UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 5 1997

OFFICE OF WATER

MEMORANDUM

SUBJECT: Establishing Site Specific Aquatic Life Criteria Equal to Natural Background

FROM: Tudor T. Davies, Director
Office of Science and Technology

TO: Water Management Division Directors, Regions 1-10
State and Tribal Water Quality Management Program Directors

In the course of reviewing State and Tribal water quality standards (WQS), EPA has identified several issues pertaining to the establishment of site specific numeric criteria on the basis of natural background conditions. EPA is issuing this policy to provide greater clarity and direction for States and Tribes who are considering establishing site specific criteria equal to natural background conditions, and for EPA Regional Offices reviewing State and Tribal water quality management programs.

Background

Site specific criteria are allowed by regulation and are subject to EPA review and approval. The Federal water quality standards regulation at 40 CFR 131.11(b)(1) requires States and authorized Tribes to adopt numeric water quality criteria that are based on section 304(a) criteria, section 304(a) criteria modified to reflect site-specific conditions, or other scientifically defensible methods. Under 40 CFR 131.5(a)(2), EPA reviews State WQS to determine whether a State has adopted criteria to protect the designated uses. Existing guidance and practice are that EPA will approve site specific criteria developed on the basis of sound scientific rationales.

Currently, EPA guidance has specified three procedures for States and Tribes to follow in deriving site specific criteria. These are the Recalculation Procedure, the Water-Effect Ratio Procedure and the Resident Species Procedure. These procedures can be found in the *Water Quality Standards Handbook* (EPA-823-B940005a, 1994). EPA also recognizes there may be naturally occurring concentrations of pollutants which may exceed the national criteria published under section 304(a) of the Clean Water Act.

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL	# of pages ▸ 3
To Keith Bean	From Bill Kramer
Dept./Agency	Phone # 202-260-5824
Fax # 916-653-0428	Fax # 202-260-5394
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

Policy

This policy applies only to site specific numeric aquatic life criteria based on natural background. States and Tribes may establish site specific numeric aquatic life water quality criteria by setting the criteria value equal to *natural* background. Natural background is defined as background concentration due *only* to non-anthropogenic sources, i.e., non-manmade sources. In setting criteria equal to natural background the State or Tribe should, at a minimum, include in their water quality standards:

(1) a definition of natural background consistent with the above;
(2) a provision that site specific criteria may be set equal to natural background;
(3) a procedure for determining natural background, or alternatively, a reference in their water quality standards to another document describing the binding procedure that will be used.

Discussion

A State or Tribal procedure for determining natural background will need to be specific enough to establish natural background concentration accurately and reproducibly. States and Tribes should also provide for public notice and comment on the definition, the provision, the procedure and the site specific numeric criteria derived from the procedure. The State or Tribe will need to document the resulting site specific numeric criteria in the State or Tribal water quality standards, including specifying the water body segment to which the site specific criteria apply. This can be accomplished through adopting the site specific criteria into the State or Tribal WQS, or, alternatively, by appending the site specific criteria to the WQS. In either case, the State or Tribe must comply with the public participation requirements of 40 CFR 131.20 and 40 CFR Part 25, and State and Tribal citizens should be able to readily determine the water quality criteria applicable to specific water bodies.

For aquatic life uses, where the natural background concentration for a specific parameter is documented, by definition that concentration is sufficient to support the level of aquatic life expected to occur naturally at the site absent any interference by humans. The State or Tribe should consider refining the designated use for the water body to more precisely define the existing aquatic life use.

This policy does not apply to human health uses. For human health uses, where the natural background concentration is documented, this new information should result in, at a minimum, a re-evaluation of the human health use designation. Where the new background information documents that the natural background concentration does not support a human health use previously believed attained, it may be prudent for the State or Tribe to change the human health use to one the natural background concentration will support (e.g., from drinking water supply to drinking water supply only after treatment).

Conclusion

This policy explains and clarifies the use of natural background conditions in establishing site specific criteria for protection of aquatic life uses. In addition to the three procedures listed above for deriving site specific criteria as discussed above, States and Tribes can address natural background conditions through refining the designated use to more accurately reflect the aquatic community present within the stream segment. EPA recognizes that there are other options available to States/Tribes to account for other ambient conditions (e.g., concentrations due to non-natural, man-made conditions) which exceed the national criteria. One such option is for a State or Tribe to conduct a Use Attainability Analysis, consistent with the requirements of 40 CFR 131.10, and adopt a use which is less than the 101(a) goal uses of the Clean Water Act, e.g., less than "fishable/swimmable", or modify a 101(a) goal use such that less stringent criteria are required. In any case, the existing uses of the water body segment must be maintained and protected.

If you have any questions or concerns regarding this policy, please contact me or have your staff contact Elizabeth Southerland, Acting Director, Standards and Applied Science Division, at 202-260-3966.

cc: Lepow, OGC
Wayland, OWOW
Cook, OWM
Dougherty, OGWDW

Public Health Goal for TETRACHLOROETHYLENE In Drinking Water

Prepared by

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Pesticide and Environmental Toxicology Section
Anna M. Fan, Ph.D., Chief

Deputy Director for Scientific Affairs
George V. Alexeeff, Ph.D.

August 2001

LIST OF CONTRIBUTORS

PHG PROJECT MANAGEMENT	REPORT PREPARATION	SUPPORT
Project Director	***Authors***	***Administrative Support***
Anna Fan, Ph.D.	Andrew Salmon, Ph.D.	Edna Hernandez
	Elinor Fanning, Ph.D.	Coordinator
Public Workshop		Sharon Davis
Yi Wang, Ph.D.	***Primary Reviewer***	Jocelyn Tan
	Joseph Brown, Ph.D.	Genevieve Vivar
External Review		
David Ting, Ph.D.	***Final Reviewers***	***Library Support***
	Anna Fan, Ph.D.	Charleen Kubota, M.L.S.
Revisions/Responses	George Alexeeff, Ph.D.	Valerie Walter
Javier Avalos, Ph.D.	Robert Howd, Ph.D.	
Robert Howd, Ph.D.		***Web Site Posting***
	Education and Outreach/Summary Documents	Edna Hernandez
	Hanafi Russell	Laurie Monserrat

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PREFACE

Drinking Water Public Health Goals

Pesticide and Environmental Toxicology Section

Office of Environmental Health Hazard Assessment

California Environmental Protection Agency

This Public Health Goal (PHG) technical support document provides information on health effects from contaminants in drinking water. PHGs are developed for chemical contaminants based on the best available toxicological data in the scientific literature. These documents and the analyses contained in them provide estimates of the levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime.

The California Safe Drinking Water Act of 1996 (amended Health and Safety Code, Section 116365), amended 1999, requires the Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and adopt PHGs for contaminants in drinking water based exclusively on public health considerations. Section 116365 specifies that the PHG is to be based exclusively on public health considerations without regard to cost impacts. The Act requires that PHGs be set in accordance with the following criteria:

1. PHGs for acutely toxic substances shall be set at levels at which no known or anticipated adverse effects on health will occur, with an adequate margin of safety.
2. PHGs for carcinogens or other substances which can cause chronic disease shall be based upon currently available data and shall be set at levels which OEHHA has determined do not pose any significant risk to health.
3. To the extent the information is available, OEHHA shall consider possible synergistic effects resulting from exposure to two or more contaminants.
4. OEHHA shall consider the existence of groups in the population that are more susceptible to adverse effects of the contaminants than a normal healthy adult.
5. OEHHA shall consider the contaminant exposure and body burden levels that alter physiological function or structure in a manner that may significantly increase the risk of illness.
6. In cases of insufficient data to determine a level of no anticipated risk, OEHHA shall set the PHG at a level that is protective of public health with an adequate margin of safety.
7. In cases where scientific evidence demonstrates that a safe dose-response threshold for a contaminant exists, then the PHG should be set at that threshold.
8. The PHG may be set at zero if necessary to satisfy the requirements listed above.
9. OEHHA shall consider exposure to contaminants in media other than drinking water, including food and air and the resulting body burden.
10. PHGs adopted by OEHHA shall be reviewed every five years and revised as necessary based on the availability of new scientific data.

PHGs published by OEHHA are for use by the California Department of Health Services (DHS) in establishing primary drinking water standards (State Maximum Contaminant Levels, or MCLs). Whereas PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations, drinking water standards adopted by DHS are to consider economic factors and technical feasibility. Each standard adopted shall be set at a level that is as close as feasible to the corresponding PHG, placing emphasis on the protection of public health. PHGs established by OEHHA are not regulatory in nature and represent only non-mandatory goals. By federal law, MCLs established by DHS must be at least as stringent as the federal MCL if one exists.

PHG documents are used to provide technical assistance to DHS, and they are also informative reference materials for federal, state and local public health officials and the public. While the PHGs are calculated for single chemicals only, they may, if the information is available, address hazards associated with the interactions of contaminants in mixtures. Further, PHGs are derived for drinking water only and are not to be utilized as target levels for the contamination of other environmental media.

Additional information on PHGs can be obtained at the OEHHA Web site at www.oehha.ca.gov.

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PUBLIC HEALTH GOAL FOR TETRACHLOROETHYLENE IN DRINKING WATER

SUMMARY

A public health goal (PHG) of 0.06 µg/L is established for tetrachloroethylene (PCE, also known as perchloroethylene) in drinking water. The PHG is based on carcinogenic effects observed in experimental animals. Exposure to PCE is carcinogenic for rodents, inducing liver cancer in mice by inhalation (NTP, 1986) or ingestion (NCI, 1977), and leukemia in rats by inhalation (NTP, 1986). Statistically significant increases in the incidence of tumors at several sites have also been observed in certain studies of workers in the dry-cleaning industry (Blair et al., 1990; Ruder et al., 1994).

For the calculation of the PHG, cancer potency estimates were made based on the recommended practices of the 1996 United States Environmental Protection Agency (U.S. EPA, 1996) proposed guidelines for carcinogenic risk assessment. According to these methods, a polynomial model is fit to the experimental data in order to establish the lower 95 percent confidence bound on the dose associated with a 10 percent increased risk of cancer (LED_{10}). The PHG was calculated assuming a *de minimis* theoretical excess individual cancer risk level of 10^{-6} from exposure to PCE. Cancer potency estimates were derived, using time-dependent models, from the observed incidences of hepatocellular carcinoma in male and female mice exposed orally to PCE. For water-derived inhalation exposures, estimates were derived from the incidences of hepatocellular adenoma or carcinoma in mice, and mononuclear cell leukemia in rats of both sexes exposed by inhalation to PCE. Based on these considerations, Office of Environmental Health Hazard Assessment (OEHHA) has established a PHG of 0.06 µg/L for PCE in drinking water.

An estimate of the concentration of PCE in drinking water protective against chronic toxicity other than cancer was derived based on neurobehavioral endpoints (related to delayed reaction times) observed in epidemiological studies of humans with occupational or environmental exposures to inhaled PCE. Uncertainty factors, allowing for extrapolation from LOAELs (0.29, 4.15 and 8.48 mg/kg-d) to NOAELs and for interindividual variation in the human population, ranged from 30 to 100. The geometric mean of three such estimates was used to derive an estimated health protective concentration in drinking water of 11 ppb (11 µg/L).

The U.S. EPA has established a maximum contaminant level goal (MCLG) of zero mg/L PCE. A maximum contaminant level (MCL) of 0.005 mg/L PCE has also been established (U.S. EPA, 1989). The California Department of Health Services currently lists an MCL of 0.005 mg/L (5 ppb). The OEHHA PHG incorporates several differences from the earlier U.S. EPA evaluation, including: 1) interspecies scaling according to the ¾ power of body weight, 2) a time-to-tumor analysis of the NCI (1977) oral mouse bioassay data, and 3) a more sophisticated human pharmacokinetic model for low-dose oral and inhalation exposures. It also is based exclusively on public health considerations, whereas the MCLs may include considerations of economic and technical feasibility.

PUBLIC HEALTH GOALS FOR CHEMICALS IN DRINKING WATER

URANIUM

August 2001

Agency Secretary
California Environmental Protection Agency
Winston H. Hickox

Director
Office of Environmental Health Hazard Assessment
Joan E. Denton, Ph.D.

Public Health Goal for
URANIUM
In Drinking Water

Prepared by

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

Pesticide and Environmental Toxicology Section
Anna M. Fan, Ph.D., Chief

Deputy Director for Scientific Affairs
George V. Alexeeff, Ph.D.

August 2001

LIST OF CONTRIBUTORS

PHG PROJECT MANAGEMENT	REPORT PREPARATION	SUPPORT
Project Director Anna Fan, Ph.D.	***Authors*** David Morry, Ph.D. Joseph Brown, Ph.D.	***Administrative Support*** Edna Hernandez Coordinator Sharon Davis Jocelyn Tan Genevieve Vivar
Public Workshop Yi Wang, Ph.D.	***Primary Reviewer*** Frank Mycroft, Ph.D.	
External Review David Ting, Ph.D.	***Final Reviewers*** Anna Fan, Ph.D. George Alexeeff, Ph.D. Robert Howd, Ph.D.	***Library Support*** Charleen Kubota, M.L.S. Valerie Walter
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PUBLIC HEALTH GOAL FOR URANIUM IN DRINKING WATER

SUMMARY

A Public Health Goal (PHG) has been developed for uranium in drinking water based on its radioactivity. All isotopes of uranium are radioactive, and the total radioactivity depends on the ratio of isotopes. The ionizing radiation from uranium is considered to be inherently carcinogenic. The PHG for uranium is based on the U.S. Environmental Protection Agency's latest cancer risk calculations for uranium exposure (U.S. EPA, 1999), and recent data on ratio of uranium isotopes in California drinking water (Wong *et al.*, 1999), from which is calculated the uranium specific activity of 0.79 pCi/µg (radioactivity output per mass unit). The resulting PHG of 0.5 ppb (0.43 pCi/L) developed for natural uranium in drinking water is based on a *de minimis* 10^{-6} lifetime cancer risk for exposure to ionizing radiation. This PHG level is supported by a study showing changes in indicators of kidney function (increased β2-microglobulin and γ-glutamyl transferase levels in the urine) in a human population, associated with a no-observed-effect-level (NOEL) of 6 µg/day. OEHHA considers cancer risks below the *de minimis* one in a million theoretical risk to be negligible.

Uranium is a naturally occurring radioactive element that is ubiquitous in the earth's crust. Uranium is found in ground and surface waters due to its natural occurrence in geological formations. The average uranium concentrations in surface, ground, and domestic water are 1, 3, and 2 pCi/L, respectively. The uranium intake from water is about equal to the total from other dietary components. Natural uranium contains 99.27 percent ^{238}U, 0.72 percent ^{235}U and 0.006 percent ^{234}U by weight. The primary noncarcinogenic toxic effect of uranium is on the kidneys. Recently published studies in rats, rabbits, and humans show effects of chronic uranium exposure at low levels in drinking water. Effects seen in rats, at the lowest average dose of 0.06 mg U/kg-day, including histopathological lesions of the kidney tubules, glomeruli and interstitium are considered clearly adverse effects albeit not severe. Histopathological effects were also seen at the same exposure level in the liver including nuclear anisokaryosis and vesiculation. Effects on biochemical indicators of kidney function were seen in urine of humans exposed to low levels of uranium in drinking water for periods up to 33 years. These effects, such as increased urinary glucose, β2-microglobulin, and γ-glutamyl transferase, are indicative of potential kidney injury rather than toxicity per se. Uranium is an emitter of ionizing radiation, and ionizing radiation is carcinogenic, mutagenic and teratogenic. A level of 0.5 ppb (0.43 pCi/L) is considered protective for both carcinogenicity and kidney toxicity and is therefore established as the PHG for natural uranium in California drinking water.

The U.S. Environmental Protection Agency (U.S. EPA) has established a maximum contaminant level (MCL) for natural uranium of 30 µg/L (ppb), based on a cost-benefit analysis (U.S. EPA, 2000). The U.S. EPA maximum contaminant level goal (MCLG) is zero. The State of California has an MCL for uranium of 20 pCi/L based on earlier studies of toxicity to the kidney in rabbits.

INTRODUCTION

Uranium occurs as a trace element in many types of rocks. Because its abundance in geological formations varies from place to place, uranium is a highly variable source of contamination in drinking water.

Other agencies have developed health protective levels for uranium (see page 23), these differ from each other and provide equivocal guidance for setting a PHG for natural uranium. The purpose of this document is to review the evidence on toxicity of natural uranium and to derive an appropriate PHG for natural uranium in drinking water.

CHEMICAL PROFILE

Uranium is a radioactive metallic element (atomic number 92). Naturally occurring uranium contains 99.27 percent ^{238}U, 0.72 percent ^{235}U and 0.006 percent ^{234}U. One microgram (μg) of natural uranium has an activity of 0.67 pCi (Cothern and Lappenbusch, 1983). This is the equilibrium specific activity for natural uranium. Natural uranium in geological formations usually has this specific activity. Natural uranium in drinking water may not be in equilibrium, and therefore its specific activity may vary, as discussed below.

U.S. EPA proposed a definition of the term "natural uranium" as uranium with a varying composition, but typically with the composition given above (Fed. Reg. 51: 34836, September 30, 1986). On an equal weight basis the radioactivity of ^{234}U is 17,000-fold and that of ^{235}U is six-fold greater than that of ^{238}U (NRC, 1983). Uranium may be found in valence states of +2, +3, +4, +5 or +6, but +6 is the most stable form and exists as the oxygen-containing uranyl cation (UO_2^{+2}) (Cothern and Lappenbusch, 1983).

The best known use of uranium is as a source of fuel for nuclear reactors and nuclear bombs. The fissionable form of uranium is the isotope ^{235}U. This isotope is only a small fraction of naturally occurring uranium. Several complex minerals are of commercial importance, including carnotite, pitchblende and tobernite (Stokinger, 1981).

ENVIRONMENTAL OCCURRENCE AND HUMAN EXPOSURE

Air

U.S. EPA measured ambient air levels of uranium in 51 urban and rural areas of the United States (U.S.) (U.S. EPA, 1986). The measured concentrations ranged from 0.011 fCi/m^3 to 0.3 fCi/m^3. Ambient air is unlikely to be a significant source of exposure to uranium outside of mining and occupational settings.

Soil

Uranium is present in soils and rocks in concentrations generally varying between 0.5 and 5 ppm (NRC, 1983). It is found in granites, metamorphic rocks, lignite, monazite sands, and phosphate deposits as well as in minerals (Cothern and Lappenbusch, 1983). Uranium enters other media (air, water, and food) from the rocks and soil.

PUBLIC HEALTH GOALS FOR CHEMICALS IN DRINKING WATER

NICKEL

August 2001

Agency Secretary
California Environmental Protection Agency
Winston H. Hickox

Director
Office of Environmental Health Hazard Assessment
Joan E. Denton, Ph.D.

Public Health Goal for NICKEL In Drinking Water

Prepared by

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PUBLIC HEALTH GOAL FOR NICKEL IN DRINKING WATER

SUMMARY

A public health goal (PHG) of 0.012 mg/L (12 µg/L or 12 ppb) is developed for soluble nickel compounds in drinking water. The evaluation is focused on soluble nickel as it is anticipated that the most prevalent exposure through drinking water will be to this form of nickel.

The PHG is based on three reproduction toxicity studies in rats (Smith et al., 1993, Springborn Laboratory, 2000a, 2000b). OEHHA identified the oral dose of 1.12 mg Ni/kg-d as the appropriate NOAEL value, from the lower dose-range Springborn Laboratory (2000b) study. This NOAEL is lower than the doses at which early pup mortality was observed (a LOAEL of 2.23 mg/kg-d was identified in the preliminary study reported by Springborn Laboratory (2000a) and a LOAEL of 1.3 mg/kg-d was identified in the study reported by Smith et al. (1993)). An overall uncertainty factor of 1,000 was used in the development of the PHG. The uncertainty factor includes factors of ten for inter-species extrapolation and intra-species variability, and an additional factor of ten to account for the potential carcinogenicity of soluble nickel by the oral route. The PHG was calculated by assuming a relative source contribution of 30 percent, a water consumption rate of 2 L/day, and an adult body weight of 70 kg.

The United States Environmental Protection Agency (U.S. EPA) had promulgated a maximum contaminant level goal (MCLG) of 0.1 mg/L and a maximum contaminant level (MCL) of 0.1 mg/L (100 ppb) for nickel in 1992. However, the MCL and MCLG for nickel were remanded on February 9, 1995. This means that while U.S. EPA is reconsidering the limit on nickel, there is currently no U.S. EPA limit on the amount of nickel in drinking water (U.S. EPA, 1999).

INTRODUCTION

The purpose of this document is to develop a PHG for soluble nickel in drinking water. Soluble nickel is the focus of this analysis as it is the most important bioactive form of nickel in drinking water. Adverse health effects associated with exposure to other forms of nickel are evaluated only if the information is relevant to the development of the PHG.

An MCL of 0.1 mg/L (100 ppb) was established by the California Department of Health Services (DHS) [California Code of Regulations (CCR) Title 22 for inorganic chemicals Section 64431].

U.S. EPA is currently reviewing existing toxicological data and has not released a new risk assessment for soluble nickel salts. U.S. EPA had earlier promulgated an MCLG of 0.1 mg/L and an MCL of 0.1 mg/L (100 ppb) for nickel (U.S. EPA, 1999). However, the federal MCL and MCLG for nickel were remanded on February 9, 1995. This means that while U.S. EPA is reconsidering the limit on nickel, there is currently no U.S. EPA limit on the amount of nickel in drinking water (U.S. EPA, 1999).

In preparing this risk assessment, discussions and information found in many review reports were used. They include: "Toxicological Review of Soluble Nickel Salts" (TERA, 1999); "Toxicological Profile for Nickel" (ATSDR, 1997); "Proposed Identification of Nickel as a Toxic

California Department of Health Services

Drinking Water Standards

Primary Maximum Contaminant Levels (MCLs) and Lead and Copper Action Levels

Last Update: February 11, 2000

Primary MCLs
Lead and Copper

Primary maximum contaminant levels (MCLs) are established by the Department of Health Services (DHS) for a number of chemical and radioactive contaminants. Primary MCLs can be found in Title 22 California Code of Regulations (CCR) for **inorganic chemicals** (§64431), **trihalomethanes** (§64439), **radioactivity** (§64441 and §64443) and **organic chemicals** (§64444). (See **DHS' compilation of drinking water statutes and regulations**.)

PRIMARY MAXIMUM CONTAMINANT LEVELS All values are in milligrams per liter (mg/L), unless otherwise noted	
Contaminant	**Primary MCL**
22 CCR §64431, Table 64431-A—Inorganic Chemicals	
Aluminum (Aluminum also as a secondary MCL of 0.2 mg/L)	1
Antimony	0.006
Arsenic	0.05
Asbestos (MFL = million fibers per liter, MCL is for fibers exceeding 10 microns in length)	7 MFL
Barium	1
Beryllium	0.004
Cadmium	0.005
Chromium	0.05
Cyanide	0.2
Fluoride	2.0
Mercury	0.002
Nickel	0.1
Nitrate (as NO_3)	45
Nitrate + Nitrite (sum as nitrogen)	10
Nitrite (as nitrogen)	1
Selenium	0.05
Thallium	0.002
22 CCR §64433.2, Table 64433.2-A, Optimal Fluoride Levels See also the Fluoride MCL, 22 CCR §64431, Table 64431-A	

Annual average of maximum daily air temperature (degrees Fahrenheit, °F)	Optimal Level (Range)
50.0 to 53.7 °F	1.2 (1.1-1.7)
53.8 to 58.3 °F	1.1 (1.0-1.6)
58.4 to 63.8 °F	1.0 (0.9-1.5)
63.9 to 70.6 °F	0.9 (0.8-1.4)
70.7 to 79.2 °F	0.8 (0.7-1.3)
79.3 to 90.5 °F	0.7 (0.6-1.2)
22 CCR §64441 and §64443—Radioactivity	
Gross alpha particle activity (including radium-226 but excluding radon and uranium)	15 picocuries per liter (pCi/L)
Gross beta particle activity	50 pCi/L
Combined Radium-226 and Radium-228	5 pCi/L
Strontium-90	8 pCi/L
Tritium	20,000 pCi/L
Uranium	20 pCi/L
22 CCR §64439—Total Trihalomethanes	
Sum of bromodichloromethane, dibromochloromethane, bromoform, and chloroform	0.1
22 CCR §64444—Organic Chemicals	
(a) Volatile Organic Chemicals (VOCs)	
Benzene	0.001
Carbon tetrachloride	0.0005
1,2-Dichlorobenzene (o-Dichlorobenzene)	0.6
1,4-Dichlorobenzene (p-DCB)	0.005
1,1-Dichloroethane (1,1-DCA)	0.005
1,2-Dichloroethane (1,2-DCA)	0.0005
1,1-Dichloroethylene (1,1-DCE)	0.006
cis-1,2-Dichloroethylene	0.006
trans-1,2-Dichloroethylene	0.01
Dichloromethane (Methylene chloride)	0.005
1,2-Dichloropropane (Propylene dichloride)	0.005
1,3-Dichloropropene	0.0005
Ethylbenzene (Phenylethane)	0.7
Monochlorobenzene (Chlorobenzene)	0.07
Methyl tert-Butyl Ether (MTBE) (MTBE also has a secondary MCL of 0.005 mg/L and an action level of 0.013 mg/L)	**0.013 (proposed)**
Styrene (Vinylbenzene)	0.1
1,1,2,2-Tetrachloroethane	0.001
Tetrachloroethylene (PCE)	0.005
Toluene (Methylbenzene)	0.15

1,2,4-Trichlorobenzene (Unsym-Trichlorobenzene)	0.07
1,1,1-Trichloroethane (1,1,1-TCA)	0.200
1,1,2-Trichloroethane (1,1,2-TCA)	0.005
Trichloroethylene (TCE)	0.005
Trichlorofluoromethane (Freon 11)	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	1.2
Vinyl chloride	0.0005
Xylenes (single isomer or sum of isomers)	1.750
(b) Non-Volatile Synthetic Organic Chemicals (SOCs)	
Alachlor (Alanex)	0.002
Atrazine (Aatrex)	0.003
Bentazon (Basagran)	0.018
Benzo(a)pyrene	0.0002
Carbofuran (Furadan)	0.018
Chlordane	0.0001
2,4-D	0.07
Dalapon	0.2
1,2-Dibromo-3-chloropropane (DBCP)	0.0002
Di(2-ethylhexyl)adipate	0.4
Di(2-ethylhexyl)phthalate (DEHP)	0.004
Dinoseb	0.007
Diquat	0.02
Endrin	0.002
Endothal	0.1
Ethylene dibromide (EDB)	0.00005
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor epoxide	0.00001
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Lindane (gamma-BHC)	0.0002
Methoxychlor	0.04
Molinate (Ordam)	0.02
Oxamyl	0.2
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated biphenyls (PCBs)	0.0005
Simazine (Princep)	0.004
2,4,5-TP (Silvex)	0.05
2,3,7,8-TCDD (Dioxin)	0.00000003
Thiobencarb (Bolero) (Thiobencarb also has a secondary MCL of 0.001 mg/L)	0.07

Toxaphene	0.003

Lead and copper have specific regulations in 22 CCR, Chapter 17.5 §64670, *et seq*. The lead and copper regulations use the term "action level" for each substance, for purposes of regulatory compliance. These action levels should not be confused with DHS' **advisory action levels for unregulated chemical contaminants**.

Action levels for copper and lead, which are to be met at customer tap, are used to determine the treatment requirements that a water system is required to complete. The action level for copper is exceeded if the concentration of copper in more than 10 percent of tap water samples collected during any monitoring period conducted in accordance with 22 CCR §64682-§64685 is greater than 1.3 mg/L. Similarly, the action level for lead is exceeded if the concentration of lead in more than 10 percent of tap water samples collected in accordance with 22 CCR §64682-§64685 is greater than 0.015 mg/L. Failure to comply with the applicable requirements for lead and copper (22 CCR Chapter 17.5) is a violation of primary drinking water standards for these substances.

LEAD AND COPPER ACTION LEVELS (22 CCR §64672.3)	
Chemical	**Action Level (mg/L)**
Copper	1.3
Lead	0.015

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California Department of Health Services

Drinking Water Standards

Secondary Maximum Contaminant Levels (MCLs)

Last Update: February 11, 2000

Secondary MCLS are established for a number of chemicals, characteristics or constituents and add taste, odor, or appearance of drinking water. (See **DHS' compilation of drinking water statutes regulations**.)

SECONDARY MAXIMUM CONTAMINANT LEVELS (see 22 CCR §64449)
All values are in milligrams per liter (mg/L), unless otherwise noted.

CONSUMER ACCEPTANCE LIMITS

Chemical or Characteristic	Secondary MCL
Aluminum (Aluminum also has a primary MCL of 1 mg/L)	0.2
Color	15 units
Copper	1.0
Corrosivity	Non-corrosive
Foaming agents (MBAS)	0.5
Iron	0.3
Manganese	0.05
Methyl tertiary butyl ether (MTBE) (MTBE also has an action level of 0.013 mg/L and a proposed primary MCL of 0.013 mg/L)	0.005
Odor-Threshold	3 units
Silver	0.1
Thiobencarb (Bolero) (Thiobencarb also has a primary MCL of 0.07 mg/L)	0.001
Turbidity	5 units
Zinc	5.0

Constituent	Secondary MCL Ranges		
	Recommended	Upper	Short Ter
Total Dissolved Solids, or	500	1,000	1,500
Specific Conductance, micromhos	900	1,600	2,200
Chloride	250	500	600
Sulfate	250	500	600

Sulfate	250	500	600

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USE ATTAINABILITY ANALYSIS FOR NINE "NATURALLY IMPAIRED" WATERS OF THE LAHONTAN REGION

California Regional Water Quality Control Board, Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe CA 96150

April 2000

Prepared by:

Judith Unsicker
Environmental Specialist IV (Specialist)
Telephone: 530-542-5417
Email: unsij@rb6s.swrcb.ca.gov

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INTRODUCTION

Because of its geological history, the Lahontan Region has many water bodies which have naturally high salinity and/or naturally high levels of certain "trace" chemical constituents, such as arsenic, which are toxic in high concentrations. Some waters also have naturally high levels of radioactive elements. The Lahontan Region has many hot or warm springs, at least two "hot creeks" affected by geothermal springs, saline desert streams such as the Amargosa River, saline/alkaline lakes, saline groundwater aquifers, and saline/alkaline wetlands associated with these systems. In addition to the multiple mapped "Hot Creeks" and "Warm Springs" in the region, geographic names such as "Salt Creek", "Amargosa"(Spanish for "bitter"), "Badwater", "Dirty Sock Hot Spring", and "Alkali Lakes" reflect historic perceptions of naturally poor water quality. Under the state and federal guidance used in the Clean Water Act Section 305(b) water quality assessment and reporting process over the last 10 years, many of these waters have been classified as "impaired", and some have been placed on the Clean Water Act Section 303(d) list of impaired water bodies which require Total Maximum Daily Loads (TMDLs). Most of the Section 303(d) listings were related to concentrations of chemical constituents exceeding drinking water standards, and were based on limited data available in the federal STORET database and in U.S. Geological Survey and California Department of Water Resources publications.

The purpose of this Use Attainability analysis (UAA) is to provide technical justification for proposed amendments to the *Water Quality Control Plan for the Lahontan Region* (Basin Plan) to remove the potential "Municipal and Domestic Supply" (MUN) beneficial use designation from nine specific water bodies. These water bodies are: Wendel Hot Springs, Amedee Hot Springs, Fales Hot Springs, Hot Creek, Little Hot Creek, Little Alkali Lake, Keough Hot Springs, Deep Springs Lake, and the Amargosa River. The locations of these water bodies are shown in Figures 1 through 5. Deletion of the MUN use would allow these waters to be removed from the Section 303(d) list, and would eliminate the necessity to prepare TMDLs for them. Some of the information in this UAA may also be used in justification for future Basin Plan amendments, Section 303(d) list revisions, and/or TMDLs for other "naturally impaired" waters of the Lahontan Region. (The term "naturally impaired" is used in this UAA for both saline waters, as defined below, and waters which have total dissolved solids concentrations below the generally accepted threshold for salinity but which have concentrations of certain trace elements exceeding state or federal water quality criteria. The latter category includes geothermal waters.)

Although the proposed Basin Plan amendments focus on the MUN use, U.S. Environmental Protection Agency (USEPA) guidance requires that attainment of other beneficial uses be analyzed in UAAs as well. "Other" uses of saline and geothermal waters of the Lahontan Region include support of unique biological communities and threatened/endangered species, water contact and non-contact recreation, and industrial uses including geothermal energy production and mineral extraction. Other possible future uses (uses of saline/geothermal waters elsewhere in the U.S.) include solar energy generation from brine ponds, and "biotechnology" use of microorganisms adapted to the extreme environmental conditions of these waters.

This UAA is a review of readily available scientific literature and information from the Internet; no new field data were collected. USEPA guidance (1994, page 2-9) allows UAAs to focus on existing data and provides that states may

> *"conduct generic use attainability analyses for groups of water body segments provided that the circumstances relating to the segments in question are sufficiently similar to make the results of the generic analyses reasonably applicable to each segment*".

Site-specific information biological information is not available for all of the saline and geothermal waters of the Lahontan Region. When such information is available, it is often based on only a few samples, and, for ephemeral water bodies, does not necessarily reflect long term conditions. The "generic" information on saline and geothermal ecosystems presented below probably applies to a great extent to the waters affected by the proposed Basin Plan amendments.

CHARACTERISTICS OF SALINE AND GEOTHERMAL WATERS

PHYSICAL AND CHEMICAL CHARACTERISTICS

The commonly used technical definition of "salinity" concerns the salinity of seawater, with specific assumptions about the chemical composition of the salts. Because the ionic concentration of inland waters is variable, the seawater-related definition does not apply (SWRCB 1980). The salinity of inland waters is generally expressed as "total dissolved solids" (TDS) or "electrical conductivity" or "specific conductivity". The definitions of these terms depend on the methods used for measurement. Hammer (1986) points out that "salinity" is the sum of all dissolved ions, but TDS is the mass of dissolved material estimated by evaporation to dryness at a specific temperature. TDS may not include bicarbonate and other ions driven off during the evaporation process. "Dissolved solids" consist of inorganic salts, small amounts of organic matter, and "dissolved materials" The main inorganic ions are carbonates, chlorides, sulfate, nitrate; sodium, potassium, calcium, and magnesium. TDS also includes phosphates, bicarbonates, and traces of manganese, iron, etc. (USEPA, 1986, McKee and Wolf, 1963).

Specific conductivity (or "conductance") is sometimes used to measure of salinity as an alternative to TDS. However, it measures the ability of water to carry an electrical current and does not account for non-ionic constituents. Values also vary depending on the relative contributions of different ions (Kubly and Cole, 1979, page 25). Specific conductivity values are usually lower than TDS or salinity values for the same water body, although there are various conversion factors. Hammer (1986) recommends that conductivity not be used to measure TDS if TDS values exceed 5 parts per thousand.

Hammer (1986) includes the following "arbitrary" classification of waters related to salt content: "fresh" waters have 0 to 0.5 parts per thousand (ppt) salts; "subsaline" waters have 0.5 to 3 ppt, and "saline" waters have 3 ppt or greater. Three ppt is equivalent to 3 grams per liter or 3,000 mg/L, the TDS threshold referenced in the California State Water Resources Control Board's (SWRCB's) "Sources of Drinking Water Policy". This concentration is also cited by Hammer as a widely recognized threshold between fresh and saline waters. The geothermal waters discussed later in this UAA have TDS levels around 1,000 mg/L, within Hammer's "subsaline" range.

Saline Lakes. Saline lakes can be classified based on the dominant types of dissolved solids. They tend to be dominated by either carbonate, chloride, or sulfate (Hammer, 1986). Chloride lakes are most common worldwide. They are uncommon in North America, but South Panamint Lake in the Mojave Desert is chloride dominated. Sulfate dominated lakes occur mostly in North America and the former Soviet Union. There are all possible intermediate types; Mono and Owens Lakes are carbonate and chloride lakes. The term "saltern" lake refers to lakes high in sodium chloride, and "soda" lakes are characterized by abundant sodium carbonates and bicarbonates (Thorpe and Covich, 1991). The upper limits of possible salinity depend on the concentrations at which different constituents become saturated and precipitate from solution. The least soluble salt is calcium sulfate (gypsum). For comparison with the Lahontan Region data below, the highest salinity on record (474 g/L) is for Don Juan Pond in Antarctica (Hammer, 1986; NRC, 1987). The global mean salinity of river water worldwide is 120 mg/L; North American waters average 142 mg/liter. Most of the soft waters in North America have salinities of less than 50 mg/L. Great Salt Lake has salinity as high as 200 g/L compared to average 35 g/L for oceans of the world (Thorp and Covich, 1991).

Internal saline lakes form in geographic regions, such as the desert portions of the Lahontan hydrologic basin, where evaporation exceeds precipitation (often due to a "rain shadow"), where salts are available from sources such as the weathering of rocks and soils, and where internal drainage permits the retention of water. Saline lakes may occupy "grabens", basins created by faulting. Lakes in internally drained regions, such as the playa lakes of the Mojave desert, rarely have any outflow. Permanent lakes are unlikely in such hot, arid climates, but because precipitation is highly variable, ephemeral lakes may appear and evaporate quickly. Many of the saline lakes and streams of the Lahontan region are remnants of larger water bodies which existed during wetter "pluvial" geologic periods. Salts in today's lakes may be "evaporites" concentrated from these larger water bodies. Other sources of salt include springs and wind transport from other drainage basins.

Lakes of internally drained regions typically have great variation in lake level and surface area, which affects salinity and thus lake biota. The specific conductance of Middle Alkali Lake in Modoc County (in the Lahontan Region) ranged from a high of 10,170 umho/cm in December 1982 to a low of 356 umho/cm in May 1983 (Patterson and Jacobson, 1983). The surface levels of these lakes depend on inflow and evaporation, and thus on long term climatic patters. There is great daily and annual variation in temperature.

Ephemeral playa lakes are often shallow, due to the flat nature of their basins and to low precipitation (Kubly and Cole, 1979). Their shallow nature results in high evaporation rates, and rapid changes in size, They are often completely mixed, and have a high percentage of their water volume in contact with sediments, which may have important impacts on chemical and biological processes. Deeper saline lakes may stratify. More energy is needed mix salt water than freshwater because of its greater density (Hammer, 1986).

The salinity of salt lakes changes seasonally, including dilution by runoff in spring, concentration by evaporation in summer, and freezing out in winter. During the latter process, the ice formed is fresh water, and the remaining saline solution is more concentrated. In highly saline lakes, cooling of water may result in precipitation of salts (Hammer, 1986). Surface salinity may change as certain minerals begin to precipitate at low temperatures, as occurs once the salinity of the lake is approximately 125 g/L (NRC, 1987). Salinity may also vary spatially when freshwater inflows lie on top of salt water (Thorpe and Covich, 1991). Kubly and Cole's (1979) survey of California playa lakes showed that salinity varied widely with space and time; the ionic sum of the most concentrated sample was almost 2500 times that of the most dilute, and there was an almost 60 fold increase in concentration in South Panamint Lake between January and May. Salts may be removed from dry lakes by wind transport ("deflation"), or they may be covered periodically by sediment from flash flooding or wind deposition.

Kubly and Cole (1979) cite a USGS study of Deep Springs Lake in 1965 which showed that surface inflow may undergo significant changes in chemical concentration or composition upon mixing with surface and groundwaters of the lake proper. The maximum increase in TDS between dilute inflow springs and concentrated playa lake water at Deep Springs was recorded in excess of 580 fold.

There are a few permanent saline lakes in the western U.S., including Great Salt Lake, Mono Lake, Pyramid Lake, and Walker Lake, although these can vary in size depending on precipitation and diversions from tributaries. However, most of the saline lakes of the Lahontan Region are ephemeral "playa" lakes. "Playas" are defined as the "shallow central basin of a desert plain, in which water gathers after a rain and is evaporated" and "playa lake" as "Broad, shallow sheets of water which quickly gather and almost as quickly evaporate, leaving mud flats or playas to mark their sites" (American Geologic Institute, 1976). For purposes of beneficial use designations, it is important to distinguish between the surface and ground water portions of a playa lake. Although some "moist playas" (see below) almost meet the definition of wetlands in having water near the surface, and in some cases such as Searles Lake, the lake sediments are saturated with brine, this water is considered ground water for purposes of the Basin Plan. The surface water is the ephemeral water which collects above the playa surface.

Scientists have classified the playa lakes of Southern California deserts into two major groups, although there are playas showing characteristics intermediate between the two. (The quotations below are from Kubly and Cole, 1979.) Group I, or "dry" playas include mostly "hard, flat, dry, cracked, claypan surfaces with little visible salt.". The dry surfaces result from low groundwater levels, loss of subsurface water to adjoining basins, or combinations of these causes. The underlying soils are fine-grained, with clay to silt sized particles. Lakes in Group I playas generally "exhibit high turbidity, contain organic matter exceeding 5% of total solids, have anions dominated by bicarbonate-carbonates, and have relatively low total dissolved solids concentrations." The salinities of Group 1 playa lakes range from 100-10,000 micromhos/cm.

Aquatic invertebrates of these lakes are typical of low to intermediate salinity waters. Winter biota include *Branchinecta* fairy shrimp. Group 1 playa surfaces are very smooth when dry, which affects their human uses. Rogers Dry Lake within Edwards Air Force Base is used for space shuttle landings, and a number of dry playas are used for the sport of landsailing.

The characteristics of Group II or "moist" playas are largely under control of ground water discharge, directly through playa sediments and from adjacent springs. The underlying soils are coarse grained and permeable in comparison with Group I playa soils. High water tables and permeable sediments facilitate capillary movement of ground water and salts. Subsequent evaporation leaves saline efflorescences on soft, irregular, "moist" or puffy crusts. Some of the salts in moist playas, "such as mirabilite (Glaubers's salts), are sensitive to temperature or humidity and can change the lake surface from firm to mushy in just a few days" (Norris, 1995).

The ephemeral lakes which form in Group II playas have relatively low turbidity, organic matter usually less than 5 percent of total solids, anions dominated by chloride or sulfate, and salinities ranging from less than 20,000 to well over 100,000 umho/cm. Interstitial brines and or soluble salts in sediments contribute major input to the TDS content of waters. Group II playas may have bordering spring fed marshes with associated semipermanent to permanent pools. Examples in the Lahontan Region are Soda Dry Lake, Deep Springs Lake, and Harper Lake. The invertebrates of Group II playas are mostly those adapted to high salinity.

The pH of saline lakes tends to be basic with values up to 11 pH units. It can increase in less saline lakes due to photosynthesis. (Hammer, 1986). In Kubly and Cole's (1979) survey of playa lakes in California, pH values ranged from 7.5 at South Panamint Dry Lake to 10.0 at Deep Springs Lake. Values greater than 8.5 (the upper limit of the Lahontan Basin Plan's water quality objective for pH) were measured in 31 of the 38 lakes sampled.

The sediments of saline lakes include vary soluble evaporites and halite (sodium chloride), less soluble precipitates, inorganic and organic matter from external sources, and organic detritus from lake biota. Sediment chemistry may change with time of day as minerals become more or less soluble depending on temperature. Sediment characteristics may reflect the original sites of deposition in Pleistocene lakes, for example at stream mouths or in embayments (Hammer, 1986; Kubly and Cole, 1979). Hammer (1986) cites a study which showed that turbidity correlated negatively with total dissolved solids in playa lakes in California. The study concluded that turbidity was largely organic and decreased with an increase in salinity.

As salinity increases, dissolved oxygen saturation occurs at lower concentrations at a given temperature. In hypersaline waters such as Mono Lake, oxygen reaches saturation at concentrations well below those in fresh water. Where stratification occurs, the bottom waters may be anoxic (Hammer, 1986, NRC, 1987). Oxygen levels below one part per million are not uncommon in ephemeral ponds, especially at night under summer temperatures.

Because of their "terminal" positions , and in some cases because of geothermal discharges, saline lakes can accumulate high levels of phosphorus. Hammer (1986) cites concentrations of 900 mg/L phosphate in Searles Lake, 60 mg/l in Mono Lake, and 73.3 mg/L in Deep Springs Lake.

Again, because of their terminal nature and/or geothermal inputs, saline lakes of the Lahontan Region may have high concentrations of trace elements such as arsenic and boron; borax is mined commercially in several Mojave Desert playas.

Saline Streams. Streams in internally drained desert regions flow for part of the year due to limited precipitation (rarely more than 100 mm per year), and may terminate in temporary or permanent lakes, or dry up without reaching lakes (Hammer, 1986). When precipitation does occur, it may be intense and cause flash flooding. Southwestern desert streams tend to have broad channels with extensive alluvial deposits (Vallett *et al.*, 1991). Some streams, such as the Mojave and Amargosa Rivers, may have most of their flow beneath the surface for most of the year, with perennial flows only in areas where geological barriers cause water to surface. Apparently there has been little study of ecosystem processes in these streams. However, research in Arizona and New Mexico (e.g., Vallett *et al.*, 1991) shows that the "hyporheic zone" (including subsurface water and sediment beneath and immediately adjacent to the streambed) can play a very important role in energy and nutrient cycling in desert stream ecosystems. Sycamore Creek, Arizona, has ground water "upwelling" and "downwelling" zones occurring over relatively short reaches of the stream. Flooding generally increases upwelling, and reduces downwelling; prolonged drying has the opposite effect. The degree of exchange of hyporheic and surface waters varies over time depending on flooding and drying. Sediment transport by floods may increase or decrease the size of the hyporheic zone and its influence on stream ecosystem processes.

Geothermal Waters. A USGS (1976) publication defines thermal springs as any spring or well water whose average temperature is noticeably above the mean annual air temperature at the sampling place. For European commercial springs, only those above 20° C are considered thermal springs. In the United States, the definition includes springs 15° F above the mean annual air temperature. Some Hot Creek (Mammoth Creek) area springs "extremely hot" with temperatures of 130° F or more (Bischoff, 1997). Norris (1995), in the context of California desert springs, states that hot springs generally have temperatures of more than 100° F (38° C). Water near the earth's surface cannot exceed the boiling point, but high pressure at greater depths can raise water temperature to 752° F or 400 °C (Bischoff, 1997).

Most hot springs are associated with faults. Faults allow surface waters to travel deeply enough to contact hot rock, and also provide pathways for heated water to rise to the surface. In volcanic areas, very hot rock is present at relatively shallow depth, and hot springs in such areas can be very hot. Warm springs are more prevalent in non-volcanic areas (Norris, 1995). Salts in the waters of hot springs come from the original meteoric waters, condensed magmatic gases, and rock-water interactions at depth (NRC, 1987). There are at least three "hot creeks" in the Lahontan Region, where water temperature, chemistry, and probably biology are significantly affected by discharges from hot springs. Hot Creek in the upper Owens River watershed is probably the best studied.

BIOLOGICAL CHARACTERISTICS

Biological data are not available for many of the saline and geothermal waters in the Lahontan Region. The following is an overview of the types of plants and animals associated with saline/geothermal waters in general, their adaptations to extreme environmental conditions, and ecological processes associated with them. More specific information on the biota of some of the nine waters currently proposed for removal of the potential MUN use is presented in the summaries of data on specific waters, below.

Biodiversity

Although desert surface waters are often ephemeral and may seem barren, they can support a wide variety of plants, animals and microorganisms when water is present. A given hypersaline lake may support large numbers of a relatively few aquatic invertebrate species (Thorp and Covich, 1991). Kubly and Cole (1979) visited 36 Mojave Desert playas in 1978-79 and collected limnologic data from ephemeral lakes and/or associated marsh pools at 24 playas. They also cultured playa sediments in the laboratory. Kubly and Cole found a "total of 84 aquatic or semi-aquatic invertebrate taxa", including four major groups: rotifers, crustaceans, insects, and snails. (The snails were thought to be from transient populations carried in by floodwaters from the Mojave River or other streams.) Sediments from 10 playa lakes supported 43 diatom taxa representing 20 genera, and three genera of blue-green algae. Flagellated green algae can move to the surface of turbid lakes, and stay below the surface during periods of strong sunlight (Carpelan, 1995). Although they have been relatively little studies, at least 30 species of protozoa are found in saline lakes worldwide.

Birds use saline lakes for feeding, resting, nesting, and staging for migration (Hammer, 1986). A number of bird species visit alkaline lakes of the Great Basin, some of them in great abundance. They include Eared Grebes, Northern Shovelers, Snowy Plovers, Avocets, Northern Phalaropes, Wilson's Phalaropes, and California Gulls. Eared Grebes reach peak numbers of 750,000 at Mono Lake in the fall (Mahoney and Jehl, 1984). A study of Middle Alkali Lake in Surprise Valley, Modoc County, (Patterson and Jacobson 1983), when the lake had a depth of about 1 meter, showed about 70 species of birds using the lake, including the rare snowy plover and sandhill crane. Flocks of waterfowl, gulls and shorebirds were abundant users of the lake during both spring and fall migration. The abundance of birds was related to abundance of invertebrate food; there were at least three species of fairy shrimp in the lake together with brine flies and other invertebrates.

Probably because of their geographic isolation over thousands of years, the saline and geothermal waters of the Lahontan Region provide habitat for a number of unique species and subspecies of plants and animals, which in some cases are found nowhere else. For example, Roesler *et al.* (1999) reported the recent discovery of a "novel unicellular phototroph" from Mono Lake which is capable of growing over the salinity range of 0 to 260 parts per thousand and the pH range of 4-12 units. Other examples of endemic organisms associated with particular water bodies are given below.

Limiting Factors and Adaptations

Organisms of saline and geothermal waters must be adapted to extreme conditions and often to wide, unpredictable temporal variations in those conditions. Adaptations include combinations of life cycle stages resistant to drying, life cycles responsive to key environmental stimuli, high tolerance for changes in osmotic concentrations, physiological regulation of internal fluids, and ability to "escape" in space and time (Kubly and Cole, 1979; Hammer, 1986).

Drought. Organisms of desert waters have two main means of adapting to drying: resistant life cycle stages, and migration. Many invertebrates survive drought as encysted embryos or larvae; some encyst as adults. A study of Rabbit Dry Lake in the Lucerne Valley showed that fairy shrimp *Branchinecta mackini* could complete a generation within a week (Carpelan, 1995) .Resting stages may be passively dispersed to new habitats by wind, birds, and migratory insects (Kubly and Cole, 1979). Microbial crusts, often less than a quarter of an inch thick and including fungi, algae, lichens, and or mosses, cover soils in many parts of the California desert, often including dry lake bottoms. The crust absorbs and holds water, and the algae within it may fix nitrogen. Microbial crusts are fragile and may be destroyed by human activities such as offroad vehicle recreation. A damaged lichenous crust may take many years to recover (Stebbins 1995). Kubly and Cole (1979) point out that even the driest appearing playa crusts contain some water. Crusts from dry type playas with greater than 50% clay-sized particles held up to 5% water, and wet type playa crusts contained as much as 32 percent water. Therefore, the resting stages of aquatic invertebrates and microorganisms may not face total dryness. Carpelan (1995) cites 20-40 fairy shrimp cysts per square inch of playa crust, along with bacteria, algae, spores, etc.

Kubly and Cole (1979) identified 66 playa lake organisms (mostly aquatic insects) which do not have drought resistant life stages and are able to survive by active migration to more permanent habitats. They may find refuges in the spring-fed wetlands which surround some moist playa lakes; the relative predictability of water in these wetlands is indicated by the presence of amphibians in some of the pools (e.g., the black toad and Great Basin spadefoot toad in the Deep Springs Lake wetlands).

Hyporheic zones of desert streams support microorganisms and a distinct invertebrate fauna. Four different invertebrates communities have been identified in the hyporheic sediments of Arizona desert streams (Vallett et al., 1991), including a "dry channel hyporheic" community which appears briefly after surface water disappears. These invertebrate habitats differ spatially and temporally, with corresponding distinctive groups of invertebrates. Habitat boundaries change over the year with upwelling and downwelling. The invertebrates can resist both flooding and drying, and some are able recolonize a given area within two days of rehydration following several months of drying.

Salinity. Table 1 summarizes information from the literature on salinity tolerance limits of a variety of organisms. Kubly and Cole (1979) concluded that species distribution in playa lakes is controlled mainly by salinity. Ability to tolerate a wide range of TDS concentration is widespread in desert aquatic organisms; only those with short life cycles in relation to the rate of increase in salt concentration can escape the need for tolerance. Different life cycle stages of a given species may have different abilities to tolerate salinity; for example, a reduction in salinity due to filling of a dry lake by runoff may trigger hatching of fairy shrimp eggs (Carpelan, 1995). Salt concentration itself is generally more important than the type of salt ion. Examples of species able to exist in hypersaline waters of diverse chemical composition in California playa lakes are

Artemia salina (a brine shrimp), *Ephydra packardi* (a brine fly); and *Trichocorixa reticulata*, a "water boatman" bug (Kubly and Cole, 1979).

Ford (1993) points out that, although salt has long been used as a food preservative, there are a number of microorganisms which grow at high salt concentrations, and some which even require these concentrations for growth. Some "halobacteria" can grow at near saturated concentrations of salt. Salt tolerant microorganisms do not adapt to salinity by actively maintaining much lower internal concentrations; they maintain equivalent internal concentrations of chemicals such as glycerol (used by the green alga *Dunaliella*) which allow their cellular processes to function. *Dunaliella* can adapt to a wide range of salt concentrations; one species is able to synthesize high levels of beta carotene which protect it against photoinhibition, and is now being used commercially for the production of beta carotene (Pick *et al.*, undated).

Blinn (1993) studied diatoms in saline lakes throughout North America, and found that diatom species diversity and number of taxa showed an inverse relationship to specific conductance, and selected diatom taxa were associated with specific anions as well as ranges of specific conductance. Concentrations of sodium, chloride, sulfate and carbonate showed a significant negative correlation with diatom species diversity.

According to Hammer (1986), saline lakes have some of the highest levels of algal productivity in the world; most of them tend to be eutrophic or hypereutrophic. There are relatively few dominant species in anyone lake. The National Research Council (1987) concluded that the algae (diatoms and green algae) of Mono Lake are fairly resistant to increased salinity, although a ten percent decrease in growth and primary productivity was predicted with each ten percent increase in salinity over the range of about 97-140 g/L TDS.

Hammer (1986) noted that the benthic green alga *Ctenocladus* of Mono Lake is able to tolerate salinity up to saturated conditions. Herbst (1998) measured nitrogen fixation by blue-green algae and bacteria in laboratory sediment cultures from Mono Lake, and showed that, while fixation could contribute as much as 76-81 % of the total nitrogen input to the lake, it could be inhibited by increasing salinity. Nitrogenase activity, an indicator of nitrogen fixation, was reduced by half when TDS increased from 50 to 100 g/L.

Compared to algae, higher plants are relatively intolerant to the salt levels found in hypersaline lakes. Some sedges colonize saline lakes but the macrophyte flora is relatively sparse (Thorp and Covich, 1991). The effects of salinity on higher plants have been studied mainly in terms of agriculture. Salt damage may include leaf scorching (sodium or chloride toxicity), prematurely yellow leaves, dropping or withering of leaves, and stunted growth. Higher plants are stressed by reduced water availability due to the increased osmotic potential of the soil solution, or by higher concentrations of specific toxic ions. Also, high sodium concentrations affect plants by changing the physical structure of the soil, making it impermeable and reducing water availability.

Plants adapt to high salinity by various means including selective salt uptake, salt exclusion by root membranes, increased succulence (which dilutes the salts), excretion by salt glands, and shedding of leaves which have accumulated salt (Hammer, 1986). Some of the plants of the alkaline wetlands of the Lahontan Region avoid accumulating high levels of salt by the same kinds of physiological adaptations found in drought tolerant desert plants, even though their roots may be constantly in water. Salt grass *(Distichlis spicata)* is adapted to a combination of high water tables, high alkalinity, and high drought tolerance (Curry, 1993).

Scientific data on the salt tolerance of native plants are limited, but many riparian species of the southwestern United States are known to be relatively intolerant, and dependent on flood flushing to remove salts. A riparian revegetation project, using cottonwood and willow poles, in New Mexico was unsuccessful because groundwater soil TDS levels were over 6000 ppm (Briggs, 1996).

Curry (1993) pointed out that many playa lakes

> *"meet the strict definitions of wetlands. They are subject to seasonal or periodic flooding, have primarily reducing soil conditions and seasonally high soil water and water tables, and may have dominant wetland plant cover. However, that plant cover is often so sparse that it challenges ecologic classification. Some playa lakes may show less than 0.0001 percent plant cover of any type throughout some years. However, after a wet period or inundation a dormant seed bank may germinate and reveal a reasonable 10-20 percent alkali- tolerant plant cover. The more persistent plants tend to be wetland indicator species, but these may not always be dominant."*

Lichvar *et al.* (1998) studied Deadman Playa near Twentynine Palms, California, where they found six winter annual species growing on the playa. They concluded that the plants were taking advantage of non saline areas within the larger saline site, which had higher water availability than areas toward the edge of the playa. They noted that halophytic shrubs, which create soil mounds, have been observed on mounds near the edges of dry claypan playas. Plants have also established on dust dunes on the Owens Lake playa, which provide soils with decreased salinity and an increased rooting zone.

The animals of saline lakes are either osmotic "conformers" or "regulators" (Hammer, 1986). Conformers' body fluids increase in salinity with that of the medium but they can tolerate the salinity. Regulators maintain lower salinity in their body fluids. Aquatic organisms of saline lakes need free water for their cellular activities. If salinity is too high, thermodynamic forces will cause loss of free water and inhibition of metabolic processes. At very high salinities, organisms may be unable to reproduce because the amount of energy required to maintain the circulatory system is so great that there is little additional energy available for reproduction and development (National Research Council, 1987; Jones and Stokes, 1993).

Although fish may enter saline lakes from tributaries during high runoff conditions, they cannot persist in ephemeral waters, and fish adapted to less extreme conditions may be killed by high salt concentrations or temperature extremes before the lakes completely dry. Hammer (1986) notes that sodium chloride waters are less stressful to fish than sulfate waters, and that alkaline waters are the most stressful. However, fish adapted to desert conditions may be able to persist under combinations of stressful circumstances. The U.S. Fish and Wildlife Service (1984) states that, in studies at Soda Spring in 1981, Mohave tui chubs (*Gila bicolor mohavensis*) survived in habitats with dissolved oxygen less than 1 mg/L, water temperature approaching 34 degrees C at the surface, salinity at 11.55 ppt (11,550 mg/L), specific conductivity at 18,000 umho/cm, and pH between 9 and 10. As shown in Tables 1 and 2, desert pupfish can survive even higher combinations of salinity and temperature.

In some saline lakes such as Mono Lake, where harsh conditions prevent the survival of many aquatic predators, including fish, populations of some aquatic invertebrates can reach very high densities, allowing nonaquatic predators such as birds to exploit abundant food supplies (National Research Council, 1987). These predators must deal with the problem of ingesting saline water along with their prey. Some birds, such as Canada geese, have salt glands which enlarge and enable them to excrete salt after ingesting hypersaline waters. California Gulls at Mono Lake visit fresh water springs and creeks several times each day to drink and bathe, and thus maintain adequate fresh water intake in spite of the alkaline waters. Eared grebes at Mono Lake do not visit fresh water sources and have never been observed drinking. Mahoney and Jehl (1984) studied captive eared grebes. The study showed that the grebes dislike the taste of Mono Lake water (which has a pH of about 10). However, grebes are able to feed at Mono Lake throughout the year, mainly on brine shrimp. They minimize their salt intake by minimizing the amount of water that they ingest during feeding. They can do this because of the specialized dimensions of their tongues and oral cavities. Laboratory studies of water with salinity at levels found in inland California saline lakes have shown adverse effects of salinity on body weight, plasma protein and serum osmolality levels, and the size of several glands in mallard ducklings. (Apparently the salt water was the only drinking water source for the test birds.) There was 60 percent mortality at a salinity of 20,000 umho/cm, and 100 percent mortality at 67,000 umho/cm (Mitcham and Wobeser, 1988).

Jones and Stokes (1993) note that changes in the salinity of saline lakes can lead to "restructuring of an entire ecosystem". The salinity of the south arm of Great Salt Lake dropped from 250 to 50 g/L between 1963 and 1987, as the lake's level rose due to increasing freshwater inflow. There were many changes in the lake's flora and fauna; the numbers of algal species increased 20 fold and macrozooplankton species increased from one (the brine shrimp *Artemia*) to one rotifer, two predatory copepods, and a predatory corixid beetle.

Temperature. Both saline and geothermal ecosystems can involve extremely high water temperatures; however, temperatures in saline lakes and streams show much greater annual, seasonal and diurnal variation. Most invertebrates of California playa lakes are able to tolerate wide ranges of temperature (Kubly and Cole, 1979). Kubly and Cole concluded that "seasonal differences in species assemblages within playa lakes are largely attributable to the varying responses of drought resistant stages to different thermal regimes and to temporal variations in the movements of migratory insects", and that reproductive activity in most aquatic insects seems restricted to spring and summer temperatures. Starkweather (1999) states that "ephemeral ponds and playa lakes in warm deserts must be considered to be among the most extreme environments on earth" and cites resting stage embryos of several kinds of crustacean in the central Mojave Desert persist in dried sediments which frequently exceed 65 degree surface temperatures in summer and undergo weeks of daily freeze-thaw cycles in winter.

Table 1. Salinity Tolerance Levels for Organisms of Inland Saline Waters. (Some literature values have been converted to mg/L from other units.)

Organism or Biological Community	Salinity (mg/L TDS) or Specific Conductance (umho/cm)	Reference
Algae		
Mono Lake algae	102,000 mg/L	National Research Council, 1987
Diatoms, lower Panamint Lake	130,000 mg/L	Hammer 1986
Diatoms, Great Salt Lake	115,000-155,000 mg/L	Hammer, 1986
Diatoms	>400,000 mg/L	Blinn (1993)
Dunaliella	200,000 mg/L	National Research Council, 1987
Higher Plants		
Salt grass and mixed dry meadow (near Mono Lake)	10,300-18,000 umho/cm	Jones & Stokes, 1993
Marsh species (near Mono Lake)	1200-3300 umho/cm	Jones & Stokes, 1993
Mesquite	18,000 mg/L	Briggs, 1996
Pickleweed	36,000 mg/L	Briggs, 1996
Saltcedar	36,000 mg/L	Briggs, 1996
Ditch grass (*Ruppia*)	160,000 mg/L	Hammer, 1986
Invertebrates		
Brine shrimp *Artemia salina* (in laboratory)	300,000 mg/L	Kubly and Cole, 1979
North American ostracodes	74, 800 mg/L	Thorp and Covich, 1991
Rotifers	100,000 mg/L	Hammer, 1986
Fairy shrimp (Branchinectidae)	40,000 mg/L	Hammer, 1986
Cladoceran *Moina hutchinsoni*	50,000 mg/L	Hammer, 1986
Insect *Trichocorixa*	Over 80,000 mg/L	Hammer, 1986
Other insects	107,000 mg/L	Hammer, 1996
Mono Lake brine shrimp, brine flies	121,000 mg/L	National Research Council, 1987
Fish		
Walker lake tui chub	12,500	Hammer, 1986
Mohave tui chub (Soda Springs)	11,000 mg/L; 18,000 umho/cm	USFWS 1984
Cichlid *Sarotherodon*	50,000 mg/L	Black, 1983
Juvenile desert pupfish	90,000 mg/L	Black, 1983
Desert pupfish eggs	70,000 mg/L	Black, 1983
Texas coastal pupfish	142,000 mg/L	Hammer, 1986

While geothermal spring sources have fairly constant temperatures, there are biologically important temperature gradients in the outflow streams. Table 2 summarizes the upper temperature limits cited in the literature for a variety of organisms.

Temperature limits for microbes cited by Ford (1993) are for growth, not survival, and bacterial spores may be even more resistant to high temperatures. Ford points out that natural habitats with sustained temperatures above 55-60 degrees C (the "thermophile" boundary) are largely limited to geothermal environments Extreme thermophiles (all microorganisms) have optima at or above 80 degrees C.

Although the outflow streams of hot springs in the Lahontan Region (Hot Creek and Little Hot Creek in the Mammoth area) are being used for maintenance of fish, there has apparently been little study of the biology of Lahontan Region springs per se. The most intensive research on hot spring biology has been done at Yellowstone National Park (Brock 1994, Ford, 1993). Such study has been possible because the Yellowstone springs, unlike those in many parts of the world, have not been developed for geothermal energy or as spas.

Most enzymes are destroyed by high temperatures. Thermophilic microorganisms have evolved enzymes which are stable at high temperatures and in some cases function best at those temperatures. There are "dozens" of kinds of thermobacteria in the Yellowstone springs; the most significant studied to date is *Thermus aquaticus,* which is found in thermal habitats throughout the world. It has a temperature range between 50-80 degrees C (122-176 degrees F) with an optimum around 70 degrees C or 158 degrees F. It produces a temperature tolerant enzyme, taq polymerase, which is used in biotechnology to copy DNA; this process is used in medical diagnosis (e.g., for AIDS), and in DNA fingerprinting, and has led to a $300 million dollar industry. Brock (1994) concluded that "Yellowstone may have a billion dollar potential for the biotechnology industry".

The Yellowstone studies also showed biological communities adapted to temperature gradients in the outflows from geothermal springs, with the positions of different kinds of microorganisms depending on the temperature of the cooling spring water (Ford, 1993). Specialized animals, including brine flies, live on the microbial mats in the runoff channels. Brine flies at Yellowstone live on the warm mats during winter and congregate there at night and during cool weather at other times of the year. Their eggs are laid and their larvae develop on the microbial mat. The adults can survive temperatures of 43 degrees C (109 degrees F) and can feed in hotter waters with surrounding air bubbles to provide insulation. The brine flies are prey for other animals, including a spider which can tolerate heat by moving rapidly over the microbial mat. In the Firehole River at Yellowstone, algae, bacteria and invertebrates grow faster than in non-geothermal waters. The Yellowstone spring channels have "virtually a tropical climate", allowing riparian wildflowers to survive and bloom when adjacent areas are still snow- covered (Brock, 1994). Larger wildlife species also use geothermal waters in winter, and winter wildlife watching has become a popular tourist activity at Yellowstone.

Dissolved oxygen. As noted above, saline lakes tend to have low dissolved oxygen concentrations at saturation compared to fresh waters. Some aquatic invertebrates have adapted to these conditions either physiologically (some, like the brine shrimp *Artemia*, have hemoglobin) or behaviorally (e.g., by staying near the surface). The fairy shrimp *Branchinecta mackini* tolerates oxygen down to about 1-2 cubic cm /liter, or roughly 10-20 percent saturation at 21 degrees C (Thorp and Covich, 1991). For comparison, the Lahontan Basin Plan's regionwide narrative water quality objective for dissolved oxygen in surface waters states that the minimum dissolved oxygen concentration shall not be less than 80 percent of saturation.

Hyporheic zones in desert streams are largely aerobic (Vallett *et al.*, 1991), reflecting dissolved oxygen replenishment through exchange with surface waters. Local anaerobic zones can occur

Table 2. Temperature Tolerance Levels for Organisms of Inland Saline and Geothermal Waters. (Upper limits unless a range is cited.)

Organism	Temperature (degrees C)	Reference
Microorganisms		
Photosynthetic bacteria	73	Ford, 1993
Other eubacteria	85-90	Ford, 1993
Archaebacteria	110	Ford, 1993
Protozoa	56	Ford, 1993
Algae	55-60	Ford, 1993
Mosses	50	Ford, 1993
Vascular plants	45	Ford, 1993
Invertebrates		
Fairy shrimp (of desert waters)	0- 40	Thorp and Covich, 1991
Ostracode	54	Thorp and Covich, 1991
Brine flies	43	Brock, 1994
Insects	45-50	Ford, 1993
Fish	38	Ford, 1993
Mohave tui chub	30	USFWS, 1984
Pupfish- Death Valley	45	Pister, 1995

because of spatial variation in organic matter, oxygen consumption rates, and hydrologic exchange. Reducing conditions may occur following long dry periods as a result of lack of exchange with oxygen rich surface water, affecting nitrogen cycling. Primary production in many southwest desert streams is believed to be nitrogen limited, but the hyporheic zone is often nutrient rich compared to surface water. Under upwelling conditions there is nutrient input to surface waters from the hyporheic zone, with elevated concentrations of nitrate nitrogen and a higher standing crop of algae (Vallett et al, 1991.)

Turbidity. In very saline lakes, turbidity is reduced due to chemical and physical processes. This results in increased light penetration and high algal productivity. Other saline lakes may be highly turbid due to wind-induced currents which suspend silt, clay, bacteria and organic matter. These lakes may have virtually no phytoplankton, and detritus serves as the main source of energy for primary consumers (Kubly and Cole, 1979).

pH. The organisms in Mono Lake, and other saline lakes in the Lahontan Region, are doubly stressed by both high salinity and high alkalinity The combination of high alkalinity and salinity appears to be very difficult to adapt to. Alkaline saline lakes with salinities greater than 150 g/l support macroinvertebrate populations(National Research Council, 1987).. Some bacteria and fungi can tolerate pH up to 13, and there are bacteria which have pH optima of 9-10. Most "alkalophile" microorganisms need sodium ions for growth. They may possess unusual surface proteins ("exoenyzmes") which are potentially commercially important for wastewater, energy production, and detergent additives (Ford, 1993).

Toxics. Some of the organisms native to inland saline waters are also capable of tolerating relatively high concentrations of toxic substances. Some bacteria are able to resist concentrations of metals toxic to most other organisms by a variety of physiological mechanisms including means to prevent the entry of metal ions into the cell, facilitate their exit from the cell, or convert metals to a less toxic form. Fungi and some algae are also tolerant to high levels of metals (Ford, 1993). In addition hypersaline lakes, the green alga *Dunaliella* is commonly found in industrial wastes, including petroleum refinery effluent.. Laboratory culture experiments indicated that ambient concentrations of heavy metals in the Dead Sea (500 ug/L zinc, 300-500 ug/l copper, 120 ug/l lead) were "not seriously limiting to life". Oren (1983) concluded that dense communities of halobacteria may survive in a state of low activity due to lack of organic nutrients, lack of phosphate, supraoptimal salinities and/or suboptimal temperatures, until an influx of fresh water triggers an algae bloom. Rowe and Hoffman (1985) documented large scale fish and bird kills at the Carson Sink playa lake in Nevada during the winter of 1986/87. At the time of the kill, the water in the Carson Sink had the following concentrations of chemicals: TDS, 20,100 mg/L, arsenic 800 ug/L, boron 40,000 ug/L, and copper 80 ug/L. Based on USEPA (1986) criteria these levels "were high enough to be potentially stressful to aquatic organisms". However, toxics could not be conclusively implicated and the kills were linked with other factors such as temperature and avian cholera. High levels of arsenic and fluoride were believed to contribute to the reductions in growth of Mono Lake microorganisms observed with increased salinity during salinity tolerance experiments (National Research Council, 1987.

WATER QUALITY STANDARDS AND CRITERIA

Current standards for waters of the Lahontan Region are contained in Chapters 2 and 3 of the 1995 *Water Quality Control Plan for the Lahontan Region* (Basin Plan) as amended in 1995, and the U.S. Environmental Protection Agency's National Toxics Rule (40 CFR 131.26). The USEPA is expected to promulgate new or revised criteria for certain toxic substances in the surface waters of California in the forthcoming "California Toxics Rule". State standards for surface and ground waters of the Lahontan Region include California Department of Health Services drinking water standards for all waters which are designated for the Municipal and Domestic Supply (MUN) beneficial use.

Designated beneficial uses are a part of California's water quality standards, together with narrative and numerical water quality objectives. Objectives, which are analogous to federal "water quality criteria" may be set at natural background water quality levels, or at levels which scientific evidence indicates are necessary for protection of beneficial uses. Beneficial uses may be "existing" uses known to occur within a particular water body, or "potential" uses which could occur in the future. The federal water quality standards regulation (40 CFR 131.10) defines "existing uses" as those which have occurred at any time since the November 1975 effective date of the regulation. The term "beneficial use" includes natural ecosystem functions and uses of water by plants and animals, as well as human uses of water. The water quality standards regulations direct that "In no case shall a State adopt waste transport or waste assimilation as a designated use for any waters of the United States."

Some saline and geothermal water bodies of the Lahontan Region have site-specific beneficial uses designated, but beneficial uses for most of these waters fall under group designations such as "Minor Surface Waters [of the ...... HU]". Table 2-1 of the Basin Plan includes separate beneficial use designations for "minor wetlands" and other types of "minor surface waters" for most HUs, but in most cases the Saline Habitat (SAL) use is not designated for these categories. All of the nine water bodies under consideration for removal of the MUN use are designated for a variety of human, aquatic life, and wildlife beneficial uses.

Table 2-1 of the Basin Plan includes both existing and potential beneficial uses. Chapter 2 of the Basin Plan discusses the rationale for designation of specific uses. Reasons for designating *potential* uses include (1) existing plans to put the water to these uses; (2) conditions such as location or demand which make such future use likely; (3) identification of the water body as a potential source of drinking water under SWRCB policy; and (4) the potential for remedial measures to ensure attainment of these uses for water bodies which do not now attain them. The Basin Plan (pages 2-3 to 2-4) recognizes that some beneficial uses of surface waters may occur only temporarily. The presence or absence of a beneficial use designation does not necessarily prevent the water from being put to the associated use. For example, geothermal energy development has occurred in several parts of the Lahontan Region using waters which are not specifically designated for the Industrial Service Supply (IND) use.

Site specific numerical water quality objectives have not been designated for the saline/geothermal waters of the Lahontan Region, with the exception of Mono Lake. In particular, site specific objectives have not been developed for these waters for naturally occurring toxic substances such as arsenic. Under the "tributary rule", site-specific water quality objectives for downstream waters apply to upstream waters which do not have site specific objectives. A number of "fresh" surface water bodies in the Lahontan Region which have geothermal waters tributary to them have site specific objectives for total dissolved solids, chloride, sulfate, and boron (for example, the Owens River, and Crowley Lake). Objectives for "Adjusted Sodium Adsorption Ratio" and "Percent Sodium", both of which are calculated from the concentration of sodium in relation to concentrations of calcium, potassium and magnesium, apply to surface waters of some watersheds. These sodium objectives relate primarily to water use for irrigation.

For waters designated MUN, the applicable standards for naturally occurring toxic substances are the Department of Health Services' drinking water Maximum Contaminant Levels (MCLs), which are referenced in the regionwide "Chemical Constituents" objectives for surface and ground waters in Chapter 3 of the Basin Plan. Applicable standards also include the narrative non-degradation objectives for surface and ground waters, and the narrative toxicity objective for surface waters. Most of the saline/geothermal surface waters of the Lahontan Region are currently designated for the Municipal and Domestic Supply (MUN) use as a result of Regional Board action in 1989 under the State Water Resources Control Board's "Sources of Drinking Water Policy". See the staff report for the proposed Basin Plan amendments (CRWQCB, Lahontan Region, 2000) for an explanation of the background for this designation.

For waters not designated MUN, the Basin Plan's narrative nondegradation and toxicity objectives still apply. Other regionwide narrative water quality objectives which could be violated under naturally occurring conditions in saline and geothermal waters include those for pH, taste and odor, and dissolved oxygen. In the case of pH, the Basin Plan specifically recognizes that :

> *"some waters of the region may have natural pH levels outside of the 6.5 to 8.5 range. Compliance with the pH objective for these waters will be determined on a case-by-case basis*" (italics added).

Table 3 is a summary of selected state and federal water quality criteria for chemical constituents which are common in saline/geothermal waters of the Lahontan Region (Central Valley RWQCB, 1998). The table includes criteria for drinking water, agricultural, and aquatic life uses. Both freshwater and salt water aquatic life criteria are cited. However it should be noted that the saltwater criteria were developed for marine and estuarine organisms and are not necessarily relevant to the biota of the inland saline waters of the Lahontan Region. Table 3 includes state Maximum Contaminant Levels (MCLs). MCLs are both drinking water standards enforceable by the California Department of Health Services, and ambient water quality standards for waters designated for the MUN use, enforceable by the RWQCB. Primary MCLs are derived from health based criteria including incremental cancer risk estimates for carcinogens and from threshold toxicity levels for noncarcinogens, with consideration of technologic and economic factors. Secondary MCLS are derived from human welfare considerations such as taste, odor, and laundry staining. Table 3 also cites some state "Public Health Goals in Drinking Water" which are levels at which no adverse effects are expected to occur with lifetime consumption of the water.

To supplement the numeric criteria in Table 3, the following narrative provides additional information on some chemical constituents which are important in saline/geothermal waters of the Lahontan Region.

Arsenic. Arsenic is often referred to as a metal, but is chemically classified as a "metalloid". It occurs in concentrations of about 5 mg/kg in the earth's crust (USEPA, 1980). Arsenic is present in volcanic gases and is commonly found in geothermal waters. The arsenic cycle varies depending upon chemical properties and hydrodynamic characteristics of the site-specific aquatic environment. Many of the processes are chemical while others occur through microbial mediation. Aquatic organisms, fish and invertebrates, and plants can concentrate arsenic, especially trimethylarsine. Adsorption and precipitation are significant factors in the cycling of arsenic in aquatic system (Ruschmeyer and Tchobanoglous, 1989).

Arsenic is used industrially in the manufacturing of glass and other produces, and as a fungicide and wood preservative, and occurs in the emissions from coal-fired power plants (USEPA, 1980). There is little industry or agricultural pesticide use in the Lahontan Region, particularly in the vicinity of the nine water bodies affected by the proposed Basin Plan amendments, and coal-fired power plants are uncommon in California. Arsenic in the waters of the Lahontan Region is presumed to come from natural volcanic or geothermal sources, from minerals concentrated in closed drainage basins over geologic time, or from windblown dust transported from desert lake basins (e.g., Owens and Mono Lakes) to other surface waters.

Arsenic is toxic to humans; ingestion of as little as 100 mg can result in severe poisoning, and as little as 130 mg has proved fatal. Chronic lower doses can accumulate in the body, and cause cancer, liver and heart problems (McKee and Wolf, 1963). In addition to cancer, arsenic has been

Table 3. Water Quality Criteria for Inorganic Constituents of Concern for Lahontan Region Saline and Geothermal Waters. All concentrations in micrograms per liter (parts per billion) unless otherwise specified. Lahontan Basin Plan water quality objectives for surface waters designated MUN are the CA Dept. of Health Services MCLs. Source: Central Valley RWQCB, 1998.

Chemical Constituent	**CA Dept. of Health Services Primary MCL**	**CA Dept. of Health Services Secondary MCL**	**CA Prop. 65 Regulatory Level**	**Agricultural Water Quality Goals**	**USEPA National Ambient Water Quality Criteria/ Freshwater Aquatic Life**	**USEPA National Ambient Water Quality Criteria/ Saltwater Aquatic Life**	**Proposed California Toxics Rule, Human Health**	**Proposed California Toxics Rule, Freshwater Aquatic Life**	**Other**
Arsenic	50		5		190 (4 day avg.) 360 (1 hr avg.)	36 (4 day avg) 69 (1 hr. avg)		150 (continuous limit) 340 (acute limit)	USEPA Drinking Water Health Advisory (SNARL) 0.02
Beryllium	4		Carcinogen	100					USEPA Drinking Water Health Advisory (SNARL) 0.008
Boron				700/750					USEPA Drinking Water Advisory (SNARL) 600
Chloride		250,000		106,000	230,000 (4 day avg) 860,000 (1 hr avg)				
Copper	1300	1000		200	Depends on water hardness	2.4 (4 day avg) 2.4 (1 hr avg)	1300	11(continuous limit) 16 (acute limit)	CA Public Health Goal in Drinking Water 170 CA Toxics Rule proposed saltwater aquatic life criteria 4.8 (acute) 3.1 (continuous)
Fluoride	1400 to 2400			1000					CA Public Health Goal in Drinking Water 1000
Lead	15		0.25 Carcinogen, reproductive toxin	5000	Depends on water hardness	8.1 (4 day avg) 210 (I hr avg)			
pH						6.5 to 8.5 units			Lahontan RWQCB objective 6.5-8.5 units
Sodium									USEPA Drinking Water Health Advisory SNARL 2000
Specific conductance		900 umho/cm		700 umho/cm					
Strontium									NAS 7 day suggested no adverse risk level 8400
Sulfate		250,000							
Total dissolved solids (TDS)		500,000		450,000					USEPA National Ambient Water Quality Criteria: Human Health- Taste and Odor or Welfare

implicated in other adverse health effects including effects on the nervous, circulatory, and gastrointestinal systems, and the liver, hearing impairment, diabetes, and developmental effects (USEPA, 1999). Higher temperatures can increase the toxicity of arsenic, but it is not affected by water hardness (USEPA, 1980).

The current primary MCL for arsenic in drinking water is 50 ug/L, and was set to protect against ski cancer. Epidemiological studies in 1988 and 1990 on Taiwanese populations exposed to "high" levels of arsenic (300- 800ug/day) had unexpectedly high levels of liver, kidney, lung, a d bladder cancer. The human body can detoxify arsenic (in terms of non-carcinogenic effects) when amounts are below 200-250 ug/day, but this may not necessarily protect against carcinogenic effects (City of Los Angeles Water Services, 1998). For comparison, representative arsenic concentrations in geothermal or geothermally influenced waters of the Lahontan Region are as follows: Wendel and Amedee Hot Springs, 180-220 ug/L; Fales Hot Springs 1100 ug/L; Little Hot Creek, 540-710 ug/L, and Little Alkali Lake 520-680 ug/L. The Amargosa River, which also receives input from mineral springs, has an arsenic concentration of 286 ug/L at Shoshone.

After a literature review including extensive epidemiological evidence from other countries such as the one cited above, the National Research Council recommended that the current standard be made more stringent. The Safe Drinking Water Act requires the USEPA to revise the existing drinking water standard for arsenic; a proposed Arsenic Rule is currently scheduled to be released on January 1, 2000, and a final rule on January 1, 2001 (USEPA, 1999). A more stringent standard may place even more Lahontan waters out of compliance with the standard and necessitate Section 303(d) listing for additional waters which are designated for the MUN use.

Excessive arsenic in irrigation water is harmful to plants through the destruction of chlorophyll and other physiological effects. Sensitivity to arsenic varies among crops. The lethal dose for livestock is about 20 mg /animal pound. A water quality criterion of 1.0 mg/L was recommended by McKee and Wolf (1963) for stock and wildlife watering, irrigation, and fish and aquatic life.

Antimony. Because many of its compounds are insoluble, McKee and Wolf (1963) state that "any dissolved antimony that might be discharged to natural waters would soon precipitate and be removed by sedimentation and /or adsorption". Antimony potassium tartrate, or "tartar emetic" has been used since ancient times as an emetic, and more recently as an intravenous treatment for schistosomiasis. The latter use has produced cardiac arrhythmia, skin eruptions, and even pneumonia. Doses of tartar emetic as 100 mg have been reported to be fatal, with symptoms similar to those of arsenic poisoning (McKee and Wolf, 1963). The current California primary MCL for antimony is 6 ug/L; the USEPA criterion for freshwater aquatic life is 30 ug/L (4 day average) and the salt water aquatic life 4 day average criterion is 35 ug/L. Of the nine waters covered by the proposed Basin Plan amendments, Little Hot Creek is apparently the only one where antimony has been analyzed. Antimony values reported from Little Hot Creek are 27-30 ug/L in the creek and 50 ug/L in the headwater hot spring.

Beryllium. Mckee and Wolf (1963) considered beryllium a relatively rare element which is unlikely to occur in natural waters. However, it has been reported from geothermal waters in the Long Valley Caldera; a sample from Little Hot Creek had a concentration of 9 ug/L. Beryllium is a recognized carcinogen and the California Primary MCL is 4 ug/L. At acid pH values, beryllium is toxic to plants. (Some of the reported pH values for the waters in question are slightly acid.) The Agricultural Water Quality Goal is 100 ug/L.

Boron. Although boron is considered a rare element, geochemical processes have greatly concentrated it in some areas. Volcanic activity is the source of most boron currently in the natural environment. High concentrations are commonly found in geothermal waters and in closed basins associated with volcanic activity. Playas and remnant lake beds, commonly found in California, are rich in boron (Ruschmeyer and Tchobanoglous, 1989) and are sometimes mined as commercial sources. McKee and Wolf (1963) state that boron in drinking water up to 30 mg/L is not harmful, but above this level it may interfere with digestion. Excessive borate may cause nausea, cramps, convulsions, and coma. Although traces of boron are essential for plant growth, excess amounts can cause leaf burn, premature leaf drop and reduced crop yields. The Agricultural Water Quality Goal is 700-750 ug/L, but McKee and Wolf cite crops which are sensitive to lower levels of boron.

Chloride. Chloride in drinking water is of concern primarily because of its impacts on palatability, although it may be injurious to some people with heart or kidney disease, and may have laxative effects for people who are used to lower concentrations. It can be tasted at concentrations as low as 61 mg/L, and imparts a salty taste at a median of 396 mg/L. "Moderate" concentrations of chloride in crop root zones (700-1500 mg/L) lead to leaf burn and injury. Chloride may affect industrial uses of water by causing corrosion of metals at 45-50 mg/L or lower.(McKee and Wolf, 1963, USEPA, 1986). McKee and Wolf state that chloride is harmful to trout at 400 mg/L; their recommended criteria include 50 mg/L for industrial use, 100 mg/L for irrigation, and 1500 mg/L for stock and wildlife watering.

Fluoride. Fluorides are not considered common constituents of natural surface waters (McKee and Wolf, 1963); however, they are common in thermal waters. Fluoride concentrations between 0.6 and 1.7 mg/L may have beneficial effects on teeth but concentrations over 4 mg/L may cause mottling and pitting of teeth (USGS, 1989). Fluoride is toxic to humans at higher concentrations, with severe symptoms at 250-400 mg and 4 g causing death. McKee and Wolf cite threshold values of about 1 mg/L for food processing, 1.0 mg/L for stock watering, and 10.0 mg/L for irrigation.

pH. The USEPA freshwater aquatic life criteria include a recommended instantaneous maximum of 6.5 to 9.0 units (Central Valley RWQCB, 1998). The Lahontan Basin Plan's regionwide narrative water quality objective is 6.5 to 8.5 units. McKee and Wolf (1963) cite a reference stating that waters with pH over 9.0 units are "unsuitable for irrigation use".

Sodium. Sodium in drinking water may be harmful to people with cardiac, circulatory, or kidney diseases. The USEPA (1986) recommends the following concentrations in drinking water: for people on low sodium diets, 20 mg/L; for people on moderately restricted diets, 270 mg/L. The taste threshold for sodium chloride is 135 mg/L and that for sodium carbonate is 34 mg/L. Sodium in irrigation water modifies soil structure, resulting in poor aeration of soil, low infiltration rates, and decreased moisture availability to plants. Sodium can also replace calcium ions in root tissues, resulting in calcium deficiency. Sprinkler irrigation with water containing high levels of sodium can cause leaf burn (McKee and Wolf, 1963). McKee and Wolf cite a recommended 2000 mg/L sodium threshold for livestock watering.

Sulfate. Sulfate causes a bitter taste in drinking water when combined in high concentrations with other ions, and may have laxative effects for people unaccustomed to higher concentrations (USGS, 1989). The secondary MCL drinking water standard of 500 mg/L sulfate was set to prevent laxative effects (USEPA, 1986). In high concentrations in irrigation water, sulfate may cause precipitation of calcium and be toxic to plants; concentrations over 500 mg/L are generally considered hazardous to crops (McKee and Wolf, 1963). In industrial water supplies, sulfate can cause problems by forming boiler scale in combination with calcium, and it increases the corrosiveness of water toward concrete (USGS, 1989; McKee and Wolf, 1963). McKee and Wolf recommended maximum sulfate concentrations of 500 mg/L for stock watering, and 200 mg/L for irrigation.

Temperature. The Basin Plan's narrative temperature objectives for surface waters, and the statewide "Thermal Plan", are concerned primarily with preventing alterations of natural temperatures as a result of human activities which lead to thermal discharges. The temperatures of geothermal springs and their outflow waters are the primary factor in their importance for recreational use, but human and livestock deaths have occurred in boiling springs. McKee and Wolf (1953) reported that temperatures of 10 degrees C are considered satisfactory for drinking water, but temperatures of 15 degrees C or higher are usually objectionable. High temperatures also affect drinking water supplies by stimulating the growth of taste and odor producing algae and altering the effectiveness of water purification processes. For aquatic life, higher temperatures decrease oxygen solubility, increase oxygen demand, and may intensify the toxicity of some chemicals.

Total Dissolved Solids, and the related parameter specific conductance, are discussed above in connection with the physical and biological characteristics of inland saline waters. TDS affects the taste of drinking water and has other effects depending on the concentrations of individual constituents. Studies have indicated that chickens, swine, cattle and sheep can survive drinking saline waters with up to 15,000 mg/l of salts of sodium and calcium combined with bicarbonates, chlorides, and sulfate, but only 10,000 mg/L of corresponding salts of potassium and magnesium. The approximate limit for highly alkaline waters containing sodium and calcium carbonates in 5,000 mg/L (USEPA, 1986).

The secondary MCL drinking water standard of 500 mg/L TDS is based primarily on palatability (USEPA, 1986). The USEPA cites a survey of 29 CA water systems for taste thresholds for TDS: levels of 1, 283-1,333 mg/L were rated "unacceptable"; water with 658-755 mg/L TDS was "good", and water with 319-397 mg/L "excellent". Very salty waters are not palatable, do not quench thirst, and may have laxative effects on new users. People have used waters supplies with 2000-4000 mg/L TDS when no better supply is available, but waters above 4000 mg/L are generally considered unfit for human use. TDS above 5000 mg/L causes bladder and intestinal irritation (McKee and Wolf, 1963). The threshold TDS level in the SWRCB's "Sources of

Drinking Water Policy (3000 mg/L) is higher than the state secondary MCL for TDS (500 mg/L).

The effects of salinity on aquatic life and higher plants are discussed above in connection with the biota of inland saline waters. The "water quality goals" for agriculture in Table 3 are from a United Nations Food and Agriculture Organization publication referenced in Central Valley RWQCB, 1998. The USEPA (1986) cites 500 mg/L TDS as a level which should have no detrimental effects on crops in general, while tolerant plants on permeable soils with careful management practices may tolerate 2000- 5000 mg/L TDS.

High concentrations of dissolved solids in industrial waters can cause foaming in boilers and interfere with the clearness, color or taste of industrial products. High levels of TDS may also accelerate corrosion (McKee and Wolf, 1963). The USEPA (1986) cites a study in which 1750 mg/L TDS reduced the service life of toilet flushing mechanisms by 70 percent and that of washing equipment by 30 percent. The 1968 cost was an additional 50 cents per 1000 gallons of water used.

BENEFICIAL USE ANALYSIS

Although the proposed Basin Plan amendments are concerned only with the Municipal and Domestic Supply beneficial use, USEPA staff have requested that this Use Attainability Analysis address all beneficial uses of the affected waters. The following discussion groups similar uses together.

Municipal and Domestic Supply (MUN)

The MUN use is defined in Chapter 2 of the Basin Plan as :

> *"Beneficial uses of waters used for community, military, or individual water supply systems including, but not limited to, drinking water supply".*

The available data show that all nine of the water bodies currently under consideration for removal of the potential MUN use designation exceed one or more of the applicable state and federal drinking water standards or criteria. Table 4 below summarizes the chemical parameters for which standards or criteria are exceeded for each water body. More detailed water quality information for each water body is presented later in this report. (It should be noted that none of these water bodies is routinely monitored for water quality, and that different parameters have been monitored in the past for different water bodies. There may be other naturally occurring trace elements which exceed standards, but which have not been monitored.) In all cases, the exceedance of drinking water standards is due to natural sources, either volcanic/geothermal sources, or concentration of evaporite chemicals in closed basins over geologic time.

The waters of geothermal springs and saline lakes have been, and still are used for drinking in other parts of the world, for therapeutic purposes, although probably not for the lifetime duration used in the formulation of drinking water criteria. Sulfurous waters from the hypolimnion of Soap

Lake, Washington, were bottled and sold as a tonic (Edmondson, 1991). "Taking the waters" for health purposes at a spa should probably be considered a water contact recreational use rather than a municipal use.

RWQCB staff are unaware of any direct municipal and domestic supply use of the nine waters in question since 1975. As noted below under the discussion of Wendel and Amedee Hot Springs, the waters of Wendel Hot Springs were used for dishwashing in a hotel kitchen during the 19th Century. Little Hot Creek and Little Alkali Lake are tributary waters which in turn are tributary to Crowley Lake, which is part of the Los Angeles Department of Water and Power's municipal supply system. However, Little Hot Creek has been estimated to provide less than one percent of the net outflow of Crowley Lake, and the flow from Little Alkali Lake to Crowley Lake is described as "runoff" and is apparently ephemeral (California DWR, 1967; USGS, 1976).

In 1997, the Lahontan RWQCB approved an NPDES permit for a reverse osmosis treatment facility to remove arsenic from a spring which provides drinking water to the community of Shoshone (which has approximately 150 people) near the Amargosa River. The waste brine from the treatment plant is discharged to a ditch tributary to the Amargosa River, but does not increase the overall natural arsenic load to the river.

The USEPA (1997) has reviewed the feasibility of 11 different technologies for removal or arsenic from drinking water; removal efficiency depends on pH and the valence state of arsenic (AsIII *vs.* AsV). The study cited addresses "low level" arsenic removal, from 50 ug/L down to 1 ppb or less; arsenic concentrations in saline/geothermal waters of the Lahontan Region can be much higher. As indicated by the Shoshone example, it may be technologically feasible to treat the nine water bodies affected by the proposed Basin Plan amendments for municipal use, but it would be expensive, at least with current technology. The California Department of Water Resources (1997 and 1998) cites seawater desalination costs of $1,200-$2,200 per acre-foot, with additional costs for conveying the water to its place of use. Deutsch (1999) states that even at the most efficient plants, a thousand gallons of desalted water costs about $2 to produce, twice the typical cost of freshwater sources. DWR (1998) cites a nationwide study in 1994 which showed that the average urban water supply cost was "almost $600 per acre-foot". According to the Water Engineering Website (1997) the energy cost for desalination by reverse osmosis has been a major reason for the high cost: a new "carbon aerogel" method developed by Lawrence Livermore Laboratory has been promoted as able to reduce energy costs by "orders of magnitude" and allowing laboratory salt concentrations of 1000 ppm to be reduced to 1 or 2 ppm. Hammer (1986) mentions one case in Saskatchewan where saline lake water is desalinated by freezing the water, pumping out the saline water, and using the ice as a domestic supply.

Even if treatment should prove feasible, the waters currently proposed for removal of the MUN use are in relatively remote areas with small populations. Some in are in protected areas (e.g., Death Valley National Park) or on public lands which are unlikely to be proposed for residential or commercial development. Conflicting beneficial uses such as hot springs use for recreation, and the need to protect wetlands and rare and endangered species habitat, would probably also reduce any demands on these waters. The intermittent nature of the Amargosa River, and the ephemeral nature of Little Alkali and Deep Springs Lakes also reduce their potential for development as water supplies, even if treatment should be feasible.

In conclusion, the nine "naturally impaired" waters in Table 4 are all in violation of one or more drinking water standards or criteria, have not supported municipal uses during the period since 1975, and are unlikely to support a MUN use in the future. Removal of the potential MUN use from these waters is scientifically justified. Better quality waters (such as wetlands and neighboring groundwater aquifers) adjacent to these nine surface waters will continue to be designated for the MUN use.

Table 4. Summary of Compliance With Drinking Water Criteria for Nine "Naturally Impaired" Waters.

Water Body Name	Sources of Drinking Water Policy TDS Threshold Exceeded?	Parameters for which Other Standards or Criteria are Exceeded	Water Quantity Considerations
Wendel Hot Springs	No	TDS, specific conductance, arsenic, sulfate, fluoride, sodium	Flow in natural springs reduced due to nearby geothermal development.
Amedee Hot Springs	No	TDS, sulfate, fluoride, boron, sodium	Flow in natural springs reduced due to nearby geothermal development.
Fales Hot Springs	No	TDS, specific conductance, sulfate, fluoride, arsenic, copper, molybdenum, lead aluminum	
Hot Creek	No	Specific conductance, fluoride, boron	
Little Hot Creek	No	Arsenic, beryllium, specific conductance, boron, lead, fluoride, antimony.	Annual flow ca. 1000 afa; evaporation increases salinity
Little Alkali Lake	Yes	TDS, Arsenic	Ephemeral
Keough Hot Springs	No	TDS	Flow 600 gallons per minute
Deep Springs Lake	Yes	TDS, specific conductance, pH	Ephemeral
Amargosa River	Yes (in Death Valley)	TDS, specific conductance, arsenic, sulfate, sodium, chloride, fluoride, boron.	Intermittent, variable annual flows

Aquatic Life Uses (WARM, COLD, SAL, RARE, BIOL, SPWN, MIGR)

The Lahontan Basin Plan defines several aquatic habitat uses. Definitions of the Cold Freshwater habitat (COLD), Warm Freshwater Habitat (WARM) and Inland Saline Water Habitat (SAL) uses are very similar:

> *"Beneficial uses of waters that support cold [or "warm" or "inland saline"] water ecosystems, including, but not limited to, preservation and enhancement of aquatic habitats, vegetation, fish, and wildlife, including invertebrates."*

In some cases waters are designated for more than one aquatic life use. The waters may vary spatially in temperature and salinity (for example, the Amargosa River is designated for both the WARM and SAL uses.

The USEPA aquatic life criteria for trace metals are expressed as one hour or four day averages, and compliance with these criteria is generally measured through bioassays with standard test organisms. To RWQCB staff's knowledge, no bioassay data are available for any of the nine water bodies. GeoProducts Corporation and Zurn/NEPCO (1987) reported that bioassays of geothermal well effluent from the aquifer that feeds Wendel and Amedee Hot Springs showed no significant differences between test and control organisms (fathead minnow, *Ceriodaphnia*, and *Selenastrum*). (In addition to geothermal effluent, the test effluent included 25 percent effluent from a wood burning power plant.) However, the limited ambient water quality data available for a number of toxic trace elements in the nine waters include some single sample values which greatly exceed aquatic life criteria values (Table 3). There are no continuous sets of chemical data, or bioassay data, available to assess compliance with one-hour or four day average criteria. At least for the geothermal springs, whose quality is not affected by variations in precipitation and runoff, it is likely that the exceedances of criteria are long term and continuous.

The relevance of the USEPA freshwater and saltwater aquatic life criteria to the native organisms and the biological integrity of California's inland saline, geothermal, and geothermally influenced waters is somewhat questionable. The saltwater life criteria are based on studies of marine and estuarine organisms and may not adequately reflect the tolerance limits of organisms native to inland saline and geothermal waters. The literature review above shows that the plants, animals, and microorganisms native to the saline and geothermal waters of the western United States are well adapted to their unique ecological conditions, including extremes of salinity and temperature. Although site specific biological data are available for only a few waters, all of the "naturally impaired" water bodies of the Lahontan Region should be considered to support at least one type of "existing" aquatic habitat use. (There are no biological data available on the geothermal springs which have been developed for energy or recreation, but this development may have affected the degree of use support.)

The 1995 Basin Plan also includes separate "Spawning, Reproduction and Development"(SPWN) and "Migration of Aquatic Organisms" (MIGR) uses. Because of the lack of biological data for most waters of the Lahontan Region, probably many more waters support these uses than are currently designated for them. The SPWN use is not restricted to fish, but applies to all aquatic organisms. To the extent that saline and geothermal waters support resident aquatic life, they may be presumed to support the SPWN use.

The Basin Plan includes two use designations which protect habitat for "Rare, Threatened, or Endangered Species (RARE) or "Biological Habitats of Special Significance (BIOL).

The RARE use is defined as:

"Beneficial uses of waters that support habitat necessary for the survival and successful maintenance of plant and animal species established under state and/or federal law as rare, threatened or endangered."

The BIOL use is defined as:

"Beneficial uses of waters that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, and areas of Special Biological Significance (ASBS) where the preservation and enhancement of natural resource requires special protection."

Deep Springs Lake and the Amargosa River are designated for these uses. The Amargosa River, Deep Springs Lake, and Amedee and Wendel Hot Springs have also been identified by the Department of Fish and Game as "Significant Natural Areas" (California DFG, 1992). As noted below, pools created from Little Hot Creek are now being used to provide habitat for the Owens tui chub, and a conservation area has been proposed in the vicinity of the Alkali Lakes for the Long Valley speckled dace.

The RARE and BIOL uses of Deep Springs Lake appear to be adequately protected by its remote location and the commitment of Deep Springs College to protection and restoration of black toad habitat. Much of the Amargosa River is protected within Death Valley National Park or in two U.S. Bureau of Land Management "Areas of Critical Environmental Concern". However, there is concern that groundwater withdrawals in Nevada may adversely affect springs, wetlands, and surface river flows which provide habitat for sensitive species.

Protection of aquatic habitat uses essentially requires maintenance of natural water quality conditions. The Basin Plan includes water quality objectives (e.g., those for dissolved oxygen and temperature) related to particular types of habitat. Findings under the nondegradation objective would be required to permit a discharge which would increase natural temperatures or increase the natural salinity of aquatic habitat

No changes in aquatic life use designations are being proposed at this time for the nine "naturally impaired" surface waters, although changes may be appropriate in the future. (For example, Little Alkali Lake is now, as a minor surface water of the Long Hydrologic Area, designated for the cold freshwater habitat use, and will continue to be so designated when a specific row is created for the lake in Table 2-1 of the Basin Plan). However, a saline habitat use would be more appropriate. Because of the high degree of biological endemism in the Lahontan Region, it is likely that further biological studies will identify additional waters which should receive the RARE and/or BIOL use designations.

Wildlife Habitat (WILD) Use

This use is defined as "

"Beneficial uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl."

All surface waters of the Lahontan Region are designated for the wildlife habitat use, although there is generally little site specific information on wildlife species and type and intensity of use. As noted in the discussion of the biology of saline and geothermal waters above, saline lakes can be very important as feeding and resting sites for migratory birds, and these birds can be important dispersal agents for the biota of the lakes. Hot springs provide important winter habitat in Yellowstone National Park; similar uses may occur in the colder parts of the Lahontan Region. The wetlands associated with saline and geothermal waters also provide habitat for wildlife adapted to local conditions. All nine "naturally impaired" waters are assumed to support existing wildlife habitat uses, and no changes in use designations are proposed at this time.

Water Quality Enhancement (WQE) Use

This use is defined as:

"Beneficial uses of waters that support natural enhancement or improvement of water quality in or downstream of a water body including, but not limited to, erosion control, filtration and purification of naturally occurring water pollutants, streambank stabilization, maintenance of channel integrity, and siltation control. "

This use generally applies to wetlands. It is not a designated use of any of the nine waters currently proposed for removal of the MUN use, although it does apply to the wetlands associated with them. Curry (1993) has pointed out that playa lakes have many of the characteristics of wetlands, and that, in the Lahontan Region:

"...the playa lakes and shoreline areas of residual water bodies, as well as the great alkali flats and lowland wetland areas all provide a vital water quality function through evaporative surface concentration of salts. Despite valid public health concerns, alkaline wetland sites are the primary points of entrainment of salts into the atmosphere. These wetlands are the "conveyor belts" that permit California to export its soluble salt and maintain large reservoirs of fresh water under arid land sites.... Only in areas with long geologic concentration of salts and little outflow such as Searles, Saline Valley and Death Valley do we find insufficient wind to export most of the accumulated salts and thus concentrate highly saline groundwaters ".

The extent to which this groundwater cleansing function occurs at Deep Springs and Little Alkali Lakes is unknown. No changes in designations of the WQE use are proposed as part of these Basin Plan amendments.

FLD Flood Peak Attenuation/Flood Water Storage Use

This use is defined as:

"Beneficial uses of riparian wetlands in flood plain areas and other wetlands that receive natural surface drainage and buffer its passage to receiving waters."

By definition, the FLD use applies only to wetlands. Playa lakes have some of the characteristics of wetlands, and as terminal lakes, store flood waters. However, Little Alkali and Deep Springs Lakes are not designated for the FLD use. No changes in designations for this use are proposed at this time.

Water Contact Recreation (REC-1) Use

The REC-1 beneficial use is defined in the Basin Plan as :

"Beneficial uses of waters used for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs."

As the Basin Plan explains, the beneficial uses of surface waters of the Lahontan Region generally include the REC-1 use in order to implement the "swimmable" goals of the federal Clean Water Act. Exceptions are made in a few cases, such as agricultural reservoirs, wastewater reservoirs, drinking water aqueducts, and in some special wildlife areas where access for REC 1 use is restricted or prohibited by the entities which control those waters.

The USEPA water quality standards guidance (1994) discusses the criteria for water contact recreation uses largely in terms of protection of human health in relation to ingestion of water, particularly in relation to bacteria standards. The guidance states that : "Recreation in and on the water... may not be attainable in certain waters, such as wetlands, that do not have sufficient water, at least seasonally". However, physical factors, which are important in determining attainability of aquatic life uses, may not be used as the basis for not designating recreational use consistent with the CWA Section 101(a)(2) goal. This precludes states from using low flows and physical factors in general as grounds for dedesignating a recreational use. "The basis for this policy is that the States and EPA have an obligation to do as much as possible to protect the health of the public. In certain instances, people will use whatever water bodies are available for recreation, regardless of the physical conditions." In order to protect public health, States must set criteria to reflect recreational use if it appears that recreation will in fact occur.

By definition, the REC-1 use applies to natural hot springs. (Some springs at the source may be too hot for water contact recreational use, but such use may occur in spring outflow streams, or in artificially developed pools, after cooling.) In the past, hot springs of the Lahontan region have been used for therapeutic as well as recreational purposes. For example, Coso Hot Springs, which is now the site of four geothermal energy power plants, was advertised in 1921 as the "Greatest Natural Radio Hot Spring in America", with a guarantee that "its 250 springs would benefit stomach diseases, rheumatism, and kidney trouble"(Putnam and Smith, 1995); it is not clear whether this use involved ingestion of the water. Recreational use of natural hot springs is currently popular enough that there are a number of Internet websites and travel guidebooks which provide information on their locations, temperatures, and the existence of parking, dressing rooms, and other developed facilities (e.g., Bischoff, 1997).

The applicability to the REC-1 use to saline lakes has been questioned due to their unsuitability as drinking water, the corrosivity of high PH to the skin, and the formation of a white crust on objects which come into contact with saturated brine solutions. However, saline waters may be attractive for contact because of the novelty of their unique properties such as their detergent nature. Mark Twain (quoted in Hinkle and Hinkle, 1949) visited Mono Lake in the 1860s and wrote about doing laundry by towing it behind a boat, and using the water as shampoo to create a lather three inches high.

Hammer (1986) noted the use of saline lakes for water contact recreation, including resorts at Great Salt Lake as early as the 1870s. The bouyancy of some salt lakes has led to their use for swimming by tourists. Windsurfing has been reported to occur on the alkali lakes of Long Valley in the Owens River watershed (Jones & Stokes, 1993), and offroad vehicle users who like the "challenge" of muddy conditions probably come into contact with the brines of some moist playas. The Searles Lake Gem & Mineral Society's web page (1999) states:

> *"For more than fifty years, countless thousands of visitors have come to Trona during the second weekend in October for the annual Gem-O-Rama. And each year more collectors converge for the 48 hours of frantic, non-stop activity to collect some of the best and most desirable evaporite mineral specimens in the world."*

The event involves manually searching through a pile of material excavated from beneath the playa surface for collectable mineral crystals. Professional geologists also conduct field trips on the Searles Lake playa involving body contact with the moist playa surface (Elizabeth Lafferty, Lahontan RWQCB staff, personal communication.) Because of their large size, and the presence of many of them within public lands, it would be vary difficult to limit recreational access to the saline lakes of the Lahontan Region.

In conclusion, all nine of the waters currently under consideration for removal of the MUN use are considered to have existing or potential REC-1 uses, even though they may not be "swimmable" in the usual sense. No changes are proposed in REC-1 use designations as part of the current Basin Plan amendments.

Non-Contact Water Recreation (REC-2) Use

The Basin Plan defines this use as:

> *"Beneficial uses of waters used for recreational activities involving proximity to water but not normally involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing,*

> *hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment in connection with the above activities."*

All of the "naturally impaired' waters of the Lahontan Region should be considered to have this use. Many of them are located on public lands open for public recreation activities such as hiking, camping, and picnicking, or are visible to the public from roads and highways even if access is restricted. Some of them have distinctive scenic features (e.g., the Mono Lake and Searles Lake tufa towers). Although playa lakes are ephemeral; they can support boating when water is present. Hammer (1986) noted the use of permanent saline lakes for boating and sailing; the bouyancy of Great Salt Lake offered the opportunity to set powerboat speed records. Kayaking has been reported on Badwater Lake in Death Valley. Even when these waters are located on private lands or military reservations, at least "aesthetic enjoyment" use by landowners or military personnel is a possibility.

Commercial and Sportfishing (COMM) Use

This use is defined as:

> *"Beneficial uses of waters used for commercial or recreational collection of fish or other organisms, including but not limited to, uses involving organisms intended for human consumption."*

The criteria for this use are human consumption criteria (i.e., the weight of fish tissue from fish caught in a particular water body which can be consumed within a certain period without adverse health effects). Bioaccumulation and bioconcentration of toxic elements by fish and other edible aquatic organisms are important considerations. Organisms from saline lakes have been harvested for food, papermaking, and fertilizer in other parts of the world (Hammer, 1986).

Although fishing may occur in Hot Creek and Little Hot Creek, the extent to which the nine "naturally impaired" water bodies support the COMM use is unknown. At least one saline water body in the Lahontan Region (Honey Lake) supports sportfishing; fish can enter the lake from the Susan River or tributaries and survive in relatively dilute water during wet years. Mono Lake brine shrimp have been harvested for commercial sale to aquarists, and by the Department of Fish and Game as food for hatchery trout (Hinkle and Hinkle, 1949). Scientists continue to collect aquatic organisms for study. Although Native Americans historically ate brine fly larvae from large saline lakes such as Mono Lake and Owens Lake. Human consumption of aquatic organisms other than fish collected from any of the nine waters has probably not occurred since the 1975 threshold date. There are no samples of fish tissue from any of these waters available to evaluate bioaccumulation of toxics; however fish sampled from some other waters in the Crowley Lake watershed under the State Water Resources Control Board's Toxic Substances Monitoring Program (TSMP) have shown "elevated" concentrations of toxic metals. A TSMP rainbow trout sample collected in 1996 from the Owens River above Crowley lake had an arsenic concentration in filet tissue which exceeded the California Office of Environmental Health Hazard Assessment's "Maximum Tissue Residue Level" (MTRL) human consumption criterion. Since human fish consumption criteria generally assume consumption over the long term; occasional consumption of fish caught by tourists probably would not result in ingestion of significant amounts of toxic chemicals of geothermal origin, even if individual fish bioaccumulate these chemicals.

As noted above, the unique adaptations of hot spring algae from Yellowstone National Park have led to a profitable biotechnology industry. The potential exists for study and biotechnology use of Lahontan Region organisms, but such use is not, to Regional Board staff's knowledge, currently being made. No changes in COMM use designations are being proposed at this time.

Agricultural Supply (AGR) Use

The Basin Plan defines this use as:

> *"Beneficial uses of waters used for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, and support of vegetation for range grazing."*

Of the nine saline/geothermal waters under consideration, all except for Deep Springs Lake are designated for the AGR use. In most cases the designation results from application of the "tributary rule" or from applications of "generic" use designations for the "minor streams and springs" category for each hydrologic unit. As summarized in Table 5, the chemical constituents in a number of these waters exceed agricultural water quality criteria for irrigation and/or stock watering. Some of them exceed watershed-specific water quality objectives for constituents such as boron, which are related to protection of agricultural uses.

Regional Board staff are not aware of any irrigated agriculture using water diverted directly from one of the nine water bodies; however, geothermal effluent from the power plant at Wendel Hot Springs (which is extracted from geothermal wells rather than the natural springs) is used to irrigate pasture land. As noted in the literature review above, most plants are intolerant of high salinity and sodium levels. Highly saline or mineralized waters are unsuitable for irrigation of most crops, although salt tolerant desert plants are being researched for agricultural use and could conceivably be grown in some desert areas of the Lahontan Region in the future.

Livestock are present in the Little Hot Creek watershed; as shown in the discussion of the creek below, the springs have been fenced to keep livestock out, and livestock impacts on creek habitat are one of the issues in protection of the endangered Owens tui chub. Overgrazing is also an issue in the area of Little Alkali Lake. Range livestock grazing may occur on public lands in the watersheds of most of the other "naturally impaired" waters in question for at least part of each year, and it is possible that livestock ingest these waters. However, there are probably better surface water supply sources in all of these areas, and the "naturally impaired" waters probably do not serve as sole, year-round livestock watering sources.

The California Department of Water Resources (1998) projected a 10 acre foot (af) water shortage (mostly for agricultural use) in the North Lahontan Basin by 2020 (a 128 af shortage in drought years). None of the options for increasing water supply which DWR considered was judged to be feasible, due either to economic or environmental reasons. DWR projects that, during droughts, pasture irrigation will probably be curtailed. DWR (1998) also predicted a water shortage of 184 af in an average year and 210 af in a drought year by 2020 for the South Lahontan Basin. The most likely options projected to meet future shortages involved State Water Project supplies and water transfers via the California Aqueduct. DWR (1998) considered reduction of outflow to playa lakes as an option for increasing water supplies in the South Lahontan Basin. It stated that

> *"... local storm runoff collects in many small playas throughout the basin, these playas generally do not contribute to groundwater recharge, due to the low permeability of playa soils. Water collected in the playas evaporates, rather than recharging groundwaters. Diversion or collection of runoff to playas and recharging to groundwater basins could result in increased groundwater supplies by elimination of the evaporation. Six dry lakebeds could potentially store an additional 1,800 af perhaps once every five years. Costs for this option are $1,000 to $3,300 per af. Water quality at the playas is generally poor, with high levels of salts and minerals. This option was deferred."*

The costs for the option described above are similar to, or higher than the costs of desalination cited under the discussion of the MUN use, above. For comparison with the projected cost of using playa runoff, DWR mentions one agricultural surface supplier in the South Lahontan Basin with weighted average water costs of $61 per acre-foot.

In conclusion, most of these waters are probably unsuitable for the AGR use due to high levels of TDS or toxic trace elements such as boron or arsenic. It might be appropriate to consider changes in agricultural use designations and/or site specific numerical water quality objectives for some of these waters in the future. However, there are no proposals to change agricultural use designations or objectives at this time.

Aquaculture (AQUA) Use

The Basin Plan defines this use as:

> *"Beneficial uses of waters used for aquaculture or mariculture operations including but not limited to, propagation, cultivation, maintenance, and harvesting of aquatic plants and animals for human consumption or bait purposes."*

None of the nine waters under consideration for removal of the MUN use is designated for the aquaculture use or currently supports aquaculture. Hot Creek in the Owens River watershed is designated for the AQUA use because of the use of its waters in the Hot Creek fish hatchery. Geothermal effluent (obtained from ground water) from the Wendel area is used in aquaculture, and no adverse impacts have been reported on 18 species of tropical fish raised in 100 percent geothermal effluent (GeoProducts and Zurn/NEPCO, 1987). Other saline or geothermal waters of the Lahontan Region could potentially be used for culturing brine shrimp or edible algae such as the blue-green *Spirulina*, or other salt-tolerant organisms, but RWQCB staff are not aware of any such proposals. No changes in the current AQUA use designations in the Basin Plan are proposed at this time.

Table 5. Summary of Compliance with Agricultural Supply Criteria for Nine "Naturally Impaired" Waters.

Water Body	Constituents Exceeding Irrigation Criteria	Constituent Exceeding Stock-watering Criteria	Comments
Wendel Hot Springs	Sulfate, TDS, specific conductance, chloride, boron	Fluoride, arsenic	
Amedee Hot Springs	TDS, chloride, boron, sulfate	Fluoride, arsenic	
Fales Hot Springs	Specific conductance, TDS, chloride, sulfate	Fluoride, arsenic	Exceeds Basin Plan narrative objective for pH
Hot Creek	Specific conductance, boron	Fluoride	Exceeds Basin Plan numeric water quality objectives for boron, TDS, and chloride.
Little Hot Creek	Specific conductance, chloride, boron, sodium	Fluoride, arsenic	Exceeds Basin Plan numeric objectives for boron, chloride, TDS, sulfate, fluoride, and narrative objective for pH
Little Alkali Lake	Boron, TDS, specific conductance, pH	Fluoride, arsenic	Exceeds Basin Plan numeric objectives for sulfate, chloride, fluoride, TDS, boron, and narrative objective for pH
Keough Hot Springs	TDS		
Deep Springs Lake	Sulfate, TDS, Specific conductance, pH	Sulfate	Exceeds Basin Plan narrative objective for pH
Amargosa River	Sulfate, chloride, TDS, boron	Sulfate, fluoride	Exceeds Basin Plan narrative objective for pH

Industrial Process Supply (PRO) Use

This use is defined as:

> "*Beneficial uses of waters used for industrial activities that depend primarily on water quality.*"

Standard references on water quality criteria (e.g., McKee and Wolf, 1963) discuss industrial use of water mainly in terms of the need for good quality water as an ingredient in food or beverage processing or in other processes such as the paper pulp industry and the need to prevent corrosion of or scale deposition on equipment. The saline and geothermal surface waters of the Lahontan Region would be considered of poor quality for most industrial process supply uses, especially those involving human food and beverages, due to high salinity and/or pH, high levels of toxic elements such as arsenic, and/or corrosivity.

The definitions of the PROC use (and the IND use below) do not really reflect one of the most widespread historic industrial uses of the saline lakes of the Mojave Desert, which is extraction of minerals from natural or manmade brine pools on the lake surface (e.g., Owens Lake) or from subsurface brine beneath dry lakebeds (Searles Lake.) Another potential industrial use of Lahontan Basin waters which depends on poor quality (high salinity) is the use of solar brine ponds for power generation. Salt gradient ponds have layers of brine with different concentrations; the most concentrated layer is at the bottom, where water temperatures can reach 200 degrees F. The bottom layer is more dense than the upper layers, which inhibits heat convection. The brine can be pumped through an external head exchanger and can be used for space heating or electricity production (U.S. Department of Energy, undated).

The nine surface waters currently under consideration for removal of the MUN use are not designated for the PRO use, and no changes in this designation are proposed at this time.

Industrial Services Supply (IND) Use

This use is defined in the Basin Plan as:

> *"Beneficial uses of waters used for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, geothermal energy production, hydraulic conveyance, gravel washing, fire protection and oil well repressurization."*

Since, by definition, this use does not require good water quality, most "naturally impaired" waters of the Lahontan Region are theoretically suitable for it. Very highly saline waters might not be suitable, since crystallization of salts and/or corrosion due to high pH could create problems with pipes and firefighting equipment. McKee and Wolf (1963) mention that firehose streams aimed at power lines can conduct electricity and cause electric shocks for firefighters, and that high levels of TDS increase the conductance. Disposal of wastewater from saline/geothermal waters after IND uses would also be a concern.

The ground waters which feed Wendel and Amedee Hot Springs have been developed for geothermal energy, and the potential exists for geothermal energy development at other hot springs in the region. Regional Board staff are not aware of any proposals to use Fales Hot Springs, Keough Hot Springs, or the springs which feed Little Hot Creek for energy production.

It is not clear whether the inclusion of "mining" in the definition of the IND use was meant to include the extraction of minerals from saline lakes. Hammer (1986) states that most of the earlier research on saline lakes worldwide was done to evaluate their potential for mineral extraction. Norris (1995) points out the widespread past or present mining of saline minerals throughout the Mojave desert at dry lakes and playas including Searles Lake, Bristol Dry Lake, Koehn Lake, and Danby Lake, and the open-pit borax mine at Boron.

The nine waters under consideration for removal of the MUN use are all at least potentially suitable for the industrial service supply use, although none of them is designated for it. No changes in designations for this use are proposed at this time.

Hydropower Generation (POW) Use

This use is defined in the Basin Plan as

"Beneficial uses of waters used for hydroelectric power generation".

POW is not a designated beneficial use of any of the nine water bodies under consideration for removal of the MUN use, and there are no current proposals for hydropower use under consideration for any of them. Most of these waters probably do not have perennial flows large enough to support hydropower uses.

Navigation (NAV) Use

This use category is defined as:

> *"Beneficial uses of waters used for shipping, travel, or other transportation by private, military, or commercial vessels."*

None of the nine waters under consideration for removal of the potential MUN use is designated for the NAV use. To RWQCB staff's knowledge, no commercial or military vessels use these waters, or have used them since 1975. No quantitative information is available on the extent of recreational boating on these waters; however, boating (at least with canoes or kayaks) is theoretically possible on Hot Creek, Little Hot Creek, Little Alkali Lake, Deep Springs Lake, and the Amargosa River when water is present. No changes in NAV use designations are proposed at this time.

Ground Water Recharge (GWR) Use

The GWR use is defined as:

> *"Beneficial uses of waters used for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers."*

All nine of the waters being considered for removal of the MUN use are designated for the Ground Water Recharge (GWR) use. In most cases the designation probably results from the tributary rule and/or from categorical designations for "minor" surface waters of a particular hydrologic unit which date back to the 1975 Basin Plans. No information is available on the amount of recharge which actually occurs, or the extent to which local soils are capable of removing salts and trace elements from recharged surface waters. Because of the high evaporation rates in some parts of the region, surface flows may not necessarily reach ground water. Because of the poor quality of these waters, their unsuitability for MUN use, and in some cases their exceedance of criteria for agricultural use, these waters may not be suitable for groundwater recharge for later extraction.

Geothermal areas tend to have multiple aquifers, with shallow freshwater aquifers overlying deep geothermal aquifers (see the discussions of the Honey Lake and Long Valley Caldera areas below). Some trace metals in geothermal waters which infiltrate into the upper aquifers may be removed by precipitation and complexation in the soil. As noted in the discussion of the water quality enhancement (WQE) use above, playas may improve groundwater quality to some extent by serving as sites for evaporative concentration of salts at the surface, where they are removed from the system by wind action. The Department of Water Resources (1998) states that playas generally do not contribute to groundwater recharge because of relatively impermeable soils. No changes are proposed at this time in current GWR use designations.

Freshwater Replenishment (FRSH) Use

This use category is defined as:

> *"Beneficial uses of waters used for natural or artificial maintenance of surface water quantity or quality (e.g., salinity)."*

Of the nine water bodies under consideration for removal of the MUN use, only Wendel and Amedee Hot Springs, Hot Creek, and Little Hot Creek are designated for the FRSH use. The latter two designations result from the "tributary rule". Due to their naturally poor quality and violations of municipal and/or agricultural use criteria, the suitability of any of these waters for "freshwater replenishment" is questionable. Ruschmeyer and Tchobanoglous (1989) concluded that geothermal discharges from the groundwater wells located near Wendel and Amedee Hot Springs served to dilute Honey Lake.

WATER QUALITY AND BENEFICIAL USES OF SPECIFIC SURFACE WATERS

The information on specific water bodies below is almost entirely from publications in the Lahontan RWQCB's South Lake Tahoe and Victorville offices. In most cases the data reflect a very limited number of samples. Due to the listing guidance in effect at the time, these waters were placed on the Section 303(d) list on the basis of such limited information. When considering revisions of water quality objectives, RWQCB staff normally seek more abundant, long term monitoring data to determine historical quality and compliance with existing standards.

Water quality is not monitored on an ongoing basis for these water bodies, and thus seasonal and annual variations cannot be analyzed. The water quality of geothermal springs can be expected to be less variable over time than that of the lakes and streams, since the latter are more affected by precipitation, runoff, and evaporation. For example, see the data in Table 7 for samples of Wendel Hot Springs taken in 1957 and 1967.

The nine specific water bodies from which the MUN use is proposed for removal are discussed in north- to –south order below.

WENDEL AND AMEDEE HOT SPRINGS, LASSEN COUNTY

Wendel and Amedee Hot Springs are groups of springs located northeast and east of Honey Lake in Lassen County (Figure 3). (Honey Lake and adjacent wetlands are also Section 303(d) listed for naturally occurring trace elements, and will be addressed in future TMDLs.) The flow in the natural springs has been drastically altered by geothermal development. The geothermal wells draw on the aquifer feeding the springs, and surface geothermal discharges are of essentially the same quality as the springs.

Honey Lake, a remnant of prehistoric Lake Lahontan, is located within a graben. Surface geological mapping shows three major faults, all of which control the existence of both fossil hot springs, indicated by a linear series of tufa mounds, and currently active hot springs. The Honey Lake region is considered a "Known Geothermal Resource Area" by the U.S. Bureau of Land Management (DWR, 1978).

The Honey Lake ground water basin is composed of three layers. The surface layer, which includes the regions' freshwater aquifers, is composed of nearshore lacustrine deposits, alluvial sediments, and minor fractured thin basalt flows. Fresh groundwater wells extend up to about 50 feet below the surface. The next layer (mudflows and lithic tuffs), provides a barrier between the fresh water and geothermal aquifers. The third unit at a depth of at least 4500 feet, includes fractured and faulted granitic rocks, which facilitate the movement of geothermal waters. The presence of Wendel Hot Springs and the artesian characteristics of several geothermal wells show that the geothermal aquifer has a hydraulic head greater than the freshwater aquifer. Both geothermal and fresh ground waters are recharged through precipitation in the surrounding mountains. (Lassen County Board of Supervisors, 1987). Geologic studies indicate that geothermal fluids percolate to a depth of 7000 feet or more, where they are heated conductively and then rise to the surface along northeast trending faults (U.S. Bureau of Reclamation, 1976).

An early U.S. Geological Survey publication (Waring, 1915) provides descriptions of the springs before development for geothermal energy production, and information on early human uses. Regarding Amedee Hot Springs, Waring states [italics added]:

> *"Scalding water forms several groups of shallow pools, mainly at six places in a belt about 600 yards long that trends nearly southwest... but one third of a mile southwest from the southern most of these main groups another hot spring forms a pool in salt-grass land... Temperatures of 172° F to 204° F (practically the boiling point at this elevation, 4,000 feet) ... [the] total discharge of hot water as measured by the flow of six run-off streams is about 700 gallons a minute. ...[In] 1909 the spring had not been improved to great extent but there was a small bathhouse beside the railroad, near one of the largest groups of springs. At the southernmost of the main groups there was also an old bathhouse, and water from one of the northernmost springs was used in preparing sheep dip. At the Amedee Hotel, a shallow well supplied water at a temperature of 134° F for kitchen use."*

Waring reported that there were no prominent deposits of tufa but that the hottest spring rose from a small tufa area.

For Shaffer (now Wendel) Hot Springs, Waring noted a continuous tufa formation nearly half a mile long with prominent crags and knolls beyond this. The main spring was about 10 yards in diameter and one to two feet deep. It was formerly a geyser but had been stopped by stones. The temperature was 204 degrees F and there was a bathhouse/vapor bath there in 1909. The estimated flow was 748 gallons per minute in 1885 and 175 gallons per minute in 1909. There were two more hot springs and pools. Waring cites an 1885 report of a 50 foot high, mushroom shaped tufa crag.

Honey Lake is located on the Pacific Flyway and is considered one of the most important waterfowl wintering refuges in the state. At least 200 bird species and a variety of wildlife including 20 small mammal species use the area. It provides year-round deer range, and pronghorn antelope winter range. Sensitive species include greater sandhill crane, bald eagle, a bat, and two rare plants. Rare aquatic invertebrates may also be present in the Wendel Hot Springs canal. (Lassen County Board of Supervisors, 1987; California Department of Food and Agriculture, 1978; U.S. Bureau of Reclamation, 1982). The Honey Lake State Wildlife Area is located just west of Wendel.

The region was sufficiently productive to support a settled lifestyle for the Honey Lake Paiute tribe, who relied on the fish resources of the lake and the plant resources along its shores and tributaries. Human occupancy goes back as far as 2000 years, and the area is now considered to have extreme cultural resource sensitivity (Lassen County Board of Supervisors, 1987).

The estimated population of Lassen County's Wendel Planning Area was about 130 people in 1987, with 108 living in the immediate Wendel area. There was no vacant housing, and little demand for housing. Possible future growth was expected to be due to geothermal development. The County plan recognizes that the soils in the Wendel area are suitable for crops and grazing, and in the Amedee area for grazing. The plan includes a geothermal resources element with policies for protection of the resource, and "geothermal industrial reserve" zoning (Lassen County Board of Supervisors, 1987).

Although the discharges from the current geothermal wells are of the same quality as the natural springs, concern has been expressed regarding their impacts on water quality and beneficial uses. Lassen County recommended that the cooling pond from the Honey Lake Power Plant be fenced and the temperature monitored in order to protect humans, livestock, wildlife. The County also recommended that the temperature in the discharge channel not be allowed to exceed 102 degrees F without fencing (Lassen County Board of Supervisors, 1987). The discharges from the geothermal power plants at Wendel and Amedee Hot Springs are, together with the Susan River (which is also affected by geothermal sources) the major sources of arsenic, boron and molybdenum to Honey Lake. During the 1980s drought, the Susan River was significantly affected by agricultural diversions, and the power plant discharges represented significant fractions of the inflow to the lake (Ruschmeyer and Tchobanoglous, 1989). At this time, the Department of Fish and Game expressed concern about use of geothermal waters to supplement wetland supplies in the wildlife refuge, due to high concentrations of arsenic and molybdenum (Lassen County Board of Supervisors, 1986).

Geothermal discharges in the Wendel area are used for agricultural irrigation and for aquaculture. GeoProducts Corporation and Zurn/NEPCO (1987) concluded on the basis of a literature review that if geothermal well effluent were mixed with cold shallow ground water before use for irrigation in the Honey Lake area, there were unlikely to be adverse impacts on the proposed crop (alfalfa) from salt buildup or trace minerals such as fluoride. GeoProducts Corporation and Zurn/NEPCO (1987) reported no significant differences between test and control groups of organisms (fathead minnow larvae, Ceriodaphnia, and Selenastrum) in bioassays of geothermal effluent combined with wood burning power plant effluent, and no adverse impacts of 100 percent effluent on 18 species of tropical fish being raised at the Honey Lake Tropical Fish Farm. Geothermal heat is also being used in 30 greenhouses at Wendel Hot Springs to grow cucumbers and tomatoes, and the operation may expand to 200 greenhouses (Karl, 1998).

Tables 6 through 9 summarize historic data on the water quality of Wendel and Amedee Hot Springs, and more recent data on the quality of the geothermal discharges. Note that the TDS levels do not exceed the Sources of Drinking Water Policy threshold of 3000 mg/L. However, the concentrations of several other constituents including arsenic and fluoride exceed drinking water criteria (see Tables 3 and 4).

There are no known direct historic (since 1975) municipal uses of the water from Wendel and Amedee Hot Springs. The flows from the natural springs have been significantly reduced due to geothermal development. The small population of the area, and the availability of better water supplies from the shallow aquifer, make it unlikely that the spring waters will be in demand for municipal use in the future. The removal of the potential MUN use designation is justified for both water bodies.

Table 6. Water Quality Data for Wendel and Amedee Hot Springs (Lassen Co. Board of Supervisors 1987)

Constituent/Units	**Wendel Hot Springs**	**Amedee Hot Springs**
Sodium (mg/L)	280	250
Chloride (mg/L)	190	160
Sulfate (mg/L)	360	300
Fluoride (mg/L)	4.1	4.4
Zinc (mg/L)	0.015	0.005
Boron (mg/L)	5.5	4.0
pH	8.4	8.4
Total Dissolved Solids (TDS), mg/L	1040	879
Sodium Absorption Ratio (SAR)	93.0	94.2

Table 7. Total Trace Element Concentrations Sampled in Wineagle and Amedee Geothermal Discharges (Ruschmeyer and Tchobanoglous, 1989). The Wineagle plant is near Wendel Hot Springs.

Station/Sample Type/Date/Units	Boron	Arsenic	Molybdenum
Wineagle/ water/ 9/88	5.70 mg/L	0.16 mg/L	0.06 mg/L
Wineagle/ water/ 10/88	4.9 mg/L	0.17 mg/L	0.10 mg/L
Wineagle/ water/ 11/88	5.34 mg/L	0.19 mg/L	0.05 mg/L
Amedee/ water/ 9/88	4.70 mg/L	0.19 mg/L	0.08 mg/L
Amedee/ water/ 10/88	4.3 mg/L	0.18 mg/L	0.07 mg/L
Amedee/ water/ 11/88	4.59 mg/L	0.20 mg/L	0.08 mg/L
Wineagle/ sediment/ 9/88	10.8 mg/kg	5.2 mg/kg	0.57 mg/kg
Wineagle/ sediment/ 10/88	14.0 mg/kg	22.2 mg/kg	0.93 mg/kg
Wineagle/ sediment/ 11/88	22.9 mg/kg	15.0 mg/kg	0.53 mg/kg
Amedee/ sediment/ 9/88	34.4 mg/kg	15.0 mg/kg	0.54 mg/kg
Amedee/ sediment /10/88	28.1 mg/kg	11.3 mg/kg	1.18 mg/kg
Amedee/ sediment/ 11/88	16.0 mg/kg	6.0 mg/kg	0.34 mg/kg

Table 8. Quality of Geothermal Well (Wineagle-1) Effluent (GeoProducts and Zurn/NEPCO, 1987).

Constituent	Concentration
Arsenic	190 ug/L
Copper	30 ug/L
Fluoride	3.6 mg/L
Boron	6.64 mg/L
Molybdenum	63 ug/L
Sodium	260 mg/L
Chloride	165 mg/L
Sulfate	298 mg/L
Mercury	1.1 mg/L
TDS	875 mg/L
Electrical Conductivity	1340 umho/cm
Sodium Adsorption Ratio	16

Table 9. Early Water Quality data for Wendel Hot Springs and Amedee Hot Springs (from California DWR, 1970)

Constituents and Units	Wendel Hot Springs (Sampled 8-8-1957)	Wendel Hot Springs (Sampled 2-15-1967)	Amedee Hot Springs Sampled 1915
Temperature (degrees F)	200	ND*	200
Specific Conductance (umho/cm @ 25 degrees)	1470	1490	ND
pH	8.2	8.5	ND
Calcium (Ca, ppm)	20	22	18
Magnesium (Mg, ppm)	0.2	0.0	trace
Sodium (Na, ppm)	276	285	232
Potassium (K, ppm)	8.1	0.0	4.9
Carbonate (CO3, ppm)	0	9	27
Bicarbonate (HOC3, ppm)	51	35	ND
Sulfate (SO4, ppm)	342	366	269
Chloride (Cl, ppm)	192	182	164
Nitrate (NO3, ppm)	0.0	0.3	ND
Fluoride (F, ppm)	2.2	ND	ND
Boron (ppm)	5.1	4.8	ND
Silica (ppm)	53	ND	94
Iron (Fe, ppm)	0.04	0.01 (total Fe)	1.8 "Al-Fe"
Aluminum (Al, ppm)	0.06	0.00	1.8 "Al-Fe"
Arsenic (As, ppm)	0.18	0.22	ND
Copper (Cu, ppm)	ND	0.00	ND
Lead (Pb, ppm)	ND	0.00	ND
Manganese (Mn, ppm)	ND	0.00	ND
Zinc (Zn, ppm)	ND	0.00	ND
TDS (ppm)	924	1010	ND
Percent Sodium	91	ND	ND
Total Hardness (CaCO3) ppm	51	ND	ND

* "ND"= "Not Determined".

Table 10. Water Quality Data for Wendel and Amedee Hot Springs (USGS samples collected in August 1976, cited in U.S. Bureau of Reclamation, 1982).

Constituent	Wendel Hot Spring	Amedee Hot Spring #1 north vent	Amedee Hot Spring #2 (middle vent)	Amedee Hot Spring #3 (south vent)
Temperature (C.)	95.5	76	92	96
pH	8.3	8.5	8.4	8.4
Total Dissolved Solids (TDS), mg/L	1,021	853	863	854
Ca (mg/L)	20	16	16	15
K (mg/L)	8	6	6	6
Mg (mg/L)	0.1	0.1	0.1	0.1
Na (mg/L)	280	235	235	235
Cl (mg/L)	185	160	160	155
SO4 (mg/L)	340	280	290	280
HCO3 (mg/L)	53	49	48	57
B	5.6	3.7	3.8	3.8
SiO2	125	100	100	98

FALES HOT SPRINGS AND HOT CREEK, MONO COUNTY

The Fales Hot Springs are located at an elevation of 7300 feet near the headwaters of Hot Creek, which is tributary to the Little Walker River in the West Walker River Hydrologic Unit (Figure 4). The springs are located near Highway 395 about 13 miles north of Bridgeport. The creek is about 5 miles long and is close to Highway 395 for much of its length. The hot springs were historically used as part of a way station on the Sonora-Mono Wagon Road, over Sonora pass to Bodie; the road was completed in 1878. The springs were later developed as part of a now closed resort, with diversions for individual bathhouses and a pool. The resort, now located on public land, is currently closed and "in disrepair". The water temperature, 150 degrees F. or more at the source, is said to be dangerous (Bischoff, 1997). NOAA (1999) gives the temperature as 180 degrees F or 82 degrees C.

Hot Creek (Figure 4) originates in springs near "Devils Gate" and is tributary to the Little Walker River and thence the West Walker River. Its water quality and temperature are affected by natural geothermal discharges from Fales Hot Springs. It should not be confused with the other Hot Creek in Mono County, which is in the upper Owens River watershed near the town of Mammoth.. There is relatively little information available on Hot Creek. It was placed on the Section 303(d) list on the basis of the STORET data summarized below. Hot Creek may also affected by highway runoff and road maintenance activities, and possibly by range livestock grazing. Hot Creek is not routinely monitored and the relative contributions of surface runoff, groundwater percolation and hot spring discharges to its flow and chemistry are unknown. There are no industrial sources of toxic chemicals in the watershed and the high levels of constituents such as boron, sulfate and fluoride are assumed to be from natural geothermal sources.

The following are summaries of water quality data for Fales Hot Springs and Little Hot Creek, collected by the U.S. Geological Survey and the California Department of Water Resources and reported in the USEPA STORET computer database. They show that, while these waters do not exceed the TDS threshold in the Sources of Drinking Water Policy (3000 mg/L), they contain constituents such as arsenic, fluoride, and sulfate in concentrations which exceed drinking water standards or criteria (see Tables 3 and 4). Note that boron was not measured in the Fales Hot Springs samples, and arsenic was not measured in Hot Creek; it is likely that arsenic and boron are present in high concentrations in both water bodies. The geothermal influence on Hot Creek is obvious when the data in Table 13 are compared with those for a sample taken at the same time from the Little Walker River above Hot Creek. The latter sample had sulfate at 2.7 mg/L, fluoride at 0.10 mg/L, boron at 0 ug/L, specific conductance at 56 umho/cm, and total alkalinity at 27 mg/L.

To RWQCB staff's knowledge, there is no existing municipal use of Fales Hot Springs or Little Hot Creek, and there are no surface water diversions for municipal use from the Little Walker and West Walker Rivers in California.. Because of their relatively small flows and remote locations Fales Hot Springs and Hot Creek are unlikely to be in demand as municipal sources in the future, even if treatment is technologically and economically feasible. The removal of the potential MUN use from both of these waters is justified.

Table 11. Water Quality of Fales Hot Springs. (Single surface sample by the USGS- August 25 1980. Source: STORET database.)

Parameter and Units	Value
Temperature (degrees C)	59
Specific Conductance (umho/cm)	2600
pH (Units)	6.3
Arsenic, dissolved, ug/L	1000
Lead, dissolved, ug/L	17

Table 12. Water Quality of Fales Hot Springs Pool (Single surface sample by CA Dept. of Water Resources, Nov. 3, 1955. Source: STORET database)

Parameter and Units	Value
Specific conductance (umho/cm)	2570
Total alkalinity (mg/L as calcium carbonate)	910
Total hardness (mg/L as calcium carbonate)	142
Chloride (mg/L)	158
Sulfate (mg/L)	260
Arsenic (ug/L)	1100
Copper, dissolved (ug/L)	20
Iron, dissolved (ug/L)	220
Manganese (ug/L)	90
Aluminum (ug/L)	90
Zinc (ug/L)	10

Table 13. Water Quality of Fales Hot Springs. (USGS data, single sample collected at surface on May 10, 1977. Source: STORET database.)

Parameter and Units	Value
Temperature (Degrees C.)	63
pH (units)	7.5
Total Alkalinity (mg/L as calcium carbonate)	910
Nitrite plus Nitrate (mg/L)	0.10
Orthophosphate (as phosphate) (mg/L)	0.34
Orthophosphate (as phosphorus) (mg/L)	0.11
Total hardness (as calcium carbonate) (mg/L)	150
Chloride (mg/L)	150
Sulfate, Total (mg/L)	270
Fluoride, Dissolved (mg/L)	5.7
Iron, Dissolved (ug/L)	90
Manganese, Dissolved (ug/L)	180
Aluminum, dissolved (ug/L)	10
U-NAT, dissolved (ug/L)	1.9
Dissolved solids (mg/L	1750

Table 14. Water Quality of Hot Creek. (Single sample by CA Dept. of Water Resources, at Little Walker Cowcamp Road, elevation 7000 feet, on August 9, 1956.)

Parameter and Units	Value
Water temperature, degrees F	51
Specific Conductance, umho/cm	1160
pH, units	8.2
Total Alkalinity, mg/L	418
Chloride, mg/L	76
Sulfate, mg/L	93
Fluoride, mg/L	1.8
Boron, ug/L	3300
Nitrate, mg/L as nitrate	1.0

LITTLE HOT CREEK AND LITTLE ALKALI LAKE, MONO COUNTY

Little Hot Creek and Little Alkali Lake (Figure 5) are located in the Long Valley Caldera, described by the Department of Fish and Game (1993) as follows:

> *"Long Valley Caldera is a large volcanic complex that forms an elongate depression and determines the location, gradient and substrate of the [Upper Owens] river. The caldera is approximately 11 miles from north to south and 20 miles from east to west. Approximately 730,000 years ago, the roof of a large magma chamber at the site erupted... As the chamber emptied, the roof collapsed, and long Valley Caldera was formed.... About 600,000 years ago, a large resurgent dome formed in the west-central portion of the caldera. During this time the caldera also contained a large lake, which is referred to as Pleistocene Long Valley Lake... Long Valley remains a region of high heat flow, with numerous hot springs located throughout."*

Jones and Stokes (1993) recognized that

> *"Geothermal activity strongly influences water quality in the Upper Owens River basin upstream of Lake Crowley reservoir. Visible geothermal activity consists of hot springs, fumaroles, and thermally altered rock primarily around Hot Creek, Little Hot Creek, Casa Diablo Hot springs, Whitmore Hot springs, and the Alkali Lakes.... These phenomena are associated with past volcanism, which has recently shown signs of renewal in the area."*

A number of surface waters influenced by volcanic activity in the Long Valley Caldera, including Hot Creek, have been placed on the Section 303(d) list, but are not being considered for removal of the MUN beneficial use designation because they contribute substantial flows to Crowley Lake and the Los Angeles municipal supply, and must therefore be considered to have "existing" MUN uses.

Groundwater temperatures greater than 200 degrees C have been measured in the western part of the Long Valley Caldera. Hydrothermal water flows from west to east and discharges in springs in the southern and eastern part of the caldera (Howle and Farrar, 1996). There are three distinct subsurface hydrologic systems in Long Valley: a shallow, unconfined groundwater system, a shallow, confined groundwater system, and a deeper geothermal system. Many springs discharge geothermal water mixed with water from the shallow groundwater system; the temperature of these springs varies depending on the degree of mixing (USGS, 1976).

A number of publications recognize the poor quality of the geothermally influenced waters of the Long Valley Caldera. Discussing the hot springs tributary to Hot Creek, the California Department of Water Resources (DWR, 1967) stated:

> " *Significant concentrations of the trace elements barium, strontium, iron and manganese and germanium are present in the hot springs and geothermal waste waters. The presence of a high concentration of germanium indicates the influence of a deep-seated magmatic body. This magma is the original source for the high concentrations of arsenic, fluoride, boron and some trace elements in the hot springs and geothermal waste waters* " (Italics added).

The California Department of Water Resources (DWR, 1967), calculated the "average" quality of hot springs and alkali lakes in the Long Valley Caldera. The average TDS for hot springs was 1,059 ppm [mg/L], and that for "Alkali Lake and related waters" is 29,734 ppm. The reported average values for arsenic, fluoride and boron in the hot spring and alkali lake categories exceeded water quality criteria. The alkali lakes were high in iron and relatively low in barium and strontium compared with the hot springs.

The USGS (1976) also reported that geothermal waters in Long Valley have high concentrations of dissolved solids, mainly sodium, bicarbonate, chloride, boron and arsenic, and "high concentrations of a host of trace elements". The USGS reported antimony in association with high arsenic concentrations at several locations. Hot spring water was considered the major source of arsenic to the Los Angeles Department of Water and Power (DWP) system and an issue of concern to the DWP for at least 25 years prior to 1976.

The Los Angeles Aqueduct domestic supply has a long term annual average arsenic concentration of 22 ug/L, most of which comes from Hot Creek. Blending and treatment reduce this concentration to an annual average of 10 ug/L. The DWP has stated that treatment to remove arsenic from the entire Los Angeles Aqueduct supply in order to meet the USEPA's potentially more stringent drinking water standard will be "quite costly", and that a water treatment facility at Hot Creek, while it would be more cost-effective, would be difficult to site because of the environmental sensitivity of the area (City of Los Angeles Water Service, 1998.)

The geothermal waters of the Long Valley caldera also affect other resources. Howle and Farrar (1996) state: The thermal springs provide unique environments for wildlife and plants and are used for recreational bathing by thousands of tourists each year". The University of California, Santa Cruz (1999) is studying the vegetation of Long Valley Caldera using Airborne Visible-Infrared Imaging Spectrometer (AVIRIS) technology. The study indicates that "Vegetation exposed to hydrothermal conditions responds in many ways, including accelerated growth cycles, influx of tolerant species groupings, and death of organisms." One of the study sites is at Little Hot Creek. The largest direct use of geothermal resources in the area is at the Hot Creek fish hatchery operated by the California Department of Fish and Game since 1932. Geothermal power has been generated in the area since 1985, with production totaling 40 megawatts from three plants at Casa Diablo in 1992.

Little Hot Creek. As shown in Figure 4, Little Hot Creek is part of a braided channel system, and different references state that it is tributary either to Hot Creek or to the Owens River. The creek is approximately four miles long from its source to Owens River, and that average annual flow of Little Hot Creek near the source between 1942 and 1965 was 1,000 acre feet, estimated to contribute 0.47 percent of the net outflow of Lake Crowley in 1967 (California Department of Water Resources (1967). In 1976, another DWR study found relatively low flow (no more than 0.15 cfs) at a downstream station in the creek, and concluded that, while appreciable runoff could occur during precipitation, the accumulation of salt residue along the creek channel and the high salinity of water backed up behind a culvert indicated extensive evaporation.

> *"During periods of high flow in Little Hot Creek, some salt residue would be dissolved and transported to Hot Creek, but the associated additional runoff to Lake Crowley would dilute this solution. These hot springs would not make any significant contribution of arsenic to Hot Creek and consequently to Lake Crowley, even during extended dry periods which are of most concern (DWR, 1976)."*

Little Hot Creek has its source in "numerous" hot springs with temperatures about 80 degrees C (USGS, 1998), and the flow from these springs is normally the only water in the creek (USGS, 1976). Water discharges were nearly constant in the three sampling periods of the USGS (1976) study. According to NOAA (1999) the Little Hot Creek Spring as a maximum surface temperature of 180 degrees F (82 degrees C). The USGS creek monitoring site is downstream of the geothermal activity and results reflect both springs and meteoric water.

Little Hot Creek was placed on the Section 303(d) list for arsenic concentrations exceeding drinking water standards. The arsenic concentration from a composite sample taken at the springs was 600 ug/L A composite sample below the confluence of the discharge from the springs on October 18, 1972 had an arsenic concentration of 540 ug/L, and an antimony concentration of 50 ug/L (USGS, 1976). Other trace elements from geothermal sources in this watershed include barium, strontium, boron, fluoride, vanadium, gallium, etc. (DWR, 1967); see Table 19 below.

The California Department of Water Resources (DWR, 1967) estimated for Little Hot Creek at the source, at an average annual flow of 1,000 acre feet, an average arsenic concentration of 0.75 ppm and an annual arsenic load of 1.0 tons; an annual fluoride concentration of 8.8 ppm and an annual load of 12.0 tons; and an average boron concentration of 10.00 ppm and an annual load of 13.6 tons. Jones and Stokes (1993) cited an arsenic concentration for Little Hot Creek of 600 ug/L and an estimated discharge to Crowley Lake of 0.3 tons of arsenic per year.

Additional water quality data for Little Hot Creek and its source spring are presented in Tables 15 through 18 and 21 below. In addition to exceeding the arsenic MCL, these water exceed the Lahontan Basin plan's objectives for the upper Owens River (Owens River above East Portal) objectives for fluoride, boron, sulfate, chloride, and total dissolved solids.

Land ownership in the Little Hot Creek watershed is divided among the Los Angeles Department of Water and Power, the U.S. Forest Service (Inyo National Forest), the U.S. Bureau of Land Management, and private parties. The hot springs at the headwaters of Little Hot Creek, on U.S. Forest Service land, are used for recreation (Bischoff 1997). Bischoff states that the cluster of hot springs has been fenced to reduce cattle damage. Karl (1999) mentions "the pool the locals have built" near the source springs.

Little Hot Creek provides habitat for one of five pure populations of the state and federally endangered Owens tui chub (Jones and Stokes, 1993). The Owens tui chub has been planted in an artificially created waterfowl pond on Little Hot Creek. The U.S. Fish and Wildlife Service (undated) has proposed a conservancy area within the Little Hot Creek watershed for the chub (*Gila bicolor snyderi*); its draft recovery plan for that species states: "The ecological uniqueness of this area and recent discoveries of new species ...suggest that future surveys may document the presence of additional unique plants and animals in the basin" (USFWS, undated).

The proposed conservation area is on U.S. Forest Service Land, and would involve 1.6 surface acres of fish habitat and 2 miles of linear habitat. It would include the source springs, their outflow and flood plain, and sodic and wet meadows. Proposed activities would include expanding habitat, eliminating non native fishes, installing a barrier to prevent upstream fish movement into the creek, protecting riparian vegetation from excessive livestock grazing, and protecting spring discharge from adverse impacts of groundwater pumping and geothermal development. (Geothermal development might decrease the flow from the springs into the creek, and alter thermal and chemical characteristics of the water.)

In conclusion, available data show that concentrations of arsenic and other trace elements in Little Hot Creek exceed drinking water standards. Because of the ephemeral nature of lower reaches of the creek, the costs of treatment, and conservation issues related to rare and endangered species, it is unlikely that there will be proposals to use the creek directly as a source of drinking water. The contribution of the creek to the Crowley Lake municipal supply is relatively small. Removal of the potential MUN beneficial use designation from Little Hot Creek is justified.

Table 15. Water Quality Data for Little Hot Creek (DWR, 1967)

Parameter	Little Hot Creek near Source, 6/16/1966	Little Hot Creek at County Road (3/22/61)	Little Hot Creek at County Road (6/13/66)
Temperature	140 degrees F	--	76 degrees F
pH	7.9	7.9	9.1
Specific conductance	1976 umho/cm	2418 umho/cm	2160 umho/cm
Sulfate	99 ppm (mg/L)	121 ppm (mg/L)	106 ppm (mg/L)
Chloride	206 ppm (mg/L)	260 ppm (mg/L)	242 ppm (mg/L)
Fluoride	8.8 ppm (mg/L)	10.4 ppm (mg/L)	11.0 ppm (mg/L)
Boron	10.0 ppm (mg/L)	7.50 ppm (mg/L)	11.20 ppm (mg/L)
TDS	1280 ppm (mg/L)	1270 ppm (mg/L)	1360 ppm (mg/L)
Arsenic	0.75 ppm (750 ug/L)	--	0.70 ppm (700 ug/L)

Table 16. Spectrographic analyses of trace elements in Little Hot Creek and waters of the Alkali Lakes area (DWR, 1967, reporting analyses from several sampling dates in 1966. Ranges are shown where applicable. Values expressed as "<" probably reflect detection limits).

Parameter	Hot Spring at Little Hot Creek	Little Hot Creek at County Road	Surface Flow from Alkali Lakes
Electrical conductivity	1908 umho/cm	2160 umho/cm	2513
TDS	1240 ppm (mg/L)	1360 ppm (mg/L)	1690
Aluminum	43 to <100 ppb (ug/L)	<100 ppb (ug/L)	<100
Barium	250 ppb (ug/L)	60 ppb (ug/L)	28 ppb (ug/L)
Cadmium	<0.1 to 12 ppb (ug/L)	<10 ppb (ug/L)	<5 ppb (ug/L)
Chromium	<0.71 to <1 ppb (ug/L)	2 ppb (ug/L)	<1 ppb (ug/L)
Copper	<0.71 to 3.3 ppb (ug/L)	10 ppb (ug/L)	14 ppb (ug/L)
Gallium	<2.9 to 11 ppb (ug/L)	<1 ppb (ug/L)	<1 ppb (ug/L)
Lead	<0.71 to <1 ppb (ug/L)	3.5 ppb (ug/L)	3 ppb (ug/L)
Molybdenum	>278 to 570 ppb (ug/L)	3.1 ppb (ug/L)	10.5 ppb (ug/L)
Nickel	1-1.6 ppb (ug/L)	1.3 ppb (ug/L)	2.5 ppb (ug/L)
Strontium	350 ppb (ug/L)	360 ppb (ug/L)	<40 ppb (ug/L)
Vanadium	0.5-1.7 ppb (ug/L)	2 ppb (ug/L)	3.2 ppb (ug/L)
Zinc	<2.9- 129 ppb (ug/L)	13 ppb (ug/L)	60 ppb (ug/L)

Table 17. Water Quality of Little Hot Creek below the hot spring (USGS station 10265160 sampled in July 18, 1990 and July 8, 1992).

Parameter and Units	**Value**
Water Temperature, degrees C	52.7 and 54
pH, units	8.14 and 8.4
Specific conductance uS/cm [=umho/cm]	1940
Discharge	0 .44 cfs
Fluoride	0.7
Beryllium ug/L	9
Boron ug/L	100-600
Copper, ug/L	1-2
Lead, ug/L	6-17
Antimony, ug/L	27-30
Total Dissolved Solids mg/L	50-80
Arsenic, ug/L	710 and 740
Mercury, dissolved , ug/L	0.1

Table 18. Water quality, flow and loading data for Little Hot Creek (Source: USGS, 1976). *The number after the slash for each chemical is the estimated rate of chemical discharge in tons per year. The first three samples were collected from the upper creek; the fourth was from a downstream station where the channel widens and the flow almost disappears.*)

Sampling date	**Sodium (mg/L)**	**Chloride (mg/L)**	**Arsenic (ug/L)**	**Specific conductance (umho/cm)**	**Flow (cfs)**	**Estimated annual discharge (afa)**
10/19/72	420/160	220/84	540/0.2	2,100	0.38	280
1/12/73	440/180	200/84	600/0.3	2,100	0.43	310
9/26/73	380/140	200/76	610/0.2	2,000	0.38	280
10/18/72	780/120	390/38	710/0.1	3,500	0.15	110

Table 19. Water Quality Data for the Little Hot Creek Spring. (Means of 1-5 samples per parameter, collected by USGS in 1983-84, reported in STORET database.)

Parameter	Value
Water temperature	81.6 C
Streamflow	0.08 cfs
Conductance	2703 umho
pH	6.76
Nitrate plus Nitrite, as N	0.10 mg/L
Phosphorus as P	0.01 mg/L
Chloride	208 mg/L
Sulfate	100 mg/L
Total alkalinity, calcium carbonate	606 mg/L(range 662-576)
Fluoride	8.52 mg/L
Barium	150 ug/L
Beryllium	3.0 ug/L
Cadmium	1.0 ug/L
Copper	10 ug/L
Iron	40 ug/L
Molybdenum	10 ug/L
Lead	10 ug/L
Residue Dissolved (@180 C)	1226 mg/L
Strontium	563 ug/L
Vanadium	6 ug/l
Lithium	2900 ug/l
Mercury	0.525 ug/L
Zinc	12 ug/L

Little Alkali Lake. Little Alkali Lake is one of a group of alkali lakes in the Long Valley Caldera northwest of Crowley Lake. It was placed on the Section 303(d) list on the basis of arsenic data cited in the Mono Basin EIR (Jones & Stokes, 1993). The Alkali Lakes receive inputs of arsenic and other elements from geothermal springs. Arsenic concentrations from seven springs in the Alkali Lakes area ranged from 350 to 680 ug/L with an average of 466 ug/L (USGS, 1976).

The USGS (1976) stated that "The springs near Big and Little Alkali Lakes and Alkali Pond are similar in chemical composition to those in Hot Creek gorge except that they are cooler and have less than half the arsenic concentration." Evaporation and loss of arsenic by chemical precipitation was indicated by the chemical analysis of springs and runoff from Little Alkali Lake. Flow from the lakes was not constant during the USGS investigation. The combined discharge from the lakes did not exceed 2 cfs when sampled. Estimates based on available data indicated that the rate of discharge was only about 1 ton per year arsenic from the Alkali Lakes as a group.

DWR (1967) stated that the Alkali Lakes' high TDS waters are concentrated by evaporation, and because of a high pH, they contain significant concentrations of carbonate ions and little or no calcium or magnesium ions. DWR estimated for the category "Surface Flow From Alkali Lakes and Vicinity", the following average concentrations and loads: arsenic 0.60 ppm and 3.3 tons per year; fluoride 8.0 ppm and 43.5 tons per year; boron 11.20 ppm and 60.9 tons per year. By comparing the ratios of different ions for different groups of waters in Long Valley Caldera, DWR concluded that arsenic is probably removed from the system by precipitation in the Alkali Lakes. The estimated average annual surface flow from "Alkali Lakes and Vicinity" to Crowley Lake was 4,000 acre feet, based on data from 1942 through 1965. This was 1.87 percent of the net outflow from Crowley Lake. Flow from Little Alkali Lake was only a part of this total.

A later study by the USGS (1976) reported that arsenic concentrations in the Alkali Lakes and pond ranged from 350-680 ug/L, and the annual loading to Crowley Lake from the group of lakes as a whole was 1.4 tons of arsenic. The USGS report concluded that the input of arsenic to Crowley Lake is mostly from the Owens River and Hot Creek, and about 10 percent of the input is from "other sources" including runoff from the Alkali Lakes. Tables 16, 20 and 21 include additional water quality data for Little Alkali Lake and vicinity.

As of the late 1980s, an unnamed springs tributary to Little Alkali Lake supported a population of the Owns speckled dace, a "species of concern". The Little Alkali Conservation Area in Long Valley has been proposed to protect the dace. It would include U.S. Bureau of Land Management and Los Angeles Department of Water and Power lands, the thermal spring, its outflow, wetland, and adjacent meadows upstream of Little Alkali Lake. Recovery actions recommended include protection against invasion by non-native species and impacts of overgrazing and groundwater pumping (USFWS, undated). Wong *et al.* (1999) reported that populations of the Owens dace, *Rhinichthys osculus* ssp. are stable except for a population near Little Alkali Lake in Long Valley which has been invaded by mosquitofish.

Table 20. Water Quality Data for the Little Alkali Lake area. (The first two samples are from springs at Little Alkali Lake; the second two are for runoff from the lake.) Source: USGS, 1976

Sampling Date and Location	Sulfate (mg/L)	Fluoride (mg/L)	Specific Conductance (umho/cm)	Arsenic (ug/L)	Boron (ugL)
7/26/73 (Springs)	81	5.4	1940	460	8,800
7/26/73 (Springs)	73	6.0	1840	490	8,900
10/19/72 (Runoff)	130	11	3600	520	12,000
9/27/73 (Runoff)	130	12	3800	680	13,000

Table 21. Water Quality Data for Little Alkali Lake and Little Hot Creek (USGS, 1976) (Range of samples collected in 1992-93) All constituents are dissolved values.

Parameter	Little Alkali Lake	Little Hot Creek
Discharge, cfs	0.3-0.8	0.4
Alkalinity (as calcium carbonate), mg/L	820-1410	620-630
Sulfate, mg/L	84-130	100
Chloride, mg/L	210-380	220
Fluoride, mg/L	6.5-11	7.2-9.8
Dissolved Solids, mg/L	2010-2390	1260-1350
Hardness (as calcium carbonate), mg/L	32-84	54-58
Specific Conductance, umho/cm	2300-3800	2000-2100
pH, units	8.3-9.1	8.2-8.8
Water Temperature, degrees C	5.0-7.5	52-57
Arsenic, ug/L (filtered)	270-680	540-610
Boron, ug/L (filtered)	8600-13000	6000-8100

KEOUGH HOT SPRINGS, INYO COUNTY

Keough Hot Springs is located on Los Angeles Department of Water and Power property about 8 miles south of Bishop and west of Highway 395 (see Figure 5). The headwaters have been developed as a resort with a swimming pool; the resort has recently been reopened. Water flows into a series of small pools and ditches, which are also used for public recreation. The temperature of the main springs is 51 degrees C, and the flow rate 2000 liters per minute. The total dissolved solids concentration is 510 mg/L, which exceeds the drinking water secondary MCL (Karl, 1999). Temperatures in the spring water cool gradually downgradient (Bischoff, 1997).

The California Department of Water Resources (1964) rated the water of Keough Hot Springs "inferior" for domestic and irrigation use due to high percent sodium and high fluoride concentration. Ground water on the west side of the Owens ground water basin, south of Bishop, was said to have a fluoride concentration up to 9 parts per million, and a percent sodium value of 92.

DEEP SPRINGS LAKE, INYO COUNTY

Deep Springs Lake is located in its own internally drained hydrologic unit in northeastern Inyo County, bordered by the White and Inyo Mountains (Figure 5). Deep Springs Lake, a moist, salt-encrusted playa, covers about 2 square miles in the southeast corner of the basin. The groundwater basin is about 41 square miles and is underlain with Quaternary alluvium to a depth of at least 775 feet. Groundwater is recharged by percolation of streamflow from the surrounding mountains; during the winter some water may pond on the lake, but it is usually dry. Springs and artesian flows show that a pressure area exists around the lake (California Department of Water Resources, 1964).

Deep Springs Lake is one of the playas studied by Kubly and Cole (1979). When sampled on May 4, 1978, it had a specific conductance of 86,000 umho/cm at 25 degrees C, a pH of 10.0, and a total phosphate (as phosphate) concentration of 30.803 mg/L. On May 30, 1979, Deep Springs Lake had a specific conductance over 100,000 umho/cm, a pH of 9.8, and a total phosphate concentration of 95.300 mg/L. In 1979, the sample was taken from "a viscous, mid-lake brine, overlying a deposit of salt sufficiently thick to be walked upon without breaking (ca. 4-5 mm)". Kubly and Cole collected brine shrimp (*Artemia salina*) and three types of flies from Deep Springs Lake. The specific conductance values cited above greatly exceed the secondary drinking water MCL of 900 umho/cm, and the agricultural water quality goal of 700 umho/com (Table 3). The pH values exceed the Lahontan Basin Plan objective (and the USEPA saltwater aquatic life criterion) which is 6.5-8.5 units.

Table 22 below provides additional information to indicate that the salt concentration in the lake varies over time. The units in this table (milliequivalents per liter) are dependent on the chemical valence of each constituent. For sulfate, the concentrations in milligrams per liter are twice as high as the concentration in the table, and they exceed the secondary MCL drinking water standard in Table 3. The sulfate concentrations in Table 22 were among the highest reported by Kubly and Cole for the southern California playa lakes they sampled. There are no site specific water quality objectives for the waters of the Deep Springs Hydrologic Unit.

Deep Springs Lake was prospected around 1920 for potassium and sodium salts but was not developed (California Department of Water Resources, 1964). Analyses cited by DWR showed that waters of the lake contained 84,200 mg/L of TDS. Water from three shallow holes sunk on the northeast shore of the lake contained a sodium chloride-sulfate brine that had about 200,000 mg/L of TDS.

The black toad, *Bufo exsul,* is native only to the Deep Springs Valley. It is related to the western toad, *B. boreas*, and has been isolated from it for at least 12,000 years. Reported habitat locations include the warm springs at Deep Springs Lake (Hall, 1991). The black toad is a federal "species of concern" and a California threatened species (California Department of Fish and Game Natural Diversity Database, 1999). The Natural Diversity Database also includes the Deep Springs snail, *Fontelicella* sp., apparently an endemic species which currently has no formal status on state and federal endangered species lists.

All of Deep Springs Valley, including the ground water basin, is owned by Deep Springs College, a small private junior college established in 1917 (DWR, 1964). The school also has grazing rights in the White/Inyo Mountains. Deep Springs College is a small (25 students) community college which runs a cattle ranch and alfalfa growing operation. An entry on the "Deep Springs Resource Management Team Project" in the California Ecological Restoration Projects Inventory (University of California, Davis 1997) indicates that the collage is cooperating with state and federal agencies and the California Native Plant Society on a project to "maintain a sustainable livestock operation and to preserve the ecology of the watershed with enhanced biodiversity and plant and wildlife habitat". Goals are to be achieved "by using principles of holistic resource management, guided by monitoring studies. The program includes monitoring of old and new grazing exclosures, annual fixed point photos, and monitoring of stream channel cross sections at five year intervals. It also includes willow planting and grazing management. Target taxonomic groups include the willow flycatcher and sage grouse as well as the black toad.

In conclusion, Deep Springs Lake has naturally high TDS levels, specific conductance, and sulfate levels which exceed the thresholds in the Sources of Drinking Water Policy, and drinking water criteria. Surface water on the lakebed is ephemeral and has no historic (since 1975) municipal supply use. Given the small population and limited land use in the watershed, and the availability of better ground water and stream water supplies, it is unlikely that there will be a demand to treat the lake water and use it for municipal supply in the future. Removal of the potential MUN beneficial use from the lake is justified and should not have any significant impacts on future domestic supplies. The potential MUN use designation will continue to apply to other surface waters (including wetlands near the lake) and to ground waters within the Deep Springs watershed. The lake supports and should continue to support saline aquatic habitat and wildlife uses appropriate to a natural playa lake in the Lahontan Region.

Table 22. Major ion concentrations for Deep Springs Lake. Concentrations are milliequivalents per liter. Alkalinity is expressed as bicarbonate-carbonate. Source: Kubly and Cole (1979).

Date Sampled	Ca	Mg	Na	K	Alkalinity	SO4	Cl	Sum
1/24/78	0.032	0.288	865.650	66.508	79.880	676.650	222.893	1,011.901
5/4/78	1.432	1.600	1,444.200	109.994	166.900	916.080	614.055	3,254.261
5/20/79	ND	BD	6,090.000	729.030	1,414.000	1,603.140	3,821.100	13,657.270

AMARGOSA RIVER, INYO AND SAN BERNARDINO COUNTIES

The Amargosa River (Figure 2) has its headwaters in Oasis Valley north of Beatty, NV, drains south through Amargosa Valley, then turns to the northwest into Death Valley, California, where it terminates in the Badwater or Death Valley Lake playa, a remnant of prehistoric Lake Manly. Surface flow in the river generally occurs only intense storms, and in a few short reaches where springs discharge into the river channel or where ground water surfaces (U.S. Bureau of Reclamation, 1975). The river drains about 13,700 square kilometers of desert land. Surface flows occur in three short stretches- the headwaters, the Shoshone -Tecopa area and the Amargosa Canyon, and in the southern end of Death Valley west of Saratoga Springs (Soltz and Naiman, 1978). Table 23 summarizes flows for the river at Tecopa. Table 26 reports flows and water depths measured during a study of pupfish habitat in Death Valley (Sada *et al.*, 1997).

Table 23. Discharge data for the Amargosa River at Tecopa, California (USGS, 1970)

Water Year	Discharge (Acre-Feet)
1962	752
1963	1840
1964	571
1965	748

The California Department of Water Resources (1964) concluded that the mineral content increases in waters obtained along the Amargosa River from north to south.. Evaporation of shallow ground water leads to accumulation of salts in ground water and near-surface sediments; these salts may be transported further down the river channel by flood waters. Minerals also come from areas containing salt and gypsum bedrock. Lake beds in the vicinity of Tecopa contain layers of salt which runoff water or percolating groundwater may dissolve.

Table 24 compares the water quality of the Amargosa River near the community of Shoshone with that of a tributary spring which supplies domestic water for about 150 people in that community. In 1997, the Regional Board approved permits (waste discharge requirements and an NPDES permit) for a reverse osmosis treatment plant for the spring water, which allowed the waste brine from the treatment system to be discharged into a ditch tributary to the river. The permits state that the background concentrations of TDS in the Amargosa River have historically exceeded the state of California secondary Maximum Contaminant Level of 500 mg/L for consumer acceptance, and the state upper and short term maximum contaminant levels of 1,000 mg/L and 1500 mg/L, respectively for consumer acceptance. Under natural, ambient conditions, the river near Shoshone also exceeds the USEPA MCL of 0.050 mg/L for arsenic in drinking water. The background concentration of arsenic in the river based on three sampling events ranged from 0.08 to 0.286 mg/L with an average of 0.15 mg/L. This exceeds the aquatic freshwater life chronic toxicity criterion (California Water Quality Goal) of 0.19 mg/L.

The permit states:

> *"The flow in the Amargosa River prior to the confluence with the spring drainage is approximately 240,000 gpd with an average arsenic concentration of 0.15 mg/l and TDS concentration of 2,000 mg/l. The source of water in the Amargosa River is from other springs and runoff. Limited information indicates that water quantity and water quality fluctuations in the Amargosa River and Shoshone Spring are related such that flows and constituent concentrations vary synchronously."*

Surface flow of the river normally ceases within about one quarter mile of its confluence with the Shoshone spring flow. When permitting the treatment facility, the Board made findings under the nondegradation policy (State Water Resources Control Board 68-16) to allow a "minor" increase in arsenic concentration in the ditch tributary to the Amargosa River (from an average concentration of 0.07 to 0.075 mg/L and from a maximum concentration of 0.11 to 0.12 mg/L), It was noted that the increase in arsenic concentration would not change the natural overall arsenic load to the ditch and the river.

The terminus of the Amargosa River, Death Valley Lake, is an elongate, moist, salt encrusted playa lake, about 40 miles long with an area of about 176 square miles. It is the largest playa in the Lahontan Region and forms an extensive salt flat (California Department of Water Resources, 1964). The DWR noted that:

> *"The infrequent surface runoff from the southern end of Death Valley is conveyed northward to Badwater by the Amargosa River. Even through the surface flow in this portion of the river is sporadic, there appears to be almost continuous subsurface flow in the sediments underlying its course."*

Table 24. Water quality data for Shoshone Spring and Amargosa River at Shoshone
(CRWQCB, Lahontan Region, 1997)

Constituent	**Spring Source**	**Amargosa River**
Arsenic	59.8 ug/L	286 ug/L
Chloride	210 mg/L	257 mg/L
Copper	0 mg/L	0.5 mg/L
Fluoride	1.88 mg/L	2.7 mg/L
Iron	0.28 mg/L	<0.2 mg/L
Magnesium	23.3 mg/L	24.0 mg/L
Manganese	0 mg/L	<0.05 mg/L
Nitrogen	<0.5 mg/L	1.1 mg/L
Sodium	272 mg/L	463 mg/L
Sulfate	228 mg/L	577 mg/L
Zinc	0.01 g/L	<1.0 mg/L
Total Dissolved Solids	950 mg/L	1856 mg/L

The DWR classified the surface flow of the Amargosa River in Death Valley as "inferior" for drinking water due to high percent sodium and high levels of TDS, specific conductance, fluoride, boron, sulfate, and chloride, and classified the surface flow on "Bad Water lake" as inferior for the same reasons.

Water supplies for wildlife in Death Valley come from springs and seeps in the mountains above the river. Domestic water supplies are all from groundwater, which either originates locally from precipitation or moves into the valley as underflow from basins on the north and east (USGS, 1977). Groundwater is considered "generally of usable quality, except the water obtained along the Amargosa River and the east side of the valley salt pan" (U.S. National Park Service, 1981).

The U.S. Geological Survey (1977) stated that:

> *"Floods on the Amargosa River periodically have filled many square miles of the saltpan to depths of a foot or more during the past few decades. The quality of surface water during local storm runoff into the valley is highly variable, depending in large part on the solubility of surface material over which flow occurs. Most of the stormflow in the Amargosa River originates outside Death Valley and contains 5,000 to 30,000 mg/L dissolved solids."*

Table 26 summarizes later data on salinity, conductivity, and temperature from samples of four reaches of the Amargosa River in Death Valley (Sada *et al.*, 1997).

Ecologically, the Amargosa River watershed is a very important place. The river and the associated wetlands support a unique assemblage of rare and sensitive plant and animal species including more than 100 species of birds, 40 species of reptiles and amphibians and 20 species of mammals (Soltz and Naiman, 1978). Ash Meadows, in Nevada, is a National Wildlife Refuge, and was designated in 1986 as a wetland of international significance, "an area exhibiting the greatest biological endemism in the USA." ("Endemic" species are those native to, and restricted to, a specific geographical area.) Ash Meadows has four endemic fish, six threatened or endangered plants, an endangered aquatic invertebrate and other endemic molluscs, and one endemic mammal). The species of Ash Meadows have been endangered by groundwater withdrawals, agricultural conversions, alteration of springs for irrigation, exotic animals (horses and burros), peat and clay mining, and offroad vehicle use (RAMSAR, 1993).

Downstream areas also support a variety of endemic animal species. The Amargosa Canyon in California and part of the Tecopa Lake Basin are U.S. Bureau of Land Management "Areas of Critical Environmental Concern" (USFWS, 1988). The Amargosa pupfish *Cyprinodon nevadensis,* has six subspecies living in isolated springs, marshes and stream courses along the Amargosa River drainage. The Amargosa River pupfish, *C. nevadensis amargosae* has two populations in permanent flows of the river, one occurring from Tecopa through the Amargosa Canyon, and the other in the short permanent flow, about 1.6 km long in Death Valley northwest of Saratoga Springs. The two flows may connect during occasional periods of heavy precipitation. Soltz and Naiman, 1978 The Amargosa pupfish is adapted to severe environmental stress including temperatures from near-freezing in winter to over 40 degrees C in summer; summer drying, which exposes fish exposure to predation by birds, and flash floods which scour the habitat. The pupfish can react to these stresses through rapid population increase, from a few tens of thousands to millions by early summer (Soltz and Naiman, 1978).

The Shoshone pupfish, *C. nevadensis shoshone,* was considered probably extinct until it was rediscovered in 1986 in spring outflow to the Amargosa River and throughout the "permanent" water segment of the river near Shoshone (Taylor *et al.,* 1988). More recent genetic studies have cast doubt on whether the "rediscovered" fish is really the "extinct" species (Miller *et al.,* 1999).

In addition to the pupfish, the Amargosa River in California supports other sensitive species. The Amargosa Canyon Speckled Dace (*Rhinichthys osculus ssp.*) a state species of special concern and federal candidate 2 species (Soltz and Naiman, 1978). The Amargosa vole (*Microtus californicus scirpensis*) is a state and federally listed endangered species which depends on disjunct pockets of wetland vegetation between Shoshone and the Amargosa Canyon. Reasons for listing included loss of the vole's historic habitat, rechannelization of water sources needed to perpetuate habitat, and groundwater pumping. Other historic and current threats to the vole and its habitat include conversion of wetlands for farming, intermittent flooding, and the introduction of exotic plant and animal species. Proposed actions for the recovery of the species include securing and protecting extant wetland habitats and water sources and managing them to maintain viable vole populations and to control exotic and competitive species and incompatible uses (U.S. Fish and Wildlife Service, 1988).

Human users in the Amargosa River watershed include a small permanent population, and a relatively large tourist population. The U.S. National Park Service (1998) reported visitation in Death Valley National Park in 1997 as 1,222,762. Water for agriculture (historically alfalfa, dates and orchard crops, cotton, pasture, and cattle ranching) comes from ground water and springs rather than the river The estimated annual water use for domestic supply and agriculture was 1000 acre-feet (California DWR, 1964; U.S. Bureau of Reclamation, 1975).

Wong *et al.* (1999) reported that native fish populations in Death Valley National Park and the Amargosa River are stable, but that a proposed 30,000 person resort community in the Nevada portion of the watershed could affect flows in Death Valley, Devils Hole, and the Amargosa River. Death Valley National Park has initiated studies to quantify water movement into Death Valley from the upgradient aquifer, including installation of monitoring wells in the Amargosa River.

In conclusion, Regional Board staff are unaware of any direct municipal supply use of the Amargosa River in California since 1975. It is unlikely to be in demand for municipal use in the future, since its flows are so variable, and since it has high concentrations of arsenic and born in addition to high total dissolved solids. The lower perennial reaches of the river are protected by the U.S. National Park Service and the U.S Bureau of Land Management for their unique ecological values. These values would probably preclude future significant surface water diversions from the river, even if treatment were otherwise feasible.

Table 25. Water Quality Data for Amargosa River at Highway 127 (discharge 0.6 cfs), Sample Date 3-21-67 (Source: USGS, 1977)

CONSTITUENT	CONCENTRATION OR VALUE
Temperature	14.5 °C.
Silica (SiO2)	22 mg/L
Iron (Fe)	120 ug/L
Calcium (Ca)	22 mg/L
Magnesium (Mg)	56 mg/L
Sodium (Na)	1,070 mg/L
Potassium (K)	49 mg/L
Bicarbonate (HCO3)	910 mg/L
Carbonate (CO3)	96 mg/L
Sulfate (SO4)	1,010 mg/L
Chloride (Cl)	500 mg/L
Fluoride (F)	5.3 mg/L
Nitrate (NO3)	1.3 mg/L
Dissolved Solids	3, 290 mg/L
Hardness as calcium carbonate (Ca, Mg)	285 mg/L
Percent sodium	87
Boron	11,000 ug/L
Specific conductance	4, 870 umho/cm
pH	8.6

Table 26. Water Quality data for Lower Amargosa River (Sada *et al.*, 1997. Data are means except for temperature, which is either a range or single value.)

Station and Season	Water Depth (cm)	Water Column Velocity (cm/sec)	Water Temperature (degrees C)	Salinity (parts per thousand) (1ppt =1,000 mg/L)	Conductivity (umhos)
Reach 1					
Spring 1994	3.6	1.3	17.0-24.5	13.3	20,000
Autumn 1994	6.0	0.0	11.0-12.0	11.0	13,667
Winter 1995	11.3	14.3	17.5-20.0	3.3	5,083
Spring 1995	5.5	1.6	27.0-31.0	14.1	24,000
Summer 1995	4.9	0.2	39.0	11.0	23,000
Autumn 1995	6.1	0.2	19.0-22.0	10.0	15,000
Reach 2					
Spring 1994	5.6	0.1	27.0-32.0	6.0	11,833
Autumn 1994	12.4	0.0	11.0-14.0	12.7	15,833
Winter 1995	7.8	0.0	12.0-17.0	9.0	11,740
Spring 1995	5.7	0.0	33.0-34.0	9.0	17,000
Summer 1995	3.9	0.0	45.0	8.0	18,000
Autumn 1995	5.8	0.0	22.0-25.0	9.0	10,900
Reach 3					
Spring 1994	6.3	0.4	25.0-27.0	17.3	28,571
Autumn 1994	9.3	0.0	16.-17.5	11.5	16,375
Winter 1995	17.1	11.4	15.0-19.0	4.0	5,800
Spring 1995	10.9	0.3	18.5-23.5	15.7	22,333
Summer 1995	9.7	0.0	26.0-32.0	9.0	14,933
Autumn 1995	13.4	0.0	20.0-21.0	7.0	11,500
Reach 4					
Spring 1994	44.3	0.0	19.0-26.0	6.6	11,125
Autumn 1994	48.3	0.0	17.0-17.5	7.8	11,000
Winter 1995	51.4	0.0	17.0-18.0	7.0	7,600
Spring 1995	35.5	0.0	17.0-18.0	7.0	10,000
Summer 1995	30.4	0.0	29.0	7.0	9,500
Autumn 1995	34.7	0.0	21.0-22.0	13.0	20,000

CONCLUSIONS AND RECOMMENDATIONS

The general and site-specific literature summarized above indicates that the sources and loads of salts and toxic trace elements in the nine water bodies affected by the proposed Basin Plan amendments are entirely natural. Sources are volcanic and geothermal, and the concentration of minerals over geologic time through evaporation in internally drained basins. Amendment of the Lahontan Basin Plan to remove the potential Municipal and Domestic Supply (MUN) beneficial use from all nine waters is justified because: 1) each water body has TDS levels or levels of toxic trace elements which meet Sources of Drinking Water Policy criteria for exclusion from the MUN use; 2) each water body exceeds at least one drinking water standard or criterion; 3) potential water supplies from each are small and in some cases, ephemeral; and 4) these waters are unlikely to be in demand as municipal sources even if treatment proves feasible.

Some of the waters in question exceed water quality criteria for other beneficial uses such as aquatic life and agriculture. Because of the special adaptations of organisms native to inland saline and geothermal waters, these waters are presumed to have "biological integrity" based on their unique natural physical and chemical characteristics, and to support aquatic life uses. Some of the designated uses for these waters result from the "tributary rule" or from categorical designations such as "minor surface waters", and are not really appropriate uses for saline or geothermal waters. When adequate resources and site- specific information about these water bodies become available, the Regional Board should consider changing these use designations as appropriate to reflect actual conditions.

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NORTH LAHONTAN BASIN

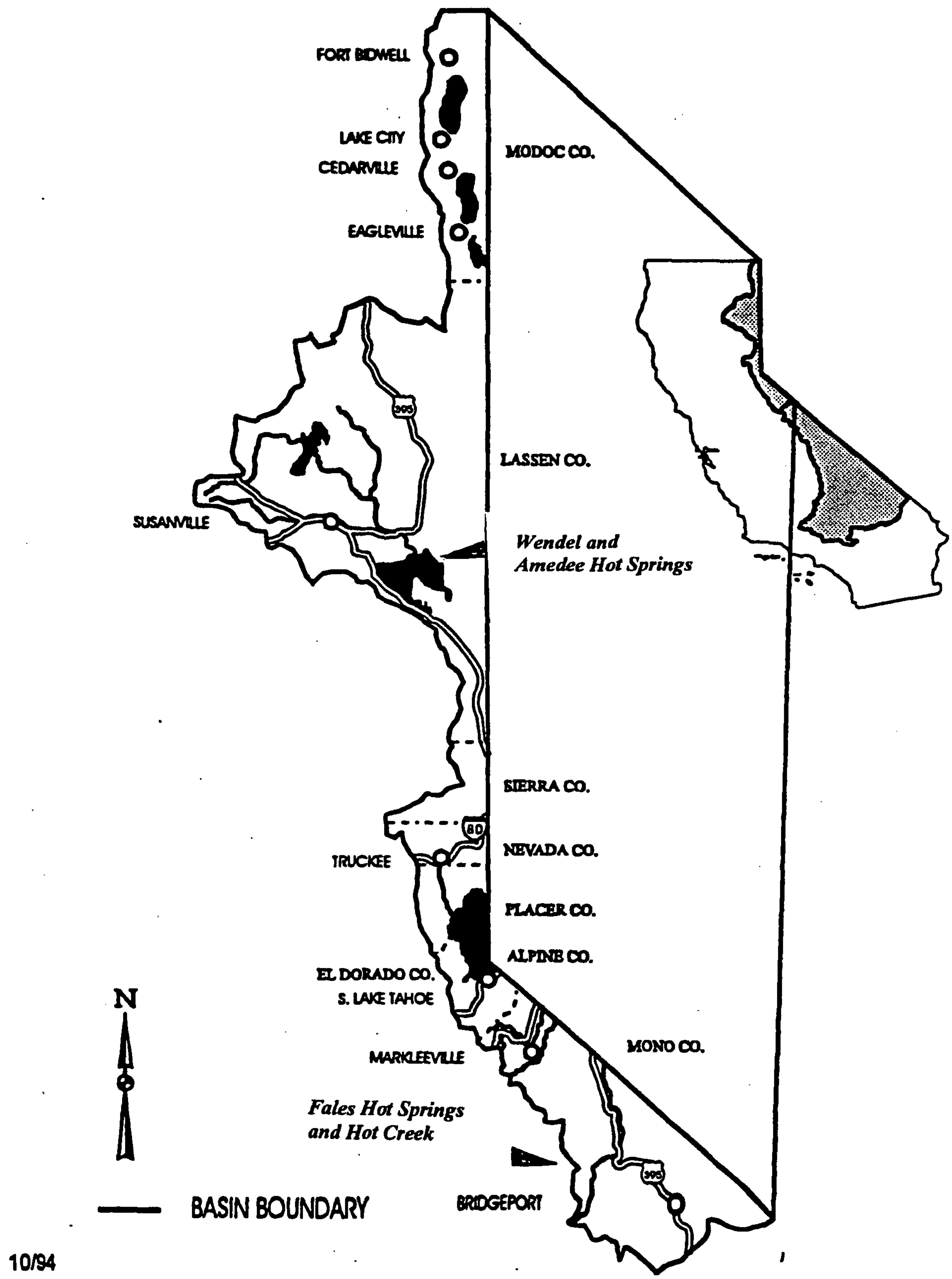
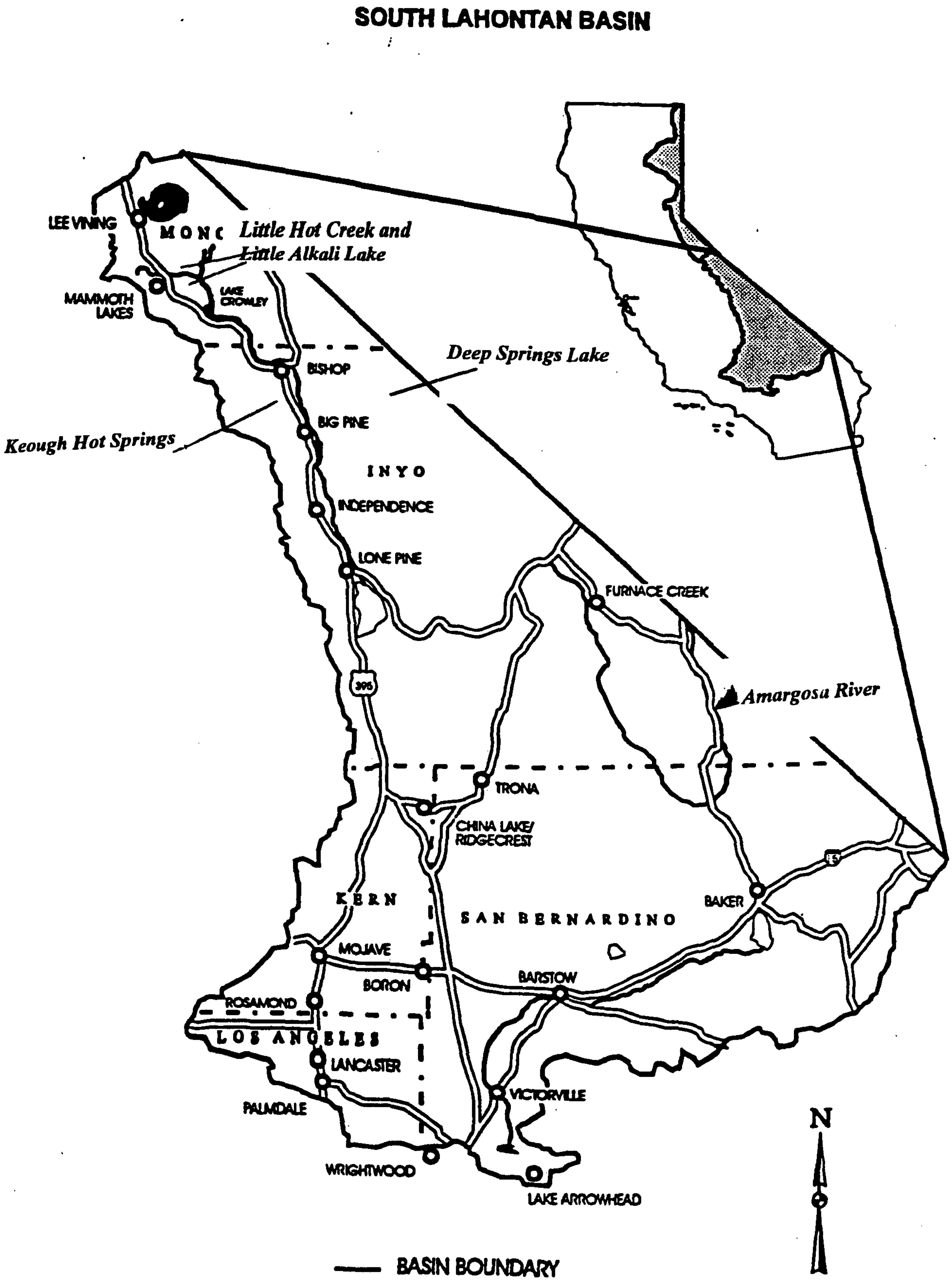


Figure 1. Map of North Lahontan Basin (Source: Lahontan Basin Plan)

Figure 2. Map of South Lahontan Basin (Source: Lahontan Basin Plan)



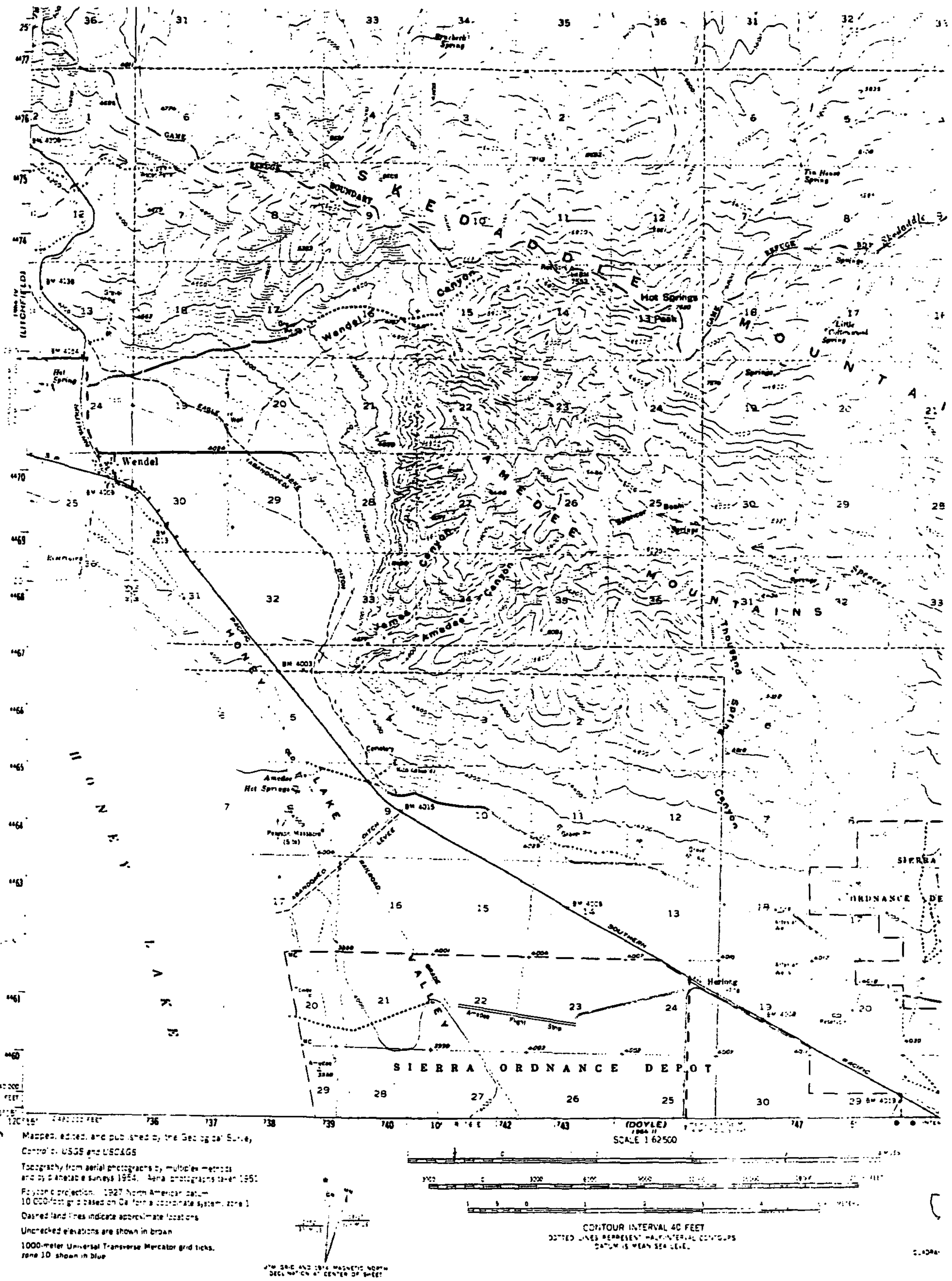


Figure 3. Locations of Wendel and Amedee Hot Springs, Lassen County. (Source: USGS Wendel Quadrangle, 15 Minutes)

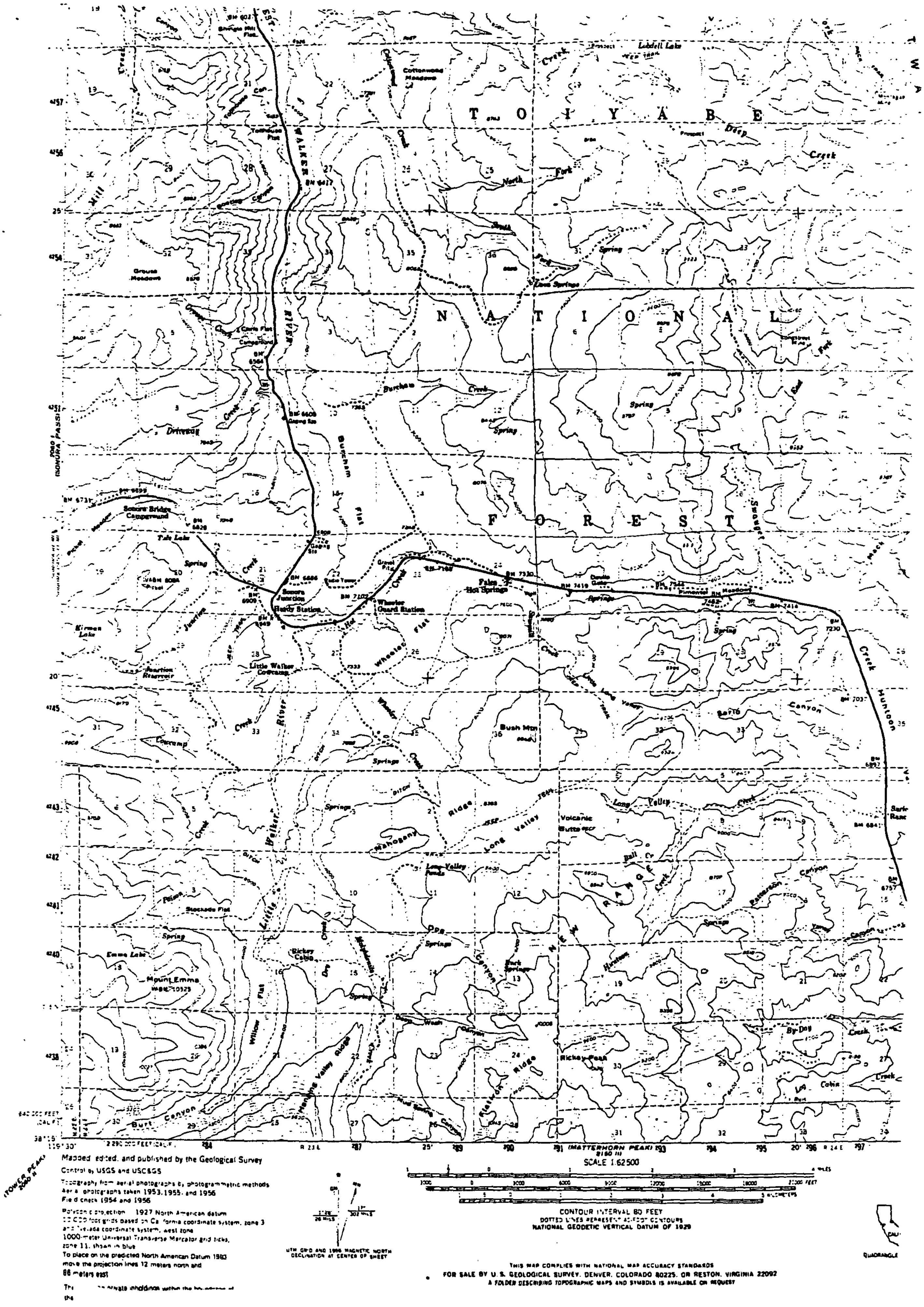


Figure 4. Locations of Fales Hot Springs and Hot Creek, Mono County. (Source:

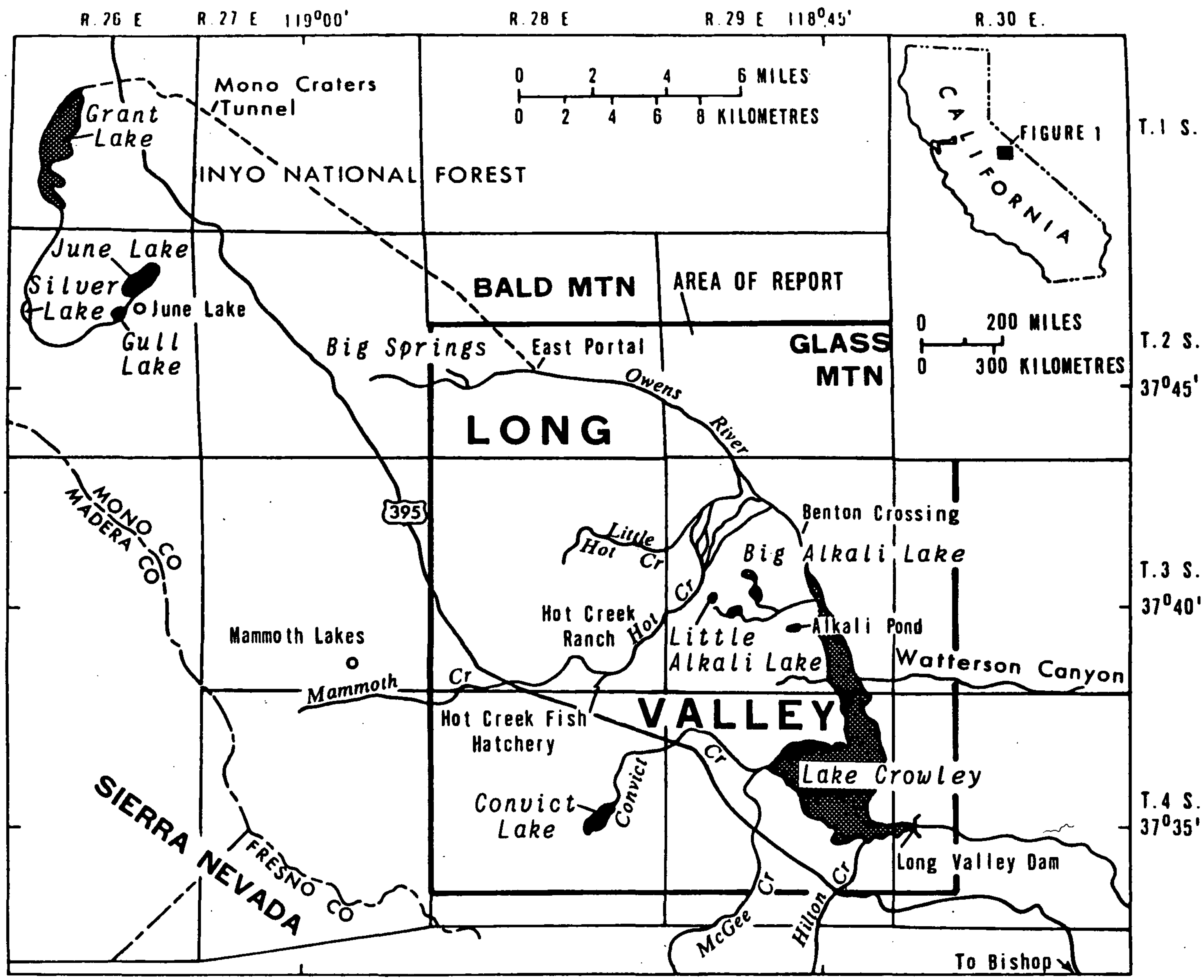
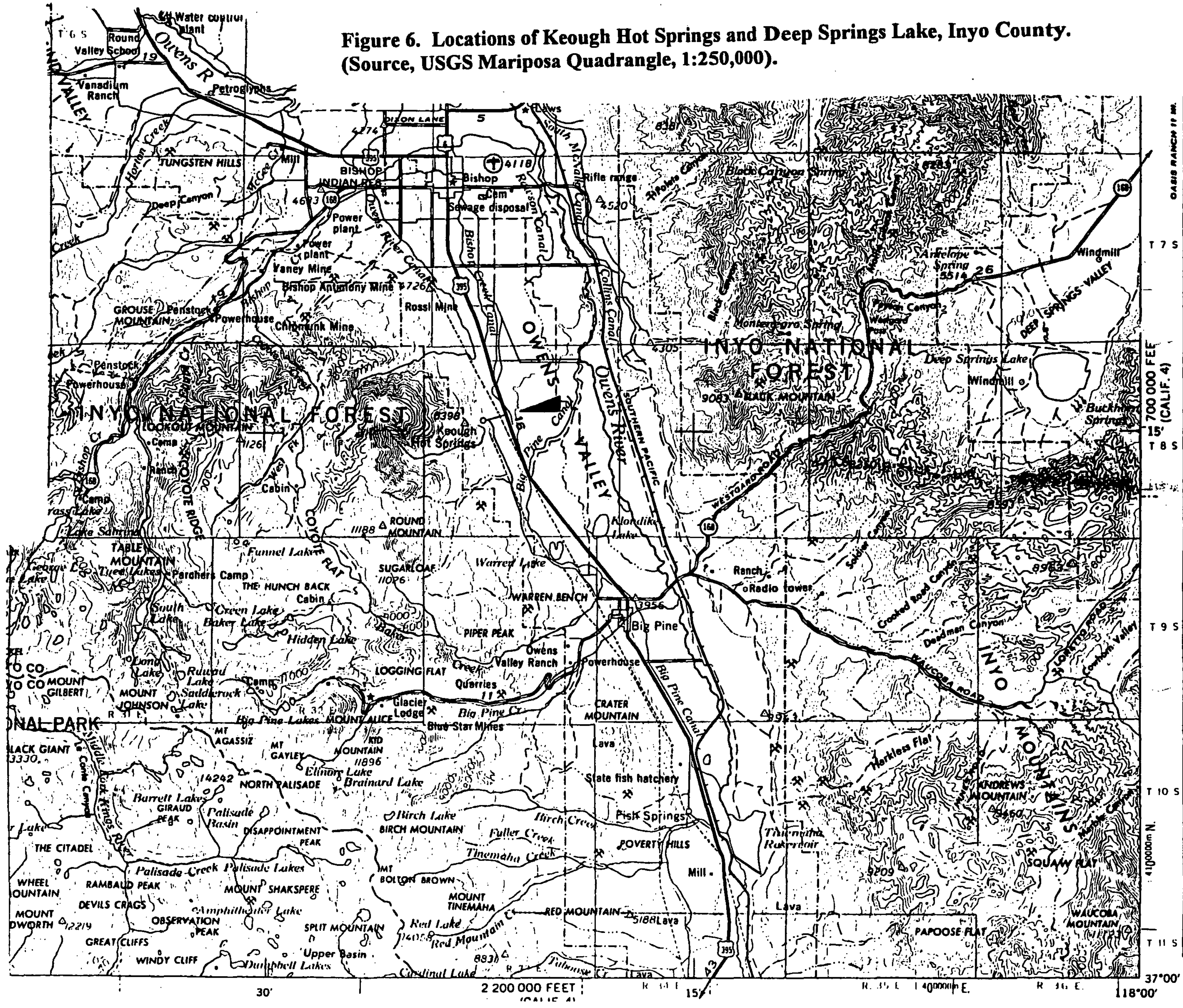


Figure 5. **Locations of Little Hot Creek and Little Alkali Lake, Mono County. (Source: USGS, 1976)**

Figure 6. Locations of Keough Hot Springs and Deep Springs Lake, Inyo County. (Source, USGS Mariposa Quadrangle, 1:250,000).



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Shellfish Safety

BACTERIAL INDICATORS on SHELLFISH WATER QUALITY

- Amar S. Menon

INTRODUCTION

The objective of microbiological monitoring of the water quality in shellfish growing areas is to provide evidence of protection against the transmission of water-borne infectious diseases. The presence of any microbial pathogens in coastal waters presents potential health risks. However, seeking these pathogens in water is impractical for routine monitoring purposes, and thus an indirect approach of using indicator organisms to measure fecal contamination is developed. The term "Indicator Organisms" are employed only to serve as an indication of fecal pollution from warm-blooded animal wastes and the possible presence of pathogenic micro-organisms. They themselves are not pathogenic and, therefore, cannot be taken as an absolute criterion for the presence or absence of pathogenic organisms in waters. This indirect method of testing waters for the presence of pathogens is necessary because of the technology limitation and cost in the detection of pathogens. Besides, the use of pathogens as the sole indicator of fecal pollution is undesirable because of the variation in number and types of pathogens in sewage and the frequency occurrence of pathogens in water is highly variable. The failure to detect the presence of pathogens in a given water body does not necessarily ensure the safety of the water from all other bacterial and viral pathogens.

INDICATOR ORGANISMS

Since most disease outbreaks associated with consumption of shellfish originated with fecal contamination, a logical approach is to seek a microbial indicator group commonly found in the feces of all warm-blooded animals. Ideally an indicator organism should satisfy the following criteria:

1. It should always be present in waters whenever pathogens are present.
2. It should occur in much greater numbers than the pathogens.
3. It should be absent, or at least very few numbers in clean waters.
4. It should not be able to proliferate to any greater extent than pathogens in aquatic environment.

5. It should respond to natural environmental stress and wastewater treatment processes and disinfectants in a manner similar to the pathogens of interests.
6. Indicator density should bear some relation to the degree or extent of pollution.
7. It should be easy to isolate, identify, and enumerate by routine laboratory procedures.

Unfortunately, no organism meets all these criteria. It is doubtful if an ideal indicator exists or will ever be found for bacterial, protozoa, and viral pathogens. So we must, therefore, deal in terms of the best indicator available. The best indicator would obviously be the one whose density correlates best with the health hazards associated with fecal contamination.

A variety of groups of bacteria and viruses have been used or recommended to measure the sanitary quality of recreational and shellfish growing waters. These range from a broad spectrum group, such as the total plate counts, to a narrow spectrum group such as Escherichia coli and specific pathogens. Of these various groups the most commonly used are the total coliform, fecal coliform, and fecal streptococcus groups.

TOTAL COLIFORMS

The most widely accepted bacterial indicator of fecal pollution in water has been the coliform group of bacteria. The coliform bacteria has been chosen as indicator of water quality for many years primarily based on the work of Escherich in 1885, in which he identified Bacillus coli, from which the name "coli-form" is derived, as being characteristic of feces of warm-blooded animals. The presence of these organisms in water was assumed to indicate a potential health hazard because of their association in the gut with a variety of pathogenic microorganisms.

However, in recent years, it was shown that coliform bacteria was in fact a heterogeneous group of bacterial species composed of Escherichia, Klebsiella, Citrobacter, Enterobacter, and Aeromonas genera. While Escherichia coli is exclusively fecal in origin, the other four genera are widely distributed in nature and commonly found in soils, on vegetation, and in industrial wastes. The non-fecal coliform biotypes are frequently associated with surface runoff and have a tendency to multiply in nutrient-rich waters. Therefore, the presence of total coliforms in surface waters does not always imply fecal contamination and the sanitary significance of these bacteria becomes doubtful if no obvious pollution source is found. For this reason, more consideration as to the origin of the coliform organisms is in order.

FECAL COLIFORMS

The inadequacy of the total coliform test in differentiating coliform bacteria of fecal origin from non-fecal source has lead to the development of the fecal coliform test. Fecal coliform is a subgroup of the total coliform group which is capable of producing gas within 24 hours at 44.5°C in EC or A-1 medium.

This group is considered to be more specific indicator for fecal contamination and was adopted by the NSSP in 1974 for the monitoring of shellfish growing waters. The advantages in using fecal coliforms as indicator are as follows:

1. The majority of coliform bacteria from the intestines of warm-blooded animals grow at elevated temperatures.
2. These organisms are of relatively infrequent occurrence except in association with fecal pollution.
3. These organisms are more resistant to the aquatic environment than are many enteric bacterial pathogens.
4. These organisms are shed in greater numbers than are most pathogens.
5. These organisms can be grown on simple media and quantified using routine laboratory procedures.

However, there are also some limitations associated with the use of fecal coliforms as an indicator group. The specifically of fecal coliforms suffers some of the same shortcomings of the total coliform group, in that it contains organisms whose source is not exclusively fecal. In fact, fecal coliforms is also a heterogeneous group that comprises of Escherichia coli, as well as thermotolerant Klebsiella biotypes. Klebsiella is not frequently present in human feces. They occurs in pulp and paper mill effluents, (1) textile processing plant wastes, (2) and other industrial sources in the absence of fecal contamination.(3) The ability of Klebsiella to multiply in polluted waters diminishes its usefulness as an indicator. Recent epidemiological study (4) indicate there is little correlation between fecal coliform density and swimming associated gastrointestinal illness in aquatic environment. Escherichia Coli and enterococci may be a better indicator for assessing health hazard risk in surface waters.

FECAL STREPTOCOCCUS

The third group of bacteria, the fecal streptococcus, has been suggested as a useful indicator of fecal contamination because they are present in large numbers in feces. They do not multiply in surface waters and are more resistance to adverse environmental conditions. Unfortunately, the fecal streptococcus, like the coliform group, also includes several biotypes which are widely distributed in nature and are of limited sanitary significance. The most valuable application of the fecal streptococcus indicator system in water quality is the development of fecal coliform to fecal streptococcus ratios that may be used to asses the source of fecal pollution.(5) If the ratio of the number of fecal coliform to fecal streptococcus is greater than 4, this generally indicates a human origin, and a ration of less than 0.7 indicates animal source. These ratios must be applied carefully as environmental factors will influence the fecal coliform and fecal rate of each in the receiving waters. For these reason, the ratios for water samples are valid only during the initial 24 hours from the source of pollution. For after 24 hours, problems with die-off tend to obscure meaningful results.

Microbiological Methods

Bacterial indicator densities in water are commonly determined either by a multiple-tube-fermentation (MPN) procedure or by a membrane filter (MF) technique. Detail description of these two methods are found in the current edition of Standard Methods for the Examination of Water and Wastewaters.(6)

Each method has its own advantages and disadvantages, but for the most part, they are considered to give comparable results, especially for fresh waters. From a statistical aspect, the MF method gives direct counts, better reproducibility of results, produces results in 24-48 hours and allows the examination of large volumes of samples than the MPN method. However, the presence of high suspended solids, heavy ions, algae, high densities of non-coliform organisms or other interfering substance in seawater may limit the application of the MF test in shellfish growing water. Presently, NSSP criteria specify the use of MPN procedure for the bacteriological examination of shellfish growing waters.

There is no world-wide agreement as to what criteria should be used to measure the safety of shellfish. It has been suggested that the shellfish standard should be based on the direct examination of the shellfish and not on the growing waters which is being practised by some countries like France and the United Kingdom. They argue that safety standards based upon shellfish product testing would be more equitable to industry since imports and domestic products would then be subject to the same standards. They also argue there is no direct correlation between water and shellfish quality and shellfish are the product that is consumed.

The basic concept of the NSSP is to control the safety of shellfish by preventing contamination of its environment, not to determine whether or not shellfish become contaminated after the fact. It is built on the premise that safe and high quality water will result in safe shellfish. It is believed that shellfish product standards are less effective than water quality standard in the classification of shellfish harvesting areas because of the following factors:

1. Various shellfish species concentrate bacteria at different rates and levels, and the same product standard probably could not be used for all species. 2. The same species of shellfish will concentrate bacteria at different rates and levels under different pumping and feeding regimes caused by diverse environmental conditions such as water temperature, suspended matter, and salinity. 3. Shellfish species will eliminate bacteria at different rates than viruses when their pumping is reduced due to low water temperatures. 4. Repeated sampling of shellfish shows wider variation in results and less homogeneity than does water sampling in the same area. 5. Shellfish in a

shellfish growing area are harder to collect and may not be available at the estuary locations chosen to assess the impact of pollution sources. 6. Negative results in shellfish analysis may give a false sense of security because some health risks (e.g. viruses) can go undetected using traditional bacterial screening methods.

CONCLUSION

Bacteriological measurement of shellfish growing water quality must be based on the detection of fecal contamination by all warm-blooded animals. The fecal coliform test is the best method now available for detecting fecal contamination in waters. The fecal coliform standard are based upon the public health assumption that the presence of fecal material in estuarine constitute a potential risk to shellfish consumption. It must be emphasized that the detection and enumeration of indicator organisms should be interpreted only as what they are intended to indicate. The presence of indicator organisms would only indicate that pollution has occurred. The qualitative determination of bacterial indicators are never intended to be the sole information to judge the health hazard associated with a particular water. A detail knowledge of the sanitary conditions of the study area is essential to make proper judgement. Bacteriological examination of shellfish growing waters should be used only as an adjunct to the sanitary survey to show the extent of fecal contamination affecting an area. Fecal contamination is often intermittent and may not be revealed by the bacteriological examination of a single water sample. The most a bacteriological report can prove is that, at the time of examination, pollution indicating organisms did or did not grow in a selected medium under laboratory conditions from a sample of water. Therefore, if a sanitary survey shows that the waters in a shellfish growing area are obviously subject to contamination from direct fecal wastes, radionuclides, or toxic substances, the shellfish area should be closed irrespective of the results of bacteriological analyses.

NB: Footnote references cannot be located at time of publishing.

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Internet Address:

http://ndep.state.nv.us/bwqp/
riv303d98.pdf

NEVADA'S 1998 303(d) LIST

Introduction

Section 303(d) of the Clean Water Act requires that States develop a list of water bodies that need additional work beyond existing controls to achieve or maintain water quality standards. The additional work necessary includes the establishment of Total Maximum Daily Loads (TMDLs). The TMDL process provides an analytical framework to identify the relative contributions of each pollutant. The TMDL identifies the sources and causes of pollution or stress, e.g., point sources, non point sources, or a combination of both, and establishes allocations for each source of pollution or stress as needed to attain water quality standards.

The section 303(d) List provides a comprehensive inventory of water bodies impaired by all sources, including point sources, nonpoint sources, or a combination of both. This inventory is the basis for targeting water bodies for watershed-based solutions, and the TMDL process provides an organized framework to develop these solutions.

METHODOLOGY

Basis For Listing

The criteria for listing were developed to identify only those waterbody segments for which there is good documentation that water quality standards are not being met. NDEP has taken the approach in this listing, and in past listings, that quantitative information is needed to serve as the basis for listing. At this time, the most comprehensive readily available water quality related data is physical and chemical water column monitoring data, and widely distributed scientifically defensible special studies. The methodology for listing focuses on data analysis; although where scientifically defensible studies are readily available these were also used. Since the majority of the narrative water quality standards are of a subjective nature and there is not quantitative information readily available to assess compliance with the narrative standards, listing is focused on violations of numeric water quality standards. The public notice and comment period provided the opportunity for other local, state, or federal agencies, members of the public or academic institutions to present additional monitoring data, ongoing research or other publications for consideration in the 303(d) listing process.

NDEP's ambient monitoring network covers each major river basin in the state. Samples are analyzed for chemical quality. Nevada does not conduct any type of biological assessments or bioassays at this time. Ambient monitoring data was assessed for exceedances of numeric beneficial use water quality standards. Beneficial use standards are contained in Nevada Administrative Code (NAC) 445A.119 to 445A.225. Other available information, studies and best professional judgment were also used in the listing decisions.

In general, a waterbody was included on the 303(d) List if the beneficial use standards were exceeded more than 25% of the time. The 1998 303(d) List was based on data from January 1996 to December 1997. A minimum of four samples collected during 1996 & 1997 was required. Federal regulations (40CFR 130.7(b)(5)(i)) require states to include waters identified on the most recent 305(b) report as "partially meeting" or "not meeting" designated uses on the 303(d) List. With limited resources to ensure that the most severe water quality problems are addressed first, Nevada choose to include only those waterbodies that are in the "not meeting" designated uses category on the 303(d) List.

Both 1996 and 1997 were wetter than average years. Devastating floods occurred in western Nevada on the Truckee, Carson and Walker Rivers in January 1997. The Carson and Walker Rivers had record high flows at many locations. Flooding is a natural process and data that shows impairment as a result of a major flood event should not serve as the basis for initiating TMDLs. Nevada Administrative Code (NAC) 445A.120.2 states that "Natural conditions may on occassion be outside the limits established by the standards." NAC 445A.121(8) states, "The specified standards are not considered violated when the natural conditions of the receiving water are outside the established limits including periods of extreme high or low flow ...." Therefore, if greater than 25% violations is the result of sampling conducted during flood conditions only, the site was not listed. The flow data for 1997 is not yet available so the only data eliminated from the analysis was data associated with the January 1997 flooding on the Truckee, Carson and Walker Rivers. When flow data is available, NDEP will re-evaluate the listing decisions.

Delisting

There are sites and parameters that were identified on the 1996 303(d) List that are not included on the 1998 303(d) List. Specific explanations for the delisting are included in the 303(d) Lists at the end of this report. In general, parameters were delisted because the waterbody now meets the water quality standards.

Prioritization & Schedule

Prioritizing water bodies enables the state to make efficient use of available resources to meet the objectives of the Clean Water Act. Priority ranking takes into account the severity of the pollution and the uses to be made of such waters.

Targeting high priority waters for TMDL development reflects an evaluation of the relative value and benefit of water bodies within the state and takes into consideration the following:

- Risk to human and aquatic life
- Degree of public interest and support
- Recreational, economic, aesthetic importance of a particular waterbody
- Vulnerability or fragility of a particular waterbody as an aquatic habitat
- Immediate programmatic needs such as:
  - waste load allocations
  - permits to be issued
  - new or expanding discharges
  - load allocations for needed BMPs.

Table One provides a summary of the dates the water quality standards were last reviewed by the State Environmental Commission and factors which influenced setting priorities. Table Two provides the priority ranking and schedule for TMDL development.

TABLE ONE

River Basin	Date of Standards Review	Important Factors in Prioritization Process
Carson	Sep 15, 1994	1. Confirmed mercury contamination. 2. Fish consumption advisory. 3. Protection of downstream wetlands. 4. Protection of downstream reservoir with high recreational usage. 5. Need to investigate nonpoint source contributions to reaches identified as water quality limited.
Humboldt	Nov 7, 1995	1. Nondesignated Area 208 Plan adopted TMDLs in 1993 for water quality impaired segments - these TMDLs may have oversimplified actual conditions. 2. Large scale mining activity is occurring in the basin. 3. Detailed nonpoint assessment currently being conducted.
Walker	Sep 13, 1985	1. Increased public and political interest. 2. Nondesignated Area 208 Plan adopted TMDLs in 1993 for non supporting segments. 3. Need to investigate nonpoint source contributions to reaches identified as water quality limited.
Snake River Basin	Sep 20, 1990	1. Need to obtain additional monitoring data.

Table One (cont.)

Colorado Basin		
Muddy River Virgin River Las Vegas Wash Las Vegas Bay	Aug 1, 1985 Aug 1,1985 Dec 17, 1987 Dec 17, 1987	1. Standards for Las Vegas Wash/Bay and Lake Mead currently being reviewed. 2. Established TMDLs for Las Vegas Wash. 3. Clark County and Las Vegas WWTF have constructed treatment facilities to meet NPDES permit limits. 4. Rapid population growth in the Las Vegas Valley. 5. NPDES permits for major facilities expired Jan 1997. 6. Unanswered questions about the role of nutrients and their impact on beneficial uses.
Truckee River	Nov 29, 1993	1. Permit WLA violations. 2. Implementation of Water Quality Agreement and assessment of assimilative capacity of flow augmentation. 3. Opportunities for nonpoint/point source trading resulting from implementation of Water Quality Agreement.

Accronyms:

DO	= Dissolved Oxygen
NH_3	= Un-ionized Ammonia
TDS	= Total Dissolved Solids
TMDL	= Total Maximum Daily Load
TP	= Total Phosphorus
TSS	= Total Suspended Solids
Temp	= Temperature
WLA	= Waste Load Allocation
WWTF	= Waste Water Treatment Facility

TABLE TWO

Nevada's Priority Ranking for TMDL Development

River Basin	High Priority 0-2 Years	Medium Priority 2-5 Years	Low Priority 5-13 Years
Carson Basin		review existing TP TMDL	metals*, turbidity*
Colorado Basin			
Virgin River			TP*, metals*
Muddy River			TP*, metals*
Las Vegas Wash/Bay	review existing TP and total ammonia TMDLs		
Humboldt Basin	review existing TP & TSS TMDLs	turbidity*, metals*	
Snake Basin			as needed
Truckee Basin		review existing TP, TN & TDS TMDLs	turbidity*
Walker Basin	revise WQS for pH	review existing TSS TMDL	TP*, iron*

* Before developing a TMDL, additional monitoring will be conducted to confirm impairment due to these pollutants.

TDS = Total Dissolved Solids
TMDL = Total Maximum Daily Load
TN = Total Nitrogen
TP = Total Phosphorus
TSS = Total Suspended Solids
WQS = Water Quality Standard

Current Status of TMDL Development

Humboldt River:

The existing TMDLs for total suspended solids (TSS) and total phosphorus (TP) are included in Nevada's Nondesignated Areas 208 Plan. The methodology used to determine the existing TMDLs oversimplified a complex situation to the point that the existing TMDL appears to lack scientific validity.

NDEP devoted a considerable amount effort during the 1994-1995 planning period evaluating the existing water quality and the existing TMDLs. This effort focused on understanding, analyzing and describing the data in relation to the extreme variations in flow conditions that occur in the Humboldt River on an annual basis. NDEP has not yet been successful in developing a methodology which adequately addresses the dynamics of the Humboldt River, but anticipates that the results of studies in the Humboldt River Basin will assist with that task.

A modification to the 208 Plan was proposed in August, 1995. The modification added language to address the situation where a discharge would improve water quality in a segment that has been identified as requiring load reductions. This modification was public noticed and no formal comments were received.

The water quality standards for the Humboldt River were revised (November 1995). During 1996-1997, the revised TSS standard was not exceeded more than 25% of the time. As a result of revisions to the water quality standards for TP and TSS, the existing TMDLs need to be reevaluated. Developing appropriate TMDLs for the Humboldt River is a priority in this 2-year planning period.

The Humboldt River Basin is the focus of a number of studies. The following described studies could provide TMDL related information. In 1998, NDEP initiated a nonpoint source assessment of the Humboldt River which is anticipated to be completed by the end of 1998. This assessment is the first step in gathering additional information for developing phased TMDLs. In addition to NDEP's nonpoint source work, USEPA has funded the University of Nevada, Reno to conduct a variety of studies on the Humboldt River including sampling invertebrates, periphyton, water chemistry and assessing the physical habitat. The U.S.Fish and Wildlife Service, U.S.Geological Survey and Barrick Goldstrike are combining resources to conduct aquatic biota monitoring.

Carson River:

In early 1996, a draft Upper Carson River Watershed Plan was completed. The draft plan underwent an extended review during which time a number of stakeholder meetings were held to discuss revisions and future implementation. The Upper Carson River Watershed Plan provides baseline information, identifies problems and presents recommendations and opportunities for watershed stakeholders to voluntarily improve the watershed. The Carson Valley Conservation District has taken the role of watershed coordinator.

Las Vegas Bay/Wash:

During 1997, NDEP conducted a detailed review of the monitoring data and water quality standards for the Las Vegas Wash and Lake Mead. One of the conclusions of the standards review is that additional study is needed to understand the role of nutrients and their ultimate impact on water quality and beneficial uses. Las Vegas Wash, Las Vegas Bay and Lake Mead did not exceed any beneficial use standards more than 25% of the time during 1996 and 1997. Over the next two year planning period, NDEP plans to investigate the liminological questions that remain unanswered. On a parallel track with the liminological investigation, NDEP also plans to evaluate existing models and available data to determine if there is a model which could be used to better describe the hydrodynamics of the Wash/Bay system.

Also during 1997, Clark County completed a 208 Water Quality Management Plan Amendment for the Las Vegas Valley which has been approved by NDEP and USEPA. The main purpose of the 1997 Amendment is to include the effects of sustained regional growth and development, to incorporate a more inclusive nonpoint source section and to provide water quality planning to a horizon year of 2020. The 1997 Amendment includes the current TMDLs for total ammonia and total phosphorus.

Truckee River:

NDEP established TMDLs for TN, TP and TDS for the Truckee River in 1994. These TMDLs have been incorporated into the NPDES permit for the Truckee Meadows Water Reclamation Facility (TMWRF). During the period from 1994 until present, TMWRF has not been able to consistently meet the waste load allocation (WLA) for total nitrogen. The compliance problem is the result of snail infestation of the nitrification towers. The snails consume the nitrifying bacteria faster than the bacteria can grow. When the snails consume the bacterial populations down to low levels, the ammonia conversion to nitrates is severely diminished and nitrogen concentrations in the final effluent increases. A 1.8 million dollar nitrification tower modification, solely for the elimination of snails, was completed in December 1996. The modification involved major piping changes, installation of a new recycle pump station and new chemical feed lines. Prior to this modification, there was no method to isolate any of the four existing towers from the final effluent discharge. The modification has allowed TMWRF staff to isolate nitrification towers so that different chemical treatments to eliminate snails could be performed on individual towers without affecting the discharge.

During the time period from December 1996 to the present, plant staff have conducted chemical/biological research to find the most effective snail treatment chemical without killing nitrifying bacteria growth on the tower media. Much progress has been made toward final effluent compliance. However, the facility is still not complying with the 500 lb/day total nitrogen waste load allocation. As a result of continued noncompliance with the permit limit for total nitrogen, NDEP issued a Finding of Alleged Violation and Order to TMWRF on November 14, 1997. The Order requires submittal of a multi-layered contingency plan and schedule that will ensure reliable performance of the nitrification facilities.

During the next 5 year planning period, the need may arise to revise the TMDLs in response to flow augmentation. The Water Quality Agreement which settles and dismisses pending litigation brought by the Pyramid Lake Paiute Tribe was signed October 1996. The Agreement provides for the acquisition of Truckee River water rights and augmentation of the flow of the Truckee River to improve water quality, habitat conditions and have the potential to increase the nutrient assimilative capacity of the Truckee River and reduce nonpoint source pollutant loading. If it can be determined that an increase in the assimilative capacity of the Truckee River has occured, a revision of the TMDLs may be necessary.

STATEWIDE OBSERVATIONS

Total Phosphorus

A relatively large number of waterbodies have been identified as impaired for total phosphorus (TP) throughout the state on both past and present 303(d) Lists. For many reaches, TP is the main or only parameter causing the waterbody to be listed as impaired. The standard of 0.1 mg/l annual average applies across much of the state. This standard is based on recommendations made in the Gold Book. These recommendations are not strongly supported in the Gold Book and are not identified as criteria, but rather as a "desired goal for the prevention of plant nuisances". Given the native soil conditions in the Great Basin and the topography that exists over much of Nevada, the suitability of the TP water quality standard must be questioned. It is clear that additional research is needed on the role of TP in eutrophication. Studies done on the Truckee River and Pyramid Lake have shown that, in fact, nitrogen rather than phosphorus is the limiting nutrient. Before a large amount of resources are devoted to developing TMDLs and control strategies, it is advisable to evaluate the suitability of the existing water quality standards.

Copper

Using a strict interpretation of the methodolgy, (>25% exceedances, minimum of 4 samples) analysis of data in STORET would result in more than half of the monitored waters in the state being listed for exceedance of the copper water quality standard. The standard is based on hardness of the water. The softer (lower hardness) the water, the more strict the standard. The State Health Lab which analyzed samples collected from monitored waters, lacked precision close to the standard in soft waters. The state lab has rounded copper data to the nearest 10 ug/l; consequently, a data value reported as 10 ug/l could actually be anywhere from 5 ug/l to 15 ug/l. This data is not adequate to assess, with any degree of certainty, whether waterbodies are impaired for copper. In the summer of 1997, NDEP began utilizing the USEPA lab for analysis of metals samples. Initial results show much lower detection limits resulting in better precision near the water quality standard for soft waters. Very few samples analyzed by the USEPA lab have been above the detection limit for copper. NDEP will postpone listing decisions for copper, until a more complete data set based on the improved analytic results is available.

303(d) List - 1998
CARSON RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
Bryant Creek near stateline	148	copper[1], iron[1], nickel[1]		
E.Fork at state line to Hwy 395	150	TSS[2], turbidity[2]		
E.Fork at Hwy 395 to Muller Ln	151	TSS[2], turbidity[2]		
E.F. at Muller Ln to Genoa and W.F. at stateline to Genoa Ln.	152	turbidity[2], TP	TP	TP[4]
Genoa Lane to Cradlebaugh	153	turbidity[3], TP	TP	TP[4]
Cradlebaugh to Mexican Gage	154	turbidity[3], TP	TP	TP[4]
Mexican Gage to New Empire	155	turbidity[3], TP	TP	TP[4]
New Empire to Dayton Bridge	156	TP, ***fish consumption advisory***[5, 6]	TP	TP
Dayton Bridge to Weeks	157	TP, mercury[5], ***fish consumption advisory***[5, 6]	TP	TP
Weeks to Lahontan Dam	158	TSS, TP, iron, mercury[5], ***fish consumption advisory***[5, 6]	TP	TP
Stillwater	126	mercury[5], arsenic, boron ***fish consumption advisory***[5, 6]		

[1] The most likely source of contamination is Leviathan Mine in California. USEPA is currently working on technical design options for a long term solution.

[2] TSS and turbidity exceedances are likely the result of record high flows in the Carson River in January 1997 during which damage to the river channel occurred. Before developing TMDLs, additional monitoring will be conducted to determine if there is non-flood related impairment.

[3] The water quality standard for turbidity changes from 10 NTU to 50 NTU at Dayton. The 10 NTU standard from Genoa to New Empire needs to be evaluated, especially since the existing TSS standard for these reaches does not reflect the same strictness. The beneficial use of a cold water fishery, the basis of the 10 NTU standard, currently is not being sustained and a use attainability analysis should procede any TMDL development.

[4] Revision of the TMDL is linked to Upper Carson Watershed Management Plan. Also, see statewide discussion about phosphorus.

[5] Carson River and Lahontan Reservoir are listed on the National Priorities List because of mercury contamination. TMDL components will be derived from the Superfund site analysis and cleanup plans.

[6] The latest result of mercury samples from the fillets of walleye, wipers (cross between walleye and striper) and white bass showed a major increase in mercury levels. The increase in mercury levels resulted in an expansion of the fish consumption advisory issued by the Nevada State Health Division.

CARSON RIVER PROBLEMS ON 1996 LIST THAT ARE NOT ON 1998 LIST:

Parameter	NAC 445A	Reason
lead	152, 155, 157	Water quality standard not exceeded more than 25% of the time during the listing period. Improved sampling procedures probably the reason for decrease in violations of the standard.

CARSON RIVER PROBLEMS NEW ON 1998 LIST:

Parameter	NAC 445A.	Reason
copper, iron, nickel	148	New monitoring data confirms suspected metals problem in Bryant Creek due to Leviathan Mine upstream
TSS, turbidity	150, 151	In January 1997, the Carson River experienced severe flooding. Peak discharge was larger than recorded for previous floods at almost all stations on the Carson River. Due to the devastation and associated repair and recovery period following the flood which occurred over at least a six to nine month period, suspended solids and turbidity water quality standards were exceeded.
TSS, iron	158	Same as listed above for 150 & 151
fish consumption advisory	156, 157, 158, 126	Due to elevated levels of mercury in fish, the existing Lahontan Reservoir fish consumption advisory was expanded in September 1997 to include the Carson River below Dayton and all of the waters in Lahontan Valley.

303 (d) List - 1998

WALKER RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
Topaz Lake	161	TSS[1], TP[1]		
W.F. at stateline to Wellington	162	pH[2], TP[1]		
W.F. near Wellington to Nordyke Road	163	pH[2], TP[1]		
Sweetwater Creek	164	TP		
E.F. at state line	165	pH[2], TP		
E.F. at state line to south of Yerington	166	TSS[1], iron[1]	TSS	TSS[3]
From confluence of the west and east forks to inlet to Weber Reservoir	167	TSS[1], iron[1]	TSS	TSS[3]
Weber Reservoir to inlet to Walker Lake	168	pH[2]		

[1] TSS, TP and iron exceedances are most likely the result of record high flows in the Walker River in January 1997 during which damage to the river channel occurred. Before developing TMDLs, additional monitoring will be conducted to determine if there is non-flood related impairment.

[2] The water quality standards are in the process of being revised (from 7.0-8.3 to 6.5-9.0) to reflect USEPA's current criteria. The data indicates that the new standard will not be violated more than 25% of the time.

[3] The existing TMDL will be evaluated as part of the water quality standards review.

WALKER RIVER PROBLEMS ON 1996 LIST THAT ARE NOT ON 1998 LIST:

Parameter	NAC 445A.	Reason
lead	162	Water quality standard not exceeded more than 25% of the time during the listing period. Improved sampling procedures are probably the reason for decrease in violations of the standard.
pH	164, 166, 167	Previous standards violations were at the high end of the acceptable pH range. Increased flow may be the cause for lower pH values during '96-'97 and attainment of the water quality standard.
TP	166, 168	A re-examination of the '94-'95 data revealed that these reaches were listed in error for TP.
copper	166	This reach does not meet the minimum criteria for listing (see statewide copper discussion).

WALKER RIVER PROBLEMS NEW ON 1998 LIST:

Parameter	NAC 445A.	Reason
TSS, TP	161	Standards violations occurred in March and May of both '96 and '97. These violations are most likely a result of an above normal snowpack and large spring runoff in both years.
TP	165	November 1996 had a unusually high TP value. If it were not for this one sample result, this reach would not be listed for TP.
TSS	166	Same as 161 above.
TSS	167	Same as 161 above.
iron	167	Unknown

303(d) List - 1998

TRUCKEE RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
E.McCarran to Lockwood	187	TP, TN[1]	TN[4], TP[4], TDS[4]	
Lockwood to Derby Dam	188	TP[2], TN[1] , turbidity[3]		
Derby Dam to Wadsworth	189	TP[2], TN[1], turbidity[3]		
Wadsworth to Pyramid Lake	190	TP[2], TN[1], turbidity[3]		
Lake Tahoe at Sand Harbor	191	TN[5]		

[1] The Truckee Meadows Water Reclamation Facility (TMWRF) has experienced operational problems due to the nitrification towers being invaded by snails which consume the nitrifying biological film. The annual average total nitrogen water quality standard was exceeded in 1996, but was met in 1997.

[2] The TMDLs at Lockwood are intended to ensure that the waters downstream are in compliance with the water quality standards.

[3] Existing water quality standard of 10 NTU is not consistent, in terms of strictness, with the existing TSS standard. Before developing TMDLs, long term trends in turbidity and the existing water quality standard need to be assessed.

[4] Planned flow augmentation, nonpoint source reduction, river restoration and water quality model enhancement may result in a revision to the existing TMDLs.

[5] Sample is taken in heavily used recreational area; consequently, violations probably represent localized conditions.

TRUCKEE RIVER PROBLEMS ON 1996 LIST THAT ARE NOT ON 1998 LIST:

Parameter	NAC 445A.	Reason
nitrite	187	Nitrite exceedances seen in '94 were a combination of extremely low flows and high levels of ammonia being discharged from TMWRF. Higher flows in '96 and '97 in addition to improvements to the effluent being discharged from TMWRF has resulted in the river attaining the water quality standard for nitrite.
TDS	190	Data for '96 and '97 is in compliance with the water quality standard. The improvement is most likely due to significant increases of flow in the river and resulting dilution of nonpoint sources both from surface and ground water.

TRUCKEE RIVER PROBLEMS NEW ON 1998 LIST:

Parameter	NAC 445A.	Reason
turbidity	187	Possibly due to higher flows in both '96 and '97

303(d) List - 1998
COLORADO RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
Virgin R. from Arizona stateline to Mesquite	175	TP[1], boron[2]		
Virgin R. Mesquite to Lake Mead	177	TP[1], boron[2]		
Muddy R. from source to Glendale	210	TP[1], iron[3]		
Muddy R. at Overton	211	arsenic[2] , boron[2]		

[1] During the next standard's review, it will be determined if the TP standard is appropriate and if TMDLs are required.

[2] Before developing a TMDL, additional data is needed to determine if boron and arsenic standards violations are the result of natural conditions.

[3] Data suggests that iron increases at higher flows, and therefore, may be naturally occurring. During the next standard's review, an evaluation will be made of whether standards violations are the result of natural phenomenon or man caused.

COLORADO R. BASIN PROBLEMS ON 1996 LIST THAT ARE NOT ON 1998 LIST:

Parameter	NAC 445A.	Reason
iron	175, 177	Only one sample had an iron concentration over the 1000 ug/l standard during the '96 - '97 review period
TP	211	Water quality standard was not exceeded during '96-'97 review period. This reach will be included in TMDL evaluation described above.
pH	192	pH did not meet the minimum criteria for listing during '96-'97 review period.

Colorado River Basin problems new on 1998 List: none.

303(d) List - 1998

HUMBOLDT RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
Osino to Palisade	204	turbidity[1], TP, iron[3]		
Palisade to Battle Mountain	205	turbidity[1], TP, iron[3]	TP, TSS	TP[2], TSS[2]
Battle Mountain to Comus	206	turbidity[1], TP, iron[3], lead[4,5]	TP, TSS, TDS	TP[2], TSS[2]
Comus to Imlay	207	turbidity[1], TP, iron[3]	TP, TSS, TDS	TP[2], TSS[2]
Above Humboldt Sink	127	iron[5], boron[5]		

[1] Turbidity exceedances appear to be occurring in the winter and spring. Before developing a TMDL, additional monitoring will be conducted to determine if exceedances are due to natural or man-made conditions.

[2] TMDLs will be reviewed and revised, if necessary, taking into account 1995 standards revisions and 1998 nonpoint source assessment.

[3] The relationship between flow and iron will be evaluated before proceeding with a TMDL.

[4] NDEP has initiated sampling to compare dissolved versus total lead concentrations. The listing is based on total recoverable data; however, the water quality standard is expressed as dissolved. Recent data suggests that lead is below detection limit.

[5] Ongoing and planned studies (see p.6) will better assist NDEP in evaluating whether impairment exists.

HUMBOLDT RIVER PROBLEMS ON 1996 LIST THAT ARE NOT ON 1998 LIST:

Parameter	NAC 445A.	Reason
lead	205, 207	Lead detected and exceeded water quality standard in only one sample during the '96 - '97 listing period. Improved sampling procedures is most likely the reason for the decrease in standards violations.
TSS	205, 206, 207	Water quality standard was revised in November 1995. Violations of current standard no longer meet the criteria for listing. The basis for the standard revision was to account for extreme variations in flow that occur annually on the Humboldt River.
arsenic	127	NDEP and USGS data both show no violations of the listing criteria of the aquatic life standard during the listing period.
lead	127	Lead was not detected during the '96-'97 listing period

HUMBOLDT RIVER PROBLEMS NEW ON THE 1998 LIST:

Parameter	NAC 445A.	Reason
turbidity, TP, iron	204	High flows in both '96 and '97 could be the cause of violations of water quality standards

303(d) List - 1998
SNAKE RIVER BASIN

REACH	NAC 445A.	POTENTIAL PROBLEMS	Existing TMDLs	Future TMDLs
Salmon Falls Ck.	216	Temperature		
Shoshone Ck.	217	Temperature		
Owyhee R. above Mill Ck.	222	TSS, turbidity, TP, iron		
Owyhee R. at China Dam	223	TSS, turbidity, TP		
Owyhee R. at Boney Lane	224	TSS, turbidity, TP, iron		

Waters in the Snake River Basin have not been listed in the past because there was not adequate data. During the '96-'97 listing period, there were 6 samples which does meet the minimum number for listing. All TSS and turbidity listings are based on 2 out of 6 exceedances which occurred in March of both '96 and '97 with the exception of one turbidity exceedance in July at China Dam. Based on the small number of samples, NDEP does not feel that there is enough information to determine if TMDLs are warranted at this time.

Summary Table for the Nutrient Criteria Documents

These tables present the recommended EPA criteria for each of the aggregate nutrient ecoregions for the following parameters: Total Phosphorus, Total Nitrogen, Chlorophyll *a*, and Turbidity or Secchi. Criteria are presented for both Lakes & Reservoirs and Rivers & Streams.

Summary of Criteria available on line at
www.epa.gov/ost/standards/nutrient.html.
Ecoregion II (mountainous west) includes the Sierra Nevada
Ecoregion III (arid west) includes desert portions of Lahontan Region.

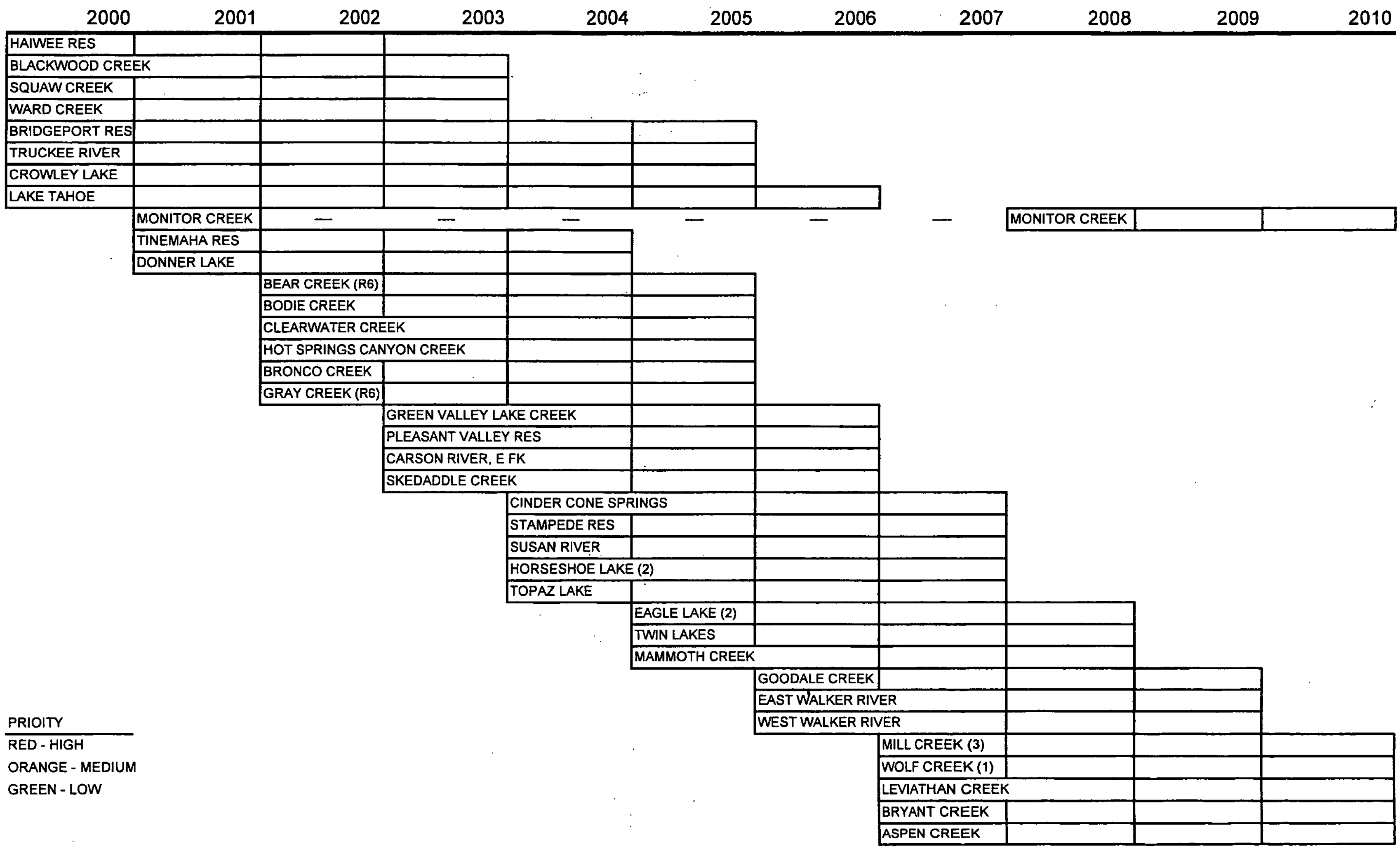
Aggregate Ecoregions for Rivers & Streams

Parameter	Agg EcoR II	Agg EcoR III	Agg EcoR VI	Agg EcoR VII	Agg EcoR IX	Agg EcoR XI	Agg EcoR XII	Agg EcoR XIV
TP μg/L	10.00	21.88	76.25	33.00	36.56	10.00	40.00	31.25
TN mg/L	0.12	0.377	2.18	0.54	0.692	0.305	0.90	0.71
Chl *a* μg/L	0.66	1.43	7.33	3.50	0.93	1.613	0.40	3.75
Turb NTU	1.30	1.84	9.89	1.70	7.02	2.30	1.90	1.94

Aggregate Ecoregions for Lakes and Reservoirs

Parameter	Agg EcoR II	Agg EcoR VI	Agg EcoR VII	Agg EcoR VIII	Agg EcoR IX	Agg EcoR XI	Agg EcoR XII	Agg EcoR XIII
TP *µ*g/L	8.75	37.5	14.75	8.00	20.00	8.00	10.00	17.50
TN mg/L	0.10	1.68	0.66	0.24	0.358	0.458	0.52	1.27
Chl *a* *µ*g/L	1.90	8.59	5.23	2.39	5.18	2.79	2.60	3.35

TMDL DEVELOPMENT SCHEDULE
(Draft June 13, 2001)



Currently listed waters that staff expect to be de-listed and waters that are listed for impairment due to flow or habitat are not shown.

California Regional Water Quality Control Board, Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development,

June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Alkali Lake, Lower	641.000	Salinity/TDS/ Chlorides	Propose to Delist 2001	1998-1999	Medium	
Alkali Lake, Middle	641.000	Salinity/TDS/ Chlorides	Propose to Delist 2001	1998-1999	Medium	
Alkali Lake, Upper	641.000	Salinity/TDS/ Chlorides	Propose to Delist 2001	1998-1999	Medium	
Amargosa River	609.000	Salinity/TDS/ Chlorides	MUN use removed	1998-1999	Medium	
Amedee Hot Springs	637.200	Metals	MUN use removed	1998-1999	Medium	
Aspen Creek	632.100	Metals	2007-2010	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Linked to Leviathan Mine CERCLA site
Aurora Canyon Creek	630.300	Habitat alterations	b	2003-2010	Low	
Bear Creek	635.200	Sedimentation /Siltation	2002-2005	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Coordinate w/ Truckee River
Big Springs	603.100	Arsenic	Propose to Delist 2001	1998-1999	Medium	
Blackwood Creek	634.200	Sedimentation /Siltation	2000-2003	1998-1999 (Ph. I), 2003-2010 (Ph. II)	High	
Bodie Creek	630.200	Metals	2002-2005	2003-2010	High	Coordinate w/ Hot Springs Canyon Creek
Bridgeport Reservoir	630.300	Nutrients	2000-2005	2003-2010	High	Coordinate w/ existing studies
Bridgeport Reservoir	630.300	Sedimentation /Siltation	2000-2005	2003-2010	High	Coordinate w/ existing studies
Bronco Creek	635.200	Sedimentation /Siltation	2002-2005	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Coordinate w/ Truckee River
Bryant Creek	632.100	Metals	2007-2010	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Linked to Leviathan Mine CERCLA site
Carson River, East Fork	632.100	Nutrients	2003-2006	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	

[a] Schedule and Priority per Resolution 6-98-6

[b] TMDLs will not be completed for waters impaired by habitat or flow

[c] Staff Report recommending delisting Pine Creek submitted to USEPA 4/14/00

California Regional Water Quality Control Board, Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development, June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Cinder Cone Springs	635.000	Nutrients	2004-2007	2000-2002	Medium	
Cinder Cone Springs	635.000	Salinity/TDS/ Chlorides	2004-2007	2000-2002	Medium	
Clark Canyon Creek	630.300	Habitat alterations	[b]	2003-2010	Medium	
Clearwater Creek	630.400	Sedimentation /Siltation	2002-2005	2003-2010	Medium	
Cottonwood Creek (1)	603.300	Water/Flow Variability	[b]	2003-2010	High	
Crowley Lake	603.100	Arsenic	Propose to Delist 2001	2000-2002	High	
Crowley Lake	603.100	Nutrients	2000-2005	2000-2002	High	
Deep Springs Lake	605.000	Salinity/TDS/ Chlorides	MUN use removed	1998-1999	Medium	
Donner Lake	635.200	Priority Organics	2001-2004	2003-2010	Low	Coordinate w/ existing studies
Eagle Lake (2)	637.300	Org. enrichment/ Low D.O.	2005-2008	2003-2010	High	
East Walker River	630.000	Metals	2006-2009	2003-2010	Medium	
East Walker River	630.000	Sedimentation /Siltation	2006-2009	2003-2010	High	
Fales Hot Springs	631.000	Metals	MUN use removed	1998-1999	Medium	
Goodale Creek	603.300	Sedimentation /Siltation	2006-2009	2003-2010	Low	
Grant Lake	601.000	Arsenic	Propose to Delist 2001	1998-1999	High	
Gray Creek	635.000	Sedimentation /Siltation	2002-2005	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Coordinate w/ Truckee River

[a] Schedule and Priority per Resolution 6-98-6

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California Regional Water Quality Control Board, Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development, June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Green Creek	630.400	Habitat alterations	b	2003-2010	Medium	
Green Valley Lake Creek	628.200	Priority Organics	2003-2006	2003-2010	Low	
Haiwee Reservoir	603.300	Copper	2000-2002	2003-2010	Low	Opportunity from Federal funding
Heavenly Valley Creek	634.100	Sedimentation /Siltation	1998-2000	1998-1999	High	
Honey Lake	637.200	Arsenic	Propose to Delist 2001	2003-2010	Medium	
Honey Lake	637.200	Salinity/TDS/ Chlorides	Propose to Delist 2001	2003-2010	Medium	
Honey Lake Area Wetlands	637.200	Metals	Propose to Delist 2001	2003-2010	Medium	
Honey Lake Wildfowl Mgmt. Ponds	637.200	Flow alterations	b	2003-2010	Medium	
Honey Lake Wildfowl Mgmt. Ponds	637.200	Metals	Propose to Delist 2001	2003-2010	Medium	
Honey Lake Wildfowl Mgmt. Ponds	637.200	Salinity/TDS/ Chlorides	Propose to Delist 2001	2003-2010	Medium	
Honey Lake Wildfowl Mgmt. Ponds	637.200	Trace Elements	Propose to Delist 2001	2003-2010	Medium	
Horseshoe Lake (2)	628.000	Sedimentation /Siltation	2004-2007	2003-2010	Low	
Hot Creek (1)	631.400	Metals	MUN use removed	1998-1999	Medium	
Hot Creek (2)	603.100	Metals	Propose to Delist 2001	1998-1999	High	

[a] Schedule and Priority per Resolution 6-98-6

[b] TMDLs will not be completed for waters impaired by habitat or flow

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California Regional Water Quality Control Board, Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development, June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Hot Springs Canyon Creek	630.300	Sedimentation /Siltation	2002-2005	2003-2010	Medium	Coordinate w/ Bodie Creek
Indian Creek (1)	632.200	Habitat alterations	[b]	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	
Indian Creek Reservoir	632.200	Nutrients	1998-2001	1998-1999 (Ph. I), 2003-2010 (Ph. II)	High	
Keough Hot Springs	603.000	Metals	MUN use removed	1998-1999	Medium	
Lake Tahoe	634.000	Nutrients	2000-2006	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	Complete before TRPA Section 208 update
Lake Tahoe	634.000	Sedimentation /Siltation	2000-2006	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	Complete before TRPA Section 208 update
Lassen Creek	637.000	Flow alterations	[b]	2003-2010	Medium	
Lee Vining Creek	601.000	Flow alterations	[b]	2000-2002	High	
Leviathan Creek	632.100	Metals	2007-2010	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	Linked to Leviathan Mine CERCLA site
Little Alkali Lake	603.100	Arsenic	MUN use removed	1998-1999	Medium	
Little Hot Creek	603.100	Arsenic	MUN use removed	1998-1999	Medium	
Mammoth Creek	603.100	Metals	2005-2008	no dates identified	High	
Mill Creek (1)	601.000	Flow alterations	[b]	2003-2010	High	
Mill Creek (3)	641.300	Sedimentation /Siltation	2007-2010	2003-2010	Medium	
Mojave River	628.200	Priority Organics	Propose to Delist 2001	2003-2010	High	

[a] Schedule and Priority per Resolution 6-98-6

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California Regional Water Quality Control Board,
Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development,
June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Monitor Creek	632.100	Metals	2001-2010	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	Linked to USFS CERCLA action; leverage USFS monitoring beginning 2001
Mono Lake	601.000	Salinity/TDS/ Chlorides	Propose to Delist 2001	1998-1999 (Ph. I), 2003-2010 (Ph. II)	High	
Owens Lake	603.300	Salinity/TDS/ Chlorides	Propose to Delist 2001	2003-2010	Low	
Owens River	603.300	Arsenic	Propose to Delist 2001	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	
Owens River	603.300	Habitat alterations	[b]	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	
Pine Creek (2)	637.300	Sedimentation /Siltation	1998-2000[c]	1998-1999 (Ph. I), 2003-2010 (Ph. II)	High	
Pleasant Valley Reservoir	603.200	Org. enrichment/ Low D.O.	2003-2006	2000-2002	High	Follow-on from Crowley Lake
Rough Creek	630.000	Habitat alterations	[b]	2003-2010	Medium	
Searles Lake	621.000	Salinity/TDS/ Chlorides	MUN use removed	1998-1999	Medium	
Skedaddle Creek	637.100	High Coliform Count	2003-2006	2003-2010	Low	
Snow Creek	634.200	Habitat alterations	Propose to Delist 2001[b]	2000-2002 (Ph. I)	High	
Squaw Creek	635.200	Sedimentation /Siltation	2000-2003	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	
Stampede Reservoir	636.000	Pesticides	2004-2007	2003-2010	Low	
Susan River	637.200	Unknown Toxicity	2004-2007	2003-2010	High	
Tinemaha Reservoir	603.200	Arsenic	Propose to Delist 2001	2003-2010	Low	
Tinemaha Reservoir	603.200	Metals	2001-2004	2003-2010	Low	Similar to Haiwee Reservoir

[a] Schedule and Priority per Resolution 6-98-6

[b] TMDLs will not be completed for waters impaired by habitat or flow

[c] Staff Report recommending delisting Pine Creek submitted to USEPA 4/14/00

California Regional Water Quality Control Board, Lahontan Region

Draft Schedule for Total Maximum Daily Loads Development, June 13, 2001

WATER BODY	HYDR UNIT	CAUSE	PROPOSED SCHEDULE	1998 SCHEDULE[a]	PRIORITY[a]	NOTES
Top Spring	637.200	Radiation	Propose to Delist 2001	1998-1999	Medium	
Topaz Lake	631.100	Sedimentation /Siltation	2004-2007	2003-2010	High	
Truckee River	635.200	Sedimentation /Siltation	1999-2005	1998-1999 (Ph. I), 2000-2002 (Ph. II)	High	
Tuttle Creek	603.300	Habitat alterations	[b]	2003-2010	Low	
Twin Lakes (Mammoth)	603.100	Nutrients	2005-2008	2003-2010	Low	
Ward Creek	634.200	Sedimentation /Siltation	2000-2003	2000-2002	High	
Wendel Hot Springs	637.200	Metals	MUN use removed	1998-1999	Medium	
West Walker River	631.000	Sedimentation /Siltation	2006-2009	2003-2010	High	
Wolf Creek (1)	632.100	Sedimentation /Siltation	2007-2010	2000-2002 (Ph. I), 2003-2010 (Ph. II)	High	

[a] Schedule and Priority per Resolution 6-98-6

[b] TMDLs will not be completed for waters impaired by habitat or flow

[c] Staff Report recommending delisting Pine Creek submitted to USEPA 4/14/00

EPA United States Environmental Protection Agency
Office of Water

Ground Water and Drinking Water

EPA 815-F-00-013
November 2000

Technical Fact Sheet: Final Rule for (Non-Radon) Radionuclides in Drinking Water

1. What are we announcing?

EPA is promulgating the final drinking water standards for (non-radon) radionuclides in drinking water: combined radium-226/-228, (adjusted) gross alpha, beta particle and photon radioactivity, and uranium. This promulgation consists of revisions to the 1976 rule, as proposed in 1991.

2. What are the requirements of this final rule?

Community water systems (CWSs), which are water systems that serve at least 15 service connections or 25 residents regularly year round, are required to meet the final MCLs and to meet the requirements for monitoring and reporting.

Non-transient, non-community water systems (NTNCWSs) will not be regulated at this time. EPA will further consider this matter and may propose to regulate radionuclides at these systems in the future. NTNCWSs are public water systems that are not a CWS and serve at least 25 of the same people more than 6 months per year (e.g., schools and nursing homes).

The final rule requires that all new monitoring be conducted at each entry point to the distribution system under a schedule designed to be consistent with the Standardized Monitoring Framework.

3. How soon after publishing the final rule will the changes take effect?

The rule will become effective on December 8, 2003, three years after the publication date (December 8, 2003). New monitoring requirements will be phased-in between that date and the beginning of the next Standardized Monitoring Framework period, December 31, 2007. "Phased-in monitoring" refers to the fact that States will require some fraction of water systems to complete their initial monitoring requirements each year of the period between the effective date (December 8, 2003) and the beginning of the new cycle (December 31, 2007). Water systems will determine initial compliance under the new monitoring requirements using the average of four quarterly samples or, at state discretion, using appropriate grandfathered data. Compliance will be determined immediately based on the annual average of the quarterly samples for that fraction of systems required by the state to monitor in any given year or based on the results from the grandfathered data. Water systems with existing radionuclides monitoring data demonstrating that the system is out of compliance with new provisions will be out of compliance on the effective date of December 8, 2003. Water systems with existing data that demonstrates non-compliance with the current (1976) rule are currently in violation of the radionuclides National Primary Drinking Water Regulations.

4. Why is this rule significant?

This rule promulgates new monitoring provisions that will ensure that all customers of community water systems will receive water that meets the Maximum Contaminant Levels for radionuclides in drinking water. Under the 1976 rule, water systems with multiple entry points to the distribution system were not required to test at every entry point, but rather to test at a "representative point to the distribution system." While the 1976 requirement did ensure that the "average customer" was protected, it did not ensure that all customers were protected. Under the new rule, all entry points will be tested and all CWS customers will be ensured of receiving water that meets the MCLs for radionuclides in drinking water. In addition, this requirement is more consistent with the monitoring requirements for other comparable drinking water contaminants.

This rule promulgates a new standard for uranium in drinking water, which will result in reduced uranium exposures for 620,000 persons. The uranium standard, which is required by the Safe Drinking Water Act, will protect drinking water customers from uranium levels that may cause toxic effects to the kidney and will reduce cancer risk. In addition, the new rule promulgates separate monitoring requirements for radium-228, which is expected to result in reduced exposure to 420,000 persons. This monitoring correction is based on sound science and is necessary for ensuring compliance with the combined radium-226/-228 standard.

5. What health effects are associated with exposure to radionuclides from drinking water?

Exposure to radionuclides from drinking water results in the increased risk of cancer. The radioactive particles (alpha, beta and gamma particles) emitted by radionuclides are called "ionizing radiation" because they ionize ("destabilize") nearby atoms as they travel through a cell or other material. In living tissue, this ionization process can damage chromosomes or other parts of the cell. This cellular damage can lead to the death of the cell or to unnatural reproduction of the cell. When a cell reproduces uncontrollably, it becomes a cancer. Certain elements accumulate in specific organs: radium (like calcium) accumulates in the bones and iodine accumulates in the thyroid.

For uranium, we must consider not only the carcinogenic health effects from its radioactive decay and the decay of its daughter products ("radiotoxicity"), but also damage to the kidneys from exposure to the uranium itself ("chemical toxicity"). Exposure to elevated uranium levels in drinking water has been shown to lead to changes in kidney function that are indicators of potential future kidney failure.

6. What are the sources of radionuclides in water?

Most drinking water sources have very low levels of radioactive contaminants ("radionuclides"), levels low enough not to be considered a public health concern. Of the radionuclides that have been observed to occur in drinking water sources, most are naturally occurring. However, contamination of drinking water sources by anthropogenic ("human-made") nuclear materials also occurs. Naturally occurring radionuclides are found in the Earth's crust and are created in the upper atmosphere. For example, trace amounts of long-lived isotopes (e.g., uranium-238, which has a half-life of almost five billion years) have been present in earth's crust since the crust first formed. As these long-lived trace radionuclides decay, shorter-lived ("more radioactive") daughter products are formed. Of particular concern are naturally occurring uranium and the naturally occurring radium isotopes, radium-226 and radium-228, which have been observed to accumulate to levels of concern in drinking water sources.

Most of the naturally occurring radionuclides are alpha particle emitters (e.g., the uranium isotopes and radium-226), but naturally occurring beta particle emitters do occur (e.g., radium-228 and potassium-40). Certain rock types contain trace amounts of the radioactive isotopes of uranium, thorium, and/or actinium. As these parent rocks weather, the resulting clays and other aquifer-forming materials may become a source of naturally-occurring radionuclides to drinking water sources. Other naturally occurring radionuclides include tritium, a beta particle emitter, which forms in the upper atmosphere through interactions between cosmic rays (nuclear particles coming from outer space) and the gases comprising the atmosphere. Tritium can be deposited from the atmosphere onto surface waters via rain or snow and can accumulate in ground water via seepage. Tritium is also formed from human activities, as described below. Natural tritium tends not to occur at levels of concern, but contamination from human activities can result in relatively high levels.

The man-made radionuclides, which are primarily beta and photon emitters, are produced by any of a number activities that involve the use of concentrated radioactive materials. These radioactive materials are used in various ways in the production of electricity, nuclear weapons, nuclear medicines used in therapy and diagnosis, and various commercial products (such as televisions or smoke detectors), as well as in various academic and government research activities. Release of man-made radionuclides to the environment, which may include drinking water sources, are primarily the result of improper waste storage, leaks, or transportation accidents.

7. How many people and how many systems will be affected by this rule?

Higher levels of radionuclides tend to be found more in ground water sources than in surface water sources, like rivers and lakes. While most water systems do not have detectable radionuclide activities, there are some areas of the country that have levels significantly higher than the national average levels. For example, some areas of the midwest have elevated radium-226 levels and some western states have elevated uranium levels compared to the rest of the United States. Separate monitoring for radium is expected to result in roughly half of one percent of the nation's 54,000 CWSs needing to take measures to lower radium in their drinking water. The uranium standard is expected to result in slightly less than one percent of CWSs needing to take measures to reduce uranium in their drinking water. Table 1 below shows the estimated number of CWSs that would be affected by this rule and the estimated population served by these water systems.

Table 1. Estimates of the Community Water Systems That Would Need to Mitigate Contaminant Levels and the Population Served by These CWSs

Regulatory Action	Number of CWSs Affected	Total Population Served
Radium-228 Monitoring Correction	~ 300	~ 420 thousand
Uranium MCL of 30 µg/L	~ 500	~ 620 thousand

8. How much will this rule cost?

Over 96% of the cost of this final rule is expected to come from the mitigation of radionuclide levels through treatment, purchasing water, developing alternate water sources, and other compliance measures. Table 2 below shows the total annualized costs of mitigation, monitoring, reporting, recordkeeping, and administration for this rule.

Table 2. Total National Annualized Costs of the Radionuclides Rule (Mitigation, monitoring, reporting, recordkeeping, and administration)

Regulatory Action	Annual Costs
Radium-228 Monitoring Correction, Mitigation Costs	~ $ 26 million
Uranium MCL of 30 µg/L, Mitigation Costs	~ $ 50 million
New Monitoring, Reporting, Recordingkeeping, and Administration Costs for all Radionuclides	~ $ 5 million

- For systems that need to take corrective action to comply with the new rule, the annual costs per system will range from $9,000 annually for the smallest community water systems to over $150,000 annually for systems serving 3,300 to 10,000, and over $500,000 annually for larger systems.
- For the small percentage of households that are served by water systems that will be required to take corrective actions because of this rule, it is estimated that households served by typical large water systems will experience increased water bills of less than $30 per year and that households served by typical small water systems (those serving 10,000 persons or fewer) will experience increased water bills of $50 - $100 per year. Costs will vary depending on the system size.

9. What are the benefits of this rule?

- The requirement for separate radium-228 monitoring is expected to result in the avoidance of 0.4 cancer cases per year, with estimated monetized health effects benefits of $ 2 million annually. Water mitigation for radium also tends to reduce iron and manganese levels and hardness, which also has significant associated benefits.
- The kidney toxicity benefits for the uranium standard can not be quantified because limitations in existing health effects models at levels near the MCL. In addition to these non-quantified kidney toxicity benefits, 0.8 cancer cases per year are expected to be avoided, with estimated monetized cancer health effects benefits of $ 3 million annually. Water mitigation for uranium also removes other contaminants, which has associated benefits.

10. Is there funding associated with this rule?

Since 1996, the Drinking Water State Revolving Loan Fund has made over $3.6 billion available for loans to help water systems improve their infrastructure. This program has now made over 1000 loans. EPA also provides funding to states that have primary enforcement responsibility for their drinking water programs through the Public Water Systems Supervision (PWSS) grants program. Other federal funds are available through Housing and Urban Development's Community Development Block Grant Program, and the Rural Utilities Service of the U.S. Department of Agriculture.

11. How did EPA consult with stakeholders?

In 1997, EPA conducted a public meeting regarding the finalization of portions of the 1991 radionuclides proposal. This meeting was advertised in the *Federal Register*. During the meeting, we discussed a range of regulation development issues with the stakeholders, including the statutory requirements, court stipulated agreement, MCLs for each of the radionuclides, the current and proposed monitoring frameworks, and new scientific information regarding health effects, occurrence, analytical methods, and treatment technologies. The presentations generated useful discussion and provided us feedback regarding technical issues, stakeholder concerns and possible regulatory options. Participants in the stakeholder meeting included representatives from water utilities, environmental and citizens groups, State drinking water programs and health departments, other federal agencies, and other groups.

In addition, during the regulation development process, we gave presentations on the radionuclides regulation at various professional conferences, meetings between State programs and EPA Regions, the American Water Works Association's Technical Advisory Workgroup (TAW), and at Tribal meetings in Nevada, Alaska, and California. Finally, we held a one-day meeting with associations that represent State, county, and local government elected officials on May 30, 2000 and discussed five upcoming drinking water regulations, including radionuclides.

Stakeholders were also asked to comment on a variety of issues in the April 21, 2000 Notice of Data Availability. We utilized the feedback received from the stakeholders during all these meetings and comments from the NODA in developing the final radionuclides rule.

12. Where can the public get more information about the final radionuclides rule?

For general information on radionuclides in drinking water, contact the Safe Drinking Water Hotline, at (800) 426-4791, or visit the EPA Safewater website at http://www.epa.gov/ safewater or the radionuclides website at http://www.epa.gov/safewater/radionuc.html.

In addition to this technical fact sheet, the following documents and fact sheets are available to the public at EPA's web site on radionuclides in drinking water:

1. *Federal Register* notice of the Notice of Data Availability
2. A Technical Support Document

A copy of the *Federal Register* notice of the final regulation, the Notice of Data Availability, or supporting material can be obtained by contacting the Safe Drinking Water Hotline at (800) 426-4791. The Safe Drinking Water Hotline is open Monday through Friday, excluding Federal holidays, from 9:00 a.m. to 5:30 p.m. Eastern Time.

CALIFORNIA
Sport Fish Consumption Advisories

State of California
Gray Davis - Governor

Cal/EPA
Wilson Hickox - Secretary

OEHHA
Joan Denton - Director

Important facts to know if you eat the fish you catch in California

Public Health Advisories And Guidance On Sport Fish Consumption
Fish are nutritious and good for you to eat. But some fish you catch may take in toxic chemicals from the water they live in and the food they eat. Some of these chemicals build up in the fish - and in you - over time. Although the chemical levels are usually low, it's a good idea to follow a few precautions in consuming fish, particularly if you eat fish often. The purpose of this brochure is to guide you to eat the fish you catch in ways that reduce your exposure to chemicals.

The Office of Environmental Health Hazard Assessment (OEHHA) provides specific consumption advice in this booklet for fish taken in areas where high levels of chemicals have been found in fish. However, because contamination levels are unknown for many locations, OEHHA also provides general advice on how to reduce your exposure to chemicals in noncommercial fish, referred to as sport fish, that you or your family catch.

These advisories are not intended to discourage you from eating fish entirely. Fish are nutritious and an excellent source of protein. The advisories should be followed to make your sport fish eating safer.

OEHHA can provide more information on the advisories and the health effects of chemical contaminants in the fish. OEHHA also has an illustrated brochure giving general advice. The brochure can be requested in several different languages. To stay current for updates and to request additional information, please check the OEHHA Web site at www.oehha.ca.gov or contact the Pesticide and Environmental Toxicology Section (PETS) of OEHHA in Sacramento or Oakland at the address given on the back cover of this booklet.

General Advice

You can reduce your exposure to chemical contaminants in sport fish by following the recommendations below. Follow as many of them as you can to increase your health protection. This general advice is not meant to take the place of advisories for specific areas, which follow later in this booklet, but should be followed in addition to them. Sport fish in most water bodies in the state have not been evaluated for their safety for human consumption. This is why we strongly recommend following the general advice given below.

Fishing Practices

Chemical levels can vary from place to place. Your overall exposure to chemicals is likely to be lower if you fish at a variety of places rather than at one usual spot that might have high contamination levels.

Be aware that OEHHA may issue new advisories or revise existing ones. Consult the Department of Fish and Game regulations booklet or check with OEHHA on a yearly basis to see if there are any changes that could affect you.

Consumption Guidelines

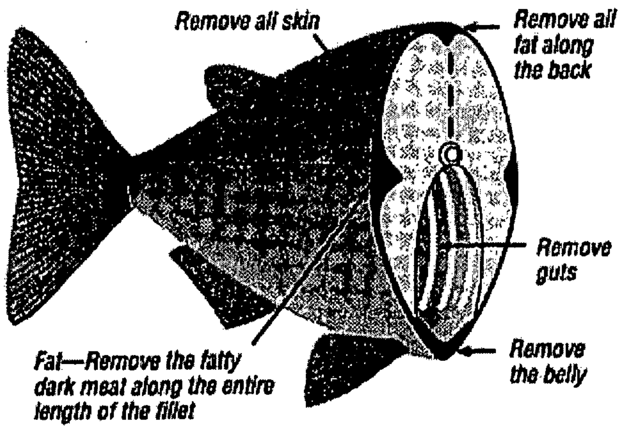
Fish Species:

Some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants.

Fish Size:
Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may become more concentrated in larger, older fish. It is advisable to eat smaller fish (of legal size) more often than larger fish.

Fish Preparation and Consumption:

- Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.
- Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.
- Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.
- Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites. This also helps to reduce the level of many chemical contaminants.



Advice for Pregnant Women

Young children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish.

The U.S. Food and Drug Administration (FDA) is responsible for commercial seafood safety. FDA has issued the following advice about the risks of mercury in fish to pregnant women and women of childbearing age who may become pregnant. The FDA advises these woman not to eat shark, swordfish, king mackerel, and tilefish. The FDA also advises that it is prudent for nursing mothers and young children not to eat these fish as well.

The US Environmental Protection Agency has also issued national advice to protect against consuming mercury in fish. They recommend that women who are pregnant or may become pregnant, nursing mothers, and young children eat no more than one meal per week on noncommercial freshwater fish caught by family or friends.

National advice for women and children on mercury in fish is available from the US Environmental Protection Agency at: http://www.epa.gov/ost/fish

and the US Food and Drug administration at: http://www.cfsan.fda.gov/~dms/admehg.html

Adjusting Fish Meal Size for Body Weight
In the site-specific guidance that follows, OEHHA gives consumption advice in terms of meals for a given period such as a meal a week, and uses an eight-ounce meal size as the standard amount allowed for the "average" adult. The average adult weighs approximately 150 pounds (equivalent to 70 kg). Because you and your family members may weigh more or less than the average adult, you can use the chart below to adjust serving sizes to body weight.

How Big Is A Meal?

If You Weigh...		Your Meal Size Should Not Exceed...	
Pounds or kilograms		*Ounces* or grams*	
19	9	1	28
39	*18*	2	*57*
58	*26*	3	*85*
77	*35*	4	*113*
96	*44*	5	*142*
116	*53*	6	*170*
135	*61*	7	*199*
154	*70*	8	*227*
173	*79*	9	*255*
193	*88*	10	*284*
212	*96*	11	*312*
231	*105*	12	*340*
250	*113*	13	*369*
270	*123*	14	*397*
289	*131*	15	*425*
308	*140*	16	*454*

**sixteen ounces is equal to one pound*

Site-Specific Consumption Recommendations
The following guidelines apply to the specific advisories that follow:

1. Eating sport fish in amounts slightly greater than what is recommended should not present a health hazard *if only done occasionally* such as eating fish caught during an annual vacation.
2. Nursing and pregnant women and young children *may be more sensitive* to the harmful effects of some of the chemicals and should be particularly careful about following the advisories. Because contaminants take a long time to

leave the body after they accumulate, women who plan on becoming pregnant should begin following the more restrictive consumption advice, a year before becoming pregnant. In this way, the levels of chemicals stored in the body can go down.

3. The limits that follow for each species and area assume that no other contaminated fish is being eaten. If you consume several different listed species from the same area, or the same species from several areas, your total consumption still should not exceed the recommended amount. One simple approach is to just use the lowest recommended amount as a guideline to consumption.
4. Just because the area where you like to fish is not included in the specific advisory areas that follow, it does not necessarily mean that it is free from chemical contamination. Sport fish in most parts of the state have not yet been evaluated for their safety for human consumption. Follow the general advice given earlier to protect your health.

The specific advisories listed below are arranged generally from north to south.

Lake Pillsbury (Lake County)
Because of elevated levels of mercury, women who are pregnant or may become pregnant within a year, nursing mothers, and children under age six should not eat fish from Lake Pillsbury. Other adults and children age six and older may eat fish from Lake Pillsbury on an occasional, but not regular, basis.

Clear Lake (Lake County) and Lake Berryessa (Napa County)
Because of elevated mercury levels, adults should eat no more than the amounts indicated below per month. Women who are pregnant or may become pregnant, nursing mothers, and children under age six should not eat fish from these lakes. Children 6-15 years of age should eat no more than one-half the amounts indicated for adults.

Fish Species	Clear Lake	Lake Berryessa
largemouth bass over 15"	1 lb.	1 lb.
largemouth bass under 15"	2 lbs.	2 lbs.
smallmouth bass all sizes	*	1 lb.
white catfish all sizes	3 lbs.	2 lbs.
channel catfish over 24"	1 lb.	3 lbs.
Channel catfish under 24"	3 lbs.	3 lbs.
rainbow trout all sizes	*	10 lbs.
brown bullhead all sizes	6 lbs.	*
Sacramento blackfish all sizes	6 lbs.	*
crappie over 12"	1 lb.	*
crappie under 12"	3 lbs.	*
hitch all sizes	10 lbs.	*

*Species not present or not tested

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Photo: Kimberly McKee-Lewis, associate wildlife biologist for the California Department of Fish and Game, caught a barracuda on a sport fish tagging effort in San Diego Bay.