CHAPTER 8

Water-quality analysis

Any viable plan to restore Hetch Hetchy Valley must assure that the quality of Bay Area residents' drinking water will not be diminished. As part of this investigation of water-supply alternatives, Environmental Defense retained Eisenberg, Olivieri and Associates (EOA) to assess the existing and future quality of water delivered by the San Francisco Public Utilities Commission (SFPUC), both with and without Hetch Hetchy Reservoir. Based on a review of raw (untreated) water-quality data from potential replacement sources, EOA determined "there does not appear to be any technical reason [why] the SFPUC Hetch Hetchy water-supply system could not be operated without the Hetch Hetchy Reservoir," though did recommend that further water-quality analysis be pursued concurrently with the examination of specific alternatives.

This chapter provides a brief overview of water-quality and treatment issues, a summary of EOA's findings, and the estimated costs for treating water from alternative sources. For a more detailed summary of EOA's findings, see Appendix B.

Overview of major contaminants and treatment

Contaminants that enter water-supply systems can pose both immediate and chronic threats to human health. Chronic risks are caused by a long list of chemicals, including lead, radon, arsenic and MTBE (methyl tertiary-butyl ether), while the most immediate risks tend to come from a range of microbiological contaminants, or pathogens. These protozoa, bacteria, or viruses generally cause mild or moderate gastroenteritis, but they can sometimes cause more severe illnesses and on rare occasions be fatal.

Two types of protozoa—giardia and cryptosporidia—are commonly associated with untreated or poorly treated water supplies. These parasites cause persistent diarrhea, and cryptosporidiosis in particular can be fatal to children, the elderly, or patients with compromised immune systems.[1] Both pathogens are resistant to chlorine disinfection.[2] The U.S. Environmental Protection Agency (EPA) has in the past several years promulgated new treatment rules for protecting water supplies from giardia and cryptosporidia. Compliance with these rules may involve one or more of a variety of technologies, including enhanced filtration and sedimentation to reduce turbidity and application of ozone and ultra-violet light.

Bacteria, which are smaller than protozoa and thus more difficult to filter thoroughly, cause typhoid and cholera—historically, among the greatest threats to human health through drinking water. These diseases, though still a serious threat in some parts of the world, have largely been eliminated in the United States. Other bacteria, including E. Coli, salmonella and shigella, can cause major health problems in untreated water or if a breakdown occurs in the treatment process. Normally, however, such bacteria are adequately treated with chlorine, chloramine or other forms of disinfection.

More than 140 viruses, including those responsible for hepatitis and meningitis, are known to infect people through their digestive tracts. While most of these viral infections are transmitted through food or direct contact, rotavirus and others are known to be transmitted through water supplies.

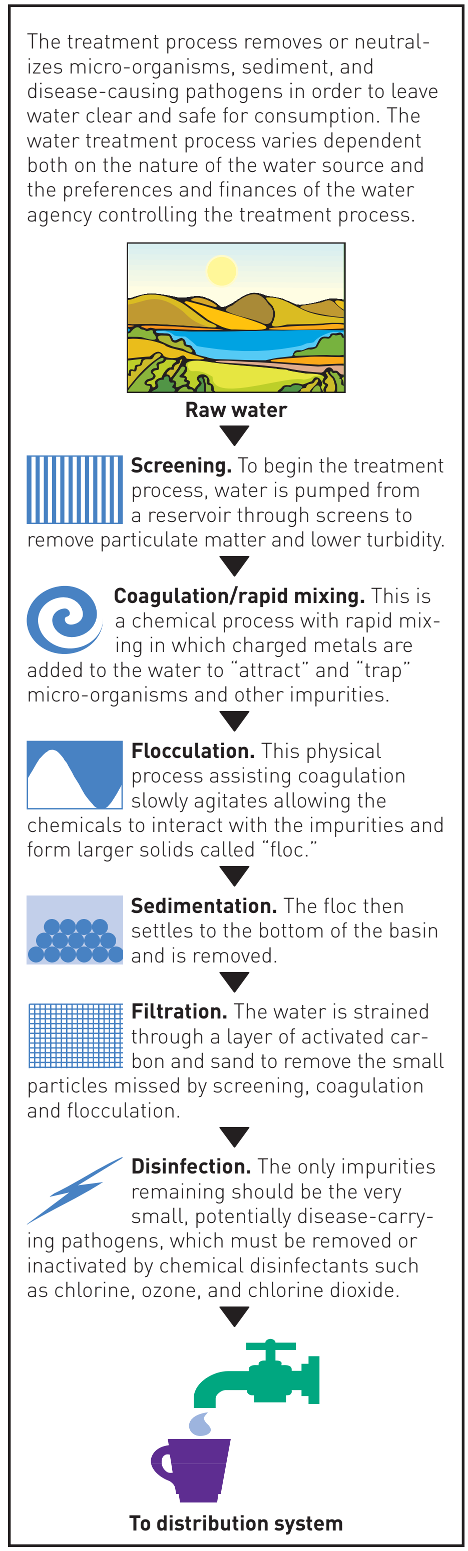
Many viruses are effectively eliminated by chlorine or chloramine disinfection. Some are resistant to these processes, though new treatment approaches using ozone or ultraviolet light may be effective against them.

In California, water quality is regulated by the EPA and the state Department of Health Services. The EPA has set National Primary Drinking Water Regulations (NPDWRs) for 16 inorganic and 54 organic chemicals.[3] The California Department of Health Services identifies seven chemicals as "of current interest, including arsenic and MTBE".[4] While high concentrations of arsenic found in wells in Bangladesh have caused a critical health problem there, arsenic is found in water systems only in certain areas of the United States, and usually in low concentrations. Disputes about acceptable levels of arsenic have most recently led to a new U.S. standard of 10 micrograms per liter, which will be implemented in 2006.

MTBE is a colorless liquid hydrocarbon that has been used to enhance gasoline. Its presence both in surface-water and groundwater supplies was a major factor in its incorporation into water-quality standards. Because MTBE is being phased out of gasoline production, it is not likely to be significant in future surface-water supplies, although it will likely persist in groundwater in some areas. Most water agencies have taken steps, such as prohibiting 2-stroke engines, to reduce or eliminate MTBE contamination in their reservoirs.

Chemical disinfection of water supplies can sometimes create unwanted side effects through the treatment processes' byproducts. For example, because water in the Sacramento-San Joaquin Delta contains both bromide and organic matter, treating these supplies with chlorine can cause formation of trihalomethanes (THMs), which are

FIGURE 8-1
Water treatment process



Source: Report of the Walkerton Inquiry, Part Two, Chapter 6: Drinking Water Treatment Technologies. pp. 189–208 suspected human carcinogens. As a result, some Delta users have switched from chlorine to other disinfection technologies, such as chloramine and ozone, though ozone reacts with bromide to form bromate—another carcinogen. The EPA may promulgate more protective standards for THMs and bromate, which could cause Delta users to modify or abandon chlorine and ozone as major means of disinfection. Agencies have found that by injecting chemicals to lower the pH of water supplies, less chlorine or ozone is needed for disinfection, resulting in lower levels of these byproducts. Ultimately some municipalities may switch to pressure-driven membranes to meet more stringent drinking water quality standards.

Given that no one process is likely to be a panacea, or even adequate for treating all contaminants, water systems normally use a multiple-barrier approach to ensuring delivery of safe and healthy water. The first step is at-the-source protection of the watersheds themselves. The second step is water treatment: methods for treating water vary, though most agencies' processes include filtration followed by chemical disinfection. Once a water supply is treated, providers must ensure that its quality is protected as it traverses the distribution system. Finally, they must monitor the quality of their delivered product to detect any breakdowns in the process, and they must be prepared to respond immediately.

For this report, the combination of source protection and treatment is particularly germane. Under a rare regulatory exemption, the SFPUC is not presently required to filter its Tuolumne River supplies. Flows that are diverted downstream of Yosemite National Park, however, are likely to have higher concentrations of some contaminants, thus warranting filtration. In any case, Hetch Hetchy Valley will not be restored unless water quality is assured. The analysis conducted by EOA is intended to be merely the initial step in determining whatever additional treatments may be necessary for ensuring that water quality would not be diminished.

Summary of water-quality findings

This section summarizes EOA's analysis, highlighting findings of particular relevance to the question of how today's high level of water quality can be maintained if Hetch Hetchy Valley is restored. The discussion below represents Environmental Defense's characterization of EOA's findings. EOA's complete report is included as Appendix B.

CURRENT SFPUC WATER QUALITY

Under its current system, the SFPUC provides water—both to San Francisco residents and those of other Bay Area communities—that is obtained from several different sources. Most of the water (85 percent) in the overall SFPUC water-distribution system comes directly from Tuolumne River supplies held in Hetch Hetchy Reservoir. The other 15 percent comes from local reservoirs in Alameda County (across the bay) and in San Mateo County (along the San Francisco peninsula).

Water from Hetch Hetchy Reservoir comes from rain and snowmelt in the Sierra Nevada. Because there is little human development in the vicinity, the water from Hetch Hetchy is very clean. Monitoring results over the past decade show scant contamination of the water by minerals and chemicals, with aluminum being the only mineral found above monitoring equipment's detection limits. Water from Hetch Hetchy is also relatively low in bacteria, viruses, and protozoa that can cause human infections. Thus the SFPUC, like New York City, has obtained a rare exemption from the EPA that allows it to distribute water without sending it through a filtration plant; Hetch Hetchy water requires only the addition of disinfectants prior to distribution. It is possible, however, that the EPA will withdraw the current exemption, thus requiring the SFPUC to filter all of its supplies, even if Hetch Hetchy Valley is not restored.

WATER QUALITY UNDER VARIOUS RESTORATION ALTERNATIVES

Restoration of Hetch Hetchy Valley means that snowmelt waters of the Tuolumne River would no longer be captured and stored within Yosemite National Park. With sufficient flow, a portion of the river could be diverted directly to the Bay Area. At other times, water supplies would be diverted downstream. In effect, the loss of storage capacity within Hetch Hetchy Valley would result in a smaller proportion of San Francisco's water being diverted from the upper watershed, and more coming from downstream locations—not only along the Tuolumne (via Don Pedro Reservoir) but possibly from the Sacramento-San Joaquin Delta as well.

The question is: How would these changes alter the quality of the water that San Franciscans drink? To answer it, data from the different potential water sources was collected and analyzed. A comparison of water samples from these sources—Don Pedro, the Sacramento-San Joaquin Delta, and Hetch Hetchy Valley—indicated that they had minor differences in overall quality, although Hetch Hetchy samples did have lower levels of several contaminants. Most important, the Hetch Hetchy water was lower in bacterial contamination and slightly lower in levels of giardia and cryptosporidia.[5] Several chemical contaminants, including MTBE and barium, were higher in the Delta and Don Pedro Reservoir. The Delta water in particular was higher in arsenic and had a greater capacity to form trihalomethanes than either the Don Pedro or Hetch Hetchy raw waters, though it is known that agencies using Delta water are able to remove arsenic through filtration, as it is largely present as suspended particles.[6]

It should be noted that in all samples, the concentrations of chemical contaminants in the raw water were below state and federal drinking-water standards. Nonetheless, given the difficulty of removing many chemical contaminants with standard water filtration, and because few actual measurements were made of many of these contaminants—for example, only three measurements of MTBE were available from the Don Pedro system—the degree of contamination with specific chemical contaminants will need to be more fully characterized in the future.

To get a preliminary estimate, however, of how water quality would be affected by restoration of Hetch Hetchy Valley, EOA evaluated three alternatives based on the storage and conveyance options considered in Chapters 6 and 7.[7] These alternatives are characterized by varying amounts of water diverted from four principal locations, though in all cases the primary source is direct diversion from high in the Tuolumne River watershed (i.e., at Early Intake). Under the first alternative, additional water is captured downstream, primarily through diversion at or just downstream from Don Pedro Reservoir. Under the second, additional water is obtained from the Sacramento-San Joaquin Delta, while under the third, the additional water comes from Don Pedro Reservoir and additional storage capacity is available in an expanded Calaveras Reservoir. In each alternative, the Tuolumne River still provides the majority of San Francisco's water on an annual-average basis.

Using current monitoring results from each facility to predict the future quality of water blended from these sources, the first alternative reflects water-quality differences between the Hetch Hetchy and Don Pedro supplies—mainly, higher bacterial counts, slightly higher turbidity (a reflection of dissolved solids), higher total organic carbon (a predictor of elevated trihalomethanes and other disinfection byproducts) and MTBE. The second alternative, reflecting differences between Hetch Hetchy and Delta supplies, results again in higher bacterial counts, even higher turbidity, higher total organic carbon, and a slight increase in MTBE. In the last alternative, results are very similar to the first, as the increased Calaveras capacity only marginally influences the total mixture.

From a health standpoint, it is assumed that the anticipated increase in bacterial counts or turbidity will necessitate filtering water from the Don Pedro Reservoir and the Sacramento-San Joaquin Delta prior to consumption. The higher turbidity of the Delta water may require some extra steps (i.e., additional coagulation and sedimentation) to remove suspended solids so that the basic filtration and disinfection processes are effective at removing harmful bacteria. The higher levels of MTBE in the Don Pedro water may be more difficult to remove by filtration techniques, though the predicted levels of 1–2 micrograms/liter (mcg/L) are well below the California state standard of 13 mcg/L. It should also be noted that MTBE levels in water sources are expected to decline, as this chemical is no longer added to gasoline in California.

With the addition of existing filtration technologies, and based on available data, the water quality predicted to result from use of the Don Pedro or Sacramento-San Joaquin Delta source should be comparable, or even superior, to the quality of water from the current Hetch Hetchy source. In particular, filtration should reduce the presence of giardia and cryptosporidia to levels lower than those present in the current scheme. Further, filtration provides an additional layer of protection from water-contamination events. Table 8-1 provides a summary of anticipated water-treatment technologies that would be employed for each of the sources.

While it is difficult to predict the future capabilities of water-treatment technologies, significant advances are being made in this field. It is likely that

TABLE 8-1
Summary of treatment requirements and recommendations

	POINT OF DIVERSION					
Treatment process	**Hetch Hetchy**	**Early intake**	**Don Pedro**	**Calaveras**	**Peninsula**	**Sacramento-San Joaquin Delta**
Screening, coagulation, flocculation, sedimentation	◇	●	◆	◆	◆	◆
Basic filtration	◇	●	◆	◆	◆	◆
Enhanced treatment	◇	◇	◇	◇	◇	●
Disinfection	◆	◆	◆	◆	◆	◆
Additional treatment						○

◆ Currently required by law
◇ May be required in the future
● Recommended to satisfy health criteria
○ Recommended to match Hetch Hetchy water quality

TABLE 8-2
Estimates of unit water treatment costs

Water source	Unit cost of treatment ($/acre-foot)*	Reference
Hetch Hetchy Reservoir diversions	5	UC Davis, CALVIN Model, Appendix G[8]
Tuolumne downstream diversions	20	UC Davis, CALVIN Model, Appendix G
Local reservoirs	250	EBMUD Local Reservoir Estimate[9]
Delta supplies	220	UC Davis, CALVIN Model, Appendix G

*Excludes capital costs

more advanced water-filtration facilities—based, for example, on recent advances in membrane and magnetic ion-exchange methods—will become cost-effective in the near future and yield even cleaner water than is projected using existing technology.

All in all, the preliminary data analysis described in this section suggests that use of alternative sources such as the Don Pedro and Sacramento-San Joaquin Delta systems will deliver water whose quality is comparable to that of the existing Hetch Hetchy system, provided that water filtration is added. As noted earlier, however, more thorough monitoring and evaluation of the various water-source options is necessary before a plan for operating the SFPUC system without Hetch Hetchy Reservoir can be adopted.

Water-treatment costs

EOA's preliminary findings enable us to estimate the costs of additional treatment for the restoration alternatives considered in this report, which assumes that the SFPUC would filter all of its supplies. Schlumberger Water Services estimated that to increase the capacity of the Sunol Treatment Plant by 160 million gallons per day (beyond the SFPUC's planned 80 million gallons per day expansion) would incur a capital cost of $134.4 million to $288 million (See Appendix A).

Table 8-2 provides estimates of the unit costs of water treatment. They are integrated with capital costs and other operating expenses in Chapter 10.

In short:

- Diversions from Hetch Hetchy Reservoir are very inexpensive to treat because they are not filtered. These supplies are currently treated with a chloramine process: chlorine is added to the water at Tesla Portal and ammonia is added in Sunol Valley.
- Diverting further downstream on the Tuolumne River would also be relatively inexpensive to treat. Chemical treatment would change little, but the water would be filtered.
- Treating water from the Delta and local reservoirs would be considerably more expensive because increases in organic matter, turbidity and other constituents need to be addressed. A variety of techniques, including chlorine dioxide and carbon dioxide injection, are currently used to remove bromide from Delta supplies. Treating water in local reservoirs often requires advanced treatment, including additional coagulation, flocculation and sedimentation, to cope with algal blooms. However, given the infrequent use of these sources, the total expected cost of treatment might not be significant.