**Fir Island Snow Goose Reserve**
**DRAFT Restoration Feasibility Study**
**Washington Department of Fish and Wildlife,**
**Fir Island, Washington**

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DRAFT

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# EXECUTIVE SUMMARY

The Fir Island Farm Restoration project is located on the Washington State Department of Fish and Wildlife (WDFW) Snow Goose Reserve on Fir Island. The WDFW owns approximately 245 acres of upland in the vicinity of Brown Slough, Dry Slough, and Claude O. Davis Slough (Fir Island Farm) in the Skagit River delta that comprises the Snow Goose Reserve (Fir Island Farm). This feasibility study provides the baseline studies, alternatives analysis, and preferred restoration plan recommendation for setting back an existing dike and restoring 130 acres of tidal marsh. The feasibility study was funded through a Salmon Recovery Funding Board Grant (Project Number 09-1444N).

The primary project restoration goals include restoration of tidal flooding, water, sediment, nutrients, and detritus and organism conveyance and processes to the marsh. Additional goals include restoring native tidal marsh and tidal channel habitat; restoring estuary rearing habitat for listed threatened and endangered species and for other fish and wildlife species; and restoring fish passage. Other project goals included minimizing impacts to landowners, maintaining parking and public uses, maintaining or improving protection from saltwater intrusion to crops, interior drainage and flooding, and maintaining the reserve Snow Goose management activities.

Baseline studies and alternatives analyses were performed for tidal hydrodynamics, interior drainage, groundwater, geomorphology, soils and wetlands, fisheries, agriculture, public use and Snow Goose management. Six project alternatives were developed for evaluation including three dike setback alternatives and three tidegate replacement alternatives with Self Regulating Tidegates (SRTs). The project alternatives were evaluated using a set of prioritization guidelines and an evaluation framework founded on the project's study goals.

Alternative 2A was selected as the preferred restoration plan. It involves a 5,500-foot-long dike setback and 130 acres of tidal marsh restoration. Alternative 2A does not include the Dry Slough channel in the project due to the likely impacts to the Hayton Farm and other risk factors. The restoration project estimates are for a potential production of 65,000 to 320,000 juvenile Chinook smolts using the area annually, while maintaining Snow Goose management activities, without impacts to interior drainage, local landowners, public use and recreation, and the Skagit farm community.

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# FIR ISLAND SNOW GOOSE RESERVE
# RESTORATION FEASIBILITY STUDY
# WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
# FIR ISLAND, WASHINGTON

## 1.0 INTRODUCTION

### 1.1 Project Background

The Fir Island Farm Restoration project is located on the Washington State Department of Fish and Wildlife (WDFW) Snow Goose Reserve located on Fir Island. The WDFW owns approximately 245 acres of upland in the vicinity of Brown Slough, Dry Slough, and Claude Davis Slough (Fir Island Farm) in the Skagit River Delta (Delta) that comprises the Snow Goose Reserve (Fir Island Farm). This feasibility study provides the baseline studies, alternatives analysis, and recommended plan for restoring 130 acres of tidal marsh on the WDFW Fir Island Farm property.

Fir Island is a 12-square-mile island within the Delta and is primarily fertile farmland. The (WDFW) Snow Goose Reserve and project site is located 3 miles east of Conway, Washington, on the south side of Fir Island Road (Figure A-1). The Fir Island Farm is located along the Skagit Bay Front area. The Bay Front area is one of the only remaining areas in the Delta estuary where the freshwater-saltwater mixing characteristics provide estuary-type fisheries habitats that are sustained throughout the year.

In the Skagit Chinook Recovery Plan (Beamer, 2005) historical diking, dredging, and draining of the Delta have significantly limited the historical extent of Delta habitats, resulting in a 75 percent loss in tidal delta rearing habitat areas. These losses in Delta-type rearing habitat areas and loss in connectivity between habitats are critical factors in limiting the number and size of juvenile Chinook salmon rearing in the Delta. Skagit River Chinook were listed as "Endangered" under the Endangered Species Act (ESA) in 1999 and restoration of Delta rearing habitats that historically supported intertidal/estuary ecosystems are key components of the Puget Sound Chinook Recovery Plan (SRSC, 2005). The Delta estuarine habitats provide the following four main interrelated habitat functions for juvenile salmon including: physiological transition from freshwater to saltwater, foraging and growth, predator avoidance, and migratory corridors (Simenstad and others, 1982; Beamer and others, 2005). In the Chinook recovery plan, there is reference to Davis and Dry Slough restoration, which is the Fir Island Farm site and therefore a key project in the recovery plan.

The Fir Island Farm restoration project site is comprised of 245 acres of land that are currently farmed, with special farming provisions made to meet the reserve's Snow Goose management objectives. Natural tidal exchange to the site has been eliminated and blocked by construction of coastal dikes along Skagit Bay and installation of one-way tidegates to provide interior farm drainage and block inflow of tides to the farm areas. The altered tidal prism combined with deposition of sediment eroded from adjacent farm fields has greatly reduced tidal channel and marsh habitat, compared to historical conditions, both inside and outside of the dikes.

The restoration of 130 acres of tidal marsh will include setting back the existing dikes, restoring tidal exchange processes to the site that will provide benefits to a multitude of species (fish, birds, and mammals). In particular, it will provide essential delta-type rearing habitat for the endangered juvenile Chinook salmon.

WDFW has undertaken the Fir Island Farm restoration feasibility study to evaluate seven different project alternatives (four dike setbacks and two tidegate replacement alternatives) and has identified a recommended restoration plan as the outcome of this study.

The project is sponsored by the WDFW. In addition to WDFW, the project has organized a steering committee to support evaluation and development of the project feasibility plan. The primary point of contact for the project is Brian Williams (WDFW). The project has a Steering Committee comprised of those members listed in Appendix A, Table A-1.

## 1.2 Project Restoration Goals

In order to support evaluation and selection of a preferred restoration alternative, WDFW and the Steering Committee developed the following restoration and project-related goals (as stated in the Salmon Recovery Funding Board Grant Application [Project Number 09-1444N]). The Steering Committee is comprised of members of the local agricultural, fish and environmental restoration, diking, drainage, and flood control community. Their expertise and input is used to guide decision making for the project. In addition, several Steering Committee members have contributed to sections of this report.

Restoration goals:

- Restoration of tidal flooding (natural process).
- Restoration of unrestricted movement of water, sediments, nutrients, detritus, and organism.
- Restoration of native tidal marsh habitat.

- Restoration of tidal channel habitat.
- Restoration of fish passage.
- Restoration of estuary rearing habitat for ESA-listed species.
- Restoration of estuary habitat for fish and wildlife species.

Project-related goals:

- Minimize impacts to adjacent private landowners.
- Maintain a public parking area.
- Maintain public uses.
- Maintain or improve the existing drainage, salt intrusion protection, and flood protection.
- Maintain Snow Goose management capabilities.

These goals were used as a framework for developing evaluation criteria for assessing and comparing each of the project alternatives. The process is described in further detail in Section 4 of this report. Each of seven alternatives were evaluated for their potential restoration of tidal processes, tidal marsh and tidal channel habitats, and resulting juvenile Chinook smolt production, as well as the likely effects on interior drainage, farm and agricultural production, and potential impacts to adjacent landowners, Snow Goose management, and public use.

In addition to performing technical evaluation of the project alternatives, WDFW and the Steering Committee have endeavored to engauge the adjacent landowners, local farming community, and interested public use entities and organizations to solicit input and comment throughout the development and evaluation of the feasibility study. Through this process, local farmers, dike and drainage district and landowners, and other user groups have provided input and feedback to the process; this input has been incorporated into the feasibility study, design, evaluation, and selection process. The outreach and coordination efforts are documented further in Section 6 of this report.

The outcome of the feasibility study evaluation process has resulted in the recommendation to implement preferred Alternative 2A. The Alternative 2A recommendation is a result of balancing several competing resources including fish habitat restoration, Snow Goose management, farming, interior drainage, flood, and public use interests. This alternative includes a 5,850-foot-long dike setback along the west side of Dry Slough and moving the structure northward roughly toward the middle of the Fir Island Farm reserve property. Alternative 2A

will provide 130 acres of estuarine tidal marsh restoration, an estimated 17 acres of tidal channels with an estimated annual juvenile Chinook smolt production potential between 65,000 up to 320,000 fish annually. Alternative 2A balances the effects on Snow Goose management, and mitigates for effects to farmland and adjacent property owners by providing additional interior drainage storage.

### 1.3 Washington Department of Fish and Wildlife (WDFW) Snow Goose Reserve Legal Description

The project is located on the Fir Island Farm Game Reserve and incorporates WDFW owned established by the Washington State Wildlife Commission in 1997 as found in the Washington Administrative Code (WAC) as referenced below:

WAC 232-16-780 (Fir Island Game Farm – 245 acres)

WAC 232-16-790 (Hayton Game Reserve – 400 additional acres)

The restoration project feasibility study is obligated to evaluate the impacts on Snow Goose as it relates to the management objectives and function of the reserve.

### 1.4 Consolidated Diking District #22 (CDD#22) and Swinomish Tribe Consent Decree on Dry Slough

Separate from the Fir Island Farm restoration feasibility study, there is a legal Consent Decree between the Swinomish Tribe and Skagit County CDD#22 at the Dry Slough tidegate resulting from previous maintenance work being performed without a federal permit. As a result of a September 5, 2008 United States District Court order favoring the interests of the Swinomish Tribe, the Swinomish Tribe and CDD#22 entered into a Consent Decree on December 10, 2008. The Consent Decree requires CDD#22 to lobby for restoring tidal inundation to approximately 225 acres of WDFW's Fir Island Farm. In the event that WDFW is unwilling to restore 225 acres at their Fir Island Farm, the Consent Decree requires CDD#22 to design, permit, and install a Self Regulating Tidegate (SRT) at the mouth of Dry Slough that creates 6.2 acres of tidal salt marsh habitat. The Consent Decree assumes that a 225-acre restoration project will be implemented at WDFW's Fir Island Farm without consideration for the needs, interests, or desires of WDFW. Because WDFW is not party to the federal lawsuit, WDFW is not bound or otherwise encumbered by the Consent Decree.

Irrespective of the Consent Decree, WDFW is interested and willing to implement a large-scale restoration project at its Fir Island Farm. To that end, WDFW has conducted a feasibility study

that evaluates a range of restoration alternatives and with the support of a consultant team and Steering Committee, selected a preferred restoration alternative that balances the need for a Snow Goose reserve and Skagit Chinook recovery. For reference, the Fir Island Farm restoration feasibility study project Alternatives 1 and 4 look similar to Consent Decree mitigation options for the 225-acre tidal marsh restoration (Alternative 1) and SRT replacement options (Alternative 4), respectively. WDFW's preferred restoration alternative proposes to restore tidal inundation to approximately 130 acres of the Fir Island Farm site and does not include Dry Slough in the restoration footprint. Acknowledging that WDFW's proposed 130 acre restoration project is smaller than the restoration footprint specified in the Consent Decree, WDFW assumes that CDD#22 will be required to install a SRT at the mouth of Dry Slough in the near future. Based on this assumption, the interior drainage analysis conducted for the Feasibility Study and proposed Phase 2 Design and Permitting project evaluated the potential interactions of WDFW's 130 acre restoration and CDD#22's SRT installation.

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# 2.0 BASELINE STUDIES

A baseline site investigation was performed for the study. This involved data collection, mapping, and characterization of a number and variety of technical study elements. The detailed study baseline was used to: (a) document existing conditions, (b) formulate study alternatives and strategies, and (c) evaluate project effects for the project preferred alternative. This section of the report summarizes key baseline information for each of the technical baseline studies. The detailed technical memoranda are included in Appendix B.

## 2.1 Project Survey Control and Datums

The study project survey coordinate system is Washington State Plane North, NAD83, NAVD88 survey datum reference system. Data and surveys provided for the study were compiled from a variety of sources and survey datum and required transformation from NAD27/NGVD29 and tidal datum into NAD83/NAVD88. Details regarding survey data sources, compilation, transformations, processing, and corrections are described in Technical Memorandum 1.1.1 – Survey in Appendix B. The following is a summary of key information and recommendations regarding project survey information.

- Project Survey Coordinate System: Washington State-Plane North, NAD83/NAVD88
- Vertical tidal transformations were evaluated using VDatum (National Oceanic and Atmospheric Administration [NOAA] tidal datum software), evaluation of local tidal gauge data, and measurement of tidal conditions at the site using water level data loggers. Tidal datum transformations (adjustments) and key tidal information (Mean Higher High Water, etc.) are listed in Table A-2.
- Survey control for the project was provided by WDFW, Al Hammond, PLS. Survey control benchmarks surrounding the project site were used as reference control points for infrastructure, topographic, and bathymetric surveys performed in support of the project. Survey control maps are provided in (Appendix C, CAD Plans, Sheet C003).
- LiDAR data were provided by the Skagit River System Cooperative (SRSC, 2004) which was field checked with GPS-RTK surveys performed in 2010. Shannon & Wilson compiled original raw survey point data and transformed the data from NAD27/NGVD29 to NAD83/NAVD88 Washington State Plane coordinates. A three-dimensional surface (TIN) was prepared for hydrodynamic modeling and for showing contours and earthwork calculations in the preliminary design. Shannon & Wilson performed survey checks on the LiDAR data, which indicate varying degrees of accuracy ranging depending upon land type and vegetative cover. Survey comparisons ranged from ± 0.4 foot vertical on roads and structures, ± 1.0 foot in levees and farm fields, ± 3.0 feet at points in and along the margins of vegetated

channels, and ± 6.0 feet observed along submerged thalweg (bathymetric) points. This study modified the LiDAR data within hydrodynamic and hydraulic models based on existing bathymetric survey data. Future engineering design work and contractor bids should have final ground and bathymetric surveys performed for all areas where earthwork and structures will be constructed. This is necessary to limit potential construction contract claims and is especially important in measuring quantities over large areas where small discrepancies in survey could result in large changes in project quantities and costs.

- Channel cross section survey data were collected along multiple cross sections and compiled with survey data collected by others for use in the hydrodynamic model and interior drainage study models. We recommend that final survey bathymetry be collected from the Fir Island dike upstream to Fir Island Road for No-Name Slough and Dry Slough West, and that all final hydraulic models be updated using this information. Upstream from Fir Island Road, we recommend thalweg profile surveys of each of the main drainage channels.
- Surveys were performed to locate all project surface water and groundwater monitoring and boring locations. It should be noted that some of the surface water gauges were lost (Brown Slough and Dry Slough in the Skagit Bay tidal channels) during the feasibility study. The notations shown in the original the Survey Technical Memorandum 1.1.1 have not been updated to show losses and changes in level loggers. Current logger installations are referenced in Technical Memorandum 1.2.1b.

We recommend in the engineering and permitting phase of the study that the project include full land-based survey (including topography, bathymetry, boundaries, structures, utilities, roads, right-of-way and easements, and environmental features such as wetlands and ordinary high water) be performed to complete data collection for inclusion in the design and bid documents. The project is a large earthwork job and using LiDAR survey without a Professional Licensed Surveyor stamp on baseline survey conditions is a potential liability for claims during construction.

## 2.2 Geology, Geomorphology and Landscape Setting

A detailed geology and geotechnical memorandum is included in Appendix B, Technical Memorandum 1.3 with a separate memorandum (Technical Memorandum 1.1.2) describing Skagit River Delta and the Skagit Bay tidal marsh areas. The following is a summary overview of geologic, geomorphologic characteristics of the project site.

### 2.2.1 Geologic Setting

The Skagit River delta is located in the northern portion of the Puget Lowland, which is an elongated, north-south depression situated between the Olympic Mountains and the Cascade Range. The Delta is part of the Skagit Bay in the Puget Sound Whidbey Basin. Skagit Bay is bounded by the Delta to the north and east, Camano Island to the south, and Whidbey Island to the west and north (Figure A-3). River inflows to Skagit Bay are from the North and South Forks of the Skagit River, the Swinomish channel between Skagit and Padilla Bays near La Conner, and the West Pass distributary of the Stillaguamish River in the southeastern area of Skagit Bay near Stanwood, Washington. Tidal inflows and drainage to the Skagit Bay are through the Saratoga Passage from the south between Camano and Whidbey Islands and Deception Pass from the north between Whidbey and Fidalgo Islands.

The Puget Lowland was subjected to six or more major glacial advances over the past several million years. The most recent of these advances, termed "Vashon," covered the region between about 18,000 and 13,500 years ago. Extensive erosion and sedimentation during the Vashon glaciation produced many of the deposits and landforms that make up the surface of the Puget Lowland.

Among the more prominent glacially derived landforms in the Puget Lowland are north-south trending troughs, like those now occupied by Puget Sound and Lake Washington. These troughs were scoured by meltwater streams that flowed beneath Vashon ice (Booth, 1994). Skagit River deltaic deposits likely occupy a trough eroded by subglacial meltwater streams (Dragovich and others, 2002).

The trough existed as a marine embayment following retreat of the Vashon ice sheet north of the Strait of Juan de Fuca. Relatively rapid deltaic sedimentation of the Skagit River subsequently filled the marine embayment. Within the past 5,000 years, the Skagit River delta front is thought to have prograded about 5 miles from Mount Vernon to its current position (Dragovich and others, 2002). High depositional rates may be attributed, in part, to sediment input from volcanic debris flows (*lahars*) originating from Glacier Peak volcano (Dragovich and others, 2000; 2002).

Surficial geologic maps show that Skagit Valley deltaic deposits consist of Holocene marsh, estuarine, tidal flat, alluvial, and lahar-derived deposits (Wunder, 1976; Pessl and others, 1989; Dragovich and others, 2002). In the subsurface, these deposits form complex sequences that interfinger with one another and which have soil characteristics that vary laterally and

vertically. Marsh, estuarine, and tidal flat deposits in the Skagit River delta sequence typically consist of soft clay and silt and/or loose fine sand. These deposits are mapped as unit Qn by Dragovich and others (2002) in the vicinity of Fir Island Farm (Figure A-4). Alluvial and lahar-derived deposits typically consist of loose sand and gravel.

The Devils Mountain fault extends east-west across the Skagit River delta approximately 2 miles north of the project site. This left-lateral oblique fault extends for at least 80 miles between the Cascade Mountains and eastern Strait of Juan de Fuca. The fault is considered to be active, which implies that the levee and dike structures will likely be subject to seismic events during the life of the structure (Johnson and others, 2001).

### 2.2.2 Geomorphology

A cursory geomorphologic study of the project site was performed to understand the historical, existing and future conditions of the restoration project site. In evaluating the project's geomorphologic characteristics and processes, the following tasks were performed:

- Describe coastal tidal and river delta processes related to flow, sediment, wood and nutrients (conceptual process-based restoration model) that will influence the project restoration site;
- Characterize and describe existing Skagit Bay tidal marsh and Skagit River Delta tidal marsh features;
- Document historical anthropomorphic changes to the marsh; and
- Evaluate geomorphologic response to dike setback and tidal marsh restoration.

The Fir Island Farm project site is located along foot of the Skagit Delta and tidal marsh margin of Skagit Bay. The project site is located midway along the Bay between the North and South Fork Skagit River forks (distributary river channels), which form the boundaries of Fir Island. The site has upstream connections to interior drainages including Dry Slough, Claude O. Davis (No-Name) Slough, and Brown Slough. Historically, these sloughs were distributary channels connected to the North Fork Skagit, but have been disconnected as part of agriculture drainage infrastructure development. Currently, these channels provide interior drainage to farms on the central and western areas of Fir Island.

Formation and progradation of the Skagit River Delta is caused by sedimentation (from alluvial, transport of glacial outwash, and lahar sediments) and deposition at the mouth of the river in the marine embayment formed by retreat of the Vashon ice sheet. River deltas are landforms that form as rivers flow into large water bodies and experience a change in profile,

slope, and floodplain confinement. The deltaic land features form over time from sedimentation that occurs as the flowing river enters the open areas of the coastal embayment or glacial trough. As sedimentation occurs, alluvial surfaces build upward and extend outward (prograde) into the marine trough, creating a fan or delta-shaped feature.

In general, river delta mainstem channel bed profiles aggrade (build up sediment deposits) over time due to sedimentation. As the bed of the channel aggrades, the river will overflow its banks into adjacent low lying floodplain areas, which form distributary channels. The process of distributary formation is termed "bifurcation" and is commonly associated with river delta and alluvial fan environments. Distributaries (as well as mainstem river channels) have alluvial processes that deliver flow, sediment, nutrients, detritus, and woody debris to the Delta and Bay Front areas.

In addition to the river delta alluvial processes, the Skagit Bay Front areas are subject to coastal tidal processes. Tidal processes include tidal prism exchange, storm surges and wave action, longshore and coastal sediment transport, large wood debris transport, and deposition and tidal marsh vegetation establishment, as wells other biological factors that can influence marsh geomorphologic composition such as Snow Goose foraging on marsh vegetation.

The current Delta is an overlapping mosaic of riverine (delta) and tidal processes. Previous studies on the Delta have identified three distinct areas along the Delta that appear to have varying degrees of influence by riverine and tidal processes (Hood, 2010b):

- South Fork Skagit Delta – Direct influence from river flows, active alluvial sedimentation, existence of numerous delta distributary channels with upstream connections, intermingled with smaller blind tidal channels along downstream margin of the Delta. Downstream from the vegetated areas of the Delta, a complex mosaic of unvegetated, braided tidal channels, sand bars, and mudflat areas exist that extend southward into the Skagit Bay area towards Saratoga Pass.
- North Fork Skagit Delta – Direct influence from river flows, active alluvial sedimentation, mainstem river meander bend channel migration, connection and occupation of blind tidal channels on the outside of the meander bend causing formation of periodic distributary channels, and sedimentary tidal channel, sand bars, and mudflat complexes out in the Skagit Bay area (albeit less complex than the South Fork Delta). Sedimentary channel patterns extend southward into Skagit Bay. The North Fork does not exhibit typical delta shapes and patterns, likely due to its position and partial confinement of geologic bedrock outcrops near Rexville.
- Skagit Bay Front Area (Fir Island Farm Area) – The current Bay Front is predominately influenced by tidal and coastal processes without current delta

distributary channel connections. Historically, the Bay Front was connected to distributary flows at Brown and Dry Sloughs. The Bay Front has sizeable tidal marshes with numerous blind tidal channels and large wood debris deposits. The Bay Front is comprised of large vegetated tidal marshes, with numerous "blind" tidal channels. The current Bay Front is bordered by a broad mudflat complex with several large tidal drainage channels that were historically connected to Dry, Claude O. Davis, and Brown Slough distributaries. It appears that large wood transport and delivery travels east-west along the Bay Front and deposits in and along the Bay Front marshes, and is likely influenced by prevailing southeasterly wind and waves.

Anthropomorphic changes to the project site were evaluated by comparing historical pre-development conditions, historical Government Land Office (GLO) survey maps and aerial photographs from the late 1800s through current 2009 aerials (Appendix B, Technical Memorandum 1.1.2). Observed changes to the delta are summarized below.

- Collins and others (2002) developed a historical interpretation of the Delta using a variety of historical maps, reports, ethnology, landscape ecology, ethnobotany, and palynology data and techniques to develop a pre-development model of the Skagit River Delta landscape. The landscape scale characterization of the Skagit Delta shows the Fir Island Farm project site as tideflats and emergent estuarine marsh. The interpretation maps show small distributary deltas and channel bifurcations from Dry to Claude O. Davis Sloughs, and longer blind channels extending upstream into Fir Island.
- Late 1800s conditions were documented on 1889 T-sheets, GLO survey maps (USBLM, 1889). During this period, two settlers, Sullivan and Calhoun, had started diking and draining the marshy flatlands in the Skagit Delta for agricultural purposes (History Link, 2010). The 1889 T-Sheet shows that diking and drainage had occurred along the margins of Brown and Dry Sloughs. The dikes did not extend as far south into the bay as today and ended roughly near the current WDFW parking area, then headed east by northeast along Claude O. Davis Slough, and then Dry Slough up to Fir Island Road. The site's tidal channels still had upstream (distributary) connections for Brown Slough and Dry Slough, which bifurcated into Dry, Claude O. Davis, MacDonald, and Wiley Sloughs. Crossings of the channels used wood bridges located along what is now Fir Island Road. During this time period, snagging and clearing of major log jams of the Skagit River extended upstream along the Skagit River South Fork allowing for upstream navigation, commerce, and development.
- 1937 historical aerial photographs were provided by Skagit County (Skagit County, 1937). The aerial shows that the Fir Island Bay Front dike is in nearly the same location along the Skagit Bay Front as today, 2011. Interviews with Skagit County CDD#22, indicate that the Bay Front dikes were extended to this alignment in 1913. Claude O. Davis Slough was closed and the dikes extended across Claude O. Davis to the western

edge of Dry Slough. Similarly, dikes on the eastern edge of Dry Slough were extended, closing off MacDonald Slough. Claude O. Davis was connected to the Bay Front with a set of tidegates (likely wood box culvert with a steel flapgate). The remaining sections of the dike follow Brown and Dry (Deer) Slough channels upstream to Fir Island Road. The channels appear to remain open to North Fork distributary flows.

- A 1956 aerial photograph was provided by WDFW for review, and included less coverage than the other photographs. In this photograph, Brown Slough and upstream Dry Slough appear to have tidegates installed at Fir Island Road to protect interior drainage areas, thereby indicating that river distributary flow connections to the North Fork Skagit were no longer present. In accordance with communications with CDD#22, the North Fork Skagit River on the opposite side of Fir Island had been closed to Dry Slough in 1951, and tidegates installed on Fir Island Road for Dry, Claude O. Davis, and Brown Slough in 1948. The Skagit Bay dikes remained along the margins of Dry Slough until 1962, when a tidegate closure was installed across the mouth of Dry Slough at the current tidegate location. The 1956 dike and tidegates configuration are tidal inflow conditions only, and would be similar to the current restoration project plans.
- A composite 2006/2009 aerial photograph shows the full configuration of the dikes since 1962. Some minor alterations and changes to the system occurred in the 1962 to 2009 period, namely the overtopping and breaching of the dikes. In the 1990 Skagit River Floods, a natural dike breach occurred at Claude O. Davis (natural breach) and a manmade breach at Dry Slough to drain flood water ponding of interior Fir Island areas. The breaches drained interior areas more quickly than the tidegates, but interior areas reflooded as tides came back in. Due to this historical location, CDD#22 is interested in a floodgate to provide increased drainage discharges for Fir Island Skagit River floods without backflow flooding from breaches and incoming tides. The breach areas damaged adjacent farm crop areas, created significant scour holes, and have residual reductions in crop production likely a result of salinity contamination of the soils.

As a result of historical diking and drainage infrastructure (tidegate) installations, the interior dike areas have been converted from historical tidal marshes and channels to farm areas. In addition to interior area losses of tidal marsh habitat, exterior areas have experience losses and changes in tidal marsh habitat. Measurements of the retreat of vegetation lines indicate that the vegetated marsh areas along the exterior margins of the Fir Island Farm dike have retreated between 400 and 1,000 feet, as observed on the 1937 and 2010 aerial photographs. This corresponds to a loss of 75 acres of tidal marsh exterior areas along the Fir Island Farm Bay Front over the past 73 years.

This observation reflects those made by many others regarding marsh vegetation losses in the Skagit Bay Front area. Hood (2010a) emphasizes the need to evaluate and understand the effects of diking and levee projects on the seaward side of the structures. The study asserts that

losses in sediment delivery (both tidal and river distributary transport mechanisms) are a primary factor in loss of marsh areas and channel vegetation. The study also indicates that the reduction in tidal prism also plays a significant role in channel marsh formation processes (within and outside the dikes). This would tend to indicate that alternatives that include dike removal would create additional tidal marsh habitat restoration benefits on the seaward side of the dikes, and that the do-nothing alternative would continue to experience losses and degradation of habitat along exterior marsh areas.

In evaluating the potential response of the project site, a geomorphologic conceptual model was developed showing the different tidal and alluvial processes as scalars (flow, sediment, nutrients, and wood) that influence the project restoration site. Historically, the Fir Island Farm site was influenced by both tidal and river distributary processes (similar to the North and especially the South Fork Delta distributaries). The current proposed restoration actions will restore tidal flow exchange, sediment, nutrient, and large wood delivery processes to the project site. Restoration of these tidal processes will result in the establishment of blind tidal channels, mud flats, shallow ponding areas, and vegetated marsh plain areas similar to existing tidal marshes along the Skagit Bay Front.

Estimates of marsh types (low and high marsh areas and other features including blind tidal channels and potential mud flats) were performed for the project. Marsh vegetation establishment was assumed to be similar to existing exterior marsh types as a function of restored area elevations. The proposed restored farm areas behind the existing dike (elevations 5 to 7 feet NAVD88) are approximately 2 feet lower than the existing exterior marsh areas (7 to 9 feet NAVD88). Based on observations of existing exterior marsh vegetation at the site and Skagit Delta vegetation data (Hood, 2009), areas below an approximate elevation of 5.5 feet NAVD88 will become mudflat due to the duration of tidal inundation. Areas between approximately 5.5 and 7 feet (the remainder of restored marsh areas) will likely have establishment of low marsh vegetation including Lyngbye's sedge (*Carex lyngbyei*, OBL), creeping bentgrass (*Agrostis stolonifera*, FACW), and ), saltmarsh bulrush (*Schoenoplectus maritimus*, OBL).

In addition to establishment of vegetated marsh plains and mudflat areas, tidal channels will form within the restoration area. Numerous investigators have developed various methods for estimating the morphologic formation, size, and number of intertidal channels within existing and restored vegetated tidal marshes (Coats and others, 2005; Fagherazzi and others, 2006; Hood, 2010b; Hood 2007; Kirwan and others, 2007; Rinaldo, 1999). In particular, three local models were considered for use in estimating tidal channel marsh response:

- Historic Channel Condition (model) – WDFW analyzed channel dimensions of Brown, Claude O. Davis, and Dry Sloughs performed for the feasibility study. Historical channels had distributary flow influence and were likely larger in size than will be expected for tidal process only restoration action. The historical channel condition was not considered an appropriate estimating tool.
- Marsh Island Regression Model (South Fork and Bay Front models) – Hood (2007) developed tidal channel dimension regression equations for South Fork and the Skagit Bay Front channels based on scaling allometry of depositional island (lobes). A single existing tidal channel along the Bay Front between Dry and MacDonald Sloughs was delineated and compared to the Marsh Island Regression Model, South Fork, and Bay Front regression models with varying parameters. The existing tidal channel dimension compared well with the Skagit South Fork regression model results, which was then used to estimate channel development and geometry for the restoration site.

Preliminary hydrodynamic modeling of the preferred alternative (discussed later in the report) indicate that the tidally inundated areas within the restored farm will have low energy, low velocity, shallow ponding over broad expanses, with localized higher flow velocities occurring through the Claude O. Davis channel breach area. The existing exterior marshes will be higher in elevation and act somewhat like a barrier island, with shallow interior ponding occurring along most of the restoration area. Preliminary modeling results indicate that tidal exchange velocities in the shallow ponding areas infrequently exceed sediment erosion and transport velocity thresholds of (1 to 2 feet per second). Sediment delivered interior to the site will likely deposit, but there will likely be little energy to erode tidal channels. Considering the low energy environment of the marsh restoration area, excavation of tidal channels is recommended for the project design. These features are relatively low cost and will provide immediate habitat benefits, allow for interior transport of sediment, and increase flow velocities within the excavated channels. Ultimately, excavation of the pilot channels will decrease the amount of time necessary for lower order tidal channels (smaller interior tidal channels further inside the marsh) to develop as a result of accelerating tidal channel development through manual excavation.

It is acknowledged that full restoration of functional flow, sediment, nutrient, and possibly large wood debris processes to the Brown and Dry Slough areas would ultimately include reconnection of Skagit River distributary channels. Reconnection of distributary channels has been identified as a necessary component of tidal delta restoration in the Skagit Chinook Recovery Plan (SRSC, 2005), and by others investigating habitat pathways (PWA, 2003).

The dike setback and tidal marsh restoration is a logical first step, as it will regain converted tidal marsh areas and restore tidal functions and processes. In addition, the location provides a secondary benefit and a key strategic location (near Brown, Claude O. Davis, and Dry Slough outlets) if a longer term distributary or cross-island connector project were to occur. A distributary reconnection project would enhance and benefit the Fir Island Farm restoration project by contributing freshwater flow, sediment, nutrient delivery, and possibly fish pathways (connectivity) to the site.

### 2.2.3 Soils and Subsurface Conditions

The interpretation of subsurface conditions is based on review of historical information and on samples recovered from twelve, 30 foot deep geoprobe explorations (Figure A-5 and Technical Memorandum 1.3). In general, five soil units were encountered:

- Dike fill (Hf) – Dike fills to heights of 8 to 10 feet above existing farm field grade at the site primarily consists of local, near-surface native materials that were pushed into place during dike construction. These soils generally consist of slightly clayey to clayey silt that resembles Holocene mudflat deposits. A Skagit County CDD#22 interview indicated that CDD#22 thought that excavation of “blue clays” came from the adjacent marsh areas. These excavations are now observed at the site as “borrow ditches.”
- Agricultural layer – A 1- to 2-foot-thick layer of silt loam starting at existing field grade. The layer is generally disturbed as a result of farming practices such as disking and tilling. The National Resource Conservation Service (NRCS) characterizes the field surface soils primarily as Skagit Silt Loam (NRCS, 2010).
- Holocene mudflat deposits (Hm) – The agricultural layer is underlain by a 2- to 7-foot-thick layer of slightly clayey to clayey silt locally interbedded with layers of silty, fine sand and fine sandy silt. This layer was assigned the geologic unit *Holocene mudflat* (Hm) which represents deposits that may have accumulated from a combination of tidal flat, estuarine, and alluvial overbank deposition. The unit is analogous to the Quaternary nearshore (Qn) unit of Dragovich and others (2002).
- Holocene alluvium (Ha) – The Ha layer underlies Hm to the bottom of the geoprobes at a depth of 30 feet below existing grade. The Ha typically consists of clean to slightly silty sand. Locally, the deposits contain layers of silty sand, scattered shell fragments, and wood debris. The dark gray color of the sand suggests its origin is largely volcanic, and that the Ha are likely related to lahar flows from Glacier Peak.
- Holocene estuarine (He) – He deposits forming 1- to 3-foot-thick layers of silt, slightly clayey to clayey silt, and silty clay with observed shell fragments were commonly observed as interlayered with Ha deposits.

## 2.3 Preliminary Geotechnical Design

A set of preliminary geotechnical analyses for side slope stability, settlement, and soil suitability were performed to develop concept-level dike design recommendations (Appendix B, Technical Memorandum 1.3). The following is a summary of preliminary geotechnical concept design recommendations:

- Concept designs should use a maximum dike side slope of 3 horizontal to 1 vertical (3H:1V) for concept design plans. The maximum dike side slope design can be optimized in Phase 2 geotechnical engineering design phase of work and potentially increase side slopes to reduce construction costs.
- Settlement estimates were made using elastic theory of a 11 foot high (new dike elevations at 17 feet NAVD88), 15 foot top-width with 3H:1V sideslopes. Underlying soils are granular and settlement will likely occur during construction of the dike on the order of ½- to 1-foot.
- Soil suitability for new dike construction varies by layer.
  - The agricultural (topsoil) layer is not likely suitable due to the amount of organic material.
  - Hm deposits in the layer 2- to 7-feet below the topsoil are likely suitable for levee construction. The on-site soil has a relatively high moisture content and was slow-drying. Moisture conditioning and/or amendments will likely be necessary to properly compact the soil, which can add to construction costs.
  - Use of the deeper Ha (sandy) materials in the proposed dike is unsuitable. The fines content of the sandy layers is too low (less than 10 percent) to produce a relatively lowly permeable dike. Mixing of higher silt content materials may be possible, but likely at a high cost.
  - Construction phasing and availability of suitable materials is a key consideration. Construction of the new dike and removal of the existing dike need to be sequenced in such a fashion to allow for breaching and removal of the existing dike at such time when the new dike is ready (design heights, finish grading, and seed establishment) and balanced with other project soil needs (such as filling borrow ditches). Import of suitable dike building material is recommended for concept design planning purposes and, during engineering design phase of work, optimization of site soil use can be developed further to target cost savings.

Geotechnical engineering studies will need to be completed for the preferred dike setback alignment during the next Phase 2 Engineering Design and Permit phase of work.

## 2.4 Skagit Bay Baseline Hydrodynamic Conditions

Hydrodynamic studies were performed for the project for two primary reasons. The first was to establish baseline tidal elevation, salinity, and temperature conditions along the Skagit Bay Front and interior drainage channels immediately next to the dikes. The second was the use of the previously developed (by Battelle – Pacific Northwest National Laboratory) Puget Sound three dimensional (3D) hydrodynamic model to evaluate tidal conditions during key spring juvenile Chinook migration periods. Baseline data regarding dike seepage, salt water intrusion, and interior drainage conditions are discussed in the following section. The following is a summary of 3D hydrodynamic modeling study of baseline spring juvenile Chinook migration conditions for a select period (Appendix B – Technical Memorandum 1.2.4).

The Puget Sound 3D hydrodynamic model is a three dimensional, unstructured grid, finite-volume coastal ocean model supported by high-resolution LIDAR data. The model has been calibrated and validated for water surface elevation, velocity, and salinity data of spring and neap tidal cycles for low- and high-river flow conditions (Yang, 2009). The benefits of using the model are that it has been calibrated, has the benefit of significant survey data improvements in Delta mudflat areas, and can be used to evaluate tidal flood inundation areas, depths, velocities, and salinity conditions.

The model geometry consists of 20,454 nodes, 38,400 elements, and 10 uniform vertical layers and the average grid size inside the Fir Island Farm project site is about 16 meters (Figure A-6). LIDAR data along the tidal channels were updated using survey data of thalweg profile elevations taken specifically for the project along Brown, Claude O. Davis, and Dry Slough.

The modeling period was set up for period from March 15 through April 15, 2003. The spring 2003 runoff period was identified by the Fir Island Farm Steering Committee as a date when sizeable amounts of fish migration data were collected, and that the system had good spring smolt out-migration numbers.

Tidal elevations along the open boundaries were obtained from XTide model predictions in Skagit Bay. Skagit River inflows used the U.S. Geological Society (USGS) stream gauge data at Mt. Vernon (USGS 122005500). The mean flow for the simulation period is 18,905 cubic feet per second (cfs), which is higher than the long-term mean of 15,000 cfs for the March-April period. Wind stick data were from the Whidbey Island weather station. Salinity boundary conditions were specified as 30 ppt at open coastal model boundaries and at 0 ppt in the Skagit

River flow locations. Initial conditions for water surface elevation, velocity, and salinity were all set to zero.

Modeling results of existing conditions were plotted for a two-week spring-to-neap tidal cycle. Model output files were generated showing a 24-hour tidal cycle in the Skagit River, Skagit Bay, and Fir Island Farm area with salinity, depth, and velocity output parameters (Figures A-7 through A-14).

Modeling output also evaluated salinity, depth, and velocity at specific nodes immediately south of the dike in the Skagit Bay Claude O. Davis Slough channel. Water surface elevations for station T1 and C1 show tidal high tide peak elevations of 8.9 feet (NAVD88) and a low tide minimum 2.3 feet. High tides are similar for points further out in Skagit Bay and near the Fir Island Farm (Bay Front) dike area, indicating no change in large scale hydrodynamics. However, low tide minimum elevations (troughs) are nearly constant at 2.9 feet (NAVD88). The muted troughs are observed in field data and are likely a result of Skagit River inflows and the Skagit Delta that does not fully drain with each tidal cycle. This hydrodynamic behavior is observed in tidal elevation data collected at the project site.

Flood tides showed depth averaged peak velocities on the order of 0.7 feet per second (fps) with depth average ebb tide peak velocities at 0.3 fps (which are at or below known velocity thresholds for erosion of silt/sand particles of up to 2.5 to 3.0 fps). Ebb tides show fairly sizeable velocities in the downstream segments of Brown, Claude O. Davis, and Dry Slough channels, for existing conditions, indicating that there is good drainage of the site. Tidal channel depths at high tide were on the order of 6.5 feet deep, with depths less than 0.5 foot deep in the higher marsh areas. Closer views of the tidal channel and tidal marsh salinities, velocity and depths are shown in the Appendix B – Technical Memorandum 1.2.4.

3D hydrodynamic modeling salinity estimates range from 0 ppt up to 14 ppt. The higher salinity peaks appear to occur at lower Skagit River flows and strong spring tide conditions. The peak salinity conditions match well to data collected in the fall of 2010. Salinity flushing for the predicted 2003 spring condition were less than the observed fall 2010 conditions where salinity remained above 5PPT for all conditions.

Depth, salinity and velocity conditions are commensurate with suitable habitat conditions for juvenile Chinook smolts utilizing the marsh during spring migration periods. The 3D hydrodynamic model was not applied for each individual project alternative presented later, but was used to evaluate the preferred restoration plan, as described later in the report.

## 2.5 Interior Surface and Groundwater Drainage Conditions

The Fir Island Farm, Snow Goose Reserve site has three major interior drainage areas, namely Brown Slough/Rawlins Road, Claude O. Davis/No-Name Slough, and Dry/McDonald Slough (Figure A-15 and Table A-3). Claude O. Davis and No-Name slough combine flows as do Dry and MacDonald Slough, hence the grouping together. These interior drainages are associated with agricultural drainage from the central portions of Fir Island. The drainage systems drain both surface water and groundwater. Characteristics of the Fir Island central drainage systems are summarized in Table A-3. The lower portions of the three drainages are permanently ponded and provide "wet" storage in the system (i.e., upper areas drain to the lower channels, which drain only as the tide goes out and tidegates open). Effects of interior agricultural drainage (such as reduction in storage and increases in flooding) are a key concern for the project. The following is a brief description of the interior drainage areas.

- **Brown Slough**

  Brown Slough is a 1.0-square mile drainage area (including Rawlins Road drainage) that historically drained to the south and west but has been reconfigured into Brown Slough (in accordance with communication with CDD#22). Brown Slough was a historic distributary and likely disconnected from the Skagit River and relegated to interior drainage functions only between 1937 and 1956. The primary drainage channel length is 6,000 feet long and flows north to south in Brown Slough with west to east flow from the Rawlins Road area to Brown Slough. The Brown Slough discharges through a single 48-inch tidegate underneath Fir Island Road, and two 48-inch, top-hinge flapgates and one 48-inch screwgate at the Brown Slough tidegate complex. Brown Slough drainage does not affect many of the project alternatives, but was considered as part of Alternative 6 (described in following sections of the report).

- **No-Name Slough**

  No-Name Slough refers to the interior, agricultural drainage area immediately east of Brown Slough drainage. The drainage area is 1.5 square miles, a manmade interior drainage system, with a 9,060-foot-long primary channel running along the north-south drainage. Historically, the drainage may have connected with Brown Slough further upstream near Fir Island Road. Currently, No-Name crosses beneath Fir Island Road west of the Fir Island Farm (Snow Goose Reserve) entrance, and then flows back east into the major north-south channel in the middle of the project site. No-Name has its confluence with Claude O. Davis Slough and discharges through two 48-inch tidegates beneath the current dike.

- **Claude O. Davis Slough**

  Claude O. Davis Slough is a small, 0.1 square mile interior drainage area located within the WDFW Snow Goose Reserve property. The primary drainage channel length is 1,330 feet and flows northeast to southwest. The Claude O. Davis Slough was a historical distributary of Dry Slough that was likely disconnected around 1913 and now connects to No-Name Slough at the dike near the previously mentioned two 48-inch flapgates.

- **Dry Slough – West**

  Dry Slough western drainage is 1.5 square mile, and the largest interior drainage area within the project study area. This drainage area is a manmade interior drainage system with a primary north-south drainage channel length of 8,110ft. The Dry Slough West channel connects with the Dry Slough East channel midway along the WDFW Fir Island Farm eastern boundary. Downstream from the confluence, Dry Slough discharges through two 48-inch culverts.

- **Dry Slough – East**

  Dry Slough East drainage is the 0.6-square mile (including drainage area downstream from the Dry Slough West confluence), historical distributary of the North Fork Skagit that was disconnected in 1962. Currently, the drainage channel is perched in elevation above much of the adjacent floodplain and is a long and narrow drainage limited to the margins of the channel. The total channel length is 17,735 feet and runs north to south to the confluence with Dry Slough – West drainage. The lower segment of Dry Slough downstream from the Dry Slough West confluence is 3,900 feet in length. Just upstream from the dike drainage outlet, Dry Slough connects with MacDonald Slough which drains farm areas from the east. Dry Slough drains through the dike through a two 48-inch tidegates.

- **MacDonald Slough**

  MacDonald Slough drainage is a 1.5-square mile historical tidal drainage (and distributary) channel draining eastern areas of the project site along the south boundary and Skagit Bay dike along the Hayton Farm property. MacDonald Slough connects at the very downstream end of Dry Slough. The primary drainage channel length is 6,190 feet and generally drains northeast to southwest and connects to Dry Slough through a single 36-inch flapgate.

### 2.5.1 Baseline Surface Water and Groundwater Data Collection on Interior Drainage Systems

Baseline data were collected for tidal and interior drainage systems. A system of data collection loggers were installed on each of Dry, No-Name/Claude O. Davis, and Brown Sloughs (Figure A-16). For reference, data logger nomenclature is as follows:

- Dry Slough – Four loggers total. Two level, temperature, conductivity loggers on the Bay side (tide side) and farm side (interior drainage side) of the dike. Two level temperature loggers upstream near Fir Island Road, one each in Dry Slough East and Dry Slough West. (i.e., SW-DS-1.0-LTC – designation indicates Surface Water – Dry Slough – 1.0 – Level Temperature Conductivity).
- No-Name and Claude O. Davis Slough – Three loggers total. Two level, temperature, conductivity loggers on the Bay side (tide side) and farm side (interior drainage side) of the dike. One level, temperature logger upstream near Fir Island Road (i.e., SW-NNS-2.3-LT).
- Brown Slough – Three loggers total. Two level, temperature, conductivity loggers on the Bay side (tide side) and farm side (interior drainage side) of the dike. One level, temperature logger upstream near Fir Island Road (i.e., SW-BS-3.0-LTC).
- Groundwater – Three level, temperature loggers total located in a longitudinal profile along the east side of Dry Slough extending northward into the Hayton Farm property (i.e., GW-GP-01-10).

Data collection parameters included level and temperature for all surface water and groundwater gauges (described in the groundwater section). For the loggers located immediately adjacent to the existing dike (both inside and outside of the dike) salinity data were collected to document salt-water intrusion and seepage conditions. Results of the data collection monitoring are included in Appendix B, Technical Memorandum 1.2.1 Interior Drainage, and summarized herein.

#### 2.5.1.1 Water Level Data Summary

The following observations were made regarding water level data for tidal and interior drainage channels (Figures A-17 through A-20).

- Downstream tidal gauge level logger data indicate that each of the tidal gauges Dry Slough 1.0, Claude O. Davis Slough 2.0, and Brown Slough 3.0 have nearly identical tidal level and water surface elevation signatures. Current monitoring efforts have been modified to collect water level, temperature, and salinity data at the SW-COD-2.0-LTC gaging station only. Observed tidal elevations ranged between 3.0 feet and 12.0 feet NAVD88.
- Interior dike gauge level logger data for SW-DS-1.1-LTC and Claude O. Davis Slough 2.1 are hydraulically connected. The interior drainage channel storage areas have nearly identical surface water elevations just inside the dike. These areas just inside the dike fill with groundwater drainage and surface water runoff, until the tidegates open on the falling tide. On a given tidal cycle, the water level for the interior gauges next to the dike rises 1 to 2 feet above the low tide drainage elevation

on each tidal cycle, and then drains with the falling tide. Observed interior drainage water surface elevations ranged between 3.5 and 5.5 feet. It was observed that when 5.5-foot water surface elevations occurred, lower elevation farm areas within the Fir Island Farm Snow Goose Reserve had winter-time flooding and were inundated.

- Upstream from Fir Island Road, No-Name and Dry Slough West (Dry Slough branches into east and west near Fir Island Road) the interior drainage channels have similar but independent and measurable differences in water surface elevations. Typically, the interior drainage elevation is slightly higher at the peak, and does not fully drain (and up to 0.5 foot higher than the downstream areas near the tidegates) at the base of each tidal drainage cycle. This is an indication that interior drainage channels and storage areas located closer to the tidegates can drain more quickly than positions located more distant. This has implications for the size and location of interior drainage storage mitigation design plans. Observed interior drainage water surface elevations ranged between 3.5 and 5.5 feet, but did not drain as much (as low in elevation and levels were slightly higher – on the order of tenths of a foot) than the downstream gauges next to the tidegates. For No-Name Slough, a data anomaly was observed in September 2010 whereby the drainage channel water surface elevations were up to 1 foot deeper over a 2-week period. At all other times, No-Name and Dry Slough West were similar in water surface elevations. It is hypothesized that irrigation activities may have been occurring in No-Name Slough at the time of the data anomaly.
- Brown Slough water surface elevations in the area upstream from the tidegate complex and Fir Island Road are independent from No-Name, Claude O. Davis, and Dry Sloughs. Brown Slough has, on average, a 2-foot head differential across the tidegate complex. Brown Slough upstream from Fir Island Road exhibited the largest changes and exchanges in water surface elevations upstream of Fir Island Road on a day-to-day basis. Overall, Brown Slough has higher peaks and similar lows when compared to No-Name and Dry Slough West gauges upstream from Fir Island Road. This is an important note as the current indication from the farm and agricultural community is that the Brown Slough system is in good operating condition as a result of the continuous downstream gate with muted interior tidal elevations, yet data indicate Brown Slough has higher water surface elevations on a daily cycle.
- Groundwater along the interior profile to the north of the Bay dike measured groundwater elevations ranging from 4.0 feet to 6.3 feet during the fall and early winter 2010. Groundwater elevations were near the soil surface in October 2010 at GW-GP-02-10 located in the southernmost Hayton farm field near the dike where the farm field is near an elevation of 6.0 feet NAVD88. 1,000 feet north, the farm field is at an elevation near 8.0 feet NAVD88 and the measured groundwater was similarly at 6.3 feet NAVD, but nearly 1.7 feet below ground level. Overall, measured groundwater elevations experienced daily fluctuations resulting from tidal influence on the groundwater table and interior drainage conditions. Groundwater monitoring wells located closer to the dike exhibited larger daily fluctuations and moving interior

from the dike, reductions in groundwater daily peaks and ebbs were noted to be less than those near the dike (indicating lower groundwater table) but only on the order of tenths of a foot. It is anticipated that as the dike is moved inward, groundwater elevations will behave similarly to those of the groundwater wells currently near the dike.

#### 2.5.1.2 Water Temperature Data Summary

The following observations were made regarding water temperature data for tidal and interior drainage channels (Figures A-21 through A-23).

- Water temperatures outside the dikes ranged from 15 degrees Centigrade (˚C) in September 2010 to 7˚C in December 2010.
- Water temperatures just inside the dikes hovered around 12˚C (and were more constant) and dropped shortly to just below 10˚C in mid-November 2010. This would tend to indicate the influence of groundwater due to the constant temperature condition. The constant temperature near the dikes is somewhat anomalous considering the water surface temperatures and trends on both upstream and downstream sides of the loggers along the inside of the dikes.
- Water temperatures along the interior drainages upstream from Fir Island Road were elevated as compared with the tidal temperatures by a few degrees ranging from 17˚C to 8˚C.

#### 2.5.1.3 Salinity Data Summary

Salinity data were collected for tidal and interior drainage channels next to the dike and tidegates, as well as at the groundwater gauges during well installation. An additional set of surface water salinity measurements were made in September 2010 to evaluate Skagit Bay and interior drainage surface water salinity conditions (Figures A-24 through A-26).

- During the daily salinity measurement made in September 2010, data indicate some variability in salinity concentrations along the Skagit Bay Front area with salinities increasing from east to west:
  - Dry Slough Salinities 5 ppt to 7 ppt
  - No-Name/Claude O. Davis salinities 8 ppt to 11 ppt
  - Brown Slough 15 ppt to 25 ppt

Interior drainage channels ranged in extents of brackish water from several hundred feet along Dry and Claude O. Davis Sloughs to observed brackish water above 5.0 ppt several thousand feet upstream in No-Name Slough. The No-Name interior drainage channel is

a dredged, and deep system that may allow more direct connection of groundwater through penetration of the deeper underlying fine sand soil layer.

Surface water monitoring of salinity across the Bay dikes were similar for Dry and Claude O. Davis Sloughs. Interior salinities were measured to be fairly constant and ranging between 7.0 and 12.0 ppt for Claude O. Davis Slough. For Dry Slough, salinities were fairly constant between 5.0 and 7.0 ppt until, during the November 2010 snow storm event, salinities bumped up to 15.0 ppt. Brackish saltwater conditions appear to extend along the interior drainage channels several hundred to several thousand feet, in which these channels areas are currently bordered by productive farmland, thereby indicating that crops can grow with existing brackish salt water conditions in the drainage channels.

Groundwater monitoring of salinity was performed during geoprobe explorations with the intent of measuring salinity at various depths in the wells to characterize saltwater intrusion characteristics. Results of the salinity monitoring in the groundwater wells indicate that near the ground surface, groundwater salinities were low and less than 5 ppt and higher salinities were observed at 15 ppt at depths of 25 feet (approximately elevation -20.0 feet) below grade. This result indicates near-surface groundwater will not likely affect farm crop production. Further north near the levee setback, farm ground surfaces are at higher elevations and the likelihood of salt water intrusion effects are further reduced.

#### 2.5.1.4 Other Water Quality Data

Water quality is an important consideration for habitat restoration. Other water quality parameters of concern include temperature, pH, fecal coliforms, dissolved oxygen, and nutrients that will influence the success of the project. Currently, these water quality data parameters were not collected in the feasibility study. It was noted during site observations that large algal blooms (mats) developed on the interior drainages of Fir Island Farm. Also, data loggers had strong smell of urine and manure when pulled and dried. It is likely that surface water and groundwater runoff contain animal waste and nutrients. The existing and proposed volume of tidal exchange and mixing on the site is significantly large compared to the interior drainage inflows, and will completely dilute poor quality interior drainage runoff. This would only be an issue at very low tides when water in the tidal channels is primarily interior drainage water flowing out through the tidegates. Continued efforts on Fir Island to improve water quality will enhance the tidal marsh restoration project.

### 2.5.2 Interior Drainage Hydrologic and Hydraulic Runoff Modeling

Setting back the dike will change the interior drainage system configuration by reducing the total drainage channel length and storage volumes in the system. Hydrologic runoff and routing, and hydraulic open channel flow models were developed and calibrated using baseline surface water elevation data described in the previous report section. The calibrated models were then used to evaluate the preferred restoration plan and changes to the interior drainage system. These calibrated models were then used to evaluate the preferred alternative interior drainage effects and to develop and size interior drainage storage facilities (i.e., storage ponds and tidegate structures) to mitigate the effects and losses in drainage storage resulting from setting back the dike (as described in later sections of the report). The following is a summary description of the hydrologic and hydraulic model development and calibration for the baseline conditions.

#### 2.5.2.1 Hydrologic Runoff, HEC-HMS Model

A hydrologic runoff, HEC-HMS (U.S. Army Corps of Engineers [USACE], 2010a) model was developed for the project interior drainage areas leading to Dry, No-Name/Claude O. Davis, and Brown Slough. The hydrologic runoff model has the capability of predicting unsteady hydrograph runoff flow rates, peaks, and durations for a range of precipitation design storm events. The application of the HEC-HMS model is used in this instance to determine precipitation surface runoff hydrographs and discharges from farm area drainages along ungauged systems. Details of the modeling setup, drainage areas, precipitation, soils, impervious surface areas, loss configuration, transformations, and model calibration and results are included in Appendix B, Technical Memorandum 1.2.1 and 1.2.1b. The hydrologic runoff model was calibrated to the October 2010 rainfall runoff event. The results of the hydrologic runoff estimates were routed through the HEC-RAS model to predict and compare with observed water surface elevations.

#### 2.5.2.2 Hydraulic Open Channel Flow, HEC-RAS Model

A HEC-RAS (USACE, 2010b) model was developed for the project interior drainage areas of Dry and No-Name/Claude O. Davis Sloughs. These model areas will be affected by the proposed project alternatives considering levee setback alternatives and changes to interior drainage areas. Details of the modeling setup including channel and floodplain geometry and data sources, drainage structures, Manning's roughness, model boundary conditions, inflow rates, and tidegate operation rule curves are included in Appendix B, Technical Memorandum 1.2.1 and 1.2.1b. The hydraulic model was used in combination with

the hydrologic runoff model to calibrate precipitation runoff to observed drainage channel water surface elevations and known downstream tidegate conditions. The hydrologic runoff and hydraulic model calibration matches the observed water surface elevations within ±0.3 feet for the No-Name Slough surface water monitoring station located just upstream of Fir Island Road (Figure A-27).

Results of the hydrologic and hydraulic model calibration indicate that a significant portion of stormwater runoff is discharged to the interior drainage channels as steady state groundwater baseflows. For the No-Name/Claude O. Davis Slough system, the 25-year, 24-hour precipitation event translates into a baseflow is 7.6 cfs with a combined groundwater and surface water hydrograph peak flow of 11.0cfs using the calibrated models. For Dry Slough, the 25-year storm baseflow is 7.8 cfs with a combined groundwater and surface water hydrograph peak flow of 11.5 cfs. These flow rates are substantially lower than other published flow rates, in particular for Dry Slough tidegate replacement studies (M&N, 2008).

The calibrated hydrologic and hydraulic models were used to evaluate the effects of the preferred restoration plan and dike setback and to size the interior drainage storage mitigation structure, as described later in the report.

## 2.6 Agriculture

The restoration project will remove active farm acreage from production and restore the reclaimed land to tidal marsh conditions. To understand the change in land use and the potential project effects, a baseline study of existing agriculture land use conditions is provided.

### 2.6.1 History of Skagit Delta Agriculture

The Skagit River originates in the North Cascades Range and descends from the mountains to the foothills, and then to a broad floodplain and delta in the Puget Sound lowlands. On the delta, downstream about 10 miles before the river's mouth, the river splits into two major distributaries, the North Fork and South Fork. The river has built an extensive delta bounded on the north by Padilla Bay, on the south by Skagit Bay, and to the west by Fidalgo Island and the Swinomish Slough. The smaller Samish River flows on the northern part of the greater Skagit River delta. Today, when talking about this area, the Skagit and Samish delta areas are most often collectively referred to as the "Skagit Delta."

The Skagit River provides 30 percent of all fresh water that flows into Puget Sound and it is the most important salmon-producing basin within Puget Sound in terms of abundance,

population diversity, and types of habitat. Native peoples inhabited nearly all of the Skagit basin and delta, and have long taken advantage of this bountiful area. Euro-American settlement of the Skagit River basin began in the 1860s. Those who came to farm the Delta found some of the most fertile soils in the world. The challenge was to wrest control of the Delta area from the river and sea. The rich soils, flat topography, and moderate climate of the Delta provide some of the most optimal farming conditions in the world.

Over several decades, a complex system of dikes and drainage infrastructure was developed to make the lower river delta lands suitable for farming. By the turn of the century, the lower Skagit River and Samish River Delta areas had an extensive network of dikes, levees, tidegates, and drainage ditches to protect these new agricultural lands from flooding and tidal inundation. By the 1960s, the Delta's complete flood protection and drainage infrastructure was in place, essentially as it exists presently. The Delta is often referred to as "the Agricultural Heartland of Western Washington," and is known worldwide for its agricultural productivity. Today, the agricultural landscape prevails on the delta, encompassing approximately 70,000 acres.

### 2.6.2 Skagit Delta's Agricultural Economy

Skagit Valley farmers raise more than 80 different high-value crops generating about $200 million annually for the local economy. The value of Skagit County's agriculture extends beyond the direct economic benefits. From every dollar of revenue generated, there is a $.51 cost in public services. Agriculture in the Skagit Delta is still dominated by small family farms, many of which are third- or fourth-generation landowners. There are at least 5,650 people engauged in employment generated by the local agricultural industry. There are three major agriculture supply dealers in Skagit County.

Crops grown in the Skagit Delta include cauliflower and broccoli, which are primarily grown for the fresh market in Washington, Oregon and British Columbia. Other crops for the fresh market such as potatoes (reds, whites, yellows and some russets) from the Skagit Delta are also in demand for their high quality. The Skagit Delta area is a major producer of cabbage, kale, table beet, Brussels sprout, and spinach seed. There are seven vegetable seed companies in the county most of which market worldwide. About half of the world's supply of beet and Brussels sprout seed is grown on the delta. More tulips, daffodils, and iris bulbs are produced in Skagit County than in any other county in the United States. Additionally, about 50 million cut flowers are grown in greenhouses and fields on the Skagit delta. Organic acreage in Skagit County is on the increase. Skagit County also ranks third in dairy production in the state.

Skagit farmers have shown a great resiliency as market conditions change, to be able to modify cropping patterns and products grown to continue to be economically viable. In the 1960s and 1970s vegetable and fruit crops for freezing and canning were the dominant productions crops. These included green peas, cauliflower, broccoli, sweet corn, carrots, strawberries, raspberries, and blueberries.

Historic vegetable and fruit processing operations moved to the Columbia Basin and other locations as many consolidations were taking place. Local Skagit Delta farmers were forced to find alternative crops. The fresh market potato business became a primary economic crop. The fresh market and on-farm processed berry production also became a major crop for the Skagit Delta. Today, crop rotation patterns would likely include potatoes every one in four years, wheat in one or two years of the four-year rotation, and some type of vegetable seed production in one of the four years. Other crop rotation options include corn for silage, grass for forage, flower bulb production, strawberries, cucumbers for pickles, and nursery production. Each individual farm operation adjusts the rotational crops to their own equipment availability and/or access to special markets such as pickle production.

Individual crops require special rotational strategies that interrupt the disease and pest cycles that could affect the production of each type of crop. Potatoes, for example, require a four-year rotation (15,000 acres annually require 60,000 acres to be available). Vegetable seed production requires an 8- to 12-year rotation depending on species. Thus 5,000 acres of active potato production would require 40,000 to 50,000 acres to maintain a good rotation.

Though several major food processors have left the area in recent years, two major companies and several smaller on-farm operations continue to secure and process raw products from Skagit Delta growers. Major crops grown for freezing are raspberries, strawberries, and blueberries. Cucumbers for pickling are regaining prominent role. These crops are noted for their superior quality.

### 2.6.3 The Skagit Delta's Agricultural Infrastructure

Levees, dikes, tidegates, and drainage ditches have protected over 70,000 acres in the Skagit Delta floodplain since the 1860s. As the early settlers discovered over 100 years ago, the Skagit delta soils require drainage to be farmed. These levees, dikes and associated tidegates prevent flooding and provide necessary drainage for agricultural use. Much of the historic estuarine habitat of the Skagit Delta is currently developed for farming and has dike and drainage infrastructure. Today, the lower delta floodplain is characterized by a vast agricultural landscape

surrounded by about 147 miles of levees and dikes, with nearly 380 miles of drainage ditches and approximately 130 tide and flood gates.

The dikes (levees) were originally constructed with the use of shovels and slip-scrapers along the South and North Forks of the Skagit River and its main stem as well as along the eastern edge of Skagit Bay. Embedded in the dikes are tidegates (the outlet valves of the drainage infrastructure). The dikes and associated tidegates prevent flooding and facilitate drainage necessary for agriculture and other uses. Tidegates are one-way check valves embedded in the dikes. They provide three major functions:

1. Tidegates prevent saltwater intrusion, which is necessary because salt kills crops and fresh water in drainage systems may be used for irrigation (SCS, 1961);
2. Tidegates maximize drainage potential by keeping the water table low to reduce soil saturation allowing an earlier start in the spring; and
3. Tidegates create a reservoir between tides in which interior drainage water can be stored for release through the tidegate during the next low tide.

Early settlers realized the absolute necessity to provide both surface and subsurface drainage in order to grow crops. Lands in the delta were cleared, diked, drained, leached, and farmed in that order. Early drainage technology was simple and consisted of open drainage ditches on the farm with larger drainage district ditches that led to tidegate outlets. It was common to take advantage of the swales, sloughs, and old channels to route drainage water. When dikes and levees were first built, the land could not be used for crops for about two to three years due to salinity effects. The early crops first grown on the Delta consisted of oats and barley that were relatively salt tolerant. Today, many of the crops grown in the Skagit Valley are two to three times more salinity sensitive than similar crops from other regions.

As time progressed, technology replaced the horse with the tractor, and some tidegates with pump stations or better tidegates, and drainage improvements allowed the land to support a larger variety of crops. Throughout the 1950s, 1960s, and 1970s, new drainage technology and active agronomic research made Skagit County a world leader in the production of several vegetable seed crops, and flower bulbs, as well as other crops. By the late 1970s, Skagit farmers were actively installing thousands of feet of subsurface patterned drainage systems rather than the old random systems in low spots in the fields. All of these new systems required an adequate drainage outlet provided by a drainage district.

Today, there is a dedicated group of small individual public dike, drainage, and irrigation districts actively coordinating and working with county, state, and federal agencies to maintain these critical flood, drainage and irrigation structures. On-farm drainage supported by a well-maintained drainage infrastructure is important for continued successful farming in the Delta.

### 2.6.4 Current Fir Island Farm Cropping

In the 1980s, the Von Moos property was purchased by WDFW to be used as a primary focal point for providing winter protection and forage areas for a declining Snow Goose population. The land was to be managed for this purpose and, to that end, has been continuously farmed and managed with annual cropping rotations that allow the property to be planted in the fall with crops that provide winter Snow Goose forage .

An agreement was formed with the adjoining landowner\farmer (Haytons) to farm WDFW's land with annual cropping patterns in exchange for planting and maintaining the Snow Goose forage crops in the winter months.

Due to the necessity to plant winter Snow Goose forage, the adjoining landowner/farmer is not able to plant commercial crops that overwinter such as wheat, grass for dairy feed, and fall-planted seed crops such as cabbage and kale. In addition, the adjoining landowner/farmer is not able to plant permanent crops such as berries and nursery production. As such, the adjoining landowner/farmer is not able to implement what may be considered a "normal" crop rotation.

These cropping selection and rotation limitations require the farmer to only plant summer annual crops that can be planted in the spring and harvested, for the most part, in time to plant and establish the Snow Goose forage crops that will be utilized in winter. The common available crops that can be planted under this scenario currently include spring-planted vegetable seed crops such as spinach, red beets, and radish or annual summer crops such as potatoes and broccoli. Late-harvested crops are problematic since they do not allow time to establish adequate forage crops to meet the contract obligations with WDFW.

The land located within WDFW's Fir Island Farm is highly productive and capable of growing virtually any of the crops typically grown in the Western maritime climate and the Skagit and Samish deltas. The only farming limitations are the contractual requirements to produce winter Snow Goose forage. The farming agreement between WDFW and the adjoining landowner\ farmer to farm WDFW's Fir Island Farm is perceived as a favorable agreement within the agriculture community because it keeps the land in useful agricultural production

while still providing a waterfowl benefit. This is the type of collaboration that will help to maintain viable long-term agriculture in the Skagit Delta.

## 2.7 Wetlands and Vegetation

A baseline wetland reconnaissance and vegetation assessment was performed for the restoration project site. A wetland reconnaissance was completed to approximate the extent of existing wetlands located on and adjacent to the project site. Additionally, a vegetation assessment was performed to assess existing Bay Front areas, and review other related literature and data sources, to assess the likelihood of establishment of similar vegetative species for the restored condition. (Appendix B, Technical Memorandum 1.6).

### 2.7.1 Wetland Reconnaissance

A reconnaissance of the site was completed to identify potential wetlands and approximate their extent and classification. Wetlands were identified using the triple-parameter approach, which considers vegetation types, soil conditions, and hydrologic conditions, as described within the USACE and Washington Department of Ecology (Ecology) wetland delineation manuals (USACE, 1987 and 2010c, Ecology, 1997).

Five data plots (two upland and three wetland) were recorded within identified potential wetland and upland plant community types to characterize existing conditions at the site. Information on vegetation, soils, and hydrology was collected at each data plot. These data plots were located in areas that exhibited conditions similar to other site wetlands (i.e., drainage patterns and hydrophytic vegetation). Using the information compiled from the on-site wetland reconnaissance, the extent and type of wetlands on and immediately adjacent to the site were approximated using aerial photography, LiDAR imagery, and salinity measurements made at the site. Potential wetlands were characterized using the Cowardin classification system (Figure A-28).

Using the Cowardin classification system, there are three general types of wetlands on and immediately adjacent to the site: estuarine, palustrine, and farmed potential wetlands. The reconnaissance characterization of these wetlands is described herein.

#### 2.7.1.1 Estuarine Wetlands

Estuarine wetlands are predominantly located south and southwest, bay-ward of the dike and within the Brown’s Slough complex. The estuarine wetland system is comprised of

estuarine intertidal emergent (E2EM), estuarine intertidal unconsolidated shore (E2US), and estuarine subtidal unconsolidated shore (E1US) Cowardin classifications. Based on salinity measurements, estuarine conditions also exist upstream of the tidegates along the interior drainage channels and upstream into No-Name Slough. No-Name Slough has an estuarine intertidal unconsolidated shore (E2US) wetland system that drains the surrounding cultivated fields and uplands.

Vegetation identified within these estuarine wetland communities is dominated by Lyngbye's sedge (*Carex lyngbyei*, OBL), creeping bentgrass (*Agrostis stolonifera*, FACW), narrow leaf cattail (*Typha angustifolia*, OBL), Pacific silverweed (*Argentina egedii*, NI), saltmarsh bulrush (*Schoenoplectus maritimus*, OBL), and baltic rush (*Juncus balticus*, FACW+). The interior drainage does not appear to support a vegetated community (as it may be actively farmed/mowed) except for a minor community along its banks comprised of herbaceous species, including reed canarygrass (*Phalaris arundinacea*, FACW).

Surficial soils catalogued on the site include tidal hydraquents, Skagit silt loam, and Sumas silt loam (NRCS, 2010). Soils observed within the estuarine wetlands include a depleted dark gray silt clay loam matrix within the upper 9 inches exhibiting dark brown concentrations and oxidized root pores. Below this, soils were a very dark greenish gray silt clay loam lacking redoximorphic features. Based on these characteristics, these wetlands appear to satisfy the depleted matrix (F3) hydric soil indicator (NRCS, 2010).

Hydrology present in these estuarine wetlands varies based on the elevation of the wetland and its resulting level and period of tidal inundation. Subtidal wetlands were inundated and the intertidal wetlands were saturated to the surface during field reconnaissance work.

#### 2.7.1.2 Palustrine Wetlands

Dry Slough and Claude O. Davis Slough have developed wetland systems comprised of palustrine scrub-shrub (PSS), palustrine emergent (PEM), and palustrine unconsolidated bottom (PUB) Cowardin classifications.

Vegetation within these palustrine wetland communities is largely dominated by common cattail (Typha latifolia, OBL), saltweed (*Atriplex patula*, FACW), nootka rose (*Rosa nutkana*, FAC), and reed canarygrass (*Phalaris arundinacea*, FACW). Other species identified within Claude O. Davis slough includes willow species (*Salix spp.*), hardstem bulrush (*Schoenoplectus acutus, OBL*), American vetch (*Vicia americana, FAC*), and Himalayan blackberry (*Rubus armeniacus*, FACU) amongst others.

Soils observed in these wetland systems were observed at two data plot locations located near the approximate wetland/upland interface and within the centerline of Claude O. Davis Slough. In the middle of Claude O. Davis Slough, soils were characterized by black, highly organic soils lacking redoximorphic features. Soils were likely muck, although tests for percent organic material were not performed. Near the wetland edge, soils exhibited a depleted dark gray, silt loam matrix with dark brown concentrations and oxidized root pores within the upper 10 inches. Below this upper layer, a middle layer of depleted dark gray sand with dark brown concentrations and oxidized root pores extended down to a depth of 15 inches. Below 15 inches, soils were comprised of very dark gray sand with dark brown concentrations and oxidized root pores. Based on the soil characteristics observed, soils within the center of Claude O. Davis Slough likely satisfied the presence of a histisol (A1) hydric soil indicator while those soils near the slough's edge satisfied the depleted matrix (F3) hydric soil indicator.

Hydrology observed included inundation of brackish surface water and saturated soils to the surface with ponding present in the middle of Claude O. Davis Slough.

#### 2.7.1.3 Potential Farm Wetlands

Wetlands may be present in parts of the cultivated farm fields, although this determination could not be verified during our wetland reconnaissance. At the time of the site reconnaissance, the farm fields had been recently plowed and vegetation had been disturbed throughout most of the site.

An undisturbed location within the cultivated farm fields was characterized in Data Plot 2. The undisturbed pocket within the cultivated fields satisfied both the hydric soils and hydrophytic vegetation criteria. Data Plot 5 was located within the cultivated fields and this portion of the cultivated field satisfied the hydric soils criteria.

For the purposes of this wetland reconnaissance, the location and extent of farmed potential wetlands were estimated based upon aerial photograph interpolation. Areas that appeared to have ponding or surface saturation were identified as farmed potential wetlands. These areas are subject to change depending upon hydrologic conditions present in the early growing season.

### 2.7.2 Vegetation Characterization

Vegetation species identified in the wetland data plots were compared with the 24 species identified within the Skagit Delta Vegetation Monitoring Data (Hood, 2009). Of the

24 monitoring species, five species and mud-line were present at the Fir Island Farm site. These similar species include Lyngbye's sedge (*Carex lyngbyei*, OBL), narrow leaf cattail (*Typha angustifolia*, OBL), saltmarsh bulrush (*Schoenoplectus maritimus* [formerly *Scirpus maritimus*], OBL), creeping bentgrass (*Agrostis stolonifera* [formerly *Agrostis alba*], FACW), and Pacific silverweed (*Argentina egedii* [formerly *Potentilla pacifica*], NI). These on-site populations for each of these five species largely fell within the typical elevation ranges identified on the reference data graph.

Given the close correlation observed between the on-site vegetation and the Skagit Delta Monitoring Data, the data can be used as a tool for predicting vegetation composition for the restored Fir Island Farm site. Vegetation predictions were used in alternatives analysis phase of work to understand what types of vegetation would likely occupy the certain elevations, which were important considerations in evaluating restored fish habitat, as well as Snow Goose foraging in native marsh areas. Later in the report, wetland impacts and effects are discussed. The vegetation characterization and predictive tool were use to outline potential areas where homogeneous cat-tail (*Typha angustifolia*) stands could become established and noted for future vegetation management monitoring and actions.

## 2.8 Fisheries

Though the Delta has been the focus of a significant body of fisheries related study, limited sampling and research has been specifically focused in the tidal blind channels, tidal estuarine habitats, and upland drainages adjacent to and within WDFW's Fir Island Farm. This baseline memorandum will provide highlights from the larger body of fisheries studies in the Skagit River Delta and summarize the fisheries studies, given the context of WDFW's Fir Island Farm Restoration Feasibility Study site.

### 2.8.1 Skagit River Estuary – General

#### 2.8.1.1 Fish Species

A variety of fish species and life stages are present in the central Fir Island region of the Skagit River Delta. Fish sampling in Brown Slough (1995 - 2003) and Dry Slough (2008) have captured juvenile Chinook salmon, juvenile Chum salmon, juvenile Coho salmon, juvenile Pink salmon, juvenile Sockeye salmon, juvenile Steelhead trout, Cutthroat trout, Bull trout, Surf smelt, Starry Flounder, Staghorn Sculpin, Three-spine Stickleback, Prickly Sculpin, Shiner Perch, and Peamouth Chub (Beamer and others, 1998, Beamer unpublished data 1995 - 2003; Skagit Fisheries Enhancement Group, 2008).

#### 2.8.1.2 Fish-related Estuarine Habitat Functions

The Puget Sound is a large estuary complex that contains several large river estuaries including the Skagit River (Redmond and others, 2005). Estuaries are defined as the mixing zone of freshwater from river outflows and the saltwater from the ocean, and are typically found within partly enclosed tidal inlets including sheltered bays, inlets, lagoons, and river Deltas (Little, 2000). Estuaries are among the most biologically productive and diverse ecosystems on Earth, and provide rich nursery habitats for salmon and other species.

The Delta can be delineated into two major areas: the freshwater tidal Delta and the estuary (Beamer and others, 2005). The estuary includes the lower freshwater areas of the Skagit River Delta where saltwater mixes with freshwater, Skagit Bay, Swinomish Channel, and Padilla Bay (Beamer and others, 2007). The upper end of the estuary is situated within the lower regions of the North and South Fork Skagit, and extends several miles upstream during summer and fall low-flow conditions, but shifts outward into Skagit Bay during higher river flows conditions (Yang and Khangaonkar 2006; 2009).

WDFW's Fir Island Farm is located adjacent to Skagit Bay between the north and south forks of the Skagit River in the estuary area of the Skagit Delta. The front of Skagit Bay where the Fir Island Farm is located is one of the only remaining areas in the Skagit Delta where the freshwater-saltwater mixing that defines estuary habitats is sustained throughout the year. The results of hydrodynamic modeling completed for the Skagit Delta (Yang and Khangaonkar 2006) indicate that most of the areas in the north and south fork are dominated by freshwater during high-flow periods of the year, when a freshwater plume extends from the north and south forks into Skagit Bay.

Skagit River estuarine habitats provide the following four main interrelated functions for juvenile salmon: physiological transition from freshwater to saltwater, foraging and growth, predator avoidance, and migratory corridors (Simenstad and others, 1982; Beamer and others, 2005).

#### 2.8.1.3 Physiological Transition

For anadromous fish species, the mixing zone of fresh and salt water of the estuary is critical for the successful physiological transition of juvenile and adult life stages between freshwater and saltwater habitats. Anadromous fish species of the Skagit River that migrate through the Skagit Delta and estuary include Chinook salmon, chum salmon, coho salmon, pink salmon, sockeye salmon, steelhead trout, cutthroat trout, and bull trout. The

species that are most dependent upon the estuary are Chinook salmon, chum salmon, pink salmon (Healy, 1991; Quinn, 2005).

#### 2.8.1.4 Foraging and Growth

The Skagit River estuary produces a significant amount of plant material called detritus that is a major source of food supply for small invertebrates that are in turn a primary prey of juvenile salmonids and forage fish species. This estuarine detritus also provides the primary base for the nearshore marine food web (Smith and others, 2005).

Certain prey items appear to be selectively chosen over others depending on the salmonid life history stage. For example, juvenile chum salmon feed on a certain type of copepod that lives on the bacteria near decaying eelgrass (Simenstad and others,1982), while prey items for small Chinook juveniles includes midges, crab larvae, flies, water fleas, and other insects and crustaceans (Healey, 1991). The intertidal, shallow sub-tidal, blind channel, and distributary channel habitats in the estuary provide juvenile salmonids with access corridors to estuary habitats producing preferred prey species (Shreffler and Thom, 1993). In addition, the interaction of tides and inundation of channel habitats provides a delivery system that transports preferred prey species from estuary habitats that are otherwise not accessible by juvenile salmonids (Smith and others, 2005).

On average, a Skagit ocean-type juvenile Chinook salmon will rear in the estuary approximately 35 days (Beamer and others, 2005). The results of an ongoing otolith (fish inner ear organ) study links juvenile Chinook salmon survival potential in Skagit Bay to rearing time in the Skagit tidal Delta (Beamer, E., pers. comm., SRSC, 2010). The growth rates of juvenile Chinook were found to be greater in estuary areas of the Skagit compared to freshwater habitats (Beamer and Larsen, 2004). The increased rearing time and faster growth rates in the estuary produces larger juvenile Chinook salmon entering Skagit Bay compared to Chinook life history types that do not have an extended rearing period (i.e., fry outmigrants), or do not rear in the high productivity habitats found in the estuary. Juvenile Chinook growth rates were found to be dependent upon diet composition and food availability in the nearshore and estuary areas of the Puget Sound, with juvenile growth rates highest in areas where insects, gammarid amphipods, decapods (crab larvae), and forage fish are abundant (Duffy and others, 2010).

The marine survival for larger juvenile Chinook salmon entering Skagit Bay was assumed to be greater than the survival for smaller juveniles, with Delta tidal rearing juveniles having an average smolt-to-adult survival rate of 0.5 percent (Beamer and others, 2005). The

marine survival rates of juvenile Chinook salmon in the Puget Sound significantly increased as a function of outmigrant size (Duffy and others, 2005). Survival to adult has been shown to be much lower for non-estuary rearing Chinook (Reimers, 1973; Levings and others, 1989). A population and life history model completed for Skagit Chinook found that estuary residency of outmigrating smolts results in higher ocean survival rates, thus improving adult return rates (Greene and Beechie, 2004). The availability of food resources is considered to be the primary factor limiting the density and growth rates of juvenile Chinook in the Skagit Delta (Greene and Beamer, 2005).

#### 2.8.1.5 Predator Avoidance

Intertidal and shallow subtidal habitats provide juvenile salmonids protection and refuge from bird and fish predators, while blind channel and side-channel estuary habitats serve as refuge from high water river discharge events.

Growth and survival are interrelated. Growth rate can affect survival as a result of how rapidly the fish can “outgrow” portions of their predator population (Beamer and others, 2005). Parker (1971) showed that smaller fish in juvenile salmon populations were eaten at a higher rate than larger fish. Juvenile salmon are generally distributed based upon water depth, with the depth of the water occupied by the fish increasing as the size of the fish increases (McCabe and others, 1986).

Declines in available prey in the estuary have been shown to result in small juvenile salmonids migrating more quickly to other areas in search of prey (Simenstad and others, 1980). The expenditure of extra energy for this migration is thought to slow growth and lead to an increased risk of predation (Smith and others, 2005).

#### 2.8.1.6 Juvenile Salmon Migration

Juvenile salmon use of estuarine habitats varies by species and by the different life history types within a species. Life history variation is important to buffer populations against changes in survival at different life stages that may result from natural or human caused catastrophes (e.g., drought, flood, volcanic eruptions, tsunamis, oil spills) (Beamer and others, 2005).

Ocean type juvenile Chinook salmon migrate to the marine environment within a few days to a few months after emerging as fry from fresh water incubation (Healy 1991). Residency of ocean type juvenile Chinook salmon in the lower riverine and estuary

environments ranges from 6 to 189 days (Simenstad and others, 1982). Beamer and Henderson (1994) documented the presence of ocean-type Chinook within the lower Skagit River between February and June. Stream type juvenile Chinook salmon, which spend at least a year in freshwater before migrating to the estuary, move directly into the offshore marine habitats without extended utilization of estuary or near-shore habitats (Simenstad and others, 1982). WDFW Skagit River Mount Vernon smolt trap data from 1998 and 2009 show that the 30-day window with the highest percent of sub-yearling Chinook salmon migrants is March 3 and April 1 (Zimmerman, 2010). The overall average peak of juvenile Chinook salmon in the tidal Delta (downstream from the fish trap and later) occurs throughout April (Eric Beamer, 2010).

Juvenile coho salmon typically spend a full year or more rearing in freshwater prior to outmigrating to the marine environment. Individual residency of yearling coho in the estuary can range from 4 to 32 days (Simenstad and others, 1982). Beamer and Henderson (1994) documented the presence of yearling coho within the lower Skagit River between February and June.

Juvenile chum salmon migrate to the lower river and estuary soon after emerging from freshwater incubation. Individual residency of juvenile chum in the estuary can range from 6 to 40 days (Simenstad and others, 1982). Beamer and Henderson (1994) documented the presence of yearling coho within the lower Skagit River between February and June.

Juvenile pink salmon migrate to the lower river and estuary soon after emerging from freshwater incubation. Pinks do not appear to be dependent upon estuarine habitats except as a zone of intermediate salinity that allows acclimatization to marine waters (Healy, 1992). Beamer and Henderson (1994) documented the presence of juvenile pinks within the lower Skagit River between February and April.

Juvenile sockeye salmon spend a full year or more rearing in freshwater prior to outmigrating to the marine environment. Juvenile sockeye do not appear to be dependent upon estuarine habitats except as a zone of intermediate salinity that allows acclimatization to marine waters (Healy, 1992). Beamer and Henderson (1994) have only documented a single yearling sockeye in the Skagit estuary and that was in February.

In summary, nearly all species of salmon use the Delta estuarine habitats with a majority of migration occurring in the February through June period.

#### 2.8.1.7 Habitat Type and Connectivity

Major habitat types found in the Skagit estuary include Delta mudflats, lagoon pocket estuaries, nearshore beaches, the offshore areas of Skagit Bay, and the vegetated Delta. These areas can be further separated into blind channels, distributary channels, shallow intertidal habitats, subtidal fringe habitats, and surface waters (Beamer and others, 2007). These habitat areas provide a wide variety of geomorphic, substrate, current, salinity, temperature, food resource, and vegetation conditions that support a diversity of fish including salmonids (salmon, cutthroat trout, and bull trout), small pelagic fishes (including Pacific herring, Pacific sand lance, and surf smelt), sculpins, flatfish, and other species such as three-spine sticklebacks and gunnels (Beamer and others, 2007).

Of these habitat types, vegetated blind channels situated along Skagit Bay and Padilla Bay were found to support the highest densities of juvenile Chinook salmon, with densities exceeding 15,000 fish per hectare (1.5 fish per square meter) in vegetated blind channels along Skagit Bay. Vegetated distributary channels situated in the lower North and South Forks of the Skagit River, and along the Swinomish Channel, had the second highest use by juvenile Chinook among estuary habitat types, with juvenile Chinook densities exceeding 7,000 fish per hectare (0.7 fish per square meter) in the shallow vegetated distributary channels of the lower north and south fork Skagit River.

In comparison, non-vegetated intertidal flats and the subtidal fringe areas of nearshore beaches had much lower densities of juvenile Chinook, with densities within the intertidal flats of Skagit Bay exceeding 700 fish per hectare (0.07 fish per meter), and densities within the subtidal fringe areas of nearshore beaches exceeding 300 fish per hectare (0.03 fish per square meter) (Beamer and others, 2007). Densities of juvenile Chinook at sites in the freshwater tidal areas of the Skagit Delta were found to exceed 10,000 fish per hectare (1.0 fish per square meter) during the spring smolt outmigration period (Beamer and others, 2005), which is lower than densities observed in estuary blind-slough habitats, but similar to densities observed in shallow vegetated distributary habitats of the lower Skagit Delta.

Substantially lower densities of juvenile Chinook (approximately 3,000 to 5,400 fish per hectare) were measured at estuary and freshwater sites where tidal and riverine processes are constrained by dikes and tidegates, including in Brown and Dry Sloughs (situated within Fir Island Farm project areas), Deepwater Slough, and Fisher Slough (South Fork Skagit) (Beamer and others, 2005; Beamer and others, 2010). Monitoring studies of the Deepwater Slough restoration project found that juvenile Chinook re-colonized restored habitats the first year

following construction, and that densities increased to over 10,000 fish per hectare (1.0 fish per square meter) three years following restoration (Beamer and others, 2006). The results of the Deepwater Slough study are promising, as they indicate that restoration projects that restore natural tidal and channel processes to impaired habitats within the Skagit Delta can result in rapid improvements in juvenile Chinook numbers.

The function of any given habitat depends on its spatial position in the landscape and its relationship to and connectivity with other habitats. Congleton and others (1981) showed that juvenile salmon abundance is not homogeneous across the Skagit River estuary. Beamer and others (2005) showed that habitat connectivity in the Skagit River estuary influences juvenile salmon abundance in many freshwater tidal and estuarine habitats. Habitat connectivity may describe how well the migratory pathways are connected for fish moving between freshwater and estuarine rearing areas. (Beamer and others, 2001).

Beamer and others (2005) defined landscape scale connectivity as the relative distances and pathways that salmon must travel to find habitat. He also considered habitat connectivity at the local scale which he described as the availability of tidal channel habitats to juvenile salmon in relation to the tidally influenced water depths in the channels. The shallow estuarine tidal channels serve as migration corridors for juvenile salmonids, while deeper water distributary channels provide migration corridors for adults (Shreffler and Thom, 1993). Distributary channels provide critical migration and movement routes between habitats.

All of the historic distributary channels across Fir Island have been disconnected from the Skagit River through post-settlement dike construction. Consequently, the historic migratory pathways for anadromous fish species across Fir Island to the central Fir Island Delta have been disconnected and the migratory pathway to the central Fir Island Delta for juvenile salmon out-migrating the Skagit River is now longer, more difficult with less connectivity. Nevertheless, migration modeling suggests that a large number of juvenile Chinook salmon moving through the complex distributary network of South Fork Skagit River will head northward along the front of Skagit Bay towards Deception Pass (Beamer and others, 2005). By improving local connectivity to Skagit Bay, and given the proximity of the project to large numbers of fish migrating out of the South Fork Skagit along the Bay Front, the Fir Island Farm restoration project has potential to significantly improve the estuary rearing capacity of juvenile Chinook in the Delta.

#### 2.8.1.8 Tidegates

The historic distributary channels across Fir Island have also been disconnected from Skagit Bay through the installation of top hinge tidegates. The low-lying land in the Skagit Delta requires tidegates and floodgates to provide adequate drainage. Tidegates are one-way check valves at the end of the drainage system that allow drainage water to flow to a marine water body during a low tide cycle and then close to prevent saltwater from entering a drainage system when the tide rises (Skagit Delta Tidegates and Fish Initiative Implementation Agreement, 2008). The primary point of access for fish between the Skagit Delta and the historic distributary channels is at those intersections where the gravity flow drainage is managed by a culvert fitted with some sort of tide regulating feature. Though tidegates do not completely block the upstream passage of fish, upstream passage is restricted to very narrow windows of the tide cycles during which the tidegate is open and the discharge velocity does not exceed the upstream swimming capabilities of the fish. The window for upstream passage is longer for larger fish than smaller fish because of their stronger swimming capabilities. The downstream passage of fish through a tidegate is also limited to low tide cycles when the water surface elevation upstream of the tidegate is sufficiently greater than the water surface elevation downstream of the tidegate to create the head differential necessary to open the tidegate (Drainage Maintenance Plan for Skagit County CDD#22, September 2005). Fish sampling in the vicinity of the tidegates in Wiley Slough and Dry Slough has resulted in very few juvenile salmonids captured upstream of the tidegates.

#### 2.8.1.9 Habitat Quality

Different fish species and different life stages of a fish species can have different tolerances to water quality parameters. The water temperature, salinity, dissolved oxygen, and turbidity characteristics of an estuarine channel or drainage watercourse influence what species will be present, when and for how long they will be present.

After reviewing a number of Fir Island drainage watercourses upstream of tidegate structures during the Skagit Drainage and Fish Initiative planning process, WDFW staff in consultation with Skagit River System Cooperative staff, generally concluded that juvenile salmon rearing in the Skagit estuary could possibly immigrate into the lower reaches of tidegate watercourses to forage on available prey. However, it was also generally concluded that the upstream distribution and duration of residence for these immigrating fish is limited by degraded water quality.

### 2.8.2 Washington Department of Fish and Wildlife's (WDFW's) Fir Island Farm Study Area

The Fir Island Farm Restoration Feasibility Study encompasses all of the estuarine and freshwater watercourses bounded by Fir Island Road to the north, the tidal marsh habitat extending approximately 1,000 feet south of the existing Skagit Bay flood dike, the dike along the west side of Brown Slough and approximately 200 feet east of Dry Slough. Skagit Bay watercourses waterward of the existing flood dikes and tidegates include natural blind tidal channels associated with Brown Slough and Dry Slough, natural tidal marsh blind channels, and manmade blind tidal channels (borrow ditches). Watercourses landward of the existing flood dikes and tidegates include the remnant channels of Dry Slough and No-Name/Claude O. Davis Slough, the managed tidal blind channel in Brown Slough, and assorted manmade interior drainage channels. Habitat baseline data and characterizations are provided for each of the three central drainage areas.

#### 2.8.2.1 Dry Slough Baseline

*Habitat Connectivity*

Dry Slough was historically a distributary channel of the North Fork Skagit River and discharged into Skagit Bay in the central Fir Island Delta region. Dry Slough was disconnected from the North Fork Skagit River in approximately 1951 by a flood dike (Nelson, 2010). The flood dike terminated the downstream migration of juvenile salmonids to the central Fir Island Delta via Dry Slough. Consequently, the migratory pathway for juvenile salmonids out migrating the Skagit River is currently longer and more difficult because the central Fir Island Delta can only be accessed by entering the Delta at the mouth of the North Fork or South Fork. Fish must adjust physiologically to brackish water and then migrating a considerable distance along the Skagit Bay Front portion of the Fir Island Delta. Dry Slough has a connectivity index of .0221 compared to .040 for the areas in closer proximity to the mouths of the North Fork and South Fork (Beamer and others, 2005).

The flood dike between the North Fork Skagit River and Dry Slough also terminated the downstream transport of sediments to the central Fir Island Delta via Dry Slough. In 2011, Shannon and Wilson compared 1937 and 2010 aerial photographs and concluded that areas along the exterior margins of the vegetated marsh in the central Fir Island Delta vicinity have retreated landward between 400 and 1,000 feet, which correspond to a loss of approximately 75 acres of tidal marsh. Phil Williams & Associates, 2004 noted that under the current disconnected river sediment supply conditions for the central Fir Island Delta, the Bay Front marsh areas will continue to erode.

*Tidegates*

Though isolated from the North Fork Skagit River in 1951, Dry Slough continued to be tidally influenced until 1964 when a flood dike and tidegates were installed across the mouth of Dry Slough (Hayton, 2011). Between 1951 and 1964, farmland adjacent to Dry Slough was protected from tidal inundation by Bay Front flood dikes and flood dikes along the east and west sides of the slough. There are currently two 48-inch-diameter culverts with top hinge tidegates at the mouth of Dry Slough.

*Fish Sampling Data*

The tidegates at the mouth of Dry Slough severely restrict fish passage between Dry Slough and Skagit Bay. The Skagit Fisheries Enhancement Group sampled fish inhabiting the mouth of Dry Slough, upstream and downstream of the existing Dry Slough tidegates, between March and June of 2008 (SREG 2008 Report). Between March and June of 2008, nine fish species were captured downstream of the tidegates including juvenile Chinook salmon, juvenile chum salmon, juvenile coho salmon, juvenile pink salmon, stickleback, sculpin, starry flounder, sand lance, and shiner perch. During this period, only two species were captured upstream of the tidegates including juvenile Chinook salmon and stickleback. Of the 210 juvenile salmon that were captured, only one juvenile salmon was captured upstream of the tidegates. The Dry Slough fish sampling results are consistent with the fish sampling results for Wiley Slough presented by the Skagit River System Cooperative in the Wiley Slough Restoration Design Report 2005. The 2005 Wiley Slough Restoration Design Report concluded that salmonids are almost completely absent above the Wiley Slough tidegates, though juvenile salmon were found just downstream of the tidegates and in adjacent sloughs.

#### 2.8.2.2 Claude O. Davis Slough

*Habitat Connectivity*

Claude O. Davis was historically a distributary channel that branched off of Dry Slough in the central region of the Fir Island Delta south of Fir Island Road. As a consequence of disconnecting Dry Slough from the North Fork Skagit River in 1951, and construction of the Skagit Bay dike system, Claude O. Davis was disconnected from the North Fork Skagit River and the Bay, thereby terminating downstream migration of juvenile salmonids in Claude O. Davis Slough. The migratory pathway for juvenile salmonids leaving the Skagit River is currently longer and has a connectivity index of .022 compared to .040 for the areas in closer proximity to the mouths of the North Fork and South Fork (Beamer and others, 2005). Similar to Dry Slough, river sediment transport to the Claude O. Davis channel has been eliminated and will continue to contribute to Skagit Delta marsh erosion conditions. No-Name Slough, which

connects at the mouth of Claude O. Davis Slough was likely a blind tidal channel at some point in time. Currently, the "slough" is a manmade drainage channel with little habitat connectivity.

*Tidegates*

Claude O. Davis Slough was disconnected from Skagit Bay in the 1930s (personal communication Stan Nelson CDD#2, 2011) by the installation of two 48-inch-diameter culverts with top hinge tidegates.

*Fish Sampling Data*

Fish have not been sampled in Claude O. Davis Slough. Given it is somewhat similar to Dry Slough, it is reasonable to assume that the baseline fish utilization in Claude O. Davis Slough is similar to that described above for Dry Slough.

#### 2.8.2.3 Brown Slough Baseline

*Habitat Connectivity*

Brown Slough was historically a distributary channel of the North Fork Skagit River that discharged into Skagit Bay in the central Fir Island Delta region. Brown Slough was disconnected from the North Fork Skagit River in approximately 1948 by a flood dike (personal communication Stan Nelson CDD#22, 2010). The flood dike terminated the downstream migration of juvenile salmonids to the central Fir Island Delta via Brown Slough. The migratory pathway for juvenile salmonids leaving the Skagit River is currently longer and has a connectivity index of .022 compared to .040 for the areas in closer proximity to the mouths of the North Fork and South Fork (Beamer and others, 2005). Similar to Dry Slough, river sediment transport to the Brown Slough channel has been eliminated and will continue contribute to Skagit Delta marsh erosion conditions.

*Tidegates*

Brown Slough was disconnected from Skagit Bay at Fir Island Road in approximately 1948 (personal communication Stan Nelson CDD#22, 2011) by the installation of a 48-inch-diameter culvert with a top hinge tidegate. Though isolated from Skagit Bay at Fir Island Road in approximately 1948, Brown Slough continued to be tidally influenced south of Fir Island Road until 1990, when emergency dike repairs necessitated the construction of a new flood and tidegate complex across Brown Slough approximately 2,000 feet downstream of Fir Island Road. Two 48-inch-diameter culverts with top hinge tidegates were installed into the new flood dike to maintain the existing upland drainage in Brown Slough to Skagit Bay. Between 1990 and 1994, the new flood dike and tidegates prevented tidal inundation of Brown Slough between Fir Island Road and the new flood dike. In 1994, as a condition for retaining the new

flood dike, an additional 48-inch-diameter culvert with a screw gate style top hinge tidegate was installed by CDD#22 into the 1990 flood dike. The design and operation of the screw gate style tidegate allows sufficient tidal inundation to maintain approximately 3.6 acres of tidal channel and 9.6 acres tidal marsh upstream of the 1990 flood dike. The screw gate style tidegate allows fish passage through the 1990 flood dike. The operation of the new screw gate style tidegate was and is strictly regulated through the state and federal permits authorizing the retention of the new flood dike. The following generally summarize the operation protocols for the screw gate style tidegate that were set forth in the drainage district's 1996 Hydraulic Project Approval for managing the tidegate:

- The combination sluice/flap gate shall be maintained in a full open position from February 1 through October 15 of any year.
- The combination sluice/flap gate may be set to a one half open position from October 16 through January 31 of any year.
- The combination sluice/flap gate may be set to a full closed position when the Skagit River water level at the riverside staff gauge in Mount Vernon reaches the 31-foot mark and the river stage is rising.
- Subsequent to closure of the combination sluice/flap gate, the gate shall be immediately returned to a full open position February 1 through October 15 or to a one-half open position October 16 through January 31 when the Skagit River water level at the riverside staff gauge in Mount Vernon drops below the 31-foot mark and the river stage is falling.

There are currently four culverts with top hinge tidegates in Brown Slough. There is one 48-inch culvert with a top hinge tidegate under Fir Island Road. There are also three 48-inch culverts with top hinge tidegates at the 1990 flood dike with one of the 48-inch tidegates having a screw gate feature that allows the gate to be raised incrementally above the culvert opening.

*Fish Sampling Data*

Fish have not been sampled in Brown Slough upstream of the Fir Island Road tidegate. In the spring of 1995, the Skagit River System Cooperative (SRSC) aggressively sampled the tidally influenced portion of Brown Slough downstream of Fir Island Road. Sampling occurred both upstream and downstream of the 1990 flood dike. SRSC captured eleven fish species. All eleven species were capture between the new 1990 dike and Fir Island Road. The captured fish species included juvenile Chinook salmon, juvenile Chum salmon, juvenile Coho salmon, Cutthroat trout, Surf smelt, Three-spine Stickleback, Staghorn Sculpin, Starry Flounder, Prickly Sculpin, Starry Flounder, Shiner Perch, and Peamouth Chub. Three-spine Stickleback was the most abundant species captured, with surf smelt the second most

abundant species captured. Juvenile Chinook salmon and juvenile chum salmon were the most abundant salmon species. The SRSC concluded that fish were able to find, occupy, and outmigrate from the habitat upstream of the 1990 dike in a similar pattern to those fish that did not navigate the open screw gate style tidegate. Fish passage through open screw gate style tidegate was not a problem (Beamer and LaRock, 1998).

SRSC annually sampled Brown Slough for juvenile Chinook salmon between 1996 and 2003. Sampling occurred both upstream and downstream of the 1990 dike (Eric Beamer unpublished data). SRSC 1995 and 1996 data demonstrate that immediately following the installation of the 1994 screw gate style tidegate, the number of juvenile Chinook salmon captured upstream of the 1990 dike exceeded the number captured downstream. Beginning in 1997 and continuing through 2003, this pattern of juvenile Chinook salmon distribution has gradually reversed itself to where the 2003 data demonstrate that the number of juvenile Chinook salmon captured downstream of the 1990 dike significantly exceed the number captured upstream.

#### 2.8.2.4 Manmade Watercourse Baseline

The manmade watercourses within the upland area of the study site are managed to provide drainage for the farmland portion of the study site and for adjacent upstream neighboring farms. Fish have not been sampled in these manmade watercourses. Juvenile salmon access to and presence in these manmade watercourses is limited by the tidegates in Dry Slough and Claude O. Davis Slough, and by water quality.

The manmade watercourses in the Bay Front tidal marsh area of the delta are remnant borrow areas where native Delta sediments were excavated to construct the existing flood dikes. They are immediately adjacent to and parallel with the waterward toe of the existing flood dikes. These borrow ditches are tidally inundated and function as tidal blind channels. To the extent that they are connected to existing natural tidal marsh channels and accessible to juvenile salmon, it is reasonable to assume that they provide juvenile salmon rearing habitat.

## 2.9 Snow Goose Management

A critical component of the restoration feasibility study is to understand the impacts of dike setback alternatives on the WDFW Fir Island Farm, Snow Goose Reserve management of Snow Goose resources. This section of the report describes the Snow Goose Reserve management objectives, status and trends of Snow Goose populations, background information and management objectives of the Snow Goose reserve.

### 2.9.1 Snow Goose Biology and Management

The population of lesser Snow Geese (*Chen caerulescens caerulescens*) that breeds on Wrangel Island, Russia represents the last major Snow Goose population breeding in Asia, and the primary Russian goose population that winters in North America. The Wrangel Island Snow Goose population winters primarily in British Columbia, Washington, and California. Overall management of this population is guided by a comprehensive plan developed through the Pacific Flyway Council and U.S. Fish and Wildlife Service (USFWS), including participation by Russia, Canada, and U.S. fish and wildlife agencies (Pacific Flyway Council, 2006).

The first systematic survey of Wrangel Island Snow Goose was conducted in 1970, when 150,000 geese were counted in early June on the breeding colony (Bousfield and Syroechkovsky, 1985). The spring population declined to about 50,000 birds by the mid-1970s due to several consecutive years of breeding failures. By the late 1980s, populations increased to almost 100,000 birds and then in the 1990s decreased to about 65,000 birds. By 2007, the spring population had increased to 140,000 on Wrangel Island due to consecutive years of good weather, low predation, and high adult survival.

The primary wintering areas for Wrangel Island Snow Goose include the Fraser River and Skagit Delta areas, and the Central Valley of California. In the 1990s, between 78 to 90 percent of the population wintered in California (Hines and others, 1999). By 2000, the ratio shifted to about 60 percent in the Fraser-Skagit Deltas and about 40 percent in California (Boyd and Cook, 2000). Wintering counts for the Fraser-Skagit Deltas have increased dramatically, from an average of about 23,000 birds in the 1970s to a peak population of 100,000+ birds in 2007-08 winter season.

The Pacific Flyway Management Plan for the Wrangel Island Population of Lesser Snow Goose (PFMP-WISGP) describes guidelines for cooperative management of the population of lesser Snow Goose that breed on Wrangel Island, Russia and winter primarily in British Columbia, Washington, and California. For a complete overview of the management goals, objectives, and strategies for the Wrangel Island Snow Goose population, as well as the biological history and status of this population, the PFMP- WISGP can be viewed at the following web-site: www.pacificflyway.gov/abstracts.asp#wilsg

### 2.9.2 Current Status of the Fraser-Skagit Snow Goose Population and Recent Habitat Utilization Trends

Midwinter Snow Goose populations in the Skagit-Fraser area have generally declined following the 2007-08 peak of 100,000+ birds. The 2008-09 winter population dropped to 57,100 birds. However, it is possible that some portion of the population was foraging outside the survey area and were not included in the total. Midwinter population levels for the 2009-10 and 2010-11 seasons were 74,000 and 63,600, respectively. Habitat utilization trends in the Skagit area have changed significantly over the past five years with major expansion in geographic area used for foraging and night feeding being the most notable:

1. Expansion in geographic area used for foraging:

   Historically, winter forage distribution in the Skagit region has typically been restricted to Fir Island and agricultural lands to the south of Stanwood, WA. The 2007-08 season saw major expansion of Snow Goose foraging activity to agricultural lands in the central Skagit Valley (north of the North Fork Skagit River), east of the Skagit River in agricultural lands between Mount Vernon and Conway, Washington, and east of Stanwood in the Silvana area. As many as 12,000 to 16,000 Snow Goose were observed routinely foraging in fields near Marysville, Washington (a daily flight distance of 40 miles). The 2010 to 2011 season saw further geographic expansion by foraging Snow Goose with agricultural lands in the northwest portion of Skagit County (north of State Route 20 and west of Interstate-5) and the agricultural lands adjacent to Cook Rd. (Burlington to Sedro Woolley) routinely utilized by foraging birds.

2. Night Feeding:

   Night feeding as a foraging behavior has been observed periodically throughout the history of Snow Goose in the Skagit/Snohomish region, but to a limited degree and in direct response to specific times of stress (extreme cold weather or intensive hunting pressure). Beginning in the late 1990s, night foraging behavior has steadily increased but has been primarily focused upon the agricultural lands on Fir Island, and to a lesser degree, agricultural lands to the south of Stanwood. The 2010 to 2011 winter season included the most intensive night foraging behavior by Snow Goose ever observed. Night foraging occurred throughout the last half of the hunting season (mid-December through January) and was focused primarily on agricultural land to the north and east of Fir Island. For a period of five to six weeks all foraging by Snow Goose (day or night) was absent from Fir Island itself. The management significance of this behavioral shift in foraging includes:

a. The total acreage of agricultural lands in Skagit County subject to Snow Goose foraging has increased by a factor of 3 (from 6,000 to almost 20,000 acres).

b. Increased night feeding behavior in the future would result in diminished hunting opportunity for local hunters. Reduced harvest capability would limit WDFW and USFWS options for managing Snow Goose population levels.

c. Expanded foraging range throughout Skagit and Snohomish Counties would most likely result in comparable increases in the number and distribution of Snow Goose crop damage complaints filed by local landowners.

d. Increases in the number of complaints about Snow Goose foraging on crops will increase public focus upon the need for cover crops on WDFW-owned or controlled lands that serve as an alternative food source for wintering geese (resulting in reduced depredation problems on privately owned lands).

e. A shift to night foraging and/or to expanded forage range away from Fir Island would have a significant impact on the social, political, and legal problems common to Fir Island itself over the past seven to eight years (reduced hunting pressure, reduced trespass violations, less stress for local residents, reduce shooting from road, fewer litter problems, more dispersed crop impacts – i.e., less impact to Fir Island farms).

### 2.9.3 Washington Department of Fish and Wildlife (WDFW) Snow Goose Wildlife Reserve

In its simplest form, a wildlife reserve is a secure habitat area (natural or artificial) that affords a particular species with unrestricted access to resources and conditions that enhance biological requirements or support management objectives for that species. Securing unrestricted access to the resources and conditions within the boundary of a reserve is accomplished via statute (Revised Code of Washington) and secured by the enforcement capability of the agency assigned the statutory authority to enforce the fish and wildlife laws of the state (WDFW). The degree to which unrestricted access to the resources and conditions within a reserve is secured cannot be duplicated outside its boundaries.

The Fir Island Farm/Hayton Snow Goose Reserve provides three basic advantages to wintering Snow Goose:

- Unrestricted access to winter wheat crops (pre-hunting season, throughout the 107-day hunting season, and post-season up to the time Snow Goose depart for northern breeding grounds in mid-April.

- Unrestricted access to fresh water (shallow ponded areas on the reserve and drainage ditches).
- Unrestricted opportunity to conserve biological energy and fat reserves in a designated area secure from hunting pressure, human disturbance associated with trespass, photographers, bird watching, aircraft, and off-site disturbance by domestic pets and farm animals.

### 2.9.4 Establishment of the Fir Island Farm/Hayton Snow Goose Reserve

#### 2.9.4.1 Acquisition of Land

WDFW purchased 224.7 acres of land originally recognized as the Von Moos Farm. Of the total 224.7 acres, 215 acres was farmable agricultural land. The primary purpose for purchasing the property was to establish a reserve for Snow Goose and to plant winter wheat as a food source for the geese. The property was purchased on April 19, 1995 for $803,000 (Deed, Deed of Right, and Lease Agreement on file). 100 percent of the purchase price was IAC (Inter Agency Committee) funded. All of the $803,000 were later used as 100 percent match for three additional NAWCA (North American Waterfowl Conservation Act) land acquisitions in north Region 4:

- Glick Property (Leque Island) – 91 acres
  Purchased: March 22, 1996
  Purchase Price: $324,500
- Johnson Property (DeBays Slough) – 75 acres
  Purchased: February 26, 1997
  Purchase Price: $144,000
- Trucker Property (DeBays Slough) – 131 acres
  Purchased: September 18, 1995
  Purchase Price: $246, 000

The surplus dollars were incorporated into acquisition costs (capitol staff time, closing costs, appraisal costs, environmental audit, surveys as needed).

#### 2.9.4.2 Designation as a Reserve

The Fir Island Farm Game Reserve incorporates WDFW-owned lands into a separate codification from lands in reserve status that are owned by the Hayton Farm (Hayton Game Reserve). Both reserves were established by the Washington State Wildlife Commission in 1997. The WAC designations and legal descriptions are as follows (Figure A-2):

- WAC 232-16-780 (Fir Island Game Farm). 245 acres (as described in the WAC) in Skagit County.
- WAC 232-16-790 (Hayton Game Reserve). 290 acres in Skagit County.
- Hayton Crop Farm (HCF) Lease and Crop Planting Agreement

The Fir Island Farm/Hayton Reserve incorporates 215 acres of farmable agricultural land and 15 acres of marsh, managed primarily for the population of lesser Snow Goose (Chen caerulescens caerulescens) that breed on Wrangel Island, Russia. Agricultural lands within the Fir Island Farm portion of the reserve (215 acres – WDFW) are leased to Robert Hayton (Hayton Crop Farm [HCF]) who plants spring crops for harvest, and has a requirement to plant the entire acreage to winter wheat forage for Snow Goose once the cash crops have been harvested in the fall. As part of his original bid for the lease option on WDFW lands (Fir Island Farm), Robert Hayton agreed to place his adjacent farm (290 acres) in Game Reserve status and plant his farm and an additional 110 acres on adjacent lands leased by HCF to winter wheat. Total winter wheat forage on both WDFW and Hayton ownerships is 645 acres. For every acre that WDFW leases to HCF, an additional 1.86 acres of winter wheat acreage are provided via the lease agreement.

#### 2.9.4.3 Snow Goose Wildlife Reserve Management Objectives

- **Objective 1. Partial Mitigation for the Anticipated Loss of Snow Goose Forage Capacity in both Skagit and Port Susan Bays Resulting from the Invasion of Non-Native Cordgrass (*Spartina anglica*)**

  *S. anglica*, commonly known as cordgrass (or Spartina), is an aggressive, noxious weed that has severely disrupted the ecosystems of native salt water estuaries in Washington State. Left unchecked, *S. anglica* out competes native vegetation and converts mudflats and estuaries into monotypic *S. anglica* meadows. As a result, important migratory shorebird and waterfowl habitats, as well as critical rearing areas for juvenile salmonids, are lost (WSDA, 2010). *S. anglica* was introduced into Puget Sound in 1961 on the eastern shore of Port Susan Bay, three miles south of Stanwood by the Research and Extension Unit of Washington State University (Ranwell, 1967; Frankel, 1987). The original purpose of the introduction was to stabilize a dike system and provide forage for cattle. Aberle (1993) reports that the plants thrived and produced seed in 1963 but, it was not until the mid 1970s when 2.7 hectares of *S. anglica* coverage was documented by WDFW, that any serious attention was focused upon the invasion.

  The Washington State Department of Agriculture (WSDA) has served as the lead state agency for the eradication of invasive *S. anglica* since 1995. WSDA facilitates and coordinates the combined eradication efforts of local, state, federal, and tribal

governments; universities; interest groups; and private landowners throughout western Washington shoreline areas. Overall, the success of the eradication effort in the Puget Sound region has been significant with an estimated 99 percent reduction in *S. anglica* from the peak infestation of more than 1,000 acres in 1997 (*Spartina* Eradication Program Progress Report – 2010). Between 2003 and 2009, over 500 acres of dense *S. anglica* meadow were treated using integrated pest management strategies (discing, crushing, digging, spraying). According to David Heimer (WDFW; Skagit Bay *Spartina* Management Synopsis – 2010), this effort not only eliminated *S. anglica* meadows, but prevented expansion and seed production which could have threatened thousands of additional acres of high quality habitat in both Skagit and Port Susan Bays. However, it is important to note that post-treatment monitoring following the 2007 and 2008 seasons indicates that, although *S. anglica* coverage and densities have significantly decreased across south Skagit Bay, seedlings are still widespread, and distribution remains relatively unchanged from 2003.

From a Snow Goose management perspective, the elimination of large and dense colonies of *S. anglica* represents a significant improvement in that:

- The mature *S. anglica* plants in these colonies (that are capable of producing viable seed) no longer pose a threat to the remaining native marsh in both Skagit and Port Susan Bays and
- Thompson (1991) describes the process whereby *S. anglica* plants slow water flow, causing sediment deposition and eventual elevation of intertidal habitat up to more than 1 meter thick. Post-meadow removal and monitoring in Skagit Bay indicates that the rate of elevation change returns to background levels within two years (Rybezyk, 2010). Morgan (2008) reports that re-colonization by *S. anglica* and native plants occurs rapidly in these accreted areas once meadow formations have been eliminated. Three-square bulrush (*Scirpus americanus*), the primary native food source for wintering Snow Goose, now has at least a chance to re-establish in historically occupied areas of the marsh.

The Fir Island Farm/Hayton Snow Goose Reserve was established to partially mitigate for the anticipated loss of Snow Goose winter forage (three-square bulrush) resulting from the invasion of non-native cordgrass (Objective 1). However, despite of the habitat improvements associated with recent *S. anglica* control efforts, substantial problems and questions regarding the full recovery of the native marshes in Skagit and Port Susan Bays persist.

- Despite of the recent *S. anglica* control and eradication effort that have established over 500 acres of estuary habitat where *S. anglica* meadows no longer exist, the 500 acres of native habitat that historically supported Snow Goose in Skagit Bay have not returned, requiring wintering birds today to continue seeking alternative (replacement) food sources such as agricultural crops.

- Although it has been documented by Morgan (2008) that re-colonization by either *S. americanus* or native plant species can occur in accreted areas following removal of *S. anglica* meadows, it remains unclear whether or not *S. americanus* will prevail in impacted areas or how long it will take to achieve native plant densities equivalent to historical levels.
- *S. anglica* seedlings are still widespread, and the distribution remains relatively unchanged from 2003 (pre-eradication), which demonstrates that consistent, yearly treatment is still needed to guard against meadow restoration (Hiemer, 2010). Under difficult economic conditions as currently exists, it is unclear if continued *S. anglica* control efforts will occur in the future as required.

In view of persistent problems and questions surrounding the *S. anglica* eradication issue, the management priority focusing upon partial mitigation for the loss of Snow Goose winter forage capacity in Skagit and Port Susan Bays (Objective 1) remains valid.

- **Objective 2. Provide Alternative Forage Capability for Wintering Snow Goose in Response to Documented Deterioration of Intertidal Marshes**

Snow Goose were rare on the Skagit Delta during the late 1800s and early 1900s (Jeffry and Kaiser, 1979). Brown (in Jewett and others, 1953) reported observation of approximately 5,000 birds in late November 1922. Hall (1936) recorded Snow Goose sightings on the Skagit Delta (5,000 birds and 12,000 birds) in January 1936. Snow Goose foraging in the early 1900s on both the Skagit and Fraser Deltas was entirely focused upon the intertidal marsh and their primary food source *S. americanus*. Historically, Snow Goose using the Fraser Delta foraged primarily in intertidal estuaries until the late 1970s, when they first began using agricultural fields (Campbell and others, 1990). Hatfield (1991) reported a similar shift to inland feeding on the Alaskan National Wildlife Reserve British Columbia during the 1970s.

Snow Goose foraging, commonly referred to as "grubbing," involves the excavation of *Scirpus spp.* in an effort to feed on underground rhizomes (Burton 1977). Significant damage to salt marsh on the Louisiana coast by Snow Goose foraging has been documented by Lynch and others (1997). Similarly, Snow Goose foraging on eastern salt marsh has resulted in severely reduced biomass and primary production (Smith and Odem, 1951; Smith, 1973).

The Fraser and Skagit Deltas are roughly the same size and they support the same dominant vegetative types (Ewing 1982, personal observation). However, Boyd (2010) reports that mean rhizome masses (*Scirpus spp.*) on the Fraser and Skagit Deltas are only at a small fraction of their potential and that maximum level and mass on the Skagit Delta were almost half that on the Fraser Delta. Boyd (2010) also suggests that the documented shift of Snow Goose foraging from intertidal habitat to inland crops may be the result of two factors:

- *Scirpus spp.* rhizomes were grubbed down to a level where the geese were unable to meet their requirements for energy or some essential nutrient.
- A food-profitability gradient exists where grazing on farms results in greater foraging returns compared to grubbing *Scirpus spp.* (Stephens and Krebs, 1986; Krebs and Davies, 1983).

Cover crops have significantly higher concentrations of nitrogen and carbohydrates and lower levels of fiber (Boyd, unpublished data). Compensating for the loss of foraging capacity of the Skagit Delta is a primary emphasis of the Fir Island Farm/Hayton Snow Goose Reserve (Objective 2). Unrestricted access to cover crops, especially during hunting season, is critical to the maintenance of body reserves for wintering Snow Goose. However, it is well documented that the contribution of nutrients from agricultural foods is also important to reproductive success. Ankney & MacInnes, 1978; and Davies & Cook, 1983 report that "the proportion of female lesser Snow Goose that nest and their potential clutch sizes vary with the magnitude of fat reserves carried to the breeding grounds."

Boyd (2010) has observed that, "In association with the impact of geese, other mechanisms are causing the upper and lower 100 to 200 meters of the *Scirpus spp.* zone to revert back to mudflat. Altogether, the entire *Scirpus spp.* zone on the Fraser Delta is moving toward a state of 'functional extinction' in as little as 15 to 20 years. This has serious negative implications for other components of the estuarine food web as well as for Snow Goose themselves. S. americanus is still an important component of their diet and, during extreme cold weather events when farms are frozen over or snowed under, they are entirely dependent on the marsh for food."

This same type of vegetation zone degradation in Skagit Bay, presumably due to the combined influences of grubbing by Snow Goose, shifts in hydrological influences, and reduced sedimentation, have been documented in the geomorphologic study for the project. The report states "Measurements of the retreat of vegetation lines indicate that the vegetated marsh areas along the exterior margins of the Fir Island Farm dike have retreated distances between 400 and 1,000 feet as observed on 1937 and 2010 aerial photographs. This corresponds to a loss of 75 acres of tidal marsh area along the Fir Island Farm Bay Front over the past 73 years." Considering that the Skagit Delta, as reported by Boyd (2008), is currently supporting maximum rhizome levels and mass approximately half that on the Fraser Delta, the *Scirpus spp.* zone on the Skagit Delta may already be approaching a state of "functional extinction." Therefore, the need for supplemental cover crops in reserve status (in addition to restoration of marsh vegetation zones) remains a critical component of management for Snow Goose both now and in the future.

- **Objective 3. Provide "Focus Crop" on WDFW-owned or Controlled Lands Designed to Reduce Snow Goose Degradation on Private Farmlands**

  As the wintering population of Snow Goose in the Fir Island/Stanwood area has increased, so have the number and severity of crop damaged complaints received from local farmers. Damage has primarily occurred to fields with green chop, winter wheat, grass seed crops, rye grass, potatoes, and grass turf. Soil compaction and poor field drainage caused by Snow Goose trampling have also been identified as problems. The most severe damage occurs in the spring months (February and March) when soil moisture content is high. Snow Goose ordinarily clip the tops of plants when foraging on green plants. However, when root systems are weakened by excess soil moisture, the birds tend to pull the entire plant from the ground. Clipped plants will sprout and continue to grow in the spring after Snow Goose have departed the area. When plants are uprooted the crop is totally destroyed.

  Generally speaking, private landowners and local community leaders view WDFW land ownerships as "the first line of defense" for mitigating Snow Goose crop damage. Leque Island and the Fir Island Farm/Hayton Snow Goose Reserve are the only two state owned properties that exist within the core Snow Goose forage area. The Fir Island Farm/Hayton Snow Goose Reserve is currently managed as a "Focus Crop" with primary emphasis upon fall and winter Snow Goose use. Focus crops are essentially cover crops that are designated for Snow Goose foraging. The basic premise is that these sites will provide alternative feeding opportunity for geese other than critical crops on private land. The more time geese spend on focus crops, the less time they spend damaging private crops. Focus crops can be managed to provide crop protection during fall or winter months or during the critical spring time period when a significant amount of post-hunting season damage occurs. The best crop type for focus crops is winter wheat (the preferred forage crop of Snow Goose). Rye grass is a more cost effective alternative to winter wheat and it has improved growth capabilities during periods of unusually cold weather. The 615 acres incorporated in the Fir Island Farm/Hayton Snow Goose Reserve provides only a portion of the energy requirements (expressed as kilocalorie, kcal) required to over winter the current population of approximately 76,000 birds (see summary of Snow Goose forage supplement programs managed by WDFW).

- **Objective 4. Enhanced Public Safety**

  Fir Island is intensively farmed. Snow Goose viewers frequently block roads when pulling over to get a better look, creating a public safety hazard, as well as an impediment to normal movement of agricultural equipment. The overwhelming demand for Snow Goose viewing poses serious problems for local residents, farmers, and local officials. Although there have been numerous "near misses" and a few minor collisions along the poorly shouldered Fir Island Road, no serious personal injuries have occurred to date (Maynard Axelson – local resident; pers. com.). The Fir Island Farm/Hayton Snow Goose Reserve was intended as a remedy to the public

safety issue associated with intensive Snow Goose watching activities on Fir Island. However, to date the reserve has not accomplished the Enhanced Public Safety objective. Recommendations from the Fir Island Snow Goose Working Group designed to resolve public safety concerns include:

- Establish a permanent vegetative screen along the Fir Island Road right-of-way that blocks the view of geese by passing motorists;
- Avoid planting focus crop (winter wheat and rye grass intended to attract Snow Goose) within 200 feet of the road;
- Improve the roadway entrance turnout and visibility; and
- Enlarge the reserve and add additional off-road parking.

- **Objective 5. Establish a Developed Snow Goose Viewing Site**

  Unofficial estimates of the number of bird-watching public that visit Skagit County over the course of a year ranges between 500,000 and 750,000 annually. The majority of that activity occurs in the fall, winter and early spring months. Although many organized and more focused bird watching groups like Audubon benefit from designated viewing sites, this segment of the viewing public tends to be self-sufficient and more aware of viewing ethics. The majority of problems associated with the general public viewing wildlife stems from that portion of metropolitan travelers who pass through Skagit County and are attracted by the spectacle of Snow Goose along the roadside. Many instances of newspaper and television coverage on eagles, swans, and Snow Goose in the area result in mass visitations from all over the Puget Sound region, ultimately causing problems for local residents and landowners alike. The purpose of a developed viewing site is to provide an opportunity for large numbers of people to gain quality access to unique wildlife resources and to provide a viewing alternative to dangerous roadside stopping, parking in residential driveways, trespassing on private property, obstructing farm equipment, and even harassment of the wildlife itself. Developed wildlife viewing sites support eco-tourism in the Skagit Valley and create strong economic benefits to local communities.

#### 2.9.4.4 Lease Revenue Projections for the Fir Island Farm/Hayton Snow Goose Reserve

The dike setback project will have an effect on the lease revenue of the reserve. The HCF pays $225 per acre as a lease amount for farming rights on the land owned by WDFW. The total lease amount is adjusted upward by the addition of a Lease Holder Excise Tax (L&E) of .1284 percent. The leasee (HCF) receives a credit for the cost of planting cover crop that is a reimbursement for the cost of tilling the ground, cost of the seed, and planting costs. For purposes of simplification, the “planting credit” has been standardized at $50 per acre for a total of 200 acres ($10,000 per growing season). For every acre that WDFW leases to HCF an

additional 1.86 acres of winter forage acres is provided via the lease agreement (See HCF Farm Lease and Crop Planting Agreement).

### 2.9.5 Cover Crop Energy Calculations and Projected Snow Goose Population Equivalents

The primary function of the Fir Island Farm/Hayton Snow Goose Reserve is driven by the winter wheat cover crops that provide forage and ultimately the metabolized energy required by wintering geese. Snow Goose begin arriving in mid-September and steadily build in number until they reach peak population level on the Skagit/Port Susan Deltas by late December. In a typical season, Snow Goose begin foraging immediately upon arrival and focus specifically on the Reserve. Beginning in late-December, Snow Goose routinely leave the Reserve and begin targeting private farmlands as a source of food. By this time cover crops in the Reserve have been heavily grazed by geese with as much as 60 percent of the biomass removed. The cover crop (and a variety of local forbs eaten by Snow Goose) continue to grow throughout the winter to varying degree with growth rates influenced by weather. Cover crop growth rates accelerate in the spring months (February through April) during which time the birds divide their foraging efforts between the reserve and private farmlands. Calculation of per-acre biomass and equivalent energy produced is based upon maximum cover crop yields in order to account for total season grazing in the Reserve by Snow Goose. Cover crop yield in the reserve is estimated at 1,600 pounds per acre (seasonally). Based upon crop energy parameters in Petrie (2009), a single acre of winter wheat cover crop yields 1,741,795 kcal with 614 kcal required per bird/per day for normal winter maintenance. Calculation of the total energy requirement for the total winter population of Snow Goose per season is as follows:

614 kcal/per bird/per day x 197 (# days Snow Goose are here in a season) x 75,410 (mid winter S.G. population) = total kcal required by winter population per season. The total kcal required to over winter the 2010-11 population of 75,410 birds is 9,121,442,780 kcal.

The Fir Island Farm/Hayton Snow Goose Reserve (615 acres) produces 1,071,203,806 kcal in winter wheat available to Snow Goose. This represents 11.7 percent of the total 9,121,442,780 total kcal required to over winter the current 2010-11 Snow Goose population of 75,410 birds. 11.7 percent of the total kcal required to over winter the entire 2010 to 2011 population of Snow Goose is sufficient to overwinter a total of 8,856 Snow Goose for an entire season (197 days). A second Snow Goose reserve in south of Stanwood (181 acres) represents 3.5 percent of the total kcal required to over winter the current (2010-11 season) winter population of 75,410 birds, which is sufficient to overwinter a total of 2,606 Snow Goose for an

entire season (197 days). The fall and winter of 2010 marked the fifth season the Snow Goose Quality Hunt Program contracted with local farmers for the placement of cover crops available to Snow Goose. This past season (2010-11) a total of 934 acres were enrolled in the program. This program provided 17.8 percent of the total kcal required to over winter the total winter population of 75,410 birds for an entire season (197 days). The combined total acreage for all programs is 1,730, which provides 33.0 percent of the total annual kcal requirements for 75,410 birds (Table A-4).

### 2.10 Public Use and Recreation

The Fir Island Farm Unit is part of the WDFW's Skagit Wildlife Area. The Skagit Wildlife Area includes approximately 16,708 acres of diverse habitats from the Bald Eagle Natural Area on upper Skagit River to the Skagit Bay Estuary and out to the San Juan Islands. The majority of the Wildlife Area is marine tidelands located on the Skagit River delta between the mouths of the North and South Forks of the Skagit River. In addition to tidelands, the Skagit Wildlife Area also includes adjoining fresh water marshes, prior converted wetlands, and various upland sites at 16 separate locations. The management goals for WDFW are to preserve habitat and species diversity for fish and wildlife resources, maintain healthy populations of game and non-game species, protect and restore native plant communities, and provide diverse opportunities for the public to encounter, utilize, and appreciate wildlife and open spaces.

WDFW understands the importance of providing access opportunities and has worked with the local community at the reserve to provide for safe public recreational activities. WDFW also recognizes that public uses must conform to the primary management objective of the reserve to provide upland resting and winter forage for Snow Goose.

The point access design of the reserve was developed to provide a viewing opportunity while providing a larger area for wildlife with limited human disturbance. Hunting is not permitted. There is currently a driveway along the northwest side of the reserve leading to a parking lot. The driveway and parking lot provide the public a safe opportunity to view wintering Snow Goose and the reserves wildlife without having to park along Fir Island Road, which creates a traffic hazard and impacts the local residents. The reserve design also allows the users access to the Bay Front dike for views of Skagit Bay estuary and the variety of wildlife that use this site throughout the year during different tidal cycles. Through an agreement with CDD#22, the public has access to approximately 640 linear feet of dike top trail from the parking lot along Brown Slough to Skagit Bay.

The reserve location on the Skagit Bay Estuary is in close proximity to the large urban populations in Seattle and Vancouver, B.C. (combined populations of over 5.5 million). This project is within easy driving distance—which provides substantial opportunities for wildlife-oriented recreation, education, and scientific study.

In addition, the reserve serves as a demonstration area to showcase the coordinated efforts of private organizations, private landowners, and government agencies, since the reserve is a partnership of public and private land.

Schools, colleges, and the scientific community visit and use this site for a variety of educational and research purposes such as shore bird capture, water quality testing, and bird strike radar testing and calibration, just to name a few.

As a part of the Fir Island Farm feasibility study a car counter was established to monitor visitors to the site and to gather baseline use data (9A-28). The car counter was installed on May 25, 2010, and has been monitored monthly. Between May 2010 and April 2011, 7,654 vehicles have been recorded visiting the site with the highest months of use being December, January, and February, respectively. These months coincide with Snow Goose use of the site. Vehicle monitoring continued through May 2011.

## 2.11 Cultural and Archaeological Resources

A preliminary cultural and archaeological resource study was performed in conjunction with development of the feasibility study for the Fir Island Farm restoration site. The detailed report is included in Appendix B (Technical Memorandum 1.9.2) and summarized herein. The study elements included:

- Summarization of cultural setting
- Summarization of previous archaeological studies
- Archival research
- Field observations during geoprobe testing
- Management recommendations

### 2.11.1 Cultural Setting

#### 2.11.1.1 Northwest Coast Salish Peoples

Numerous authors and researches have studied and provided detailed descriptions of traditional Coast Salish land use and lifeways, and references to these are provided in Appendix B, Technical Memorandum 1.9.2). The southern Northwest Coast Salish peoples that

traditionally inhabited the project area prior to European settlement lived a comfortable, successful, and highly adapted lifestyle. They excelled at resource extraction, processing, and tool and structure manufacture in this west coast environment. Their lives followed a seasonal pattern that included summer camps along the coast for shellfish and plant gathering and fishing. Permanent settlements occurred along the Skagit River in and around the mouth and Delta. In pre-contact times, the Skagit River and the surrounding coastline was likely an increasingly populated transportation corridor since shortly after the retreat of the glacial ice at the beginning of the Holocene. The riverine and terrestrial resources available traditionally on the Skagit River could comfortably support the populations of people estimated for this area near the time of contact with Europeans.

Early cultural traditions would have reflected a highly mobile hunting, foraging, and gathering lifestyle as the ice sheets were receding and landforms and ecosystems were stabilizing and transitioning in the early Holocene. Lifestyles would have become more complex with increasing populations as resources became more stable and procurement strategies improved. By 5,000 years ago, shorelines would have been fairly stable and salmon runs flourishing. Artifact assemblages along the coast reflect this increasing population and complexity in resource acquisition and social structure.

It is important to note that there is evidence for human occupation and use in this region for at least 10,000 years, although some archaeologists believe that North America was populated by migrations of people from present-day Asia crossing a bridge of land in the Bering Strait of Alaska. Local Native Americans do not believe this, as their origin narratives take place here in the islands in and around the Skagit Watershed.

The Treaty of Múckl-te-óh (Point Elliot) signed on January 22, 1855, and ratified by Congress until March of 1859 (American Friends Service Committee AFSC 1970: 36), has provisions important to the management of federal lands in the United States. Included in the Treaty of Múckl-te-óh is the Subsistence Clause (Article 5), which reserves the right of members of federally recognized tribes to fish at all usual and accustomed grounds and stations and to hunt and gather on open and unclaimed lands.

The turn of the twentieth century saw a shift in federal policy to facilitate the assimilation of native populations into the dominant culture. These policies were often in contravention of signed treaties and included practices such as the removal of children from families and traditional territories to government-sanctioned residential schools. After the 1950s, the treaty-reserved right to fish became a focus for many natives in the Puget Sound. AFSC's

*Uncommon Controversy* 1970, Fay Cohen's *Treaties on Trial*, and the 1981 *US Commission on Civil Rights* documents this period of Indian and state government clashes.

In addition to fishing, gathering rights are included in the Subsistence Clause (Article 5) of the 1855 treaty. If gathering involves collecting materials for sacred ritual, then access for gathering might be further protected under American Indian Religious Freedom Act. If gathering sites are eligible for the National Register as a Traditional Cultural Property, they are afforded another layer of protection under the National Historic Preservation Act (NHPA). It benefits all stakeholders of cultural resources in the Skagit Delta land to recognize that the Swinomish have a long history of cultural and spiritual connection to this valley.

To fully document the origins of the Traditional Peoples of the Skagit River, information from oral histories of the people who consider this valley the place of their ancestors/immortals must also be incorporated.

From the preface to her third volume of text from oral traditions, Vi Hilbert describes the value and place of narratives:

> *We do not know how long it has taken for these stories to come down to us, for we did not use the kind of calendar everyone uses today. My people marked time by referring to especially remarkable occasions, such as the year of the solar eclipse, or the period when the big log jam still blocked the Skagit River, all of our culture had to be committed to memory. To this end, our historians developed excellent memories in order to pass on important information to later generations.*
>
> *Our legends are like gems with many facets. They need to be read, savored, and reread from many angles. My elders never said to me, "this story carries such and such a meaning." I was expected to listen carefully and learn why the story was being told. Though guided, I was allowed the dignity of finding my own interpretation (1985: iv).*

Information passed down in the narratives of the people who consider this delta part of their ancestry provides the context and richness that fill in ethnographic gaps.

Traditionally, the river drainage was the primary unifying concept among the loosely organized groups of the Puget Sound Salish. Cultural distinctions were recognized along the following biogeoclimatic culture zones (AFSC 1970: 6): saltwater people, river people,

inland people, and prairie people. The land was not owned in the European understanding of ownership; in order to travel across the landscape individuals considered convenience and the feelings about the people they might encounter (AFSC 1970: 7)

Natalie Roberts (1975) provides a detailed discussion in her *History of the Swinomish Indian Tribal Community*. Sally Snyder (1964) also provides an interesting discussion in *Skagit Society and its Existential Basis: An Ethnofolkloristic Reconstruction.* Martin Sampson (1972) gives a general history with excellent photos and stories of his experiences within the Swinomish community.

In pre-contact times, habitation sites like what we might find in the village area or on the northern uplands would have been used year-round, providing close access to the diversity of resources in the valley and mountains around the Skagit River and Delta. In addition to the extensive saltwater travel during summer and winter, summer encampments in the higher elevations for resource gathering would have been common and the trails and travel corridors to these resource-gathering areas would have been well known to the users and their neighbors. Winter villages were common in the riverine and deltaic environments. The sheer volume of pre-contact shell midden still visible on the coastal stretches of northern Puget Sound is indicative of the vast numbers of people that used every bit of the coastline in this region (Figure A-30).

Roberts (1975) identifies two villages in proximity to the project area. The first was located at the mouth of Carpenter Creek on the south fork of the Skagit River between Conway and Fir (identified as village 28 in Figure 4): "Sampson (1972:19) informs us that this was the main Kikalus village at the time the land was settled by pioneers, and there were four longhouses at that time. At Fir, previously called Mann's Landing, there used to be an old Indian burial place" (Roberts 1975: 66). The second village was located at the mouth of the Skagit River's north fork and was inhabited by the *Squin-ah-mish* (identified as village 12 in Figure A-30).

> *The Squin-ah-mish people were a small band of the Swinomish or very closely related to them by association and intermarriage, who lived in the territory between the Kik-i-allus and the Swinomish, namely on the north fork of the Skagit River from its mouth at Bald Island upstream to Dry Slough, then south and west across Skagit Bay to the south half of Dugualla Bay on Whidbey Island, and then south on Whidbey to Brann's Camp (Sampson 1972: 27).*

#### 2.11.1.2 Early Skagit County

In the year 1853, the Washington Territory was officially created. At this time Skagit County, as well as Snohomish, Island, Whatcom, and San Juan Counties, were all included as part of Island County. A year later, Whatcom separated from Island and Skagit County was included with it (Oakley 2004).

In 1883, a group of local legislators fed up with Whatcom's dominance and convinced of their own future, successfully passed a bill in the territorial legislature that separated Skagit from Whatcom. LaConner was Skagit's new county seat, but only for a short time. Mount Vernon would claim that title a year later (Oakley 2004).

Large scale settlement of Skagit County did not begin until the early 1860s when two settlers, Michael Sullivan and Samuel Calhoun, began diking the marshy flat lands. "At first ridiculed, they proved that with diking, agriculture was possible on what was thought to be useless wetland" (History Link 2007).

Throughout the nineteenth century, Skagit County continued to grow and this was due in large part to agriculture, which became its main industry. Crops such as oats and peas were the initial dominant crops but they would later loose prominence to the growing of seeds. "At one point Skagit County grew 95 percent of the cabbage seed produced in the United States" (History Link 2007). As Skagit County grew, rural centers like Rexville, Skagit City, Conway and Fir began to develop.

In the late 1800s there were important river stops along the south fork of the Skagit River below Skagit City. One of these stops, then called Mann's Landing, later became the town of Fir (Bennett, 1974 and Willis,1975). Fir and its sister city, Conway, were connected by a ferry for many years. Conway became a popular railway stop in 1891 and a drawbridge replaced the ferry to Fir in 1914, both of which led to an increase in businesses moving to Conway. The principal church of the area, the Norwegian Lutheran Church, was retained in Fir. This church is the only remaining structure from the town of Fir that stands today (Willis, 1975).

In addition to agriculture, the dairy industry was also a significant contributor to the growth of early Skagit County. "At the turn of the century there were as many as 900 dairies in the county. These farms were small family operations where every cow had a name and mixed ancestry" (Oakley 2004).

Numerous historic references are available for the Skagit Valley which are referenced in Appendix B, Technical Memorandum 1.9.2.

### 2.11.2 Previous Archaeology Studies

There are 10 recorded archaeological sites on file at the Washington State Department of Archaeology and Historic Preservation (DAHP) within approximately 2 miles of the project area (Appendix B, Technical Memorandum 1.9.2). The four closest sites include 45SK343, 45SK412, 45SK86 and 45SK83.

- **45SK343**, approximately .5 mile north/northeast of the project area, is listed on the Washington State Heritage Barn Register. Located on the Axelson Family Farm, the site includes a barn, constructed in 1903, as well as a dwelling, machine shed, milk house, granary, and bull barn. The farm was founded by Elmer Axelson and is still farmed by his descendents.
- **45SK412**, approximately .5 mile northeast of the project area, is listed on the Washington State Heritage Barn Register. The barn was built in 1876 on the Hayton Homestead. In 1935, a milking shed was added to the original barn, making the barn one of the largest dairy barns in the state. The Hayton family continues to utilize the barn today.
- **45SK86,** approximately 3/5 mile northwest of the project area, is a precontact shell midden site recorded in March of 1972 by G. Robinson and J. Hollenbeck. The site extends approximately 20 meters (north-south) by approximately 10 meters (east-west) with depths of 40 centimeters along a slough in an agricultural field not far from Skagit Bay. Shell, fire-cracked rock, bone and one polished stone blade were observed at the site. (Robinson and Hollenbeck, 1972:1).
- **45SK83**, approximately ¾ mile north of the project area, is a precontact shell midden site recorded in March of 1972 by G. Robinson and J. Hollenbeck. The site extends approximately 14 meters (north-south) by approximately 11 meters (east-west) along the bank of a former slough. Shell and fire cracked rock were observed on the surface of the site (Robinson and Hollenbeck, 1972).

### 2.11.3 Field Investigations

No protected cultural resources were identified during the archaeological monitoring of the 12 geo-probe explorations for this project. The geoprobe tests were collected with a geoprobe machine from Cascade Drilling. All of the twelve geo-probe tests monitored were negative for cultural resources. Disturbed soils likely resulting from agricultural activities including disking and plowing were seen above intact alluvial deposits. Additionally lahar deposits were seen in some of the geoprobes within the layers of alluvial deposits.

### 2.11.4 Management Recommendations

Nearby evidence of cultural resources in the form of shell middens are possible indicators that other archaeological and cultural resources may be discovered during the final engineering and construction phases of the project. The management recommendations are based on the preliminary data retrieved from observing geoprobe explorations and understanding of archival research findings for the project area, including:

- Additional testing, observation, reporting and consultation with the tribes and Washington State DAHP should be performed during the final engineering and permitting phase of work to comply with NHPA, Section 106 consultation requirements.
- If protected cultural resources are uncovered (or anticipated based on additional testing and observations), development of a mitigation plan and consultation with the project's lead agency and the Washington State Department of Archaeological and Historic Preservation will be necessary.
- In the event that any ground-disturbing activities or other project activities related to this development or in any future development uncover protected cultural material (e.g., bones, shell, stone or antler tools), all work in the immediate vicinity should stop, the area should be secured, and any equipment moved to a safe distance away from the location. The project manager should contact the landowner; the Department of Archaeology and Historic Preservation; Dr. Robert Whitlam ([360] 586-3080), the Swinomish Indian Tribal Community Cultural Resources Planner, Mr. Larry Campbell ([360] 466-1236); and a professional archaeologist to help determine the appropriate management protocol for the cultural material.
- In the case of an unanticipated discovery of human remains, the project manager or landowner will cease excavation, secure the area, and contact the Skagit County Sheriff's office ([360] 336-9431) and the Skagit County Coroner, Daniel Dempsey, ([360] 336-9431) to determine if the remains are forensic. If the remains are not forensic, the Department of Archaeology and Historic Preservation State Physical Anthropologist, Guy Tasa ([360] 586-3534) will take the lead on the management of the remains.

## 2.12 Environmental Pollution and Hazardous Waste Contamination

A level one, environmental site assessment was performed by Nowicki and Associates in 1995 as part of the real estate acquisition process for establishing the reserve. The following is the executive summary from the Nowicki report:

> *A regimen of site reconnaissance, comprehensive research, lead-based paint testing, bulk asbestos analysis and preliminary soil*

> *testing (Total Petroleum Hydrocarbon [TPH]) revealed minimal environmental degradation. Surficial (6"-12") soil analysis revealed no contamination. Lead-based paint is present on the building exteriors and in the main residence. Asbestos is present in the exterior wall shingles of the main residence and the adjacent cabin (this will have to be removed prior to demolition). Considerable lead shot is likely present throughout the southern portion of the parcel. Beyond these items, nothing was identified to merit additional environmental investigation.*

The report refers to a main residence, two cabins, two barns, a garage, and a trailer. The Nowicki Report recommended demolition and removal of these structures. These structures were primarily located at and near the WDFW Fir Island Farm parking area and have since been removed. The only identified remaining structure was the hunting trailer, which is still located near Claude O. Davis Slough. The trailer will need to be demolished and removed during project construction.

The only other finding was that the original Fir Island Farm property was leased by a duck hunting club. The investigator assumed that there may be a large amount of lead shot in the southern portions of the farm (near the existing dike) that could pose soil, water quality and bio-accumulation issues if ingested by waterfowl. For lead shot to contaminate water quality, the lead would need to be exposed and subjected to acidic water. Another exposure pathway is through ingestion by waterfowl or other animals. Lead shot located in deposition environments can become buried, thereby limiting the availability to wildlife. To date, WDFW has not reported incidents of Snow Goose (or other waterfowl and wildlife) mortality that could be associated with lead shot poisoning, after 15 years of operating the reserve. Setback of the dike will inundate the area, creating sedimentation and establishment of native vegetation which will likely reduce the potential exposure to waterfowl and wildlife for lead shot contamination. Some minor areas with increased erosion (such as those near the tidal channel dike breaching areas) could mobilize the lead shot. Therefore, we recommend sizing the tidal channel area breaches in a stable width and configuration to minimize erosion and reduce the likelihood of lead shot mobilization.

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# 3.0 PROJECT ALTERNATIVES ANALYSIS AND PREFERRED PLAN

An alternatives analysis was performed for the project that evaluated various dike setback configurations and replacement of existing tidegates with SRTs on each of the Dry, No-Name/Claude O. Davis, and Brown Sloughs. This section of the report describes the evaluation process of the seven alternatives and presents the selection of the preferred restoration plan.

## 3.1 Project alternatives, concept design features and cost estimates

Seven restoration concept design alternatives have been developed for the project (Figures A-31 through A-34). Technical Memorandum 2.1 contains detailed descriptions of each alternative, design assumptions, and cost estimates (Appendix B). Alternative 0 is the No-Action, baseline condition. Alternatives 1 through 3 include dike (levee) setbacks to restore current farm areas back to saltwater tidal marsh. Alternatives 4 through 6 involve replacement of existing top-hinged tidegates with side-hinged, SRT structures, and construction of low-lying berms around the interior drainage "sloughs," to allow for partial tidal inflow to interior drainage channels and marsh areas next to Dry Slough.

The dike setback concept design Alternatives 1 through 4 each have the following project elements:

- New dike setback – Various setback alignments and lengths for a 10- to 12-foot-high dike.
- Existing dike removal and borrow ditch fill – Assume filling of all borrow ditches adjacent to existing dike (both on the bay side and landward of the dike).
- Interior drainage tidegates and pipe replacement(s) – Assumes replacement of existing tidegates and pipes at new location along existing drainages.
- Interior drainage storage pond north (inland of new dike) as mitigation for storage losses – Assumes replacement of existing interior drainage channels that will be moved outside the new dike setback.
- Flood return structure (Option) – Assumes inclusion of additional tidegates (floodgates) to allow for increased discharge and drainage to Skagit Bay to drain more quickly the Fir Island interior flooding areas.
- Parking lot and trail relocation – Assumes moving parking lot and trail north for Alternative 1 only. All other alternatives maintain existing parking lot and trail.

The SRT concept design Alternatives 4 - 6 each have the following project elements:

- Existing tidegate removal and replacement with SRTs.
- Berm construction – Assumes short berms (3 feet to 4 feet high) extending inland along margins of slough(s) to provide storage and habitat areas for SRT tidal inflow.
- Interior drainage storage ponds – Assumes replacement of existing interior drainage channels that will be located outside the new dike after it is set back.

General descriptions of the six alternatives are as follows:

- Alternative 0 (No Action): This alternative represents the baseline, existing conditions including tidal marsh, tidal channels, interior drainage channels, farm areas, levees, and parking areas.
- Alternative 1 includes the following features:
  - Setback length: 8,600 feet along east side of Dry Slough, follows existing drainage west to access road, and ties into and repairs existing section of old dike along Brown Slough.
  - Removal and borrow ditch fill length: 4,500 feet between new dike setback points.
  - Tidal marsh area restored: 203 acres of farmland and dike removal areas restored back to tidal marsh.
  - Interior drainage storage pond (mitigation): 6.9-acre storage pond located north of dike setback (shown as drainage, but measured as new habitat channels in Figures A-31 through A-34).
  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along No-Name Slough and Dry Slough.
  - Floodgate option included in concept design.
  - Relocation of parking area and trail.
- Alternative 2 includes the following features:
  - Setback length: 7,360 feet along east side of Dry Slough, crosses site to west midway along site and towards existing parking areas, and ties into existing levee near Brown Slough tidegate complex.
  - Removal and borrow ditch fill length: 4,500 feet between new dike setback points.
  - Tidal marsh area restored: 145 acres of farmland and dike removal areas restored back to tidal marsh.

  - Interior drainage storage pond (mitigation): 6.3-acre storage pond located north of dike setback (shown as drainage, but measured as new habitat channels in Figures A-31 through A-34).
  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along No-Name Slough and Dry Slough.
  - Floodgate option included in concept design.
  - No relocation of parking area and trail.
- Alternative 2a includes the following features:
  - Setback length: 5,542 feet along west side of Dry Slough (to minimize impacts to Dry Slough and Hayton Farm), crosses site to west midway along site and toward existing parking areas, and ties into existing levee near Brown Slough tidegate complex.
  - Removal and borrow ditch fill length: 4,064 feet between new dike setback points.
  - Tidal marsh area restored: 127 acres of farmland and dike removal areas restored back to tidal marsh.
  - Interior drainage storage pond (mitigation): 3.4-acre storage pond located north of dike setback (shown as drainage, but measured as new habitat channels in Figures A-31 through A-34).
  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along No-Name Slough (no replacements for Dry Slough).
  - Floodgate option included in concept design.
  - No relocation of parking area and trail.
- Alternative 3 includes the following features:
  - Setback length: 8,200 feet along west side of Dry Slough (to minimize impacts to Dry Slough and Hayton Farm), crosses site to west midway along site and toward existing parking areas, and ties into existing levee near Brown Slough tidegate complex.
  - Removal and borrow ditch fill length: 2,500 feet between new dike setback points.
  - Tidal marsh area restored: 72 acres of farmland and dike removal areas restored back to tidal marsh.
  - Interior drainage storage pond (mitigation): 4.8-acre storage pond located north of dike setback (shown as drainage, but measured as new habitat channels in Figures A-31 through A-34).

  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along No-Name Slough and Dry Slough.
  - Floodgate option included in concept design.
  - No relocation of parking area and trail.
- Alternative 4 includes the following features:
  - SRT installation: Two 48-inch MTR gates at mouth of Dry Slough replacing existing gates.
  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along Dry Slough.
  - Berm: Construction of berm along Dry Slough up to WDFW property line.
- Alternative 5 includes the following features:
  - SRT installation: Two 48-inch MTR gates at mouth of Claude O. Davis Slough replacing existing gates.
  - Tidegate replacement: Two 48-inch, top-hinge flapgate replacements along Dry Slough.
  - Berm: Construction of berm along Claude O. Davis Slough at end of visible slough.
- Alternative 6 includes the following features:
  - SRT installation: Three 48-inch MTR gates at mouth of Brown Slough replacing existing gates.
  - Tidegate replacement: None – existing gates at Fir Island Road on Brown Slough.
  - Berm: None – Berm not needed as SRT tidal inundation area bordered by existing CDD#22 dike.

Project concept design alternative cost estimates were developed for each of the six new construction alternatives (Table A-5). A detailed summary of the cost estimate assumptions is included in Technical Memorandum 2.1 (Appendix B). The following summary of pertinent cost estimate assumptions:

- Quantity takeoffs were determined using end-area methods for all major earthwork items, and not digital terrain modeling.
- The concept design cost estimate uses 2011 RS Means unit prices unadjusted for location, and/or average unit price costs for the Fisher Slough project bids from April 2010.

- A 7.8 percent sales tax was applied to the construction costs.
- Construction contingencies for this phase of study were assumed to be 25 percent for construction plus an additional 15 percent change order construction contingency.
- Project costs include the following:
  - Construction costs
  - Real estate costs including NAWCA reimbursements, adjacent land purchases, and easements
  - Engineering design costs assumed 8 percent of construction cost
  - Permitting costs assumed 2 percent of construction cost
  - Project administration of engineering and permitting assumed to be 10 percent of engineering and permitting costs
  - Construction oversight and administration costs assumed to be 10 percent of construction costs

We note that cost estimates for concept design Alternatives 1 through 6 use similar unit price estimates and quantity takeoff calculation methods and are only for comparison purposes. Cost estimate project quantities, unit prices, and contingencies were updated for the preferred restoration alternative as presented in later sections of the report.

### 3.2 Marsh Vegetation Response Analysis Methods of the Alternatives

A preliminary analysis was performed to understand the likely areas of mudflats and low and high marsh vegetation for Alternatives 1 through 4 (not including 2a which was developed later in the project). Elevations used to estimate these areas were selected from Skagit Delta Vegetation Monitoring Data (Hood, 2009) and field observations made at the site's existing tidal marsh areas. Mudflat vegetation line was selected at 5.5 feet NAVD88 based on field observations made along Brown Slough. Low marsh elevations were selected from 5.5 to 7 feet NAVD88, with high marsh elevations from 7 to 9 feet NAVD88 (Figure A-35 and A-38). It is noted that the vegetation types shown in the figures are for select data plot information only and do not represent all types of vegetation that could become established at the site. For instance, the data plots shown in the figures for high marsh do show not narrow leaf cattail (*Typha angustifolia*, OBL), but it does occur in other high marsh areas and could become established in the new marsh setback areas. More discussion of this is included in the marsh effects section of the preferred restoration plan.

### 3.3 Tidal Channel Response of the Alternatives

Predictions of the estuarine channel area for each restoration alternative were calculated with the application of a model to predict the formation of new channels on the marsh plain in combination with a delineation of the channels that exist currently. Each alternative was evaluated for the total predicted channel area of their entire post-restoration footprint as described below. Additionally, the components of each alternative landward of the dikes and seaward of the dikes were evaluated separately in order to illustrate that the benefits of marsh plain restoration extend beyond the restoration site.

Hood (2004) demonstrated that the marsh plain area benefitting from an estuary restoration action extends beyond the restoration site footprint. Modeling of the channel formation response of marsh habitat restoration has shown that channel formation is related disproportionately to the size of restoration area. In other words, a large marsh plain restoration will create and maintain a greater channel/marsh ratio than a small marsh plain restoration (and existing marsh areas will have increased channel areas).

The Fir Island Farms site is located just outside of the area described by Hood (2007) as Skagit River South Fork marsh in the area referred to by Hood as the Bay Fringe. Measurements of an existing tidal marsh channel surface area were performed on a channel just southeast of the site near the mouth of Dry Slough. The results indicated that the South Fork regression is appropriate to predict tidal channel response.

For each alternative three factors were used to estimate the predicted channel formation response including (Figure A-39); restored farm area landward of the dikes (not including channels); area of existing channels landward of the dikes; area of vegetated marsh seaward of the dikes.

Using the model described above, a value was calculated for the channel formation expected from the entire project alternative site, including restored tidal areas landward of dikes and the existing tidal marsh areas seaward of dikes, combined, and not including the landward channel areas. The resulting tidal channel area estimate was added to the area of existing channels landward of dikes for a total gross channel area for each alternative. The net (restored) tidal channel area was then calculated by subtracting the existing channels seaward of the dikes from the gross channel area for each alternative.

Existing channels were delineated from an aerial photo using a geographical information system (GIS). The aerial photo was taken in the spring of 2007 (March – April) with a resolution of one foot. Borrow ditches (ditches along the dikes excavated to provide dike material) were excluded

from the channel area. Marsh area was calculated with GIS; area landward of the dikes reflects the proposed setback scenario for each alternative. Area seaward of the dikes was delineated by identifying the most seaward extent of the marine vegetation and then calculating the area between the "vegetation line" and the existing dikes. The area associated with Brown Slough upstream of the Brown Slough tidegate complex was considered marsh area seaward of the dikes.

Existing channels landward of the dikes are the remnants of former distributary channels. While it is acknowledged that these channels are larger than what can be formed and/or maintained by tidal hydrology alone, it was assumed that due to the lack of a sediment source, the channels would remain in their post-project construction configuration for the indefinite future. Therefore the existing channels were added to the balance of total expected channel area resulting from the marsh restoration. The decision to use the existing channels in this way was made partially in response to the need to determine the relative contribution of alternatives that focus on the restoration of tidal processes using SRTs to existing channel areas only (Alternatives 4, 5, and 6). While it is acknowledged that this method may not be a precise representation of the expected benefits from the tidal marsh restoration, the calculations are valuable for determining the relative habitat benefit among alternatives.

In addition, in order to account for the limitations of channel habitat formation upstream of self regulated tidegates and the Brown Slough tidegate complex, a simple modifier was used. It was assumed that the restricted tidal exchange allowed by a SRT limits the formation and maintenance of tidal channels; therefore, the predicted channel area was reduced by applying a modifier of 50 percent. While there is no SRT at Brown Slough, the open culvert in the tidegate complex is restricted hydraulically and is assumed here to have an effect similar to a SRT.

The net expected tidal channel benefit for each alternative was determined as follows:

Net tidal channel benefit = estimated new channel formation +
existing channels landward of dikes* – existing channels seaward of dikes*

* A modifier was applied to areas upstream of proposed SRTs and for the existing channels upstream of the Brown Slough tidegate complex.

### 3.4 Smolt Production Analysis Methods for the Alternatives

Ed Connor with Puget Sound Energy employed two methods to estimate the number of Chinook smolts that would be produced by the different restoration alternatives. The first was the model described in the Skagit Chinook Recovery Plan for estimating the carrying capacity of juvenile

Chinook for the Skagit freshwater Delta and estuary (Greene and Beamer, 2005). In reviewing this method, he found that the Skagit Chinook Recovery Plan model accurately predicted juvenile Chinook densities in disturbed habitat areas where tidal and riverine flows were restricted, and in freshwater tidal habitats in the upper Skagit River Delta. However, he found that this model substantially underestimated juvenile Chinook densities in undisturbed habitats of the lower Skagit River Delta, including the estuary areas located at the lower end of the North and South Fork Skagit, and undisturbed habitats along the front of Skagit Bay.

Ed Connor developed an alterntative method to estimate juvenile Chinook densities in natural and restored estuary habitats in the lower Skagit River and along Skagit Bay. This method was developed as the "reference site model," since it uses Chinook densities measured by SRSC in 2003 (Beamer and others, 2005) at five undisturbed estuary sites located at the lower end of the North and South Fork Skagit River.

### 3.4.1 Skagit Chinook Plan Model

The Skagit Chinook Plan model is based upon two statistical relationships, the first between juvenile Chinook densities and four habitat variables, and the second between an index of these four variables and habitat connectivity. The variables used in the first relationship were discharge, water temperature, salinity, and tidal drop, and these were measured along with juvenile Chinook densities at six study sites in the Skagit Delta and estuary between 1992 and 2002. These four habitat values together explained 36 percent of the variation observed in juvenile Chinook densities among the six sites.

The second statistical relationship showed that the habitat index (combination of discharge, water temperature, salinity, and tidal drop) was significantly correlated with "connectivity," an index of channel distance and branching developed for the Skagit Chinook Recovery Plan (Beamer and others, 2005). The connectivity index combines the distance downstream from Skagit forks (confluence of North and South Fork Skagit) and the amount of channel branching at a given point in the Delta. Connectivity values decrease as the distance from the Skagit Forks increases, and the amount of Delta branching becomes greater. The connectivity index was found to explain 80 percent of the variation found in the habitat index.

The first relationship (juvenile densities versus habitat index) was then mathematically combined with the second relationship (habitat index versus connectivity index) to produce a composite statistical relationship between juvenile densities and connectivity. Connectivity explained 29 percent of the variability in juvenile Chinook observed at the six study sites (i.e.,

0.36 for first relationship multiplied by 0.80 for second relationship). The Skagit Chinook Plan model thus assumes that juvenile Chinook densities increase with increasing connectivity (Beamer and others, 2005). The model predicts that Chinook juvenile densities would be highest in the upper freshwater areas of the Delta near the Skagit Forks, and would progressively decline in a downstream basis as the distance from the forks became greater and as Delta channels become more and more branched. This relationship might be expected provided that number of outmigrating fry was limited, and assuming that access to habitats became more difficult with increasing distance and channel branching.

The carrying capacity of juvenile Chinook salmon was then estimated for the freshwater tidal and estuary habitats found in the Skagit Delta. The carrying capacity value is an estimate of the maximum density of juveniles that could be attained given that the number of fry entering the Delta was not a limiting factor (this would be expected in good spawning years). Competition for limited food resources was considered to be the most likely factor controlling the maximum density of juveniles in the Skagit Delta (Greene and Beamer, 2005). The maximum density of juvenile Chinook for both freshwater Delta and estuary habitats was calculated to be 1.31 juvenile Chinook per cubic meter. The equation used to predict the carrying capacity of juvenile Chinook based upon local connectivity index values was:

$$\text{Density (fish/m3)} = 2.718^{(-1.648 - 0.751 * (-1.345 * \ln(\text{Connectivity}) - 4.298) + 1.31)}$$

The density value predicted by this equation was then converted from a volumetric measure to an area measure by multiplying the value by 0.64 meter, the average depth of habitat assumed for the Skagit Delta (Beamer and others, 2005). This density value was then multiplied by the time period in which the Delta is used by juvenile Chinook (150 days), and then divided by the average residency period of an individual fish (35 days), to estimate the total number of smolts produced per square meter of habitat.

### 3.4.2 Reference Site Model

A validation review of the Skagit Chinook Plan model was completed by comparing densities measured at 11 sampling sites by SRSC in 2003 with the densities predicted at each site by the model. We found that the model accurately predicted densities in the freshwater areas of the upper Skagit Delta, and in disturbed (hydromodified and partially isolated) estuary habitats. The Skagit Chinook Plan model underestimated densities in undisturbed estuary and freshwater tidal sites located at the lower end of the Skagit River Delta. The model predicted densities

between 0.2 and 0.4 juveniles per square-meter in these areas, while the actual densities measured in 2003 were between 0.9 and 1.3 juveniles per square meter.

A simple reference site model was developed for predicting the density of juvenile Chinook for natural and restored habitats in Skagit estuary habitat areas, including the Fir Island Farm project areas. Average juvenile density values we used as measured by the SRSC in blind channels at four estuary sites in the lower Skagit River Delta in 2003 (Ika, Catttail Slough, Freshwater Pond, and Tom Moore Slough). The average density of juvenile Chinook measured in these channel areas was 1.1 fish per square meter of channel (4,452 fish per acre). This density value is expected to be fairly close to the carrying capacity value for these habitats, since fry outmigrant numbers estimated at WDFW's smolt trap in 2003 were relatively high (greater than 4,500,000 outmigrants).

The estimated density for estuary habitats was multiplied by 150 (total days of estuary habitat use by juvenile Chinook), and then divided this by 35 (average estuary residency of individual juvenile Chinook) to calculate the annual Chinook smolt production, as a function of tidal marsh channel habitat, for each of the restoration alternatives at the Fir Island Farm project under restored conditions.

## 3.5 Alternatives analysis

In performing the alternatives analysis, WDFW, the Steering Committee and the Consultant developed a series of metrics that were used to measure the benefits and effects of each alternative and for comparison purposes. The metric definitions are included below in Section 3.5.1. These metrics were then combined into prioritization groups and evaluated as described in Section 3.5.2.

### 3.5.1 Restoration Alternative Metric Definitions

Each individual metric used in the alternatives analysis has a specific definition as listed below. Each metric is a numerical, calculated output with specified (units of measure in parentheses). The metric quantities calculated for each of the Alternatives 1 through 5 are included in Appendix A, Table A-6.

1. Total Project Site Footprint (acres): The area of the project site equal to the sum of the area of the levee footprint, habitat channels, tidal marsh, and area of the drainage storage.

2. Total Converted Farmland (acres): The farmable area of each restoration alternative that is converted to a use other than farming, i.e., new dike footprint, new drainage storage, new tidal marsh habitat, existing channels, existing wetlands, and existing dikes.

3. Total Converted WDFW Farmland (acres): The farmable area of WDFW's Fir Island Farm for each restoration alternative that is converted to a use other than farming, new dike footprint, new drainage storage, new tidal marsh habitat, existing channels, existing wetlands and existing dikes.

4. Total Converted Private Farmland (acres): The farmable area of the Hayton Farm for each restoration alternative that is converted to a use other than farming, new dike footprint, new drainage storage, new tidal marsh habitat, existing channels, existing wetlands and existing dikes.

5. Market Value of Converted Farmland (acres): A present-time estimate of $8,200 per acre for farmland on Fir Island as determined by WDFW's Region 4 Lands Agent multiplied by the Total Converted Farmland Acres.

6. Annual Gross Value of Lost Crop Production (acres): The average market value of a mixed agriculture crop typical of Fir Island multiplied by the Total Converted Farmland Acres based on an estimated annual per acre crop production of $2,593.

7. Tidegate Fish Agreement Credits (acres): The Implementation Agreement for the Skagit Tidegate Fish Initiative establishes one credit for each acre to which tidal inundation is restored. The credits are available to the participating Skagit drainage and diking districts to offset NOAA fish passage requirements associated with district tidegate and floodgate repair and replacement.

8. Total Length of New Flood Dike (feet): Total length of new flood dike or flood berm that would be constructed for each alternative.

9. Restored Tidal Marsh Habitat (acres): The area of each restoration alternative that is tidally inundated.

10. Restoration Cost Per Acre Tidal Marsh Restored (acres): For each restoration alternative, The Total Restoration Cost (33) is divided by the Restored Tidal March Habitat (9).

11. Low Tidal Marsh Habitat Restored (acres): The area of the restored tidal marsh with a bed elevation that will support low marsh vegetation species.

12. Net Restored Channel Area Combined – South Fork Regression (acres): The predicted restored channel area calculated for the area landward and seaward of the existing dikes combined as calculated with the south fork regression model as described in Hood (2007) minus the modified baseline channel area seaward of the existing dikes.

13. Chinook Smolts Produced Annually – Chinook Model (number of fish): The number of Chinook smolts produced per year as predicted by the Skagit Chinook Model (Beamer and others, 2005) for the net channel area that is restored under each alternative. The smolt production estimates for the restoration alternatives that provide fish access via an SRT were reduced by 50 percent to account for restricted access.

14. Chinook Smolts Produced Annually – Reference Site Model (number of fish): The number of Chinook smolts produced per year as predicted by the Reference Site Model for the net channel area that restored under each alternative. The smolt production estimates for the restoration alternatives that provide fish access via an SRT were reduced by 50 percent to account for restricted fish access.

15. Chinook Smolts Produced Annually per Acre Converted Farmland (fish/acre): The Chinook Smolts Produced as determined by the Reference Site Model (14) divided by the Total Converted Farmland Acres (2). The smolt production estimates for the restoration alternatives that provide fish access via an SRT were reduced by 50 percent to account for restricted fish access.

16. Restoration Cost Per Chinook Smolts Produced – Reference Site Model – 50 Years (cost/fish/50 years): For each restoration alternative, the total cost of restoration (33) is divided by the Chinook smolts produced annually as predicted by the Reference Site Model (14). The result of this calculation is then divided by 50 to provide an annual rate.

17. Adult Chinook Produced Annually– Chinook Model (fish/year): For each restoration alternative, the Chinook smolts produced annually as predicted by the Chinook Model (13) is multiplied by the average smolt to adult survival estimate used to predict annual Chinook adult returns.

18. Adult Chinook Produced Annually - Reference Model (fish/year): For each restoration alternative, the Chinook smolts produced annually as predicted by the Reference Site Model (14) is multiplied by the average smolt to adult survival estimate used to predict annual Chinook adult returns.

19. Restoration Cost per Chinook Adult Produced – Reference Site Model – 50 Years (cost/fish/50 years): For each restoration alternative, the total cost of restoration (33) is divided by the Chinook adults produced annually (18) using the Reference Site Model and then divided by 50 to provide an annual rate.

20. Snow Goose – WDFW Total Winter Forage Area Lost (acres): Total cover crop acreage removed per each restoration alternative at WDFW's Fir Island Farm. Same as Total Converted WDFW Farmland acres.

21. Snow Goose – Hayton Total Winter Forage Area Lost (acres): Total WDFW cover crop acreage removed per the restoration alternative multiplied by 1.86.

22. Snow Goose – WDFW Total Winter Forage Caloric Lost (Kcal): The total caloric loss (Kcal) associated with the winter forage production for each restoration alternative at WDFW's Fir Island Farm. Calculation: # acres lost per Alternatives 1 through 5 x 1,600 (# pounds forage per acre) = A (Total pounds forage per acre (Alternatives 1-5), A (Total pounds forage per acre – Alternatives 1 through 5) x 453.6 (grams per pound) = B (Total grams per acre – Alternatives 1 through 5), B (Total grams per acre – Alternatives 1 through 5) x 2.4 (Kcal per gram) = C (Total Kcal forage per acre – Alternatives 1 through 5).

23. Snow Goose – Hayton Total Winter Forage Caloric Lost (Kcal): The total caloric loss (Kcal) associated with the winter forage production lost per each restoration alternative at the Hayton Crop Farm. See metric 22 for an example of how caloric loss is calculated.

24. Snow Goose – WDFW Total Number Snow Goose Supported (number of Snow Goose): The number of Snow Goose supported by the caloric (Kcal) lost per each restoration alternative at WDFW's Fir Island Farm (26). Calculation: (# acres – Alternatives 1 through 5) x 1600 (# pounds forage per acre) = A (Total pounds forage per acre per Alternatives 1 through 5), A (Total pounds forage per Alternatives 1 through 5) x 453.6 (grams per lb) = B (Total grams per # acres – Alternative 1s through -5), B (Total grams per # acres Alt 1-5) x 2.4 (Kcal/gram) = C, (614 Kcal per day/per bird, 197 days per winter season), 614 Kcal x 197 days = D (Total Kcal per bird/per season), C = (Total Kcal per # acres – alt 1-5) divided by D ( Total Kcal per bird/per season) = Total # birds supported (Alternatives 1 through 5).

25. Snow Goose – Hayton Total Number Snow Goose Supported (number of Snow Goose): The number of Snow Goose supported by the Kcal lost per each restoration alternative at the Hayton Crop Farm. See metric 24 for an example of how the number of Snow Goose supported was calculated.

26. Snow Goose – WDFW Lost Lease Revenue – WDFW Only (number of Snow Goose): The total lease revenue lost per total farmed acreage taken out of production at WDFW's Fir Island Farm for each alternative. Lost revenue projections include Lease Holder excise tax (L&E) assessments and deduct a $10,000 credit (based upon a $50 per acre x 200 acre rebate designed to compensate the lessee for the cost of seed and planting). The current lease rate for WDFW owned agricultural land is $225 per acre.

27. Snow Goose – WDFW Lost Lease Revenue – WDFW + Hayton (number of Snow Goose): The total lease revenue lost per total farmed acres taken out of production at WDFW's Fir Island Farm plus the lands taken out of production on property owned by HCF. As part of the initial bid for the lease option at WDFW's Fir Island Farm, HCF offered to include 290 acres of adjacent HCF farm acreage into the Snow Goose Reserve and plant this 290 acres and an additional 110 acres leased by HCF to winter wheat for a total of 400 acres. For every leased acre of farmland on

WDFW-owned lands, HCF contributes 1.86 acres of winter forage. For every acre taken out of production at WDFW's Fir Island Farm per each of the restoration alternative, 1.86 acres of winter forage on HCF are also lost.

28. Snow Goose - NAWCA Reimbursement Cost (dollars): The total dollars required to reimburse the NAWCA funding that was used to originally purchase WDFW's Fir Island Farm for winter forage habitat is the present time estimate of $8,200 per acre for farmland on Fir Island as determined by WDFW's Region 4 Lands Agent multiplied by the Total Converted WDFW Farmland Acres.
29. Public Access (N/A): The extent to which the existing public access, parking and wildlife viewing opportunities at WDFW's Fir Island Farm will be maintained or altered as a result of each restoration alternative.
30. Capital Cost of New Drainage/Flood Infrastructure (dollars): Capital costs associated with construction of the new flood dikes, augmented flood dikes and drainage infrastructure (culverts, tidegates, SRTs, interior drainage storage, dredging, grading, with 25 percent contingency).
31. Real Estate Acquisition, Easements, NAWCA Costs (dollars): Capital costs associated with NAWCA Reimbursement Cost, Real Estate Acquisition for Adjacent Properties, Construction Easements.
32. Engineering, Permits, Administration, Construction Oversight (dollars): Capital costs associated with engineering design, permits, project administration, and oversight during construction.
33. Total Restoration Cost (dollars): The sum of Construction Capital Costs, Real Estate Capital Costs, Project Design, Permits, Administration and Oversight Capital Costs.

### 3.5.2 Guiding Priorities Alternatives Screening

A set of guiding priorities were developed for the project by WDFW and the Steering Committee. These guiding priorities used the framework of project restoration goals, with some modification and additions, and grouped restoration goals into similar, representative categories. Group appropriate evaluation metrics (criteria) were then assigned to each priority group. The following is a list of guiding priority groups, project restoration goals, and associated evaluation metrics used as rating criteria for each alternative. During the evaluation process, it became apparent that Alternative 6, Brown Slough Tidegate Replacement with an SRT, was not a viable option, and is therefore not evaluated with the remaining Alternatives 1 through 5. The bullet and check marks listed below refer to study goals and the corresponding evaluation metrics used to evaluate those goals.

- ▪ Study Goals
- ✓ Evaluation Metric

**Restore Ecosystem Health**

- ▪ Restore tidal flooding (natural process).
- ▪ Restore unrestricted movement of water, sediments, nutrients, detritus, and organism.
- ▪ Restore native tidal marsh habitat.
- ▪ Restore tidal channel habitat.
- ✓ Maximize tidal marsh restoration (acres)
- ✓ Maximize tidal channel restoration (acres)

***while:***

**Balancing Natural Resources**

- ▪ Restore fish passage.
- ▪ Restore estuary rearing habitat for ESA-listed species.
- ▪ Restore estuary habitat for fish and wildlife species.
- ▪ Maintain Snow Goose management capabilities.
- ✓ Maximize Chinook smolt production.
- ✓ Maximizes Chinook smolts per acre converted farmland.
- ✓ Minimize Impacts to WDFW Snow Goose forage area.
- ✓ Maximize low tidal marsh habitat restored (Snow Goose forage).

**Respecting Local Agriculture**

- ▪ Minimize impacts to adjacent private landowners.
- ▪ Maintain or improve the existing drainage, salt intrusion protection, and flood protection.
- ✓ Minimize private farmland conversion.
- ✓ Minimize annual gross value of lost crop production.
- ✓ Minimize risks to existing drainage of CDD#22.
- ✓ Minimize total length of new flood dike.
- ✓ Maximize Chinook smolts per acre converted farmland.
- ✓ Maximize tidegate fish initiative credits.

**Maintaining Public Access**

- ▪ Maintain a public parking area.
- ▪ Maintain public uses.
- ✓ Maintain parking area.
- ✓ Maintain dike top trail.
- ✓ Maintain Snow Goose/wildlife viewing opportunity.

**Social-Political Factors**

- ✓ WDFW future drainage and flood liabilities.
- ✓ CDD#22 Dry Slough drainage impacts.
- ✓ CDD#22 legal consent decree.
- ✓ Snow Goose reserve functions.
- ✓ Hayton family farm impacts.

It is noted that Social-political Factors evaluation criteria do not have specific numerical values that can be determined. Risks and impacts were evaluated for each social-political criterion using a high (+0 point), medium (+10 points), and low (+20 points) (risk or impact) assessment of the criteria. The maximum value is 100 points (20 points multiplied by 5 criteria) for this priority group, similar to the others.

An example is evaluation of the risk for future drainage and flood liability. There are concerns that full restoration of Dry Slough will significantly reduce interior drainage storage that cannot be mitigated for with additional interior drainage storage. If impacts occur (or are perceived to occur), work in the drainage system will have long-term residual risks to WDFW for maintaining the interior drainage system. Therefore, alternatives that do not restore Dry Slough or remove significant interior drainage storage areas will have a lower risks and receive higher scores for future drainage and flood liabilities.

The following method was used for scoring the evaluation criteria and priority group, and ranking the alternatives.

- Each prioritization group has a total maximum score of 100 points.
- Total available points for any alternative is 500 points (5 criteria x 100 points each).
- The evaluation criteria within each prioritization group were normalized such that the maximum total for any summation set of evaluation criteria is 100 points. If there are four evaluation criteria assigned to a prioritization group, then each criterion can have a maximum point total of 25 points, which when added together would equal 100 points. If there are only two evaluation criteria, then each would have a maximum of 50 points.
- Normalization of each criterion is performed as follows:
- For maximize type scores – divide the criteria output (such as acres or fish) by the maximum output in the category to normalize. Then multiply by 100 points divided by the number of criteria in the prioritization group.

- For minimize type scores – divide the minimum criteria output total by the alternative criteria output. Then multiply by 100 points divided by the number of criteria in the prioritization group.
  - Ranking was performed using the following approach.
  - Ranking is based on a simple 1 through 6 with a rank of 1 being the best and rank of 6 being the worst.
  - Each alternative was ranked based on the highest total score for each prioritization group.
  - Alternatives were ranked using two methods:
    - Alternatives were ranked based on the total scores of criteria 1 through 5.
    - Alternatives were ranked based on the average ranking of prioritization group rankings 1 through 5.

Table A-7 shows the ranking of Alternatives by prioritization group.

Using the prioritization ranking process, the preferred alternative recommendation is Alternative 2A. This alternative ranked well for a number of key factors, including:

- Alternative 2A balances a variety of natural resources including fish restoration, farm impacts, and the reserve Snow Goose areas
- Alternative 2A limits the risks and potential impacts associated with the Social-political factors, including impacts to interior drainage storage areas, and impacts to the Hayton Family farm property.

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# 4.0 PREFERRED RESTORATION PLAN IMPLEMENTATION

The following report section provides additional information regarding preliminary engineering design, summary of benefits and effects, outline of a project implementation plan for the preferred restoration plan, Alternative 2A.

## 4.1 Preliminary Design Plans

A preliminary design CAD plan set has been developed for Alternative 2A and is included in Appendix C. The Alternative 2A concept design was further developed into a set of preliminary design plans. The hydrodynamic and interior drainage engineering studies of Alternative 2A were used to refine the design, and to identify remaining design issues that will need to be addressed moving forward into the next Phase 2 – Engineering Design and Permitting. As a result of the baseline studies and subsequent preliminary engineering studies, changes to the concept designs were incorporated into the preliminary design plans, including:

- Pre-excavate tidal marsh channels to provide immediate benefit, and initiate marsh tidal channel development further inward on the newly restored marsh.
- Determine the size of the interior drainage storage pond.
- Floodgate overflow structure for Fir Island flooding is a project option and not fully evaluated.
- Construct the dike setback in two phases:
  - Year 1 – Dike setback construction with tidal marsh channels and interior storage ponds.
  - Year 2 – Native planting irrigation with existing ditch fill and dike demolition.

Other options and contingencies are discussed further in later sections of the report.

## 4.2 Hydrodynamic Modeling and Effects of the Preferred Restoration Plan Preliminary Design

Hydrodynamic modeling was performed for Alternative 2A (Appendix B, Battelle Technical Memorandum 3.2). Large-scale images of Skagit Bay modeling results can be viewed in the technical memorandum, but it is difficult to see the effects at the project scale. A series of modeling run snapshots were made showing the Alternative 2A setback at the project scale (Figures A-40 through A-43). The following observations were made regarding tidal hydrodynamics of Alternative 2A:

- Incoming flood tide velocities were observed greater than 3.3 fps. The velocities will likely exceed the expected erosion and transport threshold for silt and sand bed and marsh materials (typically between 2.0 and 3.0 fps). High velocities occur along the Claude O. Davis and Brown Slough channel inlets to the site. It is anticipated that these tidal channels in these areas will erode and resize to a natural size. It is recommended that Phase 2 engineering design evaluate the need to excavate and resize the channels in the areas of the tidal marsh inlet breaches, and the way a spur dike along the existing dike trail near Brown Slough would perform.
- High tide inundates nearly the entire site with depths of 0.5 to 1.5 feet on the marsh plain surfaces and depths of 5.0 to 6.0 feet in the tidal marsh channels.
- Ebb tides exit through the Claude O. Davis and Brown Slough tidal channels. Velocities are not as high (in general less than 2.0 fps) as the incoming flood tide velocities, and are predicted to be below sediment transport and erosion thresholds. This may indicate that sediment transport is stronger into the site during flood tides than out of the site from ebb tides. The difference in sediment transport capacities between incoming flood and outgoing ebb tides is an indicator that the site will have long-term sedimentation and accretion of the marsh plain. The rate of accretion is dependent upon the sediment supply of material from suspended load in the tidal flows, inward delivery and transport of sediment towards the marsh along the tidal channels, and the amount of existing marsh materials that erode north towards the new restored marsh.
- Low tide hydrodynamic model predictions indicate that northern portions of the marsh will nearly fully drain, and other areas of the marsh near the existing and excavated tidal channels will have ponding on the order of 0.5 to 1.0 feet deep on the marsh and standing water depths of 3.0 to 5.0 feet in the tidal channels.
- Predicted salinities in the newly restored marsh for the spring runoff condition are estimated to range between 0 and 5 ppt, which are low-salinity environments considered high quality for juvenile Chinook migration, feeding, and rearing.

## 4.3 Interior Drainage Modeling and Effects of the Preferred Restoration Plan Preliminary Design

Interior drainage modeling was performed using the results of the hydrodynamic model tidal channel water surface elevation conditions (Appendix B, Technical Memorandum 3.3). The objective of the modeling exercise was to provide a preliminary size recommendation for the interior drainage storage pond, to be located just north of the Alternative 2A dike along the east-west section near the parking lot. A series of modeling runs were made for the analyses:

- Alternative 2A – Evaluate interior drainage storage effects of the preferred restoration plan.

- Alternative 4 – Perform independent evaluation of interior drainage effects of the adjacent Dry Slough SRT tidegate replacement and berm project. This was performed to check if there are any anticipated interior drainage effects from the separate project proposal for Dry Slough.
- Alternative 2A + Alternative 4 – Evaluate the interior drainage storage effects of the preferred restoration plan coupled with the Dry Slough SRT tidegate replacement and berm project.

By including an interior drainage storage pond, the project will mitigate the effects from loss of storage on local drainage conditions (as is demonstrated in Alternative 2A with a 200 foot wide pond). It is noted that additional study, modeling and design is required to finalize the pond and tidegate designs of these structures and current study plans are preliminary only to support the feasibility study.

### 4.3.1 Alternative 2A Interior Drainage Analysis

Alternative 2A interior drainage hydraulic conditions were evaluated using the calibrated project HEC-RAS model for a 25-year rainfall-runoff storm event occurring during spring juvenile Chinook period, using downstream tidal boundary conditions as predicted by the 3D hydrodynamic model. The results of the modeling exercise are shown in Figures A-44 through A-46 and Table A-9 (Appendix A). The focus of the modeling was to evaluate changes in water surface elevations in No-Name Slough at the Fir Island Road crossing.

- Alternative 2A was initially sized as 50-foot-wide, 1,650-foot-long storage pond to match the loss of existing interior drainage storage areas. We modeled this configuration with tidegate connections to the No-Name tidal channel through the dike, and no connection to Dry Slough. Figure A-45 shows that predicted peak water surface elevations for a 25-year storm event are 6.1 feet for the 50-foot-wide storage pond, as compared with 4.4 feet (NAVD88) for the predicted existing conditions. This is an increase in peak water surface elevation of 1.7 feet, indicating an impact to the drainage system.
- Alternative 2A was modified to a 100-foot-wide, 1,650-foot-long storage pond for a second run. Figure A-46 shows that the predicted peak water surface elevation for a 25-year storm event is 5.1 feet for the 100-foot-wide storage pond, as compared with 4.4 feet (NAVD88) for the predicted existing conditions. This is an increase in peak water surface elevation of 0.7 feet, indicating an impact to the drainage system.
- Alternative 2A was modified to a 200-foot-wide, 1,650-foot-long storage pond for a second run. Figure A-47 shows that the predicted peak water surface elevation for a 25-year storm event is 4.4 feet for the 200-foot-wide storage pond, as compared with

4.4 feet (NAVD88) for the predicted existing conditions. This is an increase in peak water surface elevation of 0.0 feet, indicating no effect.

The results indicate that for Alternative 2A a 200-foot-wide by 1,650-foot-long storage pond will be necessary to mitigate the potential effects to interior drainage storage conditions. It is noted that this modeling does not include effects on the storage pond from local tidal, hydrogeologic and groundwater conditions, which could raise local groundwater elevations, reduce the amount of available, "live" storage and require a larger pond. Increasing the size of the pond to accommodate groundwater effects is feasible for this project. It is recommended that the final storage pond size evaluate the localized groundwater effects on the interior drainage storage pond in the Phase 2 Engineering Design and Permitting phase of work.

### 4.3.2 Alternative 4 Interior Drainage Analysis

An independent modeling analysis was performed for Alternative 4 for the Dry Slough SRT project alternative being investigated by others related to the Dry Slough Consent Decree. The model has no connection between the Alternative 2A storage pond and the upstream end of Dry Slough Alternative 4. Figure A-47 and Table A-8 show the results of the modeling analysis (Appendix A). It is noted that a 0.1 foot increase in peak upstream water surface elevations was predicted for the SRT, with tidegate operations set at 7.0 feet NAVD88. This is a minor effect that can be mitigated during design of the structure.

### 4.3.3 Alternative 2A + Alternative 4 Interior Drainage Analysis

Alternative 2A and Alternative 4 were evaluated together to evaluate if the Dry Slough Consent Decree SRT project may have an impact on the Fir Island Farm feasibility study. The model involved running 25-year storm events in No-Name and Dry Sloughs, with a tidegate connection running from the east end of the No-Name storage pond into the upper end of the Dry Slough SRT constructed berm reach. Figure A-48 and Table A-8 show the results of the modeling analysis (Appendix A). It is noted that a 1.3-foot increase in peak water surface elevation is predicted for No-Name Slough and a 0.3 foot increase for Dry Slough when the alternatives are working in tandem. These effects will require mitigation design (and likely coordination) if both projects move forward and have a surface water connection. It is recommended to have a project integration and coordination task to evaluate this concern going forward.

## 4.4 Wetlands Effects

As described earlier, there are three general types of wetlands on and immediately adjacent to the site: estuarine, palustrine, and farmed potential wetlands. The preferred alternative will affect the existing wetlands as shown in Table A-9. Based on our analysis, the effects to wetlands will result in a net gain of 94.2 acres of wetlands (96.1 acres of wetland gain minus 2.9 acres of wetland loss) with 34.9 acres permanent wetland alterations and 9.1 acres of temporary wetland impacts. The majority of the wetland gain (93.2 acres) will occur from the introduction of tidal waters into the proposed estuarine marsh. The cumulative impact of these effects is the net increase of 129.1 acres of new estuarine wetlands within Skagit River delta.

As part of the preferred alternative for the Fir Island Farm Restoration project, there will be unavoidable effects to existing on site wetlands as well as likely incidental alterations to existing off-site wetlands. However, we estimate that the project will result in a net increase of 129.1 acres of estuarine wetland through wetland creation and wetland alteration (e.g., palustrine wetland converted to estuarine wetland).

## 4.5 Vegetation Management

Using species data compiled from our wetland reconnaissance and vegetation assessment as well as those weedy species of concern for WDFW Wildlife Management Areas, we developed general management recommendations for the following list of species in Table A-11.

## 4.6 Fish Habitat Restoration Effects

Nearly all species of salmon use the Skagit Delta estuarine habitats with a majority of migration occurring in the February through August period.

The tidal marsh restoration will provide habitat in the brackish mixing zone of fresh and saltwater that is critical for physiological transition from juvenile to adult life stages between freshwater and saltwater habitats.

The tidal marsh restoration will provide intertidal and shallow subtidal habitats for juvenile salmonids protection and refuge from bird and fish predators and blind channel and side-channel estuary habitats serve as refuge from high water river discharge events.

The tidal marsh restoration will provide plant material detritus, feeding invertebrates, which are juvenile salmonid and forage fish species prey.

A large number of juvenile Chinook salmon moving through the complex distributary network of South Fork Skagit River will head northward along the front of Skagit Bay towards Deception Pass (Beamer and others, 2005). By improving local connectivity to Skagit Bay, and given the proximity of the project to large numbers of fish migrating out of the South Fork Skagit along the Bay Front, the Fir Island Farm restoration project has to potential to significantly improve the estuary rearing capacity of juvenile Chinook in the Skagit River Delta.

The fish habitat restoration benefits of Alternative 2A will provide a net gain in usable tidal channels and marsh areas that will support an estimated 65,000 to 320,000 Chinook smolts annually.

### 4.7 Snow Goose Management Effects

The proposed estuary restoration project will result in the conversion of 130 acres of farmed, winter forage at WDFW's Fir Island Snow Goose Reserve, which roughly correlates to the capacity of WDFW's Reserve to annually support 1,872 snow geese , not accounting for potential feeding in the restored marsh areas. Effects of the proposed estuary restoration project at WDFW's Reserve will be mitigated by the project as follows.

The project includes a proposal by WDFW to NAWCA to offset the converted farmland (WDFW, 2011). In lieu of replacing the converted farmland through new acquisition, WDFW's proposal to NAWCA requests the flexibility to consider an annual lease program managed by WDFW as mitigation for the project. In WDFW's opinion, contracting with local growers on an annual basis for replacement of winter cover crops may be the most practical and cost-effective option and would have the following program elements.

- Short-term (annual) contracts fit well into the business models and market strategies employed by modern day farming operations. Contracts three to five years in duration can be negotiated in some cases without serious complications.
- Working the soil, planting, and crop maintenance obligations remain with the landowner and not WDFW.
- Contracted farming affords wildlife managers the option to link cover crop production with public hunting opportunity on privately owned lands (Snow Goose Quality Hunt Model) or to acquire cover crop in secure status that duplicates reserve conditions (unrestricted access for Snow Goose).
- Contracted farming links the farming community and WDFW in a manner that is both mutually beneficial and that promotes a strong working relationship over time.

- Contract farming could provide a long-term mitigation option with an "added value" component designed into the strategy.

In response to WDFW's request, in a letter dated October 28, 2011 (USFWS, 2011), NAWCA has approved WDFW's proposal to consider an annual lease program as an option for mitigating the farmable acreage converted by the proposed restoration project.

The conversion of 130 acres of farmable acreage at WDFW's Fir Island Farm Snow Goose Reserve also reduces the farmable acreage leased to the Hayton Family Farm. As a consequence, the area of the Hayton Snow Goose Reserve will be reduced by 242 acres, which roughly correlates to a the capacity of the Hayton Reserve to annually support 3,485 snow geese. The annual lease revenues paid to WDFW by the Hayton Family Farm will also be reduced by $25,706.

## 4.8 Agricultural Effects

Implementation of Alternative 2A will result in a net loss of 130 acres of prime farming land on the Skagit Delta. Through the Skagit Delta Tidegates and Fish Initiative Implementation Agreement (WWA,2008), the Skagit delta agricultural community has committed to support restoration of 2,700 acres of delta agricultural lands to estuarine habitat consistent with the Skagit Chinook Recovery Plan (SRSC, 2005). As a result of the project, the Skagit delta drainage and diking districts that are signatory to the Implementation Agreement will receive 130-acres of mitigation credits towards addressing NOAA's fish passage improvement requirements associated with the district's tidegate maintenance activities.

In addition, SCD#22 and the Fir Island community will receive new flood dikes and drainage infrastructure designed to mitigate the effects of the proposed project on existing flood protection and drainage infrastructure.

## 4.9 Public Use and Recreation Effects

Implementation of Alternative 2A will maintain existing access to the site. Recreational viewing opportunities will change in that there will be an increase in native tidal marsh areas on the reserve and a decrease in the area farmed for row crops and snow geese winter forage. Loss of trail, if it occurs, would be mitigated with additional trails and access at the site.

## 4.10 Project Implementation

### 4.10.1 Estimate of Probable Construction Cost

An engineer estimate of probable cost of the preliminary design plan (and quantity takeoff estimate) is included in Table A-12 and A-13, with detailed cost information and assumptions included in Appendix C. The engineer's estimate of cost in 2011 dollars is:

**Phase 2 Engineering Design and Permitting**

- Engineering Design – $1.0M (8 percent of construction)
- Permits - $255k (2 percent of construction)
- Administration for Engineering and Permits – $127k (10 percent of engineering and permits)

**Real Estate Costs**

- Real Estate Costs – $1.1M (including NAWCA Reimbursements and construction easements)

**Construction Costs**

- Construction – $12.8M (including 7.8 percent sales tax, 25 percent cost estimating contingency, and 15 percent change order contingency)
- Construction Oversight (8 percent of construction) – $1.0M
- Project Contingencies – $3.9M

Note: Cost estimates were derived using Fisher Slough, April 2010 unit prices, and RS Means 2011 cost books. Future funding requests should escalate construction and project cost estimates from the basis of cost date to the expected construction date (i.e., from 2010 Fisher Slough bid date to mid-point Fir Island Farm construction 2015). Escalation of 2011 construction costs using an annual 3.0% escalation rate using a 4 year period results in a 2015 construction cost of $14.4M, oversight cost of $1.1M, and contingency cost of $4.4M.

### 4.10.2 Project Contingencies

In addition to the project base cost, an additional $4.0M+ in project contingencies have been identified. These contingencies are for items that may or may not be necessary and without

additional investigation and project coordination the costs for these items will remain in question. It is recommended that each contingency be fully evaluated during final engineering design Phase 2.

- Floodgate structure – CDD#22 has expressed an interest in a new flood flow (floodgate) return structure along the dike near Dry Slough or on No-Name Slough. This structure would allow for improved drainage of the central Fir Island drainage area to Skagit Bay during large Skagit River flood conditions. Inclusion of a new flood return structure in the project is beyond the scope and WDFW's requirements to replace in-kind existing drainage infrastructure and to mitigate for project impacts. Though WDFW acknowledges that there may be an opportunity to include the new structure at the proposed project site, CDD#22 is responsible for the additional engineering, flood/drainage studies and modeling, design, and construction costs of a new flood return structure.
- A pump station is a contingency requested by CDD#22 in case interior drainage systems do not perform as planned. The engineering design and construction costs are likely on the order of $200k - $400k. Long-term maintenance cost requirements also need to be understood, as well as power to the station, repairs, and who is responsible for these costs.
- Seepage design protection – The current study findings indicate that groundwater conditions along the new setback dike setback will have similar seepage conditions to the existing dike conditions with a slightly elevated groundwater elevation next to the dike setback. A project contingency item includes installation of vinyl sheet piles and possible tidegate modifications at a cost of $2M, to prevent underseepage into the adjacent interior drainage storage pond and farms. The project will not likely need sheep pile seepage protection, as initial modeling and design results indicate appropriately sized interior drainage storage pond facilities and new tidegates will mitigate for losses in storage. However, the current feasibility study did not provide a comprehensive hydrogeologic modeling analysis of tidal groundwater seepage and mounding effects on the proposed new interior drainage system. It is therefore recommended to incorporate a hydrogeologic modeling study, coupled with the surface water interior drainage storage pond and tidegate models, to optimize design performance, and to confirm pond sizing and to provide firm documentation that the sheet pile contingency is not necessary. The cost of this study will likely be on the order of $100k to $150k. Performing the hydrogeologic modeling study will provide information on whether or not the $2M sheet pile contingency is necessary. Performing the study, and providing comprehensive documentation, could also reduce the risks for future groundwater and interior drainage and seepage claims by others.
- The Brown Slough west levee has been identified as needing additional rock repairs. Phase 2 of the project will evaluate the effects on the west dike by running the 3D

hydrodynamic model with and without a spur dike to evaluate effects on Brown Slough rock protection. If rock protection is a mitigation requirement, then an additional construction contingency of $200k for additional rock has been included.

- The Brown Slough tidegate log boom is damaged and needs repair. CDD#22 has indicated that protecting the existing tidegates infrastructure is a goal of the project and that it will likely be necessary to include it. This has not yet been finalized between WDFW and CDD#22.
- Levee bioengineering and marsh fill grading design and construction options are an additional contingency. There is an option to potentially design graded overbuild slopes and install large wood debris features along the levee tidal marsh slope to provide additional enhancement and benefits to the project, which could require another $75k to $100k in design and possibly $200k to $500k in construction (currently unknown). This cost could offset or reduce the amount of rock required (at a cost of $2.0M) at the site if it can be demonstrated that bioengineering, fill grading, large wood debris, and plantings could be used instead of rock protection. If there is an interest in these types of integrated habitat features, it is recommended to perform a separate engineering analysis during the engineering and permitting Phase 2. This would need to be coordinated between WDFW and CDD#22.
- Fir Island Road is a narrow road with possible traffic safety issues and possible construction access maintenance repair issues could be a problem. It was noted in the Snow Goose management objectives that enhanced public safety goals have not been met. A contingency has been included for the possibility of designing and constructing a new access road entrance, likely on the order of $200k to $400k for design and construction, depending on design and construction requirements.
- Disposal of contaminated dredge/excavation materials is a possibility for any project. The engineering, permit, and construction costs are unknown, with a rough contingency of $200k.
- Dry Slough Consent Decree negotiations and coordination may be necessary. While the project is not subject to the Consent Decree, there is a risk that WDFW could get involved as a third party considering the decree is located on WDFW property. Also related to Dry Slough is the additional effort and contingency that may be required for design and construction as it relates to the Dry Slough SRT.
- Cultural and/or archeological resource discovery on the project could sizeable costs for project modifications during construction (i.e., change orders) and redevelopment of the plan to accommodate avoidance (changing in construction plans) and/or mitigation.
- Permitting is subject to contingencies as each individual project may have different permitting pathways and requirements. The current project assumes that an environmental impact statement is not necessary, but could be a contingency. Also, if

the project were to be contested, it would likely occur as a result of a permit process, such as a special use hearing examiner. Additional work may be involved.

- Real estate negotiations and agreement costs are unknown at this time. There are a number of likely agreements that will need to be updated including the WDFW Hayton farm reserve, as well as WDFW CDD#22 easements. The negotiation of the landowner agreements are related to other project elements (such as a pump station contingency for CDD#22). The costs to negotiate these agreements and the implementation costs are unknown.

A rough order of magnitude cost estimate for contingencies is estimated on the order of $3M to $4M. Proactively addressing each contingency item and managing project risks will allow for mitigation of the risks and may have possible reductions in the contingency and overall project budget.

#### 4.10.3 Project Schedule

The following draft schedule could be implemented, provided funding is available.

- Engineering Design 60 percent – December 31, 2012
- Permit Application Submittal – December 31, 2012
- Engineering Design 90 percent – August 31, 2013
- Permit Award – December 31, 2013
- Construction Contract Request for Proposals – January 2014
- Construction Award – April 2014
- Phase 1 Construction – Summer 2014
- Phase 2 Construction – Summer 2015

A separate workplan and budgets have been provided to WDFW outlining likely costs to complete all aspects of project engineering studies, surveys, design, permitting, grant funding acquisition, and project ecosystem and adaptive management monitoring. The budget is estimated at $1.1M (without contingencies) and would coincide with work listed above occurring January 2012 through December 2013.

## 5.0 PUBLIC OUTREACH AND TECHNICAL REVIEW COORDINATION

WDFW has been actively engauged in public outreach for the project. A communication plan has been developed for the project outlining the public outreach process and points of engaugement for the project. This and all project study reports and updates are located on the WDFW Fir Island Farm project study site:

http://wdfw.wa.gov/lands/wildlife_areas/skagit/restoration_study.php

WDFW has also engauged in a number of public outreach activities including:

- Attendance at a CDD#22 meeting to update progress and present alternatives analysis.
- Attendance at meetings with the Hayton Family to update progress and present alternatives analysis.
- Public open house in June 2011. Presentation of the alternatives and solicitation of comments on the project. Public comments have been addressed and are posted to the feasibility study web page.
- Site visits for interested parties.
- Public open house in December 2011. Presentation of the preferred alternative and solicitation of comments on the project.
- Additional public comment periods will be available during the State Environmental Policy Act, Shoreline and Hearing Examiner Special Use processes in 2012 and 2013.

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# 6.0 CONCLUSION

The Fir Island Farm restoration feasibility study has concluded that Alternative 2A is feasible for design and construction and will provide significant ecosystem benefits from a 130-acre dike setback for tidal marsh restoration, while maintaining reserve Snow Goose management functions, and without significant impacts or effects to local agriculture, drainage, or landowners. WDFW plans to implement the Alternative 2A project as funding becomes available.

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## 7.0 CLOSURE

The conclusions and recommendations documented in this report have been prepared for specific application to this project and have been developed in a manner consistent with that level of care and skill normally exercised by members of the environmental science profession currently practicing under similar conditions in the area, and in accordance with the terms and conditions set forth in our agreement. We note that a number of authors were involved in developing the report whose work was not the direct responsibility of the consultant (i.e., fisheries, Snow Goose management, agriculture, public use, and recreation). The conclusions and recommendations presented in this report are professional opinions based on interpretation of information currently available to us and are made within the operational scope, budget, and schedule constraints of this project. No warranty, express or implied, is made. We also note that the facts and conditions referenced in this report may change over time, and that the facts and conditions set forth here are applicable as described only at the time the report was written. We believe that the conclusions stated here are factual, but no guarantee is made or implied.

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