Salton Sea

Species Conservation Habitat Monitoring and Adaptive Management Plan

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SECTION 1

INTRODUCTION

The Salton Sea Species Conservation Habitat Project (SCH Project) is located along the southern shore of the Salton Sea in Imperial County. The goal of the SCH Project is to create saline impoundments on the exposed playa to support fish and wildlife dependent on the Salton Sea. The ponds will provide near-term habitat and serve as a proof-of-concept for future phases of the SCH Project. This report provides a monitoring and adaptive management plan (MAMP) to guide post-implementation actions and assess project performance during the 10-year proof-of-concept period.

1.1 BACKGROUND

The Salton Sea[1] (the Sea) is a terminal lake, formed between 1905 and 1907 from Colorado River flooding and fed by local tributaries and agricultural runoff. Since its formation, the Sea ecosystem has changed in response to changing water levels and increasing salinity (Case et al. 2013). As of 2014, the Sea is a hypersaline ecosystem with a salinity of 54,000 mg/L (also expressed as 54 parts per thousand [ppt]) (Holdren 2014). Declining inflows in future years will result in rapid changes in the Sea's ecosystem due to increasing salinity (expected to exceed 60 ppt by 2018). Other water quality stressors will continue, such as temperature extremes, eutrophication, and related anoxia due to algal productivity.

The Sea is an important wintering and stopover site for migratory birds on the Pacific Flyway (Shuford et al. 2002). The Sea currently supports a wide variety of bird species and a limited aquatic community. The fish community has shifted over the decades from freshwater and marine species to salt-tolerant species such as introduced California Mozambique hybrid tilapia (the *Oreochromis mossambicus x O. urolepis hornorum* hybrid found at the Salton Sea) and native desert pupfish (*Cyprinodon macularius*). As salinity continues to increase, one of the most serious and imminent threats to the Sea ecosystem is the loss of fishery resources followed by a decline of fish-eating (piscivorous) birds. The birds that feed on invertebrates have more options and resources, because the invertebrate fauna has a wider range of salinity tolerances. To address the loss of the fisheries and its resulting impacts, the California Legislature appropriated funds for the purpose of implementing "conservation measures necessary to protect the fish and wildlife species dependent on the Salton Sea, including adaptive management measurements" (California Fish and Game Code section 2932(b)).

1.2 SCH PROJECT OBJECTIVES (USACOE and Resources Agency 2011 and 2013)

The SCH Project's purpose is to provide replacement for near-term habitat losses. The SCH Project's target species are those piscivorous bird species that use the Salton Sea and are dependent on shallow saline habitat for essential habitat requirements within their western geographic range.

The Project objectives include:

1. Provide appropriate foraging habitat for piscivorous bird species,
2. Develop physical structure and microhabitat elements required to support piscivorous bird species.

[1] Further background on the history and existing conditions at the Salton Sea is provided in the 2012 Salton Sea Species Conservation Habitat (SCH) Project Draft Environmental Impact Statement/Environmental Impact Report (2012 DEIS/EIR) (U.S. Army Corps of Engineers and California Natural Resources Agency 2012) and the 2013 Final EIS/EIR (U.S. Army Corps of Engineers and California Natural Resources Agency 2013).

3. Support a sustainable, productive aquatic community,
4. Provide suitable water quality for fish,
5. Minimize adverse effects on desert pupfish,
6. Minimize risk of selenium toxicity, and
7. Minimize risk of disease/toxicity impacts.

The SCH Project area encompasses 3,770 acres of exposed playa at the mouth of the New River, at the southwest end of the Salton Sea (Figure 1-1). The initial implementation phase will construct and operate two ponds (320-acres each, designated East Pond and West Pond) to create a total of 640 acres of saline pond habitat in the East New River section of the Project area. Each pond will have its own water supply infrastructure that can be operated independently, to allow manipulation of hydrologic parameters such as salinity and residence time as experimental "treatments" (Williams and Brown 2012). The SCH Project will test different operating regimes (varying salinity and residence time) between the ponds and monitor physical and biological outcomes during the first 10 years.

1.3 PURPOSE OF MAMP

The MAMP outlines a monitoring framework to evaluate the effectiveness of the SCH Project and guide adaptive management. The MAMP describes project objectives, defines expected or desired outcomes, and describes monitoring activities to track progress toward objectives and compliance with regulatory permits during the initial implementation phase. The MAMP also outlines the assessment and decision-making process that will guide adaptive management, including potential management responses that may be triggered by monitoring.

If monitoring reveals issues that require more in-depth study to reduce uncertainty for management, then the SCH Project managers, with input from experts, will identify and prioritize key questions for further monitoring or study. Focused investigations would be developed and implemented separately, based on priority and availability of funding and expertise.

1.4 MONITORING AND ADAPTIVE MANAGEMENT APPROACH

Monitoring and adaptive management is an iterative approach that uses regular monitoring and assessments to evaluate progress towards project objectives. Adaptive management acknowledges that uncertainties exist in predicting how project implementation affects important resources, and provides a scientific and institutional framework for adjusting future management decisions as understanding of the ecosystem improves (Williams et al. 2009). The SCH Project follows the steps of the adaptive management cycle:

(1) **Plan** – Identify goals and objectives, summarize expectations (conceptual models) for project outcomes, and identify uncertainties and key questions for assessment (Sections 1 and 2),

(2) **Design** – Summarize designs and operational scenarios for habitat ponds (Section 3),

(3) **Implement** –Construct and operate the ponds according to initial operating scenarios (Section 3),

(4) **Monitor** – Describe monitoring methods for measuring indicators of desired outcomes and triggers of management actions (Section 4 and 5),

(5) **Evaluate** – Analyze, synthesize, and manage data to document project outcomes, assess progress toward objectives, detect any negative outcomes, and reduce uncertainty (Section 6), and

(6) **Adapt and Learn** – Communicate findings to decision-makers and managers to determine if and when to adjust management actions and/or monitoring to improve project performance and inform future actions. (Section 7).

Figure 1-1 Salton Sea Species Conservation Habitat Project Area.

The effectiveness of SCH Project actions will be assessed by measuring physical and biological indicators of expected or desired project outcomes (Section 4). Status and trends of these indicators will be measured to evaluate progress toward objectives and to detect potential issues that may trigger a management response. An adaptive approach will be used to prioritize and phase monitoring elements for efficiency and cost-effectiveness.

The monitoring protocols (Section 5) are consistent with the overarching framework of the Salton Sea Monitoring and Assessment Plan (MAP) (Case et al. 2013). The MAP was prepared by the United States Geological Survey (USGS), California Department of Water Resources (DWR), California Department of Fish and Wildlife (DFW), and Bureau of Reclamation (Reclamation). Monitoring protocols are derived from the MAP, as well as other sampling practices used at the Salton Sea or for similar purposes. Design and implementation of SCH monitoring will be coordinated where possible with other regional survey and monitoring efforts, to ensure consistency and comparability of data.

The scientists and managers responsible for the SCH Project will annually synthesize and analyze the monitoring data. An overall review will be conducted annually to evaluate project performance. A decision-making framework will guide recommendations to SCH managers for maintaining or adjusting operations. The organizational structure and roles of participants are described in Section 7.

The MAMP is a living document, flexible enough to respond to unanticipated events and to accommodate lessons learned. Each year the field sampling program will be evaluated and updated if necessary in annual reports to be prepared by DFW.

SECTION 2

CONCEPTUAL UNDERSTANDING

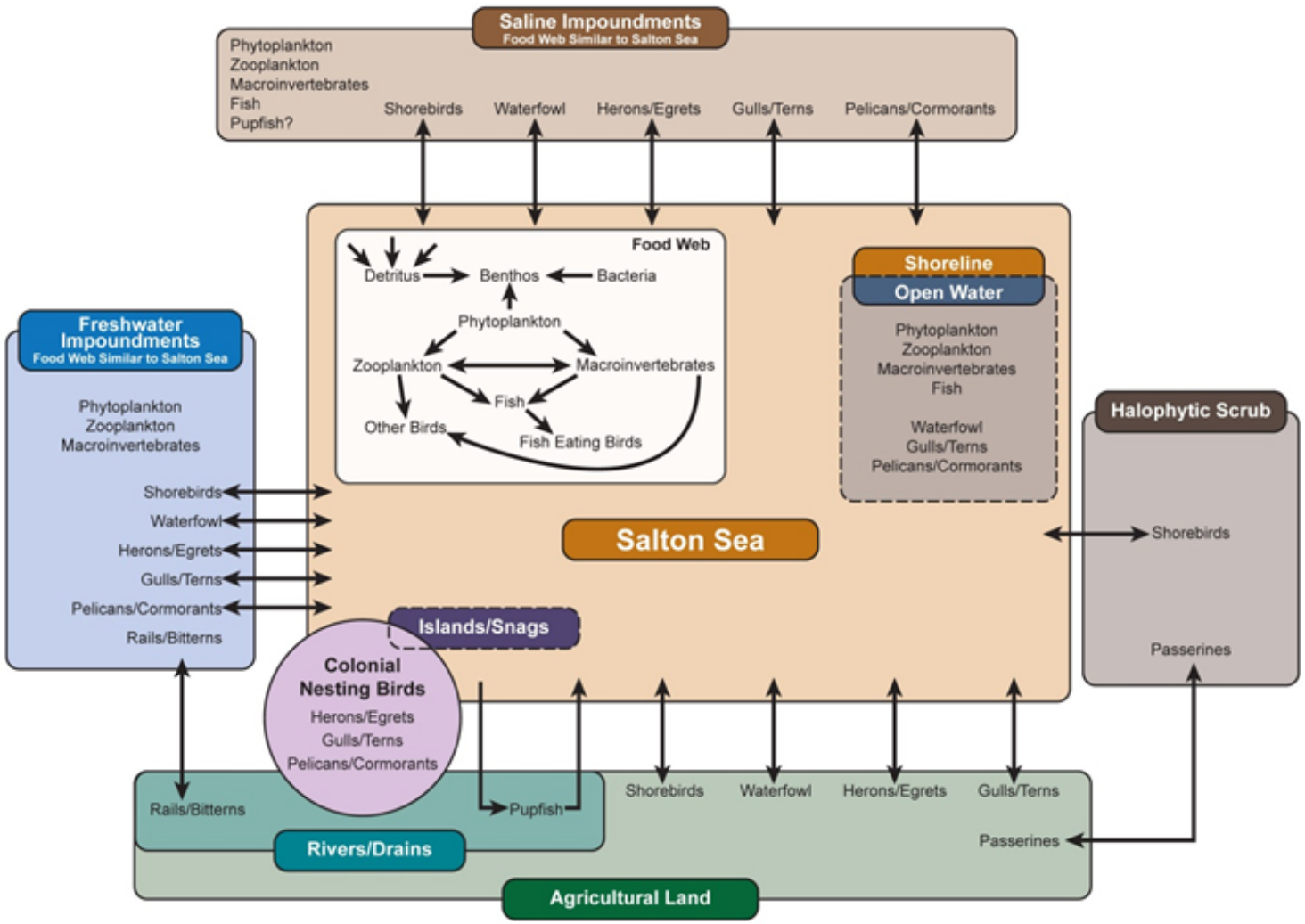
The SCH Project objectives and design are based on current understanding of the Salton Sea ecosystem, its drivers and stressors, and attributes or indicators of ecological functions. This section reviews conceptual understanding of the Salton Sea aquatic community and food-web, hydrology and water quality parameters of saline habitat, and selenium bioaccumulation. Key questions or uncertainties related to the operations and outcomes of the SCH Project are identified. These questions informed the design of the SCH Project structures and operations scenarios and monitoring program.

2.1 CONCEPTUAL UNDERSTANDING

2.1.1 Salton Sea Food-Web

The biological resources of the Salton Sea ecosystem can be depicted as a simplified food web, with various bird species foraging among different habitats in and around the Sea (Case et al. 2013) (Figure 2-1).

The Project is designed to be a saline impoundment habitat, intended to provide prey for piscivorous bird species. Phytoplankton is the basis of the aquatic food web. These algae in turn support zooplankton and benthic invertebrates, which in turn support fishes and birds. Many bird species reside at, migrate through, or winter at the Salton Sea. The target species for the SCH Project include American white pelican (*Pelecanus erythrorhynchos*), brown pelican (*Pelecanus occidentalis*), Caspian tern (*Hydroprogne caspia*), gull-billed tern (*Gelochelidon nilotica*), black skimmer (*Rynchops niger*), and double-crested cormorant (*Phalacrocorax auritus*) (USACOE and Resources Agency 2011 and 2013). The exact fish species composition is less critical than maintaining sufficient abundance of appropriate prey. Introduced California Mozambique hybrid tilapia have been the most abundant fish in the Salton Sea in recent years and are likely an important prey species for piscivorous birds. Invertebrate-eating birds historically known to forage and nest at the Salton Sea, such as black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), and snowy plover (*Charadrius nivosus*), will likely use the SCH Project as well.



Source: Salton Sea MAP (Case et al. 2013)

Figure 2-1 Conceptual Model of Salton Sea Ecosystem Food-Web.

The conceptual model developed for the SCH Project highlights physical and biotic attributes and processes important for planning, managing and monitoring of restored saline impoundments (Figure 2-2). The SCH conceptual model includes three tiers. (1) Landscape and Local Attributes are factors affecting the SCH water sources (Salton Sea and New River), factors acting in areas adjacent to the SCH ponds, and the weather experienced by the site (temperature, wind). (2) Physical Site Attributes are physical and hydrologic properties and processes within the SCH ponds. The major components of this physical structure are: internal hydrology (volume, residence time, depth), relative surface elevation (vertical structure built by accretion, erosion, and sedimentation), topographic heterogeneity (channels, islands, berms), and internal water quality parameters (such as salinity, dissolved oxygen temperature, nutrients). The physical habitat requirements of target species are also considered in this tier, such as water quality for fish and constructed islands for breeding birds. (3) Biotic Site Attributes are food web interactions within the SCH ponds that support fish and wildlife.

Arrows represent specific linkages or relationships between attributes. Thick arrows moving between tiers that do not connect to specific factors represent relationships with all attributes in the following tier. Arrow color is used to aid in following arrows and does not convey meaning.

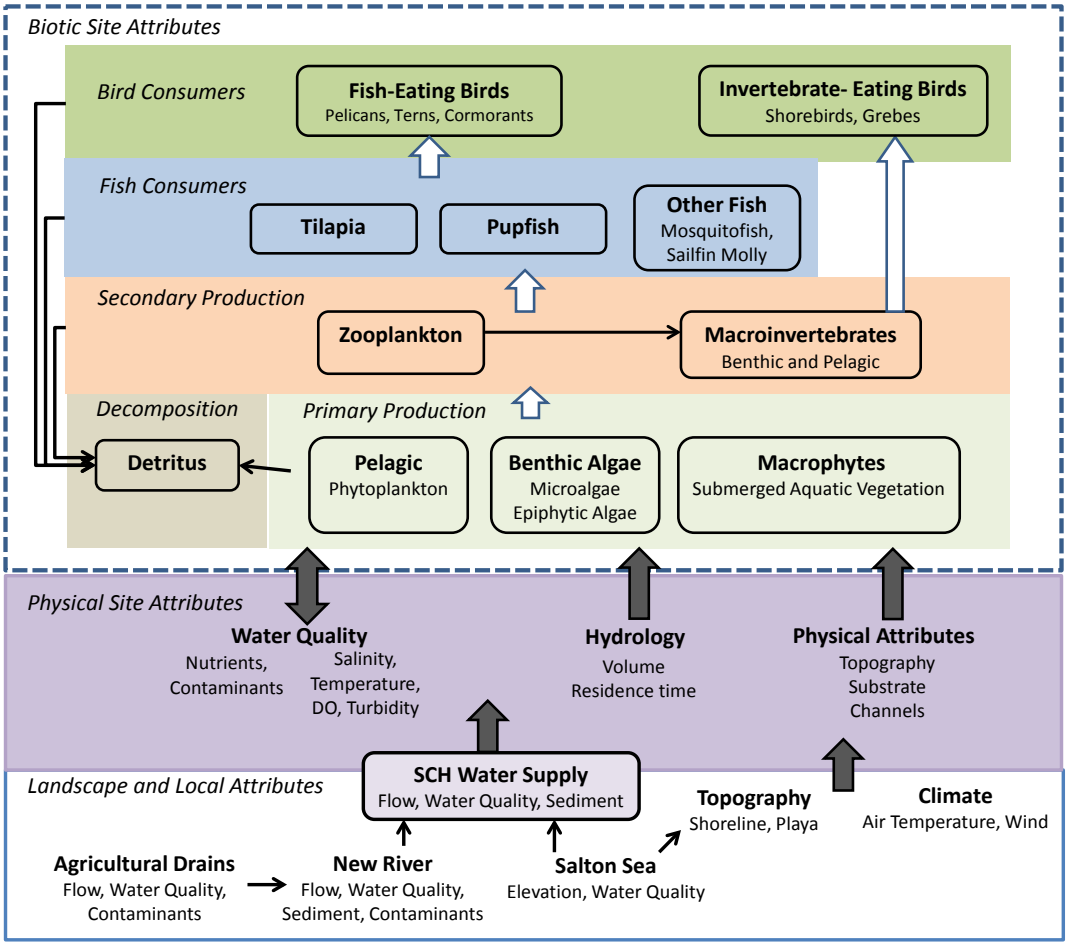


Figure 2-2 Conceptual Model of Key Attributes and Drivers at the SCH Ponds.

2.1.2 Hydrology and Water Quality of Saline Impoundments

Water quality is an important driver of aquatic productivity and community composition. Salinity in particular is a master variable for the Salton Sea ecosystem, and one of the few variables that can be

managed at the SCH ponds. Salinity directly affects osmoregulation in organisms, and drives aquatic community composition as a result of species-specific physiological tolerances. Salinity can also indirectly affect selenium bioaccumulation pathways. Higher salinity levels can suppress growth of emergent vegetation such as cattail and bulrush (Stutzenbaker 1999), which contributes detritus in a pond. Bioavailable forms of selenium can adsorb onto organic matter such as detritus (Lemly 1998).

Managing for salinity will indirectly affect concentrations of nutrients and contaminants. Compared to Salton Sea water, New River water has lower salinity, higher concentrations of nutrients and contaminants associated with agricultural runoff, and higher selenium concentrations. Water from the New River (approximately 2 ppt salinity) will be blended in varying proportions and flow rates with water from the Salton Sea (typically in excess of 50 ppt) to produce the desired pond salinity. High nutrient inputs are expected to result in high productivity by phytoplankton (algae), which would drive abundance of zooplankton, aquatic invertebrates and fish. For example, the USGS Saline Habitat Ponds were highly productive in phytoplankton and invertebrates (Miles et al. 2009) as well as pupfish (Saiki et al., 2011. Eutrophic conditions, however, may drive cycles of algal blooms and die-offs, which may cause anoxia that could impact fish and invertebrates.

Water temperature is driven by air temperature and wind. Physical pond conditions, such as water depth and topographic variability including channels, may also have some effect on the degree of thermal stratification and mixing. Deeper areas of stratified ponds may experience reduced levels of dissolved oxygen.

Hydrological modeling examined potential water quality outcomes of different Project designs and operations (*Appendix J - Special Studies* in USACOE and Resources Agency 2011 and 2013). Modeling suggests that water temperatures could drop below 11-13°C (52-55°F) during December through February. Due to high nutrient concentrations in the New River, high levels of algal growth are possible, along with oxygen deprivation problems that accompany hot weather. Seasonal anoxia could be more frequent and prolonged in spring (March through May) and fall (October) due to algal blooms. Conditions in the managed ponds could include:

- Highly eutrophic, shallow-water ponds that would be highly turbid in spring through fall,
- Water temperatures ranging from below 50 degrees Fahrenheit (˚F) (10 degrees Celsius [˚C]) during short periods of the winter, to high temperatures in the low to mid 90s ˚F (low 30s ˚C) in the late spring through early fall,
- Dissolved oxygen (DO) concentrations ranging from zero mg/L to super-saturated during daylight hours in spring to fall, and
- Models predicted that the ponds shallow depth and chronic windy conditions would keep the SCH waters well mixed, relative to the strata creation and episodic mixing that are normal in the larger Salton Sea.

2.1.3 Aquatic Community

The Salton Sea aquatic food chain is characterized by limited diversity but high abundance (DWR and DFG 2007). A stable aquatic community is one that can recover and persist in the face of short-lived disturbances, with minimal change in species composition and/or food-web dynamics. Maintaining a variety of prey species and prey life stages increases the likelihood of resilience and persistence in the face of harsh and variable environmental conditions.

The Project ponds are expected to support fish species tolerant of saline conditions. Likely candidates for stocking are one or more varieties of tilapia, which are an important forage species for fish-eating birds. This family of fishes has wide tolerances for water quality conditions, flexible diet including algae and

invertebrates, high fecundity, and distribution throughout the water column. The three tilapia species considered for stocking include California Mozambique hybrid tilapia, redbelly tilapia (*Tilapia zillii*), and blue tilapia (*Oreochromis aureus*).

The California Mozambique hybrid tilapia is highly tolerant of a wide range of salinities. In laboratory studies (reviewed by Lorenzi and Schlenk 2011), this species and the pure Mozambique tilapia can survive and acclimate to extreme salinities (up to 95 ppt) at constant temperatures (23-25°C) (Sardella et al. 2004a), although temperature deviations ±10 °C can dramatically reduce the salinity tolerance (Sardella et al. 2004b). California Mozambique hybrids cannot tolerate sudden increases in salinity, such as a direct transfer from freshwater to seawater (approximately 35 ppt), or increases greater than 25 g/L in magnitude once acclimated to a salinity of seawater or higher (Sardella et al. 2004a). Observations from aquaculture indicate that tilapia can survive brief cold snaps of a day or so (K. Fitzsimons, University of Arizona, pers. comm. 2010). While cold spells would kill some fish, typically larger fish, it is expected that other individuals would survive to recolonize (K. Fitzsimons, pers. comm.).

California Mozambique hybrid tilapia are also remarkably tolerant of low DO concentrations; they can thrive at DO concentrations of 2 mg/L, survive extended periods of 1 mg/L, and can tolerate routine dawn DO concentrations of less than 0.3 mg/L (Popma and Masser 1999). Their main drawback is whether they could handle the lowest water temperatures predicted for SCH ponds. The preferred temperature range for optimum tilapia growth is 82° to 86°F (28 to 30°C). Growth diminishes significantly at temperatures below 68°F (20°C) and death would occur below 50°F (10°C) (Rakocy and McGinty 1998). Tilapia are more vulnerable to infections by bacteria, fungi, and parasites at temperatures below 54°F (12°C) (Rakocy and McGinty 1998). For some tilapia species or strains, cold tolerance (below 13°C [55°F]) is impaired at higher salinities (Lorenzi and Schlenck 2011 in *Appendix J - Special Studies* [USACOE and Resources Agency 2011 and 2013]).

The blue tilapia can live in brackish environments, but it is most common in freshwater. In the Salton Sea area blue tilapia live in the tributary rivers. In one study, blue tilapia had good survival at 20 ppt and 30 ppt, but survival decreased to 49 percent at 35 ppt (Nugon 1997). Blue tilapia can be found in environments with a temperature range from 8 to 30°C. On the other hand, blue tilapia is less sensitive to cold than California Mozambique tilapia (Cnaani et al. 2000), and therefore might be more suitable to survive the cold winter temperature in the SCH ponds. Mean lower lethal temperature for juvenile blue tilapia was 6°C but feeding activity stopped at 11-12°C (Shafland and Pestrak 1982). The optimum temperature of adult blue tilapia is 28°C and the upper incipient lethal temperature for juveniles is 38–39°C (Baras et al. 2002). It is possible that the blue tilapia living around the Salton Sea might have hybridized with the California Mozambique hybrid, and therefore, the hybrids might show tolerances different from the blue tilapia mentioned in the previous studies.

The redbelly tilapia was introduced into drainage ditches in California to control aquatic weeds (Costa-Pierce 2003). Redbelly tilapia can tolerate direct transfer into salinities of 23.4-27.3 ppt, and can gradually acclimate to full sea water (approximately 35 ppt) (Chervinski and Hering 1973). Redbelly tilapia used to be found in the Salton Sea but now is almost exclusively in the tributary rivers. The redbelly tilapia is considered a eurythermal species, with optimal growth at 20-32°C (Hauser 1977; Tash & Witschi 1979). In a different study its optimal temperature in terms of highest feeding rate and fastest growth rate has been reported between 28.8 and 31.4°C (Platt and Hauser 1978). Redbelly tilapia becomes lethargic and loses equilibrium below 16°C, with a lower lethal limit of 6.5-14°C (Hauser 1977; Tash & Witschi 1979).

Stocking different tilapia species or strains (individually or in combination) among the SCH ponds could test which species is most sustainable and resilient, and could enhance stability of the fishery resource in the ponds in the face of seasonal and annual fluctuations in water quality parameters. Mozambique hybrid tilapia are currently abundant in the Salton Sea. Redbelly tilapia are abundant in drains at the Sea's

northern end. Tilapia resembling blue tilapia are present in the rivers, agricultural drains, and Brawley Wetlands.

Increasing the diversity of fish could buffer the effects of perturbation in a dynamic system. Other species likely to thrive in the managed ponds, under the appropriate conditions, include desert pupfish (*Cyprinodon macularius*), sailfin molly (*Poecilia latipinna*), and mosquitofish (*Gambusia affinis*). Desert pupfish is a state and federally listed species that occupies and moves among freshwater and brackish habitat in tributaries and drains surrounding the Salton Sea. Threadfin shad (*Dorosoma petenense*), an open-water species, could also be considered for stocking.

2.1.4 Selenium

Selenium is a metalloid (i.e., it can function as a metal or a non-metal) that is present in the water, sediments and biota of the Salton Sea ecosystem. Most of the selenium comes from the upper Colorado River watershed and is found in irrigation water used in the Imperial and Coachella valleys. Selenium becomes concentrated by agricultural usage and is discharged from subsurface tile drains into surface drains that flow into the Sea either directly or via tributaries (Saiki et al. 2010). The playa sediment at the New River, where the SCH Project ponds will be constructed, has low (less than 1 mg/kg) to moderate (1 to 3 mg/kg) concentrations of selenium (Amrhein and Smith 2011). Selenium concentrations in the SCH water supply are about 3.2 µg/L in the New River, 1.3 µg/L in the Salton Sea (C. Holdren, USBOR unpublished data, 2004-2010), and up to 32.8 µg/L in nearby agricultural tile drains (Saiki et al. 2010) (Table 2-1). Selenium in the New River varies throughout the year depending on runoff, agricultural practices and subsequent discharge.

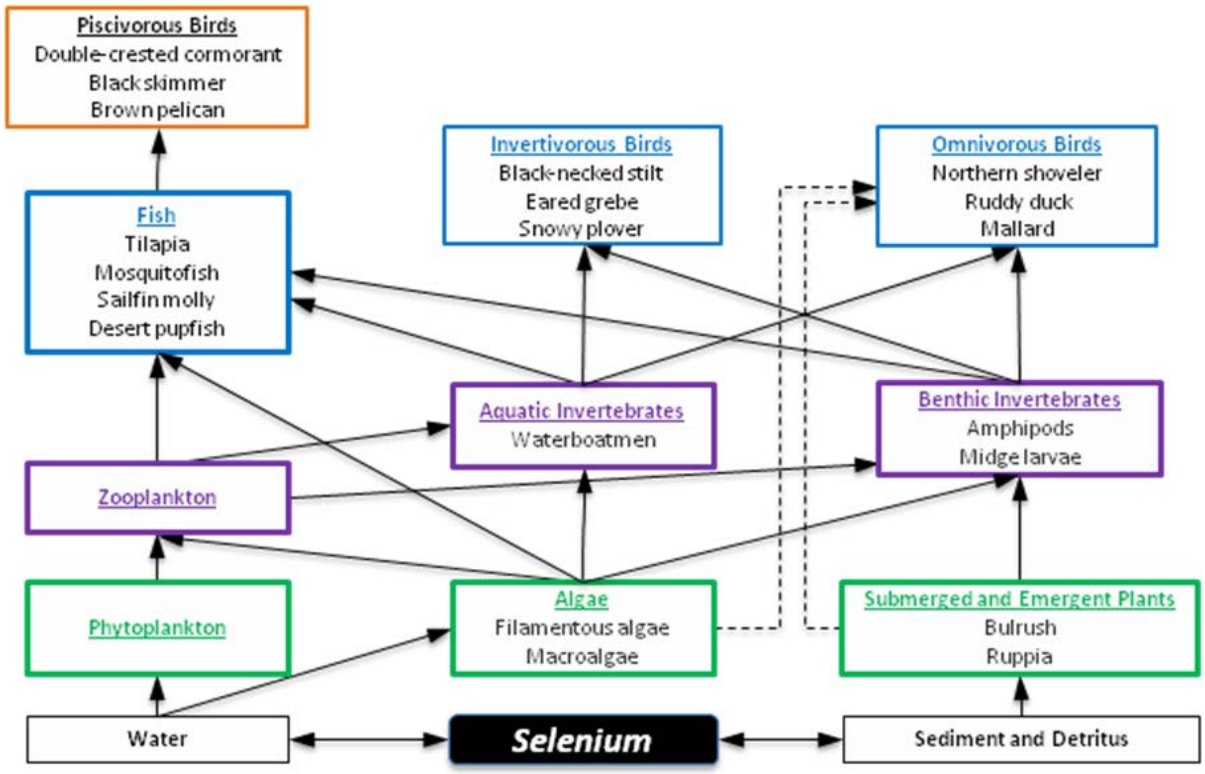
Selenium can bioaccumulate and transfer up the food web (Figure 2-3). Dissolved selenium in the water makes little or no direct contribution to bioaccumulation in animals, and only influences the concentration of selenium in particulate matter (Luoma and Presser 2009). Selenium may be transferred up the food web via intake of particulate matter, both abiotic and biotic (such as attached or free-floating microorganisms, rooted submerged and emergent plants). As selenium is transferred into the benthic or water-column invertebrates, it may then be consumed by fish or birds (secondary or tertiary consumers). Selenium concentrations can be preserved and/or biomagnifed as it passes up food webs Luoma and Presser 2009).

Toxicity thresholds for selenium in biota vary by species. Lemly (2002) proposed 3 µg/g dry weight (dw) in food-chain organisms, and 4 µg/g dw in whole fish. These thresholds were intended to represent selenium concentrations at which toxic effects first begin to occur in sensitive fish species and not the point at which all species die from selenium toxicity (Saiki et al. 2010). Selenium's most substantial effects are in developing bird embryos, ranging from reduced hatching success to teratogenic deformities at very high concentrations. In bird eggs, 6 µg/g dw is a conservative and widely reported toxicity reference value (Ohlendorf and Heinz 2011). Sensitivity to selenium varies among bird species, ranging from "sensitive" (mallard, *Anas platyrhynchos*) to "average" (stilt), and "tolerant" (avocet) (Skorupa 1998 as cited in Ohlendorf and Heinz 2011). Risk of impaired reproduction can start to occur at egg concentrations of 6-12 µg/g dw. The risk of teratogenesis starts to occur above 12 µg/g dw for sensitive species, and above 20 µg/g dw for moderately sensitive species (Ohlendorf and Heinz 2011). Cormorants and terns are likely to be fairly tolerant of selenium, in keeping with greater tolerance of other saltwater-adapted species such as avocets and snowy plover, compared to freshwater-adapted species such as mallards (personal communication, H. Ohlendorf 2010).

Table 2-1 Selenium Concentrations in Water, Sediment and Biota in the Salton Sea Region

Location	Water (µg/L)	Sediment (µg/g dw)	Aquatic Plant (µg/g dw)	Invertebrate (µg/g dw)	Fish (µg/g dw)	Bird Eggs (µg/g dw)
Salton Sea - Open Water [1] (mean and range)	-	-	0.83 (0.2-1.1)	-	10.4 (4.37 - 25.7)	
Salton Sea - Shoreline and Shallow Water[1] (mean and range)	-	-	0.72 (0.4-1.3)	6.64 (0.82-12.1)	-	5.98 (0.54-14.2)
Salton Sea[2] (range of means)	1.9-3.2	1.42-2.42	-	2.37 - 3.64	-	5.41 (Morton Bay)
Alamo River Estuary[1] (mean and range)	-	-	-	4.25 (0.7-5.7)	11.5 (4.3 - 27.9)	
New River Estuary[1] (mean and range)	-	-	-	2.7 (2.5-2.9)	9.67 (3.5-17.0)	2.81 (1.9- 3.7)
Saline Habitat Ponds[2] (range of means)	1.2-3.9	0.94-2.44	-	2.16 - 8.50	-	4.52 - 9.09
SBSSNWR[2] (range of means)	0.7-1.1	0.38-0.61	-	0.92 - 2.31	-	2.18 - 4.42
Freshwater Marsh[2] (range of means)	2.0-4.2	1.73-2.67	-	2.05 - 2.83	-	5.6 - 7.05
Agricultural Drains[3] (mean and range)	5.62 (0.70-32.8)	1.43 (0.33-10.0)	2.22 (0.75-8.26)	Chironomid 6.50 (1.39-50.6)	Mosquitofish 6.81 (3.66-20.2) Salfin molly 6.89 (3.09-30.4)	-
New River Imperial Wetlands[4] (median and range)	(2.7-5.4)	0.3 (0.2-0.8)	-	Corixid, glass shrimp, Odonate, 4.1 (2.8-5.2)	Carp 4.4 Shad 4.7 (3.3-20.0)	-
New River Brawley Wetlands[4] (median and range)	(2.2-3.9)	0.4 (0.4-0.5)	-	Corixid, Odonate, glass shrimp, crayfish 2.6-3.8 (1.5-8.2)	Carp 4.0 Shad 2.8 Tilapia 4.5 (1.9-7.3)	-

1. DWR and DFG 2006, Appendix F
2. The USGS Saline Habitat Ponds were supplied with Salton Sea and Alamo River waters, Sonny Bono National Wildlife Refuge supplied by Colorado River water, Freshwater Marsh supplied with agricultural drainwater (Miles et al. 2009),
3. Saiki et al. 2010. Values are for seven IID agricultural drains in southern Salton Sea.
4. Johnson et al. 2009.



Adapted from: Salton Sea PEIR, 2006, Appendix F Ecological Risk Assessment (DFG and DWR 2006).

Note: Not all pathways are shown (all biota can potentially receive selenium from abiotic media [water and sediment] as well as through foodweb.)

Figure 2-3 Selenium Cycling and Transport Pathways

While many bird species use the Salton Sea ecosystem for a part or all of their lives (summer breeding, wintering, or migratory stopover), the species with greatest exposure would be those that both breed at the Salton Sea and feed on aquatic invertebrates and fish in the SCH ponds. Examples of breeding species that could be exposed at the SCH ponds include double-crested cormorant, Caspian tern, black skimmer, gull-billed tern, black-necked stilt, and western snowy plover. Nesting by California brown pelican has been documented (Molina and Sturm 2004), but has not been observed in recent years.

Mean egg selenium concentrations measured in black-necked stilt eggs has varied among sites (Table 2-1). At the freshwater marsh site and Morton Bay, egg selenium concentrations exceeded 6 µg/g dw in 39 percent of black-necked stilt eggs, but hatchability did not appear affected (Miles et al. 2009).

2.2 KEY QUESTIONS AND UNCERTAINTIES

Questions and uncertainties exist regarding physical and chemical processes, physical habitat, and biological responses in the ponds. The SCH Project alternatives were designed and evaluated with consideration of available data (e.g., Miles et al. 2009) and new applied studies conducted specifically for the SCH Project design. These applied studies included characterization of contaminants in water and sediment, hydrological and water quality modeling, salinity and temperature tolerances of tilapia species, selenium ecorisk modeling, and selenium treatment by wetland vegetation (*Appendix J Special Studies* and *Appendix I Selenium Management Strategies* [USACOE and Resources Agency 2011, 2013]).

The SCH Project has been designed with consideration of these issues and uncertainties:

- **Water Loss** - The ponds will lose water due to evaporation (estimated at 6 feet per year) and possibly seepage through the bottom (unknown, but the potential range is 3 feet to 15 feet per year). The rate of seepage varies greatly depending on substrate composition, with the highest seepage rate in the area closest to the New River.
- **Water Quality** –Salinity and volume can be manipulated through operations (source water, pumping rates, water control structure operation, and residence time). Other factors are not as controllable. Water temperature and dissolved oxygen levels will be affected by ambient air temperature, wind mixing, and the nutrient-rich water supply. Ambient air temperature will affect evaporation, which will affect salinity.
- **Tolerances of Aquatic Biota -** Water quality in the ponds will affect survival and recruitment of invertebrates and fish in the ponds. Fish stocking will take into account species-specific tolerances of salinity and temperatures.
- **Relative Selenium Loading** – Selenium in river water supplying the ponds could bioaccumulate through the food web from invertebrates and fish to birds. Shorter residence time and lower salinity mean greater inputs of river water, which can increase overall selenium loading to the ponds. Releasing water from the ponds back to the Sea may help flush selenium.
- **Invasive and Emergent Vegetation Control** – Invasive vegetation, like tamarisk, and emergent vegetation such as cattails and bulrush have the potential to increase risk of selenium bioaccumulation. Increasing pond salinity can reduce establishment of emergent vegetation. Most vegetation growth is inhibited at 10 ppt salinity, but some strains could tolerate salinities up to 35 ppt. Emergent vegetation may also be controlled by periodic physical removal.
- **Vector Risk** – Mosquitoes that breed at the ponds could pose a potential human health risk. The likelihood for mosquito vector impacts is based on breeding season (March through November) and salinity tolerance of mosquito larvae (survival up to 25 ppt, complete control over 34 ppt). Raising the pond salinity could be used to control mosquitoes. Mosquito larvae may also be consumed by the fish in the ponds. The lack of emergent vegetation will eliminate interstitial spaces on the water's surface, which facilitate larval development. Monitoring and control measures are detailed in the Project environmental documents (*Appendix F - Mosquito Control Plan* [USACOE and Resources Agency 2011, 2013]).

Key questions for the Project include:

- What operations will be necessary to achieve target operational ranges of water quality (salinity) and water storage (depth, residence time) given evaporation losses and unknown rates of seepage?
- What salinity and flow regime will result in the most productive and sustainable saline aquatic ecosystem (i.e. minimal die-off events, fish abundance)?
- What is the pattern and location of erosion on berms and constructed islands?
- What is the pattern of deposition and/or scour in sedimentation basins and channels, given wind-driven wave action and sediment inputs from water supply? Will constructed channels retain their form, or will they slump or fill?
- What is the pattern of aquatic community development following filling of the ponds?
- Will the SCH ponds sustain a population of desert pupfish?
- What are the spatial and temporal patterns of bird use at the SCH ponds? How does this compare to patterns in the Salton Sea and local related habitat and impoundments?

- Will selenium levels in SCH ponds and food-web biota reach levels that could pose a risk to birds using the SCH ponds? Will birds using the SCH ponds be adversely affected by selenium?

The MAMP will address these questions and other objective-based performance questions in a phased, adaptive approach. Issues that require more in-depth analysis may be referred to focused investigations, depending on need and available funding or partners. However, the development of focused investigations is outside the scope of this MAMP.

SECTION 3

PROJECT DESIGN AND OPERATIONS

The SCH Project will create and operate two saline ponds, each with a variety of depths ranging from one to six feet deep. Physical features include existing topography and sediment, and constructed features such as berms to impound water, small islands, channels, and water control structures (weirs, pumps, pipes, and valves). Operations will manage water supply and flow rates to manipulate controllable variables such as salinity, depth (managed as water volume), and residence time. Fish stocking will be used to initiate colonization of the operational ponds. The SCH habitat creation approach is depicted conceptually in Figure 3-1.

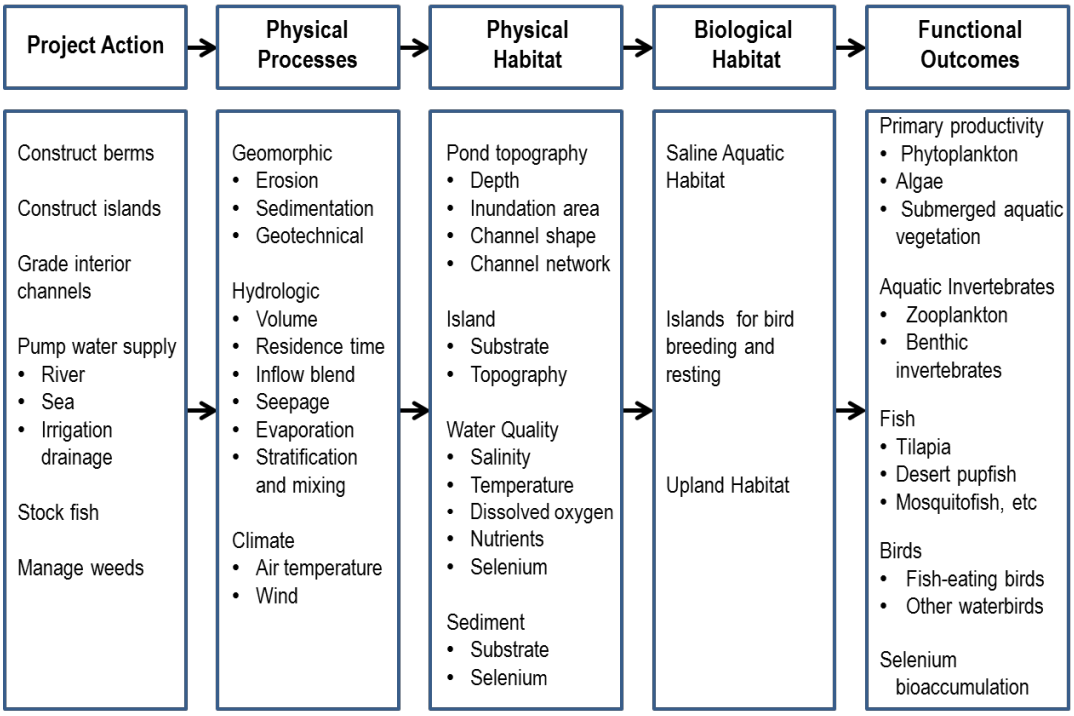


Figure 3-1 SCH Project Actions and Outcomes

3.1 POND DESIGN

Artificial ponds will be created by constructing low-height berms on recently exposed playa at the mouth of the New River. For the entire project (3,770 acres), each individual pond will be between 150 to 720 acres. Initially, two ponds approximately 320 acres each will be constructed (640 acres total) during the

implementation period addressed by this MAMP (Figure 3-2). The ground surface of the ponds will be excavated to achieve a balance between channel cuts and sufficient fill to construct the berms. Artificial habitat islands will be constructed to create roosting and nesting habitat for birds that is somewhat isolated from land-based predators such as coyotes and raccoons. Channels or swales will be graded to increase aquatic habitat diversity and to create deeper water around islands to discourage mammalian predators.

The water supply for these constructed ponds will be a blend of brackish water from the New River and saline water from the Salton Sea, with each source piped in from a pump station. Each pond will have a mixing basin where river and saline waters will be combined before being released into the pond. A deep section of each pond at the water supply inlet will serve as a sedimentation basin to allow suspended sediment contained in the influent river water to settle. An overflow weir and removable stop logs will control outflow from the ponds back to the Salton Sea. Inter-pond flow will be controlled by stop logs in the internal berm.

3.2 OPERATIONS SCENARIOS

Experimental operations scenarios are designed to test which salinity regime results in the best combination or balance of invertebrate and fish productivity, bird use, seasonal fish survival, and selenium ecorisk minimization (USACOE and Resources Agency 2011, 2013) (Figure 3-3). For example, tilapia tolerate cold conditions better at lower salinities (20 ppt) than at higher salinities (60 ppt), but selenium loading to the pond is increased (more river water equals lower salinity but higher inputs of water-borne selenium). Salinity in the ponds could also be increased as needed to control mosquito populations, control emergent vegetation growth known to bioaccumulate selenium, and limit the development of aquatic habitat that could support freshwater fish known to be predators of desert pupfish.

The managed variables and their targeted ranges are as follows:

- **Salinity** – The initial target range for the ponds will be between 20-40 ppt.
- **Storage** – The ponds will be filled to approximately 80 to 100 percent of capacity. This will affect water depth and wetted area of the pond, depending on the pond bathymetry.
- **Residence Time** – Residence time is the rate of replacement for the water in the ponds. The minimum replacement rate while maintaining constant storage is to replace the water lost to evaporation and seepage. The residence time of water in a pond will range from 2 weeks to 32 weeks. Basic replacement of the water lost to evaporation and seepage can result in a residence time of 6 weeks to 9 weeks at the higher seepage rate, depending on the time of year. The residence time can be decreased by replacing the losses and then adding an extra amount and releasing a like amount back to the Sea.
- **Fish Stocking** – The ponds will be stocked with fish species currently present in the Salton Sea basin that are tolerant of a wide range of temperature, dissolved oxygen, and salinity conditions. The species of stocked fish will be selected based on their suitability as prey items for birds as well as their physiological tolerances (DFG 2011). Candidate species for initial introduction include California Mozambique hybrid tilapia, redbelly tilapia, threadfin shad, sailfin molly, mosquitofish, and the native desert pupfish.

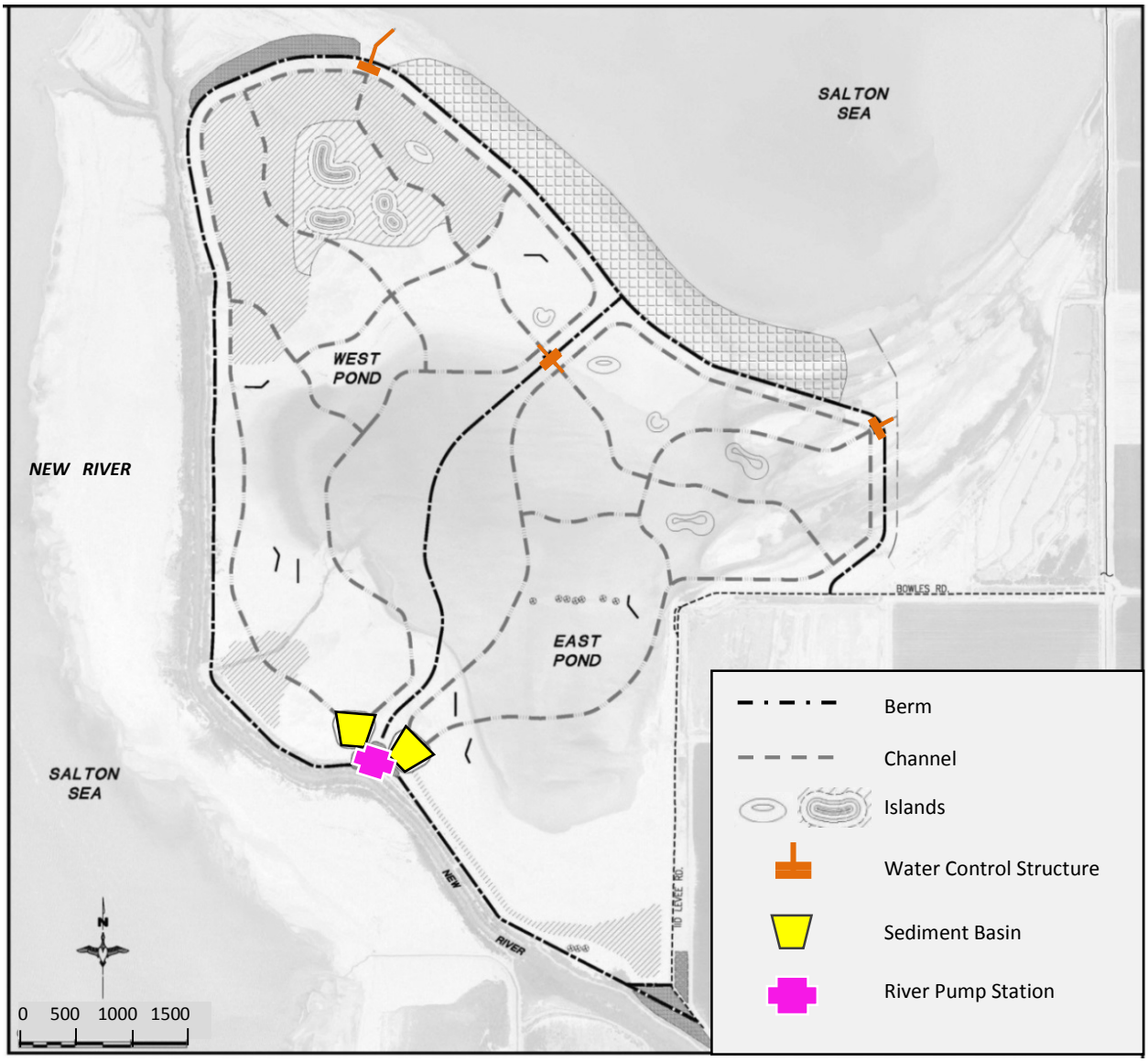


Figure 3-2 SCH Project – West Pond and East Pond

The pumps, valves, and weirs will be operated to manage water sources and flow rates to produce desired salinity, depth, and residence time. Operations scenarios are defined by salinity and the residence time of the stored water (Table 3-1). Scenario 1, the first operational scenario to be implemented, will test the lower (20 ppt in West Pond) and upper (40 ppt in East Pond) extremes of the operational range, to increase the likelihood of measuring the effect of salinity on Project performance. Each pond will be operated at the same replacement rate with a different salinity. Scenario 1 will maintain salinity constant through the year. This scenario will be run for at least two years. (Prior to establishing conditions for Scenario 1, ponds will initially be filled to 30 ppt and 30 ppt, to validate the completion of construction by the contractor.)

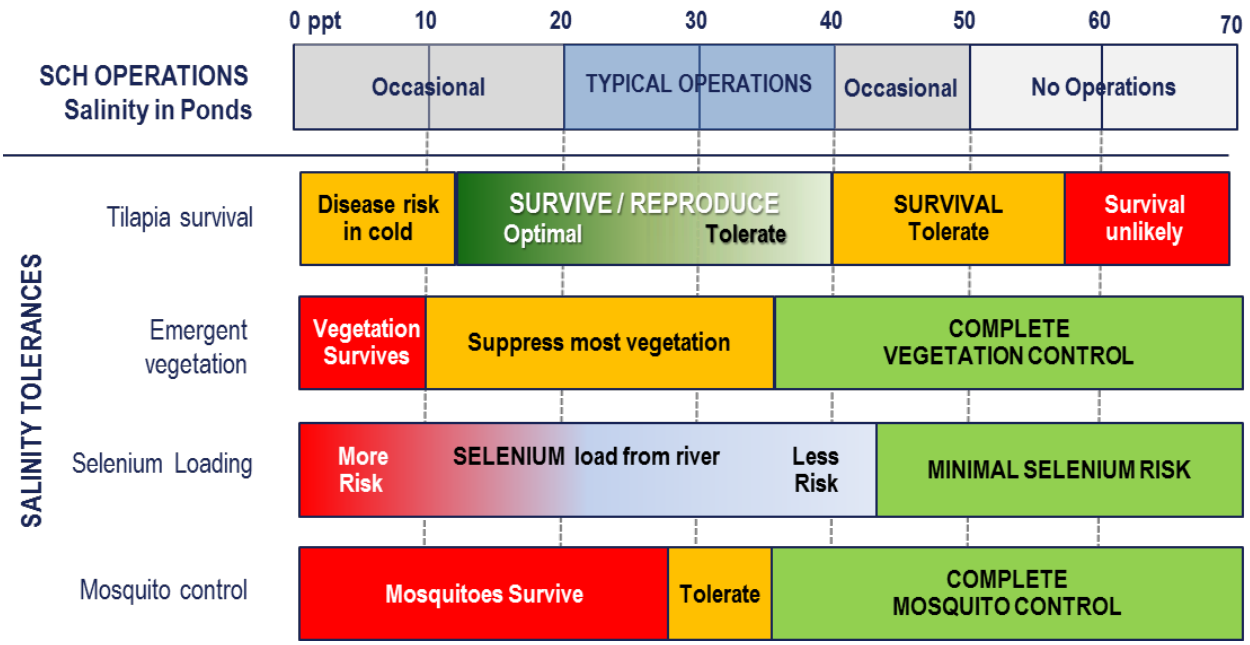


Figure 3-3 Operational Ranges and Constraints

Other operations scenarios could be tested during this 10-year implementation period, depending on management goals and feedback from monitoring. Scenarios 2 and 3 would increase inflow 10 percent or 20 percent, respectively, over the replacement rate. This would produce outflow from the pond and thus reduce the residence time, at the cost of additional pumping. With more information from monitoring, operation scenarios could be adapted to improve Project performance. Salinity regimes could be varied seasonally, instead of held constant year-round. For example, reducing salinity of inflow during the winter could enhance survival of cold-sensitive tilapia species.

Table 3-1 Proposed Experimental Operations Scenarios

	Experimental Operations Scenarios					
Parameter	Scenario 1		Scenario 2		Scenario 3	
	West Pond	East Pond	West Pond	East Pond	West Pond	East Pond
Salinity	20 ppt	40 ppt	20 ppt	40 ppt	25 ppt	35 ppt
Replacement Rate[1]	R	R	R +10%	R +10%	R +20%	R +20%
Outflow to Sea[2]	0	0	10%	10%	20%	20%

1. R=Replacement Rate, the inflow that keeps up with losses from evaporation and seepage. Percentage refers to percent of replacement rate
2. Percent of replacement rate

3.3 STAGES OF OPERATIONS AND MONITORING

The new ponds are expected to go through physical and chemical changes following wetting of the playa sediment and initial filling. Operations and monitoring will be adjusted for each stage of pond succession (Table 3-2).

Table 3-2 Stages of Operations and Pond Succession

Stage	Description	Initiation of Monitoring	Trigger to advance to next stage
1. Pond flood-up	Filling the ponds for the first time after construction is expected to take about three months using the designed pumps, and less time if portable pumps are also used.	Start monitoring inflow, water quality, bird use	Ponds are holding water within acceptable range of desired salinity and volume, and/or two months have passed since flood up started.
2. Aquatic foodweb establishment	During the filling period, the ponds will be allowed to "season" for a period of several weeks to months while undergoing various stages of chemical and biological succession. Water chemistry will likely fluctuate as compounds leach from the newly wetted soils and microbial communities are initiated.	Start monitoring invertebrates	Once phytoplankton, zooplankton and other invertebrates are established and salinity is within target range.
3. Fish stocking and establishment	Fish will be introduced to the ponds, starting with sailfin mollies and mosquitofish, then tilapia.	Start monitoring fish	Fish are present in monthly sampling.
4. Fish community persistence	Fish community will become established and persist.		Continue regular schedule of operations and monitoring, until pond operating scenario is changed and/or ponds are drained.

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SECTION 4

MONITORING APPROACH

4.1 PURPOSE OF MONITORING

The monitoring plan is designed to provide the appropriate level of information for assessment and decision-making such as:

- Operations– guide operations of pumps and weirs to maintain target conditions of salinity, water volume and flow in the ponds,
- Effectiveness – track progress toward project objectives, evaluate effectiveness of management actions, and check monitoring results for triggers for potential management responses,
- Compliance - track status of tasks required for permits issued by regulatory agencies, and
- Site Maintenance – document general site conditions and detect any issues that may trigger a standard management response (e.g., erosion control, weed control, vector control).

Implementation of monitoring will use a tiered adaptive approach. Highest priority will be (1) hydrological parameters essential for pond operations (inflow, depth, and salinity), (2) the presence of a robust community of fishes, and (3) bird use of the SCH ponds, key indicators of Project effectiveness. Monitoring of physical processes (water quality and hydrodynamics) that are key drivers of habitat function throughout the ponds is also important. Next priority is monitoring early-warning indicators of potential threats, such as selenium concentrations or mosquito larvae in ponds.

If the success indicators are progressing toward desired outcomes or within acceptable ranges of variation, then managers can continue planned operations and monitoring.

However, if the SCH Project is not progressing as expected, or if a threat indicator hits a certain threshold, a management response would be triggered. Examples of potential responses would include adjustment of short-term operations; more targeted monitoring to diagnose issues; corrective actions if known, necessary and feasible; adjustment of long-term management plans; and/or further study if necessary to reduce uncertainties. For example, if fish-eating birds are not present or at low densities, relative to nearby comparable habitats, then diagnostic monitoring of food resources (fish abundance) would be triggered. If fish abundance is significantly lower than indicated by comparable situations, this could trigger a closer assessment of water quality conditions, and possible adjustment of operations.

An overview of the SCH Project monitoring program schedule is shown in Table 4-1.

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Table 4-1 SCH Monitoring and Adaptive Management Schedule

Metric	Frequency	Method	Pre-Filling		Post-Filling		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
			Pre-Construct	Post-Construct	1 month	3 months												
General Conditions and Operations																		
Water Supply (volume, salinity)	Continuous	Stage at weir; EC of influent water			●	●	●	●	●	●	●	●	●	●	●	●	●	●
Qualitative Site Assessment	Annual	Visual inspection		●	●						●							
Photo Points	Annual or Biennial	Aerial photos	●	●							●							
Vector Control	Monthly or biweekly during mosquito season	Dipnetting of mosquito larvae								●	●	●	●	●	●			
Pest Plant Monitoring	Annual	Visual inspection									●							
Physical																		
Pond Bathymetry	Before filling, annually for 3 years, and biennial after	Transect elevation surveys		●							●							
Berm and Island Erosion	Annual	Visual inspection		●							●							
Hydrological and Water Quality																		
Water elevation	Continuous	Water level logger			●	●	●	●	●	●	●	●	●	●	●	●	●	●
Basic Water Quality (temperature, conductivity [salinity], dissolved oxygen, pH, turbidity, chlorophyll)	Continuous	Permanent sonde unit			●	●	●	●	●	●	●	●	●	●	●	●	●	●
Basic Water Quality, nutrients, contaminants	Monthly during filling, Quarterly thereafter	Grab samples, Hand held water quality meter			●	●			●			●			●			●
Selenium – water, sediment	Annual		●						●									
Biological																		
Aquatic Invertebrates	Quarterly	Net sweeps, benthic grabs or core samples			●	●	●			●			●			●		
Fish	Quarterly	Fish traps or other methods			●		●			●			●			●		

Table 4-1 SCH Monitoring and Adaptive Management Schedule

Metric	Frequency	Method	Pre-Filling		Post-Filling		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
			Pre-Construct	Post-Construct	1 month	3 months												
Birds - Waterbirds	Spring migration, Summer, Fall migration	Visual surveys	●		●	●		●		●		●		●			●	
Birds – Colonial Breeding	Biweekly January-March, Weekly April-August	Visual surveys					●	●	●	●	●	●	●	●				
Selenium – Aquatic Biota	Annual	Invertebrates, fish tissue, vegetation							●									
Selenium – Bird eggs	Annual (only if triggered by aquatic biota Se levels)	Black-necked stilt eggs lab analysis								●								
Management Decisions																		
Annual Report	Annual																	●
Management Review	Annual, or more often as needed						●	●										
Workplan Adjustments	Annual, or more often as needed							●										

4.2 OPERATIONAL MONITORING

Operations decision-making requires information on hydrology and water quality of the water supply and ponds, and climate conditions of the surrounding environment. Operational monitoring will collect data from the influent water supplies and from the stored water in the ponds, mixing basin, or intake pipelines. The parameters monitored will include:

- **Inflow** – flow will be measured in the river water pipeline, the saline water pipeline, and the Bowles Road agricultural pumps using a pressure transducer on the discharge end of the pump, or measuring the water passing the overflow weirs in the mixing basin at the river pump station.
- **Pond stage** –water elevation in each pond will be measured with a staff gage or a pressure transducer that can electronically record the stage.
- **Outflow** – any outflow from a pond will be measured as the stage of water flowing over the weir at the water control structures (located at the outlet that releases to the Sea and at the connection between the ponds).

- **Salinity** – salinity will be computed from electrical conductivity (EC) measured at the river pump station for each inflow (river and saline) and the mixing basins for each pond. A Salton Sea-specific conversion equation will be used (Watts et al. 2001)[2].
- **Climate Factors** – Uncontrollable factors that affect conditions of the ponds include rainfall, evaporation, and wind direction and speed. Weather data can be collected from an existing station, such as the CIMIS station located about 2.4 miles to the southeast of the east pond, or adding a weather station on site.
- **Calculated Parameters** – not all of the operational conditions will be directly measured. Water balance will be calculated for each pond from the inflow and outflow measurements, evaporation, stage, and pond surface area. The surface area is determined from an area-stage-volume curve. An unknown term in the balance is the seepage rate, which will be back-calculated through the water balance.

4.3 EFFECTIVENESS MONITORING

The SCH project will systematically measure indicators of ecological attributes to document conditions and changes that are expected to occur in response to the Project actions (Trulio et al. 2007). Monitoring efforts will be guided by the specific SCH Project objectives and desired outcomes, and the broader context of the Salton Sea MAP (Case et al. 2013). The MAMP describes expected outcomes for each objective and identifies appropriate indicators or parameters for monitoring (Table 4-1). Effectiveness monitoring will document status and trends, assess progress towards objectives and detect potential issues that may trigger a management response. Indicators ideally should be ecologically meaningful; efficient, cost-effective and feasible to measure; and informative for management decisions. The sampling design should take into account the range of variability in the indicator values (i.e. seasonal patterns, spatial heterogeneity in pond conditions).

To provide context for assessing status and progress toward objectives, status and trends of indicators at the Project site will be compared to pre-project site conditions where appropriate, conditions at reference sites if available and comparable, or known or hypothesized functional relationships or thresholds. The SCH ponds are not being developed as mitigation, so the standard for matching existing habitat function is a guide for comparison, but is not required by permit or other legally binding agreement. Reference or analog sites will be identified prior to Project implementation for use in future comparisons. The current status of biological resources will represent baseline conditions from which changes in status over time can be measured for the distribution, abundance, or habitat use by individual species or groups of species (Case et al. 2013). The retrospective analyses and establishment of existing conditions will be a starting point for comparison with future changes in use and will provide a guide for evaluating the performance of project implementation.

Design and implementation of SCH monitoring will be coordinated where possible with other regional survey and monitoring efforts, to ensure consistency and comparability of data. Selection of reference sites will be guided by similarity of desired habitat, target species, proximity to the project site, and/or ecological function. Potential comparison sites include but are not limited to: former USGS/Reclamation Saline Habitat Ponds (Miles et al. 2009), nearshore habitats of the Salton Sea, and managed ponds at the Sonny Bono Salton Sea National Wildlife Refuge (SBSSNWR). Comparability will depend on the parameter, sampling methodology and site-specific conditions.

[2] Because of the high sulfate concentrations in Salton Sea water, EC will underestimate salinity at higher levels if you take the readings directly from the instrument. The typical conversion is EC (umhos/cm) x 0.65 = salinity (mg/L), but the multiplier for the Sea is closer to 0.8. A better option would be to use the equation for converting EC to salinity by Watts et al. (2001).

Past and ongoing studies include biological surveys by DFW (e.g., Keeney 2009), monitoring at the SBSSNWR by the United States Fish and Wildlife Service (FWS), water quality monitoring by the Bureau of Reclamation, studies of water quality and biota in agricultural drains and rivers by USGS (e.g., Saiki et al. 2010), bird surveys by the Natural History Museum of Los Angeles County (NHMLA) (Molina and Sturm 2004), surveys for the Imperial Irrigation District's (IID) Habitat Conservation Plan/Natural Community Conservation Plan, and past special studies of selenium and other contaminants completed by university researchers (University of California Riverside, San Diego State University, University of California Berkeley) in support of the SCH Project design alternatives (Amrhein and Smith 2011, Amrhein et al. 2011, Sickman et al. 2011).

Table 4-2 Effectiveness Monitoring Objectives and Indicators

Objectives	Monitoring Category	Expected Outcomes[1]	Indicators for Monitoring	Priority[2]
1. Provide appropriate foraging habitat for piscivorous bird species.	Physical habitat	• The amount and conditions of saline pond habitat will be characterized.	• Topography / bathymetry of pond	1
	Biological	• Piscivorous birds will forage at the SCH ponds.	• Bird species, relative abundance, foraging behavior.	1
		• Fish will be present in the SCH ponds	• Fish species, relative abundance	1
2. Develop physical structure and microhabitat elements required to support piscivorous bird species.	Physical habitat	• The area and condition of constructed islands and other habitat elements will be characterized	• Location, number, topography and substrate of islands (as built)	1
	Biological	• Target bird species (pelicans, terns, cormorants, skimmers) will occupy and use the constructed islands and ponds. Community composition and relative abundance will be characterized.	• Bird species, relative abundance, and distribution among islands and ponds.	1
		• Breeding activity will be characterized.	• Bird habitat use of islands, berms and other structures	1
		• Nesting success will be characterized if resources available.	• Aerial photo of nesting, nest cameras	2
3. Support a sustainable, productive aquatic community	Physical habitat	• The amount and conditions of aquatic habitat in the SCH ponds will be characterized.	• Topography/Bathymetry	1
		• Ponds maintained at depths ranging 2-6 feet.	• Water level	2
	Biological	• Fish will be present, including tilapia.	• Fish species, relative abundance	2
		• Invertebrates will be present.	• Pelagic and benthic macroinvertebrates	2

Table 4-2 Effectiveness Monitoring Objectives and Indicators

Objectives	Monitoring Category	Expected Outcomes[1]	Indicators for Monitoring	Priority[2]
4. Provide suitable water quality for fish	Water quality	• Salinity in the SCH ponds will not exceed 40 ppt on average, and will be within the 20-40 ppt range consistent with selected operations scenario.	• Salinity	1
		• Within each pond, there will be areas with water temperature and dissolved oxygen conditions within tolerance range for forage fish.	• Temperature (water and air) • Dissolved oxygen	1
	Biological	• Fish will be present, including tilapia. • If there is a die-off event, the fish community will recover within the year.	• Fish species, relative abundance, reproductive output • Fish die-off events (timing, frequency, magnitude, species). • Water quality and climate conditions before/during die-off	1 1 1
5. Minimize adverse effects on desert pupfish	Biological	• Desert pupfish will be present in the SCH ponds.	• Pupfish abundance and distribution	1
6. Minimize Selenium risk	Water quality	• Mean selenium concentrations in pond water will not exceed 2 ug/L • Mean selenium concentrations in sediment will not exceed 4 mg/kg	• Selenium concentrations in the pond water • Selenium concentrations in sediment	1
	Biological	• Mean concentrations of selenium in foodweb biota will not exceed protective standards (invertebrates will not exceed 3 ug/g dw, fish tissue will not exceed 4 ug/g dw) and/or background levels at the Salton Sea • IF triggered by water quality or foodweb selenium measurements: Mean concentrations of selenium in sensitive bird species (black-necked stilt eggs) will not exceed background levels at the Salton Sea	• Selenium concentrations in invertebrates and fish • Selenium concentrations in black-necked stilt eggs (or other designated sentinel species)	2 3
7. Minimize risk of disease/toxicity impacts	Vector	• Density of mosquito larvae will not exceed acceptable levels defined by regional vector control	• Mosquito larvae (Breteau Index)	1
	Biological	• Avian disease outbreaks will be documented	• Dead and sick bird counts (timing, frequency, magnitude, species)	2

1. Expected outcome – desired or hypothesized outcome (project state) based on conceptual understanding and project design. For indicators where insufficient data exists to hypothesize a Project-specific outcome, status will be characterized for trend monitoring over time.

2. Priority for monitoring. Primary indicators will be monitored consistently. Monitoring of secondary indicators may occur less frequently and/or only if triggered by some event or threshold for a primary indicator.

4.4 COMPLIANCE MONITORING

Monitoring will also track compliance with regulatory permitting requirements. The status and trends of desert pupfish in the ponds will be monitored in the course of biological monitoring, to meet requirements of the Biological Opinion.

4.5 GENERAL SITE ASSESSMENTS

General inspections will be conducted annually to inform managers of needed maintenance or corrective actions. The visual survey will assess physical conditions and infrastructure, such as water control structures, erosion of berms, fencing integrity, condition of signage, trash accumulation, fire hazard, and evidence of trespass or unauthorized use by motor vehicles. Establishment of vegetation on the berms and islands, particularly of invasive species such as tamarisk, will be documented. The location and extent of these maintenance issues will be mapped and described.

Additional surveys will occur at least monthly during appropriate seasons to detect potential disease and toxicity impacts, such as die-offs of fish or birds in the ponds, and mosquito vector populations. Early detection and characterization of such problems is necessary to trigger timely management review and possible responses, such as changes in water supply operations to adjust water quality, removal of dead birds to control the spread of disease, and/or implementation of weed control measures. These observations may be made in the course of pond operations and maintenance activities and other regularly scheduled monitoring surveys.

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SECTION 5

MONITORING ELEMENTS

The SCH MAMP monitoring elements are derived from the MAP (Case et al. 2013), standard monitoring practices by CDFW staff, and other relevant protocols for monitoring habitat creation and restoration projects (e.g., Neckles et al. 2002, Roegner et al. 2008, IID 2011, Woo et al. 2011, Hobbs et al. 2012). Each monitoring element includes:

- Purpose and rationale for the monitoring activity,
- Location of sampling,
- Time period and frequency of sampling,
- General sampling protocol, and
- Overview of similar monitoring activities.

Prior to initiating monitoring activities of the SCH Project, the sampling design, field protocols and data analyses will be further detailed and refined in consultation with resource agencies and other experts. Measures to ensure the quality of the data collected and how those measures will be implemented will also be described in a Quality Assurance Project Plan (QAPP).

5.1 PHYSICAL

5.1.1 Landscape Imagery

Purpose and Rationale

Aerial photography is a valuable tool for visual documentation of landscape features for a base map and to quantify and assess changes accompanying project implementation.

Location

Aerial imagery should cover the footprint of the SCH ponds, associated infrastructure, and adjacent lands within approximately 1-2 miles of the pond boundaries. Ideally, the SCH managers and other land managers and agencies in the region, such as SBSSNWR and Imperial Irrigation District, should coordinate efforts to obtain imagery for broader areas of the south Salton Sea, thus maximizing coverage and providing cost efficiencies. A broader landscape perspective is valuable because many bird species that are the target of the project's habitat creation have home ranges larger than the SCH ponds and therefore may be moving among multiple habitats in the region.

Period and Frequency

Aerial imagery should be obtained before and after construction of new ponds. The frequency of imagery acquisition can be low (every 3-5 years) because the managed SCH ponds are not expected to undergo rapid geomorphic change. Publicly available imagery may be flown sufficiently often to serve this purpose. Otherwise, overflights could be arranged at desired periods through commercial vendors.

Sampling Protocol

Aerial photographs will be obtained following construction. Photos should be orthorectified for use in GIS applications. Google Earth photos can also be used to provide a visual record in other years and seasons (within the parameters authorized by licensing agreements).

5.1.2 Elevation and Topography

Purpose and Rationale

Elevation and topography are key factors in the structure and function of aquatic and terrestrial habitat. Wind-driven wave action within the pond could result in erosion of berms and islands, or slumping of excavated channels. Sediment inputs could fill the sediment basin and channels. The topographic survey will document as-built conditions to evaluate geomorphic changes to constructed features (islands, channels, sedimentation basin), and will provide data necessary to calculate pond storage and volume (depth-volume relationship).

Location

The topographic survey will cover the entire footprint of the SCH ponds and associated infrastructure.

Period and Frequency

Survey and mapping of the constructed ponds and features will occur immediately after construction and prior to filling. Transects will be resurveyed annually during the first three years, then once every two years until the end of the initial implementation period.

Sampling Protocol

Following construction, a survey of as-built conditions will be made to document elevation throughout the newly constructed ponds, the location of features such as islands and channels, and the substrate on islands. Permanent transects (four to ten per pond, to be determined based on as-built conditions) will be established across representative areas of the pond, including cross sections of excavated channels. All transects will be surveyed following construction to provide baseline data on channel and playa elevations prior to filling. Transect starting and ending points will be permanently marked in the field to facilitate reoccupation in subsequent monitoring years. A georeferenced elevation map will be prepared, which can be used in combination with water level data to determine the depth of inundation in the ponds over time.

Subsequent surveys of the filled ponds will be conducted by boat using GPS, revisiting the transects and measuring elevation.

5.2 HYDROLOGY

Purpose and Rationale

Water level (depth or stage) and flow rate (volume, residence time) are important attributes of aquatic habitat and hydrodynamic processes in the SCH ponds. This information is also essential for managers operating the water supply for the ponds. Water level data can be integrated with topographic surveys to create depth and area maps in GIS.

Location

Water flowing into the ponds will be measured at the river pump station, where the saline and river water supplies come together for mixing and distribution to the ponds. The river pump station has the following

equipment for each water supply (river and saline): intake line, inflow basin, weirs to East Pond and West Pond, and mixing chambers for East Pond and West Pond.

Water level within the ponds will be monitored at three locations in each pond using electronic water level loggers (Figure 5-1). The stations will be accessed by boat. Water level data should be properly georeferenced to local topographic data that are related to an established vertical elevation datum, such as the Sea water surface elevation monitoring station near the project site (USGS 10254005).

Period and Frequency

Water level will be measured daily for the life of the project. Data loggers will be downloaded weekly to a computer. During the first weeks of operations, readings will be taken daily to fine tune the diversion rates and achieve the planned conditions in the ponds. As the operation proceeds the results of the sampling will indicate the correct download frequency and frequency that the data loggers record an event.

Sampling Protocol

Water level is best measured with automated data logging pressure transducers (Roegner et al. 2008). To continuously monitor stage in the inflow basins and ponds, pressure transducers will be installed along the walls of the station to be non-obtrusive and allow access to plug a computer into the data loggers to download the data. A staff gage will also be placed in each area to allow visual reading of the stage. Saline and river flow and pond inflow will be computed based on stage relationships. At project startup, the river weir and the saline weir for both the east and west ponds will be calibrated. That is, equations will be developed to relate the upstream stage with the flow over the weir. These four equations will be used to estimate the flow over the saline weir and river weir for both ponds. The river equations will be used with the stage in the river inflow basin and the saline weir associated with the saline inflow basin stage. The sum of the east and west river weir flows will equal the total river diversion, and the same for the saline side. These two flows can also be checked against the energy use at the pumps to arrive at another estimate of the total inflow.

In addition, a probe will be installed in each mixing chamber to measure EC continuously for conversion to salinity.

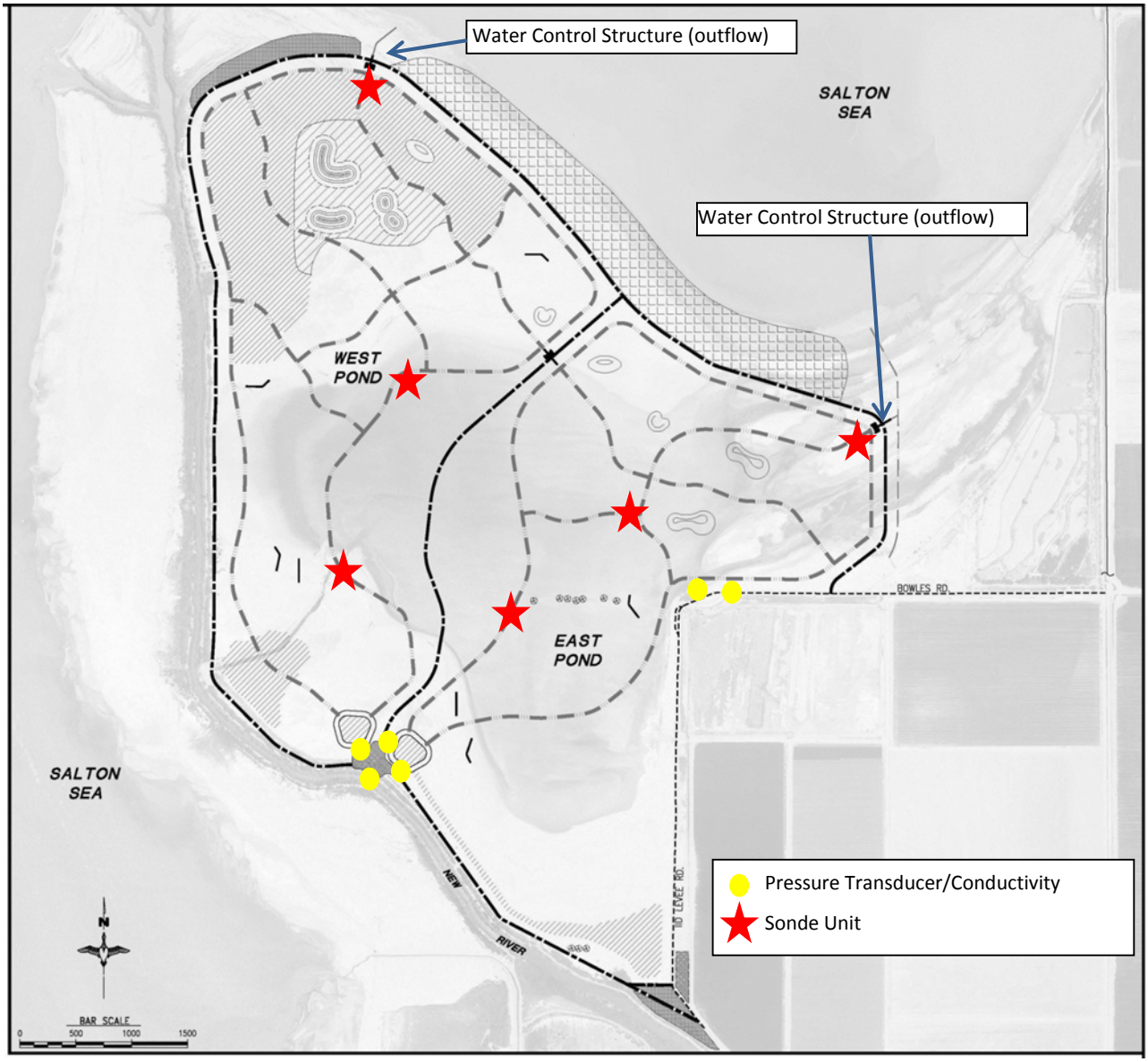

Figure 5-1 Location of Permanent Water Quality Monitoring Units in SCH Ponds

Within the ponds, continuous water level recorders, along with multiple parameter water quality probes, will be installed on a post driven into the pond bottom away from shore with a cable extending to shore for data collection. This gauge will be calibrated with direct measurement of depth from a boat at the unit. Automated instruments require proper placement to ensure comparable monitoring. The data logger should be secured submerged with sensors positioned at least 25 to 50 cm below the anticipated lowest water level, and at least 10 to 20 cm above the substrate to prevent sedimentation or abrasion. Regular maintenance (weekly or biweekly) will be required, due to anticipated fouling of the sensors.

The primary output from data loggers is a time series of water level. These relative heights should be corrected for atmospheric pressure and tied to NAVD88 and field-surveyed elevation data. This references hydrology to site topography and also facilitates comparison between sites.

5.3 WATER QUALITY

Purpose and Rationale

Water quality is a key driver of ecosystem function and condition in aquatic habitats. The Salton Sea and its environs are subject to several dynamic and complex environmental processes and conditions that affect the condition and quality of the water in relation to fish and wildlife habitat (Case et al. 2013). Processes expected to affect the SCH ponds include thermal stratification, eutrophication (nutrients and dissolved oxygen), organic production and decomposition, and selenium cycling and bioaccumulation.

The sampling frequency (continuous, quarterly/seasonal, or annual) will vary depending on the objective for monitoring, the parameter's variability, and its impact on biota.

5.3.1 Continuous Monitoring of Basic Water Quality

Location

Each pond will have three permanently installed water quality data sondes (a multiparameter instrument with several sensors). The proposed location of each sonde unit is shown in Figure 5-1. At least one unit will be deployed in the deepest area, which is close to the central berm separating the two ponds. This configuration is structured to sample the shallow depths and the habitat channels, plus sample the water as it moves across the pond from the inlet to the outlet.

Period and Frequency

Early in the operation of the ponds, readings will be taken hourly to fine tune the diversion rates and achieve planned conditions in the ponds. Water quality parameters can be recorded frequently (hourly) to capture daily and diel variations in water temperature (due to climate) and dissolved oxygen (due to algal photosynthesis and respiration). In general, the data will be downloaded weekly to a computer. As project operations proceed, the results of the sampling will be used to adjust frequency of sampling and data download.

Sampling Protocol

The sonde units will measure electrical conductivity (converted to salinity using a Salton Sea-specific conversion factor), temperature, dissolved oxygen, turbidity, and pH. Chlorophyll may also be measured. A pressure transducer is often included on water quality sondes to measure depth.

Automated instruments require proper placement to ensure comparable monitoring (Roegner et al. 2008). The sonde will be fitted in a PVC pipe mounted vertically on a wooden pole driven into the bottom of the pond. The sonde will be adjustable in the PVC pipe so that it can be set at different depths. The data logger should be secured submerged with sensors positioned at least 25 to 50 cm below the anticipated lowest water level, and at least 10 to 20 cm above the substrate to prevent sedimentation or abrasion. The depth of the unit will be read from a staff gage on the pole. The data will be recorded on a data logger on the pole that will use a radio transmitter to relay the data to the base station at the River Pump Station. Finally, a photovoltaic cell on top of the pole will provide the power to recharge the internal battery. Each site will be accessed by boat.

Each data logger will be equipped with a radio transmitter, and the collected data will be transmitted to the master receiver located at the River Pump Station. The master receiver will then transmit the data

through a cellular connection to a website for displaying the data. The storage site for the data may also be the DFW BIOS site.

5.3.2 Discrete Sampling of Water and Sediment Quality

Location

Grab samples (discrete sampling) will be collected from at least three sites within each pond, distributed among different strata based on depth, topography (channels, open deep water, open shallow water), and/or distance from influent source. Where possible, grab samples will be co-located with continuous monitoring stations (three per pond) for cross-reference and validation.

Period and Frequency

Sampling will occur quarterly: January, April, July/August, and October. Sediment sampling will occur annually in spring.

Sampling Protocol

Discrete sampling of water and sediment quality will include a combination of field measurements and grab samples. Basic water quality parameters (temperature, DO, turbidity, pH, EC, and chlorophyll) will be measured in situ using hand held probes and meters calibrated in accordance with manufacturer instructions and QAPP procedures. To document any vertical gradients, measurements will be taken throughout the water column.

Some constituents, such as nutrients, selenium and other contaminants, require more specialized analysis than a field meter can provide. Grab samples will be collected and submitted for laboratory analyses for nutrients (total phosphorus, ortho-phosphate, ammonia, nitrate, nitrite, and TKN); total selenium, selenate, and selenite; and total suspended solids. Water and sediment samples for laboratory analysis will follow procedures, sampling methods and equipment (jars, etc) provided by the testing laboratory. At each sampling point three subsamples would be collected approximately 20 to 30 m apart and then composited as one sample per sampling point (Miles et al. 2009).

Overview of Similar Monitoring Activities

Reclamation has been performing quarterly water quality monitoring at the New River outlet, among other locations (Case et al. 2013, Holdren and Montano 2002). Sediment sampling was conducted at the USGS Saline Habitat Ponds (Miles et al. 2009) and baseline studies at the New River (Amrhein and Smith 2011).

5.3.3 Selenium Sampling (Water, Sediment, and Biota)

Purpose and Rationale

Monitoring selenium in the water inflows, ponds, and the biota is needed to evaluate the ecological risk associated with selenium in the Salton Sea and created habitats. Selenium monitoring will be conducted in a phased approach.

Location

Selenium sample collection will be co-located with the water and sediment samples in the ponds. These will be collected from at least three locations in each pond. Biota samples for selenium will be the same samples collected for the purpose of monitoring benthic and water-column invertebrates. To the extent

possible, these samples will be collected near locations where fish monitoring is performed so that fish tissue samples can be obtained at the same time and selenium concentrations can be interpreted across media.

Period and Frequency

Selenium sampling is proposed to be performed for at least three years, after which the need and scale of monitoring can be re-evaluated. Water selenium concentrations will be measured quarterly, and sediment selenium will be measured annually in the spring. Biological tissue samples (invertebrates, fish, and if triggered, bird eggs) would be collected in spring, and coordinated with general invertebrate and fish surveys, whenever possible.

Sampling Protocol

Grab samples of water and sediment will be collected and submitted for laboratory analyses for total selenium, selenate, and selenite. Water and sediment sampling will use procedures and equipment (jars, etc) provided by the testing laboratory. The invertebrate and fish sampling will be performed as part of the biological monitoring. Fish tissue analyses will be performed on small fish (whole body) to evaluate ecological risks.

If selenium concentrations in water, sediment or food web biota exceed thresholds for possible bioaccumulation risk, then managers may decide to add measurements of selenium concentration in bird eggs. Bird eggs are often sensitive indicators of selenium problems within wetlands and are also sensitive indicators of organochlorine pesticide (e.g., DDE) issues. Black-necked stilt (*Himantopus mexicanus*) eggs will be targeted for collection because they are likely to be abundant, and the species is widely used for assessment of selenium exposure at the Salton Sea (Miles et al. 2009, IID 2011). Additionally, the model used to determine the design of the SCH Project was based on uptake of selenium from water to black-necked stilt eggs; therefore, measured egg concentrations of selenium could be compared to those predicted in the water-stilt egg model (USACOE and the Resources Agency 2011, 2013). If bird egg analysis is necessary, the sampling methodology will be developed further in coordination with any similar studies planned by SSSBNWR or the IID Managed Marsh (IID 2011).

Overview of Similar Monitoring Activities

Reclamation staff has been monitoring water-column selenium quarterly since 2004 (Chris Holdren, unpublished data). Monitoring funded by the IID and performed by the USGS assessed selenium in the water column of 29 direct drains and sediments (Saiki et al. 2010). USGS also assessed selenium in water, sediment, and biota at the now-decommissioned Saline Habitat Ponds (Miles et al. 2009). IID will be monitoring selenium in water, sediment and biota at their Managed Marsh Complex (IID 2011).

5.4 INVERTEBRATES

Purpose and Rationale

Water-column macroinvertebrates and benthic macroinvertebrates are important components of the aquatic food web supporting fish and birds (Case et al. 2013). The abundance and composition of invertebrates is an indicator of aquatic productivity under different management regimes, and a direct measure of food resources for fish and birds foraging in the created saline impoundments.

Following initiation of filling, the ponds will require a period to allow chemical stabilization and the establishment of invertebrate communities, which should inoculate the ponds naturally. Once the ponds' salinity is within the targeted range, the long-term invertebrate communities will become established Before this happens, ephemeral and temporary microbial and invertebrate communities will establish, but may not persist once the water conditions settle into the targeted range. Caution must be exercised not to

mistake the seasonal explosive growth of early colonizing species for the permanent community that develops once all invertebrate components are finally present.

Location

Water-column and benthic macroinvertebrate sampling will be performed at several locations (at least 10) within each pond. Sampling locations within these ponds will be determined during development of the sample design and will be similar to the locations sampled for fish.

Period and Frequency

Macroinvertebrate surveys in the SCH ponds initially are proposed to be performed for at least three years after commencing a new operations scenario, after which the need and scale of monitoring can be re-evaluated. Sampling will first occur monthly during pond filling (up to three months duration), and then annually in the spring. Additional sampling may be conducted seasonally if triggered by low abundance of fish or other concerns about aquatic productivity. For efficiency, it is desirable to collect water-column macroinvertebrate and benthic macroinvertebrate samples in the same locations. In addition, the macroinvertebrate sampling will be coordinated with water quality and sediment monitoring to produce co-located information that could help clarify how selenium and other contaminants cycle within the ecosystem.

Sampling Protocol

Replicate samples will be collected from each pond. An adequate number of replicates will be collected for an estimate of sample variability. To start with, at least three samples will be taken per sampling site (at least 10 samples per pond).

Water-column macroinvertebrates will be collected using a 1-mm mesh, framed net (or other suitable collection device) from throughout the water column and along habitat edges with approximately equal levels of effort per sampling area and habitat type.

Benthic macroinvertebrate samples will be collected by using a mini-Ponar or Ekman dredge (or other suitable collection device) to sample sediment and associated organisms from the top 10 to 20 centimeters of sediment over a known surface area. Samples will be sieved in the field using a 0.5-mm mesh sieve. Samples will be preserved in ethanol for later enumeration and identification.

Each sample will be analyzed to describe invertebrate density and species composition, and all organisms will be identified to the lowest practical taxonomic level. Some species that are difficult to identify could be analyzed as a group.

For each sampling site, physical habitat attributes such as depth, substrate, vegetation, and cover will be noted. Water quality will be measured by a hand-held water quality instrument, including water temperature, dissolved oxygen, and electrical conductivity (salinity). To document any vertical gradients, measurements will be taken throughout the water column. Coincident with sample collection, other water-quality and physical habitat attributes will be measured, including water depth, water temperature, dissolved oxygen, and electrical conductivity (salinity). Sample sites will be identified using GPS.

5.5 FISH

Purpose and Rationale

Fish monitoring will be conducted to document the type and relative abundance of (1) fish resources expected to support piscivorous bird species, and (2) desert pupfish.

A suite of forage fishes will be introduced to the ponds, namely several tilapia species, sailfin mollies, and mosquito fish. Monitoring will initially focus on survival of stocked fish and recruitment of new cohorts, and then shift to documenting long-term persistence, community composition, and relative abundance of forage fishes.

Specific questions to be answered include: 1) are fish surviving and reproducing, 2) which tilapia species develop sustainable populations, 3) how are the several fish species distributed within the ponds, and 4) what is the structure of the fish community over time?

These questions may need to be answered repeatedly, if fish die-offs occur. Simple presence/absence sampling will be conducted broadly throughout the ponds to determine which subsets of available habitat parameters are being utilized by which fish species. Demographic data (sex, size classes, breeding coloration) will also be collected to assess population-scale phenomena.

Fish monitoring will also be used to document distribution and relative abundance of desert pupfish. Desert pupfish will be introduced to the ponds and coexist with other fish species that they currently coexist with in other habitats. Piscivorous birds are expected to prey on desert pupfish as well as other fish in the SCH ponds.

Location

Fish sampling will occur at various locations (at least 10) in each pond to characterize the fish community, with sampling efforts distributed among habitat strata such as water depth, proximity to structural elements such as armored islands and berms, and tamarisk slash islands. When shallow water widgeon grass beds develop, their presence/absence will be included as a sampling site variable. Where possible, fish sampling will be co-located with sampling sites for water and sediment quality, invertebrates, and bathymetry transects across channels.

Period and Frequency

Prior to stocking fish, the ponds will require a period to allow chemical stabilization and the establishment of invertebrate communities, as described earlier. Fish sampling will commence within a month of filling, to document any early species that colonize the ponds naturally. Once food resources are established and tilapia have been introduced, fish sampling will occur annually in the spring, with a possible second collection in the fall. Fish monitoring activities are to be coordinated with invertebrate, water-quality, and sediment monitoring activities, whenever possible. Fish surveys initially are proposed to be performed for at least three years after commencing a new operations scenario, after which the need and scale of monitoring can be re-evaluated.

Sampling Protocol

Fish monitoring and sample analyses will be conducted by DFW staff. Sampling gear will be determined by physical site conditions and accessibility in the soft-bottomed SCH ponds. Most sampling will be non-destructive sampling of forage species, unless whole fish or tissue samples are required for stomach content or selenium studies. The primary sampling gear will likely be baited metal mesh traps. Crayfish traps and eel traps are similar to minnow traps, except they have a larger funnel opening (2.25 inch) and are longer (31 inch). Mesh size is ¼ inch, which is large enough to avoid capturing and handling fragile life stage (fish fry). Traps will be used to sample young-of-the year tilapia, mosquitofish, sailfin mollies and desert pupfish (if present). Traps that are set to detect presence will be set for one to four hours. The shorter set time will be necessary during periods of high temperatures, or heightened potential for algal blooms and subsequent oxygen depletion. To determine the relative abundance of species, set times will be standardized to allow catch per unit effort (CPUE) analyses.

DFW staff will also collect data opportunistically, when visual observations of fish in situ allow identification of fish to species level, and detection of breeding coloration or behavior.

Focused desert pupfish sampling will employ different trap dimensions and set times, according to the standard protocol used for regional pupfish surveys. These traps have a metal screen mesh of 1/8 inch a funnel opening of one inch and are 18 inches long. This will allow a direct comparison with similar monitoring activities around the Salton Sea.

All captured fish will be counted and identified to the species level. Up to 30 individuals of each species will be measured (standard length). The fish species that were vetted for inclusion in the SCH ponds will be released immediately. Fish not intended for inclusion in SCH ponds (e.g., carp, centrarchid species) will be destroyed.

Additional sampling methods may be used, at the discretion of the DFW biologists. For example, tilapia cannot always be identified visually to the species level in hand. To determine the relative success of the several types of tilapia that may be stocked into SCH ponds, either adult coloration or gill raker counts may be necessary. This would require using larger fish traps, throw nets, or angling, or sacrificing some individuals, specifically for this purpose. Such sacrificed individuals would also provide information about condition, reproductive status, and diet. Desert pupfish will not be sacrificed, unless as part of a Federally permitted investigation.

For each sampling site, physical habitat attributes such as depth, substrate, vegetation, and cover will be noted. Water quality will be measured by a hand-held water quality instrument, including water temperature, dissolved oxygen, and electrical conductivity (salinity). To document any vertical gradients, measurements will be taken by throughout the water column. Sample locations will be georeferenced by GPS coordinates.

Overview of Similar Monitoring Activities

The DFW performs pupfish sampling on an annual, biannual, monthly, and more frequent basis (depending on habitat) at selected drains at the north and south ends of the sea, at marina and other shoreline areas, at washes near Hot Mineral Springs, at San Felipe Creek, at Salt Creek (lower and upper), and at refuge (artificial) habitats (Keeney 2009). The USGS also has performed pupfish sampling in drains, ponds, creeks, and created saline impoundments in the Imperial Valley and Coachella Valley (e.g. Saiki et al. 2011).

5.6 BIRDS

5.6.1 Bird Surveys

Purpose and Rationale

Birds are the principal target and success criterion of the SCH Project, which is designed to provide appropriate foraging habitat for piscivorous bird species. Birds are also integrative indicators of underlying ecosystem function, such as the aquatic foodweb. Bird monitoring will document species composition, distribution and relative abundance of birds using the SCH ponds and habitat features such as islands.

Location

Bird surveys will be conducted by vehicle and/or foot around the perimeter of each impoundment. The ponds will have large areas of open water and good visibility. Observers will record the number and species of all birds within view from the perimeter of the impoundments. Other factors to be considered may include distribution of birds, visibility, observer access, and risk of disturbing nesting.

Period and Frequency

Bird surveys in the SCH ponds will be performed for at least three years, after which the need and scale of monitoring can be re-evaluated. Surveys will be performed five times a year: February, April, June, August and November. This will capture seasonal variability in species and habitat use due to migration and breeding.

Protocol and Data Collection

Observers will drive around the perimeter of the ponds and count all birds noted using binoculars and a scope mounted to the vehicle. Possible restrictions or closures may result from birds nesting on berms. If observation platforms are installed on the berms, observers will scan the ponds from these set locations as well. Other survey methodologies may be considered once the ponds are built, depending on resulting conditions of the pond features and their visibility to surveyors. Observers will characterize bird use of the ponds, noting number of birds, species composition, qualitative description of activities (e.g. foraging, breeding, roosting or loafing), distribution within the ponds, and association with any habitat features such as open water, berms, shoreline, islands, isolated snags, and pilings and platforms. Locations of observations will be documented on maps.

In addition to observations of bird species, observers will record general habitat characteristics at each of these impoundments, noting general water level (staff gage) and condition of habitat features (especially if there are changes from previous conditions). Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition at each impoundment will be recorded at the time of the survey.

Overview of Similar Current Monitoring Activities

Data from the SCH ponds will be considered in the context of other past and ongoing bird surveys at the Salton Sea. Examples include monitoring by the USFWS at the SBSSNWR, USGS monitoring and studies at the experimental saline ponds (Miles et al. 2009), and volunteer monitoring of bird use at the Torres Martinez pilot wetland project.

5.6.2 Colonial Breeding Bird Surveys

Purpose and Justification

The Salton Sea serves as an important breeding area for many colonially breeding birds such as cormorants, gulls, terns, and skimmers. The SCH Project was designed with habitat features, such as islands, intended to support breeding for target species of piscivorous birds (double-crested cormorant, Caspian tern, gull-billed tern, black skimmer). Information on breeding bird numbers and nesting success, as well as the characteristics of areas used by breeding birds, will be valuable in the planning, design, and management of the SCH Project.

Locations

Surveys will be conducted by vehicle and/or foot around the perimeter of the ponds. The entire SCH Project site will be surveyed for breeding activity. Breeding colonies could be located on the berms, islands (nine total), pond outlet structures, and adjacent shoreline.

Period and Frequency

Colonial breeding bird surveys for double-crested cormorants will be conducted biweekly during January and February to capture peak breeding periods, and weekly from February to April. Surveys for Caspian terns, gull-billed terns, and black skimmers will be conducted biweekly during March and April to

capture peak breeding periods, and weekly from April to August. Multiple visits through the season will provide information on timing (peaks and variability) and general colony success. Surveys will continue for at least three years following initiation of a new operations scenario, after which the need and scale of monitoring can be re-evaluated.

Protocol and Data Collection

Breeding bird surveys will be conducted by vehicle and/or foot around the perimeter of the ponds. Observers will use binoculars and spotting scope. Surveys will focus on target bird species (double-crested cormorant, Caspian tern, gull-billed tern, black skimmer). Breeding by other species, such as California gulls, herons and egrets, will also be recorded, since these species could affect breeding outcomes of target bird species. Observers will estimate the peak number of nesting pairs for each species (the greatest number of nests recorded on a single colony visit), and use behavioral and postural cues to estimate stage of nesting (survey methodology based on NHMLA surveys for the Salton Sea). All colonial nesting birds observed will be identified to the species level and enumerated at individual colonies. Data collected will include location, breeding activity, species composition of nesting birds, phenology, and general colony success if possible.

Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition at each survey point, will be recorded at the time of the survey. This information can be used to establish correlates of bird distribution with other ecological variables during the assessment phase of the MAP. All data will be recorded on standard data sheets, or with hand-held data loggers that will facilitate uploading information into BIOS. The location of each colony will be digitally mapped.

Because of the extreme conditions at the Salton Sea, the reproductive success of colonial breeding birds can be strongly influenced by events (such as investigator disturbance) that subject eggs and chicks to exposure and extreme heat. Under these conditions, even relatively short periods away from the nest by adult birds can result in mortality. Given the inherent risks associated with surveying nesting birds under these conditions, effort will be made to minimize disturbance of the colonies.

If deemed necessary to document nesting success and predation, cameras could supplement the colonial breeding bird survey for the breeding target species. Cameras could be mounted on poles along the berms, which would allow data retrieval without disturbing nesting. For nesting on islands, we could also consider placing 1-2 cameras per island of interest (up to 20 cameras and poles for nesting and loafing islands). Potential use of camera poles by raptors predatory on target species will be considered. Visits will be required to download data and maintain equipment.

Overview of Similar Current Monitoring Activities

The NHMLA has performed long-term annual monitoring of breeding larids (gulls and terns) at the Salton Sea since 1992 (Molina and Sturm 2004). In addition, breeding herons, egrets, cormorants, and ibises were monitored annually by the USFWS (SBSSNWR) between 1986 and 1999 (Molina and Sturm 2004). Additional colonial breeding bird surveys were carried out by Point Reyes Bird Observatory (PRBO) in 2012 (Molina and Shuford 2013). The monitoring of colonial breeding birds at the Salton Sea will be closely coordinated and integrated with the ongoing work of the NHMLA to avoid duplication and to ensure that the information is collected in a manner that meets the objectives of both programs. This monitoring activity also could include coordination with any ongoing monitoring efforts carried out by the DFW or USFWS.

5.7 DISEASE AND VECTOR CONTROL

5.7.1 Dead and Sick Bird Counts

Purpose and Justification

Bird diseases such as avian botulism, avian cholera, and Newcastle disease have caused substantial losses at the Salton Sea in the past (DWR and DFG 2007). Botulism spores occur in the sediment and are ingested by fish such as tilapia. Avian botulism typically occurred in spring, when strong winds can cause turnover of deoxygenated water in the Salton Sea, resulting in fish die-offs. Birds can die from botulism toxins ingested from dying fish or from maggots on dead birds. Avian cholera has typically occurred in winter, when migratory birds such as waterfowl congregate at the Salton Sea.

If an outbreak occurs, dead and sick birds will be collected to control the spread of disease and to aid diagnosis.

Locations

The entire SCH Project site will be surveyed by foot, vehicle, or boat for any dead or sick birds in the course of general site visits and other bird surveys.

Period and Frequency

Monitoring for dead and sick birds will occur monthly in the course of other site visits, such as general site assessment, fish and bird surveys. If disease outbreaks are detected at the SCH ponds or nearby areas such as the SSSBNWR, the frequency of sampling can be increased. Because disease outbreaks are episodic, collection and examination of dead and dying birds will be performed whenever the DFW determines that significant mortality has been detected.

Protocol and Data Collection

Surveys will be conducted by foot and vehicle along the perimeter berms, or by airboats to access pond areas where sick and dying birds may occur. Dead and dying birds will be collected and enumerated. Those working on an outbreak will wear rubber gloves and bag all carcasses. Information detailing where specimens were found and any symptoms seen in the field will be included. At the beginning of an outbreak event, several carcasses of various species will be collected for analysis to determine the presence of botulism toxin and the particular strain or to otherwise diagnose the cause of the die-off.

Overview of Similar Current Monitoring Activities

DFW and USFWS currently track bird mortality events at the Salton Sea. This monitoring activity will be coordinated with these ongoing activities.

5.7.2 Mosquito Vectors

Purpose and Rationale

Mosquitoes are considered an annoyance because of their biting, and many species are known vectors of human disease pathogens. Western equine encephalomyelitis virus and West Nile virus have been detected in adult mosquito samples from the SBSSNWR. Vector population and pathogen monitoring are fundamental components of any mosquito management program and are necessary for making informed decisions related to cost-effective mosquito management.

The SCH ponds as designed and operated will likely not be conducive to mosquito production. The operational salinity range is expected to be too salty for significant mosquito production or colonization by wetland vegetation, a favored habitat of mosquitoes. A large proportion of the pond's surface area will be open water more than two feet deep. Immature mosquitoes would be vulnerable to predation by fish, as well as disturbance and drowning by wind-driven waves.

Monitoring will locate mosquito life stages (larvae, pupae, and adults), estimate their abundance and determine species composition for the purpose of making treatment decisions. Disease surveillance will be used to detect the presence of mosquito-borne disease as part of a state-wide program. Mosquito treatments will be implemented as necessary to reduce mosquito populations and associated mosquito-borne disease risk. Further details on monitoring and control are provided in *Appendix F –Mosquito Control Plan* (USACOE and Resources Agency 2013).

Location

Adult traps will be located adjacent to the SCH ponds. Dipping for immature mosquitoes would occur on the edges of the ponds. If mosquito production occurs in the SCH ponds, it is likely to be limited to the shallow zones of the upslope periphery of the pond and maybe the berms, if aquatic vegetation and/or inundated grasses (i.e., *Distichlis*) colonize the shallow water and berms. If vegetation is found along the periphery, then monitoring for larval mosquito populations would occur at natural openings in vegetation.

Period and Frequency

Monitoring will occur from April through October. Monitoring frequency will range from weekly to twice monthly, depending on mosquito activity which is dependent on environmental conditions such as temperature. Monitoring can occur at any time during the day, and will require one half to one full day to complete.

Sampling Protocol

Immature (larvae, pupae) mosquito abundance will be monitored using dippers. A dipper is a long-handled ladle that collects a 500 ml water sample from pools potentially serving as mosquito sources. The water sample collected by dipper will be evaluated for the presence of larval mosquitoes. When mosquito larvae are present, 'dip-counts' will be used as a measure of immature mosquito abundance. Captured larvae will then be identified to species by skilled technicians.

Adult mosquitoes will be monitored using carbon dioxide-baited traps (CO_2-baited suction traps). The traps are baited with 1-2 kilograms of dry ice that attracts adult mosquitoes as it sublimates. An electric fan will force the adult mosquitoes into a collection container. Six traps are proposed for deployment adjacent to the SCH pond complex. A minimum of three traps (six traps total) should be deployed at each pond. Traps should be placed at the western and eastern ends of each of SCH ponds and at a site approximately equidistant between the traps on the east-west transect. Alternative placement of the traps could be carried out after operation of the SCH ponds begins if better trapping sites become evident. More than one trap per each component will increase the reliability of the numbers for adult mosquito population monitoring and ensure a collection if one of the traps were to fail on a particular night. Trapped adult mosquitoes will be enumerated, identified and processed for mosquito-borne disease detection in a laboratory. Labor and time constraints, as well as funds budgeted for monitoring, will determine the extent of sampling.

SECTION 6

DATA MANAGEMENT AND ASSESSMENT

6.1 DATA ANALYSIS

Data will be analyzed as soon as possible after collection of field data, and will be prioritized in the same manner as monitoring criteria: operations and compliance-driven data should be analyzed first, then effectiveness data, then any focused investigations data if collected. Minimizing the time expended between data collection and analysis increases the likelihood of adequately addressing discrepancies or data gaps and adaptive management needs. Monitoring results will be compared to previous monitoring event analyses to evaluate trends and performance.

For each monitoring element, data analyses will be developed in further detail as appropriate for the monitoring objective and data set. It is critical that the monitoring design and data analysis methods can distinguish between natural variability in the data and actual response in the parameter under evaluation (NAVFAC 2004). Analysis of the monitoring data will likely involve some form of statistical analysis or time series analysis. In cases where habitat creation is being conducted to provide a specified aerial coverage of habitat, a target level of species diversity or other specified condition, statistical analysis may not be necessary.

6.2 QUALITY CONTROL AND QUALITY ASSURANCE

Quality control (QC) is a system of routine checks to ensure the integrity, correctness, and completeness of the project data. This system may include spot-checks on methods, data acquisition, calculations, and appropriate use of any statistical analyses. Quality control is expected to be performed by the entity conducting the monitoring, and will include a careful review by the staff responsible for the data input and analysis, project documentation, and data storage. Quality assurance (QA) provides for a system of review procedures conducted by individuals/entities not directly involved in the collection/compilation of monitoring data. Quality assurance will be performed after the data are finalized and the quality control is performed.

A quality assurance program plan (QAPP) will be developed before beginning any monitoring activities, as specified in the MAP (Case et al. 2013). The QAPP will specify staffing, measurement sites, measurement protocols, data-acceptability criteria, quality-assurance/quality-control procedures, data format and databases, and reporting frequencies.

The detailed monitoring protocol will include measures to ensure the quality of the data collected. These can include, but are not limited to, procedures for calibrating or ensuring the accuracy of any instruments (for example, GPS) employed in the field, procedures for recording and transferring electronic data, methods for ensuring proper operation of field equipment during surveys, and methods for avoiding double counting or insufficient coverage of survey areas.

The Adaptive Management Review (AMR) will provide additional QC and QA of data during review of the annual monitoring report.

6.3 DATA MANAGEMENT

Data, analyses, and publications developed from this monitoring plan will be organized, stored, and made publicly accessible through a common distributed data management system, in coordination with the broader Salton Sea MAP efforts. Common protocols will be developed and applied when possible. All geospatial data will include full metadata and will be compliant with the Federal Geographic Data Committee (FGDC) standards. DFW will establish and maintain the data management system. The data collected as part of all components of the broader Salton Sea restoration program will be archived and made accessible in DFW's Biogeographic Information and Observation System (BIOS[3]) map viewer and all documentation including metadata would be accessible to the public via metadata clearinghouses and DFW's document library.

6.4 ANNUAL REPORTING

An annual progress report will summarize the monitoring program and data collected for that calendar year, update prior reports in a cumulative fashion, and include raw data as well as data analysis and comparison with compliance and performance criteria, as applicable. The annual report will describe pond operations scenario, GIS maps of sampling locations, data for each monitoring element (operations, physical, water quality, and biological), habitat conditions and environmental data during monitoring, and any recommendations for improvement of the protocol. Monitoring results that prompt consideration of immediate adaptive management or maintenance actions will be communicated in a timely manner, in advance of annual report preparation. DFW will archive the monitoring reports. Synthesis reports will be prepared at the end of Year 5, and the end of the 10-year proof-of-concept period with final recommendations for long-term SCH management.

6.5 MONITORING PROGRAM ADJUSTMENTS

Monitoring procedures, approach, and schedule may be assessed following each monitoring event. Adjustments to the monitoring program may be recommended due to changing site conditions, newly available research data, ability to combine efforts with other related research, or if monitoring methods are determined too difficult or impractical to implement. Minor adjustments are expected to occur over the monitoring period to maintain completeness and feasibility of the monitoring program.

[3] http://www.dfg.ca.gov/biogeodata/bios/

SECTION 7

ADAPTIVE MANAGEMENT

7.1 DECISION-MAKING PROCESS

7.1.1 Purpose

To track progress in meeting SCH Project objectives, the scientists and managers responsible for the Project will regularly synthesize and analyze the monitoring data and evaluate the status and trends in target resources. An overall review will be conducted annually to evaluate Project performance. A decision-making framework is established to provide recommendations to SCH managers for maintaining or adjusting operations.

In accordance with the adaptive management framework, the assessment and analysis of data are anticipated to lead to periodic adjustments in management of the SCH ponds and updates in the operations and monitoring plans, especially during the 10-year initial implementation phase. The monitoring plan is envisioned to be a living document that may undergo periodic revisions as new methods become available or if monitoring methods are not yielding the expected information.

The managers of the SCH Project must have the capacity to change practices in response to what is learned over time. Governance for adaptive management should provide a decision-making structure that fosters communication between scientists and decision makers, and has clear lines of authority where timely decisions are made and implemented. Governance for implementing adaptive management must provide for the institutional capacity to interact, learn, and adapt.

Adaptive management is a flexible implementation tool necessary for complex projects like the SCH with a medium to a long expected lifespan and many unknowns; however, adaptive management cannot be achieved without a well-defined structure with clear responsibilities for each entity or partner so that information developed can be used for the decision-making process. The organizational structure for the decision-making process is designed to achieve six functions to generate strong science-based decisions related to the objectives of the SCH:

1. Direct and adapt science to answer specific questions on how to achieve SCH Project objectives
2. Centralize, store and analyze information
3. Convert information into effective management decisions and actions
4. Evaluate actions
5. Feed information back through the adaptive management process and readjust the operational parameters
6. Inform the stakeholders

7.1.2 Organizational Structure

The organizational structure for monitoring and adaptive management is portrayed in Figure 7-1. The organizational structure will be integrated, as members of one group (e.g. Operations and Management) will also be part of other groups. The roles and responsibilities of each group may evolve on an as-needed basis. These roles include the following:

Executive Review (ER) will be conducted by DWR and DFW managers, and will be employed as needed for programmatic-level decisions. It will be required to handle exceptional managerial decisions not predicted in the MAMP, to arbitrate issues involving competing interests, or to address other policy-based issues. The ER staff will receive input from the stakeholders and release periodic updates to the public. ER staff will review the activities and decisions of the Adaptive Management Analysis group at least annually.

Adaptive Management Review (AMR) will engage the DFW project managers with technical experts from DFW and other agencies. This level is solely responsible for making decisions and taking actions related to the management of SCH. A role of AMR will be to analyze and interpret the results from the focused investigations, monitoring, and maintenance data. It will make decisions on SCH management and monitoring within the limits defined by this document. The AMR group will include expertise from other agencies, such as USFWS and IID. It will employ external science reviewers as an independent mechanism for data analysis and interpretation, and solicit their recommendations for management actions. The AMR level will also generate outreach material to the public and stakeholders. The DFW project managers will direct the site operations personnel to implement changes, after vetting them with the Executive Team.

External Science Review (ESR) is an essential component of the scientific basis of the MAMP. External review will further ensure the credibility and relevance of the science conducted under the MAMP. It will be conducted by experts from academia and scientific bodies of other agencies to provide technical recommendations to the AMR level based on the analysis and interpretation of data.

Operations, Maintenance and Monitoring (OMM) will include the day-to-day operations and maintenance, as well as ongoing monitoring at the site. These tasks will be conducted by DFW biologists as well as other staff or contractors as needed. Monitoring data will be collected, compiled and stored. Data and outputs from this level will be forwarded for analysis and interpretation at the Adaptive Management Review level.

Stakeholders are any individuals or organizations with an interest in the performance of the SCH project. These may include entities such as the Salton Sea Authority, local representatives, agencies, non-governmental organizations, and/or other entities.

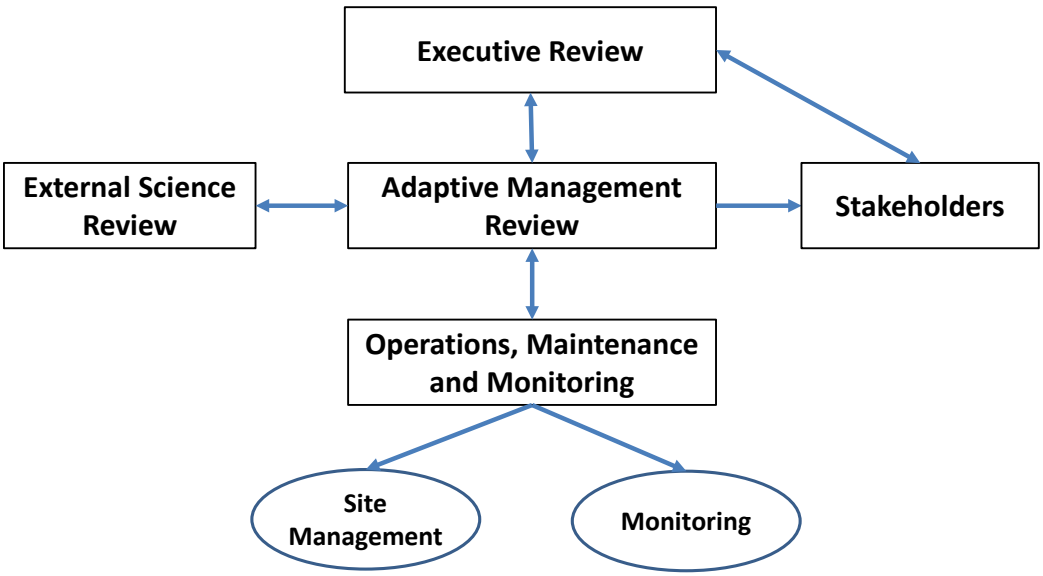

Figure 7-1 SCH Adaptive Management Organizational Structure

7.2 MANAGEMENT RESPONSES

Monitoring results will be reviewed at the AMR level and compared with management triggers to determine whether project objectives are being met. If the management triggers are activated, the AMR will suggest potential management actions that will be discussed during the annual meeting or any necessary follow-up meetings. Possible actions can include more detailed diagnostic monitoring; corrective actions if known, necessary and feasible; adjustment of short-term operations or long-term management plans; and/or further study if necessary to reduce uncertainties (Table 7-1).

Table 7-1 Potential Management Actions

Project Objective	Expected Outcome	Management Triggers	Possible Management Actions
1. Provide appropriate foraging habitat for piscivorous bird species.	Saline pond habitat available when birds are present	• <80% area inundated • Below minimum depth or area standard	• Increase flow rate to keep up with evaporation and seepage • Assess seepage rates.
	Piscivorous birds will forage at ponds	• Birds are not using ponds • No foraging at ponds by piscivorous birds	• Evaluate regional status and trends data to determine whether there is a regional decline in avian populations if such data are available. • Evaluate food resources (fish)
	Food availability forpiscivorous bird species	• Tilapia do not persist in the ponds. • Other fish species are not present, do not persist, or at low abundance	• Re-introduce tilapia in the ponds • Evaluate introduction of other fish species with different temperature and salinity tolerance thresholds • Evaluate primary and second productivity and relationship to fish production • Evaluate water quality conditions and adjust flow parameters • Provide additional artificial cover for fish species if avian foraging success is too high
2. Develop physical structure and microhabitat elements required to support piscivorous bird species.	Islands persist with designed topography	• Islands exhibit significant erosion	• Erosion control or armoring • Re-construct island if possible
	Target bird species are using islands and ponds	• Absence of a target species at ponds. • No foraging at ponds by piscivorous birds • Bird use of islands differs from reference sites • Domination and displacement by a single bird species • Avian abundance is not greater than baseline or is substantially lower than at reference sites • Nesting efforts on islands are not successful • Predators, especially mammalian, are observed on islands or berms	• Evaluate regional status and trends data to determine whether there is a regional decline in avian populations if such data are available. • Enhance substrate on surrounding berms to provide additional habitat • Enhance or modify existing island substrate or create additional island habitat • Undertake applied studies to evaluate condition of habitat and effects of possible predation, competition, and/or contaminants. • Deploy cameras to document nesting and possible predation. • If predation is documented at high levels, consider installing shelters for chicks, and/or predator removal.
3. Support a sustainable, productive aquatic community	Maintain permanent ponds 2-6 feet deep	• More than 50% of pond area is below target depth (<2 feet deep)	• Adjust flow rates and water surface elevation
	Fish will be present, including tilapia	• Tilapia do not become established • Size classes indicate poor recruitment	• Check seasonal and diurnal patterns in water quality (temperature, DO, salinity) • If fish fail to become established, consider restocking with other species
	Invertebrates will be present and abundant	• Biomass over one year is below what is observed in comparable habitats. Abundance declines below levels observed in reference ponds	• Check water quality, adjust flow rates and water surface elevation, monitor biological response

Table 7-1 Potential Management Actions

Project Objective	Expected Outcome	Management Triggers	Possible Management Actions
4. Provide suitable water quality for fish	Salinity within 20-40 ppt range on average Temperature and DO within suitable range for forage fish	• Salinity 10% outside target range >10% of time • Extreme (hot or cold) water temperature lead to fish kills without population rebounds the next year. • DO < 2 mg/L at all of a single pond's sondes for three days.	• Adjust inflows (Salton Sea or river) to manage salinity • Stock fish species that are tolerant of temperature range in pond • Assess relationships to other related environmental conditions (water temperatures, algal blooms and die-off) • Implement aeration (e.g. solar powered aerator)
5. Minimize adverse effects on desert pupfish	Pupfish present in ponds	• Fish die-off • Size classes indicate poor recruitment of desert pupfish	• Monitor for recovery • Conduct pathology tests in event of mass die-off • Assess condition of sampled fish (reproductive status, growth)
6. Minimize Selenium risk	Se concentrations in water and sediment at SCH are similar to baseline and/or below threshold levels	• Mean Se concentrations in water exceed 2 ug/L • Mean Se concentrations in sediment exceed 4 mg/kg dw	• Reduce inflow of freshwater river; increase proportion of Salton Sea water in ponds • Measure selenium concentrations in biota (invertebrates, fish)
	Se concentrations in water and foodweb biota at SCH are similar to baseline or background levels at reference sites	• Mean Se concentrations in water exceed 2 ug/L • Mean Se concentrations exceed 3 ug/g dw invertebrates or 4 ug/g dw fish tissue	• Reduce inflow of freshwater river; increase proportion of Salton Sea water in ponds • Diagnostic monitoring - measure Se concentrations in bird eggs
7. Minimize risk of disease/toxicity impacts	Mosquito larvae abundance does not exceed acceptable levels defined by regional vector control.	• Breteau Index not significantly greater than baseline or reference values	• Implement control measures in the Mosquito Control Plan • Increase flow rate through ponds • Stock fish in ponds to consume mosquito larvae
	Disease outbreaks are not more frequent or severe than existing conditions	• Avian mortalities occur as a result of disease outbreak	• Remove dead birds as per standard protocols • Determine causal agent and mode of transmission to develop other potential responses

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SECTION 8

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SECTION 9

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