Assessment of Ecological Concerns With Alternative Watel· Sources Used for Wetland Maintenance at Mason Valley Wildlife Management Area, Lyon County, Nevada

by

Stanley N. Wiemeyer, Damian K. Higgins, and Peter L. Tuttle

U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
1340 Financial Blvd, Ste. 234
Reno, Nevada 89502-7147

June 2003

/

I

i

I

I

I

¡'

L

I

Assessment of Ecological Concerns With Alternative Water Sources Used for Wetland Maintenance at Mason Valley Wildlife Management Area, Lyon County, Nevada

by

Stanley N. Wiemeyer, Damian K. Higgins, and Peter L. Tuttle[1]

u.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
1340 Financial Blvd, Ste. 234
Reno, Nevada 89502-7147

June 2003

[1] Currently at U.S. Fish and Wildlife Service, Daphne Field Office, Daphne, Alabama

TABLE OF CONTENTS

Table of Contents ii
List of Tables iii
List of Figures v
List of Appendices v
Executive Summary vi
Introduction .....
Study Area .....
Contaminant Concerns .....
Methods .....
- Monitoring Sites. .....
- Water Quality ...
- Sediment Quality .....
- Biological Samples .....
- Chemical Analyses .....
- Benthic Invertebrate Community Structure .....
- Wetland Vegetation Species Composition and Relative Abundance ... 10
- Fish Condition and Health 11
- Statistical Analysis 11
- Area Management 12

Results 13
- Water Quality 13
  - Field Data 13
  - Major Constituents 13
  - Metals and Trace Elements 14
- Sediment Quality 14
- Metals and Trace Elements in Biological Samples 15
  - Pondweed 15
  - Aquatic Invertebrates 15
  - Fish 16
- Benthic Invertebrate Community Structure 16
  - Variability Among Wetlands 16
  - Variability Among Sample Events 17
- Wetland Vegetation Species Composition and Relative Abundance 18
- Fish Condition and Health 19
  - Morphological Data 19
  - Pathogen and Histological Data 19

Discussion 19
- Water Quality 19
  - Differences Among Wetlands 19
  - Relations to State Standards 20
  - Relations to Walker River Water Quality 24

Table of Contents - *continued*·

Relations to Water Quality Data Reported by Dischargers and Others 25
Sediment Quality 26
Metals and Trace Elements in Biological Samples 27
Pondweed 27
Aquatic Invertebrates 28
Fish 29
Benthic Invertebrate Community Structure 30
Wetland Vegetation Species Composition and Relative Abundance 31
Fish Condition and Health 32
Wetland Management Recommendations 32
Acknowledgments 33
Literature Cited 34

List of Tables

1. Water deliveries to the Mason Valley Wildlife Management AreaIor the years 1995 through 2001 40
2. Analytical methods and detection limits for analyses of major constituents in water collected at Mason Valley Wildlife Area in 1999-2000 41
3. Detection limits for samples of water, sediment, vegetation, invertebrates, and fish from Mason Valley Wildlife Management Area that were analyzed for metals and trace elements 42
4. Water quality classifications for the HilsenhoffBiotic Index 43
5. Arithmetic means of field-collected data on water quality for selected wetlands on Mason Valley Wildlife Management Area, 1998-2000 44
6. Concentrations of major constituents in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000 45
7. Concentrations of metals and trace elements in water samples from wetlands at Mason VaHey Wildlife Management Area collected in March 1999 to July 2000 49
8. Concentrations of metals and trace elements in sediment samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999 51
9. Concentrations of metals and trace elements in pondweed samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999 54
10. Concentrations of metals and trace elements in aquatic invertebrate samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999 57
11. Concentrations of metals and trace elements in individual fish collected from wetlands at Mason Valley Wildlife Management Area, August, 1999 60

List of Tables - *continued*

12. Numbers and types of benthic invertebrates collected in samples from five wetland units at Mason Valley Wildlife Management Area, March-September, 1999 62
13. Summary statistics of benthic invertebrate metrics in wetland units at Mason Valley Wildlife Management Area, March-September, 1999 63
14. Sample period summary statistics of benthic invertebrate taxa dominance in five wetland units at Mason Valley Wildlife Management Area, March-September, 1999 64
15. Sample period summary statistics of benthic invertebrate measures in five wetland units at Mason Valley Wildlife Management Area, March-September, 1999 65
16. Taxonomic list of wetland vegetation observed in six wetland units at Mason Valley Wildlife Management Area, Nevada, September 1999 66
17. Vegetation coverage at six wetlands at Mason Valley Wildlife Management Area in September 1999 68
18. Morphological data for common carp and largemouth bass from wetlands at Mason Valley Wildlife Management Area 70
19. Results of histological examination of common carp and largemouth bass from wetlands at Mason Valley Wildlife Management Area 71
20. Average concentrations of selected constituents in water from the Walker River collected near Wabuska, Nevada, by the Nevada Division of Environmental Protection, January 1994 to May 2002 72
21. Flow data for the Walker River near Wabuska, Nevada, based on water years 1902-2001 from U.S. Geological Survey data 73
22. Specific conductance of water in the Walker River near Wabuska, Nevada, January 1998 to July 2000 74
23. Quarterly water quality data for the discharge from cooling ponds by Sierra Pacific Power Company, Fort Churchill Power Plant to Miller Marsh for the period of January 1996 through June 2002 and yearly estimated discharges 75
24. Quarterly water quality data from Sierra Pacific Power Company, Fort Churchill Power Plant for water delivered to north Pond for the period of October 1998 through June 2002 76
25. Water quality data for selected constituents in samples collected from North Pond by the Nevada Division of Environmental Protection, March 1999 to September 2001 77
26. Water quality of discharges by the City of Yerington to Cinnamon Pond on Mason Valley Wildlife Management Area, 1998-2000 78
27. Wetland units with species of aquatic flora not observed in other wetland units 79

List of Figures

1. Mason Valley Wildlife Management Area wetland units from which data were collected, 1998-2000 80

List of Appendices

A. Field-collected water quality data from various wetlands at Mason Valley Wildlife Management area, Lyon County, Nevada, 1998-2000 A-I
B. Nevada State water quality standards for the Walker River from the confluence of the East Walker River and the West Walker River downstream to the inlet of Weber Reservoir from the Nevada Administrative Code B-1
C. Walker River water quality data near Wabuska, Nevada, collected by the Nevada Division of Environmental Protection for the period January 1994 to May 2002 C-I
D. Nevada State water quality standards for toxic materials from the Nevada Administrative Code D-l

EXECUTIVE SUMMARY

Mason Valley Wildlife Management Area in Lyon County, Nevada, obtains water from the Walker River, groundwater via fish hatchery effluent and power plant cooling ponds, and municipal treated wastewater for wetland maintenance. The future management goal is to use the wetlands on the Area to treat water from these sources and provide discharge to the Walker River to benefit water levels in Walker Lake without impacting agricultural uses. This investigation was conducted to assess the capacity of wetlands to improve water quality for discharge and to assess the effects of alternative water sources to fish, wildlife, and their habitats on the wetlands. The objectives of the study were to: assess environmental contaminant concerns in relation to water sources and identify those with adverse effects on fish, wildlife, and their habitats; identify risks to humans using the area; document water quality for potential release; and determine if contaminants have the potential to accumulate in the wetlands and associated biota. Data collection in 1998-2000 included: field measurements of water quality in wetlands; chemical analysis of water quality in selected wetlands having different sources of water; chemical analysis of sediment, vegetation, aquatic invertebrates, and fish from selected wetlands; the assessment of plant and aquatic invertebrate community characteristics; and the assessment of fish condition and health. Intensively sampled sites included: Perk's Slough supplied by the Walker River; Cinnamon Pond supplied by the Walker River and municipal wastewater; Hinkson Slough supplied by fish hatchery effluent; Miller Marsh, a terminal wetland supplied by power plant cooling pond water adjacent to the Area; and Swan Lake and North Pond, terminal sites supplied by water from various sources and both potential discharge points to the Walker River.

In general, water quality was related to water sources and the position of wetlands in the system. The highest quality waters were in water delivery systems from the fish hatchery, Walker River, and in primary wetlands. Terminal wetlands had the poorest quality water. Water quality in Swan Lake and North Pond often did not meet water quality standards in the Walker River for total dissolved solids, total suspended solids, chloride, fluoride, sulfate, arsenic, boron, iron, and molybdenum. Elevated pH in some wetlands may not be well tolerated by some fish species.

Concentrations of arsenic in sediment exceeded threshold effect concentrations in all samples from Miller Marsh, Perk's Slough, and Swan Lake, with the samples from Miller Marsh and Swan Lake exceeding a probable effect concentration. The threshold effect concentration for cadmium was approached or exceeded in sediment samples from Swan Lake. The threshold effect concentration for copper was often exceeded in sediment samples from Swan Lake, North Pond, and Perk's and Hinkson Sloughs. Iron and manganese concentrations in sediment from Swan Lake exceeded concern levels.

Arsenic concentrations in pondweed from Miller Marsh and Swan Lake exceeded a dietary effect concentration associated with reduced weight gain in ducklings. Pondweed samples from all wetlands commonly contained boron concentrations associated with reduced weight gain in ducklings. Chromium concentrations in pondweed also commonly exceeded a threshold concentration above which adverse effects to wildlife might be expected. Mercury concentrations in at least one aquatic invertebrate sample from five wetlands exceeded a dietary effect concentration associated with adverse reproductive effects in ducks.

Chromium concentrations in fish commonly exceeded a proposed dietary effects threshold for potential adverse effects on wildlife. Most samples of fish contained mercury concentrations that exceeded the dietary effect concentration for reproductive effects in ducks, with Hinkson Slough having fish with the highest concentrations. However, fish-eating birds may be less susceptible to the effects of mercury than ducks. A human health fish consumption advisory may be needed in relation to the elevated mercury concentrations in fish from Hinkson Slough.

Operation of wetlands at the Mason Valley Wildlife Management Area as a terminal system has likely contributed to depressed water quality in terminal wetlands as well as concentrations of some elements in sediment that are cause for concern. Without discharges, these conditions will gradually worsen, with increased risks to fish, wildlife, and their habitats. However, the presence of poor water quality in terminal wetlands may preclude discharges to the Walker River unless an exemption to water quality standards is obtained. Flushing of the wetlands with good quality water would be beneficial. Continued monitoring of water quality and contaminants in sediments and biota is needed to properly assess future risks.

Disclaimer: The use of trade, product, or firm names in this report does not imply endorsement by the U.S. Fish and Wildlife Service.

INTRODUCTION

Across the United States, wetlands are being eliminated and degraded at alarming rates. In arid and semiarid regions of the western United States, increased water demand is responsible for much of the loss. In addition to upstream water diversion, changes in wetland water supplies have also contributed to alteration of processes, including changes in biogeochemical characteristics and concentration of potentially toxic contaminants in wetlands (Lemly et al. 1993). To maintain wetland habitat and aid in the disposal of effluents, the use of alternate water sources is becoming more common. Alternative water sources may include sewage effluents and industrial discharges. However, the implications of the use of alternate water sources in arid wetlands to fish, wildlife, and their habitats are not fully understood (Kadlec 1985). In many cases, differences in temperature and chemical properties may contribute to subtle shifts in habitats and wetland species composition. Additionally, a variety of potential toxicants or pathogens may directly affect fish and wildlife health.

The Mason Valley Wildlife Management Area (WMA), managed by the Nevada Division of Wildlife (NDOW), in western Nevada offered an opportunity to examine ecological concerns with a variety of alternative water sources used for wetland maintenance. High water demands and limited water supplies have contributed to severe water shortages in the Walker River basin (Horne et al. 1994). Acute water shortages presented Mason Valley WMA managers an opportunity to utilize a variety of alternative water supplies to support wetlands, beyond the water supplied by the Walker River and groundwater (through the Mason Valley Fish Hatchery). These alternative sources include: municipal treated sewage effluents (Le., City of Yerington Wastewater Treatment Facility), fish hatchery effluents (i.e., Mason Valley Fish Hatchery operated by NDOW), and cooling water from an adjacent electrical power generating station (i.e., Sierra Pacific Power Company, Fort Churchill Power Plant). Additionally, the power generating station has maintained wetlands adjacent to the WMA exclusively with cooling water. In some cases, water from these diverse sources had remained segregated in portions of the wetlands complex at the WMA. This study examined the relative impacts associated with alternative sources.

High consumptive water use in the Walker River Basin in west-central Nevada has reduced the frequency and volume of Walker River flows to Walker Lake. This has caused the lake's surface elevation to decline by as much as 140 feet and its volume to decrease by more than 70 percent (Home et al. 1994). Reduced freshwater inflow combined with high regional evaporation rates has concentrated salinity in the lake by about 400 percent. These conditions have resulted in reduced biological diversity and the loss of a self-sustaining population of threatened Lahontan cutthroat trout *(Oncorhynchus clarki henshawi)* in the lake. If current conditions continue, in the foreseeable future Walker Lake will be incapable of supporting fish, other aquatic organisms, and migratory birds that are dependent on them. The ultimate goal was to utilize the wetlands at the Mason Valley WMA to treat water from different sources so that it could be discharged to the Walker River, thereby increasing flows in the river, thus benefitting the lake. To date, the wetlands on the WMA have been operated as a terminal system, without discharge to the Walker River.

This investigation was designed to assess: 1) the capacity of wetlands on Mason Valley WMA to improve the quality of alternative water sources to meet applicable standards for discharge to the Walker River; and 2) the effects of alternative water sources to fish, wildlife, and their habitat on Mason Valley WMA. This information will be used to refine management techniques that provide the maximum benefit to water quality, wetland habitat quality, fish and wildlife health, and biodiversity. An application for a National Pollutant Discharge Elimination System (NPDES) permit would be submitted to the Bureau of Water Pollution Control of the Nevada Division of Environmental Protection (NDEP) when it is demonstrated that water from Mason Valley WMA meets applicable standards for discharge to the Walker River. The Nevada Division of Wildlife, with recommendations from the U.S. Fish and Wildlife Service (USFWS), would work with NDEP to maximize the discharge volume while ensuring that all applicable standards are satisfied and ecologically important habitat on Mason Valley WMA is not impaired. Alternative management of the WMA and potential discharges to the Walker River would be necessary if discharge standards could not be met.

The objectives of the investigation were to: 1) assess potential environmental contaminant concerns associated with various water sources used to support wetlands in and near Mason Valley WMA; 2) identify potential risks to human users of the WMA; 3) identify contaminants that have the potential to directly affect the survival, reproduction, or general health of fish and wildlife occurring on the WMA; 4) identify factors that may affect habitat quality on Mason Valley WMA; 5) document the quality of water for NDOW to potentially obtain a NPDES permit for the discharge of water from the WMA to the Walker River; 6) define relationships between water quantity and water quality; and 7) determine if persistent contaminants have the potential to accumulate in WMA wetlands to levels of concern to fish, wildlife, and their habitats. .

STUDY AREA

Mason Valley WMA is located in Mason Valley, Lyon County, Nevada, approximately 50 kilometers east southeast of Carson City, Nevada (Figure 1). Mason Valley is within the Walker River basin in west-central Nevada. Hydrology in the basin is dominated by the Walker River, which originates on the east slopes of the Sierra Nevada and terminates in Walker Lake. Climate in the area is characteristic of a mid-latitude desert (Thodal and Tuttle 1996). Wetlands on the WMA are for the most part manmade, although old drainages in the area were included in their development.

Mason Valley WMA incorporates 13,375 acres of land, which includes desert riparian, alkali desert scrub, wet meadow, fresh emergent wetland, riverine, lacustrine, and cropland habitat types (Richards 2000). The area provides important habitats in this arid region for a diverse fauna due to the mosaic of habitat types. The numbers found include 225 avian, 57 mammalian, and 17 fish species, plus 20 reptilian, and one amphibian species that are expected to occur on the area (Richards 2000). The WMA supports a variety of waterfowl species and produces waterfowl annually. Additionally, one federally listed threatened species, the bald eagle *(Haliaeetus leucocephalus)* has been identified on the WMA.

Mason Valley WMA provides a variety of recreational opportunities, with the major uses being hunting, fishing, and wildlife-related recreation (Richards 2000). Ponds of the WMA also provide warm water fishing opportunities. Principal game species include largemouth bass *(Micropterus sa/moides),* channel catfish *(lcta/urus punctatus),* white crappie *(Promoxis anu/aris),* bluegill *(Lepomis macrochirus),* black bullhead *(Ameiurus me/as),* and brown bullhead *(A. nebu/osus);* however, several of these species are in low numbers or of small size and therefore do not contribute to the overall harvest (Richards 2000). Several species of trout, including rainbow *(Oncorhynchus mykiss),* brown *(Sa/mo trulta),* and trout-crosses, have been stocked in ponds (Richards 2000).

Mason Valley WMA uses water from the sources identified above. The Nevada Division of Wildlife maintains the rights to water from the Walker River, the major source of water to the area (Table 1). Approximately 25% of the water from the Walker River is applied for agricultural use with the remaining 75% going to the wetlands (Elmer Bull, personal communication). Flows from the Walker River primarily originate from snowmelt in the Sierra Nevada. Because precipitation and the corresponding snowpack vary tremendously from year to year, annual flows in the Walker River are highly variable. Therefore, the actual amount of water deliveredto the WMA may vary considerably. During regional drought conditions, deliveries from the Walker River to the WMA are considerably less than righted amounts. Walker River water is delivered to the WMA through components of the Walker River Irrigation District agricultural water delivery system, specifically the Joggles, S.A.B., and west Hyland Ditches (Richards 2000). Walker River water deliveries are restricted to the irrigation season, which extends from March 1 to November 1 (Richards 2000). Upon entering the WMA, water may be routed through a series of four canal systems to supply water to various ponds/wetlands. Ground water from wells is occasionaliy used in wetlands, especially during periods of drought, such as in 2000 and 2001 (Table 1).

Water from additional sources is also used on wetlands on and adjacent to the WMA. Approximately 5,000 acre feet per year (AF/yr) of effluent is provided to the WMA from the NDOW Mason Valley Fish Hatchery (Table 1) which is discharged to a series of ponds (i.e., Hinkson Slough, Bass Pond, Crappie Pond, and North Pond), with excess water being transported to other ponds by a system of ditches. Hatchery water is supplied from ground water. Treated sewage effluent is received from the City of Yerington Wastewater Treatment Facility. This discharge is permitted under a NPDES permit, which allows the discharge of a maximum of 660 AF*Iyr.* Discharges from the City of Yerington averaged about 500 AF/yr for the years 1995 through 200I (Table 1). This water is delivered to Cinnamon Pond, which also receives water from the Walker River via Joggles Ditch. Groundwater that is used for cooling purposes at the Sierra Pacific Power Company, Fort Churchill Power Plant has been discharged from their cooling pond to support terminal wetlands at Miller Marsh, adjacent to the WMA. Water from the cooling pond was initially delivered to North Pond on the WMA in 1997 (Table 1). Up to 2,500 AF/yr may be delivered to North Pond; however, actual deliveries have been much lower.

CONTAMINANT CONCERNS

The diverse water sources may introduce a variety of contaminants to Mason Valley WMA or adjacent wetlands. Water quality in the Walker River, the primary water source, is generally of good quality, but has been found to exceed standards for established beneficial uses for certain constituents. Monitoring by the U.S. Geological Survey at the Walker River gage near Wabuska from 1968 to 1993 showed that Nevada water quality standards for protection of aquatic life for pH, ammonia, boron, and mercury were exceeded in five percent or more of the samples (Thodal and Tuttle 1996). The reach of the Walker River adjacent to the WMA was placed on the State of Nevada's draft 2002 303(d) List of Impaired Waters for iron and total suspended solids, whereas North Pond on the WMA was placed on the list for pH, total dissolved solids, and total phosphorus (NDEP 2002a). This indicates that these standards were not being met during the period of 1997 through 2001.

Contaminants associated with municipal waste water primarily include nutrients (primarily nitrogenous compounds and phosphates), and suspended and dissolved solids, but may also include chlorine, metals, chlorinated hydrocarbons, and viral or bacterial diseases (Brennan 1985). Contaminants of concern in wastewater treatment include: suspended solids; biodegradable organics (e.g., concerns related to biochemical oxygen demand); pathogens (e.g., bacteria and viruses); nutrients (primarily nitrogen and phosphorus); refractory organic compounds (e.g., surfactants, phenols, and pesticides); heavy metals; dissolved organic salts; and endocrine disrupting chemicals (Richardson and Nichols 1985; Purdom et al. 1994; Folmar et al. 1996; Metcalfe et al. 2001). The disposal of sewage effluent in wetlands has been linked to outbreaks of infectious avian diseases, such as avian cholera or duck plague, and toxic processes, such as avian botulism or blue-green algae poisoning (Friend 1985). These disease-related concerns may result from the introduction of pathogens, the introductions of pollutants which may affect the host's immune system, and changes to the physical and chemical properties of wetlands that favor the development and maintenance of disease problems. In the latter, such changes may include community composition and structure, increased loads of organic materials, or such things as the concentration of birds in areas remaining unfrozen during winter freezes. Risks of disease outbreaks in waterfowl brought on by contaminant-related stress may occur where waterfowl are crowded into small areas (Gilmer et al. 1982).

Contaminants associated with fish hatchery waste water would be expected to include nutrients and organic material. Fish hatchery effluents may also contain pathogenic bacteria, aquatic parasites, and chemicals and drugs used to control fish diseases (Piper et al. 1982; Thurman et al. 2002). Pathogenic bacteria and chemicals and drugs used for fish disease control are sporadic, but may be critically important.

Past monitoring of cooling water from the Sierra Pacific Power Company, Fort Churchill Power Plant demonstrates concerns with arsenic, boron, lead, mercury, and zinc. All of these contaminants have the potential to affect avian food chains and may potentially affect avian reproduction and survival.

Contamination of wetland ecosystems can result in a significant decrease in wetland productivity, as well as community and habitat functions, and lead to a loss of wetland values such as wildlife habitat and recreational activities such as hunting and fishing (Richardson 1999).

When trace metals are present at elevated concentrations or are sufficiently mobile, adverse effects to plants and animals may occur. Major ecological effects, including decreased species biomass and diversity, can occur as pollutant stress increases (Catallo 1999). However, wetlands provide a major benefit through their ability to transform, cycle, and act as a sink for nutrients. They may filter and hold 60 to 90% of suspended solids and sediment from wastewater additions prior to runoff (Richardson 1999).

METHODS

The diverse sources of water used on Mason Valley WMA and the array of associated contaminants concerns necessitated a comprehensive approach to monitoring water quality, habitat quality, and fish and wildlife. The approach included: 1) field assessment of water quality constituents in wetlands supported by various water sources; 2) chemical analysis of water quality at points of discharge and in wetlands supported by discharges; 3) assessment of sediment quality; 4) assessment of the toxicity of water and sediment; 5) determination of chemical residues in food chain organisms and fish; and 6) assessment of plant and aquatic invertebrate community characteristics.

Monitoring Sites

Wetlands supported by various water sources were monitored. In addition to monitoring areas near the point of inflow, areas removed from points of inflow were assessed to evaluate accumulation or concentration of potential contaminants. Since the primary objective of the monitoring program was to evaluate the implications of using alternative water sources, wetlands maintained exclusively with Walker River water were used as a reference. Intensive monitoring was conducted at the following six sites (Figure 1) in relation to their stated water sources and points of potential discharge:

1. Perk's Slough - primary wetland supported with Walker River water via Joggles Ditch;
2. Cinnamon Pond - primary wetland supported with treated municipal waste water and Walker River water via Joggles Ditch;
3. Hinkson Slough - primary wetland supported exclusively with fish hatchery effluent;
4. Miller Marsh - terminal wetland adjacent to the WMA supported with power plant cooling water;
5. Swan Lake - seasonal terminal wetland supported by overflow from up-gradient wetlands of various water sources (potential water discharge site to the Walker River); and,
6. North Pond - terminal wetland supported by cooling pond water, fish hatchery effluent, and overflow from up-gradient wetlands of various water sources (potential water discharge site to the Walker River).

Field monitoring of water quality was also conducted at the following sites (Figure 1):

I. Cinnamon Pond - outlet; (primary wetland);
2. Cinnamon Pond - inlet;
3. Cinnamon Pond - sewage outfall;
4. Mallard Pond - outlet; (secondary wetland);
5. Joggles Ditch - Perk's Slough Diversion; (water delivery structure);
6. Perk's Slough - outlet; (primary wetland);
7. Lower Pintail Pond - outlet; (secondary wetland);
8. Honker Lake - midpoint; (tertiary wetland);
9. Lower Gadwall Pond - outlet; (tertiary wetland);
10. Widgeon Pond - outlet; (tertiary wetland);
11. North Pond - outlet; (terminal wetland);
12. Bass Pond - outlet; (secondary wetland);
13. Hinkson Slough - outlet; (primary wetland);
14. Fish hatchery effluent - inlet to Redhead Pond; (water delivery structure);
15. Miller Marsh - midpoint; (primary wetland); and
16. Swan Lake - terminal point; (terminal wetland).

The location of all monitoring sites was recorded with the use of global positioning system equipment.

Water Quality

Field measurements of water quality were collected periodically, starting in December 1998 and running through July 2000 for some sites. Data collected included: date; time of day; ambient temperature (OC); wind speed (estimated in miles per hour, mph) and direction; water depth (centimeters; cm) and temperature (OC), dissolved oxygen milligrams per liter, mg/L), specific conductance (SC, microsiemens per centimeter, µS/cm), salinity (parts/thousand, ppt), pH (standard units; SU), and turbidity (nephroturbidity units, NTU). Temperature was measured with the temperature sensor on a Yellow Springs Instruments model 33 S-C-T meter. The meter temperature calibration was verified with a Fisher Scientific Company model 15-041 A thermometer with a manufacturer's certification to the National Institute for Standards and Technology. Dissolved oxygen was measured with a Yellow Springs Instrument Model 57 Oxygen Meter calibrated to elevation and water temperature before each use each sampling day. An Oakton Double-Junction Waterproof pH Testr 2 pH meter was used to measure pH. The pH meter was calibrated using pH 7 and 10 standards prior to use each sampling day. Specific conductance and salinity were measured with a Yellow Springs Instrument Model 33 S-C-T Meter. Meter calibration for specific conductance was checked using 1,382 mg/L (2,764 microsiemens per centimeter) reference solution prior to use each sampling day. Turbidity was measured with a HF Instruments model DRT 15 turbidimeter. The meter was calibrated to a 0.1 NTU standard before each use. Starting on August 15, 1999, these parameters were measured with a Hydrolab DataSond 4. The Hydrolab was calibrated, similar to the separate meters noted above, prior to use each day.

Whole unfiltered water samples were collected in mid-water column at the outlet of each monitored site for chemical analysis at quarterly intervals (except December 1999), starting in March 1999 and ending in July 2000. One 250 milliliter (ml) sample was collected at each of the six sites for analysis of major constituents, which included: total dissolved solids (TDS), total suspended solids (TSS), ammonia nitrogen (ammonia-N), nitrate nitrogen (nitrate-N), Kjeldahl nitrogen (K-N), total nitrogen (TN), phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), chloride, fluoride (F), sulfate (S04)' total coliforms (most probable number [mpn] or colony forming unit [cfu] perl00ml), and fecal coliforms (mpn or cfu/l00ml). These samples were delivered to the analytical laboratory within 24 hours of collection and analyses were completed within 17 days of collection. A second 250 ml sample was collected at each site and acidified to pH $\leq$ 2.0 in the field. These samples were for the analysis of metals and trace elements, which included: aluminum (AI), arsenic (As), (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), magnesium, manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), vanadium (V), and zinc (Zn). Analysis of samples for metals and trace elements were completed in May 2002. All samples were collected in certified chemically clean polypropylene bottles. All water samples were chilled in the field and refrigerated or chilled until analysis.

Sediment Quality

Sediment quality was monitored because sediment represents both a repository for a variety of environmental contaminants and a potential pathway of fish and wildlife exposure. Sediment was sampled near the inflow, mid-point, and outlet of each of the six intensively monitored wetlands in August-September 1999. At each sampling point, a composite of five samples was collected with a Wildoco model number 2422 H12 core sampler and placed in a 500-ml pre-cleaned nalgene container. Samples included the top 5 cm of each core. The samples from each point were thoroughly mixed with a stainless steel instrument and a sub-sample placed in a 60-ml chemically clean container with Teflon-lined lid. Samples were stored on ice in the field and frozen within 6 hours following collection. All sediment samples were kept frozen until analysis. Samples were analyzed for the same metals and trace elements as for the last set of water samples described above. Between each sampling site, sediment sampling equipment was washed with a brush and mild detergent, rinsed with dilute nitric acid, triple rinsed with deionized water, and submerged in site water for at least 1 minute prior to use.

Biological Samples

Biological samples were collected for analysis to assess food chain incorporation of metals and trace elements and their implications to fish and wildlife health. Samples were analyzed for the same set of constituents as the latter set of water samples described above. Samples were collected at the same locations (i.e., inlet, mid-point, outlet) and dates as sediment samples in each of the six intensively monitored wetlands. Samples included: pondweed *(Potomogeton* spp.); hemipterans (emphasis on larval stages of corixids at all sites, except no sample at the outlet of Cinnamon Pond and notonectids at the mid-point of Cinnamon Pond); and

fish. Fish were not available from North Pond. Largemouth bass and/or carp *(Cyprinus carpio)* were collected at the remaining sites.

Pondweed samples were collected with gloved hand, placed in 60-ml glass jars with Teflon lined lids in the field, placed on ice, and frozen within 6 hours upon return to the laboratory. Aquatic invertebrates were collected with a kick net by dragging the net along the sediment surface. Invertebrates were placed in chemically clean 500-ml nalgene containers, placed on ice in the field, and later sorted from debris in the laboratory. Aquatic invertebrates were placed in 60- ml chemically clean glass jars with Teflon lined lids and frozen. Between each sampling site, kick nets were washed with a brush and mild detergent, triple rinsed with deionized water, and submerged in site water for at least 1 minute prior to use.

Fish were collected using four methods. Fish from Miller and Swan Ponds and Hinkson Slough were collected with nets or a seine, those from Perk's Slough were gill-netted, and fish from Cinnamon Pond were collected by electro-fishing. Individual fish were weighed and measured, placed in clean plastic bags on ice in the field, and frozen within 6 hours upon return to the laboratory. All biological samples were kept frozen until analysis.

Chemical Analyses

Water samples collected for analysis of major constituents were analyzed by Sierra Environmental Monitoring, Inc., Reno, Nevada. Information on analytical methods and detection limits are given in Table 2.

Analyses for metals and trace elements in water, sediment, and biota were conducted at the Research Triangle Institute, Research Triangle Park, North Carolina. Water samples for determination of all elements, except Hg, were digested with a microwave oven. A 50 ml sample of water was heated in the oven in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for 15 minutes at 300 watts. The sample was then diluted to 50 ml with laboratory pure water. Inductively coupled plasma (lCP) measurements were made using a Leeman Labs Plasma Spec I sequential or ES 2000 simultaneous spectrometer. Mercury in water samples was reduced using $SnCl_4$ and analyzed by cold vapor atomic absorption, using a Leeman PS2000 Hg Analyzer.

Tissue samples were homogenized with a food processor and a sub-sample was freeze-dried for determination of moisture content. All sediment and tissue samples were digested using the following method. Using a microwave oven, 0.25 to 0.5 g of freeze dried sample was heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for 3 minutes at 120 watts, 3 minutes at 300 watts, and 15 minutes at 450 watts.' The residue was then diluted to 50 ml with laboratory pure water. For all elements in sediment and tissue samples, except As in vegetation, As and Se in sediment, and Hg in sediment and tissue, ICP measurements were then made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer. For As in vegetation and sediment, and Se in sediment, graphite furnace atomic absorption measurements were conducted using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer. For Hg measurements in tissue and sediment samples, $SnCl_4$ was used as the reducing agent, and cold vapor atomic absorption using a Leeman PS200 Hg Analyzer was employed.

The following numbers of procedural blanks were used: two water, one sediment, one vegetation, and three animal tissue (i.e., invertebrate and fish). The following numbers of samples were analyzed in duplicate: two water, one sediment, one vegetation, one invertebrate, and two fish. Reference materials that were analyzed included: one sediment, one vegetation, and four animal tissue. The following number of samples were used in spike recoveries: two water plus two spiked blank water, one sediment, one vegetation and three fish. Detection limits for samples analyzed at the Research Triangle Institute are provided in Table 3. All quality assurance/quality control and analytical results for samples analyzed at the Research Triangle Institute were assured and approved by the Patuxent Analytical Control Facility, USFWS, Laurel, Maryland.

Benthic Invertebrate Community Structure

Benthic macro-invertebrates were collected from the study plots described above at each of five intensively studied wetland units, with Swan Lake being excluded. Benthic invertebrates were collected at three fixed sites (i.e., inlet, midpoint, and outlet) within each wetland unit during March, May, and September 1999, and were assumed to be representative of the benthic invertebrate community for each wetland unit. Benthic invertebrates were collected with a Wildoco model number 2422 H12 core sampler that was rapidly lowered into the water column and pushed at least 5 cm into the sediment. While the core sampler was held in place, bottom debris was agitated by hand to dislodge any resting invertebrates, and a 500 millimeter (mm) sieve was lowered through the water column and used to capture vegetative debris as the core sampler was retrieved. Vegetative debris was examined for clinging invertebrates, with the debris discarded if no invertebrates were observed. Each sample consisted of a composite of 10 sediment samples collected at a depth of 5 cm. Samples were sieved through an 800 micron (µm) nylon mesh. All macro-invertebrates were live sorted and placed in 90% alcohol. An overall composite sample from 30 sediment samples (10 each at the inlet, midpoint, and outlet) from each wetland was used for enumeration and identification. Preserved samples were shipped to EcoAnalysts, Inc., Moscow, Idaho for identification and enumeration to family level.

Benthic-invertebrate measures calculated for this study included abundance, Hilsenhoff Biotic Index (Hilsenhoff 1977, 1982, 1987), Shannon-Wiener Diversity Index (Shannon and Weaver 1949), and Margalefs Index (Margalef 1969, Rosenberg and Resh 1993). The relative ability for distinct taxa to tolerate various levels of pollution has been described in several studies (Idaho Division of Environmental Quality 1996; Wisseman 1996). These sources assign tolerance values (the ability of members of an order, family, etc., to withstand pollution) from 1 (intolerant) to 10 (highly tolerant). Hilsenhoffs Biotic Index (HBI) was used to determine the relative tolerance of benthic-invertebrate communities in the wetland units. Although originally developed to assess low DO caused by organic loading, a purpose for which it works best (Hilsenhoff 1977, 1982, 1987), the HBI may also be sensitive to the effects of impoundment, thennal pollution, and some types of chemical pollution (Hilsenhoff 1998; Hooper 1993). Only arthropods that require DO for respiration are used in the calculation of the HBI. Organisms that are most sensitive to low concentrations of DO have low tolerance values, and organisms which have a wide tolerance, have high tolerance values. Organism tolerance values and the HBI range

from 0 to 10 (Table 4) and most macro-invertebrate species used in the calculation have determined tolerance values. This form of community-level bio-monitoring is useful when investigating whether the observed variation between invertebrate communities is attributed to a difference in water quality.

High species diversity is often considered to be indicative of a healthy, stable community (Shannon and Weaver 1949). Since numerous studies have demonstrated the effects of water quality on invertebrate diversity, a Shannon-Wiener diversity index was calculated for all macro-invertebrates within each sample. This index accounts for relative abundance among the represented taxa and increases as the number of taxa increases and as the distribution across the taxa becomes even. A third index, Margalefs index (Margalef 1958), was used to provide a comparison of taxa richness for all macro-invertebrates in wetland units, where a higher number indicates higher richness.

Wetland Vegetation Species Composition and Relative Abundance

Line-intercepts were used as sampling units to estimate coverage of a species in each wetland unit on September 15-16, 1999. The objects of interest were vegetation patches that 'occupied significant areas. The fraction of a line that crossed a was proportional to the fraction of total area covered by the vegetation. To estimate cover, it was assumed: 1) vegetation patches are randomly oriented with no preferred orientation of the major axis of the patch; and 2) established sample lines are randomly oriented across the study area. Reference to plant species are made using scientific names. All plant taxonomy follows the Jepson Manual (Hickman 1993) and "A Flora of the Marshes of Califomia." (Mason 1957).

Four line-intercept transects were established along the shoreline of each intensively studied wetland unit to determine vegetation types and species. The beginning of each transect was marked with a wooden stake near the inlet, outlet, and two midpoint locations along the hydric perimeter. Location coordinates of wooden stakes were recorded in Universal Transverse Mercator units using a Rockwell Global Positioning System Unit. All transects were 30.5 meters (01) long, except for one transect at Hinkson Slough (40 m) and one transect at Cinnamon Pond (20 m). Bearings of transects were chosen randomly using a number generator that gave a direction that entered into the wetland unit. All vegetation that occurred along the sample line within four different strata (i.e., submergent, floating, emergent, and upland or dry) were usually identified to at least the genus level. Relative abundance of dominant species were determined through the expression of a coverage estimate. Measurement parameters collected for each transect included four metrics:

1. Segment interception - Intercepts on each line were recorded by traveling from one end of the sample line to the other. The length of a line, or line segment, which crossed each vegetation patch was separately recorded and overlapping strata were measured separately by height.

2. Sample line and species summary - Data were summarized by sample line and species using each sample line as a separate sampling unit. The data on number

and lengths of each line segment for a unit was the measurement/observation for that unit.

3. Sample line percent cover - Percent cover for each sample line was estimated by determining the sum of line segments divided by total line length.

4. Overall cover - The overall estimate of cover was a weighted mean of individual sample line coverage estimates. The line lengths formed the weights.

Fish Condition and Health

A general assessment of the health and condition of common carp and largemouth bass at five sites that received different sources of water was conducted on August 18-19, 1999, with the assistance of the California-Nevada Fish Health Center of the Fish and Wildlife Service (Nichols et al. 1999). The five sites included: Hinkson Slough, Cinnamon Pond, Miller Marsh, Perk's Slough, and Widgeon Pond (water from Walker River). The assessment included:
1) organosomatic analysis and tissue sampling during field collection; 2) microbiological assays; and 3) histological evaluation of selected tissues.

A livebox was used to hold the fish on site for 1 to 3 hours prior to necropsy. Largemouth bass captured in Widgeon Pond were in a gill net for up to 24 hours prior to necropsy. MS222 was used to overdose fish. The fish were then rapidly examined for external abnormalities, weighed, and measured (total and fork length). Internal organs were examined for gross abnormalities and the following samples were collected: 1) a sterile loop that was inserted into the kidney was used to inoculate a brain heart infusion agar plate; 2) a sample of kidney was taken for *R. sa/moninarum* antigen ELISA and viral assay; and 3) histological samples of kidney, liver, and spleen were taken and fixed and later stained with hematoxylin and eosin for microscopic examination.

Statistical Analysis

SYSTAT® version 10 (SYSTAT 2000) programs were used for all statistical analyses of contaminant data. Concentrations less than the detection limit were set to one-half the limit prior to conducting analyses. Dissolved oxygen values of > 20 mg/L were set at 30 mg/L and turbidity values of > 200 NTU were set at 300 NTU prior to statistical analyses. Statistical analyses were conducted only when more than one-half of the samples for a given constituent had concentrations above the detection limit.

Data on concentrations of major and minor constituents in samples as well as field-collected water quality data were first examined to determine if the data were normally distributed and variances were similar among groups. Lilliefor's probabilities of the Kolmogorov-Smirnov one sample test was used to determine if residue concentrations of individual metals or trace elements in water or tissue samples and field-collected water quality data were normally distributed. If data were normally distributed we proceeded to determine if variances were similar among groups. The recommendation of Kirby (1993) was used, who

suggested that one should not worry about unequal variances unless the ratio of the largest to the smallest is greater than 2.0. Unequal variances among sites were often present, with the ratio often exceeding 5.0. Both of these assumptions (i.e., normal distributions and equal variances) were usually violated. Therefore we loglo transformed some data in an attempt to meet the assumptions; transformed data also did not adequately meet the required assumptions in many cases. Therefore, we used the nonparametric Kruskal-Wallis test to determine if differences occurred among sites. Spearman rank correlations were used to determine if elements within a given sample type were correlated with one another, and to determine if individual elements between sample types were correlated. Statistical significance was set at $P \leq 0.05$.

Benthic invertebrate taxonomic population data were used to calculate common quantitative community measures. Variability observed between wetland units and difference in the data among sampling events were analyzed by comparing data on presence/absence of dominant taxa and calculated metrics for benthic invertebrate families. Benthic invertebrate metrics were tested for normality using Lillefor's Test, standardized appropriately, then statistically compared using Kruskal-Wallis and Tukey tests to a significance level of $P < 0.05$ (lman and Conover 1983).

Various management activities may have influenced the results of the data collection activities described above. For example, management of water deliveries, including sources, timing, and drying and reflooding of wetlands may have affected water quality. Therefore, information is provided here that may aid in data interpretation provided below. As indicated previously, North Pond was initially filled with water from the Walker River in June 1997. This wetland inundated 175 acres of land for the first time. Since that time it has received water from the fish hatchery via Hinkson Slough and cooling water from the power plant. Hinkson Slough received water from the Walker River prior to establishment of the fish hatchery. Hinkson Slough was frequently dried and re-flooded to control carp; one such draw down occurred in March 1999. Perk's Slough was also drawn down in March 1999. Miller Marsh was established and first received water from the cooling ponds at the Fort Churchill Power Plant in the late 1990's. No discharges occurred from the cooling ponds from the late 1970's until the establishment of Miller Marsh. Prior to the late 1970's water from the power plant was discharged to the Walker River (Elmer Bull, NDOW, personal communication).

During summer months when evapo-transpiration rates are high, water from the fish hatchery has been used nearly exclusively to maintain the fish ponds (i.e., Hinkson Slough, Bass Pond, Crappie Pond, and North Pond; Richards 2000). The hatchery flow is diverted to ponds in the central and northeast portions of the WMA in winter months when evapo-transpiration rates are low.

Use of Walker River water begins in the spring and is used to raise water levels in ponds on the east of the WMA to support habitat for waterfowl and other wildlife (Richards 2000). Due to flows from the hatchery through the winter months, many ponds are full going into the spnng season.

Prescribed burning of Lower Pintail Pond occurred in March 1999. This wetland was drained after the burn in April-May 1999, with refilling occurring in June 1999, at which time there was major growth of cattails.

RESULTS

Water Quality

Field Data

Field measurements of water quality varied among wetlands and other sampling stations (Table 5; Appendix A). Statistical results should be viewed with caution as all sites were not sampled on all dates. Specific conductance was significantly different among sites ($P < 0.0005$), with the lowest mean conductance found in hatchery effluent, followed by Joggles Ditch and Hinkson Slough. Higher mean conductance values greater than 1000 microsiemens/cm were found in Miller Marsh, Swan Lake, and North Pond. Dissolved oxygen concentrations were also significantly different among sites ($P < 0.0005$), with the lower mean concentrations found in Miller Marsh and the hatchery effluent and the highest mean concentration in North Pond. The levels of pH were significantly different among sites ($P < 0.0005$) with the lowest mean value at the sewage outfall at Cinnamon Pond and the highest mean value in Widgeon Pond. Salinity concentrations were significantly different among sites ($P < 0.0005$) with the higher mean concentrations occurring at the same sites where specific conductance was elevated. Turbidity varied widely and was significantly different among sites ($P < 0.0005$). Swan Lake had the highest mean turbidity, whereas the lower mean turbidity values were found in the hatchery effluent and in Bass Pond.

Water quality data also often varied among sites in Cinnamon Pond. Specific conductance ($P < 0.0005$), pH ($P = 0.045$), and turbidity ($P < 0.0005$) were significantly different among sites, with the sewage outfall having the highest mean SC and the lowest mean pH and turbidity.

When sample sites were classified with regard to wetland type (i.e., primary, secondary, tertiary/terminal, or water delivery structure), the following differences were found among types (Kruskal-WaHis one-way analysis of variance): SC, pH, salinity, and turbidity ($P < 0.0005$), and DO ($P = 0.013$).

Major Constituents

Major constituents in water often varied widely among wetlands and occasionally varied among sampling dates within wetlands for selected constituents (Table 6). The following constituents were significantly different among sites (P values): TDS « 0.0005), TSS (0.003), K-N (0.005), P (0.019), Ca (0.034), Mg (0.002), calculated hardness (0.021), Na (0.001), chloride « 0.0005), F « 0.0005), and S04 « 0.0005). Total dissolved solids concentrations at Hinkson Slough were consistently less than 350 mg/L, whereas concentrations at Swan Lake consistently equaled or exceeded 1,000 milligrams per liter (mg/L). Total suspended solids concentrations at Miller Marsh did not exceed 50 mg/L, whereas concentrations at Swan Lake were highly variable and reached 674 mg/L. Kjeldahl-nitrogen concentrations at Perk's Slough did not exceed 1.0

mg/L, whereas concentrations at Cinnamon Pond exceeded 3.5 mg/L on two sampling dates and were always greater than 1.5 mg/L. Phosphorus concentrations at Swan Lake were highly variable and exceeded 0.80 mg/L on two dates, whereas concentrations tended to be low at both Perk's Slough and Miller Marsh. Hardness, which is based on concentrations of Ca and Mg, was the lowest at Miller Marsh, with concentrations not exceeding 85 mg/L (as $CaC0_3$). Sodium, chloride, and SO_4 concentrations at Hinkson Slough, Cinnamon Pond, and Perk's Slough were lower than at Miller Marsh, Swan Lake, and North Pond. Total dissolved solids concentrations were significantly correlated with the following major constituents (Spearman Rank Correlation, $P < 0.01$): Na ($r = 0.894$), chloride ($r = 0.853$), F ($r = 0.749$), and S04 ($r = 0.828$). The cause for the consistent absence of detectable concentrations of ammonia for the June and August 1999 sampling dates for all sites is unknown.

Metals and Trace Elements

Concentrations of the following metals and trace elements in water were significantly different (P values) among wetlands: Al (0.019), As (0.0005), B (0.001), Ba (0.008), Fe (0.017), Mg (0.001), Mo (0.0005), Sr (0.027), and V (0.008) (Table 7). Swan Lake tended to have the highest concentrations of these constituents. Beryllium, Cd, Cr, Hg, Pb, and Se were seldom, if ever Concentrations of most elements were fairly consistentcimong sampling dates within wetland units with the following exceptions: Al and Fe were clearly the lowest on the July 2000 sampling event at Miller Marsh, Perk's Slough, and Swan Lake; AI, Fe, and Mn were clearly the lowest on the March 2000 sampling event at Hinkson Slough; Al and Fe were clearly the lowest on the August 1999 sampling event at North Pond; and Mn was clearly the lowest on the March 2000 sampling event at Miller Marsh and on the July 2000 sampling event at Perk's Slough and Swan Lake. The following elements were significantly correlated with TDS (Spearman Rank Correlation): As ($r = 0.865$, $P < 0.01$), B ($r = 0.864$, $P < 0.01$), Mg ($r = 0.374$, $P < 0.05$), and Mo ($r = 0.814$, $P < 0.01$). The following elements were significantly correlated with TSS (Spearman Rank Correlation): Al ($r = 0.729$, $P < 0.01$), B ($r = -0.435$, $P < 0.05$), Ba ($r = 0.790$, $P < 0.01$), Cu ($r = 0.651$, $P < 0.01$), Fe ($r = 0.741$, $P < 0.01$), Mn ($r = 0.611$, $P < 0.01$), Ni ($r = 0.472$, $P < 0.01$), V ($r = 0.556$, $P < 0.01$), and Zn ($r = 0.570$, $P < 0.01$). Concentrations of Mg in samples analyzed as a major constituent were significantly lower than those analyzed as a trace metal (Wilcoxon Signed Ranks Test; $P < 0.0005$).

Sediment Quality

Concentrations of metals and trace elements in sediment often varied widely among sample sites within wetlands, especially for North Pond and Hinkson Slough (Table 8). No consistent pattern among locations (i.e., near inlet, mid-point, outlet) within wetlands for all wetlands was apparent. For North Pond, concentrations of all constituents, except Cu, Hg, and Se, were lowest at the inlet, intermediate at the mid-point, and highest at the outlet. For Hinkson Slough, the mid-pointhad the lowest concentrations for all constituents, exceptMo and Se where all sites had non-detectable concentrations. At Cinnamon Pond, the mid-point had the lowest concentrations for all constituents, except for Be, Cd, and Hg; Mo and Se were not detected at all sites.

Concentrations of As were significantly different among wetlands (P = 0.018). Arsenic concentrations were higher in sediment samples from Miller Marsh and Swan Lake and lowest in samples from Cinnamon Pond. Concentrations of B were also significantly different among wetlands (P = 0.025). The highest B concentrations were found in samples from Swan Lake. Mercury concentrations were significantly different among wetlands (P = 0.014), with higher concentrations in samples from Hinkson Slough than other wetlands. The concentration of each metal and trace element in sediment typically was significantly correlated ($P \leq 0.05$) with most other metals and trace elements, with the major exception of Hg which was only significantly correlated with Pb. Other elements that were not correlated with three or more other elements were As, Ba, Cr, and Sr.

Metals and Trace Elements in Biological Samples

Pondweed

Concentrations of some metals and trace elements in pondweed samples were highly variable among sites within individual wetlands as well as among wetlands (Table 9), with some within wetland variation exceeding an order of magnitude (i.e., AI, Hinkson Slough; Cr,Miller Marsh and Swan Lake; Ni, Swan Lake). Arsenic concentrations were significantly different among wetlands (P = 0.031), with higher concentrations in samples from Miller Marsh and Swan Lake than at other wetlands. Boron concentrations were significantly different among wetlands (P = 0.036), with concentrations at Hinkson Slough being much lower than at other wetlands. Cadmium concentrations were also significantly different among wetlands (P = 0.043). Magnesium concentrations were lower at Hinkson Slough, with a significant difference found among wetlands (P = 0.041). Manganese concentrations were significantly different among wetlands (P = 0.025), with lower concentrations at Hinkson Slough, North Pond, and Swan Lake than at the remaining three wetlands. Concentrations of V in pondweed samples were also significantly different among wetlands (P = 0.018), with the lowest concentrations being found at North Pond. Concentrations of Zn were somewhat higher in the samples from Miller Marsh and Hinkson Slough than at the remaining wetlands, with a significant difference among wetlands (P = 0.019). The following elements were significantly positively correlated ($P \leq 0.05$) with four or more other elements: AI, As, Cr, Cu, Fe, and NL The elements that were most commonly positively correlated with one another were metals. Zinc was significantly inversely correlated with B, Mg, and Sr, and Cu and Sr were also inversely correlated with one another.

Aquatic Invertebrates

Relatively little variation in metal and trace element concentrations in corixids occurred among sites within wetlands (Table 10) as well as no consistent pattern in concentrations in relation to locations (Le., inlet, mid-point, and outlet). Arsenic, B, and Sr concentrations were significantly different (P = 0.017,0.024, and 0.036, respectively) among wetlands (excluding data from Cinnamon Pond). The highest As concentrations were found at Lake, whereas the lowest B and Sr concentrations were found at Hinkson Slough. The following metals and trace elements were the only ones significantly correlated ($P \leq 0.05$) with one another: AI-As (r = 0.647); AI-Fe (r = 0.981); As-B (r = 0.704); As-Fe (r = 0.662); B-Ba (r = -0.656); B-Cu

(r = -0.579); B-Mn (r = 0.541); Cu-Hg (r = -0.653); and Cu-Mg (r = 0.543).

Fish

Fish were collected from five of the wetlands (Table 11). Both common carp and largemouth bass were collected only at Cinnamon Pond and Hinkson Slough. The sizes of fish of a given species often did not overlap among wetlands. Concentrations of metals and trace elements in fish are often dependent on age (related to size). Therefore, statistical analyses of the data were not possible. The sizes of the bass and carp overlapped at Hinkson Slough. Movement of fish among wetlands is generally unlikely, but may not be impossible.

Benthic Invertebrate Community Structure

Information on the numbers and types of benthic invertebrates that were collected in samples from five wetland units in 1999 is provided in Table 12. Many aquatic invertebrate taxa common to aquatic environments in Nevada were represented and included 27 Families within 13 Orders. Diptera was the best represented Order (eight Families), followed by Basommatophora (four Families), and Hemiptera (three families). Chironomidae was the most in terms of numbers of individuals in the samples of the total).

Variability Among Wetland Units

Total number of taxa identified at wetland units throughout the study (March-September 1999) ranged from 12 at Hinkson Slough to 19 at Miller Marsh (Table 13). No individual samples collected from wetland units contained every taxa found in the wetland units. Anyone individual sample contained as few as 7 percent (Cinnamon Pond) to as many as 79 percent (Miller Marsh) of all taxa found at that wetland unit during the study period.

The total number of individuals (abundance) collected from wetland units ranged from 534 at Hinkson Slough to 1,072 at Miller Marsh (Table 13); however, no sample was collected at Miller Marsh in March 1999. Kruskal-Wallis tests on abundance data indicated there were no significant differences among wetland units for the study period. Mean abundance per taxon for wetland units during the study period ranged from 20 for Miller Marsh to 44 for Cinnamon Pond (Table 13); however, abundance per taxon values were not significantly different among wetland units.

Mean HBI values for wetland units ranged from 6.2 for Miller Marsh to 6.8 for Perk's Slough (Table 13). Kruskal-Wallis tests on mean HBI values indicated there were no differences among wetland units for the entire study period. Mean Shannon-Wiener diversity indices (SWI) for the wetland units ranged from 0.68 for Hinkson Slough to 1.61 for Miller Marsh (Table 13). No significant differences occurred among wetland units. Mean Margalefs Richness Indices (MRI) for all wetland units ranged from 1.02 at Cinnamon Pond to 2.28 at Miller Marsh (Table 13). MRI values were not significantly different among wetland units.

Taxa dominance data are summarized in Table 14. Many wetland units had high numbers of Chironomidae and Caenidae that were dominant in samples. Cinnamon Pond, Hinkson Slough, and Perk's Slough were dominated by Oligochaeta and Ceratopogonidae, which are discussed in detail later in this report.

Variability Among Sample Events

Results from the benthic macro-invertebrate samples by sample event are summarized in Table 15. The total number of taxa identified in anyone sample ranged from one at Cinnamon Pond in March 1999 to 15 at Miller Marsh in May 1999. The total number of individuals (abundance) collected in samples from wetland units ranged from 53 at Hinkson Slough in March 1999 to 436 at Miller Marsh in May 1999 (Table 15). Abundance was significantly different among sample events ($P < 0.05$). All wetland units, with the exception of Hinkson Slough, had the highest levels of benthic invertebrate abundance occurring in the May sample period.

Mean abundance per taxon for wetland units during the seasonal periods ranged from 9.7 for Perk's Slough in March 1999 to 59 for Cinnamon Pond during the same period (Table 15). However, the average abundance per taxon for Cinnamon Pond is misleading because Chironomidae was the only taxon found in that sample. Excluding this sample, the highest average abundance per taxon was 51.1 for Perk's Slough in May 1999 (Table 15). Although there appeared to be high variability in abundance per taxon among wetland units, there was no significant difference in abundance per taxon among sampling events.

HBI values (Le., average tolerance) for wetland units ranged from 5.4 at Miller Marsh in September 1999 to 7.4 at Hinkson Slough in May 1999 (Table 15). Cinnamon Pond, Hinkson Slough, Perk's Slough, and North Pond had similar HBI values in benthic invertebrate communities for the entire study period (Table 13). However, there was no significant difference in HBI values among sampling events.

SWI values for the wetlands units ranged from zero at Cinnamon Pond in March 1999 to 1.92 for Miller Marsh in September 1999 (Table 15). Miller Marsh and had the highest SWI value overall for the entire study period followed by Perk's Slough (Table 13). However, SWI values were not significantly different among seasons.

Benthic invertebrate community structure in wetland units by seasonal event are discussed in detail in the following paragraphs.

<u>March 1999 Results</u> North Pond had nearly twice the number of individuals for this period compared to the other wetland units, which ranged from 53 to 59 individuals (Table 15). North Pond also had the most taxa for this period, followed by Perk Slough, Hinkson Slough, and Cinnamon Pond. Cinnamon Pond had the highest abundance per taxon; however, as previously mentioned, this sample contained only one taxon, Chironomidae. Cinnamon Pond had the highest abundance per taxon, followed by North Pond, Hinkson Slough, and Perk's Slough. Chironomidae was the most dominant taxon in all samples accounting for 85 to 100 percent of individuals in each sample with the exception of Perk's Slough, which was dominated almost equally by Caenidae (41%) and Chironomidae (40%) (Table 14).

HBI values for Cinnamon Pond, Hinkson Slough, Perk's Slough, and North Pond were similar (Table 15). SWI values for benthic invertebrates were more variable (Table 15). The SWI value in Cinnamon Pond was attributed to the collection of only one taxa (Chironomidae). Although North slightly more taxa than Perk's Slough, the higher SWIvall.le in Perk's Slough was attributable to more even distribution of individuals among taxa. North Pond and Perk's Slough had the highest MRI values, followed by Hinkson Slough and Cinnamon Pond (Table 15).

May 1999 Results Abundance in wetland units was similar in four wetlands, ranging from 375 to 436 individuals, whereas Hinkson Slough had only 140 individuals (Table 15). Hinkson Slough had a very low water level during this period to facilitate the eradication of non-native carp within the unit which likely affected the invertebrate community. Miller Marsh had the most taxa for this period, followed by North Pond, Cinnamon Pond, Hinkson Slough, and Perk's Slough.

Perk's Slough and Cinnamon Pond had the highest abundance per taxon, followed by Miller Marsh, North Pond, and Hinkson Slough (Table 15). Oligochaeta was the most dominant taxon in both Cinnamon Pond and Hinkson Slough, followed by Chironomidae (Table 14). Oligochaeta and Chironomidae combined accounted for 87 percent of individuals in Cinnamon Pond and 90 percent in Hinkson Slough. Perk's Slough and North Pond were dominated by' Chironomidae followed by Caenidae. Miller Marsh was dominated by Caenidae followed by Chironomidae (Table 14). Chironomidae and Caenidae combined in these three remaining wetland units accounted for 75 to 90 percent of individuals.

HBI values were highest for Hinkson Slough, followed by Cinnamon Pond, Miller Marsh, North Pond, and Perk's Slough (Table 15). SWI values for benthic invertebrates were highest in North Pond, followed by Miller Marsh, Cinnamon Pond, Hinkson Slough, and Perk's Slough. MRI values were highest inMiller Marsh, followed by North Pond, HinksonSlough, Cinnamon Pond, and Perk's Slough.

September 1999 Results Abundance in wetland units ranged from 130 in Miller Marsh to 341 in Hinkson Slough (Table 15). Miller Marsh had the most taxa for this period, followed by Perk's Slough, North Pond, Cinnamon Pond, and Hinkson Slough.

Hinkson Slough had the highest mean abundance per taxon, followed by Cinnamon Pond, North Pond, Perk's Slough, and Miller Marsh (Table 15). Chironomidae was the most dominant taxon in Cinnamon Pond and Hinkson Slough, followed by Oligochaeta (Table 14). Chironomidae and Oligochaeta combined accounted for 85 percent of individuals in Cinnamon Pond and 99 percent in Hinkson Slough. Perk's Slough was dominated by Oligochaeta followed by Caenidae and these two taxa combined accounted for 68 percent of individuals in the sample (Table 14). Miller Marsh was dominated by Ceratopogonidae followed by Chironomidae and Diptera (Table 14). Combining these three taxa in Miller Marsh accounted for 65 percent of individuals in the sample. Caenidae was the dominant taxa in North Pond followed by Chironomidae and these two taxa combined accounted for 80 percent of the individuals in the sample.

HBI values were highest for Perk's Slough, followed by North Pond, Cinnamon Pond, Hinkson Slough, and Miller Marsh (Table 15). SWI values for benthic invertebrates were highest in Miller Marsh, followed by Perk's Slough, North Pond, Cinnamon Pond, and Hinkson Slough. MRI values were highest for Miller Marsh, followed by North Pond, Perk's Slough, Cinnamon Pond, and Hinkson Slough.

Wetland Vegetation Species Composition and Relative Abundance

Common names of plant species observed at Mason Valley WMA in September 1999 are provided in Table 16. Results of the line-intercept transects conducted at each of the wetland

units are provided in Table 17.

Fish Condition and Health

Morphological Data

Total length of carp from Hinkson Slough, Cinnamon Pond and Perk's Slough ranged from 290 to 760 nun (Table 18). Inconsistent sampling methods among sites were used; therefore, variation in length among sites was not compared. The mean condition factor for carp from Hinkson Slough was lower than at the other sites (P = 0.003; one way analysis of variance, ANOVA; Nichols et al. 1999). All bass sampled from Perk's Slough had lesions and/or scale loss.

The of bass from Hinkson Slough, Cinnamon Pond, Miller Marsh, and Widgeon Pond ranged from 110 to 370 nun (Table 18). Variation in length among sites was not compared, again due to inconsistent sampling methods. Most bass that were captured were immature, therefore sex could not be determined in the field. Mean condition factor for bass from Hinkson Slough was lower than bass from both Cinnamon and Widgeon Ponds (P = 0.001; one way ANOVA; Nichols et al. 1999).

Pathogen and Histological Data

No significant bacterial or viral pathogens were isolated from carp or bass at any sites that were sampled (Nichols et al. 1999). Gross examination did not reveal any internal parasites in carp. A helminth parasite was observed in bass at three of the four sample sites.

No significant lesions were observed in the spleen, kidney, or liver section from both carp and bass at any of the sample sites (Table 19; Nichols et al. 1999). An encysted helminth was seen in these tissues of bass from all four sites that were sampled. Even though the encysted helminths were quite numerous in some fish (> 10 cysts), no significant lesions were associated with their presence. The heaviest infections were found in bass from Widgeon Pond. Additional information characterizing these parasites can be found in Nichols et al. (1999).

Brown pigments were observed in spleen, kidney, and liver from both fish species. Nichols et al. (1999) indicated that these endogenous pigments were identified as either lipofuscin (by its autofluorescence; excitation at 360 nanometers [om] with maximum emission at 430 om; Shimasaki et al. 1989) or hemosiderin (by its iron staining reaction; Perl's iron stain; Humason 1979).

DISCUSSION

Water Quality

Differences Among Wetlands

Field Data The quality of as demonstrated by data on conductivity, was clearly related to water Sources and the position (i.e., primary, secondary, tertiary, terminal) of wetlands in the system. The lowest conductivity values were related to water samples collected from delivery systems (e.g., hatchery effluent and Joggles Ditch) and in primary wetlands (e.g.,

Hinkson and Perk's Sloughs), followed by samples from secondary wetlands (e.g., Mallard and Lower Pintail Ponds) and tertiary wetlands (e.g., Widgeon and Lower Gadwall Ponds, and Honker Lake), with terminal wetlands (e.g., North Pond, Swan Lake, and Miller Marsh) having the highest conductivity values (Table 5). Salinity concentrations tended to follow the same trend among these sample sources. Dissolved oxygen concentrations did not appear to be related to conductivity and salinity conditions, with the lowest mean concentration found in Miller Marsh and the highest mean concentration in North Pond.

Waters at pH of 9.0 to 9.5 may not be well tolerated by some fish (Sprague 1985). Swan Lake, and Widgeon and North Ponds had pH values within this range. Elevated pH levels also increase the proportion of un-ionized ammonia (NH_3) to ionized ammonia (NH_4^+), with an increase in toxicity to fish (Sprague 1985). The turbidity values observed in the various waters that were sampled may be related to the effects of wind or the presence of common carp, especially in wetlands with low water levels.

Major Constituents In the six intensively sampled wetlands, TDS concentrations generally paralleled SC, with terminal wetlands (Le., Swan Lake, North Pond, and Miller Marsh) having the highest concentrations. TSS concentrations somewhat paralleled turbidity readings, with the same factors likely influencing both parameters. Finely divided suspended solids less than 25 mg/L do not appear to have a harmful effect on fisheries, fish production may be reduced in waters with 25 to 80 mg/L, and good fisheries are not likely in waters with 80 to 400 mg/L (Sprague 1985). The elevated concentrations of Na, chloride, F, and S04 at Swan and North Ponds and Miller Marsh are likely related to the higher TDS concentrations at these sites, as they were highly correlated with one another. Information on the potential toxicity of some constituents is provided below on the section Relations to State Standards, Major Constituents.

Metals and Trace Elements The elevated concentrations of some constituents are likely related to their solubility (e.g., As, B, Mo) as demonstrated by their high correlations to TDS or due to their presence in suspended materials (e.g., AI, Ba, Cu, Fe, Mn, V, and Zn) as shown by their correlations to TSS. Information on the potential toxicity of some metals and trace elements is provided below on the section Relations to State Standards, Metals and Trace Elements.

Relations to State Standards

Field Data Field-collected data on water quality were compared to standards in the Walker River for the reach between the confluence of the West and East Walker Rivers south of Yerington and the inlet to Weber Reservoir as provided in the Nevada Administrative Code (NAC *445A.167;* see Appendix B) to determine if standards for release could be met. The single value dissolved oxygen standards, with the most restrictive beneficial use being aquatic life, are $\geq$ 6.0 mg/L for November through May and $\geq$ 5.0 mg/L for June through October. These standards were not met on five dates at Miller Marsh, three dates at Honker Lake, two dates at Widgeon Pond, and one date each for Hinkson Slough, Perk's Slough, Lower Pintail Pond, Lower Gadwall Pond, Bass Pond, and hatchery effluent (Appendix *A).* Dissolved oxygen conditions in the wetlands under the majority of conditions should not limit discharges to the

rIver.

The pH single value standard for this reach of the river is 7.0 to 8.3, with a maximum difference of ±0.5 pH units for discharge. The maximum pH that would be allowable for release would be 8.8. This value was exceeded on a number of sampling dates at all sampling locations with the exception of the hatchery effluent and Cinnamon Pond sewage outfall (Appendix A). Discharge to the Walker River from North Pond and Swan Lake may be possible in some periods without exceeding the in the river.

The temperature standards for beneficial uses for this reach of the Walker River are ≤ 13°C for November through March, ≤ 24°C for April through June, and ≤ 28°C for July through October, with the most restrictive use being aquatic life, with a difference of ≤ 2 °C for discharge. The requirements to maintain existing higher quality (RMEHQ; the State of Nevada's equivalent of U.S. Environmental Protection Agency's antidegradation policy) provide for a temperature difference equal to 0 °C for discharge. Temperatures occasionally exceeded the standard for RMEHQ, with the standard not being met 10 times in June 1999 or 2000 and two times in March 1999 or 2000 (Appendix A). Wetlands where the standard was not met included Cinnamon Pond, Perk's Slough, Widgeon Pond, North Pond, Hinkson Slough, Miller Marsh, and Swan Lake. The low frequency of cases where the standard was not met should not preclude discharges to the river in most seasons.

The beneficial use standard for turbidity states that the increase must not be more than 10· NTU above natural conditions. Turbidity in Walker River water at Wabuska ranged widely from 1 to 100 NTU for the period January 1994 through May 2002 (Appendix C), with a mean of 24 NTU (Table 20). Turbidity at some wetland units often exceeded this mean (Table 5). However, discharges to the river from North Pond and occasionally at Swan Lake should be possible during some periods without exceeding the standard.

Major Constituents Data for major constituents of water quality were compared to standards in the Walker River for the reach between the confluence of the West and East Walker Rivers south of and the inlet to Weber Reservoir as provided in NAC 445A.l67 (see Appendix B), to determine if standards for release could be met. Total dissolved solids concentrations at Miller Marsh, Swan Lake, and North Pond consistently exceeded the standard (i.e., ≤ 500 mg/L, annual average for beneficial uses). Exceedances of the TDS standard at Swan Lake and North Pond would prevent discharge to the Walker River unless an exemption is granted. The annual average (i.e., ≤ 400 mglL) or single value (Le., ≤ 450 mglL) TDS values for RMEHQ were exceeded for two samples at Cinnamon Pond and one at Perk's Slough. The single value standard (Le., ≤ 80 *mglL* for beneficial uses) for total suspended solids was exceeded in four samples at Hinkson Slough, three samples at Cinnamon Pond, two samples at Swan Lake, and one sample at Perk's Slough. Consistent exceedances of the standard in Swan Lake would prevent discharge to the river, unless an exemption is granted.

The nitrate standard (i.e. ≤ 10 mglL for beneficial uses) was not exceeded in any sample. The standards for RMEHQ for total nitrogen are ≤ 1.2 as an annual average and ≤ 1.5 as a single value. At least one of these standards was exceeded at each wetland, except for Perk's Slough. The single value beneficial use standard for un-ionized ammonia 0.06 mglL. The percentage of un-ionized ammonia of total ammonia varies with pH and temperature. We used the table

from Thurston et al. (1979) on the percentage of un-ionized ammonia as a function of pH and temperature to determine the concentrations of un-ionized ammonia in our samples. The concentrations present in the following samples (sites, dates, and concentrations) exceeded the standard: Miller Marsh, March 15,2000,0.16 mg/L; Cinnamon Pond, March 15,2000,0.067 mg/L; Swan Lake, July 7, 2000, 0.066 mglL; and North Pond, July 6, 2000, 0.16 mglL. Nitrogen species did not frequently exceed the standards in the Walker River; therefore, discharges to the River during some periods should be possible.

The ammonia standard for the State of Nevada is being modified (NDEP 2002b). The acute (1 hour) water quality criteria for freshwater aquatic life are divided between cold water fisheries and warm water fisheries and vary with pH of the water, with ammonia concentrations declining with increases in pH. The concentrations may not exceed the criteria more than once every 3 years on the average. The chronic (30 day) criteria are divided between cases where freshwater fish early life stages may be present and where such life stages are absent. The chronic criteria are affected by both water temperature and pH. The concentration for total ammonia may not exceed the criteria more than once every 3 years on the average, and the highest 4-day average within the 30-day period should not exceed 2.5 times the chronic criteria. Data were for comparison of the criteria to the ammoniaconcentrations in only the March and July 2000 samples from this study due to missing data for one or more parameters for other dates. Both of the chronic criteria were exceeded in the samples from Miller Marsh in March 2000 (0.39 vs. 0.27 mg/L) and North Pond in July 2000 (0.23 vs. 0.14 mglL). The chronic criteria for the protection of early life stages of freshwater fish was approached at Cinnamon Pond for the March 2000 sample (1.2 vs. 1.29 mg/L). The acute standard for cold water fisheries was approached in the March 2000 sample from Miller Marsh (0.39 vs. 0.52 mg/L).

The single value beneficial use standard for chloride is $\leq$ 250 mglL and the RMEHQ annual average and single value standards are $\leq$ 30 and $\leq$ 35 mg/L, respectively. The beneficial use standard was not exceeded in water from the wetlands. However, all samples from Miller Marsh, Swan Lake, and North Pond exceeded the RMEHQ standards, and three of five from Cinnamon Pond exceeded at least one of these standards. The irrigation and watering of livestock standards for fluoride are 1 and 2 mglL, respectively (Appendix D). Both standards were consistently exceeded in all samples from Miller Marsh, Swan Lake, and North Pond. The irrigation standard was also equaled or exceeded in three samples from Hinkson Slough and one sample from Perk's Slough. Discharges to the river would not be possible unless an exemption to the standards for chloride and F is granted.

The single value beneficial use standard for 80_4 is $\leq$ 250 mg/L and the RMEHQ annual average and single value standards are $\leq$ 95 and $\leq$ 110 mg/L, respectively. The beneficial use standard was exceeded in all samples from Miller Marsh and one sample from Swan Lake. Also, at least one RMEHQ standard was exceeded in one sample from Cinnamon Pond, three additional samples from Swan Lake, and five samples from North Pond. Discharges to the river may not be unless an exemption to the standards for 80_4 is granted.

The beneficial use standards for fecal coliforms are based on a minimum of not less than five samples taken over a 30-day period. The geometric mean may not exceed 200/100 ml nor may more than 10 percent of the total samples taken during any 30-day period exceed 400/100

ml. The annual geometric mean and single value standards for RMEHQ are ≤ 100 and ≤ 200 per 100 ml, respectively. Fecal coliforms in only two samples from Cinnamon Pond exceeded the annual geometric mean RMEHQ value, with none exceeding the beneficial use values. Fecal coliform levels in North Pond and Swan Lake would not prevent discharges to the Walker River.

Metals and Trace Elements Concentrations of metals and trace elements in water were compared to aquatic life standards for the State of Nevada (NAC 445A.144; see Appendix D) to determine possible effects on aquatic life and determine if standards for release to the Walker River could be met. Most standards apply only to the dissolved fraction (filtered samples), whereas none of our samples were filtered. Standards based on dissolved concentrations include, As, Cd, Cr, Cu, Pb, Hg (acute only), Ni, Ag, and Zn. Therefore few direct comparisons could be made to State standards.

There is no State aquatic life standard for B. However, Eisler (2000b) indicated that 1,000 to 2,000 µg/L was non-hazardous in aquatic communities and that 10,000 to 12,000 µg/L may cause adverse effects to sensitive species of fish. Boron concentrations in water from Miller Marsh, Swan Lake, and North Pond were generally within the concentration range that was considered non-hazardous to aquatic communities, but were far below the concentration that may cause adverse effects in sensitive species of fish.

There is no standard for total Cr and we do not have data on the species of Cr present in our samples. The chronic standard for Cr^{+6} is 10 µg/L and applies to the dissolved fraction. The only detectable total Cr concentration was 10 µg/L, with all detection limits being below this standard. The hardness-based standard for dissolved Cr^{+3} was far above the detection limit for our samples. Therefore, the standards for chromium could not have been exceeded. The detection limit for eu was not adequate and resulted in a number of non-detectable results.

The aquatic life standard for Fe is based on total recoverable and therefore directly applies to the concentrations in the samples we collected. The standard was exceeded for the following wetland units for the following collection dates: Miller Marsh, all dates in 1999; Hinkson Slough, all dates in 1999, and July 2000; Cinnamon Pond, all dates; Perk's Slough, all dates, except July 2000; and Swan Lake, June and August 1999, and March 2000.

The acute (1 hour) aquatic life standard for dissolved Hg is 2 µg/L and was an order of magnitude higher than the detection limit (i.e., 0.2 µg/L) for total Hg in our samples, which was not exceeded. It is impossible to determine if the chronic (96 hour) standard (Le., 0.012 µg/L), which is based on total recoverable Hg, was exceeded because the detection limit was higher than the criterion.

The aquatic life standard for Mo (Le., 19 µg/L) is based on the total recoverable fraction and was equaled or exceeded at the following wetland units for the dates given: Miller Marsh, all dates; Hinkson Slough, June and August 1999; Perk's Slough, March 1999 and March 2000; Swan Lake, all dates, with the standard being exceeded by more than an order of magnitude in March 2000; and North Pond, all dates.

did not exceed the hardness-based chronic aquatic life standard for dissolved Ni in any samples. Therefore, the standard could not have been exceeded. The chronic aquatic life standard for Se (5 µg/L) is based on total recoverable. Selenium was not detected in any samples at 5.6 µg/L, which is slightly higher than the standard. The detection limit for Se was

only marginally adequate.

No State aquatic life standards are present for the following constituents that were analyzed in our samples: AI, B, Ba, Be, Mg, Mn, Sr, and V. Aluminum concentrations in all but one sample exceeded the Federal criterion (i.e., 87 Toxicity of Al in water varies considerably with species and complexation (Sparling and Lowe 1996), with speciation being affected by several environmental variables, especially pH. Aluminum has a low solubility in the pH range of 6.0 to 8.0 and is considered to be biologically inactive. Solubility increases in more alkaline solutions (Le., pH> 8.0), but biological implications are not well understood.

Discharges from North Pond would meet the aquatic life standard for Fe. However, the aquatic life standard for Mo was consistently exceeded in both North Pond and Swan Lake; therefore, discharge from these wetlands would be possible only if an exemption to the standard was granted. Uncertainty exists with regard to discharge limitations for Se because the detection limit slightly exceeded the aquatic life standard.

Concentrations of metals and trace elements in water were also compared to standards for municipal or domestic supply, irrigation, and watering of livestock provided in NAC *445A.144* (see Appendix D), to determine if standards for release to the Walker River could be met. All of these standards would need to be met as they are beneficial uses of this reach of the Walker River. All water samples from Miller Marsh, Swan Lake, and North Pond, and one of five from Hinkson Slough exceeded the municipal or domestic supply standard for As (i.e., 50 µg/L). All samples from Miller Marsh and Swan Lake, and four of five from North Pond exceeded the irrigation standard for As (Le., 100 and all samples from Miller Marsh and three of four from Swan Lake exceeded the As standard for watering of livestock (i.e., 200 µg/L). All water samples from Miller Marsh, Swan Lake, and North Pond exceeded the B irrigation standard (i.e., *750* µg/L). One water sample from Swan Lake exceeded the municipal or domestic supply standard for Cd (i.e., 5 One of five samples from Perk's Slough and two of four samples from Swan Lake exceeded the irrigation standard for Fe (i.e., 5,000 The Mn standard for irrigation (Le., 200 was exceeded in two samples each from Miller Marsh, Perk's Slough, and Swan Lake, three samples from Hinkson Slough, and one sample from Cinnamon Pond.

Discharges to the Walker River from both Swan Lake and North Pond may not be possible without an exemption to the standards due to concentrations of As, B, Fe ,and/or Mn that exceed the standards for municipal or domestic supply, irrigation, and/or watering of livestock.

Relations to Walker River Water Quality

Average concentrations of various parameters in water from the Walker River near Wabuska, from NDEP data for the period 1994 to 2002 are provided in Table 20; the detailed data are provided in Appendix C. Total metal and trace element concentrations in the samples collected by NDEP are consistent with the methodology of our study. A number of metals or trace elements were usually not detected in the wetlands and the river and included Cd, Cr, Ph, andSe. Concentrations ofCu were similar in most wetlands andthe river, except for Swan Lake, where theconcentrations were much higher than in the river. The concentrations of Fe in North Pond were lower than those found in the river, whereas they were similar in Miller Marsh and the river, with the remainder of the wetlands having higher concentrations than those found in the

river. The concentrations of Zn tended to be similar in both the wetlands and the river. Arsenic concentrations were usually much higher in the wetlands than the river. Boron concentrations were similar in the river, Hinkson Slough, Cinnamon Pond, and Perk's Slough, with the remaining wetlands having higher concentrations than the river. Magnesium concentrations were lower in Miller Marsh than the river, similar in Hinkson Slough and the river, and tended to be higher in the remaining wetlands than the river.

Comparisons were also possible for a number of major constituents. Total dissolved solids were slightly to much higher in the wetlands than the river. Total suspended solids were lower in North Pond and Miller Marsh than the River and tended to be higher in the remaining wetlands. Turbidity in the river appeared to increase during periods of higher flow (Table 21) and was highly variable among wetland units, possibly in part related to wind conditions. Comparisons of concentrations of various forms of nitrogen were difficult, with the exception of K-N which tended to be higher in the wetlands than the river. Phosphorus concentrations were also generally higher in wetlands than the river. Chloride concentrations were similar in Hinkson Slough and the river, with higher concentrations being found in the remaining wetlands. Sulfate concentrations were similar in the river and Perk's Slough and higher in other wetlands than the river. Sodium concentrations were generally slightly higher to much higher in wetlands than the river. Temperature varied greatly in both the wetlands and the river in relation to season. Dissolved oxygen concentrations tended to be similar in both wetlands and the river, with occasional low concentrations in both. Some wetlands tended to have higher pH than the river. Fecal coliform concentrations were lower in the wetlands than the river.

If concentrations of various constituents had been higher in the Walker River than in the wetlands, especially those wetlands intended for discharge, then one might make a case for allowing discharges to the even if water quality standards were not met. However, no evidence for this was found.

The u.S. Geological Survey (Clary et al. 1995; Bauer et al. 1996; Thodal and Tuttle 1996) also sampled water quality in the Walker River near Wabuska on eight dates between May 1994 and June 1995. Mean (extreme) values for parameters of interest were: SC 339 (152-476); pH 8.1 (7.9-8.2); turbidity (n = 7) 18.5 NTU (0.60-61); DO 8.3 mglL (7.0-10.6); and suspended sediment (n = 7) 116 mg/L (1-347). Dissolved oxygen and pH values were within State water quality standards, whereas the suspended sediment concentration exceeded the State standard on some dates. USGS also collected data on SC at this site during the period of our study (Jones et al. 1999; Allander et al. 2001). Monthly means for this period are provided in Table 22. Specific conductance can be used as a general indicator of water quality; however, no State standard is present for this constituent. Specific conductance of water in some wetland units consistently exceeded that found in the river (Appendix A).

Relations to Water Quality Data Reported By Dischargers and Others

The Sierra Pacific Power Company is required toreport to NDEP data on water quality in their discharges from their cooling 'pond at the Fort Churchill plant to Miller Marsh'(Table 23) and to North Pond (Table 24). Concentrations of various constituents in water discharged to Miller Marsh as reported by the Sierra Pacific Power Company (Table 23) were generally similar to the concentrations found in Miller Marsh in this study (Tables 6 and 7). Concentrations of

various constituents in water discharged to North Pond by the Sierra Pacific Power Company (Table 24) were also generally similar to the concentrations found in North Pond in this study with the following exceptions. Concentrations of TDS, fecal coliforms, and B were higher in the discharge than those found in the wetland.

Water quality data has been collected by NDEP in North Pond and a summary of the data for March 1999 through September 2001 is reported in Table 25. The concentrations of most constituents in the NDEP data were similar to those of this study with the following exceptions. Much higher concentrations of DO, TSS, and turbidity were found in this study than that reported by NDEP. Data on the quality of water discharged to North Pond (Table 24) were also compared to the data reported by NDEP. Total dissolved solids and Fe were higher in the water discharged to North Pond than in the water from North Pond as reported by NDEP.

The City of Yerington is required to report the quantity of discharge and pH and TSS in the discharge to the Mason Valley WMA, as well as fecal coliforms in Cinnamon Pond, the discharge point, with reports going to NDEP. A summary of these data for 1998 through 2000 is provided in Table 26. The discharge quantities much lower than those reported by NDOW (Table 1). The pH of the water in the discharge was slightly lower than that found at the inlet of Cinnamon Pond (Table 5), with similar results for TSS. The range of cQunts of fecal coliforms in Cinn.amon reported by the City of Yerington were similar to our findings (Table 6).

Sediment Quality

MacDonald et al. (2000) has provided consensus-based sediment quality guidelines, specifically threshold effect concentrations (TEC) and probable effect concentrations (PEC), for several metals and trace elements in relation to biological effects in freshwater ecosystems. A TEC is a concentration below which harmful effects are not likely to be observed and a PEC is a concentration above which harmful effects are likely to be observed, both of which are expressed on a dry weight basis. The TEC for As (i.e., 9.79 micrograms per gram, μg/g) was exceeded in all sediment samples from Miller Marsh, Perk's Slough, and Swan Lake, in two of three samples each at Hinkson Slough, and in one sample at Cinnamon Pond. The PEC for As (i.e., 33.0 μg/g) was exceeded in all samples from both Miller Marsh and Swan Lake. The TEC (i.e., 0.99 μg/g) for Cd was exceeded in two samples from Swan Lake and was approached in the third sample from Swan Lake. The PEC for Cd (i.e., 4.98 μg/g) was much higher than in any samples from the wetlands. Concentrations of Cr in samples from all wetlands were much lower than the TEC (i.e., 43.4 μg/g). The TEC for Cu (i.e., 31.6 μg/g) was exceeded in all samples at Swan Lake, in two of three samples each from Perk's Slough, Hinkson Slough, and North Pond, and in one sample from Miller Marsh. The PEC for Cu (i.e., 149 μg/g) was not approached or exceeded in any samples. The TEC for Hg (i.e., 0.18 μg/g) was exceeded in two samples, one each from Perk's and Hinkson Sloughs. However, the Hg concentrations in these samples were far below the PEC (i.e., 1.06 μg/g) for Hg. The TECs for Ni (i.e., 22.7 μg/g) and Pb (i.e., 35.8 μg/g) were not exceeded in any samples from the wetlands. The TEC for Zn (i.e., 121 pg/g) was exceeded in only two samples from Miller Marsh.

Persaud et al. (1993) identified a concern level for Fe in sediment of 21,200 μg/g (dry weight). This concentration was exceeded in all sediment samples from Swan Lake, two samples

at Perk's Slough, and one sample from each of the remaining wetlands. Persaud et al. (1993) also identified a concern level for Mn in sediment of 460 μg/g. This concentration was exceeded in at least one sediment sample from each wetland and all three samples from Swan Lake. Co-precipitation of trace metals or toxic non-metallic elements such as As, typically with Fe or Mn oxyhydroxides can be quantitatively significant in constructed wetland systems, with the generally insoluble precipitates retained with the wetland matrix (Rodgers 1999). This might explain, in part, the combined elevated concentrations of As, Fe, and Mn in sediment samples from Swan Lake. The toxicity threshold for Se in sediment in relation to adverse effects for fish and wildlife was identified as $\geq$ 4 μg/g (dry weight; Lemly and Smith 1987; U.S. Department of the Interior 1998). None of the sediment samples from the wetlands approached this Se concentration.

No consistent patterns in residue concentrations in sediment were observed in relation to water sources. However, elevated concentrations of some elements were often found in both water and sediment from some terminal wetlands. These included As at both Miller Marsh and Swan Lake, and Cd, Cu, Fe, and Mn at Swan Lake. There was no consistency between water and sediment for elevated Zn concentrations. The slightly elevated concentrations of Hg in one sedimentsample atboth Perk's and Hinkson Sloughs may be due to past (Hinkson Slough) or continuing (Perk's Slough) deliveries of water directly from the Walker River to these wetlands. Mercury was used in the recovery of precious metals in mining districts in the Walker River basin in the late 1800's and elevated concentrations have been found in fish and aquatic invertebrates in the basin downstream of mining districts that were active during this period (Wiemeyer 2002). Mercury is redistributed during high flow events and may have reached these wetlands. Various soil types are present in the areas of the wetlands that were sampled (Archer 1984). Metal and trace element concentrations may be affected by the geochemical makeup of the soils. Soils in the area of North Pond tend to be more alkaline than those that are present in areas of other wetlands that were sampled (Archer 1984). This may have caused the higher pH levels in water that were present at North Pond. A potential source of various metals and trace elements in sediment, and water as well, of all wetlands is wind-blown dust from tailings and evaporation ponds and other areas at the Yerington Mine which is southwest of the Mason Valley WMA. However, the constituents in dust, their concentrations, and depositional areas are currently unknown and will be the focus of future studies (Brown and Caldwell 2002).

Metals and Trace Elements in Biological Samples

Pondweed

Concentrations of metals and trace elements in pondweed were evaluated as a potential food source to migratory birds. An Al concentration of 5,000 μg/g (dry weight) was considered an adverse dietary effect level in waterfowl (Sparling 1990). This concentration was exceeded in one sample Cinnamon Pond and approached in another sample from this wetland as well as in single samples from Hinkson Slough and Swan Lake. An As concentration of 30 (dry weight) in diet of mallard *(Anas platyrhynchos)* ducklings was associated with reduced weight gain (Camardese et al. 1990). This concentration was exceeded in at least one pondweed sample from four of the six wetlands, with all three samples from both Miller Marsh

and Swan Lake exceeding this concentration.

Weight gain of mallard ducklings that received a diet containing 30 μg/g (dry weight) B was significantly reduced, whereas the reproductive success of adult mallards that received a diet containing 1000 μg/g (dry weight) was significantly reduced (Smith and Anders 1989). All but one pondweed sample contained more than 30 μg/g (dry weight) B, with none exceeding 1000 μg/g. Cadmium concentrations in pondweed samples were well below a level of concern in mallard ducklings (20 μg/g dry weight; Cain et al. 1983).

Eisler (2000a) proposed a threshold concentration of 10 μg/g dry weight Cr in the diet of wildlife above which one might expect potential adverse effects on health and reproduction. This concentration was exceeded in all but three pondweed samples, with one sample from Swan Lake and two samples from Miller Marsh exceeding it by more than an order of magnitude. Eisler (2000a) considered poultry diets containing < 200 μg/g dry weight Cu to be safe. Nearly all pondweed samples contained Cu concentrations that were an order of magnitude lower than this concentration.

Mercury concentrations in all pondweed samples were below an avian dietary effect concentration of 0.5 μg/g dry weight that was associated with adverse reproductive effects in mallards (Heinz 1979). Molybdenum concentrations in pondweed were well below a lower dietary concentration of 200 μg/g dry weight associated with reduction in birds (Eisler 2000b).

A dietary concentration of 800 μg/g fresh weight Ni has been associated with adverse effects to adult mallards (Eisler 2000a); concentrations in pondweed were far lower. An avian dietary concentration of < 5 μg/g dry weight Pb was proposed to be protective by Eisler (2000a). Lead was not detected in pondweed samples, with detection limits well below this concentration.

Selenium concentrations in pondweed were all well below the lower threshold (i.e., 3 μg/g dry weight) of dietary exposure associated with reproductive effects in birds (U.S. Department of the Interior 1998). Vanadium concentrations in pondweed were well below an avian dietary concern level (100 μg/g dry weight; White and Dieter 1978). Zinc concentrations in pondweed were below dietary effect levels proposed for the protection of birds (Eisler 2000a).

No consistent patterns in residue concentrations in pondweed were observed in relation to water sources. Arsenic and B concentrations were significantly correlated between sediment and pondweed at the wetland units (Spearman rank correlation; $r = 0.729$ and 0.604, respectively; $P < 0.01$). Elevated concentrations of As occurred in water, sediment, and pondweed at Miller Marsh and Swan Lake. The presence of elevated concentrations of Cr in some pondweed samples from Miller Marsh and Swan Lake was unexpected because it was not detected in water and concentrations in sediment were not significantly different among wetlands.

Aquatic Invertebrates

Concentrations of all metals and trace elements in invertebrate samples, except Hg, were well below dietary concern or effect levels for birds. Mercury concentrations in at least one sample from each wetland, except Cinnamon Pond, exceeded the dietary effect level (i.e., 0.5 μg/g dry weight) associated with adverse reproductive effects in mallards (Heinz 1979). However, only a portion of the diet of dabbling ducks would consist of aquatic invertebrates. Other species of birds such as American avocets *(Recurvirostra americana)* and black-necked

stilts *(Himantopus mexicanus)* would be expected include aquatic invertebrates as a significant portion of their diet. The sensitivity of these latter species to mercury is not clearly known.

No consistent patterns in residue concentrations in corixids were observed in relation to water sources. Arsenic concentrations appeared to be consistently higher in water, sediment, pondweed, and corixids at Miller Marsh and Swan Lake than at other wetlands. The following elements were significantly correlated (Spearman Rank Correlation) between sediment and corixids at the wetland units: As ($r = 0.754$, $P < 0.01$); B ($r = 0.656$, $P < 0.01$); Mg ($r = 0.582$, $P < 0.05$); and Sr ($r = 0.536$, $P < 0.05$). The following elements were significantly correlated between pondweed and corixids at the wetland units: As ($r = 0.631$, $P < 0.05$); and Cu ($r = -0.615$; $P < 0.05$).

Fish

Bass and carp from the same wetland tended to have different contaminant profiles, with bass having higher concentrations of Hg than carp, likely due to being piscivorous (Le., higher on the food chain) and carp tending to have higher concentrations of Ba, Cu, Sr, and Zn. The only constituents that exceeded concern or effect concentrations for consumption by wildlife were Cr and Hg. All Cr concentrations exceeded the proposed dietary effects threshold concentration of 10 µg/g dry weight for wildlife, above which one might expect potential adverse effects on health and reproduction (Eisler 2000a). Most samples of largemouth bass had Hg concentrations that exceeded the dietary effect concentration (Le., 0.5 µg/g dry weight) for adverse reproductive effects on mallards, with the highest concentrations being found in bass from Hinkson Slough, all of which exceeded 1.5 µg/g dry weight. Two of three carp samples from Hinkson Slough also had Hg concentrations which exceeded the dietary effect concentration. However, adult fish-eating birds appear to be capable of demethylating methylmercury, the most toxic form, thereby reducing the potential for adverse effects (Thompson 1996; Wiemeyer et al. 2001; Henny et al. 2002). However, potential adverse effects to juvenile fish-eating birds continue to be a concern.

Residues in fish were also evaluated with regard to potential adverse effects to fish health. Diminished growth and survival of immature bluegills occurred when total As residues in muscle were greater than 1.3 µg/g (fresh weight) or greater than 5 µg/g in adults (Eisler 2000b). Arsenic concentrations in fish from the wetlands were much lower than these concentrations. Adverse effects to fish may be expected when Hg concentrations in whole body reach 3 µg/g wet weight (Eisler 2000a); Hg concentrations in fish from the wetlands were much lower. The threshold concentration of Se that may effect health and reproductive success of fish is 4 µg/g (dry weight; whole body; Lemly 1996). Concentrations of Se in fish from the wetlands were much lower.

The higher Hg concentrations in fish from Hinkson Slough are consistent with the elevated concentrations of Hg in sediments from this wetland. No consistent patterns in residue concentrations in fish were observed in relation to water sources.

The concentrations of Hg on a wet weight basis in largemouth bass from Hinkson Slough ranged from about 0.36 to 0.54 µg/g. Essentially all Hgin fish in is the toxic methyl form (Wiener and Spry 1996). Human consumption of fish with methylmercury concentrations in this range should be limited to one to two 8 ounce meals per month (U.S. Environmental Protection Agency 2000).

Benthic Invertebrate Community Structure

Effective environmental management requires biological indicators to assess the status of and/or trends in resources of interest. Benthic infauna have been used extensively as indicators of environmental status in the freshwater environment (Plafkin et al. 1989; Bauer and Burton 1993; Rosenburg and Resh 1993; Barbour et al. 1995; Resh et al. 1995). Benthic organisms have a wide range of physiological tolerances, feeding modes, and trophic interactions, making them sensitive to a wide array of environmental stressors (Barbour et al. 1999). Benthic invertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects of environmental conditions. Because benthic organisms have limited mobility and cannot avoid adverse conditions, they are exposed to contaminants accumulated in sediments and low concentrations of oxygen in near-bottom waters. As a result, benthic assemblages, unlike most pelagic fauna, reflect local environmental conditions (Gray 1979). Another advantage of using benthic infauna as biological indicators is their taxonomic diversity.

Mean benthic invertebrate community metrics for the entire study period indicated that Miller Marsh ranked the highest in abundance, number of taxa, diversity, richness, and lowest in an indicator of organic pollution based upon resident intolerant (Table 13). However, subtle shifts in these metrics were observed among wetland units among sample events. Wetland units where benthic invertebrate community metrics illustrated subtle shifts were Perk's Slough and North Pond during March and North Pond for May.

During the March 1999 period, the benthic invertebrate communities were superior at North Pond and Perk's Slough. North Pond had the highest abundance, MRI, and number of taxa compared to the other wetland units during the March period. At this time Perk's Slough had the highest benthic invertebrate community diversity compared to other wetland units and nearly equaled North Pond in community richness. Cinnamon Pond had the lowest HBI value in March. As previously mentioned, Chironomidae was the only benthic invertebrate collected in Cinnamon Pond in March. This result should be interpreted with caution because Chironomidae were not identified to a species level. Certain species of Chironomidae are indicators of good quality water, whereas other species are indicative of poor quality water (Epler 2001). Excluding the HBI value for Cinnamon Pond, North Pond had the lowest HBI value in March, an indicator of "fairly significant organic pollution" according to Hilsenhoff (1987). However, HBI values for all wetland units for this period fell within the same category.

During the May 1999 period, benthic invertebrate communities were superior at North Pond and Miller Marsh. Miller Marsh had the greatest abundance of benthic invertebrates during May. However, other wetland units were comparable in terms of abundance with the exception of Hinkson Slough, which was affected during this period by wetland dessication for carp removal which was initiated in March. Miller Marsh had the highest MRI along with the most number of taxa found among wetland units for this period. North Pond also had the highest basedupon SWI values. However, Perk's Slough in May was the only wetland unit whose HBI indicated "fairly significant organic pollution." All other wetland units in May had HBI values indicating "significant organic pollution" with Cinnamon Pond and Hinkson Slough having the highest values.

The benthic invertebrate community metrics for September 1999 again indicated that Miller Marsh had the superior invertebrate community. Although Miller Marsh had the lowest abundance for this period among wetland units sampled, it had the highest number of taxa along with the highest values of diversity and richness. In addition, the HBI value for Miller Marsh was the lowest compared to other wetland units (5.4), an indicator of some organic pollution according to Hilsenhoff (1987). HBI values for Cinnamon Pond and Hinkson Slough for the same period were classified as "fair" indicating "fairly significant organic pollution," and North Pond and Perk's Slough were classified as "fairly poor," an indicator of "significant organic pollution."

Benthic invertebrate communities at wetland units can be influenced by differences in chemical water quality, available habitat, flow variability, and wetland management practices. Variations in sample collection method or analysis precision can also cause variations in the data. However, no statistical differences were detected in benthic-community metrics when comparisons were conducted among wetland units and sampling events, with the exception of abundance where it was the greatest in all wetland units during the May sample event. A greater difference between the biotic index values of the wetland units may have resulted if Chironomidae·were identified to species level.

Although benthic communities tended to be superior at Miller Marsh, these data did not correspond with data on water and sediment quality. Miller Marsh tended to have the highest concentrations of TDS, Na, chloride, F, 804' As, B, and Mo in water and the highest concentrations of As, Mo, and Zn in sediment among the wetlands sampled. The probable effect concentration for As in sediment at Miller Marsh was exceeded, above which adverse effects are expected to occur.

Wetland Vegetation Species Composition and Relative Abundance

Monitoring of vegetation characteristics can give indications of wetland health as well as provide infonnation for comparisons between plant species, flow regimes, and other wetlands, either natural or constructed. Vegetation has shown to be a sensitive measure of environmental stressors such as hydrologic alterations, eutrophication, sedimentation and siltation, and other anthropogenic disturbances (van der Valk 1981, Moore and Keddy 1989, Galatowitsch 1993, Wilcox 1995, Kantrud and Newton 1996, Stromburg and Patten 1996, Philippi et aI. 1998). There are also strong relationships between wetland vegetation and water chemistry. Vegetation can remove contaminants through uptake and accumulation in tissues, but also act as a pump by moving compounds from the sediment into the water column. The ability of vegetation to improve water quality through the uptake of contaminants is well documented (Gersburg et aI. 1986, Reddy et aI. 1989, Peverly et aI. 1995, Rai et al. 1995, Tanner et al. 1995). Water quality also has a strong influence on the wetland plant community structure (Grootjans et al. 1998, Rey Beneyas et al. 1990, Rey Beneyas and Schneider 1993).

Aquatic vegetation in each of the wetland units was highly variable in terms of species present and percent cover. Some species of aquatic vegetation were observed in only one wetland unit and not in any others (Table 27). However, certain species were present in a majority, if not all wetland units. Those species included cattail *(Typha latifolia),* algae,

pondweed, hard-stem bulrush *(Schoenoplectus acutus),* inland saltgrass *(Distichlis spicata),* and stonewort *(Tolypella* spp.).

The aquatic vegetation data collected in this study are only a description of presence/absence and coverage of aquatic flora in the wetland units. Trends in aquatic vegetation communities and characterization of water quality impacts to those aquatic vegetation communities would be possible with additional survey efforts in the future. However, determination of those trends were not possible with this study and only baseline information could be presented in this report.

Fish Condition and Health

The lower mean condition factors for carp and largemouth bass at Hinkson Slough may have been related to the low water levels that were present. The presence of lesions and scale loss in bass at Perk's Slough may have been related to the sampling method (Le., gill netting) or some other factor.

Lipofuscin is often referred to as "age pigment" and forms when cellular lipids and phospholipids are oxidized into an insoluble intracellular pigment. Nichols. et al. (1999) will accumulate lipofuscin in their cytoplasm and form aggregates of lipofuscin-filled cells. Furthermore, these aggregates form discrete brown foci in tissues. Hemosiderin is typically concentrated in the reticuloendothelial cells of the spleen and kidney as they recycle Fe from degraded erythrocytes. The focal brown pigment deposits in the kidney and spleen were entirely composed of lipofuscin in both species of fish. Hemosiderin was only observed in the liver where it represented approximately 20 percent of the brown pigment in liver, the remainder being lipofuscin. The number of fish with brown pigments in the examined organs varied among sites (Table 19). Bass from Hinkson had both the highest prevalence and severity rating of splenic lipofuscin deposits of all- of the sample groups. Although lipofuscin deposits are not considered a significant lesion, their presence suggests that many of the fish were under some level of oxidative stress (e.g., water quality, diet; Nichols et al. 1999).

WETLAND MANAGEMENT RECOMMENDATIONS

A variety of point and non-point sources of contaminants in water have been treated through the use of constructed and natural wetlands which have the ability to transform, sequester, and transfer materials in wastewater. The resulting discharge from a wetland, therefore, may decrease the impact of physical and chemical stressors on receiving waters (Rodgers 1999). However, there is no proven method for predicting wastewater assimilation in wetlands. Denitrification rates and storage are high in wetlands, therefore, outputs are generally not a problem (Rodgers 1999). Also, wetlands provide good sinks for many trace metals. The following retention efficiencies for various contaminants were compiled and reported by Rodgers Al > 35 - > 98.1; Cd 50 - > 99.7; Cr 50 - > 98.2; eu 50 - 100; Fe 84.6 - 100; Pb 80 - 95; Mn 16.4 - 90; Hg 50 - 90; Ni > 84.3 - 80; Zn 27 - 100; organic N95; ammonia-N 62 - nitrate-N 57 - 94, and T-N 51-98. Reducing sediments with overlying water with a basic pH are considered better for sorbing Zn and Cu than are oxidizing environments with an effluent pH of

less than 7.0 (Rodgers 1999). Also co-precipitation of trace metals or toxic non-metallic elements such as As, typically with Fe or Mn oxyhydroxides can be quantitatively significant in constructed wetland systems, with the generally insoluble precipitates retained with the wetland matrix (Rodgers 1999). Even though wetlands may prove useful in the treatment of waters, adverse effects to ecologically important species may occur.

Operation of the Mason Valley WMA as a terminal system, without discharge to the Walker River, has likely contributed to elevated concentrations of TDS and metals and trace elements in various wetlands, especially those at the terminus of the system. Without discharges, these conditions will gradually worsen, with increased risks for adverse effects to fish and wildlife resources. Water quality for a number of constituents in some WMA wetlands exceeds the standards that may be set by NDEP for discharge to the Walker River, possibly precluding discharge to the river. The Nevada Division of Wildlife may wish to explore various options for discharge which could include a request for a short-term variance or exemption to water quality standards in the river, possibly during high-flow periods, to flush out accumulated metals and trace elements in secondary and especially tertiary wetlands. Flushing of wetlands with good quality water would lead to improved water quality in the wetlands, whereby frequent discharges to the river might eventually be possible without exceeding existing water quality standards. However, adequate flushing of some contaminants from sediments may not be possible. Dilution of water containing elevated concentrations of constituents with fresh water prior to discharge may be another option whereby discharge standards might be met. Consideration should be given to whole effluent toxicity testing, with representative species of an aquatic invertebrate and a fish, for wetland waters prior to discharge to the Walker River. Chemical treatment of the water prior to discharge is another option; however, this would likely prove too costly to conduct.

The reuse of water, such as that from North Pond, in primary wetlands would likely result in degraded conditions in these units associated with increased concentrations of salts and chemical contaminants.

Periodic monitoring of water quality and contaminants in sediments and biota at the Mason Valley WMA, especially in response to changes in wetland management practices (e.g., post-flushing of wetlands), is needed to properly assess risks to wildlife and their habitats and to provide managers with information for managing such risks.

Acknowledgments

We thank Richard Duncan for assistance with data collection on aquatic vegetation species composition and relative abundance. Ken Nichols, J. Scott Foott, Jimmy Faukner, and Rick Harmon of the California-Nevada Fish Health Center, USFWS, Anderson, California, provided information on an evaluation of fish health. Elmer Bull, Manager of the Mason Valley WMA graciously provided information on management of the area. Diana Silsby of NDEP provided data from discharge monitoring reports for the Sierra Pacific Power Company's Fort Churchill Power Plant and the City of Yerington. John Heggeness of NDEP provided monitoring data for North Pond. Daniel Welsh, Greg Linder, Doug Hunt, and Sandy Canning provided critical reviews of a draft of the report.

LITERATURE CITED

Allander, K., G. Gortsema, D. Hutchinson, and J. Schwartzenberger. 2001. Water resources data Nevada water year 2000. U.S. Geological Survey Water-Data Report NV-00-1. xxvi + 570 pp.

Archer, W.M. 1984. Soil survey of Lyon County area, Nevada. u.S. Department of Agriculture, Soil Conservation Service. xii + 513 pp, plus maps.

Barbour, M.T., 1 Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Barbour, M.T., lB. Stribling, and lR. Karr. 1995. The multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-80 *In* W.S. Davis and T.P. Simon (eds.), Biological assessment and criteria: tools for water resource planning and decision-making. Lewis Publishers, Boca Raton, FL.

Bauer, D.J., BJ. Foster, J.D. Joyner, and R.A. Swanson. 1996. Water resources data Nevada water year 1995 lJ.S.Geological Survey Water-Data Report NV-95-1. xviii + 734 pp.

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to quality effects of grazing management on western rangeland streams. Idaho Water Resources Research Institute-University of Idaho. Submitted to U.S. Environmental Protection Agency.

Brennan, K.M. 1985. Effects of wastewater on wetland animal communities. Pages 199-223 *In* PJ. Godfrey, E.R. Kaynor, S. Pelczarski, and J. Benforado (eds.), Ecological considerations in wetlands treatment of municipal wastewaters. Von Nostrand Rienhold Company, NY.

Brown and Caldwell 2002. Draft fugitive dust work plan Yerington Mine site, July 11, 2002. Prepared for Atlantic Richfield Company, Anaconda, Montana. Prepared by Brown and Caldwell, Carson City, Nevada.

Cain, B.W., L. Sileo, J.C. Franson, and J. Moore. 1983. Effects of dietary cadmium on mallard ducklings. Environ. Res. 32:286-297.

Camardese, M.B., DJ. Hoffman, L.J. LeCaptain, and G.W. Pendleton. 1990. Effects of arsenate on growth and physiology in mallard ducklings. Environ. Toxicol. Chern. 9:785-795.

Catallo, W.l (Chair). 1999. Workgroup I Synopsis: biogeochemical processes. Pages 27-67 *in* M.A. Lewis et al. (eds.), Ecotoxicology and risk assessment for wetlands. Proceedings from the SETAC Pellston Workshop on Ecotoxicology and Risk Assessment for Wetlands. SETAC Press, Pensacola, FL.

Clary, S.L., D.R. McClary, R. Whitney, and D.D. Reeves. 1995. Water resources data Nevada water year 1994. U.S. Geological Survey Water-Data Report NV-94-1. xvii + 768 pp.

Eisler, R. 2000a. Handbook of chemical risk assessment: health hazards to humans, plants, and animals. Volume 1. Metals. Lewis Publishers, Boca Raton, FL.

Eisler, R. 2000b. Handbook of chemical risk assessment: health hazards to humans, plants, and animals. Volume 3. Metalloids, radiation, cumulative index to chemicals and species. Lewis Publishers, Boca Raton, FL.

Epler, J.H. 2001. Identification manual for the larval Chironomidae (Diptera) of North and

South Carolina. A guide to the taxonomy of the midges of the southeastern United States, including Florida. Special Publication SJ200I-SP13. North Carolina Department of Environment and Natural Resources, Raleigh, NC, and St. Johns River Water Management District, Palatka, FL. 526 pp.

Folmar, L.C., N.D. Denslow, V. Rao, M. Chow, D.A. Crain, 1. Enblom, J. Marcino, and L.J. Guillette, Jr. 1996. Vitellogenin induction and reduced serum testosterone concentrations in feral male carp *(Cyprinus carpio)* captured near a major metropolitan sewage treatment plant. Environ. Health Perspect. 104: 1096-1101.

Friend, M. 1985. Wildlife health implications of sewage disposal in wetlands, Pages 262-269 *In* PJ. Godfrey, E.R. Kaynor, S. Pelczarski, and J. Benforado (eds.), Ecological considerations in wetlands treatment of municipal wastewaters. Von Nostrand Rienhold Company, NY.

Galatowitsch, S.M. 1993. Site selection, design criteria, and performance assessment for wetland restoration in the prairie pothole region. Dissertation. Iowa State University, Ames,IA.

Garcia, K.T., R.H. Munson, R.J. Spaulding, and S.L. Vasquez. 2002. Water Resources data Nevada water year 2001. U.S. Geological Survey Water-Data Report NV-Ol-l. xxvi + 528 pp.

Gersburg, R.M., B.V. Elkins, S.R. Lyon, C.R. Goldman. 1986. Role of aquatic plants in wastewater treatment by artificial wetlands. Water Res. 20:363-368.

Gilmer, D.S., M.R. Miller, R.D. Bauer, and 1.R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Trans. North Am. Wildl. Nat. Resources Conf.47:441-452.

Gray,1.S. 1979. Pollution-induced changes in populations. Transactions of the Royal Philosophical Soc. London (B) 286:545-561.

Grootjans, A.P., W.H. Ernst, P.l Stuyfzand. 1998. European dune slakes: strong interactions of biology, pedogenesis and hydrology. Tree 13:96-100.

Heinz, G.H. 1979. Methylmercury: reproductive and behavioral effects on three generations of mallard ducks. J. Wildl. Manage. 43:394-401.

Henny, CJ., E.F. Hill, DJ. Hoffman, M.G. Spalding, and R.A. Grove. 2002. Nineteenth century mercury: hazard to wading birds and cormorants of the Carson River, Nevada. Ecotoxicology 11:213-231.

Hickman, C. J. (ed.). 1993. The Jepson Manual: higher plants of California. University of California Press, Berkeley and Los Angeles, CA.

Hilsenhoff, W.L. 1977. Use of arthropods to evaluate water quality of streams. Wisconsin Dept. Nat. Resour. Tech. Bull. 100. 15 pp.

Hilsenhoff, W.L. 1982. Using a biotic index of to evaluate water quality in streams. Wisconsin Dept. Nat. Resour. Tech. Bull. 132. 22 pp.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomol. 20:31-39.

Hilsenhoff, W.L. 1998. A modification of the biotic index of organic·stream pollution to remedy problems and to permit its use throughout the year. Great Lakes Entomol. 31:1-12

Hooper, A. 1993. Effects of season, habitat, and an impoundment on twenty-five benthic community measures used to assess water quality. M.S. Thesis. College of Natural Resources, University of Wisconsin-Stevens Point. 443 pp.

Home, A.J., J.C. Roth, and N.J., Barratt. 1994. Walker Lake - state of the lake, 1992-94. Prepared for the Nevada Division of Environmental Protection, EEHSL Report 94-2. 85 pp.

Humason, G.L. 1979. Animal tissue techniques. 4th edition. W.H. Freeman and Co., San Francisco, CA.

Idaho Division of Environmental Quality. 1996. 1996 water body assessment guidance: a stream to standards process. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, ID.

Iman, R.L. and W.J. Conover. 1983. A modern approach to statistics. John Wiley and Sons, New York. 497 pp.

Jones, C.Z., T.G. Rowe, R.J. Sexton, and DJ. Tanko. 1999. Water resources data Nevada water year 1999. U.S. Geological Survey Water-Data Report NV-99-1. xxvi + 569 pp.

Kadlec, IA. 1985. Wetlands, wastewater, and wildlife, Pages 439-443 *In* P.J. Godfrey, E.R. Kaynor, S. Pelczarski, and J. Benforado (eds.), Ecological considerations in wetlands treatment of municipal wastewaters. Von Nostrand Rienhold Company, NY.

Kantrud, H.A. and W.E. Newton. 1996. A test of vegetation-related indicators of wetland quality in the prairie pothole region. J. Aquat. Ecosys. Health 5: 177-191.

Kirby, K.N. 1993. Advanced data analysis with SYSTAT. Van Nostrand Reinhold Company, NY. 475 pp.

Lemly, A.D. 1996. Selenium in aquatic organisms. Pages 427-445 *in* W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood (eds.), Environmental contaminants in wildlife: interpreting tissue concentrations. Lewis Publishers, Boca Raton, FL.

Lemly, A.D., S.E. Finger, and M.K. Nelson. 1993. Sources and impacts of irrigation drainwater contaminants in arid wetlands. Environ. Toxico!. Chern. 12:2265-2279.

Lernly, A.D., and GJ. Smith. 1987. Aquatic cycling of selenium: implications for fish and wildlife. U.S. Department of the Interior, Fish and Wildlife Service, Fish and Wildlife Leaflet 12. 10 pp.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxico!. 39:20-31.

Margalef, R. 1958. Information theory in ecology. General Systematics 3:36-71.

Margalef, R. 1969. Diversity and stability in ecological systems. Biology 22:25-37.

Mason, H.L. 1957. A flora of the marshes of California. University of California Press, Berkeley and Los Angeles, CA. 878 pp.

Metcalfe, C.D., T.L. Metcalfe, Y. Kiparissis, B.G. Koenig, C. Khan, RJ. Hughes, T.R. Croley, R.E. March, and T. Potter. 2001. Estrogenic potency of chemicals detected in sewage treatment plant effluents as determined byinvivo assays with Japanese medaka *(Oryzias latipes).* Environ. Toxico!. Chern. 20:297-308.

Moore, *K.R.l.* and P.A. Keddy. 1989. The relationship between species richness and standing crop in wetlands: the importance of scale. Vegetatio 79: 99-106.

Nevada Division of Environmental Protection [NDEP]. 2002a. Draft Nevada's 2002 303(d) impaired waters list. Bureau of Water Quality Planning, Carson, City, Nevada.

Nevada Division of Environmental Protection. 2002b. Rationale for proposed revisions to ambient water quality criteria for ammonia. Prepared by Nevada Division of Environmental Protection, Bureau of Water Quality Planning, November 2002.

Nichols, K., J.S. Foott, J. Faukner, and R. Harmon. 1999. FY99 investigational report: health evaluation of adult carp *(Cyprinus carpio)* and largemouth bass *(Micropterus salmoides)* from Mason Valley Wildlife Management Area, NV. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center, Anderson, CA. 7 pp + appendices.

Persaud, D.R., D.R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment and Energy. Ontario. 24 pp. + appendices.

Peverly, J.H., J.M. Surface, T. Wang. 1995. Growth and trace metal absorption by *Phragmites australis* in wetlands constructed for landfill leachate treatment. Eco!. Eng. 5:21-35.

Philippi, T.E., P.M. Dixon, B.E. Taylor. 1998. Detecting trends in species composition. Eco!. App!. 8:300-308.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, andl. R.Leonard. 1982. Fish hatchery management. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 517 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocol for use in streams and rivers. EPA 440-4-89-001. United States Environmental Protection Agency.

Purdom, C.E., P.A. Hardiman, V.J. Bye, N.C. Eno, C.R. Tyler, and J.P. Sumpter. 1994. Estrogenic effects of effluents from sewage treatment works. Chern. Eco!. 8:275-285.

Rai, U.M., S. Sinha, R.D. Tripathii, P. Chandra. 1995. Wastewater treatability potential of some aquatic macrophytes: removal of heavy metals. Eco!. Eng. 5:5-12.

Reddy, K.R., E.M. D'Angelo, T.A. DeBusk. 1989. Oxygen transport through aquatic macrophytes: the role in wastewater treatment. J. Environ. Qual. 19:261-267.

Resh, V.H., R.H. Norris, and M.T. Barbour. 1995. Design and implementation of rapid assessment approaches for water resource monitoring using benthic invertebrates. Australian J. Eco!. 20: 108-121.

Rey Beneyas, J.H., F.G. Bernaldez, C. Levassor, B. Peco. 1990. Vegetation of groundwater discharge sites in the Douro basin, central Spain. J. Veg. Sci. 1:461-466.

Rey Beneyas, J.H. and S.M. Schneider. 1993. Diversity patterns of wet meadows along geochemical gradients in central Spain. J. Veg. Sci. 4: 103-108.

Richards, L. (Compiler). 2000. Mason Valley Wildlife Management Area conceptual management plan. State of Nevada, Department of Conservation and Natural Resources, Division of Wildlife. 112 pages + appendices.

Richardson, C.J. 1999. Plenary session presentation: ecological functions of wetlands in the landscape. Pages 9-25, *In* M.A. Lewis et a!. (eds.), Ecotoxicology and risk assessment for wetlands. Proceedings from the SETAC Pellston Workshop on Ecotoxicology and Risk Assessment for Wetlands. SETAC Press, Pensacola, FL.

Richardson, C.J., and D.S. Nichols. 1985. Ecological analysis of wastewater management

criteria in wetland ecosystems. Pages 351-391 *In* P.J. Godfrey, E.R. Kaynor, S. Pelczarski, and J. Benforado (eds.), Ecological considerations in wetlands treatment of municipal wastewaters. Von Nostrand Rienhold Company, NY.

Rodgers, 1.H. (Chair). 1999. Workgroup V synopsis: constructed wetlands as a risk mitigation alternative. Pages 315-342 *In* M.A. Lewis et al. (eds.), Ecotoxicology and risk assessment for wetlands. Proceedings from the SETAC Pellston Workshop on Ecotoxicology and Risk Assessment for Wetlands. SETAC Press, Pensacola, FL.

Rosenburg, D.M. and V.H. Resh. 1993. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, NY. 488 pp.

Shannon, C. E. and W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Urbana, IL. 144 pp.

Shimasaki, H., R. Maeba, and N. Ueta. 1989. Lipid peroxidation and storage of fluorescent products by macrophages in-vitro as a model of ceroid-like pigment formation. Pages *323-332, In* E.A. Porta (ed.), Lipofuscin and ceroid pigments: advances in experimental medicine and biology. Volume 266. Plenum Press, NY.

Smith, G.J., and V.P. Anders. 1989. Toxic effects of boron on mallard reproduction. Environ. Toxicol. Chern. 8:943-950.

Sparling, D.W. 1990.· Acid precipitation and food quality: inhibition of growth and survival in black ducks and mallards by dietary aluminum, calcium, and phosphorus. Arch. Environ. Contam. Toxico!. 19:457-463.

Sparling, D.W., and T.P. Lowe. 1996. Environmental hazards of aluminum to plants, invertebrates, fish and wildlife. Rev. Environ. Contam. Toxico!. 145:1-127.

Sprague, J.B. 1985. Factors that modify toxicity. Pages 124-163 *In* G.M Rand and S.R. Petrocelli (eds.), Fundamentals of aquatic toxicology. Taylor & Francis, Bristol, PA.

Stromburg, J.C. and D.T. Patten. 1996. Instream flow and cottonwood growth in the eastern Sierra Nevada of Califomia, USA. Reg. Rivers Res. Manage. 12:1-12.

SYSTAT. 2000. SYSTAT® 10 Statistics II. SPSS Inc., Chicago, IL.

Tanner, 1.S. Clayton, M.P. Upsdell. 1995. Effect of loading rate and planting on treatment of dairy farm wastewaters in constructed wetlands. II. Removal of nitrogen and phosphorous. Water Res. 29:27-34.

Thodal, C.E., and P.L. Tuttle. 1996. Field screening of water quality, bottom sediment, and biota associated with irrigation drainage in and near Walker River Indian Reservation, Nevada, 1994-95. U.S. Geological Survey Water-Resources Investigations Report 96-4214. 39 pp.

Thompson, D.R. 1996. Mercury in birds and terrestrial mammals. Pages 341-356 *In* W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood (eds.), Environmental contaminants in wildlife: interpreting tissue concentrations. Lewis Publishers, Boca Raton, FL.

Thurman, E.M., J.E. Dietze, and E.A. Scribner. 2002. Occurrence of antibiotics in water from fish hatcheries. U.S. Geological Survey Fact Sheet 120-02. 4 pp.

Thurston,R.V.,R.C. Russo, and K. Emerson. 1979. Aqueous ammonia equilibrium - tabulation of percent un-ionized ammonia. EPA Eco!. Res. Ser. EPA-600/3-79-091. Duluth, MN.

U.S. Department of the Interior. 1998. Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment. National Irrigation Water Quality

Program Information Report No.3. 198 pp. + appendices.

U.S. Environmental Protection Agency. 2000. Guidance for assessing chemical contaminant data for use in fish advisories. Volume 2. Risk assessment and fish consumption limits, third edition. EPA 823-B-00-008.

van der Valk, D.H. 1981. Succession in wetlands: a Gleasonian approach. Ecology 62:688-696.

White, D.H., and M.P. Dieter. 1978. Effects of dietary vanadium in mallard ducks. J. Toxico!. Environ. Health 4:43-50.

Wiemeyer, S.N. 2002. Mercury in biota and sediment in the Walker River Basin, Nevada and California. U.S. Fish and Wildlife Service, Reno, NY. iv + 27 pp.

Wiemeyer, S.N., 1. Miesner, P.L. Tuttle, E.C. Murphy, L. Sileo, and A. DeLong. 2001. Environmental contaminants in American white pelicans breeding at Pyramid Lake, Nevada, USA. U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office, Reno, NV. v+54pp.

Wiener, J.G., and D.J. Spry. 1996. Toxicological significance of mercury in freshwater fish. Pages 297-339, *In* W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood (eds.), Environmental contaminants in wildlife: interpreting tissue concentrations. Lewis Publishers, Boca Raton, FL.

Wilcox, D. 1995. Wetland and aquatic macrophytes as indicators in anthropogenic hydrologic disturbance. Nat. Areas 1. 15:240-248.

Wisseman, B. 1996. Common Pacific North West benthic invertebrate taxa - draft March 1996 Suggested levels for standard taxonomic effort. Aquatic Biology Associates, Inc. Corvallis, OR.

Table 1. Water deliveries (acre feet/year) to the Mason Valley Wildlife Management Area for the years 1995 through 2001. Data provided by the Nevada Division of Wildlife.

Year	Walker River[a]	Hatchery Effluent	City of Yerington Wastewater	Cooling Pond	Wells[b]
1995	16,107	4,569	448	0	0
1996	15,688	4,731	461	0	0
1997	17,544	5,045	475	147	0
1998	12,783	4,750	488	35	0
1999	18,026	5,350	504	0	0
2000	14,421	5,616	543	113	200
2001	8,679	5,569	582	623	325
Averages	14,750	5,090	500	131	75

a Approximately 75% of this water is used on wetlands,.with remainder going to agricultural uses.

b Only the estimated portion going to wetlands is reported here.

Table 2. Analytical methods and detection limits for analyses of major constituents in water collected at Mason Valley Wildlife Management Area in 1999-2000. Analyses conducted by Sierra Environmental Monitoring, Inc., Reno, Nevada.

Constituents	Methods[a]	Detection limits[b]
Total dissolved solids (TDS)	EPA 160.1	7mgIL
Total suspended solids (TSS)	EPA 160.2	I mglL
Ammonia-Nitrogen[c]	EPA 350.3	0.1 mglL
Nitrate-Nitrogen	EPA 300.0	0.1-0.3 mglL
Kjeldahl-Nitrogen	EPA 351.4	0.1 mg/L
Total Nitrogen[c]	Total	0.2-2.0 mglL
Phosphorus (P)	EPA 365.3	0.02 mglL
Calcium (Ca)	EPA 200.7	0.1-1.0 mgIL
Magnesium (Mg)	EPA 200.7	0.1-1.0 mgIL
Potassium (K)[c]	EPA 200.7	0.2 mg/L
Sodium (Na)	EPA 200.7	0.1-1.0 mglL
Chloride	EPA 300.0	0.1-1.5 mglL
Fluoride	EPA 300.0	0.1-1.0 mglL
Sulfate (S04)	EPA 300.0	0.1-1.5 mglL
Fecal coliform MFC[d]	SM 9222 D	1-2 cfu/IOOml
Total coliform MFC[d]	SM 9222 B	1-2 cfullOOml
Fecal coliform MPN[e]	SM 9221 E	2 mpn/IOOml
Total coliform MPN[e]	SM 9221 B	2 mpn/IOOml

a EPA refers to U.S. Environmental Protection Agency methods. SM refers to standard methods.
b mg/L = milligrams/liter; cfullOO ml = colony forming unit/I 00 mpn/IOO ml = most probable number/l 00 ml.
c Not all samples were analyzed for these constituents.
d MFC = membrane filter count; method used for samples with low turbidity.
e MPN = most probable number; method used for turbid samples.

Table 3. Detection limits (µg/g) for samples of water, sediment, vegetation, invertebrates, and fish from Mason Valley Wildlife Management Area that were analyzed for metals and trace elements. Concentrations are on a dry weight basis, except for water.

Element	Water	Sediment	Vegetation	Invertebrate	Fish
Al	0.0222	19.8-20.1	9.77-10.1	6.17-6.28	5.00-6.28
As	0.0056	0.495-0.502	0.977-1.01	0.617-0.628	0.500-0.628
B	0.0222	1.98-2.01	3.91-4.03	2.47-2.51	2.00-2.51
Ba	0.0011	2.97-3.01	0.977-1.01	0.617-0.628	0.500-0.628
Be	0.0004	0.198-0.201	0.195-0.202	0.124-0.126	0.100-0.126
Cd	0.0006	0.198-0.201	0.195-0.202	0.124-0.126	0.100-0.126
Cr	0.0056	0.990-1.00	0.977-1.01	0.617-0.628	0.500-0.628
Cu	0.0056	0.990-1.00	0.977-1.01	0.617-0.628	0.500-0.628
Fe	0.0222	19.8-20.1	19.5-20.2	12.3-12.6	10.0-12.6
Hg	0.0002	0.0198-0.0201	0.0391-0.0403	0.0247-0.0251	0.0200-0.0251
Mg	0.0222	19.8-20.1	19.5-20.2	12.3-12.6	10.0-12.6
Mn	0.0022	3.96-4.02	0.781-0.806	0.494-0.502	0.400-0.502
Mo	0.0044	4.95-5.02	0.977-1.01	0.617-0.628	0.500-0.628
Ni	0.0056	4.95-5.02	0.977-1.01	0.617-0.628	0.500-0.628
Pb	0.0111	4.95-5.02	1.95-2.02	1.23-1.26	1.00-1.26
Se	0.0056	0.495-0.502	0.977-1.01	0.617-0.628	0.500-0.628
Sr	0.0022	1.98-2.01	0.391-0.403	0.247-0.251	0.200-0.251
V	0.0044	4.95-5.02	0.977-1.01	0.617-0.628	0.500-0.628
Zn	0.01 11	4.95-5.02	1.95-2.02	1.23-1.26	1.00-1.26

Table 4. Water quality classifications for the RilsenhoffBiotic Index (RBI) (Hilsenhoff 1987).

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

Table 5. Arithmetic means (n) offield-collected data on water quality for selected wetlands on Mason Valley Wildlife Management Area, 1998-2000. See Appendix A for the raw data.

Sampling site	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	pH (SU)	Salinity (ppt)	Turbidity (NTU)
Cinnamon Pond - outlet	398 (15)	9.5 (14)	8.6 (12)	0.40 (15)	44 (13)
Cinnamon Pond - inlet	449 (10)	7.2 (10)	8.1 (8)	0.41 (10)	21 (8)
Cinnamon Pond - sewage	710(11)	,8.2(11)	7.8 (10)	0.56 (11)	15 (9)
Mallard Pond	395 (9)	8.5 (9)	8.6 (8)	0.52 (9)	17 (9)
Joggles Ditch	233 (9)	9.9 (9)	8.7 (7)	0.21 (9)	24 (9)
Perk's Slough	335 (15)	8.3 (15)	8.4 (12)	0.30 (15)	30 (13)
Lower Pintail Pond	403 (6)	7.1 (6)	8.7 (6)	0.30 (6)	37 (6)
Honker Lake	722 (9)	9.9 (9)	8.7 (7)	0.57 (9)	67 (9)
Lower Gadwall Pond	606 (9)	9.9 (9)	8.9 (7)	0.63 (9)	42 (9)
Widgeon Pond	460 (9)	9.5 (9)	9.1 (7)	0.45 (9)	23 (8)
North Pond	1096 (16)	11.6 (16)	9.3 (12)	0.83 (16)	40 (13)
Bass Pond	343 (9)	9.8 (9)	8.9 (6)	0.37 (9)	6 (9)
Hinkson Slough	291 (17)	8.0 (17)	8.5 (14)	0.42 (17)	72 (14)
Hatchery effluent	222 (II)	6.7 (11)	7.9 (9)	0.16(11)	2 (9)
Miller Marsh	1142(14)	6.2 (14)	8.4(11)	1.15 (13)	16 (12)
Swan Lake	1098 (8)	8.5 (8)	9.0 (7)	0.96 (8)	128 (6)

Table 6. Concentrations of major constituents in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000.

Wetland unit and date	Concentration (mg/L)[a]										
	TDS	TSS	Ammonia	Nitrate	K-N	P	Total-N	Ca	Mg	Hardness	K
Miller Marsh											
3/02/99	937	9	na	<0.2	0.47	0.21	na	22	3.7	70	11.
6/02/99	1064	20	<0.1	<0.3	0.60	0.24	<0.9	26	4.6	84	na
8/26/99	946	14	<0.1	<0.3	0.70	0.15	na	22	3.3	68	na
3/15/00	835	34	0.39	<0.3	2.3	0.23	2.3	13	1.5	39	na
7/06/00	870	50	0.16	<0.3	1.0	0.16	<1.3	14	2.2	44	na
Hinkson Slough											
3/02/99	292	115	na	<0.2	0.82	0.20	na	27	6.6	95	5.2
6/02/99	333	100	<0.1	<0.3	1.4	0.39	1.4	31	7.7	109	na
8/26/99	325	183	<0.1	<0.3	1.4	0.47	na	26	5.7	88	na
3/15/00	220	34	0.16	<0.1	0.59	0.17	0.6	19	4.6	66	na
7/06/00	240	150	0.14	<0.1	1.6	0.44	1.6	19	5.0	68	na
Cinnamon Pond											
3/02/99	414	94	na	<0.2	4.3	0.98	na	45	11.	158	8.6
6/02/99	330	66	<0.1	<0.3	1.6	0.72	1.6	36	9.1	127	na
8/26/99	270	107	<0.1	<0.3	1.8	0.39	na	31	7.8	109	na
3/15/00	489	51	1.2	0.4	3.8	0.84	4.2	48	13.	173	na
7/07/00	350	110	0.18	<0.3	1.6	0.43	<1.9	29	7.8	104	na
Perk's Slough											
3/02/99	421	123	na	<0.2	0.91	0.35	na	54	14.	192	11.
6/02/99	299	36	<0.1	<0.3	0.55	0.17	<0.8	37	8.5	127	na
8/26/99	235	28	<0.1	<0.3	0.70	0.08	na	33	7.9	115	na
3/15/00	336	79	0.24	<0.1	1.0	0.13	1.0	45	11.	158	na
7/07/00	230	76	0.18	<0.3	0.58	0.16	<0.9	21	6.3	78	na

Table 6. Concentrations of major constituents in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000. (continued)

Wetland unit and date	Concentration (mg/L)b				Tot. coliform mpn/l00ml	Fecal coliform cfu/l00ml	Tot. coliform cfu/l00ml	Fecal coliform mpn/l00ml
	Na	Chloride	F	S04				
Miller Marsh								
3/02/99	240	71.	8.3	300		<2		
6/02/99	300	83.	11.	370	22			22
8/26/99	270	72.	9.8	340				4
3/15/00	230	63.	7.2	280	23			23
7/06/00	240	69.	9.5	310		<2	52	
Hinkson Slough								
3/02/99	48	17.	1.0	52		4		
6/02/99	50	17.	1.0	57	33			8
8/26/99	49	12.	1.3	48				7
3/15/00	36	10.	0.8	39		<2	<2	
7/06/00	35	9.6	0.8	41	110			17
Cinnamon Pond								
3/02/99	69	40.	<0.5	82		170		
6/02/99	57	32	0.5	56	1600			27
8/26/99	44	19	0.4	48				110
3/15/00	94	57	0.5	100	2			<2
7/07/00	38	18	0.5	37	500			8
Perk's Slough								
3/02/99	66	29	1.1	23		24		
6/02/99	42	18	0.8	37	>1600			17
8/26/99	35	11	0.9	16				<2
3/15/00	51	21	0.8	52	<2			<2
7/07/00	29	10	0.6	20	>1600			<2

Table 6. Concentrations of major constituents in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000. (continued)

Wetland unit and date	Concentration (mg/L)[a] TDS	TSS	Ammonia	Nitrate	K-N	P	Total-N	Ca	Mg	Hardness	K
Swan Lake											
3/02/99	no sample										
6/02/99	5746	34	<0.1	<0.3	1.3	0.39	1.3	26.	12.	114	na
8/26/99	1171	674	<0.1	<0.3	3.2	1.05	na	6.7	3.1	29	na
3/15/00	1771	167	0.37	<0.3	2.4	0.84	2.4	39.	16.	163	na
7/07/00	1000	42	0.22	<0.3	1.7	0.15	<2.0	13.	17.	102	na
North Pond											
3/02/99	851	5	na	<0.2	0.92	0.33	na	25.	14.	120	13.
6/02/99	912	14	<0.1	<0.3	1.3	0.45	1.3	35.	20.	170	na
8/26/99	836	10	<0.1	<0.3	1.5	0.19	na	12.	12.	79	na
3/15/00	778	17	0.24	<0.3	1.1	0.22	1.1	29.	15.	134	na
7/06/00	920	26	0.23	<0.3	1.6	0.22	<1.9	9.1	16.	88	na

[a] TDS = total dissolved solids; TSS = total suspended solids; Ammonia = ammonia-nitrogen; Nitrate = nitrate-nitrogen; K-N = kjeldahl nitrogen; P = total phosphorus; Total-N = total nitrogen; Ca = calcium; Mg = magnesium; hardness as $CaCO_3$; K = potassium.

Table 6. Concentrations of major constituents in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000. (concluded)

Wetland unit and date	Concentration (mglL)b				Tot. coliform mpn/lOOml	Fecal coliform cfu/l00ml	Tot. coliform cfu/l00ml	Fecal coliform mpn/l00ml
	Na	Chloride	F	S04				
Swan Lake								
3/02/99	No sample							
6/02/99	190	58	3.0	160	300			13
8/26/99	250	55	4.7	130				<2
3/15/00	511	140	5.9	440	80			80
7/07/00	170	43	2.6	87	>1600			13
North Pond								
3/02/99	230	72	3.3	170		<2		
6/02/99	260	79	3.1	180	50			8
8/26/99	260	80	3.9	180				<2
3/15/00	230	64	2.3	150		<2	<2	
7/06/00	290	80	3.2	190		<2	186	

b Na = sodium; F = fluoride; 80_4= sulfate.

Table 7. Concentrations of metals and trace elements in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000.

Wetland unit and date	Concentration (µg/L)[a]														
	Al	As	B	Ba	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Sr	V	Zn
Miller Marsh															
3/02/99	1430	228	1650	37	<0.6	<5.6	7	1380	4340	126	70	7	198	23	20
6/02/99	953	302	2060	13	<0.6	<5.6	<5.6	1010	4890	363	55	9	243	16	<11.1
8/26/99	964	253	1730	31	1	<5.6	<5.6	1020	3660	272	70	7	211	12	13
3/15/00	1080	227	1460	33	<0.6	<5.6	7	985	2220	71	70	8	144	29	19
7/06/00	239	283	1910	31	1	<5.6	<5.6	349	2460	125	64	6	169	8	<11.1
Hinkson Slough															
3/02/99	4510	28	317	79	1	<5.6	10	4350	8600	223	18	8	286	22	20
6/02/99	3920	48	387	80	<0.6	<5.6	9	3820	8780	236	21	8	327	22	20
8/26/99	6730	58	363	89	2	<5.6	14	7680	8170	488	24	11	256	44	30
3/15/00	650	25	254	36	<0.6	<5.6	<5.6	816	4710	79	12	<5.6	183	11	<11.1
7/06/00	2540	42	283	48	<0.6	<5.6	8	2820	5660	130	15	7	198	19	<11.1
Cinnamon Pond															
3/02/99	4770	27	408	91	<0.6	<5.6	11	4700	13200	201	11	10	430	18	20
6/02/99	1410	31	379	54	<0.6	<5.6	7	1290	9180	157	9	8	347	15	15
8/26/99	2320	26	292	60	<0.6	<5.6	8	2530	8340	134	10	7	318	16	<11.1
3/15/00	1410	30	501	72	<0.6	<5.6	6	1280	14000	176	7	8	466	14	13
7/07/00	2780	20	288	49	<0.6	<5.6	7	2990	7360	145	6	7	249	11	20
Perk's Slough															
3/02/99	6450	27	368	100	<0.6	<5.6	11	5800	18500	360	19	10	681	18	27
6/02/99	2750	32	342	73	<0.6	<5.6	7	2720	9080	146	15	8	378	12	16
8/26/99	1660	15	307	37	<0.6	<5.6	6	1610	7290	85	11	10	181	8	<11.1
3/15/00	3080	16	333	81	<0.6	<5.6	8	2800	11100	390	19	6	344	12	12
7/07/00	400	17	262	21	<0.6	<5.6	<5.6	439	5620	23	7	<5.6	182	5	<11.1

Table 7. Concentrations of metals and trace elements in water samples from wetlands at Mason Valley Wildlife Management Area collected in March 1999 to July 2000. (concluded)

Wetland unit and date	Concentration (µg/L)[a]														
	Al	As	B	Ba	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Sr	V	Zn
Swan Lake															
3/03/99	no sample														
6/02/99	4360	305	1280	56	<0.6	<5.6	14	3530	13600	105	97	9	390	43	15
8/26/99	32900	654	1780	164	10	10	53	32900	26700	1050	70	27	331	113	87
3/15/00	14200	600	1830	142	3	<5.6	25	12800	22000	409	210	17	499	97	41
7/07/00	757	142	1090	27	<0.6	<5.6	6	543	18100	29	25	6	369	11	<11.1
North Pond															
3/02/99	663	101	1560	12	<0.6	<5.6	6	671	15100	60	47	6	394	8	<11.1
6/02/99	471	111	1740	7	<0.6	<5.6	<5.6	468	19800	78	47	7	478	6	<11.1
8/26/99	51	132	1880	13	<0.6	<5.6	<5.6	36	11700	12	54	<5.6	246	5	<11.1
3/15/00	884	78	1420	33	<0.6	<5.6	11	905	17000	45	47	7	427	8	<11.1
7/06/00	263	124	1980	14	<0.6	<5.6	<5.6	249	18900	53	52	<5.6	247	7	<11.1

[a] The following constituents were not detected in any sample at the given detection limits : Be, 0.4; Hg, 0.2; Pb, 11.1; and Se, 5.6.

Table 8. Concentrations (µg/g dry weight) of metals and trace elements in sediment samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three samples were collected in each wetland near the inlet, mid-point, and outlet.

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Aluminum	13110[a]	19310	10470	14750	13470	24140
	10960-14540[b]	13120-19700	8773-14190	7003-14810	6616-18040	22370-25960
Arsenic[c]	46.6	18.8	6.70	14.9	16.3	41.4
	41.1-47.8	17.5-24.5	5.21-18.6	7.25-16.5	7.40-21.6	37.9-49.9
Boron[c]	37.3	36.6	15.9	27.7	43.6	69.9
	33.6-42.0	33.7-54.3	15.0-20.0	12.7-31.1	17.8-54.5	68.0-73.7
Barium	145	162	154	158	108	162
	127-157	114-171	100-171	97.5-158	85.8-158	149-187
Beryllium	0.592	0.811	0.512	0.686	0.483	0.924
	0.572-0.834	0.587-1.04	0.446-0.690	0.312-0.722	0.285-0.644	0.895-0.992
Cadmium	0.382	0.781	0.487	0.490	0.683	1.04
	0.379-0.799	0.525-0.903	0.468-0.517	<0.199-0.602	0.365-0.843	0.974-1.14
Chromium	11.6	11.9	11.1	12.8	9.27	11.7
	10.7-13.7	9.19-14.5	7.40-12.6	6.00-13.3	5.13-11.1	11.7-12.9
Copper	28.8	40.1	18.6	34.7	32.0	42.9
	24.2-38.4	29.0-57.3	15.9-30.2	15.7-39.7	15.2-32.1	42.3-43.6

Table 8. Concentrations (µg/g dry weight) of metals and trace elements in sediment samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three samples were collected in each wetland near the inlet, mid-point, and outlet. (continued)

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Iron	20110	24730	17580	22140	17920	31360
	18060-21590	17590-24810	11810-21270	10290-23270	8989-22630	29620-33180
Mercury[C]	0.0485	0.0795	<0.0199	0.151	0.0238	0.0545
	0.0456-0.0533	0.0509-0.213	<0.0199-0.0231	0.0559-0.302	0.0219-0.0274	0.0452-0.0616
Magnesium	6075	7532	4513	7522	7599	13840
	4811-6759	5638-9120	3545-6138	3814-7628	3049-9448	13080-15580
Manganese	477	469	374	517	431	958
	432-890	366-580	185-488	264-915	231-620	780-1099
Molybdenum	15.1	<5.02	<4.98	<4.98	<5.00	<5.00
	14.9-22.2	<4.99-6.54	<4.98-<5.00	<4.98-<5.00	<4.99-<5.00	<4.98-<5.02
Nickel	13.3	13.4	11.0	12.3	8.94	15.5
	11.6-15.8	9.51-16.2	7.31-12.7	5.84-12.8	5.62-11.7	14.9-17.3
Lead	9.3	11.3	7.14	11.0	8.08	14.4
	7.5-10.2	9.82-17.0	5.91-10.0	5.19-11.2	5.68-9.77	14.4-17.0
Selenium	<0.498	<0.502	<0.498	<0.498	<0.500	1.19
	<0.495-<0.501	<0.499-1.11	<0.498-<0.500	<0.498-<0.500	<0.499-1.21	<0.498-1.52

Table 8. Concentrations (J..lg/g dry weight) of metals and trace elements in sediment samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three samples were collected in each wetland near the inlet, mid-point, and outlet. (concluded)

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Strontium	104	112	99.3	115	221	219
	87.3-110	102-192	96.6-121	69.3-132	76.9-223	186-241
Vanadium	52.1	57.5	43.8	52.6	34.8	72.5
	49.3-67.6	43.9-74.5	26.3-56.8	25.6-57.8	20.0-62.6	65.4-75.6
Zinc	127	61.7	37.6	61.9	41.7	77.8
	82.2-136	44.7-75.0	32.6-48.2	31.8-67.6	28.2-95.8	77.3-83.0

[a] Median.
[b] Extremes.
[c] Significant difference ($P < 0.05$) among wetlands, using Kruskal-Wallis one-way analysis of variance.

Table 9. Concentrations (µg/g dry weight) of metals and trace elements in pondweed samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Samples were collected in each wetland near the inlet, mid-point, and outlet.

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	SwanLake
Aluminum	2223[a]	1508	4830	1135	1205	2404
	1181-2891[b]	1139-2609	3654-5397	386-4697	905-1725	2009-4561
Arsenic[c]	114	14.6	18.1	13.9	10.8	81.4
	107-192	9.05-45.7	8.23-54.4	9.99-14.1	9.36-12.6	70.5-107
Boron[e]	274	593	379	37.4	440	695
	266-568	553-641	84.5-544	27.2-39.3	186-683	550-862
Barium	85.9	122	282	58.4	72.4	84.9
	73.8-162	103-164	127-444	33.1-81.3	48.1-330	82.5-113
Beryllium	<0.201	<0.199	<0.198	<0.200	<0.202	<0.201
	<0.199-<0.201	<0.196-<0.201	<0.195-<0.198	<0.197-<0.200	<0.201-<0.202	<0.201
Cadmium[c]	2.39	0.697	2.16	0.365	0.614	1.75
	1.34-2.45	0.559-1.17	1.96-2.32	<0.200-1.87	0.382-0.699	0.888-1.85
Chromium	562	9.53	39.2	14.8	39.2	84.1
	19.7-696	9.43-41.1	17.9-85.9	12.9-31.0	38.1-42.5	4.81-334
Copper	16	8.98	12.8	4.19	7.24	13.8
	9.89-20.5	7.29-9.72	7.25-15.6	3.92-14.6	7.02-8.88	7.54-15.1

Table 9. Concentrations dry weight) of metals and trace elements in pondweed samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Samples were collected in each wetland near the inlet, mid-point, and outlet.

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	SwanLake
Iron	6493	1622	5706	1173	1459	3958
	2969-7106	1145-2539	4696-5905	476-4724	1117-1870	1810-4755
Mercury	0.0973	<0.0398	<0.0397	<0.0400	0.0939	<0.0402
	0.0433-0.104	<0.0392-<0.0402	<0.0391-0.0703	<0.0394-0.215	<0.0403-0.104	<0.0402-0.0475
Magnesium[c]	4058	4661	5396	2802	5942	4824
	3555-4545	4638-5679	4282-6360	2650-4080	5074-6041	4591-7923
Manganese[c]	2157	1686	3057	505	355	284
	1558-2234	970-2958	889-16670	402-641	318-933	223-630
Molybdenum	11.2	5.14	3.62	5.54	3.69	7.44
	7.73-12.7	3.86-5.87	1.05-6.77	2.91-6.60	2.68-3.92	5.02-9.12
Nickel	33.3	3.62	7.89	2.73	12.8	23.7
	6.32-46.3	2.57-5.14	5.82-14.7	2.40-7.18	11.2-13.3	2.40-51.7
Lead	<2.01	<1.99	<1.98	<2.00	<2.02	<2.01
	<1.99-<2.01	<1.96-<2.01	<1.95-<1.98	<1.97-<2.00	<2.01-<2.02	<2.01
Selenium	<1.00	<0.996	1.83	<1.00	<1.01	<1.00
	<0.996-<1.00	<0.980-<1.00	<0.992-2.84	<0.984-<1.00	<1.00-<1.01	<1.00

Table 9. Concentrations dry weight) of metals and trace elements in pondweed samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Samples were collected in each wetland near the inlet, mid-point, and outlet. (concluded)

Element	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Strontium	106	199	448	178	290	239
	101-171	171-341	129-471	100-243	216-310	214-256
Vanadium[c]	10.2	10.0	21.4	14.0	3.07	16.4
	6.99-15.1	6.34-14.3	18.7-23.4	10.4-15.3	2.11-4.81	14.3-30.0
Zinc[c]	81.0	20.6	24.5	63.4	23.5	19.6
	49.3-119	19.7-23.3	23.6-36.9	42.9-71.6	21.8-25.5	17.8-26.8

[a] Median.
[b] Extremes.
[c] Significant difference ($P < 0.05$) among wetlands, using Kruskal-Wallis one-way analysis of variance.

Table 10. Concentrations (µg/g dry weight) of metals and trace elements in aquatic invertebrate samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three corixid samples were collected in each wetland near the inlet, mid-point, and outlet, except for Perk's Slough (n = 2), and Cinnamon Pond where one sample of corixids (Cor.) and one sample of notonectids (Not.) were collected.

	Miller Marsh	Perk's Slough	Cinnamon Pond		Hinkson Slough	North Pond	SwanLake
Element	Corixids	Corixids	Cor.	Not.	Corixids	Corixids	Corixids
Aluminum	125[a]		51.4	20.0	194	119	368
	81.4-147[b]	33.6-103			29.3-215	80.5-130	215-431
Arsenic[c]	2.65		1.23	1.20	1.61	1.76	3.37
	2.58-2.94	1.24-1.51			1.55-1.70	1.59-1.99	3.33-4.78
Boron[c]	4.55		5.81	8.04	<2.51	2.95	4.11
	4.15-5.05	2.66-2.76			<2.48-<2.51	<2.51-3.70	3.92-4.93
Barium	5.00		7.56	2.51	14.1	5.42	5.26
	4.67-5.08	2.79-11.2			10.1-16.3	3.67-6.46	4.89-5.66
Beryllium	<0.124		<0.124	<0.124	<0.126	<0.125	<0.125
	<0.124-<0.125	<0.124-<0.125			<0.124-<0.126	<0.125-<0.126	<0.124-<0.126
Cadmium	<0.124		<0.124	<0.124	<0.126	<0.125	<0.126
	<0.124-<0.125	<0.124-<0.125			<0.124-<0.126	<0.125-<0.126	<0.125-1.94
Chromium	<0.622		<0.620	<0.617	<0.628	<0.628	<0.627
	<0.620-<0.623	<0.619-<0.623			<0.620-<0.628	<0.627-0.836	<0.620-<0.628

Table 10. Concentrations (µg/g dry weight) of metals and trace elements in aquatic invertebrate samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three corixid samples were collected in each wetland near the inlet, mid-point, and outlet, except for Perk's Slough (n = 2), and Cinnamon Pond one sample of corixids (Cor.) and one sample of notonectids (Not.) were collected. (continued)

	Miller Marsh	Perk's Slough	Cinnamon Pond		Hinkson Slough	North Pond	Swan Lake
Element	Corixids	Corixids	Cor.	Not.	Corixids	Corixids	Corixids
Copper	12.5		13.5	14.0	19.0	15.2	14.5
	11.7-13.4	15.1-15.5			17.0-19.6	13.3-18.3	14.5-16.9
Iron	193		103	83.5	259	182	381
	150-231	91.3-157			90.7-287	152-185	281-424
Mercury	0.697		0.412	0.397	0.534	0.299	0.551
	0.681-0.888	0.356-0.538			0.357-0.668	0.231-0.553	0.412-0.586
Magnesium	782		678	893	850	785	903
	755-822	748-893			795-879	772-1027	836-1279
Manganese	28.5		30.9	56.7	20.4	14.7	23.1
	22.2-31.1	17.7-29.8			11.5-24.4	12.3-15.7	22.0-48.7
Molybdenum	0.795		<0.620	<0.617	0.741	0.909	0.904
	<0.622-0.852	<0.619-<0.623			0.622-1.12	0.883-1.94	0.868-0.953
Nickel	<0.622		<0.620	<0.617	<0.628	<0.628	0.663
	<0.620-0.661	<0.619-<0.623			<0.620-0.637	<0.625-0.684	<0.620-0.729

Table 10. Concentrations dry weight) of metals and trace elements in aquatic invertebrate samples collected from wetlands at Mason Valley Wildlife Management Area, September 1999. Three corixid samples were collected in each wetland near the inlet, mid-point, and outlet, except for Perk's Slough (n = 2), and Cinnamon Pond where one sample of corixids (Cor.) and one sample of notonectids (Not.) were collected. (concluded)

	Miller Marsh	Perk's Slough	Cinnamon Pond		Hinkson Slough	North Pond	Swan Lake
Element	Corixids	Corixids	Cor.	Not.	Corixids	Corixids	Corixids
Lead	<1.24		<1.24	<1.23	<1.26	<1.25	<1.25
	<1.24-<1.25	<1.24-<1.25			<1.24-<1.26	<1.25-<1.26	<1.24-<1.26
Selenium	<0.623		<0.620	<0.617	<0.628	<0.628	<0.627
	<0.620-0.688	<0.619-0.724			<0.620-0.638	<0.625-0.813	<0.620-<0.628
Strontium[c]	10.5		9.02	8.16	8.74	11.4	11.9
	9.39-11.2	8.43-9.00			8.04-8.95	11.0-12.8	10.5-12.3
Vanadium	<0.622		<0.620	<0.617	0.765	<0.627	1.34
	<0.620-<0.623	<0.619-<0.623			0.683-0.827	<0.625-<0.628	0.755-1.40
Zinc	105		108	151	113	102	100
	94.3-112	93.8-179			97.1-156	100-111	91.3-143

[a] Median.
[b] Extremes.
[c] Significant difference ($P < 0.05$) among wetlands (excluding Cinnamon Pond), using Kruskal-Wallis one-way analysis of variance.

Table 11. Concentrations (µg/g dry weight) of metals and trace elements[a] in individual fish collected from wetlands at Mason Valley Wildlife Management Area, August 1999.

Wetland	Species	Weight (g)	Al	As	B	Ba	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni
Miller Marsh	LMB	26	27.6	4.87	nd	4.28	26.3	1.93	184	0.266	2026	68.3	nd	4.04
		16	72.9	5.54	nd	6.96	72.8	3.11	536	0.228	1927	125.	1.53	18.7
		1427	16.8	5.34	nd	5.63	12.6	1.91	139	0.642	2192	26.3	nd	3.37
Perk's Slough	Carp	461	23.3	4.11	nd	8.62	13.3	5.46	135	0.431	1863	14.0	nd	2.10
		470	19.8	3.86	nd	8.62	21.4	4.52	178	0.358	1966	15.9	nd	2.45
		472	15.6	3.33	nd	5.57	49.4	4.94	302	0.414	1407	9.22	nd	4.46
Cinnamon Pond	LMB	251	19.2	4.54	nd	4.15	22.0	1.47	138	0.227	2613	17.2	nd	3.55
		115	386.	4.42	nd	8.50	24.8	2.47	543	0.510	2055	27.0	nd	5.57
		33	36.1	4.44	nd	9.00	13.1	1.52	117	0.426	2325	19.2	nd	1.96
	Carp	780	138.	5.25	7.93	19.5	103.	4.89	768	0.349	2087	76.2	1.34	18.6
		778	76.8	4.60	nd	9.88	60.2	4.08	426	0.251	2002	32.9	0.755	12.8
		1230	79.4	3.84	2.34	16.1	29.6	4.57	278	0.182	1666	17.7	nd	5.41
Hinkson Slough	LMB	608	20.2	3.77	nd	2.46	80.4	1.97	466	1.99	1540	23.6	0.892	14.6
		268	24.1	4.27	nd	2.28	30.7	1.99	215	1.73	1882	27.6	nd	7.50
		169	53.7	5.27	nd	3.62	57.0	1.81	406	1.55	2495	22.3	0.748	10.5
	Carp	641	75.6	5.60	nd	24.1	13.2	2.84	162	0.570	2753	20.7	nd	3.48
		562	203.	5.02	nd	13.0	29.9	3.33	400	0.250	2397	28.2	nd	8.74
		732	49.0	4.57	nd	13.1	20.0	2.93	207	0.637	2135	16.2	nd	3.33
Swan Pond	LMB	50	176.	6.54	5.89	7.55	51.6	3.28	418	1.03	2543	36.6	0.958	6.10

Table 11. Concentrations (µg/g dry weight) of metals and trace elements in individual fish collected from wetlands at Mason Valley Wildlife Management Area, August 1999. (concluded)

Wetland	Species	Se	Sr	V	Zn
Miller Marsh	LMB	1.33	125.	nd	84.9
		1.48	128.	nd	84.7
		1.80	144.	nd	64.7
Perk's Slough	Carp	2.32	118.	nd	243.
		1.81	121.	nd	323.
		1.61	58.4	nd	172.
Cinnamon Pond	LMB	1.78	150.	nd	62.4
		1.44	76.6	1.11	70.7
		1.18	97.7	nd	79.6
	Carp	1.31	174.	0.934	167.
		1.40	132.	nd	205.
		0.876	130.	nd	208.
Hinkson Slough	LMB	1.36	58.8	nd	57.2
		1.07	66.9	nd	55.2
		1.01	116.	nd	75.9
	Carp	2.20	270.	nd	230.
		1.49	205.	nd	216.
		1.46	162.	nd	138.
Swan Pond	LMB	1.94	310.	0.583	125.

[a] The following were not detected in any samples: Be, Cd, and Pb.

Table 12. Numbers and types of benthic invertebrates collected in samples from five wetland units at Mason Valley Wildlife Management Area, March-September, 1999.

ORDER/CLASS/PHYLUM Family	Cinnamon Pond			Hinkson Slough			Miller Marsh			North Pond			Perk's Slough		
	March	May	Sept.	March	May	Sept.	March	May	Sept.	March	May	Sept.	March	May	Sept.
EPHEMEROPTERA															
Baetidae	0	0	2	0	0	0	–	1	0	1	0	2	0	0	0
Caenidae	0	12	6	3	2	0	-	248	4	5	78	172	24	82	56
ODONATA															
Coenaarionidae	0	1	4	4	1	1	-	39	3	3	10	40	0	21	6
Libellulidae	0	0	0	0	0	0	–	0	1	1	0	4	0	1	0
HEMIPTERA															
Corixidae	0	2	3	0	1	1	-	8	0	0	50	2	0	1	0
Gerridae	0	0	1	0	1	0	-	0	C	0	0	0	0	0	0
Notonectidae	0	0	1	0	0	0	–	0	0	0	0	0	0	0	0
COLEOPTERA															
Heteroceridae	0	0	0	0	0	0	-	0	2	0	0	0	0	0	0
DIPTERA															
CeratoDoaonidae	0	2	0	0	2	1	-	14	44	0	14	1	0	0	0
Chaoboridae	0	0	0	0	0	0	-	0	0	0	0	1	0	0	0
Culicidae	0	0	0	0	0	1	–	0	0	0	0	0	0	0	0
Diptera	0	0	0	0	0	1	–	0	18	0	0	1	0	0	0
Ephydridae	0	0	0	0	0	0	-	0	11	0	0	0	0	0	0
Stratiomvidae	0	0	0	0	0	0	–	1	0	0	0	0	0	0	0
Tabanidae	0	0	0	0	0	0	–	1	1	4	1	0	1	0	0
Chironomidae	59	108	200	45	31	291	-	108	23	90	203	58	23	290	16
OLiGOCHAETA (CLASS)															
Oligochaeta	0	267	52	0	95	45	-	6	17	0	10	0	1	11	63
NEMATODA (PHYLUM)															
Nematoda	0	24	27	0	6	0	-	1	5	0	2	0	0	0	5
AMPHIPODA															
Talitridae	0	7	0	0	0	0	-	0	0	0	2	0	0	0	1
OSTRACODA (CLASS)															
Ostracoda	0	0	0	0	0	0	–	1	1	0	2	0	7	0	0
TURBELLARIA (CLASS)															
Turbellaria	0	0	0	0	0	0	-	0	0	0	1	0	0	0	0
ARACHNIDA (CLASS)															
Acari	0	5	1	0	1	0	-	1	0	0	1	4	2	2	0
BASOMMATOPHORA															
Ancvlidae	0	0	0	0	0	0	–	0	0	0	0	0	0	0	13
Lymnaeidae	0	0	0	0	0	0	-	0	0	0	1	0	0	0	1
Phvsidae	0	0	0	0	0	0	-	2	0	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	-	4	0	0	0	0	0	1	12
RHYNCHOBDELLIDA															
Glossiphoniidae	0	1	0	1	0	0	–	1	0	1	0	1	0	0	3

Table 13. Summary statistics of benthic invertebrate metrics in wetland units at Mason Valley Wildlife Management Area, March-September, 1999.

Wetland Unit	Total Number of Individuals	Total Number of Taxa Identified	Mean Abundance Per Taxon	Shannon-Wiener Diversity Index (SWI)	Margalef's Richness Index (MRI)	Hilsenhoff Biotic Index (HBI)
Cinnamon Pond	785	13	43.87	0.72	1.02	6.52
Hinkson Slough	534	12	25.84	0.68	1.14	6.65
Perk's Slough	643	15	26.13	1.27	1.38	6.76
Miller Marsh	1072	19	19.95	1.61	2.28	6.16
North Pond	766	18	23.28	1.07	1.69	6.57

Table 14. Sample period summary statistics of benthic invertebrate taxa dominance in five wetland units at Mason Valley Wildlife Management Area, March-September, 1999.

Wetland Unit	Date (1999)	First Dominant Taxa	First Dominant Taxa Percent	Second Dominant Taxa	Second Dominant Taxa Percent	Third Dominant Taxa	Third Dominant Taxa Percent
Cinnamon Pond	March	Chironomidae	100				
	May	Oligochaeta	62.24	Chironomidae	25.17	Nematoda	5.6
	September	Chironomidae	67.34	Oligochaeta	17.51	Nematoda	9.09
Hinkson Slough	March	Chironomidae	84.91	Coenagrionidae	7.54	Caenidae	5.66
	May	Oligochaeta	67.86	Chironomidae	22.14	Nematoda	4.29
	September	Chironomidae	85.34	Oligochaeta	13.19	Corixidae	0.3
Perk's Slough	March	Caenidae	41.38	Chironomidae	39.65	Ostracoda	12.07
	May	Chironomidae	70.90	Caenidae	20.05	Coenagrionidae	5.14
	September	Oligochaeta	35.80	Caenidae	31.87	Chironomidae	9.09
Miller Marsh	March						
	May	Caenidae	56.88	Chironomidae	24.77	Coenagrionidae	8.95
	September	Ceratopogonidae	33.85	Chironomidae	17.69	Diptera	13.84
North Pond	March	Chironomidae	85.71	Caenidae	4.77	Tabanidae	3.81
	May	Chironomidae	54.13	Caenidae	20.8	Corixidae	13.34
	September	Caenidae	60.14	Chironomidae	20.28	Coenagrionidae	13.99

Table 15. Sample period summary statistics of benthic invertebrate measures in five wetland units at Mason Valley Wildlife Management Area, March-September, 1999.

Wetland Unit	Date (1999)	Total Number of Individuals	Total Number of Taxa Identified	Mean Abundance Per Taxon	Percent of Taxa in Sample	Shannon-Wiener Diversity Index (SWI)	Margalefs Richness Index (MRI)	Hilsenhoff Biotic Index (HBI)
Cinnamon Pond	March	59	1	59	8	0	0	6
	May	429	10	42.9	77	1.10	1.48	7.27
	September	297	to	29.7	77	1.06	1.58	6.3
Hinkson Slough	March	53	4	13.25	33	0.57	0.76	6.32
	May	140	9	15.56	75	0.99	1.62	7.36
	September	341	7	48.71	58	0.49	1.03	6.27
Perk's Slough	March	58	6	9.67	40	1.24	1.23	6.72
	May	409	8	51.13	53	.89	1.16	6.4
	September	176	11	17.60	73	1.67	1.74	7.15
Miller Marsh	March							
	May	436	15	29.07	79	1.29	2.3	6.92
	September	130	12	10.83	63	1.92	2.26	5.4
North Pond	March	105	7	15	39	0.64	1.29	6.17
	May	375	13	28.85	72	1.39	2.02	6.62
	September	286	11	26	61	1.17	1.77	6.93

Table 16. Taxonomic list of wetland vegetation observed in six wetland units at Mason Valley Wildlife Management Area, Nevada, September 1999.

Phyla Class Order	Family	Genus and Species	Common Name or Group
Chlorophyta			
Charophyceae	Chareae	*Chara delicatula*	chara
Charales	NiteHeae	*Tolypella* spp.	stonewort
Chlorophyceae			green algae
Magnoliophyta			
Liliopsida			
Arales	Lemnaceae	*Lemna minor*	duckweed
Cyperales	Cyperaceae	*Eleocharis palustris*	common spikerush
		Schoenoplectus acutus	hard-stem bulrush
		Schoenoplectus maritimus	cosmopolitan bulrush
		Schoenoplectus robustus	sturdy bulrush
	Poaceae	*Distichlis spicata*	inland saltgrass
		Hordeum brachyantherum	meadow barley
		Muhlenbergia asperfolia	scratchgrass
		Polypogon monspeliensis	annual rabbitsfoot grass
Juncales	Juncaceae	*Juncus balticus*	Baltic rush
Najadales	Najadaceae	*Najas guadelupensis*	southern water nymph
	Potomogetonaceae	*Potomogeton* spp.	pondweed
	Ruppiaceae	*Ruppia maritima*	widgeongrass
	ZannicheHiaceae	*Zannichellia palustris*	homed pondweed
Typhales	Typhaceae	*Typha talifolia*	broad-lead cattail
Magnoliopsida			
Asterales	Ambrosiaceae	*Ambrosia* spp.	Ragweed
CaryophyHales	Chenopodiaceae	*Atriplex confertifolia*	four-wing saltbrush
		Chenopodium ambrosoides	Mexican tea
Fabales	Astragalaceae	*Astragalus* spp.	milkvetch

Table 16. Taxonomic list of wetland vegetation observed in six wetland units at Mason Valley Wildlife Management Area, Nevada, September 1999. (concluded)

Phyla Class Order	Family	Genus and Species	Common Name or Group
Haloragales	Myriophyllaceae	*Myriophyllum* spp.	water milfoil
Nymphaeales	Ceratophyllaceae	*Ceratophyllum demersum*	coon's tail
Polygonales	Polygonaceae	*Polygonum punctatum*	dotted smartweed
Salicales	Salicaceae	*Salix* spp.	willow
		Populus fremonti	Fremont cottonwood
Violales	Tamaricaceae	*Tamarix ramosissma*	salt cedar

Table 17. Vegetation coverage at six wetlands at Mason Valley Wildlife Management Area in September 1999.

Taxon	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Percent cover by taxon						
Chara delicatula	0.45	0.98				
Tolypella spp.	0.66	0.16	0.58	0.04		
Green algae	6.64	8.32	0.36	-	43.40	
Lemna minor	-	6.68	2.51	0.73		
Eleochris palustris	-	-	-	-	-	7.05
Schoenoplectus acutus	49.43	26.89	1.26	-	-	0.61
Schoenoplectus maritmus	-	-	0.49			
Schoenoplectus robustus	3.61					
Distichlis spicata	0.41	1.07	0.85	0.04		
Hordeum brachyantherum	-	-	-	0.23		
Muhlenbergia asperifolia	-	-	0.27			
Polypogon monspeliensis	-	0.12	-	0.15	-	0.74
Juncus balticus	-	-	-	-	2.13	2.66
Najas guadalupensis	-	-	-	-	9.91	
Potomogeton spp.	0.82	10.37	-	-	6.52	1.68
Ruppia maritima	-	-	-	-	0.66	
Zannichellia palustris	-	-	-	-	27.17	43.28
Typha latifolia	12.13	17.21	20.00	9.62	16.64	28.32
Ambrosia spp.	0.16					
Atriplex confertifolia	0.82					
Chenopodium ambrosiodes	-	-	-	8.90		
Astragalus spp.	-	0.08				
Myriophyllum spp.	-	1.71				
Ceratophyllum demersum	-	18.20	33.72			
Polygonum punctatum	-	-	1.70	1.90	-	0.12
Salix spp.	-	-	-	0.11		
Populus fremonti	-	-	-	0.15		

Table 17. Vegetation coverage at six wetlands at Mason Valley Wildlife Management Area in September 1999. (concluded)

Taxon	Miller Marsh	Perk's Slough	Cinnamon Pond	Hinkson Slough	North Pond	Swan Lake
Percent cover by taxon						
Tamarix ramosissima	-	-	0.18	0.95		
Percent cover by vegetation type						
Emergent	66.02	44.10	25.83	17.76	18.77	39.51
Submerged	8.57	39.75	34.66	0.08	87.66	44.96
Upland or dry	0.74	1.27	-	5.10		
Floating	-	6.68	2.51	0.73		
Percent total vegetation cover	75.12	91.80	60.04	18.52	106.43	83.73
Percent total bare/open water	24.88	8.20	39.96	81.48	-	16.27
Number of species	10	12	11	11	7	8
Number of species by form						
Emergent	3	2	8	7	2	6
Submerged	4	7	3	2	5	2
Upland or dry	3	3	0	6	0	0
Floating	0	1	1	1	0	

Table 18. Morphological data for common carp and largemouth bass from wetlands at Mason Valley Wildlife Management Area. Data reported as mean ± standard error of the mean, including condition factor (weight [g]/totallength^3 [mm] x 10^5); from Nichols et al. (1999).

	Hinkson Slough	Cinnamon Pond	Perk's Slough	Miller Marsh	Widgeon Pond
Carp					
Total (N)	9	10	10		
Female	6	6	3		
Male	3	4	7		
Total length (mm)	428±38	389±20	341±4		
Weight (g)	1123±408	812±109	531±27		
Condition factor					
Sexes combined	1.16±0.O4	1.31±O.O4	1.33±O.02		
Female	1.12±0.05	1.35±O.06	1.32±O.O5		
Male	1.24±O.O5	1.26±O.03	1.34±O.O2		
Bass					
Total (N)	10	6		2	3
Female	2	1		0	2
Male	1	1		0	1
Immature	7	4		2	0
Total length (mm)	281±17	160±22		124±14	331±15
Weight (g)	302±18	89±40		25±4.5	674±44
Condition factor	1.20±O.05	1.54±O.14		1.30±O.20	1.88±O.I4

Table 19. Results of histological examination of common carp and largemouth bass from wetlands at Mason Valley Wildlife Management Area. Data reported as the number of positive/total tissues examined for brown pigments (BP, scored 0,1,2, 3), calcium oxalate crystals within degenerative kidney tubules (CaOx kidney), and cross sections of a similar helminth found within either the kidney, liver, and/or spleen of a given fish (Helminth [KLS]). Data from Nichols et al. (1999).

	Hinkson Slough	Cinnamon Pond	Perk's Slough	Miller Marsh	Widgeon Pond
Carp					
BP> 1 kidney	7/10	7/10	3/10		
BP > 1 liver	1/10	1/9	0/10		
BP > 1 spleen	2/8	2/9	1/10		
CaOx kidney	2/10	0/9	1/10		
Helminth (KLS)	0/10	0/10	0/10		
Bass					
BP > 1 kidney	3/6	NS [a]		NS [a]	1/2
BP> 1 liver	6/9	0/6		0/2	1/3
BP> 1 spleen	7/10	0/3		0/2	2/3
CaOx kidney	0/6	NS [a]		NS [a]	0/2
Helminth (KLS)	4/10	2/6		2/2	3/3

[a] No section of that particular tissue.

Table 20. Average concentrations of selected constituents in water from the Walker River collected near Wabuska, Nevada, by the Nevada Division of Environmental Protection, January 1994 to May 2002. See Appendix C for details on times of collection and sample sizes.

	Minor constituents (ug/L)			
	Total	Dissolved	Major constituents[a]	
Arsenic	12.	13.	Temperature	11.2°C
Boron	306.	357.	DO	9.3 mglL
Cadmium	nd[b]	nd	SC	371.
Chromium	nd	nd	Lab pH	8.2 SU
Copper	6.8	1.4	Field pH	8.2 SU
Iron	1220.	94.	Turbidity	24. NTU
Lead	nd	nd	TDS	224. mg/L
Mercury	nd	nd	TSS	56. mg/L
Selenium	nd	nd	Total Nitrogen	0.67 mg/L
Zinc	13.	41.	Nitrite	nd
Calcium	29.	32.	Nitrate	0.1.3 mg/L
Sodium	38.	45.	N-Ammonia	nd
Magnesium	7100.	7700.	Kjeldahl Nitrogen	0.52 mg/L
			Total Phosphorus	0.17 mg/L
			Chloride	13. mg/L
			Sulfate	40. mg/L
			Fecal coliforms	95/100ml
			Hardness	101. mg/L

a DO = dissolved oxygen; SC = specific conductance; TDS = total dissolved solids; TSS = total suspended solids; N-Ammonia = nitrogen ammonia.

b nd = not detected in > 500/0 of samples; see Appendix C for detection limits.

Table 21. Flow (cubic feet/second) data for the Walker River near Wabuska, Nevada, based on water years 1902-2001 from U.S. Geological Survey data (Garcia et al. 2002).

Month	Monthly Mean	Maximum	Minimum
January	133	1669	7.17
February	143	905	14.0
March	154	949	10.6
April	157	1344	10.0
May	260	1262	6.00
June	486	2255	5.00
July	258	1604	0.23
August	92.6	922	0.000
September	68.9	357	0.000
October	76.8	585	0.000
November	91.8	704	1.53
December	113	854	3.42
Annual Mean	171		
Highest Annual Mean	832		
Lowest Annual Mean	12.9		
Highest Daily Mean	2740		
Lowest Daily Mean	0.00		
Annual 7 day minimum	0.00		
Maximum Peak Flow	3280		
Annual Runoff	123500 acre feet		

Table 22. Specific conductance of water in the Walker River near Wabuska, Nevada, January 1998 to July 2000. Data collected by the U.S. Geological Survey (Jones et al. 1999; Allander et al. 2001).

Month and Year	Monthly mean	Extremes
December 1998	374	324-462
January 1999	428	392-466
February 1999	320	225-406
March 1999	377	278-584
April 1999	387	293-493
May 1999	incomplete data	
June 1999	incomplete data	
July 1999	incomplete data	
August 1999	415	344-503
September 1999	433	371-668
October 1999	500	422-647
November 1999	510	457-542
December 1999	516	446-609
January 2000	460	429-480
February 2000	463	406-514
March 2000	incomplete data	
April 2000	462	356-632
May 2000	391	309-494
June 2000	345	269-447
July 2000	incomplete data	
Range of monthly means	320-516	
Range of extremes		225-668

Table 23. Quarterly water quality data for the discharge from cooling ponds by Sierra Pacific Power Company, Fort Churchill Power Plant to Miller Marsh for the period of January 1996 through June 2002 and yearly estimated discharges. Arithmetic means for all constituents, except fecal coliforms which is a geometric mean. Data provided by the Nevada Division of Environmental Protection.

Constituent	N	Mean[a]	Extremes
Arsenic	26	270 µg/L	120-530
Boron	25	1600 µg/L	1300-3100
Fluoride	26	8.2 mgIL	6.5-24
Iron	26	1100 µg/L	220-2100
Mercury	10	nd[b] µg/L	<0.5-3.9
Molybdenum	25	81 µg/L	5-160
Zinc	25	34 µg/L	<10-70
Sodium	26	224 mgIL	190-380
Total dissolved solids	26	819 mgIL	690-1300
Fecal coliforms	25	3.4/100 ml	0-238

Yearly estimated discharges in acre feet	
1998	448
1999	929
2000	1039
2001	1262

a µg/L = micrograms per liter; mg/L = milligrams per liter, ml = milliliters.
b nd = not detected in > 50% of the samples analyzed.

Table 24. Quarterly water quality data from Sierra Pacific Power Company, Fort Churchill Power Plant for water delivered to North Pond for the period of October 1998 through June 2002. Arithmetic means for all constituents, except fecal coliforms which is a geometric mean. Data provided by the Nevada Division of Environmental Protection.

Constituent	N	Mean[a]	Extremes
Arsenic	15	279	120-590
Boron	14	2238	1400-3700
Fluoride	15	10.7 mg/L	6.6-17
Iron	14	11749	300-87000
Mercury	7	nd[b] µg/L	<0.2-52
Molybdenum	14	119	35-320
Zinc	15	nd	<25-800
Sodium	14	297 mg/L	200-530
Total dissolved solids	15	1260 mg/L	730-3313
Fecal coliforms	15	10.5/100 ml	<2-300

a µg/L = micrograms per liter; mg/L = milligrams per liter; ml = milliliters.
b nd = not detected in > 50% of the samples analyzed.

Table 25. Water quality data for selected constituents in samples collected from North Pond by the Nevada Division of Environmental Protection, March 1999 to September 200La

Constituent	N[b]	Mean	Units[c]	Extremes
Dissolved oxygen	7	6.4	mg/L	4.5-7.6
Field pH	7	8.9	SU	8.4-9.25
Specific conductance	9	1395.	µS/cm	1219-1710
Total dissolved solids	9	864.	mg/L	710-1030
Total suspended solids	9	4.3	mg/L	0-10
Total nitrogen	9	1.6	mg/L.	1.23-1.78
Kjeldahl nitrogen	9	1.6	mg/L	1.16-1.77
Nitrite	9	nd[d]	mg/L	<0.01-0.03
Nitrate	9	0.02	mg/L	0-0.06
Total phosphorus	9	0.30	mg/L	0.23-0.46
Chloride	9	73.	mg/L	62-90
Sulfate	9	198.	mg/L	137-314
E. coli	8	nd	#/100 ml	<10-20
Turbidity	9	10.4	NTU	2.7-21
Arsenic	3	160	µg/L	125-207
Boron	3	1800	µg/L	1700-2000
Cadmium	3	nd	µg/L	<1
Chromium	3	nd	µg/L	<2-<5
Copper	3	10	µg/L	10
Iron	3	604	µg/L	210-1120
Lead	3	nd	µg/L	<2-<5
Mercury	3	nd	µg/L	<0.5-<5
Selenium	3	nd	µg/L	<2-2
Zinc	3	10	µg/L	10
Calcium	3	20.7	mgIL	16-26
Sodium	3	275.	mgIL	263-292
Magnesium	3	14.7	mgIL	11-17

a Where duplicate samples were collected, the means for a given date were used in calculating the overall mean. For elements, excluding nitrogen and phosphorus, results for unfiltered samples are reported. Extremes reported include duplicate samples.

b Number of dates sampled.

c mgIL = milligrams per liter; = micrograms per liter; SU = standard units; = microsiemens per centimeter; #/100 ml = number per 100 milliliters; NTU = nephroturbidity units.

d nd = not detected in > 50% of samples.

Table 26. Water quality of discharges by the City of Yerington to Cinnamon Pond on Mason Valley Wildlife Management Area, 1998-2000. Data provided by the Nevada Division of Environmental Protection.

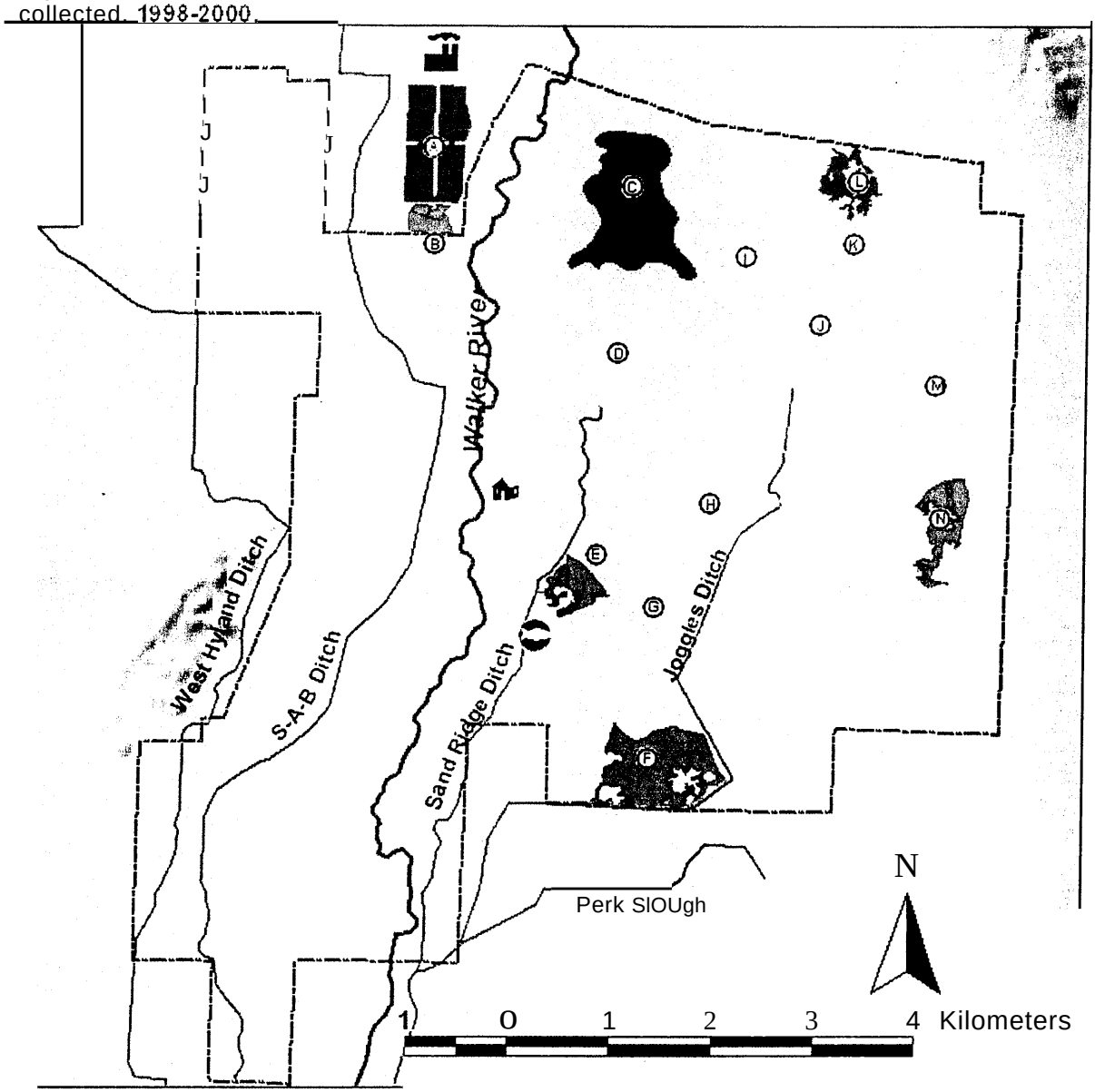
Year	Total discharge (acre feet)	Total suspended solids (mg/L[a])	pH	Fecal coliforms (number/100 ml)
1998	390[b]	21[c]	7.6[c]	4.2[d]
		(13-32)[e]	(7.3-7.9)[e]	(<2-72)[e]
1999	338[f]	26	7.6	9.1
		(13-53)	(7.1-8.0)	«1-1600)
2000	289[f]	35	7.4	4.4
		(20-49.5)	(7.0-7.65)	«1-89.6)

a mg/L = milligrams per liter.
b Estimated based on mean monthly flows.
c Arithmetic means.
d Geometric means.
e Extremes.
f As reported on monitoring report.

Table 27. Wetland units with species of aquatic flora not observed in other wetland units.

Wetland Unit	Aquatic Flora Species
Perk's Slough	*Myriophyllum* spp. *Astragulus* spp.
Hinkson Slough	*Chenopodium ambrosoides* *Populus fremonti* *Salix* spp. *Hordeum brachyantherum*
Miller Marsh	*Atriplex confertifolia* *Ambrosia spp.* *Schoenoplectus robustus*
Cinnamon Pond	*Schoenoplectus maritimus* *Muhlenbergia asperifolia*
North Pond	*Ruppia maritima* *Najas guadalupensis*
Swan Lake	*Eleochris palustris*

Figure 1. Wildlife Management Area wetland units from which were collected, 1998-2000.



LEGEND AND KEY TO WETLANDS

Mason Valley WMA Boundary
Water Delivery System
Proposed

Primary Wetlands
Walker River

Fish hery

Mason WrvlA Headqu

Sierra Pacific Fort Churchill Power Station

A. Fort Churchill Cooling Ponds
B. Marsh
C. North Pond
D. Bass Pond
E. Hinkson Slough
F. Cinnamon Pond
G. Pond
H. Mallard Pond
I. Lower Pond
J. Honker Lake
K. Widgeon Pond
L. Swan Lake
M. Lower Pintail Pond
N. Perk's Slough

APPENDICES

Appendix A. Field-collected water quality data from various wetlands at Mason Valley Wildlife Management Area, Lyon County, Nevada, 1998-2000.

Abbreviations used in the following tables: Temp. = temperature; C = ₀ Celsius; est. mph = estimated miles per hour; cm = centimeters; D.O. (mg/L) = dissolved oxygen (milligrams per liter); s.C. (uS/em) = specific conductance (microsiemens per centimeter); ppt = parts per thousand; NTU = nephroturbidity units; nr = not recorded; nd = not determined.

UTM coordinates for the sampling points were as follows:

Location	Point	Easting	Northing
Cinnamon Pond	outlet	317910	4326363
Cinnamon Pond	inlet	317455	4325701
Cinnamon Pond	sewage outfall	317413	4325710
Mallard Pond	outlet	318811	4328906
Joggles Ditch	Perk's Slough Diversion	318487	4325723
Perk's Slough	outlet	321038	4328890
Lower Pintail Pond	outlet	320496	4329747
Honker Lake	midpoint	319539	4330427
Lower Gadwall Pond	outlet	319502	4331646
Widgeon Pond	outlet	319936	4331433
North Pond	outlet	318151	4332416
Bass Pond	outlet	317596	4330336
Hinkson Slough	outlet	317317	4328053
Hatchery Effluent	inlet to Redhead Pond	317592	4327762
Miller Marsh	midpoint	315918	4331612
Swan Lake	terminal point	not recorded	
Power Plant	cooling pond	not recorded	

Location	Point	Date	Time	Air Temp. (C)	Wind Speed (est. mph)	Wind Direction	Water Movement	Water Depth (em)	Water Temp. (C)	D.O. mgIL	S.C. (uS/em)	Salinity (ppt)	pH	Turbidity (NTU)	Comments
Cinnamon Pond	oullet	4-Dec-1998	nr	nd	nd	nd	nd	nd	7.5	8.7	420	0.3	8.4	22	
Cinnamon Pond	oullet	13-Jan-1999	nr	nd	nd	nd	nd	nd	5	13.6	320	0.1	8.5	16	
Cinnamon Pond	outlet	17-Feb-1999	10:00 AM	10	30	W	high	30	6	12.2	360	0.5	10	46	
Cinnamon Pond	oullet	2-Mar·1999	11:20 AM	19	5	nd	slight chop	40	12	12	470	0.2	9.1	95	
Cinnamon Pond	outlet	18-Mar-1999	09:36 AM	13	0		none	30	10	12.8	390	0.3	10	29	
Cinnamon Pond	outlet	14-Apr-1999	11:05AM	14	0		nd	30	14	11	355	0.6	nd	46	
Cinnamon Pond	outlet	13-May-1999	11:20AM	17	5	nd	nd	30	15	10.6	380	0.5	nd	46	
Cinnamon Pond	oullet	2-Jun-1999	11:45AM	13	15	W	wind chop	nd	17	8.4	450	0.5	nd	34	
Cinnamon Pond	outlet	17-Jun-1999	11:45 AM	29	5	NW	none	25	23	7.5	360	0.5	9.1	40	water down 50 em
Cinnamon Pond	oullet	21-Jul-1999	nr	30	5W		none	40	22	5	330	0.4	8	64	
Cinnamon Pond	outlet	21-Sep-1999	10:10 AM	23	nd	nd	nd	30	20	6.5	360	0.5	8.2	36	
Cinnamon Pond	outlet	15·Mar-2000	10:05 AM	19	nd	nd	none	20	13	13.2	600	1	84	32	
Cinnamon Pond	oullet	27-Jun-2000	12:40 PM	nd	·0		none	40	26	5.2	429	0.2	7.6	nd	
Cinnamon Pond	outlet	6-Jul-2000	nr	nd	nd	nd	nd	nd	20	5.8	411	0.2	7.9	64	
Cinnamon Pond	outlet	25-Jul-2000	10:15 AM	20	0		none	20	22	nd	328	0.2	7.7	nd	
Cinnamon Pond	inlet	4-0ec-1998	nr	nd	nd	nd	nd	nd	9	9.1	600	0.5	8.3	9	sewage effluent
Cinnamon Pond	inlet	13-Jan-1999	nr	nd	nd	nd		nd							water frozen
Cinnamon Pond	inlet	17-Feb-1999	09:30 AM	8	20	W	medium	30	6	9.8	500	0.5	8.6	20	
Cinnamon Pond	inlet	18-Mar·1999	09:20AM	12	0		low	30	9	96	250	0.3	9.3	21	
Cinnamon Pond	inlet	14-Apr-1999	11:00AM	13	0		nd	30	12	8.4	520	0.5	nd	18	
Cinnamon Pond	inlet	13·May-1999	09:30AM	15	0		nd	30	13	8	480	0.5	nd	20	
Cinnamon Pond	inlet	17-Jun-1999	11:35AM	29	0		low	30	20	2.9	600	0.5	7.6	52	
Cinnamon Pond	inlet	21·Jul-1999	10:55 AM	28	5W		medium	40	19	6.3	420	0.5	7.7	16	
Cinnamon Pond	inlet	21-Sep-1999	10:00 AM	22	nd	nd	low	40	19	35	550	0.5	7.5	10	
Cinnamon Pond	inlet	27-Jun-2000	12:30 PM	nd	0		high	20	22	6.5	239	0.1	7.8	nd	
Cinnamon Pond	inlet	25-Jul·2000	10:25AM	nd	0		none	30	20	8.2	335	0.2	8	nd	
Cinnamon Pond	sewage outfall	4-Dec-1998	nr	13	nd	nd	nd	nd	6	9.3	430	0	8.4	8	
Cinnamon Pond	sewage outfall	13-Jan-1999	nr	nd	nd	nd	nd	nd	6	9.8	500	0.1	7.3	7	
Cinnamon Pond	sewage outfall	17-Feb-1999	09:14AM	9	15	W	high	15	7	10.2	550	0.5	8.4	14	
Cinnamon Pond	sewage outfall	18-Mar-1999	09:11 AM	11	0		high	20	9	9	600	0.5	8.6	10	
Cinnamon Pond	sewage outfall	14·Apr-1999	10:40 AM	13	0		nd	20	11	8.8	650	1	7.6	14	
Cinnamon Pond	sewage outfall	13-May-1999	10:50 AM	15	0		nd	20	12	9.1	600	0.5	nd	14	
Cinnamon Pond	sewage outfall	17-Jun-1999	11:30AM	28	5W		medium	10	18	6.4	900	0.8	7.5	37	
Cinnamon Pond	sewage outfall	21·Jul-1999	10:50 AM	27	5W		high	20	22	6.5	950	0.9	7.7	18	
Cinnamon Pond	sewage outfall	21-Sep-1999	09:55AM	22	nd	nd	medium flow	20	21	6.4	890	1	7.6	14	
Cinnamon Pond	sewage outfall	27-Jun-2000	12:30 PM	nd	0		high	10	22	6.4	898	0.5	7.5	nd	
Cinnamon Pond	sewage outfall	25-Jul-2000	10:20 AM	nd	0		none	20	23	7.8	842	0.4	7.7	nd	
Mallard Pond	outlet	4-Dec-1998	nr	nd	5	nd	nd	nd	7	8.6	330	0.2	8.3	18	
Mallard Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	8	10.6	280	0.05	7.8	9.2	
Mallard Pond	oullet	17-Feb-1999	08:54AM	8	10	W	medium	30	6	10.4	298	0.5	9	14	
Mallard Pond	oullet	18-Mar·1999	08:40AM	8	0		none	30	10	7.6	385	0.5	9.1	17	
Mallard Pond	outlet	15-Apr-1999	10:15AM	11	0		nd	30	14	9.5	450	0.8	9.2	17	
Mallard Pond	outlet	13·May·1999	10:30 AM	15	0		nd	30	14	8.5	400	0.5	nd	17	
Mallard Pond	oullet	17-Jun-1999	11:00AM	26	5W		none	30	23	10.8	580	1	9.2	19	
Mallard Pond	oullet	21·Jul-1999	10:40 AM	26	5W		medium	20	22	5.2	380	0.3	8.7	16	
Mallard Pond	oullet	21-Sep-1999	09:40AM	21	nd	nd	nd	40	19	5	450	0.8	7.7	24	

Location	Point	Date	Time	Air Temp. (e)	Wind Speed (est. mph)	Wind Direction	Water Movement	Water Depth (em)	Water Temp. (C)	D.O. mg/L	S.C. (uS/em)	Salinity (ppt)	pH	Turbidity (NTU)	Comments
Joggles Ditch	Perk Slough Diversion	4-Dec-1998	nr	nd	nd	nd		nd	5	10.4	200	0.1	9.1	6.2	ice crusted 5 cm
Joggles Ditch	Perk Slough Diversion	13-Jan·1999	nr	nd	nd	nd	nd	nd	2	12.8	220	0.05	84	8.4	
Joggles Ditch	Perk Slough Diversion	17·Feb-1999	09:45AM	9	20	W	low	15	6	17.8	250	0.5	9.8	26	
Joggles Ditch	Perk Slough Diversion	18-Mar-1999	09:50 AM	13	5	nd	high	30	10	10	230	0.1	9.1	18	
Joggles Ditch	Perk Slough Diversion	14-Apr-1999	11:15AM	14	0		nd	20	14	9.6	275	0.2	nd	17	
Joggles Dilch	Perk Slough Diversion	13-May-1999	11:30AM	17	5	nd	nd	20	15	8.9	300	0.1	nd	26	
Joggles Dilch	Perk Slough Diversion	17-Jun-1999	11:55 AM	30	0		low	25	20	5.9	140	0.1	8.4	76	
Joggles Ditch	Perk Slough Diversion	21-Jul-1999	11:15AM	nd	5	N	flowing	0.5	20	78	210	0.2	8.1	26	
Joggles Ditch	Perk Slough Diversion	21-Sep-1999	10:20 AM	23	nd	nd	low	10	18	6.1	270	0.5	8	12	
Perk's Slough	oUllet	4-0ec-1998	nr	nd	nd	nd	nd	nd	6	9.2	270	0.1	8.4	9.2	
Perk's Slough	oullet	13-Jan-1999	nr	nd	nd	nd	nd	nd	6	11.2	275	0.05	8.1	5.8	
Perk's Slough	outlet	17-Feb-1999	10:17 AM	10	20	W	medium	20	6	11	280	0.5	9.2	21	
Perk's Slough	outlet	2-Mar-1999	12:15PM	20	10	nd	chop	50	9	10.5	500	0.3	8.9	130	wetland drawn down approx. 1m
Perk's Slough	oullet	18-Mar-1999	10:15 AM	14	10	nd	medium	30	11	8.4	280	0.3	9	28	wetland drawn down approx. 1m
Perk's Slough	outlet	14-Apr-1999	11:30 AM	16	5	nd	low	30	14	8.8	280	0.1	nd	22	
Perk's Slough	outlet	13-May-1999	11:45AM	17	10	nd	nd	40	15	7.9	300	0.1	nd	28	
Perk's Slough	outlet	2-Jun-1999	12:00 PM	nd	15	W	wind chop	nd	15	6.5	380	0.5	nd	40	
Perk's Slough	outlet	17-Jun-1999	12:05 PM	30	5W		none	25	25	6.6	440	0.2	8.2	14	
Perk's Slough	oullet	21-Jul-1999	11:25 AM	nd	5	nd	wind chop	> 1 m	22	5.8	320	0.2	8	12	
Perk's Slough	outlet	21-Sep-1999	10:30 AM	24	nd	nd	nd	30	20	4.1	370	0.5	7.9	24	
Perk's Slough	oullet	15-Mar·2000	10:40 AM	19	nd	nd	none	30	13	7.2	420	1.2	7.6	48	
Perk's Slough	outlet	27-Jun-2000	12:50 PM	nd	0		none	20	26	6.7	327	0.2	7.7	nd	
Perk's Slough	outlet	6-Jul-2000	nr	nd	nd	nd	nd	nd	20	9.1	298	0.2	8.8	11	
Perk's Slough	outlet	25-Jul-2000	10:50 AM	nd	0		none	30	25	11.8	280	0.1	9.5	nd	
Lower Pintail Pond	outlet	4-0ec-1998	nr	10	nd	nd	nd	nd	5	8.6	410	01	8.6	21	
Lower Pinlail Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	5	5.8	440	0.1	7.8	26	
Lower Pintail Pond	outlel	17-Feb·1999	10:49 AM	10	20	W	medium	30	8	9	460	0.5	8.9	138	
Lower Pinlail Pond	outlet	18·Mar-1999	nr	14	20	nd									prescribed bum occurring
Lower Pintail Pond	outlet	14·Apr-1999	11:45AM	16	5	nd									drained after burn
Lower Pintail Pond	outlet	13-May·1999	12:10 PM	18	10	nd									drained after burn
Lower Pintail Pond	outlet	17·Jun-1999	12:50 PM	30	5	WSW	none	20	23	8.6	460	0.5	9.1	8	water filling up, cattail growth explosio
Lower Pintail Pond	oullet	21-Jul-1999	11:35 AM	nd	5W		none	25	18	5.6	375	0.3	9.8	9	
Lower Pintail Pond	outlet	21-Sep-1999	10:50 AM	25	nd	nd	high	30	20	5.2	270	0.3	7.8	18	
Honker Lake	midpoint	4-Dec-1998	nr	nd	nd	nd	nd	nd	5	5.5	450	0.5	8.3	60	
Honker Lake	midpoint	13-Jan-1999	nr	nd	nd	nd	nd	nd	7	>20	700	0.1	8.4	94	
Honker Lake	midpoint	17-Feb·1999	11:08AM	10	5	nd	nd	30	8	11	600	0.5	8.8	16	
Honker Lake	midpoint	18-Mar-1999	10:50 AM	14	15	nd	medium	20	12	7.2	700	0.8	9.3	34	
Honker Lake	midpoint	14-Apr-1999	11:50 AM	nd	5	nd	low	30	15	9.4	650	0.5	nd	35	
Honker Lake	midpoint	13-May·1999	12:30 PM	19	10	nd	nd	30	16	9.2	600	0.5	nd·	60	
Honker Lake	midpoint	17·Jun-1999	01:30 PM	31	0		none	50	22	4.8	1050	0.8	8	5.4	
Honker Lake	midpoint	21-Jul-1999	11:50 AM	nd	5	nd	none	30	20	4.5	750	0.9	9.1	2.2	
Honker Lake	midpoint	21-Sep-1999	11:00 AM	25	nd	nd	nd	40	19	7.5	1000	0.5	9.1	>200	

Location	Point	Date	Time	Air Temp. (C)	Wind Speed (est. mph)	Wind Direction	Water Movement	Water Depth (em)	Water Temp. (C)	D.O. mg/L	S.C. (uS/em)	Salinity (ppt)	pH	Turbidity (NTU)	Comments
Lower Gadwall Pond	outlet	4·Dec·1998	nr	nd	nd	nd	nd	nd	6	9.4	1050	0.8	8.6	>200	
Lower Gadwall Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	3	9.8	350	0.05	8.2	19	
Lower Gadwall Pond	oullet	17·Feb-1999	11:37 AM	11	15	W	medium	30	7	10.4	440	0.5	9.2	6.8	
Lower Gadwall Pond	outlet	18-Mar-1999	11:10AM	16	15	nd	medium	30	13	9.2	550	0.5	9.5	4.8	
Lower Gadwall Pond	oullet	14·Apr-1999	12:35 PM	nd	5	nd	low	20	18	14.6	550	0.5	nd	9.5	
Lower Gadwall Pond	outlet	13-May-1999	01:00 PM	nd	10	nd	nd	30	18	10.8	480	0.5	nd	6.8	
Lower Gadwall Pond	outlet	17-Jun-1999	01:50 PM	31	55	low		20	22	11.5	900	1	8.8	7.6	
Lower Gadwall Pond	outlet	21-Jul-1999	12:00 PM	nd	5W	none		15	25	10.2	680	0.5	10.1	4.9	
Lower Gadwall Pond	outlet	21-Sep-1999	11:10AM	25	nd	nd	nd	40	20	2.8	450	1.3	8.1	18	
Widgeon Pond	outlet	4-Dec·1998	nr	nd	nd	nd	nd	nd	6	8.8	410	0.2	8.6	32	
Widgeon Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	8	>20	350	0.05	9.5	nd	
Widgeon Pond	oullet	17·Feb-1999	11:24 AM	11	15	W	low	30	9	7.2	450	0.5	8.8	27	
Widgeon Pond	outlet	18-Mar·1999	11:40 AM	16	5	nd	low	30	15	10.4	600	0.8	9.4	66	
Widgeon Pond	oullet	14-Apr-1999	12:05 PM	nd	5	nd	low	20	16	8.5	490	0.5	nd	7.1	
Widgeon Pond	oullet	13·May·1999	12:45 PM	18	10	nd	nd	30	17	92	560	0.5	nd	27	
Widgeon Pond	outlet	17-Jun-1999	01:40 PM	31	55		medium	15	22	5.7	400	0.5	9.6	1.4	
Widgeon Pond	outlet	21-Jul·1999	12:00 PM	nd	5	nd	none	30	21	3.6	280	0.5	9.4	0.9	
Widgeon Pond	oullet	21·Sep·1999	11:20AM	25	nd	nd	nd	30	22	2.5	600	0.5	8.3	24	
North Pond	outlet	9·Jul-1998	12:30 PM	nd	nd	nd	nd	nd	24	8.3	166	0.4	8.3	nd	NOOW measurements
North Pond	outlet	4-Dec-1998	nr	nd	nd	nd	nd	nd	7	9.4	900	0.8	nd	14	
North Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	7	15.8	600	0.1	86	400	
North Pond	outlet	17-Feb-1999	12:18PM	11	30	W	medium	20	6	13.2	800	1	9.3	10	
North Pond	oullet	2-Mar·1999	01:00 PM	26	10	nd	wind chop	50	12	11.2	950	0.3	9.8	10	
North Pond	outlet	18-Mar-1999	12:10 PM	17	10	nd	medium	30	13	11.2	950	1	9.8	14	
North Pond	outlet	14-Apr-1999	12:55 PM	17	10	nd	low	30	18	12.2	1050	0.9	nd	6	
North Pond	outlet	13-May-1999	01:30PM	19	15	nd	nd	30	18	10.8	1200	0.5	nd	14	
North Pond	outlet	2-Jun-1999	12:45 PM	nd	15	W	wind chop	nd	18	9	1300	1.5	nd	8.4	
North Pond	oUllet	17-Jun-1999	02:25 PM	31	55	low		40	26	16.1	1450	1	9.3	3.8	new coontail growth on substrate
North Pond	oullet	21-Jul-1999	12:15 PM	nd	5W	low		30	25	19.2	1500	1	9.9	20	
North Pond	oullet	21-Sep-1999	11:40AM	26	nd	nd	low	40	17	7	1300	1.3	9.5	12	
North Pond	oullet	15-Mar-2000	11:25AM	19	5	N	medium	20	12	9	950	1	8.3	8.4	
North Pond	outlet	27-Jun-2000	01:20 PM	nd	0		none	50	28	10.2	1421	0.8	9.3	nd	
North Pond	outlet	6-Jul-2000	nr	nd	nd	nd	nd	nd	22	10.4	1477	0.8	9.7	4.2	
North Pond	outlet	25-Jul·2000	11:45 AM	nd	0		none	70	24	11.9	1520	0.8	10.1	nd	
Bass Pond	outlet	4·Dec-1998	nr	nd	nd	nd	nd	nd	6	9.6	220	0.1	nd	7.2	
Bass Pond	outlet	13-Jan-1999	nr	nd	nd	nd	nd	nd	7	13.8	290	0.1	8.2	5.8	
Bass Pond	oullet	17-Feb-1999	12:10 PM	11	20	W	medium	30	8	11.4	310	0.5	9.4	2.4	
Bass Pond	outlet	18-Mar-1999	12:20 PM	17	5	nd	low	30	12	10.8	375	0.5	9.1	2.8	
Bass Pond	outlet	15-Apr·1999	01:10 PM	18	10	nd	low	30	15	10.2	370	0.5	nd	2.8	
Bass Pond	outlet	13-May-1999	01:50 PM	19	10	nd	nd	30	17	10.8	380	0.5	nd	2.8	
Bass Pond	outlet	17·Jun·1999	02:40 PM	31	5	5	medium	40	23	10.4	425	0.3	9.1	2.2	
Bass Pond	outlet	21-Jul·1999	12:30 PM	nd	5	nd	nd	50	21	8	375	0.8	9.9	1.2	
Bass Pond	outlet	21·Sep·1999	12:00 PM	26	nd	nd	medium	35	15	3.2	345	0	7.9	24	

Location	Point	Date	Time	Air Temp. (C)	Wind Speed (est. mph)	Wind Direction	Water Movement	Water Depth (em)	Water Temp. (C)	D.O. mg/L	S.C. (uS/em)	Salinity (ppt)	pH	Turbidity (NTU)	Comments
Hinkson Slough	outlet	6-Apr-1997	nr	nd	nd	nd	nd	nd	10.5	12.1	292	0	8.9		NDOW measurements
Hinkson Slough	outlet	4-Dec-1998	nr	nd	nd	nd	nd	nd	6	8.8	240	0.1	nd	38	
Hinkson Slough	outlet	13-Jan-1999	nr		3	nd	nd	nd	5	12.8	200	0.05	8.7	16	
Hinkson Slough	outlet	17-Feb-1999	08:36AM		8	5W	nd	20	6	10.8	220	0.5	8.8	24	
Hinkson Slough	outlet	2-Mar-1999	12:00 PM		17	10	nd	wind chop	50	11	9.2	300	0.1	9.2	74 drawn down
Hinkson Slough	outlet	18-Mar-1999	08:27 AM		7	0		none	30	11	9.2	260	0.3	9.1	104 drawn down
Hinkson Slough	outlet	15-Apr-1999	10:10AM		11	0		nd	30	12	8	285	0.1	9.5	39
Hinkson Slough	outlet	13-May-1999	10:40 AM		16	0		nd	30	15	7.8	270	0.1	nd	24
Hinkson Slough	outlet	2-Jun-1999	11:30 AM	nd		15	W	wind chop	nd	16	5.8	390	1.5	nd	72
Hinkson Slough	outlet	17-Jun-1999	10:45 AM		26	5W	none	30	23	4.6	370	0.3	8.5	140	water level down 150 em
Hinkson Slough	outlet	21-Jul·1999	10:20 AM		25	5W	none	30	22	7.2	335	0.5	8.8	108	
Hinkson Slough	outlet	18-Aug-1999	12:00 PM		32	nd	nd	nd	24	5.3	370	0.5	9	>200	
Hinkson Slough	outlet	21-Sep-1999	09:25AM		21	nd·	nd	medium out	40	17	6.7	260	0.5	7.4	18
Hinkson Slough	outlet	15-Mar-2000	09:45AM		18	nd	nd	high	40	12	8.3	220	2	6.3	12
Hinkson Slough	outlet	27-Jun-2000	12:20 PM	nd		0		none	30	25	7.3	296	0.1	8	nd
Hinkson Slough	outlet	6-Jul-2000	nr	nd	nd	nd	nd	nd	20	6.1	313	0.2	8.1	40	
Hinkson Slough	outlet	25-Jul-2000	10:00 AM		19	0		none	40	19	6.1	318	0.2	8.1	nd
Hatchery Effluent	inlet to Redhead Pond	4-Dee-1998	nr	nd	nd	nd	nd	nd	12	7.8	200	0.1	nd	2.6	
Hatchery Effluent	inlet to Redhead Pond	13-Jan-1999	or	nd	nd	nd	nd	nd	13	7.4	220	005	7.7	0.4	
Hatchery Effluent	inlet to Redhead Pond	17-Feb-1999	09:09 AM		9	15	W	medium	15	12	72	220	0.5	8.5	0.2
Hatchery Effluent	inlet to Redhead Pond	18-Mar-1999	08:55 AM		9	0		high	30	12	7.5	215	0.1	8.6	8
Hatchery Effluent	inlet to Redhead Pond	15·Apr-1999	10:30 AM		11	0		nd	20	12	6.6	115	0.1	7.3	0.8
Hatchery Effluent	inlet to Redhead Pond	13-May-1999	11:00 AM		16	5	nd	nd	20	13	7.8	180	0.1	nd	0.8
Hatchery Effluent	inlet to Redhead Pond	17-Jun-1999	11:15AM		27	5	WNW	slow	20	14	6.4	240	0.1	8	0.44
Hatchery Effluent	inlet to Redhead Pond	21-Jul-1999	10:45 AM		27	5W	low	10	20	4.5	260	0.2	8.2	1.3	
Hatchery Effluent	inlet to Redhead Pond	21-Sep-1999	09:50 AM		22	nd	nd	low flow	20	17	5	200	0.3	7.4	1.2
Hatchery Effluent	inlet to Redhead Pond	27-Jun-2000	12:25 PM	nd		0		medium	15	15	6.8	289	0.1	7.8	nd
Hatchery Effluent	inlet to Redhead Pond	25-Jul-2000	10:05 AM		20	0		none	15	14	6.8	305	0.1	7.6	nd
Miller Marsh	midpoint	4-Dee-1998	or	nd	nd	nd	nd	nd	3	5.3	750	0.8	nd	10	
Miller Marsh	midpoint	13-Jan-1999	nr	nd	nd	nd		nd							frozen
Miller Marsh	midpoint	17-Feb-1999	12:39 PM		11	30	W	low	15	9	7.8	800	0.5	88	14
Miller Marsh	midpoint	2-Mar-1999	11:20 AM		11	nd	nd	nd	25	8	8.7	900	nd	8.9	18
Miller Marsh	midpoint	18-Mar·1999	08:10AM		6	0		none	30	9	65	900	0.8	9	16
Miller Marsh	midpoint	15-Apr-1999	09:45 AM		10	0		nd	30	11	9.2	1000	1	9.3	14
Miller Marsh	midpoint	13-May·1999	10:00 AM		15	0		nd	30	14	8.4	1000	1	nd	18
Miller Marsh	midpoint	2-Jun-1999	10:30 AM	nd	nd	nd	nd	20	15	7.3	1250	2	nd	9.2	
Miller Marsh	midpoint	17-Jun-1999	10:15AM		28	5W	none	40	23	5.8	1600	1	8.2	10	water level down 100 em
Miller Marsh	midpoint	21-Jul-1999	12:45 PM	nd		5	nd	nd	30	24	7.4	1700	1.2	8.6	24
Miller Marsh	midpoint	21-Sep-1999	09:15AM		20	nd	nd	nd	40	16	4.4	1300	3.5	7.7	26
Miller Marsh	midpoint	15-Mar-2000	12:45 PM		20	5N	none	40	16	6.4	950	1	9.4	28	
Miller Marsh	midpoint	27-Jun-2000	12:00 PM		31	0	none	40	25	4	1253	0.7	6.9	nd	
Miller Marsh	midpoint	6-Jul-2000	nr	nd	nd	nd	nd	nd	19	2.6	1271	0.7	7.4	5.6	
Miller Marsh	midpoint	25-Jul-2000	12:05 PM	nd	nd	nd	nd	nd	23	3.3	1308	0.7	7.8	nd	

Location	Point	Date	Time	Air Temp. (C)	Wind Speed (est. mph)	Wind Direction	Water Movement	Water Depth (em)	Water Temp. (C)	D.O. mgIL	S.C. (uS/em)	Salinity (ppt)	pH	Turbidity (NTU)	Comments
Swan Lake	terminal point	2-Jun-1999	12:30 PM	nd	10	W	wind chop	nd	13	8.5	850	1	nd	80	
Swan Lake	terminal point	17-Jun-1999	02:15PM	31	5	S	low	40	25	5.8	820	0.8	8.3	18	
Swan lake	terminal point	21-Jul·1999	12:10 PM	nd	5	W	none	30	24	11.8	880	0.8	99	24	
Swan lake	terminal point	21-Sep-1999	11:30AM	26	nd	nd	nd	30	18	7.8	1500	1.5	8.9	>200	
Swan lake	terminal point	15-Mar-2000	11:45 AM	19	5	N	nd	15	14	7.5	1700	2	8.3	>200	
Swan lake	terminal point	27-Jun·2000	01:10 PM	nd	0		none	40	28	8.6	856	0.4	8.3	nd	
Swan lake	terminal point	6-Jui·2000	nr	nd	nd	nd	nd	nd	21	10.6	934	0.5	9	45	
Swan lake	terminal point	25-Jul-2000	11:00 AM	nd	0		none	20	20	7.7	1242	0.7	10	nd	
Power Plant	cooling pond	25-Jul-2000	12:15 PM	nd	nd	nd	nd	nd	33	6.6	1092	0.6	9.1	nd	

Appendix B. Nevada State water quality standards for the Walker River from the confluence of the East Walker River and the West \Valker River downstream to the inlet of Weber Reservoir from the Nevada Administrative Code (NAC).

NAC 445A.167 Walker River at inlet to Weber Reservoir.

STANDARDS OF WATER QUALITY
Walker River

Control Point at the Walker River at the inlet to Weber Reservoir. The limits of this table apply to the Walker River from the inlet to Weber Reservoir to the confluence of the West Walker River and the East Walker River.

PARAMETER	REQUIREMENTS TO MAINTAIN EXISTING HIGHER QUALITY	WATER QUALITY STANDARDS FOR BENEFICIAL USES	BENEFICIAL USES
Temperature °C_ Maximum ΔT[a]	ΔT = O°C	Nov.-Mar.: ≤13°C Apr.-Jun.: Jul.-Oct.: ΔT ≤2°C	Aquatic Iife[b] and water contact recreation.
pH Units	--	S.V.: 7.0 • 8.3 ΔpH: ±O.5 Max.	Watcr contact recreation[b]• wildlife propagation[b], aquatic life, irrigation, stock watcring, municipal or domestic supplv and industrial supplv.
Total Phosphatcs (as P) - mg/l		A-Avg.: ≤0.26 S.V.: ≤0.40	Aquatic life[b], water contact recreation[b]• municipal or domestic supplv and noncontact recreation.
Nitrogen Species (N) - mg/l	Total Nitrogen A-Avg.: ≤1.2 S.V.: ≤1.5	Nitrate S.V.: ≤10 Nitrite S.V.: ≤5 Ammonia S.V.: ≤.06 (un-ionized)	Municipal or domestic supplyb, aquatic Iifeb, water contact recreation, stock watering, wlldhfc propagation and non contact recreation.
Dissolved Oxygen • mg/l	-- --	S.V.: Nov.-May: ≥6.0 Jun.-O<:I.: ≥5.0	Aquatic fifc[b], water contact recreation, wildlife propagation, stock watering, municipal or domestic suoolv and noncontact recreation.
Suspended Solids - mg/l		S.V.: ≤80	Aquatic Iife[b].
Turbiditv - NTU	--	d	Aauatic life[b] and municioal or domestic suoolv.
Color - PCU	--	c	Aauatlc lifc[b] and or domestic supplv.
Total Dissolved Solids· mg/l	A·Avg.: S.V.:	A·Avg.: ≤500	Municipal or domestic supply[b], irrigation and stock watcnng.
Chlorides·mg/I	A-Avg.: ≤30 S.V.: ≤35	-- S.V.: ≤250	Municipal or domestic supply[b], wildlife propagation, irrieation and stock waterine.
Sulfate· mgfJ	A·Avg.: S.V.: <110	S.V.: ≤250	MuniCipal or domestic supplyb.
Sodium SAR	SAR A·Avg.: ≤3	A·Avg.: ≤8	Irri.l!ation[b] and municipal or domestic supplv.
Alkalinity (as CaCO,) - mg/l	-.	less than 25% change from natural conditions	Aquatic lifc[b] and wildlife propagation.
Fecal Coliform- No.llOO ml	A.G.M.: ≤100 S.v.:	≤200/400[c]	Water contact recreation[b]• noncontact recreation, municipal or domestic supply, Irrigation, wildlife propagation and stock watennl!.

a. Maximum allowable increase in temperature above water temperature at the boundary of an approved mixing zone, but the increase must not cause a violation of the single value standard.
b. The most restrictive beneficial use.
c. Increase in color must not be more than 10 PCU natural conditions.
d. Increase in turbidity must not be more than 10 NTU above natural conditions.
e. Based on the minimum of not less than 5 samples taken over a 30-day period, the fecal coliform bacterial level may not exceed a geometric mean of 200 per 100 ml nor may more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml.

Appendix C. Walker River water quality data near Wabuska, Nevada, collected by the Nevada Division of Environmental Protection for the period January 1994 to May 2002. The location of the site is: Township 15N, Range 26E, Section 20; latitude 39^{0} 09' 00", longitude 119^{0} OS' 05".

Walker River Water Quality data at Wabuska collected by the Nevada Division of Environmental Protection

Date	Temp. deg.C	D.O. mg/L	S.C. uS/em	lab pH	field pH	Turbidity NTU	Color PL-CO	TDS mg/L	TSS mg/L
01/12/94	0.5	11.2	454	8.3	8.43	6.3	17	289	8
03/16/94	9.3	9.7	497	8.4	8.41	3.8	20	309	7
05/11/94	18	7.9	309	8.4		18	15	179	41
07/13/94	21	7.5	304	8.4	8.3	8.5	12	184	18
09/28/94	15	7.7	323	8.5	8.35	5.8	17	194	10
11/09/94	7.5	9.6	461	8.5	7.07	1	12	278	2
01/18/95	1	12.2	412	8.2		6.9	25	261	23
03/15/95	9.8	8.6	399	8.5		39	45	262	95
05/10/95	13	8.3	249	8.4	7.87	38	60	166	99
07/12/95	22	5.6	243	8	7.61	39	70	172	58
09/13/95	17	8.5	248	8.3		6.2	25	165	16
11/29/95	5	10.3	452	8.1		18	20	293	22
01/31/96	3.3	11.3	309	8.5	8.56	37	30	197	121
03/13/96	5.5	10.4	245	8.2	8.6	70	55	166	266
05/15/96	17	7.2	172	8		58	45	99	210
07/17/96	22	7.1	'177	7.5	7.99	52	25	103	240
09/11/96	17.5	7.9	374	8.3	8.04	9.3	25	227	18
11/06/96	4	11.8	438	8.3	8.24	6	5	269	28
01/22/97	3.5	11.5	267	8.1		100	55	175	180
03/19/97	11.5	9.1	296	8.3	8.2	34.2	17	175	69
05/14/97	16	7.3	174	8.2	7.96	120	40	104	252
07/16/97	21.6	8.2	282	8.4	8.44	11.9	17	173	23
09/10/97	18.4	9.9	353	8.4	8.3	18.7	15	204	38
11/25/97	5	10.5	503	8.4	8.58	5.9	5	295	11
01/22/98	5	11.2	519	8.3	8.34	19	17	322	34
03/11/98	8.4		362	8.1	7.34	50	15	255	108
05/14/98	10.1	9.5	255	7.9	8.2	72.2	25	155	184
07/15/98								111	112
09/09/98	19	7			8.2			204	19
11/10/98	5.4	11.6	427	8.3	8.4	8.1	12	249	18
01/21/99	4.5	11.48	452	8.05	8.58	16	10	254	30
03/10/99	4.7	12.36	359	7.95	8.67	19.1	5	196	26
05/12/99	16.4	8.3	279	7.82	8.1	39.7	20	144	82
07/14/99	22.8	8.05	247	7.64	8.03	25.3	15	148	65
09/09/99	16.7	3.14	413	7.91	8.39	6.9	12	231	4
11/10/99	7.6	9.93	513	7.86	8.54	7.5	12	288	16
01/26/00		10.2	416	7.92	8.67	15.8	7	282	24
03/07/00	7.2	11.69	506	8.09	8.82	22	12	292	39
05/10/00	13	8.3	475	8.35	8.1	13	17	280	26
07/06/00	17	8.8	317	8.26	7.6	11	15	180	18
09/06/00	12.25	9.3	399	8.43	8.35	7.6	12	232	16
11/15/00	1.5	11.7	493	8.31	8.59	6.1	12	314	13
01/17/01	0.2	6.03	654	8.23	8.3	5.5	7	412	13
03/14/01	6.7	10.78	608	8.4	8.25	9.1	10	370	20
06/06/01	17.5	8.3	245	8.19	8.4	18	10	149	35
08/01/01	28.3	7.8	312	8.52	8.56	11	7	190	17
09/12/01	15	8.5	331	8.23	8	8.1	7	212	14
11/14/01	5.5	10.6	460	8.27	8.2	3.3	7	240	2
01/24/02	-2	12.2	470	8.17	8.14	7.6	3	294	23
03/13/02			500	8.45	8.3	5.5	15	318	7
OS/21/02	10.75	8.7	230	8.12	8.5	32	15	151	28

Walker River Water Quality data at Wabuska collected by the Nevada Division of Environmental Protection

Date	Bicarb. as HC03 mg/L	C03 as C03 mg/L	Akal. as CaC03 mg/L	Alkal. Bicarb. as CaC03 mg/L	Alkal. Carbo as CaC03 mg/L	total N mg/L	Nitrite as N mg/L	Nitrate as N mg/L	N Ammon. Diss. mg/L	
01/12/94	173	5	150	142	8	0.78	<0.01	0.47	<0.1	
03/16/94	181	7	160	148	12	0.17	<0.01	0.02	<0.1	
05/11/94	127	7	116	104	12	0.86	<0.01	0.05	<0.1	
07/13/94	124	5	110	102	8	0.38	<0.01	0.04	<0.1	
09/28/94	129	10	122	106	16	0.34	<0.01	0.04	<0.1	
11/09/94	151	12	144	124	20	0.33	<0.01	0.02		0.1
01/18/95	151	5	132	124	8	0.42	<0.01	0.09	<0.1	
03/15/95	132	5	116	108	8	1.2	<0.01	0.42	<0.1	
05/10/95	100	7	94	82	12	0.72	<0.01	0.06	<0.1	
07/12/95	90	0	74	74	0	1.82	<0.01	0.1	<0.1	
09/13/95	102	7	96	84	12	0.73	<0.01	*b.09*	*<0.1*	
11/29/95	183	0	150	150	0	1.18	<0.01	0.16	<0.1	
01/31/96	110	10	106	90	16	0.92	<0.01	0.2	<0.1	
03/13/96	102	5	92	84	8	0.79	<0.01	0.1	<0.1	
05/15/96	85	0	70	70	0	0.66	<0.01	0.08	<0.1	
07/17/96	88	0	72	72	0	1.33	<0.01	0.13	<0.1	
09/11/96	159	5	138	130	8	0.62	<0.01	0.15	<0.1	
11/06/96	166	7	148	136	12	0.45	<0.01	0.09	<0.1	
01/22/97	107	0	88	88	0	1.21	0.02	0.19	<0.1	
03/19/97	112	5	100	92	8	0.52	<0.01	0.08	<0.1	
05/14/97	81	0	66	66	0	0.85	0.01	0.11	<0.1	
07/16/97	112	7	104	92	12	0.52	<0.01	0.1	<0.1	
09/10/97	139	5	122	114	8	0.34	<0.01	0.1	<0.1	
11/25/97	181	7	160	148	12	0.41	<0.01	0.08	<0.1	
01/22/98	181	2	152	148	4	1.24	<0.01	0.51	<0.1	
03/11/98	142	0	116	116	0	0.88	<0.01	0.21	<0.1	
05/14/98	107	0	88	88	0	0.83	0.01	0.13	<0.1	
07/15/98			66	66	20		<0.02			0.07
09/09/98			135	135	20		<0.02		<0.03	
11/10/98	154	5	134	126	8	0.7	<0.01	0.11	<0.1	
01/21/99	161	0	132	132	0	0.81	<0.01	0.44	<0.1	
03/10/99	134	0	110	110	0	0.75	<0.01	0.22	<0.1	
05/12/99	115	0	94	94	0	0.49	<0.01	0.14	<0.1	
07/14/99	105	0	86	86	0	0.78	<0.01	0.15	<0.1	
09/09/99	166	0	136	136	0	0.59	<0.01	0.13	<0.1	
11/10/99	195	0	160	160	0	0.69	<0.01	0.06	<0.1	
01/26/00	159	0	130	130	0	0.65	<0.01	0.45	<0.1	
03/07/00	183	0	150	150	0	0.56	<0.01	0.23	<0.1	
05/10/00	173	5	150	142	8	0.67	<0.01	0.09	<0.1	
07/06/00	129	0	106	106	0	0.29	<0.01	0.04	<0.1	
09/06/00	154	5	134	126	8	0.48	<0.01	0.03	<0.1	
11/15/00	185	5	160	152	8	0.29	<0.01	0.07	<0.1	
01/17/01	249	0	204	204	0	0.94	<0.01	0.33	<0.1	
03/14/01	205	7	180	168	12	0.44	<0.01	0.12	<0.1	
06/06/01	105	0	86	86	0	0.38	<0.01	O	<0.1	
08/01/01	120	5	106	98	8	0.48	<0.01	O	<0.1	
09/12/01	137	0	112	112	0	0.43	<0.01	O	<0.1	
11/14/01	178	0	146	146	0	0.35	<0.01	0.02	<0.1	
01/24/02	183	0	150	150	0	0.49	<0.01	0.11	<0.1	
03/13/02	171	2	144	140	4	0.47	<0.01	O	<0.1	
05/21/02	100	0	82	82	0	0.46	<0.01	0.02	<0.1	

Walker River Water Quality data at Wabuska collected by the Nevada Division of Environmental Protection

Date	N-total Kjeldahl mg/L	total P mg/L	P Diss. P04 mg/L	Chloride Diss. mg/L	Sulfate Diss. S04 mg/L	Fecal Strep. #/100 ml	Fecal Coli. #/100 ml
01/12/94	0.3	0.09	0.06	16	60	40	10
03/16/94	0.14	0.09	0.07	24		50	30
05/11/94	0.8	0.16	0.06	12		130	60
07/13/94	0.33	0.11	0.06	10	30	200	180
09/28/94	0.29	0.09	0.07	10		430	360
11/09/94	0.3	0.09	0.07	24		20	<10
01/18/95	0.32	0.09	0.05	19	58	50	<10
03/15/95	0.77	0.25	0.11	19		180	130
05/10/95	0.65	0.2	0.07	7		130	40
07/12/95	1.71	0.34	0.21	10	32	710	190
09/13/95	0.63	0.11	0.08	7		150	60
11/29/95	1.01	0.14	0.06	20		60	10
01/31/96	0.71	0.24	0.05	12	35	100	10
03/13/96	0.68	0.26	0.06	8	26	200	180
05/15/96	0.57	0.33	0.05	3	11	610	80
07/17/96	1.19	0.31	0.07	4	12	350	
09/11/96	0.46	0.14	0.1	10	38	200	
11/06/96	0.35	0.1	0.05	15	50	8	
01/22/97	1	0.43	0.07	12	28	90	
03/19/97	0.43	0.05	0.05	10	33	10	
05/14/97	0.73	0.49	0.08	3	11		
07/16/97	0.41	0.18	0.12	8	27	120	
09/10/97	0.23	0.17	0.12	9	34	160	
11/25/97	0.32	0.07	0.04	18	61	40	
01/22/98	0.72	0.16	0.08	20	65	<10	
03/11/98	0.66	0.26	0.06	10	37	20	
05/14/98	0.69	0.36	0.08	6	21	440	
07/15/98	0.36	0.21	0.06	4	14.1	260	
09/09/98	0.32	0.14	0.14	9	31.4	330	
11/10/98	0.58	0.09	0.06	13	41	30	
01/21/99	0.36	0.16	0.09	17	46	<10	
03/10/99	0.52	0.13	0.07	14	34	<10	
05/12/99	0.34	0.24	0.08	5	16	220	
07/14/99	0.62	0.21	0.1	5	19	170	
09/09/99	0.45	0.14	0.09	10	37	na	270
11/10/99	0.62	0.09	0.06	16	63	na	30
01/26/00	0.19	0.13	0.07	17	47	na	10
03/07/00	0.32	0.16	0.07	23	65	na	<10
05/10/00	0.57	0.23	0.15	18	58	na	50
07/06/00	0.24	0.14	0.1	9	29	na	80
09/06/00	0.44	0.14	0.09	11	42	na	90
11/15/00	0.21	0.06	0.04	23	67	na	<10
01/17/01	0.6	0.16	0.1	27	63	na	30
03/14/01	0.32	0.12	0.08	28	90	na	<10
06/06/01	0.37	0.12	0.05	8	19	na	60
08/01/01	0.47	0.12	0.06	8	29	na	260
09/12/01	0.42	0.1	0.07	9	32	na	170
11/14/01	0.32	0.06	0.05	17	53	na	10
01/24/02	0.37	0.11	0.06	18	66	na	<10
03/13/02	0.46	0.28	0.26	21	64	na	<10
OS/21/02	0.43	0.14	0.05	6	17	na	>600

Walker River Water Quality data at Wabuska collected by the Nevada Division of Environmental Protection

Date	total Cd ug/L	total Cr ug/L	total Cu ug/L	total Fe ug/L	total Pb ug/l	total Hg ug/L	total Se ug/L	total Zn ug/L	total As ug/L	total B ug/L	total Ca mg/L	total Na mg/L	total Mg mg/L	SAR	Hardness mg/L
01/12/94	*<1*	<5	<5	310	<5	<0.5	<1	<5	10	300	39	46	9	1.7	135
07/13/94	*<1*	<5	<5	290	<5	<0.5	<1	<5	13	300	25	32	7	1.5	91
01/18/95	*<1*	<5	10	600	<5	<0.5	<1	20	12	400	34	44	8	1.8	118
07/12/95	*<1*	<5	20	1590	<5	<0.5	<1	20	12	200	19	26	5	1.4	68
01/31/96	<1	<5	10	2110	<5	<0.5	<1	10	10	300	27	36	6	1.6	92
07/17/96	<1	<5	10	2140	<5	<0.5	<1	10	11	100	17	17	5	0.9	63
01/22/97	<1	<5	20	2690	<5	<0.5	<1	30	13	400	22	44	7	2.1	84
07/16/97	*<1*	<2	<2	770	<0.9	<0.1	<0.7	5	11	220	23.9	23.8	6	1.1	83
01/22/98	<1	<2	<2	1370	<1	<0.1	<0.9	13	15	482	37.4	51.2	9	2	130
07/15/98	*<1*	<3	9	4180	<2	<0.1	<0.5	13	9	104	15.6	13.3	4	0.8	57
01/21/99	<1	<5	10	1030	<5	<0.5	<2	20	13	400	36	48	8	1.9	123
07/14/99	<1	<5	0	1060	<5'	<0.5	<4	20	9	200	21	23	5	1.2	73
01/26/00	<1	<2	10	740	<2	<0.5	<2	10	14	400	32	46	8	1.9	113
07/06/00	<1	<2	10	470	<2	<0.5	<2	10	13	300	24	32	6	1.5	85
01/17/01	*<1*	<2	0	330	<2	<0.5	<2	10	18	500	52	76	13	2.4	183
08/01/01	*<2*	<5	0	470	<5	<0.5	<5	10	11	200	24	32	6	1.5	85
01/24/02	<1	<2	0	590	<2	<0.5	3	10	12	400	37	51	9	1.9	130

Walker River Water Quality data at Wabuska collected by the Nevada Division of Environmental Protection

Date	filtered Cd ug/L	filtered Cr ug/L	filtered Cu ug/L	filtered Fe ug/L	filtered Pb ug/L	filtered Hg ug/L	filtered Se ug/L	filtered Zn ug/L	filtered As ug/L	filtered B ug/L	filtered Ca *mg/L*	filtered Na mg/L	filtered Mg mg/L
01/21/99	<1	<5	0	320	<5	<0.5	<2	20	13	400	35	47	8
07/14/99	<1	<5	0	60	<5	<0.5	<2	40	9	200	21	26	5
01/26/00	<1	<2	10	60	<2	<0.5	<2	40	14	400	32	45	8
07/06/00	<1	<2	0	60	<2	<0.5	<2	30	15	300	23	33	6
01/17/01	<1	<2	0	80	<2	<0.5	<2	100	17	500	51	79	12
08/01/01	<2	<5	0	20	<5	<0.5	<5	10	12	300	24	32	6
01124/02	<1	<2	0	60	<2	<0.5	<2	50	11	400	37	55	9

Appendix D. Nevada State water quality standards for toxic materials (data for elements only from the Nevada Administrative Code (NAC).

NAC 445A.144 Standards for toxic materials applicable to designated waters. Except as otherwise provided in this section, the following standards for toxic materials are applicable to the waters specified in NAC 445A.123 to 445A.127, inclusive, and 445A.145 to 445A.225, inclusive. If the standards are exceeded at a site and are not economically controllable, the commission will review and adjust the standards for the site.

Chemical	Municipal or Domestic Supply (µg/l)	Aquatic Life (µg/l)	Irrigation (µg/l)	Watering of Livestock (µg/l)
Antimony	146[a]			-
Arsenic	50[b]		lOOe	200[d]
Arsenic (III)				
I-hour average		342[a,g]		
96-hour average	-	180[a,g]		
Barium	2.000[b]			
Beryllium	0[a]		100e	
hardness <75 mgtl				
hardness >= 75 mg/I				-
Boron	-		750[3]	5,OOOd
Cadmium	5[b]		10d	50[d]
I-hour average		0.85exp {1. I28 In(H)-3.828} a,g		
96-hour average		0.85exp{O.7852In(H)-3.490}a.[g]	-	-
Chromium (total)	100b		100[d]	1,000d
Chromium (VI)				
I-hour average		Isa,g		
96-hour average		10a.g		
Chromium (III)				
I-hour average		O.85exp{O.8190 In(H)+3.688}a,g		
96-hour average		0.85exp{O.8190 In(H)+1.561 }a,g	-	-
Copper			200[d]	SOOd
I-hour average		0.85exp{O.9422 In(H)-1.464} a,g		
96-hour average		O.85exp *{O.854S* In(H)-1.465} a,g		
Cyanide	200[a]			
I-hour average		22[3]		
96-hour average		5.2[a]	-	-
Fluoride			1,000d	2,OOOd
Iron	-	1,000[a]	5,000d	-
Lead	50[a,b]		S,OOOd	100[d]
I-hour average		0.50exp{ 1.273 In(H)-1.460}I.g		
96-hour average		0.2Sexp {1.273 In(H)-4. 70S} a,g	-	
Manganese	-		200[d]	
Mercury	2[b]			10d
I-hour average		2.0[a,g]		
96-hour average		0.012[3]		
Molybdenum		19[c]	-	
Nickel	13.4[a]		200[d]	
I-hour average		0.85exp{0.8460 In(H)+3.36127}[a,g]		
96-hour average	-	0.8Sexp{O.8460 In(H)+ 1.1645} a,g	-	-
Selenium	SOb		20[d]	SOd
I-hour average		20[a]		
96-hour average		S.Oa		
Silver		0.8Sexp {1.72 In(H)-6.52} a,g		
Sulfide				
undissociated hydrogen sulfide		2[a]		
Thallium	13[a]		-	-
Zinc			2,000d	25,000d
I-hour average		O.85exp {0.8473 In(H)+O.8604} a,g		
96-hour average		O.85exp {O.8473 In(H)+O. 76 I4} a,g		

Footnotes and References

(I) Single concentration limits and 24-hour average concentration limits must not be exceeded. One-hour average and 96-hour average concentration limits may be exceeded only once every 3 years. See reference a.

(2) Hardness (H) is expressed as mg/l $CaCO_J$.

(3) If a criterion is less than the detection limit of a method that is acceptable to the division, laboratory resuhs which show that the substance was not detected will be deemed to show compliance with the standard unless other information indicates that the substance may be present.

(4) If a standard does not exist for each designated beneficial use, a person who plans to discharge waste must demonstrate that no adverse effect will occur to a designated beneficial use. If the discharge of a substance will lower the quality of the water, a person who plans to discharge waste must meet the requirements of NRS *445A.565.*

(5) The standards for metals are expressed as total recoverable, unless otherwise noted.

a. U.S. Environmental Protection Agency, Pub. No. EPA 440/5-86-00 I, Quality Criteria for Water (Gold Book) (1986).

b. Federal Maximum Contaminant level (MCl), 40 C.F.R. §§ 141.11, 141.12, 141.61 and 141.62 (1992).

c. U.S. Environmental Protection Agency, Pub. No. EPA 440/9-76-023, Quality Criteria for Water (Red Book) (1976).

d. National Academy of Sciences, Water Quality Criteria (Blue Book) (1972).

e. California State Water Resources Control Board, Regulation of Agricultural Drainage to the San Joaquin River: Appendix D, Water Quality Criteria (March 1988 revision).

f. The criteria for trihalomethanes (total) is the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform). See reference b.

g. This standard applies to the dissolved fraction.