lower wave or long-shore current energy, and (2) have local freshwater inputs (surface or groundwater sources) where salinity is depressed during some part of the year (usually winter and spring).” Mitigation Site 1—and Crescent Harbor Creek as a source of fresh water—appear to be crucial elements in the sustainability of habitat in the downstream marsh.

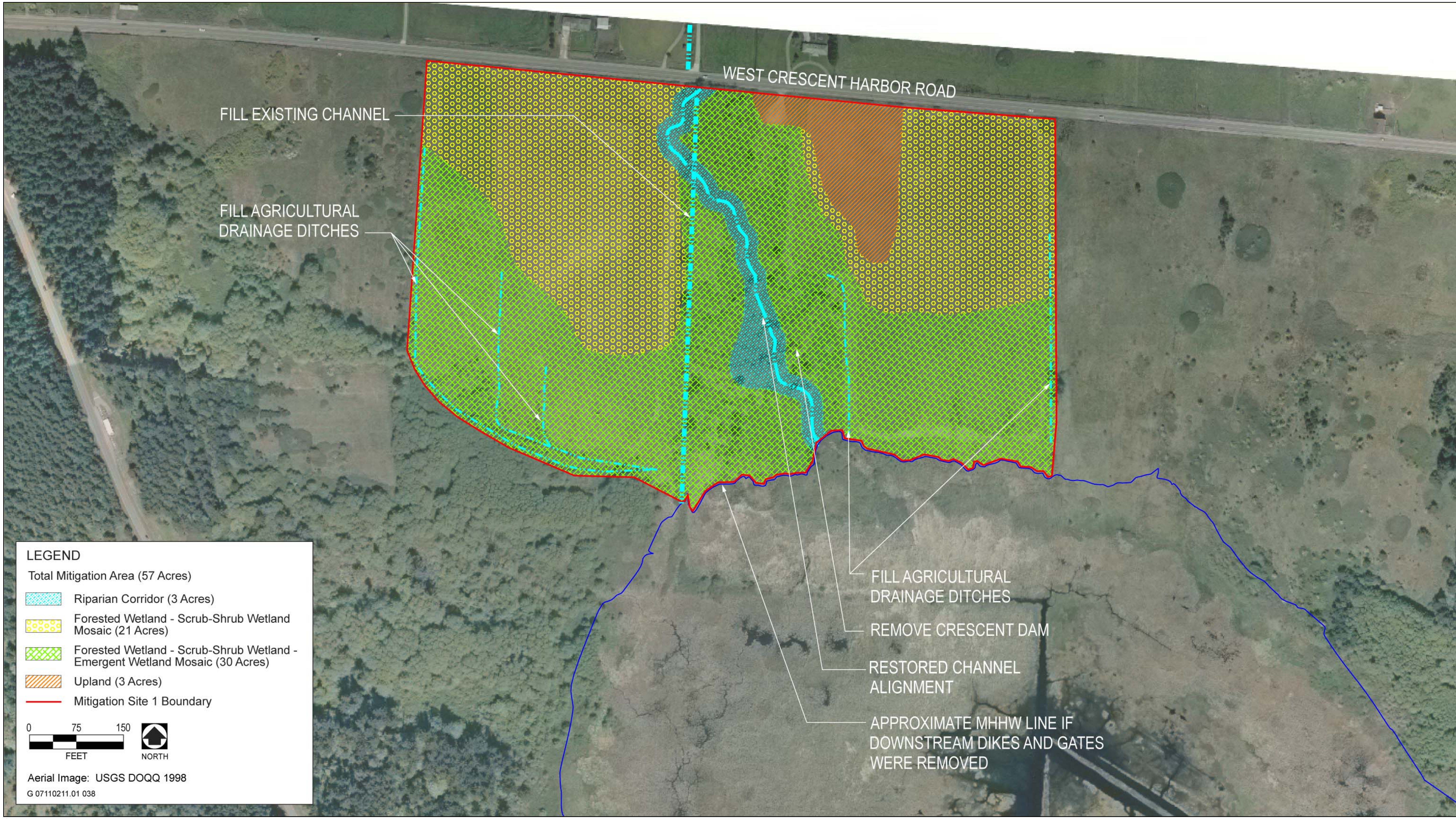
Research indicates that existing Skagit delta habitat conditions are likely limiting the capacity of delta-rearing Chinook (Beamer *et al.* 2003). Additionally, research (*ibid*) has shown:

- there appears to be a seasonal preference during the period from February through May when large numbers of fry migrant chinook utilize and appear to prefer pocket estuary habitat connected to Skagit Bay, compared to adjacent nearshore and offshore areas;
- pocket estuaries appear to offer a refuge from larger predatory fish for fry migrant Chinook, compared to the adjacent nearshore environment; and
- the shift in seasonal habitat occupancy also corresponds to fish size, which suggests that the fish within the pocket estuary may be a more isolated rearing (rather than migrating) population, or that pocket estuary habitat may be more productive than the more exposed nearshore environment.

The location of Mitigation Site 1 on the creek just upstream of a salt marsh that may soon be restored increases the potential of the conceptual restoration project to accrue environmental and societal benefits. These benefits include but are not limited to improving connectivity between Crescent Harbor Creek and the downstream salt marsh; increasing water quality in the creek and the downstream marsh; providing improved instream habitat; increasing the aesthetics of the site; and improving riparian and wetland habitats. These benefits are further described in Section 6.3.1 “Restored and Rehabilitated Functions.”

6.3 DESCRIPTION OF CONCEPTUAL SITE PLAN – CRESCENT HARBOR CREEK RESTORATION AND WETLAND HABITAT REHABILITATION

Mitigation Site 1 offers the opportunity for rehabilitation of part or all of the site. Successful rehabilitation of wetland habitats on the site requires the restoration of the site’s hydrology, which would be achieved by realigning Crescent Harbor Creek, filling the existing channel, and filling the small artificial drainage ditches. The resulting restored topography and hydrology would support the establishment of a diverse assemblage of wetland vegetation communities, including riparian wetland, forested wetland, scrub-shrub wetland, and emergent wetland (Exhibit 6-2).



Source: Prepared by EDAW in 2008

Mitigation Site 1: Conceptual Mitigation Plan **Exhibit 6-2**

Construction activities at Mitigation Site 1 site would involve excavation of the new stream channel and floodplain, placement of in-water features such as streambed gravel and large-woody debris, diversion of the stream to the new channel, filling the existing channel, removing Crescent dam, filling the small depressions and pond upstream of the dam, filling the small agricultural drainage ditches, and planting native species within the riparian corridor and associated wetlands.

CRESCENT HARBOR CREEK REALIGNMENT AND RIPARIAN CORRIDOR RESTORATION

The channel in which Crescent Harbor Creek currently flows will be filled along its entire length and a new channel will be constructed beginning just south of the culvert outlet at Crescent Harbor Road. The new channel alignment will be designed to follow the historic natural stream alignment as closely as possible, resulting in a shallower and more meandering configuration. The bed of the realigned channel will be higher in elevation than the existing, incised channel bed. The new, shallower channel will reestablish a more natural hydrologic connection between the creek, floodplain, and adjacent groundwater. The realigned stream channel will meet the existing downstream salt marsh at approximately the high tide water level. The channel design includes floodplain areas to reconnect the creek to a floodplain and associated wetlands. Exhibit 6-2 shows a 20 to 100-foot-wide riparian corridor within which the new creek alignment and associated floodplain would be located, contingent on further site investigations and final analysis of site data. Crescent dam would be removed and the spoils would be used to fill the isolated pond upstream of the dam. Data from the site investigations and technical studies described above were used to determine the preliminary channel gradient, alignment, dimensions, and other channel characteristics.

Design of the restored channel will include revegetation of the riparian corridor with site appropriate native species, and it will incorporate habitat features such as large woody debris (LWD), riffle-pool complexes, and off-channel wetland pools connected and filled during times of higher discharge (see the following paragraph).
The final planting plan along the proposed realigned channel and riparian corridor will be determined after final design of the channel is completed, and will be based on the water regime at different elevations along the realigned channel. It is anticipated that the proposed mitigation project will include the reestablishment of a forested wetland riparian corridor, with patches of scrub-shrub and emergent communities intermixed where appropriate. Existing high-value habitat features, such as large-diameter trees and any areas of high-quality wetland habitat, will be evaluated to determine whether they should be retained or relocated.

The existing hydrologically isolated pond, located west of the realigned channel and upslope from Crescent dam, will be partially filled and connected to the realigned channel as a potential high-discharge overflow area. The proposed reestablishment of a forested wetland riparian corridor along the realigned channel will include the area around the pond. Rehabilitation of this forested wetland area will entail removal of remnant piles of rock and soil left from excavation of the ponds; recontouring the area to enhance habitat quality; and establishment of site-appropriate native wetland species, especially along the shallow edges of the ponds. Rehabilitation of the vegetation in this area in association with the realigned channel will provide a seasonally inundated, near-channel habitat that would benefit, songbirds, and other wildlife through both improved habitat connectivity and improved foraging habitat.

To the northeast of Crescent dam is an artificial mosaic of low areas and sediment piles that are likely remnants of bulldozer work related to the construction of the dam and the pond. This area is drained on the northeast by an agricultural drainage ditch that is nearly 4 feet wide and up to 3 feet deep in places. Mitigation in this area will involve filling the ditch and incorporating this area into the realigned Crescent Harbor Creek riparian corridor and associated wetlands.

Restoration of Localized Site Hydrology to Allow for Rehabilitation of Artificially Drained Wetland Habitats in Lower and Higher Topographic Positions in Fields

Several small agricultural drainage ditches located in the margins of the mowed fields on both the west and east sides of the proposed realigned Crescent Harbor Creek and riparian corridor will be modified to restore local site hydrology in lower topographic positions in the fields. These small ditches (approximately 1.5 feet wide by 0.75 to 1.0 feet deep) were likely constructed to drain surface and subsurface water on the site in order to use the land for agricultural purposes. Filling these ditches will reduce the drainage of shallow soilwater that currently occurs and will contribute to raised groundwater levels. It is proposed that these areas be allowed to recover for 2 years, during which the hydrology and natural vegetation recruitment can be evaluated and further rehabilitation activities can be determined. Rehabilitation of emergent, forested, and scrub-shrub wetland plant communities in these areas will involve monitoring hydrologic conditions and natural vegetation recruitment, and developing a planting plan to reestablish site-appropriate native plant communities. A recommended plant palette is presented in Section 6.3.4.

Forested and scrub-shrub wetland plant communities consisting of native plant species will be reestablished in those areas in higher topographic conditions in the unmanaged grass fields where site hydrology is drier. The recommended plant palette presented in Section 6.3.4 identifies a range of native species suitable for drier to wetter wetland areas. The final planting plan will be influenced by the supporting hydrology and microtopography of the site and will attempt to establish a mosaic of habitat types similar to the areas adjacent to the fields.

Buffers

Based on the Ecology, USACE Seattle District, and EPA, Region 10 Joint Guidance on *Wetland Mitigation in Washington State* (Ecology, et al. 2006), it is likely that Mitigation Site 1 will require at least a 110-foot buffer. This width is based on the buffer required to protect a Category II wetland exposed to a moderate level of impact from adjacent land uses. The actual width and acreage of buffer area will depend upon the final configuration of the mitigation site; however, Mitigation Site 1 has adequate space to incorporate buffers sufficient to protect the site from potential impacts.

A majority of Mitigation Site 1 is on former agricultural land. Assuming the existing land use remains the same when the wetland mitigation is implemented, the mitigation site will be surrounded primarily by degraded wetlands and other open space. Existing high-level impacts to water quality from farming activities upstream of the mitigation site will likely continue. However, any wetland buffers will be on Navy land and will not reduce these high-level impacts. Based on these factors, a moderate level of impacts from adjacent land uses was used to estimate the required buffer width. Final buffer widths will be determined through discussions with the regulatory agencies (USACE and Ecology) during the final design and permitting phase of the proposed project.

6.3.1 RESTORED AND REHABILITATED FUNCTIONS

The existing wetland on Mitigation Site 1 is Category III, with a low level of function for hydrology and water quality, and a moderate level of function for habitat (primarily due to size and connectivity). The proposed mitigation will significantly improve hydrology and water quality functions, in addition to improving habitat in both riverine and depressional wetland classes. The outcome will likely be a Category II wetland that will provide both improved local and landscape level functions. Target wetland functions were considered using the *Washington State Rating Form for Eastern and Western Washington* (Hruby 2004a, b) and *The Methods for Assessing Wetland Functions* (Hruby et al. 1999 and 2000). Target functions were assessed for anticipated effects on hydrology, water quality, and habitat.

HYDROLOGIC FUNCTIONS

Restoration of Crescent Harbor Creek will reestablish natural stream conditions and improve hydrologic conditions locally on the site as well as at a landscape level. The current creek channel moves water through the site quickly during and following storm events. The restored creek will have a vegetated, meandering channel with an associated floodplain, resulting in decreased flow velocity and peak flows, and longer water retention onsite. Stream flows will persist for longer durations following storm events and into the dry summer.
The increased hydroperiod will improve hydrologic connectivity between the freshwater stream and the downstream salt marsh. The restored stream will also decrease streambank erosion and sediment delivery into the salt marsh and estuary. Filling the small agricultural ditches and rehabilitation of wetland vegetation in the fields will improve retention of stormwater onsite and support a more diverse assemblage of wetland communities.

WATER QUALITY FUNCTIONS

Crescent Harbor Creek is a 303d listed waterway for fecal coliform and dissolved oxygen. As mentioned above, the restored creek will slow flow velocities and increase the hydroperiod on the site. The water quality in Crescent

Harbor Creek will be improved through increased nutrients and pollutant infiltration into the soil and uptake by vegetation, resulting in improved water quality in the downstream salt marsh and estuary.

HABITAT FUNCTIONS

Rehabilitation of riparian, emergent, forested, and scrub-shrub wetland vegetation communities will improve species richness, structural diversity, and habitat connectivity between adjacent wetland communities.
In combination with the restored stream channel, Mitigation Site 1 will have improved capacity to support a more diverse assemblage of wildlife, birds, amphibians, invertebrates, and fish. The improved hydrologic and water quality conditions in Crescent Harbor Creek will improve habitat conditions in the downstream salt marsh and estuary, which provide important rearing and foraging habitat for salmonids (as described in Section 6.2). The lower reaches of Crescent Harbor Creek will potentially become accessible to and provide rearing and foraging habitat for salmonids.

6.3.2 HYDROLOGIC REGIME

There are three main anthropogenic modifications that are inhibiting the functions of the natural hydrologic regime at Mitigation Site 1: the incised and realigned channel, the dam and pond, and the agricultural drainage ditches, as described in Section 5.2.4. Collectively, these modifications to the site drain surface and subsurface water and adversely affect the hydrologic regime of the site with respect to supporting wetland functions. A key initial phase in the rehabilitation of this site is disconnecting the existing anthropogenic drainage network. Disconnecting this drainage system will reduce drainage of soilwater, and it is hypothesized that this reduced drainage will ultimately increase groundwater levels. Additionally, realigning Crescent Harbor Creek into its historic alignment will raise the channel invert and reduce the hydraulic head differential that is hypothesized to be draining shallow groundwater. The restored creek will also have improved morphology and function, providing better habitat and increasing the creek's ability to improve water quality through natural biological and filtering functions. As noted in section 5.2.4, restoration of the downstream marsh (e.g., actions to increase surface water elevations in the marsh) would probably contribute to increased base-elevations for groundwater, improving hydrologic conditions on the site.

Recovery of the site's hydrologic regime is anticipated to occur over several years. This could take longer depending on normal variations in annual precipitation. Multiple years of hydrologic data collection are required to provide a more-precise estimate of how quickly the hydrologic regime of the site may recover, and insufficient information for this purpose has been collected at this time. Additional information from ongoing monitoring (see Section 6.5) and adaptive management (see Section 6.4) will support final designs, allow for reassessment of anticipated recovery timelines, and allow modification of restoration actions in response to new information.

The entire vegetation assemblage and evapotranspiration balance of the site is heavily altered from pre-Euro-American conditions. Therefore, response of the hydrologic regime may initially be slow, but should increase over time in response to a positive feedback with vegetation establishment (e.g., wetter conditions build organic material, which holds more water, which provides opportunities for increased vegetation, and improved habitat conditions).

6.3.3 GRADING

Mitigation project grading consists of filling the existing Crescent Harbor Creek channel, excavating the new channel alignment, removing the dam and pond, and disconnecting the agricultural drainage channels. The conceptual grading plan (Exhibit 6-3) provides a mostly balanced cut and fill scenario for the site. Approximately 310 cubic yards of excess material will be produced. Some portion of this material would be used to modify the existing agricultural drains, reducing the final amount of spoil. Final-design engineering may achieve a complete balance of material on site. Deposited materials in upland areas may increase topographic diversity at the site and provide a topographic buffer to the mitigation site. Any disposal of excess materials would avoid impacts to existing mature and high value vegetation.

Analysis and engineering design were completed at a conceptual level to establish the feasibility of the mitigation project. The analysis included one-dimensional hydraulic modeling to characterize a stable channel configuration, with low potential for erosion and deposition. Details of the analysis are contained in a report establishing the basis of design (PWA 2008b).

All volume and grade estimates in the conceptual restoration plan are approximate. These estimates would be refined during final design based on design-level surveys of topography and bathymetry. An overview of the mitigation project actions is provided in the following sections.

FILL EXISTING CREEK CHANNEL

The volume of the existing creek channel is approximately 2,330 cubic yards. Material from the adjacent berm will be used to fill this channel, with a minor deficit of approximately 300 cubic yards being covered from other excavations on site—most likely surplus material from excavation of the new channel at the upstream end of the site. Channel fill work will be completed in conjunction with degrading of the adjacent berm using the same equipment. Vegetation on the steep banks of the channel will be cleared and grubbed prior to placement of fill. Valuable native vegetation on the berm or channel banks will be salvaged for replanting along the realigned channel. The final design process will determine compaction specifications and the need for any soil amendments to inhibit preferential groundwater flow into and through the channel—either from general inflow along the entire length of the channel, or specifically from where the realigned channel will cross the existing channel. The final ground surface) will be contoured to blend in with the adjacent existing topography.

The berm along the east side of the existing channel (estimated to be approximately 2,030 cubic yards) will be degraded using heavy equipment (likely a 200- or 300-series excavator) and used to fill the adjacent channel. The final ground surface (Exhibits 6-4 and 6-5) will be contoured to blend in with the channel fill actions and the adjacent existing topography. It is anticipated that all existing vegetation on the berm will be cleared and native vegetation along the eastern toe of the berm will be preserved to the extent that it does not interfere with achieving the final design grade.

CONSTRUCT NEW CREEK CHANNEL TO CONNECT WITH EXISTING HISTORIC CHANNEL

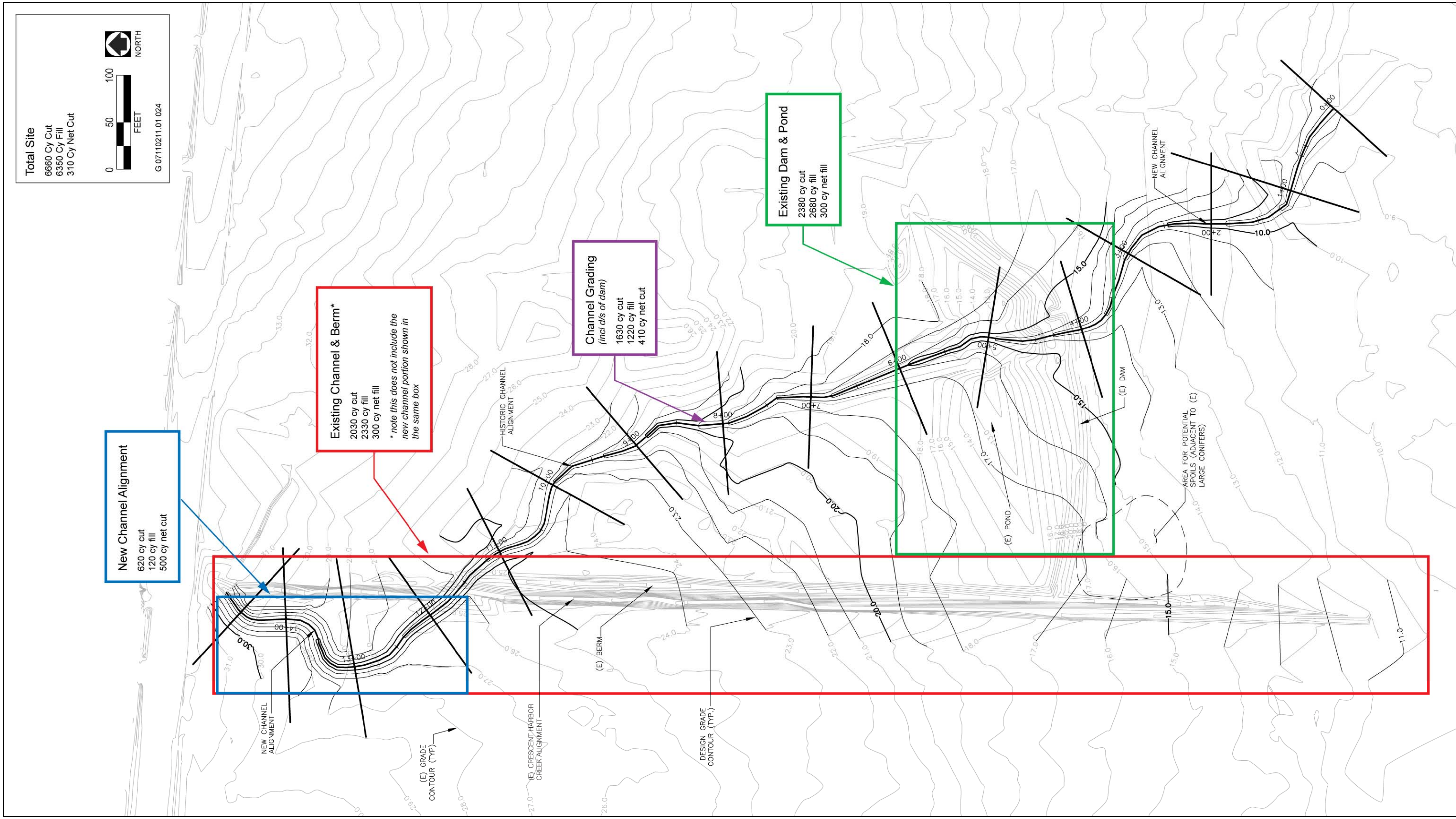
The existing segment of the historic channel presents a substantial restoration opportunity. With the creation of a new channel alignment from the culvert outfall at Crescent Harbor Road, the invert of the stream can be raised from its existing, incised alignment and be reconnected to the historic segment (Exhibits 6-4 and 6-5). In the reach currently occupied by the pond, dam, and leveled field downstream, a new channel will link the creek to the downstream marsh. With the exception of the most upstream section of channel, the combination of these actions will maintain the channel invert at an elevation no more than approximately 2.5 to 3 feet from the adjacent land surface. This will substantially decrease the amount of groundwater hydraulic head and is anticipated to assist in the recharge of groundwater levels at the site.

The restored channel will be comprised of three reaches. The upstream reach (from station 14+76 to approximately station 11+60 in Exhibit 6-4) will be an entirely new channel alignment. The middle reach (from approximately station 11+60 through station 6+00), will follow the historic alignment and require only minimal grading. The downstream reach (from station 6+00 to the marsh at station 0+00) will generally follow a former alignment suggested by historic aerial photographs, although it will require excavation of a shallow, new channel through this leveled field.

Approximate cut and fill volumes for the existing and realigned channel are illustrated in Exhibit 6-3. Despite the constraints imposed by the existing creek entering the site at a different location compared to its historic alignment, the planform characteristics of the conceptual channel design (Table 6-1) are similar to those of the historic channel (assessed through reconnaissance-level interpretation of channel alignments shown on the historic maps in Exhibits 5-9). It is important to note that although the restored channel in the middle reach (where the historic channel still exists) is shown as being less sinuous in the table, it is likely that assessment methods have introduced error, and in actuality the proposed and historic sinuosity values are very similar. The estimated historic sinuosity is based on less-accurate aerial photograph analysis, and in this undisturbed portion of the site it is unlikely that the topography has changed since the time of the photos. Thus, while we only have the historic photographs to assess historic sinuosity, we strongly suspect the proposed channel sinuosity is very similar to the historic analogue.

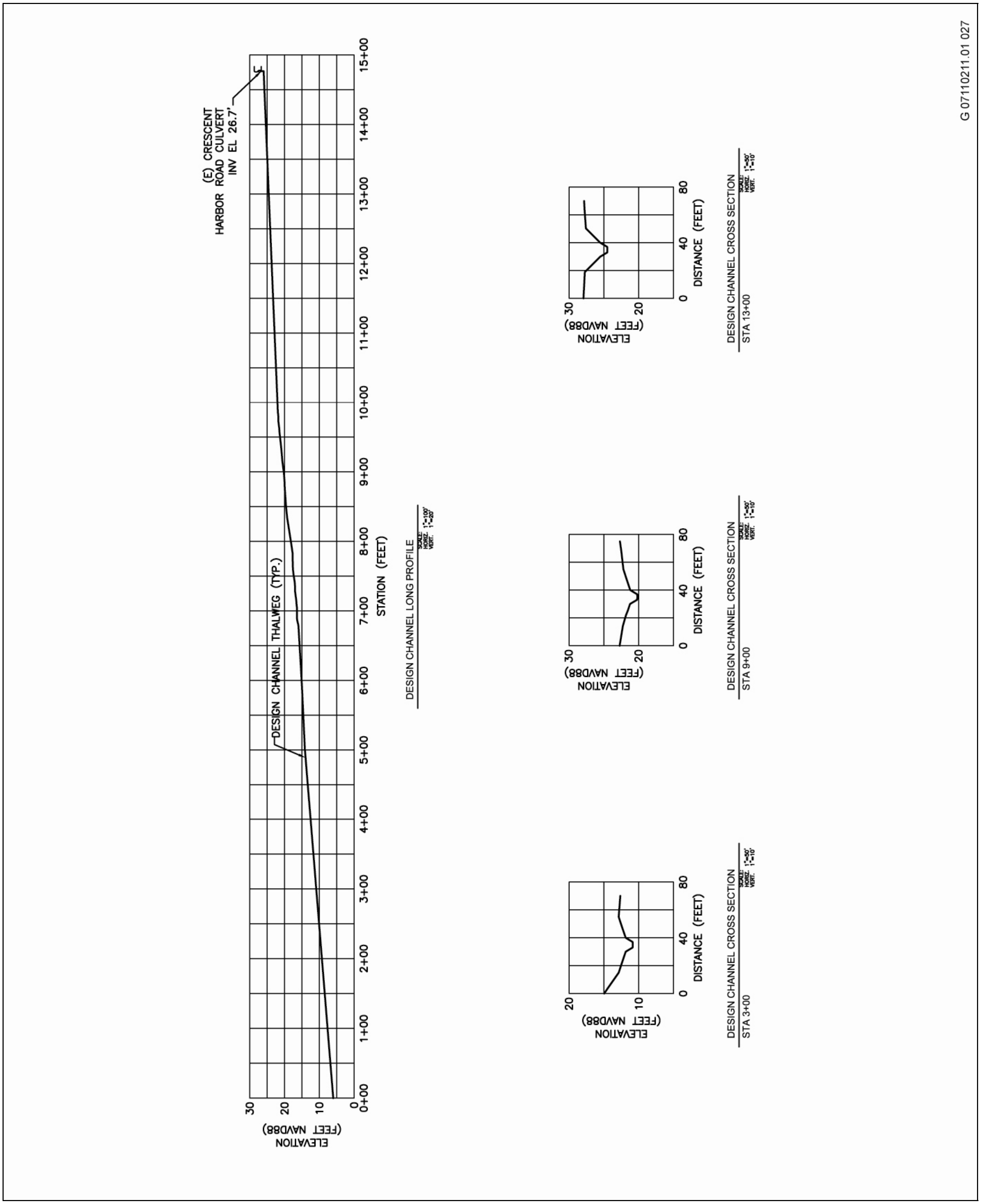
Source: Prepared PWA in 2008

Mitigation Site 1: Conceptual Realigned Crescent Harbor Creek Channel – Plan View **Exhibit 6-3**



Source: Prepared by PWA and EDAW in 2008

Mitigation Site 1: Grading Cut and Fill Summary **Exhibit 6-4**



Source: Prepared by PWA in 2008

Mitigation Site 1: Conceptual Realigned Crescent Harbor Creek Channel – Longitudinal and Cross Sections **Exhibit 6-5**

Table 6-1
Mitigation Site 1: Crescent Harbor Creek Channel Characteristics

Characteristic	Historic Channel	Design Channel
Avg Meander length (ft)	222	136.6
Avg Amplitude (ft)	48.8	24.0
Valley length (ft)	1956	1279
Valley slope	0.013	0.016
Channel length (ft)	2332	1476
Channel slope	0.011	0.014
Sinuosity	1.2	1.2

Source: Prepared by PWA in 2008

From the perspective of optimizing the channel morphology to maximize habitat and ecological processes, the upstream reach is the most challenging because of inherent design constraints. The historic channel alignment entered the site to the west of the existing culvert crossing under Crescent Harbor Road. In order to link the creek from the upstream edge of the project site, which is constrained by the existing location of the culvert crossing, with the closest part of the historic channel alignment (which is immediately east of the existing channel), a new channel must be cut through relatively-high ground to attain an alignment conducive to connecting to the historic channel. The resultant channel geometry is a compromise between excavating the large amounts of material necessary to achieve a configuration similar to the natural, wider, historic analogue cross section (shown in Exhibit 5-15) and the goal of maintaining as much geomorphic function as is feasible. Design refinement during final design may consider narrowing the channel bottom width and decreasing the slope of the banks; however, those modifications will increase cut volume. Given the approximately 300 cubic yard surplus of material that would result with the existing conceptual designs, any modifications to the current channel geometry must be balanced with other modifications to the conceptual mitigation plan.

The conceptual design of the middle and lower reaches of the restored channel (from approximately station 11+60 to station 0+00) incorporates the use of the existing, historic morphology to attain a wider, more-optimal channel geometry that requires less excavation. An important element to be refined during final design is the treatment of soils at approximately station 11+60, which is where the restored channel crosses the existing channel (to be filled). Design of the channel and floodplain in this area must eliminate diversion potential[9] and address the need for measures to reduce seepage of water from the bottom of the proposed channel into the fill of the existing channel.

[9] Diversion potential is a phrase used to describe topographic configurations where flow in a channel has the potential to divert down another alignment.

Final design of the channel will include integration of instream features to improve habitat. At this conceptual level of design, the hydraulic modeling that was used to configure the conceptual channel geometry assumed integration of large woody debris (LWD)—specifically 1-foot diameter logs partially embedded into the bed and banks of the channel at intervals of approximately 50 feet. These flow heterogeneity elements were conservatively modeled (i.e., with more channel ineffective flow area than might be found in actual installations) and were found to have relatively little increase (0.2 foot) on modeled 100-year flood water surface elevations. This indicates that final designs (which would also include hydraulic modeling to support designs and assess their likely hydraulic effects) could integrate more and/or larger LWD elements without any adverse effects on flood conveyance. Exhibit 6-6 depicts several typical LWD configurations that may be integrated into the final design to increase habitat value of the channel.

DEGRADE EXISTING DAM AND FILL POND

The dam and pond create unnaturally-high and -low topography (respectively) when compared to pre-disturbance conditions. If this topography is not modified, the pond and dam would inhibit reoccupation of Crescent Harbor Creek in its historical channel alignment. Degrading the dam and filling the pond will restructure the land surface in this portion of the site such that a new channel could be constructed to connect the historic channel segment upstream with the downstream marsh. The volume of the dam (2,380 cubic yards) is slightly less than the volume of the pond (2,680 cubic yards), resulting in the need to borrow approximately 310 cubic yards of material from other sources on site—probably from channel excavations downstream of the dam (see Exhibit 6-3 for summary of cut and fill volumes). While this element of the project is described separately from the creation of the new channel alignment, during actual construction the excavation of the dam and fill of the pond will be undertaken such that the channel through this portion of the site will be created as shown in Exhibit 6-4. All vegetation on the dam will be removed; however, it is anticipated that mature, native trees within the pond area could be preserved with careful placement of fill around their trunks. Adjacent to the existing junction of the dam and berm are several large coniferous trees that should be preserved. If material spoil is a necessary component of the mitigation project's final design, the land area adjacent to these trees is proposed as a potential spoil location (see Exhibit 6-4).

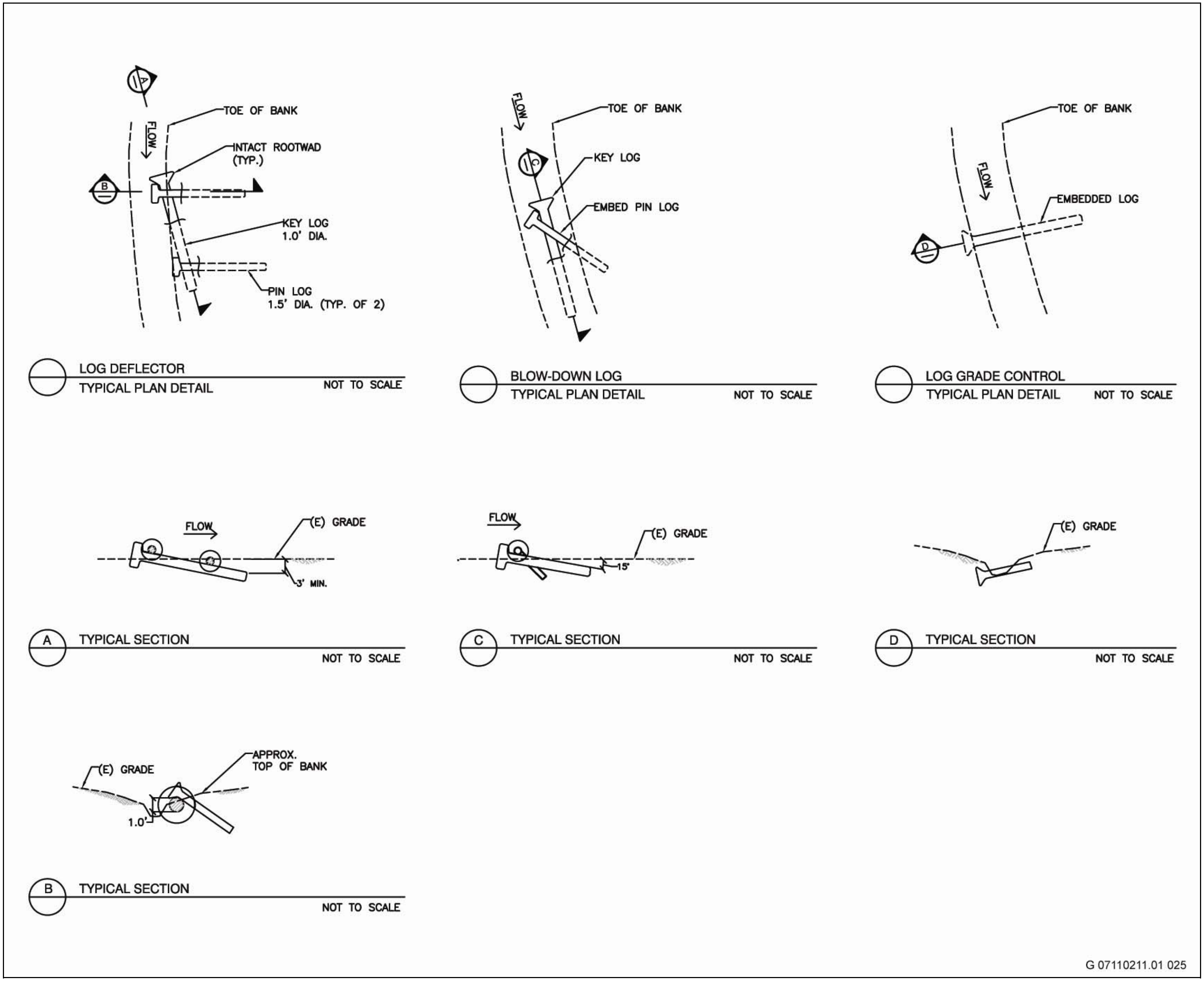
DISCONNECT AGRICULTURAL DRAINAGE CHANNELS

The small agricultural drainage channels (shown in Exhibit 5-13) will be disconnected from the drainage network through relatively small topographic modifications. While the topography of these channels was not surveyed in detail, the total volume of these drains is estimated to be less than the small surplus of material anticipated from conceptual engineering of other mitigation project actions. Work for this element of the project will likely be completed using a small, mini-excavator and hand labor. The final ground surface will be revegetated (see Section 6.3.4) and is not anticipated to require any special erosion control measures.

Mitigation Site 1: Conceptual Realigned Crescent Harbor Creek Channel – Details

Exhibit 6-6

Source: Prepared by PWA in 2008



Final Design Refinements

The final design process will integrate and account for issues beyond the scope of the current conceptual/feasibility design process. Items to be refined as the design progresses include:

- Development of a Stormwater Pollution Prevention Plan (SWPPP) and water diversion plan.
- Completion of a utility survey to confirm the absence of key infrastructure[10].
- Finalization of channel alignment based on detailed field mapping of vegetation to avoid any specimen trees or other key features.
- Completion of supplemental topographic and bathymetric surveys to better define the existing surface and better estimate excavation volumes. Specific areas include the existing dam, the area downstream of the dam, the connection of the historic channel to the marsh, and the banks of Crescent Harbor Creek at the Crescent Harbor Road culvert outlet.
- Refinement of excavation and fill volumes to account for soils lost due to clearing and grubbing, soil expansion during excavation, and soil compaction requirements during fill placement.
- Design and configuration of LWD structures, including development of criteria for sizing, placement and anchoring of structures.
- Detailed evaluation of soil material properties of the berm to determine its transmissivity when placed as fill into the incised, existing channel; and subsequent assessment of the need for a low- or non-permeable flow cutoff feature at the location where the design channel crosses the existing channel.

6.3.4 Vegetation

This section provides recommendations for enhancing native wetland vegetation following the rehabilitation of the mitigation site's hydrology. A detailed planting plan will be prepared during the final design phase.
The mitigation site includes four planting zones: riparian corridor; a mosaic of forested wetland and scrub-shrub wetland; a mosaic of forested wetland, scrub-shrub wetland and emergent wetland; and upland (Exhibit 6-7). These planting zones were determined based on current and anticipated rehabilitated hydrologic conditions, and observation of vegetation on adjacent unmanaged wetland areas. Within these planting zones, individual species will be selected from the recommended planting palette (Table 6-2) and located according to hydrologic, topographic, and soil conditions. Revegetation will be implemented in two phases. The first phase will revegetate

[10] Staff at NAS Whidbey Island confirmed the absence of utilities in this area of the project; however, a formal, in-the-field utility locate (i.e., Washington's "Call Before You Dig" 1-800-425-5555 Program) was not completed at this stage of design.