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Prepared for Bainbridge Island Trust, Wild Fish Conservancy and
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Table of Contents

Introduction.....	1
Description and Role of the Watershed Characterization.....	3
Results of Characterization.....	7
Summary.....	13

Tables

Table 1. Springbrook Creek Recommendations for Assessment Unit Management.....	10
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Figures

Figure 1. Location map.....	1
Figure 2. Project Assessment Unit Map (PAUs).....	2
Figure 3. Diagram of the components that comprise the importance model.....	3
Figure 4. Diagram of the components that comprise the degradation model.....	4
Figure 5. Management Matrix.....	5
Figure 6. Diagram of the components that comprise the sediment export model.....	5
Figure 7. Surficial geology map.....	6
Figure 8. 2011 NAIP satellite imagery for the Springbrook Creek Watershed.....	7
Figure 9. Results of the sediment model.....	8
Figure 10. Characterization results.....	9
Figure 11. Comparison of the correlation of B-BIBI and High Pulse data.....	11
Figure 12. Soil map with hydric soil.....	12
Figure 13. Fine sediment entering one of the upper ponds on the Johnson Farm property.....	14
Figure 14. Upper agricultural pond on Johnson farm.....	14
Figure 15. Example of conversion of depressional wetlands to pasture land.....	15
Figure 16. Channel clogged by reed canary grass.....	15
Figure 17. Example of a properly functioning stream system.....	16
Figure 18. Clearing of forested riparian vegetation.....	16
Figure 19. Example of measures to restore stream channel.....	17
Figure 20. Forested emergent slope wetland complex.....	17
Figure 21. Culvert and weir system.....	18

Introduction

This watershed characterization was prepared for the 999-acre Springbrook Creek Watershed located on Bainbridge Island, Kitsap County, Washington (Figure 1), upon the request of the Wild Fish Conservancy, Bainbridge Island Land Trust and City of Bainbridge Island. The purpose of the characterization is to help resource managers and planners, through a better understanding of water flow and water quality processes, identify and prioritize the best locations for restoration and protection actions and for new development.

Bainbridge Island is situated within the Puget Sound lowlands, and is delineated on its eastern boundary by the marine waters of Puget Sound, Rich Passage on the south, and Port Orchard on the west and Agate Passage on the north. The Springbrook Creek Watershed is located on the west-

central side of the Island and consists of approximately 7 sub-watersheds or Project Assessment Units (PAUs) that flow into the mainstem of Springbrook Creek, which in turn flows northwest, through a large wetland complex into Fletcher Bay (Figure 2).

The characterization uses a decision support modeling system described in Volume 1 (Water Resource Assessments, Stanley et. al. 2016) of the Puget Sound Characterization which is designed to help resource managers make watershed based decisions. It includes use of GIS data sources provided by the Wild Fish Conservancy and the City for watershed and sub-watershed boundaries and for hydrography, land cover, wetlands and stream confinement layers. Additionally, the report findings are supplemented by field observations conducted on May 10th with the Wild Fish Conservancy, Bainbridge Island Land Trust, Department of Fish and Wildlife, Suquamish Tribe, Bainbridge Island Watershed Council, and the City of Bainbridge Island.

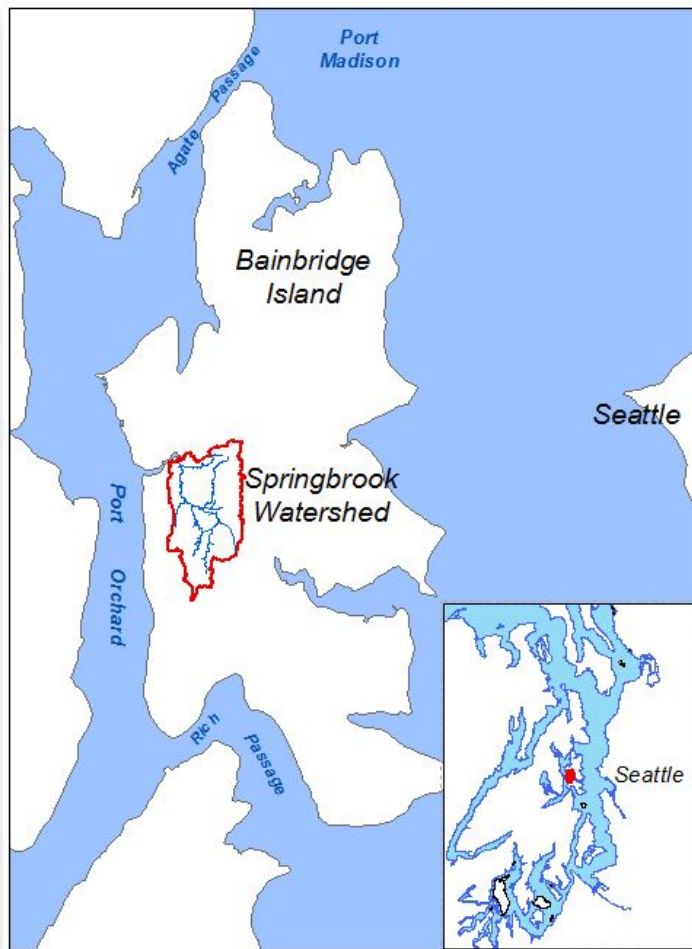


Figure 1. Location map of Springbrook Creek Watershed on the central west side of Bainbridge Island in Puget Sound, Washington.

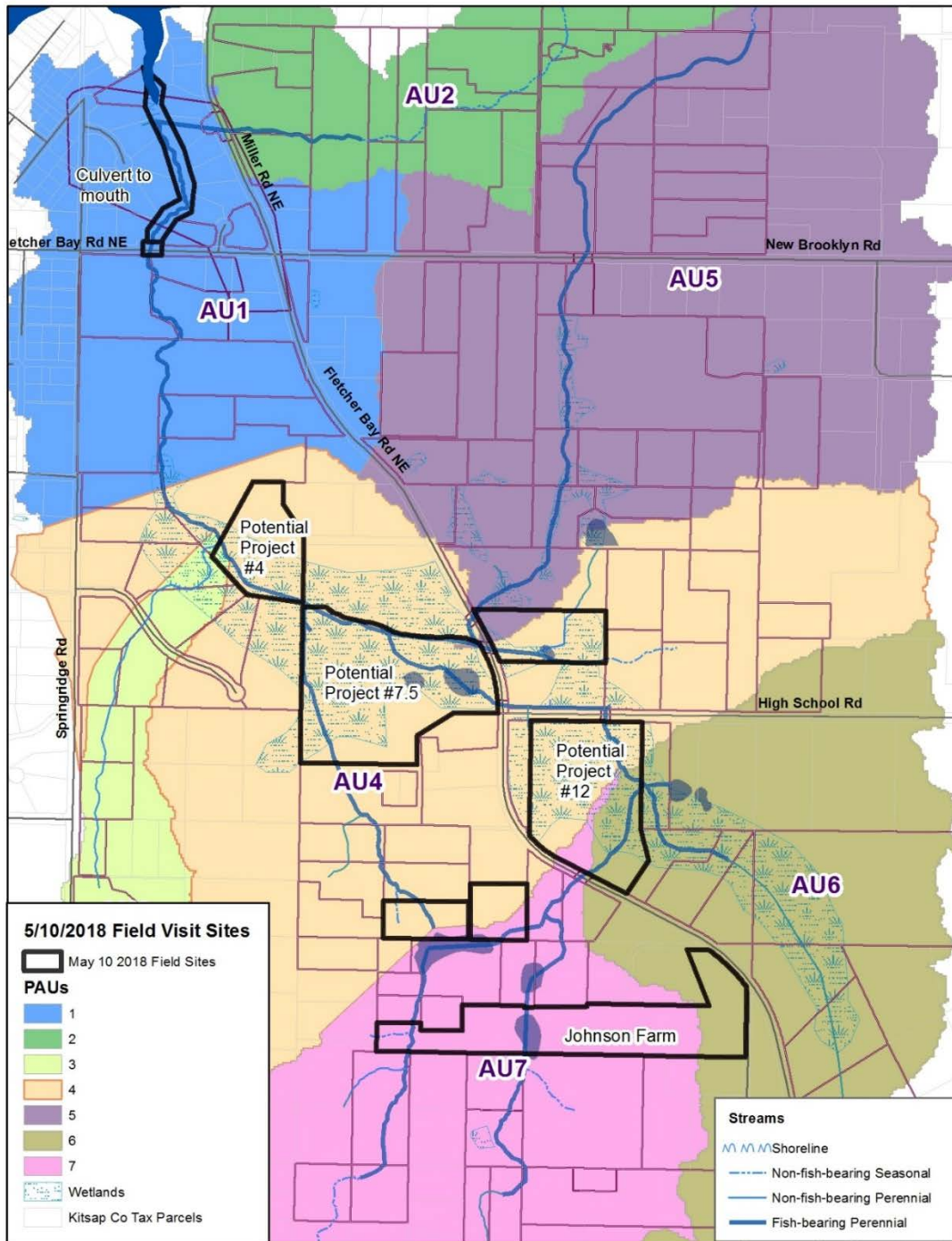


Figure 2. The Project Assessment Unit Map (PAUs) for Springbrook Creek Watershed are shown in color and are numbered 1-7 on the map. The “Potential Projects” indicate the approximate location of properties visited during the May 10, 2018 field tour. Map courtesy of Bainbridge Island Land Trust.

Description and Role of the Watershed Characterization

The Puget Sound Watershed Characterization is a decision support tool to help resource managers identify the best locations for protection and restoration actions. The tool is based on a conceptual model of the components that contribute to the delivery, movement and loss of water. For each of these components of delivery, movement and loss, there are “controls” or features on the landscape that govern water flow patterns, including:

- Forest cover which slows and regulates the delivery of precipitation;
- Wetland and floodplain areas that store and regulate the overland movement of water and;
- Surficial geology which regulates groundwater infiltration, recharge and discharge processes.

The greater the number of controls within an individual PAU the higher its importance relative to other PAUs within that watershed. The importance model is designed to give the user a picture of how a watershed should function without the changes or impacts created by human development over the past 150 years. Figure 3 presents the “importance” model (i.e. model 1) and the indicators that it uses of landscape features that control the delivery, movement and loss of water.

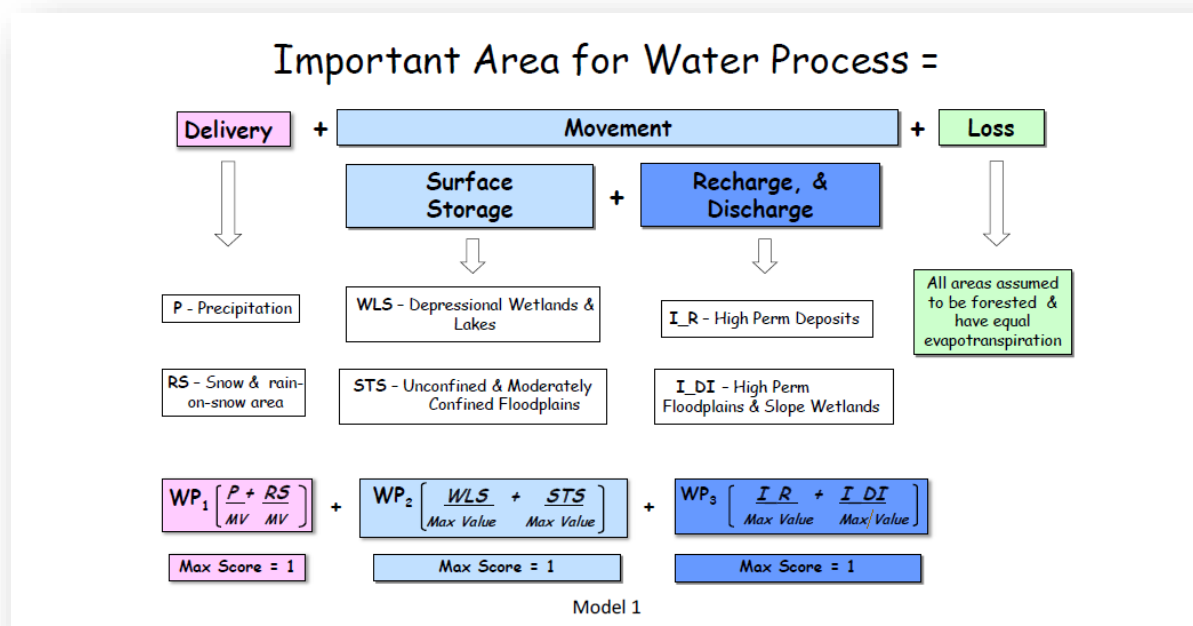


Figure 3. Diagram of the components that comprise the importance model. The physical features that control the delivery, movement and loss of water are represented by the “white boxes.” For example, a control for storage would be indicated by the presence of depressional wetlands and lakes.

In order to understand the extent of impacts to the water flow processes, the characterization uses a degradation model (model 2) which is shown in Figure 4. The degradation model looks at the degree to which each of the controls for the importance model have been changed relative to those same controls in other sub-watersheds. Typically, the greater the number of controls that are altered, the higher the degradation score.

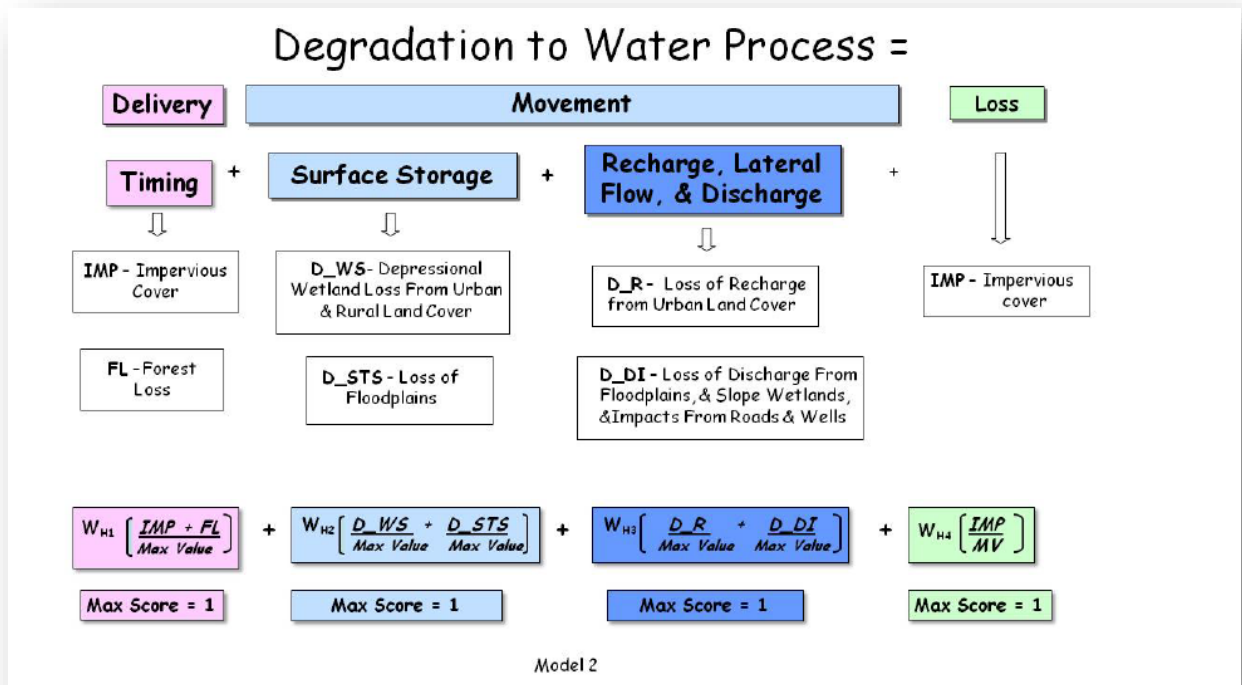


Figure 4. Diagram of the components that comprise the degradation model. The “white boxes” represent the type of alteration that would affect the controls in model 1 for the delivery, movement and loss of water. For example, the loss of wetlands and floodplains from urban development would directly affect the storage control of model 1.

The results for both the importance and degradation model can be combined in a matrix (Figure 5) that allows a user to identify what type of management action might be appropriate for a particular sub-watershed. For example, if a sub-watershed is comprised primarily of forest cover, with little to no development, higher rainfall, and large areas of permeable deposits, then that watershed would fall within the upper left quadrant of the management matrix for “protection”. On the other hand, if a sub-watershed with high importance was highly degraded, then it would fall within the “restoration” quadrant of the management matrix. Each management action is given a priority number of 1, 2 or 3 with “1” being the highest priority for consideration (e.g. P1, protection 1, has a higher priority than P3, protection 3).

Thus, the management matrix can serve as a tool to guide resource managers in identifying priority areas for both protection and restoration and help avoid management actions that would seriously affect the overall hydrologic health of a watershed.

For the characterization of sediment impacts, a model structure similar to that of the water flow processes is used. This includes a model for assessing the export potential for sediment of individual assessment units. This includes identifying the features on the landscape that control the erosion of sediment sources, sediment transport and sinks which store sediment (Figures 6 & 9). For the Springbrook Creek Watershed, only the export potential for sediment was assessed and not how these sediment processes have been degraded.

Management Matrix (9) for Protection & Restoration of Water Flow Processes with GIS Attributes

Level of Importance	High	Highest Protection P1 H, L	Protection Restoration PR1 H, M	Highest Restoration R1 H, H
		Protection P2 M, L	Protection Restoration PR2 M, M	Restoration R2 M, H
	Low	Protection/Conservation P3 L, L	Protection/Restoration PR3 L, M	Development/Restoration D L, H
		Low	Level of Degradation	High

Red Letter = H, M, or L
for **Importance** Score

Black Letter = H, M, or L
for **Degradation** Score

Figure 5. Management Matrix for combining the results of model 1 (level of importance on vertical axis) and model 2 (level of degradation on horizontal axis). The matrix is designed to assist resource managers in identifying the best locations and priority (e.g. P1>P3) for restoration and protection actions.

Export Potential for Sediment Process =

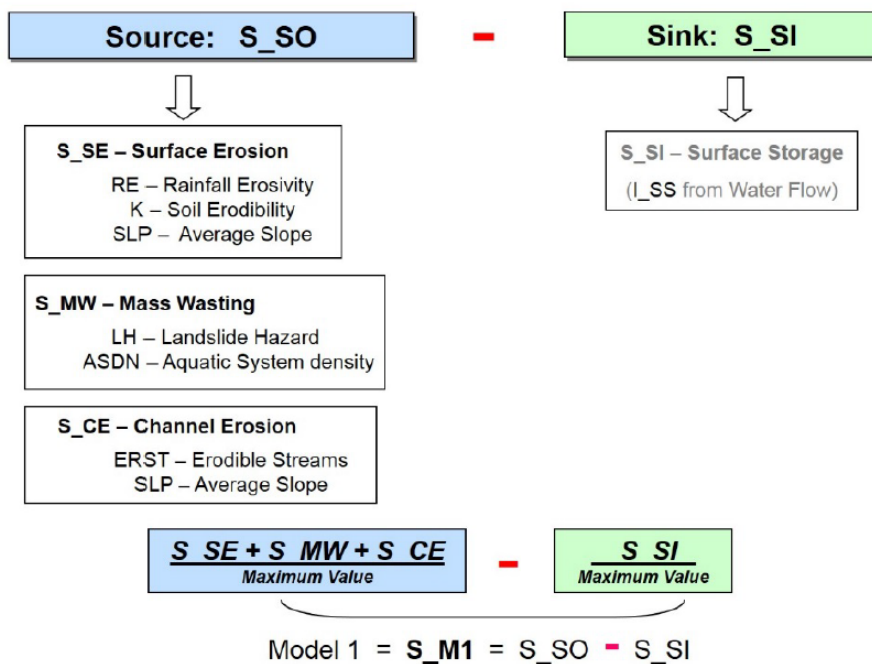


Figure 6. Diagram of the components that comprise the sediment export model. This model calculates the relative value of areas within a watershed that control sediment source and sink processes and takes the difference between those two values in order to obtain the relative export potential.

Surficial Geology

Surficial geology determines where infiltration, recharge and discharge of groundwater occurs in a watershed and is a key control for these watershed processes. The surficial geology of Bainbridge Island is, in part, the result of glaciation originating in Canada approximately 18,000 years ago and by surface erosion occurring over the last 14,500 years after the glacier's retreat. The weathering and erosion of the glacial surface deposits has been caused by the movement of surface and shallow subsurface flows and discharges, which have, in turn, created the present day stream network within the Springbrook Creek Watershed.

The glacial deposits on the island consist primarily of till, advance outwash and recessional outwash (Figure 7). Till is a highly compacted glacial deposit that has relatively low permeability and low potential for erosion. Advance outwash consists of sorted sands and gravels that were washed out in front of the advancing glacier. Due to compaction by the advancing glacier, advance outwash deposits are considered to have moderate permeability and water holding capacity. Because recessional outwash was not compacted by the retreating glacier, it is highly permeable and also has the highest capacity for storing groundwater.

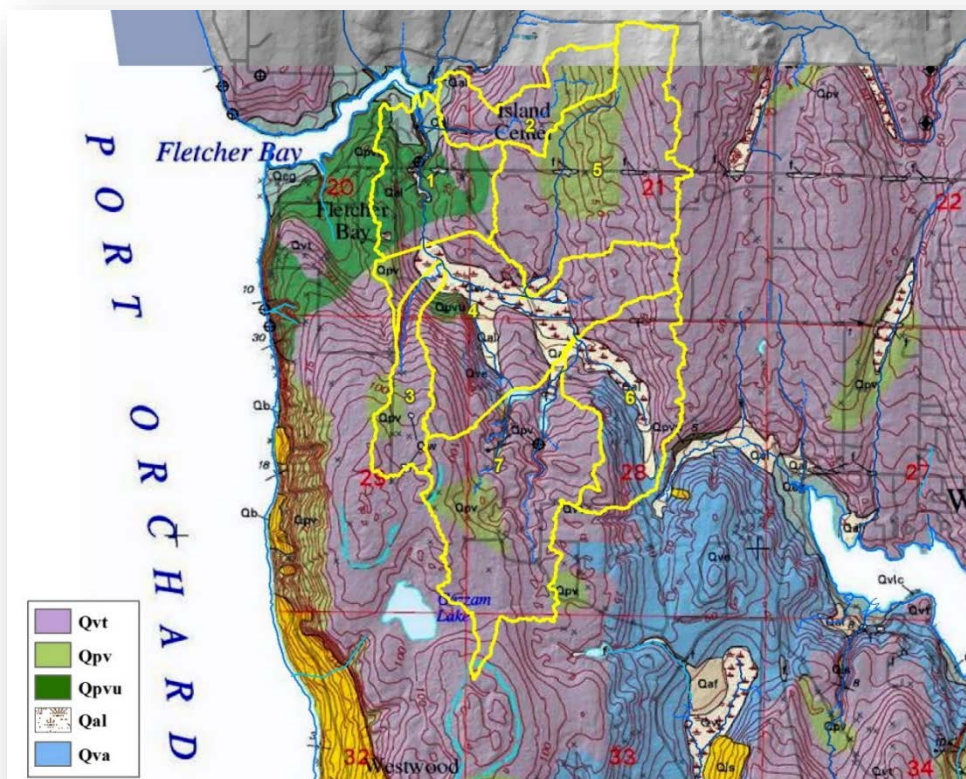
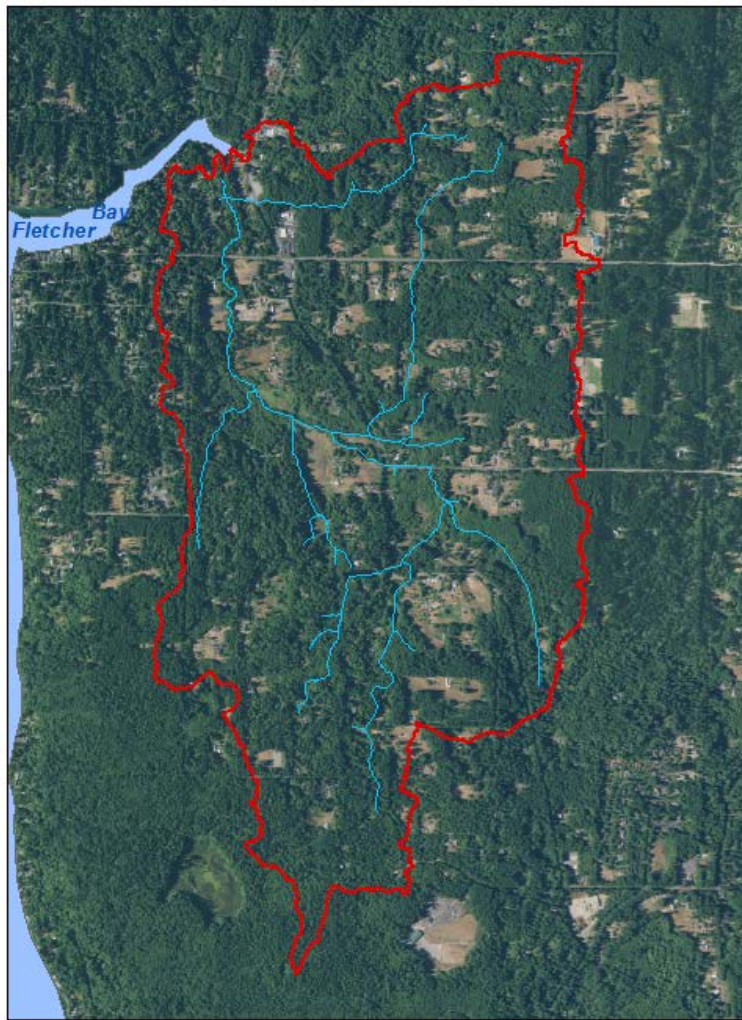


Figure 7. Surficial geology map of Springbrook Watershed. Note that the watershed is comprised primarily of low permeability till deposits (purple color: Qvt), but also contains areas of higher permeability “advance outwash” deposits (green color: Qpv) that are important for water flow processes and are primarily located in the upper watershed of Project Assessment Unit (PAU) 3 and 7 as well as in PAU 2 and 5. The “white” Qal polygon is the location of depressional wetlands (PAU 4, Figure 2) which play an important role in the storage of surface waters and is also an area of groundwater discharge. Source USGS, Haugerud, 2005.

Thus both the advance and recessional outwash deposits are present in the uplands areas of the watershed and are important for maintaining stream and wetland hydrology. These outwash deposits, however, are also susceptible to erosion due to their composition of sands and gravels.

Land Cover



Land cover also plays a significant role in regulating the delivery, movement and loss of water in the Springbrook Creek Watershed. Figure 8 presents the land cover patterns in this watershed as of 2011 National Agricultural Imagery Program (NAIP). On a relative basis, the watershed is primarily forested, with alteration consisting of rural residential development involving the clearing of forest for pasture, homes, outbuildings and roads. The southern “headwaters” portion of the watershed appears to have a lower degree of alteration relative to the central and northern portion of the watershed.

Figure 8. 2011 NAIP satellite imagery for the Springbrook Creek Watershed.

Results of Characterization

Figure 10 and Table 1 present the results of applying the Puget Sound Characterization decision support tool, to 7 project assessment units (PAUs) within the 999 acre Springbrook Creek Watershed (Figure 2). In interpreting the results, care should be taken to not directly attribute causality between the “importance” and “alteration” scores and biological, physical and chemical conditions in the stream itself. However, the results can be used to suggest management actions and guide management decisions, including protection and restoration actions. The five management action

categories are identified in Figure 5 and include: Protection, Restoration, Protection/Restoration, Protection/Conservation, and Development/Restoration.

The results presented in Figure 10, provide a conceptual “snapshot” of how the water flow and sediment processes for the overall Springbrook watershed function together. A description and summary of this conceptual “snapshot” is as follows:

- 1) The southern, steeper half of the watershed in PAUs 3, 6, 7 is important for the interception of precipitation, and its subsequent infiltration and recharge of groundwater. The combination of shallow groundwater flow and surface flows contribute to supporting stream flows within these PAUs. This part of the watershed is in relatively good condition hydrologically due to an intact forest cover and limited development. This area also has a high potential to generate and export sediment (Figure 9). There are indications that fine sediment may be impacting the ecology of the Springbrook stream system. The City of Bainbridge Island funded a 2015 study by King County to evaluate stream benthos and hydrologic data for eight streams, including Springbrook Creek (DeGasperi et al 2015).

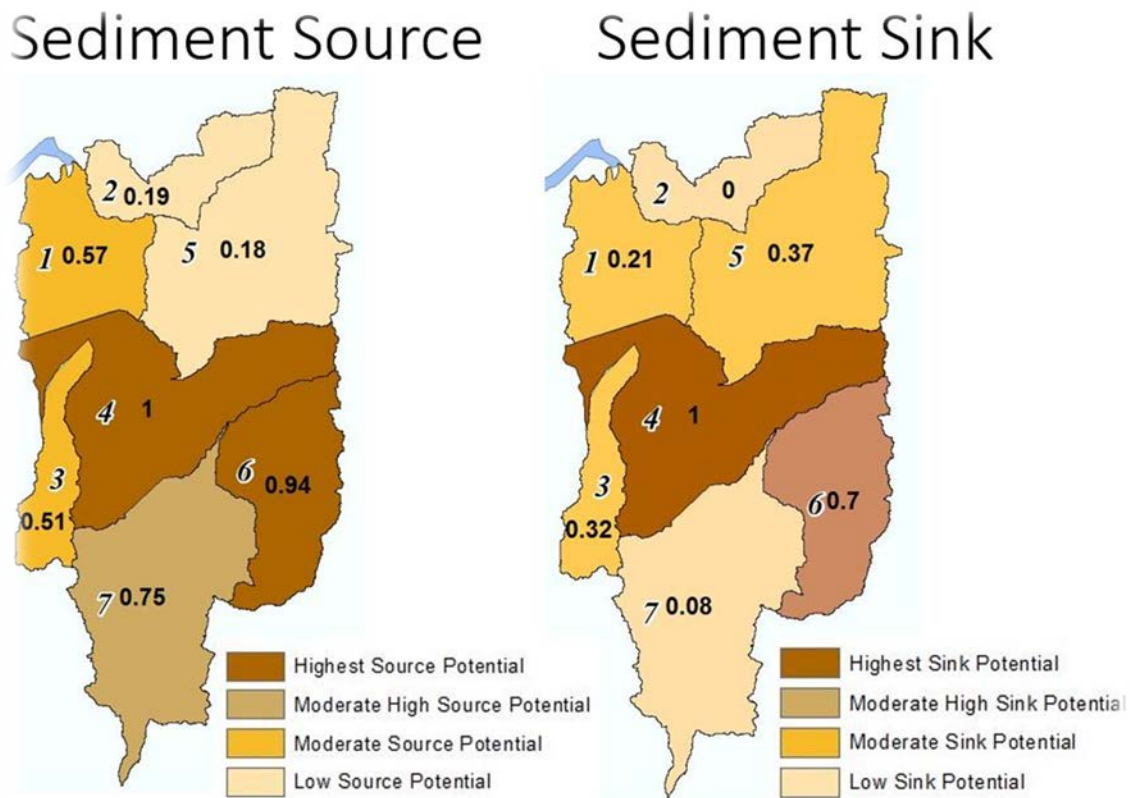
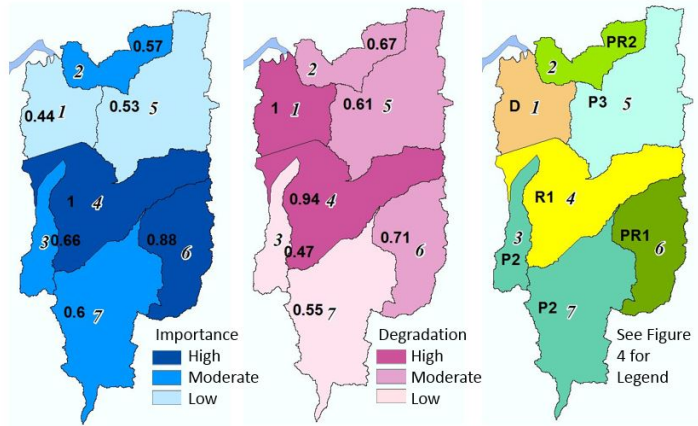
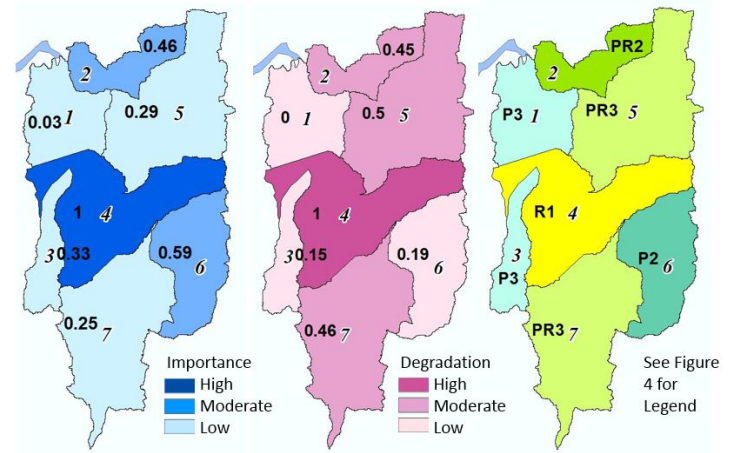


Figure 9. Results of sediment model. The left graphic shows the areas with the highest potential for generating sediment (darker colors), such as assessment units 4, 6 and 7. The right graphic shows the areas with the highest potential for retaining sediment (darker colors) such as assessment units 4 and 6.

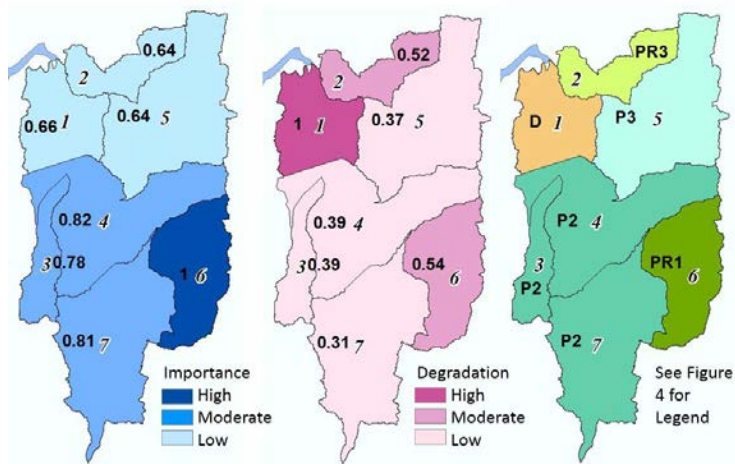
Overall Water Flow



Surface Storage



Recharge



Discharge

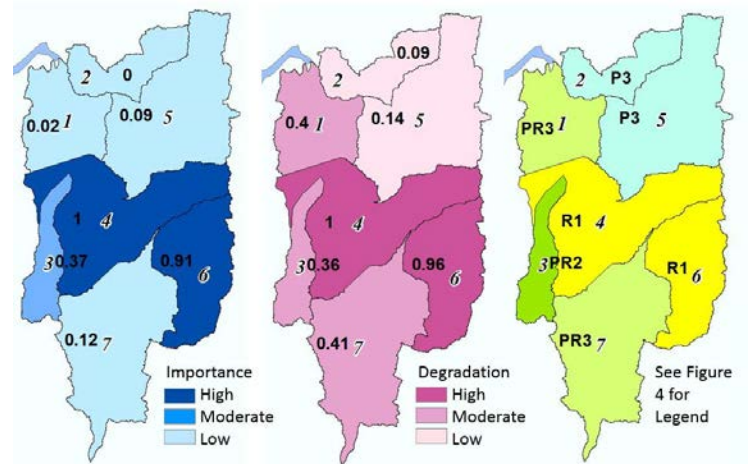


Figure 10. Water Flow Model Results. Bold numbers from 0 to 1 are the normalized scores, with a higher score indicating a higher level of importance or alteration. The numbers 1 through 7 are the PAU or project assessment unit ID number. The blue basins represent the output of the importance model; the pink basins represent the output of the degradation model and the green/yellow basins represent combined output of the two previous models using the management matrix in Figure 5.

Table 1 Springbrook Creek Recommendations for Assessment Unit Management (Use in Conjunction with Figures 5 & 10).

PAU #	Overall Results	Storage	Re-charge	Dis-charge	Restoration Priority	Protection Priority	Overall Condition of PAU and Key Issues	Recommendations
1	D	P3	D	PR3	7	6	Concrete compound weir and culvert in lower reaches impedes fish passage and affects stream fluvial dynamics. Homes have impacted the riparian corridor by removing native vegetation, introducing non-native vegetation and increasing erosion on creek banks. This PAU has lower importance and higher degradation of processes relation to other PAUs due to a relatively higher level of development and less opportunity to support watershed processes.	Concentrate development here using LID techniques. Investigate funding sources for removing compound weir and culvert system with bio-engineered alternative that re-establishes natural processes and historic longitudinal profile and gradient. Seek riparian conservation easements for properties along creek and restore native vegetation.
2	PR2	PR2	PR3	P3	4	4	Assessment unit has moderate level of urban residential development. Floodplain storage has moderate importance.	Seek riparian conservation easements for properties along creek & protect floodplain storage. Use LID techniques for development.
3	P2	P3	P2	PR2	5	3	Assessment unit is relatively intact with limited development	Seek riparian conservation easements for properties along creek.
4	R1	R1	P2	R1	1	1	Relatively widespread damage to storage & discharge processes in this assessment unit. Clearing of floodplain & wetland vegetation for rural residential farming operations and for access by owners to active stream channel. Most streams are diverted away from historic wetland areas. Clearing has encouraged growth of reed canary grass which is clogging stream channels.	This assessment unit presents the greatest opportunity for biological lift in the system and requires relatively extensive restoration measures. It is key to successful restoration of the overall system. Work with home owners to obtain conservation easement for purpose of restoring riparian and floodplain vegetation & protecting intact slope discharge areas. Existing areas of forested floodplain should be protected.
5	P3	PR3	P3	P3	6	6	Assessment unit has lower importance but moderate level of development could affect integrity of watershed. Depressional wetlands and floodplains present; important for flood storage.	Seek riparian and forest conservation easements to sustain native cover, protect wetland/stream ecosystems.
6	PR1	P2	PR1	R1	2	1	Assessment unit is relatively intact and contains part of the large depressional wetland system in the adjacent assessment unit 4	Maintain & restore forest cover; restore natural cover in wetland system. Seek riparian & wetland conservation easements.
7	P2	PR3	P2	PR3	3	2	Erosion of outwash deposits in upper watershed & transport downstream. Solar heating of water in artificial ponds may contribute to stream temperature increase.	Protect & maintain forest cover. Allow ponds to fill in and convert to shallow wetland systems which act as sediment trap & provide forested cover.

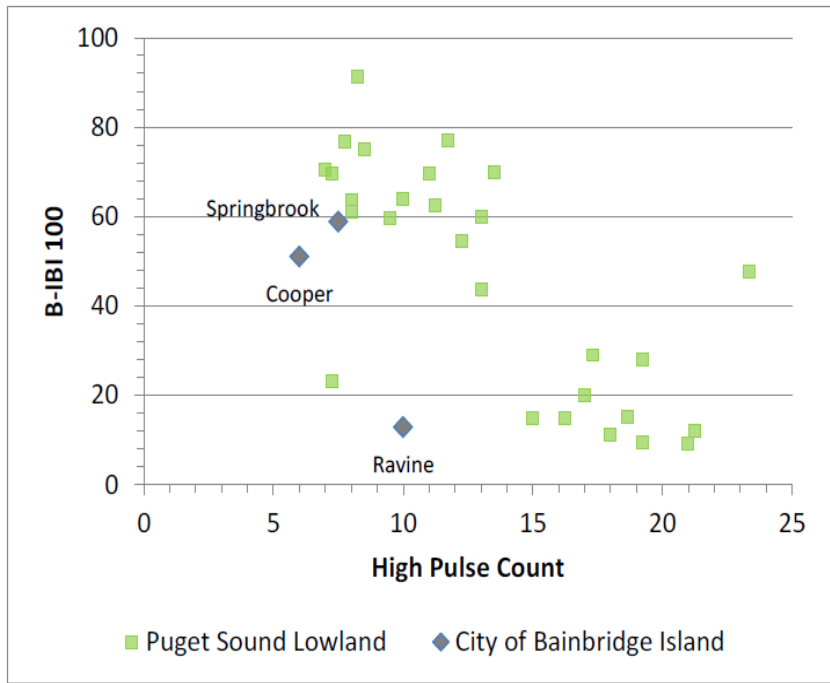


Figure 11. Comparison of the correlation of B-BIBI 100 and High Pulse data for Springbrook Creek watershed and WRIA 8 reference watersheds (green data points). Source: King County (DeGasperi 2015).

The results (Figure 11) show that while Springbrook Creek had a relatively low High Pulse Count (average of 8 per year), its Benthic Index of Biological Integrity (BIBI) scores were only fair. Streams with a lower High Pulse Counts are typically “healthier” hydrologically and biologically. Furthermore, Springbrook Creek appears to lie at the lower edge of BIBI data for WRIA 8 reference watersheds. The DeGasperi study states that fine sediment may be a contributing factor to these lower than expected BIBI scores and goes on to state that “any development within these basins may also be a contributing factor as well,

potentially delivering sediment through construction and land clearing activities and through stream bank erosion resulting from increased peak flows.” To minimize sediment export and protect water flow processes, primary land use management measures should include protection of land cover and minimization of impervious surfaces and provision of adequate buffers to protect the watersheds of stream systems.

- 2) The central, lower gradient portion of the watershed is the primary area (PAU 4 and lower portions of 5 and 6) within the watershed where deeper groundwater flows from the upper portions of PAUs 3,5,6 and 7 discharge into and are temporarily stored in both the wetlands and stream systems in this central watershed area. As a result, this area has historically been very wet (Figure 12). This discharge and storage area functions to help maintain low flows during summer and fall months and also assists in retaining and attenuating high surface flows during storms and reducing downstream flooding, erosion and transport of sediment. In addition, this area has the potential to remove sediment, nutrients, toxic organics, and heavy metals from the receiving waters (Stanley et al. 2016).

This area has been extensively altered by agricultural activities so many of these water flow and water quality processes and functions have been degraded. For example, ditching throughout the area lowers the groundwater table which can affect the water quality process of removing nitrogen through denitrification. Nitrogen, when transported via streamflow to nearshore marine waters can cause harmful algal blooms.

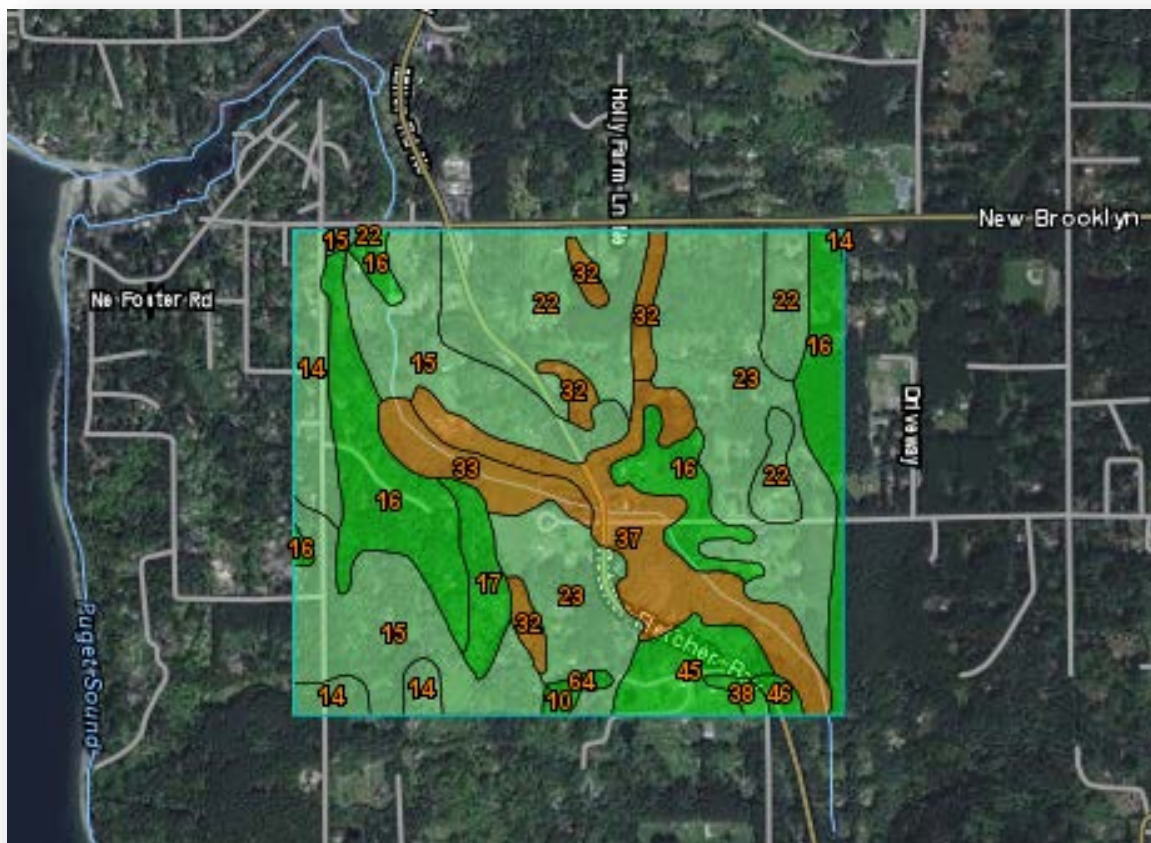


Figure 12. This soil map shows the location of hydric soils (tan colors) in PAU 4. Map unit 33 is a peat soil, indicating conditions of constant soil saturation over the past 10K+ years. Map unit 32 & 37 are mineral based hydric soils, and are also saturated for long periods of time during the year. Taken together these hydric soil units are key areas for groundwater discharge and retention of surface waters. Source: NRCS web based soil maps.

Figure 9 also indicates that PAUs 4 and 6 have a high potential for acting as both a source and sink for sediment. These conditions suggest that the restoration and protection of depressional wetlands and floodplains in these units are a high priority since they would be capable of retaining fine sediment. In addition, the process of adsorption in these depressional wetlands would act to remove phosphorous, metals and toxic organics. Primary land use management measures would be to restore the storage and water quality processes and functions in these PAUs.

- 3) The northern half of the Springbrook Watershed contributes less, on a relative basis, to the overall water flow and water quality processes. This portion of the watershed is generally more degraded, than the southern portion of the watershed. This is particularly true for assessment units such as PAU 1, which has the highest relative level of degradation and has less opportunity to attenuate stream flows or support low flows relative to PAUs 4, 6 and 7, due to its location at the bottom of the watershed (i.e. outlet to Fletcher Bay). As a result, concentrating development

within this portion of the watershed, particularly PAU 1 and 2 would serve to protect and maintain the more important PAUs in the central and southern portion of the watershed.

It is also critical, however, that Low Impact Development measures be required for new development in these PAU's in order to minimize impacts to water flow and water quality processes including protection of floodplain storage in PAU 2.

Summary

The recommendations set forth in Table 1 are a synthesis of the characterization results with field observations made on May 10, 2018. Based on this synthesis the following presents the key recommendations for the watershed:

- 1) Maintain native forest and scrub-shrub cover and minimize impervious surfaces in the headwater assessment units. This will help minimize erosion in the upper watershed particularly in assessment units 6 and 7 and reduce transport of sediment downstream.
- 2) Encourage gradual "natural" restoration of agricultural ponds in PAU 4, 5, 6 and 7 to wetland systems with emergent, scrub-shrub and forested components. This will allow trapping of sediment and creation of shading to reduce solar heating of open water areas.
- 3) Restore native forest and scrub-shrub cover within the depressional wetland systems in assessment units 4 and 6 and re-establish the stream channel. This includes providing adequate buffers widths to protect stream and watershed processes and functions.
- 4) Protect key groundwater discharge systems (slope wetlands) that are still intact, particularly in PAU 4 on slopes bordering the west boundary of the depressional wetland system.
- 5) Develop alternative "bio-engineered" (i.e. mimics natural conditions) solutions to replace culvert system at Fletcher Bay Road NE and downstream compound weir system.

During the May 10th field inspection, sediment fans were observed at the Johnson Farms agricultural ponds (Figure 13). Upstream of these ponds are deposits of outwash material (see Figure 7), which have a relatively higher rate of erosion. Because storms in Puget Sound are showing an increase in intensity and duration, it is important the forest cover be left in place for assessment units that have erosive deposits.



Figure 13. Fine sediment entering one of the upper ponds on the Johnson Farm property, assessment unit 7.



Figure 14. Upper agricultural pond on Johnson Farm, assessment unit 7. Note how the forested community shades most of the pond surface.

The open water in the agricultural ponds within the watershed is subject to increased solar heating during summer and fall months. Because these ponds are in line with Springbrook Creek, the warmer water from these ponds can influence downstream water temperature which in turn may negatively affect stream biota. In addition, open water that is held static in a pond tends to lose water through evaporation which may be



Figure 15. Example of conversion of depressional wetlands to pasture land in assessment unit 4. Hillside supports intact slope wetlands (Potential Project #7.5, Figure 8).



Figure 16. Channel clogged by reed canary grass in assessment unit 4 depressional Wetland, Potential Project #4. This also results in filling of channel with sediment.

greater than that lost through evapotranspiration. It is possible that this type of loss can affect stream flows, particularly during low flow periods. It is recommended, therefore, that these ponds be allowed to fill in slowly and create a forested, scrub-shrub ecosystem that results in greater shading of pond waters (Figure 14). Within assessment units 4, 5 and 6, agricultural operations during the 1900's resulted in the conversion of large



areas of historic forested depressional wetlands (Figure 15 & 18) into pasture lands. The creeks feeding into these systems have been channelized and flows moved to the edge of property lines away from the wetland complex. This has had the effect of partially draining these wetland systems, which has in turn changed their hydroperiods, allowing for the establishment and dominance by reed canary grass (Figures 15 & 16).

Figure 17. Example of a properly functioning stream system similar to historic conditions with forested canopy, scrub-shrub understory and sorted stream gravels without fine sediment impacts. Assessment unit 4, Potential Project #12.



Figure 18. Clearing of forested riparian vegetation (note wood piles) in floodplain of Potential Project #4, has resulted in alteration of floodplain processes. The resulting establishment of reed canary grass has altered stream flow path and decreased habitat diversity. Native forest cover provides for more diverse habitat structure and allows for the establishment of a clearly defined channel(s) as seen in Figure 17.

Efforts by landowners to restore watershed processes were evident throughout the watershed and included fencing off stream corridors and replanting buffers. This has the benefit of lowering stream water temperature through shading and eliminating reed canary grass which can completely choke the stream channel. These efforts should be continued with larger riparian buffers being created (Figure 19).



Figure 19. Example of measures to restore stream channel by fencing out livestock and replanting with a narrow forested buffer in assessment unit 4, Potential Project 7.5.

During the May 10, 2018 field survey, it was noted that extensive areas of seeps and slope

wetlands were present on the slope defining the western boundary of the depressional wetland complex in assessment unit 4 (Figure 20). The presence of skunk cabbage suggests that this area is saturated throughout the year and as such plays an important role in supporting baseflows in Springbrook Creek. These intact forested slope wetlands should be protected through conservation easements.



Figure 20. Forested, emergent slope wetland complex on the western boundary of Assessment Unit 4 (Potential Project #7.5). Note skunk cabbage, a wetland plant adapted to permanently saturated soils, in the foreground.



Figure 21. Culvert and weir system on Springbrook Creek just downstream of Fletcher Bay NE.

In PAU 1, as Springbrook Creek descends to meet its tidal channel and Fletcher Bay, it passes through a culvert under Fletcher Bay NE and through a series of downstream weirs (Figure 21).

This system was engineered to create an artificial stream gradient that met the elevation of the road culvert. The weir system, however, is beginning to fail, due to natural stream processes, which could result in the washing out of the weirs, headcutting and isolation of the culvert from the downstream streambed. This would make the upper watershed inaccessible to anadromous fish.

To avoid this, the existing culvert and weir system should eventually be replaced, with a larger bioengineered bottomless culvert that re-establishes the historic grade of the stream and eliminates the need for a “stepped” weir system.

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