

DRAFT
Nisqually National Wildlife Refuge
Estuary Restoration Project Monitoring Framework

by
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Project Background

The Nisqually National Wildlife Refuge (NWR) is located at the southern end of Puget Sound in the Nisqually River estuary. The 3,000-acre National Wildlife Refuge, established in 1974, is managed by the United States Fish and Wildlife Service (USFWS) and protects one of the few relatively undeveloped estuaries remaining in Puget Sound. Historically, the Nisqually estuary supported a variety of land uses, including subsistence hunting and gathering, logging, commercial shipping, recreational and commercial fish and shellfish harvesting, and agriculture. Approximately 1000 acres of the Nisqually estuary was diked for farming in the late 1800s and has been managed as freshwater wetlands since 1974 by Nisqually NWR. Nisqually NWR was established for the protection of migratory birds and provides crucial fish and wildlife habitat. The Refuge also provides quality wildlife-dependent recreation and educational opportunities to more than 150,000 visitors each year.

The Nisqually River estuary complex represents one of the most restorable river deltas in the region, with most of the land now owned by Nisqually NWR, the Nisqually Indian Tribe (Tribe), and the Washington Department of Fish and Wildlife (WDFW). The Tribe, Nisqually NWR, and others are actively pursuing large scale restoration of the Nisqually River estuary. Using a phased approach, the Tribe restored tidal inundation to approximately 40 acres of diked pasture in 2002 (Phase 1) and an additional 100 acres of pasture in 2006 (Phase 2), both on the east side of the river. The single largest project to restore the Nisqually River estuary will be the restoration of more than 700 acres of estuarine habitat on Nisqually NWR.

The Nisqually NWR's Comprehensive Conservation Plan (CCP) was approved in 2005 and will guide management of the Refuge for the next 15-20 years (USFWS 2005). The cornerstone of the CCP is the restoration of over 700 acres of estuarine habitat which includes over 30 acres of riparian surge plain habitat. The restoration project design alternative was selected based on an eight year planning process that included input from scientific and technical experts, numerous agencies, tribes, non-government organizations, academic institutions, public participants, and on the findings of a hydrodynamic and sediment transport (HST) model developed to assess the effects of several design alternatives on physical estuarine processes (ENSR 1999).

Restoring Puget Sound river delta habitat is recognized as a priority action for the recovery of Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) in both regional and local recovery plans (SSDC 2007; NCRT 2001). The Nisqually Fall Chinook stock is one of the 27 stocks in the Puget Sound evolutionarily significant unit listed as threatened under the federal Endangered Species Act (NCRT 2001). Chinook salmon rear extensively in estuaries and are thought to be the most estuary-dependent of the Pacific salmonids (Aitkin 1998; Fresh 2006). The estuary is also essential habitat for the Nisqually winter chum (*O. keta*), one of the largest wild runs in Washington State (WDFW and WWTIT 2002), which are known to utilize the estuary for feeding and growth (Fresh et al. 1979; Pearce et al. 1982; Ellings and Hodgson 2007). Puget Sound/Georgia Basin river delta habitat is also important for many non-salmonid fishes and birds, including shiner perch (*Cymatogaster aggregata*), starry flounder (*Platichthys stellatus*), great blue heron (*Ardea herodias*), and American wigeon (*Anas americana*) (Levy et al. 1979; Simenstad et al. 1991; USFWS 2005; Eissinger 2007; Ellings and Hodgson 2007). Nisqually NWR provides crucial migration, resting, and wintering habitat for migratory birds of the Pacific Flyway. More than 275 bird species occur on the Refuge, including a wide variety of waterfowl, shorebirds, seabirds, waterbirds, and raptors. The Nisqually NWR estuary restoration project is predicted to have widespread and significant effects on populations of fish and wildlife (USFWS 2005; Ellings and Hodgson 2007), thus creating a need for a monitoring framework which documents project implementation and the project's effectiveness in meeting objectives as well as providing information necessary for adaptive management. The specific data collection methodology for each element will be tailored to match available resources.

The Nisqually CCP outlines several broad goals for the management of the Refuge with objectives for achieving those goals. Specific CCP goals and objectives form the basis of the monitoring plan:

Nisqually NWR CCP Goal

Conserve, manage, restore, and enhance native habitats and associated plant and wildlife species representative of the Puget Sound lowlands, with a special emphasis on migratory birds and salmonids.

Objectives

1. Restore estuarine habitat to desired future conditions.
2. Protect, restore, and enhance riparian mixed forest habitat.
3. Protect, restore, and enhance a mosaic of freshwater wetlands and grasslands.

Project Description

The Nisqually NWR Estuary Restoration Project is composed of several different components. The primary component restores tidal influence to approximately 762 acres through the deconstruction of approximately 5 miles of dike. Another project component is the restoration of approximately 37 acres of freshwater tidal riparian forest (a.k.a. riparian surge plain) along the lower Nisqually River by strategically sculpting and intensively planting an area adjacent to existing surge plain forest. Lastly, a new exterior dike will be constructed to protect Refuge infrastructure and provide 246 acres of intensively managed freshwater wetlands and grasslands (Figure 1).

Construction of the project will be sequenced over 3-4 years. Construction of the new exterior dike and removal of some of the existing structures and roads within the proposed estuary restoration area will occur in 2008. In 2009, work will consist primarily of decommissioning the Brown Farm Dike and construction of the interior levees. Construction of a boardwalk and observation deck will occur in 2009/2010.

In 2008, the new exterior dike footprint will be cleared and grubbed. Approximately, 84,539 cubic yards of compacted fill will be used to create the 9,691 linear foot set-back dike. The top of the new set-back dike will range from 13.0 to 14.0 ft elevation (NGVD 29 datum). Approximately 22,428 cubic yards of compacted fill will be used to create 5,791 linear feet of new interior levees, which will range in elevation from 9 to 12.5 ft (NGVD 29 datum). Fill material will primarily be taken from borrow areas and swales within the diked area.

The new exterior dike has been configured at the southern end of the project area to direct future flood water from the Nisqually River into estuary habitat and the McAllister Creek system through a swale, thus preventing flood water from entering the diked area where Refuge infrastructure is located. A small, sinuous channel will be sculpted in the swale to mimic a tidal channel. A 48 inch tidegate will be installed in the north end of the McAllister Creek overflow channel to allow water to continue to drain from I-5 and private lands on the south side of I-5.

Two surge plain riparian sites will be enhanced by adding approximately 49,368 cubic yards of fill and contouring elevations to provide physical conditions necessary to support riparian habitat. This material will be surplus excavation from the dike removal. Higher elevations will be planted with native tree species found in adjacent surge plain forest in a phased approach.

In 2009, preparatory dirt work will be completed in the estuary restoration area prior to dike removal. Culverts, water control structures, levees, and berms not removed in 2008 will be removed. Where possible, rank reed canary grass will be mowed and disked to break up the root mat to speed restoration. Some areas will be graded, scraped, or disked to enhance salt marsh establishment. As much riprap as possible will be removed from the Nisqually River and McAllister Creek along the exterior dike. Portions may be left in

place where surge plain riparian forest prevents access. The rip rap removed will be placed on selected portions of the new exterior dike to serve as protection from the Nisqually River or disposed of. The rip rap area will be planted with native shrubs, woody debris placed at the toe, rip rap voids filled with soil, and the area seeded.

Prior to removal, the Brown Farm Dike will be cleared of trees and shrubs. Select large trees will be salvaged for use as large woody debris (LWD) within restored estuary habitat. Approximately 23,296 linear feet of existing dike will be removed to match existing grade on both sides of the dike through the excavation of 260,738 cubic yards of earth. Approximately 181,273 cubic yards of earth excavated from the dike will be used to fill the adjacent borrow ditch to match the existing grade of the marsh plain. The surplus material will be used to construct the interior levees and surge plain planting areas.

Large tidal channels will be reconnected to historic sloughs as the exterior dike is removed. Gently sloped or level profiles will be constructed to connect the elevations inside and outside of the dike and facilitate tidal flow and estuary restoration.

The 5 ½ mile Brown Farm Dike Trail will be replaced with a shorter reconfigured trail. Part of the trail will be on top of the new set back dike and part will be new boardwalk in order to continue to provide quality public access to various habitat types. Most of the new boardwalk will be located on the base of either the existing exterior dike or interior levees after dike and levee removal. The boardwalk will be installed in 2009 and 2010 using concrete pier blocks for a foundation that will support pressure treated lumber framing.

Monitoring Plan Goals and Objectives

The goals of the Nisqually NWR Estuary Restoration Project monitoring program are:

- A. Implementation Monitoring
 - a) Ensure that the project components are built as designed and to document any deviations from the design.
- B. Effectiveness Monitoring
 - a) Determine if the project objectives are being met.
- C. Adaptive Management
 - a) Provide information critical for adaptive management.

Goal A: Implementation Monitoring (Goal A will evolve as the project is implemented)

Component 1: Estuary Restoration

- (a) Was the Brown Farm Dike deconstructed according to final design?
- (b) Was the borrow ditch filled and compacted?
- (c) Were large trees placed inside restoration area?
- (d) How were the historic channels re-connected?

Component 2: Riparian/Surge plain Restoration

- (a) Was the riparian planting area constructed as designed?
- (b) Was the riparian planting area planted according to planting plan?
- (c) How much rip-rap was removed?

Component 3: Freshwater Wetland and Grassland

- (a) Was the new exterior dike built as designed?
- (b) Were the new interior levees constructed according to final design?
- (c) Was the water control system constructed according to final design?

Other:

- (a) What is the final configuration of the McAllister Creek overflow tidegate?
- (b) What is the final configuration of the entrance road swale?

Goal B: Effectiveness Monitoring

Objective 1

The first objective of the Nisqually NWR Estuary Restoration Project is to restore estuarine habitat to the desired future conditions listed in the CCP. The desired future conditions listed in the CCP are: (1) a mosaic of estuarine habitats, including native salt marsh communities; (2) major reduction of invasive reed canary grass; (3) enhanced use by juvenile salmon; (4) most ponds being connected at low tide to minimize fish entrapment; and (5) increased waterfowl, shorebird, and waterbird use. The following monitoring questions are based on the desired future conditions listed in the CCP, but have been rearticulated for integration into a process-structure-function conceptual model (in prep).

Question 1: Were the processes outlined in the hydrodynamic and sediment transport (HST) model effectively restored?

The HST model was used to evaluate estuary restoration alternatives for the Nisqually NWR. The modeling results indicated that alternatives including the current project design, where the dikes were removed to grade and the borrow ditches filled, restored the physical processes necessary for self-sustaining and effective estuary restoration. In contrast, restoration alternatives where the dikes were breached at the major sloughs but not completely removed did not effectively restore the desired processes. The primary physical processes of concern are full tidal inundation, tidal evacuation, salinity influx, and sediment transport and deposition.

Performance Metrics

- (a) Full Tidal Inundation
- (b) Full Tidal Evacuation
- (c) Salinity Influx
- (d) Sediment Transport/Deposition

Performance Criteria

- (a) High tides inundate historical sloughs and regularly flood the restoration area and developing marsh plain.
- (b) Water evacuates restoration area during a receding tide.
- (c) Salinity in the project area is conducive to estuarine vegetation.
- (d) Fluvial sediments deposited during flood events cause marsh plain to aggrade.

Performance Criteria Methods (In Prep)

- (a) Aerial photographs of Nisqually NWR will be taken at high and low tide during the 1st, 3rd, and 5th summer after project construction and again every 5th year. Global Information Systems (GIS) software will be used to assess:
 - a. wetted channel extent relative to tide height
 - b. channel connectivity at low tide (i.e., ponding)

- c. channel order of major sloughs
- (b) Water quality parameters like salinity, temperature, and dissolved oxygen will be measured at select sites within the restoration area.
- (c) The erosion and deposition of sediment within the restoration area will be measured.

Question 2: Did the restored processes bring about habitat development trajectories towards predicted habitat structures?

Performance Metrics

- (a) Salt Marsh (includes estuarine shrubs)
- (b) Open Channel
- (c) Mudflat

Performance Criteria

- (a) Salt marsh increases after restoration and distinct salt marsh communities develop as the physical (e.g. sediment accretion and erosion) and biological (e.g. nutrient uptake, shore crab burrowing) processes trend towards dynamic equilibrium.
- (b) Open channel increases after restoration and the channels diversify morphologically (i.e., channel order increases) as the physical and biological processes trend towards dynamic equilibrium.
- (c) Mudflat increases following the restoration of the tidal prism and then begins to reduce as salt marsh develops, channels diversify morphologically, and processes trend towards dynamic equilibrium.

Performance Criteria Methods (In Prep)

- (a) Aerial photographs of Nisqually NWR will be taken at high and low tide during the 1st, 3rd, and 5th summer after project construction and again every 5th year. Global Information Systems (GIS) software will be used to assess:
 - a. vegetated salt marsh coverage
 - b. open channel extent and channel order
 - c. mudflat coverage
- (b) Photo points and vegetation surveys (either linear transects or quadrants) will be taken in years 1, 2, 3, and 5 after project construction and then every 5th year at pre-established stations selected by stratified random sampling. The strata will be based on topography, orientation within the Nisqually Delta, and likely habitat development trajectory (e.g., salt marsh, mudflat, open channel, and riparian). The photos and the surveys will be used to calibrate the aerial photographs and track the development of:
 - a. vegetation communities
 - b. channel structure
 - c. other metrics (e.g., invasive plant reduction)

Question 3: Were reed canary grass and other invasive plants effectively detected and their establishment reduced, controlled, or prevented?

Performance Metrics

- (a) Reed Canary Grass and Other Invasive Plants Occurrence
- (b) Potential Invasive Plant Establishment

Performance Criteria

- (a) The extent of reed canary grass and other existing invasive plants within the restoration area reduce when the tidal prism and the associated physical and biological processes are restored.
- (b) The establishment of currently undetected invasive plants (e.g., spartina) is prevented or controlled.

Performance Criteria Methods (In Prep)

- (a) Aerial photographs of Nisqually NWR will be taken at high and low tide during the 1st, 3rd, and 5th summer after project construction and again every 5th year. Global Information Systems (GIS) software will be used to assess:
 - a. reed canary grass coverage
- (b) Rapid presence/absence invasive plant surveys will be conducted annually within the restoration area.
- (c) Detailed invasive plant surveys will be conducted as part of the general vegetation surveys.

Question 4: Does the ecological performance of the Nisqually NWR Estuary Restoration Project support juvenile Chinook?

Juvenile Chinook are a valued ecosystem component that will be used to assess the effectiveness of the restoration project. Chinook were chosen because they: (1) are considered the most estuarine dependent salmonid and are anticipated to display measurable positive responses to large scale estuary restoration; (2) utilize the estuary over an extended period of time in order to feed and grow; (3) can be evaluated at multiple scales from individual feeding behavior to long term population changes in life history diversity, productivity, and abundance; (4) have been the focus of intensive research and monitoring both in the Nisqually and throughout the region; (5) are listed under the federal Endangered Species Act and the subject of a far-reaching recovery plan; and (6) are culturally and economically important to the indigenous and non-indigenous people of Washington State.

Performance Metrics

- (a) Opportunity: Can juvenile salmon physically access habitat?
- (b) Capacity: Does the restoration site provide conditions favorable to juvenile salmon growth and survival?
- (c) Realized Function
 - a. Site Specific Response: Are juvenile salmon displaying measurable responses indicating that they are occupying the habitat and taking advantage of the sites capacity?
 - b. Ecosystem/Population Response: Are juvenile, delta-rearing wild Chinook displaying measurable responses to increased Nisqually Delta capacity?

Performance Criteria

- (a) Opportunity: Juvenile Chinook readily access the restoration area sloughs throughout their season of peak abundance (May through June), as established by baseline studies.
- (b) Capacity: The restoring salt marsh and sloughs produce insects and crustaceans that have been identified as prey for juvenile Chinook in the scientific literature.
- (c) Realized Function Site Specific Response: Juvenile Chinook readily access the restoring sloughs and take advantage of the restoring area's capacity, as indicated by a similarity between their diet composition and the composition of the invertebrate community.
- (d) Realized Function Population Response: Nisqually delta-rearing Chinook display increased estuary growth over the baseline (average 36% higher than freshwater or .57 mm/day¹).
- (e) Realized Function Population Response: Nisqually delta-rearing Chinook display increased estuary residency over the baseline (conservative average 16 days², range 10 – 35 days)

¹ Baseline average estuary growth rates for Nisqually delta-rearing Chinook may change as more Chinook otoliths are examined (see Ellings and Hodgson 2007).

Performance Criteria Methods (In Prep)

Opportunity

- (a) Fyke trapping and/or beach seining will be conducted in the restoration area and at reference sites throughout the Nisqually Delta from February – October. Sampling will be in years 1, 2, 3, and 5 after project construction and then every 5th year. Specific sites will be determined after project construction.

Capacity

- (a) Fallout, benthic, and neuston invertebrate sampling will be conducted in the restoration area and at reference sites throughout the Nisqually Delta in years 1, 2, 3, and 5 after project construction and then every 5th year. Specific sites will be determined after project construction.

Realized Function Site Specific Response

- (a) A sub-sample of unmarked and hatchery juvenile Chinook captured from within the restoration area and at reference sites will be sacrificed and their gut contents removed. Chinook diets will be analyzed using the following indices:
 - a. index of relative importance (IRI)
 - b. percent composition by number
 - c. percent composition by weight
- (b) A percent similarity index (PSI) will be computed using the percent composition by number of Chinook diet items and the percent composition by number of the sampled invertebrate community at each site, both within the restoration area and at reference locations. A high PSI value for a given sampling location indicates that the diet composition of the fish is similar to the composition of the sampled invertebrate population.

Realized Function Population Response

- (a) A sub-sample of unmarked and hatchery juvenile Chinook captured from throughout the Nisqually Delta and the Nisqually Reach nearshore will be sacrificed for otolith analysis. Chinook otolith analysis will be used to determine:
 - a. hatchery and unmarked Chinook estuary growth rate
 - b. hatchery and unmarked Chinook estuary residence time
 - c. hatchery and unmarked Chinook size at estuary entry
 - d. hatchery and unmarked Chinook life history diversity

² Baseline average estuary residence times for Nisqually delta-rearing Chinook may change as more Chinook otoliths are examined (see Ellings and Hodgson 2007).

Question 5: Does the ecological performance of the Nisqually NWR Estuary Restoration Project support waterfowl, especially dabbling ducks, and shorebirds?

Nisqually NWR provides crucial migration, resting, and wintering habitat for migratory birds of the Pacific Flyway. More than 275 bird species occur on the Refuge, including a wide variety of waterfowl, shorebirds, seabirds, waterbirds, and raptors. In order to track the ecological performance of the restoration project for supporting birds, dabbling ducks and shorebirds will be monitored.

Dabbling ducks comprise more than 90% of the waterfowl observed at the Refuge and are known to derive several important functions from the estuary (USFWS 2005). Dabbling ducks feed on the seeds, stems, and leaves of aquatic plants and several species (including American wigeon and green-winged teal) have been observed using estuarine areas in larger numbers than the managed freshwater wetlands within the dike. Within the dabbling duck guild an emphasis will be placed on monitoring American wigeon, the most abundant waterfowl species observed on the Refuge and a known estuarine associated species.

Shorebirds pass through the Refuge during their spring and fall migrations, with large numbers of individuals and species (up to 22) observed feeding on mudflats and salt marsh. Shorebirds feed on a variety of estuarine produced resources including annelids, nematodes, arthropods, and seeds of salt marsh vegetation. The dependence on estuarine derived food makes shorebirds a useful monitoring indicator to assess the effectiveness of the Nisqually NWR estuary restoration project.

Performance Metrics

- (a) Opportunity: Can dabbling ducks and shorebirds utilize the habitat?
- (b) Capacity: Does the site provide conditions favorable to the growth and survival of dabbling ducks and shorebirds species?
- (c) Realized Function: Are dabbling ducks and shorebirds taking advantage of the site's capacity?

Performance Criteria

- (a) Opportunity: Dabbling ducks and shorebirds readily utilize the restoring site during their season of historic peak abundance.
- (b) Capacity: The restoring site provides structural components (established in the scientific literature) conducive to supporting feeding and resting by dabbling ducks and shorebirds.
- (c) Realized Function: Dabbling ducks and shorebirds are observed feeding and resting at the restoring site.

Performance Criteria Methods

Methods have not been developed.

Table 1. Summary of Objective 1.

Objective 1: Restore estuarine habitat.			
Monitoring Questions	Performance Metrics	Performance Criteria	Performance Criteria Methods (In Prep)
1. Were the processes outlined in the hydrodynamic and sediment transport (HST) model effectively restored?	Full Tidal Inundation	High tides inundate historical sloughs and regularly flood the restoration area and developing marsh plain.	Aerial Photography/GIS Analysis
	Full Tidal Evacuation	Water evacuates restoration area during a receding tide.	Aerial Photography/GIS Analysis
	Salinity Incursion	Salinity in the project area is conducive to estuarine vegetation.	Water quality parameters will be measured.
	Sediment Transport/Deposition	Sediment transport and deposition cause marsh plain to aggrade.	Sediment erosion and deposition will be measured.
2. Did the restored processes instigate habitat development trajectories towards predicted habitat structures?	Salt Marsh (includes estuarine shrubs)	Salt marsh increases after restoration and distinct salt marsh communities develop over time.	Aerial Photography/GIS Analysis Photo Points and Vegetation Surveys
	Open Channel	Open channel increases after restoration and the channels diversify morphologically.	Aerial Photography/GIS Analysis Photo Points
	Mudflat	Mudflat increases following the restoration of the tidal prism and then begins to reduce as salt marsh develops	Aerial Photography/GIS Analysis Photo Points
3. Were reed canary grass and other invasive plants effectively detected and their establishment reduced, controlled, or prevented?	Reed Canary Grass and Other Invasive Plants Occurrence	The extent of invasive plants within the restoration area reduces when the tidal prism is restored.	Aerial Photography/GIS Analysis Photo Points and Vegetation Surveys
	Potential Invasive Plant Establishment	The establishment of currently undetected invasive plants is prevented or controlled	Rapid presence/absence invasive plant surveys

Table 1. Continued.

Objective 1: Restore estuarine habitat (cont.).			
Monitoring Questions	Performance Metrics	Performance Criteria	Performance Criteria Methods (In Prep)
4. Does the ecological performance of the Nisqually NWR Estuary Restoration Project support juvenile Chinook?	Opportunity	Juvenile Chinook readily access the restoration area sloughs.	Fish sampling (fyke trapping and possibly beach seining)
	Capacity	The restoring salt marsh and sloughs produce invertebrates that have been identified as prey for juvenile Chinook in the scientific literature.	Invertebrate sampling (benthic cores and fallout trapping).
	Realized Function (site specific)	Juvenile Chinook readily access the restoring sloughs and take advantage of the restoring area's capacity, as indicated by a similarity between their diet composition and the composition of the invertebrate community.	Juvenile Chinook diet analysis.
	Realized Function (population)	Nisqually delta-rearing Chinook display increased estuary growth and estuary residency over the pre-project baseline.	Juvenile Chinook otolith analysis.
5. Does the ecological performance of the Nisqually NWR Estuary Restoration Project support dabbling ducks and shorebirds?	Opportunity	Dabbling ducks and shorebirds readily utilize the restoring site throughout their season of historic peak abundance.	To be determined
	Capacity	The restoring site provides structural components (established in the scientific literature) conducive to supporting feeding and resting by dabbling ducks and shorebirds.	To be determined
	Realized Function	Dabbling ducks and shorebirds are observed feeding and resting at the restoring site.	To be determined

Objective 2

The second objective of the Nisqually NWR Estuary Restoration Project is to protect, restore, and enhance surge plain riparian habitat in the Nisqually River delta to provide foraging and breeding habitat for migratory and resident landbirds and fish. The CCP desired future conditions for riparian habitat describe a mature bottomland forest with characteristics like: (1) vegetation age diversity; (2) native plant species composition, and vegetation layers; and (3) abundance of snags and woody debris among others. A mature bottomland forest will take decades to develop, in the short term the monitoring program will focus on answering questions intended to evaluate the restoration trajectory of the riparian enhancement area.

Question 1: Is the riparian surge plain enhancement (planting area) on trajectory to reach CCP desired future conditions?

Performance Metrics

- (a) Survival of Plantings
- (b) Invasive and Non-Native Species
- (c) Native Species Colonization

Performance Criteria

- (a) Average plant survival is 50% in first 5 years after planting.
- (b) The presence of invasive and non-native plant species does not impair native plant survival.
- (c) Native species associated w/ reference areas are colonizing the project area.

Performance Criteria Methods (In Prep)

- (a) Randomly selected monitoring stations will be established within the surge plain enhancement area. At each monitoring station, the following data will be collected along a transect or within a quadrant in years 1, 2, 3, and 5 after the planting project and then every 5th year:
 - a. survival of planted vegetation
 - b. invasive/non-native plant species occurrence
 - c. natural native plant recruitment
 - d. plant species composition

Table 2. Summary of Objective 2.

Objective 2: Protect, restore, and enhance surge plain riparian habitat.			
Monitoring Questions	Performance Metrics	Performance Criteria	Performance Criteria Methods (In Prep)
Is the planting area on desired trajectory?	Survival of Plantings	Plant survival is >50% in first 5 years.	The following will be assessed at monitoring stations: a. survival of planted vegetation b. invasive/non-native plant species occurrence c. natural native plant recruitment d. plant species composition
	Invasive and Non-Native Species	Invasive and non-native plants do not impair native plant survival.	
	Native Species Colonization	Native riparian surge-plain plants colonize the project area.	

Objective 3:

A mosaic of primarily permanent and seasonal freshwater wetlands as well as riparian forests and grasslands within the new exterior dike will be protected, restored, and enhanced as foraging and nesting habitat for migratory and resident bird species, mammals, and native amphibians.

Question 1: Are the managed processes (e.g., hydrology) and structural changes (e.g., topography and bathymetry) of the 246 acres of freshwater wetlands within the new exterior dike causing the desired mosaic of habitats to form?

Performance Metrics

- (a) Permanent Freshwater
- (b) Seasonal Freshwater
- (c) Riparian
- (d) Grassland
- (e) Reed Canary Grass and Other Invasive Plants

Performance Criteria

- (a) Within the actively managed 246 acres, a habitat mosaic consisting of primarily permanent and seasonal freshwater wetlands, with smaller proportions of riparian forest and grassland habitats develop.
- (b) Water management within the individual cells enables the development of seasonal wetlands.
- (c) The extent of reed canary grass and other invasive plant species are reduced.

Performance Criteria Methods (In Prep)

- (a) Aerial photographs of Nisqually NWR will be taken during the 1st, 3rd, and 5th summer after project construction and again every 5th year. Global Information Systems (GIS) software will be used to assess the extent of the following habitats:
 - a. permanent freshwater
 - b. seasonal freshwater
 - c. riparian
 - d. grassland
 - e. reed canary grass and other invasive plants
- (b) Invasive plant and animal surveys will be conducted annually throughout the managed freshwater wetland area.

Question 2: Is the actively managed 246 acres providing habitat functions, like foraging, for key groups of birds with an emphasis on dabbling ducks and raptors?

Within the new exterior dike the hydrology will be managed to provide high quality freshwater wetlands and ponds for migratory waterfowl and other wildlife. Dabbling ducks in particular are anticipated to utilize the managed habitats extensively (USFWS 2005). For this reason, dabbling ducks will be used as an effectiveness monitoring indicator for the managed wetlands.

Raptors are apex predators at the Nisqually NWR. Raptors foraging in the managed habitats indicate that the freshwater wetlands and ponds as well as the riparian and grasslands are supporting various small mammals, birds, and other raptor prey.

Performance Metrics

- (a) Opportunity: Are dabbling ducks and raptors utilizing the managed habitat?
- (b) Capacity: Are the managed habitats providing conditions favorable to the foraging success of dabbling ducks and raptors?
- (c) Realized Function: Are dabbling ducks and raptors foraging within the 246 acres of actively managed habitat?

Performance Criteria

- (a) Opportunity: Dabbling ducks and raptors are observed utilizing the managed habitat during their season of historic peak abundance.
- (b) Capacity: The managed habitat area provides structural components (established in the scientific literature) conducive to foraging by dabbling ducks and raptors.
- (c) Realized Function: Dabbling ducks and raptors are observed foraging within the managed habitat during their season of historic peak abundance.

Table 3. Summary of Objective 3.

Objective 3: Protect, restore, and enhance a mosaic of primarily permanent and seasonal freshwater wetlands as well as riparian forests and grasslands within the new exterior dike.				
Monitoring Questions	Performance Metrics	Performance Criteria		Performance Criteria Methods (In Prep)
1. Are the managed processes (e.g., hydrology) and structural changes (e.g., topography and bathymetry) of the 246 acres within the new exterior dike causing the desired mosaic of habitats to form?	Permanent Freshwater	Within the actively managed 246 acres, a habitat mosaic consisting of primarily permanent and seasonal freshwater wetlands, as well as riparian forest and grassland habitats develop.	Water management within the individual cells enables the development of seasonal wetlands and other habitats.	Aerial Photography/GIS Analysis
	Seasonal Freshwater			
	Riparian			
	Grassland			
	Reed Canary Grass and Other Invasive Plants	The extent of reed canary grass and other invasive plant species are reduced.		Aerial Photography/GIS Analysis Rapid presence/absence invasive plant surveys
2. Is the actively managed 246 acres providing habitat functions, like foraging, for key groups of birds, with an emphasis on dabbling ducks and raptors?	Opportunity	Dabbling ducks and raptors are observed utilizing the managed habitat.		To be determined.
	Capacity	The managed habitat area provides structural components (established in the scientific literature) conducive to foraging by dabbling ducks and raptors.		To be determined.
	Realized Function	Dabbling ducks and raptors are observed foraging within the managed habitat.		To be determined.

Goal C: Provide information critical to adaptive management.

The adaptive management goal of the monitoring plan identifies the key performance criteria which will be used to guide management actions related to the Nisqually NWR Restoration Project. The restoration project is designed to restore habitat forming processes which will govern the recovery rate, trajectory, and resulting structure of the restoration area thereby requiring little maintenance or intervention. However if key project performance criteria are not met, then management actions should be considered.

Adaptive Management Performance Criteria Trigger Points are IN PREP

Some examples of potential Adaptive Management Performance Criteria Trigger Points are:

1. Ponding with obvious and extensive fish kills.
2. Survival of plantings are <50%.
3. Invasive plants impair planting survival.
4. New invasive plants are detected (e.g., spartina).
5. Nisqually River channel migration threatens exterior dike.
6. Inadequate McAllister Creek overflow tidegate floodwater evacuation capacity.
7. Inadequate entrance road swale floodwater conveyance.

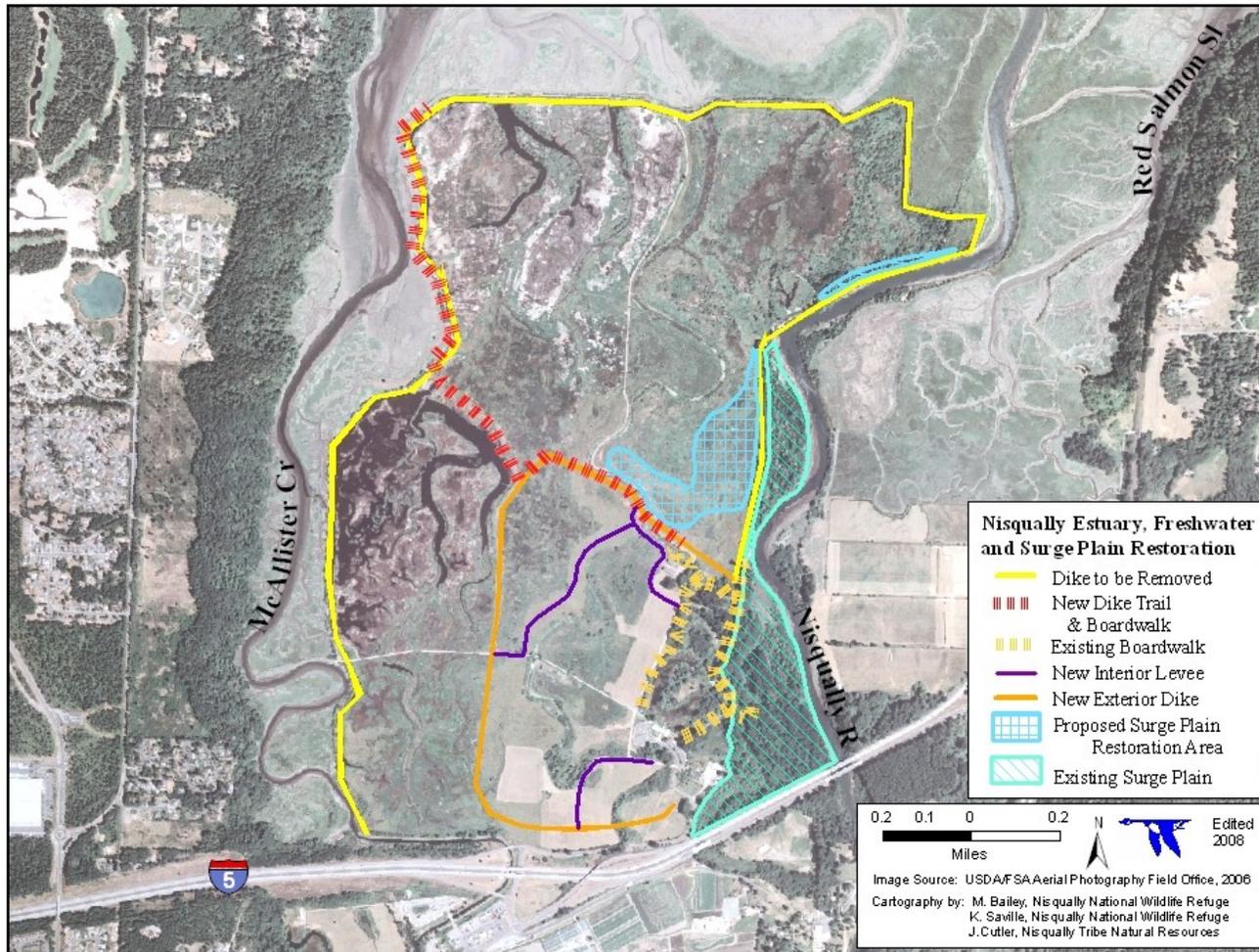


Figure 1. Nisqually River estuary restoration project map (project configuration approximate).

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