Swan Lake Restoration
Preliminary Feasibility Study
Final Report

Prepared for:
Skagit Fisheries Enhancement Group
Swan Lake Watershed Preservation Group

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Sep. 14, 2010

Executive Summary

Introduction and Purpose

The Skagit Fisheries Enhancement Group (SFEG) and the Swan Lake Watershed Preservation Group (SLWPG) have contracted Coastal Geologic Services (CGS) to perform a historic analysis as part of a preliminary restoration feasibility study for the Swan Lake Restoration Project, funded by the Salmon Recovery Funding Board. The initial goal of this project is to assess the historic character and function of Swan Lake in order to determine if there is a feasible restoration alternative(s) for improving estuarine and marine nearshore processes and fish passage at Swan Lake on northwest Whidbey Island, Island County, WA.

The analysis and reporting for this preliminary analysis project was competed in 2 tasks, which are compiled together following this *Executive Summary*. Additional background information, methods, results and recommendations are found in the 2 reports, which follow immediately:

> **Swan Lake Initial Field Assessment Final Technical Memo (Task 1)**, which documented field observations at the berm, lagoon, and tide gate areas, net shore-drift and beach processes, and introduced other background data and very preliminary alternatives.
>
> **Historic Analysis Final Report (Task 2)**, which documented and analyzed historic conditions at the site based on published geologic reports and maps, historic maps and aerial photographs, and other published and available unpublished data sources. This report also provided some direction regarding the utility of more detailed phases of a feasibility assessment, which would be fundamental to restoration/enhancement design and implementation of an enhanced connection between the Swan Lake lagoon and the Strait of Juan de Fuca.

Swan Lake is a closed lagoonal marsh, which is defined as a back-barrier wetland free of a persistent tide channel (Shipman 2008). The tide gate and culverts currently provide an anthropogenic connection between the wetland and the marine environment, the conditions of which resemble a barrier estuary or barrier lagoon (Shipman 2008). These types of embayments are valued for the fish and wildlife habitat they provide as well as the many other functions that wetlands bestow. Embayments appear to be particularly vulnerable to the pressures of development and land use changes, which has resulted in a decrease in their frequency and abundance throughout the Puget Sound region, and particularly in the greater Whidbey Basin. These shoreforms are of particular value to juvenile salmonids which utilize them for refuge from predation, foraging and osmoregulation. Therefore the restoration and enhancement of embayment shoreforms has been identified as a strategic need by the Puget Sound Nearshore Ecosystem Restoration Project (Schlenger et al. *in review*).

Conclusions and Recommendations

Although historic data that predates the extensive modification to the Swan Lake lagoon system is minimal, with the variety of data discussed in this report, we conclude that prior to modification, the system was likely a brackish water system that likely included an intertidal connection (tide channel) to the Strait that was periodically open, but likely not in a permanent or stable configuration. Due to the large size of the system and the documented presence of relatively abundant fish (including juvenile salmon) immediately west of the lagoon, the habitat enhancement potential for this site is fairly high. The (re)creation of a connection to the Strait would not constitute true restoration, but could provide valuable saltmarsh and lagoon habitat that is currently not accessible to fish. This recommendation is also consistent with recommendations in the Habitat Limiting Factors report (WSCC 2000) and the Island County Estuarine Restoration Program (Sheldon and Associates 2001).

Based on the findings of this preliminary study, the proposed more comprehensive feasibility assessment put forward in the recent funding round holds merit, and that study (to include much more detailed mapping, wave and littoral drift assessment, habitat mapping, wetland hydrology assessment, inlet analysis, reference site analysis, infrastructure analysis, and more detailed feasibility of several alternatives), should be completed.

The following Opportunities and Constraints summarize practical findings of this preliminary analysis:

Opportunities

- Adding a more direct and fish passable connection from Swan Lake to the Strait of Juan de Fuca would add on the order of 120 acres or more of coastal lagoon/estuarine habitat and also make habitat improvements on Swantown Creek possible.
- The relatively large potential tidal prism at Swan Lake suggests that some type of channel to the Strait may be quite feasible.
- Improve tidal exchange such that lagoon levels do not exceed water levels in the Strait of Juan de Fuca. This would help ameliorate upstream flooding issues (e.g. at the Fakkema property) caused by stormwater backing up at the tide gates.
- If an open channel is deemed infeasible with further analysis, then constructing a bridge or other means of engineered fish-passable structures could be used.

Constraints:

- Developed lots on the beach berm make it difficult to locate an open channel there as the channel may tend to be dynamic. The migration would likely be northward, such that placement along the developed portion of the berm may not be feasible.
- This reach of shore likely has a high littoral drift rate and high wave energy, which will require additional analysis and engineering assessment.
- Any channel would need to pass under West Beach Road, requiring a bridge or other engineered structure.
- Island County only owns the southern and central portions of the study area where the lake is and not the two large parcels to the north where one potential channel location is. These properties would need to be acquired or easements secured before a channel could be located to the north.
- The northern property is the location of a communications cable, so special consideration of the cable would need to be made if it is still in use (attempts to reach the owners were not successful).
- Area wells and septic systems must not be impacted by additional intrusion of saltwater.

memorandum

Date: July 12, 2010

To: Sue Madsen, Skagit Fisheries Enhancement Group

Cc: GayLynn Beighton, Swan Lake Watershed Preservation Group

From: Jim Johannessen, Licensed Engineering Geologist and MS, Jonathan Waggoner, CGS

Re: **DRAFT Swan Lake Initial Field Assessment Technical Memo**

Introduction and Purpose

Coastal Geologic Services, Inc. (CGS) staff, under contract to the Skagit Fisheries Enhancement Group (SFEG) and working with the Swan Lake Watershed Preservation Group (SLWPG), visited Swan Lake to assess the feasibility of restoring or enhancing tide channel connection to improve fish passage and access to the lagoon. It is located in northwest Whidbey Island along the Strait of Juan de Fuca, approximately 3.5 miles west of the town of Oak Harbor (Figure 1).

Swan Lake is a closed lagoonal marsh, which is defined as a back-barrier wetland free of a persistent tide channel (Shipman et al. 2008). The tide gate and culverts currently provide an anthropogenic connection between the wetland and the marine environment, the conditions of which resemble a barrier estuary or barrier lagoon (Shipman et al. 2008). These types of embayments are valued for the fish and wildlife habitat they provide as well as the many other functions that wetlands bestow. Embayments appear to be particularly vulnerable to the pressures of development and land use changes, which has resulted in a decrease in their frequency and abundance throughout the Puget Sound region, and particularly in the Whidbey Basin. These shoreforms are of particular value to juvenile salmonids which utilize them for refuge from predation, foraging and osmoregulation. Therefore the restoration and enhancement of embayment shoreforms has been identified as a strategic need by the Puget Sound Nearshore Ecosystem Restoration Project (SNAR *in review* 2010).

This memo serves to document observations made by CGS staff on April 28 and June 29, 2010 during site visits to the lake and vicinity, which is the deliverable for Task 1 in the Scope of Work. The topics addressed in Task 1 included field assessment of current nearshore conditions surrounding Swan Lake, and an evaluation of the berm. The reconnaissance was focused on the tide gates and flow, the conditions at the berm, the presence of a historic ebb tidal delta and tide channel, and a preliminary examination of if and where a tide channel may feasibly be restored and other alternatives that would enhance tidal connectivity between Swan Lake and Strait of Juan de Fuca. Existing data including LiDAR, aerial photography, and other published and available unpublished data sources helped to focus the on-the-ground examination of site characteristics.

Limited background information is included here to provide context for the site and the potential restoration/enhancement project. The next and final work product for this project entails a short report documenting historic conditions (Task 2 memo) at the site. This (Task 1) memo and the results of the historic analysis (Task 2 memo) will be used to determine if to proceed with the more detailed phases of a feasibility assessment, which would be fundamental to restoration/enhancement design and implementing an enhanced connection between the Swan Lake lagoon and the Strait of Juan de Fuca.

Site Conditions

The lagoon was mapped by the U.S. Coast Survey in 1871 as marsh and open water with no direct tidal connection to the Strait (T-sheet 1253, Figure 2). Currently the berm and lagoon are heavily altered as a result of considerable ditching, dikes and tidegates, which were initially installed in approximately 1918, shortly after Drainage District 1 was established (WSCC 2000).

Site Context

The Swan Lake lagoon is located at the terminus of approximately 7 square miles of watershed, the sixth largest in Island County. The majority (95%) of the watershed was reported as being in agricultural or forestry land use designation by Island County Public Works (1997). The lesser, developed portion of the watershed however, includes a golf course and a rapidly expanding residential population (WSCC 2000). The lake is fed by Swantown Creek. Much of Swantown Creek, which empties into the southeastern corner of the lagoon, has been channelized, and the two detention ponds at the golf course cause the flow to be intermittent. Swantown Creek has been identified as a location of moderate restoration potential for salmonids restoration (WRIA 6 STAG 2005). WDFW rated the restoration potential for chum and coho as high (Kearsley 1996). However, prior to restoring habitat in the middle or upper watershed, the tidal connectivity from the Strait into the lagoon must first be restored to enable fish to access the creek.

Little data has been collected to date on fish presence within the Swan Lake lagoon. Limited seining occurred within a single channel of the lake in November of 2007. At that time more than 100 three-spine sticklebacks (*Gasterostreus aculeatus*) and two Pacific staghorn sculpin (*Leptocottus armatus*) were caught (Shappart 2007). Three-spine sticklebacks inhabit fresh to brackish water, with some populations being anadromous (Frose and Pauly 2010). Adult Pacific staghorn sculpin inhabit brackish to marine environments (Frose and Pauly 2010). Seining by the Wild Fish Conservancy in 2005 reportedly found yellow perch (*Perca flavescens*), a freshwater to brackish fish, and three-spine sticklebacks (Wait et al. 2007). These seining results suggest that Swan Lake maintains at least brackish conditions. Neither seining operation found salmonids in Swan Lake, although numerous salmonids have been caught at Sunset Beach immediately west of the Lake (Wait et al. 2007).

Water quality monitoring undertaken by SLWPG (WA DOE 2010) measured salinity in the lake between 2007 and 2009 (Figure 3). All 124 lake and ditch samples showed at least brackish conditions (greater than 0.5 ppt). Salinities generally ranged between 10 and 25 ppt (parts per thousand), although lows of below 5 ppt were seen in January 2009 and highs above 30 in August 2009. In contrast, seawater has a salinity of around 35 ppt. The brackish conditions within Swan lake indicates that the restoration of fish-passable marine connectivity could provide as much as 100 acres of estuarine rearing, refuge foraging, and osmoregulation habitat for juvenile salmonids and other species, as well as access to the creek.

Beach and Coastal Processes

Net shore-drift, or the long-term effect of littoral drift was mapped at the study area by Ralph Keuler in a US Geological Survey map (1988). Net shore-drift is northward and northeastward at the study area. The net shore-drift cell (also called a littoral cell) originates near Point Partridge at the westernmost tip of Whidbey Island within Fort Ebey State Park. The drift cell continues up to the southwest shore of Deception Pass (Figure 1). The rate of sediment transport is not known at this time within the drift cell or at the study area, however the rate is judged to be fairly high compared to other Puget Sound area drift cells.

After marine water levels rose rapidly following the last glaciation approximately 5,000 years ago, the area that is now the lagoon was likely an embayment that extended east to include the present lake area. Following near-stabilization of sea level approximately 5,000 years ago, northward net shore-drift likely first formed an intertidal bar, then a supratidal barrier spit that protected the embayment that prograded northward. As the spit prograded, the opening of "Swan Bay" would have become smaller and smaller until the spit reached the far northern end and nearly or fully enclosed the bay. The porous nature of the beach deposits comprising the berm would likely allow most water to flow through to the Strait. During periods of high freshwater inputs, excess water would have overtopped the berm to create a new tide channel. As flows returned to normal, wave would again desposit the naturally high quantity of littoral drift sediment into the channel to close it.

No definitive evidence of a permanent tide channel from the lake to the Strait of Juan de Fuca was found for this effort to date. Very little information is available prior to the many alterations to the site. However, a more detailed investigation of historic conditions are the berm and lagoon will occur as part of Task 2. The 1871 T-sheet does show a minor bulge in the shoreline at the northern end of the lake along both the high and low water line (Figure 2). This convex shore feature appears as if it could have been the location of an ebb tidal delta, although no channel was drawn through the berm in the 1871 map. It may have been that if the tide channel was an ephemeral feature and was not open at the time of the 1871 survey.

During an interview long-time resident Chuck Bos, who grew up at Swan Lake, mentioned that "before his time, there was an ongoing problem with the lake level getting too high at the north end and water running overtop a low area of land."

One way to try to determine if a tide channel was present at the site prior to development is to look for a relict ebb tidal delta on the intertidal and subtidal beach. Due to the high wave energy at the site (the wave fetch is on the order of 75 miles) it is very likely if that if an ebb tidal delta had existed it would not have persisted more than several decades in such a high energy environment. It appears that considerable amounts of fill were placed over the upper beach in the 20th century for bulkheads, yards, houses, and this would have further obscured the predevelopment nature of the site.

Lagoon and Marsh

Swan Lake has been heavily altered by development in the surrounding areas since at least the late 1800's. Mapping completed in 1871 shows the open water area at approximately 75 acres (Figure 2). Aerial photographs from 2007 show the open water area as approximately 45 acres. This was 40% smaller, although flow through the system was completely controlled and the lake level (and open water area) varies seasonally. The entire complex was on the order of 100 acres in size in 2007, and on the order of 140 acres in the 1871 T-sheet. Therefore, an estimated 17% of the total marsh area was lost between 1871 and 2007 (63 acres to 52 acres). A large portion of the eastern extent of the 1871 lagoonal marsh area was directly converted to uplands for pasture following construction of the ditch, dike, and tide gate system (Figure 2).

The extensive ditch complex, initially constructed in the early 20th or late 19th century, can still be clearly seen in the field and in the 2007 aerial photographs of the area. The most prominent ditches run to the east and south of the tidegate area. These two ditches appeared to be several feet deep at the time of the site visit. It is assumed that the ditches were considerably deeper when they were initially constructed and that sedimentation over the decades has decreased the channel depth. Numerous smaller ditches can be seen from aerial photography, particularly in the northern and southeastern portions of the lagoon. The north-south ditch that parallels West Beach Road is not directly connected to the lake/lagoon. Rather, it is connected through two culverts in the central western portion of the lake that go through a low levee, and both appear to have originally been tide gates, but the flaps are no longer present. This inner, second division (the low levee) between the tidegates to the Strait and lagoon presents an additional barrier to fish passage (Photo page 1).

Sheldon and Associates (1999c) reported that "Swantown Marsh is only partially functioning as saltmarsh habitat. About 40% of the wetland currently exists as saltmarsh habitat, the remainder being freshwater marsh (40%), mudflat (20%), and open water (10%)." This work appears to be rough estimates, and not actual delineations based on much data.

North Low-elevation Area

Geomorphic interpretation of aerial photographs suggested that the area immediately north of the north end of the beach houses may have been the location of a historic tide channel(s) from the Strait of Juan de Fuca to the lake. This area was investigated during the field visit and a limited amount of hand level shots were collected to estimate elevation in that area. These data were combined with LiDAR mapping of the adjacent roadway for elevation control (approximately +12.6 ft MLLW). The field reconnaissance revealed several low elevation linear features extending generally northward from the roadway fill prism immediately north of the bend in the road where it leaves the beach (Figure 4, Photo Page 2). The low elevation areas were located slightly landward of the park trail on the beach berm. Limited elevation data were collected for this northern low area using a totalstation with direct rod measurement. Elevations were related to MLLW using direct observations of water level in the Strait correlated to predicted water levels. These data revealed that the northern low area followed roughly parallel to the berm, and was as low as +6.9 ft MLLW, below the level of MHHW (+7.5 ft MLLW) in the area. South of the road bend the, the marsh surface was as low as +5.9 ft MLLW, although no linear trend of the low could be discerned.

A series of low elevation coastal wetlands were present between 1,000 and 6,000 ft northeast of the West Beach Rd. bend, within the state park (Figure 4). These are all linear features that parallel the berm and may represent old tide channels from the larger Swan Lake wetland complex.

This northern low-elevation area near the bend in West Beach Rd. would have been a natural location for a tide channel prior to development and modifications of the marsh system. This is because the net shore-drift or long term littoral transport is northward along this shore and any channel would have tended to have been pushed northward due to the dominant, incident wave angles are from the west to southwest and corresponding northeastward net shore-drift. The trend of the low-elevation, linear features were completely consistent with the trend of the natural berm and the dominant wave energy at the site. Surveying revealed that the lows north of the bend in West Beach Rd. were below the elevation of MHHW; suggesting they were probably active enough to maintain this form. Further investigation of the elevations, morphology, and sediment composition at the surface and below surface of these features should be carried out.

Road and Tide Gates

West Beach Road overlays fill placed on the berm between Swan Lake and the Strait of Juan de Fuca. The road on the berm appears to have been constructed some time between 1939 and 1942, as monument installation/recovery sheets noted no road was in place in 1939 and a “recently constructed” road was present in 1942 (National Geodetic Survey 2010). The roadway LiDAR data and surveying showed that the landward portion of the road near the tidegates was at approximately +10.0 ft MLLW. This appears generally correct as a 12/8/04 photo showed water running over the road and into the lake at a day with a recorded tide of +10.26 ft MLLW at Port Townsend.

Two culverts connect the Swan Lake lagoon to the fairly narrow ditch running parallel to West Beach Rd (Figure 1, Photo Page 1). Both culverts had tidegate hardware, although the flaps were no longer present. Water was actively draining out of the lagoon to the western ditch during the April 28th field visit, although the eastern culvert was completely submerged. Both culverts appear to be considerably undersized for their purpose, as the lagoon water level was on the order of a foot higher than in the ditch. The northern culvert’s invert elevation (ie: inside bottom surface elevation) was at +2.2 ft MLLW.

Three culverts were observed connecting the road ditch to the Strait of Juan de Fuca. The first, a 15” corrugated steel pipe, has been abandoned, as the waterward side, located in the northern tide gate well, has been plugged, and the elevation at the landward end appeared too high to effectively drain the lagoon except during the highest water levels (Photo Page 1). The south culvert, a 30” concrete pipe was partially submerged by water with an invert elevation of +0.7 ft MLLW, and had strong flow toward the Strait during the field assessment. It appears that a 24” plastic culvert had been slipped into the larger, older culvert. A grate had been installed in front of the pipe, although it was choked with vegetation, and leaned partially open allowing water to flow around the sides. The north culvert running beneath the road was below the water surface on the ditch side, and had been partially blocked by rocks that apparently had fallen from the roadbed above. The grate had been removed and placed on the side of the bank. The south pipe’s invert elevation was also +0.7 ft MLLW.

Investigation of the tide gate wells was conducted on June 29, 2010 as part of the limited topographic surveying effort. Both wells were constructed of concrete, and on the order of 10 ft deep. A concrete baffle had been constructed relatively recently, as the plywood used in forming the baffle was still visible in places. The northern tide gate well contained a functioning flap gate over the pipe leading from the lagoon. The flap appeared to have been part of the recent maintenance work performed by the County. The southern well contained a flap gate on the pipe through the central baffle, although the flap appeared to be rusted open, and so was not functional.

Two culverts emerge on the lower beachface approximately 350 ft west-norhtwest from the lagoon, both of which are surrounded by boulders that were likely placed to attenuate wave energy (Photo Page 1). The northern culvert was a terra cotta pipe protected with a concrete cover and a small concrete patch. The pipe was mostly full of sediment, but water was seen flowing out at the beach, although at lower volumes than the southern culvert. The southern culvert was constructed of corrugated steel pipe, also protected by a cover of poured concrete, and was slightly perched above the beach surface. A smaller plastic culvert was inserted inside the larger corrugated pipe. A large volume of water was flowing out the southern culvert during the field visit. Based on observed water levels at Port Townsend (adjusted for Sunset Beach) at the time of the field visit, the culvert outlet met the beach at an elevation of approximately +0.1 ft MLLW.

Restoration Alternatives

No Action

The no action alternative implies no change to the existing conditions of the tide gates or greater Swan Lake area. This alternative would be a continuation of existing conditions with almost no fish passage between the Strait and the lake and minimal exchange of nutrients and sediment in this same area. However, increased blockage of the existing tidegates is likely due to continued littoral transport on the beach. Also the tide gates are quite deteriorated and would likely become worse in coming years, unless replaced. This would lead to increased water levels in the western ditch and the lake with associated impacts to adjacent properties. This would also result in decreased salinity of the lagoon water with subsequent changes to the marsh vegetation assemblages.

Due to concerns with flooding from the Strait via overwash over the berm/road, and also from the land side during high precipitation events, the no action alternative appears to not be viable over a period of several years or longer as maintenance will very likely be required. This is without considering the potential benefit to nearshore habitat associated with restoration/enhancement..

Open Channel

Development of an open channel connection at the northern end of the marsh complex offers the highest degree of habitat improvement and restoration of natural processes. It appears at this stage that the best location for an open channel would be at the north end through the low elevation area just north of the bend in the road (which was discussed in several places above). Development of an open channel connection would require construction of a bridge for West Beach Road, likely to be located immediately east of the bend in the road. An existing foot trail would also need to be relocated landward from its current location in the state park to meet up with a sidewalk on the new bridge.

The open channel would extend on the order of 1,800 ft from the open water of the lake to just north of the road. Most of this area is already occupied by wetlands, is of relativity low elevation, and extensive excavation would not be required. However, ground disturbance would be greater than with the other alternatives, as “starter” channel would be required to connect the lagoon to the new tide channel. This alternative would involve the need to acquire property or at least an easement through up to two parcels. One of these is owned by GT Group Telecom, owners of the northern parcel.

Engineered Opening

Another alternative would be to construct an engineered opening through the berm to allow for fish passage and enhanced water, nutrient, and sediment flow between the Strait and the lagoon. The opening could either be located at existing tidegate area or at another location further north. The existing location would be a strong candidate as there is an existing legal use established and it is a short distance relative to locations much further north. Initial evaluation indicates that the opening should probably not be placed further south as it would be exposed to slightly greater wave energy. Placing the opening considerably further north would have advantages in terms of wave energy due to the change in shore orientation, as the shore here bends away from the predominant wave approach angle. Another significant benefit of placing the opening north of the end of the shore protection and houses would be that the beach berm is fairly narrow immediately north of the end of the shore protection, likely due to wave refraction from the walls and associated beach erosion in this area. This would tend to limit the amount of sedimentation in this area. However this would require greater amount of excavation through the backshore marsh area.

The opening would need to contain what may be a large span to accommodate the opening below the road. The length of span required has not been determined at this time as there are many data gaps and further analyses would be required. The span may be much larger than what could be accommodated with a box culvert or other simple structure. Therefore a bridge and associated armoring of the bridge supports may be required for this alternative. However, an open channel may increase flooding, and mapping and an impact analysis would need to be carried out to determine if an engineered open channel would be viable.

Another alternative approach for an engineered opening could include several very large tidegate(s) installed to regulate water levels in the lake/lagoon. Of particular importance would be to allow adequate flushing to maintain high water quality in the lake and low enough water velocities to facilitate and enhance fish passage.

Regardless of the type of engineered structure that might be installed, such an approach would require regrading formerly filled areas and some of the existing drainage ditches to allow for sufficient tidal exchange. Depending on how the channel would be created, there may also be a need for shore protection on the Strait side to both maintain the opening and keep it from migrating. This alternative may also include the need for armor to protect the adjacent houses and would likely require maintenance due to the high volume of littoral drift along the beach.

Other Considerations

Additional data collection and analyses are required to attain greater understanding of the coastal processes at the site and to thoroughly assess the feasibility of the various alternatives prior to initiating design work. The historical analyses summarized in the Task 2 memo will address the likelihood that an open or intermittent channel was present prior to modification which will also aid in the decision-making process.

Upon reflecting on field observations, some additional recommendations are offered below that were not included within the scope of this preliminary investigation. Due to the extensive modifications of the shores of the study area and current and historic adjacent land uses, there was a great lack of vegetation higher than grasses around much of the lagoon-marsh. Further enhancement of the Swan Lake nearshore could entail marine riparian plantings of shrubs and trees around the perimeter of the lagoon-marsh. A more diverse and dense marine riparian buffer could provide sources of shade and terrestrial invertebrates upon which salmonids are known to forage, habitat structure (LWD), flood attenuation and pollution abatement, particularly from adjacent agricultural land (Brennan 2007).

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Coastal Geologic Services Inc.

Jim Johannessen,
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Jonathan Waggoner

ATTACHMENTS:

Figure 1. Swan Lake vicinity map showing net shore-drift cells for northern Whidbey Island
Figure 2. T-sheet number 1253 mapped 1871 by US Coast Survey
Figure 3. Water quality monitoring stations
Figure 4. Oblique aerial photo taken 6/20/06 of north low-elevation area with zoom area
Photo Page 1. Tidegates and culverts
Photo Page 2. Northern low elevation area

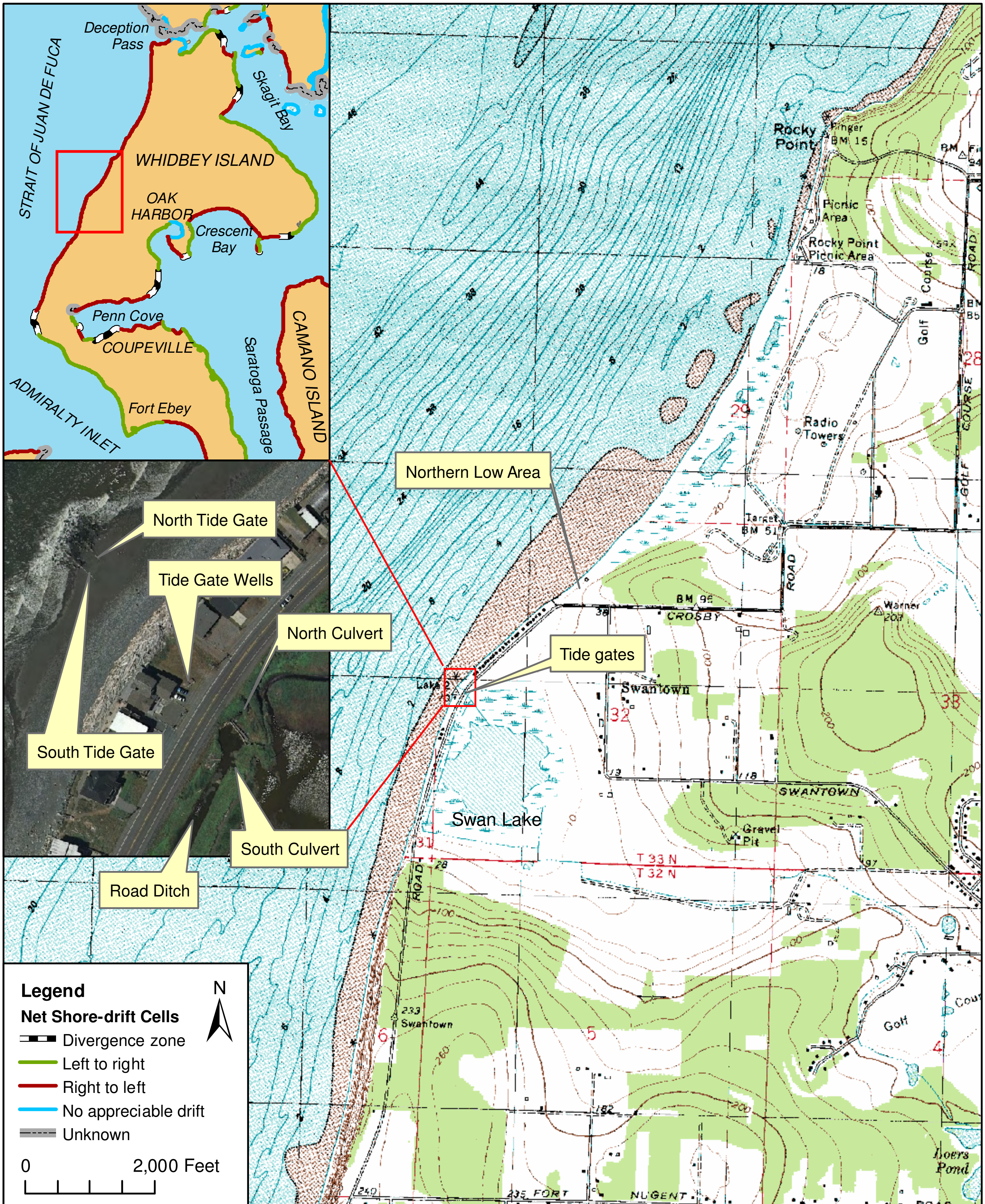

Figure 1. Swan Lake vicinity map showing net shore-drift cells for northern Whidbey Island.
USGS topographic map shown

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Figure 2. T-Sheet number 1253 mapped 1871 by the US Coast Survey overlain on 2007 aerial photograph. Note "bulge" in shoreline at low and high water at northern end of lake, a possible ebb tidal delta. *Aerial courtesy Island County (2007)*

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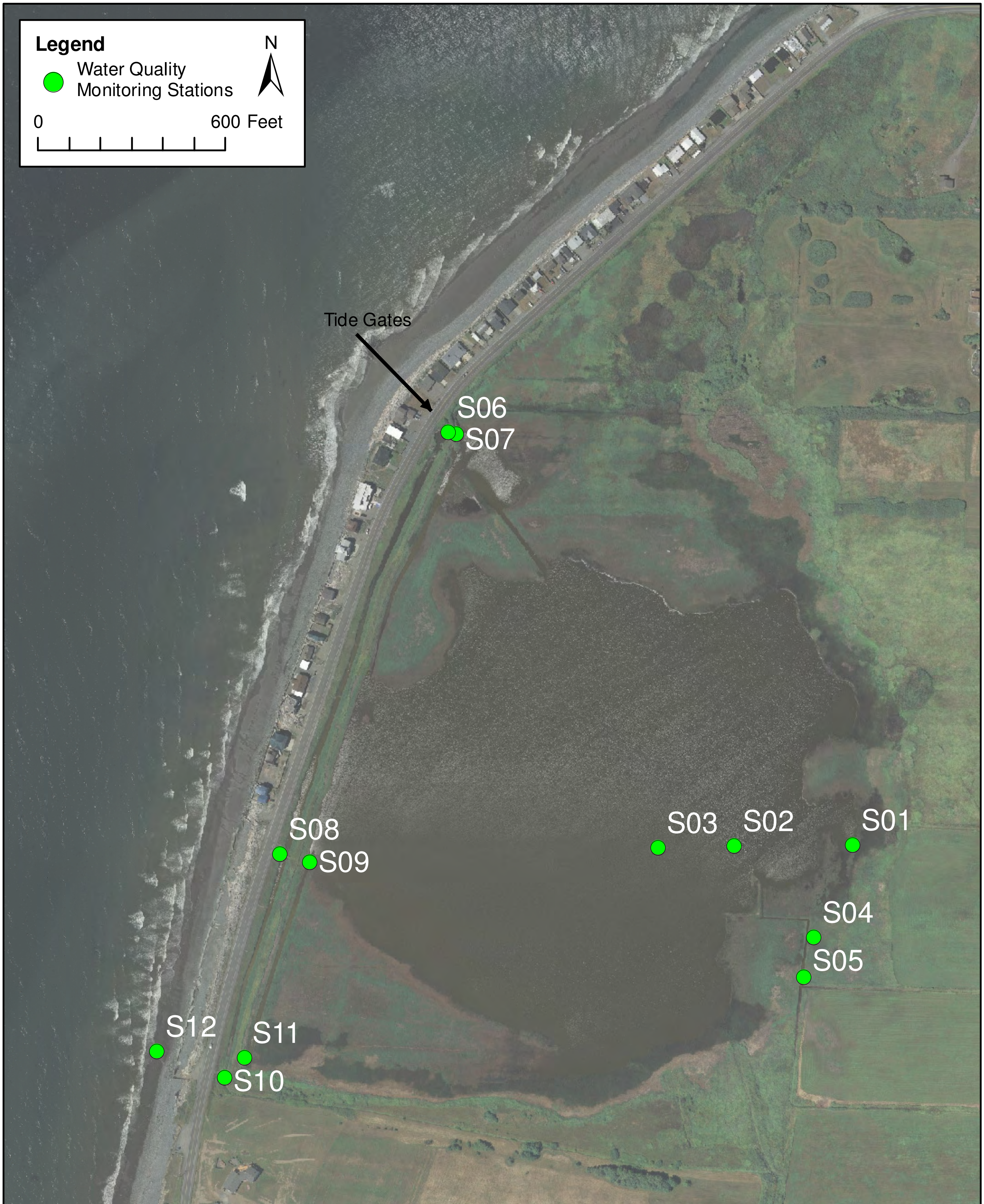

Figure 3. Location of water quality monitoring stations sampled by SLWPG (WADOE 2010).

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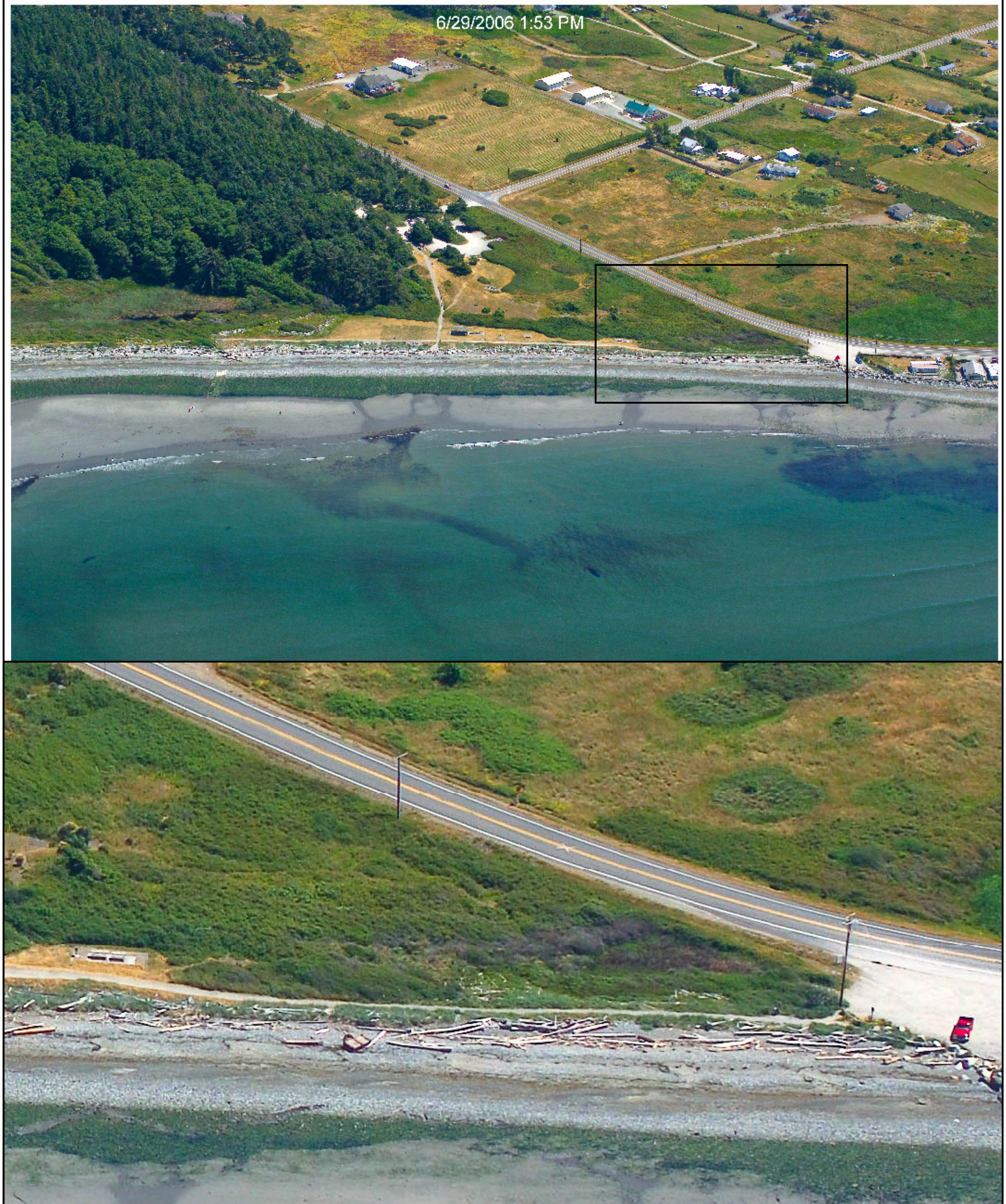

Figure 4. Oblique aerial photo taken 6/29/2006 by WA Dept of Ecology.
Lowest elevation areas have gray vegetation at time of photo,
trending near-parallel with beach.

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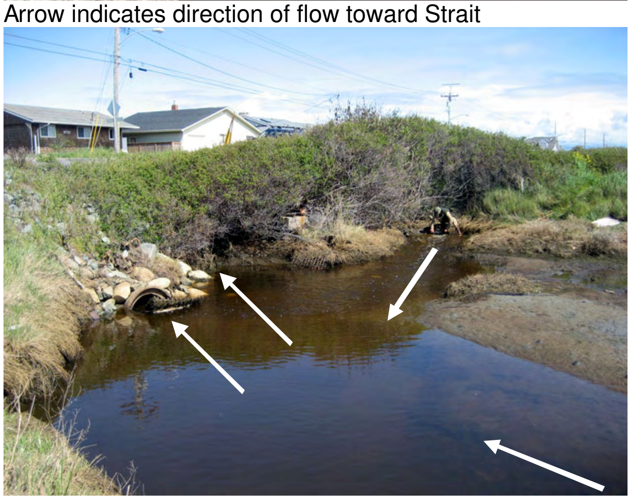
Arrow indicates direction of flow toward Strait

Arrow indicates direction of flow from lagoon to ditch



Arrows indicate direction of flow toward Strait

Tidegates and protective rock

Northern tidegate – Strait side (note partial blockage and water flowing)

Southern tidegate – Strait side

Photo Page 1. Tidegates and culverts on 4/28/10.

Trail on berm, looking north toward Park

Low area north of West Beach Rd, looking north

Low area north of West Beach Rd, looking southwest

Low area north of West Beach Rd, looking west

Low area north of West Beach Rd, looking southwest

Low area north of West Beach Rd, looking southwest

Photo Page 2. Northern low elevation area on 4/28/10.

Swan Lake Restoration Preliminary Feasibility Study: Historic Analysis, Task 2 (of 2) Final Report

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Introduction and Purpose

The Skagit Fisheries Enhancement Group (SFEG) and the Swan Lake Watershed Preservation Group (SLWPG) have contracted Coastal Geologic Services (CGS) to perform a historic analysis as part of a preliminary restoration feasibility study for the Swan Lake Restoration Project, funded by the Salmon Recovery Funding Board. The initial goal of this project is to assess the historic character and function of Swan Lake in order to determine if there is a feasible restoration alternative(s) for improving estuarine and marine nearshore processes and fish passage at Swan Lake, Island County, WA (Figure 1).

Swan Lake is a closed lagoonal marsh, which is defined as a back-barrier wetland free of a persistent tide channel (Shipman 2008). The tide gate and culverts currently provide an anthropogenic connection between the wetland and the marine environment. Conditions resemble a barrier estuary or barrier lagoon (Shipman 2008). These types of embayments are valued for the fish and wildlife habitat they provide as well as the many other functions that wetlands bestow. Embayments appear to be particularly vulnerable to the pressures of development and land use changes, which has resulted in a decrease in their frequency and abundance throughout the Puget Sound region, and particularly in the greater Whidbey Basin. These shoreforms are of particular value to juvenile salmonids which utilize them for refuge from predation, foraging and osmoregulation. Therefore the restoration and enhancement of embayment shoreforms has been identified as a strategic need by the Puget Sound Nearshore Ecosystem Restoration Project (Schlenger et al. *in review*).

This report is the second and final deliverable for the project. The first deliverable was the Task 1 Technical Memo (Johannessen and Waggoner 2010) that documented field observations at the berm, lagoon, and tide gate areas, net shore-drift and beach processes, and introduced other background data and very preliminary alternatives. The Task 1 Technical Memo should be used in conjunction with this report. This report documents and analyzes historic conditions at the site.

Existing data used for this report included published geologic reports and maps, historic maps and aerial photographs, and other published and available unpublished data sources covering historic conditions in the study area. This report also provides some direction regarding the potential, more detailed phases of a feasibility assessment, which would be fundamental to restoration/enhancement design and implementation of an enhanced connection between the Swan Lake lagoon and the Strait of Juan de Fuca.

Geologic Setting and Processes

Geology in the Swan Lake area was mapped by the Washington Division of Geology and Earth Resources (Dragovich et al. 2005). The greater Northwest Whidbey Island area is composed of a series of glacial and non-glacial units from multiple glacial ice sheet advances and interglacial periods in the Quaternary period (Easterbrook et al. 1967, Easterbrook 1992). Uplands surrounding Swan Lake generally contain glaciomarine deposits that contain relict shorelines and beach deposits of the Everson Interstade (Dragovich et al. 2005, Figure 2). These units contain sand with inter-beds of silt and pebbly sand. Occasional outcrops of till (diamicton; or a mixture of clay, silt, sand and gravel in varying proportions) of the Vashon Stade also occur in the uplands. The low elevation area surrounding the lagoon at Swan Lake was mapped as peat of Quaternary age, which also outcrops on the intertidal beach waterward of Swan Lake and adjacent northern low elevation areas (Figure 2).

Several potentially significant faults are found in the northern Puget Lowland and eastern Strait of Juan de Fuca region (Gower et al. 1985). These include the southern Whidbey Island fault, the Devils Mountain fault, and associated structures (Gower et al. 1985; Johnson et al. 1996) as well as the recently identified Oak Harbor Fault (Dragovich et al. 2005; Figure 2). Mapping was based on the integration of seismic-reflection data, well logs, and information from outcrops. Quaternary activity was documented at the Devils Mountain fault and two recently defined structures, the Strawberry Point and Utsalady Point faults (Johnson et al. 2001). These faults are the “major components of an oblique-slip transpressional deformation zone that extends westward for more than 75 miles (125 km) from the Cascade Range foothills across the eastern Strait of Juan de Fuca” (Johnson et al. 2004).

The local deformation style observed in northwest Whidbey Island is consistent with the high-angle deformation observed in the strata near the active fault structures such that it is unlikely that Pleistocene glacial shear caused the Quaternary deformation (Johnson et al. 2001, Dragovich et al. 2005). Also, the deformation in the fault zones is not easily related to deep-seated landsliding—tilted Pleistocene strata are deformed over areas that are too broad to be attributed to landsliding. Further evidence for these faults includes offset stratigraphy and subtle topographic lineaments or risers (Dragovich et al. 2005).

Subsurface analysis by Dragovich et al. (2005) also supports significant Quaternary deformation. For example, data from boring logs demonstrate apparent late Pleistocene to Holocene(?) offset of Strawberry Point fault no. 1 north of Oak Harbor (Figures 2 and 3). Stratigraphic offset between these borings indicates a south-side-up movement at multiple faults in the area, which is consistent with fault offset relations to the east (Johnson et al. 2001, Dragovich et al. 2005). The Strawberry

Point fault no. 1 is located approximately 3 miles northeast of Swan Lake, and the Utsalady Point faults nos. 5 and 6 are located approximately 2 miles northeast of Swan Lake, while the Oak Harbor fault is located immediately north of the lake. All of these faults have a south side down displacement, best shown in the cross section in Figure 2. In addition, a syncline (a fold in rock layers that slope upward on both sides away from a common low point; see Figure 2 cross section), which can cause localized depression of the sediment units, is mapped running through the southern half of the lagoon. The proximity of the faults with associated vertical land movements, the mapped syncline, and relatively low elevation of the Whidbey Formation and Vashon till around the lake suggest that not only has the area has been tectonically active but also that the Swan Lake area has not been uplifted and instead may have been down-dropped.

The vertical land movements outlined above and the presence of a syncline at Swan Lake are in contrast to vertical land movement identified at a different location by Kelsey et al. (2004). Information for the Keystone area was referenced in a report for Crockett Lake (Herrera Environmental Consultants 2007), which is located 10 miles south of Swan Lake. The Swan Lake area is closely bounded by the likely active faults discussed above, as well as the series of anticlines and synclines, which are more distant from the traces of the South Whidbey fault zone near Crockett Lake (Figure 3), such that no inferences can be made between tectonics at the Crockett Lake area and Swan Lake.

A series of 4 muddy sand sheets were mapped within the tidal marsh peat at Swantown that are inferred to have been deposited by tsunamis (Williams and Hutchinson 2000). Detailed coring and mapping was carried out on both the north and south sides of the tide gate area. All 4 of the sand sheets contain marine microfossils and have internal stratification. They record repeated inundation by marine waters into the marsh over a short time period by distinct pulses of sediment-laden saltwater, consistent with deposition by a tsunami wave train. The 4 layers were radiocarbon-dated to 1160–1350, 1400–1700, 1810–2060, and 1830–2120 cal BP (calibrated years before present; Williams and Hutchinson 2000). The overlap in age between the two youngest layers and inferred great earthquake events at the Cascadia plate boundary, approximately 150 miles (250 km) to the west, suggests that the sand sheets were emplaced by tsunamis from this source area. The two older layers (which do not correlate with plate-boundary events) may be products of tsunamis caused by earthquakes on local faults in the Strait of Juan de Fuca or by submarine landslides in this area (Williams and Hutchinson 2000).

The presence of strandlines or relict shorelines (solid blue lines on Figure 2) clearly indicates that the entire lower Swantown Creek Valley was inundated by marine waters approximately 11,000 to 13,000 years before present, when glacial ice sheets were melting rapidly and the land had not yet rebounded. Global sea level rose faster then isostatic rebound and caused marine waters to inundate areas that are now above sea level. As the land gradually rebounded upward following deglaciation (due to removal of the mass of ice), the study area later experienced falling relative sea levels. This created the relict shorelines higher then today's beaches (Figure 2). These older beach terraces were mapped as extending as high as 160 ft above MSL (mean sea level).

As discussed in the Task 1 memo (Johannessen and Waggoner 2010), net shore-drift is northeastward at the site (Keuler 1988), originating at Point Partridge on westernmost Whidbey

Island extending all the way to the south Shore of Deception Pass (Figure 1). Coastal geomorphic interpretation indicates that a gravel and sand spit very likely prograded northeastward across the mouth of the former embayment. This is a classic pattern of coastal evolution for areas of irregular topography and moderate sand and gravel sediment supply such as this. The spit likely did not reach all away across the lagoon for a considerable length (perhaps millennia) of time as the volume of sediment required to build a spit platform in deep water is very large (Meistrell 1972), and the volume of tidal water going in and out of the large embayment would likely have maintained an open channel or an intertidal channel for a considerable period of time. The lagoon was introduced as “a shallow tidal lake that has developed in the lee of a sandy barrier beach” by Williams and Hutchinson (2000). Coastal processes will also be discussed in the *Summary and Conclusions* section below.

Microfossil analysis was carried out by Williams and Hutchinson (2000) when investigating what they concluded to be tsunami deposits at the site. Variability was found through analysis of microfossils in the cores collected in the 2000 study. Peats immediately adjacent to the tsunami deposits were found to be devoid of diatoms, with only a few freshwater species found there. The marsh was concluded to be of “limited tidal influence at the time that E4 was deposited” (deposited approximately 2000 cal BP). Additional samples of peat were analyzed in the Williams and Hutchinson (2000) study and the conclusion was made that the peat that surrounded the tsunami deposits, but was not tsunami deposits, was “deposited in a low salinity marsh or wet meadow environment at or near the elevation of high tides, or that the enclosing barrier beach limited the input of saltwater into the marsh”. The tsunami deposit E2 (deposited approximately 2000 cal BP) contained in excess of 95% littoral, mud flat, saltmarsh, and brackish marsh affinities, including dominant species of *Amphora commutate* and *N. pergrina*, both common members of brackish low marsh/upper mud flat communities. Layer E3 contained 2 specimens of high marsh foraminifers.

Williams and Hutchinson (2000) pointed out that the deposition of the inferred tsunami deposits was centered on the area where the tide gate is now, and not across the length of the barrier that they sampled. They inferred a possible tide channel prior to the tsunami events, stating:

> *“The geomorphology of the coastline at the time of deposition is unknown; however, the presence of Scirpus maritimus and brackish marsh foraminifers in the peat indicates at least limited tidal influence. The geometry of the deposits suggests the presence of a topographic low or a tidal channel in the vicinity of the modern culvert. Ocean water breached the sand barrier at this point or surged up the tidal channel.”*

This obviously is a directly applicable conclusion for this effort, which will be discussed in the *Conclusions and Recommendations* section below.

Historic Analysis

Relevant maps, photographs, and other information were researched and compiled to document historic geomorphic conditions at Swan Lake. Volunteers from SLWPG also assisted CGS in data searches. Data sources included 1850s data through present mapping and aerial photographs to compile a chronology of conditions and changes, both natural and artificial, along with land use changes in the study area and at adjacent coastal properties. The most promising data sources were acquired and reviewed. Maps that appeared spatially accurate and aerial photographs of suitable scale and detail were scanned, imported to ArcGIS, georectified, and analyzed. Maps were prepared documenting the findings of the historic analysis, and how the findings pertain to current conditions at Swan Lake. Primary sources of historic mapping are listed in Table 1.

Table 1. Primary historic data sources.

Year	Source
1871	USC&GS T-Sheet
1891	Plat of Juanita, Island County
1941	Aerial photograph – US War/Army Dept. – flown at 1:34,600
1958	Aerial photograph – Island County
1969	Aerial photograph – WDNR/Island County
1990	Aerial photograph – WDNR/Island County
2007	Aerial photograph – Island County

1800s Mapping

Mapping carried out by the Government Land Office (GLO) in the 1850s showed the lagoon and marsh, but the mapping was no more accurate than sketches. These GLO maps were focused primarily on determining section boundaries for land claim purposes, and the level of natural detail recorded varied, and spatial accuracy away from section corners was quite variable. The 1858 map in particular shows the marsh to be approximately 1 mile east of the shoreline. Notes made during the time of the GLO map were equally uninformative, with only passing mentions of "bulrush swamp", "marsh lands", "rush swamp", and "marshy rush lands" around the perimeter of section 32 where Swan Lake is located. No other descriptive report was included.

The Swan Lake area was fist carefully mapped by cartographers in the U.S. Coast Survey in 1871. The lagoon area was mapped as saltmarsh and open water with no apparent direct tidal connection mapped to the Strait of Juan de Fuca (T-sheet 1253 by USC&GS, UWRHP 2005; Figure 4). No descriptive report was found for this T-Sheet. The University of Washington River History Group georeferenced the early T-sheets of Puget Sound and also created a GIS polygon dataset from the T-sheet mapping based on the original symbology and the original map legends and methods (UWRHP 2005). The symbols for the marsh surrounding the open water was clearly depicted as "saltmarsh" in the UWRHP work and extended waterward to the "gravel and rock, above shoreline" barrier beach deposits and landward away from the lagoon to the forested areas (Figure 4, Table 2). The mapped saltmarsh also extended immediately landward of the barrier berm north of the Swan Lake, apparently linking the backshore wetlands in Joseph Whidbey State Park.

Another feature of note is a "bulge" in the 1871 shoreline mapping in the northern portion of the beach berm. Both the mean high water (MHW) and mean lower low water (WLLW) lines exhibit the waterward bulge (Figure 4). The shape of the feature appears to indicate the presence of an ebb tidal delta, although no clear channel was drawn on the map. Permanent channels were often marked directly on maps as solid lines connecting the upper and lower beach. The "bulge" occurs in an area with otherwise relatively linear MHW and MLLW lines. Therefore this feature may then be evidence of an ebb tidal delta for an intermittent channel that was not open at the time of the mapping.

Table 2. Known historic changes to Swan Lake, 1858 to present.

Year	Feature/ Event	Source
1858	Government Land Ordinance survey observes “bulrush swamp”, “marsh lands”, “rush swamp”, and “marshy rush lands”	US BLM
1871	USC&GS mapping, no settlement activity noted. Mapped saltmarsh surrounding Swan Lake, starting landward of beach berm.	USC&GS/ NOAA
1891	200 rods (3,300 ft) of ditch completed at Swan Lake	Island County Sun (July 11, 1891)
1891-1915	Tide gate (sluice) installed within this period	Undated land sale document of E.T. Hill
1918	Drainage District No. 1 established for the watershed that drains into Swan Lake.	WSCC 2000
1939-1941	Road constructed on beach berm between lagoon and the Strait of Juan de Fuca	NGS benchmark notes for LAKE (PID TR0508) and aerial photo analysis
1941	Vegetated area waterward of new road, prominent main ditch visible. Road only continues to near south end of low elevation area. Surrounding uplands and entire lower stream valley appear mostly cleared of trees and in agricultural use.	Aerial photo analysis
1958	First house seen on berm at north end, construction continues through today. Ditch present parallel and landward of road.	Aerial photo analysis
1969	Approximately 25 cabins/houses present on berm, mostly on north end.	Aerial photo analysis
1970’s	Sunset Beach plots constructed on south end of berm using concrete walls and backfill to create buildable lots extending over intertidal. Following fill, and prior to house construction, the walls fail and the site is abandoned. Initial failure visible in 6/9/77 oblique air photo.	Aerial photo analysis
1990	Approximately 10 cabins/houses present on berm south of tide gate, north end mostly built out.	Aerial photo analysis
2007	New flap gate installed and pipe slip-lined on north tide gate; south gate remains stuck open.	Whidbey News Times (9/27/07)

The Plat of Juanita, completed by E.T. Hill in 1891, contains some interesting parcel boundaries. The boundary between lots 13-14 and 15-16 especially appears to be located close to an existing ditch near the tide gates (Figure 5). Multiple boundary lines (17-18, 21-22, 26-33, 27-32, etc.) look like they bisect parcels at the edge of the lake. A colored and annotated version of the plat map (WSHS catalog no. 2010.0.340; Figure 5) was undated, but the date is thought to be on the order of 1905 to 1915 (J. Werlink pers. com. 2010). The map contains an additional line parallel to the above parcels lines labeled “ditch” and “sluice”, apparently indicating that these are in fact ditches already in place. A paragraph from the Island County Sun dated 7/11/1891 states that J.S. Metzler from Swantown “has just finished putting in 200 rods [3,300 ft] of underground ditches to drain a marsh” providing evidence for early alterations to the hydrology of the lagoon, which possibly included a tide gate(s). Both the Plat of Juanita and the newspaper article appear to firmly date the construction of ditches at Swan Lake as starting no later than 1891.

A former landowner reports that the marsh was drained and used for cultivation early in the twentieth century (Wes Maylor, personal communication 1997; as referenced in Williams and

Hutchinson 2000). As reported in the 1 memo (Johannessen and Waggoner 2010), during an interview with long-time resident Chuck Bos (SLWPG 2009), who grew up at Swan Lake, he mentioned that “before his time, there was an ongoing problem with the lake level getting too high at the north end and water running overtop a low area of land.”

1900s to Present Changes

The National Geodetic Survey (NGS) set a benchmark (LAKE, PID TR0508) near the tide gates in 1939 with a reference mark (RM #2) set in the northern concrete tide gate box. Notes made during setting mention a “large rectangular concrete box 10 ft high” at the beach end of a ditch and that a “pile break-water protects the beach in this vicinity for about 100 feet”. The 10 ft-high box is likely the north tide gate well prior to filling of the lot. There is also mention of a fence and “an unpainted shack” in the vicinity of the monument. The subsequent recovery note dated 1942 mentions that a road had been constructed in the mean time. This would place the road construction date somewhere between 1939 and 1942. The road does appear to have been constructed by the time of the 6/27/41 aerial photo (Figure 6a). However, it does not appear to continue up the hill to the south as it does today.

Subsequent aerial photographs show a progression of shoreline development following road construction on the beach berm (Table 2). A 1958 photograph shows one house on the north end of the road, and no indication of the shack found in 1939 (Figure 6b). By the time of the 1969 aerial photograph much of the beach berm north of the tide gate has been developed. Both the 1990 and 2007 photographs show the continued development of the site (Figure 6c). The progression of aerial photographs also show the lake level being quite low in the earlier photographs, but close to the 1871 level in both 1990 and 2007.

The area of the ponded water varied widely in the different aerial photos, especially as compared to the 1871 T-sheet. This was also discussed in the Task 1 memo (Johannessen and Waggoner 2010), and differences in the dates and stream flow directly affect the ponded water area, other than changes due to differing conditions at the tide gates. In general, the ponded water area was quite large in 1871, quite small in the 1941 through 1969 photos due to the tide gates, and again large since 1990 (Figures 6a-6c). Ditches were quite extensive in 1958 and 1969, extending south of the current lagoon, well to the east in the creek flood plain, and all the way up to the road on the north end, areas that are often inundated at present. Extensive haying or agricultural use of the wetlands of the present lagoon was occurring in 1969—and likely in 1958 as well, although the 1958 photo is not as clear. With the much lower water levels during the majority of the 1900s, it is likely that some amount of compaction and local subsidence has occurred in the peat throughout the Swan Lake area. This would occur due to oxidation of the organic soils of the peat and greatly accelerated (aerobic) decomposition.

Several ground photos taken by local residents illustrate the variability of water levels in the lagoon over the recent past (Figure 7). Storms have also affected lagoon water levels as overwash from the Strait has flooded Swan Lake on a number of occasions (Figure 8). Overwash during high water storms still occurs even after the berm appears to have been raised with the addition of fill prior to house construction, and also likely during road building.

Past Recommendations

The following recommendations were made for the Swan Lake system in the Habitat Limiting Factors report (WSCC 2000):

- Explore remaining acquisition or conservation easement opportunities for properties in the vicinity of Swantown marsh and the riparian corridor along Swantown Creek.
- Remove or repair the culverts, tide gate and other drainage structures connecting Swantown Marsh to saltwater to allow for fish passage. Restore the open connection to saltwater by creating an open channel between West Lake Road. Install a large box culvert or conspan or bridge under the road south of the Swantown community.
- Fill in the drainage ditches paralleling West Lake Road and other ditches in the area.
- Allow natural drainage channels to form within the wetland. Reconstruct the stream channel in the lowland farmlands.
- Remove exotic species and revegetate the riparian areas associated with the salt marsh and stream channel.
- Evaluate the potential effect of the existing sea walls on the beach with regards to maintaining the proposed channel mouth.

The following recommendations were made for the Swan Lake system in the Island County Estuarine Restoration Program (Sheldon and Associates 2001):

- Acquire property
- Remove culverts, tidegate, and other drainage structures
- Restore open connection to saltwater with open channel
- Install box culvert or bridge at West Beach Rd
- Locate open channel at culvert or southwest corner
- Fill ditches along road
- Plant wetland buffer
- Interpretive signs
- Assess hydrology and install structures to prevent downcutting of outlet channel
- Develop plan for restoring creek between gold course and lagoon for salmonids

Additional Work

Additional work that is planned to be completed in late 2010 includes water level monitoring and sediment coring. Water levels in Swan Lake and Swantown Creek will be monitored using three pressure transducers. Water levels in the Strait will be taken from existing NOAA monitoring stations and correlated to local MLLW. Additionally, flow rate and stage for the creek will be checked periodically to help determine the freshwater inputs into Swan Lake.

Sediment cores will be advanced in select locations of Swan Lake and surrounding wetlands, particularly the northern area where historic maps, geomorphic analysis, and anecdotal evidence has indicated a tide channel would likely have been located. Cores will be examined in the field and select portions stored for future examination. The core sub-samples will be analyzed for the presence of seeds and other organic matter as indicators of a salt or fresh water dominated system.

Conclusions and Recommendations

Net shore-drift, or the long-term effect of littoral drift was mapped at the study area by Ralph Keuler in a US Geological Survey map (1988). Net shore-drift is northward and northeastward at the study area. The net shore-drift cell (also called a littoral cell) originates approximately 5.5 miles to the southwest of Swan Lake near Point Partridge at the westernmost tip of Whidbey Island within Fort Ebey State Park (Figure 1). The drift cell continues approximately 8.5 miles further to the northeast to the southern shore of Deception Pass.

Coastal geomorphic interpretation indicates that the lagoon and barrier berm likely developed over time following deglaciation (after the Fraser glaciation) and subsequent relative sea level rise and glacial rebound. This scenario would have relative sea level higher than today soon after ice-free conditions were reestablished between 11,000 and 13,000 years before present, and marine water extended as high as approximately 160 ft MSL adjacent to Swan Lake (Dragovich et al. 2005; Figure 2). The Swantown Creek floodplain was very likely an embayment at this point in time. Vertical rebound of the landmass then outpaced marine inundation and relative sea level was falling at the study area. By approximately 5,000 years ago, the majority of the rebound of the land is thought to have taken place, and global sea level rise had mostly leveled off. The study area likely still contained an embayment of some type.

The near stabilization of sea and land levels approximately 5,000 years ago likely set the stage for the development of the major depositional coastal landforms such large spits, as introduced in the *Geologic Setting and Processes* section, above. A classic pattern of coastal evolution would have the spit very likely prograding northeastward across the mouth of the former Swan Lake area embayment. The spit would have likely extended further across the bay mouth for a considerable length of time as sediment transport continued and some sediment was lost offshore. Also, the volume of tidal water going in and out (tidal prism) of the large embayment would likely have maintained an open channel or an intertidal channel for a considerable period of time.

The rate of sediment transport is not known at this time at the study area or at other locations within the drift cell, however the rate is judged to be fairly high compared to other Puget Sound area drift cells. Evidence of the high net shore-drift rate is available in the time series of air photos for the Rocky Point area located approximately 2.5 miles north of Swan Lake. There, a large spit formed atop pre-existing intertidal bars (analogous to a high spit platform) just north of Rocky Point between 2001 and 2006. By 2009, the spit was approximately 2,700 ft long and up to 300 ft wide (above MHHW). This rapid accretion rate is evidence of the high net shore-drift rate in the drift cell. The majority of feeder bluffs in the drift cell up-drift of Rocky Point are also up-drift of Swan Lake. Review of aerial photos at Swan Lake indicates that no noticeable accretion has occurred in the immediate study area. Therefore, the high volumes of littoral sediment are presently transported past the Swan Lake area.

The lagoon was introduced as “a shallow tidal lake that has developed in the lee of a sandy barrier beach” by Williams and Hutchinson (2000). As described above, based on extensive sediment coring, identification of microfossils, and radiocarbon dating, these authors also concluded that the lagoon had “at least limited tidal influence” prior to tsunami events and that: “The geometry of the [tsunami] deposits suggests the presence of a topographic low or a tidal channel in the vicinity of the modern culvert."

The presence of the "bulge" which is lined up in both the MHW and MLLW shorelines directly cross-shore in the earliest reliable map (1871; Figures 4 and 6a) suggests that an ebb tidal delta also may well have been present 1,000 ft northeast of the tide gates. There are not other good explanations for the presence of these features in otherwise near-linear shores in a high wave energy environment away from bluffs and bedrock outcrops. If present, an ebb tidal delta may have been intermittent, in response to large precipitation/runoff (opening) and/or storm wave events (closing). The fact that this potential ebb tidal delta does not show up in the 1941-2010 data sources is not surprising, as the hydrology of the lagoon system was modified soon after 1871.

The presence of the topographic low located just north of all of the houses on the berm near the north end of the lagoon and wetland suggests that this area was a location of a tide channel (Figure 9, also see Task 1 memo Figure 4 and Photo Page 2). Points in the wetlands there just north of the road were as low as +6.9 ft MLLW. South of the road bend, the marsh surface was as low as +5.9 ft MLLW in the limited area surveyed.

Currently the berm and lagoon are heavily altered as a result of considerable ditching, dikes and tide gates, which had begun to be installed as early as 1891, and likely expanded around 1918, shortly after Drainage District 1 was established (WSCC 2000). Earliest evidence tells of 3,300 ft of ditches being installed by July of 1891. A later, undated land sale document indicates that at least one tide gate had been installed by approximately 1910.

Saltmarsh vegetation was present in the lagoon in 1871, as mapped by the US Coast and Geodetic surveyors (Figure 4). Overwash of the berm occurs periodically under present tide gate conditions (Figure 8), and the failing tide gates allow some volume of marine water to enter the lagoon (as discussed in the Task 1 memo). Saltmarsh vegetation is widespread around the lagoon at present, including pickleweed (*Salicornia virginica*) and saltgrass (*Distichlis spicata)*, such that conditions obviously already support this vegetation community and would not need to be substantially altered for enhancement of habitat conditions. However, if water levels in the lagoon were allowed to vary more in line with tidal levels in the Strait, the marsh vegetation may have to migrate up in elevation.

The water level in the 2007 air photo was between +2 and +3 ft MLLW (Figure 10), indicating that the bottom of the ponded water area in the lagoon visible in Figure 6c was lower. Full topographic and bathymetry has not yet been collected for the lagoon area. Restoration/enhancement may be more feasible than earlier due to the likely compaction and local subsidence of peat soils. Preliminary and unverified analysis of LiDAR data suggests the area below MHHW is currently on the order of 120 acres. With what appears to be an area on the order of 120 plus acres in size with a moderately large tidal prism by Puget Sound are standards, the restoration/habitat enhancement potential is fairly high.

Although historic data that predates the extensive modification to the Swan Lake lagoon system is not extensive, with the data discussed in this report that included the entire lagoon fringe mapped as salt marsh in 1871 coring data and other items as discussed, we conclude that prior to modification, the system was likely a brackish water system that likely included an intertidal connection (tide channel) to the Strait that was periodically open, but likely not in a permanent or stable configuration. Due to the large size of the system and the documented presence of relatively abundant fish (including juvenile salmon) immediately west of the lagoon, the habitat enhancement potential for this site is fairly high. Although the recreation of a connection to the Strait may not constitute true restoration, this action could provide valuable saltmarsh and lagoon habitat that is currently not accessible to fish. This habitat enhancement recommendation is also consistent with recommendations in the Habitat Limiting Factors report (WSCC 2000) and the Island County Estuarine Restoration Program (Sheldon and Associates 2001).

Based on the findings of this preliminary study, the proposed more comprehensive feasibility assessment put forward in the recent funding round holds merit, and that study (to include much more detailed mapping, wave and littoral drift assessment, habitat mapping, wetland hydrology assessment, inlet analysis, reference site analysis, infrastructure analysis, and more detailed feasibility of several alternatives), should be completed.

The following Opportunities and Constraints summarize practical findings of this preliminary analysis:

Opportunities

- Adding a more direct and fish passable connection from Swan Lake to the Strait of Juan de Fuca would add on the order of 120 acres or more of coastal lagoon/estuarine habitat and also make habitat improvements on Swantown Creek possible.
- The relatively large potential tidal prism and moderate sized drainage area at Swan Lake suggests that some type of channel to the Strait may be quite feasible.
- Improve tidal exchange such that lagoon levels do not exceed water levels in the Strait of Juan de Fuca. This would help ameliorate upstream flooding issues (e.g. at the Fakkema property) caused by stormwater backing up at the tide gates.
- If an open channel is deemed infeasible with further analysis, then constructing a bridge or other means of engineered fish-passable structures could be used.

Constraints:

- Developed lots on the beach berm make it difficult to locate an open channel there as the channel may tend to be dynamic. The migration would likely be northward, such that placement along the developed portion of the berm may not be feasible.
- This reach of shore likely has a high littoral drift rate and high wave energy, which will require additional analysis and engineering assessment.
- Any channel would need to pass under West Beach Road, requiring a bridge or other engineered structure.
- Island County only owns the southern and central portions of the study area where the lake is and not the two large parcels to the north where one potential channel location is. These properties would need to be acquired or easements secured before a channel could be located to the north.

- The northern property is the location of a communications cable, so special consideration of the cable would need to be made if it is still in use (attempts to reach the owners were not successful).
- Area wells and septic systems must not be impacted by additional intrusion of saltwater.

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ATTACHMENTS:

Figure 1. Location and net shore-drift map
Figure 2. Geology map plan view and cross section
Figure 3. Map showing Quaternary fault traces, including active fault zones
Figure 4. T-sheet 1253 with interpretation
Figure 5. Circa 1910 Land sale advertisement drawn on 1891 Plat of Juanita
Figure 6a. 1871 T-Sheet and 1941 aerial photograph
Figure 6b. Aerial photographs from 1958 and 1969
Figure 6c. Aerial photographs from 1990, 2007

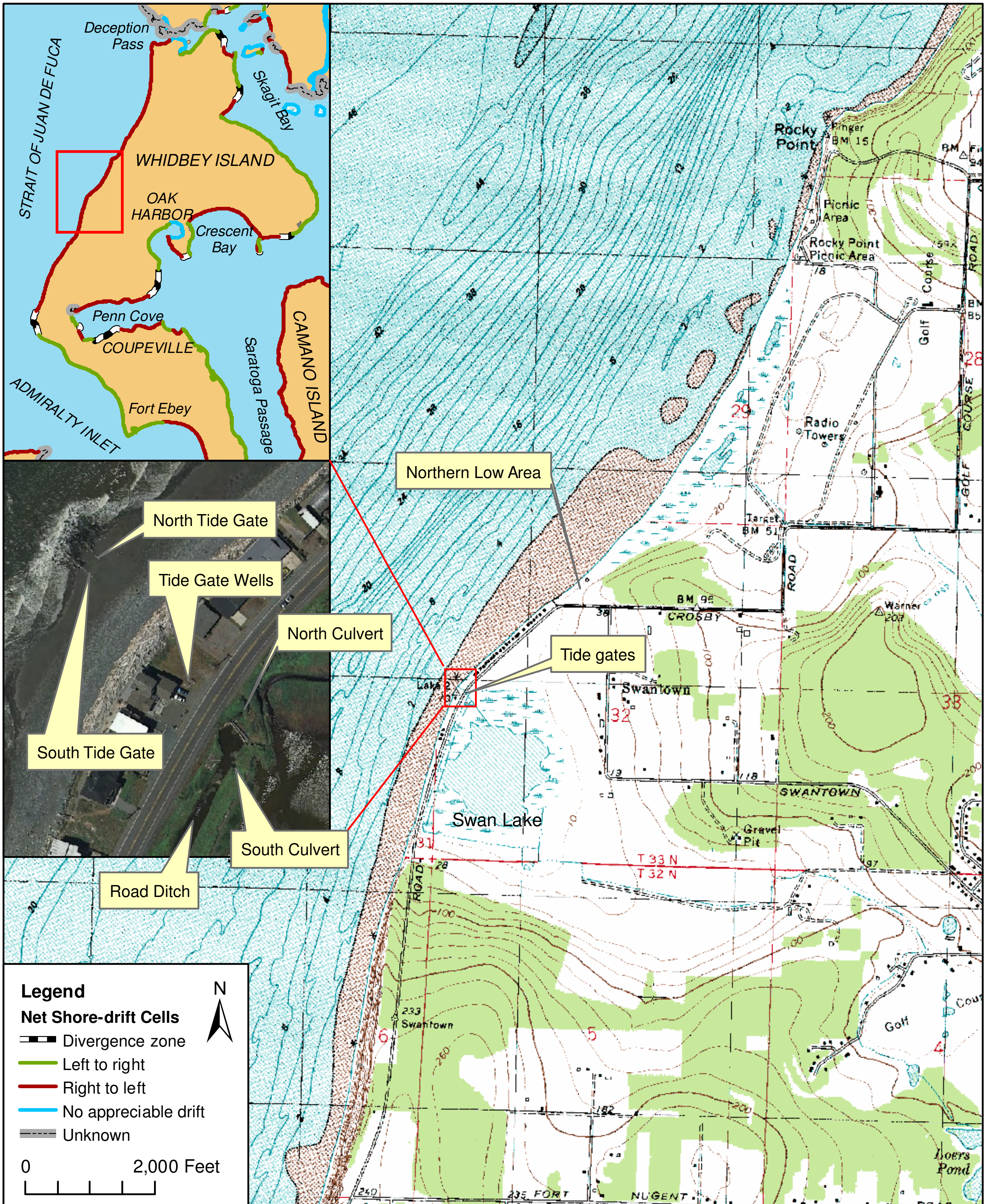

Figure 1. Swan Lake vicinity map showing net shore-drift cells for northern Whidbey Island.
USGS topographic map shown

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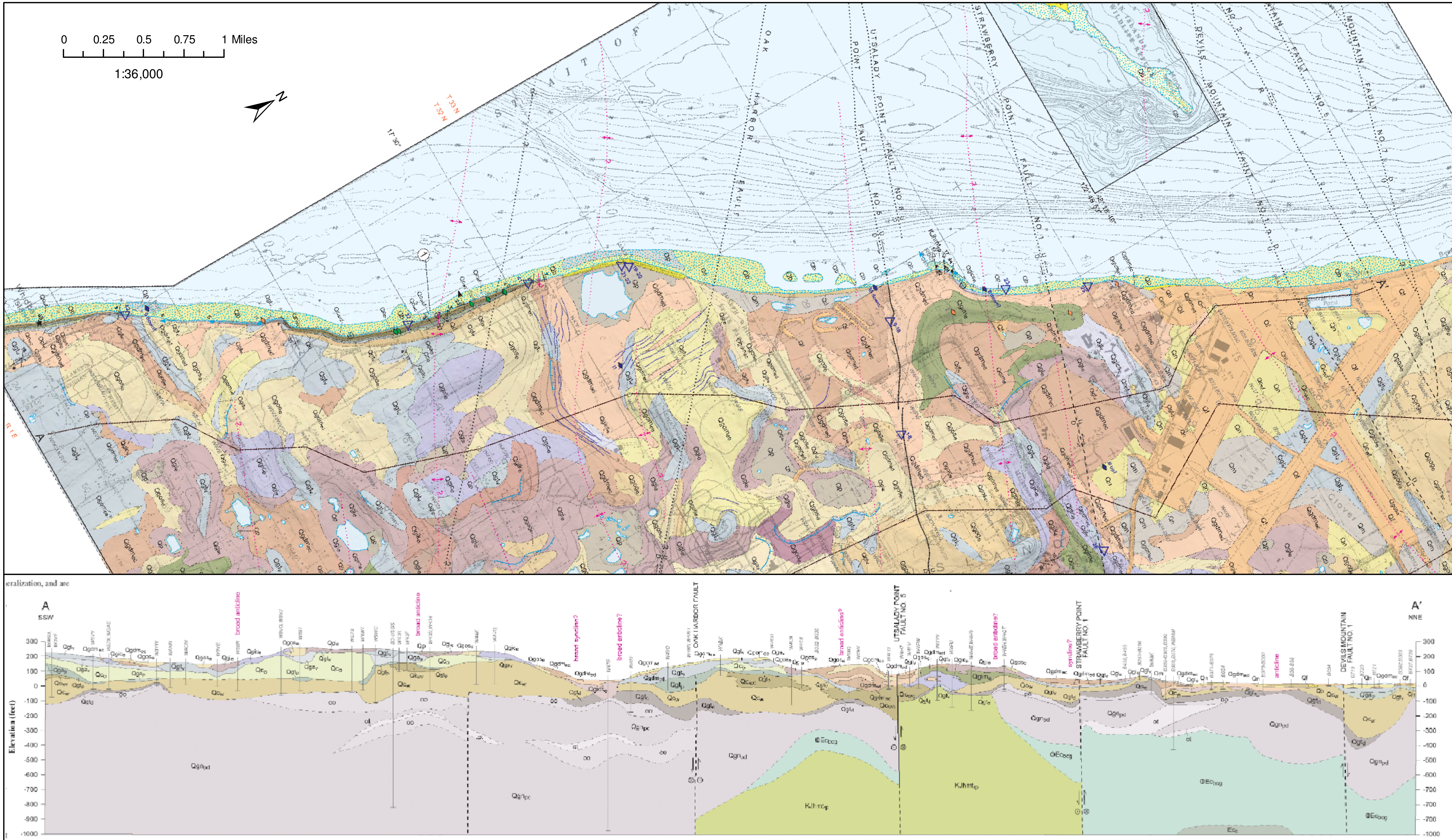

Figure 2. Geologic map plan view and cross section (Dragovich et al. 2005).

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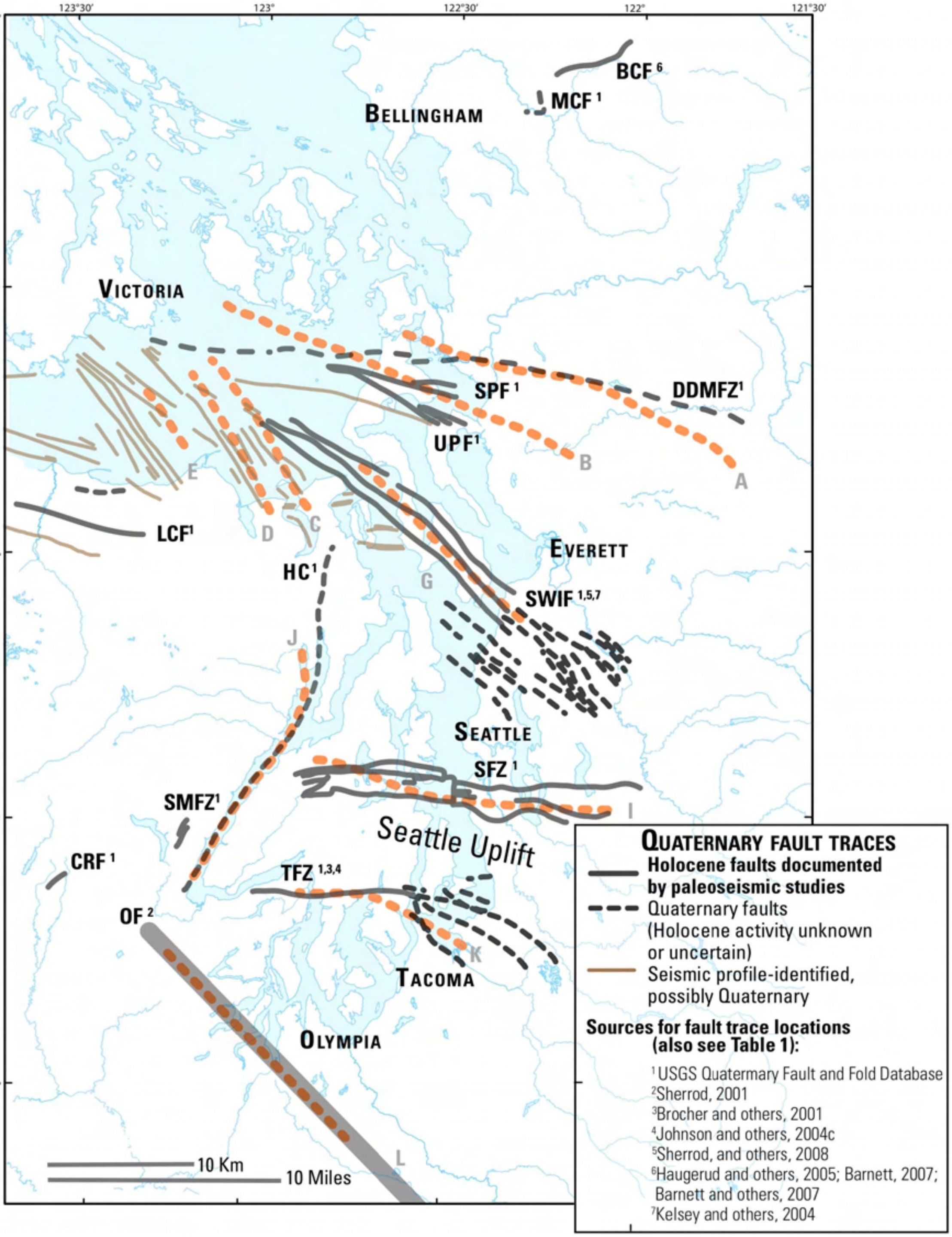

Figure 5. Map showing Quaternary fault traces, including active fault zones, mapped before 2009 in the Puget Lowland, from USGS Quaternary Fault and Fold Database (USGS, 2006) and subsequent studies. Faults that have documented Holocene earthquakes are shown in black; faults that have unknown Holocene activity, but probable activity during Quaternary, in gray. Newly mapped fault traces not included in USGS Quaternary Fault and Fold Database also are shown. Inferred Quaternary fault structures from Gower and others (1985) are denoted by orange dashed lines and labeled in gray. Abbreviations: BCF, Boulder Creek Fault; CRF, Canyon River Fault; DDMFZ, Darrington-Devils Mountain Fault Zone; HC, Hood Canal Fault; LCF, Lake Creek-Boundary Creek Fault; MCF, Macaulay Creek Fault; OF, Olympia Fault; SFZ, Seattle Fault Zone; SMFZ, Saddle Mountain Fault Zone; SPF, Strawberry Point fault; SWIF, South Whidbey Island Fault; TFZ, Tacoma Fault Zone; UPF, Utsalady Point Fault.

Figure 3. Map showing quaternary fault traces, including active fault zones (Barnett et al. 2010).

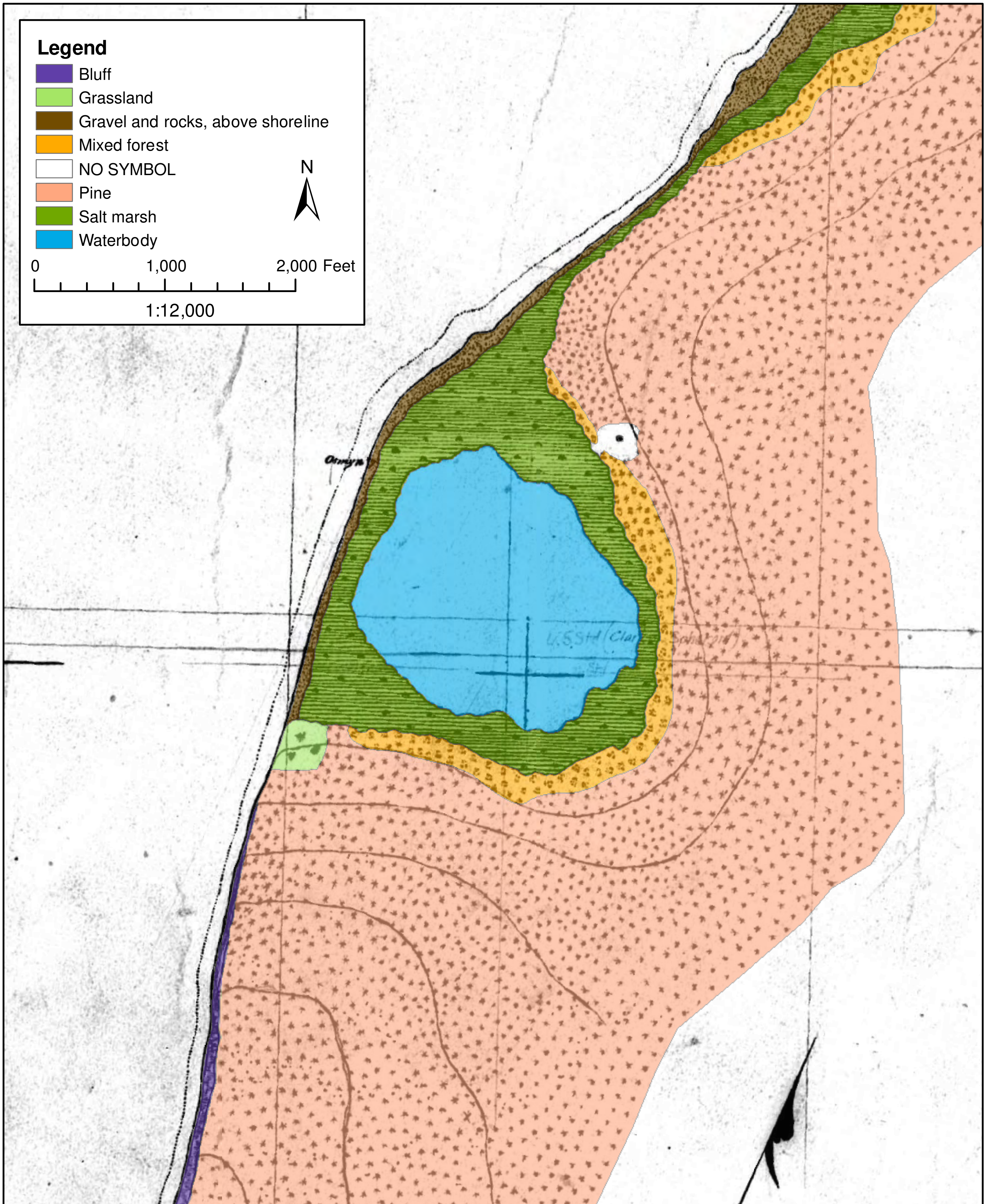

Figure 4. T-Sheet number 1253 from 1871 with interpretation by the Puget Sound River History Project, University of Washington (2005).
T-Sheet by USCGS 1871

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Figure 5. Circa 1910 Land sale advertisement drawn on 1891 Plat of Juanita.
Map courtesy WA State Historical Society; 2007 Island County aerial photo shown for reference.

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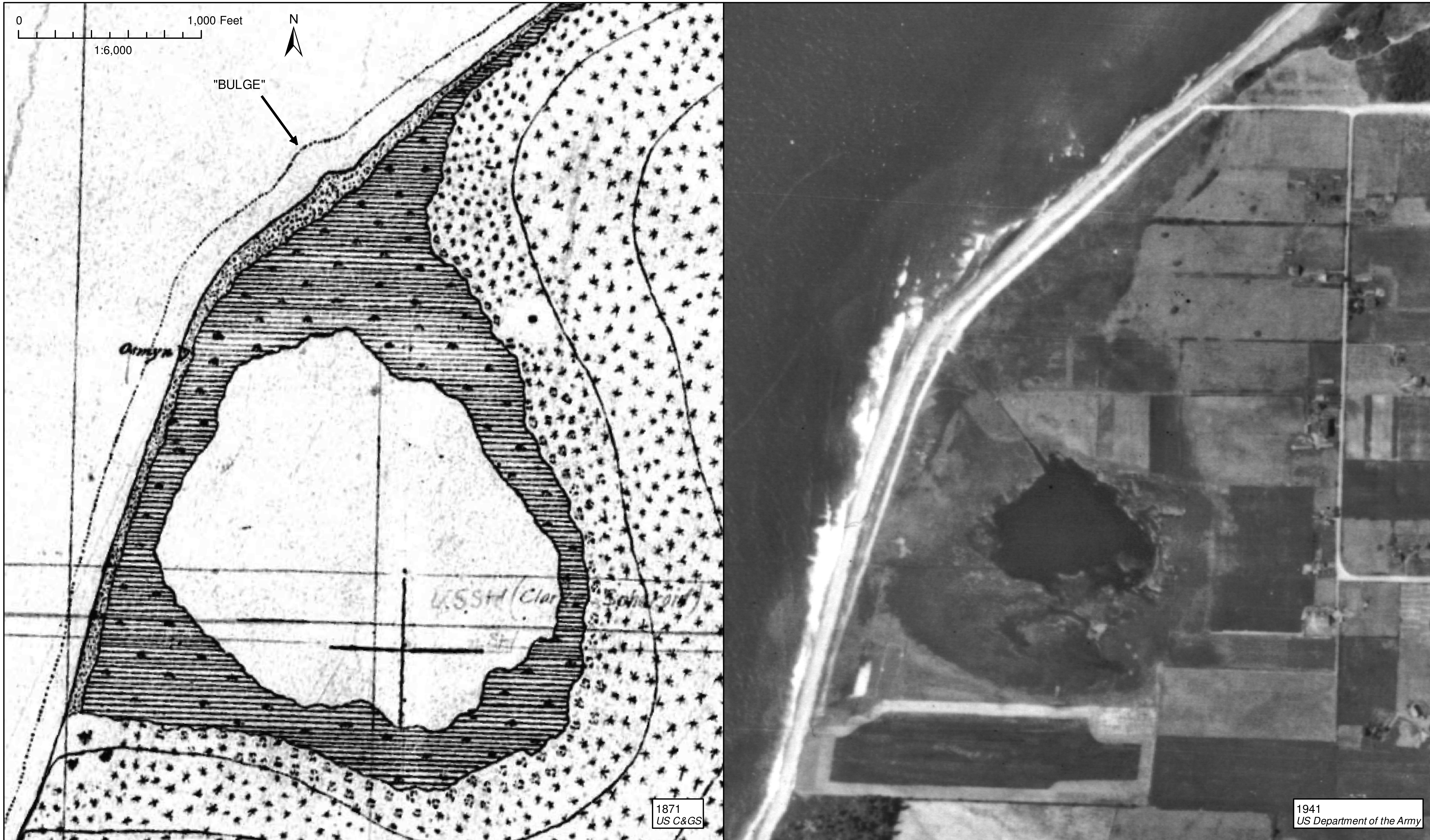

Figure 6a. 1871 T-Sheet (no. 1253) and 1941 aerial photograph.
Note beach "bulge" mapped in 1871, possibly the location of an intermittent tide channel.

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Figure 6b. Aerial photographs from 1958 and 1969.
Note very low lake levels and well-defined drainage ditches in 1958 and 1969 photos. Also, first house appaers at north end in 1958 with much greater build-out by 1969.

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Figure 6c. Aerial photographs from 1990 and 2007.
Note the high water level in 1990 and 2007, likely due to lack of tide gate maintenance following dissolution of Drainage District No. 1.
2007 water level was on the order of +2 to +3 ft MLLW based on field survey.

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5/15/08

8/11/08

11/15/08

1/13/09

4/28/10

5/5/10

Figure 7. Photo page with various photos of lake level taken by local residents. Top of pile is 8.6' MLLW, bottom is 1.6' MLLW. Overall fluctuation approximately 5 ft.

December 1982

December 1982

November 1990

November 1990

November 2004

November 2004

Figure 8. Photo page with post storm images.

Figure 9. North end of Swan Lake showing topographic data and selected spot elevations collected on 29 June, 2010. Elevations shown are in local mean lower low water (MLLW). Note that much of low area is below MHHW, which is +7.5 ft MLLW is this area.
Air photo from Island County (2007)

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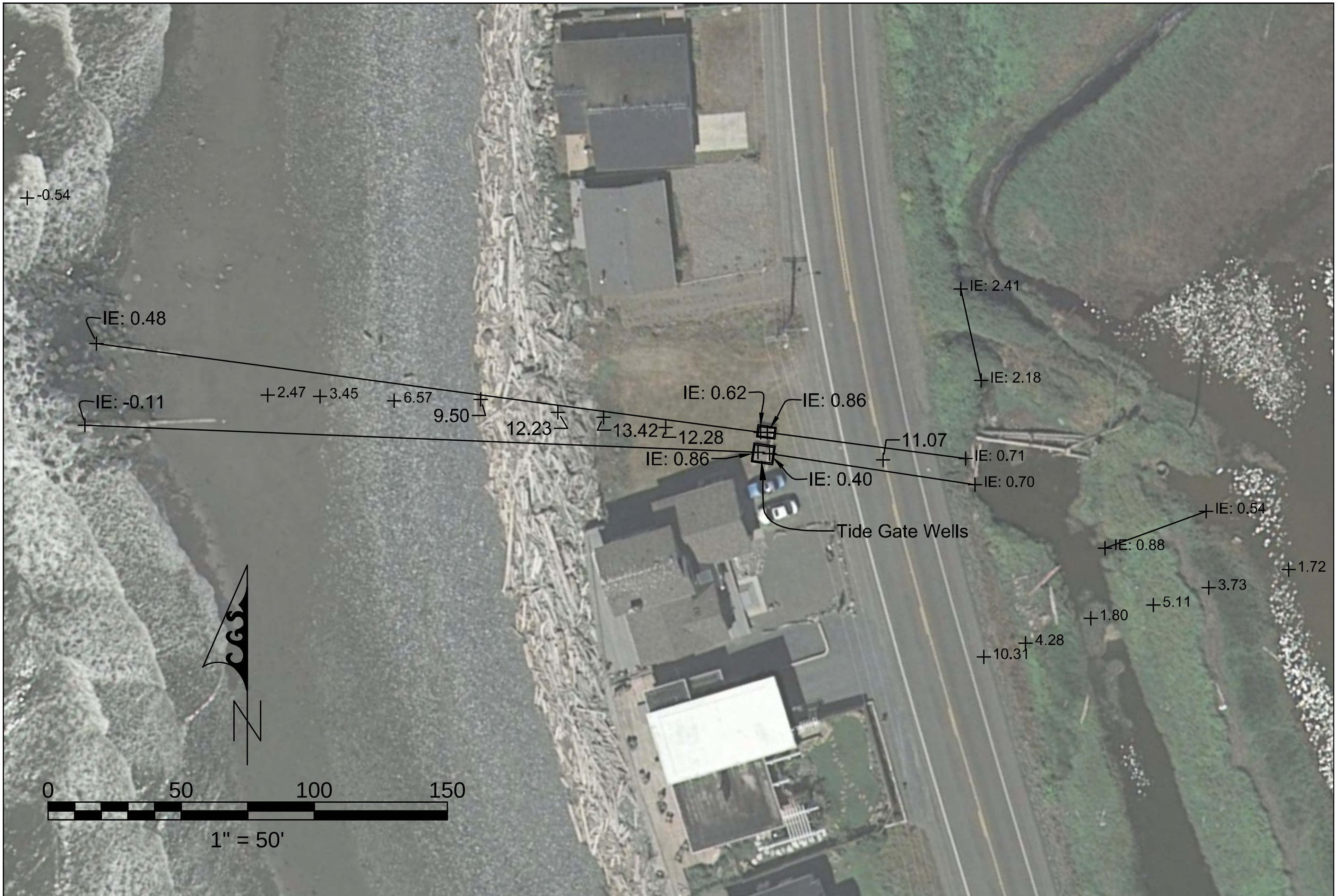

Figure 10. Tide gates and vicinity at Swan Lake showing invert elevations (IE) and selected spot elevations collected on 29 June, 2010. Elevations shown are in local mean lower low water (MLLW). Black lines indicate location of pipes. Lagoon (main basin) water surface at time of survey was +3.73 ft MLLW and falling approximately 1 $\frac{1}{2}$ hours after low tide of -0.9 ft MLLW.
Air photo from Island County (2007).

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