Effectiveness of Beaver Pond Levelers as a Means to Control Beaver Caused Flooding in Urban Areas

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EXECUTIVE SUMMARY

Beaver pond levelers are used as a beaver management tool to assist in controlling beaver pond levels with the intention of maintaining sufficient beaver habitat. This practicum attempts to show that flexible pond levelers are an effective means with which to prevent flooding of roadways in urban areas and yet preserve beaver habitat. Flexible pond levelers were used at an established beaver pond located within a wetland along Scriber Creek in western Washington. The results show water levels dropped 1.5 feet after installation of pond levelers in the immediate area of the beaver dam. Taking all factors into consideration the flexible pond leveler is a good tool to relieve flooding in the immediate area surrounding a beaver dam.

INTRODUCTION

The site selected as a model for this practicum is located between Larch Way and 44th street in Lynnwood, Washington. It is located in an urban setting and the beaver dam has caused flooding of 44th street, a nearby major road upstream of the primary dam. The study area for this practicum includes the approximately 10 acres of wetland created by Scriber Creek, the primary beaver dam, and the section of 44th street that has been flooding (Appendix A). The primary beaver dam is located approximately 0.25 mile downstream of 44th Street. This practicum will attempt to show that flexible pond levelers are an effective means with which to prevent flooding of roadways in urban areas and yet preserve the beaver habitat. The levelers have been installed at the primary beaver dam in an attempt to reduce the likelihood of flooding on 44th street, which is a major artery of Lynnwood. It is believed that after installation of a flexible pond leveler, the water level at 44th street will recede to a level that is low enough to allow water fluctuations without flooding the roadway.

The primary beaver dam is nearly 90 feet across and before the levelers were installed, it had a 4-foot water surface elevation change from above the dam to below the dam. It appears to be a very well established beaver dam that has been there for years. A large ponded area that appears to extend to 44th Street has formed behind the primary...
beaver dam. Installation of the levelers was expected to alter the site’s characterization to some extent due to expected changes in water elevation.

The “primary dam area” is an area, approximately 400 X 200 feet, surrounding the primary beaver dam located just to the west of a new housing development (Appendix A). The housing development is currently comprised of seven new homes on a cul-de-sac. There is a native growth protection area (NGPA) that is about 100 feet wide between the nearest homes and the study area. Due to the size of the flooded area (approximately 10 acres) there were two levelers, rather than one, installed on December 15th 2004. Altering the water regime within the wetland above the primary beaver dam will possibly affect the species of vegetation found within the wetland and where within the wetland a given species grows. Another possible outcome of the water level drop is an alteration in the behavior of the beavers. If the water level is lowered too much, the beavers may choose to relocate.

LITERATURE REVIEW

LIFE HISTORY OF BEAVERS

Beavers are the largest member of the rodent family in North America, usually weighing 30 to 60 pounds as adults. Known as “ecosystem engineers” (Jones et al, 1994), beavers use branches, mud, and logs to form ponds, and ultimately alter the ecosystem by allowing new space for saplings to grow and flooding the root systems of established trees causing them to die. Unfortunately, their constructive
tendencies often come into conflict with human-managed landscapes and infrastructure. Beavers are blamed for blocking culverts and dam spillways, flooding of agricultural lands and roadways, and the destruction of both crop and ornamental trees. “In Louisiana beavers are responsible for some of the greatest economic losses of any mammalian species involved in mammal/human conflicts.” (LeBlanc, 1997) In the southeastern U.S. it is estimated that over $40 billion in damage have been done to crops, forests, roads, and other properties in a recent 40 year period (Arner and Dubose, 1982) and USDA (2002) studies show that beaver damages in the state of Minnesota increased each year during the period from 1997 to 2000.

Beaver habitat requirements include enough water to avoid predation and allow for access to a food source. Typically, water levels of three feet in depth or more provide suitable habitat for beavers in flat topographic areas. In areas of flat topography a dam may be no more than three feet tall or as much as ten feet high in mountainous areas. Beavers will travel over 100 yards to reach their food if necessary, often searching for food at night. Beavers typically prefer trees or shrubs such as aspen, willow, and cottonwood as food, but are adaptable animals and will feed on other woody plants if necessary (Miller and Yarrow, 1994).

**MITIGATING MEASURES FOR PROPERTY DAMAGE DUE TO BEAVERS**

There are two common methods to deal with these human/beaver conflicts, lethal and non-lethal. There are differing opinions on the effectiveness of lethal methods for resolving human/beaver conflicts. Some feel it is the fastest and most reliable means with which to remove a beaver family. However, in an urban setting many of the lethal means may not be an option due to the risk of harm to other animals or humans. Some of
the lethal methods used include shooting, leg-hold traps, snares, and body-grip traps. However, as of the year 2000 it is illegal to kill beavers in the state of Washington with a trap due to Initiative-713. Live traps such as Hancock traps can still be used provided the trapper acquires the appropriate permits.

Beaver ponds have many positive attributes ecologically. They provide habitat for many other wetland species. Juvenile Coho salmon rely on beaver ponds to provide them with safe rearing habitat (Pollack et al, 2004). Other fish species use the course woody debris from beaver lodges as cover (France 1997, Collen and Gibson 2001). Beaver ponds can also provide great aesthetic value. Sportsmen use them for fishing and hunting sites. Waterfowl extensively use beaver ponds for nesting, foraging, and cover. (Arner and Hepp 1989, Novak 1987). Because of these benefits, and more, many people would rather use means that preserve the beaver ponds, while controlling the flooding.

There are a number of non-lethal control methods. Habitat alteration through forest type conversion has been suggested (Payne, 1989). Habitat alteration works on the theory that if the habitat is less then ideal for the beavers they will relocate to an area that better suits them. For example, if only species of trees that beavers do not care for were growing in the area they are more likely to go elsewhere in search of those trees that they do like. Increased culvert sizes have also been suggested for reducing the likelihood of plugging by beavers (Jensen P.G., Curtis P.D., Hamelin D.L. 1999). Grills, small mesh devices, and grates are often used, but require frequent maintenance because they clog easily (D’Eon 1995). Other, more effective devices include Flexible Pond Levelers (Appendix B), Beaver Deceivers (Appendix C), Pre-Dams, Beaver Bafflers, Wooden Pipes, and Clemson Beaver Pond Levelers (Appendix D) (Brown, et al 2001). These
devices are used as a drainage bypass around or through beaver dams to lower water levels above the dams without dismantling them and eliminating beaver habitat. The water leveler devices are used because of their potential to prevent further flooding by the beavers and yet allow the area to be conserved as beaver induced wetlands. The best option depends on the circumstances of each individual situation.

**METHODS**

Site characterization was performed using aerial photographs and site observations in the November of 2004. Soil assessments were taken at the same time. The study period was from November 1\(^{st}\) of 2004 to March 31\(^{st}\) of 2005. The purpose of the study was to show that flexible pond levelers can be used successfully to aid in controlling flooding caused by beaver dams in an urban setting, while maintaining the beaver habitat. The study area (Appendix A), in Lynnwood, was chosen because of its location in an urban setting and the flooding being caused, in part, by the beaver dam.

**HYDROLOGIC ASSESSMENT**

Staff gage installation was performed on November 8\(^{th}\), 2004 at two locations within the subject wetland. The first staff gage was installed at the upstream end of the study area immediately after Scriber Creek passes under 44\(^{th}\) street. This location was designated as station A. The second staff gage was installed approximately 50 feet to the north of the primary beaver dam. This location was designated as station B. The two staff gages were installed at the opposite ends of the study area to assist in determining the water surface slope, so as to ascertain how quickly the pond was draining. Water
level readings were taken from the two staff gages at least every two weeks throughout the study period.

On December 13\textsuperscript{th}, 2004 notching of the primary dam took place. Notching is the process of removing a portion of the beaver dam to lower the water level behind the dam to assist in installation of the levelers. In this situation the top portion of the entire dam was removed rather than a single large portion being taken out. This increased the likelihood that the dam would remain stable through the event. If the dam had been damaged too much and collapsed there would have been considerable flooding downstream. On December 15\textsuperscript{th}, 2004 two flexible pond levelers were installed by crew members of the Washington Conservation Corps and staff of Snohomish County. A GPS unit was used to measure water surface elevation readings. A bench mark reading, a staff gage mark, and a water surface reading were shot at each end of the wetland with the GPS equipment. The water level was noted on each staff gage and using the GPS readings of water surface levels was converted into real elevations to determine actual water surface elevation fluctuations through the study period.

Precipitation data for the study period was collected by the Snohomish County staff and retrieved from their website. Daily rainfall totals were gathered to determine
how effective the pond levelers were at keeping water levels low during rainfall events, when water levels typically rise within the stream.

Another objective of installing the pond levelers was that the habitat would be acceptable to support the beaver population after the levelers were installed. To determine if this was achieved the pond depth was checked by Snohomish County staff to assure that pond levels were approximately 3 feet or greater in depth. Beavers want the safety of the water while using the trees for food and building supplies. If the pond level drops too quickly or too much, the beavers may lose water access to their needed trees.

**SOIL ASSESSMENT**

A soil assessment was taken from each side of Scriber Creek and from varying elevations in order to characterize soils within the study area. Soil pits were dug with a sharp shooter to a depth of 15-20 inches and a slab of soil was lifted from the pit to determine soil colors with a Munsell Soil Color Chart. Varying soil types were measured with a tape to determine the depths of each soil horizon, and soil textures were determined using a soil texture flow chart.

**VEGETATION ASSESSMENT**

Wetland vegetation identification was performed as early as possible in the fall so as to utilize leaves before they were dropped. Vegetation identification was done using “Wetland Plants of Western Washington” (Cooke, 1997) and “Plants of the Pacific Northwest Coast” (Pojar, 1994)
SITE CHARACTERIZATION

HYDROLOGY

Scriber Creek is located within the Swamp Creek sub-basin which is within the Lake Washington Basin. The water enters the study area through a culvert on the western side that passes under 44th street. The current culvert is six feet in diameter, but has been so filled with sediment it is functioning at a fraction of its potential capacity. The City of Lynnwood is currently working on plans to install a larger box culvert. Scriber Creek appears to have been channelized at some point as it is very straight through the northern portion of the study area. The water is channeled through a large wetland covering approximately 10 acres before it enters the primary dam area. The study area is primarily comprised of a palustrine emergent permanently flooded and palustrine forested, according to the Cowardin classification system. Using the hydrogeomorphic model, it would be classified as a riverine wetland with unidirectional flow. Downstream from the study area Scriber Creek joins with Swamp Creek flowing to the south, which flows into the Sammamish River and eventually into Lake Washington.

On the upstream side of the beaver dam the creek has widened to a large shallow lake like feature that has many small hummocks of trees, reed canarygrass, and rushes. On the downstream side of the primary beaver dam, the creek’s main channel narrows down to approximately 15 feet in width. The stream narrows to approximately 10 feet in width after a smaller abandoned dam, located approximately 50 yards further downstream.

SOILS

Three soil pits were excavated within the study area, and data collected at these pits is provided in Table 1 (Appendix A). According to the NRCS, the predominant soil type found at the study site is #34, Mukilteo Muck. Soil pit #1 was about 15 feet to the
east of the primary beaver dam (Appendix A). The A horizon was silty loam in texture and approximately 7 inches in depth. The B horizon was a gleyed soil that was sandy clay loam in texture. Mottles were common in frequency, medium in size and distinct. Soils at soil pit #1 were found to be hydric.

Soil pit #2 was dug about 20 feet to the northwest of the beaver dam’s western end. The A horizon was about 9 inches in depth and sandy clay in texture. The B horizon was sandy clay loam in texture and found from 9 inches to the bottom of the soil pit at approximately 19 inches in depth. Soils at soil pit #2 were found to be hydric.

Soil pit #3 was about 50 feet to the south of the center of the main beaver dam. The A horizon was silty clay loam in texture and found to be about 8 inches in depth. The B horizon was sandy clay loam in texture as well, but contained many pebbles and stones, most likely deposited by the creek as soil pit #3 was close to the center of the creek. Soil pit #3 was not found to be hydric. This was also likely due to the frequent deposition and flushing of soils by the creek.

Table 1
Soil Pit #1

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Munsell color</th>
<th>Texture</th>
<th>Redox features</th>
<th>Hydric</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0”-7”</td>
<td>10YR 1/2</td>
<td>Silty clay loam</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>7”-15”</td>
<td>10 Y N/6</td>
<td>Sandy clay loam</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Soil Pit #2

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<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Munsell color</th>
<th>Texture</th>
<th>Redox features</th>
<th>Hydric</th>
</tr>
</thead>
<tbody>
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<td>10YR 1/3</td>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>9”-19”</td>
<td>10Y N/6</td>
<td>Sandy clay loam</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Soil Pit #3

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Munsell color</th>
<th>Texture</th>
<th>Redox features</th>
<th>Hydric</th>
</tr>
</thead>
<tbody>
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<td>10YR 1/2</td>
<td>Silty clay loam</td>
<td>No</td>
<td>No</td>
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<tr>
<td>B</td>
<td>8”-17”</td>
<td>10YR 2/4</td>
<td>Sandy clay loam</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**VEGETATION**

The study area is comprised of two Cowardin classes: palustrine forested and palustrine emergent. The forested portion of the study area is mainly located on the boundaries of the study area and in the vicinity of the primary dam area. The remainder of the study area is mainly comprised of emergents. The dominant species within the forested study area is red alder (*Alnus rubra*). Under the canopy of the red alders the dominant shrub is salmonberry (*Rubus spectabilis*). Other species of plants found throughout the study area include vine maple (*Acer circinatum*), creeping buttercup (*Ranunculus repens*), water parsley (*Oenanthe sarmentosa*), yellow iris (*Iris pseudocorus*), piggyback plant (*Tolmiea menziesii*), and reed canarygrass (*Phalaris arundinacea*). Throughout the emergent portion of the study area the dominant emergent species is *reed canarygrass, which is a nonnative invasive species*. Reed canarygrass is generally not found in the forested portions of the wetland within the primary dam area. This is most likely due to the shade provided by the trees. Other species of plants through the emergent portion of the wetland include yellow iris (*Iris pseudocorus*) and soft rush (*Juncus effusus*).

A prominent feature of the entire wetland area is the large number of snags, likely produced from the flooding of the forested area due to the beaver dam. They appear to mainly be red alder snags, however, due to decomposition the species is difficult to
determine. The majority of the emergents within the wetland are growing around these snags.

Immediately to the east of the study area is a Native Growth Protection Area (NGPA) that buffers the wetland from a new housing development. The NGPA is forested and contains mature western red cedars (*Thuja plicata*) with an understory of soft rush (*Juncus effusus*) and red-osier dogwood (*Cornus sericea*). Many of the plants within this area are still staked and may currently be irrigated as irrigation pipes are present.

The upland area to the west of the study site is forested and dominated by red alder (*Alnus rubra*). The understory is predominately comprised of salmonberry (*Rubus spectabilis*), and red-osier dogwood (*Cornus sericea*) shrubs.

**RESULTS**

The intent of installing the flexible pond levelers was to lower the level of water in the flooded area low enough to prevent flooding of 44th street. The flexible pond levelers did effectively drop the water levels at station B (at the primary beaver dam) while providing sufficient depth to maintain the beaver habitat. Water levels dropped rapidly and steadily by approximately 1.5 feet in the primary dam area after the notching of the dam and installation of the pond levelers (Figure 1).
With the installation of the levelers and subsequent drop in water levels at station B it is unlikely that there will be any flooding within that portion of the study area. There was a drastic drop in water surface elevation after the installation of the levelers and they have not shown any signs of being unable to keep up with rain events since that time. A storm event occurred on January 17th 2005 which dropped over a half of an inch in a relatively short period of time. During the storm event the water levels at station B rose, but not higher than during the pre-pond leveler installation period. After the storm event, water levels dropped down to a lower level than were observed before the storm event.

Water levels were observed throughout the study period at station A near 44th Street. During the study period the water at station A did not drop to as low of levels as desired (Figure 2). After the pond leveler installation on December 15, 2004, water levels at
station A did not drop below levels recorded prior to the pond leveler installation.

Water levels rose on the day of the storm on January 17, 2005, however, they did not drop to lower levels than before the pond leveler installation after the storm event.

During the study period the difference between water surface levels between stations A and B increased with time (Figure 3). This occurred because while the water levels at station B dropped the water levels at station A stayed at approximately the same level, so the difference between the two levels increased. This was an indication that there was another object besides the primary beaver dam that was holding water back somewhere in between station A and station B.
Snohomish County conducted a site visit on March 22nd to attempt to determine the location of the object blocking the flow of water. During the visit they found a relic beaver dam in the channelized portion of Scriber Creek approximately 0.1 mile downstream of station A.

Snohomish County staff dismantled the dam, however the water levels near station A did not drop as desired. The County will again attempt to locate other blockages and dismantle them in the near future. It is expected that with the removal of the blockage the study area water surface will level out resulting in a lower water surface elevation at station A.
DISCUSSION

There are a number of reasons that could explain why the water surface elevations have not leveled out between stations A and B. As discussed above, a relic beaver dam may be a blockage causing a backup of water up to station A. Another reason is that the reed canarygrass has grown in so thick at approximately 0.15 mile downstream from station A that it is acting as a blockage. Also, there may be silt from upstream collecting in the reed canarygrass and holding the water back in the upper portion of the study area. It is also possible that the study area is too large for one pond leveler to be effective. It is approximately a quarter of a mile between station A and station B. That may be too great of a distance for the pond levelers to be effective.

It is likely that the less than average rainfall during the winter of 2005 played a strong role in the effects of the results. The Lynnwood/Everett area of western Washington has, on average, 24.97 inches of precipitation for the months of October through March. The 2004/2005 winter saw 20.21 inches for those same months. Having 4.76 inches less than average precipitation may have been the difference between several flooding events and the one (Figure 4) that occurred within that time frame.

As this situation has shown, there are a number of external factors that can control how effective water control devices can be. During the study period the local precipitation was less than average (Figure 4), however, if there had been above average
precipitation the results may have likely been very different. Given that this site has a history of flooding, and taking into consideration that the water levels did not drop significantly at station A, it is likely that there would have been more flood events if there had been heavier precipitation levels.

Providing enough escape volume for the water of the beaver pond with a water control device while maintaining sufficient beaver habitat and remaining cost effective can prove difficult. Taking into consideration the potential for above average precipitation in the Pacific Northwest adds yet another challenge. Some sites may require multiple installations to aid in determining the number of levelers required for the site. Determining the number of levelers and pipe diameter requires experience on the part of the installer. Water control devices such as the pond levelers have been used with mixed results, but have strong potential. With new innovations being developed and more practitioners gain experience with water level control devices, they may prove to be a key element in the management of flooding due to beavers.

**REGULATORY SETTING**

Activities within critical areas, including streams and wetlands are regulated at the federal, state, and local level. Downstream from the subject wetland Scriber Creek joins with Swamp Creek flowing to the south and eventually joining the Sammamish River before it flows into Lake Washington. Therefore, Scriber Creek is a tributary of navigable waters and would be subject to the federal Clean Water Act, section 404, and would require a standard individual permit or a nationwide permit from the Army Corps of Engineers. With the necessity of the Section 404 Permit, a Section 401 Permit from the Washington State Department of Ecology would be required as well. Due to the fact
that Scriber Creek is not currently and was not historically a navigable water it would not be subject section 10 of the Rivers & Harbors Act.

State permits are also required for the beaver dam project. Work involving any alteration to the beaver dam requires a Hydraulic Permit Approval from the Washington Department of Fish and Wildlife. Snohomish County staff obtained a programmatic JARPA that is used for their pond leveler installations before any alterations were performed on the Scriber Creek dam. The Scriber Creek wetland is less than 20 acres, has a mean annual flow under 20 cubic feet/sec., and is not subject to the tide. Therefore, it would not be subject to the Shoreline Management Act, which is administered by the Washington State Department of Ecology.

Snohomish County regulates activities on the study area as well. The entire site is within the southwest Snohomish County urban growth area. “Snohomish County Code Chapter 32.10, Critical Areas Regulations (CAR), was adopted April 1995 in response to the Growth Management Act, as a method of insuring protection of the county’s natural resources. Included in the designation of critical areas are wetlands, fish and wildlife habitat conservation areas, and geologically hazardous areas (erosion, landslide, seismic, and mine hazard areas). The purpose of CAR is to define critical areas and regulate development activities in critical areas to safeguard the public health, safety, and welfare.” Permits would be required for grading and most development to comply with the CAR of Snohomish County. Snohomish County rates wetlands using the Washington State Department of Ecology Wetland Rating System for Western Washington. Using this methodology it was determined that the Scriber Creek Wetland is a Category 2 wetland. The CAR requires the replacement of the functions and values of filled wetlands.
with no specific direction for replacement ratios. As guidance the applicable replacement ratio recommendations would be 1:1 for emergent class portion of the wetland and 1.5:1 for the scrub shrub portion. It also requires a 100ft. buffer width for streams within an urban setting.

**SCRIBER CREEK WATERSHED RESTORATION OPPURTUNITIES**

Flooding of streams and wetlands is a frequent problem in urban areas. To alleviate the flooding of 44th street the wetlands upstream could be restored. Restoration of these wetlands would allow for increased flood storage capacity. The study area is located within the Lake Washington Basin, an area comprised of the Cedar River, Sammamish River, Lake Washington, Lake Sammamish, and other smaller tributaries (Appendix E). It is heavily urbanized and contains the cities of Seattle, Bellevue, Renton, and Issaquah. Scriber Creek is located within the Swamp Creek sub-basin (Appendix F). Downstream from the study area Scriber Creek joins with Swamp Creek flowing to the south and eventually joining the Sammamish River before it flows into Lake Washington. Due to its location within the watershed much of the impacts upon the Lake Washington watershed are not felt within Scriber Creek itself. However, that is not to say that Scriber Creek does not feel the impacts of human activities. The source of Scriber Creek is located within a heavily urbanized area of Lynnwood and the waters of Scriber Creek are only flowing for a short time before they are diverted underground.

Due to the heavy urbanization upstream of the study area and the site’s location within the watershed, the most benefit to the study area would be accomplished by targeting the restorations upstream from the site. Currently, Chinook Salmon make it as far upstream as the study area, near the primary dam (2000, King County).
upstream of the study area would increase the likelihood of the salmon making it further up into Scriber Creek, and possibly assist in increasing the numbers of returning salmon. Restoring natural processes such as sediment transport and scouring would benefit the salmon by providing more recruitment of spawning and habitat substrates. Downstream from the study area Scriber Creek and Swamp Creek are relatively heavily vegetated on their stream banks and have a reasonable amount of meander. Although there is potential for effective restoration within this area, it is upstream where the efforts would have the most impacts. This could hold true for both increased salmon habitat and water quality, another goal of the restoration plan. Wildlife habitat would also be included as a goal of the project. Finally, education is an important objective/goal of the restoration plan. The area is heavily populated, and there is an opportunity for education and outreach that should not be missed.

**LOCAL SCALE RESTORATION SITES**

There are seven potential restoration sites at and upstream of the study area. Appendix G provides a map of the approximate location of these sites. Restoration site #1 is located within a quarter of a mile of the source of Scriber Creek there is an undeveloped area near a strip mall that Scriber Creek flows through. The site would need to have invasive species removed, but is heavily vegetated with native shrubs and trees as well, and would make for a relatively easy restoration site that would help improve water quality at a key location on the creek. Scriber Creek curls through the area and appears to have a natural meander at this point. Natural processes and functions appear to have the opportunity to operate well at this point. However, upon leaving this immediate location
Scriber Creek travels within a pipe underground through what is currently an area under construction in a strip mall.

After traveling under the strip mall, Scriber Creek resurfaces as it passes through a green belt and apartment complex. Upon leaving the apartment complex the creek travels in a pipe again, under a street and a mobile home park where restoration site #2 was identified. The mobile home park encompasses one of the largest areas that Scriber creek spends underground. If the western half of the mobile home park was purchased and the creek was daylighted at this location, there could potentially be very positive benefits for the stream. At this point the creek is still relatively small and would not require too wide a corridor to provide ample vegetation for cover and other functions. There would be very little threat of flooding due to the size of the creek at this stage. The downside to this site would be the necessary displacement of low-income housing. There is very little space in the local area to use as replacement housing and what space there is would likely be too expensive to justify low-income housing.

After leaving the mobile home park Scriber Creek travels both above and below ground through a commercial area. After crossing under Highway 99 it passes through a recent restoration site and into a residential area where restoration site #3 was identified. This area has the potential to be an excellent opportunity for community involvement. It is a relatively small neighborhood that could provide excellent stewardship and volunteer sources for invasive removal and native plantings.

After leaving the residential area Scriber Creek travels to Scriber Lake Park where restoration site #4 was identified. It is a Lynnwood City park that serves as a natural area for walking and biking. The City of Lynnwood has already looked into the possibility of
beginning restoration work on Scriber Lake (City of Lynnwood, 2004). The concern with this potential project is the possibility of sky-rocketing cost. There is a likelihood of high levels of contaminants within the soils of the lake and that could drive up the costs dramatically. They hope, however, to improve water quality and habitat.

Site #5 is located downstream from site #4 and is a green belt where the creek has been channelized, but there is space to allow for more meandering of the creek. Moving the location that the creek enters the area to the west and allowing the creek to meander more naturally would address those issues.

Site #6 is located where Scriber Creek passes under 44th street. At this site the existing culvert could be replaced with a large box culvert. The new box culvert would allow better passage of salmon, as the existing culvert is heavily silt laden.

Site #7 is the upstream portion of the study area. It is currently infested with reed canarygrass and the stream has been channelized at this point (Appendix H). This restoration site could be restored to native shrub and forested wetland. The stream channel meander could also be restored. The presence of a relatively large wetland area with beavers in such an urbanized setting could provide opportunity to convert the area to a low impact park which would provide educational benefits to the public. It would provide the opportunity to educate the public regarding not only wetland wildlife and habitats, but the entire restoration process.

Water quality improvement is an important function of wetlands that can be measured. Tools for measuring water quality would need to be utilized throughout the process of the restoration and included in the monitoring after completion. Salmon
numbers and location could also be used as an indication of success or failure of the project.

Smaller scale restoration project upstream of the study site would be most beneficial to the study site. It would have direct positive impacts and be much more cost effective than a sweeping watershed project. Installing bottomless or box culverts, planting native species, removing invasive species of plants and educating the public would help ensure the health of Scriber Creek. A small number of important restoration projects could have crucial and positive effects on Scriber Creek’s landscape.

Acknowledgements: Thanks go out to David Mach, Erik Christianson, and Diane Hennessey, all of which contributed greatly in one fashion or another. A special thanks to Jake Jacobson for all of his assistance and inspiration with this paper.
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Matt Maynard
Wetland Science Management Certification
May, 2005
Appendix A - Sribber Creek Study Area
Appendix B

Beaver Management – Flexible Leveler Plans

- Used to control water levels while keeping dam.
- Inlet needs to be at least 10 feet from dam.
- Pipe needs to carry base flow.
- Low cost and easy to install.
- Fish friendly.
Appendix C

Beaver Management – Beaver Deceiver Plans

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Matt Maynard
Wetland Science Management Certification
May, 2005
Appendix D
Clemson Pond Leveler

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10' section, 10&quot; dia. PVC pipe (Schedule 40)</td>
</tr>
<tr>
<td>1</td>
<td>PVC cap for 10&quot; dia. PVC pipe (Schedule 40)</td>
</tr>
<tr>
<td>1</td>
<td>10' x 8' PVC pipe reducer coupling (Schedule 40)</td>
</tr>
<tr>
<td>4</td>
<td>86&quot; sections, 3/4&quot; dia. plastic roll pipe (water pipe), 160 psi grade</td>
</tr>
<tr>
<td>4</td>
<td>3/4&quot; metal couplings for roll pipe</td>
</tr>
<tr>
<td>16</td>
<td>3/4&quot; x 2' galvanized eyebolts</td>
</tr>
<tr>
<td>16</td>
<td>3/4&quot; galvanized nuts</td>
</tr>
<tr>
<td>16</td>
<td>3/4&quot; galvanized washers</td>
</tr>
<tr>
<td>16</td>
<td>16&quot; sections, 8 ga. galvanized wire (medium hardness)</td>
</tr>
<tr>
<td>2</td>
<td>96&quot; sections, 2&quot; x 4&quot; 12 1/2 ga. galvanized welded wire</td>
</tr>
<tr>
<td>2 lbs</td>
<td>Crab trap clamps (fasteners)</td>
</tr>
</tbody>
</table>

The above materials are required to assemble the intake device for the Clemson Beaver Pond Leveler. The carrying pipe (flow pipe) may consist of 20 to 40 feet of 8" diameter PVC, Schedule 40 with coupling sleeves and elbows appropriate to the desired configuration.
Appendix E - Lake Washington Basin

- Practicum Site
Appendix F - Swamp Creek Sub-basin
Appendix G - Potential Restoration Sites

- Potential Restoration Site
  1– Vacant lot near Scriber Creek Source
  2– Mobile home park
  3– Residential neighborhood
  4– Scriber Lake
  5– Natural area
  6-44th Ave
  7-Study area
Appendix H

Pre-restoration Study Site

Post-restoration Study Site