Miami Wetlands Enhancement Project:

Six-Year Post-Implementation Monitoring Report

Tillamook Estuaries Partnership
A National Estuary Project

Prepared by
Scott Jay Bailey, Project Manager
Tillamook Estuaries Partnership
613 Commercial Street
Garibaldi, Oregon 97118
503-322-2222

November 2017

I dedicate this report to Danny and Janna Crabb. They championed the project from the beginning, made their property available for it and were steadfast supporters throughout. I always looked forward to site visits when I could stop by and chat (and sometimes even pick some blueberries). Their friendship and support made working on this project a real joy.

Funding for this work was provided by the Oregon Watershed Enhancement Board, through Grant No. 211-1012-8406.

I also acknowledge the support of The Nature Conservancy of Oregon. Their acquisition of the northern parcel and partnership with the Crabb's in securing a conservation easement on their parcel ensure the long-term conservation of the Miami Wetlands.

Numerous other individuals and organisations made this work possible and assisted with work presented in this report. I can't name them all here, but their support was critical to the successful completion of this report. I couldn't have done it without them.

Table of Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

This document provides information on post-restoration conditions at the site of Tillamook Estuaries Partnership's (TEP) Miami Wetlands Project (the project). It includes general background information on the project and the project site, information on the methods used to collect data on physical and biological attributes of the site, and the results of our pre-construction data collection efforts. The document primarily incorporates information from work completed by TEP and Vigil Agrimis, Inc (VAI) staff. The primary purpose of the data collection effort reported here was to document post-restoration conditions at the site to allow comparisons with baseline conditions and evaluate the effectiveness of our efforts relative to project goals.

The Miami River watershed is one of five 5th-field watersheds that drain into Tillamook Bay on Oregon's north coast. Areas near the mouths of coastal rivers, where freshwater intermingles with ocean water, provide important habitats for juvenile salmonids as they transition from freshwater to marine existence. This area of the Miami basin has been dramatically affected by past agricultural uses and development of transportation and utility infrastructure. Several salmonid species are known to rear in the lower Miami basin but, given the above, the quantity and quality of rearing habitats were low before the project was initiated. In 2004, Tillamook Estuaries Partnership (TEP) began working with landowners at the mouth of the Miami River to develop a project to improve habitat conditions for salmonids in this area. Through this effort, TEP identified properties along both banks of the river totaling approximately 58 acres on which to conduct such a project.

The site straddles the river and is bounded to the north, west and south by transportation corridors and on the east largely by the north bank of the river. This area has been substantially affected by human activities and even the oldest known aerial photograph of the site (ca. 1939) depicts considerable anthropogenic alterations. Several structures occur on and adjacent to the project site, Hobson and Struby creeks were routed into a constructed channel where they pass through the property during the early 1900s, and a series of drainage channels were constructed sometime during the mid- 1900's. The portion of the project site north of the Miami River was used primarily for agricultural purposes (livestock grazing and grass hay production) for much of the 1900's and the early years of this century. The portion of the project site south of the river also was used for livestock grazing throughout much of the 20th century. However, grazing ceased on the property when it was purchased by the current owners in 2000.

Beginning in 2006, we collected information on a variety of physical and biological attributes of the site to establish baseline conditions. These included water levels, water quality, soil qualities, vegetation structure and composition, and fish and wildlife resources. This information provided a foundation to evaluate the effects of restoration actions at the site. We continued to collect data on this suite of attributes post-restoration (2011-2017).

To gather the aforementioned data, we established nine linear transects at the project site (six running approximately east-west on the parcel north of the river and three running approximately north-south on the parcel south of the river). To improve data collection efficiency and allow us to look for relationships among studied variables, we collected the bulk of our data along these transects.

During both baseline and post-restoration studies, the site was generally quite wet. In our baseline study, precipitation had pronounced and widespread effects on water surface elevations. Response to

rain events was often dramatic, but levels at many wells dropped quickly and remained lower in the absence of precipitation. In areas distant from beaver-influenced surface water channels, water was typically below ground and surface elevations fluctuated regularly in response to precipitation events. Areas in proximity to beaver-influenced channel segments, on the other hand, had higher and more consistent minimum levels and water often inundated the surface. In addition, the effects of precipitation events tended to be more subtle in these areas (except during large storm events when overbank flows from the Miami River could inundate the entire site). Tides had pronounced effects on water levels in surface water channels, but appeared to have little influence on ground water levels. Post-restoration data generally support conclusions reached in our baseline report.

Several factors likely influence water temperatures at the site including ambient air temperature; precipitation; water temperatures in Tillamook Bay, the Miami River and its tributaries; vegetation type and cover; and others. We lacked data to evaluate the influence of all of these factors on water temperatures at the site. However, based on our analyses, ambient air temperature appeared to be one of the prime influences on water temperatures at the site. Surface water temperatures fluctuated daily and mirrored the rise and fall of ambient temperatures. Ground water temperatures did not fluctuate daily, but did vary seasonally (as did average ambient air temperature). During all seasons, water temperatures at the site generally remained below Oregon Department of Environmental Quality standards established to maintain the cold water environments needed to support salmonids and other aquatic life. As a result the site provides cold water refuge for aquatic organisms and contributes cold water to the lower Miami River.

Specific conductance of water in TNC parcel channel system ranged from very low-salinity freshwater conditions (<100 µS/cm) to polyhaline conditions nearing that of ocean water (>30,000 µS/cm). Fresh water was common throughout the system during all seasons, but conditions were highly variable in the lower portion of the Hobson-Struby channel and throughout the tidal channel system (from the lower end of the common tidal channel to the upper reaches of the blind, E channel system). As would be expected, seasonal precipitation levels substantially influenced water salinity in the lower portions of the Hobson-Struby channel and the tidal channel system. The upper Hobson-Struby channel system had fresh water year-round.

Dissolved oxygen concentrations in the TNC parcel channels fluctuated regularly. It appears that tides, precipitation and beavers all influence dissolved oxygen levels at the site. During spring and winter, dissolved oxygen concentrations generally remained high. Means during our fall deployments were variable. In September, they typically resembled summer conditions, but by October they were similar to winter and spring. Summer levels were low relative to all other seasons, but there was considerable variability across the site. Dissolved oxygen levels often dropped to critically low levels on some portions of the site during summer, but other areas continued to provide water with higher dissolved oxygen levels. Despite recording some critically low dissolved oxygen levels during our work, we did not observe any unusual die offs of fish or other aquatic wildlife that would cause alarm. Low summer dissolved oxygen levels were associated with beaver impoundments. It seems likely that low dissolved oxygen levels were the norm throughout most of the pre-restoration ditch system during summer and early fall. As a result, restoration actions have almost certainly improved conditions relative to dissolved oxygen by providing for more variability during periods when beaver impounded channels contain poorly oxygenated water.

During both baseline and post-restoration studies, we collected and analyzed soil samples from throughout the site to determine organic matter content and salinity levels. Our data indicates that the silty soils throughout the site were high in organic matter and predominantly non-saline. However, areas in and adjacent to tidally influenced channels had slightly saline soils.

During both baseline and post-restoration, the Miami Wetlands Project site was very densely vegetated. Vegetation at the site appears to be responding positively to project actions. Native species have continued to increase in stature and area covered and, although still very abundant, non-native and invasive species appear to be slowly, but steadily, declining. The increase in diversity, abundance and size of woody plant species has been particularly noticeable, as has the expansion of native graminoids (e.g., slough sedge (*Carex obnupta*), small-fruited bulrush (*Scirpus microcarpus*), several rushes [*Juncus* spp.], and others).

As of fall 2017, native trees and shrubs planted at the site have increased in size to the point where many individuals are well above the height of the grasses and other plants that previously dominated much of the site. In many areas, planted trees are greater than 5 meters tall and have altered the vertical structure of the site relative to baseline conditions. Wetland species plantings (slough sedge, small-fruited bulrush, etc.) also have persisted and spread. As a result, there has been a marked visual change in vegetation on the site and it has transitioned from a non-native grass-dominated area to one where native trees, shrubs and graminoids are far more prominent (ideally, these species will come to dominate the site). Beaver activities dramatically influence hydrology and vegetation at the site.

We identified 11 different plant communities in five different general categories: fiver Palustrine emergent wetland communities, two riparian communities, one Palustrine scrub shrub community, two upland communities and a community that occurred on disturbed areas. The emergent wetland communities were dominated by herbaceous species and distinguished from one another primarily based on species diversity (particularly the relative dominance of reed canary grass) and percent total cover. Trees and shrubs were much more prominent in these communities post-restoration. During baseline, a reed canary grass-dominated emergent community occurred over a large portion of the site. Post-restoration, the distribution of this community shrank considerably. It was replaced by more diverse emergent communities and tree/shrub dominated communities. Emergent communities in which native species are more dominant were widespread. Distribution of riparian communities also increased. Riparian communities were dominated by native trees and shrubs and were distinguished from one another based on the structure and composition of understory vegetation and prominence of shrub species. The Palustrine scrub shrub community increased and was dominated by native shrubs and small trees. It typically had a dense understory dominated by reed canary grass. Upland communities were dominated by herbaceous species and, in terms of structure and composition, were similar to the emergent communities. However, these communities occurred on portions of the site that lacked wetland hydrology. The disturbed community was variously dominated by shrubs and herbaceous species and occurred primarily along Highway 101, the former overhead utility corridor on the Crabb parcel, and adjacent to residential and agricultural areas.

We identified 69 unique macroinvertebrate taxa in 2010 and 53 in 2016. During both periods insects accounted for most of the taxa (~75 percent). True flies accounted for a majority of insect taxa, and most true flies were non-biting midges (Chironomids). A variety of other taxa also occurred in samples during both years. Total abundance appeared higher in 2016 than 2010. Small crustaceans (amphipods, copepods, isopods and ostracods) and insects (especially the larvae of chironomids and other dipterans) are important components of the diets of juvenile salmonids and these groups were well represented in the samples obtained from the Miami Wetlands during baseline and post-restoration. Troublingly, invasive New Zealand mud snails were found in the 2016 samples. They occurred in large numbers at only one sample site and were absent from over half the 2016 sites.

We conducted surveys for five secretive marsh bird species: American bittern, American coot, Pied-billed grebe, Sora, and Virginia rail. Sora and Virginia rail were commonly detected at the Miami Wetlands site, year-round. The other species generally occupy habitats that differ somewhat from those at the Miami Wetlands site. However, all occur in Tillamook County given the mobility of these other species it is not out of the question for any of them to occur at the site.

We obtained fish data through a variety of sources during baseline and post-restoration. During snorkel surveys, we observed considerably more fish (predominantly juvenile coho) from 2014 on than during baseline and the first few years post-restoration. Based on our post-restoration fish surveys (and the suite of other data reported above), we are confident that conditions for fishes at the site are improved as compared to pre-project times. Not only does habitat quality appear to have improved, the amount of potentially suitable habitat for fishes has expanded greatly. We created approximately 2,000 linear feet of new channels as part of the construction efforts for this project and additional aquatic habitat has formed subsequent to project construction. As noted above, much of the TNC parcel has become inundated by beaver activities and beavers have created several new channels. Expansion of aquatic habitat has occurred on the Crabb parcel as well. Much of the area now inundated is capable of supporting fishes (at least seasonally) in fairly high numbers. Although we have not quantified fish use of these areas, we regularly observed fishes and other aquatic wildlife in these inundated areas and in the channel system when at the site.

We recorded incidental observations of a variety of other wildlife species during our work at the site. A list of these species as well as a list of plant species occurring on the site, a variety of charts and tables, and numerous aerial and ground photos are provided as appendices to this document.

This document presents conditions at the Miami Wetlands site as of 2016-2017 and compare these to pre-restoration conditions at the site. It paints a picture of a site that has changed substantially from pre-restoration conditions. The quality of terrestrial habitats has improved as native plants (especially trees and shrubs) have become more diverse and abundant, and aquatic habitats have increased in quantity and quality. Overall, the restoration effort appears to be moving the site in a positive direction relative to goals established before the work began.

We recommend longer-term monitoring of the site to continue to track its evolution. While monitoring with the same frequency and intensity of work done for this report is probably not warranted, it would be informative to resample several parameters on an approximately five-year interval. We also recommend additional habitat restoration and enhancement work in the watersheds that feed the Miami Wetlands from above. Several barrier culverts occur in both the Hobson and Struby watersheds and additional habitat enhancement work is also needed in the watersheds.

1.0 Introduction

This document provides information on a variety of parameters that have been monitored since 2008 - before implementation of restoration and enhancement actions - at Tillamook Estuaries Partnership's (TEP) Miami Wetlands Project site (the project). It includes general background information on the project and the project site, information on the methods used to collect data on physical and biological attributes, the results of our post-implementation data collection efforts and comparisons of these data with baseline information reported in an earlier TEP document (Bailey 2011). The document primarily incorporates information from work completed by TEP staff, but also includes information from tasks completed by contractors.

The primary goals of the project, as identified in the Habitat Enhancement Plan prepared by Vigil-Agrimis, Inc. (VAI 2008), are to:

- improve connectivity between on-site wetlands and the mainstem Miami River,
- increase the quantity and quality of on-site aquatic habitats,
- restore the historical character of on-site vegetation, and
- enhance riparian vegetation along the Miami River to increase shading and provide a source of wood for in-channel large woody debris recruitment.

We conducted the work reported here to allow comparison with baseline conditions at the site and provide for an assessment of the effectiveness of restoration and enhancement efforts relative to project goals. In addition, we have used this data to inform post-construction vegetation planting efforts at this site and enhancement work completed at other wetland sites on Oregon's north coast. It also allows us to look at relationships among the many variables for which we have collected data.

1.1. Background

The Miami River watershed is one of five 5th-field watersheds that drain into Tillamook Bay (Figure 1). Five species of anadromous salmonids are known to occur in the watershed: coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and cutthroat trout (*O. clarkii*). Pacific and Western brook lamprey (*Entosphenus tridentatus* and *Lampetra richardsoni*, respectively) also occur in the basin, as do a number of other native, non-game fish species.

Reduced habitat complexity and degraded water quality have been identified as primary factors affecting salmonid populations along the Oregon coast. These factors are evident in the Miami Basin and can largely be attributed to historical and current land use practices. Bio-Surveys, LLC (2007) reported that salmonid production within the basin was largely dependent on the lower mainstem, but that land use impacts had reduced the production potential of this area.

Areas near the mouths of coastal rivers, where freshwater intermingles with ocean water, provide important habitats for a variety of species. These transitional areas are particularly important for juvenile salmonids as they transition from freshwater to marine existence. Relative to the other four river systems in the Tillamook Bay Watershed, the Miami Basin is small and isolated (Figure 1), and, as a result, the transitional area at its mouth is small. Further, the lower portion of the basin has been affected by past agricultural and residential uses and development of

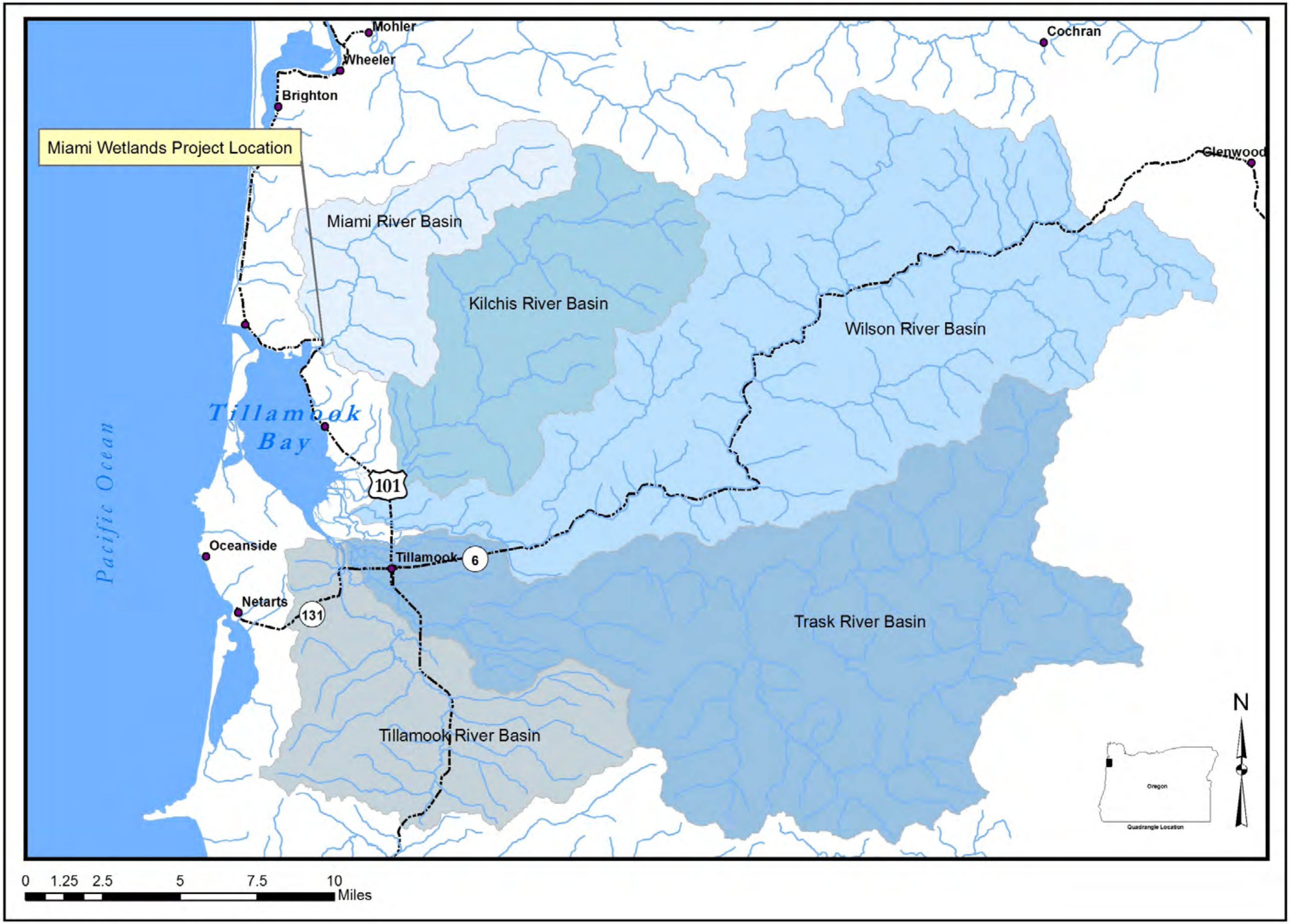


Figure 1. Location of Miami River Basin and Miami Wetlands.

transportation and utility infrastructure. Several salmonid species rear in the lower Miami basin but, given the above, the quantity of tidal wetland rearing habitats in the Miami basin is low and habitat quality has been (and continues to be) affected by anthropogenic uses.

In 2004, TEP began working with landowners at the mouth of the Miami River to develop a project to improve habitat conditions for salmonids in this area. Through this effort, TEP identified properties along both banks of the river totaling approximately 58 acres on which to conduct such a project (figures 1 and 2).

In 2008, VAI completed a site assessment and habitat enhancement plan for the aforementioned properties (VAI 2008). This plan identified existing and historical on-site habitats, opportunities and constraints for enhancement, and a variety of preliminary enhancement alternatives. Associated with this effort, VAI compiled existing relevant data and began some on-site data collection.

In 2009, VAI completed a plan to monitor the effectiveness of habitat enhancement actions at the site (VAI 2009). Along with providing some background information and outlining the proposed enhancement actions, this plan identified existing data, data gaps, monitoring questions and indicator categories, and data collection and analysis methods. This plan is discussed in more detail below.

In 2010, plans for habitat enhancement actions at the site were finalized, additional pre-construction data was collected to supplement existing data, and construction was initiated. Initial plans were to complete construction activities during summer 2010. However, weather and other complications slowed progress and, although we completed a majority of construction activities in 2010, some work was needed during summer 2011 to complete the implementation phase of the project.

Preparation for planting of native herbaceous and woody vegetation began during fall 2010 and planting began in early 2011. Additional planting occurred during the winters of 2011-12, 2012-13, 2013-14, and 2014-15. Maintenance of plantings (e.g., weed control, mortality replacement planting, etc.) was performed during each summer from 2011 to 2017. The goal of the Miami Project's re-vegetation effort is to shift vegetation at the site from a predominately palustrine emergent (PEM) plant community (resulting from years of agricultural use) to a complex palustrine scrub-shrub (PSS) plant community.

1.2. Project Site Description

The approximately 58-acre Miami Wetlands Project site occurs near the mouth of the Miami River in Tillamook County, Oregon (Figure 2). The site straddles the river and is bounded to the north, west, and south by transportation corridors and on the east largely by the north bank of the river. A majority of the site is under private ownership, but a portion is within the Oregon Department of Transportation's Highway 101 right-of-way. After project construction, the parcel north of the river was purchased by The Nature Conservancy (hereafter TNC parcel) and a conservation easement was placed on the parcel south of the river (hereafter Crabb parcel.

The project area has been substantially affected by human activities and even the oldest known aerial photograph of the site (ca. 1939) depicts considerable anthropogenic alterations (Figure 3). This photo clearly shows transportation infrastructure and agricultural and residential

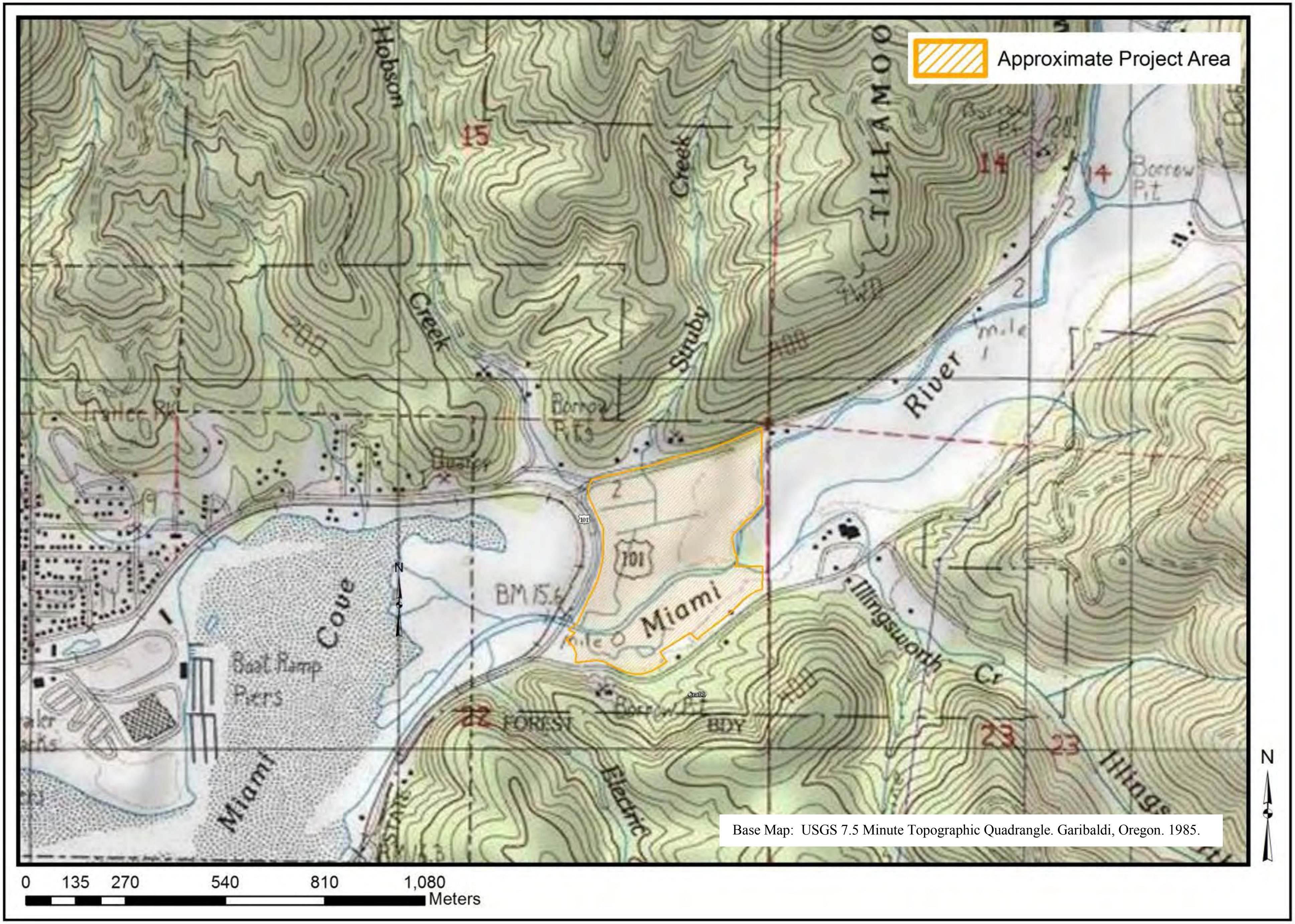


Figure 2. Miami Wetlands Project location.

Figure 3. Historical aerial photograph of Miami Wetlands (ca. 1939). Note the U.S. Highway 101 and railroad rights-of-way, other road corridors and agricultural and residential development. Also note paucity of riparian vegetation along river. Photo not-to-scale.

development on and adjacent to the project site. It depicts essentially treeless river banks in the project area, and meandering tributary channels on both sides of the river. It also appears that Hobson and Struby creeks had been diverted from their original channels at the time of this photo. In it, the creeks are flowing in a constructed channel along the east side of Highway 101 (but the channel is less evident than in later aerial photographs – see below). This differs from a 1924 map of the area (Figure 4) which depicts the Hobson Creek channel flowing directly into Tillamook Bay (west of the 1939 location).

A more recent pre-project, aerial photo from 2005 is included as Figure 5. This photo depicts additional human alterations to the project area. Most notable are a network of drainage ditches, a house and detached garage on the TNC parcel and an overhead, utility corridor spanning the entire project area. Other changes from earlier conditions are also evident, including more riparian vegetation along the Miami River and reduced size and distinctiveness of the tidal channel and pond on the Crabb parcel (VAI [2008] speculated that this channel may have been widened and deepened to function as a log pond). We do not know exactly when the drainage ditch network was constructed. They are absent from the 1939 aerial, but are depicted on a 1985 U.S. Geological Survey topographic map of the area (Figure 2), so it is likely that they were constructed during the mid-1900's. Modern-looking, flexible, perforated, plastic drainpipes unearthed during the construction phase of the wetland enhancement project indicate that actions designed to facilitate drainage of the site continued into the latter 20th century. The Hobson-Struby channel paralleling Highway 101 is clearly evident in the 2005 photograph.

Before project construction began in 2010, the presence of beaver dams and the condition of vegetation along the drainage ditches on the TNC parcel indicated that the system had not been actively maintained for several years. Although the system was connected to the Miami River, obstructions impeded flows and allowed water to move out of the channels and perennially saturate a substantial portion of the site (predominantly in the northern and western portions of the TNC parcel).

The TNC parcel was used primarily for livestock grazing and grass hay production for much of the 1900's and the early years of this century (hay was being harvested as recently as 2009). The Crabb parcel also used as pasture throughout much of the 20th century. However, livestock grazing ceased when the current owners purchased it in 2000.

Small levees occur along both banks of the river within the project boundaries. It is unclear if these are natural or constructed levees. If constructed, it is unknown when they were constructed, but the paucity of riparian vegetation along the river banks in the 1939 aerial suggests that levees may have been constructed around that time (possibly in conjunction with construction of Highway 101 and the bridge spanning the Miami River). Small mammals (beaver, nutria, muskrat, etc.) and/or hydraulic actions have created a number of breaches in these levees since their construction (particularly on the south bank).

Elevations within the project area range from approximately 6-14 ft above mean sea level (NAVD88). The TNC parcel gradually rises upward from west to east with much of the property occurring in the 10-14 ft elevation zone. However, before restoration actions were implemented a microtopography of low hummocks, shallow depressions, small potholes, and

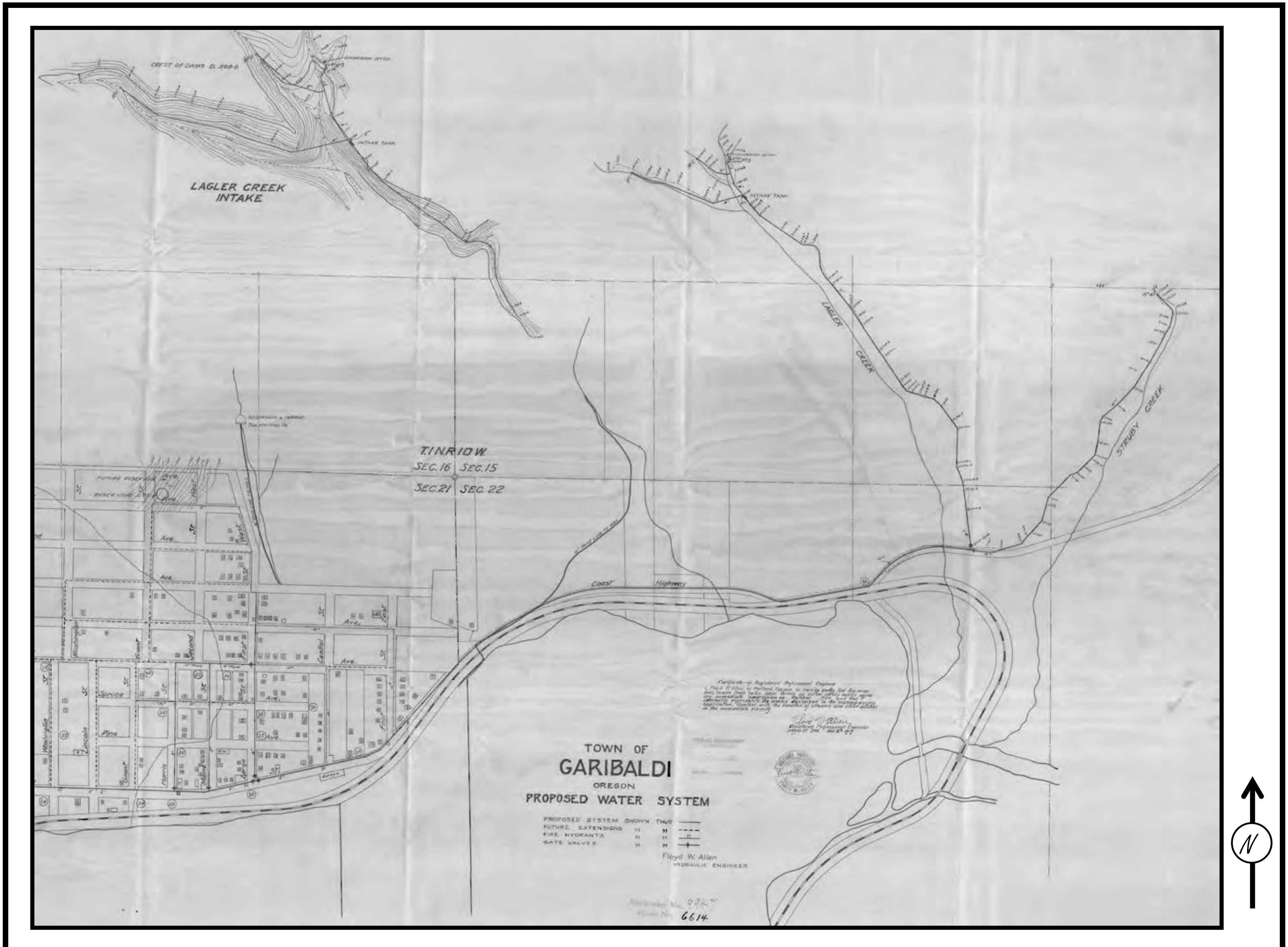


Figure 4. Historical map of the Town of Garibaldi (ca. 1924). Note that Hobson Creek (referred to as Lagler Creek on this map) crosses the Highway 101 Right-of-Way and empties directly into Tillamook Bay, unlike its current configuration where it empties into the Miami River upstream of the river's confluence with the Bay. Not-to-scale.

Figure 5. Pre-project aerial photograph of Miami Wetlands (ca. 2005). Note the two structures, the network of drainage ditches and the Hobson-Struby channel on the northern parcel. Also note the overhead utility corridor running southeast to northwest across the entire project area and the increase in riparian vegetation along the river as compared to Figure 3. Photo not-to-scale.

narrow channels was evident (not to mention the network of 4-6 ft deep, steep-sided, constructed channels).

Elevations on the Crabb parcel range from approximately 6 ft along the river to approximately 14 ft near the Ekroth Road right-of-way. In general, the terrain there slopes gently upward from north to south with a shallow depression running east-west through the central portion of the parcel (the historical channel and pond depicted in the 1939 aerial photograph). VAI (2008) compared elevations on either side of U.S. Highway 101 to determine if construction of the highway had appeared to influence sediment accumulation in the area. They concluded that elevations in the area are consistent with a landform that generally slopes uphill in an easterly direction from the bay and that construction of the highway does not appear to have resulted in abnormal soil accumulation east of the highway.

Four different soils occur within the project area. These are: Brenner silt loam, Condorbridge gravelly medial loam, Coquille silt loam, and Nehalem silt loam (Figure 6 – USDA Natural Resources Conservation Service, Web Soil Survey, *http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx*).

Condorbridge gravelly medial loam is a well-drained soil of fan-type depositional areas. It is derived from alluvium and/or debris flow deposits of igneous and sedimentary rock. This soil is rare within the project area, occurring only along its north and south margins (at the toe of slopes that bound the Miami River valley).

Nehalem silt loam and Brenner silt loam are floodplain soils whose parent materials are alluvium derived from igneous and sedimentary rock. Both occur in the eastern portion of the project area. Nehalem silt loam is a well-drained soil, whereas Brenner silt loam is poorly drained.

Coquille silt loam is the predominate soil within the project area, occurring on approximately 80 percent of the site. It is a very poorly-drained, tidal marsh soil whose parent material is estuarine deposits. Based on the NRCS Soil Survey, this soil type is typically nonsaline to very slightly saline. (0.0 to 4.0 dS/m – 0.0 to 4,000 µS/cm).

All construction activities associated with the project occurred within the portion of the site where Coquille silt loam occurs (with the exception of a borrow pit dug within the portion of the project site where Nehalem silt loam occurs). Soil from the above-mentioned pit was used to fill drainage ditches during project construction.

More detailed information on the pre-construction state of the project area and how it compares with post-project conditions is provided in the results section of this report and by Bailey (2011).

The 2010 restoration project:

- Filled in l,700 feet of drainage ditches on the TNC parcel,
- Filled 900 feet of the constructed Hobson/Struby creeks channel (where it paralleled Highway 101 and Miami-Foley Road) and re-routed the streams into 1,800 feet of newly excavated meandering channel on the TNC parcel (Figure 7),
- Excavated 2,700 feet of blind tidal channels on the TNC parcel (Figure 7),

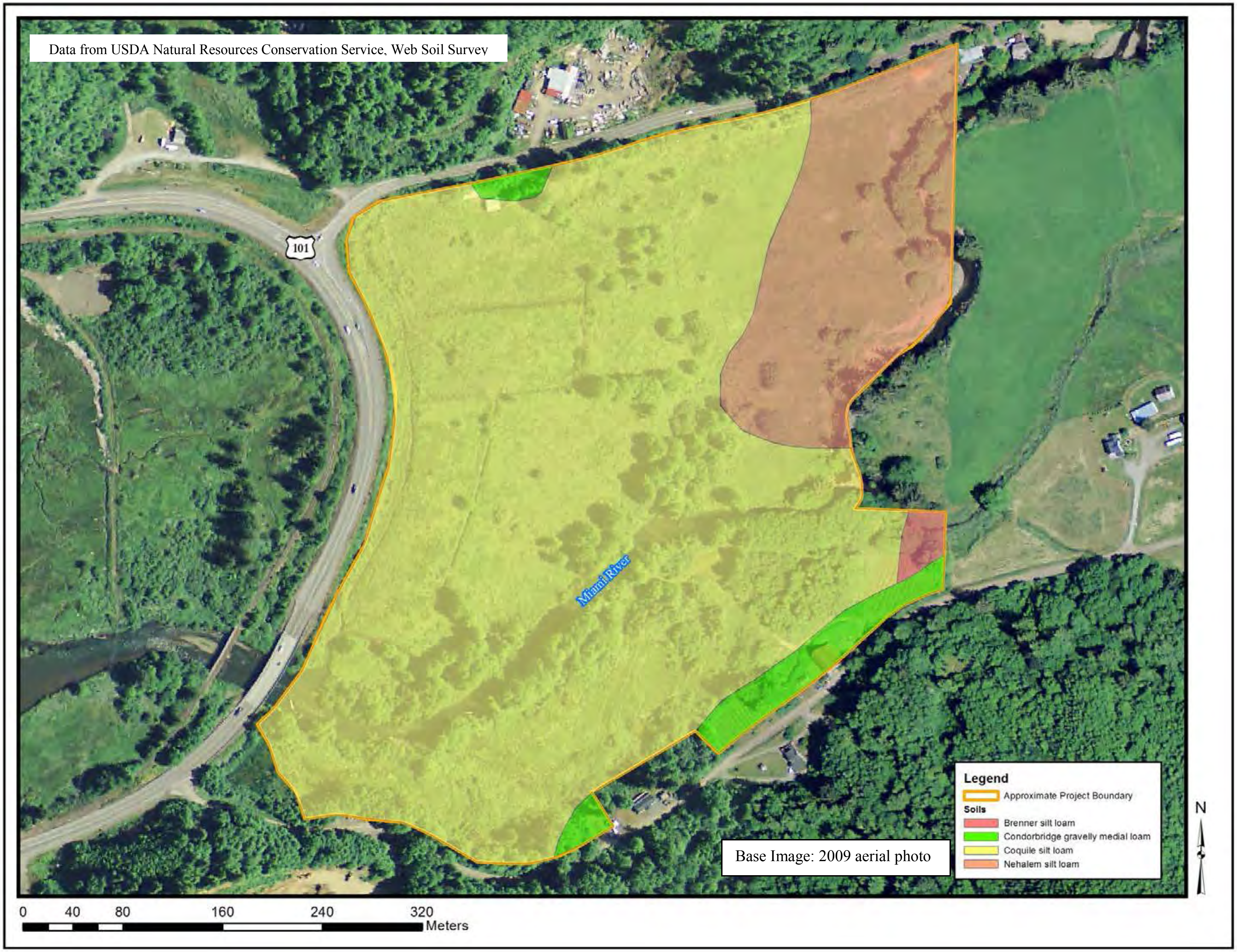


Figure 6. Approximate distribution of soil types within the Miami Wetlands site.

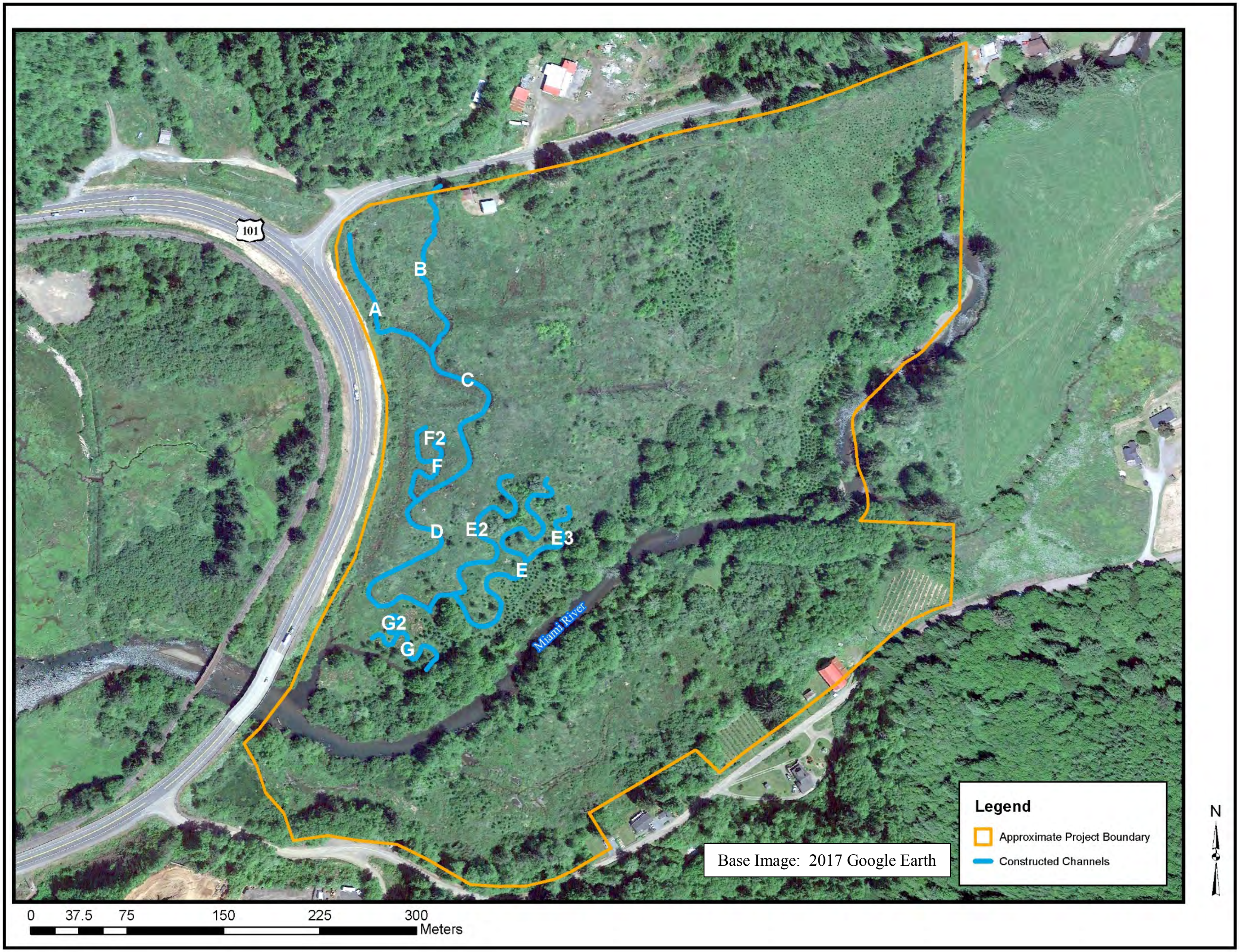


Figure 7. Channel system constructed on TNC parcel during restoration efforts.

- Placed 183 pieces of large wood in channels and on the floodplain on TNC and Crabb parcels,
- Constructed a low area crossing for landowner access on the Crabb parcel,
- Removed the overhead utility system that bisected the project area from southeast to northwest and moved it into an underground conduit running outside the site boundary, and
- Planted thousands of native trees, shrubs and herbaceous plants throughout the project area (including riparian areas along both banks of the Miami River, restored wetland areas and the upland area in northeastern TNC parcel). This action also included mechanical control of invasive, non-native plant species near planted specimens to reduce competition until the plantings were "free to grow." Mortality replacement planting in areas where survival of planted specimens was lower than desired also occurred (mortality generally due to changing hydrologic conditions associated with beaver activities).

Figure 8 provides a 2017 aerial image of the project. Changes in the site associated with the restoration project are evident in this photo, particularly when compared with the 2005 pre-restoration aerial included as Figure 5.

The remainder of this report will discuss methods used to evaluate the site and provide information on the current state of the site. It also provides comparisons with pre-project conditions and evaluates the efficacy of the project relative to its stated goals. Because the bulk of restoration actions occurred on the TNC parcel, our monitoring efforts have focused more on this parcel than the Crabb parcel.

2.0 Methods

This section summarizes the methods used to collect and analyze data on physical and biological attributes reported in this document. They are consistent with methodologies used for the baseline report on this project site (Bailey 2011). We established nine linear transects across the wetland restoration portions of the project site: six running approximately east-west on the TNC parcel and three running approximately north-south on the Crabb parcel. To improve data collection efficiency and allow us to look for relationships among studied variables, we collected the bulk of the data incorporated in this report along these transects (Figure 9).

2.1. Physical Attributes

We collected data on a variety of physical attributes at the site including ground water and surface water levels, water quality (temperature, conductivity and dissolved oxygen), soils (organic matter and salinity), and channel profiles. We obtained tide and precipitation data used in analyses from external sources, not on-site measurements. The following sections detail methods used to collect these physical data.

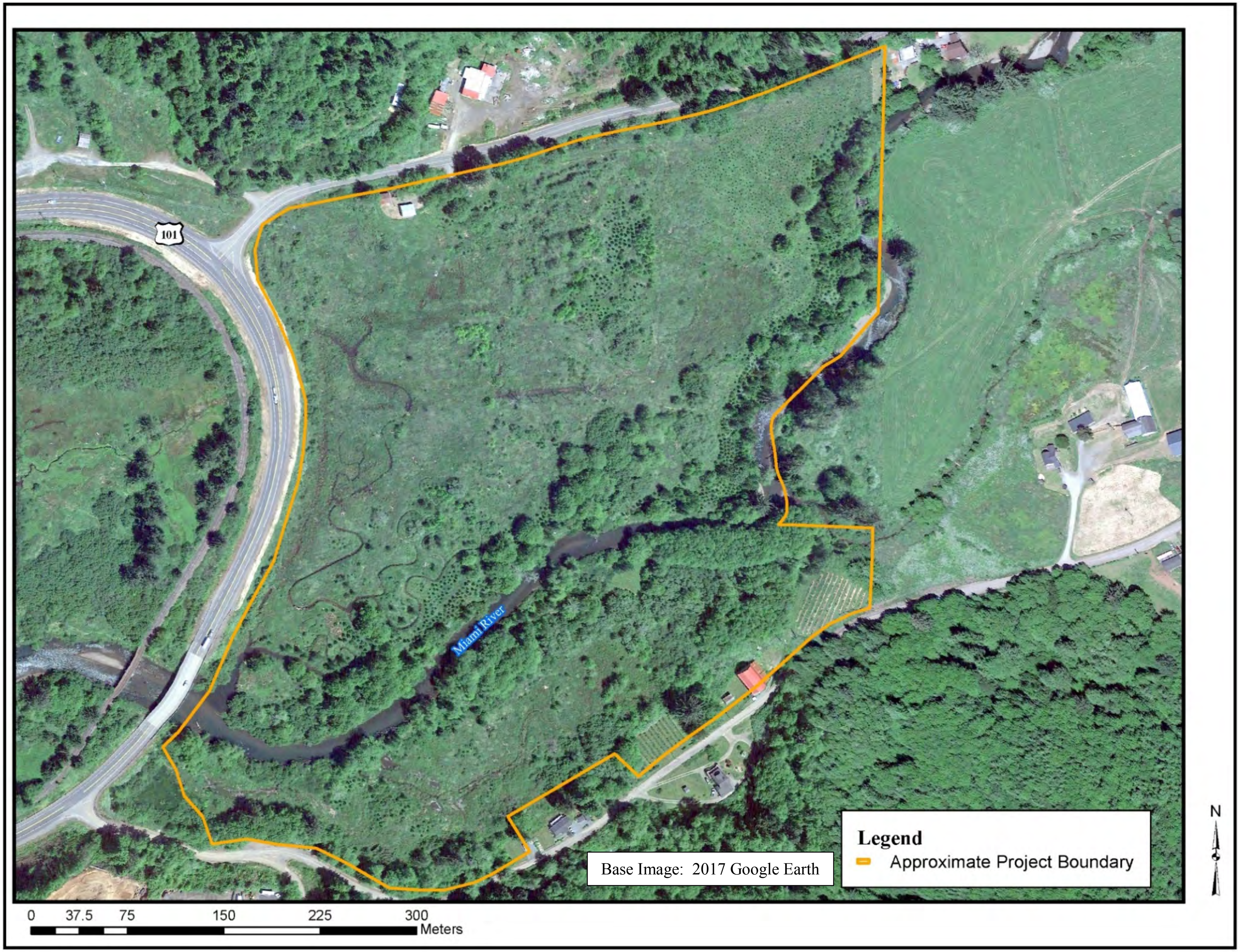


Figure 8. Post-project aerial photograph of Miami Wetlands (August 2017). Compare with Figure 5, pre-project aerial.

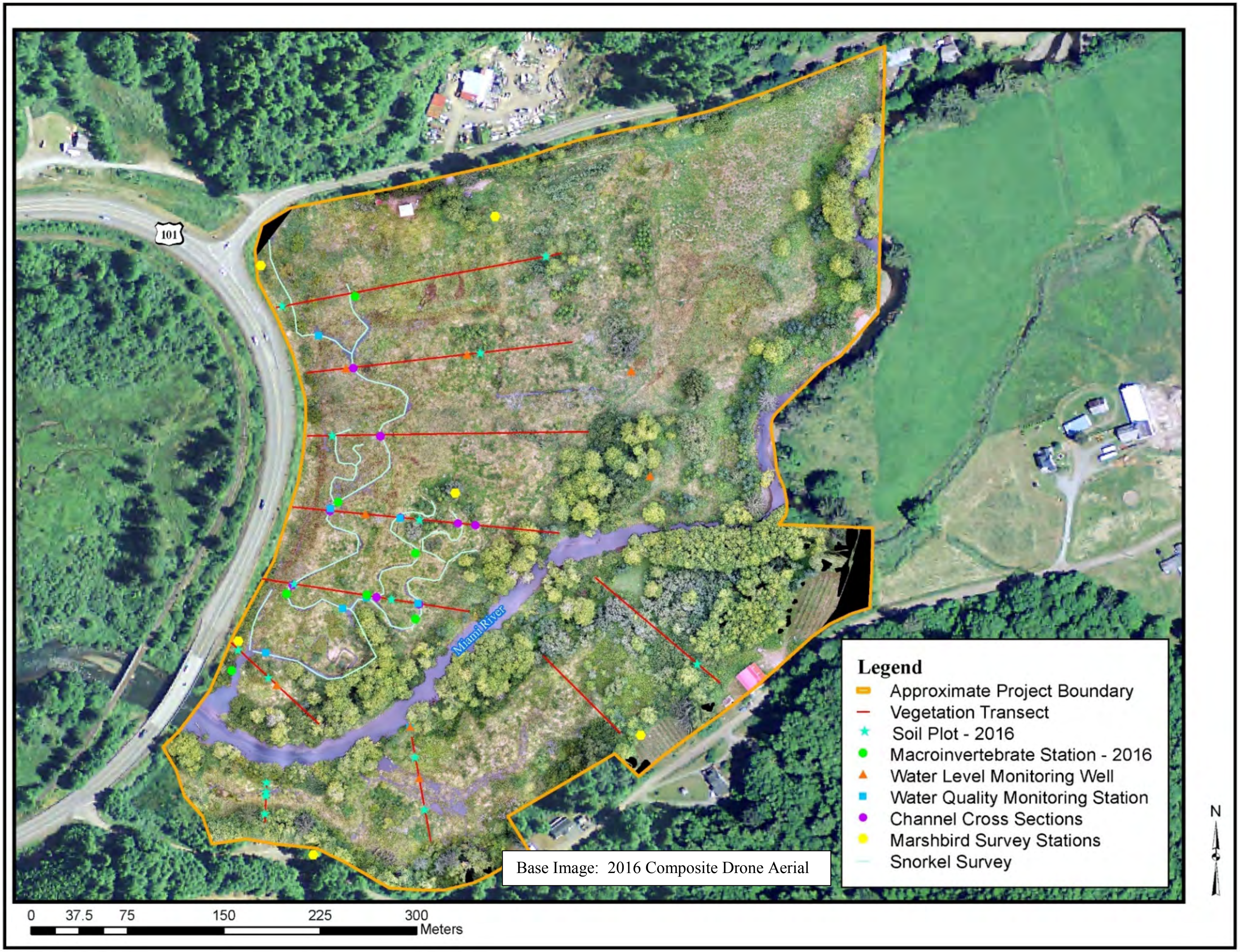


Figure 9. Transects and stations for data collection used to monitor several physical and biological attributes of Miami Wetlands site.

2.1.1. Tide and Weather Data

We used tide and weather data to help determine how tides, precipitation and air temperature influence water quantity and quality at the site. As noted above, we did not measure tide and weather data at the project site. Instead, we obtained these data from publicly available sources.

We obtained tidal data for the Garibaldi Tide Gage (Station ID: 9437540) from the National Oceanic and Atmospheric Administration (NOAA), Tides and Currents website (*https://tidesandcurrents.noaa.gov/waterlevels.html?id=9437540*). This gage is located at the Port of Garibaldi, a little over one mile west of the Project site (across the predominantly shallow Miami Cove portion of Tillamook Bay).

We obtained daily average air temperature and precipitation data through the Weather Underground website (https://www.weatherunderground.com). Unfortunately, only daily weather data (not hourly) was available, which limits statistical analyses using this data set. There are no official weather stations within the Miami Basin. As a result, we relied on data from the Tillamook Airport located approximately 11 miles southeast of the project site (Figure 10).

2.1.2. Water Elevation Monitoring

We collected hourly water elevation data at eight monitoring wells scattered throughout the project area (Figure 11, Table 1). All of the wells were installed before restoration was implemented. Two of the wells were installed by U.S. Fish and Wildlife Service (USFWS) staff in 2006 (LL-1 and LL-2) and the remainder (MW-4, 5, 6, 7, 9 and 12) were installed by VAI staff in 2008. Six other wells were measured manually (infrequently) during baseline data collection, but were not utilized during the work conducted for this report. They are not depicted on Figure 11, but are included in baseline report figures (Bailey 2011). Each well site was surveyed by VAI staff to establish its elevation and coordinates.

Table 1. Ground surface and logger sensor elevations for monitoring wells at the Miami Wetlands.

Well ID	Ground Surface Elevation* (ft)	Levelogger Sensor Elevation (ft)
MW-4	9.96	8.04
MW-5	9.90	7.98
MW-6	10.66	8.74
MW-7	10.69	8.77
MW-9	10.65	8.73
MW-12	8.50	6.58
LL-1	4.64	4.90
LL-2	5.10	5.54

*Elevation datum = NAVD88

LL-1 was located adjacent to the south bank and within the active channel of the Miami River and LL-2 within the pond/channel south of the river that is evident in the 1939 aerial photograph (Figure 3). These two wells were constructed from 1.5-inch, slotted, PVC pipe (four-foot long

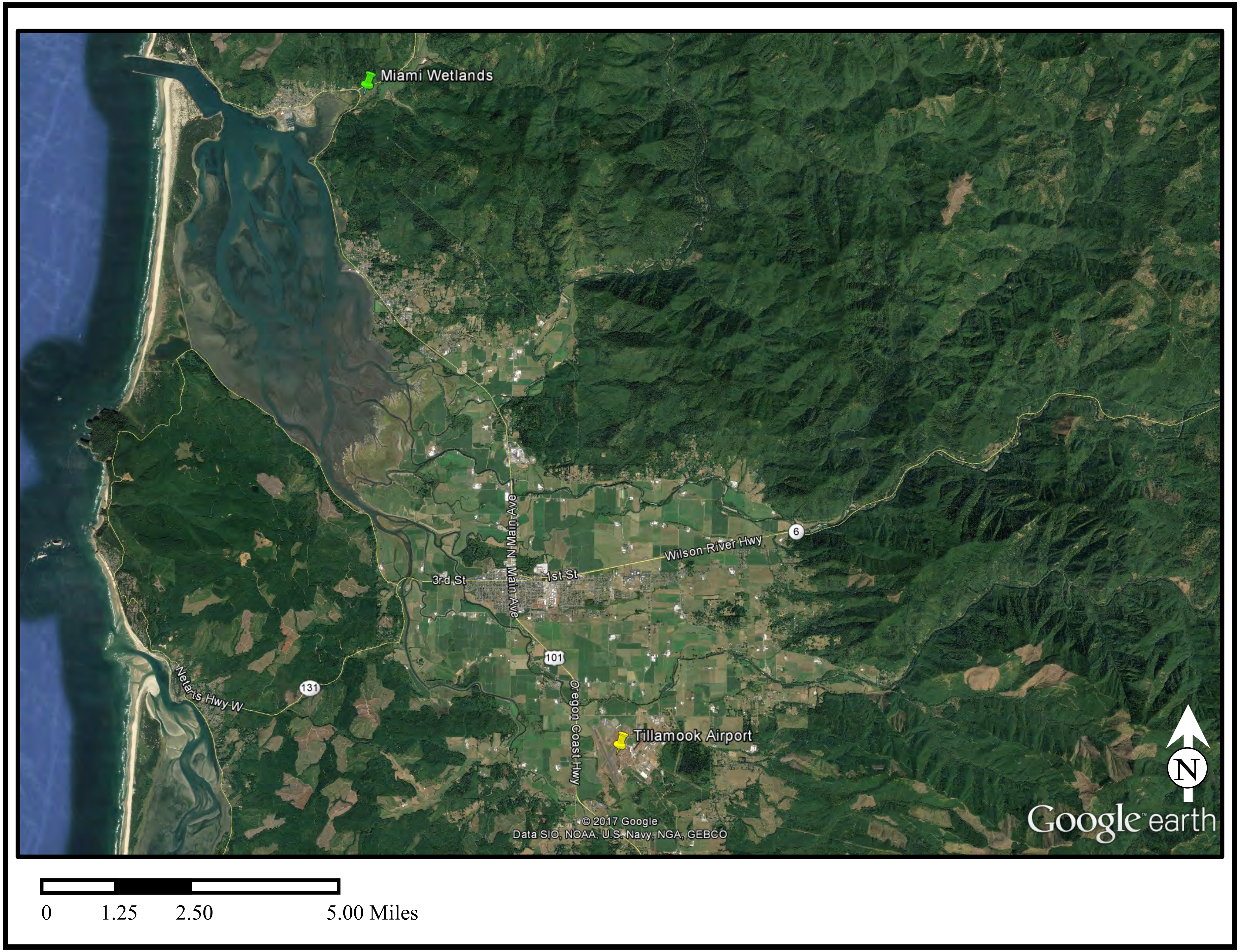


Figure 10. Location of weather station used to obtain air temperature and precipitation data used in some analyses.

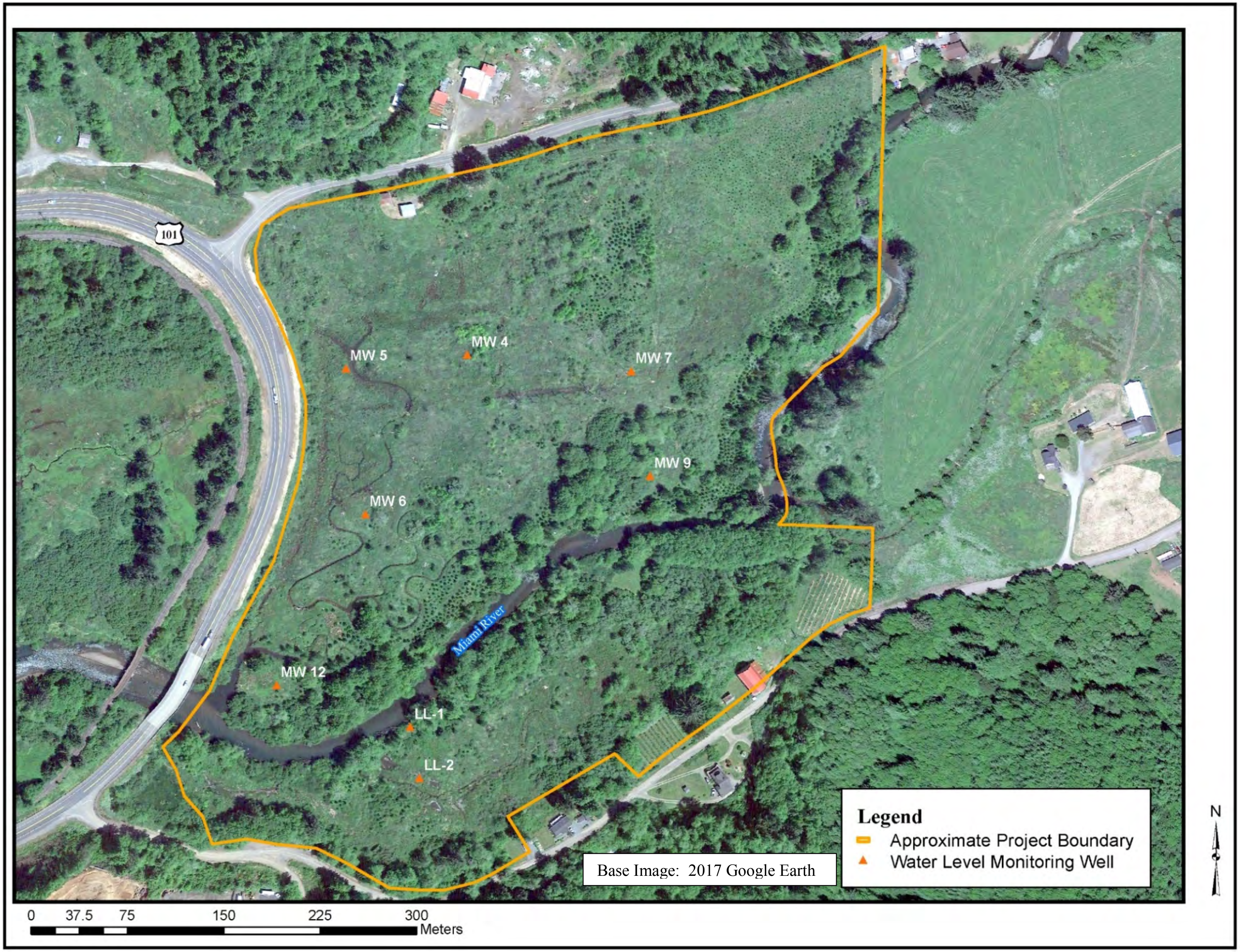


Figure 11. Locations of water level monitoring wells at Miami Wetlands.

pieces) held in place by two t-posts. These were installed such that the bottom of each pipe was level with the bottom of the channel in which it was located.

Unlike the USFWS wells which sampled surface water levels, the VAI wells (MW-4, 5, 6, 7, 9 and 12) were constructed to sample groundwater in areas outside of active stream/tidal channels. These wells were made from 1.5-inch, solid-wall PVC pipe (four foot pieces). The lower half of each pipe was perforated and the bottoms were capped. The pipes were installed such that the bottom two-feet was imbedded into the soil and top two-feet remained above ground. The imbedded portions were screened with filter sock and the ground surface around the well was sealed with bentonite. Each well was equipped with a continuous data logger (Solinst Model 3001 Levelogger Gold®, hereafter "levelogger"). During early baseline data collection, some leveloggers were programmed with a 15-minute sampling interval. However, the interval was extended to one-hour for the bulk of baseline data collection and this interval was maintained throughout post-construction monitoring.

Leveloggers have a pressure transducer that measures the collective pressure of the atmosphere and liquid above the sensor. As a result, atmospheric pressure data is needed to calculate the level of the liquid above the sensor. We deployed a continuous data logger to measure atmospheric pressure at the project site (Solinst Model 3001 Barrologger Gold®, hereafter "barrologger"). We programmed the barrologger with a sampling interval synchronous to the levelogger sampling interval. This provided for direct compensation of levelogger data with Solinst's Levelogger software. This proprietary software directly communicates with the loggers for evaluation, programming, and downloading of stored data. It also allows for easy and rapid compensation of levelogger data by subtracting atmospheric pressure measured with the barrologger from the collective pressure measured by the levelogger. The software also converts the levelogger pressure data and reports the height of the water column above the sensor in metric (cm) or standard units (inches).

We calculated water surface elevations by adding the recorded height of the water column above the sensor to the sensor elevation. We determined the level of the water surface relative to ground surface elevation by calculating the difference between the water surface elevation and ground surface elevation for each sample at each well site. We used a variety of statistical tests to analyze these data and reference these analyses, where applicable, in later sections.

Because all restoration engineering design and assessment work was completed in standard units (as opposed to metric), we elected to stay with these units for all elevation, height and distance measurements reported in this report.

2.1.3. Water Quality Monitoring

We collected data on three water quality parameters pre- and post-restoration: temperature, conductivity (salinity) and dissolved oxygen. We used continuous data loggers to collect this data for surface water at several locations on the TNC parcel (Figure 12). We used two RBR DO-1050® loggers and two Onset Hobo U26® loggers to collect dissolved oxygen data and four Solinst 3001 LTC Levelogger Junior® loggers to collect conductivity (salinity) data. The Hobo U26 and Solinst 3001 LTC also record temperature data. These loggers were hung in 4" perforated PVC pipe held in place in the channel with t-posts. The bottom of the PVC was capped and rested on the channel bottom. Loggers were hung such that sensors measured the lower 1-2 feet of the water column. Due to their limited number, we focused all of our efforts with these

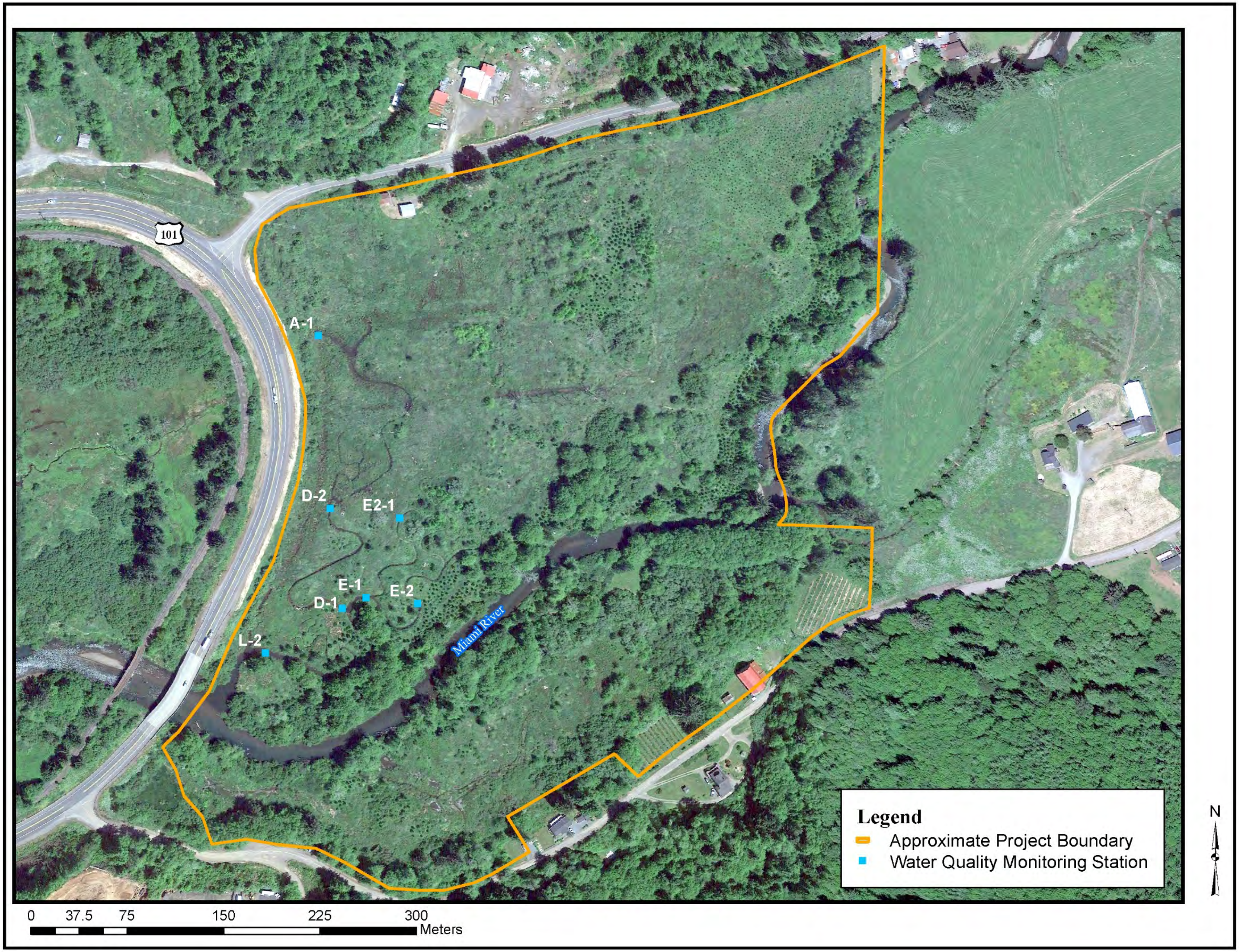


Figure 12. Locations of sampling stations for surface water quality at Miami Wetlands.

loggers in the newly constructed channel system on the TNC parcel (Hobson-Struby system [channels A, B, C, and D] and tidal channel system [E channels]).

In addition to the dissolved oxygen and conductivity loggers described above, we also obtained water temperature data at the water level monitoring wells discussed in Section 2.1.2 and depicted on Figure 10. The loggers deployed at these sites collected temperature data simultaneous to water level data. As noted above, two of these wells were located in open water channels (LL-1 and LL-2) and the remainder monitored ground water temperatures (MW-4 through 7, MW-9, and MW-12).

We did not collect continuous surface water dissolved oxygen (DO) and conductivity data over the course of our monitoring effort. Instead, we co-located a DO logger and a conductivity logger at sampling sites depicted in Figure 12 for several two-to-four week deployments each year. Since summer is when dissolved oxygen is most likely to drop to critically low levels for salmonids, we focused most of our sampling during this period. For comparison, we also completed several deployments during spring, fall and winter months. We did not have enough loggers to sample all sampling sites simultaneously. As a result, we sampled a different set of four sites during each deployment. For consistency, and to better understand tidal influences on the site, we deployed a paired set of loggers at station L-2 during most sampling periods. The three remaining logger pairs were alternated among the remaining stations, but we sampled some stations more frequently than others. Due to tidal influences, some sampling stations were located in channel sections that regularly drained and often did not have measurable surface water. Other stations were in channel sections that remained continuously-watered. We focused more sampling effort on the latter stations than those that drained regularly.

We compare our dissolved oxygen data to State of Oregon water quality standards (OAR 340-041-0016). For estuarine waters and waterbodies identified as providing habitat for cool-water aquatic life the dissolved oxygen concentration may not be <6.5 mg/L. For water bodies identified by Oregon Department of Environmental Quality (ODEQ) as providing habitat for cold-water aquatic life, the dissolved oxygen concentration may not be <8.0 mg/L. For water bodies identified as active spawning areas for anadromous salmonids and resident trout species (spawning through fry emergence periods) the dissolved oxygen content may not be <11.0 mg/L. Given the geographic location of the site and the salmonid habitats/life stages it supports, we felt that the estuarine/cool water standard of 6.5 mg/L was the most applicable for this study and so charts in this report present our data relative to this standard.

We used the salinity scale developed by Cowardin, et al (1979) to define water and soil salinity levels (Table 2). In charts included in this report, we present our data relative to reference points along this scale.

2.1.4. Soils

We collected soil samples at 16 locations during vegetation sampling completed in June 2016 (Figure 13). These samples were analyzed by A&L Western Agricultural Laboratories (Portland, Oregon [A&L]) for a variety of soil quality variables. We focused on two primary variables that we also analyzed during the pre-construction report for this project: organic matter and salinity. We did not analyze soil color or texture for this report, but did analyze these components for the pre-construction report. As with pre-construction sampling, all soil samples were obtained from within the top six inches of the soil profile and care was taken to exclude above ground organic matter.

Table 2. Cowardin salinity classes for wetland and deepwater habitats and NRCS Soil Salinity Classes.

	Cowardin			**NRCS**	
	Coastal Modifiers[1]	Inland Modifiers[2]	Specific Conductance (dS/m / µS/cm)	Specific Conductance (dS/m / µS/cm)	Soil Salinity Class
	Fresh	Fresh	<0.8 / <800	<2 / <2,000	Non-Saline
(Brackish)	Oligohaline	Oligosaline	0.8-8 / 800-8,000	2 to <4 / 2,000-<4,000	Very Slightly
(Brackish)	Mesohaline	Mesosaline	8-30 / 8,000-30,000	4 to <8 / 4,000-<8,000	Slightly Saline
(Brackish)	Polyhaline	Polysaline	30-45 / 30,000-	8 to <16 / 8,000-	Moderately Saline
	Euhaline	Eusaline	45-60 / 45,000-	>16 / >16,000	Strongly Saline
	Hyperhaline	Hypersaline	>60 / >60,000		

[1] Coastal modifiers are used for Marine and Estuarine systems.

[2] Inland modifiers are used for riverine, lacuastrine and Palustrine systems

[3] The term “Brackish” should not be used for inland wetlands or deepwater habitats.

2.1.4.1. Soil Organic Matter - A&L used the Loss-on-Ignition (LOI) method to analyze the 16 samples for percent organic matter. This method determines the amount of organic matter in a soil sample by calculating the weight change of the sample resulting from prolonged exposure to very high temperature (360 ^{o}C). Details regarding this method are included in the Soil, Plant and Water Reference Methods for the Western Region, 4th Edition, (Miller et al. 2013).

2.1.4.2. Soil Salinity - Soluble salt content of soils (soil salinity) is typically determined by examining the electrical conductivity (EC) of soil-deionized water solutions/extracts (ASCE 1990). As the salt load in the soil increases, the value for electrical conductivity also increases. A&L employed the Saturated Paste Extract (SP) method to assess soil salinity in the 16 samples we collected in 2016. Miller et al. (2013) provide details for this method. It provides a direct measure of total soluble salts in the soil because it closely approximates the water content of soils under field conditions, and the results are thought to be the best predictor of plant response. Most scientific literature reporting soil salinities present results based on this method.

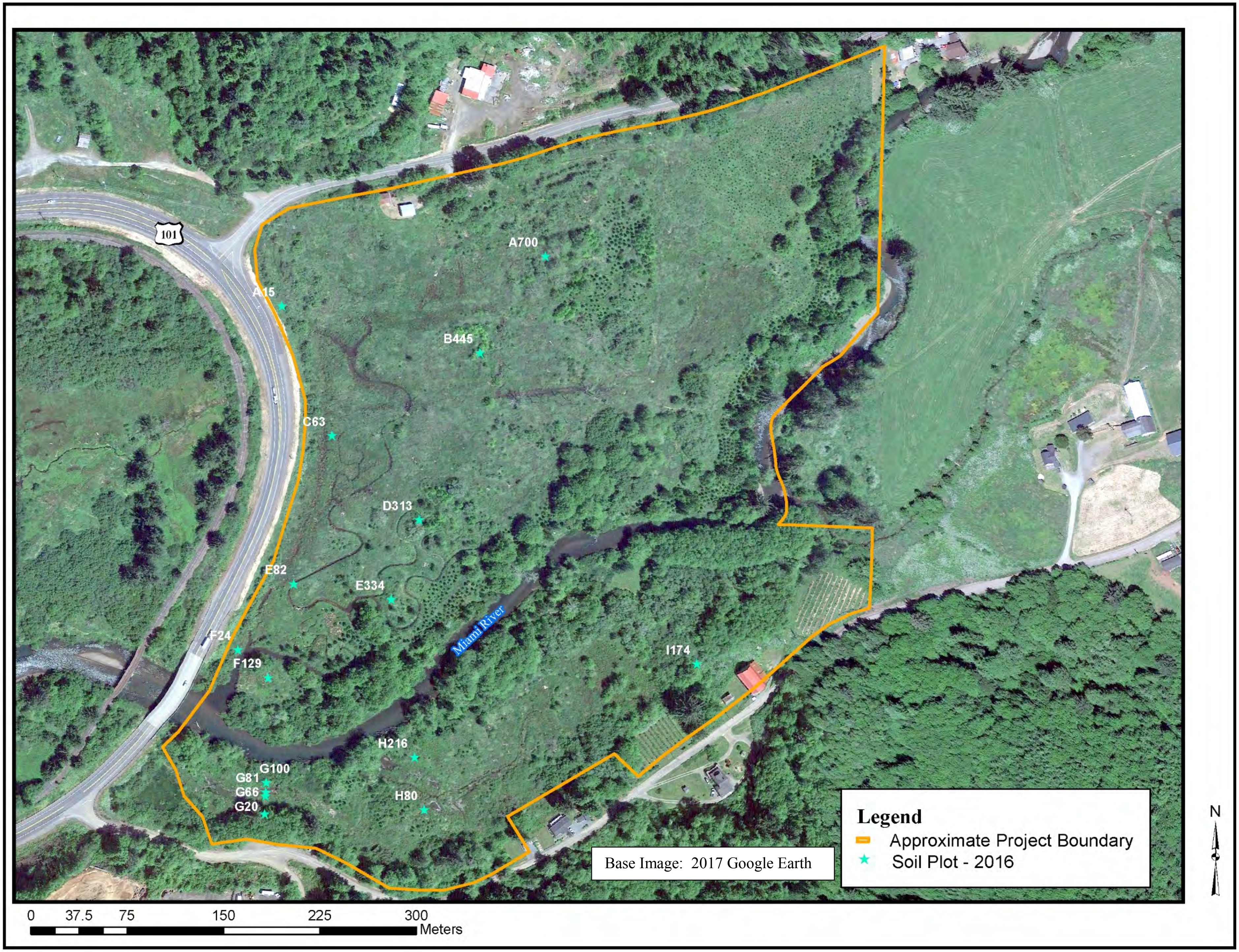


Figure 13. Location of soil organic matter and soil salinity samples collected June 2016 at Miami Wetlands.

For our pre-construction study, we tested soil salinity in-house using an alternative method to SP (referred to as $EC_{1:2}$ in Bailey 2011). We converted our pre-construction results with a regression equation for fine textured soils developed by Hogg and Henry (1984) to allow for comparisons with studies using the SP method, We reported both the measured electrical conductivity ($EC_{1:2}$) and converted values in deciSiemens per meter [dS/m] and microSeimens per centimeter (µS/cm). For this document we use the converted values reported by Bailey (2011) in comparisons of pre- and post-construction soil salinities at Miami Wetlands.

2.1.5. Channel Cross Sections

Bailey (2011) did not collect or report channel cross section data for the pre-construction channel system. However, in 2012 we began collecting cross sectional data to track the evolution of the channel system constructed during restoration of the TNC parcel. Cross sections were established where permanent monitoring transects on the TNC parcel crossed each constructed channel (figures 9 and 14). We did not collect channel cross section data on the Crabb parcel.

We established "permanent" end points for each cross section. At each site, we selected points several feet lateral to each channel bank and marked these points with rebar and a 5 ft section of 1" pvc pipe. We used an optical survey level and stadia rod to determine the elevation of the ground surface at each end point relative to previously established survey points.

During each sampling bout, we pulled a fiberglass measuring tape taut and level between the two markers. We recorded the distance from the tape to the ground surface at 0.5 ft intervals beginning at the marker on the right channel bank (as facing downstream) and ending at the marker on the left channel bank. We collected profile data during October 2012, August 2014 and January 2016. We were unable to measure channel cross sections immediately after their construction, so we use as-designed channel widths and elevations as comparison for our post construction profiles in later sections of this report.

2.2. Biological Attributes

We collected data on a variety of biological resources at the site including vegetation, macroinvertebrates, secretive marsh birds, and fishes. The following sections detail methods used to collect and analyze data for these resources. In addition to the formal data collection efforts detailed below, we often made observations incidental to other activities at the site and refer to this information in discussions later in the document.

2.2.1. Vegetation

Bailey (2011) reported on several aspects of the vegetation that occurred on-site before restoration was implemented. In brief, that work developed a plant list and plant community descriptions, provided a variety of information on the distribution, structure and composition of on-sight vegetation and produced a pre-restoration vegetation community map for the site. For our post-restoration studies, we repeated the methods and analyses employed during the pre-construction work and sampled survival of native species planted as part of the restoration effort. This work allows us to quantify changes to vegetation that have occurred since enhancement actions concluded and evaluate the success of our restoration planting work.

All vegetation data was collected along the linear transects discussed earlier. We used several different field methods to obtain data on species composition and distribution, relative

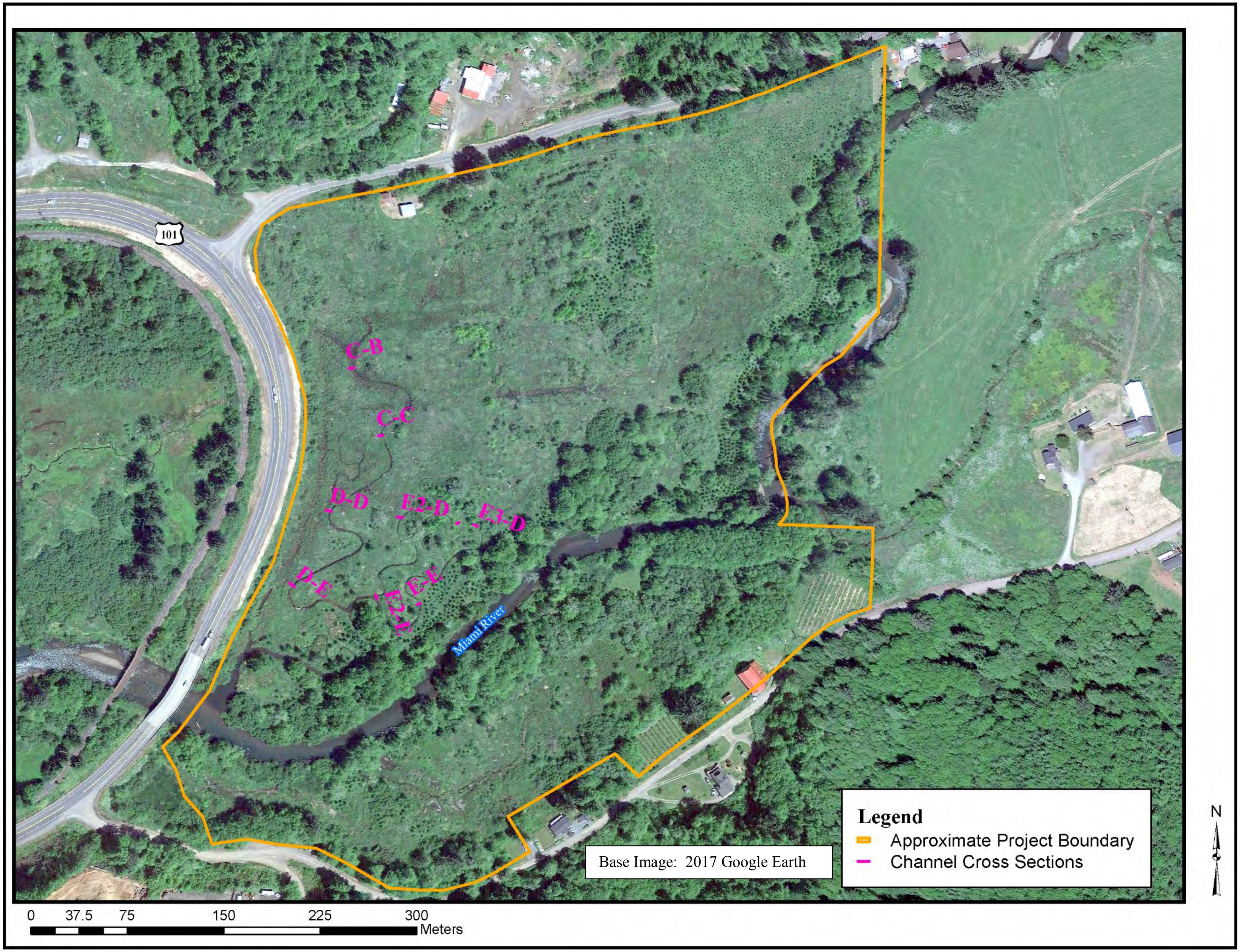


Figure 14. Location of channel cross section sampling stations at Miami Wetlands.

abundance, and cover: line-intercept, 1-m^2 quadrats for herbaceous species, and 5m radius circular plots for tree and shrub species. Survival of restoration plantings was assessed through data collected in 0.1 acre circular plots. The following sections describe these data collection methods and the analyses performed with the data. We used this information along with interpretation of repeat aerial and ground-based photography to revise the vegetation community map of the site developed through baseline studies.

2.2.1.1 Line Intercept - Line intercept data was collected along the entire length of each transect depicted in Figure 9 during June 2012, 2014 and 2016 (figures 15-18). This method typically is used to evaluate foliar cover and species composition (by cover) for shrubs, trees, grasses, and forbs and consists of horizontal measurements of plant intercepts along a tautly stretched tape measure. It is best suited for use in plant communities where individual plants are easy to distinguish and (as typically implemented) is less well-suited for use in dense grasslands or other communities where it is difficult to discern individual plants. The Miami site is densely vegetated (cover is very high over the entire site) and often there are multiple species growing together, their foliage intermingled. As a result, we modified the method to meet our purposes.

Typically, line-intercept transects are 50-100 m long, but because we wanted to understand the gross distribution and composition of vegetation at the site we completed the method along the entire length of the data collection transects that had been established during the early planning stages of the project (Figure 9). Rather than record each individual intersect (something that would have been impossible in the dense and tangled vegetation on the site) we recorded intercepts of clusters or clumps of similar vegetation. For example, Reed Canary-grass (*Phalaris arundinacea* - PHAR) and Slough Sedge (*Carex obnupta* - CAOB) were common on the site. Each species occurred as single-species clusters and together in mixed-species clusters, with one or the other species being dominant. These different clusters often occurred along a single transect, transitioning from one to another. As the tape passed through these areas we would record the beginning and end of each cluster that intersected the tape (e.g., PHAR, PHAR/CAOB, CAOB, CAOB/PHAR). Where transects crossed open water (with no overhanging vegetation) we recorded "open water." We encountered a few areas with sufficient bare ground to warrant recording "bare ground". We recorded tree and shrub species encountered along transects, but in many cases these species were overhanging areas where other species clearly provided the greatest ground cover (e.g., a tree branch overhanging a very, dense patch of slough sedge). In such cases, the species that clearly provided the dominant ground cover was considered dominant in our analysis (and for presentation purposes in this report – see below). Tree and shrub species were considered dominant for analysis purposes only when they were the only species encountered or when understory vegetation beneath them was sparse.

We entered line intercept data for each transect into an Excel® spreadsheet for analysis. We calculated Percent Total Cover for each dominant species by dividing the total of all intercepts for that type by total transect length and multiplying by 100. We calculated Percent Relative Cover for each vegetation type by dividing the sum of the encounters for each type by the sum of all vegetation intercepts (open water and bare ground were excluded for this analysis) and multiplying by 100.

For the results section of this report, in addition to providing text and summary tables for the line-intercept data we also used ArcGIS® software to visually display the data. We created

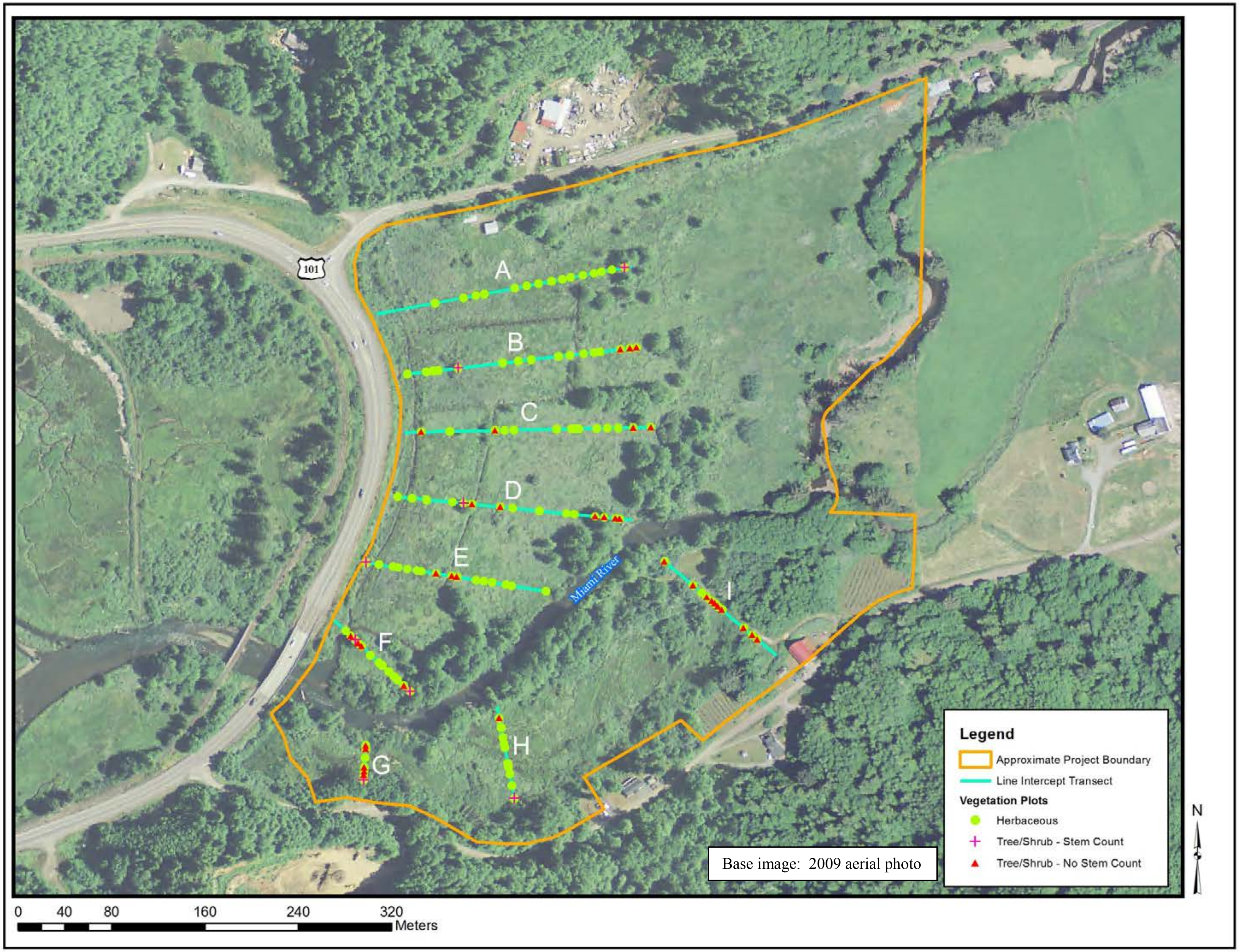


Figure 15. Line-intercept transects and vegetation sampling plots completed June 2010 for baseline studies at Miami Wetlands.

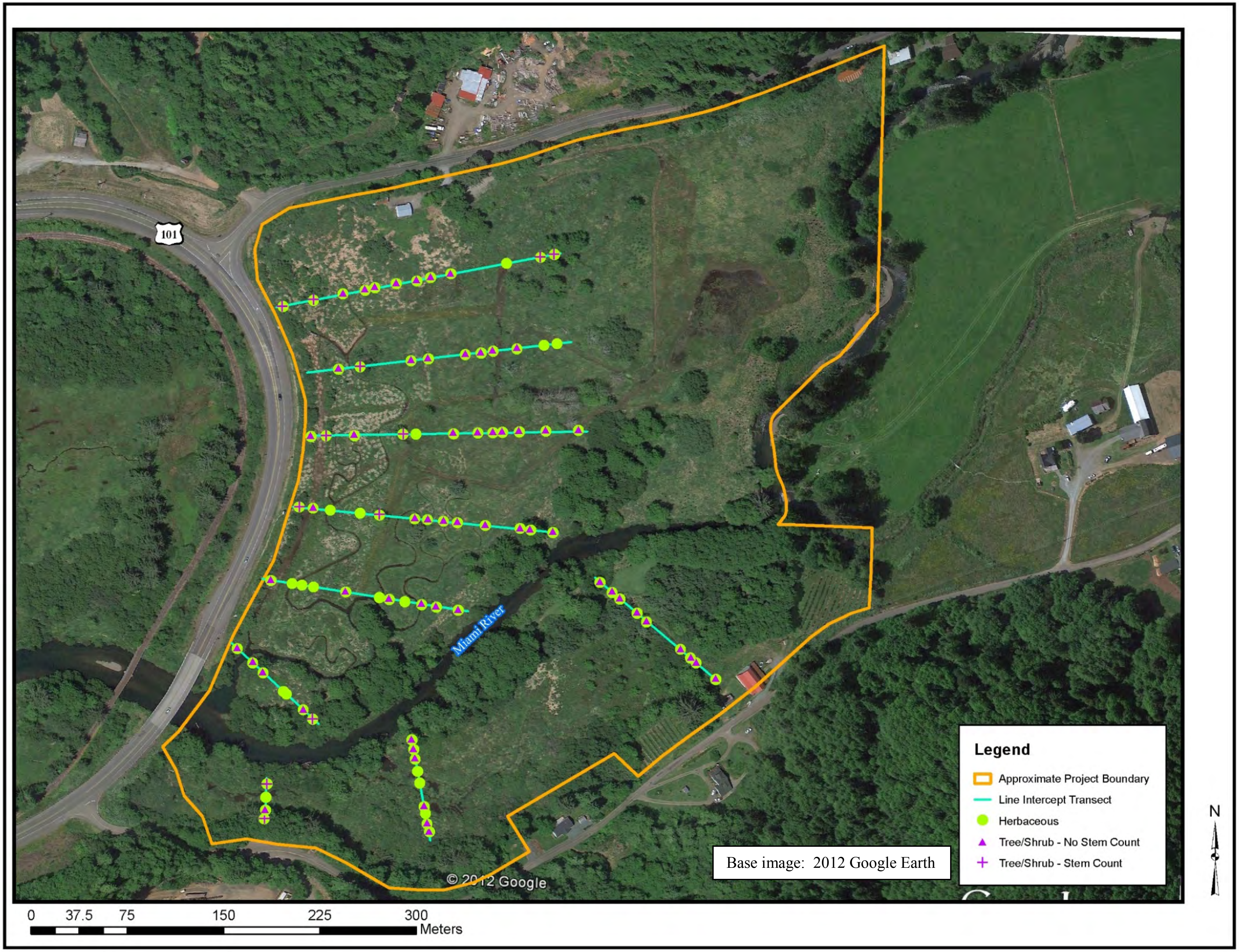


Figure 16. Line-intercept transects and vegetation sampling plots completed during June 2012 for post-restoration studies at Miami Wetlands.

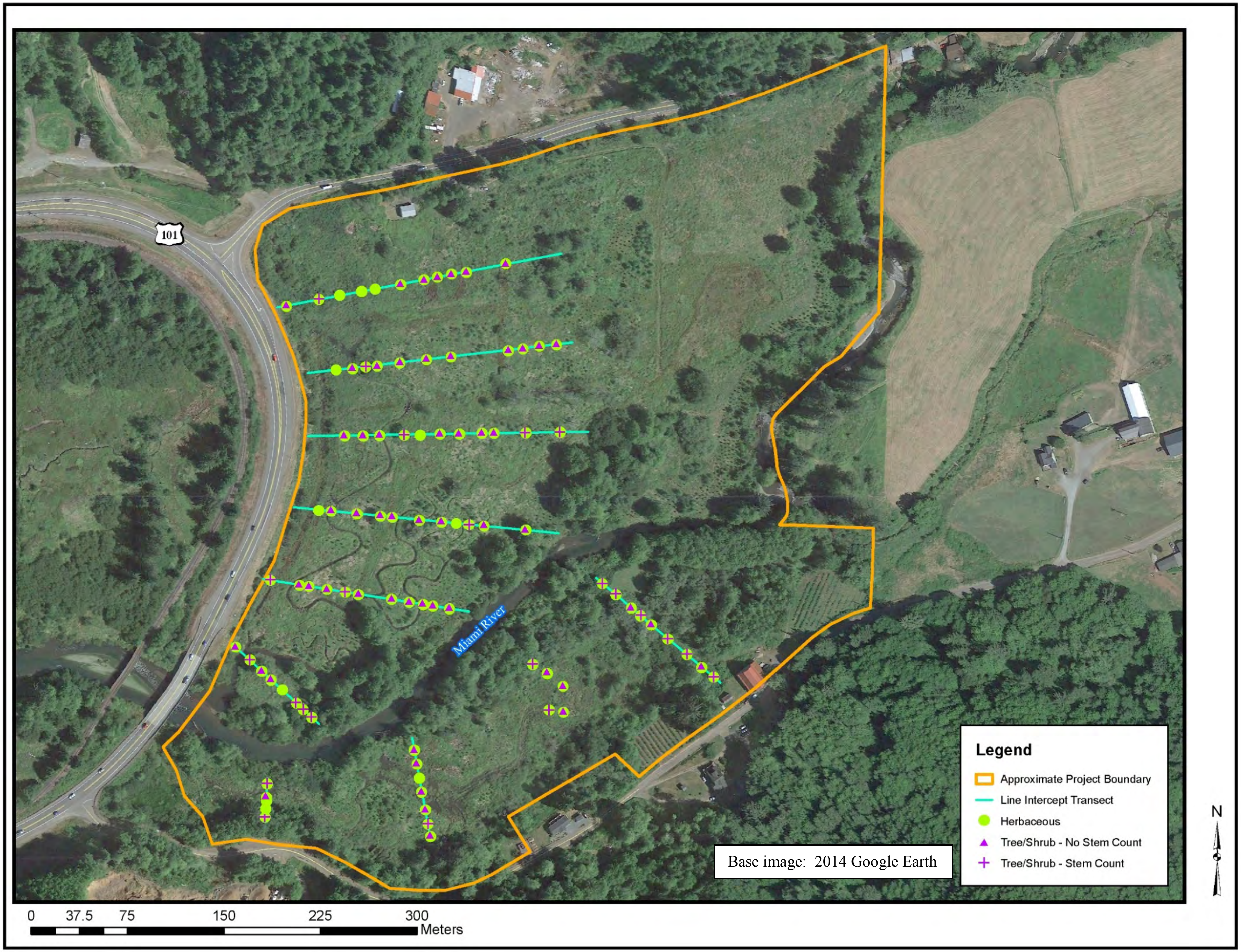


Figure 17. Line-intercept transects and vegetation sampling plots completed during June 2014 for post-restoration studies at Miami Wetlands.

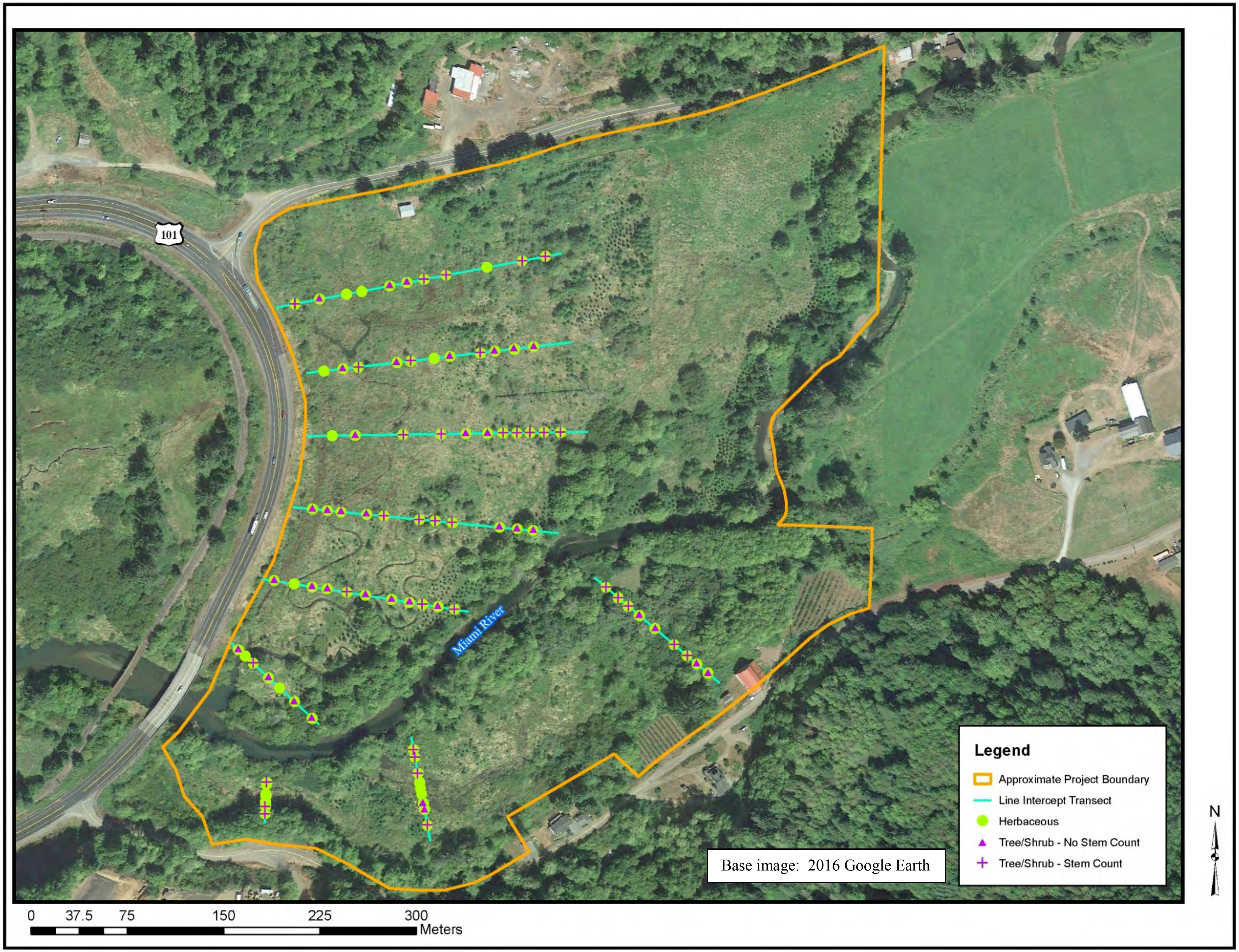


Figure 18. Line-intercept transects and vegetation sampling plots completed during June 2016 for post-restoration studies at Miami Wetlands.

segmented polylines in which each recorded intercept is identified as a unique segment based on the dominant species encountered. Each segment is colored based on a color-coding scheme with a unique color for each dominant species. Color-coding is consistent among the four separate line-intercept data sets we present in this fashion.

We recognize that the above methodology provides an oversimplified view of plant community composition and does a poor job of capturing and expressing the variation and complexity of vegetation at the site. However, we believe it has value in that it provides for a solid understanding of the distribution of dominant plant species and a good estimate of vegetative cover over a large portion of the site. We utilized other methods to better understand and evaluate the variation and complexity of vegetation at the site (see below).

2.2.1.2 Nested Vegetation Plots – We used a nested-plot vegetation sampling protocol to further assess herbaceous and woody vegetation at the site. An herbaceous vegetation sample was taken at all nested-plot locations. If woody vegetation greater than 1m tall was present within a 5 meter radius of a point, we also completed a tree/shrub plot. If trees >3 cm diameter at breast height (dbh) occurred within the 5m radius plot, we mea

For each of our sampling bouts (2010, 2012, 2014 and 2016), we selected nested-plot locations before implementing field work. We used a random number generator to identify plot locations (based on distance from the transect starting point) for each transect (up to 15 plot locations per transect in 2010 and up to 11 in subsequent years). During the selection process, randomly generated points were added to the list of potential plot locations if they were at least 5 m from previously selected points (to avoid overlap of the 5-m circular plots which, if sampled, were centered on the same points). During each year, we added a few randomly selected locations that did not meet the above distance criteria to the list of potential plot locations used to guide field work. These served as back-up locations in case field conditions made it impossible or impractical to use of one or more of the primary plot locations. Figures 15-18 depict the locations of nested vegetation plots completed during pre- and post-restoration monitoring efforts in 2010, 2012, 2014 and 2016. The following sections further describe this plot methodology.

2.2.1.2.a 1m^2 Herbaceous Vegetation Plots – We sampled herbaceous vegetation using 1-m^2 quadrats constructed from ¾” PVC pipe to delineate plot boundaries. At each plot location, we aligned the bottom left corner of the quadrat with the randomly selected point on the fiberglass measuring tape (laid out as described in section 2.2.1.1). We identified all herbaceous plant species within the quadrat to species (except when lack of key characteristics precluded identification to this level[1]) and visually estimated the percent cover associated with each species. Woody plants less than one meter in height were included in this assessment. We also estimated the percentage of bare ground, organic litter, and open water within each plot. We entered all data from these plots into an Excel® spreadsheet file for further analyses.

We used information collected in 2016 using this and other vegetation sampling methods, along with review of aerial photographs and on-the-ground visual assessments, to revise the plant

---

[1] Because this work was done during late spring (before some key diagnostic features typically develop), some plants were only identifiable only to genus.

community distribution map created for the baseline report (plant communities were differentiated based primarily on species dominance and diversity - see Results).

After revising the plant community distribution map, we assigned each $1m^2$ plot (2016 data only) to a specific plant community based on where the plot occurred relative to the revised map. This allowed us to calculate mean Percent Total Cover and mean Percent Relative Cover for each herbaceous species in each community. We also calculated Species Richness, two diversity indices (Simpson's Index of Diversity and Shannon-Weiner Index), and Evenness for each identified plant community.

Species Richness (S) is the simplest of all the measures of species diversity. It is simply the number of species found in a community. As such, this measure does not indicate how the diversity of the population is distributed among those particular species.

Simpson's Index of Diversity (D) is a measure that accounts for both species richness and the relative abundance of each species in a community. This index represents the probability that two individuals randomly selected from within a community will belong to different species. In this equation, D ranges from 0.0 to 1.0, with 0.0 representing no diversity and 1.0 representing infinite diversity. As species richness and evenness increase, diversity increases. The formula for Simpson's Index of Diversity is:

$$D = 1 - \frac{\sum_{i=1}^{S} n_i \,(n_i - 1)}{N(N-1)}$$

where *S* is the number of species (Species Richness), *N* is the mean Percent Total Cover for the community and *n* is the mean Percent Total Cover of a species within that community.

The Shannon-Wiener Index (H') is a diversity measure that originated with information theory and is based on measuring the uncertainty observed within a particular system. Like Simpson's index, this index accounts for both abundance and evenness of the species present. The degree of uncertainty of predicting the species of a random sample is related to the diversity of a community. If a community is overwhelmingly dominated by one species (low diversity), the uncertainty of prediction is low (a randomly-sampled species is most likely going to be the dominant species). However, if diversity is high, uncertainty is high. For ecological studies, the value of the index typically ranges from 0.0 (low diversity) to 4.0 (high diversity).

The formula for the Shannon-Wiener Index is:

$$H' = -\sum_{i=1}^{S} p_i \, lnp_i$$

where *S* is the number of species (Species Richness), p_i is the proportion of the total sample belonging to the *i*th species, and *ln* is natural logarithm.

Evenness (E) is a measure of how similar the abundance of different species is within a community. The value for this measure ranges from 0.0 to 1.0, with 1.0 being complete evenness. Evenness (*E*) is computed using species richness (S) and the Shannon-Wiener index (H').

The formula for Evenness is:

$$E = H'/lnS$$

where *H'* is the Shannon-Wiener Index Value, *S* is the total number of species (Species Richness), and *ln* is natural logarithm.

2.2.1.2.b 5m Radius Tree and Shrub Plots – If woody plants greater than 1m tall were present within 5m of a point, we completed a 5m circular plot. When reading these plots, we estimated Percent Canopy Cover for each woody species rooted within the plot boundary. When trees or shrubs with >3cm diameter at breast height (dbh) occurred within the 5-meter radius plot, we counted all rooted stems and measured diameter at breast height (DBH) for each one >3cm dbh. We placed each measured stem into one of five dbh size classes (Class 1 = 3-15cm, Class 2 = 15-30cm, Class 3 = 30-50cm, Class 4 = 50-90cm and Class 5 = 90+cm). On figures 15-18 we depict plots without dbh data with a solid triangle (▲) and those where dbh data was collected with a plus sign (+).

We completed many of the same analyses for this data that we did for the 1m^2 herbaceous plot data discussed above. Together these data sets were used to describe vegetation communities on the site.

2.2.1.4 Restoration Planting Survival Monitoring – Our post-project monitoring efforts included a specific effort to monitor the survival of the wetland and riparian restoration plantings that were part of the overall restoration effort for the Miami project. Because Bailey (2011) reported pre-restoration baseline conditions, protocols used to assess restoration planting survival are not described in that document.

Wetland plantings have occurred on approximately 23 acres of the site and riparian plantings on approximately 10.5 acres. Planting in both wetland and riparian zones was completed in areas on both sides of the Miami River (Figure 19). We monitored our revegetation efforts to determine if and where mortality replacement planting may have been needed and to assess the performance of the various species used for replanting. Survival monitoring was completed within this approximately 34-acre portion of the site during each fall 2011 through 2016.

Within the approximately 23 acres wetland planting zone we planted thousands of native trees, shrubs and herbaceous wetland plants. As a result, it was not possible to track the fate of each individual plant used for the replanting effort. Therefore, we used 0.1 acre circular plots (37.2 ft radius) to sample the wetland planting zones and estimate survival for each species. Like most other monitoring efforts at the site, we sampled the wetland planting zones primarily along permanent monitoring transects established during baseline data collection efforts (see Figure 9). For all annual sampling efforts, the center point for each of the plots along transects was randomly selected before beginning field work. We used a random number generator to select the distance of the plot center points from the

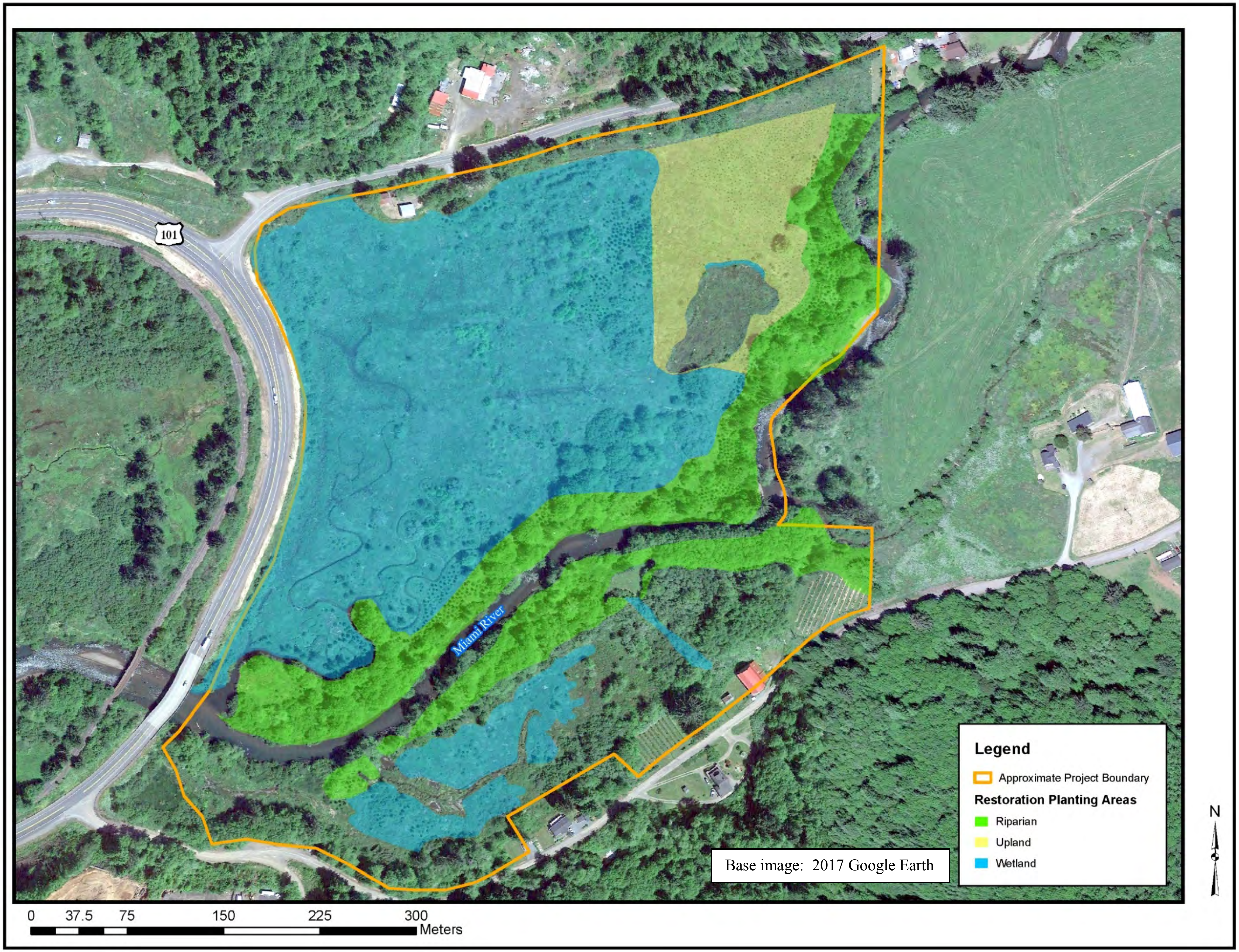


Figure 19. Restoration planting zones at Miami Wetlands.

transect starting points (transects north of the river run from west to east and transects south of the river run from south to north). Randomly generated locations that were less than 80 ft from previously selected plot locations were discarded (to avoid plot overlap). While in the field, we navigated to each of these points with a handheld GPS and used a 37.2 ft length of rope to define the plot limits. One crew member held one end of the rope at the randomly selected point and recorded data, while the other crew member pulled the rope taut and assessed the status of all planted specimens within the 37.2 ft radius (0.1 acres) defined by the length of rope.

During each year of our survival monitoring effort, we also sampled additional plots in wetland planting areas on the Crabb parcel that were not located along the previously established transects. Due to the network of watercourses in this portion of the project site, we were unable to safely access substantial sections of the permanent monitoring transects during our fall survival monitoring. As a result, we needed to establish addtional plots to bolster the the number of plots south of the river. Unlike plot locations along the permanent transects, these plot locations were not randomly selected before beginning field work. Instead, we selected these locations in the field. To select plot center points, we stood within areas between the permanent transects where plantings had occurred and tossed a pencil with flagging tied to it over our shoulder into the air. The spot where the marked pencil landed was used as the plot center point. Once the plot center location was picked, we assessed the status of all planted specimens within a 0.1-acre circular plot as described above. Restoration construction continued into summer 2011, so spring 2011 plantings were limited to areas that would not be impacted by the yet to be completed construction activities. As a result, we completed only 20 survival monitoring plots during the fall 2011 sampling effort. Because additional areas were planted during subsequent years, we increased the number of plots for the 2012-2016 sampling efforts to between 28 and 34 plots per year. Figure 20 depicts plot locations for all years of post-restoration survival monitoring.

We did not sample 0.1 acre plots to track survival of our restoration plantings in the approximately 10.5 acre riparian planting zone. Because of the size and configuration of riparian planting areas, and because we planted fewer individual plants and only tree and shrub species were used, we we able to complete an annual census of these areas to track survival for these plantings. We conducted this census each year from 2011-2014.

In 2013, an approximately 3-acre upland area in the northeast portion of the site was planted by TNC. This area was outside our original wetland and riparian restoration areas and, as a result, we did not monitor survival for plantings in this area (but these plantings are visible on recent aerial images of the site).

2.2.2. Macroinvertebrates

Macroinvertebrates include freshwater insects, crustaceans, mollusks, bivalves and other invertebrates greater than one half millimeter in size. They play important roles in food chains and ecosystem processes, are easy to collect and inexpensive to process and analyze, and show strong responses to many stressors. As a result, macroinvertebrates are commonly used for assessing the biological integrity of aquatic systems.

For baseline, we sampled aquatic macroinvertebrates at seven locations where our study transects crossed the channels on the TNC parcel. For this report, we collected macroinvertebrate samples on May 11, 2016 at seven locations where our study transects crossed constructed channels on the TNC parcel (Figure 21). During both sampling sessions, we also collected water quality data (salinity/conductivity, dissolved oxygen, and temperature) using handheld meters at each macroinvertebrate sample site. We followed the same collection and post-collection methodologies (summarized below) for the baseline and post-restoration efforts.

We used methodology similar to that described by Mazzacano (2009) to collect macroinvertebrate samples. We used a one foot wide D-frame dip net with 500 µm mesh to collect the samples. At each station, we collected a composite sample of nine separate one meter long net sweeps (all collected from along the bank on which we were standing). Individual sweeps were spaced 1 meter apart, beginning four meters downstream of the transect crossing point and ending four meters upstream of the crossing point (a nine meter bank segment). For each sweep, we pulled the net from the bottom of the channel upwards for one meter along the soil bank material and into the submerged lower portion of bankside vegetation.

To reduce the volume of very fine sediment in the net bag after all of the composite sweeps were taken, we submerged the bottom of the net bag in the water and gently stirred the contents while swirling and bouncing the net in the water. Samples were placed in a bucket and the net was rinsed with clean water over the bucket. Any fish or amphibians were removed, and larger pieces of debris were rinsed and discarded. The material was then poured through a sieve with 500 µm mesh, and rinsed to further remove fine sediment. To avoid introducing additional invertebrates into the sample, all rinse water (collected from the adjacent channel) was poured through a 500 µm mesh sieve prior to use. Following these procedures, the sample material was transferred to a one-liter Nalgene jar and 95% ethanol was added as a preservative. For maximum preservation, sample volume comprised no more than 75% of the jar and ethanol was added until the container was at maximum capacity. After an approximately 24 hour period, the ethanol in each sample was poured off and replaced with fresh ethanol.

For the post-restoration effort, we sent the preserved samples to Cole Ecological, Inc. in Greenfield, MA (CEI) for processing and classification. CEI first sorted a 300-organism subsample from each sample using a 30-square Caton gridded tray (Caton 1991) or an 8-cell sieve. The protocol called for use of the entire sample if the 300-organism threshold could not be be reached in a subsample. However, all post-restoration samples had greater than 300 organisms and so subsamples were used for all subsequent work. Organisms in each subsample were sorted into a series of vials, arranged taxonomically. Following subsampling, a scan was performed for a maximum of 15 minutes on the remaining material from each sample site to remove representative specimens of any larger taxa that were not encountered during subsampling. Large/rare organisms were placed in a separate vial. Following sorting, CEI identified macroinvertebrates from the sorted subsamples to the lowest practical levels of taxonomic resolution. Target taxonomic levels were generally genus/species for most aquatic insects (as much as condition and maturity allowed), family/genus/species for mollusks, order for microcrustaceans, genus/species for crustaceans, order for mites (Trombidiformes), and class for aquatic worms (Oligochaeta). Samples were all identified by SFS-certified taxonomists, Ann Gregoire and Michael Cole[2]. CEI entered raw taxonomic and count data into an Excel®

[2] Michael Cole also completed identifications for our baseline report.

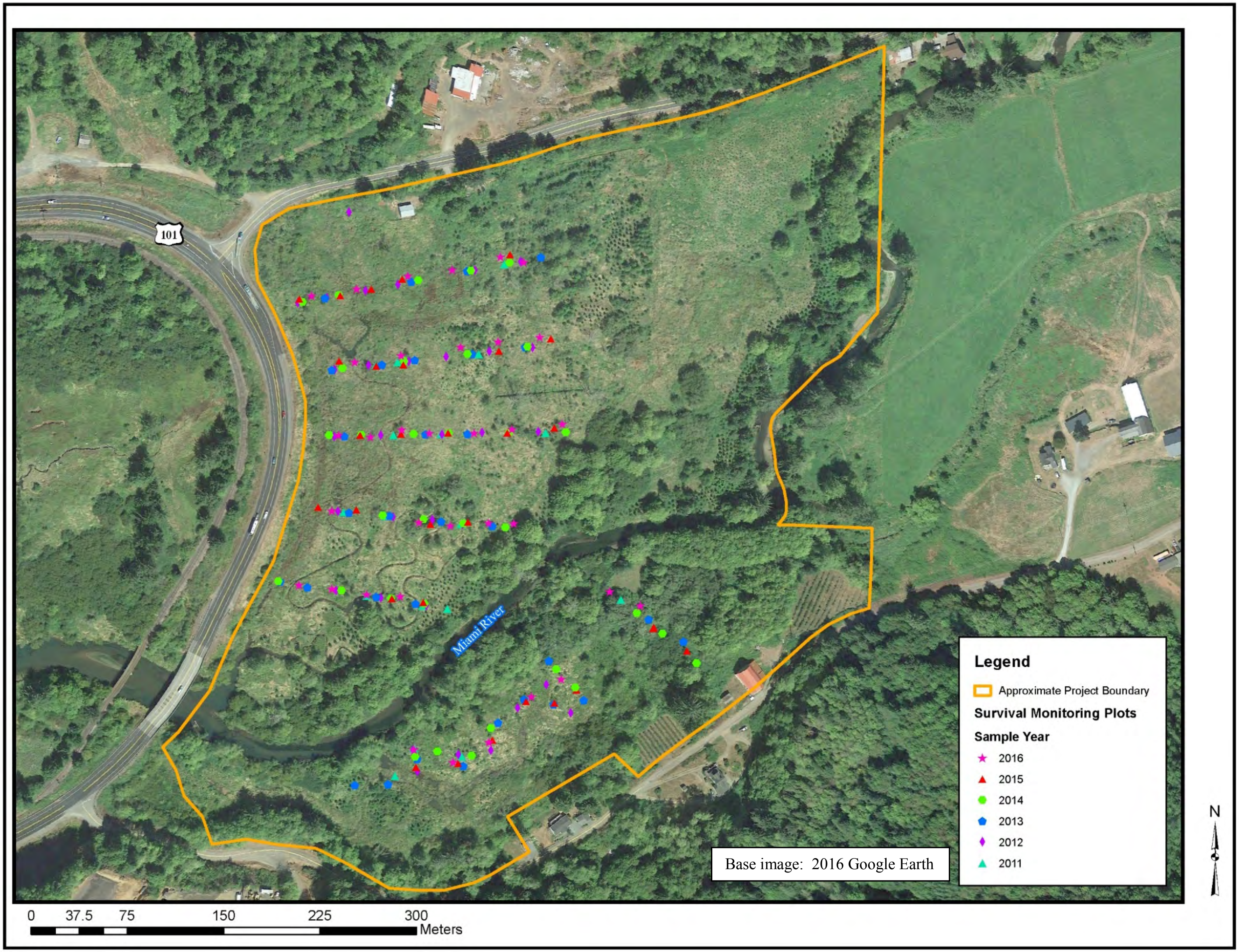


Figure 20. Location of restoration planting survival monitoring plots at Miami Wetlands.

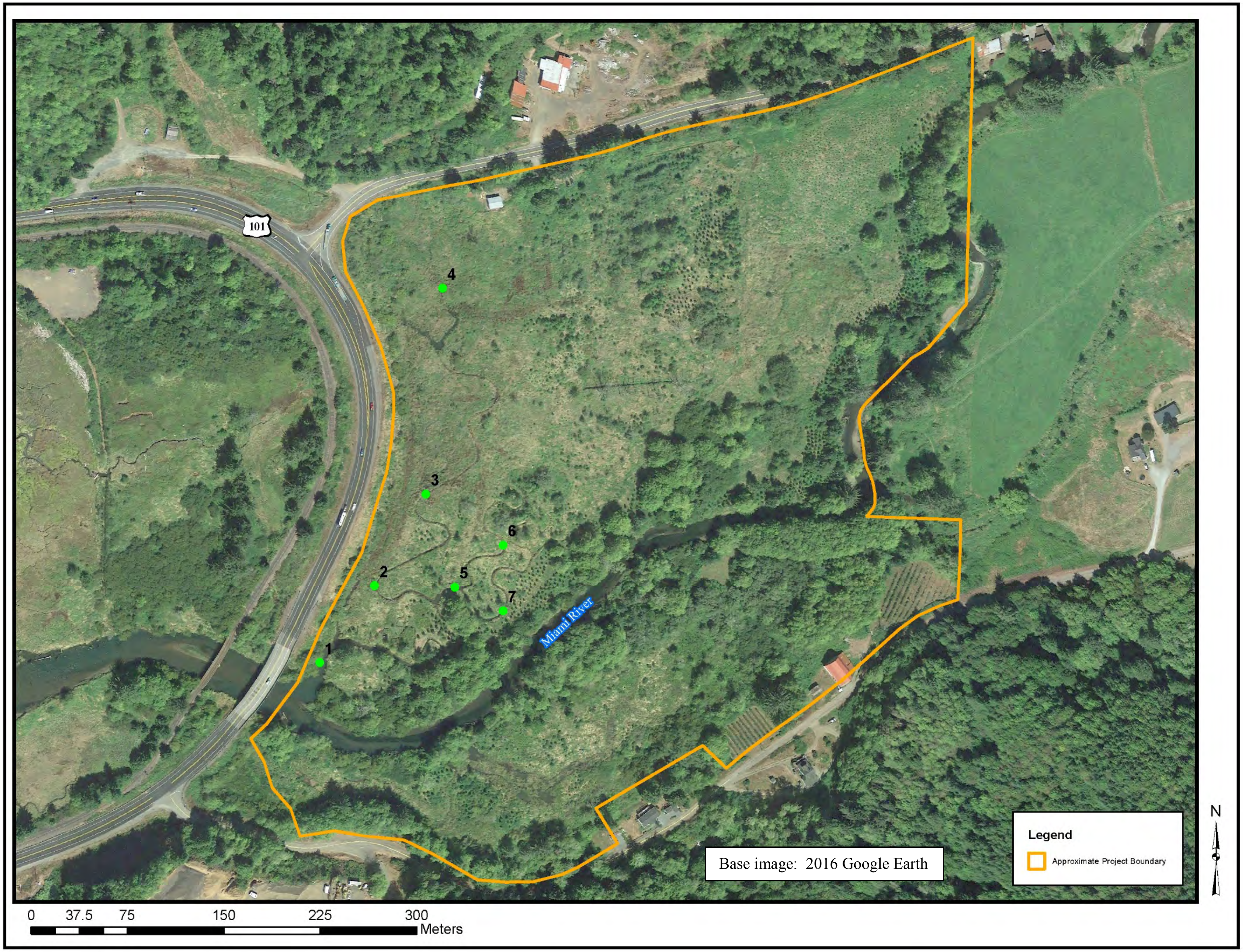


Figure 21. Location of 2016 macroinvertebrate sampling plots at Miami Wetlands.

spreadsheet file and returned this data and the sorted and classified macroinvertebrates to TEP. We calculated mean count and percent relative abundance for each invertebrate taxa and compared the species assemblage to our Miami baseline data and the limited information available for similar environments in Oregon. Oregon Department of Environmental Quality (DEQ) and others have developed models that use aquatic macroinvertebrates as indicators of biological conditions and surrogates for watershed health. However, western Oregon reference data for these models currently have only been developed for fast moving, wadeable streams. As a result, these models are not currently applicable for sites like the Miami Wetlands and we did not conduct such analyses.

2.2.3. Secretive Marsh Bird Surveys

We expected changes in the structure and composition of vegetation at the project site to affect the suitability of the site for waterbirds that typically occupy emergent wetlands. As a result we conducted surveys for selected marsh birds on during May 2010 for our baseline report (Bailey 2011) and repeated these surveys during May 2012 and 2014 and June 2013 following protocols developed by Conway (2009). We surveyed from the same locations during the both pre- and post-restoration efforts (Figure 22).

We obtained recorded calls of focal species (MP3 format) for this area from the author of the protocol. The MP3 file included five minutes of silence followed by exactly 30 seconds of calls for each of the focal marsh bird species that are expected breeders in this area (Sora [*Porzana carolina*], Virginia Rail [*Rallus limicola*], American Bittern [*Botaurus lentiginosus*], American Coot [*Fulica americana*], and Pied-billed Grebe [*Podilymbus podiceps*]) interspersed with 30 seconds of silence between the call of each species (total length of the recording was 10 minutes). For each species, the 30 seconds of calls consist of a series of the most common calls interspersed with approximately five seconds of silence.

We began each survey session approximately 30 minutes before official sunrise and concluded each session within two hours after sunrise. Tidal elevations varied among the surveys. Weather conditions and background noise during each of the surveys were within acceptable limits as identified in the protocol. During each survey, we broadcasted the recording described above from each station depicted in Figure 22 using an MP3 player connected to a battery-powered bullhorn. As per the protocol, we surveyed the stations in the same order during each survey.

2.2.4. Fishes

We obtained baseline fish data through a variety of methods and sources including a spring 2010 snorkel survey, summer 2010 and 2011 fish salvage efforts and review of Tillamook Bay Rapid Bio-Assessment data (Bio-Surveys, LLC 2005, 2006, 2007). The scope and methods for each of these efforts are detailed in our baseline report (Bailey 2011), but are not incorporated into this document. Areas where baseline fish data were collected are depicted on Figure 23.

We completed a variety of work to assess post-restoration fish use and Figure 24 depicts areas where this work was conducted. The following sections describe these efforts.

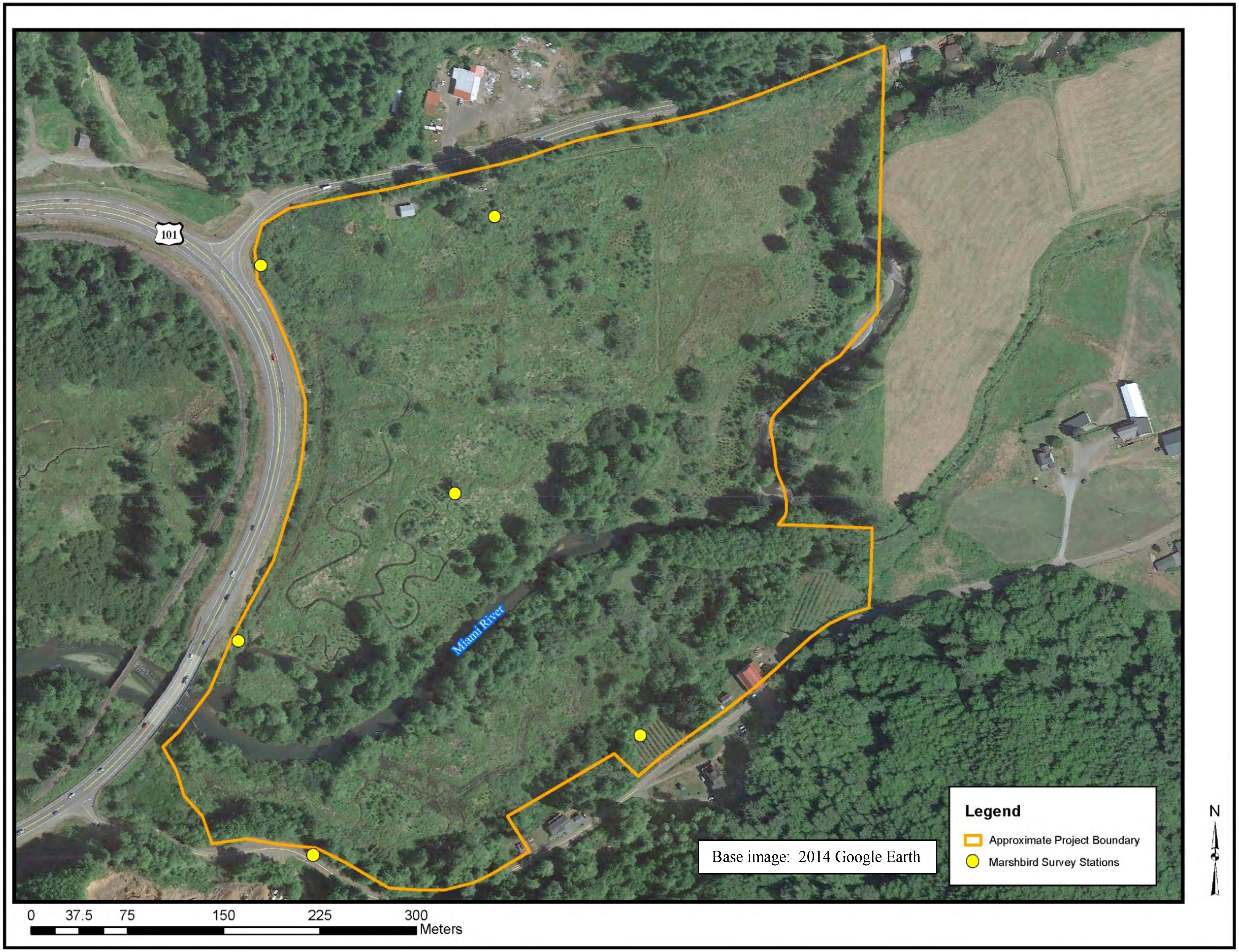


Figure 22. Location of marsh bird survey stations at Miami Wetlands.

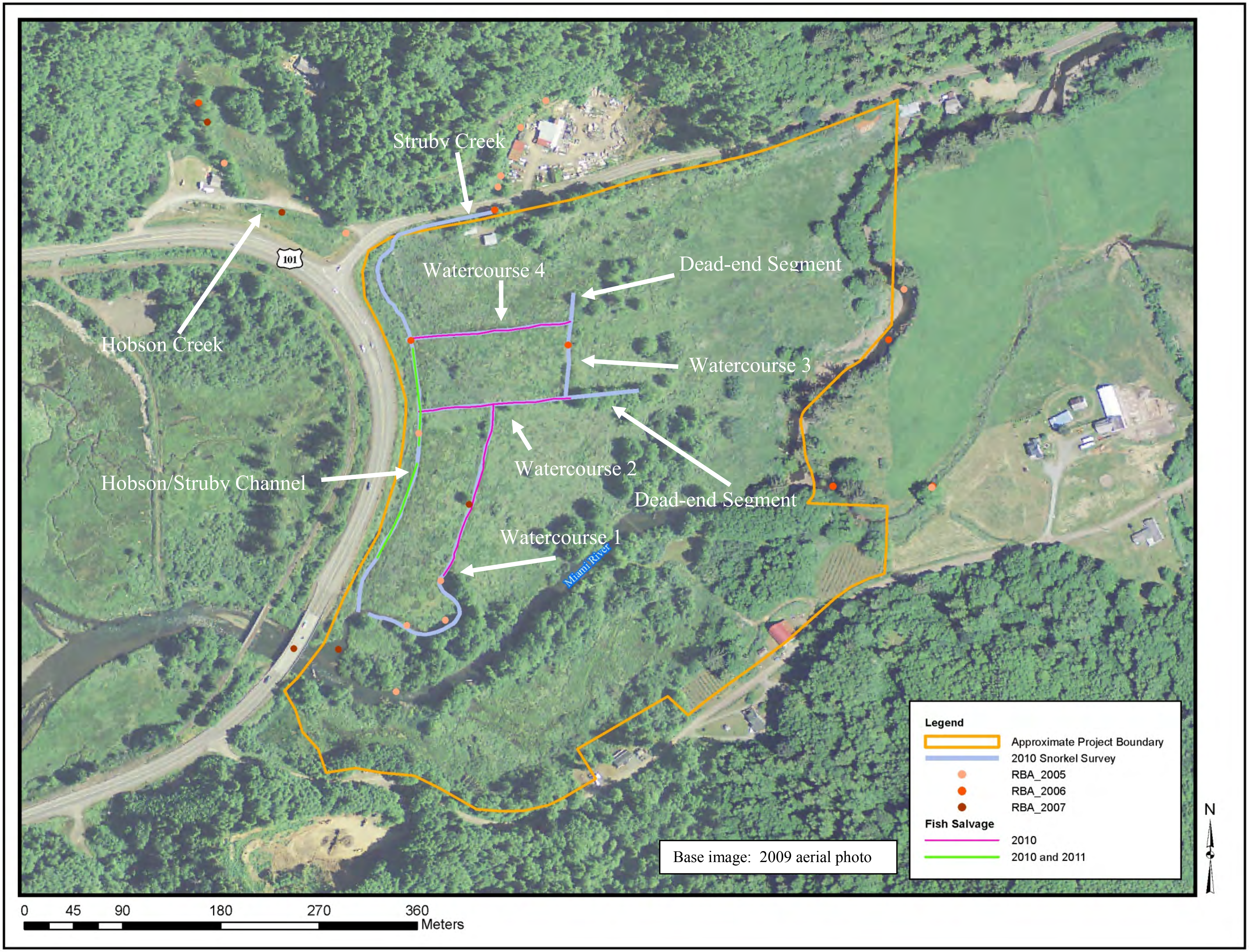


Figure 23. Location of baseline fish data collection efforts at Miami Wetlands.

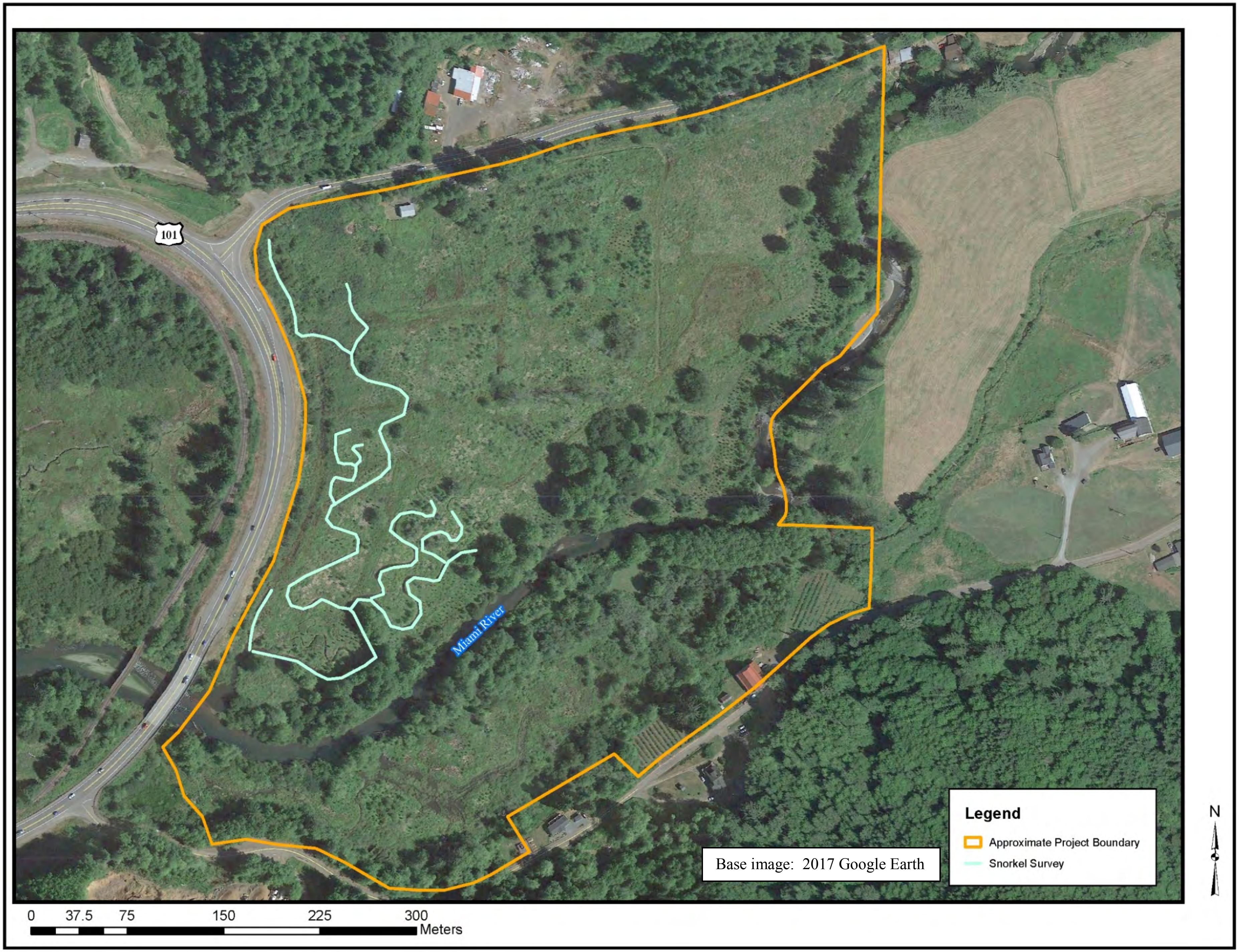


Figure 24. Location of post-restoration fish snorkel survey efforts at Miami Wetlands.

TEP staff conducted daytime snorkel surveys during April 2012, March and April 2013-14, and May 2015. This work was generally similar in scope to the spring 2010 snorkel survey conducted by Oregon Department of Fish & Wildlife (ODFW) staff. During these efforts one or two TEP staff members searched some of the constructed channels in their entirety and spot-checked others. The goal of these surveys was to identify fish species and life stages present, provide insights into the distribution of fishes within the channel system, and to enumerate individuals to the extent possible. Like the pre-restoration snorkel work, this work lacked sufficient rigor to quantify fish use of the site or estimate fish population numbers.

In addition to the TEP snorkel surveys, we contracted with Bio-Survey, LLC to conduct a nighttime snorkel survey during March 2016. Like the TEP survey work, the goal of this survey was to identify fish species and life stages present, provide insights into the distribution of fishes within the site, and to enumerate individuals to the extent possible. It was not designed to quantify fish use of the site or estimate fish population numbers. During this work, Bio-Surveys staff snorkeled most channels north of the river in their entirety and spot checked two of the smaller channels. Beaver activities within the Hobson-Struby channels have resulted in a complex, braided system of shallow, secondary and tertiary channels and backwater areas that support fishes but do not lend themselves to snorkel work. Bio-Surveys staff used overhead illumination to count fish in an approximately 12 m^2 backwater area to get a sense for how significant such off-channel habitats are for juvenile salmonids in the project site.

Bio-Surveys has conducted numerous snorkel surveys in Oregon's coastal watersheds and are recognized snorkel survey experts. They conducted the 2005-2007 RBA survey referenced for the baseline report. The scope and timing of the survey completed for this report differed from the RBA protocol, so the data are not directly comparable. However, we believe it was of great value to have the Miami site revisited by the same surveyor who lead what is undoubtedly the most extensive snorkel survey effort ever completed for the Tillamook Bay Watershed (and that provided data to inform the baseline report). Their visits to the site provide for some level of consistency between pre- and post-restoration fish survey work, and comparison of general habitat-quality observations made during the different survey efforts.

3.0 Results and Discussion

This section summarizes the results of our post-construction data collection efforts. It builds off the findings of our pre-restoration baseline work (Bailey 2011) and describes the site after implementation of restoration actions. In it, we also compare and contrast the post-restoration data with baseline data, describe measurable changes in site conditions that have occurred over the approximately six years since restoration construction work at the site was completed. Where possible, we present probable reasons for these changes and discuss how they may affect habitat quality and use of the site by salmonids and other wildlife.

3.1. Physical Attributes

In this section, we report the results of our efforts to document post-restoration physical attributes at the Miami Wetlands. We report on a variety of attributes including ground water elevations, surface water elevations (stream and tidal channel levels), several water quality parameters (temperature, conductivity and dissolved oxygen), soil organic matter and salinity, and channel profiles.

3.1.1. Water Elevation Monitoring

This section reports post-restoration water surface elevations at the site, discusses the influence of tides, precipitation and other factors on these levels and provides comparisons with pre-restoration conditions. Appendix A supports this section with graphs depicting water level data collected pre- and post-restoration. Figure A1 depicts water levels relative to ground surface. Figure A2 provides two graphs for each well site: one depicts well water levels relative to ground surface and daily precipitation and the other depicts well levels relative to mean sea level and tides.

In our baseline report, we concluded that the site was generally quite wet prior to restoration actions – it was bisected by the Miami River, the TNC parcel included hundreds of feet of constructed stream and drainage ditch channels and the Crabb parcel included remnants of an historical secondary river channel. Much of the restoration area was regularly inundated and ground water levels remained at or within a few feet of the ground surface over "drier" portions of the site. We noted that several factors influenced water surface elevations at the site including precipitation, proximity to surface water channels and tides. Beavers appeared to be responsible for much of the inundation, their actions impounding channels and flooding adjacent areas. There was significant seasonal variation of water surface levels, but seasonal means were typically within a few inches of one another. In general (and as to be expected), mean water levels were highest during winter and spring and lowest in the summer. Fall was a period of recharge with mean levels typically intermediate between summer and winter.

In our baseline study, precipitation had pronounced and widespread effects on water surface elevations. Response to rain events was often dramatic, but levels at many wells dropped quickly and remained lower in the absence of precipitation. In areas distant from beaver-influenced surface water channels, water was typically below ground and surface elevations fluctuated regularly in response to precipitation events. Areas in proximity to beaver-influenced channel segments, on the other hand, had higher and more consistent minimum levels and water often inundated the surface. In addition, the effects of precipitation events tended to be more subtle in these areas (except during large storm events when overbank flows from the Miami River could inundate the entire site). Tides had pronounced effects on water levels in surface water channels, but appeared to have little influence on ground water levels. Post-restoration data generally support conclusions reached in our baseline report.

Based on our post-restoration work, precipitation continued to have pronounced and widespread effects on water surface elevations at the site. It had a marked seasonal effect on water levels at all wells and, during heavy precipitation events, dramatically increased water levels across the entire site (Appendix A).

We used a One-Way ANOVA for Correlated Samples (Lowry 2017) to evaluate the Null Hypothesis (H_o) that mean water surface elevations at each well did not differ seasonally[3]. If the ANOVA showed significant seasonal variation, we also used Tukey's Honestly Significant Difference (HSD) Test to evaluate pairwise comparisons among seasonal water surface elevations and determine which seasons differed from one another. To help in understanding how precipitation affected well water levels, we also used these same statistical tests to evaluate

[3] Spring: March 1 – May 31, Summer: June 1 – August 31; Fall: September 1 – November 30, Winter: December 1 – February 28 (February 29 during leap years)

Table 3. Mean seasonal water levels at six ground water and two in-channel wells at the Miami River Wetlands and daily precipitation at Tillamook Airport.

Well ID	Spring (in)	Summer (in)	Fall (in)	Winter (in)	ANOVA[¥] F / df
	Water Level Relative to Ground Surface ($\bar{X}$ ± 1SE)				
MW-4[*§]	2.4 ± 0.12 N = 2,181	-16.08 ± 0.12 N = 2,181	-1.08 ± 0.12 N = 2,181	7.56 ± 0.12 N = 2,181	6,152.76 / 3
MW-5[*§]	1.08 ± 0.00 N = 2,181	0.00 ± 0.00 N = 2,181	1.80 ± 0.12 N = 2,181	4.44 ± 0.12 N = 2,181	1,030.55 / 3
MW-6[*]	-0.24 ± 0.00 N = 2,182 a	-0.24 ± 0.00 N = 2,182 a	2.16 ± 0.12 N = 2,182	5.16 ± 0.12 N = 2,182	1,286.26 / 3
MW-7[*§]	-1.80 ± 0.12 N = 2,182	-21.72 ± 0.12 N = 2,182	-14.52 ± 0.24 N = 2,182	4.32 ± 0.12 N = 2,182	4,609.93 / 3
MW-9[*§]	-20.40 ± 0.12 N = 2,182	-23.16 ± 0.00 N = 2,182	-18.00 ± 0.24 N = 2,182	-8.64 ± 0.24 N = 2,182	1,820.88 / 3
MW-12[*§]	-20.16 ± 0.12 N = 2,182	-21.84 ± 0.12 N = 2,182	-15.84 ± 0.24 N = 2,182	-7.92 ± 0.24 N = 2,182	1,222.59 / 3
LL-1[*§]	16.56 ± 0.24 N = 2,183	12.72 ± 0.24 N = 2,183	20.76 ± 0.36 N = 2,183	33.24 ± 0.36 N = 2,183	1,032.18 / 3
LL-2[*§]	27.00 ± 0.12 N = 2,184	29.40 ± 0.12 N = 2,184	28.20 ± 0.24 N = 2,184	30.84 ± 0.24 N = 2,184	84.21 / 3
Daily Precipitation at Tillamook Airport[*€]	0.13 ± 0.04 N = 71 a,b	0.03 ± 0.01 N = 71 a,c	0.16 ± 0.03 N = 71 b,c	0.46 ± 0.08 N = 71	16.15 / 3

Data collected 03/01/2015 through 02/29/2016. Spring = March 1 – May 31, Summer = June 1 – August 31, Fall = September 1 – November 30, Winter = December 1 – February 29

[*]Significant seasonal variation (P<0.0001).

[§]All seasonal pairwise comparisons differ significantly (P<0.01)

[€]Not all seasonal pairwise comparisons for MW6 and daily precipitation differed significantly. For these rows, cells containing the same letter do not differ significantly from one another, but all other pairwise comparisons are significantly different (P<0.01)

[¥]ANOVA F-value and degrees of freedom (df) daily precipitation recorded at the Tillamook Airport over the same period (H_o = mean daily precipitation did not differ seasonally). We collected post-restoration water level data over an approximately six-year period, and this resulted in a data set with several hundred thousand records. At all wells, seasonal means from one year to the next were similar and seasonal means for each year were comparable to those calculated using the combined post-restoration data set. Based on this (and to facilitate our analyses), we completed all statistical tests of post-restoration water level data using only the 2015 data set. This year provided a complete data set for all wells and allowed for a few years of adjustment to occur after restoration actions. We observed significant seasonal variation at all well sites during 2015 (Table 3). At most sites, all seasonal pairwise comparisons differed significantly ($P<0.01$), but spring and summer levels for well MW-6 did not differ from one another. Although seasonal variation was statistically significant, mean levels at most wells typically varied only a few inches from one season to the next. The statistically strong variation in seasonal well water levels we observed is interesting in light of our analysis of daily precipitation at the Tillamook Airport over this same period (Table 3). There was significant seasonal variation in daily precipitation in 2015 ($F = 16.15$, $df = 3$, $P<0.0001$), but only half of the pairwise comparisons were significant. Spring, summer and fall rainfall did not differ significantly from one another, but winter rainfall differed significantly from all other seasons. Although not all pairwise comparisons of rainfall data were significant, mean daily precipitation varied noticeably among seasons and our well data appears consistent with the rainfall data. In general, well levels and daily precipitation were highest during winter and lowest during summer. Spring and fall well levels were intermediate between summer and winter, with fall levels generally a bit higher than spring.

During our post-restoration monitoring, water often remained subsurface at wells that were not in close proximity to channels with beaver impoundments (Figure A2, Table 3). At these wells (MW4, MW7, MW9 and MW12 – see Figure 11 for locations), mean water surface elevations were considerably higher during periods of regular rainfall (spring, fall and winter) than during summer when precipitation was low. Water level at these wells was very responsive to precipitation. Even moderate rainfall events by Tillamook County standards (0.5 to 1.0 inches in 24 hours) had a noticeable influence on their levels (Figure A2). At wells located in proximity to channels with beaver impoundments (i.e., MW5 and MW6), water was typically near or above the ground surface during all seasons. These wells appeared to have a more muted response to precipitation as compared to wells that were not in proximity to impoundments. Levels tended to fluctuate very little in response to light- to moderate-rains, but typically responded dramatically to rainfall events that exceeded two inches in 24 hours.

As noted above, beaver activities substantially influenced water levels at the site. Wells that were close to channel segments with beaver impoundments had higher and more consistent levels (relative to ground surface) than wells further removed from channels. To further illustrate the influence of beavers on water levels at the site, we refer you to figures for wells MW4, MW5 and MW6 in Appendix A. MW4 was in close proximity to one of the ditches that was filled as part of our restoration efforts. Before restoration actions, this ditch supported a beaver impoundment and water levels at MW4 remained near or above the ground surface during all seasons. Once we removed this impoundment and filled the ditch, water levels became more variable with summer levels typically remaining well below the ground surface. In 2014, beavers began constructing trails and shallow channels that conveyed water from the Hobson-Struby channel east towards MW4, and they continued to modify and expand these features through the end of our study in early 2017. Concurrent with these beaver activities, minimum levels at MW4 began increasing and our recent impression is that this area appears to be transitioning towards a more regularly inundated state, similar to the pre-restoration period. Wells MW5 and MW6 also were located in close proximity to beaver-influenced ditch segments that were filled during restoration construction work in 2010 and 2011. During our baseline work, water surface levels were typically at or above the ground surface during all seasons at both of these wells. However, similar to MW4 water levels at both of these wells plummeted during dry periods during restoration efforts and for a few years following this work (from summer 2010 through spring 2013). Water was often at or above the ground surface during fall, winter and spring at MW6, but typically below ground at MW5 during this period (Appendix A). In June 2013, beavers constructed a channel-spanning dam in the Hobson-Struby channel near well MW5, and during summer 2014 they constructed another channel-spanning dam a short distance from MW6 (Figure 11). They continued to modify these areas, constructing new channels and smaller check-dams through the end of our study in early 2017. As graphs in Appendix A clearly demonstrate, beaver activities resulted in a rapid increase in base water levels in the vicinity of wells MW5 and MW6, and levels remained consistently at or above the ground surface at both wells during all seasons for the remainder of our study. An account of beaver activities and their influence on water levels at wells MW5 and MW6 site is included as a case study in Pollock et al. (2017). Beaver activities have caused water from the Hobson-Struby channel to spread laterally and, as a result, a large portion of the TNC parcel outside of the channels is perennially inundated (or nearly so - Figure 25). Similar lateral inundation from channels on the Crabb parcel also is occurring (Figure 25). Based on our work, it is safe to conclude that the contributions of Hobson and Struby creeks and other freshwater that enters the site would not have the same influence on water levels in the absence of beavers.

Unlike precipitation (and beavers), tidal influences on water levels were very weak across most of the site during all conditions. Tides primarily influenced in-channel (surface water) levels (particularly the blind, tidal channel system on the TNC parcel [E channels] and the Miami River), rather than ground water levels. We used Pearson product moment correlation to evaluate our 2015 summer and winter well data and hourly water levels at the Garibaldi tide gage. Based on these analyses, tides had virtually no influence on water levels at nearly all of our wells during summer 2015 ($r \leq 0.1$, $P_{\text{two-tailed}} < 0.05$, df = 2,199 to 2,204 – for wells MW4, MW5, MW6, MW7, MW9, MW12 and LL2). Tides did substantially influence water levels at LL1 (located below head-of-tide in the Miami River channel) during summer 2015, but even at this location, only about half of the variation in well water level could be attributed to tidal fluctuations ($r = 0.55$, $P_{\text{two-tailed}} < 0.0001$, df = 2,203). Results of our correlation analyses of winter data were more mixed. Similar to the above results, tides had very little influence over water levels at half of the wells ($r \leq 0.1$, $p < 0.001$, df = 2,179-80 – Wells MW4, MW5, MW7 and MW9). Twenty to 40 percent of the variability in water levels at wells MW6, MW12, LL1 and LL2 during winter could be attributed to tidal fluctuations (MW6 – $r = 0.2$, $p < 0.0001$, df = 2180; MW12 – $r = 0.3$, $p < 0.0001$, df = 2180; LL1 – $r = 0.4$, $p < 0.0001$, df = 2181; LL2 – $r = 0.4$, $p < 0.0001$, df = 2182). The decrease in tidal influence at LL1 relative to summer makes sense. Mean daily precipitation is substantially higher during winter than summer (Table 3) and its influence over river levels undoubtedly increases accordingly. Hydrographs provided in Appendix A support the above correlation results. The LL1 hydrograph is distinctly different from the MW4, MW5, MW6, MW7, MW9 and MW12 hydrographs over our entire study period. It is similar to the LL2 hydrograph until restoration was completed in 2011. From that time forward, the two hydrographs are distinctly different and the difference in tidal influence

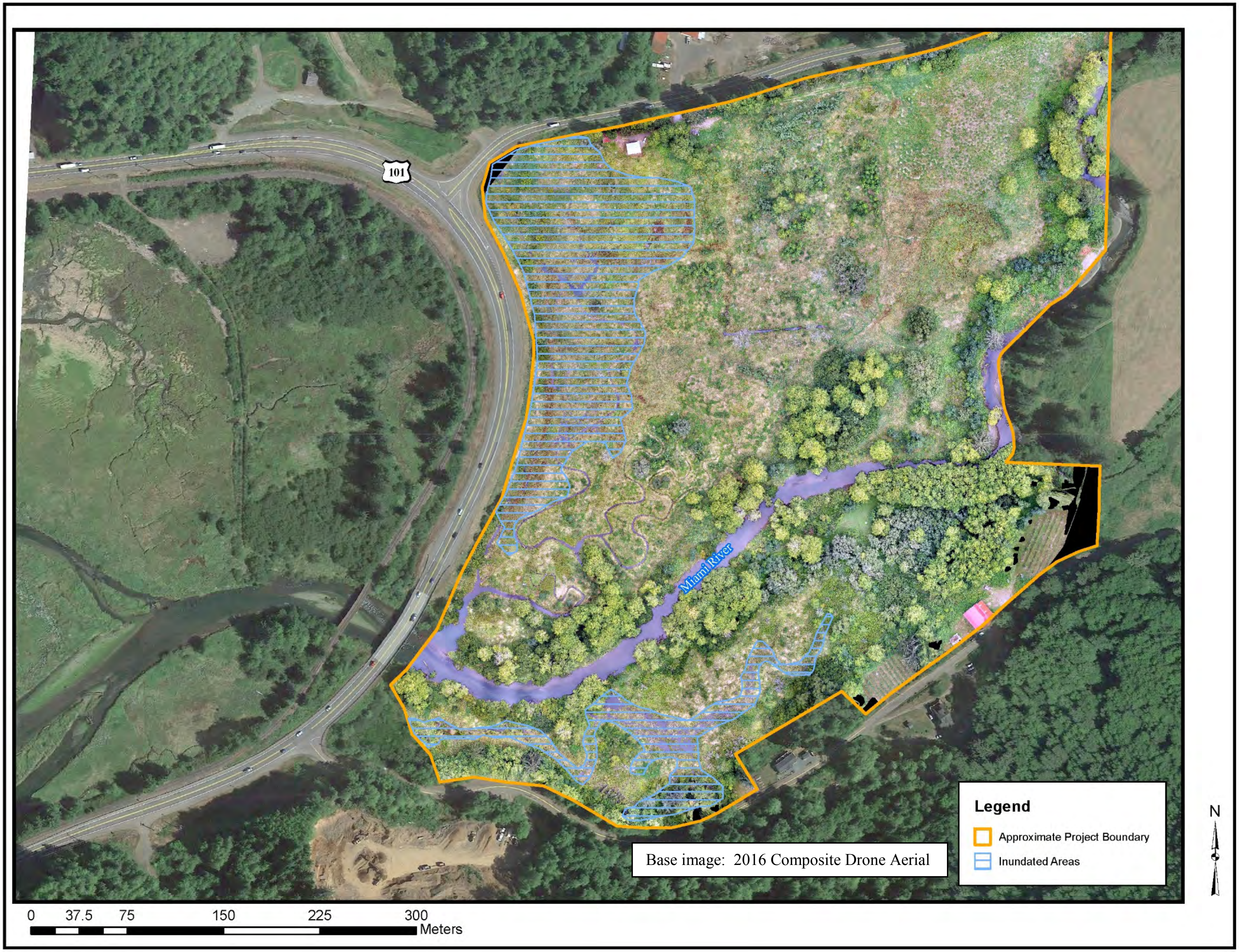


Figure 25. Approximate distribution of perennially inundated areas on the Miami Wetlands.

between summer and winter periods at LL2 is apparent in its post-restoration hydrograph. We did not complete correlation analyses of tide and water level data for our baseline report. However, based on review of hydrographs, we reported that tides appeared to have some influence over water levels at LL1 and LL2, but under most circumstances did not appear to measurably affect water surface elevations at other wells. For LL1, we concluded that under most circumstances high tides greater than 6.0 ft resulted in a marked increase in water surface elevation, but low tides (even minus tides) did not appear to result in a decrease in water surface elevations below seasonal base flow levels. We noted that LL-2 exhibited a similar pattern to LL-1, except during summer when base water surface elevations in the river were below six feet. We also reported that tides appeared to have some influence over water levels at MW12 during when river levels were high, but not under low-flow conditions. During periods of abundant rainfall, tidal influences at LL-1, LL-2 and MW-12 were most often overshadowed by the effects of stormwater. The results of our post-restoration work appear consistent with these conclusions.

As noted above, the findings of our post-restoration water level monitoring are generally consistent with our baseline work. The same factors that influenced pre-restoration levels remained relevant, and the degree of their influences appeared unchanged.

Where substantial restoration construction work occurred on the TNC parcel (e.g., ditches filled, channels constructed, etc.), water levels initially dropped, but by 2014 water levels had increased and the areas appeared to be stabilizing (primarily a result of beaver activities). Some areas returned to conditions similar to the pre-restoration period (Appendix A and Table 4 – see MW5). In other areas, conditions are somewhat wetter than before (Appendix A and Table 4 – see MW6) and elsewhere conditions are similar during some periods, but considerably wetter during others (Appendix A and Table 4 – see MW7). We believe that the changes at MW7 are driven by two primary factors. Some soil needed to fill ditches in the western portion of the parcel was "borrowed" from an approximately 0.7 acre roughly circular area approximately 150 feet east of MW7. This area has become a shallow seasonal pond during much of the fall, winter and spring seasons and is much wetter than its previous state (wetland conditions have developed). In addition, MW7 is located approximately 100 ft northeast of the terminus of a portion of the drainage ditch system that was not filled during restoration (the portions of the ditch system referred to as Watercourse 3 and Dead End Segment in Figure 23). This segment is disconnected from the current channel system, but receives substantial seasonal water input from rain (and probably other sources, including groundwater). As a result, water is impounded and spreads laterally during wet seasons. Both of these factors have caused the portion of the TNC parcel surrounding MW7 to become seasonally wetter than baseline conditions. Water levels at wells outside of restoration construction zones on the TNC parcel, remained similar before, during and after construction activities (Appendix A and Table 4 – see MW9 and MW12).

The Crabb parcel appears to be generally wetter post-restoration (water levels at LL2 were higher during all seasons - Appendix A, Table 4). We are unsure of the exact cause(s) of this change. Beaver were active in this area during pre- and post-restoration periods (although the footprint of their actions appears to have broadened, which is undoubtedly playing a role in water levels on this parcel). As a result, it would appear that restoration actions are at least partly responsible for this change. However, we do not believe that any of the work we did on the parcel would have directly enhanced the height of water at LL2 (in and of itself). It is possible that the large wood structure constructed near the mouth of the channel in which LL2 is

Table 4. Mean seasonal pre- and post-restoration water levels at six ground water and two in-channel wells at the Miami River Wetlands Site.

Well ID	Water Level Relative to Ground Surface ($\overline{X}$ ± 1SE) Spring (in) Pre	Spring (in) Post	Summer (in) Pre	Summer (in) Post	Fall (in) Pre	Fall (in) Post	Winter (in) Pre	Winter (in) Post
MW-4	3.00 ± 0.00 N = 4,934	3.24 ± 0.00 N = 6,595	0.00 ± 0.00 N = 2,752	-10.92 ± 0.12 N = 6,619	1.68 ± 0.12 N = 4,335	1.32 ± 0.12 N = 6,550	3.60 ± 0.00 N = 4,319	7.44 ± 0.00 N = 6,007
MW-5	5.04 ± 0.00 N = 4,934	2.04 ± 0.00 N = 6,595	3.60 ± 0.00 N = 2,753	0.60 ± 0.00 N = 6,620	3.00 ± 0.00 N = 4,335	3.12 ± 0.00 N = 6,550	4.92 ± 0.00 N = 4,320	4.80 ± 0.00 N = 6,008
MW-6	-6.00 ± 0.12 N = 4,934	0.24 ± 0.00 N = 5,835	-3.60 ± 0.12 N = 2,752	-0.60 ± 0.00 N = 4,412	0.12 ± 0.12 N = 4,335	2.88 ± 0.00 N = 5,981	-3.72 ± 0.12 N = 4,320	3.84 ± 0.00 N = 6,009
MW-7	-4.80 ± 0.12 N = 4,830	-1.68 ± 0.12 N = 6,598	-21.48 ± 0.12 N = 2,644	-21.00 ± 0.00 N = 6,619	-10.56 ± 0.12 N = 4,333	-10.20 ± 0.12 N = 6,549	-2.52 ± 0.12 N = 4,320	3.24 ± 0.00 N = 6,010
MW-9	-18.12 ± 0.12 N = 4,934	-18.60 ± 0.12 N = 6,134	-23.04 ± 0.00 N = 2,754	-23.16 ± 0.00 N = 4,408	-19.44 ± 0.12 N = 4,335	-16.80 ± 0.12 N = 6,079	-15.72 ± 0.12 N = 4,319	-12.36 ± 0.12 N = 6,010
MW-12	-18.12 ± 0.12 N = 4,934	-18.36 ± 0.12 N = 6,598	-21.72 ± 0.12 N = 2,755	-21.84 ± 0.00 N = 6,620	-17.88 ± 0.12 N = 4,335	-15.12 ± 0.12 N = 6,550	-13.08 ± 0.12 N = 4,320	-10.92 ± 0.12 N = 6,010
LL-1	19.68 ± 0.12 N = 6,486	20.64 ± 0.12 N = 6,600	13.92 ± 0.12 N = 3,585	12.48 ± 0.12 N = 6,620	18.00 ± 0.36 N = 2,184	22.32 ± 0.24 N = 6,551	23.04 ± 0.24 N = 2,722	29.88 ± 0.12 N = 6,011
LL-2	20.88 ± 0.12 N = 6,485	28.20 ± 0.12 N = 6,603	22.32 ± 0.12 N = 4,419	32.04± 0.12 N = 6,622	20.16 ± 0.12 N = 4,368	30.24 ± 0.24 N = 6,552	23.52 ± 0.12 N = 4,319	29.88 ± 0.12 N = 6,016

Pre-restoration data collected 03/06/2008 – 05/31/2010.

Post Restoration data collected 03/01/2014 – 02/24/2017.

Spring = March 1 – May 31, Summer = June 1 – August 31, Fall = September 1 – November 30 and Winter = December 1 – February 28 or 29 located stabilized the area and allowed beavers to enhance a dam near the confluence of the channel and the Miami River (a dam that has persisted at the site during our entire study), but we do not have data that verifies this speculation.

3.1.2. Water Quality Monitoring

This section reports post-restoration water quality data collected at the site and discusses the influence of tides, precipitation, ambient temperature and other factors on these variables. We report water quality temperature data from the eight monitoring wells distributed across the project site equipped with continuous data loggers (Figure 11, Table 1). As discussed above, wells varied with respect to the ambient conditions in which they existed. Wells LL-1 and LL-2 were located in areas with perennial open water: LL-1 was located in the mainstem Miami River channel and LL-2 sampled the side channel on the Crabb parcel (upstream of a beaver dam that separated this channel from the mainstem). The remaining wells were located at terrestrial sites and primarily monitored groundwater temperatures (although some sampled regularly-inundated portions of the site). We also report results of short-duration deployments (two to four weeks) of temperature, conductivity and dissolved oxygen loggers in surface water channels on the TNC parcel (Figure 12).

3.1.2.1. Water Temperature – Numerous factors affect water temperature in streams and other aquatic environments including air temperature, solar angle and shade, stream configuration andchannel morphology, stream origin and velocity, vegetation types and coverage, land-use, percentage of impervious area, and others. Typically, there are multiple factors influencing water temperature at a given site (including both on-site and off-site influences) and it is difficult to isolate these influences and identify the extent to which individual factors affect observed temperatures.

In our baseline report, we indicated that several factors likely influenced water temperatures at the Miami Wetlands site including air temperature, precipitation, tides, vegetation coverage, upstream conditions, and others. This remained true during post-restoration monitoring. Many of these individual factors are not independent of one another. For example, ambient air temperature influences the temperature of precipitation, and air temperature in coastal areas is correlated with ocean temperature. Assessing the effects of most of these factors and untangling the intricacies of the aforementioned interactions are beyond the scope of this report. We lack data from many of the external sources that likely affect water temperatures at the site. For example, we have little or no water temperature data from Tillamook Bay or from upstream in the Miami River and Hobson and Struby creeks. These data would be needed to evaluate the influences that tidal fluctuations and fresh water inputs have on site conditions. Based on the above, our statistical analyses of water temperature data from the site are limited to seasonal comparisons and comparisons of pre- and post-restoration conditions. We also relate our findings to regulatory standards and habitat requirements of salmonids.

We used a One-Way ANOVA for Correlated Samples to evaluate the Null Hypothesis that mean water temperature at our monitoring wells did not differ seasonally. Where seasonal differences were significant, we also used Tukey's HSD Test to evaluate pairwise comparisons among seasonal mean water temperatures. Based on these tests, there was significant seasonal variation in mean water temperature at all wells during the 2015 sampling period (Table 5). All pairwise

Table 5. Mean seasonal water temperatures at six ground water and two in-channel wells at the Miami River Wetlands and mean seasonal average daily temperature at Tillamook Airport.

Well ID	**Temperature ($\bar{X}$ ± 1SE)** **Spring (°C)**	**Summer (°C)**	**Fall (°C)**	**Winter (°C)**	**ANOVA[¥] F / df**
MW-4[*§]	10.3 ± 0.01 N = 2,181	13.7 ± 0.02 N = 2,181	13.4 ± 0.03 N = 2,181	9.5 ± 0.01 N = 2,181	9,027.89 / 3
MW-5[*§]	10.2 ± 0.01 N = 2,181	13.5 ± 0.02 N = 2,181	12.7 ± 0.03 N = 2,181	9.6 ± 0.01 N = 2,181	6,904.34 / 3
MW-6[*§]	10.7 ± 0.01 N = 2,182	14.0 ± 0.02 N = 2,182	13.1 ± 0.02 N = 2,182	9.2 ± 0.01 N = 2,182	11,808.17 / 3
MW-7[*§]	10.7 ± 0.02 N = 2,182	14.2 ± 0.02 N = 2,182	13.9 ± 0.04 N = 2,182	9.7 ± 0.02 N = 2,182	6,428.55 / 3
MW-9[*§]	10.5 ± 0.02 N = 2,182	13.7 ± 0.02 [illegible]	13.3 ± 0.03 N = 2,182	9.1 ± 0.02 N = 2,182	9,809.98 / 3
MW-12[*§]	10.5 ± 0.02 N = 2,182	14.0 ± 0.02 N = 2,182	13.1 ± 0.03 N = 2,182	8.5 ± 0.02 N = 2,182	10,034.28 / 3
LL-1[*§]	10.0 ± 0.03 N = 2,183	14.1 ± 0.02 N = 2,183	12.2 ± 0.04 N = 2,183	8.8 ± 0.01 N = 2,183	7,270.63 / 3
LL-2[*§]	11.0 ± 0.03 N = 2,184	15.5 ± 0.02 N = 2,184	12.9 ± 0.04 N = 2,184	8.0 ± 0.02 N = 2,184	9,281.95 / 3
Daily Average Air Temperature at Tillamook Airport[*€]	10.6 ± 0.28 N = 71 a	15.7 ± 0.29 N = 71	11.2 ± 0.47 N = 71 a	8.1 ± 0.39 N = 71	65.21 / 3

Data collected 03/01/2015 through 02/29/2016. Spring = March 1 – May 31, Summer = June 1 – August 31, Fall = September 1 – November 30 and Winter = December 1 – February 29

[*]Significant seasonal variation (P<0.0001)

[§]All seasonal pairwise comparisons differ significantly (P<0.01)

[€]Not all seasonal pairwise comparisons for average daily air temperature differed significantly. For this row, cells containing the same letter do not differ significantly from one another, but all other pairwise comparisons are significantly different (P<0.01)

[¥]ANOVA F-value and degrees of freedom (df) comparisons for all wells differed significantly from one another. In general, mean water temperatures were lowest during winter. Spring means were typically about 1ºC warmer than winter. Summer and fall temperatures were similar (fall usually slightly cooler) and generally 3-4ºC higher than winter temperatures.

We were unable to obtain hourly air temperature data for the Tillamook Airport needed to evaluate relationships between ambient air temperature and post-restoration well water temperatures. However, mean water temperatures at all wells were similar to mean daily average air temperature during all seasons in 2015 (Table 5). In addition, the relationship of seasonal mean air temperatures to one another mirrored that of seasonal mean well water temperatures described in the section above. Further, pre-restoration well water temperatures were positively correlated with ambient air temperatures at the Tillamook Airport (Bailey 2011). Our pre-restoration analyses indicated that 40 to 70 percent of the variability in well water temperatures could be attributed to variation in ambient temperature). Our pre-restoration results indicated that ambient air temperature exerted greater influence over surface water temperatures than ground temperatures. Variation in ambient air temperature accounted for approximately 56 and 70 percent of the variability in water temperatures at wells LL2 and LL1 during pre-restoration studies, respectively. On the other hand, variation in ambient temperatures accounted for less than half of the variability at all of ground water wells. Given the above, we believe it is safe to assume that ambient air temperature continued to exert substantial influence over post-restoration water temperature at the site. It likely remains the single most important external influence on water temperatures at the site, and likely affects surface water somewhat more than ground water.

Like our pre-restoration studies, we compared post restoration well water temperatures to State of Oregon water quality standards related to water temperature and its effects on the biological cycles of salmonids (ODEQ 2007). The purpose of these standards is to protect designated temperature-sensitive, beneficial uses, including specific salmonid life cycle stages in waters of the State. Two standards are applicable to the Miami River basin: 1) Salmon and Trout Rearing and Migration Temperature Criteria, and 2) Salmon and Steelhead Spawning Use Criteria. The rearing and migration criterion is a year-round standard, but it is superseded by the spawning use criteria from October 15 - May 15. Under these standards, the 7-day running average for water temperature cannot exceed 18 ºC for rearing and migration and 13 ºC for spawning.

Our post-restoration well data indicates that water temperatures at the Miami Wetlands site (including in the lower mainstem Miami River) remain suitable for salmonids year-round and consistently meet both of the above State of Oregon standards. The same was true for our baseline well data. Appendix B provides graphs of water temperature data for all of our well sites over an approximately nine year period (beginning about two years before restoration and ending approximately six years post-restoration. In addition to water temperature data, these graphs depict daily average air temperature data over this same period and the applicable State of Oregon temperature standards. Not only do these graphs clearly demonstrate that well water at the site consistently meets state temperature standards for salmonids, they also illustrate the similarity of water temperatures at the site from year-to-year.

We also collected temperature data during several two to four week deployments of conductivity and dissolved oxygen loggers in constructed channels on the TNC parcel from 2012 through

2016. Figure 12 depicts site locations for these deployments. Appendix C provides graphs of these data organized by season (i.e., Figure C1 - Spring: March 1 – May 31, Figure C2 - Summer: June 1 – August 31, Figure C3 - Fall: September 1 – November 30 and Figure C4 - Winter: December 1 – February 28 or 29). We did not complete analyses of these surface water data similar to those completed for the level logger well data, but review of the data and graphs indicates general support for the findings presented above.

At these sites, water temperatures during all seasons were typically below the aforementioned state standards (Appendix C). Daily maximum and minimum temperatures during winter deployments were consistently below state standards. Daily maximum temperatures sometimes (spring and fall) or often (summer) exceeded the state standard temperature at some or most sites (Appendix C), but daily minimums typically were below the standard. As a result, mean temperatures during all deployments were below state standards (only summer means at a few sites even approached the state standard temperatures – means for most deployments were several degrees lower). Even during summer months, portions of the site (particularly the Hobson-Struby channel) continued to provide cool water conditions. It is important to reiterate that compliance with the state standards is based on 7-day running average temperatures. While we did not complete 7-day running average analyses with our data sets, it is not likely that the results of such an analysis would conflict with our above statements.

Our data indicate that the site consistently provides cool surface water conditions and is an abundant source of cool groundwater in the lower Miami River basin. With respect to water temperature, the site contributes positively to habitat conditions for salmonids and other aquatic species during all seasons.

3.1.2.2. Conductivity/Salinity – Salts (in the water and soil) strongly influence species distribution and habitat quality for both plants and animals. To evaluate on site conditions relative to salinity, we measured specific conductance of in-channel surface water on the TNC parcel during several two to four week data logger deployments from 2012 through 2016. The bulk of our deployments were during summer months, but we made some deployments during all seasons. We rotated placement of loggers among several sites (Figure 12), but focused more attention on sites that remained consistently watered (as opposed to portions of the tidal channel system that typically only had water during high tide events). We selected deployment sites to provide information from a range of on-site conditions – from areas where tidal influence was likely to be strong to areas more likely to be influenced by freshwater inputs from Hobson and Struby creeks. We did not complete statistical analyses with our conductivity data. Instead, we use this data to better understand and describe the degree and extent of the influence of saline water on site conditions, and for general comparisons among seasons and, to a more limited degree due to a paucity of pre-restoration data, between pre- and post-restoration conditions. Appendix D provides graphs of data for all post-restoration conductivity logger deployments completed from 2012 through 2016. The following sections describe seasonal conditions at the various stations during our post-restoration monitoring. They are followed by a general summary of on-site water salinity and comparison with pre-project conditions.

We completed three spring deployments, one each spring during 2014, 2015 and 2016 (Appendix D, Figure D1). Rain and high tides greater than eight feet were common during each deployment. We monitored station L-2 (near the confluence of the on-site channel system and the Miami River) during all three deployments. We also deployed loggers in several portions of the tidal channel system and in the middle and lower reaches of the Hobson-Struby channel. Water in the lower and middle Hobson-Struby channel (stations D-1 and D-2, respectively) was nearly always fresh. However, the lower reach did become mildly brackish during a single, very high tide event in 2015. Conditions were more variable in the tidal channel system, but even these channels contained predominantly fresh water during spring. During each deployment, water at Station L-2 peaked at or near polyhaline levels in conjunction with a few very high tide events (9+ feet above sea level), but quickly returned to freshwater conditions as tides receded. Water in the upper and lower tidal channel system (stations E-1, E-2 and E2-1) became brackish during these very high tides, but also returned quickly to freshwater conditions as tides ebbed. During smaller magnitude high tides, the E channel system remained predominantly fresh.

We completed 12 summer deployments – three in 2012, 2013 and 2014, two in 2015 and one in 2016 (Appendix D, Figure D2). Precipitation varied during these deployment periods - conditions were predominantly dry, but some rain occurred during most deployments. High tides were low to moderate, rarely exceeding eight feet. We monitored station L-2 during nearly all deployments and the lower Hobson-Struby channel (Station D-1) and lower reach of the tidal channel system (E channel system, Station E-1) during many deployments. We also made several deployments in the middle and upper reaches of the Hobson-Struby channel. The upper reaches of the E channel system are often without water during summer and we did not make any deployments in these areas. Water in the upper Hobson-Struby channel (Station A-1) was consistently very fresh during all deployments and levels varied over a very small range relative to other stations. The middle reach (Station D-2) was nearly always very fresh, but did become mildly- to moderately-brackish for a short time during extended dry periods when high tides approached or exceeded eight feet. Water in the lower Hobson-Struby channel (Station D-1) also was predominantly fresh. However, salinity there regularly peaked at or near the upper-mesohaline boundary and during several deployments conditions remained brackish to oligohaline for extended periods. Water near the Miami River confluence (Station L-2) and in the lower E channel system (Station E-1) also was often fresh, but regularly peaked at or near polyhaline levels. Brackish conditions often persisted in these areas over extended periods when higher-high tides were at or near eight feet. However, these areas tended to remain entirely fresh during extended periods with smaller high tides (high tides generally below seven feet).

We completed eight fall deployments – two in 2012 and 2014, three in 2013 and one in 2016 (Appendix D, Figure D3). Precipitation varied during these deployments – some rain occurred during each deployment, but some deployments saw very little rain while others were more consistently wet. High tides were moderate to large, often near or above eight feet. We monitored station L-2 during all deployments and the lower tidal channel system (Station E-1) during all but one deployment. We monitored the lower Hobson-Struby channel (Station D-1) during half of the deployments and also made deployments in the middle and upper reaches of the Hobson-Struby channel (stations D-2 and A-1, respectively) and the upper reaches of the E channel system (stations E-2 and E2-1). Like other periods, water in the upper Hobson-Struby channel remained continuously very fresh during all deployments (with limited variation). The middle Hobson-Struby channel was predominantly fresh, but did become brackish for a short period during a single deployment. Water in the lower Hobson-Struby channel was often fresh, but peaked at higher levels and was often brackish for extended periods during multiple deployments. The E channel system and near the Miami River confluence often had extended periods of brackish conditions and salinity regularly peaked at or above the upper-mesohaline boundary. However, these areas also had extended periods with fresh water conditions (typically when high tides remained below approximately 7.5 feet).

We completed three winter deployments – one in 2013 and two during 2014-15 (Appendix D, Figure D4). Rain regularly fell during these deployments – sometimes in large amounts. Periods of large high tides (near or above nine feet) occurred during each deployment. We monitored stations L-2 and E-1 during all deployments, and the lower Hobson-Struby channel (Station D-1) during two deployments. We made single deployments in the middle and upper reaches of the Hobson-Struby channel (stations D-2 and A-1, respectively) and the upper E channel system (Station E-2). Freshwater conditions predominated at all stations during these deployments. In fact, saline conditions only were recorded during periods when high tides exceeded nine feet. During a five day period in January 2014 water in lower Hobson-Struby channel, lower E channel and near the Miami confluence peaked near mesohaline levels during a period of low- to moderate-rainfall and high tides at or near nine feet. Although peak salinities were high during this period, fresh water conditions quickly returned when tides ebbed. Water at Station L-2 peaked at moderate oligohaline levels during two discrete high tide events in January 2014. During these two peaks, water at all other stations remained fresh (even at station E-1 in the lower portion of the E channel system).

The following sections summarize our salinity monitoring results and provide a general characterization of the influence of marine waters on the TNC parcel. Specific conductance of water in TNC parcel channel system ranged from very low-salinity freshwater conditions (<100 µS/cm) to polyhaline conditions nearing that of ocean water (>30,000 µS/cm). Fresh water was common throughout the system during all seasons, but conditions were highly variable in the lower portion of the Hobson-Struby channel and throughout the tidal channel system (from the lower end of the common tidal channel [Station L-2] to the upper reaches of the blind, E channel system [stations E2-1 and E-2] [figures 7 and 12]).

The upper portion of the Hobson-Struby system was dominated by the combined inputs of Hobson and Struby creeks and water remained entirely fresh. Specific conductance in this area did not exceed 100 µS/cm during any season and levels fluctuated over a very small range at all times. The middle reach of the Hobson-Struby channel provided predominantly fresh water conditions during all seasons, but some saltwater intrusion occurred during summer and fall dry periods when high tides approached or exceeded eight feet. The lower reach of the Hobson-Struby channel was much more variable during all seasons – fresh water conditions predominated, but water in this reach was often mildly brackish and sometimes peaked at polyhaline levels. During rainy seasons, the lower channel was overwhelmingly fresh. However, during tides exceeding approximately 8.5 feet, salinities could briefly rise to mesohaline levels. Conditions in the lower Hobson-Struby channel were even more variable during dry periods. During these periods when high tides were generally at or below eight feet, water in this reach was mostly fresh but oscillated over a fairly wide salinity range as tides ebbed and flooded. During dry periods when high tides were large (greater than 8.5 feet), brackish conditions predominated in the lower Hobson-Struby channel.

Salinity levels in the tidal channel system were even more variable. While water in these channels also was often fresh, particularly during wet seasons, it also regularly peaked at or near polyhaline levels and could remain brackish for extended periods during the dry season. This monitoring revealed considerable distinction between upper and lower reaches of the E channel system in terms of the amount of time that channels were wetted. Channel bottom elevations in the upper reaches (6-8 feet) were considerably higher than in the lower reaches (3-5 feet) and the upper reaches were only intermittently wet - typically only containing sufficient water to monitor salinity levels during short periods when tides exceeded approximately 8.5 feet and during periods of extended rain. Conversely, the lower tidal channel reaches were continuously wet, with water depths ranging from approximately 2-5 feet (depending on tides and precipitation). As a result of this arrangement, when the upper reaches were sufficiently wetted to measure salinity, levels there usually were similar to those in the lower reach. During periods with large high tides and little rainfall, water in the upper E channels was typically brackish. During rainy periods, freshwater conditions were more typical. Salinity in the lower portion of the E channel system was highly variable. During periods with large high tides (8.5+ feet), salinity would typically spike at mesohaline levels (even during wet seasons). When large tides coincided with little rainfall, water in this portion of the channel system was often brackish (oligohaline) and sometimes mesohaline conditions persisted for several days. During periods of heavy rainfall and dry periods when high tides were small (generally <7 feet), water in the lower E system was typically fresh.

The Hobson-Struby channel confluences with the E channel system just below Station E-1. Below this point, water from both systems interact with the Miami River and Tillamook Bay through a single common channel. Station L-2 monitored the lower portion of this channel. Salinity levels at L-2 were more variable than any of our other stations. They ranged from fresh to mesohaline levels during nearly every deployment, often swinging from one to the other with each tide cycle. At times salinity here peaked at levels equivalent to ocean water (lower polyhaline). During dry periods brackish conditions often dominated here, but during wet periods freshwater conditions were more common.

Based on the above, saline water from Tillamook Bay is regularly present in a large portion of the TNC parcel channel system. It influences the entire tidal channel system (E channel system) which has limited upstream inputs, and the lower to middle reaches of the Hobson-Struby channel which receives flows from two small streams that originate off-site. It does not appear to play a role in the upper reaches of the Hobson-Struby system. Figure 26 depicts the general extent of saltwater incursion on the TNC parcel. Saline water is heavier than freshwater and typically moves upstream against freshwater flows as a wedge along the channel bottom. Salt water almost certainly penetrates the TNC parcel via the tidal channel system in this manner and, thus, appears predominantly confined to the channels (as opposed to the adjacent floodplains). The persistence of salt-intolerant plant species (e.g., small-fruited bulrush [*Scirpus microcarpus*]) along the channel banks and on the floodplain and our soil salinity data appear to support this statement. Given the above, it is likely that saltwater substantially influences in-channel conditions in the shaded area on Figure 26, but has a more subtle influence on the adjacent floodplain.

We did not obtain any water salinity data from the Crabb parcel. Our soil salinity data (from baseline studies and this work – see Section 3.1.3) suggest that saltwater does enter the parcel or that salts accumulate on the parcel due to impounding and evaporation with limited freshwater inputs. However, water level and vegetation studies (halophytic species are absent) suggest that

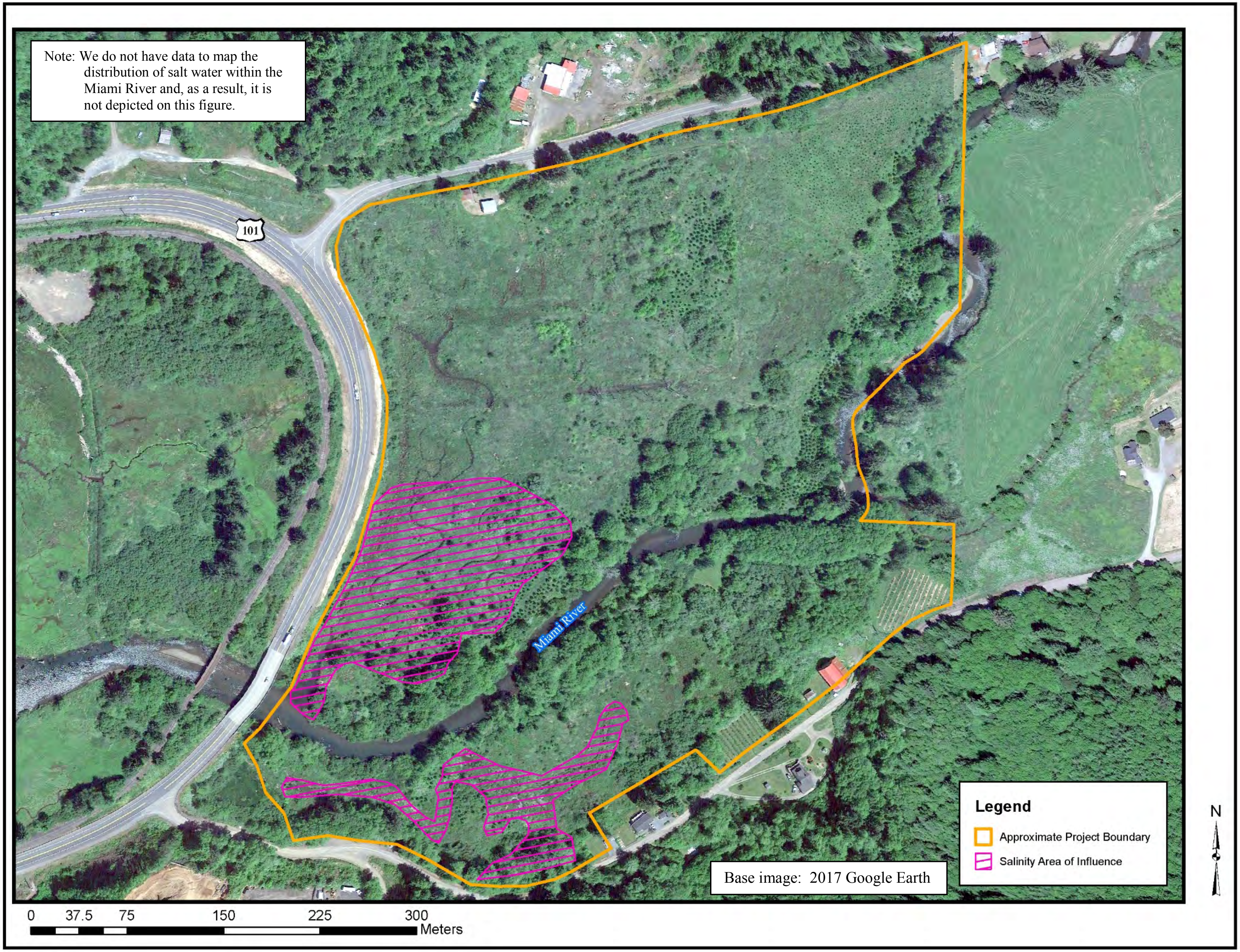


Figure 26. Approximate area of influence of saline water at Miami Wetlands.

freshwater conditions predominate on this parcel. Further study is necessary to better understand the dynamics of this parcel with respect to tidal/saline influence.

We did not obtain any pre-restoration salinity data, so direct comparison with pre-restoration conditions is not possible. However, we did make two deployments in 2010 before all restoration construction work was complete – one in July 2010 and one in December 2010 (Bailey 2011). During each deployment we placed one logger in the lower common tidal channel (Station L-2) and one in the lower Hobson-Struby "ditch." Conditions at both stations were similar during each deployment. In the summer, salinity at both stations would briefly peak at polyhaline levels during each higher-high tide, but freshwater conditions would rapidly return and persist until the next higher-high. In the winter, freshwater conditions persisted except during two large higher-high tides after several days of little to no rain when salinity peaked briefly at oligohaline levels. We do not know how far into the parcel saline water penetrated before restoration. However, the post-restoration channel system on the TNC parcel is much better connected to downstream areas than the drainage ditch system of the pre-restoration period. As a result, it is likely that restoration actions have allowed saline water to more readily flow into the site and penetrate further up the channels than during pre-restoration times. This has undoubtedly increased the diversity of aquatic environments on a large portion of the site and will likely result in a more diverse plant and animal community.

3.1.2.3. Dissolved Oxygen – Dissolved oxygen is an important component of aquatic habitats. We measured dissolved oxygen concentrations with data loggers colocated with the salinity loggers during all deployments described in the previous section. The bulk of our deployments were during summer months, when dissolved oxygen is typically most limited, but we made some deployments during all seasons. We only had two dissolved oxygen data loggers for a portion of our monitoring efforts, but two additional loggers were added in fall 2013 and all four loggers were used for subsequent deployments. All dissolved oxygen data was collected on the TNC parcel.

We did not complete statistical analyses with our dissolved oxygen data. Instead, we use this data to describe dissolved oxygen conditions in the constructed channels on the TNC parcel and compare our findings to State of Oregon water quality standards (OAR 340-041-0016). We make general comparisons among seasons and with our limited pre-restoration data. Appendix E provides graphs of data for all post-restoration dissolved logger deployments completed from 2012 through 2016. The following sections describe seasonal conditions during our post-restoration monitoring. They are followed by a summary of site conditions and comparison of our results to State of Oregon standards and pre-project conditions.

We completed three spring deployments, one each spring during 2014, 2015 and 2016 (Appendix E, Figure E1). Rain and high tides greater than eight feet were common during each deployment. We monitored station L-2 (near the confluence of the on-site channel system and the Miami River) during all three deployments. We also deployed loggers in several portions of the tidal channel system and in the middle and lower reaches of the Hobson-Struby channel. Dissolved oxygen concentrations at all sites fluctuated daily, but the magnitude of these fluctuations varied among stations. Concentrations in the Hobson-Struby channel (stations D-1 and D-2) were high (typically <9.5 mg/L) during all deployments. Conditions were more variable in the tidal channel system. The lower common channel (Station L-2) and lower E channel system (Station E-1) generally had moderate to high dissolved oxygen concentrations (typically ≥8.5 mg/L), but mean concentrations in the less-regularly watered upper E system reaches were typically in the 6.5-7.0 mg/L range and concentrations sometimes were <6.5 mg/L (stations E-2 and E2-1).

We completed 12 summer deployments – three in 2012, 2013 and 2014, two in 2015 and one in 2016 (Appendix E, Figure E2). As noted above, summer is typically the season when dissolved oxygen levels are most limiting for aquatic wildlife. Precipitation varied during these deployment periods - conditions were predominantly dry, but some rain occurred during most deployments. High tides were low to moderate, rarely exceeding eight feet. We monitored station L-2 during nearly all deployments and the lower Hobson-Struby channel (Station D-1) and lower reach of the tidal channel system (E channel system, Station E-1) during many deployments. We also made several deployments in the middle and upper reaches of the Hobson-Struby channel. The upper reaches of the E channel system are often without water during summer and we did not make any deployments in these areas. Dissolved oxygen concentrations were highly variable during summer and typically dropped as summer progressed. As above, dissolved oxygen concentrations at all sites fluctuated daily, but the magnitude of these fluctuations varied among stations. Concentrations in the middle and upper Hobson-Struby channel (stations D-2 and A-1, respectively) generally remained low during summer (means ranged from 1.8 to 5.9 mg/L) and levels sometimes dropped to below 1.0 mg/L in the upper reaches. Concentrations in the lower Hobson-Struby channel (Station D-1) also were highly variable (means ranged 1.6 to 8.1 mg/L), but typically remained somewhat higher than in the middle and upper reaches of the system. Concentrations in the lower E channel system (Station E-1) also varied widely (means ranged from 3.5 to 7.2 mg/L), but concentrations during most deployments exceeded 5.5 mg/L. Dissolved oxygen concentrations near the Miami River confluence (Station L-2) varied less than in other areas (range 4.6 – 6.6 mg/L), and most often exceeded 5.5 mg/L. Although dissolved oxygen levels were very low in some portions of the site during most summer deployments, the range of variability across the site was high and areas with higher concentrations (more suitable for aquatic life) occurred during each deployment.

We completed eight fall deployments – two in 2012 and 2014, three in 2013 and one in 2016 (Appendix E, Figure E3). Precipitation varied during these deployments – some rain occurred during each deployment, but some deployments saw very little rain while others were more consistently wet. High tides were moderate to large, often near or above eight feet. We monitored station L-2 during all deployments and the lower tidal channel system (Station E-1) during all but one deployment. We monitored the lower Hobson-Struby channel (Station D-1) during half of the deployments and also made deployments in the middle and upper reaches of the Hobson-Struby channel (stations D-2 and A-1, respectively) and the upper reaches of the E channel system (stations E-2 and E2-1). In general, concentrations were lower during early fall than late fall (when temperatures cooled and rains increased). As during other seasons, dissolved oxygen concentrations at all sites fluctuated daily, but the magnitude of these fluctuations varied among stations. Dissolved oxygen concentrations throughout the Hobson-Struby system were variable – concentrations in early-fall generally were below 6.0 mg/L, but late-fall concentrations typically exceeded 8.5 mg/L. The E channel system was somewhat less variable than the Hobson-Struby system, and concentrations generally exceeded 5 mg/L (means ranged from 3.2 to 6.7 mg/L). The lower common tidal channel (Station L-2) most often had concentrations in excess of 6.0 mg/L (means ranged from 4.3 to 10.5 mg/L).

We completed three winter deployments – one in 2013 and two during 2014-15 (Appendix E, Figure E4). Rain regularly fell during these deployments – sometimes in large amounts. Periods of large high tides (near or above nine feet) occurred during each deployment. We monitored stations L-2 and E-1 during all deployments, and the lower Hobson-Struby channel (Station D-1) during two deployments. We made single deployments in the middle and upper reaches of the Hobson-Struby channel (stations D-2 and A-1, respectively) and the upper E channel system (Station E-2). Dissolved oxygen concentrations were high at all stations during winter deployments. Means ranged from 6.4 to 11.5 mg/L and exceeded 8.0 mg/L at most stations.

The following sections summarize the results of our dissolved oxygen monitoring and provide a general characterization of the site relative to this parameter. In addition, we compare our results to State of Oregon water quality standards for dissolved oxygen[4] and to our very limited, pre-restoration data. The site technically occurs within the Tillamook estuary, so we compare our results to the 6.5 mg/L cool-water standard in text and figures.

Dissolved oxygen concentrations in channels on the TNC parcel from 2012 through 2016 ranged from very low (<1.0 mg/L) during summer to very high (>11.0 mg/L) during winter and spring (Appendix E). During spring and winter, dissolved oxygen concentrations at the site generally remained high. Mean concentrations exceeded the 6.5 mg/L state standard at most stations during all deployments (most means exceeded 8.0 mg/L). The exceptions to this statement occurred at single stations during January and March 2014 when mean concentrations in the lower and upper portions of the E channel system were 6.4 mg/L, respectively. Means during our fall deployments often were below the 6.5 mg/L standard (typically 4.5 to 6.0 mg/L), but most deployments occurred during September when weather conditions were similar to summer. During our single October deployment in 2013, means at all stations exceeded the 6.5 mg/L standard (and exceeded 10.0 mg/L at half of the stations). Means during our summer deployments often were below the 6.5 mg/L standard – 75 percent of our summer deployments (9 of 12) had station means below the standard. During these deployments, means at most stations generally exceeded 4.5 mg/L, but during July 2014 means at two Hobson-Struby stations fell to below 2.0 mg/L and means below 4.0 mg/L occurred during 2014, 2015 and 2016. Although low dissolved oxygen concentrations were common in summer, during all but two summer deployments, concentrations at some stations met or exceeded the state standard. In other words, even though dissolved oxygen levels often dropped to critically low levels on some portions of the site during summer, portions of the site continued to provide water with dissolved oxygen levels suitable for aquatic life. Despite recording some critically low dissolved oxygen levels during our work, we did not observe any unusually large die offs of fish or other aquatic wildlife during our monitoring efforts.

Generally, summer dissolved oxygen concentrations were lower in the Hobson-Struby channel than in other parts of the channel system on the TNC parcel. Oxygen is dissolved into water through direct absorption from the atmosphere, during rapid movement (especially as it tumbles over rocks and other obstacles), and as a waste product of plant photosynthesis. Oxygen also

[4] State of Oregon water quality standards for dissolved oxygen (OAR 340-041-0016). For estuarine waters and waterbodies identified as providing habitat for cool-water aquatic life dissolved oxygen may not fall below 6.5 mg/L. For water bodies identified by ODEQ as providing habitat for cold-water aquatic life, the dissolved oxygen concentration may not be <8.0 mg/L and for water bodies identified as active spawning areas for anadromous salmonids and resident trout species (spawning through fry emergence periods) the dissolved oxygen content may not be < 11.0 mg/L.

dissolves easier in cool water than warm water. Given these facts, it may seem counterintuitive for dissolved oxygen levels to be lower in the Hobson-Struby channel system than in other portions of the site (particularly since water in the stream tends to remain cool, even during summer). However, it is important to remember that within the Miami Wetlands site the Hobson-Struby channel system is highly influenced by beavers. There are numerous dams along the channels and signs of beaver are ubiquitous throughout (including beaver scat and gnawed stems). Beavers appear to use other channels predominantly for transport – all dams and lodges are located in the Hobson-Struby channel system and evidence of beaver presence is most abundant there. Bledzki et al, (2011) reported lower dissolved oxygen concentrations in streams inhabited by beaver than in ones lacking beaver. These authors attributed the difference to increases in dissolved organic carbon and nitrogen associated with beaver presence. Higher concentrations of these elements increases bacterial production, which in turn lowers dissolved oxygen levels (increased biological oxygen demand).

We did not obtain dissolved oxygen data from the Crabb parcel. However, given that channels on this parcel are largely fed by rain and flooding (no perennial streams flow into this parcel) and that beaver are present, it is likely that aquatic environments on this parcel have low dissolved oxygen levels during summer and early fall.

We did not obtain any pre-restoration dissolved oxygen data, so direct comparison with pre-restoration conditions is not possible. However, we did make two deployments in 2010 while restoration construction was ongoing – one in July 2010 and one in December 2010 (Bailey 2011). During each deployment we placed one logger in the lower common tidal channel (Station L-2) and one in the lower Hobson-Struby "ditch." Conditions at both stations were similar during each deployment. During summer, dissolved oxygen generally remained at or above the 6.5 mg/L standard, and winter levels were consistently above 8.0 mg/L. Neither of these stations were located above beaver impoundments. The post-restoration channel system on the TNC parcel is better connected to outside influences (and there is better internal connectivity among channels). In addition, beaver impoundments occurred throughout the pre-restoration drainage ditch system (as opposed to being predominantly within a single portion of the post-restoration channel system). Given the above, it seems likely that low dissolved oxygen levels were the norm throughout most of the pre-restoration ditch system during summer and early fall. As a result, restoration actions have almost certainly improved conditions relative to dissolved oxygen by providing for more variability during periods when beaver impounded channels contain poorly oxygenated water.

3.1.3. Soils

We anticipated that the Miami Wetlands Project would modify vegetation composition and structure, inundation patterns (for both fresh and brackish waters), and soil moisture content at the site, and that these changes could alter soil characteristics and influence other physical and biological factors at the site. This section presents information on post-restoration soil organic matter and salinity and contrasts these results with pre-restoration conditions.

3.1.3.1. Soil Organic Matter - Soil organic matter influences many of the physical, chemical and biological properties of soil. It contributes to soil structure, water holding capacity, nutrient cycles, biological activity, water and air infiltration rates, cation exchange capacity and other soil properties.

There are two general types of wetland soils, mineral and organic. Organic soils have lower bulk densities (weight per unit of volume) than mineral soils. As a result, organic soils have more pore space and greater water holding capacity than mineral soils. Water often moves slower through organic soils, which can reduce the extent and severity of downstream flooding, increase and prolong groundwater contributions to stream baseflows during drought periods, and ameliorate water temperatures in adjacent water bodies. In addition, organic soils have a greater potential to remove excess nutrients and other pollutants and, as a result, can alter the chemistry of the waters moving through them and transform nutrients into other forms.

We collected 16 soils samples for loss-on-ignition testing to evaluate organic matter content (Figure 10). In general, soil samples from the site in 2016 had very high organic matter content, ranging from approximately 9-29 percent (Table 6). Mean soil organic matter content for these samples was 17.8 + 1.2 percent (mean $\pm$ 1SE). Although we did not analyze soil texture for these samples, like baseline, all were fine textured silt.

The results of our 2016 soil organic matter testing are consistent with our baseline study. Pre-restoration soil samples had similarly high organic matter content (mean $\pm$ 1SE = 18.9 $\pm$ 1.5 percent). We collected all samples during both pre- and post-restoration studies from within the upper 12 inches of Coquille Silt Loam soils (Figure 6). Notable characteristics of the upper horizons of this soil series include an abundance of slightly decomposed plant material and fine and medium roots (USDA Natural Resources Conservation Service, Web Soil Survey). Therefore, the results of our analysis are not unexpected.

3.1.3.2. Soil Salinity – Soluble salts can accumulate in soils and affect soil physical and chemical properties, plant growth and vegetation composition. In agricultural terms, soil salinity in excess of 1,000 µS/cm may affect salt-sensitive crops and levels above 2,000 µS/cm require salt tolerant plant species. Significant salt accumulation is uncommon in areas where rainfall exceeds 20 inches per year. However, salt deposition can occur due to sea spray and tidal inundation in coastal areas and along brackish rivers and estuaries. Because the Miami Wetlands site is tidally-influenced and the restoration project substantially increased the amount of tidal channels and their connectivity, we tested for soil salinity during both pre- and post-restoration periods to determine whether restoration actions are altering soil salinity at the site. Soil texture is an important consideration when evaluating salinity. Coarser soils hold less water to dilute the salts than fine soils and this can affect conductivity readings. As a result, we evaluated soil texture in conjunction with our pre-restoration soil salinity studies. Because soil textures are unlikely to have changed in the six years since our pre-restoration work, we did not evaluate soil texture for our post-restoration soil samples.

Our 16 post-restoration soil samples ranged from non-saline to slightly saline (100-7,400 µS/cm; tables 2 and 6). All samples from the TNC parcel were Non-saline. In fact, only two samples (E82 and F129) approached the 1,000 µS/cm threshold for salt-sensitive species mentioned above, and both were in the southwest portion of the site where saline water enters the site via the tidal channel connection with the mainstem river channel. Sample E82 came from an area regularly inundated by overbank flows from the Hobson-Struby channel and F129 from an area that is flooded during very high river flows or tides in excess of approximately nine feet. Conversely, all but two of the samples from the Crabb parcel were Very Slightly Saline or

Slightly Saline. The two Non-saline samples came from the old utility corridor and the levee separating the Miami River from the parcel (samples I74 and G100, respectively) – areas that typically are wetted through precipitation (and only occasionally by flooding). The remaining samples from this parcel came from within the wetland portion of the parcel, in proximity to the channel system. These samples came from areas that are continuously-saturated (or nearly so) by water from the channel.

The results of our 2016 soil salinity testing are consistent with our baseline sampling and with descriptions for the soil type that we sampled. All baseline samples from the TNC parcel were Non-saline. Similar to 2016, the only 2010 samples that approached 1,000 µS/cm were from near channels in the southwest portion of the parcel. Baseline samples from wetland areas on the Crabb parcel were Very Slightly Saline and those from along the levee and utility corridor were Non-saline. As mentioned previously, our 2016 samples were all Coquille Silt Loam. The USDA, NRCS Web Soil Survey Map Unit Description for this soil describes it as silt loams or silty clay loams that are typically non-saline to very slightly saline. However, Brophy et al. (2011) reports soil salinities from tidal wetland sites at other Oregon estuaries. Three of these sites were on Coquille Silt Loam soils and had measured soil salinities in the Mesohaline and Polyhaline ranges.

Table 6. Results of Loss on Ignition and Saturated Paste Extract analyses to determine percent organic matter and salinity for June 2016 soil samples from the Miami Wetlands site.

Soil Pit ID*	Organic Matter (%)	Soil Salinity (µS/cm)	NRCS Soil Salinity Class**
A-15	20.1	300	Non-saline
A-700	19.5	200	Non-saline
B-445	16.9	100	Non-saline
C-63	20.4	400	Non-saline
D-313	14.8	100	Non-saline
E-82	17.7	800	Non-saline
E-384	15.6	200	Non-saline
F-24	16.3	300	Non-saline
F-129	15.2	900	Non-saline
G-20	28.9	2,100	Very Slightly Saline
G-66	17.7	2,400	Very Slightly Saline
G-81	9.0	2,800	Very Slightly Saline
G-100	14.0	1,100	Non-saline
H-80	25.6	7,400	Slightly Saline
H-216	18.6	4,200	Slightly Saline
I-74	15.0	200	Non-saline

*See Figure 13 **See Table 2

3.1.4. Channel Cross Sections

We surveyed channel cross sections during October 2012, August 2014 and January 2016, but were unable to measure profiles immediately after the channels were constructed. As a result, we compare our field-measured profiles to as-designed channel widths and bottom elevations. We measured four cross sections on the Hobson-Struby channel (Channel C/D), two profiles each on tidal channels E and E2, and one profile on tidal channel E3. Cross sections are located where permanent transects cross the constructed channels (Figure 14), and are identified by two characters separated by a hyphen. The first character corresponds to the channel ID and the second character corresponds to the permanent transect ID. For example, Cross Section D-E is located where Channel D is crossed by Transect E. Appendix F provides graphs of each channel cross section from 2012 through 2016. The following sections describe the evolution of channels post-construction.

3.1.4.1. Hobson-Struby Channel Complex (Channels A, B, C, D and F) - After construction, we observed recruitment and deposition of silt, sand, gravels and other streambed materials along the length of the Hobson-Struby channel. Our first post-construction cross section survey in 2012 identified that the Hobson-Struby creeks channel (channels C and D) had aggraded approximately one foot along much of its length, but channel width remained relatively stable. With the exception of Section C-B, which is located a few meters downstream of a large beaver dam constructed during summer 2013, cross sectional profiles along the Hobson-Struby Channel have remained relatively unchanged since 2012 (Appendix F – Sections C-B, D-C, D-D and D-E). We have observed localized sloughing of bank material in the area near Section C-B, probably because widespread inundation in this area has resulted in less-stable, saturated soils. Banks along much of the remainder of this channel appear relatively stable, but ongoing dam-building has increased the size of the inundated zone and re-directed flows along this channel and it seems likely that channel alterations will continue as a result.

Immediately post-construction, we observed that the constructed C/D channel (Hobson-Struby channel) appeared to have more active flow than during pre-project times when the creeks were conveyed in their former ditch-like common channel. This increased flow was responsible for the movement and deposition of substrate materials noted above. However, since summer 2013 beaver dam building in the Hobson-Struby system has dramatically altered flows, and stream velocity in the channel during much of our post-restoration work was low. Beavers also have created numerous additional flow paths and channels in the area and water originating in Hobson and Struby creeks has inundated a substantial portion of the TNC parcel (Figure 25). This has accentuated flows in other channels. For example, the small F channel system (Figure 7) was originally a backwater tributary to the C/D channel (without upstream inputs). However, the redirected flows from the A and B channels flow overland and into the upper F channels, dramatically improving habitat quality of these channels for salmonids. We did not measure channel profiles on the F channels.

We have not collected cross section data from either the Hobson or Struby creeks channels (A and B channels, respectively). However, we have noted substantial changes along these reaches since project construction. During construction in 2010-11, the existing channels for these creeks were simply “enhanced” with hand tools to provide for more direct flows towards the constructed common channel (C channel, Figure 7). Since construction, pronounced beaver activity has turned the entire northwest corner of the TNC parcel into a complex system of braided channels and overland flows and the A and B channels are far less distinct than they were immediately post-construction.

3.1.4.2. Tidal Channel Complex (Channels E, E2, and E3) - The primary tidal channels (E channels) have responded more variably than the Hobson-Struby channels. The lower portions of these channels have remained fairly stable since construction: there has been some localized bank sloughing that has widened and aggraded portions of the lower reaches, but in general channel width and bottom elevations remain similar to the original channel designs (Appendix F, Sections E-E and E2-E). Although we have observed sloughed material lingering for short periods, it appears that tidal flow in the lower portion of these channels has been sufficient to minimize accumulation of this material, but not so great as to scour the channels and increase their depth.

The upstream portions of the E channels have changed more substantially since they were constructed, and each channel has responded somewhat differently. Bottom elevation in the upper portion of the E2 channel (Appendix F, Section E2-D) has aggraded a few inches and there has been some localized bank sloughing which has widened the channel in places. Bottom elevations in the upper portions of Channels E and E3, on the other hand, had aggraded a foot or more above design elevations by 2016 (Appendix F, Sections E-D and E3-D). Localized sloughing of bank material also has occurred along each of these channels. Bottom elevations in the upper portion of the E2 channel were considerably lower than the E and E3 channel to begin with and, as a result, this channel is more regularly inundated with tidal flows. It seems likely that this more frequent and energetic flow regime has limited deposition of bottom materials in this channel. We attribute the greater accumulation of bottom materials in the upper portions of the E and E3 channels to their higher beginning elevations and less frequent tidal inundation (see water quality data from these reaches that demonstrate episodic inundation).

3.2. Biological Attributes

Below we report the results of our efforts to document post-restoration biological attributes at the Miami Wetlands. As noted earlier, we collected data on a variety of biological attributes at the site including vegetation, macroinvertebrates, secretive marsh birds, and fishes. The following sections summarize these data.

3.2.1. Vegetation

Below are results of our post-restoration vegetation studies. We report on information collected through line-intercept transects, 1-m^2 quadrats for herbaceous species and 5m radius circular plots for tree and shrub species. We also report the results of annual restoration planting survival monitoring. We compare post-restoration results to baseline conditions, and use the suite of information gathered to quantify various aspects of onsite plant communities. We used this information along with aerial and ground imagery to create an updated vegetation community map for the site.

Vegetation at the site appears to be responding positively to project actions. Native species have continued to increase in stature and area covered and, although still very abundant at the time of this writing, non-native and invasive species appear to be slowly, but steadily, declining. The increase in diversity, abundance and size of woody plant species has been particularly noticeable, as has the expansion of native graminoids (e.g., slough sedge (*Carex obnupta*), small-fruited bulrush, several rushes [*Juncus* spp.], and others).

As of fall 2017, native trees and shrubs planted at the site have increased in size to the point where many individuals are well above the height of the grasses and other plants that previously dominated much of the site. In many areas, planted trees are greater than five meters tall and have altered the vertical structure of the site relative to baseline conditions. Wetland species plantings (slough sedge, small-fruited bulrush, etc.) also have persisted and spread. As a result, there has been a marked visual change in vegetation on the site and it has transitioned from a non-native grass-dominated area to one where native trees, shrubs and graminoids are far more prominent (ideally, these species will come to dominate the site). Planted trees and shrubs are clearly visible on more recent aerial photographs of the site and there is a noticeable contrast between these and pre-construction aerials. Appendix G provides a sequence of aerial images from 2005-2017. Figure 27 provides a high-resolution, composite aerial photograph created from a 2016 drone overflight. Figure 28 is a digital surface model (DSM) generated from drone aerial imagery overlaid on the 2016 aerial of the site. It depicts vegetation canopy height with a two-foot interval color ramp. When reviewing this image, please bear in mind that the DSM was constructed with data from a drone with consumer-grade gps technology (not high-precision, survey grade equipment). In addition, the 3D algorithm that creates DSM from aerial imagery also can result in errors. As a result, the image does not necessarily reflect the true height of all vegetation on the site, but it does provide a reasonable approximation of canopy height at the site. From our review, it appears that (when viewed in vertical bands) the middle ½ of the image is consistent with reality, but the western and eastern quarters are less accurate. It appears that values depicted in the western ¼ are somewhat lower than actual heights and those in the eastern ¼ are somewhat higher. Reviewed in aggregate, the images in this report provide powerful evidence of gross changes to vegetation that have occurred because of restoration at the site (particularly for woody species).

As reported previously, beaver activities continue to dramatically influence hydrology and vegetation at the site. Numerous dams and trails (some of which have rather quickly become knee-deep channels) have been constructed and evidence of beaver movement and foraging on woody plants is widespread, particularly on existing and planted willows. Through their dam building and trailing efforts, beavers have altered hydrological conditions of the site and many areas that were relatively dry during the first two to three years post-construction were inundated during the latter portion of our post-restoration monitoring. This changing hydrology is influencing vegetation at the site because only those species tolerant of continuous inundation are able to persist in the wettest areas. This process was noted beginning with our 2013 interim reporting and dam building and trailing has continually shaped the property since that report was submitted. Inundation and rodent predation have been the primary cause of mortality for our restoration planting efforts. On several occasions during fieldwork completed for this report, we noted previously robust and healthy trees and shrubs that had become standing dead vegetation due to recent inundation or girdling by rodents. While this individual mortality was notable, survival for our plantings was generally high across the site.

The following sections summarize the results of our vegetation monitoring efforts.

Figure 27. High-resolution aerial photograph of Miami Wetlands. Photo is a composite of approximately 300 individual photographs taken with a drone flying approximately 100 ft above the ground during August 2016.

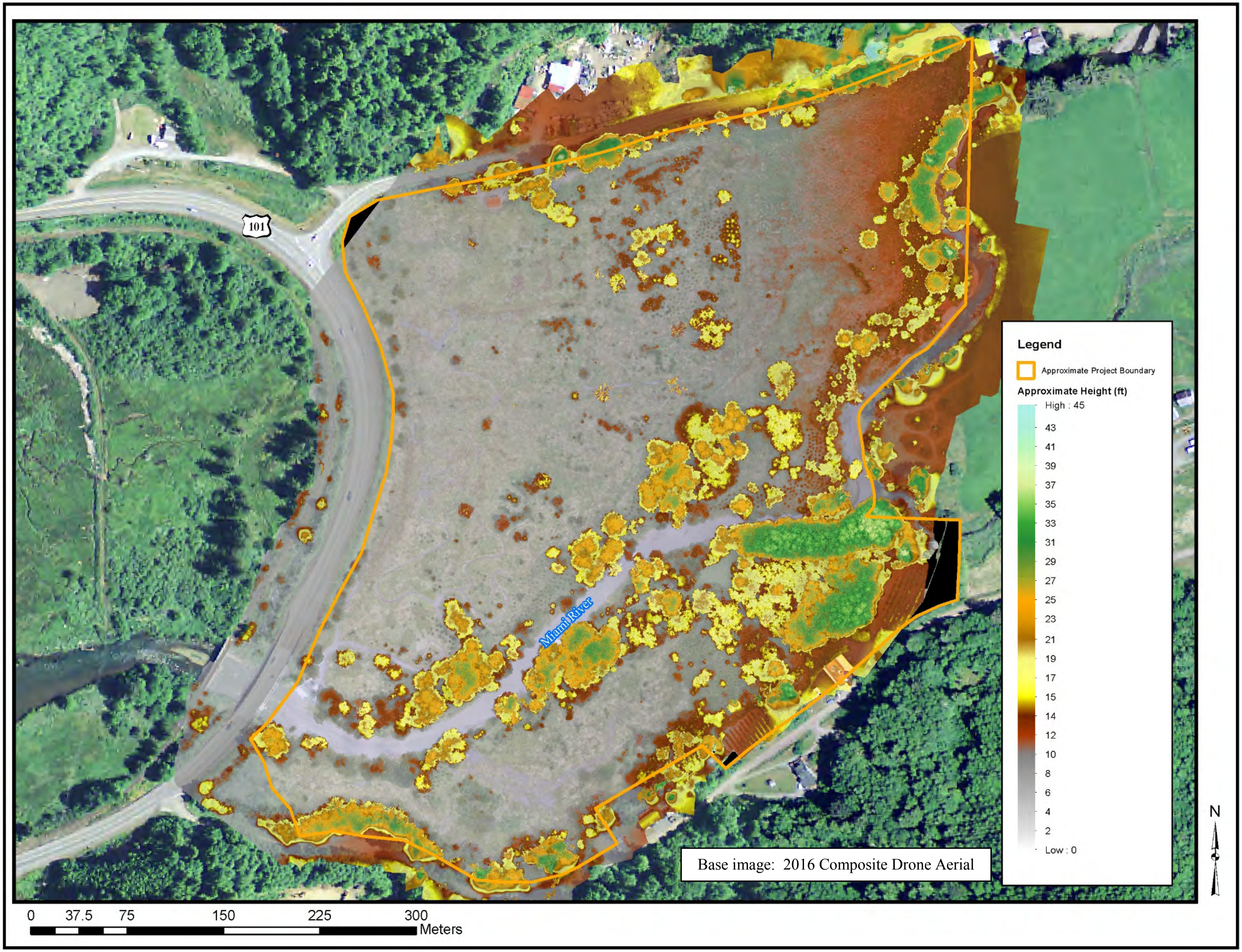


Figure 28. Digital elevation model generated from drone aerial imagery overlaid on aerial photograph of Miami Wetlands.

3.2.1.1. Line Intercept - Although similarities remain between our pre- and post-restoration line intercept data, there are notable differences that indicate the site is trending in the desired direction relative to vegetation composition. The following sections elaborate on notable findings from our line-intercept studies, and compare and contrast this information with baseline conditions. Summary tables for our pre- and post-construction line intercept data are provided in Appendix H. In addition, figures in Appendix I visually depict line intercept data as color-coded, segmented lines (each dominant species is given a unique color along the length of each transect). These lines are overlaid on aerial photographs of the site. Appendix I figures include pre- and post- construction line intercept data and viewing them together provides a sense of the change that has occurred with vegetation on the site. Appendix J provides endpoint photos from transects completed in 2010 and 2016.

Mean percent total vegetation cover[5] ($\pm$ 1 SE) along the nine sampled transects remained high from baseline through 2016 (pre-construction = 95.1 $\pm$ 1.6 percent, 2012 = 92.2 $\pm$ 1.9 percent, 2014 = 84.6 $\pm$ 5.5 percent and 2016 = 92.2 $\pm$ 2.0 percent). Although mean total cover dropped somewhat after restoration construction, it did not differ significantly among our sampling bouts (ANOVA for correlated samples – $F = 0.84$, $df = 3$, $P = 0.5$). While cover has remained high, the site has become more diverse and species distribution has shifted.

There was a nearly two-fold difference for open water encountered along the study transects between 2010 (4.9 $\pm$ 1.6 percent) and 2014 (9.2 $\pm$ 2.9 percent), but the difference between baseline and 2016 (6.1 $\pm$ 1.5 percent) was less substantial (Appendix H). Despite the considerable expansion of the channel system (pre vs. post) and subsequent beaver activities (which appear to have increased the amount of inundated land within the project site), the amount of mean total cover provided by open water has not changed significantly since project implementation (ANOVA for correlated samples – $F = 2.3$, $df = 3$, $P = 0.10$). Some post-restoration open water was associated with small openings in vegetation created by restoration actions that subsequently were inundated due to beaver activities. Many of these areas transitioned from open water to vegetation (with standing water at its base) as the site recovered and adjusted. In addition, open water associated with channels decreased as bankside vegetation grew in stature and increasingly overhung the channels.

We recorded substantial amounts of dead and downed vegetation (litter) in 2014 (mean total cover = 5.7 percent). This was the first and only year that we recorded plant litter on our transects (there was litter during each sampling bout, but it typically was buried under live vegetation and so it was not recorded – 2014 was different). We are unclear exactly what contributed to the large amount of litter we observed that year. Some of it was piles of dead vegetation (primarily reed canary grass) associated with particularly heavy maintenance of restoration plantings (mechanically removed from around planted specimens). However, we also noted a considerable amount of dead slough sedge at the site in spring 2014 and percent cover for this species declined substantially as compared to previous sampling efforts (Appendix H, tables 1-3). This species was not targeted during mechanical plant release, so we speculate that

[5] The term "Total Vegetation Cover" refers to the percentage of ground covered by live vegetation. In our summary tables for this data we provide cover data for several plant species and also include measures of open water, bare ground and dead and downed vegetation (plant litter). Relative cover is the cover of a particular species as a percentage of total live plant cover (this measure excludes bare ground, litter and open water). Relative cover will always tally up to 100%, even when total vegetation cover is low.

periods of abnormally cold winter temperatures during winter 2013/14 may have contributed to the large amount of dead-and-downed slough sedge at the site. We did not note similar die backs for other wetland graminoids in 2014. In fact, percent cover for small-fruited bulrush expanded substantially between 2012 and 2014. While it is true that we detected a reduction in ground cover for slough sedge in our spring 2014 sampling effort along all transects (Appendix H), it does not appear that this was a major die-off. Instead, it appears that while above ground portions of many plants died back, the root systems remained viable. In 2016, the amount of slough sedge recorded increased, but had not recovered to pre-2014 levels. Further discussion of slough sedge and other native graminoids is provided below.

Although reed canary grass (*Phalaris arundinacea*) remained very common during all sampling bouts, we recorded decreasing cover of patches dominated by this species over the course of our post-restoration monitoring (Appendix H). Mean percent relative cover for patches dominated by this species during pre-restoration studies was approximately 65 percent. Mean relative cover dropped only slightly between pre-restoration and 2014 (2012 - 62.7 percent and 2014 - 62.3 percent), but by 2016 it had dropped to approximately 55 percent. Despite this apparent decreasing trend, mean relative cover for reed canary grass-dominated patches did not differ significantly between our pre- and post-restoration studies (ANOVA for correlated samples – $F = 2.01$, $df = 3$, $P = 0.1$). Regardless, the declining trend for this species is encouraging.

Mean combined relative cover ($\pm$ 1 SE) of patches dominated by native wetland graminoids (i.e., Slough sedge, small-fruited bulrush, Baltic rush [*Juncus balticus*], soft rush [*J. effusus*], arctic rush [*J. arcticus*], ovoid spikerush [*Eleocharis ovata*] and common spikerush [*E. palustris*]) increased from approximately 18 percent during our pre-construction studies to 23 percent in 2016 (Appendix H). However, pre- and post-restoration means did not differ significantly (ANOVA for correlated samples – $F = 0.77$, $df = 3$, $P = 0.5$). Despite this lack of statistical significance, there are notable differences among our pre- and post-restoration data sets that suggest conditions are trending in a positive direction relative to native graminoids. Although mean relative cover of slough sedge-dominated patches dropped approximately five percent between 2010 and 2016, this difference was not significant (Student's t for correlated samples – $t = -1.17$, $df = 8$, $P_{two\text{-}tailed} = 0.3$) and we encountered patches dominated by this species on every transect during each of our four sampling bouts. Slough sedge is an aggressive competitor and its persistance at approximately the same level of cover despite a notable die-back is encouraging. As of 2017, conditions for this plant are very favorable over a large portion of the site, and we anticipate it will become more prevalent in the future. Mean relative cover for small-fruited bulrush-dominated patches rose approximately five percent between 2010 and 2016. While this change also is not statistically significant (Student's t for correlated samples – $t = 1.8$, $df = 8$, $P_{two\text{-}tailed} = 0.1$), our data documents substantial expansion of this species on the site. Patches dominated by small-fruited bulrush were only encountered along a single transect in 2010, but by 2016 this species dominated patches along seven of the nine transects. The number of transects with Baltic rush- and soft rush-dominated patches increased similarly from 2010 to 2016 (Baltic rush – one transect in 2010 and four in 2016, soft rush – four transects in 2010 and seven in 2016). Spikerush-dominated patches (both ovoid and common spikerush) persisted on transects G and H throughout our study, and the relative cover of these plants on both transects increased between 2010 and 2016.

Mean relative cover for invasive blackberry-dominated patches decreased significantly among our sampling efforts (ANOVA for correlated samples – $F = 3.14$, $df = 3$, $P = 0.04$). Based upon Tukey's HSD, mean relative cover for blackberries in 2012 (0.5 percent) was significantly lower ($P < 0.05$) than baseline (3.5 percent), but 2014 (1.4 percent) and 2016 (1.4 percent) means did not differ from baseline (Appendix H). Pre-construction, we encountered blackberries along four of nine transects (and they accounted for > 5 percent relative cover for two of those transects – almost 20 percent on Transect I). In 2012, 2014 and 2016 they provided > 5 percent relative cover on only a single transect (Transect I). Although the size of the infestation along Transect I decreased somewhat after baseline, it appears that level of our mechanical vegetation clearing efforts in this area were insufficient to control this aggressive species.

We seeded areas disturbed during restoration construction with a mix of native grasses and forbs. By 2012, one of the species in the mix (meadow barley [*Hordeum brachyantherum*]) dominated these areas. It accounted for nearly five percent of relative vegetation cover at the site that year (Appendix H). In 2014, however, patches dominated by this species accounted for less than 0.5 percent relative cover. By 2016, no meadow barley-dominated patches were recorded. Areas where this species dominated in 2012 became progressively more diverse and by 2016 a host of primarily native species (predominantly native graminoids discussed above) occupied these areas.

Vegetation at the site has become more diverse post-restoration, and the number of dominant species per transect differed significantly among our sampling efforts (ANOVA for correlated samples – $F = 5.64$, $df = 3$, $P = 0.005$). In our baseline study, we encountered a mean of 6.3 dominant species per transect (Appendix H). By 2012 this number had increased to 8.0, and in 2014 and 2016 the mean number of dominant species per transect was 10.1 and 10.4, respectively. Based on Tukey's HSD, the increase from baseline to 2012 was insignificant, but the number of dominant species per transect in 2014 and 2016 was significantly greater than baseline ($P < 0.05$ and $P < 0.01$, respectively). Total number of dominant species did not differ significantly between 2014 and 2016.

Many of the species/attributes discussed above are color coded on the tables provided in Appendix H to assist in comparing them across sampling bouts. Other notable differences between our pre- and post-restoration data are not highlighted in this fashion, but are no less important or interesting. As noted in the methods section, tree and shrub species were only recorded as dominant on line intercept transects when they were the only species encountered (single species patch) or when understory vegetation beneath them was sparse. In areas where understory vegetation provided the most substantial ground cover, trees and shrubs were not considered dominant for our line intercept data. Several species of trees and shrubs were absent or recorded only in trace amounts during our baseline line intercept work. These included Sitka spruce (*Picea sitchensis*), cascara (*Frangula purshiana*), black cottonwood (*Populus trichocarpa*), black twinberry (*Lonicera involucrata*), red alder (*Alnus rubra*) and willows (*Salix* spp.). By 2016, the mean relative cover for these species individually ranged from approximately 0.5 to over 6 percent (Appendix H). We used the aggregate mean relative cover of these species to assess the difference between pre- and post-restoration conditions. Based on Student's t for correlated samples, these species provided significantly more cover ($t = 7.69$, $df = 8$, $P_{two\text{-}tailed} < 0.0001$) in 2016 ($1.4 \pm 0.2$ percent) than during baseline (0.4 ± 0.2 percent). During baseline, only two of the six species noted above were recorded along transects and they were only recorded along four of the nine transects. However, we encountered all six species along our 2016 transects and one or more provided measurable cover along each of the nine transects. Although the amount of cover provided by woody species in 2016 remained low relative to some other species, their measurable (and statistically significant) increase is further indication that the site is transitioning in a manner consistent with restoration goals.

3.2.1.2. Nested Vegetation Plots – As noted above, we used a nested-plot design and sampled herbaceous vegetation with 1m^2 herbaceous plots and woody plants with 5m radius circular plots at randomly selected points along our study transescts. Table 7 is a summary of our nested vegetation plot work. For each sampling round, it includes the total number of nested vegetation plot locations sampled, the number of tree/shrub plots sampled, the proportion of nested-plot locations where tree/shrub plots were completed, the total number of tree/shrub plots with trees >3cm dbh and the proportion of tree/shrub plots with dbh measurements.

Table 7. Summary information for nested vegetation plots completed at Miami Wetlands site.

Sampling Bout (Year/Restoration Period)	Number of Nested-Plot Locations Sampled[1]	Number of 5m radius Tree/Shrub Plots Sampled[2]	Proportion of Nested-Plots with Trees/Shrub Plots (%)	Number of Plots with Stem Counts[3]	Proportion of 5m radius Plots with Stem Counts (%)
2010 / Pre	112	44	39	8	18
2012 / Post	93	68	73	14	21
2014 / Post	93	79	85	22	28
2016 / Post	86	69	80	32	46

[1] We completed a 1-m2 herbaceous vegetation plot at all nested-plot locations

[2] If woody vegetation >1m tall occurred within 5m of randomly selected nested-plot locations, we completed a 5m radius tree/shrub plot

[3] We measured dbh and counted total number stems for all woody plants >3cm diameter at breast height within 5m plot (stem count)

The proportion of tree/shrub plots completed increased significantly after restoration. In 2012, we completed significantly more tree/shrub plots than during our 2010 baseline sampling (Pearson Chi-square = 23.47, $P < 0.0001$). The proportion of 5m radius plots for the three post-restoration sampling bouts did not differ from one another (Chi-Square 4.03, df = 2, $P = 0.1$). The proportion of 5m radius plots where dbh measurements were taken (stem plots) increased significantly over the course of our monitoring effort. The proportion of stem plots did not differ among our 2010, 2012 and 2014 sampling bouts (Chi-square = 1.85, df = 2, $P > 0.1$), but the proportion of stem counts completed in 2016 was significantly greater than during 2014 (Pearson Chi square = 5.46, $P < 0.002$).

During baseline studies, we measured dbh primarily for red alder and large willows. Most baseline dbh measurements were small trees (classes 1 and 2, see Section 2.2.1.2.b), but we recorded a few larger alders. Similar to baseline, red alder and willows were the most often-measured species in 2012 and 2014, and most measured stems were class 1 or 2. However, in 2014 we also recorded dbh for a few black cottonwood and Sitka spruce trees planted as part of restoration. In 2016, a majority of planted specimens remained in classes 1 and 2. Although willow and alder remained common, many dbh measurements were for Sitka spruce, black cottonwood, cascara, and black twinberry planted at the site between 2011 and 2013.

The above sections are a testament to the amount of woody vegetation planted at the site as part of this restoration effort. They speak to the fact that these planting efforts have been widely distributed throughout the site and that planted specimens had good survival and growth throughout the monitoring period for this report (see below). Data from our shrub/tree plots reflect the young age and small stature of planted specimens (relative to their mature size) during our monitoring effort and the paucity of large trees within the areas sampled by our transects, but it also reflects growth of these plantings over this short period. The fact that individual plants representing a suite of native woody species have achieved measurable size, is evidence that the restoration effort is transitioning positively relative to its stated goals. We further discuss the results of the $1m^2$ and 5m radius plots and how this information was used to characterize vegetation communities in Section 3.2.1.4, below.

3.2.1.3. Restoration Planting Survival Monitoring – We planted a mix of container-grown trees, shrubs and wetland forbs and graminoids and cuttings of willow and other species each winter/spring from 2011 through 2013. Container-grown tree species planted included Sitka spruce, black cottonwood, red alder, western red cedar (*Thuja plicata*), cascara, Pacific crabapple (*Malus fusca*), and big-leaf maple (*Acer macrophyllum*). Shrubs included black twinberry, Pacific ninebark (*Physocarpus capitatus*), Douglas spirea (*Spirea douglasii*), red-flowering currant (*Ribes sanguineum*), and red osier dogwood (*Cornus sericea*). Herbaceous plants included cow parsnip (*Heracleum lanatum*), small-fruited bulrush, and slough sedge. During the first two planting seasons, we typically planted in areas where no previous planting had occurred. However, by the 2013 planting season all zones within the wetland and riparian zones (Figure 19) had been planted. As a result, our planting efforts in 2013 (and some very limited planting in 2014) were primarily mortality-replacement and density-increase plantings (limited footprint efforts to replace plants in areas of unacceptably high mortality or increase the density of plantings in specific areas). We also planted the upland zone in the northeastern portion of the TNC parcel during 2013 (Figure 19). However, that portion of the parcel is not within the footprint of our original wetland restoration project so we did not monitor survival of those plantings for this report (they do, however, appear to be doing very well as evidenced in aerial photographs of the site included in this report).

During each summer from 2011 -2017, we completed 2-3 plant release sessions (i.e., using mechanical methods to control competing vegetation around planted specimens to give them a competitive advantage). Throughout this effort, much of the work was accomplished with power tools (primarily string trimmers fitted with brush blades). However, as desirable, native plants have become more abundant and interspersed among and within patches of non-native species an increasing amount of the plant release work was completed with non-motorized tools (primarily small scythes). We employed a small crew of restoration planting professionals (3-4 crew members) for the bulk of our plant release work, but also received assistance from larger youth crews on several occasions.

We monitored survival of our wetland plantings each fall from 2011 through 2016 with 0.1-acre circular plots (37.2 ft radius circular plots). We did not complete sample plots within the riparian planting zone. Because these areas were narrow strips and predominantly trees and shrubs were planted, we conducted a complete census of these areas annually from 2011-2015. Below, we separately report on the results of our monitoring efforts for each of these zones.

Data from our survival monitoring efforts informed our mortality replacement plantings in areas where we observed greater than acceptable tree, shrub and/or forb mortality. For example, in the areas affected by beaver activities where tree and shrub mortality was high we replanted only with species more tolerant of very wet conditions. We also increased our use of chicken wire cages to minimize potential for beaver predation on recently planted specimens. Finally, we adjusted our plant pallet for re-plants to exclude species that were performing poorly.

We have had good survival of our restoration plantings and, as a result, we witnessed changes in the structure and composition of on-site vegetation during our approximately six year monitoring effort. These changes are discussed in detail elsewhere in this report. Below we summarize our annual survival monitoring efforts for the wetlands and riparian planting zones depicted on Figure 19.

3.2.1.3.a. Wetland Planting Zone – We sampled 20 - 0.1-acre circular plots in the wetland planting zone during fall 2011, and increased the number of plots to 31 during sampling in 2012 and 2013. In 2014, 2015 and 2016, we sampled 32, 28 and 34 plots, respectively.

In 2011, we could identify dead plants to species with a high degree of certainty. However, the passage of time and multiple planting incursions made survival sampling increasingly difficult, and by 2014 it was often impossible to find, let alone identify, plants that had died years before. In addition, the repeated planting efforts made it difficult to interpret our results in terms of percent survival. As a result, in this report we only estimate percent survival with our 2011-2013 data. For our 2014-2016 data, we report estimated numbers of live plants per acre.

In general, we observed good survival of planted specimens within the wetland planting zone during the 2011-2013 sampling periods (Table 8). In 2011, aggregate survival rates for trees, shrubs and cuttings were very high (>85 percent for each groups) and survival of all species within each group was high (>75 percent). Although we noted high mortality for trees in some areas of the site (generally associated with inundation or rodent predation), survival rates for all tree species remained $\geq$70 percent through 2013. Some shrub species had similarly high survival rates through 2013, but shrub survival was more variable. In 2012, we recorded substantial mortality for a few shrub species (30-50 percent mortality). Survival for one of these species, Pacific ninebark, continued to drop, and by 2014 it was no longer encountered in survival plots. Results for other species were more variable. For example, survival for Douglas spirea in 2012 was 69 percent, but it rose to 83 percent in 2013 and continued its strong presence through 2016. We did not note any mortality for cuttings in 2011, but by 2013 approximately 1/3 of cuttings in our plots had died. We attribute this to two factors. While most cuttings were willow stakes, we also planted some Pacific ninebark and Douglas spirea cuttings. Cuttings for these two species fared poorly and by 2013, most were dead (container grown Douglas spirea, however, had high survival). We also recorded substantial mortality for willow cuttings on the TNC parcel in 2013. This was primarily a result of rodent predation (beaver foraging and girdling of trunks by small mammals). These results led us to protect some willows with cages to reduce beaver herbivory.

Over half of herbaceous plants planted during our first round of restoration planting (winter 2010-11) perished in their first year (Table 8). We attribute this to very cold weather conditions that occurred shortly after plant materials were delivered to the site, but before they were planted. During this period, potted herbaceous plants were exposed to below-freezing conditions for several days while they were stored above ground in waxed cardboard boxes. We believe that this damaged the roots of many individual plants and, as a result, many were dead when planted (or died shortly after). Since they were dormant at the time of planting, we had no way of knowing they had been compromised until our fall 2011 survival monitoring. We attribute the increase in survival for herbaceous plants in 2012 and 2013 to two factors. We planted herbaceous plants in groups of three and marked each group with a bamboo pole. During survival monitoring, we counted the number of living plants at each marker pole. Most of the herbaceous species we planted at the site reproduce and spread by rhizomes, so individuals that survived after 2011 were able to grow and spread. If this resulted in three or more plants near a marker pole that was within our sample plots, we would not record any mortality at that marker. This phenomenon could account for some of the increase in herbaceous plant survival in 2012 and 2013. In addition, we planted herbaceous species during our mortality replacement and density increase planting and the survival rate for herbaceous plants from these planting efforts was likely higher than during the 2011 planting season when the aforementioned cold damage occurred.

Table 8. Survival rates for restoration plantings in the wetland planting zone at the Miami Wetlands site from 2011-2013.

Sample Year	**Percent Survival**				**Plots Sampled**
	Trees	**Shrubs**	**Herbaceous Plants**	**Cuttings**	
2011	92	87	45	100	20
2012	71	71	61	92	31
2013	76	84	70	66	31
2011-2013 Mean ± 1SE	79.7 ± 5.5	80.7 ± 4.3	58.7 ± 6.3	86.0 ± 8.9	27.3

As noted above, we did not estimate survival for plantings in the wetland zone with data collected after 2014. Instead, we use our survival monitoring data to estimate the number of planted plants alive per acre within the wetland zone (Table 9). From 2014-2016, there were an average of approximately 380 planted specimens alive per acre within the wetland planting zone (47 trees, 174 shrubs, 129 herbaceous plants and 29 cuttings). Plants per acre for all plant types (trees, shrubs, etc.) remained similar throughout this period. To provide a sense of the relationship of our 2011-2013 percent survival estimates and our 2014-2016 live plants per acre estimates, Table 9 also includes an estimate of live plants per acre for our 2013 data set.

3.2.1.3.b. Riparian Planting Zone – We did not sample restoration plantings in the Riparian Planting Zone (Figure 19). Instead, we completed an annual census of these plantings from 2011-2015. For this work, we did not differentiate among species or growth form (i.e., trees and shrubs

– few forbs/graminoids were planted in the riparian zones and we did not track their fate), and simply counted live (and dead when present) individuals within this zone. We planted this zone during spring 2011 and, based on our monitoring results, we did not complete any mortality replacement or density increase plantings in it. We planted 1,273 trees and shrubs within the riparian zone on the TNC parcel, and 408 trees and shrubs in the riparian zone on the Crabb parcel. Our plantings included a mix of the species listed above and trees greatly outnumbered shrubs. We cleared competing vegetation from around these plants where needed through 2015.

Survival in the riparian planting zone remained very high throughout the time that we monitored these plants (Table 10). Trees and shrubs planted in this zone have thrived and grown considerably since 2011. In fact, these plants are evident on recent aerial images of the site included in this report and many were > 20 feet tall by summer 2016 (Figure 28). Because of this restoration project, there are now approximately 1,500 native trees and shrubs (including many conifers) along this 0.5 mile reach of the lower Miami River that were not there prior to 2010. What was once a riparian community overwhelmingly dominated by red alder has become a much more diverse community where a mix of native species are providing increasingly more cover and vertical structure.

Table 9. Estimated number of live plants per acre for restoration plantings in the wetland planting zone at the Miami Wetlands site from 2013-2016.

Sample Year	**Live Plants Per Acre**				**Total Plants Per Acre**
	Trees	**Shrubs**	**Herbaceous Plants**	**Cuttings**	
2013	78	155	136	97	466
2014	60	144	144	32	381
2015	51	162	119	32	364
2016	66	180	125	23	394
2014-2016 Mean $\pm$ 1SE	59.0 $\pm$ 3.8	162.0 $\pm$ 9.0	129.3 $\pm$ 6.5	29.0 $\pm$ 2.6	379.7 $\pm$ 7.5

Table 10. Survival rates during 2011-2015 census of trees and shrubs planted in the riparian planting zone at the Miami Wetlands site.

Sample Year	**Percent Survival**	
	TNC Parcel	**Crabb Parcel**
2011	92	97
2012	90	96
2013	88	95
2014	87	94
2015	87	94

3.2.1.4. Plant Community Mapping – During our baseline work at the Miami Wetlands site, we identified 10 different vegetation communities in five different general categories. These were: Palustrine Emergent Wetland 1 (PEM1), Palustrine Emergent Wetland 2 (PEM2), Palustrine Emergent Wetland 3 (PEM3), Palustrine Emergent Wetland 4 (PEM4), Palustrine Scrub Shrub (PSS), Riparian 1, Riparian 2, Upland 1, Upland 2, and Disturbed. These were designated following classification principles for wetland habitats established by Cowardin, et al. (1979). We maintain this same list, with one addition – Palustrine Emergent Wetland 5 (PEM5), for this report and update their descriptions based on our 2016 data (where applicable). As noted earlier, we only sampled portions of the project area where restoration construction actions were completed. As a result, we did not sample vegetation within several of the above plant communities and only lightly sampled others. Baseline and post-restoration descriptions for upland communities are based on visual assessment only and descriptions of riparian communities are supported by limited data.

The following sections describe vegetation communities at the site and are informed by the results of $1m^2$ herbacious plots and 5m radius tree/shrub plots (and other vegetation sampling efforts) completed during 2010 and 2016. We hereafter refer to the 1m2 plots as "herbaceous plots" and the 5m radius plots as "tree/shrub plots." Figure 29 depicts the pre-restoration distribution of the above plant communities. Figure 30 depicts an updated vegetation community map based on 2016 sampling results and interpretation of aerial photos and other resources. Appendix K provides representative photographs of vegetation communities occurring at the site.

Palustrine Emergent Wetland 1 (PEM1) – PEM1 was the most widely distributed community during our baseline work. It covered large portions of the site on both sides of the river (Figure 29) and occurred primarily in drier areas. We completed 46 herbaceous plots and 10 tree/shrub plots within areas covered by this community during baseline sampling. In 2016, this community was substantially less prominent (Figure 30). It contracted around two core areas on the TNC parcel. After restoration, native graminoids became a more substantial component of much of the area where PEM1 occurred during baseline and by 2016 those areas had transitioned into other plant communities (see below). We completed 14 herbaceous plots and 13 tree/shrub plots within areas occupied by this community during our 2016 vegetation sampling effort.

During baseline, this community had extremely high cover (98 percent) and reed canary grass accounted for nearly all of it (mean relative cover 94 percent). Native graminoids were present in trace amounts, but sometimes formed small islands within the larger reed canary grass-dominated area. Trees and shrubs were present, but there were few species and cover was very low. Blackberry was a prominent shrub in the baseline community.

In 2016, total cover for herbaceous species in PEM1 remained very high (approximately 92 percent) (Table 11). This was a very simple community - Diversity and Evenness for herbaceous vegetation were very low (Table 13). Only four herbaceous species occurred in PEM1 plots, and reed canary grass provided nearly all of the cover. Relative cover did not exceed one percent for any of the other herbaceous species. No measurable bare ground or standing water was encountered on herbaceous plots in this community, but vegetative litter was recorded at a few plots.

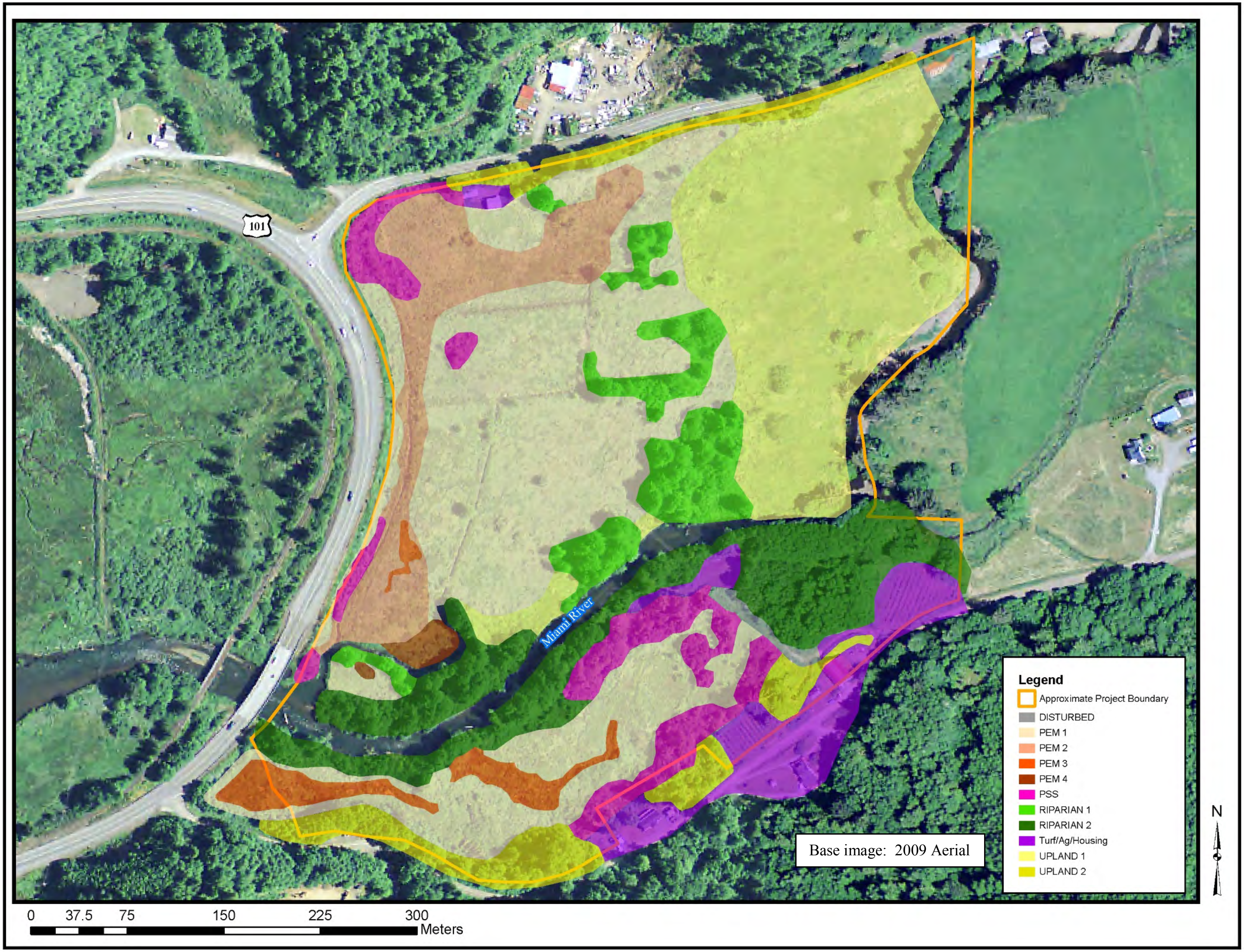


Figure 29. Map depicting vegetation community distribution at the Miami Wetlands during June 2010.

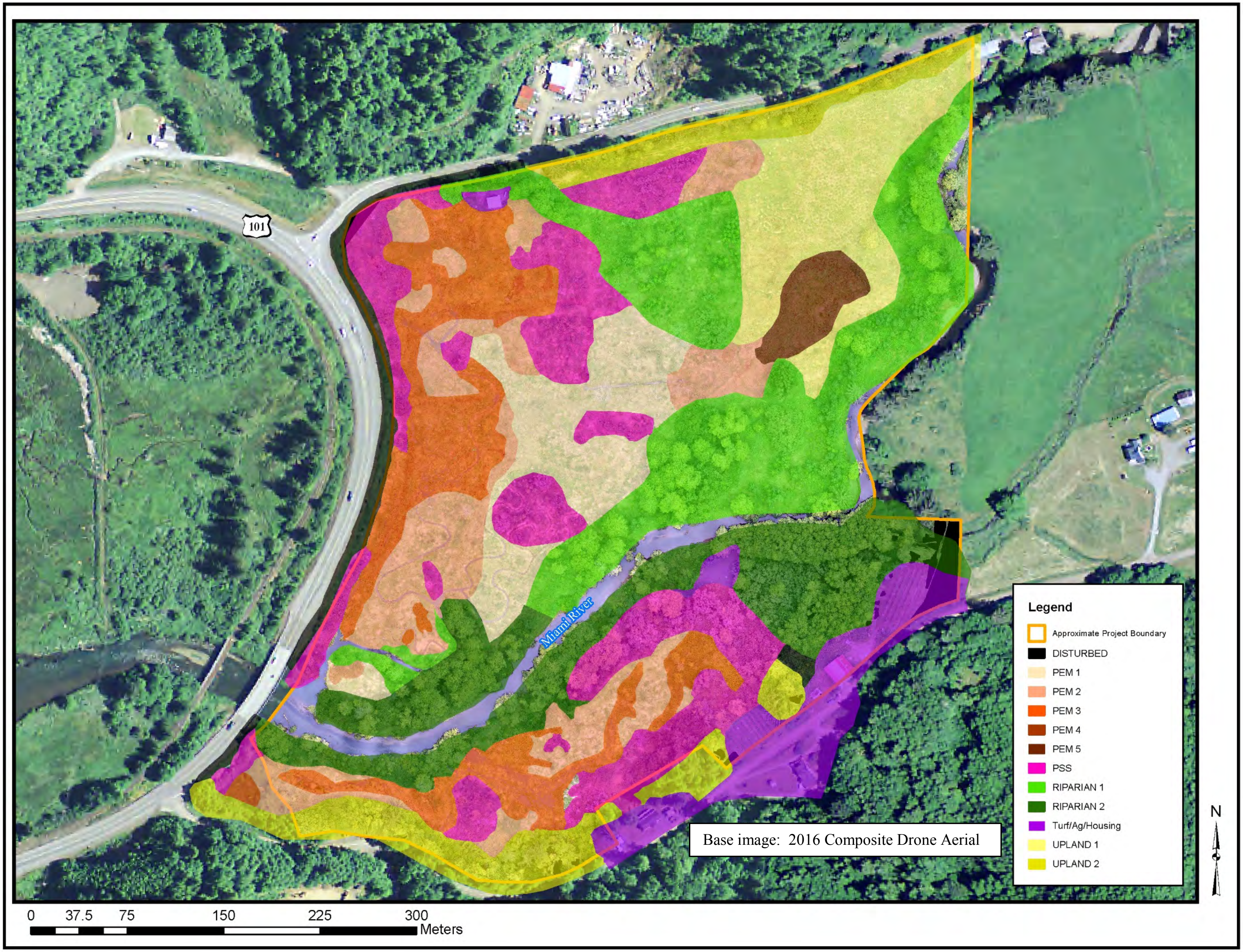


Figure 30. Map depicting vegetation community distribution at the Miami Wetlands during June 2016.

Table 11. Summary data for June 2016 5-m radius circular tree/shrub plots for vegetation communities at the Miami Wetlands site. Plots sampled grasses, forbs, ferns, horsetails and individuals of woody species < 1m tall. Larger woody specimens were sampled in 5m circular plots. Table provides means for percent total cover, percent total cover by species, percent relative cover by species, and the number of plots completed within each vegetation community. Species codes are provided in the project plant list included as Appendix L. Willows (*Salix* spp.), non-native blackberries (*Rubus* spp.), and touch-me-nots (*Impatiens* spp.) were lumped for this analysis. No plots were completed in the upland plant communities, so those communities are not represented in this table.

a).

PEM1		Species Encountered in Plots				Total Cover (%)
N Plots		PHAR	LOCO	AREG	IMspp	
14	Total Cover (%)	90.2	0.9	0.6	0.1	91.9
	Relative Cover (%)	98.3	1.0	0.6	0.1	

b).

PEM2		Species Encountered in Plots																Total Cover (%)
N Plots		PHAR	CAOB	SCMI	LOCO	JUEF	JUBA	IMspp	ELOV	COSE1	VIGI	SPDO	HELA	EPCI	EQAR	ATFI	AREG	
20	Total Cover (%)	44.7	9.7	8.9	4.7	4.3	1.6	1.3	1.3	0.8	0.6	0.5	0.3	0.2	0.1	0.1	0.1	78.5
	Relative Cover (%)	56.9	12.3	11.3	5.9	5.4	2.0	1.7	1.6	1.0	0.7	0.6	0.3	0.2	0.1	0.1	0.1	

c).

PEM3		Species Encountered in Plots														Total Cover (%)
N Plots		PHAR	CAOB	SCMI	JUBA	LOCO	ELOV	JUEF	COSE1	ELPA	IMspp	VIGI	TYLA	AREG	GAsp	
17	Total Cover (%)	24.2	14.2	6.7	6.5	4.7	4.7	2.6	2.4	1.5	1.3	0.9	0.3	0.3	0.2	70.4
	Relative Cover (%)	34.3	20.1	9.5	9.3	6.7	6.7	3.8	3.3	2.1	1.8	1.3	0.4	0.4	0.3	

Table 11. (continued)

d).

Palustrine Scrub Shrub		Species Encountered in Plots									Total Cover (%)
N Plots		PHAR	CAOB	JUEF	JUBA	SCMI	IMspp	LOCO	SAspp	ATFI	
25	Total Cover (%)	61.6	10.3	5.0	3.8	3.6	1.1	0.6	0.6	0.04	86.8
	Relative Cover (%)	71.0	11.9	5.8	4.4	4.2	1.3	0.7	0.7	0.05	

e).

Riparian 1		Species Encountered in Plots			Total Cover (%)
N Plots		PHAR	LOCO	CIAR	
6	Total Cover (%)	98.3	0.8	0.8	100
	Relative Cover (%)	98.3	0.8	0.8	

f).

Riparian 2		Species Encountered in Plots									Total Cover (%)
N Plots		Turf Grass	TOME	OXOR	PHAR	ATFI	POMU[a]	IMspp.	COSE1	CAOB	
2	Total Cover (%)	25.0	12.5	10	5.0	5.0	3.5	2.5	2.5	1.5	72.5
	Relative Cover (%)	34.5	17.2	13.8	6.9	6.9	4.8	3.4	3.4	2.1	

[a] small bracken fern were classified as herbaceous, while older, larger plants were considered shrubs

Table 11. continued

g).

Disturbed		Species Encountered in Plots					Total Cover (%)
N Plots		RUspp.[a]	PHAR	IMspp	RARE	EQAR	
2	Total Cover (%)	55.0	7.5	5.0	3.3	3.0	70.5
	Relative Cover (%)	78.0	10.6	7.1	4.6	4.3	

[a] young blackberry canes were classified as herbaceous, while older, larger canes were considered shrubs

Table 12. Summary data for June 2016 5-m radius tree/shrub plots for vegetation communities at the Miami Wetlands site. Plots sampled individuals of woody plant species > 1m tall. Table provides means for percent total vegetation cover, percent total cover by species, percent relative cover by species, and the number of plots completed within each vegetation community. Species codes are provided in the project plant list included as Appendix L. Willow (*Salix* spp.) and non-native blackberry (*Rubus* spp.) species were lumped for this analysis. No plots were completed in the Upland1, Upland 2, or Disturbed plant communities, so they are not represented in this table.

a).

PEM1		Tree Species						Shrub Species			
N Plots		PISI	POTR	ALRU	FRPU	THPL	Total Tree Cover (%)	LOIN	SAspp.	SPDO	Total Shrub Cover (%)
13	Total Cover (%)	3.7	1.6	0.5	0.4	0.2	6.4	6.2	1.6	0.9	8.5
	Relative Cover (%)	57.8	25.3	7.2	6.0	3.6		72.1	18.9	10.6	

b).

PEM2		Tree Species						Shrub Species					
N Plots		ALRU	FRPU	MAFU	PISI	POTR	Total Tree Cover (%)	LOIN	SAspp.	SPDO	SARA	COSE2	Total Shrub Cover (%)
15	Total Cover (%)	5.7	2.0	1.1	0.6	0.5	9.9	8.5	5.9	1.7	0.1	0.1	16.2
	Relative Cover (%)	57.4	20.3	11.2	6.4	4.7		52.7	36.2	10.3	0.4	0.4	

c).

PEM3		Tree Species					Shrub Species					
N Plots		ALRU	FRPU	MAFU	PISI	Total Tree Cover (%)	LOIN	SAspp.	RUspp	PHCA	COSE2	Total Shrub Cover (%)
8	Total Cover (%)	5.0	1.3	0.6	0.3	7.1	5.9	2.9	0.3	0.3	0.1	9.4
	Relative Cover (%)	70.2	17.5	8.8	3.5		62.7	30.7	2.7	2.7	1.3	

Table 12. (continued)

d).

Palustrine Scrub Shrub		Tree Species						Shrub Species						
N Plots		ALRU	POTR	PISI	THPL	FRPU	Total Tree Cover (%)	SAspp	LOIN	RUspp	SPDO	COSE2	SARA	Total Shrub Cover (%)
24	Total Cover (%)	6.5	2.4	0.5	0.3	0.2	9.9	24.6	5.3	1.8	0.8	0.1	0.0	32.5
	Relative Cover (%)	65.8	24.1	5.5	2.5	2.1		75.5	16.4	5.3	2.3	0.3	0.1	

e).

Riparian 1		Tree Species				Shrub Species				
N Plots		ALRU	THPL	PISI	Total Tree Cover (%)	RUspp	SAspp	SARA	RUSP	Total Shrub Cover (%)
6	Total Cover (%)	36.7	4.5	4.5	45.7	7.0	0.8	0.8	0.8	9.4
	Relative Cover (%)	80.3	9.9	9.9		73.7	8.8	8.8	8.8	

f).

Riparian 2		Tree Species			Shrub Species					
N Plots		ACMA	FRPU	Total Tree Cover (%)	SAspp	SARA	LOIN	POMU	RUSP	Total Shrub Cover (%)
2	Total Cover (%)	5.0	2.50	7.5	57.5	37.5	25.0	12.5	3.5	92.5
	Relative Cover (%)	62.5	33.3		62.2	40.5	27.0	13.5	3.8	

Table 12. continued

f).

Disturbed		Tree Species		Shrub Species				
N Plots		PISI	Total Tree Cover (%)	RUspp	SARA	RUSP	SAspp.	Total Shrub Cover (%)
2	Total Cover (%)	0.5	0.5	47.5	25.0	12.5	8.3	95.0
	Relative Cover (%)	100		50.0	26.3	13.2	10.5	

Table 13. Values for Simpson's Diversity Index (D), Shannon-Wiener Diversity Index (H'), Evenness (E), and Species Richness (S) based on herbaceous species in plots on the Miami Wetlands during June 2016.

Plant Community	Number of Plots	D	H'	E	S
PEM1	14	0.03	0.10	0.07	4
PEM2	20	0.65	1.52	0.55	16
PEM3	17	0.82	2.02	0.76	14
PEM4[a]	0	N/A			
PSS	25	0.48	1.06	0.48	9
Riparian 1	6	0.03	0.10	0.09	3
Riparian 2[b]	2	0.82	1.96	0.85	10
Upland 1[a]	0	N/A			
Upland 2[a]	0	N/A			
Disturbed[b]	2	0.38	0.75	0.54	4

See text for full plant community names and descriptions. Based on data from 86 - 1m^2 herbaceous plots.

[a] = No plots completed in these communities

[b] = Community not well sampled by plots

Table 14. Values for Simpson's Diversity Index (D), Shannon-Wiener Diversity Index (H'), Evenness (E), and Species Richness (S) based on trees and shrubs in plots on the Miami Wetlands during June 2016.

Plant Community	No. of Plots	Trees				Shrubs			
		D	H'	E	S	D	H'	E	S
PEM1	13	0.70	1.14	0.71	5	0.49	0.79	0.72	3
PEM2	15	0.68	1.21	0.75	5	0.62	0.98	0.61	5
PEM3	8	0.54	0.88	0.64	4	0.57	0.91	0.56	5
PEM4[a]	0	N/A				N/A			
PEM5[a]	0	N/A				N/A			
PSS	24	0.56	0.95	0.59	5	0.41	0.81	0.42	7
Riparian 1[b]	6	0.34	0.63	0.58	3	0.49	0.87	0.62	4
Riparian 2[b]	2	0.51	0.64	0.92	2	0.37	1.06	0.66	5
Upland 1[a]	0	N/A				N/A			
Upland 2[a]	0	N/A				N/A			
Disturbed[b,c]	2	N/A				0.66	1.20	0.87	4

See text for plant community names and descriptions. Based on data from 70 – 5m radius tree/shrub plots.

[a] = No plots completed in these communities

[b] = Community not well sampled by plots

[c] = Too few tree species present to calculate diversity

Shrubs and trees were encountered at almost all 2016 plots in PEM1 (mostly planted specimens), but they provided only limited cover (Table 12). This differed greatly from baseline. During baseline, trees and shrubs were a very limited component in PEM1. Only two tree species (red alder and Sitka willow (*Salix sitchensis*) were present, and shrubs were limited to two species of blackberry (Armenian blackberry [*Rubus armenicus*] and cut-leaf blackberry [*R. lacinatus*]). During 2016, woody plants continued to provide limited cover in this community, but Species Richness, Diversity and Evenness values for trees and shrubs increased considerably over baseline (and were similar to other to other communities) (Table 14). Tree species present in this community included, in decreasing order of dominance, Sitka spruce, black cottonwood, red alder, cascara and western red cedar. Shrubs included black twinberry, willows and Douglas spirea. All of these species were part of our restoration plant pallet, and most trees and shrubs encountered on plots were planted as part of our restoration efforts.

Palustrine Emergent Wetland 2 (PEM2) – This was the second most widely distributed emergent wetland community during baseline and covered a large portion of the site north of the river (Figure 29). It occurred primarily on wetter portions of the site. We completed 31 herbaceous plots, but only 7 tree/shrub plots, within areas covered by this community during baseline. As noted elsewhere, changing hydrology has inundated large portions of the site that previously were drier. This has allowed for the spread and increasing dominance of native graminoids in areas previously overwhelmed by reed canary grass, and has influenced the distribution of the PEM2 and PEM3 communities. In 2016, this community was more prominent than during baseline (Figure 30). It expanded laterally from its core on the TNC parcel and occurred in several other areas of this parcel. It also was prominent on the Crabb parcel. We completed 20 herbaceous plots and 15 tree/shrub plots within areas occupied by this community during our 2016 vegetation sampling effort.

During baseline, percent total cover of herbaceous species for this community was high (approximately 85 percent), and Species Richness, Diversity and Evenness were considerably higher than for PEM1. Reed canary grass dominated this community (approximately 52 percent relative cover), but other large grass-like species (i.e., slough sedge, soft rush, and small-fruited bulrush) also provided substantial cover (approximately 36 combined relative cover). Other herbaceous species encountered in this community were generally present in trace amounts. Trees were rare during baseline sampling and provided little cover. A variety of shrubs were present and provided approximately 17 percent total cover. Willows were the dominant shrub species, but blackberry also were very common and provided nearly as much cover as willows.

In 2016, total herbaceous cover in this community remained high (approximate 79 percent) and reed canary grass continued to provide a majority of herbaceous cover (approximately 57 percent relative cover) (Table 11). Native graminoids also continued to provide substantial cover (approximately 33 percent aggregate relative cover) and a variety of other species were recorded in trace amounts. In 2016, we recorded four times as many herbaceous species in PEM2 than PEM1, and many species provided considerable cover. Diversity and Evenness of herbaceous vegetation were moderately-high relative to other communities (Table 13). Five species each provided greater than five percent relative cover. Measurable bare ground and standing water were encountered on approximately ¼ of the plots in this community, and vegetative litter was recorded at a few plots.

Similar to PEM1, the tree/shrub component in this community in 2016 differed from baseline. In 2016, shrubs and trees were encountered at almost all plot locations (Table 12). Although trees provided limited total cover in this community in 2016, we recorded five different native tree species and each accounted for greater than 5 percent relative cover. Shrubs continued to provide approximately 17 percent total cover, but (unlike baseline) we only recorded native species. Three of the six species encountered each provided greater than 10 percent relative cover. Diversity and Evenness values for trees and shrubs increased considerably over baseline and were similar to other 2016 communities (Table 14). Tree species present in this community included, in decreasing order of dominance, red alder, cascara, Pacific crabapple, Sitka spruce and black cottonwood. Shrubs included black twinberry, willows, Douglas spirea, red elderberry (*Sambucus racemosa*), and red-osier dogwood.

Palustrine Emergent Wetland 3 (PEM3) – This community was uncommon during baseline and occurred on very wet portions of the wetland (largely in association with channels) in two patches south of the river and a single small patch north of the river (Figure 29). During baseline, we completed seven - herbaceous vegetation plots within areas covered by this community, but no tree/shrub plots. By 2016, this community had expanded greatly and occurred in large blocks on both the Crabb and TNC parcels (Figure 30). We completed 17 herbaceous plots and 8 tree/shrub plots within areas occupied by this community during our 2016 vegetation sampling effort.

Percent total cover of herbaceous species for this community during baseline was low relative to PEM1 and PEM2 (approximately 69 percent), but Species Richness, Diversity and Evenness were high. Unlike PEM1 and PEM2, no single species accounted for a majority of the herbaceous cover in this community. Reed canary grass, Baltic rush, cattail (*Typha latifolia*), and small fruited bulrush all exceeded 10 percent relative cover. Ovoid spikerush, skunk cabbage (*Lysichiton americanum*), slough sedge, and tall fescue (*Festuca arundinacea*) all had greater than five percent relative cover. A number of other species encountered in this community were generally present in trace amounts. Percent relative cover was typically less than two percent for these species. We did not record any trees or shrubs in this community during baseline work. Measurable amounts of standing water and vegetative litter occurred on several plots in this community, but bare ground was very limited.

In 2016, total herbaceous cover in this community was nearly identical to baseline (approximate 70 percent) (Table 11). We recorded six native graminoids in this community and, in aggregate, these provided nearly half of the relative cover in this community. Reed canary grass accounted for approximately 1/3 of the cover. We recorded a variety of other species in small amounts. Diversity and Evenness of herbaceous vegetation were higher for this community than for any other community (Table 13). Six species each provided greater than 5 percent relative cover. Measurable standing water was encountered on approximately ½ of the plots in this community, and vegetative litter and bare ground were recorded at a few plots.

Similar to other communities, the tree/shrub component in this community in 2016 differed considerably from baseline. In 2016, we recorded shrubs and trees at over half of nested plot locations (Table 12), but both groups provided limited cover. We recorded four different native tree species, but red alder was by far the most abundant of these (Table 9). Shrubs provided a similar level of cover to trees, and black twinberry and willows accounted for a vast majority of shrub cover. Diversity and Evenness values for trees and shrubs were similar to the other palustrine emergent communities in 2016 (Table 14).

Palustrine Emergent Wetland 4 (PEM4) – PEM 4 occurred on two moist areas north of the river during baseline (Figure 29). We completed two herbaceous vegetation plots, but no tree/shrub plots in this community. During baseline percent total cover of herbaceous species for this community was extremely high (100 percent) and three species (slough sedge, tall fescue, and Pacific silverweed [*Argentina egedii*]) accounted for approximately 90 percent of the vegetative cover. Slough sedge accounted for over half of the cover provided by these species. Unlike other PEM communities at the site, reed canary grass was only present in trace amounts in this community. This community was uncommon during baseline and its description was hampered by the small number of plots completed within it. Areas where it occurred during baseline were classified as PEM 2 or PEM3 in 2016.

Palustrine Emergent Wetland 5 (PEM5) – This was a newly identified community in 2016. It is developing in the area on the TNC parcel excavated for borrow material during construction (Figure 30). As noted previously, this area collects stormwater and has become much wetter than it was pre-restoration (it is probably best described as a seasonal, shallow pond). PEM5 is substantially different from other PEM communities on the site. It includes some species found in other communities including reed canary grass and native graminoids including slough sedge and small-fruited bulrush, but it also includes species that were uncommon or not noted elsewhere. These include burreed (*Sparganium emersum*), blunt spikerush (*Eleocharis obtusa*), needle spike rush (*E. acicularis*), Bolander's rush (*Juncus bolanderi*), dagger-leaf rush (*J. ensifolius*), and tapertip rush (*J. acuminatus*). Since the area where this community occurs was not covered by our study transects, we do not have any plot data for it.

Palustrine Scrub Shrub (PSS) – This community occurred primarily on wet areas on both sides of the river during baseline (Figure 29). Baseline consisted of seven herbaceous plots and seven tree/shrub plots within areas covered by this community. In 2016, this community had expanded (primarily into areas classified as PEM1 during baseline) and it was considerably more common (Figure 30). Many of the areas where it occurred in 2016 were planted during restoration and survival and growth of these plant materials drove transition from an emergent herbaceous community to a scrub shrub community with greater than 30 percent cover for woody plants. We completed 25 herbaceous plots and 24 tree/shrub plots during our 2016 sampling effort.

During baseline, percent total cover of herbaceous species was high (approximately 92 percent), as were Species Richness, Diversity and Evenness. The herbaceous portion was dominated by reed canary grass (approximately 47 percent relative cover). Percent relative cover for each of the remaining 18 herbaceous species recorded was less than 10 percent. Shrubs were an important component of this community, but trees were rare. Mean percent cover for tree species was approximately two percent, provided entirely by red alder. Total cover provided by shrub species was approximately 38 percent. Although we recorded seven shrub species in these plots, willows (Hooker's willow [*Salix hookeriana*] and Sitka willow) accounted for majority of shrub cover in this community. Other shrub species were present only in trace amounts.

In 2016, total herbaceous cover in this community was similar to baseline (approximate 87 percent), but we encountered fewer species and reed canary grass was more dominant (Table 11).

Reed canary grass accounted for 71 percent relative cover, and four native graminoids, in aggregate, accounted for approximately 26 percent. Other species occurred in trace amounts. Diversity, Evenness and Species Richness were somewhat low relative to the PEM communities discussed above, and relative to baseline (Table 13). Measurable standing water, bare ground and vegetative litter occurred at a few plots. We attribute the change in the herbaceous component of this community between baseline and 2016 to the fact this this community expanded rapidly and now occurs largely in areas where reed canary grass once dominated (former PEM1 areas).

Similar to other communities, the tree/shrub component in the PSS community in 2016 differed from baseline, but the proportion of tree/shrub plots relative to herbaceous plots was similar. In 2016, we recorded shrubs and trees at all but one nested plot location within this community (Table 12). Trees provided a similar amount of total cover to the 2016 PEM communities. Red alder and black cottonwood accounted for a majority of tree cover. Shrubs provided approximately 32 percent total cover. Willows and black twinberry accounted for approximately 91 percent of shrub cover. Blackberry accounted for approximately five percent relative cover and other species occurred in only trace amounts. Diversity and Evenness values for trees and shrubs were similar to the palustrine emergent communities (Table 14).

Riparian 1 – During baseline, this community occurred as discrete patches adjacent to channels north of the river (Figure 29). We differentiate this community from Riparian 2 largely based on differences in the understory (herbaceous vegetation) and shrub components. Riparian 2 had a more diverse understory and shrubs, reed canary grass was uncommon and native species were more abundant. We completed 12 herbaceous vegetation plots and 11 tree/shrub plots in the Riparian 1 community in 2010. Percent total cover of herbaceous species was high (approximately 92 percent), but Species Richness, Diversity and Evenness were very low. Reed canary grass accounted for nearly all herbaceous cover (approximately 95 percent relative cover). Shrubs and trees were an important component, but diversity measures for these species were very low. Mean percent total cover for trees during baseline was approximately 27 percent, provided entirely by red alder. Total cover provided by shrubs was approximately 21 percent, almost entirely blackberry. In 2016, this community had expanded considerably (Figure 30). It occupied many areas on the east half of the TNC parcel that were classified as upland or PEM1 during baseline. The upland classification was due largely to the fact that the eastern portion of the TNC parcel was drier than other areas and generally lacked trees and shrubs. It also included a number of herbaceous species that were less common in PEM communities at that time. Our plots largely missed the Riparian 1 community in 2016 and we completed only six herbaceous plots and six tree/shrub plots.

In 2016, total herbaceous cover for Riparian 1 plots was extremely high (100 percent), and we encountered fewer species than during baseline (Table 11). Reed canary grass accounted for nearly all of the herbaceous cover (98 percent relative cover). Two other weedy species occurred in trace amounts. Diversity, Evenness and Species Richness were very low relative to baseline and to other communities in 2016. We did not record measurable standing water, bare ground or vegetative litter in Riparian 1 plots. The above description of the herbaceous component of this community largely holds true for the new areas where it occurs, but where there were no sample plots. Reed canary grass and other weedy herbaceous species were common throughout these areas.

The proportion of tree/shrub plots relative to herbaceous plots for Riparian 1 was similar to baseline (Table 12). Trees provided considerably more cover than in the aforementioned communities in 2016. In our plots, red alder accounted for a majority of tree cover (80 percent relative cover) and western red cedar and Sitka spruce provided equal cover (10 percent relative cover each). Other tree species occurring in the Riparian 1 community, but not recorded in plots, included big-leaf maple and black cottonwood. In our plots, shrubs provided approximately nine percent total cover, and blackberry accounted for a vast majority of it (74 percent relative cover). Willows, red elderberry and salmonberry (*Rubus spectabilis*) accounted for equal amounts of the remaining shrub cover. Black twinberry also was common in the new areas of this community, but was not encountered in plots. Species Richness, Diversity and Evenness were low for trees relative to the above communities, but were similar to other communities for shrubs (Table 14).

Riparian 2 –During baseline and in 2016, this community occurred adjacent to both banks of the river within the project area (along the entire south bank and a portion of the north bank - figures 29 and 30). As a result, it was largely missed by transects during all sampling efforts, and our description of it relies, in large part, on anecdotal observations (not data from our vegetation studies). As noted above, we distinguished this community from the Riparian 1 community largely due to differences in understory vegetation and shrubs. The herbaceous component of this community is dominated by native species and is very diverse, while Riparian 1 has a very simple understory community dominated by reed canary grass. This community also has a more diverse shrub component with a mix of mostly native species. During baseline, we completed four herbaceous vegetation plots and four tree/shrub plots within areas covered by this community. In 2016, we completed only two nested-plots in this community (each with an herbaceous and a tree/shrub plot).

Total cover of herbaceous species in our 2010 plots was low relative to other communities identified at the site (64 percent), but Species Richness, Diversity and Evenness were high. No single herbaceous species was clearly dominant throughout this community. In fact, most species did not exceed 20 percent relative cover and few accounted for less than two percent. Measurable amounts of bare ground and vegetative litter were encountered on portions of a few plots, but standing water was not recorded for this community. As to be expected, shrubs and trees were an important component of this community during baseline. However, only two tree species were present, and tree cover was largely provided by red alder. Total cover provided by shrubs was high. Willows accounted for approximately half of the total shrub cover, but black twinberry, red elderberry and blackberry also were common. Diversity and Evenness were moderate for shrubs in this community during baseline.

Please bear in mind that we completed only two plots within this community in 2016 and information provided in tables 11-14 for this community are based on very limited plot data. As a result, the description below for this community relies in large part on simple observations, not empirical data. While we feel that the herbaceous plot data presented in tables 11 and 13 reasonably represent this community, we believe the tree and shrub plot data presented in tables 12 and 14 do not accurately reflect this community (particularly with respect to trees and total shrub cover).

In 2016, the herbaceous component of this community largely resembled baseline. Common and conspicuous herbaceous species included slough sedge, lady fern (*Athyrium filix-femina*), redwood-sorrel (*Oxalis oregano*), piggy-back plant (*Tolmeia menziesii*), cow parsnip, creeping buttercup (*Ranunculus repens*), horsetail (*Equisetum arvense*) and others (Table 11). Given the tree and shrub canopy of this community, the understory is sparser than in most other communities (approximately 60-70 percent total cover). The tree and shrub community remained dominated by species such as red alder, willows, black twinberry and red elderberry (Table 12). These species continued to provide the most significant contributions to woody cover in this community in 2016. However, species planted during restoration including Sitka spruce, western red cedar, black cottonwood, big-leaf maple, cascara, and others have survived and grown substantially and are becoming increasingly important components of this community. Total tree and shrub cover in this community almost certainly exceeds 60 percent, but we believe tables 12 and 14 underestimate tree diversity and cover and overestimate shrub cover (although they reasonably reflect shrub species present and their relative role in the community).

Upland 1 – During baseline, this community occurred in the eastern portion of the TNC parcel (Figure 29). This portion of the site lacked wetland hydrology and was not classified as wetland during pre-design wetland delineation of the site and, under many conditions, soil moisture is lower here than on wetland portions of the site. The community continued to occur in this general portion of the site during 2016, but its distribution had decreased considerably (Figure 30). We did not complete any vegetation plots within areas covered by this community during baseline or post-restoration. As a result, no cover data was collected for this community and description of it is based solely on visual assessment.

The baseline herbaceous component of this community was very dense and variously dominated by reed canary grass and tall fescue. Several other herbaceous species including Canada thistle (*Cirsium arvense*), birdsfoot trefoil (*Lotus corniculatus*), colonial bentgrass (*Agrostis capillaries*), and others were also present in this community. Trees and shrubs were uncommon - a few red alder were scattered through areas covered by this community and Armenian and cut-leaf blackberries were common in some portions.

By 2016, the footprint of this community was greatly reduced and its structure and composition also differed from baseline. Plantings along the banks of the Miami River converted a substantial portion of the area classified as this community during baseline into a forested riparian zone (see Riparian 1, above). Additionally, the site where borrow materials were obtained during construction had converted into a unique wetland community (see PEM5, above). Further, this area was planted with a variety of trees and shrubs during 2013 and 2014. While the herbaceous component of this community remains similar to baseline, the tree and shrub component is changing dramatically. Trees and shrubs were densely distributed in this community in 2016. Sitka spruce was by far the most common tree species, but western red cedar and clumps of big-leaf maple were also present. We also planted a diverse mix of shrubs including thimbleberry (Rubus parviflorus), salmonberry, black twinberry Western sword fern (*Polystichum munitum*) and red-osier dogwood. Due to their young age, woody plants provided little cover in this community in 2016. However, they are surviving and growing so their influence on the area should continue to increase.

Upland 2 – During baseline and in 2016, this community occurred both north and south of the Miami River on slopes adjacent to roads that bound the project area (figures 29 and 30). We did not complete any vegetation plots within areas covered by this community. As a result no cover data is available for it and description of the community is based solely on visual assessment.

Trees and shrubs dominated this community during baseline and in 2016, but it also included a limited herbaceous component. Common and conspicuous understory plants included sword fern, Bracken fern (*Pteridium aquilinum*), creeping buttercup and piggyback plant. The tree canopy was dominated by red alder, and Sitka spruce was present, but less common. The shrub layer was dominated by black twinberry, red elderberry and salmonberry (*Rubus spectabilis*), and blackberry were locally abundant.

Disturbed – During baseline, we identified a disturbed vegetation community along the overhead utility line right-of-way where it crossed the Crabb parcel (Figure 29). We completed three herbaceous vegetation plots and two tree/shrub plots within the area covered by this community. In 2016, we continued to classify a portion of this area of the Crabb parcel as disturbed and mapped an additional disturbed area along the east side of the Highway 101 right-of-way (Figure 30). We completed two herbaceous and two tree/shrub plots in this community in 2016, both were in the disturbed area on the Crabb parcel. Species composition of disturbed communities can vary widely and the plot data for 2016 does not reflect the community along the margins of Highway 101.

In 2010, percent total cover of herbaceous species for this community was very high (99 percent), and Species Richness, Diversity and Evenness also were high relative to other communities on the site. Creeping buttercup was by far the most abundant herbaceous species in this community, accounting for approximately 43 percent of the total herbaceous cover. A variety of other grasses, forbs, and ferns also occur in this community but none accounted for more than 10 percent of the total cover. Because the utility right-of-way where this community occurred was regularly cleared to provide access, shrubs and trees were minor components of this community during baseline. No tree species were recorded in this community and most shrub species occurred primarily along its margins. Mean total cover for shrubs was approximately 31 percent. Armenian blackberry accounted for a vast majority of the shrub cover in this community. Diversity and Evenness for shrubs were low, with most shrub species having less than 10 percent relative cover.

In 2016, the disturbed community on the Crabb parcel had an herbaceous component dominated by young blackberry canes and other weedy, predominantly non-native species (Table 11). The shrub component had very high cover and few species. Blackberry and red elderberry accounted for a majority of shrub cover. Trees were rare – we encountered a few small, planted Sitka spruce, but they provided almost no cover. The disturbed community along Highway 101 was dominated by reed canary grass and included a variety of other weedy herbaceous plants and shrubs. Small clumps of Japanese knotweed (*Fallopia japonica*) occasionally occur in this area (but we have regularly cut these down and hauled away the debris).

3.2.2. Macroinvertebrates

We sampled for aquatic macroinvertebrates in 2010 (baseline) and again in 2016. We collected samples in May during both years and followed the same protocol during both efforts. Post-collection processing and assessment procedures also were consistent for both years.

The lab protocol we utilized to assess macroinvertebrate samples is standardized to use 300 organisms from each sample for identification. Some full samples have more than 300 organisms, so only a portion of the sample (a subsample) is needed to reach the 300-organism threshold (subsamples can slightly exceed 300). When full samples do not contain over 300 organisms, the entire sample is evaluated. In 2010, we had four samples that contained <300 organisms, so the samples were evaluated in their entirety. Two of these samples had less than 200 organisms (one had only 109). Three baseline samples contained sufficient numbers that they could be subsampled. For two of the samples, 50 percent of the sample was needed to obtain 300 organisms, and one required 75 percent of the sample to reach the 300-organism threshold.

During baseline, we identified 69 unique macroinvertebrate taxa (Table 15). In addition to Species Richness, we also calculated two diversity indices (i.e., Simpson's Index of Diversity [D] and Shannon-Weiner Index [H']) and Evenness (E) for our baseline macroinvertebrate data (see Section 2.2.1.2.a for a discussion of these measures). Based on these analyses, diversity of the baseline macroinvertebrate community was high (D = 0.95, H' = 2.51) and Evenness was moderate (E = 0.59). Most (75 percent) of the macroinvertebrates in our baseline samples were insects (51 unique insect taxa). True flies accounted for a majority of insect taxa (38 dipteran taxa, 75 percent of all insects identified), and approximately 75 percent of true flies were non-biting midges (Chironomids - 29 unique taxa). In terms of number of individuals recorded, the single most abundant taxon during baseline was the gastropod, *Menetus opercularis* (12.5 percent relative abundance). This species is an air-breathing, freshwater snail and it occurred in all but two samples. The stations where this species was absent were the two stations most likely to have brackish water conditions. The fact that this species was absent from these stations provides fairly convincing evidence that brackish, estuarine waters regularly occupied the lower portions of the drainage ditch system on the TNC parcel before restoration actions were completed. The next two most abundant taxa were species of Chironomids with relative abundances of 11.3 and 8.9 percent, respectively. One occurred in all but one sample and the other occurred in all samples. Only six taxa had greater than five percent relative abundance and most occurred only in trace amounts.

There were many similarities between our 2010 and 2016 macroinvertebrate samples, but there were also substantial differences. The following paragraphs present our 2016 results and relate them to the baseline data. Aquatic macroinvertebrate communities are highly variable, spatially and temporally. They are also respond to environmental changes and, as a result, have been used to assess environmental conditions and as indicators of ecosystem status and state. It is almost certain that changes between sample years in this study were, in part, influenced by the restoration effort. However, given the inherent variability in macroinvertebrate communities other factors are certainly at play and, as a result, we do not attempt to quantify what is driving differences between sample years.

Our 2016 samples had considerably greater numbers of organisms than our 2010 samples. We collected seven samples in 2016 (Figure 21) and all had >300 organisms and so all were subsampled (Table 16). None required more than approximately 50 percent of the sample to reach the 300-organism threshold – three required <25 percent of the sample. Because we collected samples from throughout the channel systems during both years, it appears that

Table 15. Macroinvertebrate taxa recorded from benthic samples obtained during May 2010 at the Miami Wetlands site.

Taxonomic Classification						Station ID						
						P-1[1]	P-4[3]	P-10[1]	P-6[1]	P-3[1]	P-8[2]	P-11[3]
Phylum	**Class**	**Order**	**Family**	**Genus/species**	**Life stage**				**(count)**			
Annelida	Oligochaeta			Oligochaeta		2	5	6	8	6	3	6
Arthropoda	Arachnida	Sacoptiformes		Oribatei								1
		Trombidiformes		Trombidiformes		18	4	6	9	1	10	
	Crustacea			Copepoda		13	4		61	9	5	2
				Ostracoda		17	29	3	74	1	3	14
		Amphipoda	Corophidae	*Americorophium* sp.				4				
			Crangonyctidae	*Crangonyx* sp.					2			
			Gammaridae	*Gammarus* sp.				4				40
		Isopoda	Asellidae	*Caecidotea* sp.			8	2	12	5	61	32
				Gnorimosphaeroma sp.				1				
			Idoteidae	Idoteidae				5				10
	Entognatha	Collembola		Collembola		1	1				2	
	Insecta	Coleoptera	Dytiscidae	Agabus sp.	Adult						1	
				Dytiscidae	Immature		1		4	1		
				Hydroporinae	Larva					1		
			Haliplidae	*Haliplus* sp.	Adult		1					
				Haliplus sp.	Larva	1						
			Scirtidae	Scirtidae	Larva					1		
		Diptera	Ceratopogonidae	Ceratopogoninae	Larva	2	4	11	13		2	9
			Chironomidae	*Brillia* sp.	Larva	5	5		1	13	2	4
				Chironomidae	Pupa	2	1	1		2	9	4
				Chironomus sp.	Larva	9	6	24	1	8	6	1
				Cladopelma sp.	Larva	13	2					
				Corynoneura sp.	Larva		2		3	9	3	
				Cryptotendipes sp.	Larva		1					
				Dicrotendipes sp.	Larva	6					2	1
				Endochironomus sp.	Larva	8	1		1		1	1
				Glyptotendipes sp.	Larva	1						
				Heterotanytarsus sp.	Larva		3	1	3	2	9	9
				Heterotrissocladius sp.	Larva		6	1	5	3	10	27
				Larsia sp.	Larva		2			1		
				Limnophyes sp.	Larva	3			3	2		
				Macropelopiini/Procladiini	Larva	79	60		2	18	38	8
				Metriocnemus sp.	Larva					2		

Table 15. continued

				Micropsectra/*Tanytarsus* sp.	Larva	5	26	11	13	5	57	45
				Omissus sp.	Larva		2		1	1	6	10
				Orthocladiinae	Immature							2
				Orthocladiinae	Larva							1
				Orthocladius complex	Larva				1			7
				Paramerina sp.	Larva					6		
				Parametriocnemus sp.	Larva							5
				Paratanytarsus sp.	Larva	3	6	15			1	12
				Prodiamesa sp.	Larva					2	1	
				Psectrocladius sp.	Larva							2
				Rheocricotopus sp.	Larva	1			1	2	2	3
				Sergentia sp.	Larva	1	6	5	7		6	1
				Stempellina sp.	Larva							1
				Stempellinella sp.	Larva		1		1	3	4	
				Thienemanniella sp.	Larva					1		
				Thienemannimyia Gr.	Larva	1	4		2	12	2	6
			Dixidae	*Dixa* sp.	Larva						1	
				Dixella sp.	Larva	2	4			2		
			Empididae	*Chelifera*/*Metachela* sp.	Larva							2
				Neoplasta sp.	Larva			1				1
			Phoridae	Phoridae	Larva	1		1		1		6
			Simuliidae	*Simulium* sp.	Larva							1
			Tabanidae	Tabanidae	Larva						1	
		Ephemeroptera	Baetidae	Baetis tricaudatus	Larva					1		3
				Callibaetis sp.	Larva					1		
				Pseudocloeon sp.	Larva				1	9	2	1
		Megaloptera	Sialidae	*Sialis* sp.	Larva		3			1		2
		Odonata	Coenagrionidae	Coenagrionidae	Immature		1		1			
		Plecoptera	Nemouridae	*Amphinemura* sp.	Larva					1		1
		Trichoptera	Hydroptilidae	*Oxyethira* sp.	Larva			1				
			Limnephilidae	*Limnephilus* sp.	Larva	22	19	5	2		7	22
Mollusca	Gastropoda		Ancylidae	*Ferrissia* sp.		7	7		2	6	6	
			Planorbidae	*Menetus opercularis*		69	76		12	24	45	
				Planorbidae	Immature				26		6	2
			Pleuroceridae	*Juga* sp.			3			2	3	
	Pelecypoda		Pisidiidae	Pisidiidae		5	13		10	18	1	
Nemata				Nemata				1		1		5
Total Number of Individuals Obtained from Sample						**297**	**317**	**109**	**282**	**184**	**318**	**310**
Percent of full sample needed to obtain ≥300 individuals						**100%**	**50%**	**100%**	**100%**	**100%**	**75%**	**50%**

Table 16. Macroinvertebrate taxa recorded from benthic samples obtained during May 2016 at the Miami Wetlands site.

Taxonomic Classification						Station ID						
						1	2	3	4 (count)	5	6	7
Phylum	**Class**	**Order**	**Family**	**Genus/species**	**Life stage**							
Annelida	Oligochaeta			Oligochaeta		8	12	126	7	44	20	4
Annelida	Polychaeta			Polychaeta		1				1		
Arthropoda	Arachnida	Trombidiformes		Trombidiformes		6			3	1	10	2
Arthropoda	Crustacea			Copepoda			3	5		22	8	3
				Ostracoda				1	2	9	5	13
		Amphipoda	Corophidae	Americorophium		35	7			58	28	17
			Crangonyctidae	Crangonyx				1				
			Gammaridae	Ramellogammarus		16	19		1	18	17	8
		Isopoda	Asellidae	Caecidotea		5	8	4	55			
		Mysida	Mysidae	Mysis		2	1			1	1	2
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabus	Adult							1
			Haliplidae	Haliplus	Larva							1
		Diptera	Ceratopogonidae	Ceratopogoninae	Larva	12	6	5	6	19	31	25
			Ceratopogonidae	Dasyhelea	Larva							2
			Chironomidae	Chironomidae-Unidentified	Pupa	10	1		9		2	4
				Chironomini-Unidentified	Early Instar						4	
				Chironomus	Larva		50	96		63	5	70
				Corynoneura	Larva		1		4			1
				Cryptotendipes	Larva							1
				Heterotanytarsus	Larva			1	1			
				Heterotrissocladius	Larva	5	3	3				
				Larsia	Larva						6	2
				Macropelopia	Larva				7			
				Micropsectra/Tanytarsus	Larva	129	15	16	14	73	145	134
				Orthocladius complex	Larva							1
				Parakiefferiella	Larva			1				
				Parametriocnemus	Larva			1				
				Paraphaenocladius	Larva					1		1

Table 16. continued

				Paratanytarsus	Larva	3				4		
				Paratendipes	Larva	11	182	21	30	1	10	1
				Procladius	Larva	2	2	3	4	1	21	17
				Prodiamesa	Larva	1	8	11	16			
				Psectrocladius	Early Instar					1		
				Psectrocladius	Larva							1
				Psectrotanypus	Larva						3	1
				Sergentia	Larva			1				
				Stempellinella	Larva	2		8	121			
				Tanypodinae	Early Instar					1		
				Tanypodinae	Early Instar	1		11	7	2	12	
				Tanypodinae	Immature				1			1
			Dixidae	Dixella	Larva				1			
			Empididae	Clinocera	Larva				1			
			Tabanidae	Chrysops	Larva					3	1	2
		Ephemeroptera	Baetidae	Baetis	Early Instar				1			
			Baetidae	Labiobaetis	Larva		1		2			
			Leptophlebiidae	Paraleptophlebia	Larva				2			
		Hemiptera	Corixidae	Corixidae	Immature						1	3
			Veliidae	Microvelia								1
		Megaloptera	Sialidae	Sialis	Larva				1	1	2	3
		Odonata	Aeshnidae	Aeshnidae	Early Instar						2	
		Trichoptera	Lepidostomatidae	Lepidostoma	Larva					1		2
			Limnephilidae	Limnephilidae	Early Instar					1		
				Limnephilidae	Immature	2	1	1				1
Mollusca	Gastropoda		Planorbidae	Planorbidae	Immature			1	2			
			Pleuroceridae	Juga					4			
		Littorinimorpha	Hydrobiidae	Potamopyrgus antipodarum		82	1			3		
Mollusca	Pelecypoda		Pisidiidae	Pisidiidae	Immature				19		1	
Nematoda				Nemata				4		1	2	
Total number of individuals obtained from sample for analysis						**333**	**321**	**321**	**321**	**330**	**337**	**325**
Percent of full sample needed to obtain ≥300 individuals						**53%**	**40%**	**22%**	**23%**	**43%**	**20%**	**27%**

macroinvertebrates generally occurred in greater abundance across a larger portion of the site during 2016 than in 2010.

In 2016, we identified 53 unique macroinvertebrate taxa (Table 16). While these samples contained fewer species than the 2010 samples, diversity and evenness were similar to baseline (D = 0.91, H' = 2.64, E = 0.66). The proportion of insects in the 2016 samples was also similar to baseline (72 percent - 38 unique insect taxa). Additionally, the proportion of insects that were true flies (Dipterans – 27 taxa) and the proportion of true flies that were non-biting midges (Chironomids – 22 taxa) also were similar to baseline (71 and 82 percent, respectively). Micropsectra/Tanytarsus chironomids were the most abundant taxa in our 2016 samples (23.6 percent relative abundance). However, these occurred in much greater numbers in the samples from the tidal channels than in Hobson-Struby channel samples (Table 16). Similar to baseline, only five other species exceeded five percent relative abundance, and most species occurred in low numbers (tables 15 and 16, Figure 31). Some notable differences and similarities between the two data sets include:

- *Menetus opercularis*, the most abundant species in the baseline samples, was absent from the 2016 samples.
- Oligochaete worms occurred in low numbers in all 2010 samples, but were abundant in some 2016 samples.
- Polychaete worms were rare in both years.
- Chironomids were abundant in both years, but there were substantial differences in the composition of this community between years.
- Troublingly[6], New Zealand mud snails (*Potamopyrgus antipodarum*) were present in 2016, but were not present in 2010. In 2016, they occurred in three samples (the vast majority in a single sample from the lower common tidal channel (Station 1, Figure 21).
- There were fewer mollusks in the 2016 samples than the 2010 samples.
- The relative abundance of copepods, ostrocods and isopods were lower in 2016 than during baseline, but the relative abundance of amphipods was higher
- Dipterans accounted for approximately 2/3 of the organisms in the 2016 samples, but less than half of the organisms in the 2010 samples.
- There were fewer mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddis flies (Trichoptera) in 2016 samples than in the 2010 samples.

Figure 32 further illustrates similarities and differences between 2010 and 2016 Miami Wetlands invertebrate fauna. It is a stacked bar chart depicting composition of the 2010 and 2016 at higher taxonomic levels (class and order). The color scheme is similar to Gray (2011) to facilitate general comparison with information presented in her study of benthic invertebrates at several tidal wetland sites in Oregon. In general, invertebrate fauna at her study sites were highly variable, temporally within sites and spatially among sites. While there are some similarities with fauna at Gray's scrub and forested wetland study sites, there are notable differences in the invertebrate community at Miami wetlands fauna and all of her sites. High- and low-marsh sites in her study had substantially different invertebrate communities than Miami Wetlands.

[6] New Zealand mud snails have been present in Tillamook Bay for some time and occur in large numbers in some areas, so it not surprising that they would show up at Miami Wetlands.

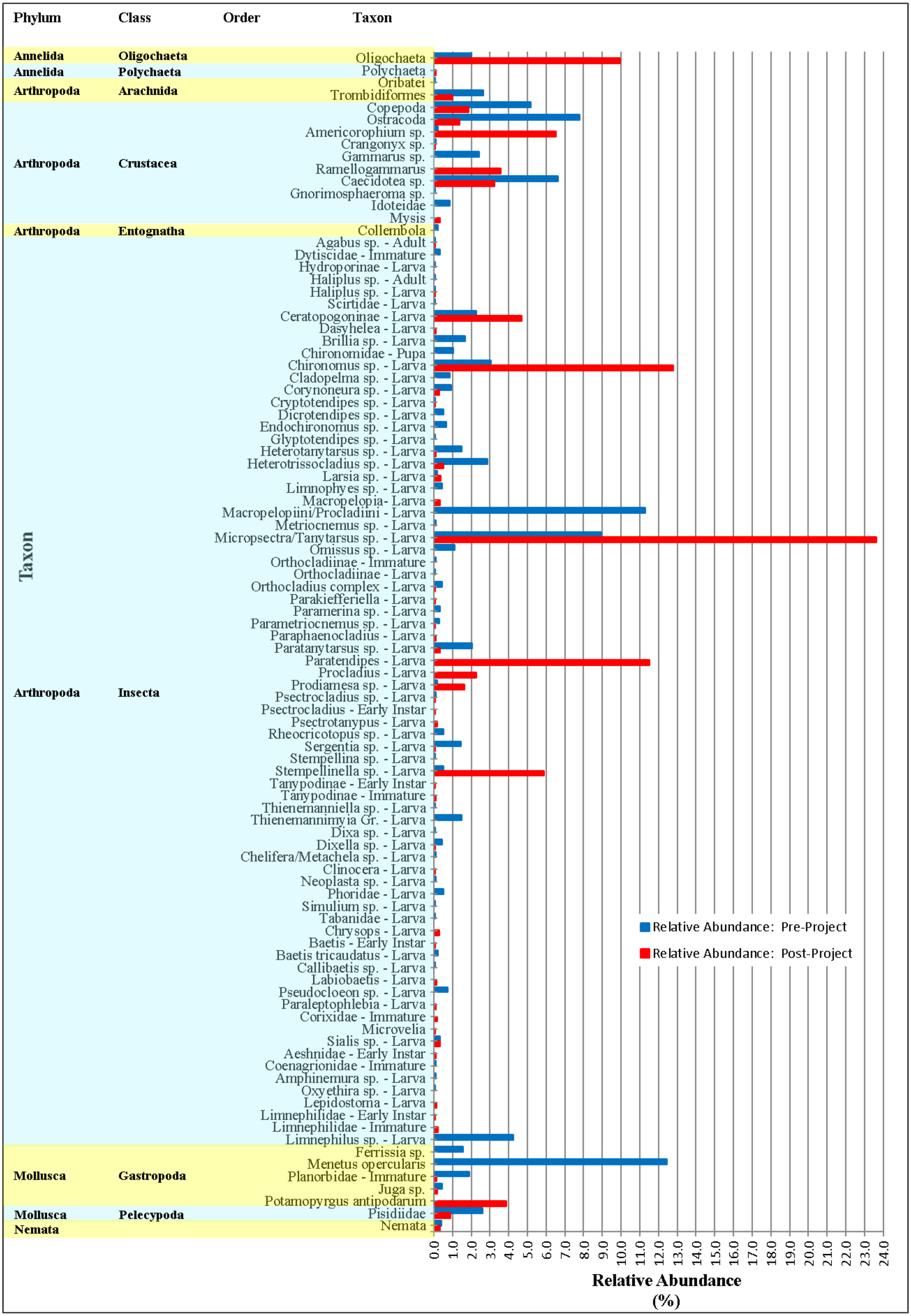


Figure 31. Relative abundance of macroinvertebrate taxa recorded from benthic samples obtained during May 2010 and May 2016 at the Miami Wetlands Project Site.

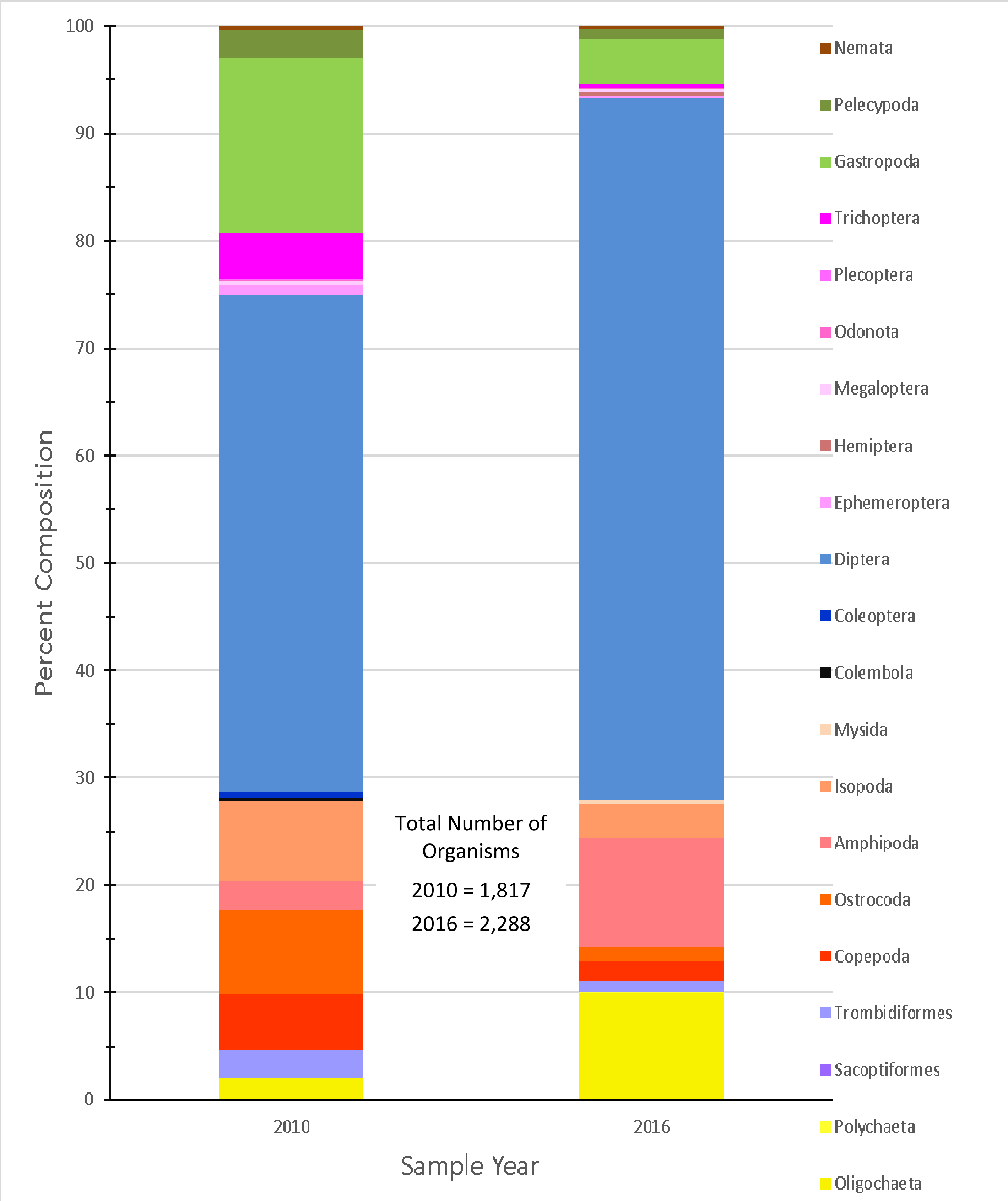


Figure 32. Composition of macroinvertebrate samples from the Miami Wetlands in 2010 and 2016.

Several studies have reported diets of juvenile salmonids (Loftus and Lenon 1977, Murphy et al. 1988, Brennan et al 2004, and Sather et al. 2008 to name a few). Small crustaceans (amphipods, copepods, isopods and ostracods) and insects (especially the larvae of chironomids and other dipterans) are important components of the diets of juvenile Chinook, Chum, and Coho salmon. These were well-represented groups in baseline and post-restoration samples obtained from the Miami Wetlands. The considerably larger number of organisms in the 2016 samples suggests that, from the standpoint of prey availability, habitat quality for juvenile salmonids has improved since baseline.

3.2.3. Secretive Marsh Birds

As noted earlier, during spring 2010-2014 we conducted breeding season surveys for five secretive marsh bird species: American bittern, American coot, Pied-billed grebe, Sora, and Virginia rail. We also made observations of some of these species incidental to other work at the sites.

During baseline surveys in 2010 and 2011, sora was the only one of these species detected. We also detected this species incidental to other work at the site on several other occasions. None of the other four species were detected during baseline surveys or during other baseline work at the site.

During post-restoration surveys (2012-2014) we detected both sora and Virginia rail. We also regularly detected both of these species incidental to other fieldwork. We did not detect any of the other target species during surveys or incidental to other field work. After 2013, we detected sora and/or Virgina rail nearly every time we were at the site. Their detections become so commonplace, that after 2014 we discontinued marsh bird surveys.

Sora is the most widely distributed North American rail. The species generally occupies freshwater wetlands with shallow to intermediate water depths, dominated by grass-like emergent vegetation, especially cattails (*Typha* spp.), sedges (*Carex* spp., *Cyperus* spp.), burreed (*Sparganium* spp.) and bulrushes (*Scirpus* spp.) (Melvin and Gibbs 1996). Habitats at the Miami Wetlands meet this general description, the site is within the general distribution of the species, and the species is known from other Tillamook County and Oregon coastal areas (Combs 2006a, East Cascade Audubon Society Tillamook County Checklist, North Oregon Coast Birding Trail Checklist). As a result, it is not surprising that Sora were detected at the site during breeding season surveys or during other fieldwork. Records for the species in western Oregon and our observations indicate that sora are resident at the site year-round.

Virginia rails prefer wetlands where upright emergent vegetation is interspersed with open water, mudflats, and/or matted vegetation and typically avoid emergent stands with high stem densities or large amounts of residual vegetation (Conway 1995, Combs 2006c). The species is considered uncommon along the north Oregon coast during all seasons (North Oregon Coast Birding Trail Checklist). During baseline, we speculated that the pre-restoration site was less suitable for this species than for Sora and that this accounted for the lack of baseline detections. However, as noted above, we regularly observed this species post-restoration. The species is regularly observed at other tidal wetlands in Tillamook Bay. Our observations indicate that Virginia rail are year-round residents of the site.

American coots and Pied-billed grebes are most often found at water bodies with heavy stands of emergent aquatic vegetation and moderately-deep, standing water within those stands of vegetation (Muller and Storer 1999, Brisbin et al. 2002). Both species regularly occur along the Oregon coast during non-breeding periods, but are uncommon breeders in the area (Combs 2006b, Spencer 2006, North Oregon Coast Birding Trail Checklist). Given that these are common species in western Oregon it would not be unusual to encounter them at or near the site, but neither have been confirmed on-site to date.

American Bitterns generally occupy large, freshwater wetlands with tall, emergent vegetation (Lowther et al. 2009). These authors report that the species rarely occurs in tidal marshes and Herziger and Ivey (2006) and the North Oregon Coast Birding Trail Checklist both consider the species uncommon along the Oregon Coast during all seasons. Given this information, it is possible for American bittern to occur at the Miami Wetlands site, but it has been confirmed to date.

3.2.4. Fishes

As noted above, we obtained pre-restoration fish data through a variety of methods and sources: Tillamook Bay Rapid Bio-Assessment data (RBA) for 2005-7, spring 2010 snorkel survey, and summer 2010 and 2011 fish salvage. We obtained post-restoration fish data primarily through snorkel surveys. The following paragraphs provide a general discussion of fishes known or expected to occur at the Miami Wetlands site, followed by results from our post-restoration surveys and comparison of these results with baseline studies.

A comprehensive study of the fish community of the Miami River basin has not been conducted. However, two studies have evaluated the fish community of Tillamook Bay, including tidal wetlands (Bottom and Forsberg 1978, Ellis 1999 and 2002) and two other documents provide information on fishes from the nearby Wilson River (Rose 2000, Duck Creek Associates 2008). These four documents list a number of different species that could potentially occur at the Miami Wetlands site. These include, but are not limited to, five salmonids (Chinook, Coho and Chum salmon and Steelhead and Cutthroat trout), two sturgeons (Green sturgeon [*Acipenser medirostris*] and White sturgeon [*A. transmontana*]), three lampreys (Pacific lamprey [*Lampetra tridentata*], Western brook lamprey [*L. richardsoni*], and River lamprey [*L. ayresi*]), several sculpins (including Prickly sculpin [*Cottus asper*], Torrent sculpin [*C. rhotheus*], Reticulate sculpin [*C. perplexus*], Coastrange sculpin [*C. aleuticus*], Riffle sculpin [*C. gulosus*], and Pacific staghorn sculpin [*Leptocottus armatus*]), and the three-spined stickleback (*Gasterosteus aculeatus*). Given that the Miami Wetlands site is very low in the Miami River drainage and brackish estuarine water regularly inundates a portion of the site a variety of other marine and estuarine species may also venture onto the site. However, these species are likely only occasional visitors and a full accounting of them is beyond the scope of this document.

During baseline, the following fishes were recorded at the Miami Wetlands site: coho salmon, steelhead and cutthroat trout, western brook lamprey (ammocetes of other species may also have been present, but juvenile lamprey were not identified to species), three-spined stickleback, and sculpin (also not identified to species).

Prior to restoration actions, aquatic habitats on the site occurred within the drainage ditch system on the TNC parcel and the remnant channel on the Crabb parcel, but only aquatic habitats on the

TNC parcel were evaluated for fishes.. During the Tillamook Bay Rapid Bio-Assessment (RBA) surveyors conducted snorkel counts within and adjacent to the Miami Wetlands project area during each of three summers (2005-7). This effort was designed primarily to survey juvenile Coho and the summer survey timing precluded observation of juvenile Chum and greatly limited potential for juvenile Chinook observations (both species out-migrate to marine and/or estuarine waters shortly after emerging from gravel nests during spring months). As a result, Coho, Cutthroat and Steelhead were the primary salmonids recorded during these surveys. Observations of non-salmonid fishes were not recorded during the RBA. Average density of juvenile Coho in pools on the TNC parcel during these efforts was approximately 0.4 fish/m^2 (Bio-Surveys, LLC 2007). RBA surveyors observed juvenile Steelhead trout at the Miami Wetlands site only during the 2007 effort. Average density of juvenile Steelhead during this period was approximately 0.4 fish/m^2. Cutthroat trout were observed during each of the three survey efforts. Average Cutthroat density also was approximately 0.4 fish/m^2. Zero+ trout (young of the year trout not identified to species) were observed during all three survey efforts. Average density of 0+ trout within Miami Wetlands pools was approximately 0.5 fish/m^2. No juvenile Chinook or Chum salmon were observed during these surveys (not surprising given that these survey efforts were completed during summer – after juvenile Chinook and Chum have migrated out of their natal freshwater habitats). Based on these numbers, pools at the Miami Wetlands site typically contained approximately two juvenile salmonids per square meter of surface area during the summers of 2005-7. During the RBA, the largest single group of salmonids observed at stations within the Miami Wetlands site was nine (eight coho and one cutthroat).

Bio-Surveys, LLC (2007) reported that spawning habitats were very limited in both Hobson and Struby creeks and speculated that most salmonids observed in these streams during the surveys were upstream migrants from the mainstem Miami River, not fish that hatched from redds within these streams. They also report that although habitats in the wetland were degraded due to past conversion of the site for agricultural purposes, the creeks provide fresh water inputs into the lower Miami system and, if restored, the wetlands could provide "high quality summer and winter salmonid habitat" and a "low saline refugia for juvenile salmonids."

During June 2010, ODFW Biologist, Phil Simpson completed a snorkel survey of the channels within the portion of the Miami Wetlands site north of the Miami River. During this effort, he recorded all salmonids and lamprey observed and where observations occurred. Although he noted the presence of large numbers of Three-spined stickleback throughout the areas he surveyed, he did not report numbers for this species nor did he record observations of any other non-salmonid fishes.

Simpson observed juvenile Coho in all surveyed channels with the exception of the dead-end segments of Watercourses 2 and 3 (Figure 23, Table 17). Coho observations were not distributed evenly throughout the surveyed channels. Instead, they were concentrated primarily on the downstream sides of beaver dams or other in-stream structures. For example, 67 of the 71 juvenile Coho observed in the Hobson-Struby Channel were recorded on the downstream side of a beaver dam located near the mouth of the channel. Simpson also observed Cutthroat trout in all of the surveyed channels (except the dead-end segments). These fish ranged in age from juvenile to adult. Many of the adults appeared to be sea-run fish and these individuals made up a majority of the Cutthroat trout observed in Watercourse 4. Unlike Coho, which were observed in clusters, Cutthroat trout were distributed throughout the reaches where they were observed. Simpson observed only one Steelhead trout during his survey. This was a juvenile fish in Watercourse 3. Simpson observed nine adult Brook lamprey in the upper portion of the Hobson-Struby channel. All of these fish were actively spawning and were associated with two redds constructed in the gravel substrate of this portion of the channel. Three-spined stickleback occurred in all surveyed channels. Simpson did not attempt to record numbers for this species, but did note that the species was abundant throughout all surveyed reaches. Simpson made special note of the dead-end segments of watercourses 2 and 3 (Figure 23). He reported that no fish were observed in these segments and that water temperature increased and visibility decreased notably in these segments.

Table 17. Fish observations made during June 2010 snorkel survey at Miami Wetlands.

Channel ID	Surveyed Length (ft)	Number of Individuals Observed				
		Coho	Cutthroat	Steelhead	Brook Lamprey	Three-spined Stickleback
Hobson-Struby Channel	412	71	16		9	Present throughout
Struby Creek*	192	Not Surveyed – No pools				
Watercourse 1	366	120	3			Present throughout
Watercourse 2	128	2	4			Present throughout
Watercourse 3	61	26	4	1		Present throughout
Watercourse 4	153	4	16			Present throughout
Dead-end Segments	174	No Fish Observed				

*upstream of its confluence with Hobson Creek, but south of Miami-Foley Road.

The final source of pre-construction fish data available to us are the results of fish salvage efforts needed to remove fish from existing channels before they could be cleared of bankside vegetation and filled with soil. Due to weather and other unforeseen circumstances, construction was not completed in a single summer (as originally planned). As a result, we completed two separate fish salvage efforts (July and September 2010 and August 2011).

During the 2010 effort, we completed salvage actions in all of the existing channels that were to be filled as part of the restoration project (Figure 23). In most channels, minnow trap deployment was followed by pole seining and dip netting (block nets also were deployed to exclude fish from cleared areas). Fish were captured and relocated from most of the TNC parcel channels. However, to minimize potential for capture mortality we primarily used pole seines to flush fish downstream and out of the construction zone along the Hobson-Struby channel (without capturing and handling them). As a result, we handled and counted fish captured in Watercourses 1-4, but did not enumerate fish flushed from the Hobson-Struby channel.

We recorded five separate fish taxa during the 2010 salvage effort (coho, cutthroat, lamprey ammocetes, three-spined stickleback, and sculpin – we did not identify Lamprey or Sculpin to species during this effort). Juvenile coho were the most abundant salmonid salvaged during the 2010 operation (approximately 400 were captured and relocated during 2010). The species occurred in all of the channels where salvage operations were conducted, but most (approximately 70 percent) were captured in Watercourse 1. Cutthroat trout were uncommon during the 2010 salvage effort. Only 12 Cutthroat were captured and relocated (all from watercourses 2 and 4). Approximately 50 lamprey were captured and relocated from watercourses 2 and 4 during 2010. Given that Brook Lamprey were observed spawning on site during June 2010, it seems likely that the ammocetes observed during salvage operations belonged to this taxa. However, because it is very difficult to differentiate juvenile lamprey, we made no attempt to identify ammocetes to species. Three-spined stickleback was by far the most numerous species captured during this salvage effort. While we captured and relocated approximately 1,000 individual stickleback, many, many more were not salvaged. We captured and relocated approximately 350 sculpins during 2010. Similar to stickleback, we observed many more sculpin that we were able to capture and relocate. Based on habitat preferences, the sculpin species most likely to regularly occur at the Miami Wetlands site is the Prickly sculpin (*C. asper*). However, many coastal sculpin species appear similar and we did not attempt to identify sculpin captured during salvage. All fish captured in channels during 2010 were relocated to the mouth of Illingsworth Creek, a tributary of the Miami River located just upstream of the Miami Wetlands site.

In 2010, construction of a new Hobson-Struby channel was completed and stream flow was directed into this new channel. Although plugs were constructed at the upstream and downstream ends of the old channel, we were unable to completely fill the old channel during 2010. As a result, this activity was scheduled for completion during summer 2011. Although this channel was drained and prepped for filling during 2010, it was inundated during winter floods and needed to be drained and cleared of fishes before any construction actions could occur in 2011. We used backpack electrofishing equipment and dip nets to conduct this salvage action.

Results of the 2011 fish salvage effort were similar to those of the 2010 operations, but we only captured four separate fish taxa during the 2011 salvage effort (coho, lamprey, sculpin, and three-spined stickleback). Coho were abundant in the 2011 sample (approximately 320 were captured and relocated). We captured approximately 35 lamprey ammocetes during 2011. Sculpin and three-spined stickleback also were abundant in 2011. We captured approximately 225 sculpin and just over 1,400 stickleback. Similar to 2010, we observed far more of each of these species than we were able to capture and relocate. All fishes captured during the 2011 salvage operation were immediately released into the newly constructed Hobson-Struby channel.

Since all baseline fish data was obtained from the TNC parcel, we limited our post-restoration fish surveys to that portion of the site. Figure 24 depicts areas searched during post-restoration fish surveys.

During snorkel surveys conducted from 2012-2016 visibility in the tidal channel system was generally poor to fair, so we expended considerably more survey effort in the Hobson-Struby system during all surveys (which tended to have good visibility). We observed few fishes in the tidal channels during all snorkel surveys. We have observed fishes in these channels incidental to other fieldwork on many occasions, however. These incidental observations have included juvenile salmonids (some coho, but most unidentified), sculpin and large schools of stickleback.

Visibility was generally better in the Hobson-Struby creeks channel and we were able to observe many fishes in this channel system during our survey efforts. During many surveys, we were unable to positively identify some juvenile salmonids we observed (beyond the fact that they were quite obviously salmonids). Based on baseline information and a contracted survey conducted by a very experienced snorkel survey crew, we assume these were often were juvenile coho, but since we could not positively identify them at the time we report them here as unidentified juvenile salmonids.

In April 2012, we completed a single snorkel survey. During our survey effort, we observed the following fishes (all in the Hobson-Struby channel system):

46	–	unidentified salmonid parr[7]
26	–	coho parr
2	–	salmonid fry (unidentified)
1	–	steelhead smolt

The number of juvenile salmonids observed during the 2012 effort, is comparable to observations made during the pre-construction snorkel survey conducted in 2010. However, survey conditions during 2012 were less favorable than during 2010 because the 2012 survey was conducted during a period of higher stream flows. During 2012, we observed a few groups of 20+ juvenile salmonids at wood structures along the Hobson-Struby channel.

We completed two snorkel surveys at the site in 2013: one survey on March 14, and one on April 25. We only attempted to snorkel the tidal channels (E channels) during our March survey effort. Visibility in the tidal channels was once again extremely poor (i.e., less than one foot) and, as a result, we did not spend much time attempting to survey these channels nor did we observe any fishes in these channels during the survey. However, we did observe approximately 20 unidentified salmonids in the lower tidal channel while completing other field tasks on the same day as our March snorkel survey effort. This was not unusual. We often observed small salmonids (some coho, but most unidentified) and large schools of stickleback in these channels from the banks while performing fieldwork at the site.

We snorkeled the Hobson-Struby channel complex during both the March and April survey sessions. Visibility was moderate to good in the channels conveying the flows of Hobson and Struby creeks (i.e., channels A, B, C and D), but quite poor in the tributary channel (G channel). We observed few fish during our March survey effort, even around the in-channel wood structures where fish have typically been common during previous surveys. In fact, we recorded fewer fish during this effort than during any snorkel survey effort completed at the site since 2011. Although visibility was somewhat lower and flows somewhat swifter during this survey than during other surveys, it is unclear why so few fish were observed during this effort. All of the fish we observed during the March effort were within the Hobson-Struby common channel

[7] Parr-The developmental life stage of salmon and trout between alevin and smolt, when the young have developed parr marks and are actively feeding in fresh water.

Fry-An early stage of development in young salmon or trout. During this stage the fry is usually less than one year old, has absorbed its yolk sac, is rearing in the stream, and is between the alevin and parr stage of development.

Smolt-Refers to the salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted for life in the marine environment.

complex (Channels A, C and D) and most were in close proximity to in-stream wood. We observed the following during the March 2013 survey effort:

10	–	unidentified salmonids[8]
5	–	coho par
1	–	salmonid fry (species unidentified)

We observed considerably more fish during the April 2013 survey effort. In fact, we recorded more fish during this effort than during any previous post-construction survey at the site. As during previous efforts, most fish were observed in close proximity to in-channel wood structures. However, we also observed nearly 20 unidentified salmonids while walking in-channel between areas that we snorkeled. With the exception of two unidentified salmonids near the mouth of channel G, all fish observed during the April survey were in the Hobson-Struby channel complex (Channels A, B, C and D). During the April 2013 survey effort, we observed the following:

17	–	unidentified salmonids
97	–	coho parr
7	–	cutthroat adults
1	–	steelhead fry

Similar to other efforts, we observed most fish during these surveys in proximity to in-stream large wood structures, but some were observed in pools not associated with large wood (e.g., beaver impoundments) and some were observed in areas with other stream bed types (e.g., riffles, etc.). We observed 20-50 juvenile coho at two of the large wood structures along the Hobson-Struby channel.

We completed two snorkel surveys in 2014: one survey on March 25, and one on April 10. We limited our snorkel survey activities in 2014 to the Hobson-Struby Channel complex (Channels A, B, C, D and F).

During our March 25 survey effort, visibility was poor to very poor throughout the C, D and F channels, as well as the lower portions of the A and B channels. Visibility was somewhat improved in the upper portions of the A and B channels. These conditions made for a difficult survey with limited results – we saw very few fish and it was extremely difficult to positively ID the few fish we did observe. We observed no fish in the C, D and F channels or within the lower portions of the A and B channels during this survey effort. In the upper A and B channels, we observed approximately three dozen fishes. Many of the fish we observed in these channels were in the pool immediately below the culvert where Miami Foley Road crosses Hobson Creek. As with previous attempts to survey this pool, fish immediately fled into the culvert and out of view and so were mainly unobservable. We were unable to positively ID most fish during this survey (we did positively ID two 6+ inch long cutthroat in the upper B channel). We also found a single, dead steelhead parr in the lower A channel during this survey. Although the results of this survey were disappointing, we know that salmonids were present in good numbers at the time of this survey. We base this statement on observations made incidental to other fieldwork completed at

[8] This was a single group of fish. Most were larger individuals (6+ inches), but the observation was too brief and the fish retreated into an inaccessible area. As a result, positive identification was not possible.

the site on the previous day (March 24). During this fieldwork, we observed (from above) approximately a dozen small salmonids in the lower D channel and at least 100 in the lower portion of the A channel. While we were unable to identify all of these fish, many appeared to be coho par. We observed a few larger fish (6+ inches) that appeared to be cutthroat trout.

Survey conditions improved during our April 10 outing, but we still encountered areas where low visibility limited our ability to count and ID fishes. During this effort we observed fishes throughout much of the Hobson-Struby channel complex (several salmonid species plus other species). Notable observations during this visit included a single, small starry flounder (*Platichthys stellatus*) in the lower Hobson-Struby channel (where saltwater was often present, see water quality section), and a very large school of salmonids in the beaver pond that formed at the confluence of the A and B channels. Many of these were 3+ inch coho smolts, but the sheer size of the school made positive ID of all individuals impossible-therefore we classified them all as unidentified salmonids. The following is a summary of our April 10, 2014 observations:

400+	–	unidentified salmonids
150	–	coho parr
5	–	steelhead parr
63	–	cutthroat (parr/adults)
51	–	unidentified trout fry (species unidentified)
Numerous	–	three-spined stickleback
Numerous	–	sculpin
1	–	starry flounder

Similar to our previous snorkel survey efforts, we observed most fish during 2014 surveys in proximity to in-stream large wood structures and in pools not associated with large wood (e.g., beaver impoundments). However, we also recorded observations in other portions of the channels.

We completed a single snorkel survey in 2015 (May 14). Like the previous year, we limited our survey to the Hobson-Struby Channel complex (Channels A, B, C, D and F). Survey conditions were variable – some areas had good visibility, while it was moderate to poor in others. Fish were abundant during this survey effort and we noted fish in areas lateral to the channels that were unsuitable for snorkeling (shallow, inundated areas among dense vegetation). Temporally, this was the latest survey we completed during our monitoring effort. The following is a summary of our May 15, 2015 observations:

15	–	unidentified salmonids
523	–	coho parr
150	–	coho smolt
15	–	steelhead parr
53	–	cutthroat (par/adults)
Numerous	–	three-spined stickleback
Numerous	–	sculpin

In 2016, we contracted Bio-Surveys, LLC to snorkel survey the site and prepare a report of their findings. All previous snorkel work at the site was completed during daylight hours, but this survey was conducted at night. The crew surveyed all channels on the TNC parcel except the G system. All surveyed channels, except E2 and E3, were snorkeled in their entirety. Channels E2 and E3 were spot surveyed. Table 18 summarizes this survey effort. The vast majority of fish observed were juvenile coho (800+ individuals). Also of note is the presence of chum fry. This was the first time this species was documented during our work at the site. All chum were observed in the lower channel system where saltwater was often present. The survey crew also observed numerous three-spined stickleback and sculpin throughout the site, but these were not enumerated (and are not included in Table 18).

Table 18. Results of snorkel survey at Miami Wetlands conducted by Bio-Surveys, LLC on March 4, 2016.

Channel ID	Survey Length	Avg Channel Width (ft)	Avg Channel Depth (ft)	Positive flow	Visibility	Coho parr	Chum fry	Sthd*	Cutt*
A	500	4	2	yes	Good	150			3
B	375	3	2	yes	Good	338			
C	1155	6	3	yes	Good	233			
D	220	7	4	yes	Good	18			4
E1	75	5	5	no	Good	10			
E2	160	4	4	no	Fair	7			2
E3	365	4	4	no	Fair	15		1	3
F	315	1.5	1	no	Good	32			
G	Not Surveyed								
H	150	3	3	yes	Good	2	8		
I	575	15	5	yes	Good	12	5		2

*Not differentiated by age/size class

In addition to snorkeling the channel system, Bio-Surveys also completed a quick assessment of fishes using the shallowly-inundated, heavily-vegetated areas lateral to the channels. For this effort, they viewed a small area (~8 ft x 15 ft x 2 inch average depth) from with high powered lights. In this backwater there were four coho parr. This translates to approximately four fish per 100 square feet. While this was a very quick effort and is insufficient to quantify fish use of these off-channel areas, it suggests that (given the amount of this type of habitat present at the site during the survey) there were likely thousands of young coho using these areas during the survey that were not enumerated by this survey work. These areas provide high-quality rearing habitat for salmonids and have increased considerably since baseline.

We observed considerably more fish from 2014 on than during baseline and the first few years post-restoration. Based on our post-restoration fish surveys (and the suite of other data reported above), we are confident that conditions for fishes at the site are improved as compared to pre-project times. Not only does habitat quality appear to have improved, the amount of potentially suitable habitat for fishes has expanded greatly. We created approximately 2,000 linear feet of new channels as part of the construction efforts for this project and additional aquatic habitat has formed subsequent to project construction. As noted above, much of the TNC parcel has become inundated by beaver activities and beavers have created several new channels. Expansion of aquatic habitat has occurred on the Crabb parcel as well. Much of the area now inundated is to be capable of supporting fishes (at least seasonally) in fairly high numbers. Although we have not quantified fish use of these areas (beyond Bio-Surveys 2016 work), we regularly observed fishes and other aquatic wildlife in these inundated areas when at the site.

3.2.5. Other Vertebrate Species

We recorded incidental observations (including sign (e.g., tracks, scat, etc.) and actual observations of individuals) of reptiles and amphibians, birds, and mammals while conducting fieldwork at the site. Appendix M provides a list of these species. This list is not intended as an exhaustive list of vertebrate species potentially occurring at the site. We did not conduct species-specific surveys or specialized sampling techniques beyond those discussed previously.

4.0 Summary and Recommendations

The above sections present conditions at the Miami Wetlands site as of 2016-2017 and compare these post-restoration conditions to pre-restoration conditions at the site. They paint a picture of a site that has changed substantially from pre-restoration conditions. The quality of terrestrial habitats has improved as native plants have become more diverse and abundant, and aquatic habitats have increased in quantity and quality. Overall, the restoration effort appears to be moving the site in a positive direction relative to goals established before the work began. Appendices N and O provide repeat photographs that depict the evolution of the site.

We recommend longer-term monitoring of the site to continue to track its evolution. While monitoring with the same frequency and intensity of work done for this report is probably not warranted, it would be informative to resample several parameters on an approximately five-year interval. At a minimum, we recommend repeating the line intercept and nested vegetation plot work described above on an approximately five-year interval. We also recommend analyzing soil organic matter and salinity concurrent with the vegetation work. Further fish sampling work (especially with more focus on summer, fall and winter periods) would be enlightening.

We also recommend additional habitat restoration and enhancement work in the watersheds of Hobson and Struby creeks. There are problematic culverts in both basins, but Hobson Creek is particularly influenced by road stream crossings (Bailey 2012). A total of five problem culverts occur in these watersheds. They collectively impede upstream passage for aquatic organisms to approximately 1.5 miles of stream habitats and adversely affect stream functions and processes. Two of the culverts are under Miami-Foley Road, a Tillamook County-owned road, and their replacement will be fairly expensive and complicated. The remaining three are on infrequently used private roads and would be considerably less complicated and expensive. All five culverts are in poor condition and they should probably be treated in the near-term (or they will fail and require emergency replacement. The uppermost barrier in Hobson Creek is a complete adult barrier and prevents access to over 0.5 miles of potential spawning habitats for coho, steelhead and cutthroat. A private parcel downstream from this culvert to Miami Foley Road has been listed for sale for several years. Acquisition of this land for conservation purposes, with subsequent restoration, would contribute positively to the Miami Wetlands and improve habitat conditions within the Hobson Creek (and lower Miami) watershed immensely.

5.0 Literature Cited

American Society of Civil Engineers (ASCE). 1990. Agricultural salinity assessment and management, ASCE Manuals and Reports on Engineering Practice: No. 71. K.K. Tanji, Editor. American Society of Civil Engineers, New York, New York. 619 pp.

Bailey, S.J. 2011. Miami Wetlands Enhancement Project: Baseline Monitoring Report. Unpublished report. 79 pp. + Appendices.

Bailey, S.J. 2012. Culvert Assessment and Prioritization Plan for Fish Passage in the Tillamook Bay Watershed, Tillamook County, Oregon – Version 1.1. Unpublished report. 35 pp + appendices.

Bio-Surveys, LLC. 2005. Tillamook Bay rapid bio-assessment. Unpublished report to Tillamook Estuaries Partnership. 78 pp. + data and GIS files.

_____. 2006. Tillamook Bay rapid bio-assessment. Unpublished report to Tillamook Estuaries Partnership. 84 pp. + data and GIS files.

_____. 2007. Tillamook Bay rapid bio-assessment. Unpublished report to Tillamook Estuaries Partnership. 90 pp. + data and GIS files.

Bledzki, L.A., J.L. Bubier, L.A. Moulton and T.D. Kyker-Snowman. 2011. Downstream effects of beaver ponds on the water quality of New England first- and second-order streams. Ecohydrology 4:698-707.

Bottom, D., and B. Forsberg. 1978. The Fishes of Tillamook Bay. Oregon Department of Fish and Wildlife, Project No. F-100-R. 56 pp.

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stanatiou. 2004. Juvenile salmonid composition, timing, distribution, and diet marine nearshore waters of central Puget Sound in 2001 - 2002. King County Department of Natural Resources and Parks. Seattle, WA. 164 pp.

Brophy, L.S., C.E. Cornu, P.R. Adamus, J.A. Christy, A. Gray, L. Huang, M.A. MacClellan, J.A. Doumbia, and R.L. Tully. 2011. New Tools for Tidal Wetland Restoration: Development of a Reference Conditions Database and a Temperature Sensor Method for Detecting Tidal Inundation in Least-disturbed Tidal Wetlands of Oregon, USA. Prepared for the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET). 199 pp.

Brisbin, Jr., I. Lehr and Thomas B. Mowbray. 2002. American Coot (*Fulica americana*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online 11/06/2017: *https://birdsna.org/Species-Account/bna/species/y00475/introduction*

Caton L. 1991. Improved subsampling methods for the EPA "Rapid Bioassessment" benthic protocols. Bulletin of the North American Benthological Society 8:317-319.

Combs, B. 2006a. Sora. Pp 194-196. *in* Birds of Oregon: A general reference. Marshall, D.B., M.G. Hunter, and A.L. Contreras, eds. Oregon State University Press, Corvallis, OR.

Combs, B. 2006b. American coot. Pp 196-198. *in* Birds of Oregon: A general reference. Marshall, D.B., M.G. Hunter, and A.L. Contreras, eds. Oregon State University Press, Corvallis, OR.

Combs, B. 2006c. Virginia rail. Pp 192-194. *in* Birds of Oregon: A general reference. Marshall, D.B., M.G. Hunter, and A.L. Contreras, eds. Oregon State University Press, Corvallis, OR.

Conway, C.J. 1995. Virginia Rail (*Rallus limicola*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online 11/06/2017: *https://birdsna.org/Species-Account/bna/species/virrai/introduction*

Conway,C. J. 2009. Standardized North American Marsh Bird Monitoring Protocols, version 2009-2. Wildlife Research Report #2009-02. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Access online 11/06/2017 at *https://pubs.er.usgs.gov/publication/2000109*

Duck Creek Associates, Inc. 2008. Wilson River Watershed Analysis. Prepared for the Oregon Department of Forestry, Salem, OR. 344 pp. + appendices.

Ellis, R.H. 2002. Fish use of Tillamook Bay: synthesis report for monitoring conducted 1999 through 2001. Unpublished report prepared for Tillamook County Estuary Partnership. 61 pp + appendices.

Ellis, R.H.. 1999. Tillamook Bay: Fish use of the estuary. Unpublished report prepared for The Tillamook Bay National Estuary Project and Tillamook County Cooperative Partnership Garibaldi, Oregon. 87 pp. + appendices.

Gray, A. 2011. Benthic invertebrates at CICEET study sites. Appendix 11 *in* Brophy, L.S., C.E. Cornu, P.R. Adamus, J.A. Christy, A. Gray, L. Huang, M.A. MacClellan, J.A. Doumbia, and R.L. Tully. 2011. New Tools for Tidal Wetland Restoration: Development of a Reference Conditions Database and a Temperature Sensor Method for Detecting Tidal Inundation in Least-disturbed Tidal Wetlands of Oregon, USA. Prepared for the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET). 199 pp.

Herziger C. and G.L. Ivey. 2006. American bittern. Pp 60-62. *in* Birds of Oregon: A general reference. Marshall, D.B., M.G. Hunter, and A.L. Contreras, eds. Oregon State University Press, Corvallis, OR.

Hogg, T.J. and J.L. Henry. 1984. Camparison of 1:1 and 1:2 suspensions and extracts with the saturation extract in estimating salinity in Saskatchewan soils. Canadian Journal of Soil Science 64:699-704.

Loftus W.F. and H.L. Lenon. 1977. Food habits of the salmon smolts, *Oncorhynchus tshawytscha* and *O. keta*, from the Salcha River, Alaska. Transactions of the American Fisheries Society 106:235-240

Lowry R. 2017. Concepts and Applications of Inferential Statistics. Online textbook accessed 11/06/2017 at: *http://vassarstats.net/textbook/*

Lowther, Peter, Alan F. Poole, J. P. Gibbs, S. Melvin and F. A. Reid. 2009. American Bittern (Botaurus lentiginosus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online 11/06/2017: *https://birdsna.org/Species-Account/bna/species/amebit/introduction*

Mazzacano, C., S. Foltz, and S. H. Black. 2009. Developing an invertebrate index of biological integrity in Pacific Northwest wetlands. Project Completion Report to the Oregon Watershed Enhancement Board, OWEB Grant # 208-3046. The Xerces Society for Invertebrate Conservation, Portland, Oregon. 23 pp. + appendices.

Melvin, Scott M. and James P. Gibbs. 1996. Sora (*Porzana carolina*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online 11/06/2017 at: *http://bna.birds.cornell.edu/bna/species/250*

Miller R.O., R. Gavlak and D. Horneck. Soil, Pplant and water reference methods for the western region, 4th edition. WREP-125. Accessed online 11/06/2017 at *https://www.ipni.net/ipniweb/conference/wnmc.nsf/e0f085ed5f091b1b852579000057902e/31afdf35bb372912852580ce00502c3b/$FILE/Western%20States%20Manual-2013.pdf*

Muller, Martin J. and Robert W. Storer. 1999. Pied-billed Grebe (Podilymbus podiceps), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online 11/06/2017: *https://birdsna.org/Species-Account/bna/species/pibgre/introduction*

Murphy, M.L., J.F. Thedinga, and K.V. Koski. 1988. Size and diet of juvenile Pacific Salmon during seaward migration through a small estuary in southeastern Alaska. Fishery Bulletin 86:213-222.

North Oregon Coast Birding Trail Checklist. Accessed online 11/06/2017 at *http://www.oregoncoastbirding.com/PDFs/6%20Birding%20Trail%20Checklist.pdf*

Oregon Department of Environmental Quality. 2007. Division 041 – Chapter 45 – Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon (OAR 340-041)

Pollock, M.M., G.M. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2017. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.0. United States Fish and Wildlife Service, Portland, Oregon. 219 pp. Accessed online 11/06/2017 at: *https://www.fws.gov/oregonfwo/promo.cfm?id=177175812*

Rose, C.E. 2000. Environmental Variables as Predictors of Fish Assemblages in the Tillamook Basin, Oregon. Unpublished Thesis, Oregon State University, Corvallis, Oregon.

Sather, NK, GE Johnson, AJ Storch, DJ Teel, JR Skalski, TA Jones, EM Dawley, SA Zimmerman, AB Borde, C Mallette, and R Farr. 2009. Ecology of Juvenile Salmon in Shallow Tidal Freshwater Habitats in the Vicinity of the Sandy River Delta, Lower Columbia River, 2008. PNNL-18450, final report submitted to the Bonneville Power Administration by Pacific Northwest National Laboratory, Oregon Department of Fish and Wildlife, National Marine Fisheries Service, and University of Washington.

Spencer, K. 2006. Pied-billed grebe. Pp 28-30. *in* Birds of Oregon: A general reference. Marshall, D.B., M.G. Hunter, and A.L. Contreras, eds. Oregon State University Press, Corvallis, OR.

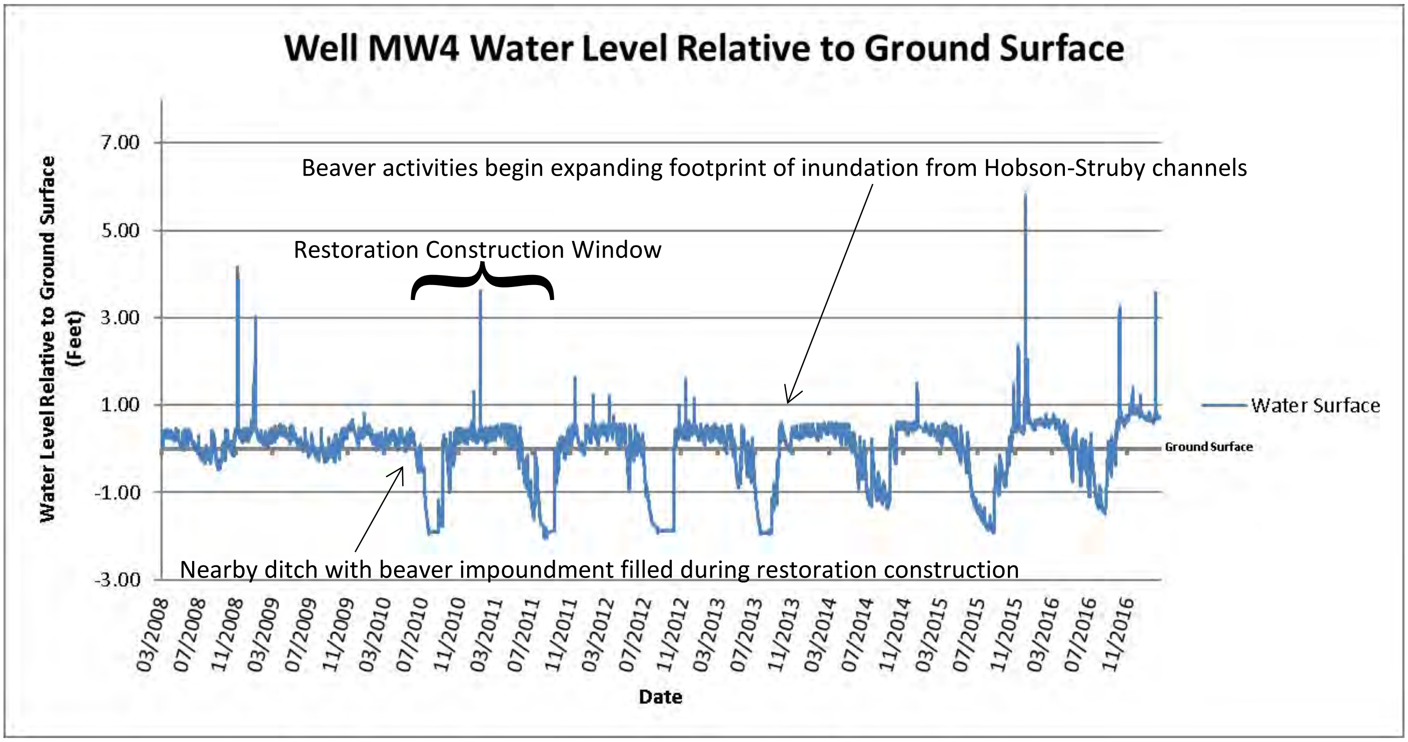
Vigil-Agrimis, Inc. 2008. Miami wetlands habitat enhancement plan. Unpublished report prepared for Tillamook Estuaries Partnership. 36 pp. + appendices.

Vigil-Agrimis, Inc. 2009. Miami wetlands habitat enhancement effectiveness monitoring plan. Unpublished report prepared for Tillamook Estuaries Partnership. 16 pp. + appendices.

Appendix A

Graphs depicting water levels at Miami Wetlands from March 2008 through February 2017

Figure A1. Water levels relative to ground surface for six groundwater and two in-channel wells at Miami Wetlands from March 2008 through February 2017. Discontinuous lines indicate data gaps.



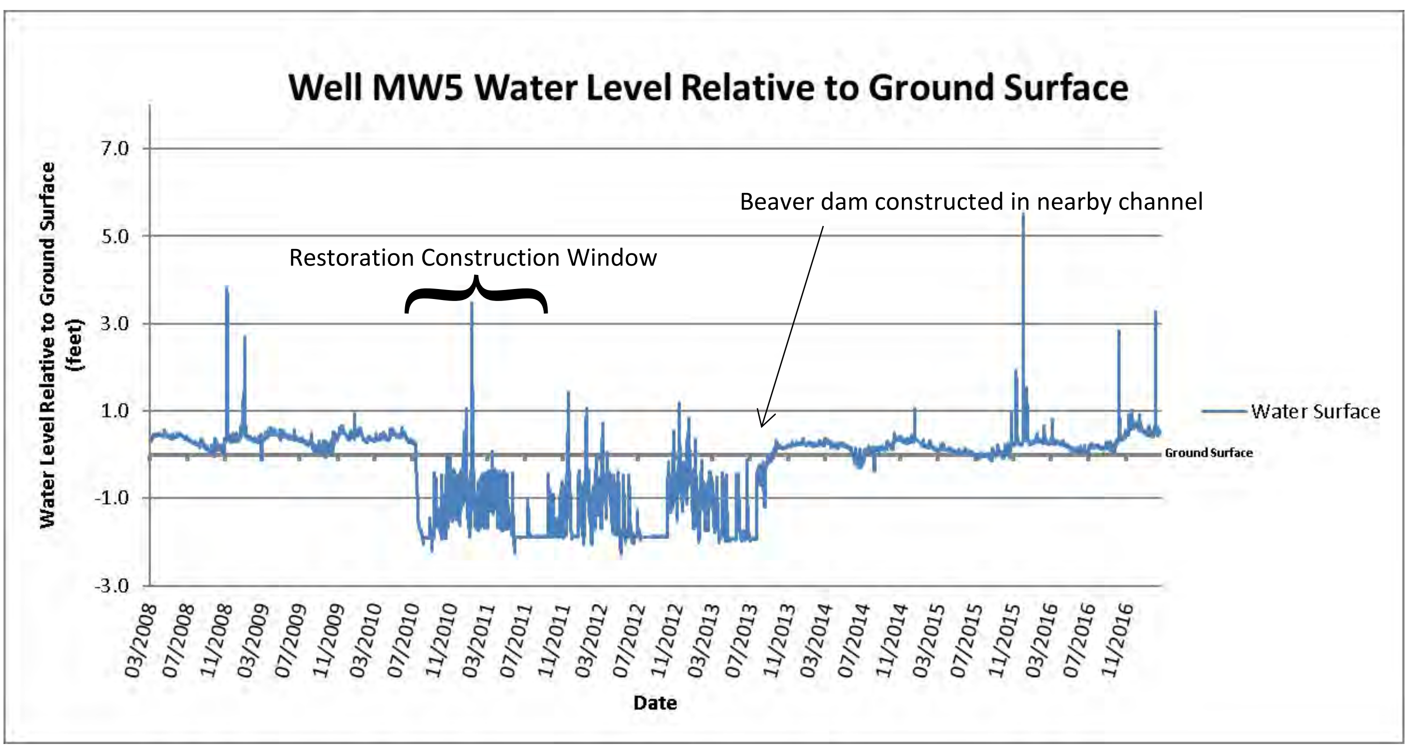
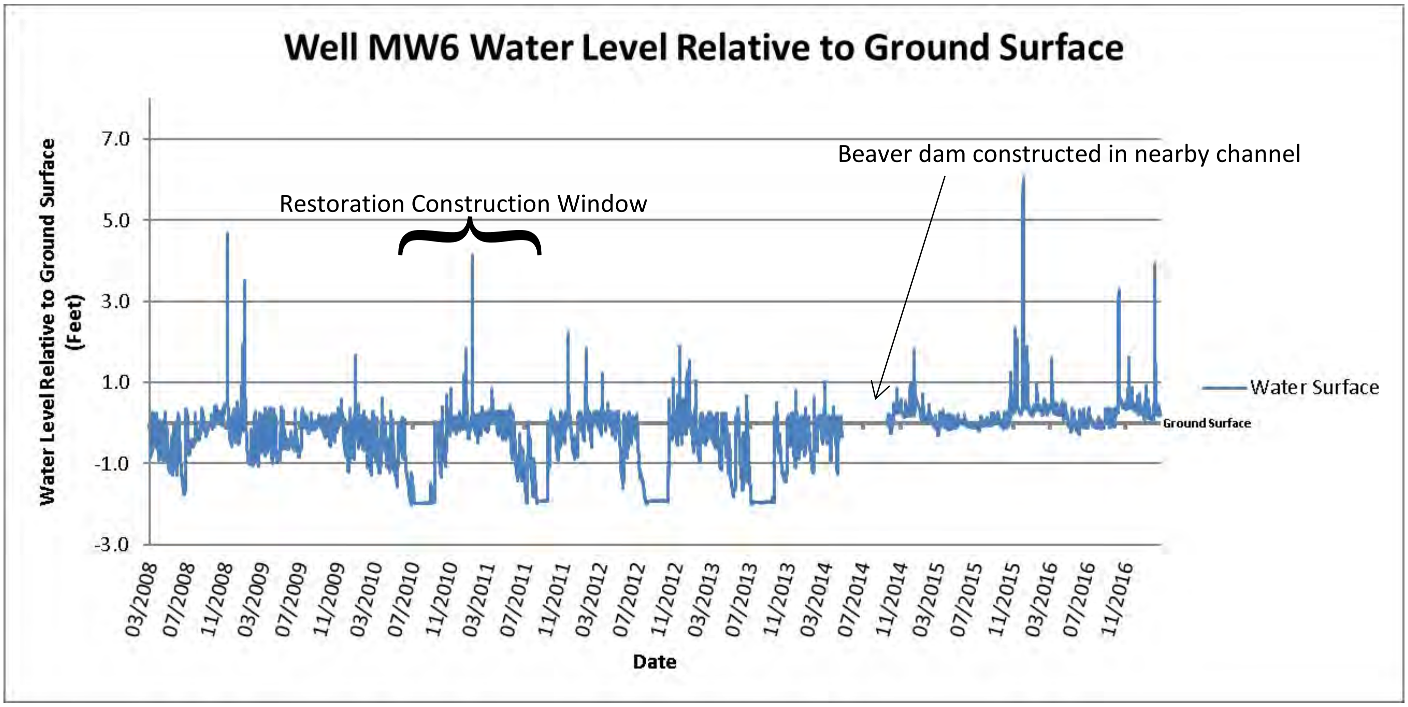


Figure A1. continued



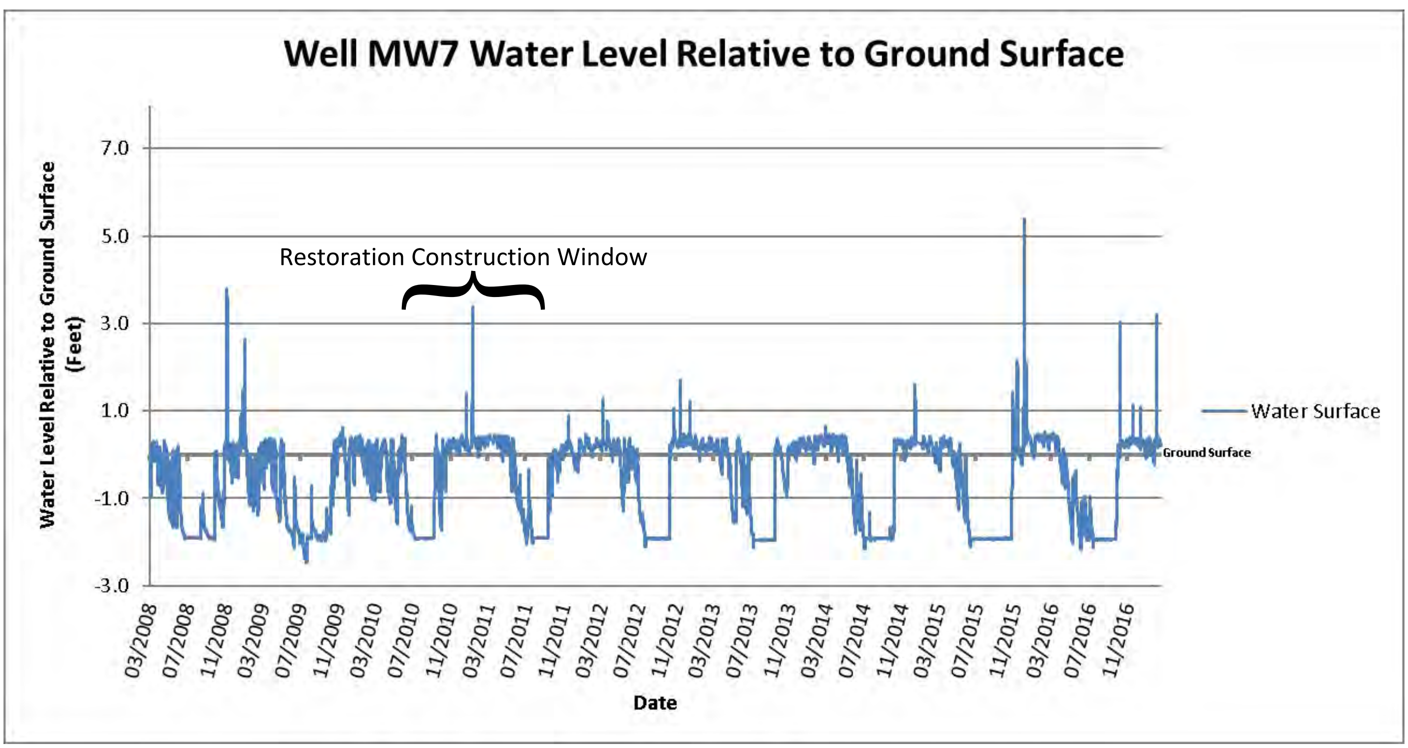
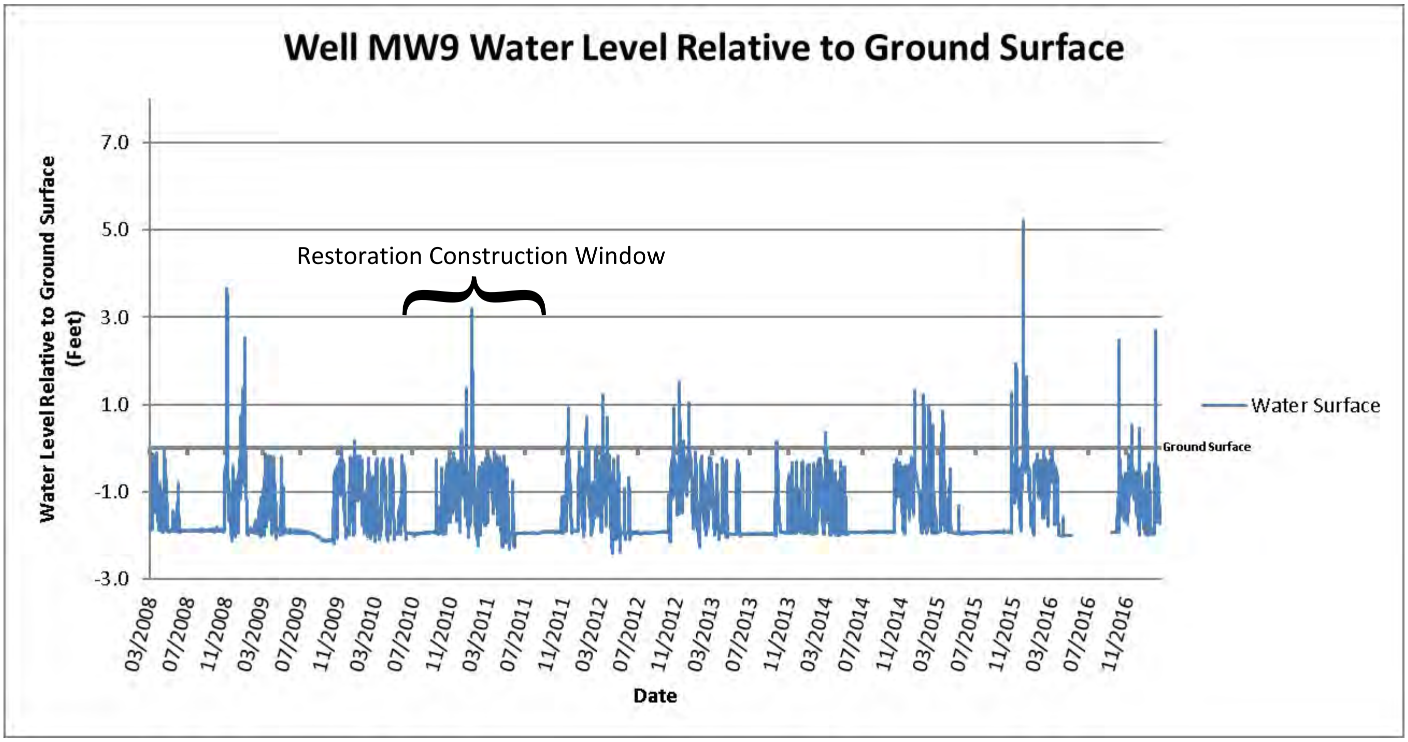


Figure A1. continued



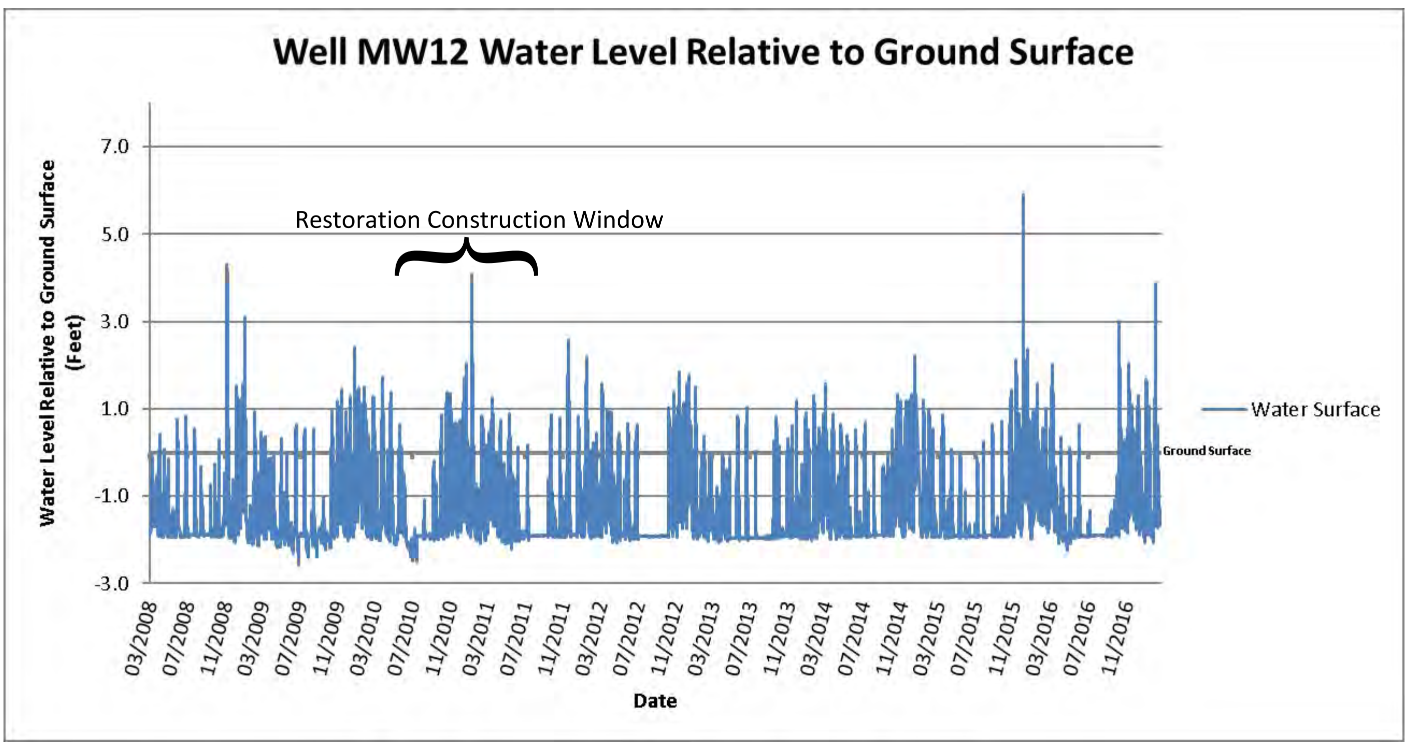
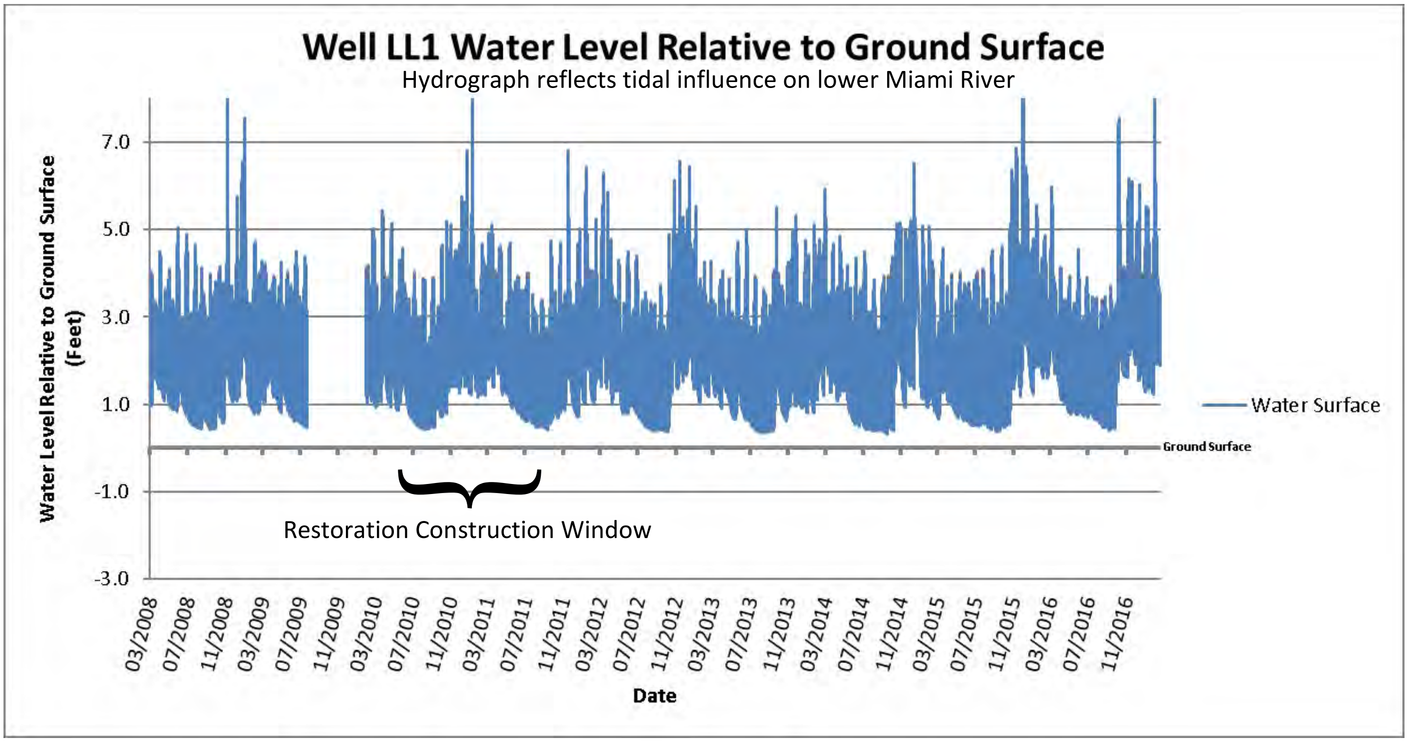


Figure A1. continued



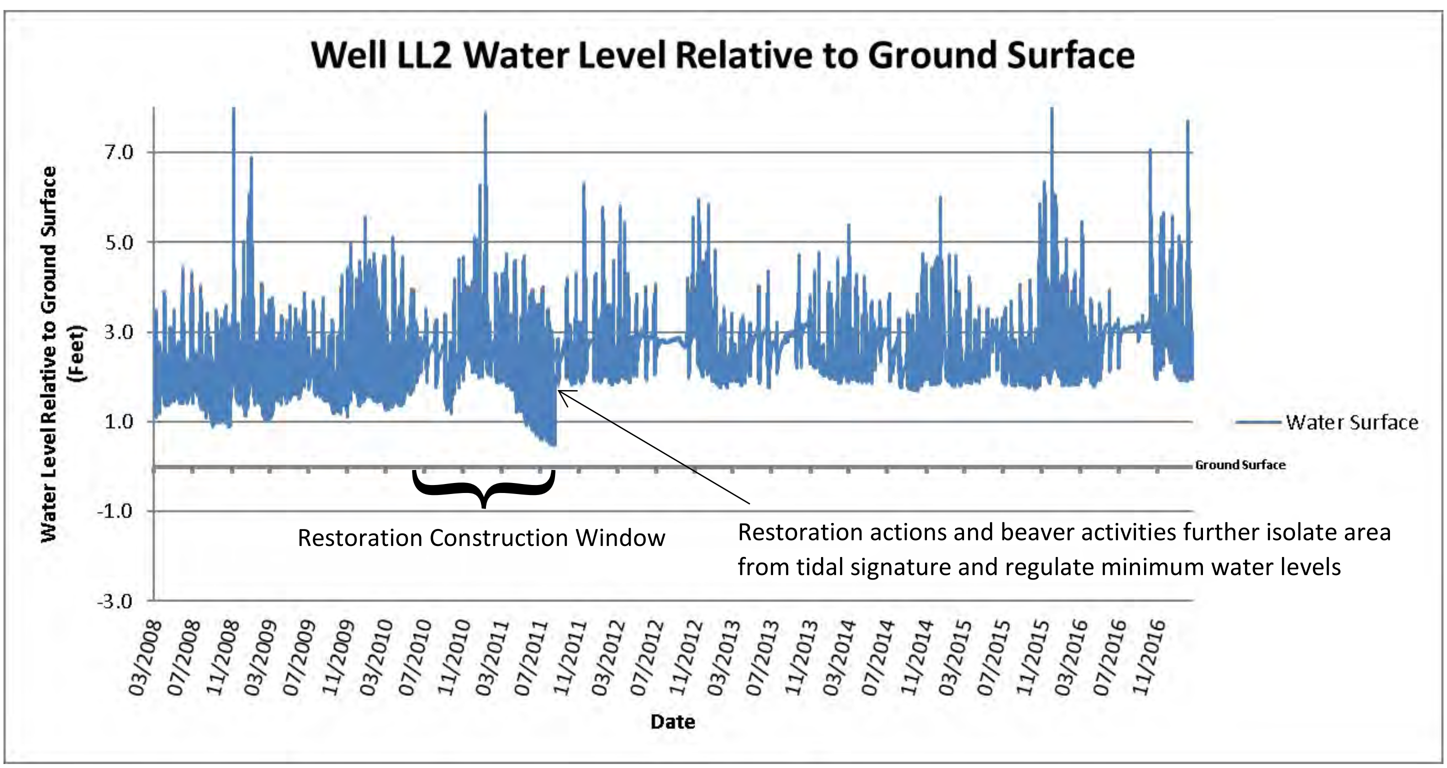
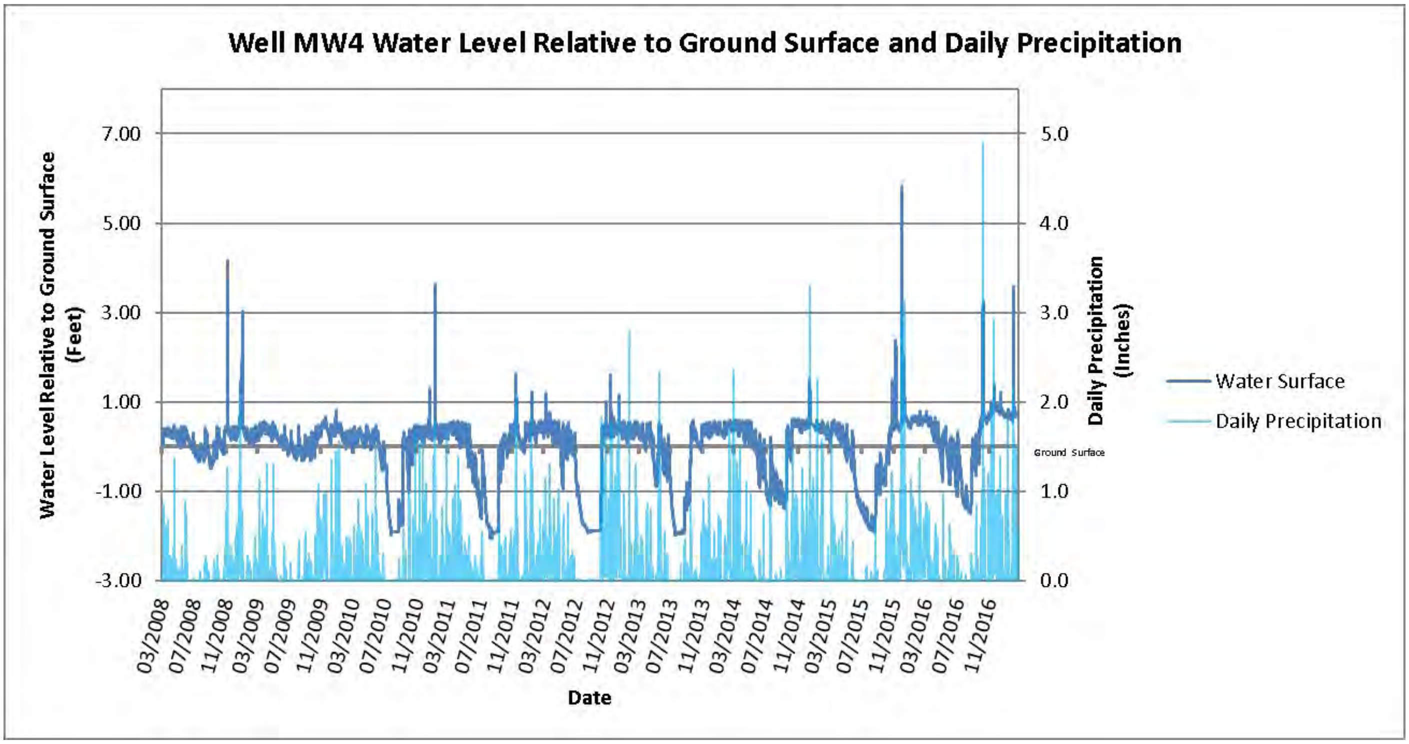


Figure A2. Water levels relative to ground surface and daily precipitation and water level relative to mean sea level and tides for six groundwater and two in-channel wells at Miami Wetlands from March 2008 through February 2017.



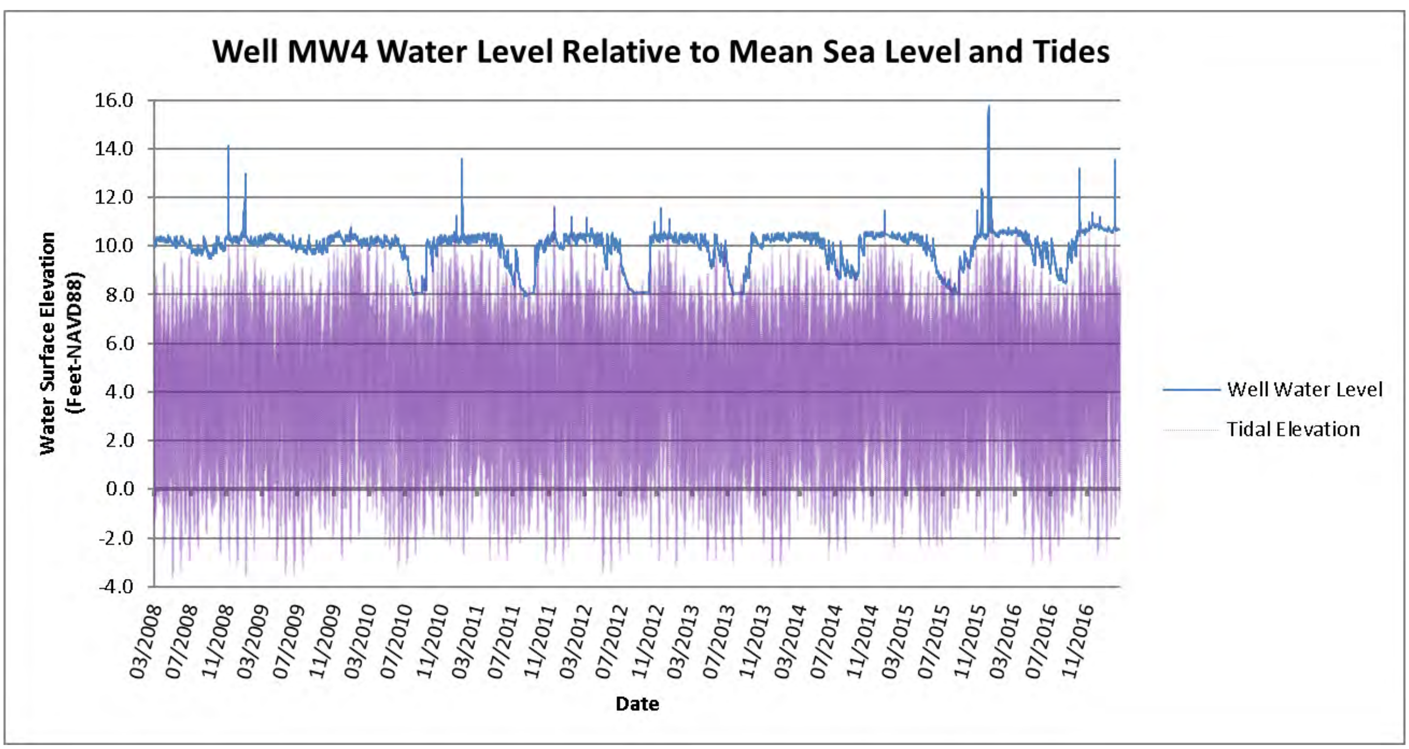
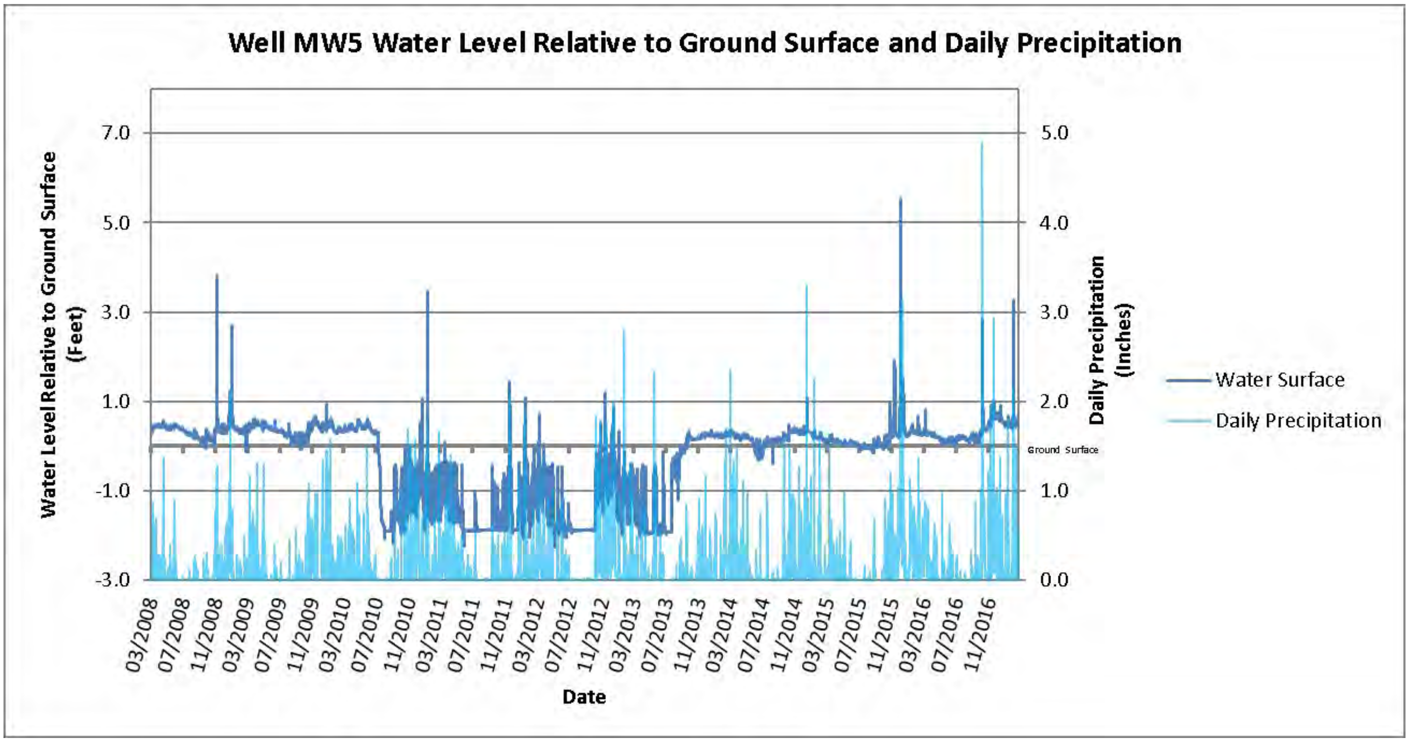


Figure A2. continued



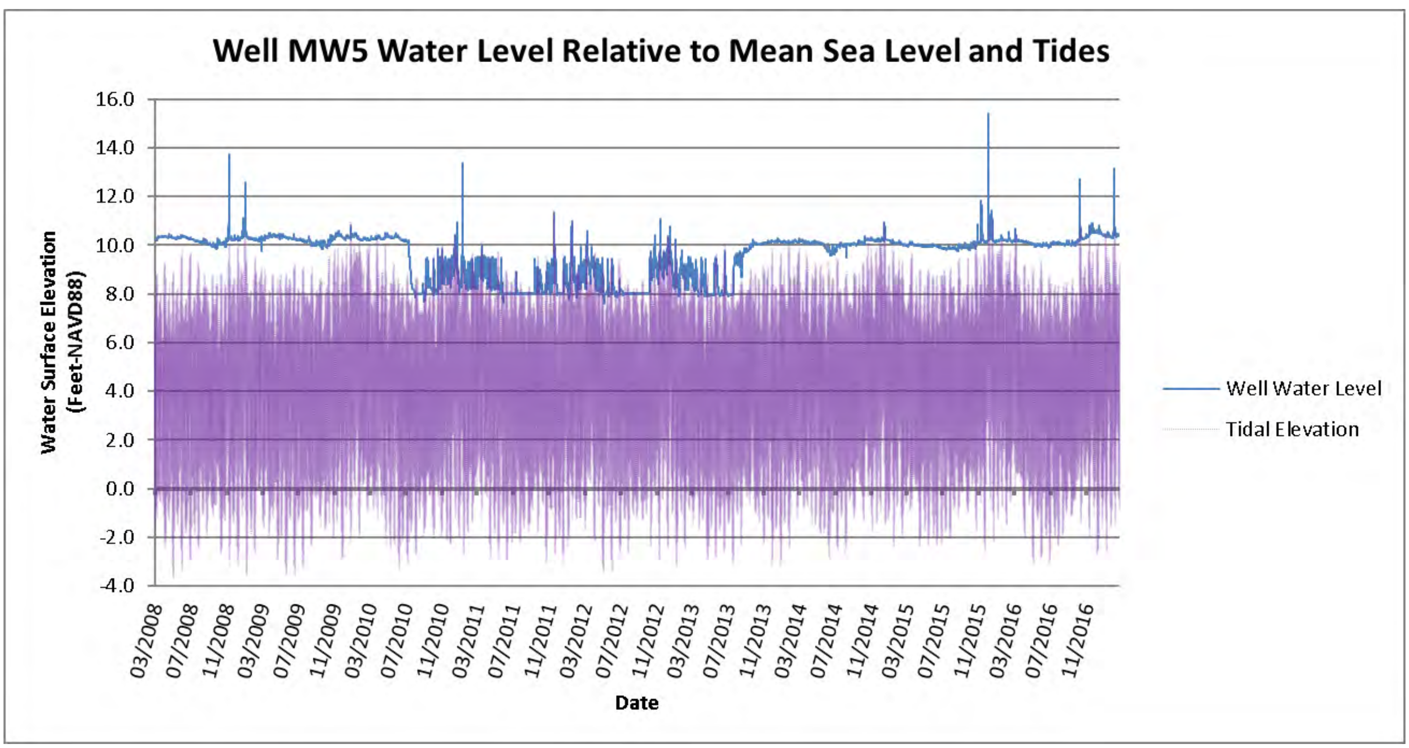
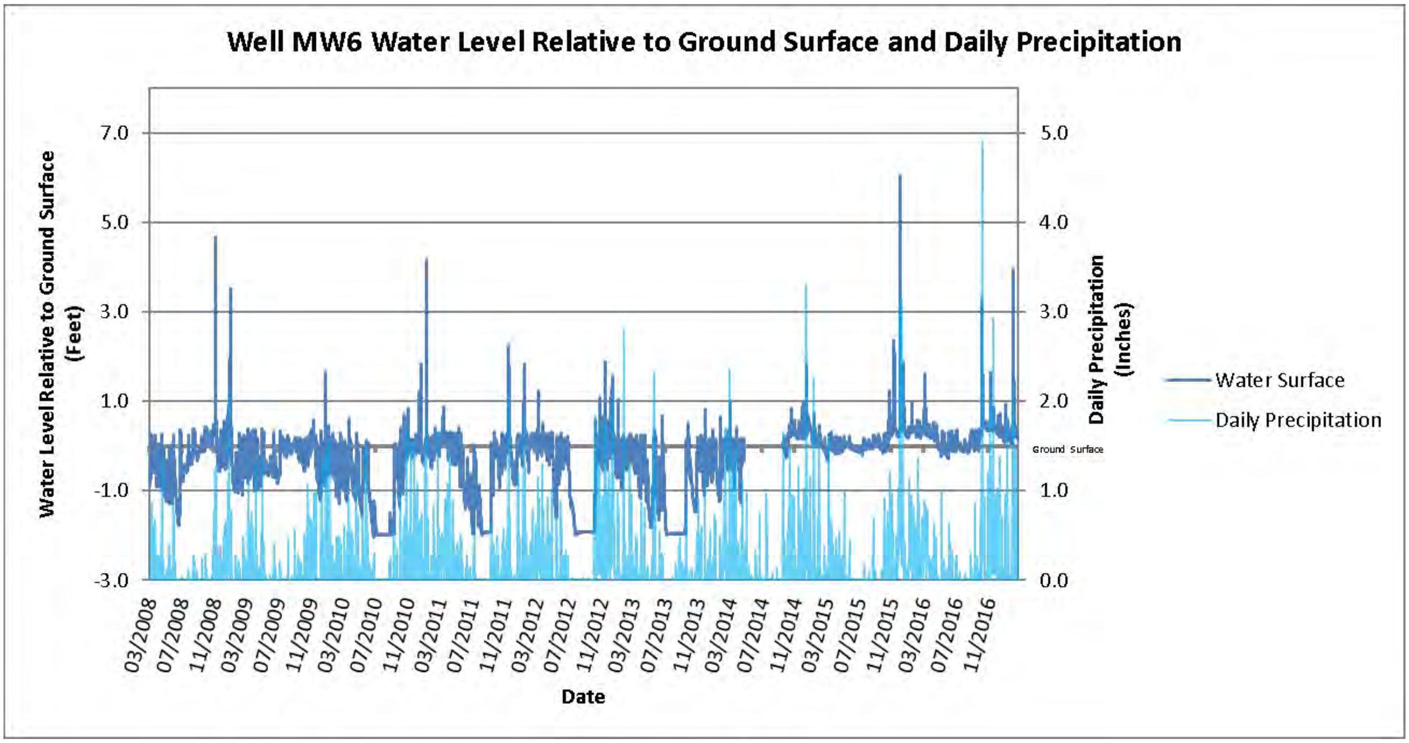


Figure A2. continued



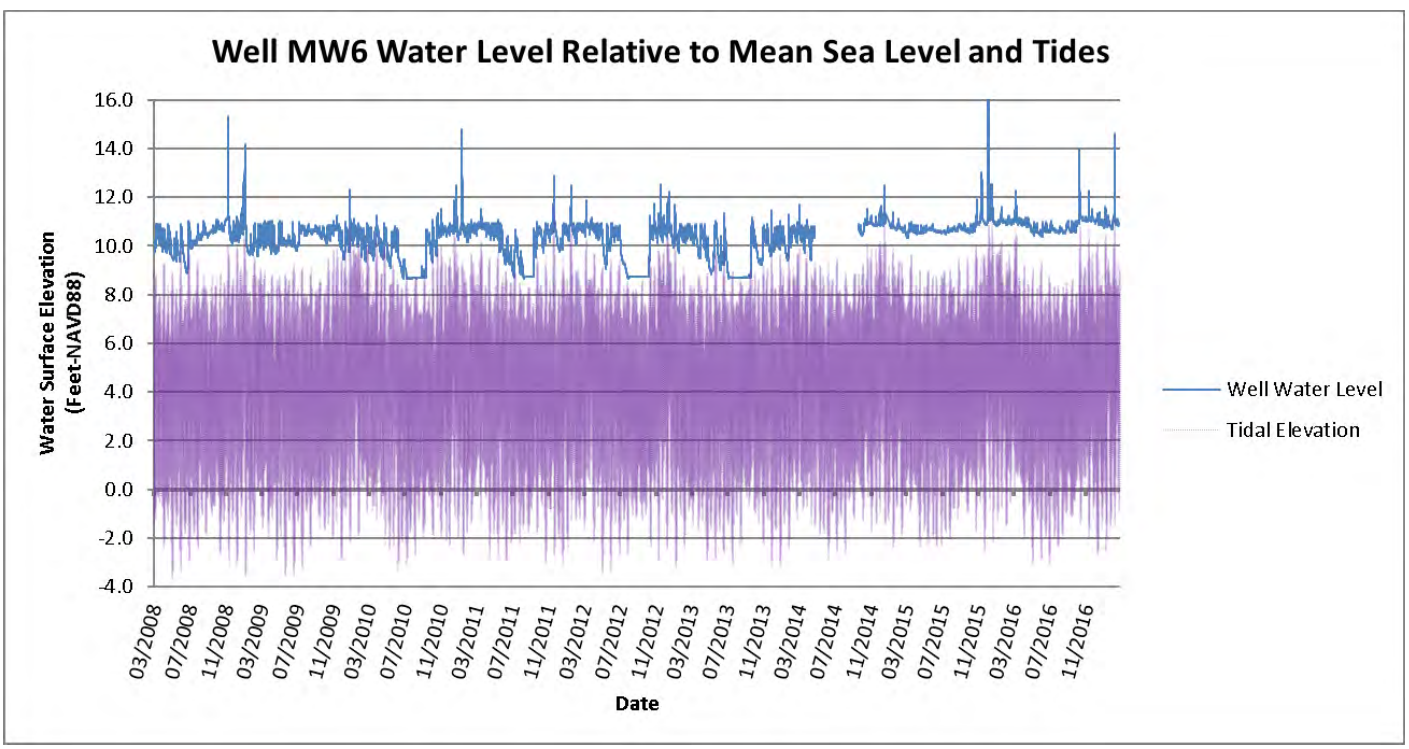
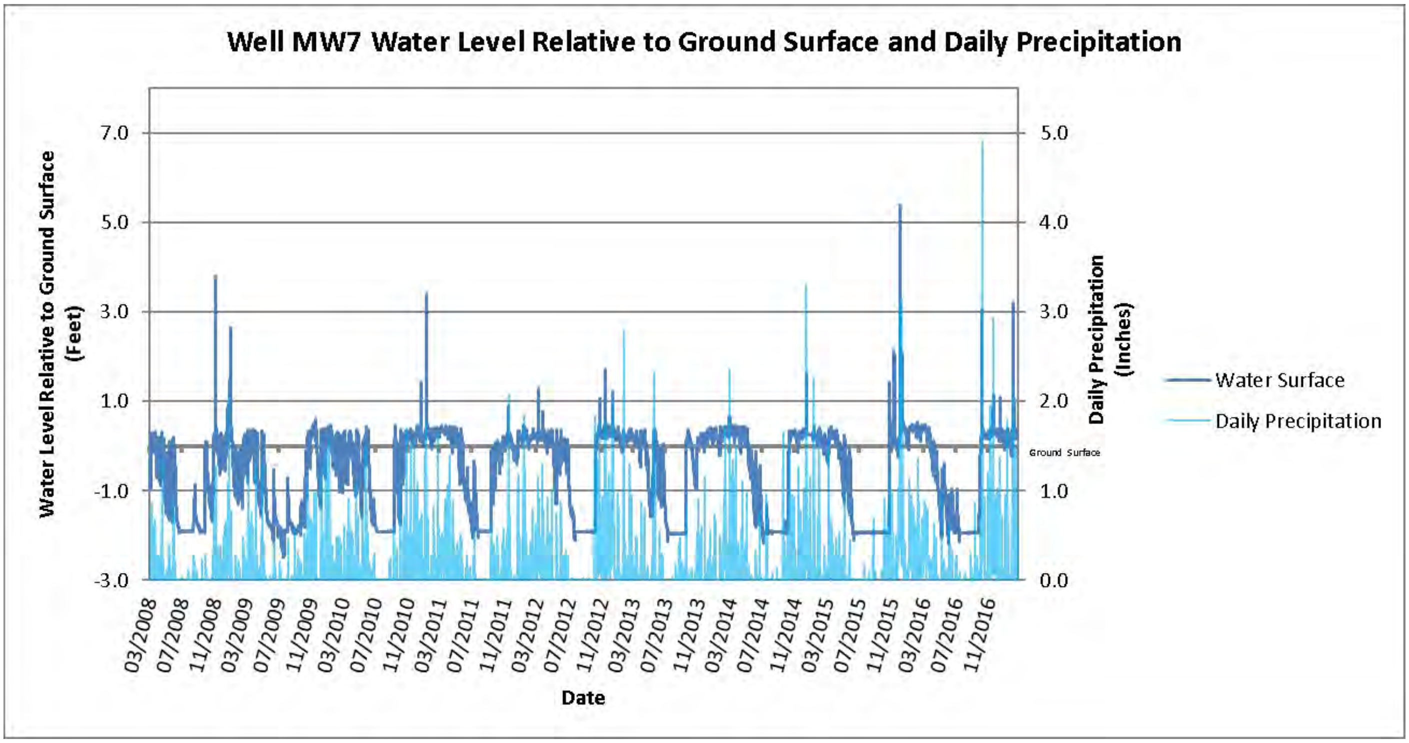


Figure A2. continued



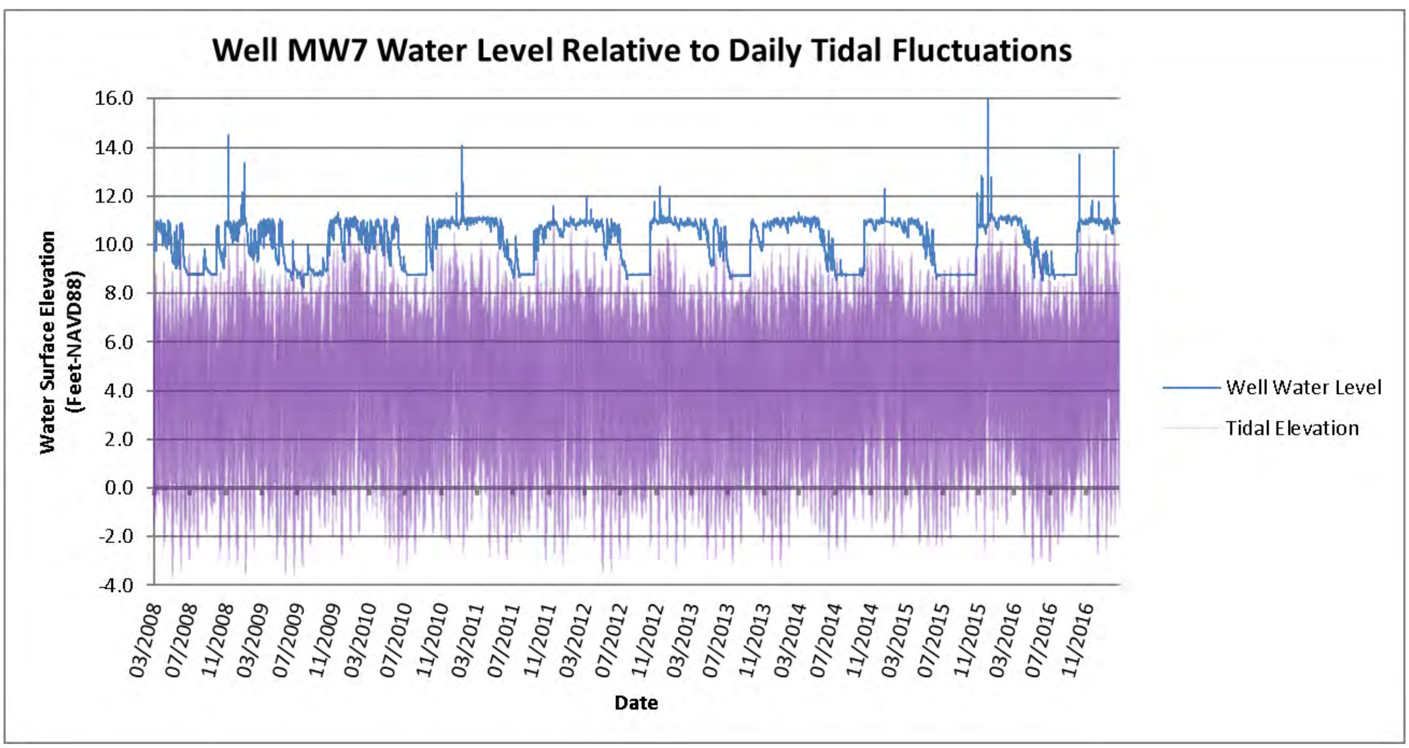
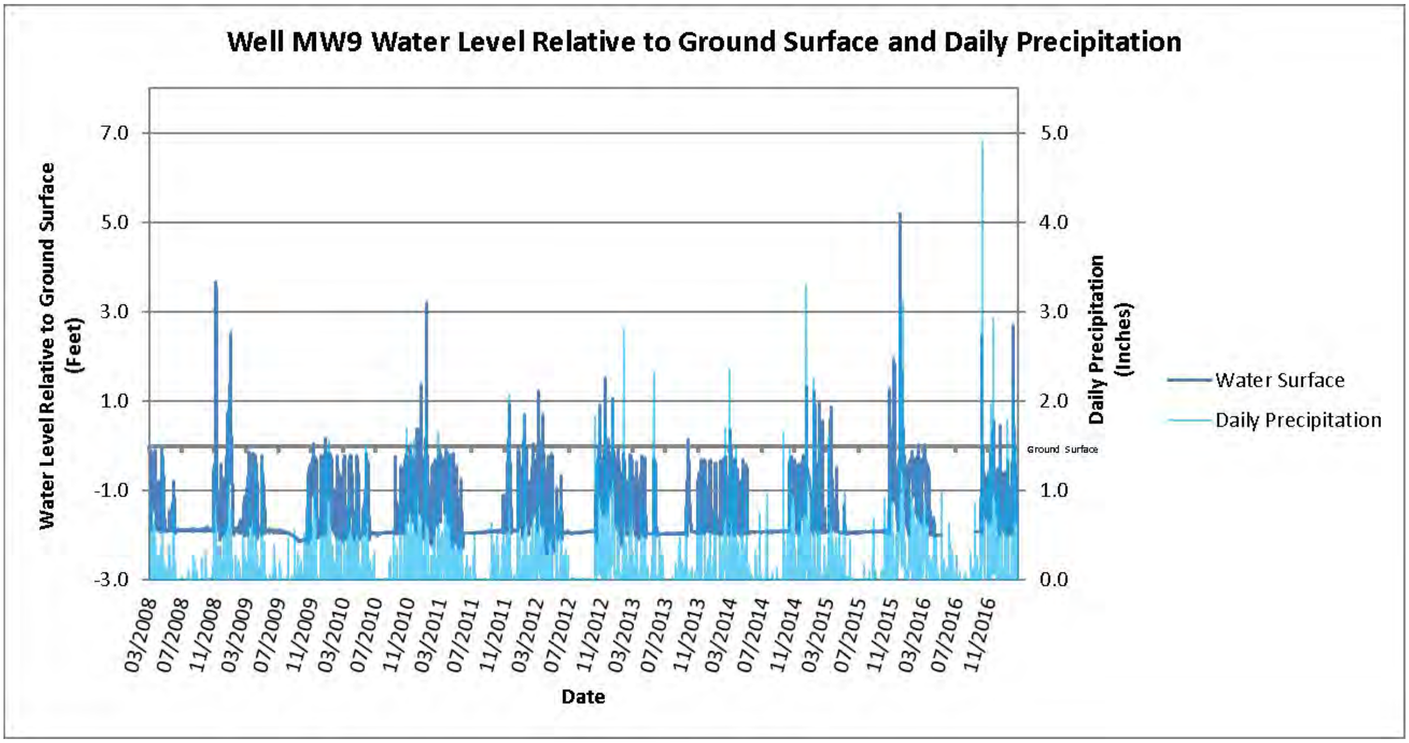


Figure A2. continued



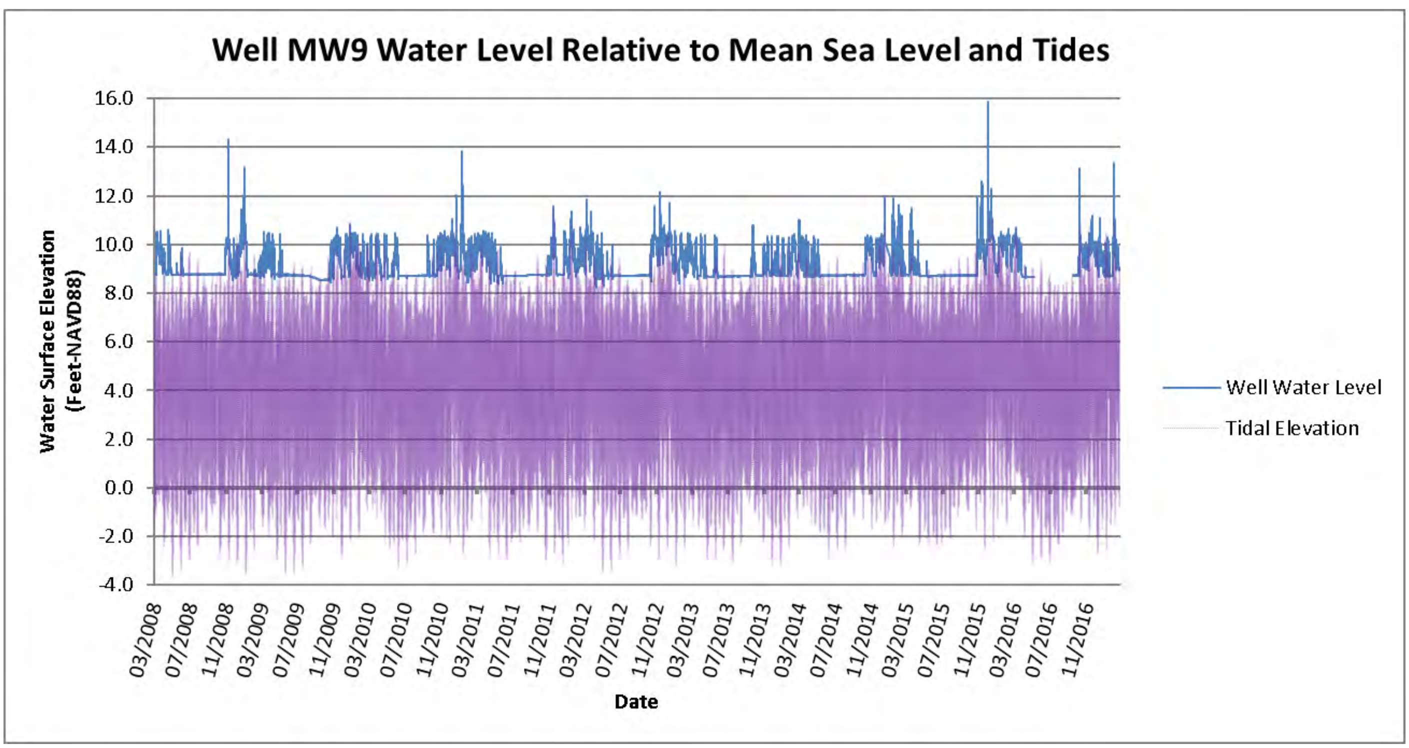
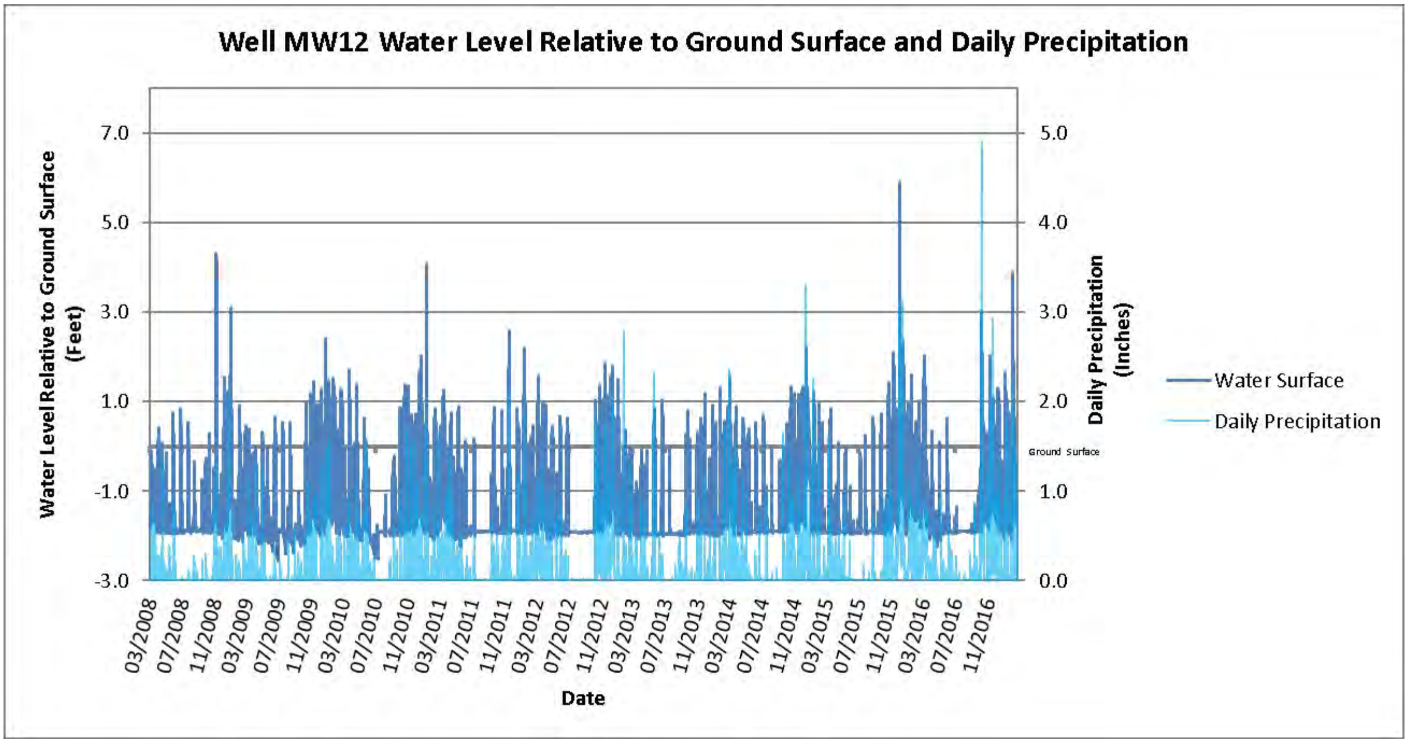


Figure A2. Continued



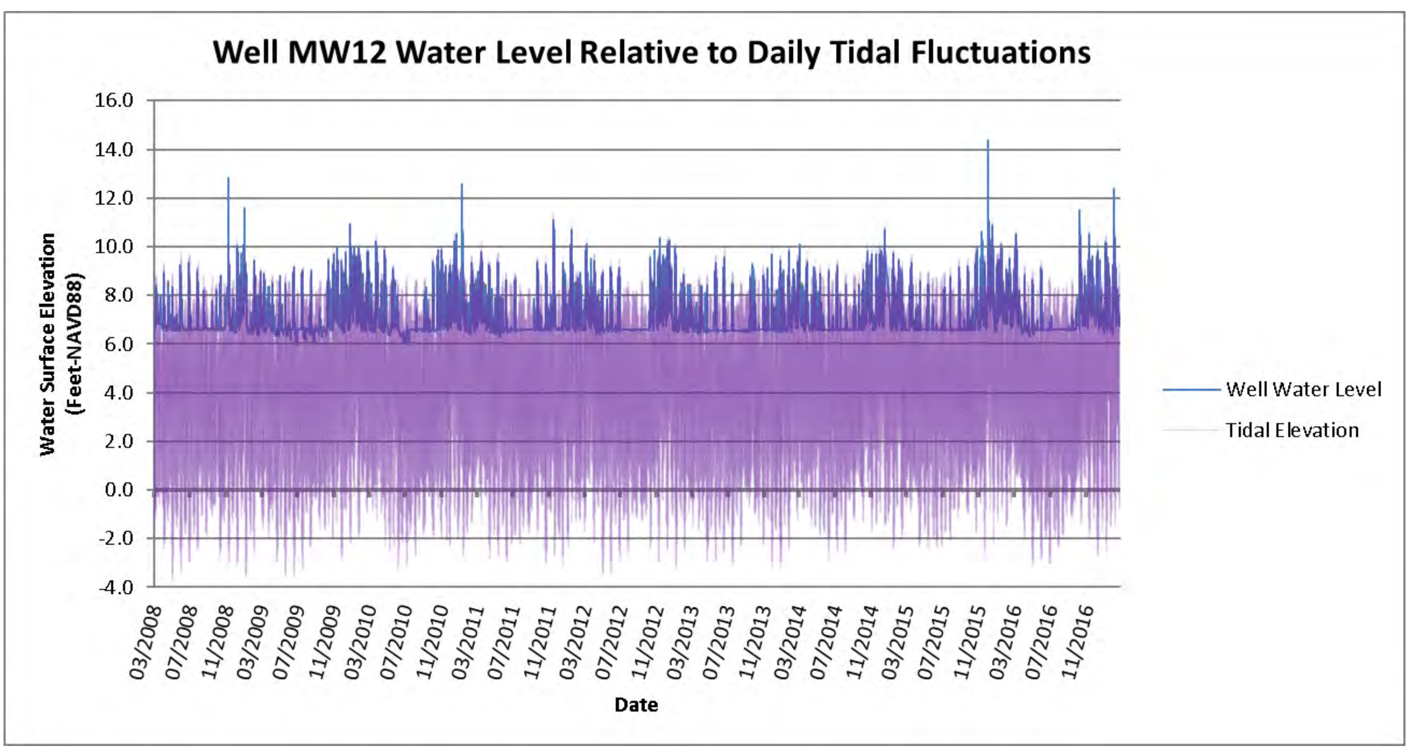
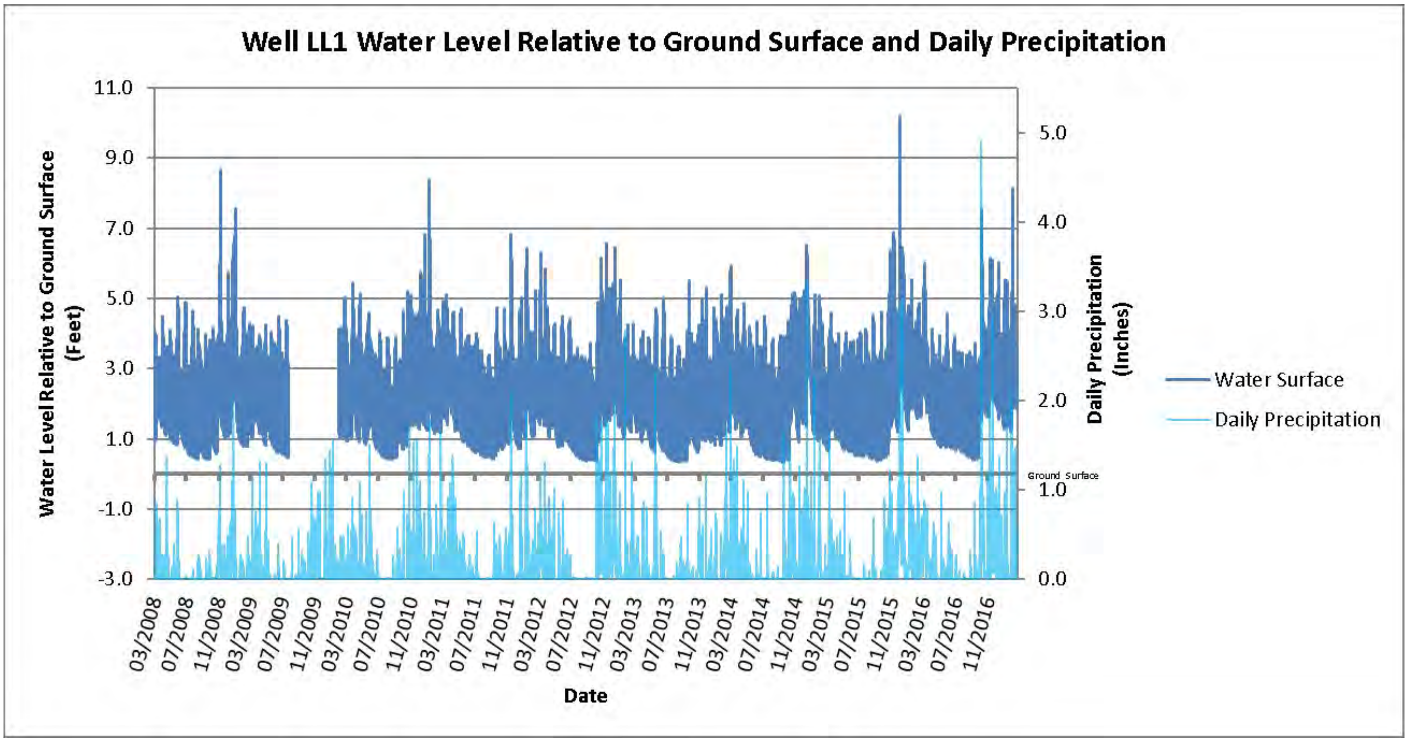


Figure A2. Continued



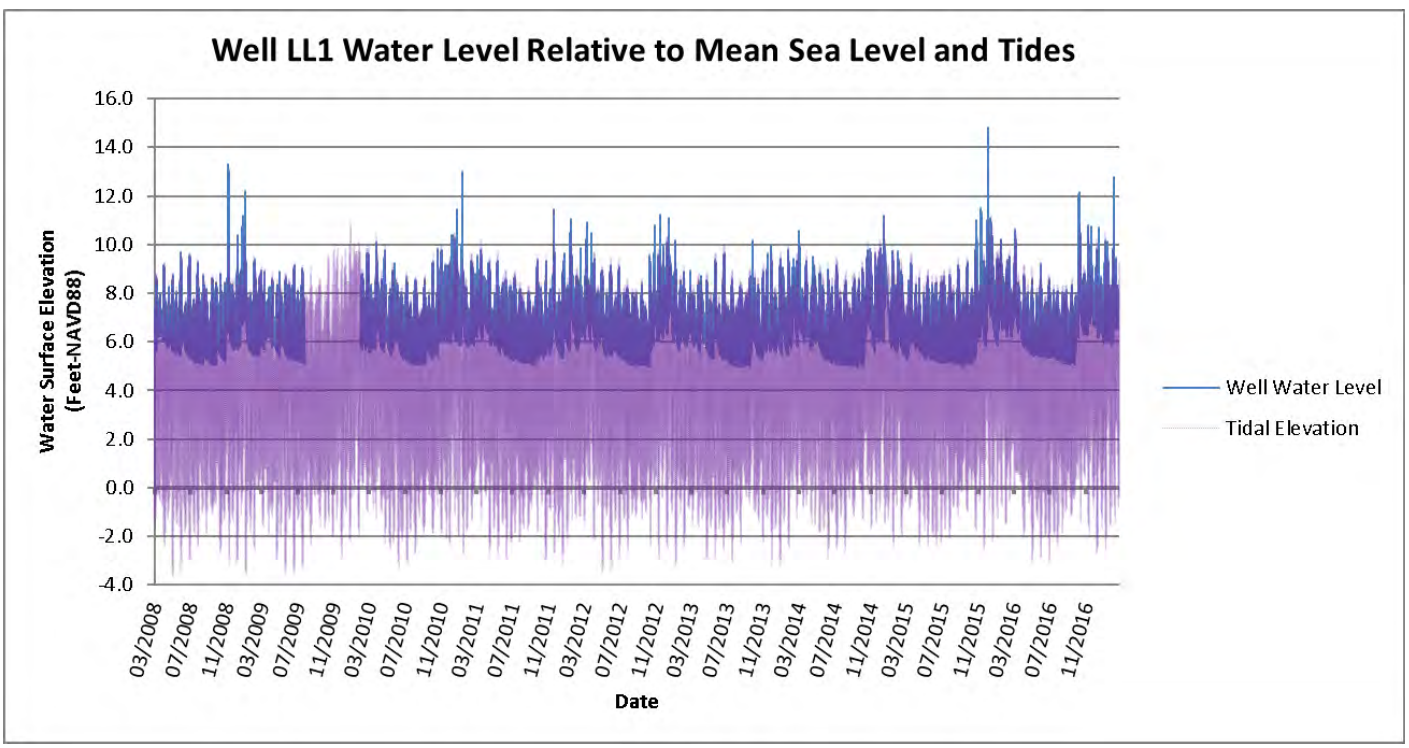
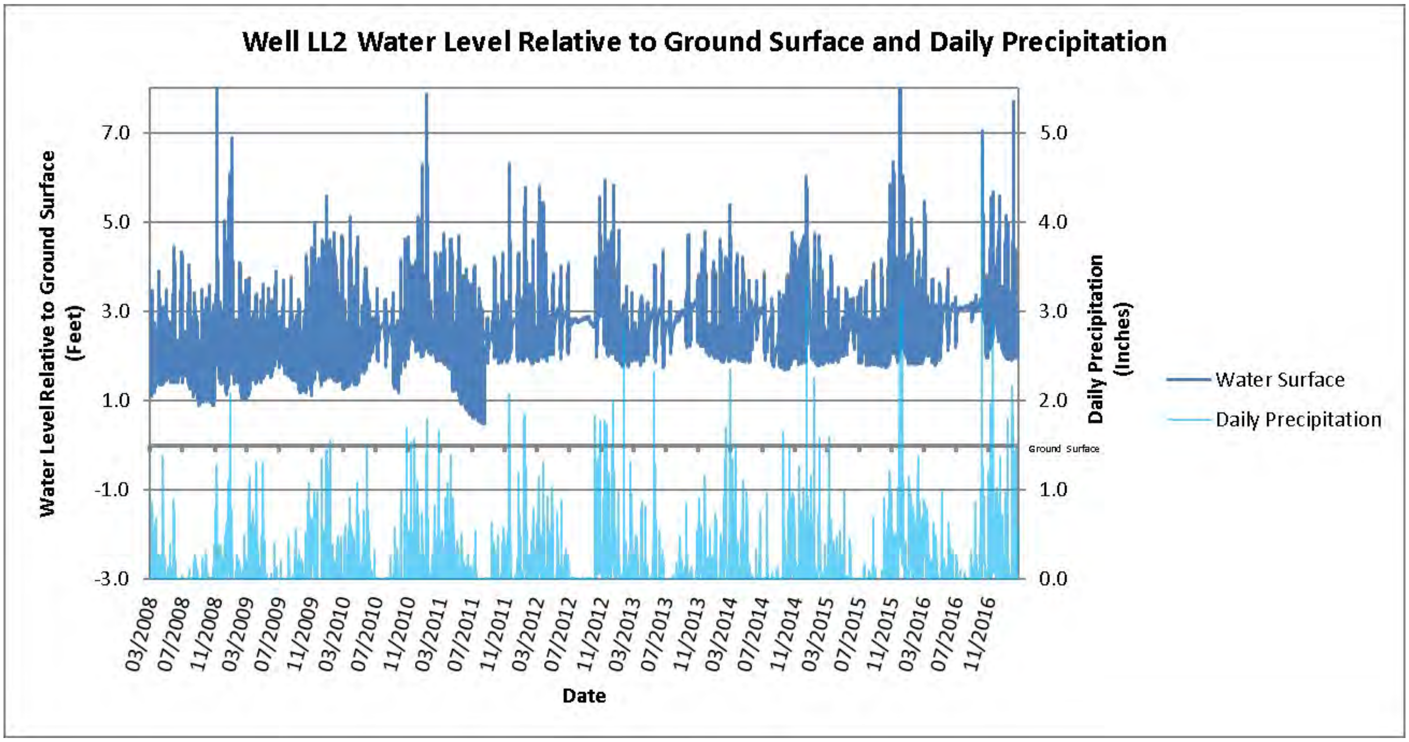
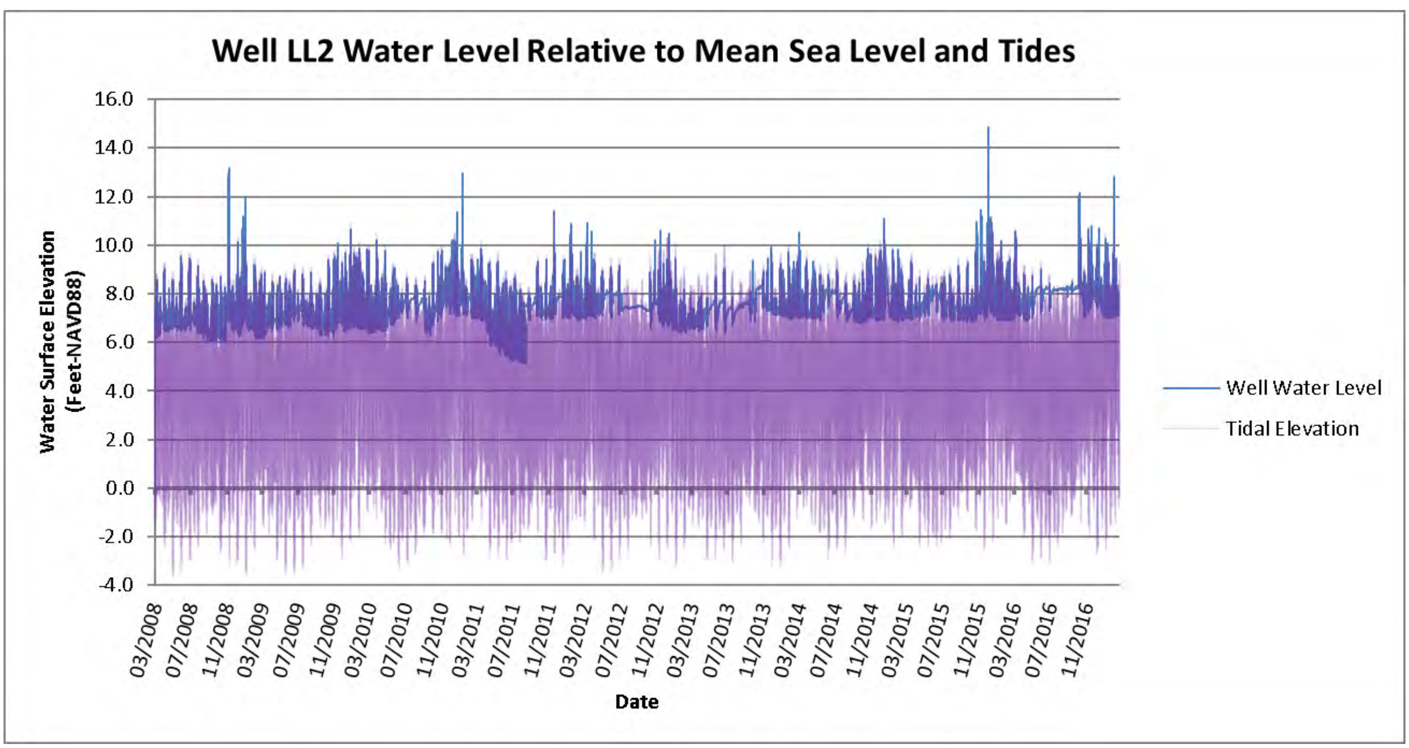


Figure A2. continued

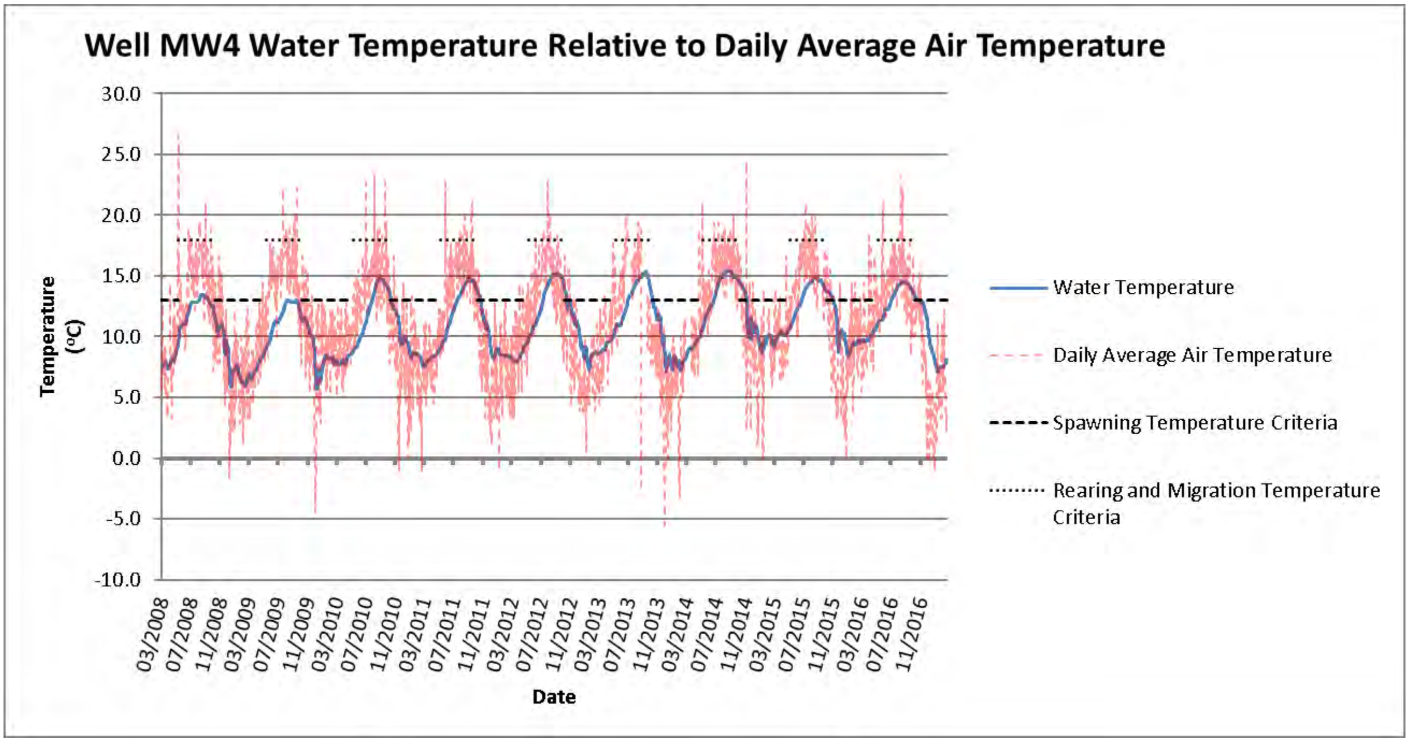


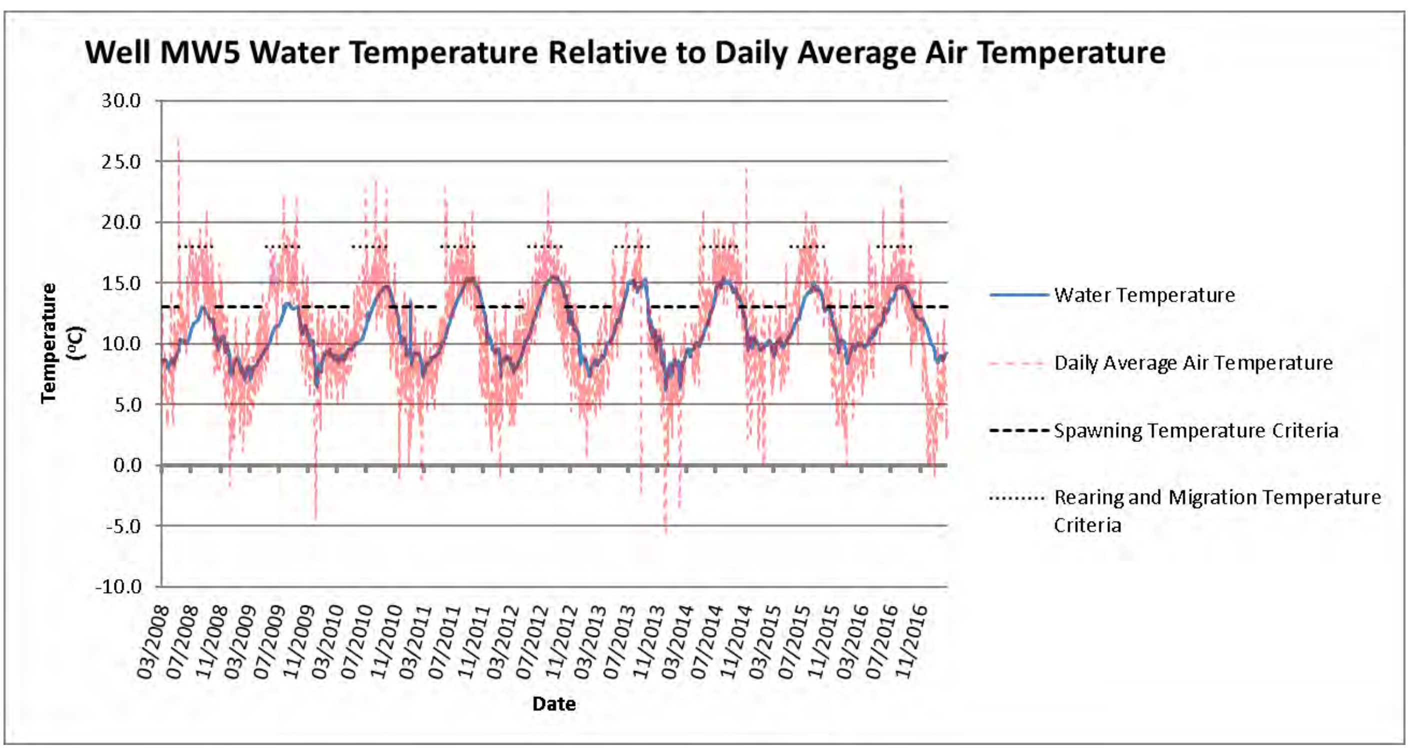


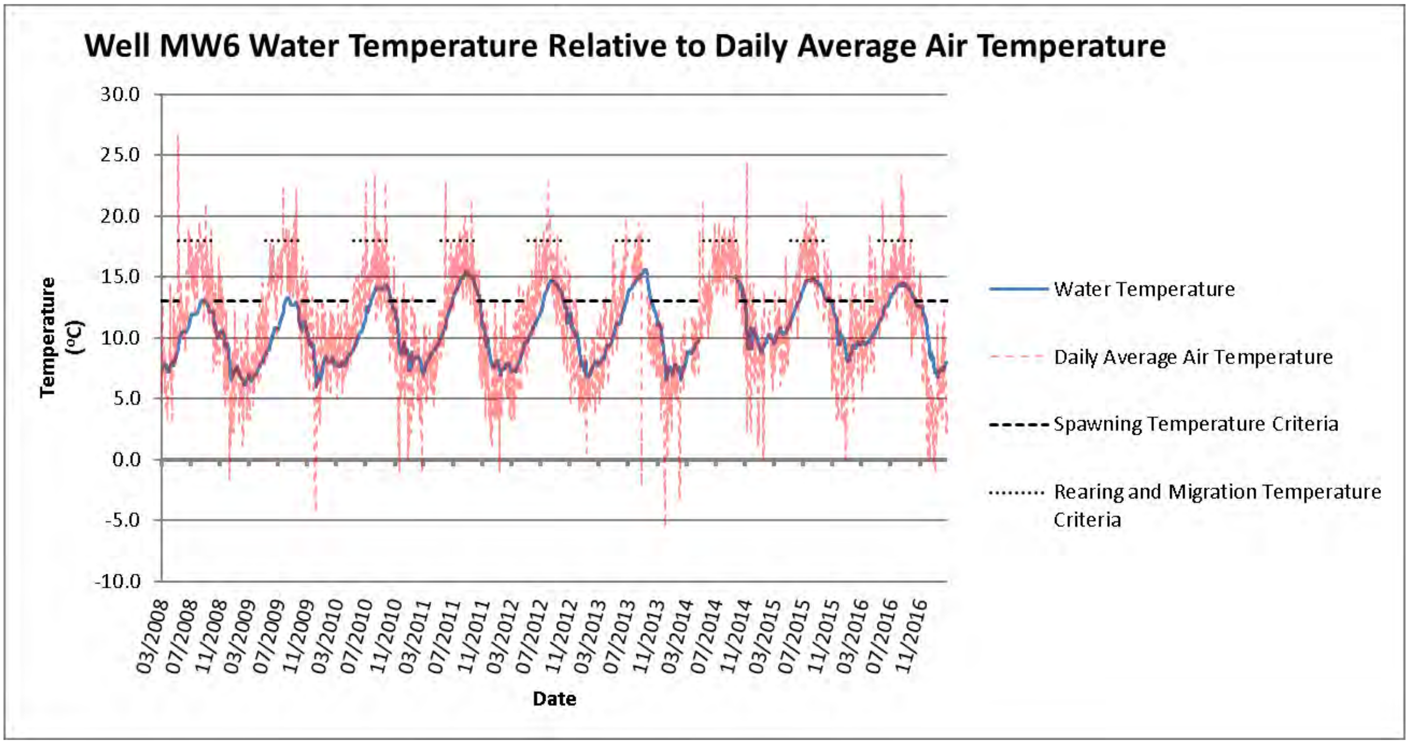
Appendix B

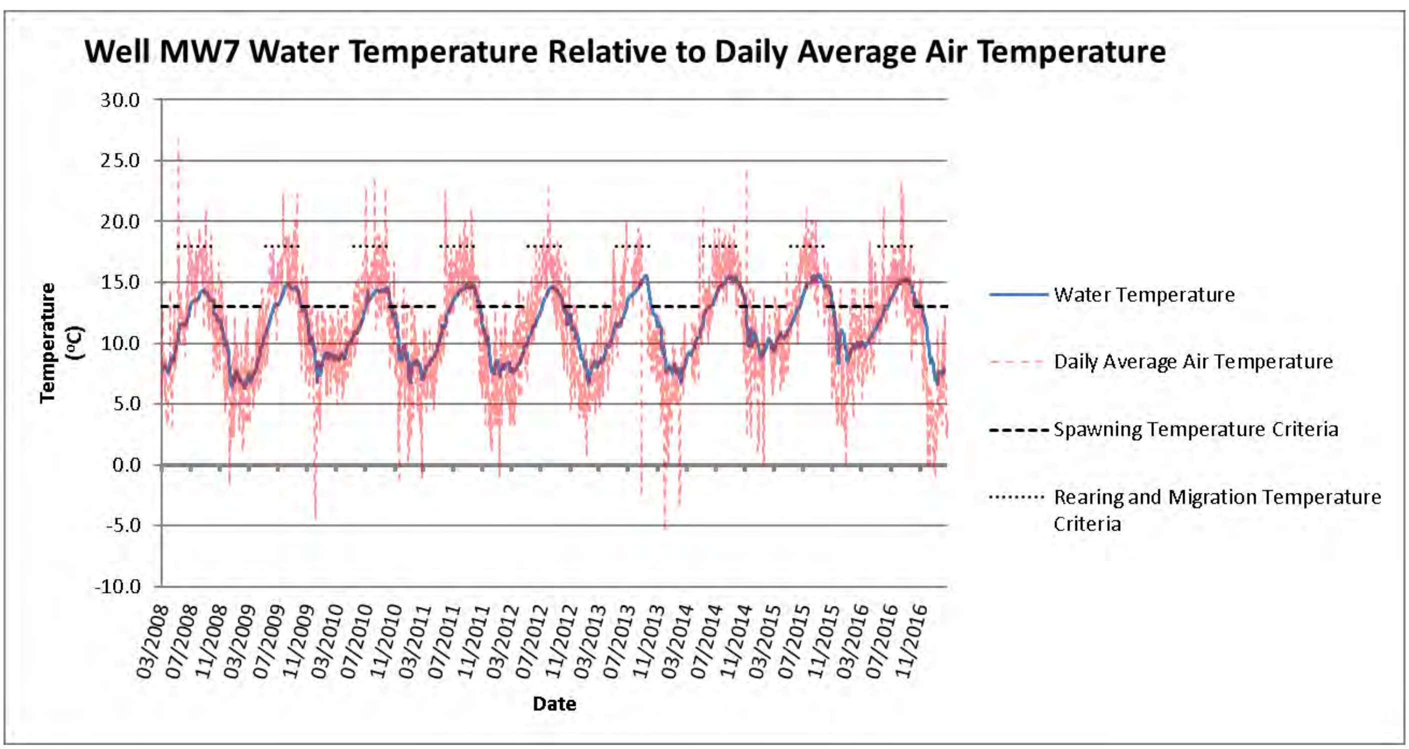
Graphs depicting water temperatures in water level monitoring wells at Miami Wetlands from March 2008 through February 2017

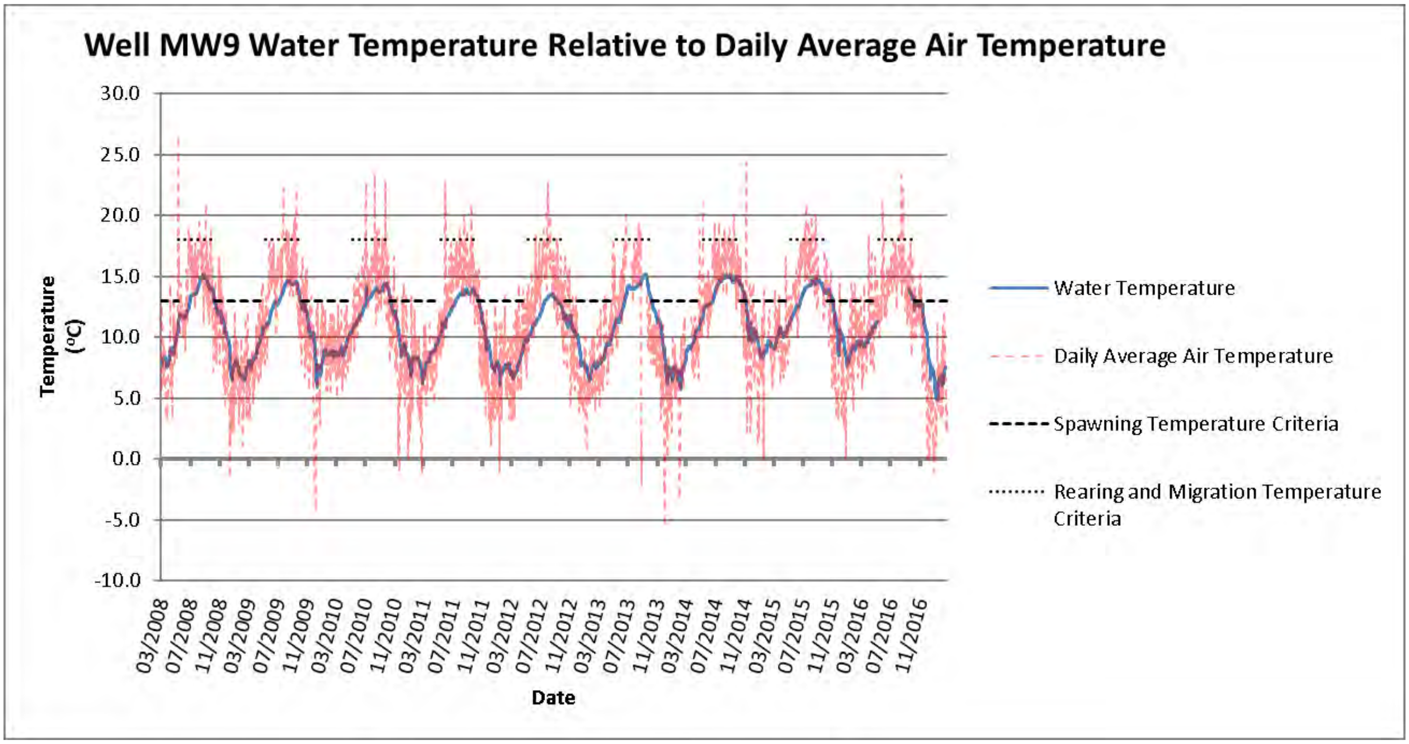
Figure B. Graphs depicting water temperatures in water level monitoring wells at Miami Wetlands from March 2008 through February 2017

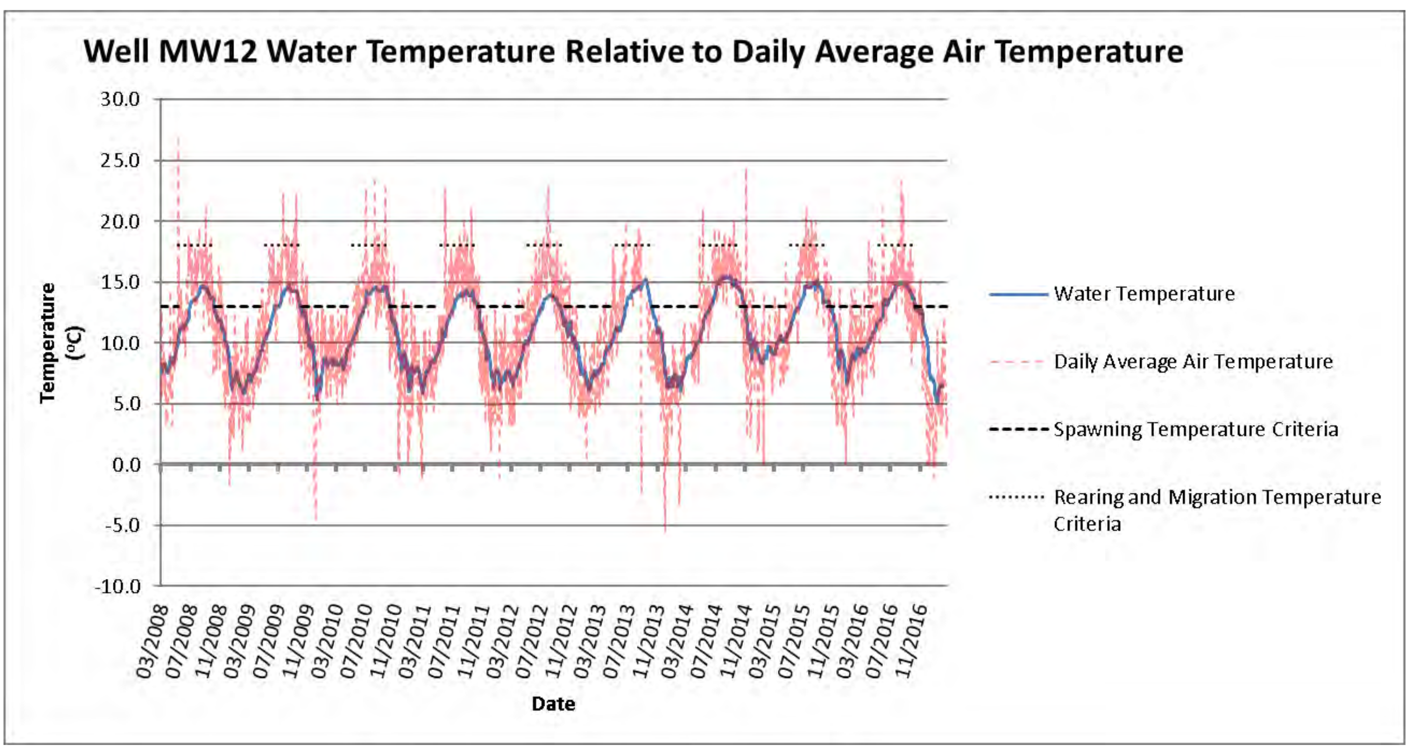


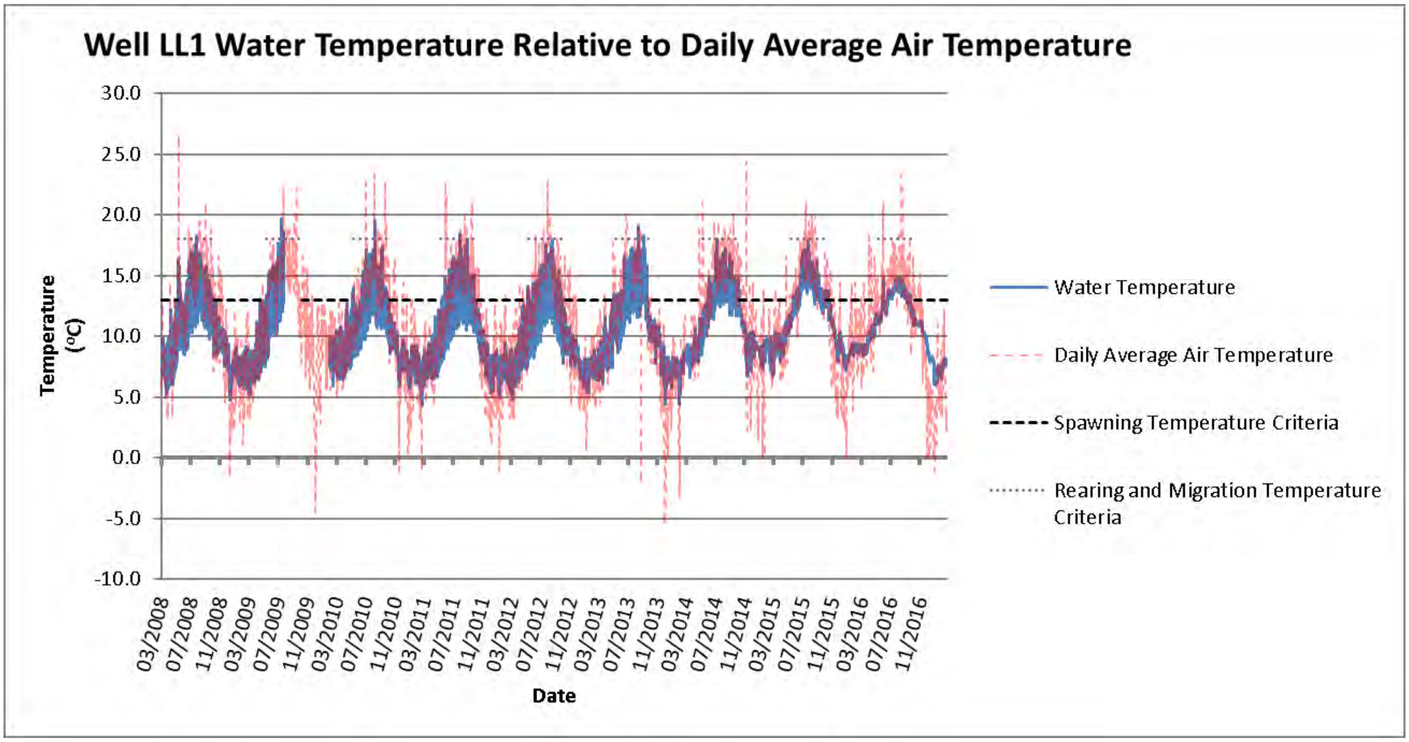



Well MW6 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria

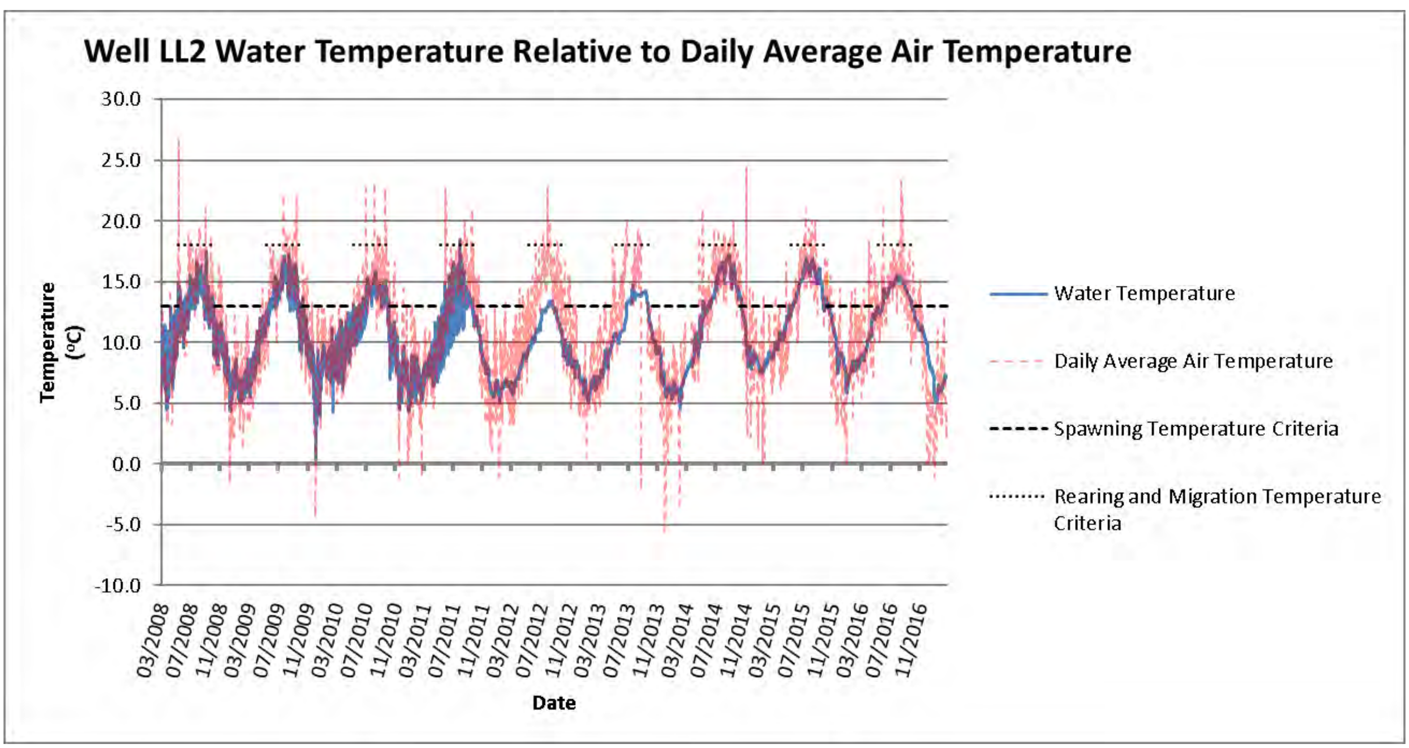

Well MW7 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria


Well MW9 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria


Well MW12 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria



Well LL1 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria

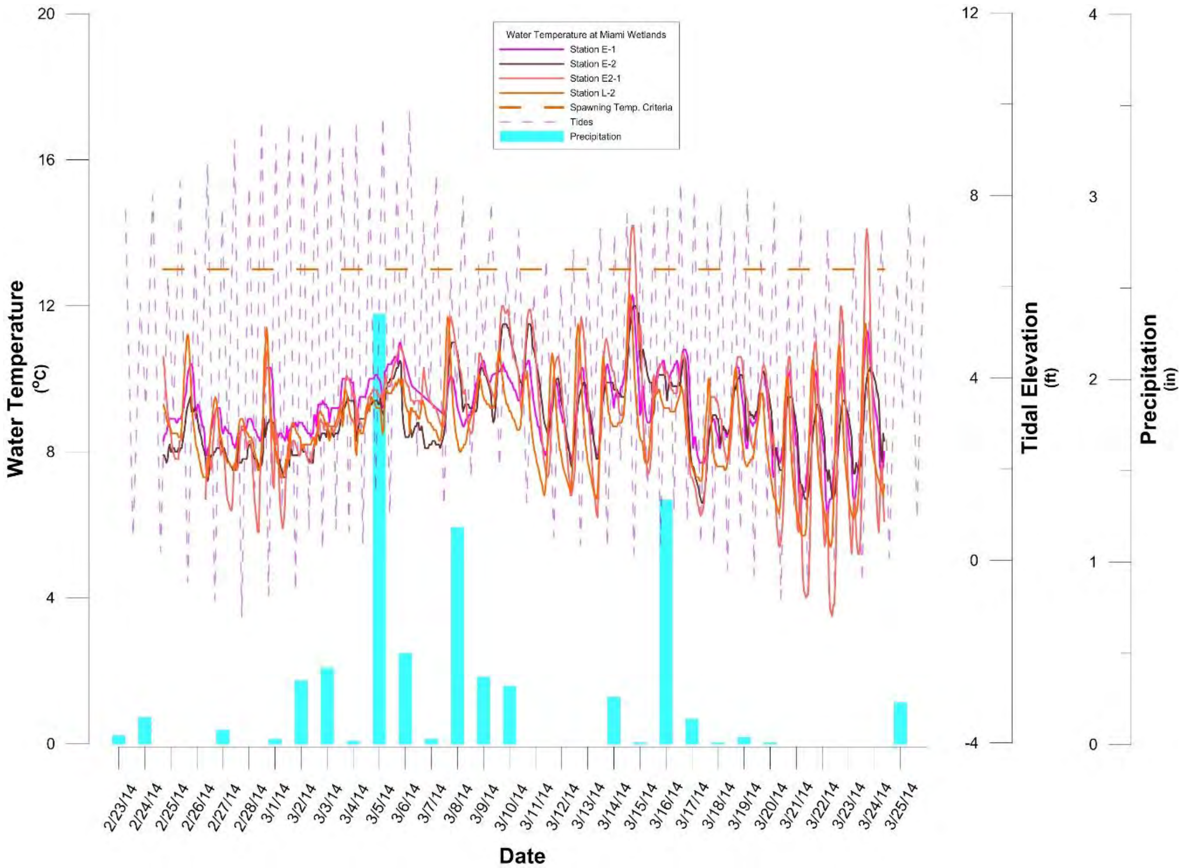


Well LL2 Water Temperature Relative to Daily Average Air Temperature
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (ºC)
03/2008
07/2008
11/2008
03/2009
07/2009
11/2009
03/2010
07/2010
11/2010
03/2011
07/2011
11/2011
03/2012
07/2012
11/2012
03/2013
07/2013
11/2013
03/2014
07/2014
11/2014
03/2015
07/2015
11/2015
03/2016
07/2016
11/2016
Date
Water Temperature
Daily Average Air Temperature
Spawning Temperature Criteria
Rearing and Migration Temperature Criteria

Appendix C

Graphs depicting post-restoration water temperatures in constructed channels at the Miami Wetlands

Figure C1. Graphs depicting post-restoration water temperatures in constructed channels at the Miami Wetlands during spring 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



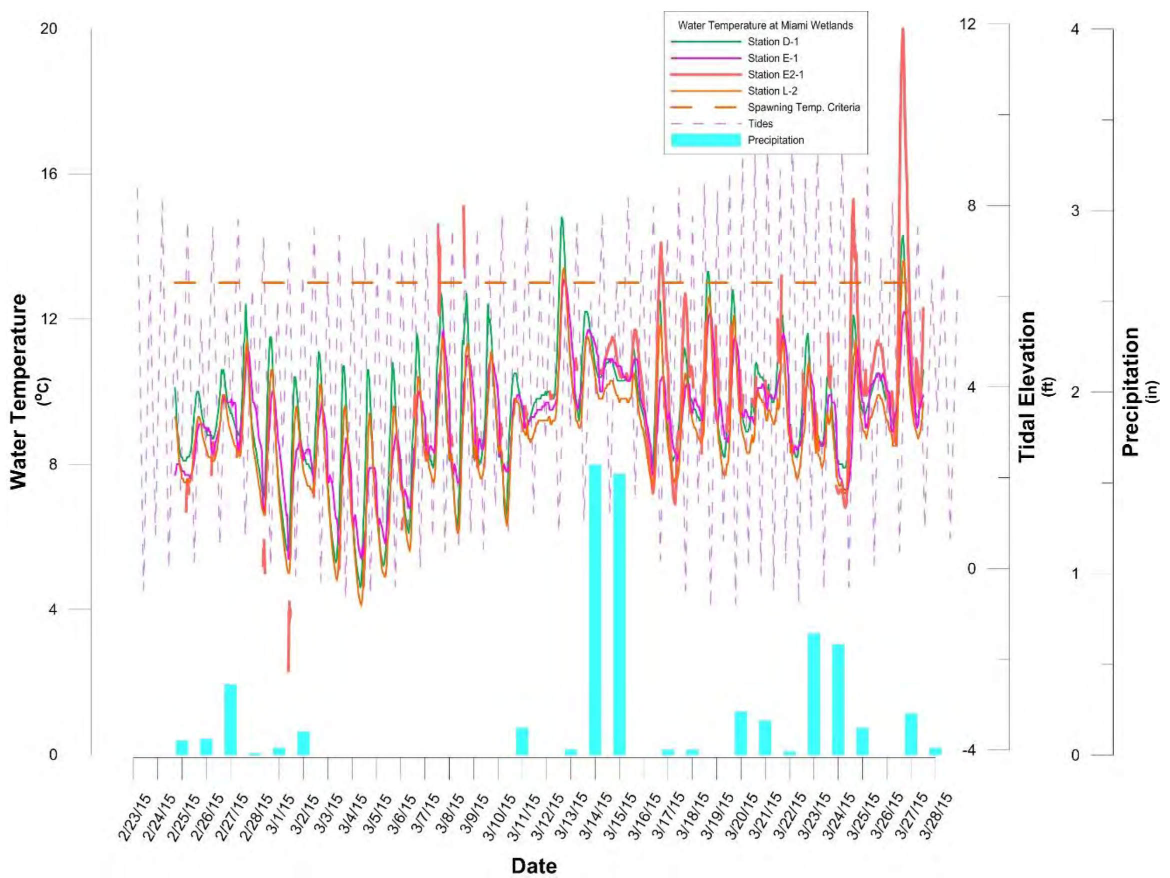


Figure C1. continued

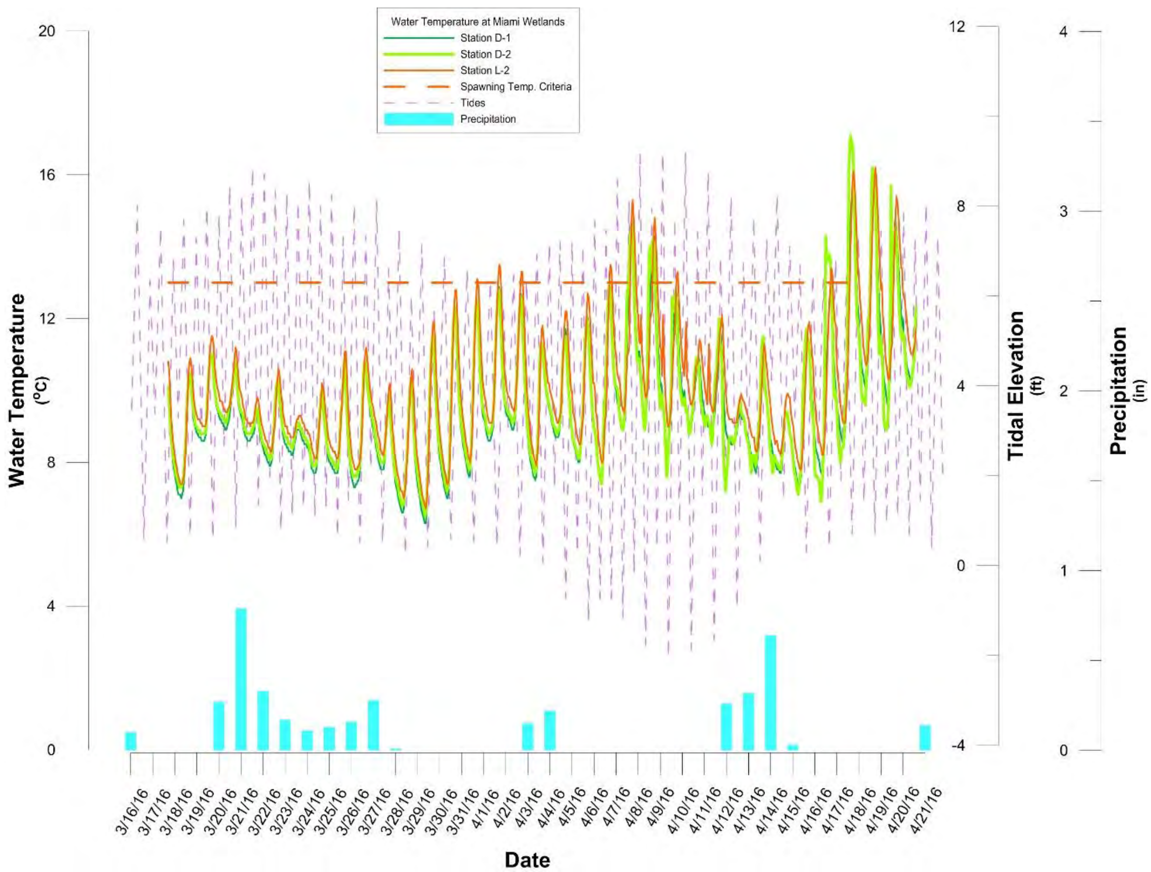
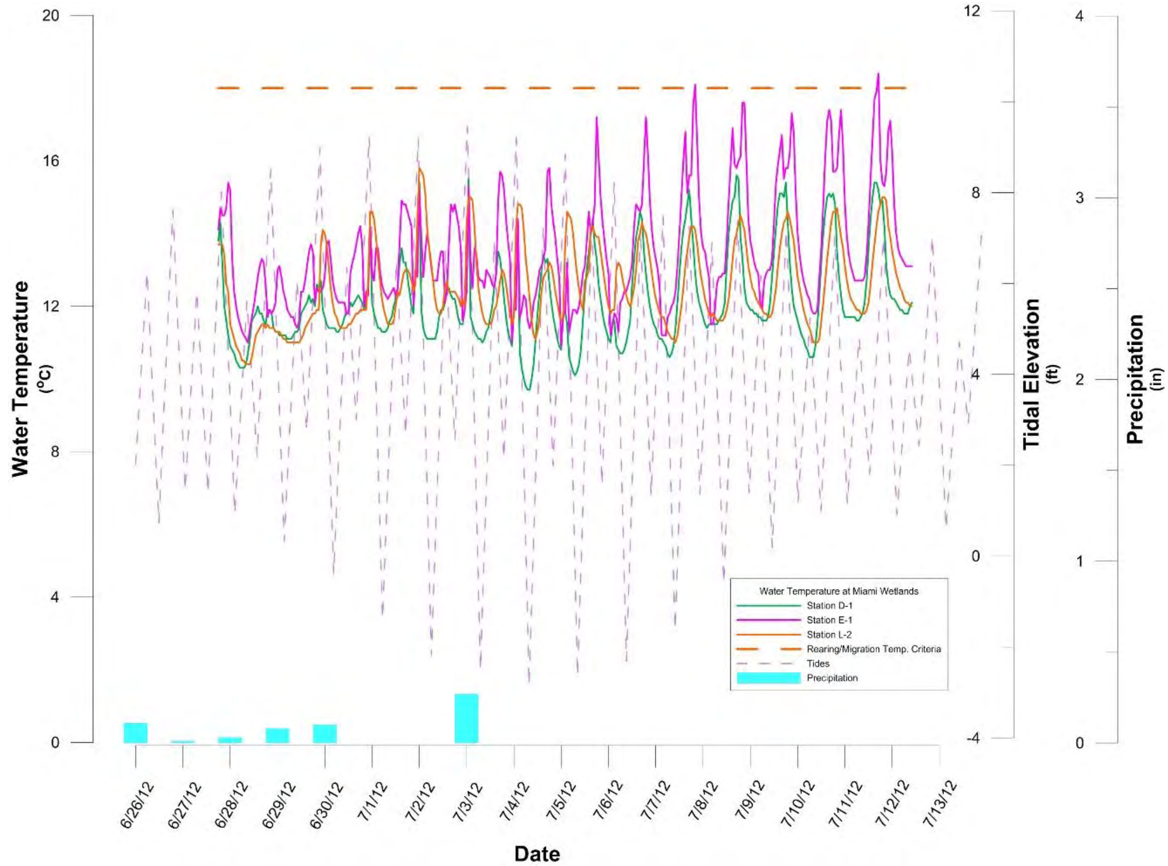


Figure C2. Graphs depicting post-restoration water temperatures in constructed channels at the Miami Wetlands during summer 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



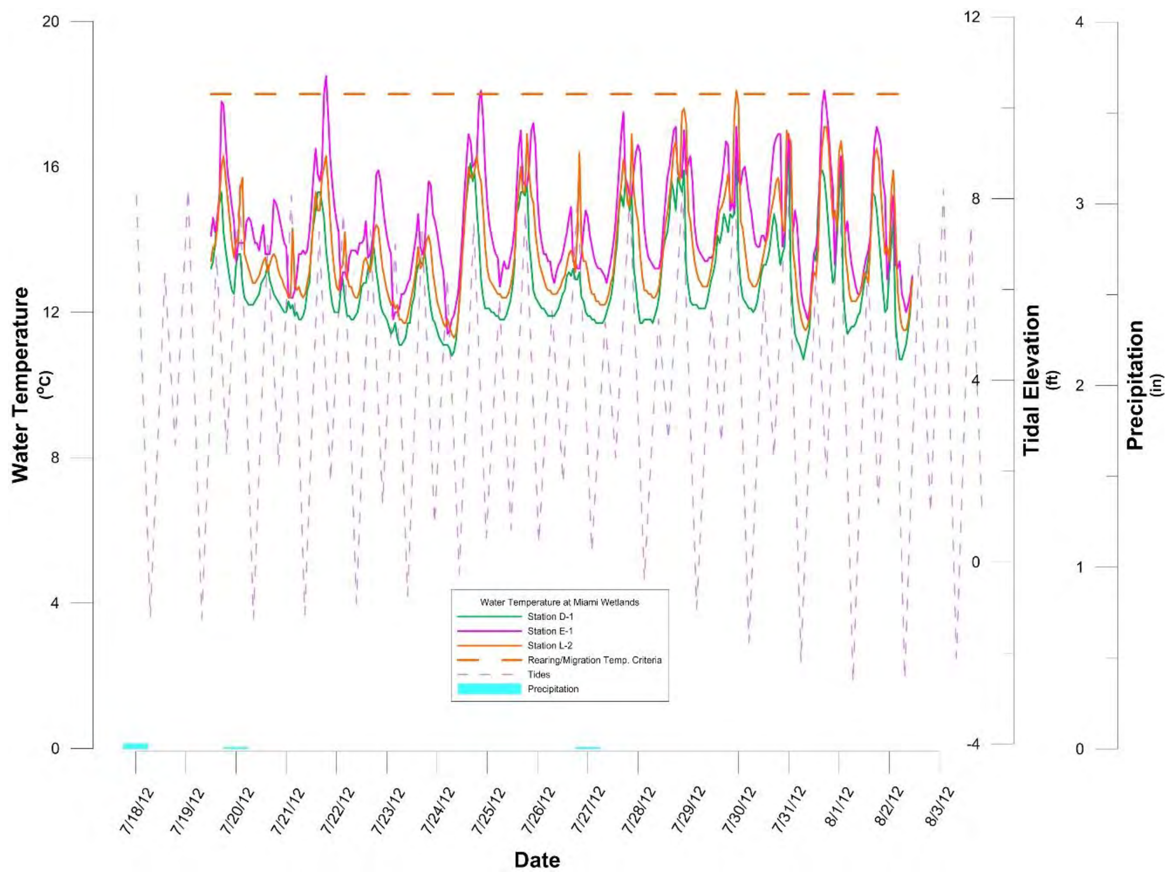
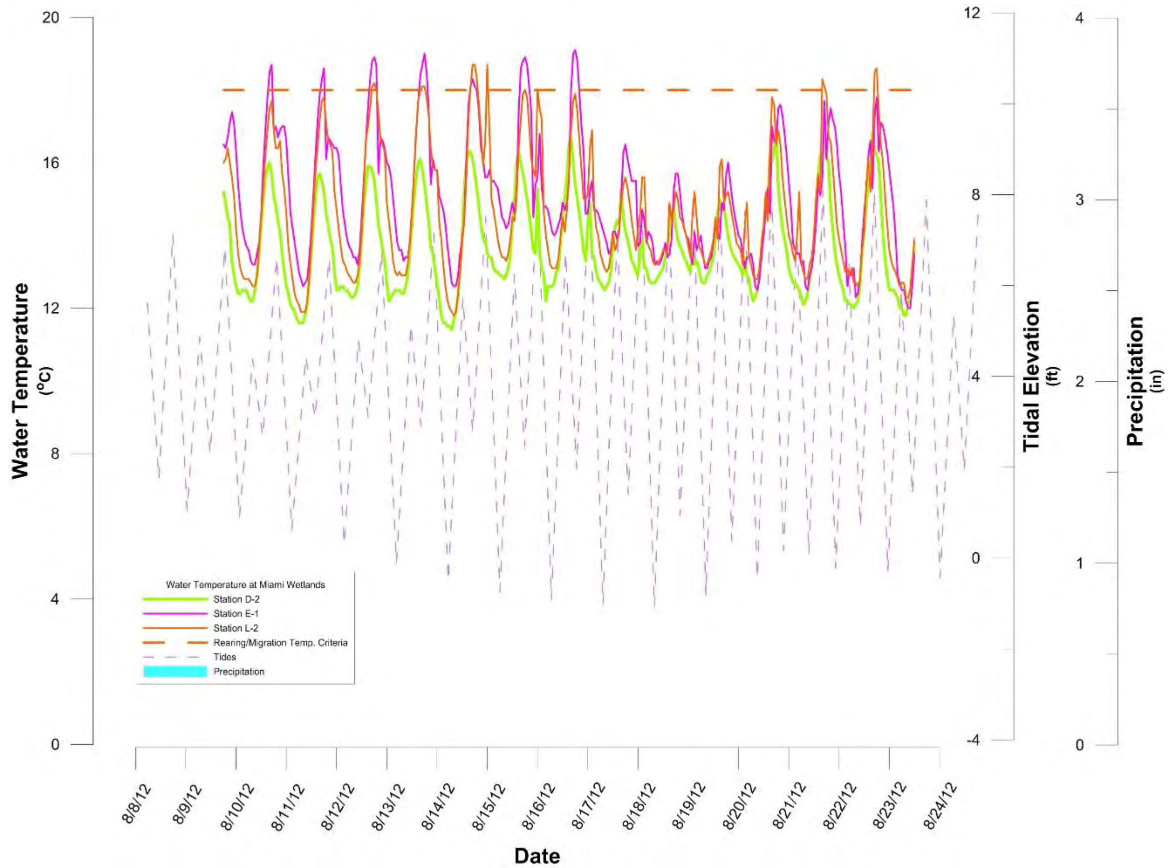


Figure C2. continued



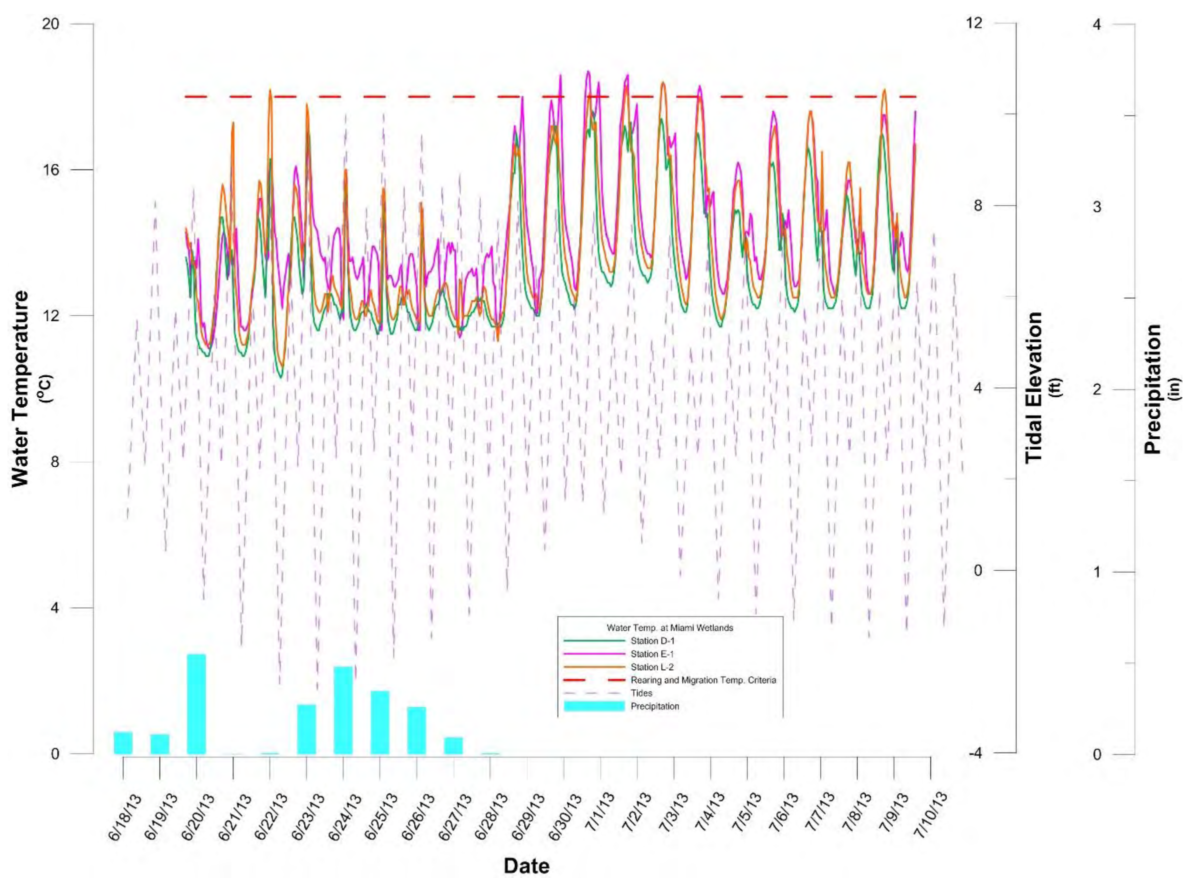
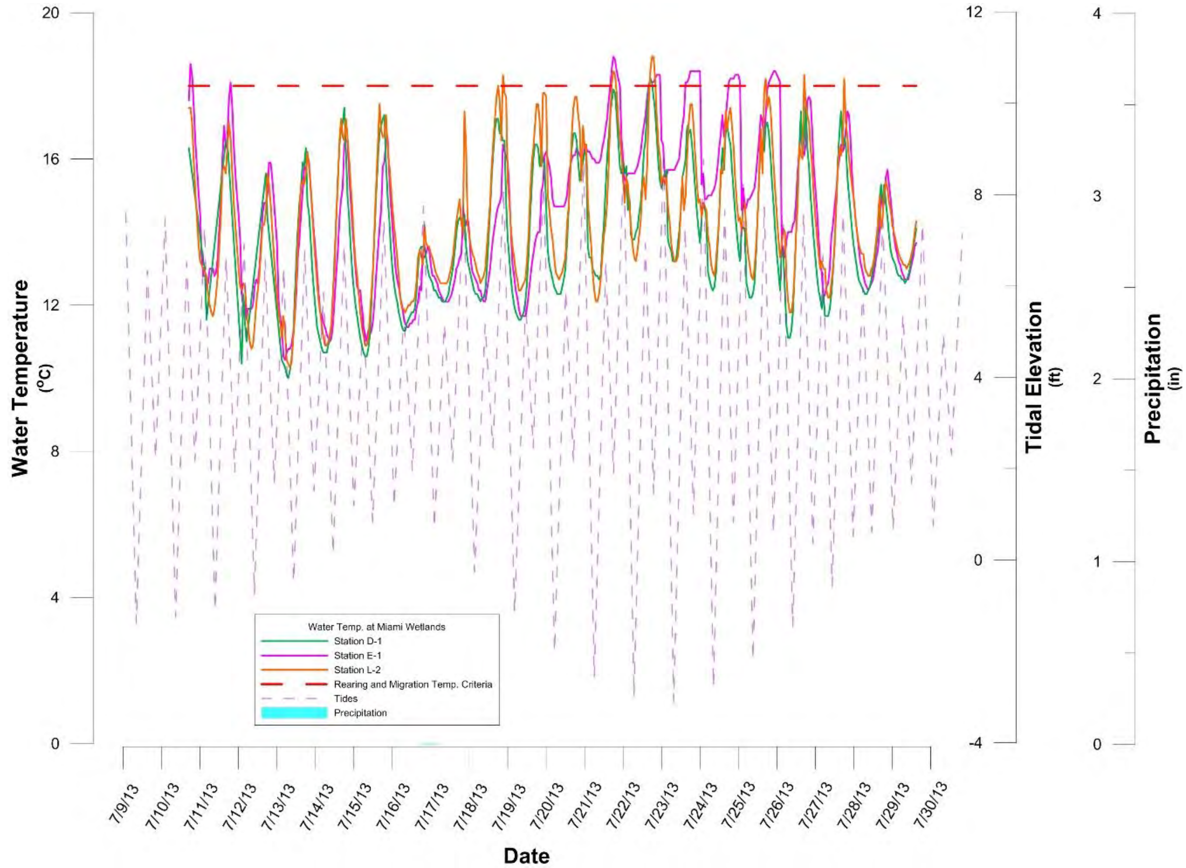


Figure C2. continued



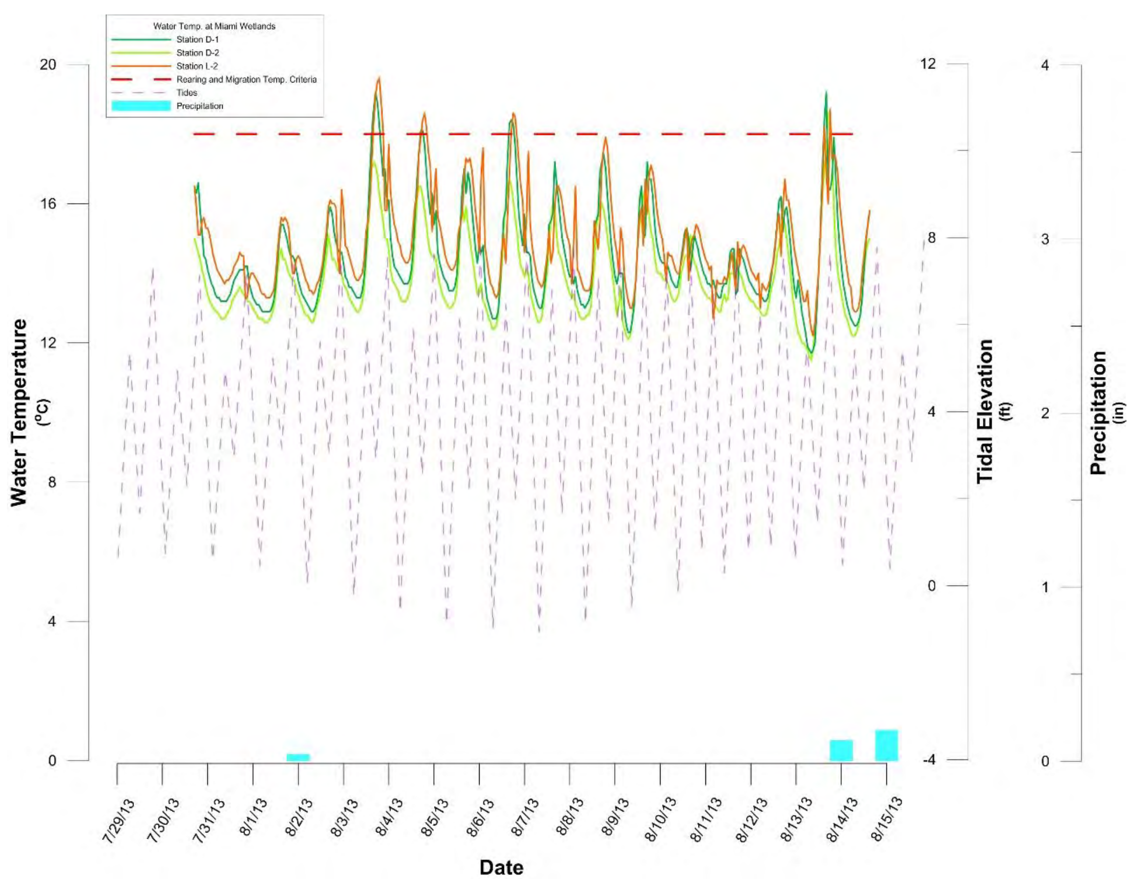
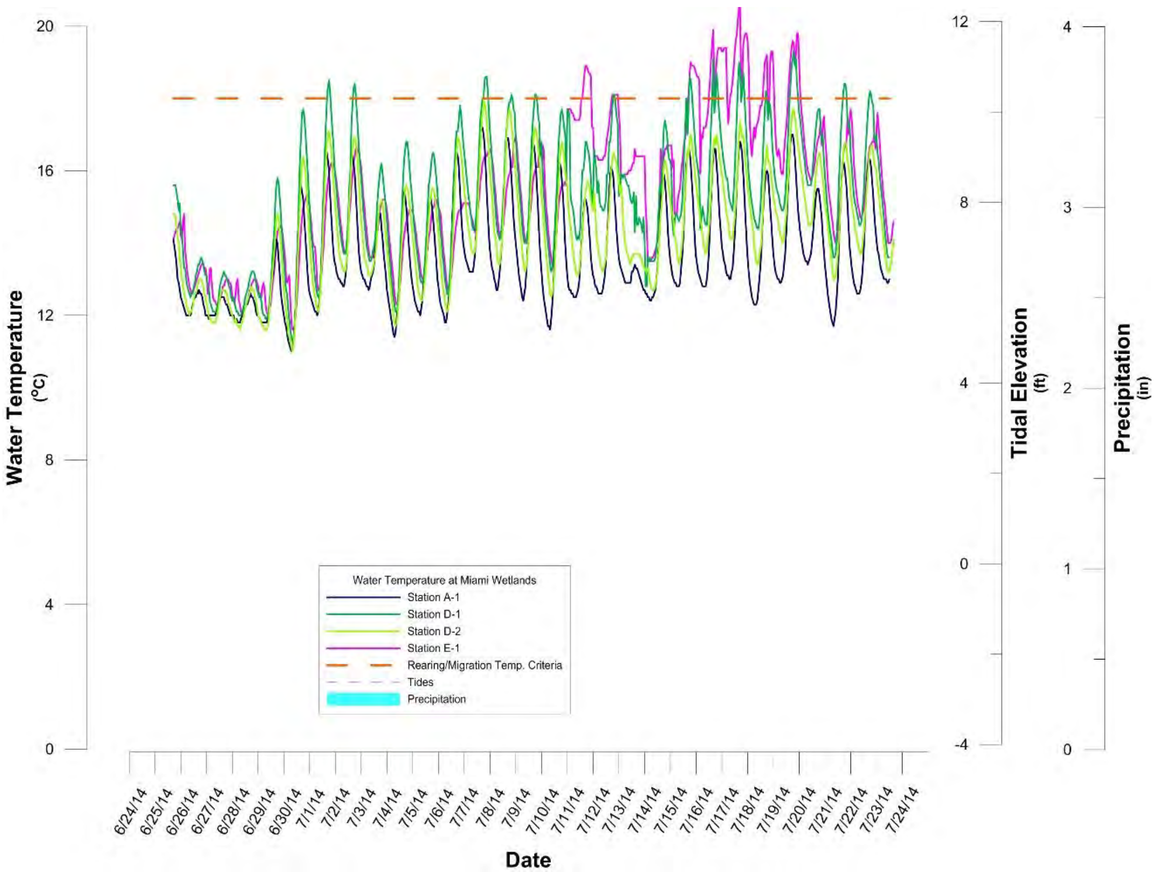


Figure C2. continued



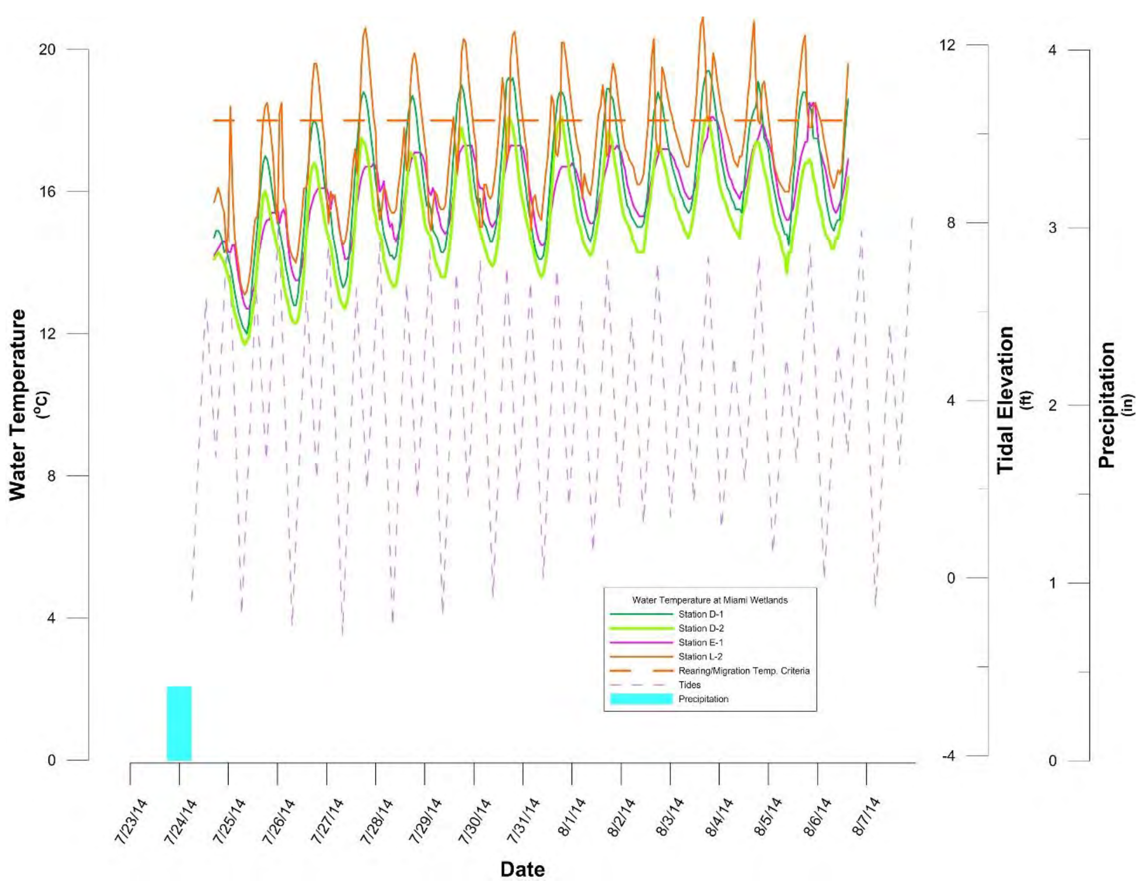
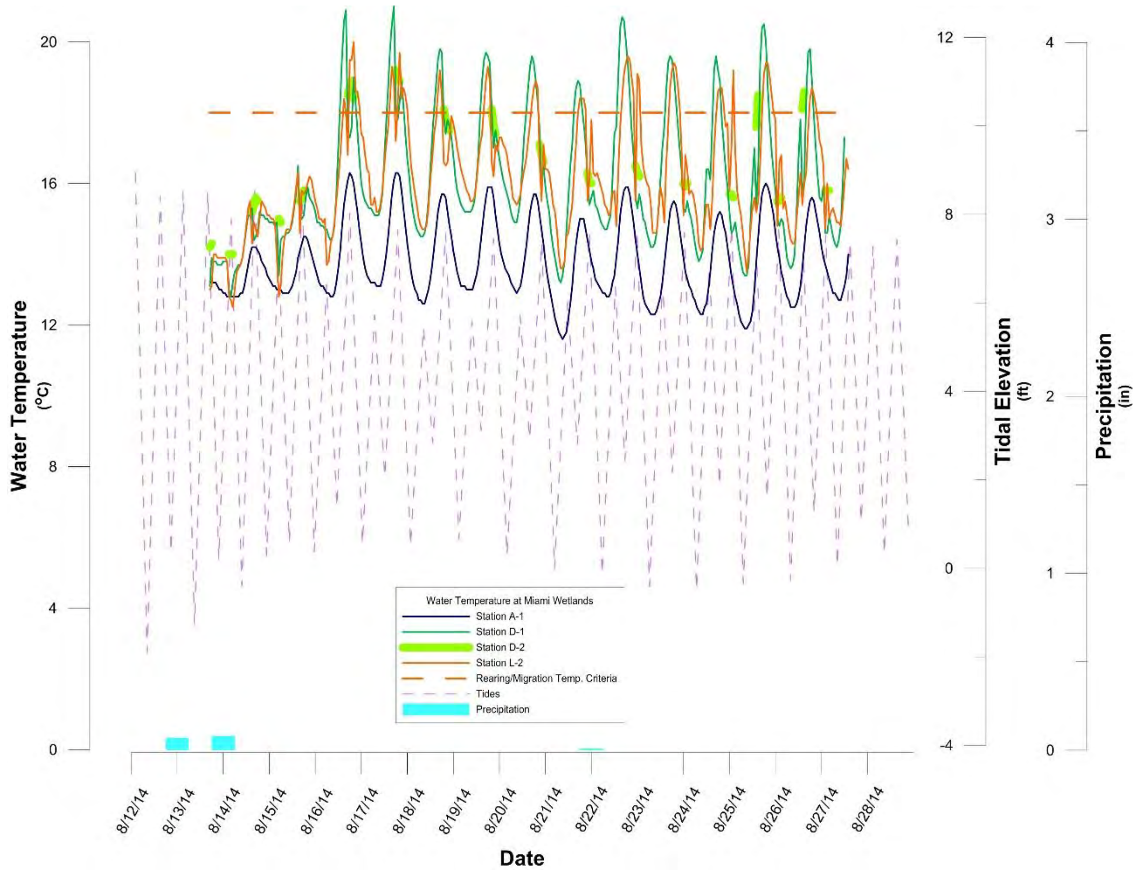


Figure C2. continued



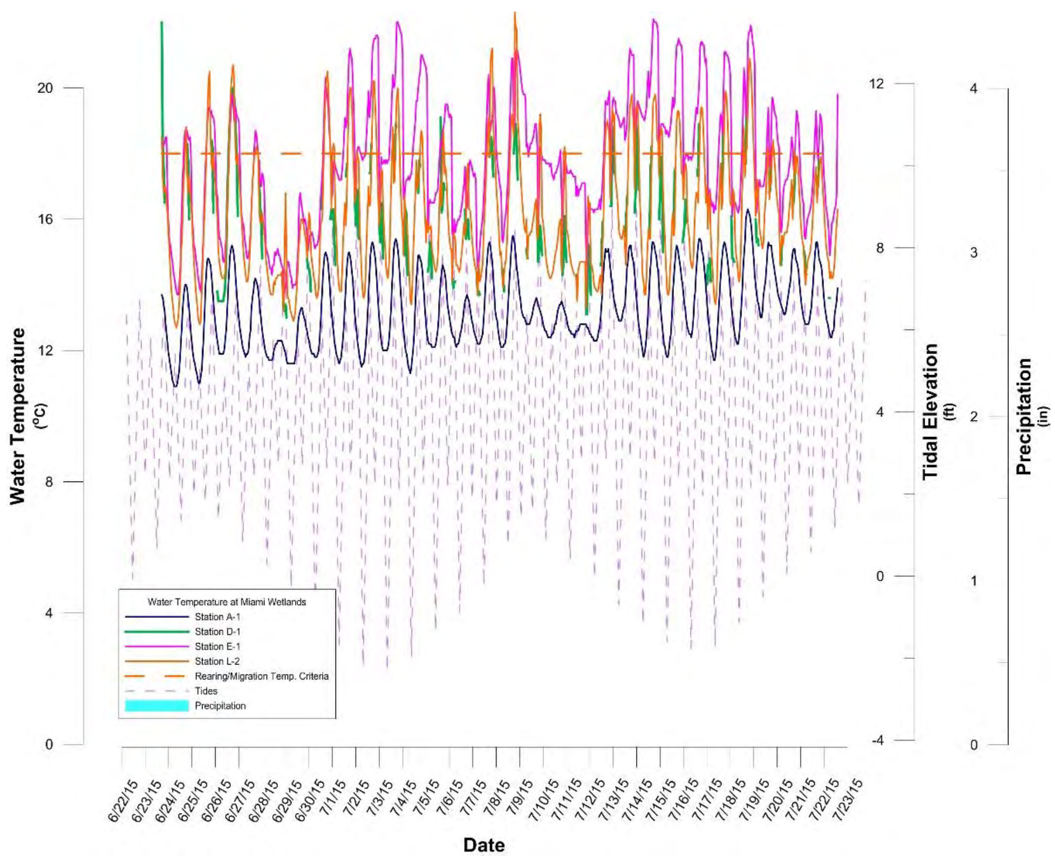
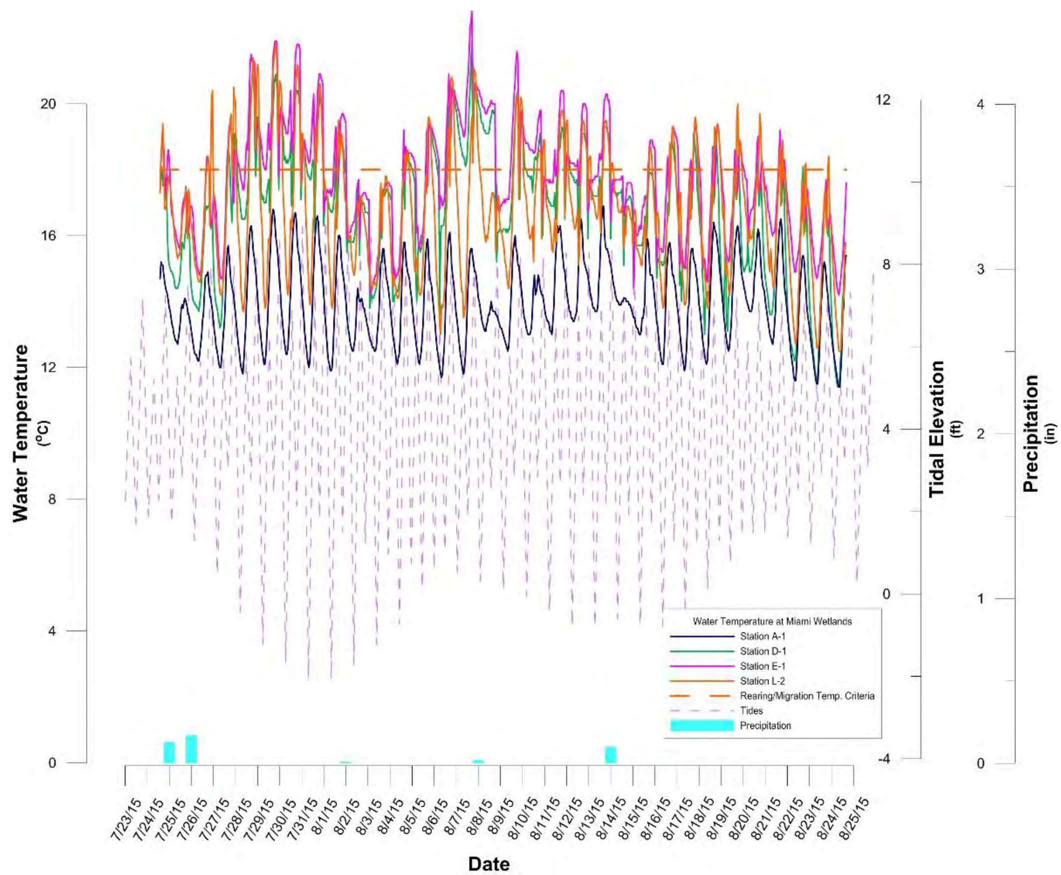


Figure C2. continued



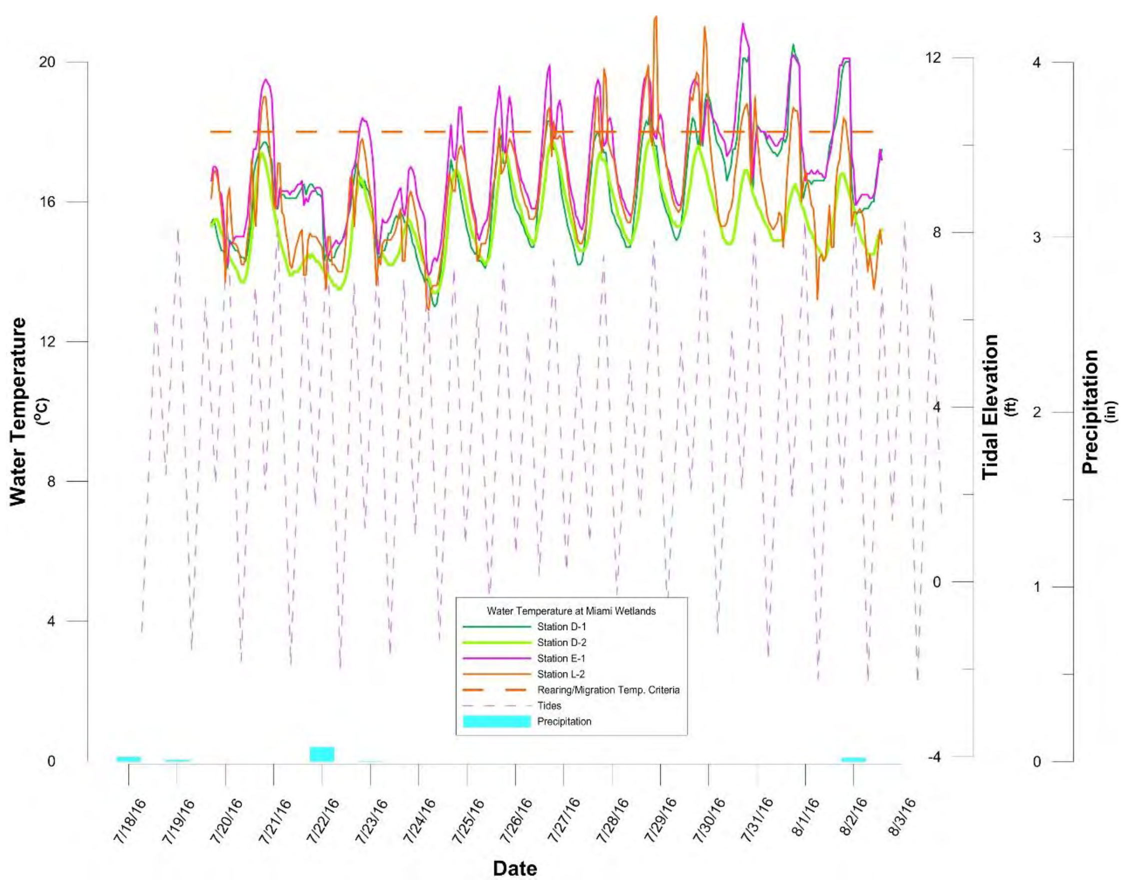
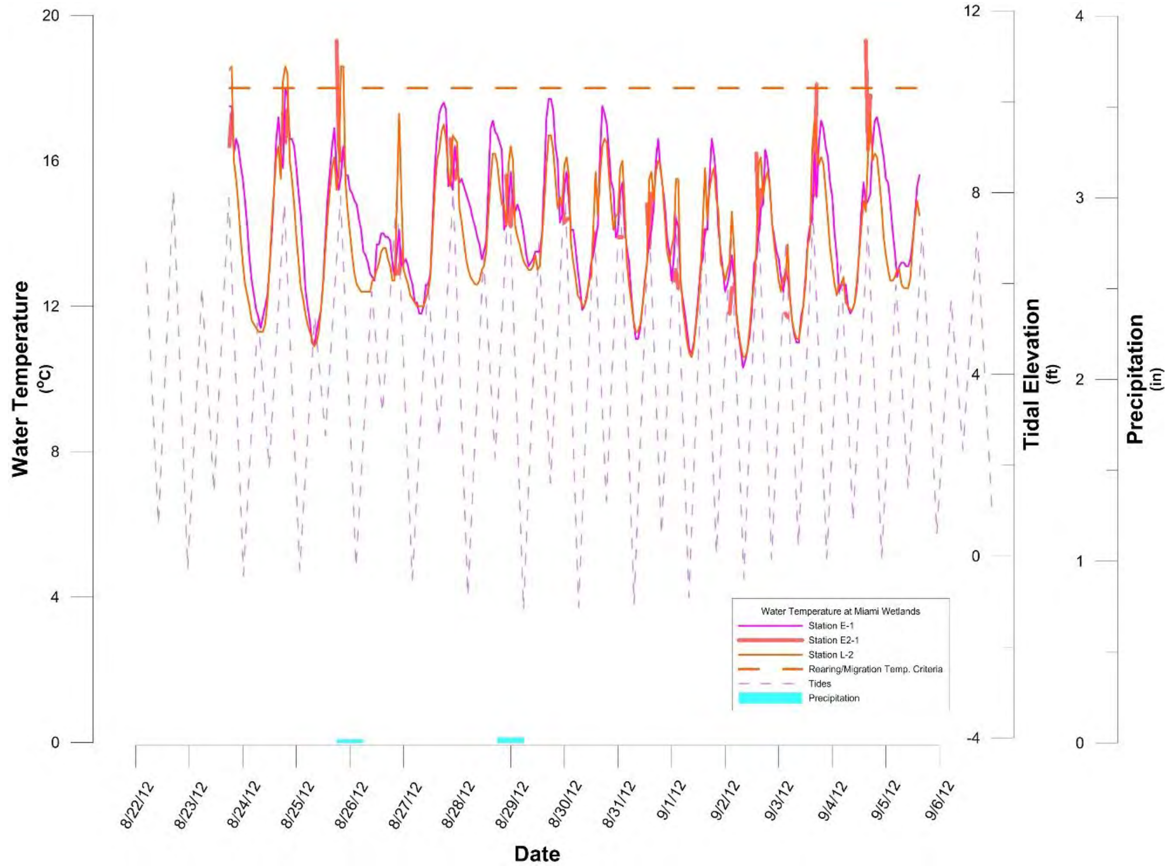


Figure C3. Graphs depicting post-restoration water temperatures in constructed channels at the Miami Wetlands during fall 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



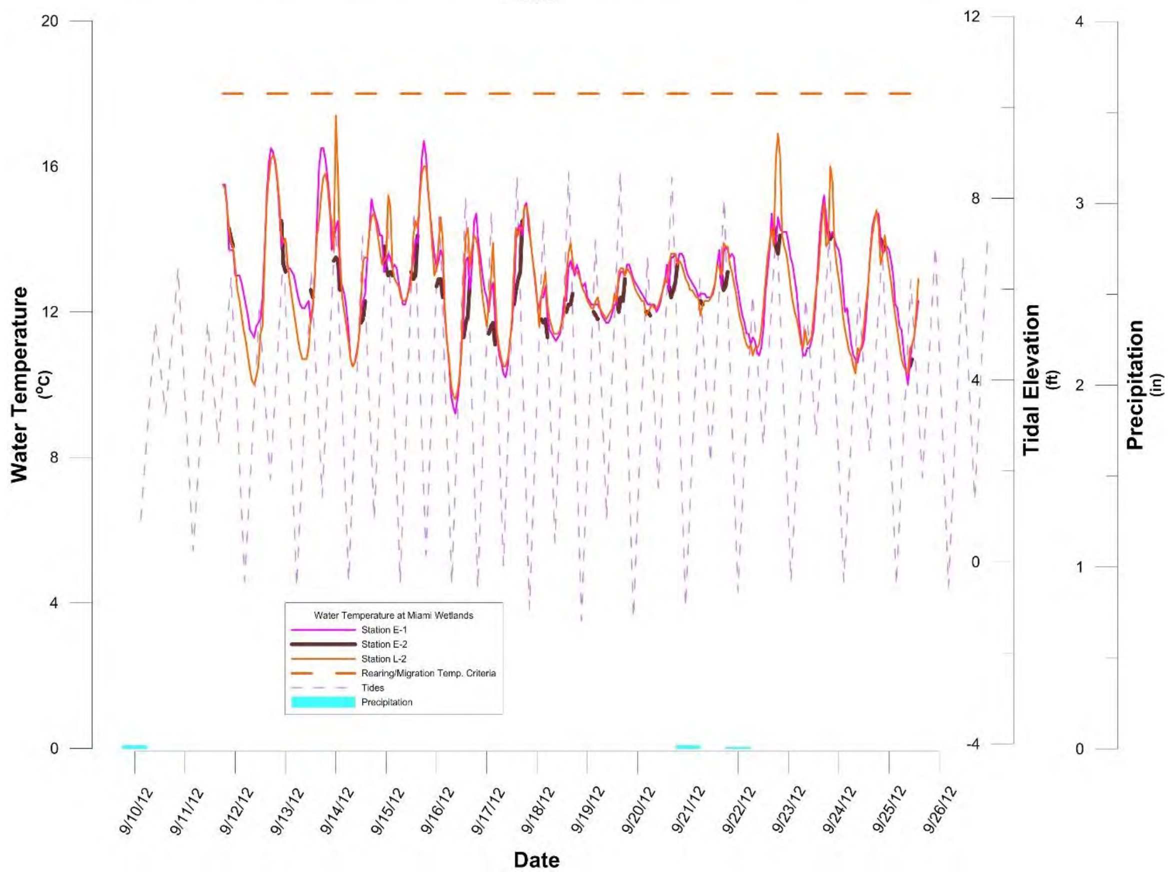
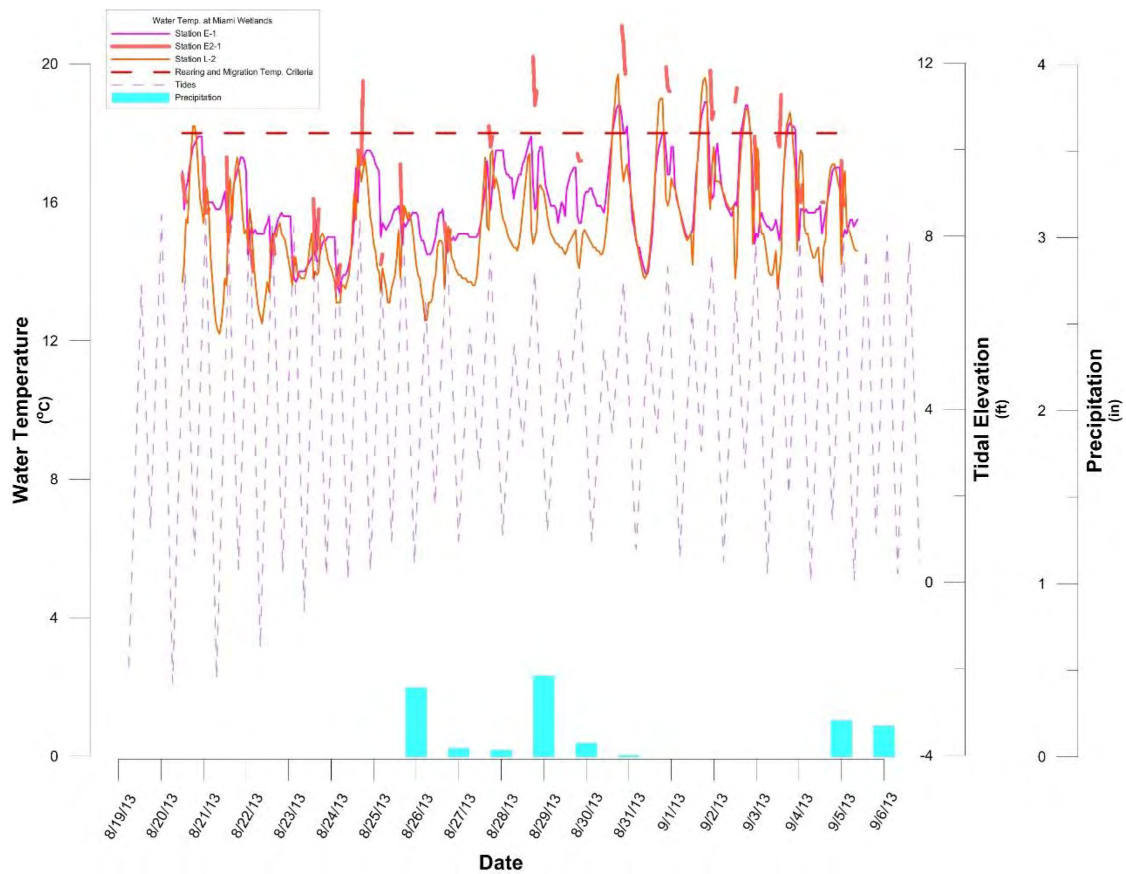


Figure C3. continued



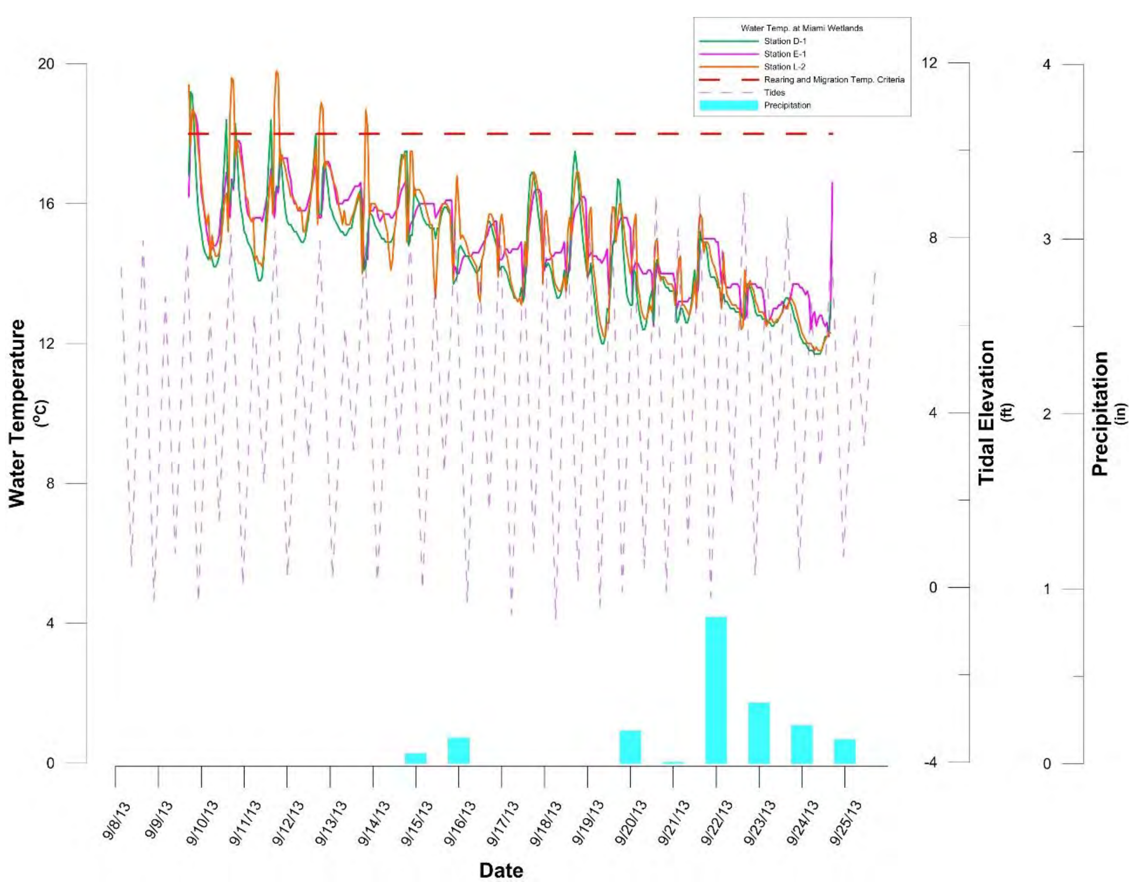
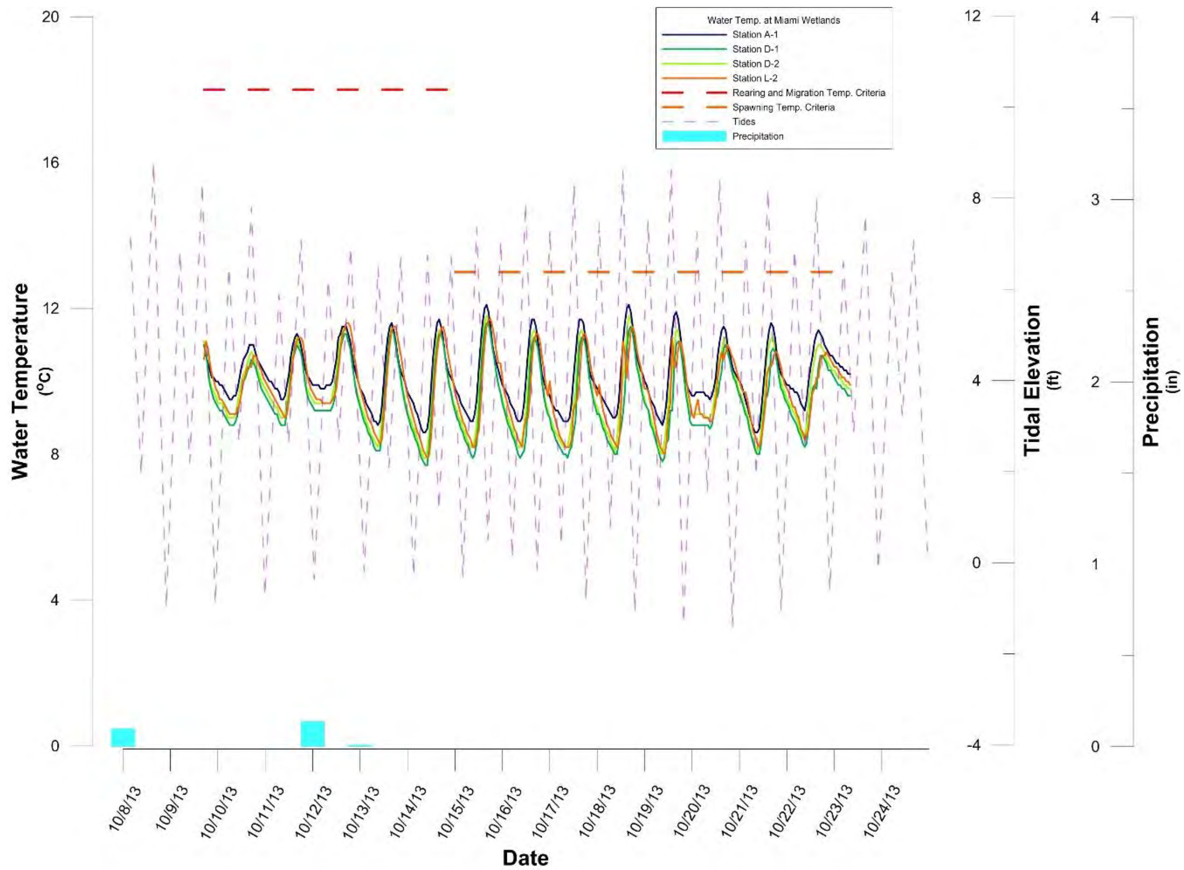


Figure C3. continued



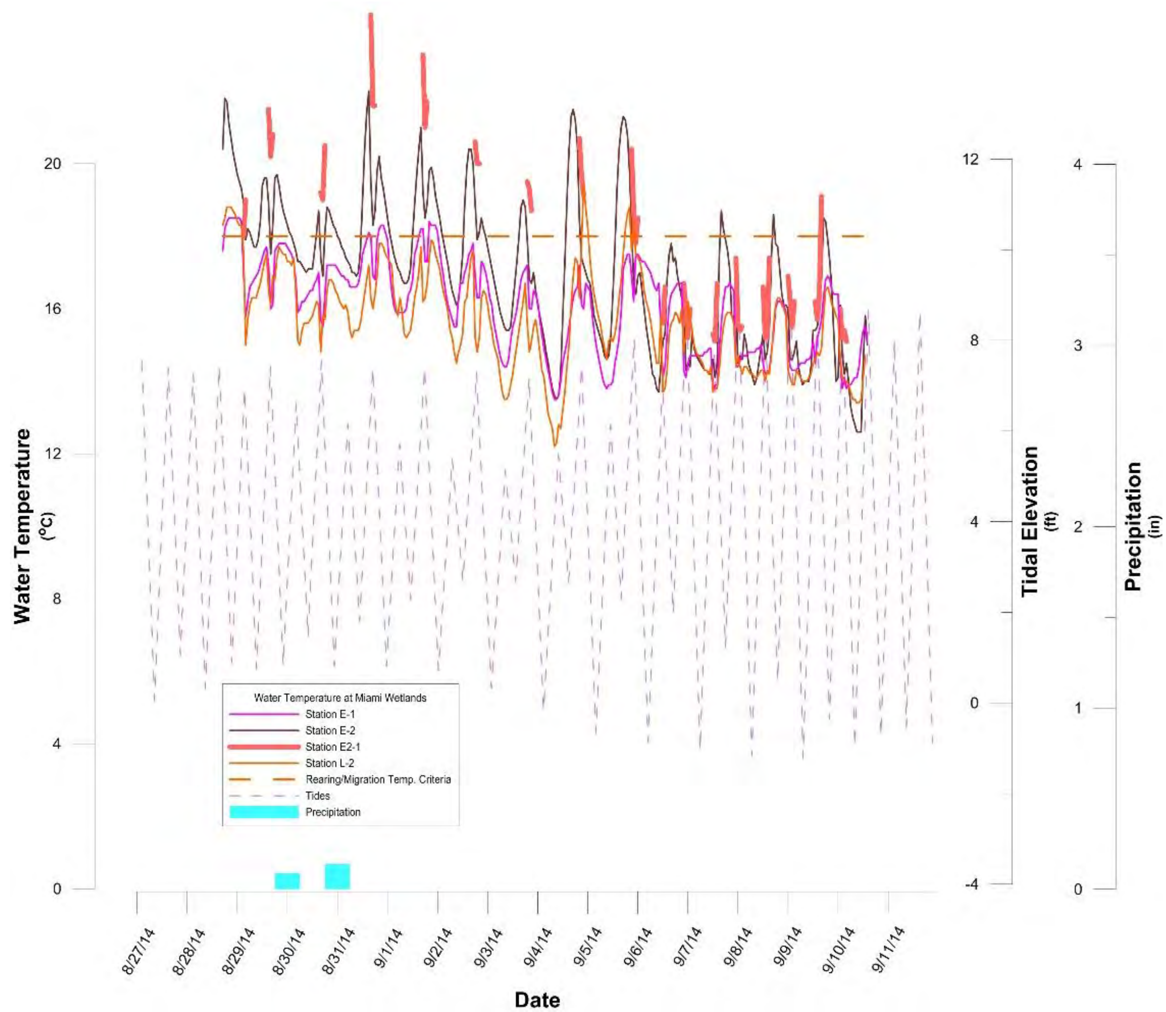
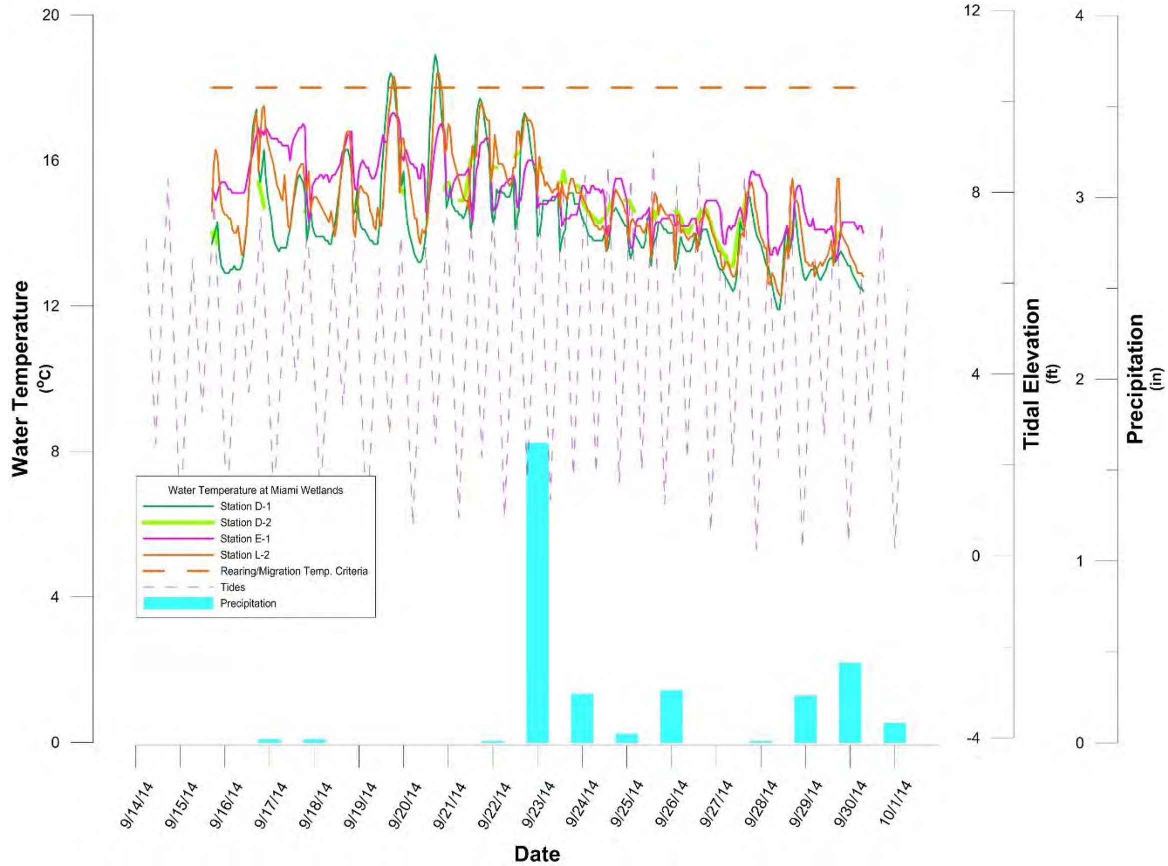


Figure C3. continued



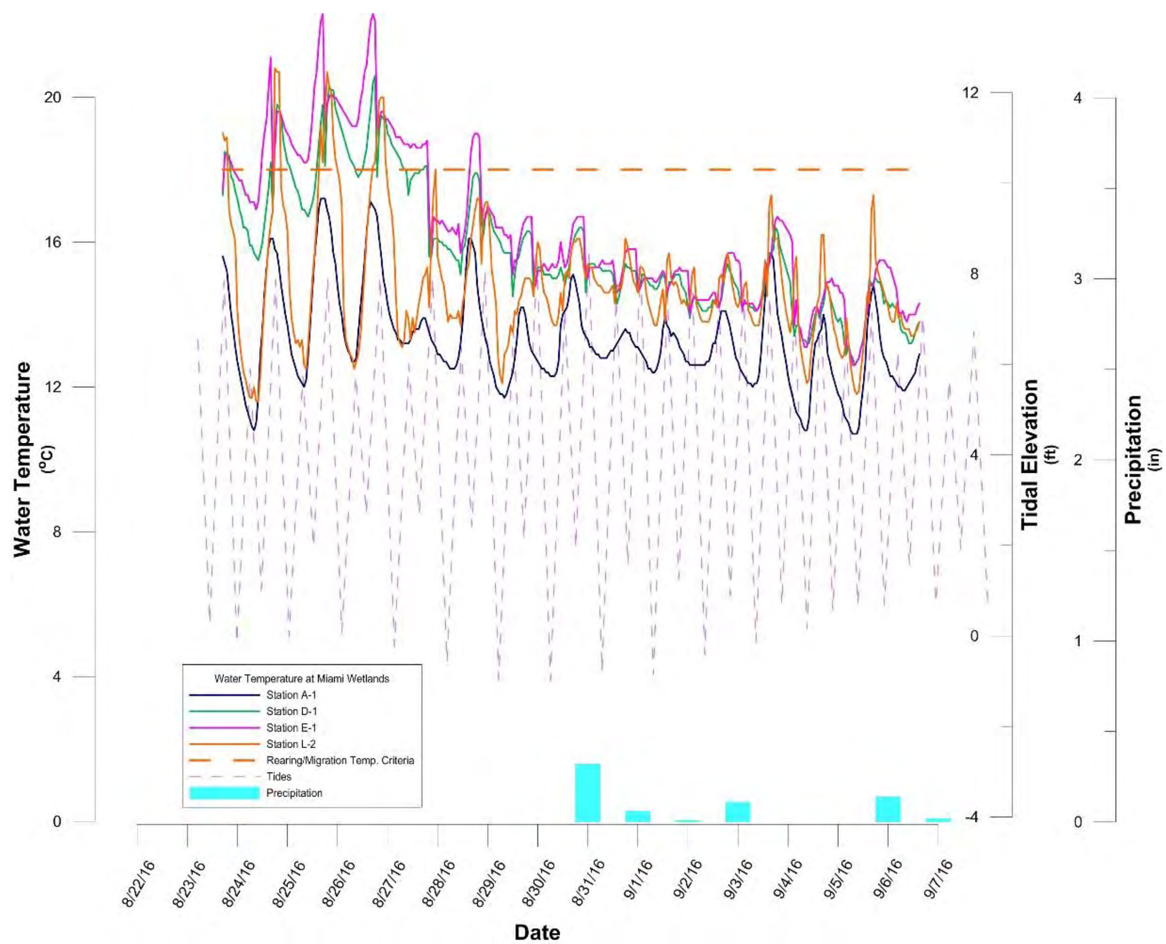
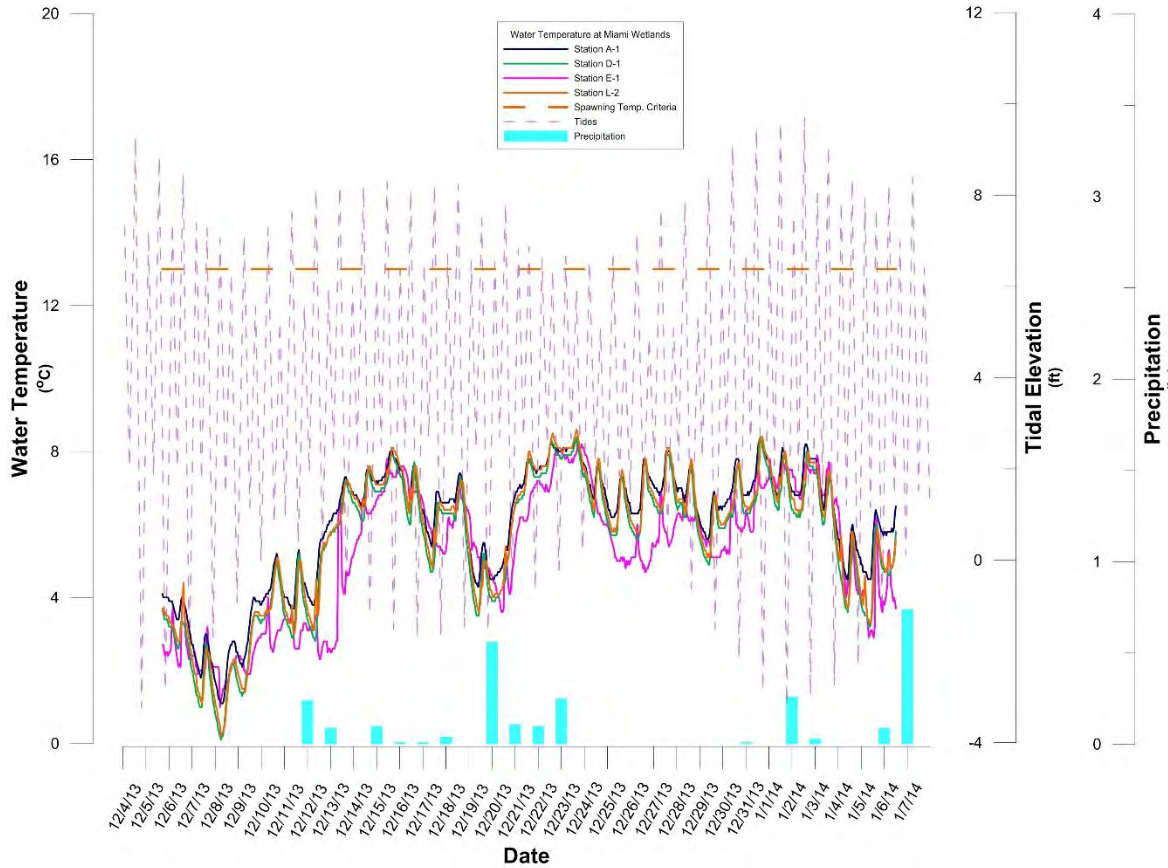


Figure C4. Graphs depicting post-restoration water temperatures in constructed channels at the Miami Wetlands during winter 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



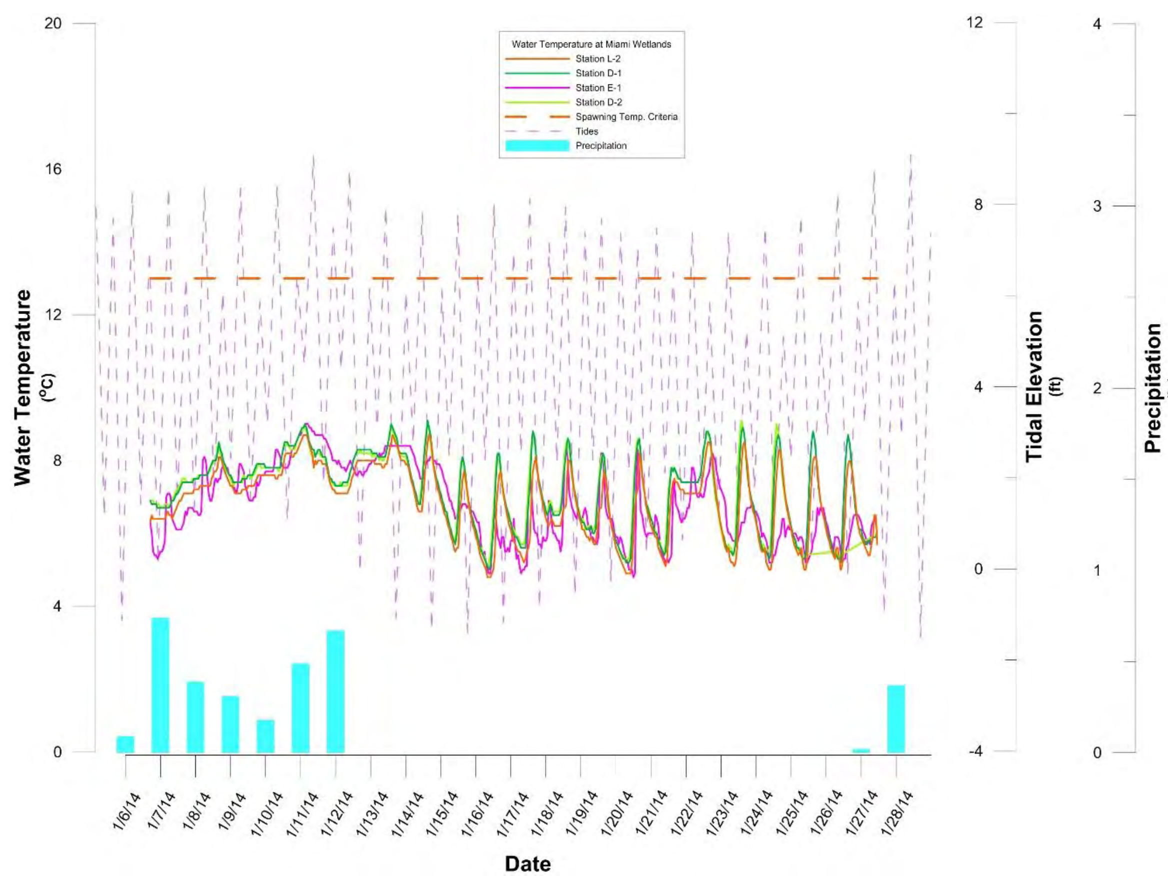
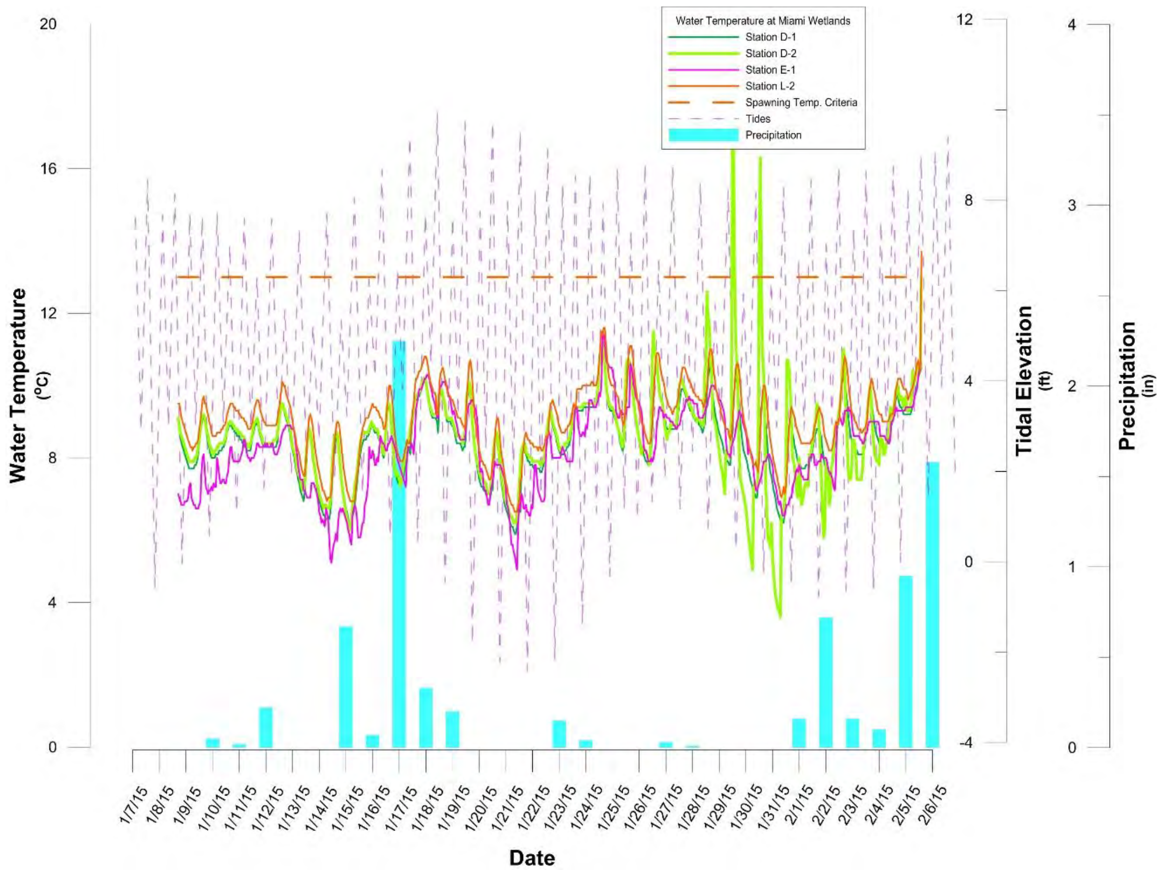


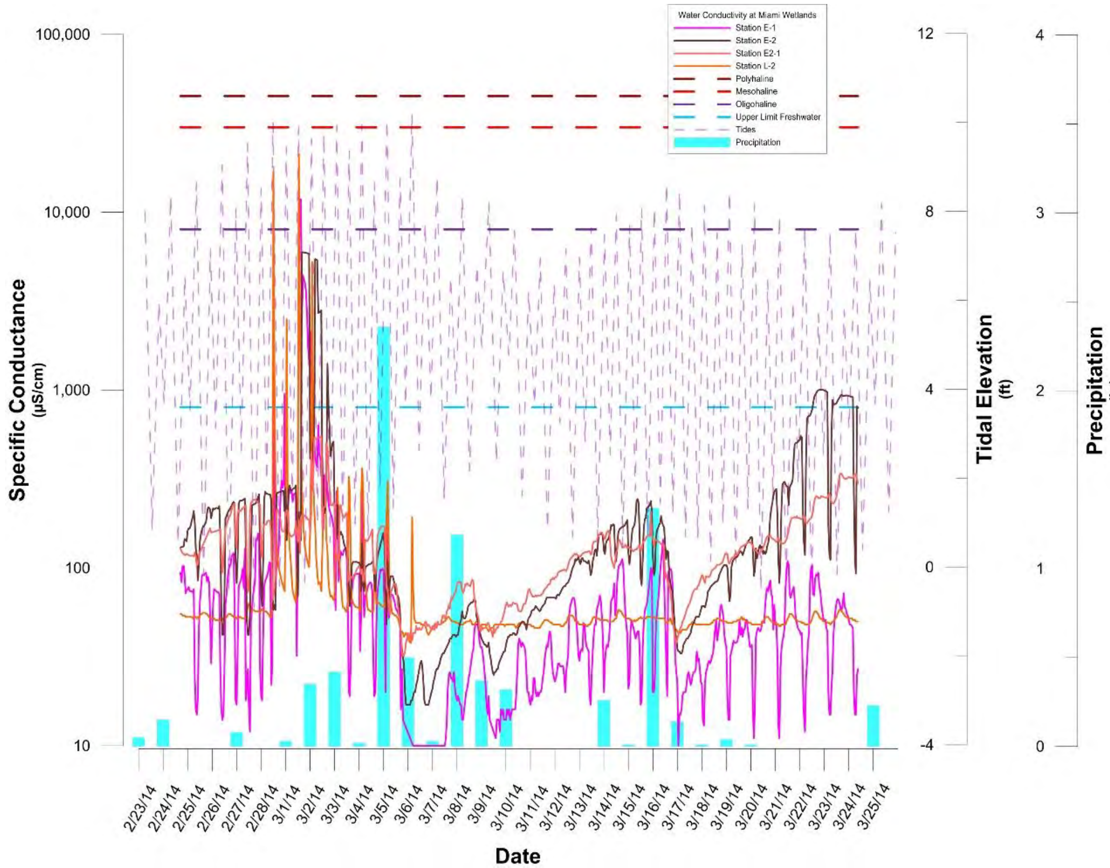
Figure C4. Continued



Appendix D

Graphs depicting post-restoration specific conductance levels for water in constructed channels at the Miami Wetlands

Figure D1. Graphs depicting post-restoration specific conductance levels in constructed channels at the Miami Wetlands during spring 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



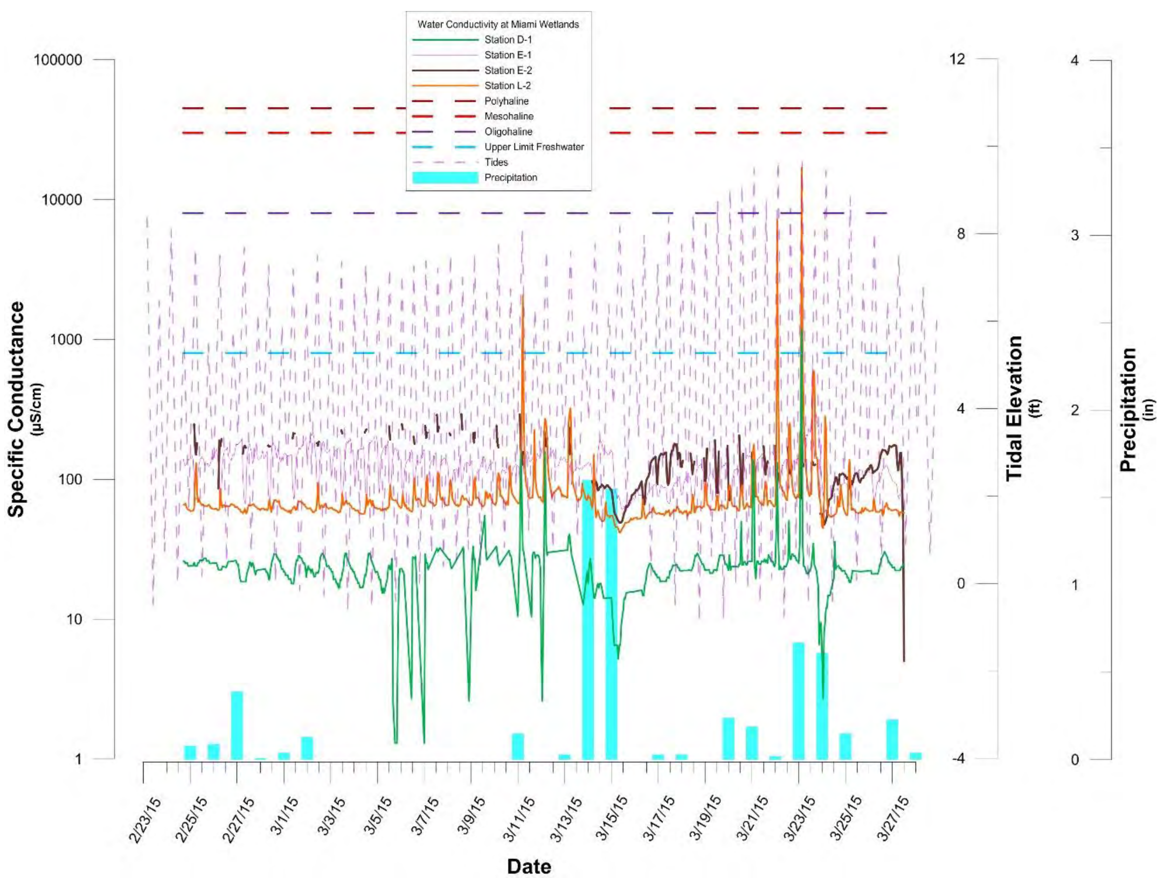


Figure D1. continued

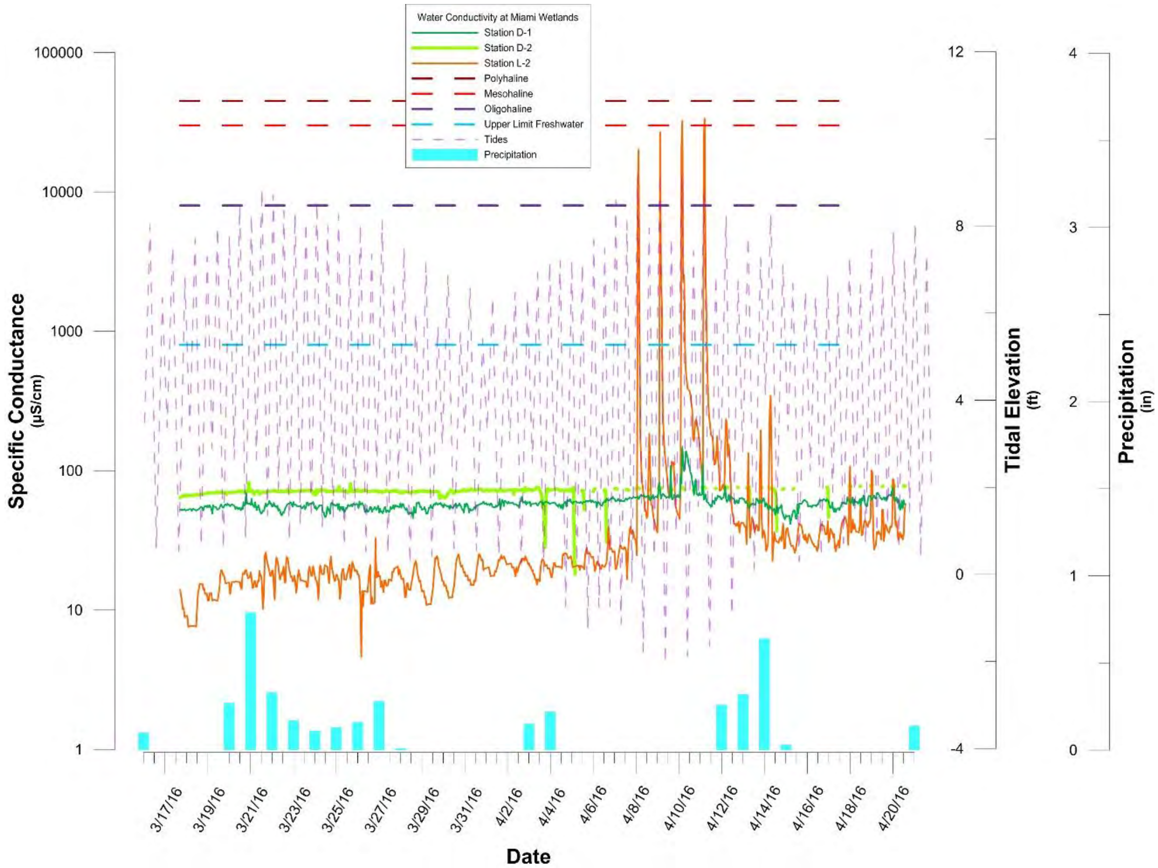
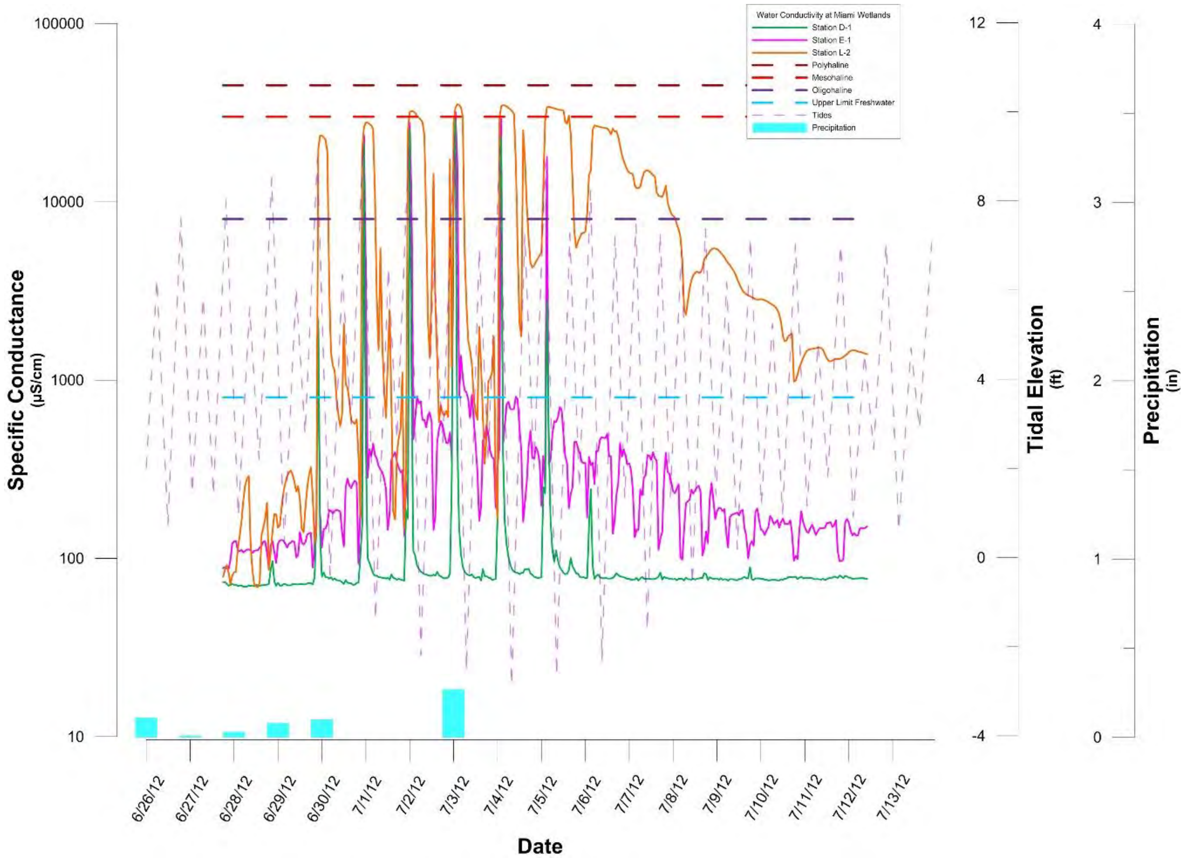


Figure D2. Graphs depicting post-restoration specific conductance levels in constructed channels at the Miami Wetlands during summer 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



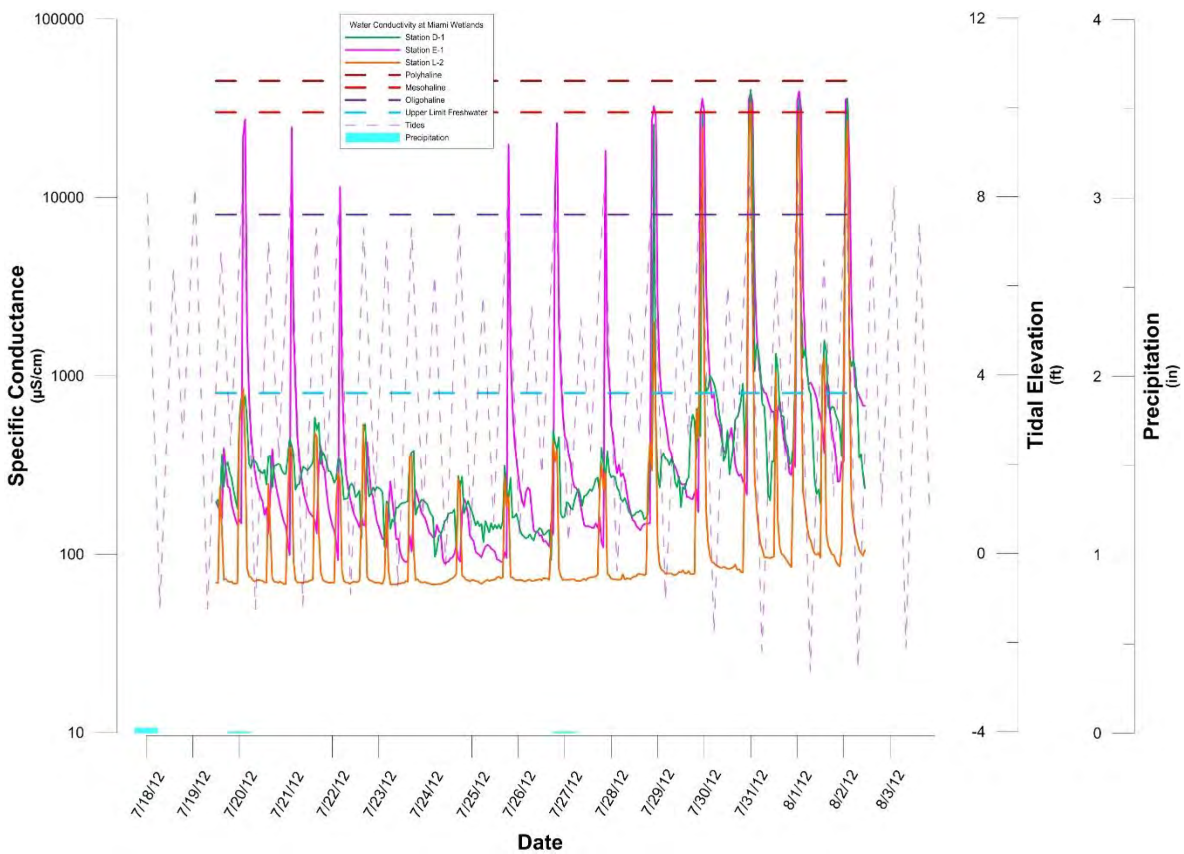
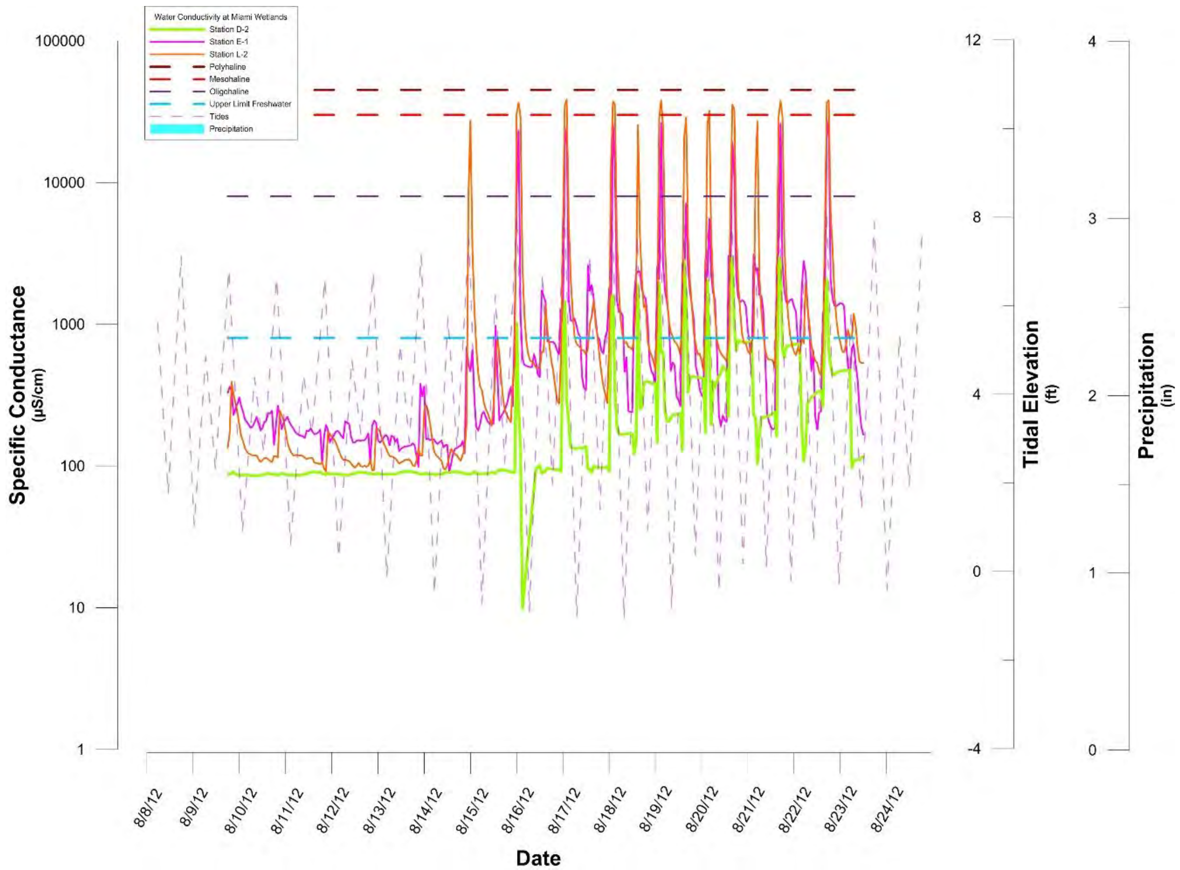


Figure D2. continued



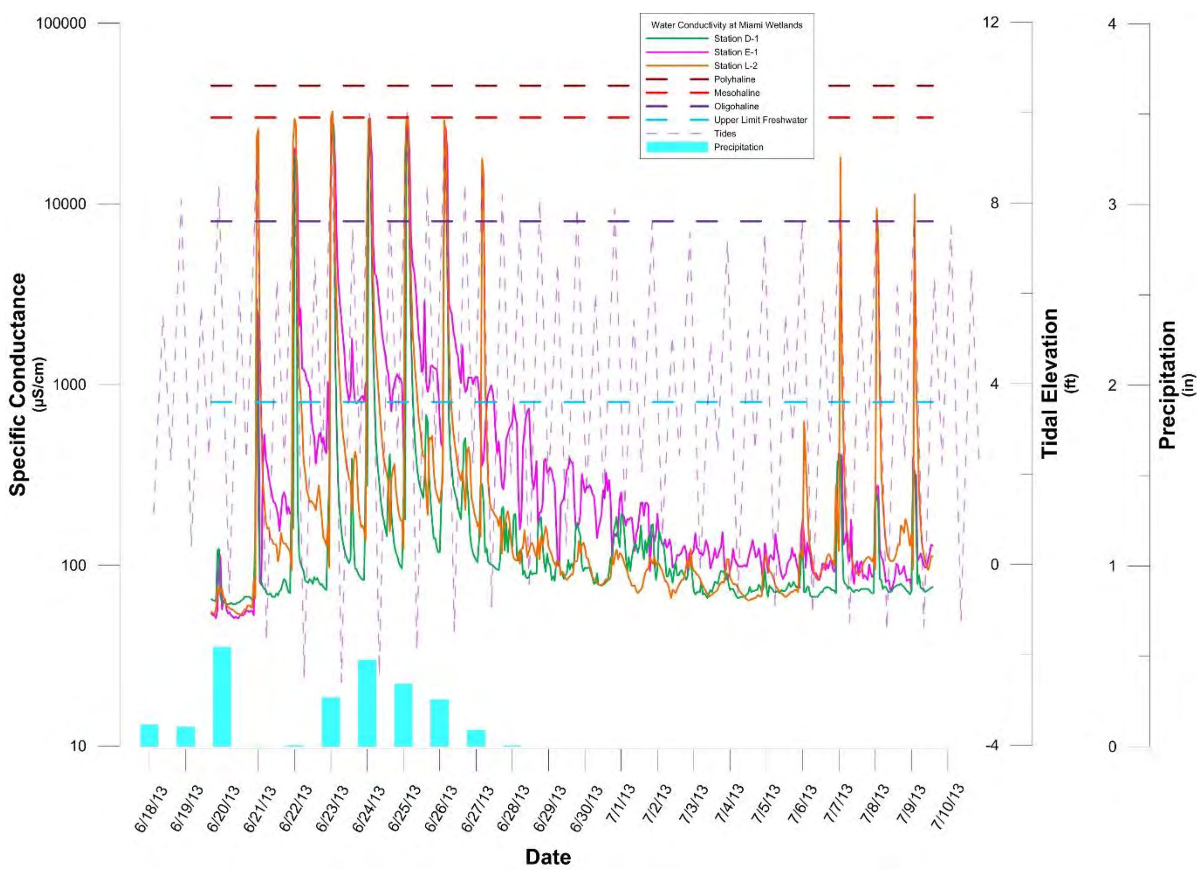
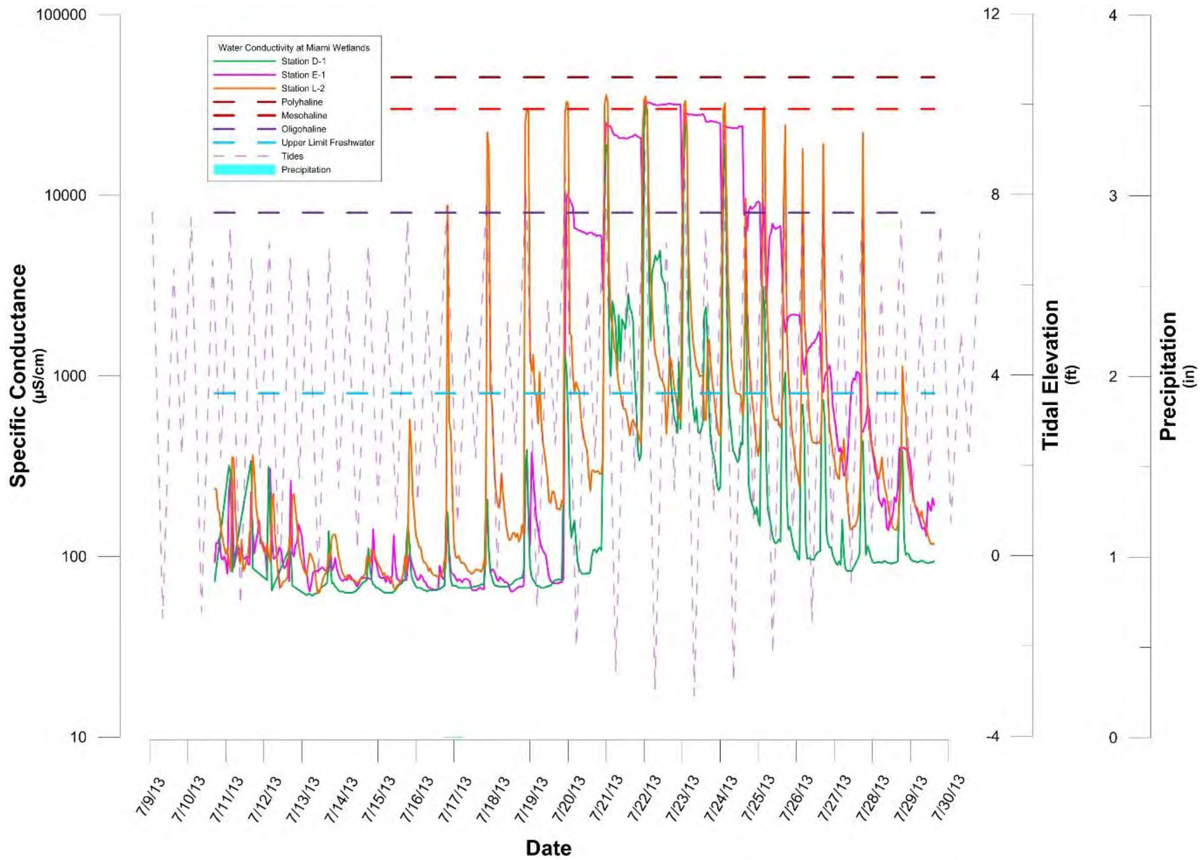


Figure D2. continued



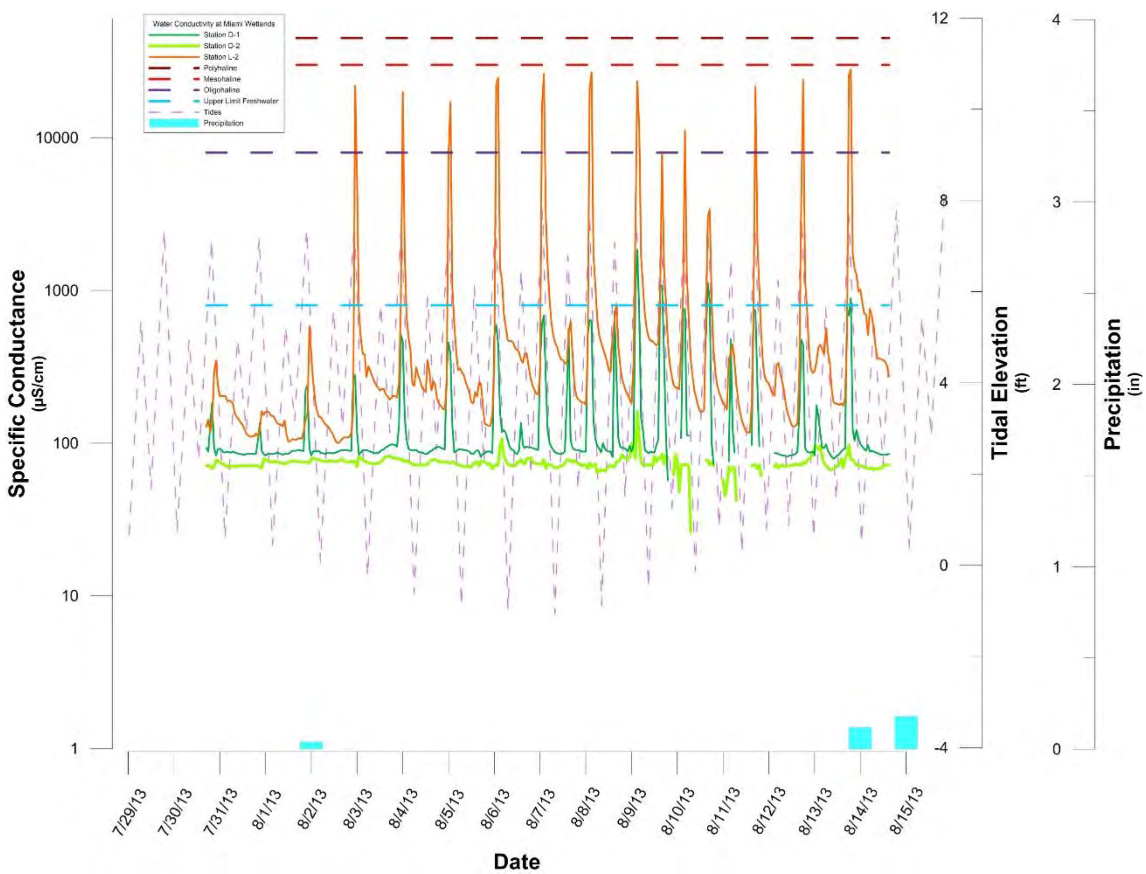
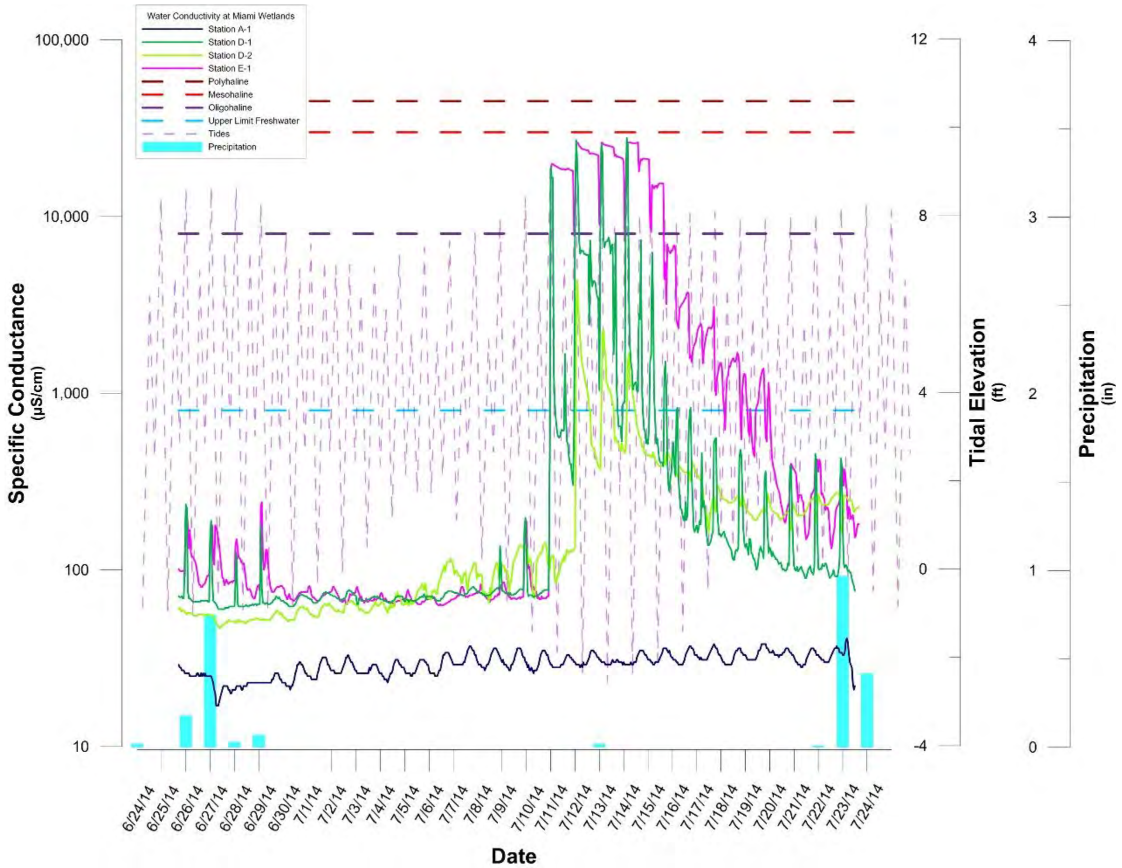


Figure D2. continued



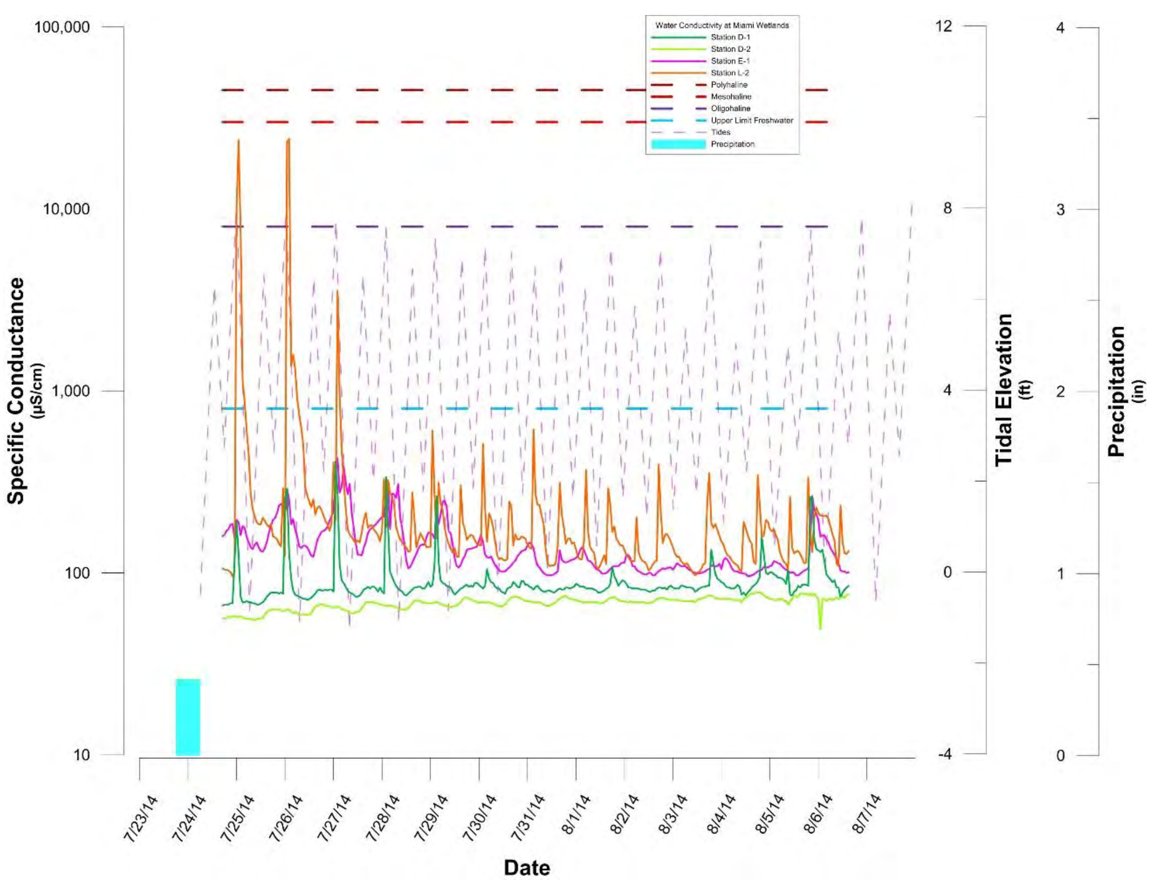
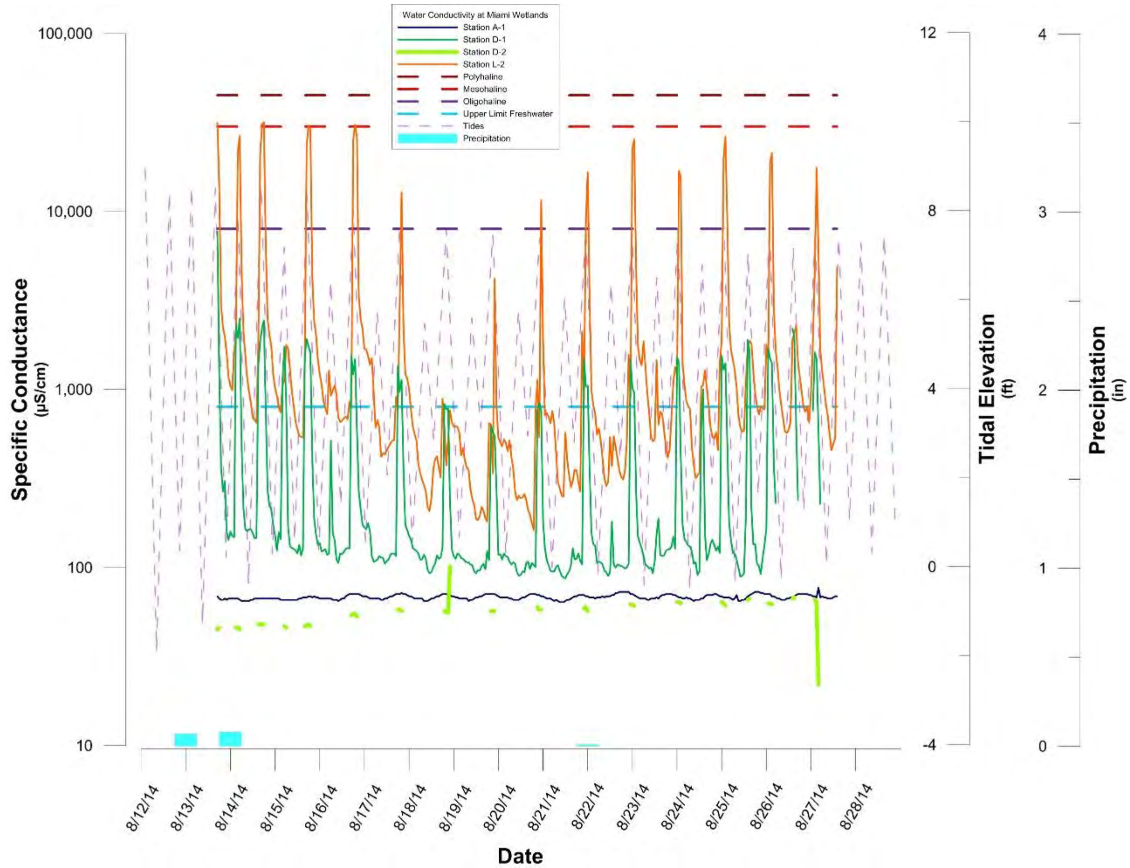


Figure D2. continued



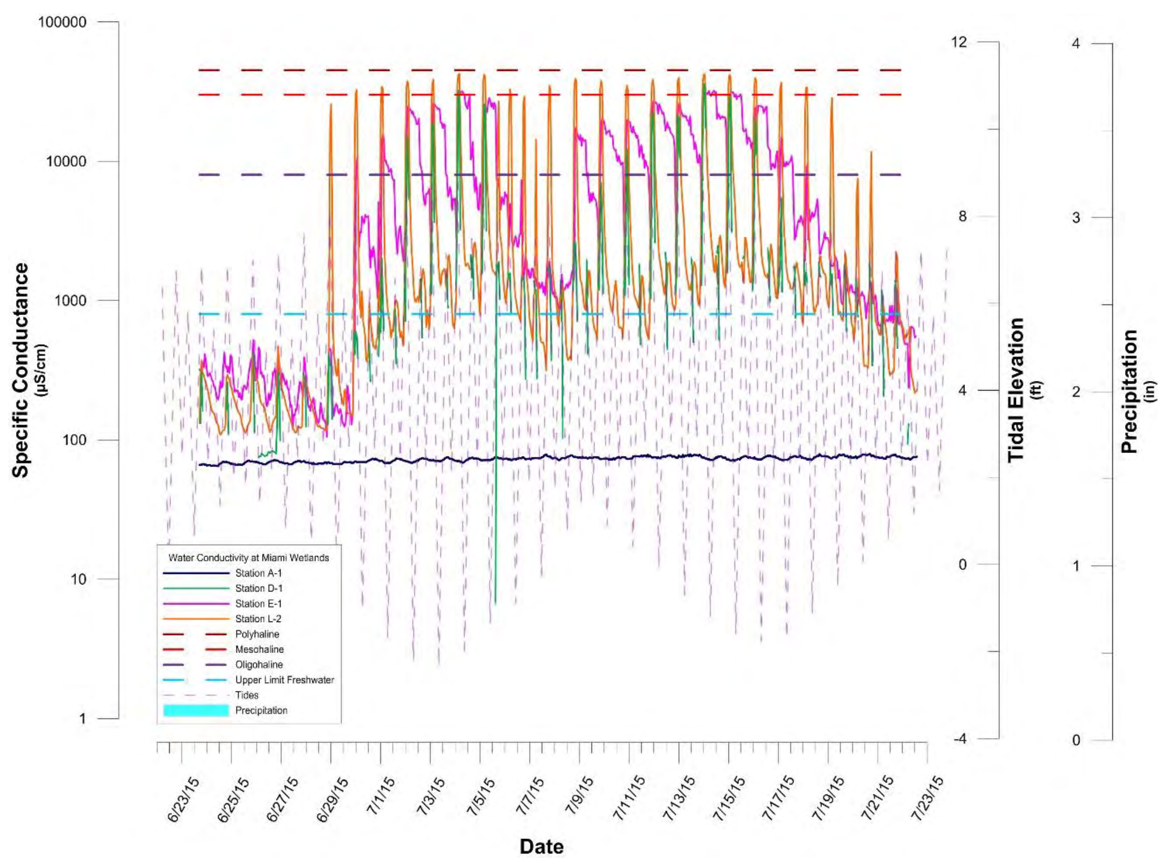
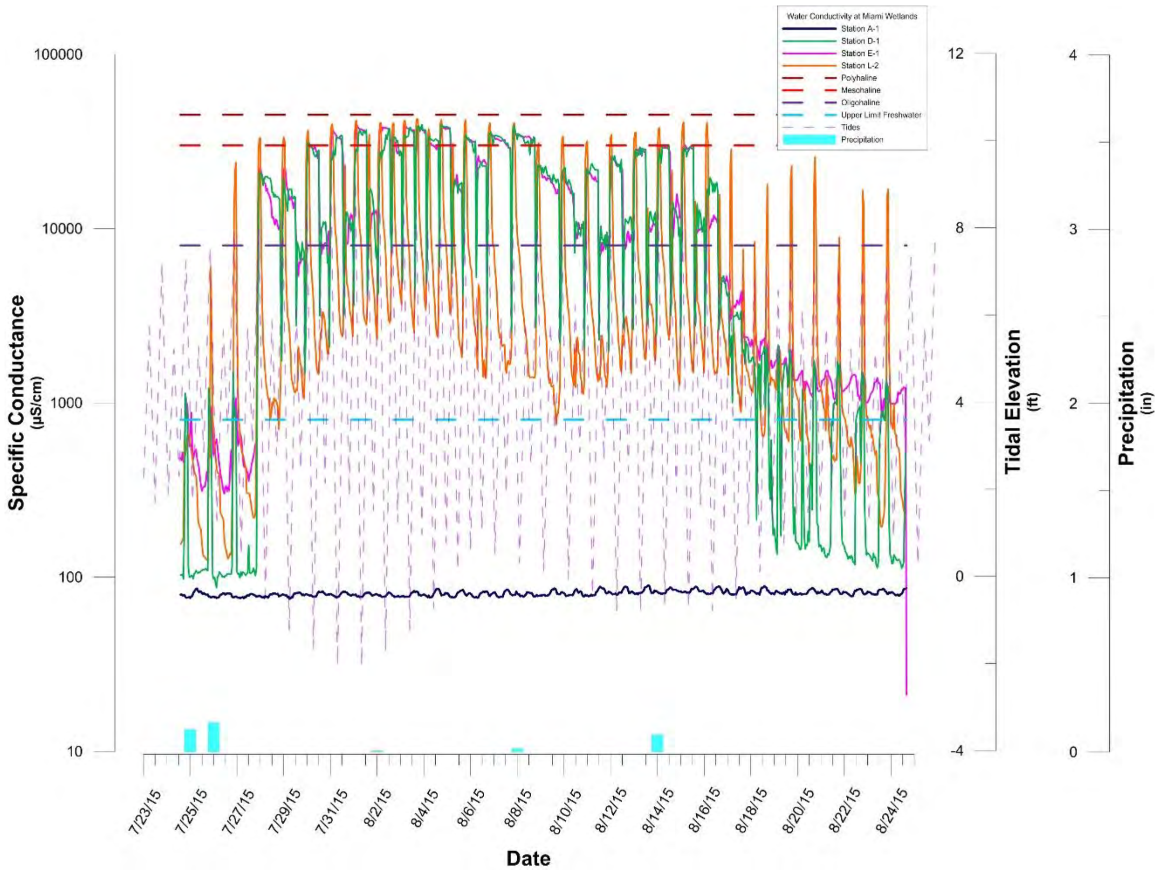


Figure D2. continued



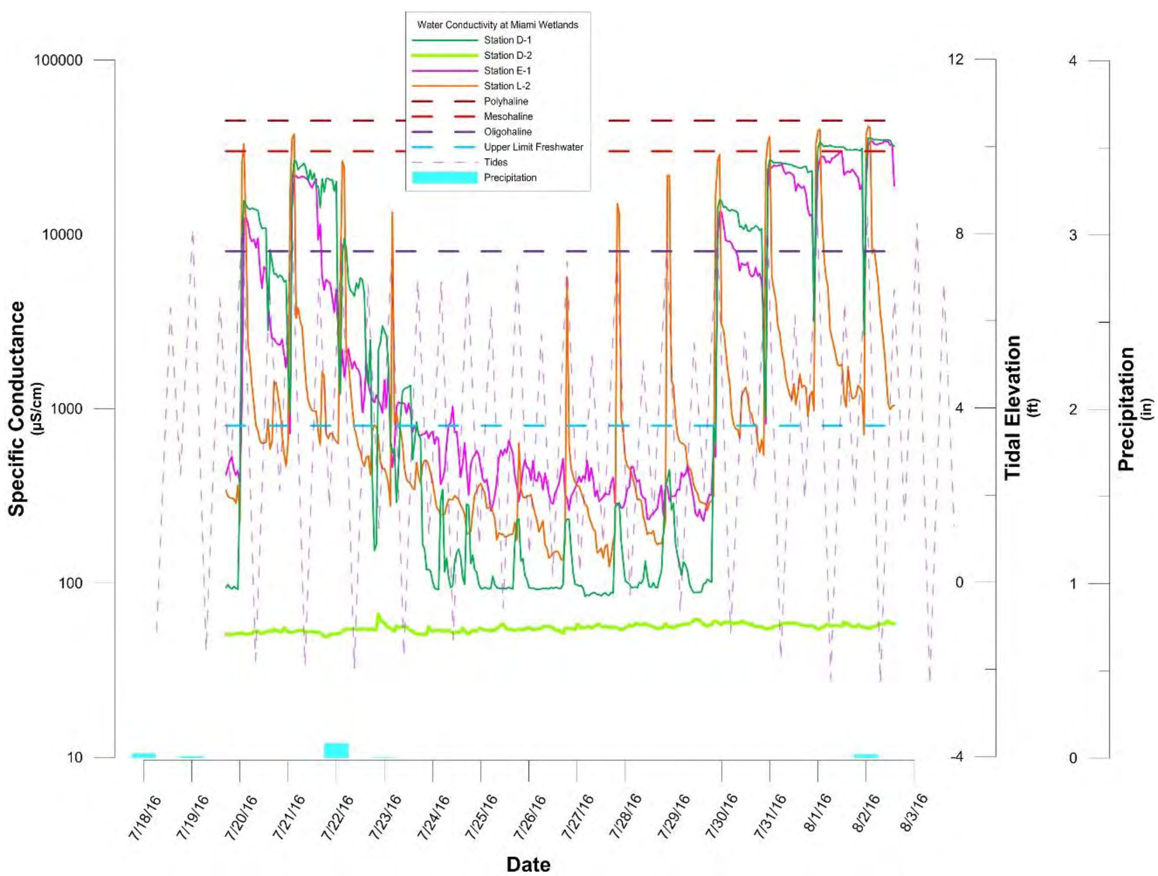
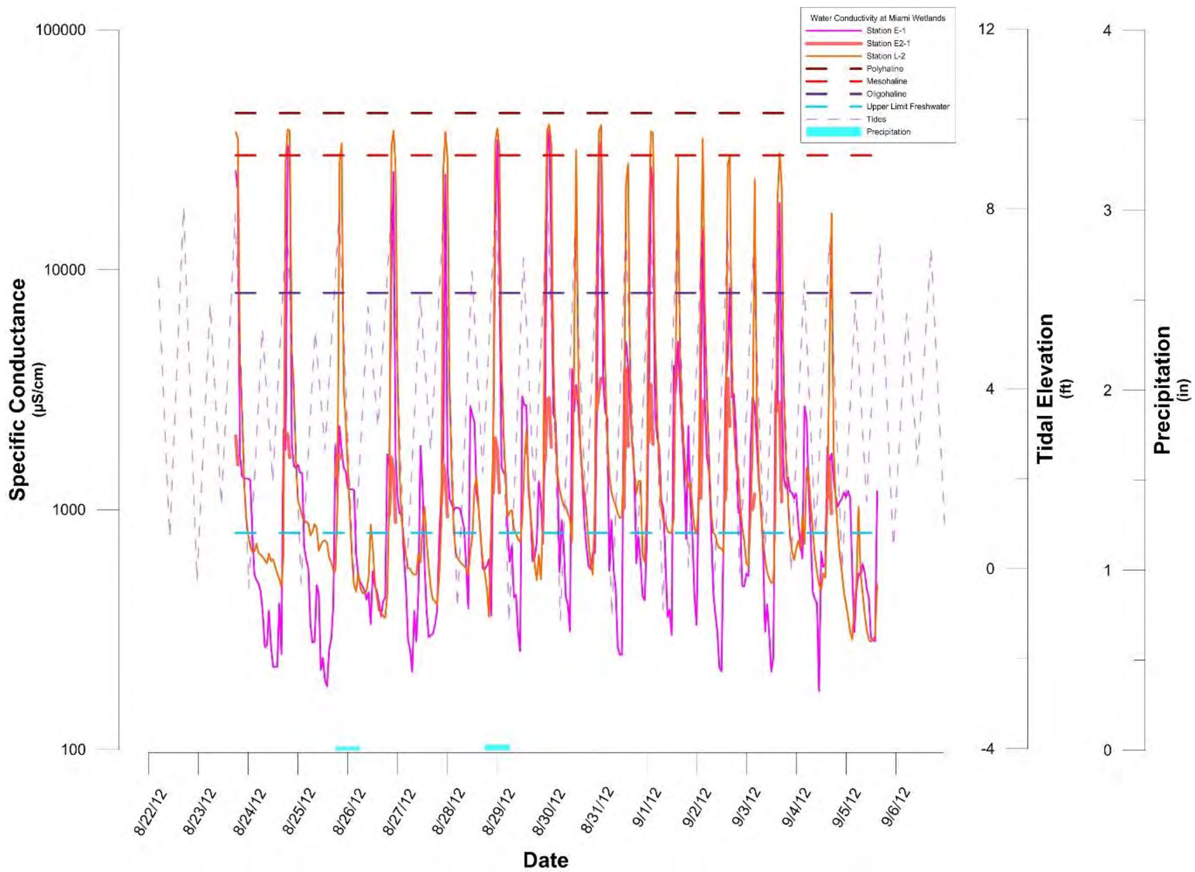


Figure D3. Graphs depicting post-restoration specific conductance levels in constructed channels at the Miami Wetlands during fall 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



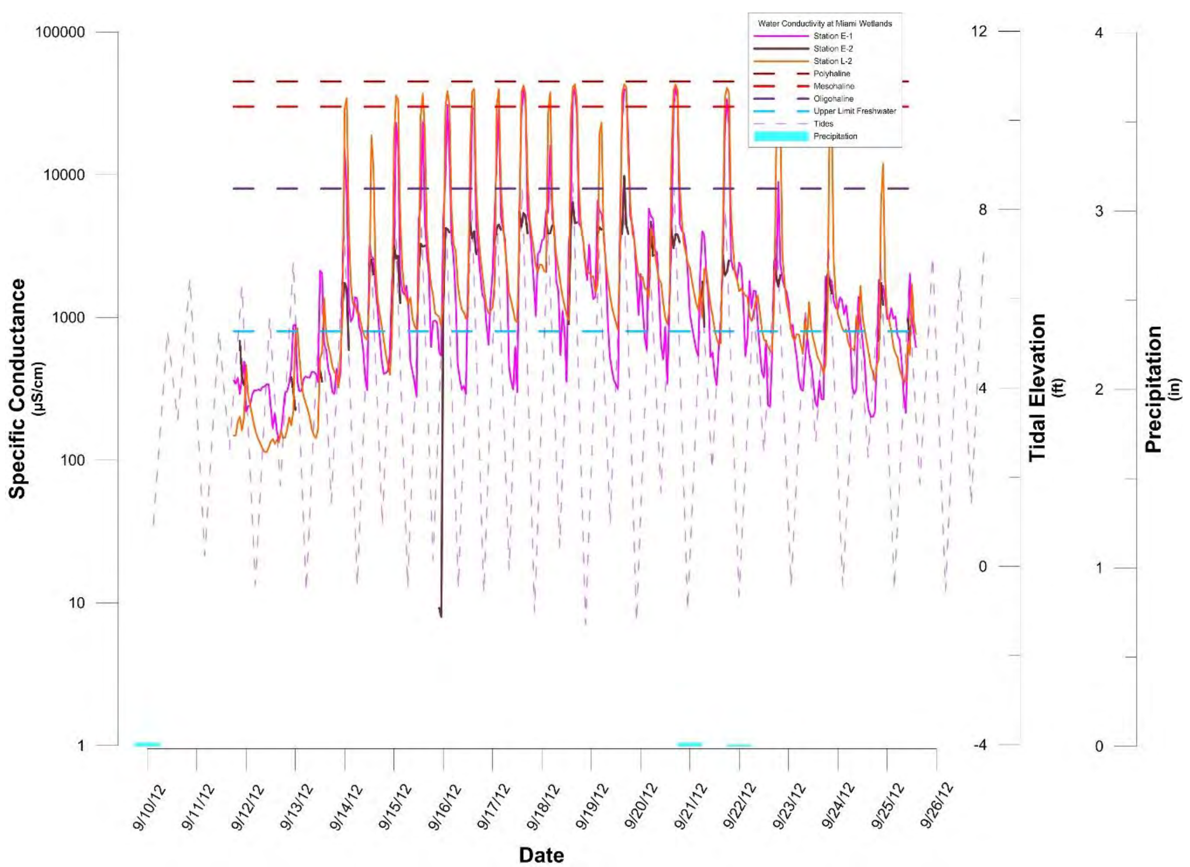
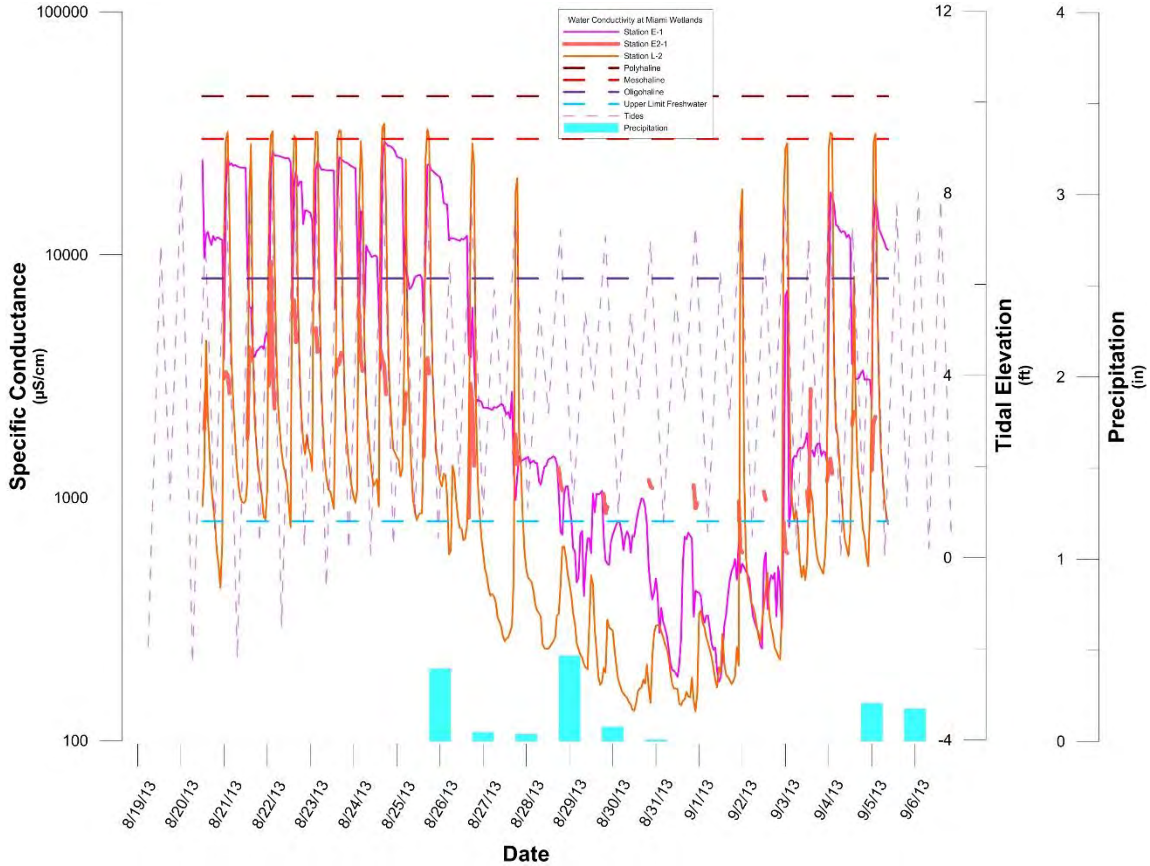


Figure D3. continued



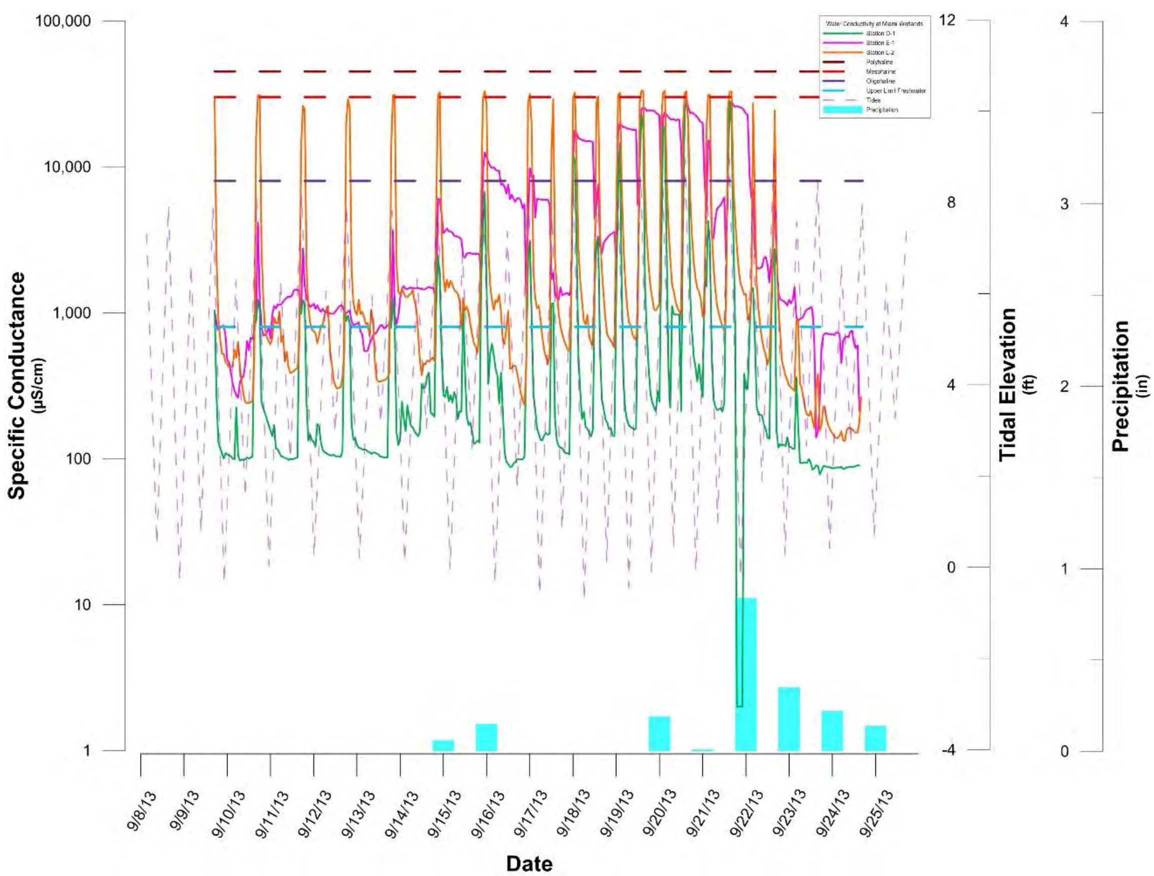
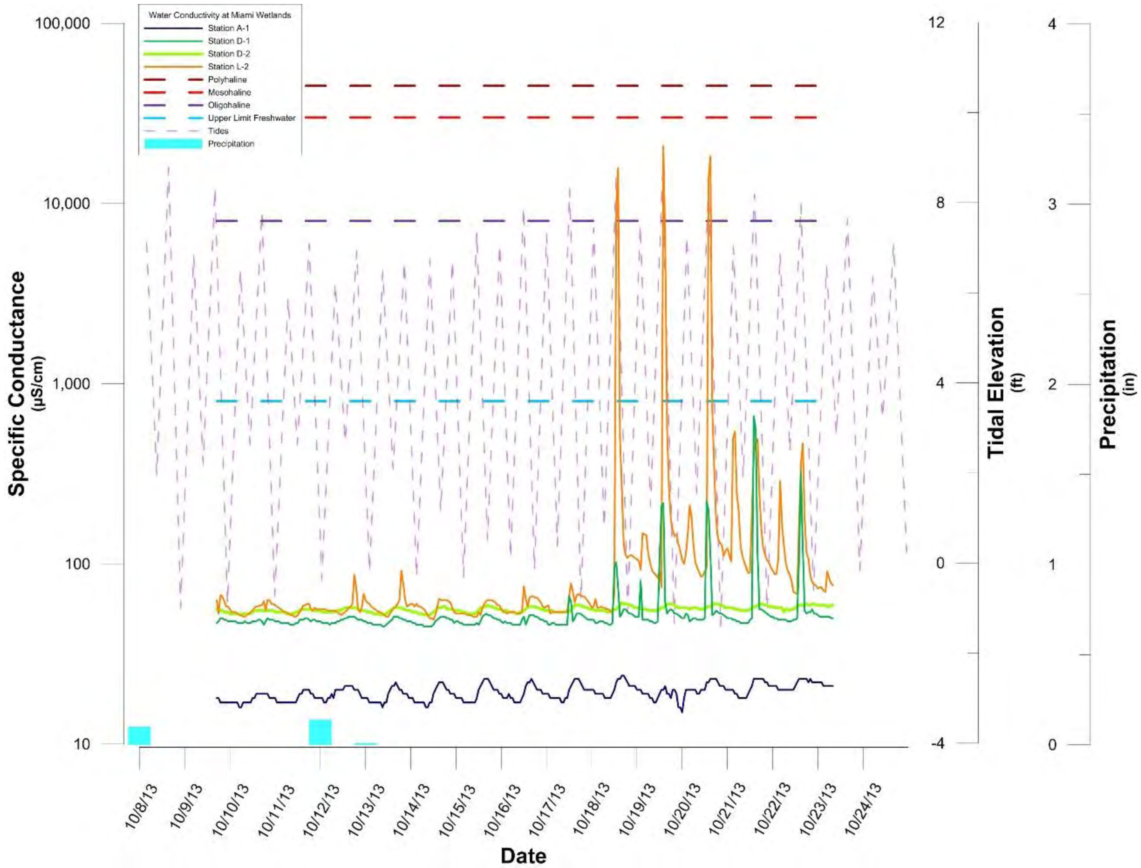


Figure D3. continued



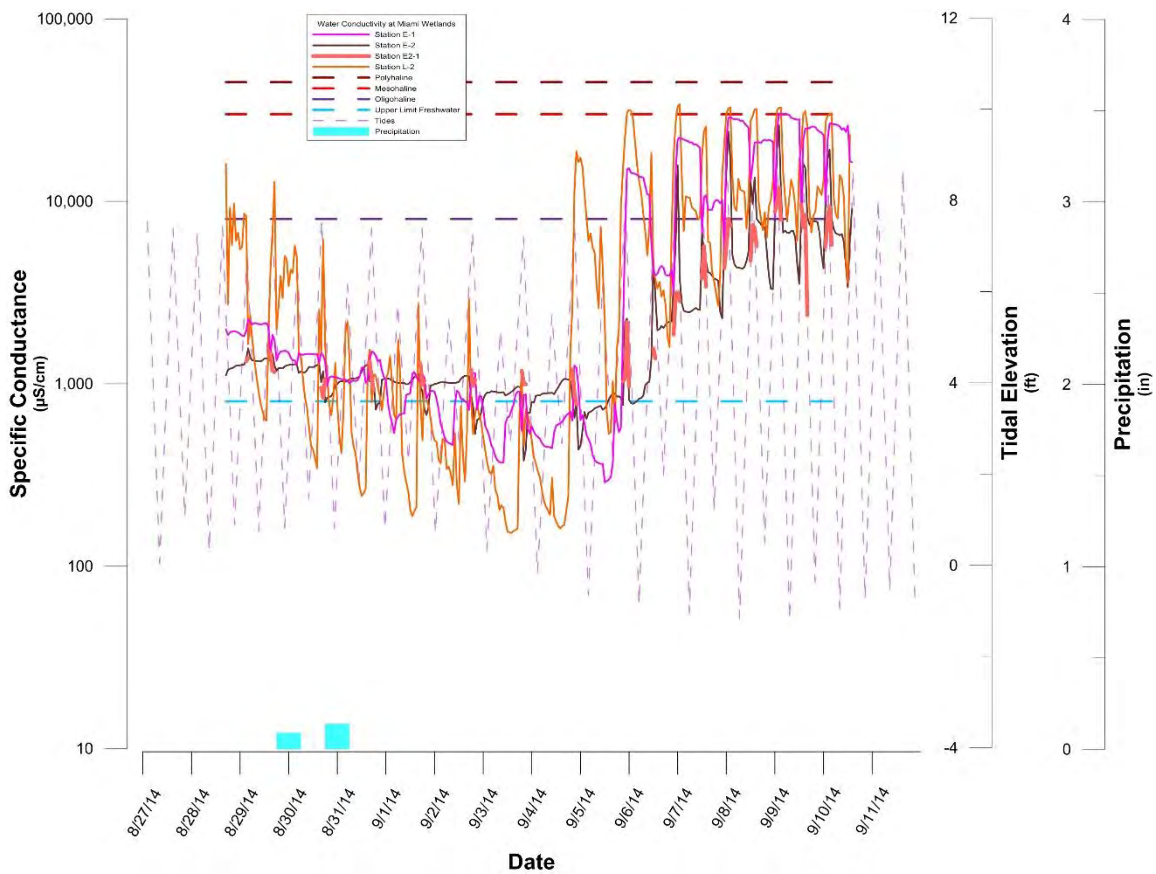
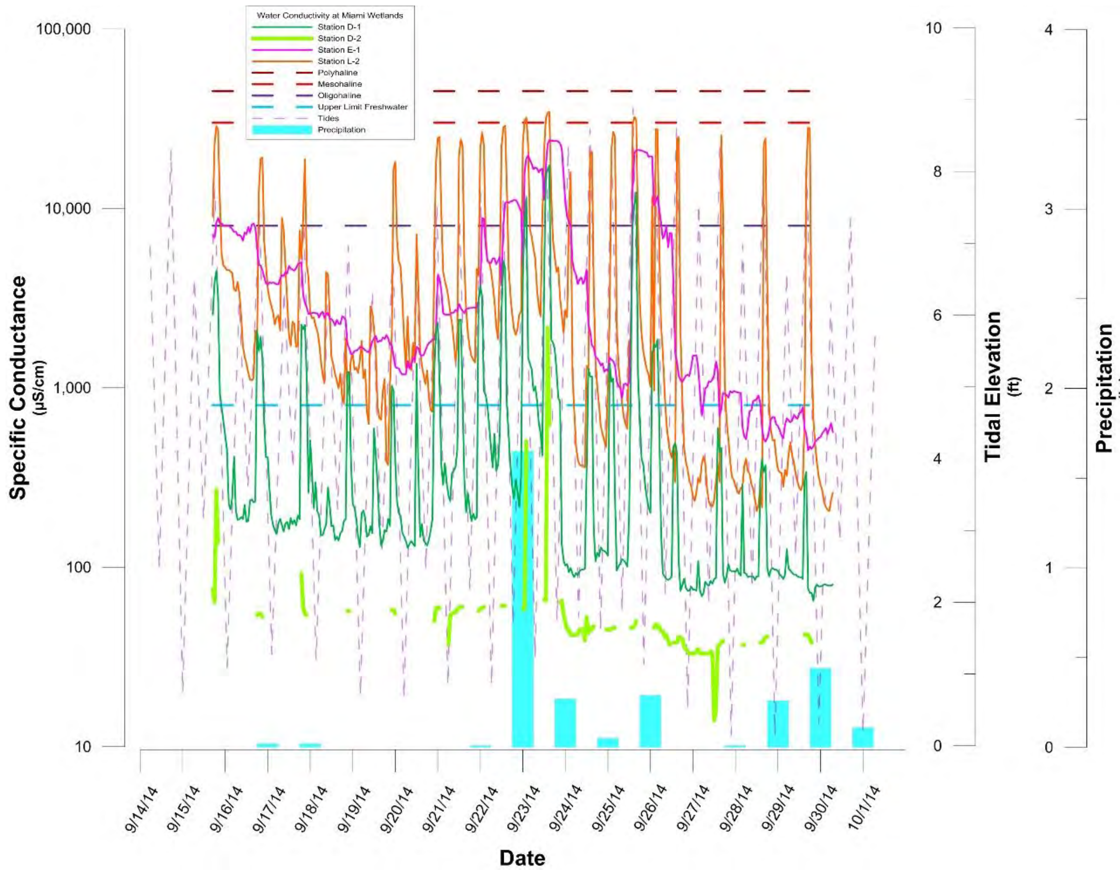


Figure D3. continued



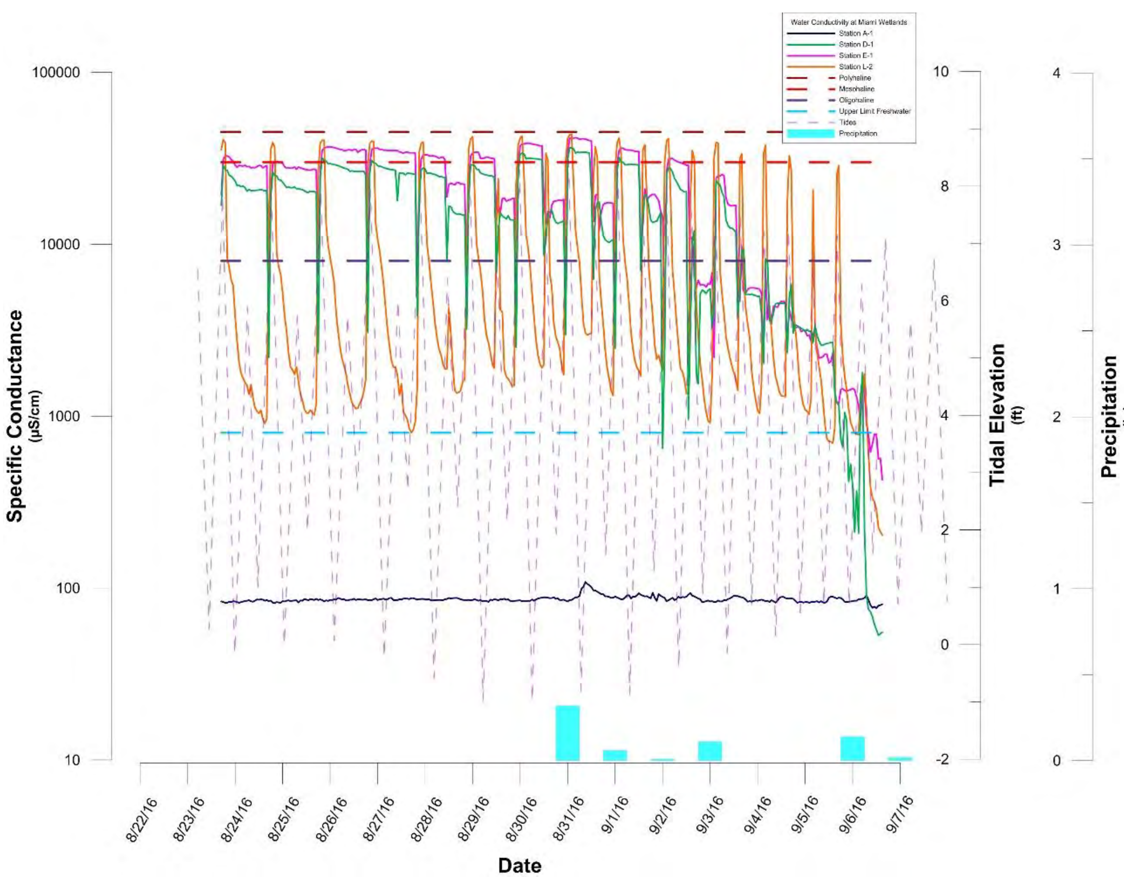
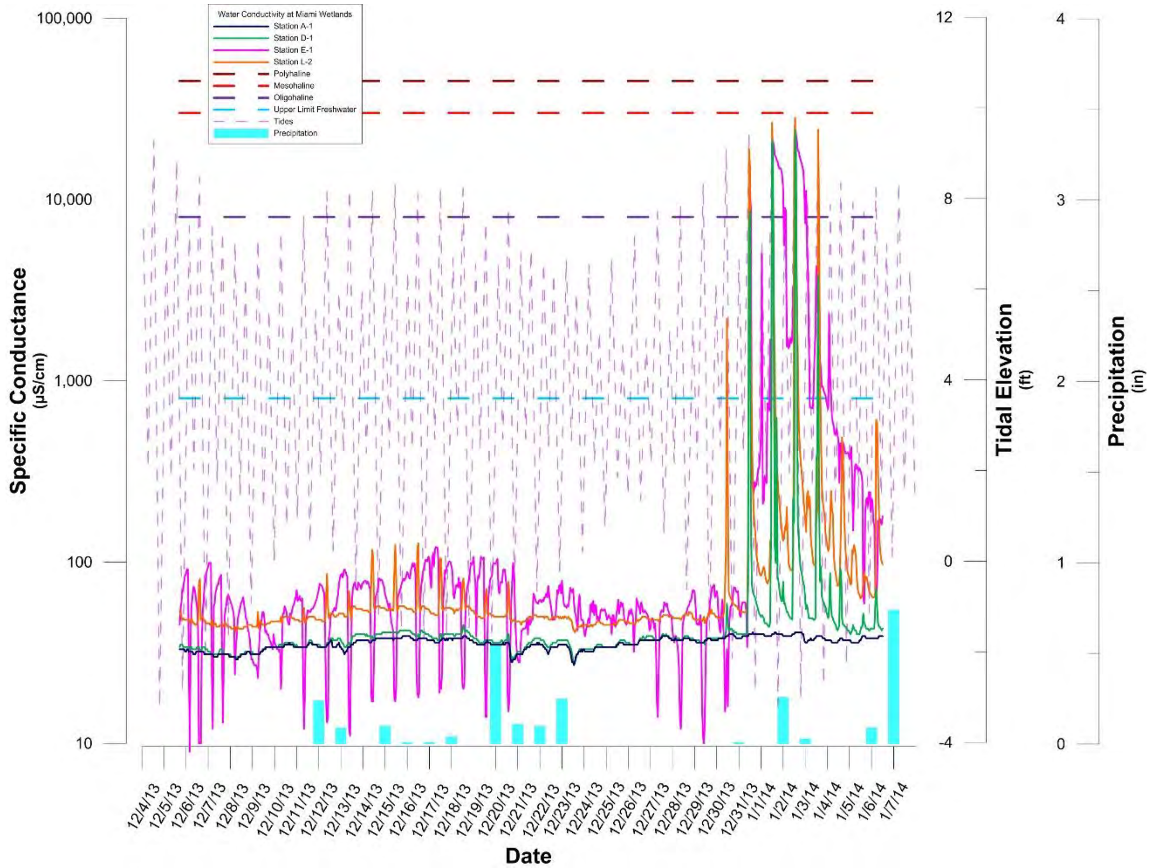


Figure D4. Graphs depicting post-restoration specific conductance levels in constructed channels at the Miami Wetlands during winter 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



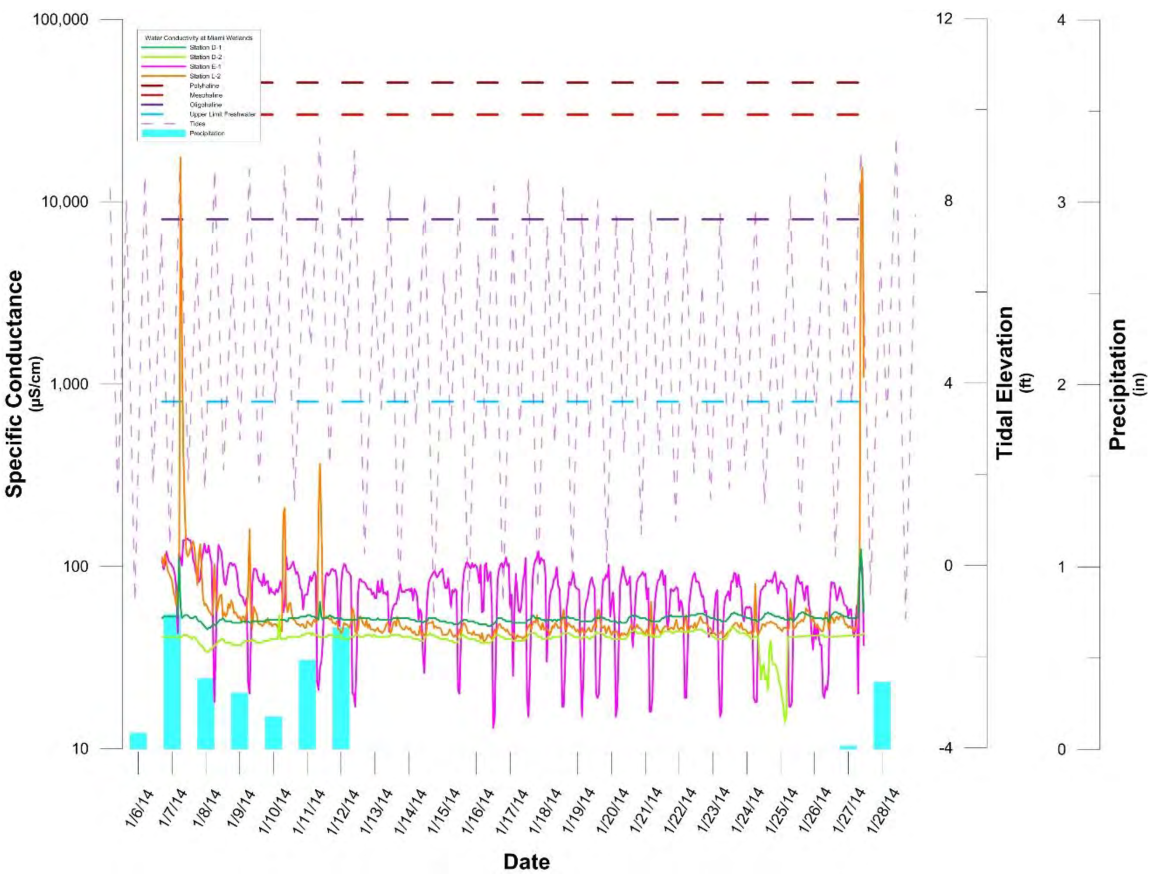
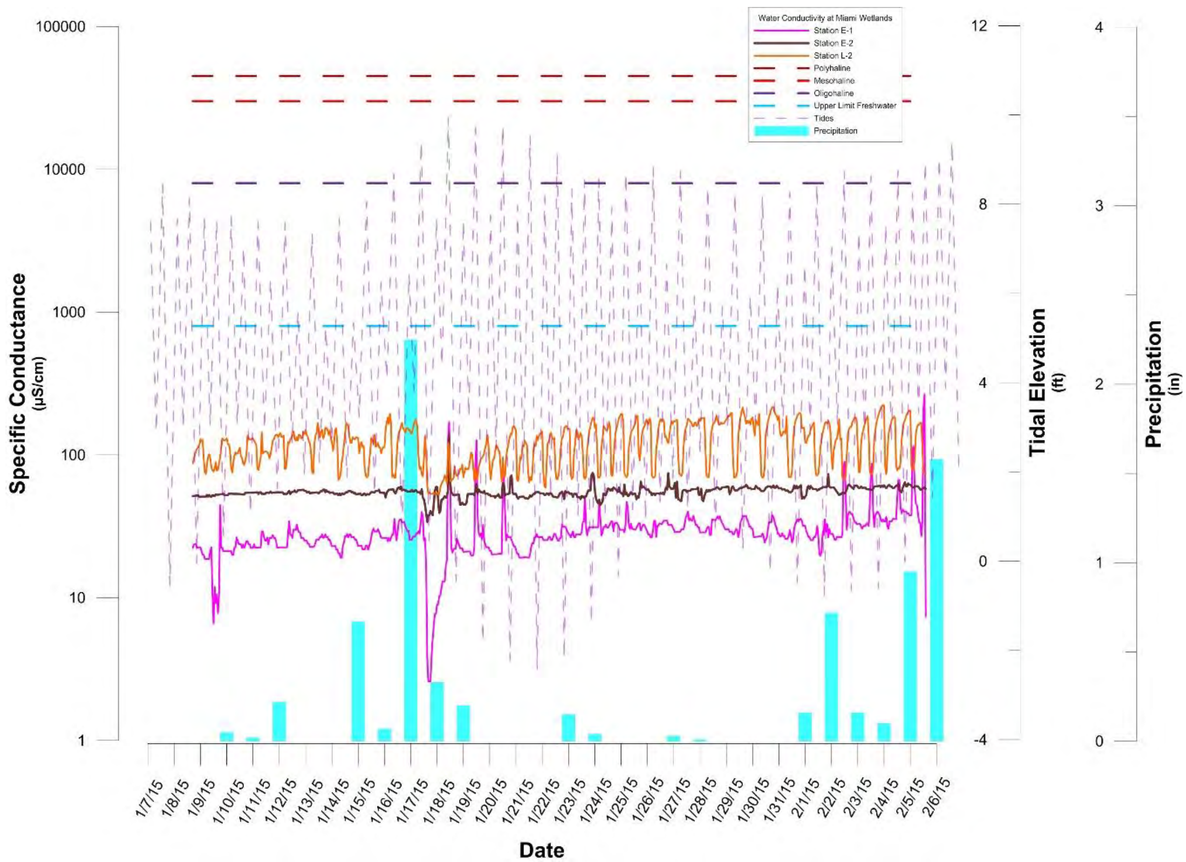


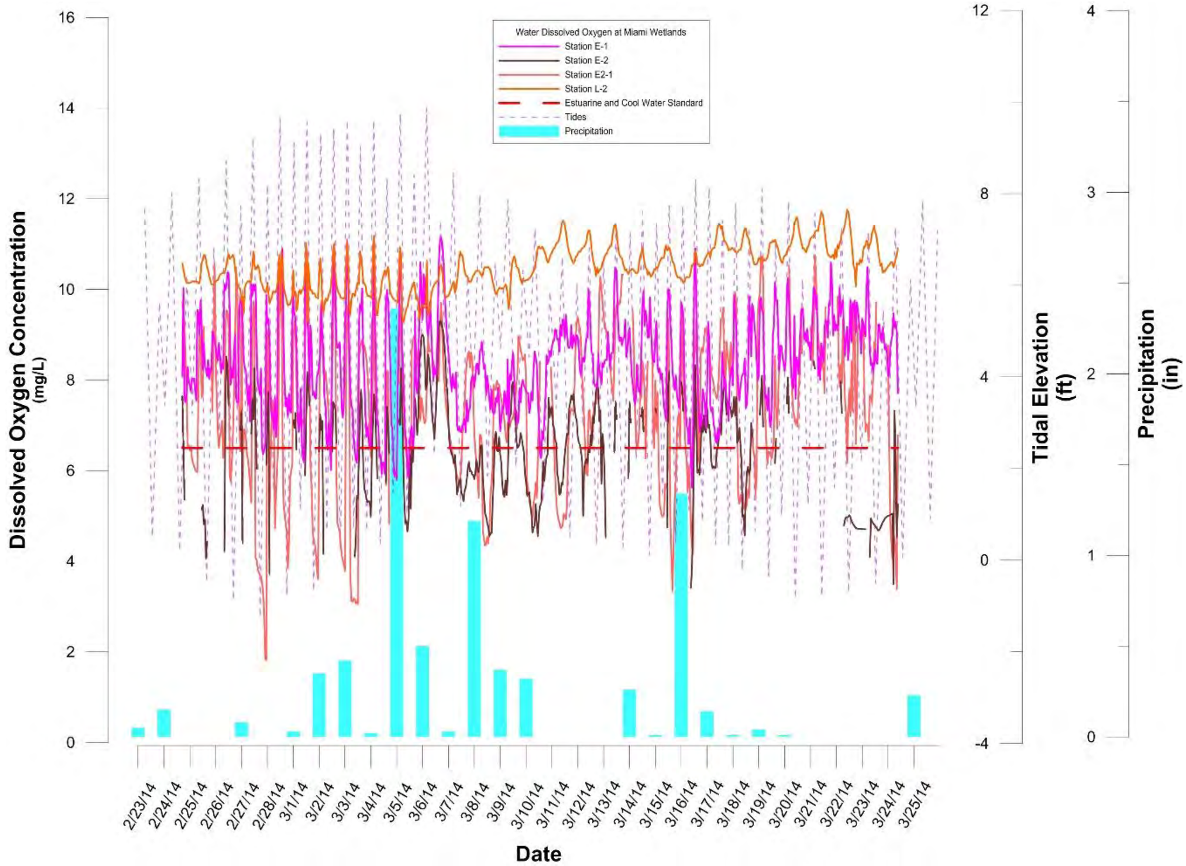
Figure D4. continued



Appendix E

Graphs depicting post-restoration dissolved oxygen levels for water in constructed channels at the Miami Wetlands

Figure E1. Graphs depicting post-restoration dissolved oxygen levels in constructed channels at the Miami Wetlands during spring 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



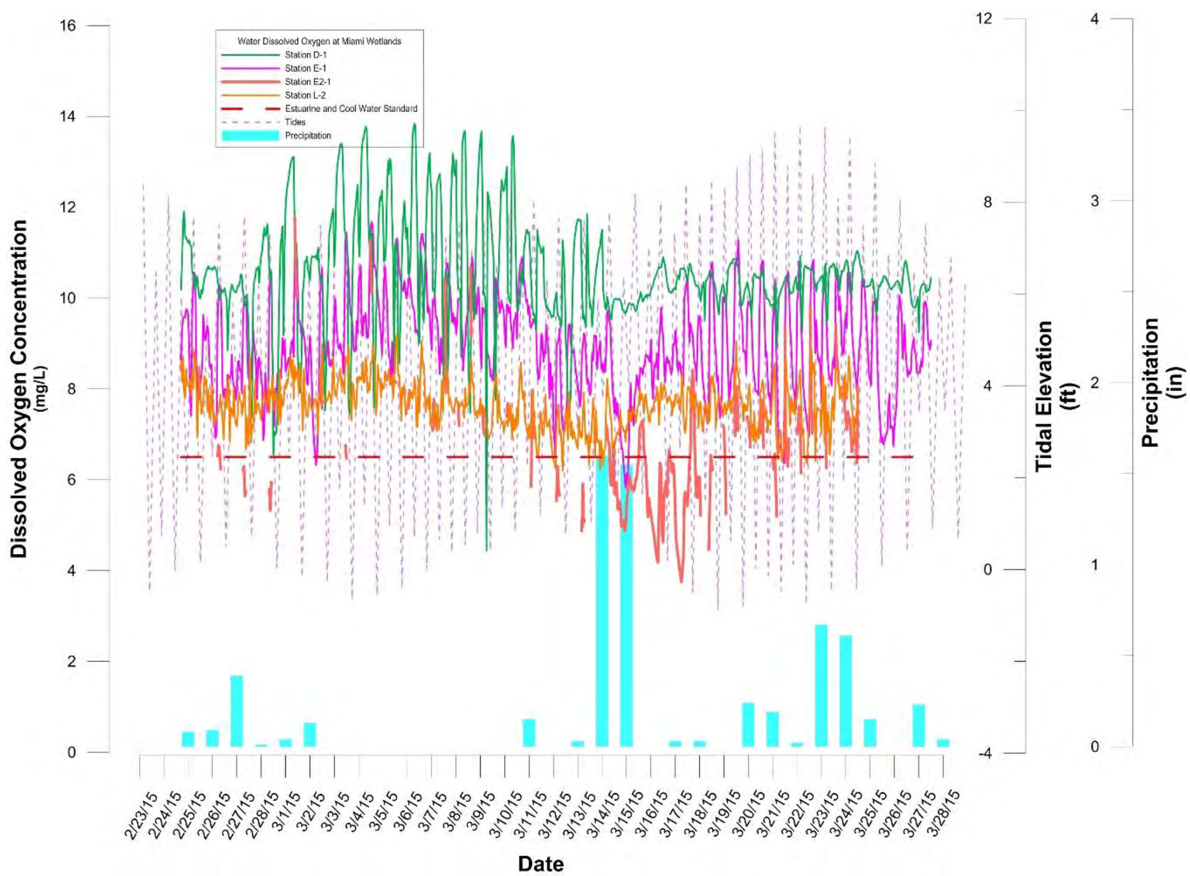


Figure E1. continued

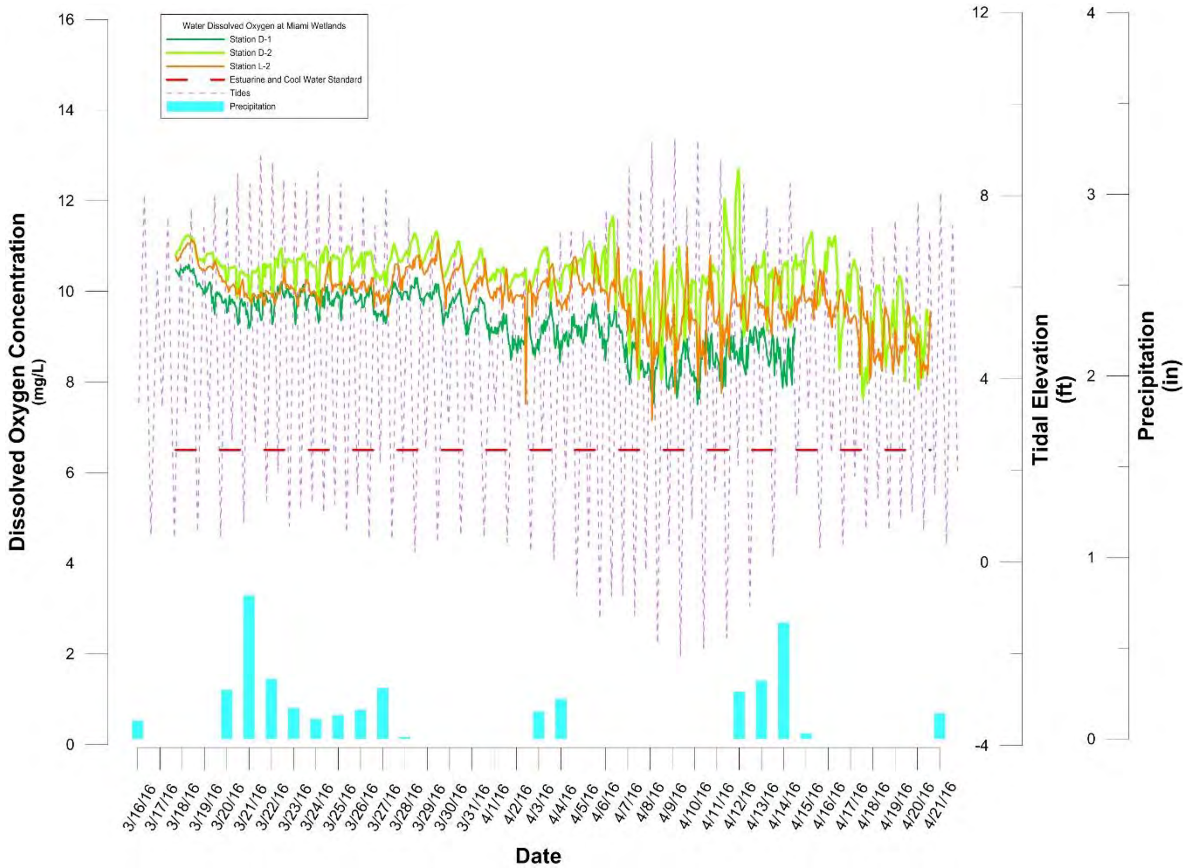
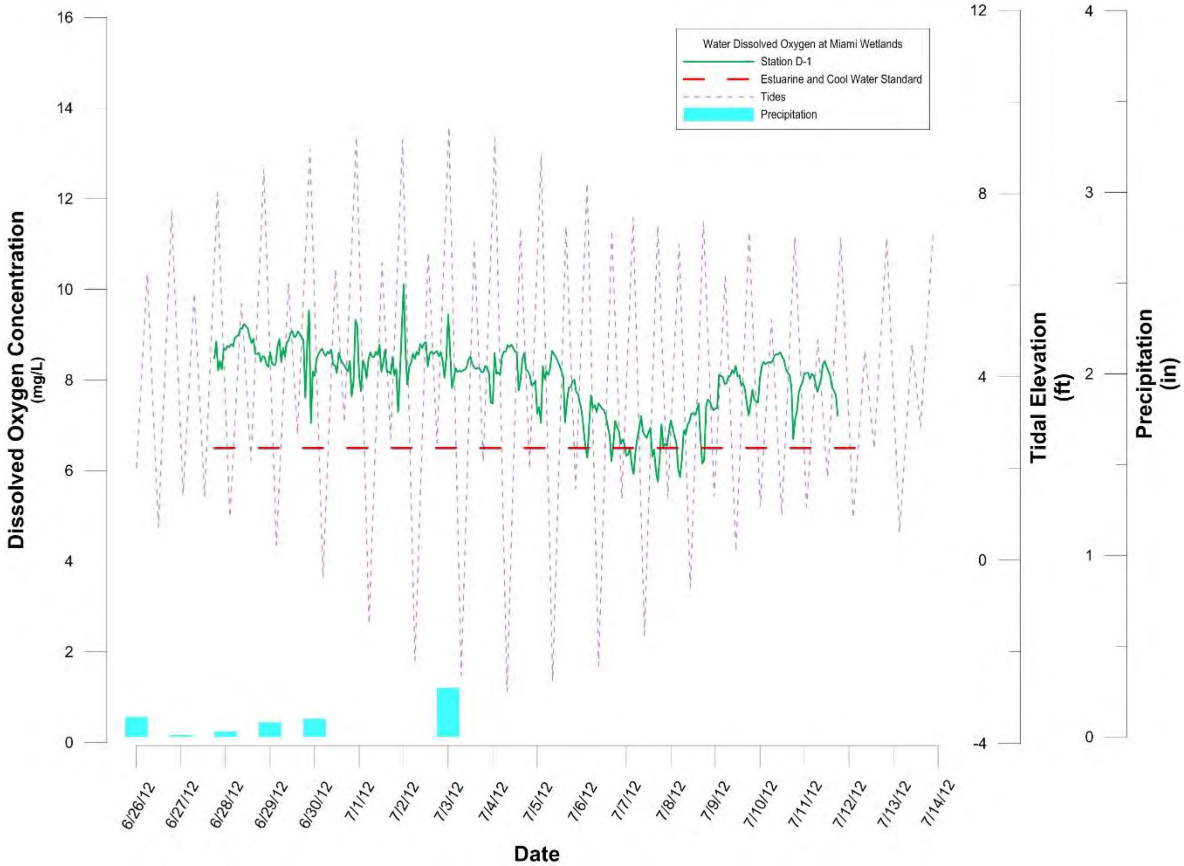


Figure E2. Graphs depicting post-restoration dissolved oxygen levels in constructed channels at the Miami Wetlands during summer 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



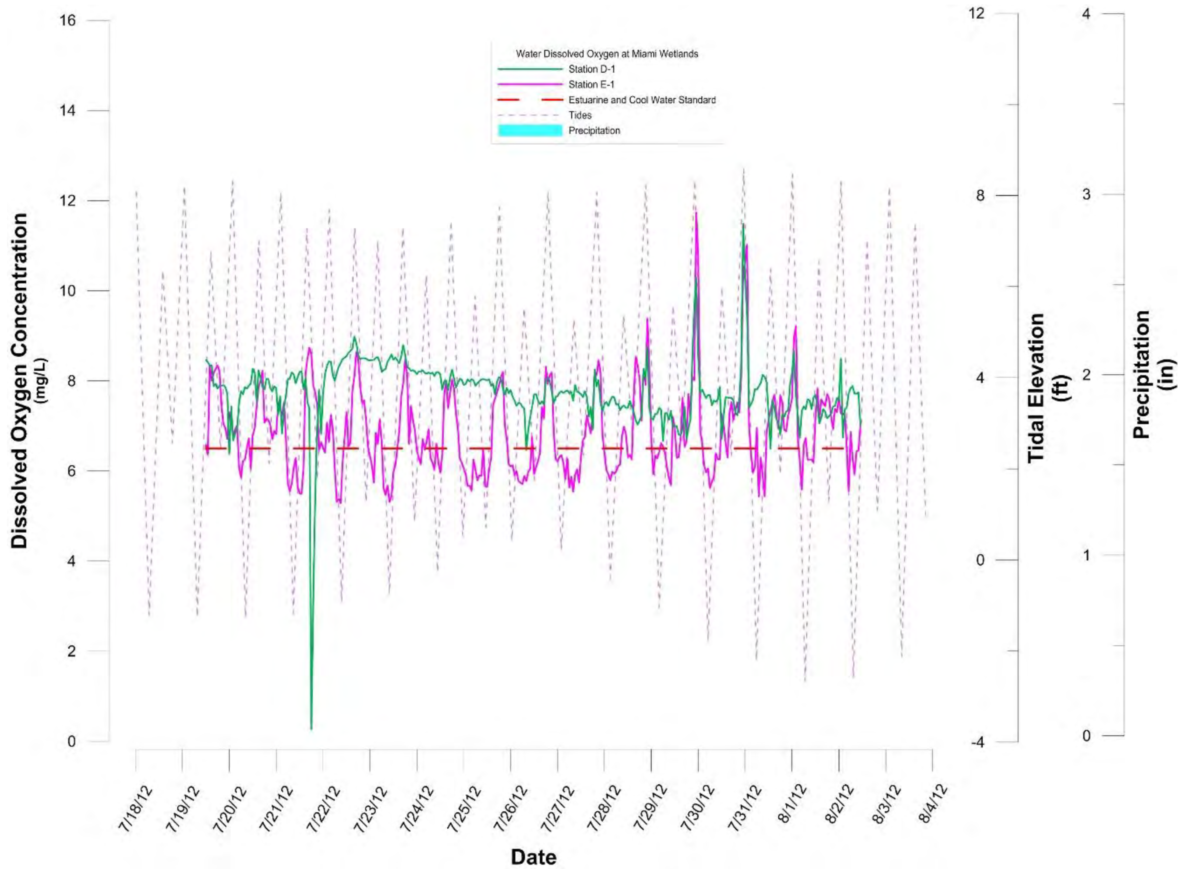
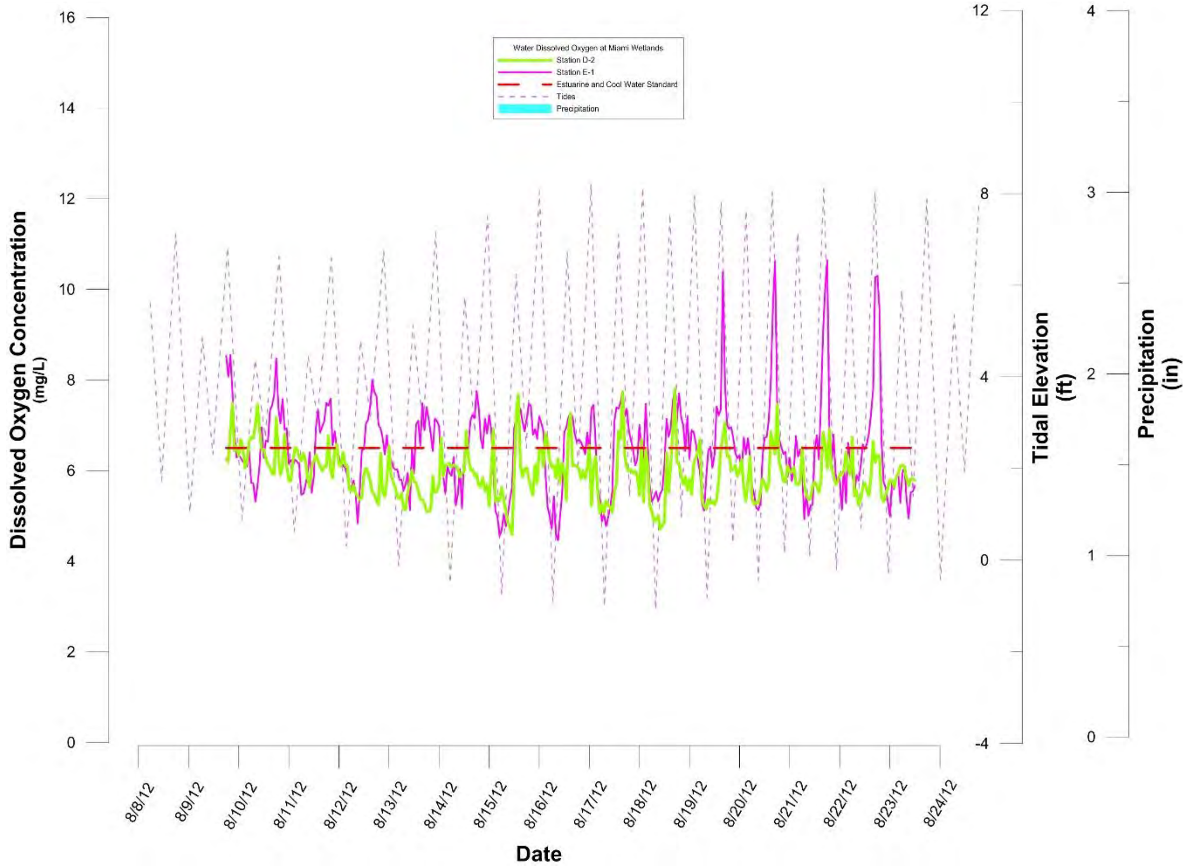


Figure E2. continued



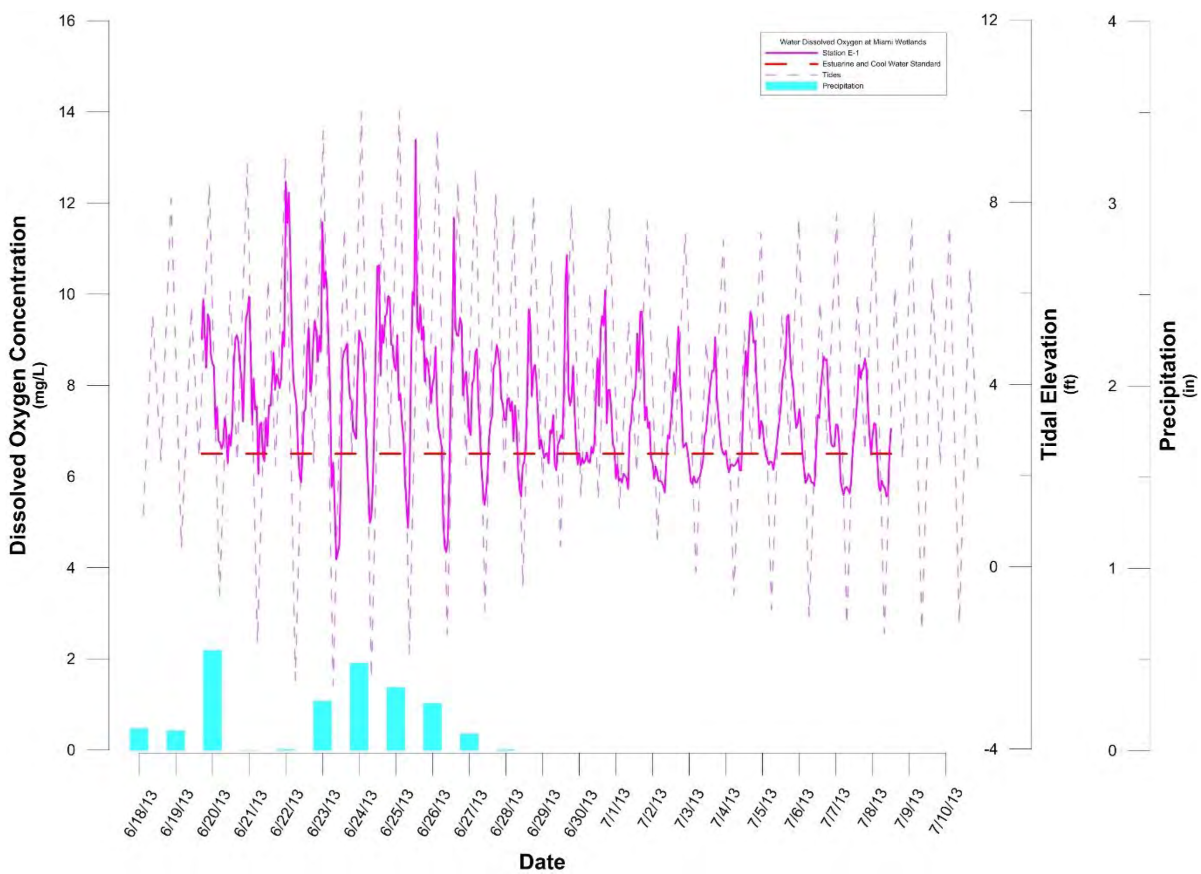
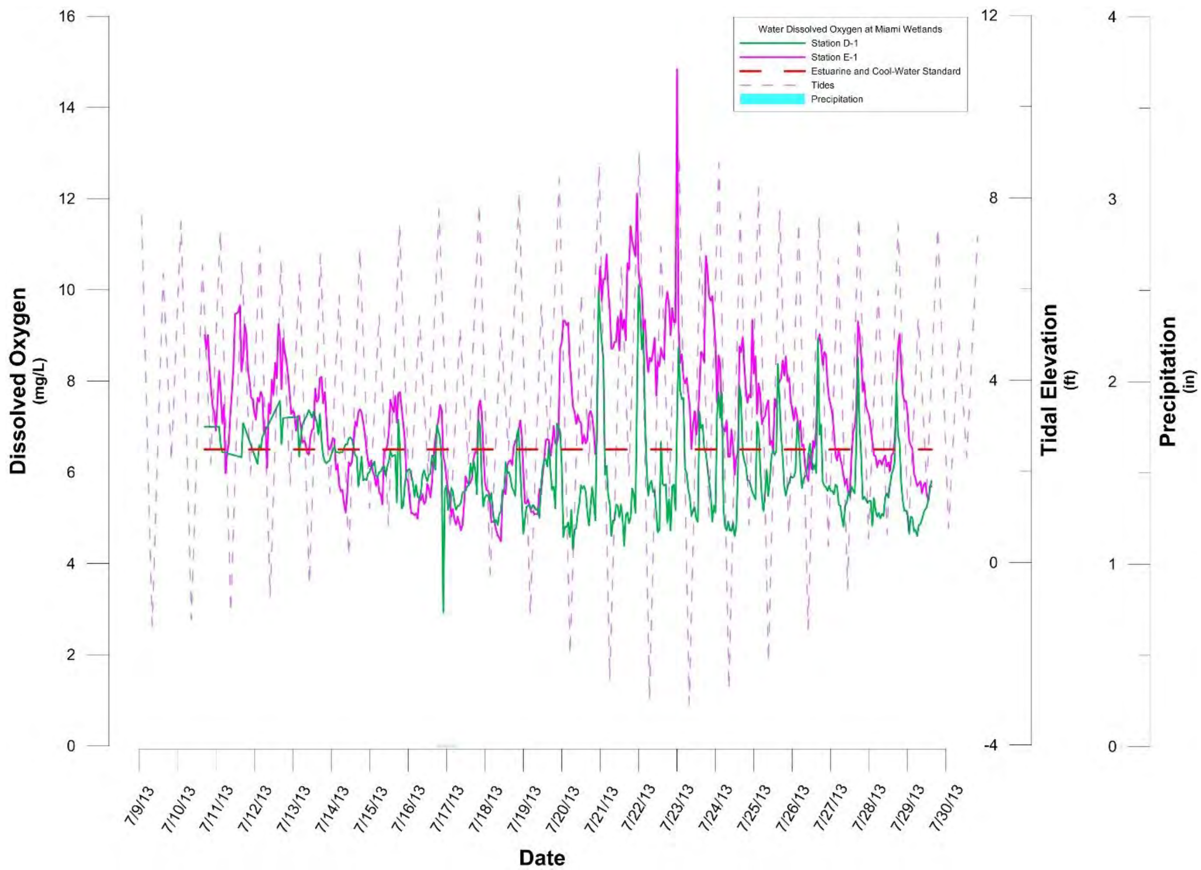


Figure E2. continued



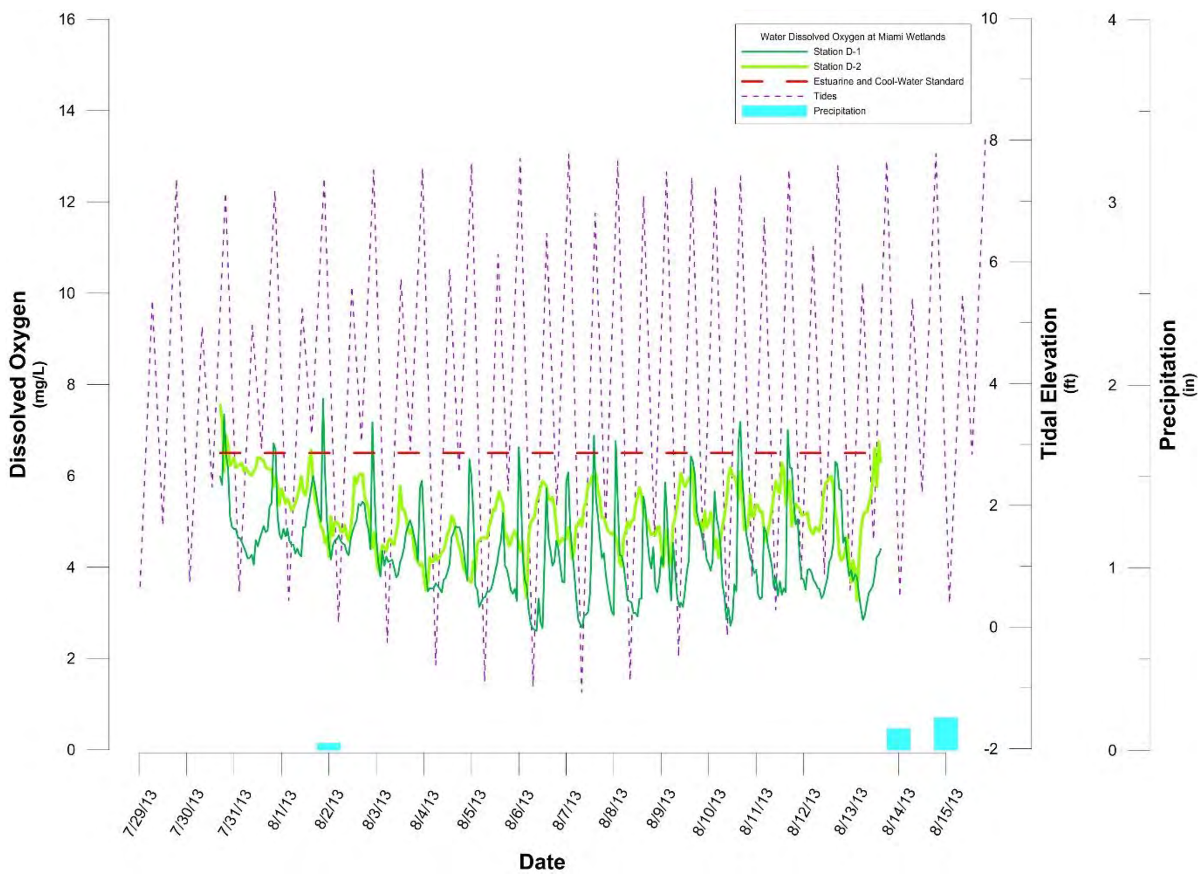
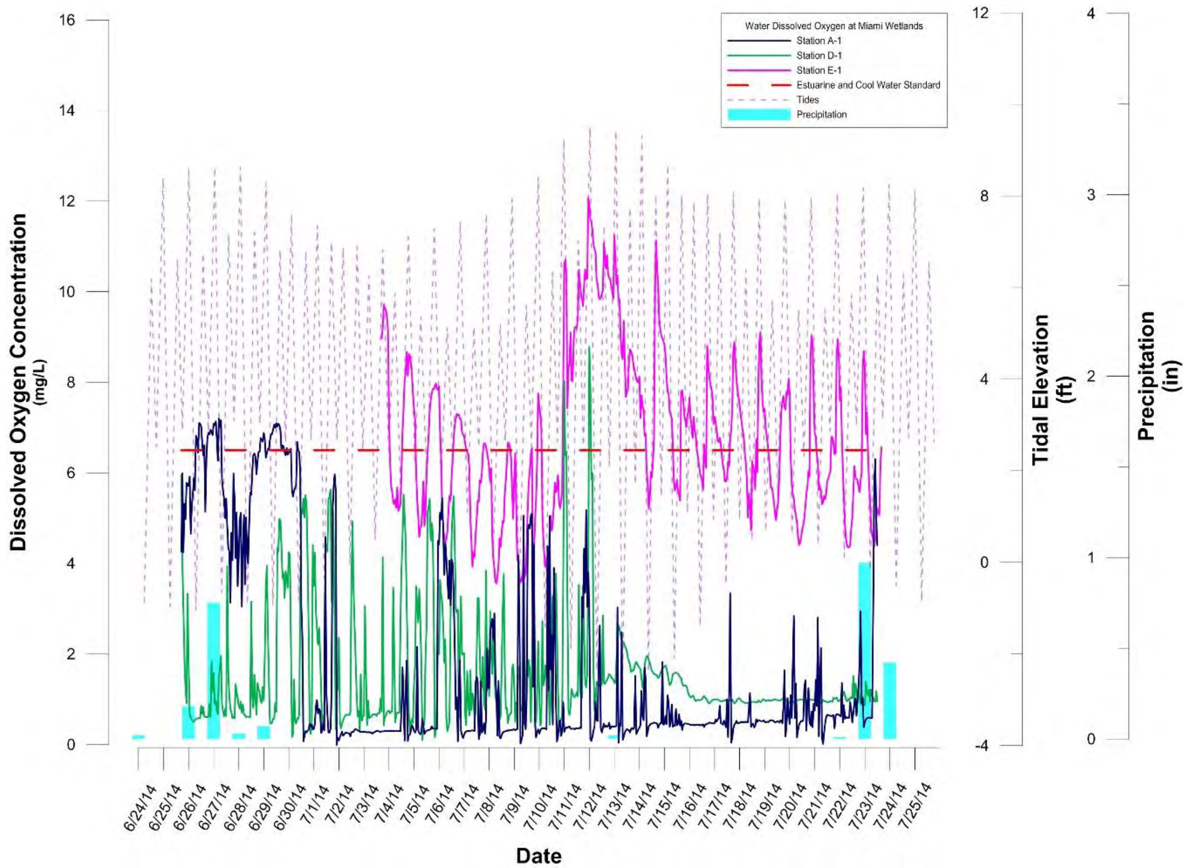


Figure E2. continued



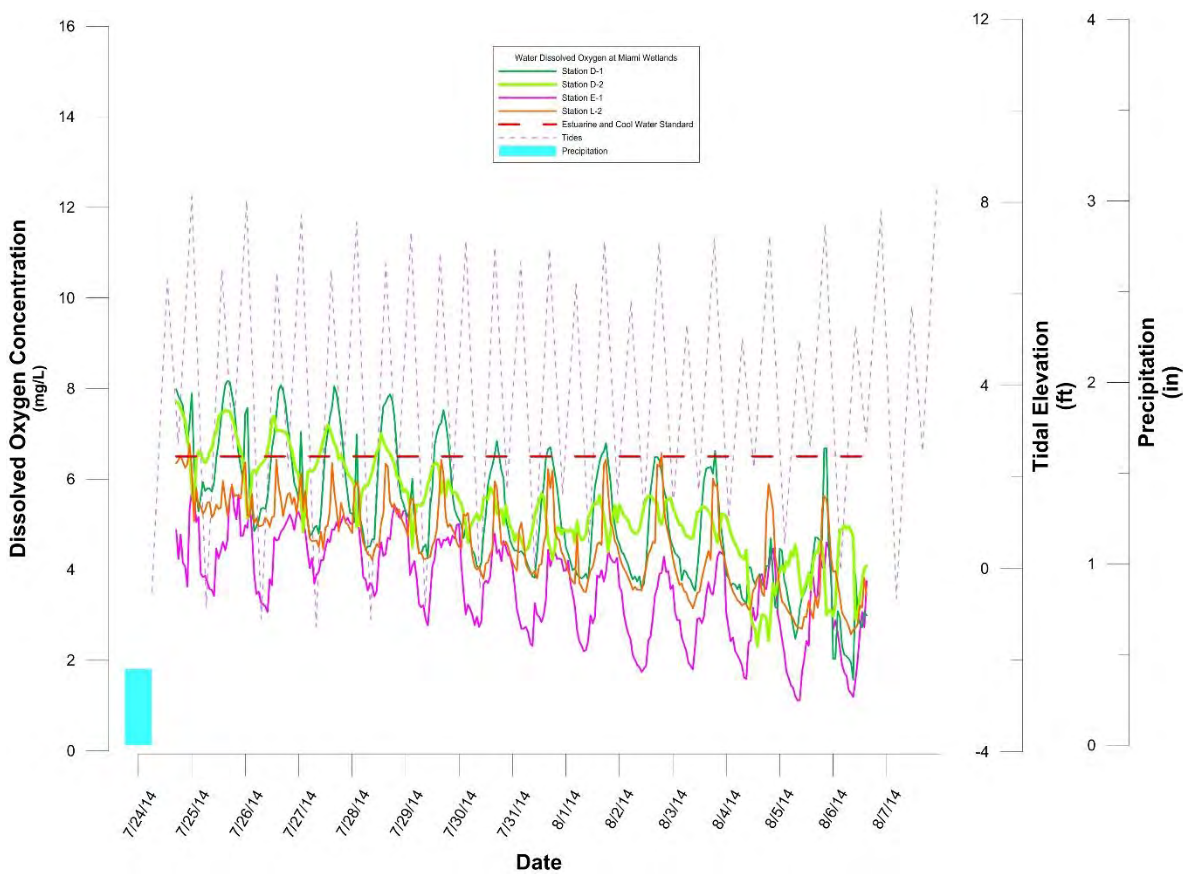
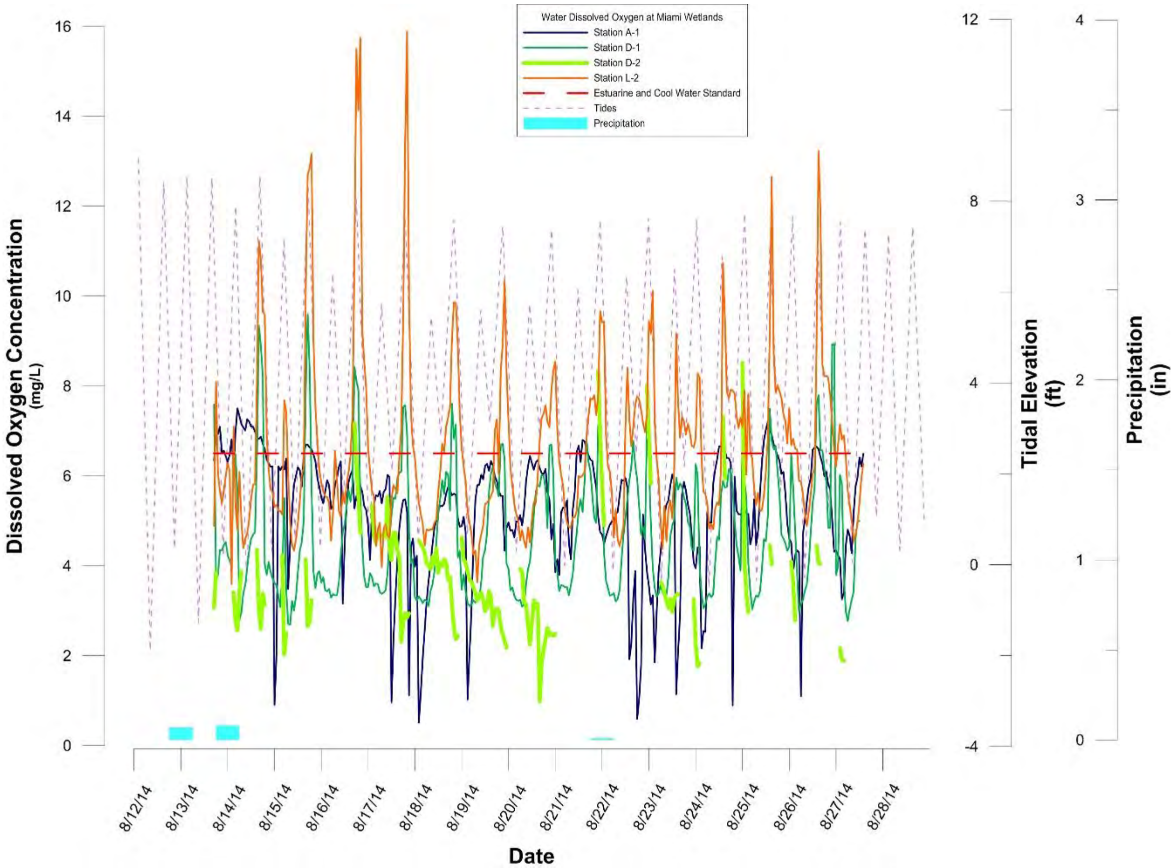


Figure E2. continued



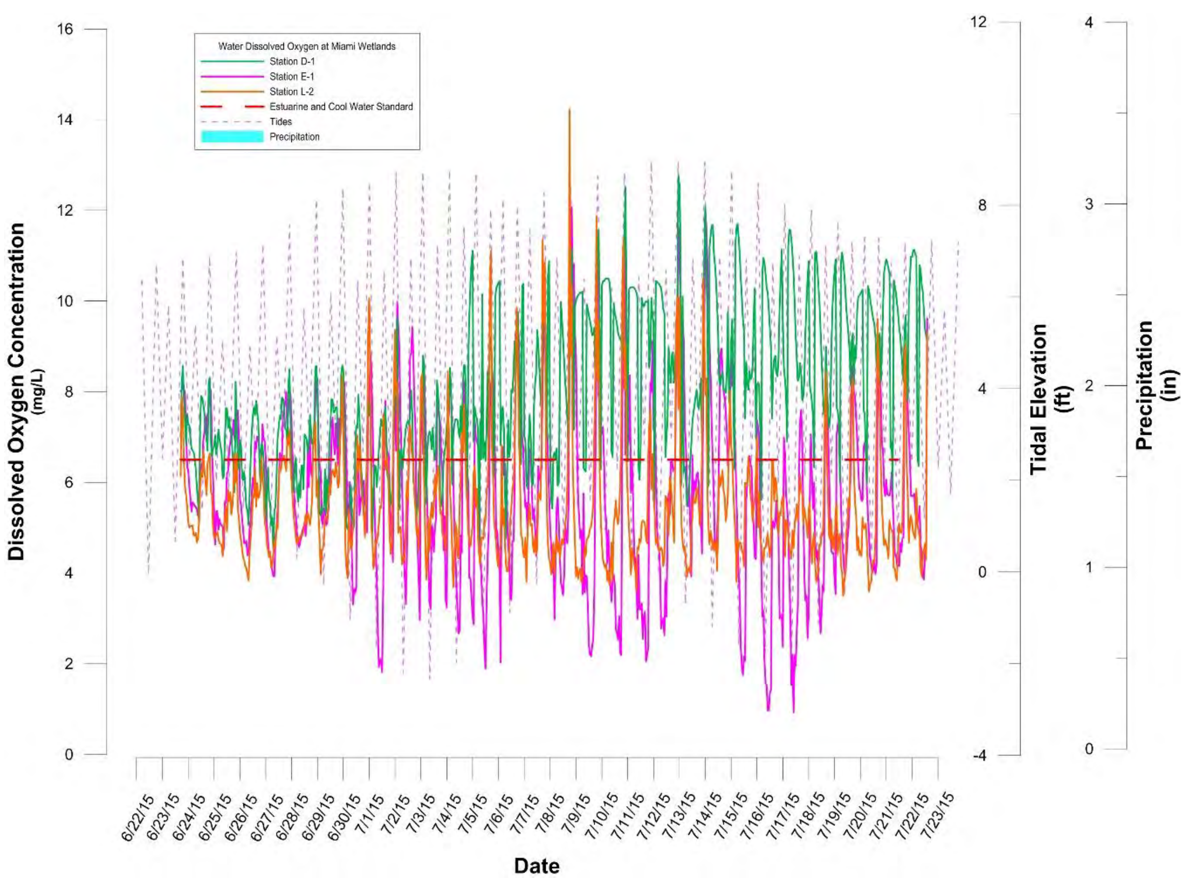
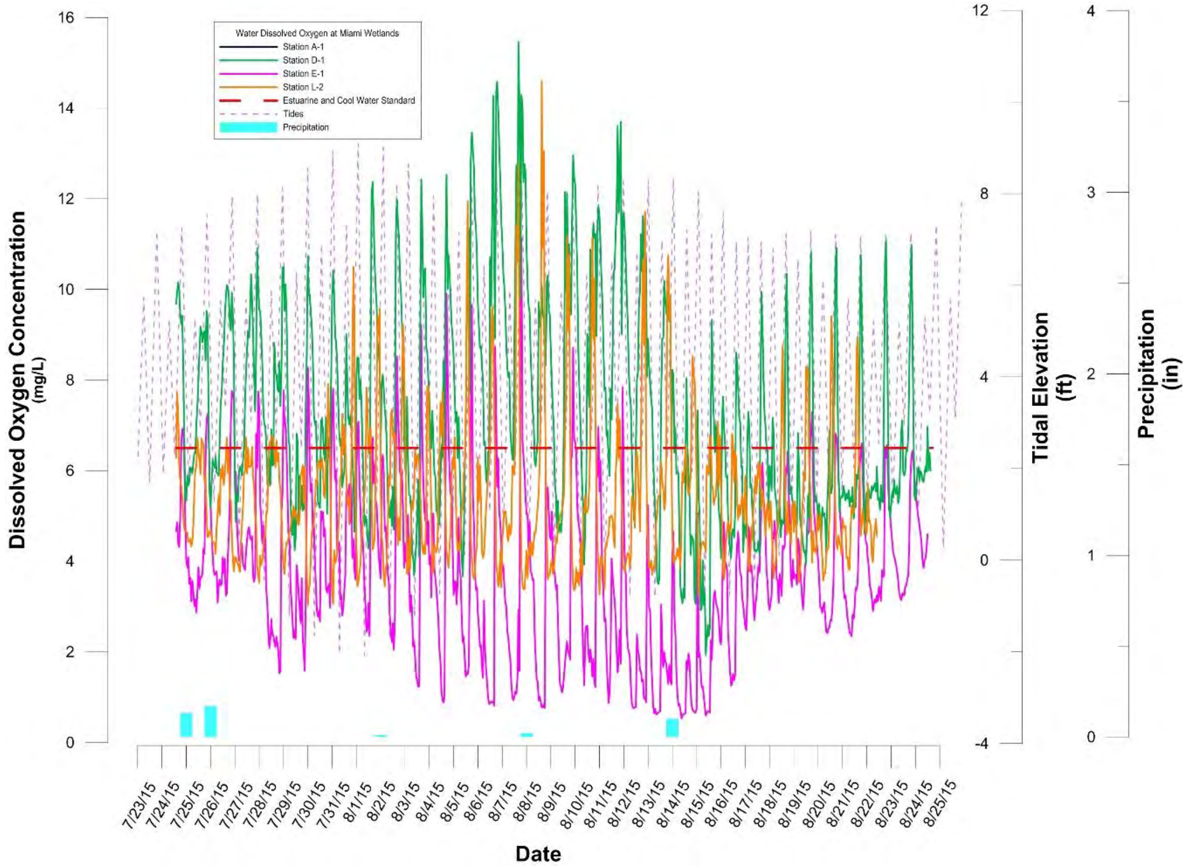


Figure E2. continued



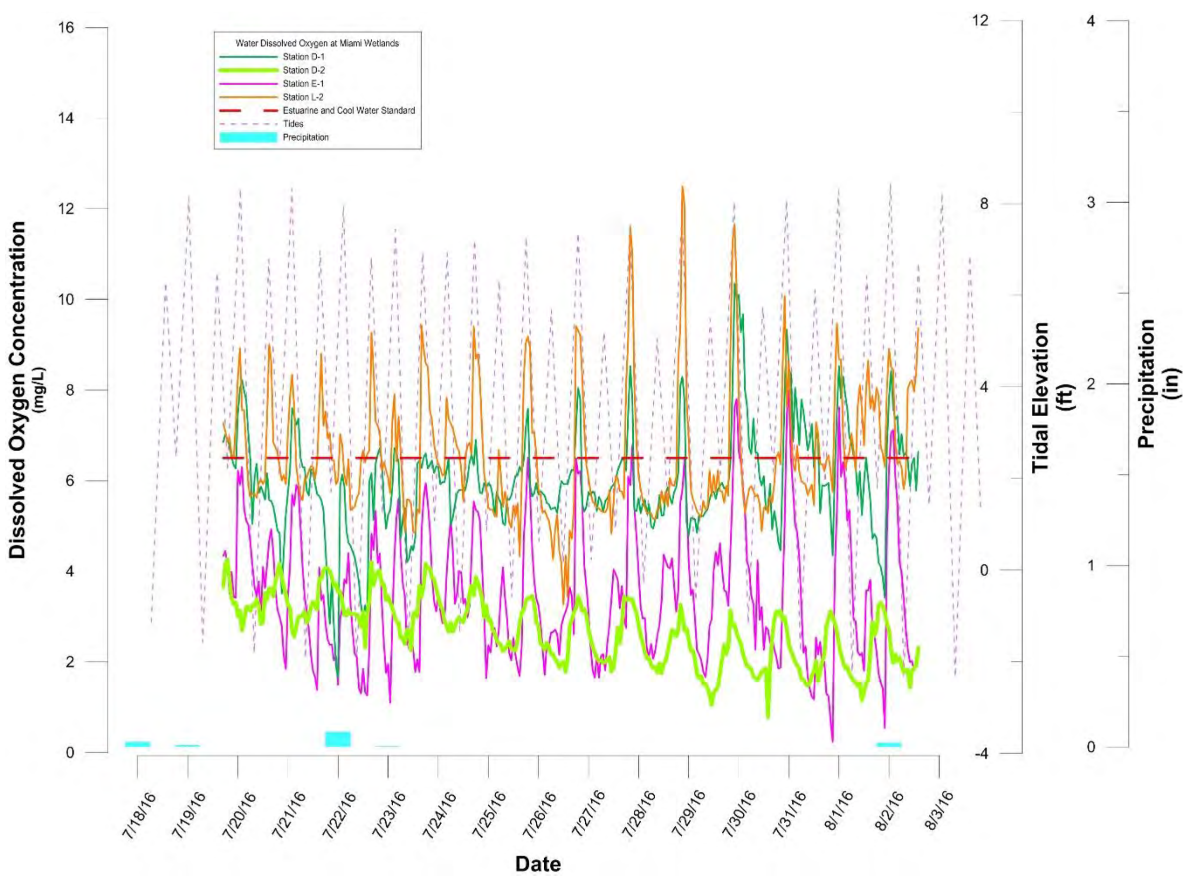
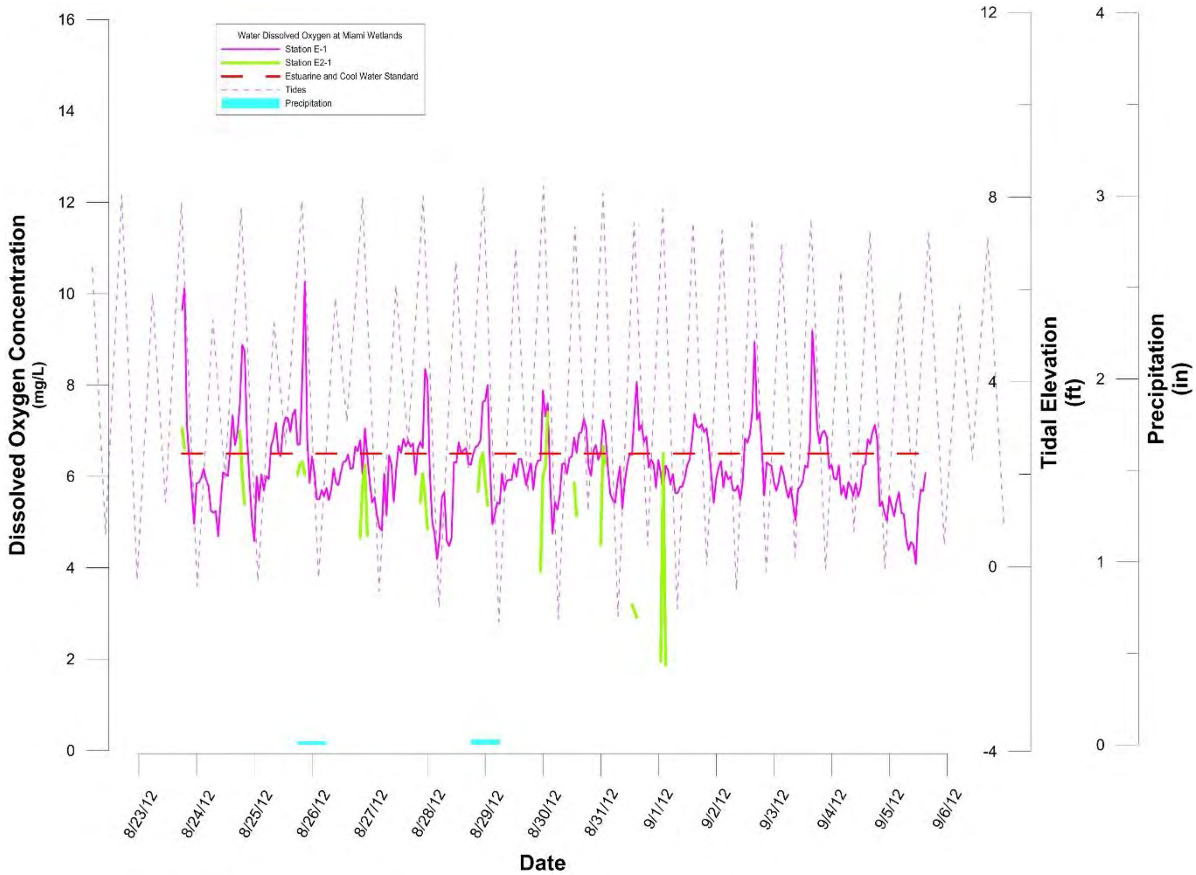


Figure E3. Graphs depicting post-restoration dissolved oxygen levels in constructed channels at the Miami Wetlands during fall 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



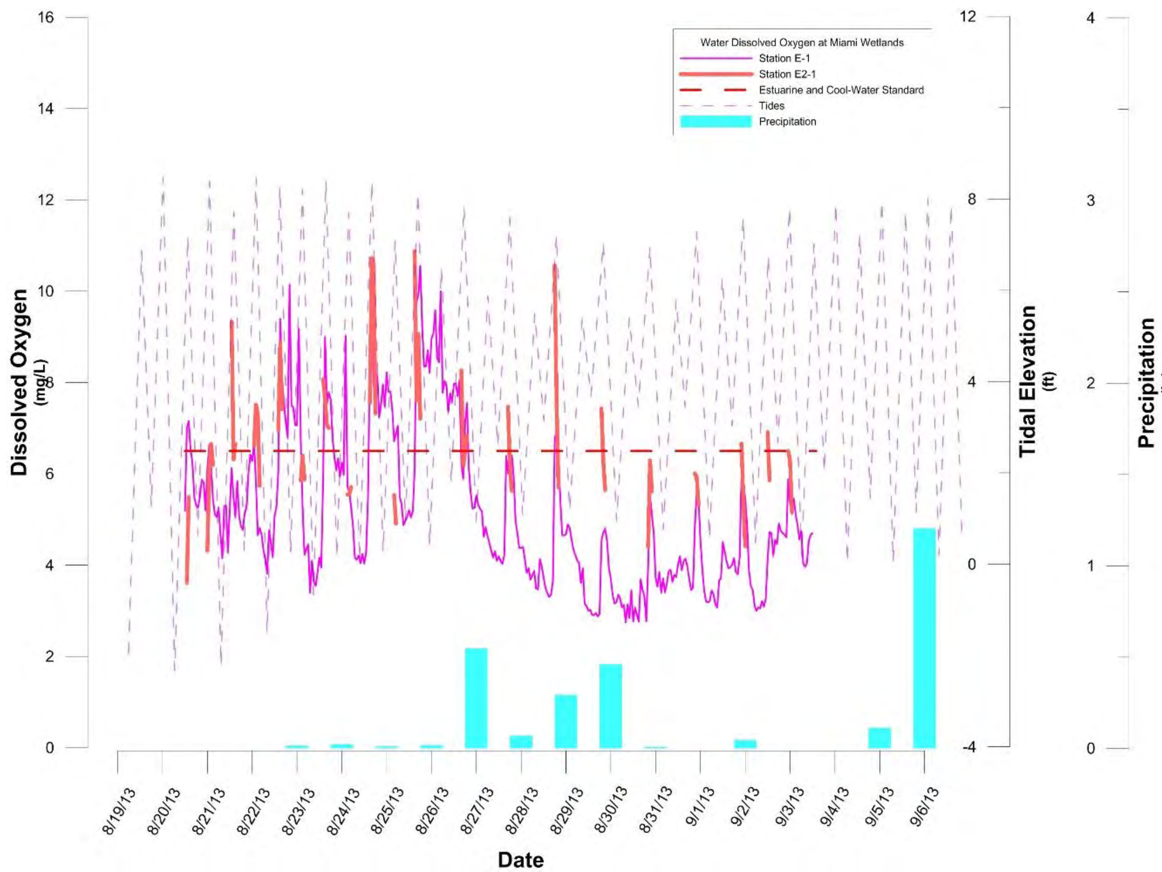
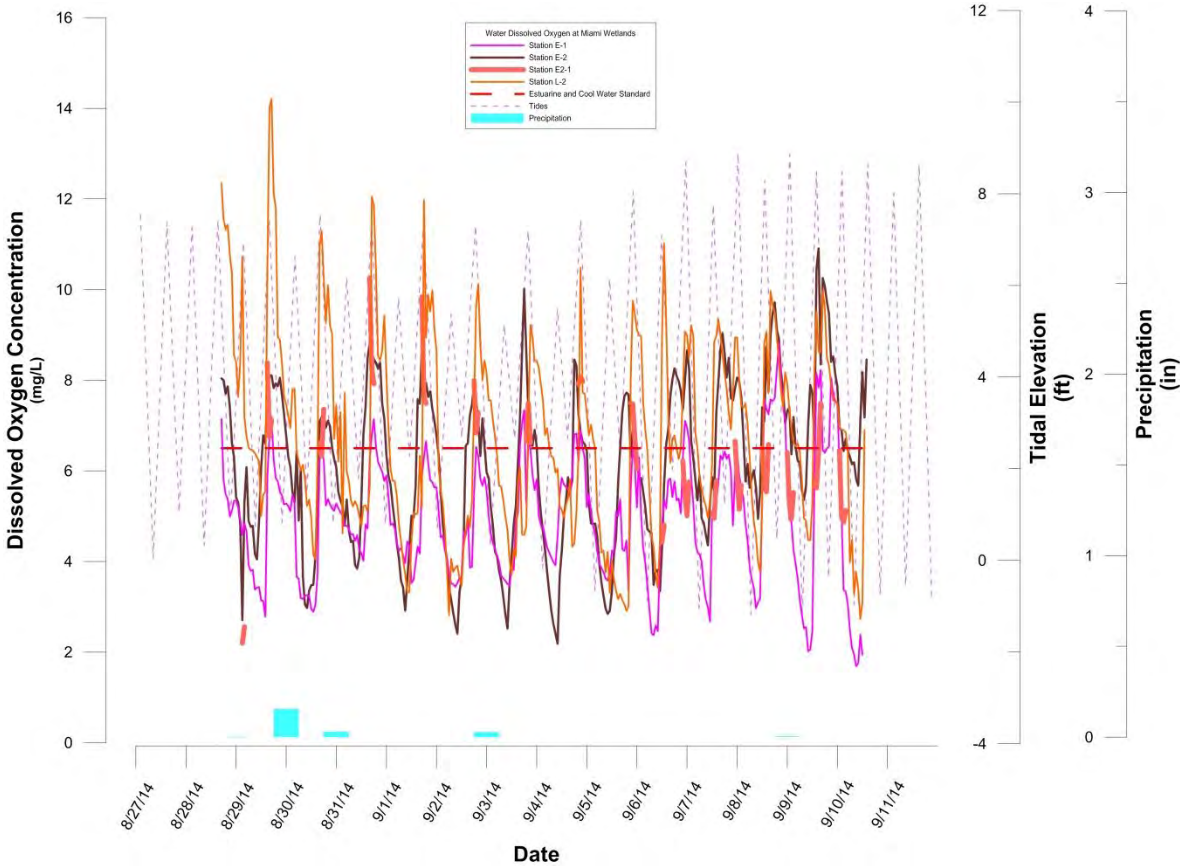


Figure E3. continued



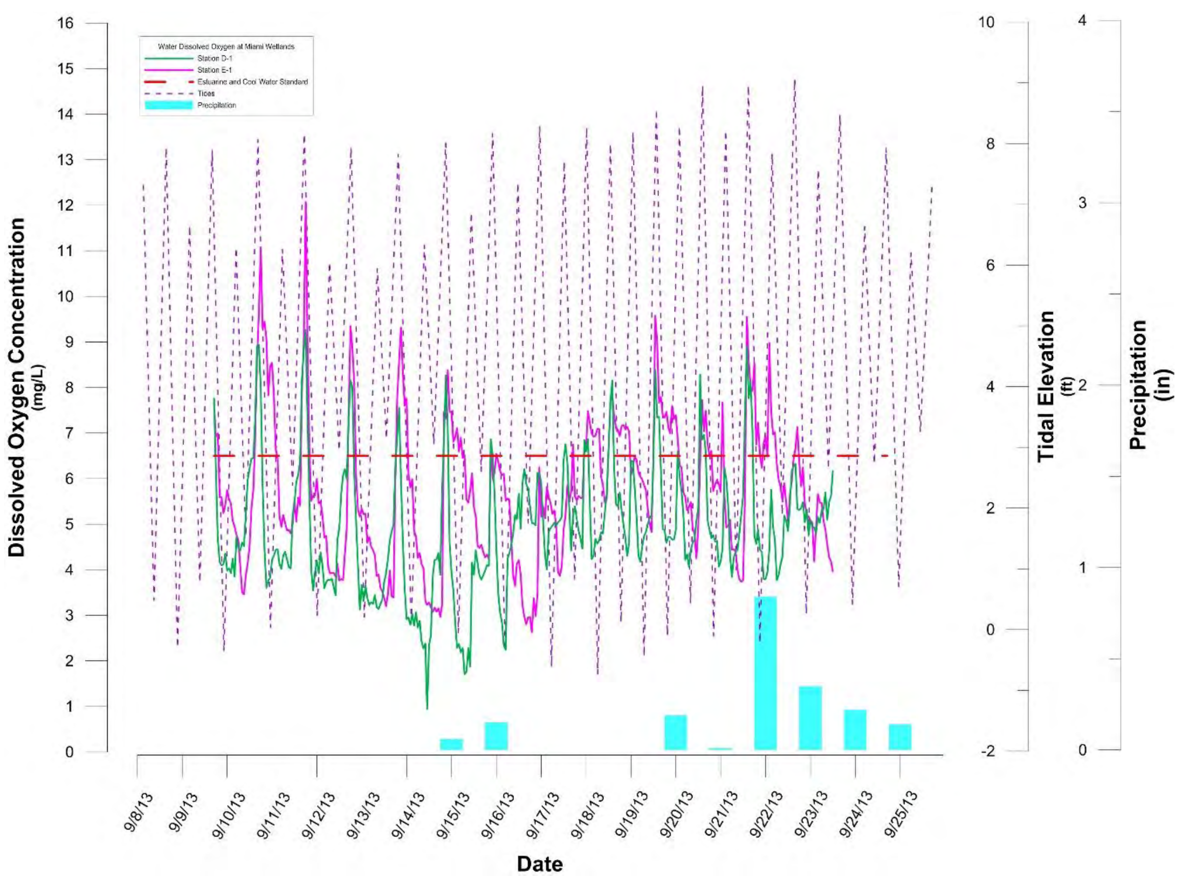
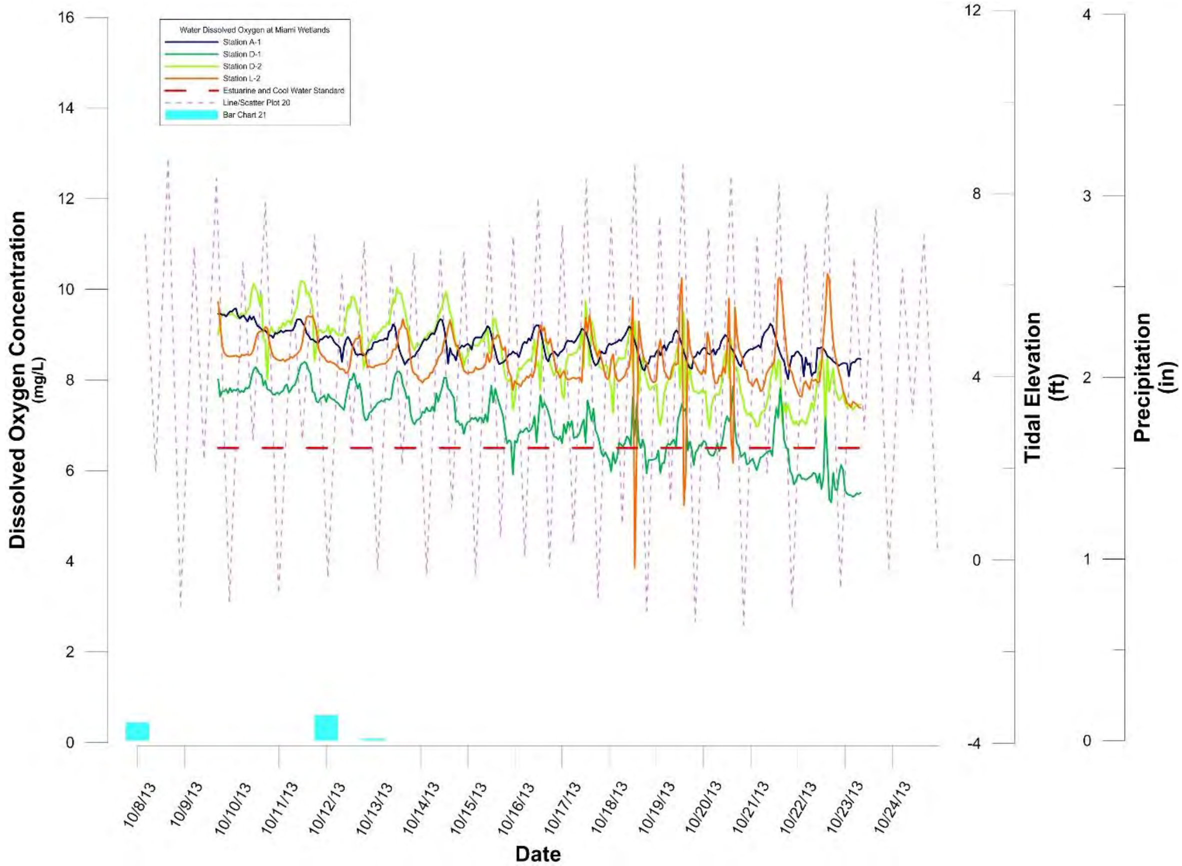


Figure E3. continued



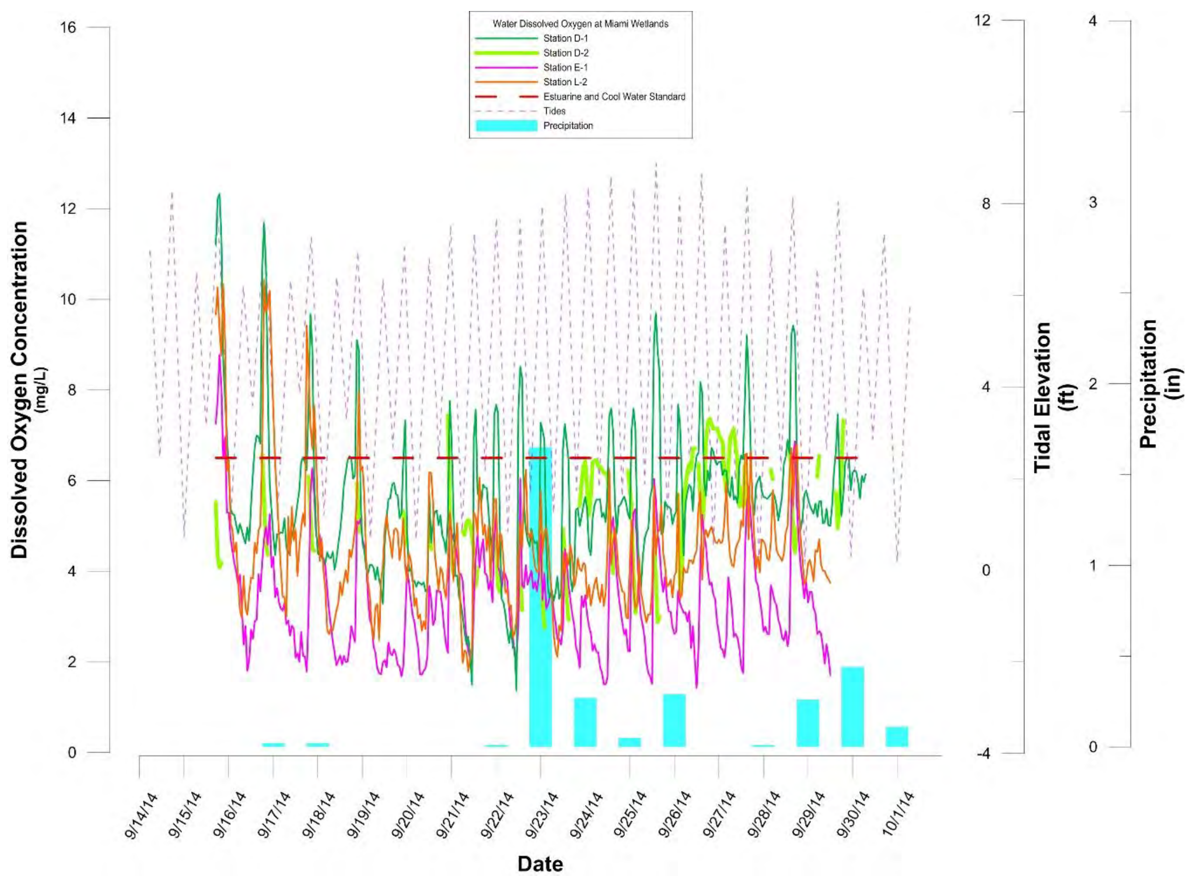


Figure E3. continued

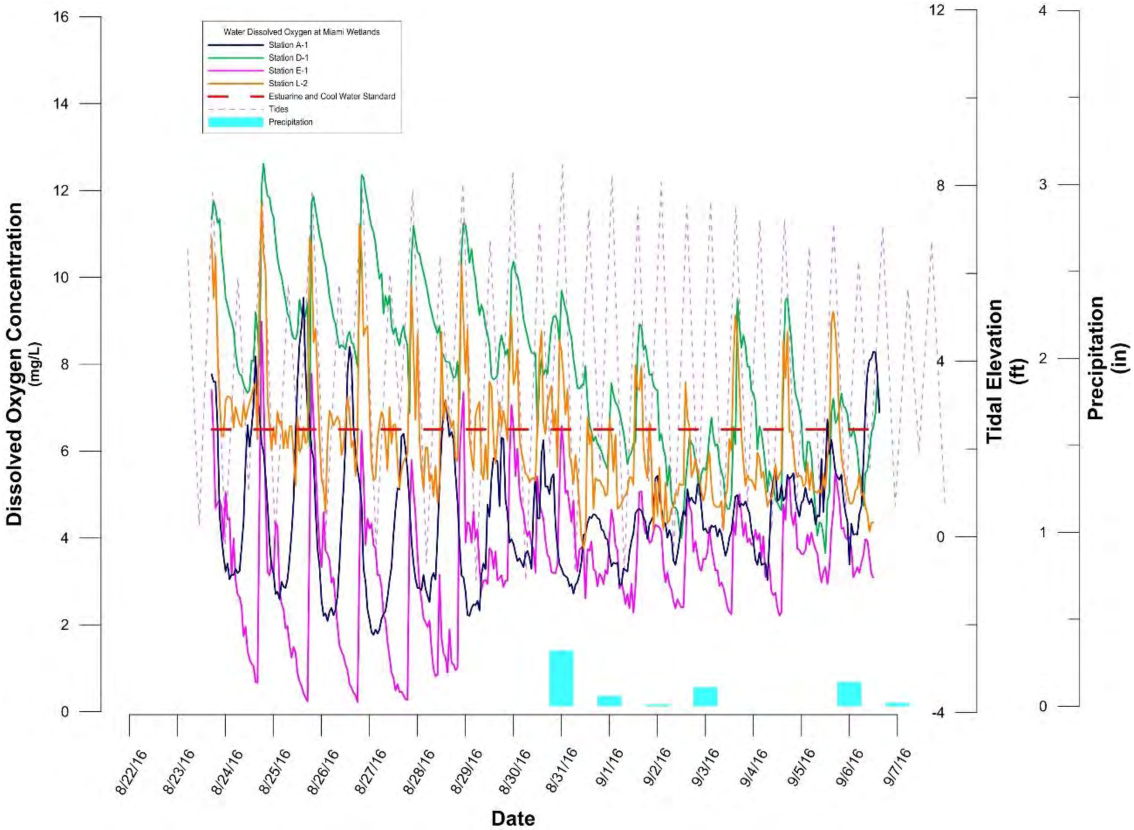
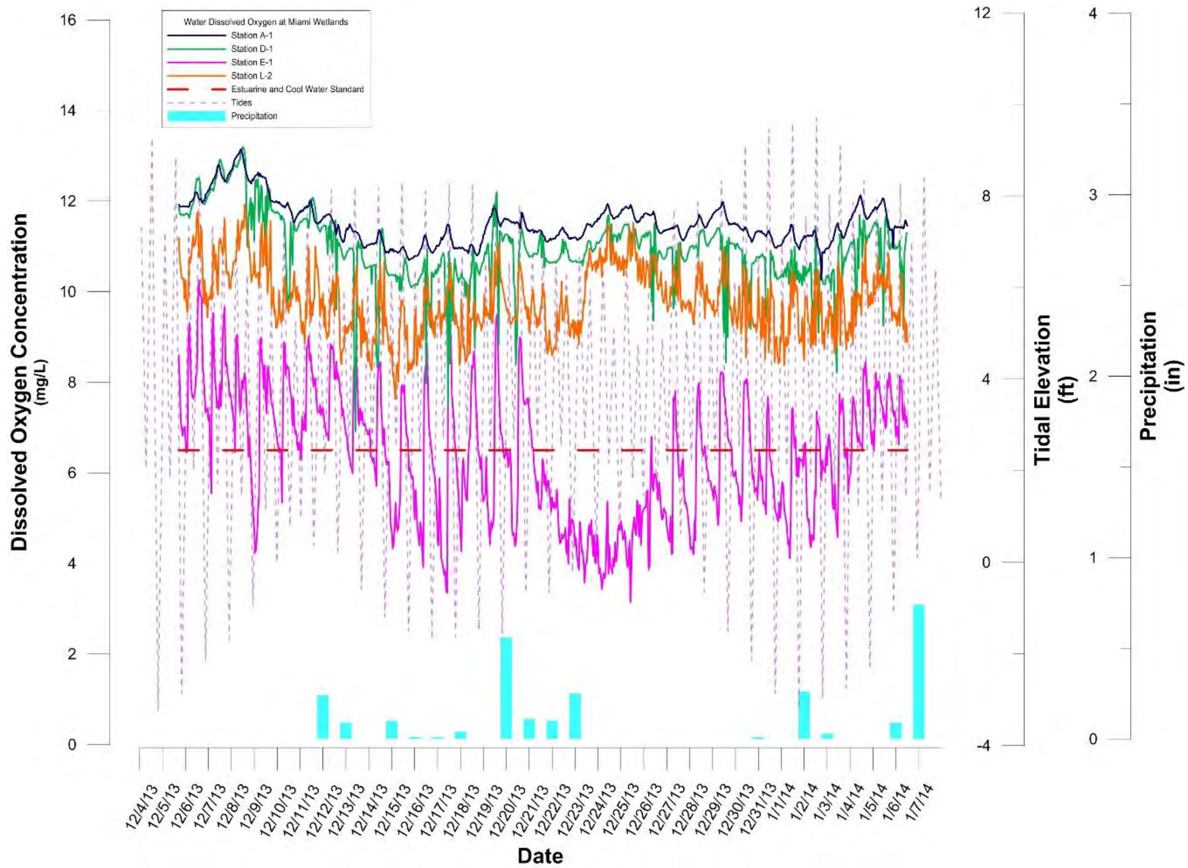


Figure E4. Graphs depicting post-restoration dissolved oxygen levels in constructed channels at the Miami Wetlands during winter 2012-2016. Precipitation and tidal data also included. Discontinuous lines indicate missing data due to low water levels.



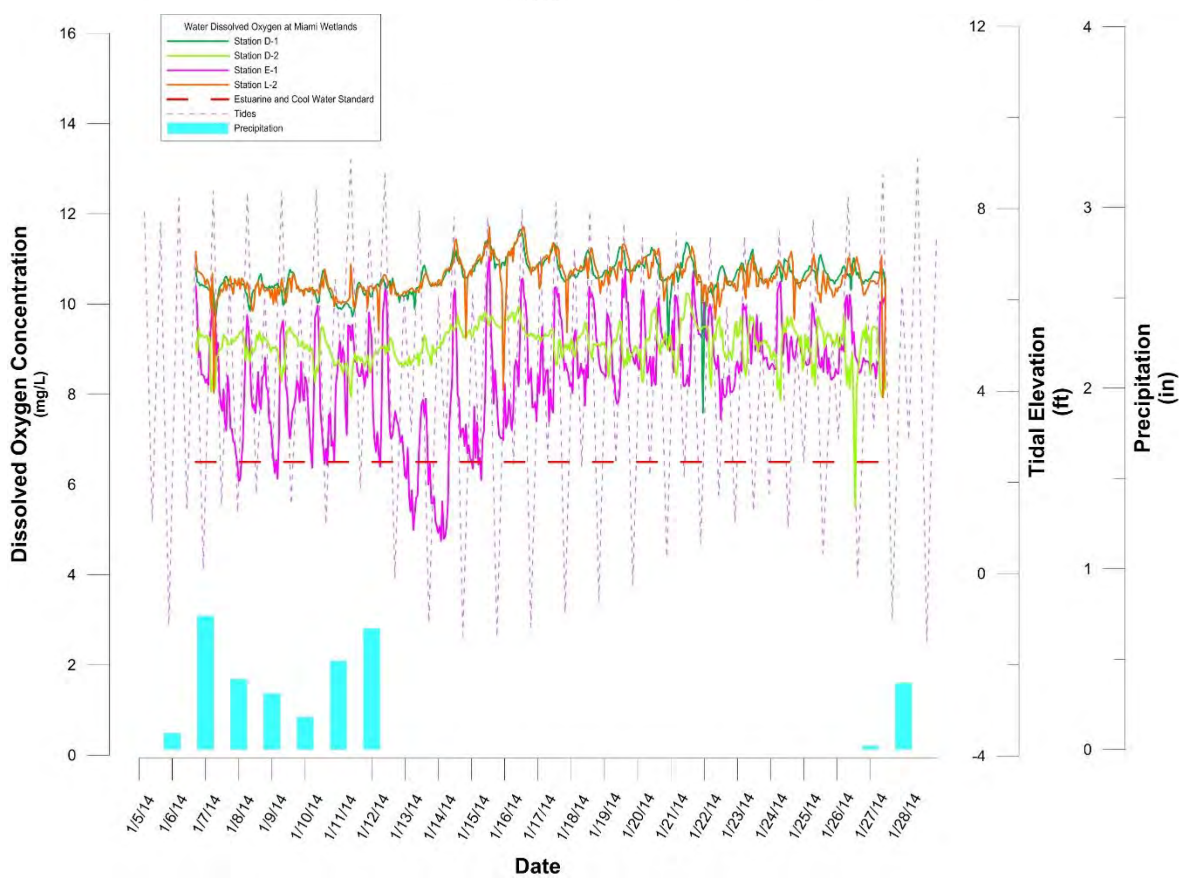
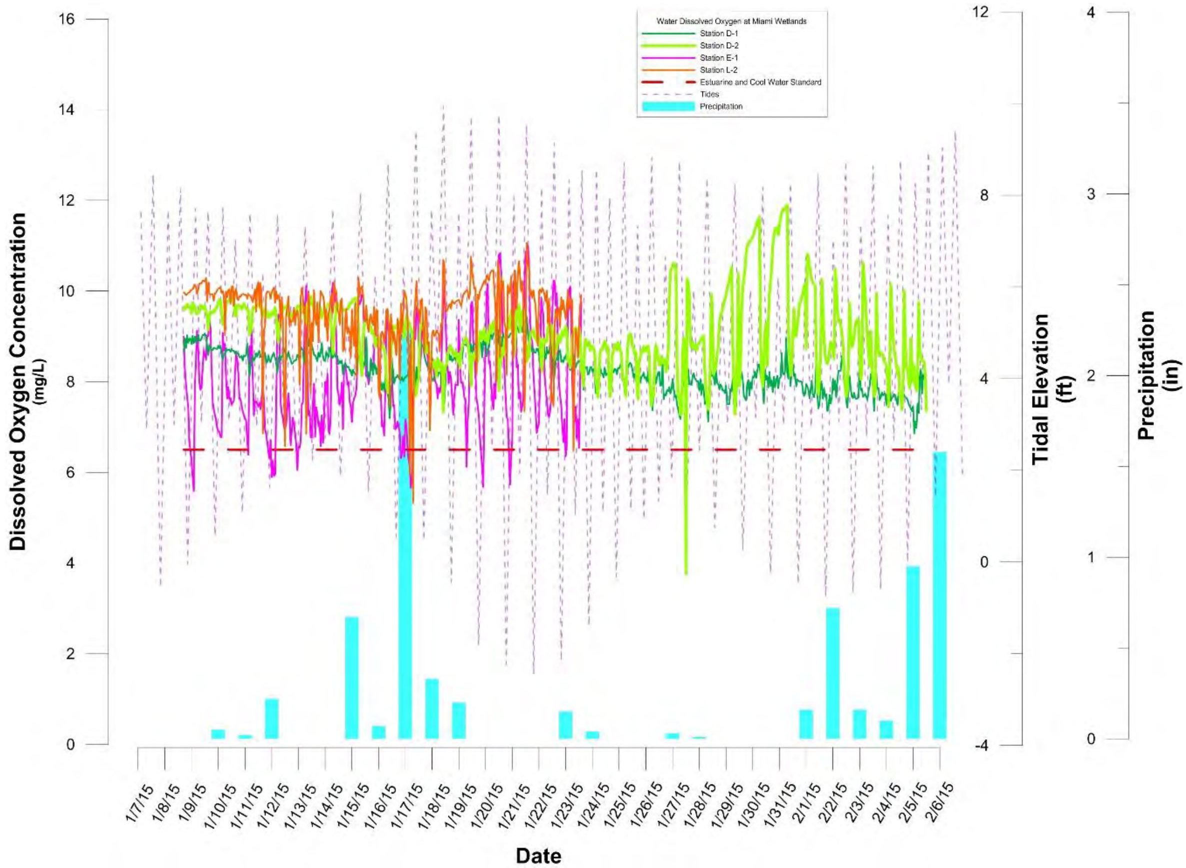


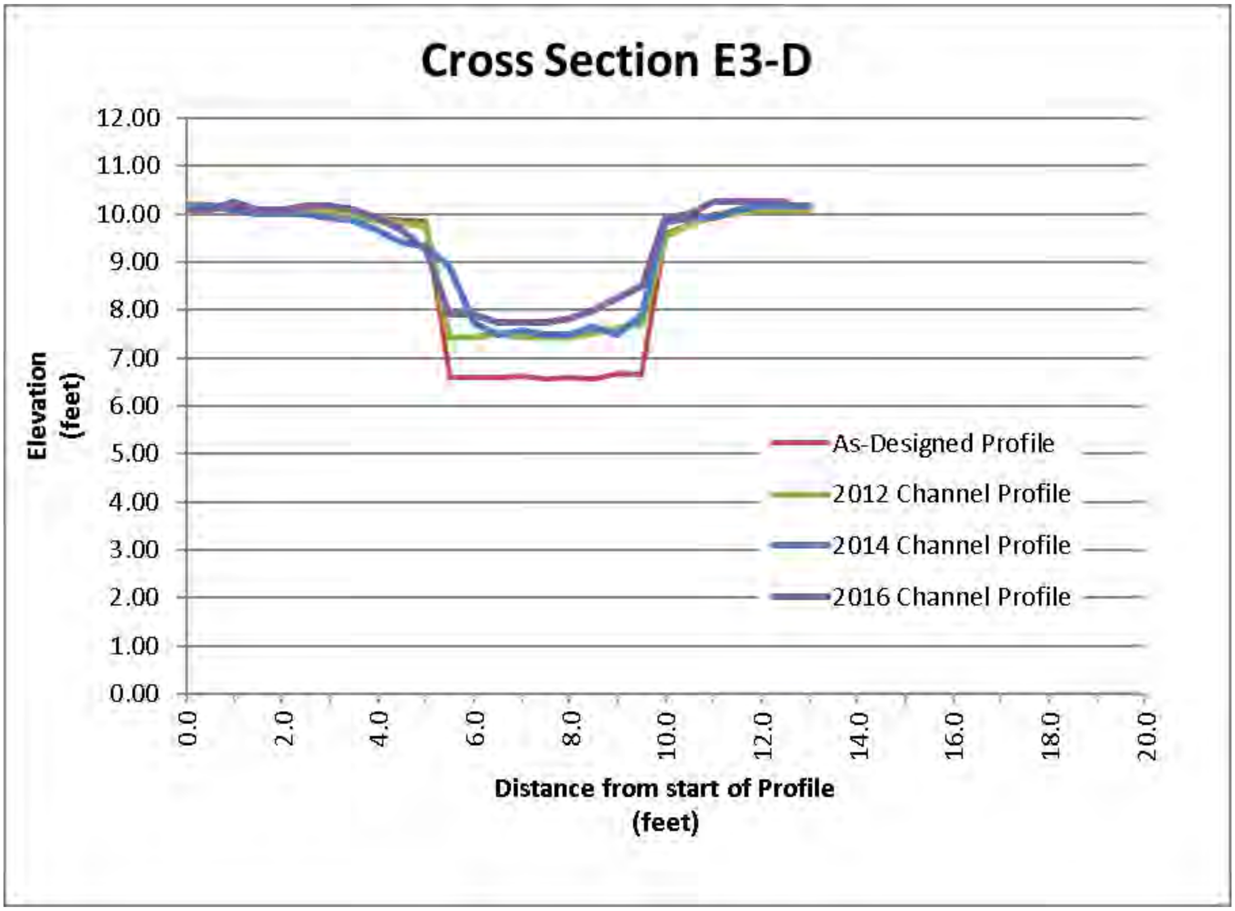
Figure E4. Continued



Appendix F

Graphs depicting cross sections of constructed channels at the Miami Wetlands

Figure F1. Graphs depicting cross sections of constructed tidal channels (E channel system) at the Miami Wetlands.



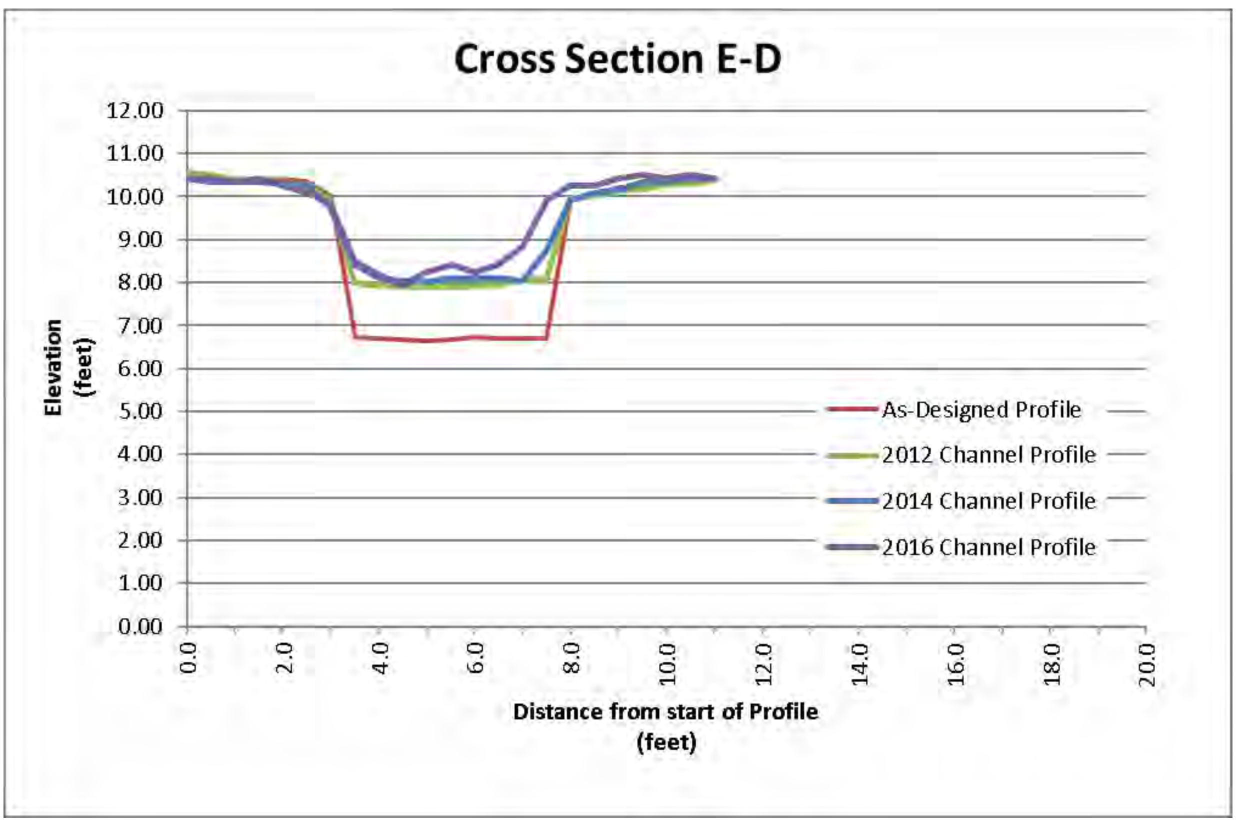
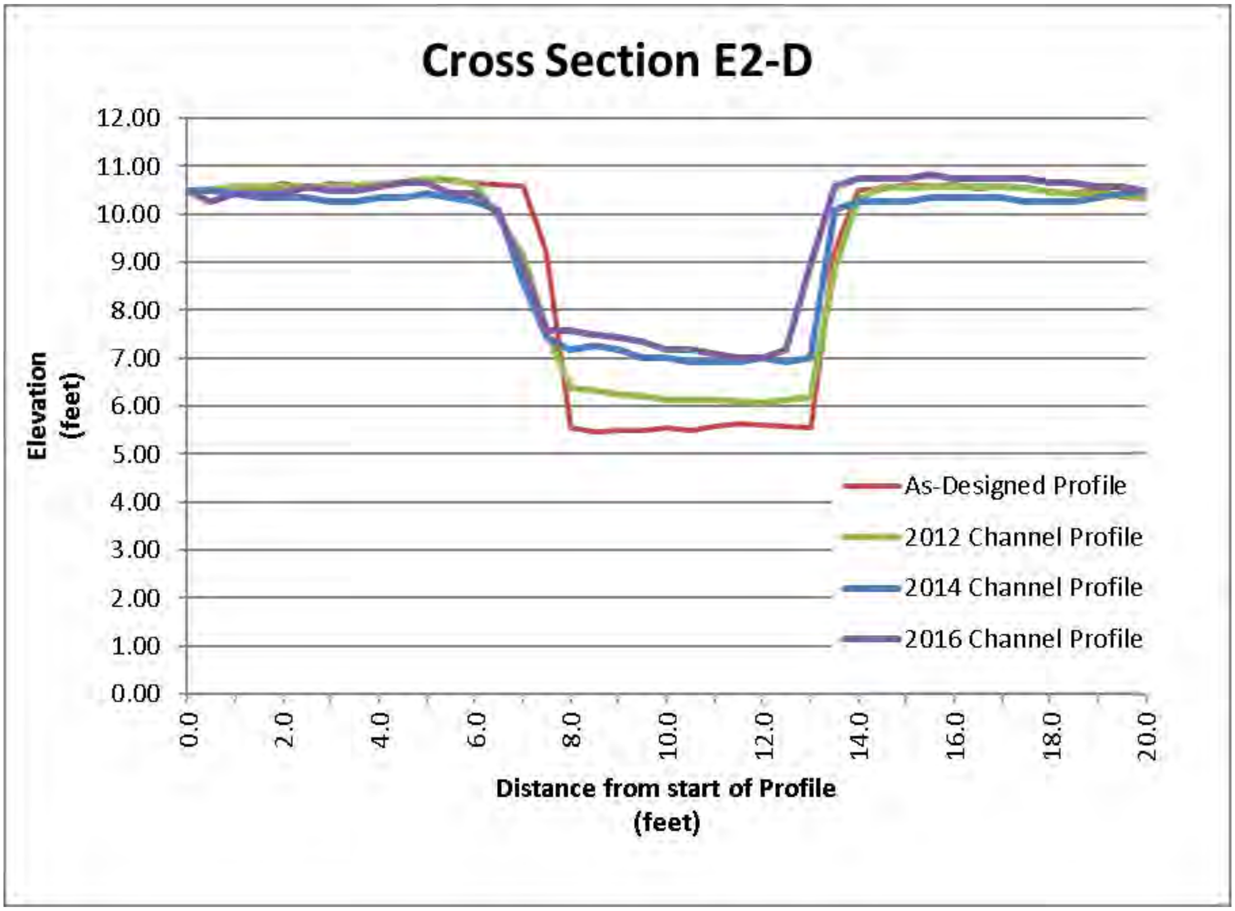


Figure F1. continued



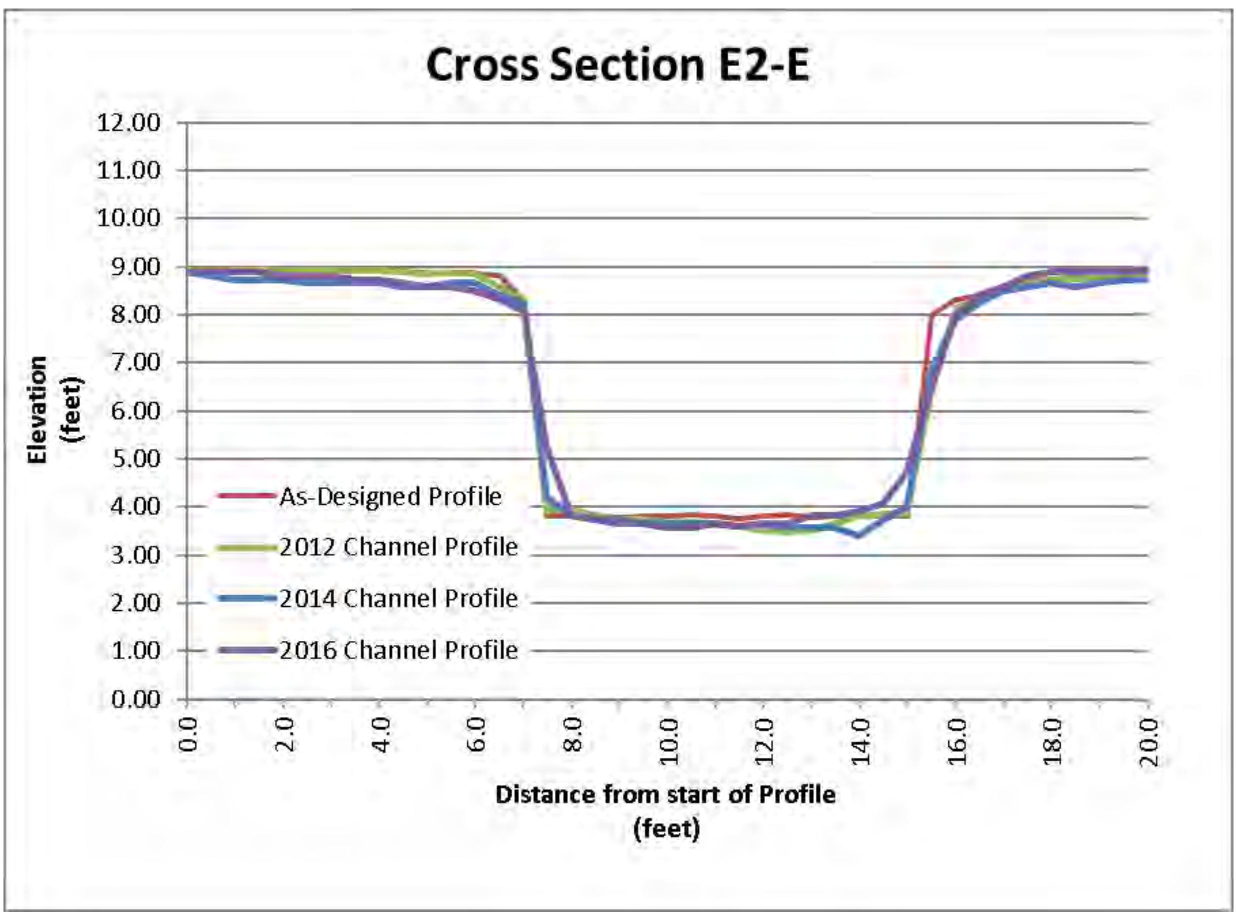


Figure F1. continued

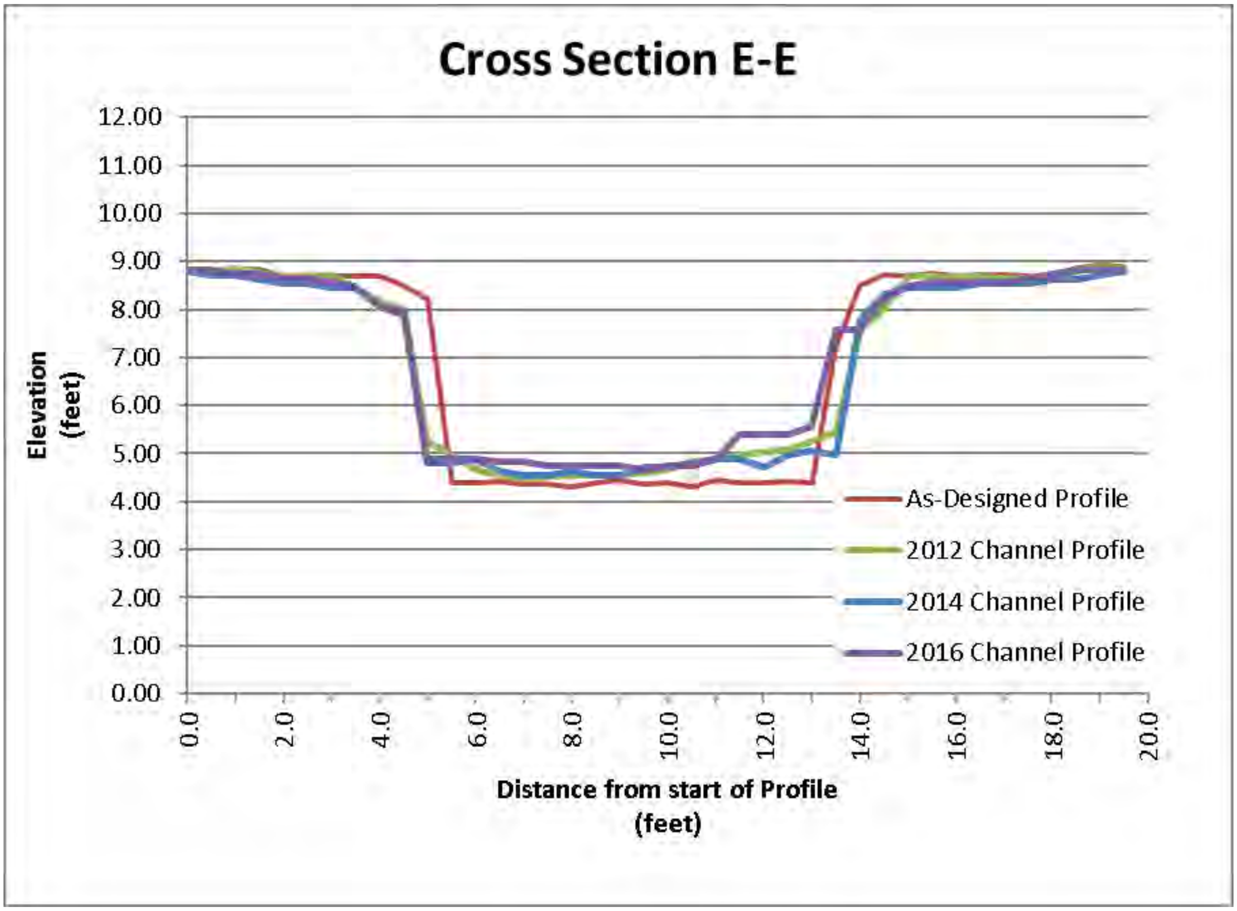
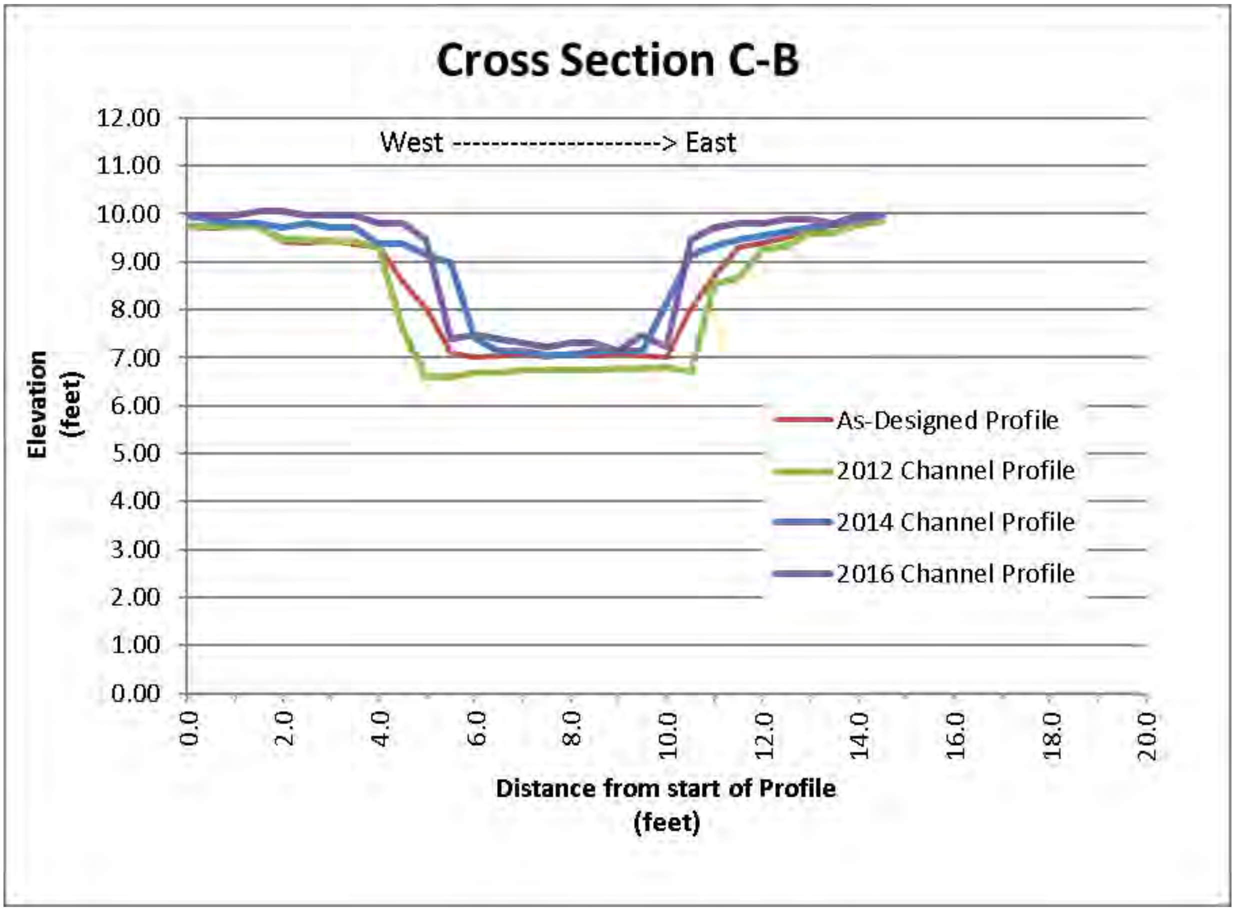


Figure F2. Graphs depicting cross sections of constructed stream channels (Hobson-Struby channel system) at the Miami Wetlands.



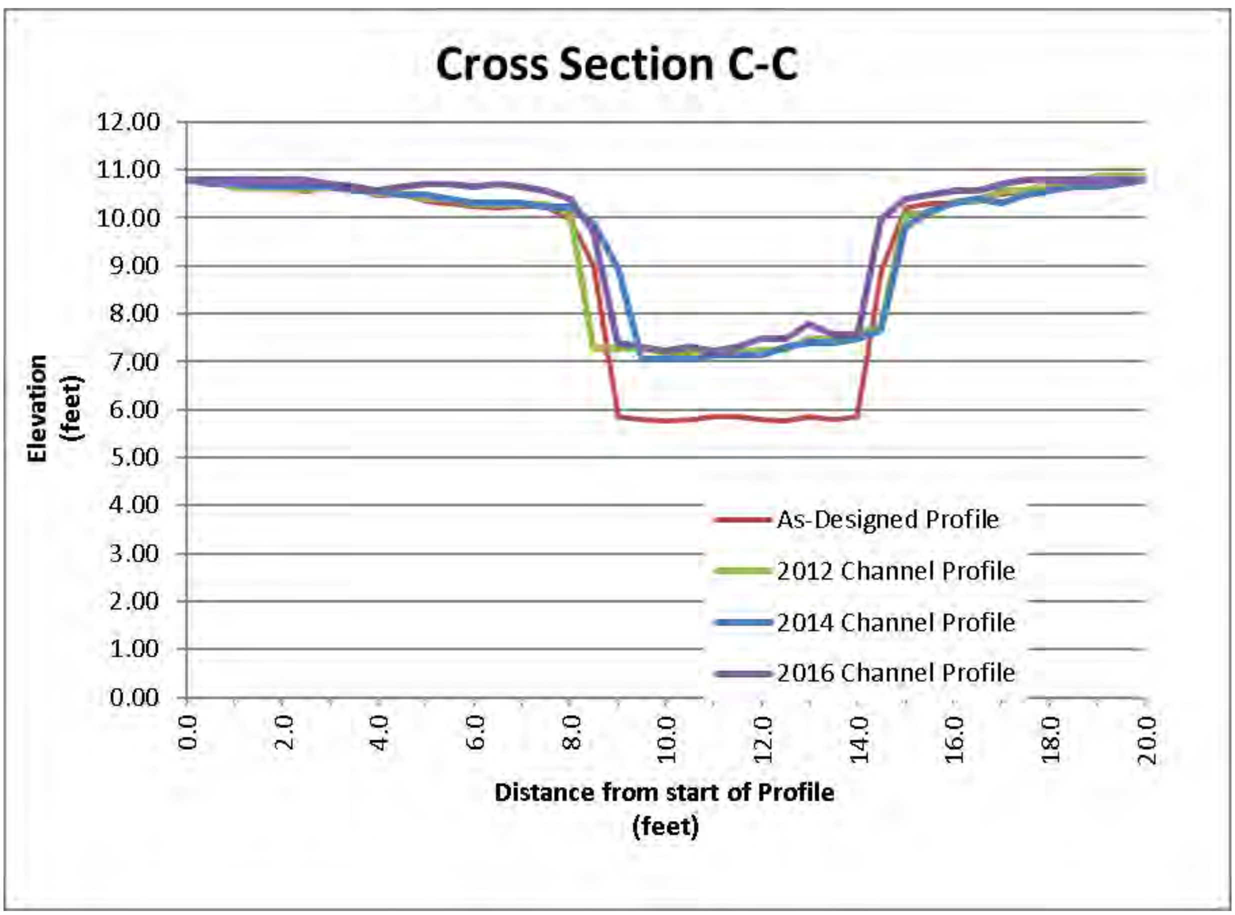
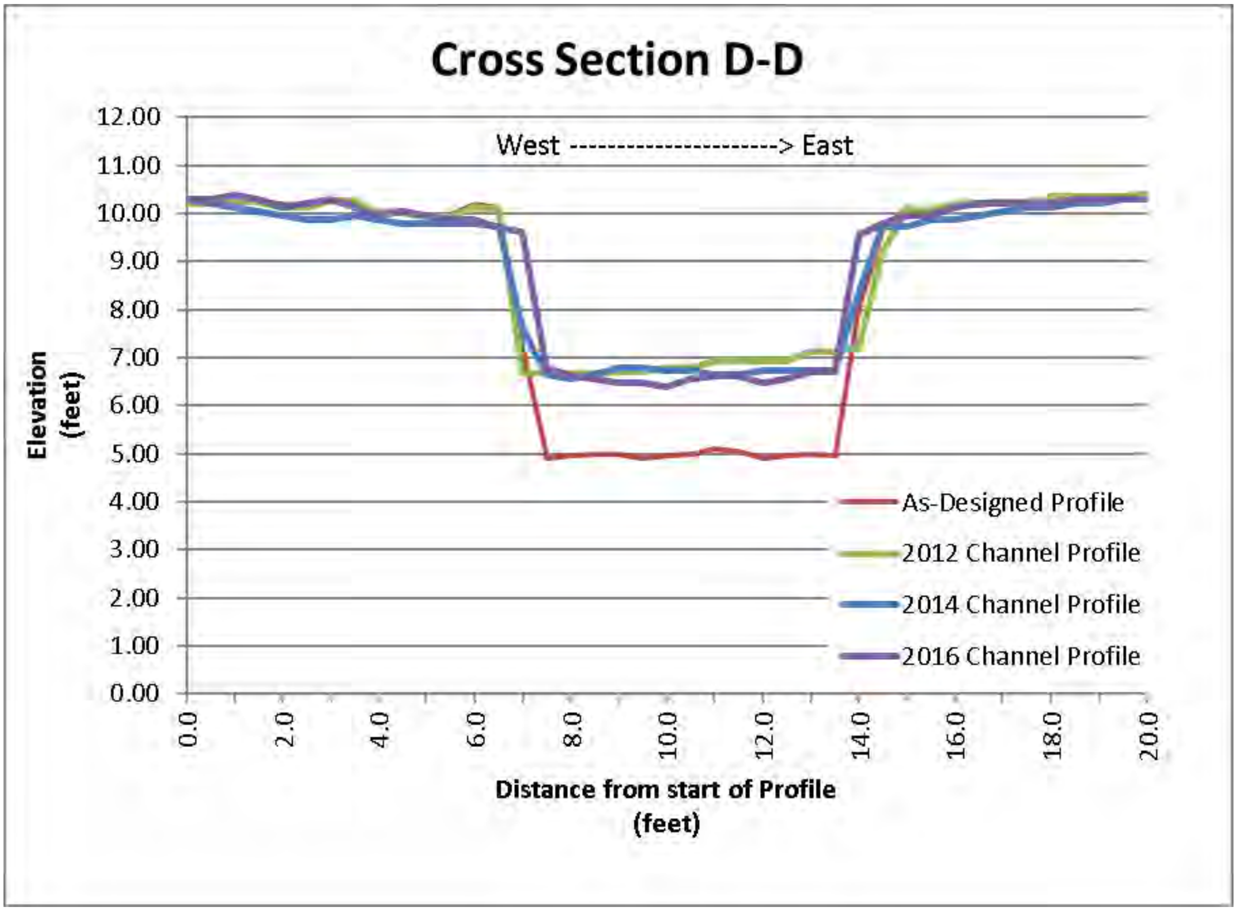
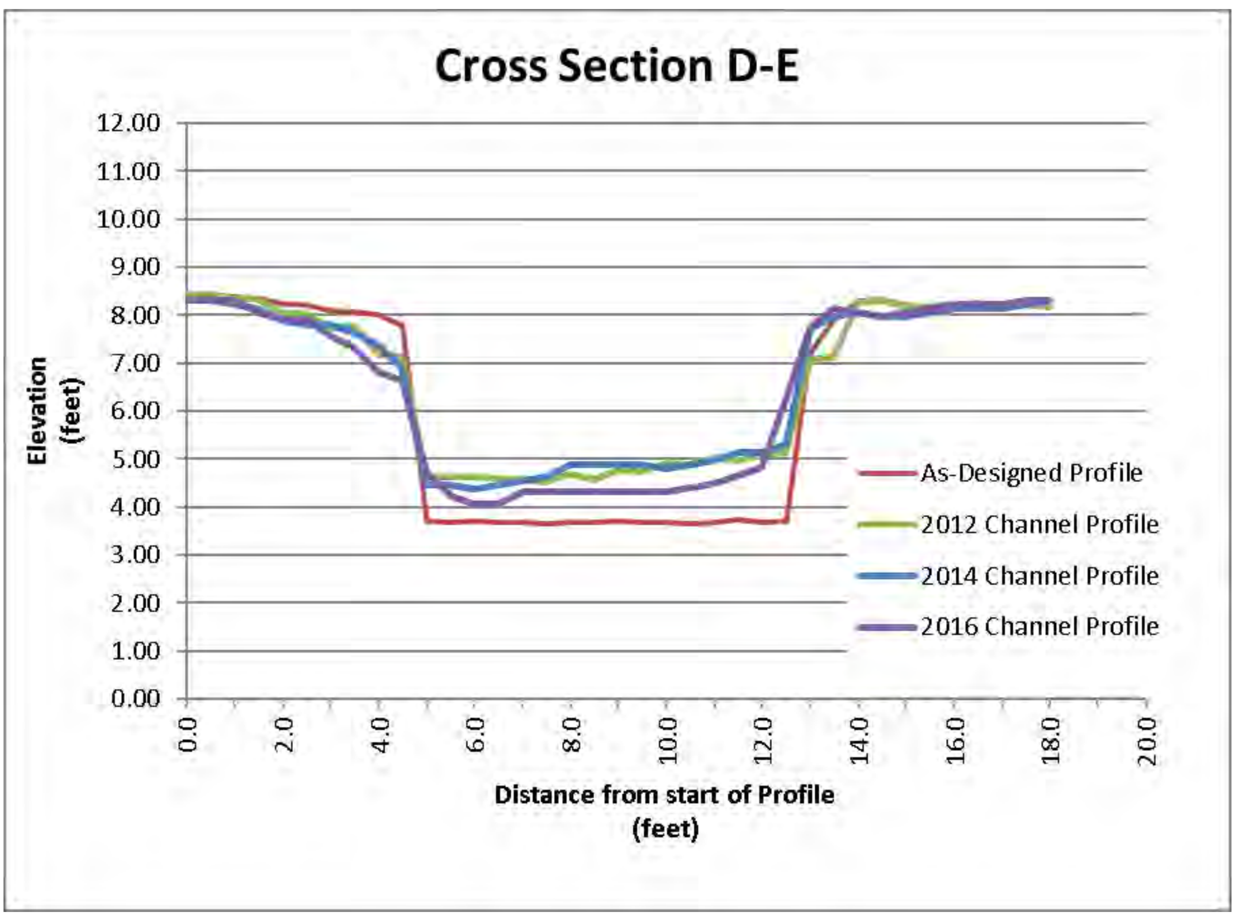


Figure F2. continued





Appendix G

Google Earth© images of Miami Wetlands from 2005 - 2017

Miami Wetlands Restoration Site
Pre-Restoration

Miami Wetlands Restoration Site During-Restoration

Miami Wetlands Restoration Site
Post-Restoration—Year 1

Scale: 1 inch = 261 feet

Image Date: July 2012

Miami Wetlands Restoration Site
Post-Restoration—Year 3

Scale: 1 inch = 261 feet

Image Date: July 2014

Miami Wetlands Restoration Site
Post-Restoration—Year 5

Miami Wetlands Restoration Site
Post-Restoration—Year 6

Scale: 1 inch = 261 feet

Image Date: June 2017

Appendix H

Summary tables for line intercept vegetation transects at Miami Wetlands 2010, 2012, 2014 and 2016

Table H1. Line intercept data summary for pre-construction vegetation survey (2010).

	% Cover by Transect (Total Cover/Relative Cover)									Mean (Total/Relative)	SE (Total/Relative)
	A	B	C	D	E	F	G	H	I		
Open H_2O	0.7 / NA	3.3 / NA	2.3 / NA	2.6 / NA	5.9 / NA	8.9 / NA	15.1 / NA	5.3 / NA	0.0 / NA	**4.9 / NA**	**1.6 / NA**
Bare Ground	-	-	-	-	0.1 / NA	-	-	-	-	**0.0 / NA**	**0.0 / NA**
Bentgrass spp.	-	-	-	-	-	-	-	-	0.4 / 0.4	**0.0 / 0.0**	**0.0 / 0.0**
Red Alder	-	-	-	-	-	-	3.6 / 4.2	-	-	**0.4 / 0.5**	**0.4 / 0.5**
Pacific Silverweed	-	-	-	-	-	-	-	2.6 / 2.8	-	**0.3 / 0.3**	**0.3 / 0.3**
Lady Fern	-	-	-	-	-	-	-	-	2.4 / 2.4	**0.3 / 0.3**	**0.3 / 0.3**
Slender-foot Sedge	-	-	-	-	-	-	-	-	0.1 / 0.1	**0.0 / 0.0**	**0.0 / 0.0**
Slough Sedge	7.3 / 7.3	5.6 / 5.8	10.9 / 11.2	5.5 / 5.6	11.5 / 12.2	6.5 / 7.1	42.5 / 50.0	10.2 / 10.8	24.2 / 24.2	**13.8 / 14.9**	**4.1 / 4.8**
Water-starwort	-	-	-	-	-	-	-	0.6 / 0.6	-	**0.1 / 0.1**	**0.1 / 0.1**
Common Foxglove	-	-	0.6 / 0.6	-	-	-	-	-	-	**0.1 / 0.1**	**0.1 / 0.1**
Spikerush species	-	-	-	-	-	-	2.2 / 2.5	3.0 / 3.1	-	**0.6 / 0.6**	**0.4 / 0.4**
Watson Willowherb	-	-	-	-	-	-	-	-	0.2 / 0.2	**0.0 / 0.0**	**0.0 / 0.0**
Common Horsetail	-	-	-	-	-	-	-	-	0.2 / 0.2	**0.0 / 0.0**	**0.0 / 0.0**
Tall Fescue	-	-	-	-	6.4 / 6.8	18.0 / 19.8	-	-	-	**2.7 / 2.9**	**2.0 / 2.2**
Bedstraw	-	-	-	-	-	-	-	1.3 / 1.4	-	**0.1 / 0.2**	**0.1 / 0.2**
Touch-Me-Not species	-	-	-	-	-	-	-	-	1.9 / 1.9	**0.2 / 0.2**	**0.2 / 0.2**
Baltic Rush	-	-	-	-	2.0 / 2.1	-	-	-	-	**0.2 / 0.2**	**0.2 / 0.2**
Soft Rush	0.3 / 0.3	5.9 / 6.1	0.4 / 0.4	-	0.1 / 0.1	-	-	-	-	**0.8 / 0.8**	**0.6 / 0.7**
Lawn	-	-	-	-	-	-	-	-	4.4 / 4.4	**0.5 / 0.5**	**0.5 / 0.5**
Birdsfoot Trefoil	-	2.4 / 2.5	-	-	-	-	-	-	-	**0.3 / 0.3**	**0.3 / 0.3**
Black Twinberry	-	-	-	-	-	-	-	-	4.0 / 4.0	**0.4 / 0.4**	**0.4 / 0.4**
Skunk Cabbage	1.6 / 1.6	1.9 / 2.0	-	-	-	-	-	0.5 / 0.6	-	**0.4 / 0.5**	**0.3 / 0.3**
Reed Canarygrass	90.2 / 90.8	72.1 / 74.5	85.8 / 87.8	89.5 / 91.8	74.0 / 78.8	48.2 / 52.9	35.3 / 41.6	45.6 / 48.2	18.4 / 18.4	**62.1 / 65.0**	**8.7 / 8.6**
Rough Bluegrass	-	-	-	-	-	2.5 / 2.7	-	-	-	**0.3 / 0.3**	**0.3 / 0.3**
Creeping Buttercup	-	-	-	-	-	-	-	-	19.4 / 19.4	**2.2 / 2.2**	**2.2 / 2.2**
Blackberry species	-	6.7 / 6.9	-	2.5 / 2.5	-	-	-	3.0 / 3.2	19.3 / 19.3	**3.5 / 3.5**	**2.1 / 2.1**
Willow species	-	2.1 / 2.1	-	-	-	16.0 / 17.5	-	-	3.3 / 3.3	**2.4 / 2.5**	**1.7 / 1.9**
Red Elderberry	-	-	-	-	-	-	-	-	1.9 / 1.9	**0.2 / 0.2**	**0.2 / 0.2**
Small-fruited Bulrush	-	-	-	-	-	-	-	13.6 / 14.3	-	**1.5 / 1.6**	**1.5 / 1.6**
Cattail	-	-	-	-	-	-	-	14.3 / 15.1	-	**1.6 / 1.7**	**1.6 / 1.7**
Giant Vetch	-	-	-	-	-	-	1.4 / 1.7	-	-	**0.2 / 0.2**	**0.2 / 0.2**
Total Vegetation Cover for Transect	**99.3%**	**96.7%**	**97.7%**	**97.4%**	**94.0%**	**91.1%**	**84.9%**	**94.7%**	**100.0%**	**95.1%**	**1.6%**
Total Number of Dominant Species	**4**	**7**	**4**	**3**	**5**	**5**	**5**	**10**	**14**	**6.3**	**1.2**

Table H2. Line intercept data summary for first post-construction vegetation survey (2012).

	% Cover by Transect (Total Cover/Relative Cover)									Mean (Total/Relative)	SE (Total/Relative)
	A	B	C	D	E	F	G	H	I		
Open H_2O	4.1 / NA	2.2 / NA	1.3 / NA	8.2 / NA	7.9 / NA	8.0 / NA	15.3 / NA	17.6 / NA	-	**7.2 / NA**	**2.0 / NA**
Bare Ground	2.8 / NA	1.9 / NA	1.1 / NA	-	-	-	-	-	-	**0.6 / NA**	**0.4 / NA**
Red Alder	-	-	-	-	-	-	5.9 / 6.9	-	-	**0.7 / 0.8**	**0.7 / 0.8**
Lady Fern	-	-	-	-	-	-	-	0.8 / 0.9	-	**0.1 / 0.1**	**0.1 / 0.1**
Slough Sedge	9.4 / 10.1	2.6 / 2.7	3.0 / 3.0	2.3 / 2.5	9.4 / 10.2	11.2 / 12.1	45.0 / 53.2	21.0 / 25.5	17.6 / 17.6	**13.5 / 15.2**	**4.5 / 5.4**
Hedge Bindweed	-	-	-	-	-	0.2 / 0.3	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Douglas Spirea	0.1 / 0.1	-	-	-	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Spikerush species	-	-	-	-	-	-	3.2 / 3.7	-	-	**0.4 / 0.4**	**0.4 / 0.4**
Common Horsetail	-	-	-	-	-	-	-	-	6.7 / 6.7	**0.7 / 0.7**	**0.7 / 0.7**
Tall Fescue	-	-	-	-	12.1 / 13.1	2.0 / 2.2	-	-	-	**1.6 / 1.7**	**1.3 / 1.4**
Western Brome	-	-	0.4 / 0.4	-	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Meadow Barley	-	11.1 / 11.6	11.3 / 11.6	5.8 / 6.3	8.9 / 9.7	-	-	-	-	**4.1 / 4.3**	**1.7 / 1.8**
Touch-Me-Not species	4.4 / 4.7	-	-	-	-	-	-	-	-	**0.5 / 0.5**	**0.5 / 0.5**
Baltic Rush	0.5 / 0.5	-	0.8 / 0.9	-	2.0 / 2.2	-	-	1.5 / 1.8	-	**0.5 / 0.6**	**0.3 / 0.3**
Soft Rush	5.1 / 5.5	3.5 / 3.6	5.2 / 5.4	5.5 / 6.0	2.7 / 2.9	-	-	3.6 / 4.3	-	**2.8 / 3.1**	**0.8 / 0.8**
Lawn	-	-	-	-	-	-	-	-	5.9 / 5.9	**0.7 / 0.7**	**0.7 / 0.7**
Birdsfoot Trefoil	-	-	-	2.6 / 2.8	3.7 / 4.0	-	-	-	-	**0.7 / 0.8**	**0.5 / 0.5**
Black Twinberry	0.1 / 0.1	0.8 / 0.8	0.3 / 0.3	-	-	-	-	-	6.7 / 6.7	**0.9 / 0.9**	**0.7 / 0.7**
Skunk Cabbage	3.1 / 3.3	-	-	-	-	-	-	-	1.5 / 1.5	**0.5 / 0.5**	**0.4 / 0.4**
Reed Canarygrass	67.0 / 71.9	77.4 / 80.7	74.0 / 75.8	72.9 / 79.4	52.3 / 56.8	55.6 / 60.4	29.3 / 34.6	45.6 / 55.4	49.8 / 49.8	**58.2 / 62.7**	**5.3 / 5.2**
Pacific Silverweed	-	-	-	-	-	5.7 / 6.2	-	-	-	**0.6 / 0.7**	**0.6 / 0.7**
Creeping Buttercup	-	-	-	-	-	-	-	-	0.5 / 0.5	**0.1 / 0.1**	**0.1 / 0.1**
Blackberry species	-	-	-	-	-	-	-	-	4.4 / 4.4	**0.5 / 0.5**	**0.5 / 0.5**
Willow species	1.9 / 2.1	0.4 / 0.4	0.3 / 0.3	-	-	17.3 / 18.8	-	-	2.2 / 2.2	**2.5 / 2.6**	**1.9 / 2.0**
Red Elderberry	-	-	-	-	-	-	-	-	1.3 / 1.3	**0.1 / 0.1**	**0.1 / 0.1**
Small-fruited Bulrush	1.6 / 1.7	0.1 / 0.2	1.4 / 1.4	2.8 / 3.1	0.8 / 0.8	-	-	8.3 / 10.0	3.5 / 3.5	**2.1 / 2.3**	**0.9 / 1.1**
Narrowleaf Burreed	-	-	0.4 / 0.4	-	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Sitka Spruce	-	-	0.4 / 0.4	-	0.2 / 0.2	-	-	-	-	**0.1 / 0.1**	**0.0 / 0.0**
Giant Vetch	-	-	-	-	-	-	1.4 / 1.6	1.7 / 2.1	-	**0.3 / 0.4**	**0.2 / 0.3**
Total Vegetation Cover for Transect	**93.2%**	**95.9%**	**97.6%**	**91.8%**	**92.1%**	**92.0%**	**84.7%**	**82.4%**	**100.0%**	**92.2%**	**1.9%**
Total Number of Dominant Species	**10**	**7**	**11**	**6**	**9**	**6**	**5**	**7**	**11**	**8.0**	**0.8**

Table H3. Line intercept data summary for second post-construction vegetation survey (2014).

	% Cover by Transect (Total Cover/Relative Cover)									Mean (Total/Relative)	SE (Total/Relative)
	A	B	C	D	E	F	G	H	I		
Open H_2O	1.8 / NA	3.9 / NA	3.9 / NA	13.2 / NA	8.6 / NA	8.5 / NA	15.3 / NA	27.5 / NA	-	**9.2 / NA**	**2.9 / NA**
Bare Ground	-	-	-	-	-	-	4.5 / NA	-	-	**0.5 / NA**	**0.5 / NA**
Plant Litter	2.7 / NA	2.8 / NA	0.3 / NA	2.5 / NA	4.1 / NA	0.8 / NA	16.6 / NA	21.7 / NA	-	**5.7 / NA**	**2.6 / NA**
Sweet Vernal Grass	-	-	0.3 / 0.3	-	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Red Alder	-	-	-	-	-	-	0.9 / 1.4	-	-	**0.1 / 0.2**	**0.1 / 0.2**
Lady Fern	-	-	-	-	-	-	2.2 / 3.5	1.1 / 2.2	1.0 / 1.0	**0.5 / 0.7**	**0.3 / 0.4**
Water-starwort	-	-	-	-	-	-	1.3 / 2.1	-	-	**0.1 / 0.2**	**0.1 / 0.2**
Slough Sedge	4.8 / 5.0	1.2 / 1.3	2.6 / 2.7	2.0 / 2.4	0.5 / 0.5	10.3 / 11.4	9.0 / 14.1	15.3 / 30.1	6.7 / 6.7	**5.8 / 8.2**	**1.7 / 3.1**
Canada Thistle	-	-	-	-	0.2 / 0.2	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Red Osier Dogwood	-	-	0.2 / 0.2	0.3 / 0.3	0.3 / 0.3	-	-	-	-	**0.1 / 0.1**	**0.0 / 0.0**
Douglas Spirea	-	0.3 / 0.3	-	-	0.3 / 0.3	-	-	-	-	**0.1 / 0.1**	**0.0 / 0.0**
Spikerush species	-	-	0.1	0.3	-	-	1.8	-	-	**0.2 / 0.4**	**0.2 / 0.3**
Common Horsetail	-	-	-	-	-	-	-	-	1.0 / 1.0	**0.1 / 0.1**	**0.1 / 0.1**
Tall Fescue	-	-	-	-	5.4 / 6.1	2.0 / 2.2	-	-	-	**0.8 / 0.9**	**0.6 / 0.7**
Bedstraw	-	-	-	-	0.1 / 0.2	-	-	1.1 / 2.2	-	**0.1 / 0.3**	**0.1 / 0.2**
Cow Parsnip	-	-	0.3 / 0.3	-	-	-	0.4 / 0.7	-	-	**0.1 / 0.1**	**0.1 / 0.1**
Meadow Barley	-	-	0.2 / 0.2	-	2.4 / 2.7	-	-	-	-	**0.3 / 0.3**	**0.3 / 0.3**
Touch-Me-Not species	6.6 / 6.9	2.2 / 2.3	-	-	-	-	-	1.7 / 3.3	2.4 / 2.4	**1.4 / 1.7**	**0.7 / 0.8**
Arctic Rush	-	-	-	-	-	-	-	0.8 / 1.5	-	**0.1 / 0.2**	**0.1 / 0.2**
Baltic Rush	-	0.9 / 1.0	0.5 / 0.5	4.7 / 5.5	5.5 / 6.3	-	-	-	-	**1.3 / 1.5**	**0.7 / 0.9**
Soft Rush	11.7/12.3	1.5 / 1.6	1.1 / 1.1	1.0 / 1.2	1.0 / 1.2	1.8 / 2.0	-	-	-	**2.0 / 2.2**	**1.2 / 1.3**
Lawn	-	-	-	-	-	-	-	-	5.1 / 5.1	**0.6 / 0.6**	**0.6 / 0.6**
Birdsfoot Trefoil	-	1.5 / 1.6	0.4 / 0.4	0.4 / 0.5	0.7 / 0.8	-	-	0.8 / 1.5	-	**0.4 / 0.5**	**0.2 / 0.2**
Black Twinberry	-	-	0.6 / 0.7	1.8 / 2.1	1.0 / 1.1	-	8.1 / 12.7	-	6.1 / 6.1	**2.0 / 2.5**	**1.0 / 1.4**
Skunk Cabbage	2.3 / 2.4	-	-	-	-	-	-	-	-	**0.3 / 0.3**	**0.3 / 0.3**
Reed Canarygrass	64.6 / 67.7	82.8/88.8	78.6/82.0	71.7/85.1	60.3/69.1	49.3 / 54.4	19.1/30.0	20.0/39.4	44.6/44.6	**54.6 / 62.3**	**7.8 / 7.1**
Sitka Spruce	-	0.4 / 0.4	-	-	1.4 / 1.6	-	-	-	0.2 / 0.2	**0.2 / 0.3**	**0.2 / 0.2**
Pacific Silverweed	-	-	-	-	-	8.8 / 9.7	-	-	-	**1.0 / 1.1**	**1.0 / 1.1**
Kentucky Bluegrass	-	-	-	-	-	1.8 / 2.0	-	-	-	**0.2 / 0.2**	**0.2 / 0.2**
Blackberry species	-	-	-	-	-	-	-	-	12.9/12.9	**1.4 / 1.4**	**1.4 / 1.4**
Red Elderberry	-	-	-	-	-	-	-	-	2.3 / 2.3	**0.3 / 0.3**	**0.3 / 0.3**
Willow species	3.4 / 3.6	0.7 / 0.7	3.7 / 3.9	0.7 / 0.8	4.8 / 5.4	16.5 / 18.2	-	-	5.1 / 5.1	**3.9 / 4.2**	**1.7 / 1.9**
Small-fruited Bulrush	2.0 / 2.1	1.9 / 2.1	7.2 / 7.6	1.3 / 1.6	3.6 / 4.1	-	20.7/32.5	10.0/19.7	12.4/12.4	**6.6 / 9.1**	**2.3 / 3.6**
Total Cover for Transect	**95.4%**	**93.2%**	**95.8%**	**84.3%**	**87.4%**	**90.7%**	**63.6%**	**50.8%**	**100.0%**	**84.6%**	**5.5%**
Total Number of Dominant Species	**7**	**10**	**13**	**10**	**15**	**7**	**9**	**8**	**12**	**10.1**	**0.9**

Table H4. Line intercept data summary for second post-construction vegetation survey (2016).

2016	% Cover by Transect (Total Cover/Relative Cover)									Mean (Total/Relative)	SE (Total/Relative)
	A	B	C	D	E	F	G	H	I		
Open H_2O	2.9 / NA	2.2 / NA	3.5 / NA	11.7 / NA	8.1 / NA	7.2 / NA	6.7 / NA	12.9 / NA	0.0 / NA	**6.1 / NA**	**1.5 / NA**
Bare Ground	0.6 / NA	-	-	-	-	-	12.6 / NA	0.0 / NA	1.7 / NA	**1.7 / NA**	**1.4 / NA**
Pacific Silverweed	-	-	-	-	-	6.0 / 6.5	-	-	-	**0.7 / 0.7**	**0.7 / 0.7**
Red Alder	2.1 / 2.1	3.7 / 3.8	-	-	-	-	1.4 / 1.8	-	-	**0.8 / 0.9**	**0.4 / 0.5**
Lady Fern	-	0.2 / 0.2	-	-	-	-	1.3 / 1.7	2.2 / 2.5	6.4 / 6.5	**1.1 / 1.2**	**0.7 / 0.7**
Slough Sedge	11.8 / 12.2	3.3 / 3.3	6.2 / 6.4	2.9 / 3.3	3.3 / 3.6	13.5 / 14.5	11.2 / 13.9	17.5 / 20.1	7.1 / 7.2	**8.5 / 9.4**	**1.7 / 2.0**
Hedge Bindweed	-	-	-	-	-	-	-	1.7 / 1.9	-	**0.2 / 0.2**	**0.2 / 0.2**
Red-osier Dogwood	-	-	-	0.1 / 0.2	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Orchardgrass	-	-	-	-	-	0.2 / 0.3	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Tufted Hairgrass	-	-	0.3 / 0.3	-	-	-	-	-	-	**0.0 / 0.0**	**0.0 / 0.0**
Spikerush species	-	-	-	-	-	-	7.2 / 8.9	4.3 / 5.0	-	**1.3 / 1.5**	**0.9 / 1.1**
Tall Fescue	-	-	-	-	3.8 / 4.1	1.7 / 1.8	-	-	-	**0.6 / 0.6**	**0.5 / 0.5**
Touch-me-Not species	0.7 / 0.7	-	-	-	-	-	-	-	4.4 / 4.4	**0.6 / 0.6**	**0.5 / 0.5**
Arctic Rush	-	-	-	-	-	-	-	0.8 / 0.9	-	**0.1 / 0.1**	**0.1 / 0.1**
Baltic Rush	0.5 / 0.5	-	0.8 / 0.9	-	2.0 / 2.2	-	-	1.5 / 1.8	-	**0.5 / 0.6**	**0.3 / 0.3**
Soft Rush	15.1 / 15.7	1.1 / 1.2	2.6 / 2.7	3.8 / 4.3	3.9 / 4.3	0.3 / 0.4	-	1.1 / 1.3	-	**3.1 / 3.3**	**1.6 / 1.6**
Lawn	-	-	-	-	-	-	-	-	2.7 / 2.7	**0.3 / 0.3**	**0.3 / 0.3**
Birdsfoot Trefoil	-	0.2 / 0.2	-	-	4.4 / 4.8	1.8 / 2.0	-	-	-	**0.7 / 0.8**	**0.5 / 0.6**
Black Twinberry	-	1.2 / 1.3	2.3 / 2.4	4.7 / 5.4	3.7 / 4.0	-	9.0 / 11.1	6.0 / 6.9	-	**3.0 / 3.5**	**1.0 / 1.3**
Skunk Cabbage	2.3 / 2.3	-	-	-	-	-	-	-	-	**0.3 / 0.3**	**0.3 / 0.3**
Reed Canarygrass	53.3 / 55.2	72.5 / 74.1	72.6 / 75.2	60.0 / 68.0	53.8 / 58.6	45.3 / 48.8	31.0 / 38.5	22.3 / 25.6	46.2 / 47.0	**50.8 / 54.6**	**5.7 / 5.5**
Sitka Spruce	-	0.5 / 0.5	1.5 / 1.6	0.7 / 0.8	2.8 / 3.0	-	-	1.9 / 2.2	-	**0.8 / 0.9**	**0.3 / 0.4**
Western Sword Fern	-	-	-	-	-	-	3.1 / 3.8	-	-	**0.3 / 0.4**	**0.3 / 0.4**
Black Cottonwood	-	1.6 / 1.6	-	4.2 / 4.8	-	6.0 / 6.5	-	-	-	**1.3 / 1.4**	**0.8 / 0.8**
Cascara	-	-	-	1.3 / 1.5	-	-	-	3.4 / 3.9	2.7 / 2.7	**0.8 / 0.9**	**0.4 / 0.5**
Blackberry species	-	-	-	0.1 / 0.1	-	-	-	-	12.6 / 12.8	**1.4 / 1.4**	**1.4 / 1.4**
Red Elderberry	-	-	-	-	-	-	-	-	8.2 / 8.3	**0.9 / 0.9**	**0.9 / 0.9**
Willow species	6.4 / 6.7	5.0 / 5.1	4.7 / 4.9	-	6.0 / 6.6	18.2 / 19.6	2.4 / 3.0	1.7 / 1.9	7.7 / 7.8	**5.8 / 6.2**	**1.8 / 1.9**
Small-fruited Bulrush	5.2 / 5.4	7.1 / 7.2	4.8 / 4.9	6.9 / 7.9	4.5 / 4.9	-	13.9 / 17.3	17.5 / 20.1	-	**6.7 / 7.5**	**1.9 / 2.3**
Douglas Spirea	-	-	0.5 / 0.6	0.1 / 0.1	1.0 / 1.1	-	-	-	-	**0.2 / 0.2**	**0.1 / 0.1**
Piggy-back Plant	-	-	-	-	-	-	-	-	0.5 / 0.5	**0.1 / 0.1**	**0.1 / 0.1**
Giant Vetch	-	-	-	-	-	-	-	6.6 / 7.6	-	**0.7 / 0.8**	**0.7 / 0.8**
Total Vegetation Cover	**96.50%**	**97.80%**	**96.50%**	**88.30%**	**91.90%**	**92.80%**	**80.70%**	**87.10%**	**98.30%**	**92.20%**	**2.00%**
Total Number of Dominant Species	**7**	**13**	**10**	**12**	**12**	**8**	**9**	**13**	**10**	**10.4**	**0.7**

Appendix I

Line intercept data from 2010, 2012, 2014 and 2016 depicted as color-coded lines overlaid on aerial photographs of the Miami Wetlands

Figure I1. Aerial photograph of Miami Wetlands Restoration Project site with segmented polylines depicting 2010 pre-construction line intercept data. Non-native or invasive species are depicted in shades of red, purple and orange, while native species are greens. 2009 base image.

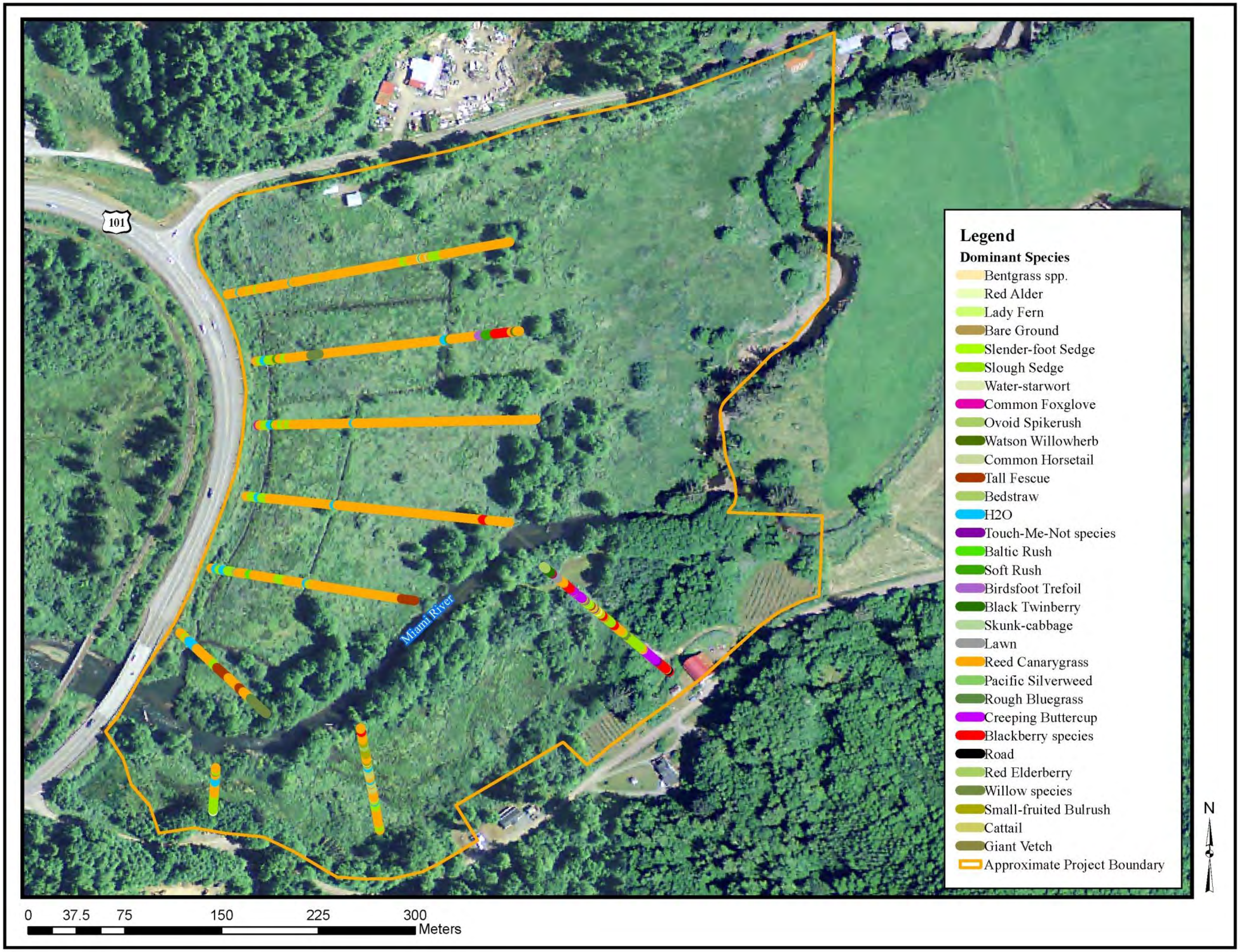


Figure I2. Aerial photograph of Miami Wetlands Restoration Project site with segmented polylines depicting 2012 post- construction line intercept data. Non-native or invasive species are depicted in shades of red, purple and orange, while native species are greens. 2012 base image.

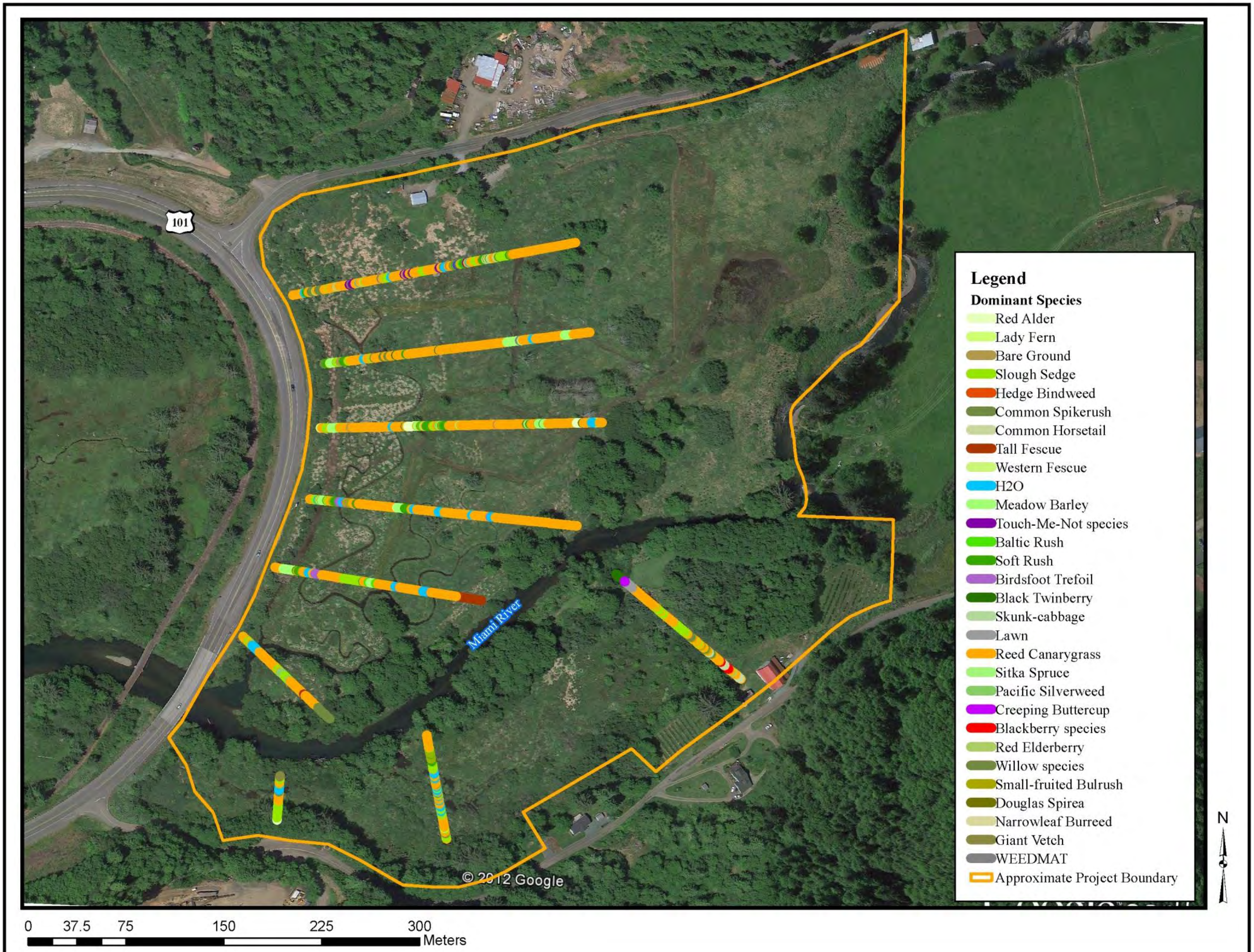


Figure I3. Aerial photograph of Miami Wetlands Restoration Project site with segmented polylines depicting 2014 post-construction line intercept data. Non-native or invasive species are depicted in shades of red, purple and orange, while native species are greens. 2014 base image.

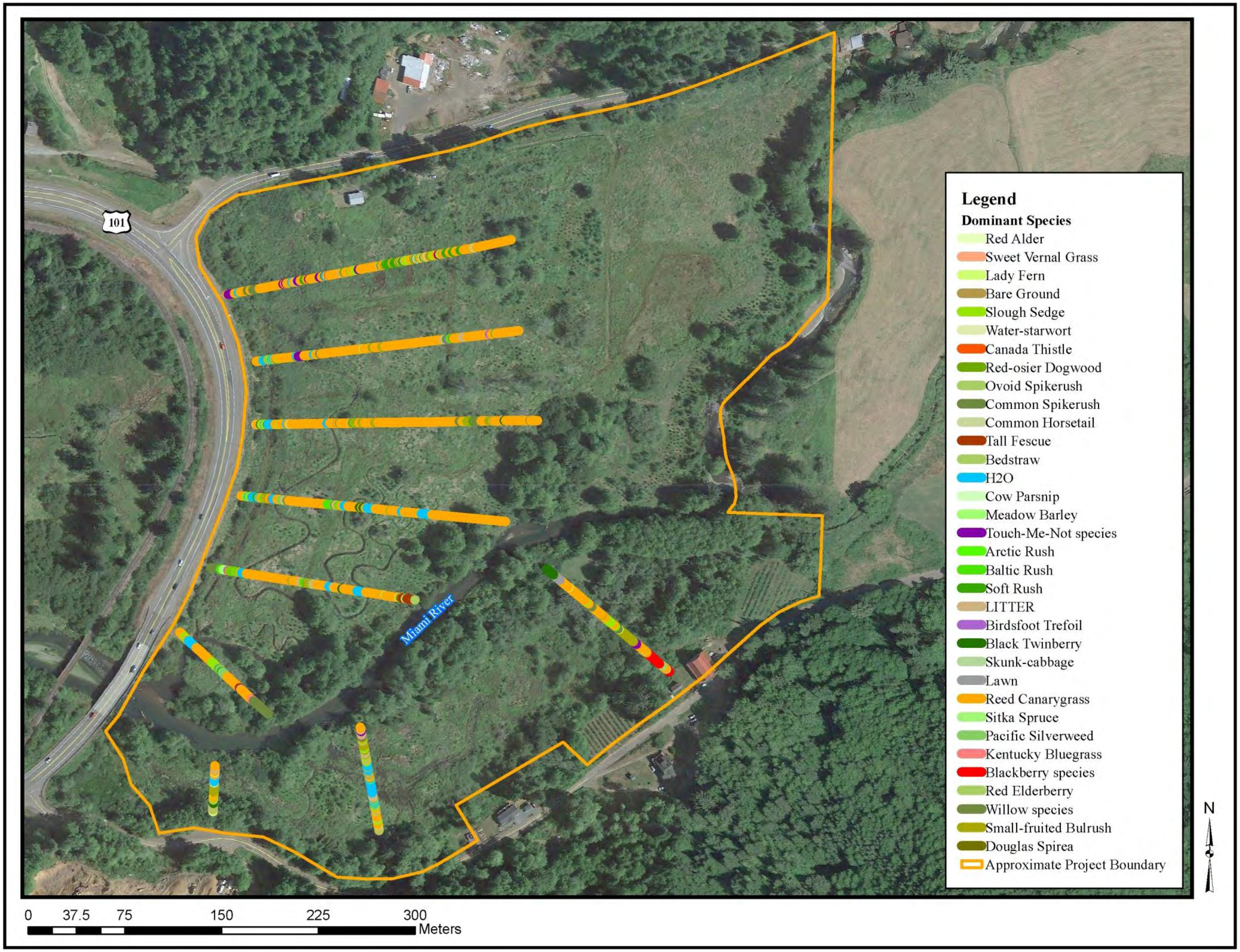
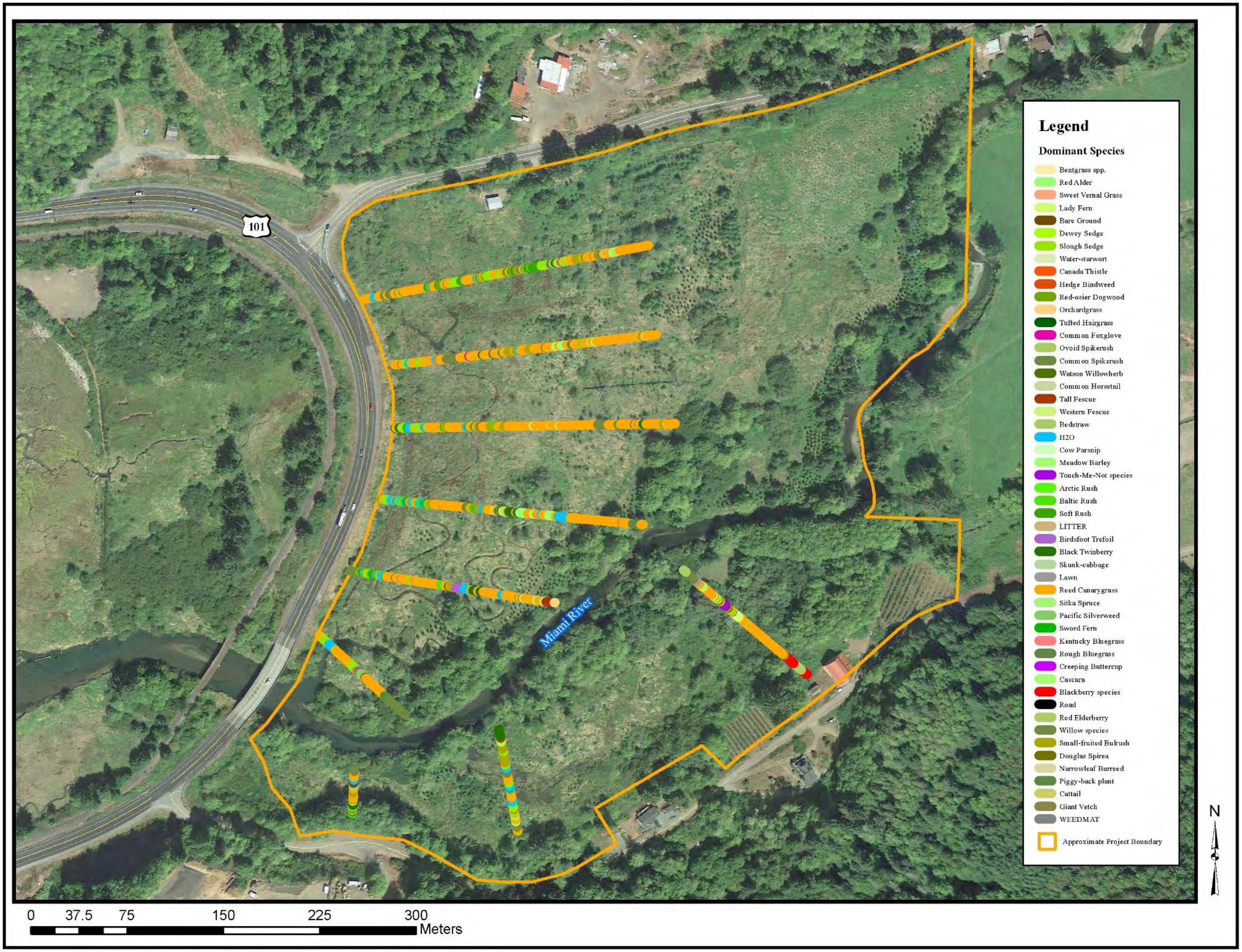


Figure I4. Aerial photograph of Miami Wetlands Restoration Project site with segmented polylines depicting 2016 post- construction line intercept data. Non-native or invasive species are depicted in shades of red, purple and orange, while native species are greens. 2016 base image.



Appendix J

Tranect end point photos from June 2010 and 2016 vegetation sampling

Transect A – East to West June 15, 2010

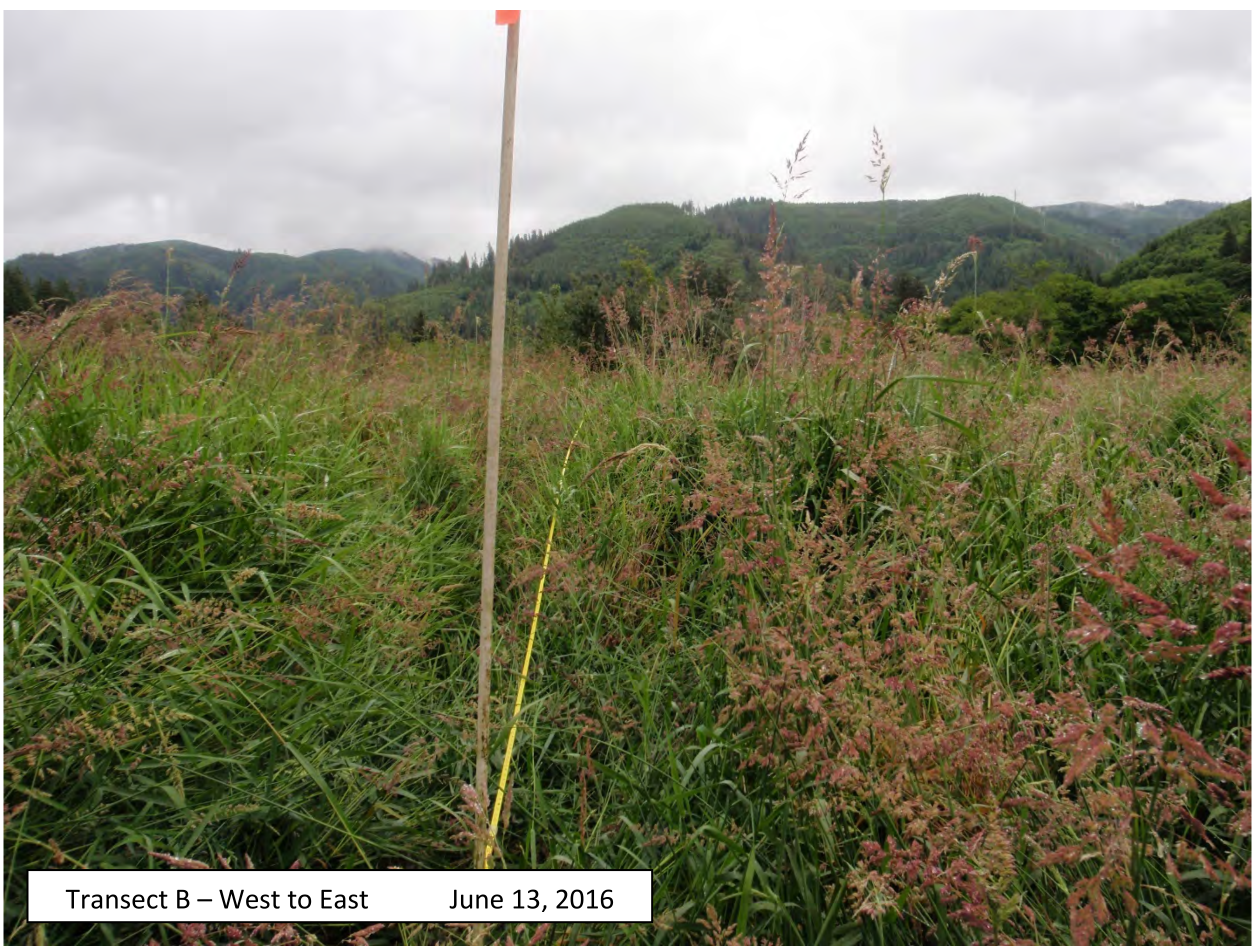
Transect A – West to East June 15, 2010

Transcect A – East to West June 13, 2016

Transect A – West to East June 13, 2016

Transect B – East to West June 15, 2010

Transect B – East to West June 13, 2016



Transect B – West to East June 13, 2016

Transect B – West to East   June 15, 2010

Transect C – West to East   June 15, 2010


Transect C – East to West June 15, 2010


Transect C – East to West June 13, 2016


Transect C – West to East June 13, 2016

Transect D – West to East June 15, 2010


Transect D – East to West June 14, 2016

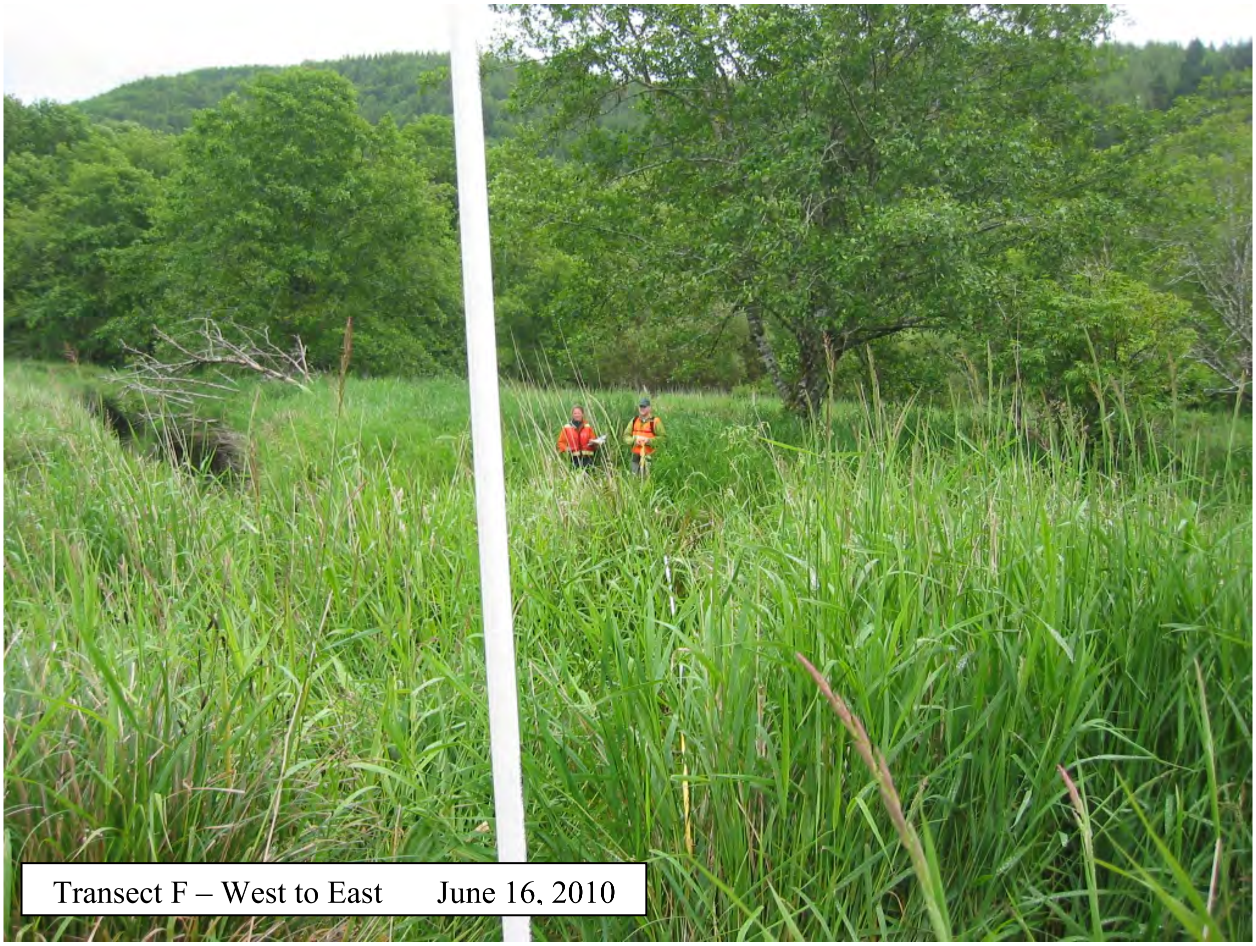

Transect D – West to East June 14, 2016

Transect D – East to West June 15, 2010


Transect E – West to East June 16, 2010

Transect E – East to West June 14, 2016

Transect E – West to East June 14, 2016



Transect F – West to East June 16, 2010

Transect G – North to South June 14, 2010

Transect F – East to West June 14, 2016

Transect F – West to East June 14, 2016

Transect G – South to North June 14, 2010


Transect G – South to North June 15, 2016


Transect G – North to South June 15, 2016

Transect H – North to South June 14, 2010

Transect H – South to North June 14, 2010


Transect H – South to North June 15, 2016


Transect H – North to South June 15, 2016

Transect I – North to South June 14, 2010

Transect I – South to North June 14, 2010

Transect I – South to North June 15, 2016

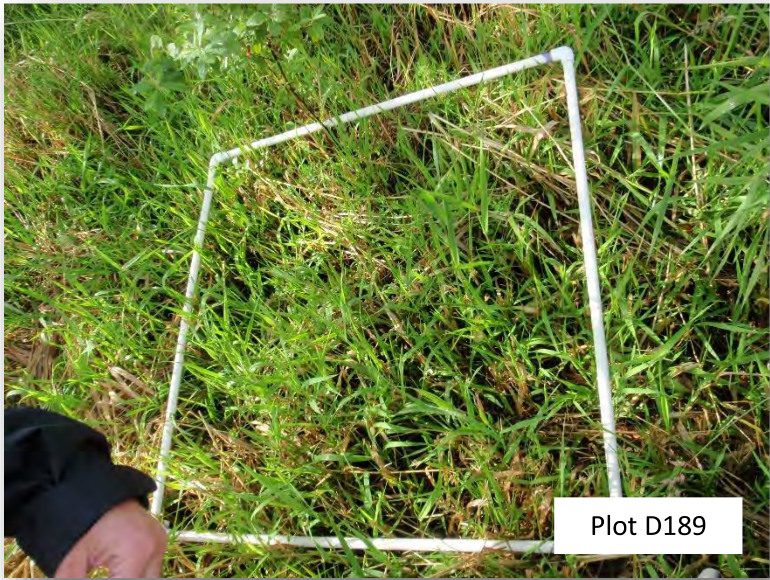
Appendix K

Representative photos of vegetation communities at Miami Wetlands

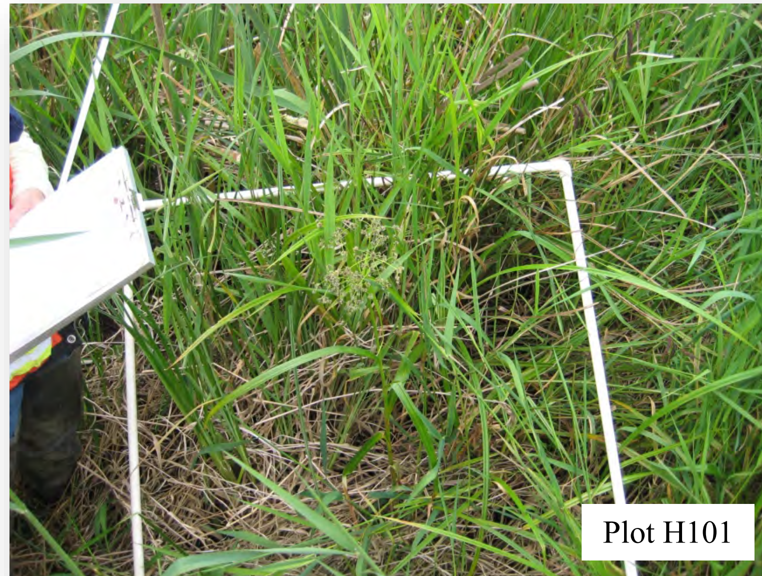
Close-up and overview photos of PEM1 Vegetation Community during June 2010

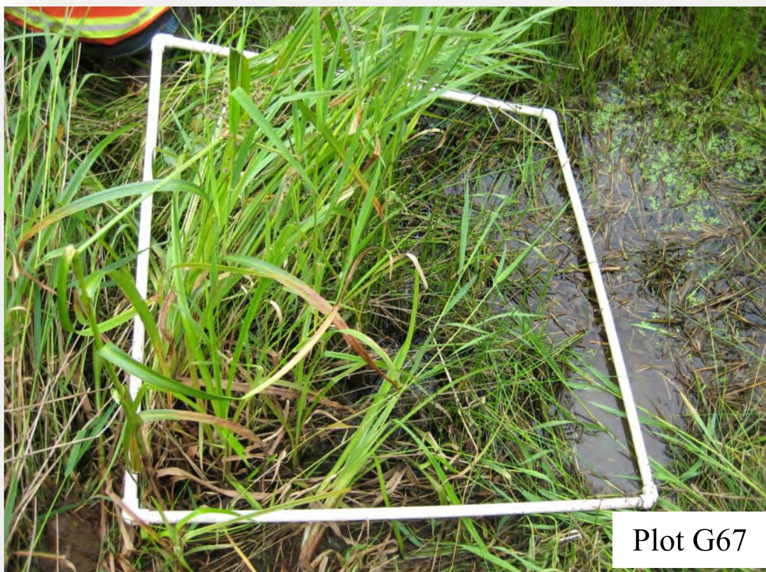
Close-up and overview photos of PEM1 vegetation community during June 2016

Close-up and overview photos of PEM2 Vegetation Community during June 2010



Close-up and overview photos of PEM2 vegetation community during June 2016

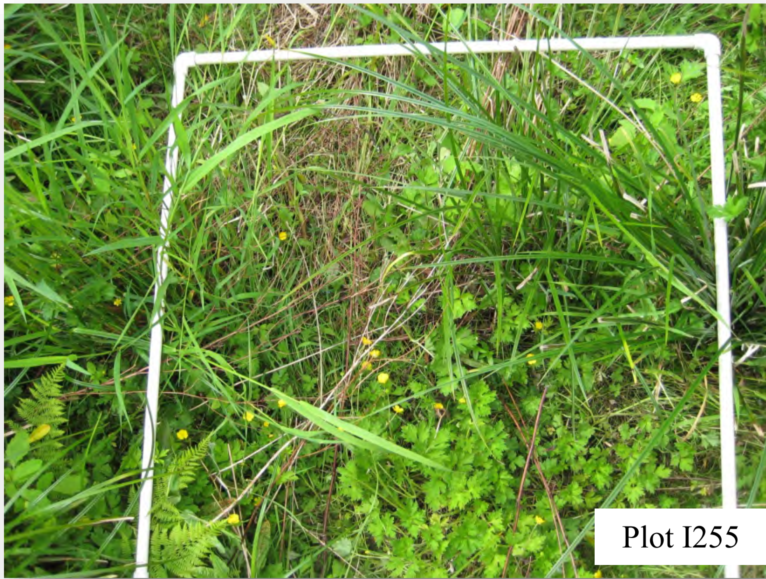




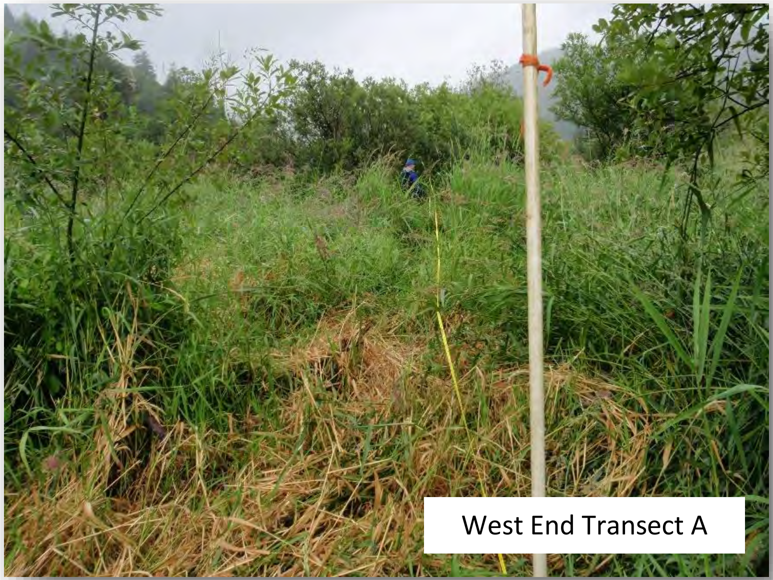
Close-up and overview photos of PEM3 Vegetation Community during June 2010

Close-up and overview photos of PEM3 vegetation community during June 2016

Close-up and overview photos of PEM4 Vegetation Community During June 2010



Close-up and overview photos of PSS Vegetation Community during June 2010



Close-up and overview photos of PSS vegetation community during June 2016


Plot D625


Plot F64


Plot B644


Plot D567

Close-up and overview photos of Riparian 1 Vegetation Community during June 2010

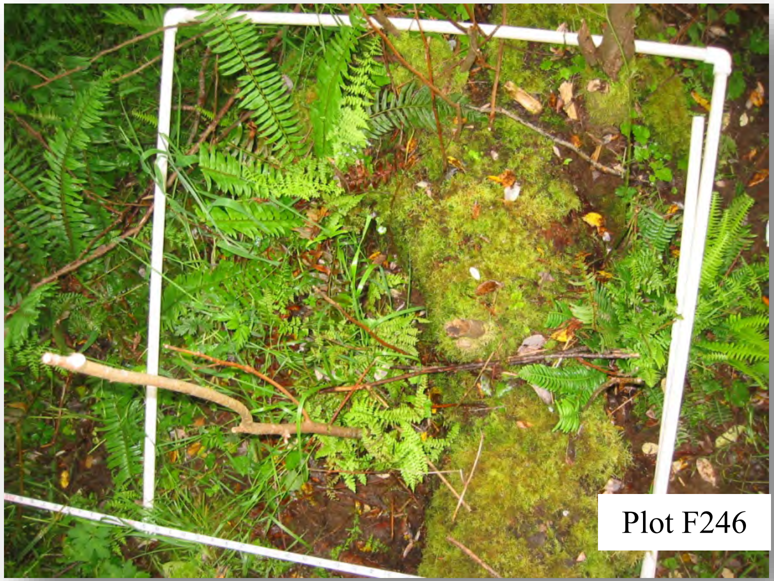

Plot A640


East End Transect A

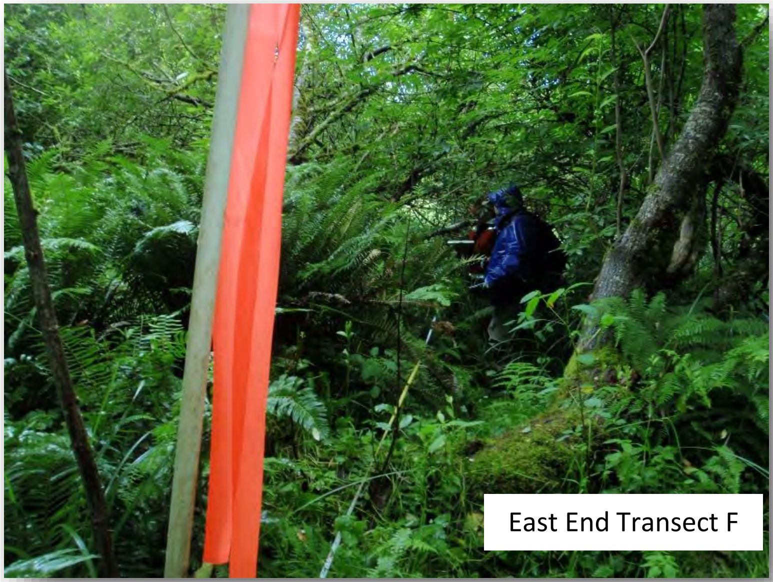

East End Transect D


East End Transect E

Close-up and overview photos of Riparian 1 vegetation community during June 2016



Close-up and overview photos of Riparian 2 Vegetation Community during June 2010



Close-up and overview photos of Riparian 2 vegetation community during June 2016

Appendix L

Plant species known to occur at Miami Wetlands

Four Letter Code	Latin Name	Common Name	Wetland Indicator Status
ACCI	*Acer circinatum*	Vine maple	FAC
ACMA	*Acer macrophyllum*	Bigleaf maple	FACU
AGCA	*Agrostis capillaris*	Colonial bentgrass	FAC
ALRU	*Alnus rubra*	Red alder	FAC
ALPR	*Aloperurus pratensis*	Meadow foxtail	FACW
ANOD	*Anthoxanthum odoratum*	Sweet vernal grass	FACU
AREG	*Argentina egedii*	Pacific silverweed	OBL
ATFI	*Athyrium filix-femina*	Lady fern	FAC
BLSP	*Blechnum spicant*	Deer fern	FAC
CAsp	*Callitriche* sp.	Water-starwort	OBL
CADEW	*Carex deweyana*	Dewey's sedge	FACU
CAOB	*Carex obnupta*	Slough sedge	OBL
CAST	*Carex stipata*	Saw-beak sedge	OBL
CIAR	*Cirsium arvense*	Canada thistle	FACU
CLSI	*Claytonia sibirica*	Siberian spring beauty	FAC
COAR	*Convulvulus arvensis*	Field bindweed	UPL
COFO	*Digitalis purpurea*	Common foxglove	FACU
COSE1	*Convulvulus sepium*	Hedge bindweed	UPL
COSE2	*Cornus sericea*	Red osier dogwood	FACW
CRDO	*Craetaegus douglasii*	Douglas hawthorn	FAC
DAGL	*Dactylis glomerata*	Orchardgrass	FACU
DECE	*Deschampsia cespitosa*	Tufted hairgrass	FACW
ELAC	*Eleocharis acicularis*	Needle spikerush	OBL
ELOB	*Eleocharis obtusa*	Blunt spikerush	OBL
ELOV	*Eleocharis ovata*	Ovoid spikerush	OBL
ELPA	*Eleocharis palustris*	Common spikerush	OBL
EPCI	*Epilobium ciliatum (watsonii)*	Watson willowherb	FACW
EQAR	*Equisetum arvense*	Common horsetail	FAC
FEAR	*Festuca arundinacea*	Tall fescue	FAC
FRPU	*Frangula purshiana*	Cascara	FAC
GAsp	*Gallium* sp.	Bedstraw	
GEMA	*Geum macrophyllum*	Oregon avens	FACW
GLBO	*Glyceria borealis*	Northern mannagrass	OBL
HEHE	*Hedera helix*	English ivy	
HELA	*Heracleum lanatum*	Cow parsnip	FAC
HOBR	*Hordeum brachyantherum*	Meadow barley	FACW
HOLA	*Holcus lanatus*	Velvetgrass	FAC
IMCA	*Impatiens capensis*	Spotted touch-me-not	FACW
IMNO	*Impatiens noli-tangere*	Yellow touch me not	FACW
IRPS	*Iris pseudoacorus*	Yellow flag iris	OBL
JUAC	*Juncus acuminatus*	Tapertip rush	OBL
JUAR	*Juncus arcticus*	Arctic rush	FACW
JUBA	*Juncus balticus*	Baltic rush	FACW
JUBO	*Juncus bolanderi*	Bolander's rush	OBL

Four Letter Code	Latin Name	Common Name	Wetland Indicator Status
JUEF	*Juncus effuses*	Soft rush	FACW
JUEN	Juncus ensifolius	Swordleaf rush	FACW
JUPA	*Juncus patens*	Grooved rush	FACW
LOIN	*Lonicera involucrata*	Black twinberry	FAC
LOCO	*Lotus corniculatus*	Birdsfoot trefoil	FAC
LOUL	*Lotus ulignosus*	Large birdsfoot trefoil	FAC
LYAM	*Lysichiton americanum*	Skunk-cabbage	OBL
MAFU	*Malus fusca*	Crabapple	FACW
OXOR	*Oxalis oregano*	Redwood sorrel	FACU
PHAR	*Phalaris arundinacea*	Reed canary grass	FACW
PHCA	*Physocarpus capitatus*	Pacific ninebark	FACW
PISI	*Picea sitchensis*	Sitka spruce	FAC
PLMA	*Plantago major*	Common plantain	FACU
POPA	*Poa palustris*	Fowl bluegrass	FAC
POPR	*Poa pratensis*	Kentucky bluegrass	FAC
POTR	*Poa trivialis*	Rough bluegrass	FACW
POCU	*Polygonum cuspidatum*	Japanese knotweed	FACU
POMU	*Polystichum munitum*	Western sword fern	FACU
POTR	*Populus trichocarpa [balsamifera]*	Black cottonwood	FAC
PSME	*Pseudotsuga menziesii*	Douglas fir	FACU
PTAQ	*Pteridium aquilinum*	Bracken fern	FACU
RAOC	*Ranunculus occidentalis*	Common buttercup	FAC
RARE	*Ranunculus repens*	Creeping buttercup	FACW
RISA	*Ribes sanguineum*	Red-flowering currant	FACU
RUAR	*Rubus armenicus*	Armenian blackberry	FACU
RULA	*Rubus lacinatus*	Cut-leaf blackberry	FACU
RUPA	*Rubus parviflorus*	Thimbleberry	FAC
RUSP	*Rubus spectabilis*	Salmonberry	FAC
RUUR	*Rubus ursinus*	Trailing blackberry	FAC
RUAC	*Rumex acetosella*	Sheep sorrel	FACU
RUCR	*Rumex crispus*	Curly dock	FAC
RUOB	*Rumex obtusifolius*	Broadleaved dock	FAC
SAHO	*Salix hookeriana*	Hooker's willow	FACW
SALU	*Salix lucida ssp lasiandra*	Pacific willow	FACW
SAPI	*Salix piperi*	Scouler willow	FACW
SASI	*Salix sitchensis*	Sitka willow	FACW
SARA	*Sambucus racemosa*	Red elderberry	FACU
SCMI	*Scirpus microcarpus*	Small-fruited bulrush	OBL
SPDO	*Spirea douglasii*	Douglas spirea	FACW
SPEM	*Sparganium emersum*	Narrowleaf burreed	OBL
STCO	*Stachys chamissonis var. cooleyae*	Coast hedge nettle	FACW
TOME	*Tolmeia menziesii*	Piggy-back plant	FAC
TYLA	*Typha latifolia*	Cattail	OBL

Four Letter Code	Latin Name	Common Name	Wetland Indicator Status
URDI	*Urtica dioica*	Stinging nettle	FAC
VAAM	*Vallisneria americana*	Tapegrass	OBL
VIAM	*Vicia americana*	American vetch	FAC
VIGI	*Vicia gigantea*	Giant vetch	FAC

OBL	Obligate Wetland	Almost always occurs (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).

Appendix M

Vertebrate species observed at Miami Wetlands (excluding fishes)

Latin Name	Common Name
REPTILES and AMPHIBIANS	
Ambystoma gracile	Northwestern salamander
Taricha granulose	Rough-skinned newt
Hyla regilla	Pacific treefrog
Rana aurora ssp. *aurora*	Northern red-legged frog
Thamnophis ordinoides	Northwestern garter snake
Thamnophis sirtalis ssp. *concinnus*	Red-spotted garter snake
Elgaria coerulea	Northern alligator lizard
BIRDS	
Phalacrocorax auritus	Double-crested cormorant
Ardea herodias	Great blue heron
Cathartes aura	Turkey vulture
Buteo jamaicensis	Red-tailed hawk
Haliaeetus leucocephalus	Bald eagle
Pandion haliaetus	Osprey
Porzana carolina	Sora
Rallus limicola	Virginia rail
Charadrius vociferous	Killdeer
Actitis macularia	Spotted sandpiper
Tyto alba	Barn owl
Bubo virginiana	Great horned owl
Ceryle alcyon	Belted kingfisher
Colaptes auratus	Northern flicker
Contopus sordidulus	Western wood-pewee
Empidonax difficilis	Pacific-slope flycatcher
Empidonax traillii	Willow flycatcher
Vireo gilvus	Warbling vireo
Corvus brachyrhynchos	American crow
Corvus corax	Common raven
Aphelocoma californica	Western scrub-jay
Tachycineta thalassina	Violet-green swallow
Poecile atricapillus	Black-capped chickadee
Cistothorus palustris	Marsh wren
Regulus calendula	Ruby-crowned kinglet
Catharus ustulatus	Swainson’s thrush
Turdus migratorius	American robin
Bombycilla cedorum	Cedar waxwing
Vermivora celata	Orange-crowned warbler
Dendroica coronate	Yellow-rumped warbler
Dendroica petechia	Yellow warbler
Geothlypis trichas	Common yellowthroat
Pipilo maculates	Spotted towhee
Melospiza melodia	Song sparrow
Zonotrichia leucophrys	White-crowned sparrow

Latin Name	Common Name
BIRDS	
Zonotrichia atricapilla	Golden-crowned sparrow
Junco hyemalis	Dark-eyed junco
Pheucticus melanocephalus	Black-headed grosbeak
Agelaius phoeniceus	Red-winged blackbird
MAMMALS	
Canis latrans	Coyote
Odocoileus hemionus ssp. *columbianus*	Columbian black-tailed deer
Ursa americanus	American black bear
Procyon lotor	Northern raccoon
Thomomys mazama	Western pocket gopher
Castor canadensis	American beaver
Microtus townsendii	Townsend's vole
Ondatra zibethicus	Muskrat
Myocastor coypus	Nutria
Lontra Canadensis	North American river otter

Appendix N

Repeat perimeter photos 2010 and 2017


June 2010


April 2017


June 2010


April 2017


June 2010


April 2017


June 2010


April 2017


June 2010


April 2017


June 2010


April 2017


June 2010


April 2017

June 2010

April 2017

June 2010

April 2017


June 2010


April 2017


June 2010


April 2017

June 2010

April 2017

Appendix O

Repeat interior photos 2010-2017

Miami Wetlands Repeat Photographs - Additional Photos

North Lateral Ditch and Double Wood Structure on Hobson-Struby Channel

Pre-Construction - June 2010

During-Construction - August 2011

Post-Construction - Jan. 2013

Post-Construction - June 2013

North Lateral Ditch and Double Wood Structure (continued)

Post-Construction - Dec. 2013

Post-Construction—Sep. 2014

Post– Construction—March 2016

Post– Construction—May 2017

Hobson-Struby Confluence (looking upstream)

Immediate Post-Construction - Oct. 2010

Post-Construction - June 2011

Post-Construction - Jan. 2013

Post-Construction - June 2013

Hobson-Struby Confluence (continued)

Post-Construction - Dec. 2013

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Miami Wetlands Repeat Photographs - Additional Photos

Hobson Cr. Wood Structure (looking upstream)

Post-Construction - June 2010

Post-Construction - Jan. 2013

Post Construction - June 2013

Post Construction - Dec. 2013

Hobson Cr. Wood Structure (continued)

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Hobson-Struby Channel Plus Floodplain Wood Structure (looking upstream)

Post-Construction - Sep. 2010

Post-Construction - Jan. 2013

Post-Construction - June 2013

Post-Construction - Dec. 2013

Hobson-Struby Channel Plus Floodplain Wood Structure (continued)

Post-Construction - Sept. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Miami Wetlands Repeat Photographs - Additional Photos

Double Wood Structure on Hobson-Struby Channel (looking downstream)

Post-Construction - Sep. 2010

Post-Construction - Oct. 2010

Post-Construction - Jan. 2013

Post Construction - June 2013

Double Wood Structure on Hobson-Struby Channel (continued)

Post-Construction - Dec. 2013

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Double Wood Structure on Hobson-Struby Channel (looking upstream)

During-Construction - Sep. 2010

Post-Construction - Oct. 2010

Post-Construction - Jan. 2013

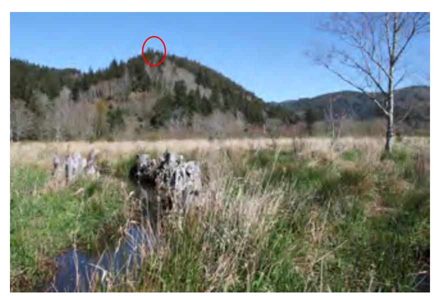
Post-Construction - June 2013

Double Wood Structure on Hobson-Struby Channel (continued)

Post-Construction - Dec. 2013

Post-Construction—Sep. 2014

Post– Construction—Mar. 2016



Post– Construction—May 2017

Miami Wetlands Repeat Photographs - Additional Photos

Wood Structure on Lower Hobson-Struby Channel (looking upstream)

Post-Construction - Oct. 2010

Post-Construction - Jan. 2013

Post-Construction - June 2013

Post-Construction - Dec. 2013

Wood Structure on Lower Hobson-Struby Channel (continued)

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Hobson-Struby Channel Confluence With Tidal Channel (looking downstream)

Post-Construction - Oct. 2010

Post-Construction - Jan. 2013

Post-Construction - June 2013

Post-Construction - Dec. 2013

Hobson-Struby Channel Confluence With Tidal Channel (continued)

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Miami Wetlands Repeat Photographs - Additional Photos

Confluence of E and E2 Tidal Channels (looking upstream)

Post-Construction - Aug. 2010

Post-Construction - Jan. 2013

Post-Construction - June 2013

Post-Construction - Dec. 2013

Confluence of E and E2 Tid-al Channels (continued)

Post-Construction—Sep. 2014

Post-Construction—Mar. 2016

Post-Construction—May 2017

Wood Structure at South End of the Old Hobson-Struby Ditch Fill

Post-Construction - April 2012

Post-Construction - Dec. 2013

Post-Construction - Sep. 2014

Post-Construction - Mar. 2016

Wood Structure at South End of the Old Hobson-Struby Ditch Fill (continued)

Post-Construction - May 2017

Miami Wetlands Repeat Photographs - Additional Photos

Beaver Dam constructed summer 2014 at confluence of channels C and F (paired images)

Post-Construction - Sep. 2014

Post-Construction - Sep. 2014

Post-Construction - Mar. 2016

Post-Construction - Mar. 2016

Beaver Dam constructed summer 2014 at confluence of channels C and F (continued)

Post-Construction - May 2017

Post-Construction - May 2017