Attachment 8
Aquatic Invasive Species Discipline Report

CAPITOL LAKE – DESCHUTES ESTUARY

Long-Term Management Project Environmental Impact Statement

Aquatic Invasive Species Discipline Report

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Executive Summary

This Aquatic Invasive Species Discipline Report describes the potential impacts of the Capitol Lake – Deschutes Estuary Long-Term Management Project on aquatic invasive species in the area surrounding the project. The Capitol Lake – Deschutes Estuary includes the 260-acre Capitol Lake Basin, located on the Washington State Capitol Campus, in Olympia, Washington. Long-term management strategies and actions are needed to address issues in the Capitol Lake – Deschutes Estuary project area. An Environmental Impact Statement (EIS) is being prepared to document the potential environmental impacts of various alternatives and determine how these alternatives meet the long-term objectives identified for the watershed. This report was originally prepared to support the Draft EIS, and has been revised for the Final EIS. In general, revisions have been made to provide additional information, update and expand analyses and findings, refine measures to mitigate potentially significant impacts, and correct inadvertent errors. Notable substantive revisions in the Aquatic Invasive Species Discipline Report are as follows:

- Updated plant AIS information from a weed management report prepared in December 2021.
- Removed Canada geese as an animal AIS because they are considered a nuisance species rather than an invasive species.
- Added results of a New Zealand mudsnail survey of Budd Inlet that was conducted in April 2022 in response to comments received on the Draft EIS.
- Expanded on the discussion of salt tolerance and the potential for New Zealand mudsnails to spread from dam removal.
- Expanded on the discussion of potential of marine AIS introductions in the project area.
- Expanded on the discussion of potential AIS spread from boat access to the project area.
- Added a description of AIS inspection and decontamination stations in Whatcom County as a successful example of decontamination that could be replicated in the project area.
- Made revisions as needed in response to comments from the Washington Department of Fish and Wildlife – the state agency with jurisdiction over aquatic invasive animal species.

- Changed the operational impact findings for the Estuary and Hybrid Alternatives from substantial beneficial effects to minor beneficial effects because the aquatic invasive plant species that would be eliminated as a result of reintroduced saltwater are relatively common in the region.

Aquatic invasive species (AIS) include nonnative plants and animals that rely on the aquatic environment for a portion of their life cycle and can spread to new areas of the state, causing economic or environmental harm. The impacts of construction and operation of each alternative are assessed based on the potential of project alternatives to result in changes in abundance or distribution of AIS within or outside the project area from AIS transport into or out of the project area. Where impacts are identified, the report discusses measures that can be taken to minimize or mitigate potential impacts. The analysis examines the No Action Alternative, as well as three action alternatives: Managed Lake, Estuary, and Hybrid.

Under the No Action Alternative, Capitol Lake would remain closed to the public and AIS would continue to be managed through this form of containment, and by using methods aimed at maintaining low population densities. The New Zealand mudsnail population is not likely to substantially increase within the lake or move far outside the lake because it appears not to have done so in the at least 10 years since its initial detection in 2009, based on the most recent survey in 2015 and lack of reported sightings outside the lake since then. The containment of these AIS is a highly effective method of avoiding the spread because of the absence of public access, which is the primary way that AIS are spread to new waterbodies. In the absence of public access or meaningful intervention, the populations of other AIS invertebrates, fish, and mammals would be expected to continue to expand within the basin at current low rates. Based on this, under the No Action Alternative, the risk for AIS in Capitol Lake to spread to otherwise non-invaded water bodies is expected to be **less-than-significant**.

Prior to construction of all action alternatives, Capitol Lake would be treated to significantly reduce AIS populations within the waterbody and reduce the risk of potential spread once construction activities began. Management actions prescribed under an AIS Management Plan may include the use of herbicides/pesticides to reduce the number of purple loosestrife seeds and live New Zealand mudsnails. Under all build alternatives, areas of Capitol Lake would be dredged during construction and the dredge sediment would be beneficially reused within the Capitol Lake Basin to create habitat areas. Reusing the dredged material onsite is a key design feature that would further minimize the potential transport of AIS outside the project area. Off-site transport of excess dredge material for the Estuary and Hybrid Alternatives would require additional Best Management Practices (BMPs) or treatment to prevent the spread of AIS in those materials.

The Estuary and Hybrid Alternatives include removing the 5th Avenue Dam, reintroducing saltwater to the basin and creating a brackish environment. The introduction of saltwater would have a **minor beneficial effect** in terms of reductions in freshwater AIS populations that are intolerant to higher salinities. However, these species are relatively abundant in local lakes and their spread from the basin is not as much of a concern as it is for the salt tolerant AIS populations. There would be a potential for high priority AIS populations of purple loosestrife and New Zealand mudsnails to spread outside the project area following the 5th Avenue Dam removal given their tolerance of higher salinities. However, those populations have naturally transported through the dam and have not established in Budd Inlet in over 10 years, and the Capitol Lake Basin would be treated before construction to further minimize the risk of spread. Therefore, construction would have a **less-than-significant impact** related to AIS distribution under the Estuary and Hybrid Alternatives.

Under all action alternatives, the basin would be reopened to the public and would feature boardwalks and dock and the waters would be open for non-motorized recreational vessels. The increase in pedestrian and boating activity could increase the spread of AIS outside the project area, as well as potentially introduce new AIS to the project area. A critical component of all action alternatives is the installation and required use of decontamination stations for all vessels or other recreational gear that enters and exits the waterbody. All action alternatives would also avoid or minimize spread of AIS by posting educational signage warning recreational users of AIS presence and AIS populations would be monitored as prescribed in an AIS Management Plan to ensure decontamination effectiveness.

Construction and operation impacts of the No Action and Action Alternatives are summarized in Tables ES.1 and ES.2.

Table ES.1 Summary of Construction Impacts and Mitigation Measures

Impact	Impact Finding	Mitigation (Summarized)	Significant and Unavoidable Adverse Impact?
Managed Lake Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	In addition to BMPs and other measures included in Section 5.7.1.2: • Implement measures outlined in an AIS Management Plan to reduce potential spread. • Dredge material would not be removed from the project area.	No
Estuary Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	In addition to BMPs and other measures included in Section 5.7.1.2: • Implement measures outlined in an AIS Management Plan to eradicate or reduce the purple loosestrife population and reduce the New Zealand mudsnail population prior to dam removal.	No
Hybrid Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	In addition to BMPs and other measures included in Section 5.7.1.2: • Implemented measures outlined in an AIS Management Plan to eradicate or reduce the purple loosestrife population and reduce the New Zealand mudsnail population prior to dam removal.	No

Table ES.2 Summary of Operations Impacts (including Benefits) and Mitigation Measures

Impact	Impact Finding	Mitigation (Summarized)	Significant and Unavoidable Adverse Impact?
No Action Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	Containment and other minor management practices would continue to reduce potential spread outside the project area.	No
Managed Lake Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	In addition to BMPs and other measures included in Section 5.7.1.3: • Periodic treatment to reduce the New Zealand mudsnail population according to AIS Management Plan.	No
Estuary Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	BMPs and other measures to minimize impacts are included in Section 5.7.1.3.	No
Hybrid Alternative			
Increase spread of aquatic invasive plants and animals	Less-than-significant	BMPs and other measures to minimize impacts are included in Section 5.7.1.3.	No

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List of Acronyms and Abbreviations

Acronyms/ Abbreviations	Definition
AIS	Aquatic invasive species
BMPs	Best management practices
DNA	Deoxyribonucleic acid
EIS	Environmental Impact Statement
Enterprise Services	Washington State Department of Enterprise Services
GA	Washington State Department of General Administration
mm	Millimeters
NAM	Northwest Aquatics Management, LLC
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
WDFW	Washington Department of Fish and Wildlife

1.0 Introduction and Project Description

1.1 PROJECT DESCRIPTION

The Capitol Lake – Deschutes Estuary includes the 260-acre Capitol Lake Basin, located on the Washington State Capitol Campus, in Olympia, Washington. The waterbody has long been a valued community amenity. Capitol Lake was formed in 1951 following construction of a dam and provided an important recreational resource. Historically, the Deschutes Estuary was used by local tribes for subsistence and ceremonial purposes. Today, the expansive waterbody is closed to active public use. There are a number of environmental issues including the presence of invasive species, exceedances of water quality standards, and inadequate sediment management.

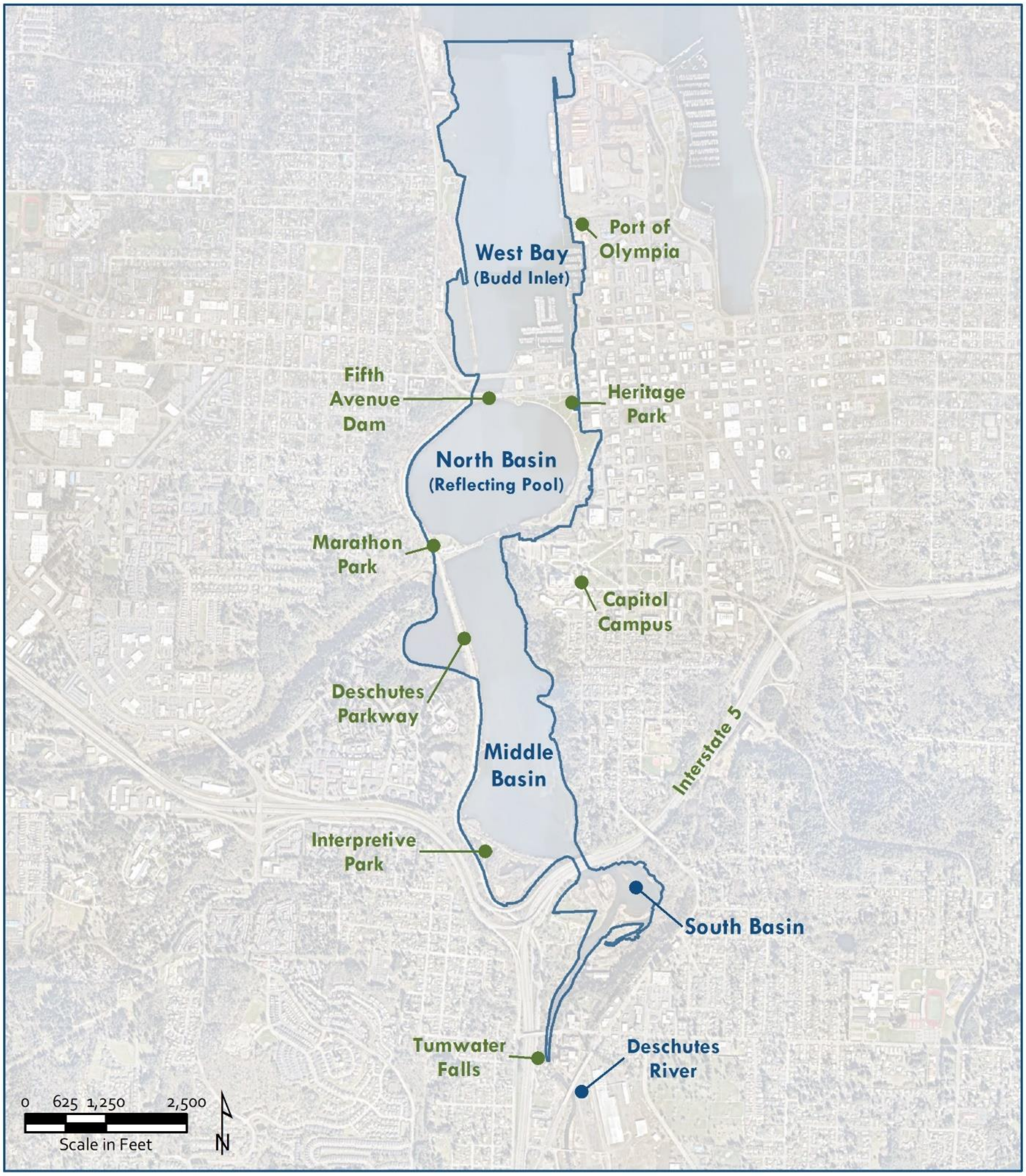
The Washington State Department of Enterprise Services (Enterprise Services) is responsible for the stewardship, preservation, operation, and maintenance of the Capitol Lake Basin. The 260-acre Capitol Lake Basin is maintained by Enterprise Services under long-term lease agreement from the Washington Department of Natural Resources.

In 2016, as part of Phase 1 of long-term planning, a group of stakeholders representing a broad range of interests, in collaboration with the state, identified shared goals for long-term management and agreed an Environmental Impact Statement (EIS) was needed to evaluate a range of alternatives and identify a preferred alternative. In 2018, the state began the EIS process. The Draft EIS was published on June 30, 2021, and evaluated four alternatives: a Managed Lake, Estuary, Hybrid, and a No Action Alternative.

The long-term management alternatives are evaluated against the shared project goals of: improving water quality; managing sediment accumulation and future deposition; improving ecological functions; and enhancing community use of the resource. Refer to Figure 1.1 for the project area for long-term management.

Within the Final EIS, Enterprise Services has identified the Estuary Alternative as the preferred environmentally and economically sustainable long-term management alternative for the Capitol Lake – Deschutes Estuary. The EIS process has maintained engagement with the existing Work Groups, which include the local governments, resource agencies, and tribe. It also provides for expanded engagement opportunities for the public, such as a community sounding board.

Figure 1-1 Project Area



1.2 SUMMARY OF PROJECT ALTERNATIVES

1.2.1 Managed Lake Alternative

The Managed Lake Alternative would retain the 5th Avenue Dam and Bridge in its existing configuration. The 5th Avenue Dam would be overhauled to significantly extend the serviceable life of the structure. The reflecting pool within the North Basin would be maintained, and active recreational use would be restored in this area. Sediment would be managed through initial construction dredging and recurring maintenance dredging in the North Basin only. Sediment from construction dredging would be used to create habitat areas in the Middle Basin to support improved ecological function, habitat complexity, and diversity. Sediment would continue to accumulate and over time would promote a transition to freshwater wetlands in the South and Middle Basins. Boardwalks, a dock, and a boat launch would be constructed for community use.

This project would also construct a new, approximately 14-foot-wide bike and pedestrian bridge south of the existing 5th Avenue Bridge to provide a dedicated recreational trail connection.

1.2.2 Estuary Alternative

Under the Estuary Alternative, the existing 5th Avenue Dam and Bridge would be removed, and an approximately 500-footwide (150-meter-wide) opening would be established in its place. This would reintroduce tidal hydrology to the Capitol Lake Basin, returning the area to estuarine conditions where saltwater from Budd Inlet would mix with freshwater from the Deschutes River. Sediment would be managed through initial construction dredging in the Capitol Lake Basin and recurring maintenance dredging within West Bay. Dredged materials from construction dredging would be used to create habitat areas in the Middle and North Basins to promote ecological diversity, though tideflats would be the predominant habitat type. Boardwalks, a dock, and a boat launch would be constructed for community use. This alternative also includes stabilization along the entire length of Deschutes Parkway to avoid undercutting or destabilization from the tidal flow. Existing utilities and other infrastructure would be upgraded and/or protected from reintroduced tidal hydrology and saltwater conditions.

The Estuary Alternative has been updated in the Final EIS to include a new 5th Avenue Bridge that would be constructed south of the existing 5th Avenue Dam and Bridge. The new bridge would include a vehicle lane, bike lane, and sidewalk in each direction, with the sidewalk on the south side providing a dedicated recreational trail connection. This bridge would be constructed and connected to the transportation system before the existing 5th Avenue Dam and Bridge are removed.

Adaptive management plans would be developed to improve ecological functions and manage invasive species during the design and permitting process.

1.2.3 Hybrid Alternative

Under the Hybrid Alternative, the existing 5th Avenue Dam and Bridge would be removed, and an approximately 500-footwide (150-meter-wide) opening would be established in its place. Tidal hydrology would be reintroduced to the western portion of the North Basin and to the Middle and South Basins. Within the North Basin, a curved and approximately 2,600-foot-long (790-meter-long) barrier wall with a walkway would be constructed to create an approximately 45-acre reflecting pool adjacent to Heritage Park. The reflecting pool of the Hybrid Alternative has been updated in the Final EIS to be groundwater-fed, rather than saltwater. Construction and maintenance of this smaller reflecting pool, in addition to restored estuarine conditions in part of the Capitol Lake Basin, gives this alternative its classification as a hybrid.

Sediment would be managed through initial construction dredging in the Capitol Lake Basin and recurring maintenance dredging within West Bay. In the Middle and North Basins, constructed habitat areas would promote ecological diversity, though tideflats would be the predominant habitat type. Boardwalks, a dock, and a boat launch would be constructed for community use. This alternative also includes stabilization along the entire length of Deschutes Parkway to avoid scour or destabilization. Existing utilities and other infrastructure would be upgraded and/or protected from reintroduced tidal hydrology and saltwater conditions.

The Hybrid Alternative would also construct a new 5th Avenue Bridge, as described for the Estuary Alternative, prior to removing the existing 5th Avenue Dam and Bridge.

Adaptive management plans would be needed to improve ecological functions, manage invasive species, and maintain water quality in the freshwater reflecting pool.

1.2.4 No Action Alternative

The No Action Alternative represents the most likely future expected in the absence of implementing a long-term management project. The No Action Alternative would persist if funding were not acquired to implement the Preferred Alternative. A No Action Alternative is a required element in a SEPA EIS and provides a baseline against which the impacts of the action alternatives (Managed Lake, Estuary, Hybrid) can be evaluated and compared.

The No Action Alternative would retain the 5th Avenue Dam in its current configuration, with limited repair and maintenance activities, consistent with the scope and scale of those that have received funding and environmental approvals over the past 30 years. In the last 30 years, the repair and maintenance activities have been limited to emergency or high-priority actions, which occur sporadically as a result of need and funding appropriations.

Although Enterprise Services would not implement a long-term management project, current management activities and ongoing projects in the Capitol Lake Basin would continue. Enterprise Services would continue to implement limited nuisance and invasive species management strategies.

In the absence of a long-term management project, it is unlikely that Enterprise Services would be able to procure funding and approvals to manage sediment, improve water quality, improve ecological functions, or enhance community use. The No Action Alternative does not achieve the project goals.

1.3 CONSTRUCTION METHODS FOR THE ACTION ALTERNATIVES

This impact analysis relies on the construction method and anticipated duration for the build alternatives, which are described in detail in Chapter 2 of the EIS.

2.0 Regulatory Context

2.1 RESOURCE DESCRIPTION

This report describes aquatic invasive plant and animal species in the study area and evaluates the potential impact of each project alternative on invasive species populations and their spread outside the study area. Invasive species are nonnative organisms that cause economic or environmental harm and can spread to new areas of the state (RCW 79A.25.310). Aquatic invasive species (AIS) are invasive species that rely on the aquatic environment for all or a portion of their life cycle. Nonnative, non-indigenous, or exotic species are those species that are present outside of their natural range. Unlike invasive species, nonnative species do not necessarily hinder or prevent the survival of native species within the ecosystem. Nuisance species may be native or nonnative and may cause ecological and economic harm.

2.2 FEDERAL AND STATE LAWS, PLANS, AND POLICIES

Several federal, state, and local government policies, regulations, and ordinances relating to the eradication and management of invasive species apply to this project. Such regulations and policies influence planning, land use, and management activities that can impact fish and wildlife species and their habitats within the study area. Tables 2-1 and 2-2 summarize federal and state regulations and programs for AIS eradication and management. While several federal laws may address AIS, such as the Clean Water Act, Coastal Management Zone, Fish and Wildlife Conservation Act, and the Magnuson-Stevens Fishery Conservation and Management Act, the primary purpose of these regulations is not invasive species management. For more information on these regulations, see the Fish and Wildlife Discipline Report and the Wetlands and Vegetation Discipline Report.

Table 2-1 Aquatic Invasive Species Federal Regulatory Programs and Policies

Regulatory Program or Policies	Lead Agency	Description
Aquatic Nuisance Species Task Force	U.S. Fish and Wildlife Service	U.S. Fish and Wildlife Service coordinates with federal agencies and partners to prevent and control AIS and provide expertise and support for action-oriented partnerships (84 FR 56832; October 23, 2019).
Executive Order 13112 – Invasive Species	National Invasive Species Council	This executive order prevents federal agencies from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species (USDA 1999).
Federal Insecticide, Fungicide, and Rodenticide Act	U.S. Environmental Protection Agency	This Act requires the study of the consequences of pesticide usage and requires users to register when purchasing pesticides. All pesticides must be registered (licensed) by USEPA. Registration ensures that pesticides will be properly labeled and used in accordance with specifications that will not cause unreasonable harm to the environment (7 USC §136 et seq. 1996).
National Invasive Species Act	U.S. Department of Agriculture	An Act to prevent and control infestations of the coastal inland waters of the United States by the zebra mussel and other nonindigenous aquatic nuisance species (H.R. 4283; 104th Congress 1996).
Executive Order 13751 – Safeguarding the Nation from the Impacts of Invasive Species	National Invasive Species Council	An Act that directs actions to coordinate federal prevention and control efforts related to invasive species (USDA 2016).

Table 2-2 Aquatic Invasive Species State Regulatory Programs and Policies

Regulatory Program or Policies	Lead Agency	Description
Invasive Species Policy Coordination	Washington Invasive Species Council	The council is tasked with providing policy level direction, planning, and coordination to the various public and private entities working throughout Washington State in order to prevent and control the spread of harmful invasive species.
Aquatic Invasive Species Prevention	Washington Department of Fish and Wildlife	Aquatic invasive species prevention is regulated under RCW 77.135. Required authorization for prohibited and regulated species is described under RCW 77.135.040.
Invasive Species Law	Washington Department of Fish and Wildlife	RCW 77.15.160, 77.15.803, 77.15.809, and 77.15.811 enforce the Invasive Species Law. RCW 77.135.110 prohibits transporting any visible native and nonnative aquatic animals, plants, or other organisms, as well as raw water on any boat, trailer, fishing gear, or bait well.
Washington State Noxious Weed Law	Washington State Noxious Weed Control Board	RCW 17.10 provides for the creations of the state noxious weed board, county noxious weed boards, the state noxious weed list, landowner responsibilities in noxious weed control, and the ability of employees of the state weed board, county weed boards, or Washington State Department of Agriculture to carry out their duties and authorities assigned under this chapter.

2.3 LOCAL LAWS, PLANS, AND POLICIES

Table 2-3 describes the regulatory programs implemented by the study area communities.

Table 2-3 Local Laws, Plans, and Policies

Regulatory Program or Policies	Lead Agency	Description
Critical Area Development Regulations	Olympia Municipal Code	This Code creates regulations regarding the presence of invasive species in critical areas, riparian buffers, and mitigation/restoration sites (OMC 18.32).
Fish and Wildlife Habitat Conservation Areas	Tumwater Municipal Code	This Code creates regulations regarding the removal of noxious weeds and invasive plants and addresses introduction of invasive and nonnative plant species (TMC 16.32).
Noxious Weed Control	Thurston County Noxious Weed Control Board	The Thurston County Noxious Weed Control Board fulfills the requirements of RCW 17.10 and establishes policies and procedures in accordance with statutes and state regulations, adopts rules and regulations for noxious weed control, and prepares the annual Noxious Weed List (Thurston County 2020a).

3.0 Methodology

3.1 DATA SOURCES AND COLLECTION

An extensive literature review was conducted for this report. Over 75 data sources were reviewed for the AIS evaluation, including management plans, surveys, databases, and research papers.

3.1.1 Management Plans

The management plans reviewed include vegetation management, reports on permit needs, annual reports of aquatic weed treatments, New Zealand mudsnail management options, and recommendations for future and ongoing invasive species treatments. The primary management plans used in the evaluation that provided recent and relevant information include:

- Deschutes River Estuary Restoration Study: Biological Conditions Report (Garono et al. 2006)
- Capitol Lake New Zealand Mudsnail Management Options (WDFW 2016a)
- Capitol Lake Weed Management Services 2018 Annual Report (NAM 2018)

3.1.2 Surveys

Several surveys have been conducted to monitor the presence and distribution of AIS in Capitol Lake, and some surveys were associated with AIS treatment and removal efforts. The primary surveys used in this evaluation that provided recent and relevant information include:

- Capitol Lake Vertebrate and Invertebrate Inventory (Herrera 2004)
- Capitol Lake Weed Management Services Bottom Screen Report (NAM 2011) and Annual Reports (NAM 2013, 2014, 2016, 2017, 2018, and 2020; Aquatechnex 2021)
- 2012 Milfoil Weevil Population Survey in Capitol Lake and East Mitigation Pond (EnviroScience 2013)

- 2011 Distribution Survey for *Potamopyrgus antipodarum* (New Zealand mudsnail) in the North and Middle Basins of Capitol Lake (Johannes 2011a)
- 2011 Distribution Survey for *Potamopyrgus antipodarum* (New Zealand mudsnail) in Southern Budd Inlet (Johannes 2011b)
- 2013 and 2015 Surveys for *Potamopyrgus antipodarum* (New Zealand mudsnail) (of freshwaters) Within a Five-Mile Radius of Capitol Lake (Johannes 2013 and 2015)

In response to comments received on the Draft EIS, Enterprise Services elected to conduct a second shoreline survey of Budd Inlet in April 2022 (Johannes 2022) to determine whether NZMS had spread into Budd Inlet since none were found in the 2011 survey of Budd Inlet. The 2022 survey report is presented in Appendix A. The investigation included 21 survey sites, 16 of which were previously surveyed in 2011 and included several sites adjacent to various freshwater inputs. Existing transport of NZMS suspended in water and attached to debris through the dam during high river flow events, has provided an ongoing pathway for NZMS to move from Capitol Lake into West Bay and Budd Inlet. The 2022 shoreline survey allowed the EIS Project Team to better evaluate whether NZMS would persist in West Bay after removal of the 5th Avenue Dam under the Estuary and Hybrid Alternatives.

3.1.3 Databases

To maintain the most recent evidence of invasive species presence and spread in the area, several databases were reviewed. The main databases used in this evaluation that provided recent and relevant information include:

- Federal Noxious Weeds (USDA 2020)
- Noxious Weed layer on the Show Me Everything map (Thurston County 2020b)
- Nonindigenous Aquatic Species (USGS 2020)
- Aquatic Invasive Species (WDFW 2020b)
- Washington Marine Vegetation Atlas (WDNR 2020)

3.1.4 Research Papers

Research papers and studies used in this evaluation explored a diverse range of topics including detection, species biology (specifically as it relates to the overall success of an AIS in a nonnative area), population fluctuations, transport and spread, and treatment options and effectiveness. Some examples of research papers used in this evaluation include:

- A review of salinity tolerances for the New Zealand mudsnail (*Potamopyrgus antipodarum*, Gray 1843) and the effect of a controlled saltwater backflush on their survival in an impounded freshwater lake (LeClair and Cheng 2011)
- Environmental DNA as a new method for early detection of New Zealand mudsnails (Goldberg et al. 2013)

- A quantitative evaluation of the effect of freezing temperatures on the survival of New Zealand mudsnails (*Potamopyrgus antipodarum*; Gray 1843), in Olympia Washington's Capitol Lake (Cheng and LeClair 2011)
- Proposed removal of Capitol Lake dam and potential spread of *Potamopyrgus antipodarum* (New Zealand mudsnail) into Budd Inlet, Thurston County, Washington (Johannes 2021)
- Recommendations for Capitol Lake New Zealand mudsnail management (Stockton-Fiti 2018)
- Survival and passage of ingested New Zealand mudsnails through the intestinal tract of rainbow trout (Bruce et al. 2009)

3.2 SELECTION OF THE STUDY AREA

The study area is based on the local aquatic resources where AIS could be directly affected by the project, and does not include distant water bodies where AIS potentially could be transported to by the project. The study area includes the Capitol Lake Basin (the North Basin, Middle Basin, South Basin, and Percival Cove), Percival Creek up to Highway 101, the Deschutes River upstream of Tumwater Falls, and Lower Budd Inlet extending north from the 5^{th} Avenue Dam to southern end of Squaxin Park (formerly Priest Point Park) near the mouth of Mission Creek (47 07'N) (Figure 1.1). The study area extends approximately 100 feet from the edge of these waters to encompass emergent plant and mammal AIS.

3.3 ANALYSIS OF IMPACTS

Adverse impacts and beneficial effects related to both construction and long-term operation are evaluated, with a focus on comparatively evaluating the alternatives. In general, construction-related impacts are primarily associated with lake sediment dredging and dam construction (repair or removal) because that activity represents the major construction impact. Future, long-term adverse impacts, and beneficial effects associated with AIS populations and control actions for each of the four project alternatives are evaluated using a combination of historical trends, current conditions, and future projections of environmental factors affecting AIS.

Assessments of potential adverse impacts and beneficial effects are based on many factors including:

- Anticipated changes in abundance and distribution for each species
- Relative potential for transport and establishment within and outside the study area
- Control priority, eradication potential and potential management options of each species
- Relative effectiveness and non-target species impacts of control measures
- Potential for short- and long-term recreational use restrictions

Qualitative categories such as "less-than-significant" and "significant" are used to assess the relative magnitude of adverse impacts related to AIS. Significant increases in AIS populations or distribution by an alternative are considered to be an adverse impact, whereas significant decreases in AIS populations or distribution are considered a beneficial effect of the alternative.

3.3.1 Identification of Construction Impacts

Sediment dredging, dredged material placement for constructing habitat areas, and dam construction (repair or removal) are the primary construction activities affecting AIS. These activities have the potential adverse impact of spreading existing AIS in Capitol Lake to other water bodies if the following occur:

- AIS associated with suspended sediment and debris care are not contained.
- Construction equipment is not properly decontaminated before it leaves the lake.
- Dredged material is not properly decontaminated before it leaves the lake.
- Equipment is not properly decontaminated before use in the lake, leading to the introduction of new AIS.

Dredging and dredge material placement has the potential beneficial effect of reducing existing AIS populations through burial.

Repairs to the existing 5th Avenue Dam have the potential adverse impact of spreading existing AIS in Capitol Lake to Budd Inlet and adjacent streams if the construction area is not properly contained. Other construction activities potentially affecting AIS by improper equipment decontamination include construction of the boardwalks and docks, and the pedestrian and bicycle bridge.

For this evaluation, the magnitude of short-term adverse impacts is considered less-than-significant or significant, as follows:

- **Less-than-significant**—Impacts are considered less-than-significant if there would be no substantial increased risk, relative to existing conditions, of introducing new AIS to a water body during construction that would impact native species or recreational use. Any potential short-term effect of construction on the abundance of existing AIS within a water body is considered less-than-significant because AIS are inherently resilient to disturbance and expected to recover from short-term changes in abundance.
- **Significant**—Impacts are considered significant if there would be a substantial increased risk, relative to existing conditions, of introducing new AIS to a water body during construction that would impact native species or recreational use.

The adverse impacts and beneficial effects of construction on each AIS are described for each alternative in Section 5.0 Impacts and Mitigation Measures.

3.3.2 Identification of Operational Impacts

Changes in the salinity and recreational use of the Capitol Lake Basin are the primary operational impacts to AIS that could be positive or negative. That is, increased salinity has the beneficial effect of reducing survivorship of freshwater AIS, and increased recreational use has the potential adverse impact of increasing the potential for further spread of AIS. Maintenance dredging also has the potential for introducing new AIS if equipment is not properly decontaminated or spreading AIS from offsite transport of dredged sediments.

For this evaluation, the magnitude of long-term (operational) adverse impacts are considered less-than-significant or significant, as follows:

- **Less-than-significant**—Impacts are considered less-than-significant if no substantial increase (e.g., less than a 50 percent increase) is expected for the abundance or distribution of existing AIS within the study area, or if the potential for existing AIS to spread to other water bodies is expected to not substantially increase and impact native populations or recreational use, relative to the existing condition.
- **Significant**—Impacts are considered significant if a substantial increase (e.g., more than 50 percent increase) is expected for the abundance or distribution of existing AIS within the study area, or if the risk of introducing new AIS would substantially increase for waters inside or outside the study area and impact native populations or recreational use, relative to the existing condition.

Long-term beneficial effects related to AIS are evaluated in terms of minor, moderate, or substantial beneficial effects where expected decreases in AIS abundance or distribution inside or outside the study area are considered beneficial. The impact of regular operations on each AIS is described for each alternative in Section 5.0 Impacts and Mitigation Measures.

4.0 Affected Environment

Capitol Lake has a well-documented presence of AIS including plants, invertebrates, fish, and aquatic mammal species. The presence of AIS has resulted in closure of Capitol Lake to all public use. This section briefly describes the species biology, documented presence in Capitol Lake, the ecological impact of the AIS presence, and previous efforts to control the presence and spread of invasive species.

The biology of an invasive species provides information on its ability to outcompete native species for resources. Before an invasive species can become a nuisance in an ecosystem after being introduced, it must survive, grow, and reproduce in the new environmental conditions. Thus, an invasive species must acquire a high rate of population growth, invading new regions before it finally alters the structure and function of the invaded ecosystem (Alonso and Castro-Díez 2008). The existing presence and spread of AIS provide data on the pathway and possible containment. Biological invasions often represent a major ecological and economic problem. The description of ecological impacts will inform the potential impacts or benefits for each alternative. Previous efforts to control AIS presence and spread, both in Capitol Lake and outside the study area, inform future decisions for control efforts that differ based on each alternative explored in later sections.

4.1 AQUATIC INVASIVE PLANTS

Aquatic invasive plants found in Capitol Lake and the surrounding water bodies include purple loosestrife (*Lythrum salicaria*), yellow flag iris (*Iris pseudacorus*), reed canarygrass (*Phalaris arundinacea*), fragrant water lily (*Nymphaea odorata*), Eurasian watermilfoil (*Myriophyllum spicatum*), and curlyleaf pondweed (*Potamogeton crispus*). Table 4-1 describes their classification on the Washington State Noxious Weed List (2020), distribution in the study area, and relative abundance in study area.

Table 4-1 Aquatic Invasive Plants Observed in the Study Area

Scientific/ Common Name	State Status[a]	Water Body	Relative Abundance	Source
Emergent				
Lythrum salicaria Purple loosestrife	Class B High Priority	Capitol Lake, Deschutes River, Budd Inlet	High in the South Basin; low in other basins	NAM 2018; Aquatechnex 2021
Iris pseudacorus Yellow flag iris	Class C	Capitol Lake	High in the South and Middle Basins; Moderate in Percival Cove; low in the North Basin.	NAM 2018; Aquatechnex 2021
Phalaris arundinacea Reed canary grass	Class C	Capitol Lake	Present at unknown locations in 2006	Ecology 2020a
Floating Leaved				
Nymphaea odorata Fragrant waterlily	Class C	Capitol Lake	Low in North Basin and Percival Cove; low to zero in Middle Basin and South Basin	NAM 2018; Aquatechnex 2021
Submersed				
Myriophyllum spicatum Eurasian watermilfoil	Class B High Priority	Capitol Lake	Moderate in South Basin and Middle Basin; low in North Basin Percival Cove	NAM 2018; Aquatechnex 2021
Potamogeton crispus Curlyleaf pondweed	Class C	Capitol Lake	High in Middle Basin; Moderate in North Basin and Percival Cove; unknown in South Basin	Aquatechnex 2021

[a] Washington State Noxious Weed Class (WNWCB 2020) or High Priority Invasive Species (WISC 2020c).

Class A noxious weeds are nonnative species whose distribution in Washington is still limited. Eradication of Class A noxious weeds is required by law. Class B noxious weeds are nonnative species whose distribution are limited to portions of Washington. Control of Class B noxious weeds is required in regions where they are not yet widespread in order to prevent new infestations. Class C noxious weeds are widespread in Washington or are of special interest to the agricultural industry (WNWCB 2020).

4.1.1 Presence in Capitol Lake

The biology, ecological and recreational implications, distribution, and abundance of aquatic invasive emergent, floating-leaved, and submerged plants in Capitol Lake are described in the following sections. Distribution, abundance, and management efforts are described in approximate chronological order for each plant species.

4.1.1.1 Emergent Plants

Purple Loosestrife

Purple Loosestrife (WNWCB 2020)

Purple loosestrife (*Lythrum salicaria*) is a Class B Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) and a High Priority invasive species (WISC 2020c). Control of Class B species is required by the Thurston County Noxious Weed Board. The plant is a nonnative emergent species typically found in freshwater and brackish wetlands, along streams, and in other wet areas. It has narrow, lance-shaped leaves; showy purple flowers that occur in erect spikes at the top of stems from late June through October; and a rhizomatous growth pattern. The plant is a vigorous grower that spreads by rhizomes or by seed. Each plant may produce up to 2.7 million seeds annually. The seeds can be viable for several years, but because the seeds are small and carry little food reserves, germination must occur when photosynthesis can occur immediately (USDA 2020). Purple loosestrife forms dense colonies that outcompete native plant species and provide minimal wildlife habitat (Ecology 2001). These dense colonies can also be detrimental to aesthetics and inhibit access to shorelines for recreation (RMI 2001). Management of purple loosestrife is a costly effort requiring repeated monitoring and removal efforts to prevent its spread.

Distribution and Abundance Within the Study Area

Purple loosestrife was first discovered in Capitol Lake in 1986. By 1987, the infestation was described as "bad" (Washington State Department of General Administration [GA] 2002). Figure 4.1 presents a map of purple loosestrife historical observations from 1988 through 2010 along with observation points colored red where it had been eradicated. Figure 4.2 presents the map of purple loosestrife distribution with observation points colored purple for the 2018 survey (NAM 2018), and Figure 4.3 presents observation points for the 2021 survey, which did not include a survey of the South Basin (Aquatechnex 2021). Purple loosestrife was most abundant in the South Basin but was present along the shorelines of all three basins, the mitigation area, and Percival Cove. Only one plant was observed in the North Basin, and no plants were observed along the east shoreline of the Middle Basin in 2018. Purple loosestrife abundance was similar in 2021 with the addition of three plants observed along the east shoreline of the Middle Basin (Aquatechnex 2021). Although purple loosestrife is a high-priority species based on its aggressive growth and potential impacts on native species, it is not likely significantly impacting native wildlife or recreation in the Capitol Lake Basin based on its current abundance and the emergent plant diversity.

Figure 4-1 Purple Loosestrife Distribution in Capitol Lake from 1988 to 2010

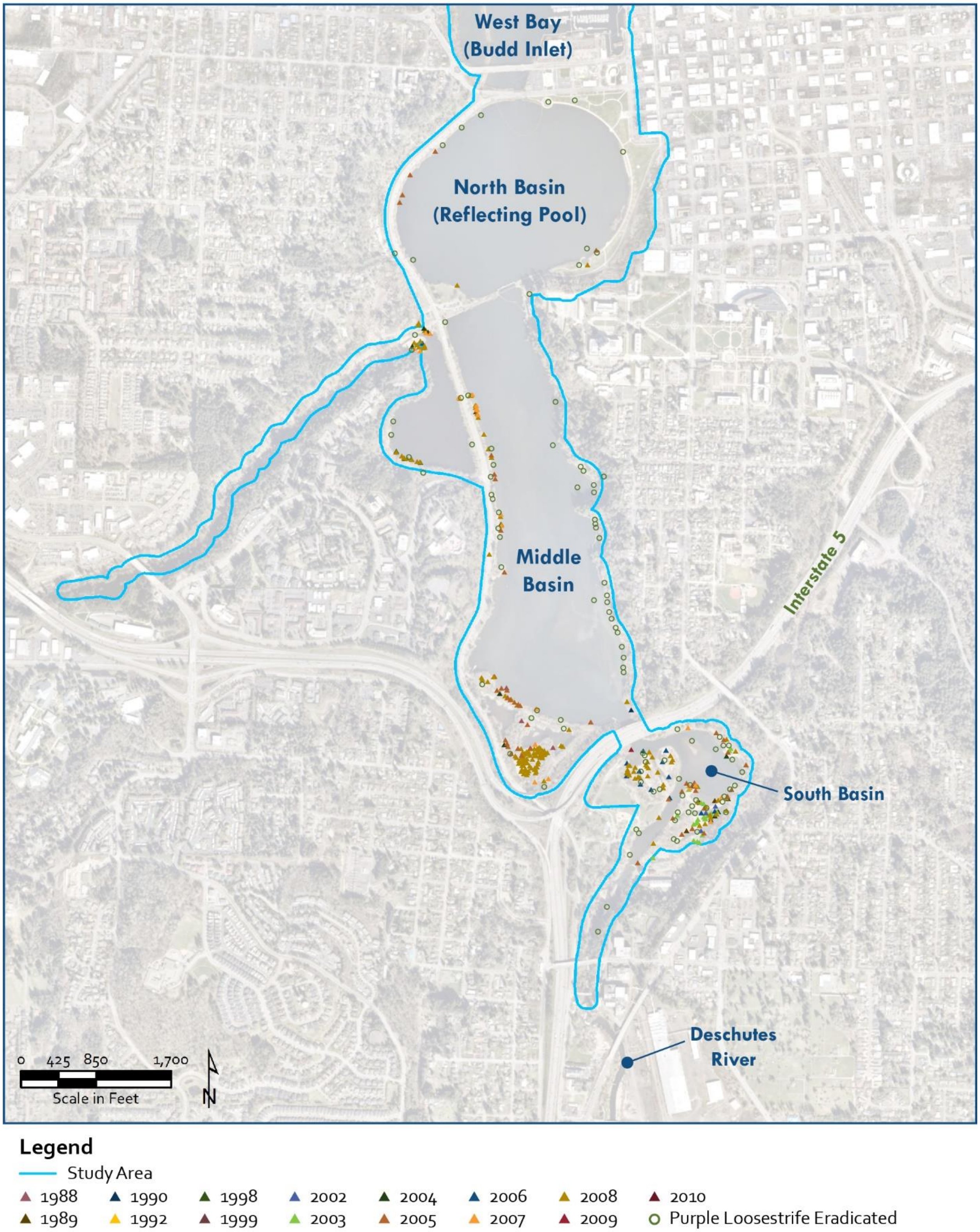


Figure 4-2 Purple Loosestrife Distribution in Capitol Lake in 2018

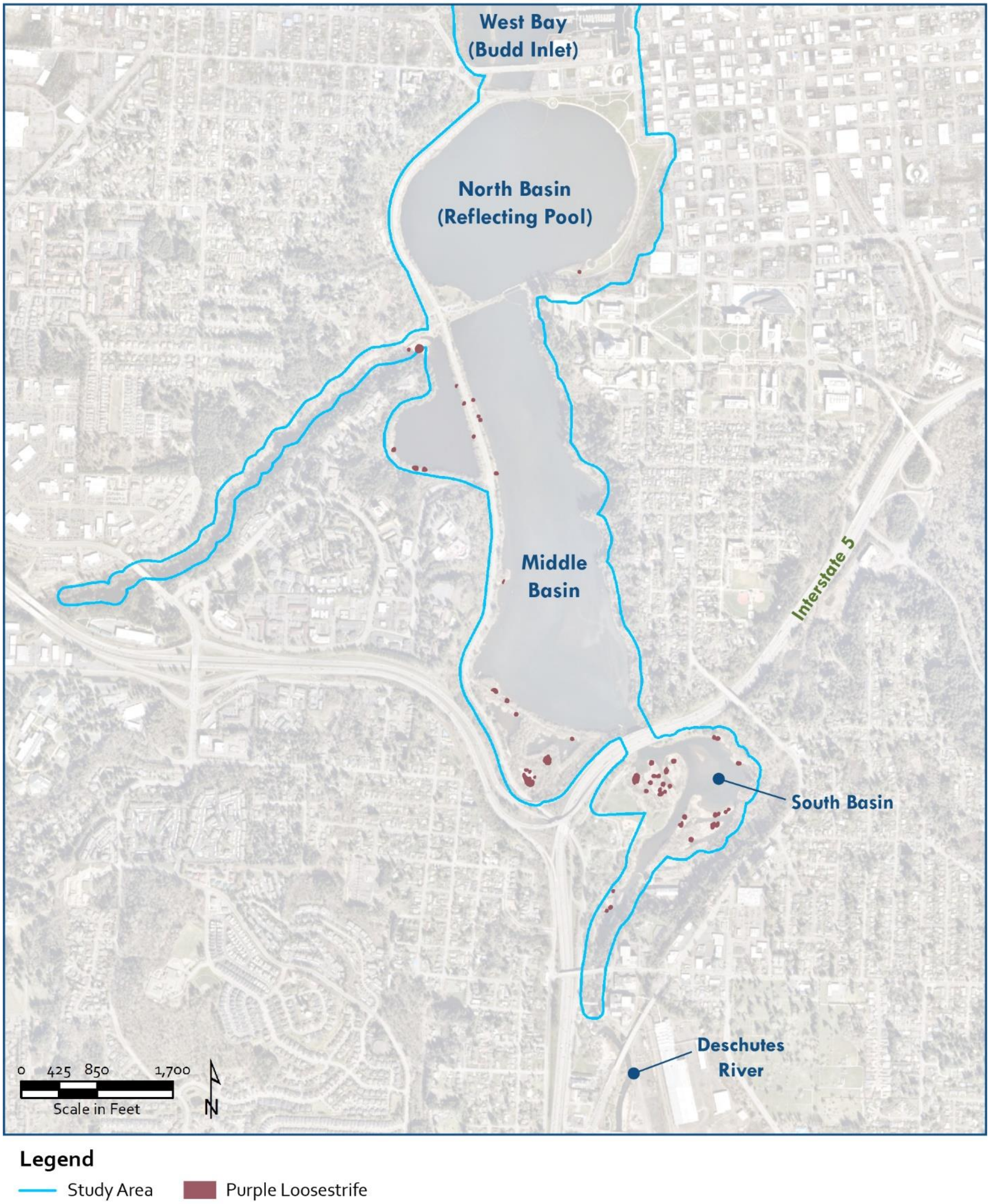


Figure 4-3 Purple Loosestrife Distribution in Capitol Lake in 2021

Legend

- Study Area
- Purple Loosestrife

Management Approaches

In 1987, the Thurston County Noxious Weed Control Board and the GA began communicating to organize efforts to control purple loosestrife. From 1989 to 1993, various maintenance groups and contracted groups for the GA removed flower heads to prevent seed distribution. From 1993 to 1995, the GA contracted with Resource Management, Inc. to perform aquatic herbicide treatments on purple loosestrife in Capitol Lake, but information on the relative effectiveness of the treatments was not available.

From 1996 to 2000, the GA returned to removing flower heads to control purple loosestrife because the herbicide treatments did not eradicate purple loosestrife. Based on the results of these efforts, it was determined that seed production is controlled by flower head removal, but stem densities still increase in the case of flower head removal. It was determined that future efforts should include treatment of the entire plant along with seed removal. The lack of continuity in treatments from year to year and the lack of monitoring after control efforts were implemented limits the understanding of the efficacy of management actions.

In 1998, wetland soils from the southern end of the Middle Basin were removed and replaced as a mitigation measure for Heritage Park, subsequently soils bordering the constructed wetland mitigation ponds in Interpretive Park were quickly infested with purple loosestrife. In 1999, the Thurston County Noxious Weed Board released 5,000 galerucella beetles (*Galerucella calmariensis*) as a form of biological control for loosestrife populations in the Interpretive Park wetland ponds. Later reports indicate that purple loosestrife showed signs of beetle activity; however, the population of beetles was not dense enough to control the purple loosestrife infestation in this area (NAM 2013, 2017).

In 2000, the infestation of purple loosestrife was determined to have been reduced by 80 percent from levels in 1987 (NAM 2013). In 2001, the GA adopted the Capitol Lake Integrated Purple Loosestrife Management Plan, which established the goal to eradicate purple loosestrife from Capitol Lake and adjacent areas (RMI 2001). This plan describes results from a field survey done by aquatic biologists in December of 2000 and input from GA Grounds Supervisor Mark Robb. According to these sources, approximately 2.5 acres of dense purple loosestrife colonies were present in the wetland mitigation area at the south end of the Middle Basin. Approximately 1.3 acres of moderate-density purple loosestrife were also present in this area. Approximately 1.9 acres of low-density loosestrife were present in the mitigation area and along the western shorelines of the Middle Basin. In December 2000, the total area of purple loosestrife infestation was approximately 5.7 acres along 1.4 miles of shoreline in Capitol Lake. The established seed bank was estimated to be sufficient to support regrowth for a minimum of 10 years.

The 2001 Capitol Lake Integrated Purple Loosestrife Management Plan recommended a combination of surveillance, public education, chemical control with glyphosate spot-treatment, biological controls (insect introductions), and manual removal to eradicate the plant from Capitol Lake. This plan stressed the importance of consistency, monitoring, and data collection in effectively eradicating purple loosestrife.

From 2008 to 2015, purple loosestrife was treated with a 3 percent solution of glyphosate and plant mortality was observed within one week of application. From 2016 to 2018, a 15 percent solution of Imazapyr replaced the glyphosate treatments, and seed head removal continued. Plant mortality from imazapyr treatments was observed within one to two weeks of application (NAM 2017). Management activities in 2019 were not conducted due to an oil spill preventing lake access. In 2019, continued use of surveys, seed head removal, and imazapyr treatments was recommended for future years (NAM 2020). Survey results and observations from the management efforts are described in the following paragraphs.

From 2009 through 2012, purple loosestrife was densely populated in the South Basin and in the mitigation areas at the south end of the Middle Basin (NAM 2013). It reduced from moderately populated in 2009 to sparsely populated from 2010 through 2012 on the western side of the Middle Basin and in Percival Cove, and only up to two plants were observed in the North Basin.

In 2013, reduced densities were observed in the South Basin and the Middle Basin mitigation area. Surveys in 2013 indicated the lowest recorded populations of purple loosestrife, indicating the positive impacts of management strategies (NAM 2014). However, purple loosestrife populations increased slightly in 2014 to low densities in the South and Middle Basins, moderate densities in Percival Cove and in the mitigation areas at the southern end of the Middle Basin, and none in the North Basin (NAM 2016).

The 2015 surveys indicated a continued increase in purple loosestrife populations to high densities in the South Basin and Percival Cove, moderate in the mitigation area at the south end of the Middle Basin, and low in the Middle and North Basins (NAM 2016). These density ratings did not change in 2016, 2017, or 2018 (NAM 2017, 2018). No assessment or survey was completed in 2019 due to an oil spill that prohibited access to the lake (NAM 2020). The 2021 survey results (Aquatechnex 2021) were similar to the 2018 results (see Figures 4.2 and 4.3).

Yellow Flag Iris

Yellow Flag Iris (WNWCB 2020)

Yellow flag iris (*Iris pseudacorus*) is a Class C Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) that grows along shorelines in shallow water in wetlands, and at the edges of lakes or slow-moving rivers. Control of this Class C species is not required in Capitol Lake by the Thurston County Noxious Weed Board. The plant is perennial, grows 2 to 3 feet tall, and produces pale to dark yellow flowers with brownish purple mottled markings. Yellow flag iris spreads by rhizomes and by seed to form large clumps that outcompete native vegetation, reducing habitat complexity for wildlife. Rhizome fragments may re-root and form new plants, enabling the plant to further spread. The plant is toxic to livestock, not palatable to most wildlife, and its resin may irritate human skin. Dense clumps of yellow flag iris may inhibit access to shorelines for recreation. Management of yellow flag iris is costly, requiring repeated monitoring and removal efforts to prevent its spread.

Distribution and Abundance Within the Study Area

Yellow flag iris is known to have dominated wetland plant communities in Capitol Lake in 1992 and very likely existed in the area prior to this date (GA 1992). Survey results and observations from the management efforts are described in the following paragraphs.

In 2008, survey records indicate approximately 500 yellow flag iris plant clusters on Enterprise Services property in Capitol Lake. Yellow flag iris was densely populated in the South and Middle Basin and in Percival Cove, and moderately populated in the North Basin (NAM 2013). A total of 3,015 square feet of dense yellow flag iris colonies in Heritage Park, Percival Cove, and the Interpretive Park wetland ponds at the south end of the Middle Basin were treated in 2008 with glyphosate.

The number of yellow flag iris plant clusters significantly reduced to 250 in 2009 and to 200 in 2010; however, yellow flag iris remained densely populated in the South Basin and Percival Cove. The population on the eastern shoreline of the Middle Basin was significantly reduced in comparison to 2008. The density of yellow flag iris in the Middle Basin overall and in the North Basin in 2009 was moderate (NAM 2013).

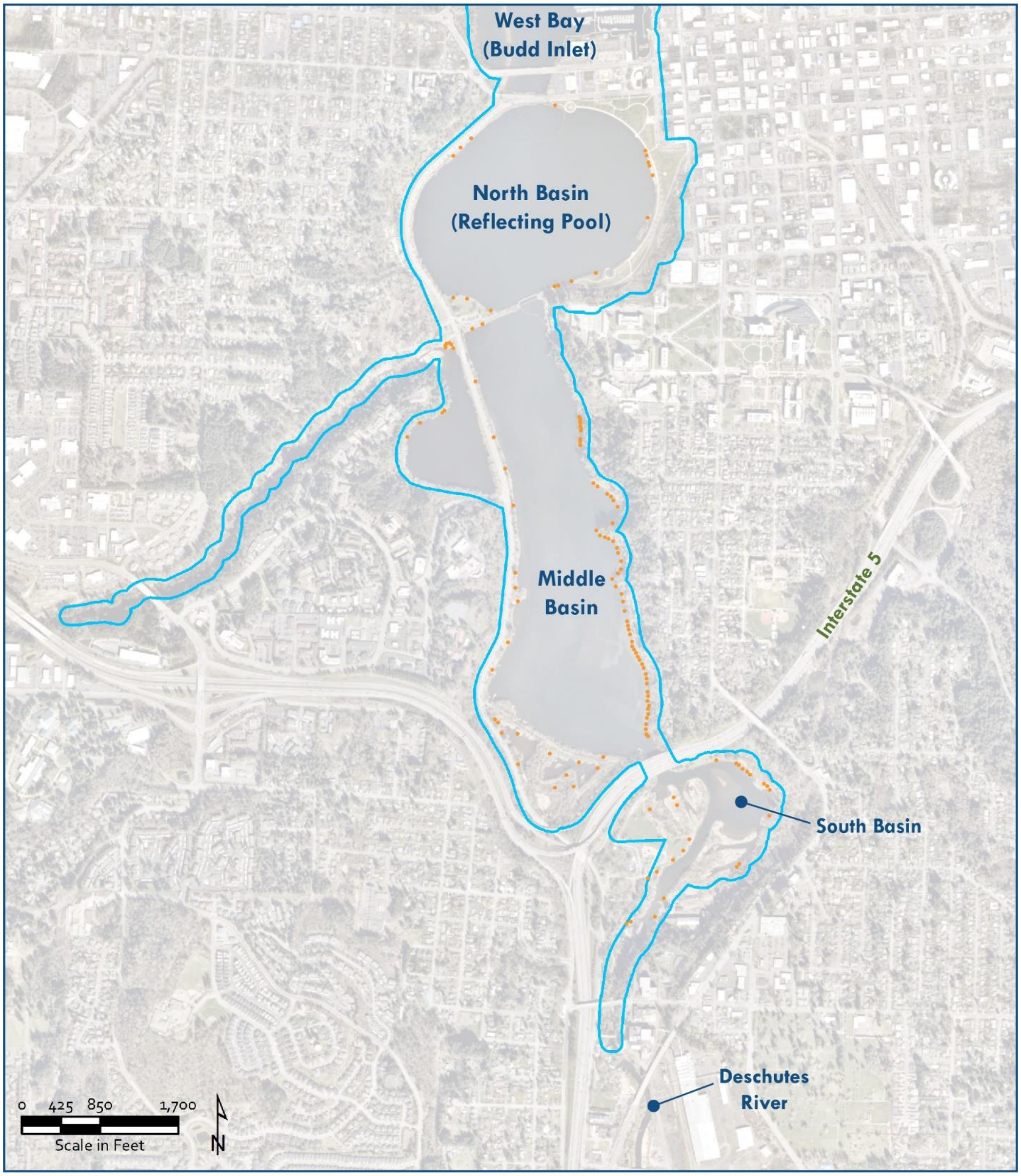
In 2011, the survey team transitioned from tracking groups of plants in previous years to tracking individual plants. Approximately 450 yellow flag iris plants were observed in 2011, increasing the density in the South, Middle, and North Basin and in Percival Cove. However, plants were generally smaller and immature compared to those observed in 2008 and 2009, indicating some success in the glyphosate treatments despite the remaining presence of dense populations (NAM 2013).

In 2012 and 2013, approximately 100 yellow flag iris plants were observed at a moderate density in the South Basin, Percival Cove, and in the North Basin, and a high density in the Middle Basin. The decrease in the number of plants from 2011 to 2012 suggest the success of herbicide and manual control efforts (NAM 2013). However, the number of observed plants doubled to 200 in 2014 along with an increase to high density in the South Basin and Percival Cove (NAM 2014). The increase in yellow flag iris in 2014 may have resulted from higher water levels during the growing season, providing favorable conditions for the growth of the plant (NAM 2014).

The number of yellow flag iris plants observed on Enterprise Services property was relatively consistent at 135 plants in 2015, 142 plants in 2016,148 plants in 2017, and 125 plants in 2018 (NAM 2016, 2017, 2018). Overall, yellow flag iris was densely populated in the South and Middle Basins, particularly on the eastern shoreline of the Middle Basin, while the population density was moderate in Percival Cove and low in the North Basin. It was concluded that yellow flag iris populations could be further reduced if plants on private properties were either treated with imazapyr or manually removed.

Figure 4.4 presents the map of yellow flag iris distribution with observation points colored orange for the 2018 survey (NAM 2018), and Figure 4.5 presents observation points for the 2021 survey, which did not include a survey of the South Basin (Aquatechnex 2021). As described above, yellow flag iris was documented as most abundant along the east shoreline of the Middle Basin, but was present in all three lake basins, the Interpretive Park wetlands, and Percival Cove. Plant abundance substantially decreased from 2018 to 2021 in the North and Middle Basins. Yellow flag iris is not likely significantly impacting native wildlife or recreation in the Capitol Lake Basin based on its current abundance and the emergent plant habitat diversity.

Figure 4-4 Yellow Flag Iris Distribution in Capitol Lake in 2018

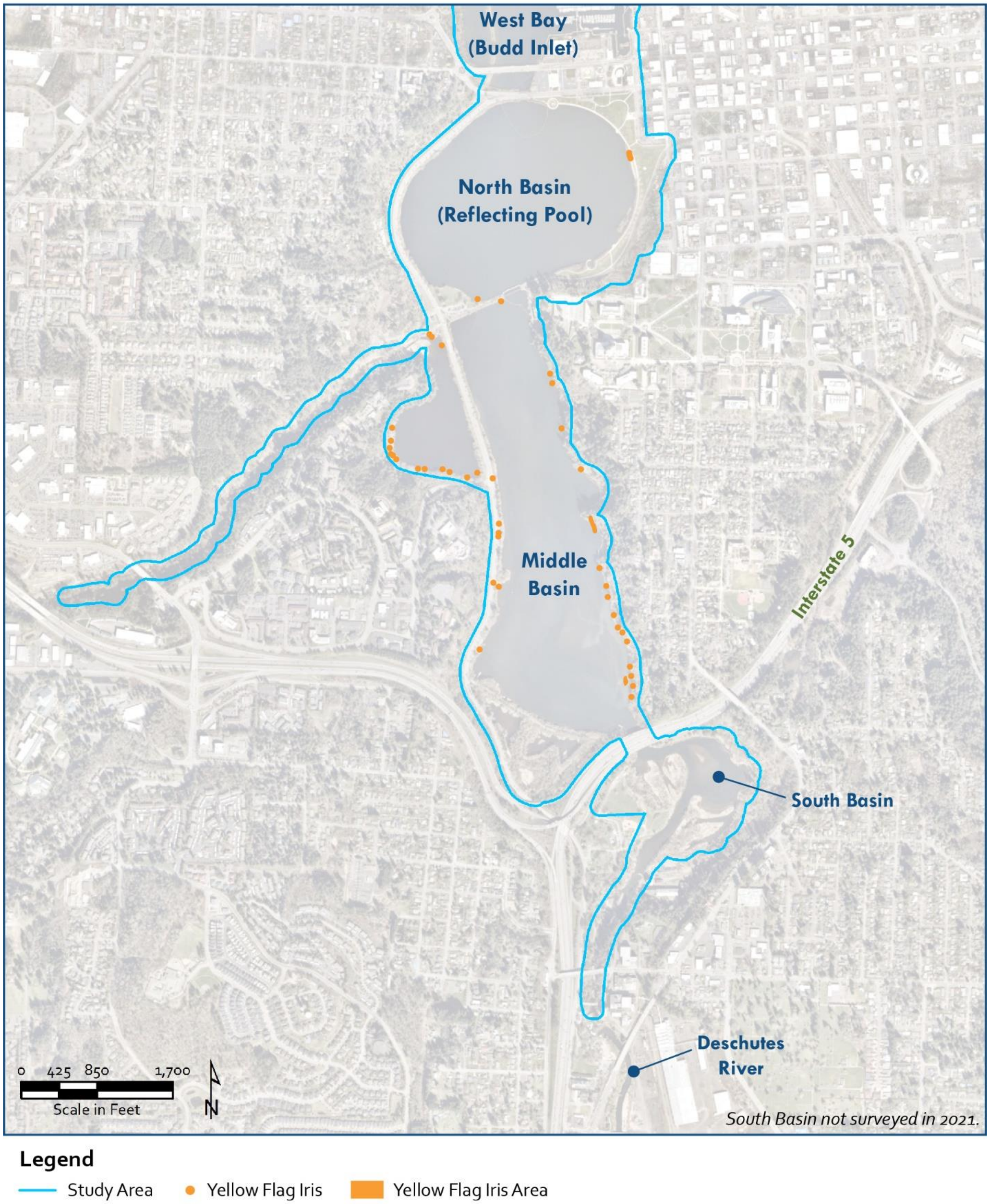


Legend

Study Area

Yellow Flag Iris

Figure 4-5 Yellow Flag Iris Distribution in Capitol Lake in 2021



Management Approaches

From 2008 to 2015, yellow flag iris was surveyed annually and treated with a 3 percent solution of the aquatic herbicide glyphosate. Plant die-off was observed 1 to 2 weeks after application (NAM 2013). In 2016, treatment was transitioned to a 1.5 percent solution of imazapyr (NAM 2016). Plant die-off was observed 1 to 2 weeks after application. The imazapyr chemical treatment continued in 2017 and 2018 (NAM 2018). During each year of management, yellow flag iris was treated and counted on all Enterprise Services property adjacent to the shoreline of Capitol Lake. Seeds were removed from plants on residential properties adjacent to the shoreline of Capitol Lake, but these plants were not included in survey numbers.

Reed Canarygrass


Reed Canarygrass (WNWCB 2020)

Reed canarygrass (*Phalaris arundinacea*) is a Class C Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) that grows along the margins of lakes and streams and in wetlands in wet open areas. The plant is a tall, coarse, perennial grass (Ecology 2001). Stems may grow to be 2 meters tall with leaves that are blue-green when new and straw-colored when dry, and pinkish flowers at full bloom. Reed canarygrass spreads by rhizomes and by seed to form dense monoculture colonies that outcompete native vegetation, reduce habitat complexity for wildlife, and inhibit recreational activities along shorelines. It grows too densely to be used by waterfowl for cover and is not eaten by many wildlife species. It may provide amphibian habitat. It also slows and filters surface water during storm events, thus providing important hydrologic and water quality functions.

Distribution and Abundance Within the Study Area

Reed canarygrass is known to have dominated wetland plant communities in Capitol Lake in 1992 and very likely existed prior to this date (GA 1992). It was observed in Capitol Lake in 2004 as dominant in nearly monospecific (one species only) patches, but a map of its distribution is not available (Ecology 2020a). Reed canarygrass is not likely significantly impacting native wildlife based on the current emergent plant diversity in in the Capitol Lake Basin.

Management Approaches

Reed canarygrass has not been the focus of any documented large-scale management or monitoring efforts reviewed for this study. As a result, detailed descriptions of its presence in Capitol Lake are unavailable; however, it is very likely present in wetlands adjacent to all basins due to the lack of control efforts.

4.1.1.2 Floating-Leaved Plants

Fragrant Water Lily


Fragrant Water Lily (WNWCB 2020)

Fragrant water lily (*Nymphaea odorata*) is a Class C Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) that grows on the edges of lakes and ponds. Control of this Class C species is not required by the Thurston County Noxious Weed Board. The plant produces fragrant white or pinkish flowers that float on the surface of the water (Ecology 2001). Fragrant water lily has large, round floating leaves and is rooted in the sediment below the water surface. The plant spreads by seed as well as with long, thick rhizomes that grow just beneath the sediment surface and produce new plants and thread-like roots. Fragrant water lily may form large, dense stands in water, outcompeting native aquatic vegetation and inhibiting recreational access along shorelines.

Distribution and Abundance Within the Study Area

Records of fragrant water lily in Capitol Lake do not indicate significant issues with large infestations of this plant. The first records of management efforts begin in 2008, when the GA contracted with NAM to control aquatic invasive plants in Capitol Lake. A 2008 survey found no clusters of fragrant water lily in the South Basin, 2 clusters in the Middle Basin, 15 clusters in Percival Cove, and 4 clusters in the North Basin (NAM 2013). Fragrant water lily very likely existed prior to this 2008 survey, although no records confirming its prior presence were available for this study.

Figure 4.6 presents the map of fragrant water lily distribution with observation points colored light green for the 2018 survey (NAM 2018), and Figure 4.7 presents observation points for the 2021 survey, which did not include a survey of the South Basin (Aquatechnex 2021). In 2018, fragrant water lily plants were observed at three locations in the North Basin (north, southwest, and southeast nearshore areas) and four locations in Percival Cove, but not in the Middle or South Basins. The 2021 survey results showed a similar low abundance in the North Basin and Percival Cove (Aquatechnex 2021). Fragrant water lily is not likely significantly impacting native wildlife or recreation in the Capitol Lake Basin based on its current abundance and the aquatic plant habitat diversity.

Management Approaches

Management of fragrant water lily is costly, requiring repeated monitoring and removal efforts to prevent its spread. From 2008 to 2018, fragrant water lily was routinely surveyed and managed by NAM with repeated cuttings of leaves and tops of stems to stress the plants. During each year of management, NAM repeatedly cut and counted all clusters of fragrant water lily on Capitol Lake (NAM 2013, 2018). No clusters were found in the South Basin or the Middle Basin by any survey from 2010 through 2018. Slightly fewer clusters were observed over time in Percival Cove, ranging from 11 in 2010 to a minimum of 6 in 2018. Clusters in the North Basin ranged from one to five until a maximum of seven were observed in 2018.

Figure 4-6 Fragrant Water Lily Distribution in Capitol Lake in 2018

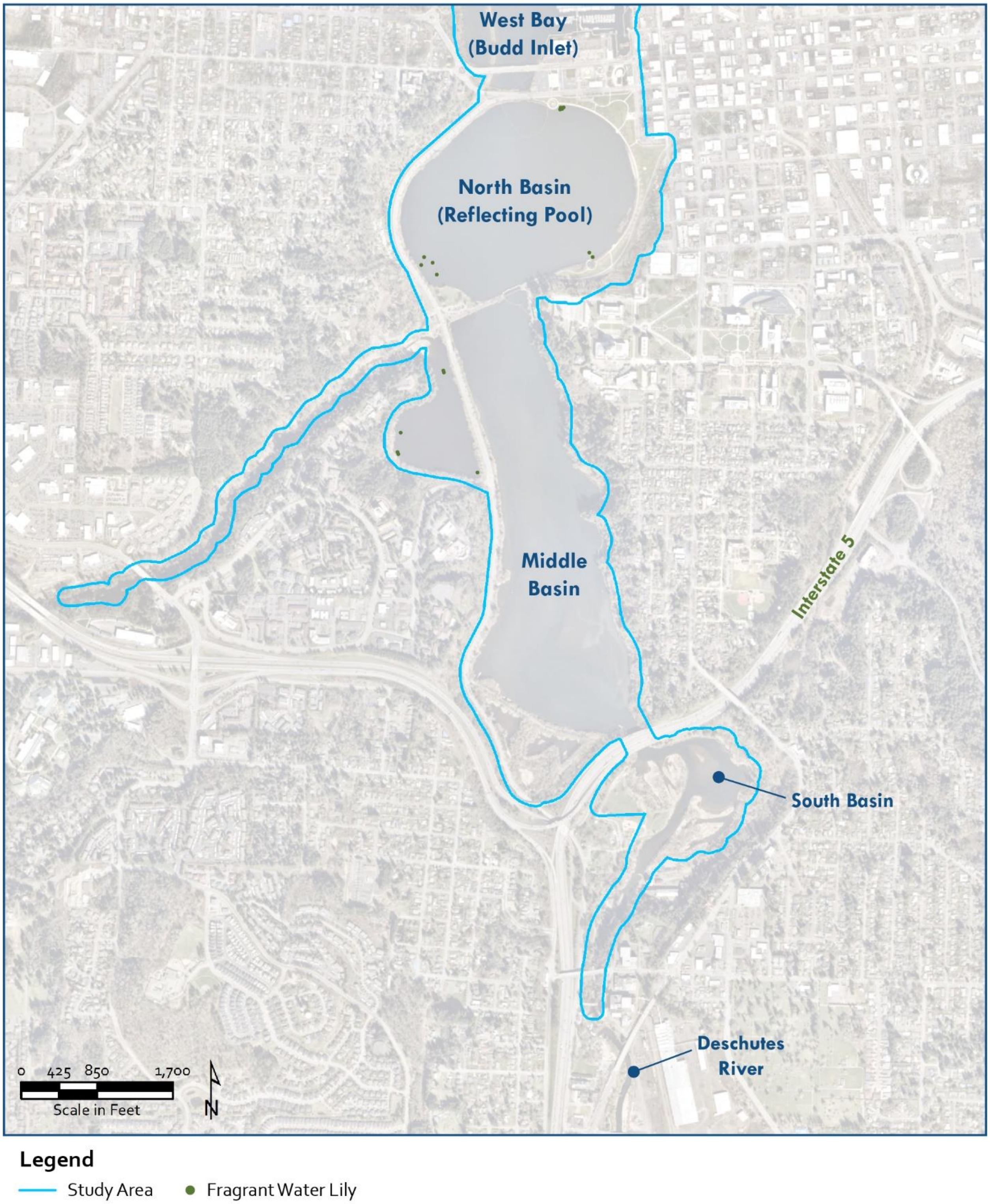
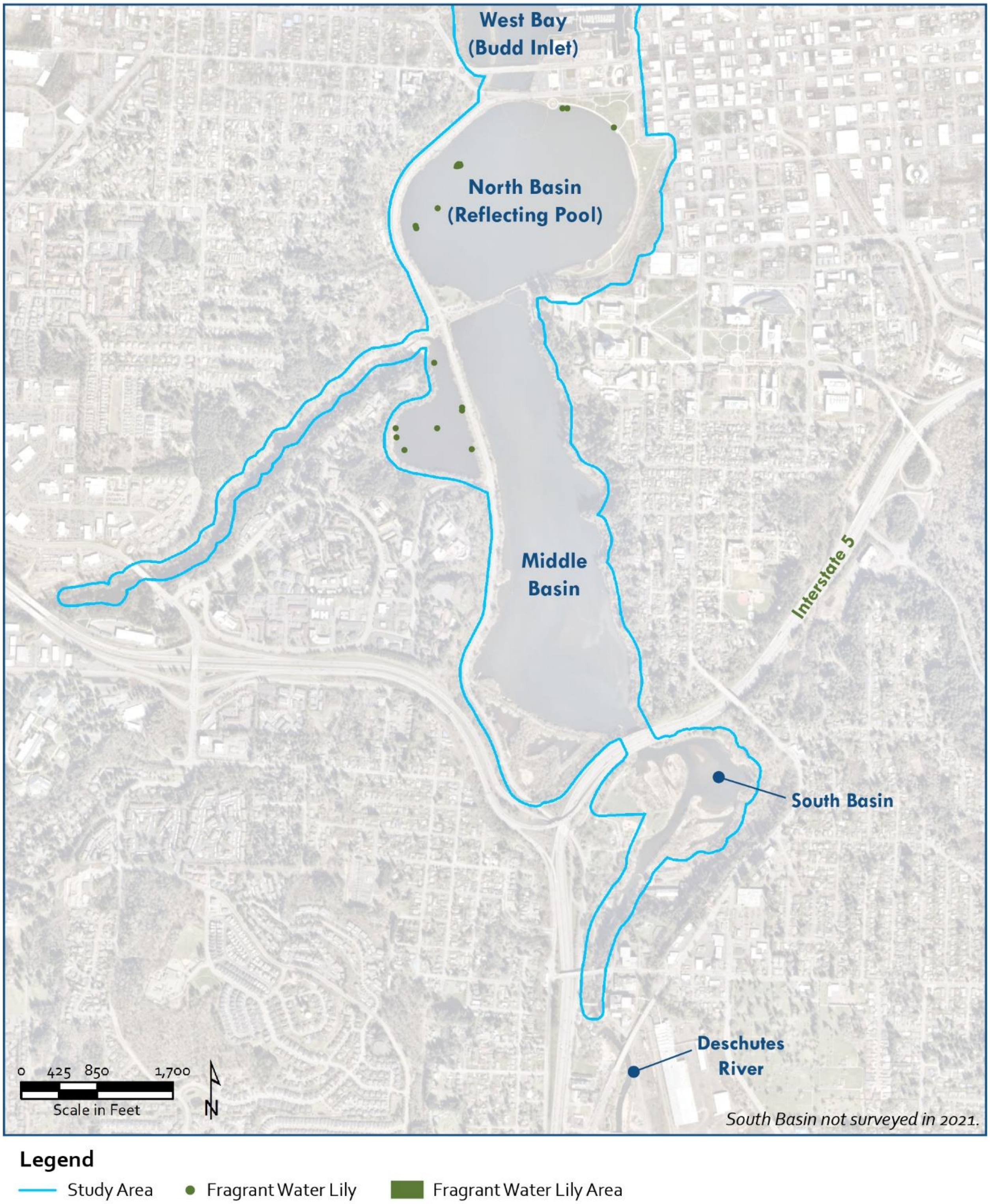


Figure 4-7 Fragrant Water Lily Distribution in Capitol Lake in 2021



4.1.1.3 Submersed Plants

Eurasian Watermilfoil


Eurasian Watermilfoil (WNWCB 2020)

Eurasian watermilfoil (*Myriophyllum spicatum*) is a Class B Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) and a High Priority invasive species (WISC 2020c) that grows submersed below water surfaces. Control of this Class B species is not required by the Thurston County Noxious Weed Board. The plant has feather-like underwater leaves, emergent flower spikes, and many fibrous roots (Ecology 2001). Roots may form on broken plant fragments, enabling the plant to spread by plant fragments in addition to spreading by rhizomes. The abundance of viable plant fragments allows this plant to rapidly spread and colonize new areas and it commonly forms dense, thick mats early in the growing season due to its rapid growth rate of up to 1 foot per week. These mats reduce sunlight and oxygen in underlying waters, thus degrading water quality, outcompeting native vegetation, decreasing habitat quality for native fish species, and inhibiting recreational activities. Management of Eurasian watermilfoil is costly, requiring repeated monitoring and removal efforts to prevent its spread.

Distribution and Abundance Within the Study Area

A representative of the Thurston County Noxious Weed Board first reported Eurasian watermilfoil in Capitol Lake in September 2001 (GA 2004). The Thurston County Department of Water and Waste Management subsequently conducted an aquatic plant survey of the lake in October 2001 and identified Eurasian watermilfoil in the Middle and North Basins of the lake (Aquatechnex 2003).

Figure 4.8 presents the map of Eurasian watermilfoil distribution with observation points colored red for the 2018 survey (NAM 2018), and Figure 4.9 presents observation points for the 2021 survey, which did not include a survey of the South Basin (Aquatechnex 2021). In 2018, individual plants and patches of plants were observed in all three basins, the Interpretive Park wetland ponds, and Percival Cove. The large patch observed in the North Basin adjacent to the dam had not been observed in previous surveys. The 2021 survey results showed a similar distribution except for fewer locations along the west shore of the Middle Basin and only one plant in Percival Cove (Aquatechnex 2021). Although Eurasian watermilfoil is a high-priority species based on its aggressive growth and potential impact on native species, it not likely significantly impacting native wildlife or recreation in the Capitol Lake Basin based on its current abundance and the aquatic plant habitat diversity. Native submersed plants currently impact boat navigation of the lake in summer because they grow to water surface over most of the lake area, as noted during lake water quality monitoring for the EIS project (N. Maas, Herrera Environmental Consultants, Inc., personal communication).

Figure 4-8 Eurasian Watermilfoil Distribution in Capitol Lake in 2018

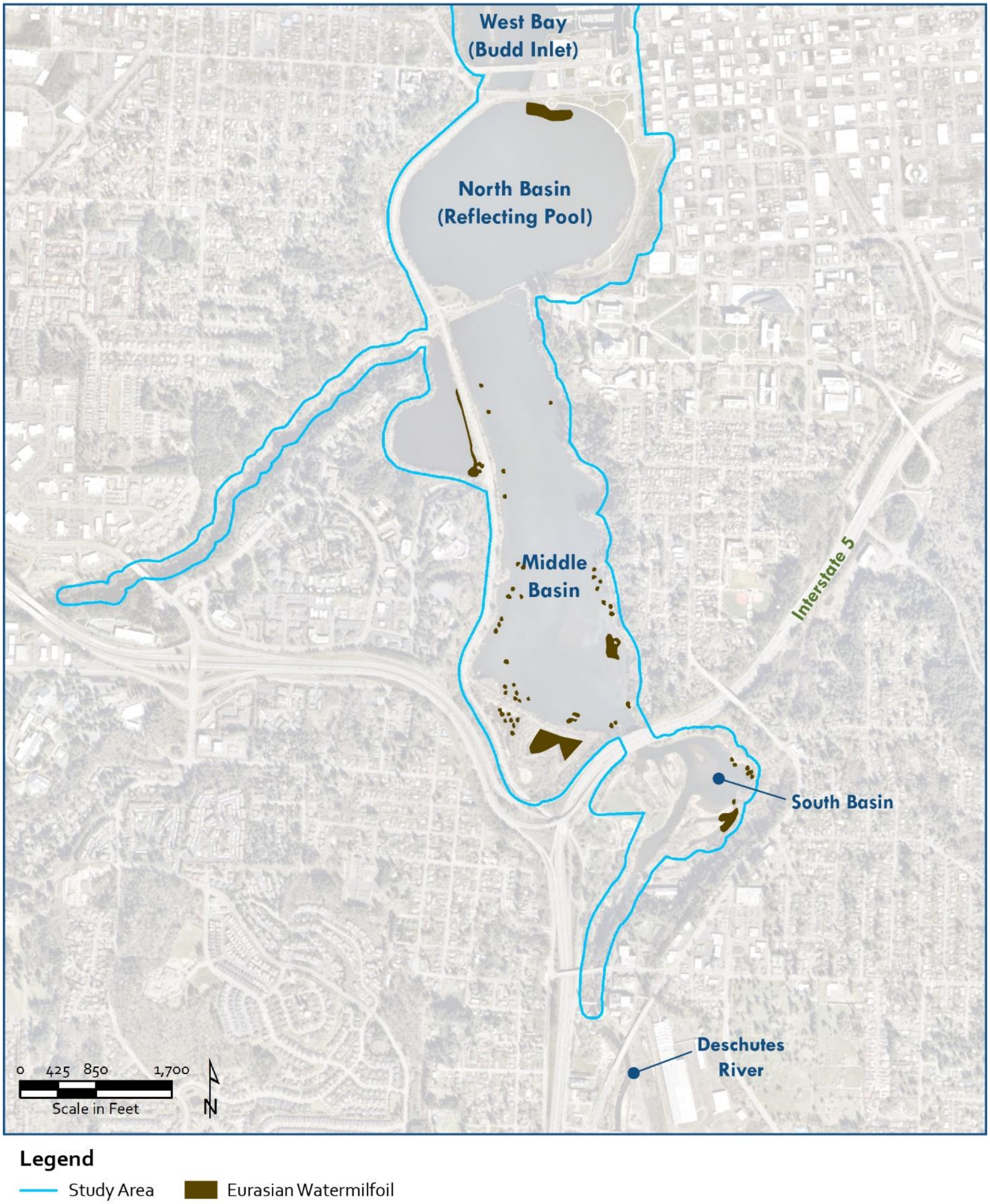
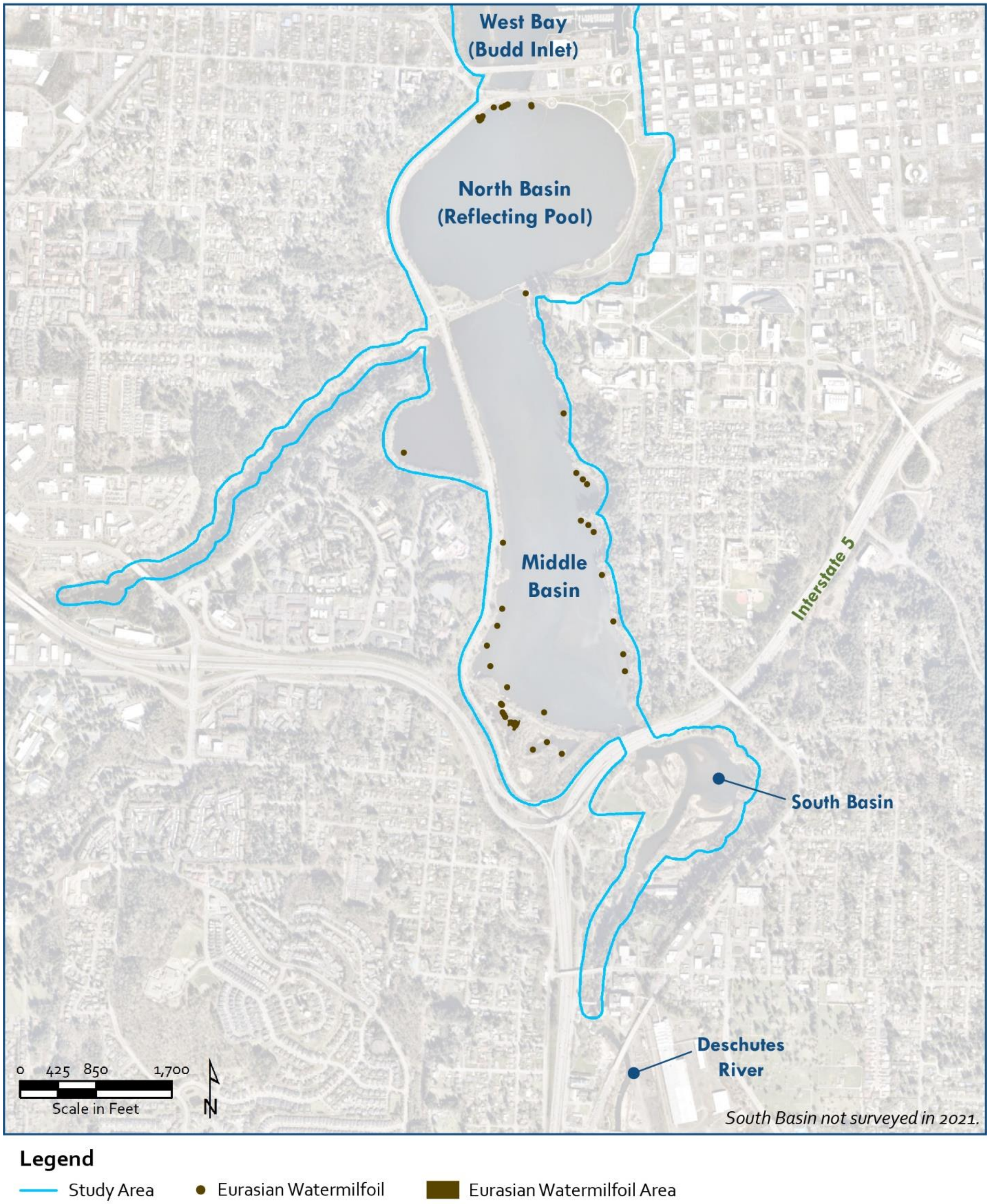


Figure 4-9 Eurasian Watermilfoil Distribution in Capitol Lake in 2021



Management Approaches

In response to the discovery and survey, the Capitol Lake Adaptive Management Plan (CLAMP) steering committee adopted an Invasive Aquatic Vegetation Management Plan in 2002 that included a triclopyr monitoring plan with preapplication testing in Capitol Lake and Budd Inlet to establish baseline data so that the effects of treatment activities could be fully understood as maintenance efforts continue.

On July 19, 2004, Aquatechnex applied triclopyr to Eurasian watermilfoil in the South Basin, Middle Basin, Percival Cove, and in the Interpretive Park wetland ponds. On July 29, 2004, Aquatechnex applied triclopyr to Eurasian watermilfoil in the North Basin. The Washington Department of Agriculture monitored the application process and noted that triclopyr was effective in killing Eurasian watermilfoil, dissipated quickly, and did not harm native aquatic vegetation. Eurasian watermilfoil plants in the South Basin were not completely eradicated due to flow from the Deschutes River limiting the contact time of triclopyr on treated vegetation in this area. Remaining plants were hand pulled in August of 2004 (GA 2004).

In the spring and summer of 2005, the GA monitored Capitol Lake to identify any Eurasian watermilfoil plants. Fewer than 100 plants were identified in the South Basin and in the Interpretive Park wetland ponds. Divers hand pulled these plants and used a water vacuum to capture any floating fragments. Monitoring was repeated in 2005 after manual removal, and no regrowth was observed.

From 2007 to 2018, NAM annually surveyed and manually removed Eurasian watermilfoil by boat and/or snorkel team (NAM 2018). In 2007, 1,386 plants were removed from the South and Middle Basins. The number of plants removed from these basins decreased annually thereafter, to 171 plants in 2008, 132 plants in 2009, 51 plants in 2010, 36 plants in 2011, 7 plants in 2012, and 6 plants in 2013 and 2014. The number of plants removed then increased to 56 plants in 2015 and 2016, 80 plants in 2017, and 105 plants in 2018.

Eurasian watermilfoil was first reported in Percival Cove as one plant in 2009 and continued to increase in abundance until hand removed by divers in 2012 and 2013 when 3,500 and 1,320 pounds were removed, respectively (ACERA 2013). Fewer than 20 plants were removed each year from Percival Cove in 2015 through 2018 (NAM 2018).

Eurasian watermilfoil was first reported in the west Interpretive Park wetland pond as 27 plants in 2009 that decreased to 8 plants in 2015, and ultimately increased to 15 to 20 plants in 2018 (NAM 2018). Dense plants were also observed in the east Interpretive Park wetland pond in 2015.

Eurasian watermilfoil was first reported in the North Basin as one plant in 2010, but not again until 2018 when a patch was observed just east of the 5th Avenue Dam (NAM 2018).

In 2019, an oil spill prevented access to Capitol Lake for vegetation surveys and management. NAM reported a high likelihood that Eurasian watermilfoil would continue to expand, consistent with monitoring results in 2018. NAM recommended that maintenance strategies for 2020 include in-depth surveys, individual plant marking, diver dredging, and shading cloths over individual plants (NAM 2020).

The GA implemented a Eurasian watermilfoil weevil (*Euhrchipsis lecontei*) biocontrol strategy for the east Interpretive Park wetland pond in August 2009. These efforts were monitored in 2009 and 2010, and an additional control effort was implemented by installing bottom barriers. Initial monitoring results at the time indicated that weevils could survive stocking, overwinter, and may grow to populations that control Eurasian watermilfoil in small water bodies. Results were somewhat inconclusive due to site disturbance (GA 2010). Weevils survived the saltwater flush of Capitol Lake in 2010. Over time, the Eurasian watermilfoil population reestablished in the east pond (NAM 2018), indicating a lack of long-term success for this control strategy.

Bottom barriers were effective in eliminating Eurasian watermilfoil growth in the Interpretive Park wetland ponds and were first installed in the main lake body in 2009 and in the west pond for clusters of multiple plants. A total of 675 square feet of bottom barriers were installed in Capitol Lake in 2009 and were observed to have remained intact and be effective in 2011. In 2010, an additional 225 square feet of bottom barrier was installed in the west pond (NAM 2011). Additional information on bottom barrier removal and maintenance was not available for this study; however, the increase in Eurasian watermilfoil in recent years indicates a lack of ongoing maintenance and reduced effectiveness of the bottom barriers. Without maintenance or replacement, the effectiveness of bottom barriers is reduced by displacement, degradation, or sediment accumulation.

Curlyleaf Pondweed

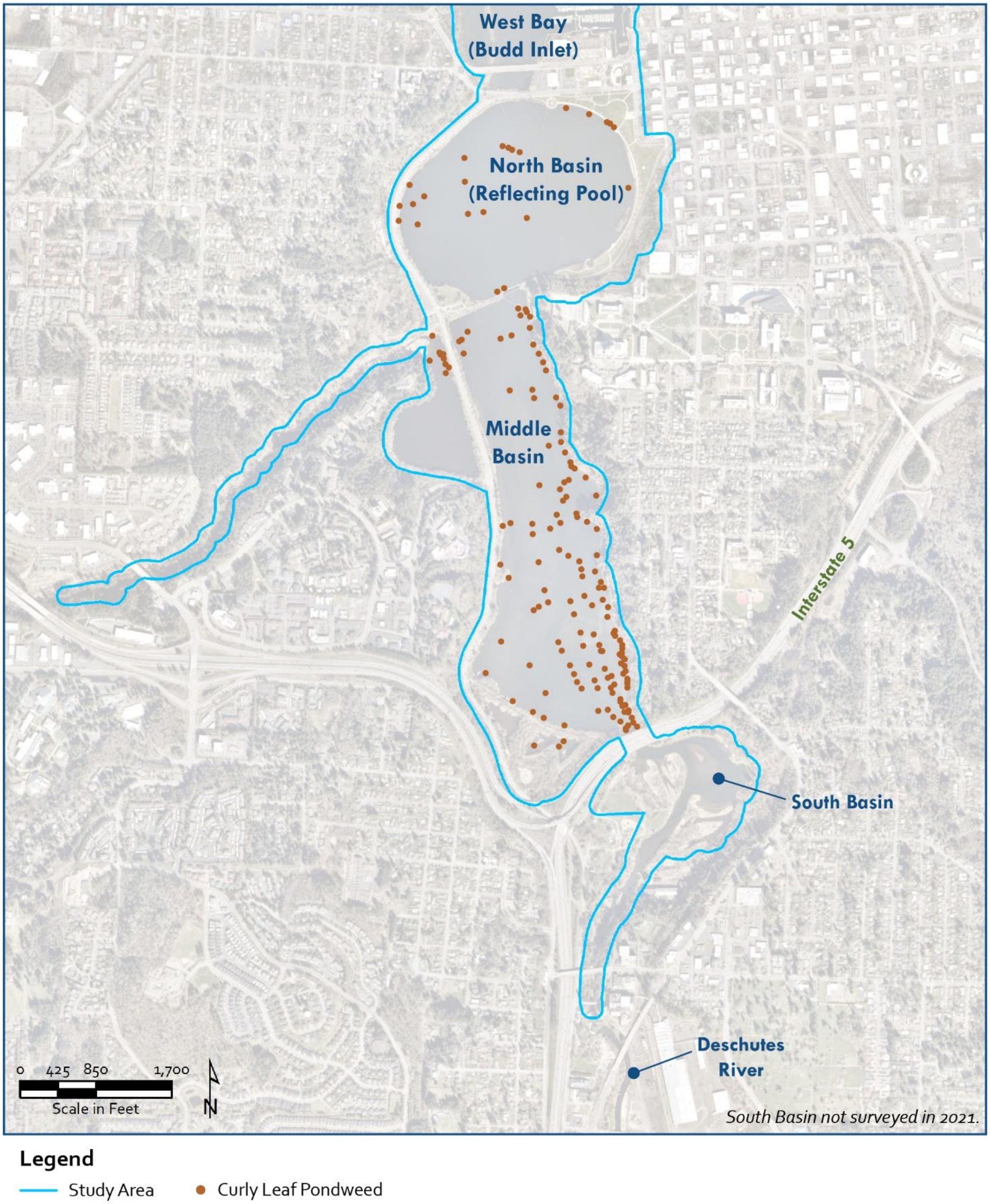
Curlyleaf pondweed (*Potamogeton crispus*) is a Class C Washington State Listed Noxious Weed (Washington State Noxious Weed Control Board 2020) that grows submersed below water surfaces in shallow to deep and still to flowing water. Control of this Class C species is not required by the Thurston County Noxious Weed Board. Leaves are olive-green to reddish-brown, oblong, stiff, and translucent with wavy edges and three prominent veins (Ecology 2001). Curlyleaf pondweed may grow stems up to 90 centimeters long and small flowers with four petal-like leaves that emerge above the water surface. The plant spreads by rhizomes and by seed. Curlyleaf pondweed may form dense surface mats that reduce sunlight and oxygen in underlying waters, thus degrading water quality, outcompeting native vegetation, decreasing habitat quality for native fish species, and inhibiting recreational activities.

Curlyleaf Pondweed (WNWCB 2020)

Distribution and Abundance Within the Study Area

Curlyleaf pondweed was observed and documented in Capitol Lake in 2001, 2003, 2004, and 2006 (Ecology 2020a), and likely existed prior to these records. Its density was not noted for the 2006 survey, but results of the 2006 survey indicate its presence as sparse with a wide patchy distribution that was most abundant in the south end of the lake. Curlyleaf pondweed distribution was not mapped or noted in the aquatic weed surveys conducted in 2012 through 2018, but was mapped in 2021 where it was found to be very abundant (over 130 plants) in the Middle Basin, moderately abundant (23 plants) in the North Basin, and low abundance (10 plants) in the Percival Cove (Figure 4.10) (Aquatechnex 2021).

Figure 4-10 Curly Leaf Pondweed Distribution in Capitol Lake in 2021



Curlyleaf pondweed may be significantly impacting native wildlife in the Middle Basin but not in other basins of Capitol Lake based on its current abundance and the aquatic plant habitat diversity.

Management Approaches

Management of curlyleaf pondweed can be costly; however, it is only occasionally problematic in Washington. Due to the historically low abundance of this plant, it was not considered to be a problematic species in Capitol Lake, and as such has not been the focus of any management efforts. Treatment of curly leaf pondweed was recommended in 2021 due to its increased abundance (Aquatechnex 2021).

4.1.2 Presence in Upstream Waters

Purple loosestrife has been observed and documented upstream of Capitol Lake on the Deschutes River (Thurston County 2020b). Although no other aquatic invasive plants have been mapped on the Deschutes River or Percival Creek, it is possible that other aquatic invasive plant species are present upstream of the lake. No aquatic invasive plant monitoring or management efforts are known to have occurred on the Deschutes River or Percival Creek.

4.1.3 Presence in Budd Inlet

Purple loosestrife has been documented downstream of Capitol Lake in Budd Inlet (Thurston County 2020b). No other aquatic invasive plant species are mapped in Budd Inlet. With the exception of several species of cordgrass (*Spartina* spp.) no other Class A noxious weeds are salt tolerant; therefore, they are unlikely to be found in Budd Inlet.

4.2 AQUATIC INVASIVE ANIMALS

Aquatic invasive animals found in Capitol Lake and the surrounding water bodies include four invertebrate, five fish and one mammal species. Table 4-2 describes their classification on the WDFW AIS database (WDFW 2020b) and distribution and relative abundance in the study area. Although resident Canada geese are considered a nuisance species that has been managed around Capitol Lake in the past, they are a native species and not considered an AIS (WDFW 2020c) and therefore are not addressed further in this report.

4.2.1 Presence in Capitol Lake

The biology, documented presence in Capitol Lake, potential economic and ecological impact of the species, and possible management actions for invertebrates, fish, and mammal are described below.

Table 4-2 Aquatic Invasive Animals Observed in the Study Area

Scientific/ Common Name	Classification[a]	Water Body	Relative Abundance	Source
Invertebrates				
Potamopyrgus antipodarum New Zealand mudsnail	Prohibited Level 3 Species	Capitol Lake	20,000 snails per square meter in limited areas of the North Basin	Johannes 2011
Corbicula fluminea Asiatic clam	Regulated Type C Species	Capitol Lake	Approximately 287 snails	Herrera 2004
Radix auricularia European ear snail	Regulated Type C Species	Capitol Lake	Approximately 38 snails	Herrera 2004
Fish				
Cyprinus carpio Common carp	Regulated Type A Species	Capitol Lake	Fewer than 200 fish	Herrera 2004
Ameiurus nebulosus Brown bullhead	Regulated Type A Species Game fish	Capitol Lake	Fewer than 50 fish	Herrera 2004
Micropterus salmoides Largemouth bass	Regulated Type A Species Game fish	Capitol Lake	Fewer than 200 fish	Herrera 2004
Perca flavescens Yellow perch	Regulated Type A Species Game fish	Capitol Lake	Fewer than 50 fish	Herrera 2004
Mammals				
Myocastor coypus Nutria	Prohibited Level 3 Species	Capitol Lake	Fewer than 25 animals	Herrera 2004

[a] Classification by the Washington State Department of Fish and Wildlife Aquatic Invasive Species Database (WDFW 2020b) or High Priority invasive species status (WISC 2020c).

4.2.1.1 Invertebrates

New Zealand Mudsnail


New Zealand mudsnail (WISC 2020a).

New Zealand mudsnail (*Potamopyrgus antipodarum*) is a Prohibited Level 3 species (WDFW 2020b) and High Priority (WISC 2020c) invertebrate AIS. It is a very small freshwater snail with an elongated shell, approximately 4 to 6 millimeters (mm) with five to eight right-turning whorls and an operculum that can seal the opening of the shell. The operculum allows the mudsnail to protect itself from short-term exposure to most chemicals, from extended periods of desiccation, and allows them to survive outside water for long periods of time. New Zealand mudsnails are grazers and feed on attached periphyton and decaying plant and animal material (Haynes and Taylor 1984). Under ideal habitat conditions, they can be found in densities up to 500,000 snails per square meter (Richards 2004; Hall et al. 2003).

The New Zealand mudsnail is dioecious (separate male and female sexes) and bears live young (Wallace 1978). Female mudsnails can reproduce sexually or asexually, producing cloned genetically identical offspring. Thus, one female is enough to initiate a new population, and all introduced populations outside of New Zealand are entirely clonal (Zaranko et al. 1997). New Zealand mudsnails are found in shallow freshwater and brackish water ecosystems. In general, they have a broad environmental tolerance to diverse ranges of temperature, osmotic concentrations, flows, substrates, and disturbance regimes, although clonal lineages may have varied tolerances to environmental conditions (Dybdahl and Lively 1995; Jokela et al. 1999; LeClair and Cheng 2011). Due to their ability to survive outside the aquatic environment for several weeks to months, new populations can be established through transportation on contaminated boots, gear, and equipment.

While the New Zealand mudsnail has no natural predators in Washington, laboratory studies show that rainbow trout and steelhead will feed on New Zealand mudsnails; however, fish derive little or no energy value from eating snails because the snails are capable of passing through the fish's digestive system alive and intact (Bruce et al. 2009). Although there have been documented incidences of New Zealand mudsnails found in Chinook salmon stomach contents (Bersine et al. 2008), it is unlikely that New Zealand mudsnails are a common or important prey for juvenile Chinook salmon when other preferred prey species are present.

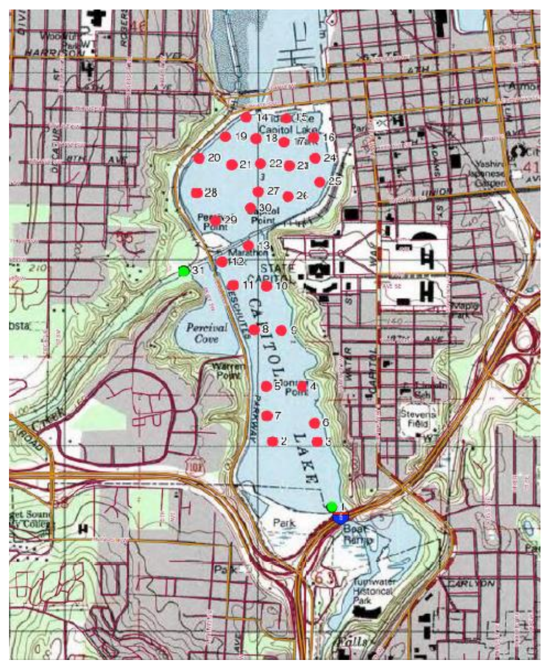
Many of the ecological impacts of the New Zealand mudsnail can be attributed to the extreme rate of population growth and high densities it can reach (Alonso and Castro-Díez 2008). The New Zealand mudsnail consumes high amounts of periphyton (i.e., algae attached to rocks and other substrates) and excretes high amounts of total ammonia, dominating both the carbon and nitrogen cycles (Hall et al. 2003; Hall et al. 2006; Alonso and Castro-Díez 2008). In addition to outcompeting native species for natural resources, their ability to withstand highly variable environmental conditions allows New Zealand mudsnails to take advantage of changing environmental conditions, including climate change, to further spread and outcompete native species (Alonso and Castro-Díez 2008). By outcompeting native species, the New Zealand mudsnail reduces prey species for native fish, resulting in reduced body weight and health of native salmonids (Richards 2004; Vinson and Baker 2008; Alonso and Castro-Díez 2012).

Biofouling is the major economic impact associated with the introduction of New Zealand mudsnails, in general. New Zealand mudsnails have been documented to pass through water pipes and emerge from domestic taps (Ponder 1988) and can block water pipes and meters (Zaranko et al. 1997). Other economic costs are related to the vulnerability of threatened or endangered species, research and development expenses incurred by agency and university personnel to prevent further spread of New Zealand mudsnails, extra steps and equipment required to prevent the further spread of invasive species, and contamination of private hatcheries and subsequent regulation and prohibition of their operations (Proctor et al. 2006).

Distribution and Abundance Within the Study Area

The invasion of the New Zealand mudsnails in fresh and brackish water habitats spans across Europe, Australia, Japan, and North America (Johannes 2013). In the United States, an all-female population of New Zealand mudsnails was discovered in the middle Snake River, Idaho, in 1987 (Taylor 1987). Since its discovery, they have spread to 10 western states, including Washington in 2002 (Davidson et al. 2008). Washington waters with more than 20 specimens of New Zealand mudsnails currently include the mouth of the Columbia River, the lower Chehalis River, Kelsey Creek and Thornton Creek (King County), Lake Washington, and Capitol Lake (USGS 2020). Small populations (under 5 specimens) of New Zealand mudsnails have been observed in several other streams and lakes in Western Washington.

New Zealand mudsnails were first observed in Capitol Lake in 2009 (Bartleson 2010; Bensen 2010; Johannes 2010). A 2011 survey of Capitol Lake detected New Zealand mudsnails in 29 of the 31 sites investigated (Johannes 2011a; see map inset). A 2013 survey of 83 sites around Capitol Lake and the surrounding area, detected New Zealand mudsnails in three locations: North Basin, Middle Basin, and the mouth of the Deschutes River, but did not extend into nearby creeks and tributaries (Johannes 2013; USGS 2020). No New Zealand mudsnails were observed in the five new sites in streams and lakes that were surveyed within a 5-mile radius of Capitol Lake in 2015, and populations detected in the 2013 survey were still observed in low numbers (Johannes 2015). No New Zealand mudsnails were detected at the mouth of Percival Creek (Johannes 2015), suggesting that they had not migrated further upstream into Percival Creek in the 6 years from when they were originally observed in Capitol Lake to the most recent mudsnail survey.

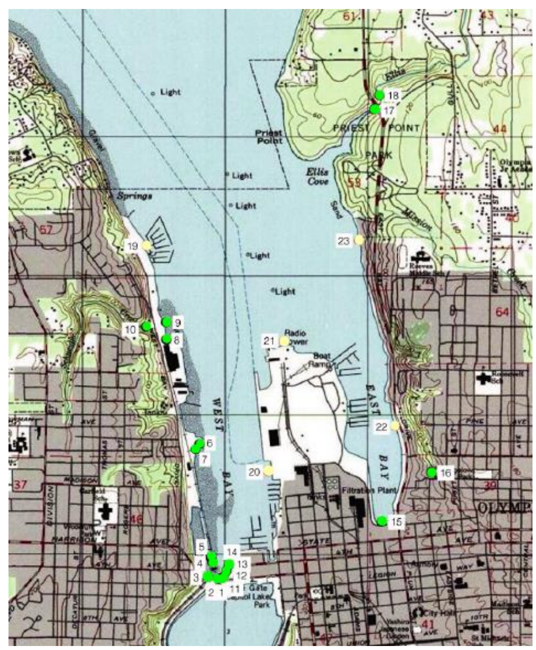


New Zealand mudsnail distribution in Capitol Lake in 2011 (red points positive, green points negative) (Johannes 2011a)

Although New Zealand mudsnails have been shown to tolerate salinities greater than the 26 to 30 parts per thousand (ppt or practical salinity unit), there are limited data, Best Available Science studies, or literature regarding the adaptation of this freshwater species to high salinity environments. Salinity tolerance has been shown to increase with marine water exposure, with overall tolerance dependent on temperature and the rate of acclimatization to the higher salinity (LeClair and Cheng 2011; Stockton-Fiti 2018). New Zealand mudsnails in Capitol Lake reside exclusively in freshwater habitat with no saltwater exposure to develop potential tolerance or resilience.

New Zealand mudsnail tolerance to salinity is dependent on temperature and the rate of acclimatization to the higher salinity (LeClair and Cheng 2011). A study of New Zealand mudsnails in the Columbia River estuary found the mudsnails are more tolerant of acute salinity stress with LC50 values (lethal concentration causing 50 percent mortality) averaging 38 ppt salinity versus only 22 ppt salinity for mudsnails from a freshwater source (Devils Lake) (Hoy et al. 2012).Snails observed in brackish water, however, are not thriving in a way that would significantly impact native populations. Salinity in Budd Inlet ranges between 23 and 27 ppt (Schoch and Dethier 1999), within the New Zealand mudsnail salinity tolerance.

In 2022, a shoreline survey was completed around Budd Inlet to evaluate whether New Zealand mudsnails had spread into West Bay given the discharge of debris through the 5th Avenue Dam during high river flow events (Johannes 2022). The investigation included 21 sites, 16 of which were previously surveyed in 2011 and several sites adjacent to various freshwater inputs were included. No New Zealand mudsnails were found as part of this survey along Budd Inlet (Johannes 2022). Most sites collected in Budd Inlet had marine fauna present, indicating conditions would allow for colonization if the species were tolerant to the salinity level found in Budd Inlet. Because New Zealand mudsnails were not found during this survey, the study concluded it is likely that year-round salinity levels are too high anywhere in Budd Inlet for New Zealand mudsnails to survive.



New Zealand mudsnail survey locations in 2011 (green points) and in 2022 (green and yellow points) in Budd Inlet that were all negative (Johannes 2022)

New Zealand mudsnails are currently affecting recreational opportunities in the project area, but their impact on native wildlife is unclear. Several native species of snails are also abundant in Capitol Lake, and since the last survey was conducted, the New Zealand mudsnail population had not overtaken the benthic community in the lake as was expected (Pleus 2016).

Management Approaches

Management of New Zealand mudsnails occurs through natural environmental conditions and physical and chemical treatments. Given the species persistence, prevention of repeated introductions and further spread will also heavily rely on public outreach and education. Literature review, preliminary testing, and professional judgement were used to identify a set of factors that may affect the spread and mortality of New Zealand mudsnails in Capitol Lake. These include:

- Freezing
- Heat and desiccation
- Saltwater backflush
- Depth and water temperature
- Presence of structures
- Substrate grain size
- Calcium concentration and water hardness
- Introduced chemical agents

Freezing can increase the mortality response when the lakebed is drained and exposed to hard freezing weather conditions for a few consecutive days. The use of this measure is highly dependent upon weather conditions that must be both cold and dry without insulating snow, which is an unusual combination of conditions for the Capitol Lake area. The effectiveness of freezing is also limited by short periods of freezing and the resulting shallow freezing depths in Puget Sound lowland lakes. Enterprise Services lowered the level of the lake between December 15 and 18, 2016 to freeze mudsnails in shallow waters and on exposed sediments (Enterprise Services 2016). New Zealand mudsnail mortality varied depending on location. For example, mortality near Marathon Park was approximately 50 percent, whereas areas along Powerhouse Road were approximately 90 percent. These differences were attributed the proportion of the survey areas exposed to freezing conditions where less mortality was observed where more area was below ice cover (Enterprise Services 2016).

Heat and desiccation through local weather conditions is more frequently achieved than dry and freezing conditions. However, this seasonally dependent action requires several consecutive hot-dry days and has been shown in productive lakes to cause nuisance odors from decaying algae and aquatic plants and animals. Both the freezing and heat factors are limited in Capitol Lake by the mild climate and constant inflow from the Deschutes River. However, artificial heat sources such as propane torches or artificial freezing sources such as dry ice could be deployed as adaptive management techniques to kill mudsnails present on sediments exposed during drawdown.

In an experiment that tested New Zealand mudsnail tolerance to osmotic and thermal shock, researchers found the snails had significantly higher mortality at higher salinities that increased with higher temperatures (Paolucci and Thuesen 2020). While increasing the salinity may increase mortality, an experimental backflush to treat New Zealand mudsnail populations in Capitol Lake in 2010 found the treatment reduced the entire macroinvertebrate community (Adams 2010). Researchers speculated that after the lake returned to normal freshwater conditions, the backflush could result in a larger mudsnail population as a product of rapid reproduction and newly available resources that are no longer consumed by competing species (Adams 2010).

How water depth and temperature affect the New Zealand mudsnail distribution in Capitol Lake has been studied by WDFW but is not well understood. Given the resiliency of this species, it is unlikely that manipulation of these factors by regulating lake outflow would significantly impact the mudsnail population.

The presence of structures in the water column may influence the success of New Zealand mudsnail populations, but this factor is not well understood. Anecdotal information from Capitol Lake suggests the snails prefer locations with legacy piers, debris, and other uneven substrate features. Structures are presumed to provide shelter from various threats and an ability to regulate ambient conditions such as temperature or light.

Substrate grains size is also poorly understood regarding population success. New Zealand mudsnail have been found to thrive in silt and gravel dominated environments. Capitol Lake's Middle and North Basins are almost entirely a fine silt substrate. The southern end of the system is dominated by gravel. Presence/absence surveys have not found New Zealand mudsnail in the southern, graveled portion of the lake, but it is not clear if substrate grain size is the factor limiting New Zealand mudsnail migration to the southern portion of the lake.

Calcium concentration and water hardness are linked with New Zealand mudsnail success. Literature review has identified a pattern of greater snail population success in waters with a high mineral content. Most water systems influenced by urban development have a greater hardness than their natural counterparts. As with other factors discussed here, it is difficult to conceive how calcium concentration and water hardness could be altered to successfully affect the existing snail infestation.

Efficacy information has been identified for various chemical agents through literature review and recent laboratory analyses. Areas where chemical eradication may be possible include water bodies that can be isolated from the drainage, such as small lakes and ponds, irrigation canals, and fish hatcheries. Chemical eradication from the lake basin may not be possible due to the continuous inflow of river water diluting chemical concentrations and limiting the ability to achieve the required contact time to kill all organisms. Two chemical agents examined for use in Capitol Lake are Bayluscide (with niclosamide as the active ingredient) and sodium chloride. Bayluscide acts quickly, killing the New Zealand mudsnail before they have a chance to respond or find protection (Nautilus Environmental 2011). The lethal action of sodium chloride is much slower, allowing the snail to close its operculum and wait for the toxic level of the introduced agent to dissipate. Additional lab analysis for sodium chloride treatments would be needed to better understand how it might perform in a field application. Neither chemical is currently allowed for aquatic use under the Aquatic Invasive Species Management Permit, but application of either chemical may be allowed by an experimental use permit or addition of the chemical to the existing permit as part of its 5-year update, which is due in 2026 (Ecology 2020b).

In addition to treatment efforts to control New Zealand mudsnail population growth and spread, public outreach and education can help to prevent the spread by human activity. Signage warns recreational users at Marathon Park of New Zealand mudsnail infestations. Although educational outreach is a helpful first step in encouraging additional public monitoring and control, signs alone are not effective to preventing the spread of invasive species.

European Ear Snail


European ear snail (Kipp et al. 2019).

The European ear snail (*Radix auricularia*), also known as the big-ear radix, is a species of medium-sized freshwater snail. The shell is thin, roundly ovate, and very inflated, such that the last whorl comprises 90 percent of its volume. It is native to Europe and temperate Asia, found in slow-moving rivers and streams, ponds, lakes, and wetlands. The European ear snail has a wide tolerance for temperatures and specific conductivities (Vinarski and Serbina 2012; von Oheimb et al. 2016).

There is limited information available on the European ear snail effects on native ecosystems; however, it is likely similar to the information described above for the New Zealand mudsnail. The invasive European ear snail reduces native invertebrate diversity by consuming large amounts of primary producer biomass and altering ecosystem functions (Hall et al. 2003; Riley et al. 2008). In some environments, European ear snail may prey on juvenile snails, directly impacting native snail populations (Deng 1997).

Distribution and Abundance Within the Study Area

Originally, the European ear snail was likely introduced accidentally on plants imported to North American greenhouses (Kipp et al. 2020). Subsequent introductions may have occurred through releases from aquaria and the European ear snail is now found in 22 of the 50 United States, including California, Idaho, Montana, Oregon, and Washington (Kipp et al. 2019). The European ear snail was first documented in Capitol Lake in 2003 (Herrera 2004) but was not found in any sites investigated in or around Capitol Lake during the 2011 or 2013 surveys (Johannes 2011a; Johannes 2013). European ear snail is not likely significantly impacting native wildlife in the Capitol Lake Basin based on its current abundance and the aquatic habitat diversity.

Management Approaches

Although there is little information on species-specific control and management efforts for European ear snail, preventing the spread by educating the public and applying chemical treatments are the most likely options to reduce their impacts.

Asiatic Clam


Asiatic clam (Foster et al. 2019).

The invasive Asiatic clam (*Corbicula fluminea*) is a freshwater bivalve that originates from Asia (Britton and Morton 1979). The species is opportunistic, adapting to a wide range of freshwater ecosystems and utilizes both filter- and deposit-feeding strategies, feeding on phytoplankton and zooplankton (Way et al. 1990). The Asiatic clam is 2 to 3 cm in size and has an oval-triangular shell that ranges from dark olive green to black (Foster et al. 2019). Reproductive strategies of the Asiatic clam include sexual reproduction with both sexes or hermaphrodites and several other unusual reproductive features, ranging from oviparity and ovoviviparity to euviviparity (Korniushin and Glaubrecht 2003; CABI 2020a).

Oxygen availability may be one of the most critical factors affecting their population growth and distribution, with mature individuals requiring greater than 70 percent dissolved oxygen saturation for survival (McMahon 1979). Due to this high oxygen demand, Asiatic clams typically inhabit well-oxygenated streams and lake shallows. The maximum tolerable salinity for Asiatic clams is approximately 13 parts per thousand, but this concentration can only be withstood for a short time (Aguirre and Poss 1999). Although they can survive in water temperatures as low as 2° Celsius, the clams prefer warmer habitats (McMahon 2002).

Ecological impacts include altering the physical, chemical, and biological characteristics of the invaded water body. Asiatic clams change ecological conditions within invaded ecosystems through their burrowing, feeding activity, and density (Sousa et al. 2008). Through burrowing in substrate, they may displace and/or reduce available habitat for native species. Their feeding versatility and rapid rate of reproduction contribute to the clam's ability to quickly establish colonizing populations in a broad range of aquatic habitats and is capable of shifting zooplankton communities in favor of copepods by selectively removing rotifers (Beaver et al. 1991), altering the biota of a habitat and leading to the disruption of benthic and pelagic community structure (Sickel 1986; Sousa et al. 2008). This can affect aquatic birds and increase the frequency of nuisance species and algal blooms. Drastic reductions in native species populations are also observed due to direct competition with Asiatic clams for limited resources (Devick 1991).

Distribution and Abundance Within the Study Area

Since the first known introduction in 1937 to the Columbia River, the Asiatic clam has been observed in 46 states, the District of Columbia, and Puerto Rico, and has spread to 45 hydrologic units in Washington State (USGS 2020). The mechanism for dispersal within North American is unknown (Foster et al. 2019). In 2003, approximately 287 Asiatic clams were documented in the North Basin along the west shoreline of Capitol Lake at a depth of 7 feet (Herrera 2004). Full impacts of Asiatic clams in Washington has not been fully investigated, but there are numerous reports where shells from die-offs clog water supply systems or degrade freshwater swimming beaches. The Asiatic clam was found at one location in Black Lake during the 2011 survey of sites outside Capitol Lake (Johannes

2011a) and at three sites as either shell fragments or complete dead shells in Black Lake during the 2013 survey of sites outside Capitol Lake (Johannes 2013), but there were no documented sightings in the Percival Creek that flows from Black Lake into Capitol Lake (Johannes 2013; USGS 2020). The Asiatic clam is not likely significantly impacting native wildlife in the Capitol Lake Basin based on its past abundance and the aquatic habitat diversity.

Management Approaches

Few options exist for the management of established Asiatic clam populations due to the persistence of larval stages in the water column. Chemical treatments (chlorination and bromination) are used for both juveniles and adults, but these treatments can cause severe environmental damage in open water systems if administered incorrectly (INDNR 2009). Physical and benthic barriers and diver-assisted suction could be used for species control (Wittmann et al. 2012; State of Michigan 2020), as well as dry ice applications (Coughlan et al. 2018), and open-flame burn treatments of exposed Asiatic clam beds (Coughlan et al. 2019). Dredging is also a treatment option, but also removes native organisms and can miss veligers or juveniles (State of Michigan 2020).

4.2.1.2 Fish

Common Carp

Common carp (Nico et al. 2020).

The common or European carp (*Cyprinus carpio*) can be identified by several features, including large scales, two barbels on each side of the mouth, and the first dorsal and anal fin spines are serrated. Most carp are bronze-gold to golden yellow on the sides and yellowish white on the belly. This species generally inhabits lakes, ponds, and the lower sections of rivers with moderately flowing or standing water, but is also known from brackish-water estuaries, backwaters, and bays. In its native range, the species occurs in coastal areas and estuaries withstanding salinities up to 14 ppt. In the United States, the common carp has been observed in waters with salinities as high as 17.6 ppt (Nico et al. 2020), which is much less than the 26 to 30 ppt range observed in Budd Inlet.

Larval common carp feed primarily on zooplankton. Feeding habits of juvenile and adults include benthic organisms, vegetation, detritus, plankton, chironomids, small crustaceans, and gastropods (Nico et al. 2020). The common carp are an important seed dispersal vector for aquatic plants.

The feeding habits and movements of the common carp are quite disruptive, often disturbing sediments and increasing turbidity. These actions can retard the growth of submerged aquatic vegetation, disturb spawning and nursery areas of native fish, and affect food sources for native waterfowl (Nico et al. 2020). In addition to competing with native fishes for natural resources, common carp also prey on the eggs of other fish species and may be responsible for the decline of native species (Nico et al. 2020).

Distribution and Abundance Within the Study Area

In Washington, the common carp are found in 23 watersheds, including the Deschutes watershed and greater Puget Sound area (USGS 2020). Common carp were observed in Capitol Lake during a 2003 survey but were not identified as a dominant species (Herrera 2004). Common carp is not likely significantly impacting water quality or native wildlife in the Capitol Lake Basin based on its current abundance.

Management Approaches

Due to impacts of the common carp, concentrated efforts in other areas to permanently eliminate fish include trapping, seining, and poisoning, but few were successful (NPS 2019). In addition, common carp abundance has been successfully reduced using electrofishing in Seattle's Green Lake; and lake associations in Thurston County have held carp fishing derbies to remove carp (R. Zisette, Herrera Environmental Consultants, Inc., personal communication).

Brown Bullhead

The brown bullhead (*Ameriurus nebulosus*) is a member of the catfish family and is identified by the presences of strong barbs or serrations on the back edge of its pectoral spines, and pigmentation in the chin barbels. They are often found in muddier, warmer waters and can tolerate high water temperatures and low dissolved oxygen levels that would be lethal to most other fish.

Brown bullhead (Fuller and Neilson 2020a).

Although full estimates or documentation of the impact from brown bullhead on habitat and native populations are lacking, the brown bullhead may increase the physical disturbance in freshwaters habitat during their benthic feeding activities. The aggressive foraging may be necessary to dislodge certain benthic prey items, which in-turn can increase turbidity and lead to altered productivity and nutrient cycling. In addition to outcompeting native species for natural resources, the brown bullhead preys on small fishes and invertebrates, reducing native populations.

Distribution and Abundance Within the Study Area

Brown bullhead are native to the Atlantic and Gulf Slope drainages from Nova Scotia and New Brunswick to Mobile Bay, Alabama, and east to the Apalachicola and Mississippi Rivers (Fuller and Neilson 2020a). Introduced brown bullhead may have been intentionally stocked around the United States for food and sport and has been reported in Washington as early as 1880 (Fuller and Neilson 2020a). After being introduced, the brown bullhead become established. During a study to inventory invertebrate and vertebrate populations in Capitol Lake, fewer than 50 brown bullheads were observed (Herrera 2004). Brown bullhead is not likely significantly impacting native wildlife in the Capitol Lake Basin based on its current abundance.

Management Approaches

Previous efforts to control brown bullhead populations include enhancing native predation. Brown bullheads are the most susceptible to predators in the developmental stages. Other methods of eradication using physical removal and chemical agents; however, both those treatment options affect native species, as well.

Largemouth Bass

The largemouth bass (*Micropterus salmoides*) occupy a variety of habitats ranging from large lakes, rivers, and reservoirs, to smaller water bodies including ponds and creek pools. Largemouth bass are opportunistic feeders that exploit a variety of prey and are highly piscivorous as adults. They differ from the smallmouth bass with a darker greenish-black color, prominent dark horizontal band along the midline, and the large maxillary that extends fully past their eye.

Largemouth bass (Fuller et al. 2020b).

Largemouth bass impact populations of small native fish directly through predation, sometimes resulting in the decline or extirpation of native species (Fuller et al. 2020b). The increased predation at one or more lower trophic levels could result in altered ecosystem processes (e.g., primary productivity and nutrient cycling) (CABI 2020b).

Distribution and Abundance Within the Study Area

Largemouth bass have been intentionally stocked for the sports fishery in several states and countries. In Washington, the largemouth bass has been intentionally stocked since the 1890s and is currently found in 58 watersheds including the Nisqually River watershed (Fuller et al. 2020b). The inventory of invertebrates and vertebrates in Capitol Lake observed fewer than 200 largemouth bass (Herrera 2004). Largemouth bass are also present in several small lakes surrounding the watershed (USGS 2020). Largemouth bass is not likely significantly impacting native wildlife in the Capitol Lake Basin based on its current abundance.

Management Approaches

Management options for largemouth bass populations focus on harvest regulations. When largemouth bass become a nuisance species, more liberal fishing regulations help control population to reduce predation on native fish species.

Yellow Perch

Yellow perch (*Perca flavescens*) are identified by their golden-yellow coloring, although the intensity of the color may vary with age and water clarity. This species has a high tolerance for low oxygen levels and acidification and is known to survive winterkill (CABI 2020c). Yellow perch prefer clear waters and remain close to shore near vegetation (CABI 2020c).

Yellow perch (Fuller and Neilson 2020b).

Yellow perch compete with native salmonid species for food and likely prey on native juvenile fish species. Nonnative predators, including yellow perch, reduce the abundance and diversity of native prey species in several Pacific Northwest rivers (Fuller and Neilson 2020b). Predation of yellow perch on small native species may also alter the ecosystem, changing the structure of zooplankton and phytoplankton communities, as well as native fish populations. Yellow perch are also a host for viral hemorrhagic septicemia, spring viremia of carp virus, and infectious hematopoietic necrosis (USFWS 2019).

Distribution and Abundance Within the Study Area

Like the largemouth bass, yellow perch have spread throughout the country through intentional stocking for the sport fishery. Yellow perch were introduced to Washington in the 1890s and have since spread to 52 watersheds, including the Deschutes River watershed (Fuller and Neilson 2020b; USGS 2020). The inventory of invertebrates and vertebrates conducted on Capitol Lake documented fewer than 50 yellow perch (Herrera 2004). Yellow perch is not likely significantly impacting native wildlife in the Capitol Lake Basin based on its current abundance.

Management Approaches

Management options for yellow perch populations focus on harvest regulations, similar to small- and largemouth bass management described above. More liberal fishing regulations help control population to reduce predation on native fish species.

4.2.1.3 Mammal

Nutria

Nutria (*Myocastor coypus*) is a Prohibited Level 3 species (WDFW 2020b) and High Priority (WISC 2020c) mammal AIS. Nutria are semi-aquatic rodents native to South America. Adults are approximately two feet long with dark brown fur and large, orange teeth. Although they are often mistaken for beavers, nutria have a thin tail. Nutria breed year-round and can produce up to three litters a year, with a litter size ranging from 2 to 9 young. In their introduced range, nutria have few natural predators.

Nutria (WISC 2020b).

Although they are well adapted for movement on land, nutria are more at home in the water and prefer slow-flowing streams, lakes, and freshwater marshes as well as brackish and saltwater habitats. Nutria are herbivores and feed particularly on wetland plants, targeting the base of plant stems and digging for roots and rhizomes in the winter. They often construct circular platforms of compacted, coarse emergent vegetation for use during feeding, birthing, resting, and grooming. They also construct burrows in levees, dikes, and embankments.

Nutria negatively impact invaded ecosystems. Their feeding activity destroys marsh vegetation, transforming marsh areas into open water and displacing native species (Hilts et al. 2019); their burrows undermine water management infrastructure and destabilize banks, increasing erosion along shorelines (Carter and Leonard 2002); and they host infectious diseases that affect humans, livestock, and wildlife (Woods et al. 1992; Drake 2005).

Distribution and Abundance Within the Study Area

In 1935, nutria were brought to Washington for use in the fur industry. Whether they escaped or were intentionally released when fur farming was no longer profitable, nutria spread rapidly throughout western Washington. Nutria observations in Capitol Lake were first recorded in 1975 (Entranco 1997). Although nutria is a high-priority species based on its potential impacts, it is not likely significantly impacting water quality or native plants and wildlife in the Capitol Lake Basin based on its current abundance.

Management Approaches

Feral populations of nutria are managed by shooting and trapping. Eradication is preferable for small to medium size populations, but some level of control is essential in most cases if eradication is not feasible. Fences, walls, and other structures can reduce nutria damage, but high costs usually limit their use. No chemical repellents for nutria are currently registered. Other rodent repellents (such as Thiram) may repel nutria, but their effectiveness has not been determined (LeBlanc 1994).

The USDA Wildlife Service was under contract from 2014–2019 to manually control the population. A total 23 nutria were removed from August 2014 through August 2017 (C. Martin, Enterprise Services, personal communication). In 2017, the USDA Wildlife Service conducted a survey for areas of fresh nutria activity and removed one nutria (USDA 2018). No nutria were observed during night survey efforts, and an estimated number of nutria in the basin was not determined (USDA 2018).

4.2.2 Presence in Upstream Waters

The documented presence of aquatic invasive animal species in upstream waters that flow into Capitol Lake, including the Deschutes River, Percival Creek, and nearby freshwater lakes are described in the following sections.

4.2.2.1 Invertebrates

The surveys conducted by Johannes (2011, 2013, and 2015) in Capitol Lake also reviewed the surrounding area to document the spread of New Zealand mudsnail outside the immediate study area. In 2013, the New Zealand mudsnail was found for the first time near the mouth of the Deschutes River (Johannes 2013; USGS 2020).

The European ear snail was not found in any sites surveyed outside Capitol Lake (Johannes 2011a; Johannes 2013; USGS 2020). During surveys of Capitol Lake and the surrounding watersheds, the Asiatic clam was found in Black Lake and at one of its outlets, but no documented sightings in the Percival Creek that flows from Black Lake into Capitol Lake (Johannes 2013; USGS 2020).

4.2.2.2 Fish

There have not been any comprehensive surveys documenting the presence of common carp in and in waters flowing into Capitol Lake. Although common carp are documented in Long Lake (USGS 2020), most information on potential presence is based on literature reviews (Herrera 2004; Hayes et al. 2008).

The brown bullhead is documented in several waters surrounding Capitol Lake, including the Grass Lake Refuge, Black Lake, Chambers Lake, Hicks Lake, Long Lake, and Southwick Lake (USGS 2020). Black Lake flows through Black Lake Ditch and Percival Creek to Capitol Lake.

Several lakes surrounding Capitol Lake have documented presence of largemouth bass, including Black Lake, Trosper Lake, Barnes Lake, Susan Lake, Munn Lake, Hewill Lake, Ward Lake, Smith Lake, and Chambers Lake (USGS 2020). Some of these lakes are small and may be intentionally stocked for sport fishing.

Yellow perch are found in several lakes and streams surrounding Capitol Lake, including Black Lake, Ken Lake, Grass Lake Refuge, Trosper Lake, Hewitt Lake, Smith Lake, Chambers Lake, Long Lake, Hicks Lake, and Bigelow Lake (USGS 2020). Some of these lakes are small and may be intentionally stocked for sport fishing.

4.2.2.3 Mammal

Outside Capitol Lake, nutria is also found above the mouth of the Deschutes River upstream of the South Basin, but not above Tumwater Falls (USGS 2020).

4.2.3 Presence in Budd Inlet

European Green Crab (UW 2020)

Invasive species are problematic for urban estuaries (Simenstad et al. 2005). In addition to the known AIS in the freshwater habitat, the Capitol Lake – Deschutes Estuary would be susceptible to invasion by nonnative marine species found in Puget Sound estuaries under the Estuary and Hybrid Alternatives and are described here. These species of concern include two invasive crabs, the European green crab (*Carcinus maenas*) and Chinese mitten crab (*Eriocheir sinensis*), which have yet to invade southern Puget Sound but are prone to inhabit several estuaries from California to British Columbia. The European green crab was discovered on the Washington coast in 1998 in Willapa Bay and Grays Harbor, and later in Makay Bay (WDFW 2022). Since 2016, they have been detected in San Juan Islands, Padilla Bay, Drayton Harbor, Lummi Bay, Sequim Bay, Dungeness National Wildlife Refuge, and Hood Canal, among other areas. As of early 2022, European green crabs have not been detected within Puget Sound south of Admiralty Inlet. Chinese mitten crabs have been detected in the Columbia River but no other Washington waters (USGS 2020).

Other high-priority invasive marine animal species for Washington state include the Asian marine clam (*Corbula amurensis*), tunicates (sea squirts), and Atlantic salmon (*Salmo salar*) (University of Washington 2020). Three invasive tunicate species are present in Puget Sound, while the Asian marine clam has not been observed in Washington and Atlantic salmon have never established a reproducing population in Puget Sound.

5.0 Impacts and Mitigation Measures

5.1 OVERVIEW

This section describes the probable significant impacts related to aquatic invasive plants and animals from the No Action Alternative (Section 5.2), Managed Lake Alternative (Section 5.4), Estuary Alternative (Section 5.5), and Hybrid Alternative (Section 5.6). This section also identifies mitigation measures that could avoid, minimize, or reduce the identified impact below the level of significance.

5.2 NO ACTION ALTERNATIVE

Under the No Action Alternative, Capitol Lake would remain closed to the public and AIS would continue to be managed using containment and other methods aimed at maintaining low population densities. The New Zealand mudsnail population is not likely to substantially increase within the lake or move far outside the lake because it appears not to have done so in at least six years between its introduction in 2009 and the most recent monitoring in 2015, particularly in the absence of public access and the lack of reported sightings since 2015. Similarly, in the absence of public access or meaningful intervention, the populations of other AIS invertebrates, fish, and mammals would be expected to continue to expand at current low rates. Based on this, under the No Action Alternative, the risk for AIS in Capitol Lake to spread to otherwise non-invaded water bodies is expected to be **less-than-significant**.

5.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

The action alternatives have in common several adverse impacts and beneficial effects associated with construction and operation. The extent of these impacts related to AIS may vary between alternatives and are addressed under the impacts and mitigation described for each alternative section. The goal for AIS management under all action alternatives is to prevent the spread and further distribution of AIS, with purple loosestrife and New Zealand mudsnails being the primary AIS of concern. The eradication of New Zealand mudsnails is assumed to not be feasible under any of the action alternatives regardless of the best management practices and mitigation measures implemented because of their resistance to extreme environmental factors and treatment, and their ability to reproduce and establish new populations from a single survivor. Eradication of the purple loosestrife is possible, but difficult.

5.3.1 Impacts from Construction

Construction-related impacts common to all action alternatives are associated with dredging and placement or export of dredged sediments.

Prior to construction of all action alternatives, Capitol Lake would be treated to significantly reduce AIS populations within the waterbody and reduce the risk of potential spread once construction activities began. Dredging and other construction activities would occur in in the North and Middle Basins. Most or all dredged material would be used within the basin to create habitat areas; this is a key design element to avoid or minimize the transport of AIS species from the project area.

Best management practices to reduce and contain turbidity during dredging would minimize the potential for substantial transport of invertebrate AIS over the 5th Avenue Dam and into Budd Inlet during construction. Turbidity levels would be less than existing conditions during large storm events so it is reasonable to conclude that plant fragments and invertebrate AIS would be contained through construction.

Dredging and placement of dredged material for habitat areas would occur where few Eurasian watermilfoil plants are located and would not likely affect the abundance of this species in the lake because most of the population is located along the southern shorelines of the Middle Basin and within the South Basin, which is largely outside the construction area. Similarly, purple loosestrife, yellow flag iris, and fragrant water lily are generally not located in the areas of dredging, constructed habitat, or new overwater structures. Based on pre-treatment of AIS throughout Capitol Lake, implementation of BMPs to reduce turbidity, and the small portion of the populations located within the construction areas, initial dredging of any action alternative would have **less-than-significant adverse impacts** related to AIS populations and distribution. Dredging and placement of dredge materials in the habitat areas may have **minor beneficial effects** due to removal and burial of some plant and invertebrate AIS.

Some dredge material would be transported out of the study area for the Estuary and Hybrid Alternatives, but export is not assumed under the Managed Lake Alternative. Thus, dredge sediment export would provide a potential vector for transmission of purple loosestrife seeds and invertebrate AIS outside the Capitol Lake Basin for two of the three alternatives. However, sediments exported from the Capitol Lake Basin during construction would be treated prior to transport. Treatment methods may include chemical (e.g., salt or Bayluscide) or physical (e.g., desiccation, heating or freezing) techniques that would need to be proven effective prior to transport. The sediment would only be disposed of at an approved upland site; the upland placement site may be monitored to ensure no purple loosestrife plants or other AIS become established. Therefore, there would be a **less-than-significant adverse impact** related to AIS outside the Capitol Lake Basin from export of sediment dredged during construction.

All construction equipment would be appropriately decontaminated before entering and leaving the site to prevent import or export of AIS, consistent with state-required protocol for work in areas of AIS. With these measures, construction would have **less-than-significant adverse impacts** related to changes in abundance and distribution, or potential import or export of AIS.

Construction of the action alternatives would have **no impacts** on fish and mammal AIS because these animals would avoid construction activities and would not be transported outside the Capitol Lake Basin.

5.3.2 Impacts from Operation

Operation of the action alternatives has a greater potential to impact the distribution and abundance of aquatic invasive plants and animals than the No Action Alternative due to resumption of active recreational use and recurring maintenance dredging.

Active use of the waterbody would be restored under the action alternatives following construction. Long-term operations common to all action alternatives with potential impacts related to AIS include:

- Recurring maintenance dredging to maintain target depths.
- Habitat area maintenance (including removing plant AIS).
- Recreational use involving pedestrian use and fishing from new boardwalks and a dock, and non-motorized watercraft access to the Capitol Lake - Deschutes Estuary.

The operation of the action alternatives is not likely to affect the abundance or distribution of aquatic invasive plants in Capitol Lake or other lakes in the study area, provided that the measures outlined in a project-specific AIS Management Plan and BMPs are implemented, including use of decontamination stations, educational signage and ongoing monitoring of AIS. The constructed habitat areas would increase the amount of shallow-water habitat preferred by the New Zealand mudsnail and other invertebrates. After being planted with native emergent, wetland, and upland native species, the habitat areas would increase the amount of forage and refuge habitat for nutria. The constructed habitat area varies among the action alternatives but would be small relative to the overall project area. Given the small amount of shallow water habitat for invertebrate AIS and forage/refuge habitat for mammal AIS, habitat areas would have a **less-than-significant adverse impact** related to AIS abundance and distribution. Within the habitat areas, Enterprise Services would continue to manage aquatic invasive plant species, limiting their expansion. As part of a Habitat Enhancement Plan for the constructed habitat areas, aquatic invasive plants would be removed and adaptive management actions taken as necessary to ensure native plant survivability.

The risk of expanding the distribution of AIS from maintenance dredging is considered low because prior to construction, the Capitol Lake Basin would be treated to substantially reduce and/or eradicate plant and invertebrate AIS. The handling of sediment dredged during maintenance dredging varies by alternative and is discussed in more detail below. Maintenance dredging would have **no impact** on the distribution or population size of fish or mammal AIS.

Under all action alternatives, portions of the basin would be open to pedestrian traffic and fishing along the boardwalks and dock, and to non-motorized boating activity limited to watercraft carried by hand. Motorized watercraft would be prohibited from launching from the hand-carried boat launches that are established in the Capitol Lake Basin. While there would be no physical barrier prohibiting access of motorized vessels under the Estuary and Hybrid Alternative, there would be a relatively low clearance (e.g., less than 6 feet at high tide) for motor boats to pass under the new 5th Avenue Bridge, which would limit motorized vessel access from Budd Inlet. The 5th Avenue Dam would remain a barrier to all boats under the Managed Lake Alternative. The hand carried boat launches would not be constructed to support motorized vessels.

The risk for importation of new plant AIS or exportation of existing plant AIS from reintroduced boating in the Capitol Lake Basin would be low because plant AIS are primarily imported and exported to water bodies by plant fragments and seeds that collect in or on motorized watercraft and launching devices (i.e., boats and trailers). Hand-carried nonmotorized watercraft can become contaminated with plant fragments, seeds, New Zealand mudsnails, and other AIS through external contamination of watercraft or gear (e.g., mud-caked on hull and plant fragments on attached gear) or by contaminated footwear while launching or retrieving watercraft. A critical component of the action alternatives is the installation and operation of decontamination stations at the designated boat access locations, and at the reestablished fishing dock in the Middle Basin for use prior to and after launching/fishing.

Access and potential transport of AIS would be addressed in the AIS Management Plan. For pedestrians, education signs would be installed at strategic locations to warn people of the presence of AIS and direct citizens to use decontamination stations to prevent further spread. WDFW's AIS Unit will be consulted during development of the decontamination stations and their installation and maintenance, as well as adaptive management actions based on use and effectiveness information. As a result, operation of the action alternatives would have **less-than-significant adverse impacts** related to plant AIS because operations are not anticipated to substantially affect the abundance and distribution of invasive plant populations within or outside the study area.

The increase in traffic and activity on the shoreline and in the water would increase opportunity for the New Zealand mudsnail to spread outside Capitol Lake. New Zealand mudsnails can survive for long periods of time on hard material, such as shoes, watercraft, and other recreational equipment. To avoid and minimize this impact, decontamination stations would be installed, maintained, and operated for all action alternatives at a new boat launch in Marathon Park, the existing boat launch at Tumwater Historical Park and at the Interpretive Park for decontaminating footwear, fishing gear, and non-motorized vessels used in Capitol Lake. A decontamination station may also be installed at the West Bay Park boat launch, if needed, under the Estuary and Hybrid Alternative given the ability for boats to travel from Budd Inlet to the Capitol Lake Basin once the 5th Avenue Dam is removed. Decontamination of vessels and gear is highly effective in stopping the spread of New Zealand mudsnail to other waterbodies. Foot access to the water would also be restricted to areas where decontamination stations exist and decontamination of boots at a decontamination station would be required.

Lake Whatcom Decontamination Station (T. Ward)

A similar approach has been implemented in Whatcom County, where boats and equipment are inspected at four checkpoints before entering Lake Whatcom and Lake Samish to ensure they are clean, drained, and dry and are not transporting aquatic invasive species (Lake Whatcom Management Program 2022). Boats are decontaminated at a checkpoint if there are deemed to be an AIS threat, which was performed on less than 10 percent of the inspected boats. The main AIS of interest in Whatcom County lakes are the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*D. bugensis*), but the program also inspects for the New Zealand mudsnail, Asian clams, Eurasian watermilfoil, and other invasive plants.

Monitoring by WDFW has shown that this program has been effective in preventing the introduction of zebra or quagga mussels to Whatcom County as none have been found in the lakes since the program began 10 years ago. To date, the program has conducted almost 100,000 inspections and has intercepted 29 boats transporting or suspected of transporting zebra or quagga mussels, 1,366 boats transporting vegetation, and another 3,579 boats that were either wet or found to be transporting standing water. In 2018, the program detected New Zealand mudsnails in Lake Padden and has since detected them in nearby streams. No mudsnails have been detected in Lake Whatcom, Lake Samish, or at any of the four checkpoints. Non-motorized watercraft usage hit record highs during the pandemic in 2020 and 2021.

The action alternatives would also include educational signs that warn recreational lake users of the presence of New Zealand mudsnails and their potential to spread. Signage would notify recreationalists that water access is only permitted in areas where a decontamination station is provided; this helps to ensure decontamination is occurring. While the educational signs would not entirely prevent further spread of New Zealand mudsnails, they would inform the public of the importance and requirement of using the decontamination stations.

The decontamination stations initially would be attended to educate users and ensure 100 percent compliance during observation hours. Attended stations would be staffed by trained personnel to provide inspection and decontamination of all watercraft and personal equipment. It is anticipated that the stations would be attended during daylight hours every day of the week except holidays. Monitoring would be conducted to confirm and track the use and effectiveness of attended stations. If monitoring indicates recreationalists are effectively using the stations and very few AIS are present on equipment, then the stations may be converted to unattended stations in the future. Effective use of education and decontamination stations is considered necessary to reduce impacts to **less-than-significant** levels for the spread of AIS.

5.4 MANAGED LAKE ALTERNATIVE

5.4.1 Impacts from Construction

In addition to impacts common to all action alternatives, construction impacts of the Managed Lake Alternative related to AIS would primarily be associated with the following:

- Dredging in the North Basin and using dredge material to create habitat areas. Maintaining dredged material within the system is a key design element that avoids the transport of AIS species from the project area.
- Repairing the 5th Avenue Dam.

Impacts from initial dredging and other construction activities would be as described in Section 5.3.1. Implementation of best management practices during construction would limit the potential export or import of plant and invertebrate AIS resulting in **less-than-significant adverse impacts** and some **minor beneficial effects** related to potentially burying aquatic invasive plants and New Zealand mudsnails. There would be **no impacts** associated with repairing the 5th Avenue Dam because all repair work would be contained with the spillways, conducted overwater, or conducted on the Budd Inlet side of the dam where no known freshwater invasive species are present. Construction of the Managed Lake Alternative would have **no impacts** on fish or mammal AIS.

5.4.2 Impacts from Operation

Operational impacts of the Managed Lake Alternative related to AIS would generally be as described in Section 5.3.2, impacts common to all alternatives. Active use of the project area would be restored following construction with impacts primarily associated with the following:

- Recurring maintenance dredging in the North Basin to maintain target depths
- Pedestrian and bicycle use on boardwalks
- Non-motorized boating in the lake
- Fishing from a reconstructed dock and boats

Operation of the Managed Lake Alternative would have **less-than-significant adverse impacts** related to plant and animal AIS because operations are not anticipated to substantially affect the abundance and distribution of invasive plant and animal populations within or outside the study area.

Under the Managed Lake Alternative, maintenance dredging would occur in the North Basin. The sediment that is exported after maintenance dredge events would be chemically or physically treated, as required by AIS transportation regulations, to prevent the transport of live New Zealand mudsnails. After treatment and during transport, sediments would be covered and only disposed of at an approved upland site. The upland placement site may be monitored to ensure no AIS become established at the placement site.

Material dredged from the Managed Lake would not be suitable for placement at an open water disposal site in Puget Sound because of the presence of the New Zealand mudsnail, which is not expected to be eradicated from the freshwater environment and would persist at the high densities similar to those under the No Action Alternative. Best management practices and compliance with AIS transportation regulations would result in **less-than-significant adverse impacts** related to changes in abundance and distribution of New Zealand mudsnails and other invertebrate AIS. Maintenance dredging activities would have **no impact** on the distribution or population size of fish or mammal AIS.

Portions of the lake would be open to pedestrian traffic along the boardwalks and dock, and to non-motorized boating activity limited to watercraft carried by hand. The impacts associated with increased recreational use would be as described in Section 5.3.2. Effective use of educational signage and decontamination stations would result in **less-than-significant adverse impacts** related to the spread of New Zealand mudsnails and other invertebrate AIS to other freshwater bodies. There would be the opportunity to introduce AIS to Capitol Lake from outside sources, but the potential for new AIS to be introduced to Capitol Lake would be minimized by using decontamination stations upon both entry and exit from the lake.

The reintroduction of fishing within Capitol Lake would have **minor beneficial effects** by reducing invasive fish species. This management approach is effectively used in other systems for controlling AIS populations. There would be **no impact** on mammal AIS.

5.5 ESTUARY ALTERNATIVE

5.5.1 Impacts from Construction

Construction impacts of the Estuary Alternative related to AIS would generally be as described in Section 5.3.1, impacts common to all alternatives. Construction impacts related to AIS associated with the Estuary Alternative primarily relate to the following activities:

- Dredging in the North Basin and Middle Basin and using dredged material to create habitat areas in both basins. Maintaining dredged material within the system is a key design element that avoids or minimizes the transport of AIS species from the project area.
- Removing the 5th Avenue Dam following the completion of dredging and habitat area construction, allowing the entire Capitol Lake Basin to become filled with marine water, creating a brackish estuarine environment.

In addition to impacts common to all action alternatives, construction impacts of the Estuary Alternative on aquatic invasive plants and animals would primarily be associated with removal of the 5th Avenue Dam. Implementation of best management practices and decontamination during dredging and other construction activities would limit the potential export or import of plant and invertebrate AIS resulting in **less-than-significant adverse impacts**. Best management practices to reduce and contain turbidity during dredging would result in **less-than-significant adverse impacts** as actions are not anticipated to significantly increase transport of AIS outside the Capitol Lake Basin. Removal and burial of a small proportion of the plant and invertebrate AIS populations would result in **minor beneficial effects**.

Although the Capitol Lake Basin would be treated prior to construction, removing the 5th Avenue Dam could have **significant adverse impacts** from the potential transport of purple loosestrife, if any plant fragments or seeds remained viable after treatment. Purple loosestrife seeds are salt tolerant and could become plants if they settle near a freshwater stream or river mouth. Impacts would be avoided if the purple loosestrife population in Capitol Lake is eradicated or dramatically reduced several years before dam removal to eliminate viable seeds in sediments (see mitigation measures described in Section 5.7). Dam removal would have **no impact** related to the spread of other invasive plant species in Capitol Lake because these species have a general lack of salt tolerance so they are unlikely to successfully travel and become established in a nearby freshwater stream or river; or if they do become established, they are unlikely to impact native species due to their common presence in the region.

Dam removal could also flush a significant number of New Zealand mudsnails into Budd Inlet, but it is assumed there would be a high mortality from this initial flush. New Zealand mudsnails transported downstream after dam removal would not have had saltwater exposure and therefore, high mortality is expected. Some New Zealand mudsnails could potentially drift on floating debris to freshwater streams and rivers discharging to the Puget Sound shoreline. However, the current operation of the 5th Avenue Dam does not serve as a significant barrier to the movement of New Zealand mudsnails into Budd Inlet, so removal is not predicted to significantly increase its risk of spread into Budd Inlet (Johannes 2021, 2022) compared to conditions that have existed since their establishment in Capitol Lake. The rate of transport to Budd Inlet may increase with dam removal due to sediment scour during low tide, but the potential spread of New Zealand mudsnails outside of the project area would have **less-than-significant adverse impacts** if mitigation measures are implemented to reduce transport by reducing the population in Capitol Lake prior to removing the dam, as described further as mitigation measures in Section 5.7.

Construction of the Estuary Alternatives would have **no adverse impacts** related to fish and mammal AIS because these animals would avoid construction activities and would not be transported outside the Capitol Lake Basin. Fish AIS would be transported outside the basin during dam removal but are unlikely to survive transport in marine waters to become established in a stream or river.

5.5.2 Impacts from Operation

Operational impacts of the Estuary Alternative related to AIS would generally be as described in Section 5.3.2, impacts common to all alternatives. Active use of the project area would be restored following construction with impacts related to AIS primarily associated with the following:

- Recurring maintenance dredging would occur in impacted areas of West Bay.
- Pedestrian and fishing use of boardwalks and docks along the shoreline.

- Access to the estuary would be open to recreational non-motorized watercraft and decontamination stations would be provided in Marathon Park, Tumwater Historical Park Interpretive Park, and potentially West Bay Park.
- Incidental use of the estuary may occur via boat access from Budd Inlet, though the low trestle design of the new 5th Avenue Bridge would restrict access to some motorized vessels during high tides.

5.5.2.1 Aquatic Invasive Plants

The impact of recreational access on aquatic invasive plants under the Estuary Alternative would be as described in Section 5.3.2, impacts common to all alternatives. Enterprise Services would continue to manage aquatic invasive plant species, limiting their expansion.

Removal of the 5th Avenue Dam could increase the long-term movement of seeds and plant fragments into Budd Inlet downstream of the study area. However, transport of AIS occurs under existing conditions when sediment and other debris is discharged during high river flow events. These events are defined as levels of 11 feet or more on the Deschutes River near the Rainier Station, and were examined on the National Weather Service, Advanced Hydrologic Prediction Service (NOAA 2020). In the past 20 years, the Deschutes River exceeded flood stage 25 times at an average frequency of around once per year (NOAA 2020). During these events, seeds, plant fragments and other debris are moved over the 5th Avenue Dam and into West Bay. And despite this transport, the population and distribution of AIS have not measurably increased outside of the project area. Comparatively, under the Estuary Alternative, there will be fewer freshwater plant AIS populations due to saltwater affecting their abundance. Therefore, the introduction of saline waters in the Estuary Alternative would likely have **minor beneficial effects** related to decreased distribution and abundance of freshwater plant AIS, primarily those saltwater-intolerant species other than purple loosestrife. The eradication of saltwater-intolerant plant AIS would not be a substantial beneficial effect because the populations are low and these plants are commonly present in nearby lakes.

Purple loosestrife is the only freshwater plant AIS within the Capitol Lake Basin that is tolerant of saltwater. Treatment would occur prior to construction in an attempt to eradicate the species, but some plant fragments or seeds may still exist. Thus, purple loosestrife may not be eradicated when saline waters enter the Capitol Lake Basin after dam removal.

Other plant species have low to no tolerance to brackish water and would likely be eliminated in the North and Middle Basins, but these species may survive the low salinities expected in the South Basin, Percival Cove, and the Interpretive Center ponds. Enterprise Services would continue to manage the remaining aquatic invasive plant species, limiting their abundance and distribution. The risk of new plant AIS invading the estuary would be low due to saline conditions and boat launching being limited to hand carried watercraft; and motorboats from marine waters are not likely to carry marine or freshwater AIS plants and would not travel close to vegetated areas of the estuary shoreline.

The risk for importation of new plant AIS or exportation of existing plant AIS from reintroduced boating in the Capitol Lake Basin would be low because boat launching would be limited to hand-carried watercraft at designated boat access locations. Decontamination stations would also be provided and staffed at these locations as described in Section 5.3.2. Also, if incidental motorboat or non-motorized watercraft access occurs via Budd Inlet to the Estuary Alternative, the vessels would have limited contact with plant fragments and seeds that exist along the shoreline in shallow water, which is not conducive to boating. Thus, recreational access would result in **less-than-significant adverse impacts** to plant AIS.

Maintenance dredging of impacted areas of West Bay would have **no impact** on plant AIS because none would be present in the saline waters.

5.5.2.2 Aquatic Invasive Animals

The impact of recreational access on aquatic invasive animals under the Estuary Alternative would be as described in Section 5.3.2, impacts common to all alternatives.

Following the removal of the dam and the initial flush, several freshwater aquatic invasive animals that are tolerant of brackish water would continue to be present near freshwater sources, although with much more limited distribution and abundance. Removal of the dam barrier would increase the potential for suspended New Zealand mudsnails, either individually or attached to debris, to be washed into Budd Inlet by high river flow during low tides. However, the current operation of the 5th Avenue Dam does not appear to serve as a significant barrier to the movement of New Zealand mudsnails into Budd Inlet, and these species have not appeared to colonize Budd Inlet in the past 10 years of dam operations. Therefore, removal of the 5th Avenue Dam is not expected to significantly increase the risk of spread into Budd Inlet (Johannes 2021, 2022).

Exported New Zealand mudsnails could settle at the shallow mouths of streams feeding Budd Inlet, and possibly beyond. However, there is no indication that these streams have become infested since the New Zealand mudsnails invaded the lake in 2009 and, presumably, they have been discharged through the dam in high river flows. Although river discharge rates would not increase with the Estuary Alternative, sediment and debris input to Budd Inlet would increase without the 5th Avenue Dam.

After an initial reduction in population associated with introducing saltwater into a freshwater environment, the mudsnail population may increase from post-treatment/construction levels over time in the Capitol Lake Basin as they become acclimatized to estuarine waters under the Estuary Alternative, which has occurred in the Columbia River Estuary (Hoy et al. 2012). Given the apparent lack of downstream spread over the past 10 years and the significantly decreased abundance expected in the Estuary Alternative, the potential increase in transport and survival outside the study area by the dam removal would have a **less-than-significant adverse impact** on New Zealand mudsnails because they do not thrive in a saltwater environment.

As described in Section 5.3.2, the increase in pedestrian and non-motorized watercraft use would increase the potential for spread of invertebrate AIS outside the study area. Although the New Zealand mudsnail population would be significantly reduced by the conversion to a brackish environment, the increase in activity on and around the estuary would potentially increase spread of New Zealand mudsnails to other freshwater bodies by equipment (boots and boats) contacting estuary. Any incidental motorboat access from Budd Inlet is not likely to import or export invertebrate AIS from the estuary because they are not likely to contain invertebrate AIS upon entering the estuary or to contact nearshore sediments where the AIS may continue to be present within the estuary.

Although launching motorized boats into the former lake basin would be prohibited, motorboat access to marine waters within the former lake basin would not be prevented for the Estuary and Hybrid Alternatives. However, the new 5th Avenue Bridge would be a low trestle design that would restrict boat access at high tides. Additionally, there is a low risk for marine motorboats contacting freshwater inputs with mudsnails because of shallow depths at the nearshore inputs. It is unlikely that a mudsnail attached to a marine motorboat would survive the transport from a freshwater input through Budd Inlet and into a freshwater lake or river.

The implementation of educational signs and decontamination stations described in Section 5.3.2.2 would dramatically reduce the potential spread to a **less-than-significant adverse impact** on invertebrate AIS.

Although most of the fish AIS are somewhat tolerant of brackish water found in estuaries, few, if any, would be expected to establish themselves in a brackish habitat or in other freshwater habitats along the Puget Sound shoreline. Therefore, removing the 5th Avenue Dam would have a **less-than-significant adverse impact** on fish AIS because there would not be a substantial increase in abundance or distribution outside of the study area.

Nutria are found in brackish and saltwater environments and would tolerate the transition to an estuarine environment. Because their distribution is not limited by the 5th Avenue Dam, the dam removal would have **no impact** on nutria.

Recreational use of the estuary would have **no impact** on any remaining fish or mammal AIS populations.

Maintenance dredging under the Estuary Alternative would occur in impacted areas of West Bay only, not within the Capitol Lake Basin. The New Zealand mudsnail is not expected to be in the sediment that would be dredged under the Estuary Alternative because of the salinity levels within West Bay and because maintenance dredging would occur in deeper water used for navigation. In addition, the dredged sediments would have primarily originated from the Deschutes River, which does not have an established population of New Zealand mudsnails.

Although New Zealand mudsnails are tolerant of higher salinity levels that can be found in West Bay, few if any are assumed to be present at the target dredging depths because the New Zealand mudsnail prefers shallow water habitat. For this reason, sediment dredged during the maintenance dredging could be suitable for placement at an open water disposal site in Puget Sound. The sediment would have to be sampled for New Zealand mudsnails and purple loosestrife seeds to demonstrate suitability, treated (if necessary), and the environmental agencies with jurisdiction would have to approve the in-water placement. Suitable open water disposal sites located farther from sensitive freshwater sources and Budd Inlet may be considered as alternatives to the Anderson-Ketron Island Disposal Site to further minimize risk to spreading AIS. (Chemical suitability of the sediment would also have to be confirmed, refer to the *Sediment Quality Discipline Report* for more detail.) In-water placement of dredged sediment would result in a significant costs savings for the project compared to upland disposal; it also reduces truck trips from surface streets and the associated greenhouse gas emissions.

If the sediment is not suitable for in-water placement, it would be transloaded into trucks and hauled to an upland placement site, using BMPs consistent with those described for the Managed Lake Alternative.

Maintenance dredging activities would have **no impact** on distribution or abundance of invertebrate, fish or mammal AIS because no animal AIS would likely be present in the dredging area.

5.6 HYBRID ALTERNATIVE

5.6.1 Impacts from Construction

Construction impacts of the Hybrid Alternative related to AIS would generally be as described for the Estuary Alternative in Section 5.5.1. Construction impacts related to AIS associated with the Hybrid Alternative primarily relate to the following activities:

- Dredging in the North Basin and Middle Basin and using dredge material to create habitat areas. Maintaining dredged material within the system is a key design element that avoids or minimizes the transport of AIS species from the project area.
- Removing the 5th Avenue Dam following the completion of dredging and habitat area construction, allowing the entire Capitol Lake area to become filled with saltwater, creating a brackish estuarine environment. A smaller freshwater reflecting pool would also be developed.

The impact of construction activities on aquatic invasive plants and animals under the Hybrid Alternative would be as described for the Estuary Alternative in Section 5.5.1. For most plant and invertebrate AIS, construction activities would have **less-than-significant adverse impacts** or **minor beneficial effects**. Although the Capitol Lake Basin would be treated prior to construction, removing the 5th Avenue Dam could have **significant adverse impacts** related to the distribution and spread of purple loosestrife, if any plant fragments or seeds remained viable after treatment. There would be **no impacts** related to plant AIS from constructing the reflecting pool.

Dam removal could also flush a significant number of New Zealand mudsnails into Budd Inlet that could potentially drift to freshwater streams and rivers discharging to the Puget Sound shoreline. The potential spread of New Zealand mudsnails outside of the project area is considered a **less-than-significant adverse impact**. The current operation of the 5th Avenue Dam does not appear to serve as a significant physical barrier to the movement of New Zealand mudsnails into Budd Inlet, so removal is not predicted to significantly increase its risk of spread into Budd Inlet (Johannes 2021). Measures to reduce New Zealand mudsnail populations in Capitol Lake prior to the removal of the dam would be implemented to further reduce the potential spread. Construction activities would have **no impacts** on fish and mammal AIS.

5.6.2 Impacts from Operation

Operational impacts of the Hybrid Alternative related to AIS would be as described for the Estuary Alternative in Section 5.5.2. Active use of the project area would be restored following construction with impacts related to AIS primarily associated with the following:

- Recurring maintenance dredging would occur in impacted areas of West Bay.
- Pedestrian and bicycle use of boardwalks along the shoreline.
- Access to the estuary would be open non-motorized watercraft and decontamination stations would be provided in Marathon Park, Tumwater Historical Park and Interpretive Park, and potentially West Bay Park.
- Incidental use of the estuary would also occur via boat access from Budd Inlet.
- The reflecting pool would be fed by groundwater and maintained as a freshwater pool.

The impacts associated with the operation of the Hybrid Alternative would be as described for the Estuary Alternative in Section 5.5.2. Recreational access would result in **less-than-significant adverse impacts** to plant AIS. The introduction of saline waters in the Hybrid Alternative would likely have **substantial beneficial effects** on the distribution and abundance of freshwater plant AIS, primarily those saltwater intolerant species other than purple loosestrife.

The potential increase in downstream transport of invertebrate AIS outside the study area from removal of the 5th Avenue Dam would have a **less-than-significant adverse impact** on New Zealand mudsnails due to the reduced population expected in the estuarine waters. Dam removal would have **less-than-significant impacts** on fish AIS and **no impact** on nutria.

The implementation of educational signs and decontamination stations would dramatically reduce the potential spread to a **less-than-significant adverse impact** on invertebrate AIS. Recreational use of the estuary would have **no impact** on any remaining fish or mammal AIS populations.

Maintenance dredging of impacted areas of West Bay would have **no impact** related to plant AIS because none would be present. Maintenance dredging activities would have **no impact** on distribution or abundance of invertebrate, fish, or mammal AIS because no animal AIS would likely be present in the dredging area.

Operation of a freshwater reflecting pool would require ongoing maintenance to maintain water quality and manage AIS. AIS eradication is considered possible by chemical treatment of the pool because, unlike Capitol Lake, inflow and outflow could be regulated and the pool would not be naturally flushed by large volumes of river or tidal waters to dilute the added chemical and reduce chemical contact time.

Also, potential refuge areas from treatment would be minimal due to the limited amount of shoreline habitat and structures in the constructed pool. If AIS are not successfully eradicated, the implementation of educational signs and a decontamination station at the reflecting pool would dramatically reduce the potential spread to a **less-than-significant adverse impact** related to plant or invertebrate AIS. Recreational use of the pool would have **no impact** on any remaining fish or mammal AIS populations.

5.7 AVOIDANCE, MINIMIZATION, AND MITIGATION MEASURES

Enterprise Services would avoid and minimize potential impacts by complying with regulations, permits, plans, and authorizations. These anticipated measures, and other mitigation measures that could be recommended or required, are described below.

5.7.1 Measures Common to All Action Alternatives

5.7.1.1 AIS Management Plan

An AIS adaptive management plan, in consultation with affected jurisdictions, would be developed and implemented for the preferred alternative during the future phase. Elements of the adaptive management plan would vary depending on the alternative and AIS abundance, and generally include:

- Conduct monitoring of New Zealand mudsnails to identify their abundance within Capitol Lake and adjacent waters and of purple loosestrife seeds to identify their abundance and viability in lake sediments.
- Determine which chemical treatment tests should be conducted and can be permitted by Ecology's National Pollutant Discharge Elimination System (NPDES) permit program and the associated treatment restrictions for reducing the New Zealand mudsnail population before construction to reduce its potential spread during construction.
- Design and conduct New Zealand mudsnail treatment tests with chemicals known to be effective by application to lake waters or exposed sediments during a drawdown, and with site-specific environmental controls using saltwater backflushing and drawdown desiccation or burning without chemicals.
- Obtain experimental use authorization to apply and test effectiveness of select chemicals that are not included in the Aquatic Invasive Species Management Permit (Ecology 2020b), and add effective chemicals to a future permit update for site-wide use prior to construction.
- Prepare and implement a New Zealand mudsnail treatment plan using the preferred methodology if and where the population is large enough to warrant treatment.
- Prepare and implement a purple loosestrife treatment plan with a goal of eradication before construction begins to avoid or minimize downstream migration of seeds during operations.
- Specify best management practices for avoiding or minimizing the export of AIS through the dam during construction, such as the use of turbidity curtains and AIS monitoring.

- Conduct long-term monitoring of New Zealand mudsnails and purple loosestrife in the study area and adjacent waters to track changes in abundance for adaptive management.
- Research and design attended or unattended decontamination stations and establish a maintenance and monitoring plan to ensure their continued effectiveness.
- Design and install education signs at strategic locations to inform citizens of the AIS threat and requirements for preventing their spread.

5.7.1.2 During Construction

No transport of High Priority AIS outside of Capitol Lake is allowed by state law RCW 77.135. No transport of High Priority AIS, as designated by WISC, in the Capitol Lake Basin include purple loosestrife, Eurasian watermilfoil, New Zealand mudsnail, and nutria. The risk for AIS transport would be reduced to low by implementing the following best management practices during construction:

- Aquatic conveyances entering and leaving Capitol Lake would meet "clean, drain and dry" requirements under RCW 77.135.110 as described by WDFW (2016). These requirements, in consultation with WDFW's AIS Unit, will be established in the AIS Management Plan.
- Operators of aquatic conveyances, such as vessels and construction equipment to be used in Capitol Lake would obtain an Aquatic Invasive Species Permit from WDFW that sets forth prevention and decontamination requirements and how to prevent the spread of AIS prior to work in the study area per WAC 220-640-100. Most to all dredge material from construction would remain within the system to further avoid potential spread of AIS. Dredge material exported for the Estuary and Hybrid Alternatives would be treated to remove viable AIS before transportation to an approved upland location as described for maintenance dredging during operation.

5.7.1.3 During Operation

During maintenance dredging, vessels and dredging equipment would follow the same regulatory requirements described for construction above. All transported dredge material would follow the AIS management plan for transport and any upland disposal of dredge materials containing viable purple loosestrife seeds or New Zealand mudsnails, which includes:

- Treating materials in trucks or railcars to kill New Zealand mudsnails.
- Covering dredge materials to prevent loss of viable seeds or mudsnails during transport.
- Covering dredged material at an upland beneficial reuse or disposal site with a soil layer, not disturbing the disposed materials for a specified period.
- Post-placement monitoring of the upland beneficial reuse or disposal site for a specified duration to ensure no plant growth at the site.
- Conduct sampling of material dredged from West Bay under the Estuary and Hybrid Alternatives to determine whether high priority plant or invertebrate AIS exist within the sediment. If sampling demonstrates that the material is free of AIS, and is chemically suitable, it would be disposed of at an open water disposal site in Puget Sound.

Boat and foot access would be restricted to reduce the potential spread of New Zealand mudsnails from the project area for all action alternatives. Non-motorized boat access would be restricted to permanent attended or unattended decontamination stations located in Marathon Park, Tumwater Historical Park, and Interpretive Center for all built alternatives, and possibly in West Bay Park under the Estuary and Hybrid Alternatives. All recreational boats arriving and leaving the stations would be decontaminated to prevent spread of AIS both into and from the area, but would not be required to obtain an Aquatic Species Permit. Boat and equipment decontamination would be performed by a trained inspector at an attended decontamination station or would be performed by the user at an unattended decontamination station. Operations of attended or unattended decontamination stations will be determined for the AIS Management Plan based on the observed New Zealand mudsnail population and risk for offsite transport. Recreational boats would be inspected and decontaminated prior to launching at the decontamination stations to prevent introductions of AIS from other waters in accordance with the AIS Management Plan.

5.7.2 Measures Specific to Each Action Alternative

5.7.2.1 Managed Lake

The following measures could reduce impacts related to the spread of AIS. These measures could be implemented in addition to those that would be included in regulatory authorizations.

Construction

As part of the AIS Management Plan, a New Zealand mudsnail treatment plan would be prepared, in consultation with affected jurisdictions, with measures to significantly reduce the population prior to and perhaps during construction. This is a critical measure to avoiding or minimizing the spread of AIS during and after construction. The plan would consider the management approaches effective in managing mudsnails within Capitol Lake, which likely include backflushing, drawdown, freezing, desiccation, burning, and/or chemical treatment. The plan would propose the appropriate amount and duration of treatment to reduce the mudsnail population and obtain necessary authorizations for the treatment. An assessment of conditions within the study area would determine the mudsnail abundance and distribution and the frequency of treatment necessary to maintain low abundance. It would also outline measures to avoid the spread of any AIS outside of the study area, such as use of turbidity curtains to contain suspended sediment and debris that may contain AIS and monitoring of discharged waters for the presence of AIS.

Operation

Potential treatment options outlined in the AIS Management Plan could be used to control New Zealand mudsnail abundance and distribution around Capitol Lake if the population dramatically increases over the long term. Depending on efficacy during construction and permitting requirements, chemical treatments could continue to be applied following construction in coordination with the regulatory agencies. The chemical treatments may only target High Priority AIS such as New Zealand mudsnail, purple loosestrife, and Eurasian watermilfoil. Chemical treatments, including sodium chloride and Bayluscide, would be assessed based on New Zealand mudsnail distribution and density, targeting areas of the highest density. However, chemical treatments severely impact native species. It may be difficult to obtain a permit for large-scale chemical treatments of the lake; it is likely to require coordination with the Washington State Departments of Ecology and Fish and Wildlife and other regulatory agencies to authorize use of chemicals that are registered by USEPA but not specifically approved by the Aquatic Invasive Species Management Permit. Thus, the benefits and impacts of treatment would be carefully weighed during preparation of the AIS Management Plan.

While eradication is generally considered not to be feasible given the extent of the New Zealand mudsnail infestation and their resiliency, chemical treatment is a useful method for significantly reducing the population and limiting its spread outside the study area. It would also continue to avoid and minimize potential impacts from AIS to ecological functions and recreation within the project area. Periodic monitoring around sites of known presence and absence of New Zealand mudsnail populations would be used to ensure effectiveness of treatment and decontamination procedures.

5.7.2.2 Estuary and Hybrid Alternatives

The following measures could reduce impacts related to the spread of AIS under both the Estuary and Hybrid Alternatives. These measures could be implemented in addition to those that would be included in regulatory authorizations.

During Construction

As part of the AIS Management Plan, Enterprise Services, in consultation with affected jurisdictions, would prepare a treatment plan to significantly reduce AIS populations prior to and perhaps periodically during construction of the estuary and freshwater reflecting pool. This is a critical measure to avoiding or minimizing the spread of AIS during and after construction. The plan would consider backflushing, drawdown, freezing, desiccation, burning, and/or chemical treatment prior to construction and determine the amount and duration of treatment to reduce potential downstream transport from the study area. This treatment would likely impact freshwater native species; however, these species are not likely to survive under the Estuary and Hybrid Alternatives because of increased salinity and continued inflow of marine water during high tide.

Treatment would likely be performed for only purple loosestrife and New Zealand mudsnail due to their high saltwater tolerance and higher risk for infesting downstream waters. Purple loosestrife would be treated multiple times before construction to minimize the viable seed bank in the lake sediments. New Zealand mudsnails may require treatment on only one occasion after construction of the habitat areas and reflecting pool in case of contact with exposed organisms, and sufficient time should be allowed for chemical inactivation before dam removal or pool discharge. An assessment of conditions within the study area would determine the frequency necessary to maintain low distribution and abundance and limit the risk of spread outside the study area.

During Operation

Much of the New Zealand mudsnail and other AIS populations would be managed by the introduction of saltwater to the study area after removing the 5th Avenue Dam. Although many species are tolerant to brackish water, the estuarine habitat would be expected to significantly reduce their density and limit their distribution to freshwater sources within the study area, which would occur along shallow shoreline areas with continuous inflow from groundwater springs, storm drains, Percival Creek, and the Deschutes River. Due to the likely persistence of New Zealand mudsnails in upstream portions of the Estuary and Hybrid Alternatives and in the freshwater reflecting pool, additional mitigation measures such as targeted chemical treatments in areas of high concentrations may be needed to prevent potential significant adverse impacts to ecological functions or recreation from their continued presence. However, additional treatments may be severely limited or not permittable under estuarine conditions due to difficulties containing the chemical and in providing a sufficient contact time to be effective. Chemical treatments, including sodium chloride and Bayluscide, would be assessed based on New Zealand mudsnail distribution and density, targeting areas of the highest density. However, chemical treatments severely impact native species and are not currently authorized for use under the Aquatic Invasive Species Management Permit. It may be difficult to obtain a permit for large-scale application of chemical treatments of the estuary or reflecting pool, and would require coordination with the Washington State Departments or Ecology and of Fish and Wildlife to authorize use of chemicals that are registered by USEPA but not specifically approved by the Aquatic Invasive Species Management Permit. Thus, the benefits and impacts of treatment would be carefully weighed during preparation of the AIS Management Plan.

In addition to the decontamination stations in Marathon Park, Tumwater Historical Park and Interpretive Center for all action alternatives, decontamination stations could also be established within the City-owned West Bay Park for the Estuary and Hybrid Alternatives and in Heritage Park for the freshwater reflecting pool. Boat and equipment decontamination at West Bay Park would help to minimize the potential spread of high-priority species from boaters that may take out at this downstream location, after boating in the Capitol Lake Basin. A personal equipment decontamination station at the freshwater reflecting pool may be needed to prevent the spread of New Zealand mudsnails if eradication is not achieved during construction.

Restoring access to Budd Inlet by removing the 5th Avenue Dam could also provide a vector for estuarine and saltwater invasive species, such as the European green crab (*Carcinus maenas*), Chinese mitten crab (*Eriocheir sinensis*), the Asian marine clam (*Corbula amurensis*), tunicates (sea squirts), and Atlantic salmon (*Salmo salar*) (University of Washington 2020), to inhabit the project area. The presence of estuarine and saltwater high-priority species in the Estuary and Hybrid Alternatives should be monitored along with other aquatic invasive and nuisance species, so that immediate action can be taken if they are discovered. This expectation would be outlined in the AIS adaptive management plan.

5.7.3 Significant Unavoidable Adverse Impacts

There would be no significant unavoidable adverse impacts related to AIS under any of the action alternatives.

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Appendix A

2022 New Zealand Mudsnail Survey of Budd Inlet

Deixis Consultants

SURVEY FOR *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) IN THE WEST AND EAST BAYS OF SOUTHERN BUDD INLET, THURSTON COUNTY, WASHINGTON.

Potamopyrgus antipodarum (Gray, 1843). Height 4.7 mm.
Specimen from Capitol Lake, Olympia, Washington.

Final Report

Prepared for:
Washington State Department of Enterprise Services,
Olympia, Washington

EDWARD J. JOHANNES
May 10, 2022

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DISCLAIMER

SURVEY FOR *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) IN THE WEST AND EAST BAYS OF SOUTHERN BUDD INLET, THURSTON COUNTY, WASHINGTON.

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May 10, 2022

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INTRODUCTION

Background

Potamopyrgus antipodarum (Gray, 1843) (New Zealand mudsnail) (NZMS) has become a worldwide invasive species in fresh and brackish water habitats in Europe, Australia, Japan, and North America. In the U.S., Dwight Taylor first discovered the NZMS in the middle Snake River, Idaho (Taylor, 1987; Bowler, 1991). Since its discovery in the U.S. over three decades ago, the NZMS has spread to most western states, including Washington State. On October 22, 2009, it was discovered in Capitol Lake, Marathon Park, Olympia, Thurston County, Washington (Bartleson, 2010; Johannes, 2015). As a consequence of the Capitol Lake introduction, the U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife (WDFW), and Washington State Department of Enterprise Services (DES; formerly Washington Department of General Administration), jointly came together to manage and control the NZMS population. As part of the efforts to contain the NZMS introduction in Capitol Lake, DES had Deixis Consultants conduct a survey of Budd Inlet in 2011 for the NZMS (Johannes, 2011). Currently, DES is investigating all options regarding the management of Capitol Lake including the removal of the Fifth Avenue Dam holding back the lake (Floyd-Snider, 2016; Johannes, 2021). Of concern is the possibility that NZMS could spread into Budd Inlet if the dam is removed.

Budd Inlet Physical Characteristics

Budd Inlet is the southernmost water body in the Puget Sound, the city of Olympia lying at its southern end. As a result, the inlet's salinity is less when compared to the rest of the Puget Sound. In Budd Inlet, salinity measurements have been found to range between 27.96-29.5 ppt and 23-27 ppt (Olson-Forster, 1975; Schoch & Dethier, 1999). Salinity measurement taken near the Fifth Avenue Dam was found to be 28.7 ppt (Hallock, 2010). The inlet is approximately 7 miles long and 2 miles wide near its center. The West and East bays lie at its southern end divided by a peninsula. Because tidal range increases with distance from the Pacific Ocean in the Puget Sound, the second greatest tidal range is seen in Budd Inlet at 4.4 m (LOTT, 1998). The Deschutes River mouth was once an integral part of Budd Inlet, formerly consisting of intertidal mudflats that formed an estuary in West Bay. It is now occupied by an artificially created lake, Capital Lake, which is held back by the Fifth Avenue Dam, an earth dam with an 80-foot concrete spillway structure with two steel gates that open upward, allowing the lake to empty into the bay (George *et al*., 2006).

Previous Benthic Surveys of the Puget Sound Conducted near or in Budd Inlet

Several surveys for introduced and native marine species in Puget Sound were conducted by The Nearshore Habitat Program, Washington State Department of Natural Resources near or in Budd Inlet. One such survey, that was conducted over a decade before the discovery of NZMS in Capitol Lake, included a site at the northeast end of Budd Inlet at Boston Harbor Marina in 1998 (Cohen *et al.*, 1998). Some of the other surveys conducted before the discovery of NZMS in Capitol Lake were undertaken in or in adjacent inlets or bays to Budd Inlet (Schoch & Dethier, 1999, 2001; Cohen *et al.*, 2001; Deithier *et al.* 2003; Deithier, 2005, 2006; Deithier & Berry, 2008; Garono *et al.*, 2006). None of these surveys reported the occurrence of the NZMS in southern Puget Sound. In 2011 the first survey for the NZMS was conducted in Budd Inlet below the outfall of Capitol Lake at the Fifth Avenue Dam and nearby sites in West and East bays (Johannes, 2011). During that survey and this one most sites were found to have a strictly marine mollusk fauna. Site 2 adjacent to the Fifth Avenue Dam was found during the 2011 survey to have *Assiminea californica* (Tryon, 1865) (California assiminea) present. Despite the presence of this brackish water snail, no NZMS was found in Budd Inlet in the vicinity of this site adjacent to the dam outlet during the 2011 survey.

PROJECT DESCRIPTION

As was done in 2011, DES had Deixis Consultants conduct a survey of Budd Inlet for the NZMS (Johannes, 2011). A total of 3 days were conducted in the field on April 20, 21, and 22, 2022 to survey 23 sites. Eighteen sites surveyed in 2011 were revisited during this survey. Two of these sites (8 and 9) could not be accessed during this survey because the means of entry were blocked by fencing with posted no trespassing signs **(Appendix C, p. C4).** An additional 5 new sites in Budd Inlet were designated by the DES to be surveyed (**Figure 1**). Several sites are concentrated at the southern end of Budd Inlet near the outlet for Capitol Lake below the Fifth Avenue Dam. Two sites are located in creeks and 1 is in a spring in the Budd Inlet basin (**Figure 1**; **Appendix A**). The survey was conducted during a period of low tides occurring during daylight hours from April 18 to the 23 which allowed more access to the intertidal zone (**Appendix D**). Sites occur from the southern end of Budd Inlet at the Fifth Avenue Dam (outlet of Capitol Lake) north to Ellis Cove (**Figure 1**). A qualitative assessment of population densities was to be determined for NZMS at each site.

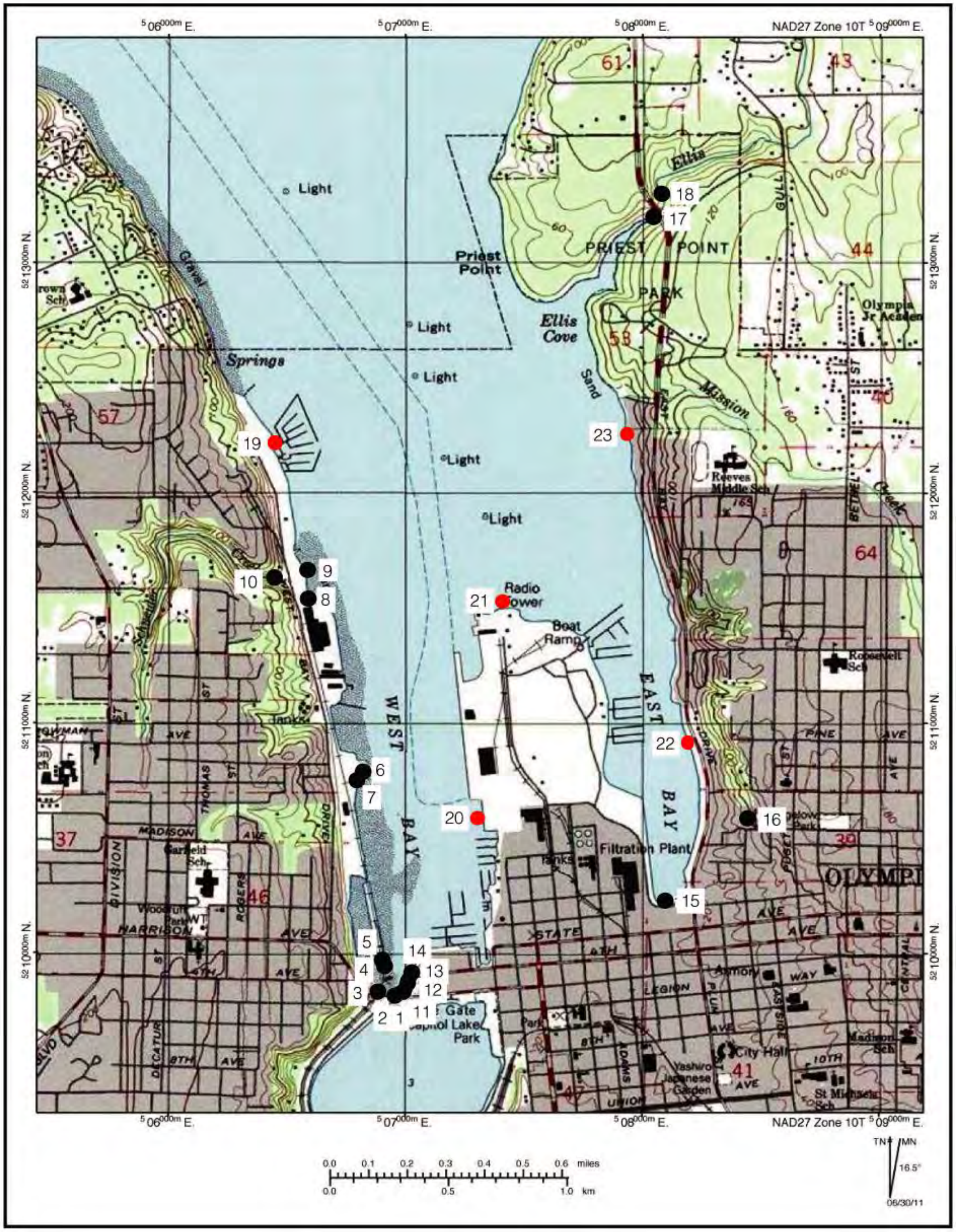

FIGURE 1. Map of Survey Area in Southern Budd Inlet, Olympia, Thurston County, Washington. Locations of numbered sites (see **Appendix A** and **B** for details). Sites indicated by black dotes were surveyed during the 2011 survey (Johannes, 2011). All, except sites 8 and 9, were revisited during this survey. Sites indicated by red dotes were added to this survey by DES. Map created with National Geographic TOPO!® ©2006. Base map USGS 1: 24,000 Tumwater 7.5' Quadrangle.

Methods

Field Collections

Standard methods in malacology were used to implement the survey. Search methods varied according to substrate type. In general, all sites were spot-sampled to ensure completeness of coverage and sampling of major subhabitats. In coarse substrate areas with cobbles or boulders, a random sample of stones was removed and scrubbed with a brush in a 7.5" X 13" clear plastic tray partially filled with water. After the stones were scrubbed the tray was examined for the NZMS. Areas with mud, sand or silt substrate were sampled by excavating small areas of bottom sediment to a depth of about 3 cm using a dip net with a 20 cm diameter and effective mesh size of 40 (Tyler equivalent 35 mesh: openings 0.425 mm). The net was shaken just above the water surface to allow the fine sediment to fall through the net. Any organic debris that did not go through was carefully "floated" out of the net leaving the heavier material behind. Small portions of the sieved substrate were dumped from the net into a 7.5" X 13" clear plastic tray partially filled with water. The substrate was thinly spread out in the tray and examined for NZMS in the field. This was repeated until the net was empty. The 2011 sites were relocated or the coordinates obtained for the 5 new sites designated by DES using a Garmin eTrex Vista® HCx GPS receiver. Each site required about 1 hour to sample. Notes on collection conditions, substrate, habitat, and associated flora and fauna were made at each site (see **Appendix A** for details). All sites were also photographed (**Appendix C**). Identification of marine mollusks, crustaceans, annelids, and marine plants was made in the field where possible. Photos were taken or dead examples collected when difficulties were encountered with identifications. Kozloff (2000), Jensen (1995), Harbo (1997), and Morris (1966) were consulted for the identification of the marine taxa.

Decontamination Procedures

Before leaving a site, any mud or sediment adhering to the rubber boots was removed, with a stiff-bristled brush if necessary. Decontamination protocols as suggested by Hosea & Finlayson (2005) were followed. Based on their results Formula 409® disinfectant was determined to be the best compromise in regards to effectiveness in killing the NZMS versus the corrosive impact on waders or rubber boots and other equipment; cost, availability, and toxicity to the user or environment. A Rubbermaid 10-gallon water cooler jug was used to contain a solution of 1:1 Formula 409® disinfectant with tap water where waders or rubber boots, dip nets and trays would be placed for 5 minutes after surveying a site. After being dipped into the 50% diluted Formula 409® solution they were rinsed in a water-filled bucket covered with a lid to prevent spillage. This water was disposed of later down the sewer. After being decontaminated and before proceeding to the next site waders or rubber boots, collecting gear, and trays were also visually examined for any adhering NZMS.

Laboratory Procedures

Identification of marine taxa in the field proved problematic at a few sites. Photos were taken, but, if necessary, only dead examples were collected for later examination in the lab. Identification of freshwater taxa (*Juga silicula*) was not problematic in the field and none were retained. Relaxation, fixation, and preservation using 70% ethyl alcohol were not necessary to preserve the material as no NZMS were found. None of the dead samples collected will be retained for further study.

RESULTS

A total of 21 sites were surveyed during this project. Sixteen sites were previously surveyed in 2011 (2 of these sites (8 and 9) could not be revisited during this survey) in which 3 had no mollusks present (1 marine and 2 freshwater sites; **Appendix A** and **B**). Eighteen marine sites, 1 spring, and 2 creeks were sampled. Introduced species (2 marine mollusks) were found at 2 sites (**Appendix A** and **B**). Most sites collected in Budd Inlet had a marine fauna present. There was observed during this survey a noticeable decrease in the diversity and abundance of the marine fauna when compared to the 2011 survey. The impact of the heat dome that occurred in late June through mid-July of 2021 possibly contributed to this decline. No NZMS were found at any of the sites.

DISCUSSION

Introduced Mollusks Found in Budd Inlet

A total of 7 introduced mollusks have been reported from Puget Sound (Cohen *et al.*, 1998). During this survey, only the introduced Pacific oyster (*Crassostrea gigas* (Thunberg, 1793)) and the Japanese littleneck (*Venerupis philippinarum* (Adams & Reeve, 1850)) were found (**Appendix B**). Two additional introduced mollusks were found during the 2011 survey. They were the softshell (*Mya arenaria* Linnaeus, 1758) and European Melampus (*Myosotella myosotis* (Draparnaud, 1801) (Johannes, 2011).

Introduced Mollusks

Common names, and species endings, are generally those of Turgeon *et al.* (1998) where possible. Higher taxonomic arrangement is that of Vaught (1989).

Family Ostreidae

Crassostrea gigas **(Thunberg, 1793) (Pacific oyster)**

This Japanese oyster was the first reported introduction to the Puget Sound region in 1875 (Cohen *et al.*, 1998). Introduced for aquaculture in 1917 to the Puget Sound region to replace the native Olympia oyster (*Ostrea conchaphila* (Carpenter, 1857)), which was seriously dwindling due to overharvesting (Kincaid, 1929). It has been considered by some to be an invasive species, where it is outcompeting native species, such as the Olympia oyster in Puget Sound, Washington.

Family Veneridae

Venerupis philippinarum **(Adams & Reeve, 1850) (Japanese littleneck)**

This Japanese clam was inadvertently introduced into British Columbia, Canada in 1936 when it was imported with the Pacific oyster (Harbo, 1997). It has spread from British Columbia south to California (Harbo, 1997). This is the only clam for which there has been extensive development of aquaculture in recent years in British Columbia and Washington (Harbo 1999).

CONCLUSIONS

The primary objective of this project was to survey southern Budd Inlet for the NZMS. The NZMS occurred at none of the 21 sites surveyed. Most, except for the freshwater sites, were dominated by a strictly marine fauna (**Appendix B**). Only site 2 near the Capitol Lake dam spillway had the brackish water mollusk species *Assiminea californica* present (Johannes, 2011). This species was not found during this survey. Based on the marine molluscan fauna found at surveyed sites, it is unlikely that the southern Budd Inlet maintains year-round salinity level low enough for the NZMS to survive there.

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APPENDIX A: SITE DESCRIPTIONS.

UTM coordinates (based on NAD27 all in Zone 10). Decimal latitude and longitude coordinates (based on WGS-84) Coordinates obtained using a Garmin eTrex Vista® HCx GPS receiver and confirmed with Google Earth. Elevations are derived from National Geographic TOPO!® ©2006 and Google Earth. Geographic names, road names, and numbers were confirmed using Google Earth. For a map of the sites see **Figure 1**. Sites 8 and 9 were not visited during this survey. The entries from the Johannes (2011) report for sites 8 and 9 are included here.

Site entry format: Project site number; locality name; coordinates (UTM; decimal latitude/longitude); quadrangle (name and year); county; state; drainage; geographic description; elevation; depth; locality remarks; habitat description; collector remarks; date collected, and collector.

Collector abbreviations are as follows:

EJ= Edward J. Johannes
BB= Bert Bartleson, Olympia, Washington

1. West of Fifth Avenue Dam spillway 1. Zone 10: 506,978E 5,209,831N; 47.04375, -122.90939. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Just below the high tide line on the W. side of the spillway of the Fifth Avenue Dam, below (N. of) 5th Ave W., West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Rip-rap boulders are mostly covered by *Balanus* just below the high tide line. *Mytilus trossulus* (live), *Lottia pelta* (live), and *Balanus glandula* (live). Cobbles were washed in the tray. No NZMS. 4/22/2022 EJ!

2. West of Fifth Avenue Dam spillway 2. Zone 10: 506,961E 5,209,825N; 47.04369, -122.90962. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. At or just below the high tide line on the W. side of the spillway of the Fifth Avenue Dam, below (N. of) 5th Ave W., West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Rip-rap boulders mostly covered by *Balanus glandula*; very rare *Salicornia* growing between the rip-rap; just below high tide line. No *Myosotella myosotis* or *Assiminea californica* seen. Cobbles were washed in the tray. No NZMS. 4/22/2022 EJ!

3. West of Fifth Avenue Dam spillway 3. Zone 10: 506,885E 5,209,834N; 47.04377, -122.91062. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. At or just below the high tide line on the W. side of the spillway of the Fifth Avenue Dam, below (N. of) 5th Ave W., West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Mud-gravel flat with rip-rap at the high tide line. Seep flowing through the site. Dip net sampled. No NZMS. 4/22/2022 EJ!

4. Beach north of 4th Avenue bridge. Zone 10: 506,920E 5,209,846N; 47.04478, -122.91015. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach, West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Beach; upper part rocky; lower mud; *Salicornia* present. *Littorina sitkana* (live), *Littorina scutulata* (live), *Mytilus trossulus* (live), *Clinocardium nuttallii* (dead), *Macoma inquinata* (dead), *Balanus glandula* (live) and *Lottia pelta* (live). Dip net sampled. No NZMS. 4/22/2022 EJ!

5. Creek outflow north of 4th Ave bridge. Zone 10: 506,900E 5,209,971N; 47.04501, -122.91042. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Outflow of creek at railroad trestle, N. of 4th Ave bridge, West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Outflow of creek; mussel beds on mud substrate. *Littorina scutulata* (live), *Protothaca staminea* (dead), abundant *Mytilus trossulus* (live), and *Balanus glandula* (live). Dip net sampled. No NZMS. 4/21/2022 EJ!

6. Beach at West Bay Park. Zone 10: 506,818E 5,210,796N; 47.05243, -122.91148. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach at City of Olympia West Bay Park, W. side of West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Beach with cobble substrate. *Venerupis philippinarum* (dead), *Mytilus trossulus* (live), *Macoma inquinata* (dead), *Littorina sitkana* (live), *Littorina scutulata* (live), and *Balanus glandula* (live). Dip net sampled and cobbles washed in the tray. No NZMS. 4/21/2022 EJ!

7. Creek outflow at West Bay Park. Zone 10: 506,791E 5,210,755N; 47.05206, -122.91184. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Unnamed creek outfall at the beach in City of Olympia West Bay Park, W. side of West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 0'. Creek with a sand-cobble substrate; outfall covered during high tide. Shells of dead *Mya arenaria and Protothaca staminea* litter the beach. Dip net sampled and cobbles washed in the tray. No NZMS. 4/21/2022 EJ!

8. Creek at Smythe Landing. Zone 10: 506,584E 5,211,542N; 47.05915, -122.91455. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Unnamed creek outfall culvert at Smythe Landing, W. side of West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 2". Creek with a sand-boulder substrate; outfall culvert covered during high tide. *Littorina scutulata* (live), *Myosotella myosotis* (live), *Balanus glandula* (live), *Venerupis philippinarum* (dead), *Mytilus trossulus* (live), *Mya arenaria* (dead), *Crassostrea gigas* (dead), *Saxidomus giganteus* (dead) and *Hemigrapsus nudus* (live). No NZMS. 6/16/2011 EJ, BB! Not revisited because public access is no longer allowed.

9. Schneider Creek outfall at Smythe Landing. Zone 10: 506,591E 5,211,662N; 47.06023, -122.91446. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Schneider Creek outfall

culvert at Smythe Landing, W. side of West Bay, Budd Inlet, Olympia. Elev. -3'. Depth 12". Creek with a mud-sand substrate; outfall covered during high tide. *Mytilus trossulus* (live), *Littorina scutulata* (live), *Clinocardium nuttallii* (dead), *Venerupis philippinarum* (dead), *Crassostrea gigas* (dead), *Mya arenaria* (dead), *Hemigrapsus* sp. (live), *Balanus glandula* (live) and gribble worms. No NZMS. 6/16/2011 EJ, BB! Not revisited because public access is no longer allowed.

10. Schneider Creek behind Smythe Landing. Zone 10: 506,448E 5,211,628N; 47.05992, -122.91634. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Schneider Creek behind Smythe Landing, Olympia. Elev. 25'. Depth 4-10". Creek with a silt-cobble substrate; no macrophytes. Dip net sampled and cobbles washed in the tray. No NZMS. 4/21/2022 EJ!

11. East of Fifth Avenue Dam spillway 1. Zone 10: 507,005E 5,209,843N; 47.04385, -122.90904. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. E. side of the spillway of the Fifth Avenue Dam, between 5th Ave W. and 4th Ave W. bridge, West Bay, Budd Inlet, Olympia. Elev. -20'. Depth 0'. Rip-rap boulders are mostly covered by *Mytilus trossulus* and *Balanus glandula* below the high tide line. Cobbles were washed in the tray. No NZMS. 4/22/2022 EJ!

12. East of Fifth Avenue Dam spillway 2. Zone 10: 507,013E 5,209,863N; 47.04403, -122.90893. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. E. side of the spillway of the Fifth Avenue Dam, between N. of 5th Ave W. and 4th Ave W. bridge, West Bay, Budd Inlet, Olympia. Elev. -20'. Depth 0'. Rip-rap boulders mostly covered by *Mytilus trossulus* and *Balanus*; below high tide line. Cobbles were washed in the tray. No NZMS. 4/22/2022 EJ!

13. East of Fifth Avenue Dam spillway 3. Zone 10: 507,021E 5,209,889N; 47.04427, -122.90882. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. E. side of the spillway of the Fifth Avenue Dam, below 4th Ave W. bridge on S. side, West Bay, Budd Inlet, Olympia. Elev. -20'. Depth 0'. Rip-rap boulders are mostly covered by *Mytilus trossulus*, and *Balanus* below the high tide line. Outfall culvert present, but no flow. *Mytilus trossulus* and *Balanus* (live). Not collected. Cobbles were washed in a tray. No NZMS. 4/22/2022 EJ!

14. East of Fifth Avenue Dam spillway 4. Zone 10: 507,034E 5,209,919N; 47.04454, -122.90865. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. E. side of the spillway of the Fifth Avenue Dam, below 4th Ave W. bridge on N. side, West Bay, Budd Inlet, Olympia. Elev. -20'. Depth 0'. Rip-rap boulders mostly covered by *Mytilus trossulus* and *Balanus*; below high tide line. Large seep present. *Mytilus trossulus* and *Balanus glandula* covered rip-rap. *Littorina sitkana* (live), *Littorina scutulata* (live), and *Macoma inquinata* (dead). Cobbles were washed in the tray. No NZMS. 4/22/2022 EJ!

15. Moxilie Creek outfall at the head of East Bay. Zone 10: 508,090E 5,210,277N; 47.04730, -122.89475. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Moxilie Creek outfall at the head of East Bay, Budd Inlet, Olympia. Elev. -10'. Depth 0'. Creek outfall; mud-cobble substrate. Seeps present. Outfall covered during high tide. *Mytilus trossulus* (live) and *Balanus glandula* (live). Dip net sampled. No NZMS. 4/20/2011 EJ!

16. Bigelow Springs. Zone 10: 508,441E 5,210,585N; 47.05051, -122.89009. Tumwater 1994 quad., Thurston Co., Washington. Bigelow Springs near the intersection of Bigelow Avenue NE and Quince Street NE, City of Olympia Bigelow Park. Elev. 108'. Depth 0-1'. Cold spring with a silt-cobble substrate; patchy *Rorippa*; some *Scirpus*, grasses. Dip net sampled. No NZMS. 4/20/2011 EJ!

17. Ellis Creek outfall at Ellis Cove. Zone 10: 508,070E 5,213,205N; 47.07410, -122.89538. Tumwater 1994 quad., Thurston Co., Washington. Ellis Cr. Ellis Creek outfall at the head of Ellis Cove, just W. of East Bay Drive NE crossing, Priest Point Park. Elev. -3'. Depth 0-6". Small creek with a mud-sand substrate; cobbles in patches. Outfall culvert covered during high tide. *Balanus glandula* present. Dip net sampled and cobbles washed in the tray. No NZMS. 4/20/2011 EJ!

18. Ellis Creek east of East Bay Drive NE. Zone 10: 508,070E 5,213,309N; 47.07503, -122.89496. Tumwater quad., Thurston Co., Washington. Ellis Cr. Ellis Creek just E. of East Bay Drive NE crossing, City of Olympia Priest Point Park. Elev. 45'. Depth 0-1'. Small creek with a silt-gravel substrate; no macrophytes. Dip net sampled. Rare *Juga silicula* present. None retained. No NZMS. 4/20/2022 EJ!

19. West Bay Marina. Zone 10: 506,441E 5, 212,213N; 47.06519, -122.91643. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. West Bay Marina at 2100 W. Bay Drive NW, West Bay, Budd Inlet, Olympia. Elev. -4'. Depth 0-3'. Intertidal zone with a mud-cobble substrate; rip-rap and wood retaining wall above. Abundant shell and wood fragments. Dip net sampled and cobbles washed in the tray. Live *Lottia pelta*, *Littorina scutulata*, *Littorina sitkana*, and *Mytilus trossulus*. Dead *Protothaca staminea*. No NZMS. 4/21/2022 EJ!

20. Beach at Port Plaza. Zone 10: 507,310E 5,210,575N; 47.05044, -122.90501. Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach below access bridge to a pier at City of Olympia Port Plaza, West Bay, Budd Inlet. Elev. -3. Depth 1-2'. Beach intertidal zone with mud-silt substrate. Long dead *Nassarius* sp., live *Mytilus trossulus*, and dead *Protothaca staminea*. Dip net sampled. No NZMS. 4/20/2022 EJ!

21. Beach off North Point. Zone 10: 507,351E 5,211,633N; 47.05996, -122.90445 Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach off North Point directly north of radio station KGY (95.3 KGY and 96.9 KAYO), Budd Inlet, Olympia. Elev. -4. Depth 1'. Intertidal flat with mostly mud substate. Dead *Protothaca staminea* and *Mya arenaria*. Dip net sampled. No NZMS. 4/20/2022 EJ!

22. Beach at East Bay Overlook. Zone 10: 508,188E 5,210,901; 47.05336, -122.89344 Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach W. of East Bay Drive NE, below City of Olympia East Bay Overlook, East Bay, Budd Inlet, Olympia. Elev. -4. Depth 0'. Intertidal zone with mud substrate; rip rap along bank. Dip net sampled. No NZMS. 4/20/2022 EJ!

23. Beach public access at Howard Avenue Northwest. Zone 10: 507,900E 5,212,274N; 47.06572, -122.89721 Tumwater 1994 quad., Thurston Co., Washington. Puget Sound. Beach at public access at the terminous of Howard Avenue NW, East Bay, Budd Inlet. Elev. -3. Depth 1'. Intertidal zone with oyster bed over a mud substrate; further out just mud substrate. Live *Crassostrea gigas* beds. Dip net sampled. No NZMS. 4/20/2022 EJ!

APPENDIX B: SITE FAUNAL TABLE OF MOLLUSKS FOUND IN SOUTHERN BUDD INLET AND TRIBUTARIES.

Mollusk faunal tables at collection sites visited during this survey. Sites with no mollusks are blacked out. Sites in red were visited in 2011 but not during this survey. For locality details see **Appendix A** and for site map see **Figure 1**.

Table Explanation:
*=introduced species
+=live
o=dead
-=not present

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND IN SOUTHERN BUDD INLET AND TRIBUTARIES.

TAXON NAME	SITE NUMBERS												
	1	2	3	4	5	6	7	8	9	10	11	12	13
GASTROPODS													
Lottia pelta	+	-	-	+	-	-	-				-	-	+
Juga silicula	-	-	-	-	-	-	-				-	-	-
*Potamopyrgus antipodarum**	-	-	-	-	-	-	-				-	-	-
Littorina scutulata	+	-	+	+	+	+	-				-	-	-
Littorina sitkana	+	-	-	+	-	+	-				-	-	-
Nassarius sp.	-	-	-	-	-	-	-				-	-	-
BIVALVES													
Mytilus trossulus	+	-	+	+	+	+	-				+	+	+
*Crassostrea gigas**	-	-	-	-	-	-	-				-	-	-
Clinocardium nuttallii	-	-	o	o	-	-	-				-	-	-
Macoma inquinata	-	-	-	o	-	o	-				-	-	-
Protothaca staminea	-	-	-	-	o	-	o				-	-	-
*Venerupis philippinarum**	-	-	-	-	-	o	-				-	-	-
*Mya arenaria**	-	-	-	-	-	o	o				-	-	-
SPECIES OF CONCERN	0	0	0	0	0	0	0			0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	2	1			0	0	0	0
FRESHWATER SPECIES	0	0	0	0	0	0	0			0	0	0	0
MARINE SPECIES	4	0	3	6	3	6	2			0	1	1	2
TOTAL SITE DIVERSITY	4	0	3	6	3	6	2			0	1	1	2

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND IN SOUTHERN BUDD INLET AND TRIBUTARIES (cont.).

TAXON NAME	14	15	16	17	18	19	20	21	22	23	TOTAL SITE OCCUR-ENCES
GASTROPODS											
Lottia pelta	+	-	[redacted]	[redacted]	-	+	-	-	-	-	4
Juga silicula	-	-	[redacted]	[redacted]	+	-	-	-	-	-	1
*Potamopyrgus antipodarum**	-	-	[redacted]	[redacted]	-	-	-	-	-	-	0
Littorina scutulata	+	-	[redacted]	[redacted]	-	+	-	-	-	-	7
Littorina sitkana	+	+	[redacted]	[redacted]	-	+	-	-	-	-	6
Nassarius sp.	-	-	[redacted]	[redacted]	-	-	o	-	-	-	1
BIVALVES											
Mytilus trossulus	+	+	[redacted]	[redacted]	-	+	+	-	-	-	12
*Crassostrea gigas**	-	-	[redacted]	[redacted]	-	-	-	-	-	+	1
Clinocardium nuttallii	-	-	[redacted]	[redacted]	-	-	-	-	-	-	2
Macoma inquinata	o	-	[redacted]	[redacted]	-	-	-	-	-	-	3
Protothaca staminea	-	-	[redacted]	[redacted]	-	o	o	o	-	-	5
*Venerupis philippinarum**	-	-	[redacted]	[redacted]	-	-	-	-	-	-	1
*Mya arenaria**	-	-	[redacted]	[redacted]	-	-	-	o	-	-	3
SPECIES OF CONCERN	0	0	0	0	0	0	0	0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	1	0	1	4
FRESHWATER SPECIES	0	0	0	0	1	0	0	0	0	0	1
MARINE SPECIES	5	2	0	0	0	5	3	2	0	1	15
TOTAL SITE DIVERSITY	5	2	0	0	1	5	3	2	0	1	16

APPENDIX C: PHOTOS OF SITES SURVEYED IN SOUTHERN BUDD INLET.

Figure C1. Photos of sites visited on April 20, 2022. A. Site 20. B. Site 21. C. Site 15. D. Site 16.

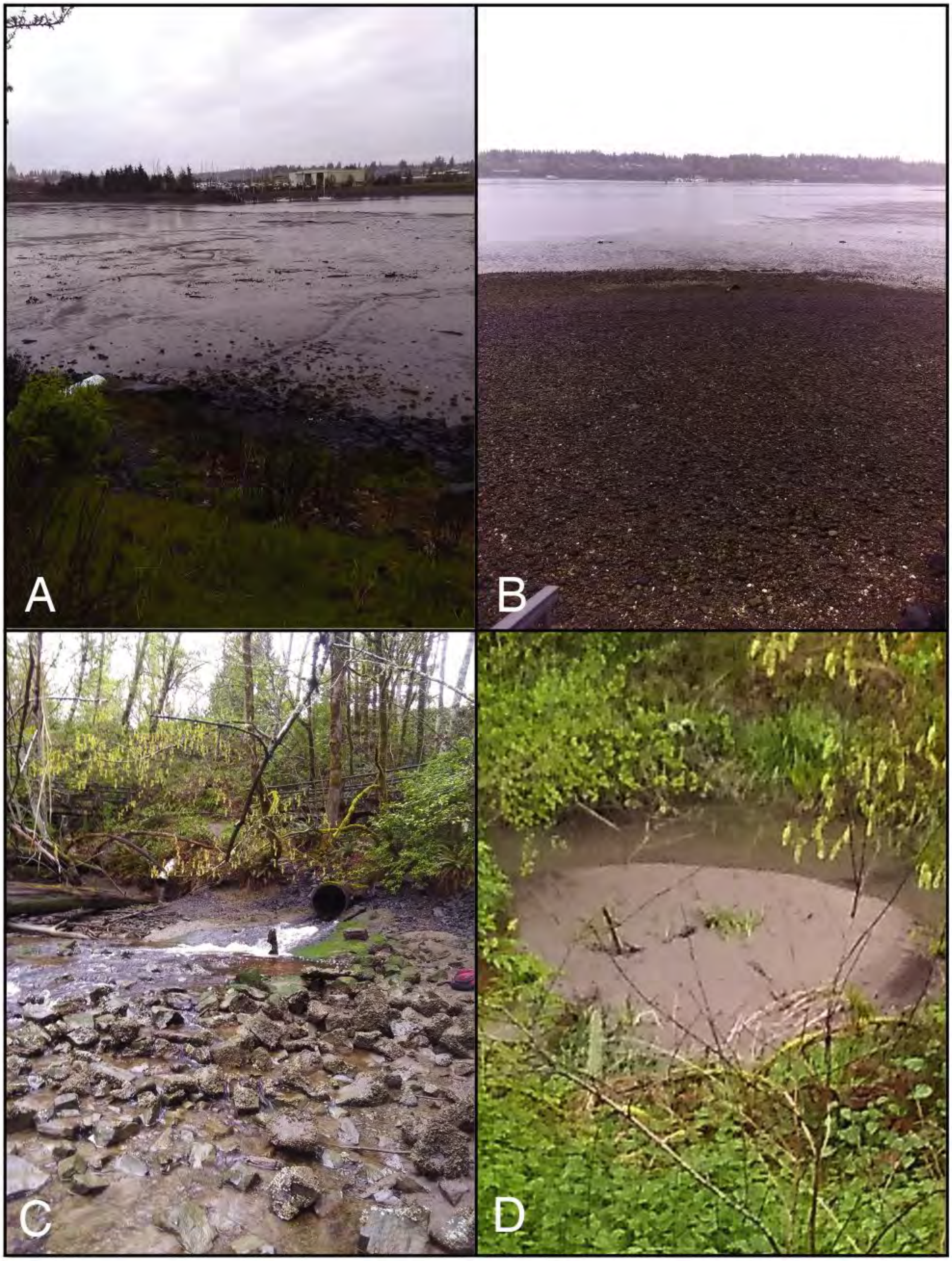

Figure C2. Photos of sites visited on April 20, 2022. A. Site 22. B. Site 23. C. Site 17. D. Site 18.

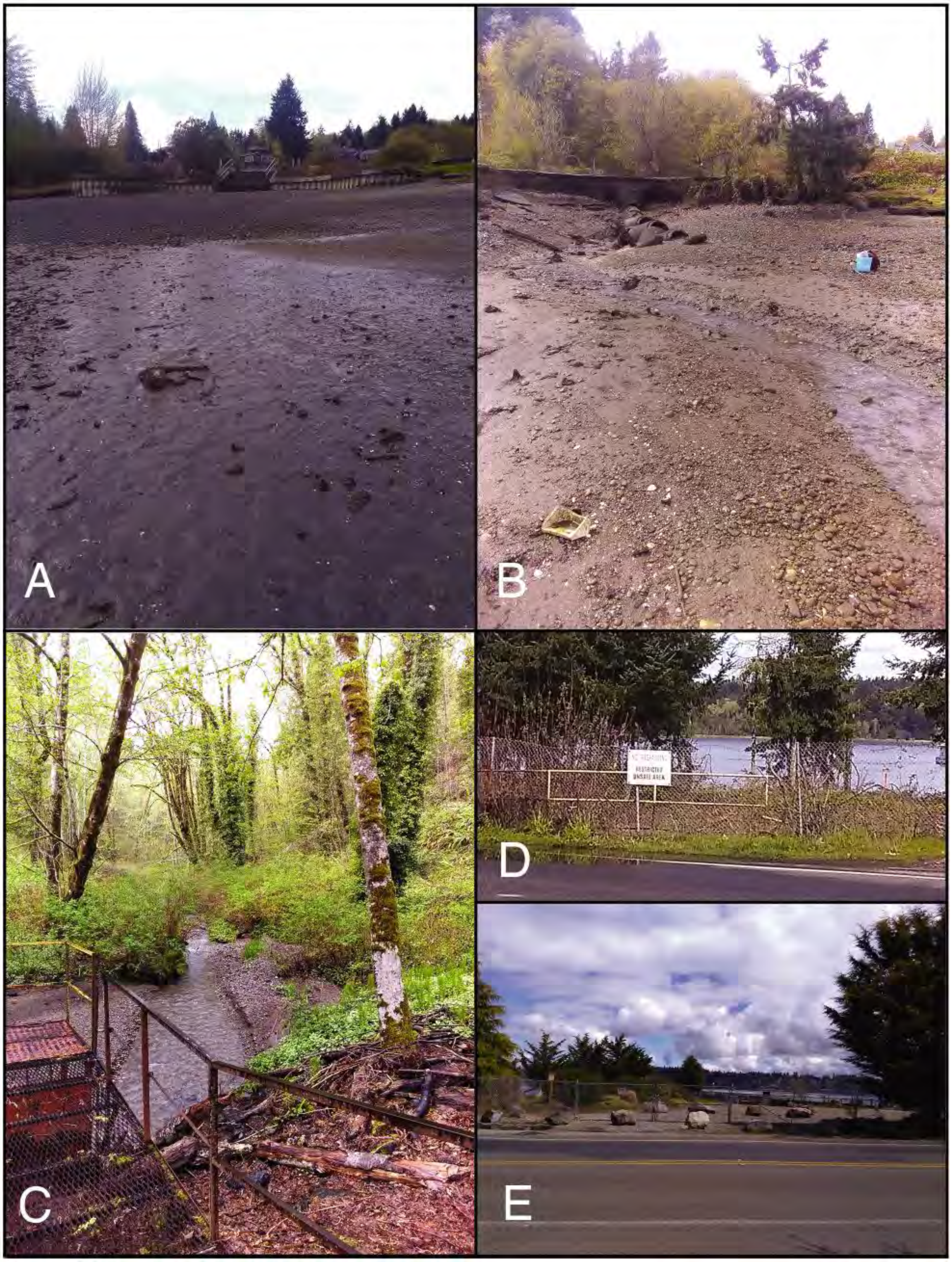

Figure C3. Photos of sites visited on April 21, 2022. A. Site 6. B. Site 7. C. Site 10. D. Fence with a posted hazard warning sign near sites 8 and 9. E. Fence blocking access to sites 8 and 9 with posted no trespassing signs.

Figure C4. Photos of sites visited on April 21, 2022. A. Site 19. B. Site 5. C. Site 4. D. Photos of sites near Capitol Lake dam outlet were visited on April 22, 2022. Sites 11, 12, and 13.

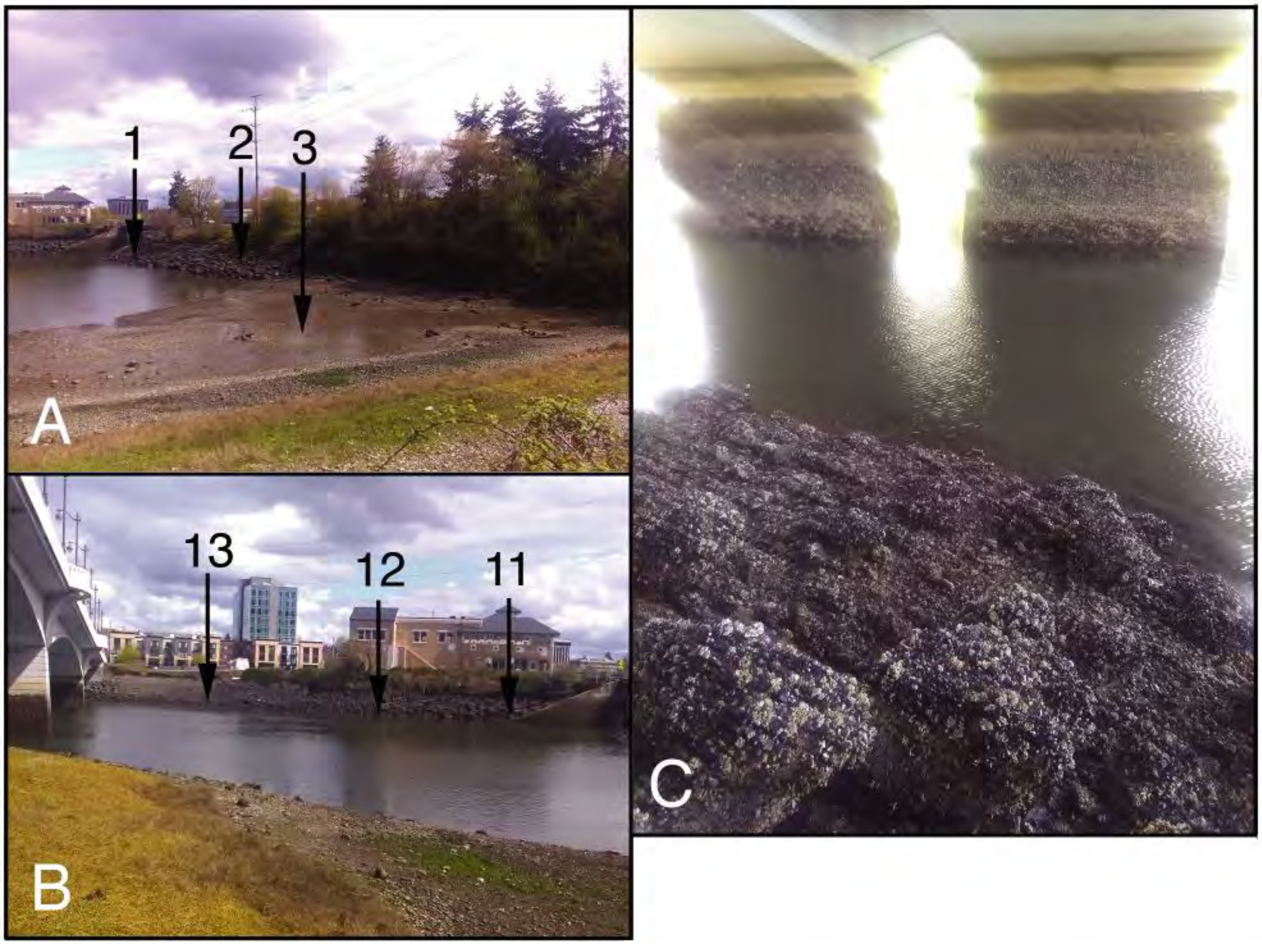

Figure C5. Photos of sites visited on April 22, 2022, near Capitol Lake dam outlet. A. Sites 1, 2, and 3. B. Sites 11, 12, and 13. C. Site 14.

APPENDIX D: PUGET SOUND TIDE TABLE FOR APRIL, 2022.

TABLE 2. PUGET SOUND TIDE TABLE FOR APRIL, 2022.

Day	High	Low	High	Low	High
Fri 01	5:50 AM PDT 11.19 ft	12:06 PM PDT 1.60 ft	6:18 PM PDT 10.02 ft		
Sat 02		12:06 AM PDT 2.55 ft	6:14 AM PDT 11.06 ft	12:38 PM PDT 0.80 ft	7:07 PM PDT 10.12 ft
Sun 03		12:47 AM PDT 3.69 ft	6:40 AM PDT 10.82 ft	1:12 PM PDT 0.22 ft	7:55 PM PDT 10.16 ft
Mon 04		1:28 AM PDT 4.84 ft	7:07 AM PDT 10.45 ft	1:45 PM PDT −0.11 ft	8:44 PM PDT 10.14 ft
Tue 05		2:11 AM PDT 5.89 ft	7:36 AM PDT 9.96 ft	2:22 PM PDT −0.17 ft	9:36 PM PDT 10.04 ft
Wed 06		3:00 AM PDT 6.78 ft	8:08 AM PDT 9.38 ft	3:02 PM PDT 0.03 ft	10:34 PM PDT 9.86 ft
Thu 07		4:01 AM PDT 7.44 ft	8:43 AM PDT 8.74 ft	3:48 PM PDT 0.42 ft	11:45 PM PDT 9.69 ft
Fri 08		5:37 AM PDT 7.76 ft	9:30 AM PDT 8.10 ft	4:42 PM PDT 0.89 ft	
Sat 09	1:08 AM PDT 9.67 ft	7:54 AM PDT 7.47 ft	10:41 AM PDT 7.57 ft	5:45 PM PDT 1.28 ft	
Sun 10	2:17 AM PDT 9.81 ft	8:53 AM PDT 6.85 ft	12:08 PM PDT 7.34 ft	6:52 PM PDT 1.45 ft	
Mon 11	3:03 AM PDT 10.01 ft	9:25 AM PDT 6.15 ft	1:27 PM PDT 7.49 ft	7:54 PM PDT 1.44 ft	
Tue 12	3:35 AM PDT 10.21 ft	9:47 AM PDT 5.35 ft	2:33 PM PDT 7.93 ft	8:48 PM PDT 1.43 ft	
Wed 13	3:59 AM PDT 10.41 ft	10:08 AM PDT 4.37 ft	3:29 PM PDT 8.50 ft	9:34 PM PDT 1.59 ft	
Thu 14	4:21 AM PDT 10.60 ft	10:32 AM PDT 3.20 ft	4:19 PM PDT 9.12 ft	10:16 PM PDT 1.99 ft	
Fri 15	4:43 AM PDT 10.80 ft	11:00 AM PDT 1.88 ft	5:08 PM PDT 9.74 ft	10:57 PM PDT 2.66 ft	
Sat 16	5:07 AM PDT 10.97 ft	11:32 AM PDT 0.53 ft	5:58 PM PDT 10.29 ft	11:39 PM PDT 3.55 ft	
Sun 17	5:33 AM PDT 11.07 ft	12:08 PM PDT −0.72 ft	6:49 PM PDT 10.73 ft		
Mon 18		12:23 AM PDT 4.57 ft	6:02 AM PDT 11.06 ft	12:48 PM PDT −1.70 ft	7:42 PM PDT 11.00 ft
Tue 19		1:09 AM PDT 5.61 ft	6:35 AM PDT 10.91 ft	1:31 PM PDT −2.28 ft	8:40 PM PDT 11.06 ft
Wed 20		2:00 AM PDT 6.54 ft	7:12 AM PDT 10.57 ft	2:19 PM PDT −2.38 ft	9:42 PM PDT 10.95 ft
Thu 21		2:59 AM PDT 7.28 ft	7:54 AM PDT 10.03 ft	3:11 PM PDT −2.04 ft	10:53 PM PDT 10.75 ft
Fri 22		4:13 AM PDT 7.69 ft	8:49 AM PDT 9.30 ft	4:10 PM PDT −1.37 ft	
Sat 23	12:12 AM PDT 10.63 ft	5:54 AM PDT 7.53 ft	10:04 AM PDT 8.50 ft	5:16 PM PDT −0.56 ft	
Sun 24	1:25 AM PDT 10.67 ft	7:34 AM PDT 6.65 ft	11:40 AM PDT 7.92 ft	6:27 PM PDT 0.22 ft	
Mon 25	2:22 AM PDT 10.81 ft	8:38 AM PDT 5.38 ft	1:18 PM PDT 7.84 ft	7:38 PM PDT 0.88 ft	
Tue 26	3:05 AM PDT 10.94 ft	9:24 AM PDT 4.01 ft	2:43 PM PDT 8.18 ft	8:41 PM PDT 1.53 ft	
Wed 27	3:39 AM PDT 11.02 ft	10:02 AM PDT 2.67 ft	3:53 PM PDT 8.71 ft	9:35 PM PDT 2.28 ft	
Thu 28	4:06 AM PDT 11.02 ft	10:35 AM PDT 1.46 ft	4:53 PM PDT 9.25 ft	10:23 PM PDT 3.16 ft	
Fri 29	4:31 AM PDT 10.93 ft	11:06 AM PDT 0.45 ft	5:44 PM PDT 9.74 ft	11:08 PM PDT 4.12 ft	
Sat 30	4:54 AM PDT 10.76 ft	11:35 AM PDT −0.35 ft	6:32 PM PDT 10.15 ft	11:51 PM PDT 5.06 ft	

Lowest April tides during daylight hours are highlighted in red.
https://www.tidetime.org/north-america/united-states/puget-sound-calendar-apr.htm