Year 5 Habitat Monitoring Report

Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington
Project # 0148440600 The Boeing Company

Prepared for:

The Boeing Company
Seattle, Washington

4/28/2020

Year 5 Habitat Monitoring Report

Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington
Project # 0148440600 The Boeing Company

Prepared for:

The Boeing Company
Seattle, Washington

Prepared by:

Wood Environment & Infrastructure Solutions, Inc.
3500 188th Street SW, Suite 601
Lynnwood, Washington 98037
USA
T: 425-921-4000

4/28/2020

Table of contents

List of tables

List of figures

List of appendices

List of acronyms and abbreviations

Boeing	The Boeing Company
cm	centimeter(s)
Ecology	Washington State Department of Ecology
GPS	global positioning system
MLLW	mean lower low water
mm	millimeter
NOAA	National Oceanic and Atmospheric Administration
PSEP	Puget Sound Estuary Program
RCRA	Resource Conservation and Recovery Act
Sites	North Site (Building 2-122 Project) and South Site (Building 2-40s Complex and Southwest Bank Project)
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

In 2013, The Boeing Company (Boeing) constructed two habitat projects at Boeing Plant 2 along the Duwamish Waterway in Seattle and Tukwila, Washington (Figure 1) (AMEC, 2014). The projects were constructed in accordance with a Consent Decree executed in December 2010 between the Natural Resource Trustees (National Oceanic and Atmospheric Administration [NOAA], U.S. Fish and Wildlife Service [USFWS], Washington State Department of Ecology [Ecology], Suquamish Tribe, and Muckleshoot Indian Tribe) and Boeing. The two projects restored and/or created off-channel and riparian habitats in the Lower Duwamish Waterway in an area where they had been largely eliminated due to channelization and industrialization of the Waterway.

This report documents maintenance and monitoring activities performed for the projects during the fifth year (Year 5) after construction of the habitat projects was completed.

1.1 Overview of Habitat Projects

The projects involved construction of habitat at two sites:

- *North Site—Building 2-122 Project*: creation of a blind channel at the north end of Plant 2 adjacent to Boeing's Building 2-122 that restored shoreline and created off-channel habitat (Figure 2); and
- *South Site—Building 2-40s Complex and Southwest Bank Project*: removal of the overwater portion of the Building 2-40 complex at the south end of Plant 2 and subsequent restoration of shoreline along the Southwest Bank and the site of the former Building 2-40 Complex (Figure 3).

The habitat projects were designed to create habitat within three elevation zones:

- Riparian zone (above elevation +12 feet relative to mean lower low water [MLLW]),
- Marsh zone (+12 to +5.5 feet MLLW), and
- Intertidal zone (+5.5 to +2 feet MLLW).

The projects include the following key elements:

- Grading, backfilling with clean materials, and placement of soil amendments to reshape the shoreline and create a blind embayment channel;
- Planting native marsh and riparian plants to establish a vegetation community;
- Placing and securing large woody debris bundles;
- Construction of goose-exclusion fencing to reduce herbivory of plantings; and
- Installing a temporary irrigation system consisting of an overhead sprinkler system in the riparian zone (above +12 feet MLLW).

Upon completion of construction in 2013, the habitat projects had created 2.64 acres of habitat in the marsh zone (+5.5 to +12 feet MLLW), 1.52 acres of habitat in the riparian zone (above +12 feet MLLW), and an estimated 1.08 acres in the intertidal zone (+2 to +5.5 feet MLLW) (AMEC, 2014).

Construction of the habitat projects was conducted concurrent with the Duwamish Sediment Other Area and Southwest Bank Corrective Measure under the Resource Conservation and Recovery Act (RCRA) (Amec Foster Wheeler et al., 2016). Construction of the corrective measure was completed in 2015.

Details regarding design, construction, and maintenance and monitoring requirements for the habitat projects have been reported previously (AMEC et al., 2012a; AMEC, 2014).

1.2 Maintenance and Monitoring Program

As part of the Consent Decree for the project, a joint Trustee/Boeing technical team developed a Scope of Work (Appendix A of the Consent Decree) that described (1) the maintenance and monitoring plan to be developed and implemented to determine if the goals and objectives of the habitat projects are met; and (2) the success criteria, monitoring methods, and monitoring frequency that would be used.

The maintenance and monitoring activities conducted at the North Site and South Site (collectively "the Sites") conform to the requirements set forth in the *Maintenance and Monitoring Plan*, included as Appendix F of the *Final Habitat Design Report* (AMEC et al., 2012a). Table 1 provides a list of monitoring activities to be conducted during specified years after construction of the habitat projects was completed. This report documents the maintenance and monitoring activities conducted during Year 5, which covers the time period from January 2019 through December 2019. Monitoring results are reported in the context of conditions existing immediately following construction of the habitat projects (Year 0) in 2014 (AMEC, 2014) and in some cases relative to results of Year 1, Year 2, Year 3, and Year 4 monitoring (Amec Foster Wheeler, 2016, 2017, and 2018; Wood, 2019, respectively). Subsequent monitoring activities will be conducted during specified years following construction according to the schedule in Table 1.

Ongoing monitoring provides the information needed to determine if the success criteria developed by the joint Trustee/Boeing technical team are being met. Success criteria are applied to the Sites as a whole. If the success criteria are not met, additional contingency or adaptive management measures may be applied, in consultation with the Trustees, during the monitoring period.

1.3 Purpose of this Report

This report serves four main purposes:

- Document ongoing routine maintenance activities conducted during Year 5 (January 2019–December 2019);
- Document contingency measures and adaptive management activities conducted during Year 5;
- Report the results of habitat monitoring activities performed during Year 5; and
- Summarize future adaptive management strategies to be implemented or continued.

2.0 Routine Maintenance Activities

This section documents routine, ongoing maintenance activities conducted at the Sites during Year 5, which covers the time period from January 2019 through December 2019. Routine maintenance activities are specified in the *Maintenance and Monitoring Plan* (AMEC et al., 2012a).

2.1 Watering

Watering using the overhead sprinkler system was initiated in the riparian zone following initial construction of the habitat areas in 2013. The system was controlled during the growing season by an automated clock. Frequency and duration of watering were adjusted depending on results of visual inspection of the health and vigor of the plants.

During the growing season in 2018, the overhead sprinkler system at the North Site was inoperable during most of the growing season. At the South Site, the watering duration was intentionally reduced to

start hardening the plants for reducing and eventually terminating supplemental irrigation in the future. During the growing season in 2019, the irrigation was fully functional for both the North and South Sites. The irrigation system was monitored and adjusted during the summer months, depending on weather conditions, to irrigate the plants. As with past years, the watering duration was intentionally reduced to continue hardening the plants in preparation of termination of the supplemental irrigation in the future. The irrigation system was established at the time of the initial planting, and in recent years vegetation growth in some locations has created interference with the spray patterns of the irrigation heads. As a result, the irrigation coverage is not equal for all plants. In some cases, plants have been selectively pruned to reduce interference with irrigation spray.

2.2 Mulching

Additional mulching around individual plants was performed on an as-needed basis during the first two growing seasons. Mulch helps retain soil moisture by reducing evaporation and controlling erosion. Mulching also provides nutrients to the plants. Mulch was also used to inhibit weed growth, reduce competition for nutrients by the plants, and encourage plant development. Mulch at the base of each plant was replenished in selected areas along the South shoreline in February–March 2016. Additional mulch was not added around the base of the plants at the North or South Sites in 2017, 2018, or 2019. However, routine maintenance continues to be performed to create a clear zone around the base of smaller shrubs and trees to reduce competition for nutrients. Clearing around larger shrubs and trees has not been performed.

2.3 Weeding

Weeding was performed on an as-needed basis during the growing season. When possible, the entire weed plant was removed. In some cases when complete removal of individual weeds was not efficient, the weeds were trimmed back to reduce development and reduce the potential for spreading. Weeds listed on the King County noxious weed list (King County, 2019) were removed immediately. Weeding was performed using simple hand tools (e.g., rakes and hoes).

Several noxious weed species identified in the King County noxious weed list and in the original *Maintenance and Monitoring Plan* (AMEC et al., 2012a) have been observed at the Sites and are being actively removed. These include a small amount of Himalayan blackberry (*Rubus armeniacus*), Scotch broom (*Cytisus scoparius*), butterfly bush (*Buddleja davidii*), tansy ragwort (*Senecio jacobaea*), wild carrot (*Daucus carota*), and bull thistle (*Cirsium vulgare*). Development of blackberry on the Sites increased in 2019. During the growing season, additional effort was required to control blackberry growth at both the North and South Sites. Manual control of blackberry was implemented, including digging up plants and roots and removing the material from the Sites.

Bird's-foot trefoil (*Lotus corniculatus*), a non-native species, has outperformed the native grasses originally hydroseeded at the Sites. The plant can grow to a height of 2 to 3 feet, potentially outcompeting and shading small trees and shrubs. The plant continues to be a persistent problem in the riparian and high intertidal areas at both Sites and is being removed where possible or is being aggressively trimmed back from planted trees and shrubs. Field observations in 2019 included bird's-foot trefoil showing signs of stress during hot/dry weather in areas where supplemental irrigation is not functioning or where the spray pattern is impeded by other vegetation.

Cordgrass (*Spartina* spp.) species have not been observed at the Sites. Knotweed (*Polygonum* spp.) was observed in a small contained area at the North Site during 2016; however, this species has not been observed since. The entire plant including roots was removed from the Sites and disposed of at an

approved facility. Chemical treatment was not used prior to removal, but regrowth has not been observed and additional outbreaks have not been observed since 2016.

Areas at the North Site with small patches of reed canarygrass (*Phalaris arundinacea*) previously controlled by removal have been routinely monitored. Several additional small patches have been observed at the Sites and are being actively removed. In 2019, reed canarygrass continued to establish on the North Site with limited development occurring at the South Site. Maintenance crews use manual control methods for reed canarygrass, including manually digging up the plant and roots and removing the material from the Sites.

Common St. Johnswort (*Hypericum perforatum*) also occurs in limited areas on the North and South Sites. St. Johnswort is not a regulated weed in King County and does not require control by the County but is on the state noxious weed list. Maintenance crews remove this species using manual control methods, including digging up the plant and roots and removing the material from the Sites.

2.4 Dead Plant Removal

Dead plants within the riparian zone have either been left in place or cut back with the trimmings left in place to help create a duff layer. Root balls of dead plants have been left in place. This practice has been continued through 2019. Allowing the plant parts to naturally decompose facilitates soil development by creating a natural duff layer high in organic material.

2.5 Debris Removal

Debris removal within the marsh area has consisted of removing items that have drifted onto the shoreline during high tides and become stranded. Items removed from the shoreline include anthropogenic items, such as shoes, furniture, bottles, and dimensional lumber. Some undesirable vegetation fragments, including both non-native and ornamental plant material, were removed and properly disposed of at an approved facility. Anthropogenic items are removed from the Sites and disposed of at an approved location.

Large branches, tree trunks, and other woody debris that became tangled within the goose exclusion fencing were removed to prevent damage to the fencing. A majority of the natural woody debris is retained. Larger branches are moved up into the riparian habitat to prevent damage to the fenced enclosures. If the material is of sufficient size, it is anchored in the marsh habitat. These larger pieces were added to the existing piles of large woody debris or anchored in place to provide additional habitat complexity and additional shoreline erosion control. Smaller woody debris was left on the Sites to encourage soil development and create a natural ground cover. This smaller material is mobile and ebbs and flows with the tides and during storm events.

3.0 Contingency Measures

Contingency measures are activities implemented in the event that a success criterion is not met because of design or installation flaws. Localized problems with slope instability were identified between 2013 and 2015 in two areas: (1) at the tip of the peninsula at the North Site, along the river channel side of the peninsula (within the intertidal zone up to elevation +11 feet MLLW), and (2) in areas with large active (focused discharge) seeps along the shoreline at the South Site. The problem areas and the various contingency measures employed to address them in previous years were described in the Year 1 and Year 2 Habitat Monitoring Reports (Amec Foster Wheeler, 2016, 2017).

Monitoring of the contingency measures implemented through August 2016 to address these slope stability issues, and the effectiveness of the applied solutions is described below. These areas, along with

the entirety of the shorelines at the North and South Sites, continue to be monitored following the completion of the contingency measures. In 2019, no stability issues were observed; the changes that were observed along the shoreline in 2019 are considered typical for this river system.

3.1 North Site

In July 2016, gravel fill was placed to stabilize the exposed shoreline and to protect the embayment at the North Site (Amec Foster Wheeler, 2017). Approximately 61.7% (0.27 acre of 0.48 acre) of the area between +5.5 feet MLLW and +8 feet MLLW and 33.0% (0.38 acre of 1.15 acres) of the area between +8 feet MLLW and +12 feet MLLW was covered with gravel. In total, approximately 39.9% of the marsh area (+5.5 to +12 feet MLLW) was covered with gravel.

Fascines comprising live shoots of Hooker's willow (*Salix hookeriana*) were placed in the upper intertidal area (at approximately +11 feet MLLW), just below the top of the gravel fill, to help stabilize the remaining vegetation. The gravel fill has stabilized the slopes and protected the embayment. The existing vegetation above the gravel fill is thriving; however, the viable shoots of Hooker's willow that had shown limited growth subsequently yellowed and died. The poor survival of the live shoots in the fascines placed at the toe of the existing scarp may be related to the higher salinities present during the low summer river flows at the North Site. Live stakes of Hooker's willow planted at slightly higher elevations showed better survival.

Within the embayment at the North Site, a small area (less than 300 square feet) of slumping has occurred. No stabilization of this area has been conducted to address the slumping. The area continues to be monitored for additional movement or failure during the weekly maintenance activities, but contingency measures (stabilization) have not been required. No significant changes were observed in 2019, and much of this area was covered in vegetation.

3.2 South Site

Multiple active seeps with focused discharge of groundwater and surface water along the bank were filled with coarse gravel (2-inch-minus rounded rock) with the approval of the Trustees during 2014 and 2015 (Amec Foster Wheeler, 2016). The placement of the rounded rock has stabilized the existing active seeps. Some smaller seeps along the shoreline have been noted in the subsequent years; however, these seeps are characteristic of expected shoreline conditions and no stabilization of these seeps has been required.

4.0 Adaptive Management

Adaptive management approaches are adopted if success criteria are not met because of changing site conditions, mortality due to herbivory, or routine maintenance activities not being sufficient. Boeing has adopted the following adaptive management approaches to address ongoing problems with plant survival at the habitat projects.

4.1 Herbivore Control

Problems associated with herbivory within the marsh and riparian habitats are ongoing, and additional measures have been initiated to control grazing by Canadian geese (*Branta canadensis*) and reduce riparian plant damage from nutria (*Myocastor coypus*), beaver (*Castor canadensis*), and other animals.

4.1.1 Goose Control

Boeing has continued to use a combination of goose-harassment techniques (i.e., dog patrols) and small fenced enclosures, which have been determined to be effective in reducing herbivory by geese at the

North and South Sites. A majority of the original goose-exclusion fencing for the Sites was determined to be noneffective and removed, although a few small sections of the original fencing have been retained and extended to enclose some of the original plants that survived. Small fenced enclosures (approximately 100 to 200 square feet) have been installed around the replanted plots at the North and South Sites. These small enclosures have been beneficial in protecting plants from the geese during early plant establishment. During this same period, the fencing also helps protect the plants from debris that washes up along the shoreline. Monitoring of the plants within these partial enclosures indicates that goose herbivory may reduce overall growth but not overall survival of established plants. In 2018, some of the fencing was removed from those areas where hardstem bulrush (*Schoenoplectus acutus*) and softstem bulrush (*Schoenoplectus tabernaemontani*) plants displayed strong growth and vigor. Geese seem to have less interest in these plants once the plants mature. In 2019, additional fencing was removed during the late fall and winter months. Fencing has been retained in some areas where it still appears beneficial to plant development. These areas generally include locations along the outer shoreline edges.

Dog patrols for goose harassment have been ongoing periodically at the Sites since January 2016. Generally, dog patrols were performed on a variable schedule from mid-winter (January-February) until as late as early summer (June-July). The schedule of the patrols was variable to prevent the geese from discerning a standardized pattern. In 2018, dog patrols were performed from January through the end of October (Wood, 2019). In 2019, dog patrols resumed in March and continued through May after the nesting/new gosling period was complete. Monitoring continues along the shorelines at both Sites for goose activity. In 2019, the goose population size was very limited. The geese have been observed along the shoreline with little or no damage to the vegetation. Mature vegetation as observed at the Sites appear to be of less interest to the geese and are better able to sustain herbivory damage.

Based on the maturity of vegetation and hardiness against herbivory, the need for goose-harassment techniques and exclusion fencing has decreased. Thus, dog patrols have been reduced in frequency and duration in 2019, and goose-exclusion fencing continued to be removed in select areas.

4.1.2 Control of Riparian Plant Damage

Damage inflicted by herbivores on selected species of trees and shrubs within the riparian zone has been reduced as vulnerable plants have grown and matured. The seasonal use of tree tubes has been discontinued.

During 2019, no new beaver damage was observed. In August 2018, damage to four trees was found and attributed to beavers. The trees were cut down approximately 12 inches above the ground and left in place. In all cases, the root structure of the tree was intact. In 2019, most of these trees have started to develop new growth.

Surface disturbance and digging around the bases of scattered trees and shrubs in the riparian zone at the South Site increased significantly in 2019. During late fall through early spring, much of the open herbaceous areas have been tilled up, resulting in the top layer of sod, including roots, being pulled back and left scattered along the surface. When these areas are encountered, efforts have been made to reposition the sod to contact the soil surface to encourage re-establishment. Typically, the sod is quickly displaced again. It appears that small mammals, possibly raccoons (*Procyon lotor*), are doing this to gain access to grubs found in the soil. Investigation of the soil has revealed a healthy quantity of grubs present. Some of the disturbed areas have become re-established with revegetation, while other areas struggle to fully regain vegetative coverage. These activities do not appear to have impacted growth or survival of nearby shrubs or trees. In addition, scattered areas covered by grasses and herbaceous ground cover have been disturbed, possibly by foraging crows (*Corvus brachyrhynchos*).

Signs of disturbance and associated impacts to plant vigor will continue to be monitored.

4.2 Replanted Marsh Plots

During 2017, new plants were installed within an additional 30 enclosures within the embayment at the North Site and 130 enclosures at the South Site (a total of 60 plots at the North Site and 160 plots at the South Site) (Amec Foster Wheeler, 2018). The test plots were planted with mix of hardstem bulrush, seacoast bulrush (*Scirpus maritimus*), and Lyngbye's sedge (*Carex lyngbyei*) plugs. Approximately 8,000 plants were planted, with approximately 40 to 80 plants within each 100- to 200-square-foot enclosure.

The simple fenced enclosures used plastic mesh fencing because it was easy to repair when damaged and quick to construct. The overall height of the structure also appears to provide some protection of the plants from wave action and can prevent debris from landing on the plants as tidal levels change. The fence enclosure was also effective in keeping geese from feeding on the vulnerable plantings.

During the growing season in 2019, fencing continued to be removed from the planting plots in areas where vegetation was mature and showed less damage from herbivory. Fencing has been retained in areas where it still appears beneficial to plant development. These areas generally include locations along the outer shoreline edges.

4.3 Additional Riparian Plantings

A small (2-foot by 5-foot) area within the riparian zone at the South Site was planted in December 2016 with seeds from the native herbaceous groundcover species gumweed (*Grindelia integrifolia*) (Amec Foster Wheeler, 2018). The area was subsequently fenced to reduce herbivory during the first year. The fence was removed by December 2017. Initial observations found some grazing damage to the plants following removal of the fencing. In 2018, these plants have started to display strong growth. The small test area has done well filling in and competing against the bird's-foot trefoil, and further development is anticipated in 2020. Six additional areas (2-foot by 5-foot) were seeded in fall 2018 (Wood, 2019). The areas were fenced or covered with coir fabric to reduce seed predation and herbivory until they germinate and become established. In 2019, gumweed development at these six locations was minimal or non-existent. The new areas will continue to be monitored during the routine maintenance visits by the project landscape architect. Additional patches of gumweed have been observed growing in several locations along the shorelines at both North and South Sites. These plants have self-colonized from a local seed source.

In Fall 2019, 200 Hooker's willow stakes were installed along the shorelines at the North and South Sites. The willows were placed between elevations +13 feet MLLW and +16 feet MLLW. The willows were evenly distributed between the two Sites, with 100 stakes at the North Site and 100 stakes at the South Site.

Tree cuttings and transplanted trees have been planted throughout the Sites over the past several years as well. Vegetation maintenance on the Boeing campus in areas outside of the shoreline but near the Sites has generated plant material suitable for use on the Sites. These plant sources include unwanted trees adjacent to the bioswales at the South Site and along the security fences at both Sites. These cuttings and, in some cases, transplanted young trees with root balls intact have been planted in areas exhibiting lower levels of riparian tree cover in an attempt to reuse available local source material and increase riparian tree cover and density.

4.4 Ongoing Plant Maintenance

Landscaping contractors have been conducting maintenance activities at the North and South Sites on a weekly basis under supervision of the project landscape architect. General maintenance activities conducted are outlined in Section 2.0. Additional adaptive management activities are described below.

4.4.1 Replanting of Dislodged Plants

Smaller riparian trees and shrubs whose root balls had been partially excavated by erosion or that had been blown over by wind were straightened and heeled in or staked. The problem with plants damaged during windstorms has increased as plants mature and get bigger. During a windstorm in December 2018, several of the larger red alders (*Alnus rubra*) (up to approximately 12 feet in height) were blown over. The fallen trees were broken down into smaller sections and left on site. The open areas were back planted with available black cottonwood (*Populus trichocarpa*) starts. Additional staking has been added to vulnerable trees. Trees or shrubs with broken limbs or split trunks have been trimmed to prevent additional damage. Replanting efforts for these blown down or broken trees have continued in 2019. The landscape maintenance crews have continued to back plant areas where alder trees have died with black cottonwood.

4.4.2 Fertilizer Application

No fertilizer was applied during 2019.

4.4.3 Self-Colonizing Vegetation

Several riparian vegetation species have self-colonized within the Sites. Field observations have included black cottonwood, sweet gale (*Myrica gale*), and madrone (*Arbutus menziesii*), as well as small patches of gumweed (see Section 4.3). These areas will continue to be monitored as vegetation continues to develop.

4.5 Control of Non-Native/Invasive Species

Small patches of two invasive species found in 2016, Japanese knotweed (*Polygonum cuspidatum*) and reed canarygrass, were controlled by grubbing the entirety of the plant root structure (Amec Foster Wheeler, 2017). Japanese knotweed has not been observed since. However, small patches of reed canarygrass continued to grow at the North Site in 2019. Control efforts are ongoing, including removing the entire plant and roots to the extent possible, and disposing the material off site.

Control of the invasive yellow flag iris (*Iris pseudacorus*) in the marsh and lower riparian zones is ongoing. Control of invasive tansy ragwort, Scotch broom, and Himalayan blackberry is ongoing in the riparian zone. Control of non-native species in the riparian zone, such as clover (*Trifolium* sp.), thistle (*Cirsium* sp.), wild carrot, and butterfly bush, is also ongoing. The non-native bird's-foot trefoil is being controlled by grubbing in some areas, by aggressive mowing in other areas, and by being cut back to reduce interference with the native vegetation. Visual surveys and control of other invasive and undesirable non-native plants are being conducted during the ongoing weekly and biweekly maintenance activities.

4.6 Insect Pests

Attacks on Pacific and Sitka willows (*Salix lucida* ssp. *lasiandra* and *Salix sitchensis*, respectively) and a limited number of black cottonwoods at the North and South Sites by the larval stage of an insect known as the poplar and willow borer continued in 2019. Plants previously attacked and damaged by the willow borer that survived the initial attack continue to grow, but new growth (height) is damaged. Additional control measures, such as application of an insecticide, have not been instituted. Continued monitoring will be conducted during ongoing weekly and biweekly maintenance activities.

4.7 Debris Removal and Capture of Large Woody Debris

Anthropogenic debris is being removed by the maintenance crews. Crews remove material that constitutes an average of approximately a 20- to 30-gallon container of material on a weekly basis.

Small pieces of wood and plant debris are left in place unless accumulations threaten existing marsh plantings. Larger branches are moved into the riparian zone. Larger branches and small trees are also grouped together into larger bundles in the upper intertidal and lower riparian zones or anchored to the existing bundles of large woody debris. Naturally recruited logs of suitable size and wood type are being captured, moved to the upper intertidal zone, and anchored to add to the ecological functioning of the Sites. In 2019, additional large logs have been captured at the Sites and temporarily anchored in the upper intertidal area to existing log bundles or net piles (Figure 4). It is anticipated that the logs already captured as well as any additional suitable pieces of large woody debris recruited to the Sites will be permanently anchored in the upper intertidal zone using soil anchors and chain or cable during summer 2020.

4.8 Site Maintenance and Oversight

Habitat maintenance at the Sites has required a fairly consistent level of effort following initial site establishment. For the past several years, maintenance crews have been working on site once per week. From approximately April through November, a crew of two maintenance staff perform necessary activities at the Sites for 8 hours (1 day) per week. From approximately November through April, a crew of two maintenance staff perform necessary activities for a half-day (4 hours) once per week. This winter/early spring schedule of weekly maintenance has been more efficient than a biweekly schedule, as it allows for routine site tasks to be more effectively accomplished and results in less accumulation of debris and trash requiring cleanup.

Oversight of the maintenance crews initially included hands-on oversight for the entire 8-hour crew shift. In earlier years post-construction, the maintenance crews were new to the Sites and many concurrent tasks were ongoing. The Sites were also subjected to high levels of herbivory by geese, nutria, and insects, which required a high level of effort and time to support plant establishment and maintain exclusion fencing. Maintenance of the irrigation system also required more time and effort in previous years because the younger, less-established plants required more irrigation than the more-established plants currently require.

In recent years, oversight needs have decreased somewhat. The current crew lead has worked the Sites for several years now and is very familiar with the tasks and site conditions. Fewer evolving site conditions occur, and maintenance tasks have decreased in frequency and intensity as plants have matured and become more established. Irrigation is continuing to be less of a concern as watering is decreased over time to harden maturing plants. Ongoing oversight continues to be necessary so that adaptive management tasks are performed appropriately, depending on variable site conditions, and to continue vigilant monitoring of habitat conditions, including shoreline changes and noxious weed identification, among others.

One key component that has allowed for a slight decrease in oversight and maintenance crew effort has been the consistent staffing of the maintenance crew, in particular the crew lead. Without this consistency, additional hands-on oversight would be required so that ongoing site tasks were performed in a manner conducive to Site habitat goals and consistent with the adaptive management practices at the Site.

5.0 Habitat Monitoring

This section documents the results of Year 5 habitat monitoring conducted in 2019.

5.1 Goals and Objectives

The goal of the two projects was to create self-sustaining habitats that will restore and enhance ecosystem processes that support the array of key species groups. The projects were intended to restore

important habitat types historically present in the Duwamish Waterway and provide appropriate habitat diversity and ecological niches necessary for foraging and refuge opportunities for juvenile salmon, birds, and resident fish species. The goal of monitoring is to provide the information needed to determine if the success criteria developed by the joint Trustee/Boeing technical team are being met.

5.2 Success Criteria

The success criteria and monitoring methods and frequency were developed by the joint Trustee/Boeing technical team, as described in Section 1.2. The success criteria are used during the monitoring period to determine if the project's goals are being met. Success criteria are applied to the Sites as a whole. The criteria chosen were adapted from monitoring guidelines developed for the Duwamish Waterway (USFWS, 2000) and Commencement Bay (CBNRT, 2000) restoration projects and from monitoring guidelines documented in other sources. The success criteria were chosen because: (1) they can be measured, and (2) contingency or adaptive management measures exist that can be applied during the monitoring period if the criteria are not being met.

Results of habitat monitoring are evaluated relative to the following success criteria:

- Physical Criteria:
  - intertidal area;
  - intertidal stability, slope erosion;
  - elevation and channel morphology; and
  - tidal circulation.
- Biological Criteria:
  - marsh vegetation areal coverage (including invasive species);
  - marsh vegetation survival/species composition;
  - riparian vegetation areal coverage (including invasive species);
  - riparian vegetation survival; and
  - herbivore control measures.
- Other Criteria:
  - fish presence; and
  - invertebrate prey resources.

In addition, monitoring of soil structure and site salinity was conducted for the habitat projects in 2015, although no success criteria were established for these metrics. Monitoring for fish presence was rescheduled to begin in 2016 with an additional round of monitoring added to the monitoring program in Year 5 to maintain 6 years of fish monitoring. Marsh/riparian insect (i.e., fallout) production will be conducted in Year 7 (2021) and Year 10 (2024) for the habitat projects. All of the criteria are not measured or evaluated each monitoring year (Table 1).

5.2.1 Physical Criteria

During Year 5 (2019), monitoring of selected physical criteria was conducted, as shown in Table 1. The habitat areas were surveyed using standard topographic survey methods by a licensed surveyor in July

2019. Additional monitoring of selected physical criteria will be conducted in Year 7 (2021) and Year 10 (2024; Table 1).

5.2.1.1 Intertidal Area

The intertidal areas of the habitat projects were assessed at Year 0 (2014) and were shown to be constructed as designed (AMEC, 2014). Portions of the North and South Sites subsequently had areas of slope instability that required the implementation of contingency measures to address the problems. These contingency measures were implemented in 2014, 2015, and 2016 (see Section 3.0). Figure 5 and Figures 6a–6c show isopachs of the difference in elevation of the 2019 surfaces at the North and South Sites, respectively (based on surveys conducted in July 2019) compared to the Year 2 post-construction surface. Figures 7a–7g and 8a–8g show cross sections through the habitat projects showing the post-construction (Year 0), Year 2 (August 2016), and Year 5 (July 2019) surfaces.

Monitoring Methods

A standard topographic survey of the North and South Sites was conducted by a licensed surveyor in July 2019. Spot elevations on a 10-foot grid were collected and used to develop surface contours of the constructed habitats (intertidal and marsh zones between approximately +2 feet MLLW and +12 feet MLLW and riparian zone between approximately +12 feet MLLW and +18 feet MLLW). The results of the Year 5 monitoring surveys were compared to results of the Year 0 and the Year 2 surveys to identify changes in area within the zone enclosed by the +12 foot MLLW and +2 foot MLLW elevation contours. Additional surveys of the intertidal area will be conducted in Years 7 and 10 (Table 1).

Success Criteria

The area within the zone enclosed by the +12 foot MLLW and +2 foot MLLW elevation contours during the Year 5 survey should be no less than 90% of the area measured during the Year 0 monitoring.

Monitoring Results

Results of the Year 0, Year 1, Year 2, and Year 5 monitoring are summarized in Table 2. The total area between the +12 foot MLLW and +2 foot MLLW elevation contours increased from 3.72 acres in Year 0 to 4.17 acres in Year 5, an increase of 12%. The total area within the zone bounded by the +12 foot MLLW and +2 foot MLLW elevation contours during the Year 5 survey was 127% of the area specified in the Consent Decree and meets the success criterion of 90% of the area measured during Year 0 monitoring.

5.2.1.2 Intertidal Stability/Slope Erosion

The intertidal areas of the habitat projects surveyed at Year 0 (2014) and Year 2 (2016) were compared to the current surface (Year 5, surveyed July 2019; Table 2).

Monitoring Methods

Traditional survey techniques were used in July 2019 to assess intertidal stability and slope erosion at both the North and South Sites. The acreage within the riparian zone (above +12 feet MLLW), the marsh zone (+12 to +5.5 feet MLLW), and the intertidal zone (+5.5 to +2 feet MLLW) was measured (Table 2) using the results of the July 2019 survey. Intertidal stability and slope erosion will be assessed by subsequent surveys to be conducted in Years 7 and 10 (Table 1).

Success Criteria

The area within the three elevation zones (above +12 feet MLLW; +12 to +5.5 feet MLLW; and +5.5 to +2 feet MLLW) will remain no less than 75% of the area defined in the Consent Decree for 5 years.

Monitoring Results

The results of the Year 0, Year 1, Year 2, and Year 5 (July 2019) monitoring are presented in Table 2. The Year 5 areas within the riparian, marsh, and intertidal zones (above +12 feet MLLW, +12 to +5.5 feet MLLW, and +5.5 to +2 feet MLLW, respectively) were within the success criteria of 75% of the area defined in the Consent Decree. The total combined area within the three zones increased from 5.23 acres in Year 0 to 5.73 acres in Year 5, an increase of 9.6%. This increase is based on the survey performed in July 2019, well after implementation of contingency measures in 2016 (Year 2) to address localized areas of erosion and slope instability found along the peninsula constructed at the North Site (see Section 3.1).

5.2.1.3 Elevation/Channel Morphology

Elevation and channel morphology were assessed at Year 5 (post-construction). Elevation and channel morphology will be assessed subsequently in Years 7 and 10 (Table 1).

Monitoring Methods

The topographic survey results (Section 5.2.1.1) as well as selected photo points (Appendix A) were used to evaluate channel morphology and stability.

Success Criteria

No success criteria have been defined for elevation/channel morphology.

Monitoring Results

Elevation contours for the North Site (Figure 5) demonstrate the stability of the serpentine drainage channel within the embayment at the North Site. Photographs taken in June 2019 during low tides at photo points within the entrance of the embayment show the developed channel morphology (Appendix A, Photos 2, 16, 17, and 20–28). Although some migration and movement of the channel have occurred, along with over-steepening of the slopes in some areas and accumulation of fine sediments in others, the developing channel appears to be stable.

5.2.1.4 Tidal Circulation

Tidal circulation was assessed during Year 5 using periodic visual surveys.

Monitoring Methods

Periodic visual surveys of the habitat project were conducted during low tides at least once per month during the peak of the juvenile salmonid outmigration (March to June 2019) and during the growing season (March to October 2019).

Success Criteria

The goal is for the tidal amplitude, as determined by both timing and elevation of high and low tide events, to be equivalent inside and outside of the project area.

Monitoring Results

No evidence of impeded tidal flow or potential fish stranding was observed during the time monitoring was conducted.

5.2.2 Biological Criteria

The goal of the marsh and riparian plantings is to establish a functioning tidal marsh community that will provide critical habitat functions, such as feeding and refuge for anadromous salmonids and other species. The establishment of marsh vegetation is one of the primary objectives of the Trustees. Wetland vegetation is one of the most obvious and straightforward indicators of habitat condition. Vegetation provides habitat structure for aquatic and terrestrial organisms, facilitates sediment accretion and buildup of marsh substrate, and serves as a source of organic material to support detritus-based food webs. Marsh functioning is facilitated by riparian vegetation that surrounds or overhangs the marsh habitats.

During construction, a mix of native trees and shrubs (Table 3) were planted within the riparian zone (above +12 feet MLLW) adjacent to the marsh areas. Within the marsh zone (+5.5 to +12 feet MLLW), native marsh species (Table 3) were planted as individual plugs or in vegetated coir mats colonized with different monocultures. An additional riparian shrub (Hooker's willow) and an additional bulrush species (American bulrush, *Schoenoplectus americanus*) were also planted at the North and South Sites during subsequent replanting activities (Table 3). In addition to these planted species, a mix of volunteer shrub and herbaceous species occur on the North and South Sites (Table 3).

Year 5 monitoring of the vegetation community condition included field surveys for species composition and canopy development within the marsh and riparian habitats. In addition, periodic visual monitoring of the vegetation within the riparian and marsh habitats was conducted to identify potential problems, such as colonization by invasive species or excessive herbivory, and to attempt to address the problems. Overall success in achieving the performance goals for the marsh areas was assessed based on the following biological criteria.

5.2.2.1 Marsh Vegetation Areal Coverage

Marsh areal coverage was assessed at Year 5 and compared to results from the Year 0 (as planted), Year 1, Year 2, and Year 3 surveys to calculate percentage change in total area of marsh vegetation cover. Marsh areal coverage will also be assessed in Years 7 and 10 (Table 1).

Monitoring Methods

The areal extent of marsh and riparian vegetation cover was mapped using a submeter global positioning system (GPS) instead of the traditional survey techniques proposed in the *Maintenance and Monitoring Plan* (AMEC et al., 2012a). Monitoring was conducted in August 2019 during the active growing season. The areal extent of vegetation cover was determined qualitatively by a biologist walking the outer limits of the vegetated areas for each zone (i.e., marsh and riparian). Areas with large patches of bare ground were excluded from the areal mapping, while areas with small patches (i.e., less than about 6 feet by 6 feet in size) of bare ground were included within the mapped vegetated area. The total marsh vegetation cover included areas planted with vegetated mats or plugs where the plants had become established and areas colonized by recruited species, such as dwarf spikerush (*Eleocharis parvula*) and grasswort (*Lilaeopsis* sp.).

Success Criteria

The overall goal for marsh areal coverage is for areal coverage of plants to be stable or increasing for 10 years.

Monitoring Results

Marsh vegetation areal coverage below +12 feet MLLW measured in Year 5 was compared to the area initially planted (Year 0) and the area measured in Year 1 (Table 4). Total areal coverage of installed marsh plants initially decreased between the Year 0 and the Year 1 monitoring events (Table 4). However, results

of the Year 2 survey showed that the community had stabilized and areal cover had begun to increase and continued to increase in Year 3. The Year 3 survey results showed an increase of about 15% in areal coverage of planted and naturally recruited marsh vegetation compared to Year 2 (Table 4). The results of the Year 5 survey show a decrease of 14% in areal coverage of planted and naturally recruited marsh vegetation compared to Year 3. In Year 5, marsh vegetation areal coverage was similar to that measured in Year 2 (Table 4).

Figure 9 shows the boundaries of areas where marsh plants were found in 2017 (Year 3) and in 2019 (Year 5). As shown in Figure 9, much of the change in areal coverage of marsh vegetation was observed at the South Site between +5.5 feet MLLW and +8 feet MLLW along the shoreline. Dwarf spikerush is the dominant species in this elevation band at both Sites. Dwarf spikerush was not originally planted but was an early colonizer and seems to prefer growing on the coir mats that were installed in this elevation range at the Sites. One factor that may explain the decrease in areal vegetation cover in the +5.5 to +8 foot MLLW range could be the continued decomposition and sedimentation of the coir mats. With less coir mat area available to grow on, dwarf spikerush cover in these areas has decreased. In addition, river scour in the +6 to +8 feet MLLW range has also likely contributed to loss of some vegetation in this range. This scour appears more focused or noticeable in the southern portions of the South Site where the bank grades are steeper.

Significant shoreline erosion appears to have been effectively controlled at the North Site (see Section 3.1). The areas with significant erosion (i.e., the waterway side of the peninsula and the mouth of the embayment) at the North Site had a complete loss of vegetation below approximately +11 feet MLLW by 2016. Stabilization of these areas by placing rounded gravel mix (see Section 3.1 of the *Year 2 Habitat Monitoring Report* [Amec Foster Wheeler, 2017]) in August 2016 resulted in near-term loss of marsh area for plant recruitment. The placement of fascines constructed of Hooker's willow in the upper intertidal zone (+11 feet MLLW) helped stabilize the slopes and improve the biological functioning in this area. In 2019, the area where gravel was placed to stabilize the shoreline showed some recruitment of marsh plants approximately 18 inches to 24 inches downslope just below +12 feet MLLW. Both Douglas aster (*Aster subspicatus*) and Pacific silverweed (*Potentilla anserina*) have been observed along with some tufted hairgrass (*Deschampsia cespitosa*) growing within areas stabilized with gravel, representing about 39.9% of the marsh area (+5.5 to+12 feet MLLW) at the North Site. The extent of these three species is sporadic and patchy within these gravel areas, likely based on the presence and accessibility of suitable microhabitats for plants to root in and thrive within this gravel layer.

See Section 5.2.2.2 for further discussion of marsh vegetation establishment and cover in conjunction with cover class and line-intercept methods.

5.2.2.2 Marsh Vegetation Survival/Species Composition

Marsh species composition was assessed at Year 5 using the Daubenmire cover class method and the line-intercept method of vegetation surveys. Survival of the marsh vegetation originally planted at the Sites could not be assessed due to the low overall survival at the North and South Sites. Marsh species composition will also be assessed in Years 7 and 10 (Table 1).

Monitoring Methods

Permanent transects were established during the first year of biological monitoring (Figure 4). The permanent transects were laid out by a qualified biologist after consultation with the Trustees. Transects were located in areas representative of the marsh community as a whole. Each vegetation monitoring transect was defined by two permanent markers, as indicated on Figure 4. The permanent markers were surveyed, and their elevation determined using traditional survey techniques. Transects connecting the

two markers were established generally perpendicular to the shoreline (baseline) or elevation contours. Transects extended downgradient from the edge of the riparian zone (where possible) into the marsh zone for marsh vegetation sampling (see Figure 4). The transects ranged from 50 feet to 107 feet in total length.

For the Daubenmire cover class survey, individual sampling locations (quadrats) were established along each transect. Twenty-five quadrats measuring 0.5 by 0.5 meter (total sampling area of 0.25 square meter per quadrat) were established along transects within each marsh restoration area (North and South Sites). The placement and distribution of quadrats along each transect were guided by the Trustee's requirement for approximately equal numbers of quadrats within each of five marsh planting zones originally defined in the design documents. These planting zones were defined based on elevation and identified based on typical representative species:

- Douglas aster zone (+12 feet MLLW to either +10.5 feet MLLW [North Site] or +11 feet MLLW [South Site]),
- Tufted hairgrass zone (+10.5 feet MLLW [North Site] or +11 feet MLLW [South Site] to +9.5 feet MLLW),
- Pacific silverweed zone (+9.5 feet to +8 feet MLLW),
- Lyngbye's sedge zone (+8 feet to +7 feet MLLW), and
- Bulrush zone (+7 feet to +5.5 feet MLLW).

Five quadrats were established within each planting zone at the North and South Sites. Quadrats were defined with one edge along the transect, with the square extending from the transect line either upstream or downstream, alternating for each station along each transect. The distance of each quadrat from the start point of the surveyed transect was determined and recorded along with the quadrat frame orientation (extending upstream or downstream from the transect). The Daubenmire method was used to estimate plant cover by species by surveying each of the established quadrats.

The line-intercept method of vegetation surveying was used to estimate percent cover by vegetation type (i.e., tree, shrub, herbaceous, non-native, or invasive) along each of the established transect lines.

Success Criteria

No specific survival goals were formulated beyond Year 3. The following benchmarks were to be used:

- 25% cover of clonal dominants (e.g., pickleweed/saltgrass, bulrush, sedge) at Year 3,
- 50% cover of clonal dominants at Year 5, and
- No less than 75% cover of clonal dominants at Year 10.

While no specific performance criterion was established for marsh vegetation cover as whole, the overall composition of marsh vegetation and percent cover are evaluated and presented below. Marsh vegetation includes species initially planted at the Sites (i.e., Douglas aster, tufted hairgrass, Pacific silverweed, Lyngbye's sedge, bulrush) as well as volunteer species that have colonized the Sites (e.g., dwarf spikerush and common spikerush [*Eleocharis palustrus*], grasswort, various rushes, orache [*Atriplex patula*], western dock [*Rumex occidentalis*], and willowherb [*Epilobium* sp.]).

In addition, the project was not to contain more than 5% cover by area of non-native or invasive plant species. Invasive plant species of special concern include, but are not limited to, cordgrass (*Spartina spp.*), purple loosestrife (*Lythrum salicaria*), reed canarygrass, and common reed (*Phragmites communis*).

Monitoring Results

The results of the marsh species composition and percent cover survey conducted using the Daubenmire and line-intercept methods are presented in Table 5.

Clonal Dominants and Marsh Vegetation

Clonal dominants were surveyed using the Daubenmire method and included seacoast bulrush, Lyngbye's sedge, dwarf and common spikerush, and grasswort. Overall coverage by clonal dominants from +5.5 to +12 feet MLLW averaged 38.4%. While no performance criterion was set for clonal dominants in Year 5, a benchmark goal for Year 5 was 50% cover of clonal dominants.

Marsh vegetation cover included those species initially planted at the Sites as well as native volunteer species that have colonized the Sites; non-native and invasive species cover are discussed separately. Total marsh vegetation cover from +5.5 to +12 feet MLLW surveyed by Daubenmire and line-intercept methods, respectively, totaled 54.7% and 69.2%.

It is important to note that in developing the design of the habitat project, Boeing discussed with the Trustees that marsh plants at restoration sites in the Lower Duwamish Waterway generally colonized the intertidal area above an elevation of approximately +8 feet MLLW, with few marsh plants occurring below this elevation (see Appendix E of the *Final Habitat Design Report* [Amec et al., 2012b]). The Trustees asked Boeing to attempt to establish marsh plantings between elevation +5.5 and +8 feet MLLW (low marsh), even though data collected on the Lower Duwamish suggested that marsh plants would not thrive in this elevation range. Boeing agreed to attempt to establish the low marsh plantings by installing pre-vegetated coir mats. Due to a number of factors that have been described in previous monitoring reports, the low marsh (elevation +5.5 to +8 feet MLLW) plants have not successfully established.

Although the Year 5 benchmark for clonal dominants was set at 50% cover, establishment of marsh vegetation was one of the primary objectives of the Trustees. Establishment of the upper marsh vegetation (elevations from +8 to +12 feet MLLW) reflects this primary objective. Year 5 marsh vegetation cover measured using the Daubenmire method averaged 23.4% from +5.5 to +8 feet MLLW, and 75.6% from +8 to +12 feet MLLW. Based on discussions with the Trustees related to the unlikely success of marsh colonization below +8 feet MLLW, the Year 5 upper marsh (+8 to +12 feet MLLW) vegetation cover may be considered to exceed the Year 5 benchmark of 50% cover.

The 2019 Daubenmire cover data were further reviewed for differences in marsh vegetation cover between the North Site and South Site (Table 5). For the North Site, marsh vegetation cover was 42.8% between +5.5 and +8 feet MLLW, representing about 100% of the area at the North Site that is not covered with gravel. Approximately 86.7% of the area between +8 and +12 feet MLLW at the North Site is covered by marsh vegetation, which again represents about 100% of the area without gravel cover. In comparison, the South Site marsh vegetation cover was 0.5% at elevations between +5.5 and +8 feet MLLW and 62.5% between +8 and +12 feet MLLW.

As discussed in Section 5.2.2.1, dwarf spikerush is the dominant species in the elevation band +5.5 to +8 feet MLLW at both Sites. Dwarf spikerush was not originally planted but was an early colonizer and seems to prefer growing on the rough substrate texture offered by the coir mats that were installed in this elevation range at the Sites. The continued decomposition and sedimentation of the coir mats has reduced the available area that dwarf spikerush seems to prefer for establishment, resulting in decreased cover by dwarf spikerush. It has been observed that areas not covered with coir mats have sparse or no colonization by dwarf spikerush. In addition, river scour and sediment transport in the +6 to +8 feet MLLW range has also likely contributed to loss of some vegetation in this range. This scour appears more focused or noticeable in the southern portions of the South Site, where the bank grades are steeper.

Sediment transport and deposition are observed along shallower grades throughout both Sites in the +6 to +8 feet MLLW range.

With the exception of the North Site embayment, which likely provides ideal conditions for low marsh plant growth, it is not unexpected that marsh plant growth has not been robust between +5.5 feet MLLW and +8 feet MLLW (Amec et al., 2012b). Replanting of marsh vegetation has focused on elevations above +8 feet MLLW, and plants at those elevations have exhibited robust growth.

Furthermore, the permanent transects that were established during the first year of biological monitoring (Figure 4) may not reflect a representative sample of the overall distribution and variability of marsh vegetation within the Sites. Transects were located in areas that were representative of the marsh community as a whole at the time the transects were established. However, vegetation development over time has occurred in a naturally heterogenous pattern, with patches of dense vegetation interspersed with lightly vegetated and bare areas, similar to vegetative patterns observed throughout this reach of the Duwamish River.

The monitoring program relies on a limited number of transects that encompass a significant distance of shoreline. In this case, eight transects are distributed along approximately 1,600 feet of shoreline in the North Site, and seven transects are distributed along approximately 1,500 feet of shoreline in the South Site. In several instances, the existing transect is located in an area that happens to have fairly sparse or no vegetation growth, while vegetation on either side of the transect is growing much more densely or of more variable species composition. Both scenarios accurately reflect the variability of conditions at the Sites, but the limited number of transects and their unique locations may not accurately capture the overall species composition and cover at the Sites.

Invasive and Non-Native Species

Cover of invasive species estimated using Daubenmire and line-intercept methods was less than 0.1%, with control measures ongoing. Cover by non-native species (primarily bird's-foot trefoil) estimated by the Daubenmire and line-intercept methods, respectively, was 0.7 and 0.9%. Control of non-native plants (primarily bird's-foot trefoil but including some non-native clovers [*Trifolium* sp.]) remains an ongoing maintenance task at the Sites.

The success criteria for percent cover of non-native and invasive species is 5%. Based on both the Daubenmire and line-intercept methods of estimating cover, both Sites meet the performance criterion. Efforts to control bird's-foot trefoil will continue during routine maintenance activities at both the North and South Sites. In addition, the isolated patches of Japanese knotweed found at the North Site during maintenance activities in June 2016 were thoroughly grubbed out and have not returned since. In 2019, reed canarygrass continued to establish on the North Site with limited development occurring at the South Site. The presence of reed canarygrass along the transition zone of marsh and riparian habitats is typical of observations at other sites along this portion of the Duwamish River. Maintenance crews use manual control methods for reed canarygrass, including manually digging up the plant and roots and removing the debris from the Sites.

5.2.2.3 Riparian Vegetation Areal Coverage and Species Composition/Percent Cover

Riparian vegetation coverage (including species composition of riparian plants and invasive species) was assessed for the North and South Sites at Year 5. Riparian vegetation coverage will also be assessed in Years 7 and 10 (Table 1).

No further assessment of riparian vegetation survival is included in the monitoring schedule (Table 1). Note that Table 1 in this Year 5 report has been revised to match the monitoring schedule as originally presented in the *Maintenance and Monitoring Plan* (AMEC et al., 2012a). Previous reports (e.g., Year 3 and

Year 4) had erroneously switched riparian vegetation survival and riparian vegetation coverage monitoring schedules.

Monitoring Methods

The overall areal extent of riparian and marsh vegetation cover was mapped using a submeter GPS, as described in Section 5.2.2.1. Monitoring was conducted in August 2019 during the active growing season. The overall areal extent of vegetation cover was determined qualitatively by a biologist walking the outer limits of vegetated areas for each zone (i.e., marsh and riparian).

Species and life form composition was assessed at Year 5 using the Daubenmire cover class method and the line-intercept method of vegetation surveys. Permanent transects were established during the first year of biological monitoring (Figure 4). The permanent transects were laid out by a qualified biologist after consultation with the Trustees. Transects were located in areas representative of the riparian community as a whole. Each vegetation monitoring transect was defined by two permanent markers, as indicated on Figure 4. The permanent markers were surveyed and their elevation determined using traditional survey techniques. Transects connecting the two markers were established generally perpendicular to the shoreline (baseline) or elevation contours. Transects extended upgradient from the edge of the riparian zone (where possible) toward the upland for riparian vegetation sampling (see Figure 4). The transects ranged from 50 feet to 107 feet in total length.

For the Daubenmire cover class surveys, individual sampling locations (quadrats) were established along each transect. Twenty-five quadrats measuring 0.5 by 0.5 meter (total sampling area of 0.25 square meter per quadrat) were randomly distributed along transects within each riparian restoration area (North and South Sites). Three to five quadrats were located along each of the transects shown on Figure 4. Quadrats were defined with one edge along the transect, with the square extending from the transect line either upstream or downstream, alternating for each station along each transect. The distance of each quadrat from the start point of the surveyed transect was determined and recorded along with the quadrat frame orientation (extending upstream or downstream from the transect).

Monitoring of species composition and species cover was conducted in August 2019 during the growing season. The Daubenmire method was used to estimate plant cover by species by surveying each of the established quadrats.

The line-intercept method of vegetation surveying was used to estimate percent cover by vegetation type (i.e., tree, shrub, herbaceous, non-native, or invasive) along each of the established transect lines.

Tree canopy development was assessed using a spherical densiometer using the methodology described in the *Maintenance and Monitoring Plan* (AMEC et al., 2012a). A concave spherical densiometer was used to measure canopy cover or canopy closure in riparian areas with each measurement recorded from a location 12 feet from the origin of each permanent vegetation transect. The densiometer is held at elbow height approximately 12 to 18 inches in front of the body, and a reading is taken from each of the four cardinal directions (i.e., north, south, east, and west). The four canopy readings are averaged to provide a single result for each transect.

Success Criteria

No performance criterion was established for overall riparian vegetation areal coverage; however, riparian vegetation percent cover should be stable or increasing over time (see Table 1, Note 5).

For Year 5, the percent cover of native trees should be greater than 40% and the percent cover of native shrubs should be greater than 50%. Bare ground should be less than 10%.

No performance criterion was set for native herbaceous plant cover beyond Year 3; however, shrub cover is anticipated to decrease over time as the forested/shrub canopy increases (see Table 1, Note 5).

Invasive species cover should be less than 5% by Year 5 and beyond. The percent of bare ground present in Year 5 should be less than 10%.

Monitoring Results

Areal Coverage

The overall areal extent of the riparian areas was mapped qualitatively in Year 5 (Figure 9). Minimal observable change (6% increase) in the plan view area covered by the riparian vegetation was observed between 2017 (Year 3) (Amec Foster Wheeler, 2018) and 2019 (Year 5) (Table 4), demonstrating general overall stability of vegetation cover at the Sites (Figure 9). No observable change (0%) in the area covered by riparian vegetation was observed at the South Site compared to the 2017 survey results; the North Site exhibited a 16% increase in riparian vegetation cover from 2017 (Year 3) (Amec Foster Wheeler, 2018) to 2019 (Year 5).

Species Composition/Percent Cover

Tree and Shrub Species

Most of the trees and shrubs initially planted at both the North and South Sites remain at the Sites. In addition, several riparian vegetation species have self-colonized within the Sites, primarily red alder, black cottonwood, sweet gale, and madrone, as well as small patches of gumweed.

The results of the riparian species composition and percent cover survey using the Daubenmire and line-intercept methods are presented in Table 6. Total vegetative cover (including tree, shrub, and herbaceous cover) based on surveys conducted using the Daubenmire and line-intercept methods, respectively, averaged 94.5% and 171.9%.

Estimates of percent cover of trees using the Daubenmire and line-intercept methods, respectively, were approximately 27.6% and 48.3%. The performance criteria for the two Sites overall were not met during the Year 5 monitoring event; however, tree cover at the North Site (42.1% and 57.9% measured using the Daubenmire and line-intercept method, respectively) and at the South Site (42.3% using the line-intercept method) met the success criterion. Tree cover continues to be lower than the criterion of 40% when estimated using the Daubenmire method at the South Site. A number of willow and cottonwood trees have been damaged by repeated attacks by boring beetles that have resulted in death or stunted growth and limited the overall development of the tree structure and canopy. A second major contributor to low tree cover is blowdown by strong winds. Finally, beaver activity has impacted a limited number of trees.

Percent cover of shrubs estimated using the Daubenmire and line-intercept methods, respectively, was 15.1% and 33.7%. Shrub cover continues to be lower than the criterion of 40% at both Sites. The low shrub cover at the North Site may be a shading response owing to the higher proportion of tree cover. The shrub cover at the South Site is currently higher than the shrub cover at the North Site. The higher cover by shrubs at the South Site may reflect the lower proportion of tree cover at the South Site.

Canopy development measured with a spherical densiometer averaged 43.0% for both Sites. Canopy cover remained nearly the same at the North Site and averaged 49.9% (compared to 55.5% in 2018). Canopy development measurements increased markedly at the South Site to 36.1% (compared to 11.6% in 2018). No performance standard for canopy cover was established for the Sites; however, measurements of riparian canopy cover remain a useful tool to help identify the benefits offered to lower canopy layers. The shade provided by trees increases the diversity of habitats below, which provides additional habitat for those plant species that do not thrive in areas of direct sun. The increased canopy

cover may also contribute to shading out the growth of blackberry and reed canarygrass. Trees also help develop soil conditions in the long-term by contributing to the duff layer. Further, the presence of trees helps reduce goose activity on the Sites by reducing the extent of open areas in which geese prefer to congregate.

Herbaceous Species

Herbaceous plant cover (consisting of the applied grass seed mix and volunteer plants) estimated using the Daubenmire and line-intercept methods, respectively, was 51.8% and 89.9%. No performance criterion for herbaceous plant cover was established beyond Year 3.

Bare Ground

Bare ground percent cover was estimated using the Daubenmire method and was 23.4% for the Sites overall. This result is above (and therefore does not meet) the performance standard for Year 5 of less than 10%. However, bare ground cover at the North Site was 7.9% and meets the performance standard. Bare ground cover was higher at the South Site (33.1%). Several factors have resulted in bare ground at the Sites, including shading by trees and in some cases shrubs; herbivory by geese and other wildlife; active control of the bird's-foot trefoil by mowing and physical removal; as well as the naturally heterogenous or patchy distribution of vegetation as would be expected to occur at the Sites.

Ground cover vegetation has been highly impacted by wildlife. For several years it has been assumed that both raccoons and crows have been tilling up large areas of vegetation in search of grubs (i.e., Japanese beetles or June bugs). The raccoons create the initial disturbance as they roll up and displace large clumps of vegetation and sod. Following the disturbance by raccoons, large groups of crows tend to gather and rummage through the displaced clumps of vegetation, further breaking up and spreading the clumps. This type of activity has been observed at other locations at the Boeing facility and at other sites along the Duwamish River and outlying areas.

Invasive and Non-Native Species

Estimates of invasive species cover using the Daubenmire and line-intercept methods, respectively, were 0.4 and 5.3%. The Year 5 performance criterion is less than 5% cover of invasive species. Cover estimates for invasive species (primarily Himalayan blackberry) based on the line-intercept data at the South Site (6.3%) currently marginally exceed the performance criterion. The South Site currently meets the performance criterion for cover by invasive species measured using the Daubenmire method (0.3%). The North Site currently meets the performance criterion for cover by invasive species (measured using both the Daubenmire [0.6%] and line-intercept methods [3.7%]). Active control measures to control invasive species such as Himalayan blackberry are continuing during the routine maintenance activities.

There is no performance criterion for cover by non-native species in riparian habitat. Cover by non-native species (primarily bird's-foot trefoil and clover) estimated using the Daubenmire and line-intercept methods, respectively, was 15.6% and 20.1%. Active control of the bird's-foot trefoil by mowing and physical removal is continuing during routine maintenance activities.

As discussed in Section 5.2.2.2, the permanent transects that were established during the first year of biological monitoring (Figure 4) may not reflect a representative sample of the overall distribution and variability of marsh and riparian vegetation within the Sites. Transects were located in areas representative of the vegetation communities as a whole at the time they were established. However, vegetation development over time has occurred in a naturally heterogenous pattern, with patches of dense vegetation interspersed with lightly vegetated and bare areas, similar to vegetative patterns observed throughout this reach of the Duwamish River. The limited number of transects may not accurately capture the overall species composition, cover, and variability at the Sites.

5.2.2.4 Marsh and Riparian Vegetation Herbivory Control

The effectiveness of herbivory control measures continues to be periodically assessed during the growing season (March through October). Debris snagged on the fencing was removed to maintain the integrity of the remaining fence. Fencing has been removed in select areas where mature vegetation shows sufficient maturity and vigor to be resilient against geese herbivory. Fencing has been retained in some areas where it still appears beneficial to plant development. Goose harassment patrols with dogs continued in 2019 (Section 4.1.1).

Monitoring Methods

Periodic visual surveys of the goose exclusion fencing installed at the habitat project were conducted during the weekly maintenance activities during 2019. Periodic visual surveys of the fenced enclosures continued during the routine maintenance activities.

Success Criteria

There are no numerical success criteria; however, evidence of damage to the installation or obvious herbivory may trigger additional monitoring and implementation of contingency measures.

Monitoring Results

Grazing by geese and other waterfowl on the marsh plantings, such as Lyngbye's sedge, tufted hairgrass, Pacific silverweed, and the hardstem/softstem/seacoast bulrushes, continues to be a potential problem. Young plants can be grazed and are susceptible to being dislodged, but the adaptive management approach to this herbivory (discussed in Section 4.1) is keeping the goose grazing under control.

5.2.3 Additional Monitoring Requirements

Additional monitoring requirements described in the *Maintenance and Monitoring Plan* (AMEC et al., 2012a) include sampling for fish presence, infauna community development, and marsh/riparian insect (i.e., fallout) production within the footprint of the restoration projects. The purpose of this monitoring activity is to provide data as requested by the Trustees. No success criteria, contingency measures, or adaptive management activities are associated with this monitoring requirement. Failure of fish to use the areas or for the benthic infauna or terrestrial insect community to develop could indicate that a basic restoration goal is not being met and will trigger discussions regarding possible causes.

5.2.3.1 Fish Presence

Fish usage at the North Site was assessed at Year 5. Sampling was conducted on March 28, May 7, and June 5, 2019. Fish presence will be assessed again in Years 7 and 10 (Table 1). Monitoring was conducted under Scientific Research Permit 19386 from NOAA's National Marine Fisheries Service, Recovery Permits TE56731B-0 and TE56731B-1 from the USFWS, and Scientific Collection Permit #19-055 from the Washington Department of Fish and Wildlife.

Monitoring Methods

Fish usage of the embayment at the North Site was assessed using a fyke net to collect the fish present in the embayment. The live box of the fyke net was placed off the mouth of the embayment (Figure 4) with wings extending up into the upper intertidal area along the east shore and toward the ridge of the peninsula on the west side. The fyke net and wings were deployed during a falling tide. All the fish within the embayment below approximately +8 feet MLLW were funneled into the net as the tide fell. An area of approximately 0.36 acre was sampled. All the fish were herded within the live box of the fyke net by the

time the tide reached approximately +2 feet MLLW. During the period that the tide was falling, fish that had entered the live box were periodically removed from the live box, anesthetized using tricaine methanesulfonate (MS-222), measured (fork length in millimeters [mm]), and placed in a separate cooler to recover. Once a minimum of 100 fish were measured for a species the remaining individuals were counted and released. Once the anesthetized fish recovered, they were released unharmed back into the Waterway. The results of the monitoring are summarized in Tables 7 and 8 and described below.

Monitoring Results

The results of the monitoring for fish usage at the North Site are presented in Table 7 and Table 8. The most abundant species caught in 2019 was chum salmon (*Oncorhynchus keta*; Table 8) during the May sampling event, and the most abundant non-salmonid species caught was shiner perch (*Cymatogaster aggregate*; Table 7) during the June event. Juvenile pink salmon (*O. gorbuscha*; Table 8) were not present in 2019 (odd year). Pink salmon exhibit a strict two-year life cycle, thus even- and odd-year populations do not interbreed and are tracked separately. Wild chinook salmon (*O. tshawytscha*; Table 7) were present during the May and June sampling events. No clipped juvenile chinook salmon were collected, and the abundance of chinook salmon was lower than in 2018 (Table 8).

March 2019

Fish collected during the March 2019 sampling event included juvenile chum salmon as the dominant species (Table 8). Additional fish species observed consisted of three-spine stickleback (*Gasterosteus aculeatus*), staghorn sculpin (*Leptocottus armatus*), and speckled dace (*Rhinichthys osculus*) (Table 8), but the abundances of these other species were low.

Chum salmon fork lengths (based on a representative sample of 98 individuals of the total count of 1,020) ranged from 34 to 43 mm with an average length of 38.8 mm (Table 7).

May 2019

Chum salmon were the dominant species collected during the May 2019 sampling event (1,038 individuals, Table 7). Fork lengths for chum salmon (based on a representative sample of 126 individuals of the total count of 1,038) ranged from 38 to 60 mm with an average of 45.3 mm (Table 7).

The chinook salmon caught were unclipped fish (possible wild fish). The two individual chinook salmon captured both had fork length measurements of 50 mm (and therefore an average of 50 mm; Table 7).

Five additional fish species were caught: starry flounder (*Platichthys stellatus*), three-spine stickleback, shiner perch, snake prickleback (*Lumpenus sagitta*), and staghorn sculpin (Table 8). Staghorn sculpin were the second most abundant species (Table 8).

June 2019

Chum salmon and chinook salmon were present during the June 2019 sampling event; however, the dominant catch species was shiner perch, with a total count of 511; Table 8). The chinook salmon caught were unclipped fish (possibly wild fish; Table 7).

Three additional fish species were caught: starry flounder (total count of 31), three-spine stickleback (total count of 6), and staghorn sculpin (total count of 112; Table 8).

5.2.3.2 Invertebrate Prey Resources

Invertebrate prey resources were assessed at Year 5. Invertebrate prey resources will also be assessed in Years 7 and 10 (Table 1). Monitoring was conducted under Scientific Collection Permit #19-055 from the Washington Department of Fish and Wildlife.

Monitoring Methods

Benthic organisms were sampled by collecting core samples along transects established in the North and South Sites. At both Sites, three transects each approximately 50 feet long were established running along the shoreline generally following the elevation contour (Figure 4). The transects in each Site were established to represent three elevation strata (Figure 4):

- high marsh (approximately +11 feet MLLW),
- low marsh (approximately +8 to +7 feet MLLW), and
- unvegetated sand/mudflat (approximately +5 to +4 feet MLLW).

Five replicate cores with a diameter of 10 centimeters (cm) were collected along each transect to a depth of 10 cm. The sample locations visited during the Year 1 and Year 2 monitoring events were different from the Year 3 infauna core sampling locations. The transects sampled in Year 3 are shown on Figure 4 and were reoccupied in 2019. The new collection areas are more sheltered than the previous sample areas (Year 1 and Year 2) and the sediments were finer-grained, especially the samples collected at the +4 feet MLLW elevation.

Individual cores were handled, preserved, and stored following recommendations for sampling benthic macroinvertebrate assemblages specified in Puget Sound Estuary Program (PSEP) protocols (PSEP, 1987) and in the Standard Operating Procedure provided in Appendix E of the *Maintenance and Monitoring Plan* (AMEC et al., 2012a). In each sample collected, benthic invertebrates were identified and enumerated to the lowest practical taxonomic level by regional experts familiar with the fauna of Pacific Northwest estuarine habitats.

Monitoring Results

A summary of the results of the invertebrate prey resource monitoring is presented in Table 9 and Figure 10. Table 10 provides a comparison of the total invertebrate abundances by major taxonomic group for monitoring conducted in Years 1, 2, 3, and 5. Data tables with organism counts and various metrics (i.e., dominant taxa, species diversity, richness, evenness) by sample are presented in Appendix B, Table B-1 and B-2.

Benthic invertebrates were found at all elevations at the North Site and at the +7 feet MLLW and +11 feet MLLW elevations at the South Site. Benthic invertebrates were not identified in the samples collected at the +4 feet MLLW elevation at the South Site. This transect was in an exposed, sandy area without vegetation and the conditions and substrate at the sampling locations may be responsible for the apparent lack of infauna.

Benthic invertebrate assemblages at the other elevations were numerically dominated by oligochaetes and polychaetes. Oligochaetes were present at all elevations, with the highest density at the +7 feet MLLW elevation at the North Site. The Enchytraeidae oligochaetes (a mostly terrestrial family) was found at all tidal elevations at the North Site and at the +7 feet MLLW and +11 feet MLLW transects at the South Site. *Paranais birsteini* in the family Naididae is an aquatic estuarine species. The Naididae were found at all tidal elevations (highest density at +7 feet MLLW) at the North Site. The Naididae were absent from the samples collected at the South Site. Polychaetes were present in the North Site at +4 feet MLLW and

+7 feet MLLW, represented by the tube-building *Manayunkia speciosa* in the family Fabriciidae, an aquatic estuarine species. Polychaetes were not observed at the South Site. A patchy distribution of organic matter may be a driving factor in the variability found in oligochaete and polychaete abundances between the North and South Sites, between elevations, and between samples collected along each sampling transect.

After polychaetes, diptera larvae were the most abundant taxon in the samples collected at +7 feet MLLW and +11 feet MLLW at both Sites (Table 10). The samples collected at +4 feet MLLW at the North Site were numerically dominated by the polychaete *Neanthes limnicola*, with an average density of 6.6 individuals per core, and by the crustacean amphipod *Americorophium salmonis*, with an average density of 5.4 individuals per core (Table 9). The tube-building polychaete *Hobsonia florida* was present at +4 feet MLLW and +7 feet MLLW at the North Site with an average density of 2.6 individuals per core at +4 feet MLLW.

Fallout Insect Production

Terrestrial insect production associated with the marsh/riparian community was not assessed in Year 5 but will be assessed in Years 7 and 10 (Table 1) once the riparian vegetation develops sufficiently to provide a ready source of insects.

5.2.3.3 Recontamination

Recontamination monitoring is conducted as part of the Resource Conservation and Recovery Act (RCRA) process. Therefore, compliance criteria are listed separately from performance criteria in Table 1. The compliance criteria that are used to assess potential recontamination are the Washington State Department of Ecology's Sediment Management Standards (SMS) Sediment Quality Standards (SQS; WAC 173-204-320). The restoration Sites were not monitored during 2019 for potential recontamination. The next round of post-construction sediment monitoring (Year 5 Post-Construction Sediment Monitoring) will be conducted in 2020.

6.0 Future Adaptive Management

Boeing plans to continue its approach to controlling goose herbivory by using harassment techniques (i.e., dog patrols) to discourage geese at the Sites as needed. As of May 2019, the dog patrol was stopped. Fencing for enclosures is being removed where it is no longer required. Both the North and South Sites continue to be monitored for impacts resulting from geese. As the replanted marsh plants continue to mature and become better able to withstand grazing damage, management for goose herbivory is anticipated to decrease.

Boeing does not plan any additional marsh plantings at this time but will continue to monitor the replanted areas to assess survival and growth of the marsh vegetation. Boeing expects the marsh plantings to continue to grow and spread outside of the existing enclosures and will continue to remove the existing enclosures while monitoring the marsh plantings for overall survival and growth. A decision on complete removal of the fencing would be made in consultation with the Trustees.

Control of bird's-foot trefoil by mowing and limited grubbing to control its growth around and on desirable plants will continue at both the North and South Sites. The bird's-foot trefoil continues to compete with the native herbaceous stock; however, coverage of the bird's-foot trefoil has decreased slightly in the riparian zone at the North Site (10.6% in 2019 versus 12.3% in 2018). This decrease may be because of the limited watering that occurred at the North Site in 2018 that was followed by extensive die-back of bird's-foot-trefoil, and the reduced watering that occurred in some locations at the North Site in 2019 due to blockage by existing vegetation. In addition, the North Site has had increased colonization

by cottonwood. Areas with increased canopy cover at either Site tend to exhibit less development of bird's-foot-trefoil. Bird's-foot-trefoil cover has increased slightly in the riparian zone at the South Site (12.7% in 2019 versus 11.8% in 2018). In general, the level of effort expended in control during 2019 remained the same as in 2018 and will likely remain the same in the coming years until a mature canopy is established and supplemental watering is discontinued.

In August 2016, Boeing discussed with the Trustees the limited use of chemical treatments to control bird's-foot trefoil and potentially other invasive species (e.g., Japanese knotweed, reed canarygrass, or cordgrass). Boeing conducted limited applications of Rodeo®, an herbicide formulation manufactured by Dow AgroSciences, in two areas (each area approximately 5 meters by 5 meters) at the South Site where bird's-foot trefoil was present. Overall, herbicide control of bird's-foot trefoil was effective when applied to plants with healthy foliage; however, it also killed desirable plants. If continued treatment of bird's-foot-trefoil with herbicide is not implemented, the trefoil is likely to become re-established if not controlled by other methods. Boeing has decided to limit the use of the herbicide for general control of the bird's-foot trefoil and to continue manual methods of control (i.e., mowing and grubbing). Manual methods will continue to be used for the control of other invasive species.

The small area of native gumweed planted at the South Site in December 2016 has become established. In 2018 these plants began to display strong growth and competition against the bird's-foot trefoil. Six additional areas (2 feet by 5 feet) were seeded in the fall of 2018 and will remain fenced until they become established. The gumweed continues to grow and provide a seed source to the Sites. Additional gumweed seed was planted in winter 2018, and several small areas of gumweed have self-colonized at the Sites. The planted areas will be monitored, and additional areas will be established as plants or seeds become available.

7.0 Summary

The following table summarizes the Year 5 performance criteria from the *Maintenance and Monitoring Plan* (AMEC et al., 2012a) and the Year 5 monitoring results.

Criteria	Measured Parameter	Year 5 Performance Criterion	Year 5 Monitoring Result	Year 5 Performance Criterion Met?
Physical Criteria				
Intertidal area	Area	>75% design	127% of design	Yes
Intertidal stability/ slope erosion	Area in each elevation zone	>75% of area in Consent Decree	103% +12 feet MLLW 114% +5.5 to +12 feet MLLW 164% +2 to +5.5 feet MLLW	Yes
Elevation/channel morphology	Slope	No threatening erosion	No threatening erosion observed	Yes
Tidal circulation	Visual inspection	Equivalent inside and outside	Equivalent inside and outside	Yes
Biological Criteria				
Marsh vegetation areal coverage	Percent cover	Stable or increasing	14% decrease from Year 3, stabilizing.	Yes

Criteria	Measured Parameter	Year 5 Performance Criterion	Year 5 Monitoring Result	Year 5 Performance Criterion Met?
Marsh invasive species and non-native species	Percent cover	<5% invasive & non-native	<1%	Yes
Riparian vegetation areal coverage	Percent cover native tree	>40%	27.6% (Daubenmire) 48.3% (Line-Intersect)	No
Riparian vegetation areal coverage	Percent cover native shrub	>50%	15.1% (Daubenmire) 33.7% (Line-Intersect)	No
Riparian bare ground	Percent cover	<10%	23.4%	No
Riparian invasive species	Percent cover	<5%	<1% (Daubenmire) 5.3% (Line-Intersect)	Yes
Marsh and riparian vegetation herbivory control	Visual inspection	Properly functioning	Adaptive management practices effectively controlling herbivory	Yes

Three success criteria were not met for Year 5: riparian shrub and tree coverage and riparian bare ground. The low shrub cover at the North Site may be a shading response to the higher proportion of tree cover. The higher cover by shrubs at the South Site may reflect the lower proportion of tree cover at the South Site. The low tree cover at the Sites may be due to repeated damage by boring beetles, blowdown by strong winds, and beaver activity. In addition to these factors, the permanent transects established for estimated species composition and coverages may not accurately capture the overall distribution and variability of vegetation within the Sites, as previously discussed. When reviewing the Sites visually, shrub and tree growth appear generally healthy and developing toward a more dense, native riparian community. Riparian shrub and tree vegetation will continue to be monitored, and adaptive management measures may be implemented if coverages continue to remain well below criterion levels.

Based on the monitoring conducted in 2019, marsh plants at the North Site are colonizing virtually all of the area suitable for marsh colonization (above +5.5 feet MLLW and not covered by gravel). At the South Site, only a small portion of the area between elevations +5.5 feet MLLW and +8 feet MLLW is colonized by marsh plants. As discussed in Section 5.2.2.2, it is not unexpected that marsh plants would not thrive in this elevation range. Above +8 feet MLLW at the South Site, about 63% of the area is colonized by marsh plants. Although this percentage cover is greater than the success criterion of 50%, it is significantly lower than the marsh cover at the North Site at these elevations (86.7%), which likely reflects the difference in suitability of the habitat between the two Sites.

The South Site overall is more exposed to wind and boat traffic and exhibits signs of river scour and sediment transport in the +6 to +8 feet MLLW range. These conditions have likely contributed to loss of some vegetation in this range. Sediment transport along the shallower grades reduces suitable habitat for marsh plants to root within and anchor to. In addition, marsh plants such as the dwarf spikerush have relatively shallow roots and are dormant in the winter months when river levels rise and greater scour events occur. Scour appears more focused or noticeable in the southern portions of the South Site where the bank grades are steeper. However, it is likely that the Sites are being used by juvenile salmonids and other fish species, which demonstrates that the Sites are providing valuable ecosystem functions and benefiting trust resources.

8.0 References

AMEC Environment & Infrastructure, Inc.; Dalton, Olmsted & Fuglevand, Inc.; and Floyd|Snider, Inc. (AMEC et al.). 2012a. Maintenance and Monitoring Plan, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

———. 2012b. Habitat Parameter Identification Review, Appendix E in Final Habitat Design Report, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

AMEC Environment & Infrastructure, Inc. (AMEC). 2014. Habitat Project Construction Completion Report, Duwamish Sediment Other Area and Southwest Bank Corrective Measure and Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler). 2016. Year 1 Habitat Monitoring Report, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

———. 2017. Year 2 Habitat Monitoring Report, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

———. 2018. Year 3 Habitat Monitoring Report, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

Amec Foster Wheeler Environment & Infrastructure, Inc.; Dalton, Olmsted & Fuglevand, Inc.; and Floyd|Snider, Inc. (Amec Foster Wheeler et al.). 2016. Corrective Measure Implementation Report, Duwamish Sediment Other Area and Southwest Bank Corrective Measure, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

Commencement Bay Natural Resource Trustees (CBNRT). 2000. Commencement Bay Natural Resource Damage Assessment Restoration Monitoring Plan. National Oceanic and Atmospheric Administration, U.S. Department of Interior, and the State of Washington, Seattle, Washington, http://beta.darp.aspensys.com/northwest/cbay/pdf/cb-mon1.pdf (accessed August 18, 2006).

King County Noxious Weed Control Program (King County). 2019. King County Noxious Weed List. King County, Department of Natural Resources and Parks, Water and Land Resources Division, Seattle, Washington, https://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/laws/list.aspx.

Puget Sound Estuary Program (PSEP). 1987. Recommended Protocols for Sampling and Analyzing Subtidal Benthic Macroinvertebrate Assemblages in Puget Sound. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington, and Puget Sound Water Quality Authority, Olympia, Washington.

U.S. Fish and Wildlife Service (USFWS). 2000. Elliott Bay/Duwamish Restoration Program: Intertidal Habitat Projects Monitoring Program. Prepared for the Elliott Bay/Duwamish Restoration Program Panel by USFWS, Western Washington Fish and Wildlife Office, Lacey, Washington.

Wood Environment & Infrastructure Solutions, Inc. (Wood). 2019. Year 4 Habitat Monitoring Report, Habitat Project, Boeing Plant 2, Seattle/Tukwila, Washington. Prepared for The Boeing Company, Seattle, Washington.

Tables

TABLE 1

MONITORING FREQUENCY FOR BOEING PLANT 2 RESTORATION PROJECTS [1]

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

	Component	Monitoring Year							
		Year 0 (2014)	Year 1 (2015)	Year 2 (2016)	Year 3 (2017)	Year 4 (2018)	Year 5 (2019)	Year 7 (2021)	Year 10 [2] (2024)
Physical Criteria	Intertidal Area [3] Intertidal Stability/Slope Erosion [3] Elevation/Channel Morphology [3]	x	x	x			x	x	x
	Tidal Circulation		x	x			x		
	Sediment/Soil Structure		x [4]						
	Site Salinity		x [4]						
Biological Criteria	Marsh Vegetation Areal Coverage [5]	x [6]	x	x	x		x	x	x
	Marsh Vegetation Survival/Species Composition [5]	x [6]	x	x	x		x	x	x
	Riparian Vegetation Areal Coverage	x [6]	x	x	x		x	x	x
	Riparian Vegetation Survival	x [6]	x	x	x	x			
	Marsh and Riparian Vegetation Herbivory Control [7]		x	x	x	x	x		
Additional Monitoring Requirements	Fish Presence			x	x	x [8]	x	x	x
	Invertebrate Prey Resources		x	x	x		x	x	x
	Fallout Insect Production [9]							x	x

Note(s)

1. This table has been revised from previous years monitoring reports due to typographical error in previous reports (riparian vegetation survival and areal coverage schedules had been switched). The monitoring schedule presented herein corresponds to that presented in the Maintenance and Monitoring Plan (AMEC et al., 2012).
2. Monitoring may be conducted in Year 11 if additional contingency measures are implemented after Year 5.
3. Additional monitoring may be conducted following a peak flow event in excess of 13,200 cfs as recorded at the USGS Green River gage (12113000) near Auburn, Washington.
4. Sediment/soil structure monitoring was rescheduled during Year 1 with approval of Trustees.
5. Additional monitoring may be conducted if marsh communities show poor survival.
6. As-planted survey conducted following initial planting.
7. Herbivore control measures should be maintained for a minimum of 4 years following planting (or replanting) and monitored for 5 years.
8. Fish monitoring was not conducted in Year 1. Additional monitoring was conducted in Year 4 to provide a total of 6 years of monitoring. The monitoring was rescheduled with approval of Trustees.
9. Fallout insects will only be assessed after marsh and riparian communities have become well established.

Abbreviation(s)

cfs = cubic feet per second
USGS = U.S. Geological Survey

TABLE 2

SURVEYED AREAS WITHIN MARSH, RIPARIAN, AND INTERTIDAL ZONES

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

	Habitat Zones			
Project Areas	**Above +12 feet MLLW**	**+5.5 to +12 feet MLLW**	**+2 to +5.5 feet MLLW)**	**Total Area (ac) [1]**
Planned Habitat Areas From Consent Decree [2]				
Total (ac)	1.5	2.5	0.8	4.8
Constructed Habitat Based on As-Built Elevations Contours [3]				
North Site	0.57	1.45	0.39	2.40
South Site	0.95	1.19	0.69	2.83
Total (ac)	1.52	2.64	1.08	5.23
Year 1 Habitat Areas (2015)				
North Site	0.56	1.41	0.47	2.44
South Site	0.95	1.19	0.86	3.00
Total (ac)	1.51	2.60	1.32	5.43
Change in Area from Constructed Habitat by Year 1 (2015)				
North Site	-0.01	-0.04	0.08	0.03
South Site	0.00	0.00	0.16	0.17
Total (ac)	-0.01	-0.04	0.25	0.20
Year 2 Habitat Areas (August 2016) [4]				
North Site	0.56	1.61	0.41	2.58
South Site	0.96	1.21	0.89	3.06
Total (ac)	1.52	2.83	1.30	5.64
Change in Area from Constructed Habitat by Year 2 (August 2016)				
North Site	-0.01	0.17	0.02	0.18
South Site	0.01	0.02	0.20	0.23
Total (ac)	0.00	0.19	0.22	0.41
Year 5 Habitat Areas (July 2019)				
North Site	0.59	1.59	0.41	2.58
South Site	0.97	1.27	0.91	3.15
Total (ac)	1.55	2.86	1.31	5.73
Change in Area from Year 2 (2016) to Year 5 (July 2019)				
North Site	0.03	-0.03	0.00	0.00
South Site	0.01	0.06	0.02	0.09
Total (ac)	0.03	0.03	0.02	0.09
Areas Measured in 2019 as Percentage of Constructed Habitat				
Total (ac)	103%	108%	122%	110%

Note(s)

1. Sums of individual values may not match totals presented due to rounding of significant figures.
2. Habitat areas from Section 3.0 of Appendix A of the Consent Decree. Boeing committed to create at least 90% of the areas identified in the Consent Decree, or a lesser amount if otherwise approved by the Trustees.
3. Construction of the shoreline bank below about elevation +5.0 feet MLLW had not been completed at the time the areas were calculated. The habitat area between +2.0 and +5.5 feet MLLW was estimated based on the constructed +5.5-foot MLLW contour and the design +2-foot MLLW contour. The actual area between +2.0 and +5.5 feet MLLW was reassessed during Year 1 monitoring after dredging and backfilling were completed.
4. The area between +12 feet MLLW and +5.5 feet MLLW at the North Site was measured after stabilization of the outer areas of the peninsula with a rounded gravel mix. Placement of up to 3+ feet of material increased the area within the +12 feet MLLW and +5.5 feet MLLW habitat zone. Slight changes in elevation resulted in a significant increase in the area between +5.5 feet MLLW and +2 feet MLLW at the South Site due to a shallow gradient in this area.

Abbreviation(s)
ac = acres
MLLW = mean lower low water

TABLE 3

RIPARIAN AND MARSH SPECIES OBSERVED ON SITE

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Common Name	Scientific Name	Planted Species	Volunteer Species	Riparian (R) or Marsh (M)	Growth Form
Bigleaf maple	*Acer macrophyllum*	X		R	*Tree*
Red alder	*Alnus rubra*	X	X	R	*Tree*
Pearly everlasting	*Anaphalis margaritacea*		X	R	*Herb*
Madrone	*Arbutus menziesii*		X	R	*Tree*
Douglas aster	*Aster subspicatus*	X		M	*Herb*
Orache	*Atriplex patula*		X	M	*Herb*
Paper birch	*Betula papyrifera*		S	R	*Tree*
Butterfly bush	*Buddleja davidii*		X	R	*Shrub, Noxious*
Lyngbye's sedge	*Carex lyngbyei*	X		M	*Graminoid*
Sedge (unknown)	*Carex sp.*		X	R	*Graminoid*
Centaury	*Centaurium erythraea*		X	R	*Herb, Non-native*
Bull thistle	*Cirsium vulgare*		X	R	*Herb, Noxious*
Red-osier dogwood	*Cornus sericea*	X		R	*Shrub*
Western hazelnut	*Corylus cornuta*	X		R	*Shrub*
Cotoneaster	*Contoneaster sp.*		X	R	*Shrub*
Black hawthorn	*Crataegus douglasii*	X		R	*Tree*
Scotch broom	*Cytisus scoparius*		X	R	*Shrub, Noxious*
Wild carrot	*Daucus carota*		X	M	*Herb, Noxious*
Tufted hairgrass	*Deschampsia cespitosa*	X		M	*Graminoid*
Common spikerush	*Eleocharis palustrus*		X	M	*Graminoid*
Dwarf spikerush	*Eleocharis parvula*		X	M	*Graminoid*
Willowherb	*Epilobium sp.*		X	R	*Herb*
Redstem stork's bill	*Erodium cicutarium*		X	R	*Herb*
Oregon ash	*Fraxinus latifolia*	X		R	*Tree*
Bedstraw	*Galium sp.*		X	R	*Herb*
Gumweed	*Grindela integrifolia*	X	X	R	*Herb*
Oceanspray	*Holodiscus discolor*	X		R	*Shrub*
Common St. Johnswort	*Hypericum perforatum*		X	R	*Herb, Non-native*
Yellow-flag iris	*Iris pseudacorus*		X	M	*Herb, Noxious*
Rush (unknown)	*Juncus sp.*		X	R	*Graminoid*
Prickly lettuce	*Lactuca serriola*		X	R	*Herb, Non-native*
Grasswort	*Lilaeopsis sp.*		X	M	*Graminoid*
Twinberry	*Lonicera involucrata*	X		R	*Shrub*
Bird's-foot trefoil	*Lotus corniculatus*		X	R	*Herb, Non-native*
Tall Oregon grape	*Mahonia aquifolium*	X		R	*Shrub*
Mint	*Mentha arvensis*		X	R	*Herb*
Sweet gale	*Myrica gale*		X	R	*Shrub*
Reed canarygrass	*Phalaris arundinacea*		X	R, M	*Graminoid, Noxious*
Pacific ninebark	*Physocarpus capitatus*		X	R	*Shrub*
Sitka spruce	*Picea sitchensis*	X		R	*Tree*
Shorepine	*Pinus contorta contorta*		X	R	*Tree*
Black cottonwood	*Populus trichocarpa*	X	X	R	*Tree*
Pacific silverweed	*Potentilla anserina*	X		M	*Herb*
Bitter cherry	*Prunus emarginata*	X		R	*Tree*
Douglas-fir	*Pseudotsuga menziesii*	X		R	*Tree*
Bald-hip rose	*Rosa gymnocarpa*	X		R	*Shrub*
Himalayan Blackberry	*Rubus armeniacus*		X	R	*Shrub, Noxious*
Western dock	*Rumex occidentalis*		X	R	*Herb*

TABLE 3

RIPARIAN AND MARSH SPECIES OBSERVED ON SITE

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Common Name	Scientific Name	Planted Species	Volunteer Species	Riparian (R) or Marsh (M)	Growth Form
Hooker's willow	*Salix hookeriana*	X		R	*Shrub*
Pacific willow	*Salix lasiandra*	X		R	*Shrub*
Sitka willow	*Salix sitchensis*	X		R	*Shrub*
Hardstem bulrush	*Schoenoplectus acutus*		X	M	*Graminoid*
American bulrush	*Schoenoplectus americanus*	X		M	*Graminoid*
Softstem bulrush	*Schoenoplectus tabernaemontani*	X		M	*Graminoid*
Seacoast bulrush	*Scirpus maritimus*	X		M	*Graminoid*
Tansy ragwort	*Senecio jacobaea*		X	R	*Herb, Noxious*
Snowberry	*Symphoricarpos albus*	X		R	*Shrub*
Clover (unknown)	*Trifolium sp.*		X	R	*Herb, Non-native*
Vetch (unknown)	*Vicia sp.*		X	R	*Herb, Non-native*

Note: Plant nomenclature from USDA PLANTS database (https://plants.sc.egov.usda.gov; last accessed 2/21/2020).

TABLE 4

ESTIMATED AREAL COVERAGE OF MARSH AND RIPARIAN VEGETATION — YEAR 0 THROUGH YEAR 5 MONITORING [1,2]

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

	North Site							South Site							Total						
	Year 0 (2014 as-builts)	**Year 1 (2015)**	**Year 2 (2016)**	**Year 3 (2017)**	**Year 5 (2019)**	**Year 3 to Year 5 Increase (Loss)**	**Year 3 to Year 5 Percent Change (%)**	**Year 0 (2014 as-builts)**	**Year 1 (2015)**	**Year 2 (2016)**	**Year 3 (2017)**	**Year 5 (2019)**	**Year 3 to Year 5 Increase (Loss)**	**Year 3 to Year 5 Percent Change (%)**	**Year 0 (2014 as-builts)**	**Year 1 (2015)**	**Year 2 (2016)**	**Year 3 (2017)**	**Year 5 (2019)**	**Year 3 to Year 5 Increase (Loss)**	**Year 3 to Year 5 Percent Change (%)**
Marsh (acres with vegetation below +12 feet MLLW)	1.45	0.93	1.00	1.09	1.09	0.00	0%	1.19	0.86	1.03	1.24	0.92	(0.32)	-26%	2.64	1.79	2.03	2.33	2.01	(0.32)	-14%
Riparian (acres with trees and shrubs above +12 feet MLLW) [3]	0.57	0.58	0.56	0.56	0.65	0.09	16%	0.95	1.02	1.04	1.04	1.04	0.00	0%	1.52	1.60	1.60	1.60	1.69	0.09	6%

Note(s)

1. Monitoring was conducted during the growing season in June 2015 for Year 1, June-July 2016 for Year 2, August 2017 for Year 3, and August 2019 for Year 5.
2. Estimated area is provided in acres.
3. The area with riparian cover stabilized by 2017. Active measures (pruning and removal) have been conducted to limit or prevent the spread of volunteer trees and shrubs into the landscaping of the surrounding facility.

Abbreviation(s)

MLLW = mean lower low water

TABLE 5

MARSH ZONE — PERCENT COVER ESTIMATES

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Marsh Zone		North & South Sites Average Daubenmire (% cover)			North Site Daubenmire (% cover)			South Site Daubenmire (% cover)			North & South Sites Average Line Intercept (% cover)	North Site Line Intercept (% cover)	South Site Line Intercept (% cover)
		Both Sites Overall [1]	+5.5 to +8 ft MLLW	+8 to +12 ft MLLW	Site Overall	+5.5 to +8 ft MLLW	+8 to +12 ft MLLW	Site Overall	+5.5 to +8 ft MLLW	+8 to +12 ft MLLW	Both Sites Overall [1]	Site Overall	Site Overall
Marsh (Planted and Volunteer)		54.7	23.4	75.6	69.1	42.8	86.7	37.7	0.5	62.5	69.2	75.9	61.3
Clonal Dominants [2]		38.4	23.4	48.4	46.2	42.8	48.5	29.1	0.5	48.2	n/a	n/a	n/a
Planted Marsh Species		32.5	5.3	50.6	36.1	9.8	53.7	28.2	0	47.0	n/a	n/a	n/a
Douglas aster	*Aster subspicatus*	2.1	0	3.4	3.3	0	5.5	0.6	0	1.0			
Lyngbye's sedge	*Carex lyngbyei*	7.6	0	12.6	6.1	0	10.2	9.3	0	15.5			
Tufted hairgrass	*Deschampsia cespitosa*	0.9	0	1.5	1.2	0	2.0	0.6	0	1.0			
Pacific silverweed	*Potentilla anserina*	8.9	0	14.9	13.7	0	22.8	3.3	0	5.5			
Seacoast bulrush	*Scirpus maritimus*	13.0	5.3	18.1	11.8	9.8	13.2	14.4	0	24.0			
Volunteer Plants		22.2	18.1	25.0	33.0	33.0	33.0	9.5	0.5	15.5	n/a	n/a	n/a
Dwarf spikerush	*Eleocharis parvula*	8.8	10.4	7.8	14.1	19.0	10.8	2.6	0.3	4.2			
Rush (unknown)	*Juncus* sp.	0.3	0	0.5	0.6	0	1.0	0	0	0			
Grasswort	*Lilaeopsis* sp.	9.0	7.7	9.8	14.2	14.0	14.3	2.8	0.3	4.5			
Softstem bulrush	*Schoenoplectus tabernaemontani*	3.4	0	5.7	3.4	0	5.7	3.4	0	5.7			
Orache	*Atriplex patula*	0.3	0	0.5	0	0	0	0.6	0	1.0			
Western dock	*Rumex occidentalis*	0.4	0	0.6	0.6	0	1.0	0.1	0	0.2			
Willowherb	*Epilobium* sp.	0.1	0	0.1	0.1	0	0.2	0.0	0	0			
Non-native		0.7	0	1.1	0	0	0	1.5	0	2.5	0.9	0	2.0
Bird's-foot trefoil	*Lotus corniculatus*	0.7	0	1.1	0	0	0	1.5	0	2.5			
Invasive		0	0	0.1	0	0	0	0.1	0	0.2	0	0	0
Reed canarygrass	*Phalaris arundinacea*	0	0	0.1	0	0	0	0.1	0	0.2			

Note(s)

1. The values presented for both sites overall is a weighted average based on the proportional area (acres) of each site.
2. Species considered as clonal dominants include Lyngbye's sedge, seacoast bulrush, dwarf and common spikerush, and grasswort.

TABLE 6

RIPARIAN ZONE — PERCENT COVER ESTIMATES

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Riparian Zone		North & South Sites Average Daubenmire (% cover) [1]	North Site Daubenmire (% cover)	South Site Daubenmire (% cover)	North & South Sites Average Line Intercept (% cover) [1]	North Site Line Intercept (% cover)	South Site Line Intercept (% cover)
Riparian Cover (includes trees, shrubs, and herbaceous)		94.5	125.0	75.4	171.9	190.8	160.1
Tree cover		27.6	42.1	18.5	48.3	57.9	42.3
Red alder	*Alnus rubra*	13.8	26.5	5.9			
Bigleaf maple	*Acer macrophyllum*	0.0	0.1	0			
Oregon ash	*Fraxinus latifolia*	0.4	0	0.6			
Black cottonwood	*Populus trichocarpa*	10.4	8.8	11.4			
Birch	*Betula papyrifera*	1.2	3.1	0			
Black hawthorne	*Crataegus douglasii*	0.4	0	0.6			
Douglas-fir	*Pseudotsuga menziesii*	0.8	2.1	0			
Sitka spruce	*Picea sitchensis*	0.6	1.5	0			
Shrub cover		15.1	9.6	18.6	33.7	32.9	34.2
Tall Oregon Grape	*Mahonia aquifolium*	1.2	2.1	0.6			
Cotoneaster	*Cotoneaster sp.*	0.0	1.2	0			
Red-osier dogwood	*Cornus sericea*	0.6	0.6	0.6			
Oceanspray	*Holodiscus discolor*	0.5	1.2	0			
Twinberry	*Lonicera involucrata*	2.1	3	1.5			
Bald-hip rose	*Rosa gymnocarpa*	3.3	1.5	4.5			
Pacific willow	*Salix lasiandra*	1.5	0	2.5			
Sitka willow	*Salix sitchensis*	0.0	0	0			
Snowberry	*Symphoricarpos albus*	5.5	0	8.9			
Herbaceous cover (includes volunteers)		51.8	73.3	38.3	89.9	100	83.6
Grass Mix		30.5	44.4	21.8			
Volunteer Plants		21.3	28.9	16.5	n/a	n/a	n/a
Douglas aster	*Aster subspicatus*	9.7	16.1	5.7			
Pacific silverweed	*Potentilla anserina*	0.4	0	0.6			
Juncus (unknown)	*Juncus* sp.	2.3	3.8	1.3			
Tufted hairgrass	*Deschampsia cespitosa*	4.1	3	4.8			
Asteraceae (unknown)		0.2	0.6	0			
Orache	*Atriplex patula*	1.7	1.5	1.8			
Bedstraw (unknown)	*Galium* sp.	0.1	0	0.1			
Redstem stork's bill	*Erodium cicutarium*	0.2	0.6	0			
Sedge (unknown)	*Carex* sp.	0.1	0	0.1			
Pearly everlasting	*Anaphalis margaritacea*	1.3	3.3	0			
Willowherb	*Epilobium* sp.	1.3	0	2.1			
Non-native		15.6	13.7	16.8	20.1	17.1	21.9
Bird's-foot trefoil	*Lotus corniculatus*	11.9	10.6	12.7			
Clover (unknown)	*Trifolium* sp.	0.1	0	0.1			
Prickly lettuce	*Lactuca serriola*	0.5	1.3	0			
Vetch (unknown)	*Vicia sp.*	0.7	1.8	0			
Common St. Johnswort	*Hypericum perforatum*	2.5	0	4			
Invasive		0.4	0.6	0.3	5.3	3.7	6.3
Himalayan blackberry	*Rubus armeniacus*	0.4	0.6	0.3			
Yellow-flag iris	*Iris pseudacorus*	0	0	0			
Bare Ground		23.4	7.9	33.1	n/a	n/a	n/a

Note
1. The values presented for both sites overall is a weighted average based on the proportional area (acres) of each site.

TABLE 6

RIPARIAN ZONE — PERCENT COVER ESTIMATES

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Riparian Zone		North & South Sites Average Daubenmire (% cover) [1]	North Site Daubenmire (% cover)	South Site Daubenmire (% cover)	North & South Sites Average Line Intercept (% cover) [1]	North Site Line Intercept (% cover)	South Site Line Intercept (% cover)
Riparian Cover (includes trees, shrubs, and herbaceous)		94.5	125.0	75.4	171.9	190.8	160.1
Tree cover		27.6	42.1	18.5	48.3	57.9	42.3
Red alder	*Alnus rubra*	13.8	26.5	5.9			
Bigleaf maple	*Acer macrophyllum*	0.0	0.1	0			
Oregon ash	*Fraxinus latifolia*	0.4	0	0.6			
Black cottonwood	*Populus trichocarpa*	10.4	8.8	11.4			
Birch	*Betula papyrifera*	1.2	3.1	0			
Black hawthorne	*Crataegus douglasii*	0.4	0	0.6			
Douglas-fir	*Pseudotsuga menziesii*	0.8	2.1	0			
Sitka spruce	*Picea sitchensis*	0.6	1.5	0			
Shrub cover		15.1	9.6	18.6	33.7	32.9	34.2
Tall Oregon Grape	*Mahonia aquifolium*	1.2	2.1	0.6			
Cotoneaster	*Cotoneaster sp.*	0.0	1.2	0			
Red-osier dogwood	*Cornus sericea*	0.6	0.6	0.6			
Oceanspray	*Holodiscus discolor*	0.5	1.2	0			
Twinberry	*Lonicera involucrata*	2.1	3	1.5			
Bald-hip rose	*Rosa gymnocarpa*	3.3	1.5	4.5			
Pacific willow	*Salix lasiandra*	1.5	0	2.5			
Sitka willow	*Salix sitchensis*	0.0	0	0			
Snowberry	*Symphoricarpos albus*	5.5	0	8.9			
Herbaceous cover (includes volunteers)		51.8	73.3	38.3	89.9	100	83.6
Grass Mix		30.5	44.4	21.8			
Volunteer Plants		21.3	28.9	16.5	n/a	n/a	n/a
Douglas aster	*Aster subspicatus*	9.7	16.1	5.7			
Pacific silverweed	*Potentilla anserina*	0.4	0	0.6			
Juncus (unknown)	*Juncus* sp.	2.3	3.8	1.3			
Tufted hairgrass	*Deschampsia cespitosa*	4.1	3	4.8			
Asteraceae (unknown)		0.2	0.6	0			
Orache	*Atriplex patula*	1.7	1.5	1.8			
Bedstraw (unknown)	*Galium* sp.	0.1	0	0.1			
Redstem stork's bill	*Erodium cicutarium*	0.2	0.6	0			
Sedge (unknown)	*Carex* sp.	0.1	0	0.1			
Pearly everlasting	*Anaphalis margaritacea*	1.3	3.3	0			
Willowherb	*Epilobium* sp.	1.3	0	2.1			
Non-native		15.6	13.7	16.8	20.1	17.1	21.9
Bird's-foot trefoil	*Lotus corniculatus*	11.9	10.6	12.7			
Clover (unknown)	*Trifolium* sp.	0.1	0	0.1			
Prickly lettuce	*Lactuca serriola*	0.5	1.3	0			
Vetch (unknown)	*Vicia sp.*	0.7	1.8	0			
Common St. Johnswort	*Hypericum perforatum*	2.5	0	4			
Invasive		0.4	0.6	0.3	5.3	3.7	6.3
Himalayan blackberry	*Rubus armeniacus*	0.4	0.6	0.3			
Yellow-flag iris	*Iris pseudacorus*	0	0	0			
Bare Ground		23.4	7.9	33.1	n/a	n/a	n/a

Note
1. The values presented for both sites overall is a weighted average based on the proportional area (acres) of each site

TABLE 7

FISH MONITORING — YEAR 5 [1]

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Species	Sampling Event	March 28, 2019				May 7, 2019				June 5, 2019			
		Count	Minimum Length (mm)[2]	Maximum Length (mm)[2]	Average Length (mm)[2]	Count	Minimum Length (mm)[2]	Maximum Length (mm)[2]	Average Length (mm)[2]	Count	Minimum Length (mm)[2]	Maximum Length (mm)[2]	Average Length (mm)[2]
Salmonidae													
Chum	*Oncorhynchus keta*	98	34	43	38.8	126	38	60	45.3	1	52	52	52.0
Chum (not measured)		922				912							
Chum (total by event)		1020				1038				1			
Pink	*Oncorhynchus gorbuscha*												
Pink (not measured)													
Pink (total by event)													
Chinook (clipped)	*Oncorhynchus tshawytscha*												
Chinook (clipped not measured)													
Chinook (not clipped)						2	50	50	50.0	2	62	72	67.0
Chinook (not clipped, not measured)													
Chinook (clip not recorded)													
Chinook (total by event)						2				2			
Coho (not clipped)	*Oncorhynchus kisutch*												
Cutthroat	*Oncorhynchus clarkii*												
Steelhead (clipped)	*Oncorhynchus mykiss*												
Steelhead (not clipped)													
Steelhead (total by event)													
Mountain whitefish	*Prosopium williamsoni*												
Pleuronectidae													
Starry flounder	*Platichthys stellatus*					4	86	189	143.5	31	24	135	48.0
Gasterosteidae													
Three-spine stickleback	*Gasterosteus aculeatus*	6	32	35	33.5	9	40	60	49.9	6	28	70	47.7
Embiotocidae													
Shiner perch	*Cymatogaster*					1	105	105	105.0	511	75 [3]	140 [3]	105.9 [3]
Cottidae													
Staghorn sculpin	*Leptocottus armatus*	4	37	51	42.3	59	12	129	36.0	112	20	136	47.1
Stichaeidae													
Snake Prickleback	*Lumpenus sagitta*					2	35	38	36.5				
Cyprinidae													
Speckled dace	*Rhinichthys osculus*	1	56	56	56.0								
Cyprinidae (unidentified)													
Total Fish		**1031**				**1115**				**663**			

Note(s)

1. Monitoring conducted during spring outmigration using a fyke net at the North Site embayment. Sampling conducted on a falling tide.
2. Measurements are for fork length (in millimeters).
3. Minimum, maximum, and average fork length (in millimeters) based on measurement of 99 fish.

Abbreviation(s)

mm = millimeters

TABLE 8

TOTAL FISH ABUNDANCE BY MONTH FOR YEAR 2, YEAR 3, YEAR 4, AND YEAR 5 [1]

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Species	Sampling Year	Year 2 – 2016			Year 3 – 2017			Year 4 – 2018			Year 5 - 2019		
	Event	March Count	April Count	June Count	March Count	April Count	June Count	March Count	April Count	June Count	March Count	May Count	June Count
Salmonidae													
Chum	*Oncorhynchus keta*	78	46		1,606	7,208	68	681	173	7	1,020	1,038	1
Pink	*Oncorhynchus gorbuscha*	12			3			936	170				
Chinook	*Oncorhynchus tshawytscha*		260			67	190		12	164		2	2
Coho	*Oncorhynchus kisutch*		1										
Cutthroat	*Oncorhynchus clarkii*								1				
Steelhead	*Oncorhynchus mykiss*		35										
Mountain whitefish	*Prosopium williamsoni*	3			8								
Pleuronectidae													
Starry flounder	*Platichthys stellatus*	4	4	101	3		21	4	1	47		4	31
Gasterosteidae													
Three-spine stickleback	*Gasterosteus aculeatus*	15	1	57	6	3	60	11	11	173	6	9	6
Embiotocidae													
Shiner perch	*Cymatogaster aggregate*	2	401	1,017			80			1,937		1	511
Cottidae													
Staghorn sculpin	*Leptocottus armatus*	25	1	240		2	413	10	13	218	4	59	112
Stichaeidae													
Snake prickleback	*Lumpenus sagitta*									7		2	
Cyprinidae													
Speckled dace	*Rhinichthys osculus*	18	1				1				1		
Cyprinidae (unidentified)									1				
Total Fish		**157**	**750**	**1,415**	**1,626**	**7,280**	**833**	**1,642**	**382**	**2,553**	**1,031**	**1,115**	**663**

Note(s)

1. Monitoring conducted during spring outmigration using a fyke net at the North Site embayment. Sampling conducted on a falling tide.

TABLE 9

AVERAGE INVERTEBRATE PREY RESOURCES PER CORE IN YEAR 5

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

	North Site						South Site					
	+4 feet MLLW		+7 feet MLLW		+11 feet MLLW		+4 feet MLLW		+7 feet MLLW		+11 feet MLLW	
Benthic Taxon [1]	**Average Count Per Core [2]**	**SD**	**Average Count Per Core [2]**	**SD**	**Average Count Per Core [2]**	**SD**	**Average Count Per Core [2]**	**SD**	**Average Count Per Core [2]**	**SD**	**Average Count Per Core [2]**	**SD**
Nematoda												
Nematoda (unidentified)	0	± 0	0.2	± 0.4	0	± 0	0	± 0	0	± 0	0	± 0
Oligochaeta												
Enchytraeidae	2	± 4	52.2	± 24.59	18.6	± 26.8	0	± 0	1	± 1.55	5.2	± 3.19
Paranais birsteini	0.2	± 0.4	6.2	± 6.79	0.6	± 0.8	0	± 0	0	± 0	0	± 0
Lumbricina	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0.2	± 0.4
Lumbriculidae	0	± 0	0.4	± 0.8	0	± 0	0	± 0	0.2	± 0.4	0	± 0
Polychaeta												
Hobsonia florida	2.6	± 3.72	0.2	± 0.4	0	± 0	0	± 0	0	± 0	0	± 0
Manayunkia aestuarina	0	± 0	1.4	± 1.74	0	± 0	0	± 0	0	± 0	0	± 0
Manayunkia speciosa	0	± 0	40.8	± 30.71	0	± 0	0	± 0	0	± 0	0	± 0
Neanthes limnicola	6.6	± 2.33	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Gastropoda												
Potamopyrgus antipodarum	0	± 0	2.2	± 2.99	0.2	± 0.4	0	± 0	0.2	± 0.4	0	± 0
Truncatelloidea	0	± 0	1.6	± 2.73	0.4	± 0.8	0	± 0	0	± 0	0	± 0
Crustacea												
Americorophium salmonis	5.4	± 10.31	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Americorophium spinicorne	0.2	± 0.4	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0
Arachnida												
Tyrrellia sp.	0	± 0	0.2	± 0.4	0	± 0	0	± 0	0	± 0	0	± 0
Diptera-Chironomidae												
Hydrosmittia sp.	0	± 0	0	± 0	0.4	± 0.49	0	± 0	0	± 0	0.2	± 0.4
Diptera - Other												
Ceratopogonidae	0	± 0	1	± 1.26	0	± 0	0	± 0	0	± 0	0	± 0
Dasyhelea sp.	0	± 0	0.4	± 0.8	0.2	± 0.4	0	± 0	0	± 0	0	± 0
Diptera	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0.2	± 0.4
Dolichopodidae	0	± 0	2.6	± 1.74	0.6	± 0.8	0	± 0	0.2	± 0.4	0.2	± 0.4
Gonomyia sp.	0	± 0	0	± 0	0.8	± 1.6	0	± 0	0	± 0	0	± 0
Muscidae	0	± 0	0.2	± 0.4	0	± 0	0	± 0	0	± 0	0	± 0
Ormosia sp.	0	± 0	1	± 1.26	1	± 1.55	0	± 0	0	± 0	0.2	± 0.4
Tipula sp.	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0.4	± 0.49
Tipulidae	0	± 0	0	± 0	1	± 1.1	0	± 0	0	± 0	0	± 0
Coleoptera												
Optioservus sp.	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0.2	± 0.4
Ordobrevia nubifera	0	± 0	0	± 0	0	± 0	0	± 0	0	± 0	0.2	± 0.4
Total Abundance (average per core)	17	± 11.68	110.6	± 46.01	23.8	± 26.29	0	± 0	1.6	± 1.36	7	± 1.67
Richness (Total Unique Taxa) (average per core)	2.8	± 1.17	6.4	± 1.62	3.6	± 1.5	0	± 0	1.25	± 0.43	2.6	± 1.36

Note(s)

1. Standardized benthic data with pelagic and terrestrial taxa omitted. "Total Unique Taxa" are those that were the most highly resolved within their family. Less-resolved or ambiguous taxa are excluded to limit possible duplication in calculating taxa richness. For instance, a family level identification within a sample that also includes genus level identifications from the same family would not be counted as a "unique taxon."
2. Average count per core (0.0314 m^2) based on five cores collected per station along a 50-foot transect.

Abbreviation(s)

MLLW = mean lower low water
m^2 = square meters
SD = standard deviation

TABLE 10

TOTAL INVERTEBRATE PREY ABUNDANCES BY TRANSECT FOR YEAR 1, YEAR 2, YEAR 3, AND YEAR 5

Year 5 Habitat Monitoring Report

Habitat Project, Boeing Plant 2

Seattle/Tukwila, Washington

		North Site			South Site			
		+4 feet MLLW	+7 feet MLLW	+11 feet MLLW	+4 feet MLLW	+7 feet MLLW	+11 feet MLLW	Average Abundance per Sample
Major Benthic Taxonomic Groups [1]	Sample Year	Total Count per Station [2]	Total Count per Station	Total Count per Station	Total Count per Station	Total Count per Station	Total Count per Station	
Nematoda	Year 1	11	6			12		1.0
	Year 2				1			0.03
	Year 3							0.00
	Year 5		1					0.03
Oligochaeta	Year 1	679	522	64	9	3436	345	168.5
	Year 2	41	66	110	90	99	39	14.8
	Year 3	16	1162	203	26	164	2	52.4
	Year 5	11	294	96		6	27	14.5
Polychaeta	Year 1							0.0
	Year 2	1	3					0.1
	Year 3	56	9					2.2
	Year 5	46	212					8.6
Molluscs (Gastropods)	Year 1		1					0.03
	Year 2							0.0
	Year 3	3	31		2			1.2
	Year 5		19	3		1		0.8
Crustacea	Year 1	4			3	10		0.6
	Year 2	1			6			0.2
	Year 3	158				5	2	5.5
	Year 5	28						0.9
Arachnida	Year 1	4			3	9	6	0.7
	Year 2							0.0
	Year 3			1				0.03
	Year 5	0	1					0.03

TABLE 10

TOTAL INVERTEBRATE PREY ABUNDANCES BY TRANSECT FOR YEAR 1, YEAR 2, YEAR 3, AND YEAR 5

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

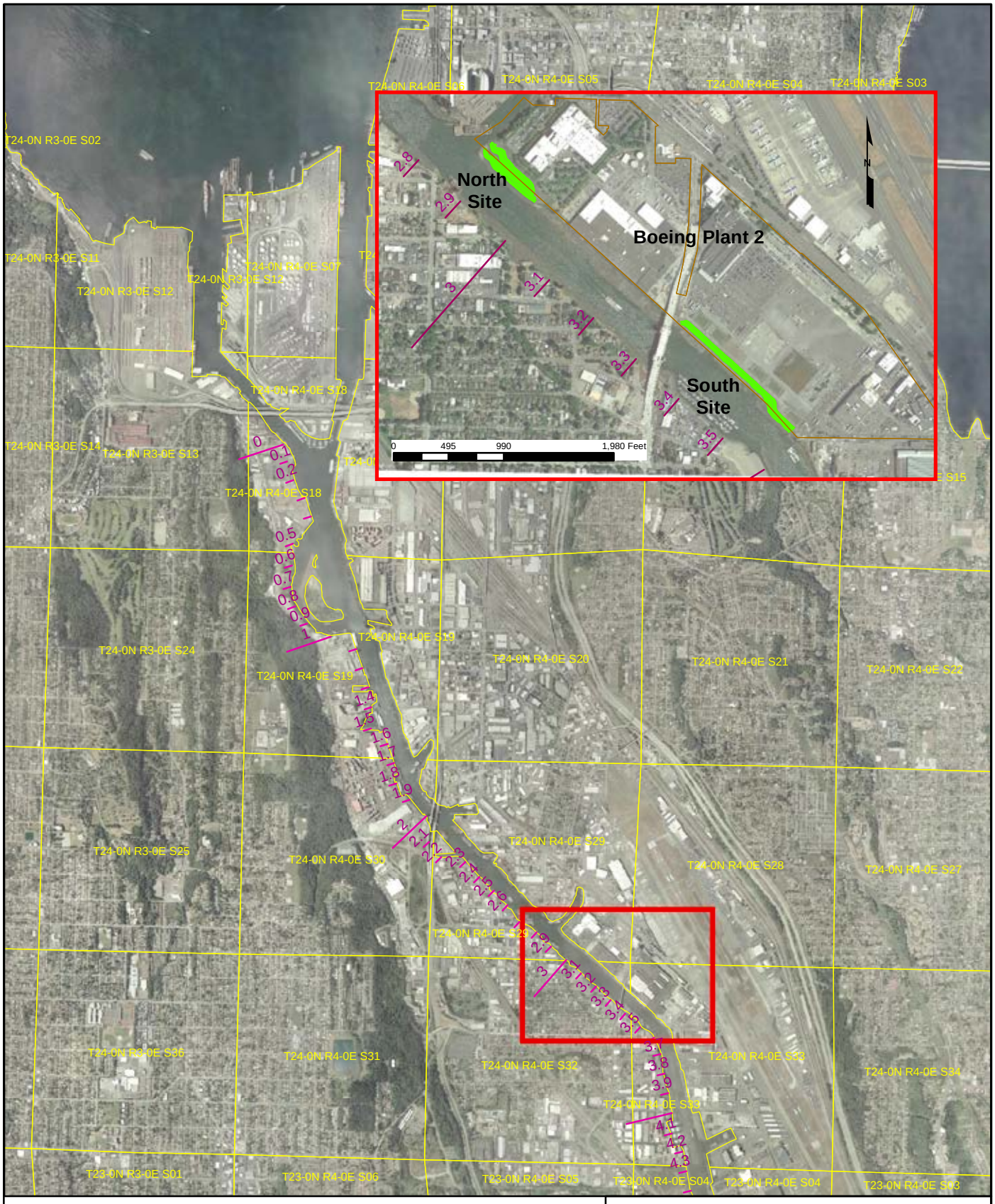
		North Site			South Site			
		+4 feet MLLW	+7 feet MLLW	+11 feet MLLW	+4 feet MLLW	+7 feet MLLW	+11 feet MLLW	Average Abundance per Sample
Major Benthic Taxonomic Groups [1]	Sample Year	Total Count per Station [2]	Total Count per Station	Total Count per Station	Total Count per Station	Total Count per Station	Total Count per Station	
Diptera (Chironomidae)	Year 1	1	1	1	3	18		0.8
	Year 2					2	1	0.1
	Year 3		42	21		12		2.5
	Year 5			2			1	0.1
Diptera (Other)	Year 1	6	104	10	1	38	14	5.8
	Year 2	5	2	3	6	13	3	1.07
	Year 3		235	18		4		8.6
	Year 5		26	18		1	5	1.7
Collembola	Year 1			4		1	65	2.3
	Year 2							0.0
	Year 3							0.0
	Year 5							0.0
Coleoptera	Year 1		1			1	3	0.2
	Year 2							0.0
	Year 3							0.0
	Year 5						2	0.1
Hemiptera	Year 1					2	1	0.1
	Year 2							0.0
	Year 3							0.0
	Year 5							0.0
Total Abundance	Year 1	705	638	79	19	3528	434	180.1
	Year 2	42	66	110	97	98	39	15.1
	Year 3	233	1479	243	28	185	4	72.4
	Year 5	85	553	119		8	35	26.7

Note(s)
1. Standardized benthic data with pelagic and terrestrial taxa omitted.
2. Total combined count for all five cores collected along a 50-foot transect for each station.

Abbreviation(s)
MLLW = mean lower low water

Figures

File Path: L:\BOEING\004 Shoreline Habitat\3000 Reports\Year_5_Habitat_Monitoring\Figures\Figure 1 Year 5 Vicinity.mxd



Street Address: 7755 East Marginal Way South
Seattle, Washington 98370

Aquatic System: Lower Duwamish Waterway
(River Mile 2.9 to 3.6)
USGS Hydrological Unit Code: 17110013

County: King County
Section: 28, 29, 32, 33
Township: 24N
Range: 4E

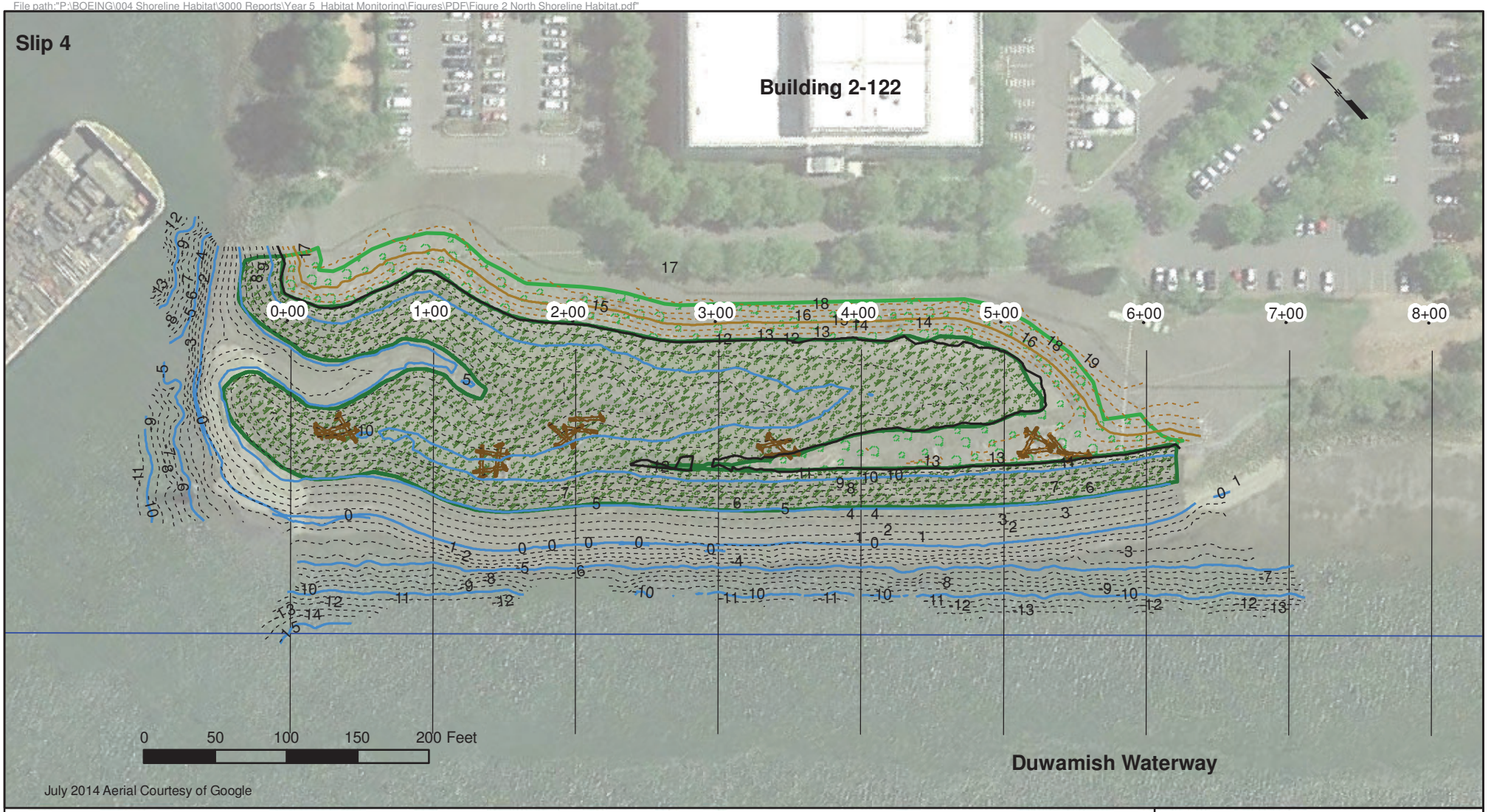
Tax Parcels: 0022000005, 0022000165, 0022000195, 2924049056, 2924049098, 2185000005, 2824049009, 3324049002, 2924049112, 001600020, 292404HYDR, and 322404HYDR

BOEING

VICINITY MAP
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date: 12/17/2019	Proj No. 01484400440
		Figure 1

File path:"P:\BOEING\004 Shoreline Habitat\3000 Reports\Year 5 Habitat Monitoring\Figures\PDF\Figure 2 North Shoreline Habitat.pdf"



Legend

- Riparian Plantings (Design)
- Marsh Plantings (Design)
- Installed Log Bundle

Elevation Contours

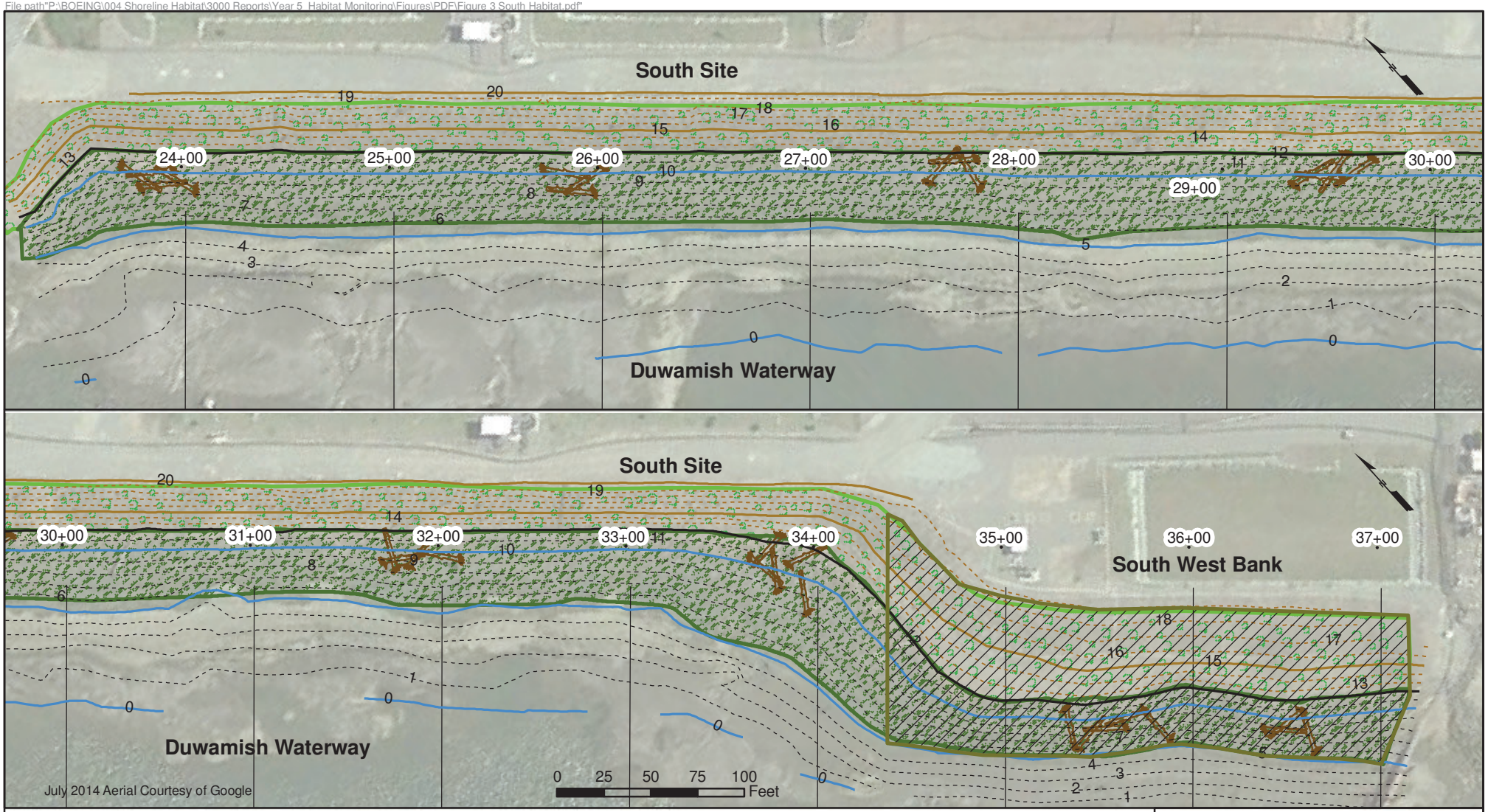
- Below +12 ft MLLW (contour interval 5 feet)
- Below +12 ft MLLW (contour interval 1 feet)
- Above +12 ft MLLW (contour interval 5 feet)
- Above +12 ft MLLW (contour interval 1 feet)
- Elevation datum: 0 = MLLW

BOEING

NORTH SITE HABITAT PROJECT
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date: 12/17/19	Project No. 0148440440
		Figure 2

File path"P:\BOEING\004 Shoreline Habitat\3000 Reports\Year 5 Habitat Monitoring\Figures\PDF\Figure 3 South Habitat.pdf"



Legend

- Riparian Plantings (Design)
- Marsh Plantings (Design)
- Area Replanted Following Southwest Bank Re-excavation and Outfall Repair in 2014
- Installed Log Bundle

Elevation Contours

- Below +12 ft MLLW (contour interval 5 feet)
- Below +12 ft MLLW (contour interval 1 feet)
- Above +12 ft MLLW (contour interval 5 feet)
- Above +12 ft MLLW (contour interval 1 feet)
- Elevation datum: 0 = MLLW

BOEING

SOUTH SITE HABITAT PROJECT
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date:12/17/2019	Project No. 0148440440
		Figure 3

File Path: L:\BOEING\004 Shoreline Habitat\3000 Reports\Year_5_Habitat_Monitoring\Figures\Figure 4 Habitat Monitoring Stations.mxd

Slip 4

North Site

MP037 MP039 MP038 MP040 MP047 MP041 MP043 MP046 MP042 MP044 MP035 MP045 MP036 MP029 MP031 MP033 MP030 MP034 MP032

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00

0 200 Feet

July 2014 Aerial Courtesy of Google

Overview

North Site

Boeing Plant 2

South Site

N

July 2014 Aerial Courtesy of Google

South Site

MP027 MP025 MP023 MP021 MP019 MP028 MP026 MP024 MP022 MP020 MP003 MP017 MP002 MP015 MP018 MP001 MP016

24+00 25+00 26+00 27+00 28+00 29+00 30+00 31+00 32+00 33+00 34+00 35+00 36+00 37+00

Duwamish Waterway

0 50 100 150 200 Feet

July 2014 Aerial Courtesy of Google

Elevation Contours (2019)

- +5.5 ft MLLW contour
- +8 ft MLLW contour
- +12 ft MLLW contour
- Elevation datum: 0 = MLLW

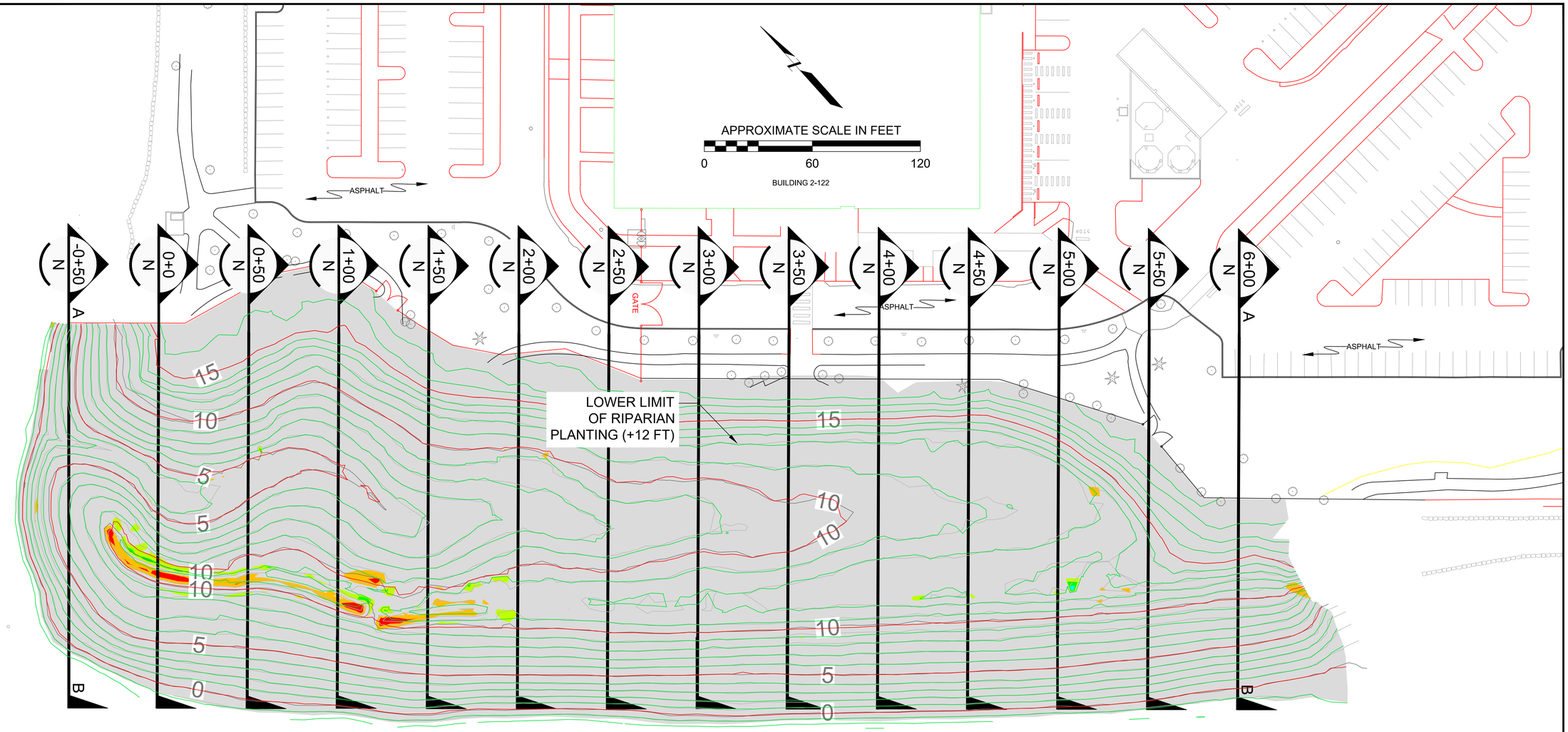
- Vegetation Survey Transects and Survey Points (Riparian and Marsh)
- Infauna Transects and Survey Points (5 10-cm x 10-cm cores)
- Installed Fish Net Piles
- Installed Log Bundle
- Captured (or New) Log

- MP037 — Monitoring Points Used to Established Transects
- Fyke Net Installation

MONITORING POINTS AND ESTABLISHED MONITORING TRANSECTS
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date: 01/16/2020	Project No. 0148440440
		Figure 4

BOEING



Elevation Datum: 0=MLLW

DIFFERENCE BETWEEN YEAR 2 ELEVATIONS (AUGUST 2016) AND YEAR 5 ELEVATIONS (JULY 2019)

- +2.4 to +2.0
- +2.0 to +1.5
- +1.5 to +1.0
- +1.0 to +0.5
- +0.5 to -0.5
- -0.5 to -1.0
- -1.0 to -1.5

EXPLANATION

10 — YEAR 2 CONDITION SURVEY ELEVATION CONTOURS (AUGUST 2016)

YEAR 5 CONDITION SURVEY ELEVATION CONTOURS (JULY 2019)

NOTES:

1. POSITIVE ISOPACH VALUES INDICATE NET ACCUMULATION OF SEDIMENT
2. NEGATIVE ISOPACH VALUES INDICATE NET LOSS OF SEDIMENT

BOEING

NORTH SITE ISOPACH AND CROSS SECTION LOCATIONS STATION -0+50 TO 6+00

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 5

Plot Date: 01/13/20 - 6:53pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\appdata\local\temp\AcPublish_3452\, Drawing Name: North Area Shoreline Habitat Monitoring 2019 Cross Sections 010620 Yr 5 Report.dwg

APPROXIMATE SCALE IN FEET

0 40 80

LIMIT OF AUGUST 2016 CONDITION SURVEY

LOWER LIMIT OF RIPARIAN PLANTING (+12 FT)

DUWAMISH WATERWAY

APPROXIMATE SCALE IN FEET

0 60 120 240

EDGE OF DUWAMISH WATERWAY NAVIGATION CHANNEL

DIFFERENCE BETWEEN YEAR 2 ELEVATIONS (AUGUST 2016) AND YEAR 5 ELEVATIONS (JULY 2019)

- +2.4 to +2.0
- +2.0 to +1.5
- +1.5 to +1.0
- +1.0 to +0.5
- +0.5 to -0.5
- -0.5 to -1.0
- -1.0 to -1.8

EXPLANATION

YEAR 2 CONDITION SURVEY ELEVATION CONTOURS (AUGUST 2016)

YEAR 5 CONDITION SURVEY ELEVATION CONTOURS (JULY 2019)

NOTES:

1. POSITIVE ISOPACH VALUES INDICATE NET ACCUMULATION OF SEDIMENT
2. NEGATIVE ISOPACH VALUES INDICATE NET LOSS OF SEDIMENT

Elevation Datum: 0=MLLW

BOEING

SOUTH SITE ISOPACH AND CROSS SECTION LOCATIONS STATION 23+00 TO 29+00

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 6a

Plot Date: 01/09/20 - 12:20pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\Documents\Boeing-ShorelineHabitat\, Drawing Name: S Area-Condition Cross Sections 2019 Yr 5 Report.dwg

APPROXIMATE SCALE IN FEET

0 40 80

28+50 29+00 29+50 30+00 30+50 31+00 31+50 32+00 32+50 33+00 34+00 34+50

LIMIT OF AUGUST 2016 CONDITION SURVEY

LOWER LIMIT OF RIPARIAN PLANTING (+12 FT)

20 15 10 5

APPROXIMATE SCALE IN FEET

0 60 120 240

DUWAMISH WATERWAY

EDGE OF DUWAMISH WATERWAY NAVIGATION CHANNEL

DIFFERENCE BETWEEN YEAR 2 ELEVATIONS (AUGUST 2016) AND YEAR 5 ELEVATIONS (JULY 2019)

- +2.4 to +2.0
- +2.0 to +1.5
- +1.5 to +1.0
- +1.0 to +0.5
- +0.5 to -0.5
- -0.5 to -1.0
- -1.0 to -1.8

EXPLANATION

YEAR 2 CONDITION SURVEY ELEVATION CONTOURS (AUGUST 2016)

YEAR 5 CONDITION SURVEY ELEVATION CONTOURS (JULY 2019)

NOTES:

1. POSITIVE ISOPACH VALUES INDICATE NET ACCUMULATION OF SEDIMENT
2. NEGATIVE ISOPACH VALUES INDICATE NET LOSS OF SEDIMENT

Elevation Datum: 0=MLLW

BOEING

SOUTH SITE ISOPACH AND CROSS SECTION LOCATIONS STATION 29+00 TO 34+00

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100

wood.

Figure 6b

Plot Date: 01/09/20 - 12:20pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\Documents\Boeing-ShorelineHabitat\, Drawing Name: S Area-Condition Cross Sections 2019 Yr 5 Report.dwg

CROSS SECTION 32+00

CROSS SECTION 33+00

CROSS SECTION 34+00

LOWER LIMIT OF RIPARIAN PLANTING (+12 FT)

APPROXIMATE SCALE IN FEET
0 40 80

APPROXIMATE SCALE IN FEET
0 60 120 240

DUWAMISH WATERWAY

EDGE OF DUWAMISH WATERWAY NAVIGATION CHANNEL

DIFFERENCE BETWEEN YEAR 2 ELEVATIONS (AUGUST 2016) AND YEAR 5 ELEVATIONS (JULY 2019)

- +2.4 to +2.0
- +2.0 to +1.5
- +1.5 to +1.0
- +1.0 to +0.5
- +0.5 to -0.5
- -0.5 to -1.0
- -1.0 to -1.8

EXPLANATION

YEAR 2 CONDITION SURVEY ELEVATION CONTOURS (AUGUST 2016)

YEAR 5 CONDITION SURVEY ELEVATION CONTOURS (JULY 2019)

NOTES:
1. POSITIVE ISOPACH VALUES INDICATE NET ACCUMULATION OF SEDIMENT
2. NEGATIVE ISOPACH VALUES INDICATE NET LOSS OF SEDIMENT

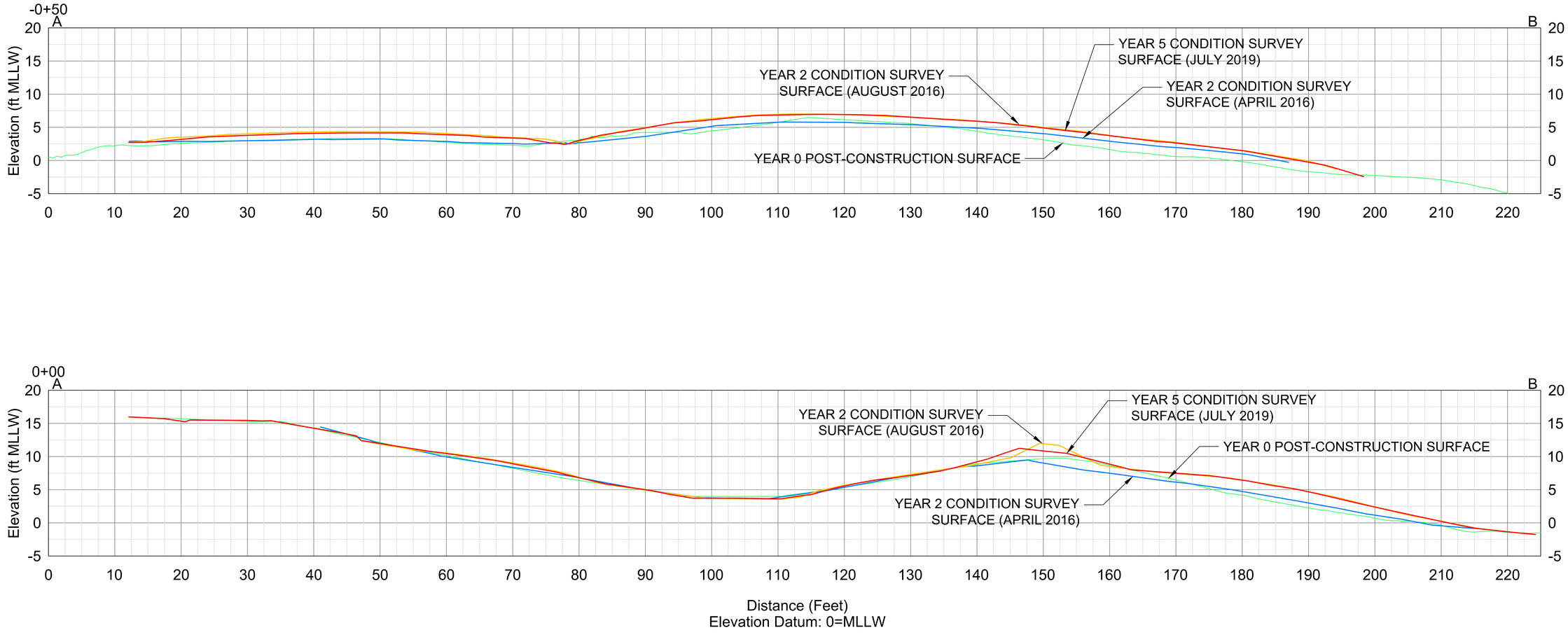
Elevation Datum: 0=MLLW

BOEING

SOUTH SITE ISOPACH AND CROSS SECTION LOCATIONS STATION 32+00 TO 37+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 6c

Plot Date: 01/09/20 - 12:20pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\Documents\Boeing-ShorelineHabitat\, Drawing Name: S Area-Condition Cross Sections 2019 Yr 5 Report.dwg



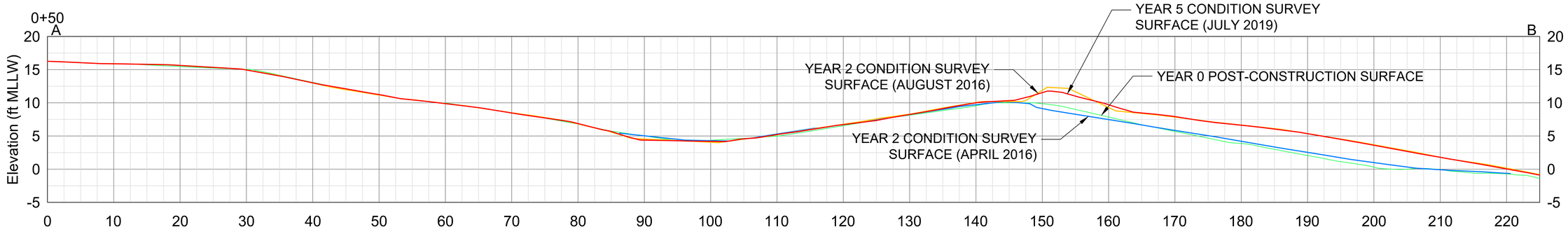
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

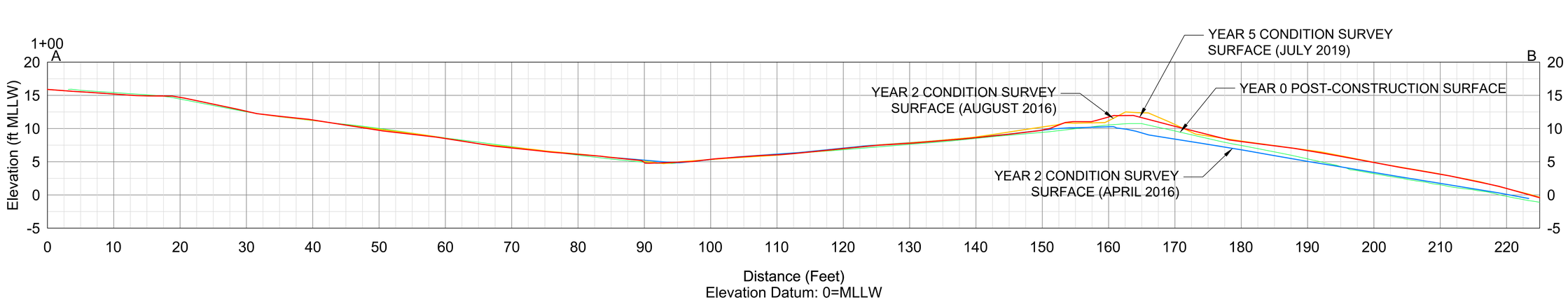
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS -0+50 AND 0+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7a





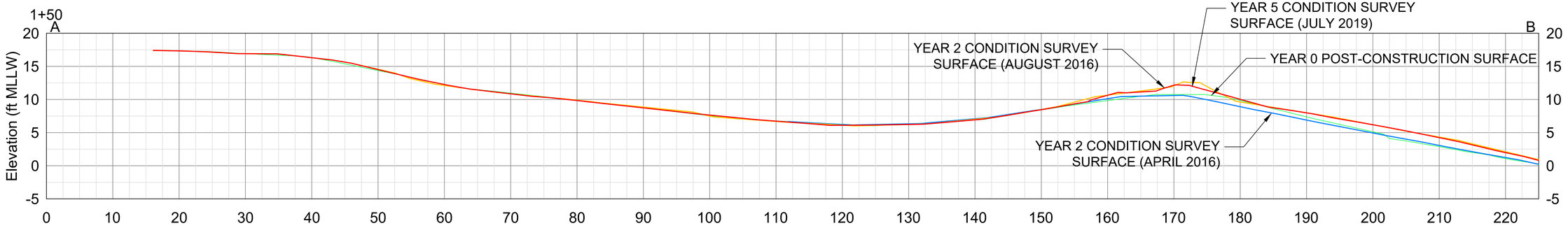
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

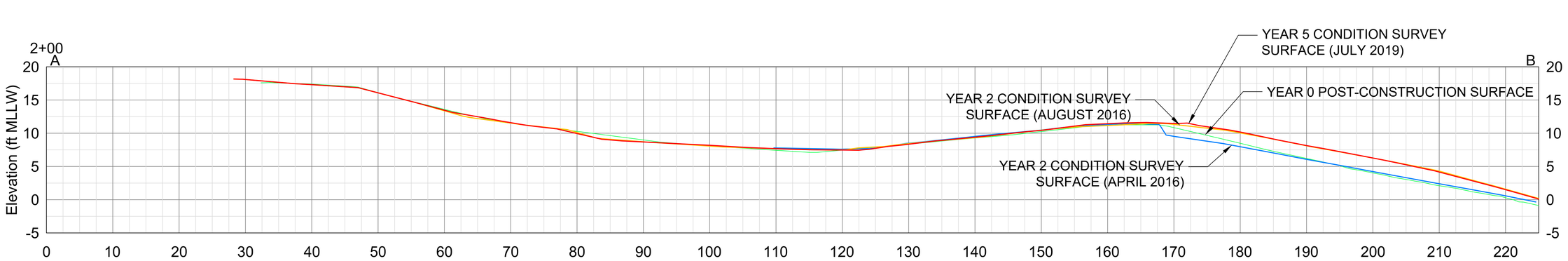
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 0+50 AND 1+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7b





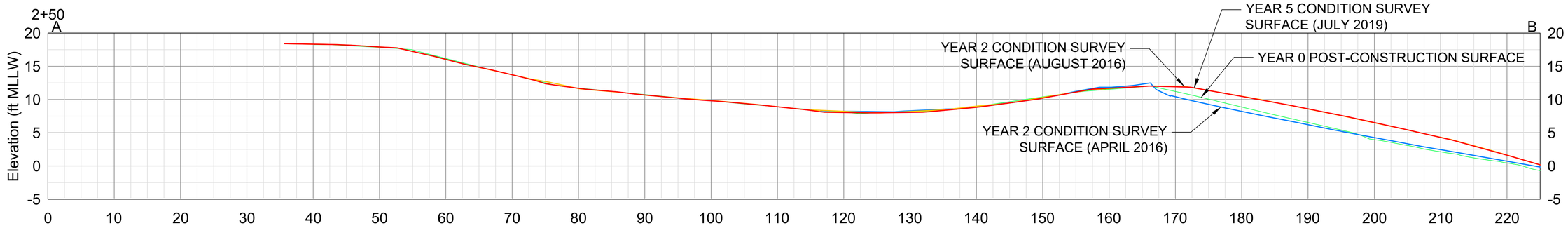
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

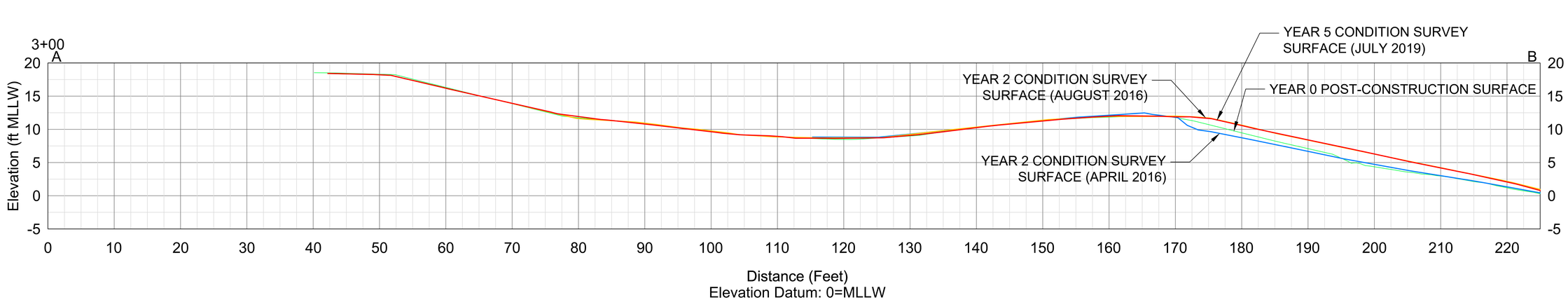
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 1+50 AND 2+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7c





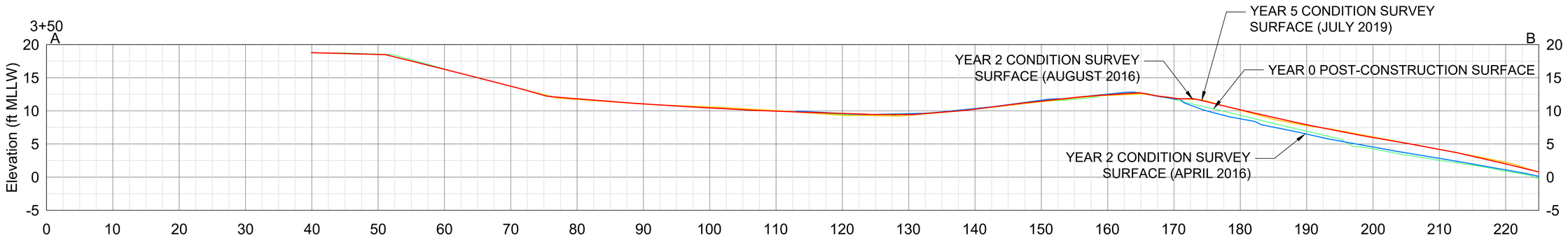
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

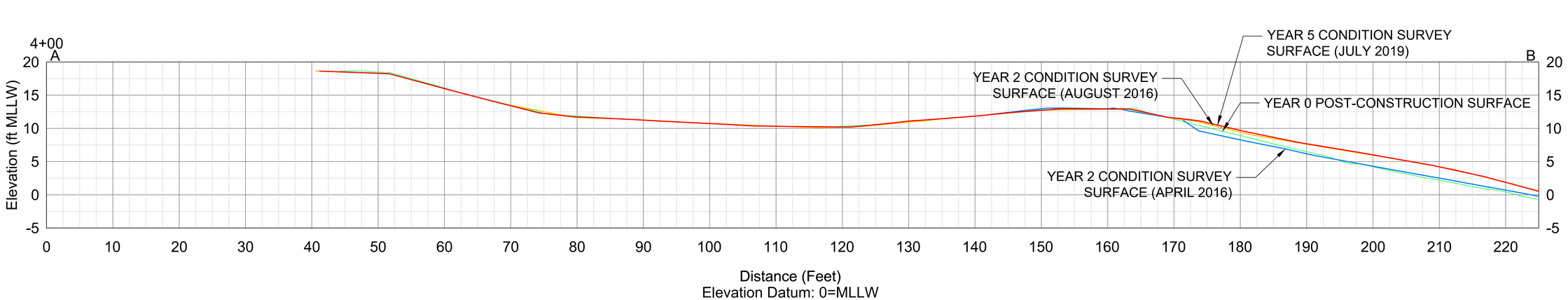
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 2+50 AND 3+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7d





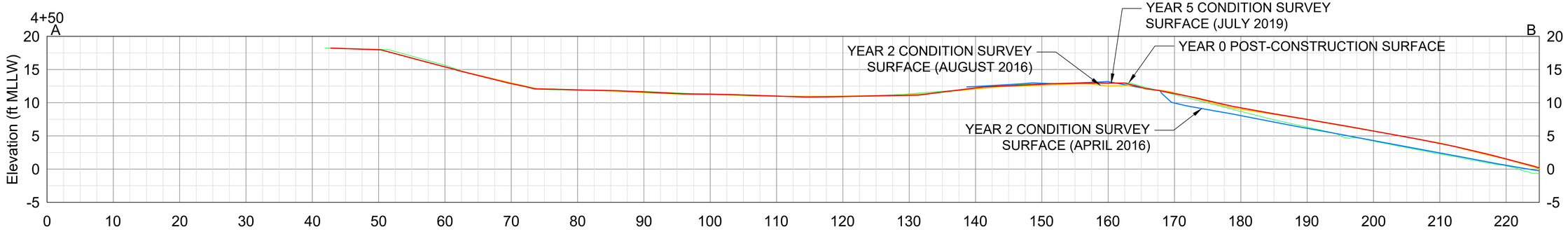
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

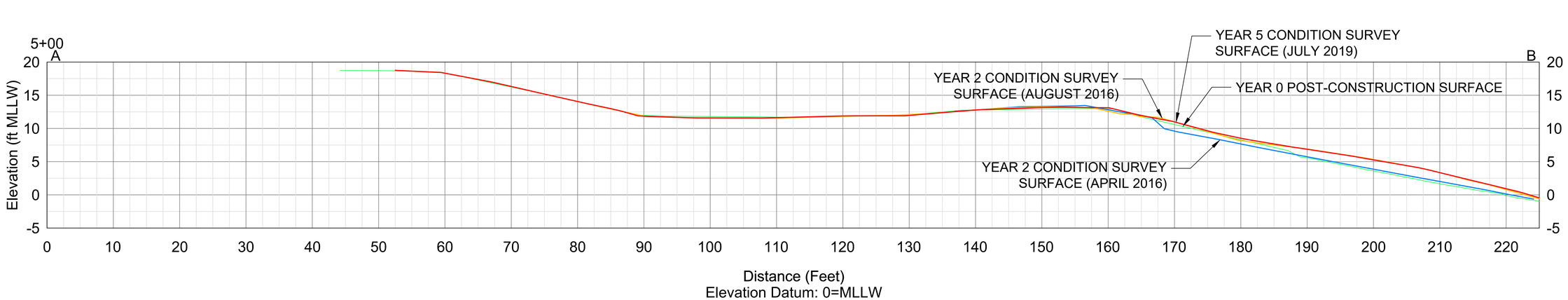
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 3+50 AND 4+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7e





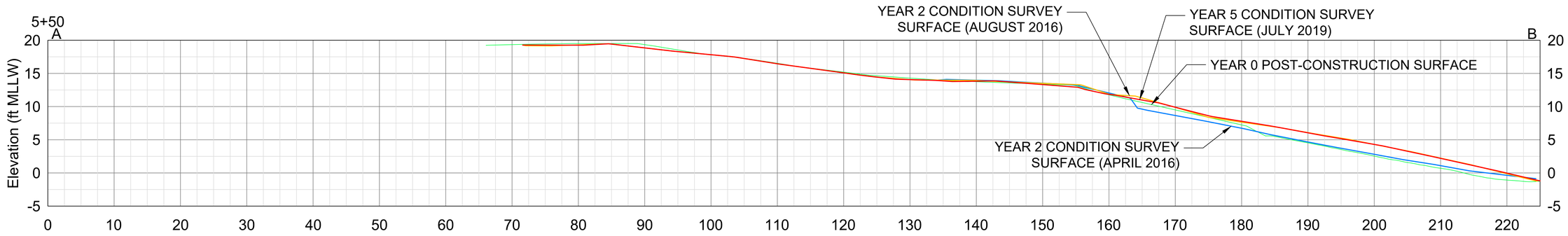
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

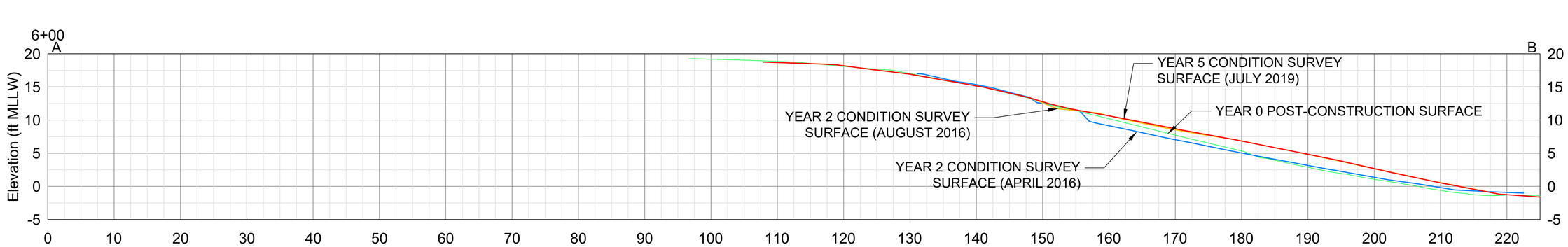
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 4+50 AND 5+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7f





Distance (Feet)
Elevation Datum: 0=MLLW

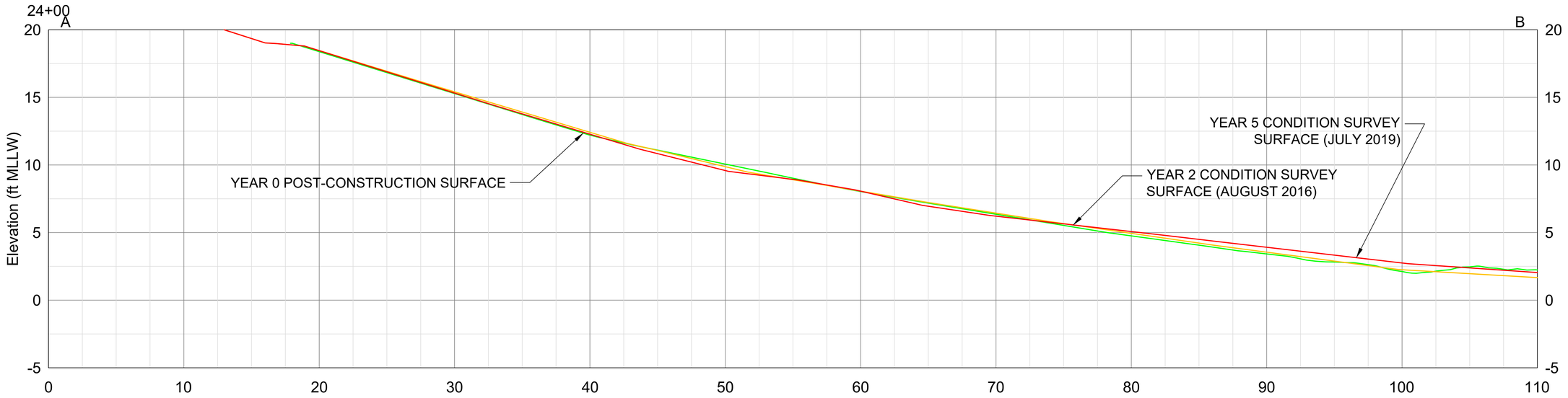
SLOPE STABILIZATION INCLUDED THE PLACEMENT OF UP TO 3+ FEET OF ROUNDED GRAVEL MIX (d50 of 1½ inch).

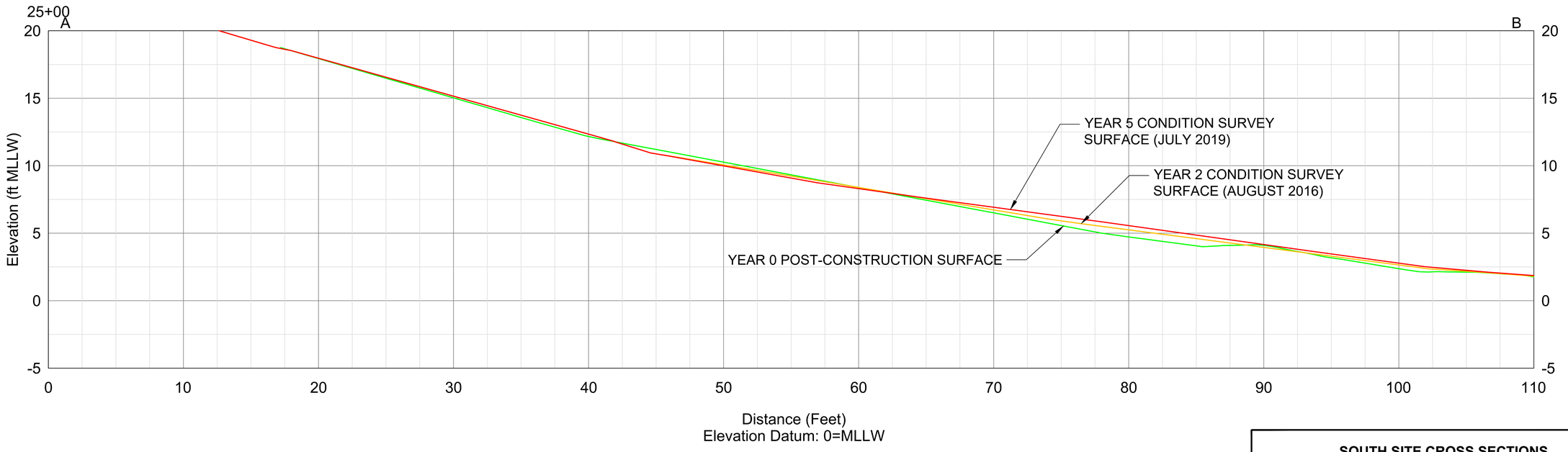
- YEAR 0 POST-CONSTRUCTION SURFACE
- YEAR 2 CONDITION SURVEY SURFACE (APRIL 2016) BEFORE SLOPE STABILIZATION
- YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016) AFTER SLOPE STABILIZATION
- YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

NORTH SITE CROSS SECTIONS
STATIONS 5+50 AND 6+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-06-2020	Project No. 0148440100
wood.		Figure 7g





YEAR 0 POST-CONSTRUCTION SURFACE

YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

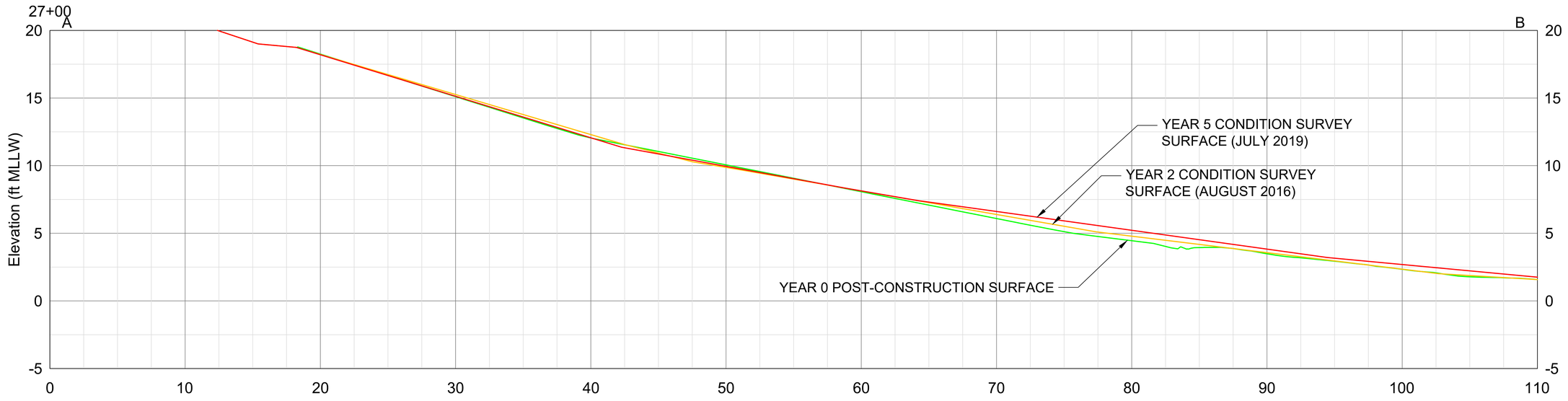
YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 24+00 AND 25+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8a

Plot Date: 01/09/20 - 12:20pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\Documents\Boeing-ShorelineHabitat\, Drawing Name: S Area-Condition Cross Sections 2019 Yr 5 Report.dwg



YEAR 0 POST-CONSTRUCTION SURFACE

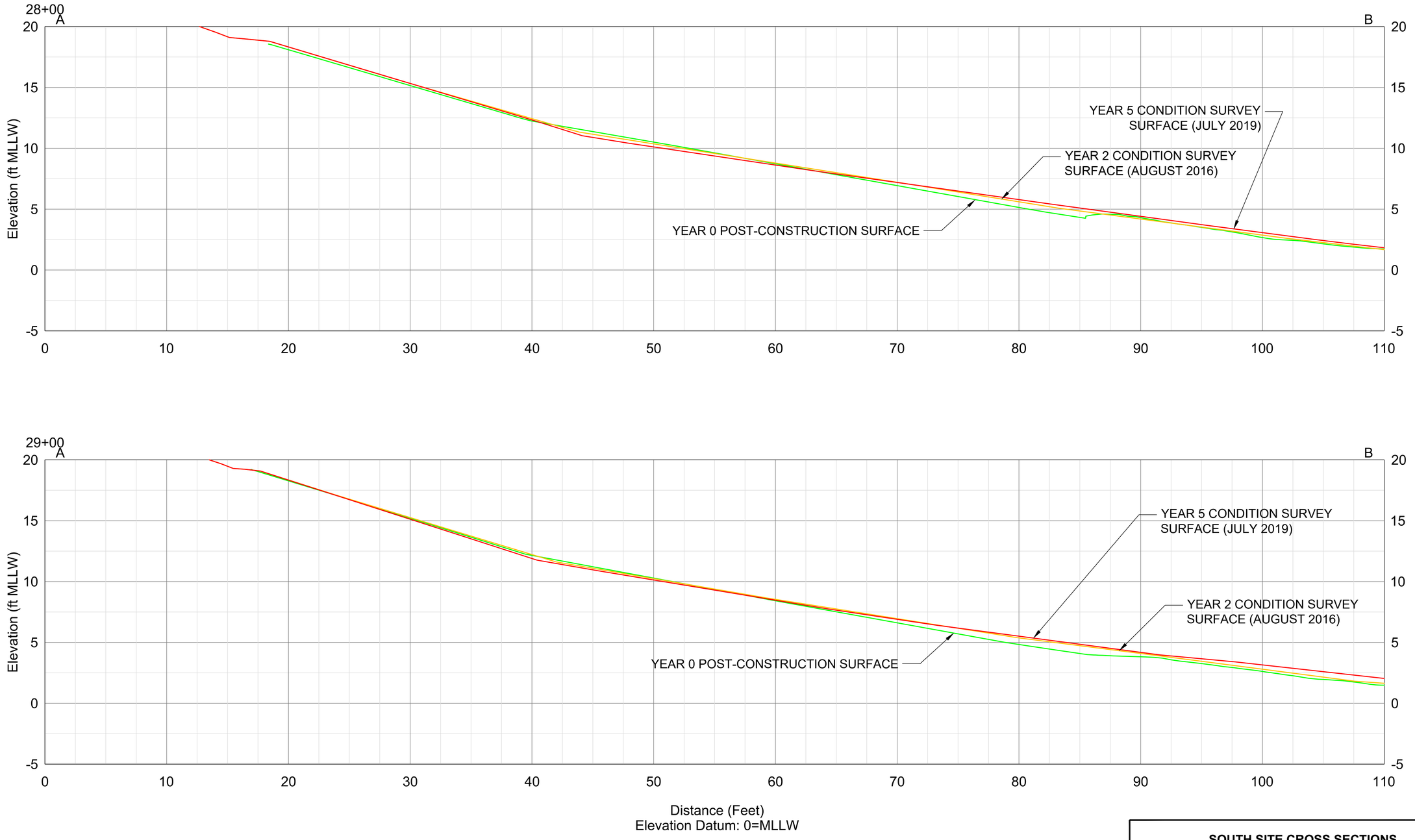
YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 26+00 AND 27+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8b



YEAR 0 POST-CONSTRUCTION SURFACE

YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

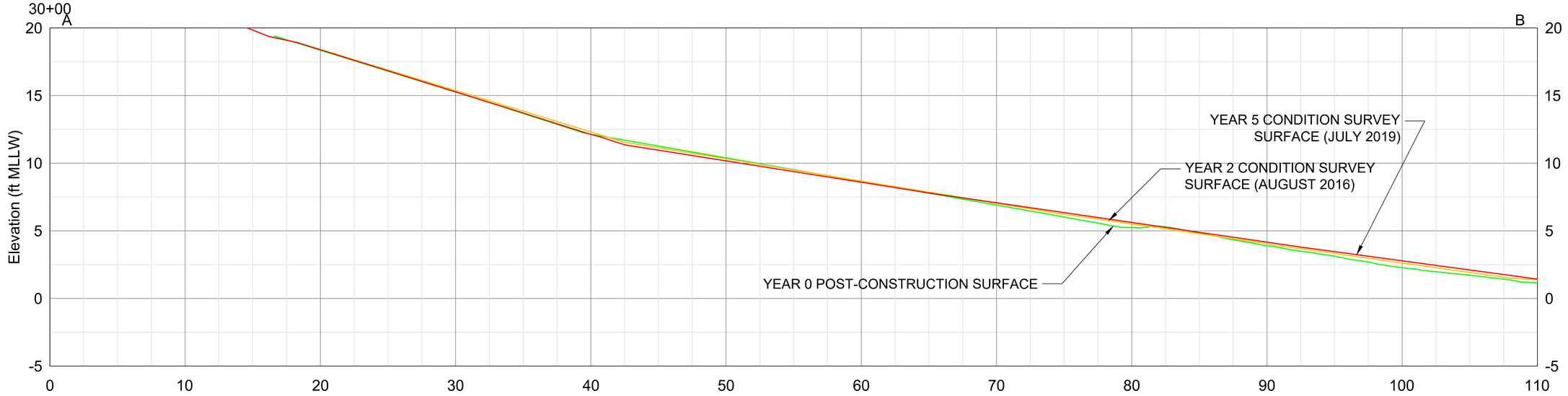
YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

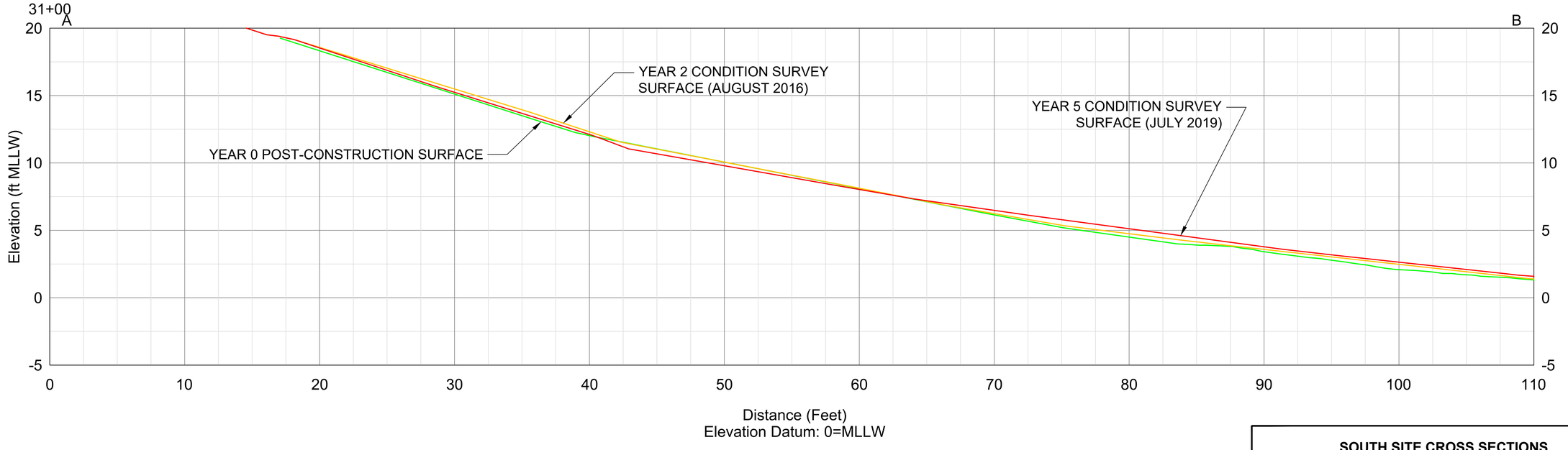
BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 28+00 AND 29+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8c

Plot Date: 01/09/20 - 12:20pm, Plotted by: adam.stenberg
Drawing Path: C:\Users\adam.stenberg\Documents\Boeing-ShorelineHabitat\, Drawing Name: S Area-Condition Cross Sections 2019 Yr 5 Report.dwg





YEAR 0 POST-CONSTRUCTION SURFACE

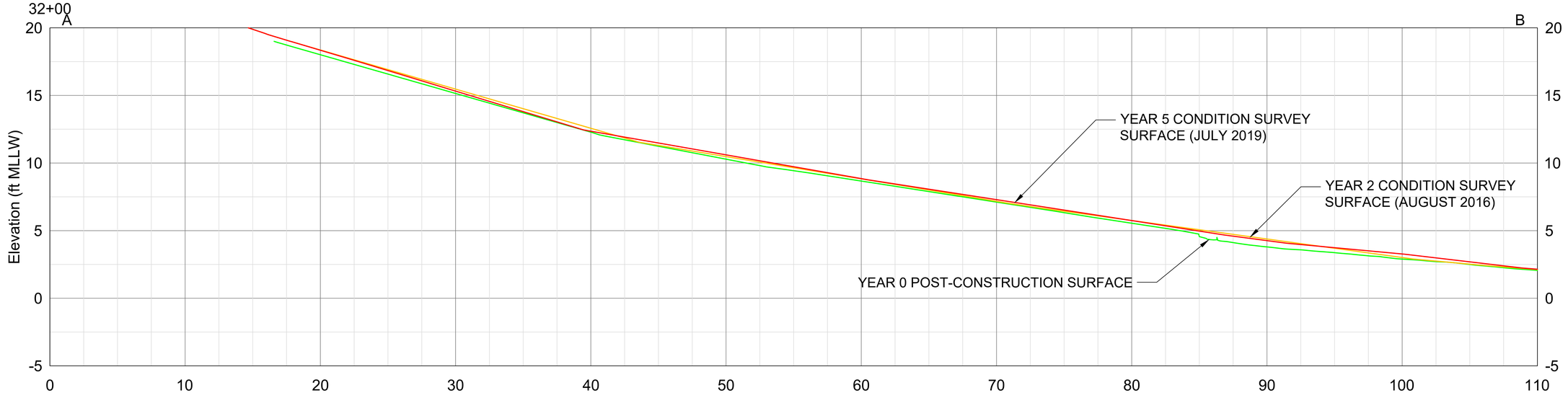
YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

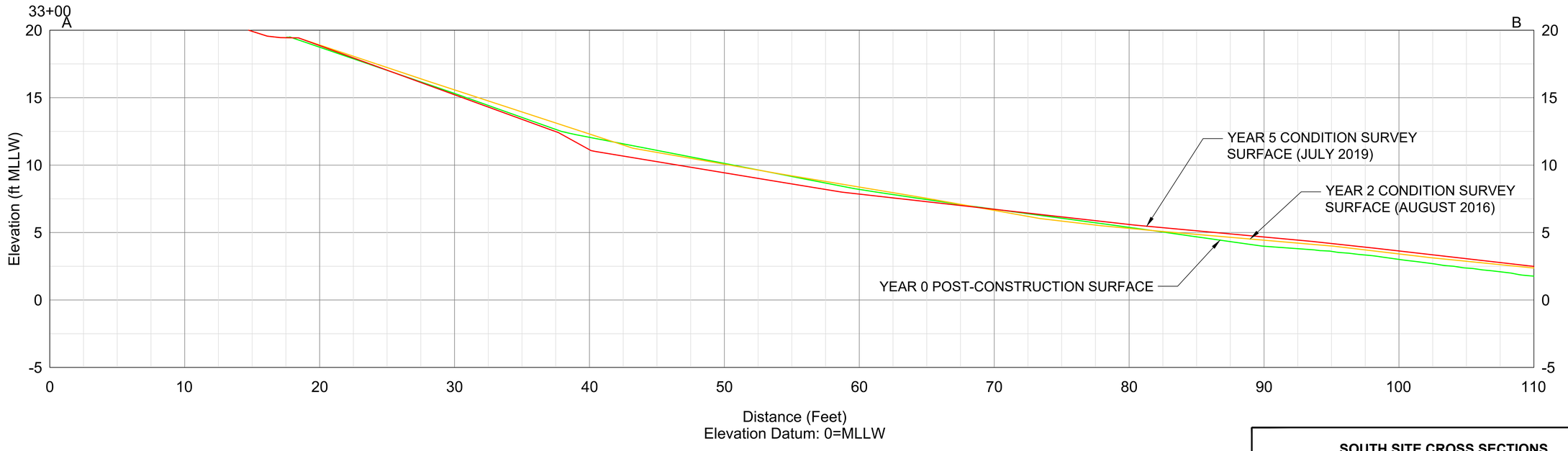
YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 30+00 AND 31+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8d





YEAR 0 POST-CONSTRUCTION SURFACE

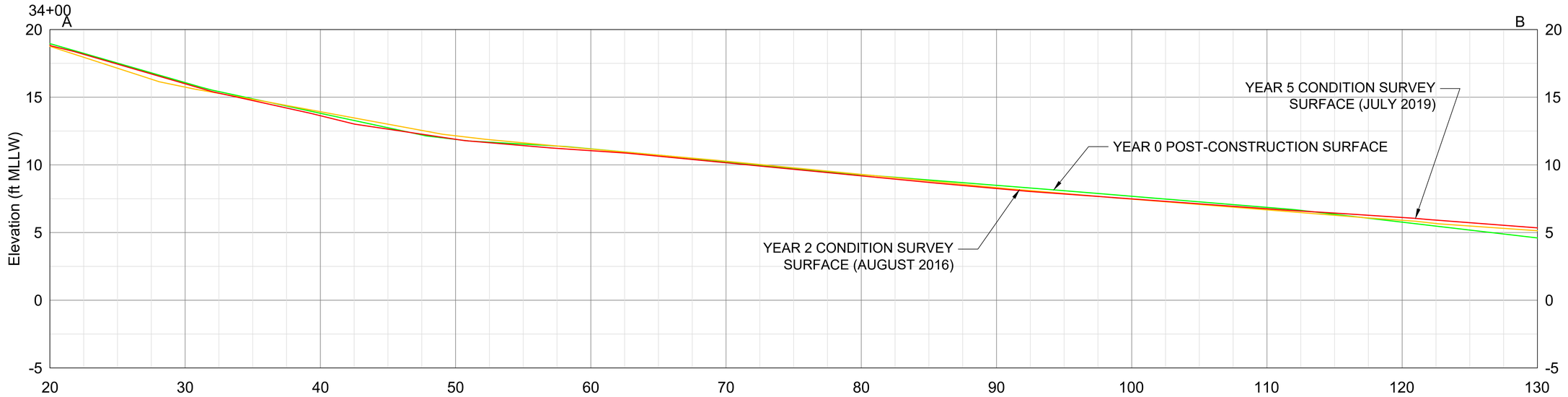
YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

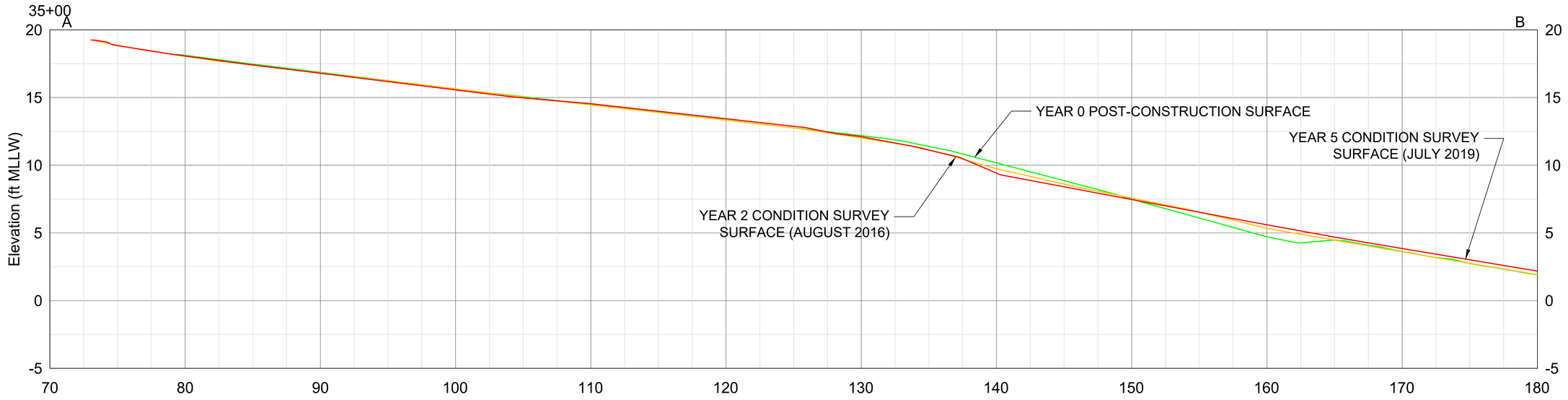
YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 32+00 AND 33+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8e





YEAR 0 POST-CONSTRUCTION SURFACE

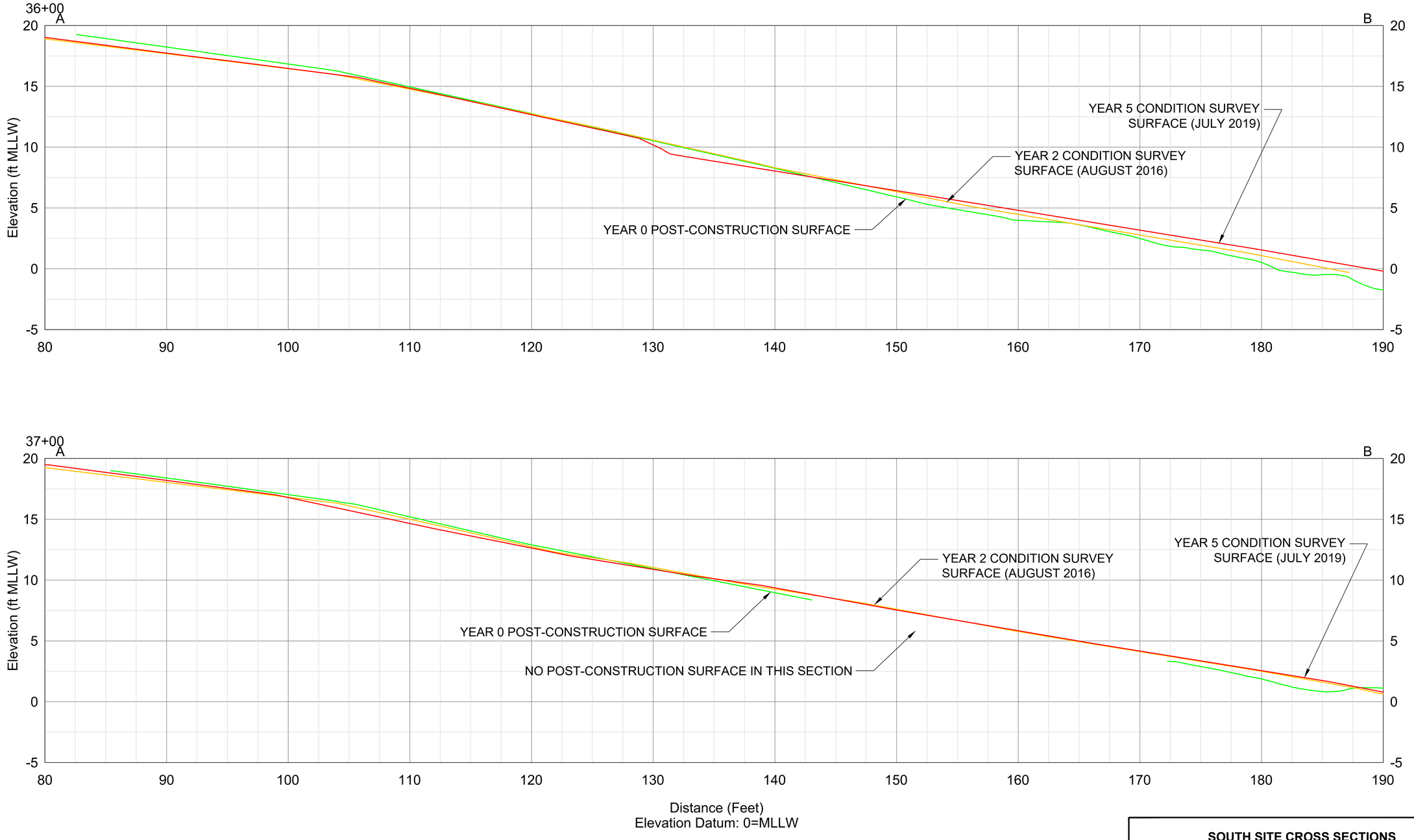
YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

BOEING

SOUTH SITE CROSS SECTIONS
STATIONS 34+00 AND 35+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8f



YEAR 0 POST-CONSTRUCTION SURFACE

YEAR 2 CONDITION SURVEY SURFACE (AUGUST 2016)

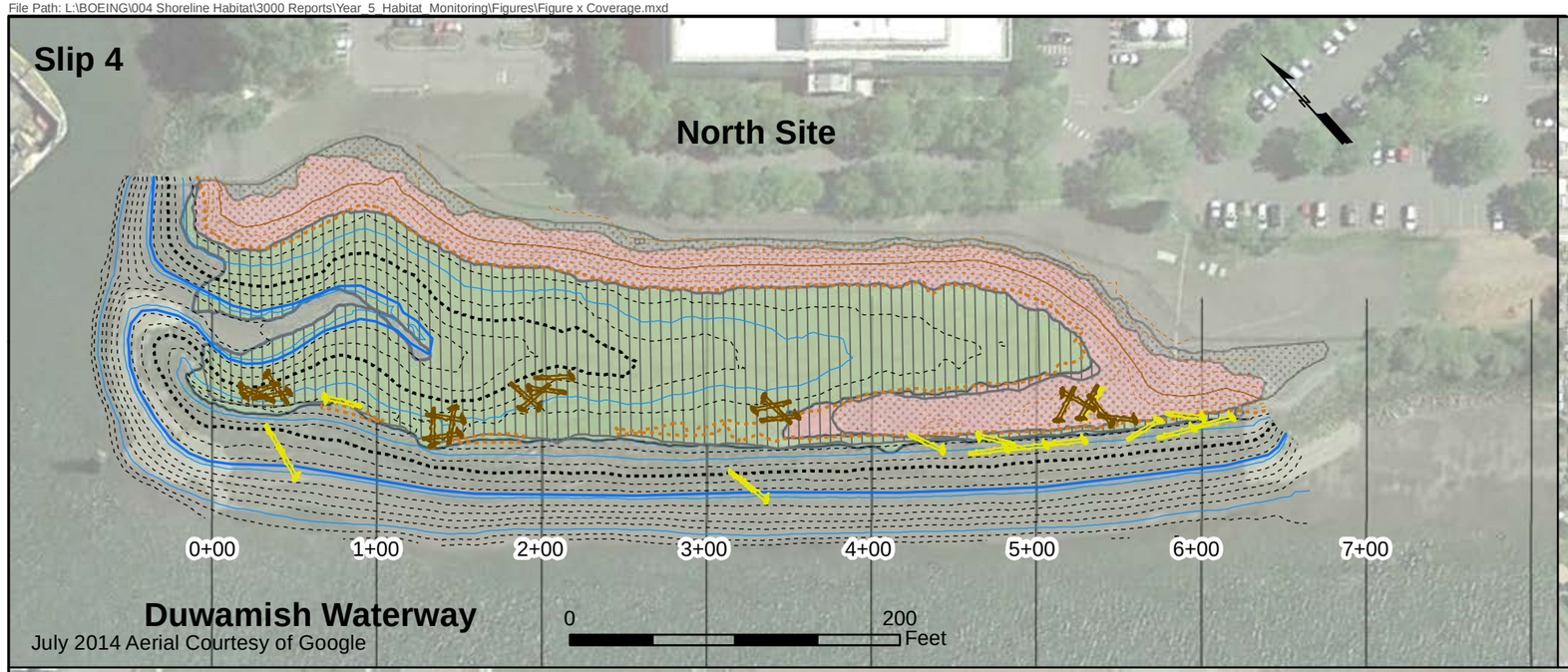
YEAR 5 CONDITION SURVEY SURFACE (JULY 2019)

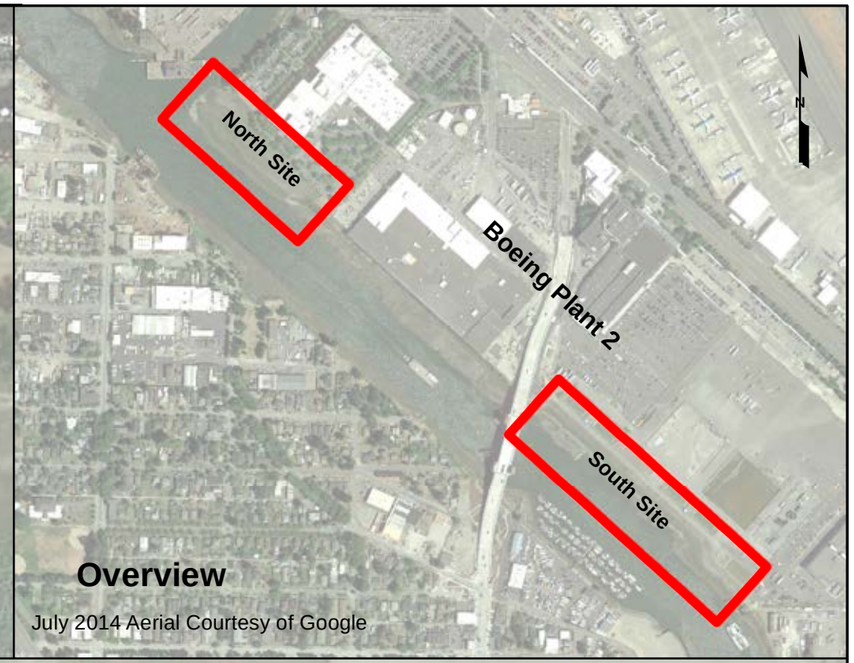
BOEING

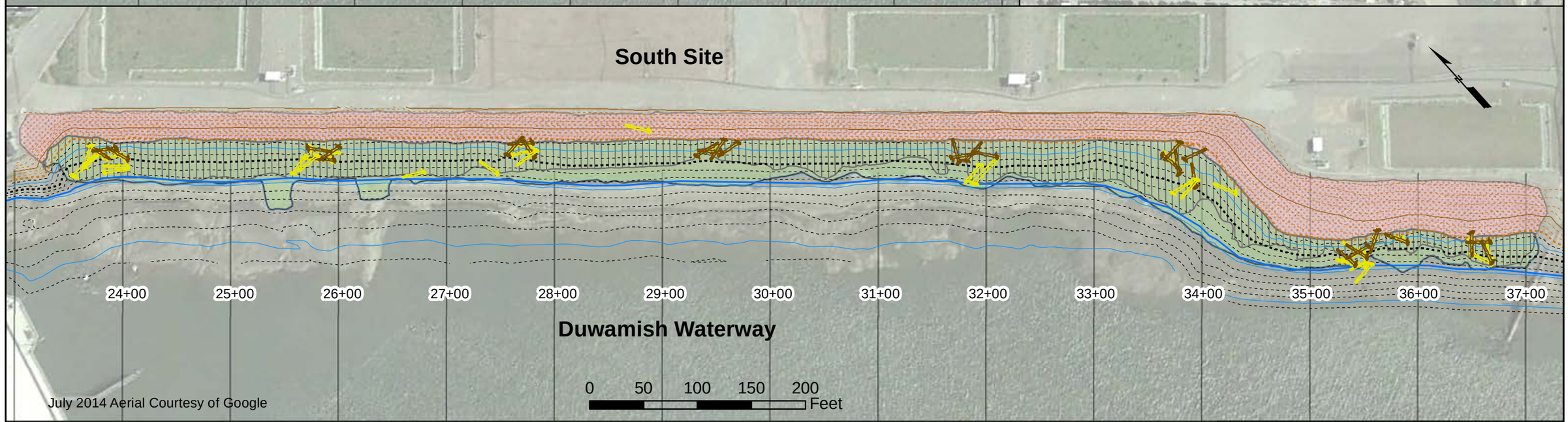
SOUTH SITE CROSS SECTIONS
STATIONS 36+00 AND 37+00
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: APS	Date: 01-09-2020	Project No. 0148440100
wood.		Figure 8g

File Path: L:\BOEING\004 Shoreline Habitat\3000 Reports\Year_5_Habitat_Monitoring\Figures\Figure x Coverage.mxd







Monitoring Results

2017	2019
Marsh Area	Marsh Area
Riparian Area	Riparian Area

Elevation Contours (2019 survey)

- +5.5 ft MLLW contour
- +8 ft MLLW contour
- +12 ft MLLW contour

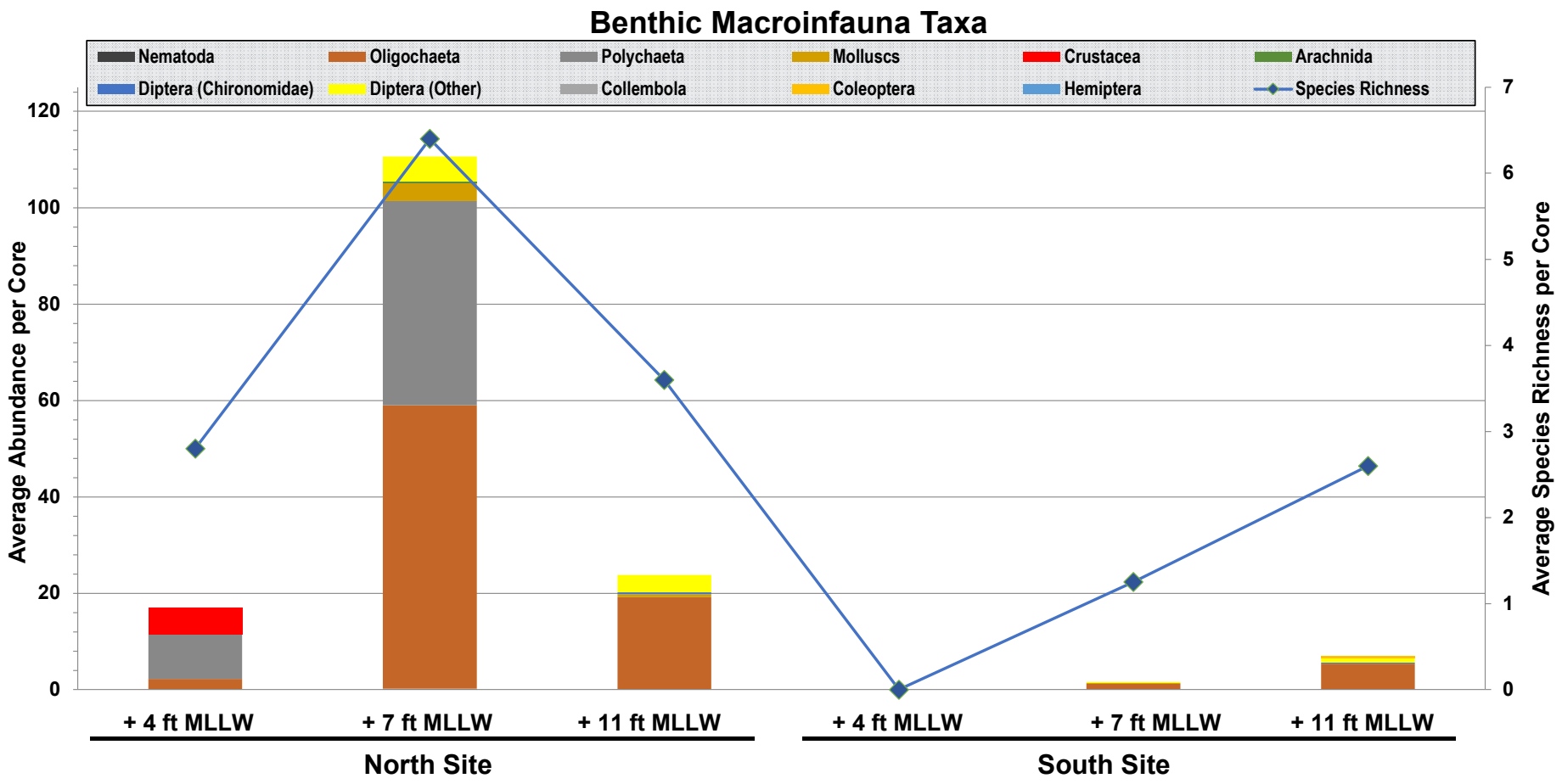
Elevation datum: 0 = MLLW

- Installed Log Bundle
- Captured (or New) Log

BOEING

APPROXIMATE COVERAGE OF MARSH AND RIPARIAN VEGETATION AT THE NORTH AND SOUTH HABITAT SITES
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date: 01/16/2020	Project No. 0148440440
		Figure 9



AVERAGE MACROINFAUNA ABUNDANCE AND TAXA RICHNESS PER CORE

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

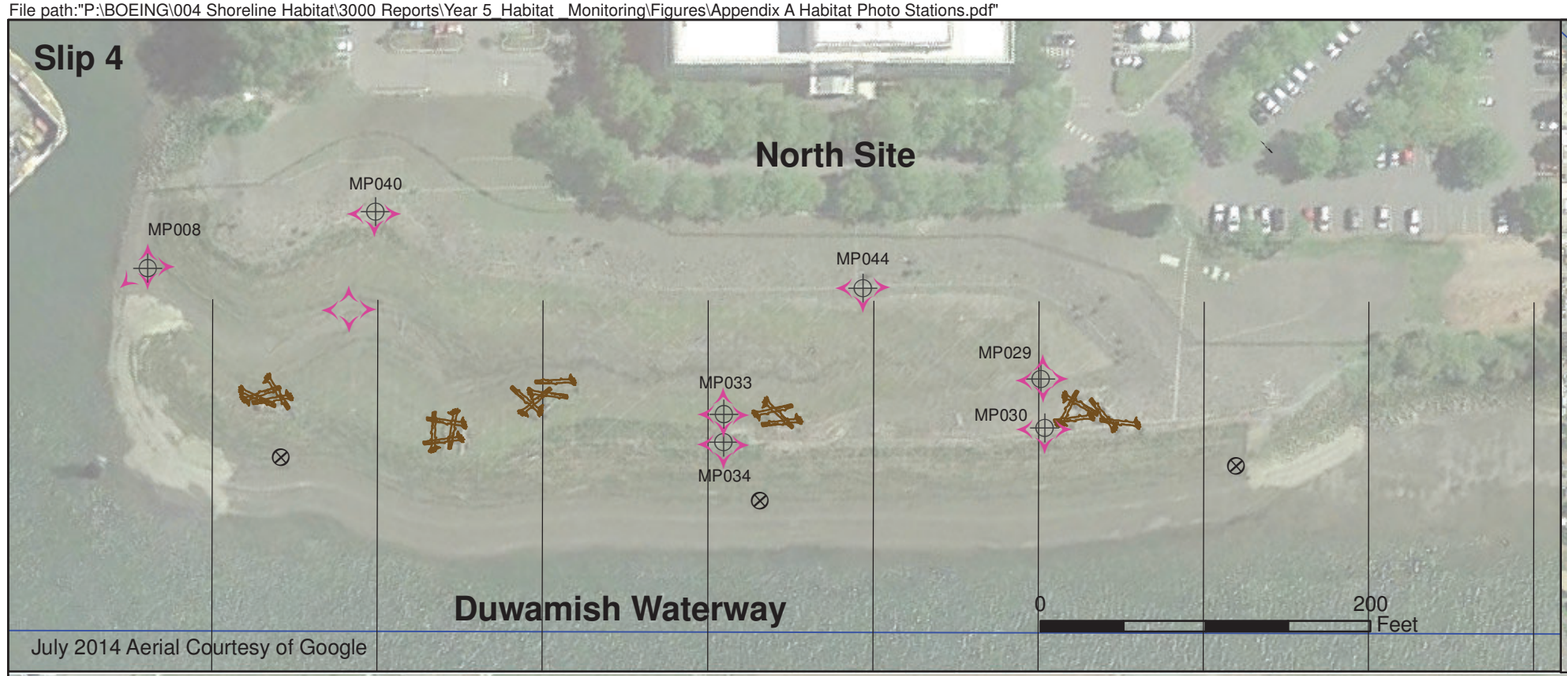
BOEING

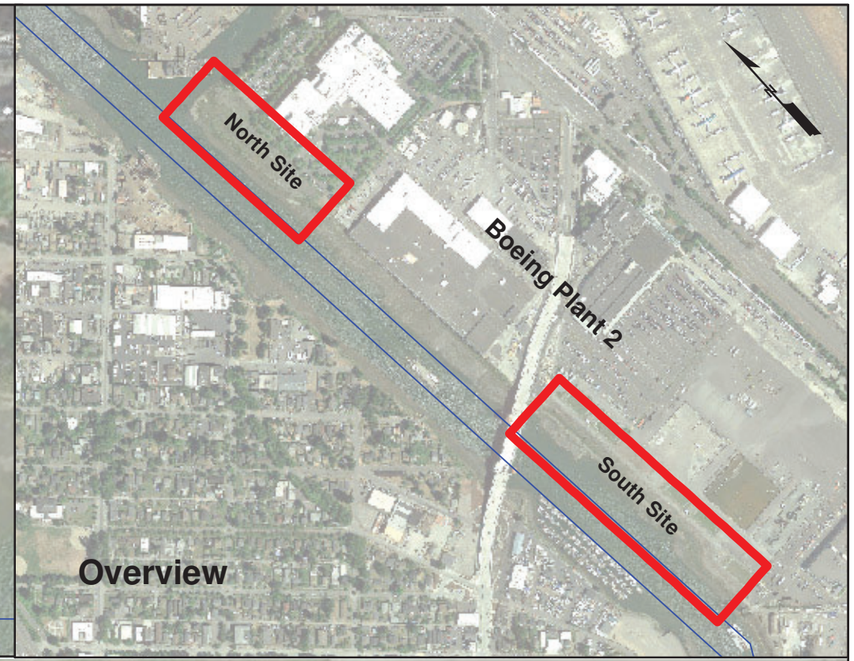
BY: TLP
Project No. 0148440600
Date: 8/15/2019

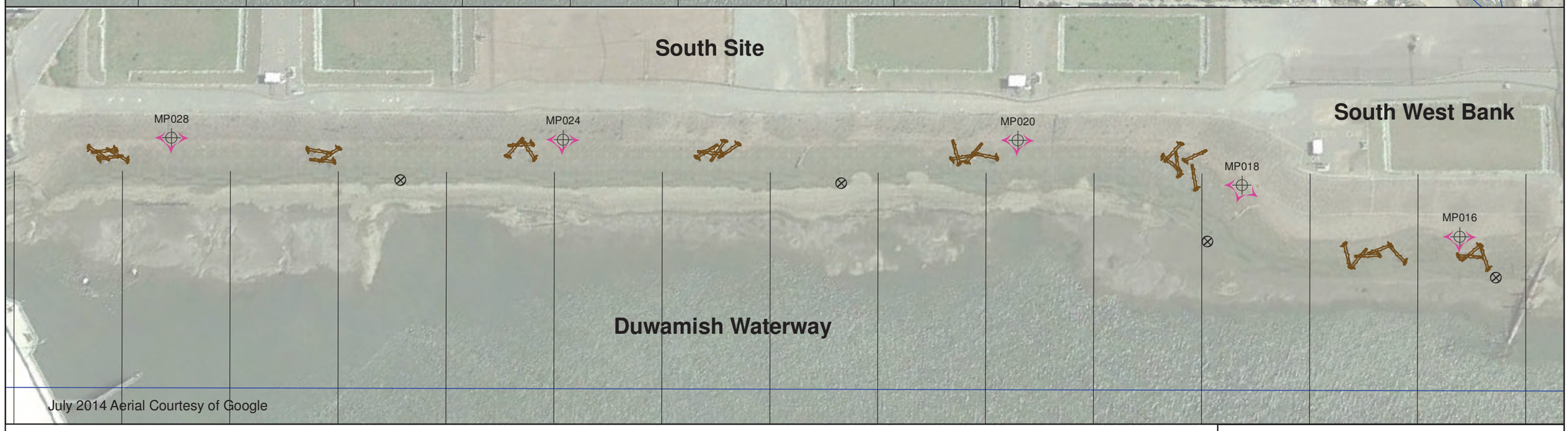
Figure 10

Appendix A
Habitat Photo Points: June 2019

File path:"P:\BOEING\004 Shoreline Habitat\3000 Reports\Year 5_Habitat_ Monitoring\Figures\Appendix A Habitat Photo Stations.pdf"







Legend

- Monitoring Points
- Photo Points and Direction
- Fish Net Piles

BOEING

PHOTO POINTS
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

By: TLP	Date: 01/16/2020	Project No. 0148440440
		Figure **A-1**

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 1: MP040 looking south (upstream)

Photo 2: MP040 looking west (to shoreline)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 3: MP040 looking north (downstream)

Photo 4: MP044 looking south (upstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 5: MP044 looking west (to shoreline)

Photo 6: MP044 looking north (downstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 7: MP029 looking south (upstream)

Photo 8: MP029 looking west (to shoreline)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 9: MP029 looking north (downstream)

Photo 10: MP029 looking east (to upland)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 11: MP030 looking south (upstream)

Photo 12: MP030 looking west (to shoreline)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 13: MP030 looking north (downstream)

Photo 14: MP033 looking south (upstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 15: MP033 looking west (to shoreline)

Photo 16: MP033 looking north (downstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 17: MP033 looking east (to upland)

Photo 18: MP034 looking south (upstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 19: MP034 looking west (to shoreline)

Photo 20: MP034 looking north (downstream)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 21: Terminus of MP037/ MP038 transect in channel looking south (upstream)

Photo 22: Terminus of MP037/ MP038 transect in channel looking west (to shoreline)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 23: Terminus of MP037/ MP038 transect in channel looking north (downstream)

Photo 24: Terminus of MP037/ MP038 transect in channel looking east (to upland)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 25: MP008 looking south (to upstream of embayment)

Photo 26: MP008 looking west (to shoreline of main channel)

APPENDIX A
NORTH HABITAT PHOTO POINTS: JUNE 2019
Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 27: MP008 looking northwest (downstream to main channel)

Photo 28: MP008 looking east (to Slip 4)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 29: MP028 looking south (upstream)

Photo 30: MP028 looking west (to shoreline)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 31: MP028 looking north (downstream)

Photo 32: MP024 looking south (upstream)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 33: MP024 looking west (to shoreline)

Photo 34: MP024 looking north (downstream)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 35: MP020 looking south (upstream)

Photo 36: MP020 looking west (to shoreline)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 37: MP020 looking north (downstream)

Photo 38: MP018 looking south (upstream)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 39: MP018 looking west (to shoreline)

Photo 40: MP018 looking north (downstream)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 41: MP016 looking south (upstream)

Photo 42: MP016 looking west (to shoreline)

APPENDIX A
SOUTH HABITAT PHOTO POINTS: JUNE 2019

Year 5 Habitat Monitoring Report
Habitat Project, Boeing Plant 2
Seattle/Tukwila, Washington

Photo 43: MP016 looking north (downstream)

Appendix B
Benthic Infauna Monitoring Results

Table B-1
Benthic Infauna Monitoring Results
Taxa Report

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	**South Site**				
	Strata	**+4 ft MLLW**				
	Sample ID	**MP1-A**	**MP1-B**	**MP1-C**	**MP1-D**	**MP1-E**
	Collection Date	**06-06-2019**	**06-06-2019**	**06-06-2019**	**06-06-2019**	**06-06-2019**
	Percent Subsampled	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
	EcoAnalysts Sample ID	**7273.3-1**	**7273.3-2**	**7273.3-3**	**7273.3-4**	**7273.3-5**
Coleoptera	Optioservus sp.	0	0	0	0	0
	Ordobrevia nubifera	0	0	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	0	0	0	0	0
Diptera	Ceratopogonidae	0	0	0	0	0
	Dasyhelea sp.	0	0	0	0	0
	Diptera	0	0	0	0	0
	Dolichopodidae	0	0	0	0	0
	Gonomyia sp.	0	0	0	0	0
	Muscidae	0	0	0	0	0
	Ormosia sp.	0	0	0	0	0
	Tipula sp.	0	0	0	0	0
	Tipulidae	0	0	0	0	0
Annelida	Enchytraeidae	0	0	0	0	0
	Hobsonia florida	0	0	0	0	0
	Lumbricina	0	0	0	0	0
	Lumbriculidae	0	0	0	0	0
	Manayunkia aestuarina	0	0	0	0	0
	Manayunkia speciosa	0	0	0	0	0
	Neanthes limnicola	0	0	0	0	0
	Paranais birsteini	0	0	0	0	0
Gastropoda	Potamopyrgus antipodarum	0	0	0	0	0
	Truncatelloidea	0	0	0	0	0
Crustacea	Americorophium salmonis	0	0	0	0	0
	Americorophium spinicorne	0	0	0	0	0
Acari	Tyrrellia sp.	0	0	0	0	0
Other Organisms	Nematoda	0	0	0	0	0
	TOTAL	**0**	**0**	**0**	**0**	**0**

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	South Site				
	Strata	+7 ft MLLW				
	Sample ID	MP2-A	MP2-B	MP2-C	MP2-D	MP2-E
	Collection Date	06-06-2019	06-06-2019	06-06-2019	06-06-2019	06-06-2019
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00
	EcoAnalysts Sample ID	7273.3-6	7273.3-7	7273.3-8	7273.3-9	7273.3-10
Coleoptera	Optioservus sp.	0	0	0	0	0
	Ordobrevia nubifera	0	0	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	0	0	0	0	0
Diptera	Ceratopogonidae	0	0	0	0	0
	Dasyhelea sp.	0	0	0	0	0
	Diptera	0	0	0	0	0
	Dolichopodidae	0	0	0	0	1
	Gonomyia sp.	0	0	0	0	0
	Muscidae	0	0	0	0	0
	Ormosia sp.	0	0	0	0	0
	Tipula sp.	0	0	0	0	0
	Tipulidae	0	0	0	0	0
Annelida	Enchytraeidae	0	1	0	4	0
	Hobsonia florida	0	0	0	0	0
	Lumbricina	0	0	0	0	0
	Lumbriculidae	0	0	0	0	1
	Manayunkia aestuarina	0	0	0	0	0
	Manayunkia speciosa	0	0	0	0	0
	Neanthes limnicola	0	0	0	0	0
	Paranais birsteini	0	0	0	0	0
Gastropoda	Potamopyrgus antipodarum	1	0	0	0	0
	Truncatelloidea	0	0	0	0	0
Crustacea	Americorophium salmonis	0	0	0	0	0
	Americorophium spinicorne	0	0	0	0	0
Acari	Tyrrellia sp.	0	0	0	0	0
Other Organisms	Nematoda	0	0	0	0	0
	TOTAL	**1**	**1**	**0**	**4**	**2**

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	**South Site**				
	Strata	**+11 ft MLLW**				
	Sample ID	**MP3-A**	**MP3-B**	**MP3-C**	**MP3-D**	**MP3-E**
	Collection Date	**06-06-2019**	**06-06-2019**	**06-06-2019**	**06-06-2019**	**06-06-2019**
	Percent Subsampled	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
	EcoAnalysts Sample ID	**7273.3-11**	**7273.3-12**	**7273.3-13**	**7273.3-14**	**7273.3-15**
Coleoptera	Optioservus sp.	0	0	1	0	0
	Ordobrevia nubifera	0	1	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	0	0	1	0	0
Diptera	Ceratopogonidae	0	0	0	0	0
	Dasyhelea sp.	0	0	0	0	0
	Diptera	0	0	1	0	0
	Dolichopodidae	0	0	0	1	0
	Gonomyia sp.	0	0	0	0	0
	Muscidae	0	0	0	0	0
	Ormosia sp.	0	0	1	0	0
	Tipula sp.	0	0	1	0	1
	Tipulidae	0	0	0	0	0
Annelida	Enchytraeidae	8	7	0	3	8
	Hobsonia florida	0	0	0	0	0
	Lumbricina	0	0	0	1	0
	Lumbriculidae	0	0	0	0	0
	Manayunkia aestuarina	0	0	0	0	0
	Manayunkia speciosa	0	0	0	0	0
	Neanthes limnicola	0	0	0	0	0
	Paranais birsteini	0	0	0	0	0
Gastropoda	Potamopyrgus antipodarum	0	0	0	0	0
	Truncatelloidea	0	0	0	0	0
Crustacea	Americorophium salmonis	0	0	0	0	0
	Americorophium spinicorne	0	0	0	0	0
Acari	Tyrrellia sp.	0	0	0	0	0
Other Organisms	Nematoda	0	0	0	0	0
	TOTAL	**8**	**8**	**5**	**5**	**9**

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	North Site				
	Strata	+4 ft MLLW				
	Sample ID	MP45-A	MP45-B	MP45-C	MP45-D	MP45-E
	Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00
	EcoAnalysts Sample ID	7273.3-16	7273.3-17	7273.3-18	7273.3-19	7273.3-20
Coleoptera	Optioservus sp.	0	0	0	0	0
	Ordobrevia nubifera	0	0	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	0	0	0	0	0
Diptera	Ceratopogonidae	0	0	0	0	0
	Dasyhelea sp.	0	0	0	0	0
	Diptera	0	0	0	0	0
	Dolichopodidae	0	0	0	0	0
	Gonomyia sp.	0	0	0	0	0
	Muscidae	0	0	0	0	0
	Ormosia sp.	0	0	0	0	0
	Tipula sp.	0	0	0	0	0
	Tipulidae	0	0	0	0	0
Annelida	Enchytraeidae	0	0	10	0	0
	Hobsonia florida	1	1	1	0	10
	Lumbricina	0	0	0	0	0
	Lumbriculidae	0	0	0	0	0
	Manayunkia aestuarina	0	0	0	0	0
	Manayunkia speciosa	0	0	0	0	0
	Neanthes limnicola	9	5	7	3	9
	Paranais birsteini	0	1	0	0	0
Gastropoda	Potamopyrgus antipodarum	0	0	0	0	0
	Truncatelloidea	0	0	0	0	0
Crustacea	Americorophium salmonis	26	1	0	0	0
	Americorophium spinicorne	1	0	0	0	0
Acari	Tyrrellia sp.	0	0	0	0	0
Other Organisms	Nematoda	0	0	0	0	0
	TOTAL	**37**	**8**	**18**	**3**	**19**

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	North Site				
	Strata	+7 ft MLLW				
	Sample ID	MP46-A	MP46-B	MP46-C	MP46-D	MP46-E
	Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00
	EcoAnalysts Sample ID	7273.3-21	7273.3-22	7273.3-23	7273.3-24	7273.3-25
Coleoptera	Optioservus sp.	0	0	0	0	0
	Ordobrevia nubifera	0	0	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	0	0	0	0	0
Diptera	Ceratopogonidae	0	3	0	0	2
	Dasyhelea sp.	0	0	0	0	2
	Diptera	0	0	0	0	0
	Dolichopodidae	0	2	4	5	2
	Gonomyia sp.	0	0	0	0	0
	Muscidae	0	0	0	1	0
	Ormosia sp.	2	0	0	3	0
	Tipula sp.	0	0	0	0	0
	Tipulidae	0	0	0	0	0
Annelida	Enchytraeidae	16	85	34	69	57
	Hobsonia florida	0	0	1	0	0
	Lumbricina	0	0	0	0	0
	Lumbriculidae	2	0	0	0	0
	Manayunkia aestuarina	0	3	4	0	0
	Manayunkia speciosa	0	20	88	36	60
	Neanthes limnicola	0	0	0	0	0
	Paranais birsteini	0	5	19	1	6
Gastropoda	Potamopyrgus antipodarum	0	1	2	8	0
	Truncatelloidea	1	0	0	7	0
Crustacea	Americorophium salmonis	0	0	0	0	0
	Americorophium spinicorne	0	0	0	0	0
Acari	Tyrrellia sp.	0	1	0	0	0
Other Organisms	Nematoda	0	0	0	1	0
	TOTAL	**21**	**120**	**152**	**131**	**129**

AMEC Duwamish Benthic Infauna 2019
Taxa Report

EcoAnalysts, Inc.
LIFE IN WATER

	Site	North Site				
	Strata	+11 ft MLLW				
	Sample ID	MP47-A	MP47-B	MP47-C	MP47-D	MP47-E
	Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
	Percent Subsampled	100.00	100.00	100.00	100.00	100.00
	EcoAnalysts Sample ID	7273.3-26	7273.3-27	7273.3-28	7273.3-29	7273.3-30
Coleoptera	Optioservus sp.	0	0	0	0	0
	Ordobrevia nubifera	0	0	0	0	0
Diptera-Chironomidae	Hydrosmittia sp.	1	0	0	0	1
Diptera	Ceratopogonidae	0	0	0	0	0
	Dasyhelea sp.	0	0	1	0	0
	Diptera	0	0	0	0	0
	Dolichopodidae	1	0	2	0	0
	Gonomyia sp.	4	0	0	0	0
	Muscidae	0	0	0	0	0
	Ormosia sp.	1	4	0	0	0
	Tipula sp.	0	0	0	0	0
	Tipulidae	3	1	0	0	1
Annelida	Enchytraeidae	4	6	72	2	9
	Hobsonia florida	0	0	0	0	0
	Lumbricina	0	0	0	0	0
	Lumbriculidae	0	0	0	0	0
	Manayunkia aestuarina	0	0	0	0	0
	Manayunkia speciosa	0	0	0	0	0
	Neanthes limnicola	0	0	0	0	0
	Paranais birsteini	0	0	1	0	2
Gastropoda	Potamopyrgus antipodarum	0	0	0	1	0
	Truncatelloidea	0	0	0	2	0
Crustacea	Americorophium salmonis	0	0	0	0	0
	Americorophium spinicorne	0	0	0	0	0
Acari	Tyrrellia sp.	0	0	0	0	0
Other Organisms	Nematoda	0	0	0	0	0
	TOTAL	**14**	**11**	**76**	**5**	**13**

Table B-2
Benthic Infauna Monitoring Results
Metrics Report

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	South Site				
Strata	+4 ft MLLW				
Sample ID	MP1-A	MP1-B	MP1-C	MP1-D	MP1-E
Collection Date	06-06-2019	06-06-2019	06-06-2019	06-06-2019	06-06-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-1	7273.3-2	7273.3-3	7273.3-4	7273.3-5
Abundance Measures					
Corrected Abundance	N/A	N/A	N/A	N/A	N/A
Average Abundance (per Taxon)	N/A	N/A	N/A	N/A	N/A
Dominance Measures					
Dominant Taxon	N/A	N/A	N/A	N/A	N/A
Dominant Abundance	N/A	N/A	N/A	N/A	N/A
2nd Dominant Taxa	N/A	N/A	N/A	N/A	N/A
2nd Dominant Abundance	N/A	N/A	N/A	N/A	N/A
3rd Dominant Taxa	N/A	N/A	N/A	N/A	N/A
3rd Dominant Abundance	N/A	N/A	N/A	N/A	N/A
% Dominant Taxon	N/A	N/A	N/A	N/A	N/A
% 2 Dominant Taxa	N/A	N/A	N/A	N/A	N/A
% 3 Dominant Taxa	N/A	N/A	N/A	N/A	N/A
Richness Measures					
Taxa Richness	N/A	N/A	N/A	N/A	N/A
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	N/A	N/A	N/A	N/A	N/A
Shannon-Weaver H' (log 2)	N/A	N/A	N/A	N/A	N/A
Shannon-Weaver H' (log e)	N/A	N/A	N/A	N/A	N/A
Margalef's Richness	N/A	N/A	N/A	N/A	N/A
Pielou's J'	N/A	N/A	N/A	N/A	N/A
Simpson's Heterogeneity	N/A	N/A	N/A	N/A	N/A

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	South Site				
Strata	+7 ft MLLW				
Sample ID	MP2-A	MP2-B	MP2-C	MP2-D	MP2-E
Collection Date	06-06-2019	06-06-2019	06-06-2019	06-06-2019	06-06-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-6	7273.3-7	7273.3-8	7273.3-9	7273.3-10
Abundance Measures					
Corrected Abundance	1.00	1.00	N/A	4.00	2.00
Average Abundance (per Taxon)	1.00	1.00	N/A	4.00	1.00
Dominance Measures					
Dominant Taxon	Potamopyrgus antipodarum	Enchytraeidae	N/A	Enchytraeidae	Dolichopodidae
Dominant Abundance	1.00	1.00	N/A	4.00	1.00
2nd Dominant Taxa	N/A	N/A	N/A	N/A	Lumbriculidae
2nd Dominant Abundance	0.00	0.00	N/A	0.00	1.00
3rd Dominant Taxa	N/A	N/A	N/A	N/A	N/A
3rd Dominant Abundance	0.00	0.00	N/A	0.00	0.00
% Dominant Taxon	100.00	100.00	N/A	100.00	50.00
% 2 Dominant Taxa	100.00	100.00	N/A	100.00	100.00
% 3 Dominant Taxa	100.00	100.00	N/A	100.00	100.00
Richness Measures					
Taxa Richness	1.00	1.00	N/A	1.00	2.00
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	0.00	0.00	N/A	0.00	0.30
Shannon-Weaver H' (log 2)	0.00	0.00	N/A	0.00	1.00
Shannon-Weaver H' (log e)	0.00	0.00	N/A	0.00	0.69
Margalef's Richness	N/A	N/A	N/A	0.00	1.44
Pielou's J'	N/A	N/A	N/A	0.00	1.00
Simpson's Heterogeneity	N/A	N/A	N/A	0.00	1.00

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	South Site				
Strata	+11 ft MLLW				
Sample ID	MP3-A	MP3-B	MP3-C	MP3-D	MP3-E
Collection Date	06-06-2019	06-06-2019	06-06-2019	06-06-2019	06-06-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-11	7273.3-12	7273.3-13	7273.3-14	7273.3-15
Abundance Measures					
Corrected Abundance	8.00	8.00	5.00	5.00	9.00
Average Abundance (per Taxon)	8.00	4.00	1.00	1.67	4.50
Dominance Measures					
Dominant Taxon	Enchytraeidae	Enchytraeidae	Diptera	Enchytraeidae	Enchytraeidae
Dominant Abundance	8.00	7.00	1.00	3.00	8.00
2nd Dominant Taxa	N/A	Ordobrevia nubifera	Hydrosmittia sp.	Dolichopodidae	Tipula sp.
2nd Dominant Abundance	0.00	1.00	1.00	1.00	1.00
3rd Dominant Taxa	N/A	N/A	Optioservus sp.	Lumbricina	N/A
3rd Dominant Abundance	0.00	0.00	1.00	1.00	0.00
% Dominant Taxon	100.00	87.50	20.00	60.00	88.89
% 2 Dominant Taxa	100.00	100.00	40.00	80.00	100.00
% 3 Dominant Taxa	100.00	100.00	60.00	100.00	100.00
Richness Measures					
Taxa Richness	1.00	2.00	5.00	3.00	2.00
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	0.00	0.16	0.70	0.41	0.15
Shannon-Weaver H' (log 2)	0.00	0.54	2.32	1.37	0.50
Shannon-Weaver H' (log e)	0.00	0.38	1.61	0.95	0.35
Margalef's Richness	0.00	0.48	2.49	1.24	0.46
Pielou's J'	0.00	0.54	1.00	0.86	0.50
Simpson's Heterogeneity	0.00	0.25	1.00	0.70	0.22

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	North Site				
Strata	+4 ft MLLW				
Sample ID	MP45-A	MP45-B	MP45-C	MP45-D	MP45-E
Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-16	7273.3-17	7273.3-18	7273.3-19	7273.3-20
Abundance Measures					
Corrected Abundance	37.00	8.00	18.00	3.00	19.00
Average Abundance (per Taxon)	9.25	2.00	6.00	3.00	9.50
Dominance Measures					
Dominant Taxon	Americorophium salmonis	Neanthes limnicola	Enchytraeidae	Neanthes limnicola	Hobsonia florida
Dominant Abundance	26.00	5.00	10.00	3.00	10.00
2nd Dominant Taxa	Neanthes limnicola	Americorophium salmonis	Neanthes limnicola	N/A	Neanthes limnicola
2nd Dominant Abundance	9.00	1.00	7.00	0.00	9.00
3rd Dominant Taxa	Americorophium spinicorne	Hobsonia florida	Hobsonia florida	N/A	N/A
3rd Dominant Abundance	1.00	1.00	1.00	0.00	0.00
% Dominant Taxon	70.27	62.50	55.56	100.00	52.63
% 2 Dominant Taxa	94.59	75.00	94.44	100.00	100.00
% 3 Dominant Taxa	97.30	87.50	100.00	100.00	100.00
Richness Measures					
Taxa Richness	4.00	4.00	3.00	1.00	2.00
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	0.34	0.47	0.37	0.00	0.30
Shannon-Weaver H' (log 2)	1.14	1.55	1.23	0.00	1.00
Shannon-Weaver H' (log e)	0.79	1.07	0.85	0.00	0.69
Margalef's Richness	0.83	1.44	0.69	0.00	0.34
Pielou's J'	0.57	0.77	0.78	0.00	1.00
Simpson's Heterogeneity	0.46	0.64	0.57	0.00	0.53

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	North Site				
Strata	+7 ft MLLW				
Sample ID	MP46-A	MP46-B	MP46-C	MP46-D	MP46-E
Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-21	7273.3-22	7273.3-23	7273.3-24	7273.3-25
Abundance Measures					
Corrected Abundance	21.00	120.00	152.00	131.00	129.00
Average Abundance (per Taxon)	5.25	15.00	21.71	14.56	21.50
Dominance Measures					
Dominant Taxon	Enchytraeidae	Enchytraeidae	Manayunkia speciosa	Enchytraeidae	Manayunkia speciosa
Dominant Abundance	16.00	85.00	88.00	69.00	60.00
2nd Dominant Taxa	Lumbriculidae	Manayunkia speciosa	Enchytraeidae	Manayunkia speciosa	Enchytraeidae
2nd Dominant Abundance	2.00	20.00	34.00	36.00	57.00
3rd Dominant Taxa	Ormosia sp.	Paranais birsteini	Paranais birsteini	Potamopyrgus antipodarum	Paranais birsteini
3rd Dominant Abundance	2.00	5.00	19.00	8.00	6.00
% Dominant Taxon	76.19	70.83	57.89	52.67	46.51
% 2 Dominant Taxa	85.71	87.50	80.26	80.15	90.70
% 3 Dominant Taxa	95.24	91.67	92.76	86.26	95.35
Richness Measures					
Taxa Richness	4.00	8.00	7.00	8.00	5.00
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	0.35	0.44	0.52	0.52	0.43
Shannon-Weaver H' (log 2)	1.15	1.45	1.72	1.73	1.43
Shannon-Weaver H' (log e)	0.80	1.01	1.19	1.20	0.99
Margalef's Richness	0.99	1.46	1.19	1.45	0.83
Pielou's J'	0.58	0.48	0.61	0.58	0.61
Simpson's Heterogeneity	0.42	0.47	0.60	0.60	0.58

AMEC Duwamish Benthic Infauna 2019
Metrics Report

EcoAnalysts, Inc.
LIFE IN WATER

Site	North Site				
Strata	+11 ft MLLW				
Sample ID	MP47-A	MP47-B	MP47-C	MP47-D	MP47-E
Collection Date	06-07-2019	06-07-2019	06-07-2019	06-07-2019	06-07-2019
Percent Subsampled	100.00	100.00	100.00	100.00	100.00
EcoAnalysts Sample ID	7273.3-26	7273.3-27	7273.3-28	7273.3-29	7273.3-30
Abundance Measures					
Corrected Abundance	14.00	11.00	76.00	5.00	13.00
Average Abundance (per Taxon)	2.33	3.67	19.00	1.67	3.25
Dominance Measures					
Dominant Taxon	Enchytraeidae	Enchytraeidae	Enchytraeidae	Enchytraeidae	Enchytraeidae
Dominant Abundance	4.00	6.00	72.00	2.00	9.00
2nd Dominant Taxa	Gonomyia sp.	Ormosia sp.	Dolichopodidae	Truncatelloidea	Paranais birsteini
2nd Dominant Abundance	4.00	4.00	2.00	2.00	2.00
3rd Dominant Taxa	Tipulidae	Tipulidae	Dasyhelea sp.	Potamopyrgus antipodarum	Hydrosmittia sp.
3rd Dominant Abundance	3.00	1.00	1.00	1.00	1.00
% Dominant Taxon	28.57	54.55	94.74	40.00	69.23
% 2 Dominant Taxa	57.14	90.91	97.37	80.00	84.62
% 3 Dominant Taxa	78.57	100.00	98.68	100.00	92.31
Richness Measures					
Taxa Richness	6.00	2.00	4.00	2.00	4.00
Diversity/Evenness Measures					
Shannon-Weaver H' (log 10)	0.70	0.29	0.11	0.28	0.41
Shannon-Weaver H' (log 2)	2.32	0.97	0.38	0.92	1.35
Shannon-Weaver H' (log e)	1.61	0.67	0.26	0.64	0.94
Margalef's Richness	1.89	0.43	0.69	0.91	1.17
Pielou's J'	0.90	0.97	0.19	0.92	0.68
Simpson's Heterogeneity	0.84	0.53	0.10	0.67	0.53