# Arboretum Creek Headwaters Project

## 30% Design Report

July 18, 2022

**Prepared for: Friends of Arboretum Creek**

This project is funded by the King County Wastewater Treatment Division and King County Flood Control District with support from the Seattle Parks Foundation

**Acknowledgements**

Friends of Arboretum Creek (FOAC) would like to thank the following organizations for collaborating on the development of this project to date:

King County Department of Natural Resources and Parks Wastewater Treatment Division (KCWTD)

King County Flood Control District (KCFCD)

Arboretum Foundation (AF)

Seattle Parks and Recreation (SPR)

University of Washington Botanic Gardens (UWBG)

Seattle Public Utilities (SPU)

Seattle Department of Transportation (SDOT)

Seattle Parks Foundation (SPF)

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## Contents

# Executive Summary

Friends of Arboretum Creek (FOAC) has been advocating for, coordinating, and leading restoration efforts in and around Arboretum Creek for several years. The purpose of this Alley and Alder Springs re-connection project is to re-connect these springs, and the year-round roadway seep on 28th Avenue East just south of Alley Springs, to Arboretum Creek in order to address the issue of a lack of summertime flow. This project aims to restore the natural hydrology of the Arboretum Creek watershed by connecting Alley and Alder Springs with Arboretum Creek while also addressing localized flooding and currently untreated stormwater runoff. It s envisioned that this project will work in concert with other investments made to restore habitat and water quality in Arboretum Creek, including plans to remove the culvert in the downstream reach, replacing it with an open creek channel. Efforts are also on-going to restore native vegetation along Arboretum Creek.

Arboretum Creek flows north through the Washington Park Arboretum in Seattle, Washington, emptying into Union Bay in Lake Washington. The headwaters of Arboretum Creek is located just to the Northeast of the Japanese Garden. Arboretum Creek flows in an open channel throughout its length (excluding 4 small bridges and where it crosses under Lake Washington Blvd) until the very last reach, where it travels through a culvert before entering Union Bay and Lake Washington. Alley Springs is a natural seep surfacing into a drainage structure referred to as a sand box at the alley entering 28th Ave E between E Ward St and E Aloha St. Alder Springs begins as a hillside seep at the dead-end of 26th Ave E off of E Helen St., flowing north downhill under the stairway, then turns to the southeast along E Prospect, then enters a drainage structure and flows in a pipe down the hill into Washington Park.

The 30% design includes the conveyance of Alley and Alder Springs into the Washington Park Arboretum and the collection and conveyance of stormwater from, 28th Ave E. (from Aloha St to Prospect St), the parking lot near the Japanese Gardens and also Lake Washington Boulevard. These flows then enter a constructed treatment wetland where water quality treatment is provided. The effluent from the Japanese Garden Ponds enters the same water quality treatment facility. The water quality treatment facility then discharges via groundwater to a restored Arboretum Creek headwaters.

This project, now named the Arboretum Creek Headwaters Project, is currently at the 30% design phase of development, thanks to a grant from King County Wastewater Treatment Division. Next steps include continuing coordination with stakeholders and the FOAC Advisory Group, collecting additional information, and proceeding with further design development then construction.

# 1. Background and Purpose

Friends of Arboretum Creek (FOAC) is a community-driven non-profit organization with a mission to 'maximize the diversity of life in Arboretum Creek… while rekindling the love affair between Seattle and nature!". FOAC has been advocating for, coordinating, and leading restoration efforts in and around Arboretum Creek for several years. One of the issues that Arboretum Creek faces is a lack of dry weather (summertime) flow that is important for stream health, specifically water quality and for aquatic and avian habitat. FOAC identified several nearby springs, Alley and Alder Springs, that surface in the hillside to the west of Arboretum Creek as potential sources to supplement summer base flows and were historically part of Arboretum Creek watershed prior to the construction of Lake Washington Boulevard circa 1905.

The purpose of this project is to re-connect these springs to Arboretum Creek in order to address the issue of a lack of summertime flow. This project aims to restore the natural hydrology of the Arboretum Creek watershed by reconnecting Alley and Alder Springs to Arboretum Creek. In addition to the benefits to stream health and habitat, this project is designed to also provide benefits to people. These benefits to people include capturing and treating stormwater runoff that currently causes localized flooding both in the residential neighborhoods and proximate to the Japanese Garden entrance along Lake Washington Boulevard. Currently, this stormwater runoff enters the combined sewer system, taking up capacity in the King County interceptor which also contributes to combined sewer overflows downstream in the system. By re-routing and treating these flows, this project provides several benefits to both people and the environment and including helping to protect the Japanese Gardens and buildings from flooding. These multi-objective benefits are described in this report.

It is envisioned that this project will work in concert with other investments made to restore habitat and water quality in Arboretum Creek, including plans to remove the culvert in the downstream reach, replacing it with an open creek channel. Efforts are also on-going to restore native vegetation along Arboretum Creek.

# 2. Existing Conditions

Arboretum Creek flows north through the Washington Park Arboretum in Seattle, Washington, emptying into Union Bay in Lake Washington. The headwaters of Arboretum Creek is located just to the Northeast of the Japanese Garden (see Figure 1). Arboretum Creek flows in an open channel throughout its length until it enters a culvert before entering Union Bay and Lake Washington.

**Figure 1 – Arboretum Creek headwaters, looking South along Lake Washington Boulevard**

Washington Park is one of the City of Seattle's busiest parks, including with both park visitors and bike and vehicular users crossing the Park via Lake Washington Boulevard. The Arboretum Collections are world-renowned and attract many visitors, as do the Japanese Garden. Numerous species of wildlife and birds frequent and use this area as a protected habitat. This project provides the opportunity to improve conditions for both people and bird/wildlife users of the area.

The natural hydrology of the Arboretum Creek tributary area has been disrupted by development, occurring initially in the early 1900s. While Washington Park is mainly pervious surface, allowing rainwater to infiltrate, the rest of the Arboretum Creek tributary area is residential/commercial with streets and buildings creating impervious surface. Stormwater from the effective impervious surfaces flows to inlets and into pipes. A combined sewer trunkline pipe owned by King County parallels Arboretum Creek, accepting a large portion of the stormwater flowing from the Arboretum Creek tributary area, having been diverted to the combined sewer from its natural course of Arboretum Creek. Washington Park is generally flat, with steep slopes up to the surrounding tributary residential/commercial areas.

Alder and Alley Springs, once at the surface, currently flow through pipes and in roadside ditches and enter the King County combined sewer system. See Figure 2 for locations of these springs.


**Figure 2 – Locations of Alder and Alley Springs, in relation to Arboretum Creek Headwaters**

In the upland residential area (where Alder and Alley Springs emerge at the ground surface) there is often ponded water on the street surface on 28th Ave E near E. Helen Street and E. Ward Street during the wet season (October through April). During storms, there is often 6 inches or more of standing water on 28th Ave E in the area shown in Figure 3.

Alley Springs is a natural seep surfacing into a drainage structure referred to as a 'sand box' at the alley entering 28th Ave E between E Ward St and E Aloha St (Figure 4). Alley Springs then flows through pipes that are part of the combined sewer network, and on to the King County sewer trunk line in Washington Park. Figure 5 shows the seep along 28$^{th}$ Ave E. between E. Aloha St. and E. Ward St. Alder Springs begins as a hillside seep at the dead-end of 26$^{th}$ Ave E off of E Helen St., flowing north downhill under the stairway, then turns to the Southeast along E Prospect, then enters a drainage structure (Figure 6) and flows in a pipe down the hill into Washington Park. (This project included desktop information gathering to verify that flow from Alley and Alder Springs do both currently enter the combined sewer system.) Based on FOAC data collection, Alley Springs has an approximate dry-weather flow of approximately 8 gallons per minute and Alder Springs has a dry-weather flow of approximately 19 gallons per minute. The base flow in both Alley and Alder Springs appears to not be influenced by extremely dry weather in that the flow continues throughout the dry season.

**Figure 3 – Residential Area in the Arboretum Creek Tributary Area (Looking East up E Helen St. at 28th Ave E/E Prospect Street)**

**Figure 4 – Alley Springs in the 'sand box' drainage structure**


**Figure 5 – Seep at 28th Ave East (between E. Aloha and E Ward Streets)**

**Figure 6 – Alder Springs at 26$^{th}$ Ave E and E Prospect Street**

## 3. Feedback Received to inform 30% Design Development

FOAC and the Jacobs team received the following feedback, both on the Concept Design (10% design) and in the early stages of 30% Design development:

- Master Plan Implementation Group (MPIG): no low flow diverter to Japanese Garden Ponds

- SPR ProView on 2/1/22: Direction on which of 2 locations for centralized water quality treatment so as to minimize impacts to trees and other infrastructure and collections; Expressed interest in maximizing how much stormwater is treated (optimizing space available); Concept is consistent with 2001 Arboretum Master Plan (see next slide)

- Field Visit on 3/11/22 with SPR and UW Botanical Gardens team: Feedback on design considerations – footprint, culvert location, tree impacts, planting plan, human experience including aesthetics, maintenance considerations

- FOAC Advisory Group on 4/7/22: Do extend Arboretum Creek and enhance headwaters; Do treat what exists Japanese Garden Ponds; Do provide additional peak flow reduction as feasible given space limitations.

The slide deck from the 4/7/22 FOAC Advisory Group meeting is included as Appendix A of this report. (Note that feedback received on the 30% design is summarized later in this report.)

# 4. Information Collection and Review to Inform 30% Design

Collection and review of data and information from existing sources was useful in development of the 30% design. This section describes the process taken to collect and review this existing data and information at this design stage while more focused efforts (including field survey and geotechnical exploration) are planned for the next phase of design development. This 30% design is based on survey information from past projects. A survey plan was developed as part of this phase which includes identification of survey needs specific to this project.

## 4.1. Geotechnical Information Review

While no new geotechnical data was collected as part of this phase of the work, the Jacobs team reviewed reports from past, proximate projects within the Washington Park Arboretum. Review of the reports from the Multi-Use Trail project (including Anchor QEA 2014) suggest that the 30% design elements of this Arboretum Creek Headwaters project are feasible with the soils and geotechnical conditions at the site. While existing groundwater data is limited, the site proposed for the subsurface gravel wetland has a high groundwater table. This has been considered in the design of that facility. Additional geotechnical data and information will be collected in the next phase of the project.

## 4.2. Water Level Monitoring

FOAC has been measuring water levels in Alley and Alder Springs and in Arboretum Creeks since November 2021. The Arboretum Creek monitoring location is at the Wilcox Bridge. Figures 7, 8, and 9 show this data as compared to precipitation data at the SeaTac airport precipitation gage. Alley Springs does appear to have a modest, delayed response to wet weather. The delay in response is likely due to Alley Springs emerging as a spring, with groundwater levels rising as a result of that wet weather. Alder Springs also has a modest response to wet weather, though the response is more immediate than in Alley Springs. Arboretum Creek has a larger and more immediate wet-weather response, as is expected in a larger lowland creek.

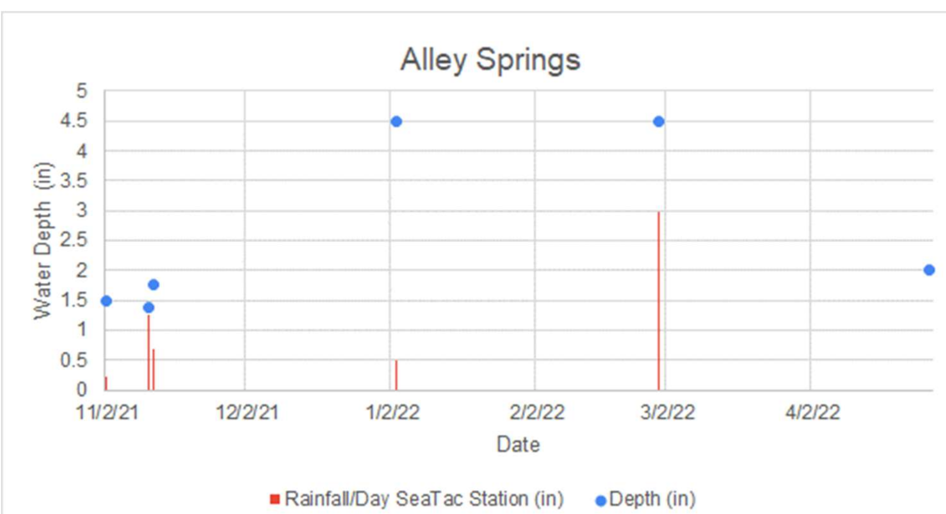


**Figure 7 – Alley Springs Water Level Monitoring as Compared to Precipitation**

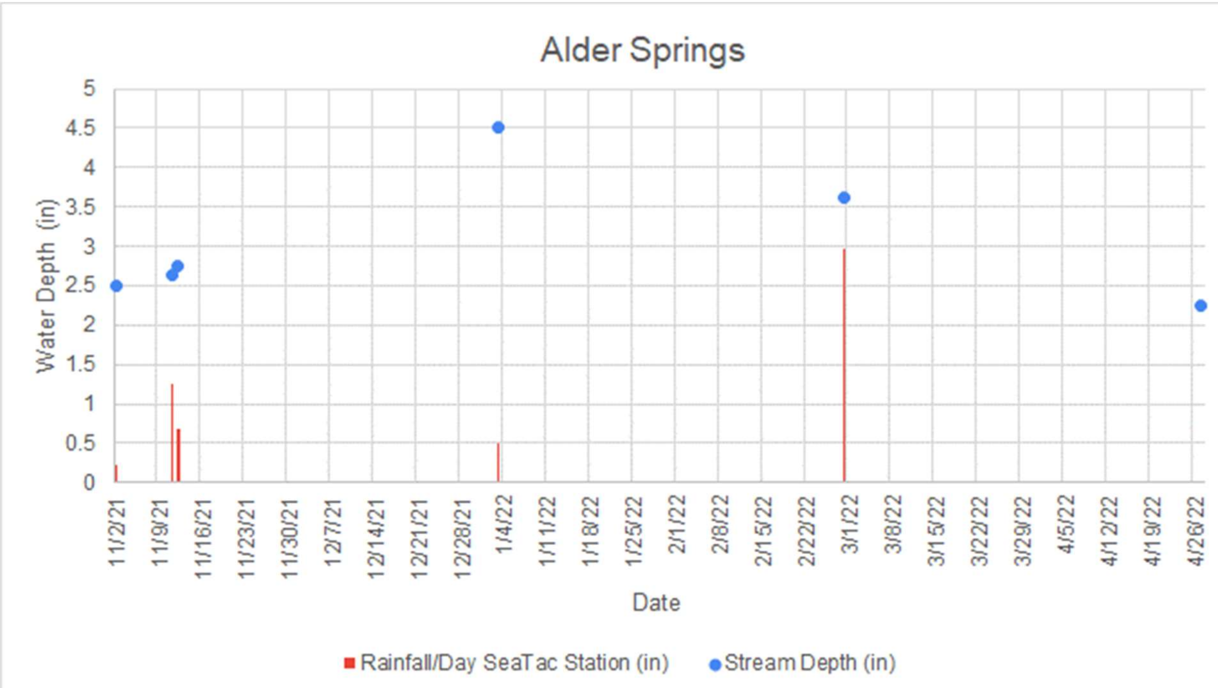


**Figure 8 – Alder Springs Water Level Monitoring as Compared to Precipitation**

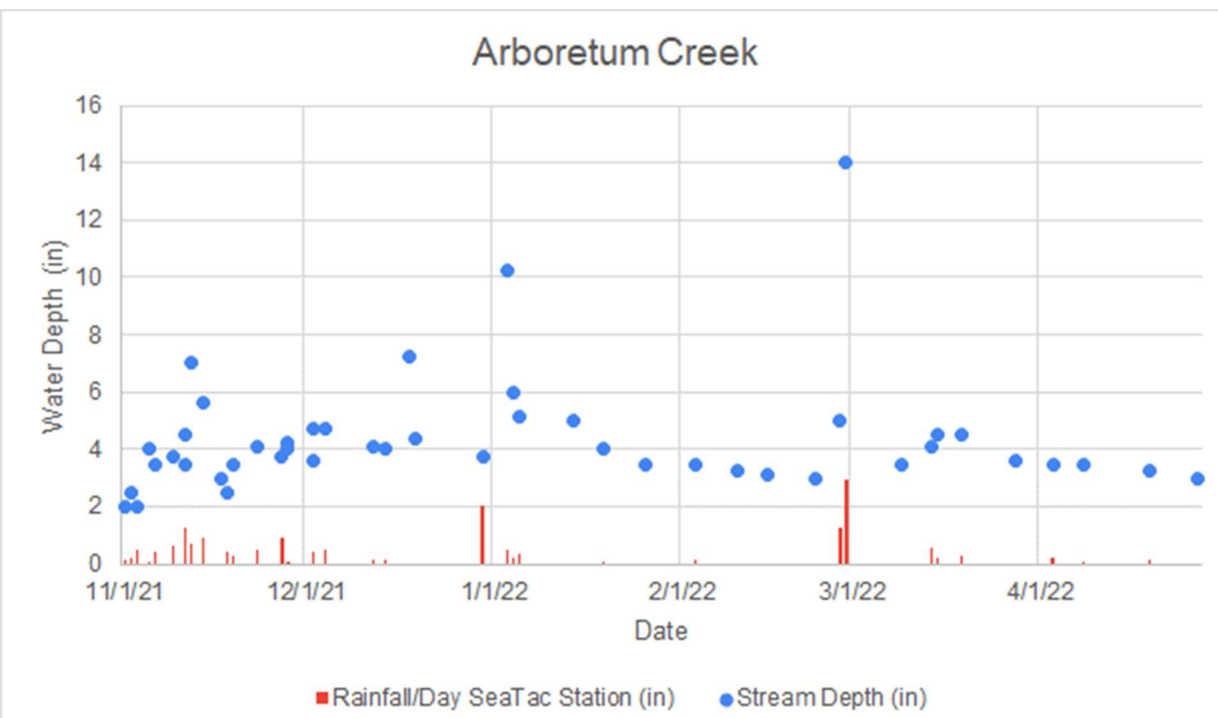


**Figure 9 – Arboretum Creek Water Level Monitoring as Compared to Precipitation**

There are limitations of this data, such as not having stage-discharge curves to calculate the flow, and equipment challenges with monitoring water levels with such small depths, including the 28th Ave. seep. That said, these data do help characterize the wet-weather response of Alder and Alley Springs and Arboretum Creek that will help in design development.

## 4.3. Survey Plan Development

No topographical field survey has been conducted for this project to date. Instead, the base map and design were informed by using available LIDAR and also survey from past proximate projects. Once the footprint of the project was defined (both the treatment facility and also the conveyance), the physical bounds of survey needs were determined. Topographical survey is needed in the area of the treatment facility as well as all along the pipe conveyance route at least 25' on either side. Survey must be conducted at and near Alley and Alder Springs as well as the 28th Avenue E. seep. Survey must also include utilities (sewer, water, storm) and also trees, especially those that may be impacted by and/or protected during this project. Rights-of-Entry must be obtained from Seattle Parks and Recreation as land owners of the Washington Park Arboretum. All other survey efforts outside of the Washington Park Arboretum would be within the public Right-of-Way (ROW). It is recommended that the survey be performed in two phases. The first phase would be the largest effort, surveying in everything currently onsite. The second phase would be focused on surveying in any geotechnical borings or utility locates that were collected, as well as any survey needs missed during the first phase.

# 5. 30% Design of the Arboretum Creek Headwaters Project

The 30% design includes the conveyance of Alley and Alder Springs (and the 28th Ave E. seep) into the Washington Park Arboretum and the collection and conveyance of stormwater from the parking lot near the Japanese Gardens and also Lake Washington Boulevard. These flows then enter a constructed treatment wetland where water quality treatment is provided. The effluent from the Japanese Garden Ponds enters the same water quality treatment facility. The water quality treatment facility then discharges via groundwater to a restored Arboretum Creek. An additional design element that is now possible with the subsurface wetland is the added benefit of extending Arboretum Creek along and on top of the treatment facility. This adds approximately 250 feet of creek to Arboretum Creek, with the new headwaters at the new discharge point at the end of the new stormwater conveyance line to the facility.

Appendix B contains the 30% Design Plans for this project. The sections of this report describe each of the project elements.

## 5.1. Alley and Alder Springs Conveyance

Alley Springs and the 28th Ave E seep are conveyed in a new 12″ pipe along 28th Ave E. New inlets intended to capture more stormwater and prevent roadway flooding are planned at E Helen Street. A 12″ pipe conveys Alley Springs and also additional inlets towards Prospect. Flow from Alder and Alley Springs comes together at this point along Prospect Street. An 18″ diameter pipe conveys flows down the hill from Prospect Street. Then, an 18″ pipe conveys the flow from there to the pre-settling structures. The pre-settling structure is made up of two maintenance holes with a large 48″ diameter pre-settling pipe and is located under the sidewalk at the parking lot of the Japanese Gardens. The pre-settling structure provides for the removal of larger trash, floatables, and solids to not send these items to the treatment facility. After pre-settling, the 18″ pipe following Lake Washington boulevard under the sidewalk, while receiving flow from the street through inlets, and then crosses at a minimum depth of 1-foot of cover under Lake Washington Boulevard into the subsurface treatment wetland. An 18″ pipe is of a sufficient size to convey flows towards the treatment facility, but detailed pipe sizing analysis will be performed at a later stage of design.

## 5.2. Water Quality Treatment and Arboretum Creek Headwaters

### 5.2.1. Treatment Design Criteria

Stormwater that is currently partially discharged to a combined sewer and partially surface flow that enters Arboretum creek will be diverted to an enhanced wetland treatment process (EWTP). The EWTP will improve water quality in Arboretum creek, reduce flows that could contribute to CSO events in the combined sewer, and provide a perennial base flow in Arboretum Creek. The goal of the EWTP is to treat the maximum amount of base flow coming from Alley and Alder Springs during dry weather, as those flows are still contaminated through stormwater contamination. The next desired flow to be treated by the facility is the 24-hour water quality storm from the contributing drainage basins (7.55 acres ). To understand how the EWTP will function during peak storm events, the peak storm event for this project is classified as twice the volume of the 24-hour water quality storm, as opposed to a 100-year storm. The main target pollutants to be treated by the EWTP are Total Suspended Solids (TSS), total copper, total zinc, total phosphorus (P), Nitrate-Nitrogen, Ammonia (N), fecal coliform bacteria, oil and grease, and temperature.

Flows from Alley and Alder Springs were determined by field observation and collection by FOAC from the spring sources during dry weather, which results in a total of 0.388 million gallons per day (MGD). The stormwater flows were calculated using the 2012 Western Washington Hydrological Model (WWHM). The stormwater flows from the WWHM are based on the required 24-hour water quality treatment volume, which is derived from the 2021 City of Seattle's Stormwater Manual (SSWM) 22.805.090 Minimum Requirements for Treatment and requires 91% of the total runoff volume for the 2-year 24-hour storm to be treated. Based on the treatment mechanics of the sub-surface water quality treatment, the facilities treatment performance is based on a wastewater calculation model, as opposed to traditional stormwater treatment calculations using WWHM or similar model. The flows from WWHM and data collection were put into the treatment model in terms of MGD as treatment is based on a residence time through each media cell as described in section 5.2.2 of this report. The design flows used for each model scenario are shown in Table 1 and Table 2 shows the expected concentration loading range of each target pollutant (based on values from the literature). (Note that 6-ppd quinone will be included in the list of pollutants evaluated during future design phases.)

**Table 1: Design Flows to the Water Quality Treatment Facility**

| Source of Flow | Description (and Area, if applicable, in acres) | Mechanism of delivery towards treatment facility | Dry Weather Flow (MGD) | WQ Flow Rate (MGD) | Peak Flow Rate (MGD) |
|---|---|---|---|---|---|
| Alder Springs | baseflow; fluctuation observed with wet weather | via conveyance pipe around Japanese Gardens then crosses Lake Washington Blvd. in new culvert | 0.0274 | 0.03 | 0.035 |
| Alley Springs | baseflow; fluctuation observed with wet weather | via conveyance pipe around Japanese Gardens then crosses Lake Washington Blvd. in new culvert | 0.0115 | 0.015 | 0.02 |
| 28th Ave E Seep | Baseflow; anecdotally, assumed increased with wet weather | via conveyance pipe around Japanese Gardens then crosses Lake Washington Blvd. in new culvert | 0.005 | 0.008 | 0.010 |
| Stormwater Runoff - Upland residential area | land use is single family residential (3.32 acres) | via conveyance pipe around Japanese Gardens | 0.000 | 0.082 | 0.164 |
| Stormwater Runoff - Parking Lot | Parking lot (0.81 acres) | via conveyance pipe around Japanese Gardens prior to pre-settling | 0.000 | 0.026 | 0.052 |
| Stormwater Runoff - Lake Washington Blvd. | Lake Washington Blvd (0.59 acres) | inlet structures downstream of pre-settling | 0.000 | 0.017 | 0.034 |
| Japanese Garden ponds | no effluent during dry months; approximately 25-50 koi (area 2.84) | via new culvert under Lake Washington Blvd | 0.000 | 0.013 | 0.026 |
| **Totals** | **7.55 acres** | - | **0.04** | **0.19** | **0.34** |

**Table 2: Estimated Pollutant Concentrations* for each source of flow to the water quality treatment facility**

| Drainage Basin | TSS (mg/L) | total copper (ug/L) | total zinc (ug/L) | Total P (ug/L) | Nitrogen (mg/L) | fecal coliform bacteria (cfu/100ml) | Oil and Grease (mg/L) |
|---|---|---|---|---|---|---|---|
| Alder Springs | 130[1]<br>15-23 [9] | 0[3] | 0[3] | 0[4]<br>60-91[9] | 9.5 (nitrate-N)[5]<br>1.9-2.6 (nitrate-N)[9] | 0[6]<br>4-8[9] | 0[7,8]<br>6.5[9] |
| Alley Springs | 130[1]<br>4-5 [9] | 0[3] | 0[3] | 0[4]<br>85-119[9] | 9.5 (nitrate-N)[5]<br>2.2-2.5 (nitrate-N)[9] | 0[6]<br>26-410[9] | 0[7,8]<br>3.2[9] |
| 28th Ave E Seep | 130[1] | 0[3] | 0[3] | 0[4] | 9.5 (nitrate-N)[5] | 0[6] | 0[7,8] |
| Stormwater Runoff - Upland residential area | 93.12[2] | 9.0-19.0[2] | 47-129[2] | 97-343[2] | 0.083-0.151 (Ammonia N)[2] | 1184-30106[2] | 2.27-5.89[2] |
| Stormwater Runoff - Parking Lot | 106.28[2] | 21-44[2] | 124-204[2] | 93-330[2] | 0.127-0.311 (Ammonia N)[2] | 4068-32323[2] | 2.87-9.50[2] |
| Stormwater Runoff - Lake Washington Blvd. | 106.28[2] | 21-44[2] | 124-204[2] | 93-330[2] | 0.127-0.311 (Ammonia N)[2] | 4068-32323[2] | 2.87-9.50[2]<br>1.8-2.5[9] |
| Japanese Garden ponds | 100.0 [10]<br>37 [9] | 20[10] | 70[10] | 0.2[10]<br>0.2[9] | 10[10]<br>3.1[9] | 2500[10]<br>17[9] | 1.5[10]<br>3.3[9] |

*Estimated based on these information sources:

1. https://pubs.usgs.gov/wri/1996/4312/report.pdf
2. https://www.seattle.gov/Documents/Departments/SPU/Documents/AppendicesofItegratedPlan.pdf, Table 3-7,pg 3-14
3. https://www.pca.state.mn.us/sites/default/files/copper7.pdf
4. https://pubs.usgs.gov/fs/2012/3004/#:~:text=Phosphorus%20is%20largely%20retained%20in,or%20downward%20to%20an%20aquifer.
5. https://www.sciencedirect.com/science/article/pii/S0048969721047070
6. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/coliform020715_fin2.pdf
7. https://files.dep.state.pa.us/environmentalcleanupbrownfields/LandRecyclingProgram/LandRecyclingProgramPortalFiles/CSSAB/2004/fprg_chap3.pdf
8. https://pubs.usgs.gov/sir/2005/5104/PDF/SIR20055104.pdf
9. FOAC local data 2018-2020; Technical Memoranda #2-#4 (available from FOAC: galvind53@gmail.com)
10. From database maintained internal to Jacobs Engineering, for use in evaluating the water quality treatment effectiveness of subsurface gravel wetlands (unpublished)

### 5.2.2. Function (How it Works)

The EWTP consists of 4 treatment cells in series and an extension of Arboretum Creek alongside and over the cells. Treated water will discharge to Arboretum Creek both by surface discharge and hyporheic discharge as springs and seeps. The EWTP design includes features to increase groundwater discharge to Arboretum Creek within the footprint of the new creek extension and into the existing creek bed downstream of the new construction.

As shown in Figure 10 (see also Appendix B for the full set of plans), Cell 1 has a primary focus of course filtration, settling, and absorption of oil and grease and organic compounds that can bond to available carbon in a wood chip media. Cell 1 provides a peaking buffer to damping stormwater surges and will distribute flow uniformly throughout the depth of the treatment media. Cell 1 will have an aerobic component that supports bacteria to convert ammonia nitrogen to nitrate and nitrite nitrogen.

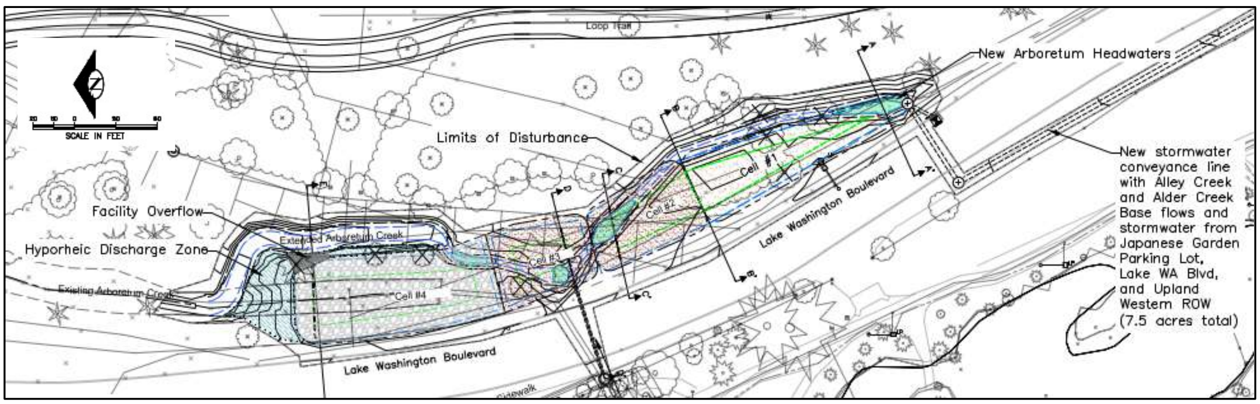


**Figure 10 – The layout of proposed Arboretum Creek headwaters and the subsurface gravel wetland providing water quality treatment**

Cell 2 and Cell 3 are anaerobic biochemical reactors with an organic media blend designed to absorb metals, and support growth of bacteria that convert nitrate and nitrite nitrogen to nitrogen gas which will vent to the atmosphere. A gravel berm separates Cells 2 and 3 and has a membrane liner on the upstream face to force water to well up and over the berm.

The sub-surface water elevation in Cells 1 and 2 is at elevation 62.5 and in Cells 3 and 4 the water surface elevation is at 60.5, with the assumption that existing groundwater is at elevation 56.0. An additional flow stream enters cell 3 from the overflow of the Japanese garden Koi pond in a pipe with invert elevation 60.7 feet.

Cell 4 is a subsurface horizontal flow treatment wetland with gravel media to remove biomass from bacteria living and consuming or converting nutrients in the upstream cells. Cell 4 will infiltrate treated water through hyporheic flow into groundwater and into the new extension of Arboretum Creek. Cell 4 will also have surface water discharge of treated water into the extension of Arboretum Creek during high flow events.

The surface of the 4 treatment cells will be planted with wetland plants and trees that can survive with their roots in saturated soil conditions. The EWTP surface area is essentially a hydroponic garden with water flowing through a non-soil subsurface media. A layer of dry wood chips and gravel will be placed above the water surface elevation in each cell and will have a variable depth above water level to create a variable unsaturated root zone for the target plant species. Several areas will have depressions in the treatment media that are below the water surface elevation to create small open water areas with emergent wetland vegetation. Plant roots are part of the treatment process since they feed and harbor bacteria, fungi, and micro-organism that increase treatment capacity. Plants also remove nutrients from the water that flows through their root zone.

**Pretreatment and Cell 1**

A water quality treatment (also known as 'pretreatment') maintenance hole structure with oil water separator, trash screening, and heavy sediment settling capabilities will be located in the Japanese gardens parking lot near the location where the stormwater will be diverted from the combined sewer to the EWTP.

A new 18" diameter ductile iron pipe will connect to the pretreatment maintenance hole structure and cross under Lake Washington Boulevard to discharge at invert elevation 62.7' into an open water pool. The water surface level of the splash pool will be 62.5'.

Storm water that flows down Lake Washington Boulevard will enter a new stormwater inlet structure at the north curb near the splash pool and will be piped to the splash pool at the same location. A pile of 12" minus riprap at the end of both pipes will be placed so that it covers the pipes from view and creates an aeration splash feature.

Cell 1 of the EWTP contains the splash pool at the southern end and screened 1/2" to 2" average diameter wood chips that are screened to remove sawdust and fines. The total surface area of Cell 1 is 1927 square feet or 0.044 acres. This cell has a sloped bottom that starts at elevation 61.0' and slopes down to elevation 57' which is a minimum of 1' above the assumed regional groundwater elevation of 56'. This pretreatment cell with course wood chips will absorb oil and grease, settle out heavy solids, and screen out debris that could lead to partial plugging the finer organic media used for treatment in Cells 2 and 3. The aerobic portion of Cell 1 will convert ammonia to nitrate and nitrite through nitrification mediated by bacteria.

Cell 1 will dampen peak flows and help convey the stormwater to a depth that causes it to be uniformly distributed throughout the media in downstream cells. The soil in the excavation area has a high clay content, as indicated by nearby borings, and will have a relatively low rate of transmissivity. Cell 1 is not intended to discharge to groundwater. The new extension of Arboretum Creek will extend across Cell 1 all the way to the open water splash pool. The invert of the creek extension will be above the normal water level in the treatment cells so the creek bed will be dry in all but peak storm events when the creek extension will flow full length to help divert peak event flows around the treatment facility. High flow bypass should only occur for brief periods during the peak runoff of one or two largest storms per year.

It is anticipated that Cell 1 will remove 6-ppd quinone from the flow through the facility. The next phase of this project will include an analyses based on available literature.

**Cell 2 and Cell 3 Biochemical Reactors**

After passing through pretreatment and Cell 1, the storm water flows underground to Cell 2 of the wetlands system. Cell 2 consists of a subsurface flow-based, anaerobic biochemical reactor (BCR) to remove nitrogen via denitrification.

Wetland Cell 2 has a water surface elevation of 62.5 and a wet surface area of about 0.032 acres. The water surface steps down in elevation through the process train with gravity flow between Cells 2 and 3. The berm that separates Cells 2 and 3 is designed with crushed ¾" gravel and a membrane liner over the upstream face. The top edge of the liner is at elevation 62.5 so that water from Cell 2 will spill over the top of the lined face of the berm and cascade through the gravel berm material down to elevation 60.5'. The cascading will occur over the full width of the berm at the level top edge of the liner which acts as a "long crested weir" approximately 30 feet long. The thin film of water spilling over the berm will entrain air in the cascade as water trickles in a thin film over the 2-foot depth by approximately 30 wide section of wet, but not saturated, gravel. This aeration zone will convert remaining ammonia to nitrate and nitrite.

Nitrite and nitrate produced in Cell 2 will be removed through coupled nitrification and denitrification in the biologically active media in the berm and Cell 3.

Cell 2 has a sloped bottom from elevation 57' to elevation 53' so part of the cell bottom is below the regional groundwater elevation. Cell 2 will have some interaction with groundwater and will provide an increased head on the groundwater surface that will prevent groundwater from entering the cell and will cause some treated stormwater from the downstream end of Cell 2 to discharge into groundwater that will surface in Arboretum Creek immediately downstream of the EWTP. Cell 3 has a bottom elevation of 53' and will also contribute flow of treated stormwater to groundwater that will surface again in seeps and springs in Arboretum Creek.

Water from Cell 2 treatment media is collected from the width of the bottom and side slopes in infiltrators, slotted stormwater drainage arches that form a void or drainage conveyance channel on the wetland cell bottom liner. A similar infiltrator drainage channel is located in the upstream edge of Cell 3 at the base of the gravel berm to help distribute flow from Cell 2 uniformly throughout the media of Cell 3. The resistance to flow through the media will cause it to naturally seek the path of least resistance. The mass of media and labyrinth of micro-pore passageways through it ensures a relatively uniform plug flow throughout the media as long as surface flooding is prevented.

Cell 2 and Cell 3 are anaerobic BCR cells consisting of a media of saturated organic matter (65 percent wood chips, 10 percent grass hay, and 25 percent sawdust) The nearly constant year-round level of natural heat in the groundwater, soil, and below ground media will be conserved with the dry insulation layer of wood chips and organic media above the water surface to reduce the potential for freezing in winter and to increase temperature sensitive biological activity throughout the wetlands. As water moves through the wetland media, it will lose heat in summer and gain heat in the winter.

Cell 2 and Cell 3 will provide passive biological pH reduction; sorption of metals to organic surfaces; and anaerobic degradation. Oxidized nitrogen (i.e., $NO_2$-N, $NO_3$-N) will be removed through biological denitrification to innocuous nitrogen gas. Incidental removal of organic compounds is anticipated through physical adsorption to organic matter surfaces.

**Cell 4 Vegetated Subsurface Flow Wetland**

Cell 4 is a vegetated, subsurface flow wetland for polishing with horizontal flow in gravel media that improves removal of nitrogen. Excess carbon, oxygen-demanding substances (e.g., biochemical oxygen demand [BOD] and chemical oxygen demand [COD]), and any sulfur or biofilm produced from Cells 2 and 3 will be subject to biological degradation and passive oxidation. The surface of the wetland will be planted with trees and wetland plants so roots can extend almost completely through the rock media. Plants will add organic detritus to the wetland surface and to the pore spaces in the media. Plants will remove nutrients from the water for growth. Water passes through the gravel root zone in Cell 4 and then flows by gravity through a hyporheic transition zone to allow continuous flow to Arboretum Creek.

**Cell 4 Hyporheic Discharge and Surface Discharge to Arboretum Creek**

Cell 4 treated water will discharge to Arboretum Creek by both hyporheic flow and surface flow. During dry weather it is anticipated that all treated water will discharge to Arboretum Creek by hyporheic flow. Cell 4 has a bottom elevation of 53' and will contribute flow of treated stormwater to groundwater that will surface again in seeps and springs in Arboretum Creek which has an invert elevation of 56' just downstream of the EWTP.

The extension of Arboretum Creek rises in elevation as it passes beside Cell 4 but the creek extension invert is below the water level in Cells 3 and 4. The berm that separates the creek extension and the treatment cells will include native clay soil but will be modified with addition of sandy loam soil to have a higher permeability. The permeability can be engineered to allow a desired rate of discharge through the soil berm into the creek extension channel.

It is currently envisioned that all dry weather flow will discharge through the bottom of the treatment cells into groundwater and surface in existing natural springs and seeps in the existing channel of the creek immediately downstream of the EWTP. The creek extension is anticipated to capture hyporheic flow of about 10% to 20% of the additional flow above dry weather flow that occurs during average wet weather. All flow above this rate would discharge by surface flow into the creek extension from a depressed section of the perimeter of Cell 4 in the NW corner adjacent to the creek extension which will serve as an overflow spillway.

An infiltrator drainage channel is located in the bottom of Cell 4 at the base of the terminal berm to help collect flow from near the bottom and bring it to near the top of the cell for surface discharge. The upper ends of the infiltrator system will be 2 feet below the top of the gravel media. The depressed area at the overflow spillway would have an invert of 60.5’ so that as the flow into the treatment cells increases and hyporheic capacity is exceeded, the water level in Cells 3 and 4 would rise until it overflows this outlet spillway section and flows into the creek extension. The channel from the overflow spillway to the invert of the creek extension will be lined with a geotextile to prevent erosion and will be covered in 12” minus angular riprap to create an aeration cascade.

The extension of Arboretum Creek beside and downstream of Cell 4 has an invert that slopes at about 6% to create a rapid flow section that will also be lined with riprap to aerate the water before it enters the natural channel of Arboretum Creek. The target DO for surface discharge water is 6 mg/L.

The anticipated treatment results for the subsurface biological treatment wetlands are summarized in Table 3 for each of the design flows (dry weather, water quality storm, and peak storm). Operational inflow concentrations are assumed and based on existing data; the final basis of design will be confirmed in the next phase of design of the system.

Based on the initial design criteria of treating Alley and Alder Springs base flows before entering Arboretum Creek, the facility meets the City of Seattle target removal thresholds for TSS (over 80% removal), along with removal for Nitrate-Nitrogen and Ammonia. However, during the water quality storm, the model shows that the target removal thresholds are not met. However, the model does not consider the pre-settling structure prior to the facility and the hyporheic discharge into the Creek as additional removal filters, therefore the model is conservative, and the facility is likely to meet removal thresholds for the water quality storm. The same modeling assumptions are applied during the peak storm flows, where it is likely that the facility is treating more than what the model shows. Further modeling analysis is proposed prior to final design of the facility. Temperature was not modeling during this phase but by filtering and upwelling of the hyporheic discharge to the creek from the facility will keep temperatures cooler rather than a traditional open water facility. Further analyses will be performed during 60% design development, including evaluation of the effectiveness at removing 6-ppd quinone from the facility inflows.

Table 3: EWTP Treatment Results for Target Pollutant for Each Flow Scenario

| Flow Scenario | Dry Weather Flow (0.44 MGD) | | | Water Quality Storm (0.67 MGD) | | | Peak Wet Weather Flow (0.93 MGD) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Facility Performance** | Influent Con-centration | Percent Removal | Effluent Con-centration | Influent Con-centration | Percent Removal | Effluent Con-centration | Influent Con-centration | Percent Removal | Effluent Con-centration |
| **TSS (mg/L)** | 130.0 | 96% | 5.0 | 121.6 | 60% | 48.5 | 242.0 | 41% | 143.0 |
| **total copper (ug/L)** | 0.0 | n/a | 0 | 7.1 | 9% | 6.4 | 3.7 | 5% | 0.0 |
| **total zinc (ug/L)** | 0.0 | n/a | 0 | 38.5 | 4% | 36.8 | 19.7 | 4% | 0.0 |
| **Total P (ug/L)** | 0.0 | n/a | 0 | 23.8 | 0.1% | 23.7 | 11.6 | 0% | 0.0 |
| **Nitrate-Nitrogen (mg/L)** | 9.5 | 86% | 1.3 | 7.5 | 6% | 5.92 | 3.8 | 11% | 3.4 |
| **Ammonia-N, (mg/L)** | 0.01 | 100% | 0.00 | 0.04 | 67% | 0.01 | 0.02 | 66% | 0.0 |
| **fecal coliform bacteria (cfu/100ml)** | 0 | n/a | 0 | 3545 | 9% | 3212 | 1758 | 5% | 1675.6 |
| **Oil and Grease (mg/L)** | 0 | n/a | 0 | 0.8 | 78% | 0.17 | 0.4 | 73% | 0.1 |

### 5.2.3. Form (How it Looks)

Figure 11 shows a rendering of what the Arboretum Creek Headwaters and subsurface gravel wetland will look like once constructed. Figure 12 (from the Plans, shown in Appendix B) show the proposed planting zones. Generally, each cell will have a zone of plantings suitable to the subsurface material, when topped with soil for plantings. As presented to SPR Proview on 6/14/22, this planting plan is a place to begin a more detailed study and collaborative design process on how this facility will look and what plants will be planted at the site.

Approximately 8 trees will be removed to construct the facility, however, new trees such as different willow varieties that are more suitable for wet root conditions will be planted. The existing Azalea bushes could be salvaged and replanted in support of the historical Azalea Way.


**Figure 11 – Visualization of Proposed Arboretum Creek Headwaters and the Centralized Water Quality Treatment at the Arboretum Headwaters**

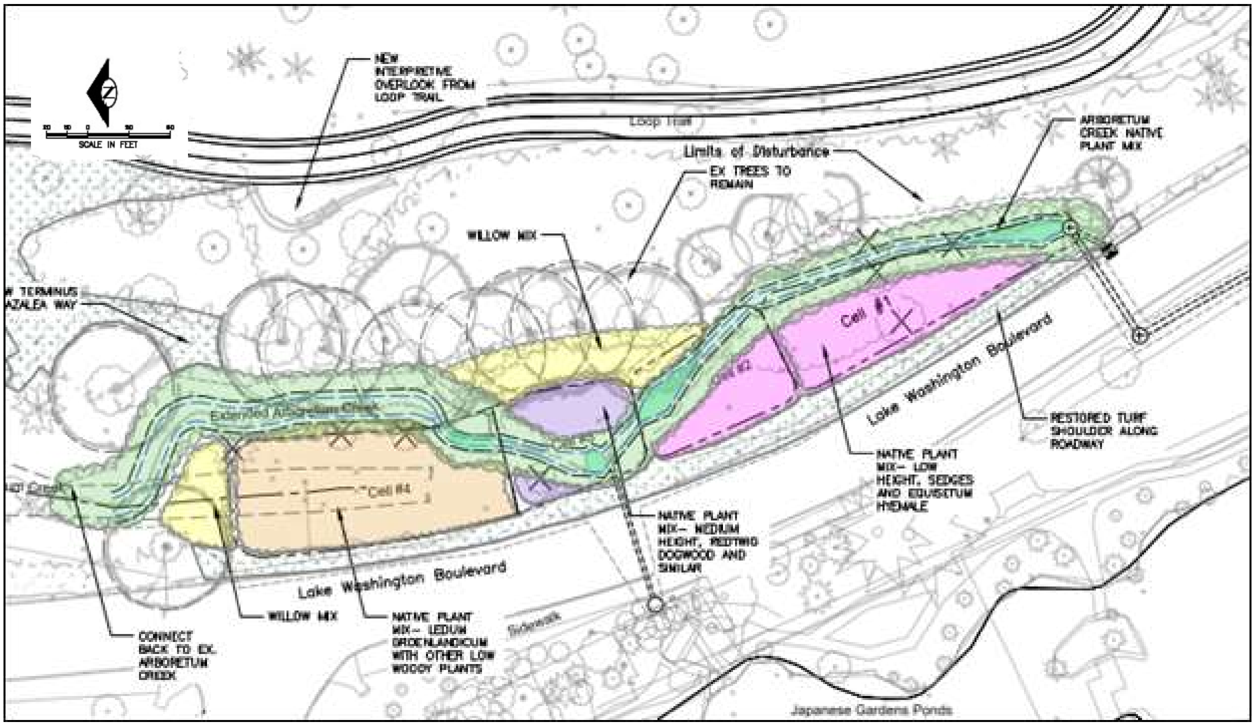


**Figure 12 – Proposed Planting Plan for the Arboretum Creek Headwaters and Subsurface Gravel Wetland**

### 5.2.4. Maintenance Requirements

The below-ground four-cell enhanced passive wetland process requires little maintenance. The operating water level in each cell is fixed to get the greatest hydraulic retention time (HRT) in the space available. A sample can be collected from the discharge weir structure and at the outlet end of each cell to track the cell's treatment performance.

Vegetation management will include removal of invasive plants and replanting as necessary throughout the year to maintain good plant density. The wetland bottom infiltrators have cleanouts that allow jet rodding if reduced flows indicate partial plugging. The organic media and woodchips will decay very slowly in the saturated conditions similar to what exists in peat bogs. The dry organic matter above the water level in each cell will decay more rapidly. If the finish elevation of the surface changes to a point that additional open water areas are visible additional organic media should be added.

It is anticipated that approximately 4-6" of additional arborist wood chips will be needed every 2 years. These would be placed on top of the facility with no excavation required. The submerged organic media should have a life expectancy of 20 years, with full replacement of that submerged media at a 20-year frequency. (Estimated costs of maintenance are shown later in this report in the section on cost. Note that the Jacobs team recommends an additional 1.0 FTE for vegetation maintenance to both care for this facility and also address the staffing shortages in this location.) Soil and debris should not be placed over the organic or gravel media unless the media is separated from the soil by a membrane layer to prevent soil from filling the void spaces in the media and reducing flow capacity.

## 5.3. Potential Additive Features

As stated earlier in this report, this project is intended to maximize benefits both to aquatic and avian habitat and people. Therefore, several potential 'add-ons', or 'additive features' were identified for further consideration, pending further feasibility review, collaboration with stakeholders, and funding discussions. Many of these 'additive features' (such as treatment of the Japanese Garden Ponds effluent) have already been incorporated into the project. Table 4 shows additional 'additive features' that can be considered by the FOAC and Stakeholders to maximize benefit, should funding be obtained.

**Table 4 – Potential Additive Features (Funding Dependent)**

| Additive Features | Image showing this Additive Feature |
|---|---|
| **<u>Prospect Ave E streetscape improvements</u>**<br><br><u>benefit(s):</u> traffic calming and pedestrian/bike safety on Prospect Ave E<br><br><u>images to the right:</u> existing conditions along Prospect Ave E (top) and potential streetscape improvements (bottom)<br><br><u>next steps</u>: coordination with SDOT, SPU, and SPR; identification for City requirements (for bike, pedestrian, and vehicular use) to determine if this use of the streetscape is allowed per City code; coordination with SPR/SDOT regarding property ownership<br><br><u>potential partnerships/funding sources</u>: SPU, SDOT, SPR | <br> |
| **<u>Prospect Ave E streetscape improvements and Arboretum Community access</u>**<br><br><u>benefit(s):</u> traffic calming and pedestrian/bike safety on Prospect Ave E; Community access to Washington Park Arboretum<br><br><u>images to the right:</u> graphic showing proposed improvements<br><br><u>next steps</u>: coordination with SDOT, SPU, and SPR; identification for City requirements (for bike, pedestrian, and vehicular use) to determine if this use of the streetscape is allowed per City code; coordination with SPR/SDOT regarding property ownership<br><br><u>potential partnerships/funding sources</u>: SPU, SDOT, SPR |  |

## 5.4. Estimate of Project Costs

The estimate of total capital costs is shown in Table 5 below, which is an Association for the Advancement of Cost Engineering (AACE) Class 4 Estimate of Construction Cost (with a +50%/-30% accuracy). The Included in total capital cost is an estimate of construction costs plus soft costs, property costs, and construction management costs. Table 6 shows an estimate of maintenance costs for the project.

**Table 5 - Estimate of Total Capital Cost**

| Element of Total Capital Costs | Description | Estimated Amount (and accuracy range) |
|---|---|---|
| **Estimate of Construction Costs** | Association for the Advancement of Cost Engineering (AACE) Class 4 Cost Estimate, with accuracy of +50%/-30%, appropriate for a concept level of design; note that this estimate of construction costs has increased as compared to the Class 5 cost estimate prepared at the 10% level of design development, reflecting modifications to the design as well as anticipated market conditions. | **$2,300,000** (accuracy of -30%/ +50%) |
| **Soft Costs** | Soft costs include: Information Gathering (ex: survey, geotechnical data collection, critical areas delineation, traffic analysis), Design, Stakeholder Engagement, Coordination with Permitting entities as well as preparation and submittal of permit applications, Public Engagement, Project Administration (by administering entity), and Construction Management)<br>In the infrastructure and environmental restoration field, soft costs are typically estimated, for planning purposes, at between 60-80% of construction costs depending on project complexity and administrating entity. Shown here is a range of soft costs based on 70% of construction costs. As this project progresses, this estimate of soft costs can and should be further refined.<br>(Note that these soft costs are intended to be inclusive of all such costs, from project planning through construction, and so therefore a portion of these soft costs have already been incurred and paid. **See section 7.2 for an updated estimate of yet-to-be-incurred soft costs and the outstanding funding need.** | **$1,610,000** (estimated as 70% of construction costs) |
| **Property** | Estimated as 0% of construction costs; currently, no property costs are anticipated (though subject to change as the project evolves) | $0 |
| **Estimated Total Capital Costs**<br><br>(low end of $2,576,000 based on -30% for construction costs and soft costs of 60% of construction costs; high end of $6,210,000 based on +50% of construction costs and soft costs of 80% of construction costs) | | **$3,910,000**<br><br>(estimated range of $2,576,000 - $6,210,000 based on construction cost estimate accuracy of -30%/+50% and uncertainty in soft costs of between 60-80%) |

Table 6 - Estimate of Maintenance Costs Over the First 20 years

| Element of Maintenance Cost | Notes | Amount |
|---|---|---|
| **Water Quality Treatment Facility**<br>*(assumed 100-year design life, in 20-year cycles, with annual maintenance costs shown below for each year in a 20-year cycle; Assume replacement of key facility elements at year 20 in each 20-year cycle)*<br>*In addition to what's shown here, recommend funding an additional 1.0 FTE for maintenance of plants, etc. While a full FTE might not be enough, there is a need for additional FTE(s) are needed for maintenance of proximate areas within the Washington Park Arboretum including the loop trail.* | | |
| Water Quality Treatment Facility – Annual maintenance for Years 1-19 (vegetation management, arborist woodchips, irrigation in the early years for plant establishment) | 5000 sf at $4.50 per sf | $22,500 |
| Water Quality Treatment Facility – Year 20 | Replacement of submerged media in all cells, replanting of all vegetation | $500,000 (estimated based on construction cost estimate for these elements) |
| **Piped Conveyance and Pretreatment Maintenance Hole** | | |
| Piped Conveyance – annual maintenance cost (years 1-100) | Estimated to be 1% of capital cost of piped conveyance | $2,500 |
| Annual maintenance cost of pretreatment maintenance hole (located within Japanese Garden Parking Lot) (years 1-100) | Assumed cleaned out quarterly, using vactor or similar truck | $10,000 |

# 6. Permitting Needs

The permits that would be required for this project in its 30% design level of development are identified and discussed in this section. These include federal, state, and local regulatory processes. Appendix C identifies the specific permits and regulatory processes identified as required for this project at the federal, state, and local levels.  And while as the project develops the permitting requirements may change, this draft list of permit requirements helped inform the 30% design and will be updated in future project phases in order to inform design at those future phases.

As noted in Appendix C, the National Historic Preservation Act (Section 106) and the Endangered Species Act requirements (both federal regulatory processes) may likely take the longest to prepare and to review by the regulatory entities and therefore it is recommended that these permit application activities be started at the same time as 60% design commencement.

# 7. Next Steps and Schedule

As stated earlier, this project is a 30% design level of development, though key information still needs to be collected (topographical survey, geotechnical information). The next steps to be taken by FOAC are described here.

## 7.1. Additional Data Collection

FOAC intends to proceed, via contract amendment with its consultants, to move forward from 30% to 60% design, including additional data and information collection to inform decision-making and the 60% design process. Such data and information will likely include:

- Topographical survey information
- Geotechnical data collection
- Information on the location of buried utilities in the path or footprint of the project

Note: FOAC is assuming that there is no additional water pressure data or depth measurements required for this project.

## 7.2. Stakeholder Engagement, Project Funding, and Potential Partnerships

FOAC and the Jacobs team also met with SPR ProView on 6/14/22 to receive feedback on the 30% design. The slide deck from that meeting is in Appendix A in this report. FOAC also presented this 30% design to the FOAC Advisory Group on 7/14/22. Upon completion of this report, FOAC will meet with the Master Plan Implementation Group (MPIG) to solicit feedback on this 30% design.

FOAC plans to continue to work with the FOAC Advisory Group through future stages of this project. However, it is the intention of FOAC to hand over responsibility for this project to Seattle Parks and Recreation after the 60% design is complete.

As appropriate, FOAC (or SPR) expects to present to SPR's ProView, ProView Tech, and properties committees at the various design milestones (i60% and 90%). FOAC will also continue coordination with MPIG. Topics for likely discussion are construction funding and maintenance requirements & responsibilities. Coordination with these entities is critical to the design (and funding) of this project.

Community meetings to update neighbors will be important as the design progresses. However, the major portion of this project will take place on SRP property, with the balance happening primarily in the public right of way.

Thanks primarily to King County, FOAC has secured nearly $.7M in grant funding to complete the project design. In addition, all of the ongoing FOAC project management costs, starting in 2017, have been provided at no charge. Plus, the stakeholder time donated via our quarterly Advisory Meetings, and multiple MPIG and ProView Meetings have been at no charge as well. The bottom line is a large portion of the soft costs estimated in Table 5 have already been addressed. (FOAC is estimating approximately $1 million in grant dollars secured and costs avoided.)

Going forward, seed funding relevant to construction and maintenance, may be highly persuasive in securing capital allocation and matching funds. Given the length of capital planning windows, every dollar of support secured today may have a multiplying impact on future capital planning and donations.

## 7.3. Final Design, Permitting and Construction

Now that the project is at a 30% design level, FOAC and the Jacobs team can proceed with 60% design development and Additional Data Collection (see 5.1). As is industry standard at the 60% design development phase, detailed hydrologic and hydraulic modeling of the conveyance system and modeling and analyses of the treatment facility capacity and effectiveness will be performed, building off of preliminary analyses at the 30% design phase that is documented in this report. Permitting activities that are required (see Appendix C) are extensive. As noted in the table in Appendix C, the National Historic Preservation Act (Section 106) and the Endangered Species Act requirements (both federal regulatory processes) may likely take the longest and therefore it is recommended that these permit application activities be started at the same time as 60% design commencement. After design to the 60% design level, permitting applications may be submitted. After Final Design is completed, the project can proceed to construction. After construction, it is anticipated that facility effectiveness monitoring will be required by either the permitting entities and/or as a requirement of construction grants.

## 7.4. Project Milestone Schedule

The proposed milestone shown below has anticipated dates for 60% design completion and completion and submittal of permit applications, a 12-month permit application review period by the regulatory entities, then final design through construction. The schedule also shows the anticipated hand-off of this project from FOAC to SPR. Construction is expected to take approximately 18 months over two (2) dry-weather seasons. It is anticipated that this project will have post-construction monitoring requirements. While it is not yet known the duration of required monitoring, a period of 5 years is typical though it may be as long as 10 years. This monitoring is not shown on the schedule below:

- July 2022 – Completion of 30% Design
- August – November 2022 – Completion of additional information gathering (survey, geotechnical exploration)
- May 2023 – Completion of 60% Design
- June 2023 – hand-off of project from FOAC to SPR (?)
- July 2023 – Submittal of Permit Applications (will take 2 months after 60% design is complete to make permit-specific plan set, and all needed calculations; begin preparing permit materials as early as June 2022 when 60% design starts)
- July 2024 – Obtain permits (permit review period is anticipated to be 1 year. If permits take longer than this all subsequent timing will be impacted.)
- October 2024 – 90% Design completed
- December 2024 – 100%/Final Design Completed
- January 2025 – Construction Project is Advertised
- June 2025 – Construction begins
- December 2026 – Construction completed (construction to take 18 months, over two ‘in-water work periods’)
- Monitoring Period – Anticipate long-term monitoring is required to confirm continued effectiveness of the water quality treatment facility (duration to be determined during permitting)

# 8. References


Friends of Arboretum Creek (FOAC) 2021. Alder Creek to Arboretum Creek Reconnection Conceptual Design Report. May 19, 2011. Prepared by Jacobs and Berger, funded by the King County Wastewater Treatment Division with support from The Seattle Parks Foundation.

Anchor QEA 2014. Geotechnical Engineering Design Report Washington Park Arboretum Multi-Use Trail and Bridge Project. May 2014. Prepared by Anchor QEA for The Berger Partnership.