably high projections for the cost of a new reservoir, as well as for constructing and operating a new water treatment plant. At a minimum, the State Report should have made it very clear in its summary that the total costs include the cost of significant water supply expansion, instead of burying this information in the appendices. Therefore the State Report, while finding that restoration is feasible, does not provide a fair or representative estimate of the replacement and restoration costs.
>
> Further concerns about the State Report's cost estimates are presented below and in "Analysis of DWR Hetch Hetchy Cost Estimates", October 4, 2006, prepared by Bookman-Edmonston/GEI Consultants (see Attachment 2).

The State Report found that "future studies should be carried out to a consistent level across all issues, beginning with benefits".

> Environmental Defense agrees. We understand that it is a difficult undertaking to measure what the value of a restored valley would be, though as noted in Resources Secretary Chrisman's letter that launched the study effort leading to the State Report, "there are approaches that can be used."[1] We are disappointed that the State Report provides very little information related to the economic and environmental benefits of a restored valley and look forward to a comprehensive investigation of what

[1] See Attachment 1, letter from Resources Secretary Chrisman to Assemblymembers Wolk and Canciamilla, November 8, 2004.

> the value of a restored Hetch Hetchy Valley in Yosemite National Park would be.

The State Report suggested that "in future studies Hetch Hetchy restoration should be supported by a robust stakeholder process and that such studies cannot be led by the State alone."

> Environmental Defense agrees. Future studies should provide an opportunity for broad stakeholder involvement, including the communities who rely on the Tuolumne River for water and power as well as the interested public. These studies should address restoration in the context of California's future, including anticipated needs for water and power supplies, as well as for recreation. The challenge will be to construct a process that will give confidence to all parties that their needs will be met as studies proceed and a complete restoration proposal is evaluated.

Thank you again for the opportunity to testify. I am happy to answer any questions.

Additional Comments

The California Resources Agency's "Hetch Hetchy Restoration Study" has done the public a valuable service in summarizing the findings of the many Hetch Hetchy restoration studies produced over the last two decades. Having provided substantial input into the review process, Environmental Defense is in most cases pleased by the State Report's comprehensive discussion of existing studies and the need for more research. We believe, however, that the State Report overstates the potential costs and fails to adequately explore the benefits of restoration. This written testimony provides in greater detail Environmental Defense's perspective on the information provided by the State Report.

Feasibility

The State Report splits the question of feasibility into two categories, technical and financial. Regarding the first, the Report plainly concludes that "It does appear technically feasible to restore the Hetch Hetchy Valley." It leaves open to question, however, whether restoration is "financially feasible" and describes several areas where more work must be done to arrive at any such conclusion.

While undefined in the report, "financial feasibility" can reasonably be interpreted as whether it is within the public interest to allocate substantial funds to the cause of restoring Hetch Hetchy Valley. To answer that question, it is important to understand more fully the benefits of restoration, the costs of restoration, and how those costs might be allocated among those who would benefit from a restored valley.

In spite of the statement the State made when it announced its intention to study restoration, the State Report includes very little information related to what the economic benefits of a restored valley would be. Drawing solely from benefits studies of other dam removal projects, the state estimated the potential annual benefits of a restored valley as a range which stretched from $26 million to $6 billion.

The State Report's estimate for the full cost of restoration ranges from $3 billion to $10 billion, a much narrower range than that reported for benefits, but still quite large. Environmental Defense contends that restoration can be accomplished at less than the lower end estimate of $3 billion – see below for detailed comments on the flaws in the State Report's cost estimates.

Neither the State Report nor any previous studies make any definitive recommendation about how restoration should be financed. Environmental Defense believes that it is premature to propose any specific plan. Instead, in the context of California's future, including anticipated needs for water and power supplies, as well as for recreation, a more detailed restoration plan should be developed, including both water and power replacement components associated directly with Hetch Hetchy restoration, and a valley restoration plan. Public and potential private support for such a plan would determine to what extent public funding would be warranted and, ultimately, whether restoration is "financially feasible".

Documents Reviewed by State Report Team

The State Report is based on a review of existing studies of Hetch Hetchy Valley, which it divides into government studies completed between 1988 and 1990, and more recent analyses completed between 2002 and 2005. The more recent group includes Environmental Defense's *Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley*. The San Francisco Public Utilities Commission did not submit a comprehensive study, but did provide a series of four technical reports, prepared by consultants, that the State Report describes as "essentially a rebuttal to the ED report." The State Report acknowledges the "Environmental Defense reply to the SFPUC's technical reports", submitted August 19, 2005. The State Report, however, does not acknowledge two additional documents that Environmental Defense submitted for review, so it is unknown to what extent the findings in those documents were considered. These documents are:

- *Cherry Intertie Alternative* (February, 2005), which shows that an intertie from the SFPUC conveyance system to Holm Powerhouse below Cherry Lake would perform largely the same hydrologic purpose as an intertie to Don Pedro Reservoir; and
- *Hetch Hetchy Water Supply in Context* (May, 2005), which provides a list of projects that have developed 6.4 million acre-feet of storage, more than 17 times the volume of Hetch Hetchy Reservoir, in California during the last 15 years[2].

Restoration of the Valley

In its assessment of the ecosystem restoration of Hetch Hetchy Valley, the State Report largely relied on information from the 1988 National Park Service report. The NPS report provides a useful but very general inventory of vegetation and wildlife surrounding the valley floor. The methodology it used to describe how plants and animals would respond under various scenarios for restoring the valley is, however, outdated. In the last 18 years since the NPS report was published, major advances have been made in the field of ecosystem restoration which could help guide the development of restoration alternatives, as well as provide estimates for how long thorough restoration would take.

The State Report indicates that should the valley be restored "new data on alternatives would need to be collected and analyzed" including various scenarios regarding draining the reservoir, dam removal or modification, and managing

[2] These documents are available from Environmental Defense on request.

restoration. Based on case studies for other river restoration projects which were collected and evaluated by the University of Wisconsin, Environmental Defense believes that the best approach for restoration would be to drain the reservoir over a period of 3-5 years[3]. As the reservoir is drained, restoration of exposed areas could be carefully managed and invasive species could be controlled. In general, Environmental Defense agrees with the conclusion in the State Report that "with a higher degree of appropriate active management, ecosystem recovery time would be minimized."

The State Report does include a comparison of "Hetch Hetchy Outdoor Visitor Uses" with and without the reservoir. Unfortunately, the summary table (Figure 4-2) is misleading because it leads the reader to believe that the activities presently available to Hetch Hetchy visitors are on par with what would be available if the valley is restored. Figure 4-2 obscures what is obvious: primary park activities such as hiking, walking, rock climbing and camping would be vastly enhanced by a restored valley floor.

Deciding how to manage a restored valley and to what degree development should be allowed is an important discussion that will require broad public input. While Yosemite Valley is a mecca for tourists from around the world, it is often criticized for its traffic jams, extensive development and pollution. The opportunity to restore Hetch Hetchy Valley is an opportunity to create a better version of Yosemite Valley, one that is visitor and family friendly and that provides ready access to the wonders of nature.

Dam Removal or Modification

Environmental Defense agrees with the State that is possible to pursue restoration without removing O'Shaughnessy Dam. The dam could be breached with a hole big enough to accommodate the Tuolumne River during flood stage. The dam would be a prominent non-natural feature at the mouth of the valley. Visitors at the base of Kolana Rock, however, would be very close to cliffs thousands of feet high and would scarcely notice a 300-foot dam a mile downstream. And if those visitors travel another ½ mile up the nine mile long valley, they would not even be in view of the dam. Environmental Defense believes that restoration should be considered with or without the dam in place. And if the dam is left place while the valley is restored, future generations can choose whether they wish to remove it.

[3] Bennet, A. et al, "Hetch Hetchy Valley: A Plan for Adaptive Restoration," University of Wisconsin, 2004

Benefits of a Restored Valley

The State Report points out that there is very little information enumerating public use opportunities and benefits of restoration. Despite the dearth of available information on economic benefits, the State Report clearly states that increasing recreational opportunities in the valley would "likely have a positive economic impact on the communities in the area and strengthen Yosemite National Park's role as a primary economic engine for the communities in the central Sierra Nevada region of the state." Moreover, the State Report asserts that future demand for recreational opportunities, like those enabled by a restored Hetch Hetchy Valley, would be "substantial". Environmental Defense agrees with these findings of the State Report and believes that a comprehensive study of the economic benefits of restoration is warranted.

The State Report suggests that the annual benefits of a restored valley could range from $26 million to $6 billion, depending on what sorts of values are measured. The estimation of the direct benefits from restoration, such as revenues flowing to the park and local economy from increased visits (which represent the low end of the State's range), is relatively straightforward. Estimating what value restoration holds for the affected public, however, is a more involved task. Like a visit to the Grand Canyon, Yellowstone, the Statue of Liberty or so many of our national parks, the *value* of a visit to a restored Hetch Hetchy Valley is worth far more than the *cost* of making the trip. The upper bound of the state's benefit range attempts to capture some of this "non-use" value, by citing numbers from contingent valuation studies carried out for other comparable resources and projects. But due to Hetch Hetchy's unique history and unprecedented scale, the relevance of past studies to Hetch Hetchy's case is questionable.

An original study, employing contingent valuation techniques to the particular case of Hetch Hetchy would offer important insight into the public's valuation of such a gain as the restoration of Hetch Hetchy Valley. It should undertake the difficult task of assessing the value of an experience for which there may often not be a similar alternative, and it should also reference a burgeoning literature that ascribes existence values to scenic places that capture people's imagination, but which they may never have a chance to visit themselves. While such an effort was understandably beyond the scope of the State's study, it remains very clearly the largest information gap in the restoration debate. As a result, the debate has been largely dominated by discussions of cost, while the potentially very large economic benefits of restoration have received little attention. It is crucial that we have a better-serving estimate of the benefits at stake in Hetch Hetchy Restoration in the debate moving forward.

Overview of Cost Issues

Overall, the State Report used a very conservative belt-and-suspenders approach to estimate the cost of a restoration plan that did not include any attempt to identify a least-cost solution. The State Report's cost estimate of between $3 and $10 billion for the entire project is unreasonably high, and has caused significant negative reaction to the proposal for restoration.

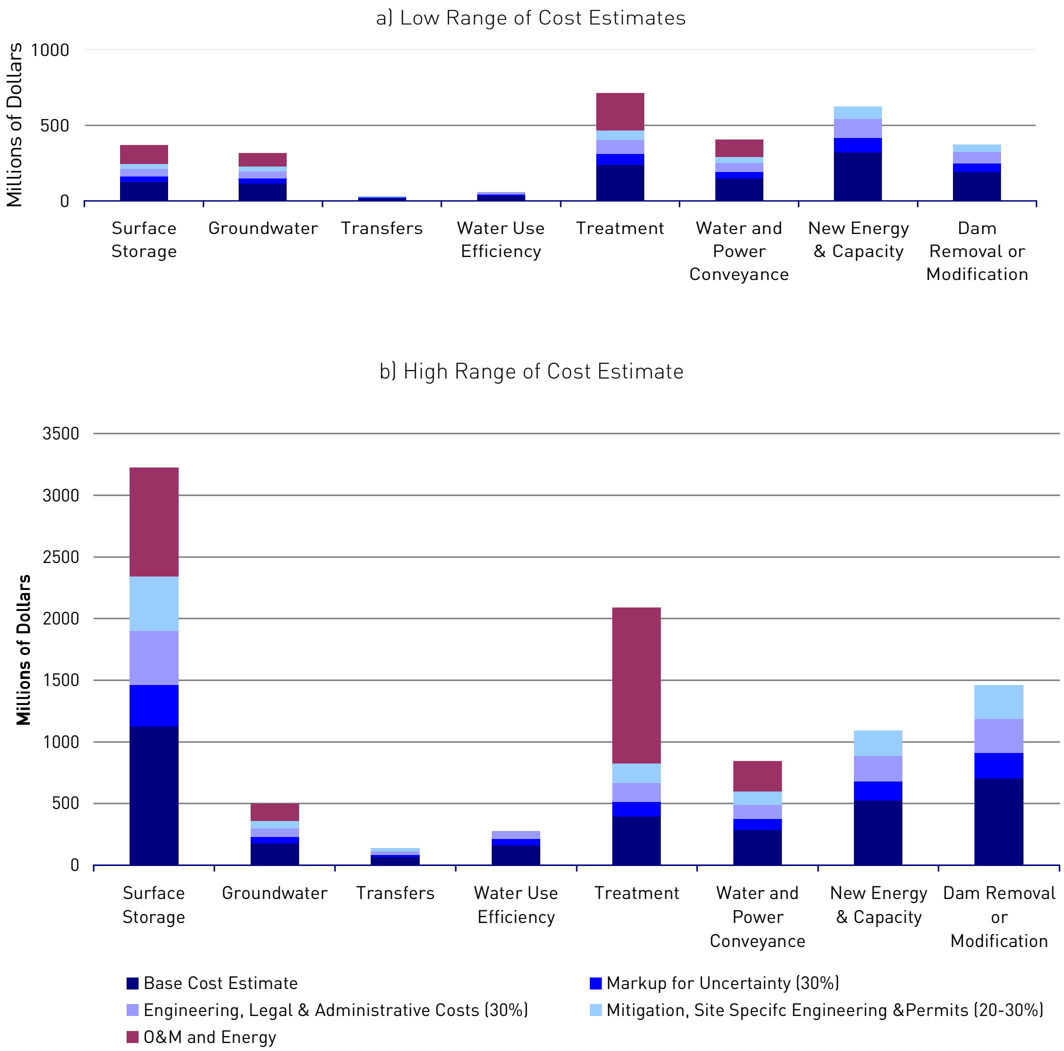
There are a number of specific aspects of its cost estimates which deserve reevaluation, including:

- The State Report includes new facilities and programs that would provide three to four times as much water as Hetch Hetchy Reservoir currently provides;
- The State Report includes a very expensive reservoir project that should be not be included as part of any reasonably low-cost proposal;
- The State Report assumes that no project is ever built on budget, and applies an overly generous 30% allowance for contingencies to all cost estimates of water and power replacement and of valley restoration, inflating the total cost estimate of a restoration plan;
- The State Report has assumed that the cost of virtually all projects will be increased by 30% for engineering, legal and administrative costs (ELA) and 20-30% for mitigation, site-specific engineering and permitting costs (MSP), rather than applying those costs in varying degree to the extent that they are warranted. Again, this significantly inflates the cost estimates;
- Combining adders for contingencies, ELA and MSP more than doubles all construction cost estimates. As described by Bookman-Edmonston/GEI Consultants, this is "highly unusual" even at a reconnaissance level of analysis." (see Attachment 2);
- The State Report assumes capital costs for water treatment that are in excess of the actual costs of recently completed projects; and
- The State Report overestimates the operating costs of water treatment plants.

These and other concerns related to the cost of a restoration plan are discussed in more detail below. Environmental Defense believes that a restoration plan can be fully developed that would cost far less than the $3 billion lower estimate found in the State Report. We also believe that a cooperative effort among interested parties would provide the best forum for identifying and implementing a cost-effective plan.

FIGURE 1

Hetch Hetchy Restoration Study Cost Estimates (California Resource Agency)



- A 30% "uncertainty estimate" is added to all base construction estimates, creating a total component cost.
- To each component cost, and additional 30% is added for engineering, legal and administrative costs (ELA)
- To each component cost, and additional 20-30% is added for mitigation, site-specific engineering and permitting costs (MSP)
- Most items require an annual 2% cost for ongoing operations and maintenance. Applying the State's parameters for study period and discount rate, as well as allowance for contingencies, ELA and MSP results in life cycle O&M costs of approximately 74% of the initial construction estimate.

Water Supply Modeling

Environmental Defense appreciates the State Report's finding that "Some good work has been done on modeling of the existing Hetch Hetchy system, as well as modeling of water and power replacement options for the restoration of Hetch Hetchy Valley." The State Report's general description of Environmental Defense's TREWSSIM (Tuolumne River Equivalent Water Supply Simulation Model) is accurate. The State is correct that the modeling studies completed by UC Davis and Environmental Defense are at the "concept level", and more detailed study is needed.

The State acknowledges that it did no water supply modeling of its own.

Water Supply Replacement Options

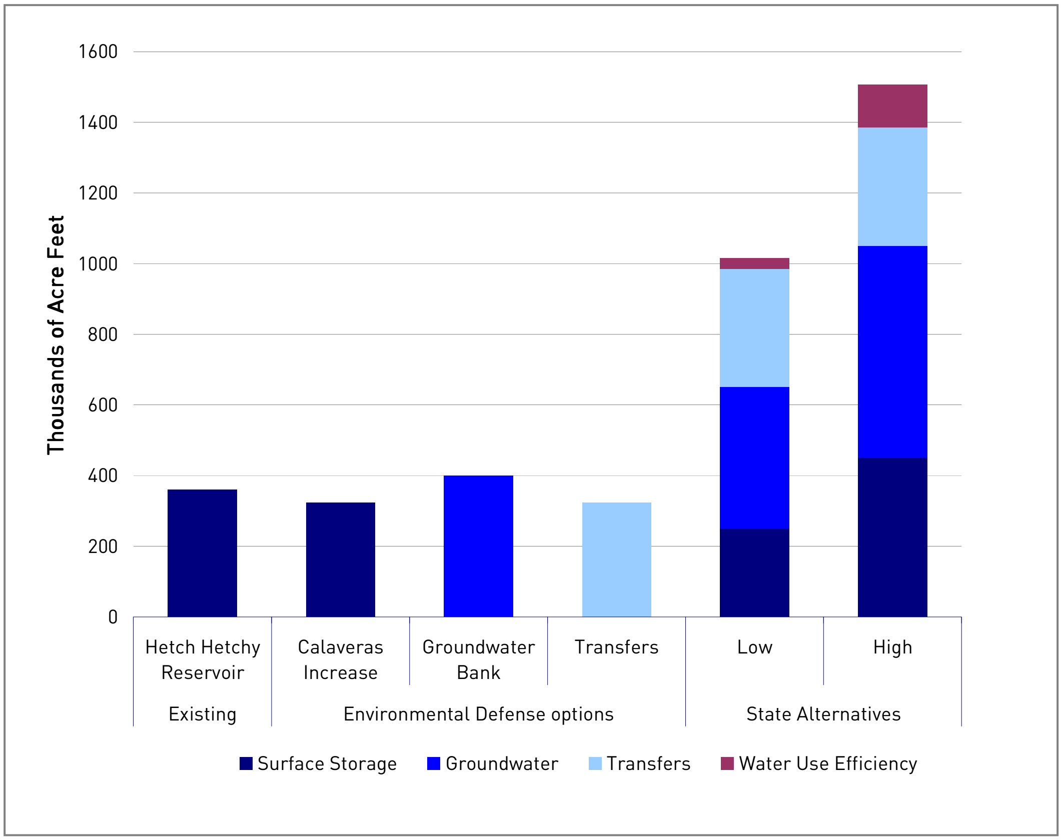
The State Report includes new facilities and programs that would provide three to four times as much water as Hetch Hetchy Reservoir currently provides. As the basis for its cost estimates, the State Report uses "the most comprehensive water supply and power replacement alternative" that Environmental Defense modeled. The water management components assumed in the State Report's cost estimate include:

- 250-450 TAF new surface storage
- 200-300 cfs peak groundwater extraction capacity (400 TAF storage volume)
- 400 cfs Don Pedro Intertie
- 56 TAF maximum annual dry year water transfers
- 5-20 TAF increased water use efficiency

The State Report's selection of water supply replacement components vastly overstates the amount that would be required. While the State observes that its resource mix was patterned after an alternative submitted by Environmental Defense, it neglects to incorporate the important fact that that particular alternative also included an anticipated significant increase in demand (as projected by the SFPUC). Since the reservoir expansion in this alternative was proposed by the SFPUC to meet future demand and used as such in modeling studies, Environmental Defense did not include its cost in the cost of restoration. The State Report should have done the same. It should not have included the cost of meeting future demand as part of the cost of restoration.

The State Report includes *all* water supply replacement components (surface storage, groundwater storage, transfers and water-use efficiency) on both the low end and high end of its cost range. As a result, the State Report's low-end estimates include facilities to replace the supply by a factor of 2.85 and the high-end estimate would replace the supply by a factor of 4.21. The State Report suggests a number of potential rationales for increasing, rather than replacing, water supply, and ascribing

FIGURE 2
Water Supply Alternatives



The water supply alternatives evaluated in the State Report would provide between three and four times as much water supply as Hetch Hetchy Reservoir currently provides.

Surface and groundwater storage values are comparable on a one-for-one basis with the existing storage in Hetch Hetchy Reservoir. Total supplies from transfers and conservation are assumed to derive over a six-year drought period, consistent with the historic drought of record for the Tuolumne River basin that occurred from 1987 to 1992.

the full cost to the cost of restoring Hetch Hetchy Valley, but does not provide justification for any of these rationales.

The State points out that it "chose this mix of facilities upon which to pattern its cost estimates because it provides a diverse mix of benefits". Environmental Defense agrees that water systems should employ a diverse set of resources to maximize reliability, but notes that Hetch Hetchy Reservoir represents only about 25% of the

SFPUC's total system storage, and it is not necessary to replace it with a diverse mix of resources to provide an equivalent level of supply.

The State Report speculates "that a one-for-one replacement of Hetch Hetchy water supplies would not be adequate to support restoration of the valley." Environmental Defense believes that it is not appropriate for the State to assume that a significant increase in water supply would be necessary to support restoration. Further, the State Report should have made it very clear in the report's summary that the total costs include the cost of significant water supply expansion. Instead this information is buried in the appendices.

In further explanation of its inclusion of an increased water supply, the State Report notes "broad objectives [that] may include environmental mitigation and enhancement, improved recreation, and replacement of power supply, not only water supply replacement." If the State believes, for example, that replacement with groundwater storage would be less efficient than the current reservoir, it should explain why and attempt to quantify degree to which additional supply would be needed.

The merits of restoration should be judged against the cost of providing services equivalent to those provided by the existing reservoir. If an approach is ultimately taken that leads to a comprehensive plan that includes additional water and power benefits as well as restoration benefits, then the sum total of all those benefits should be weighed against the plan's total cost.

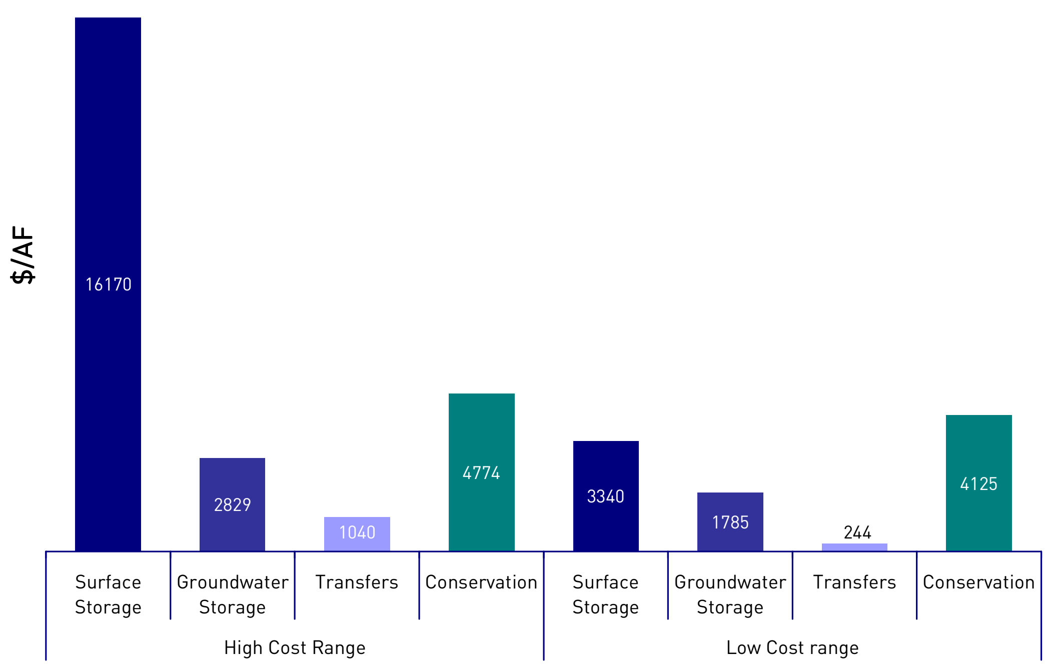
<u>The Highly Variable Cost of Water Supply Replacement</u>

Embedded in the State Report is a wide variety of costs associated with water supply replacement. Indeed, the highest cost option is more than 66 times the cost of the lowest cost option. Certainly it would be incumbent on any restoration plan to consider the most cost-effective water and power replacement alternatives.

Figure 3 compares the cost, on a per acre-foot basis, of each of the four resource options at the low and high cost ranges. The actual water provided to the SFPUC is relatively small, only an average of 13,000 acre-feet per year, as water supply modeling has shown that upwards of 95% of the system's water can be provided by its other reservoirs and the river's natural flow, as long as an intertie is built between the SFPUC conveyance system and either Don Pedro or Cherry Reservoirs and institutional issues involved in developing such an intertie are addressed.

The State Report's widest ranges in cost for any study component are for surface storage - from $500 to $2500 per acre-foot of storage. The State Report did not attempt to identify a least-cost restoration scenario but merely laid out a list of

FIGURE 3
Unit Cost of Replacement Supply



The State Report's highest estimate for the cost of water supply replacement is more than 66 times its lowest estimate.

- All values calculated by Environmental Defense based on the State Report's findings.
- All unit costs are determined by apportioning annualized life-cycle costs across the average water supply benefit. The costs are generally high, but it is important to note that the benefits occur in the driest years, when other system resources are inadequate to meet full system demands.
- Surface storage costs use the State's base costs for reservoir construction ($500-2500 per acre-foot), which are then increased by 30% to account for contingencies, 30% of engineering, legal and administrative costs, and 20-30% for site-specific engineering, mitigation and permits, as well as operations and maintenance costs. Essentially, $2500/acre-foot becomes, when fully burdened, $7162/acre-foot. While the State used different sizes for surface reservoirs, for this analysis each reservoir is prorated to 400 TAF.
- Groundwater costs are based on 200 and 300 cfs of extraction capacity. Analysis with Environmental Defense TREWSSIM model suggests 200 cfs is sufficient to provide system reliability for a 400 TAF groundwater bank, but 300 cfs is used as a more conservative assumption in the State's high-end cost estimate.
- Transfer costs in the State Report appear to be based on an average of 10 TAF per year, compared to the 13 TAF per year that is needed, so the State's cost figures were adjusted upward.
- Conservation would save water in all years but from a financial perspective would be needed only in critically dry years. Note that even the State's high-end estimate of 20 TAF per year would fall far short of the supply needed in a drought, and that the costs for additional measures might be incrementally higher.

components and potential costs. Environmental Defense believes that it is incumbent on advocates and public agencies alike to seek least-cost solutions.

At the high end of the State Report's cost estimates, the base cost of a 450,000 acre-foot replacement reservoir is estimated to be $1.125 billion. The total life cycle cost of this reservoir (see below for explanation of the State Report's cost "adders"), would be $3.223 billion. Using the State Report's discount rate and study period, the unit cost of the water provided by this project would be approximately $16,170 per acre-foot, more than 15 times the fully-burdened high-end assumption of $1,040 per acre-foot for transfer supplies. Any reservoir which promised water delivery at that cost is unlikely to be constructed.

The unit costs for generating additional supply are particularly high because the water supply benefits occur only in dry years. Further study should be able to identify additional water supply replacement components that would be more cost effective. For example, under the conditions faced by the SFPUC, it would be worthwhile to consider whether an environmentally sensitive desalination project could replace the dry year supplies that would be lost if Hetch Hetchy Valley is restored. Desalination might also provide a degree of diversity to improve local reliability, in case an unexpected calamity should befall the SFPUC's San Joaquin pipelines through which 85% of its water flows.

Conveyance

The State Report includes four potential conveyance projects as part of its restoration plan. They are (1) an intertie from Holm Powerhouse (below Cherry Reservoir) to the Mountain Tunnel, (2) an intertie from Don Pedro Reservoir to the Foothill Tunnel, (3) a modified intake to the Canyon Tunnel, and (4) an expanded South Bay Aqueduct. Environmental Defense agrees that it is appropriate to consider these projects, but also believes that the State Report's descriptions of their potential placements and purposes should be broadened. Further, there are additional conveyance options, such as interties with other Bay Area agencies or between the Stanislaus and Tuolumne watersheds, which could increase overall system performance and should be evaluated in the context of valley restoration.

Water supply modeling by Environmental Defense has shown that interties from either Holm Powerhouse or Don Pedro Reservoir to the SFPUC conveyance system would enable the SFPUC to continue to divert Tuolumne River supplies to meet more than 95% of its needs without Hetch Hetchy Reservoir. There are slight differences in how the two interties could be expected to perform.

The State Report characterizes the intertie at Holm as a power supply alternative. It would in fact serve both water and power uses. While the SFPUC initially considered this project to increase hydropower production, it could well serve as the principal means to deliver stored Tuolumne River supplies to the Bay Area during summer and fall when run-of-river diversions below Hetch Hetchy Valley are not possible. As discussed in Environmental Defense's *Cherry Intertie Alternative*, this intertie would be marginally inferior to an intertie at Don Pedro from a water supply perspective, but would be superior from a hydropower perspective.

Environmental Defense's *Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley* suggests three different locations for an intertie to Don Pedro Reservoir: directly from Don Pedro to the Foothill Tunnel, from Don Pedro to Moccasin Reservoir, and from below La Grange Reservoir to the San Joaquin Pipelines. A fourth alternative would be to divert from the lower Tuolumne River, just above its confluence with the San Joaquin River, to the San Joaquin Pipelines. Such an intertie would allow for water to stay in the Tuolumne River longer, providing instream benefits. Water for this intertie might be diverted from a "gallery" under the river to minimize environmental impacts and enhance water quality.

It may well be a good idea to construct interties to both Cherry and Don Pedro Reservoirs. Being able to use either intertie would allow for maximization of water supply, hydropower and instream benefits.

Environmental Defense's proposal to restore Hetch Hetchy Valley, like almost all other such proposals, relies on a Tuolumne River solution. About 85% of the SFPUC's water comes from the Tuolumne River, while the remaining 15% is derived from Bay Area watersheds. During drought years, the SFPUC has taken Delta water from the San Francisco Bay-Delta estuary through the South Bay Aqueduct. Environmental Defense believes that the SFPUC should continue to rely on the Tuolumne River for the vast majority of its water supply. We also believe, without regard to the restoration of Hetch Hetchy Valley, that the SFPUC should establish an intertie to the State Water Project, either through an expanded South Bay Aqueduct or through a connection directly to the California Aqueduct.

The SFPUC would rarely, or might even never, use an intertie to the State Water Project. It would be invaluable, however, as insurance in case its Tuolumne River source were for any reason (such as earthquake, tunnel collapse, or terrorism) unavailable. While the SFPUC and its customers naturally prefer the higher quality of Tuolumne supplies, having an alternative supply for emergency conditions could prevent a water supply outage that would be catastrophic to Bay Area communities.

A connection to the State Water Project would of course require an agreement between the SFPUC and the Department of Water Resources, in which State Water Contractors would certainly be concerned that their own rights be protected. It could provide access, however, to supplies from throughout the State, that could be acquired through transfer or banking arrangements, and therefore could significantly enhance reliability for the SFPUC and its customers. Since an intertie to the State Water Project would provide additional reliability to the SFPUC, at least a portion of its cost, should it be constructed as part of a restoration plan, should be attributed to increased reliability and not to restoration.

Water Quality

The State Report finds that standard filtration would be required for all SFPUC supplies if Hetch Hetchy Valley is restored. Environmental Defense agrees.

The State Report assumes that an additional 240 millions of gallons per day of filtration capacity would be required. This is an overstatement. Since the SFPUC's current WSIP would increase by filtration capacity at Sunol by 40 millions of gallons per day, the remaining need to increase filtration capacity would be only 200 MGD.[4]

The State Report does not mention that the SFPUC may lose its current exemption (allowed by the California Department of Health Services and the U.S. Environmental Protection Agency) from filtering all of its water supplies. If the exemption is lost, the SFPUC would need to expand water filtration capacity anyway, and it would not be appropriate to ascribe the cost of treatment plant expansion to the cost of restoring Hetch Hetchy Valley. The State Report should have made such a finding and reported on the low-end of its cost range a scenario that does not include the cost of an expanded water treatment plant.

The projected treatment costs should reflect the costs realized by recently implemented projects, provided such information is available. *Paradise Regained* included examples of recently completed and under-construction plants. Costs for these plants included such as items such as treated water storage, as well as all contingencies, mitigation, administration, legal and engineering costs. These costs averaged approximately $1 per gallon per day of treatment capacity. The State Report used this approximate number as a starting place, then more-than-doubled it to account for contingencies, engineering and other factors to derive the low end of its estimate.

At the high-end, the State began with a base construction cost of $1.65 per gallon per day of treatment capacity. The fully burdened cost of this plant cost would then be $3.43 per gallon per day of filtration capacity, more than three times the cost of plants that have recently been put into service.

[4] See "AB1823: Notice of Changes to Water System Improvement Program", SFPUC, March 8, 2006.

The unit cost of projects referenced in *Paradise Regained*, as well as several other recent water treatment plants (see Attachment 2), is compared to the projected costs of water filtration capacity in the State Report.

FIGURE 4
Comparative Water Treatment Plant Costs

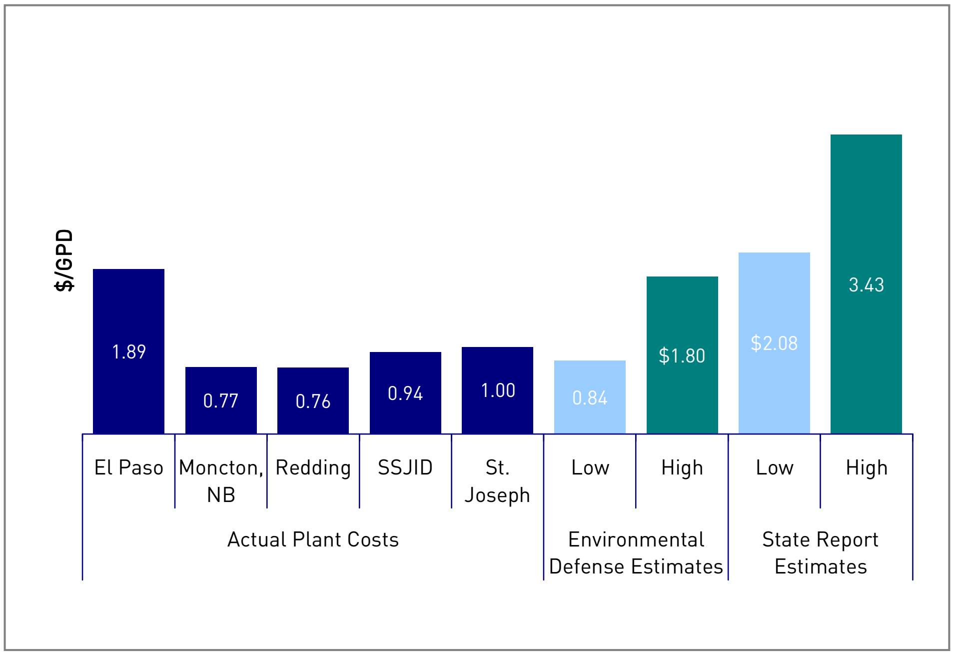


Figure 4 compares the actual unit cost of recently completed water treatment plants with the high and low estimates used by Environmental Defense and the State Report.

The State Report, at the high end of its cost range, includes $2.5 billion for the total life cycle costs for Operations and Maintenance[5]. These are costs that would occur only if no additional interties are built within the Tuolumne River watershed and the SFPUC acquires a significant portion of its supply from the Bay-Delta. This is not an alternative that any restoration advocates have recently proposed – all recent proposals have relied on a continued reliable supply of Tuolumne River water flowing to the SFPUC's customers. The State Report's high-end estimated costs for Operations and Maintenance should have been much lower.

[5] Appendix G reports this value as $1.57 billion. This figure, however, does not incorporate the State's 30% cost adders for both engineering, legal and administrative costs (ELA) and for mitigation, site-specific engineering and permitting costs (MSP).

With respect to industrial water quality, the State Report notes that "industrial users, who often require a water quality even better than potable, could be affected as well by a change in water source and treatment, in that their own on-site treatment facilities would need to be changed, upgraded, or used more frequently to treat a different water quality." (Appendix D-7)

Environmental Defense recognizes that some industries serviced by Hetch Hetchy have exceptional ("ultrapure") water quality requirements. However, to the extent that a restoration scenario continues to rely on Tuolumne River alternatives, Environmental Defense believes that the impact on on-site water treatment efforts by the industries will be minimal.

To investigate water quality concerns of industrial water users, Environmental Defense retained Eisenberg, Olivieri and Associates (EOA) to carry out a planning level analysis of the potential impacts on industrial water users under a restoration scenario (see Attachment 3). EOA examined projected differences in key water quality parameters (hardness, TDS, conductivity) concentrations in the treated water, and found that with downstream Tuolumne water the differences would be relatively minor, and would not be expected to have a significant cost impact on industrial water users.

EOA carried out several case studies based at a research facility in Livermore that occasionally must switch from a Tuolumne River water supply to a particular groundwater source (with quality comparable to raw Delta water). One examined impacts on the operation of the facility's several cooling towers. A second case-study examined the impacts at a research-scale semiconductor manufacturing operation, and a final case study examined a metal finishing facility. While in some cases, minor changes were required to adjust to the altered input water quality, many components of the on-site treatment system remained the same and stayed on a comparable maintenance schedule. Throughout each of these examples, it is important to note that, because virtually all restoration proposals would at most only occasionally rely on a small portion of Delta water, the impacts on industrial water customers would be substantially less than those described in the case studies. Furthermore, it should be noted that the emphasis of Environmental Defense's proposal for water supply replacement is on continued utilization of Tuolumne River supplies, whose quality far exceeds that of Delta water.

Contingencies

Understanding that projects are often, though not always, completed over-budget, it makes sense to allow for uncertainty on the high end of any range of estimates. The State Report uses a relatively high estimate of 30% for all components under all alternatives. For many components, such as those based on the actual full cost of previous projects, the contingency should be reduced.

The Bureau of Reclamation, for example, uses a range of 15-25% for contingencies, depending on how much is known about a particular proposed project (see Attachment 2). Environmental Defense believes it would have been more appropriate for the State Report to use a range of 15-25% for contingencies for the potential new projects. For project costs that are based on previous experience, the actual cost of the projects should be used, though adjusted for inflation.

Engineering, Legal and Administrative Costs

The State Report assumes that the cost of virtually all projects will be increased by 30% for engineering, legal and administrative costs (ELA). As the 30% is applied to the base construction cost plus the anticipated contingency, the full effect is a 39% increase over construction costs. This figure is higher than normal, especially for large projects (see Attachment 2).

Mitigation, Site-specific Engineering and Permitting Costs

Similar to the cost adder for ELA, the State Report assumes that the cost of virtually all project costs should be increased by 20-30% to account for mitigation, site-specific engineering and permitting costs (MSP). Again, these cost adders are unusually high and should diminish percentage-wise as the size of a project is increased (see Attachment 2).

The adders for ELA and MSP are uniformly applied to all cost categories, including non-capital items such as operations and maintenance, energy replacement, and transfers, where they would often not be applicable. These adders would vary across cost type, being minimal (if applicable at all) for some O&M costs, such as the variable costs of operating a water treatment plant (see Attachment 2). The ELA and MSP adders for these non-capital cost comprise $.4 billion in the State Report's low-end-estimate and $1.45 billion of the State Report's high-end cost estimate and warrant reevaluation.

Flood Control in the Tuolumne River watershed

There is no explicit requirement at Hetch Hetchy Reservoir to provide space for flood control. The reservoir's flood control requirements were moved downstream to Don Pedro Reservoir when it was completed in 1970.

As the State Report, notes, however, Hetch Hetchy Reservoir can provide "incidental flood control". While there is no requirement to maintain flood control space in

Hetch Hetchy Reservoir, the reservoir provides some indirect flood control benefits on the Tuolumne and lower San Joaquin Rivers." The State Report finds that future studies should consider the technical and legal aspects of flood control. Environmental Defense agrees, noting also that the overall degree of flood control protection on the Tuolumne River includes a number of factors, including management of all reservoirs in the watershed, and the river channel capacity below La Grange Reservoir.

It should be noted, however, that the San Francisco Public Utilities Commission in its own planning states that it employs a 30,000 acre-foot flood control reservation, from October through March, at Hetch Hetchy Reservoir. To be consistent with this level of protection for the entire watershed, in modeling the Tuolumne River system without Hetch Hetchy Reservoir, *Paradise Regained* imposed an additional 30,000 acre-feet of flood control capacity on the SFPUC's water bank in Don Pedro Reservoir.

<u>Native Americans</u>

The State Report provides a fairly general description of the perspectives of Native Americans related to restoring Hetch Hetchy Valley in Yosemite National Park. Restoration is a complicated matter and given that five federally-recognized tribes have historical and cultural ties to Hetch Hetchy Valley, it is not surprising that there are diverging opinions among the tribes on certain issues, such as land ownership and future use of the valley. Therefore, these tribes should be among the stakeholder groups in any restoration planning process.

Environmental Defense generally agrees with the tribes' priorities regarding a future restoration scenario, including avoiding the type of overdevelopment which currently exists in Yosemite Valley, restoring native plants and wildlife and providing tribal access to ceremonial grounds. Moreover, we agree that as a restoration plan is developed, the tribes should have a key role in managing recreational development and protecting resources. Environmental Defense believes a comprehensive survey and inventory of cultural resources in and around Hetch Hetchy Valley should be completed to guide the appropriate future use of the valley.

<u>Items for Further Study</u>

The State identifies areas where further study is needed throughout its report, and in Chapter 7, provides a list of "Important Issues to be Addressed". In general, Environmental Defense concurs with the State that a restoration plan can be best developed with more fully developed research in several areas, including:

- Benefits of restoration – While costs may be more objectively assessed, it is essential that an acceptable approach for understanding the benefits that restoration would provide be pursued. Any evaluation of benefits should include the role that restoration would play in the context of statewide environmental and recreation objectives.

- Statewide water supply – What role would a restoration plan play in the context of statewide water supply objectives?
- Global warming – What is the relationship between any plan to restore Hetch Hetchy Valley and the anticipated effects of global warming?
- Regional water supply – How would a restoration plan meet the water and power supply needs of all communities that rely on the Tuolumne River? How can restoration plan increase reliability for the SFPUC and its customers?
- Filtration – Is it likely that the SFPUC will be required to filter its water in coming decades?
- Groundwater - What are the most likely potential sites for groundwater storage, for either direct use by the SFPUC or through a banking agreement with other agencies that could replace the storage currently provided by the existing reservoir?
- Surface Storage – What sites would best provide new or expanded surface storage? What impacts or benefits would result from building or expanding another reservoir?
- Desalination - Could desalination provide a cost-effective and environmentally solution for the limited water supply replacement that would be needed? Where could a plant be located?
- New Conveyance - What are the hydrological, water quality and institutional issues associated with potential new interties between the existing SFPUC conveyance system and other locations, both within and beyond the Tuolumne watershed? In addition to the potential interties previously discussed in these comments, interties between Bay Area agencies as well as between the Stanislaus and Tuolumne watersheds should be considered, both to facilitate restoration of Hetch Hetchy Valley and to optimize system performance. The potential value of access to sources outside the Tuolumne watershed, in case the existing San Joaquin pipelines were rendered useless through earthquake, terrorism, drought or other disaster, should be considered.

Attachment 1:
Letter from California Resources Secretary Chrisman
to Assemblymembers Wolk & Canciamilla
November 8, 2004

STATE OF CALIFORNIA
resources
AGENCY

ARNOLD SCHWARZENEGGER, Governor
MIKE CHRISMAN, Secretary

November 8, 2004

Honorable Joe Canciamilla
Member of the Assembly
State Capitol, Room 2141
Sacramento, California 95814

Honorable Lois Wolk
Member of the Assembly
State Capitol, Room 6012
Sacramento, California 95814

Dear Assemblymembers:

Thank you for your sharing your interest in research recently released that explores potential elements of any future effort to restore the Hetch Hetchy Valley in Yosemite National Park. On behalf of the Governor, I am pleased to respond to your letter of September 9, 2004.

Consistent with its mission to thoughtfully manage the State's natural resources, the Resources Agency shares your interest in the recent studies by Environmental Defense and U.C. Davis detailing a plan for replacement of the water and power provided by the Hetch Hetchy Reservoir so that the valley might be restored. These studies, along with others that have been conducted in past years, may provide a foundation for discussions of the complex opportunities and challenges associated with restoring a Yosemite National Park valley and the water and energy resource needs of a growing State.

For the purpose of initial review, the Department of Water Resources and the Department of Parks and Recreation (DPR) will consider aspects of Hetch Hetchy restoration. Specifically, I have asked the Department of Water Resources (DWR) to review the growing body of studies and analyses that have been prepared over the last 20 years including Environmental Defense and U.C. Davis efforts, and summarize the range of conclusions and considerations in this work. Additionally, DWR will consider the larger water supply impacts. Clearly, one of the foremost challenges posed by the proposal stems from the fact that California, faced with significant water demands, needs a net increase in water storage capacity, not a decrease. Any plan to remove or modify existing water storage systems would need to be balanced by a viable alternative plan to at a minimum, replace the water supply now provided by the Hetch Hetchy reservoir.

1416 Ninth Street, Suite 1311, Sacramento, CA 95814 Ph. 916.653.5656 Fax 916.653.8102 http://resources.ca.gov

Although it is very difficult to place a value on the existence or acquisition of a natural feature, there are approaches that can be used. I have asked the DPR to work with the National Park Service (NPS) to identify accepted economic approaches to estimate a parkland value for a restored Hetch Hetchy Valley. Consideration of factors such as what relief, if any, might a Hetch Hetchy restoration offer to the heavy visitation pressure on Yosemite Valley may add value for this review.

The work program I have outlined is substantial and will need to be accomplished within the constraints of existing staff and budget. This review will be of limited value unless it is conducted in collaboration with affected local agencies and with appropriate federal participation. I will keep you informed of our progress.

California, its governor and its citizens, are committed to economically feasible restoration of ecosystems and preservation of open space. This commitment translates into an interest in reasonable proposals for expanding our trust resources. At the same time, we are a rapidly growing state and we are struggling with the challenges of improving water supply reliability and providing reliable power. As the various interests discuss the prospect of restoring Hetch Hetchy, we must balance our dreams and aspirations, our limited financial resources, and our need for water and power reliability. I look forward to developing additional information to support a public policy discussion that may arise on the future of Hetch Hetchy.

Sincerely,

Mike Chrisman

Mike Chrisman
Secretary for Resources

cc: Governor's Office

Attachment 2:
Bookman-Edmonston/GEI Consultants
Comments on DWR Cost Estimates
October 5, 2006

GEI Consultants
Bookman-Edmonston Division

Comments on DWR Hetch Hetchy Cost Estimates[1]
October 5, 2006

Geotechnical
Environmental and
Water Resources
Engineering

Overall DWR Cost Estimate

1. The DWR cost estimate[2] includes water supply elements that more than replace the water supply capacity that would be lost from removal of O'Shaughnessy Dam. While DWR's stated goals to improve statewide water management is commendable, providing elements that improve SFPUC's overall water supply are not appropriate for this analysis of alternatives to the existing system.

2. The most recent cost estimates for items in the SFPUC's Water System Improvement Plan should be subtracted from the cost of the replacement alternatives. This applies to upgrades to water treatment facilities as well as the plan to rebuild of Calaveras Reservoir with the potential to expand it at a later date.

3. By more than replacing existing water supply capacity and not accounting for SFPUC's planned improvements, the costs used by DWR significantly overstate the cost of Hetch Hetchy replacement alternatives.

Contingency

4. Contingency funds are included in project budgets to manage risk. Contingencies are generally applied as percentages of construction cost components to cover uncertainties in the quality of the data upon which the design is based. As information improves as the project planning progresses from reconnaissance level to preliminary design to final design the contingency should be progressively decreased. Some contingency is typically included in the final design to cover extra construction costs due to extra or omitted incidental items, unforeseen site conditions, and other uncertainties.

5. Contingencies recommended by the U.S. Bureau of Reclamation for reconnaissance-level investigations are 25 percent for the types of facilities considered in the Hetch Hetchy restoration planning (viz. dams, diversion works, pumping plants, canals, power plants, and transmission lines)[3]. The Bureau's recommended contingency for preliminary designs for these facilities is 15 percent. DWR typically uses 15 percent contingency for preliminary designs.

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[1] Mark S. Williamson, Bookman-Edmonston, Sacramento on behalf of Environmental Defense
[2] DWR, 2006, *Hetch Hetchy Restoration Study*, p.48
[3] In Alvin S. Goodman, 1984, *Principles of Water Resources Planning*, p. 287-8

GEI Consultants, Inc
3100 Zinfandel Drive, Suite 500, Rancho Cordova, California 95670
916.631.4500 fax: 916.852.6385

6. *Paradise Regained* Appendix 1 presents conceptual level cost estimates to which a contingency of 25 percent[4] for conceptual level cost estimates. At a conceptual level estimate, costs are expected to be between 70 and 150 percent of actual construction costs. This confidence range is mischaracterized by DWR as a "-30/+50 percent contingency"[5].

7. DWR estimates should include contingencies no higher than 25 percent. For items based on SFPUC preliminary designs (e.g. water treatment plants, reservoirs, and pipelines) the contingency should be no higher than 15 percent. As noted in item 2 above, if SFPUC estimates have escalated since the 2002 CIP, these escalated costs and associated contingencies should be subtracted for the items that the SFPUC is planning to construct.

8. DWR estimates non-energy operations and maintenance (O&M) cost at 2 percent of capital cost plus 30 percent contingency, and then adds another 30 percent contingency to this estimate[6]. Thus, contingency is inappropriately added twice, and non-energy O&M costs are overstated by at least 30 percent ($70-210 million).

Engineering, Legal and Administrative Costs

9. Engineering, legal, and administrative (ELA) costs used in *Paradise Regained* Appendix 1 were 20 percent[7]. A rule-of-thumb for projects of this size is to allow about 6 percent of the estimated construction cost for engineering, with the remainder distributed for legal and administrative support.

10. The State's procedure of adding 20 to 30 percent in addition to ELA costs for mitigation, permitting, and site-specific engineering is highly unusual. If there are mitigation or engineering issues of this magnitude, they merit development of additional specific information and a separate line item in the cost estimate. If identified environmental issues require mitigation of this magnitude, alternative less destructive alternatives should be developed.

11. The State has multiplied the ELA cost by the 30 percent contingency described above. This is equivalent to stating that engineering, legal, and administrative costs will add 39 percent to the estimated capital cost. Engineering, legal and administrative costs for a facility of a certain size should be approximately the

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[4] *Paradise Regained*, Apx. A, p. 4 of 51

[5] DWR, 2006, *Hetch Hetchy Restoration Study*, p.42, Figure 6-1

[6] DWR, 2006, *Hetch Hetchy Restoration Study*, p. G-14, Tables G-10 and G-11

[7] 20 percent for ELA, multiplied by the 25 percent contingency factor yield an effective ELA rate of 25 percent – in other words, if contingent costs increase, ELA is assumed to increase proportionately

same regardless of the facility cost. Thus, these costs should decrease as a percentage of capital cost as costs increase.

12. Likewise, the State has multiplied the costs of mitigation, permitting, and site-specific engineering by the 30 percent contingency. This adds another 39 percent to the estimated capital cost. Mitigation, permitting, and site-specific engineering for facilities of certain size (e.g. a 1000-foot-long pipeline) should be approximately the same regardless of the facility cost. Thus, these costs should decrease as a percentage of capital cost as costs increase.

13. The State's total cost engineering, legal, administration, mitigation, permitting, and site-specific engineering is up to 108 percent of the estimated construction cost. More than doubling the estimated capital cost to account for uncertainties is highly unusual even at a reconnaissance level of analysis.

14. The State has included a present worth estimate of increased annual O&M costs as part of the direct cost, and applied the 108 percent adder[8] for contingency, ELA, mitigation, and permitting. This is not appropriate. Some O&M costs will increase along with increased capital cost, but much of the O&M cost is associated with the operating costs for equipment and treatment plants. It is unreasonable to assume costs to pump water will increase with capital cost.

Water Treatment Plant Costs

15. Data used for estimating water treatment plant costs in "Paradise Regained" were drawn from a variety of sources and based on varying levels of design[9]:
    a. South San Joaquin Irrigation District, actual construction cost
    b. City of Turlock, preliminary design
    c. EBMUD, conceptual design
    d. Olivehain, preliminary design
    e. St. Joseph, actual construction cost
    f. Sunol, SFPUC 2004 Capital Improvement Plan budget, preliminary design

16. These estimates were remarkably consistent at about $1.00 per gpd (gallons per day) of capacity. These estimates were so consistent that additional effort to make the estimates more comparable (e.g. removing transmission pipeline or wet well storage costs that may have been included) were not deemed necessary.

17. Other water treatment plant costs:
    a. A 7.0 mgd water treatment plant expansion in Redding, California was completed in 2006 at a cost of $5.35 million ($0.76 per gpd).

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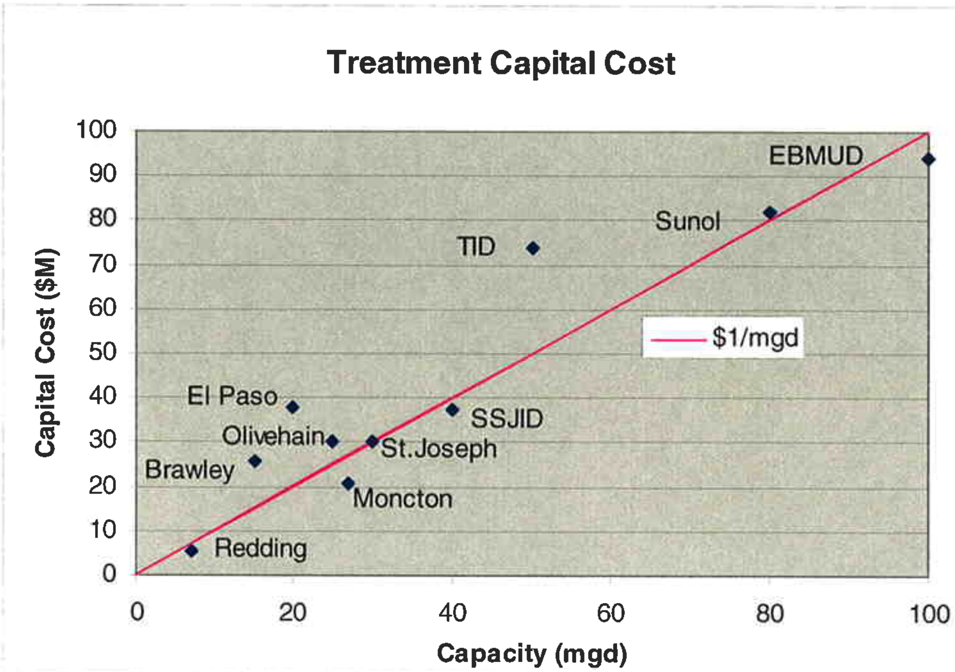
[8] A 140 percent adder is applied for non-energy O&M (see item 8)

[9] *Paradise Regained*, Apx. A, p. 10 of 51

b. The 27.0 mgd (expandable to 36 mgd) Moncton, NB water treatment plant was completed for $20.7 million ($0.77 per gpd).
c. A 20 mgd expansion to the El Paso Water Treatment Plant was completed for $37.8 million ($1.89 per gpd).
d. The 15 mgd (expandable to 30 mgd) water treatment plant for Brawley, California has a preliminary design an estimated cost of $25.7 million ($1.71 per gpd) including water storage ponds and a 5,600-foot discharge pipeline.
e. A revised summary of treatment plant costs is presented below.



18. Five of the ten treatment plants surveyed have been constructed. The unit cost of these five constructed plants range from $0.76 to $1.89 per gpd of capacity and average $1.07 per gpd of capacity. Contingencies should not be applied to these actual costs.

19. The $1.00 per gpd, plus 20 percent for ELA, plus 25 percent contingencies (for a total burdened cost of $1.50 per gpd) used in Paradise Regained is believed to be a reasonable basis for a conceptual-level cost estimate, versus the $3.43 per gpd used by DWR.

Attachment 3:
EOA Report
Industrial Water Quality Review for
Hetch Hetchy Reservoir Alternatives
March 24, 2006

INDUSTRIAL WATER QUALITY REVIEW

FOR HETCH HETCHY RESERVOIR ALTERNATIVES

Prepared for

Environmental Defense

Prepared by

EOA, Inc.

1410 Jackson St.
Oakland, CA

TECHNICAL MEMORANDUM

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Industrial Water Quality Review for Hetch Hetchy Reservoir Alternatives

Executive Summary

This technical memorandum extends earlier work conducted by EOA in connection with the 2004 Environmental Defenses report *Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley*. It provides a planning level analysis of the potential impacts on industrial water users as related to future water quality without the Hetch Hetchy Reservoir. The alternatives considered herein are consistent with those investigated previously as described in the *Paradise Regained* report.

Representative industrial applications that are especially sensitive to delivered water quality are identified, and the point-of-use water treatment processes typically employed by those industries are described. The identified industries included metal finishing, microelectronics processing, and biotechnology (production and R&D). These industries typically require water characterized as "ultrapure". To meet this requirement, a biotechnology facility would employ an on-site treatment system to further treat water delivered through the public water supply system. Such a system would typically consist of some or all of the following treatment steps: pre-filtration, softening, activated carbon adsorption, microfiltration, UV disinfection, reverse osmosis (RO), electrodeionization, and submicron filtration. Similar treatment processes are employed by the metal finishing and microelectronics industries, although not every point-of-use treatment system will utilize each process listed.

Projected water quality data for future alternatives with and without the Hetch Hetchy Reservoir (as described in the *Paradise Regained* report) are tabulated, and key differences are summarized. Relative to industrial water quality requirements, the most significant differences are those related to increased levels of total dissolved solids, hardness, and alkalinity, and possibly, certain minerals (e.g. silica) or trace organics (e.g. MTBE). Changes in the microbiological characteristics of finished water (i.e. water delivered to users) under the different alternatives are expected to be negligible.

For alternatives that rely primarily on continued use of Tuolumne River water (i.e. the "Maximize Don Pedro Diversion" and "Don Pedro Diversion and an Expanded Calaveras Reservoir" alternatives, the projected differences in key water quality parameter concentrations in the treated water would be relatively minor, and would not be expected to have a significant impact on industrial water users.[1]

For the "Maximizing Delta Diversion" alternative, the increased concentrations of key water quality parameters are such that point-of-use treatment requirements and/or operating costs could be impacted. Table ES-1 shows projected annual average concentrations for hardness, TDS, and

[1] Since these alternatives are based on projected demand flows in 2030, even the "Future with Hetch Hetchy Reservoir" alternative shows some increased levels of key water quality parameters as a greater percentage of local water is used to meet the incremental demand.

conductivity under future (2030) demand conditions of 339 ac-ft yr, with average concentrations under drought conditions shown in parenthesis. An examination of Table ES-1indicates that under the "Maximize Delta Diversion" alternative, concentrations of these constituents are nearly double those projected for the "Future with Hetch Hetchy Reservoir" alternative, although still remaining in a range characteristic of a high quality water supply. The concentrations listed are significantly lower than those of 100% raw Delta water (see Table 2 of this memorandum), because under the "Maximize Delta Diversion" alternative, the delivered water would be a blend of water from the Delta and other sources (including Tuolomne River water).

Table ES-1. Water Quality Comparison for Case Studies
Projected Quality of Delivered Water under various Treatment/Delivery Alternatives

Source Water	Hardness total mg/L	TDS (mg/L)	Conductivity (umhos/cm)
Future with HH Reservoir	27 (35)	52 (67)	82 (105)
Maximize Don Pedro Alternative	19 (19)	32 (33)	46 (45)
Don Pedro Diversion / Expanded Calaveras Alternative	43 (50)	30 (30)	42 (41)
Maximize Delta Diversion Alternative	43 (50)	100 (120)	167 (204)

Three industrial treatment process elements were selected for more detailed evaluation using case study examples. These included reverse osmosis (RO) and deionization (DI), which are typical components of ultrapure treatment process train. The RO process utilizes a semi-permeable membrane which allows water to pass though, while providing a barrier to salts and other larger molecules. The process generates a low-salinity product (permeate) stream which contains 70-80 % of the influent flow, and a high salinity reject stream consisting of 20-30% of the flow. RO systems may be used to remove the majority of salts before further "polishing" by a DI or EDI system. A point-of-use treatment process operating on 100% Hetch Hetchy water might not include the RO component because of the very low total TDS of that water.

DI systems employ the principals of ion exchange to remove dissolved minerals from feedwater, by exchanging hydrogen ions for positively charged cations (e.g. sodium) and hydroxyl ions for the negatively charged anions (e.g. chloride) present in the feed water. The hydrogen and hydroxyl ions combine to form water. When the exchangeable ions are depleted, the DI resins must be replaced or regenerated. Electrodeionization (EDI) is a form of DI that utilizes an ion exchange membrane operating in an electric field to effect separation of salts fro the feed stream.

Cooling towers were also selected, because of their widespread use in many industrial processes and their sensitivity to feedwater quality. All of the processes examined are sensitive to general water quality parameters such as TDS, hardness, alkalinity, and conductivity, and may have specific sensitivities to individual constituents (e.g., silica, iron, chlorine).

The case studies involved a research facility in the Livermore Valley that occasionally must switch from a Hetch Hetchy water supply to a Zone 7 water supply (groundwater). In terms of water quality, the Zone 7 raw water has similarities to the raw water from the Delta, although hardness, TDS and/or conductivity are higher in the Zone 7 water. Also, because water delivered under the

“Maximizing Delta Diversion” alternative would consist of Delta water blended other source waters (or possibly subject to additional water treatment beyond current levels), the impacts on industrial customers receiving water via a “Maximize Delta Diversion” alternative would be substantially less that those described in the case studies. With this in mind, it is emphasized that these case studies illustrate how industrial customers could be impacted by changes in water quality, however they do not predict the types of impacts that are likely to be seen under any of the alternatives suggested.

Case Study 1 - Cooling Tower: The research facility operates a number of different sized cooling towers, which vary in their rates of water consumption from around 1000 to about 10,000 gallons/day. When operating on low salinity Hetch Hetchy water (conductivity of ~40 uohms/cm), the systems operate at 10 concentration “cycles” (i.e. the controller setpoint for blowdown water discharged from the system is 400 uohms/cm). When operating on high salinity Zone 7 water conductivity (~700 uohms/cm), the blowdown setpoint is 2000 uohms/cm), corresponding to 3.1 concentration cycles. The change in setpoints for the two water sources illustrates that for cooling towers, the overall water quality is considered, and operation is not strictly tied to single indicator such as TDS or conductivity.

Measurements of increased water usage while operating on Zone 7 water were confounded by seasonal differences in cooling loads, but conservatively estimated to be about 50%. (A calculation based on concentration cycles would predict a 40% increase). This translated to an increase in water costs on the order of $1.26/1000 gallons used. Chemical treatment costs increased by an estimated $1.06/100 gallons. It should be emphasized again that these increases reflect a much more dramatic change in water quality than would be expected under any of the alternatives describe in the *Paradise Regained* report.

Case Study 2 - Ultrapure Water for Semiconductor Manufacturing Operation: This case study examined impacts from the same change in water sources at a research-scale semiconductor manufacturing operation that uses approximately 400 gal/day of ultrapure water generated through a system consisting of softening beds (a special type of DI resin), additional DI treatment, and filters. Prior to adding an RO unit (see below), facility operators found that while on Zone 7 water, the softening beds required more frequent replacement. They also report that the filters required more frequent replacement while on Hetch Hetchy water. There was no change in the replacement frequency of the final DI resins, although this probably reflects sub-optimal use of resin capacity (i.e. replacement on a fixed time schedule), since increased rates of resin depletion would be expected with the higher salinity Zone 7 water. Of greater significance was the decision by the facility to add an RO unit to accommodate the changes in water source, effectively isolating the downstream components from the changes in water quality. The capital and operating costs of the RO system (including a 25% increase in water use associated with the reject stream) was partially offset by reduced O&M costs of the downstream treatment components.

Case Study 3 – Ultrapure Water for Metal Finishing Facility: This case study involved a small (2000 gal/week) treatment system for a plating line, using a series of resin beds and filters for hardness removal and deionization. When the source water changed to Zone 7 water, the 25 micron filters at the beginning of the treatment train required more frequent replacement than when on Hetch Hetchy water, at a cost of approximately $0.67/1000 gallons produced. The DI tanks and 5 micron filters remained on the same maintenance schedule, again suggesting that the resin capacity was underutilized when on Hetch Hetchy water. For a system where resin capacity was optimized, the expectation would again be that the frequency of replacement (particularly for the 1st stage DI resins) would be proportional to the TDS of the incoming water.

Conclusions

The results from this and from the previous water quality investigation indicate that differences between future conditions with the Hetch Hetchy Reservoir versus alternatives based on either the "Maximize Don Pedro Diversion" or the "Don Pedro Diversion and an Expanded Calaveras Reservoir" are likely to have a minimal impact on the finished water quality, and thus minimal impact on industrial facilities with high water quality requirements.

Impacts to industrial water users could occur under the "Maximize Delta Diversion" alternative, because concentrations of certain key water quality parameters would increase more significantly. For example, under that scenario, a facility which operated cooling towers on 100% Hetch Hetchy water would likely experience an increase in water usage on the order of 20%, along with increased costs for chemical treatment.

For ultrahigh purity water (UPW) applications, the impacts of changing to the higher salinity source water would depend on specific point-of-use treatment process. The greatest impact would occur at the "front end" of such systems (i.e. initial filters and softening units). For resin-based softening, the frequency of resin replacement/regeneration could be expected to increase in proportionately to the incoming source water hardness. For treatment systems depending entirely on DI resins for salinity removal (i.e. no RO process), the increase in replacement/regeneration frequency for the 1st stage resins would be roughly proportional to the increased TDS levels. (In both cases, the increased frequency may be less if resin capacity is not fully utilized to begin with). For systems that utilize RO as a front end process, the salinity of the RO concentrate (reject) stream would increase, but reject flows (and hence water consumption) would not change significantly. In such cases, the RO unit would largely buffer downstream processes from the changes in water quality, although minor increases in O&M costs for downstream processes could be expected.

Industrial Water Quality Review for Hetch Hetchy Reservoir Alternatives

1.0 Introduction

Environmental Defense is investigating the feasibility of restoring the Hetch Hetchy Valley by exploring alternatives for the water supply, water quality and power benefits currently made possible by the Hetch Hetchy Reservoir. A previously conducted planning level investigation considered the potential technical, operational, and political issues associated with alternative operations for the City of San Francisco's water and power system. The results of that investigation were published in 2004 (Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley).

This technical memorandum complements and extends the previous investigation by providing a planning level review of the potential impacts on industrial water users for future water quality without the Hetch Hetchy Reservoir compared to future water quality with the Reservoir. The alternatives considered herein are consistent with those investigated previously as described in the Paradise Regained report.

This planning level review is comprised of three tasks:

- Identify principal Bay Area industries that are especially sensitive to water quality. Describe the water quality requirements for those industries and typical water treatment approaches that are currently used by those industries;
- Review water quality monitoring data from the previous study to determine potential changes in finished water that would impact the industries identified in Task 1; and
- To the extent feasible, provide estimates of the incremental costs for additional water treatment that would be needed under the various water supply alternatives.

2.0 Bay Area Industries & Typical Water Treatment Approaches

2.1 Representative Bay Area Industries

The approach for this planning level review was to identify principal Bay Area industries whose manufacturing and/or Research and Development (R&D) processes are especially sensitive to water quality. The two principal criteria for inclusion in this analysis were that the industries had to be common in the Bay Area and demand a high level of water quality.

Based on the results of a report published by the Silicon Valley Leadership Group (SVLG, 2005), this review focuses on the high-tech (metal finishing and microelectronics) manufacturing and biotech industries. These two types of industries were in the top four categories of respondents to the SVLG survey and represented a total of 57% of the respondents. Financial/professional services and internet/communications/utilities were the other top respondents, however these types of businesses generally do not have high water quality requirements. It is noteworthy that the SVLG survey reported that the cost of water and water quality issues ranked highly as important issues to Bay Area businesses.

Metal finishing, microelectronics processing, and biotech production and research & development processes were reviewed to identify common water quality requirements and water treatment approaches. The common theme among these industries is that they require ultra pure water (UPW) for production processes.

Metal finishing and microelectronics facilities are generally concerned with particulate, ionic and organic contamination that could be detrimental to the integrity of microchip circuitry. UPW is used in these industrial processes for product cleaning and rinsing during the manufacturing process (Baird, et al. 2001).

Biotech facilities use high purity water for production, processing, formulation, cleaning and rinsing. Biotech facilities are generally concerned with microbial (including endotoxins) and chemical contaminants that may compromise standards of safety, efficacy, strength, purity and quality of their products (Baird, et al. 2001).

Minimum requirements for purified water in the biopharmaceutical community are set forth in the United States Pharmacopoeia (USP 24). The Food and Drug Administration (FDA) enforces implementation of these regulations. The biopharmaceutical industry sets operating specifications to meet regulatory standards (Baird, et al. 2001). The operating specifications lead the biopharmaceutical industry to operate by prescribed treatment processes rather than choosing alternative treatment processes to meet final water quality concentrations.

Recommendations for water quality for various types of products in the microelectronics industry are available in the American Society for Testing Materials (ASTM) document entitled "Standard Guide for Ultrapure Water Used in the Electronics and Semiconductor Industry". However, water quality is not specifically regulated for these industries. Microelectronic facilities develop their own internal quality specifications. Typically, these specifications are based on processing requirements rather than contaminant concentrations in the feed or product water. Therefore, for microelectronics facilities operation and design of UPW systems is an owner-prescribed process of developing and testing (Baird, et al. 2001).

2.2 Representative Water Treatment Processes Used by Bay Area Industries

UPW is water whose electrical resistivity depends only on the hydroxyl and hydronium ions in the water. Use of UPW allows the electrical resistivity of a semiconductor to be a function of the band gap of the semiconductor rather than impurity concentrations (Donovan 2005). Performance of water treatment systems are often monitored by measuring the specific conductance of the UPW water rather than measuring the concentrations of specific contaminants in the water.

Water treatment systems producing high purity or UPW from potable water supplies for these industries vary among industries and individual facilities within a specific industry. There are several processes that are generally common to both high-tech and biotech industries. The two most commonly used treatment processes by these industries are reverse osmosis and deionization (or ion exchange).

For example, two representative water treatment systems for the Biotech industry are as follows:

- Multimedia filtration, softening, activated carbon adsorption, microfiltration, ultraviolet light (UV) disinfection, reverse osmosis (RO), continuous electrodeionization, and submicron filtration (Baird, et al. 2001); and
- Pre-filtration, hardness reduction, disinfection removal, filtration, UV disinfection, RO, deionization, final filtration (US Filter 2001).

Similarly, three representative water treatment systems for the microelectronics industry are:

- Filtration, preheat heat exchanger, micron filtration, RO, UV disinfection, continuous electrodeionization, mixed bed ion-exchange, and submicron filtration;
- Pretreatment, two pass RO, deionization, vacuum degasification, UV disinfection, and ultrafiltration (US Filter 1999); and
- Softening, ionization exchange, RO, ozonization, radiation treatment, carbon beds and chemical disinfection (Shadman 2001).

2.3 Overview of Industrial Processes

The industrial water processes selected for evaluation herein include reverse osmosis, deionization, and cooling towers. The use of reverse osmosis and deionization water treatment processes was introduced in the previous section. Cooling towers were also selected for this evaluation because of their ubiquitous use as industrial water processes and because of their sensitivity to water quality. The following discussion presents a brief description of these three water treatment processes and the sensitivity of each process to water quality.

Interviews with water treatment supply companies indicated that overall water quality and individual water quality parameters can both be important factors in water treatment process design and operations. It is important to understand that overall water quality can vary within a given distribution area. While there are general guidelines that can be followed, this variability should not be overlooked as it is an important design consideration.

2.3.1 Reverse Osmosis

Reverse Osmosis is a process which uses pressure to force pure water through a semi-permeable membrane. The water left behind with concentrated salts is referred to as the reject stream. RO can remove particles less than 0.001 microns in diameter. Rejection rates depend on many factors including the membrane used, feedwater quality and saturation percentage of critical membrane foulants. The lower the reject rate the greater the product water yield. Suspended solids need to be removed before RO treatment to prevent membrane plugging (Pontius 1990). RO maintenance typically is comprised of replacing membranes.

2.3.2 Deionization

Deionization uses the principals of ion exchange to remove dissolved minerals from feedwater. Dissolved minerals can be either positively charged cations or negatively charged anions. Therefore, deionization requires the use of two resins, which may be in separate “beds” or mixed. . One resin exchanges hydrogen ions for the cationic contaminants in the feedwater, while the other resin exchanges hydroxyl ion for anionic contaminants. The hydrogen and hydroxyl ions combine to form water. The hardness, alkalinity, total dissolved solids (TDS) and total suspended solids in the feedwater can affect the operation of the ion exchange beds. Once the impurities of the feedwater have replaced all of the exchangeable ions in the resin, it must be replaced or regenerated (Kemmer 1988). Higher concentrations of hardness, alkalinity and/or TDS require more frequent replacements or regeneration of resin beds.

Electrodeionization is a type of DI process that utilizes ion exchange membrane "plates" with a direct current (DC) electrical field that drives salt ions into adjacent concentrating compartments. It is often used after an RO process, and like RO, generates a reject stream that contain the removed salts.

2.3.3 Cooling Towers

Cooling towers are a component of recirculating water systems that are used to maintain specific temperatures in industrial processes. In these systems, heat is transferred to the recirculating water in the cooling system. The water then moves on to the cooling tower where heat is released through evaporation. The water then recirculates back through the cooling system. Because of evaporation, dissolved and suspended solids are concentrated in the remaining water. To prevent a build up of this concentrated water, water is bled from the system (this process is known as "blowdown"). Water is added to the system to balance the amount of water evaporated or lost through blowdown. If chemicals are used to prevent corrosion and/or scaling, chemical addition may also be needed to ensure concentrations remain constant in the system.

Some important properties of water used for cooling systems are conductivity, pH, alkalinity and hardness. These properties can impact cooling water systems with respect to corrosion, scale, fouling and microbiological contamination. Low alkalinities increase the likelihood for corrosion, whereas excessively high alkalinities may contribute to scale formation. In general, low pHs increase corrosion potential and high pHs increase the potential for scale formation. The effectiveness of biocide effectiveness can also depend on pH. Hardness refers to the amount of calcium and magnesium present in the water and is related to the water's potential for scale formation. Chemicals used to control scale do so by lowering pH and/or keeping scale-forming minerals dispersed in solution. Although high levels of hardness are undesirable, chemical programs to prevent scale or control corrosion often require a certain hardness. Cooling water treatment programs are also designed to function within a specific range of conductivity (or TDS), which is maintained by controlling blowdown rates. (Nalco 2005).

3.0 Water Quality Review

3.1 Alternative Source Water Supplies

Under the current SFPUC water system operations, water is delivered from three sources: Hetch Hetchy Reservoir, Hetch Hetchy Reservoir after storage in a local reservoir, and local water after storage in a local reservoir. If the SFPUC water system were to be operated without the use of the Hetch Hetchy Reservoir in the future, it is possible that water could also be delivered from the Don Pedro Reservoir and the San Joaquin Delta.

Environmental Defense identified several operational alternatives that were evaluated in the Paradise Regained report. The alternatives investigated were intended to bracket the water qualities of potential future operations of the SFPUC water system both with and without the use of the Hetch Hetchy Reservoir. From a planning level engineering perspective many other potential alternatives could be considered to be combinations of those investigated. The alternatives that were investigated as part of the water quality evaluation were as follows:

- Existing (base) conditions;
- Future conditions with Hetch Hetchy Reservoir, includes Calaveras Reservoir and increased demand;
- Future conditions without Hetch Hetchy Reservoir, maximizing a Don Pedro diversion,
- Future conditions without Hetch Hetchy Reservoir, maximizing a Delta diversion; and
- Future conditions without Hetch Hetchy Reservoir, using a Don Pedro diversion and an expanded Calaveras Reservoir.

As noted above, there would be different water qualities associated with each of the potential alternatives.

3.2 Raw Water Quality

The planning level water quality evaluation projected the raw water quality for each of the alternatives based on available data. The <u>raw</u> Hetch Hetchy supply is of higher quality than any of the other available raw waters (Don Pedro, Delta, or Local water). Key differences between raw water supplies may be summarized as follows:

- Aluminum, barium, and manganese are lower in the Hetch Hetchy raw water than in the other raw waters.
- Iron concentrations in the Hetch Hetchy raw water is lower than either Don Pedro or local waters.
- Chromium concentrations in the Hetch Hetchy raw water are lower than in the Delta water.
- MTBE concentrations in the Hetch Hetchy raw water is lower than either Don Pedro or the Delta water.
- All minerals and general parameters in the Hetch Hetchy raw water are lower than in the Delta raw water with the possible exception of nitrate and nitrite.
- All minerals and general parameters in the Hetch Hetchy raw water are lower than in the local water with the possible exceptions of phosphate and silica
- Most minerals and general parameters are present in Don Pedro water in similar concentrations to those in Hetch Hetchy water. Sulfate, calcium, and magnesium are present in Don Pedro water in higher concentrations than in Hetch Hetchy water.
- Hardness, alkalinity, specific conductance, total dissolved solids, and color are higher in Don Pedro water than the Hetch Hetchy water.
- Total coliform and fecal coliform levels are lower in the Hetch Hetchy raw water than in other raw waters. The fecal coliform levels in the Don Pedro and local water are also very low.

Water quality data was also available for two treated water supplies: Hetch Hetchy and the local water supply. Average concentrations of constituents with at least 10% or greater of the observations reported above the detection limits are presented in Table 1. It was assumed for the purpose of the water quality evaluation, that in cases where at least 90% of the observed data for a particular constituent were below detectable limits for all water sources, that the concentrations of that constituent were effectively equivalent in all waters.

Table 1. Average Concentrations of Detectable Constituents in Raw and Treated Waters

		Raw Waters				Treated Waters	
Contaminant	**Units**	Hetch Hetchy Supply	Don Pedro Supply	Local Supply	Delta Supply	Hetch Hetchy	Local Water
Inorganic Chemicals							
Aluminum	ug/L	70	112	94	164	62	27
Barium	ug/L	**5**	26	68	110	21	67
Chromium	ug/L	**2.2**	**3.3**	**2.6**	4.6	**3.3**	**3.0**
Copper	ug/L	6.8	10.6	8.6	4.0	10.4	20.0
Iron	ug/L	39	121	76	41	37	22
Manganese	ug/L	5.3	12.7	10.7	31.4	7.3	7.7
Zinc	ug/L	10.2	13.2	**9.0**	**8.0**	**12.7**	**13.0**
Organic Chemicals							
Methl Tertiary Butyl Ether	ug/L	**0.5**	2.8	**0.5**	1.1	**1.3**	**1.3**
Total Trihalomethanes	ug/L	**0.5**	**0.5**	**0.5**	451	36.6	32
Minerals and General Parameters							
Nitrate (as NO_3)	mg/L	**0.4**	**0.6**	1.8	0.6	**0.6**	1.4
Nitrite (as N)	mg/L	**0.06**	**0.11**	0.40	**0.11**	**0.10**	**0.11**
Chloride	mg/L	**2.8**	**3.0**	7.0	52.3	3.6	19.0
Sulfate	mg/L	0.6	1.9	19.8	30.6	1.2	33.0
Calcium	mg/L	1.3	3.8	27.2	15.8	3.6	22.0
Hardness (as $CaCO_3$)	mg/L	4	17	104	84	14	100
Magnesium	mg/L	**0.4**	1.9	9.5	10.5	0.4	9.2
Phosphate	mg/L	**0.06**	0.05	**0.06**	0.13	**0.05**	0.05
Potassium	mg/L	0.4	0.5	1.3	1.5	0.4	1.4
Silica	mg/L	3.8	7.0	5.8	14.5	3.9	8.3
Sodium	mg/L	**3.0**	**3.0**	9.9	39.4	3.0	21.0
Total Dissolved Solids	mg/L	11	31	148	216	27	189
Turbidity	NTU	0.5	2.5	10.3	12.7	0.5	0.1
Total Organic Carbon	mg/L	1.4	**0.5**	4.4	3.8	1.36	2.5
Specific Conductance	uS/cm	11.5	40.3	239.3	373.8	43.1	297.4
Alkalinity (as $CaCO_3$)	mg/L	4.8	18.0	96.8	66.1	84.9	94.7
Color	units	8.9	22.8	25.4	40.1	7.3	**3.0**
pH	units	7.1	8.4	7.7	7.4	9.5	8.5
Microbiological							
Total Coliform	MPN/100ml	7	13	30	210	**2**	**2**
Fecal Coliform	MPN/100ml	2	2	1	55		

Notes:

1. Total THM data for Delta supply represents TTHM formation potential, THM data for other raw source waters represent measured total THM concentrations.
2. Shaded cells indicate that greater than 90% of the observed values were reported to be below detectable limits.

Reference: Rosekrans 2004

The primary differences between the two treated water sources listed in Table 1 (i.e., disinfected Hetch Hetchy water and filtered & disinfected SVWTP water) may be summarized as follows:

- Hetch Hetchy water has extremely low total dissolved solids, specific conductance, and hardness;

- SVWTP water is lower in aluminum and iron; and
- Hetch Hetchy water is lower in barium, copper and alkalinity, and minerals (chloride, sulfate, calcium, magnesium, silica, and sodium).

3.3 Finished Water Quality for Alternatives

The planning level water quality evaluation also reviewed water treatment options for the alternatives described above. The expected differences in treated water quality (i.e. water delivered to users) for the various alternatives are discussed below along with a preliminary assessment of potential impacts on industrial water users.

3.3.1 Future Conditions with Hetch Hetchy Reservoir

It was assumed that the water quality of the Hetch Hetchy finished water will not change appreciably from existing conditions. This assumption is not to indicate that normal variation in water quality does not occur, but rather that operational changes or source water fluctuations will not significantly impact the overall water quality of the finished Hetch Hetchy water.

3.3.2 Future Conditions without Hetch Hetchy Reservoir: Maximizing Don Pedro Diversion

Based on the water quality analysis conducted previously, it is projected that there could be slight differences in water quality between future conditions with Hetch Hetchy Reservoir and an alternative based on maximizing a Don Pedro diversion, even with the recommended water treatment systems in place. Depending on efficacy of water treatment, concentrations of some inorganic constituents (e.g. iron, aluminum) may be greater for the Maximize Don Pedro Diversion Alternative than in the current/future Hetch Hetchy finished water. However, concentrations of these contaminants will remain low enough that modifying or adding further treatment would not be warranted for general use of the municipal water supply. For industrial uses with high water quality requirements, the differences between future conditions with Hetch Hetchy Reservoir and an alternative based on maximizing a Don Pedro diversion are likely to have minimal impact on the finished water from existing point-of-use treatment processes (e.g. reverse osmosis, deionization).

It was noted in the water quality evaluation that MTBE in the Don Pedro Reservoir raw water is of potential concern for the municipal water supply. The data examined for that report include one detection (at 5 ug/L) out of three raw water samples from Don Pedro Reservoir. Using the conservative approach of evaluating non-detects at the detection limit, an average value of 2.8 ug/L was calculated.[2] The report noted that MTBE levels will decline as a result of California's phase-out of MTBE as a fuel additive.

The presence of MTBE at levels that could conceivably exist in finished water under the "maximizing Don Pedro Reservoir" scenario would not be a concern relative to use in cooling towers, but may be a concern for sensitive industrial applications requiring UPW. The ability of

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[2] For Delta water, where MTBE was detected in 11 of 48 samples, the average was 1.1 ug/L. In both cases, actual averages are probably less than the calculated values, because of the way non-detects were evaluated.

existing industrial point-of-use water treatment processes to removing MTBE down to acceptable levels would depend on the levels present in the feed water and the specific treatment processes employed. (Existing systems that included an organics removal component would likely not require additional treatment). If additional point-of-use treatment were required for MTBE removal, the most likely process would be a granular activated carbon optimized for removal of trace organic compounds. The costs associated with such additional treatment would be industry and process-specific. Most of the published cost data is for systems designed for much higher levels of MTBE in the feedwater. Total amortized costs for MTBE removal cited in one reference ranged from $0.13 to $1.17/1000 gallons treated.

3.3.3 Future Conditions without Hetch Hetchy Reservoir: Maximizing Delta Diversion

The inclusion of water from the Delta into the raw water blend will have a greater impact on raw water quality than the Maximize Don Pedro alternative. Several different treatment options would be available under this alternative. For example, full conventional treatment could be used on the blended raw waters or separate treatment processes could be used for the different source waters. In either case, the water treatment would produce relatively high quality finished water. However, it is possible that the resultant product water would have increased levels of hardness and other constituents compared to the existing treated water, depending on the specific water treatment approach selected.

If the water treatment resulted in finished water with increased levels of hardness and other constituents relative to the existing water, point-of-use treatment may be necessary for specific industrial uses that required lower hardness or TDS levels. For highly sensitive industries (such as metal finishing, microelectronics, and bio tech) this would likely involve adding softening to their existing water treatment systems, which could impact operational costs (e.g. more frequent ion exchange resin regeneration requirements).3

For cooling tower use, higher hardness and salinity levels would likely impact operating costs because of higher water use resulting from increased blowdown and/or increased chemical use (e.g. anti-scalants).

3.3.4 Don Pedro Diversion and an Expanded Calaveras Reservoir

The same water quality issues apply to this alternative as the "Maximizing Don Pedro Diversion" alternative because the finished water qualities are so similar. Only minimal, if any, impacts are expected on industrial uses relative to Hetch Hetchy water.

4.0 Case Studies Illustrating the Potential Impacts of Alternative Water Sources on Industrial Processes

With respect to the potential impact on industrial processes, the previous section described several important considerations. Those considerations are as follows:

[3] It is worth noting that under the Maximizing Delta Diversion scenario outlined in the previous study, Environmental Defense's projections indicate that Delta water would still comprise only a portion of the delivered water. The projected raw water TDS levels of 100 mg/L (120 mg/L under drought conditions), while higher than the existing (Hetch Hetchy) water, would not be considered high relative to most other water sources.

- The current treated water from Hetch Hetchy is lower in total dissolved solids, specific conductance, hardness, barium, copper, alkalinity, and minerals than the current treated local water.
- The current treated water from Hetch Hetchy is higher in aluminum and iron than the current treated local water.
- It is anticipated/assumed that the water quality of Hetch Hetchy finished water will not change appreciably from existing current conditions in the "Future conditions with Hetch Hetchy Reservoir" scenario.
- For industrial uses with high water quality requirements, the differences between future conditions with Hetch Hetchy Reservoir and alternatives based on either a "maximizing a Don Pedro diversion" or a "Don Pedro diversion and an Expanded Calaveras Reservoir" are likely to have minimal impact on the finished water.
- The inclusion of water from the Delta into the raw water blend will have a greater impact on raw water quality than either of the other options. Several different treatment options would be available, all of which would produce high quality finished water. If the finished water were to have increased levels of hardness and other constituents relative to the existing water, point-of-use treatment may be necessary for specific industrial uses that require lower hardness and/or TDS levels.

This section illustrates via three case studies how water quality can impact industrial processes. These case studies are based on real industrial sites in the Livermore Valley (northern California) which occasionally switch from a Hetch Hetchy water supply to a Zone 7 water supply (groundwater). In these case studies the costs associated with changes in water quality are estimated based on the projected increased use of potable water (e.g. larger percentage of input water is discharged as reject in RO process or blowdown from cooling towers), additional treatment requirements for industrial point-of-use process (e.g. filtration or softeners before RO or DI system) and increased maintenance costs (changing resins).

In terms of water quality, the Zone 7 raw water has similarities to the raw water from the Delta, although hardness, TDS and/or conductivity are higher in the Zone 7 raw water. Also, because water delivered under the "Maximizing Delta Diversion" alternative would consist of Delta water blended with Tuolomne River and local source waters (or possibly subject to additional water treatment beyond current levels), the impacts on industrial customers receiving water via a "Maximize Delta Diversion" alternative would be substantially less that those described in the case studies. With this in mind, it is emphasized that these case studies illustrate how industrial customers could be impacted by changes in water quality, however they do not predict the types of impacts that are likely to be seen under any of the alternatives suggested.

A comparison of selected water quality constituents for the three case studies is presented in Table 2. Inspection of Table 2 indicates that Hetch Hetchy treated water is lower than Zone 7 treated water in hardness, TDS, and conductivity. Average concentrations for those constituents are also presented for raw Delta water for comparison.

Table 2. Water Quality Comparison for Case Studies (I)
Source Waters

Source Water	Water Type	Hardness (as CaCO3) mg/L	TDS (mg/L)	Conductivity (umhos/cm)
Zone 7 Annual Consumer Confidence Report [1]				
Del Valle WTP	treated	101	270	454
Patterson Pass WTP	treated	88	239	405
Mocho Wellfield	treated	391	572	903
Stoneridge Well	treated	261	398	633
Hopyard Wellfield	treated	331	476	757
Environmental Defense Report				
Hetch Hetchy	treated	14	27	43
Local Water	treated	100	189	297
Delta	raw	84	216	374

Notes: 1. Zone 7 water quality data from the Zone 7 *2004 Annual Consumer Confidence Report*

Table 3 shows projected concentrations of the same water quality constituents for four future treatment/delivery alternatives described in the Environmental Defense report, based on demand in the year 2030. Because the water delivered under each alternative is a blend of several sources, the constituent concentrations for the "non-Hetch Hetchy" alternatives in Table 3 are lower than those in the individual source waters listed in Table 1 or Table 2. For the same reason, the "Future with Hetch Hetchy" values are slightly higher than for 100% Hetch Hetchy water. The values in Table 3 are probably more representative of the changes that facility would experience under a future scenario without Hetch Hetchy reservoir. Thus, for these key constituents, the case studies which follow describe a more extreme change in water quality than would likely occur.

Table 3. Water Quality Comparison for Case Studies (II)
Projected Quality of Delivered Water under various Treatment/Delivery Alternatives

Source Water	Hardness mg/L	TDS (mg/L)	Conductivity (umhos/cm)
Future with HH Reservoir	27 (35)	52 (67)	82 (105)
Maximize Don Pedro Alternative	19 (19)	32 (33)	46 (45)
Don Pedro Diversion / Expanded Calaveras Alternative	43 (50)	30 (30)	42 (41)
Maximize Delta Diversion Alternative	43 (50)	100 (120)	167 (204)

From Environmental Defense Report, Appendix B, Tables 3.5, 4.2, 4.5, 4.4 respectively. Values are annual average concentration estimates, with drought average estimates in parenthesis. Values for each alternative represent a blend of sources to meet an assumed future (2030) demand of 339 ac-ft yr. For example, "Future with HH Reservoir" reflects weighted concentrations for blend of Tuolumne River water from upstream, Tuolumne River via local storage, and local from local storage.

4.1 Case Study 1: Cooling Towers

Operational requirements for cooling towers depend on overall quality of the make up water and cannot be uniquely characterized by any single constituent. Water quality properties of importance to cooling tower operation include conductivity, TDS (total dissolved solids) pH, alkalinity, and hardness. Conductivity is a measure of the water's ability to conduct electrical current, and is an indicator of the amount of dissolved minerals present. TDS is closely related to conductivity, in that it provides a direct measurement of dissolved solids. However, conductivity is typically used for field measurements and for automatic controllers used to remove water (blowdown) from a cooling tower sump. High harness levels are associated with the tendency to form chemical deposits (scale) on equipment surfaces. pH and alkalinity are related, and are associated with the tendency for the water to be corrosive. Low pH and low alkalinity are associated with increased corrosion. Both also play a role in scale formation (excessive pH/alkalinity can promote scale formation). Chemical treatments are used in cooling tower system to control corrosion, reduce scale formation, and to reduce microbial and other types of fouling. In general, waters with higher levels of conductivity/TDS/hardness require greater use of chemicals, and also require operation at higher blowdown rates, because salts concentrate to critical levels after a fewer number of concentration "cycles"

This case study is for a campus-type research facility with several, different sized cooling towers in operation. In terms of water use, the towers vary in size from about 1,000 to 10,000 gal/day. When using Hetch Hetchy water, the cooling towers operate at approximately 10 cycles. The conductivity of the make-up water is ~40 uohms/cm (Table 2), while the blowdown controller setpoint is 400 uohms/cm. Cooling tower cleaning is typically performed on a quarterly basis.

When using Zone 7 water, cooling towers are operated at 3-4 cycles.[4] The conductivity of the make-up water is ~700 uohms/cm, and the blowdown controller setpoint is 2,000 uohms, resulting in operation at slightly over 3 concentration cycles. If the cooling towers were consistently run on Zone 7 water, maintenance staff anticipate that more frequent cleanings and maintenance of the cooling towers would be needed.

Maintenance staff collect periodic meter readings for water usage at the cooling towers. In 2004, the entire facility site switched from SFPUC (Hetch Hetchy) to a Zone 7 water supply during the months of July through October. Cooling tower usage were evaluated for 192 days while the site was receiving Hetch Hetchy water (Feb-June, Nov-Dec) and 126 days (June-Oct) while the site was receiving Zone 7 water. Based on these data, the average water use for five cooling towers of differing sizes was calculated. These calculations indicate that the water usage while on Zone 7 water ranged from 55% - 135% greater than when on Hetch Hetchy water, with an overall average increase of 90% for the facility as a whole. A portion of the increase must be attributed to the increased fraction of the cooling demand that is satisfied by evaporation during the summer months (as opposed to non-evaporative heat exchange, which is plays a more significant role during the colder months), and possibly other factors. For the specified blowdown setpoints, an increase in water usage of about 40% would theoretically be expected when operating on Zone 7 water, to provide the equivalent amount of evaporative cooling. (The theoretical increase

[4] To extent to which these setpoints were optimized for each water source is unknown, but are within the range of values seen in the literature.

is strongly dependent on the allowable blowdown conductivity, and would increase if the setpoint were lowered for Zone 7 water).[5]

Assuming conservatively that 50% of increased water use was attributable to the higher TDS (Zone 7) source water, and based on this facility's water rate of $2.52/1000 gallons, the increased water costs associated would be on the order of $1.26 per 1000 gallons for this facility.

Chemical treatment costs increased by approximately 73% ($1170) during the period when the Zone 7 water was used, from and average of $1,610/month to $2,780/month. This increase is somewhat less than the proportional to the overall average increase in water used. Again assuming that 50% percent of the observed 90% average increase in flow is attributable to the different water source, this translates to $650/month, or about $1.06/1000 gallons for this facility. This calculation should b e considered rough, but gives some sense of the magnitude of changes for this facility.[6].

In extrapolating these finding to other possible scenarios (i.e. the scenario where Delta water would be substituted for Hetch Hetchy water), it is import to note that Delta water has lower concentrations of key water quality parameters (TDS/conductivity/hardness) than the Zone 7 water, as indicated in Tables 2. Furthermore, the water delivered under the "Maximizing Delta Diversion scenario" would be a blend of various sources, and the resulting conductivity and TDS values would reflect that blend, as indicated in Table 3. In the *Paradise Regaine*d report, annual average values for TDS and conductivity for the "Maximizing Delta Diversion" alternative were 100 mg/L and 167 uohms/cm, respectively, for the "annual average" case, and 120 mg/L and 204 uohms/cm, respectively for the "drought average" case. Using a value of 200 uohms/cm, and conservatively assuming a blowdown concentration of 800 uohms/cm (4 cycles), water usage could be expected to increase by 20%.

4.2 Case Study 2: Ultra Pure Water at a Semiconductor Manufacturing Facility

The second case study is for a research scale semiconductor manufacturing facility in the Livermore Valley. The facility has the following manufacturing processes: crystal slicing, lapping and polishing, sample etching and cleaning, diffusion and drive-ins, lithography, thin film deposition and crystal growth. This facility requires ultra pure water for rinsing processes and relies on deionization for water treatment. The deionization system consists of softening beds, ion exchange units, and final filters, and produces approximately 400 gallons of DI water per day. Recently a reverse osmosis unit was added to the water treatment system at a cost of approximately $15,000.

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[5] For example, if the blowdown conductivity for the Zone 7 water were set at 1400 uohms/cm, only two concentration cycles could occur, and water usage would increase by approximately 100% over that for a "Hetch Hetchy only" (40 uohms/cm) supply. This example is provided for illustration only. Adjustments to chemical treatments would probably be more cost effective than operating at such a low concentration cycle.

[6] It is interesting to note that one water treatment representative noted that Hetch Hetchy water, with its characteristic low alkalinity, can be more corrosive than Zone 7 water (in spite of its lower salinity), and thus require higher doses of corrosion control chemicals. However, the hardness of the Zone 7 water is significantly higher, and probably is a more important factor in overall chemical treatment requirements.

The three water quality parameters of primary concern for DI system operations and maintenance are hardness, TDS, and chlorine. Harder water will require a softener exchange tank before the ion exchange tanks or RO unit. Higher TDS will require more frequent cleaning or changing of the resin beds. Water that is high in chlorine requires a carbon filter or sodium bisulfite addition to remove the chlorine before the RO or DI system.

Maintenance logs for this facility show the frequency of maintenance prior to the addition of the reverse osmosis unit was approximately biweekly regardless of the source water. However there were differences in the type of maintenance performed based on the source water. The final filters were replaced more often during periods of Hetch Hetchy use (approximately $110 each) and softening beds were replaced more often during periods of Zone 7 water use (approximately $68 each). The DI tanks were also replaced (approximately $68/tank) every few weeks regardless of source water. Flow volumes under the two regimes are not known with sufficient accuracy to calculate unit costs.

With the addition of the RO unit, overall maintenance requirements are lower, and differences in maintenance for the two sources are not discernable. Although not a significant factor at this scale, water usage is higher because of the RP reject stream (the RO system rejects approximately 25% of the incoming flow as concentrate), and the RO unit itself will eventually require maintenance or replacement. (Smaller reverse osmosis membranes are typically replaced, while larger membranes are cleaned and regenerated to extend their life). Costs for RO membranes (4 used for this system) are approximately $100 - $150 per membrane.

Although the system described above is a small volume system, the experience at this facility illustrates that for ultra-pure water systems, the effects of changing water sources primarily impact the "front end" process elements (softening and/or RO) units. For softening units, the impact of higher hardness levels will be that softening resins will need to be exchanged or regenerated more frequently. Assuming that the full capacity of softening units is utilized before replacement, the increase in frequency can be roughly predicted based on the relative harness of the two water sources, i.e. if hardness doubled, then softening units would need to be replaced twice as often. For systems that include an RO component, the RO will for the most part shield the downstream (e.g. DI or electro-DI and final filters) from the impact of changes in source water quality. According to one vendor contacted, the volume of RO concentrate from a UPW package system would not change significantly over the range of TDS values represented by the different source waters in Table 3. The greatest impact would be for UPW systems that do <u>not</u> have an existing RO component, where such a unit must be added to accommodate the new water source, as was the case above.[7] In such cases, additional costs would be incurred for RO unit itself, membrane maintenance/replacement, and of the additional water used (for commercial UPW packages, the RO reject stream is about 25%-33% of the incoming flow). Such additional costs would be offset in part by reduced operating costs for the downstream components (filters and DI resins).

[7] The system described initially did not have an RO component. In this case, the Hetch Hetchy supply, after softening, was of sufficient quality that an RO unit was not required in advance of the DI unit. This may not be the case universally. One vendor of electro-DI equipment specifies a feedwater requirement consisting of RO permeate with silica <0.01 ppm, iron <0.01 ppm, and TOC <0.5 ppm as C.

4.3 Case Study 3: Ultra Pure Water at a Metal Finishing Facility

The third case study considers a metal finishing facility that uses a three-stage DI treatment system. The treatment train includes 25 micron filters, resin tanks for organics removal, mixed bed DI resin tanks (hardness and salinity removal) , 5 micron filters, polishing DI resin tanks, 5 micron filters, UV and 5 micron filters. The treatment system typically produces 2,000 gallons of water per week. During normal operating conditions, the DI tanks and the filters are changed approximately every six months ($250 for six tanks).

When the source water changed to Zone 7 water, the 25 micron pre-filter required replacement more frequently than with Hetch Hetchy water. On average, these filters needed changing every two months. At a cost of approximately $6/filter, this corresponds to an increased cost of $0.67/1000 gallons produced (materials only). The DI tanks and 5 micron filters remained on the same maintenance schedule. This suggests that the resin capacity was underutilized when on Hetch Hetchy water, which may be typical for small and medium size facilities, where resin replacement is done on a fixed schedule (time or gallons basis). For a system where resin capacity and replacement was closely monitored and optimized, the expectation would be that the frequency of replacement (particularly for the 1st stage DI resins) would be proportional to the TDS of the incoming water.

5.0 Conclusions

Several alternative strategies for operating the SFPUC water system without the Hetch Hetchy Reservoir were identified and investigated previously (EOA 2004, Environmental Defense 2005). As part of that investigation, for each alternative potential and appropriate water treatment technologies were identified that would result in water quality that is effectively equivalent to the current finished water quality.

In this report, the potential impacts to industrial facilities of operating the SFPUC water system without the Hetch Hetchy Reservoir was further investigated. Bay Area industries that are especially sensitive to water quality were identified and an overview of typical water treatment approaches was provided. Water quality data were then reviewed to determine potential changes in finished water quality that could impact the identified industries. Finally, three cases studies were reviewed to illustrate how changes in water quality could impact industrial facilities.

The results from this and from the previous water quality investigation indicate that differences between future conditions with the Hetch Hetchy Reservoir versus alternatives based on either the “Maximize Don Pedro Diversion” or the “Don Pedro Diversion and an Expanded Calaveras Reservoir” are likely to have a minimal impact on the finished water quality, and thus minimal impact on industrial facilities with high water quality requirements.

The differences between future conditions with Hetch Hetchy Reservoir and an alternative based on “Maximizing Delta Diversion” could have an impact on industrial users if the resulting finished water has significantly increased levels of TDS and/or other constituents. The case studies provided herein provide an illustration of how industrial facilities could be impacted by water quality under that scenario. These case studies effectively describe a worst case scenario for industrial facilities served by SFPUC, as the change in key water quality constituents observed in the case studies was more dramatic than is projected under the "Maximizing Delta Diversion" alternative.

For cooling tower applications, the case study results coupled with a simple theoretical analysis, indicate increased water usage on the order of 50% would result if high TDS/conductivity (e.g 700 uohms/cm) water were supplied. Chemical treatment requirements would also increase under this scenario, though at a level somewhat less than proportional to the increase in flow. Because water delivered under the "Maximizing Delta Diversion" alternative would be a blend of various sources (with an estimated conductivity of 175-200 uohms/cm), the projected increase in water usage for that alternative would be approximately 20%.

For ultrahigh purity water (UPW) applications, the impacts of changing to a higher salinity source water would depend of specific treatment process. The greatest impact would be to the "front end" components (i.e. initial filters and softening units). For resin-based softening, the frequency of resin replacement/regeneration could be expected to increase in proportionately to the incoming source water hardness. For treatment systems depending entirely on DI resins for salinity removal (i.e. no RO process component), the increase in replacement/regeneration frequency for the 1st stage resins would be proportional to the increased TDS. (In both cases, the increased frequency may be less than indicated if resin capacity is not fully utilized to begin with). For systems that utilize RO, the salinity of the RO concentrate (reject) stream would increase, but reject flows (and hence water consumption) would not change significantly. Although the RO unit largely isolates the final treatment processes (e.g. DI or electro-DI and final filters) from the higher concentrations in the source water, some increase O&M costs for those components could be expected. Systems without an RO component might find it necessary (or more economical) to add RO to the treatment process, to buffer downstream processes. In such cases, water usage for the UPW process stream would increase by 25%-33% as a result of the RO concentrate waste flow.[8]

[8] For a high volume system, a second stage RO component to concentrate the RO reject could be used to reduce the volume of concentrate flow.

6.0 References

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