Environmental Site Assessment of Stella's Landing

Project Report
Science, Management and Outreach of Contaminated Sites
ESCI 454, Spring 2017

Report No. 17-06 June 2017

Western Washington University

Sustainable Communities Partnership

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PREFACE

A group of students worked in winter and spring of 2017 on an assessment of the marsh at the west end of the Stella's Landing site. The students were enrolled in a two-quarter capstone sequence focused upon science, management, and outreach related to contaminated sites. In the winter course, Stella's Landing was used as an example site, while students learned site assessment methodologies. In essence, students developed a plan for how to conduct actual assessments in the succeeding quarter. Two student teams prepared posters that were shared with Edmonds staff on March 15, 2017, at the WWU campus. In the spring course, two student teams performed assessments that involved site visits, lab analyses, interviews, and detailed review of records pertaining to Stella's Landing. Each team wrote a report, and the two reports are included within this document. The two teams visited Edmonds on June 9, 2017, to present their work to an audience of officials and interested citizens.

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Phase I Environmental Site Assessment

Stella's Landing

Edmonds, WA

Western Washington University

Herbal Environmental

Emily Rahlmann, Sarah Bailey, Monica Hope

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List of Acronyms

ASTM.....American Society for Testing and Materials
AUL.....Activity and Use Limitations
CERCLA.....Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS.....CERCLA Information System
CORRACTS.....RCRA Corrective Action Sites
Ecology.....Washington State Department of Ecology
ERNS.....Emergency Response Notification System
HREC.....Historically Recognized Environmental Condition
NFRAP.....No Further Remedial Action Planned
NPDES.....National Pollutant Discharge Elimination System (Water Quality Permit System Data)
NPL .....National Priority List
RCRA.....Resource Conservation and Recovery Act of 1976
REC.....Recognized Environmental Condition
SCP.....Sustainable Cities Partnership
SMOCS.....Science and Management of Contaminated Sites
SR104.....State Route 104
TSD.....Transporters, Storage, and Disposal
USA.....United States of America
WWU.....Western Washington University

Executive Summary

The primary investigators on this project conducted a Phase I Environmental Site Assessment (ESA) for Stella's Landing (Subject Property) in the City of Edmonds, Snohomish County, Washington. The primary investigators are undergraduate students and this work was completed as a class project; they collectively comprise the Herbal consulting firm. The Subject Property is approximately 2.4 acres of land with a marsh at the west end of the lot. The Subject Property is a private, residential condominium complex with no prior development, which differs from the majority of properties for which ESAs have been conducted.

This Phase I ESA was conducted in general accordance with the American Society for Testing and Material (ASTM) Standard entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Assessment Process*. The purpose of this Phase I ESA is to identify recognized environmental conditions (RECs) and historical RECs (HRECs) in connection with the Subject Property. The ASTM Standard defines a REC as:

> "The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with laws. The term is not intended to include de minimis conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be de minimis are not recognized environmental conditions."

The ASTM Standard defines a HREC as:

> "Environmental condition which in the past would have been considered a recognized environmental condition, but may or may not be considered a recognized environmental condition currently."

Overview of Subject Property History

Prior to 1976, the Subject Property was an undeveloped portion of Edmonds Marsh in the City of Edmonds. The development of SR 104, which currently borders the western edge of the Subject Property, occurred between 1976 and 1986. SR 104 bisected Edmonds Marsh, resulting in a new marsh, called Stella's Marsh, which is connected to Edmonds Marsh by way of a small culvert. In 1997, the Subject Property was developed and the Stella's Landing complex was built, with a section of Stella's Marsh remaining adjacent to the complex.

Summary of Findings, Opinions and Conclusions

Now that Herbal has conducted the Phase I ESA, we suggest three potential contributors to the species composition change in Stella's Marsh. One potential contributor is the lower precipitation in 2013 compared to the preceding and following years. The second contributor is a lack of full functionality prior to 2014 in the culvert beneath SR 104 that connects Stella's Marsh with Edmonds Marsh. This suggestion is based on information provided by residents of the Subject Property in good faith during an interview process. The final contributor is nonpoint source contamination from stormwater runoff into Stella's Marsh. This suggestion is based on Herbal's observations of the Subject Property.

1.0 Introduction

1.1 Purpose

The primary investigators and researchers on this project are Emily Rahlmann, Sarah Bailey, and Monica Hope, hereafter collectively referred to as Herbal Environmental, or Herbal. The primary investigators are undergraduate students and this work was completed as a class project at Western Washington University (WWU). During the 2016/17 Academic Year, WWU partnered with the City of Edmonds through the Sustainable Communities Partnership. Through this partnership, Edmonds communicated to WWU faculty a desire that a Phase I Environmental Site Assessment (ESA) be conducted at the Stella's Landing Marsh (the Subject Property). Efforts were coordinated, and the Phase I ESA was assigned to Herbal through the Environmental Science 454 capstone class, Science, Management and Outreach of Contaminated Sites (SMOCS).

The Phase I ESA was requested of the City by residents of a local property who wanted to know why the marsh on their property (Subject Property) was showing changes in species composition, specifically a large increase in invasive species. Residents compiled multiple documents summarizing their recollections of the issue, which are included in Appendix A and B.

The purpose of a Phase I ESA is to perform all appropriate inquiries into the ownership and uses of a Subject Property in order to identify, through the process prescribed by the American Society for Testing and Materials (ASTM), recognized environmental conditions (RECs) and historical RECs (HRECs) associated with the Subject Property. A REC is defined by ASTM as, "the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater or surface water of the property". ASTM also defines a HREC as "an environmental condition which in the past would have been considered a recognized environmental condition, but may or may not be considered a recognized environmental condition currently."

1.2 Detailed Scope-of-Services

This Phase I ESA was performed in accordance with ASTM E 1527-13 (Standard Practice for ESAs: Phase I ESA Process) and included the following tasks:

- Records review of reasonable ascertainable information
- Site reconnaissance
- Physical setting description
- Interviews with present owners and residents, and local city officials

Herbal's scope of service did not include any non-scope considerations as listed in Section 13 of ATSM E 1527-13. Additionally, chain-of-title records, an Environmental Lien search and Activity and Use Limitation (AUL) search, and hydrogeologic and geologic information were not included in the scope of work.

1.3 Significant Assumptions

Herbal assumes that all information given by the Owner is complete and correct. Owner is defined as the 41 individuals or trusts who own condominiums on the Subject Property. Herbal also assumes the Owner has provided Herbal with all reasonably ascertainable prior environmental reports concerning the Subject Property. Finally, Herbal assume that this Phase I ESA report will be read in its entirety by the reader.

This report summarizes observed RECs and HRECs for the Subject Property. Environmental conditions and regulations are subject to change and reinterpretation. Current observations may not represent conditions in the future.

1.4 Limitations, Exceptions, and Additions

The findings within this ESA used information that was reasonably ascertainable, meaning the information obtained was publicly available, obtainable within the time constants for this project, and practically reviewable.

In a traditional Phase I ESA, a section entitled "User Provided Information" is normally included prior to the "Records Review" section. In the absence of a user, this section has been omitted.

An addition has been made to this report that is not normally present in a Phase I ESA. Historical precipitation data has been included to further inform the reader regarding the variation in annual precipitation.

Typically, a Phase I ESA is conducted prior to the Phase II ESA. In this case, Phase I and Phase II were conducted simultaneously by two different student groups because of time limitations associated with the academic calendar.

1.5 Special Terms and Conditions

The findings in this ESA are based on the accuracy and completeness of the information and conditions of the Subject Property as of June 6th, 2017 and when the public information was obtained.

2.0 Site Description

2.1 Location and Legal Description

The Subject Property is Stella's Landing condominium complex located at 402 and 404 3rd Avenue in the City of Edmonds, Snohomish County, Washington, 98020 (Appendix C). The Subject Property consists of 41 different tax parcels of land with a total acreage of approximately 0.63 acres. The tax parcels and associated acreage are listed in Table 2.1-1. All parcels are located in Section 23 of Township 27 North, Range 3 East. The latitude and longitude of the approximate center of the Subject Property is 47.48'26.1 N and 122.22'53.9 W. Building plans were obtained by Herbal and are included in Appendix D. One feature of note on the building plans is an oil water separator located on the Road and Storm Drainage plan. The presence of the separator on the Subject Property was not confirmed by Herbal.

Table 2.1-1 Subject Property Tax Parcels and Associated Acreage.

Tax Parcel Number	Acreage[1]	Tax Parcel Number	Acreage[1]
00843300210100	0.00	00843300120100	0.00
00843300210200	0.00	00843300120200	0.00
00843300210300	0.00	00843300120300	0.00
00843300210400	0.00	00843300120400	0.00
00843300220100	0.00	00843300120500	0.00
00843300220200	0.00	00843300120600	0.00
00843300220300	0.00	00843300120700	0.00
00843300220400	0.00	00843300120800	0.00
00843300220500	0.00	00843300120900	0.00
00843300220600	0.00	00843300121000	0.00
00843300230100	0.00	00843300130100	0.00
00843300230200	0.00	00843300130200	0.00
00843300230300	0.00	00843300130300	0.00
00843300230400	0.00	00843300130400	0.00
00843300230500	0.00	00843300130500	0.00
00843300230600	0.00	00843300130600	0.00
00843300110100	0.00	00843300130700	0.00
00843300110200	0.00	00843300130800	0.00
00843300110300	0.00	00843300130900	0.00
00843300110400	0.00	00843300131000	0.00
00843300110500	0.00		

[1] Due to the Snohomish County Assessor's designation methods for condominiums with acreage less than 1 acre, all acreages are listed at 0.00. The Subject Property is a condominium community currently owned by 41 individuals or trusts.

2.2 Current Use of Subject Property

The Subject Property is currently designated as "single-family residence condominium multiple" under Snohomish County use code. The Subject Property is occupied by 41 individuals or families. The marsh is used for aesthetic purposes by the residents of the Subject Property and the surrounding properties.

2.3 Description of Subject Property Structures, Roads, and Improvements

2.3.1 Existing Structures

There are currently two buildings located on the Subject Property that were constructed in 1995. The construction permit for the buildings was obtained and confirms that this was the first and only development on the Subject Property (Appendix E). The building plans were also obtained, showing the plans for construction of 402 and 404 3rd Avenue, Edmonds, WA.

The Subject Property has a private drainage system that includes stormwater features. The stormwater features on the property are known as facility features and detention facilities. These features are mainly catch basins, which are constructed to improve downstream water quality by reducing the speed of stormwater runoff. This is done by collecting rain and runoff until the basin is full, and then allowing water to flow out. Most of them are located on the southern side of both buildings, with two facility features located on the eastern side of the property, bordered by 3rd Avenue South. One culvert is located on the Subject Property, at the southwestern corner of building 404. This culvert leads into a storm ditch which empties into the marsh at the northern side of the property. A map of the Subject Property's drainage system is included in Appendix F.

The marsh adjacent to the Subject Property has multiple inputs. These include the previously mentioned storm ditch, as well as overflow from Shellabarger Creek. As depicted in Appendix F, Shellabarger Creek is located south of the Subject Property and is diverted north towards the property when the creek intersects State Route 104 (SR104). The diverted creek then flows under SR104 through two culverts that are located south of the Subject Property. Each of the culverts are three feet wide. There is a storm ditch directly adjacent to SR104 on the east side of the road. The storm ditch flows north from the culverts to a storm line, and is intended to help decrease flooding of SR104 during high precipitation events. A culvert and storm catch basin are located on the Subject Property off SR104, and collect runoff from SR104. The runoff is discharged into the marsh through an eight-inch pipe.

Through personal communication (5/10/2017), Michael Cawrse, a stormwater engineering technician for the City of Edmonds, was consulted and contributed to the information presented in this section. During normal precipitation events, Shellabarger Creek flows through the two culverts south of the Subject Property under SR104 and into Edmonds Marsh. Water flowing south from the marsh and through the storm ditch also enters the culverts and flows into Edmonds Marsh. During high precipitation events, the culverts cannot handle the increased flow, and some of the water is diverted north into the storm ditch and the marsh located on the Subject Property. One of the reasons this occurs is due to sediment filling the culverts under SR 104. According to Cawrse, the culverts currently are not fully functioning due to sediment and vegetation impeding flow. The culverts are maintained by the Washington State Department of Transportation (WSDOT) and the last maintenance was conducted in 2014.

2.3.2 Existing Roads

The Subject Property is bounded by 3rd Avenue South to the east and SR104 to the west.

2.4 Current Use of Adjoining Properties

The following properties were noted adjacent to the Subject Property:

- Edmonds Marsh is located west of the Subject Property, across SR104.
- Located east of the property is 3rd Avenue South with single-family residences beyond.
- Located north of the property is a single-family residence.
- Located south of the property is a multiple-family residence.

3.0 Subject Property Information

3.1 Title Records

Chain-of-title records were not a part of this Phase I ESA's scope of work.

3.2 Environmental Liens or Activity and Use Limitations

No environmental liens of Activity and Use Limitations exist for the subject property. This was confirmed in an Environmental Radius Report from Nationwide Environmental Title Research Online (Appendix G).

3.3 Specialized Knowledge

The term "specialized knowledge" herein refers to information on the environmental condition of the property that would not be available in public records or other sources as referenced in this report and could only be obtained from disclosure by the owner, occupants, or operators on the property from personal experience and observation.

Anne-Marie Sykes, the Key Site Manager, has lived at the property for 12 years and has observed and documented the ecological changes in the marsh. She was not aware of any environmental issues due to hazardous activities or spills on the Subject Property.

Priscilla Thurber has lived at the Subject Property for 22 years. She moved in when most of the building was complete, but construction had not finished entirely. She has observed the ecological changes in the marsh. Her account supported the Key Site Manager's information. She was not aware of any environmental issues due to hazardous activities or spills on the Subject Property.

Other occupants of the property with specialized knowledge include Roy Combley, James Wold, Ralph Sanders, Letitia Brown, Phyllis Keiley-Tyler and Judy Wangen. All listed occupants have observed changes in the marsh and support the Key Site Manager's accounts and information. None were aware of any environmental issues due to hazardous activities or spills on the Subject Property.

3.4 Valuation Reduction for Environmental Issues

There is no sale pending for the subject property and therefore no valuation statements are made here.

3.5 Owner, Property Manager and Occupant Information

The Subject Property is a condominium community currently owned by 41 individuals or trusts. The current occupants are 41 individuals or families who reside in their condominiums.

3.6 Reasons for Performing the Phase I ESA

In November 2013, residents of Stella's Landing observed a decline in cattail vegetation in the marsh and became concerned. In Appendix B, the author Anne-Marie Sykes incorrectly listed 2014 as the year when residents took notice of the species change. In her interview, this mistake was identified and recognized by Herbal. A few residents contacted the city and various individuals and organizations in attempts to understand what changes were occurring in the marsh and how they had occurred. In September 2017, WWU partnered with the City of Edmonds through the Sustainable Cities Partnership. The goal of this partnership is for students to complete projects that address problems identified by the City of Edmonds. One of the problems identified was the changing plant species composition of the marsh adjacent to Stella's Landing. The Phase I ESA was selected by both parties as the best assessment method for this problem.

4.0 Records Review

4.1 Prior Environmental Reports

Herbal was provided with a relevant study conducted in the area of Stella's Marsh by Joe Scordino, the project leader of Edmonds Stream Team. The Edmonds Stream Team is composed of Edmonds-Woodway High School students who are members of the Students Saving Salmon club.

The students have been conducting a citizen-science project since September 2015. Water quality monitoring is occurring at 16 sites across Edmonds (Appendix H) and is done monthly. Initial data was compiled into a report in June 2016, and material from that report is discussed below.

Three of the Edmonds Stream Team monitoring sites are in the vicinity of Stella's Marsh (Appendix H), referred to as Shellabarger Marsh in the report. One site, called F1, is located where Shellabarger Creek intersects SR104. Another monitoring site, called J1, is on the Subject Property directly to the east of SR104, where the culvert and storm ditch are located. The final site, called K1, is located directly west across SR104 from J1, where a storm ditch and culvert are located in the Edmonds Marsh. Upstream of the Stella's vicinity are two other Stream Team sites (C1 and D1) and downstream, in the Edmonds Marsh, are four others (K2, L1, L2 and N1).

The 2016 Stream Team report describes the background and hydrology of the area, specifically of Shellabarger Creek. Shellabarger Creek drains a basin of 378 acres and the watershed is developed heavily. The creek passes through many pipes under roadways and the daylighted reaches are located in residential areas, where residential runoff may occur. This runoff is coming from yards, homes, and gardens, and therefore may contain higher than usual levels of nutrients, toxicants, and/or fecal coliform bacteria associated with pet wastes.

Water collected at all three monitoring sites had high levels of bacteria: counts of fecal coliform bacteria exceeded 100 colonies/100 mL in February and April of 2016. In addition, all sites had very low concentrations of dissolved metals, and mercury was not found at any site.

The monitoring sites in the upstream regions of Shellabarger Creek (C1 and D1) had lower fecal coliform counts than the most downstream sites (J1 and K1), indicating that the source of fecal coliform bacteria is downstream of the upper reaches of the creek and upstream of Stella's. When compared with other monitoring sites, Shellabarger Creek (C1, D1, F1) showed average trends in temperature, dissolved oxygen, pH, and conductivity from October 2015 to May 2016. The creek had nitrate concentrations lower than other sites from October 2015 to March 2016. Stella's Marsh (J1) was documented as having lower dissolved oxygen than the lower areas of Shellabarger Creek (F1). Three ranges of petroleum hydrocarbons were detected in lower Shellabarger Creek (F1) in the fall, winter and spring. The highest concentrations of diesel and oil range were found in lower Shellabarger Creek (F1) in the spring.

The report also contains data on water samples taken from the culvert in Stella's Marsh (J1) and the inlet culvert to Edmonds Marsh (K1). The data shows no salinity present at the inlet to Edmonds (K1), thus the authors concluded that at the times sampled, there was no salinity present in Stella's Marsh. Sampling for salinity was conducted at low tide during the spring and summer months, when the tidegate at the outlet of Edmonds Marsh is open. Dissolved oxygen in Edmonds inlet (K1) exceeded minimum requirements for salmon (Washington Water Quality Standards), with an average of 9.4 mg/L from October 2015 to May 2016. The water temperature followed expected seasonal trends. The pH of water flowing through the Edmonds Marsh was within the range suitable for salmon and aquatic life (Washington Water Quality Standards), averaging a pH of 7 from October 2015 to May 2016. Testing for Total Petroleum Hydrocarbons was done, and concentrations of compounds in the diesel and oil range were found at the Edmonds Marsh inlet (K1) in the spring of 2016.

The report concludes that there are no serious water quality issues that would require further investigation. However, monitoring should continue. A number of recommendations were made by the authors of the report to improve local water quality, including removal of animal wastes, elimination of use of fertilizers in the watershed, and the incorporation of low impact development in future plans.

4.2 Physical Setting Sources

4.2.1 Topography

Herbal reviewed United States Geological Survey (USGS) 7.5 minute topographic maps (Appendix C). The Subject Property is located at an elevation of approximately 40 feet above sea level. Adjacent properties to the west are at lower elevations of approximately 20 feet above sea level. Eastern adjacent properties are at increasing elevations above 40 feet above sea level.

4.2.2 Soils

Herbal accessed the United States Department of Agriculture's web soil survey. Surface soil information indicates that the Subject Property is located in an area mapped as Mukilteo muck. This soil type is classified as a hydric soil that is very poorly drained. (USDA).

Through personal communication (4/27/2017), Doug Gresham, a wetland specialist with the Washington State Department of Ecology, was consulted for his expertise. Gresham visited the

Subject Property in March 2016. Gresham was unable to take soil cores due to the muck consistency of the soil.

4.2.3 Sensitive Receptors

No sensitive receptors were identified.

4.3 Environmental Record Sources

Current federal, state and tribal database listings for hazardous waste and other potentially impaired sites within specific search distances were identified for the Subject Property and area by Herbal. These sites were reviewed to ascertain whether they pose any RECs to Subject Property.

The following federal, state and tribal environmental databases were reviewed:

- Federal NPL site list
- Federal Delisted NPL List
- Federal Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS)
- Federal CERCLIS No Further Remedial Action Planned (NFRAP) Sites List
- Federal Resource Conservation and Recovery Act (RCRA) Information System-Corrective Action (CORRACTS) Facilities List
- Federal RCRA Non-CORRACTS Transporters, Storage, and Disposal (TSD) Facilities List
- Federal RCRA Generators List
- Federal Institutional Controls/Engineering Controls Registries
- Federal Emergency Response Notification System (ERNS) List
- State and Tribal Leaking Storage Tank Sites
- State and Tribal Registered Storage Tank Lists
- State and Tribal Voluntary Cleanup Sites
- State- and Tribal-Equivalent NPL
- State- and Tribal-Equivalent CERCLIS
- State and Tribal Landfill and/or Solid Waste Disposal Sites Lists
- State and Tribal Brownfields Sites

4.3.1 Subject Property

The subject property was not listed in any of the databases listed in Section 4.3 (Appendix G).

4.3.2 Adjoining Properties

Database findings indicate that within a 0.5 mile radius from the subject property, there are 21 cleanup sites listed under the Washington State Toxics Cleanup Program. Four of the sites are ranked for their hazard level, while the other 17 did not warrant this ranking. The sites and relevant information are summarized in the Table 4.3.2-1.

Table 4.3.2-1 List of WA State Cleanup Sites within a 0.5 mile radius of the Subject Property.

Site Name	Site Status	Cleanup Type	Hazard Ranking	Address (in Edmonds, WA 98020)
Mar Vel Marble LLC	Awaiting Cleanup	No Process		202 MAIN ST
4th Ave N Building	No Further Action	Voluntary Cleanup Program		130 4TH AVE N
EDMONDS DRY STORAGE PORT OF EDMONDS	Awaiting Cleanup	No Process	5	400 ADMIRAL WAY
Alaska Northwest Publishing Co	No Further Action	Voluntary Cleanup Program		130 2ND AVE S
Port of Edmonds W Dayton	Cleanup Started	Independent Action	5	120-190 W DAYTON ST
210 5TH AVE S PROPERTY	No Further Action	Voluntary Cleanup Program		210 5TH AVE
Unocal Edmonds Bulk Fuel Terminal 0178	Cleanup Started	Ecology-supervised or conducted	1	11720 UNOCO ROAD
Edmonds Office Site	No Further Action	Voluntary Cleanup Program		131 2ND AVE S
Main Street Building	No Further Action	Independent Action		110 MAIN ST
ARCO 0822	Cleanup Started	Voluntary Cleanup Program	5	202 5TH AVE S
Old Mill Town Mall	Cleanup Started	Voluntary Cleanup Program		201 5TH AVE S
AMTRAK Depot Edmonds	No Further Action	Independent Action		211 RAILROAD AVE
Anderson Marine	Cleanup Started	Independent Action		100 RAILROAD AVE
Old Mill Bus Barn	Cleanup Started	Independent Action		400 BLOCK MAPLE ST
Edmonds Public Safety Building	Cleanup Started	Independent Action		250 5TH AVE N
EDMONDS VETERINARY HOSPITAL	No Further Action	Independent Action		313 5TH AVE S
EDMONDS PUBLIC WORKS	No Further Action	Independent Action		200 DAYTON ST
Port of Edmonds Fur Breeders Building	Cleanup Started	Independent Action		335 ADMIRAL WAY
U S POSTAL SERVICE – EDMONDS	No Further Action	Independent Action		201 MAIN ST
Shell Creek Grill	No Further Action	Independent Action		526 MAIN ST
TOMLINSON PROPERTY	No Further Action	Voluntary Cleanup Program		117 5TH AVE S

4.4 Historical Use of Subject Property and Adjoining Properties

4.4.1 Aerial Photographs

Historic aerial photographs provided by the City of the Edmonds and dated 1947, 1955, 1964, 1967, 1976, 1985, and 1989 were reviewed as a part of this assessment. Copies of the historical aerial photos are presented in Appendix I. The results of this review are included in the Table 4.4.1-1.

Table 4.4.1-Aerial photographs review of Subject Property and surrounding areas.

Year	Subject Property Use	Adjacent Property Use
1947	The west quadrant of the Subject Property appeared to be a marsh, while the east quadrant appeared to be grass. A roadway, 3rd Ave., was already in place bordering the east side of the Subject Property.	The parcels adjacent to the Subject Property appeared mostly vacant with the exception of several small, scattered, residences. Most residences appear to the east of 3rd Ave..
1955	The Subject Property remained unchanged.	No changes to land use were noted for the surrounding properties except that a few more residences appeared.
1964	A square building was visible on the east quadrant of the Subject Property. The remainder of the east quadrant appeared to be grass and the west quadrant appeared to be a marsh.	Land use for surrounding properties appeared to be more developed. To the east of 3rd Ave. most properties have residences and there appears to be a string of residences to the south of the Subject Property.
1967	The Subject Property remained unchanged.	No changes to land use were noted from the surrounding properties.
1976	The roadway, which is now SR104, appears at the western border of the Subject Property. The remainder of the Subject Property appeared unchanged.	The apartment complex to the south of the subject property was developed. No other significant changes to land use were identified.
1985	SR104 is fully developed at the western border of the Subject Property. The west quadrant of the Subject Property appears to have become marshier.	No changes to land use were noted for the surrounding properties except that buildings are developed to the north of the property, across from SR104.
1989	The Subject Property remained unchanged.	No significant land use changes were noted for surrounding properties.

4.4.2 Fire Insurance Maps

Historic Sanborn fire insurance maps of the City of Edmonds were reviewed, for the years 1909 and 1926, but the Subject Property was not included within the vicinity of the maps. Copies of the Sanborn maps are presented in Appendix J.

5.0 Information from Site Reconnaissance

5.1 Methodology and Limiting Conditions

Herbal conducted a Subject Property visit on April 13th, 2017, which consisted of a walking survey of the exterior areas of the condominium buildings and of the boundary areas of the marsh as well as limited areas in the marsh. Weather conditions at the time of the visit were cloudy and overcast with temperatures in the mid-50's Fahrenheit.

The grounds of the Subject Property were visually inspected by Herbal for evidence of potential Subject Property contamination, the presence of hazardous or regulated substances, and for evidence of a disturbed marsh. To evaluate the marsh, Herbal observed evidence of surface disturbances, stressed vegetation, invasive species, standing water, pipes, and other indicators of disturbances to the marsh. Photographs of the site reconnaissance are included in Appendix K.

Herbal took special note of the stormwater runoff on the Subject Property. There are multiple routes of stormwater runoff input to Stella's Marsh. On the western edge of the marsh, a culvert and storm catch basin are located adjacent to SR104, and collect runoff from SR104 (Appendix F). The runoff collects in the basin until it is full, and the runoff is then discharged into the marsh. South of the condominium buildings on the Subject Property, the driveways slope downwards towards the marsh (Appendix K). When runoff is flowing down the driveways and towards the marsh, it is collected in a culvert at the bottom of the driveways. This culvert discharges the runoff into a storm ditch that flows through a bioswale and directly into the marsh (Appendix F). If the runoff drains into the Subject Property's drainage system and does not flow over the driveways, the runoff may flow through multiple facility features, which are typically catch basins, and a detention facility (Appendix F). Catch basins and detention facilities slow the flow of water and allow particles to settle out before the water is discharged to the natural environment. After flowing through these, the runoff is collected in the culvert at the bottom of the driveway, and then discharged into the marsh through the storm ditch (Appendix F).

5.2 General Subject Property Setting

The subject property consists of 41 tax parcels that is bounded by 3rd Avenue South to the east and SR104 to the west. Neighboring properties to the north and south are single family residences and apartment complexes.

5.3 Interior Observations

The reviewed areas of the buildings are currently in use as residential and communal areas. The floors are either carpet or sheet vinyl, and the walls and ceilings are sheetrock.

5.4 Exterior Observations

- The parking garages and driveways slope downward towards the bioswale that separates Stella's Landing from the marsh.
- The bioswale runs parallel to the marsh and has pipes feeding into it at both ends. There is a storm ditch that flows through the bioswale from the south to the north, where it empties into the marsh.
- Standing water was noted at the outlet of the storm ditch leading into the marsh.
- Blue sheens on the water surface were observed in the storm ditch leading to the marsh.
- Invasive species, including bittersweet nightshade, Himalayan blackberry, and English ivy were observed in the marsh on the Subject Property.

- A highway, SR104, borders the west end of the Subject Property and isolates Stella's Marsh from the larger Edmonds Marsh, with which it was contiguous before construction of SR104.
- Shellabarger Creek runs parallel to the south end of the Subject Property and is stopped by SR104, which then forces the creek to move north towards the Subject Property to enter a culvert which directs flow west to Edmonds Marsh.
- No hazardous substances, petroleum products and/or containers were observed or identified.
- No aboveground storage tanks were observed on the Subject Property.
- No odors were observed.
- No drums were observed on the Subject Property.
- No sources of PCBs from electrical or hydraulic equipment were observed.

5.5 Adjacent Properties

- Edmonds Marsh is located west of the Subject Property, separated by SR104.
- Located east of the property is 3rd Avenue South with single-family residences beyond.
- Located north of the property is a single-family residence.
- Located south of the property is a multiple-family residence.

6.0 Interviews

6.1 Interview with Residents

Herbal interviewed residents of Stella's Landing including Priscilla Thurber (22 years occupancy), James Wold (5 years occupancy), Ralph Sanders (3 years occupancy), Letitia Brown (5 years occupancy), Phyllis Keiley-Tyler (14 years occupancy), Judy Wangen (20 years occupancy), and Key Site Manager Anne-Marie Sykes (12 years occupancy) as part of the Phase 1 ESA. Interviews were conducted in person on April 13th, 2017. Questions posed to residents by Herbal are included in Appendix L. Information obtained during the interview process has been incorporated as appropriate throughout the report. Key information from that interview is presented below:

- No spills or leaks are known to have impacted the subject property.
- There have been no known reported releases of hazardous substances at the subject property.
- The subject property was constructed in 1997 and has been used as a residential community since then.
- First observable change in Stella's Marsh occurred in November 2013.

6.2 Interview with Local Government Officials

Herbal interviewed Jennifer Leach, the Environmental Education and Sustainability Coordinator for the Edmonds Department of Parks, Recreation and Culture on April 13th, 2017. She supported the residents account of what had occurred in the marsh and the key information stated in Section 6.1.

7.0 Findings and Opinions

7.1 HRECs and RECs

The Phase I ESA did not identify any historical recognized environmental conditions or recognized environmental conditions.

7.2 De Minimis Conditions

This assessment did not reveal any *de minimis* conditions in conjunction with the Subject Property.

7.3 Data Gaps

A data gap is considered the lack of or inability to obtain information required by ASTM Practice E1527 despite good faith efforts by Herbal to gather such information. A data gap by itself is not considered significant. The following data gaps were identified during performance of the Phase I ESA. The significance of the data gaps is discussed below.

- Chain of title information for the Subject Property was not part of the scope of this Phase I ESA. Given the lack of historical use of the Subject Property and past ownership information provided by historical resources, the inability to access this information is not considered a significant data gap.
- An Environmental Lien search and AUL search was not part of the scope of this Phase I ESA. Interviews with the residents of the Subject Property indicated that there are no environmental liens on the property. Given the lack of historical use of the Subject Property and past ownership information provided by historical resources, the inability to access this information is not considered a significant data gap.
- Hydrogeologic and geologic information for the Subject Property was not part of the scope of this Phase I ESA. Herbal did not have the resources to reasonably ascertain this information. This data gap is considered significant and in future studies it could be beneficial to examine these features.

7.4 Additional Investigations

Herbal was requested to perform an ASTM E1527 non-scope item.

7.4.1 Historical Precipitation Data

During the course of Phase I ESA, a request was made that Herbal review historical precipitation data to see if there was any change in the environmental conditions at the marsh prior to the outbreak of invasive species which may have contributed to the change. Data was obtained from the closest official weather station to the Subject Property, a National Oceanic and Atmospheric Administration station located in Everett, WA (Weather Underground 2017). The graph of historical cumulative precipitation data can be found in Appendix M.

In the graph, it is clear that in the years 2010-2012 there were higher cumulative amounts of total precipitation than in the year 2013, which was also the year residents first noticed the presence of invasive species in the marsh. In the years following, from 2014-2016, the total precipitation trend was similar to that of the years 2010-2012, except that in 2015 there was a period of time during which low levels of precipitation were reported, similarly to 2013. Residents noted that by 2015, invasive species were found throughout the entirety of the marsh, which could be explained by the low levels of precipitation in 2015, as well as in 2013.

7.5 Other Environmental Issues

As we conclude this assessment, Herbal has suggestions about the cause of the change in species composition on the Subject Property. As mentioned in Section 7.4.1, in 2013 there was substantially less precipitation than in the preceding and following years. The invasive species, bittersweet nightshade, is less tolerant of hydric soils or soils saturated with water (Forest Health Staff 2006). In 2013, the lower precipitation would have caused the soils present in the marsh to be less saturated than they had been in previous years. With less saturated soil, bittersweet nightshade would be more likely to survive within the marsh. This corresponds with the observations from the residents that the change in species composition began in 2013.

Another potential contributor to the change in species composition is the culverts adjacent to the Subject Property not functioning at full capacity. The culverts connecting Edmonds Marsh and the east side of SR104 are currently partially filled with sediment and vegetation, according to Michael Cawrse (personal communication 5/10/2017), Doug Gresham (personal communication, 4/27/2017), and Herbal's observations. The sediment and vegetation impede flow and exchange of water between the western Edmonds Marsh and the Stella's portion. The alteration of the water flow input into the marsh could alter soil saturation. The alteration of flow in conjunction with the lack of precipitation in 2013 could have impacted the soil saturation to such an extent that bittersweet nightshade would have been able to survive within the marsh.

Another hydrologic factor which was not included in the scope of Herbal's assessment is changes to the groundwater table, as groundwater can impact the hydrology and hydrogeology of the marsh and surrounding areas (Hunt et al. 1999, Perlman 2016). Due to its potential effects, groundwater flow around Stella's Marsh warrants further investigation.

A final possible contributor to the change in Stella's Marsh is contamination from nonpoint sources, specifically stormwater runoff from SR104, the driveways in Stella's Landing, and roads at a higher elevation than Stella's Landing. During high precipitation events, there is increased overland flow of water which results in higher levels of contaminants in the water. Contamination from nonpoint sources consists of a variety of substances, which can affect the growth of many plants in different ways (Brown & Peake 2006, Hoffman et al. 1985, Zhang et al. 2010). Nonpoint sources of contamination could have created favorable conditions for the introduction of bittersweet nightshade in the marsh and the persistent manner in which it grew. Herbal has limited information about nonpoint sources as they are not normally investigated in a Phase I ESA.

If residents desire a return of native plant species to Stella's Marsh, we suggest direct invasive removal. Stella's Marsh is classified as a wetland under Washington State regulations, and use of herbicides on invasive plants within a designated wetland is likely not allowable under those regulations. Following consultation with appropriate regulators, future action could involve direct pulling and removal of the invasive species. This can be done by sectioning the marsh into quadrants and coordinating removal within each quadrant. By removing invasive plant species, the native plants will have a greater chance of thriving in the marsh.

8.0 Conclusions

Herbal has performed a Phase I Environmental Site Assessment in conformance with the scope and limitations of ASTM Practice E1527 of 402 3rd Ave South in Edmonds, WA, the Subject Property. Any exceptions to, or deletions from, this practice are described in Sections 1.4 and 7.3 of this report. This assessment has revealed no evidence of recognized environmental conditions in connection with the Subject Property.

9.0 References

ASTM Standard E1527. 2013. "Environmental Site Assessments: Phase I Environmental Site Assessment Processes." ASTM International, West Conshohocken, PA, 2003. 10.1520/C0033-03, www.astm.org. Accessed 3/9/2017.

Brown, J.N., Peake, B.M. 2005. Sources of heavy metals and polycyclic aromatic hydrocarbons in urban stormwater runoff. *Science of The Total Environment.* 359: 145-155.

Cawrse, Michael. 2017 April 27. Personal communication.

City of Edmonds GIS. 2017. City of Edmonds. http://maps.edmondswa.gov/Html5Viewer/?viewer=html Accessed 5/4/2017.

Edmonds Stream Team. 2016. "Edmonds Water Quality Monitoring Project - Preliminary Report." Edmonds-Woodway High School Students Saving Salmon, Edmonds, WA.

Forest Health Staff. 2006. Weed of the Week: Bittersweet Nightshade Solanum dulcamara. USDA Forest Service, Washington, DC.

Gresham, Doug. 2017 April 27. Personal communication.

Hoffman, E.J., Latimer, J.S., Hunt, C.D., Mills, G.L., Quinn, J.G. 1985. Stormwater runoff from highways. *Water Air Soil Pollut.* 25(4): 349-364.

Hunt, R.J., Walker, J.F., Krabbenhoft, D.P. 1999. Characterizing the hydrology and the importance of ground-water discharge in natural and constructed wetlands. *Wetlands.* 19(2): 458-472.

NETR Online. 2017. "Environmental Radius Report." Nationwide Environmental Title Research, LLC, Tempe, AZ.

Perlman, H. 2016. "Aquifers and Groundwater". United States Geologic Survey, United States Department of the Interior. https://water.usgs.gov/edu/earthgwaquifer.html Accessed 6/8/17.

Weather Underground. 2017. The Weather Company. https://www.wunderground.com/company/legal?mr=1 Accessed 5/31/17.

Zhang, Z., Rengel, Z., Meney, K. 2010. Polynuclear aromatic hydrocarbons (PAHs) differentially influence growth of various emergent wetland species. *Journal of Hazardous Materials.* 182: 689-695.

Appendices

Appendix A. Description of problem in Stella's Marsh.
(authored by resident and Key Site Manager Anne-Marie Sykes)

Historically part of Edmonds Marsh, Shellabarger Marsh (4.7 acres) has been physically disconnected from the larger wetland system by State Route 104 and surrounding urban development. This bisected marsh is believed to be hydrologically connected via Shellabarger Creek, however, years of surrounding development and sedimentation have likely altered that hydrology. In 2013, residents of the Stella's Landing condo complex observed the beginnings of a dynamic species composition change within Shellabarger Marsh as bittersweet nightshade encroached into areas previously dominated by cattail (Typha sp.). By 2015, the residents were so alarmed by the growth of "the weed" and subsequent loss of wildlife (primarily waterfowl and song bird) use of this portion of marsh that they reached out for help to determine what could be done to reverse the impact of the bittersweet nightshade encroachment.

In April 2015, Keeley O'Connell, a marine ecologist and contractor to the City of Edmonds for environmental project management, performed a site visit of Shellabarger Marsh at the Stella's Landing condos. Ms. O'Connell recommended a wetland biologist be brought in to research historic vegetation composition, current hydrology and sedimentation conditions and develop strategies for controlling bittersweet nightshade and re-establishing the cattail vegetation community.

Keeley O'Connell worked with wetland biologists at Shannon&Wilson (currently on contract with the City for Willow Creek daylighting project design) to develop a scope of work that would be used to secure foundation grant monies by the Stella's Landing condo association to contract the wetland biologists directly. Grant monies were not secured and the project is currently on hold.

Recommended SCOPE OF SERVICES

Task 1 – Background Research and Site Visit

- Research the site history of Stella's Marsh by conducting interviews with City staff regarding management of the marsh, past control of purple loosestrife (*Lythrum salicaria*), and stormwater management within the area, and request and review any available City maps or documentation of the Shellabarger Marsh system.
- Investigate recent physical changes in Shellabarger Marsh by conducting a site visit, reviewing available aerial imagery, and comparing available Light Detection and Ranging remote sensing data. Dense cattail growth in the wetland may skew elevations reflected in the LIDAR; if this is the case, the LIDAR analysis will be used to the extent practicable.
- Research habitat requirements, including preferred hydric regime, soils, and pollution and water quality sensitivity of bittersweet nightshade and cattail.
- Given the highly urbanized environment surrounding Stella's Marsh and variety of contributing variables effecting change in the wetland, it may be difficult to identify the exact causes of the species composition change within the site. However, we anticipate being able to identify potential triggers.

Task 2 – Strategy Development

- Following the investigative and data collection phase, develop possible control strategies that may be employed to control bittersweet nightshade and re-establish the cat tail vegetation community.

Task 3 – Recommended Actions and Strategies Letter

- Complete a Recommended Actions and Strategies letter report describing the findings. The letter report will include a summary of the Shellabarger Marsh site history

investigation, potential methods of bittersweet nightshade control, and a regulatory section that outlines environmental permitting requirements associated with the potential strategies.

Anne-Marie (Marty) Sykes has lead the effort amongst the Stella's Landing condo association to address the dynamic changes they are seeing in Shellabarger marsh.

This is who Marty has reached out to to date:

* Keeley O'Connell. Keeley is a marine ecologist and habitat restoration project manager with a local environmental non - profit called EarthCorps. She has worked with the City for about five years on the restoration of Edmonds Marsh and the protection of the Shellabarger and Willow Creek watersheds.

* Carrie S. Hite. Carrie is Director of Parks, Recreation and Cultural Services Department for the City of Edmonds. She has been invaluable in the information she has provided on the involvement of the City of Edmonds in marsh restoration.

* Doug Gresham. Dept. of State Ecology. Doug is the expert on the Edmonds ecology and confirmed that indeed we have full rights to go onto our wetlands to remove invasive weeds. We would only need a permit if down the road, there was to be any excavating to remove silt etc. He added that there are grants available for this kind of work and he can help with all of that. He also said that when we remove all of the weed, he would come and test the water of our creek –free of charge.

* John Cooke. As a Biology teacher at the Edmonds High School. John, along with his students, was instrumental in starting a salmon hatchery in North Bothell and saving Chase Lake from development. However, he is best known for savings the Edmonds Marsh as it is today. Now retired, John continues with his work on restoration of wetlands and has been instrumental in giving us options for research and in dealing with the weed.

Appendix B. Timeline of problem in Stella's Marsh.
(authored by resident and Key Site Manager Anne-Marie Sykes)

Stella's Wetlands

Time-line document

Oct. 2016

Date unknown but before negative changes in wetland: The Beacon (Edmonds Local Paper) and TV showings of Edmonds City Council Meetings tell of creeks being cleaned out that flow downhill above wetlands (example area from 9th Ave down to 3rd Ave and on to the Puget Sound), to restore the return of fish that once spawned in these creeks. This may have changed the make-up of the water in the wetland. Other possibility is that sludge may have been carried down during the clearing of the creeks and resulted in sludge being collected in the wetland allowing or bringing in the growth of non-native plants.

2014

NOV. First viewing of the drastic change in our wetlands; thought to be caused by a storm. See photos. Watch and wait policy since no one had any idea of why this had happened.

2015

MARCH/APRIL No change

* Invitation to Rich Lindsey, City of Edmonds, Parks Manager to see if he could shed any light on the continuing devastation. (Meeting with Marty Sykes)

* Invitation to Keeley O'Connell to survey the scene. She identified the beginnings of the invasive Bittersweet Nightshade – south eastern corner of the marsh. (Meeting with Priscilla Thurber, Jim Wold, Marty Sykes)

*Invitation to Carrie Hite to try to gain even more insight and some solution to our problem. (Meeting with Marty Sykes)

*Invitation to John Cooke to see if he had any ideas on why this has happened. John was involved in major projects on the Edmonds Marsh, using local high school students. (Meeting with Jim Wold, Priscilla Thurber, Marty Sykes)

MAY - large area of the wetlands now consumed by the weed.

* Long telephone conversation with Doug Gresham – Wetland Specialist. Washington State Department of Ecology. (Marty Sykes) Photos and a written summary of our concerns sent to him.

MAY 21 Keeley O'Connell volunteered a presentation to our residents on the marsh system.

JULY 7 First application to the Hazel Miller Foundation (sponsored by EarthCorps)

OCT. 22 Letter from Carrie Hite received - City of Edmonds - in support of our application to Hazel Miller.

** Nearly all of the wetlands now consumed by the weed- looked like a sea of green!

NOV. Rejection from the Hazel Miller Foundation

2016

JAN. Second application to the Hazel Miller Foundation

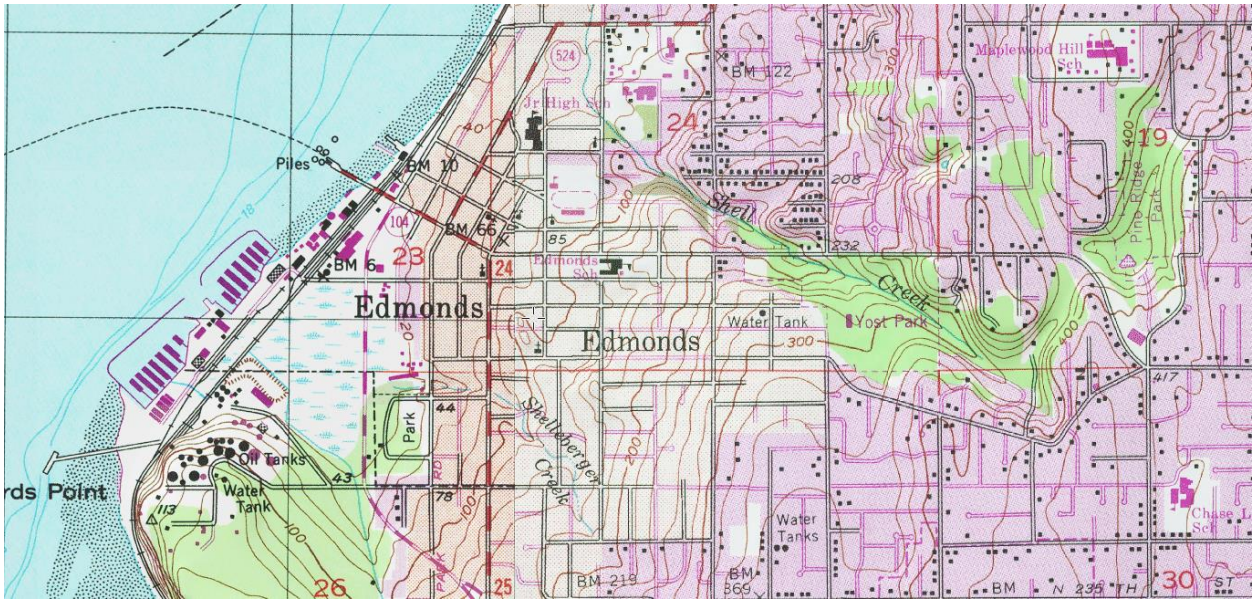
MARCH Rejection from the Hazel Miller

MARCH 31 On site visit from Doug Gresham. We received our first real insight into the possible causes. Doug sent a letter to the City asking for specific information on their implementation of water studies involving flow of storm water.

APRIL City trucks seen to be cleaning out the culverts on SR 104.

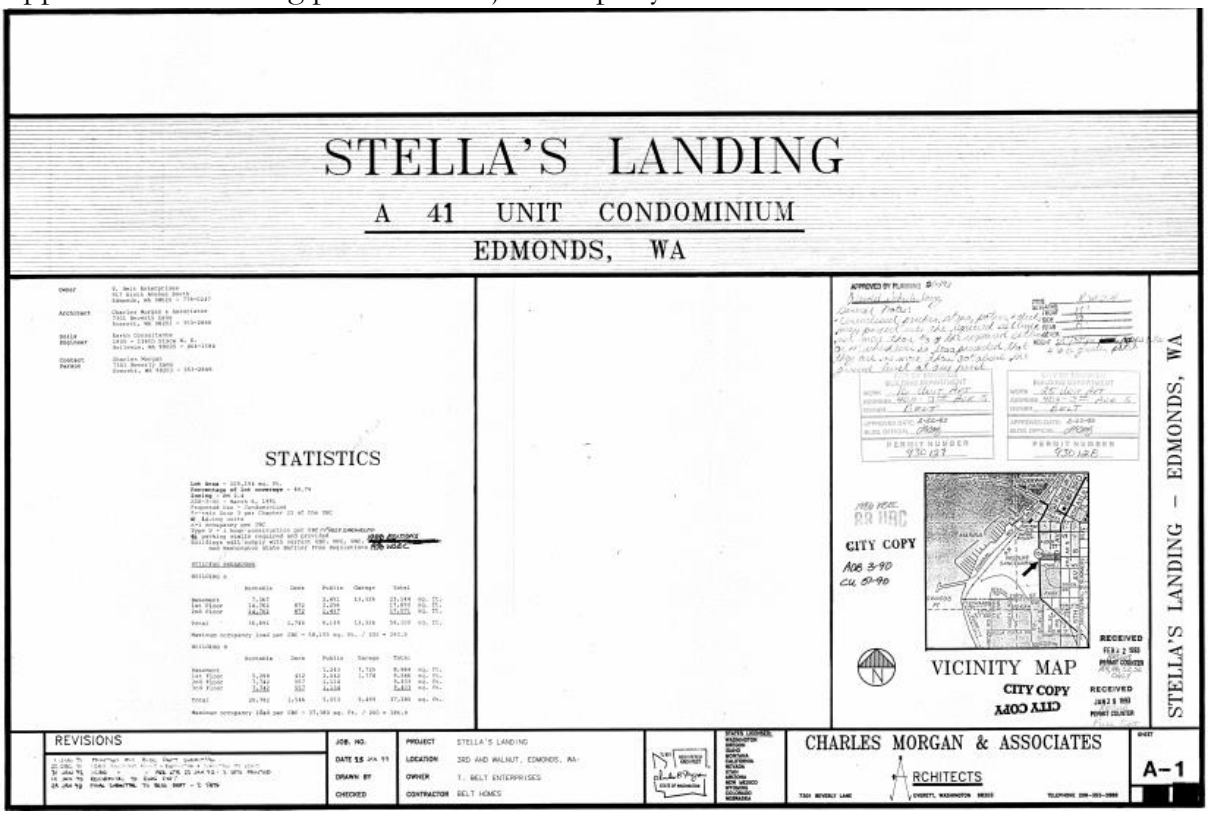
JUNE New growth of cattails seen around the edge of the wetlands, and many new invasive weeds growing on top of the Sweet Nightshade.

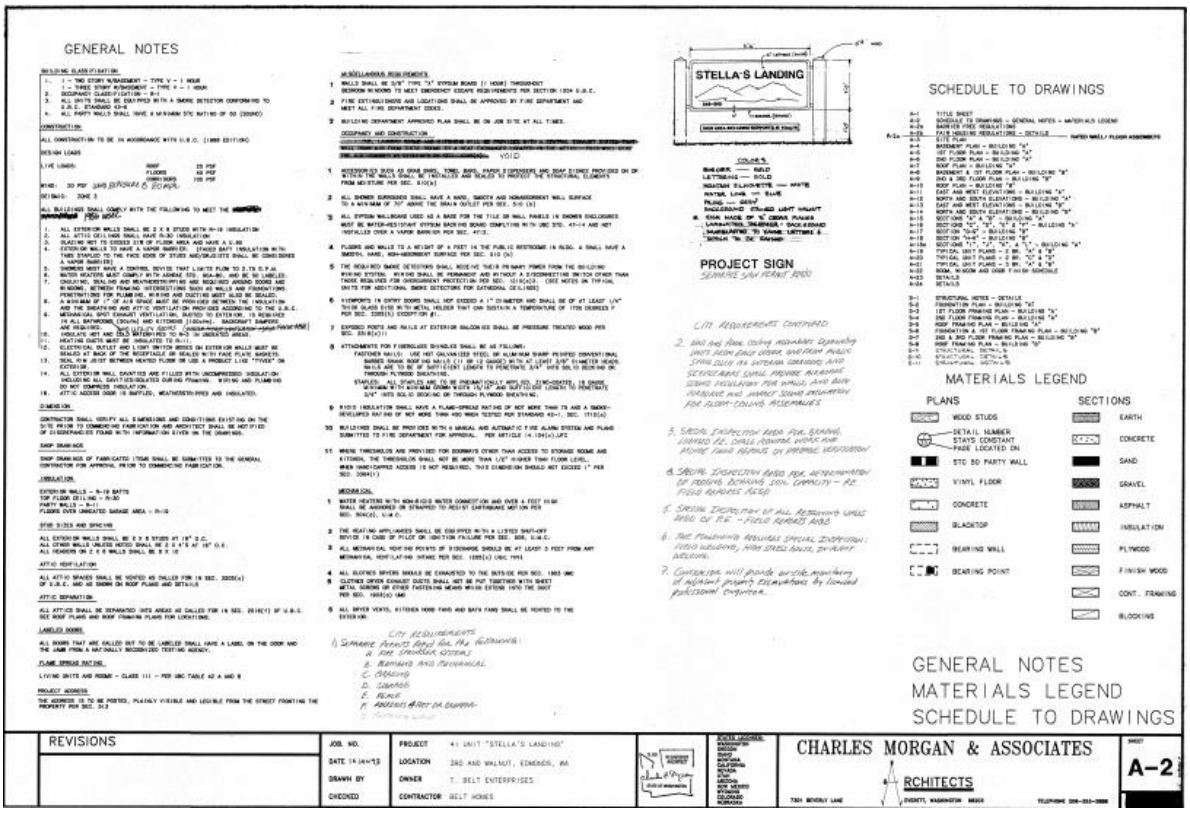
Appendix C. USGS 7.5 minute topographic map of Subject Property and surrounding area.

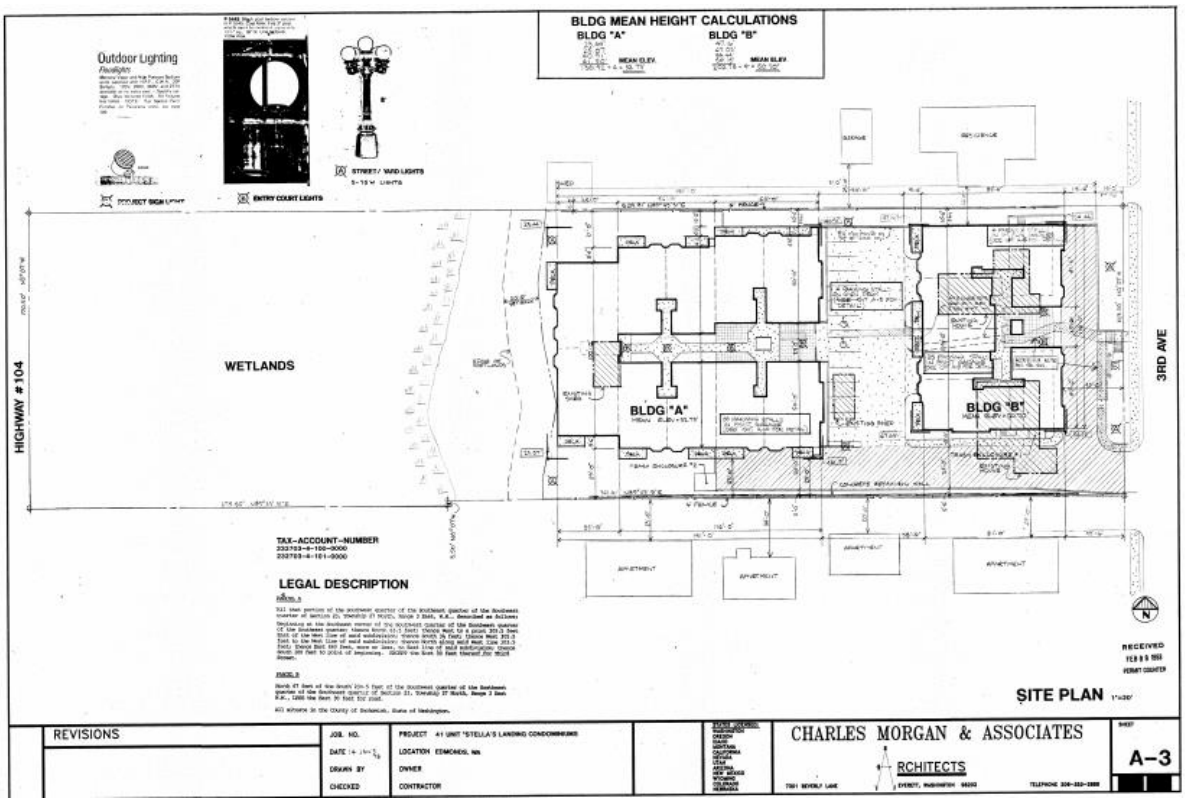


https://mappingsupport.com/p/gmap4.php?ll=37.750531,-119.590496&z=15&t=t4

Appendix. D. Building plans for Subject Property.



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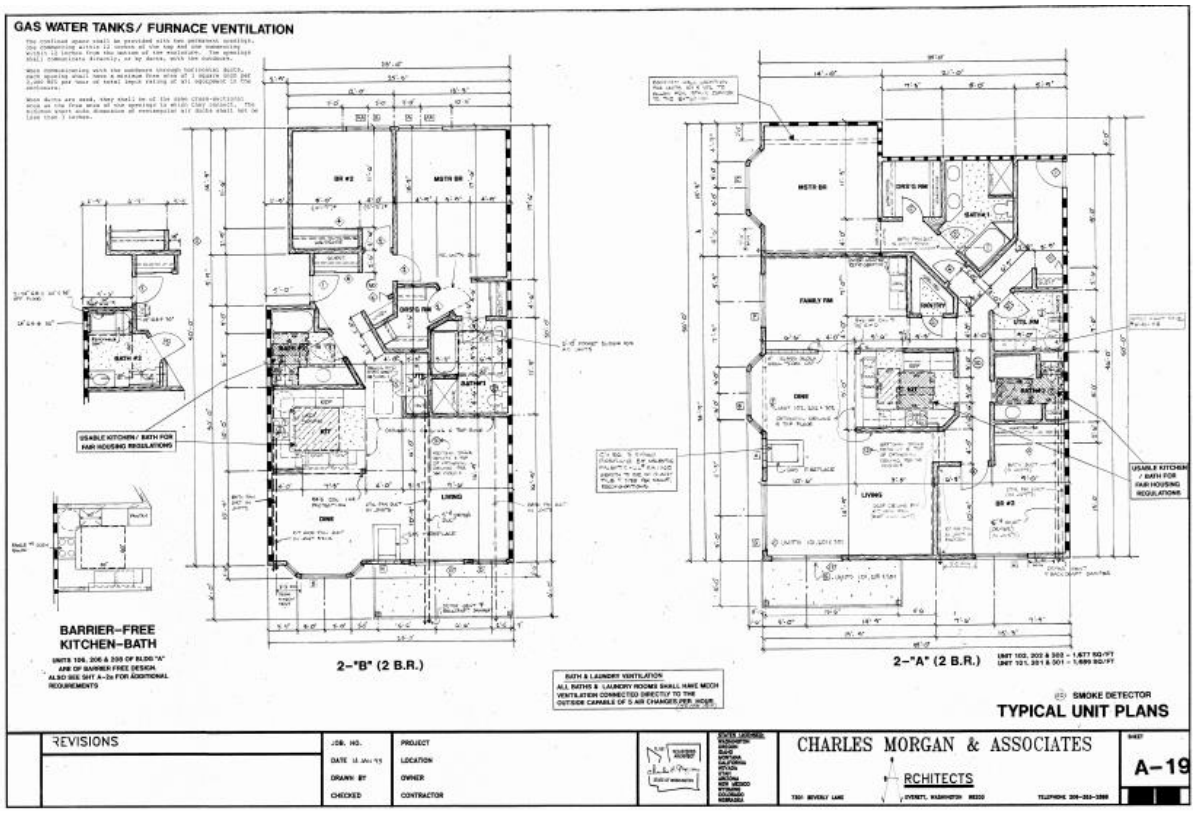
BLDG "A"
BLDG "B"
Outdoor Lighting
STREET/ YARD LIGHTS
ENTRY COURT LIGHTS
WETLANDS
HIGHWAY #104
3RD AVE
BLDG "A"
BLDG "B"
TAX-ACCOUNT-NUMBER
LEGAL DESCRIPTION
SITE PLAN
REVISIONS
JOB. NO.
DATE
DRAWN BY
CHECKED
PROJECT 41 UNIT "STELLA'S LANDING CONDOMINIUMS
LOCATION EDMONDS, WA
OWNER
CONTRACTOR
CHARLES MORGAN & ASSOCIATES
ARCHITECTS
A-3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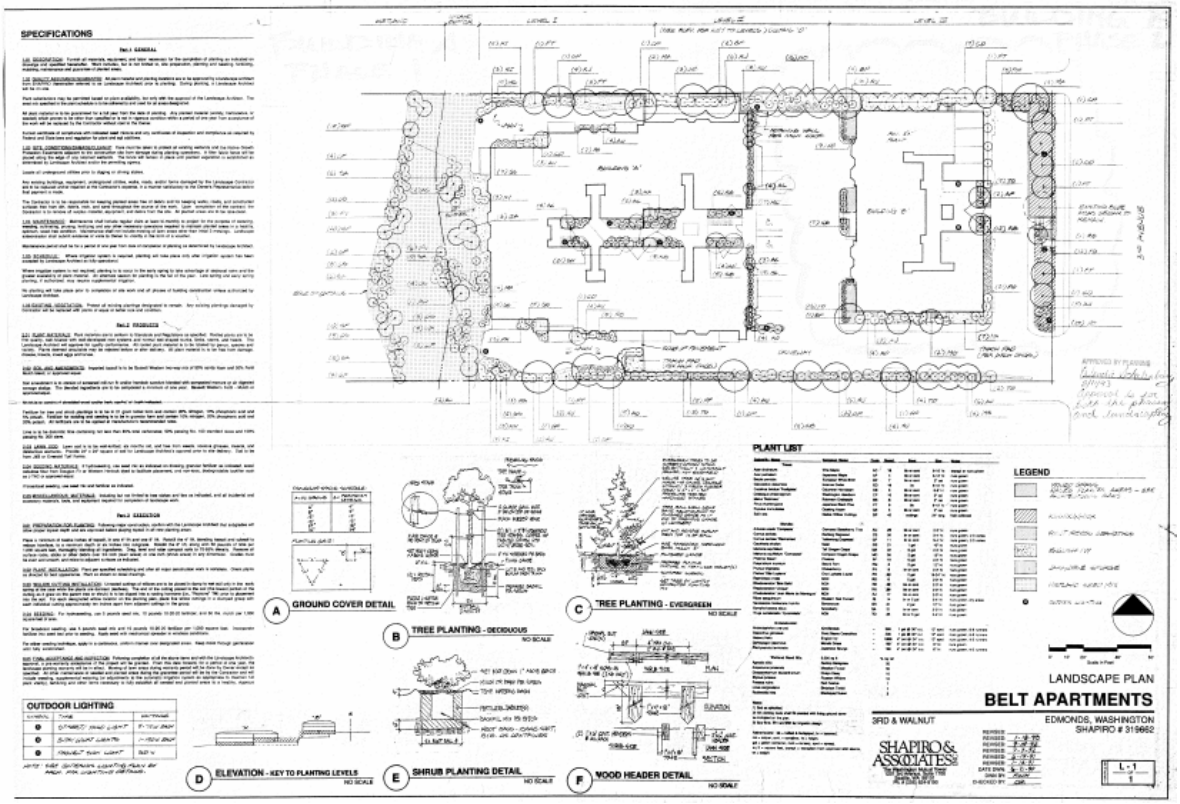
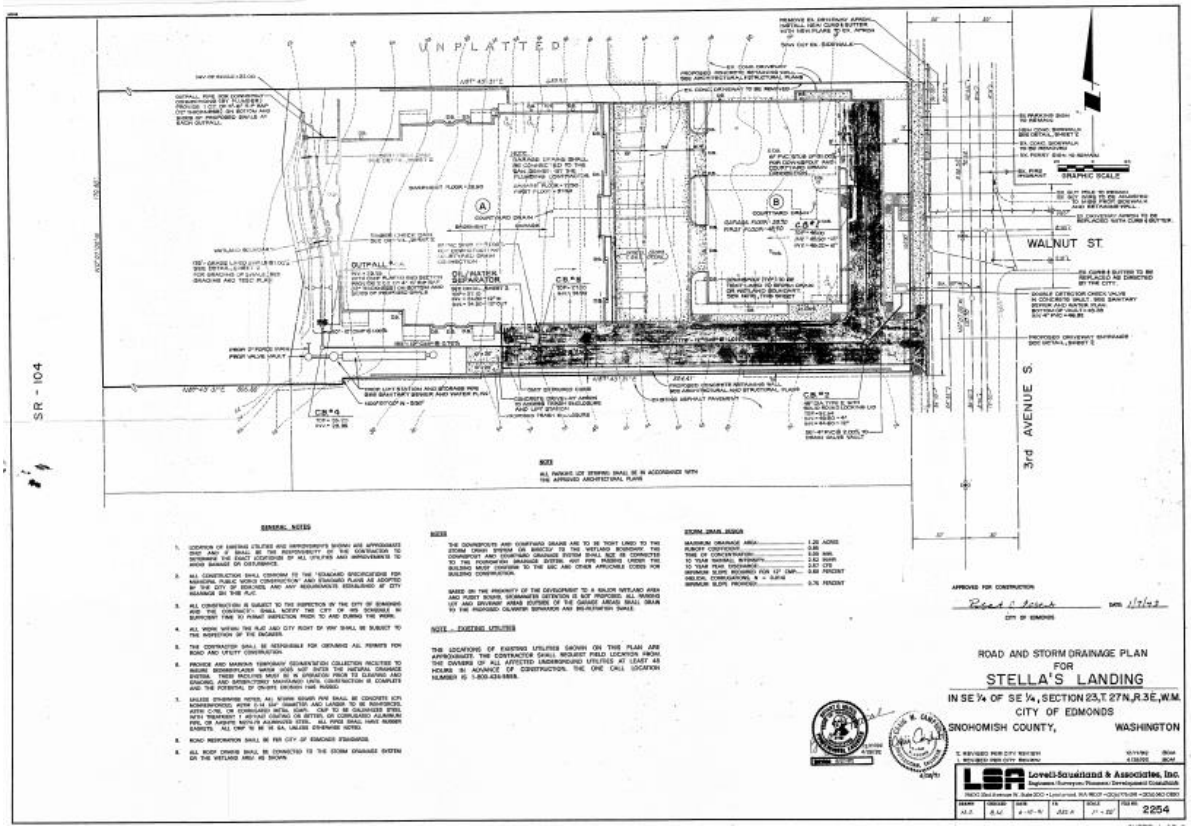
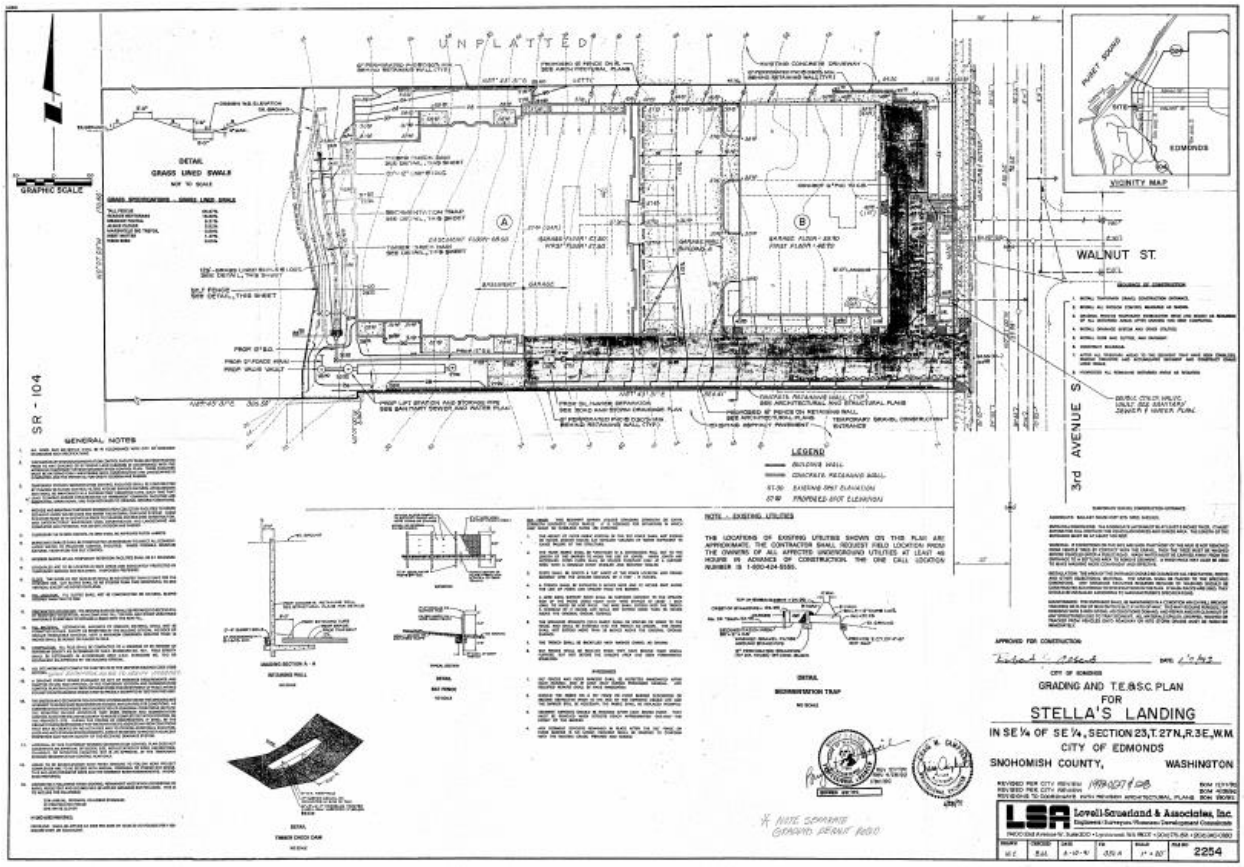
USABLE KITCHEN / BATH FOR FAIR HOUSING REGULATIONS
BARRIER-FREE KITCHEN-BATH
2-"B" (2 B.R.)
2-"A" (2 B.R.)
BATH & LAUNDRY VENTILATION
SMOKE DETECTOR
TYPICAL UNIT PLANS
REVISIONS
JOB. NO.
DATE
DRAWN BY
CHECKED
PROJECT
LOCATION
OWNER
CONTRACTOR
CHARLES MORGAN & ASSOCIATES
ARCHITECTS
A-19


SPECIFICATIONS
PLANT LIST
LEGEND
GROUND COVER DETAIL
TREE PLANTING - DECIDUOUS
TREE PLANTING - EVERGREEN
OUTDOOR LIGHTING
ELEVATION - KEY TO PLANTING LEVELS
SHRUB PLANTING DETAIL
WOOD HEADER DETAIL
LANDSCAPE PLAN
BELT APARTMENTS
3RD & WALNUT
EDMONDS, WASHINGTON
SHAPIRO # 319662
SHAPIRO & ASSOCIATES
L-1


UNPLATTED
WALNUT ST.
3rd AVENUE S.
SR - 104
OIL/WATER SEPARATOR
GENERAL NOTES
APPROVED FOR CONSTRUCTION
ROAD AND STORM DRAINAGE PLAN
FOR
STELLA'S LANDING
IN SE ¼ OF SE ¼, SECTION 23, T 27 N, R 3 E, W.M.
CITY OF EDMONDS
SNOHOMISH COUNTY, WASHINGTON
Lovell-Sauvland & Associates, Inc.
2254


UNPLATTED
GRAPHIC SCALE
DETAIL
GRASS LINED SWALE
NOT TO SCALE
WALNUT ST.
3rd AVENUE S
SR - 104
VICINITY MAP
EDMONDS
GENERAL NOTES
LEGEND
BUILDING WALL
CONCRETE RETAINING WALL
EXISTING SPOT ELEVATION
PROPOSED SPOT ELEVATION
NOTE - EXISTING UTILITIES
THE LOCATIONS OF EXISTING UTILITIES SHOWN ON THIS PLAN ARE APPROXIMATE. THE CONTRACTOR SHALL REQUEST FIELD LOCATION FROM THE OWNERS OF ALL AFFECTED UNDERGROUND UTILITES AT LEAST 48 HOURS IN ADVANCE OF CONSTRUCTION. THE ONE CALL LOCATION NUMBER IS 1-800-424-5555.
DETAIL
BIORETENTION TRAP
APPROVED FOR CONSTRUCTION
CITY OF EDMONDS
GRADING AND T.E.&S.C. PLAN
FOR
STELLA'S LANDING
IN SE ¼ OF SE ¼, SECTION 23, T.27N., R.3E., W.M.
CITY OF EDMONDS
SNOHOMISH COUNTY, WASHINGTON
Lovell-Sarsfield & Associates, Inc.
2254

Appendix E. Construction permit for Subject Property.

CITY OF EDMONDS
CONSTRUCTION PERMIT APPLICATION

OWNER
OWNER NAME/NAME OF BUSINESS: T. Belt Enterprises
MAILING ADDRESS: 917-9th Avenue South
CITY: Edmonds WA ZIP: 98020 TELEPHONE NUMBER: (206) 778-0247

ARCHITECT
NAME: Charles Morgan & Associates
ADDRESS: 7301-Beverly Lane
CITY: Everett WA ZIP: 98203 TELEPHONE NUMBER: (206) 353-2888

CONTRACTOR
NAME: Belt Homes
ADDRESS: 917-9th Avenue South
CITY: Edmonds WA ZIP: 98020 TELEPHONE NUMBER: (206) 776-2829
STATE LICENSE NUMBER: BELT*TE348L7

LEGAL DESCRIPTION
Legal Description of Property - include all easements
(See Attached)
Tax Account Parcel No. 232703-4-100-0000
232703-4-101-0000

JOB DESCRIPTION
[X] NEW [ ] ADD/ALTER [ ] REPAIR [ ] DEMOLISH [ ] REMODEL [ ] WOOD STOVE/INSERT
[ ] RESIDENTIAL [X] COMMERCIAL [ ] APT. BLDG.
[X] GRADING ~~[illegible]~~ CYDS. [ ] CARPORT GARAGE [X] RETAINING WALL/ROCKERY
[ ] PLUMBING [ ] MECHANICAL [ ] SIGN [X] FENCE (____ x ____ FT) [ ] SWIM POOL [ ] RENEWAL
(TYPE OF USE, BUSINESS OR ACTIVITY) EXPLAIN: Residential Use
NUMBER OF STORIES: 3 + Bsmt (Bldg B) NUMBER OF DWELLING UNITS: 16
DESCRIBE WORK TO BE DONE (ATTACH PLOT PLAN)
Construction of a 16 unit condominium building. Renewed as 940433 & 950344
STRUCT CALLS BY MICHAEL P. McCANN, PE
SOILS PERMIT BY EARTH CONSULTANTS ROBERT S. LOWNSON, PE
Plan Check No. 405 HEAT: GAS CONVERTING 12.59 %

This Permit covers work to be done on private property ONLY. Any construction on the public domain (curbs, sidewalks, driveways, marquees, etc.) will require separate permission.
Permit Application: 180 Days
Permit Limit: 1 Year - Provided Work is Started Within 180 Days

HOLD HARMLESS
"Applicant, on behalf of his or her spouse, heirs, assigns and successors in interest, agrees to indemnify, defend and hold harmless the City of Edmonds, Washington, its officials, employees, and agents from any and all claims for damages of whatever nature, arising directly or indirectly from the issuance of this permit. Issuance of this permit shall not be deemed to modify, waive or reduce any requirement of any city ordinance nor limit in any way the City's ability to enforce any ordinance provision."

I hereby acknowledge that I have read this application; that the information given is correct; and that I am the owner, or the duly authorized agent of the owner. I agree to comply with city and state laws regulating construction; and in doing the work authorized thereby, no person will be employed in violation of the Labor Code of the State of Washington relating to Workmen's Compensation Insurance.
SIGNATURE (OWNER OR AGENT): Thomas E. Belt/Owner Thomas E. Belt DATE SIGNED: 6/10/91

ATTENTION
IT IS UNLAWFUL TO USE OR OCCUPY A BUILDING OR STRUCTURE UNTIL A FINAL INSPECTION HAS BEEN MADE AND APPROVAL OR A CERTIFICATE OF OCCUPANCY HAS BEEN GRANTED. UBC CHAPTER 3.
102-87

USE ZONE: RM2.4 PERMIT NUMBER: 930127
JOB ADDRESS: 402 - 3rd Ave. S. SUITE/APT #

ENGINEERING
LEGAL DESCRIPTION CHECK | SUBDIVISION NO. | LID NO.
PUBLIC RIGHT OF WAY PER OFFICIAL STREET MAP. EXISTING 60 REQUIRED DEDICATION 0 PROPOSED (60)
TESCP Approved [ ] RW Permit Required [ ] Street Use Permit Req'd [ ] Inspection Required [ ] Sidewalk Required [ ]
REMARKS
L.D.C. WORING, READ TIGHTLINE & DRAINAGE
INSP READ
Final Insp & Final READ
ENGINEERING MEMO DATED 1/8/93 REVIEW BY RCG

WATER
METER SIZE 2" BUILDING SUPPLY SIZE 2 1/2" NO. OF FIXTURES
REMARKS PRV READ

PLANNING
SIGN AREA ALLOWED 7 ft PROPOSED 7 ft
SEPA REVIEW COMPLETE 4-16-90 EXEMPT EXP
ADB NO. 3-90 SHORELINE # NA
VARIANCE OR CU CU-51-90 PLANNING REVIEW BY EJS DATE 7-22-91
SETBACKS — FEET FRONT 15' SIDE 10' REAR 15' HEIGHT 25/30 LOT COVERAGE 45%
REMARKS
RESTRICTIVE COVENANT 9212070817
See Fire Dept Memo Dated 4/1/92

BUILDING
CHECKED BY TLB06/83 TYPE OF CONSTRUCTION V-1HR CODE 88 HEIGHT 25/30
SPECIAL INSPECTOR REQUIRED [X] YES AREA 37,380 OCCUPANCY GROUP R1/B1 OCCUPANT LOAD 187
REMARKS
PROGRESS INSPECTIONS PER UBC 305
THERMAL INSUL PER 1986 WA ENERGY CODE
PERF. BOND #123,807 POSTED:
FINAL INSPECTION REQUIRED

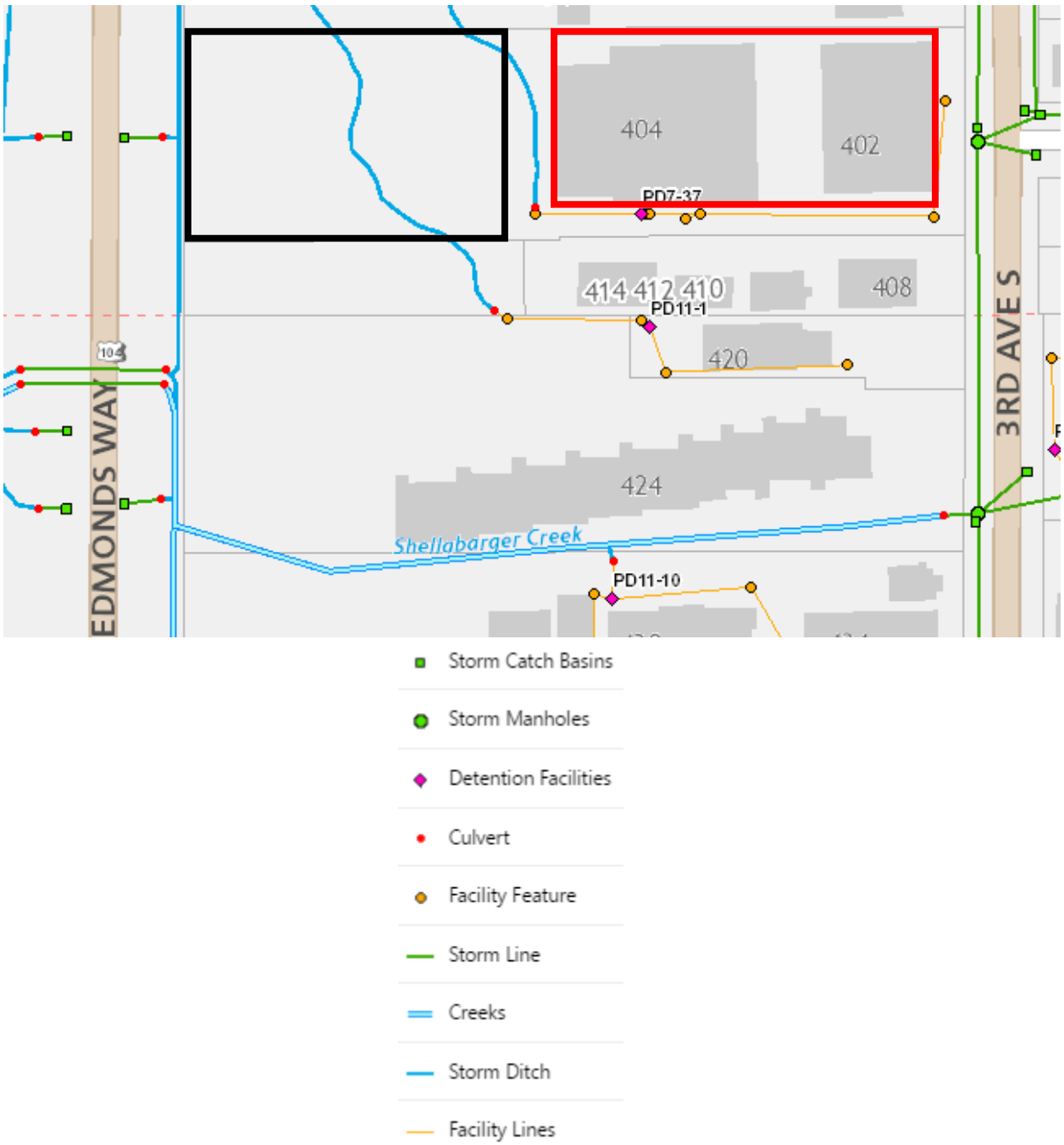
	VALUATION	FEE	
PLAN CHECK FEE		3047	
BUILDING	1,689,297	5420	
PLUMBING	SEPARATE	PERMIT	
MECHANICAL	SEPARATE	PERMIT	
GRADING/FILL			
STATE SURCHARGE		44.50	
STORM DRAINAGE FEE			
ENG. INSPECTION FEE			
SIGN		36	
PLAN CHECK DEPOSIT	Pd	-3047	14890
TOTAL AMOUNT DUE		5500.50	16307

ATTENTION
THIS PERMIT AUTHORIZES ONLY THE WORK NOTED
INSPECTION DEPARTMENT
CITY OF EDMONDS
CALL FOR INSPECTION 771-3202

APPLICATION APPROVAL
This application is not a permit until signed by the Building Official or his/her Deputy; and fees are paid and receipt is acknowledged in space provided.
OFFICIAL SIGNATURE: 2-22-93
RECEIPTED BY: DATE: 3-10-93

ORIGINAL — File YELLOW — Inspector PINK — Owner GOLD — Assessor

Appendix F. Map and legend of drainage system on Subject Property and surrounding areas.
(City of Edmonds GIS 2017). Stella's Landing is outlined in red, and their section of the marsh is outlined in black.



Appendix G. Results of Environmental Radius Report for Subject Property and surrounding areas.

Summary

Flood Zones Hazard Map Federal Emergency Management Agency (FEMA)

	< 1/4	1/4 - 1/2	1/2 - 1
National Priorities List (NPL)			
CERCLIS List			
CERCLIS NFRAP			
RCRA CORRACTS Facilities			
RCRA non-CORRACTS TSD Facilities			
Federal Institutional Control / Engineering Control Registry			
Emergency Response Notification System (ERNS)	1	55	1
US Toxic Release Inventory			
US RCRA Generators (CESQG, SQG, LQG)		1	
US ACRES (Brownfields)			
US NPDES	1	7	2
US Air Facility System (AIRS / AFS)	1		
WA Underground Storage Tanks	17	36	5
WA Leaking Underground Storage Tanks	6	18	
WA Confirmed and Suspected Contaminated Sites		13	3
WA Cleanup Sites with No Further Action		5	
WA Landfills			
WA Brownfields			
WA Activity and Use Limitations		1	

Appendix H. Map of Edmonds Stream Team monitoring sites.
(Sites within vicinity of Subject Property are F1, J1, and K1)

Appendix I. Aerial photographs of Subject Property and surrounding areas.

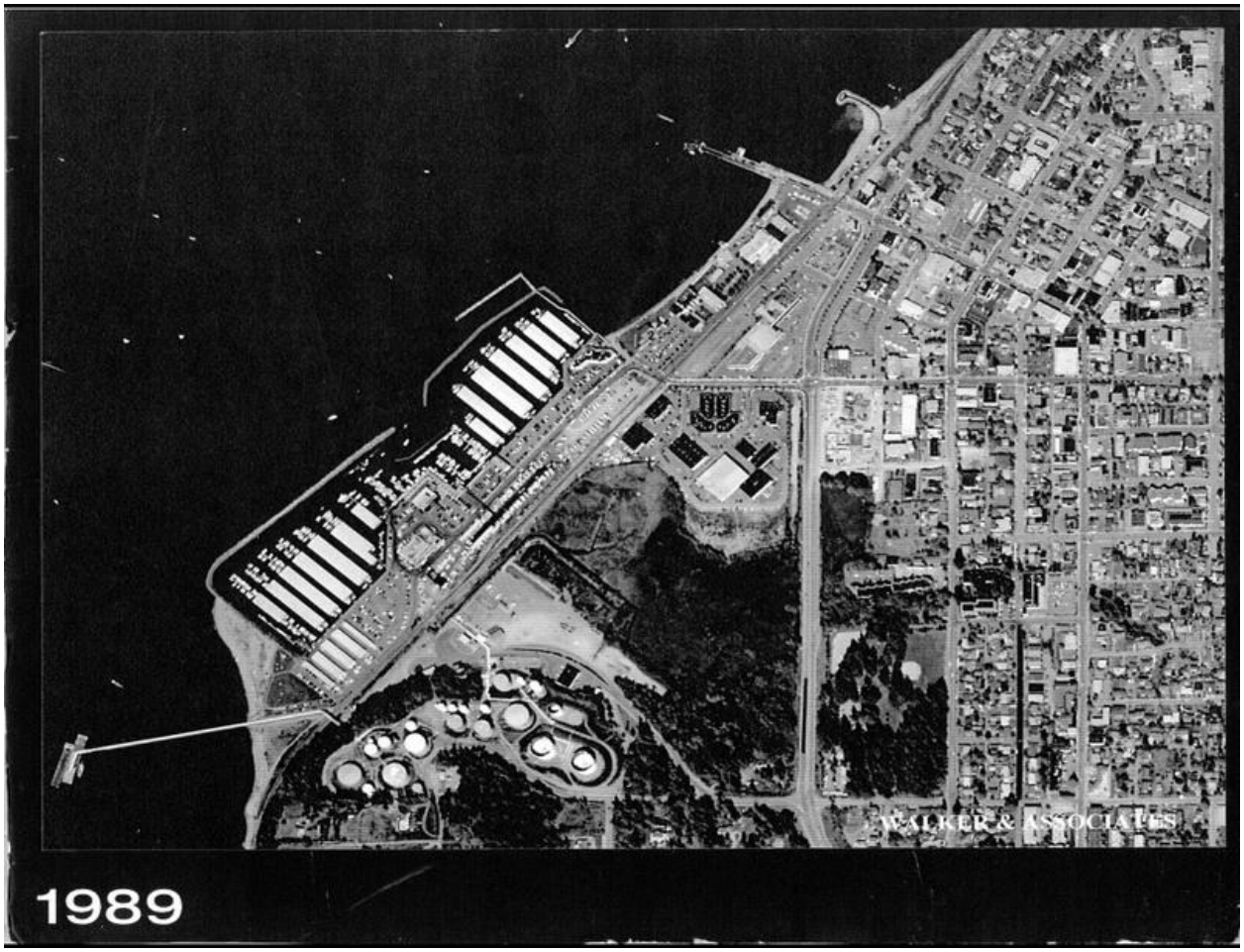
Aerial photograph of Subject Property vicinity in 1947.

Aerial photograph of Subject Property vicinity in 1955.

Aerial photograph of Subject Property vicinity in 1964.

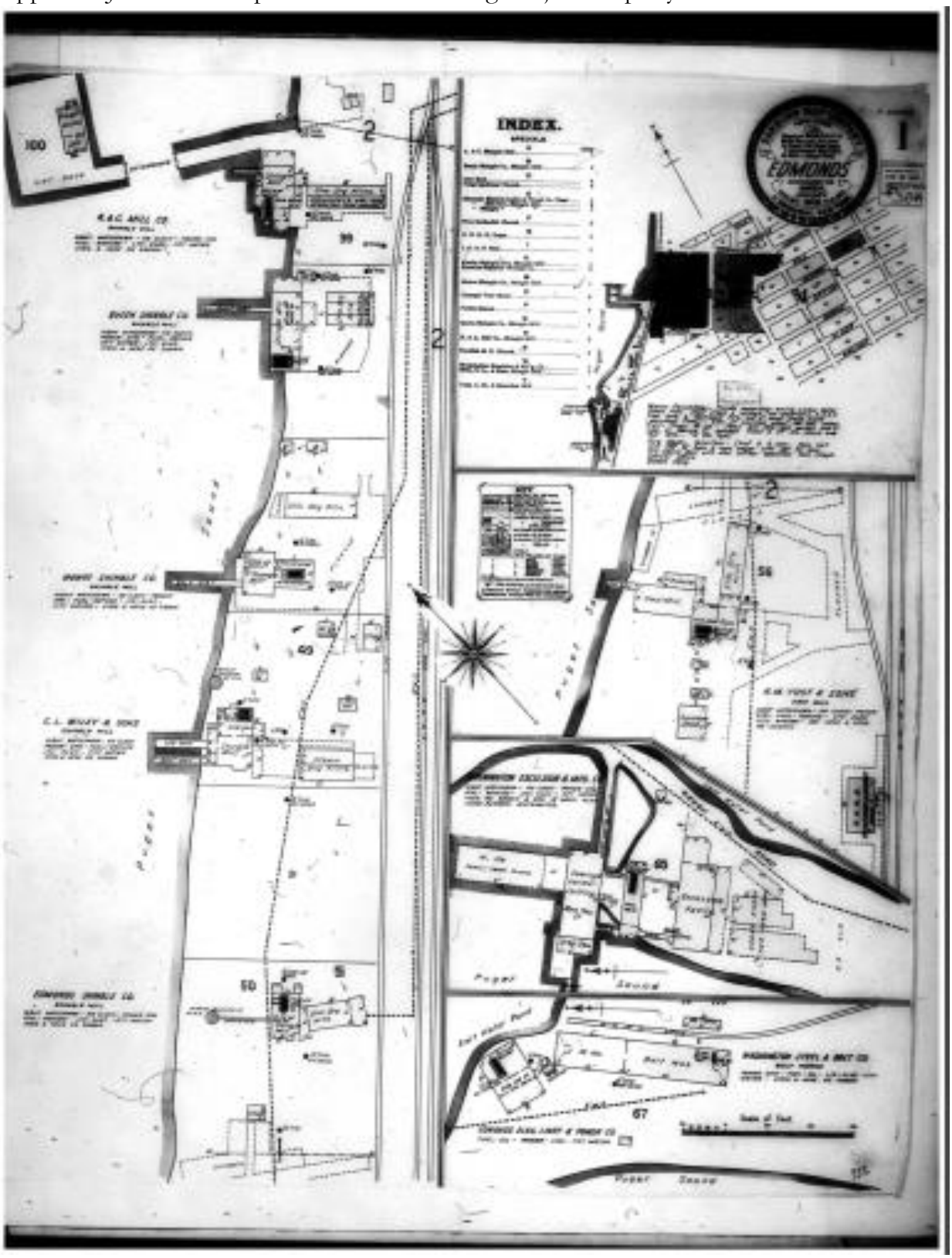
Aerial photograph of Subject Property vicinity in 1967.

Aerial photograph of Subject Property vicinity in 1985

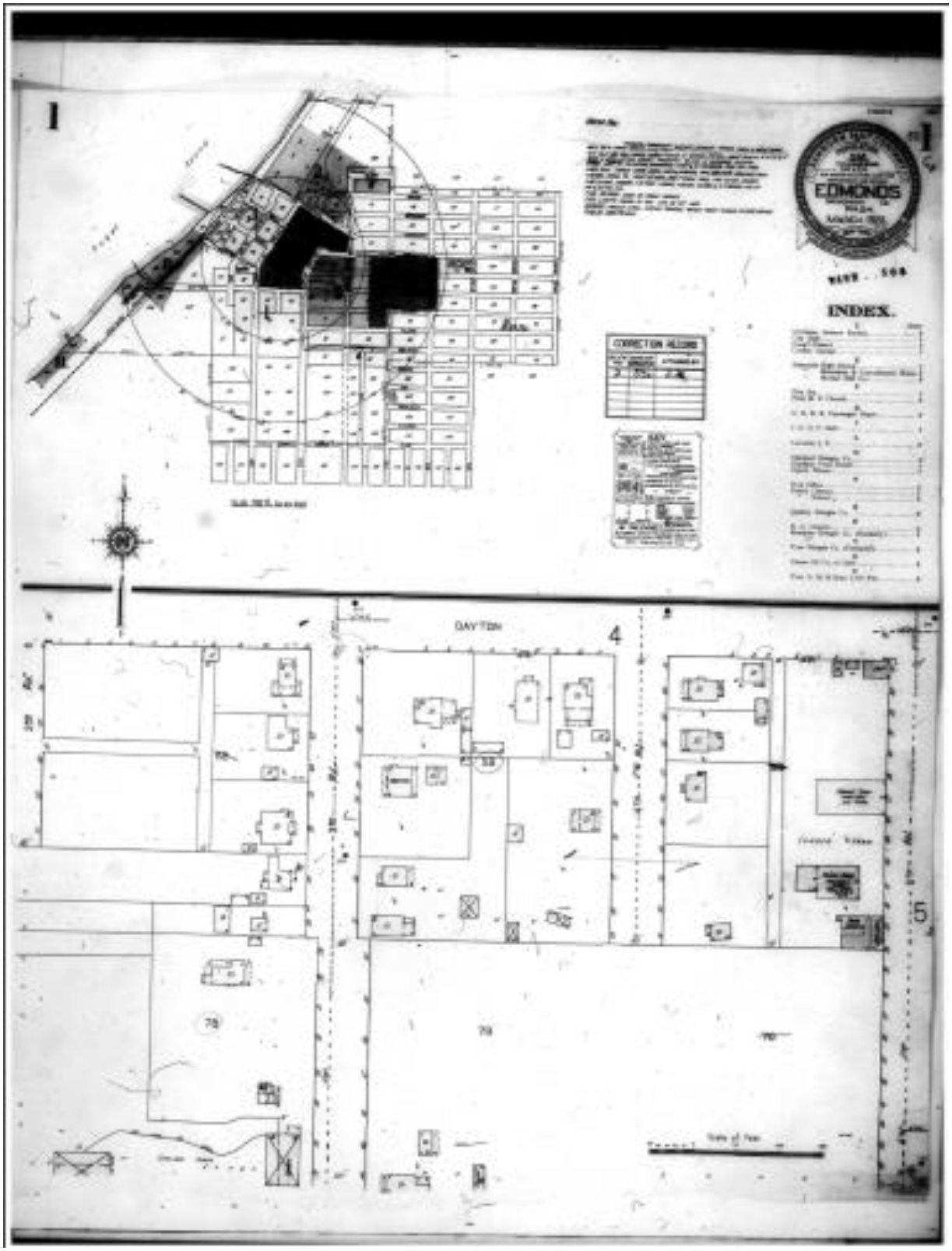


Aerial photograph of Subject Property vicinity in 1989.

Appendix J. Sanborn maps of areas surrounding Subject Property.



Sanborn map showing area surrounding Subject Property in 1909.

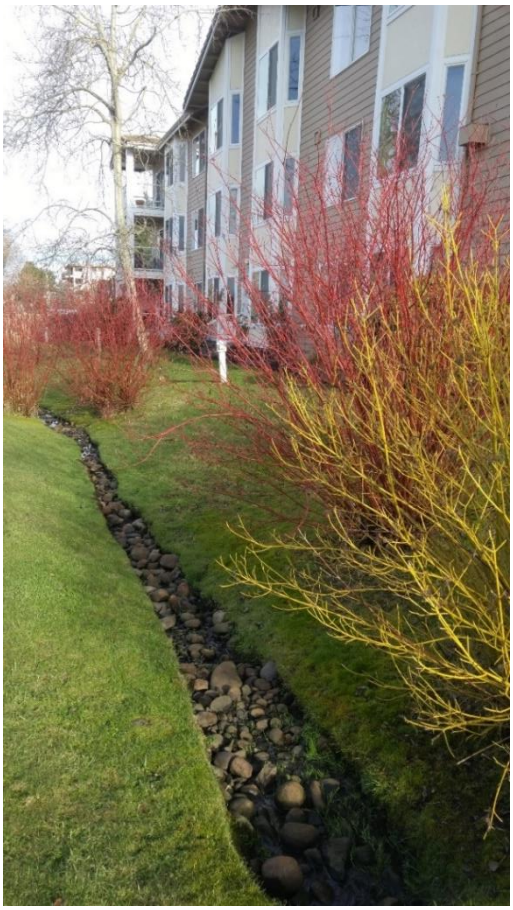


Sanborn map showing area surrounding Subject Property in 1926.

Appendix K. Photographs from site reconnaissance.

View facing east of sloped driveway.

View facing north of bioswale and storm ditch leading into marsh.



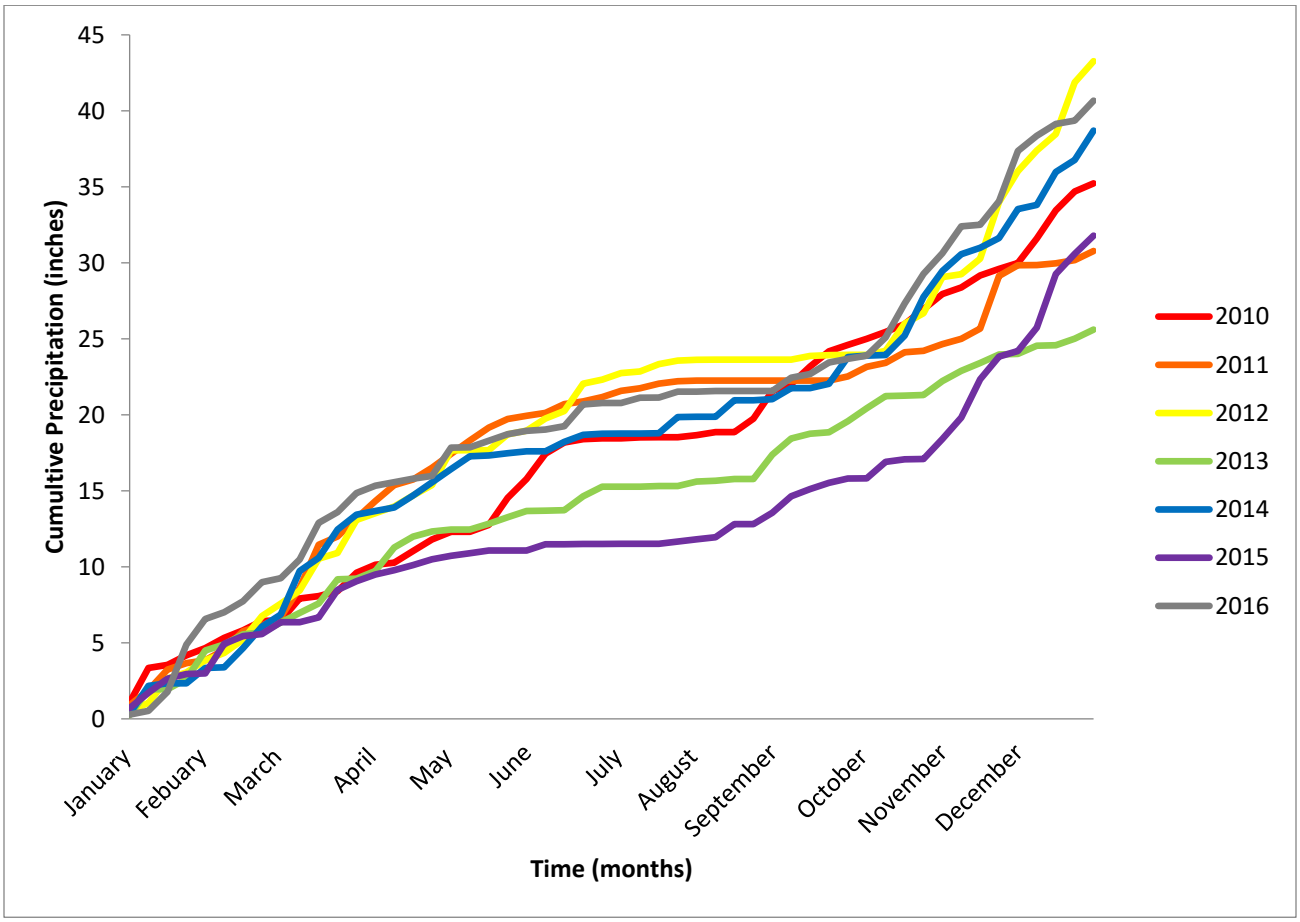
View facing north of storm ditch leading into marsh with 404 3rd Ave S, Edmonds WA in background.

View of standing water in storm ditch leading into marsh.

Appendix L. Interview Questions for Residents and Key Site Manager.

1. How long have you lived at this address?
2. Are you aware of any spills or hazardous materials activities on this site?
3. When did you first notice a change in Stella's Marsh?
4. What type of changes did you observe and would you say it has changed over time? (Changes in vegetation composition, species, changes to culverts)
    a. Have you ever observed cleaning activity or other changes around culverts connected to Stella's?
5. Who are the residents that have observed changes in the marsh or made any other relevant observations?
6. When was it decided to formally take action on finding out what happened to Stella's Marsh?
7. Did you observe any unusual events or activities prior to the changes in the marsh that may have had an impact?
8. After observing the changes in Stella's Marsh are you aware of any activities that have occurred in the marsh?
9. Who have you contacted for advice and professional opinions?
10. Any other information that may be helpful during the course of our investigation?
11. Have you looked at any documents or contacted anyone to give their professional opinion?

Appendix M. Historical precipitation data from Everett WA weather station. (Weather Underground 2017).



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Phase II Environmental Site Assessment

Stella's Landing

Edmonds, WA

Western Washington University

K. Diep, W. Carstens, J. Ensign, & J. Morris

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1.0 Executive Summary

Through the Sustainable Cities Partnership, Western Washington University and the City of Edmonds partnered to engage students in community projects and address specific issues faced by the City. In the class "The Science, Management, and Outreach of Contaminated Sites," two groups addressed the environmental conditions associated with a parcel of private land and a wetland located on the property, called Stella's Landing and Stella's Marsh, respectively.

The purpose of the Phase II Environmental Site Assessment (ESA) is to evaluate the environmental conditions at the site with a scientific approach, following the recommendations and findings of the Phase I ESA. Due to time constraints, Phase I and Phase II of the ESA were conducted concurrently; the final report of the Phase I ESA was authored by Rahlmann et al. (2017).

The objective of the Phase II ESA was to determine if nonpoint source pollution has contributed to differences in vegetative cover of the native cattail (*Typha latifolia*) and invasive bittersweet nightshade (*Solanum dulcamara)* found in Stella's Marsh. Based on the results of this assessment, the differences in vegetative cover are likely not caused by nonpoint source pollution entering into the wetland.

The following is recommended as future work: assess the micro-topography of the site, consider groundwater levels and hydrology, and consider historical precipitation patterns and species' seasonal growing conditions.

2.0 Introduction

A Phase II Environmental Site Assessment (ESA) was conducted at the property at 404 3rd Avenue South, Edmonds, Washington, 98020 (Stella's Landing), in conformance with the scope and limitations of ASTM Practice E 1903-11. Our objective was to determine if a relationship existed between nonpoint source pollution and the vegetation patterns observed in Stella's Marsh. We approached this objective through several tasks: 1) identify potential pollution sources and determine if contamination is present in the wetland, 2) characterize wetland soils and sediments (hereafter referred to as soils since we did not distinguish between them), 3) determine the vegetation composition and abundance, and 4) evaluate if a relationship exists between potential contamination, soil characteristics, and patterns in vegetation.

2.1 Purpose

In 2013, residents of Stella's Landing became concerned about a section of the Edmonds Marsh, locally known as Stella's Marsh. They noticed that their cattail-dominated wetland changed due to the encroachment of bittersweet nightshade, an invasive wetland species (Rahlmann et al. 2017). Through the Sustainable Cities Partnership, the City of Edmonds and Western Washington University collaborated to address the concerns of residents at Stella's Landing.

Upon consideration of observations communicated by residents at Stella's Landing, we opted to collect field data designed to determine if the vegetation composition of the wetland was associated with contaminants and/or other disturbances. Typically, the Phase II ESA is conducted after the findings of the Phase I ESA. Due to time constraints, both phases were

conducted concurrently. Results may help guide future studies or management decisions regarding Stella's Marsh.

2.2 Objective

The objective for this assessment was to determine if a relationship existed between nonpoint source pollution and the vegetation patterns observed in Stella's Marsh. We completed this in four tasks:

First, we identified potential sources of pollution entering Stella's Marsh and developed a sampling plan to address them (Figure 1). The first potential source was a stormwater runoff drain, located at the north end of the boundary between Stella's Marsh and the Stella's Landing residential condominium complex. The second potential source was located at the mouth of Shellabarger Creek, which flows adjacent to the south boundary of Stella's Marsh and drains into the south end of the marsh. This is near State Route (SR)-104, also a potential source of contamination, which meant we could not easily distinguish Shellabarger Creek inputs from SR104 inputs. Sampling was conducted along an 80 meter (m) transect that connects the stormwater runoff drain with the mouth of Shellabarger Creek (Figure 2).

The second task was to determine the dominant types of vegetation along the transect and measure the abundance of each species. Along the 80 m transect, 1-m^2 quadrats were used to estimate the percent cover of both cattail and bittersweet nightshade.

The third task was to characterize the wetland soil along the transect and the water quality of the potential sources. Soils were analyzed for total metals, polycyclic aromatic hydrocarbons (PAHs), nutrients and organic matter. Water was analyzed for total metals and total petroleum hydrocarbons, which is the sum of benzene, toluene, ethyl benzene, and xylene (TPH-BTEX).

Our final task was to determine if the concentrations of contaminants in the wetland soils were correlated to the vegetation patterns observed in the wetland. Statistical analyses were used to determine if soil characteristics were significantly different along the transect. In addition, we used statistical analyses to determine if significant relationships existed between the dominant species in a particular quadrat and the chemical characteristics of the soil in that quadrat.

3.0 Background

3.1 Site Description

Stella's Marsh is located in Edmonds, Washington, and is connected to the greater Edmonds Marsh. The two wetlands are separated by SR104 (Figure 1), but are linked by a culvert to allow water flow between the two (Rahlmann et al. 2017). There is considerable urban upland to the east of Stella's Marsh, such that urban runoff can flow into the marsh. Two storm drains from the city empty directly into Stella's Marsh on the east side of the wetland. Shellabarger Creek flows into the marsh on the south end of the wetland. Edmonds receives large amounts of precipitation throughout the year with mild temperatures. The National Cooperative Soil Survey has identified the soil in Stella's Marsh as Mukilteo Muck (US Department of Agriculture 1998).

Long-time residents of Stella's Landing report that Stella's Marsh was once dominantly cattails. Since 2015, they have observed bittersweet nightshade outcompeting the cattails. Bittersweet nightshade dominates Stella's Marsh at the southern end of the wetland, where Shellabarger Creek flows into Stella's Marsh. Roughly 20 m north of the mouth of Shellabarger Creek, the abundance of nightshade begins to decrease and the native cattails flourish (Rahlmann et al. 2017).

4.0 Phase II Activities

4.1 Conceptual Site Model and Sampling Plan

The conceptual site model takes into consideration the potential distributions of contaminants with respect to sources of stormwater, disturbances such as culverts or drainage outlets, and the patches of invasive and native plants.

The sampling plan included water and soil sampling and a vegetation survey along a transect in Stella's Marsh (Figure 2). A total of four water sampling sites were located as possible sources of stormwater runoff (Figure 2). Potential sources were determined to be Shellabarger Creek, the Northern Stormwater Runoff Output (NSRO), the Southern Stormwater Runoff Output (SSRO), and the culvert opening that connects Edmonds Marsh to Stella's Marsh. The soil and vegetation sampling occurred along an 80 m transect where a gradient of plant species composition was observed; the end of the transect (at 80 m) was on the banks of Shellabarger Creek, so no vegetation or soil data was collected at this point on the transect. This transect began at the NSRO (47.80747N 122.38187W) and ended at the mouth of Shellabarger Creek near SR104 (47.80697N 122.38255W).

4.2 Methods

4.2.1 Water

Water collection was based on the "Industrial Stormwater Monitoring and Sampling Guide" (USEPA 2009). We collected samples between approximately 5:00 and 6:00 pm, shortly after a rain event on 4/26/17 (total precipitation = 1.75 cm, National Weather Service Daily Summary). We measured temperature and dissolved oxygen (DO) using a field YSI probe. We measured salinity with a refractometer, and pH with an Oakton pH probe. We collected the water samples in amber glass containers (provided by ALS Environmental Laboratory, Everett, WA) for TPH-BTEX analysis and in 50 ml plastic centrifuge tubes for metal analysis. Samples were transported in a cooler with ice, then transferred to storage at 4°C until analysis, with the exception of samples for metals analysis, which were stored at room temperature.

4.2.2 Soil

Soil collection was adapted from the method outlined in "Legacy Management CERCLA Sites. Quality Assurance Project Plan" (Department of Energy 2007). We collected soil samples two times.

In the first soil sampling event on 5/2/2017, five soil samples were collected for PAH analysis at 11, 29, 45, 60, and 70 m from the NSRO along the established transect and one meter away from the transect. Information on plant species composition was also collected at these sites, as described in Section 4.2.3.

In the second soil sampling event on 5/6/2017, a 1-m^2 quadrat was placed along the transect every 10 m between 0 and 70 m, for a total of 8 locations to match the locations of the vegetation data collected on 4/26/17 (Section 4.2.3). In each quadrat, three samples were collected using a small plastic hand shovel, based on a systematic random sampling approach (Zhang 2007). GPS waypoints were taken at every quadrat. Soils from this sampling event were analyzed for organic matter content, nutrients, and metals by ICP-MS. Metals, organic matter and nutrients analyses were completed for all replicates.

4.2.3 Vegetation

Methods for vegetation surveying were adapted from "Standard Operating Procedures: Terrestrial Plant Community Sampling" (USEPA 1994). We collected information on composition and abundance of vegetation two times.

The first vegetation survey was conducted on 4/26/17. Along the transect, 1-m^2 quadrats were placed on the southeast side of the transect every 5 m from 0 to 70 m, for a total of 16 quadrats. The percent cover of cattails, bittersweet nightshade and bare soil was estimated in each quadrat. Additional observations, such as other species of vegetation present, were recorded.

The second vegetation survey was conducted on 5/2/17. Quadrats were placed along the transect at the 11, 29, 45, 60, and 70 m mark (see Section 4.2.2). The locations for these quadrats were selected to ensure at least one quadrat included only cattails, one quadrat included only bittersweet nightshade, and at least one quadrat included a mixture of the two species.

At each quadrat, photos were taken and a GPS waypoint was recorded (Appendix I). For statistical analyses, vegetation data collected every 10 m from 0 to 70 m on 4/26/17 and all data collected on 5/2/17 is used; the percent cover data is averaged for the two sampling periods when data was collected from the same location (±1 m) on the transect.

4.2.4 Organic Matter

Organic matter content of each sample was determined according to the loss on ignition (LOI) method (ASTM 1993). Soil was placed in a covered dish and heated at 440°C until the sample reached a constant mass.

4.2.5 Nutrient Analysis

Soil samples were analyzed for nitrogen, potassium, and phosphorous using an NPK Soil Test Kit (Code 3-5880, LaMotte Company). The content of each chemical in the samples was classified as low, medium, or high. According to the instructions, the values for low, medium, high (respectively) for each chemical were as follows: 40, 160, and 320 lb nitrogen/A/6" soil; 8, 20, and 64 lb phosphorous/A/6" soil; and 40, 80, and 160 lb potassium/A/6" soil. Results are converted from the low, medium, and high categories into these numeric values and are presented in Appendix II.

4.3 Chemical Analyses

Water samples were analyzed for TPH-BTEX according to USEPA (2014) by ALS Environmental Laboratory in Everett, Washington.

Soil samples were analyzed for PAHs according to USEPA (1998) by ALS Environmental Laboratory. The sum of the individually measured PAHs are reported as the total PAHs and are used for statistical analyses (Table AII-1).

Water samples were digested according to EPA (1996).

Approximately 0.3 g of dried soils were microwave digested with 3 ml trace metal grade (TMG) HCl and 9 ml HNO3 (TMG) in a Milestone Ethos EZ Microwave Digestion System following the Soil protocol (Milestone digestion application #03-001 (9/14/99)). The digestates were diluted with NanoPure water to 5% HNO3 (TMG).

All digested samples were analyzed for metals by ICP-MS at Western Washington University in the Advanced Materials Science and Engineering Center (AMSEC) lab.

4.4 Statistical Analyses

A one-way ANOVA was conducted for comparisons between the eight quadrats along the transect for metals, organic matter, and nutrients. A post hoc Tukey HSD test was conducted to test for significant results.

A Pearson correlation coefficient was computed to assess relationships between percent cattails or bittersweet nightshade and selected metals or organic matter; metals and organic matter were used as an average of three per quadrat for the correlations.

All statistical analyses were completed using R software.

5.0 Presentation and Evaluation of Results

Of note, although we did find chemical contamination in soils at Stella's Marsh, it is unlikely that humans would be exposed to the chemicals in the soils such that toxicity would be expected. The vegetation in the wetland, however, is likely to be exposed, so toxicity to vegetation was considered as part of the literature reviews presented in this section.

5.1 Sources of Contamination

We identified four potential sources of contamination at Stella's Landing and analyzed water samples from those sites. Concentrations of TPH-BTEX were below the reporting limits of 1 μg/L for benzene, toluene, and ethylbenzene and 3 μg/L for xylenes.

5.2 Soil Characterization

Total PAH concentrations in soils increased as distance from the NSRO increased (Figure 3). Thus, the primary source of PAHs in the wetland is not the stormwater runoff from the residential complex, but instead is likely SR104 or Shellabarger Creek, with SR104 being the most likely source given the lack of detections in the Shellabarger Creek water samples and knowledge of road contributions of PAHs to surrounding land (e.g. Benfenati et al. 1992; Pathirana et al. 1994).

A suite of 21 metals was analyzed, but results are presented for the 12 metals with concentrations above the quantification limit, including: aluminum, arsenic, cadmium,

chromium, copper, iron, potassium, magnesium, manganese, nickel, lead, and zinc (Figures 4a-4k). General trends are summarized below:

- Aluminum, chromium, copper, magnesium, nickel, potassium and lead showed a trend where the first three sites along the transect (closest to Stella's Landing) are not different from each other, and then the concentrations of metal increase with distance along the transect (furthest from Stella's Landing; A to A' on Figures 4 a, d, e, g, h, j, and k).
- Arsenic and cadmium had a trend where the concentrations at the first site (closest to Stella's Landing) was relatively high, the concentrations at the second site was relatively low, and then the concentrations at the rest of the sites gradually increase along the transect (from A to A' on Figures 4 b and c).
- Iron concentration had no clear pattern along the transect (Figure 4f).
- There was high variability in the manganese concentrations at the first site (closest to Stella's Landing) and relatively high average concentrations, but this was not significantly different than four of the sites. None of the other sites were different (Figure 4i).

In addition to PAH and metals concentrations, we assessed the organic matter content of the soil (Figure 5). Organic matter content was highest in the middle of the transect, but did not explain the vegetation patterns we observed. This is best demonstrated by the three samples closest to the NSRO; these had the greatest percent of cattails, but a range of organic matter content.

5.3 Description of Vegetation along Transect

From the NSRO at Stella's Landing (A) to approximately 25 m, cattails were the primary vegetation species present and no bittersweet nightshade was observed. From 35 m to 50 m (A to A'), bittersweet nightshade predominated with 75 to 85% cover and little to no cattails. From 55 to 80 m, there was a mixture of cattails and bittersweet nightshade (Figure 6).

5.4 Correlation Results

Analyses were conducted for percent cattail and percent bittersweet nightshade against all measured variables of soil (metals, total PAHs, and organic matter) by computing Pearson's correlation coefficients. An example of the correlations is presented as Figure 7. Correlations were variable and showed a mix of positive and negative results, but correlations for both vegetation types against all other variables were not statistically significant (Appendix III).

6.0 Discussion of Findings and Conclusions

6.1 Metals and Vegetation

If there were a cause and effect relationship between metal contamination and ability of the bittersweet nightshade to establish, we would expect an increasing percent of nightshade as the metals concentrations increased (i.e. a positive correlation), indicating that the metals are toxic to the cattails and the nightshade is more tolerant of the metals. There were no significant positive or negative correlations between any of the concentration of metals in soil and percent cattail cover, or any of the metals and bittersweet nightshade cover (Figure AIII-1). Although we saw no significant results that support a relationship between metals and vegetation type, a literature review shows that some metals can have adverse effects on cattails (*T. latifolia*). In the studies discussed below, all of the exposures were with metals in solution as opposed to soil; because we

measured metals in the soils at Stella's Marsh, it is not appropriate to compare the concentrations from the reviewed literature to concentrations in the field, but the discussion does imply that metal toxicity can be a factor, and warrants a more complete literature review to add perspective to the field results.

- One study found that root and shoot dry weight and leaf elongation were not affected, but root growth of *T. latifolia* was inhibited in seedlings after 72 days of exposure to 0.05 μg/ml copper or 0.10 μg/ml nickel (Ye et al. 1997a)
- Ye et al. (1997b) exposed *T. latifolia* seedlings to 20 μg/ml lead, 1 μg/ml zinc, or 0.25 μg/ml for 21 days. Longest leaf elongation and root and shoot dry weight were not affected by the lead, but root elongation was inhibited. Longest leaf and root elongation were inhibited in the zinc exposures. Leaf and root elongation, and shoot and root dry weight were inhibited by the cadmium; additionally, most of the leaves were chlorotic.
- In a study by Karathanases and Johnson (2003), cattails were exposed to coal mine effluent, and they found that a mixture of metals that included 10.9 mg/L of manganese elicited no visible signs of toxicity for *T. latifolia*.
- There was limited information on how aluminum, arsenic, potassium, magnesium, and chromium affect *T. latifolia*.
- We did not find information on how the metals we examined affect bittersweet nightshade.

These studies support that metals can affect cattail growth, with root elongation being the most sensitive effect. When we examined potential correlations between metal concentration and percent cover of both vegetation species, the results showed no significant correlations. Since there were no significant correlations, metals are probably not a contributing factor to the distribution and composition of the vegetation in the wetland, but we did not examine the cattails in Stella's Marsh for symptoms of toxicity, such as changes to root and leaf growth. We can not exclude the possibility that contaminants caused sub-lethal effects to the cattails, as supported by the literature. If this were of interest, future work could focus on relating biomass of cattails to metal concentrations in the soils.

6.2 PAHs and Vegetation

According to Maliszewska-Kordybach and Smreczak (2000), PAHs in soils stimulate plant growth at low concentrations but significantly inhibit plant growth at higher concentrations. The authors tested four concentrations of a PAH mixture containing fluorene, anthracence, pyrene, and chrysene on six plant species to observe the effects on growth. Their results showed that low concentrations of PAHs in the soils (1-10 mg/kg dry soil) stimulated the growth of *Helianthus annus L.* (common sunflower) and *Phaseolus vulgaris L* (common bean), but higher concentrations (100 mg/kg dry soil) inhibited growth on all tested plants. Root length and stem length were both significantly inhibited at 100 mg/kg dry soil of the PAH mixture. The authors hypothesize that the low toxicity is due to the low bioavailability and water solubility of PAHs. Although PAHs can damage cell membranes, which could result in genetic mutation, slow growth, and weakening of the plant, it is difficult for PAHs to penetrate into plant tissue to do so.

Cattails have been shown to be effective at absorbing PAHs from water. Kahn (2007) exposed narrow leaf cattail pollen, referred to as cattail fiber, to a series of PAHs in water and found that roughly one gram of cattail fiber removed 0.1 to 11 mg of PAHs. This could explain our results

that showed PAHs with a higher concentrations in soils at the mouth of Shellabarger Creek, where no cattails were present, while PAH concentrations decreased as cattail coverage increased (Figure 7). Alternatively, it could be that there were simply more PAHs present near Shellabarger Creek because those sites were closer to the road, and it is well established that incomplete combustion of gasoline produces PAHs that accumulate in soils near roads (as discussed in Section 5.2).

6.3 The Wetland Environment and Vegetation Presence

Wetland environments are low flow systems, which means that with increasing vegetation there is less water flow on the surface. As a result, both toxic and beneficial chemicals tend to deposit and accumulate in the soil via deposition of sediments from the water (Kadlec 1995). This decreased flow may also contribute to altered sedimentation and organic matter regimes within wetland systems.

The tolerance of *T. latifolia* to salinity ranges from <4 mS cm-1 to <9 mS cm-1 and to pH from 6.5 to 8.5; if salinity or pH is outside of these ranges, there could be an effect on the availability and retention of nutrients to the plants (Calheiros et al. 2007). It is established that cattails benefit from higher amounts of phosphorous, and concentrations of leaf K, Mg, Ca, Mn and Mo were positively correlated with phosphorous availability (Li et al. 2010). Additionally, bittersweet nightshade may prefer soils rich in nitrogen rather than phosphorous (Waggy 2009). This all supports that a change in nutrient availability caused by salinity or pH changes could affect cattail and bittersweet nightshade growth.

Other work has shown that species within the genus Typha inhabit areas with lower nutrients and organic matter (Werner and Zedler 2002). Not a lot of literature relates bittersweet nightshade to levels of organic matter. In our study, organic matter was highest in the center of the transect, however there was no pattern in relation to species abundance. Specifically, higher percentages of cattails occurred in both the lower and higher ranges of organic matter (Figure 5). The literature also supports that cattails can break down and remove organic matter from the soil (Calheiros et al. 2008). It is not clear, therefore, whether the organic matter is altered by the cattails or whether bittersweet nightshade has a preference for higher organic matter.

Although we did not investigate particle size of the wetland soils, it may play a role in colonization of bittersweet nightshade. Cattails have higher performance and propagation in clay aggregates than sand. Bittersweet nightshade, in New Jersey, was more likely to occur in sites with higher percentages of sand. However, there are several other instances which exemplified the range of soil types in which it can occur, namely loam and clay (Waggy, 2009).

Although there is evidence that a wetland environment itself may be more conducive for the colonization of either native or invasive species, our work does not support whether it is the case that bittersweet nightshade was present at Stella's Marsh because of any specific component of the wetland environment. We also can not eliminate the possibility that the bittersweet nightshade may have been merely introduced to the marsh near A' and is spreading throughout the wetland.

6.4 Vegetation Hydrologic Preferences and Precipitation Data

6.4.1 Cattail

According to the US Army Corps of Engineers (2012), cattails are herbaceous, emergent plants. The base of this plant grows in submerged conditions with the roots in flooded soil or seasonally saturated soils. Cattails are obligate wetland plants that almost always occur in wetlands. They are typically found in standing water or seasonally saturated soils that are saturated near the surface for 14 or more consecutive days.

We focused part of our literature review on how cattails fare in drier soils. Li et al. (2004) showed that periodic drought conditions reduced biomass production as well as height of cattails. Root growth was also inhibited by experimentally created periodic drought conditions. Drought conditions were simulated by watering the plants only when the soil water potential was between -0.5 and -0.8 MPa. They concluded that *T. latifolia* is susceptible to drought conditions.

6.4.2. Bittersweet Nightshade

Bittersweet nightshade can occur in relatively undisturbed areas, but prefers areas that have been disturbed. The plant typically occurs in areas that have an annual precipitation of 32 to 45 inches and also occurs in maritime-influenced regions like the Pacific Northwest (Waggy 2009). Bittersweet nightshade is a facultative plant, and these types of plants occur in both wetlands and areas that are not wetlands. They can occur in a wide variety of habitats and have a wide tolerance of soil moisture conditions (US Army Corps of Engineers 2012). Though it can succeed in fairly dry soil, it grows best in moist situations and can tolerate a fair amount of shade (Invasive Plant Atlas of New England 2007).

6.4.3 Precipitation Data

Figure 8 shows the cumulative precipitation data collected from a NOAA station in Everett over the years 2010 to 2016. In 2013 and 2015 there was low cumulative precipitation relative to other years. Stella's Landing residents noticed the invasion of bittersweet nightshade in late 2013. Since 2013 was a relatively dry year, the cattails could have been stressed, allowing the bittersweet nightshade to invade the wetland, since bittersweet nightshade can succeed in both dry and moist soil. Based on these observations, we believe this potential cause of the change in plant species warrants further investigation.

7.0 Recommendations

We suggest future studies be conducted on the wetland, but first recommend a complete investigation of the literature on environmental conditions that are favorable to bittersweet nightshade and stressful to cattails. The advantage of this as a first step is that it is a low cost way to guide future field work, ensuring the efficiency of that field work. Based on our work, we recommend future work focused on the hydrology of this wetland, although particle size analysis should also be completed.

For further studies related to the invasion of bittersweet nightshade at Stella's Marsh we recommend analyzing the micro-topography of Stella's Marsh. According to Werner and Zedler (2002) stormwater sedimentation can alter the micro-topography of a wetland, which may result in reduced species richness and an increase in invasive species. The authors suggest that

sedimentation creates a disturbance that promotes invasive species establishment. Once the invasive plants are established, they have the potential to expand over the wetland and reduce species richness.

Based on the precipitation records of Edmonds (Figure 8) from 2010 through 2016, we hypothesize that a change in precipitation, hydrology, or some combination of both, could be correlated to the invasion of bittersweet nightshade. We do not have information on how the culvert that connects the Edmonds Marsh to Stella's Marsh or long-term changes to the regional groundwater table may have impacted wetland hydrology. It is possible that some combination of these altered the wetland hydrology enough to allow for the colonization of the bittersweet nightshade. To investigate these possibilities, we recommend installing piezometers in Stella's Marsh to understand groundwater contributions and flow, and monitoring salinity as a way of understanding the input from the Edmonds Marsh. Cole et al. (1997) used piezometers and wells to monitor water levels and ground water in wetlands to determine if groundwater was a source of water for the wetland plants. Studies on the wetland hydrology could support whether this is a factor in where the wetland species are able to colonize.

References

Alonso-Castro A.J., C. Carranza-Alvarez, M.A. Alfaro-De la Torre, L. Chavez-Guerrero, and R.F. Garcia-De la Cruz. 2009. Removal and accumulation of cadmium and lead by *Typha latifolia* exposed to single and mixed metal solutions. Archives of Environmental Contamination and Toxicology. 57(4): 688-696.

ASTM Standard 2974-87, 1993, "Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils," ASTM International, Philadelphia, PA.

Bah A.M., H. Dai, J. Zhao, H. Sun, F. Cao, G. Zhang, and F. Wu. 2011. Effects of cadmium, chromium and lead on growth, metal uptake and antioxidative capacity in *Typha angustifolia*. Biological Trace Element Research. 142(1):77-92.

Benfenati E., S. Valzacchi, G. Mariani, L. Airoldi, and R. Fanelli. 1992. PCDD, PCDF, PCB, PAH, cadmium and lead in roadside soil: relationship between road distance and concentration. Chemosphere 24(8): 1077-1083.

Brunham W., and L.I. Bendell. 2011. The effect of temperature on the accumulation of cadmium, copper, zinc, and lead by *Scirpus acutus* and *Typha latifolia*: a comparative analysis. Water, Air, and Soil Pollution. 219(1):417-428.

Calheiros C. S., A.O. Rangel, and P.M. Castro. 2008. Evaluation of different substrates to support the growth of *Typha latifolia* in constructed wetlands treating tannery wastewater over long-term operation. Bioresource technology, 99(15): 6866-6877.

Cole C.A., R.P. Brooks, and D.H. Wardrop. 1997. Wetland Hydrology as a Function of Hydrogeomorphic (HGM) Subclass." Wetlands 17(4): 456-467.

Day, P.R. 1965. Particle fractionation and particle-size analysis. Ch 43 in Methods of Soil Analysis, Part 1. CA Black, ed. American Society of Agronomy, Madison. P 545-567

Department of Energy. "Legacy Management CERCLA Sites. Quality Assurance Project Plan." (2007): n. pag. July 2008. Web.

Invasive Plant Atlas of New England. 2007. *Solanum dulcamara*. Invasive Plants of New England. Retrieved from https://www.invasive.org/weedcd/pdfs/ipane/Solanumdulcamara.pdf

Kadlec R.H. 1995. Overview: surface flow constructed wetlands. Water Science & Technology 32:1–12.

Karathanasis A.D., and C.M. Johnson. 2003. Metal removal potential but three aquatic plants in an acid mine drainage wetland. Mine Water and the Environment. 22(1):22-30.

Khan E., S. Khaodhir, and P. Rotwiron. 2007. Polycyclic aromatic hydrocarbon removal from water by natural fiber sorption. Water Environment Research. 79(8):901-911.

Khateeb W.A., and H. Al-Qwasemeh. 2014. Cadmium, copper and zinc toxicity effects on growth, proline content and genetic stability of *Solanum nigrum L.*, a crop wild relative for tomato; comparative study. Physiology and Molecular Biology of Plants. 20(1):31-39.

King County. 2016. Bittersweet Nightshade. King County. Retrieved from http://www.kingcounty.gov/services/environment/animals-and-plants/noxious weeds/weed-identification/bittersweet-nightshade.aspx

Li S., S.R. Pezeshki, and S. Goodwin. 2004. Effects of soil moisture regimes on photosynthesis and growth in cattail (*Typha latifolia*). Acta Oecologica. 25(1-2):17-22.

Li S.W., J. Lissner, I.A. Mendelssohn, H. Brix, B. Lorenzen, K.L. McKee, and S. Miao. 2010. Nutrient and growth responses of cattail (*Typha domingensis*) to redox intensity and phosphate availability. Annals of Botany. 105:175–184.

Maliszewska-Kordybach B., and B. Smreczak. 2000. Ecotoxicological activity of soils polluted with polycyclic aromatic hydrocarbons (PAHs) - Effect on Plants. Environmental Technology. 21(10): 1099-1110.

Pathirana S., D.W. Connell, and P.D. Vowles. 1994. Distribution of polycyclic aromatic hydrocarbons (PAHs) in an urban roadway system. Ecotoxicology and Environmental Safety. 28(3): 256-269.

Taylor G.J., and Crowder A.A. 1984. Copper and nickel tolerance in *Typha latifolia* clones from contaminated and uncontaminated environments. Canadian Journal of Botany. 62(6):1304-1308.

Rahlmann E., S. Bailey, and M. Hope. 2017. Phase I Environmental Site Assessment: Stella's Landing, Edmonds, WA. Final report, produced for Sustainable Cities collaboration between Western Washington University and Edmonds, WA.

US Army Corps of Engineers. 2012. National wetland plant list indicator rating definitions. Engineer Research and Development Center. ERDC/CRREL TN-12-1.

US Department of Agriculture. 1999. "Mulkiteo Series," National Cooperative Soil Survey, retrieved from https://soilseries.sc.egov.usda.gov/OSD_Docs/M/MUKILTEO.html

USEPA. 1994. Standard operating procedures: terrestrial plant community sampling. SOP #2037. EP-W-09-031. Washington, DC.

USEPA. 1996. Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma – Mass Spectrometry. Office of Water, Engineering and Analysis Division. Method 1638. Washington, DC.

USEPA.1998. Semivolatile organic compounds by gas chromatography/mass spectrometry (GC/MS). Method 8270. Washington, DC.

USEPA. 2009. Industrial Stormwater Monitoring and Sampling Guide. EPA 832-B-09-003. Washington, DC.

USEPA. 2014. Aromatic and halogenated volatiles by gas chromatography using photoionization and/pr electrolytic conductivity detectors. Method 8021B. Washington, DC.

Waggy M.A. 2009. *Solanum dulcamara*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, February 1].

Werner K.J., and J.B. Zedler. 2002. How sedge meadow soils, microtopography, and vegetation respond to sedimentation. Wetlands 22(3): 451-466.

Woo I., and J.B. Zedler. 2002. Can nutrients alone shift a sedge meadow towards dominance by the invasive *Typha glauca*? Wetlands 22: 509–521.

Ye Z.H., A.J.M. Baker, M.H. Wong, and A.J. Willis. 1997a. Copper and nickel uptake, accumulation and tolerance in *Typha latifolia* with and without iron plaque on the root surface. The New Phytologist. 136:481-488.

Ye Z.H., A.J.M. Baker, M.H. Wong, and A.J. Willis. 1997b. Zinc, lead and cadmium tolerance, uptake and accumulation by *Typha latifolia*. The New Phytologist. 136(3):469-480.

Zhang C. "Environmental Sampling Approaches: Where and When." Fundamentals of Environmental Sampling and Analysis. Hoboken: Wiley, 2007. 56-57. Print.

Figures

Figure 1. Map of Stella's Marsh in relation to the broader Edmonds Marsh, bisected by State Route 104. The selected section of the map in yellow is Stella's Marsh. The road map on the right depicts the location of Edmonds relative to the Seattle area in Washington State.

Figure 2. Conceptual Site Model of Stella's Marsh. Stormwater runoff water sampling points, labeled in blue, are (1) Northern Stormwater Runoff Output (NSRO), (2) the Southern Stormwater Runoff Output (SSRO), (3) Shellabarger Creek, and (4) the culvert opening that connects Edmonds Marsh to Stella's Marsh. The yellow line connecting point sources A (NSRO) and A' (Shellabarger Creek) represents the soil and vegetation sampling transect.

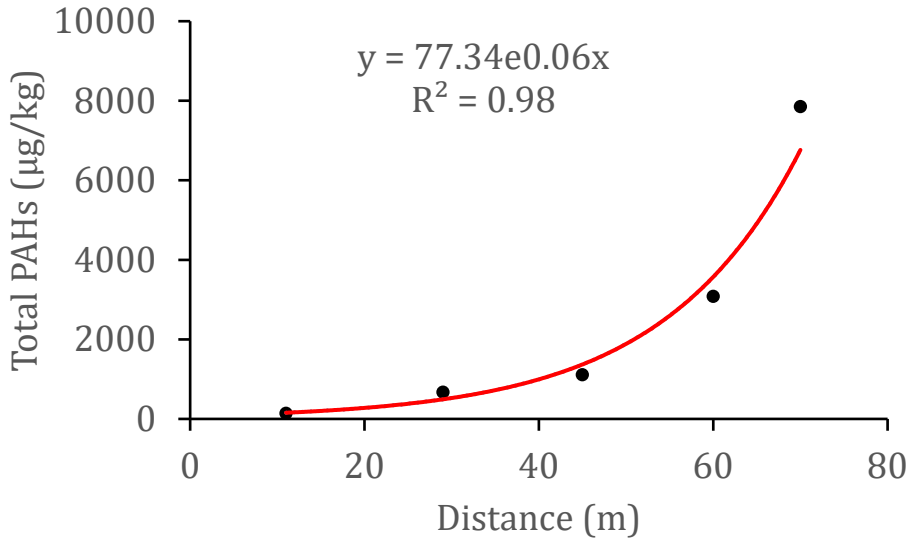

Figure 3. Concentrations of total PAHs (µg/kg) in the soil plotted against distance from the NSRO. The red line represents the best-fit line.

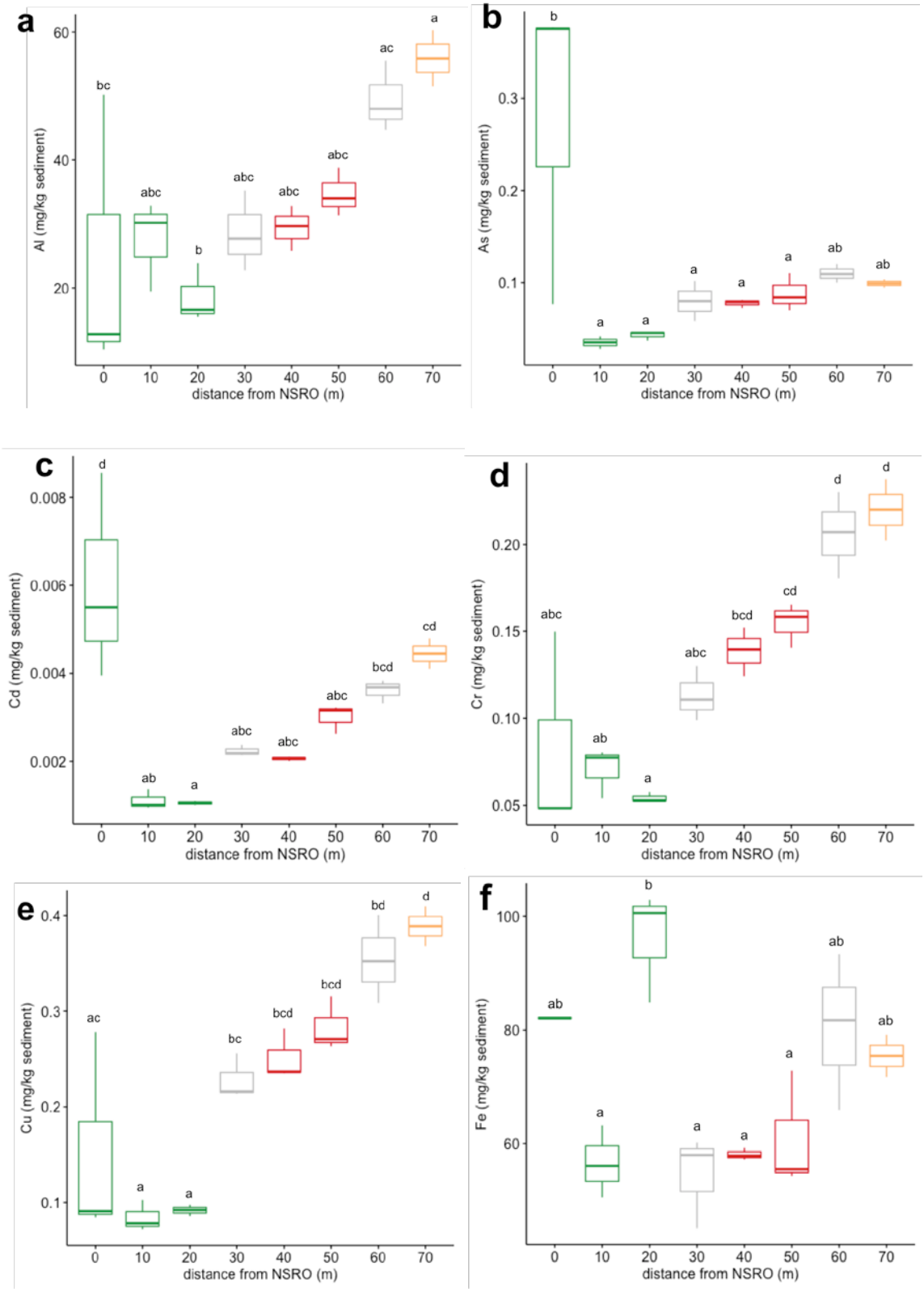

Figure 4. Continued.

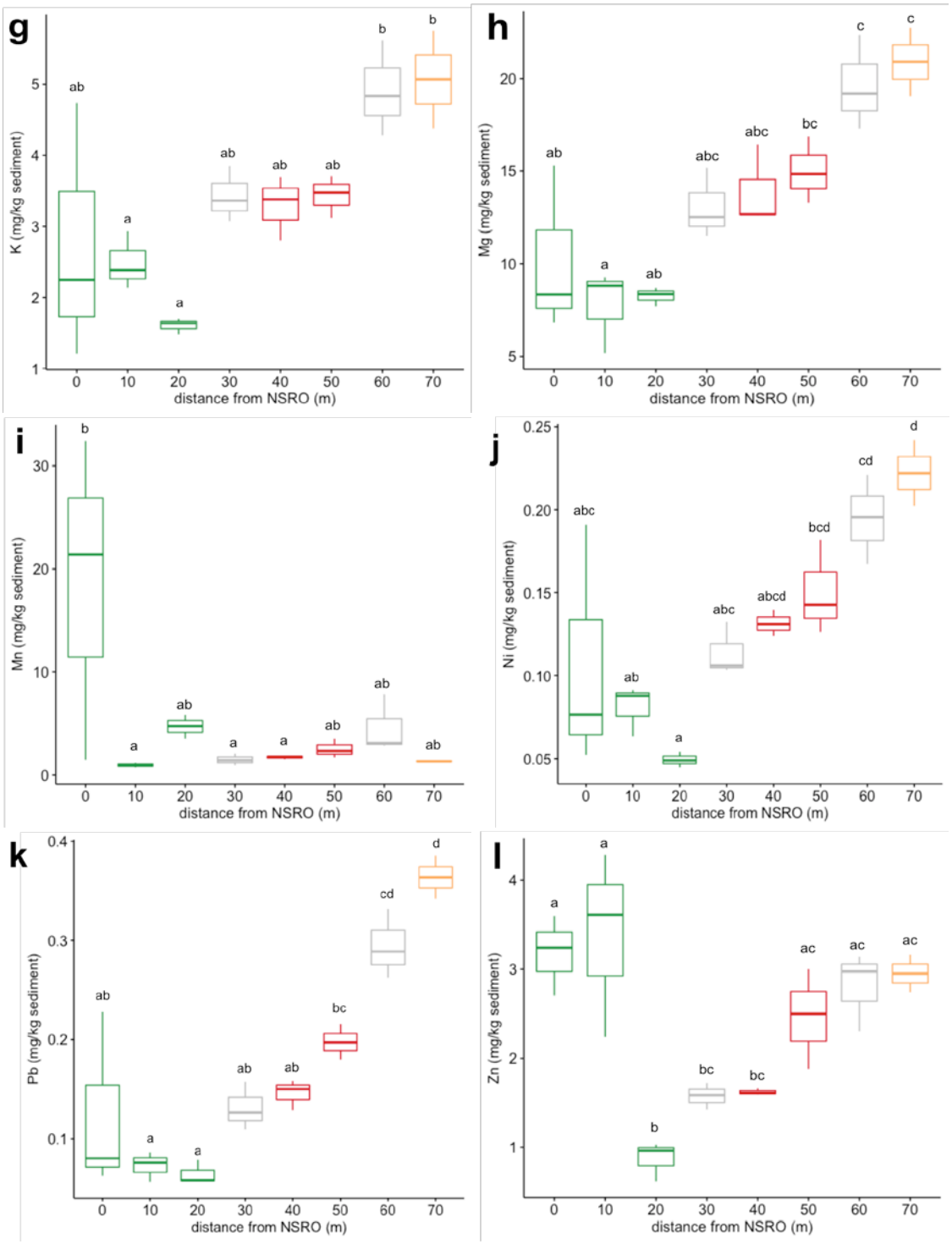

Figure 4. Concentrations of metals in soil samples at Stella's Marsh: a) aluminum b) arsenic c) cadmium d) chromium e) copper f) iron g) potassium h) magnesium i) manganese j) nickel k) lead l) zinc. Concentrations are per dry weight of sample. Percent cover of cattails is represented by different colors: 80-100% cattail (green), 40-60% cattail (grey), 20-40% cattail (orange), and 0-20% cattail (red). No data for 60-80% cattail. Letters represent post hoc comparisons using Tukey HSD test. If letters are the same, that indicates no significant difference between those groups. n= 3.

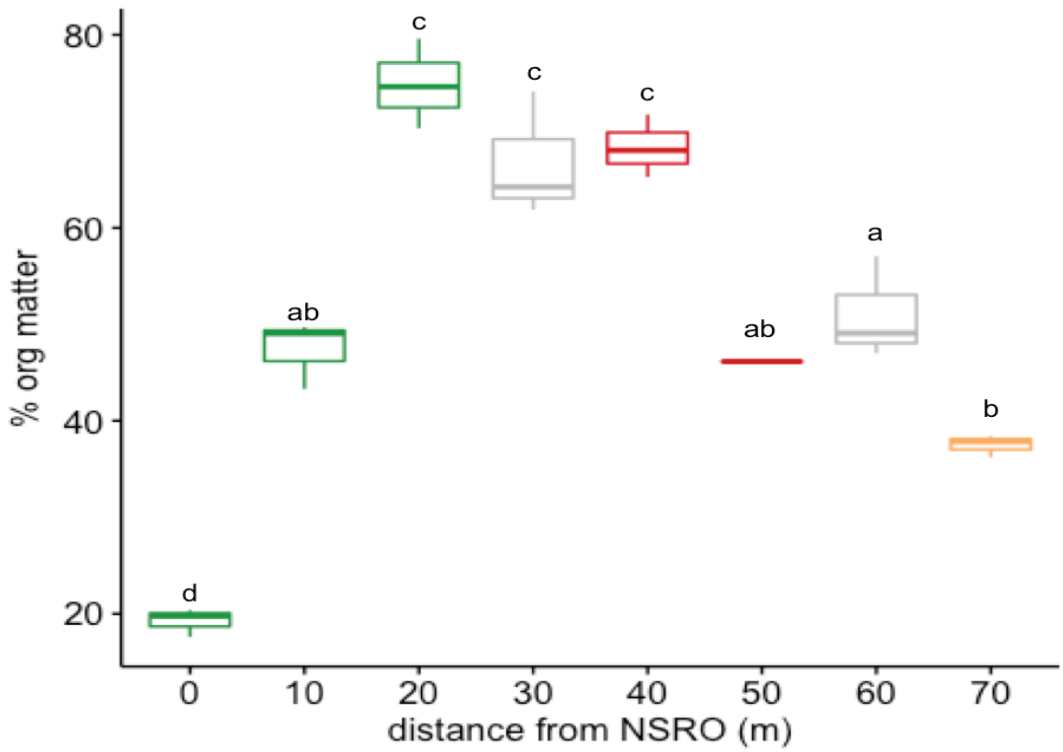

Figure 5. Distance versus percent organic matter in soil samples in Stella's Marsh. Percent cover of cattail is represented by different colors: 80-100% cattail (green), 40-60% cattail (grey), 20-40% cattail (orange), and 0-20% cattail (red). No data for 60-80% cattail. Letters represent post hoc comparisons using Tukey HSD test. If letters are the same, that indicates no significant difference between those groups. n=3, except at 50 m, which had n=1.

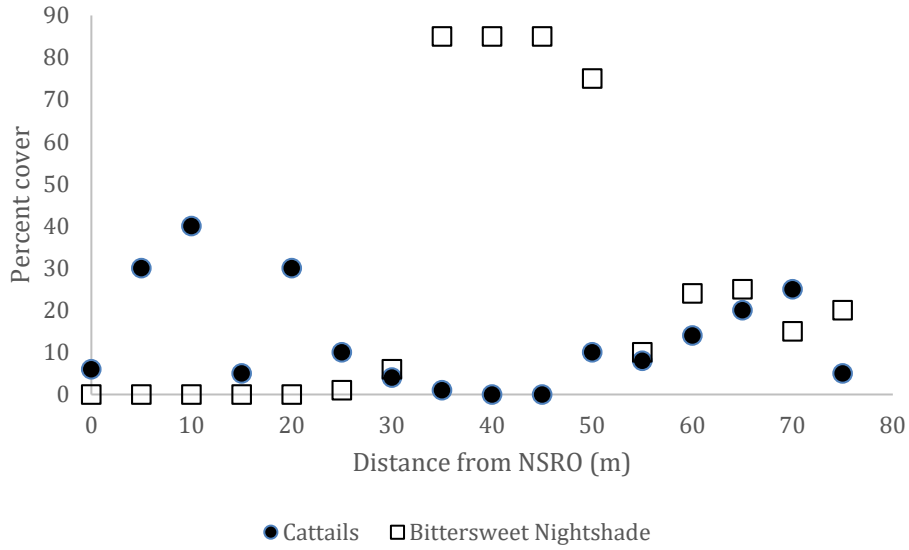

Figure 6. Percent cover from 4/26/17 sampling event.

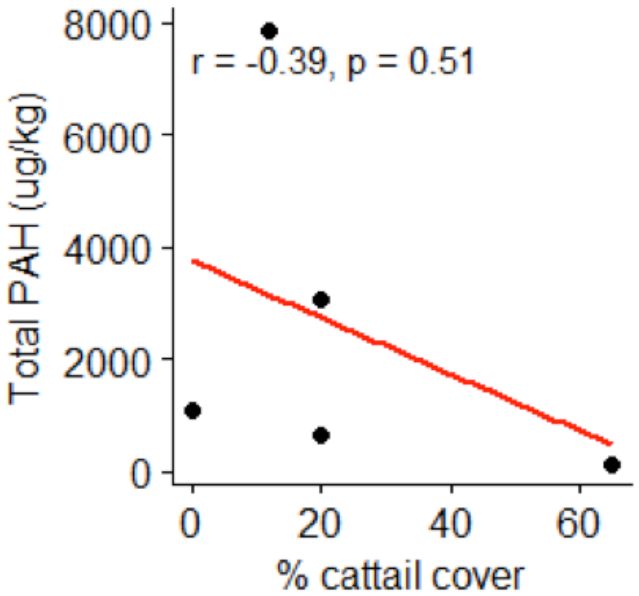

Figure 7. Concentrations of total PAHs (µg/kg) plotted against cattail coverage (%). The red line represents the best-fit line.

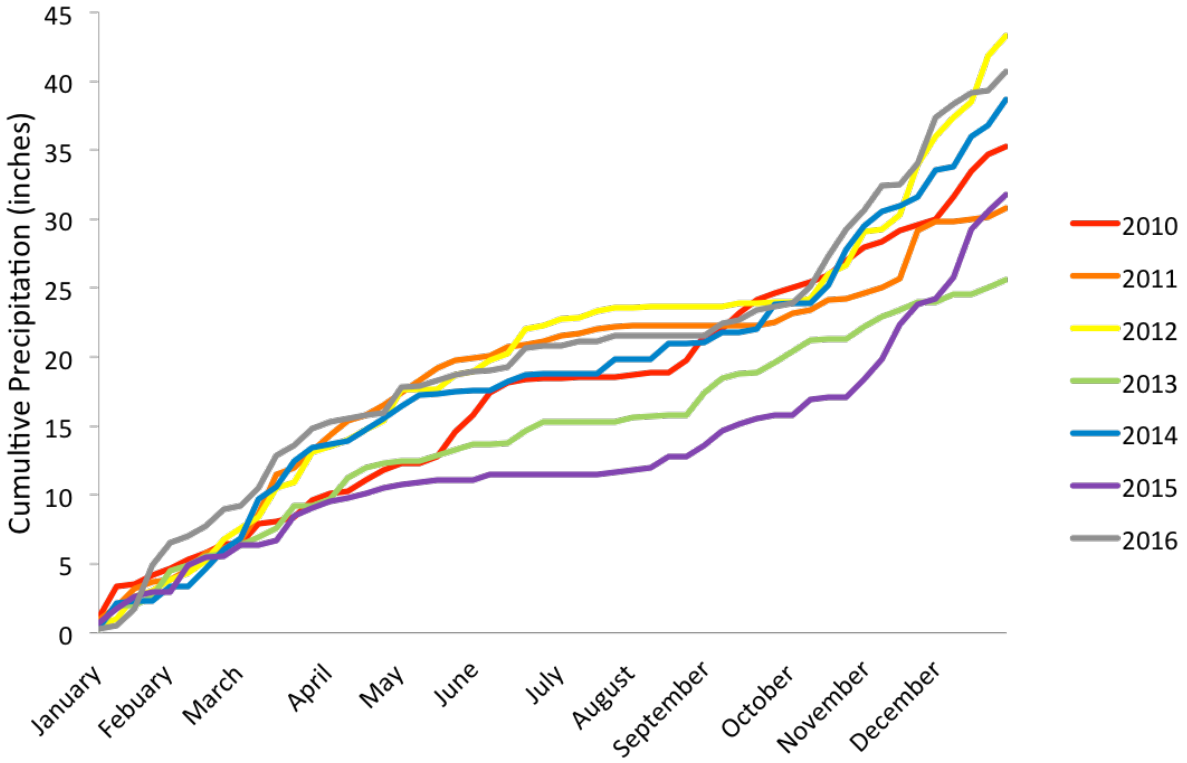

Figure 8. Precipitation records of Edmonds from 2010 to 2016. Data was collected from NOAA in Everett. Figure was created by Rahlmann et al. (2017).

Appendix I

Table AI-1. Information about percent cover of each vegetation type and bare space in each quadrat sampled along the transect. Associated information for each quadrat, such as date recorded, the meter mark on the transect, site number, and if a photo was taken are included.

Vegetation Data Associated with Metals in Soil Data								
Date	**m on transect from A to A'**	**Site #**	**Photo (Y/N)**	**Waypoint N**	**Waypoint W**	**Cattail Cover**	**Nightshade Cover**	**Bare space**
4/26/2017	0	1	Y	47.80747	122.3819	6	0	94
4/26/2017	5	2	Y	47.80745	122.382	30	0	70
4/26/2017	10	3	Y	47.80743	122.382	40	0	60
4/26/2017	15	4	Y	47.80742	122.3821	5	0	95
4/26/2017	20	5	Y	47.80736	122.3821	30	0	70
4/26/2017	25	6	Y	47.80734	122.3821	10	1	89
4/26/2017	30	7	Y	47.80729	122.3822	4	6	90
4/26/2017	35	8	Y	47.80728	122.3823	1	85	14
4/26/2017	40	9	Y	47.80722	122.3822	0	85	15
4/26/2017	45	10	Y	47.80718	122.3823	0	85	15
4/26/2017	50	11	Y	47.80712	122.3823	10	75	15
4/26/2017	55	12	Y	47.8071	122.3824	8	10	82
4/26/2017	60	13	Y	47.80707	122.3824	14	24	62
4/26/2017	65	14	Y	47.80705	122.3824	20	25	55
4/26/2017	70	15	Y	47.807	122.3825	25	15	60
4/26/2017	75	16	Y	47.80697	122.3826	5	20	75
Vegetation Data Associated with PAH in Soil Data								
Date	**m on transect from A to A'**	**Site #**	**Photo (Y/N)**	**Waypoint N**	**Waypoint W**	**Cattail Cover**	**Nightshade Cover**	**Bare space**
5/2/2017	70	17		47.80703	122.3826	12	75	13
5/2/2017	60	18		47.8071	122.3825	20	12	68
5/2/2017	45	19		47.80721	122.3823	0	85	15
5/2/2017	29	20		47.80733	122.3822	20	25	55
5/2/2017	11	21		47.80743	122.382	65	0	35

Figure AI-1. Pictures of Sites 1-9, where Site 1 is at 0 m and Site 9 is at 40 m from the NSRO. Sites 2 through 8 are increasing increments of 5 m along the transect. Data from sites 1, 3, 5, 7 and 9 were used in statistical analyses.

Figure AI-1. Pictures of Sites 10-16, where Site 10 is at 45 m and Site 16 is at 75 m from the NSRO. Sites 11 through 15 are increasing increments of 5 m along the transect. Data from sites 11, 13, and 15 were used in statistical analyses.

Appendix II.

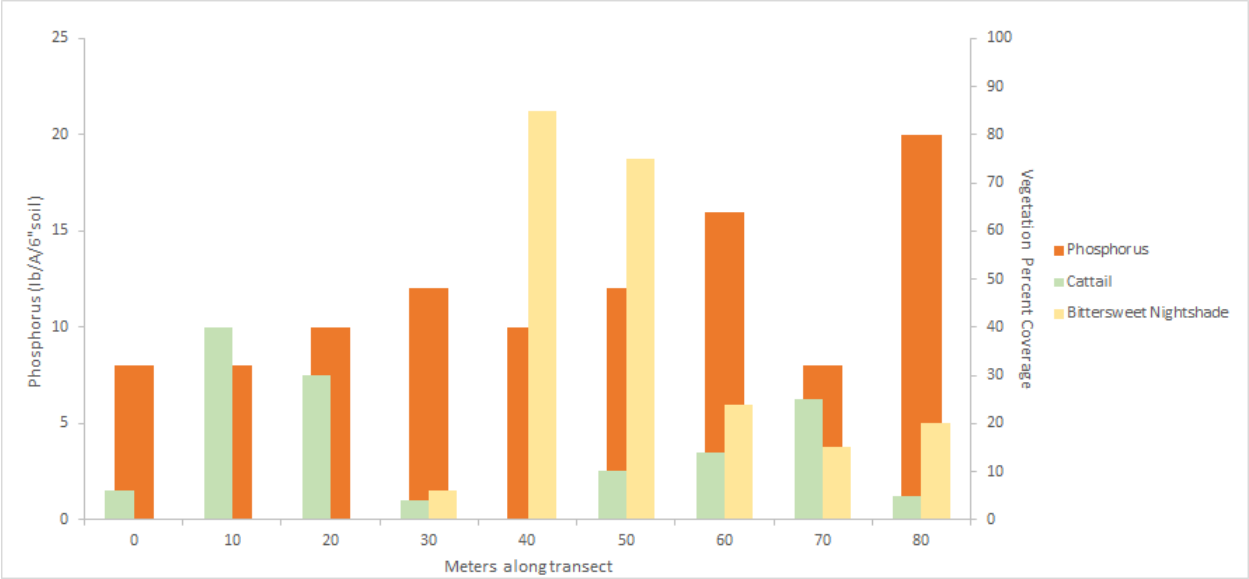

Figure AII-1. The phosphorous content (lb/A/6" soil) along the 80 m vegetation transect. The measured categories of low, medium, and high are translated into content based on information in the LaMotte Company NPK Soil Test Kit instructions.

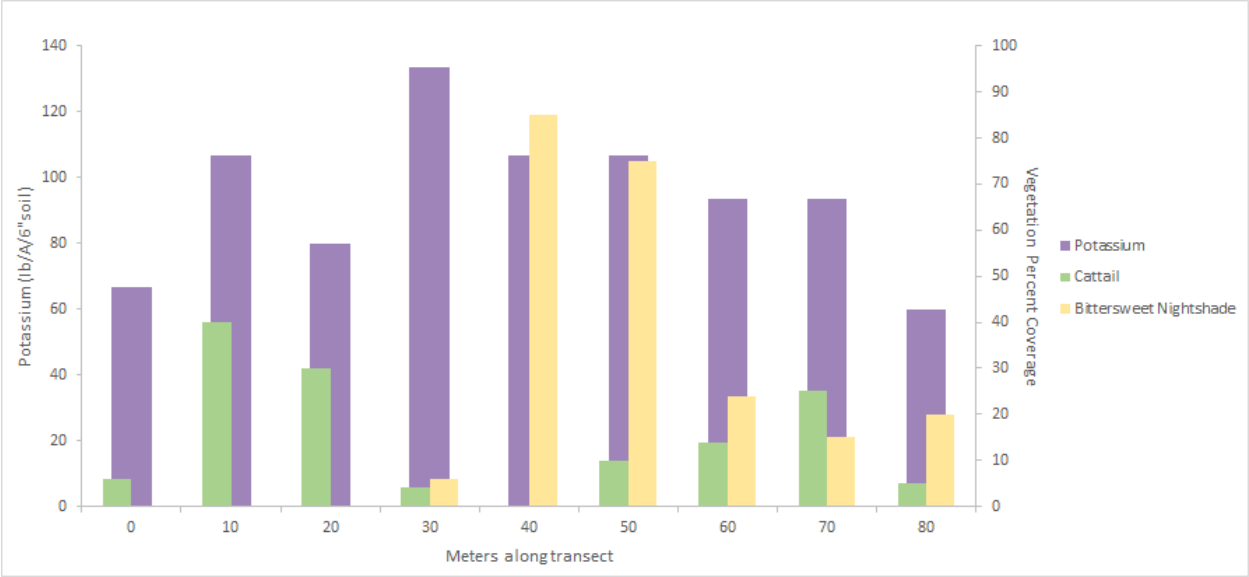

Figure AII-2. The potassium content (lb/A/6" soil) along the 80 m vegetation transect. The measured categories of low, medium, and high are translated into content based on information in the LaMotte Company NPK Soil Test Kit instructions.

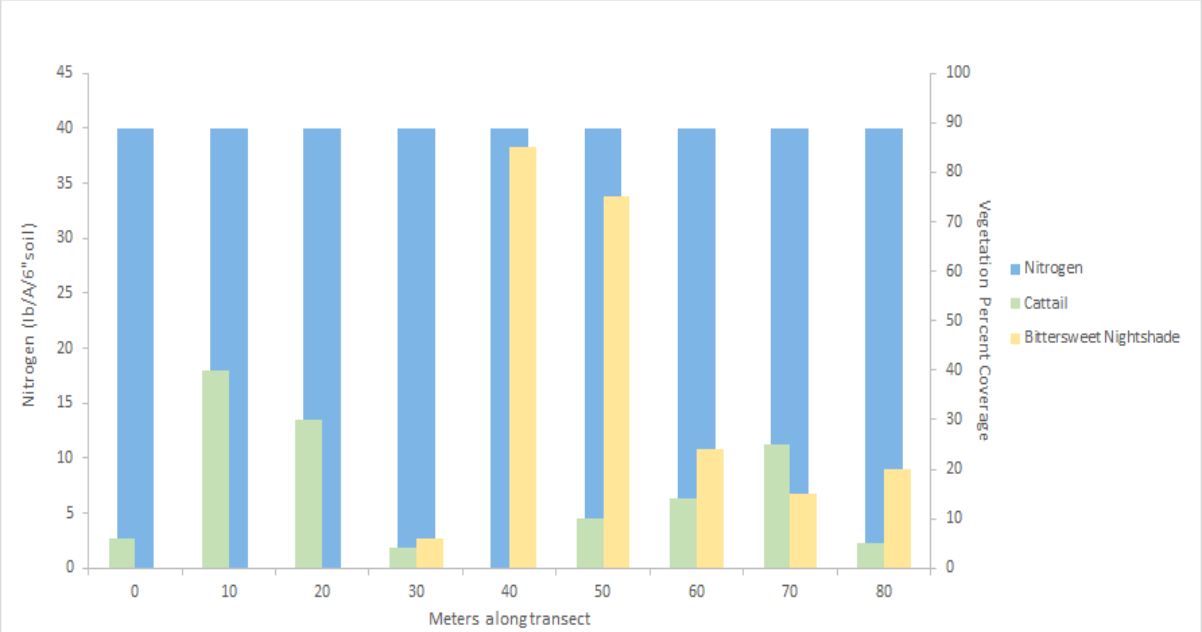

Figure AII-3. The nitrogen content (lb/A/6" soil) along the 80 m vegetation transect. The measured categories of low, medium, and high are translated into content based on information in the LaMotte Company NPK Soil Test Kit instructions.

Table AII-1. PAH concentrations in soils collected on 5/2/17. All concentrations are in µg/kg as wet weight soil.

	Distance				
Type of PAH (µg/kg)	**11 m (10m)**	**29 m (30 m)**	**45 m**	**60 m**	**70 m**
Naphthalene	U	U	U	U	U
2-Methylnaphthalene	U	U	U	U	U
1-Methylnaphthalene	U	U	U	U	U
Acenaphthylene	U	U	U	U	U
Acenaphthene	U	U	U	U	U
Fluorene	U	U	U	U	U
Phenanthrene	U	83	84	210	520
Anthracene	U	U	U	U	42
Fluoranthene	66	230	240	550	1400
Pyrene	75	200	190	420	1000
Benz[a]anthracene	U	U	52	150	470
Chrysene	U	160	160	330	810
Benzo(b)fluoranthene	U	U	U	520	1300
Benzo(k)fluoranthene	U	U	U	110	330
Benzo(a)pyrene	U	U	84	210	550
Indeno(1,2,3-cd)pyrene	U	U	120	240	560
Dibenzo(a,h)anthracene	U	U	U	U	150
Benzo(ghi)perylene	U	U	180	340	720
Total PAHs	141	673	1110	3080	7852

U = Analyte analyzed for but not detected at level above reporting limit.

Appendix III.

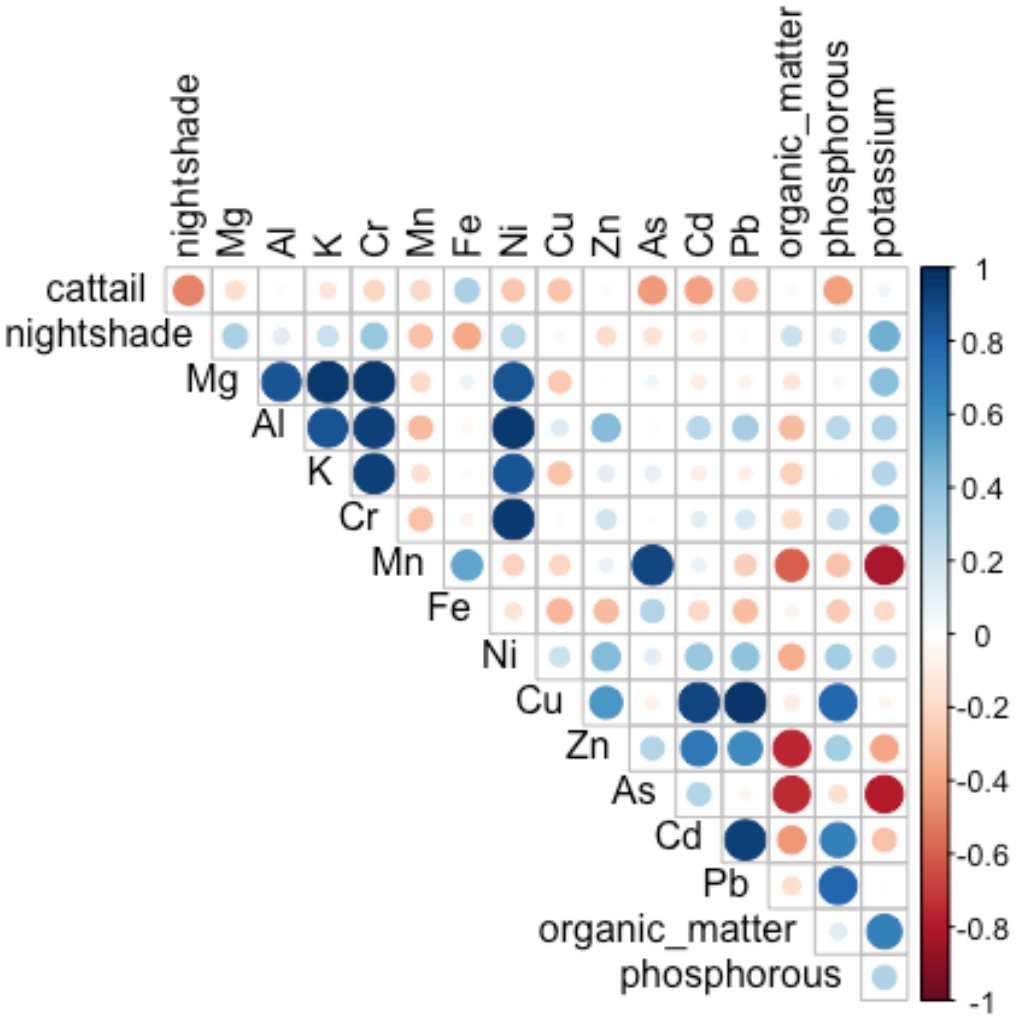

Figure AIII-1. Correlation matrix comparing relationships between all variables. Size of circle represents p-value to determine significance. Circles that fill the square box are statistically significant ($p<0.05$). Color and shading represents strength of correlation (i.e. correlation coefficient). Dark blue represents a strong, positive correlation; dark red represents a strong negative correlation. Of specific interest for this study are the comparisons between chemistry variables and cattail and nightshade. The correlation of cattails with total PAHs is included as Figure 7.