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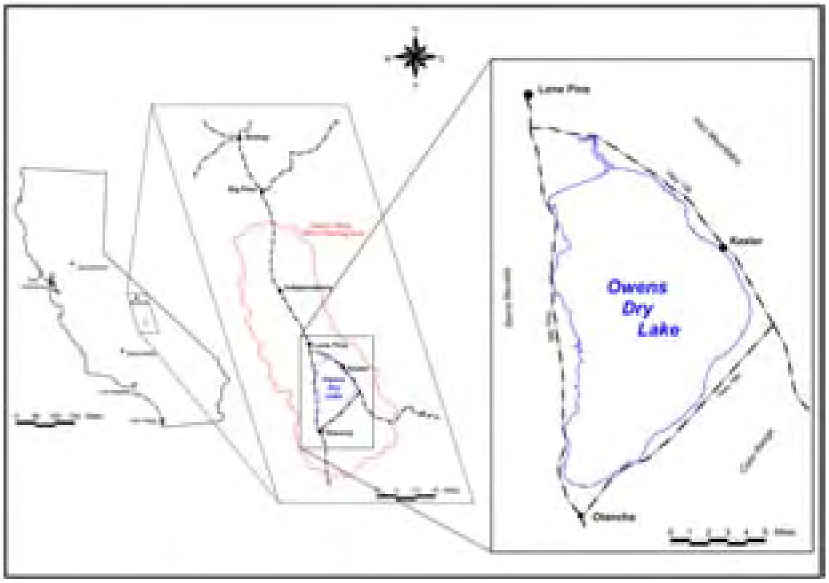

Owens Lake Valley PM10 Planning Area

Screening Ecological Risk Assessment of Proposed Dust Control Measures

July 2007

Owens Lake SLERA Report Cover

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SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
OF
SELECT DUST CONTROL MEASURES
BEING APPLIED AT
OWENS LAKE
KEELER, INYO COUNTY, CALIFORNIA

JULY 2007

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Quality Assurance/Quality Control

The undersigned Kleinfelder personnel certify that this report is true and accurate to the best of their knowledge.

____

Kurt A. Frantzen, PhD, CHMM July 30, 2007
Project Manager

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1.0 Introduction

1.1 Background

1.1.1 Site of Interest

The site of interest in this ecological Screening Level Risk Assessment (SLERA) includes 14.6 square miles of the 110-square-mile (70,000-acre) dry Owens Lake bed, located within the Owens Valley, Inyo County, California. The Great Basin Unified Air Pollution Control District (District) regulates fugitive dust (PM10) emissions in the Owens Valley Planning Area consistent with the requirements of the National Ambient Air Quality Standards (NAAQS) (Figure 1)[1].

The proposed project site lies southwest of the Inyo Mountains, northwest of the Coso Range, and east of Mount Whitney in the Sierra Nevada mountain range. State Highway 136 lies along the north-northeast margin of the lake, State Highways 136 and 190 bound the lake on the east, the intersection of State Highway 190 and U.S. Highway 395 bound the lake on the south, and the western edge is bounded by U.S. Highway 395 (Figure 2). The topography is flat with an elevation range of approximately 3,600 feet above mean sea level (msl) (the historic shoreline) to approximately 3,554 feet above msl (the existing brine pool), a difference of 46 feet between the highest and the lowest area of the lakebed.

The City of Los Angeles diverted water from the Eastern Sierra beginning around 1913 via the Los Angeles Aqueduct. The subsequent loss of water input to the lake resulted in a significant drop of water from the historic shoreline and the development of a brine pool and exposed dry lakebed sediments by around 1930. These exposed sediments are dispersed into the air by prevailing winds, with the resulting dust storms most prevalent in spring and fall.

The emitted airborne particulate is small enough to travel great distances and can cause significant ecological and human health effects, including serious respiratory ailments. In fact, the dried lakebed has been the largest single source of PM10 emissions in the United States for many years, with annual emissions of more than 80,000 tons and 24-hour concentrations as high as 130 times standard[2]. Between 2000 through 2004, of the 100 highest 24-hour PM10 value days measured in the entire United States, 78 days occurred at Owens Lake, 21 days occurred at Mono Lake, and one day occurred elsewhere (El Paso, TX)[3]. The District estimates that approximately 40,000 permanent residents that live in, or visit, the area are affected by Owens Lake particulate emissions[4].

In 1987, the U.S. Environmental Protection Agency (USEPA) designated the Owens Valley Planning Area (Figure 1) as non-attainment for the National Ambient Air Quality Standards (NAAQS) for PM10. The result of this designation was that a plan, known as a State Implementation Plan (SIP), was required demonstrating how NAAQS would be attained[5]. Because of the SIP (1998), the City of Los Angeles Department of Water and Power (LADWP) began constructing Dust Control Measures (DCMs) on the lakebed.

[1] Sapphos, 2007, §1 page 1-1
[2] Sapphos, 2003, §2.2 page 2-3
[3] Sapphos, 2007, §1.4 page 1-1
[4] Sapphos, 2007, §1.4 page 1-1
[5] Sapphos, 2003, §1

1.1.2 Implementation of Initial DCMs

Installation of the initial DCM was complete in 2001 for the North Sand Sheet, using a technique called Shallow Flooding (described below)[6]. That project (Phase I) resulted in the conversion of 13.5 square miles of primarily barren playa (Zones 1 & 2). Several infrastructure items were built simultaneously to support this and future DCMs. This included a 210-foot-wide water pipeline corridor to distribute water from the Los Angeles Aqueduct to the east side of the lakebed. A 50-foot-wide power line easement and an 80-foot-wide north access road corridor also were constructed.

In 2002, approximately 6 square miles of the Southern Zones Dust Control Project (Phase II, IV & V) were installed[7]. This project applied two different DCMs to barren playa and transmontane alkaline meadow (TAM), namely, Managed Vegetation (Phase II) and Habitat Shallow Flooding (Phases IV & V, described below), and included various associated facilities, such as irrigation systems, drainage systems, power supply systems, and auxiliary facilities. The Managed Vegetation DCM used saltgrass (*Distichlis spicata*) with at least 50% of each acre consisting of evenly distributed live and dead vegetation.

Besides the implementation of the aforementioned DCMs, the 1998 SIP required the District to commit to study the lakebed and its ongoing propensity to generate PM10 dust. This study effort resulted in a revision of the SIP in 2003 to refine the actual areas necessary for control[8]. In November 2003, the District ordered the LADWP to expand the DCM coverage of the lakebed up to a total of 29.8 square miles. This expanded coverage was implemented between December 2003 and December 2006; and it resulted in the completion of approximately 26 square miles of shallow-flooded lakebed (Figure 3) and 3.8 square miles of managed vegetation (compare Figures 4 and 5), as well as a small portion of Gravel Covering DCM (Figure 6).

1.1.3 Monitoring Results

The 2003 SIP required, besides DCM implementation, that the District monitor emissions from the lakebed. The purpose of this monitoring was to identify other areas (beyond the 29.8 square miles) requiring PM10 controls to meet air quality standards. The Clean Air Act requires “contingency measures” in case the initial control strategy does not achieve compliance. One contingency measure was for the District to complete a Supplemental Control Requirements (SCR) analysis to determine the need for additional dust controls.

Based on data collected between July 2002 and June 2004, the District completed the SCR analysis and issued (December 21, 2005) a determination that additional lakebed area would require DCMs to achieve compliance. Based on the SCR analysis and many discussions the District and LADWP agreed to construct the additional DCMs. These additional DCMs are the subject and focus of this report.

1.1.3.1 Proposed Additional Dust Control Measures

The proposed additional DCM project (Phase 7, Figure 7) includes 14.6 square miles (9,344 acres) of control measures within the lakebed[9]. This project consists of:

- 12.2 square miles of Supplemental Dust Control Areas (DCAs), including:
  - — 9.2 square miles of Shallow Flooding and
  - — 3.0 square miles of Moat and Row,

[6] Sapphos, 2007, §1.8 page 1-6
[7] *Op cit.*
[8] Sapphos, 2007, §1.4 page 1-2
[9] Sapphos, 2007, §1.9 page 1-7

- 0.5 square mile of Channel Area that may require DCMs and
- 1.9 square miles of Study Area, of which some or all may require controls after 2010.

By 2010, at least 42.57 square miles of DCMs are to be operational[10]. As much as 44.92 square miles may require controls at some point. Detail about the proposed additional DCMs (Shallow Flooding and Moat and Row) follows below. Figure 8 presents additional detail regarding the location of all DCAs[11].

Shallow Flooding

The shallow flooding DCM consists of releasing water along the upper edge of the Owens Lake bed and allowing it to spread and flow down gradient toward the center of the lake (Figure 9)[12]. To achieve good dust control efficiency, at least 75% of each square mile under control must be sufficiently wetted to achieve surface-saturated soil or standing water between October 1 and June 30 annually (Figure 4). Approximately 4 acre-feet of water per annum is required to control lakebed dust emissions. Except for limited habitat maintenance flows, no water is released between July 1 and September 30, a period when dust storms typically do not occur.

The chief management objective for this DCM is dust control. Surface water salinity in these areas varies widely between 10,000 to 450,000 mg/L total dissolved solids (TDS), at times exceeding suitable biological production conditions. Therefore, selected areas under shallow flooding are operated to maintain conditions sufficient to provide biologically critical habitat; these areas are designated as "***habitat shallow flooding***."

Moat and Row

The general form of the moat and row DCM is an array of earthen berms (rows) about 5 feet high with sloping sides, flanked on either side by ditches (moats) about 4 feet deep (Figure 10)[13]. Moats serve to capture moving soil particles, and rows physically shelter the downwind lakebed from the wind. Individual moat and row elements follow a serpentine layout, generally paralleling one another, and spaced at variable intervals to minimize the fetch between rows along predominating wind directions.

PM10 control effectiveness of the moat and row design may increase when combined with other DCMs (such as vegetation, water, gravel, sand fences) or the addition of other features to enhance sand capture and sheltering or to directly protect the lakebed surface from wind erosion (compare Figures 8 and 11)[14]. The effectiveness of the array may also be increased by adding moats and rows to the array by decreasing the distance between moats and rows within the array. The District does not currently approve this DCM. Therefore, the final form of this DCM will largely be determined based on the results at lakebed test areas, which currently are undergoing separate environmental review by the District (see the orange-colored areas shown in Figure 7).

[10] Sapphos, 2007, §1.9 page 1-7
[11] The figure comes from: Great Basin Unified Air Pollution Control District and City of Los Angeles Department of Water and Power, 2006, *Settlement Agreement Resolving City's Challenge to the District's Supplemental Control Requirement (SCR) Determination for the Owens Lake Bed* (issued on December 21, 2005, and modified on April 4, 2006), Los Angeles, CA.
[12] Sapphos, 2007, §1.9 page 1-8
[13] *Op cit.*
[14] The figure comes from the reference in Footnote 11.

1.1.3.2 Channel Area

The SCR analysis concluded that 0.5 square mile of channel areas (Figure 7) were of concern[15]. These areas include natural drainage channels with the potential to be emissive areas, and therefore may require DCMs. Moreover, these areas may have significant resource issues and regulatory constraints that could affect the type and location of DCMs that can be implemented within these areas.

1.1.3.3 Study Area

Included in the current project area are 1.9 square miles of study areas (Figure 7)[16]. These areas may be (dust) emissive, but either the location or magnitude of the dust emissions is uncertain. The District will continue to collect data in these four areas until 2010 to determine their emissivity through the course of the project.

1.2 SLERA Scope of Work

In March 2007, Sapphos Environmental, Inc. (Sapphos) retained Kleinfelder East, Inc. (Kleinfelder) to prepare a Screening Level Ecological Risk Assessment (SLERA) to address the ecological hazards that may be associated with the two types of DCMs, *i.e.*, Shallow Flooding and Moat and Row, at the Phase 7 project areas shown in Figures 7, 8 and 11. Typically, the goal of the SLERA is to determine whether constituents (toxic chemicals or other types of ecological stress [or stressors]) at a site pose a potential hazard to plants, animals, and habitats at or around that site. In this case, the goal of the SLERA is to assess the ecological effect of the two proposed DCMs on the study area as compared to the current baseline case of barren playa lakebed.

The objective of a SLERA is to fulfill Steps 1 and 2 outlined in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* [17]. Kleinfelder prepared this SLERA in two stages.

1. **Problem Formulation**[18]—Problem formulation is the compilation of background information, existing data, and reasoning to frame the ecological hazard to be addressed. The problem formulation also focuses the SLERA on the particular hazards most likely to be problematic (ecotoxicity or other types of stress effects) and to identify the biotic receptors or habitat of greatest concern. The result is development of an ecological Conceptual Site Model (CSM) and establishment of the assessment and measurement endpoints for the SLERA. Problem formulation follows a five-step process:

    a. **Ecological Setting**—this step describes the ecological setting of the site, identifies critical biological resources of the habitats within the site and identifies the constituents of potential ecological concern (COPECs) and critical stressors (*e.g.*, chemicals, water quality and habitat alteration).

    b. **Identification of Chemical Fate and Transport Mechanisms—**if there are COPECs or other identified stressors, Kleinfelder will identify their type, occurrence, movement and other critical details depending upon the COPEC or stressor during this step of problem formulation.

[15] Sapphos, 2007, §1.9, page 1-9
[16] *Op cit.*
[17] USEPA, 1997b, ERAGS
[18] Kleinfelder submitted a final Technical Memorandum on June 29, 2007 as the deliverable for Task 1 of Kleinfelder's contract; this document is incorporated herein.

c. **Ecotoxicological Issues—**this step identifies the mechanisms of toxicity associated with the identified COPECs or stressors and the likely categories of biotic and habitat receptors that could be affected.

d. **Ecological Assessment and Measurement Endpoints—**in this step of problem formulation, the assessment and measurement endpoints are identified. Assessment endpoints include important resources such as habitat or biota to be protected. Measurement endpoints are the means by which the assessment endpoints can be evaluated (for example, when certain chemical concentrations in environmental media exceed particular criteria established to protect plants, fish or wildlife).

e. **Ecological Conceptual Site Model—**in this step of problem formulation, Kleinfelder outlined a draft ecological Conceptual Site Model (CSM). The CSM is a schematic of the site and environs, presenting information regarding sources, the release, transport and fate of site-related chemicals, exposed plant or animal receptors, or critical habitat. The CSM provides a way to address the environmental problem at hand by stating testable hypotheses posed as questions. From these questions, the analytical and evaluative structure and approach of the SLERA will be explained.

2. **Screening-Level Exposure Estimate and Risk Calculation**

a. During this stage of the SLERA, Kleinfelder prepared an evaluation of exposure to COPECs in a manner consistent with USEPA's ecological risk assessment guidelines (ERAGs)[19] and California EPA's (Cal-EPA)[20] ecological risk assessment guidance. In the current case, Kleinfelder considered exposure to different environmental media under three cases: the baseline case (existing barren playa) as well as the two proposed DCMs, namely, shallow flooding and moat & row.

b. Kleinfelder considered the potential effects on and responses of receptors within the proposed project area potentially exposed to the COPECs or stressors.

c. Kleinfelder outlined exposure scenarios for each DCM and appropriate receptor populations considering COPEC chemical fate and transport, as well as biotic or other stressor variables, and the biology and ecology of the relevant receptors to define the potential for, and magnitude of, exposure.

d. Kleinfelder prepared a screening-level characterization of potential ecological hazard posed by the COPECs and physical stressors at the site.

[19] USEPA, 1998, *Final Guidelines for Ecological Risk Assessment*, Risk Assessment Forum, USEPA, Washington, D.C., EPA/630/R-95/002F.

[20] DTSC (Department of Toxic Substances Control), 1996, *Guidance for Ecological Risk assessment at Hazardous Waste Sites and Permitted Facilities*, California Environmental Protection Agency, Human and Ecological Risk Division.

1.3 Report Structure

This report is structured as follows:

- Introduction
- Problem Formulation
- Ecotoxicity Assessment
- Screening-Level Risk Evaluation
- Conclusions
- Supporting Materials
    - References
    - Tables
    - Figures
    - Appendices

2.0 Problem Formulation

2.1 Ecological Setting

2.1.1 Land Use

The State Lands Commission (Commission) owns and operates Owens Lake in trust for the people of the State of California. While not subject to local regulatory authority, the Inyo County General Plan recognizes the location of state and federally owned lands at the lake, designating the proposed project area as Natural Resources as well as State and Federal Lands[21]. This use designation, "*is applied to land or water areas that are essentially unimproved and planned to remain open in character, [and] provides for the preservation of natural resources, the managed production of resources, and recreational uses*." The Inyo County Zoning Ordinance designates the proposed project area as predominantly OS-40: Open Space Zone, 40-acre minimum lot size[22].

The Commission leases some of the lakebed to public and private entities (such as US Borax and the District) for mining, grazing, and rights-of-way[23]. The delta area is used for recreation, including hunting, bird watching, and fishing. Surrounding the lake, land use includes livestock grazing and the US Borax salt processing facility.

2.1.2 Geology and Hydrogeology

Owens Lake is part of a chain of lakes formed during the late Pleistocene epoch, about 1.8 million years ago. The lakes extended from Mono Lake (previously a much larger lake known as Lake Russell) in the north to Manley Lake, the southernmost of the chain, in what is now Death Valley. During much of this time, water from the Owens Valley basin flowed out of Owens Lake through Rose Valley and into China Lake. The high stand of the lake that produced the shorelines at an elevation of 3,880 feet above mean sea level (msl) is estimated to have occurred 15,000–16,000 years ago. Since that time, the surface extent of the water of Owens Lake decreased—although two deep cores on the lake bed have failed to identify any previous episodes of complete desiccation[24]. Uplift processes in the Coso Range, combined with a post-glacial drying trend eliminated overland outflow from the basin about 3,000 years ago. The result was a closed lake basin, losing water only through surface evaporation and transpiration. This internal drainage, combined with the arid environment, created the highly saline condition of remaining surface waters and playa soils at the bottom of the Owens Valley basin. Even in the 1800s, when it was used as a navigable waterway, Owens Lake was an alkali lake[25].

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[21] County of Inyo Planning Department, 2001, *Land Use Element of the County of Inyo General Plan Update*, Independence, CA, December.
[22] County of Inyo, County Code, Title 18: "Zoning," See http://www.countyofinyo.org/planning/zonord.html
[23] Sapphos, 2004,
[24] Smith, G.I., and J.L. Bischoff (eds.), 1993, *Core OL-92 from Owens Lake, Southeast California,* U.S. Geological Survey Open File Report 93-683; and Smith, G.I., and W.P. Pratt, 1957, *Core Logs from Owens, China, Searles, and Panamint Basins, California*. U.S. Geological Survey Bulletin 1045-A.
[25] Alkali lakes are a type of salt lake where evaporation concentrates naturally occurring soluble mineral salts that are often carbonate or hydroxide salts of either alkali metals (*e.g.,* sodium) or alkaline earth metals (*e.g.,* calcium) and that often forming a crust of these basic salts across a large area (based upon definitions in American Heritage Dictionary, 2000, Houghton Mifflin Company, fourth edition).

2.1.3 Soils and Sediments

As the lake shrank in size becoming a relatively small brine pool and a large desert playa, the lakebed changed from being fine lacustrine sediments of an alkaline lake (before 1913) to an essentially dry lake covered by abundant sulfate and carbonate salts in 1921. The evaporative salt crust regenerates from upwelling groundwater resulting in heaving and breaking of the crust due to volumetric changes[26] (Figure 12).

The playa has three basic types of sediments according to Gill *et al.* [27]: soft saline crust (surficial soft material, essentially no crust with a white salty appearance), salt-silt-clay (a clean hard crust without loose particles present) and salt-silt-clay-sand (a loose broken crust with loose sedimentary material atop crust).

Sodium salts of carbonate, bicarbonate and sulfate dominate the salt crust, which contrasts with other California playas rich in sodium chloride. This sodic soil situation results in volumetric phase changes resulting in crust heaving. According to Lopes[28], the lakebed surface morphology presents the following features:

- Beach ridges—these beach deposits occur around the lakebed margin, particularly along the west, with linear, diversely vegetated ridges parallel with the lake margin
- Delta Deposits—occurs at the entry of the Owens River into the lakebed
- Dunes and Megaripples—sand dunes occur near the delta and the southern tip of the lakebed
- Mudflats—occur near beach deposits and spring discharge and have a smooth texture and dark brown to dark green color
- Salt Crust—is a Sandflat with compound, surficial salt crusts
- Salt Pan—underlies the brine pool
- Sandflat—is located along the eastern lake margin, composed of fine-medium sands and thin salt crusts
- Spring Mounds—occur along a line at the southern end of the lakebed

With the significant amount of DCMs now in place, Lopes' surficial morphology is essentially of historical value. More relevant is the District's 1997 final EIR[29] description of eight demonstrable playa environments (based on soil characteristics, depth to groundwater and salinity):

1. Northwest Area—northwest corner of the lakebed, west of the Delta
2. Owens River Delta
3. Northeastern Sand Sheet—south and east of the Delta and Salt Pan
4. Keeler Transition Zone—area near Keeler
5. Salt Plan—surrounds the eastern margin of the brine pool
6. Crusted Clay Area—southeastern band layered between the Salt Pan and the shoreline zone
7. Southeastern Shoreline Zone—occurs along the eastern and southeastern lakebed margin
8. Southern Transition Zone—lies between the Salt pan and the Southern Sand Sheet
9. Southern Sand Sheet—southern end of the lakebed

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[26] Kohen, DS, *et al.*, 1994, as cited by Levy, *et al.* 1999.
[27] Gill, TE, *et al.*, 2002, Table 1
[28] Lopes, TJ, 1987, *Hydrology and Water Budget of Owens Lake, California*, MS Thesis University of Nevada, Reno, UMI Dissertation Services No. 1332290.
[29] GBUAPCD, 1997

The current DCM project is generally spread across environments 1 and 6-9 (see Figure 8).

Prior to the implementation of any DCMs (and still present in many places at the lake), there occurred a thin horizon or interval of dry soil overlying briny shallow groundwater[30]. This shallow groundwater supports wetlands around the lake's margin, and it comes to the surface at the shore of the brine pool. Implementation of the initial DCMs sought to create the following conditions:

- Managed vegetation areas—where a somewhat deeper dry soil profile mantle area has been created through the installation and operation of subsurface drainage. The area also has a low volume irrigation system that operates during saltgrass growing season.
- Shallow flooding areas—where shallow groundwater is augmented by winter irrigation. No drains are located within these areas; as a result, groundwater seasonally rises to the land surface. A small layer of the shallow unconfined groundwater is fed into the DCM drainage and irrigation system.

2.1.4 Water

Owens Lake is the natural hydrologic sink of the Owens Valley. Thus, water and dissolved salts coming from various sources within the watershed collect here, and this process has continued for 2,000 to 4,200 years[31]. In this climatic zone, evaporation dominates over precipitation; therefore, over the years Owens Lake has witnessed a natural mineral concentrating effect resulting in strongly saline and alkaline water quality.

Generally, water types and sediments are defined on the amount of total dissolved solids measured (in the over lying water in the case of sediment; ‰—in parts per thousand)[32]:

- Fresh Water—<1‰ (1,000 ppm or mg/L)
- Brackish Water—1-30‰ (1,000-30,000 ppm or mg/L)
- Saline Water—30-50‰ (30,000-50,000 ppm or mg/L) (saltwater generally ranges 30-34‰)
- Brine—>50‰ (>50,000 ppm or mg/L)

2.1.4.1 Surface Water

The largest surface water body near the project area is located in the west central and lowest part of the playa is the brine pool of approximately 25.5 square miles[33]. As we will see, waters in the area of the lake are at least brackish, generally more saline than seawater and in the case of the brine pool upwards of 10 times more saline than seawater. Mountain runoff and other surface waters discharge to the lake generally via the Owens River through a vegetated delta. Besides precipitation and storm flows, other surface waters present at the site include the springs, seeps and wetlands, as well as the shallow flooded areas used as a DCM. As summarized by CH2M Hill[34], water inflowing via the river, infiltrating the lakebed, and recharging shallow groundwater, approaches 6,000 ac-ft/yr.

[30] CH2M HillCH2M Hill, 2003a, Page 9
[31] Cochran, 1988
[32] USGS, 2007, On-Line Glossary, see http://ga.water.usgs.gov/edu/dictionary.html#S; Tchobanoglous, G and ED Schroeder, 1985, *Water Quality*, Addison-Wesley, p. 6. Brine is a (nearly) saturated salt (sodium chloride) solution.
[33] CH2M Hill, 2003a, page 3
[34] *Op cit.*

2.1.4.2 Groundwater

Groundwater comes from snowmelt, rainfall, or mountain runoff. Groundwater conditions at the lake are generally saline to briny and vary in depth below grade from 2-4 feet in the area of the delta down to around 10-16 feet in the area of the crusted clay area, as well as a shallow unconfined aquifer running from 0-30 feet bgs. Subsurface flow to the ranges between 5,000 and 20,000 ac-ft/yr, while groundwater recharge from these sources ranges between 5,400 and 13,000 ac-ft/yr[35]. Shallow groundwater in the area of the lakebed generally has an upward gradient due to the confined nature of the underlying aquifer[36].

2.1.5 Habitat, Ecological Communities and Biota

Owens Lake presents a significant diversity of habitat based on playa, which vary in their quality to support phreatophyte[37] [38], and perennial grass/sedge and faunal communities. Various studies indicate that almost 300 aquatic and terrestrial wildlife species potentially occur at the lake[39]. Areas contributing to fugitive PM10 dust emissions lack substantial vegetation, and the majority of the proposed project area is open playa with little or no vegetation present. Based upon recent work of Sapphos[40], the cover types likely to occur at or near the project area can be identified.

2.1.5.1 Potential Natural Vegetation and Cover Types

While playa predominates, there are two plant communities occurring within the proposed project, namely, Dry Alkali Meadow (DAM) and Shadscale. These three cover types are discussed in more detail below.

Cover Type #1: Barren or Playa— covering 8,729 acres of the proposed project area, the bare alkaline playa[41] is the dominant cover type (CT). According to Sapphos (2007a), no vascular plants grow in these areas. The underlying soils drain poorly, and have high salinity or alkalinity due to evaporation of water that accumulates in closed drainages.

Cover Type #2: Dry Alkaline Meadow (including Emissive & Non-Emissive areas)—DAM covers approximately 189 acres of the proposed project site. It has a dense to open growth of perennial grasses and sedges that are usually low growing. Saltgrass (*Distichlis spicata*) dominates this habitat type. This plant community is a type of Transmontane Alkaline Meadow (TAM). The meadow presents relatively few species growing on the fine-textured, more or less permanently moist, alkaline soils. The most common co-occurring plant species in DAM are alkali pink (*Nitrophila occidentalis*), shadscale (*Atriplex confertifolia*), and Parry's saltbush (*Atriplex parryi*), which occur on slight rises within the saltgrass clumps. On the western edge, particularly in the southwestern corner, several additional species occur in low numbers, including common three-square (*Schoenoplectus pungens*), Baltic rush (*Juncus balticus*), and many other upland species listed in the floral compendium. This community corresponds to Sawyer and Keeler-Wolf's Saltgrass series (CNDDB Code 41.200.00) and Holland's Transmontane Alkali Marsh (Element Code: 52320).

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[35] *Op cit.*
[36] GBUAPCD, 1997 and CH2M Hill, 2003a
[37] Elmore, AJ, JF Mustard and SJ Manning, 2003, Regional Patterns of plant community response to changes in water: Owens Valley, California, *Ecol. Applic.* 13(2):443-460.
[38] Phreatophyte plants have very long roots to acquire moisture at or near the water table as an adaptation to arid environments.
[39] Sapphos, 2004, §3.2
[40] Sapphos (2007a)
[41] Davis *et al.*, 1998, Type #46000

Cover Type #3: Shadscale—Shadscale (*Atriplex confertifolia*) dominated habitat occurs on approximately 426 acres of the proposed project site. Parry's saltbush (*Atriplex parryi*) also occurs in this cover type, and is considered by other investigators to be a locally dominant species. This community type includes a few other species such as saltgrass, greasewood (*Sarcobatus vermiculatus*) and bush seepweed (*Suaeda moquinii*). This community corresponds to Sawyer and Keeler-Wolf's Shadscale series (CNDDB Code 36.320.00) and Holland's Shadscale scrub (Element Code: 36140).

Cover Type #4: Scattered Shadscale—this cover type is similar to the Cover Type #3, but the prevalence of shadscale is more diffuse and limited.

The following table summarizes the land area covered by these plant community cover types. The location of each cover type across the lakebed and within the proposed project area is shown in Figure 13.

Potential Natural Vegetation and Cover Types, Listed Status and Acreage within Project Area

Plant Community	Element Code/Type	Current Status	Acres (Percent Of Total)
Barren	N/A	N/A	8,483 (90.8%)
Dry Alkali Meadow (a type of Transmontane Alkaline Meadow [TAM])	41.200.00 (CNDDB) 52320 (Holland)	G4, S4	436 (4.7%)
Shadscale	36.320.00 (CNDDB) 36140 (Holland)	G4, S3.2	255 (2.7%)
Scattered Shadscale	36.320.00 (CNDDB) 36140 (Holland)	G4, S3.2	170 (1.8%)
TOTAL			9,344

Key:

Gx = Global ranks (CNDDB)
G1: Fewer than 6 viable occurrences worldwide and/or 2,000 acres
G2: 6 to 20 viable occurrences worldwide and/or 2,000–10,000 acres
G3: 21–100 viable occurrences worldwide and/or 10,000–50,000 acres
G4: Greater than 100 viable occurrences worldwide and/or greater than 50,000 acres
G5: Community demonstrably secure due to worldwide abundance

Sx = State ranks (CNDDB; the state rank is assigned much the same way as the global rank, except state ranks in California often also contain a threat designation. Threat designation does not constitute legal protective status.)
S1: Fewer than 6 viable occurrences statewide and/or fewer than 2,000 acres
S2: 6 to 20 viable occurrences statewide and/or 2,000–10,000 acres
S3: 21 to 100 viable occurrences statewide and/or 10,000–50,000 acres
S4: Greater than 100 viable occurrences statewide and/or greater than 50,000 acres
S5: Community demonstrably secure statewide
Threat ranks (CNDDB)
x.1: Very threatened x.2: Threatened x.3: No current threats known

* = Pursuant to Holland, merits special consideration

Source: CDFG, 2005 and Holland 1986

2.1.5.2 Biota

CH2M Hill[42] anticipated that the lake's water and soil chemistry and natural history provides an indication of resulting environmental quality conditions upon the implementation of the DCMs (in particular, the reintroduction of water onto the lakebed. CH2M Hill stated that a, "[r]ich, saline habitat will ensue where there is free water at concentrations low enough to permit development of a food chain."[43] The Sapphos (2007) initial study summarizes some of the available data indicating that even though Owens Lake is hypersaline and alkaline it has a significant record of observed biota inhabiting, or at least using, the aforementioned cover types or communities. The following organisms represent a reasonable range (for the purposes of this SLERA) of biota that the proposed DCMs might affect.

Flora

- Owens Valley Checkerbloom—there are four plant species listed as endangered, threatened, rare, or candidates for listing pursuant to the federal or state Endangered Species Acts identified as having the potential to occur in west-central Inyo County[44]. Although it is unexpected to occur within the project area, it may occur nearby.
- Saltgrass—as discussed above, this is a more typical plant species to be exposed.

Wildlife

Twelve wildlife species listed as endangered, threatened, rare, or candidates for listing under the Endangered Species Acts potentially occur in west-central Inyo County[45]. However, based upon previous studies cited by Sapphos, none of these species is likely to occur within the project area. Eleven locally important wildlife species potentially occur within or adjacent to the proposed project area, including willet (*Catoptrophorus semipalmatus*), Franklin's gull, (*Larus pipixcan*), Nuttall's woodpecker (*Picoides nuttallii*) and sage sparrow (*Amphispiza belli*). Forty-eight special status wildlife species potentially occur in the region[46]. Of these species, the most likely to occur, and that reflect a range of potentially exposed biota across trophic levels, are:

- Western Snowy Plover—this bird (*Charadrius alexandrinus nivosus*) is the most commonly observed of all of the special status species within the proposed project area.
- Owens Valley Vole—although possibly occurring in the area, this vole (*Microtus californicus vallicola*) is unobserved recently; nevertheless, it constitutes an important food web species that may be exposed within the project site.
- Northern Harrier—although not readily observed, this top predator raptor (*Circus cyaneus*) is known to occur in the area.

Invertebrates

Eleven locally important wildlife species have potential to occur within or adjacent to the proposed project area. The tiger beetle is likely to occur within the project area, as are the important food sources of brine shrimp and brine flies (that is within standing pools of water[47]:

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[42] CH2M Hill (2003a) page 8
[43] *Op cit.*
[44] Sapphos, 2007, §3.4
[45] *Op cit.*
[46] *Op cit.*
[47] See Sapphos, 2007, Table 3.4-3.

— Tiger Beetle—this group of beetles is of particular note because of their sensitivity (as a special status species), diversity (several species occur in the region) and potential occurrence within the project area.

— Brine Shrimp—this organism (*Artemia* spp.) is important due to its potential for exposure and importance within the food web at the lakebed.

— Brine Flies—this fly (also called shore flies of the Family *Ephydridae*) consumes algae, bacteria and organic waste from both brine shrimp and other organisms.

2.2 Chemicals of Potential Ecological Concern (COPECs)

2.2.1 Soil and Sediment

The soils and sediments of the Owens Lake bed accumulate a considerable amount of various salts. This accumulation is the result of surface evaporation of shallow groundwater, runoff and flow from the river, but generally, as more input comes from groundwater, the chemical constituents of the lakebed are likely to reflect the chemical composition of local shallow groundwater. Because there is no project area-specific data available to Kleinfelder, we will integrate soil/sediment chemistry data from several sources:

- A published paper by Gill *et al*[48] describes the elemental geochemistry of the lake's wind-erodible playa sediments (Table 1).
- The composition of Owens Lake soils and sediments has been analyzed during several soil mapping efforts. These data are available from CH2M Hill's[49] environmental monitoring program baseline and approach document (Table 2).
- Environmental monitoring data published by CH2M Hill on behalf of LADWP as part of the SIP process that provides certain additional insights to lakebed soil quality[50]. In 2002, sediment samples were collected from three seep areas around the lake and these are shown in Table 3[51].

The soil chemistry data indicate that lakebed soils and sediments are saline and sodic (see the footnote for additional detail[52]), alkaline (a high pH >9) and rich in calcium and magnesium salts with elevated levels of boron, bromine, lithium and sodium.

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[48] Gill, *et al.*, 2002, Table 2
[49] CH2M Hill, 2003a, Table D-1
[50] CH2M Hill, 2003b, 2004, 2005a&b, 2006, 2007
[51] CH2M Hill, 2003c, Table 13
[52] The following note comes from CH2M Hill (2003a, page 10):

> *Soils across Zones 3 and 4 are classified as saline sodic soils. By definition, these soils are characterized by an electrical conductivity of the saturation paste extract (ECe) greater than 4 dS/m and an exchangeable sodium percentage (ESP) greater than 15. Most of the lakebed soils actually exhibit an ESP approaching 100, sodium adsorption ratio (SAR) of extracts from 500 to 15,000, and ECe of more than 100 to 200 dS/m in the surface 12 inches of soil. As a result of the high sodium concentrations in these soils and high clay fractions, it is important to maintain the salinity above some critical threshold to avoid deterioration of the soil structure. The presence of other cations (and high-bulk salt concentrations) in the soil solution helps to reduce the swelling effects caused by sodium that can, with wetting and drying, collapse the soil structure such that permeability to air and water is severely restricted. To reclaim these soils without destroying soil structure, the salinity of irrigation water must be maintained above the threshold irrigation water electrical conductivity (ECi).*
>
> *Drip irrigation experiments conducted on the DIVIT plots, using an ECi of 7 to 8 from the SFIP well, showed little sign of clay dispersion and soil collapse around emitters. At the Agrarian Farm flood irrigation panels, however, application of River Well water with an ECi of 1 to 2 dS/m did deteriorate*

2.2.2 Surface Water and Groundwater

Water quality data are available from the following sources:

- A published paper by Levy et al.[53] describes the shallow groundwater chemistry of the eastern lake (Table 4).
- The CRWQCB Lahontan Region's 2005 technical report[54], concerning the municipal and domestic supply (MUN) Beneficial Use Designation (BUD) for Owens Lake, provides relevant data (Table 4).
- CH2M Hill's[55] environmental monitoring program baseline and approach document summarizes general water quality conditions (Table 5).
- There are more or less three years (2003-2006) of environmental monitoring data published by CH2M Hill on behalf of LADWP as part of the SIP process[56]. These data provide considerable water quality trends from different operating components.
  - Operational Ponds—are a part of the water management system supporting the various drainage collection and irrigation systems, and provide for flow/saline-level equalization. Samples from the pond reflect conditions of this water (see Figure 14A).
  - Shallow Flooding Areas—samples are collected from surface water released to these DCM areas (see Figure 14B).
  - Habitat Shallow Flood Areas—samples are collected from surface water released to these DCM areas (see Figure 14C).
  - Managed Vegetation—samples are collected from surface water released to these DCM areas, when they are under irrigation (Kleinfelder was unable to obtain any trend data for this DCM).
  - Observation Wells—there are eight shallow groundwater wells along the perimeter of the Phase 1 dust control area (see Figure 14D).

These data indicate that the waters in, under, and around the project area are a strong solution of dissolved salts making it hypersaline (a TDS[57] >35‰ or EC[58] [59] >40 dS/m), sodic[60] (SAR >12), and alkaline (with a basic pH >9.0), and rich in aluminum, arsenic, boron, lithium, molybdenum and silver, among other metals and metalloids.

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surface soil structure. To date, these are the best empirical tests of irrigation water quality impacts on soil structure in clay-dominated soils on Owens Lake.

[53] Levy, DB, JA Schramke, KJ Esposito, TA Erickson, and JC Moore, 2002, The shallow ground water chemistry of arsenic, fluorine and major elements: Eastern Owens Lake, California, *Appl Geochem* 14:53-65, Table 1.
[54] CRWQCB 2005 MUN Beneficial Use Designation document, Tables 7, 8 and 11
[55] CH2M Hill, 2003a, Table 3
[56] CH2M Hill, 2003b, 2004, 2005a&b, 2006, 2007
[57] TDS = Total Dissolved Solids (
[58] EC = Electrical Conductivity
[59] To convert EC to TDS: EC (dS/m) x 640 = TDS (mg/L) [from CRWQCB 2005, page 17]. However, according to CH2M Hill (2003a, Appendix B) the relationship between these two measurements in not linear and thus recommend a different conversion tool: EC=190.63 x (1 − exp [-6.715E-6 x TDS]).
[60] Sodic water has high sodium (Na^+) levels compared to calcium (Ca^{2+}) and magnesium (Mg^{2+}) levels. Sodicity of water is expressed as the sodium adsorption ratio (SAR), SAR = (Na x 0.043) / √{[(Ca x 0.05) + (Mg x 0.083)] / 2.

2.2.3 Identification of COPECs, Exposure Point Concentrations, and Stressors

Considering the affected habitats and potential target receptors, points of likely exposure include soils and sediments, surface waters and groundwater. A review of several reports[61] suggests that there may be several COPECs occurring in surface water, groundwater, and soil and sediment at toxic levels, including arsenic, boron, copper, fluorine, iron, selenium and vanadium.

2.2.3.1 Soil COPECs and Exposure Point Concentrations

There are no detailed and specific data specific to areas included within the project area. For this reason, the typical COPEC selection process could not be followed, and Kleinfelder therefore simply included as many constituents (heavy metals and metalloids) for which sufficient data were available and that are typically addressed in a SLERA (Table 6).

Exposure point concentrations (EPCs, chemical concentrations at points where biota encounter environmental media) are critical in determining exposure intake and subsequent risk of adverse effects on receptors. Due to the lack of specific area data and the screening nature of this assessment, the exposure point concentrations were selected using the available site-wide values, reflecting a high but not necessarily maximum value (Table 6).

2.2.3.2 Water COPECs and Exposure Point Concentrations

As with soil, there are no detailed water data specific to areas included within the project area. However, the application of shallow flooding in this next phase of DCMs, can be evaluated using the available data and a consideration of the trend analysis of water quality in this DCM. Kleinfelder simply included as many constituents (heavy metals and metalloids, as well as pH, salinity,) for which sufficient data were available (Table 7). Because of the naturally elevated salt levels in waters of the lake, water EPCs (Table 7) were set at available average levels (concentrations).

2.2.3.3 Other Stressors

Additionally, certain of Owens Lake clay soils are inherently fragile[62] and as discussed above the waters present at the lake are rich in dissolved salts. Thus, several additional stressor metrics are important for evaluating the media as they may act individually or in concert to cause stress to biota. These metrics include (additional detail concerning these stressors follows later):

- Salinity—Salinity is a problem when salts accumulate in the root zone and negatively affect plant growth via hindering plant root absorption of water from surrounding soil. Soil water salinity affects soil physical properties causing flocculation, *i.e.*, fine particles bind together into aggregates, leading to the loss of soil pores and causing decreased water penetration (and retention) and gaseous exchange and resulting in significant soil compaction.
- Sodium levels—Excess sodium has the opposite effect of salinity on soils. As sodium concentrations become too high, soil dispersion occurs due to clay platelet and aggregate swelling. Too many large sodium ions induce expansion and separation of clay particles causing swelling and soil dispersion. Soil dispersion hardens soil, which results in reduced water infiltration, reduced hydraulic conductivity through the soil, and surface crusting.

[61] CRWQCB 2005, Table 14, see also CH2M Hill, 2003a
[62] The soil is sensitive to erosion or loss of its structure, which are both due to the soil's salt balance.

- pH/Alkalinity—soil pH is a measure of the acidity or alkalinity of the soil[63]. Generally, pH between 6 and 7 are considered normal and most favorable for plant growth and development. In the current case, pH approaches or exceeds 9.0, making it strongly alkaline. Under these conditions, calcium, magnesium, and molybdenum become more available in the soil solution. In contrast, aluminum, iron, manganese, copper, zinc, phosphorous and boron become less available. Such a high pH will suppress beneficial microbial growth and development within the soil column.
- Soil Structure and Nutrient Resource Stress[64]—The "natural" saline/sodic/alkaline soil (of the project area) presents a stress condition to most biota that cannot tolerate the elevated levels of salinity, sodium, and pH, as well as decreasing the availability of nutrients and poor soil structure. These conditions form a gradient where the severity of salinity, sodium concentrations, pH and soil structure and fertility improve towards conditions that are more normal and conducive to a variety of flora and fauna as compared to a limited number. Thus, these conditions form a complex gradient of stress that results in different habitats and cover types across the lakebed, along its margin, and where more freshwater conditions occur.

2.3 Chemical Fate and Transport

COPECs occur at Owens Lake in and move through a semi-closed hydraulic complex creating a chemical milieu in the playa soil, sediment, and sodic-saline waters (both surface waters and groundwater):

- Upwelling of groundwater may deliver new heavy metal and metalloid salts into the soils.
  - Artesian waters in the area demonstrate increasing pH, alkalinity and TDS in the direction of the center of the lakebed.[65] Bicarbonate and carbonate anions dominate these waters.
  - Shallow groundwaters are similar to the artesian waters, but are more greatly affected by their interaction with surficial soil and sediment, and the concentrating effect of surface evaporation[66].
  - The soil and sediment profile has a surface richer in sodium, sulfate, chlorine and chloride, and potassium, while calcium, silicon, aluminum, iron and magnesium are generally more uniformly distributed throughout the profile[67].
  - As the waters concentrate near the soil surface, carbonate minerals precipitate first followed by sulfate mineral salts[68]. Boron, arsenic, fluorine, lithium, selenium will remain in solution
- Irrigation delivers various salts to, and will dissolve and remove other salts from, the soil column:
  - Irrigation waters may be comprised of one or both of the following water types:
    - Saltwater from:
      - — Storage (operation) ponds,
      - — Tailwater (overland or return flow/surface runoff), and
      - — Shallow groundwater that flows into buried drains; and

[63] Natural Resources Conservation Service (NRCS), 2004, *Soil Quality Thunderbook*, Soil Quality Indicators: pH.
[64] James, JJ, RL Tiller and JH Richards, 2005, Multiple resources limit plant growth and function in a saline-alkaline desert community, *J Ecol.* 93:113-126. Donovan, LA and JH Richards, 2000 Juvenile shrubs show differences in stress tolerance, but no competition or facilitation, along a stress gradient, *J Ecol*. 88:1-16.
[65] Levy, *et al.*, 1999
[66] *Op cit.*
[67] *Op cit.*
[68] *Op cit.*

        - Freshwaters from the aqueduct.
    - Irrigation waters comprised of a mixture of saltwater and freshwater are used on the Managed Vegetation and Habitat Shallow Flood DCAs during the growing season of saltgrass, and saltwater is used in the Shallow Flood DCAs.

- Within the soil-sediment column:
    - The soil column is at a high pH and under reducing (anoxic) conditions due to the lack of oxygen penetration into soil pores, which become saturated with various salts and minerals[69].
    - The salts and minerals can move upwards as water evaporates from the soil surface[70];
    - Some salts and minerals also may migrate downward through the column during precipitation events, or in the case of shallow flooding or irrigation. When overland flows occur, salts may dissociate and liberate COPECs into the flowing water. Soil water then percolates to shallow groundwater from Managed Vegetation DCAs and there is seepage to groundwater from the operation ponds and the (Habitat) Shallow Flooding DCAs.
- In fugitive dust emissive areas, COPECs may migrate from the site via windblown dust.

2.4 Exposure Pathways

An ***exposure pathway*** is the course that a chemical may take from a source to an individual receptor, and includes:

- A **Source** and **Release Mechanism**,
- An **Exposure Point**—is a location in the environment (*e.g.*, soil, surface water, sediment, and the like) where contact may occur between a receptor and a COPEC, and
- An **Exposure Route**—is the mechanism by which a receptor contacts a COPEC (ingestion of contaminated media or dietary items [uptake by plants] and skin contact with contaminated media, such as soil).

Five elements define a complete Exposure Pathway:

- A ***contaminant source***, such as any waste disposal area;
- A ***contaminant release and transport mechanism***, which might carry contaminants from the source to points where exposure may occur;
- A ***point of exposure***, where actual or potential contact with contaminated media may occur;
- A ***route of exposure*** (inhalation, ingestion, absorption); and
- A ***receptor population*** that could be exposed to the contaminants at the point of exposure.

2.4.1 Potential Exposure Pathways

The possible states of an exposure pathway are as follows:

- It **exists** when all five elements exist.
- It **potentially exists** when at least one element is not fully known but others are identifiable.
- It **does not exist** when one element does not exist, has not existed in the past, and will not exist in the future.

[69] CH2M Hill, 2003, page 18
[70] CH2M Hill, 2003, page 17

With regard to the proposed project, the primary environmental media most likely encountered by biota are soil and sediment through digging or burrowing, dermal contact, and incidental ingestion of soil or sediment along with food items. Sediment and surface soil also can act as secondary contaminant sources. The various inorganic metals/metalloids persist in the environment, and if bioavailable and biologically accessible to biota, they may accumulate and in certain cases biomagnify through the food chain.

In the current case, the shallow flooding DCAs contain the following source media: soil and irrigation/flood water. The moat and row DCAs similarly contain soil but in certain times of the year shallow groundwater may rise sufficiently in moat areas where biota might be able to access it.

2.4.2 Source

The sources of COPECs include the lakebed soils and sediments and natural waters, as discussed previously.

2.4.3 Release/Transport Mechanisms

This was discussed previously under §2.3.

2.4.4 Points & Routes of Exposure

Kleinfelder concludes that (potentially) complete pathways of exposure are present.

- **Soil/Sediment**—incidental ingestion of the media along with food items and dermal contact with the media;
- **Water**—ingestion of, or absorption from, contaminated water; and
- **Prey**—biomagnification (*e.g.*, selenium) in predators at higher trophic levels.

2.4.5 Ecological Receptors

This site has many ecological biotic and habitat receptors , but it is beyond the SLERA's scope to evaluate every resource. Ecological resources that could be affected include (USEPA, 1997b and 2003a):

- Rare, endangered, or threatened (RET) species or critical habitat for such species,
- Particular biota within an assessment population or community, such as organisms critical to the food chain,
- Critical game, resource, or harvested species, and
- Larger areas with important habitat (e.g., certain plant assemblages, sensitive aquatic communities or wetlands)

As discussed in §2.1.5.2, several ecological receptors are likely to be exposed. Additional details about these receptors are provided in Section 2.4.5.1 through 2.4.5.4.

2.4.5.1 Plants—saltgrass

Saltgrass (*Distichlis spicata*) a graminoid (grass-like plant in the family *Poaceae*) is a low stiff perennial ranging from 0.5-1.5 feet tall[71]. It has straight vertical stems with tapering leaves arranged in two opposite rows, and which end with sharp points. It reproduces by seed or asexually via long horizontal rootstocks growing about 6 inches underground. It is a facultative wetland plant, occasionally found in non-wetland areas, and common in saline soils. In terms of

[71] USDA, NRCS, 2007, *The PLANTS Database* (http://plants.usda.gov), National Plant Data Center, Baton Rouge, LA 70874-4490 USA

its wildlife habitat values, saltgrass is of minor value (2-5%) in the diet of large mammals and of low value (5-10%) in diet of small mammals. For water birds, it is of low dietary value but provides moderate, occasional cover. It requires sufficient water, will grow at salinities between 0.1-1.5 %, and can tolerate salinity approaching 3%[72]. It is capable of secreting salt via special glands on the surface of its leaves.

2.4.5.2 Invertebrates

Tiger Beetle—this beetle (family *Cicindelidae*, Order *Coleoptera* Suborder *Adephaga*) occurs near the project area as it favors warm, humid areas with high light intensity and warm temperatures. These beetles prefer flat, bare, dry soil into which they can burrow. They inhabit salty playas as they can tolerate the moderate salinity of a salt crust. Adults bury themselves in soil to escape predators and unfavorable weather, and to hibernate during the winter, emerging once warmer conditions prevail in the spring. The tiger beetle serves as prey for other, larger insects (dragonflies), mammals and birds (such as the insectivores American avocet and the western snowy plover).

Brine Shrimp—are one food source for the birds. They are filter feeders and predominantly eat green algae because of its small size; otherwise they consume diatoms and golden brown algae. The shrimp hatch in the spring from cysts laid the previous fall. Cysts are essential to the repopulation of a surface water body.

Brine Fly—there are two identified species of brine flies: *Ephedra cinerea* and a larger species *E. hians*. Adult flies and their larvae feed on bacteria and algae growing on various hard surfaces underwater. The adult is 3-6mm long with an average lifespan of 3-5 days. Egg laying is continuous during summer when females typically lay approximately 75 eggs on or near the water surface. Larvae survive completely submerged and receive dissolved oxygen from the water that passes through gills. To emerge, larvae rise to the surface enclosed in an air bubble, and then they go ashore via the wind where they become another food source for birds and other predators.

2.4.5.3 Mammals—Owens Valley Vole

The Owens Valley vole (*Microtus californicus vallicola*) is one of 17 named subspecies of the California vole (*M. californicus*). It occupies a disjunct range in the Owens Valley and is a California Species of Special Concern. Like the California vole, it is active diurnally and nocturnally year-round, foraging primarily on the stems and leaves of grasses and forbs, but using grass seeds during dry times[73]. In general, voles live in runway and burrow systems under the grass cover in meadow or pasture (using it as refuge from predators); thus, because the project area is often bare or with sparse vegetation, it will occur only rarely within the project area until or unless sufficient vegetation develops. Voles will eat a wide variety of foods including, almost any grasses, or herbaceous plants as well as seeds. In playa areas across the southwestern United States, some voles (*e.g.*, meadow and montane voles) prefer saltgrass and can consume their own weight in grass in one day[74]. The Owens Valley vole tends to prefer irrigated areas[75]. These voles are a prey for predators including diurnal and nocturnal raptors, mammalian carnivores, and snakes.

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[72] Arshad, SA and AT Harrison, 1999, Great Salt Lake Playa Foodweb Project, Saltgrass (http://people.westminstercollege.edu/faculty/tharrison/gslplaya99/saltgrass.htm)
[73] Hall, ER, 1981, *Mammals of North America*, John Wiley & Sons
[74] Vogel, MA and AT Harrison, 1999, Great Salt Lake Playa Foodweb Project, Voles of the Great Salt Lake (http://people.westminstercollege.edu/faculty/tharrison/gslplaya99/voles.htm)
[75] Nelson, FC, 2007,

2.4.5.4 Birds—Western Snowy Plover[76]

Snowy plover (*Charadrius alexandrinus*) populate coastal and inland areas of North and South America, Europe, Africa and Asia. This small bird (15-17 cm long and 34-58 g weight) nests on sand beaches, salt flats and river channels. Juvenile and adult snowy plover populations that breed in inland California migrate to coastal California or west coast of Baja California for winter, departing as early as September – early November; and they return to the region in late March[77]. There is high likelihood that adults return to former breeding and wintering grounds in consecutive years.

Inland breeding habitat features include proximity to surface water seeps, on barren to sparsely vegetated ground at alkaline-saline surface water bodies, riverine sand bars, or at salt-evaporation or sewage-agricultural wastewater ponds. Nests are on open ground; and nesting at Owens Lake occurs on alkali or sand wash substrate, located in vehicle tracks or on wood debris or saltgrass, and at distances of 10 to several hundred meters from surface water[78].

Snowy plover nest clutch size averages three eggs. Individuals may brood 1-3 successful clutches per season; or up to six clutches per season, if earlier clutches are lost. Egg incubation averages 26 days. Chicks leave nest within hours of hatching and begin to feed independently, with paternal care through fledging at 28-33 days post-hatch. Average lifespan of the bird is 2.7 years.

While on the coast, the birds forage on beaches, tide flats, salt flats and salt ponds, in 1-2 cm deep water or on beach detritus or dune vegetation. When inland these plover forage along the lakeshore, seeps and streams, on wet areas or dry playa. Plover feed by probing for insects. At saline lakes, diet includes brine fly larvae, adult flies, beetles and brine shrimp. The diet of coastal residents includes crabs, worms, flies, beetles, clams, amphipods and ostracods.

Mortality results from predation, severe weather (winds bury eggs, high water flooding of nests, hail), desertion or separation from parents, disturbance by human activities, collision or entanglement, abnormal development, and disease. Snowy plover are less sensitive to elevated selenium levels, which alter embryonic development in other species (Black-necked stilts).

Despite resilience to stressful environments, snowy plover populations are severely limited by human activities that disturb their habitat, physically damage or disrupt nesting activity. Pacific coastal populations in the US and Baja California are listed as threatened species by the US Fish and Wildlife Service, and is designated a Species of Special Concern in California.

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[76] Summarized from: *The Birds of North America Online*, No. 154, GW Page, JS Warriner, JC Warriner, and PWC Paton (http://Bna.birds.cornell.edu/BNA) (Cornell Lab of Ornithology and American Ornithology Union)
[77] CH2M Hill (2004-2007) does not discuss the plover's residence period at Owens Lake in their monitoring reports.
[78] CH2M Hill, 2004-2007

2.5 Ecological Assessment and Measurement Endpoints

The identification of ecological assessment endpoints and measures is critical to the SLERA process. They provide the focus of the SLERA, link the SLERA with the EIR, and ensure that the methodologies and results of the SLERA are technically sound. Most importantly, they ensure that the values[79] of the site are considered from an ecological standpoint in the construction of the DCMs. The ecological values of the site include populations and communities of plants and animals in terrestrial and wetland habitats. In broad terms, the values to be protected (*Assessment Endpoints*) for each of these habitat types includes the structure and function of site ecosystems, and the survival and reproduction of flora and fauna typical of the region.

Measurement endpoints are actual measurements (estimates) for evaluating assessment endpoints, and are the basis for evaluating risk. The following table summarizes the assessment and measurement endpoints to be used in this SLERA.

Assessment Endpoints	Measures of Exposure	Measures of Effect
Aquatic / Wetland Habitat		
Aquatic Invertebrate Community (composition, density or diversity)	COPEC concentrations in surface waters	Media concentrations demonstrable of adverse effects (*e.g.,* compositional changes, density decreases or diversity decreases)
Benthic Invertebrate Community (composition, density or diversity)	COPEC concentrations in sediments	Media concentrations demonstrable of adverse effects
Semi-aquatic avian species (survival, reproduction, growth and abundance)	COPEC concentrations in surface waters, soil/sediments, food, and body/egg burden	Media or tissue concentrations demonstrable of adverse effects (fertility, fecundity, growth and/or survival)
Terrestrial Habitat		
Critical Habitat	COPEC concentrations	Patchiness Media concentrations demonstrable of adverse effects
	Decrease in Area	Change in areal coverage
Plant Community (composition, density or diversity)	COPEC concentrations in soil/sediment	Media concentrations demonstrable of adverse effects
Terrestrial Invertebrate Community (composition, density or diversity)	COPEC concentrations in soil/sediment	Media concentrations demonstrable of adverse effects
Small Mammals (survival, reproduction, growth and abundance)	COPEC concentrations in media & biota	Media concentrations or doses demonstrable of adverse effects
Avian species (survival, reproduction, growth and abundance)	COPEC concentrations in media & biota	Media concentrations or doses demonstrable of adverse effects

[79] Values in this case refers to the concept of ecological services, which define specific ecosystem functions that are valued by humans

2.6 Conceptual Site Model

A Conceptual Site Model (CSM) is a schematic of the site and environs, presenting information regarding sources; the release, transport and fate of site-related chemicals; exposed plant or animal receptors; or critical habitat. Essentially, it provides a way to formulate the environmental problem at hand by stating testable hypotheses, posed as questions, namely:

- Are site-related COPECs or stressors present?
- Are known or potential ecological receptors sufficiently exposed to COPECs or other stressors so that ecological effects could occur?
- If present, could the concentrations of site-related COPECs, or conditions arising due to the presence of these stressors, be sufficiently elevated to impair identified ecological receptors and related resources?

Figure 15 presents the CSM for this SLERA, which is composed of three parts:

- The main portion of the CSM presents a flowchart schematic outlining the physical environment and a generic (representative) biotic food web that is potentially present at and around the project area.
- Figure 10-A depicts the phreatophytic typology relevant to the cover types at and around the project area and their relationship to the generalized depth to groundwater[80].
- Figure 10-B depicts the cycling, uptake and equilibrium processes that can affect inorganic COPEC bioavailability in the soils and waters at the project site.

The CSM presents the various biological receptors discussed above, and that may exist within the cover types of interest, and have the potential for exposure to COPECs and other stressors present in the project area. Table 8 lists these exposure pathways.

[80] Based upon the analysis of Elmore *et al.*, 2003, Figure 2.

3.0 Ecotoxicity Assessment

The ecological conditions at the lakebed are partly the result of natural conditions and partly the result of human interaction with the resources of the Owens Valley. As discussed by Sapphos[81] and others, Owens Lake is a young dry lake and its surface is yet to stabilize. Human activities enhanced the desiccation of an alkaline lake and the formation of a large playa with the diversion of the Owens River. The resulting landform presents, with its underlying soil/sediment and groundwater, as well as the environment (climate, elevation, etc.), an ecologically stressful condition for many biota. This baseline condition is not at issue in this SLERA.

The DCMs represent a human intervention in this stabilization by causing a transition from a playa to a moderated soil type that may or may not ultimately transition into a vegetated state. In this SLERA, we are interested in whether there is a potential for ecological risk resulting from the implementation of two DCMs: Shallow Flooding, and Moat and Row. The DCM project processes should not increase or exacerbate ecological impacts arising from COPECs or other stressors.

Normally in a SLERA, the analyst is concerned about certain chemicals occurring at elevated concentrations relative to the surrounding media or baseline condition, which collectively may pose a significant ecological risk to one or more biotic receptors either through direct exposure or through the food chain. However, the situation at the proposed project area is not just elevated concentrations in soil, water or other media of a select group of hazardous substances. The analysis must take into consideration the extreme (for most biota) baseline condition, in order to differentiate whether the two DCMs themselves (which are in fact alterations of existing cover types) result in significant differences that might result in a potentially significant ecological hazard to exposed biota or resources.

3.1 Ecotoxicity

The ecological effect of a chemical depends on many factors, such as its concentration in the environment and/or receptor organism, its accessibility and bioavailability to biota, synergistic interactions among constituents, the duration and frequency of exposure to that constituent, the receptor species and the metabolic rate and metabolic process characteristics of the receptor species. Chemicals can affect biota and ecosystems in both lethal and sub-lethal ways, such as the following:

- Altered development, behavior, metabolic and physiological systems,
- Increased susceptibility to disease, parasitism, or predation
- Disrupted reproductive functions
- Mutations or other causes of reduced offspring viability

Kleinfelder used a set of environmental screening criteria to evaluate the COPECS in soil-sediment and water (see Tables 8 and 9). The purpose of these criteria is to determine whether an ecological hazard might be caused by the environmental conditions under consideration and help focus decision-making on those DCMs that might pose an unacceptable risk to the environment.

Table 9 presents criteria for soil and sediment and Table 10 presents water quality criteria (see additional information on each criterion and a reference citation in the cited table). Kleinfelder obtained these criteria from several sources, including the US Department of Energy (USDOE) Oak Ridge National Laboratory (ORNL, 2006) Risk Assessment Information System (RAIS) Ecological Benchmark Database. The criteria set for soils and sediment, and water, was designed for a variety of potential

[81] Sapphos, 2003, 2004, 2007

receptors: fish, aquatic invertebrates, macrobenthic invertebrates, microorganisms, plants, soil invertebrates and upper trophic level organisms, in order to provide range of protectiveness in the analysis. Water criteria are primarily developed for freshwater; however, there are some marine criteria.

The environmental conditions of the baseline case (barren playa) present a range of stresses (and potential ecological hazard) on biota influencing community properties (structure and distribution) and functionality (productivity and nutrient cycling). The parent materials (rock and soil) and waters (surficial and groundwater) of the baseline case constraint the possible ecosystem structure and function at the site. Thus, the application of DCMs within the project area may increase or decrease concentrations of certain COPECs and either exacerbate or ameliorate other stressor conditions. These ecological stressors include:

> **Toxicity Stress**—some waters and soils contain elevated levels of various elements, metals and metalloids. Boron is essential for plant growth as a micronutrient. When high concentrations of boron in water occur, plant growth and development will be depressed. Similarly, others like arsenic, copper and vanadium pose toxicity to various wildlife, as does selenium, which also biomagnifies within the food chain.
>
> **Sodicity Stress**—the sodium problem may not only pose a toxic stress, but more often it affects soil permeability, which decreases the infiltration and retention of water and decreases gaseous exchange. This structural problem develops when water contains relatively more sodium ions than divalent calcium and magnesium ions while the total concentration of salts is generally not very high. Accumulation of sodium within the soil-mineral exchange complex results in a breakdown of soil aggregates that maintain water and gaseous permeability.
>
> **Salinity Stress**—this results from the quantity of salts dissolved in water. All water contains potentially injurious salts and nearly all the dissolved salts remain in the soil after the applied water evaporates, transpirates, or drains. Unless these salts leach from the root zone, they ultimately accumulate impacting soil infauna and plant growth.
>
> **Alkalinity Stress-Benefit**—is a measure of the buffering capacity of water and soil, or the capacity of bases to neutralize acids or resist change in pH. Buffering materials are primarily the bases bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-). They also may include borates, silicates, phosphates, ammonium, sulfides and organic ligands. Alkalinity not only helps regulate the pH of a water body or soil column, but bioavailable metal content as well. Bicarbonate and carbonate ions in water can remove toxic metals (such as lead, arsenic and cadmium) by precipitating the metals out of solution. High alkalinity exerts a significant effect on growing medium fertility and plant nutrition, unless it becomes too high, as in the present case when the resulting pH is very basic (>8.2).
>
> **Soil Structure and Nutrient Resource Stress—**
>
> - As discussed above, sodic conditions can damage soil structure to such a degree that the soil becomes essentially impermeable to water and gases. This condition is quite evident on the playa cover type.
> - The resulting soil condition also may cause the capture (via sorption and/or capture) of nutrients, thus decreasing normal nutrient cycling. Nutrient limitations (nitrogen [N], phosphorous [P] and magnesium [Mg]) interact together to decrease the growth, decrease the distribution and simplify the community structure of plant species in saline/alkaline areas of the Mojave Desert[82].

[82] James, Tiller and Richards, 2005

- Optimal plant growth, distribution and community structure depends upon a complex interaction of nutrient availability, tolerance of elevated concentrations of COPECs and tolerance of the stresses posed by sodic/saline/alkaline conditions[83, 84].

3.2 Ecotoxicity Criteria

Kleinfelder compiled a set of criteria for soil-sediment and water quality for use in this SLERA (Table 9 Soil/Sediment Quality Criteria and Table 10 Water Quality Criteria). These criteria will provide a basis for evaluating the available environmental condition data to determine whether the conditions may pose a toxic or related stress condition and thereby create an ecological hazard.

These criteria provide a reasonable basis for evaluating environmental media in most environments, namely freshwater and soils typically found in urban and agricultural environments. However, as discussed previously, the baseline conditions at Owens Lake are severe: strongly saline, sodic and alkaline. Therefore, the typical criteria used in a SLERA must be used with caution and with an understanding of the context.

In selecting criteria to use in the screening-level risk evaluation, Kleinfelder followed several rules:

- Soil—we relied on USEPA's (2007) ecological soil screening levels (Eco-SSLs) because of the robust analysis used in the development of the criteria. When Eco-SSLs were not available we selected appropriate criteria for plants, invertebrates, birds or mammals from either Long, *et al.* (1995) Effects Range Low [ERL] marine benchmarks, Efroymson, *et al.* (1997a) for invertebrate benchmarks, Efroymson, *et al.* (1997b) for plant benchmarks, or USEPA (2003c) Region 5 Ecological Screening Levels[85].
- Water—we relied on marine water values developed by Texas[86]; when criteria were not available from that set of criteria we selected benchmark criteria from the USEPA primary and secondary ambient water quality criteria. In these cases, we preferred acute values. These values were chosen because in the current case, the environment is already enriched in various inorganic metals and metalloid and salts and the biota present will have adapted to the strong solution conditions.

In selecting criteria to evaluate the saline-sodic-alkaline conditions of the site, Kleinfelder relied on the upper-end of soil quality values discussed in the USDA/NRCS (2004) Soil Quality Thunderbook.

[83] Donovan and Richards, 2000
[84] Gardner, CMK, KB Laryea and PW Unger, 1999, Soil Physical Constraints to Plant Growth and Crop Production, United Nations Food and Agricultural Organization, AGL/MISC/24/99, Rome, see their Figure 1 which is based upon Lai 1994 cited in the paper.
[85] The ESLs represent a protective benchmark (e.g., water quality criteria, sediment quality guidelines/ criteria, and chronic no adverse effect levels) for 223 contaminants (based on the RCRA 40 CFR 264 Appendix IX list of hazardous substances) and four environmental media (i.e., air, water, sediment and soil).
[86] TCEQ, 2003

4.0 Screening-Level Risk Evaluation

4.1 Introduction

The objective of a SLERA is to fulfill Steps 1 and 2 outlined in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (ERAGS, USEPA, 1997b). The goal of the SLERA is to determine whether constituents from the site could pose a hazard to plants, animals, or ecologically valuable habitats in the vicinity of the site.

> Step 1 involves the compilation of existing data and formulation of the ecological problem (Problem Formulation) at hand at the site and a toxicity (ecological effects) evaluation.
>
> Step 2 involves the development of exposure and ecological hazard estimates.

From these results, a conclusion can be drawn as to whether site contaminants pose a negligible hazard or whether additional evaluation or other action is required. This is the first Scientific Management Decision Point (or SMDP) of the ecological risk framework (USEPA 1997b and 1998). Step 1 of the ERAGS process was documented in Sections 1 through 3 of this report. The following discussion outlines Kleinfelder's approach to the Step 2 analysis.

4.1.1 Impact Assessment Protocol

Normally in a SLERA, the analyst applies a simple screening method for comparing environmental media concentrations to established thresholds that are based on scientific studies of the ecotoxicology of the COPECs. This SLERA will require the use of several criteria in concert with the definition of a reference condition.

- First, Kleinfelder evaluated the exposure conditions within the baseline case and compared that with exposures anticipated for the two DCMs (which are altered versions of Cover Type #1 or CT-1):
  - Baseline—Playa (CT-1)
  - Shallow Flooding or Habitat Flooding DCM (CT-1 SF/HF)
  - Moat and Row DCM (CT-1 MR)
- Next, Kleinfelder compared the environmental stressor levels expected at each cover type: This comparison of conditions included several stressor metrics that allow an evaluation of exposure and ecological effect (*i.e.,* risk of an adverse impact):
  - Toxic stressor metric—a comparison of inorganic (metal or metalloid) concentrations in soil, sediment, and water occurring within each cover type against appropriate ecotoxicity criteria. This comparison uses a ratio method (typically called a Hazard Quotient (HQ), *i.e.*, media concentration divided by media criterion). This evaluation will include, where available, criteria for microbes, plants, invertebrates (benthic, aquatic and terrestrial), mammals and small birds. The criteria are screening thresholds that approximate an environmental concentration point below which adverse effects are unlikely. For this assessment, Kleinfelder used the following decision logic for evaluating a particular metric:
    - If HQ < 1, then the likelihood of an adverse effect is low to negligible;
    - If HQ > 1 but < 5, then an adverse effect is possible but may not be probable;
    - If HQ > 5, then an adverse effect is probable; and
    - If HQ > 50, then the likelihood of observing acute effects (severe and rapidly occurring effects such as mortality) is probable.

- Sodic:Saline:Alkalinity Metric—this metric involves a comparison of measured or expected conditions to criteria for good fertility. We will apply an HQ calculation similar to that described above.
- Soil Structure/Resource Stress Metric—this metric uses qualitative statements regarding the likely soil structure, nutrient and other resources available within the cover type.
- General Biological Condition—ecological monitoring data are available for at least some of the different project DCAs[87]. These data will provide a qualitative metric for evaluating resulting biologic conditions. For example, observed mortality, tissue concentrations, bird counts, etc.

4.1.2 Weight of Evidence

To evaluate the overall hazard to assessment endpoints, Kleinfelder will used a qualitative weight-of-evidence approach following the method of Bettinger *et al.,* (1995) as summarized below.

- **Weight**—strength of the measurement endpoint: For each measurement used in evaluating the likelihood of an adverse ecological effect, a qualitative evaluation will be performed to determine the degree to which the measurement meets the evaluation criteria for the assessment. The qualitative degrees of evaluation (High, Moderate and Low) are levels of strength assigned to each measurement for each criteria.
- **Risk of Harm**—the risk versus no-risk outcome of the measurement: The outcome of each measurement is evaluated as to whether or not a risk of ecological harm exists or if a risk of harm cannot be determined. An affirmative or negative qualitative (Yes or No) value is assigned to that measurement endpoint.
- **Magnitude**—definitiveness (likelihood) of the risk or no-risk outcome, and characterized as low or high. When evaluating risk magnitude, the particular cover type area was considered, primarily because of the variability in biota distribution. Additionally, the mobility of higher-level organisms (*e.g.,* fish, mammals and birds) does not lend itself to the assumption that such organisms dwell in a single location around a single sample location, but rather are limited by habitat quality or physical impediments.

Finally, to complete the assessment, the different measurements or metrics are pooled, integrating the weight, risk of harm and magnitude of the measurement endpoint. To simplify the presentation, each measurement is assigned an alphanumerical value and plotted on a matrix (see below).

Example Weight of Evidence Matrix

Risk of Harm	Magnitude	Low Weight (1)	Medium Weight (2)	High Weight (3)
Yes (+)	High (2)	+2	+4	+6
	Low (1)	+1	+2	+3
Indeterminate	0	0	*	0
No (-)	Low (1)	-1	-2	-3
	High (2)	-2	-4	-6

The matrix is considered a plane where the center of the matrix is the fulcrum and each alphanumeric value (e.g., A, B, C, etc) adds weight that tilts the plane, either “towards” or “away” from the indication of hazard. To facilitate the hazard characterization, each cell within the matrix is assigned a numerical value based on the weight (1 to 3), risk of harm (+ of -), and magnitude of harm (1 or 2). Once the alphanumeric values are assigned to cells in the matrix, they are summed:

[87] CH2M Hill, 2003, 2003a &b, 2004, 2005a&b, 2006 and 2007

- If the sum is positive, then there is a better than even chance that an adverse ecological effect will occur.
- If the sum is negative, then no-risk is concluded.
- If the sum is zero, then there is insufficient data to make a reasonable conclusion regarding the likelihood of an adverse ecological effect.

In the following sections, we discuss the findings of each of the aforementioned comparisons and the meaning and implications of the findings in terms of the ecological hazard that might be posed by the two DCMs proposed for the project area.

4.2 Exposure Conditions by Cover Type

4.2.1 Exposure Conditions to be Considered

As discussed previously, Kleinfelder concludes that (potentially) complete pathways of exposure are present.

- **Soil/Sediment**
  - Incidental ingestion of the medium along with food items
  - Dermal contact with the media
- **Water**
  - Ingestion of the medium
  - Absorption from the medium
- **Prey**
  - Bioaccumulation[88] of COPECs within organisms
  - Biomagnification[89] of COPECs (*e.g.*, selenium) in predators at higher trophic levels

4.2.2 Baseline Condition—Playa (CT-1)

Organisms using the playa will be exposed to COPECs in soil and sediment (see Table 6). Generally, they would not be exposed to water, except when shallow groundwater seeps occur in the home range of the organism (see Table 7—shallow groundwater).

[88] Bioaccumulation is defined as the increase in concentration in organisms as they take in contaminated air, water, or food because a particular substance is only very slowly metabolized or excreted.
[89] Biomagnification is defined as the process whereby certain substances such as pesticides or heavy metals move up the food chain, work their way into rivers or lakes, and are eaten by aquatic organisms such as fish, which in turn are eaten by large birds, animals or humans. The substances become concentrated in tissues or internal organs as they move up the chain.

4.2.3 Shallow Flooded/Habitat Shallow Flooded DCM (CT-1 SF/HF)

Organisms using the flooded DCAs will be exposed to COPECs in soil and sediment (see Table 6). During much of the year, they also may be exposed to water. According to CH2M Hill[90], during normal DCM project operations saltwater is collected by:

- Field drains that capture percolation below the managed vegetation DCM,
- Perimeter drains that capture seepage around areas of shallow flooding
- Surface drains that collect tailwater (overland flow waters) from areas of shallow flooding

Typically, this saltwater is controlled and recycled within the project. Freshwater from the aqueduct is added to the system to modulate the strength of the resulting solution (balancing salinity, sodicity and pH). Other water in the system is recycled through the drainage and saltwater systems. This collected saltwater is then used:

- Applied directly to shallow flooding areas, which also can receive aqueduct water, or
- Mixed with aqueduct water for application to areas of managed vegetation

Salt concentrations in water released to the flooding units are controlled by regulating the level of recycle water dilution in the water supply. As water spreads across a DCA, evapoconcentration will result in an increase (perhaps 10-fold[91]) compared to applied concentrations. The flooding units operate over a wide range of concentrations, but have a chemical profile consistent with shallow groundwater. Habitat flooding uses less concentrated water in order to enhance the biological habitat quality of those DCAs compared to shallow flooding DCAs.

In order to evaluate exposure to water, the following water COPEC (Table 7) levels will be used:

- Shallow Flooded DCM—directly measured levels or subsurface drainage data for evaluating heavy metals
- Habitat Shallow Flooded DCM—directly measured levels or shallow groundwater data for evaluating heavy metals

4.2.4 Moat & Row DCM (CT-1 MR)

Organisms potentially using moat and row DCAs will be exposed to COPECs in soil and sediment (see Table 6). Generally, they would not be exposed water; although if the moat is sufficiently deep it is possible for shallow groundwater to seep and possibly to pool. Regardless, for the purpose of this assessment, Kleinfelder assumed that exposure to water would not occur with this DCM. If exposure to water was considered in the moat and row scenario, then the assessment would be no different than that for the playa cover type. The design of this scenario was to clarify for the purposes of this assessment the contributions to potential ecological hazard made by COPECs in soil-sediment versus COPECs in water.

[90] CH2M Hill, 2003a page 11
[91] CH2M Hill, 2003a, page 20

4.3 Screening-Level Risk Estimation

4.3.1 Ecotoxicity Metric by Cover Type

Kleinfelder compared soil concentrations to soil-sediment quality criteria in Table 11, and water concentrations to water quality criteria in Table 12. The Hazard Quotients for each COPEC in these tables are presented in a color-coded scheme following the logic described previously in Section 4.1.1.

The findings indicate that the various inorganic metals, metalloids, and salts in water contribute more to potential ecological hazard than those in soil by an order of magnitude. For example, a comparison of the results shown in Table 11 [soil] to those in Table 12 [water] demonstrates that more water COPECs have Hazard Quotients greater than unity than soil COPECs, and the Hazard Quotients for water COPECs are generally greater.

In soils, the analysis suggests that ecological hazard would be most significant for plants (in particular caused by the level of boron). Additionally, the quotients calculated in this analysis for barium and selenium to birds suggest that the hazards posed by these COPECs are significant.

Water may pose a significant hazard due to the presence of arsenic, barium, cadmium, copper and sodium.

In regards to the cover types:

- The most significant risk is found in the shallow flooding DCM (CT-1 SF), primarily because of the significantly high salt and inorganic COPECs in the water used in that DCM.
- Habitat shallow flooding CT-1 HSF) is somewhat less at risk, due solely to the COPEC concentrations carried in shallow groundwater being lower than in the subsurface drainage.
- The playa (CT-1) was similar to habitat flooding.
- The lowest hazard is associated with the Moat & Row DCM (CT-1 MR). This is solely due to the simplifying assumption that water (shallow groundwater) would not occur within this DCM. Had water been included the result would have been similar to that seen for either playa of habitat flooding. This finding suggests that the greatest amount of potential ecological impact comes from the COPECs in water as compared to soil.

4.3.2 Sodicity : Salinity : Alkalinity Metric by Cover Type

In all cases, each cover type is hypersaline, sodic and alkaline and pose potential ecological hazards (see the data for conductivity/salinity, pH and Sodium Adsorption Ratio [SAR] in Tables 11 and 12); the difference is a matter of scale.

- Moat & Row DCM (CT-1 MR)—although the cumulative hazard across COPECs and stressors is lowest for this DCM compared to the others (see Table 13), this finding may be an artifact of this assessment. If shallow groundwater did contribute to this system, then the conditions would be essentially equivalent to that seen with the playa cover type.
- Habitat Shallow Flooding (CT-1 HSF)—this DCM has the next lowest cumulative hazard (Table 13), suggesting that the conditions would be worse than moat and row, similar to barren playa but much better than shallow flooding. This cumulative hazard result due to a decreased SAR, which is the result of careful control of irrigation water salinity and sodicity.

- Playa (CT-1)—this is the baseline case, which is known to be stressful to plant communities and fauna[92].
- Shallow Flooding DCM (CT-1 SF)—this evaluation suggests that this DCM may be exposed to the greatest potential for ecological risk.

These conditions confirm the control strategy outlined by CH2M Hill[93].

4.3.3 Soil Structure/Resource Stress Metric by Cover Type

The alkaline, saline and sodic nature of this system exists in each cover type and DCM (Tables 1-5). High saline water will increase soil salinity and impair plant growth. On the other hand, too dilute the natural soil sodium will disperse clay aggregate, collapsing the soil structure and decreasing soil penetration by water and plant roots. For the DCMs to function effectively care must be taken to control the strength of the irrigation water in order to maintain vegetative vigor (in the case of the managed vegetation DCM) and soil stability and structure in all of the flooding DCMs[94]. In the baseline case of barren playa and in the case of moat and row, no effort to control these conditions exist and the soil structure and resulting resource stress will likely be greater in these areas, as compared to shallow flooding and habitat shallow flooding (or managed vegetation).

4.3.4 General Biological Condition by Cover Type

The CH2M Hill monitoring reports provide valuable biological data and observations that can inform this SLERA.

4.3.4.1 Food Chain Analysis of Natural Springs vs. Shallow Flood Project Zones

CH2M Hill[95] collected aquatic invertebrate tissue samples from natural springs Apr-Jun 2002 and from shallow flood areas in May 2003 and they compared the resulting tissue data to ecotoxicological screening levels for bird dietary exposure. The resulting analysis showed the percentage of aquatic invertebrate tissue samples demonstrating excursions beyond the screening levels (see Figures 16A and 16B). Figure 16A indicates that a large fraction of aquatic invertebrates had potentially toxic levels of barium and boron. A minority of invertebrates sampled from the Zone 2 shallow flood environment exhibited concentrations above screening levels for arsenic, chromium and vanadium. However, the chromium and vanadium concentrations were not reported for the 2002 natural spring samples due to analytical interference.

While this data seems to indicate some uptake of toxic levels of certain elements, there is no apparent difference in the food chain bioavailable metals between the natural spring areas and the shallow flood DCAs. The lack of arsenic, chromium and vanadium data for brine flies from the natural seep areas is a limiting aspect of the study. More information is needed to determine body burdens later in summer (with reduced water availability and increased salinity) to clarify the bioaccumulation of heavy metals within food chain organisms.

CH2M Hill compared the average metal and metalloid concentrations reported for different food chain items sampled from natural springs and shallow flood areas in 2001 through 2003, relative to ecological screening levels[96]. In 2002, aquatic plants, fish and aquatic invertebrates sampled

[92] Donovan and Richards, 2000 and James, Tiller and Richards, 2005
[93] CH2M Hill, 2003a, pages 14-23
[94] *Op cit.*
[95] CH2M Hill, 2003c, Table 28 and CH2M Hill, 2004, Table B-4
[96] CH2M Hill, 2003b, 2003c, 2004

from natural spring and project areas were collected and analyzed for metals[97]. The prey item collection occurred in May-June, coincident with the nesting of snowy plovers and American avocets. Table 14 below details the magnitude of metal concentrations detected in different food chain items from different areas in relation to the screening levels. Average concentrations are expressed as a ratio of their respective screening level, which is analogous to the toxicity quotient method for calculating hazard quotients in a risk assessment.

COPECs present in prey items at mean concentrations above the respective bird dietary exposure screening level include:

- These data suggest that barium and boron is problematic in all food items and environments, with mean concentrations in food chain items of up to 18 and 28-fold greater than their respective screening levels.
  - Barium is most concentrated in aquatic plants and "other invertebrates."
  - Boron is most problematic in aquatic plants and brine flies.
  - There is no apparent difference in invertebrate body burdens between natural springs and shallow flood environments exists for these metals.
- Mercury was slightly above its screening level in aquatic plants from natural springs.
- Zinc was slightly above its screening level in natural spring fish and other invertebrates.

Any conclusions based upon these data should be qualified for several reasons:

- Sample numbers, time of collection and analytical results were different for each area. Therefore, statistical comparison of food chain metal concentrations in organisms from seeps vs. project areas is not possible.
- These comparisons were based on 2001-2003 data reported by CH2M Hill, but there are no similar ecological screening data available for 2004 and later.
- CH2M Hill noted discrepancies in the 2002 aquatic invertebrate data were noted (see note 3 in Figure 16A.

4.3.4.2 Concentrations of Metals in Bird Eggs

Figure 16B compares the concentrations of metals American avocet egg[98] tissue collected from nests in the shallow flood DCA (SF) along the Mainline in 2003[99]. This chart shows the frequency of eggs containing concentrations of various metals above screening ecotoxicity criteria for bird dietary exposure[100]. The majority of analyzed eggs contained zinc and chromium at concentrations in excess of toxicity thresholds. Zinc and chromium inorganic burdens in eggs that have the highest potential avian toxicity, but they did not directly correspond with food chain organism body burdens. Copper and mercury excursions occurred at low frequency only in the southern zone flooding DCA.

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[97] The statistics for these analytical results are in Table 3 CH2M Hill, 2003b.

[98] Avocet nesting season observed beginning late April/early May, peaking in mid-June, and ending mid-July (according to the Point Reyes Biological Observatory (PRBO), 2002, Fig 12). In contrast, snowy plover nesting activity begins in late March, peaking mid June and ending early-mid August (PRBO, 2002, Fig 8).

[99] CH2M Hill, 2003b, Table B-5

[100] Toxicity thresholds identified by CH2M Hill for certain analytes: Arsenic (As) 2.8 mg/kg dw; Boron (B) 66 mg/kg (USDI, 1998; toxicity threshold); Chromium (Cr) 3.2 mg/kg (Eisler, 2000); Copper (Cu) 5.5 mg/kg; Mercury (Hg) 1.65 mg/kg (USDI, 1998; toxicity threshold); Molybdenum (Mo) 33 mg/kg; Selenium (Se) sensitive 10 mg/kg (USDI, tox threshold); and Zinc (Zn) 50 mg/kg (USDI, 1998; NOEL).

Table 14
Average Concentration of Elements in Aquatic Food Chain Organisms / Eco Risk Screening Level for Bird Dietary Exposure

	Natural Springs				Natural Springs
	2001				2002
Element	Aquatic Plants	Fish	Other Invertebrates	Brine Flies	Brine Flies
Arsenic	0.6	0.1	0.1	0.3	0.1
Barium	18.1	3.0	2.1	6.7	5.0
Boron	18.4	1.3	3.5	26.0	25.3
Chromium					
Manganese	0.5	0.1	0.1	0.2	0.1
Mercury	1.2	0.6	0.5	0.2	0.04
Selenium					0.04
Vanadium					
Zinc	0.4	2.0	1.4	0.4	0.4

	NZ Shallow Flood				SZ Shallow Flood
	2001-2002		2003		2003
Element	Brine Flies	Other Invertebrates	Brine Flies	Other Invertebrates	Brine Flies
Arsenic	0.2	0.1	0.4	0.03	0.3
Barium	1.8	17.4	1.1	1.1	2.6
Boron	21.3	1.1	28.4	1.0	14.2
Chromium			0.1	0.4	0.1
Manganese	0.1	0.1	0.1	0.2	0.1
Mercury	0.03	0.1			
Selenium	0.1	0.01	0.1	0.1	0.5
Vanadium			0.6	0.9	0.6
Zinc	0.4	1.0	0.3	0.5	0.1

Source:
CH2M Hill, 2003b, Table 3 (2001-2002 data)
CH2M Hill, 2003c, Table 28 (2002 Natural Springs data)
CH2M Hill, 2004, Table B-4 (2003 Northern and Southern Zones Shallow Flood data)

- Figure 16A indicated that the concentration of chromium exceeded the screening threshold for bird dietary exposure in 12% of brine fly samples collected in the 2003 egg-laying season. The table above tells us that the mean concentration of chromium in brine flies collected from the shallow flooding DCA in 2003 were below the avian dietary risk threshold.
- Zinc concentrations in brine fly samples collected in 2003 were all below the screening dietary criterion, while average concentrations in springs and flooding area samples in 2001-2002 were slightly above the zinc risk threshold (see table above).

Mercury and copper were not analyzed in aquatic invertebrates collected in 2003; therefore, more detailed analysis of the hazards posed by these COPECs is not possible. However, among food chain item samples collected in 2001-2002, only aquatic plant average concentrations exceeded the screening criterion for mercury.

Unfortunately, only 2003 baseline data were available for considering egg tissue burdens. Egg collection to date appears to be limited to two collections: May 28 from the Northern sand sheet and June 26 from the Southern Zone Operation Ponds. Consideration of late season dietary exposure levels for juveniles and in combination with toxicity/salinity, stress on avian populations is not possible with the currently available data set. Such an analysis could be useful in monitoring or evaluating the potential of ecological risk.

4.3.4.3 Snowy Plover Population Data

In 2001 and 2002, the Point Reyes Biological Observatory (PRBO) conducted snowy plover surveys of Zones 2, 3, and 4. Figure 17 shows snowy plover nest outcomes for several project areas. Significant nest failure rates were observed in 2001 in all areas surveyed, other than Zone 4 natural springs. In 2002, nest abundance and hatch success increased markedly in Zone 2, but both decreased in Zone 4 relative to 2001 (possibly due to construction activities in Zone 4, and/or dry conditions in 2002[101]). The hatch success rate in both natural and SF project areas among nests monitored in 2003 was high (80% or more[102]).

These bird population surveys included transects across areas proposed as DCAs in the current Phase 7 moat and row or shallow flood alternative (see Figure 11 for the locations of these areas). These areas were more intensively surveyed in 2001 than 2002, with the following results:

- Area T1-2 had three nests in 2001 and one in 2002.
- Area T1-5 had no nests in either 2001 or 2002.
- Area T1-4 had 10 nests in 2001 and one in 2002.
- The T12-1 moat and row demo area had no observed snowy plover nests.

Figure 18A shows snowy plover adult population counts in the different areas of Owens Lake between 2001 and 2006. The data indicate a trend of increasing abundance from 167 in 2001 to 602 in 2006. Adults appear to use the Zone 2 shallow flooding DCAs more than other area, shifting to Zones 3 and 4 shallow flooding DCAs in 2006-07.

The Phase 1-2 shallow flooded and managed vegetation DCAs are among the areas with the lowest adult snowy plover abundance; the west shore, natural springs, and Zone 1 shallow flooding DCA were used more. The fewest nests occurred between the Brine Pool and Mainline Road (Zone 3).

The 2001-2002 PRBO survey data indicate that the area surveyed corresponding to the Phase 7 T-1 area (proposed for moat and row) were not significant habitat for plover nesting or general use; and over time the preferred habitat has since shifted towards the Zone 2 shallow flooding DCAs. It is reasonable to conclude that additional shallow flooding areas would increase suitable habitat for this species.

[101] Ruhlen and Page, 2002, p. 13
[102] CH2M Hill, 2003b, p. B-12

4.3.4.4 Other Bird Population Data

American Avocet Nesting and Population Census

The PRBO 2002 survey included a census of American avocets, which increased markedly as breeding activity around seeps expanded into the Zone 2 shallow flooding DCAs between 2001 and 2002. Avocets prefer nesting in wetter areas and ponds with vegetation; and in 2002, they were predominantly in Zone 2 flooded areas or on berms and roads. Nesting activity peaked in Zone 2 in mid-June and finished by mid-July[103]. Figure 18B shows increased use of shallow flooding DCAs between 2001 and 2006. The avocet preference shifted from Zone 2 shallow flooding areas (2001-2002) to Zone 3-4 flooding areas in 2006-07.

Black Necked Stilts Lakebed Population Census

Black necked stilts have not been observed to nest at Owens Lake; and the census data (Figure 18C) indicate a low adult population size in the May-June snowy plover surveys.

Gulls

California gulls are the predominant gull species observed in the May-June surveys (Figure 18D). The populations increased markedly in the Zone 2 SF between 2004 and 2005, and expanded into the Zones 3-4 SF areas in 2006-2007.

Common Ravens

A common raven population census was conducted in May and June of 2006-2007 (Figure 18E), suggesting a shift from Zone 2 SF to spring areas. Raven predation on plovers does not seem to be significantly affecting plover populations[104]. The Zone 2 and 3-4 shallow flooding DCAs are seeing increasing plover and avocet populations. The census suggests a plateau in their respective populations between 2004 and 2007, and a shift in distribution to the Zones 3-4 flooding project areas from Zone 2.

4.3.4.5 Bird Mortality

Figure 19 presents mortality incidence as reported during opportunistic bird surveys conducted by CH2M Hill[105]. There was a high prevalence of juvenile ring-billed gull carcasses found near the Operation Ponds in Zone 3 during May to December in 2003. A carcass analysis indicated parasite infestation, elevated brain sodium levels as well as elevated (relative to background) levels of arsenic, boron, selenium, mercury and cadmium in liver.

4.3.4.6 Overall Bird Utilization of DCAs

Figure 20 details the number of individual species or species groupings (gulls, grebes, etc) documented to be present in different areas of the southern project zone between 2003 and 2005. These data were compiled from opportunistic observation surveys as well as from quantitative area surveys. The data provide a comparison of different project area and the relative diversity of the assembled species over time. Figure 21 compares the frequency of all bird sightings in different project areas over the fall of 2004 and winter of 2005.

These data suggest preference for either habitat shallow flooding or the operational ponds over the more prevalent shallow flooding DCAs.

[103] Ruhlen and Page, 2002, Fig. 12
[104] Page and Rulen, 2006
[105] CH2M Hill, 2005, quarterly observations

While it is difficult to discern annual or seasonal trends due to the limited data and differing survey area coverage and intensity of surveys conducted, the following observations can be made:

- Habitat shallow flood and operation pond areas of the Southern project zones were used by similar numbers as the natural spring areas
- Habitat shallow flood and operation pond areas of the Southern project zones were used by more species of birds than managed vegetation and shallow flood areas.
- Use by avian species observed opportunistically in Oct 2004 – March 2005 indicates that Habitat shallow flood and operation pond areas have a similar frequency of sightings, which are much higher than in the SF area during these seasons.

4.3.5 Risk Estimation Matrix

To complete the assessment, the different measurements or metrics are pooled, integrating the weight, risk of harm and magnitude of the measurement endpoint. To simplify the presentation, each measurement is assigned an alphanumerical value and plotted on a matrix (as described previously). The matrix provides a technique to interpret graphically the "weight of evidence" produced in the current assessment. As each alphanumeric value (e.g., A, B, C, etc) is added to the matrix, the "weight" of each value tilts the plane "towards" or "away" from the indication of ecological hazard. To facilitate the hazard characterization, each cell within the matrix is assigned a numerical value based on the weight (1 to 3), risk of harm (+ of -), and magnitude of harm (1 or 2). Once the alphanumeric values are assigned to cells in the matrix, they are summed:

- A positive sum indicates a better than even chance that an adverse ecological effect will occur.
- A negative sum indicates ecological effect will not occur.
- A zero sum indicates that the data are insufficient to make a reasonable conclusion regarding the likelihood of an adverse ecological effect.

Kleinfelder assigned the following values to the three measurements and then plotted them on the weight-of-evidence matrix:

A. Ecotoxicity Metric
B. Sodic:Saline:Alkaline Metric
C. Soil Structure/Resource Stress Metric
D. Biology Metric

Below, a weight-of-evidence matrix is presented for each evaluated cover type/DCM.

Playa CT-1

Risk of Harm	Magnitude	Low Weight	Medium Weight	High Weight
Yes	High	+2	A— +4	B— +6
	Low	+1	+2	C—+3
Indeterminate	0	0	D—*	0
No	Low	-1	-2	-3
	High	-2	-4	-6

CONCLUSION: The ecological risk to biota from exposure to the various salts and inorganic metals/metalloids is <u>significant</u>. This assessment has low to moderate uncertainty associated with it.

Shallow Flooding CT-1SF

Risk of Harm	Magnitude	Low Weight	Medium Weight	High Weight
Yes	High	+2	A— +4	B— +6
	Low	+1	+2	C—+3
Indeterminate	0	0	*	0
No	Low	-1	-2	-3
	High	-2	-4	D— -6

CONCLUSION: The ecological risk to biota from exposure to the various salts and inorganic metals/metalloids is <u>significant</u>. This assessment has low to moderate uncertainty associated with it.

Habitat Shallow Flooding CT-1HSF

Risk of Harm	Magnitude	Low Weight	Medium Weight	High Weight
Yes	High	+2	A— +4	B— +6
	Low	+1	+2	C—+3
Indeterminate	0	0	*	0
No	Low	-1	-2	-3
	High	-2	-4	D— -6

CONCLUSION: The ecological risk to biota from exposure to the various salts and inorganic metals/metalloids is <u>significant</u>. This assessment has low to moderate uncertainty associated with it.

Moat & Row CT-1MR

Risk of Harm	Magnitude	Low Weight	Medium Weight	High Weight
Yes	High	A—+2	+4	B— +6
	Low	+1	+2	C—+3
Indeterminate	0	D—0	*	0
No	Low	-1	-2	-3
	High	-2	-4	-6

CONCLUSION: The ecological risk to biota from exposure to the various salts and inorganic metals/metalloids is <u>significant</u>. This assessment has moderate to high uncertainty associated with it.

5.0 Conclusions

5.1 Assessment Findings

Kleinfelder East, Inc. (Kleinfelder) was retained to prepare a Screening Level Ecological Risk Assessment (SLERA) concerning the implementation of the two types of DCMs, i.e., Shallow Flooding and Moat and Row, at the Phase 7 project areas. The objective of a SLERA is to fulfill Steps 1 and 2 outlined in USEPA's Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. The goal of the SLERA is to determine whether constituents (toxic chemicals or other types of ecological stress) from the site pose a potential risk to plants, animals, and/or ecologically valuable habitats at or around the site.

The majority (93.5%) of the project area is barren playa. The soil/sediment ranges from soft saline crust to salt-silt-clay to salt-silt-clay-sand. Sodium salts of carbonate, bicarbonate, and sulfate dominate the salt crust, which contrasts with other California playas rich in sodium chloride.

The soils and sediments of the playa display significant levels of certain inorganic constituents: arsenic, barium, boron, bromine, lithium, and silver. This medium is highly enriched in sodium; and carbonate and sulfate salts likely predominate over chloride salts. The pH of these soils and sediments is significantly elevated (>9). The concentrations of these inorganic metals and metalloids approach in some cases, and in others exceed available screening criteria for ecological toxicity. The salinity and alkalinity of the soils also pose a significant stress to plants and soil invertebrates similar to that seen in other dry lake playas in California and the southwest. Furthermore, these conditions significantly affect soil structure and availability of nutrients. Of course, the ecological criteria are based upon controlled testing designed for evaluating natural systems with much more dilute chemistry and lower pH, which presents a significant uncertainty into the SLERA.

Owens Lake is the natural hydrologic sink of the Owens Valley. Thus, water and dissolved salts coming from various sources within the watershed end up here, and this has continued for thousands of years. In this climatic zone, evaporation dominates over precipitation; therefore, over the years Owens Lake has witnessed a natural concentrating effect resulting in historic strongly saline and alkaline waters water quality.

The waters (surficial and groundwater) of Owens Lake are typically very saline, with elevated concentrations of inorganic metals and metalloids (for example, arsenic, boron, chloride, copper, and selenium). As with soil, water quality criteria are designed for much more dilute systems, and only a few marine criteria are available. Moreover, the high pH and alkalinity, as well as significant levels of total dissolved solids and sodium present a condition that ranges form highly brackish/saltwater to brine, which significantly limit the development, growth, diversity, and success of aquatic food chains in surface waters at the lake. This water system supports extremophile microorganisms and algae, with brine flies and shrimp in areas with appropriate conditions supporting their recruitment and developmental success, which then may provide a food source to shorebirds and other animals.

Owens Lake presents a basic barren playa habitat, which diversifies at the lake's margins at the delta and where seeps occur. When habitat quality improves, it supports phreatophytic floral and faunal communities. According to the accumulated studies, almost 300 aquatic and terrestrial wildlife species have the potential to occur at the lake. Observations of avian fauna over the last few years, since the development of the shallow flooding DCM, suggest some improvement in abundance and diversity.

Reported data on saltgrass and avian tissue/eggs indicate that biota are exposed to and accumulate various inorganic metals and metalloids. However, these data and biotic occurrence survey data suggest that the lakebed conditions present a stress gradient, which decreases towards upland areas. Recent literature on abiotic stress tolerance and the effects of plant-plant interactions for desert shrubs indicate that resource (nutrient) limitations are critical to scrub/shrubs along a salinity-alkalinity gradient.

The DCMs proposed for use in Phase 7 include a significant increase of shallow flooding and the application of a new dust control method called moat and row. Shallow flooding involves the application of water during critical times of the year to maintain field capacity of the soils and in the case of habitat flooding, control of salt (and total dissolved solids) is critical to enhance the flooded areas' to support biotic use. Its application will likely promote the value of the area to avian fauna (as demonstrated by the avian population surveys discussed in §4.3.4), and it increases the amount of available water. However, this assessment suggests that this increased water availability also will present an increased opportunity for exposure to toxic inorganics (compare Tables 10, 11 and 12).

In contrast, moat and row is essentially a surficial modulation of barren playa to decrease crust and provide surficial undulation to capture moving soil particles and physically shelter the downwind lakebed from the wind. As it is a dry state DCM, it is essentially no different from barren playa in terms of the exposure potential that it presents to biota. However, the excavated moat may allow shallow groundwater to infiltrate to the surface and thereby present a new exposure pathway to groundwater that otherwise would not exist. The associated ecological risk would be similar to that estimated for shallow flooding (see Table 13[106]).

The application of the two DCMs in the Phase 7 project area is an extension of the DCMs that will increase the amount of controlled flooding across the lakebed playa and modulate a small area to playa to control dust while not increasing water availability. Flooding involves an area under a carefully managed water budget and water quality to provide appropriate nutrients while seeking to control salinity. While it increases the availability of more toxic inorganic metals and metalloids (Tables 10 and 11), it also provides an enhanced habitat for avian fauna (Figure 20 and 21). The available biotic abundance and diversity data reviewed in §4.3.4 suggest that flooding generally improves overall habitat conditions, despite the increased potential for exposure to COPECs. The moat and row DCM does not alter conditions significantly to effect a change in the ecological hazard posed by the playa.

5.2 Ecological Significance

In conclusion, the available data indicate that proposed DCMs while enhancing dust control will not generally increase the ecological risk (compared to barren playa) in the case of moat and row, while flooding may increase the potential for exposure and ecological hazard. Nevertheless, in the case of flooding the risk of ecological impact is mitigated by providing improved habitat, nutrient availability, and food chain support (food items such as algae that is a food item for brine flies and brine shrimp, which are food items for birds such as the snowy plover). This SLERA demonstrated that hazards from the various inorganic constituents at Owens Lake is possible, but the available data also suggest that significant hazards (as evidenced by mortality, see Figures 19-21) perhaps are not realized or at least has not been documented.

[106] Remember that this SLERA assumed that the moat and row DCM had no water added to it, resulting in the least amount of cumulative hazard among the different DCMs and in comparison to the baseline base of barren playa, where it was assumed that shallow groundwater occasionally break through the lakebed surface thus presenting a potential for exposure to biota (Table 12)

5.3 Scientific-Management Decision Point

In §2.6, Kleinfelder presented a CSM for the site (Figure 15), which formulated the environmental problem graphically in terms of testable hypotheses, originally posed as questions. The data collected as part of this SLERA allow these hypothetical questions to be answered:

- *Are COPECs present in surface water, groundwater and soil-sediment within proposed project area or site?* **Yes**
- *Is the exposure known or are potential biotic receptors sufficiently exposed to COECs media so that ecological effects could occur?* **Yes**
- *If present, could the concentrations of Site-related COECs be sufficiently elevated to impair identified ecological receptors and related resources?* **Yes**

Consistent with USEPA Ecological Risk Assessment Guidance for Superfund (ERAGS) (1997), the Scientific/Management Decision Point (SMDP) of the assessment process is to focus on whether the information available to the site risk manager is adequate for making a risk management decision. According to the guidance, there are three possible decisions at this point regarding information adequacy, the level of risk involved and whether more assessment is required. Kleinfelder concludes that the information is adequate for decision-making purposes and the information indicates a potential for adverse ecological impacts for the baseline case of barren playa. The moat and row DCM may pose less ecological hazard if it remains dry. While the shallow flooding and habitat flooding DCMs may provide an opportunity for increased exposure to various COPECs it also provides improved habitat that is documented to result in increasing biotic utilization.

5.4 Recommendations

Kleinfelder recommends that the monitoring program already in-place be continued in order to evaluate on a continuing basis whether ecological impacts might develop because of the proposed DCM project. Monitoring provides a mechanism to manage both water and soil quality in concert with observations and monitoring of biota at the lake. However, we recommend that it be enhanced in order to provide additional biomonitoring data (tissue body burden, species abundance and diversity) collected (semi-) annually, in a fashion similar to water quality. To date there is little or no biomonitoring data available. Currently, this appears to be the best and easiest approach to mitigating potential ecological risks.

6.0 References

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Limitation of Liability

Kleinfelder prepared this report in accordance with generally accepted standards of care that exist in California at this time. This report may be used only by Sapphos and the District and only for the purposes stated, within a reasonable time from its issuance, but in no event later than one (1) year from the date of the report. All information gathered by Kleinfelder is considered confidential and will be released only upon written authorization of Sapphos and the District or as required by law. Non-compliance with any of these requirements by Sapphos and the District or anyone else, unless specifically agreed to in advance by Kleinfelder in writing, will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and Sapphos and the District agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized use or non-compliance.

Risk assessments are subject to the limitations imposed by the scientific information available at the time of the assessment. This report was not designed to quantify or identify all potential risks to ecological resources associated with the site defined herein. This assessment also does not provide a guarantee regarding the amount of risk at the site. Risks that have been quantified reflect only the specific exposure scenarios identified in this report. In addition, risk estimates may change as new scientific or technical information becomes available that may modify exposure parameters and toxicity values. Other risk assessment professionals may reasonably employ different approaches and methods to this or similar projects.

Kleinfelder offers various levels of investigative and engineering services to suit the varying needs of different clients. It should be recognized that definition and evaluation of geologic and environmental conditions are a difficult and inexact science. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions present. Although risk can never be eliminated, more-detailed and extensive investigations yield more information, which may help understand and manage the level of risk. Since detailed investigation and analysis involves greater expense, our clients participate in determining levels of service that provide adequate information for their purposes at acceptable levels of risk. More extensive studies, including subsurface investigations or field tests, may be performed to reduce uncertainties. Acceptance of this report will indicate that Sapphos and the District has reviewed the document and determined that it does not need or want a greater level of service than provided.

Regulations and professional standards applicable to Kleinfelder's services are continually evolving. Techniques are, by necessity, often new and relatively untried. Different professionals may reasonably adopt different approaches to similar problems. As such, our services are intended to provide Sapphos and the District with a source of professional advice, opinions and recommendations. Our professional opinions and recommendations [are/will be] based on our limited number of field observations and tests, collected and performed in accordance with the generally accepted engineering practice that exists at the time and may depend on, and be qualified by, information gathered previously by others and provided to Kleinfelder by Sapphos and the District. Consequently, no warranty or guarantee, expressed or implied, is intended or made.

TABLES

Table 1
General Lakebed Soil Quality
Owens Lake DCM SLERA

KLEINFELDER
EXPECT MORE®

		Gill Data By Soil Class				USEPA 2005
Soil	Units	L	S	C	All	Background Soil Calif.
Aluminum	ppm	41,122	43,350	45,533	42,506	75,633
Arsenic	ppm	21	18	13	19	5
Barium	ppm	281	293	330	294	598
Boron	ppm	ND	ND	ND	ND	26
Cadmium	ppm	ND	ND	ND	ND	0.36
Calcium	ppm	71,156	94,500	88,767	80,294	23,691
Chromium	ppm	27	33	29	29	120
Cobalt	ppm	ND	ND	ND	ND	14
Copper	ppm	23	24	22	23	39
Iron	ppm	21,833	19,750	21,333	21,219	36,867
Lead	ppm	28	25	27	27	26
Lithium	ppm	ND	ND	ND	ND	26
Magnesium	ppm	22,744	34,525	30,167	27,081	12,227
Manganese	ppm	572	523	530	552	640
Mercury	ppm	ND	ND	ND	ND	0.2
Molybdenum	ppm	ND	ND	ND	ND	1.6
Nickel	ppm	13	14	14	14	47
Phosphorus	ppm	ND	ND	ND	ND	819
Potassium	ppm	20,822	20,025	21,067	20,669	18,311
Selenium	ppm	ND	ND	ND	ND	0.2
Silver	ppm	ND	ND	ND	ND	0.8
Sodium	ppm	101,089	75,425	60,200	87,006	16,160
Sulfur	ppm	26,322	14,000	8,000	19,806	918
Strontium	ppm	ND	ND	ND	ND	208
Tin	ppm	ND	ND	ND	ND	1.3
Vanadium	ppm	72	69	BD	70	118
Zinc	ppm	75	68	71	72	113

NOTES: ND No data BD Below Detection
L Salt-Silt-Clay-Sand, with a loose, broken crust and loose sediments atop
S White, salty-appearing soft crust on surface or no crust, highly erodible
C Salt-Silt-Clay, with a clean, harder crust without loose particles
See Appendix Table A-1 for details

SOURCES: Gill, TE, DA Gillette, T Niemeyer and RT Winn, 2002, Elemental geochemistry of wind-erodible playa sediments, Owens Lake, California, *Nuc Instrum Methods Phys Res B* 189:209-213. Table 2
USEPA, 2005, *Guidance for Developing Ecological Soil Screening Levels* , OSWER Directive 9285.7-55, Attachment 4-1

Table 2
General Soil Quality
Owens Lake DCM SLERA

KLEINFELDER
EXPECT MORE®

Constituent *	Mean	Max	Min	Std Dev	Mean	Max	Min	Std Dev	Notes
	(see units at left)				(meq/100 g)				
Aluminum (ppm)	38,288	80,000	4,000	19,282					
Arsenic (ppm)	39	400	1	59	0.1	1	0.003	0.2	Equivalent weight assumes 2 eq/mol.
Boron (ppm)	2,512	14,000	130	2,437	23	130	1	23	
Bromine (ppm)	67	880	20	111					
Calcium (ppm)	45,434	140,000	4,200	31,235	227	700	21	156	Major cation results show more Ca and Mg relative to Na than soil survey analyses.
Chlorine (ppm)	44,800	154,000	20	40,578	126	434	0.06	114	
Fluorine (ppm)	36	280	0.5	41					
Iron (ppm)	4,737	17,000	950	3,319					
Mercury (ppm)	<0.5	<0.5	<0.5						
Potassium (ppm)	5,023	19,000	800	2,948	13	49	2	8	
Magnesium (ppm)	14,526	129,000	2,100	18,192	120	1,062	17	150	
Sodium (ppm)	82,082	237,000	700	59,707	357	1,030	3	260	
Selenium (ppm)	<0.5	0.6	<0.5						One hit at 0.6, located well outside of project boundary, along the eastern shore of the lakebed.
Silicon (ppm)	196,239	343,000	26,000	84,239					
Sulfate (ppm)	45,250	170,000	28	41,748	94	354	0.06	87	
Tot Alk (% CaCO3)	21	49	1.7	11					
Na2CO3 wt%	9.0	35	0.9	7.3					
NaHCO3 wt%	2.3	15	0.0	2.8					
NaCl wt%	7.6	23	0.04	6.2					
Na2SO4 wt%	6.8	27	0.05	6.1					
Tot. sol. salts wt%	24	77	0.05	18					
INSOL wt%	72	100	12	21					
FREE_H20	5.7	33	0.00	6.5					

* Units in this column are for the first 4 columns only.

Source: CH2MHill, 2003a, Table A-1 Summary of 119 Surface Soil Samples

Table 3
Lakebed Spring Sediment Quality
Owens Lake DCM SLERA

KLEINFELDER
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	Sample ID	Dirty Socks Spring Sediment	Swede's Pasture Spring Sediment	Tubman Spring Sediment	
	Sample Date	June-02	June-02	June-02	
Parameter	Units				RDL
Aluminum	mg/kg	9,600	7,500	17,000	10
Arsenic	mg/kg	16	10	11	1
Barium	mg/kg	410	220	360	1
Boron	mg/kg	260	120	240	10
Cadmium	mg/kg	0.5	0.5	0.5	1
Chromium	mg/kg	1.5	4.7	8.9	3
Copper	mg/kg	9.1	9.5	18	2
Iron	mg/kg	7,700	7,400	15,000	10
Lead	mg/kg	1.5	1.5	1.5	3
Lithium	mg/kg	600	450	640	1
Magnesium	mg/kg	40,000	20,000	44,000	10
Manganese	mg/kg	320	260	460	3
Mercury	mg/kg	0.03	0.03	0.03	0.05
Molybdenum	mg/kg	2.5	2.5	2.5	5
Nickel	mg/kg	1.5	1.5	9.2	3
Potassium	mg/kg	5,700	4,400	7,900	10
Selenium	mg/kg	0.25	0.25	0.25	0.5
Silver	mg/kg	2.4	0.5	2	1
Sodium	mg/kg	14,000	6,700	11,000	10
Sulfate	mg/kg	317	526	380	10
Vanadium	mg/kg	28	21	49	5
Zinc	mg/kg	19	33	39	3
Alkalinity	mg/kg	10,476	3,947	7,042	10
Moisture (%)	%	37	24	29	0.01

Note: Values reported in mg/kg dry weight   RDL Reported detection limit

Source: CH2M Hill, 2003, Annual Monitoring Report, April, Owens Lake, CA
Table 13: Ecological Monitoring of Sediment and Water

Table 4
Overview of General Surface Water and Groundwater Quality Data
Owens Lake DCM SLERA

KLEINFELDER
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	Water Quality Comparison					Comparison of Constituent Parameters (mg / L)																	
Location and Depth (m) to groundwater	EC $_{25°C}$ (dS / m)	T °C	pH stnd.	Alkalinity (mg CO_3^{2-} / L)	TDS * (mg / L)	Arsenic	Boron	Cadmium	Calcium	Chloride	Chromium	Copper	Fluorine	Lead	Lithium	Magnesium	Nitrate	Potassium	Selenium	Silicon	Sodium	Sulfate	Vanadium
Artesian waters																							
Keeler Well (37.5)	1.3	23	7.5	290	766	0.04	NA	NA	33	98	NA	NA	1.2	NA	0.78	64.00	NA	29	NA	28.5	160	110	NA
Well AW-2 (NA)	2.4	23.1	8.8	530	1,530	0.28	NA	NA	1.7	210	NA	NA	2.2	NA	1.1	0.72	NA	36	NA	28.9	570	47	NA
Sulfate Well (≥145)	3.3	26.1	8.6	880	2,030	<0.02	NA	NA	1.2	260	NA	NA	1.1	NA	0.65	1.20	NA	21	NA	26.3	700	0.7	NA
Shallow Groundwater																							
Station 1																							
SP-1 (0.6)	165	26.5	9.7	43,000	282,000	163	NA	NA	1.12	133,000	NA	NA	45	NA	23	<0.35	NA	11,300	NA	80	114,000	23,600	NA
MP-1 (1.5)	99	19.8	9.3	6,000	84,500	9.54	NA	NA	0.92	48,900	NA	NA	12	NA	3.8	0.04	NA	3,690	NA	25.4	30,500	3,280	NA
MP-2 (3.0)	41	20.0	9.1	2,200	25,100	2.66	NA	NA	0.66	13,450	NA	NA	6.4	NA	1	0.07	NA	995	NA	28	9,225	634	NA
Station 2																							
SP-2 (0.6)	147	24.5	9.8	55,000	3,000,000	118	NA	NA	0.82	135,000	NA	NA	37	NA	33	<0.35	NA	11,000	NA	74.5	124,000	23,800	NA
MP-3 (1.5)	120	14.5	9.3	9,600	112,000	15.2	NA	NA	1.68	57,950	NA	NA	21	NA	4.5	1.40	NA	4,450	NA	25.9	43,700	6,600	NA
MP-4 (3.0)	48	15.3	9.2	1,900	28,700	1.43	NA	NA	0.92	15,900	NA	NA	7.6	NA	1	<0.50	NA	1,240	NA	29.5	9,330	533	NA

Notes: NA indicates well log information not available OR analytical data not provided
SP Shallow Piezometer
MP Metal Piezometer
TDS Total Dissolved Solids
* TDS was calculated from EC as: TDS approximately equals. EC (dS/m) x 640.

Source: Levy, DB, JA Schramke, KJ Esposito, TA Erickson, and JC Moore, 2002, The shallow ground water chemistry of arsenic, fluorine and major elements: Eastern Owens Lake, California, Appl Geochem 14:53-65.

Shallow Groundwater Water Quality Range					Constituent Parameters in Owens Lake Shallow Groundwater (mg / L)																	
					Arsenic	Boron	Cadmium	Calcium	Chloride	Chromium	Copper	Fluorine	Lead	Lithium	Magnesium	Nitrate	Potassium	Selenium	Silicon	Sodium	Sulfate	Vanadium
63 - 178			16,393 - 64,590	40,192 - 113,920																		
		Constituent Concentration Range ==>			11.3 - 164.3	0.199 - 2.2	0.003 - 0.047	NA	NA	0.38 - 1.6	0.014 - 0.15	NA	0.003 - 0.057	NA	0.076 - 0.14	0.021 - 0.073	0.63 - 7.6	0.093 - 1.0	NA	NA	2.6 - 54.3	0.12 - 0.73

Source: Table 11 in CRWQCB 2005 MUN Beneficial Use Designation document

Type / Location	pH	Total Dissol. Solids	Arsenic	Chloride	Potassium	Selenium	Sodium	Sulfate
Units	stnd.	mg/L	µg/g	mg/L	mg/L	µg/g	mg/L	mg/L
Springs Near Lake Shoreline * (ave. 16 samples)	8.40	2,735	NA	488	NA	NA	738	245
2001 Owens Lake Data **								
Panel 28 Pump Sta.	NA	575,000	47.4	133,000	NA	0.01	NA	44,000
Runoff Pool	NA	28,500	8.98	8,250	NA	0.003	NA	5,550
Brine Pool	NA	430,000	40.4	91,600	NA	0.008	NA	26,300
Wetland Runoff	NA	1,000	0.1	306	NA	0.001	NA	127
Sulfate Well, Keeler	NA	7,150	0.494	1,220	NA	0.001	NA	263

Sources: * Table 7 in CRWQCB 2005 MUN Beneficial Use Designation document
** Table 8 in CRWQCB 2005 MUN Beneficial Use Designation document (If less than reporting limit, value set at 1/2 limit)

Table 5
Comparison of Shallow Groundwater, DCM Drainage Waters and Brine Pool Water Quality Data
Owens Lake DCM SLERA

KLEINFELDER
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Name	Units	Average Concentration (units to left)			Average Abundance (mmolar)			Relative Abundance (% of cations or anions)		
		Groundwater [a]	Subsurface Drainage [b]	Brine Pool [c]	Groundwater [a]	Subsurface Drainage [b]	Brine Pool [c]	Groundwater [a]	Subsurface Drainage [b]	Brine Pool [c]
No. of samples		151	9	5						
Ammonium	mg/L	2.8			0.2	0.0	0.0	0%	0%	0%
Calcium	mg/L	689	0.3	0.0	17	0.008	0.0	1%	0%	0%
Magnesium	mg/L	165	0.4	0.0	7	0.02	0.0	0%	0%	0%
Potassium	mg/L	2,266	2,524	4,840	58	71	124	3%	3%	2%
Sodium	mg/L	39,971	45,031	116,800	1,738	2,162	5,078	95%	97%	98%
Cation Summary	mg/L				1,820	2,234	5,202	100%	100%	100%
Bicarbonate	mg/L	45,262	5,871	7,720	742	106	127	42%	5%	3%
Borate	mg/L	2,182	3,280	7,088	36	60	117	2%	3%	2%
Carbonate	mg/L	d	15,635	50,400	0.0	289	840	0%	15%	18%
Chloride	mg/L	31,478	44,687	120,600	888	1,392	3,402	51%	70%	72%
Hydroxide	mg/L		0.0	0.0	0.0	0.0	0.0	0%	0%	0%
Nitrate	mg/L	4.7	162	4	0.076	3	0.07	0%	0%	0%
Nitrite	mg/L		0.09	0.0	0.0	0.002	0.0	0%	0%	0%
Phosphate	mg/L	37	141		0.4	0.2	0.0	0%	0%	0%
Sulfate	mg/L	8,505	12,702	25,200	89	130	262	5%	7%	6%
Anion Summary	mg/L	85,730			1,756	1,980	4,747	100%	100%	100%
Chg total	% error [d]		-0.2	-0.3	0.0					
Total	mg/L	130,580	129,012	332,971						
Sodium Adsorption Ratio	Molar1/2	433	1,875	d						
Salinity [e]	dS/m	78	91	170						
Acidity	p(Molar)		10	10						
Total Alkalinity	mg/L		33,433	89,600						
Organic Carbon	mg/L		142	434						
Aluminum	mg/L		0.2	0						
Arsenic	mg/L	15	25	58.6	0.2	0.4	0.8			
Barium	mg/L		0.0	0						
Boron	mg/L	388	583	1260	36	60	117			
Cadmium	mg/L		0.0009	0						
Chromium	mg/L		0.07	0.1						
Cobalt	mg/L		0.005	0						
Copper	mg/L	0.024	0.4	1.04						
Iron	mg/L	0.16	3	8.8						
Lead	mg/L		0.01	0						
Lithium	mg/L		1	0						
Manganese	mg/L	0.087	0.02	0						
Mercury	mg/L		0.003	0						
Molybdenum	mg/L		2	1.02						
Nickel	mg/L		0.0002	0						
Phosphorus	mg/L	12	79	166	0.4	3	5			
Selenium	mg/L	0.21	0.5	0.84						
Silicon	mg/L	38	131	248	1	5	9			
Silver	mg/L		0.00004	0						
Strontium	mg/L		0.1							
Sulfur	mg/L		2,107		0.0					
Tin	mg/L		0.007							
Titanium	mg/L		0.1			40,000	13,029			
Vanadium	mg/L		0.04	0						
Zinc	mg/L		0.02	0						

Notes:
a GBUAPCD piezometers at 4 and 10' depth, April 1993.
Note Table D-1 contains more recent data, summarized separately for each piezometer depth, and includes surface water chemistry.
Se was 0.265 and 0.147, and Cu 0.026 and 0.021, mg/L in 4' and 10', respectively, in May 2000. Their average shown.
b GBUAPCD research sites, Oct 1998 through March 2000. Several minor analytes are only represented in one sample.
c GBUAPCD samples, March 2000.
d Not measured, and very low in anoxic groundwater at Owens Lake.
e EC as reported

Source: CH2MHill, 2003, Baseline Data and Approach for Developing the Water and Ecosystems Monitoring Program at Owens Lake. Table 3

Table 6

Soil / Sediment COPEC List and Exposure Point Concentrations

Owens Lake DCM SLERA

KLEINFELDER
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Analytical Parameter	COPEC Concentration * ‡	USEPA 2005 ℓ Background Soil Calif.
Aluminum	42,506	75,633
Arsenic	39	5.1
Barium	410	598
Boron	2,512	26
Bromine	67	0.9
Cadmium	1	0.4
Calcium	80,294	23,691
Chlorine	44,800	not available
Chromium	29	120
Copper	23	39.0
Fluorine	36	365.0
Iron	21,219	36,867
Lead	28	26
Lithium	640	26
Magnesium	27,081	12,227
Manganese	552	640
Mercury	0.03	0.21
Molybdenum	2.5	1.6
Nickel	14	47
Potassium	20,669	18,311
Selenium	0.5	0.18
Silver	2	0.8
Sulfate	45,250	not available
Sulfur	19,806	918
Vanadium	72	118
Zinc	75	113
Sodium	82,082	16,160
pH †	9.4	not available

ND = not detected

* Units are mg//kg or ppm unless indicated otehrwise.

‡ COPEC's selected as highest average concentration cited in Tables 1, 2 or 3

ℓ USEPA, 2005, Eco-SSL Guidance Document Attachment 4-1

† From Appendix Table A-2 surface soil average

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Table 7
Water COPEC List and Exposure Point Concentrations
Owens Lake DCM SLERA

Parameter	Conductivity ‡	pH ‡	Total Alkalinity ‡	Salinity ‡	Sodium ‡
Units	dS/m	stnd.	mg $CaCO_3$/L	mg/L TDS	mg/l
Operation Pond (2002-2006)					
Mean	103	9.7	41,531	122,020	53,871
Minimum	63	9.1	14,500	53,500	28,500
Maximum	157	10.3	65,100	390,000	98,000
N	38	38	6	34	7
Shallow Flooding (2002-2006)					
Mean	118	9.7	46,500	140,124	69,400
Minimum	28	9.1	20,000	18,000	17,000
Maximum	180	10.5	84,000	380,000	155,000
Count	37	38	4	35	5
Habitat Shallow Flooding (2002-2006)					
Mean	54	9.7	17,020	49,595	18,122
Minimum	2	8.3	400	1,600	530
Maximum	140	10.4	52,000	134,667	59,000
Count	28	28	5	26	6
Managed Vegetation (2002-2006)					
Mean	118	9.5	9,686	37,694	12,411
Minimum	8	8.7	130	1,400	800
Maximum	386	10.4	49,333	83,000	49,000
Count	11	11	6	8	5

	Sodium Adsorption Ratio	Salinity [e]	Acidity	Total Alkalinity
	Molar1/2	dS/m	p(Molar)	mg/L
Shallow Groundwater *	433	78	9.2	17,104
Subsurface Drainage †	1,875	91	10	33,433

	Aluminum	Arsenic	Barium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Shallow Groundwater *	0.17	20	0.12	357	0.009	0.3	0.003	0.023	0.28	0.006	2.8	0.024
Subsurface Drainage †	0.19	25	0.04	583	0.0009	0.07	0.005	0.4	3	0.01	1	0.02

	Mercury	Molybdenum	Nickel	Selenium	Vanadium	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Shallow Groundwater *	0.0001	1.4	0.01	0.20	0.12	0.01
Subsurface Drainage †	0.003	2	0.0002	0.5	0.04	0.02

* Data from Table 5 or CH2MHill, 2003a, Table D-1
† Data from Table 5
‡ Raw data from CH2MHill, 2003b, 2004, 2005a&b, 2006, 2007; see Figures 14A-D

Table 8
Exposure Pathway Analysis
Owens Lake DCM SLERA

KLEINFELDER
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Receptor	Exposure Media	Potential Exposure Pathway	Potentially Complete?	To Be Analyzed?	Comment
Aquatic Invertebrates	Surface Water	Direct Contact	Yes	Yes	Brine shrimp occurrence possible
Benthic Invertebrates	Surface Water	Direct Contact	Yes	Yes	Brine flies occurrence possible
	Sediment	Direct Contact	Yes	Yes	Brine flies occurrence possible
		Ingestion	Yes	Yes	Brine flies occurrence possible
Semi-aquatic Birds (plover)	Surface Water	Direct Contact	Yes	No	
		Ingestion	Yes	Yes	
	Sediment	Direct Contact	Yes	No	
		Ingestion	Yes	Yes	
	Forage/Prey	Ingestion/Food-Chain Transfer	Yes	??	Not usually done in SLERA
Plants	Surface Water	Direct Contact	Yes	Yes	
	Soil/Sediment	Direct Contact	Yes	Yes	
Terrestrial Invertebrates	Surface Water	Direct Contact	?	No	Possible due to flooding
	Soil/Sediment	Direct Contact	Yes	Yes	
Small Mammals	Surface Water	Ingestion	?	Yes	Limited due to salinity
	Soil/Sediment	Direct Contact	Yes	Yes	
	Forage/Prey	Ingestion/Food-Chain Transfer	Yes	??	Not usually done in SLERA
Avian (plover)	Soil/Sediment	Direct Contact	Yes	Yes	
	Forage/Prey	Ingestion/Food-Chain Transfer	Yes	??	Not usually done in SLERA
Raptor	Surface Water	Ingestion	?	No	Unlikely
	Soil/Sediment	Direct Contact	?	No	May occur in area, not definitive
	Forage/Prey	Ingestion/Food-Chain Transfer	?	No	Not usually done in SLERA

Table 9
Ecotoxicity Criteria -- Soil/Sediment
Owens Lake DCM SLERA

		Long et al 1995	USEPA R-V Eco Criteria		Efroymson et al 1997		NRCS	USEPA Eco-SSLs				SLERA			
		Sediment	Sediment	Soil	Soil	Soil	Soil	Soil				Selected Criterion			
Analyte	Units (dry wt.)	Marine ERL			Earthworms †	Plants ‡	Quality	Plants	Invertebrates	Avian	Mammal	Plants	Invertebrates	Avian	Mammal
Aluminum	mg/kg							only a COPEC if pH <5.5				NA	NA	NA	NA
Arsenic	mg/kg	8.2	9.79	5.70	60	18		18	NA	43	46	18	60	43	46
Barium	mg/kg			1.04	330	500		NA	330	NA	2,000	500	330	1	2,000
Boron	mg/kg					0.5		Not Done				0.5	NA	NA	NA
Cadmium	mg/kg	1.2	0.99	0.002	140	32		32	140	0.77	0.36	32	140	0.77	0.36
Calcium	mg/kg							Not Done				NA	NA	NA	NA
Chloride	mg/kg							Not Done				NA	NA	NA	NA
Chromium	mg/kg	81	43.4	0.4	0.4	1		NA	NA	26	34	1	0.40	26.00	34.00
Cobalt	mg/kg		50	0.14		13		NA	NA	120	230	120		120.00	230.00
Copper	mg/kg	34	31.6	5.4	61	100		70	80	28	51	70	80.00	28.00	51.00
Iron	mg/kg	46.7						only a COPEC if pH <5 or >8				47	NA	NA	NA
Lead	mg/kg		35.8	0.05	1,700	120		120	1,700	11	56	120	1,700	11	56
Lithium	mg/kg							Not Done				NA	NA	NA	NA
Magnesium	mg/kg							Not Done				NA	NA	NA	NA
Manganese	mg/kg					500		220	450	4,300	4,000	220	450	4,300	4,000
Mercury	mg/kg	0.15	0.17	0.1	0.1	0.3		Not Done				0.3	0.1	0.1	0.1
Molybdenum	mg/kg					2		Not Done				2	NA	NA	NA
Nickel	mg/kg	20.9	22.7	13.6	200	30		38	280	210	130	38	280	210	130
Phosphate	mg/kg							Not Done				NA	NA	NA	NA
Potassium	mg/kg							Not Done				NA	NA	NA	NA
Selenium	mg/kg			0.03	70	1		Pending				1	70	0.03	0.03
Silver	mg/kg	1	0.5	4.04		2		NA	NA	4.2	14	2	4	4	14
Sodium	mg/kg							Not Done				NA	NA	NA	NA
Strontium	mg/kg							Not Done				NA	NA	NA	NA
Sulfur	mg/kg							Not Done				NA	NA	NA	NA
Tin	mg/kg			7.62		50		Not Done				NA	NA	NA	NA
Vanadium	mg/kg			1.59		2		NA	NA	7.8	280	2	2	8	280
Zinc	mg/kg	150	0.12	6.6	120	190		Pending				190	120	7	7
Salinity (EC)	dS/m						<4					<4			
Acidity/Alkalinity	pH						<8.2					<8.2			

References
Long, ER, DD MacDonald, SL Smith and FD Calder, 1995 (Effects Range Low benchmarks)
† Efroymson, RA, ME Will and GW Suter, 1997a (Invertebrates)
‡ Efroymson, RA, ME Will and GW Suter, 1997b (Plants)
USEPA 2003c Region 5 Ecological Screening Levels
USEPA 2007 Ecological Soil Screening Levels (Eco-SSLs)
USDA/NRCS, 2004, Soil Quality Thnunderbook, Soil Quality Guideline

NA = Not Availaible, insufficient data

Table 10
Ecotoxicity Criteria -- Water
Owens Lake DCM SLERA

KLEINFELDER
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		Suter and Tsao (1996)1,a						USEPA 2,3				TCEQ 2003 4	SLERA
		Tier II		Lowest Chronic Value				Freshw.		Marine		Marine	Selected
Analyte	Units	Secondary Acute	Secondary Chronic	Fish	Daphnids	Other Inverts	Aquatic Plants	CMC (acute)	CCC (chronic)	CMC (acute)	CCC (chronic)		Criteria
Aluminum	mg/L			1.9	3.3		0.46	0.75	0.09				0.5
Arsenic *	mg/L			0.91	3.0		2.3	0.34	0.15	0.069	0.036		2.3
Arsenic (dis)	mg/L									0.069	0.036	0.078	0.078
Barium	mg/L	0.11	0.004									25	25
Boron	mg/L	0.03	0.002	8.8									0.03
Cadmium *	mg/L			0.00015	0.0017		0.002	0.001	0.0002	0.04	0.009		0.001
Cadmium (dis)	mg/L									0.04	0.009	0.01	0.01
Calcium	mg/L			116.00									116
Chloride	mg/L							860.00	230.00				860
Chromium III *	mg/L			0.04	0.07		0.40	0.57	0.07				0.07
Chromium VI *	mg/L			0.04	0.07		0.40	0.02	0.01	1.10	0.05		1.1
Chrom. III (dis)	mg/L											0.1	0.1
Chrom VI (dis)	mg/L									1.09	0.05	0.05	0.05
Cobalt	mg/L	1.50	0.023	0.005	0.29								0.29
Copper *	mg/L			0.00023	0.0038	0.01	0.00	0.01	0.01	0.0048	0.0031		0.005
Copper (dis)	mg/L									0.0040	0.0026	0.0036	0.0036
Iron	mg/L			0.16	1.3				1				1.3
Lead *	mg/L			0.012	0.019	0.026	0.5	0.065	0.0025	0.21	0.081		0.21
Lead (dis)	mg/L									0.20	0.077	0.005	0.005
Lithium	mg/L	0.26	0.014										0.26
Magnesium	mg/L			82									82
Manganese	mg/L	2.3	0.12	1.1	1.8								1.8
Mercury	mg/L		0.0013	0.001	0.0002		0.005	0.0014	0.0008	0.0018	0.0009	0.0011	0.0011
Mercury (dis)	mg/L									0.0015	0.0008		0.0015
Molybdenum	mg/L	16	0.37	0.88									0.9
Nickel *	mg/L			0.01	0.04	0.13	0.00	0.47	0.05	0.07	0.008		0.07
Nickel (dis)	mg/L									0.07	0.008	0.013	0.013
Phosphorus	mg/L										0.0001		0.0001
Potassium	mg/L			53									53.00
Selenium	mg/L			0.09	0.09		0.10		0.01	0.29	0.07	0.14	0.14
Selenium (dis)	mg/L									0.29	0.07		0.14
Silver	mg/L		0.00036	0.0026	0.00012		0.03	0.0034		0.0032			0.0032
Silver (dis)	mg/L									0.0027		0.0002	0.0002
Sodium	mg/L			680									680
Strontium	mg/L	15	1.5	42									15
Tin	mg/L	2.7	0.073	0.35				0.00046	0.000063	0.00037	0.00001		0.00037
Vanadium	mg/L	0.28	0.02	1.9	0.08								0.08
Zinc *	mg/L			0.05	0.04		0.03	0.12	0.12	0.09	0.08		0.09
Zinc (dis)	mg/L									0.09	0.08	0.08	0.08
TDS [5]	mg/L												6,400
Salinity [5]	dS/m												10
Acidity [5]	pH												<8.2
Sodium Adsorption Ratio	Molar1/2												12

Notes: a Freshwater benchmarks.
* Hardness-dependent freshwater criteria (assumed 100 mg/L as CaCO3).
(dis) Values calculated using App. A of USEPA 2006
f pH 6.5-9.0
Based on tributyltin

References: 1 Suter, G.W. II, and C.L. Tsao, 1996
2 USEPA, 2006, National Recommended Water Quality Criteria
3 USEPA, 2001b, Update Ambient Water Quality Criteria for Cadmium EPA 822-R-01-001
4 TCEQ, 2003
5 USDA/NRCS, 2004

Table 11
Hazard Quotient Evaluation of Soil/Sediment
Owens Lake DCM SLERA

KLEINFELDER
EXPECT MORE®

Analytical Parameter	COPEC Concentration	SLERA Selected Criterion				Soil Hazard Quotient (HQ)			
		Plants	Invertebrates	Avian	Mammal	Plants	Invertebrates	Avian	Mammal
Aluminum	42,506	NA	NA	NA	NA				
Arsenic	39	18	60	43	46	2.2	0.7	0.9	0.9
Barium	410	500	330	1	2,000	0.8	1.2	410	0.2
Boron	2,512	0.5	NA	NA	NA	5,024			
Bromine	67	NA	NA	NA	NA				
Cadmium	0.5	32	140	0.77	0.36	0.02	0.004	0.65	1.4
Calcium	80,294	NA	NA	NA	NA				
Chlorine	44,800	NA	NA	NA	NA				
Chromium	29	1	0.4	26	34	29	73	1.1	0.86
Copper	23	70	80	28	51	0.33	0.29	0.83	0.45
Fluorine	36	NA	NA	NA	NA				
Iron	21,219	47	NA	NA	NA	451			
Lead	28	120	1,700	11	56	0.23	0.02	2.5	0.5
Lithium	640	NA	NA	NA	NA				
Magnesium	27,081	NA	NA	NA	NA				
Manganese	552	220	450	4,300	4,000	2.5	1.2	0.13	0.14
Mercury	0.03	0.3	0.1	0.1	0.1	0.10	0.3	0.3	0.3
Molybdenum	2.5	2	NA	NA	NA	1.3			
Nickel	14	38	280	210	130	0.36	0.05	0.06	0.1
Potassium	20,669	NA	NA	NA	NA				
Selenium	0.5	1	70	0.03	0.03	0.50	0.01	16.67	17
Silver	2	2	4	4	14	1.2	0.6	0.57	0.17
Sulfate	45,250	NA	NA	NA	NA				
Sulfur	19,806	NA	NA	NA	NA				
Vanadium	72	2	2	8	280	36	36	9.2	0.26
Zinc	75	190	120	7	7	0.39	0.62	11	11
Sodium	82,082	NA	NA	NA	NA				
pH †	9.4	8.2	NA	NA	NA	1.1			
Salinity (EC)	NA	<4	NA	NA	NA				

NA = not available
* Units are mg//kg or ppm unless indicated otehrwise.

Hazard Quotient Color Coding

If HQ <1.0	no risk of impact
If 1.0 > HQ < 5.0	the risk of an impact is possible and may not be probable
If 5.0 > HQ < 50	the risk of an impact is probable
If HQ > 50	the risk of observing acute effects is probable

Table 12
Hazard Quotient Evaluation of Water
Owens Lake DCM SLERA

KLEINFELDER
EXPECT MORE®

Analytical Parameter	Units	COPEC/Stressor Concentration		SLERA Selected Criteria	Water Hazard Quotient (HQ)	
		Shallow Flooding	Habitat Shallow Flooding		Shallow Flooding	Habitat Shallow Flooding
Conductivity ‡	dS/m	118	54	10	12	5.4
pH ‡	stnd.	10	10	8.20	1.2	1.2
Total Alkalinity ‡	mg CaCO3/L	46,500	17,020			
Salinity ‡	mg/L TDS	140,124	49,595			
Sodium ‡	mg/l	69,400	18,122	680	102	27
		Subsurface Drainage	Shallow Groundwater		Subsurface Drainage	Shallow Groundwater
Aluminum	mg/L	0.19	0.17	0.5	0.4	0.4
Arsenic	mg/L	25	20	2.3	10.8	8.9
Barium	mg/L	0.04	0.12	25	0.002	0.005
Boron	mg/L	583	357	0.03	19,437	11,887
Cadmium	mg/L	0.0009	0.009	0.001	0.88	9.2
Chromium	mg/L	0.07	0.31	0.07	1.0	4.5
Cobalt	mg/L	0.005	0.003	0.29	0.02	0.01
Copper	mg/L	0.42	0.023	0.005	87	4.8
Iron	mg/L	3.4	0.28	1.3	2.6	0.21
Lead	mg/L	0.01	0.006	0.21	0.06	0.03
Lithium	mg/L	1.3	2.8	0.26	5.0	11
Manganese	mg/L	0.024	0.024	1.8	0.01	0.01
Mercury	mg/L	0.003	0.0001	0.0011	2.4	0.09
Molybdenum	mg/L	2.3	1.4	0.9	2.7	1.6
Nickel	mg/L	0.0002	0.013	0.07	0.002	0.19
Selenium	mg/L	0.53	0.20	0.14	3.9	1.5
Vanadium	mg/L	0.040	0.122	0.08	0.50	1.5
Zinc	mg/L	0.024	0.015	0.09	0.27	0.16
Sodium Adsorption Ratio	Molar1/2	1,875	433	12	156	36
Salinity e	dS/m	91	78	10	9.1	7.8
Acidity	p(Molar)	10	9	8.2	1.2	1.1

Hazard Quotient Color Coding

If HQ <1.0	no risk of impact
If 1.0 > HQ < !	the risk of an impact is possible and may not be probable
If 5.0 > HQ < !	the risk of an impact is probable
If HQ > 50	the risk of observing acute effects is probable

Table 13
Hazard Evaluation of Playa vs. Three DCMs
(Shallow Flooding, Habitat Shallow Flooding and Moat Row)
Owens Lake DCM SLERA

KLEINFELDER
EXPECT MORE®

Analytical Parameter	Soil Hazard Quotient (HQ)				Soil Hazard Index	Water Hazard Quotient (HQ)		Cumulative Hazard Across Media			
	Plants	Invertebrates	Avian	Mammal		Shallow Flooding	Habitat Shallow Flooding	Playa	Shallow Flooding	Habitat Shallow Flooding	Moat & Row
Conductivity						12	5.4	12	12	5.4	
pH	1.1				1.1	1.2	1.2	1.2	1.2	1.2	1.1
Sodium Adsorption Ratio						156	36	156	156	36	
						Subsurface Drainage	Shallow Groundwater				
Aluminum						0.41	0.36	0.4	0.4	0.4	
Arsenic	2.2	0.65	0.91	0.85	4.6	10.8	8.9	14	15	14	4.6
Barium	0.82	1.2	410	0.21	412	0.0016	0.0047	412	412	412	412.3
Boron	5,024				5,024	19,437	11,887	16,911	24,461	16,911	5,024
Bromine											
Cadmium	0.02	0.004	0.65	1.4	2.1	0.88	9.19	11	3	11	2.1
Calcium											
Chlorine											
Chromium	29	73	1.1	0.9	104	1.0	4.5	108	105	108	104.0
Cobalt						0.02	0.01	0.01	0.02	0.01	
Copper	0.33	0.29	0.83	0.45	1.9	87	5	6.7	89	7	1.9
Fluorine											
Iron	451				451	2.6	0.21	452	454	452	451
Lead	0.23	0.016	2.5	0.50	3.3	0.06	0.03	3.3	3	3	3.3
Lithium						5.0	11	11	5	11	
Magnesium											
Manganese	2.5	1.2	0.13	0.14	4.0	0.01	0.01	4.0	4	4	4.0
Mercury	0.1	0.3	0.3	0.3	1.0	2.43	0.09	1.1	3	1	1.0
Molybdenum	1.3				1.3	2.65	1.57	2.8	4	3	1.3
Nickel	0.36	0.048	0.064	0.10	0.57	0.0023	0.19	0.8	0.6	0.8	0.6
Potassium											
Selenium	0.50	0.01	17	17	34	3.9	1.5	35	38	35	34
Silver	1.2	0.60	0.57	0.17	2.5			2.5	3	3	2.5
Sodium						102	27	27	102	27	
Sulfate											
Sulfur											
Vanadium	36	36	9.2	0.3	81	0.50	1.5	83	82	83	81
Zinc	0.4	0.6	11	11	22	0.27	0.16	23	23	23	22
Cumlative Hazard Across COPECs / Stressors								18,277	25,976	18,150	6,152

Hazard Quotient Color Coding

If HQ <1.0	no risk of impact
If 1.0 > HQ	the risk of an impact is possible and may not be probable
If 5.0 > HQ	the risk of an impact is probable
If HQ > 50	the risk of observing acute effects is probable

FIGURES

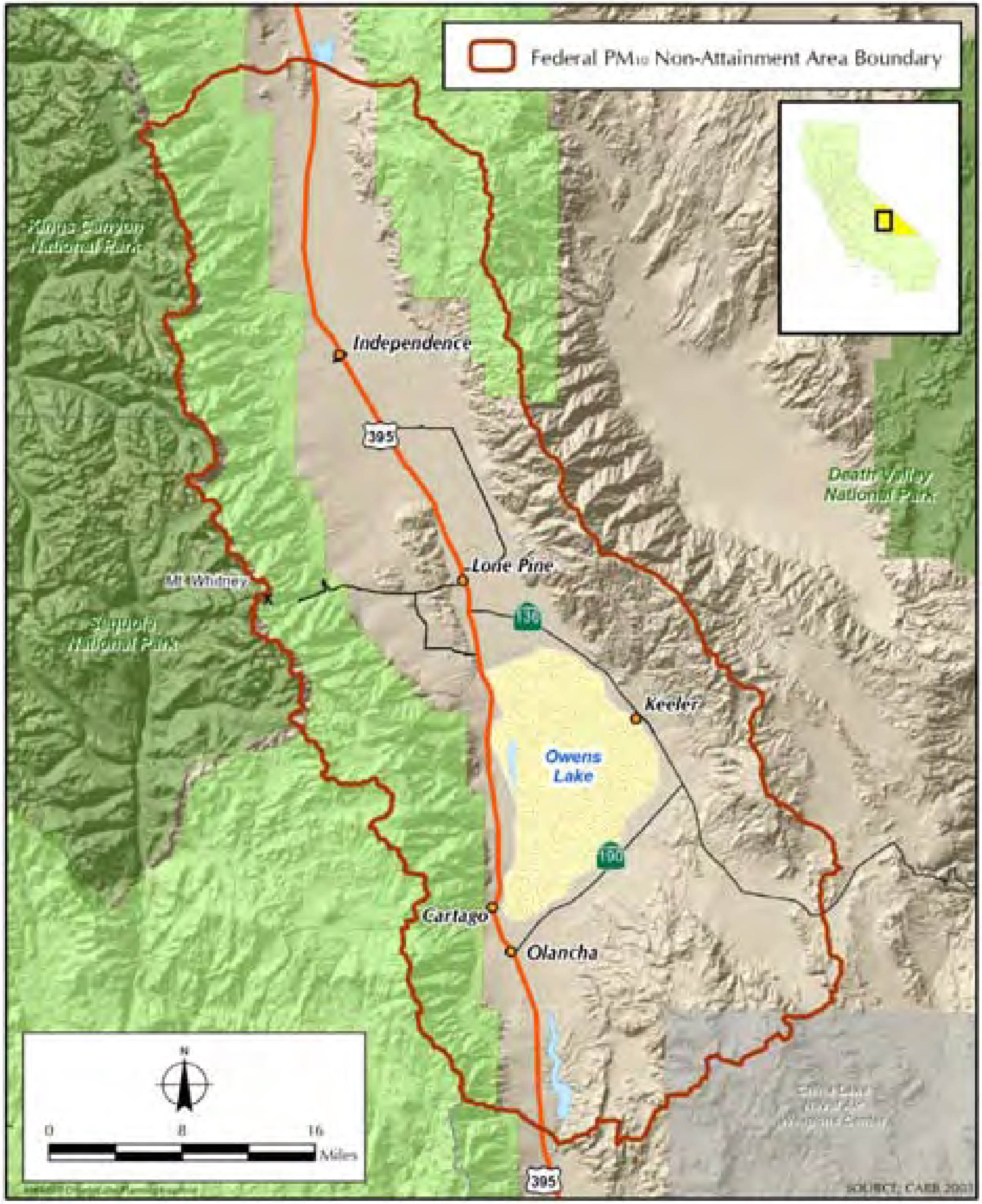


Figure 1 Owens Valley Planning Area

Source: Sapphos Environmental, 2007, Initial Study of the 2008 State Implementation Plan

Figure 2 Owens Lake Sensit Grid

Source: Sapphos Environmental, 2007, Initial Study of the 2008 State Implementation Plan

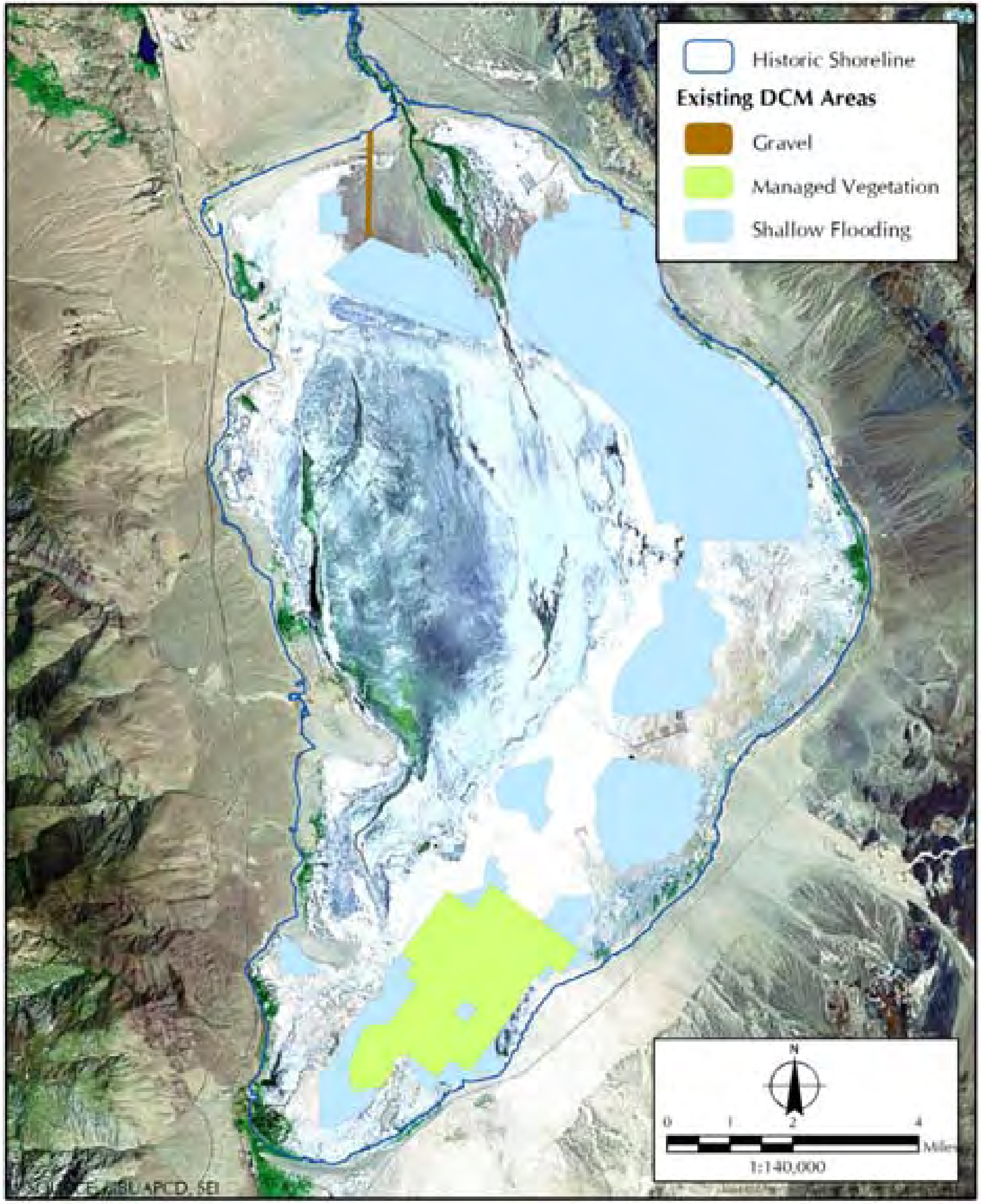


Figure 3 Existing Dust Control Measures
Source: Sapphos Environmental, 2007, *Op cit.*

Figure 4 Shallow Flooding DCM

Source: District via Sapphos Environmental, 2007, *Op cit.*

Figure 5 Managed Vegetation DCM
Source: District via Sapphos Environmental, 2007, *Op cit.*

Figure 6 Gravel DCM
Source: District via Sapphos Environmental, 2007, *Op cit.*

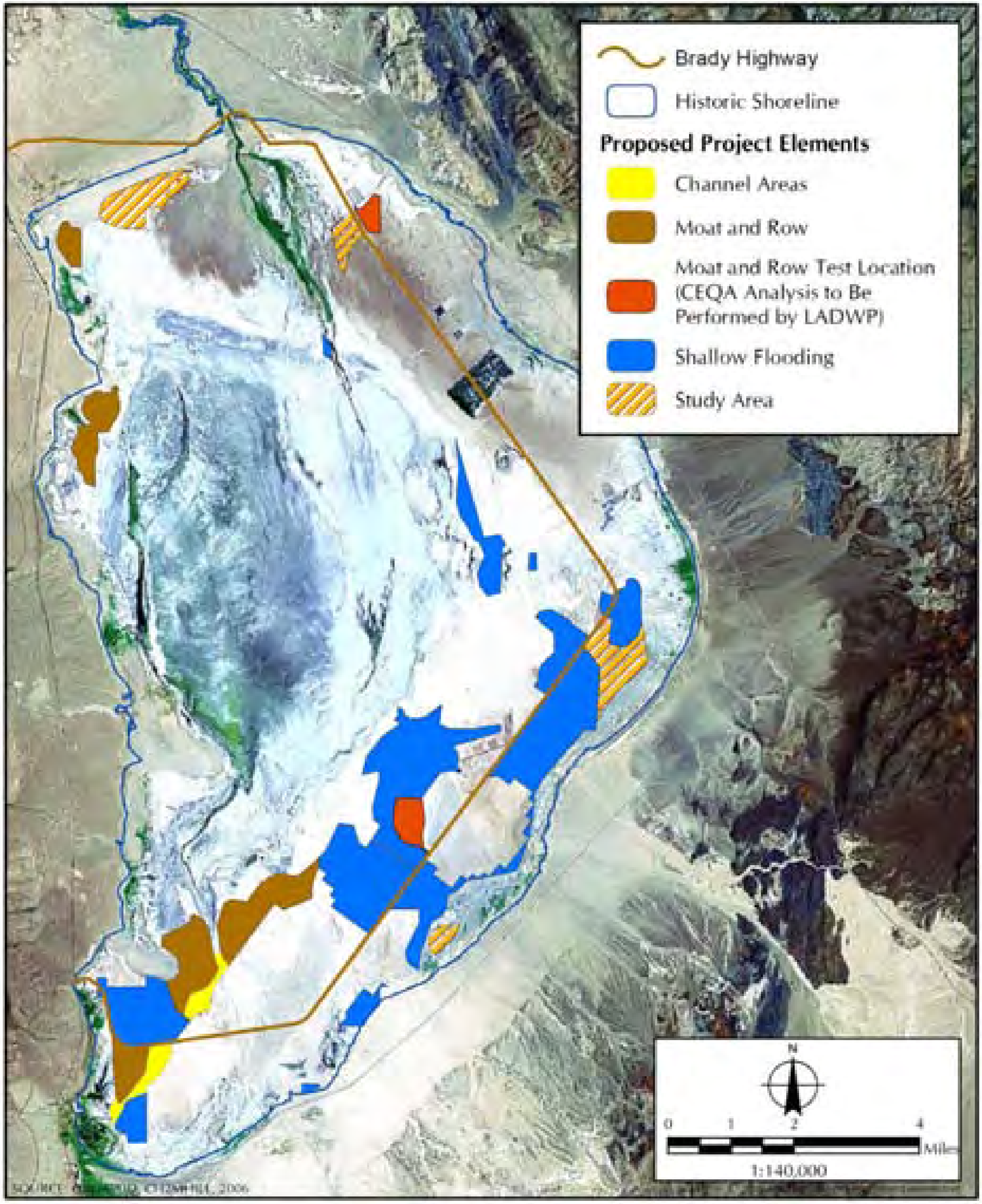


Figure 7 Project Area and Proposed Project Elements
Source: Sapphos Environmental, 2007, *Op cit.*

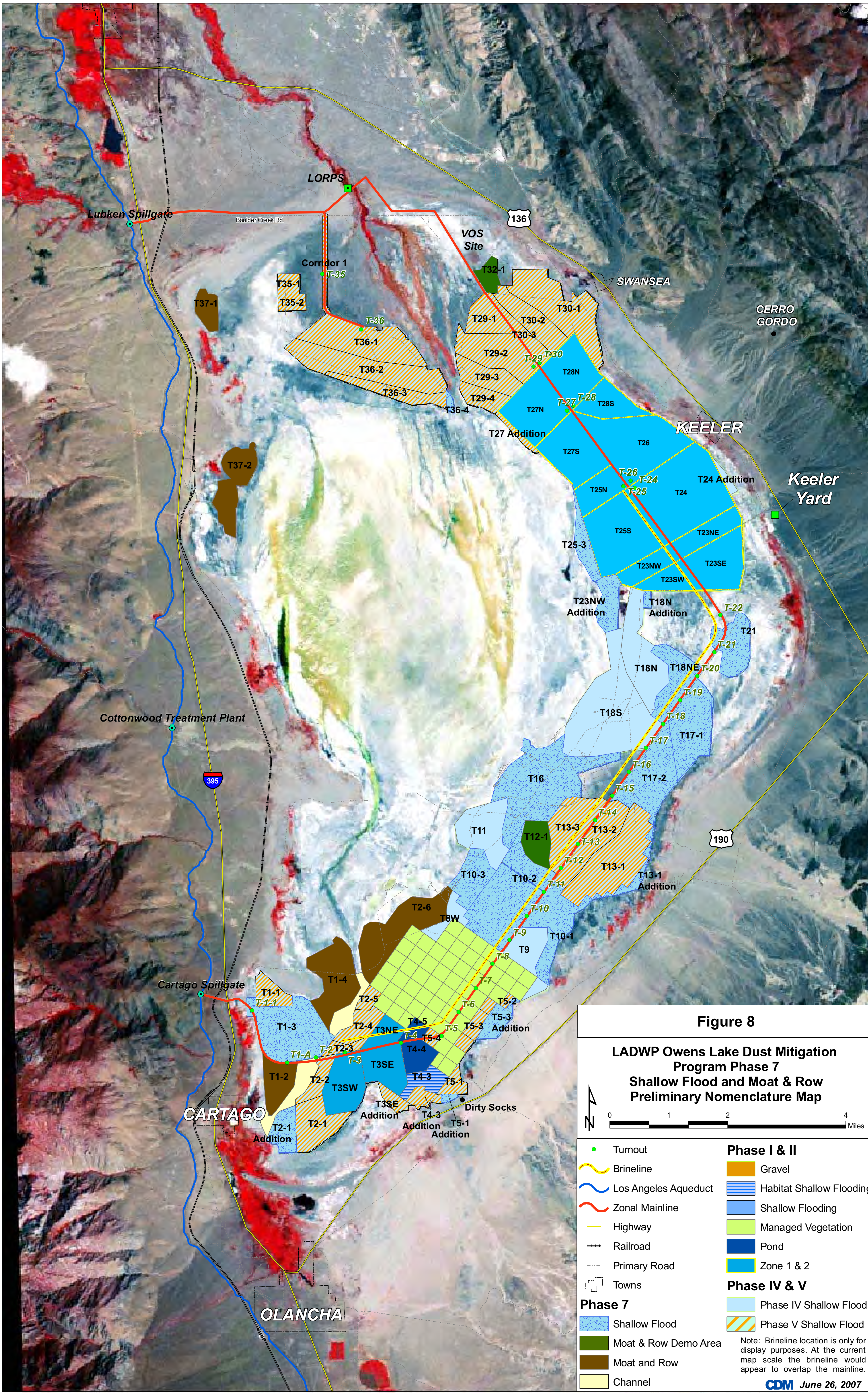


Figure 8

LADWP Owens Lake Dust Mitigation Program Phase 7 Shallow Flood and Moat & Row Preliminary Nomenclature Map

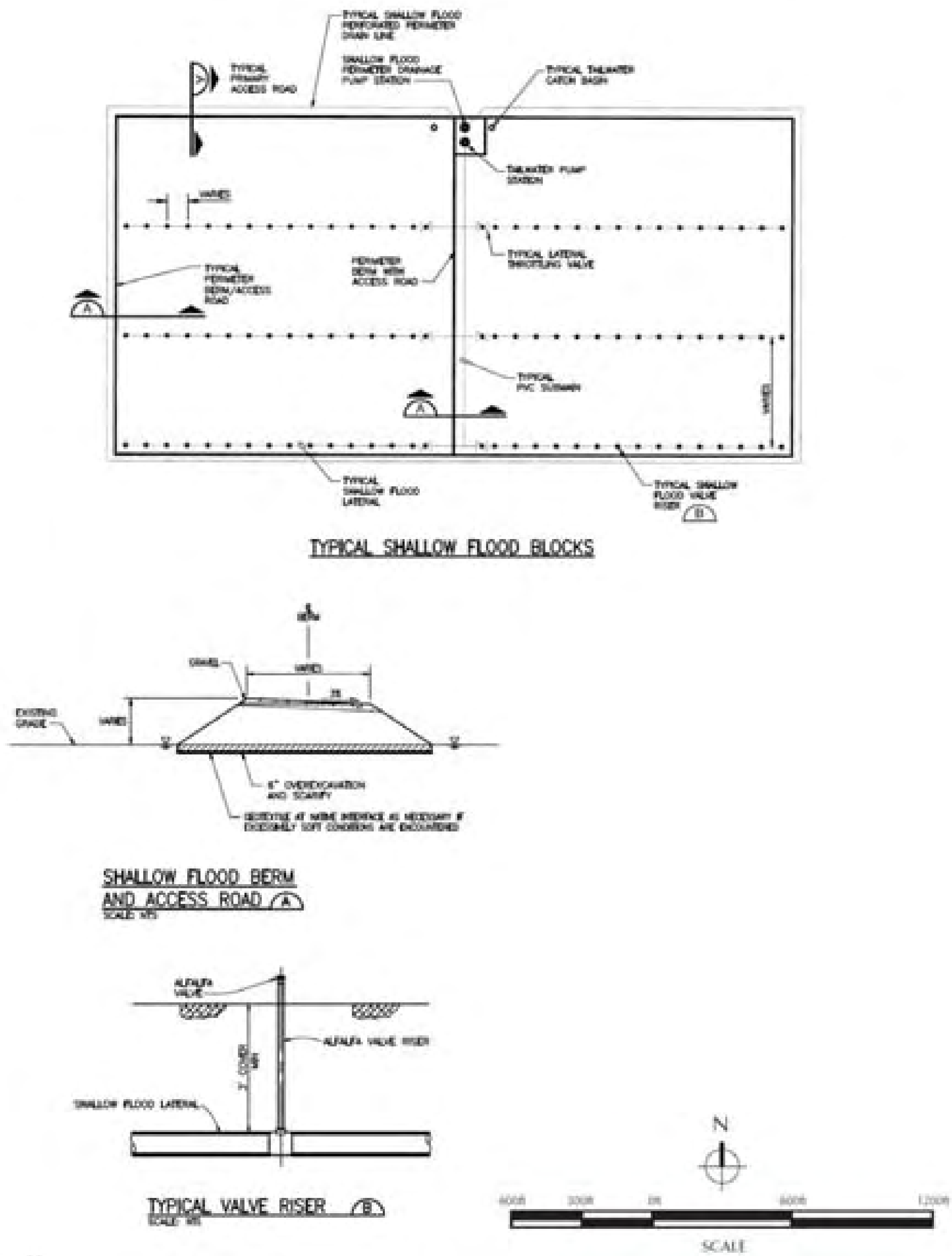


Figure 9 Shallow Flooding DCM Layout

Source: CH2MHill via Sapphos Environmental, 2007, *Op cit.*

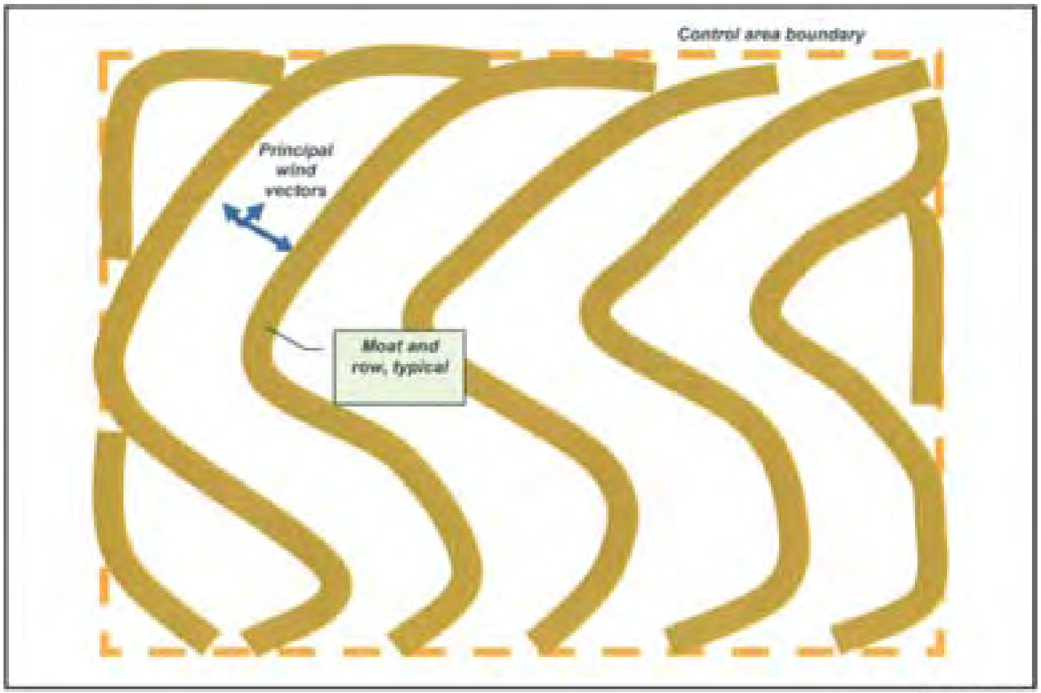


EXHIBIT 1
Moat and Row Array Plan View (schematic)

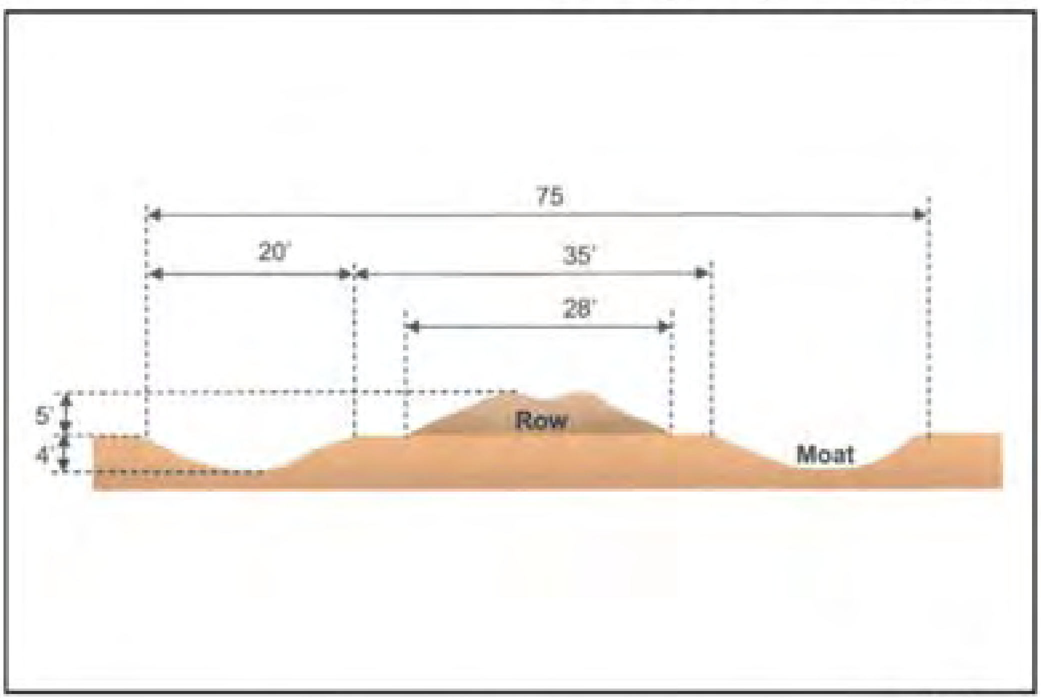
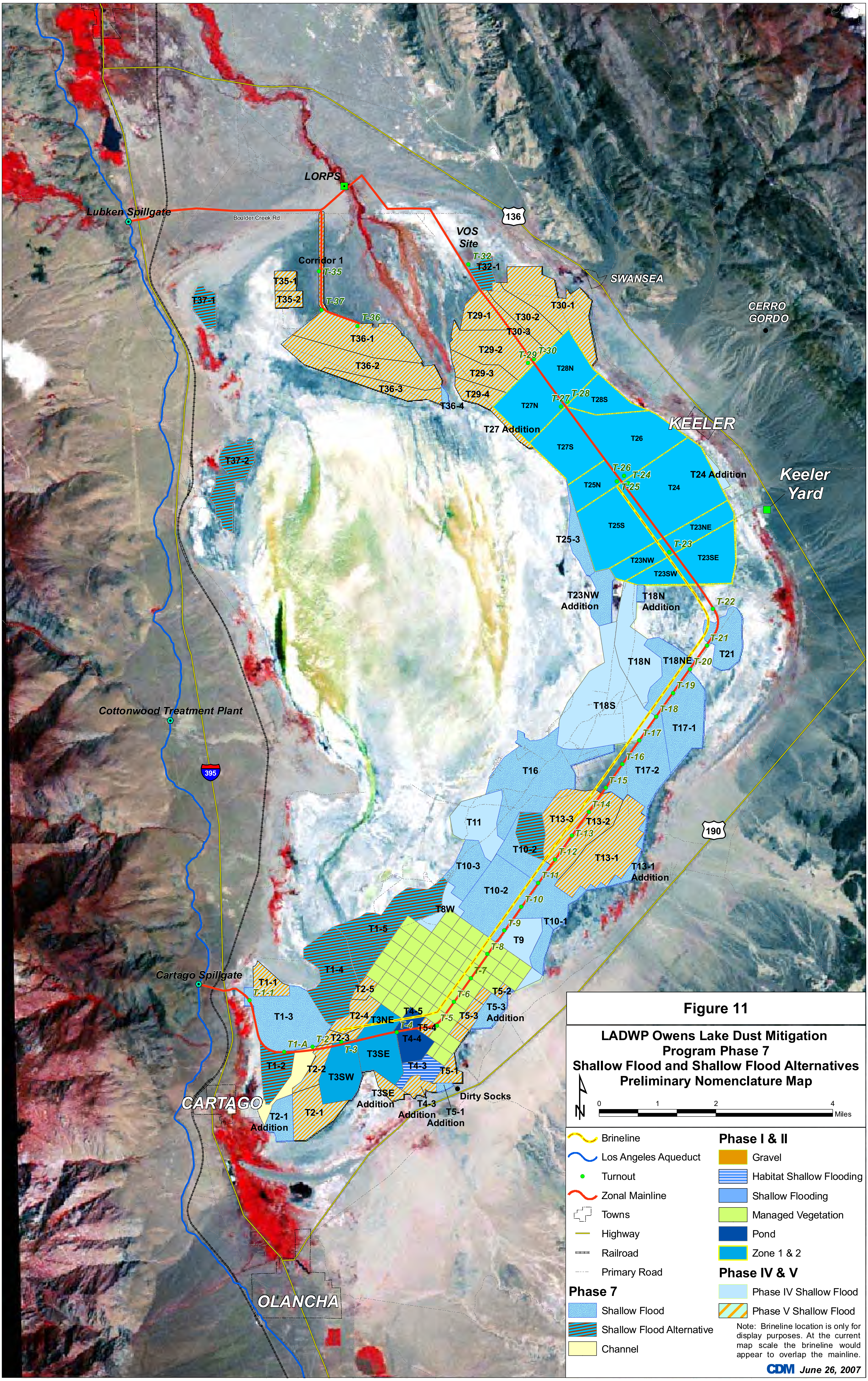


EXHIBIT 2
Profile of Moat and Row with Approximate Dimensions (schematic)

Figure 10 Moat and Row DCM

Source: District via Sapphos Environmental, 2007, *Op cit.*



LORPS
Lubken Spillgate
Boulder Creek Rd
136
VOS Site
Corridor 1
SWANSEA
CERRO GORDO
KEELER
Keeler Yard
Cottonwood Treatment Plant
395
190
Cartago Spillgate
CARTAGO
OLANCHA
Dirty Socks
T-32 T32-1
T35-1 T35-2 T-35 T-37 T-36
T37-1 T37-2
T36-1 T36-2 T36-3 T36-4
T29-1 T29-2 T29-3 T29-4 T-29
T30-1 T30-2 T30-3 T-30
T28N T28S T-28
T27N T27S T-27 T27 Addition
T26 T-26 T-24 T-25
T24 T24 Addition
T25N T25S T25-3
T23NE T23NW T23SE T23SW T-23
T23NW Addition
T18N Addition
T-22
T-21 T21
T18N T18NE T-20 T18S
T-19 T-18 T-17 T17-1
T-16 T17-2 T16
T-15 T-14
T13-3 T13-2 T-13 T13-1 T13-1 Addition
T11 T10-2 T-12 T10-3 T-11 T10-2 T-10 T10-1
T8W T-9 T9 T-8
T1-5 T1-4 T-7
T1-1 T-1-1 T2-5 T-6 T5-2
T1-3 T2-4 T3NE T4-5 T-4 T-5 T5-3 T5-3 Addition
T1-A T-2 T2-3 T5-4 T4-4 T-3 T3SE
T1-2 T2-2 T3SW T4-3 T5-1
T3SE Addition T4-3 Addition T5-1 Addition
T2-1 Addition T2-1
Figure 11
LADWP Owens Lake Dust Mitigation Program Phase 7
Shallow Flood and Shallow Flood Alternatives
Preliminary Nomenclature Map
N
0 1 2 4 Miles
Brineline
Los Angeles Aqueduct
Turnout
Zonal Mainline
Towns
Highway
Railroad
Primary Road
Phase 7
Shallow Flood
Shallow Flood Alternative
Channel
Phase I & II
Gravel
Habitat Shallow Flooding
Shallow Flooding
Managed Vegetation
Pond
Zone 1 & 2
Phase IV & V
Phase IV Shallow Flood
Phase V Shallow Flood
Note: Brineline location is only for display purposes. At the current map scale the brineline would appear to overlap the mainline.
CDM June 26, 2007

Wind-Eroded Salt Crusts

Emissive Soils at Owens Lake Dry Lake Bed

Close-Up of Heaved Salt Crust Exposing Emissive Material

Figure 12 Emissive Soil Sources

Source: Sapphos Environmental, 2004, *Op cit.*

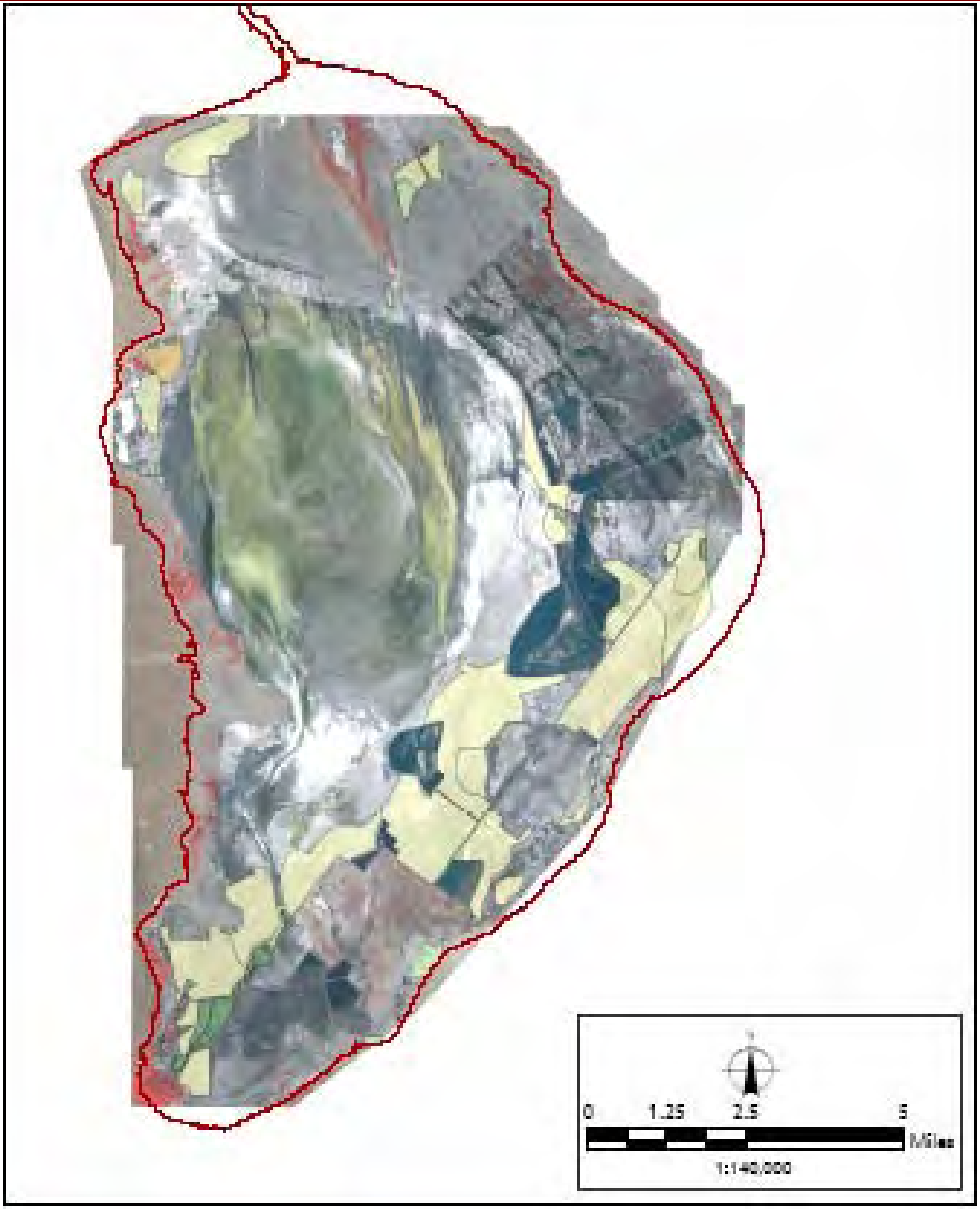


Figure 13 Plant Communities in the Project Area
Source: Sapphos Environmental

Figure 14A
Operation Ponds Water Quality Trend Analysis
Owens Lake DCM SLERA

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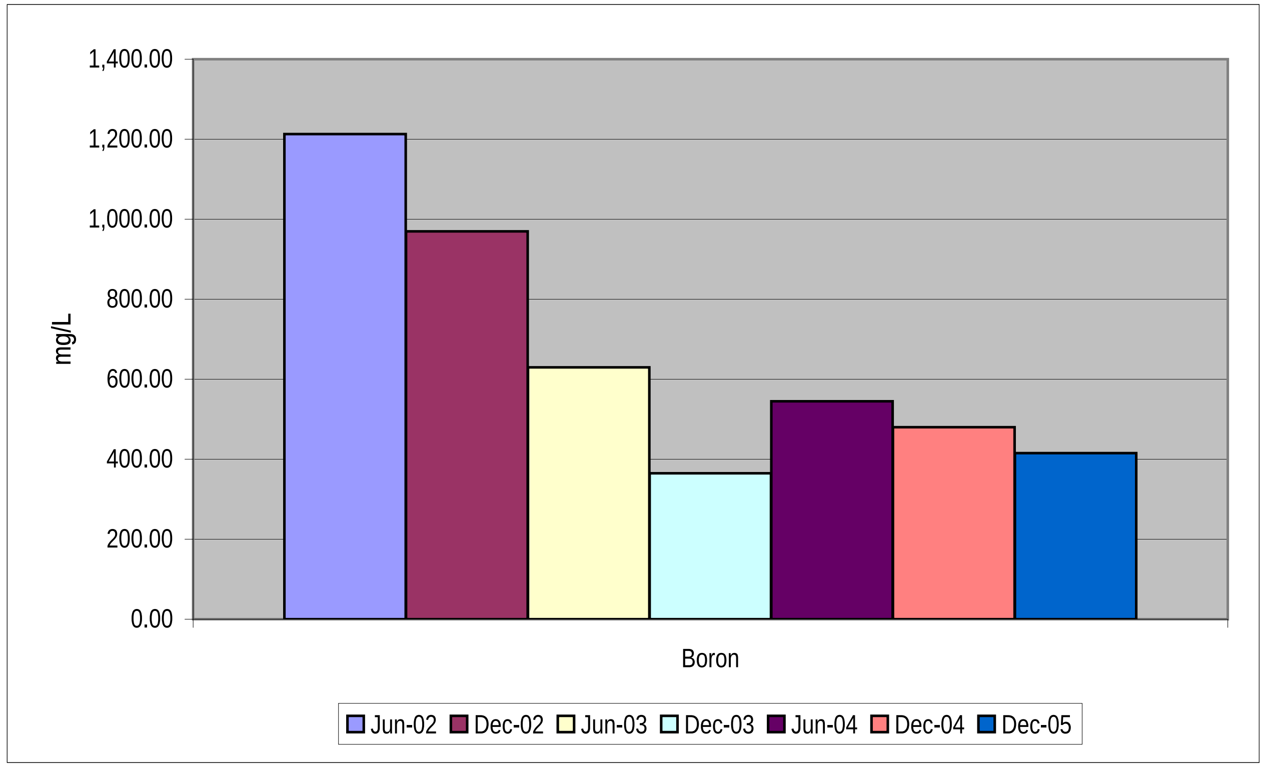

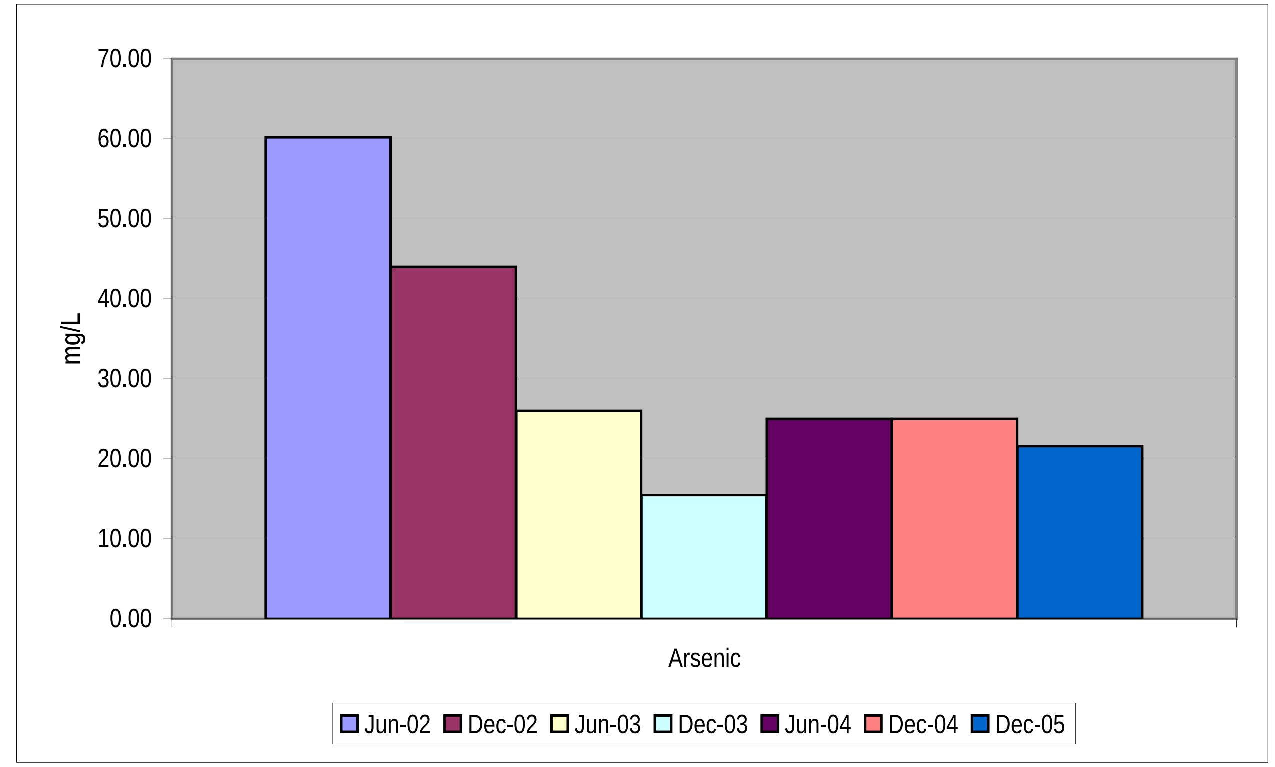

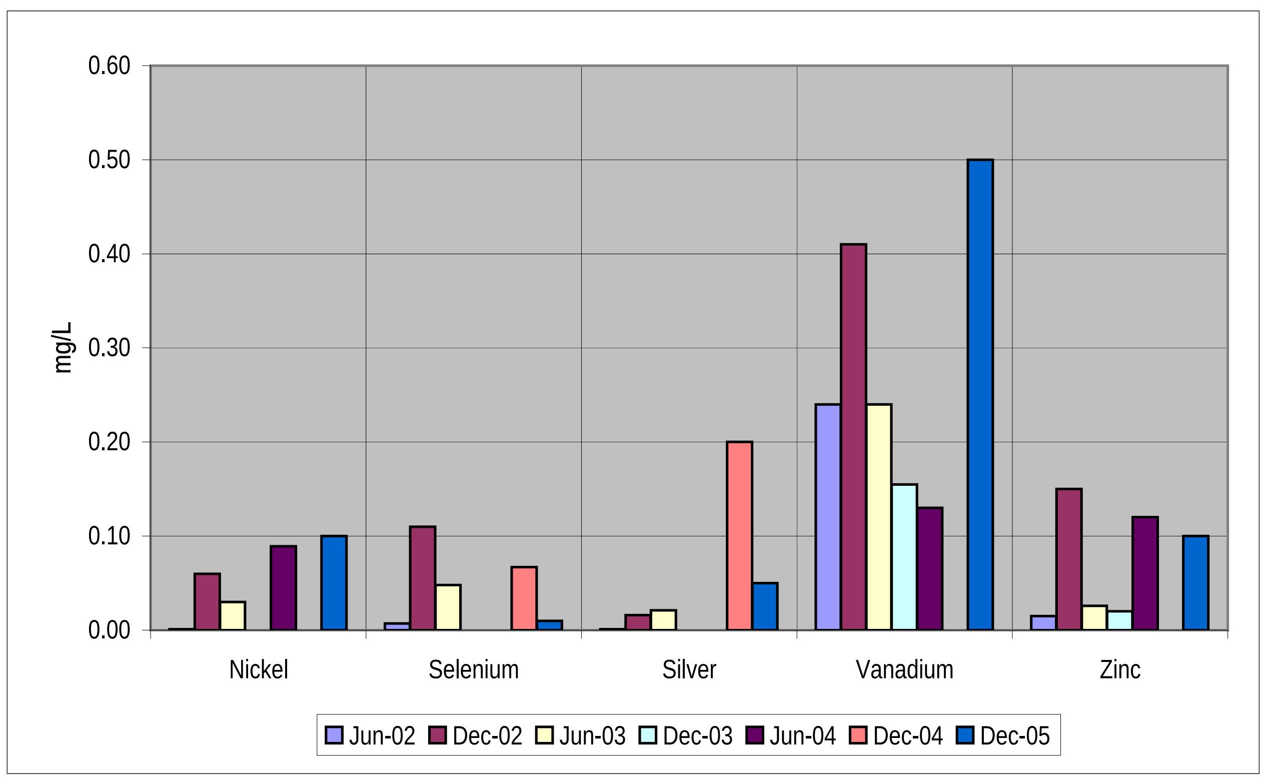

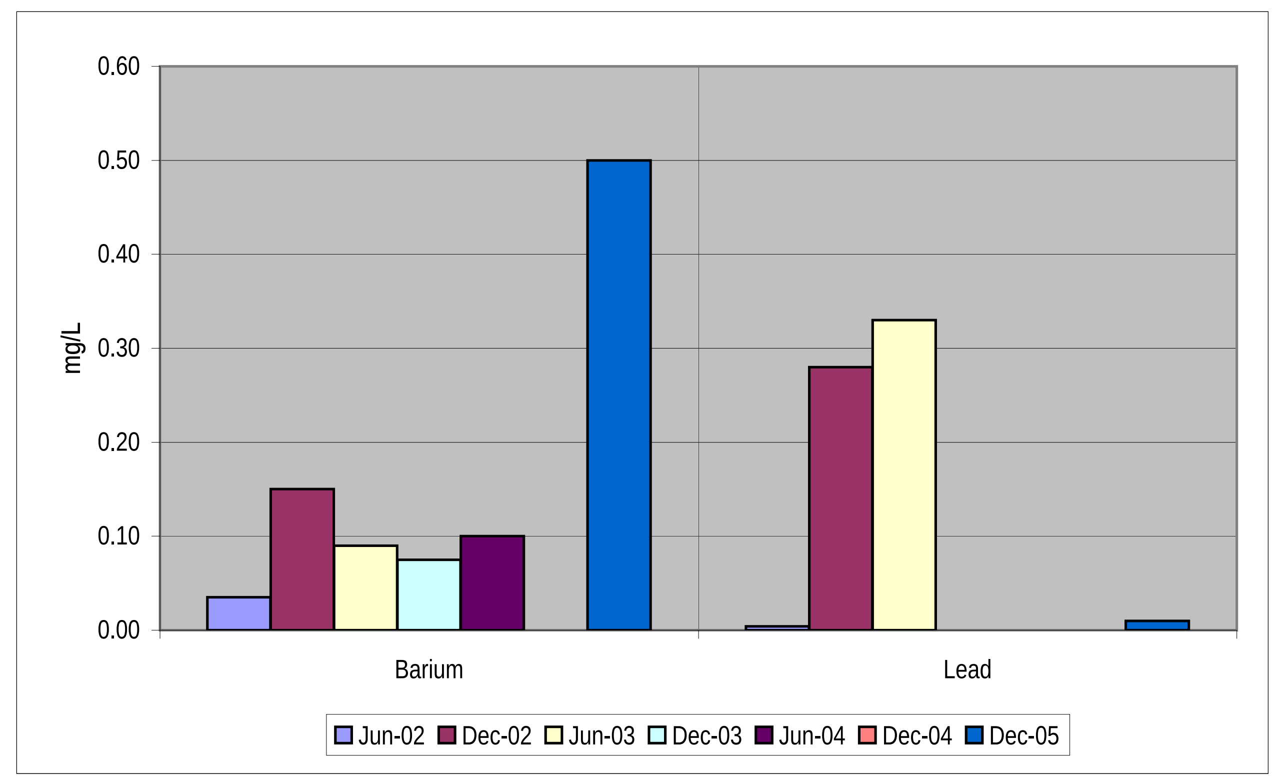

Figure 14B
Shallow Flooding Water Quality Trend Analysis
Owens Lake DCM SLERA

KLEINFELDER
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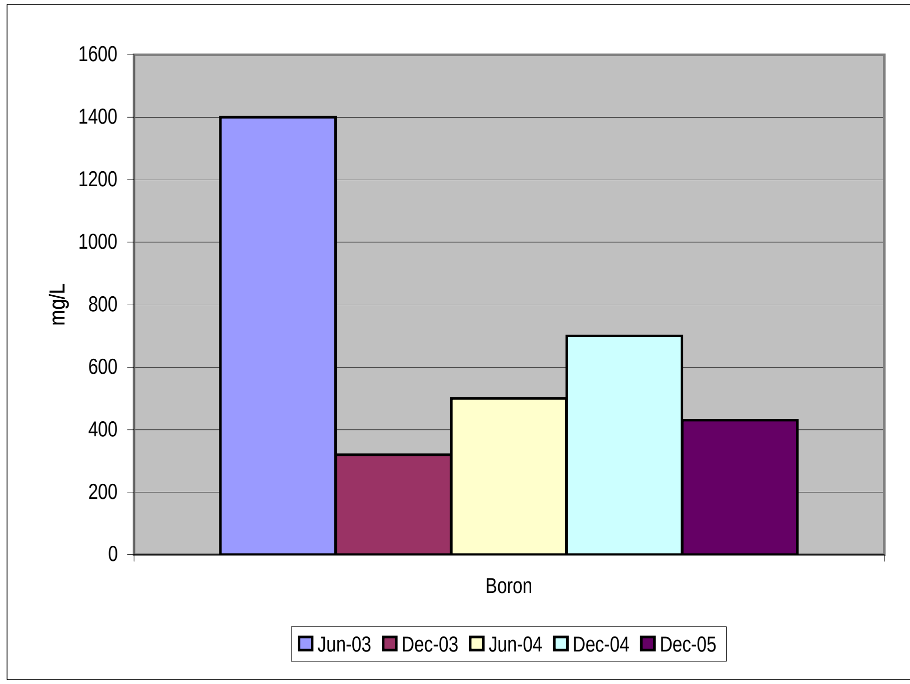

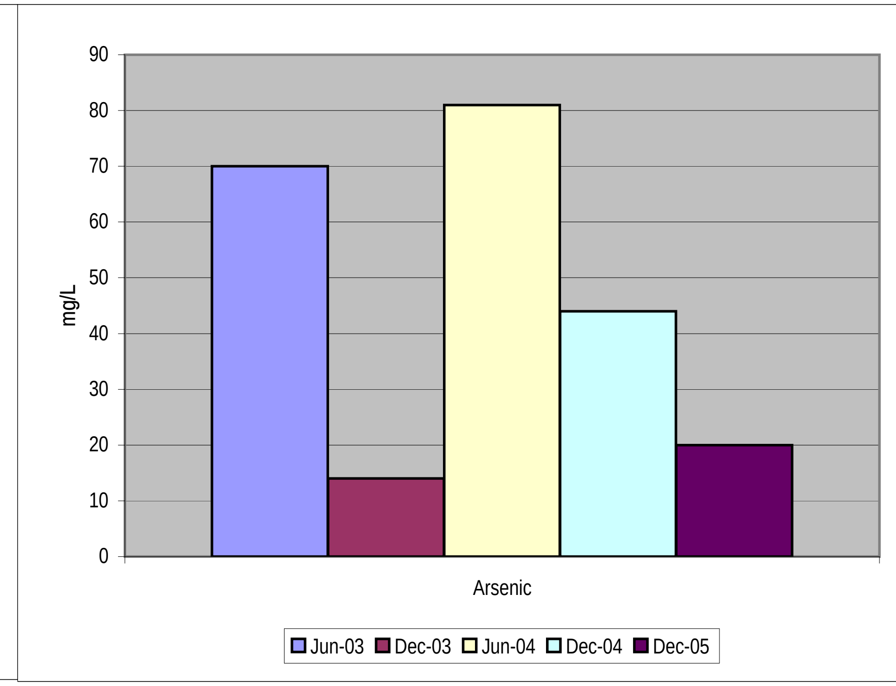

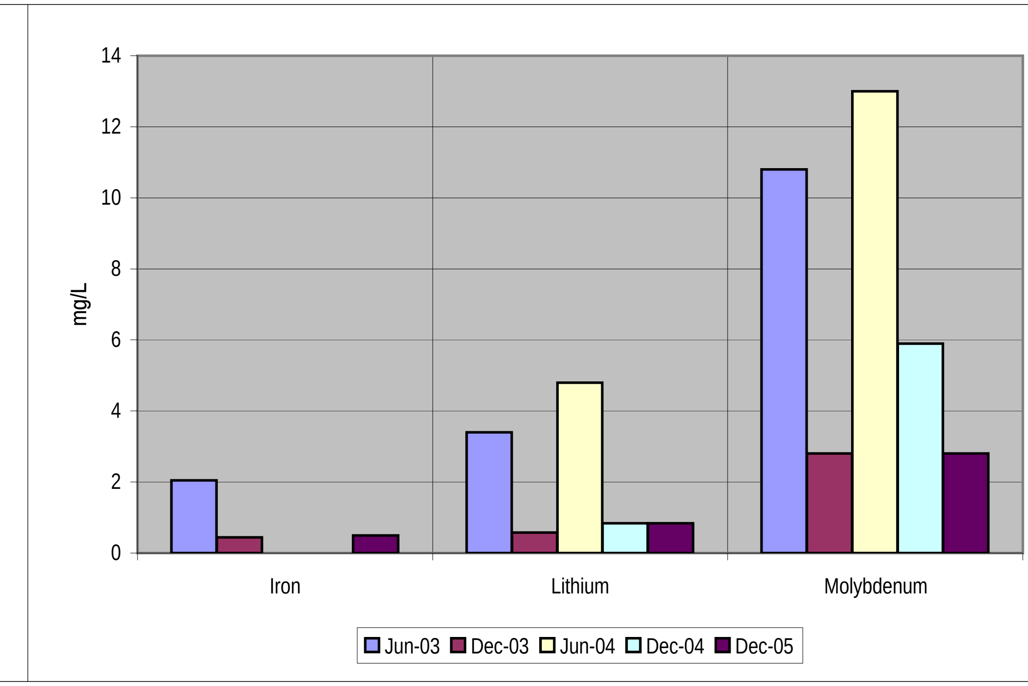

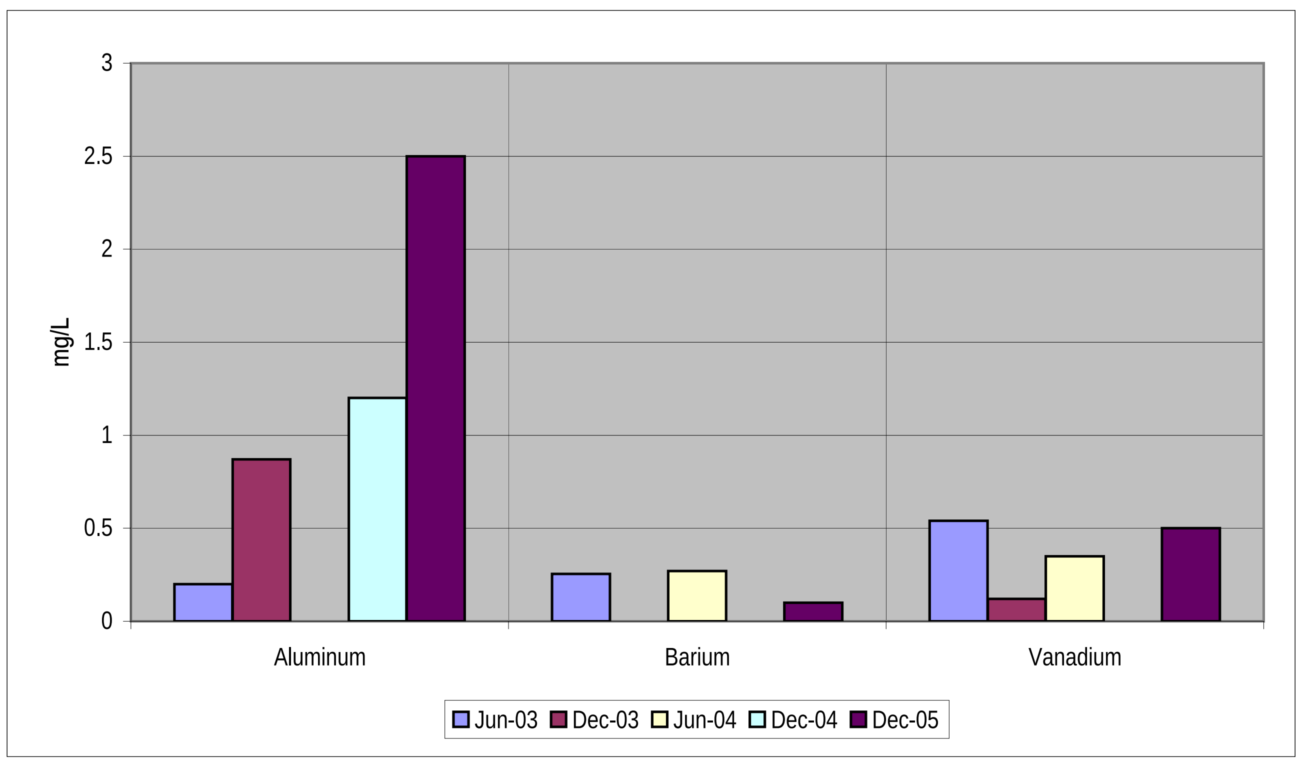

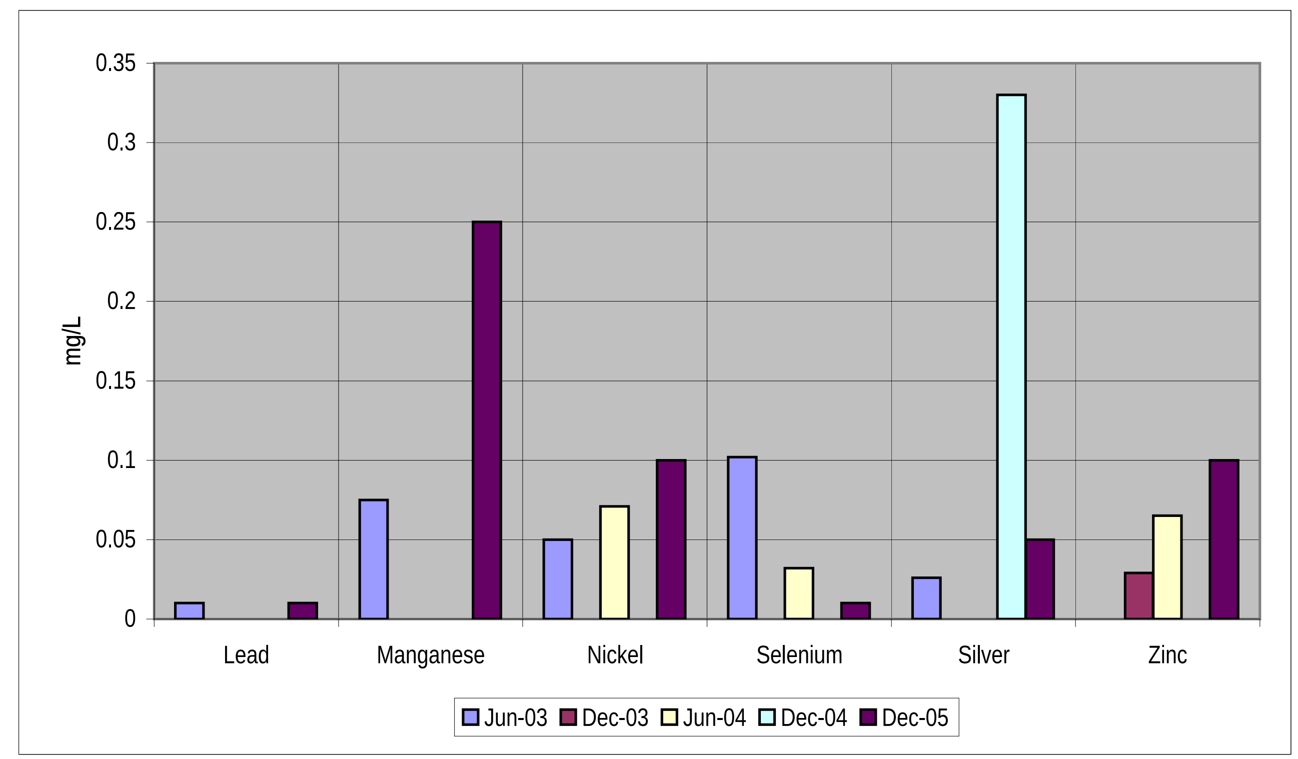

Figure 14C
Habitat Shallow Flooding Water Quality Trend Analysis
Owens Lake DCM SLERA

KLEINFELDER
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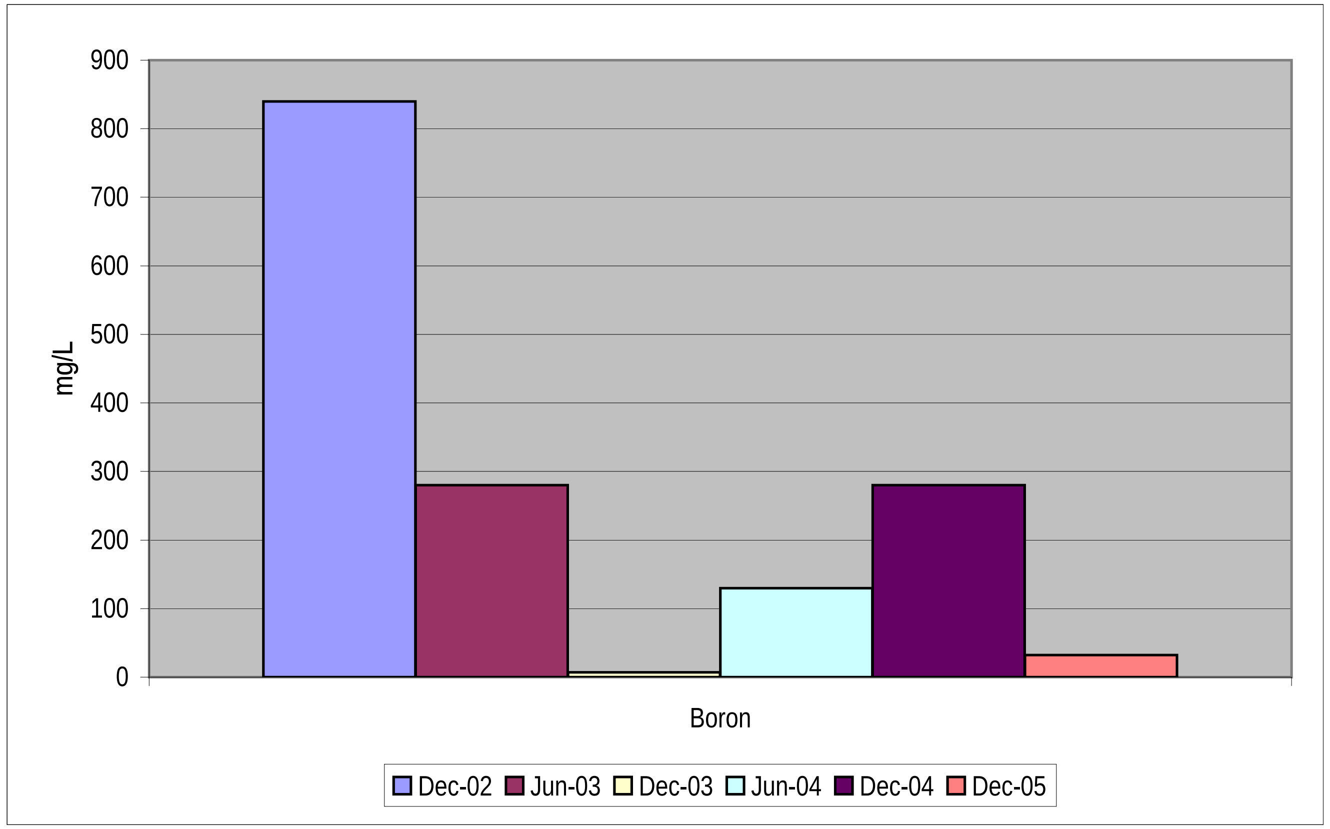

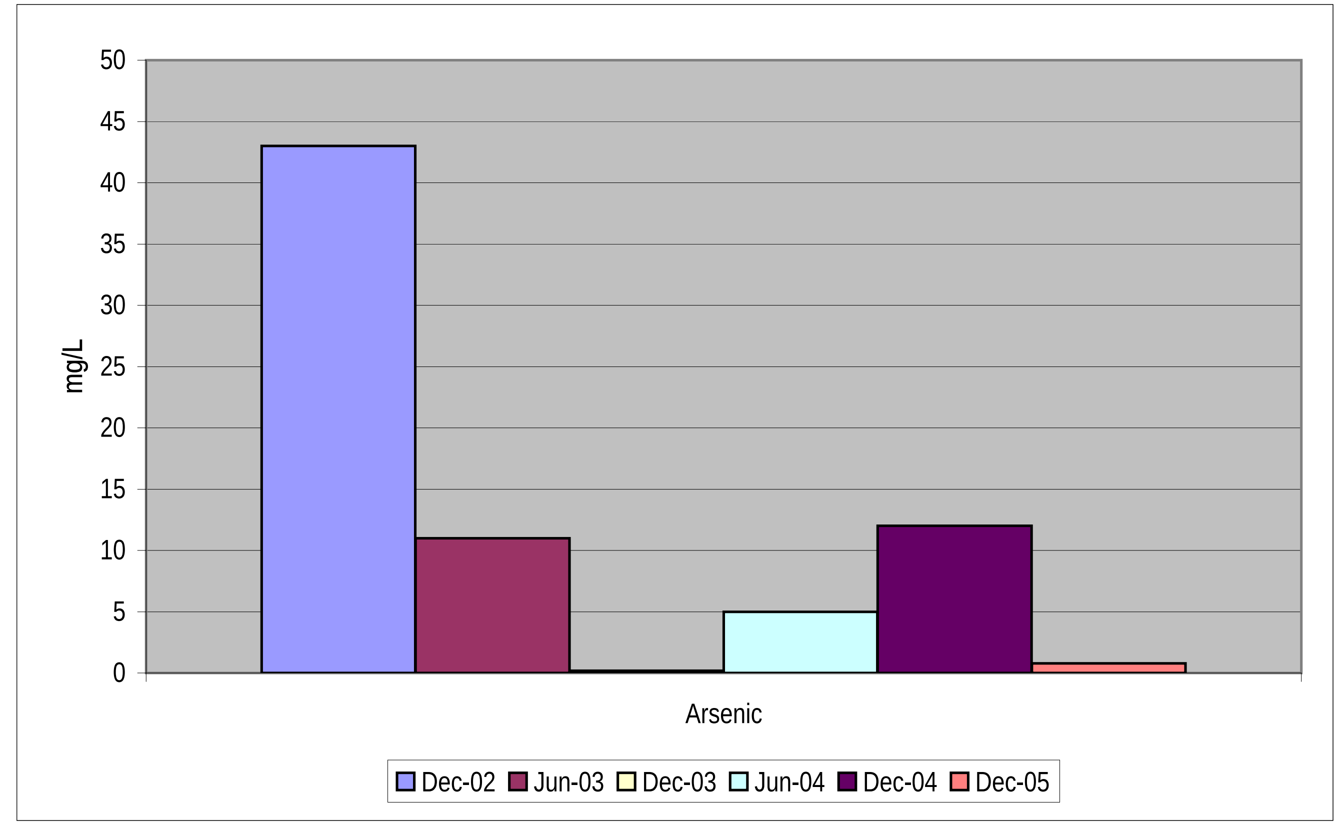

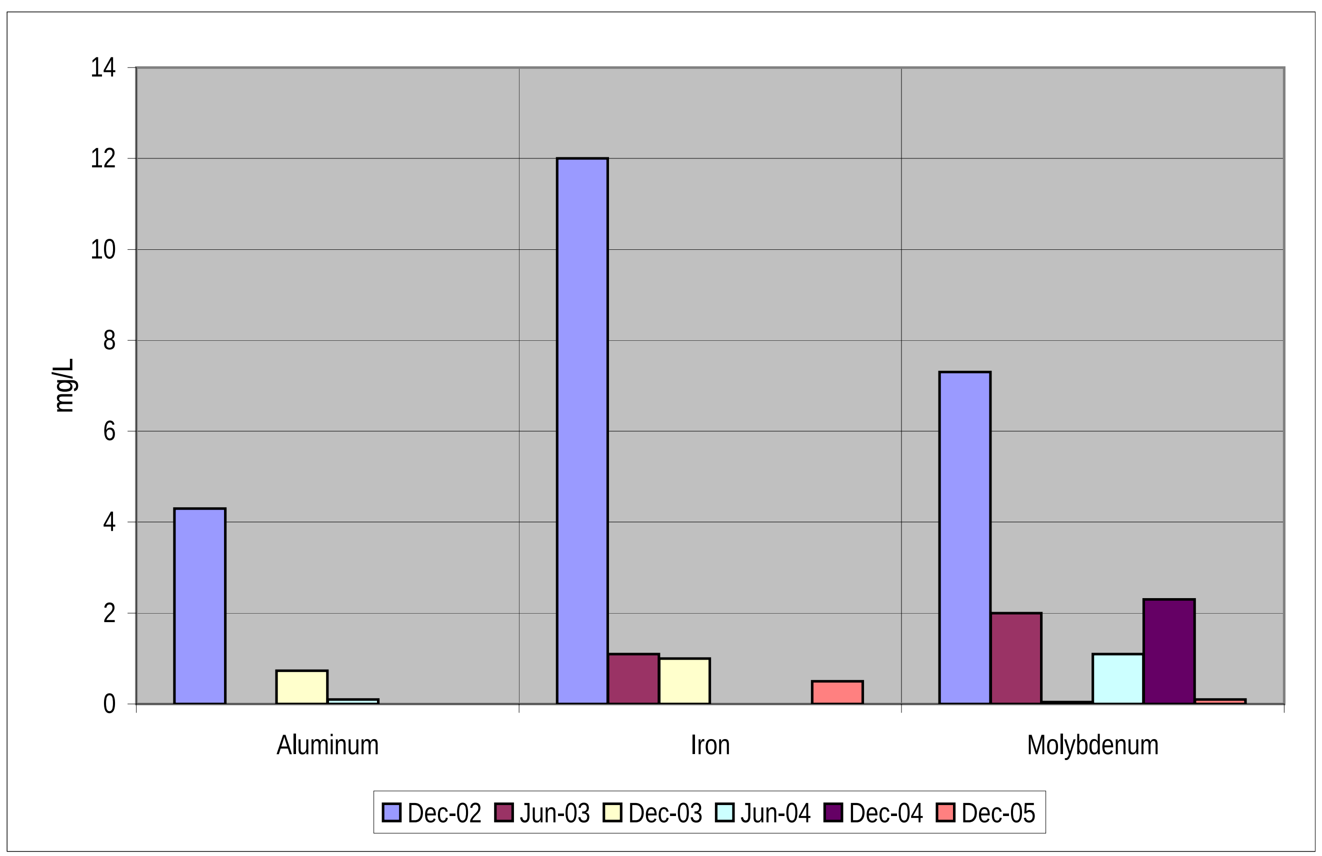

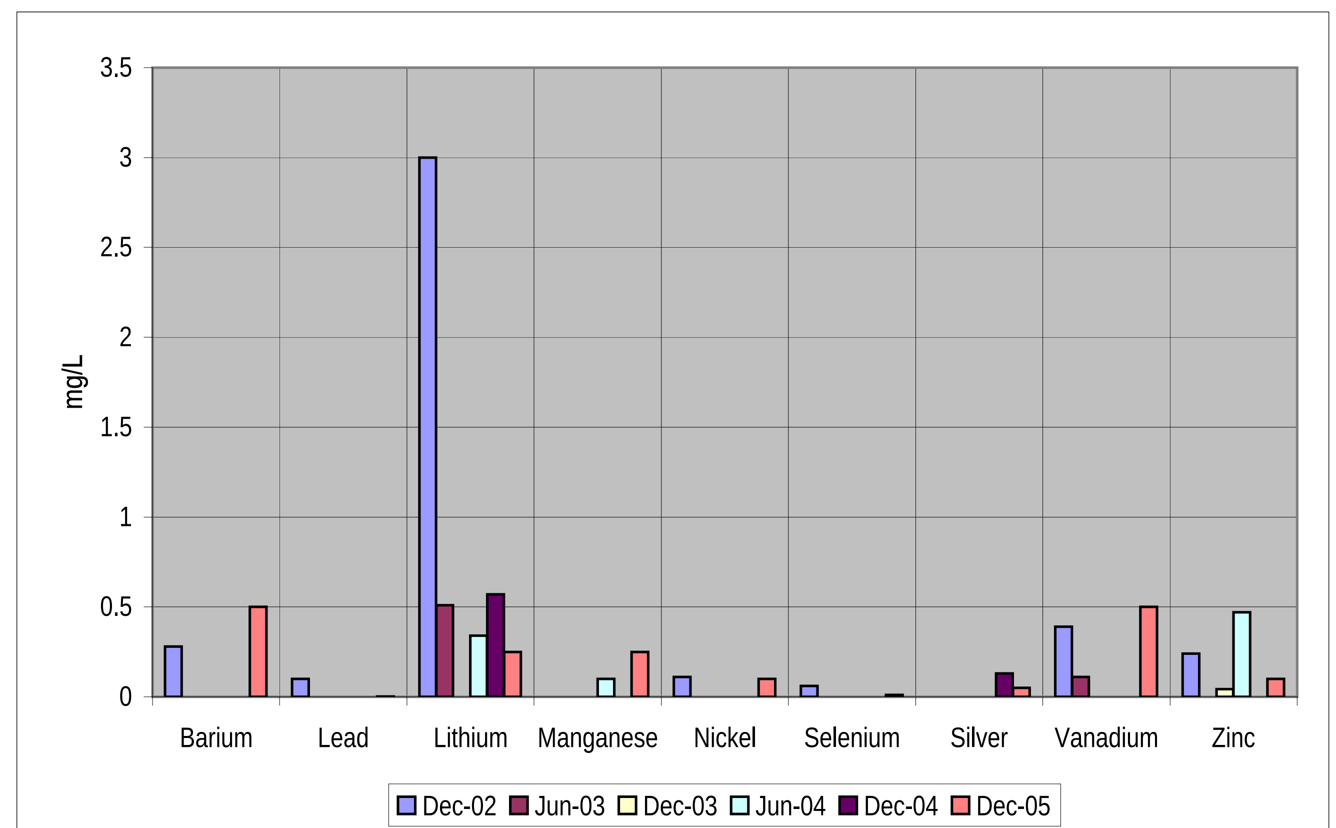

Figure 14D
Observation Wells Water Quality Trend Analysis
Owens Lake DCM SLERA

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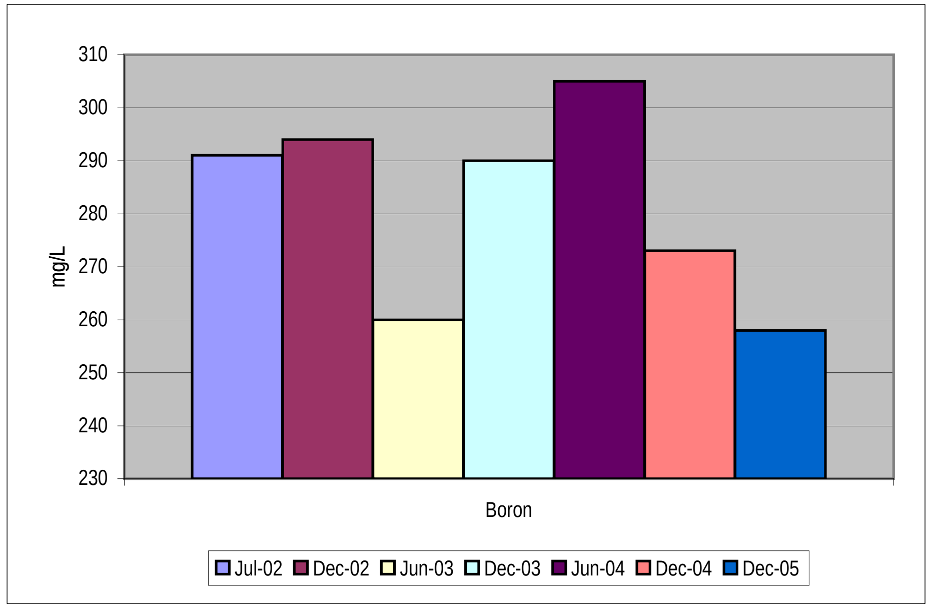

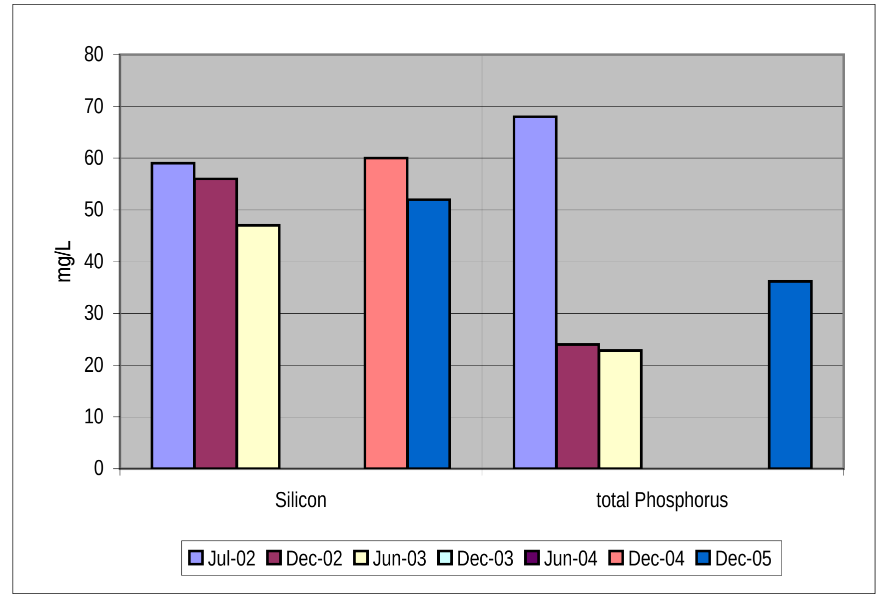

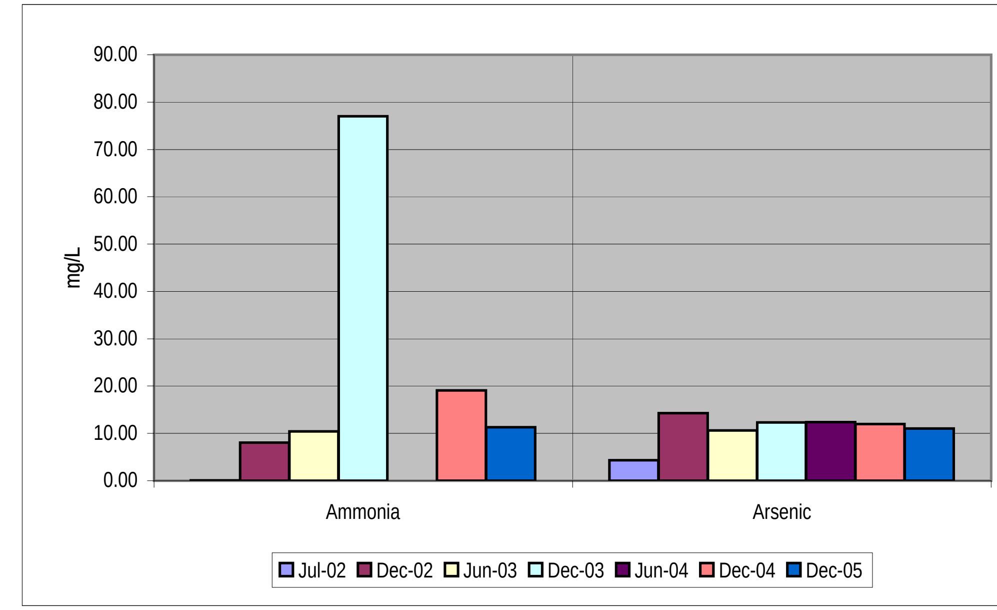

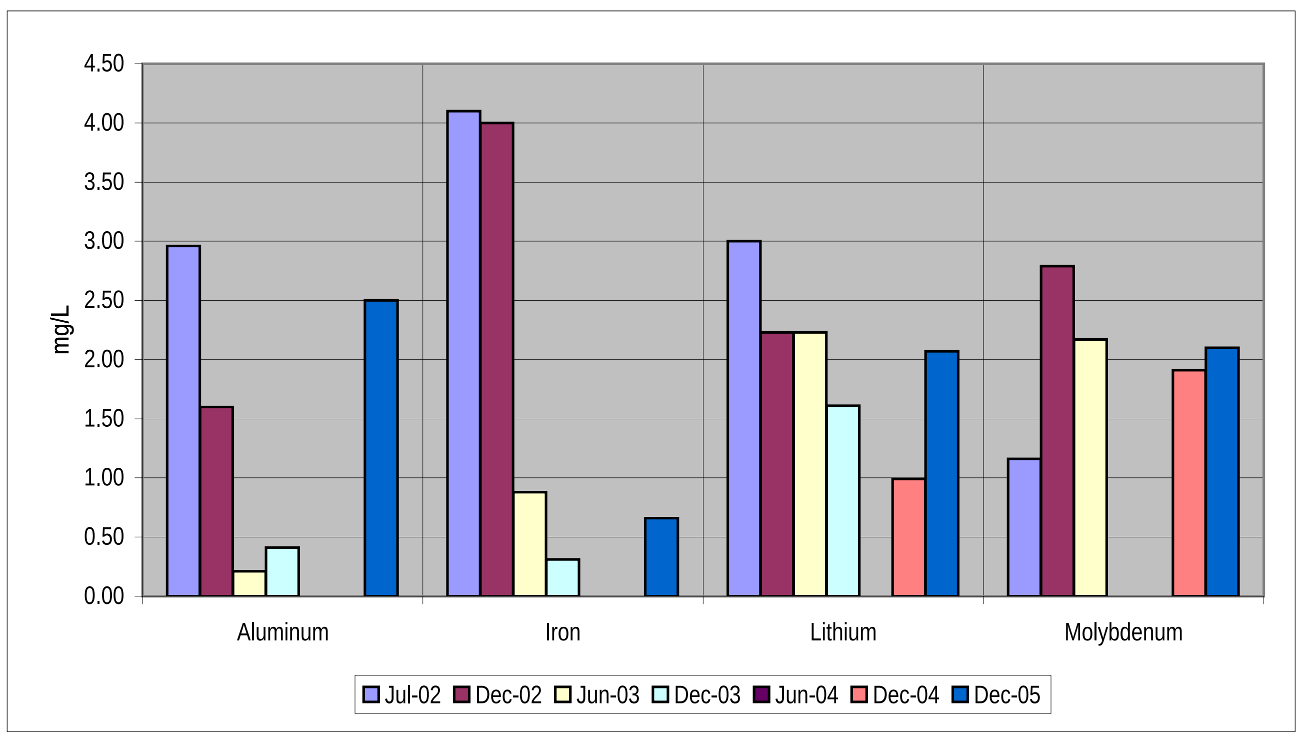

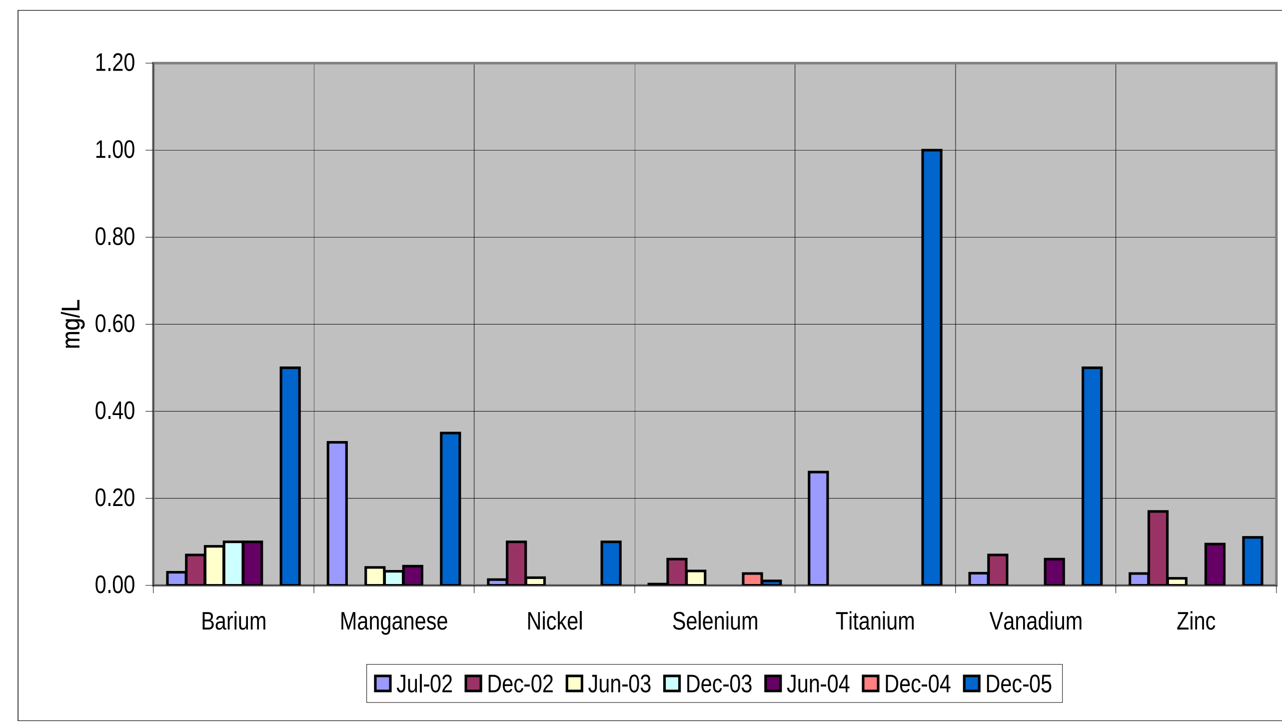

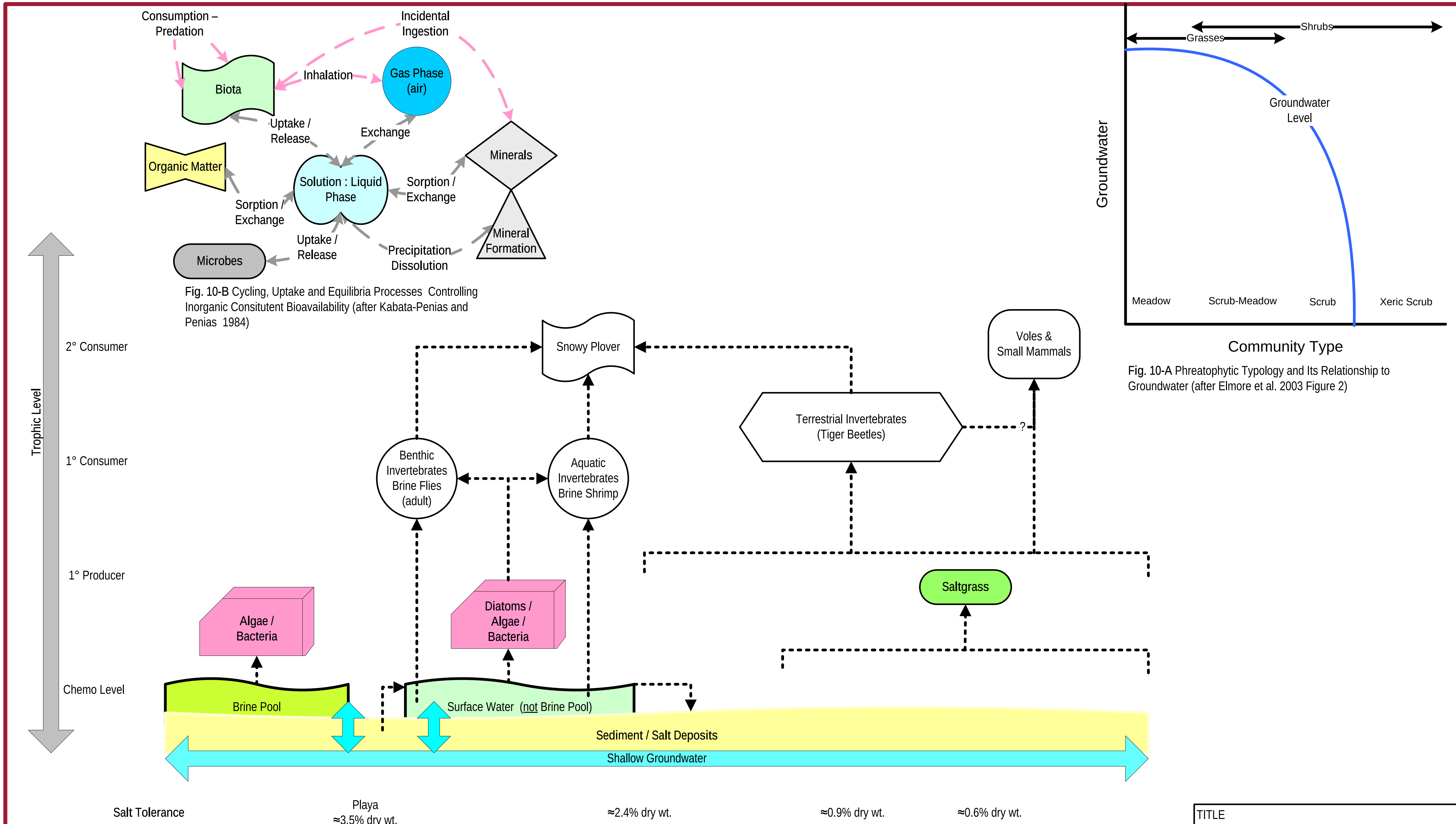

CSM Based On: Harrison, T, 1998, *The Great Salt Lake Playa Food Web*, accessed 04/17/07 (http://people.westminstercollege.edu:80/faculty/tharrison/gslfood/index.html)

TITLE

Figure 15
Conceptual Site Model
Dust Control Measure SLERA
Owens Lake, Inyo County, California

FILENAME
OWENS LAKE SLERA CSM.VSD

KLEINFELDER EXPECT MORE

Figure 16
Food Chain Analysis
Owens Lake DCM SLERA

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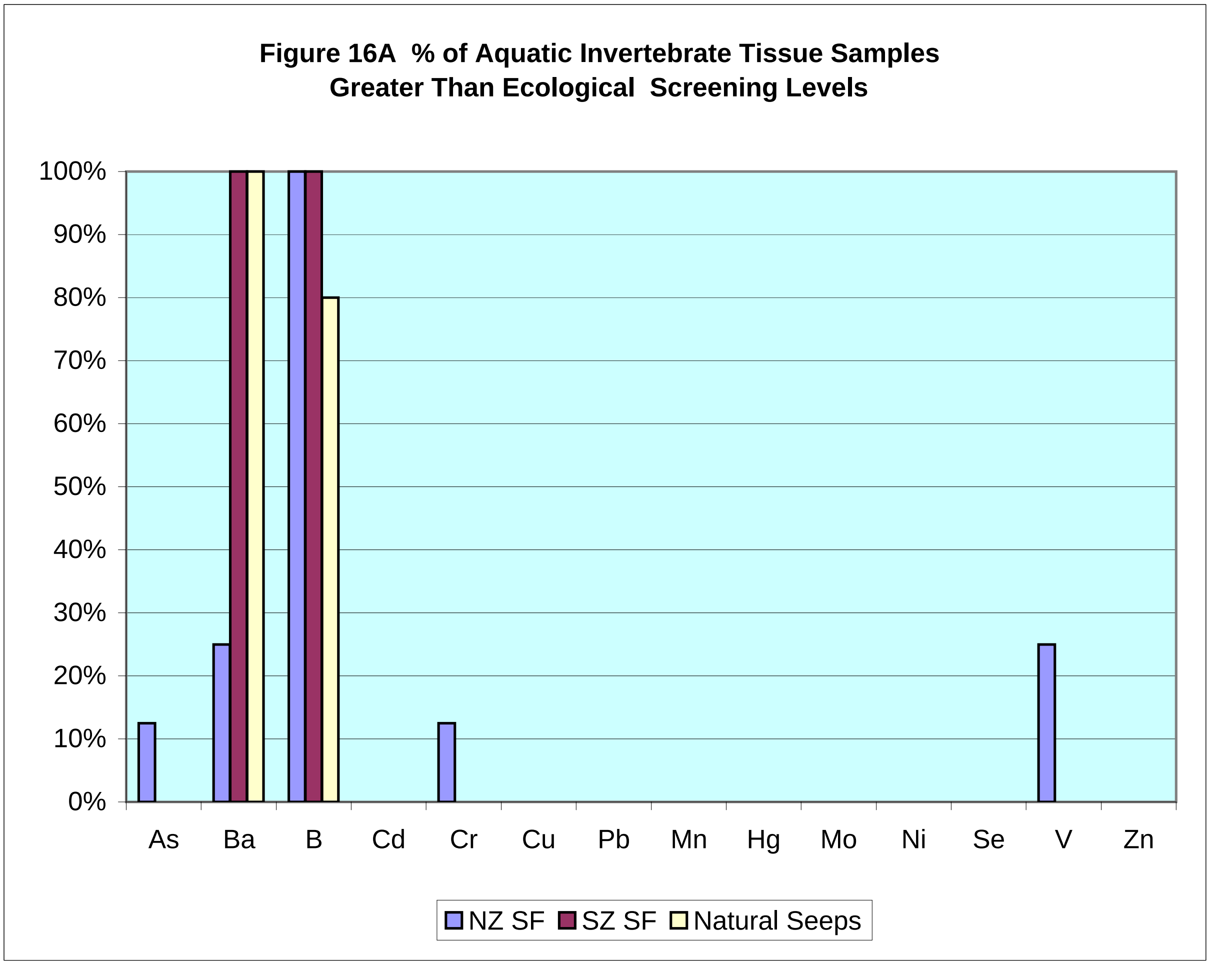
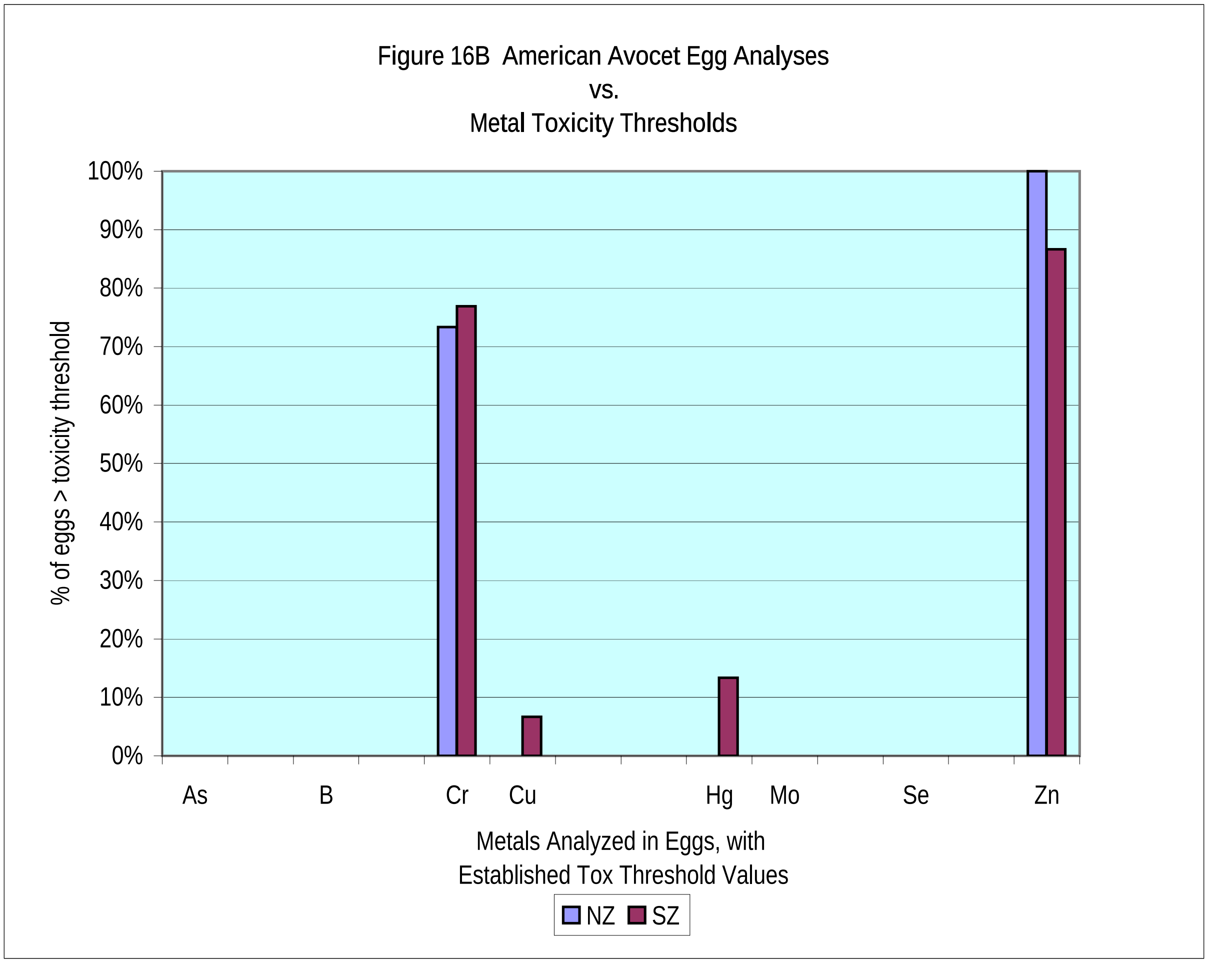


Notes :

1. Brine fly samples were collected from two Owens Lake shallow flooded operation areas
   NZ= northern zone (Zone 2), SZ= southern zone (Zones 3 and 4), in May 2003.
2. Samples from natural spring/seep areas were collected in April - June 2002 (n=1, Swedes Pasture; n=2, Tubman Springs; n=2, Dirty Socks)
3. The 2002 eco sampling data reported in Table 28 are different from those reported for the same dates and sampling locations in the Eco Risk Screening Tech. Memo 2002 Monitoring Results.
   Tech Memo Table 3 reported metal samples mean and max; samples of brinefly and other invertebrates in natural springs included samples above screening values for As, Ba, B, Hg,and Zn.
   Data presented in the 2002 tech memo are assumed to have been corrected in the 2003 Annual Report.

Source: Data compiled from Table 28 of April 2003 Owens Lake Annual Monitoring Report, and Table B-4 of April 2004 OL Annual Monitoring Report, App B, Eco Risk Screening 2003 Monitoring Report.

Figure 16
Food Chain Analysis
Owens Lake DCM SLERA



Notes : 1. Eggs were collected from nests in the Northern Zone (NZ, Zone 2) or Southern Zone along Main Line Rd (SZ, Zones 3-4) areas, in May and June, 2003, resp.
2. Number of eggs analyzed for each element in each zone ranged from n=4 to n=16.

Source: Data compiled from Table B-5 of Eco Risk Screening 2003 Monitoring Report, in the April 2004 Annual Monitoring Report.

Figure 17
Snowy Plover Hatch Success
Owens Lake DCM SLERA

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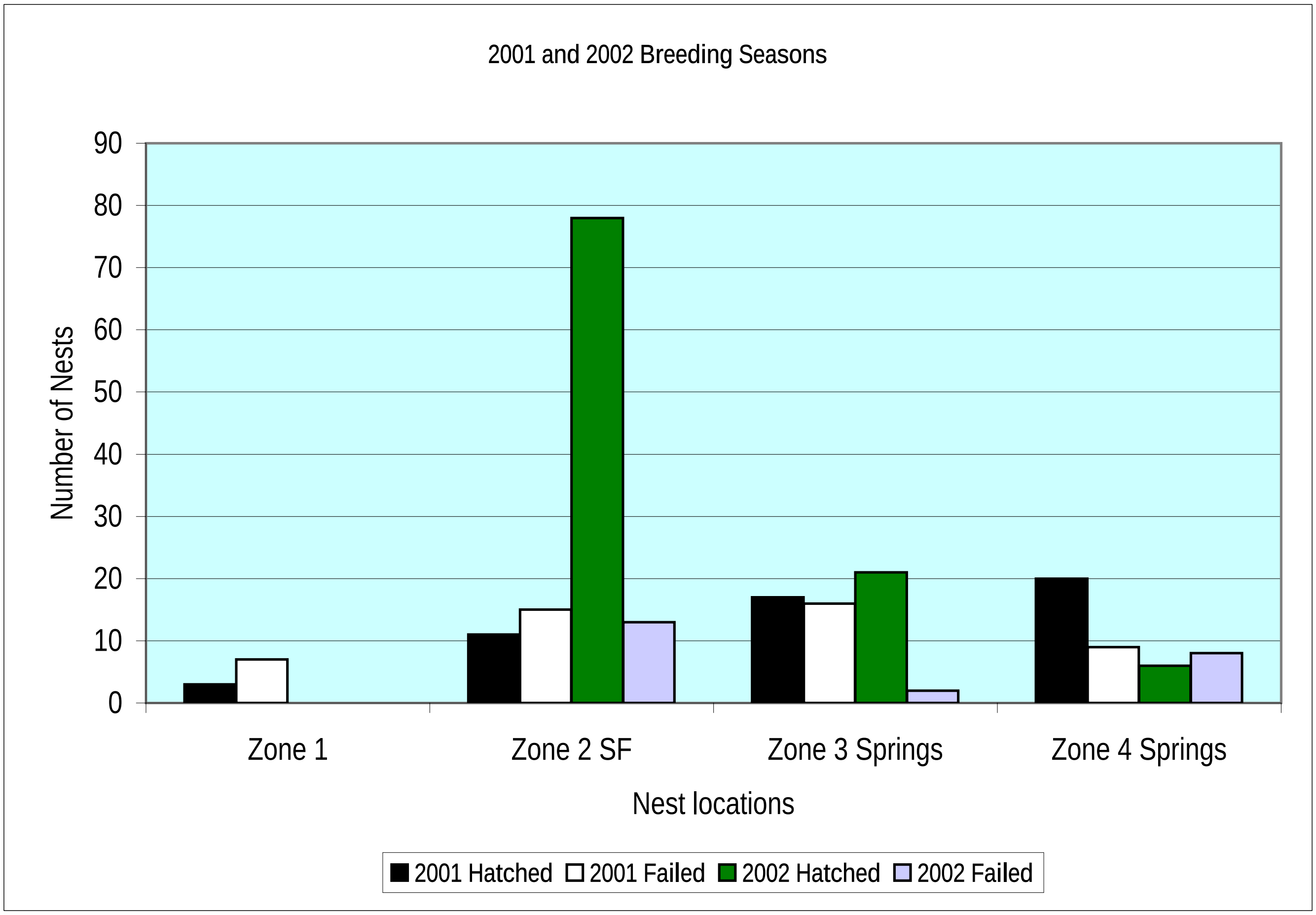

Notes: Zone 1 was only surveyed in 2001.
Zone 2 surveyed in 2001 during construction and 2002, year 1 of Shallow Flood operation.
Zone 3 surveys found plover nesting along springs adjacent to the DCA, including Tubman and Whiskey Springs
Zone 4 includes nesting along the Dirty Socks Seep, Southwest Seep, Phase II DCA and Cartago Creek.

Source: 2001 and 2002 nesting data were obtained from Pt Reyes Bird Observatory reports.

Figure 18
Avian Population Abundance 2001-2007
Owens Lake DCM SLERA

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Figure 18A. Snowy Plover Adults
May - June Surveys

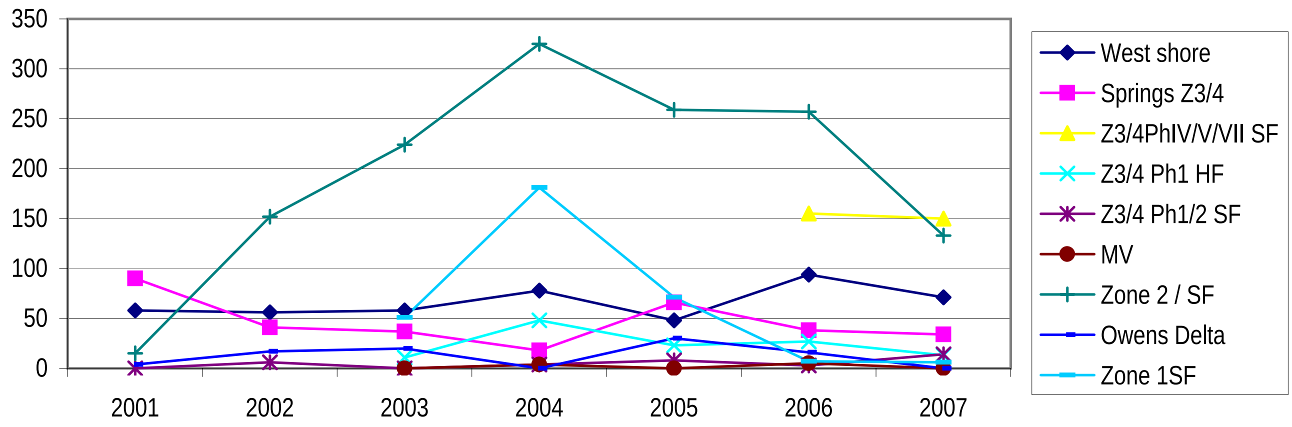

Figure 18B. American Avocet Adults May - June Surveys

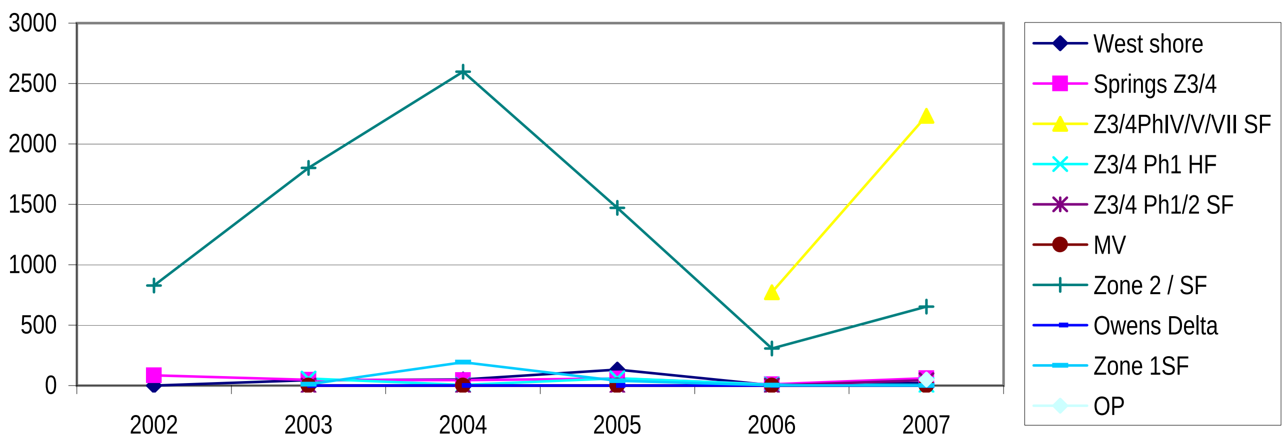

Figure 18C. Black-necked Stilt Adults May - June Surveys

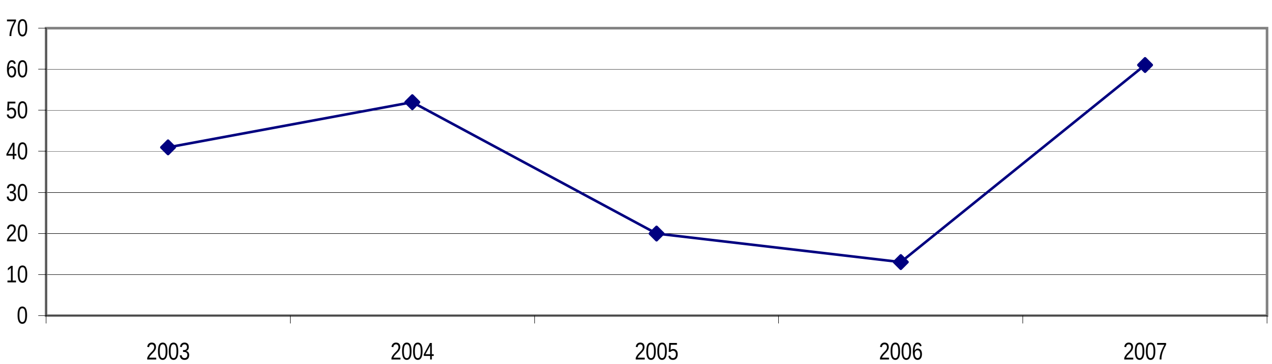

Figure 18
Avian Population Abundance 2001-2007
Owens Lake DCM SLERA

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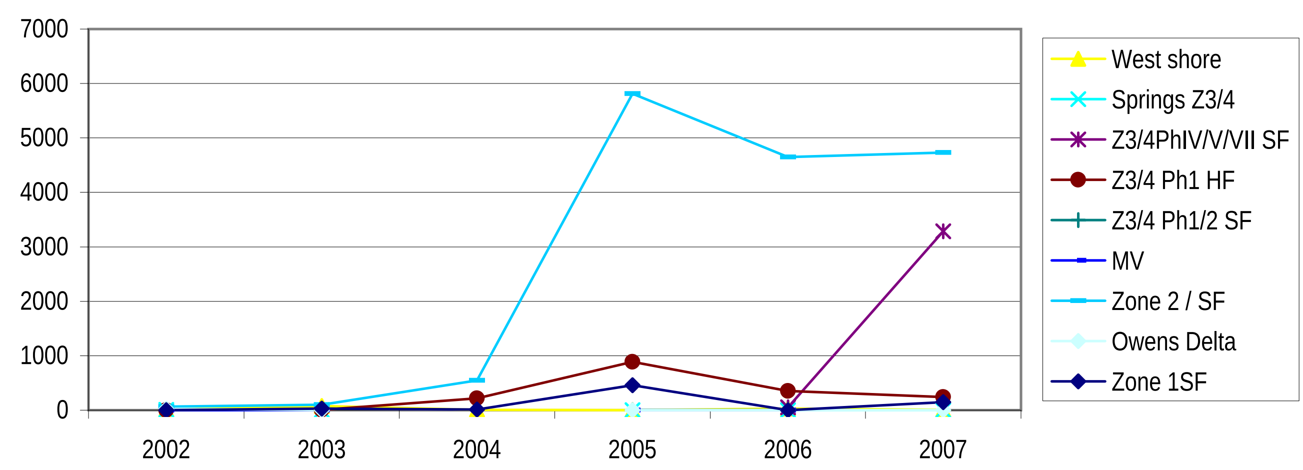

Figure 18D. Adult and Immature Gulls May - June Surveys

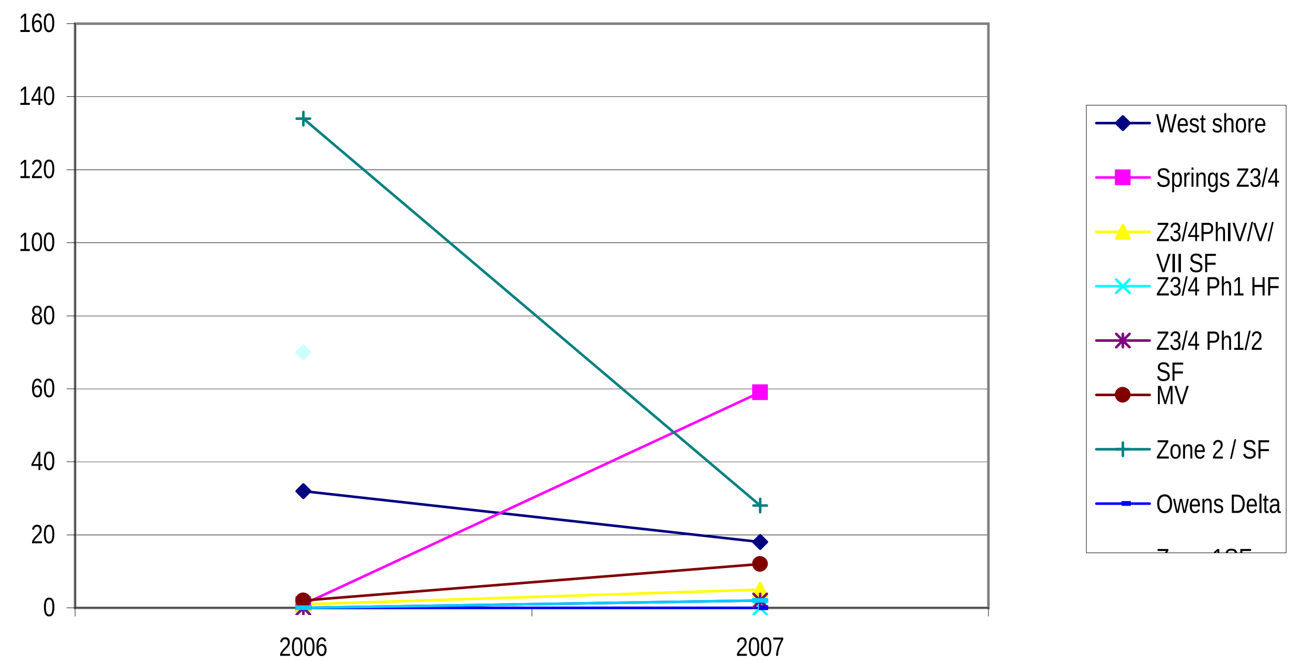

Figure 18E. Common Ravens

Source: Ruhlen, T. and Gary Page 2001, 2002, 2004, 2005
Page, G. and T. Ruhlen, 2006
2007 data: excel spreadsheets (Append 1 SNPL data, Append 2 AMAV etc data, Append 3 Raven)

Figure 19
Non-predatory Bird Mortality
Southern Zone Project Areas 2002-2005
Owens Lake DCM SLERA

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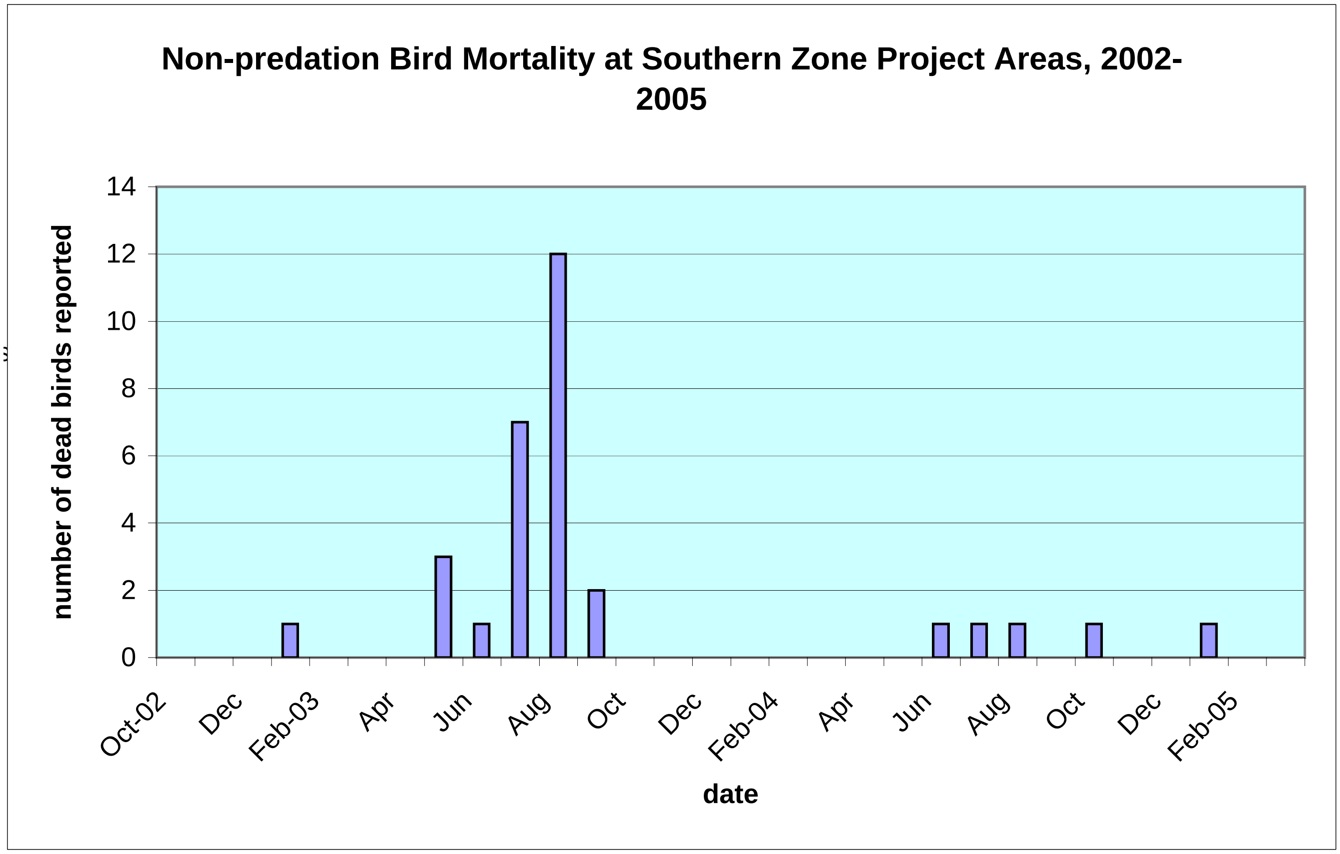

Notes: Identifications and locations where found:
one black-crowned night heron at shore of OP (Jan 2 one gull (Oct 2004), and
22 juvenile ring billed gulls (located along with feeding gulls at OP, June -Sept. 2003),
three gulls (Jun - Aug 2004, location not given),
feeding gulls at OP, Jun through Sep 2003), three gulls (Jun - Aug 2004, location not given), one gull (Oct 2004), and
one ferruginous hawk (location not given, Jan 2005).
May 2003 opportunistic observations indicate no mortalities, but
2003 ecological risk screening monitoring report indicates three mortalities in May 2003
(Bonaparte's gull at SE shore of OP, juvenile ring-billed gull, and American avocet)

Source: CH2MHill, 2003c, 2004, 2005, Survey data

Figure 20
Avian Population Relative Diversity Across
Project Areas (2002 - 2005)
Owens Lake DCM SLERA

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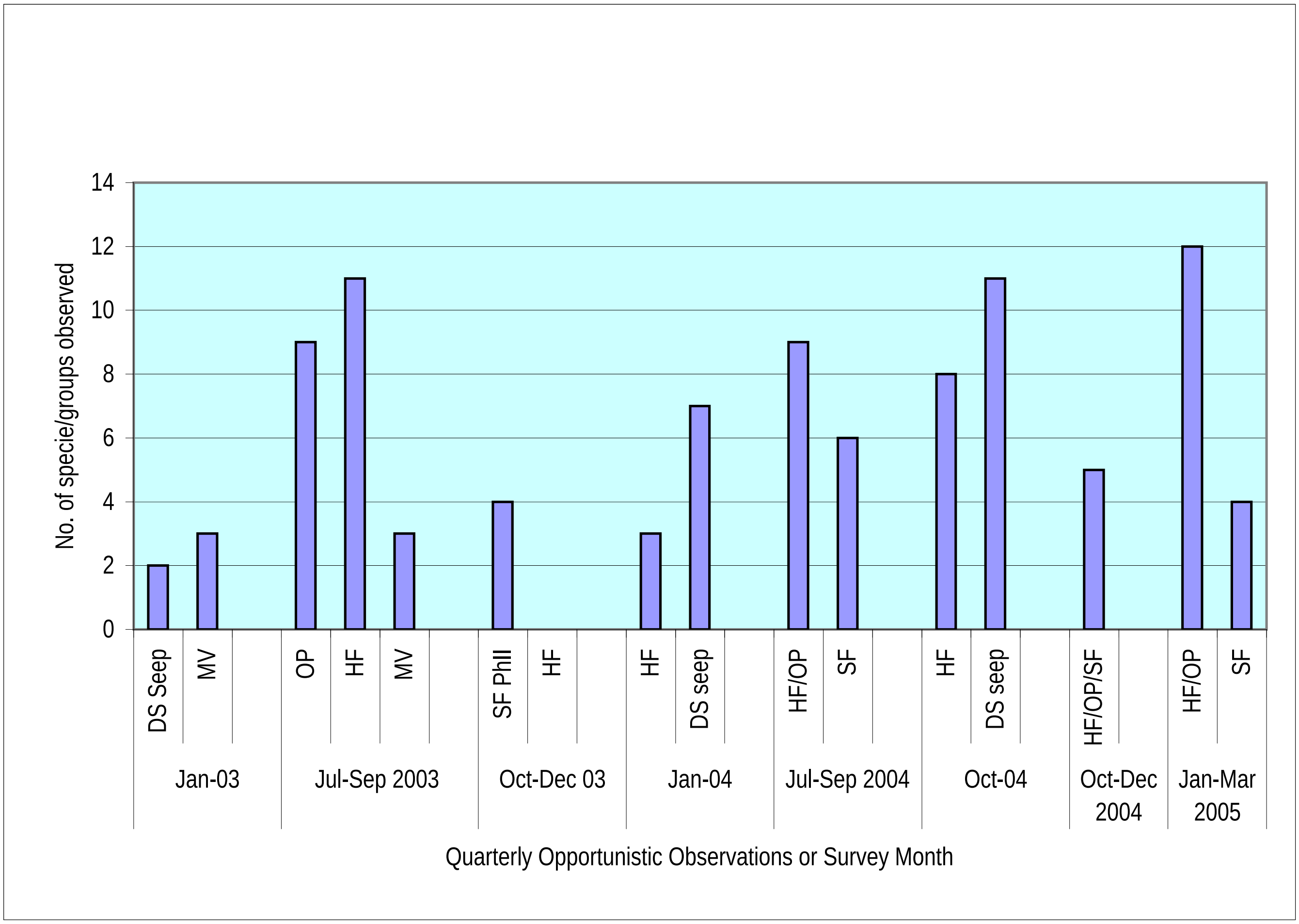

Notes: DS Seep: Dirty Socks Outflow MV: managed vegetation OP: operation ponds
HF: habitat shallow flooding SF: shallow flooding.
Data came from quantitative surveys of all wildlife present in a project area (Jan-03, Jan-04, and Oct-04) or from non-quantitative opportunistic observations noted in report text or survey tables
Individual species or bird groupings identified on different dates/quarters are enumerated above to compare diversity of avian population assemblages using the project areas.
The species or larger groupings enumerated include:
American avocet, white-footed Ibis, black-neck stilt, gulls, grebes, cinnamon teal, peregrine falcoln, sandpipers, Wilson's phalarope, greater yellowlegs, marbled gadwit, horned lark, small mammals, predators (fox), raven, killdeer, ruddy duck, common snipe, northern harrier, marsh wren, house finch, sparrows, waterfowl, pelican, long-billed dowitcher, snowy plover, black-bellied plover, amer. Widgeon, long-billed curlew, gadwall, mallard, amer. Coot, geese, bufflehead, pintail, other ducks, shorebirds, roadrunner, cranes.
Certain individual species were summed into a group to compare specific identification data with opportunistic observations. For example, identifications of ring-billed/Bonaparte's/California/western gulls were counted as a single species grouping to allow comparison with opportunistic observation of "gulls". "Grebes", "sandpipers", and "sparrows" were likewise grouped together. Thus, this chart indicates relative diversity among sightings across different zones, but undercounts actual species diversity. Where "shorebirds" and "other ducks" were observed in addition to gulls, grebes, and identified single species, they were likewise counted as a single specie/group observation.

Source: CH2MHill, 2003, 2004 and 2005 Annual Monitoring Reports

Figure 21
Bird Observation Frequency Across Project Areas
Owens Lake DCM SLERA

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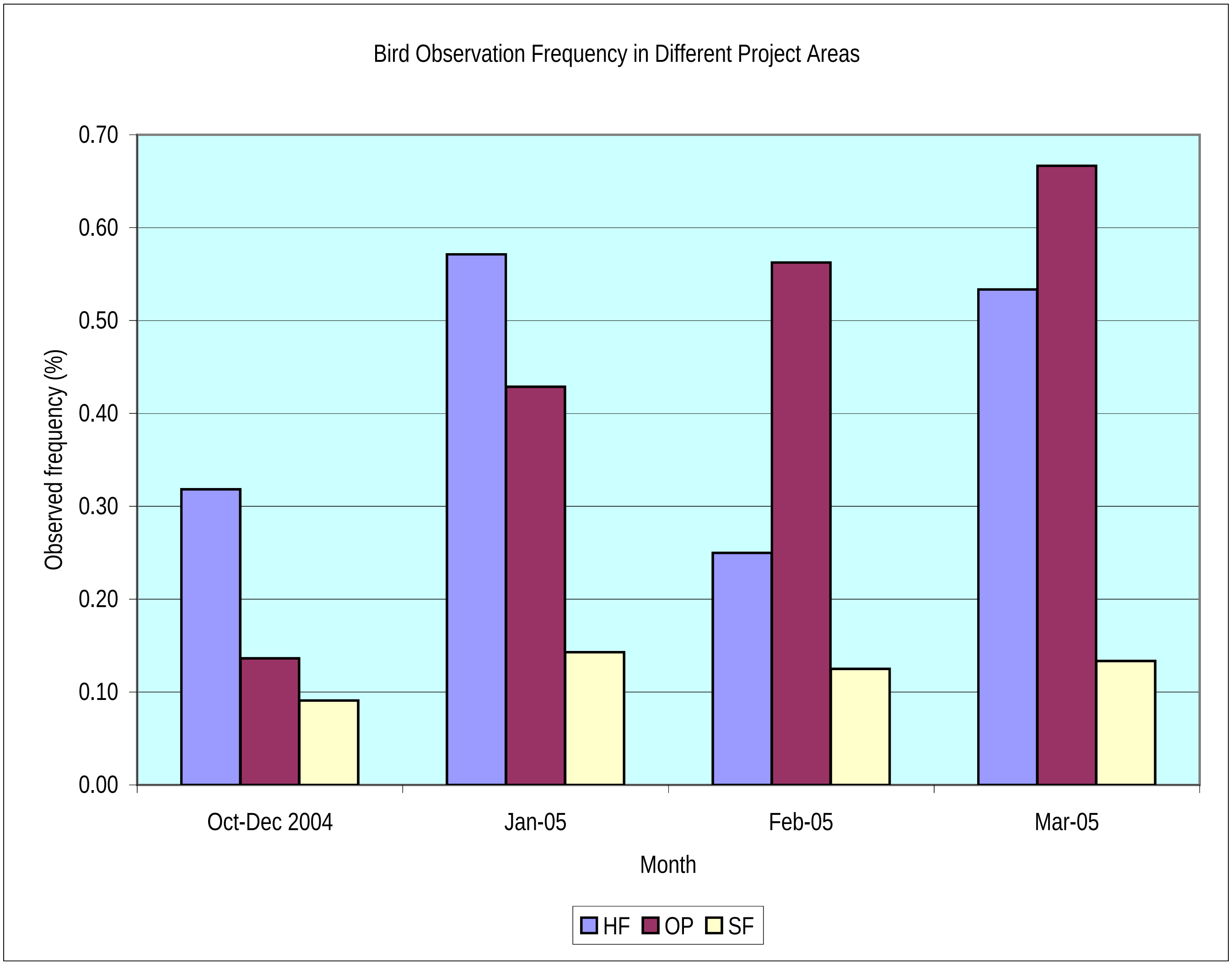

Notes: HF: Habitat shallow flood; OP: operation ponds; SF: shallow flooding.

Source: CH2MHill, 2005, Frequency of opportunistic bird sightings for Jan-Mar 2005, Table 7
Quarterly bird sighting frequencies from Sec. 6.1.3.4.

APPENDICES

Appendix A – Tables A-1 and A-2

Table A-1
General Lakebed Soil Quality
Owens Lake DCM SLERA

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Date	Class	Na		Mg		Al		Si		S		Cl		K		Ca		Ti		V		Cr		Mn	
		%	±%	%	±%	%	±%	%	±%	%	±%	%	±%	%	±%	%	±%	%	±%	ppm	±	ppm	±	ppm	±
08/11/95	L	7.58	2.72	1.65	0.63	4.3	0.36	18.1	1.2	1.79	0.16	5.01	0.34	2.26	0.15	5.5	0.36	0.25	0.02			41	9	680	50
10/27/95	L	14.6	2.7	1.96	0.56	3.93	0.33	16.9	1.1	2.47	0.19	11.5	0.8	2.05	0.14	4.72	0.31	0.19	0.01					510	40
11/04/95	L	10.2	2.2	1.6	0.46	4.53	0.34	18.7	1.2	2.49	0.19	7.06	0.47	2.49	0.17	4.44	0.29	0.26	0.02			31	10	730	50
12/22/95	L	12	2.1	1.76	0.44	4.27	0.32	17.2	1.1	4.95	0.34	4.67	0.31	1.94	0.13	4.38	0.29	0.2	0.01	46	24	27	8	590	40
01/24/96	L	8.32	1.58	2.26	0.37	5.34	0.38	20.6	1.4	2.5	0.18	4.17	0.28	2.73	0.18	4.57	0.3	0.27	0.02	95	32	21	10	750	50
02/09/96	L	14.9	2.64	1.96	0.54	4.09	0.33	16.6	1.1	2.8	0.21	11.9	0.8	1.89	0.13	6.03	0.4	0.2	0.01	74	25			500	40
03/17/96	L	8.02	1.88	2.88	0.47	3.54	0.27	19.3	1.3	3.05	0.22	3.11	0.21	1.82	0.12	11.4	0.75	0.13	0.01			29	8	470	30
08/23/96	L	8.56	2.19	3.35	0.56	3.02	0.26	19.1	1.3	1.87	0.15	4.07	0.27	1.58	0.11	11.6	0.76	0.13	0.01			19	8	400	30
11/17/96	L	6.8	1.74	3.05	0.45	3.99	0.3	20.2	1.4	1.77	0.14	2.94	0.2	1.98	0.13	11.4	0.7	0.16	0.01			24	9	520	40
12/08/96	S	10.3	2	2.8	0.5	4.79	0.35	19.8	1.3	2.44	0.18	5.54	0.37	2.24	0.15	6.05	0.4	0.23	0.02	70	28	26	9	630	40
12/27/96	S	6.82	1.76	3.18	0..21	4.54	0.34	20.7	1.4	1.39	0.11	3.14	0.21	2.19	0.15	8.75	0.58	0.2	0.01					580	40
01/10/97	S	5.02	1.8	4.36	0.56	3.17	0.26	21.5	1.5	0.66	0.08	2.08	0.14	1.93	13.5	10.6	0.7	0.19	0.01	67	29	39	10	530	40
01/18/97	S	8.03	1.95	3.47	0.52	4.84	0.36	19..4	1.3	1.11	0.1	6.16	0.41	1.65	0.11	12.4	0.81	0.13	0.01			34	8	350	30
01/27/97	C	4.19	1.8	2.64	0.47	4.84	0.36	22.3	1.5	0.39	0.07	1.98	0.14	2.07	0.14	9.47	0.62	0.2	0.01			31	9	540	40
03/18/97	C	6.36	1.87	3.81	0.53	4.04	0.31	20.7	1.4	0.83	0.08	4.05	0.14	2.03	0.14	9.83	0.65	0.16	0.01			27	9	460	40
05/12/97	C	7.51	2.02	2.6	0.49	4.78	0.36	20.9	1.4	1.18	0.11	4.77	0.15	2.22	0.15	7.33	0.48	0.23	0.02			30	9	590	40
Average	L	10		2.3		4.1		19		2.6		6.0		2.1		7.1		0.2		72		27		572	
Average	S	7.5		3.5		4.3		21		1.4		4.2		2.0		9.5		0.2		69		33		523	
Average	C	6.0		3.0		4.6		21		0.8		3.6		2.1		8.9		0.2				29		530	
Average	All	8.7		2.7		4.3		20		2.0		5.1		2.1		8.0		0.2		70		29		552	

Table A-1
General Lakebed Soil Quality
Owens Lake DCM SLERA

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Date	Class	Fe		Ni		Cu		Zn		Ga		As		Br		Rb		Sr		Zr		Ba		Pb	
		ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±	ppm	±
08/11/95	L	2.83	0.19	13	4	30	4	93	8	17	3	24	5	83	8	140	10	640	50	54	13	280	60	31	7
10/27/95	L	2.11	0.14	10	3	18	3	78	6	14	3	38	5	87	8	91	9	470	30	77	12	180	50	29	6
11/04/95	L	2.83	0.19	19	4	35	4	100	8	13	3	35	6	95	9	120	10	470	40	53	12	260	60		
12/22/95	L	2.28	0.14	9	3	21	3	73	6	13	3	15	4	37	5	100	9	450	30	53	11	190	50	24	6
01/24/96	L	3.09	0.2	13	4	36	4	100	10	15	3	13	5	68	7	150	13	500	37	50	12	350	60	31	7
02/09/96	L	2	0.13			21	3	69	6	9	3	7	4	41	5	88	8	580	40	49	11			24	6
03/17/96	L	1.41	0.09	10	3	11	2	46	4	9	3	17	4	11	3	88	8	0.11	0.01	69	14	390	60		
08/23/96	L	1.37	0.09	16	3	16	3	47	4	11	3	21	4	12	3	85	8	0.12	0.01	54	13	190	50		
11/17/96	L	1.73	0.11	14	3	21	3	66	6	13	3	18	4	22	4	83	8	0.11	0.01			410	60		
12/08/96	S	2.54	0.17	18	4	30	4	93	7	17	3			20	4	120	10	640	50	55	12	270	60	30	6
12/27/96	S	2.18	0.14	11	3	20	3	71	6	10	3	22	4	18	4	100	10	910	60	84	14	320	60	17	6
01/10/97	S	1.97	0.13	13	4	27	4	69	6	16	3	12	5	13	4	100	10	0.11	0.01	68	16	260	60	27	7
01/18/97	S	1.21	0.08	15	3	18	3	40	4	6	3	20	4	18	3	75	7	0.12	0.01	93	15	320	60		
01/27/97	C	2.13	0.14	14	4	21	3	69	6	158	3					110	10	950	70	62	14	350	60	32	7
03/18/97	C	1.81	0.12	16	4	18	3	57	5	12	3	14	4	17	4	94	9	0.11	0.01			390	60	19	6
05/12/97	C	2.46	0.16	12	3	28	4	86	7	15	3	11	5	32	5	130	11	52	52	62	13	250	60	31	7
Average	L	2.2		13		23		75		13		21		51		105		346		57		281		28	
Average	S	2.0		14		24		68		12		18		17		99		388		75		293		25	
Average	C	2.1		14		22		71		62		13		25		111		334		62		330		27	
Average	All	2.1		14		23		72		22		19		38		105		354		63		294		27	

Concentrations are in parts per million except as %. Blank fields indicate element not present above minimum limit of detection.

Source: Gill, TE, DA Gillette, T Niemeyer and RT Winn, 2002, Elemental geochemistry of wind-erodible playa sediments, Owens Lake, California, Nuc Instrum Methods Phys Res B 189:209-213. Table 2

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Fmu	Depth Class*	Clay	Sand	pH	EC	B.D.	As	K	B	Ca	Mg	Na	Cl	SO4	CO3	HCO3	NO3
	(inches)	(%)	(%)	p(molar)	(dS/m)	(g/cm3)	(meq/100 g)										
A1	0	4	93	9.7	162		0.70		378	0.20	0.10	1007	553	133	448	0	0.10
	6	20	64	9.6	121	1.27	0.93	41	148	1.45	0.46	1716	712	187	514	26	0.20
	12	33	32	9.5	191	0.70	1.67	46	171	0.27	0.00	2663	1419	326	619	75	0.70
	24	11	70	9.6	147	1.25	1.43	61	139	0.31	0.21	2173	963	236	600	37	0.05
	36	19	65	9.7	132	0.60	1.42	56	106	0.50	0.16	1695	873	227	448	24	0.00
	72	41	25	9.7	111	0.70	0.60	32	85	0.10	0.00	1244	700	189	328	0	
B3	0																
	6	1	96	9.6	122	1.40	0.90	54	142	2.60	0.80	1804	711	201	544	0	
	12	4	90	9.2	163		1.50	70	172	0.50	0.50	2338	953	287	816	44	
	24	0	98	9.8	54		0.30	22	61	2.10	1.00	858	291	84	248	0	
	36	1	99	9.6	53		0.50	22	57	5.60	1.70	851	293	86	288	4	
CL1	0			9.6	171				677								
	6	34	29	9.6	189	0.86	2.74	60	181	0.44	0.30	2516	1309	396	659	121	0.20
	12	42	13	9.6	192	0.67	2.13	64	153	0.13	0.00	2214	1747	591	537	68	0.15
	24	39	12	9.6	203	0.70	1.80	70	163	0.38	0.28	2650	1504	480	637	55	0.05
	36	33	21	9.5	195	0.58	1.98	71	155	0.16	0.08	3198	1586	420	570	58	0.00
	72	48	5	9.6	187	0.80	0.50	61	137	0.15	0.05	1866	1315	342	544	42	0.00
CL2	0			9.4	203				443								
	6	25	35	9.9	180	0.90	2.10	50	235	0.96	0.26	2741	1263	566	774	16	0.30
	12	33	33	9.6	207	0.78	2.20	57	170	0.18	0.00	2940	1710	470	924	86	0.13
	24	27	41	9.5	240	0.76	3.23	91	253	0.19	0.07	3797	2368	608	1113	93	0.08
	36	38	13	9.4	227	0.61	2.75	90	198	0.19	0.09	3671	2119	564	794	173	0.00
	72	36	16	9.5	213	0.65	0.70	59	133	0.15	0.00	2381	1535	327	632	44	0.00
CT1	0			9.7													
	6	20	34		217	1.00	5.00	97	312	0.20	0.10	3726	1380	348	632	0	
	12	13	58	9.2	128		1.90	58	292	0.10	0.00	1975	824	172	704	0	
	24	26	28	9.7	248		4.30	120	290	0.20	0.20	4336	1970	481	1020	44	
CT2	0																
	6	13	64	9.5	187	1.00	2.56	66	236	0.44	0.32	2957	1140	283	845	67	
	12	16	43	9.3	274	0.83	3.40	123	320	0.63	1.00	4627	2333	666	1488	330	
	24	12	65	9.6	214	0.90	3.40	99	294	0.40	0.08	3413	1835	527	1041	68	
	36	12	54	9.5	183	1.05	2.90	72	203	1.40	0.53	3637	1216	380	912	57	
	72	11	56	9.4	258	0.60	3.00	137	315	1.17	0.50	5629	2760	738	1089	36	
CT3	0	38	27	9.4	229		7.10	182	1140	1.00	0.90	7709	3450	1620	984	0	
	6	24	46	9.5	211	1.40	2.50	75	298	0.47	0.50	4764	1657	781	699	11	0.50
	12	29	42	9.6	215	0.90	4.10	118	298	0.30	0.30	3567	1685	497	696	8	0.20
	24	28	52	9.5	148	1.20	2.33	82	232	0.43	0.60	3428	1567	470	886	57	0.00
	36	25	37	9.3	223		2.30	95	262	0.60	0.33	4985	1753	524	1067	99	
D1	0																
	6	1	94	10.1	6	1.50		3	22	0.60	3.45	79	38	8	30	0	
	24	2	96	10.1	5	1.50	0.20	3	25	8.15	19.40	67	27	42	35	8	
	36	1	95	10.1	12		0.20	6	37	7.25	18.30	141	67	46	55	4	
G1	0	4	91	9.9	94	1.60	1.70	19	132	0.40	0.15	1198	570	110	428	28	
	24	25	70	9.7	167		2.80		176	0.20	0.10	1911	1140	271	656	92	0.10
	36	10	84	9.6	143	1.80	3.80	58	204	0.85	0.45	2614	683	225	844	34	

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Fmu	Depth Class*	Clay	Sand	pH	EC	B.D.	As	K	B	Ca	Mg	Na	Cl	SO4	CO3	HCO3	NO3
	(inches)	(%)	(%)	p(molar)	(dS/m)	(g/cm3)	(meq/100 g)										
J1	0			9.6	168		1.00	35	651	0.40	0.20	4050	937	1790	1560	30	
	6	39	20	9.4	160	0.81	1.88	63	144	0.33	0.11	2054	1225	322	517	30	0.20
	12	48	13	9.9	130	0.88	1.50	45	110	0.15	0.03	1669	950	310	471	53	0.10
	24	47	14	9.6	178	0.75	0.90	49	153	0.15	0.00	1895	1140	373	528	28	#DIV/0!
	36	39	24	9.5	82	0.95	0.83	35	40	0.33	0.58	1021	579	144	188	1	0.00
	72	54	9	9.7	107	0.90	0.40	168	62	0.09	0.19	1177	767	246	246	17	0.00
J2	0																
	6	43	11	9.4	205	0.75	3.85	112	233	0.15	0.15	2397	1575	396	820	8	
	12	46	8	9.5	187	0.75	1.90	98	160	0.00	0.25	1856	1380	388	564	0	
	36	44	9	9.5	172	0.75	1.50	75	133	0.00	0.00	1814	1186	389	524	0	
	72	54	6	9.5	143	0.85	0.20	73	100	0.05	0.15	1422	960	278	444	0	
J3	0			9.6	150				490								
	6	35	26	9.3	215	0.62	3.16	84	267	0.30	0.02	3444	1714	1098	826	87	0.10
	12	29	33	9.4	192	0.65	1.38	71	147	0.23	0.05	2972	1402	342	664	41	0.60
	24	39	13	9.5	192	0.56	2.18	81	182	0.18	0.00	3036	1686	442	846	64	0.03
	36	40	13	9.4	186	0.60	2.00	76	236	0.40	0.00	3070	1220	377	704	76	
	72	42	13	9.5	169	0.68	1.30	67	121	0.19	0.03	2369	1270	290	600	39	0.00
J4	0	31	38	9.4	202		2.60	62	403	0.30	0.00	3923	1460	436	1150	208	
	6	23	50	9.9	158	1.08	1.93	42	188	0.89	0.38	2975	903	329	1397	100	0.23
	12	47	18	9.5	209	0.72	3.00	76	238	1.29	0.28	3506	1615	424	987	78	0.20
	24	31	23	9.6	197	0.63	2.35	59	182	0.75	0.17	3353	1469	506	976	126	0.05
	36	40	15	9.4	216	0.66	2.32	69	208	0.20	0.01	3958	1526	518	881	98	0.00
	72	40	18	9.5	181	0.75	0.95	53	144	0.23	0.08	2496	1238	380	707	75	0.00
J5	0			9.6	172		5.50		286	0.10	0.50	4917	3100	279	1680		
	6	43	15	9.7	162	0.78	3.80	61	142	0.15	0.00	2279	1215	412	768	86	0.30
	12	36	15	9.8	146	0.63	1.95	57	88	0.15	0.00	1765	1069	328	496	47	0.05
	24	34	19	10.0	117	0.60	1.30	50	34	0.10	0.00	1430	959	217	304	8	0.00
	36	43	17	10.0	101	0.70	1.70		78	0.10	0.00	1108	745	183	232	0	0.00
	72	48	12	9.9	108	1.80	1.45	38	56	0.10	0.00	1206	785	184	294	2	0.00
K1	0	1	95	9.6	223	1.50	6.70	106	409	1.80	1.70	3815	1460	547	840	0	
	6	6	90	9.7	167	1.55	2.78	72	221	0.65	0.68	3101	973	349	698	11	
	12	62	10	9.5	144	1.10	2.50	54	159	1.20	1.25	2563	926	243	492	0	
	24	50	26	9.6	156	1.12	2.36	64	168	0.38	0.26	2690	1054	237	475	2	
	36	60	8	9.4	98	1.10	0.30	41	61	0.45	0.40	1813	644	139	196	4	
	72	55	11	9.8	71	0.90	0.10	28	31	0.25	0.30	857	519	70	100	0	
K2	0			9.2	227				586								
	6	10	74	9.6	209		2.90	68	214	0.20	0.00	2649	1330	361	848	88	
	12	67	2	9.6	195	0.90	3.30		238	0.10	0.00	2533	1720	427	608	24	0.20
	24	53	8	9.6	188	0.90	3.30		211	0.20	0.00	2307	1440	458	544	80	0.10
	36	54	5	9.6	187	0.90	1.15	73	153	0.15	0.00	2097	1310	347	536	48	0.00
	72	35	17	9.7	175	0.70	1.80	48	117	0.20	0.00	1968	1321	290	398	62	0.00
K3	0	4	96	9.6	112	1.60	3.20	31	111	0.70	0.40	2022	654	160	400	0	
	6	5	92	9.7	171	1.40	3.07	104	271	6.90	5.57	1998	1156	284	684	0	
	12	39	13	9.3	217	0.80	0.90	83	141	0.70	0.70	4039	1470	390	936	8	
	24	25	60	9.5	189	1.35	4.00	117	337	1.40	2.57	2560	1397	380	679	0	
	36	55	8	9.3	176	1.00	2.75	91	218	0.30	0.40	2425	1180	276	636	56	
	72	64	5	9.5	166		0.53	92	175	0.13	0.27	1982	1180	232	368	1	

Fmu	Depth Class*	Clay	Sand	pH	EC	B.D.	As	K	B	Ca	Mg	Na	Cl	SO4	CO3	HCO3	NO3
	(inches)	(%)	(%)	p(molar)	(dS/m)	(g/cm3)	(meq/100 g)										
L1	0	54	18	9.6	186		2.27	66	474	0.17	0.07	5200	3117	1224	864	0	0.90
	6	57	11	9.6	151	0.89	1.41	55	151	0.27	0.10	2157	1081	303	510	40	0.16
	12	59	8	9.8	124	0.93	0.83	44	106	0.20	0.09	1563	895	236	395	22	0.11
	24	60	7	9.8	126	0.91	0.72	41	93	0.30	0.10	1664	951	267	395	31	0.08
	36	61	6	9.9	99	0.92	0.44	147	75	0.24	0.08	1284	637	211	293	12	0.03
	72	58	9	9.8	114	0.91	0.51	36	94	0.21	0.13	1496	734	255	371	42	0.02
L2	0																
	6	8	81	9.6	156	1.40	2.70	53	222	0.50	0.00	2883	925	270	696	72	
	24	51	13	9.4	201	1.00	4.60	105	269	0.35	0.30	2785	1405	407	824	12	
	36	57	9	9.5	166	0.95	0.35	75	138	0.45	0.55	2083	1200	241	440	0	
	72	58	7	9.6	178	0.95	0.30	80	134	0.05	0.10	2733	1304	287	568	4	
L3	0	9	80	9.4	238		3.80	102	446	0.20	0.10	3480	2210	479	688	0	
	6	58	10	9.7	128	0.98	0.68	35	117	0.14	0.06	1597	759	216	466	47	0.13
	12	65	8	9.8	86	1.00	0.95	17	98	0.17	0.03	1236	646	129	328	25	0.20
	24	70	2	10.1	76	0.90	0.30	17	57	0.10	0.05	949	452	113	248	0	0.00
	36	67	6	10.1	77	1.00	0.30	15	48	0.35	0.05	989	474	170	200	1	0.00
	72	58	7	10.1	75	0.90	0.25	15	58	0.17	0.07	917	440	143	203	1	0.00
L4	0			9.7													
	6	55	8	9.4	162	0.93	1.43	60	110	0.33	0.23	2239	1117	245	347	0	
	12	55	14	9.5	107	0.97	0.50	39	68	0.13	0.17	1207	753	187	181	0	
	36	59	6	9.8	94	0.90	0.50	32	57	0.00	0.00	976	632	184	192	0	
	72	59	9	9.8	70	0.90	0.60	27	43	0.05	0.20	779	483	138	140	0	
L5	0																
	12	63	6	9.4	164	1.00	2.50	99	192	0.00	0.00	1693	1090	345	640	24	
	24	64	1	9.4	164	1.10	2.30	60	158	0.00	0.00	1802	1130	318	616	0	
	36	66	4	9.5	143	1.00	0.30	80	100	0.00	0.10	1285	993	251	512	0	
	72	61	6	9.5	121	0.90	0.50	54	78	0.00	0.00	1300	958	183	384	0	
L6	24	53	6	9.6	163	1.30	1.20	57	274	2.00	0.40	2658	1090	284	768	0	
	36	51	6	9.5	130	1.00	0.80	37	235	0.20	0.30	2073	756	303	664	32	
	72	55	8	9.5	118	1.00		36	158	0.30	0.30	2092	677	226	528	84	
OD1	0	2	93	9.9	89	1.53	0.21	16	202	0.30	0.17	366	229	37	131	2	0.08
	6	5	90	9.7	112	1.55	0.97	53	127	2.82	0.80	1339	705	186	524	19	0.09
	12	3	90	10.0	70	1.45	0.87	59	68	4.07	1.50	889	466	117	378	1	0.10
	24	4	85	9.9	80	1.51	0.67	56	81	0.76	0.30	957	496	129	371	7	0.03
	36	3	89	9.8	76	1.53	0.69	43	81	1.78	0.48	915	441	117	352	14	0.03
	72	4	91	9.8	104	1.40	0.83	66	108	0.50	0.22	1288	432	173	426	36	0.00
OD2	0			9.5	221				559						240		
	6	12	66	10.0	68		0.40		65	0.10	0.00	653	426	94	472	0	0.15
	12	3	93	10.4	13		0.10		16	0.10	0.00	131	175	21	56	0	0.00
	24	1	90	10.4	19		0.10		22	0.10	0.10	183	181	35	76	0	0.00
	36	3	87	10.0	74		0.20		68	0.10	0.10	803	483	151	66	4	0.00
PL1	0																
	6	6	88	9.9	149	1.40	2.40	70	199	4.50	3.30	2053	756	304	1020	0	
	12	6	88	9.9	179	1.50	2.90	117	281	4.70	1.30	2463	1030	418	1290	0	
	36	25	29	9.3	245		5.30	232	407	0.00	0.30	3852	2480	795	1680	48	
	72	3	94	9.7	145		1.40	98	173	2.20	1.60	1697	869	228	800	0	

KLEINFELDER
EXPECT MORE®

Fmu	Depth Class*	Clay	Sand	pH	EC	B.D.	As	K	B	Ca	Mg	Na	Cl	SO4	CO3	HCO3	NO3
	(inches)	(%)	(%)	p(molar)	(dS/m)	(g/cm3)	(meq/100 g)										
PS1	0			9.5	213				31								
	6	10	71	10.2	115		1.00		195	0.20	0.00	1336	609	121	824	0	0.20
	24	34	66	9.6	173	0.50	1.60		122	0.10	0.00	1784	1120	246	512	0	0.00
SA1	12	63	9	9.7	138	0.80	0.60	42	66	0.20	0.30	2182	942	205	288	0	
	24	55	8	9.6	109	0.90	0.00	33	57	0.20	0.20	1495	717	308	104	0	
	72	65	4	9.4	142	0.80	1.20	40	103	0.20	0.30	2373	925	227	400	24	
SA2	0	28	39	9.4	261		4.40	98	710	0.20	0.00	3228	1940	508	864	0	
	6	44	29	9.5	148	1.10	1.33	53	219	0.03	0.00	1804	846	295	680	49	
	12	58	11	9.4	260		3.80	83	439	0.10	0.00	2297	1820	434	752	8	
	24	57	11	9.4	170	1.00	1.48	56	186	0.10	0.00	2007	1073	304	554	63	
	72	60	8	9.5	154	0.95	0.50	50	139	0.20	0.30	2003	1012	287	566	34	
SA3	0	27	38	9.2	210		21.40		599	0.10	0.10	5804	449	1670	976	80	2.40
	6	19	38	9.3	234	1.40	8.00	135	385	0.30	0.25	6866	2060	807	1006	28	
	12	21	53	9.8	179	0.90	5.30	56	279	0.40	0.20	2944	835	211	744	0	
	24	52	16	9.4	188	1.03	3.16	68	210	0.50	0.10	3104	1223	416	712	42	0.20
	36	68	5	9.7	144	0.90	0.30		116	0.10	0.10	1738	1090	217	416	32	0.00
	72	55	16	9.3	213		1.30	74	178	0.40	0.20	3180	1340	426	720	16	
SH2	0	21	55	9.3	229	1.40	3.40	80	380	2.00	1.70	3718	1590	421	912	48	
	24	39	28	9.5	156	1.10	2.00	51	183	1.90	1.70	2760	891	216	776	68	
ST1	0	4	92	9.7	157		0.30		364	0.10	0.05	413	257	45	200	0	0.05
	6	7	84	9.7	147	1.44	1.53	59	166	0.30	0.14	2204	921	243	739	10	0.10
	12	14	54	9.6	161	1.00	2.20	83	186	2.25	0.50	2226	1128	280	632	12	0.10
	24	12	73	9.6	152	1.42	1.47	64	154	0.95	0.54	2139	936	271	709	21	0.07
	36	21	43	9.5	200	0.57	4.38	144	256	0.31	0.13	5980	2098	446	967	31	0.00
	72	27	45	9.7	91		0.67	72	86	0.13	0.03	1339	559	166	504	35	0.00
ST2	0																
	6	9	89	9.6	195	1.50	3.10	74	223	0.20	0.30	4102	1260	429	752	0	
	36	35	18	9.3	204	1.10		100	263	0.40	0.30	3471	1470	414	744	40	
TL1	0	1	98	10.1	10	1.50		6	25	0.80	0.90	125	56	11	64	0	
	36	4	95	9.8	18	1.50		9	37	0.40	0.00	228	121	18	72	0	
	72	6	86	9.6	41			22	50	0.20	0.00	690	226	53	168	8	
TR1	0			9.8	186		8.40		276	0.10	0.00	5291	440	131	944	120	
	6	16	43	9.8	182	1.10	1.10	63	172	1.10	0.90	5614	1660	460	1200	184	
	12	56	29	9.5	214	0.80	2.80	75	216	0.40	0.60	5715	2235	546	1266	132	0.60
	24	17	70	10.0	174	1.30	2.55	70	118	0.40	0.30	4188	1655	450	692	20	0.40
WT1	0																
	6	12	70	9.6	198	1.25	2.10	67	240	0.57	0.23	3904	1241	324	710	0	
	24	11	66	9.4	233	1.30	3.30	95	287	0.55	0.40	5228	1719	501	1038	88	

Source: CH2MHill, 2003a, Table A-2. Summary of soil sampling data from soil survey

Fmu = mapping unit as described in SWWI (2000). Data summarized by depth classes, defined as follows:

0: Top of sample at 0 inches depth

6: Other samples with top at or below 6 inches

12: Other samples with top at or below 12 inches

24: Other samples with top at or below 24 inches

36: Other samples with top at or below 36 inches

72: Other samples with top at or below 72 inches

Soil and Water West, Inc. (SWWI). 2000. Owens Lake bed soil survey. Prepared for GBUAPCD, May 26, 2000.