U.S. Fish & Wildlife Service

Comprehensive Conceptual Restoration Plan

for the

Hart Mine Marsh,

Cibola National Wildlife Refuge

September 2007

Comprehensive Conceptual Restoration Plan
for the
Cibola National Wildlife Refuge's
Hart Mine Marsh
September 2007

Provided to U.S. Bureau of Reclamation – Lower Colorado Region
Attention: Gregg Garnett

by

U.S. Fish and Wildlife Service – Southwest Region
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1.0 INTRODUCTION

The United States Fish and Wildlife Service (Service) has evaluated the potential of restoring marsh habitat on the Cibola National Wildlife Refuge's (refuge) Hart Mine Marsh Unit. This document provides the Services' recommended manner to restore, improve, and manage the Hart Mine Marsh. It is a conceptual plan that focuses on establishing, protecting, and maintaining a mosaic of habitat conditions that will meet refuge objectives. In order to fully implement this plan we anticipate a commitment of both federal and non-federal resources.

1.01 Primary Report Objectives

1) To describe a restoration approach that will restore the marsh to a complex and dynamic habitat mosaic which will be managed to mimic important natural processes and to address the constraints imposed by existing abiotic conditions. The created habitat will: A) result in habitat for desired species that meets biological requirements through various life history stages; and, B) have a high likelihood of long term success by monitoring key indicator variables and adapting management according to those indicators.

2) Determine if the recommended restoration approach can be done in a manner consistent with the Service mission and refuge purposes, as well as meet the program requirements of the Lower Colorado River Multi Species Conservation Program (LCR MSCP).

1.1 Project Background

The refuge occupies an area of 17,267 acres and is located along 12 miles of the lower Colorado River in Imperial County, California and La Paz County, Arizona. It is about 20 miles south of Blythe, California, and about 42 miles north of Yuma, Arizona (Figure 1). The refuge contains wetland and riparian habitats that are rare in this arid ecoregion of dry washes and desert bench lands. The refuge is composed of the 600-acre Cibola Lake, approximately 10 miles of Colorado River backwaters, various moist soil units, approximately 2,000 acres of operational farmland, two historic river meanders (Three Finger Lake and Hart Mine Marsh), and 785 acres of desert ridge and dry-wash land. There are five integrated management units: Arizona North, Hart Mine Marsh, Island, California, and the Cibola Lake.

Cibola NWR was established on August 21, 1964, by Public Land Order 3442. It was "*…reserved for the use of the…United States Fish and Wildlife Service, as the Cibola National Wildlife Refuge…*" and "*…subject to their use for reclamation or wildlife refuge purposes.*"

Most of the refuge's lands were withdrawn from the public domain for refuge purposes or for the Colorado River Storage Project, although some lands were acquired in fee title. There are presently no non-federal parcels (in-holdings), within the refuge boundary. In addition, the refuge owns the bottom of the existing Colorado River where the river bypasses the "old river channel" as well as the Arizona side of the old river channel’s bottom. The Service has a 49-year lease on the California side of the “old river channel” bottom.

The Cibola NWR is the only refuge on the lower Colorado River (LCR) explicitly designated for mitigating the negative impacts of channelizing the Colorado River. Congress created the refuge largely in response to concerns associated with straightening of the LCR in the Cibola reach of the river, as the old river channel’s meander was cut off by the “dry cut” (this dredging project was completed in the mid nineteen-sixties).

Historically, belts of vegetation existed along the river, with cottonwood and willow being the dominant riparian forest species. John Bartlett, one of the commissioners of the 1852 boundary survey, mentioned the dense forest of willow, cottonwood, and mesquite that filled the river’s bottomlands. Many researchers have noted the significant changes that have occurred over the last hundred years within the LCR’s floodplain. Dr. Robert Ohmart (1998) noted that:

> In 1894, Mearns estimated that about 160,000 - 180,000 ha of alluvial bottomland between Fort Mohave and Fort Yuma were covered by riparian vegetation. As of 1986, total riparian vegetation comprised only about 40,000 ha, approximately 25% of the available bottomland estimated by Mearns. Roughly 40% of the area remaining in 1986 was covered by pure salt cedar; an additional 43% consisted of native plants mixed with salt cedar; 16.3% was covered by honey mesquite and/or native shrubs; and only 0.7% could be considered mature cottonwood or willow habitat.

Today, little of the native riparian habitat remains along the entire LCR, with most of it occurring on the four national wildlife refuges (Bill Williams River, Havasu, Imperial and Cibola). Marsh habitats and seasonal wetlands are also rare on the river, with the refuges harboring most of these communities, as well.

Prior to the development of the LCR, the river was a highly dynamic system where annual flow volumes would differ by orders of magnitude as a result of the annual spring flood pulse. Very active geomorphic processes of erosion and deposition created complex floodplain landforms that supported a mosaic of habitat types, including backwaters, seasonal and ephemeral wetlands, riparian forest, and shrublands (Mueller and Marsh 2002). However, disturbances to natural processes, including dams, channelization, and agricultural drains have caused channel incision, disconnecting the floodplain from the river and reducing the annual variability in flow (Busch and Smith

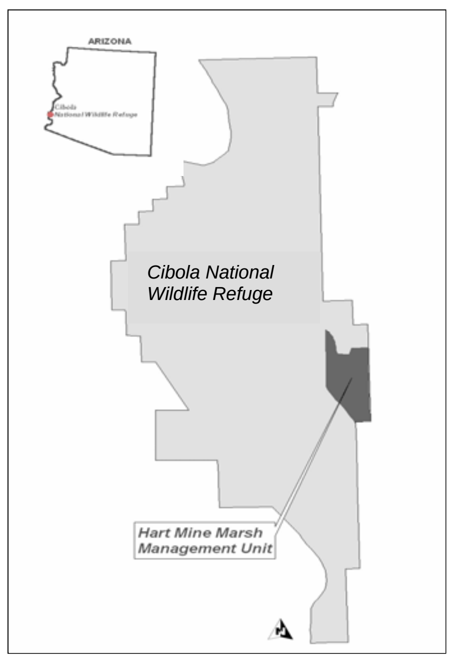

Figure 1. Location of Cibola NWR and the Hart Mine Marsh.

1995). The hydrologic stability introduced into the Colorado River by dams and channelization hastened the replacement of the diverse vegetative communities by aggressive non-native species that formed large stands of monotypic communities.

The current condition of the Hart Mine Marsh reflects the changes seen elsewhere on the LCR. As the project area was once part of the active floodplain of the LCR, upstream dams and channelization has caused the river to deeply incise and interrupt the hydrologic connection between the marsh and the active channel. A summary description of the marsh's current conditions is provided in Section 2 of this report. A more complete description of the existing conditions in the marsh is provided in Appendix A. Broadly speaking, the Hart Mine Marsh is a decadent wetland that occupies 646 acres with poor water quality, marginal wetland/marsh habitat, and saline soils, with some areas completely devoid of vegetation.

1.11 Role of the Lower Colorado River Multi Species Conservation Program

The Service is partnering with the U.S. Bureau of Reclamation (Reclamation) through the Lower Colorado River Multi Species Conservation Program to restore the Hart Mine Marsh to provide habitat for threatened and endangered species.

The LCR MSCP is a state/federal/private partnership that, when implemented over the next 50 years, aims to "ensure long-term compliance with applicable federal and state environmental laws, while permitting the continued utilization of lower Colorado River water and power resources." Reclamation is the implementing agency for the LCR MSCP, and is interested in the potential for this on-refuge project to produce marsh habitat mitigation credit for the program.

The LCR MSCP specifically targets restoring habitats for the Yuma clapper rail (*Rallus longirostus yumanensis*) in this reach of the river ("Reach 4" for the LCR MSCP). The Service fully supports this goal: the Yuma clapper rail is considered an umbrella species with habitat needs that overlap other species of interest, including the California black rail (*Laterallus jamaicensis coturniculus*), western least bittern (*Ixobrychus exilis hesperis*) and the Colorado River cotton rat (*Sigmodon arizonae plenus*).

While the Service views the partnership with Reclamation as a critical component to the restoration work at the Hart Mine Marsh, the Service is aware that LCR MSCP goals and objectives for this refuge unit are focused on marsh habitat improvement for the benefit of the Yuma clapper rail. The Service will continue to take advantage of other funding and partnering opportunities to support the restoration components that are beyond the scope of the LCR MSCP.

1.2 General Assumptions

In order to develop this restoration plan, certain assumptions were made regarding pertinent policy and administrative matters, and hydrologic, geomorphic, and biological concerns. The general assumptions in this plan are:

- sufficient staff will be in place to manage the unit;
- the refuge's water rights are sufficient to implement this plan;

- the LCR Water Master (Reclamation) water accounting policies will continue to provide an *unmeasured return flow credit* to the refuge on the order provided since 2003;
- past water use, estimated at 7.23 acre feet per acre, accurately predicts future water needs;
- implementing this plan will not negatively affect downstream entities or other refuge units;
- it will be possible to flush accumulated soil salts;
- proposed infrastructure will maximize adaptive management capacity;
- water of sufficient quality can be delivered to the marsh;
- the area's geomorphology corresponds with expected soil textures (i.e. ridges have coarser soils, swales are finer);
- a viable seedbank of desired species exists within the soils or surrounding area; and,
- data acquired to date represents typical marsh conditions.

1.3 Service Policies, Guidelines and Procedures

The mission of the National Wildlife Refuge System (NWRS) is to "administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." The first guiding principle of the NWRS holds that "We are land stewards, guided by Aldo Leopold's teachings that land is a community of life and that love and respect for the land is an extension of ethics. We seek to reflect that land ethic in our stewardship and to instill it in others."

The NWRS *Improvement Act* of 1997 states that each refuge will be managed to fulfill refuge purpose(s) as well as to help fulfill the NWRS mission. Per the *Improvement Act*, "These purpose(s) and our mission will be accomplished by ensuring that the biological integrity, diversity, and environmental health of each refuge are maintained and, where appropriate, restored."

The Service's *Biological Integrity, Diversity and Environmental Health* policy (601 FW 3) provides guidance on implementing the above clause from the NWRS *Improvement Act*. One of the key statements is "The highest measure of biological integrity, diversity and environmental health is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions." (601 FW 3, 3.10.) Furthermore, this policy:

> provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems. Further, it provides managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions; and where appropriate and in concert with refuge purposes and System mission, restore lost or severely degraded components. (601 FW 3, 3.3.)

The policy provides guidelines for determining how and when it is appropriate to restore lost elements of biological integrity, diversity and environmental health. One of the principles stated in the policy is that "…we will restore lost or severely degraded elements of integrity, diversity and environmental health…" (601 FW 3, 3.7 D). It goes on to say that "…we favor management that restores or mimics natural ecosystem processes or functions…" (601 FW 3, 3.7 E).

The Service policy on *Habitat Management Practices* (620 FW 1) directs refuges to manage ecosystems holistically, and to "Manage invasive species to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species." (620 FW 1, G.)

The Service policy titled *An Ecosystem Approach to Management* (052 FW 1) states: "As the Service, working closely with others, carries out its mission and mandates, it will constantly strive to contribute to the effective conservation of natural biological diversity through perpetuation of dynamic, healthy ecosystems." (1.3 B (1)). Section 1.8 B (2) of this policy describes goals in an ecosystem approach:

> (a) Goals: Goals reflect desired future conditions in the ecosystem…and should incorporate the following concepts: (i) perpetuation of natural communities of plants and animals; (ii) maintenance of naturally-occurring structural and genetic diversity; (iii) needs of rare and ecologically important species; (iv) minimization of habitat fragmentation; (v) maintenance of uncontaminated land and water; (vi) continued role of natural processes (e.g., fire, floods); (vii) control of undesirable exotic species; and (viii) maintenance of compatible, sustainable human activities.

It is the clear intent of this plan that any restoration activities at the Hart Mine Marsh will comply with ecosystem-based goals. This document represents the Service's assessment of how to frame this restoration effort to meet the Service's restoration and management policies and guidelines, while maintaining compatibility with the refuge's purposes. The refuge will ensure compatibility, per Service policy, once (and if) this project moves forward. Generally speaking, the Service believes that if the restoration work adequately addresses the topics discussed in this document, it is probable that this restoration project will be deemed compatible.

1.31 Strategic Habitat Conservation

> *"Solutions to problems cannot be commanded. They must be discovered."*
> K.N. Lee 1993

The Service recently (July 2006) adopted, through partnership with the U.S. Geological Survey, a Strategic Habitat Conservation (SHC) framework for setting and achieving conservation objectives at multiple scales, based on the best available information, data, and ecological models. Full implementation of SHC requires four elements that occur in an adaptive management loop: (1) Biological Planning, (2) Conservation Design, (3) Conservation Delivery, and (4) Monitoring and Research (see Figure 2).

No level of theory, planning, and design becomes meaningful until implemented. However, the framework for SHC becomes "strategic" because on-the-ground actions are based on planning and design and measured through monitoring and research. Through these strategies, habitat conservation can measurably benefit targeted populations. The value of adaptive management as an iterative process has become widely recognized. SHC represents a form of adaptive management specifically tailored to achieve effective habitat conservation.

SHC: Guiding Principles

1. Habitat conservation is simply a means to attain our true goal – the conservation of populations and ecological functions that sustain them.

2. Defining measurable population objectives is a key component of SHC, at any scale.

3. Biological Planning must use the best scientific information available, both as a body of knowledge and a method of learning. Our understanding of ecological conditions is never perfect. An essential element of SHC is managing uncertainty through an iterative cycle of planning, doing, and evaluating.

4. Management actions, decisions, and recommendations must be defensible and transparent; thus, the implementation of SHC must be systematic, well documented, and explicit about the nature and magnitude of potential errors.

5. Conservation strategies consist of dynamic suites of objectives, tactics and tools that change as new information enters the SHC cycle.

6. Partnerships are essential, both for management and for developing conservation strategies.

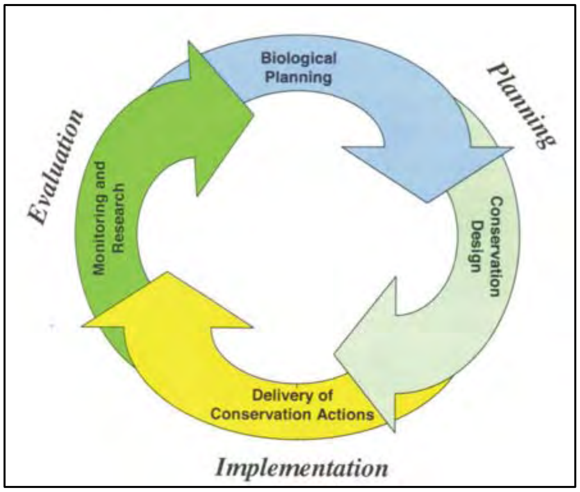

Figure 2: Strategic Habitat Conservation.

SHC clearly applies many of the precepts of adaptive management, which since its inception in the 1970s, has been increasingly used by federal agencies for natural resource management (Lee and Lawrence 1986). Adaptive management's development stems from attempts to understand complex human and natural systems and address frequent "fixes that backfired" (Blann and Light 2000). In its simplest form, it can be described as "learning by doing," and as such, can be a powerful tool for natural resource management under conditions of uncertainty stemming from imperfect and incomplete information. Rather than constraining decision making into rigid pre-determined outcomes, adaptive management encourages natural resource managers to treat management decisions as "hypotheses and opportunities for learning rather than as final solutions," (Ibid).

The project described in this report is based upon both peer reviewed research and applied science on desert river ecosystems. However, this project is somewhat unique to the lower Colorado River, and there is much to be learned. In addition, the assumptions described in Section 1.2 are, in the light of new data, open to review, revision, and even deletion. Indeed, aspects of this restoration plan are bound to face many challenges, and an adaptive management strategy will be necessary to mitigate some of the restoration plan's unforeseeable shortcomings. Land management and restoration will always take place under conditions of imperfect information – thus, it is essential for the long term success of this project that an active management plan, with an aggressive monitoring component, be developed at an early stage.

1.4 Abiotics, Physical Processes & the Hart Mine Marsh Wetland Review

The Service's long history and experience in restoring and managing public lands, coupled with a growing body of research, has demonstrated that long term success can be greatly increased by taking abiotics and physical processes into account when designing wetland restoration projects (Rundle and Fredrickson 1981, McGinnies et al. 1976, Boettinger and Richardson 2001, Cluff et al. 1983, Fredrickson and Taylor 1982).

The abiotics of a restoration site form the bounds and parameters within which restoration can take place. For instance, soil conditions influence important wetland characteristics, as soil texture controls water holding capacity, and soil chemistry influences vegetative propagation and ongoing vegetative health (Badger and Ungar 1988, Boettinger and Richardson 2001, McGinnies et al. 1976). While abiotics constrain what vegetative communities can potentially inhabit a given area, certain key physical processes largely determine the actual composition of vegetative communities and whether they are composed of desirable or undesirable plant communities (Fredrickson and Taylor 1982).

For desert river ecosystems, the shape and magnitude of the annual hydrograph, especially the post snowmelt flood peak, is a key ecosystem process. Geomorphic processes of erosion and deposition are driven during the flood peak, and the patterns and rates of sediment transport and deposition associated with geomorphic processes are the primary factors affecting wetland formation and structure (Saucier 1994). The magnitude and types of deposited sediments greatly influences hydrology, water quality and drives the distribution and formation of wetland plant communities (Bornette et al. 1998, Hupp 2000, Johnson 2000). It is therefore vital to understand the site specific nature of these processes when planning restoration projects and to incorporate this understanding into the design and implementation of wetland management.

In order to develop a restoration plan for the Hart Mine Marsh that places a priority on abiotics and physical processes, the Service hosted a Wetland Review at the Cibola NWR. An interdisciplinary gathering of approximately 20 scientists representing a range of federal, state, NGO, and private concerns, met over three days to generate the integral components of a restoration plan. A central concern during the Wetland Review was to develop a restoration plan that functioned within not only the abiotic and physical process constraints of the Hart Mine Marsh, but within the administrative and policy sideboards that exist for the marsh and for the refuge.

There were three core restoration components that were identified at the Wetland Review. First, the marsh should be divided into separate subunits by following the dominant geomorphic breaklines. Second, it will be necessary to maximize infrastructure capacity over as large a footprint as possible. The whole of the Hart Mine Marsh, as well as individual subunits, must be able to be filled and drained independently of the Cibola Lake and, ideally, the other subunits. This will allow the refuge to address the significant abiotic constraints, most notably the hyper saline soils and to a lesser extent, the high nitrate levels, as well as to maximize the refuge's ability to manage for a mosaic of habitat types. Lastly, each subunit will be managed to simulate important historic physical processes that have been interrupted. For example, disturbance caused by the spring flood peaks will be replaced with alternative sources of disturbance, such as mechanical treatment or prescribed fires. Additionally, the management capacity created by the improved infrastructure will allow units to be flooded in a way that roughly mimics (even if in reduced scope and scale) the shape of the natural hydrograph.

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2.0 SITE DESCRIPTION & SUITABILITY ASSESSMENT

2.01 Site Assessment Background

Summary of Existing Conditions Report: In April, 2007 the Service authored an interim report that detailed the work done to date to characterize the Hart Mine Marsh Unit. This *Existing Conditions Report* (ECR) provided a summary description of the known biotic and abiotic conditions associated with the Hart Mine Marsh Unit, with a focus on those characteristics pertinent to restoration activities. The ECR provided a description for the following broad subject areas: surface topography, soils, geomorphic setting, vegetative cover, and various hydrologic components including water quality and a description of surface water and groundwater conditions. The ECR also concluded that the Cibola NWR has sufficient Colorado River water rights to support restoration activities at the Hart Mine Marsh Unit.

While this restoration plan makes significant use of the information contained within the ECR (included as Appendix A), the reader is referred to the *Existing Conditions Report* itself for a more detailed understanding of the types of data collected, the method of collection, and other details.

2.1 Topography

A topographic map of the site was developed based on Reclamation and Service survey data collected from four surveys conducted between 2004 and 2007. A high percentage of the proposed project area is inaccessible for ground surveys due to heavy salt cedar growth. In 2005, narrow openings were mechanically cleared through the vegetation to allow semi-random cross-section surveys. The resulting accessible portions of the project area, while a small portion of the overall whole, were thoroughly surveyed. The survey data was used to generate a rudimentary two-foot contour interval contour map (Figure 3) which is considered sufficient for conceptual planning purposes.

The available topographic data indicates that the project area falls on average about 2 feet from north to south, and is relatively flat from east to west (sloping slightly towards the river). Instantaneous water surface elevations from Arnett Ditch show that there is a fall of about 0.5 feet over 2.6 miles. The unit's highest elevation is in the southeast corner, which rises steeply as a result of alluvial fans created by the mine-tailings filled eastern washes. Historic channels form the unit's lowest elevations (probably formed by high river flows river prior to the development of the river's dams and levees). These features are typically positioned some 1 to 2 feet below the surrounding grade.

The density of the available survey data is considered too low to produce a map with sufficient accuracy for specific design calculations (e.g., cut /fill volumes, final subunit designations, precise elevational management targets, etc.). An important near-term objective is to develop a better topographic characterization, perhaps through additional vegetative clearance and a subsequent LIDAR flight and refined digital terrain model prior to engineering design.

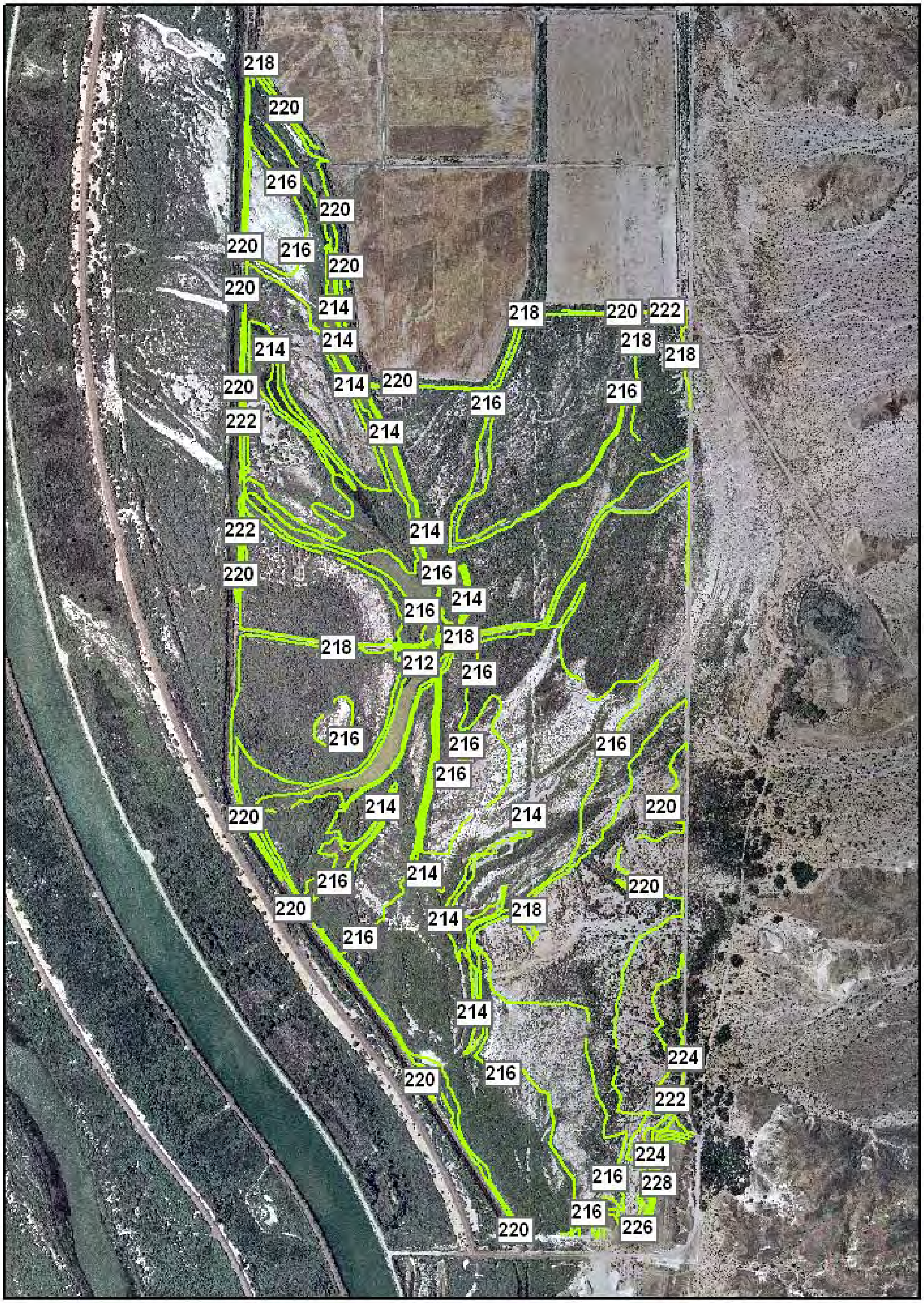

Figure 3. Two foot contour interval topographic map of the Hart Mine Marsh. Contours were estimated from Reclamation survey points and aerial photography. Many areas on this map have no survey points, thus contours are for general reference only and not intended for construction or design purposes.

2.2 Hydrology and Water Quality

As discussed earlier in this document, there have been many hydrologic alterations to the lower Colorado River's hydrology, resulting in largely negative changes to the river valley's ecological resources. In its current state, Hart Mine Marsh provides a case study of how altered hydrology negatively impacts water dependent natural systems. Through providing a hydrologic characterization of the Hart Mine Marsh Unit, a range of specific restoration issues can be addressed, including: 1) the benefits of emulating the shape of the natural hydrograph within management units; 2) the adequacy of the refuge's water entitlements to support restoration efforts; and 3) the need to flush accumulated soil salts.

2.21 Historic and Current Hydrology

<u>Historic Hydrology</u>

The hydrology of the Hart Mine Marsh has significantly changed from when it was a part of the active floodplain of the lower Colorado River. Historically, the spring/early summer flood peak and subsequent baseflow recession were the dominant features of the lower Colorado River hydrologic regime. Overbank flooding was a common feature during the flood peaks and flood waters would frequently rework the landforms of the Hart Mine Marsh. Groundwater levels would follow the surface water hydrograph, where the groundwater table would typically be at its highest level during and after flood events. As river levels subsided during the fall and winter seasons, groundwater levels would also recede, reaching their lowest levels during the winter months.

<u>Current Hydrology</u>

In the modern setting, however, the lower Colorado River has been channelized and disconnected from the former floodplain, including the Hart Mine Marsh. The river's hydrograph has been altered so that it no longer resembles the shape and form of the historic hydrograph (Figure 4). Instead, river levels in the Cibola Reach are controlled by Parker Dam releases, which are largely based on downstream irrigation demands and power production concerns, resulting in a highly unnatural hydrograph.

The extensive series of levees prevent floodwaters from reaching the marsh, interrupting the important physical processes of erosion, deposition, and groundwater recharge. In its current state, surface water inputs to the Hart Mine Marsh are from three main sources: the Arnett (drainage) Ditch, the refuge's Unit 2 irrigation ditch, and tributary inflows from adjacent alluvial fans. In its current state, the surface water hydrology of the marsh is highly dependant upon irrigation practices and episodic precipitation events in the uplands. Additionally, all three surface water sources largely terminate in the marsh, with there only being limited surface water outflows. This has strong implications for water quality concerns, and will be addressed in that section.

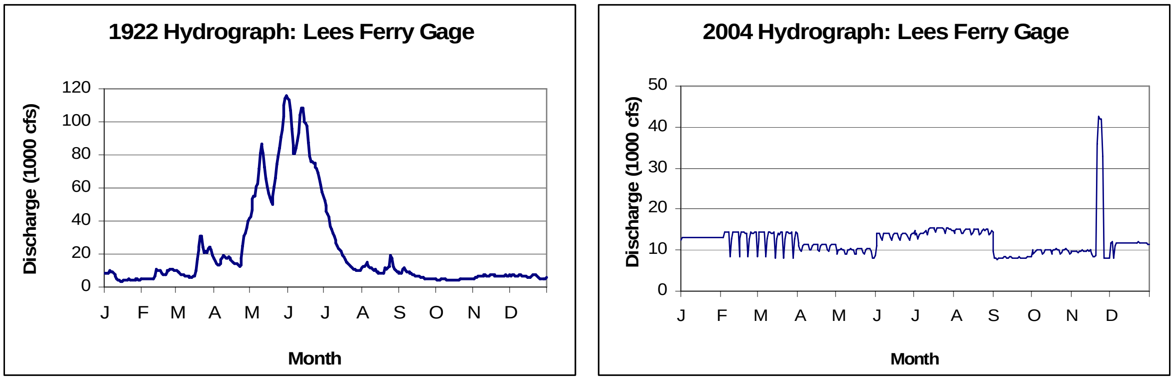

Figure 4. A comparison of LCR hydrographs before and after the construction of the LCR's major dams. The effect of upstream dams on the hydrograph is clearly visible.

To characterize the project area's groundwater system, in 2006 the Service and Reclamation installed 12 shallow groundwater monitoring wells (Figure 5). For the most part, groundwater flow paths are south to southeast. The groundwater hydrology of the Hart Mine Marsh is controlled by river elevations, the Unit 2's irrigation ditch, and to a lesser extent, the Arnett Ditch. Relative proximity to these controls largely determines the magnitude of impact upon the marsh's groundwater hydrology. For example, groundwater levels in areas closer to the lower Colorado River are highly controlled by river levels, while groundwater levels in areas closer to Unit 2 are more controlled by irrigation practices and by ditch water levels.

2.22 Altered Hydrology: Restoration and Management Implications

Over the past year, the Service has studied the hydrology of the Hart Mine Marsh to develop an understanding of how the current hydrologic regime will effect the restoration and subsequent management of the marsh. Service personnel have gathered hydrologic data for nearly one irrigation season and it is assumed that this data is representative of average conditions. While the currently available data is limited, characterizing the hydrologic regime can assist with the restoration of the Hart Mine Marsh in two primary areas: managing soil salts, and emulating the shape of the natural hydrograph within individual management units.

As discussed throughout this document, accumulated soil salts in the Hart Mine Marsh is a central restoration consideration. Soil data indicates that salt levels throughout much of the marsh exceed the toxicity threshold of desired vegetative species. These elevated salt levels are chiefly due to evaporative concentration of surface water and contributions via groundwater sub-flow. Thus, an essential first step to restoring the marsh to preferred vegetative cover types habitat is flushing accumulated soil salts. Data regarding depth to groundwater is necessary to evaluate the ability to flush salts. Groundwater must be low enough so that accumulated soils salts are mobilized when management units are flooded and drained. Average depth to water for the entire Hart Mine Marsh is approximately 5.2 ft, a depth sufficient to effective flush salts (Vradenburg *personal communication*). Groundwater depths do not seem to have dramatic seasonal maxima or minima (Figure 6), suggesting that there may not be a groundwater-based preferred season to flush salts.

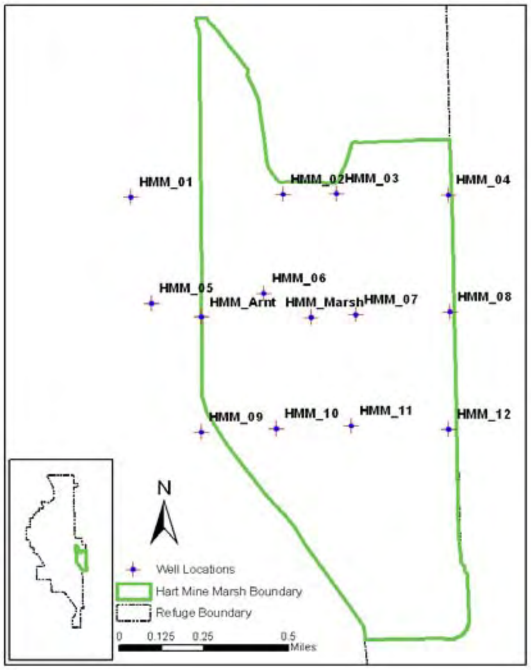

Figure 5. Location of shallow ground-water monitoring wells. Note: **HMM_Arnt** and **HMM_Marsh** are monitoring stations measuring the surface water elevation of the Arnett Ditch and the Hart Mine Marsh.

The Colorado River and irrigation drain water levels, however, play an important role in regulating depth to groundwater. One of the management implications for flushing accumulated soil salts is that river and ditch levels, as well as depth to groundwater, should be monitored and evaluated prior to flushing. Preventing flushed salts from negatively impacting Cibola Lake is an additional management concern.

Additionally, irrigation practices should be managed so that water levels in irrigation drains are not too high, thereby impeding the ability to flush salts. Once soil salts are at a level conducive to the propagation of desired plant species, water management regimes that emulate the historic hydrograph should be employed and subsequently evaluated.

The dominant feature of the natural hydrograph is the spring/summer flood pulse. While emulating the shape of the natural hydrograph may be a desirable management scenario, topography, infrastructure, and geomorphology are important controls upon the ability to do so. The notable feature of Hart Mine Marsh topography is that there is little overall relief. The low relief likely means that there is little overall hydraulic head throughout the marsh, and between individual management units. This in turn may limit the ability to move water on and off of individual management units. It is possible that changes to water delivery and drainage infrastructure may alleviate some of these issues. However, the Arnett Ditch probably plays a key role in the elevated levels of soil salts via groundwater sub-flow. Care should be taken when designing drainage infrastructure so that this potential problem is addressed. It will also be important for design considerations to take into account the need to manage and protect Cibola Lake (the elevations of which may play an important role in affecting elevations in the marsh, the Arnett Ditch and the proximate groundwater systems). Deviation from emulating the natural hydrograph may be necessary to address other management objectives, such as controlled burning, mechanical treatments, flushing salts, etc.

2.23 Water Budget Summary

As detailed in the ECR (Appendix A), an initial assessment of the refuge's lower Colorado River water rights determined that the refuge has sufficient rights to support restoration at the Hart Mine Marsh. This assessment reviewed the refuge's enabling legislation, past and projected water uses, and past and current accounting practices followed by Reclamation.

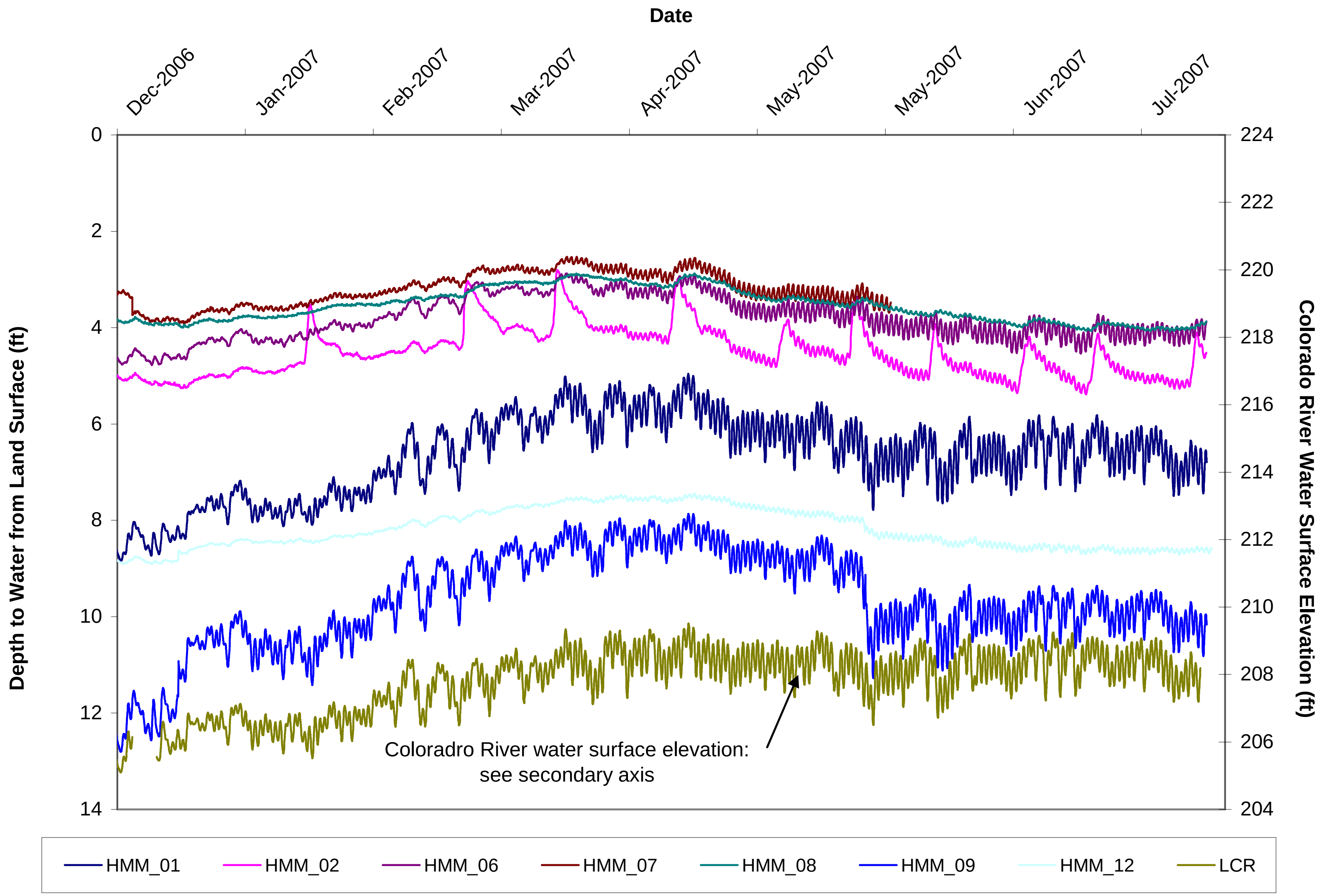

Figure 6. Depth to groundwater from land surface of selected monitoring wells and Lower Colorado River water surface elevations. River levels are shown on the right axis. Several monitoring wells closely follow the shape of the river's hydrograph, demonstrating the effects of river levels on groundwater dynamics.

Of particular note, the water rights assessment assumed that the refuge's past water use levels (estimated at 7.23 acre-feet per acre) are a reasonable prediction of future water needs. An additional assumption is that Reclamation will not make significant changes to their current water accounting policies, especially regarding the current practice where individual diverters receive an unmeasured return flow credit of a certain magnitude.

If these assumptions prove reasonable, it is conservatively estimated that the refuge is unlikely to commit more than 58% of its available water entitlements to this project. This estimate does not include water from the Arnett Ditch or the refuge's 7,500 acre-feet per year second diversionary water right.

While recognizing that significant assumptions have been made in this water budget assessment, the Service supports committing its water resources at the level expected to be needed for the Hart Mine Marsh restoration project.

2.24 Water Quality

A limited water quality assessment was conducted of the Hart Mine Marsh, Arnett Ditch, and the Unit 2 Ditch to: 1) characterize the existing conditions at the marsh; 2) determine the nature of surface water inputs to the marsh; and 3) assess the suitability of the Arnett Ditch as a surface water input for managing Hart Mine Marsh water levels.

While resources and time constraints did not allow for a robust site characterization, conditions were assessed by surface water grab samples and by a multi-parameter water quality probe. Grab samples were collected twice, once during August, 2006, and once during May, 2007. Readings were taken with the water quality probe concurrent with grab samples. Sample collection was timed to asses the relative difference in water quality at the beginning (May) and the end (August) of the irrigation season. An additional sample using the water quality probe was taken October, 2006. Grab samples were sent to an analytical laboratory and analyzed for nutrient levels, anion and cation levels, and chlorinated and organophosphorous pesticides (see Appendices A and B for results). To address Reclamation's concern that the initial Arnett Ditch sampling site was not representative, an additional Arnett Ditch site was added (see Figure 7 for sampling locations).

Analysis of water quality parameters suggest that water quality conditions in the Hart Mine Marsh are better at the start of the irrigation season and may tend to decrease throughout the course of the season. The other sampling locations did not demonstrate any clear trends. In the Hart Mine Marsh, levels of nitrate + nitite – N, ammonia – N, total phosphorous, chloride, sodium, and conductivity were lower in May-2006 than in August-2007. This is consistent with the assumption that levels of analytes are concentrated within the water column throughout the summer growing season as a result of evaporation. It is important to note that ammonia – N can be toxic to aquatic life, and toxicity is increased depending upon temperature and pH. Thus, the warmer temperatures and higher pH of the Hart Mine Marsh further increase the toxicity of the ammonia – N concentrations in the marsh.

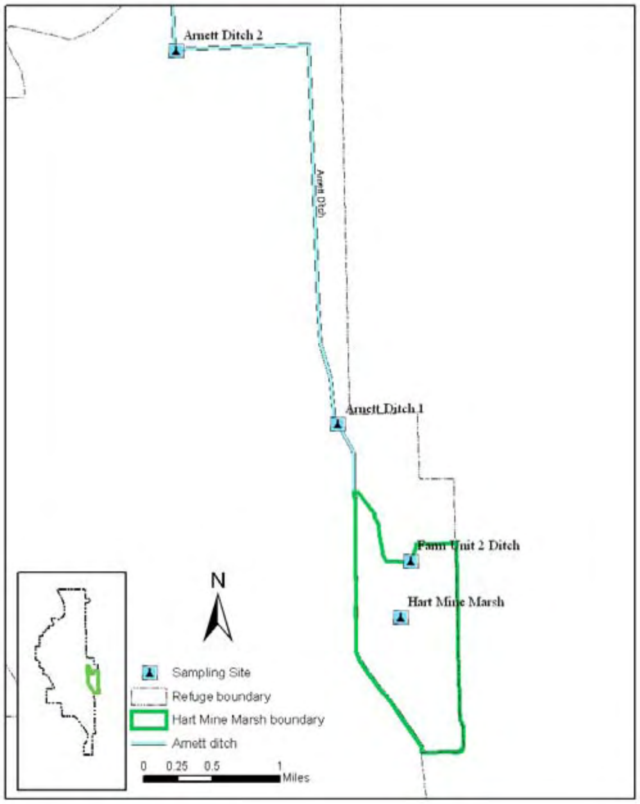

Figure 7. Location of water quality sampling sites.

Additionally, the soil data indicates that high levels of nitrate – N exist within the soils of the Hart Mine Marsh. This suggests that there is an external source of nitrogen to the marsh. However, nitrogen cycling is very complex and dependant upon a large number of variables. With only two data points to analyze the nitrogen dynamics of the system (and with no sediment analysis performed), it is difficult to determine if the Arnett Ditch or the Unit 2 Ditch is the primary source of nitrogen. Nitrate – N can be associated with mine tailings; Hart Mine Marsh's namesake mine may be another possible source of nitrate - N.

Conductivities of all three sampling locations were high for a fresh water system (ranging between 2,520 µS/cm – 23,900 µS/cm) indicating significant salt loading (Figures 8 & 9). Laboratory analysis of surface water grab samples was consistent with these concentrations. In the Arnett Ditch and the Unit 2 Ditch, chloride levels were at a minimum of 707 mg/L, a maximum of 2,150 mg/L, and sodium levels were at a minimum of 414 mg/L and a maximum of 1,190 mg/L. The values of chloride and sodium were significantly higher in the Hart Mine Marsh: 10,700 mg/L and 4,860 mg/L respectively. These concentrations meet or exceed toxicity thresholds for a variety of plants and invertebrates (U.S. Department of Interior 1998). Conductivities at the Arnett 2 location (see Figure 7) were within the range of other sampling locations. Additionally, dissolved oxygen levels at this location were the lowest of all sites sampled. As such, this location forms the lower boundary of dissolved oxygen as a water quality indicator. As discussed above, surface water inputs largely terminate in the Hart Mine Marsh. The salt concentration and conductivity data corroborates the hypothesis that the evaporative concentration of salts within the surface water of the marsh contributes to the overall salt problem within the management unit.

The results of the water quality analysis of the Hart Mine Marsh, the Arnett Ditch, and the Unit 2 Ditch support the recommendations made elsewhere in this conceptual restoration plan. Infrastructure must be improved to reduce the salt load within the system. Additionally, water of sufficient quality must be made available to achieve wildlife habitat goals. Regarding the irrigation return ditches, both the Arnett Ditch and the Unit 2 Ditch may have water of sufficient quality at certain times throughout the year to support management goals. However, there are important concerns about nutrient levels and conductivities that limit the reliability of both ditches to serve as year round sources of surface water to the Hart Mine Marsh. Both should be regularly monitored for nutrients and conductivity, and management adapted accordingly.

2.3 Soils Baseline Conditions

During the fall of 2006, soil samples were collected at 22 locations at three different depths: 0 to 2 inches, 24 to 26 inches and 34 to 36 inches. The samples were analyzed at a commercial laboratory for pH, electrical conductivity, Ca Mg, Na, exchangeable Na percent, B, NO_3-N, PO_4-P, K, and Zn. The findings of the 2006 soil survey were consistent with soils work conducted in the area by the USDA Soil Conservation Service (now the Natural Resource Conservation Service) in the late 1980's (USDA-SCS, 1989)(see Figure 10).

The details for the soil investigation can be found in the ECR (Appendix A). In summary, the most remarkable feature of the Hart Mine Marsh soils is their high salinity, ranging from 0.69 dS/m to over 307 dS/m, while the average salinity was 83.5 dS/m. To place these values in context, many types of vegetation become salt stressed when levels exceed 2 dS/m. The high soil salinity at the Hart Mine Marsh presents a serious constraint to revegetation and management of aquatic ecosystems. Future unit management should include a long-term salinity reduction program.

In addition, soil nitrate levels were high, with a minimum value of 1 mg/kg, a maximum value of 123 mg/kg, and an average value of 12/4 mg/kg. Two possible sources may be from high inputs of ammonium from Arnett Ditch agricultural runoff or mine drainage from the east.

2.4 Surficial Geologic Map of the Hart Mine Marsh

Incorporating knowledge of geomorphic landforms, in concert with other key abiotics (soils, hydrology, etc.) can significantly increase the likelihood of achieving biologically defined restoration objectives (Fredrickson and Taylor 1982). Therefore, the geomorphology of the Hart Mine Marsh Unit was mapped under a contract with William Lettis & Associates (Appendix A). This description of the project area's surficial geology documented seven different geomorphic units, most of which are fluvial deposits directly associated with historic and paleo-channels of the Colorado River floodplain. The locations of the mapped units are shown on Figure 10.

A primary finding was subtle micro-topographic features that may have formed from the recession of overbank floodwater. Alternatively, these features may have formed as drainage features following precipitation events. It is asserted that these are important features that correlate well with heterogeneous habitat conditions, and should be maintained when possible.

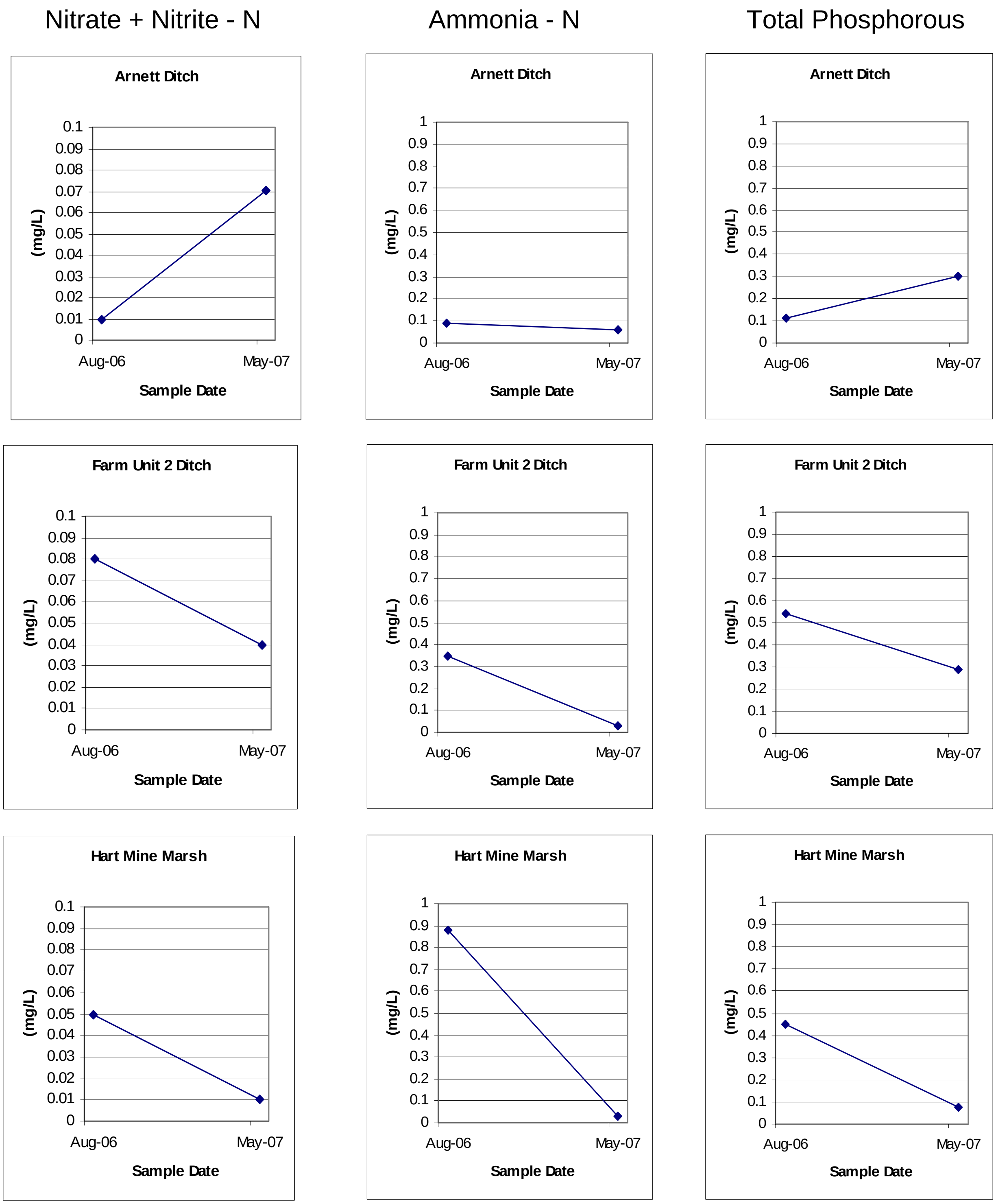

Figure 8. Seasonal variability of nutrient concentrations.

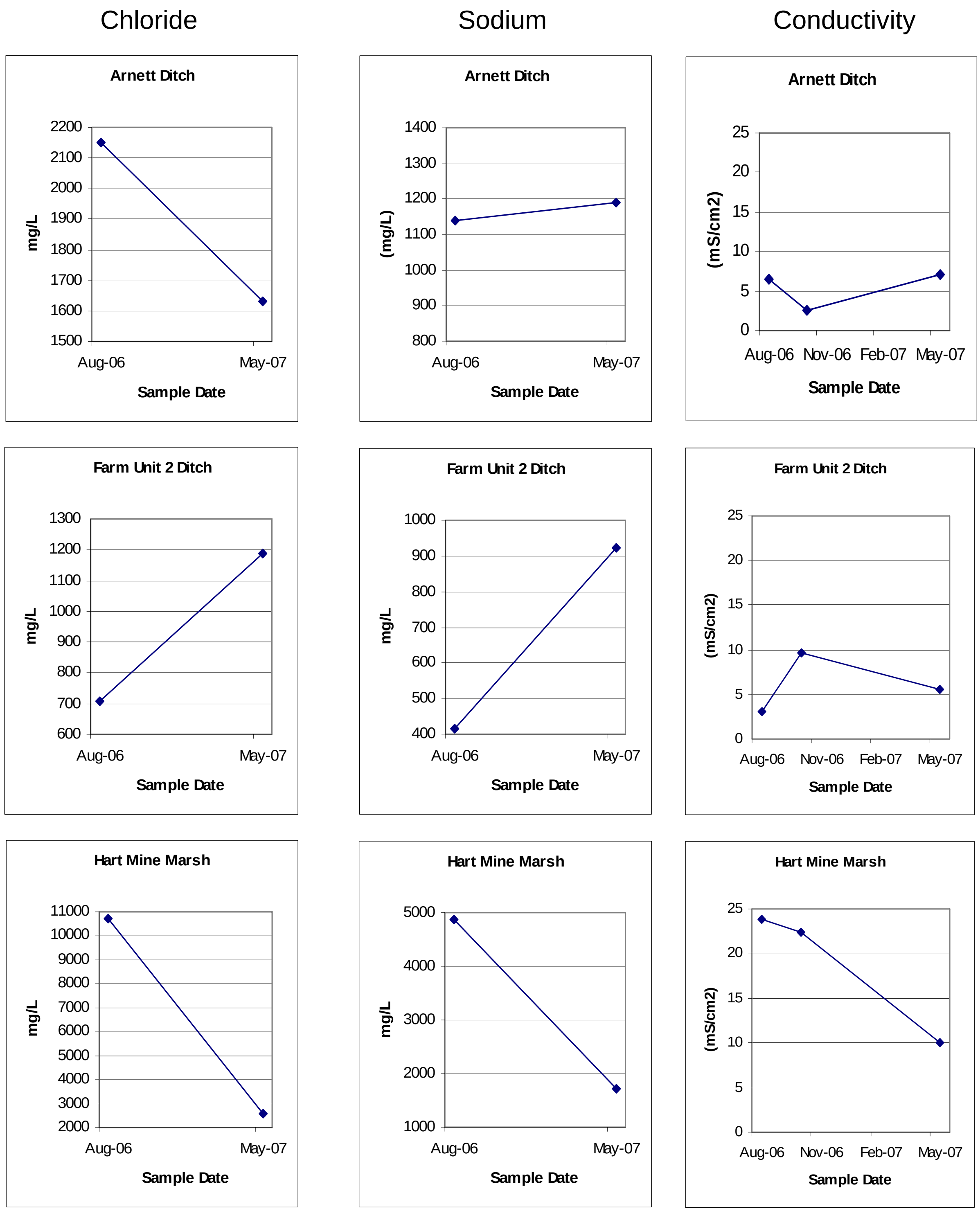

Figure 9. Seasonal variability of selected anions, cations, and conductivity.

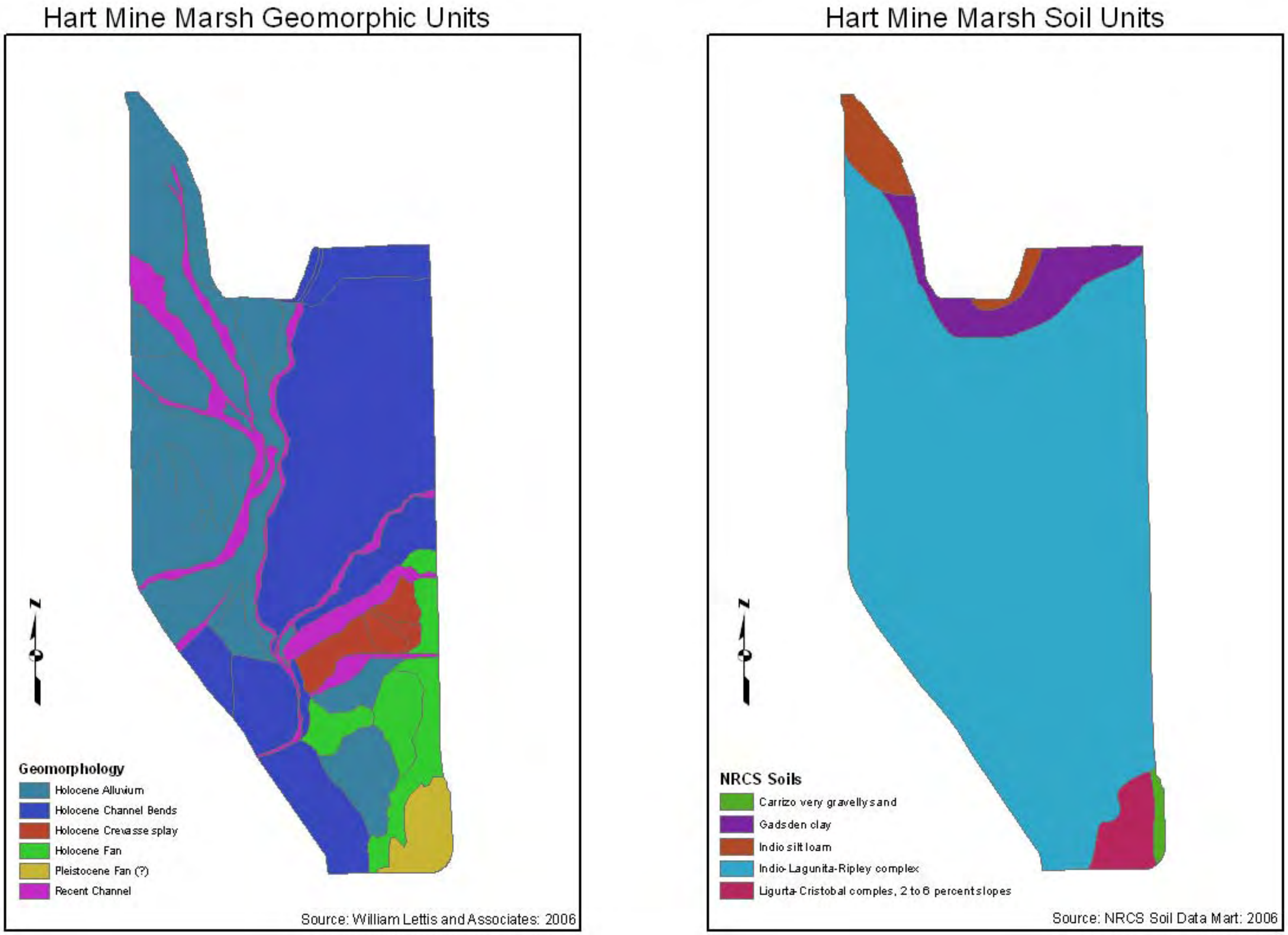

Figure 10. A comparison of the geomorphology and soils of the Hart Mine Marsh

Significant earthwork is a likely component of this restoration project. Restoration goals that may involve earthwork include: increasing the wetland area that would meet the LCR MSCP's 12-inch water depth criteria for Yuma clapper rail; construction of earthen berms to separate subunits; and changes to the water delivery and drainage system. It is recommended that there be a thoughtful assessment of the relative costs and benefits associated with earthwork that would tend to homogenize topography. It is asserted that topographic and geomorphic variability maintained within the project area will translate into more variable and functional habitats.

2.5 Vegetation Inventory

The Service's Region 2 Habitat and Population Evaluation Team conducted a comprehensive spatial vegetation inventory of the 646 acre Hart Mine Marsh Unit on Cibola NWR (see Figure 11 and Appendix A). The field inventory was conducted over two days in April, 2006. Community, species and structural classifications were derived through ocular estimations while in the field. Over 70 percent of the area was classified during the field data collection portion of the inventory, while the remainder was classified through photo interpretation. Plant communities were classified to the Association level of the National Vegetation Classification System (NVCS). The Association level is the NVCS's most detailed characterization.

A total of 8 different plant communities were identified and associated with 3 distinct landforms occurring in the project area. The majority of the Hart Mine Marsh Unit encompasses the historic Colorado River floodplain. Over 80% of this area has been invaded by mixed and monotypic stands of salt cedar *(Tamarix ssp.)*. The densest and most robust stands of salt cedar were found in the areas adjacent to active water channels and in lower elevation areas that appeared to pool surface water. Areas directly adjacent to open water or currently active channels contained areas of tall emergent plant communities dominated by cattail *(Typha ssp.)* and bulrush *(Schoenoplectus ssp.)*. See Appendix A for a table of vegetation communities and acreages.

The plant communities on the east central portion of the marsh are influenced by alluvial deposition (alluvial fan) resulting from an arroyo entering the river's historic floodplain from the east. This portion of the site contains the most plant diversity and appears to be closest to functioning within the natural process of the system, although plant community composition may seem to indicate possible influences from adjacent man made perturbations and disruptions in natural hydrological processes. The eastern edge of this area is woodland dominated by mesquite (*Prosopis* (*glandulosa var. torreyana, velutina*) and wolfberry (*Lycium ssp.*)). Further west, the area transitions from a course alluvial aggregate towards finer materials. The toe of the alluvial fan is dominated by iodinebush *(Allenrolfea occidentalis)* and areas of sparse salt cedar.

A relatively small portion of the southeast corner of the unit can be classified as upland. This area is a mesa top that is disconnected from the floodplain. It is dominated by sparse creosote bush *(Larrea tridentate)* and little else.


U.S. Fish and Wildlife Service
Cibola National Wildlife Refuge
Hart Mine Marsh Unit Veg Inventory 2006
Allenrolfea occidentalis Shrubland, Type 6 - Very young and low growth - 25.4 acres
Larrea tridentata / Sparse Understory Shrubland Association, Type 6 - Very young and low growth - 10.9 acres
Pluchea sericea Seasonally Flooded Shrubland [Placeholder], Type 5 - Stands with dense shruby growth - 0.1 acres
Prosopis (glandulosa var. torreyana, velutina) Woodland [Placeholder], Type 3 - Intermediate size trees with dense understory - 20.0 acres
Suaeda moquinii Shrubland Association, Type 6 - Very young and low growth - 7.8 acres
Tamarix ssp / Sparse Alien Shrubland Association, Type 5 - Stands with dense shruby growth 39.0 acres
Tamarix ssp / Sparse Alien Shrubland Association, Type 6 - Very young and low growth 2.0 acres
Tamarix ssp. mixed, Type 5 - Stands with dense shruby growth - 8.3 acres
Tamarix ssp. monotypic, Type 3 - Intermediate size trees with dense understory - 242.6 acres
Tamarix ssp. monotypic, Type 5 - Stands with dense shruby growth - 155.6 acres
Tamarix ssp. monotypic, Type 6 - Very young and low growth - 1.1 acres
Tamarix ssp. standing dead, Type 4 - Intermediate size trees with little or no understory - 0.1 acres
Tamarix ssp. standing dead, Type 5 - Stands with dense shruby growth - 20.8 acres
Typha latifolia - Schoenoplectus acutus Herbaceous Association, Type 5 - Stands with dense shruby growth 9.8 acres
Unconsolodated material sparse vegetation (soil, sand and ash), Type 6 - Very young and low growth - 82.2 acres
water, Type 6 - Very young and low growth - 10.9 acres
N
Vegetation inventory produced by the
U.S. Fish and Wildlife Service,
Habitat and Population Evaluation Team (HAPET).
For more information pertaining to data accuracy
and/or the methods used to produce these data please
contact the HAPET Office, 505.248.6432,
Albuquerque, New Mexico (patrick_donnelly@fws.gov).
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2.6 Site Description & Suitability Assessment -- Literature Cited

Fredrickson, L. H., and T. S. Taylor. 1982. Management of Seasonally Flooded Impoundments for Wildlife, U.S. Fish and Wildlife Service Resource Publication 148, Washington, D.C., USA.

Hautzinger, A., Kundargi, D, Donnelly, P. *Hart Mine Marsh* - *Existing Conditions Report*, USFWS, National Wildlife Refuge System, Region 2, 2007. (Appendix A)

U.S. Department of Agriculture-Soil Conservation Service, *Cibola NWR Comprehensive Farm and Water Management Plan*, February, 1989

U.S. Department of the Interior, 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Washington, D.C.

Vradenburg, John, 2007 Land Management Research Demonstration Biologist, *personal communication* Bosque del Apache National Wild Refuge, New Mexico.

3.0 DESCRIPTION OF DESIRED HABITAT TYPES

Working within the interactions of ecosystem processes, abiotic conditions, and wetland dynamics is at the center of the Service's perspective on restoring the Hart Mine Marsh. Both research and direct land management experience has demonstrated that this type of process based restoration can greatly increase the potential for long term success of wetland restoration (Rundle and Fredrickson 1981, McGinnies et al. 1976, Boettinger and Richardson 2001, Cluff et al. 1983, Fredrickson and Taylor 1982). Towards that end, five key components were analyzed to develop this conceptual restoration plan: 1) historic and existing habitat; 2) abiotics, including soils, hydrology, and water quality; 3) geomorphology, 4) topography; and, 5) administrative, policy, and funding sideboards. Historic and existing habitat, geomorphology, and topography were used to subdivide the Hart Mine Marsh into examples of possible smaller management units.

Geomorphology, soils, and topography were used to generate possible infrastructure locations. A combination of all five components will be utilized to determine the potential habitat type (or types) each subunit will be managed for. Figure 12 illustrates one possible restoration scenario using the above criteria, and will be used throughout this section for discussion purposes.

3.1 Management Unit Delineation

To effectively restore the Hart Mine Marsh, it will likely be necessary to divide the marsh into smaller subunits. Doing so serves a number of purposes. First, it will allow for more effective management by breaking up the full unit into smaller, more manageable acreages. Second, it will allow for more effective flushing of accumulated soil salts – a process that is integral to the propagation of desired plant species and to establishing and maintaining water chemistry conditions needed for habitat to support aquatic organisms. Lastly, it will enable the management of a variety of habitat types – a management scenario that is at the center of the Service's restoration policy objectives.

The subunits illustrated in Figure 12 demonstrate one possible scenario of subdividing the Hart Mine Marsh. In this scenario, designating subunits was based primarily on 1) breaklines between floodplain landforms (e.g. abandoned channels, scroll bars and alluvial fans) and 2) existing habitat. In general, these breaklines follow natural topographic contours; creating dikes or levees along these features will likely minimize the total amount of earthwork necessary to create subunits. Designing levees that follow natural contours is likely to maximize wetland productivity by allowing wetland impoundments to be dewatered completely to simulate natural dry cycles and allow the use of heavy equipment for mechanical or chemical treatments (Laubhan et al. 2004).

Additionally, soil deposition typically follows geomorphological trends. For example, soils are typically coarser on the higher elevation ridges, and finer on the lower elevation swales. Thus, the water holding capacity of a specific unit can be forecasted by assessing an area's geomorphological setting, and the expected topographic and pedological trends.

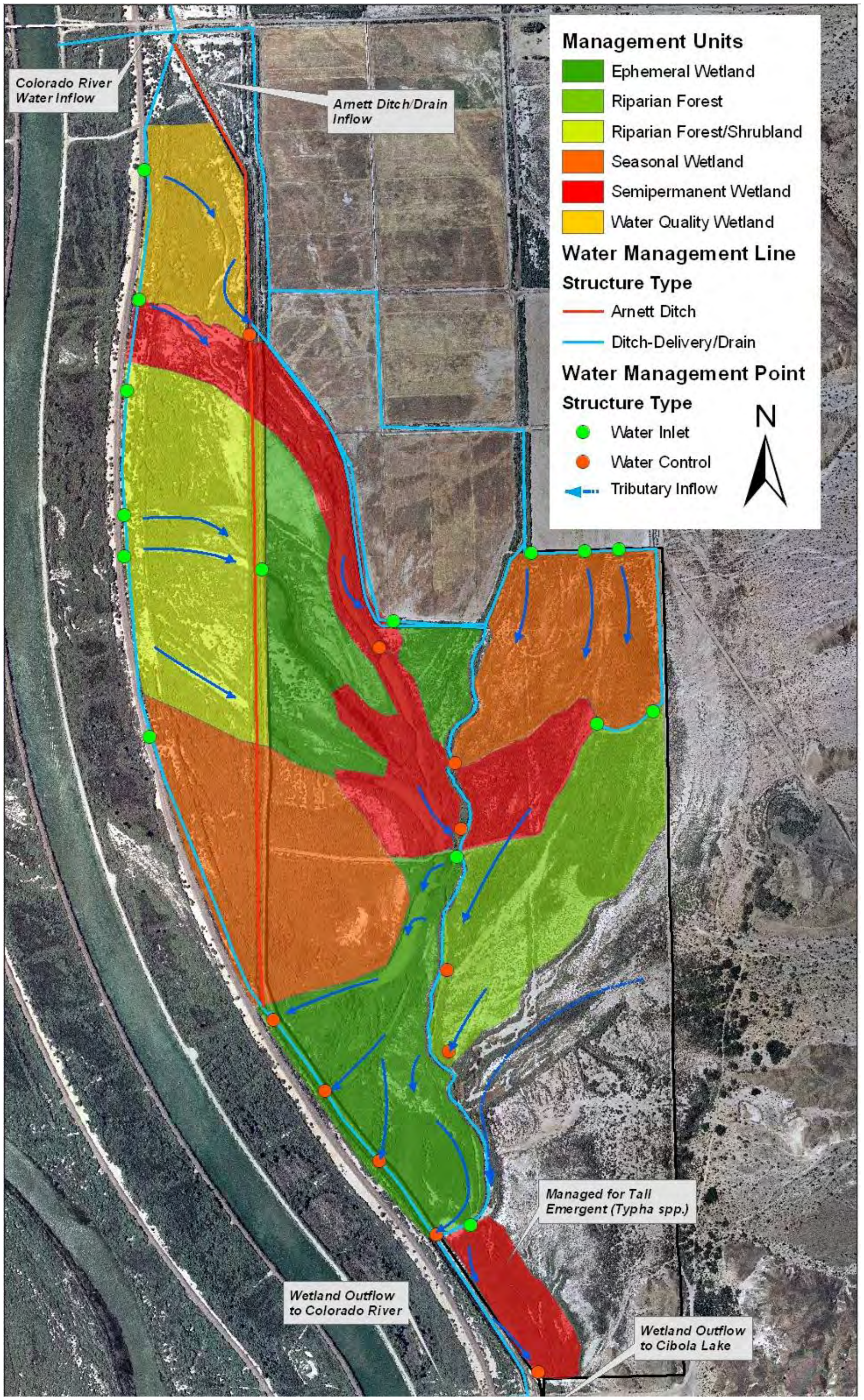

Figure 12. Conceptual Site Plan, describing potential habitat types and infrastructure improvements at the Hart Mine Marsh. This site plan is conceptual in nature and for discussion purposes only. It does not imply a Service or LCR MSCP commitment to developing the specific habitat types, nor the potential infrastructure components, in the specified locations, but a rather, a general commitment to a mosaic of habitats and a robust infrastructure.

Existing habitat was the other main criteria used to designate potential subunits within Hart Mine Marsh. Viable wetland habitat exists within the marsh, portions of which support Yuma clapper rail habitat. Thus, existing wetland habitat should be delineated, and either preserved as separate management units or incorporated into a subunit and preserved therein.

3.2 Infrastructure

Within the context of process-based restoration, key physical processes largely determine the actual composition of vegetative communities and whether they are composed of desirable or undesirable plant communities (Fredrickson and Taylor 1982). For desert river ecosystems, the annual hydrograph's shape and magnitude is a key ecosystem process. Thus, a central assumption to this restoration plan is that restoring the hydrologic processes and plant communities at the Hart Mine Marsh will require the construction of new water management structures (e.g., levees, water control structures and water supply and discharge systems) that facilitate the inflow, distribution and outflow of water.

The development of these structures will allow for the management of water necessary to create the abiotic conditions necessary for the germination and growth of desirable wetland plant communities, to control invasive plants and to alter soil and water chemistry (Fredrickson 1991). The infrastructure delineated in Figure 12 is meant to highlight two important design considerations for developing the infrastructure at Hart Mine Marsh. First, infrastructure should be developed so water levels within subunits can be managed independently of other subunits, and to protect Cibola Lake from marsh outflows that could be laden with poor quality water. Second, due to low relief throughout the marsh, infrastructure should be designed to maximize hydraulic head, considered to be largely a function of: 1) releases from Parker Dam, which dictates river position in the Cibola Reach, and 2) irrigation practices at the refuge's Unit 2).

Developing a water infrastructure at Hart Mine Marsh that enables the management of subunits independent from other units will allow for important management controls that will increase the likelihood of restoration success. For instance, managing soil salinity levels is an important concern for the initial and long term success of the project. As it stands, soil salts are at a level that exceeds the toxicity threshold of many desired plant species. To foster propagation of desired plant species, it will be necessary to flush a substantial amount of the accumulated salts from the subunits. The independent water level management within subunits greatly increases the ability to do this effectively. Once soil salts are at an acceptable level, the proposed infrastructure will enable individual units to be managed for a variety of habitat conditions with a degree of independence from the other units' management objectives.

Further, each unit should be designed to allow the impoundment and removal of water independent of other units. This will allow the flexibility to manage units on a unit-by-unit basis and make it possible to alter habitat conditions by applying management actions in a rotational manner to each individual unit. This is a vital design component that will allow managers to simulate the natural fluctuations within the annual hydrograph of the LCR and maintain long-term habitat viability. As an example, a wetland impoundment could be kept dry to simulate drought conditions, to mimic a disturbance event, or to improve productivity in existing plant communities, while other impoundments could be managed to simulate wet cycle conditions to provide habitat for species with limited mobility and life-cycle requirements that call for higher moisture levels.

A primary design consideration for the marsh is the lack of topographic relief. Canal design and water control structures, such as Langemann gates, should be selected to maximize overall hydraulic head. Doing so will increase the ability to flush salts, maximize irrigation efficiency, reduce staffing requirements, and promote better simulation of hydrologic processes.

The restoration plan must incorporate the impact of external influences on conditions at Hart Mine Marsh from external influences. Specifically, design considerations should account for the impact of Reclamation's river operations on the project area, and how refuge operations at Unit 2 and Cibola Lake affect the marsh.

Another design consideration is addressing elevated nitrogen levels. A typical approach to address high nitrogen levels is through constructed wetlands (see Figure 12's *Water Quality Wetland*). These units perform as engineered treatment systems that can be designed to utilize natural processes involving the microbial assemblages of wetland vegetation and soils to assist in the lowering of nitrogen concentrations. Constructed wetlands are engineered to:

> take advantage of many of the same processes that occur in natural wetlands, but do so within a more controlled environment. Some of these systems have been designed and operated with the sole purpose of treating wastewater, while others have been implemented with multiple-use objectives in mind, such as using treated wastewater effluent as a water source for the creation and restoration of wetland habitat for wildlife use and environmental enhancement. (EPA, 2000)

3.3 Potential Habitat Types

Cibola NWR has a significant water right that can be used for wetlands and riparian habitat management. However, the current water control infrastructure is limited and has inhibited successful ecological management of the Hart Mine Marsh Unit. Plant communities illustrated in Section 3.3 are based on the objective of developing a water control infrastructure and management plan that will provide abiotic and biotic conditions suitable for a mosaic of riparian and wetland habitat types. This diversity of plant communities and hydrologic conditions are designed to meet the annual life cycle demands of resident and migrant waterbirds and other wildlife species. As depicted in Figure 12, an overarching concern for the restoration design at the Hart Mine Marsh is to foster a mosaic of habitats that address the widest possible suite of species needs.

Within all habitat types delineated in this document, invasive species control is a critical management concern. For instance, parrot feather (*Myriophyluum aquaticum*) is a common non-native invasive plant species that occurs in deep water wetland areas. Giant salvinia (*Salvinia molesta*) is another aquatic invasive plant that is of mounting concern in this reach of the lower Colorado River. Other invasive species that merit attention include Quagga mussels (*Dreissena* *bugensis*), the common bullfrog (*Rana catesbeiana*), and salt cedar (*Tamarix spp.*). Salt cedar will continue to be an invasive species of great management concern, particularly during drawdowns between March and October (Dr. Kathleen Blair, 2007 *personal communication*).

Figure 13. Examples of habitat mosaics at Bosque del Apache National Wildlife Refuge (NM). Habitat restoration of this type may be possible at the Hart Mine Marsh.

3.31 Wetlands

The reduction and degradation of LCR wetland habitat has negatively impacted many wildlife species. Historically, the LCR's wetland habitat was related to over bank flood events and groundwater connectivity. Wetlands would have been most abundant in the late spring and early summer and again in the winter when evapotranspiration was lowest and surface water could pool where groundwater was closest to the surface. Shallow seasonal wetlands would result from over bank flood events, while semi-permanent wetlands may have been formed during flood events but would likely have persisted for longer periods, often for multiple years. Ephemeral wetlands would likely have developed following heavy localized rain events or from exposure to sub-flow and/or high water tables.

Successful unit management emulates the historic hydrograph of the region, and in doing so, promotes vegetation that would naturally occur (Nilsson et al 1991). The resulting faunal responses will reflect the quality of the vegetation established and other abiotic and biotic conditions that historic wildlife species utilized.

3.32 Semipermanent Wetlands

Sojda and Solberg (1995) describe four stages of a semipermanent wetland: dry, regenerating, degenerating, or lake marsh (Figure 14). Key elements to the productivity of these systems are prolonged periods of flooding intermixed with periods of drought. Perennial plants adapted to withstanding periods of prolonged flooding dominate semipermanent wetlands. Plant community heterogeneity is a function of water depth and duration of flooding. Deep water areas greater than 1 meter will likely be open water and dominated by submergent native vegetation unless invasive plant species are present.

Cattail (*Typha spp.*) and bulrush (*Schoenoplectus ssp* , formerly classified as *Scirpus spp.*) occur in water depths of 1 meter or less (water turbidity levels influence the depth that the plants can persist at). Site establishment occurs by seed dispersal on bare soil and dominance of bulrush or cattail is determined by soil conditions during germination. Cattail and bulrush seeds do not germinate under more than 0.5 inch (1.3 cm) deep water. Sunlight, in combination with other environmental factors, is critical to germination. Deeper water or shading in dense stands filters out enough light to prevent germination. One of the primary reasons cattails are so prolific is that seeds germinate under a wide range of temperatures when the soil is at nearly saturated conditions. The optimum soil surface temperature is 86^{o} F (30^{o} C) (Ibid). Bulrush has a higher tolerance for saline conditions during germination; this feature can be used to foster bulrush communities. Both species reproduce vegetatively and can respire when soils are anoxic under flooded conditions.

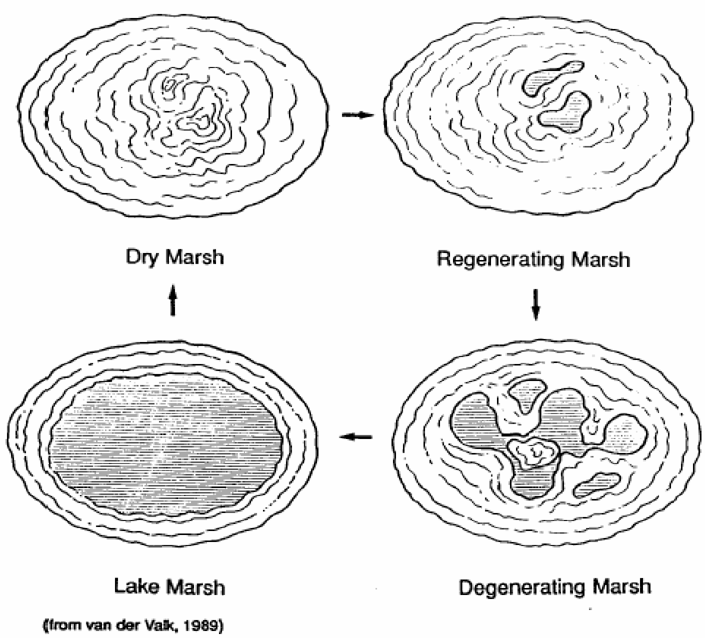

Figure 14. The four stages of a semipermanent wetland during a standard wet and dry cycle. Lines represent vegetation zones that become apparent in the regenerating marsh stage, while areas filled with black represents open water (adapted from van der Valk 1989).

In water depths of 4.7 inches (12 cm) to moist soil levels, there is a transition to short emergent perennial plants including sedges (*Carex spp.)* and rushes (*Schoenoplectus ssp., and Juncus spp.)* as well as annual plants. Vegetation within semipermanent wetlands can shift rapidly to a monoculture of tall emergent plants. If water regimes remain constant or populations of herbivorous mammals are low, these monocultures may rapidly reduce associated waterbird use (Fredrickson and Reid 1988).

Restoration and management of semipermanent wetlands will benefit red-winged (*Agelaius phoeniceus*) and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) (nesting and migration), wintering waterfowl (roosting and foraging – depending on the selected species), colonial and wading birds (breeding and foraging), herptiles (breeding, wintering, foraging), and small mammals (foraging). Of particular concern is an endemic sub-species (perhaps a full

Figure 15. Two examples of the vegetative communities and structure associated with managed semipermanent wetlands that are possible at the Hart Mine Marsh.

species) of cotton rat (*Sigmodon arizonae plenus*). It appears to have been historically associated with wetlands and the last confirmed record of the species was on Cibola NWR.

As previously noted, a species of particular concern is the Yuma clapper rail, which requires wetland habitats dominated by tall emergent vegetation. The highest density of Yuma clapper rails occurs in cattail or bulrush stands with lower stem densities with interspersed open channels and downed vegetation (Smith 1974, Ohmart and Smith 1973). Breeding birds show some preference for transition zones between emergent wetlands and upland either along the wetland perimeter or elevated areas within the wetland (Smith 1974). Research indicates that Yuma clapper rails prefer water depths less that 0.3 m (12 inches) with floating vegetation in open water areas (Tomlinson and Todd 1973, Ohmart and Smith 1973). This habitat requirement would be supported by management plans that monitor community succession and use disturbance to maintain appropriate stem densities. Another avian species which is confined to marshes and is of particular concern is the California black rail (*Laterallus jamaicensis coturniculus)*. It is associated with somewhat shallower water depths and different vegetation types (more reliance on grasses and sedges) than is associated with the Yuma clapper rails along the LCR.

3.33 Seasonal Wetlands

Wetlands reflect the annual hydrograph of a localized watershed. They also reflect an area's local biotic and abiotic conditions, including: salinity, nutrient availability, organics, and soil oxygen availability. Annual duration of inundation is usually variable but can persist for several weeks to months depending on climate conditions, depth of groundwater table, and soil horizon characteristics. Vegetation communities are a product of soil saturation and temperatures during the growing season and are heterogeneous across zones of drying and germination periods (Table 1). Annual grasses and forbs that germinate under moist soil conditions are the dominant vegetation in early succession wetlands but perennial species including sedges (*Carex sp*.), Baltic rush (*Juncus arcticus*), hardstem (*Scirpus acutus*) and Three-square bulrush (*Scirpus pungens*) often transition in over time. Also Colorado River Hemp, often considered an agricultural nuisance, is a native annual on the LCR that may play a significant role in soil development as it fixes nitrogen.

Tall emergent perennials (cattail and bulrush) may colonize when longer hydroperiods occur. Indicator species are barnyard grass (*Echinochloa spp.*), sprangletop (*Leptochloa spp*), smartweed (*Polygonum spp*.), toothcup (*Ammania coccinea*), dock (*Rumex spp*.), and pigweed (*Amaranthus spp.*). Problem species associated with seasonal wetlands include Johnson grass (*Sorghum halepense*), cocklebur (*Xanthium spp*.), perennial pepperweed (*Lepidium latifolium*), kochia (*Kochia scoparia*), and bindweed (*Convolvulus arvensis*). Fountain grass, cattail and bulrush can become problems. Depending on the patterns of wetting, salt cedar (*Tamatix spp.*), giant reed (*Arundo donax*) and *Phragmites spp.* can also become significant problems.

Figure 16.Two different seasonal wetlands during the winter (left) and fall (right). Note the extensive utilization of migratory waterfowl and the diverse vegetative communities.

3.34 Ephemeral Wetlands

Ephemeral wetlands occur in areas where groundwater occurs close to the surface and that experience seasonal variation in the groundwater hydrograph. In many riparian systems of the Southwest this type of wetland was historically extensive. Ephemeral wetlands (Figure 17) are also a product of summer precipitation that occurs in basins and pans where surface water temporarily pools. High evaporation rates during the summer often result in higher salinity levels in the soil associated with ephemeral wetlands. Common plant communities are saltgrass (*Dystichlis spicata*) meadows that transition to alkali (*Sporobolus airoides*) or giant sacaton (*Sporobolus wrightii*) as well as catch-fly Gentian (*Eustoma exaultum*), yerba mansa (*Anemopsis californica*), and saltmarsh fleabane (*Pluchea camphorate*), depending on the timing of wetting and drying. These species are highly used by many native insects. Where the wetting period is short compared to the dry period, both pickleweed (*Allenroffea occidentalis*) or arrowweed (*Pulchea purpurescnes*) may occur in large stands depending on soil salinity levels.

Table 1 Effects of drawdown timing on common wetland species.

	Species		Drawdown date		
Family	Common name	Scientific name	Early[a]	Midseason[b]	Late[c]
Grass	Swamp timothy	*Heleochloa schoenoides*	+[d]	+++	+
	Rice cutgrass	*Leersia oryzoides*	+++	+	
	Sprangletop	*Leptochloa* sp.		+	+++
	Crabgrass	*Digitaria* sp.		+++	+++
	Panic grass	*Panicum* sp.		+++	++
	Wild millet	*Echinochloa crusgalli* var. *frumentacea*	+++	+	+
	Wild millet	*Echinochloa walteri*	+	+++	++
	Wild millet	*Echinochloa muricata*	+	+++	+
Sedge	Red-rooted sedge	*Cyperus erythrorhizos*		++	
	Chufa	*Cyperus esculentus*	+++	+	
	Spikerush	*Eleocharis* spp.	+++	+	+
Buckwheat	Pennsylvania smartweed	*Polygonum pensylvanicum*	+++		
	Curltop ladysthumb	*Polygonum lapathifolium*	+++		
	Dock	*Rumex* spp.		+++	+
Pea	Sweetclover	*Melilotus* sp.	+++		
	Sesbania	*Sesbania exalta*	+	++	
Composite	Cocklebur	*Xanthium strumarium*	++	+++	++
	Beggarticks	*Bidens* spp.	+	+++	+++
	Aster	*Aster* spp.	+++	++	+
Loosestrife	Purple loosestrife	*Lythrum salicaria*	++	++	+
	Toothcup	*Ammania coccinea*	+	++	++
Morning glory	Morning glory	*Ipomoea* spp.	++	++	
Goosefoot	Fat hen	*Atriplex* spp.	+++	++	

a - Drawdown completed within the first 45 days of the growing season(site dependent)..
b - Drawdown after first 45 days of growing season (site dependent).
c - Late summer drawdown (site dependent).
d+ = fair response; ++ = moderate response; +++ = excellent response.
(From Fredrickson 1991)

Figure 17. An ephemeral saltgrass wetland at Bosque del Apache National Wildlife Refuge.

Higher salinities and the presence of highly cellulose plant materials make ephemeral wetlands productive invertebrate habitats. Seasonal production of fairy shrimp (*Artemiidae*), brine flies (*Ephydridae*), and other halophytic invertebrates provide the needed resources for breeding waterbirds. Ephemeral wetlands provide foraging habitat for numerous small mammals (*Heteromyidae* and *Dipodidae*), and several herptiles including toads (*Pelobatidae* and *Bufonidae*), lizards (*Crotaphytidae* and *Phrynosomatidae*), and snakes (*Colubridae* and *Viperidae*), all of which utilize these habitats for breeding, hibernation, and foraging. Although historically common, ephemeral wetlands are now rare in western riparian systems. Modern management of western river systems has incised river channels, lowered groundwater levels and muted groundwater hydrographs.

3.35 Forests and Shrublands

Along with the goal of restoring a diverse wetland component to Hart Mine Marsh Unit, there is the opportunity to reestablish other characteristic plant communities historically common on the LCR (Mueller et al 2002). For the purposes of this document, the categories of plant communities are based on very general distinctions in structure.

Within the historic mosaic of wildlife habitat types along rivers, native forests provide the plant species, structural diversity, and varying abiotic conditions (light exposure, soil texture, soil moisture, and ground temperature are examples) that support a number of bird, reptile, and mammal species. These forests vary from dense patches of trees to open savannah-like parks. Different animal species utilize riparian forests, based on a number of factors including: forest patch size, structure and diversity of plants, and seasonal availability of moist substrate or open water. Some wildlife species would be expected to move through these patchy areas in search of food or shelter so the species examples listed below could apply to more than one habitat type. A simplified description of three different forest types follows.

Figure 18. Two examples of dense forest. The first is of a young dense forest, and the second is of a mature canopy forest.

3.36 Dense Forests

Dense forests are categorized here as forests of different age classes, from newly established young trees to mid-age forests. The defining characteristic of these forests is the number of stems per acre. Historically, seedling establishment occurred at various elevations on the floodplain depending on the magnitude of river flows (Scott et al 1997). In altered river systems, dense young forests are often found on river channel sandbars and high flow side channels and low terraces with a connection to the occasional surface water and shallow groundwater (Stromberg et al 1993). The plant species most commonly associated with young dense forests are coyote willow (*Salix exigua*), Goodding's willow (*Salix gooddingii*), and cottonwood (*Populus sp*.) These young forests provide nesting habitat for the southwestern willow flycatcher (*Empidonax trallii extimus*), Bell's vireo (*Vireo bellii*), and a number of other neotropical migrant birds.

As cottonwoods mature and provide more shade to the floodplain surface, coyote willow thins out and other, more shade-tolerant, understory species are more common including seepwillow (*Baccharis salicifolia*). These mid-age to mature "canopy" forested areas provide food, roosting and nesting opportunities for a number of bird species including woodpeckers, with the Gila woodpecker (*Melanerpes uropygialis*) known to nest on the refuge, bald eagle (*Haliaeetus leucocephalus*), and assorted hawks (Figure 18). Small mammals, snakes and lizards would be frequent foragers in these forests.

3.37 Open Forests

Open forests (Figure 19) are found in many riparian areas due to both anthropogenic alterations to the system and natural system functions. Historically, high flows would remove some of the dense plant material established on the lower terraces of the floodplain. These scoured areas, if not reestablished with a new cohort of native trees, would initially become established with annual grasses that would transition into perennial grasses and woody shrubs without further disturbance. Plant density and shaded area is much reduced in these open forest areas. Some of the anthropogenic uses or impacts leading to the development of open forests include uncontrolled grazing, human-caused fires that reduce the density of trees, and wood harvesting.

Figure 19. An example of an open forest.

These impacts have occurred on southwestern rivers for at least the last few hundred years and have altered, in concert with modified water management practices, the occurrence of the habitat mosaic that once was associated with the hydrology and geomorphology of this river system. Wildlife species expected to use the area include birds like the phainopepla (*Phainopepla nitens*), western tanager (*Piranga ludoviciana*), and lesser nighthawks (*Chordeiles acutipennis*). Vermilion flycatcher (*Pyrocephalus rubinus*) and other flycatchers would be expected to use these types of habitat if close to open water. Bobcat (*Felis rufus*) and pocket gopher (*Geomys sp*.), and other small mammals are usually found in open forests.

3.38 Shrublands

Southwestern riparian shrublands are described here as three types which transition from those closest to open water (what historically would have been the river's edge) to more xeric conditions.

Figure 20. Dense willow shrubland, adjacent to shallow groundwater.

The first type of shrubland is the dense coyote willow stand. These shrubs form dense monotypic stands adjacent to open water or shallow groundwater. They are distinguished from young mixed stands mentioned above as young dense forests because they typically occur as a dense clump of a single species, expanding in size but consistent in height, i.e. there is no diversity in structure for this habitat type (Figure 20). Historically, these shrubs would be found on point bars or islands within the river's active channel or adjacent to the river's edge. These shrubs are now often found along ditch and drain banks. They are not associated with high salinity levels in soil or in water. They provide shelter, foraging habitat, and in some cases nesting structure for southwestern willow flycatcher (*Empidonax trallii extimus*), Bewick's wren (*Thryomanes bewickii*), and yellow warbler (*Dendroica petechia*) among others.

Figure 21. Screwbean mesquite shrubland associated with more mesic conditions.

The second type of shrubland is usually associated with plants that require a shallow groundwater table, tolerate higher soil salinity levels, and have fine-grained soil texture (Figure 21). Velvet (*Prosopis velutina*) and screwbean mesquite (*Prosopis pubescens*), and iodinebush *(Allenrolfea occidentalis)* occur in these areas along with alkali sacaton (*Sporobolus airoides*) and some *Muhlenbergia* grass species. Wildlife species found on the refuge and would presumably be attracted to this type of habitat include the hermit thrush (*Catharus guttatus*), Lucy's warbler (*Vermivora luciae*), lazuli bunting (*Passerina amnoena*), western meadowlark (*Sturnella neglecta*), and long-billed curlew (*Numenius americanus*, if substrate is saturated). These areas have a diverse assemblage of invertebrate species. Small mammals and mule deer (*Odocoileus hemionus*) would forage in these areas.

The third type of shrubland is found in courser-grained floodplain soils. Honey mesquite (*Prosopis glandulosa*), wolfberry (*Lycium sp*.) and sand sage (*Artemisia filifolia*) are three plant species associated with this shrubland type. Grass species would be similar to those found in upland areas adjacent to the Hart Mine Marsh (Figure 22). Wildlife use of both these more xeric

Figure 22. Two examples of shrublands associated with more xeric conditions.

shrublands is diverse: numerous species of small mammals such as the hispid cotton rat (*Sigmodon hispidus*), reptiles, and birds such as warbler species (McGrath and van Riper 2005), mourning (*Zenaida macroura*) and white-winged doves (*Zenaida asiatica*), falcons, Gambel's quail (*Callipepla gambelii*), burrowing owl (*Athene cunicularia*), and the Crissal thrasher

(*Toxostoma crissale*) would be expected to use these areas. Rodents using this transition area from xeric riparian to desert plant communities could include the genus *Dipodomys, Perognathus* or *Chaetodipus.* Coyotes (*Canus latrans*) would also be expected to move through these areas.

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4.0 POTENTIAL MANAGEMENT ACTIONS

This section describes the proposed potential management actions associated with improving and restoring habitat quality and diversity at the Hart Mine Marsh Unit, Cibola National Wildlife Refuge. The proposed project is designed to improve and restore habitats through expansion of infrastructure capability, salinity reduction, water quality improvements, removal of exotic vegetation, and the establishment of native vegetation. Project goals are re-establishing the hydrologic and biologic components of Colorado River wetland habitat and establishing functional habitats composed of native tree and shrub species, saltgrass meadows, and upland grasslands.

4.1 Proposed Restoration Phases (Hart Mine Marsh)

The project will be implemented in three phases; details of each of the phases and the related activities are shown below.

The first phase will be *planning and design*. The tasks and activities within this phase are information gathering and analysis, planning, and design. Much of the site characterization and planning tasks have already been accomplished in the topographic survey, *Existing Conditions Report*, and the *Comprehensive Conceptual Restoration Plan* (Stallings, 2007). The remaining tasks are to complete the survey and prepare a topographic map with sufficient detail to complete the engineering design, prepare a restoration and management plan, and develop an engineering design.

The second phase will be *implementation*. The tasks and associated activities within this phase are vegetation clearing and grubbing (root removal), which will be followed by infrastructure construction. With the initial control of non-desirable vegetation completed, and the critical pieces of the enhanced infrastructure in place, the implementation phase will move onto soil reclamation, continued weed control, and revegetation. The timeline for the individual management units will probably diverge at this point; some of the units may take years to reclaim, while others may be ready for restoration relatively quickly (Ibid).

The final phase of the project will be *monitoring* and *adaptive management*. As described in Section 1, the Service has endorsed an adaptive-management approach, referred to as Strategic Habitat Conservation (SHC). This framework provides a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. Management is treated as a deliberate experiment for the purpose of learning. Practices are designed to discriminate between alternative models, and thus reveal the "best" management action. This endorsement by the Service to the SHC framework represents a commitment to meaningfully implement the tenets of adaptive management, which requires careful implementation, monitoring, evaluation of results, and adjustment of objectives and practices, and is a critical piece of the Service's intent regarding this restoration project.

Some of the tasks and activities that make up each of the phases may overlap phases. For example, most of the Weed Control Task will take place during the Project Implementation

Phase, but some amount of salt cedar must be removed to complete the survey (Design Phase) and will be ongoing (Management Phase). Additionally, several of the tasks and activities will be iterative. For example, review of the restoration plan may generate issues that need to be addressed during the engineering design process. The Service anticipates that negotiations with the LCR MSCP will be necessary to determine which features of the plan meet the LCR MSCP's funding requirements (LCR MSCP, 2004). Further, it is anticipated that the outcome of discussions with the LCR MSCP may change restoration plans and timelines and inform which project components will be funded through other partnerships.

4.12 Phase I --Planning and Design.

Task 1 Characterize the Site:

Activity 1. Characterize key abiotics (e.g., soils and hydrology) and prepare the *Existing Conditions Report*. Completed.

Activity 2. Perform detailed Site Survey and Topographic Depiction / Digital Terrain Model (some amount of salt cedar must be removed to complete the survey).

Task 2 Engineering Design and Restoration/Management Plan Preparation:

Activity 1. Prepare *Comprehensive Conceptual Restoration Plan*. Completed.

Activity 2. Prepare *Engineering Design* and *Management Plan*. This will include stamped engineered drawings, technical specifications, detailed management unit descriptions, hydrology, desired vegetation type on each unit, soil reclamation requirements, detailed weed control plan, revegetation plan, specific adaptive management strategies, and ongoing management activities (Save our Bosque Task Force, 2007).

Activity 3. Prepare *Monitoring Plan*.

Activity 4. Continue discussions with LCR MSCP regarding the cost sharing structure.

Task 3. Obtain necessary permits and authorizations

4.13 Phase II –Implementation

Task 1. Brush clearing

Task 2. Construction and earth movement:

Activity 1. Infrastructure expansion.

Activity 2. Construction of earthen levees to sub-divide the marsh.

Activity 3. Excavation to sculpt bottom of project area designated for wetland habitat.

Task 3. Soil reclamation:

Activity 1. Apply gypsum to sodic soils as needed.

Activity 2. Cycles of applying and draining water to individual management units.

Activity 3. Cover crop to suppress weeds and raise organic matter levels (as needed).

Task 4. Weed control:

Activity 1. Mechanical weed control.
Activity 2. Chemical weed control.

Task 5. Active restoration of native vegetation:

Activity 1. Identify local genetic material source (seeds, cuttings, etc.). Collect material and grow it out (as needed). Time sensitive- may take several years.
Activity 2. Prepare soil for planting (as needed).
Activity 3. Planting.

Task 6. Passive restoration of native vegetation.

4.14 Phase III--Monitoring and Adaptive Management

Task 1. Implementing management actions.

Task 2. Monitoring to observe the results of those actions.

Task 3. Use the results to update knowledge and adjust future management actions accordingly. By repeating this cycle and increasing to the body of knowledge about the system in question, managers are able to refine their prescriptions to more closely meet the original objectives.

4.2 Anticipated Environmental Benefits

This project is expected to result in the following benefits:

- Restoration of the currently degraded marsh wetland area/saltgrass meadow to contribute to regional habitat diversity and integrity and to provide additional habitat for wetland obligate or facultative species that reside in or migrate through the area;
  - Of special note, habitat supporting the Yuma clapper rail (a species of high priority for the Service and the primary species of concern to the LCR MSCP) would be found within the lower lying portions of the project area;
- Restoration of native cottonwood-willow vegetation that would provide habitat for a diverse assemblage of wildlife species (see Section 3);
- Removal of exotic salt cedar will;
  - Reduce wildfire risk in the project vicinity, thus protecting nearby vegetation and habitat, and reducing the risk of wildlife habitat damage, and impacts associated with fire suppression;
  - Facilitate the creation and sustainability of large blocks of marsh habitat for the Yuma clapper rail; and,
  - Provide an increase in plant species and structural diversity within the historic floodplain of the lower Colorado River.

4.3 Potential Management Actions Section 4 -- Literature Cited

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5.0 HART MINE MARSH-CCRP CONCLUSION

This document contains the U.S. Fish and Wildlife Service's recommendations for restoring and managing a mosaic of habitat types at the Cibola National Wildlife Refuge's Hart Mine Marsh Unit in a manner that complies with the National Wildlife Refuge System's mission and the refuge's purposes. The recommendations found within this document are largely conceptual in nature and are intended to provide the foundation and framework for a detailed restoration plan. An important secondary purpose of the document is to evaluate the potential for restoring portions of the Hart Mine Marsh in fulfillment of the program requirements of the Lower Colorado River Multi Species Conservation Program

The Hart Mine Marsh restoration project seeks to restore the marsh to a complex and dynamic habitat mosaic that would be managed to mimic or restore important natural processes within the constraints imposed by site conditions and policy requirements. A habitat mosaic will better meet multi-species needs by providing necessary biological requirements through various life history stages. Past restoration experience shows there is a strong correlation between the degree to which a project incorporates abiotic characteristics (e.g., soils and hydrology) into its restoration and management activities and the level of success a restoration project has in meeting its goals and objectives.

Furthermore, successful long term restoration must include a rigorous monitoring program that tracks key indicator variables and has sufficient management flexibility to adapt to information generated by these key indicators. Towards this end, the Service advocates a project design that applies the Service's policies and guidelines related to adaptive management and ecosystem management principles as detailed in Section 1.3

An important consideration for the Service's endorsement of this restoration project is the availability of the refuge's entitlements to the diversion and use and of lower Colorado River water. In this document the Service has determined that the refuge's water entitlements are sufficient to support this project. However, this determination is based upon the assumption that the current policy framework administered by the U.S. Bureau of Reclamation does not change substantially during the lifetime of this project. Specifically, Service support of this project assumes that the refuge's unmeasured return flow credit will remain stable.

While the Service is aware that the non-marsh components of the restoration work advocated in this plan go beyond the scope of the LCR MSCP, the Service is committed to managing the Hart Mine Marsh in as holistic a manner as possible. Further, the Service is optimistic that other resources, beyond those provided by the LCR MSCP, can be secured to expand the restoration work to cover the majority of this management unit's area.

Through the analyses described within this document, and those conducted previously in the *Existing Conditions Report*, it is the Services' opinion that there is high potential for restoration at the Hart Mine Marsh to meet the National Wildlife Refuge System's mission in a manner compatible with the refuge's purposes and with the objectives of the LCR MSCP.

Appendices

Appendix A

Existing Conditions Report

Hart Mine Marsh:

Existing Conditions Report

April 30, 2007

Interim Report:

Work Done to Date Regarding Evaluating the Potential of Restoring the Cibola National Wildlife Refuge's Hart Mine Marsh Unit

Supplied to USBR Lower Colorado
(Gregg Garnett)

by

USFWS Region 2
(Andrew Hautzinger, Darrell Kundargi
& Patrick Donnelly)

Hart Mine Marsh Existing Conditions Report: Table of Contents

<u>Hart Mine Marsh</u>:

Existing Conditions Report

1. INTRODUCTION

The United States Fish and Wildlife Service (Service) is evaluating the potential of restoring marsh habitat on the Cibola National Wildlife Refuge's Hart Mine Marsh Unit. This document is an interim product that details the work done thus far to characterize the Hart Mine Marsh unit's existing conditions. As data collection and analyses will continue through the summer of 2007, this report will be updated and modified as more information becomes available. Additionally, the final version of this report will be incorporated into the Service's *Comprehensive Conceptual Restoration Plan for Hart Mine Marsh*, due to be finalized on September 7, 2007.

1.2 Primary Report Objectives:

Goal 1: Determine if the restoration of the Hart Mine Marsh is compatible with both the objectives of the LCR MSCP and objectives, with available resources, to the Cibola NWR.

Goal 2: Describe data gathered to inform the design of the restoration plan and identify opportunities and constraints for restoration.

Goal 3: Describe data gathered that will provide the baseline for the development of success criteria for the restoration project and long-term monitoring of the project.

1.3 Background

The Service is collaborating with the U.S. Bureau of Reclamation (Reclamation) on this project, as both these sister agencies are members of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a state/federal/private partnership that, when implemented over the next 50-years, hopes to "ensure long-term compliance with applicable federal and state the environmental laws, while permitting the continued utilization of lower Colorado River water and power resources". Reclamation is the implementing agency for the LCR MSCP, and is interested in the potential for this on-refuge project to produce marsh habitat mitigation credit for the program.

The LCR MSCP is committed to restore 512 acres of marsh habitat along the lower Colorado River. Reclamation is approaching landowners, including wildlife refuges, to assess their willingness to dedicate their land and water for restoration or creation of these specific habitats. Reclamation hopes to be able to claim marsh mitigation credit under the LCR MSCP for the Hart Mine Marsh project, when the habitat meets the appropriate performance criteria. The Service is working with Reclamation to determine if the Hart Mine Marsh project will work within this context.

According to the terms of the LCR MSCP, certain biological requirements need to be met for mitigation credits to be produced. For marsh habitat, these requirements are specified in terms of four target species of interest. These species are: the Yuma Clapper Rail, the California Black Rail, the Least Bittern, and the Colorado River Cotton Rat.

Requirements specific to the Yuma Clapper Rail, the Least Bittern, and the Colorado River Cotton Rat are: mosaic of marsh vegetation species and open water in greater-than-acre patches with emergent vegetation at varying water depths (for the Yuma Clapper Rail, water depths not to exceed twelve inches.) Marsh habitats created for California Black Rail will also provide habitat for these species.

In addition, the California Black Rail requires moist soil marshes in greater-than-acre patches with a predominance of three-square bulrush at water depths not to exceed one-inch.

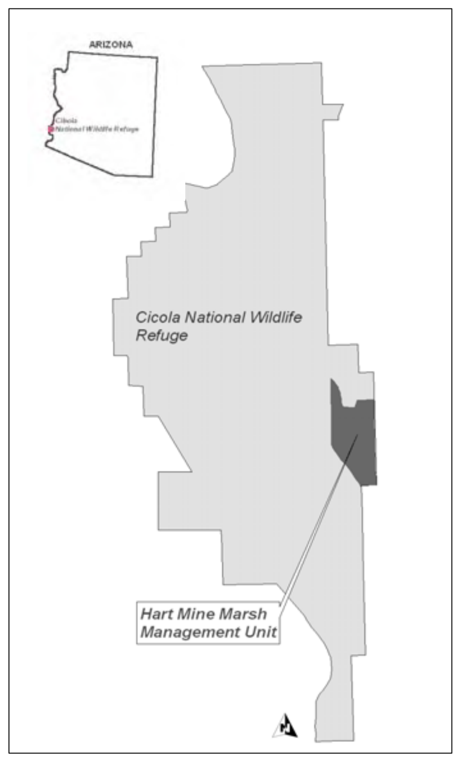

Figure 1. Location of Cibola NWR and the Hart Mine Marsh.

1.4 Hart Mine Marsh

Hart Mine Marsh is a decadent marsh located on Cibola NWR (Figure 1). The entire marsh occupies 646 acres, 123 acres of which are estimated to be upland habitat (and would not apply to marsh restoration activities). Currently, drainage water from the refuge's agricultural fields enters Hart Mine Marsh through gated structures in the Arnett Ditch, and culverts from Farm Unit 2. There is limited outflow from the marsh, therefore drain water typically "dead ends" in the marsh to stagnate and evaporate, resulting in poor water quality, marginal marsh habitat, and saline upland areas, some completely devoid of vegetation.

2.0 TOPOGRAPHY

A topographic map of the site was developed based on Reclamation survey data. According to the data received from Reclamation and field observations, much of the proposed area was not accessible for survey due to heavy tamarisk growth. Narrow openings were cleared through the brush using heavy equipment to allow cross section surveys at near random intervals. Those portions of the project area that were accessible were thoroughly surveyed.

A topographic map was generated using Reclamation data and Autodesk LDD software, converting survey points and 3D polylines to form a triangulated irregular network (TIN), and finally elevation contours using a utility software that interpolates the TIN. Typically, generating a topography map would start with an even distribution of survey point data covering the project area, and 3D polylines connecting some of these points to define linear features. The Reclamation survey had neither. 3D polylines were created by digitizing over photo images and estimating the Z values based on nearby survey points, vegetation types, visual observations in the field, and at times, educated guessing. In some areas, no survey points were available, so the Z values are estimated. The overall result is a surface (Appendix 1) that is conceptual, but provides a sufficient starting point for conceptual designs. The field data has insufficient point density to produce a map truthful to the ground (e.g., one that could be used for engineering designs.)

The topographic data shows that the project area falls on average about 2’ from north to south, and relatively flat from east to west, sloping slightly toward the river. The southeast corner of the project area is higher in elevation than other areas, rising steeply as a result of alluvial fans created by washes to the east, and mine tailings. The lowest elevations are associated with historical channels created by high river flows prior to the construction of dams and levees, averaging about 1’ to 2’ below the surrounding grade.

Most of the area (80% +) is relatively flat, and conducive to flood irrigation or ponded water conditions, although the existing infrastructure presents a severe limitation. Some earthwork would be required to create units for greater irrigation efficiency and management. The amount of earthwork required cannot be quantified at this time, requiring first the completion of a conceptual design(s) and additional survey work once the area is cleared of brush.

3.0 EXISTING HYDROLOGY AND WATER QUALITY

3.1 Overall Water Budget for the Cibola Refuge

3.11 Water Use -- General

Water used at the refuge broadly falls into two categories: (1) water that is mechanically diverted from the Colorado River and applied to actively managed lands, and (2) water that is passively used by native and non-native vegetation on refuge lands that are not actively managed. The refuge has annual water entitlements that allow the active diversion of water from the Colorado River of 27,000 acre-feet, plus 7,500 acre-feet for circulation purposes. The refuge’s consumptive use entitlements (which are legally defined in the Arizona vs. California Supreme Court Decree as being “diversion minus measured return flow”) equal 16,793 acre-feet.

Water is diverted in three locations through the use of pumps to irrigate three primary habitat management areas. These include Farm Unit 1, Farm Unit 2, and the Island Unit. Each primary management area has a pumping station that lifts water from the river to lined ditches for conveyance of water to the individual habitat units. Pumps consist of vertical turbine pumps mounted on platforms located in the river.

There are several factors that influence the amount of the Colorado River water used by the refuge. These include the area of actively managed lands, the type of habitat (i.e., moist soil vs. native riparian), management practices, and refuge water entitlements. Long-term climate change could also have a significant impact on water use, but is speculative and beyond the scope of this report.

3.12 Cibola NWR Water Entitlements and Water Accounting

Congress established the Cibola NWR on August 21, 1964, by Public Land Order 3442. The enabling legislation concisely described the refuge’s purpose as being ". . . *reserved for use of the United States Fish and Wildlife Service, as the Cibola National Wildlife Refuge*" and "*subject to their use for reclamation or wildlife refuge purposes*."

In order for the refuge to meet these congressionally defined purposes, the refuge was granted rights to divert and use water from the lower Colorado River. In 1982, the Secretary of the Interior reserved a specified amount of Colorado River water for use on the Cibola NWR based on the date that refuge lands were withdrawn (August 21, 1964).

These “entitlements” to Colorado River water were designed to allow the refuge to meet its land management responsibilities, in support of wildlife habitats, in the form of a “Secretarial Reservation” as published in the Federal Register, Vol. 17, No. 237, December 9, 1982, pp. 55430-31:

Consistent with the February 9, 1944, contract between the United States and the State of Arizona, notice is given that the following amount of Colorado River water is reserved for the United States for use on the Cibola National Wildlife Refuge in Arizona: The diversion of 27,000 acre-feet annually from the mainstream or the consumptive use of 16,793 acre-fee annually from the mainstream, which ever is less, with a priority date of August 21, 1964.

A secretarial reservation of water is allowed through Section 5 of the Boulder Canyon Project Act, authorized by Congress in 1928. The Act allows the Secretary of the Interior to enter into contracts for the storage and delivery of river water for beneficial uses. Since a public agency cannot enter into a contract with itself, the Secretary can “reserve” water for use by a federal agency. A secretarial reservation is considered a “second priority” (sixth being the lowest), meaning that it is only subordinate to first priority rights, also known as present perfected rights, which were established at the time the Act was authorized. In years when water supplies are insufficient, water is first withdrawn from those with a lower priority (as opposed to other federal water project contracts where shortages are shared among contractors). Thus, Cibola NWR's water entitlements are of relatively high priority and would only be subject to reductions during the most extreme shortages. As such, reductions in deliveries due to periods of low precipitation were not assumed.

In addition, the refuge also has 7,500 acre-feet for providing circulation, as published in the Senate Report 408, 90th Congress, First Session: "The annual water requirement for the refuge is (1) *7,500 acre-feet diverted from the main stream for circulation water with minimal consumptive use*, and (2) 27,000 acre-feet diverted from the main stream or the consumptive use of 16,793 acre-feet of main stream water, whichever is less, with a priority date of August 21, 1964."

This additional entitlement of 7,500 acre-feet has typically been tied, in concept, to Cibola Lake, although the Service would maintain that the establishing authority is sufficiently broad to merit the consideration of applying this *circulatory water* to support Hart Mine Marsh as well. At the present time, the refuge does not have a dedicated diversion associated with this circulatory water right.

Reclamation represents the Secretary of Interior on the lower Colorado River and in this capacity is often referred to as the "Water Master". The Water Master has the arduous responsibility of accounting for Colorado River water use. As part of their accounting process, the Water Master tracks diversions from the river by water entitlement holders, and return flows if a portion of the diverted water is unused and returned to the river for the benefit of downstream users. Again, the *consumptive use* represents diversions less measured return flows.

As part of Reclamation's water use accounting system, some water entitlement holders also receive an *unmeasured return flow credit*. This credit represents diverted river water that makes its way back into the river system, primarily in the form of subsurface percolation and seepage. Reclamation applies said credit by applying a multiplier against the measured diversion value, the resultant of which is then used to reduce the entitlement holder's consumptive use. Cibola NWR currently receives a 38% unmeasured return flow credit.

As of 2003, Reclamation has instituted the practice of directly applying the unmeasured return flow credit to a given diverter, thus providing significant relief to entitlement holders like Cibola NWR. Prior to 2003, Reclamation provided the unmeasured return flow credits at the lower basin states (NV, CA and AZ) level, and no direct relief was provided to individual diverters within a given state. The Service has requested that Reclamation provide written confirmation that this new practice is now the official policy of the Water Master, which the analysis within this report assumes is the case.

3.13 Past Water Use

Water diverted from the Colorado River for use at Cibola NWR is used for a combination of wildlife habitat and cooperative farming: both farms units (#1 and #2) have lands that are leased to private farmers who grow crops, of which a portion is dedicated to wildlife. Habitats actively managed that use river water include woody riparian (cottonwood and mesquite), moist soils, and seasonal wetlands.

All water diverted for actively managed lands at Cibola NWR is measured to ensure the refuge is within its legal entitlement. To date, the maximum diversion for the refuge is approximately 14,000 acre-feet. In the recent past, no measured return flow has occurred. Table 1 shows measured diversions for each of the three diversion points since 1998 (as measured by the Service). Table 1 also shows the consumptive use amount charge to the refuge, as published by Reclamation in their water accounting reports.

As there are currently no measured return flows associated with the refuge, prior to 2003 the Service has used a conservative interpretation that consumptive use is equal to diversions. As shown in the table, if "diversion" equates to "consumptive use" for the refuge, then the refuge's annual consumptive use approaches the consumptive use limit of 16,793 acre-feet. However, when an unmeasured return flow credit is directly applied (assumed from 2003 and beyond), and assuming no measured return flows, it is anticipated that the refuge will not exceed its consumptive use entitlement before it reaches its diversionary cap of 27,000 acre-feet.

Since 1998, the refuge has added several acres of new habitat, primarily in Farm Unit 1 and the Island Unit. New habitat projects have included riparian vegetation and moist soil units. Predictably, the annual use of water at Cibola NWR has generally increased during that period. Figure 2 illustrates a trend of steadily increasing water consumption.

3.14 Future Water Use

An important objective of this analysis is to determine the amount of water available, if any, for new habitat improvements at Hart Mine Marsh. The basis of the analysis is to quantify the amount of water necessary to operate and maintain habitat and farming operations, and project the water that will be used once the refuge completes development of habitat areas already in process or currently planned.

In the past several years, the refuge has made substantial progress improving lands and irrigation systems to develop new habitats, primarily in Farm Unit 1 and the Island Unit. For example, approximately 600 acres of new lands [1] have been cleared, leveled,

[1] Habitat units include Hippy Burn, Long Pond, and Crane Roost.

Table 1. Cibola NWR River Diversions & Consumptive Use Charges (acre-feet per annum)

Year	Farm Unit 1	Farm Unit 2 *	Island Unit	Total Diversion	Reclamation's Consumptive Use
1998	6,609	1,690	2,150	10,449	6,435
1999	4,980	1,228	3,030	9,238	8,161
2000	5,004	1,244	2,831	9,079	14,567
2001	4,276	1,913	4,339	10,528	11,025
2002	8,112	1,591	4,135	13,838	13,339
2003	7,562	1,456	4,425	13,443	8,335
2004	6,824	1,300	3,140	11,264	6,982
2005	6,494	1,188	3,803	11,485	6,812
2006	7,122	2,779	3,903	13,804	n/a

*Farm Unit 2 diversions include Cibola Sportsman Club diversions
Data Source: Consumptive Use values: *USBR--Colorado River Accounting and Water Use Reports (Arizona, California and Nevada) (1998-2005)*, while all other data comes from Service gages at each refuge units (note: all 2006 values are provisional).

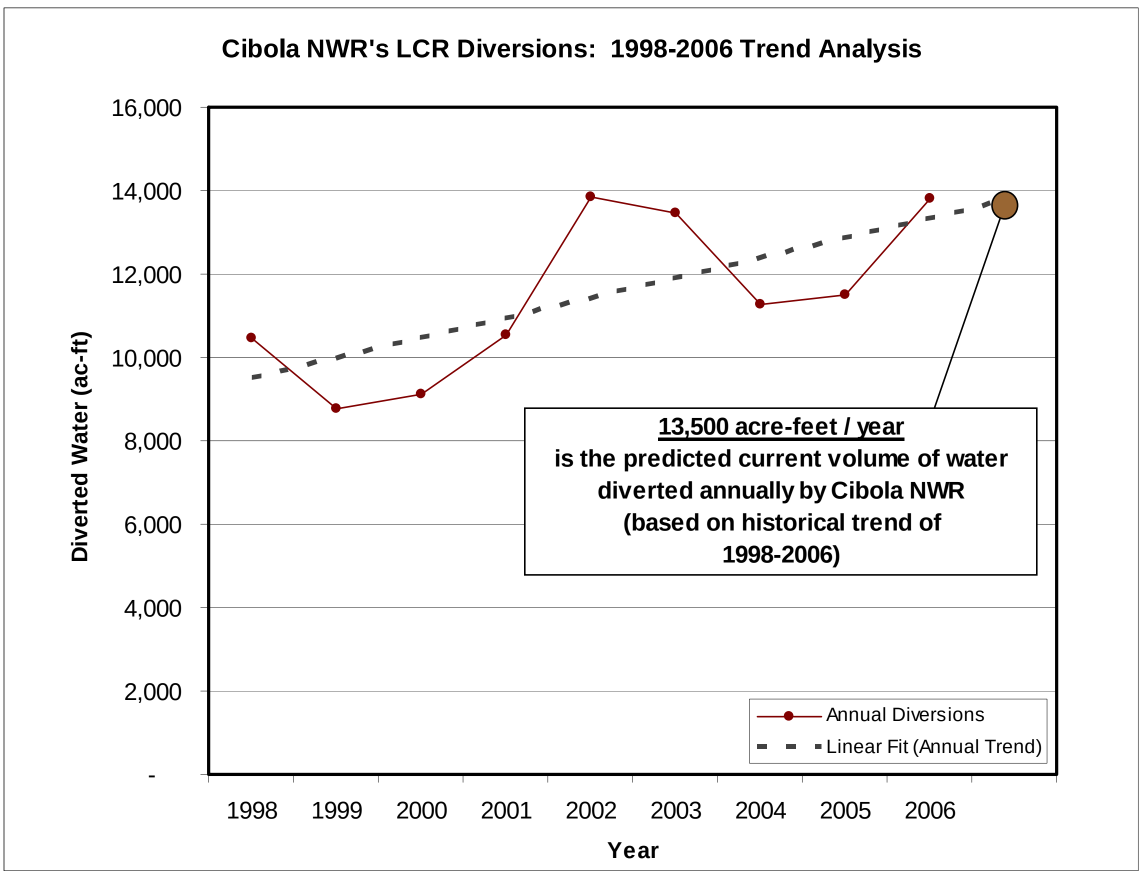

Figure 2. Cibola NWR's lower Colorado River water diversions from 1998 to 2006 showing an overall increase in use due to the addition of new habitat units.

and water systems constructed to develop new habitat areas, but are either not functioning or not fully functioning at this time. Once these areas are planted or seeded, water will be required to develop and manage the units.

Assumptions used to estimate the amount of surplus water that may be available for new projects are listed as follows:

- **Water Reservations –** Some lands on the refuge have been improved (i.e. cleared, earthwork, irrigation systems, etc.), but have not been placed into operation. In addition, some lands associated with a habitat unit are part of a pre-existing plan for future development. Estimates for water use of said areas were accounted for and "reserved", thereby reducing available entitlements for new projects (i.e. Hart Mine Marsh) accordingly. [2] Since resources were previously dedicated to develop selected areas, and the completion of all planned habitat units (avoiding fragmentation) is important to the habitat value of adjacent units, water for said areas was given first priority.

- **Unmeasured Return Flow Credit –** The current unmeasured return flow credit of 38% was used in determining the amount of water that can be diverted and used for refuge objectives without exceeding the consumptive use entitlement. This value was calculated at 27,292 acre-feet annually.

- **Return Water –** Neither the drain water from irrigation activities conveyed in the Arnett Ditch, nor the 7,500 acre-feet circulation flow water entitlement were included in the estimates of available supplies.

- **Water Use –** A unit water use value (acre-feet per acre) was calculated based on existing uses (recorded diversions) and refuge lands that are actively managed (irrigated). Although ET values are available for various types of vegetation, historical use patterns based on actual management practices may be the best indicator of future demands. Water use can vary depending on the type of habitat/vegetation of a given area. However, since water use on individual units was not measured, and the actual types of all proposed habitats are unknown, an overall *average* unit demand was calculated for water demand projections that include planned developments.

  For purposes of this study, actual demands (recorded diversions[3]) were divided by the area of actively managed lands (1,867 acres), equating to an annual unit demand of 7.23 acre-feet per acre. This value is greater than accepted ET estimates for crops and habitats that exist at the refuge, which generally range from approximately 4.5 to 5.5 acre-feet per acre. However, ET values do not account for other factors that can raise water use, such as irrigation efficiency,

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[2] Includes approximately 800 acres in the north and northwest section of Farm Unit 1, and approximately 270 acres of "fill in" areas within the existing Island Unit.

[3] Based on predicted current diversions from 1998-2006 period of record shown in Table 2.

conveyance losses, salt management, habitat objectives, etc. Thus, an average unit demand of 7.23 acre-feet per acre is within the range of plausible values that could be used for planning exercises. It should be noted that extensive development of new riparian habitat (and associated management for special status species) could result in unit demands substantially greater than the estimated value used in this study.

Table 2. Cibola NWR -- Water Use Projections (ac-ft/yr)

Status	Farm Unit 1	Farm Unit 2	Island Unit	Total	Water Use[4]
Actively Managed	1,120	362	385	1,867	13,500
Proposed	796	-	268	1,064	7,693
Other (private) [5]		92			(665)
			Projected Use		20,526
Maximum allowable DIVERSION that would not exceed Consumptive Use Entitlement (with unmeasured return flow credit applied)					27,292
Diversion Entitlement (maximum diversion allowable per entitlement)[6]					27,000
Available Water for Other Projects (Surplus)					6,474

Based on the surplus water calculated of 6,474 acre-feet and the unit water demand estimate of 7.23 acre-feet/acre, it is estimated that a total of 895 additional acres can be developed at the refuge using diverted lower Colorado River water without exceeding the refuge's entitlements.

In the event that there are changes in the assumptions used to develop these estimates, the amount of surplus water could vary significantly. For example, if the unmeasured return flow credit were to be reduced or eliminated, it is doubtful that any surplus water would remain available. Average unit water demands greater than the 7.23 ac-ft/acre projected would also adversely impact surplus supplies

[4] Water use = acres x 7.23 ac-ft (where 7.23 ac-ft is the water duty associated with the refuge's actively managed lands)(e.g., 1,867 acres * 7.23 acre-ft/acre = 13,500 acre-feet)
[5] Private lands (north of Farm Unit 2) whose water diversions are included in the records of diversions, but are not counted against refuge entitlements.
[6] Since the diversion entitlement is greater than the consumptive use entitlement (with the unmeasured return flow credit applied), the diversion allowance dictates.

3.2. Hydrology and Water Quality at the Hart Mine Marsh

3.21 Surface and Ground Water Hydrology

The greatest controls on the surface water hydrology of the lower Colorado River and its effects on the Cibola NWR and the Hart Mine Marsh are Parker Dam releases, channelization, and the extensive series of levees. Of these, Parker Dam releases arguably play the most significant role in controlling the refuge's hydrology, while the others play a lesser, yet still important role. Parker Dam's most notable changes to the hydrograph in the Cibola reach are the dampening of peak flood levels, removal of the annual spring flood pulse and diurnal hydroelectric pulses. Channelization and levees have removed important overbank flood processes that were historically coincident with these flood events, including sheet flow, sediment deposition and transport, and seasonal fluctuations in ground water elevations.

To characterize the surface water hydrology of the LCR at the Cibola NWR, the Service used water surface elevation data from the Reclamation's gage referred to as *Colorado River at Cibola*. Initial analysis of the groundwater hydrology at the Hart Mine Marsh was based upon data from an array of 12 groundwater wells drilled into the shallow alluvial aquifer (see Figure 3). Each well was instrumented with a pressure transducer datalogger to obtain water surface elevation (WSEL) and temperature data. Additionally, surface water elevations at the Arnett Ditch and Hart Mine Marsh are being recorded using dataloggers (See Figure 4). It is important to note that the equipment at the Arnett Ditch and Hart Mine Marsh have not yet been surveyed for elevation, removing our ability to assess relative water surface elevations. This work will take place early spring, 2007.

At this initial stage of data collection, hourly data from an approximately two week period, from December 13 – 27, 2006, were analyzed. The LCR's role as a control on ground water hydrology was examined using regression analysis. The reader should note that while regression analysis is often used as a statistical model to examine surface and ground water interactions, the approach does suffer from limitations as a statistical model. Hydrologic efficiency, or the "dampening" of surface water fluctuations as reflected by ground water elevations, often creates a scenario where the multiple coefficient of determination (R^2) values may suggest that there is not a link between dependant and independent variables when one actually exists. With that said, regression analysis of WSEL data from the LCR and ground water monitoring wells indicates that for the period of time examined, the river is a dominant control on groundwater levels between the LCR and the Arnett Ditch. Monitoring wells HMM_01 and HMM_09, located between the LCR and the Arnett Ditch, closely track WSEL of the LCR, with R^2 values of 0.94 and 0.98, respectively.

Furthermore, regression analysis indicates that the LCR river levels exert a control on groundwater levels to the east of the Arnett Ditch: monitoring well HMM_10 tracks WSEL of the LCR with an R^2 of 0.90. Statistical models for monitoring well HMM_06

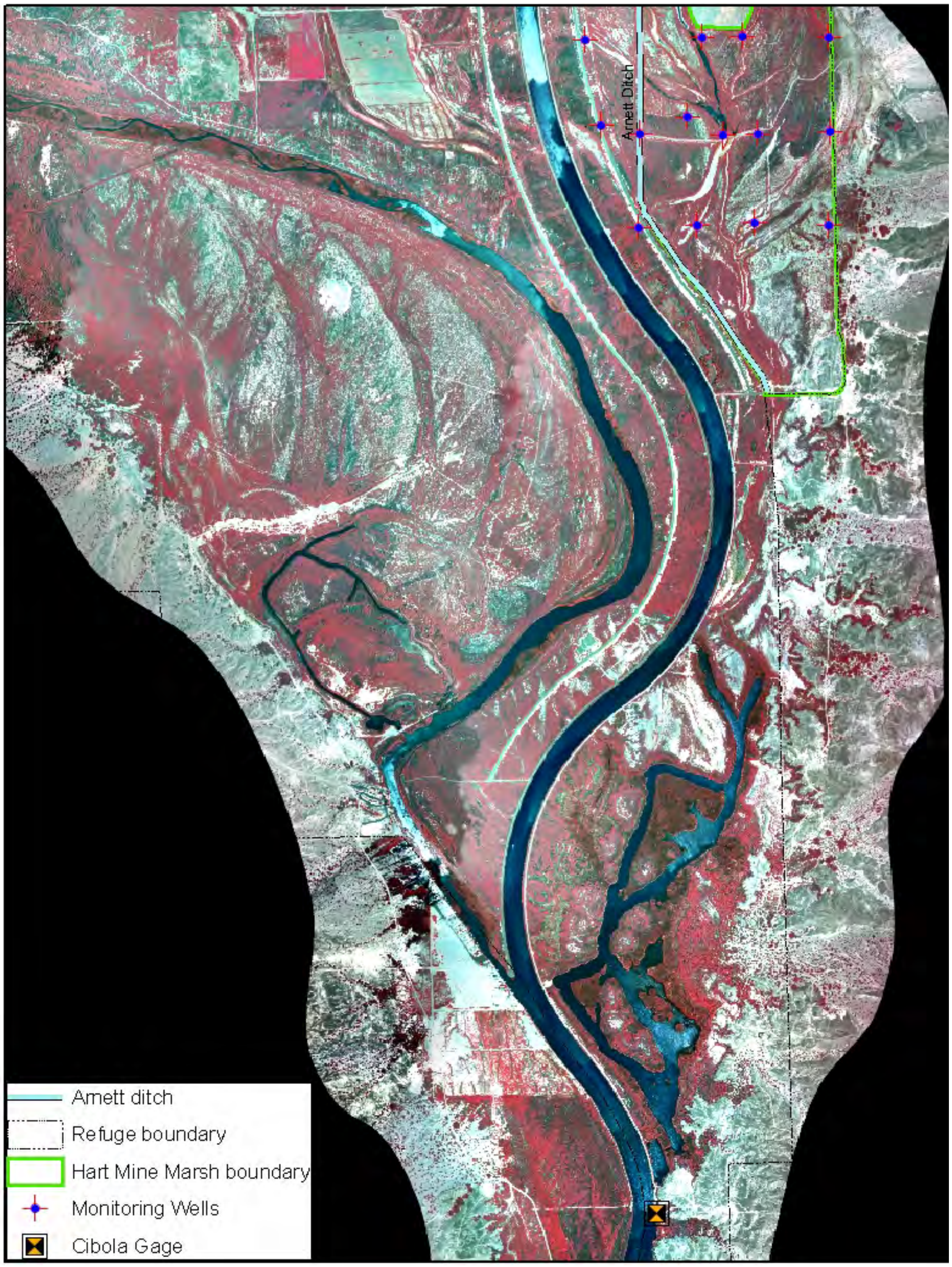

Figure 3. Location of monitoring wells and surface water dataloggers. The USBR's Cibola Gage is located at the lower extent of the image.

visa-vie the LCR did not produce as good a fit (R^2=0.70). The general shape of the WSEL curve for monitoring well HMM_06 suggests that it is also tracking the WSEL of the LCR, but that there is an overall dampening of the curve. This dampening may be the result of some hydrologic property related to the subsurface matrix. Wells HMM_02 and HMM_08 follow the overall WSEL trend, suggesting further dampening of the LCR WSEL curve. The properties of wells HMM_02, HMM_06, and HMM_08 discussed here are mostly speculative and will be subject to further analysis.

The overall trend revealed by this initial analysis is that the Hart Mine Marsh is hydrologically connected to the lower Colorado River, suggesting that Parker Dam operations will figure into future restoration considerations. Additionally, the effects of the Arnett Ditch and Hart Mine Marsh water levels on the hydrology of the study area have not been examined (an effort that awaits the 2007 irrigation season). It is probable that the Arnett Ditch in particular is influencing not only the ground water hydrology of the Hart Mine Marsh, but may be a potential source of elevated levels of salinity, nutrients and contaminants in both the soils and the waters of the Hart Mine Marsh.

3.22 Water Quality

As an aquatic ecosystem, water quality conditions at the Hart Mine Marsh management unit play a significant role in the functioning of existing habitat. To assist with site characterization, water quality conditions were sampled at multiple points in time at the Arnett Ditch, the Farm Unit 2 drain, and the Hart Mine Marsh. The Arnett Ditch is an agricultural drain, and serves as a main source of surface water at the Hart Mine Marsh (precipitation, alluvial fan runoff are other contributors). The ditch originates outside of the Hart Mine Marsh; it forms the western boundary as it flows through the Marsh, and terminates at the southern end of the Hart Mine Marsh. The Farm Unit 2 drain forms the northern boundary of the Hart Mine Marsh.

One water quality sample was taken at the northern extent of the ditch’s path through the marsh. A second sample was taken in the Farm Unit 2 drain[7], and a third sample was taken in the marsh itself (see Figure 5). In August and October of 2006, dissolved oxygen (DO), pH, and conductivity were measured using a Hydrolab H2O water quality sonde. Grab samples were taken in August 2006 for laboratory analysis (see Appendix 3 for water quality results). Flow velocities at the time of sampling were negligible, suggesting that the upstream agricultural fields were not being actively irrigated and that flushing was not taking place.

Initial analysis of water quality parameters suggest that conditions in the Arnett Ditch are consistent with water bodies that have agricultural influences. For all parameters discussed in this section, elevated concentrations can also be attributed to evaporation.

[7] At the time of sampling, the Farm Unit 2 drain was not hydrologically connected to the Hart Mine Marsh. However, a culvert connecting the two water bodies suggest that the two may be connected at certain water levels.

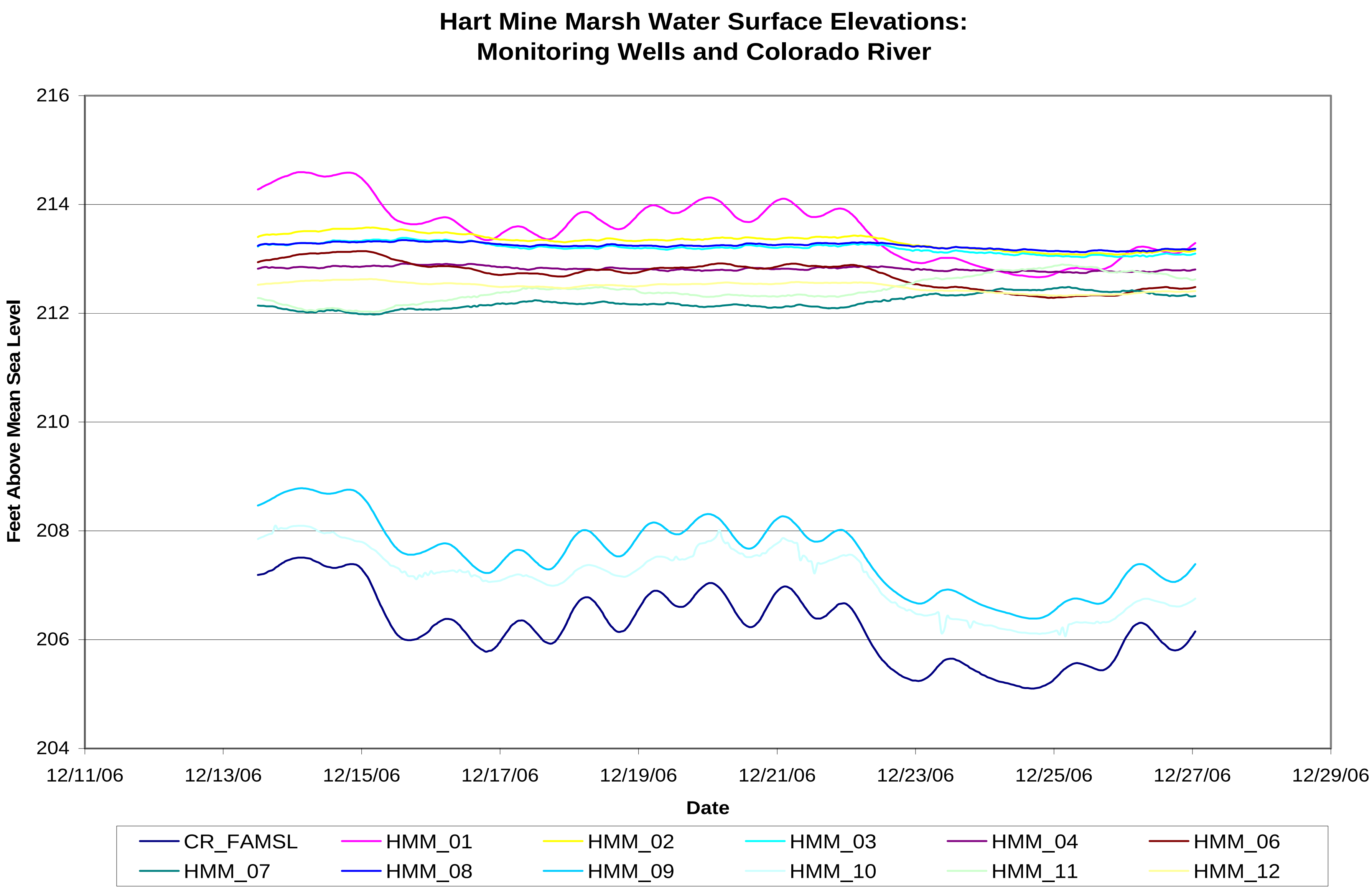

Figure 4. Relative elevations of Hart Mine Marsh ground water monitoring wells and lower Colorado River (at Cibola Gage) demonstrate a clear connection between the LCR and groundwater between the LCR and the Arnett Ditch.

The minimum value of pH was 6.95 and the maximum was 9.45, with a mean value of 8, in the moderately alkaline range. Nutrient levels of nitrogen and phosphorous were elevated, and salt content was high (measured both by conductivity, and levels of sodium and chloride). Nitrogen concentrations as nitrate+nitrite – N were low (0.01 – 0.08 mg/L), while ammonia – N levels were high (0.09 – 0.88 mg/L) (U.S. EPA 2000).

High levels of ammonia – N can be toxic to aquatic life, and toxicity is increased depending upon temperature and pH. Thus, the warmer temperatures and higher pH of the Hart Mine Marsh further increase the toxicity of the ammonia – N concentrations in Hart Mine Marsh. Additionally, ammonia – N can be associated with mine tailings. This complicates tracing the source of ammonia – N in the Hart Mine Marsh. It is possible (and still undetermined) that during precipitation events of sufficient intensity, Hart Mine Marsh's namesake mine may be a source of ammonia via runoff.

Additionally, total phosphorous concentrations (0.114 – 0.541 mg/L) were high relative to other arid land water bodies (Ibid). This data suggests that upstream nutrient inputs are flushed into the Arnett Ditch and when water levels drop, remain in the ditch. While DO levels at the benthic interface were not measured, it is likely that hypoxic or anaerobic conditions exist. This would create reducing conditions where nitrate+nitrite – N could be metabolized by benthic biota and converted to gaseous form and ammonium-N. Phosphorous measured as total P would be released as a byproduct of benthic metabolism (Wetzel 2001).

Salt concentrations were also consistent with the effects of agricultural activity. Conductivities were high for a fresh water system (2,520 µS/cm – 23,900 µS/cm) indicating significant salt loading. Laboratory analysis of surface water grab samples bore this out (see Appendix 3). In the Arnett Ditch and Farm Unit 2 drain, chloride levels were at a minimum of 707 mg/L, a maximum of 2,150 mg/L, and sodium levels were at a minimum of 414 mg/L and a maximum of 1,140 mg/L. The values of chloride and sodium were significantly higher in the Hart Mine Marsh, 10,700 mg/L and 4,860 mg/L respectively. These concentrations meet or exceed toxicity thresholds for a variety of plants and invertebrates (U.S. Department of Interior 1998).

4.0 SOILS BASELINE CONDITIONS

Soils result from the weathering of geologic material. Rainfall and surface runoff can chemically breakdown rock, as well as transport and deposit rock particles elsewhere. Once in place, water continues to break down and chemically alter minerals and organic matter into different soil types. The type of soil is dependent on the type of parent material, the climate, the topography, the vegetation, time, and management.

Soils vary continuously over the surface of the earth; to map soils a range of characteristics to be included in a mapped unit and a scale must be determined. The scale of the NRCS Soil Survey maps is 1:24,000. At this scale the minimum size of a

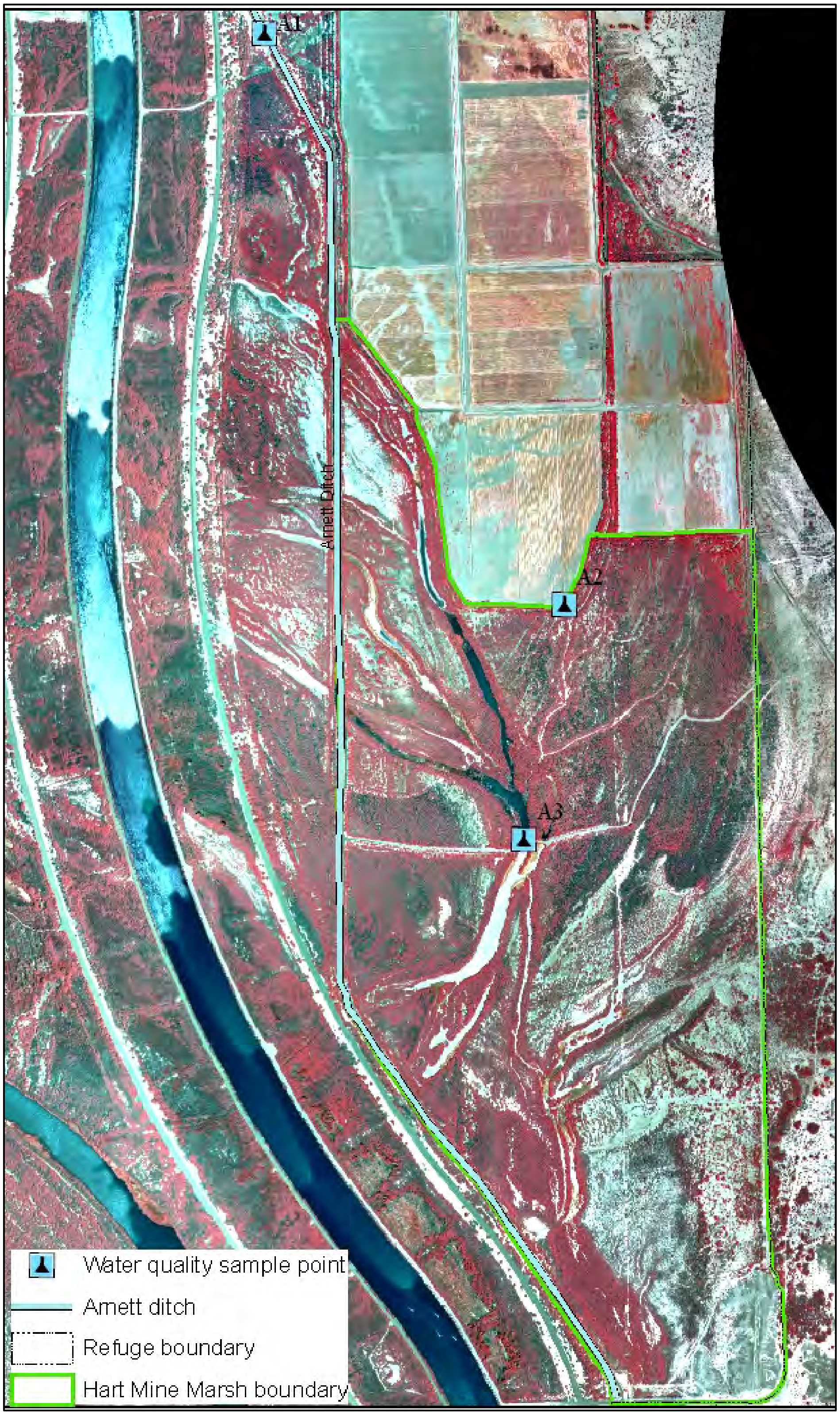

Figure 5. Location of water quality sample sites.

delineated soil unit is 5.7 acres; soil units smaller than 5.7 acres will not be shown on this type of map. A more detailed soil map will show features that are too small to appear on the soil survey (Singer & Munns, 1996).

This section includes a discussion a of sections of the Natural Resource Conservation Service (USDA-NRCS) Soil Survey, a geomorphic map of the site prepared in October 2006, and the results of soil sampling and analysis at 22 locations at 3 depths in the Hart Mine Marsh conducted in October and December 2006.

4.1 The NRCS Soil Map

The soils mapped at the Hart Mine Marsh are typical for soils forming on alluvial fans and flood plains in the Sonoran Desert. The NRCS has mapped three main soil types at the Hart Mine Marsh. The locations of the map units are shown on Figure 6.

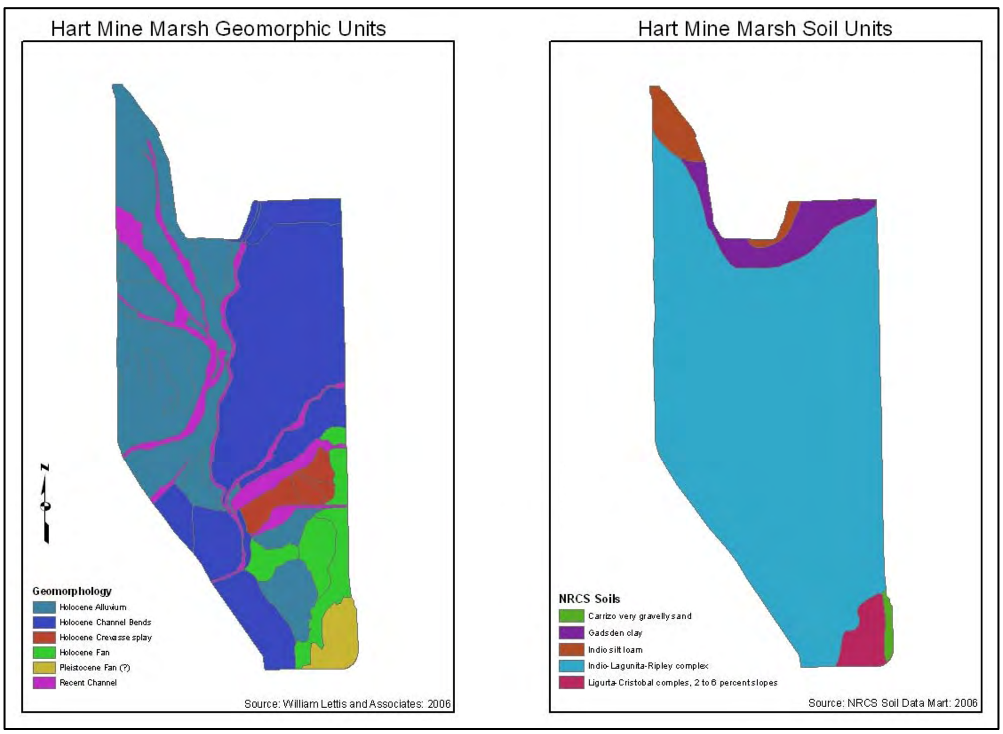

Figure 6. Comparison of surficial geology map (left) and NRCS soil map units (right) at the Hart Mine Marsh unit.

Gadsen Clay-(Map Unit 8)- this soil is found on found on flood plains (slopes are 0 to 1 percent). It is a deep soil; typical profile has a clay texture to 60 inches and the depth to a restrictive laver is greater than 60 inches. Gadsen is rated as having no limitations for use in creating ponds. The high content of shrink swell clays in this soil leads to severe limitations for use creating levees or embankments (See Attached Ponds and Embankments (CA).

Indio-Lagunita-Ripley Complex (Map Unit 16)

*Indio (35% of the complex)—*this soil is found on found on flood plains and alluvial fans (slopes are 0 to 1 percent). It is a deep soil; typical profile has a surface silt loam horizon from 0 to 6 inches and a stratified very fine sandy loam horizon from 6 to 63 inches. This soil has a strongly sodic horizon within 30 inches of the soil surface. Indio is rated as having relatively severe limitations for use creating ponds; the permeability is 0.6-2"/hour. This soil has a very high piping potential.

Lagunita (25% of the complex)-- this soil is found on found on terraces (slopes are 0 to 2 percent). It is a deep soil; typical profile has a surface loamy sand horizon from 0 to 8 inches and a loamy sand horizon from 8 to 60 inches. This soil has a moderately sodic horizon within 30 inches of the soil surface. Lagunita is rated as having severe limitations for use creating ponds; the permeability is > 2"/hour. This soil has a very high piping.

Ripley (25% of the complex)-- this soil is found on found on drainageways (slopes are 0 to 1 percent). It is a deep soil; typical profile has a surface silt loam horizon from 0 to 6 inches, a fine sandy loam horizon from 6 to 25 inches, and a sand horizon from 25 to 60 inches. This soil has a slightly sodic horizon within 30 inches of the soil surface. Ripley is rated as having severe limitations for use creating ponds; the permeability is > 2"/hour. This soil has a very high piping potential.

Ligurta-Cristobal Complex, 2 to 6 percent slopes (Map Unit 21)

*Ligurta (65% of the complex)--*this soil is found on found on alluvial fans (slopes are 2 to 6 percent). It is a deep soil; typical profile has a surface very gravelly loam horizon from 0 to 2 inches and a very gravelly clay loam horizon from 2 to 60 inches. This soil is moderately to strongly saline (16.0 to 32.0 mmhos/cm).

*Cristobal (25% of the complex)--*this soil is found on found on alluvial fans (slopes are 2 to 6 percent). It is a deep soil; typical profile has a surface very gravelly loam horizon from 0 to 2 inches, a very gravelly clay loam horizon from 2 to 25 inches, and a very gravelly clay loam horizon from 25 to 60 inches. This soil is moderately to strongly saline (16.0 to 32.0 mmhos/cm).

4.2 Surficial Geologic Map of the Hart Mine Marsh

William Lettis & Associates prepared a short text and GIS database that summarizes their surficial geologic mapping of floodplain deposits within the project site (October, 20 2006; letter and Map are attached in Appendix 2). They mapped seven different geomorphic units at the site most of which are fluvial deposits directly associated with historic and paleo-channels of the Colorado River (floodplain). The locations of the mapped units are shown on Figure 6. Past wetland restoration activities (Fredrickson 2003) have shown that incorporating knowledge of geomorphic landforms can significantly increase the likelihood of achieving the restoration objectives.

4.3 Site Soil Analysis

Soil samples were collected at 22 locations at three different depths: 0 to 2 inches, 24 to 26 inches and 34 to 36 inches. The locations of the sample sites are shown on Figure 7. The samples were analyzed at a commercial laboratory. The analysis package included pH, electrical conductivity, Ca Mg, Na, exchangeable Na percent, B, NO_3-N, PO_4-P, K, and Zn.

4.31 Soils Results

A summary of the data is shown in Table 2 (See Appendix 3's Report of Soil Analysis for complete data set).

Table 3. Summary of Saturation Percentage, pH, EC and ESP for 22 samples at depths of: 0-2", 24-26", and 34-36".

Sample Depth		**SP %**	**pH**	**EC x10^3** (decSiemen/m)	**ESP %**
0-2 "	Average	56.36	7.67	159.60	44.27
0-2"	St Dev	20.40	0.62	142.73	19.26
0-2"	Range			0.69-307	
24-26"	Average	50.23	8.01	45.19	31.45
24-26"	St Dev	18.74	0.37	30.46	13.26
24-26"	Range			0.98-118	
34-36"	Average	49.05	8.03	45.87	31.79
34-36"	St Dev	20.69	0.29	30.11	11.96
34-36"	Range			5.32-119	

The SATURATION PERCENTAGE is the number of grams of water required to saturate 100 grams of soil. The water-holding capacity of a soil when irrigated and allowed to drain is approximately half the SP. About half the water-holding capacity is available for crop use. Approximate relationship of SP to soil texture follows:
Below 20 Sandy or Loamy Sand
20 – 35 Sandy Loam
35 – 50 Loam or Silt Loam
50 – 65 Clay Loam
65 – 150 Clay

EC_e ELECTRICAL CONDUCTIVITY of the saturation extract is an index of salt content expressed as millimhos per centimeter or decisiemens per meter at 25° C.
Below 0.5--Water penetration may be impaired.
Under 2--No salinity problem for most crops.
2 - 4--Restricts growth of very salt-sensitive crops.
4 - 8 Restricts growth of all but moderately salt-tolerant crops.
8 - 16--Restricts growth of all but very salt-tolerant crops.
Above 16Only a few salt-tolerant crops grow satisfactorily.

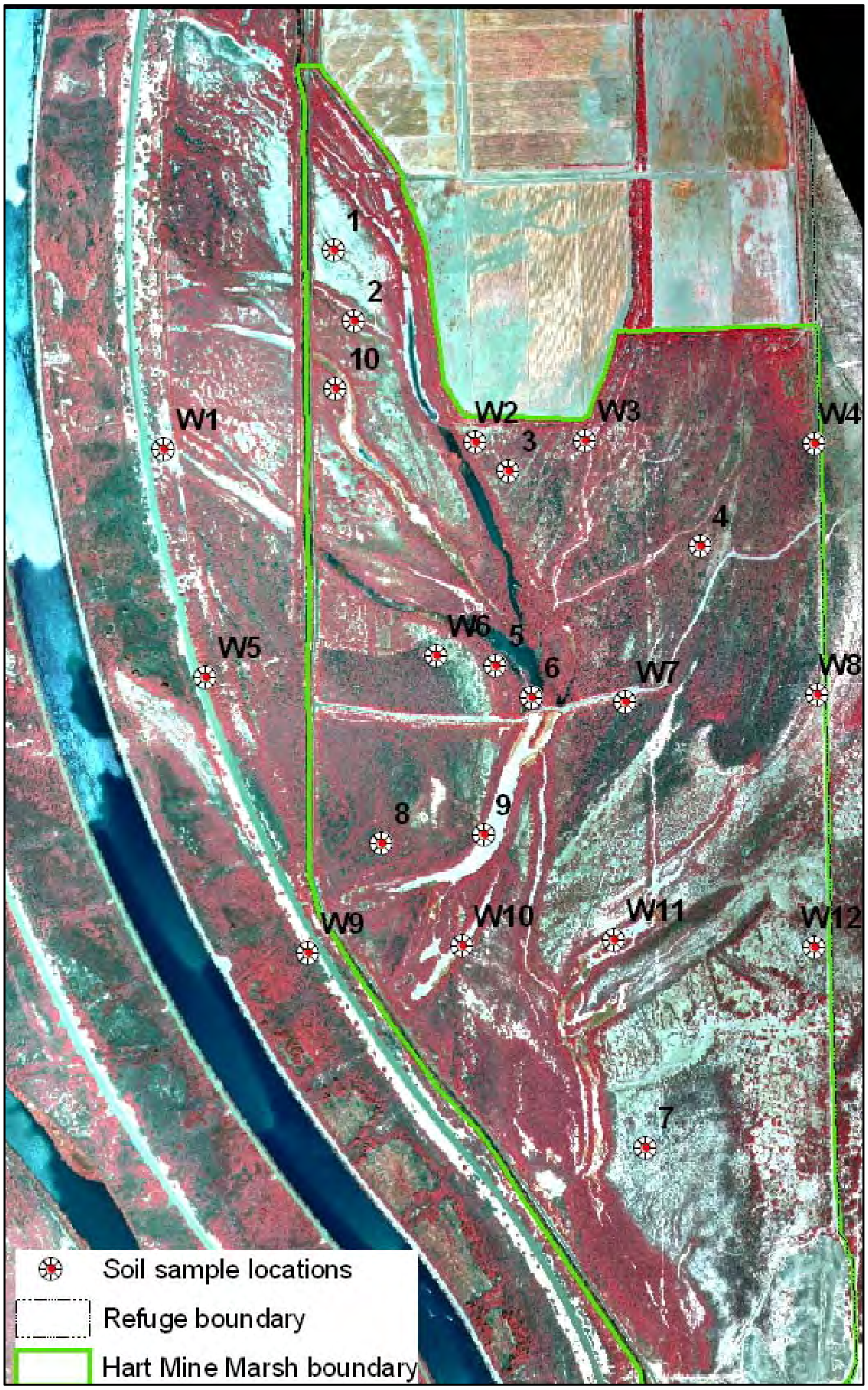

Figure 7. Soil sample locations, includes samples taken from soil pits and monitoring well drill holes.

ESP EXCHANGEABLE SODIUM PERCENTAGE is the degree to which the soil exchange complex is saturated with sodium. It is used to determine soil permeability and potential phytotoxicity. Organic soils have no minerals, so are not affected by sodium.
Below 10--No permeability problem; however, sodium sensitive plants may show phytotoxicity such as chlorosis or slight yield reduction.
10 - 15--Soils with SP above 50 may have problems with permeability and/or phytotoxicity.
Above 15--Permeability problems are likely on all mineral soils except those with an SP below 20. Most crops show phytotoxicity

4.4 Soils Discussion

Salinity is a soil property referring to the amount of soluble salt in the soil. It is generally a problem of arid and semiarid regions. Electrical conductivity (EC) is the most common measure of soil salinity and is indicative of the ability of an aqueous solution to carry an electric current. Plants are detrimentally affected, both physically and chemically, by excess salts in some soils and by high levels of exchangeable sodium in others. Soils with an accumulation of exchangeable sodium are often characterized by poor structure and low permeability making them unfavorable for plant growth.

By agricultural standards, soils with an EC greater than 4 dS/m are considered saline. In actuality, salt-sensitive plants may be affected by conductivities less than 4 dS/m and salt tolerant species may not be impacted by concentrations of up to twice this maximum agricultural tolerance limit.

Information about the conditions required by native species in the arid southwest has been painstakingly collected over the last several decades on numerous restoration projects. The native species requirements data presented in Table 4 was collected at Bosque del Apache NWR and generally supports the conclusion presented in Anderson, Russell, and Ohmart's "Riparian Revegetation" (2004).

Table 4. Salinity, Soil and Water Table Planting Requirements for Selected Riparian Species at Bosque del Apache National Wildlife Refuge, New Mexico.

Species	**Soil EC (dS/m)**	**Soil Type**	**Water Table Depth (ft)**
Cottonwood	<1.0-2.5	Sandy-Loamy	4.9-12.8
Black Willow	<1.0 -2.9	Sandy- Clay Loam	3.9-10.2
New Mexico Olive	<1.0-2.5	Sandy-Loamy	<3.9
Skunkbush Sumac	<1.0-2.5	Sandy-Loamy	<3.9
Sliver Buffaloberry	<1.0-2.5	Loamy- Clay Loam	<3.9
Screwbean Mesquite	3.0 -7.99	Clay Loam – Clay	<3.9
Wolfberry	3.0 -7.99	Sandy-Loamy	<3.9
Four-Wing Saltbush	8.0-13.99	Sandy-Loamy	<3.9-6.4

Nitrate numbers are quite high. This is in contrast to the high ammonium and low nitrate numbers seen in the water quality analysis. These numbers would be consistent with high inputs of ammonium associated with either agricultural runoff or mine drainage carried into the marsh in the Arnett ditch. The ammonium is subsequently oxidized to nitrate by soil microbes in a process known as nitrification.

While the NRCS mapped soil series at the site do have elevated ECs (Indio and Cristobal have saline or sodic subsoils in the range of 16-32 dS/m), the soils sampled at the Hart Mine Marsh have ECs that are substantially higher than predicted by the NRCS. The high Ecs are presumably due to the lack of flushing which has exacerbated the problem. The high EC of the soils at the Hart Mine Marsh present a serious constraint to restoration at the site. Management will have to include a long-term salt salinity reduction program.

5.0 VEGETATION INVENTORY

April of 2006, the USFWS Region 2 Habitat and Population Evaluation Team (HAPET) completed a comprehensive spatial vegetation inventory of the 646 acre Hart Mine Marsh unit on Cibola NWR (see Figure 8). The inventory was conducted over 2 days in which field crews collected data across the Unit. Data were collected utilizing a sample design (plots) derived from an object based classifier generated from a 2001 1–foot GSD color infrared image. Field crews used handheld GPS field computers to navigate to and record plot (polygon) plant community, species, species density and structure. Community, species and structural classifications were derived through ocular estimations while in the field. Over 70 percent of the Unit area was classified during the field data collection portion of the inventory. The remainder of the area was classified through photo interpretation. Photo interpretation was conducted at a level of direct recognition, using the filed data as the training source. Because of the high percentage field data collected and level of recognition used in the photo interpretation process an accuracy assessment was not conducted. The overall accuracy can be assumed to be > 90%.

Plant communities were classified to the Association level of the National Vegetation Classification System (NVCS). The Association level is the most detailed level of NVCS. It classifies plant communities at the floristic level, identifying the dominate species at multiple strata of the plant community.
Hink-Omart structural classification was used to record plant community structure.

A total of 8 different plant communities were identified and associated with 3 distinct landforms occurring in the unit (Figure 8). The majority of the Unit encompasses the historic Colorado River floodplain. Over 80% of this area has been invaded by mixed and monotypic stands of Salt Cedar *(Tamarix ssp.)*. The densest and most robust stands of Salt Cedar were found the areas adjacent to active water channels and in lower elevation areas that appeared to pool surface water. Areas directly adjacent to open water or currently active channels contained areas of tall emergent plant communities

Figure 8. Vegetation Inventory of the Hart Mine Marsh

dominated by Cattail *(Typha ssp.)* and *(Schoenoplectus ssp.)* Bull Rush (See Appendix 5 for a table of vegetation communities and acreage).

The plant communities on the east central portion of the marsh are influenced by alluvial deposition (alluvial fan) resulting from an arroyo entering the historic floodplain from the east. This portion of the site contains the most plant diversity and appears to be closest to functioning within the natural process of the system, although plant community composition may seem to indicate possible influences from adjacent man made perturbations and disruptions in natural hydrological processes. The eastern edge of this area is woodland dominated by Mesquite *(Prosopis (glandulosa var. torreyana, velutina)* and Wolfberry *(Lycium ssp.)*. Further west the area transitions from a course alluvial aggregate to fine. The toe of the alluvial fan is dominated by Iodinebush *(Allenrolfea occidentalis)* and areas of sparse Salt Cedar.

A relatively small portion of the southeast corner of the unit can be classified as upland. This area is mesa top disconnected form the floodplain. It is dominated by sparse Creosote bush *(Larrea tridentate)* and little else.

6.0 HART MINE MARSH RESTORATION POTENTIAL

There is an array of possible Hart Mine Marsh restoration alternatives, and corresponding development and management efforts, ranging from fairly passive to intensely active. Obviously, active alternatives likely entail commitment of greater resources, but are probable to yield greater value. Any alternatives developed must meet both the Cibola NWR's needs and the goals and objectives of the LCR MSPCP program.

Any restoration effort at Hart Mine Marsh must involve a commitment of resources to create and maintain the project in the form of funding, personnel, and water. In essence, personnel is actually a funding issue, so resources can be simplified to equal money and water. Since grant money is not commonly available for operations, the decision to restore all or a portion of Hart Mine Marsh will require a long-term commitment of these resources by the federal government to ensure project success.

Habitat types making up a restoration project at Hart Mine Marsh can be broadly categorized as riparian/woody revegetation, seasonal/moist soil wetlands, permanent water, or crops. The portion of each type of habitat is partially dictated by local conditions, including the variables of soil texture, soil chemistry, and depth to groundwater. Of these characteristics, soil chemistry is easily the most feasible variable to change or modify (yet still far from easy…). Since habitat type and local conditions are not always compatible (e.g. ponded water in coarse sands, riparian vegetation in saline soils), some area/habitat combinations can be "ruled out" early in the decision making process. Afterward, decisions become more preference based.

6.1 Hart Mine Marsh: Restoration Alternatives

It should be re-emphasized that it is highly probable that this project will only move forward if it addresses the needs of the refuge and the LCR MSPCP, and be feasible with available resources. Since water availability is relatively predictable and perhaps the most rigid of the resources, restoration alternatives were developed based on water. Restoration alternatives can be broadly defined as described herein:

1. **Alternative 1 - Arnett Ditch Supply :** This alternative assumes that only passive water (water from Arnett Ditch, seepage water from Farm Unit 2, standing groundwater) would be used to restore the marsh. Water could be lifted from the ditch mechanically, or simply raised with water control structures and diverted via gravity into select units. Re-routing of the Arnett Ditch so it drains directly into the marsh has been discussed. Under this alternative, no direct delivery of diverted river water to the marsh would occur. Depending on the type of habitat developed (e.g. marsh, riparian or mesquite), some conveyance facilities (pumps, pipe, etc.) may be required.

2. **Alternative 2 – Combination Arnett Ditch and River Water Supply:** This alternative would include using a combination of Arnett Ditch water and water from a Colorado River water diversion. Existing Farm Unit 2 gravity conveyance systems could be extended to newly developed areas in the marsh. Ideally, water from the ditch would be combined with river water in the conveyance system to improve the quality of the ditch water, which would likely require mechanical lifting.

3. **Alternative 3 – River Water Supply:** This alternative would use river water solely from expansion of existing diversion and conveyance facilities. Similar to Alternative 2, Farm Unit 2's water conveyance systems would be extended to newly developed areas. This alternative would provide the highest quality of water for the project, but would likely entail the highest costs (e.g., pumping costs, etc.). Fully separating Hart Mine Marsh from all drain waters is likely to provide maximum improvement of marsh conditions, and should be considered if direct river diversions are the exclusive source of water for the project.

6.2 Hart Mine Marsh: Water Budget Discussion

The water demands associated with restoration efforts at Hart Mine Marsh can vary widely with: (1) acres of habitat developed, (2) type of habitat developed, and (3) management/objectives of habitat. However, for initial planning purposes, it is assumed that the average water use for the project will reflect that found elsewhere on the refuge.

River water that can be legally diverted and utilized by the project is a potential constraint to Alternatives 2 and 3. As discussed earlier in this document, there is approximately 6,474 acre-feet of discretionary entitlement water available for new restoration efforts on the refuge, or approximately 895 acres of land with water.[8] While the entire Hart Mine Marsh unit is approximately 646 acres[9], it is estimated that some 123 acres are upland in nature, and not considered part of the proposed marsh restoration area.[10]

Thus, the initial estimate of acres at Hart Mine Marsh that have the potential to support marsh habitat is approximately 523 acres, which equates to roughly 81% of the unit. Further, if the water demand of 7.23 acre-feet per acre is applied to the 523 acres, it is roughly estimated that an annual volume of water required will be 3,781 acre-feet per annum. This volume of water represents 58% of the 6,474 acre-feet that is estimated as the amount of available water that Cibola NWR has to support ALL future projects. Alternatives 1 and 2 include use of Arnett Ditch water.

Due to the high salinity content found in the soil at Hart Mine Marsh, and the relatively high salinity content of the return water (as well as other water quality concerns associated with the ditch), the authors recommend that over the next months a priority be placed upon better characterizing the advantages and disadvantages associated with using Arnett Ditch water to support the restoration of Hart Mine Marsh.

It is suggested that the feasibility of re-routing the drain water such that it is returned to the river be evaluated. The returned water could potentially be measured and deducted from the refuge's diversion entitlement, thereby allowing additional diversions. Since Arnett Ditch's flow is not measured, the potential credit is not quantifiable at this time. Depending on the measured return flow credit from Arnett Ditch water, and the type of habitat developed, it is plausible that full restoration of the Hart Mine Marsh could proceed based on Alternative 3's assumptions.

It is important to emphasize that the provisional water budget analysis put forth in this document is believed to be conservative in nature, especially in that it did not assess the potential use of water from the Arnett Ditch (which has an unknown volume) nor from the 7,500 acre-feet per year circulatory water right the refuge possess (an entitlement that has never been put to explicit use).

It is the Service's understanding that the LCR MSCP is looking at the Hart Mine Marsh project to support approximately 100 acres of marsh habitat that would be have mitigation credit associated with it. Hence, the assessed maximum acreage for marsh habitat of 523 acres is likely to be in excess of what would be directly associated with the LCR MSCP program.

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[8] Assumes 7.23 acre-feet per acre annual demand.

[9] Hart Mine Marsh area does not include areas west of the Arnett Ditch and east of the Colorado River.

[10] Higher ground on the southeast side of the marsh (above 218') would be difficult to irrigate with existing
gravity conveyance systems, and would be difficult to flood irrigate due to steep topography.

6.3 Hart Mine Marsh Restoration: Conclusions

The existing conditions report met Goal 1, which is to determine if the restoration of the Hart Mine Marsh is compatible with both the objectives of the LCR MSCP and objectives and resources available to the Cibola National Wildlife Refuge. It appears that restoration of the marsh is possible and can be designed to meet the objectives of the LCR MSCP and the refuge. While there are constraints (e.g. high salinity) to restoration of the marsh, there are well established methodologies with reclaiming saline/sodic soils.

It also appears that restoration of the marsh is compatible with water quantities available to the refuge. Because the restoration of the marsh will require the flushing of substantial amounts of salts out of the marsh, the design will have to include protection of water quality in Cibola Lake if the project is to be compatible with the overall objectives of the refuge. The refuge does have an entitlement to 7,500 acre feet of water for circulation purposes which may be needed to protect water quality in the lake.

The report met Goal 2, which is to describe data gathered to inform the design of the restoration plan and identify opportunities and constraints for restoration. The data described in the report will be essential to the development of the restoration plan. One section that will require further data gathering and analysis is hydrology. To fully characterize seasonal groundwater profiles and agricultural runoff and returns will require monitoring over a longer period of time (e.g., complete yearly cycle).

The report did identify and quantify several important constraints that will have to be taken into account in the preparation of the restoration plan for the marsh. Water quality in the Arnett Ditch and lack of circulation back to the river are major concerns which have exacerbated soil salinity and may cause ammonium toxicity in both the restored marsh and Cibola Lake.

An additional major constraint is the lack of an effective means to control water elevations and delivery of water to the marsh, and to evacuate water form the marsh. The area's low slope and minimal differences in relative heads are important site considerations, as is the need to promote a mosaic of habitats and an effective method to flush salts.

It is highly recommended that the selected restoration approach provides the maximum amount of management flexibility. Achievement of this goal is best facilitated by robust infrastructure improvements associated with water delivery and control. The greatest degree of flexibility would be gained by having multiple options for water control, associated with both the inflow and outflow portions of the project's infrastructure. While detailing these elements is beyond the scope of this report, effective infrastructure improvements that allow for managing for a wide array of conditions is deemed critical if restoration efforts are to be successful.

The report met Goal 3, which is to describe data gathered that will provide the baseline for the development of success criteria for the restoration project and long-term monitoring of the project. In particular, the vegetation mapping and soil data compiled in this report will serve as the baseline to compare pre-project and post-project conditions.

Project Timeline

- A Wetland Review Workshop is scheduled to meet in April 10-12, 2007 to discuss the project's options;
- Data acquisition will continue through summer 2007;
- Final *Comprehensive Conceptual Restoration Plan for Hart Mine Marsh* is due in September 2007;
- The Service and Reclamation will hold a meeting in early FY08 to discuss next steps.

Final Conclusion

After review of the data compiled in this report, our initial assessment indicates that the proposed project is both feasible and likely to meet the goals and objectives of the LCR MSCP and the National Wildlife Refuge Service.

7.0 Existing Conditions Report: List of Figures and Tables

8.0 Existing Conditions Report: BIBLIOGRAPHY

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9.0 Existing Conditions Report: APPENDICES

(available under separate cover)

9.1 Appendix 1. Topography: Contour Maps & USBR Survey

9.2 Appendix 2. Geomorphic Assessment (William Lettis & Associates)

9.3 Appendix 3. Water Quality Lab Results and xls File

9.4 Appendix 4. Soils

9.5 Appendix 5. HMM Vegetation Communities and Acreages

9.1 Appendix 1 -- Topography: Contour Maps & USBR Survey

9.11 Appendix 1 Topographic Contour Map (1 of 2)

9.12 Appendix 1 Topographic Contour Map (2 of 2)

9.13 Appendix 1 USBR Hart Mine Marsh Survey

MATCH LINE SEE SHEET 2

PROJECT NO.	-
DESIGNED BY:	-
DRAWN BY:	PG
SURVEYED BY:	USBR
CHECKED BY:	
DATE	1/17/07
SHEET	1 OF 2

CIBOLA NWR
HART MINE MARSH
ESTIMATED CONTOURS

SHORELINE ®
ENGINEERING & RESTORATION

3152 Noblecrest Lane
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MATCH LINE SEE SHEET 1

CIBOLA NWR
HART MINE MARSH
ESTIMATED CONTOURS

PROJECT NO. -
DESIGNED BY: -
DRAWN BY: RG
SURVEYED BY: USBR
CHECKED BY:
DATE: 1/17/07
SHEET 2 OF 2

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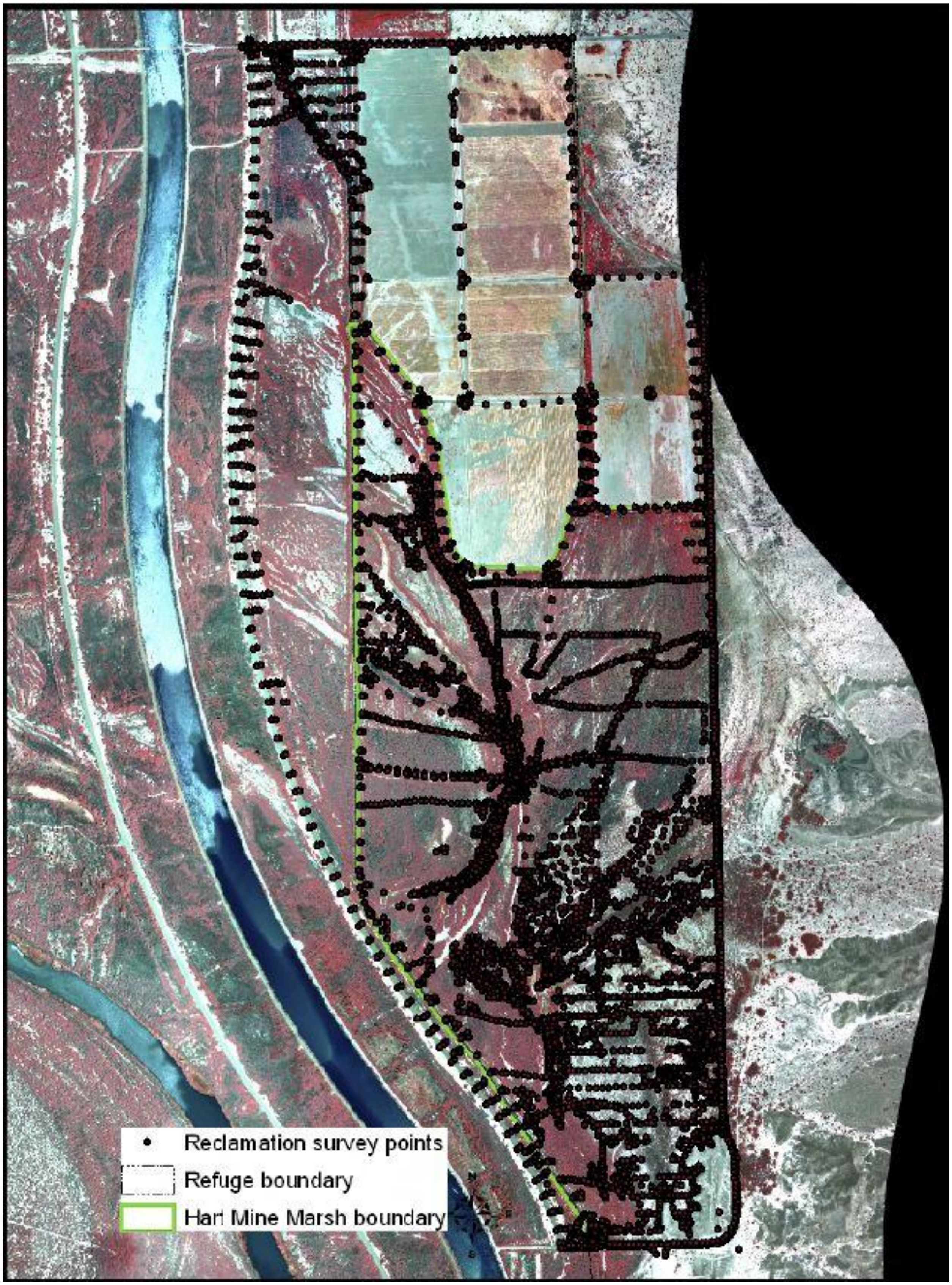
Reclamation survey points
Refuge boundary
Hart Mine Marsh boundary

9.2 Appendix 2 -- Geomorphic Assessment (4 page letter from William Lettis & Associates)

WLA
WILLIAM LETTIS & ASSOCIATES, INC.
1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
tel (925) 256-6070 fax (925) 256-6076

October 20, 2006

Mr. Darrell Kundargi
Hydrologist
U.S. Fish and Wildlife Service
Branch of Water Resources
500 Gold Street SW, Ste 9016
Albuquerque, NM 87102

Subject: **Surficial Geologic Map of the Hartmine restoration Area, Cibola National Wildlife Refuge, Arizona**

Dear Mr. Kundargi:

William Lettis & Associates, Inc. is pleased to provide this letter and GIS database that summarizes our surficial geologic mapping of floodplain deposits within the Hartmine Restoration area of the Lower Colorado River in Cibola National Wildlife Refuge, Arizona. This project is designed to help land managers and scientists effectively characterize, monitor and restore this area. We provide the surficial mapping as a GIS database (see attached shape files).

Our approach in delineating the surficial deposits in the Hartmine Restoration area was to analyze 1938 aerial photography and input the geologic interpretation into a GIS. We utilized black and white aerial photography taken in April, 1938 and geo-rectified in 2006 as part of a USGS open-file report (Norman et al., 2006). Infra-red imagery taken in 2004 also were reviewed for additional detail, although the mapped units were based on deposits visible on the 1938 photographs. In conjunction with the analysis of aerial photography, the USGS 7.5-minute Picacho NW quadrangle topographic map was used to assess deposit boundaries and landform origin. Map units were delineated through interpretation of planform patterns, tonal contrasts and elevation differences. Vegetation type, alignments, and densities also provided information from which to differentiate map units. We developed surficial geology map units on the basis of recent similar mapping projects in the inner Rio Grande valley (Pearce and Kelson, 2003). This mapping effort was entirely an office-based analysis of aerial photographs and did not include field verification of mapped units. The GIS database delivered is a polygon shape file and associated metadata. Each polygon feature is attributed with a name and description of the mapped unit. The digital database was created in ArcMap 9.1 and is provided in State Plane Coordinates, NAD 83.

Results

The geologic units mapped were classified on the basis of both genetic origin and age, as best interpreted from the aerial photography. On the 1938 imagery, we identified deposits and landforms that reflect active fluvial processes, as well as deposits and landforms that are late Pleistocene (tens of thousands of years old), late Holocene (within the past few thousand years) or recent (within the past couple of centuries).

Fluvial deposits directly associated with historic or paleo-channels of the Colorado River are grouped into two map units for each deposit-age group. These two groups include deposits associated with: outside channel bends (Hcb) and crevasse splays (Hcs). Deposits derived from tributary arroyos draining into the inner Colorado River Valley are designated by Hfa (Holocene alluvial fan) or Pfa

(Pleistocene alluvial fan). Modern channels are differentiated as Rch (Recent channels). In some locations, the genetic origin of individual alluvial deposits was not easily distinguished, as a result of indistinct signatures on the imagery or dense vegetation. In the absence of field investigation, specific unit designation is not possible. These undifferentiated Holocene alluvial deposits are therefore designated as “Hal”.

In addition to delineating surficial geologic deposits within the inner Colorado River valley, we note the generalized characteristics of vegetation within each map polygon. As noted above, we base this simple characterization on the type and density of vegetation land cover determined from the 1938 vintage imagery. Similar to the classification used by Pearce and Kelson (2003)m the vegetation classes are defined as follows:

Class 0	Water
Class 1	Bare soil
Class 2	Bare soil and grasses
Class 3	Grasses
Class 4	Grasses and shrubs
Class 5	Mixed grass, shrubs and trees
Class 6	Low-density trees and shrubs
Class 7	High-density trees and shrubs
Class 8	Disturbed lands

Our intent with this classification scheme is to (1) differentiate geologic map units associated with distinct vegetation types and densities, and (2) provide a relative numerical scale that reflects a general succession of vegetation development on fluvial deposits in the inner valley. For example, cross-cutting fluvial relationships in the inner valley suggest that relatively younger deposits are associated with Classes 1, 2, or 3, and relatively older deposits are associated with Classes 5, 6, or 7. Our intent in developing this numerical classification is that the database will be used for identifying any possible correlations between vegetation characteristics and geologic map units, and for analyzing progressive changes in vegetation through time. This effort refines a similar classification completed by Hendrickx and Harrison (2000) and Pearce and Kelson (2003) for the Rio Grande Valley and in central New Mexico.

Observations

Although this map was generated based on the land features visible in the 1938 aerial photos, some comparisons with the 2004 satellite imagery were noted. Changes in vegetation within the Hartmine Restoration area are the most significant difference visible between the 1938 photos and the 2004 photos. The changes in vegetation are due in part to the encroachment of the invasive phreatophyte, tamarisk, (salt cedar). Another obvious vegetation change is the area along the northwestern edge of the study area which was cleared for agriculture in the late 1930’s but is vegetated in the 2004 imagery. Other changes could be linked to seasonal variations or water table variations.

There are only a few subtle changes in the actual geomorphic landforms during this same time period. Because this area has not been developed, the same processes that were sculpting the land forms in the late 1930’s are still active today. For example, the crevasse splays present in the southwest corner of section five were distinguishable mainly from the vegetation patterns on the 2004 maps. It is presumed that these were originally formed by the Colorado River when it was still flowing along this particular channel bend. The crevasse splays were, therefore, present in the 1938 and are mapped as such, even though they are not as easily distinguished in the 1938 photos. Several of the channels visible in the 1938 photos are much more pronounced in the 2004 photo particularly in the area just north of the mapped crevasse splays. Again, this type of change could be a result of water table changes due to seasonal variations between the photos or invasion of tamarisk, as opposed to geomorphic changes in stream positions.

It has been a pleasure to provide this information to the USFWS. If there are any questions or if we can be of further assistance, please do not hesitate to call either of the undersigned,

Respectfully,
WILLIAM LETTIS & ASSOCIATES, INC.

Keith I Kelson, C.E.G.
Principal Geologist

Anne C. Tillery, C.F.M.
Senior Staff Geologist

Enclosure (GIS shapefiles)

References

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9.3 Appendix 3 -- Water Quality Lab Results (28 pages) and spreadsheet file

AQUATIC CONSULTING & TESTING, INC.

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27 September 2006

Mr. Darrell Kundargi
US Fish and Wildlife Service
500 Gold Avenue Southwest
Albuquerque, New Mexico 87102

Attached please find the results for the samples submitted on 16 August 2006. Data packages are also included for subcontracted organic analyses.

Please note that some dissolved metals are slightly higher than total metals. We believe that the difference is the result of slightly different concentrations in the two separate samples (one for total and one for dissolved metals processing) collected. Should you wish us to check the total concentration on the non-preserved sample from which the dissolved values were obtained, please contact us and we would be happy to do so at your request. Please note that in those cases, both dissolved and total concentrations detected were well below any of the surface water maximum levels.

Please also note that the laboratory PQL for mercury is 0.5 ug/L and the chronic A&W maxima are as low as 0.01 ug/L. Measurement at that level requires ultra clean sampling techniques and ultra low level mercury analysis.

For those metal constituents with Arizona surface water standards, a table has been attached showing the results and the maximum level for each designated use.

Respectfully,

Frederick A. Amalfi, Ph.D.
Laboratory Director

Designated Use	As, max ug/L	Hg, max ug/L	Se, max ug/L
DWS	50 T	2 T	50 T
FC	1450 T	0.6 T	9000 T
FBC	50 T	420 T	7000 T
PBC	420 T	420 T	7000 T
AgI	2000 T	NNS	20 T
AgL	200 T	10 T	50 T
Sample AZ	4 T	<0.5 T	<2 T
Sample A1	<2 T	<0.5 T	<2 T
Sample A3	<2 T	<0.5 T	<2 T
A&Wc Acute	360 D	2.4 D	20 T
A&Wc Chronic	100 D	0.01 D	2.0 T
A&Ww Acute	360 D	2. D	20 T
A&Ww Chronic	190 D	0.01 D	2.0 T
A&Wedw Acute	360 D	2.6 D	50 T
A&Wedw Chronic	190 D	0.2 D	2.0 T
A&We Acute	440 D	5.0 D	33 T
Sample AZ	8 D	<0.5 D	<2 T
Sample A1	5 D	<0.5 D	<2 T
Sample A3	2 D	<0.5 D	<2 T

Limits from Title 18, Chapter 11, Section109 Numeric Water Quallity Standards. Arizona Administrative Code 2002. NNS= no numeric standard

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LABORATORY REPORT

Client: U.S. Fish & Wildlife Service
500 Gold Avenue SW
Albuquerque, NM 87102

Date Submitted: 08/16/06
Date Reported: 09/27/06

Attn: Darrell Kundargi

Project: HMM

RESULTS

Client ID: A2
ACT Lab No.: BN09538

Sample Type: Surface Water
Sample Time: 08/15/06 13:00

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	08/17/06	08/17/06	SM 2320 B	138.	mg/L as CaCO3
Ammonia - N	08/22/06	08/22/06	350.2	0.35	mg/L as N
Chloride	08/17/06	08/17/06	325.3	707.	mg/L
Nitrate + Nitrite - N	08/22/06	08/22/06	SM4500NO3 E	0.08	mg/L as N
Phosphorus, Total	08/18/06	08/18/06	365.3	0.541	mg/L as P
Sulfate	08/28/06	08/28/06	SM4500SO4 D	581.	mg/L
Total Kjeldahl Nitrogen	08/24/06	08/24/06	351.3	2.67	mg/L as N
Arsenic, Dissolved	09/14/06	09/14/06	200.9	0.008	mg/L
Arsenic, Total	09/01/06	09/01/06	200.9	0.004	mg/L
Calcium, Dissolved	08/21/06	08/21/06	200.7	177.	mg/L
Calcium, Total	08/28/06	08/28/06	200.7	202.	mg/L
Magnesium, Dissolved	08/21/06	08/21/06	200.7	66.8	mg/L
Magnesium, Total	08/28/06	08/28/06	200.7	77.6	mg/L
Mercury, Dissolved	08/28/06	08/28/06	245.1	<0.0005	mg/L
Mercury, Total	08/28/06	08/28/06	245.1/7470A	<0.0005	mg/L
Selenium, Dissolved	08/29/06	08/29/06	200.9	<0.002	mg/L
Selenium, Total	08/29/06	08/29/06	200.9	<0.002	mg/L
Sodium, Dissolved	08/21/06	08/21/06	200.7	364.	mg/L
Sodium, Total	08/28/06	08/28/06	200.7	414.	mg/L
Chlorinated Pesticides	08/22/06	08/24/06	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	08/21/06	08/28/06	8141A	See Attached *	ug/L

RESULTS

Client ID: A1
ACT Lab No.: BN09539

Sample Type: Surface Water
Sample Time: 08/15/06 16:00

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	08/17/06	08/17/06	SM 2320 B	223.	mg/L as CaCO3
Ammonia - N	08/22/06	08/22/06	350.2	0.09	mg/L as N
Chloride	08/17/06	08/17/06	325.3	2150.	mg/L
Nitrate + Nitrite - N	08/22/06	08/22/06	SM4500NO3 E	0.01	mg/L as N
Phosphorus, Total	08/18/06	08/18/06	365.3	0.114	mg/L as P
Sulfate	08/28/06	08/28/06	SM4500SO4 D	1060.	mg/L
Total Kjeldahl Nitrogen	08/24/06	08/24/06	351.3	1.31	mg/L as N
Arsenic, Dissolved	09/14/06	09/14/06	200.9	0.005	mg/L
Arsenic, Total	09/01/06	09/01/06	200.9	<0.002	mg/L
Calcium, Dissolved	08/21/06	08/21/06	200.7	413.	mg/L
Calcium, Total	08/28/06	08/28/06	200.7	466.	mg/L
Magnesium, Dissolved	08/21/06	08/21/06	200.7	126.	mg/L
Magnesium, Total	08/28/06	08/28/06	200.7	147.	mg/L
Mercury, Dissolved	08/29/06	08/29/06	245.1	<0.0005	mg/L
Mercury, Total	08/28/06	08/28/06	245.1/7470A	<0.0005	mg/L
Selenium, Dissolved	08/29/06	08/29/06	200.9	<0.002	mg/L
Selenium, Total	08/29/06	08/29/06	200.9	<0.002	mg/L
Sodium, Dissolved	08/21/06	08/21/06	200.7	1220.	mg/L
Sodium, Total	08/28/06	08/28/06	200.7	1140.	mg/L
Chlorinated Pesticides	08/22/06	08/24/06	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	08/21/06	08/28/06	8141A	See Attached *	ug/L

RESULTS

Client ID: A3
ACT Lab No.: BN09540

Sample Type: Surface Water
Sample Time: 08/15/06 16:50

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	08/17/06	08/17/06	SM 2320 B	70.	mg/L as CaCO3
Ammonia - N	08/22/06	08/22/06	350.2	0.88	mg/L as N
Chloride	08/17/06	08/17/06	325.3	10700.	mg/L
Nitrate + Nitrite - N	08/22/06	08/22/06	SM4500NO3 E	0.05	mg/L as N
Phosphorus, Total	08/18/06	08/18/06	365.3	0.450	mg/L as P
Sulfate	08/28/06	08/28/06	SM4500SO4 D	3950.	mg/L
Total Kjeldahl Nitrogen	08/24/06	08/24/06	351.3	6.00	mg/L as N
Arsenic, Dissolved	09/14/06	09/14/06	200.9	0.002	mg/L
Arsenic, Total	09/01/06	09/01/06	200.9	<0.002	mg/L
Calcium, Dissolved	08/21/06	08/21/06	200.7	1350.	mg/L
Calcium, Total	08/28/06	08/28/06	200.7	1490.	mg/L
Magnesium, Dissolved	08/21/06	08/21/06	200.7	517.	mg/L
Magnesium, Total	08/28/06	08/28/06	200.7	518.	mg/L
Mercury, Dissolved	08/29/06	08/29/06	245.1	<0.0005	mg/L
Mercury, Total	08/28/06	08/28/06	245.1/7470A	<0.0005	mg/L
Selenium, Dissolved	08/29/06	08/29/06	200.9	<0.002	mg/L
Selenium, Total	08/29/06	08/29/06	200.9	<0.002	mg/L
Sodium, Dissolved	08/21/06	08/21/06	200.7	4220.	mg/L
Sodium, Total	08/28/06	08/28/06	200.7	4860.	mg/L
Chlorinated Pesticides	08/22/06	08/24/06	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	08/21/06	08/28/06	8141A	See Attached *	ug/L

* Analysis performed by Test America (AZ0426)

Reviewed by: [signature]

Frederick A. Amalfi, Ph.D.
Laboratory Director

TestAmerica
ANALYTICAL TESTING CORPORATION

LABORATORY REPORT

Prepared For: Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project:USFWS-NM / HMM

Sampled: 08/15/06
Received: 08/17/06
Issued: 08/28/06 14:11

NELAP #01109CA California ELAP#2446 Arizona DHS#AZ0426 Nevada #AZ907

The results listed within this Laboratory Report pertain only to the samples tested in the laboratory. The analyses contained in this report were performed in accordance with the applicable certifications as noted. All soil samples are reported on a wet weight basis unless otherwise noted in the report. This Laboratory Report is confidential and is intended for the sole use of TestAmerica and its client. This report shall not be reproduced, except in full, without written permission from TestAmerica. The Chain of Custody, 1 page, is included and is an integral part of this report.
This entire report was reviewed and approved for release.

CASE NARRATIVE

LABORATORY ID	CLIENT ID	MATRIX
PPH0509-01	BN-09538	Water
PPH0509-02	BN-09539	Water
PPH0509-03	BN-09540	Water

SAMPLE RECEIPT: Samples were received intact, at 2°C, on ice and with chain of custody documentation.

HOLDING TIMES: All samples were analyzed within prescribed holding times and/or in accordance with the TestAmerica Sample Acceptance Policy unless otherwise noted in the report.

PRESERVATION: Samples requiring preservation were verified prior to sample analysis.

QA/QC CRITERIA: All analyses met method criteria, except as noted in the report with data qualifiers.

COMMENTS: No significant observations were made.

SUBCONTRACTED: Refer to the last page for specific subcontract laboratory information included in this report.

Reviewed By:

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	 Sampled: 08/15/06 Received: 08/17/06

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte AZ	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PPH0509-01 (BN-09538 - Water)								
Reporting Units: ug/l								
Aldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
alpha-BHC	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
beta-BHC	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
delta-BHC	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
gamma-BHC (Lindane)	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Chlordane	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/24/2006	
4,4'-DDD	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDE	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDT	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Dieldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan I	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan II	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan sulfate	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
Endrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin aldehyde	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin ketone	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor epoxide	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Methoxychlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Toxaphene	EPA 608	6H22055	5.0	ND	1	8/22/2006	8/24/2006	
Surrogate: Tetrachloro-m-xylene (35-115%)				*55 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*68 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	 Sampled: 08/15/06 Received: 08/17/06

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
A1								
Sample ID: PPH0509-02 (BN-09539 - Water)								
Reporting Units: ug/l								
Aldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
alpha-BHC	EPA 608	6H22055	0.10	**0.94**	1	8/22/2006	8/24/2006	
beta-BHC	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
delta-BHC	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
gamma-BHC (Lindane)	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Chlordane	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/24/2006	
4,4'-DDD	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDE	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDT	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Dieldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan I	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan II	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan sulfate	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
Endrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin aldehyde	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin ketone	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor epoxide	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Methoxychlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Toxaphene	EPA 608	6H22055	5.0	ND	1	8/22/2006	8/24/2006	
Surrogate: Tetrachloro-m-xylene (35-115%)				*61 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*71 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica

ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	 Sampled: 08/15/06 Received: 08/17/06

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PPH0509-03 (BN-09540 - Water)								
Reporting Units: ug/l								
Aldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
alpha-BHC	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
beta-BHC	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
delta-BHC	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
gamma-BHC (Lindane)	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Chlordane	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/24/2006	
4,4'-DDD	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDE	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
4,4'-DDT	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Dieldrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan I	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan II	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endosulfan sulfate	EPA 608	6H22055	0.20	ND	1	8/22/2006	8/24/2006	
Endrin	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin aldehyde	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Endrin ketone	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Heptachlor epoxide	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Methoxychlor	EPA 608	6H22055	0.10	ND	1	8/22/2006	8/24/2006	
Toxaphene	EPA 608	6H22055	5.0	ND	1	8/22/2006	8/24/2006	
Surrogate: Tetrachloro-m-xylene (35-115%)				*48 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*64 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	Sampled: 08/15/06 Received: 08/17/06

TOTAL PCBS (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PPH0509-01 (BN-09538 - Water)								
Reporting Units: ug/l								
Aroclor 1016	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1221	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1232	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1242	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1248	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1254	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1260	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Surrogate: Decachlorobiphenyl (45-120%)				*77 %*				
Sample ID: PPH0509-02 (BN-09539 - Water)								
Reporting Units: ug/l								
Aroclor 1016	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1221	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1232	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1242	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1248	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1254	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1260	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Surrogate: Decachlorobiphenyl (45-120%)				*92 %*				
Sample ID: PPH0509-03 (BN-09540 - Water)								
Reporting Units: ug/l								
Aroclor 1016	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1221	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1232	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1242	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1248	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1254	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Aroclor 1260	EPA 608	6H22055	1.0	ND	1	8/22/2006	8/22/2006	
Surrogate: Decachlorobiphenyl (45-120%)				*69 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS-NM / HMM

Report Number: PPH0509

Sampled: 08/15/06
Received: 08/17/06

METHOD BLANK/QC DATA

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Data Qualifiers
Batch: 6H22055 Extracted: 08/22/06										
Blank Analyzed: 08/22/2006 (6H22055-BLK1)										
Aldrin	ND	0.10	ug/l							
alpha-BHC	ND	0.10	ug/l							
beta-BHC	ND	0.10	ug/l							
delta-BHC	ND	0.20	ug/l							
gamma-BHC (Lindane)	ND	0.10	ug/l							
Chlordane	ND	1.0	ug/l							
4,4'-DDD	ND	0.10	ug/l							
4,4'-DDE	ND	0.10	ug/l							
4,4'-DDT	ND	0.10	ug/l							
Dieldrin	ND	0.10	ug/l							
Endosulfan I	ND	0.10	ug/l							
Endosulfan II	ND	0.10	ug/l							
Endosulfan sulfate	ND	0.20	ug/l							
Endrin	ND	0.10	ug/l							
Endrin aldehyde	ND	0.10	ug/l							
Endrin ketone	ND	0.10	ug/l							
Heptachlor	ND	0.10	ug/l							
Heptachlor epoxide	ND	0.10	ug/l							
Methoxychlor	ND	0.10	ug/l							
Toxaphene	ND	5.0	ug/l							
Surrogate: Tetrachloro-m-xylene	*0.360*		*ug/l*	*0.500*		*72*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.448*		*ug/l*	*0.500*		*90*	*45-120*			
LCS Analyzed: 08/23/2006 (6H22055-BS1)										**Q8**
Aldrin	0.400	0.10	ug/l	0.500		80	35-120			
alpha-BHC	0.440	0.10	ug/l	0.500		88	45-120			
beta-BHC	0.473	0.10	ug/l	0.500		95	50-120			
delta-BHC	0.503	0.20	ug/l	0.500		101	50-120			
gamma-BHC (Lindane)	0.432	0.10	ug/l	0.500		86	40-120			
4,4'-DDD	0.577	0.10	ug/l	0.500		115	55-120			
4,4'-DDE	0.473	0.10	ug/l	0.500		95	50-120			
4,4'-DDT	0.556	0.10	ug/l	0.500		111	55-120			
Dieldrin	0.473	0.10	ug/l	0.500		95	50-120			
Endosulfan I	0.431	0.10	ug/l	0.500		86	50-120			
Endosulfan II	0.470	0.10	ug/l	0.500		94	55-120			
Endosulfan sulfate	0.591	0.20	ug/l	0.500		118	60-120			

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	Sampled: 08/15/06 Received: 08/17/06

METHOD BLANK/QC DATA

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Data Qualifiers
Batch: 6H22055 Extracted: 08/22/06										
LCS Analyzed: 08/23/2006 (6H22055-BS1)										Q8
Endrin	0.521	0.10	ug/l	0.500		104	55-120			
Endrin aldehyde	0.543	0.10	ug/l	0.500		109	55-120			
Endrin ketone	0.539	0.10	ug/l	0.500		108	55-120			
Heptachlor	0.410	0.10	ug/l	0.500		82	40-115			
Heptachlor epoxide	0.411	0.10	ug/l	0.500		82	50-120			
Methoxychlor	0.546	0.10	ug/l	0.500		109	55-120			
Surrogate: Tetrachloro-m-xylene	*0.378*		*ug/l*	*0.500*		*76*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.509*		*ug/l*	*0.500*		*102*	*45-120*			
LCS Dup Analyzed: 08/22/2006 (6H22055-BSD1)										
Aldrin	0.371	0.10	ug/l	0.500		74	35-120	8	30	
alpha-BHC	0.401	0.10	ug/l	0.500		80	45-120	9	30	
beta-BHC	0.437	0.10	ug/l	0.500		87	50-120	8	30	
delta-BHC	0.445	0.20	ug/l	0.500		89	50-120	12	30	
gamma-BHC (Lindane)	0.403	0.10	ug/l	0.500		81	40-120	7	30	
4,4'-DDD	0.501	0.10	ug/l	0.500		100	55-120	14	30	
4,4'-DDE	0.421	0.10	ug/l	0.500		84	50-120	12	30	
4,4'-DDT	0.485	0.10	ug/l	0.500		97	55-120	14	30	
Dieldrin	0.431	0.10	ug/l	0.500		86	50-120	9	30	
Endosulfan I	0.402	0.10	ug/l	0.500		80	50-120	7	30	
Endosulfan II	0.438	0.10	ug/l	0.500		88	55-120	7	30	
Endosulfan sulfate	0.527	0.20	ug/l	0.500		105	60-120	11	30	
Endrin	0.469	0.10	ug/l	0.500		94	55-120	11	30	
Endrin aldehyde	0.495	0.10	ug/l	0.500		99	55-120	9	30	
Endrin ketone	0.494	0.10	ug/l	0.500		99	55-120	9	30	
Heptachlor	0.383	0.10	ug/l	0.500		77	40-115	7	30	
Heptachlor epoxide	0.387	0.10	ug/l	0.500		77	50-120	6	30	
Methoxychlor	0.512	0.10	ug/l	0.500		102	55-120	6	30	
Surrogate: Tetrachloro-m-xylene	*0.351*		*ug/l*	*0.500*		*70*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.479*		*ug/l*	*0.500*		*96*	*45-120*			

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS-NM / HMM

Report Number: PPH0509

Sampled: 08/15/06
Received: 08/17/06

METHOD BLANK/QC DATA

TOTAL PCBS (EPA 608)

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Data Qualifiers
Batch: 6H22055 Extracted: 08/22/06										
Blank Analyzed: 08/22/2006 (6H22055-BLK1)										
Aroclor 1016	ND	1.0	ug/l							
Aroclor 1221	ND	1.0	ug/l							
Aroclor 1232	ND	1.0	ug/l							
Aroclor 1242	ND	1.0	ug/l							
Aroclor 1248	ND	1.0	ug/l							
Aroclor 1254	ND	1.0	ug/l							
Aroclor 1260	ND	1.0	ug/l							
Surrogate: Decachlorobiphenyl	*0.479*		*ug/l*	*0.500*		*96*	*45-120*			
LCS Analyzed: 08/22/2006 (6H22055-BS2)										**Q8**
Aroclor 1016	3.43	1.0	ug/l	4.00		86	45-115			
Aroclor 1260	3.65	1.0	ug/l	4.00		91	55-115			
Surrogate: Decachlorobiphenyl	*0.433*		*ug/l*	*0.500*		*87*	*45-120*			
LCS Dup Analyzed: 08/22/2006 (6H22055-BSD2)										
Aroclor 1016	3.77	1.0	ug/l	4.00		94	45-115	9	30	
Aroclor 1260	4.16	1.0	ug/l	4.00		104	55-115	13	25	
Surrogate: Decachlorobiphenyl	*0.494*		*ug/l*	*0.500*		*99*	*45-120*			

LCS = Lab Control Standard

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS-NM / HMM

Report Number: PPH0509

Sampled: 08/15/06
Received: 08/17/06

DATA QUALIFIERS AND DEFINITIONS

Q8 Insufficient sample received to meet method QC requirements. Batch QC satisfies ADEQ policies 0154 and 0155.

ND Analyte NOT DETECTED at or above the reporting limit or MDL, if MDL is specified.

RPD Relative Percent Difference

Aquatic Consulting & Testing 1525 W. University, Suite 106 Tempe, AZ 85281 Attention: Chris Christian	Project ID: USFWS-NM / HMM Report Number: PPH0509	 Sampled: 08/15/06 Received: 08/17/06

Certification Summary

Subcontracted Laboratories

Aerotech Laboratories, Inc. *Arizona Cert #AZ0610*

1501 W Knudsen Drive - PHX, AZ 85027

Analysis Performed: 8141A-Full

Samples: PPH0509-01, PPH0509-02, PPH0509-03

TestAmerica - Irvine, CA *NELAC Cert #01108CA, California Cert #1197, Arizona Cert #AZ0671, Nevada Cert #CA72-2002-63*

17461 Derian Ave. Suite 100 - Irvine, CA 92614

Method Performed: EPA 608

Samples: PPH0509-01, PPH0509-02, PPH0509-03

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

SUBCONTRACT ORDER - PROJECT # PPH0509

SENDING LABORATORY:	RECEIVING LABORATORY:
TestAmerica - Phoenix, AZ	TestAmerica - Irvine, CA
9830 South 51st Street, Suite B-120	17461 Derian Ave. Suite 100
Phoenix, AZ 85044	Irvine, CA 92614
Phone: (480) 785-0043	Phone :(949) 261-1022
Fax: (480) 785-0851	Fax: (949) 261-1228 IPH2110
Project Manager: Linda Eshelman	

Analysis	Expiration	Due	Comments
Sample ID: PPH0509-01 Water	**Sampled: 08/15/06 13:00**		
608 (Pest./PCBs)-I	08/22/06 13:00	08/28/06 12:00	Irvine
Containers Supplied:			
1 L Amber (PPH0509-01A)			
1 L Amber (PPH0509-01B)			
Sample ID: PPH0509-02 Water	**Sampled: 08/15/06 16:00**		
608 (Pest./PCBs)-I	08/22/06 16:00	08/28/06 12:00	Irvine
Containers Supplied:			
1 L Amber (PPH0509-02A)			
1 L Amber (PPH0509-02B)			
Sample ID: PPH0509-03 Water	**Sampled: 08/15/06 16:50**		
608 (Pest./PCBs)-I	08/22/06 16:50	08/28/06 12:00	Irvine
Containers Supplied:			
1 L Amber (PPH0509-03A)			
1 L Amber (PPH0509-03B)			

BT 8/19/06 10:40

SAMPLE INTEGRITY:

All containers intact: ☑ Yes ☐ No	Sample labels/COC agree: ☑ Yes ☐ No	Samples Received On Ice:: ☑ Yes ☐ No	
Custody Seals Present ☐ Yes ☑ No	Samples Preserved Properly: ☑ Yes ☐ No	Samples Received at (temp): 1	

Released By	Date	Time	Received By	Date	Time
[signature]	8/15/06	18:00	Fed Ex		
			[signature]	8/19/06	1000

Thursday, August 31, 2006

Linda Eshelman
Del Mar
9830 South 51st Street
Suite B-120
Phoenix, AZ 85044

TEL: (480) 785-0043
FAX (480) 785-0851

RE: PPH0509

Order No.: 06080716

Dear Linda Eshelman:

Aerotech Environmental, Inc. received 3 sample(s) on 8/18/2006 for the analyses presented in the following report.

This report includes the following information:
- Case Narrative.
- Analytical Report: includes test results, report limit (Limit), any applicable data qualifier (Qual), units, dilution factor (DF), and date analyzed.
- QC Summary Report.

This communication is intended only for the individual or entity to whom it is directed. It may contain information that is privileged, confidential, or otherwise exempt from disclosure under applicable law. Dissemination, distribution, or copying of this communication by anyone other than the intended recipient, or a duly designated employee or agent of such recipient, is prohibited. If you have received this communication in error, please notify us immediately and destroy this message and all attachments thereto. If you have any questions regarding these test results, please do not hesitate to call.

Sincerely,

Cindy Bentley
Project Manager

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Aerotech Environmental, Inc. **Date:** *31-Aug-06*

CLIENT: Del Mar
Project: PPH0509
Lab Order: 06080716

CASE NARRATIVE

Samples were analyzed using methods outlined in references such as:
- ·Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.
- ·Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.
- ·Methods for the Determination of Organic Compounds in Drinking Water: Supplement III, EPA/600/R-95/131, August 1995.
- ·Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition.
- ·40 CFR, Part 136, Revised 1998. Appendix A to Part 136 - Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.
- ·NIOSH Manual of Analytical Methods, Fourth Edition, 1994.
- ·Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, 1999.

Aerotech Environmental Laboratories (AEL) holds Arizona certification no. AZ0610.

Aerotech Environmental Laboratories (Laboratory ID 154268) is accredited by the American Industrial Hygiene Association (AIHA) in the industrial hygiene program for the analytical techniques noted on the scope of accreditation.

Analytical Comments:
All method blanks and laboratory control spikes met EPA method and/or laboratory quality control objectives for the analyses included in this report.

Data Qualifiers:
Listed below are the data qualifiers used in your analytical report to explain any analytical or quality control issues. You will find them noted in your report under the column header "QUAL". Any quality control deficiencies that cannot be adequately described by these qualifiers will be addressed in the analytical comments section of this case narrative.

Q8 Insufficient sample received to meet method QC requirements. Batch QC requirements satisfies ADEQ policies 0154 and 0155.

■ Main Laboratory: 4645 E. Cotton Center Boulevard, Building 3, Suite 189 Phoenix, AZ 85040 Phone: 602.437.3340 Toll Free: 866.772.5227 Fax. 623.445.6192 www.aeroenvirolabs.com
■ Tucson Facility: 4455 S. Park Ave. Ste. 110 Tucson, AZ 85714 Phone: 520.807.3801 Fax: 520.807.3803

Aerotech Environmental, I — Analytical Report

Date: *31-Aug-06*

CLIENT:	Del Mar	**Client Sample ID:**	PPH0509-01 A2
Lab Order:	06080716	~~**Tag Number:**~~	
Project:	PPH0509	**Collection Date:**	8/15/2006 1:00:00 PM
Lab ID:	06080716-01A	**Matrix:**	AQUEOUS

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ORGANOPHOSPHORUS PESTICIDES		**SW8141A**				Analyst: **HH**
Chlorpyrifos	< 2.5	2.5		µg/L	1	8/28/2006
Demeton, Total	< 5.0	5.0		µg/L	1	8/28/2006
Diazinon	< 2.5	2.5		µg/L	1	8/28/2006
Disulfoton	< 2.5	2.5		µg/L	1	8/28/2006
Ethion	< 2.5	2.5		µg/L	1	8/28/2006
Fenthion	< 2.5	2.5		µg/L	1	8/28/2006
Malathion	< 2.5	2.5		µg/L	1	8/28/2006
Methyl parathion	< 2.5	2.5		µg/L	1	8/28/2006
Parathion	< 2.5	2.5		µg/L	1	8/28/2006
Surr: TPP (Surrogate)	81.7	49.6-123		%REC	1	8/28/2006
Surr: Tributylphosphate (Surrogat	81.8	51.7-113		%REC	1	8/28/2006

Footnotes: All analysis performed at AEL Phoenix laboratory unless indicated by footnotes.
(1) AEL - Tucson Laboratory
(2) AEL - Knudsen Laboratory
(3) The holding time for pH analysis is immediate. For the most accurate result, the pH should be taken in the field within 15 minutes of sampling.

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■ Corporate Address: 1501 W. Knudsen Drive, Phoenix, Arizona 85027 Phone: 623.780.4800 Toll Free: 800.651.4802 Fax: 623.780.7695 www.aerotechlabs.com

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Aerotech Environmental, I **Analytical Report** **Date:** *31-Aug-06*

CLIENT:	Del Mar	**Client Sample ID:**	PPH0509-02 A1
Lab Order:	06080716	**Tag Number:**	
Project:	PPH0509	**Collection Date:**	8/15/2006 4:00:00 PM
Lab ID:	06080716-02A	**Matrix:**	AQUEOUS

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ORGANOPHOSPHORUS PESTICIDES		**SW8141A**				Analyst: **HH**
Chlorpyrifos	< 2.5	2.5		µg/L	1	8/28/2006
Demeton, Total	< 5.0	5.0		µg/L	1	8/28/2006
Diazinon	< 2.5	2.5		µg/L	1	8/28/2006
Disulfoton	< 2.5	2.5		µg/L	1	8/28/2006
Ethion	< 2.5	2.5		µg/L	1	8/28/2006
Fenthion	< 2.5	2.5		µg/L	1	8/28/2006
Malathion	< 2.5	2.5		µg/L	1	8/28/2006
Methyl parathion	< 2.5	2.5		µg/L	1	8/28/2006
Parathion	< 2.5	2.5		µg/L	1	8/28/2006
Surr: TPP (Surrogate)	90.6	49.6-123		%REC	1	8/28/2006
Surr: Tributylphosphate (Surrogat	90.5	51.7-113		%REC	1	8/28/2006

Footnotes: All analysis performed at AEL Phoenix laboratory unless indicated by footnotes.

(1) AEL - Tucson Laboratory

(2) AEL - Knudsen Laboratory

(3) The holding time for pH analysis is immediate. For the most accurate result, the pH should be taken in the field within 15 minutes of sampling.

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■ Corporate Address: 1501 W. Knudsen Drive, Phoenix, Arizona 85027 Phone: 623.780.4800 Toll Free: 800.651.4802 Fax: 623.780.7695 www.aerotechlabs.com

Aerotech Environmental Laboratories
a division of Aerotech Laboratories, Inc.

Aerotech Environmental, I **Analytical Report** **Date:** *31-Aug-06*

CLIENT:	Del Mar	**Client Sample ID:**	PPH0509-03
Lab Order:	06080716	**Tag Number:**	43
Project:	PPH0509	**Collection Date:**	8/15/2006 4:50:00 PM
Lab ID:	06080716-03A	**Matrix:**	AQUEOUS

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ORGANOPHOSPHORUS PESTICIDES		**SW8141A**				Analyst: **HH**
Chlorpyrifos	< 2.5	2.5		µg/L	1	8/28/2006
Demeton, Total	< 5.0	5.0		µg/L	1	8/28/2006
Diazinon	< 2.5	2.5		µg/L	1	8/28/2006
Disulfoton	< 2.5	2.5		µg/L	1	8/28/2006
Ethion	< 2.5	2.5		µg/L	1	8/28/2006
Fenthion	< 2.5	2.5		µg/L	1	8/28/2006
Malathion	< 2.5	2.5		µg/L	1	8/28/2006
Methyl parathion	< 2.5	2.5		µg/L	1	8/28/2006
Parathion	< 2.5	2.5		µg/L	1	8/28/2006
Surr: TPP (Surrogate)	63.8	49.6-123		%REC	1	8/28/2006
Surr: Tributylphosphate (Surrogat	63.7	51.7-113		%REC	1	8/28/2006

Footnotes: All analysis performed at AEL Phoenix laboratory unless indicated by footnotes.

(1) AEL - Tucson Laboratory

(2) AEL - Knudsen Laboratory

(3) The holding time for pH analysis is immediate. For the most accurate result, the pH should be taken in the field within 15 minutes of sampling.

■ Main Laboratory: 4645 E. Cotton Center Boulevard, Building 3, Suite 189 Phoenix, AZ 85040 Phone: 602.437.3340 Toll Free: 866.772.5227 Fax. 623.445.6192 www.aeroenvirolabs.com
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Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Aerotech Environmental, Inc.

Date: *31-Aug-06*

CLIENT: Del Mar
Work Order: 06080716
Project: PPH0509

ANALYTICAL QC SUMMARY REPORT

TestCode: 8141AZ_w

Sample ID: **MB-26713** SampType: **MBLK** TestCode: **8141AZ_w** Units: **µg/L** Prep Date: **8/21/2006** RunNo: **78215**
Client ID: Batch ID: **26713** TestNo: **SW8141A** Analysis Date: **8/28/2006** SeqNo: **929673**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	<2.5	2.5									
Demeton, Total	<5.0	5.0									
Diazinon	<2.5	2.5									
Disulfoton	<2.5	2.5									
Ethion	<2.5	2.5									
Fenthion	<2.5	2.5									
Malathion	<2.5	2.5									
Methyl parathion	<2.5	2.5									
Parathion	<2.5	2.5									
Surr: TPP (Surrogate)	40.15	5.0	50	0	80.3	51.1	116				
Surr: Tributylphosphate (Surrogate)	38.52	5.0	50	0	77.0	46.8	117				

Sample ID: **LCS-26713** SampType: **LCS** TestCode: **8141AZ_w** Units: **µg/L** Prep Date: **8/21/2006** RunNo: **78215**
Client ID: Batch ID: **26713** TestNo: **SW8141A** Analysis Date: **8/28/2006** SeqNo: **929674**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	8.042	2.5	10	0	80.4	72.8	103				Q8
Demeton, Total	14.94	5.0	20	0	74.7	64.5	104				Q8
Diazinon	8.574	2.5	10	0	85.7	70.9	107				Q8
Disulfoton	9.406	2.5	10	0	94.1	66.5	106				Q8
Ethion	7.388	2.5	10	0	73.9	72.7	104				Q8
Fenthion	8.891	2.5	10	0	88.9	73.6	102				Q8
Malathion	10.06	2.5	10	0	101	70	109				Q8
Methyl parathion	8.692	2.5	10	0	86.9	64.1	110				Q8
Parathion	7.995	2.5	10	0	79.9	73.7	103				Q8
Surr: TPP (Surrogate)	46.64	5.0	50	0	93.3	51.1	116				
Surr: Tributylphosphate (Surrogate)	44.19	5.0	50	0	88.4	46.8	117				

Qualifiers:
- E Value above quantitation range
- ND Not Detected at the Reporting Limit
- H Holding times for preparation or analysis exceeded
- R RPD outside accepted recovery limits
- J Analyte detected below quantitation limits
- S Spike Recovery outside accepted recovery limits

■ Main Laboratory: 4645 E. Cotton Center Boulevard, Building 3, Suite 189 Phoenix, AZ 85040 Phone: 602.437.3340 Toll Free: 866.772.5227 Fax. 623.445.6192 www.aeroenvirolabs.com
■ Tucson Facility: 4455 S. Park Ave. Ste. 110 Tucson, AZ 85714 Phone: 520.807.3801 Fax: 520.807.3803

Aerotech Environmental Laboratories
a division of Aerotech Laboratories, Inc.

CLIENT: Del Mar
Work Order: 06080716
Project: PPH0509

ANALYTICAL QC SUMMARY REPORT

TestCode: 8141AZ_w

Sample ID: **LCSD-26713** SampType: **LCSD** TestCode: **8141AZ_w** Units: **µg/L** Prep Date: **8/21/2006** RunNo: **78215**
Client ID: Batch ID: **26713** TestNo: **SW8141A** Analysis Date: **8/28/2006** SeqNo: **929675**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	9.020	2.5	10	0	90.2	72.8	103	8.042	11.5	35	Q8
Demeton, Total	14.51	5.0	20	0	72.5	64.5	104	14.94	2.95	35	Q8
Diazinon	8.348	2.5	10	0	83.5	70.9	107	8.574	2.67	35	Q8
Disulfoton	8.744	2.5	10	0	87.4	66.5	106	9.406	7.30	35	Q8
Ethion	8.640	2.5	10	0	86.4	72.7	104	7.388	15.6	35	Q8
Fenthion	9.625	2.5	10	0	96.2	73.6	102	8.891	7.93	35	Q8
Malathion	9.501	2.5	10	0	95.0	70	109	10.06	5.70	35	Q8
Methyl parathion	8.741	2.5	10	0	87.4	64.1	110	8.692	0.564	35	Q8
Parathion	8.494	2.5	10	0	84.9	73.7	103	7.995	6.06	35	Q8
Surr: TPP (Surrogate)	47.98	5.0	50	0	96.0	51.1	116	46.64	0	0	
Surr: Tributylphosphate (Surrogate)	46.43	5.0	50	0	92.9	46.8	117	44.19	0	0	

Qualifiers:

E	Value above quantitation range	H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted recovery limits

■ Main Laboratory: 4645 E. Cotton Center Boulevard, Building 3, Suite 189 Phoenix, AZ 85040 Phone: 602.437.3340 Toll Free: 866.772.5227 Fax. 623.445.6192 www.aeroenvirolabs.com
■ Tucson Facility: 4455 S. Park Ave. Ste. 110 Tucson, AZ 85714 Phone: 520.807.3801 Fax: 520.807.3803

Aerotech Environmental Laboratories Sample Receipt Checklist

Project Checked By: ________

Laboratory Number: 06-08-0716		Checklist completed by: [signature] Signature/Date 8-18-06	
Client Name: Del Mar/Test America			
Matrix: Water	Carrier Name: Client	Date/Time Rec'd: 8-18-06 1921	By: RF

Temperature of Samples? 3.9 °C — Circle one: Blue Ice / **Wet Ice** (circled) / Not Present

	Yes	No*	Not Present
Shipping container/cooler in good condition?	X		
Custody seals intact on shipping container/cooler?			X
Custody seals intact on sample containers?			X
Chain of Custody present and relinquished/received properly?	X		
Chain of Custody agrees with sample labels?	X		
Samples in proper containers/bottles?	X		
Sample containers intact?	X		
All samples received within holding time?	X		**See Comment about Chlorine and pH
Is there sufficient sample volume to perform the tests?	X		
40mL vials for volatiles & SOCs received with zero headspace?			X

Soil Containers:
- Brass Sleeve ____
- Glass Jar ____
- Methanol ____
- Plastic Bag ____
- Encore Samplers ____

Total number of bottles received: 6 — IH sample media:

If applicable, how many sample bottles were shipped from AEL-Tucson? N/A X

Number of containers received by preservative and by sample number: (If more than 15 samples are rec'd, please continue on separate sheet(s))

Preservative	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A-General	2	2	2												
B-HNO3															
C-H2SO4															
D-HCl															
E-Na2S2O3															
F-NaOH															
G-Sulfide															
H-Na Sulfite															
I-MCAA															
J-Methanol															
K-HAA															
L-Other															

Water-pH acceptable upon receipt? Yes ____ No ____ N/A X

Preservative & pH		pH of samples upon receipt	If pH requires adjustment, list sample number, and reagent ID. number
Metals	<2		
Nutrients	<2		
Total Phenols	<2		
413 (O&G)	<2		
418 (TPH)	<2		
Cyanide	>12		
Sulfide	>9		

**Any No response must be detailed in the comments section below. Contact the PM immediately to determine how to proceed. Refer to SOP 11-001.04, Section 1.8.6. Continue on back if additional space is needed.*

***The holding time for pH and Total Residual Chlorine analysis is immediate. For the most accurate result, the pH and Total Residual Chlorine should be taken in the field within 15 minutes of sampling.*

Comments:

Corrective Action:

TestAmerica
ANALYTICAL TESTING CORPORATION

06-08-0716

SUBCONTRACT ORDER - PROJECT # PPH0509

SENDING LABORATORY:	RECEIVING LABORATORY:
TestAmerica - Phoenix, AZ	Aerotech Labs
9830 South 51st Street, Suite B-120	1501 W Knudsen Drive
Phoenix, AZ 85044	PHX, AZ 85027
Phone: (480) 785-0043	Phone :623-780-4800
Fax: (480) 785-0851	Fax: (623) 445-6250
Project Manager: Linda Eshelman	

Standard TAT is requested unless specific due date is requested => Due Date:__________ Initials:______

Analysis	Expiration	Comments
Sample ID: PPH0509-01 Water	**Sampled: 08/15/06 13:00**	
8141A-Full-O	08/22/06 13:00	Aerotech
Containers Supplied:		
1 L Amber (PPH0509-01C)		
1 L Amber (PPH0509-01D)		
Sample ID: PPH0509-02 Water	**Sampled: 08/15/06 16:00**	
8141A-Full-O	08/22/06 16:00	Aerotech
Containers Supplied:		
1 L Amber (PPH0509-02C)		
1 L Amber (PPH0509-02D)		
Sample ID: PPH0509-03 Water	**Sampled: 08/15/06 16:50**	
8141A-Full-O	08/22/06 16:50	Aerotech
Containers Supplied:		
1 L Amber (PPH0509-03C)		
1 L Amber (PPH0509-03D)		

SAMPLE INTEGRITY:

All containers intact: ☐ Yes ☐ No	Sample labels/COC agree: ☐ Yes ☐ No	Samples Received On Ice:: ☐ Yes ☐ No	
Custody Seals Present: ☐ Yes ☐ No	Samples Preserved Properly: ☐ Yes ☐ No	Samples Received at (temp): 3 9 [illegible]	

Released By	Date	Time	Received By	Date	Time
Tori Shaw	8/18/06	0900	[signature]	8/18/6	0900
[signature]	8/18/6	0921	[signature]	8/18/06	0921

[illegible]
[illegible] University Dr.
Suite [illegible]
Tempe, AZ 85281
(480) 921-8044
(480) 921-0049 FAX
E-Mail Address: cchristian@aquaticconsulting.com
Attention: Chris Christian

Subcontract Chain of Custody

DATE August 16, 2006 PAGE 1 OF 1

Subcontract Laboratory:

Test America - Phx
P.M.:Linda Eshelman
9830 South 51st Street Suite 120 B
Phoenix, AZ 85044
Telephone 480-785-0043
Attn: Sample Receiving

AC&T Sample ID	Date	Time	Matrix	Lab ID	EPA 608	EPA 8141	Number of Containers
BN-08889	08/02/06	5:00 PM	AQ	PPH0509-01	X	X	2

Sampler Name: d. Kundargin

Project Name: USFWS-NM
Project Number: HMM
Notes:

Sample Receipt
No. Containers: 2
Custody Seals:
Received Intact: Yes No
Received Cold: Yes No
Temperature: 2-2-2
PRIORITY Standard

RELINQUISHED BY:
Signature: T Johnsen Time: 09:37
Printed Name: T. Johnsen Date: 8/17/2006
Aquatic Consulting & Testing

SAMPLED RECEIVED BY:
Signature: Bob Eldredge Time: 8/17/06
Printed Name: Date: 8/17/2006
09:37

RELINQUISHED BY:
Signature: Bob Eldredge Time: 10:20
Printed Name: Date: 8/17/2006

SAMPLED RECEIVED BY:
Signature: [signature] Time: 10:20
Printed Name: [illegible] S Date: 8/17/2006
Test America - Phx

AQUATIC CONSULTING & TESTING, INC.
1525 W. University Drive, Suite 106 • Tempe, AZ 85281
Phone: (480) 921-8044 • Fax: (480) 921-0049

CHAIN OF CUSTODY

PWS ID #________

PAGE ___ OF ___

Client Name: US Fish & Wildlife Service
Address: 500 Gold Avenue SW
Street
Albuquerque, NM 87102
City, State, Zip
Phone: 505 248-6430
Fax: 505 248 7950
Contact: Darrell Kundargi
Sampler Signature: [signature]

PO#
Project: HMM
Remarks: 795^{00} per sample quote

Chemistry Cl, SO4, Alk EPA 608, 8141 | **Biology** | **Biomon** | **No. of Containers**

SAMPLE ID	SAMPLE Date	SAMPLE Time	AM/PM	SAMPLE TYPE	Metals (See Below)	❑ TDS ❑ TSS ❑ TS ❑ SETT ❑ TVS ❑ VSS	❑ O+G ❑ TPHC ❑ MBAS ❑ CN ❑ Sulfide	❑ BOD ❑ COD ❑ New Source	❑ Tot.P ❑ O-PO4	❑ Nitrate + Nitrite ❑ Nitrite	❑ TKN ❑ Ammonia	❑ THMs ❑ HAAs	❑ Phenol ❑ 420.1 ❑ 625 ❑ 8270	❑ 8260 ❑ 624 ❑ BTEX	❑ Perchlorate ❑ Radio ❑ Asbestos	Total Coliform ❑ P/A ❑ Colilert ❑ MPN	❑ E. Coli ❑ Fecal Strep	Fecal Coliform ❑ MPN ❑ MF	❑ MICRO SCOPE ID	❑ Plate Count ❑ BIOLOG		❑ Acute ❑ Chronic	❑ AWET (SWRO)			$Na_2S_2O_3$	H_2SO_4	HNO_3	NONE	NaOH	NaOH/ZnAc	Laboratory Number
A2	8/15	1300	AM PM	SW	X			X	X	X	X	X															1	1	5			BN-09538
			AM PM																													
A1	8/15/06	1600	AM PM	↓	X			X	X	X	X	X															1	1	5			9539
			AM PM																													
A3	8/15	1650	AM PM	↓	X			X	X	X	X	X															1	1	5			9540
			AM PM																													
			AM PM																													
			AM PM																													
			AM PM																													
			AM PM																													
			AM PM																													
			AM PM																													
			AM PM																													

Metals: ❑ Al ❑ Sb ☒ As ❑ Ba ❑ Be ❑ B ☒ Cd ☒ Ca ❑ Cr ❑ Co ❑ Cu ❑ Au ❑ Fe ❑ Pb ☒ Mg ❑ Mn ☒ Hg ❑ Mo ❑ Ni ☒ Se ❑ Ag ☒ Na
❑ Sr ❑ Tl ❑ Sn ❑ Ti ❑ V ❑ Zn

[X] TOTAL [X] DISSOLVED [ ] SDWA [ ] TCLP [ ] RCRA

Sample Types: DW, GW, SW, WW, AQ, Soil, Sludge or Solid

Sample Receiving:	1. Relinquished By: [signature]	2. Relinquished By:	3. Relinquished By:
Intact: X Yes ___ No	Date: 8/16/06 Time: 16:35 AM/PM	Date: Time: AM/PM	Date: Time: AM/PM
Temp: 9°C Auth Init: ___	1. Received By: T. Johnsen	2. Received By:	3. Received By:
Pres: 6 Yes(V) 9/15 No/Lab +3 LAB FiHl Pres	Date: 8-16-06 Time: 16:35 AM/PM	Date: Time: AM/PM	Date: Time: AM/PM
Sterile: ___ Yes X No			
Total # containers: 21			

Attn: Your signature on this document authorizes analysis regardless of sample condition at time of submittal

By signing this chain of custody, the designated client and agent agree to pay Aquatic Consulting & Testing, Inc. for all services rendered in conjunction with the submitted samples within 30 days of invoice. It is the client's responsibility to note purchase order numbers or other responsible parties on the form and failure to do so does not constitute justification for non-payment.

White-Laboratory Yellow-Report Pink-Client

Sample delivery group # : -027

AQUATIC CONSULTING & TESTING, INC.
1525 W. University Drive, Suite 106 • Tempe, AZ 85281
Phone: (480) 921-8044 • Fax: (480) 921-0049

CHAIN OF CUSTODY

Pd 9/27
PWS ID # $2460.75

PAGE ___ OF ___

Client Name: US Fish & Wildlife Service
Address: 500 Gold Avenue SW
Street
Albuquerque, NM 87102
City, State, Zip
Phone: 505 248-6430
Fax: 505 248 7950
Contact: Darrell Kindergan
Sampler Signature: [signature]

PO#: ___
Project: ||MM
Remarks: 795.00 per sample quote

SAMPLE ID	SAMPLE Date	SAMPLE Time	SAMPLE TYPE	Metals (See Below)	TDS / TSS / TS / SETT / TVS / VSS	O+G / TPHC / MBAS / CN	BOD / COD / New Source (Cl, SO4, Alk)	Tot.P / O-PO4	Nitrate + Nitrite / Nitrite	TKN / Ammonia	THMs / HAAs (EPA 608, 8141)	H2SO4	HNO3	NONE	Laboratory Number
A2	8/15	1300 PM	SW	X			X	X	X	X	X	1	1	5	
A1	8/15/06	1600 PM		X			X	X	X	X	X	1	1	5	
A3	8/15/06	1650 PM		X			X	X	X	X	X	1	1	5	

Metals: ☐ Al ☐ Sb ☒ As ☐ Ba ☐ Be ☐ B ☒ Cd ☒ Ca ☐ Cr ☐ Co ☐ Cu ☐ Au ☐ Fe ☐ Pb ☒ Mg ☐ Mn ☒ Hg ☐ Mo ☐ Ni ☒ Se ☐ Ag ☒ Na
☐ Sr ☐ Tl ☐ Sn ☐ Ti ☐ V ☐ Zn

[X] TOTAL [X] DISSOLVED [ ] SDWA [ ] TCLP [ ] RCRA

Sample Types: DW, GW, SW, WW, AQ, Soil, Sludge or Solid

Sample Receiving:
Intact: X Yes ___ No
Temp: 9 C Auth Init: ___
Pres: 6 Yes/V 15 No/Lab
Sterile: ___ Yes X No
Total # containers: 21

1. Relinquished By: [signature] Date: 8/16/06 Time: 16:35
1. Received By: [signature] Date: 8-16-06 Time: 16:35
2. Relinquished By: Date: Time: AM PM
2. Received By: Date: Time: AM PM
3. Relinquished By: Date: Time: AM PM
3. Received By: Date: Time: AM PM

Attn: Your signature on this document authorizes analysis regardless of sample condition at time of submittal

By signing this chain of custody, the designated client and agent agree to pay Aquatic Consulting & Testing, Inc. for all services rendered in conjunction with the submitted samples within 30 days of invoice. It is the client's responsibility to note purchase order numbers or other responsible parties on the form and failure to do so does not constitute justification for non-payment.

White-Laboratory Yellow-Report Pink-Client

Sample delivery group # :

Water Quality Results:

Sonde Data

Site ID	Date	Time	Temp (ºC)	Conductivity (mS/cm^2)	DO (mg/L)	DO (%Sat)	pH
A1	8/15/2006	16:00	31.71	6.51	12.79		7.27
A2	8/15/2006	13:00	36.3	3.14	7.68	127.1	6.95
A3	8/15/2006	16:50	36.86	23.9	11.77		8.73
A1	10/4/2006	10:30	25.64	2.52	6.3	83.1	7.91
A2	10/4/2006	11:40	28.49	9.66	8.45	116	8.22
A3	10/4/2006	13:00	31.49	22.4	10.06	156	9.45

A1=Arnett Ditch A2=Farm Unit 2 Drain A3=Hart Mine Marsh

9.4 Appendix 4 -- Soils (four pages of laboratory analyses)

1910 McKinley, Suite 110 93728

DELLAVALLE Laboratory, Inc.
Chemists and Consultants

1910 W. McKinley, Suite 110, Fresno, CA 93728
FAX (559) 268-8174 - (800) 228-9896 - (559) 233-6129

Report of Soil Analysis

Hugh Rafmon

Life Science! Inc
1209 Esplanade Ste 1
Chico CA 95926
15301
50

Lab No. 99324
Sampled
Submitted 10/31/2006
Submitted by Lisa Stallings
Reported 11/8/2006
Job/Ranch/Site Gbola NWR
Copy To Life Science! Inc - Woodland
FAX 530 668-5675
E-Mail

Identification NA

			%			---meq/l---				%	T/ac-6"	---Lime---		mg/l	---mg/kg---				
			SP	pHs	EC x10[3]	Ca	Mg	Na	Cl	ESP	GR	Req lbs/ac-6"	+/-	B	NO_3-N	PO_4-P	K (AA)	K H_2SO_4	Zn
No.	Description	Methods	S1.00	S1.10	S1.20	S1.60	S1.60	S1.60	S1.40		S15.10	S2.50	Hndbk 60-23a	S1.50	S3.10	S4.10	S1.80	S5SA	S6.10
1	1-A		61	7.8	205	60.5	410	1327		55.8	0.0		++++	1.3	63	24	497		3.2
2	1-B		55	8.0	70.57	53.9	113	443		41.3	0.0		++++	0.8	6	7	287		1.0
3	1-C		60	8.0	80.92	53.0	120	402		38.4	0.0		++++	0.6	2	5	262		1.2
4	2-A		60	7.8	226	87.1	377	1503		59.1	0.0		++++	1.7	26	28	915		5.4
5	2-B		44	7.8	80.40	80.1	182	508		40.0	0.0		++++	1.6	2	6	321		1.3
6	2-C		32	7.8	34.80	40.8	62.1	253		33.6	0.0		++++	1.2	2	2	140		0.7
7	3-A		58	7.4	224	169.0	280	1502		59.4	0.0		++++	0.9	52	45	832		4.9
8	3-B		34	7.9	56.95	49.0	83.8	373		39.9	0.0		++++	1.3	3	5	127		0.5
9	3-C		28	8.0	103	87.8	139	665		49.5	0.0		++++	1.2	7	8	119		0.7
10	4-A		61	7.0	405	204.0	674	2566		64.2	0.0		++++	6.2	123	18	1012		4.3
11	4-B		31	7.7	71.17	86.8	133	447		38.1	0.0		++++	1.2	3	2	160		0.3
12	4-C		29	7.7	51.61	75.1	89.1	289		31.4	0.0		++++	1.1	2	<2	85		0.2
13	5-A		66	7.3	88.20	188.0	144	477		34.8	0.0		++++	0.9	4	21	505		9.6
14	5-B		37	7.8	19.61	37.7	36.1	145		25.5	0.2		++++	0.8	2	2	169		0.6
15	5-C		26	8.0	11.27	28.0	13.1	58.0		15.3	0.8		++++	0.4	2	<2	42		0.2
16	6-A		100	6.8	44.83	66.7	89.8	289		32.0	0.0		++++	1.4	2	18	471		5.5
17	6-B		79	7.9	7.63	20.7	10.1	39.2		11.9	0.8		+++	<0.1	3	21	624		3.4
18	6-C		82	7.9	6.31	14.5	10.4	35.6		12.0	0.4		+++	0.2	2	16	497		4.4
19	7-A		31	6.6	501	411.0	1277	2602		58.7	0.0		+++	18.1	16	11	840		1.9
20	7-B		41	7.6	118	108.0	169	726		47.3	0.0		++++	4.0	2	4	356		1.8
21	7-C		38	7.5	119	122.0	210	760		46.2	0.0		++++	3.5	2	2	565		0.7
22	8-A		71	7.7	85.80	55.9	126	580		46.9	0.0		+++	0.8	28	21	359		7.3
23	8-B		66	7.8	19.81	36.5	31.8	114		21.5	0.0		++++	0.2	2	10	324		2.6
24	8-C		60	7.8	53.09	60.5	114	314		32.5	0.0		++++	0.4	2	2	193		1.2
25	9-A		88	7.1	33.60	56.8	48.2	238		32.0	0.0		++++	0.6	4	14	481		6.8
26	9-B		74	7.8	18.55	36.8	29.0	98.7		19.4	1.7		++++	<0.1	2	12	434		4.3

DELLAVALLE Laboratory, Inc.
Chemists and Consultants

1910 W McKinley, Suite 110, Fresno, CA 93728
FAX (559) 268-8174 - (800) 228-9896 - (559) 233-6129

Report of Soil Analysis

Life Sciencel Inc
1208 Esplanade Ste 1
Chico CA 95926
15301
50

Identification NA

Lab No. 99324
Sampled
Submitted 10/31/2006
Submitted by Lisa Stallings
Reported 11/8/2006
Job/Ranch/Site Gbola NWR
Copy To Life Sciencel Inc - Woodland
FAX 530 668-5675
E-Mail

No.	Description	Methods	% SP S1.00	pHs S1.10	EC x10^3 S1 20	Ca (meq/l) S1.65	Mg (meq/l) S1.60	Na (meq/l) S1.60	Cl (meq/l) S1.40	% ESP	GR T/ac-6" S'5.10	Lime Req lbs/ac-6" S2.50	Lime +/- Hndbk 60-23a	B mg/l S1.50	NO_3-N mg/kg S3.10	PO_4-P mg/kg S4.10	K (AA) mg/kg S1 60	K H_2SO_4 mg/kg SSSA	Zn mg/kg S6.10
27	9-C		82	7.7	35.44	60.3	56.4	231		30.3	0.0		++++	0.3	2	4	328		1.9
28	10-A		66	7.2	198	157.0	375	1192		51.6	0.0		+++	2.2	3	22	657		4.9
29	10-B		73	7.6	36.38	39.1	63.2	256		34.0	0.0		+++	0.7	2	3	366		1.5
30	10-C		76	8.0	51.04	41.7	99.3	306		34.4	0.0		+++	0.9	1	3	381		1.8

NO_3-N NITRATE-NITROGEN is extracted with 1.0 Normal potassium chloride and expressed as ppm. Nitrogen levels are guides to use with tissue analyses, soil profile nitrogen levels and other information.

PO_4-P PHOSPHATE-PHOSPHORUS is extracted with 0.5 Molar sodium bicarbonate solution at pH 8.5 and expressed as ppm. Critical levels are listed below.

K (AA) POTASSIUM is extracted with 1.0 Normal ammonium acetate solution at pH 7 and expressed as ppm. Critical levels are listed below and should be used with tissue analyses and plant conditions.

K (H_2SO_4) POTASSIUM is extracted with an H_2SO_4 solution and expressed as ppm. When K is low, this method predicts responses more accurately. Soils with less than 2000 ppm K-H_2SO_4 are deficient.

Zn, Mn, Fe, Cu ZINC, MANGANESE, IRON, COPPER are extracted with DTPA-TEA solution and expressed as ppm. Specific critical levels are listed below by crop.

	ppm Zn	Mn	Fe	Cu
Response Likely Below	0.5		2.0	
Response Not Likely Above	1.0	1.0	4.5	0.2

SO_4-S SULFATE SULFUR is extracted with 1 Molar lithium chloride and expressed as ppm. Critical levels are listed below.

CROP GUIDE

The following guide for soil nutrients should be considered along with other factors. Only critical levels listed are supported by correlative information. For critical levels of specific crops not listed, call Dellavalle Laboratory, Inc.

	PO_4-P (ppm)	K (ppm)	SO_4-S (ppm)	Zn (ppm)
Alfalfa:				
Response likely below	10	50	5	-
Response not likely above	20	80	10	-
Barley and Wheat:				
Response likely below	6	40	5	0.2
Response not likely above	12	60	10	0.8
Cantaloupe:				
Response likely below	8	80	-	0.4
Response not likely above	12	100	-	0.6
Corn:				
Response likely below	6	50	-	0.3
Response not likely above	12	80	-	1.0
Cotton (loamy soils):				
Response likely below	5	80	-	0.4
Response not likely above	9	100	-	1.0
Cotton (clay soils):				
Response likely below	5	100	-	0.4
Response not likely above	9	140	-	1.0
Lettuce (cool season):				
Response likely below	15*	50	-	0.5
Response not like above	25	80	-	1.0
Lettuce (warm season):				
Response likely below	5	50	-	0.5
Response not likely above	9	80	-	1.0
Pasture and Range:				
Response likely below	5	40	5	
Response not likely above	20	60	10	
Potatoes (mineral soils):				
Response likely below	12*	100	-	0.3
Response not likely above	25	150	-	0.7
Rice:				
Response likely below	6	60	-	0.5
Sorghum:				
Response likely below	4*	40	-	0.2
Response not likely above	9	60	-	0.5
Sugar Beets:				
Response likely below	5*	40	-	0.1
Response not likely above	12	70	-	0.2
Tomatoes:				
Response likely below	6*	100	-	0.3
Response not likely above	20	140	-	0.7
Other Field and Warm Season Vegetables:				
Response likely below	5	50	-	0.2
Response not likely above	9	70	-	0.5
Other Cold Season Vegetables:				
Response likely below	10*	50	-	0.5
Response not likely above	20	80	-	1.0

*Plants may be especially responsive to PO_4-P fertilization when planted in cool early spring soils. Suggested PO_4-P levels do not apply if crop follows rice.

DELLAVALLE®
Laboratory, Inc.
Chemists and Consultants

1910 W. McKinley, Suite 110 • Fresno, CA 93728
(559) 233-6129 • (800) 228-9896
www.dellavallelab.com

SOIL INTERPRETATION GUIDE

Soil analyses provide information on a soil's nutrient-supplying ability, salinity, acidity or alkalinity. Fertilizer and amendment recommendations can be made using soil analyses coupled with the field's crop history, water supply and the general level of management. This interpretation was developed based upon correlation studies conducted under California conditions by university and government researchers.

SP SATURATION PERCENTAGE is the number of grams of water required to saturate 100 grams of soil. The water-holding capacity of a soil when irrigated and allowed to drain is approximately half the SP. About half the water-holding capacity is available for crop use. Approximate relationship of SP to soil texture follows:

Below 20	Sandy or Loamy Sand
20 - 35	Sandy Loam
35 - 50	Loam or Silt Loam
50 - 65	Clay Loam
65 - 150	Clay
Above 150	Usually Peat or Muck

pH_s DEGREE OF ACIDITY OR ALKALINITY of a saturated soil.

Below 4.2	Too acid for most crops.
4.2 - 5.5	Acceptable for acid-tolerant crops.
5.5 - 8.4	Acceptable for most crops.
Above 8.4	Possible sodium problem; however, sodium problems can occur below 8.4.

EC_e ELECTRICAL CONDUCTIVITY of the saturation extract is an index of salt content expressed as millimhos per centimeter or decisiemens per meter at 25° C. Salt will restrict crop growth as follows:

Below 0.5	Water penetration may be impaired.
Under 2	No salinity problem for most crops.
2 - 4	Restricts growth of very salt-sensitive crops.
4 - 8	Restricts growth of all but moderately salt-tolerant crops.
8 - 16	Restricts growth of all but very salt-tolerant crops.
Above 16	Only a few salt-tolerant crops grow satisfactorily.

Cl CHLORIDE in the saturation extract is expressed in milliequivalents per liter. For most crops, chloride is not a factor when the electrical conductivity is in a safe range.

Ca, Mg, Na CALCIUM, MAGNESIUM, SODIUM ions in the saturation extract are expressed in milliequivalents per liter and are used to calculate ESP.

ESP EXCHANGEABLE SODIUM PERCENTAGE is the degree to which the soil exchange complex is saturated with sodium. It is used to determine soil permeability and potential phytotoxicity. Organic soils have no minerals, so are not effected by sodium.

Below 10	No permeability problem; however, sodium sensitive plants may show phytotoxicity such as chlorosis or slight yield reduction.
10 - 15	Soils with SP above 50 may have problems with permeability and/or phytotoxicity.
Above 15	Permeability problems are likely on all mineral soils except those with an SP below 20. Most crops show phytotoxicity.

GR GYPSUM REQUIREMENT is the amount of gypsum, or its equivalent, required to furnish sufficient calcium to correct a sodium-caused permeability problem and/or phytotoxicity. It is determined when the ESP is above 10; Ca+Mg is less than three times the EC_e or pH_s is above 8.4. GR is expressed in tons of 100% gypsum per acre-six inches of soil.

Lime LIME when reported by one to four pluses (+) indicates that acid-forming amendments (such as sulfur or sulfuric acid) may be used in place of gypsum. The number of pluses estimates the amount of lime present; a minus (-) indicates no lime present. The use of acidifying amendments may cause excessive pH reductions if used in the absence of lime.

A numeric lime value is reported when pH_s is below 6.0. This number indicates the amount of 100% lime ($CaCO_3$) in pounds per acre-six inches required to adjust pH_s to 6.0.

B BORON in saturation extract is expressed as ppm and is required for crop growth but may be toxic. This test evaluates the soil's potential for boron toxicity. Use a different test to detect deficiencies.

Below 0.5	Not toxic for most crops but may be insufficient for some.
Above 1	Sensitive crops may show visible injury.
5	Semi-tolerant crops may show visible injury.
10	Tolerant crops may show visible injury.

9.5 Appendix 5 -- Hart Mine Marsh Vegetation Communities and Acreages

Vegetation Community (NVCS Association)	***Acres***
Allenrolfea occidentalis Shrubland, Type 6 - Very young and low growth	25.4
Larrea tridentata / Sparse Understory Shrubland Association, Type 6 - Very young and low growth	10.9
Pluchea sericea Seasonally Flooded Shrubland [Placeholder], Type 5 - Stands with dense shruby growth	0.1
Prosopis (glandulosa var. torreyana, velutina) Woodland [Placeholder], Type 3 - Intermediate size trees with dense understory	20
Suaeda moquinii Shrubland Association, Type 6 - Very young and low growth	7.8
Tamarix ssp / Sparse Alien Shrubland Association, Type 5 - Stands with dense shruby growth	39
Tamarix ssp / Sparse Alien Shrubland Association, Type 6 - Very young and low growth	2
Tamarix ssp. mixed, Type 5 - Stands with dense shruby growth	8.3
Tamarix ssp. monotypic, Type 3 - Intermediate size trees with dense understory	242.6
Tamarix ssp. monotypic, Type 5 - Stands with dense shruby growth	155.6
Tamarix ssp. monotypic, Type 6 - Very young and low growth	1.1
Tamarix ssp. standing dead, Type 4 - Intermediate size trees with little or no understory	0.1
Tamarix ssp. standing dead, Type 5 - Stands with dense shruby growth	20.8
Typha latifolia - Schoenoplectus acutus Herbaceous Association, Type 5 - Stands with dense shruby growth	9.8
Unconsolodated material sparse vegetation (soil, sand and ash), Type 6 - Very young and low growth	82.2
water, Type 6 - Very young and low growth	10.9

Appendix B

Data Acquired After Existing Conditions Report

(Post April 2007)

Appendix B

Data Acquired After Existing Conditions Report

(Post April 2007)

Water Quality Data

AQUATIC CONSULTING & TESTING, INC.

1525 W. University Drive, Suite 106
P.O. Box 1510
Tempe, Arizona 85281
Phone: (480) 921-8044 • FAX: (480) 921-0049

Lic. No. AZ0003

LABORATORY REPORT

Client: U.S. Fish & Wildlife Service
500 Gold Avenue SW
Albuquerque, NM 87102

Date Submitted: 05/25/07
Date Reported: 06/28/07

Attn: Darrell Kundargi

Project: HMM

RESULTS

Client ID: A 1
ACT Lab No.: BP06489

Sample Type: Surface Water
Sample Time: 05/25/07 09:45

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	05/30/07	05/30/07	SM 2320 B	360.	mg/L as CaCO3
Ammonia - N	06/01/07	06/01/07	SM4500NH3 D	0.06	mg/L as N
Chloride	05/29/07	05/29/07	325.3	1630.	mg/L
Nitrate + Nitrite - N	06/04/07	06/04/07	SM4500NO3 E	0.07	mg/L as N
Phosphorus, Total	06/01/07	06/01/07	365.3	0.299	mg/L as P
Sulfate	06/06/07	06/06/07	SM4500SO4 D	1350.	mg/L
Total Kjeldahl Nitrogen	05/31/07	06/04/07	351.4	1.0	mg/L as N
Arsenic, Total	06/05/07	06/05/07	200.9	0.002	mg/L
Calcium, Dissolved	05/29/07	05/29/07	200.7	417.	mg/L
Calcium, Total	06/06/07	06/06/07	200.7	508.	mg/L
Magnesium, Dissolved	05/29/07	05/29/07	200.7	143.	mg/L
Magnesium, Total	06/06/07	06/06/07	200.7	159.	mg/L
Mercury, Dissolved	06/01/07	06/01/07	245.1	0.0014	mg/L
Mercury, Total	06/01/07	06/01/07	245.1/7470A	<0.0002	mg/L
Selenium, Total	06/12/07	06/12/07	200.9	<0.002	mg/L
Sodium, Dissolved	05/29/07	05/29/07	200.7	922.	mg/L
Sodium, Total	06/06/07	06/06/07	200.7	1190.	mg/L
Chlorinated Pesticides	05/29/07	05/31/07	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	05/30/07	06/06/07	8141A	See Attached *	ug/L

RESULTS

Client ID: A 2
ACT Lab No.: BP06490

Sample Type: Surface Water
Sample Time: 05/25/07 09:30

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	05/30/07	05/30/07	SM 2320 B	216.	mg/L as CaCO3
Ammonia - N	06/01/07	06/01/07	SM4500NH3 D	0.03	mg/L as N
Chloride	05/29/07	05/29/07	325.3	1190.	mg/L
Nitrate + Nitrite - N	06/04/07	06/04/07	SM4500NO3 E	0.04	mg/L as N
Phosphorus, Total	06/01/07	06/01/07	365.3	0.286	mg/L as P
Sulfate	06/06/07	06/06/07	SM4500SO4 D	988.	mg/L
Total Kjeldahl Nitrogen	05/31/07	06/04/07	351.4	1.3	mg/L as N
Arsenic, Total	06/05/07	06/05/07	200.9	0.008	mg/L
Calcium, Dissolved	05/29/07	05/29/07	200.7	322.	mg/L
Calcium, Total	06/06/07	06/06/07	200.7	328.	mg/L
Magnesium, Dissolved	05/29/07	05/29/07	200.7	123.	mg/L
Magnesium, Total	06/06/07	06/06/07	200.7	125.	mg/L
Mercury, Dissolved	06/01/07	06/01/07	245.1	<0.0002	mg/L
Mercury, Total	06/01/07	06/01/07	245.1/7470A	<0.0002	mg/L
Selenium, Total	06/12/07	06/12/07	200.9	<0.002	mg/L
Sodium, Dissolved	05/29/07	05/29/07	200.7	765.	mg/L
Sodium, Total	06/06/07	06/06/07	200.7	924.	mg/L
Chlorinated Pesticides	05/29/07	05/31/07	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	05/30/07	06/06/07	8141A	See Attached *	ug/L

RESULTS

Client ID: A 3
ACT Lab No.: BP06491

Sample Type: Surface Water
Sample Time: 05/25/07 08:48

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Alkalinity, Total	05/30/07	05/30/07	SM 2320 B	239.	mg/L as CaCO3
Ammonia - N	06/01/07	06/01/07	SM4500NH3 D	<0.03	mg/L as N
Chloride	05/29/07	05/29/07	325.3	2580.	mg/L
Nitrate + Nitrite - N	06/06/07	06/06/07	SM4500NO3 E	0.01	mg/L as N
Phosphorus, Total	06/01/07	06/01/07	365.3	0.075	mg/L as P
Sulfate	06/06/07	06/06/07	SM4500SO4 D	1890.	mg/L
Total Kjeldahl Nitrogen	05/31/07	06/04/07	351.4	1.3	mg/L as N
Arsenic, Total	06/05/07	06/05/07	200.9	<0.002	mg/L
Calcium, Dissolved	05/29/07	05/29/07	200.7	505.	mg/L
Calcium, Total	06/06/07	06/06/07	200.7	573.	mg/L
Magnesium, Dissolved	05/29/07	05/29/07	200.7	204.	mg/L
Magnesium, Total	06/06/07	06/06/07	200.7	219.	mg/L
Mercury, Dissolved	06/01/07	06/01/07	245.1	<0.0002	mg/L
Mercury, Total	06/01/07	06/01/07	245.1/7470A	<0.0002	mg/L
Selenium, Total	06/12/07	06/12/07	200.9	<0.002	mg/L
Sodium, Dissolved	05/29/07	05/29/07	200.7	1560.	mg/L
Sodium, Total	06/06/07	06/06/07	200.7	1730.	mg/L
Chlorinated Pesticides	05/29/07	05/31/07	EPA 608	See Attached *	ug/L
Organophosphorus Pesticides	05/30/07	06/06/07	8141A	See Attached *	ug/L

* Analysis performed by Test America (AZ0426)

Reviewed by: Frederick A. Amalfi

Frederick A. Amalfi, Ph.D.
Laboratory Director

AQUATIC CONSULTING & TESTING, INC.
1525 W. University Drive, Suite 106 • Tempe, AZ 85281
Phone: (480) 921-8044 • Fax: (480) 921-0049

CHAIN OF CUSTODY

PWS ID #

PAGE ___ OF ___

Branch of Natural Resources
USFWS
Client Name: Darrell Kundargi
Address: 500 Gold Ave, SW (Street)
ABQ, NM 87102 (City, State, Zip)
Phone: 505/248-6430
Fax: 505-248-7950
Contact: Darrell Kundargi
Sampler Signature: [signature]

PO#: 15% Discount
Project: HMM
Remarks: See Attached List

SAMPLE ID	SAMPLE Date	SAMPLE Time	AM/PM	SAMPLE TYPE	Metals (See Below)	Tot.P / O-PO4 / Cl, SO4	Nitrate + Nitrite / Alk	TKN / Ammonia	Cl. Pest (608)	Org.P Pests (8141)	$Na_2S_2O_3$	H_2SO_4	HNO_3	NONE	NaOH	NaOH/ZnAc	Laboratory Number
					X	X	X	X									
A 1	5/25/07	9:45	AM	SW	↓	↓	↓	↓	↓	↓		1	1	5			BP-06489
A 2	5/25/07	9:30	AM	—	↓	↓	↓	↓	↓	↓		1	1	5			6490
A 3	5/25/07	8:48	AM	—	↓	↓	↓	↓	↓	↓		1	1	4			6491

Chemistry: ☐ Metals (See Below); ☐ TDS ☐ TSS ☐ TS ☐ SETT ☐ TVS ☐ VSS; ☐ O+G ☐ TPHC ☐ MBAS ☐ CN ☐ Sulfide; ☐ BOD ☐ COD ☐ New Source; ☒ Tot.P ☐ O-PO4; ☒ Nitrate + Nitrite ☐ Nitrite; ☒ TKN ☒ Ammonia; ☐ THM's ☐ HAAS; ☐ Phenol ☐ 420.1 ☐ 625 ☐ 8270; ☐ 8260 ☐ 624 ☐ BTEX; ☐ Perchlorate ☐ Radio ☐ Asbestos

Biology: ☐ Total Coliform ☐ P/A ☐ Colilert ☐ MPN; ☐ E. Coli ☐ Fecal Strep; Fecal Coliform ☐ MPN ☐ MF; ☐ MICRO SCOPE ID; ☐ Plate Count ☐ BIOLOG

Biomon: ☐ Acute ☐ Chronic; ☐ AWET (SWRO)

No. of Containers

Metals: ☐ Al ☐ Sb ☒ As (T) ☐ Ba ☐ Be ☐ B ☐ Cd ☒ Ca (T+D) ☐ Cr ☐ Co ☐ Cu ☐ Au ☐ Fe ☐ Pb ☒ Mg (T+D) ☐ Mn ☒ Hg (T+D) ☐ Mo ☐ Ni ☒ Se (T) ☐ Ag ☒ Na (T+D)
☐ Sr ☐ Tl ☐ Sn ☐ Ti ☐ V ☐ Zn

[ ] TOTAL [ ] DISSOLVED [ ] SDWA [ ] TCLP [ ] RCRA

Sample Types: DW, GW, SW, WW, AQ, Soil, Sludge or Solid

Sample Receiving:
Intact: X Yes ___ No
Temp: 8°C Auth Init: ____
Pres: (✓) Yes/N of 14 No/Lab +3 LAB Filtrations
Sterile: ___ Yes X No
Total # containers: 20

1. Relinquished By: [signature]
Date: 5/25/07 Time: 13:58 PM
1. Received By: T. Johnsen
Date: 5-25-07 Time: 13:58

2. Relinquished By:
Date: Time: AM PM
2. Received By:
Date: Time: AM PM

3. Relinquished By:
Date: Time: AM PM
3. Received By:
Date: Time: AM PM

Attn: Your signature on this document authorizes analysis regardless of sample condition at time of submittal

White-Laboratory Yellow-Report Pink-Client

Sample delivery group #: -013

TestAmerica
ANALYTICAL TESTING CORPORATION

LABORATORY REPORT

Prepared For: Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project:USFWS

Sampled: 05/25/07
Received: 05/25/07
Issued: 06/06/07 16:42

NELAP #01109CA Arizona DHS#AZ0426

The results listed within this Laboratory Report pertain only to the samples tested in the laboratory. The analyses contained in this report were performed in accordance with the applicable certifications as noted. All soil samples are reported on a wet weight basis unless otherwise noted in the report. This Laboratory Report is confidential and is intended for the sole use of TestAmerica and its client. This report shall not be reproduced, except in full, without written permission from TestAmerica. The Chain of Custody, 1 page, is included and is an integral part of this report.
This entire report was reviewed and approved for release.

CASE NARRATIVE

LABORATORY ID	CLIENT ID	MATRIX
PQE0953-01	BP-06489	Water
PQE0953-02	BP-06490	Water
PQE0953-03	BP-06491	Water

SAMPLE RECEIPT: Samples were received intact, at 2°C, on ice and with chain of custody documentation.

HOLDING TIMES: All samples were analyzed within prescribed holding times and/or in accordance with the TestAmerica Sample Acceptance Policy unless otherwise noted in the report.

PRESERVATION: Samples requiring preservation were verified prior to sample analysis.

QA/QC CRITERIA: All analyses met method criteria, except as noted in the report with data qualifiers.
N1 - Calibration Verification recovery was below the method control limit for this analyte. An additional check standard was analyzed at the reporting limit to ensure instrument sensitivity at the reporting limit. Samples ND.

COMMENTS: No significant observations were made.

SUBCONTRACTED: Refer to the last page for specific subcontract laboratory information included in this report.

Reviewed By:

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS

Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PQE0953-01 (BP-06489 - Water)								**D3**
Reporting Units: ug/l								
Aldrin	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
alpha-BHC	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
beta-BHC	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
delta-BHC	EPA 608	7E29089	0.22	ND	1.1	5/29/2007	5/31/2007	
gamma-BHC (Lindane)	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
Chlordane	EPA 608	7E29089	1.1	ND	1.1	5/29/2007	5/31/2007	
4,4'-DDD	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
4,4'-DDE	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
4,4'-DDT	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	N1
Dieldrin	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
Endosulfan I	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Endosulfan II	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Endosulfan sulfate	EPA 608	7E29089	0.22	ND	1.1	5/29/2007	5/31/2007	
Endrin	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Endrin aldehyde	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Endrin ketone	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	
Heptachlor	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Heptachlor epoxide	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	V1
Methoxychlor	EPA 608	7E29089	0.11	ND	1.1	5/29/2007	5/31/2007	N1
Toxaphene	EPA 608	7E29089	5.5	ND	1.1	5/29/2007	5/31/2007	
Surrogate: Tetrachloro-m-xylene (35-115%)				*77 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*96 %*				

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS

Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PQE0953-02 (BP-06490 - Water)								**D3**
Reporting Units: ug/l								
Aldrin	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
alpha-BHC	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
beta-BHC	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
delta-BHC	EPA 608	7E29089	0.22	ND	1.09	5/29/2007	5/31/2007	
gamma-BHC (Lindane)	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
Chlordane	EPA 608	7E29089	1.1	ND	1.09	5/29/2007	5/31/2007	
4,4'-DDD	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
4,4'-DDE	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
4,4'-DDT	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	N1
Dieldrin	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
Endosulfan I	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Endosulfan II	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Endosulfan sulfate	EPA 608	7E29089	0.22	ND	1.09	5/29/2007	5/31/2007	
Endrin	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Endrin aldehyde	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Endrin ketone	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	
Heptachlor	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Heptachlor epoxide	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	V1
Methoxychlor	EPA 608	7E29089	0.11	ND	1.09	5/29/2007	5/31/2007	N1
Toxaphene	EPA 608	7E29089	5.4	ND	1.09	5/29/2007	5/31/2007	
Surrogate: Tetrachloro-m-xylene (35-115%)				*67 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*90 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica

ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS

Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Method	Batch	Reporting Limit	Sample Result	Dilution Factor	Date Extracted	Date Analyzed	Data Qualifiers
Sample ID: PQE0953-03 (BP-06491 - Water)								**D3**
Reporting Units: ug/l								
Aldrin	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
alpha-BHC	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
beta-BHC	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
delta-BHC	EPA 608	7E29089	0.27	ND	1.33	5/29/2007	5/31/2007	
gamma-BHC (Lindane)	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
Chlordane	EPA 608	7E29089	1.3	ND	1.33	5/29/2007	5/31/2007	
4,4'-DDD	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
4,4'-DDE	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
4,4'-DDT	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	N1
Dieldrin	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
Endosulfan I	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Endosulfan II	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Endosulfan sulfate	EPA 608	7E29089	0.27	ND	1.33	5/29/2007	5/31/2007	
Endrin	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Endrin aldehyde	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Endrin ketone	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	
Heptachlor	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Heptachlor epoxide	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	V1
Methoxychlor	EPA 608	7E29089	0.13	ND	1.33	5/29/2007	5/31/2007	N1
Toxaphene	EPA 608	7E29089	6.7	ND	1.33	5/29/2007	5/31/2007	
Surrogate: Tetrachloro-m-xylene (35-115%)				*79 %*				
Surrogate: Decachlorobiphenyl (45-120%)				*99 %*				

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS
Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

METHOD BLANK/QC DATA

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Data Qualifiers
Batch: 7E29089 Extracted: 05/29/07										
Blank Analyzed: 05/30/2007 (7E29089-BLK1)										
Aldrin	ND	0.10	ug/l							
alpha-BHC	ND	0.10	ug/l							
beta-BHC	ND	0.10	ug/l							
delta-BHC	ND	0.20	ug/l							
gamma-BHC (Lindane)	ND	0.10	ug/l							
Chlordane	ND	1.0	ug/l							
4,4'-DDD	ND	0.10	ug/l							
4,4'-DDE	ND	0.10	ug/l							
4,4'-DDT	ND	0.10	ug/l							
Dieldrin	ND	0.10	ug/l							
Endosulfan I	ND	0.10	ug/l							
Endosulfan II	ND	0.10	ug/l							
Endosulfan sulfate	ND	0.20	ug/l							
Endrin	ND	0.10	ug/l							
Endrin aldehyde	ND	0.10	ug/l							
Endrin ketone	ND	0.10	ug/l							
Heptachlor	ND	0.10	ug/l							
Heptachlor epoxide	ND	0.10	ug/l							
Methoxychlor	ND	0.10	ug/l							
Toxaphene	ND	5.0	ug/l							
Surrogate: Tetrachloro-m-xylene	*0.373*		*ug/l*	*0.500*		*75*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.417*		*ug/l*	*0.500*		*83*	*45-120*			
LCS Analyzed: 05/30/2007 (7E29089-BS1)										**Q8**
Aldrin	0.410	0.10	ug/l	0.500		82	40-115			
alpha-BHC	0.431	0.10	ug/l	0.500		86	45-115			
beta-BHC	0.467	0.10	ug/l	0.500		93	55-115			
delta-BHC	0.449	0.20	ug/l	0.500		90	55-115			
gamma-BHC (Lindane)	0.445	0.10	ug/l	0.500		89	45-115			
4,4'-DDD	0.484	0.10	ug/l	0.500		97	55-120			
4,4'-DDE	0.449	0.10	ug/l	0.500		90	50-120			
4,4'-DDT	0.526	0.10	ug/l	0.500		105	55-120			
Dieldrin	0.438	0.10	ug/l	0.500		88	55-115			
Endosulfan I	0.458	0.10	ug/l	0.500		92	55-115			
Endosulfan II	0.484	0.10	ug/l	0.500		97	55-120			
Endosulfan sulfate	0.468	0.20	ug/l	0.500		94	60-120			

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

TestAmerica
ANALYTICAL TESTING CORPORATION

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS

Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

METHOD BLANK/QC DATA

ORGANOCHLORINE PESTICIDES (EPA 608)

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Data Qualifiers
Batch: 7E29089 Extracted: 05/29/07										
LCS Analyzed: 05/30/2007 (7E29089-BS1)										**Q8**
Endrin	0.446	0.10	ug/l	0.500		89	55-115			
Endrin aldehyde	0.486	0.10	ug/l	0.500		97	50-120			
Endrin ketone	0.505	0.10	ug/l	0.500		101	55-120			
Heptachlor	0.431	0.10	ug/l	0.500		86	45-115			
Heptachlor epoxide	0.445	0.10	ug/l	0.500		89	55-115			
Methoxychlor	0.476	0.10	ug/l	0.500		95	60-120			
Surrogate: Tetrachloro-m-xylene	*0.396*		*ug/l*	*0.500*		*79*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.462*		*ug/l*	*0.500*		*92*	*45-120*			
LCS Dup Analyzed: 05/30/2007 (7E29089-BSD1)										
Aldrin	0.348	0.10	ug/l	0.500		70	40-115	16	30	
alpha-BHC	0.367	0.10	ug/l	0.500		73	45-115	16	30	
beta-BHC	0.407	0.10	ug/l	0.500		81	55-115	14	30	
delta-BHC	0.388	0.20	ug/l	0.500		78	55-115	15	30	
gamma-BHC (Lindane)	0.381	0.10	ug/l	0.500		76	45-115	15	30	
4,4'-DDD	0.414	0.10	ug/l	0.500		83	55-120	16	30	
4,4'-DDE	0.382	0.10	ug/l	0.500		76	50-120	16	30	
4,4'-DDT	0.451	0.10	ug/l	0.500		90	55-120	15	30	
Dieldrin	0.370	0.10	ug/l	0.500		74	55-115	17	30	
Endosulfan I	0.389	0.10	ug/l	0.500		78	55-115	16	30	
Endosulfan II	0.410	0.10	ug/l	0.500		82	55-120	17	30	
Endosulfan sulfate	0.392	0.20	ug/l	0.500		78	60-120	18	30	
Endrin	0.385	0.10	ug/l	0.500		77	55-115	15	30	
Endrin aldehyde	0.407	0.10	ug/l	0.500		81	50-120	18	30	
Endrin ketone	0.422	0.10	ug/l	0.500		84	55-120	18	30	
Heptachlor	0.375	0.10	ug/l	0.500		75	45-115	14	30	
Heptachlor epoxide	0.377	0.10	ug/l	0.500		75	55-115	17	30	
Methoxychlor	0.401	0.10	ug/l	0.500		80	60-120	17	30	
Surrogate: Tetrachloro-m-xylene	*0.346*		*ug/l*	*0.500*		*69*	*35-115*			
Surrogate: Decachlorobiphenyl	*0.397*		*ug/l*	*0.500*		*79*	*45-120*			

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing
1525 W. University, Suite 106
Tempe, AZ 85281
Attention: Chris Christian

Project ID: USFWS

Report Number: PQE0953

Sampled: 05/25/07
Received: 05/25/07

DATA QUALIFIERS AND DEFINITIONS

D3	Minimum reporting level (MRL) adjusted to reflect sample amount received and analyzed.
N1	See case narrative.
Q8	Insufficient sample received to meet method QC requirements. Batch QC satisfies ADEQ policies 0154 and 0155.
V1	CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.
ND	Analyte NOT DETECTED at or above the reporting limit or MDL, if MDL is specified.
RPD	Relative Percent Difference

TestAmerica - Phoenix, AZ
Linda Eshelman
Project Manager

Aquatic Consulting & Testing	Project ID: USFWS	
1525 W. University, Suite 106		Sampled: 05/25/07
Tempe, AZ 85281	Report Number: PQE0953	Received: 05/25/07
Attention: Chris Christian		

Certification Summary

Subcontracted Laboratories

Aerotech Laboratories, Inc. *Arizona Cert #AZ0610*

4645 E. Cotton Center Blvd. Bldg. #3, #189 - Phoenix, AZ 85044

Analysis Performed: 8141A-Full

Samples: PQE0953-01, PQE0953-02, PQE0953-03

TestAmerica - Irvine, CA *NELAC Cert #01108CA, California Cert #1197, Arizona Cert #AZ0671, Nevada Cert #CA72-2002-63*

17461 Derian Ave. Suite 100 - Irvine, CA 92614

Method Performed: EPA 608

Samples: PQE0953-01, PQE0953-02, PQE0953-03

TestAmerica
ANALYTICAL TESTING CORPORATION

IQE2773

SUBCONTRACT ORDER - PROJECT # PQE0953

SENDING LABORATORY:	RECEIVING LABORATORY:
TestAmerica - Phoenix, AZ 9830 South 51st Street, Suite B-120 Phoenix, AZ 85044 Phone: (480) 785-0043 Fax: (480) 785-0851 Project Manager: Linda Eshelman	TestAmerica - Irvine, CA 17461 Derian Ave. Suite 100 Irvine, CA 92614 Phone :(949) 261-1022 Fax: (949) 261-1228 Project Location: Arizona

Analysis	Expiration	Due	Interlab Price	Surch	Comments
Sample ID: PQE0953-01 Water	**Sampled: 05/25/07 09:45**				
608 (Pest only)-I	06/01/07 09:45	06/06/07 12:00	$ 112.00	0%	
Containers Supplied:					
1 L Amber (PQE0953-01A)					
1 L Amber (PQE0953-01B)					
Sample ID: PQE0953-02 Water	**Sampled: 05/25/07 09:30**				
608 (Pest only)-I	06/01/07 09:30	06/06/07 12:00	$ 112.00	0%	
Containers Supplied:					
1 L Amber (PQE0953-02A)					
1 L Amber (PQE0953-02B)					
Sample ID: PQE0953-03 Water	**Sampled: 05/25/07 08:48**				
608 (Pest only)-I	06/01/07 08:48	06/06/07 12:00	$ 112.00	0%	
Containers Supplied:					
1 L Amber (PQE0953-03A)					
1 L Amber (PQE0953-03B)					

A.P.
1335
05/26/07

SAMPLE INTEGRITY:

All containers intact:	☒ Yes ☐ No	Sample labels/COC agree:	☒ Yes ☐ No	Samples Received On Ice::	☒ Yes ☐ No
Custody Seals Present:	☐ Yes ☒ No	Samples Preserved Properly:	☒ Yes ☐ No	Samples Received at (temp):	2.5

Released By	Date	Time	Received By	Date	Time
[signature]	5/25/07	1700	Fedex	5/25/07	1700
			[signature]	5/26/07	1000

#330

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Friday, June 08, 2007

Linda Eshelman
Test America - Phoenix
9830 South 51st Street
Suite B-120
Phoenix, AZ 85044

TEL: (480) 785-0043
FAX (480) 785-0851

RE: PQE0953

Order No.: 07050983

Dear Linda Eshelman:

Aerotech Environmental Laboratories received 3 sample(s) on 5/29/2007 for the analyses presented in the following report.

This report includes the following information:
- Case Narrative.
- Analytical Report: includes test results, report limit (Limit), any applicable data qualifier (Qual), units, dilution factor (DF), and date analyzed.
- QC Summary Report.

This communication is intended only for the individual or entity to whom it is directed. It may contain information that is privileged, confidential, or otherwise exempt from disclosure under applicable law. Dissemination, distribution, or copying of this communication by anyone other than the intended recipient, or a duly designated employee or agent of such recipient, is prohibited. If you have received this communication in error, please notify us immediately and destroy this message and all attachments thereto. If you have any questions regarding these test results, please do not hesitate to call.

Sincerely,

Evvere Anthony
Project Manager

Aerotech Environmental Laboratories

Date: *08-Jun-07*

CLIENT: Test America - Phoenix
Project: PQE0953
Lab Order: 07050983

CASE NARRATIVE

Analyses included in this report were performed by Aerotech Environmental Laboratories (AEL), 4645 E. Cotton Center Boulevard, Building 3, Suite 189, Phoenix, AZ.

AEL is licensed through the State of Arizona (License No. AZ0610), and holds NELAC accreditation (OR100001) through the State of Oregon for the analytical techniques noted on the scope of accreditation.

AEL is also accredited by the American Industrial Hygiene Association (AIHA) in the industrial hygiene program for the analytical techniques noted on the scope of accreditation.

Samples were analyzed using methods outlined in references such as:
-Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.
-40 CFR, Part 136, July 2006. Appendix A to Part 136 - Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.
-Methods for the Chemical Analysis of Water and Wastes, EPA/600/4-79-020, Revised March 1983.
-Methods for the Determination of Organic Compounds in Drinking Water: Supplement III, August 1995, EPA/600/R-95/131.
-Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA, 3rd Edition 1986, and Updates.
-Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA, Second Edition, 1999.
-NIOSH Manual of Analytical Methods, Fourth Edition, 1994. NIOSH Method 7300 analyses are performed using a modified digestion procedure to eliminate the use of perchloric acid.

Analytical Comments:
All method blanks and laboratory control spikes met method and/or laboratory quality control objectives for the analyses included in this report.

Data Qualifiers:
Listed below are the data qualifiers used in your analytical report to explain any analytical or quality control issues. You will find them noted in your report under the column header "QUAL". Any quality control deficiencies that cannot be adequately described by these qualifiers will be addressed in the analytical comments section of this case narrative.

V5 CCV recovery after a group of samples was above acceptance limits. This target analyte was not detected in the sample. Acceptable per EPA Method 8000B.

Aerotech Environmental Laboratories

Analytical Report

Date: *08-Jun-07*

CLIENT:	Test America - Phoenix	**Client Sample ID:**	PQE0953-01
Lab Order:	07050983	**Tag Number:**	
Project:	PQE0953	**Collection Date:**	5/25/2007 9:45:00 AM
Lab ID:	07050983-01A	**Matrix:**	WATER

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ORGANOPHOSPHORUS PESTICIDES		**SW8141A**				Analyst: **CL**
Chlorpyrifos	< 2.5	2.5	V5	µg/L	1	6/6/2007
Demeton, Total	< 5.0	5.0		µg/L	1	6/6/2007
Diazinon	< 2.5	2.5		µg/L	1	6/6/2007
Disulfoton	< 2.5	2.5		µg/L	1	6/6/2007
Ethion	< 2.5	2.5	V5	µg/L	1	6/6/2007
Fenthion	< 2.5	2.5		µg/L	1	6/6/2007
Malathion	< 2.5	2.5	V5	µg/L	1	6/6/2007
Methyl parathion	< 2.5	2.5		µg/L	1	6/6/2007
Parathion	< 2.5	2.5		µg/L	1	6/6/2007
Surr: TPP (Surrogate)	78.4	16.2-151		%REC	1	6/6/2007
Surr: Tributylphosphate (Surrogat	78.5	13.8-156		%REC	1	6/6/2007

Footnotes: All analysis performed at AEL Phoenix laboratory unless indicated by footnotes.

(1) The holding time for pH analysis is immediate. For the most accurate result, the pH should be taken in the field within 15 minutes of sampling.

Aerotech Environmental Laboratories

Analytical Report

Date: *08-Jun-07*

CLIENT:	Test America - Phoenix	**Client Sample ID:**	PQE0953-02
Lab Order:	07050983	**Tag Number:**	
Project:	PQE0953	**Collection Date:**	5/25/2007 9:30:00 AM
Lab ID:	07050983-02A	**Matrix:**	WATER

Analyses	Result	Limit	Qual	Units	DF	Date Analyzed
ORGANOPHOSPHORUS PESTICIDES		**SW8141A**				Analyst: **CL**
Chlorpyrifos	< 3.2	3.2	V5	µg/L	1	6/6/2007
Demeton, Total	< 6.4	6.4		µg/L	1	6/6/2007
Diazinon	< 3.2	3.2		µg/L	1	6/6/2007
Disulfoton	< 3.2	3.2		µg/L	1	6/6/2007
Ethion	< 3.2	3.2	V5	µg/L	1	6/6/2007
Fenthion	< 3.2	3.2		µg/L	1	6/6/2007
Malathion	< 3.2	3.2	V5	µg/L	1	6/6/2007
Methyl parathion	< 3.2	3.2		µg/L	1	6/6/2007
Parathion	< 3.2	3.2		µg/L	1	6/6/2007
Surr: TPP (Surrogate)	77.1	16.2-151		%REC	1	6/6/2007
Surr: Tributylphosphate (Surrogat	74.9	13.8-156		%REC	1	6/6/2007

Footnotes: All analysis performed at AEL Phoenix laboratory unless indicated by footnotes.

(1) The holding time for pH analysis is immediate. For the most accurate result, the pH should be taken in the field within 15 minutes of sampling.

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Date: *08-Jun-07*

CLIENT: Test America - Phoenix
Work Order: 07050983
Project: PQE0953

ANALYTICAL QC SUMMARY REPORT

TestCode: 8141az_w

Sample ID: **MB-29476** SampType: **MBLK** TestCode: **8141az_w** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039349**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	<2.5	2.5									
Demeton, Total	<5.0	5.0									
Diazinon	<2.5	2.5									
Disulfoton	<2.5	2.5									
Ethion	<2.5	2.5									
Fenthion	<2.5	2.5									
Malathion	<2.5	2.5									
Methyl parathion	<2.5	2.5									
Parathion	<2.5	2.5									
Surr: TPP (Surrogate)	44.03	5.0	50	0	88.1	51.9	134				
Surr: Tributylphosphate (Surrogate)	45.49	5.0	50	0	91.0	49.6	133				

Sample ID: **LCS-29476** SampType: **LCS** TestCode: **8141az_w** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039350**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	10.54	2.5	10	0	105	61.5	125				
Demeton, Total	20.01	5.0	20	0	100	53.9	126				
Diazinon	12.08	2.5	10	0	121	64.6	125				
Disulfoton	10.24	2.5	10	0	102	66.9	121				
Ethion	11.03	2.5	10	0	110	50.9	129				
Fenthion	11.86	2.5	10	0	119	62.5	129				
Malathion	8.974	2.5	10	0	89.7	65.2	129				
Methyl parathion	10.27	2.5	10	0	103	62.1	129				
Parathion	9.921	2.5	10	0	99.2	60.9	121				

Qualifiers: * Value exceeds Maximum Contaminant Level ND Not Detected at the Reporting Limit

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Date: *08-Jun-07*

CLIENT: Test America - Phoenix
Work Order: 07050983
Project: PQE0953

ANALYTICAL QC SUMMARY REPORT

TestCode: 8141az_w

Sample ID: **LCS-29476** SampType: **LCS** TestCode: **8141az_w** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039350**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Surr: TPP (Surrogate)	45.24	5.0	50	0	90.5	51.9	134				
Surr: Tributylphosphate (Surrogate)	45.32	5.0	50	0	90.6	49.6	133				

Sample ID: **LCSD-29476** SampType: **LCSD** TestCode: **8141az_w** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039358**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	10.71	2.5	10	0	107	61.5	125	10.54	1.52	35	
Demeton, Total	19.92	5.0	20	0	99.6	53.9	126	20.01	0.454	35	
Diazinon	11.56	2.5	10	0	116	64.6	125	12.08	4.39	35	
Disulfoton	10.60	2.5	10	0	106	66.9	121	10.24	3.44	35	
Ethion	10.23	2.5	10	0	102	50.9	129	11.03	7.51	35	
Fenthion	12.90	2.5	10	0	129	62.5	129	11.86	8.43	35	
Malathion	11.11	2.5	10	0	111	65.2	129	8.974	21.3	35	
Methyl parathion	11.72	2.5	10	0	117	62.1	129	10.27	13.2	35	
Parathion	11.53	2.5	10	0	115	60.9	121	9.921	15.0	35	
Surr: TPP (Surrogate)	43.58	5.0	50	0	87.2	51.9	134	45.24	0	0	
Surr: Tributylphosphate (Surrogate)	43.27	5.0	50	0	86.5	49.6	133	45.32	0	0	

Sample ID: **07050961-02AMS** SampType: **MS** TestCode: **8141AZ_W** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039353**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	11.58	2.7	10.64	0	109	52.8	135				
Demeton, Total	19.71	5.3	21.28	0	92.6	50	150				

Qualifiers: * Value exceeds Maximum Contaminant Level ND Not Detected at the Reporting Limit

Aerotech Environmental Laboratories

a division of Aerotech Laboratories, Inc.

Date: *08-Jun-07*

CLIENT: Test America - Phoenix
Work Order: 07050983
Project: PQE0953

ANALYTICAL QC SUMMARY REPORT

TestCode: 8141az_w

Sample ID: **07050961-02AMS** SampType: **MS** TestCode: **8141AZ_W** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039353**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diazinon	11.86	2.7	10.64	0	111	54.7	130				
Disulfoton	11.17	2.7	10.64	0	105	31.3	139				
Ethion	11.05	2.7	10.64	0	104	27.2	149				
Fenthion	12.19	2.7	10.64	0	115	53.2	132				
Malathion	11.41	2.7	10.64	0	107	53.9	129				
Methyl parathion	12.41	2.7	10.64	0	117	23.2	145				
Parathion	10.18	2.7	10.64	0	95.7	54.6	126				
Surr: TPP (Surrogate)	48.96	5.3	53.19	0	92.0	16.2	151				
Surr: Tributylphosphate (Surrogate)	46.49	5.3	53.19	0	87.4	13.8	156				

Sample ID: **07050961-02AMSD** SampType: **MSD** TestCode: **8141AZ_W** Units: **µg/L** Prep Date: **5/30/2007** RunNo: **87867**
Client ID: Batch ID: **29476** TestNo: **SW8141A** Analysis Date: **6/1/2007** SeqNo: **1039354**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorpyrifos	10.52	2.5	10	0	105	52.8	135	11.58	9.61	35	
Demeton, Total	17.85	5.0	20	0	89.2	50	150	19.71	9.92	35	
Diazinon	10.72	2.5	10	0	107	54.7	130	11.86	10.1	35	
Disulfoton	9.406	2.5	10	0	94.1	31.3	139	11.17	17.1	35	
Ethion	8.263	2.5	10	0	82.6	27.2	149	11.05	28.9	35	
Fenthion	10.32	2.5	10	0	103	53.2	132	12.19	16.7	35	
Malathion	9.581	2.5	10	0	95.8	53.9	129	11.41	17.4	35	
Methyl parathion	10.32	2.5	10	0	103	23.2	145	12.41	18.3	35	
Parathion	9.456	2.5	10	0	94.6	54.6	126	10.18	7.36	35	
Surr: TPP (Surrogate)	41.83	5.0	50	0	83.7	16.2	151	48.96	0	0	
Surr: Tributylphosphate (Surrogate)	40.39	5.0	50	0	80.8	13.8	156	46.49	0	0	

Qualifiers: * Value exceeds Maximum Contaminant Level ND Not Detected at the Reporting Limit

Aerotech Environmental Laboratories Sample Receipt Checklist   Project Checked By: ______

Laboratory Number: 07-05-0983	Completed By/On: Jovan Espinoza 5/29/07
Client Name: Test America	Date/Time Rec'd: 5/29/07 07:51 By: AG
Matrix: Air Soil (Aqueous) Oil Sludge Solid WW DW	Carrier Name: Client

Temperature	Cooler #1 4.5 °C	Cooler #2 °C	Cooler #3 °C	Cooler #4 °C
Temp. Read With	Thermometer (IR)	Thermometer IR	Thermometer IR	Thermometer IR

Client or PM made aware of temp. out of range? Yes No   Circle one: Blue Ice (Wet Ice) Not Present

	Yes	No*	Not Present
Shipping container/cooler in good condition?	✓		
Custody seals intact on shipping container/cooler?			✓
Custody seals intact on sample containers?			✓
Chain of Custody present and relinquished/received properly?	✓		
Chain of Custody agrees with sample labels?	✓		
Samples in proper containers/bottles?	✓		
Sample containers intact?	✓		
All samples received within holding time?	✓		**See Comments about Chlorine and pH
Is there sufficient sample volume to perform the tests?	✓		
40mL vials for volatiles & SOCs received with zero headspace?			✓

Soil Containers:
Brass Sleeve ____
Glass Jar ____
Methanol ____
Plastic Bag ____
Encore Samplers ____
Sterile Plastic ____

Total number of bottles received: 5   IH sample media: ______

If applicable, how many sample bottles were shipped from AEL-Tucson? N/A ✓

Number of containers received by preservative and by sample number:(If more than 10 samples are rec'd, please continue on separate sheet(s)).

Preservative	Simple***	1	2	3	4	5	6	7	8	9	10
A-General		2	2	1							
B-HNO3											
C-H2SO4											
D-HCl											
E-Na2S2O3											
F-NaOH											
G-Sulfide											
H-Na Sulfite											
I-MCAA											
J-Methanol											
K-HAA											
L-Other											

*Any No response must be detailed in the comments section. Contact the PM immediately to determine how to proceed. Refer to SOP 11-001 and continue on back if additional space is needed.

**The holding time for pH and Total Residual Chlorine analysis is immediate. For the most accurate results, the pH and Total Residual Chlorine should be taken in the field within 15 minutes of sampling.

***The Simple box is only to be used when there is one bottle per preservative in equal sample sets.

Water-pH acceptable upon receipt? Yes ___ No ___ N/A ✓

Preservative & pH		pH of samples upon receipt	If pH requires adjustment, list sample number and reagent I.D. number.
Metals	<2		
H_2SO_4	<2		
1664	<2		
Cyanide	>12		
Sulfide	>9		

Comments: ______

TestAmerica
ANALYTICAL TESTING CORPORATION

07-05-0983

SUBCONTRACT ORDER - PROJECT # PQE0953

SENDING LABORATORY:	RECEIVING LABORATORY:
TestAmerica - Phoenix, AZ	Aerotech Laboratories, Inc.-OUT
9830 South 51st Street, Suite B-120	4645 E. Cotton Center Blvd. Bldg. #3, #189
Phoenix, AZ 85044	Phoenix, AZ 85044
Phone: (480) 785-0043	Phone :(602) 437-3340
Fax: (480) 785-0851	Fax: (623) 445-6256
Project Manager: Linda Eshelman	Project Location: Arizona

Standard TAT is requested unless specific due date is requested. => Due Date: ________ **Initials:** ________

Analysis	Expiration	Comments
Sample ID: PQE0953-01 Water Sampled: 05/25/07 09:45		
8141A-Full-O	06/01/07 09:45	Aerotech

Containers Supplied:
1 L Amber (PQE0953-01C)
1 L Amber (PQE0953-01D)

Analysis	Expiration	Comments
Sample ID: PQE0953-02 Water Sampled: 05/25/07 09:30		
8141A-Full-O	06/01/07 09:30	Aerotech

Containers Supplied:
1 L Amber (PQE0953-02C)
1 L Amber (PQE0953-02D)

Analysis	Expiration	Comments
Sample ID: PQE0953-03 Water Sampled: 05/25/07 08:48		
8141A-Full-O	06/01/07 08:48	Aerotech

Containers Supplied:
1 L Amber (PQE0953-03C)

SAMPLE INTEGRITY:

All containers intact: ☐ Yes ☐ No	Sample labels/COC agree: ☐ Yes ☐ No	Samples Received On Ice:: ☑ Yes ☐ No
Custody Seals Present: ☐ Yes ☐ No	Samples Preserved Properly: ☐ Yes ☐ No	Samples Received at (temp): ________

Released By	Date	Time	Received By	Date	Time
Paul Newman	5/29/07	0730	[signature]	5/29/07	0730
[signature]	5/29/07	0751	[signature]	5/29/07	07:51

4 ro

Aquatic Consulting & Testing

PQE0953

1525 W. University Dr
Suite 106
Tempe, AZ 85281
(480) 921-8044
(480) 921-0049 FAX
E-Mail Address: christian@...
Attention: Chris Christian

Subcontract Chain of Custody

DATE May 25, 2007

Subcontract Laboratory

Test America, Inc.
9830 South 51st Street Suite 120 B
Phoenix, AZ 85044
Telephone 480-785-0043
Attn: Sample Receiving

AC&T Sample ID	Date	Time	Matrix	Lab ID	Cl Pest 608	OrgPhos Pest 8141	Number of Containers
BP-06489	5/25/2007	9:45 AM	SW	PQE0953-1	X	X	4
BP-06490	5/25/2007	9:30 AM	SW	-2	X	X	4
BP-06491	5/25/2007	8:48 AM	SW	-3	X	X	3

Sampler Name: D. Kundarsi

Project Name	Sample Receipt	
USFWS	No. Containers:	11
Project Number	Custody Seals:	
:	Received Intact:	(Yes) No
Notes:	Received Cold:	(Yes) No
	Temperature:	2.2°C
	PRIORITY	Standard

RELINQUISHED BY:		RELINQUISHED BY:	
Signature: A Zach	Time: 1454	Signature: [signature]	Time: 1516
Printed Name: Tony Zach	Date: 5/25/2007	Printed Name: Johnson	Date: 5/25/2007
Aquatic Consulting & Testing		TA	
SAMPLED RECEIVED BY:		**SAMPLED RECEIVED BY:**	
Signature: [signature]	Time: 1454	Signature: [signature]	Time: 1516
Printed Name: Johnson	Date: 5/25/2007	Printed Name: TA	Date: 5/25/2007
TA		Test America, Inc.	

Appendix B

Data Acquired After Existing Conditions Report

(Post April 2007)

Well Data: Daily Average

CIBOLA National Wildlife Refuge: Hart Mine Marsh Well Elevation Data

This information is provided to USBR as a portion of the Hart Mine Marsh

Comprehensive Conceptual Restoration Plan as Appendix B

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
12/14/06	348	214.6	213.5	213.3	212.9	214.4	213.1	212.0
12/15/06	349	213.9	213.5	213.4	212.9	213.6	213.0	212.0
12/16/06	350	213.6	213.4	213.3	212.9	213.2	212.8	212.1
12/17/06	351	213.5	213.3	213.2	212.8	213.2	212.7	212.2
12/18/06	352	213.7	213.3	213.2	212.8	213.4	212.8	212.2
12/19/06	353	213.9	213.4	213.2	212.8	213.7	212.8	212.2
12/20/06	354	213.9	213.4	213.2	212.8	213.6	212.9	212.1
12/21/06	355	213.9	213.4	213.2	212.8	213.7	212.9	212.1
12/22/06	356	213.3	213.4	213.2	212.8	213.1	212.7	212.2
12/23/06	357	213.0	213.2	213.1	212.8	212.6	212.5	212.3
12/24/06	358	212.7	213.1	213.1	212.8	212.4	212.3	212.4
12/25/06	359	212.8	213.1	213.1	212.8	212.5	212.3	212.4
12/26/06	360	213.2	213.1	213.1	212.8	212.9	212.4	212.4
12/27/06	361	213.4	213.2	213.1	212.8	213.1	212.6	212.3
12/28/06	362	213.3	213.1	213.1	212.8	213.0	212.5	212.3
12/29/06	363	213.0	213.1	213.0	212.7	212.8	212.4	212.4
12/30/06	364	212.9	213.0	213.0	212.7	212.6	212.3	212.4
12/31/06	365	213.1	213.0	213.0	212.7	212.8	212.4	212.5
01/01/07	1	212.9	213.0	213.0	212.7	212.6	212.3	212.5
01/02/07	2	213.3	213.0	212.9	212.7	213.1	212.5	212.4
01/03/07	3	213.2	213.0	212.9	212.7	212.9	212.4	212.4
01/04/07	4	213.1	213.0	212.9	212.7	212.9	212.4	212.4
01/05/07	5	213.3	213.0	212.9	212.6	213.0	212.5	212.5
01/06/07	6	213.2	212.9	212.9	212.6	212.9	212.4	212.5
01/07/07	7	213.6	213.0	212.9	212.6	213.4	212.5	212.5
01/08/07	8	213.7	213.1	213.0	212.6	213.5	212.7	212.4
01/09/07	9	213.7	213.1	213.0	212.6	213.6	212.7	212.3
01/10/07	10	213.7	213.1	213.0	212.7	213.5	212.7	212.3
01/11/07	11	213.9	213.2	213.1	212.7	213.7	212.8	212.2

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
01/12/07	12	213.8	213.2	213.0	212.6	213.7	212.8	212.2
01/13/07	13	213.8	213.2	213.0	212.6	213.7	212.8	212.3
01/14/07	14	213.9	213.2	213.0	212.6	213.7	212.8	212.2
01/15/07	15	213.6	213.2	213.0	212.6	213.4	212.7	212.3
01/16/07	16	214.1	213.2	213.1	212.7	213.9	212.9	212.2
01/17/07	17	214.2	213.3	213.1	212.6	214.1	213.0	212.1
01/18/07	18	214.1	213.3	213.2	212.6	213.9	213.0	212.1
01/19/07	19	214.0	213.3	213.2	212.6	213.7	212.9	212.1
01/20/07	20	213.6	213.3	213.2	212.6	213.4	212.8	212.2
01/21/07	21	213.6	213.3	213.2	212.6	213.3	212.8	212.2
01/22/07	22	213.7	213.2	213.1	212.6	213.5	212.8	212.2
01/23/07	23	213.8	213.3	213.1	212.6	213.6	212.8	212.2
01/24/07	24	213.7	213.2	213.1	212.6	213.4	212.8	212.2
01/25/07	25	213.65	213.26	213.17	212.65	213.37	212.75	212.22
01/26/07	26	213.56	213.30	213.22	212.69	213.24	212.74	212.21
01/27/07	27	213.74	213.34	213.25	212.70	213.51	212.77	212.22
01/28/07	28	213.70	213.38	213.28	212.71	213.43	212.81	212.18
01/29/07	29	213.91	213.42	213.31	212.74	213.70	212.89	212.15
01/30/07	30	213.74	213.44	213.34	212.76	213.45	212.88	212.12
01/31/07	31	213.60	213.96	213.77	212.80	213.21	212.83	212.14
02/01/07	32	213.57	214.52	214.46	212.92	213.15	212.95	212.08
02/02/07	33	213.76	214.12	214.05	212.98	213.43	212.99	212.06
02/03/07	34	213.86	213.92	213.85	212.99	213.57	213.01	212.03
02/04/07	35	213.97	213.85	213.78	213.00	213.69	213.04	212.00
02/05/07	36	214.23	213.83	213.74	213.01	214.01	213.14	211.96
02/06/07	37	214.11	213.81	213.72	213.01	213.86	213.14	211.93
02/07/07	38	213.90	213.67	213.63	213.00	213.63	213.07	211.94
02/08/07	39	214.05	213.63	213.56	212.98	213.86	213.09	211.95
02/09/07	40	213.88	213.61	213.54	212.97	213.63	213.05	211.96
02/10/07	41	214.09	213.62	213.55	212.98	213.89	213.09	211.96
02/11/07	42	214.05	213.55	213.50	212.98	213.86	213.10	211.94
02/12/07	43	214.03	213.54	213.47	212.95	213.84	213.08	211.96
02/13/07	44	214.08	213.55	213.47	212.95	213.88	213.10	211.94
02/14/07	45	214.43	213.58	213.45	212.92	214.31	213.20	211.92
02/15/07	46	214.48	213.60	213.47	212.91	214.34	213.25	211.89

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
02/16/07	47	214.54	213.64	213.50	212.94	214.39	213.28	211.87
02/17/07	48	214.59	213.68	213.54	212.96	214.43	213.34	211.83
02/18/07	49	214.29	213.67	213.57	213.00	214.06	213.26	211.83
02/19/07	50	214.65	213.67	213.53	212.97	214.52	213.34	211.81
02/20/07	51	215.03	213.70	213.52	212.93	214.93	213.45	211.78
02/21/07	52	215.03	213.70	213.52	212.93	214.93	213.45	211.78
02/22/07	53	215.06	213.87	213.66	213.01	214.90	213.60	211.67
02/23/07	54	214.48	213.79	213.63	213.00	214.26	213.45	211.71
02/24/07	55	214.27	213.68	213.56	212.98	214.04	213.29	211.79
02/25/07	56	214.69	213.75	213.61	213.02	214.52	213.42	211.74
02/26/07	57	215.01	213.80	213.62	213.02	214.87	213.52	211.69
02/27/07	58	215.39	213.89	213.67	213.03	215.26	213.66	211.63
02/28/07	59	215.31	213.90	213.67	213.02	215.18	213.69	211.60
03/01/07	60	214.90	213.86	213.67	213.02	214.72	213.60	211.62
03/02/07	61	214.81	213.85	213.66	213.03	214.62	213.56	211.63
03/03/07	62	214.41	213.75	213.61	213.01	214.18	213.39	211.71
03/04/07	63	214.96	214.50	214.36	213.10	214.74	213.59	211.65
03/05/07	64	215.22	215.08	214.88	213.26	214.94	213.82	211.51
03/06/07	65	215.69	214.91	214.68	213.34	215.44	213.94	211.43
03/07/07	66	215.53	214.70	214.50	213.39	215.28	213.95	211.38
03/08/07	67	215.40	214.56	214.35	213.39	215.09	213.89	211.38
03/09/07	68	215.08	214.44	214.22	no data	214.73	213.76	211.43
03/10/07	69	215.27	214.35	214.13	no data	214.93	213.74	211.44
03/11/07	70	215.54	214.21	213.98	no data	215.24	213.80	211.43
03/12/07	71	215.75	214.08	213.86	no data	215.49	213.86	211.40
03/13/07	72	215.76	214.16	213.90	no data	215.49	213.88	211.38
03/14/07	73	215.86	214.20	213.91	no data	215.58	213.90	211.38
03/15/07	74	215.70	214.21	213.92	no data	215.44	213.89	211.36
03/16/07	75	215.27	214.17	213.91	no data	215.00	213.80	211.40
03/17/07	76	215.37	214.13	213.89	no data	215.07	213.76	211.43
03/18/07	77	215.75	214.07	213.82	no data	215.48	213.83	211.41
03/19/07	78	215.51	213.92	213.69	no data	215.29	213.80	211.43
03/20/07	79	215.38	213.94	213.70	no data	215.14	213.74	211.46
03/21/07	80	215.50	214.00	213.73	no data	215.24	213.76	211.46
03/22/07	81	215.73	214.37	213.99	no data	215.42	213.85	211.41

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
03/23/07	82	216.02	215.29	214.96	no data	215.66	214.07	211.28
03/24/07	83	216.14	215.04	214.75	no data	215.79	214.12	211.23
03/25/07	84	216.23	214.79	214.49	no data	215.90	214.13	211.19
03/26/07	85	215.91	214.63	214.36	no data	215.59	214.05	211.22
03/27/07	86	216.00	214.54	214.26	no data	215.69	214.05	211.21
03/28/07	87	215.97	214.46	214.17	no data	215.68	214.04	211.22
03/29/07	88	215.65	214.25	214.01	no data	215.40	213.96	211.26
03/30/07	89	215.30	214.17	213.95	no data	215.05	213.83	211.34
03/31/07	90	215.35	214.15	213.93	no data	215.06	213.78	211.37
04/01/07	91	215.51	214.14	213.91	no data	215.21	213.79	211.39
04/02/07	92	216.06	214.14	213.86	no data	215.77	213.88	211.39
04/03/07	93	215.98	214.13	213.82	no data	215.73	213.90	211.40
04/04/07	94	216.16	214.15	213.82	no data	215.89	213.93	211.38
04/05/07	95	216.04	214.17	213.84	no data	215.79	213.94	211.37
04/06/07	96	215.51	214.09	213.80	no data	215.28	213.82	211.43
04/07/07	97	215.70	214.01	213.72	no data	215.44	213.76	211.49
04/08/07	98	215.88	214.01	213.70	no data	215.63	213.79	211.50
04/09/07	99	215.79	214.00	213.69	no data	215.55	213.78	211.51
04/10/07	100	215.83	213.98	213.67	no data	215.59	213.77	211.53
04/11/07	101	216.21	214.03	213.69	no data	215.95	213.85	211.49
04/12/07	102	215.79	214.01	213.68	no data	215.56	213.82	211.47
04/13/07	103	215.68	213.94	213.62	no data	215.47	213.75	211.53
04/14/07	104	215.52	213.93	213.63	no data	215.28	213.69	211.57
04/15/07	105	215.79	214.28	213.97	no data	215.48	213.76	211.54
04/16/07	106	216.05	215.05	214.70	no data	215.70	213.96	211.40
04/17/07	107	215.98	215.00	214.70	no data	215.62	214.01	211.33
04/18/07	108	216.34	214.74	214.44	no data	215.99	214.04	211.31
04/19/07	109	216.27	214.61	214.30	no data	215.95	214.05	211.28
04/20/07	110	215.96	214.41	214.14	no data	215.69	214.01	211.26
04/21/07	111	215.77	214.12	213.88	no data	215.55	213.89	211.34
04/22/07	112	215.97	214.16	213.89	no data	215.72	213.88	211.38
04/23/07	113	215.75	214.13	213.85	no data	215.53	213.84	211.42
04/24/07	114	215.66	214.07	213.80	no data	215.42	213.76	211.48
04/25/07	115	215.63	214.05	213.78	no data	215.37	213.73	211.52
04/26/07	116	215.70	214.00	213.72	no data	215.45	213.70	211.57

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
04/27/07	117	215.26	213.78	213.55	no data	215.06	213.58	211.66
04/28/07	118	215.28	213.72	213.49	no data	215.04	213.48	211.74
04/29/07	119	215.30	213.67	213.41	no data	215.07	213.43	211.81
04/30/07	120	215.43	213.64	213.37	no data	215.20	213.43	211.84
05/01/07	121	215.35	213.61	213.33	no data	215.13	213.41	211.85
05/02/07	122	215.48	213.57	213.27	no data	215.26	213.39	211.89
05/03/07	123	215.42	213.53	213.23	no data	215.21	213.40	211.89
05/04/07	124	215.18	213.50	213.21	no data	214.97	213.36	211.90
05/05/07	125	215.36	213.46	213.16	no data	215.13	213.34	211.93
05/06/07	126	215.38	213.45	213.14	no data	215.17	213.36	211.93
05/07/07	127	215.47	213.76	213.33	no data	215.24	213.41	211.92
05/08/07	128	215.23	214.19	213.84	no data	214.93	213.45	211.89
05/09/07	129	215.29	214.18	213.91	no data	214.98	213.46	211.85
05/10/07	130	215.05	213.96	213.71	no data	214.73	213.37	211.89
05/11/07	131	215.43	213.87	213.60	no data	215.14	213.42	211.89
05/12/07	132	215.28	213.79	213.51	no data	215.00	213.39	211.90
05/13/07	133	215.23	213.71	213.43	no data	214.95	213.35	211.93
05/14/07	134	215.44	213.68	213.38	no data	215.18	213.38	211.93
05/15/07	135	215.70	213.69	213.36	no data	215.45	213.45	211.91
05/16/07	136	215.56	213.69	213.36	no data	215.33	213.46	211.90
05/17/07	137	215.46	213.66	213.33	no data	215.24	213.44	211.91
05/18/07	138	215.01	213.61	213.30	no data	214.81	213.36	211.95
05/19/07	139	214.87	213.51	213.24	no data	214.60	213.23	212.02
05/20/07	140	215.05	213.50	213.21	no data	214.79	213.26	212.03
05/21/07	141	215.28	213.63	213.28	no data	215.03	213.31	212.02
05/22/07	142	215.28	214.51	214.18	no data	214.96	213.45	211.95
05/23/07	143	215.18	214.58	214.27	no data	214.85	213.52	211.86
05/24/07	144	214.88	214.21	213.94	no data	214.56	213.44	211.86
05/25/07	145	214.64	213.93	213.71	no data	214.32	213.30	211.95
05/26/07	146	214.29	213.72	213.54	no data	213.92	213.11	212.07
05/27/07	147	214.71	213.64	213.43	no data	214.41	213.14	212.10
05/28/07	148	214.77	213.58	213.35	no data	214.51	213.16	212.10
05/29/07	149	214.74	213.48	213.25	no data	214.48	213.10	212.15
05/30/07	150	214.79	213.43	213.18	no data	214.53	213.10	212.10
05/31/07	151	214.87	213.39	213.13	no data	214.63	213.11	no data

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

Date	Day (Julian)	HMM_01 (ft)	HMM_02 (ft)	HMM_03 (ft)	HMM_04 (ft)	HMM_05 (ft)	HMM_06 (ft)	HMM_07 (ft)
06/01/07	152	214.61	213.32	213.07	no data	214.36	213.05	no data
06/02/07	153	214.77	213.25	212.99	no data	214.54	213.01	no data
06/03/07	154	214.93	213.22	212.95	no data	214.70	213.04	no data
06/04/07	155	215.08	213.20	212.91	no data	214.87	213.07	no data
06/05/07	156	215.29	213.19	212.88	no data	215.10	213.12	no data
06/06/07	157	214.81	213.20	212.88	no data	214.59	213.05	no data
06/07/07	158	215.14	213.81	213.45	no data	214.88	213.15	no data
06/08/07	159	214.52	214.02	213.77	no data	214.21	213.16	no data
06/09/07	160	214.34	213.67	213.48	no data	214.01	213.00	no data
06/10/07	161	214.38	213.51	213.32	no data	214.06	212.93	no data
06/11/07	162	214.57	213.41	213.20	no data	214.29	212.93	no data
06/12/07	163	214.75	213.35	213.11	no data	214.51	212.96	no data
06/13/07	164	215.25	213.36	213.08	no data	215.02	213.08	no data
06/14/07	165	215.18	213.35	213.06	no data	214.95	213.11	no data
06/15/07	166	214.86	213.31	213.01	no data	214.67	213.07	no data
06/16/07	167	214.76	213.20	212.94	no data	214.49	212.91	no data
06/17/07	168	214.88	213.20	212.92	no data	214.65	212.96	no data
06/18/07	169	214.87	213.17	212.88	no data	214.65	212.94	no data
06/19/07	170	214.92	213.14	212.84	no data	214.71	212.93	no data
06/20/07	171	214.96	213.13	212.83	no data	214.74	212.95	no data
06/21/07	172	214.88	213.10	212.81	no data	214.65	212.93	no data
06/22/07	173	214.71	213.06	212.77	no data	214.49	212.89	no data
06/23/07	174	214.48	212.97	212.70	no data	214.24	212.77	no data
06/24/07	175	214.59	212.93	212.65	no data	214.37	212.74	no data
06/25/07	176	214.77	213.24	212.87	no data	214.53	212.80	no data
06/26/07	177	215.02	213.77	213.45	no data	214.74	212.97	no data
06/27/07	178	215.35	213.85	213.57	no data	215.06	213.11	no data
06/28/07	179	215.08	213.68	213.40	no data	214.79	213.08	no data
06/29/07	180	215.41	213.58	213.28	no data	215.16	213.12	no data
06/30/07	181	214.68	213.44	213.17	no data	214.40	212.97	no data
07/01/07	182	215.16	213.36	213.07	no data	214.89	212.97	no data
07/02/07	183	215.41	213.33	213.01	no data	215.20	213.06	no data
07/03/07	184	214.74	213.22	212.93	no data	214.49	212.91	no data
07/04/07	185	214.99	213.16	212.87	no data	214.75	212.90	no data
07/05/07	186	215.27	213.11	212.79	no data	215.05	212.93	no data

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

Date	**Day (Julian)**	**HMM_01** (ft)	**HMM_02** (ft)	**HMM_03** (ft)	**HMM_04** (ft)	**HMM_05** (ft)	**HMM_06** (ft)	**HMM_07** (ft)
07/06/07	187	214.66	213.02	212.71	no data	214.46	212.83	no data
07/07/07	188	214.66	212.92	212.64	no data	214.41	212.72	no data
07/08/07	189	214.95	212.90	212.59	no data	214.74	212.76	no data
07/09/07	190	215.13	213.06	212.70	no data	214.92	212.83	no data
07/10/07	191	215.43	213.68	213.18	no data	215.17	213.06	no data
07/11/07	192	215.26	213.88	213.49	no data	214.96	213.13	no data
07/12/07	193	215.14	213.66	213.33	no data	214.86	213.09	no data
07/13/07	194	214.85	213.49	213.18	no data	214.58	212.99	no data
07/14/07	195	214.80	213.36	213.08	no data	214.51	212.89	no data
07/15/07	196	214.91	213.31	213.02	no data	214.65	212.93	no data
07/16/07	197	214.81	213.24	212.95	no data	214.53	212.89	no data
07/17/07	198	214.97	213.19	212.88	no data	214.73	212.90	no data
07/18/07	199	214.93	213.17	212.85	no data	214.69	212.91	no data
07/19/07	200	215.23	213.16	212.82	no data	215.01	212.96	no data
07/20/07	201	214.80	213.12	212.79	no data	214.59	212.91	no data
07/21/07	202	215.05	213.10	212.76	no data	214.84	212.91	no data
07/22/07	203	215.18	213.12	212.77	no data	214.98	212.98	no data
07/23/07	204	215.14	213.13	212.78	no data	214.94	213.02	no data
07/24/07	205	214.89	213.10	212.75	no data	214.70	212.97	no data
07/25/07	206	214.74	213.05	212.72	no data	214.54	212.92	no data
07/26/07	207	214.51	213.02	212.70	no data	214.31	212.89	no data
07/27/07	208	214.44	213.01	212.70	no data	214.24	212.88	no data
07/28/07	209	214.56	213.00	212.70	no data	214.35	212.88	no data
07/29/07	210	214.62	213.03	212.72	no data	214.42	212.89	no data
07/30/07	211	214.80	213.50	213.10	no data	214.56	212.99	no data
07/31/07	212	214.63	213.94	213.55	no data	214.33	213.07	no data
08/01/07	213	214.53	213.69	213.41	no data	214.23	213.03	no data
08/02/07	214	no data	no data	no data	no data	no data	no data	no data

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.3	208.7	208.0	212.1	212.6	214.5	216.6
213.3	207.9	207.4	212.1	212.6	214.5	216.6
213.3	207.5	207.2	212.3	212.5	214.5	216.6
213.2	207.5	207.1	212.4	212.5	214.5	216.7
213.2	207.8	207.3	212.5	212.5	214.6	216.5
213.2	208.1	207.5	212.4	212.5	214.6	216.5
213.3	208.0	207.7	212.3	212.5	214.6	216.5
213.3	208.0	207.6	212.3	212.6	214.6	216.5
213.3	207.2	207.0	212.4	212.5	214.5	216.6
213.2	206.8	206.4	212.6	212.4	214.5	216.5
213.2	206.5	206.2	212.8	212.4	214.5	216.4
213.1	206.7	206.3	212.8	212.3	214.5	216.6
213.2	207.2	206.7	212.7	212.4	214.5	216.5
213.2	207.5	206.7	212.1	212.5	214.5	216.5
213.1	207.3	no data	212.1	212.4	214.5	216.4
213.1	207.0	no data	212.1	212.4	214.5	216.6
213.1	206.8	no data	212.0	212.3	214.5	216.5
213.1	207.2	no data	211.9	212.4	214.5	216.4
213.1	206.9	no data	211.9	212.3	214.5	216.4
213.1	207.5	no data	212.0	212.4	214.5	216.4
213.1	207.2	no data	212.0	212.4	214.5	216.4
213.1	207.2	no data	212.0	212.4	214.5	216.4
213.0	207.8	no data	212.0	212.5	214.5	216.4
213.0	208.0	no data	212.0	212.5	214.5	216.4
213.0	208.6	no data	212.1	212.6	214.5	216.4
213.1	208.6	no data	212.2	212.6	214.5	216.4
213.1	208.7	no data	212.2	212.7	214.5	216.5
213.1	208.6	no data	212.3	212.7	214.5	216.5
213.2	208.9	no data	212.3	212.7	214.5	216.5

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.1	208.8	no data	212.4	212.7	214.5	216.5
213.1	208.8	no data	212.4	212.7	214.5	216.6
213.1	208.8	no data	212.4	212.7	214.5	216.5
213.1	208.4	no data	212.3	212.7	214.5	216.6
213.2	209.1	no data	212.4	212.8	214.5	216.6
213.2	209.2	no data	212.5	212.8	214.5	216.7
213.2	209.0	no data	212.5	212.8	214.5	216.7
213.2	208.8	no data	212.5	212.8	214.6	216.7
213.2	208.4	no data	212.5	212.8	214.5	216.7
213.2	208.4	no data	212.4	212.8	214.5	216.6
213.2	208.6	no data	212.3	212.8	214.5	216.6
213.2	208.7	no data	212.3	212.8	214.5	216.6
213.2	208.4	no data	212.3	212.8	214.5	216.6
213.22	208.44	no data	212.28	212.77	214.53	216.66
213.23	208.26	no data	212.26	212.77	214.53	216.68
213.23	208.64	no data	212.26	212.78	214.53	216.65
213.24	208.49	no data	212.34	212.79	214.53	216.63
213.27	208.81	no data	212.33	212.82	214.53	216.61
213.29	208.49	no data	212.40	212.83	214.53	216.63
213.30	208.23	no data	212.35	212.79	214.54	216.63
213.32	208.13	no data	212.30	212.78	214.54	216.68
213.35	208.48	no data	212.27	212.79	214.54	216.76
213.38	208.64	no data	212.30	212.80	214.54	216.64
213.41	208.77	no data	212.34	212.83	214.53	216.60
213.44	209.12	no data	212.49	212.88	214.53	216.60
213.46	208.94	no data	212.56	212.90	214.53	216.66
213.47	208.69	no data	212.54	212.89	214.53	216.83
213.46	208.96	no data	212.28	212.90	214.53	216.76
213.46	208.70	no data	212.01	212.89	214.53	216.67
213.48	209.00	no data	212.02	212.92	214.53	216.73
213.49	208.96	no data	211.97	212.94	214.53	216.70
213.47	208.95	no data	211.97	212.94	214.53	216.65
213.48	209.00	no data	211.96	212.95	214.53	216.64
213.47	209.43	no data	211.85	212.99	214.53	216.63
213.47	209.47	no data	211.81	213.01	214.52	216.64

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.50	209.52	no data	211.79	213.03	214.52	216.66
213.53	209.55	no data	211.69	213.06	214.52	216.70
213.55	209.19	no data	211.70	213.05	214.52	216.73
213.54	209.65	no data	211.70	213.09	214.53	216.76
213.54	210.02	no data	211.57	213.13	214.53	216.78
213.54	210.02	no data	211.57	213.13	214.53	216.78
213.62	210.00	no data	211.36	213.22	214.52	216.88
213.60	209.42	no data	211.41	213.17	214.53	216.85
213.57	209.19	no data	211.52	213.11	214.53	216.82
213.61	209.66	no data	211.59	213.17	214.52	216.82
213.63	209.99	no data	211.49	213.22	214.52	216.85
213.66	210.33	no data	211.34	213.29	214.53	216.87
213.66	210.28	no data	211.27	213.31	214.53	216.88
213.66	209.88	no data	211.32	213.28	214.53	216.86
213.66	209.79	no data	211.38	213.28	214.53	216.86
213.63	209.36	no data	211.50	213.21	214.52	216.81
213.67	209.87	no data	211.52	213.26	214.53	216.84
213.74	210.03	no data	211.35	213.32	214.54	216.88
213.80	210.48	no data	211.24	213.38	214.57	216.92
213.85	210.35	no data	211.16	213.42	214.60	217.00
213.88	210.21	no data	211.15	213.41	214.66	216.70
213.89	209.90	no data	no data	213.37	214.75	216.63
213.89	210.08	no data	no data	213.38	214.79	216.68
213.90	210.36	no data	no data	213.42	214.81	216.74
213.92	210.59	no data	no data	213.47	214.82	216.71
213.93	210.60	no data	no data	213.49	214.85	216.68
213.93	210.68	no data	no data	213.51	215.04	216.66
213.94	210.57	no data	no data	213.53	215.23	216.64
213.94	210.22	no data	no data	213.50	215.31	216.61
213.94	210.28	no data	no data	213.50	215.39	216.61
213.94	210.62	no data	no data	213.54	215.46	216.67
213.93	210.48	no data	no data	213.55	215.49	216.61
213.91	210.36	no data	no data	213.53	215.51	216.54
213.91	210.44	no data	no data	213.55	215.52	216.59
213.93	210.58	no data	no data	213.58	215.54	216.71

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.98	210.77	no data	no data	213.61	215.57	216.82
214.03	210.88	no data	no data	213.63	215.61	216.70
214.07	210.99	no data	no data	213.67	215.64	216.68
214.09	210.75	no data	no data	213.66	215.67	216.66
214.09	210.85	no data	no data	213.68	215.70	216.64
214.08	210.85	no data	no data	213.68	215.71	216.75
214.07	210.63	no data	no data	213.66	215.72	216.69
214.04	210.34	no data	no data	213.62	215.72	216.58
214.04	210.34	no data	no data	213.62	215.73	216.58
214.03	210.46	no data	no data	213.64	215.73	216.61
214.00	210.93	no data	no data	213.68	215.74	216.70
213.98	210.91	no data	no data	213.69	215.74	216.70
213.98	211.05	no data	no data	213.71	215.75	216.69
213.99	210.98	no data	no data	213.72	215.77	216.67
213.98	210.59	no data	no data	213.68	215.78	216.64
213.94	210.71	no data	no data	213.66	215.77	216.61
213.91	210.87	no data	no data	213.67	215.77	216.61
213.89	210.80	no data	no data	213.66	215.76	216.61
213.88	210.84	no data	no data	213.66	215.76	216.59
213.90	211.14	no data	no data	213.70	215.77	216.61
213.89	210.83	no data	no data	213.69	215.77	216.60
213.84	210.76	no data	no data	213.65	215.77	216.58
213.84	210.60	no data	no data	213.62	215.77	216.62
213.86	210.75	no data	no data	213.64	215.77	216.66
213.92	210.90	no data	no data	213.66	215.78	216.67
214.02	210.85	no data	no data	213.67	215.78	216.67
214.07	211.15	no data	no data	213.72	215.79	216.69
214.08	211.13	no data	no data	213.73	215.80	216.76
214.08	210.94	no data	no data	213.73	215.82	216.86
214.03	210.83	no data	no data	213.70	215.83	216.78
214.02	210.97	no data	no data	213.71	215.83	216.72
213.98	210.83	no data	no data	213.70	215.83	216.66
213.94	210.73	no data	no data	213.66	215.83	216.61
213.93	210.69	no data	no data	213.66	215.82	216.60
213.91	210.76	no data	no data	213.66	215.81	216.66

CIBOLA NWR: Hart Mine Marsh Well Data

Mean Daily: based on average of hourly observations

Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.83	210.44	no data	no data	213.60	215.80	216.58
213.79	210.42	no data	no data	213.56	215.78	216.50
213.73	210.42	no data	no data	213.54	215.76	216.50
213.70	210.52	no data	no data	213.53	215.74	216.51
213.68	210.46	no data	no data	213.52	215.74	216.48
213.64	210.56	no data	no data	213.50	215.76	216.33
213.62	210.52	no data	no data	213.49	216.05	216.27
213.61	210.33	no data	no data	213.47	216.19	216.24
213.58	210.45	no data	no data	213.45	216.23	216.28
213.55	210.47	no data	no data	213.44	216.23	216.34
213.55	210.52	no data	no data	213.45	216.23	216.36
213.58	210.26	no data	no data	213.42	216.26	216.28
213.62	210.29	no data	no data	213.40	216.55	216.20
213.61	210.08	no data	no data	213.36	216.78	216.22
213.60	210.42	no data	no data	213.38	216.87	216.24
213.58	210.31	no data	no data	213.36	216.90	216.23
213.56	210.27	no data	no data	213.34	216.93	216.21
213.53	210.46	no data	no data	213.35	216.96	216.20
213.53	210.69	no data	no data	213.37	216.97	216.22
213.53	210.61	no data	no data	213.36	216.99	216.25
213.51	210.55	no data	no data	213.35	217.04	216.27
213.50	210.20	no data	no data	213.31	217.08	216.24
213.46	210.00	no data	no data	213.25	217.12	216.19
213.45	210.14	no data	no data	213.25	217.14	216.19
213.44	210.33	no data	no data	213.26	217.15	216.23
213.47	210.26	no data	no data	213.25	217.18	216.23
213.54	210.16	no data	no data	213.24	217.19	216.19
213.59	209.96	no data	no data	213.19	217.19	216.15
213.59	210.97	no data	no data	213.02	217.18	216.14
213.53	210.61	no data	no data	212.98	217.16	216.12
213.50	211.05	no data	no data	212.90	217.14	216.10
213.48	211.12	no data	no data	212.91	217.12	216.08
213.43	211.10	no data	no data	212.92	217.10	216.06
213.42	211.15	no data	no data	212.89	217.08	216.04
213.41	211.24	no data	no data	212.89	217.06	216.03

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.38	210.99	no data	no data	212.89	no data	no data
213.35	211.16	no data	no data	212.86	no data	no data
213.33	211.31	no data	no data	212.84	no data	no data
213.32	211.46	no data	no data	212.85	no data	no data
213.32	211.65	no data	no data	212.86	no data	no data
213.29	211.22	no data	no data	212.88	no data	no data
213.30	211.45	no data	no data	212.85	no data	no data
213.36	210.82	no data	no data	212.85	no data	no data
213.35	210.64	no data	no data	212.81	no data	no data
213.33	210.70	no data	no data	212.75	no data	no data
213.29	210.90	no data	no data	212.73	no data	no data
213.26	211.09	no data	no data	212.73	no data	no data
213.28	211.55	no data	no data	212.73	no data	no data
213.29	211.51	no data	no data	212.78	no data	no data
213.26	211.24	no data	no data	212.80	no data	no data
213.22	211.14	no data	no data	212.79	no data	no data
213.21	211.26	no data	no data	212.72	no data	no data
213.19	211.26	no data	no data	212.73	no data	no data
213.16	211.31	no data	no data	212.72	no data	no data
213.16	211.35	no data	no data	212.71	no data	no data
213.16	211.27	no data	no data	212.71	no data	no data
213.14	211.12	no data	no data	212.70	no data	no data
213.10	210.89	no data	no data	212.69	no data	no data
213.08	211.00	no data	no data	212.64	no data	no data
213.06	211.14	no data	no data	212.63	no data	no data
213.09	211.31	no data	no data	212.63	no data	no data
213.16	211.58	no data	no data	212.64	no data	no data
213.20	211.37	no data	no data	212.68	no data	no data
213.20	211.68	no data	no data	212.67	no data	no data
213.18	211.05	no data	no data	212.70	no data	no data
213.15	211.47	no data	no data	212.64	no data	no data
213.14	211.72	no data	no data	212.65	no data	no data
213.11	211.15	no data	no data	212.69	no data	no data
213.09	211.37	no data	no data	212.63	no data	no data
213.06	211.62	no data	no data	212.63	no data	no data

CIBOLA NWR: Hart Mine Marsh Well Data
Mean Daily: based on average of hourly observations
Values are Feet Above Mean Sea Level (FAMSL)

HMM_08 (ft)	**HMM_09** (ft)	**HMM_10** (ft)	**HMM_11** (ft)	**HMM_12** (ft)	**HMM_Marsh** (ft)	**HMM_Arnett** (ft)
213.03	211.11	no data	no data	212.66	no data	no data
213.01	211.08	no data	no data	212.61	no data	no data
212.99	211.35	no data	no data	212.57	no data	no data
212.99	211.51	no data	no data	212.59	no data	no data
213.03	211.70	no data	no data	212.61	no data	no data
213.11	211.54	no data	no data	212.65	no data	no data
213.14	211.46	no data	no data	212.66	no data	no data
213.12	211.20	no data	no data	212.64	no data	no data
213.09	211.15	no data	no data	212.61	no data	no data
213.09	211.25	no data	no data	212.57	no data	no data
213.08	211.16	no data	no data	212.59	no data	no data
213.06	211.32	no data	no data	212.58	no data	no data
213.04	211.30	no data	no data	212.59	no data	no data
213.03	211.58	no data	no data	212.59	no data	no data
213.00	211.23	no data	no data	212.61	no data	no data
212.98	211.45	no data	no data	212.59	no data	no data
213.00	211.58	no data	no data	212.58	no data	no data
213.03	211.56	no data	no data	212.61	no data	no data
213.02	211.35	no data	no data	212.63	no data	no data
213.00	211.22	no data	no data	212.61	no data	no data
212.99	210.99	no data	no data	212.59	no data	no data
213.01	210.92	no data	no data	212.57	no data	no data
213.01	211.05	no data	no data	212.58	no data	no data
213.02	211.10	no data	no data	212.60	no data	no data
213.03	211.21	no data	no data	212.61	no data	no data
213.08	210.98	no data	no data	212.63	no data	no data
213.12	210.88	no data	no data	212.61	no data	no data
no data	no data	no data	no data	no data	no data	no data

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Aerial view of Hart Mine Marsh, September, 2005

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