Sediment Source Loading to Fish Creek and Ponds

Prepared for
Ramsey-Washington Metro Watershed District

November 2007

BARR

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Executive Summary

Excess sediment loading to Fish Creek, its upstream tributary channel, and water quality pond has been a District concern for some time. This study identifies major sediment loading sources to those areas as well as potential mitigation strategies to reduce excess sediment loading. Source contributions of sediment were determined through the use of sediment fingerprinting; a technique designed to calculate the fraction of the total sediment load that originates from various sources. To help determine sediment impact to Fish Creek and the ponds, sediment from the Double Driveway Pond was analyzed giving the following results:

Site	Percent Contribution	Total Load (tons)
Stream Bank Erosion	73-79%	46
Bailey Nursery	14-17%	9.6
Surrounding Watershed Soils	7-10%	5.2

Stream bank erosion contributes the most sediment with respect to loading to the Double Driveway Pond and the average particle size was relatively high (D_{50} = 0.16 mm, clayey sand/lean clay). Runoff from Bailey Nursery contributed the next largest loading; however, average particle size was the smallest of soil sampled from contributing areas (D_{50} = 0.075 mm, silty sand). The small particle size, along with visual observations at the site, indicates that the sediment transported from Bailey Nursery is finer than tat typically found in stormwater runoff and a substantial portion may not be settled by traditional ponding techniques. Thus, the estimated sediment contribution to the Double Driveway Pond is not indicative of the total amount of loading coming from Bailey Nursery and it is likely this finer sediment is traveling further downstream into Fish Creek.

Two general improvements are recommended to reduce sediment loading from upstream areas to Fish Creek (Figure 1). The first improvement recommendation is design depth restoration and aggressive maintenance of the Double Driveway Pond (dredging at a frequency of every three years). The second improvement is the installation of a passive polymer system (similar to the PFS project near Tamarack Swamp) to promote settling of fine particles in the existing east pond on Bailey property. The initial capital cost of these two projects is approximately $129,000 with an annual cost of $750 per pound total phosphorus (based on the estimated amount in the sediment) removed.

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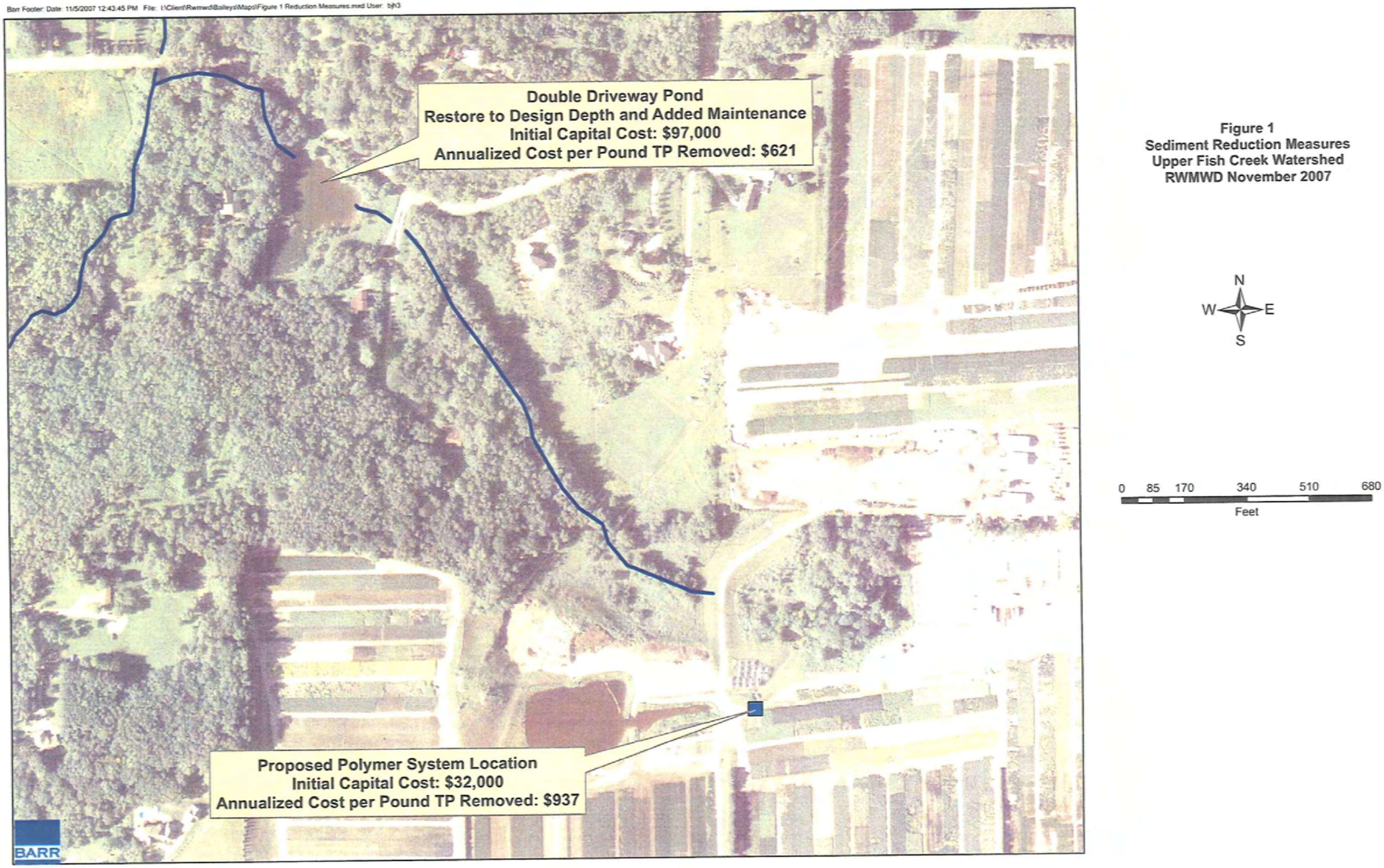

Figure 1
Sediment Reduction Measures
Upper Fish Creek Watershed
RWMWD November 2007

1 Introduction

Sediment loading to Fish Creek and its upstream tributary system has been a concern for the Ramsey Washington Metro Watershed District (District) over the past two decades. The Double Driveway Pond (the first pond located downstream of Bailey Nursery) has experienced sediment loading at a rate that far exceeds that of storm water ponds elsewhere in the District, resulting in increased maintenance and associated costs. Although improvements have been made in the general watershed area, sediment loading to this pond, the creek, and other areas further downstream continues to be a problem. On four occasions over the past 15 years, the District has removed deposited sediment from holding ponds along Fish Creek downstream of Bailey Nursery. A map of the general area is shown in Figure 2.

Past sediment source studies and load reduction measures have focused on the Bailey Nursery site and include:

- Flow retention berm constructed
- Weir and overflow pipe constructed to increase detention time at the western Bailey pond
- 12" pipe installed to drain water from the western Bailey pond to the wetland
- Flotation silt curtain installed to prevent short circuiting at the outlet of the eastern Bailey pond, increasing water retention time
- Stream bank restored at upper reach of creek

According to conversations with Bailey staff, it appears that these improvements have helped to retain more sediment in the on-site pond instead of allowing it to move downstream. Dredging frequency of the eastern pond has increased due to increased sediment retention after changes were made to the drainage system. However, on-site erosion problems and elevated sediment transport remain and Bailey Nursery management realizes that sediment loading from the nursery continues to impact downstream water resources. In particular, the finer sediment particles remain especially difficult to manage and can be transported further downstream than typical suspended sediment in storm water. Bailey has confirmed that a sale of the property for residential development purposes may occur within the next five to ten years, but they remain interested in cooperating with the District to continue on-site work to reduce current sediment loading to downstream areas.

In order to reduce erosion along the creek, attempts were made to secure temporary easements for access to the creek running from Bailey Nursery to the Double Driveway Pond. Easement was granted by Bailey Nursery and approximately 25% of the stream bank has been restored. However, Staff were previously unsuccessful in obtaining signatures from all affected property owners to complete channel stabilization and erosion repair work in the channel.

Due to the high level of sediment loading to Fish Creek and ponds, a study was initiated to help determine the major sources of sediment loading. The study focused on potential upstream sources of soil and sediment including: surrounding watershed areas, Bailey Nursery, and the stream banks of the creek itself.

A statistical soil identification method called sediment fingerprinting was used to help determine the major source or sources of sediment to the creek and ponds. Sediment fingerprinting allows for the differentiation of source sediment collected from a single area of accumulation (i.e. the Double Driveway Pond). It has been used successfully in previous studies (O'conner et al. 2006, Walling 2005) and has been used to pinpoint source sediment loading here in Minnesota, other areas of the country, and different regions around the world.

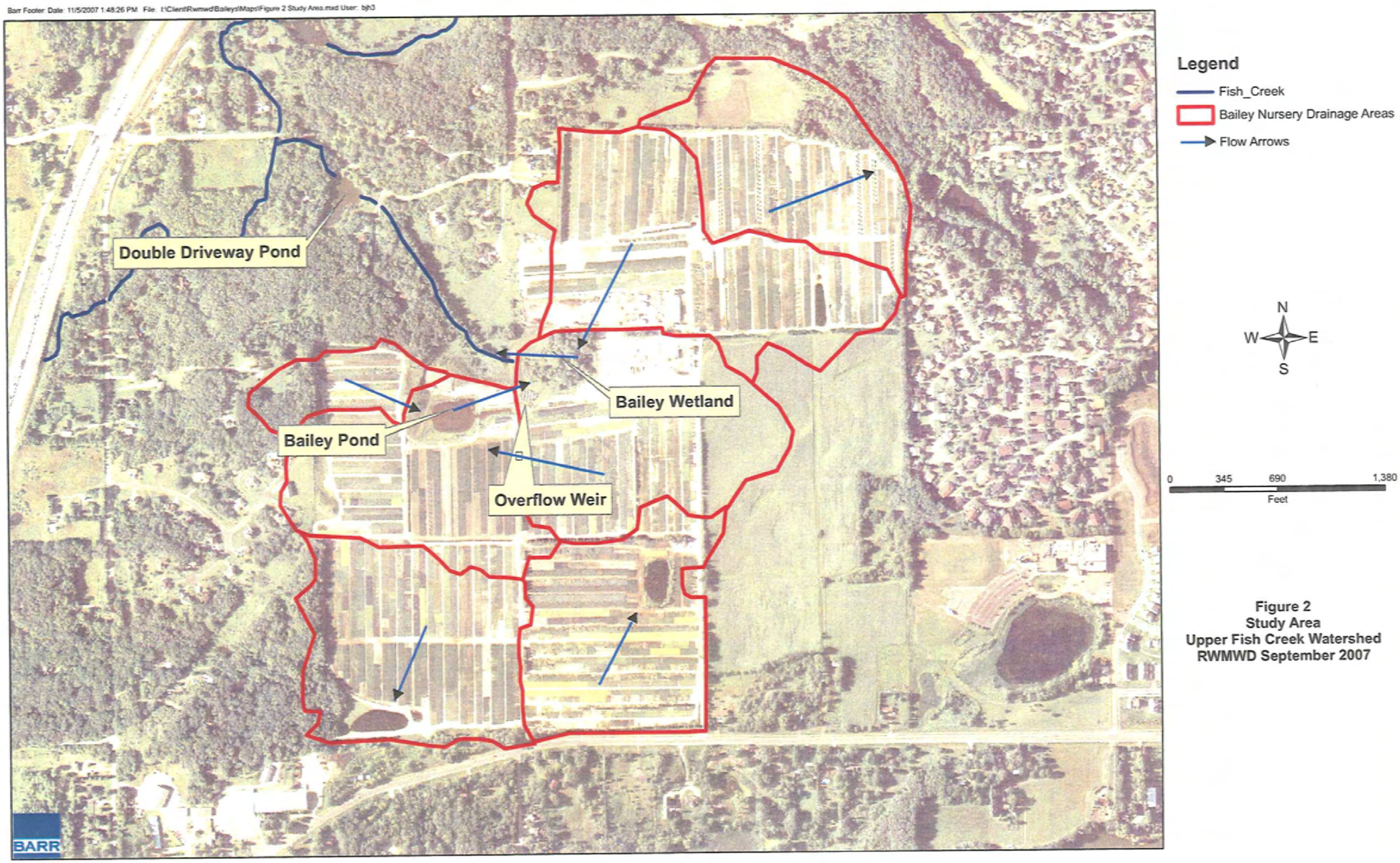

Figure 2
Study Area
Upper Fish Creek Watershed
RWMWD September 2007

2 Methods

2.1 Sediment Collection

Soil and sediment samples were collected on April 9th, 2007 (Table 1) from the following areas:

Table 1. Sample Locations and Number of Cores Collected in Each Grouping.

Location	# of samples
Bailey Nursery road and plant row cover	2
Bailey Nursery Pond (East Side)	1
Bailey Wetland and Overflow	2
Stream Bank/Bed (Upper and Lower)	2
Surrounding Watershed	2
Double Driveway Pond	4

Samples were collected from areas that are potential sources for sediment loading to the creek (Figure 3). The top 4 cm of soil or sediment were collected from each site; however, the sediment collected from Bailey Pond was separated into two samples of 2 cm depth each. This was done because it appeared that only the top two cm of sediment had accumulated since the most recent dredging of the pond. Samples of soil were collected with a stainless steel spoon and deposited into clean, plastic sampling containers at each site. Sediments from the deep areas of the eastern Bailey pond and Double Driveway Pond were collected using a gravity coring device and placed into clean, plastic sampling containers on-site.

Sediment was collected from three areas in the Double Driveway Pond. One sample was collected from both the inlet and outlet and two samples were collected from the middle of the pond. The two middle samples were combined into one composite sample.

2.2 Sediment Analysis

Sediment samples were analyzed for water content by oven drying for 24 hours at 105 °C. Samples were then shaken through a sieve to remove debris larger than 1.2 mm for comparison purposes. Loss on ignition (LOI) of the samples was measured after combustion at 550 °C for 2 hours (Håkansson and Jansson 1983). The LOI result is used to determine percent organic matter and estimate sediment density. Elemental composition and grain size were determined by Braun Intertec, Inc. in Bloomington, MN.

Barr Footer: Date: 11/5/2007 1:48:07 PM File: I:\Client\Rwmwd\Baileys\Maps\Figure 3 Soil Sample Locations and Reduction Measures.mxd User: bjh3

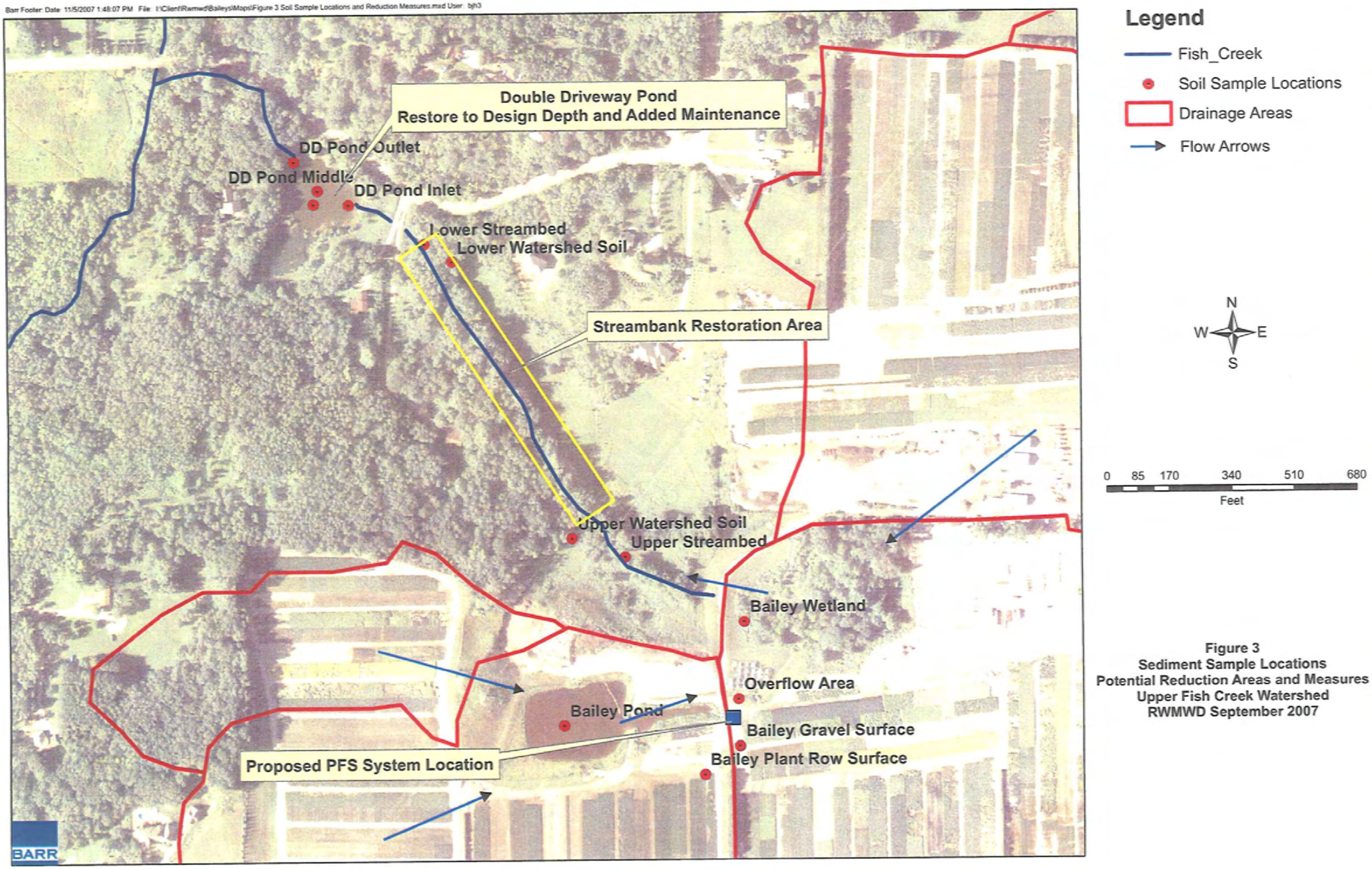

Figure 3
Sediment Sample Locations
Potential Reduction Areas and Measures
Upper Fish Creek Watershed
RWMWD September 2007

A suite of nine parameters was analyzed using inductively coupled plasma emission spectrometry (ICP) for the statistical sediment fingerprinting process and included Ca, Al, Fe, K, Ba, Va, Ni, Cr, and Be. Grain size distribution was performed on the dry, sieved samples using hydrometer analysis.

2.3 Sediment Fingerprinting

Using the set of analyzed sediment chemical parameters, statistical tests were conducted to determine if significant differences between the parameters could be detected. For example, the difference between Ca concentrations in the different soil samples was statistically significant at a p-value of less than 0.10 using a standard t-test. The difference, therefore, made Ca a good choice in the fingerprinting model to help determine source loading to the creek. Al, Ba, Ni, and Be also showed significant differences between some of the samples. The parameters above make up the composite signature. For more information on the sediment fingerprinting process, see appendix A.

3 Results and Discussion

3.1 Sediment Results and Data

Sediment loading from the upper watershed was monitored at the inlet to the Double Driveway Pond in 2005. Approximately 62 tons of sediment and particulate matter flowed through the creek and into the pond coming from all sources upstream of the monitoring site (including Bailey Nursery). According to P8 modeling conducted based on the area within the Bailey Nursery site that can impact Fish Creek (approximately 90 acres), about 24 tons of sediment is transported annually. However, based on the depth of 'new' sediment collected from the pond for this study, the total loading to the pond appears to be higher. Based on the sediment accumulated since the most recent dredging of the eastern pond (Fall 2006), approximately 50 tons of sediment accumulates each year. It is likely that this additional amount of sediment is coming from erosion problems within the Bailey Nursery site. Approximately 80% of the load to this pond settles out with the remainder moving downstream.

Elemental composition from ICP analysis for the sediment source areas is presented in Table 2 for the 9 parameters used in the sediment fingerprinting analysis. The data below indicate that there are differences in composition of the soil samples collected from different areas. This is expected because, for example, the artificial substrate used for the roads at the Bailey Nursery site will have a different makeup than natural watershed soil.

Table 2. Average Chemical Sediment Characteristics of Samples Collected from the Study Area.

Soil Collection Areas	Ca	Al	Fe	K	Ba	Va	Ni	Cr	Be
	(g/kg)	(g/kg)	(g/kg)	(g/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Stream bank	**4.05**	**11.35**	**17.5**	**1.125**	**94.5**	**31.5**	**15**	**20.5**	**0.66**
Watershed	**4.45**	**7.6**	**14.5**	**0.965**	**73.5**	**30**	**12.35**	**17**	**0.485**
Baily road/row cover	**48.5**	**5.65**	**15**	**0.825**	**31.5**	**30**	**9.55**	**14.5**	**0.42**
Bailey wetland/overflow	26	5.45	14.5	0.87	49.5	26.5	10.2	14	0.44
Bailey Pond	42	15.5	25.5	2.3	118	42.5	23	29	0.8
Double Driveway Pond	**11**	**12**	**19**	**1**	**95**	**33**	**16**	**22**	**1**

The samples from the Bailey wetland/overflow area and the Bailey Pond were not used in the analysis because it appears that the composition of the soil collected was substantially affected by the Bailey Nursery site and would have represented a 'double counting' of the effects from soil originating from the nursery. Thus, only the areas in bold in the table above, Stream bank, Watershed, and Bailey road/row cover were used in the statistical analysis to estimate source loading to the Double Driveway Pond via Fish Creek.

3.2 Sediment particle size

Grain size analysis was conducted on all samples to determine the average particle size and differences in size between samples (Table 3). It is important to note that all samples were initially sieved through a 1.2 mm sieve so that only the fraction likely to be transported a substantial distance during storm events was evaluated. D_{50} represents the average particle size.

Table 3. Average Particle Size (D_{50}) of Soil from Collected Samples

Soil Collection Areas	D50 (µm)
Double Driveway Pond	77.0
Stream bank	**160.5**
Watershed	**117.5**
Baily road/row cover	**74.5**
Bailey wetland/overflow	153.0
Bailey Pond	31.0

Of the sites considered as source areas to the creek, soil from Bailey road and plant row cover had the smallest median (D_{50}) particle size indicating that the soil contains a substantial portion of smaller sized particles even though the road and plant cover areas are layered with rock making the bulk sediment contribution appear coarser. The small size of these particles may indicate that these types of particles will travel further and settling using basic ponding techniques for storm water retention may not effectively remove the suspended particles. This also may have caused an underestimate in loading to the Double Driveway Pond if all of the sediment originating from Bailey Nursery did not settle out at this location. The stream bank soil samples had the largest median particle size indicating that this type of sediment will settle out from runoff water more quickly than the other types sampled.

3.3 Percent Contribution and Loading

Percentage of source loading to the Double Driveway Pond was determined based on the chemical and physical makeup of the sediments collected from the pond and potential source areas. Even though samples were collected from both Bailey Pond and Bailey Wetland/Overflow areas, these samples were not used because it was apparent that the Bailey Nursery site had affected the chemical composition (elevated Ca, likely due to the use of crushed limestone at the Bailey Nursery site) of the soils samples in these areas. This was not entirely unexpected because these areas were initially designed to reduce sediment loading to the downstream creek and ponds.

Based upon the fingerprinting analysis, the estimated percent contributions of sediment loading to the Double Driveway pond from the selected source areas for this study are shown Table 4.

Table 4. Estimated Percent Contribution of Annual Sediment Loading From Selected Source Areas.

Site	Percent Contribution	Total Load (tons)
Stream Bank Erosion	73-79%	46
Bailey Nursery	14-17%	9.6
Surrounding Watershed Soil	7-10%	5.2

Stream bank erosion contributes the greatest amount of sediment loading (73-75%) to the Double Driveway Pond but sediment loading from the Bailey Nursery site composes a significant contribution as well at 14-17%. Loading from watershed soils was lowest at 7-10% percent. Total loads from these areas, based on 2005 data collected at the inlet to the Double Driveway Pond, were approximately 46, 9.6 and 5.2 tons, respectively

Considering the grain size analysis, visual observations of runoff water, and the present sedimentation basin on the Bailey Nursery site, it is likely that a substantial fraction of the sediment load from Bailey Nursery is comprised of finer, silt-like material. As seen in Appendix B, water flowing from the Bailey Nursery site is generally colored a light brown and is extremely cloudy. This condition was also noticed during on-site visits from 1999 onward, including the April 2007 sample collection event. Given the results from the sediment analysis and the visual observations made at the site, it appears that finer material in the runoff from the Bailey Nursery site may remain suspended in flows that reach the Double Driveway Pond and eventually continue on through to the downstream portions of Fish Creek. Traditional ponding techniques may not be adequate to completely remove the finer particles coming from Bailey Nursery.

Additional contribution of sediment load may also come from an uncontrolled area of runoff at the northwestern portion of the property. From on-site visits and conversations with Bailey Nursery staff, it appears that some storm water flow and associated sediment loading is bypassing the wetland to the north of the access road in this area. The overall contribution of sediment, when compared to other areas in this study may be low, but some modification to this portion of the site may be beneficial to reduce overall loading downstream of the Bailey Nursery site. There was no apparent erosion problem at the site during the most recent visit in 2007.

4 Sediment Load Reduction and Costs

4.1 Reduction Measures

Two areas were focused on to reduce sediment loading to Fish Creek and the downstream ponds. The sediment load from the stream channel between Bailey Nursery and the Double Driveway Pond was targeted due to the high loading determined from the fingerprinting process. In addition, reduction options for the finer sediment coming from the Bailey Nursery site were also investigated. Although loading from this site was less than that from the stream, it is still a substantial amount and the analysis conducted likely underestimates the total load coming from this area. Costs are presented in pounds TP removed from the system. To arrive at this figure, an estimated amount of particulate phosphorus was used per unit sediment removed (approximately 0.12%).

4.2 Stream Bank Load Reduction

As stated previously, attempts were made to secure easements for temporary access to the creek running from Bailey Nursery to the Double Driveway Pond so that work on stream bank and channel erosion problems could be completed. Easement was granted by Bailey Nursery and approximately 25% of the stream bank has been restored. However, the Staff was previously unsuccessful in obtaining easement access from all affected property owners to complete channel stabilization and erosion repair work in the channel and, thus, restoration is not complete. Even if easement was granted, stream bank stabilization will likely be an ongoing issue requiring maintenance and upkeep. Assuming easement access was granted, capital cost would be $323,000 with an estimated annual cost of $1002 per pound total phosphorus removed.

With the current difficulties obtaining easements for restoring the stream bank, another option was considered to contain impacts from this loading source. Maintaining the Double Driveway Pond at an approximate design depth of 4 feet would increase settling efficiency and help remove the sediment load contributed by the upstream creek. Maintaining the pond depth would be an ongoing process that would include dredging at a greater frequency to sustain sediment removal efficiency in the pond. Capital cost for this option is approximately $97,000 with an estimated annual cost of $621 per pound of total phosphorus removed.

4.3 Polymer Treatment

A number of methods are available to reduce sediment loading from Bailey Nursery to the creek and downstream pond. Chemical flocculants and coagulants can be used to attract small, suspended particles in water, helping them to settle out of the water column faster. Previous applications have shown turbidity reductions (suspended particles) between 90 and 99 percent in similar situations. Because the nursery has a pond on the east side of the property that acts as a sedimentation basin, this option may be feasible. Chemicals flocculants and coagulants can be used as an 'inside the pipe' passive treatment system that can minimize operating costs over the long term.

Barr has previously evaluated a group of the currently available polymers that can be useful in removing fine particulates from storm water. Table 5 lists three examples of treatment materials that would be applicable in this situation. For the in-pipe/storage vault treatment system, any of the three treatment materials shown could be placed in a manhole insert and passively deliver flocculants/coagulants to passing storm water. The material developed by Soil Net LLC consists of two different types of solid pellets that are used together. One is made of solid flocculation pellets and the other is a starch-based polymer. They should be applied in equal amounts in the manhole treatment system. It is estimated that two pounds of the pellets (one pound of the flocculation pellets and one pound of the polymer) can treat one acre-foot of runoff and effectively reduce turbidity and suspended sediment.

CFM has developed 1 pound polymer disks that are intended to be applied in the same way as the Soil Net product. These discs work the same as the pellet based flocculent/coagulant by slowly dissolving, allowing the polymer to enter solution and increase settling of suspended solids. CFM claims that a one pound disc can treat 2 to 5 acre-feet of storm water.

The use of Floc Logs (Applied Treatment Systems, Inc.) was also investigated. A Floc Log (approximately 10 pounds in weight) is a co-polymer blended block that can be placed in a pipe, ditch or any area of continuous water flow. Similar to the products above, the block slowly dissolves, releasing a polymer that helps fine particles settle out of turbid water. According to the manufacturer, approximately 5 pounds of Flog Log material can treat 1 acre-foot of flow.

It should be noted that the ideal polymer to remove fine sediment from the water and the amount of polymer required is site specific due to high variability between sediment type, flow conditions, and other chemical or physical properties between sites. The manufacturer can choose or design an appropriate polymer system based on site specific characteristics for optimal sediment removal. The three solutions listed above represent a range of options available to decrease sediment loading in this situation. Laboratory analysis of water from the site will help better identify the most appropriate polymer for use to reduce sediment loading to the creek and downstream ponds.

4.3.1 Load reduction at Bailey Nursery using Polymer Treatment

Based on rainfall for an average year from April through October (25.6 inches, 2005), an estimated 154 acre-ft of runoff would flow from the portion of the site that drains to the pond (approximately 90 acres of the nursery site). Based on the estimated amount of each polymer needed and the associated cost expected, an annual cost estimate was developed for treating the entire flow from the Bailey site that reaches the eastern pond (Table 5). A vault or in-line modification of the existing pipe would also need to be constructed on-site, along the pipe that runs underneath the nursery to the pond. The vault should come downstream of the overflow structure to prevent any polymer from entering the wetland area (Figure 3).

Further study of runoff coming from Bailey Nursery will also be needed to properly apply a polymer treatment system to remove suspended sediment from the water. Bailey Nursery frequently irrigates their plants resulting in relatively stable low flows of runoff into the pipe system throughout the summer. This may result in additional dosing costs that are not included in this study.

Table 5. Cost Ranges for Different Treatment Materials used at the Bailey Pond PFS

Material	Cost/Lb	Sizing (lbs required/ac-ft runoff)	Estimated Annual Cost of Material
Flocculent Pellet and Starch-Based Polymer Pellet Applied Together	$35	2	$9,500
CFM Polymer Disks	$60	1-2	$8,100-$16,200
Floc Logs	$10	5.5	$8,600

Capital cost for the polymer system (retrofit vault and passive delivery system) is expected to be $32,000 with an estimated annual cost (based on the high end of the polymer costs listed above) of $937 per pound of total phosphorus removed.

4.3.2 Previous Experiences using Polymer Treatment Systems in RWMWD

Polymer treatment systems have been previously installed at the Tamarack Swamp location in Woodbury. These systems were designed as manhole type systems where the elevation of storm water rises to meet the polymer contained within mesh bags. Polymer was supposed to dissolve and move out of the mesh bags and into the storm water. However, the polymer started forming longer chains within the mesh bags and the increased size of the polymer prevented it from moving through the mesh bags installed at these sites. This problem can be alleviated through the use of a larger size opening containment structure that will prevent the polymer from clogging. Testing of the polymer with collected storm water samples will help better determine the specific setup needed for this site. In addition, a wider range of polymers are available for use and the variety of options should help improve site specific design for this type of system.

4.3.3 Discussion of Polymer Use

Applications of polymers to reduce sediment loading and improve settling of solids range from direct application to exposed soils at construction sites to removing heavy metals and turbidity from wine and beer. The NRCS and EPA have completed guidance on using anionic polymers for use on construction and agricultural sites and the USDA has approved specific polymers for use in food production. When applied properly, polymers can be a safe and effective way to reduce fine sediment suspended in solution.

4.4 Annualized Costs

A baseline estimate for current removal at the Double Driveway Pond of 60% sediment retention was used to compare options. The current level of removal was estimated based upon approximate elevation of the bottom of the pond. The sediment currently removed by the pond is not included in any of the calculations in order to normalize the removals between stream restoration and pond deepening so only the additional sediment removed from potential project implementation is counted. Final, total sediment removal for the options considered to reduce sediment load from stream bank erosion (Table 6) were estimated to be 80% (with pond deepening and continued dredging at the Double Driveway Pond) or 82% (stream restoration). Total sediment removal from the Bailey Nursery site would improve to 90% (with a PFS installed at the Bailey Nursery Pond).

Table 6. Estimated Percentage Sediment Removal at Each PFS Site

Site	Estimated Current Removal	Design Improvement	Removal with PFS
Bailey Pond	82	N/A	90+
Double Driveway Pond	60	80-90	N/A
Stream Restoration	60	82	N/A

Only additional sediment removed beyond current conditions at the eastern Bailey Nursery pond was used in the cost benefit analysis. Sediment removal estimates and annualized costs are listed in Table 7. Costs are shown for the separate options including, stream restoration, Double Driveway Pond improvements and dredging, and the PFS system. Combined costs of the polymer system and either option for stream sediment reduction are included as well. Maintenance activities including polymer renewal, stream bank maintenance, and sediment dredging are included in these estimates. Expected reduction in dredging activity due to the stream restoration option is also accounted for.

Double Driveway Pond improvement is approximately 38% less expensive than stream restoration based on overall cost and sediment removed from the system. Maintaining the design depth of the pond will help the system to remove sediment and reduce loading further downstream. In combination with a PFS at the Bailey Nursery, it is expected to cost $749 for each pound of total phosphorus removed with these options.

Stream restoration is more expensive when compared to the Double Driveway option, but restoration will substantially decrease loading to the pond itself. However, restoration will not completely eliminate sediment loading due to natural erosion of the stream bank and bed over time. Stream restoration along with the Bailey Nursery PFS will cost approximately $978 for every pound of total phosphorus removed.

4.5 Additional Benefits

An additional benefit to increased sediment removal is the reduction of pollutant transport generally associated with suspended particles or sediment. These pollutants can include metals, nutrients, pesticides, herbicides, etc. It is not currently known if pesticide or herbicide transport through this system is a problem or if Bailey Nursery is using either of these types of compounds on site. This issue should be approached with care, especially if future cooperation with Bailey Nursery on the sediment issue is desired. If the use of these chemicals is ongoing, sediment disposal will be an issue unless Bailey Nursery can keep the dredge spoils on-site. However, this issue is not a creation of any of the projects proposed herein and should be dealt with by the nursery management.

Table 7. Annualized Costs Including Maintenance, Contingency and Engineering

Proposed Project	Capital Cost (2007 $)[1]	Annual Maintenance (2007 $)[2]	Annualized Capital Cost (A/P I = 6%, n = 20, Factor = 0.0872)	Total Annual Costs (2007 $)	Annual TP Removed (lbs removed)[3]	Annualized Cost per Pound TP Removed[4]
Bailey Pond PFS (High End Cost)	$32,000	$16,198	$2,800	$18,998	20	$937.00
Improved Double Driveway Pond Collection System	$96,542	$10,056	$8,400	$18,456	30	$621.00
Stream Restoration	$322,608	$4,983	$28,100	$33,083	33	$1,002.00
Bailey Pond PFS + Double Driveway Pond	$128,542	$26,255	$11,200	$37,455	50	$749.00
Bailey Pond PFS + Stream Restoration	$354,608	$21,181	$30,900	$52,081	53	$978.00

General Notes:

[1]Costs are in 2007 dollars and include a 30% engineering cost and a 30% contingency

[2]Includes dredging or stream bank maintenance and polymer renewal

[3]Removal based on PFS (with pond improvement if applicable) or reduced erosion

[4]TP removed estimate based on the avearge particulate phosporus associted with sediment removed

4.6 Potential Funding Sources

It may be appropriate for fund from the District's BMP cost share program to be applied toward the Bailey PFS. It is likely that an arrangement can be worked out, in which, Bailey Nursery covers the cost of polymer containment system and any additional dredging (if needed) while the District supplies the polymer for the PFS (approximately 10% increase in sediment retention in the pond). Considering the approximate 10% increase in sediment retained by the pond, total sediment removed will increase, but frequency of dredging may not because the additional amount removed is a fraction of total sediment already retained by the pond. Various grants are available through state and federal programs as well to help with the cost of reducing sediment loading to the creeks and ponds. More information on these grants can be found in the Appendix, section C.

5 Recommendations

The largest sediment loading source to the Fish Creek and downstream ponds comes from erosion of the stream bank and sediment bed of the creek running from the Bailey Nursery site to the pond (Figure 3). Corrective measures, including design depth restoration and increased frequency of dredging (every three years) at the Double Driveway Pond will be the most cost effective approach to controlling sediment from the stream bank erosion areas upstream. Increased maintenance of the Double Driveway Pond is currently a less expensive option when compared to stream bank restoration, due to the expected costs associated with easement acquisition. Restoration of the design pond depth will increase sediment retention and reduce loading to downstream areas. Initial restoration of the pond can be completed as part of the 2008 CIP maintenance work.

In addition a retro-fit PFS at the Bailey Nursery container yard will help contain Bailey's fine silt and sediment on site and ultimately decrease sediment and pollutant loading to Fish Creek and downstream. A polymer system will reduce fine grained sediment in flows entering the creek from Bailey Nursery. This finer material is not easily removed by traditional ponding techniques. An in-line system constructed between the overflow weir and the eastern Bailey Nursery pond would help reduce suspended sediment in water flowing through the downstream creek and ponds. The benefits of this system combination are listed below:

- Passive nature of treatment
- Small amount of area needed to implement the measure under current conditions
- Relatively low cost compared to other options
- Demonstrated beneficial results with similar types of scenarios
- Potential for pollutant reduction as well
- Keeps Bailey Nursery sediment (and all it carries with it) on Bailey property

In addition, polymers can be a safe tool with regard to the environment when used at proper doses. There are many different forms of polymers available and it is therefore important to investigate which polymer is not only effective for sediment removal, but safe for the environment. More information can be found in the Innovative Technology Case Study: Use of polymers to reduce turbidity, suspended solids and nutrients in surface water runoff.

Further study is recommended to determine the most appropriate choice of polymer to reduce sediment particles in runoff from Bailey Nursery. Polymer selection and dose can depend on many parameters including flow, type of suspended particles, pH, temperature and mixing time. With further laboratory and in-field testing, a more accurate sediment load removal and expected cost estimate can be refined based on the results of the analysis.

The Bailey staff recognizes that there are on-site erosion problems and that sediment loading from the site continues to be a problem downstream of the nursery. As mentioned, conversations with Bailey Staff have indicated that management is willing to continue to cooperate with the District to improve the quality of runoff coming from the nursery. The District's cost share program could be used to partially fund the Bailey Nursery PFS. It appears likely that Bailey Nursery would be willing to increase dredging frequency of the eastern pond, if need be, to accommodate the PFS and additional sediment removal from the Nursery. Other funding sources (listed in the appendix) may help offset the total cost of this sediment loading reduction project. Upon Board approval, staff should discuss this project concept with Bailey Nursery and work out the cost share agreements.

6 References

Barr Engineering. 2007. Innovative Technology Case Study: Use of polymers to reduce turbidity, suspended solids and nutrients in surface water runoff.

Håkansson L. and M. Jansson. 1983. Principles of lake sedimentology. Springer-Verlag, Berlin, 316pp.

O'conner, B.L., P.L. Brezonik and L.K. Hatch. 2006. The use of sediment fingerprinting techniques within the Minnesota River Basin. Manuscript.

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A Sediment Fingerprinting

The second step of the fingerprinting process involves applying the composite parameter signature to a mixing model as shown in the following equation.

$$\sum_{i=1}^{n}\left[\frac{Ci-(Pa1(Sa1,i)(Za1)+Pa2(Sa2,i)(Za2)+\ldots)}{Ci}\right]^2$$

$$0 \le Pa \le 1$$

$$\sum_{a=1}^{n} Pa = 1$$

Where:

Ci = Double Driveway Pond sediment concentration of parameter i

Pai = Percent contribution from source a

Sa,i = Soil concentration of signature of parameter i from source a

Za = Particle size correction factor

The analysis combines the mean characteristics of the source soils and calculates an average that represents a model of the sediment values determined from the Double Driveway Pond sediment samples. This modeled output is then compared to the actual values determined for the pond sediment for each characteristic and the objective functions are summed along with a weighting factor. Minimizing this sum (basically the variation or error within the model) results in the values that determine the approximate sediment loading percentages from the areas identified in Table 1. A particle size correction factor is used to normalize results between samples of differing composition. Other studies have successfully used this process to determine the main sources of sediment and soil loading to areas of concern (O'conner et al. 2006, Walling 2005).

B Bailey Nursery Photos

Northwest Bailey Pond

Lower creek erosion near the inlet to Double Driveway Pond

Double Driveway Pond inlet after recent dredging in spring 2007

Stream bank erosion in the upstream portion of the creek near the outlet from Bailey wetland

C Potential Funding Sources

Agency/ Organization	Program/Criteria	Eligible Applicants	Deadline	Contact
MPCA	**Open Grant Program**—Funds projects to develop environmentally sustainable practices in Minnesota through voluntary partnerships and goal-oriented, economically driven approaches to pollution prevention and resource conservation; maximum grant $40,000; requires a 25% match	Any	Dates not currently set	www.pca.state.mn.us/grants/
MPCA	**319 Grant**—Funds projects that address a nonpoint-source pollution issue; cannot be spent on diagnostic work (other than TMDL development); requires a one-to-one match, up to $300,000 available.	All entities except federal agencies	September 6, 2007	www.pca.state.mn.us/water/cwp-319.html
MPCA	**Clean Water Partnership Program**—Funds projects that address a nonpoint-source pollution issue; cannot be spent on in-lake treatment; requires a one-to-one match; grant awards up to $300,000	Local unit of government must sponsor a CWP project. The applicant can be a lake association, joint powers board, or other entity but it must involve a local unit of government, which becomes the fiscal agent.	Only continuing projects will be funded this round (2007)	www.pca.state.mn.us/water/cwp-319.html
Legislative-Citizen Commission on Minnesota Resources (LCMR)	**LCMR Grants**—Funds are recommended to the legislature for special projects that maintain and enhance Minnesota's natural resources.	Any	September 4, 2007	www.lccmr.leg.mn/

Agency/ Organization	Program/Criteria	Eligible Applicants	Deadline	Contact
U.S. Environmental Protection Agency (EPA)	**Targeted Watershed Grants**—Governors and tribal leaders are invited to nominate their leading watersheds organizations for the grants. For 2006, EPA will award up to $16 million to as many as 20 of the nation's outstanding watershed practitioners; grant guidelines encourage innovative solutions to achieving measurable water quality improvements	Governors nominate watershed organizations	No current round set	http://www.epa.gov/twg/twg_basic.html
Board of Soil and Water Resources (BSWR)	**Local Water Management Planning Challenge Grants**—Proposed projects must implement priority action items in an approved local water management plan. Eligible projects include: land and water treatment (i.e., install erosion or water quality improvement practices) inventories (e.g., inventory public and private drainage systems) water quality monitoring education activities Up to $25,000, one-to-one match required	Local units of government including counties, watershed districts, and watershed management organizations.	October 1, 2007	www.bwsr.state.mn.us/grants costshare/lwplanning/index.html
U.S. Department of Agriculture – Natural Resources Conservation Service	**Small Watershed Program (PL - 566) in Minnesota**—Provides technical and financial assistance to local organizations for planning and carrying out watershed projects. Limited to watersheds less than 250,000 acres in size.	Local organizations	Rolling	www.mn.nrcs.usda.gov/programs/water_resources/pl566_projects-new.html