National Park Service
U.S. Department of the Interior

Kaloko-Honokōhau
National Historical Park

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Kaloko-Honokōhau

IN REPLY REFER TO:
L54 2015-10

August 12, 2015

Ms. Suzanne D. Case, Chairperson
Commission on Water Resource Management
P.O. Box 621
Honolulu, HI 96809

Subject: Specific information requested under Item C.3.a) of Preliminary Order HA-WMA-2013-1

Dear Chairperson Case:

The above referenced Preliminary Order requested specific information from the National Park Service (NPS) about the quantity of groundwater needed to support the natural and cultural resources of Kaloko-Honokōhau National Historical Park. The NPS determined that the existing quantity of fresh groundwater flowing through the Park is needed to support its groundwater-dependent resources (letter dated May 29, 2015). You informed the NPS that this was an unsatisfactory response (letter dated June 23, 2015).

The attached report presents the information relied upon by the NPS in making its determination. The NPS believes that this report, in addition to the specific information submitted by the NPS in response to Items C.3.b) and c) of the Preliminary Order (dated May 29, 2015), and the Commission's Preliminary Findings of Fact (dated January 30, 2015), and the information in the NPS petition for Water Management Area Action (dated September 13, 2013), are sufficient to determine that water-dependent public trust resources within the Keauhou Aquifer System are threatened by the combination of existing and proposed groundwater withdrawals.

A decision by the Commission to hold a public hearing on the matter will allow all stakeholders to provide input and will create the necessary administrative record to support a decision to designate the Keauhou Aquifer System a Water Management Area for groundwater. We believe that the management framework that exists in designated areas will increase our ability to cooperate around issues involving the stewardship of groundwater resources.

Sincerely,

Tammy Ann Duchesne
Superintendent

Attachment: Response to the Commission on Water Resource Management Request for Specific Information on the Quantity of Water Needed to Support Natural and Cultural Resources in Kaloko-Honokōhau National Historical Park

Response to the Commission on Water Resource Management Request for Specific Information on the Quantity of Water Needed to Support Natural and Cultural Resources in Kaloko-Honokōhau National Historical Park

Prepared by the National Park Service
August 2015

Executive Summary

Ola i ka wai – water is life. Water is also essential for the preservation of natural and cultural public trust resources in Kaloko-Honokōhau National Historical Park. This report to the State of Hawaiʻi Commission on Water Resource Management presents information relied upon by the National Park Service in determining that the current quantity of fresh groundwater flowing through the Park is the minimum amount required to support the Park's groundwater-dependent natural and cultural resources. This determination focused on aquatic resources that are at or near threshold conditions, or that require optimal conditions to avoid impairment of Park resources and values.

Groundwater within the Keauhou Aquifer System Area has been affected by changes in land use and declining rainfall. Groundwater salinity is increasing to the north and south of the Park, and groundwater levels are declining inland of the Park. Contaminants and human-caused nutrient enrichment within the Park's waters are evidence of its connection to the Keauhou Aquifer System. The National Park Service believes that additional groundwater withdrawals, if not optimally located, will exacerbate these observed trends and damage the Park's natural and cultural resources.

A reduction in the quantity of fresh clean groundwater flowing into the Park will lower groundwater levels and increase the salinity of the Park's fishponds, wetlands, and anchialine pools. Scientific and scholarly information indicate that these changes will adversely affect the ecological integrity of aquatic habitat for culturally important and rare native species. Reduced freshwater discharge will also increase the vulnerability of these aquatic ecosystems to drought and climate change. Additional losses in nursery habitat for native fish, in wetland habitat for endangered native waterbirds, or in anchialine pool habitat for the endemic damselfly that is now candidate for listing as endangered or threatened, due to new groundwater withdrawals for non-public trust purposes, would jeopardize the Park's natural and cultural resources and harm state public trust resources.

Maintaining the current flow of fresh clean groundwater through the Park is vital to fulfilling the Park's mission, purpose, and values. The National Park Service, therefore, requested that the Commission maintain groundwater withdrawals at 2014 levels in the area that contributes freshwater to Kaloko-Honokōhau National Historical Park. This geographic area includes many active wells and is less than 50% of the Keauhou Aquifer System Area.

The National Park Service believes that the Commission has an ample and sound technical and legal basis to continue the process to designate the Keauhou Aquifer System a Water Management Area for groundwater, and to schedule a public hearing on the designation petition.

Contents

Background

Kaloko-Honokōhau National Historical Park encompasses about 600 acres of terrestrial habitat and about 600 acres of marine waters and coral reef habitat. Fresh groundwater discharges to fishponds, wetlands, anchialine pools, tide pools, and nearshore waters within the Park (Figure 1). This fresher, colder, more buoyant groundwater mixes with seawater and creates estuarine conditions that support diverse and culturally significant aquatic ecosystems (e.g., Parrish et al. 1990; Johnson et al. 2008; Knee et al. 2008; Beets et al. 2010; Grossman et al. 2010).

On September 13, 2013, the National Park Service (NPS) requested that the State of Hawaiʻi Commission on Water Resource Management designate the Keauhou Aquifer System Area as a State Water Management Area for groundwater. The request, made by a petition for Water Management Area Action, was filed to protect natural and cultural public trust resources in the Park and was signed by the NPS Pacific West Regional Director.

The Commission visited the Park on September 17, 2014. On December 10, 2014, the Commission issued Preliminary Findings of Fact regarding the matter. On December 29, 2014, the Commission issued Preliminary Order HA-WMA-2013-1. Item C.3.a) of the Order requested that the NPS provide the Commission "*the quantity of ground water needed to support"* natural and cultural resources in the Park.

On May 20, 2015, at the Commission's monthly meeting, and in a letter dated May 29, 2015 to the Chairperson, the NPS stated that the existing quantity of fresh groundwater discharging in the Park was needed to support groundwater-dependent natural and cultural resources. In a letter dated June 23, 2015, the Chairperson stated "*no change from current conditions is an unsatisfactory response*" to the Preliminary Order.

This report presents information relied upon by the NPS in determining that the current quantity of fresh groundwater flowing through the Park is the minimum amount required to support the Park's groundwater-dependent natural and cultural public trust resources. This report incorporates information from the NPS' petition and the NPS' response to the Commission's Preliminary Findings of Fact (letter dated January 30, 2015), in addition to presenting new information.

This report should not be considered an exhaustive account of all of the aquatic species in the Park and how much freshwater they require at each stage of their life cycle. While much is known about fish and wildlife and their habitat in the Park, these ecosystems are complex and continuously changing. Using our current knowledge and understanding, the NPS has focused on those aquatic species that are at or near threshold conditions for their survival, or that require protection of optimal conditions to avoid impairment of the Park's resources and values.

In order to provide a policy and scientific context for the NPS' determination, this report will review the mission of the Park, the congressional mandate of the NPS, and the management policies that direct the NPS to prevent unacceptable impacts and impairment of Park resources and values. These resources and values are also beneficiaries of the protections afforded by the public trust doctrine as it governs water management in Hawaiʻi.

Park Mission & Mandate

In 1978, Congress established Kaloko-Honokōhau National Historical Park "*to provide a center for the preservation, interpretation, and perpetuation of traditional Native Hawaiian activities and culture, and to demonstrate historic land use patterns as well as to provide a needed resource for the education, enjoyment, and appreciation of such traditional Native Hawaiian activities and culture by local residents and visitors*" [16 USC 396d(a)].

As mandated by Congress, the NPS administers the Park pursuant to the laws, regulations, and policies applicable to units of the national park system. The fundamental law for national parks is commonly referred to as the 1916 Organic Act, which requires the NPS "*to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*" [4 USC 100101(a), 100301 *et seq.*].

In creating the Park, Congress instructed the NPS to administer the Park in accordance with the guidelines provided in "*The Spirit of Ka-loko-Hono-kō-hau, a proposal for the establishment of a Ka-loko Honō-ko-hau National Cultural Park, Island of Hawai'i, State of Hawai'i*" (Honokōhau Study Advisory Commission 1974) [16 USC 396d(c)].

Congress also authorized the Secretary of the Interior to "*enter into agreements with other governmental entities and private landowners to establish adequate controls on air and water quality and the scenic and esthetic values of the surrounding land and water areas*" [16 USC 396d(d)(4)].

The Park's 1994 General Management Plan sets out the policies and actions to perpetuate the traditional use of the Park's cultural sites and features, to provide for cultural and natural resource protection, restoration, and management based upon the best available scientific data, and to provide quality visitor experience and education (NPS 1994).

The significance and importance of fresh clean groundwater to the mission of the Park cannot be overstated. The Spirit Report declares that "*the dynamic thread that ties the environment together is water*" (Honokōhau Study Advisory Commission 1974). Traditional and customary Native Hawaiian practices rely heavily on the quality and quantity of groundwater in the Park (Roy & Nahale 1975; Maly & Maly 2002; Peterson & Orr 2005; Scheuer & Isaki 2015). Noting the connection between the natural and cultural resources in the Park, the Hawai'i State Land Use Commission ruled that "*any impacts to waters in the National Park would, in and of itself, be an impact to cultural resources*" (Docket A00-732, Finding of Fact 190).

Limits of Acceptable Change

NPS Management Policies direct park managers to avoid unacceptable impacts – those changes that "*individually or cumulatively, would be inconsistent with a park's purposes or values or impede the attainment of the park's desired future conditions for natural and cultural resources*" (NPS 2006). This metric of "unacceptable change" is the policy basis for the NPS' request that the State of Hawai'i not allow groundwater withdrawals to increase above the 2014 average in the geographic area of concern for the NPS.

The NPS has preliminarily determined that the area of concern is less than 50% of the Keauhou Aquifer System Area. This geographic area encompasses the lands where rainfall and fog drip recharge the groundwater systems that contribute freshwater to the Park, as well as the areas within which a pumped well will capture water that would otherwise flow through the Park. The diffuse discharge of fresh groundwater within this geographic area cannot be directly measured, but the area will be further delineated in the near future based upon the most current data and modeling.

The current quantity of fresh groundwater flowing through the Park is the minimum volume necessary to preserve and protect the water-related natural and cultural public trust resources at the limit of acceptable change. Further reduction in discharge would produce unacceptable changes to the Park's public trust resources and frustrate the NPS' ability to manage for and maintain current resource conditions and processes. Left unchecked, the Park's resources and values would eventually continue to degrade from a condition of unacceptable change to one of "impairment."

NPS Management Policies define impairment as any impact to a park unit's resources or values that are necessary to fulfill the specific purposes identified in the park unit's enabling legislation or proclamation or that are key to the biological or cultural integrity of the park (NPS 2006). These policies define park resources and values as "*…the park's scenery, natural and historic objects, and wildlife, and the processes and conditions that sustain them … including the ecological, biological, and physical processes that created the park and continue to act upon it …*" Impairment to a park unit's resources and values is expressly prohibited unless the park's enabling legislation or proclamation explicitly provides otherwise. Nothing in Kaloko-Honokōhau National Historical Park's enabling legislation authorizes the impairment of the Park's natural and cultural public trust resources in order to accommodate the withdrawal of groundwater for non-public trust purposes.

Within the context of its congressional mandate and management policies, the NPS has identified groundwater-dependent resources in the Park for which a decrease in fresh groundwater flow would produce unacceptable change. These resources include nursery habitat for native fish, essential habitat for two species of endangered native waterbirds, and breeding habitat for an endemic damselfly that is a candidate for listing under the Endangered Species Act. These resources and the important role of freshwater in maintaining the ecological integrity of these resources are discussed in the following sections of this report.

Traditional Hawaiian Fishpond Aquaculture and Subsistence Fishing

> *As far as I'm concerned it is critical that all that we have in the groundwater supply be maintained in perfect condition for the sake of our people that are living in this area. The time will come when they will need that and we cannot afford to jeopardize our marine life along the shorelines …Traditional practices can still be maintained without any trouble as far as the park is concerned, I'm sure… Our traditional rights involved the fishing supply drastically, I mean radically. We cannot afford to jeopardize that… If we don't allow our freshwaters to produce the proper quantity of fish we're not going to have our traditional practices. One leads to the other. Gathering rights begins right there, preservation of the shoreline.*
>
> (David 'Mauna' Roy Jr., Chairman of the Kaloko-Honokōhau Advisory Commission, in testimony to the State of Hawai'i Land Use Commission, Docket A00-732, July 18, 2001).

The Park's fishponds and fishtrap provided tranquil embayments for storing, raising, and fattening *ʻamaʻama* or striped mullet (*Mugil cephalus*), *ʻōpae* or shrimp (*Penaeus marginatus)*, and *awa* or milkfish (*Chanos chanos*) (Peterson & Orr 2005). According to oral history interviews, the following species were also collected in the Park's fishponds: *halahala* or baby amberjack (*Seriola* sp.), *ʻōʻio* or bonefish (*Albula* vulpes), *pāpio* or young crevalle (*Caranz* sp.), and *ʻaʻama* or black crab (*Grapsus* sp.) (Peterson & Orr 2005). Other culturally important native fish observed in the Park include *āholehole* or Hawaiian flagtail (*Kuhlia sandvicensis*) and *ʻoʻopu akupa* (*Eleotris sandwicensis*), among others (Brasher 1999; Beets et al. 2010; MacKenzie & Bruland 2012).

This report focuses on the protection and propagation of the native striped mullet, one of two species of native mullet and a culturally significant estuarine species in Hawaiʻi. Mullet were highly prized by Hawaiian royalty and appear in many Hawaiian legends as a "supernatural fish" (Wyban 1992).

Striped mullet are diadromous and euryhaline. Adult (> 3 years) mullet migrate offshore during winter months to spawn. Larvae (when about 16-20 mm long) return in small schools to intertidal estuarine-like habitat along the coast.

Striped mullet were once plentiful in Hawaiʻi, but their numbers have declined due to habitat alteration (Shomura 1987; Nishimoto et al. 2007). The number of fishponds used to cultivate mullet and other estuarine species has declined over the last century from about 360 in 1778 to only two in 2003 (Costa-Pierce 1987; Nishimoto et al. 2007). The State of Hawaiʻi is working to protect essential nursery habitat for juvenile striped mullet, and found that traditional Hawaiian fishponds may need further protection (Nishimoto et al. 2007).

Hawaiian fishponds are cultural treasures and valuable educational tools; through ancient fishponds, Hawaiians can reclaim and perpetuate a living heritage of aquaculture (Wyban 1992). Because the NPS is working to restore Kaloko Fishpond for traditional aquaculture, maintaining optimal natural growing conditions for the striped mullet is essential to support harvesting practices. It is not sufficient that this principal aquaculture species merely be present in the fishpond. Conditions must be optimal to support healthy productive stocks of striped mullet that can endure harvesting pressure in order to restore traditional Hawaiian aquaculture at Kaloko Fishpond.

Kaloko Fishpond

Hawaiian fishponds are considered one of the most important technological, social, economic, and cultural concepts developed in ancient Hawaiʻi (Keala et al. 2007). Kaloko Fishpond is one of three traditional aquaculture sites located within the Park and is one of the Park's most significant cultural resources (Figure 1). Numerous oral histories and interviews document fresh groundwater outflow, seeps and springs in and around Kaloko Fishpond, and the harvesting of mullet and milkfish from Kaloko Fishpond for residents of Kona and Hilo until the late 1950s (Roy & Nahale 1975; Parrish et al. 1990; Wyban 1996; Maly & Maly 2002; Peterson & Orr 2005; Scheuer & Isaki 2015).

Kaloko Fishpond is a *loko kuapā* or shoreline pond enclosed by a constructed seawall. *Loko kuapā* are unique to the Hawaiian Islands and are considered the ultimate aquaculture achievement of the Native Hawaiians (e.g., Summers 1964; Costa-Pierce 1987). *Loko kuapā* were used to raise many aquatic species, especially mullet and milkfish. They were stocked with *pua ʻama* or mullet fingerlings, which were then grown to adulthood and harvested. Kaloko Fishpond has good natural recruitment of both mullet and milkfish (written communication, Tyler Paikuli-Campbell, NPS, 6/19/2015). The last stocking is believed to have occurred in the mid 1900's (Wyban 1996).

The Kaloko Fishpond *kuapā* (seawall) extends 800 feet across an 11-acre natural spring-fed embayment. The seawall was damaged repeatedly over time by tsunamis in 1946 and 1960, hurricanes, and wave and wind action. The seawall was restored between 1995 and 2012.

Kaloko Fishpond is open to the sea through two *ʻauwai kai* (channels). The channels allow water exchange and circulation within the pond. *Mākāhā* (sluice gates) were placed within the channels to regulate the movement of fish. The spaces between the wooden poles of the gates were large enough to allow young fish to enter the pond, but too small for large fish to escape. *ʻAuwai o ka mākāhā* are considered to be the outstanding technological feature of ancient Hawaiian fishponds.

It is estimated that Kaloko Fishpond has been in existence since the late 1500s (Tomanari-Tuggle & Tuggle 2006). Until 1848, Kaloko Fishpond belonged to the *aliʻi* or ruling chiefs of Kona as a ready source of striped mullet, especially during the *kapu* (prohibition) season (Kikuchi & Belshe 1971; Wyban 1996). After the Māhele of 1848, Kaloko Fishpond was awarded to Prince Lota Kamehameha (Kamehameha V) (Land Commission Award 7715) and changed ownership several times until being acquired by the NPS in 1986 (Land Court Document No. 1422276).

Importance of Fresh Groundwater to Native Striped Mullet Habitat

The survival and growth of striped mullet are salinity and temperature dependent at all life stages. Except for spawning adults and the early larval stages, striped mullet inhabit coastal estuarine-like waters (Nishimoto et al. 2007). Optimal salinity for striped mullet eggs is full strength seawater (e.g., Sylvester et al. 1975). Optimal conditions for the survival of striped mullet larvae are estimated to occur within a salinity range of 26-28 ppt (74-80% seawater) at 25º C (Sylvester and Nash 1975; Sylvester et al. 1975; Nash & Shehadeh 1980; Collins 1985).

Freshwater tolerance increases with body size. Juvenile striped mullet inhabit protected shallow estuarine areas, congregating where there is significant freshwater outflow from streams or submarine groundwater discharge (Nishimoto et al. 2007). In one study, juvenile striped mullet grew fastest at 17 ppt and 25º C (Peterson et al. 2000). The Commission acknowledged that juvenile mullet "*depend on a euryhaline or brackish water environment for the nursery stage of their life cycle*" (Contested Case Hearing CCH-MO97-1, Finding of Fact 147). The Hawaiʻi State Division of Aquatic Resources has also found a positive relationship between fresh groundwater discharge into estuaries and juvenile fish recruitment (Shimoda et al. 2014).

The native striped mullet plays a critical role in controlling algal growth in estuarine conditions (written communication, Robert T. Nishimoto, 8/9/2015). Striped mullet are herbivorous and feed on plant detritus and microscopic algae, particularly diatoms that thrive in brackish water (Summers 1964; Collins 1985; Wyban 1992). Chris Cramer of the Maunalua Fishpond Heritage Center notes that striped mullet are also attracted to *limu ele ele* (*Enteromorpha prolifera*), a type of edible seaweed that is common wherever freshwater streams or springs enter the ocean (Abbot 1984). The following was told to Mr. Cramer by fisherman John Kelly http://www.maunalua.net/Maunalua_Bay_Fishponds.html):

> *Because the mullet always swim against the current because they eat the stuff that clings to the Ele Ele (seaweed)'.That's that green filamentous seaweed that grows about this long and half an inch wide and very thin. You see it at Waikiki and wherever there's freshwater, you know. This Ele Ele seaweed has little things that cling to it, the mullets' mouth is shaped in order that they eat those little things.*

That's their food supply. The way they determine how to find the Ele Ele seaweed is they always swim against the current. They know where the freshwater is: you can taste the freshwater. So they swim against the current in order to find the Ele Ele seaweed where it grows in the freshwater.

The Commission has determined that a reduction in groundwater discharge may adversely affect the growth and availability of *limu* (seaweeds) in nearshore waters (Contested Case Hearing CCH-MO97-1, Finding of Fact 144). One study indicates that the growth rate of *limu manauea* (*Gracilaria coronopifolia*), a culturally important species native to the Kona Coast, increases as salinity decreases below that of seawater, with optimal conditions occurring at a salinity of about 27 ppt (80% seawater) (Amato 2009; Duarte et al. 2010).

Traditional Hawaiian fishponds were strategically located where a mixture of nutrient-rich freshwater and ocean water created a productive brackish-water environment. Areas where freshwater springs or streams discharge into shallow coastal waters provide protective habitat and optimal growing conditions for mullet fingerlings (Summers 1964; Nishimoto et al. 2007). The estuary-like conditions allowed a consistent yield of fish with little or no need for supplemental fertilization (Keala et al. 2007). Incoming fresh groundwater not only made shoreline ponds more productive, according to Hawaiians, brackish water also produced the sweetest of fish (Wyban 1992; Keala et al. 2007).

Water depth, temperature, salinity, dissolved oxygen, and nutrient composition are all important factors in fishpond aquaculture and all of these parameters are affected by fresh groundwater discharge. Fish need oxygen to survive and a dissolved oxygen concentration of 5 milligrams per liter (mg/L) is considered optimum for the culture of fish in Hawaiian fishponds; as temperature and salinity of the water increases, the amount of available dissolved oxygen decreases (Keala et al. 2007). Nutrient enrichment beyond background levels can also deplete oxygen by causing excessive plant growth and unhealthy or toxic conditions in the fishpond and nearshore waters (e.g., Keala et al. 2007; Dailer et al. 2010).

According to Nash & Shehadeh (1980), the optimum salinity for the growth of broodstock mullet in ponds is brackish water with a salinity of 10-25 ppt. Madden & Paulsen (1977) surveyed 67 Hawaiian fishponds to determine their suitability for the culture of mullet. Of the 6 ponds that they selected as having "excellent" potential for traditional mullet production, 5 had salinities from 2-5 ppt. They state that optimal salinity for the culture of mullet in Hawaiian fishponds is between 5 and 20 ppt.

Current Conditions

All marine fishing and shoreline gathering activities in the Park must be conducted in accordance with state laws and regulations. At this time, Park visitors are permitted to engage in subsistence fishing (by use of a fishing pole) at Kaloko Fishpond. The State of Hawaiʻi requires that any gill-nets used within the Park's marine waters be locally constructed and handmade of natural fibers.

The NPS is actively restoring Kaloko Fishpond so that it can be managed as a traditional Hawaiian fishpond and support traditional and customary practices. Restoration of the Kaloko Fishpond seawall was completed in 2012 and the NPS continues regular maintenance and repair. Kaloko Fishpond had a noticeable recruitment of striped mullet in 2015 (written communication, Tyler Paikuli-Campbell, NPS, 6/19/2015).

The NPS is identifying and evaluating methods to sustainably harvest fish in the Park and is striving to conduct a fish harvest at Kaloko Fishpond within the year. Overharvesting of striped mullet in Kaloko Fishpond will be prevented through the use of traditional methods of resource management and protection, and by teaching participants about the sustainability of such methods.

Salinity varies spatially and with depth in Kaloko Fishpond. The most recent salinity transect indicates that the salinity of water in Kaloko Fishpond ranges between 14.8 and 28.0 ppt (42% to 80% seawater) (Table 1). Figure 2 compares optimal conditions for the propagation of striped mullet with salinity measurements from Kaloko Fishpond over time. These data indicate that water in some areas of Kaloko Fishpond currently exceeds the optimal range for the growth of juvenile striped mullet (Figure 2).

The current flow of fresh groundwater to Kaloko Fishpond must be maintained in order to protect the current temperature, salinity, dissolved oxygen, and nutrient composition of this water body. The NPS believes that a reduction in fresh groundwater discharge within the Park will reduce nursery habitat for the native striped mullet. This habitat and the productivity of culturally important fish must be preserved in accordance with the Park's unique enabling legislation and the Organic Act. The NPS also recognizes that the striped mullet is an important public trust resource in Hawaiʻi for both ecological and cultural reasons. **The loss of native juvenile fish habitat, or a loss in the productivity of Kaloko Fishpond due to new groundwater withdrawals for non-public trust purposes, would jeopardize one of the core functions of the Park and damage a state public trust resource.**

Endangered Native Waterbird Habitat

Kaloko Fishpond, ʻAimakapā Fishpond, and their associated wetlands are listed as "Core Wetlands" by the U.S. Fish & Wildlife Service (USFWS) in their Recovery Plan for Hawaiian Waterbirds (USFWS 2011) (Figure 1). Core Wetlands are areas that support large populations of Hawaiian waterbirds and provide permanent habitat that is essential for their survival and recovery.

Core Wetlands in the Park are maintained by fresh groundwater and provide important feeding and breeding sites for two native waterbirds that were federally listed as endangered in 1970. ʻAimakapā Fishpond is considered one of two key breeding areas for the endangered waterbirds on Hawaiʻi Island.

The endangered *ʻalae keʻokeʻo* or Hawaiian coot (*Fulica americana alai*) is a small endemic diving bird whose chicks are able to swim and forage as soon as their down has dried. Nesting habitat includes freshwater and brackish ponds and taro fields (State of Hawaiʻi 2005). Native Hawaiians considered the coot to be a deity (State of Hawaiʻi 2005) and Wyban (1992) considers the coot to be a symbol of "*cultural continuity.*"

The endangered *aʻeo* or Hawaiian stilt (*Himantopus mexicanus knudseni*) is a slender wading bird whose chicks leave the nest within 24 hours but remain with their parents for several months. Nesting occurs on freshly exposed mudflats with low-growing vegetation and islands in fresh and brackish-water ponds (State of Hawaiʻi 2005).

Importance of Fresh Groundwater to Native Waterbird Habitat

Hawaiian coots and stilts both need access to freshwater to successfully rear their young while the chicks are unable to fly. Hawaiian stilts have a wider salinity tolerance than Hawaiian coots, but are more productive in freshwater (i.e., more breedings and higher success rates) (written communication, Aaron Nadig, USFWS, 9/15/2014). The salinity threshold for young waterbirds is estimated to be about 10 ppt (29% seawater) based upon observations at sites on Oahu (written communication, Aaron Nadig, USFWS, 6/29/2015).

Avian botulism (*Clostridium botulinum*) is the most prevalent disease affecting Hawaiian waterbirds. In 1994, an avian botulism outbreak at ʻAimakapā Fishpond decimated the endangered Hawaiian coot population in the pond; changes in physical and biotic factors, including salinity and reduced fresh groundwater influx, were identified as potential contributing factors (Morin 1996; Morin 1998).

Lowered groundwater levels and saltwater intrusion resulting from reduced fresh groundwater discharge will adversely affect the food availability and integrity of coastal wetland habitat for Hawaiian waterbirds, and ultimately the long-term recovery of these endangered species (State of Hawaiʻi 2005; USFWS 2011).

Current Conditions

The Hawaiian coot and the Hawaiian stilt were once common in Hawaiʻi but are now endangered due to loss of wetland habitat and increased predation by introduced animals. Other threats that have contributed to the decline of the endangered waterbirds, and that continue to be detrimental, include the alteration of hydrology, specifically the modification of wetland habitat to provide municipal water sources (State of Hawaiʻi 2005; USFWS 2011).

In accordance with the Spirit Report (Honokōhau Study Advisory Commission 1974), the NPS manages ʻAimakapā Fishpond primarily to avoid adverse effects to wildlife that inhabit the pond. The most recent salinity transect recorded salinities between 11.5 and 12.9 ppt (33% to 37% seawater) in ʻAimakapā Fishpond (Table 1). These data indicate that water in some areas of ʻAimakapā Fishpond currently exceeds the estimated salinity threshold of 10 ppt for young endangered waterbirds (Figure 2).

Habitat protection, including fresh groundwater flow, is the key to the continued survival and recovery of the endangered native Hawaiian waterbirds. The endangered Hawaiian coot and Hawaiian stilt must be able to reproduce in the Park. Habitat for endangered native Hawaiian waterbirds in the Park must be preserved in accordance with the Park's unique enabling legislation, the Organic Act, and the Endangered Species Act. The NPS also recognizes that the endangered Hawaiian coot and the endangered Hawaiian stilt are important public trust resources in Hawaiʻi for both ecological and cultural reasons. **Loss of Core Wetland waterbird habitat in the Park due to new groundwater withdrawals for non-public trust purposes would both increase the risk of the extirpation of endangered waterbirds from the Park and damage a state public trust resource.**

Anchialine Pool Habitat

The NPS has identified over 185 anchialine pools within the Park's boundaries (NPS 2015a). Anchialine pools are brackish coastal water bodies that contain a mixture of seawater and fresh groundwater. Anchialine pool habitat is threatened statewide by habitat change and loss (State of Hawai‘i 2005; Marrack et al. 2015).

The Park's anchialine pool habitat supports diverse endemic biota including three species of Hawaiian anchialine shrimp (*Halocaridina rubra, Metabetaeus lohena, Palaemonella burnsi*), and a species of *pinao‘ula* (damselfly), the orange-black Hawaiian damselfly (*Megalagrion xanthomelas*).

‘Ōpae ‘ula (*Halocaridina rubra*) have profound cultural significance to Native Hawaiians who use them both as a food source and as bait for catching fish (e.g., Maly & Maly 2002; Peterson & Orr 2005). The other two shrimp species and the native orange-black Hawaiian damselfly are currently candidates for listing as threatened or endangered under the Endangered Species Act. Candidate species, according to the USFWS, face immediate, identifiable threats. This report focuses on the protection of breeding habitat for the candidate damselfly.

Importance of Fresh Groundwater to Native Damselfly Habitat

The orange-black Hawaiian damselfly is an endemic species whose habitat includes streams, anchialine pools, and coastal wetlands. The egg and larval life stages of the orange-black Hawaiian damselfly are exclusively aquatic (e.g., Tango 2010). Immature damselfly larvae emerge after 21 days and live in the water under submerged vegetation.

Field observations indicate that the endemic orange-black Hawaiian damselfly can tolerate salinities as high as 8 ppt (Polhemus 1996). Laboratory studies provide evidence that the eggs and larvae of the orange-black Hawaiian damselfly are sensitive to increased salinity and temperature, and indicate that larvae exhibit a threshold response to salinity above 15 ppt, with no larvae surviving at 20 ppt (57% seawater) (Tango 2010). The NPS believes that reduced fresh groundwater discharge, saltwater intrusion, or dewatering of anchialine pools in the Park will adversely affect the ability of this candidate species to reproduce in the Park.

Current Conditions

The endemic orange-black Hawaiian damselfly was once one of the most abundant damselflies in the Hawaiian Islands, but habitat loss and introduced species have contributed to its current status as a candidate species (e.g., Polhemus 1996). The native damselfly is no longer found on Kaua‘i, and is restricted to a total of 16 populations across O‘ahu, Maui, Moloka‘i, Lāna‘i and Hawai‘i. Therefore, there is a strong likelihood that it will be listed by the USFWS as threatened or endangered.

The Park's anchialine pools provide important breeding habitat for the orange-black Hawaiian damselfly. A 2008-2009 inventory indicated that the mean salinity of the Park's anchialine pools is about 15 ppt (43% seawater) (NPS 2015a). Figure 1 shows the anchialine pools in the Park where orange-black Hawaiian damselfly breeding was documented in the two most recent surveys (written communication, David Foote, USGS, 4/14/2015).

Two of the anchialine pools in the Park where orange-black Hawaiian damselfly breeding was observed in the 2014-2015 survey (HA_Kaloko_007 and HA_Kaloko_032) were sampled at least 15 times between 2004 and 2014. Salinity ranged from 11.1 to 15.3 ppt over this period (NPS 2015a). While it is important to be cautious about extrapolating thresholds derived from laboratory experiments to field conditions, it is also important to recognize that the salinity of water in these pools is near the published threshold of 15 ppt for the damselfly larvae, and that reduced fresh groundwater discharge will increase salinity beyond this threshold (Figure 2).

Preserving anchialine pools that support existing populations of damselflies, and protecting key breeding habitats is essential to reducing the risk of extinction of native damselflies (State of Hawaiʻi 2005). The endemic orange-black Hawaiian damselfly is a candidate for listing under the Endangered Species Act and must be able to complete its life cycle in the Park. Habitat for the orange-black Hawaiian damselfly in the Park must be preserved in accordance with the Park's unique enabling legislation and the Organic Act. **Degradation and loss of anchialine pool habitat in the Park for the endemic orange-black Hawaiian damselfly due to new groundwater withdrawals for non-public trust purposes would both increase the risk of species extinction and damage a state public trust resource.**

Threats to Fresh Groundwater Discharge

Fresh groundwater supports native plants and animals in the Park, and the cultural practices and recreational activities that rely upon them, all of which are at risk from changing environmental conditions and human activities. The following existing and potential future threats to the supply of fresh groundwater in the Park were considered by the NPS in its determination of the quantity of groundwater needed to support the Park's natural and cultural public trust resources.

Declining Rainfall and Rising Sea Level

The sustainability of the Keauhou Aquifer System's fresh groundwater supplies and aquatic ecosystems are threatened by declining rainfall, periods of drought, and sea-level rise (e.g., State of Hawaiʻi 2011; Wallsgrove & Penn 2012). Nearshore areas such as the Park are the most vulnerable to warmer, drier conditions (Keener et al. 2012).

Rainfall has been declining statewide in Hawaiʻi for nearly a century (Giambelluca et al. 2013; Univ. of Hawaii 2014). The Kona area has experienced the largest long-term declines in annual rainfall (Frazier 2014) and the drying trend is expected to continue on the dry leeward sides of the islands for the next 25 to 55 years (Timm 2014). Periods of low mean rainfall during 1984-2008 coincided with periods of lowest groundwater recharge in the Kona area (Engott 2011). Declining rainfall will reduce the amount of freshwater available for drinking and irrigation.

Sea level in Hawaiʻi has also risen as much as one foot over the past century (NOAA 2013). Rising sea level is expected to exacerbate saltwater intrusion into the coastal groundwater system.

Reducing fresh groundwater discharge to water-dependent natural and cultural public trust resources increases the vulnerability of these resources to the adverse effects of decreasing rainfall, drought, and climate change. Preserving existing flows of fresh groundwater through the Park will increase the resiliency of these resources and their ability to adapt to changing environmental conditions. The NPS believes that maintaining diverse and resilient aquatic ecosystems is a necessary natural defense against the risks related to these threats.

Groundwater Withdrawals

Groundwater withdrawals within the Keauhou Aquifer System Area have increased from 3.5 million gallons per day (Mgal/d) in 1978 to 14.5 Mgal/d in 2014. Under the existing management framework, the state may continue to permit new uses until total withdrawals reach the state-determined sustainable yield of the Keauhou Aquifer System (38 Mgal/d).

The sustainability of the Keauhou Aquifer System's freshwater supplies is dependent upon the spatial distribution as well as the magnitude of these groundwater withdrawals. Withdrawals are now two times higher in the Park's four *ahupuaʻa* (historic Hawaiian land divisions) than in the Keauhou Aquifer System as a whole (279 vs. 138 gallons per day/acre, respectively).

The methodology that the Commission uses to calculate the sustainable yield assumes that groundwater recharge in the Keauhou Aquifer System flows from the slopes of Hualalai to the coast and that all withdrawals from the coastal freshwater-lens (basal) system and the inland impounded (high-elevation) system reduces groundwater discharge to coastal areas.

Although it is generally agreed that withdrawals from the coastal freshwater-lens system will lower groundwater levels and contribute to saltwater intrusion in the coastal aquifer, it is more difficult to predict how the coastal system will respond to withdrawals at higher elevations. It is generally assumed that groundwater flows from *mauka* (the mountains) to *makai* (the ocean) in the area of the Park and geochemical analyses confirm that groundwater from the inland high-elevation system eventually recharges the coastal freshwater-lens system (Fackrell & Glenn 2014; Tillman et al. 2014a; Tillman et al. 2014b, Kelly & Glenn 2015). The nature of the geologic structures that impound groundwater at higher elevations in this area, however, is uncertain.

One well in the area of the Park (Kamakana Well No. 3959-001) indicates the presence of a coastal confined groundwater system deep below the freshwater-lens system (Wilson Okamoto Corporation and Hoʻokuleana LLC 2013; Tillman et al. 2014b). The geographical extent of this confined system, and its recharge and discharge areas, are presently unknown.

It has been speculated that the coastal freshwater-lens system is not hydrologically connected to either the inland or deep confined systems in the area near the Park (e.g., Wilson Okamoto Corporation and Hoʻokuleana LLC 2013). Under this scenario, the coastal freshwater-lens system would be entirely dependent upon local rainfall to mitigate the effects of saltwater intrusion on pumped wells and aquatic ecosystems, and to flush contaminants from the system. The coastal system would then be even more vulnerable to groundwater withdrawals from, and the injection of brine into, the freshwater-lens system, to declining rainfall, to sea-level rise, and to contamination.

According to fundamental hydrologic principals, peer-reviewed published groundwater models (e.g., Oki et al. 1999), and the Commission's Preliminary Findings of Fact, groundwater withdrawals in the area of the Park from the coastal freshwater-lens system, and to a lesser degree from the inland impounded system, capture fresh groundwater that would otherwise discharge to fishponds, wetlands, anchialine pools, tide pools, and nearshore marine waters within the Park. A reduction in fresh groundwater flowing through the Park will lower groundwater levels and increase the salinity of the Park's waters. The NPS believes there is sufficient credible evidence to indicate that such changes in the area of the Park will adversely affect the Park's natural and cultural public trust resources and the Native Hawaiian traditional and customary practices that rely upon them.

The NPS recognizes that there is uncertainty regarding the extent of the hydrologic connection between the inland and coastal systems, the hydrologic connection between these groundwater systems and a deeper confined system, the role of perched groundwater, and the extent of the recharge and discharge areas for these groundwater systems (e.g., Tillman et al. 2014a; Tillman et al. 2014b, Kelly & Glenn 2015; Whittier et al. 2015). However, as stated by the Hawaiʻi Supreme Court, the lack of full scientific certainty does not extinguish the presumption in favor of public trust purposes or vitiate the Commission's affirmative duty to protect such purposes when they are threatened by existing and reasonably foreseeable future groundwater withdrawals (*see* Waiāhole Combined Contested Case Hearing, Appeal from the Commission on Water Resource Management, August 22, 2000).

Observed Changes

Land use has changed dramatically around the Park since it was established in 1978. Although water resources within the Park remain generally uncontaminated, there is evidence of human-caused impacts on water quality.

In 1996, phenol, a semi-volatile organic compound used in industrial and domestic products, was detected at low concentrations in three wells in the Park (Oki et al. 1999). In 2009, three pharmaceuticals present in wastewater (carbamazepine, sulfamethoxazole, and thiabendazole) were detected at low concentrations in KAHO Well 2 (4161-002); one pharmaceutical (carbamazepine) was detected in an anchialine pool in the Park near the harbor; and laundry fabric brighteners were detected in three other anchialine pools in the Park, in all of the Park's observations wells, and in ʻAimakapā Fishpond (Hunt 2014). Nutrient inputs have increased in Honokōhau Bay and the early impacts of increased loadings on the coral ecosystem are evident (Parsons et al. 2008). In 2008, the state identified Honokōhau Bay as impaired under the Clean Water Act for increased nutrients and that listing remains in effect today.

The presence of contaminants and human-caused nutrient enrichment in the Park's waters is evidence of their connection to the Keauhou Aquifer System Area and of the aquifer's susceptibility to contamination. Given estimated travel times of 30+ years from groundwater recharge to discharge areas, the full extent of such pollution may not yet be fully evident along the coast (Kelly & Glenn 2015).

The observed response of the Keauhou Aquifer System Area to changes in recharge, groundwater withdrawals, and wastewater injection further demonstrates the urgency of protecting fresh groundwater discharge to natural and cultural public trust resources in the Park. This section of the report reviews salinity data collected from the fishponds, anchialine pools, and observation wells in the Park over time, and observed changes in groundwater levels and salinity elsewhere in North Kona. This report focuses on salinity because of the importance of salinity in creating the estuarine conditions for the native species described here to thrive, because of its historic record of measurement, and because it is directly related to the quantity of fresh groundwater in the Park. Overall, salinity data indicate changes in salinity beyond background levels and outside of the natural variability caused by ocean tides.

Salinity in the Park

Fishponds

Several studies of Kaloko and ʻAimakapā Fishponds provide information on long-term changes in salinity. Morin (1998) and Brasher (1999) both reviewed existing salinity data for one or both of the fishponds and Brasher (1999) incorporated new data. The 2005 Coastal Watershed Condition Assessment (Hoover & Gold 2005) analyzed these and other existing data for long-term trends. Table 1 summarizes the salinity data reviewed in the above studies and incorporates new data.

The 2005 Assessment concluded that, overall, salinities in both Kaloko and ʻAimakapā Fishponds were lower in 1971 than in more recent sampling, but sampling artifacts, such as the use of different instrumentation, and the varying integrity of the Kaloko Fishpond seawall over time, make the use of historic salinity data from the fishponds problematic (Hoover & Gold 2005). Salinity data from ʻAimakapā Fishpond is more robust because the fishpond is separated from the sea by a natural sand barrier, and these data can be used to support qualitative statements about long-term trends in salinity. Recent data indicate that the salinity of ʻAimakapā Fishpond remains higher than it was prior to 1975 (Figure 2).

Anchialine Pools

Oral histories and witness testimony on behalf of the NPS substantiate that Native Hawaiians once utilized certain fresh groundwater springs and anchialine pools in the Park for drinking water (Honokōhau Study Advisory Commission 1974; Roy & Nahale 1975; Maly & Maly 2002; Scheuer & Isaki 2015). Monitoring data indicate that there is no potable water in the Park today.

The freshest water measured in the Park's anchialine pools by the NPS had a salinity of 2.5 ppt (7% seawater) at high tide on December 12, 2008, about 8 hours after a significant rainfall event (pool HI_Honoko_21) (personal communication, Sallie Beavers, NPS, 2010; NPS 2015a).

Previous studies provide information about the salinity of the groundwater discharging to the Park's anchialine pools over time:

- A 1972-1973 survey of 318 anchialine pools in West Hawaiʻi indicated that the salinity of pools that appear to be within the present-day boundaries of the Park ranged from 4 to 18 ppt (11% to 51% seawater) (Maciolek & Brock 1974).

- A 1988 survey of 10 anchialine pools indicated that salinity ranged from 8.5 to 21.5 ppt (21% to 61% seawater) (Chai (unpubl.), *as cited in* Jackson & Rosenlieb 1989).

- A 1994-1996 survey of 16 anchialine pools in and adjacent to the Park indicated that salinities ranged from 8 to 17 ppt (24% to 48% seawater) (Brock and Kam 1997).

- A 2004-2006 survey of 8 anchialine pools in the Park indicated that salinities ranged from 4.8 to 15.68 ppt (14% to 45% seawater) (Bienfang 2007).

- A 2003-2006 survey of 42 anchialine pools in the Park indicated that salinities ranged from 8.2 to 25.0 ppt (23% to 71% seawater) (Knee et al. 2008).

The 2005 Coastal Watershed Condition Assessment reviewed anchialine pool salinity data from a number of studies completed between 1972 and 2005; the authors concluded that salinities were much lower in 1972 than in later studies, but cautioned that variability due to sampling artifacts, tidal effects, and the low frequency of sampling should be considered when discussing long-term salinity trends in the anchialine pools (Hoover & Gold 2005).

In 2008, the NPS Pacific Island Inventory & Monitoring Network implemented an anchialine pool monitoring protocol to assess current ecosystem health and trends over time; water quality is one of the "vital signs" monitored by the NPS under this protocol (Jones et al. 2011). The NPS anchialine pool database and a summary report for the period 2008-2011 are available online (NPS 2015a; Raikow & Farahi 2014). Average salinities in 183 anchialine pools in the Park during the period 2004-2014 ranged from 8.4 to 25.6 ppt (24-73% seawater) (NPS 2015a). These data indicate that surface conditions in the anchialine pools remain relatively constant despite large daily water-level fluctuations due to the ocean tide (Marrack et al. 2015).

Although it is difficult to confirm the location of the anchialine pools examined in previous inventories, the NPS has been able to identify two pools in the Park that have been sampled repeatedly since 1972 (HA_Kaloko_015 and HA_Honoko_123). Table 2 summarizes the salinity data from these two anchialine pools and Figure 3 provides a visual summary of the data and their variability. Salinity appears to be trending upward in these pools.

Groundwater Observation Wells

Three shallow observation wells were installed in the Park in 1996 in cooperation with the U.S. Geological Survey (USGS) (Figure 1), as part of an NPS-funded study to evaluate the potential effects of groundwater withdrawals on water resources (Oki et al. 1999). The total depths of the wells range from 31 to 69 ft below land surface.

Salinity, specific conductance, and chloride have been measured periodically in the Park's wells for various studies. Periodic measurements recorded by the USGS are listed in Table 3. The 2005 Coastal Watershed Condition Assessment analyzed several data sets for possible long-term trends; the authors found a statistically significant ($p \leq 0.05$) increasing trend in salinity in KAHO Well 1 (4061-001) and KAHO Well 3 (4161-001), but cautioned against the use of linear regression analysis for these time-series data because the temporal distribution of the periodic data was sparse and uneven (Hoover & Gold 2005).

In 2007, the NPS began a program to continuously monitor water levels and specific conductance in the Park's wells (Izuka et al. 2011). Transducers used for continuous measurements are fixed at a certain depth in the well. These data are more useful for identifying long-term salinity trends than periodic measurements, which sample water at either the top or bottom of the well, or water pumped from the well.

Continuous data from the period 2007-2013 have been reviewed and processed by the USGS and are available online (NPS 2015b). The continuous data give some perspective on the manner in which ocean tides affect groundwater levels and salinity in the coastal aquifer. Groundwater levels fluctuated between 0.3 and 2.8 ft above mean sea level during this time (Figure 4).

Specific conductance during 2007-2013 was continuously monitored in KAHO Well 2 and KAHO Well 3. Specific conductance fluctuated between 9 and 15 millisiemens/cm (17-28% seawater) in these wells over the same period (Figure 4). A downward trend in specific conductance is apparent in both observation wells. This trend coincided with declining chloride concentrations in observation well MW400 (4162-004), located on the boundary between the Park and the Shores at Kohanaiki development (Figure 1). Water-level modeling confirms that this trend cannot be attributed to changes in the ocean tide or air pressure (Cutillo & Stevenson 2013).

During the Commission's September 17, 2014, site visit and meeting, representatives of both the NPS and the Shores at Kohanaiki indicated that excess irrigation water from the Kohanaiki golf course and nursery was the most likely cause of declining salinity in the three shallow observation wells. The golf course desalinates about 1.2 Mgal/d of brackish groundwater from the freshwater lens adjacent to the Park in order to produce useable irrigation water.

The flow of excess irrigation water from the Shores at Kohanaiki development into the Park is also supported by highly elevated concentrations of nitrogen and nitrate (a form of nitrogen commonly used in fertilizer) measured in groundwater around the Park's northern boundary in 2009 (Hunt 2014; Raikow & Farahi 2014). The USGS attributed the elevated nutrient levels to fertilizer contamination (Hunt 2014). Nitrate concentrations in 2014 remained at or above 2009 levels in the two Park wells located nearest to the boundary (Table 3). Nitrate also remains elevated above background levels in the Shores of Kohanaiki injection well (UH-2594) (*see* February 2015 Type I Sampling Report Analytical Results dated 3/16/2015).

The flow of low-salinity nutrient-enriched water into the Park demonstrates the unanticipated effects of pumping, irrigation, and wastewater injection on the coastal groundwater system, and the need for required monitoring to be accompanied by management triggers.

Salinity in Other Locations

Increases in salinity, groundwater-level declines, as well as human-caused nutrient enrichment, have been identified in other observation and pumped wells located within the Keauhou Aquifer System. These changes are described here to document that changing land uses and environmental conditions are affecting groundwater quality and quantity in the Keauhou Aquifer System.

The Kahaluʻu Shaft (3557-005) and Wells (3557-001 to -004), located about seven miles south of the Park, are completed in the coastal freshwater-lens groundwater system and provide much of the drinking water for North Kona. Groundwater withdrawals from the shaft and wellfield began around 1976 and averaged 6 Mgal/d in 2014.

In 2004, the County of Hawaiʻi Department of Water Supply notified the public that water from the Kahaluʻu Shaft and Wells, and the Hōlualoa Well (3657-01), showed elevated levels of sodium and chloride due to saltwater intrusion from overpumping.

The U.S. Environmental Protection Agency recommends that sodium levels in drinking water not exceed 60 mg/L and that chloride levels not exceed 250 mg/L. The County cautions that for persons on a sodium-restricted diet, sodium concentrations greater than 120 mg/L could be problematic (County of Hawaiʻi 2014). In 2014, sodium levels in drinking water from the Kahaluʻu wellfield were as high as 200 mg/L. As of May 2015, chloride levels were as high as 460 mg/L in the Kahaluʻu Shaft (County of Hawaiʻi 2015).

The National Energy Laboratory of Hawai‘i Authority (NELHA) is an 870-acre ocean science and technology park located on Keahole Point, about two miles north of the National Park. NELHA pumps about 30 Mgal/d of seawater and discharges it into onshore surface trenches throughout the facility for its tenants. NELHA currently has 34 observation wells and monitors groundwater quality on a quarterly basis. Well 1 and Well Set 2 are located closest to the Park and have valuable long-term historical monitoring records. The 2013 NELHA annual report states that salinity is trending upward in Well 1 and Well 2B (Figure 5) and describes elevated concentrations of nutrients such as nitrate in these wells due to the activities of NELHA's tenants (Olsen 2013).

The Commission's 2014 Preliminary Findings of Fact document a moderate but steady groundwater-level decline in the inland high-level system since 1991, confirming the trend previously identified by Bauer (2003). The Commission attributed the declines to reduced rainfall, groundwater pumping, and well construction.

Summary & Conclusion

Traditional Native Hawaiian knowledge and the best available scientific research tell us that culturally important and rare native aquatic species in Kaloko-Honokōhau National Historical Park are sensitive to changes in the quality and quantity of freshwater. For parameters such as salinity, each species has optimal levels at which it thrives, a range of tolerance within which it can survive and reproduce, and thresholds outside of which it cannot. The NPS does not manage the Park for any one species or water-quality parameter, but strives to maintain the cultural and natural landscape of Kaloko-Honokōhau and its biodiversity to realize the mission of the Park and its congressional mandate, and to further the protection of the state's natural and cultural public trust resources.

The response of the coastal and inland groundwater systems within the Keauhou Aquifer System Area to declining rainfall, rising sea level, increasing wastewater discharge, and increasing groundwater withdrawals is complex and the relative long-term severity of these very real risks is not precisely known. Available data, however, indicate that groundwater levels are declining inland of the Park, that the salinity of the coastal aquifer is increasing to the north and to the south of the Park, and that groundwater salinity and nutrient concentrations within the Park have been affected by surrounding land-use activities. The NPS believes that additional groundwater withdrawals, if not optimally located, will exacerbate these observed trends and damage the Park's natural and cultural public trust resources.

The native striped mullet, endangered native waterbirds, and the endemic orange-black Hawaiian damselfly are indicator species – that is, they are sensitive to changes in environmental conditions. Yields of striped mullet produced from Hawaiian fishponds and populations of Hawaiian waterbirds and damselflies have declined dramatically due in part to habitat loss and degradation. Habitat protection is the key to their recovery, to the perpetuation of traditional practices, and to preserving the diversity of life along the Kona Coast.

Kaloko Fishpond is one of the few remaining fishponds for the culture of the native striped mullet in Hawai‘i. Core Wetlands in the Park provide essential habitat for the survival and recovery of two endangered native waterbirds. Anchialine pools in the Park provide essential habitat for endemic anchialine pool species, including a damselfly that is a candidate for listing as endangered or threatened under the Endangered Species Act. All of these species are at risk today and further reductions in fresh groundwater discharge in the Park will push current groundwater salinity beyond known thresholds for these species.

The potential adverse effects of reducing fresh groundwater discharge on the Park's aquatic resources are described in the 2013 NPS petition for designation, in the NPS response to the Commission's Preliminary Findings of Fact, and in this report. These data establish that to preserve nursery habitat for native juvenile fish, to prevent the extirpation of rare native species from the Park, and to preserve the water-related natural and cultural public trust resources within the Park for current and future generations, requires maintaining the current magnitude and natural variability of fresh groundwater discharge.

The NPS believes that the information provided to date constitutes an ample and sound technical and legal basis upon which the Commission can decide to continue the designation process and schedule a public hearing.

Ola i ka wai – water is life – and the spirit of Kaloko-Honokōhau National Historical Park.

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Tables

Table 1. Summary of salinity data from Kaloko and ‘Aimakapā Fishponds.

Fishpond	Interval	Salinity (ppt)	Percent seawater	Source
KALOKO	1963	23	66%	Sparks (1963)
	1971	4 - 29	11% to 83%	Kikuchi & Belshe (1971)
	1974	7 - 18	20% to 51%	Maciolek & Brock (1974)
	1988	22.3 - 35.5	67% to 100%	Chai (unpbl.), *as cited in* Bhambare (1996)
	1994	18 - 34	51% to 97%	William Meyer, USGS (pers. comm.), *as cited in* Morin (1998)
	1994 – 1996	11.4 - 33.8	33% to 97%	Brock and Kam (1997)
	1995	11.5 - 31.5	33% to 90%	Bhambare (1996)
	1997	22 - 33.5	63% to 96%	Brasher (1999)
	2000	32.2 - 33.7	92% to 96%	Marine Research Consultants (2012)
	2003 – 2006	10.9 - 32.6	31% to 93%	Knee et al. (2008)
	2005	13.9 - 32	40% to 91%	Weijerman et al. (2008)
	2004 – 2007	10.5 - 33.8	30% to 97%	Bienfang (2007, 2008)
	2007	10.8 - 28.6	31% to 82%	Marine Research Consultants (2012)
	2007 – 2009	14.0 ± 0.8	36% to 37%	MacKenzie and Bruland (2012)
	2012	14.8 - 28.0	42% to 80%	Marine Research Consultants (2012)
‘AIMAKAPĀ	1963	9	26%	Sparks (1963)
	1971	7.9	23%	Kikuchi & Belshe (1971)
	1974	7 - 8	20% to 23%	Maciolek & Brock (1974)
	1994	13	37%	William Meyer, USGS (pers. comm.), *as cited in* Morin (1998)
	1994 – 1996	10.8 - 13.3	31% to 38%	Brock and Kam (1997)
	2000	12.9 - 13.4	37% to 38%	Marine Research Consultants (2012)
	2001	≈ 11.8 - 13.0	34% to 37%	TNWRE (2002)
	2003 – 2006	11.8 - 13.2	34% to 38%	Knee et al. (2008)
	2004 – 2007	10.7 - 13.8	30% to 39%	Bienfang (2007, 2008)
	2007 – 2009	12.7 ± 0.1	36% to 37%	MacKenzie and Bruland (2012)
	2007	12.5 - 12.7	36%	Marine Research Consultants (2012)
	2012	11.5 - 12.9	33% to 37%	Marine Research Consultants (2012)

Table 2. Summary of salinity data for two anchialine pools in Kaloko-Honokōhau National Historical Park. Pool 015 is also known as Kahinihiniula and is of cultural significance. (SD = standard deviation).

	Pool HA_Kaloko_015		**Pool HA_Honoko_123**		
Year	Average salinity ±SD (ppt)	Sample size	Average salinity ±SD (ppt)	Sample size	Source
1972	5-6	n/a	4	n/a	Maciolek & Brock 1974
1994	9.06 ± 0.41	2	8.15 ± 0.09	2	Brock & Kam 1997
1995	8.70	1	8.28	1	
1996	9.06 ± 0.54	3	8.40 ± 0.22	3	
2002	9.13	1	-	-	NPS 2015a
2004	9.39 ± 0.33	5	-	-	
2005	8.91 ± 1.01	10	7.74 ± 0.27	11	
2006	9.76 ± 0.37	7	8.65 ± 0.22	6	
2007	9.74 ± 0.25	4	9.34 ± 0.13	3	
2008	10.70 ± 0.86	8	9.07 ± 0.21	4	
2009	9.69 ± 0.33	4	9.18 ± 0.09	2	

Table 3. Field/lab water-quality data collected by the USGS from observation wells in Kaloko-Honokōhau National Historical Park (http://waterdata.usgs.gov/nwis). (*unfiltered).

Well name & number	Date & time (HST)	Temperature (deg C)	Specific conductance* (mS/cm at 25 deg C)	Chloride (mg/L)	Nitrate+nitrite (mg/L as N)
KAHO Well 1 (4061-001)	9/3/1997 13:19			5600*	
	8/27/2002 12:05	23.6	19.00		
	7/23/2009 16:30	20.8	19.70		0.899
	12/1/2009 14:20		16.20		1.33
	6/21/2012 9:20	20.8	18.80	6400	
	6/21/2012 15:40	20.5	18.90	6410	
	3/21/2013 17:00	21.0	18.90	6320	
	8/25/2014 16:38	20.8	20.00	6250	0.94
KAHO Well 2 (4161-002)	9/3/1997 10:48			2600*	
	3/4/1998 9:07			2700*	
	8/26/2002 16:45	22.0	9.17		
	7/23/2009 10:00	20.4	10.10		1.29
	12/1/2009 15:50		9.43		1.38
	6/19/2012 8:45	21.3	8.89	2840	
	6/19/2012 16:45	20.0	8.95	2850	
	3/18/2013 14:00	21.2	8.92	3650	
	8/25/2014 12:57	20.7	8.79	2150	1.91
KAHO Well 3 (4161-01)	9/3/1997 9:05			3200*	
	8/27/2002 11:20	21.8	11.10		
	7/23/2009 14:10	20.4	12.20		1.12
	12/1/2009 10:00		11.30		1.13
	6/19/2012 10:30	20.9	11.30	3640	
	6/19/2012 15:20	19.8	11.50	3910	
	3/21/2013 15:10	20.6	11.20	3940	
	8/25/2014 14:48	20.5	10.50	3370	1.28

Figures

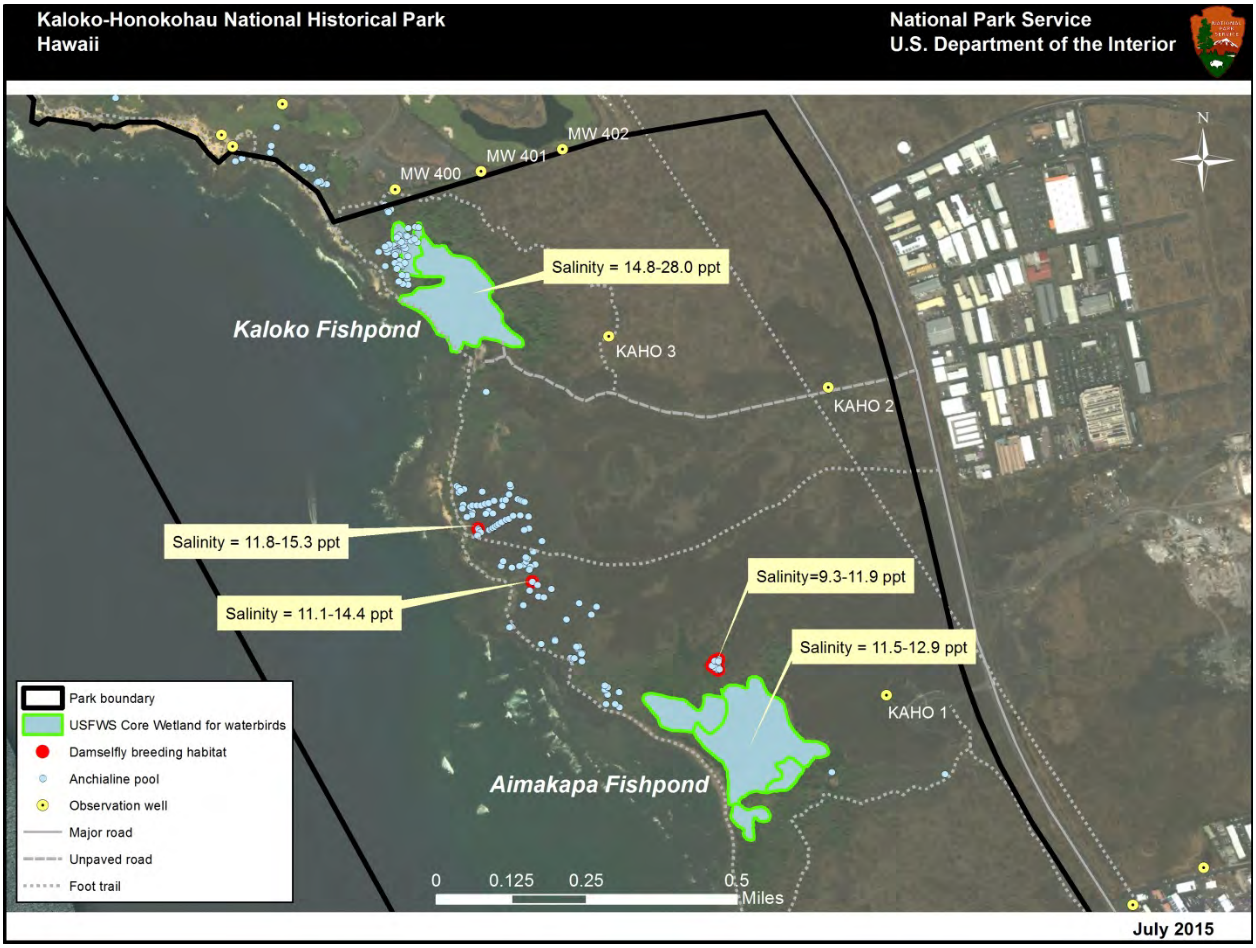


Figure 1. Map showing the location of U.S. Fish & Wildlife Service Core Wetlands for endangered native waterbirds in the Park (USFWS 2011), and the anchialine pools in the Park where the orange-black Hawaiian damselfly breeding has been documented (written communication, David Foote, USGS, 4/14/2015). Also shown are the ranges of recent salinity transects in the fishponds (Marine Research Consultants 2012) and salinity measurements in the anchialine pools (NPS 2015a; Raikow & Farahi 2014). Core wetlands are areas that support large populations of Hawaiian waterbirds and provide permanent habitat that is essential for waterbird survival and recovery.

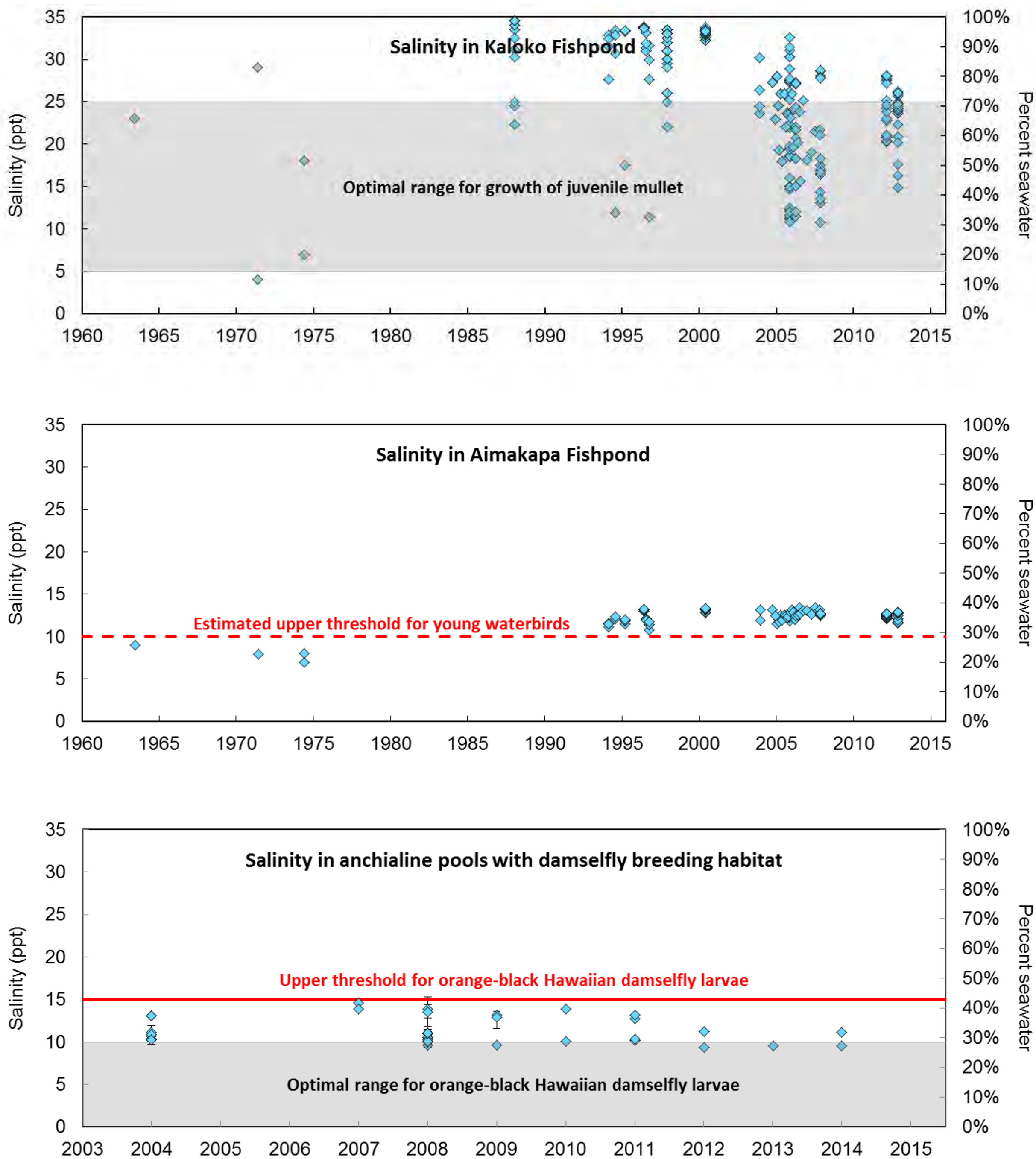


Figure 2. Charts showing periodic salinity measurements from Kaloko Fishpond (top), from ʻAimakapā Fishpond (middle) and from anchialine pools in the Park where orange-black Hawaiian damselfly breeding was observed in the two most recent surveys (bottom). The sources of the fishpond salinity data are provided in Table 1, and the source the anchialine pool salinity data is the NPS (2015a). Also shown are optimal conditions for the growth of juvenile striped mullet (Madden & Paulson 1977; Nash & Shehadeh 1980; Peterson et al. 2000); the estimated upper threshold for young endangered waterbirds (written communication, Aaron Nadig, USFWS, 6/29/2015); and the optimal and threshold conditions for the survival of orange-black Hawaiian damselfly larvae (Tango 2010).

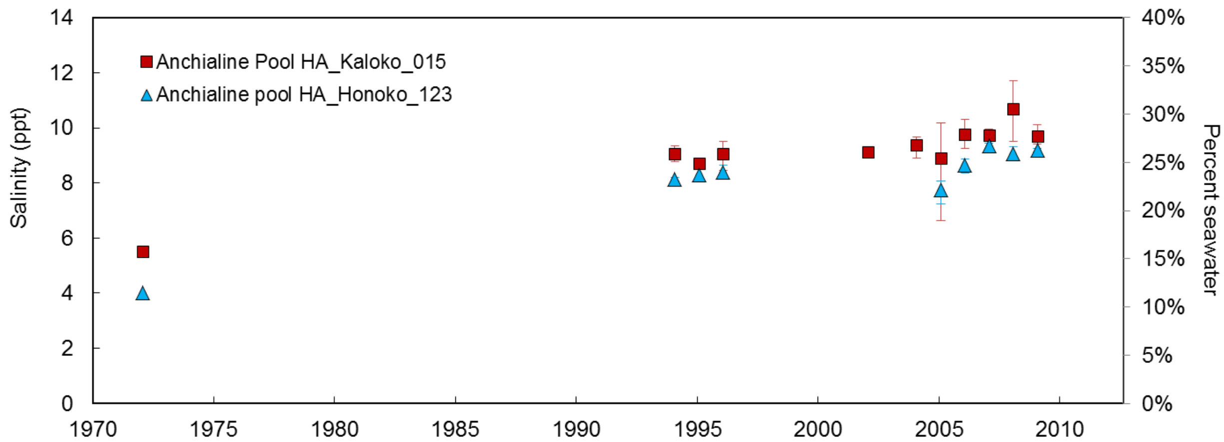


Figure 3. Chart showing average salinity with minimum and maximum values, from two anchialine pools in the Park, over time. The sources of the data are provided in Table 2.

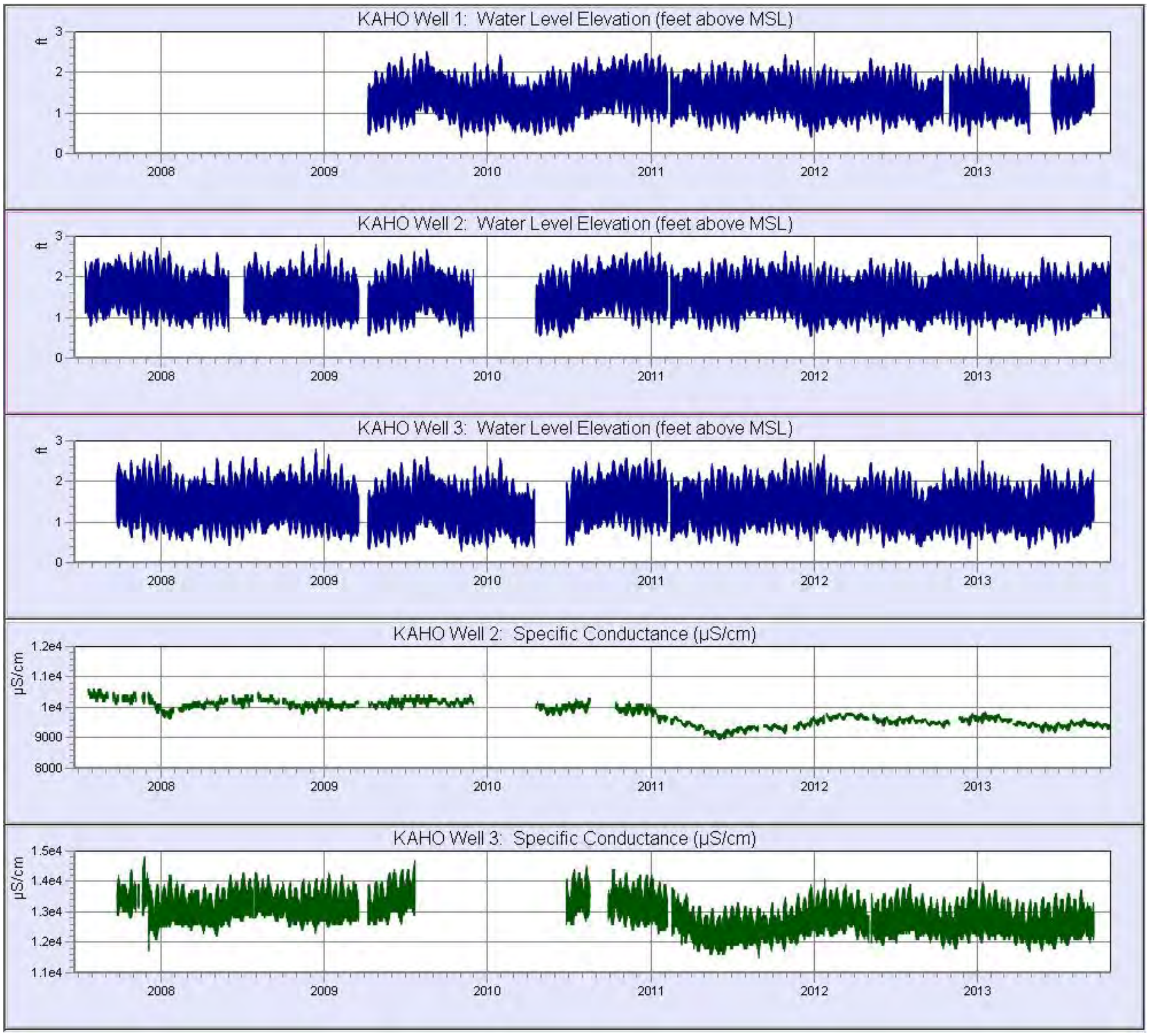
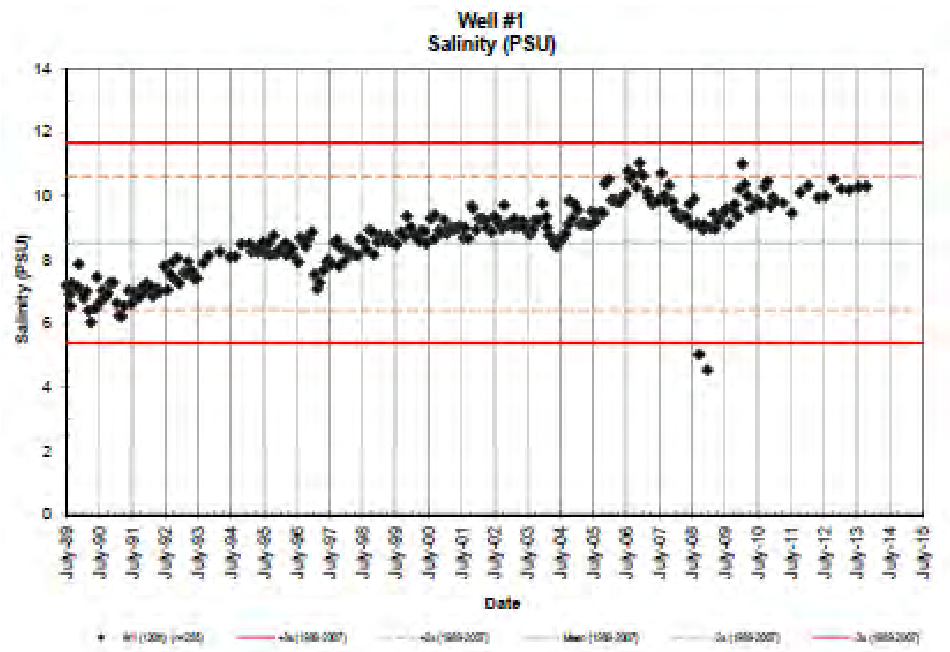


Figure 4. Charts showing continuous water-level and specific conductance data collected by the NPS and the USGS from the three observation wells in the Park (NPS 2015b). (µS/cm = microsiemens per centimeter).



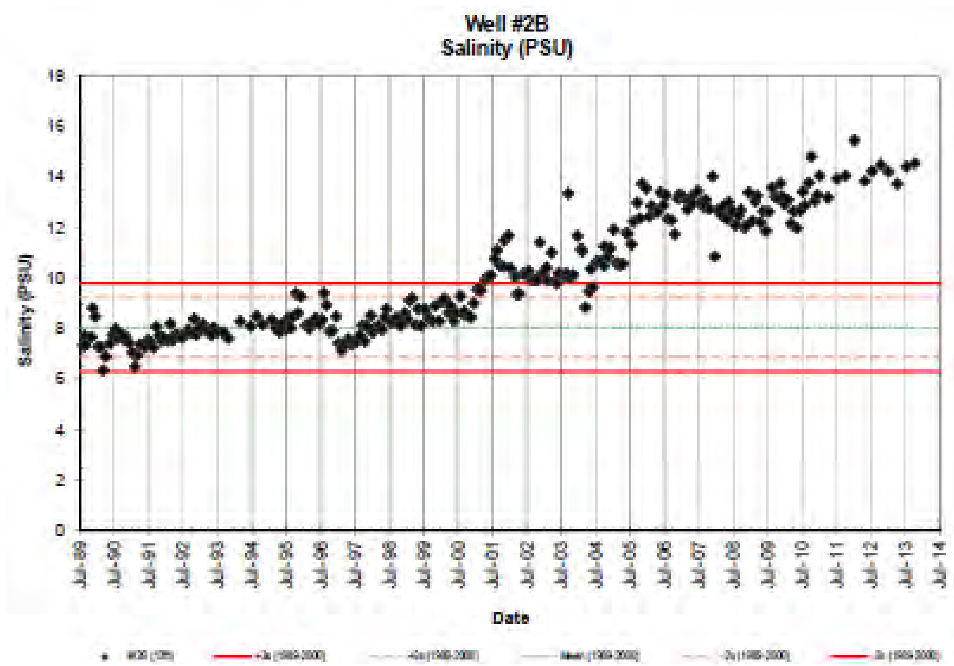


Figure 5. Charts showing historic salinity records for two NELHA observation wells (*from* Olsen 2013). Baseline is considered the mean (dotted green line) and detected changes are considered to be outside the calculated three standard deviations (solid red line).