BASELINE STREAM CONDITIONS
MAY CREEK DRAINAGE IMPROVEMENT
CIP#9A1205

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King County

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1 Summary

King County Department of Natural Resources and Parks proposes to remove sediment and in-channel plants that obstruct water flow from portions of May Creek in May Valley to increase channel capacity and reduce flood duration in adjacent pastures. The stream in this area is nearly flat and flows through large wetlands, many of which are currently used as pastures for horses.

Historically, May Valley provided floodwater storage for tributaries draining the upper May Creek basin. Limited capacity to transport sediment through the flat valley allowed sediment to accumulate. Land owners periodically cleared the stream of sediment and in-channel plants until about the 1940's (King County 1995). Since then, development in the upper watershed to the north and south of May Valley has increased stormwater run-off, leading to an increase in the frequency and duration, but not magnitude, of flooding in May Valley (King County 1995). Some infilling of the May Creek channel by fine sediment mobilized during flooding has probably contributed to increased flooding in the valley. Chronic winter flooding of some properties in May Valley limits the use of these properties for pasture and grazing livestock, mostly horses.

We evaluated stream baseline conditions on about 2,800 feet of May Creek, beginning about 328 feet downstream of 148th Ave SE, near river mile (RM) 4.35, and ending near RM 4.87. In the proposed project area, May Creek flows through a flat, formerly ditched channel in an oversized valley formed by glacial meltwater (King County 1995). The valley is bordered on the north by Cougar and Squak mountains, which are bedrock, and on the south by the East Renton Plateau, which is formed by glacial deposits.

The flat May Valley reach of May Creek stores stormwater and sediment, slowly releasing both to a higher gradient ravine downstream of the study reach. Slow water and abundant cover from overhanging vegetation in the study reach provide rearing and refuge habitat for coho salmon, cutthroat trout, and rainbow/steelhead trout. These fishes also use the mainstem creek as a migration corridor to spawning and rearing habitat in tributaries such as the North Fork, Cabbage Creek, Country Creek, and Tributary 0291A. Stormwater and sediment storage in the valley also help maintain spawning and rearing habitat for salmon in reaches of May Creek located downstream of May Valley, primarily from RM 0.2 to RM 3.9, which is identified as a "Locally Significant Resource Area" in the May Creek Current and Future Conditions Report (King County 1995). Five species of salmon are found in May Creek downstream of May Valley: chinook, sockeye, and coho salmon, and cutthroat and rainbow/steelhead trout (King County 1995).

Puget Sound Chinook salmon and steelhead are listed as threatened under the Federal Endangered Species Act. If the proposed project requires a federal permit or has federal funding, then endangered species act consultation for Chinook salmon and steelhead will be necessary.

Key Points:

1. May Valley was historically an area of floodwater and sediment storage as the nearly flat stream braided through extensive wetlands. The channel was ditched between 1910 and 1936 for agriculture (King County 1995). The ditched channel filled with sediment and was dredged in the 1940's to reduce flooding, and refilled with sediment again by the 1960's (King County 1995). Heavy truck farming was taking place in the valley during this time, and agricultural fields were plowed right up to the top of the stream banks (King County 1995).

2. Current sediment sources to May Creek in May Valley have not been clearly identified. The May Creek Erosion Stabilization Draft Report (Anchor QEA, LLC 2010) only addresses erosion downstream of May Valley. It is unclear if flows in the flat valley reach have enough power to transport sediment the nearly two miles from upstream sources to the project area, and large sediment plumes from tributaries were not observed during site visits. Gravel transported to May Creek from Long Marsh Creek creates one of the few potential spawning areas within the project area. Erosion is present in May Canyon, a ravine located about 0.7 mile downstream of the project area (King County 1995, Anchor QEA 2010). The May Creek Hydraulic Analysis (King County 2010) evaluated whether sediment removal in the valley would worsen erosion in the ravine. The analysis showed that there is no substantial difference between the rate of erosion that occurs in the ravine under existing conditions and the erosion that would occur under any of the sediment removal alternatives.

3. Areas of the valley that are designated as open space, where flooding does not threaten homes or pastures, and where an intact woody riparian corridor exists, provide pockets of refuge for rearing and migrating fish. If left intact, these areas may provide refuge for fish affected by sediment removal elsewhere in the valley.

4. The proposed project ("Ineffective Flow Project #1") is one of four conceptual ineffective flow projects described in the May Creek Drainage and Restoration Plan (Geoengineers 2008). The combined length of the four conceptual projects is about 2.26 miles of May Creek in May Valley, which is 75% of the valley length and 32% of May Creek's entire length. A total of 33 projects are identified in the drainage and restoration plan (Geoengineers 2008). These projects include the four ineffective flow projects (direct channel modifications) described above, as well as 29 indirect channel modifications such as culvert and bridge replacements, and wetland and steam enhancements (Geoengineers 2008).

2 Introduction

King County Department of Natural Resources and Parks, Water and Land Resources Division (KC DNRP) proposes to remove sediment and in-channel plants from portions of May Creek within May Valley to increase channel conveyance capacity and reduce flood duration in adjacent pastures. A total of four "ineffective flow" channel clearing projects are described in the May Creek Drainage and Restoration Plan (GeoEngineers 2008). The four projects together total about 2.26 miles, which is about 75% of the total length of May Creek in May Valley, and about 32% of the total seven-mile length of May Creek. Thirty-three projects are identified in the drainage and restoration plan (Geoengineers 2008). These projects include the four ineffective flow projects (direct channel modifications) described above, as well as 29 indirect channel modifications such as culvert and bridge replacements, and wetland and steam enhancements.

We studied existing conditions on about 2,800 feet of May Creek, beginning about 328 feet downstream of 148th Ave SE, near river mile (RM) 4.35, and ending near RM 4.87, and roughly corresponding to the area of May Creek identified in "Ineffective Flow Project #1" (GeoEngineers 2008, Figure 1). Our study evaluates the suitability of the stream as fish habitat, and physical processes affecting the stream, stream channel, and stream inhabitants. Included in the study is a review of existing literature and information about May Creek, a qualitative general site survey which evaluates the physical and biological characteristics of the channel and the surrounding areas, and quantitative measurements of in-stream fish habitat, riparian and in-stream plants, and bank conditions.

May Creek Channel Restoration Project

Project Vicinity

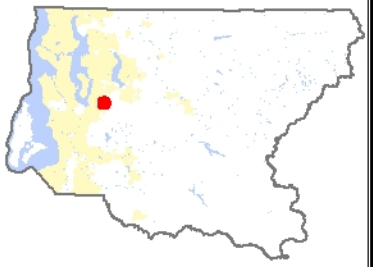
Study Area

Mile Markers

Stream

Incorporated Areas

Cougar Mountain Wildland Park



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March 2010

King County

0 95 190 380 570 760 Feet

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Figure 1

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3 Methods

3.1 Literature Review

We reviewed the following information to identify natural drainage system features and provide background information prior to field visits:

- May Creek Current and Future Conditions Report, March 1995. King County Surface Water Management Division;
- May Creek Basin Action Plan, April 2001. King County Department of Natural Resources, Water and Land Resources Division;
- May Creek Drainage and Restoration Plan, December 2008. GeoEngineers;
- May Creek Erosion Stabilization Draft Report, May Creek Sediment Transport Study Phase 3, January 2010. Anchor QEA, LLC;
- May Creek Hydraulic and Hydrologic Analysis. 2010. King County Department of Natural Resources, Water and Land Resources Division;
- Particle Size Evaluation of May Creek Water Channel Soils, Job Number 1B1205, Task MTR. 2010. King County Department of Transportation, Materials Lab, Renton, WA.
- Washington Department of Fisheries. 1975. A Catalogue of Streams and Salmon Utilization. Volume 1. Olympia, Washington;
- Snyder et al. 1973. Soil Survey of King County Area, Washington. Soil Conservation Service;
- King County Sensitive Areas Map Folio. 1990. Maps 4 (Duwamish) and 9 (Issaquah).

3.2 Field Methods

We visited the study area on three occasions in 2010: twice in the winter when flows were high, and once during summer low flow. We conducted reconnaissance-level evaluations during the winter visits, and a detailed in-stream, bank, and riparian study during the summer visit.

On February 1, 2010 King County Roads Environmental Unit Senior Ecologists Erick Thompson and Kerry Bauman walked about 2,800 feet of May Creek, beginning about 328 feet downstream of 148th Ave SE, near RM 4.35, and proceeding upstream to the

“red barn” at about RM 4.87(Figure 1). We walked May Creek to visually characterize channel morphology, bank condition, substrate, in-stream aquatic habitat, large wood, and riparian plant communities and land-uses. We measured wetted channel width and depth in representative locations, but high water prevented identification of bankful channel width and depth.

We used field observations to characterize the present condition of the stream channel, including its suitability as fish habitat and its apparent conveyance capacity for water and sediment. We also noted any fish, other aquatic organisms, and wildlife or wildlife signs we noticed during the survey, and took photographs to provide a visual record (Appendix A).

On August 16 and 17, 2010 we assessed in-stream habitat using several combined methods including Timber-Fish-Wildlife (Pleus et. al. 1999) and Fish Habitat Relations (FHR), as modified by King County from the USDA Forest Service Stream Habitat Classification and Inventory Procedures for Northern California (McCain et al. 1990). We identified and measured habitat units, collected information on residual pool depth (maximum pool depth minus tail-out depth), pool-forming factors, pool quality (Platts et al. 1987) and large woody debris (LWD). We used the Timber-Fish-Wildlife definition of LWD (wood that lies or protrudes within the vertical axis of bankful width, Pleus et al. 1999). We recorded LWD diameter and length, variety (coniferous or deciduous), stability (pinned, buried, attached rootwad, free to go), and whether the LWD was forming a pool or trapping sediment.

For each habitat unit we also identified bank type (armored, sloped, vertical, and undercut) and estimated the percent and type of overhanging, instream rooted, and “floating mats” of vegetation. We used a handheld GPS unit to survey broad-scale riparian plant communities (forest, shrub, or grassland) and bank vegetation types (tree, shrub, or grass dominated).

4 Existing Conditions

4.1 General Site Survey

The general site survey is qualitative, based on information obtained through review of existing background information and observations made during site visits. Results of the general site survey should not be viewed as a systematic, quantitative evaluation of the features described.

4.1.1 Existing Drainage System

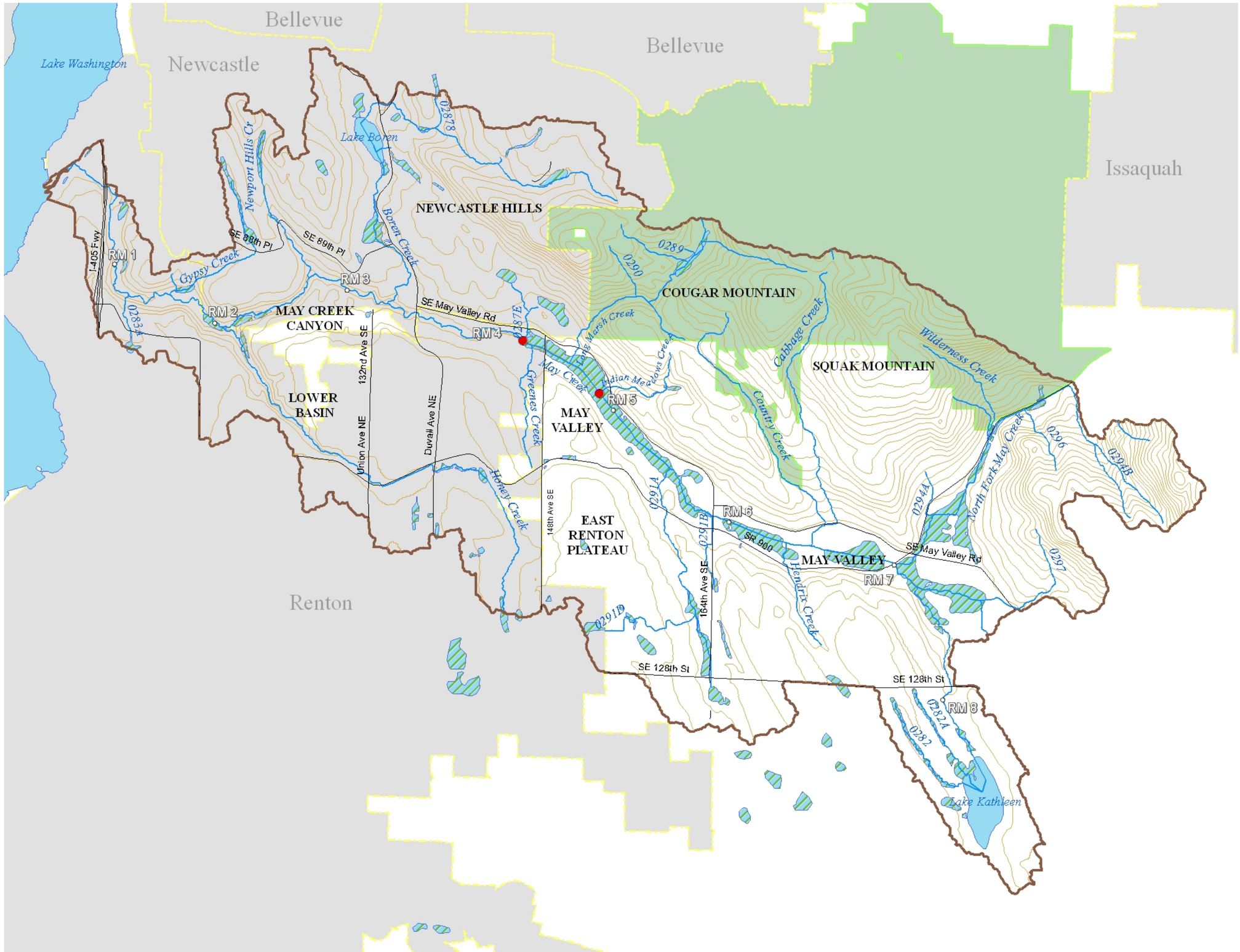
May Creek is about seven miles long, with about 19 miles of tributary streams, draining about 14 square miles in eastern King County (Figure 2, King County 1995). Three headwater creeks join at the top of May Valley to form the main channel, which flows through the valley and a narrow, erosive ravine before flowing into Lake Washington (Figure 2).

The bedrock foothills of Cougar Mountain, Squak Mountain, and Newcastle Hills form the uplands north of May Valley, and a gently rolling plateau of glacial deposits (East Renton Plateau) forms the uplands south of May Valley (King County 1995). The valley itself was carved by glacial meltwater, and is underlain by 200 to 500 feet of unconsolidated glacial sediments (King County 1995).

Tributaries descending through the glacial deposits of the plateau to the south and across the steep bluffs of the ravine are highly erosive and contribute large amounts of sediment to May Creek, whereas tributaries descending from the bedrock-underlain foothills to the north of May Valley are less erosive (King County 1995). May Valley was historically an area of sediment deposition and flood storage, and the stream channel braided through extensive wetlands. The stream was put in a ditched single-strand channel so the surrounding floodplain could be used for agriculture. Storm and surface water storage in May Valley is important for controlling erosion in the ravine, which is experiencing erosion in both the mainstem and tributaries (King County 2001, Anchor QEA 2010).

May Creek Channel Restoration Project

May Creek Basin



Study Area
River Mile
Streets
Streams
50 Foot Contours
May Creek Basin
Water Features
Wetlands (NWI)
Incorporated Areas
Cougar Mountain Wildland Park

N

March 2010

King County

0 900 1,800 3,600 5,400 7,200 Feet

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Figure 2

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4.1.2 Riparian Land Use and Vegetation

Small berry and horse farms, and open space are the primary remaining land-uses in May Valley. Wetlands that have been converted to horse pastures border both sides of the stream in the project reach, except for the area downstream of 148th Ave SE, which is open-space associated with the Stonegate development (Figure 3). Reed canarygrass (*Phalaris arundinaceae*) is pervasive. Stands of willow (*Salix spp.*) and red alder (*Alnus rubra*) in the downstream portion of the project reach greatly improve the stream channel from a habitat and natural channel morphology perspective. These woody plants stabilize stream banks, provide shade, food, and hiding cover, and affect in-stream habitat by providing hard points that create a mixture of slow-water and fast water areas.

The channel in the upstream portion of the project reach, which lacks woody plants and is almost exclusively vegetated with reed canarygrass, is more uniform and has filled in with up to 18 inches of sediment, making the surrounding area prone to flooding. Sources of this sediment are unclear. It may be deposited by tributaries and stored in the valley, or it may be eroded from surrounding horse pastures, deposited in the stream channel, and stored in the valley. Horse pastures in the vicinity of the filled-in channel sections slope toward the stream and are muddy throughout much of the year (Appendix A, Photos 42, 44, 56, 59, 64, 67).

4.1.3 Adjacent Wetlands

Wetlands are present along May Creek through most of the project area. Many wetlands have been converted to horse pastures and will be described in more detail under separate cover. Dominant vegetation is reed canarygrass. We saw both resident and migratory waterfowl using the open water wetland on the south side of May Creek, including mallards (*Anas platyrhynchos*), American widgeon (*A. Americana*), and wood ducks (*Aix sponsa*).

4.1.4 Animal Habitat and Use

May Creek and associated wetlands provide habitat for a wide variety of animals. Although we did not see terrestrial wildlife during site visits, we can assume that the following species use habitats within the study area: deer, bobcat, coyote, raccoon, moles, voles, and mice, as well as waterfowl and songbirds. We saw two buck rubs on willows adjacent to the stream; one rub was downstream of the 148th Ave SE Bridge, near RM 4.4, and one rub was upstream of the bridge, near RM 4.5. We saw both resident and migratory waterfowl in the open water wetland on the south side of May Creek near RM 4.75, including mallards, American widgeon, and wood ducks. Although we did not see them, salamanders, frogs, and crayfish are probably present in aquatic habitats within the proposed project area.

May Creek Channel Restoration Project

Stream Features

- Study Area
- River Mile
- Streets
- Streams
- Incorporated Areas
- Cougar Mountain Wildland Park

N

March 2010

King County

0 60 120 240 360 480 Feet

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Figure 3

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4.1.5 Riparian Soils, Bank Stability, and Channel Morphology

From our vantage on the streambanks in February, it looked as though the project reach of May Creek has two primary channel forms, which are influenced by the riparian plant community. In areas where willows are present and in contact with stream flow, the channel form appears to be mostly forced pool riffle, with pools being forced by scour against channel-spanning willow branches or willow stems within the active channel. In areas where riparian vegetation consists of reed canarygrass or trees high on the banks, the channel form appears to be plane-bed. Both channel forms derive from past excavations and ditching for agriculture and sediment deposition. The channel gradient is flat throughout.

We confirmed the two general channel forms described above when we made more detailed observations in August. However, water flow patterns appear to simplify when water elevations drop below the level needed to contact willow branches spanning the channel. The mix of slow water and fast water we observed during higher flows in February was thus simplified to uniform slow-water glides, or shallow pools too small to identify individually, during the habitat survey conducted in August.

In February the water was too high for us to see the banks in most locations. Where banks were visible, stability looked good. A more detailed assessment of bank conditions performed in August confirmed that most banks are stable. Results of the more detailed survey are presented in Section 4.6.

The King County Area Soils Survey maps soils in May Valley as mostly Alderwood and Bellingham soils. Alderwood soils formed in glacial deposits, and Bellingham soils formed in alluvium found mostly in depressions in glacial deposits (Snyder et al. 1973). We did not sample soil during site visits, but soils observed in soil pits during the wetland delineation will be described under separate cover.

4.2 Stream Habitat

We could not wade most of the stream reach during the February 1, 2010 survey because the water was too deep. Most observations and limited measurements were made while standing on the banks. The August 16 and 17, 2010 in-stream habitat survey was conducted during low flow so we could quantify habitat and bank conditions. Given the highly variable nature of stream flows, the low flow stage is considered the most repeatable and thus the standard for comparisons over time. We divided the surveyed portion of May Creek into four reaches based mostly on the nature of the riparian corridor (Figure 3).

In-stream habitat in the surveyed reach of May Creek is influenced by riparian plant communities. Aquatic habitat is more complex in places where the riparian corridor has woody plants, such as willows, actively engaged with the stream channel and

connected floodplain. Overhanging or rooted willow branches or stems provide cover and hard points necessary for bedform complexity, producing both turbulent and non-turbulent flow areas, backwaters and riffles, and shade and nutrients during the summer (Appendix A, photos 9, 12, 14, 23, 25). Areas with no woody riparian plants are more uniform and tend to have accumulations of fine sediments in the channel (Appendix A, Photos 4, 5, 10, 11, 13, 47, 50 to 58, 60, 61).

Habitat units as we encountered them in sequence along the study area during the August 16 and 17, 2010 survey are presented in Figure 4 and Appendix B.

May Creek within the project limits was dominated by slow water glides (Table 1, Figure 5). Pools made up about one quarter of the surface area in Reaches One and Two, about ten percent of the area in Reach 3, and about 13 percent of the area over the entire surveyed reach; no pools were present in Reach Four (Figure 5). All of the pools were lateral scour pools except one mid-channel pool in Reach One (Table 2). Fast water was limited to a single low-gradient riffle at the 148th Ave SE bridge, and a couple of pool tail-outs in Reach One (Figure 4).

Many of the areas inventoried as glide during the low-flow stream survey had both turbulent and non-turbulent flow during the February stream reconnaissance. This is most apparent in Reach Two, which has a relatively wide, mature, willow-dominated riparian corridor. Dense willow branches cross the stream channel throughout this reach, functioning like a debris complex and creating numerous backwater areas during higher flows. This reach is well-connected with its floodplain, and some floodplain terracing is present, which also increases habitat complexity during higher flows. The wider forested riparian area has shaded out reed canarygrass. In areas where reed canarygrass dominates, such as Reach Four, the channel tends to be deeper and has thicker accumulations of fine sediment (Appendix B).

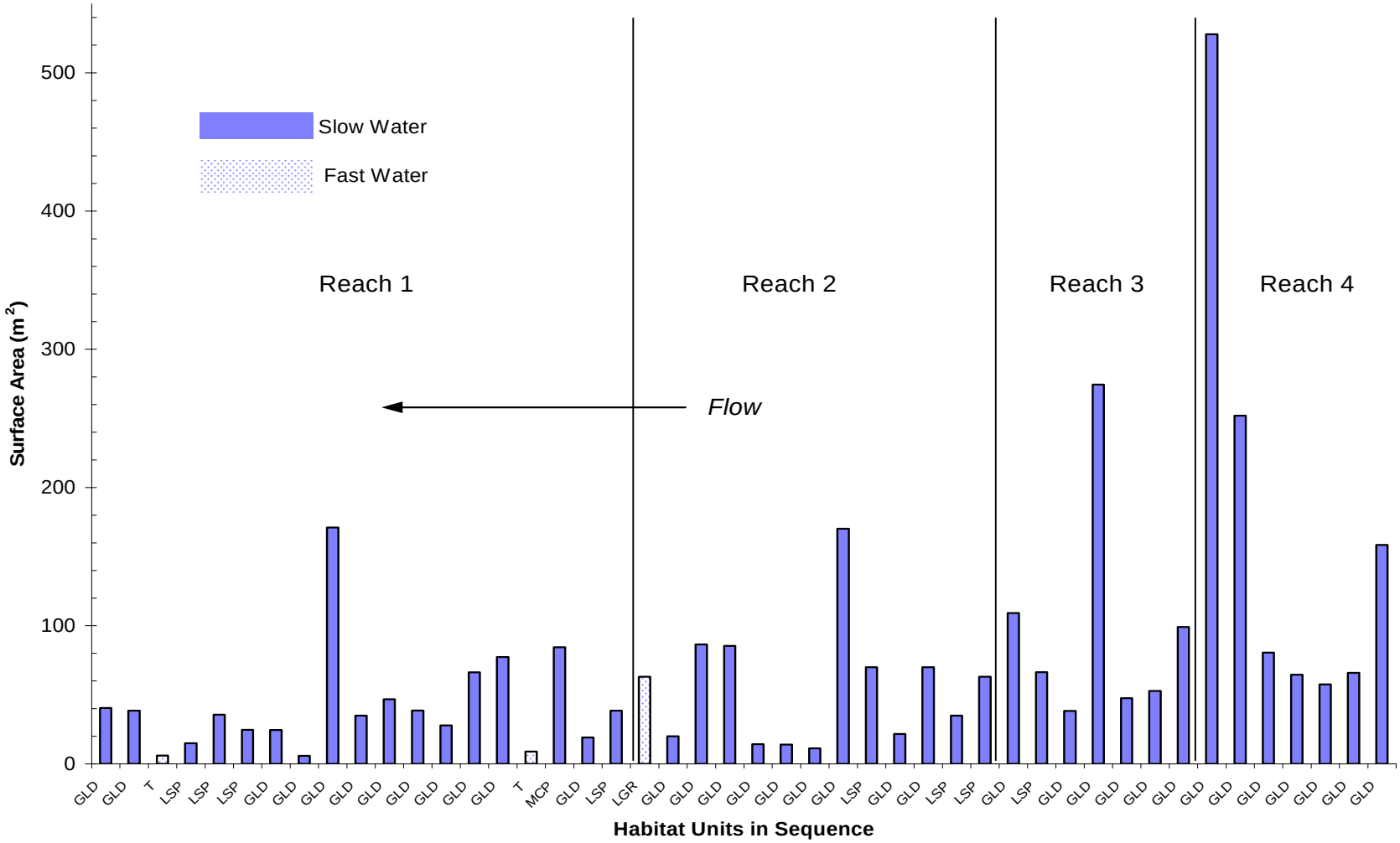

Figure 4. Habitat in Sequence in the study area. Dotted area is fast water, solid area is slow water. GLD= glide, T= tail-out, LSP= lateral scour pool, MCP= mid-channel pool, LGR=low gradient riffle. May Creek Channel Restoration, CIP #9A1205.

Table 1. Habitat Survey Summary. Summary of habitat, bank condition, and riparian and instream plants measured during the August 2010 habitat survey. LB=left bank, RB= right bank, water flows from Reach 4 to Reach 1. May Creek Channel Restoration, CIP #9A1205.

	Reach 1		Reach 2		Reach 3		Reach 4		Entire[1]	
HABITAT										
Average Wetted Width (m)	3.9		3.5		3.5		3.9		3.7	
Average Wetted Depth (m)	0.3		0.3		0.4		0.5		0.34	
Bankful Width (m)[2]	5.2[3]		14		NA		NA		NA	
Bankful Depth (m)[2]	1.5[3]		0.7		0.8		1.3		NA	
Percent Glide	74		68		90		100		85	
Percent Pool	25		23		10		0		13	
Percent Riffle	2		9		0		0		2	
Ave Residual Pool Depth (m)	0.6		0.5		0.3		NA			
Average Pool Quality[4]	4.2		3.7		3.0		NA		3.9	
Number of Pools	5		3		1		0		9	
Number of LWD	0		0		2		0		2	
PLANTS	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
Percent Grass	59	64	25	26	39	71	100	96	67	72
Percent Willow/Grass	6	7	42	45	0	0	0	0	8	9
Percent Willow	7	4	14	22	0	0	0	0	22	16
Percent Rooted Grass/Reeds	0		0		7		56		21	
Percent Floating Mats	7		4		2		8		6	
Area Floating Mats (m^2)	30.8		14.4		12.0		51		85.4	
BANKS	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
Percent Sloped Bank	9	18	53	45	71	75	51	49	46	47
Percent Undercut Bank	12	12	21	15	3	14	0	0	8	9
Percent Vertical Bank	69	65	26	39	19	10	49	49	43	43
Percent Armored Bank	10	6	0	0	7	0	0	0	4	1

[1]Averaged over the entire project area, not an average of reach averages
[2]Measured in representative locations, not in every habitat unit.
[3]grass-dominated area
[4]Platts et al. (1987). The Pool Quality Index is a scale of one to five, with five been the best pool quality.

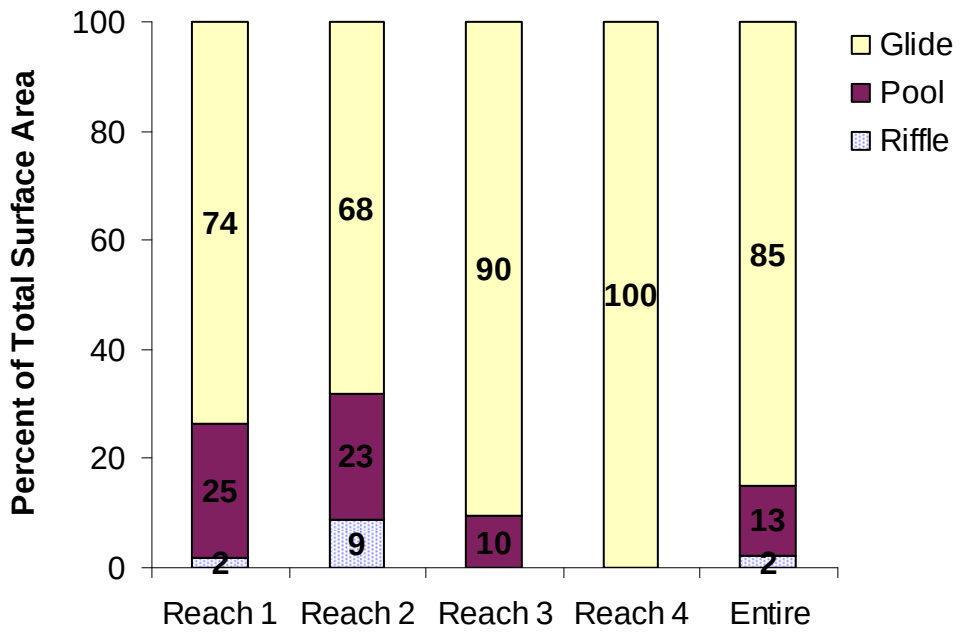

Figure 5. Habitat Unit Proportions, as surface area (m^2). Dotted area is fast water, solid area is slow water. Water flows from Reach 4 to Reach 1. May Creek Channel Restoration, CIP #9A1205.

Table 2. Pool Characteristics. PQI is a pool quality rating system developed by Platts et al. (1987) where pools are given a score of 1 to 5 (highest quality), LWD=large woody debris. May Creek Channel Restoration, CIP #9A1205.

Pool Characteristics			
Total Pools			9
Pool Types		**Number**	**Percent**
	Mid-channel Pool	1	11
	Lateral Scour Pool	8	88
Average residual pool depth (m)			0.5
Average PQI rating			3.9
Average pool length (m)			14
Average pool area (m^2)			52.3
Average pool volume (m^3)			20.2
Percent slow water pools			100
Percent fast water pools			0
Percent pools associated with LWD			22

The four surveyed reaches are described in greater detail below.

Reach One: Stonegate property line (about RM 4.33) to 148th Ave SE bridge (RM 4.46). Reach one consisted of 74 percent glide, 25 percent pool, and two percent riffle (Figure 5). Habitat units in sequence are presented in Figure 6. The effect of riparian plant communities is pronounced in Reach One. Most of the reach has a mature willow-

dominated riparian corridor, with reed canarygrass dominating the understory. Wetted channel width is 32 to 49 feet. Substrate consists mostly of fine-grained sand and silt, but some small gravels (one to two-inch size) are exposed in fast water areas. As described above, overhanging and rooted willow branches and stems provide cover and hard points to create complex in-stream aquatic habitat. Water is clear and cold. The mixture of slow water and fast water habitats and abundant cover provide good rearing habitat for coho salmon (*Oncorhynchus kisutch*) and trout (*O. clarki* and *O. mykiss*). We also saw a buck rub on a willow in this reach (Appendix A, Photo 8). The channel is well connected with its floodplain, and the reach provides flood storage.

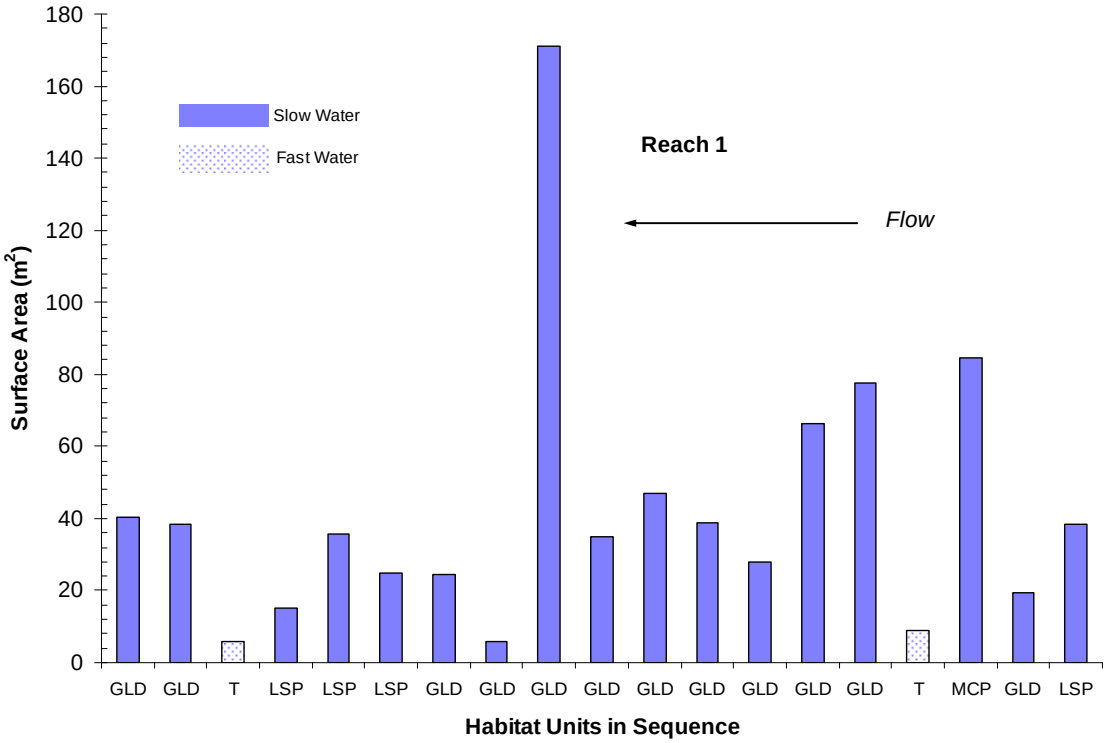

Figure 6. Reach One Habitat. Habitat as it occurs in sequence in Reach One. Dotted area is fast water, solid area is slow water. GLD=glide, T= tail-out, LSP= lateral scour pool, MCP= mid-channel pool. May Creek Channel Restoration, CIP #9A1205.

Interspersed among the willow-dominated areas are a few stretches of stream with no woody riparian plants (Figure 3). The riparian corridor in these areas is dominated by reed canarygrass. Flow is uniformly slow and deep, with deep accumulations of fine sediment. Wetted width is about 13 feet, wetted depth is about 4.9 feet, and fine sediment accumulation is about 1.6 feet. These stretches of stream are less structurally complex than the willow-dominated areas, and reed canarygrass is the primary influence on in-stream fish habitat. Although reed canarygrass-dominated slow water, uniform, channels provide limited habitat for most species of salmonids, these areas do provide rearing habitat for coho salmon fry because the grass slows the water current and provides hiding cover and shade.

The channel becomes wider and shallower, and accumulations of fine sediment disappear near the entrance to the forested riparian corridor (Figure 3). Wetted channel width is about 19 feet; wetted depth is about 1.6 feet, and one to three-inch clean, loose gravels dominate the substrate, with some cobbles present along the channel edges. Red alder, willows, Indian plum (*Oemleria cerasiformis*), sword fern (*Polystichum munitum*), and reed canarygrass are dominant riparian vegetation. The forested reach may provide spawning habitat for coho salmon and trout, as well as rearing habitat.

We observed Greenes Creek during a site visit on March 1, 2010, when the May Creek stream level was substantially lower than on February 1, 2010 (Appendix A, Photo 6). Greenes Creek flows from the East Renton Plateau toward the left (south) bank of May Creek at about RM 4.4 (Figure 3). The creek did not enter May Creek at the time of the site visit, but instead dissipated and infiltrated in the adjacent wetland (Appendix A, photo 7). We saw no sediment deposition from Greenes Creek in either the wetland or in May Creek.

Reach Two: 148th Ave SE Bridge (about RM 4.46) upstream to fence line (about RM 4.55). Reach Two consisted of 68 percent glide, 23 percent pool, and nine percent riffle (Figure 5). Habitat units in sequence are presented in Figure 7. Reach Two has a relatively wide, mature willow-dominated riparian corridor. In-stream habitat is mixed riffle and glides or pools. Substrate is dominated by accumulations of fine sediments. This reach is well-connected with its floodplain. We observed evidence of recent overbank flooding and flood storage in the riparian corridor. We saw a second buck rub on a willow in this reach (Appendix A, Photo 26).

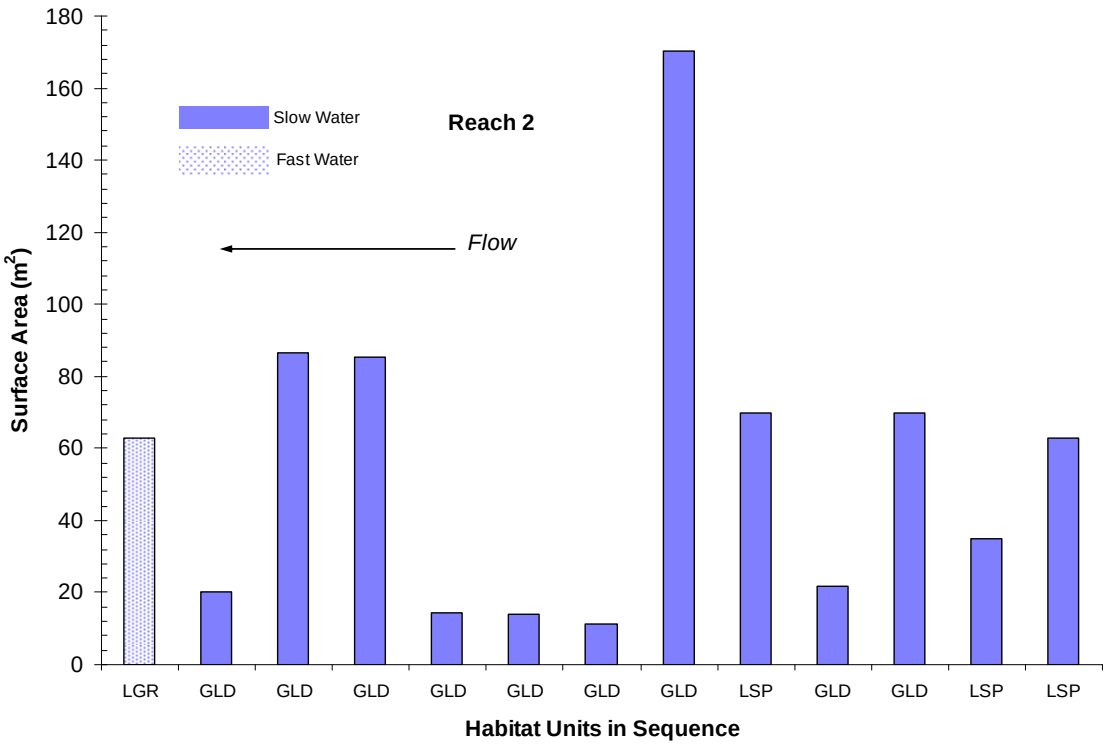

Figure 7. Reach Two Habitat. Habitat as it occurs in sequence in Reach Two. Dotted area is fast water, solid area is slow water. LGR=low gradient riffle, GLD=glide, LSP=lateral scour pool. May Creek Channel Restoration, CIP #9A1205.

Reach Three: Fenceline (about RM 4.55) upstream to end of woody riparian corridor (about RM 4.7). Reach Three consisted of 90 percent glide and 10 percent pool (Figure 5). Habitat units in sequence are presented in Figure 8. Willows are absent and the mature red alder-dominated riparian corridor is much narrower, about 10 feet wide, in Reach Three. Reed canarygrass dominates the understory, and horse pastures are present on both sides of the stream. The wetted channel width is about 21 feet and the wetted depth is about 3.0 feet, substrate is mostly fine sediment. The horse pasture on the right bank is about three to four feet above the February 2010 water surface, suggesting that the channel in this reach is currently large enough to transport higher flows than those present during our survey (Appendix A, Photo 44). The increased channel capacity in this area is likely a result of sediment that was removed by King County in 2002 as part of a channel obstruction removal pilot project.

Long Marsh Creek enters May Creek on the right bank at about RM 4.62 (Figure 3). This tributary is a source of gravels to May Creek and there are about 65 feet of stream with spawning-sized gravels around the stream confluence (Appendix A, Photos 30, 32, 37, 38).

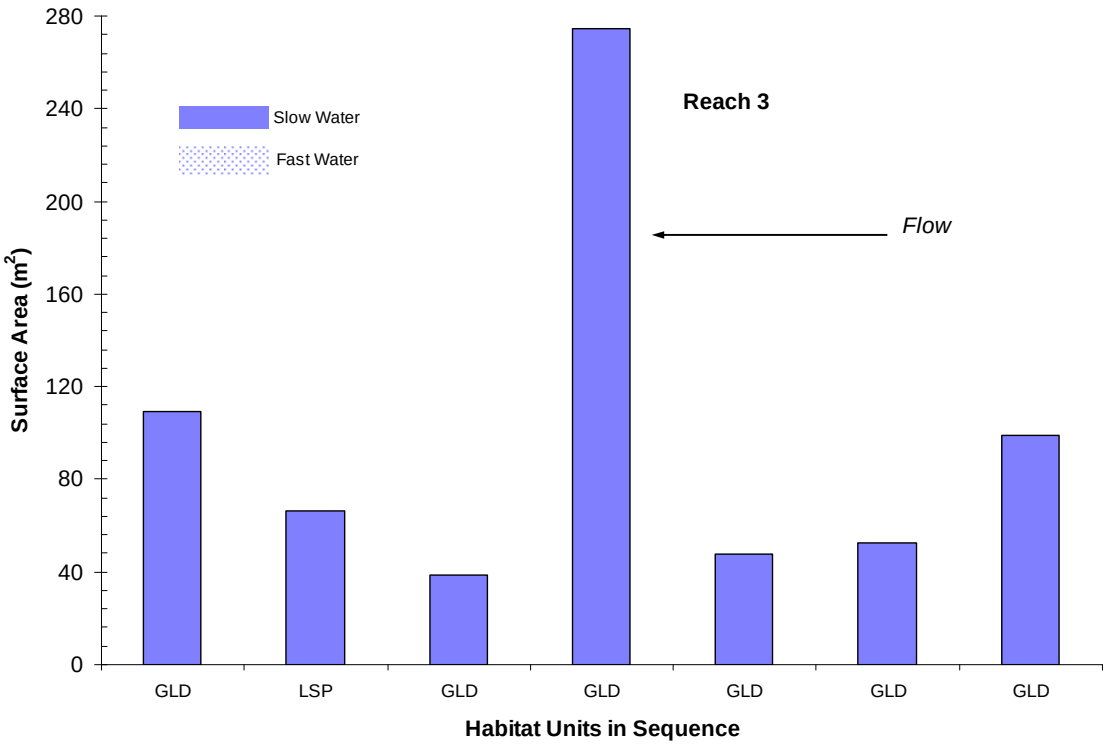

Figure 8. Reach Three Habitat. Habitat as it occurs in sequence in Reach Three. Solid area is slow water. GLD= glide, LSP=lateral scour pool. May Creek Channel Restoration, CIP #9A1205.

Reach Four. End of woody riparian corridor (about RM 4.7) to red barn (about RM 4.9). Reach Four consisted of 100 percent glide (Figure 5). Habitat units in sequence are presented in Figure 9. The riparian corridor in Reach Four consists almost entirely of reed canarygrass. The channel is straight, narrow, and deep, and has less capacity to contain water than the other reaches. Wetted channel width is about 13 feet, wetted depth is about 4.3 feet, and fine sediment deposited on the channel bottom is one to 1.6 feet deep.

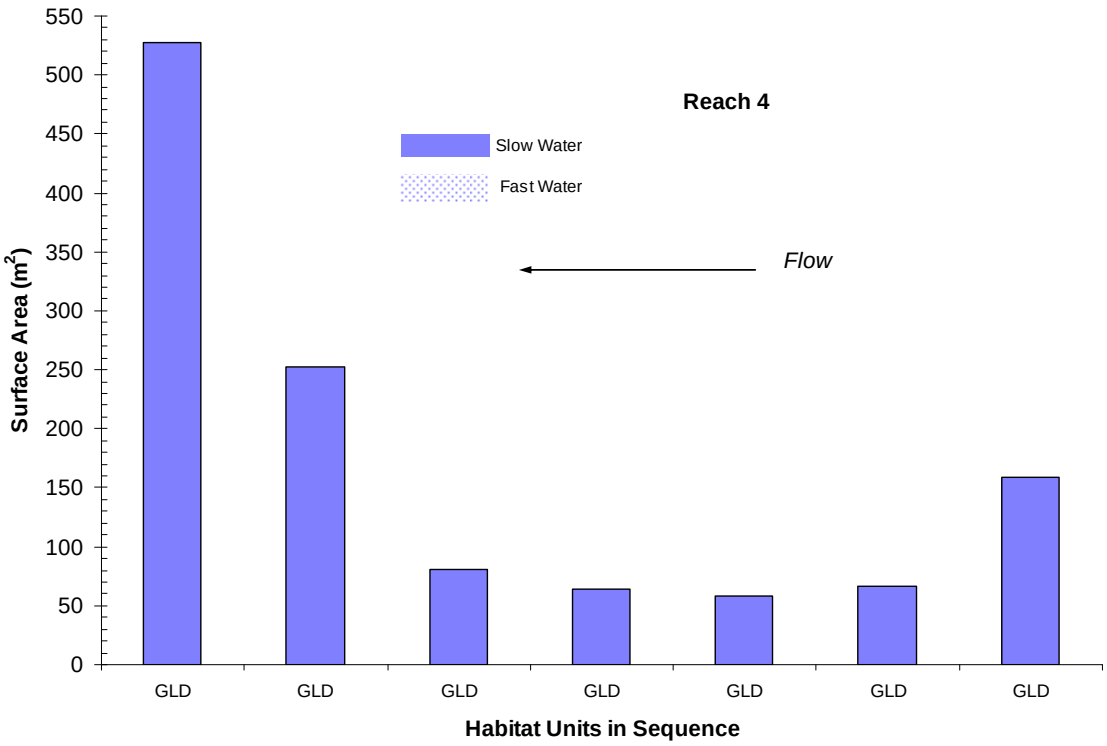

Figure 9. Reach Four Habitat.. Habitat as it occurs in sequence in Reach Four. Solid area is slow water. GLD= glide. May Creek Channel Restoration, CIP #9A1205.

During the February 1, 2010 site visit, pastures on both banks of the stream were flooded. It was not clear whether the flooding was entirely a result of overbank flow from May Creek, or a combination of overbank flow and high groundwater level. Water from the flooded pasture on the left bank was flowing into May Creek at the time of our survey, and overbank flow from May Creek seemed to be flooding the pasture on the right bank (Appendix A, Photo 48). It was difficult for us to find the May Creek channel in some of the flooded areas, and we could not find the confluence of Indian Meadows Creek, so we were unable to evaluate sediment inputs from this tributary. It also looked as though erosion from muddy horse pastures upslope of May Creek may contribute sediment to the stream.

During a follow-up site visit on March 1, 2010 we were able to find the Indian Meadows Creek confluence with May Creek (Appendix A, Photos 63 to 68). This stream drains Grand Ridge on the north side of May Valley and is piped and channelized along a private driveway before entering the right bank of May Creek at about RM 4.88 (Figure 3). Substrate in the flat, unpiped portions of this stream consisted of spawning-sized gravels that are routinely removed from the channel prior to reaching May Creek (Appendix A, Photos 64, 65, 67). A small deposit of fine sediment from Indian Meadows Creek is present in May Creek at the confluence, but the sediment does not appear to have much effect on the channel's capacity to contain flow.

4.3 Substrate

Stream substrate consists almost entirely of mineral sediments, most of which are fine-grained silts and sands (Table 3, Figure 10). We observed small pockets of small to large gravels at the downstream end of the surveyed area, in Reach One, and at the Long Marsh Creek alluvial fan in Reach Two. Sediment was deep within much of the stream, especially in Reach Four, which lacks woody plants and is almost exclusively vegetated with reed canarygrass. The channel cross-section is also more uniform in Reach Four, and on average 1.5 feet of sediment had accumulated in the channel there (Appendix B).

Table 3. Substrate. Dominant and subdominant substrate size classes observed on the stream bed (surface area estimates). May Creek Channel Restoration, CIP# 9A1205.

Size Class	Dominant (%)	Subdominant (%)
1: Sand, silt, clay, muck (<0.25" or <0.8 cm)	94	91
2: Small gravel (0.25"-1" or 0.9-2.5cm)	2	1
3: Large gravel (>1"-3" or 2.6-7.5cm)	4	7
4: (>3"-6" or 7.6-15cm)	0	1
5: (>6"-12" or 15.1-30cm)	0	0
6: (>12"-40" or 30.1cm-1m)	0	0
7: (>40" or >1m)	0	0
8: (Bedrock)	0	0

May Creek bottom sediments were sampled by the King County Department of Transportation Materials Laboratory (King County, May 2010 and October 2010). In the area of 146th Avenue SE, the channel bottom is composed of sands and gravels to well-graded gravel. Larger gravel, cobbles and occasional boulders are also present. In the relatively flat and low gradient portions of May Valley in the area of 148th Avenue SE the hard channel is composed of silty-sand and sandy-silt. At the confluence with Long Marsh Creek the hard channel bottom is composed of well graded gravel. A variable layer of soft muck is present within the stream channel behind constrictions in the channel. The muck was sampled 25 feet upstream of a private bridge at RM 4.6. A modified Loss on Ignition analysis (LOI) was performed and the sediment organic content was about 28 percent. The exact source of this high organic content is unknown; however, the tributary stream channels within the project area do not contain the same muck material and the most likely source are pastures, agricultural fields, and grass and tree litter within and above the project limits. Sediment sample results are presented in Table 4.

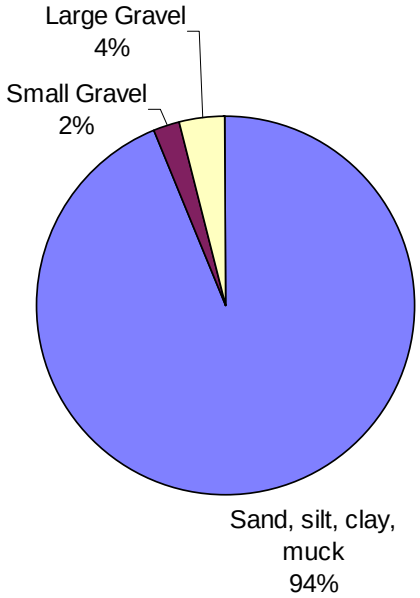

Figure 10. Stream Substrate. Proportion of dominant stream substrate sampled during the habitat survey. May Creek Channel Restoration, CIP #9A1205.

Table 4. Detailed streambed substrate, analyzed by King County Materials Lab in May and October 2010. May Creek Channel Restoration, CIP #9A1205

Location	Depth		
	0 to 3 inches	**3 to 6 inches**	**Organics**
Reach 1: ~75 ft downstream of 148th bridge	silty sand		
Reach 2: ~ 100 ft upstream of 148th bridge	sandy silt		
Reach 3: Long Marsh Creek confluence	well graded gravel		
Reach 4:~25 ft upstream of RM 4.6	sandy silt	silty sand	28%

4.4 Large Woody Debris and Pool Quality

Nine pools were inventoried in the habitat survey (Table 2). Six of the pools were formed from scour against willows. Of the remaining three pools, one was formed by scour against the 148th Ave SE abutment, one was bed-formed, and one appeared to be the result of prior sediment removal. Pool quality varied little within the surveyed reach, ranging from a score of three to a score of five on the PQI rating system (Table 2 , Platts et al. 1987).

We found no debris jams and few individual large pieces of wood within the banks of the surveyed reach of May Creek (Table 1). We inventoried only two pieces of LWD within the surveyed stream. However, in many places willow branches extend over the active channel and are the principal cause in the formation of six of the nine pools we surveyed.

4.5 Riparian and In-Stream Vegetation

Woody and herbaceous plants rooted in the banks had branches and fronds hanging over the active stream channel along much of the surveyed reach (Figure 11). Over 80 percent of both streambanks had either reed canarygrass or willows hanging over the channel. Both willows and reed canarygrass were present in Reaches One and Two, but only reed canarygrass was present in Reaches Three and Four (Figure 11).

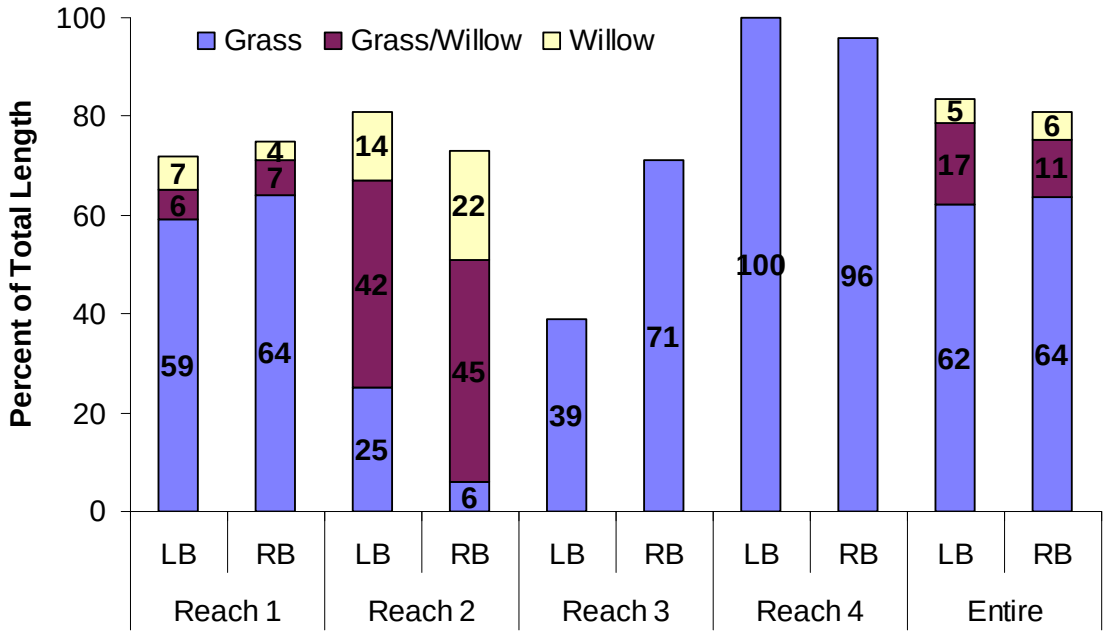

Figure 11. Overhanging Plants. Proportion of stream length with plants overhanging the channel. If bar does not total 100%, then remainder is percent with no overhanging plants. For example, 72% of the length of the left bank in Reach 1 has overhanging plants (59% reed canarygrass, 6% both grass and willow, and 7% willow only, so 28% of the bank has no overhanging vegetation). LB= left bank, RB= right bank, grass= reed canarygrass, water flow is from Reach 4 to Reach 1. May Creek Channel Restoration, CIP #9A1205.

Overhanging plants provide cover for fish rearing and seeking refuge along the streambanks. Streams with good riparian cover have high inputs of terrestrial insects because the insects live on the plants and fall into the stream, providing food for fish. Leaves falling into the stream provide a source of nutrients, especially nitrogen, needed for properly functioning aquatic foodwebs. Roots of overhanging plants stabilize soil and

prevent bank erosion. Riparian plants also shade the water and help prevent temperatures from rising on sunny days. The water temperature on August 16, 2010 was 59 Fahrenheit, while the ambient air temperature was 80 to 85 Fahrenheit, illustrating the cooling effect of riparian plants.

We defined instream vegetation as rooted plants within the active channel, and mats of plants floating on the water surface; willow branches overhanging the channel were not quantified, and plants rooted on the bank and overhanging the channel are presented in Figure 11. Nearly three-quarters of the surveyed reach consisted of open channel (Figure 12). Open channel did not have plants rooted in the channel, nor mats of plants floating in the channel, but plants rooted on the bank and hanging over the channel were present along both banks for much of this area. About twenty-one percent of the remaining channel had reed canarygrass rooted in the wetted channel. Most of this rooted reed canarygrass was in Reach Four, where 56 percent of the channel had rooted grass; no grass was rooted in the channel in Reaches One and Two (Figure 12). All of the study reaches had a small proportion (less than 10%) of their surface area covered with floating mats of plants (Figure 12, Table 2). Rooted and floating mats of reed canrygrass and bur-reed (*Sparganium angustifolium*) provide cover for juvenile salmonids rearing in the stream.

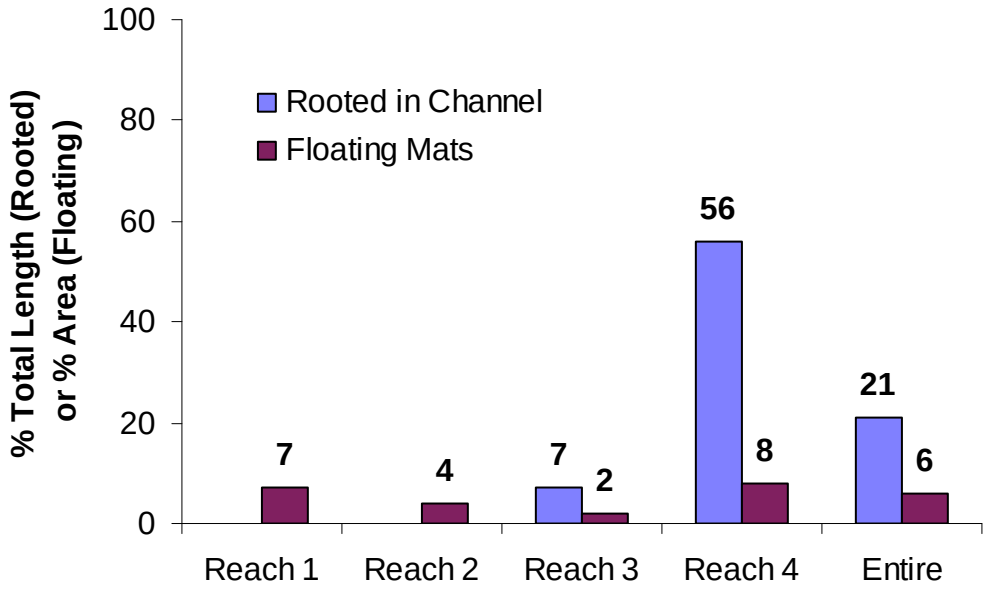

Figure 12. In-Stream Plants. Proportions of rooted plants and floating plant mats. If bar for rooted plants does not total 100%, then remainder is percent with no rooted plants. For example, 7% of the length of Reach 3 has rooted plants in the stream channel, so 93% of the stream channel has no rooted plants, and 2% of the stream has plant mats floating in the channel so 98% of the channel has no floating plant mats. Water flows from Reach 4 to Reach 1. Plants rooted in the bank and hanging over the channel may also have been present along both banks for most of this area. May Creek Channel Restoration, CIP #9A1205.

We measured a total of about 129 square yards (yd^2) of floating mats of reed canarygrass and bur-reed in the about 4,096 yd^2 of surveyed stream channel (Table 2). Over half of these floating mats (61 yd^2) were in Reach Four; Reach One had 37 yd^2 of floating mats, Reach Two had 17 yd^2, and Reach Three had 14 yd^2.

4.6 Bank Condition

Most of the banks in the surveyed portion of May Creek were vertical or sloped (Figure 13). Some banks were undercut in Reaches One, Two, and Three, and some bank armoring was present in Reaches One and Three (Figure 13). Left and Right banks were similar throughout the surveyed reach. All banks appeared to be stable.

The erosion of streambanks, whether natural of from human causes, can deliver sediment to a stream, impairing water quality and fish habitat. Streams in forested or undeveloped land often have more stable flows and less sediment than streams in cultivated or developed watersheds (Lines et al. 1979). Artificially straightened channels may be prone to bank erosion (Harvey et al. 1985). Alonso and Combs (1990) have shown that a straightened and deepened channel had higher banks and increased bank failure. Dense stands of reed canarygrass on the banks of May Creek in May Valley may help control erosion rates because the dense masses of roots hold soil.

Undercut banks typically provide better rearing habitat for fish and other aquatic species than vertical or sloped banks. However, the large amount of overhanging vegetation throughout the study area compensates for the less desirable bank types, so they do not limit rearing or cover opportunities for fish.

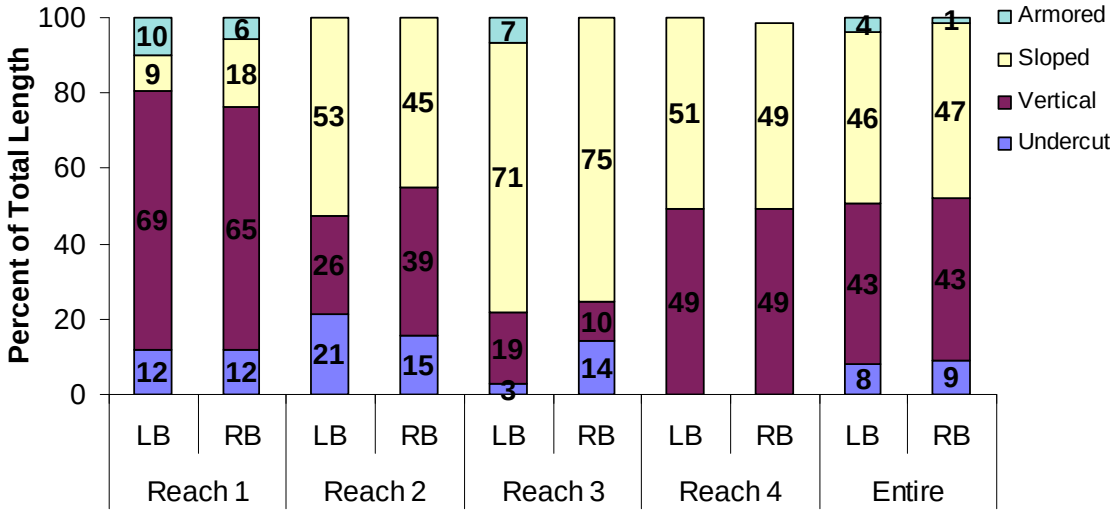

Figure 13. Proportion of bank types. LB=left bank, RB=right bank, water flows from Reach 4 to Reach 1. May Creek Channel Restoration, CIP #9A1205.

4.7 Fish Habitat and Use

May Creek historically was an important salmon stream in the Lake Washington Basin (WDF 1975). The stream supported five species of salmonids: Chinook (*Oncorhyncus Tschawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon, and rainbow/steelhead (*O. mykiss*) and cutthroat (*O. clarki*) trout (King County 1995). Salmon still use the stream and its tributaries even though their numbers have decreased (King County 1995). Chinook and sockeye salmon are found in the lower reaches of May Creek but they most likely do not travel upstream as far as May Valley (King County 1995). Coho salmon and rainbow/steelhead and cutthroat trout rear in May Valley and use it as a travel corridor to upstream spawning habitat in the North Fork, Cabbage and Country Creeks, and Tributary 0291A (King County 1995).

Although we did not conduct a formal census of fish in the surveyed reach of May Creek, we observed many schools of salmonids during the August habitat survey (Appendix B). Most schools were about 10-30 individual juvenile fish, and appeared to have both coho salmon and trout.

Stormwater stored in May Valley helps maintain spawning and rearing habitat downstream. Floodwaters stored in the valley are released slowly and are thus less likely to scour redds in spawning beds located downstream. Slow release of stormwater from the valley also probably decreases the potential erosion of ravine walls from storm flows.

May Creek is located in Watershed Resource Inventory Area (WRIA) 8: Lake Washington Basin. It is a King County Critical Areas Ordinance Class F (fish present) stream, with 165-feet regulatory buffers. Puget Sound Chinook salmon and steelhead are listed as threatened under the Federal Endangered Species Act.

5 Discussion

May Valley historically was an area of floodwater and sediment storage. The nearly flat stream braided through extensive wetlands. The channel was ditched between 1910 and 1936 for agriculture (King County 1995). The ditched channel filled with sediment and was dredged in the 1940's to reduce flooding, and refilled with sediment again by the 1960's (King County 1995). Heavy truck farming was taking place in the valley during this time, and agricultural fields were plowed right up to the top of the stream banks (King County 1995).

Sediment sources to May Creek in May Valley have not been clearly identified. The May Creek Erosion Stabilization Draft Report (Anchor QEA, LLC 2010) only addresses erosion downstream of May Valley. The flat valley reach may not have enough power to transport sediment nearly two miles from upstream sources to the project area, and large sediment plumes from tributaries were not observed during site visits. Gravel transported to May Creek from Long Marsh Creek creates one of the few potential spawning areas within the project area. Gravels in Indian Meadows Creek that are removed from the channel before they reach May Creek could provide additional spawning habitat.

While erosion in the ravine is an ongoing problem, the *May Creek Hydraulic and Hydrologic Study* (King County 2010a), which evaluated several alternatives for sediment removal in the valley, shows that there is no substantial difference in the erosion that occurs in the ravine under existing conditions and erosion that would occur under any of the proposed sediment removal alternatives. If sediment removal is proposed in areas of the valley that are designated as open space, where flooding does not threaten homes or pastures, and where an intact woody riparian corridor provides better fish habitat, mitigation would likely be required to offset the negative affects that the sediment removal would have on fish habitat. These areas may provide pockets of refuge for rearing and migrating fish, and may provide such refuge for fish affected by sediment removal in the valley.

The proposed project ("Ineffective Flow Project #1") is one of four conceptual ineffective flow projects described in the May Creek Drainage and Restoration plan (Geoengineers 2008). The combined length of the four conceptual projects is about 2.26 miles of May Creek in May Valley, which is 75% of the valley length and 32% of May Creek's entire length. A total of 33 projects are identified in the drainage and restoration plan (Geoengineers 2008). These projects include the four ineffective flow projects (direct channel modifications) described above, as well as 29 indirect channel modifications such as culvert and bridge replacements, and wetland and steam enhancements.

6 References

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Appendix A: Photo Log

Appendix A. May Creek Channel Restoration photograph log. Photo perspective is looking upstream unless otherwise noted. Left bank is on the left side when facing downstream.

Photo 1. Entrance to forest at downstream end of survey; perspective is looking downstream.

Photo 2. Cobbles in forested area.

Photo 3. Perspective is looking downstream.

Photo 4. No woody riparian plants.

Photo 5.

Photo 6. Greenes Creek.

Photo 7. Greenes Creek. No surface flow to May Creek but greener grass probably marks subsurface route.

Photo 10. Perspective is looking downstream.

Photo 8. Buck rub on willow.

Photo 11.

Photo 9.

Photo 12. Willows provide cover and in-stream structure.

Photo 13.

Photo 14.

Photo 15.

Photo 16. Newly planted spruce on left bank open space property.

Photo 17.

Photo 18. Ponded water downstream of 148th Ave SE bridge.

Photo 19. 148th Ave SE bridge.

Photo 20. 148th Ave SE.

Photo 21. Looking downstream under 148th Ave SE bridge.

Photo 22. Upstream of 148th Ave SE bridge.

Photo 23.

Photo 24.

Photo 25.

Photo 26. Another buck rub on willows.

Photo 27.

Photo 28.

Photo 29.

Photo 30. Confluence of Long Marsh Creek.

Photo 31. Footbridge over May Creek near Long Marsh Creek.

Photo 32. Looking upstream at Long Marsh Creek confluence. Gravels at confluence.

Photo 33.

Photo 34.

Photo 35.

Photo 36.

Photo 37. Long Marsh Creek, looking up the channel from May Creek.

Photo 38. Looking down May Creek from Long Marsh Creek.

Photo 39. Narrow alder riparian corridor upstream of Long Marsh Creek confluence.

Photo 40. Right bank armor.

Photo 41.

Photo 42. Pasture on left bank.

Photo 43. View of right bank.

Photo 46. End of woody riparian corridor.

Photo 44. Horse in right bank pasture.

Photo 47.

Photo 45. Flooded left bank pasture.

Photo 48. Flooded left bank pasture flowing into May Creek.

Photo 49. Flooding adjacent to May Creek.

Photo 50. Looking upstream toward Red Barn.

Photo 51. Looking downstream.

Photo 52. Flooding along both banks of May Creek.

Photo 53.

Photo 54. Flooded pasture near Red Barn.

Photo 55.

Photo 58. Looking downstream from near Red Barn.

Photo 56. May Creek channel near Red Barn.

Photo 59. Muddy pasture on left bank.

Photo 57.

Photo 60.

Photo 61.

Photo 62. Red Barn driveway bridge across May Creek, looking south. 2/1/10.

Photo 63. Looking toward May Creek on 3/1/10. Indian Meadows Creek is in ditch .

Photo 64. Indian Meadows Creek culvert outlet. Excavated gravels are piled on banks.

Photo 65. Indian Meadows Creek culvert outlet.

Photo 66. Indian Meadows Creek looking toward May Creek. All gravels are deposited in this reach.

Photo 67. Indian Meadows Creek, looking upstream from May Creek. All gravels are deposited in short reach indicated by arrow. Stream substrate is fines below lower culvert.

Photo 68. Confluence of Indian Meadows Creek with May Creek, 3/1/10. Minimal sediment deposition at confluence: May Creek is more than a meter (3 ft) deep.

Appendix B: Data Tables

Appendix B: May Creek Habitat Survey Summary

Survey Date: August 16 & 17, 2010
Staff: Thompson/Bauman/Clark

All measurements are metric

		Reference Distance	Habitat Type	Unit length	Mean width	Average Depth	Maximum Depth	Residual Pool Depth	Unit area (m²)	Unit Volume (m³)	PQI	LWD #
Reach 1 ***Begin/Downstream end***	1	0	GLD	9	4.5	0.18			40.50	7.29		
	2	9	GLD	11	3.5	0.35			38.50	13.48		
	3	20	T	2	3	0.1			6.00	0.60		
Scour against overhanging willows formed pool	4	22	LSP	5	3	0.3	0.53	0.43	15.00	4.50	4	
Scour against overhanging willows formed pool	5	27	LSP	8.5	4.2	0.3	0.55	0.45	35.70	10.71	4	
Scour against overhanging willows formed pool	6	35.5	LSP	5.5	4.5	0.35	0.6	0.45	24.75	8.66	4	
	7	41	GLG	7	3.5	0.2			24.50	4.90		
	8	48	GLD	1.8	3.3	0.18			5.94	1.07		
	9	49.8	GLD	57	3	1			171.00	171.00		
	10	106.8	GLD	10	3.5	0.4			35.00	14.00		
	11	116.8	GLD	18	2.6	0.45			46.80	21.06		
	12	134.8	GLD	9	4.3	0.2			38.70	7.74		
	13	143.8	GLD	8	3.5	0.38			28.00	10.64		
	14	151.8	GLD	17	3.9	0.5			66.30	33.15		
	15	168.8	GLD	18	4.3	0.3			77.40	23.22		
	16	186.8	T	2.6	3.4	0.19			8.84	1.68		
Possibly Historic Dredged Pool	17	189.4	MCP	13	6.5	0.5	1.06	0.87	84.50	42.25	5	
	18	202.4	GLD	5.5	3.5	0.16			19.25	3.08		
148th AVE S.E. Bridge / Scour along abutment formed pool	19	207.9	LSP	7	5.5	0.45	0.75	0.59	38.50	17.33	4	
Reach 2	20	214.9	LGR	14	4.5	0.2			63.00	12.60		
	21	228.9	GLD	10	2	0.3			20.00	6.00		
	22	238.9	GLD	24	3.6	0.3			86.40	25.92		
	23	262.9	GLD	28.5	3	0.2			85.50	17.10		
	24	291.4	GLD	6.5	2.2	0.55			14.30	7.87		
	25	297.9	GLD	5.6	2.5	0.2			14.00	2.80		
	26	303.5	GLD	3.5	3.2	0.55			11.20	6.16		
	27	307	GLD	46	3.7	0.2			170.20	34.04		
Scour against overhanging willows formed pool	28	353	LSP	17.5	4	0.45	0.72	0.62	70.00	31.50	4	
	29	370.5	GLD	6.2	3.5	0.3			21.70	6.51		
	30	376.7	GLD	14	5	0.16			70.00	11.20		
Bank formed pool	31	390.7	LSP	10	3.5	0.25	0.54	0.36	35.00	8.75	3	
Scour around willow	32	400.7	LSP	15	4.2	0.4	0.75	0.63	63.00	25.20	4	
Reach 3	33	415.7	GLD	26	4.2	0.35			109.20	38.22		
Scour against bank and roots creat pool	34	441.7	LSP	19	3.5	0.25	0.5	0.3	66.50	16.63	3	1
Longmarsh Creek Alluvial Fan	35	460.7	GLD	12	3.2	0.28			38.40	10.75		
	36	472.7	GLD	61	4.5	0.5			274.50	137.25		1
	37	533.7	GLD	17	2.8	0.55			47.60	26.18		
	38	550.7	GLD	16	3.3	0.3			52.80	15.84		
	39	566.7	GLD	30	3.3	0.5			99.00	49.50		
Reach 4	40	596.7	GLD	160	3.3	0.6			528.00	316.80		
	41	756.7	GLD	36	7	0.3			252.00	75.60		
	42	792.7	GLD	23	3.5	0.45			80.50	36.23		
	43	815.7	GLD	17	3.8	0.4			64.60	25.84		
	44	832.7	GLD	18	3.2	0.55			57.60	31.68		
	45	850.7	GLD	22	3	0.4			66.00	26.40		
	46	872.7	GLD	48	3.3	0.6			158.40	95.04		
End / Upstream End at Red Barn Bridge / Indian Meadow Creek Alluvial Fan		920.7										

Appendix B: May Creek Habitat Survey Summary

Survey Date: August 16 & 17, 2010
Staff: Thompson/Bauman/Clark

All measurements are metric

		Reference Distance	Habitat Type	Unit Length	LB Overhanging Vegetation Percent	LB Overhanging Vegetation Length (m)	RB Overhanging Vegetation Percent	RB Overhanging Vegetation Length (m)	LB Bank Type Type	LB Bank Type (m)	RB Bank Type Type	RB Bank Type (m)	In-Stream Plants % Rooted	In-Stream Plants Floating (m2)
Reach 1 ***Begin/Downstream end***	1	0	GLD	9	100% RCG	9.0	100% RCG	9.0	Sloped	9	Sloped	9		
	2	9	GLD	11	100% RCG	11.0	100% RCG	11.0	Vertical	11	Vertical	11		
	3	20	T	2	100% RCG	2.0	100% RCG	2.0	Vertical	2	Vertical	2		
Scour against overhanging willows formed pool	4	22	LSP	5	100% RCG	5.0	100% RCG	5.0	Vertical	5	Vertical	5		2.3
Scour against overhanging willows formed pool	5	27	LSP	8.5	100% RCG and Willow	8.5	100% RCG and Willow	8.5	Undercut (.8m)	8.5	Undercut (.3m)	8.5		
Scour against overhanging willows formed pool	6	35.5	LSP	5.5	None	0.0	None	0.0	Sloped	5.5	Vertical	5.5		
	7	41	GLG	7	None	0.0	None	0.0	Vertical	7	Sloped	7		
	8	48	GLD	1.8	90% RCG and Willow	1.6	90% RCG and Willow	1.6	Sloped	1.8	Vertical	1.8		4
	9	49.8	GLD	57	100% RCG	57.0	100% RCG	57.0	Vertical	57	Vertical	57		18
	10	106.8	GLD	10	50% Willow	5.0	50% RCG	5.0	Vertical	10	Vertical	10		
	11	116.8	GLD	18	20% RCG and Willow	3.6	75% RCG	13.5	Vertical	18	Vertical	18		
	12	134.8	GLD	9	100% RCG	9.0	20% RCG and Willow	1.8	Vertical	9	Sloped	9		
	13	143.8	GLD	8	50% RCG	4.0	50% RCG	4.0	Vertical	8	Vertical	8		
	14	151.8	GLD	17	100% RCG	17.0	100% RCG	17.0	Undercut (.5m)	17	Undertcut (.5 m)	17		2
	15	168.8	GLD	18	50% Willow	9.0	50% Willow	9.0	Vertical	18	Vertical	18		
	16	186.8	T	2.6	30% Willow	0.8	100% RCG and Willow	2.6	Vertical	2.6	Vertical	2.6		
Possibly Historic Dredged Pool	17	189.4	MCP	13	100% RCG	13.0	100% RCG	13.0	Sloped	13	Sloped	13		4.5
	18	202.4	GLD	5.5	Bridge	5.5	Bridge	5.5	Armored	5.5	Armored	5.5		
148th AVE S.E. Bridge / Scour along abutment formed pool	19	207.9	LSP	7	Bridge	7.0	Bridge	7.0	Armored	7	Armored	7		
Reach 2	20	214.9	LGR	14	50% Willow	7.0	70% Willow and RCG	9.8	Sloped	14	Sloped	14		
	21	228.9	GLD	10	100% Willow and RCG	10.0	100% Willow and RCG	10.0	Vertical	10	Vertical	10		6
	22	238.9	GLD	24	100% RCG and Willow	24.0	100% RCG and Willow	24.0	Vertical	24	Vertical	24		
	23	262.9	GLD	28.5	100% RCG	28.5	80% RCG and Willow	22.8	Sloped	28.5	Sloped	28.5		
	24	291.4	GLD	6.5	100% RCG	6.5	100% RCG	6.5	Vertical	6.5	Vertical	6.5		
	25	297.9	GLD	5.6	100% RCG	5.6	100% RCG	5.6	Vertical	5.6	Vertical	5.6		8.4
	26	303.5	GLD	3.5	100% RCG and Willow	3.5	100% RCG and Willow	3.5	Undercut (.5M)	3.5	Vertical	3.5		
	27	307	GLD	46	80% Willow and RCG	36.8	60% Willow	27.6	Sloped	46	Sloped	46		
Scour against overhanging willows formed pool	28	353	LSP	17.5	60% Willow and RCG	10.5	60% Willow and RCG	10.5	Sloped	17.5	Vertical	17.5		
	29	370.5	GLD	6.2	45% Willow	2.8	45% Willow	2.8	Vertical	6.2	Undercut (.3m)	6.2		
	30	376.7	GLD	14	100% Willow	14.0	100% Willow	14.0	Undercut (.3m)	14	Undercut (.3m)	14		
Bank formed pool	31	390.7	LSP	10	40% Willow	4.0	50% RCG and Willow	5.0	Undercut (.4m)	10	Undercut (.3m)	10		
Scour around willow	32	400.7	LSP	15	70% RCG	10.5	30% Willow and RCG	4.5	Undercut (.2 -.5m)	15	80% Vertical, 15% Sloped, 5% undercut (.2m)	12		
Reach 3	33	415.7	GLD	26	60% Willow and RCG	15.6	70% RCG	18.2	60% vertical, 20% sloped, 20% undercut (.2m)	15.6	Undercut (.2-.4m)	26		
Scour against bank and roots creat pool	34	441.7	LSP	19	80% RCG and Willow	15.2	80% RCG	15.2	Vertical	19	Vertical	19		
Longmarsh Creek Alluvial Fan	35	460.7	GLD	12	30% RCG	3.6	10% RCG	1.2	Armored / Vertical	12	Sloped	12		
	36	472.7	GLD	61	60% RCG	36.6	60% RCG	36.6	Sloped	61	Sloped	61		
	37	533.7	GLD	17	100% RCG and Red Alder	17.0	100% RCG	17.0	Sloped	17	Sloped	17	70% RCG and bur-reed	
	38	550.7	GLD	16	40% RCG and roots	6.4	70% RCG	11.2	Sloped	16	Sloped	16		
	39	566.7	GLD	30	100% RCG	30.0	100% RCG	30.0	Sloped	30	Sloped	30		**12**
Reach 4	40	596.7	GLD	160	100% RCG	160.0	100% RCG	160.0	Vertical	160	Vertical	160	50% RCG and bur-reed	24
	41	756.7	GLD	36	100% RCG	36.0	60% RCG	21.6	Sloped	36	Sloped	36		27
	42	792.7	GLD	23	100% RCG	23.0	100% RCG	23.0	Sloped	23	Sloped	23	15% RCG and bur-reed	
	43	815.7	GLD	17	100% RCG	17.0	100% RCG	17.0	Sloped	17	Sloped	17	100% RCG and bur-reed	
	44	832.7	GLD	18	100% RCG	18.0	100% RCG	18.0	Sloped	18	Sloped	18	60% bur-reed	
	45	850.7	GLD	22	100% RCG	22.0	100% RCG	22.0	Sloped	22	Sloped	22	100% RCG	
	46	872.7	GLD	48	100% RCG	48.0	100% RCG	48.0	Sloped	48	Sloped	48	100% RCG and bur-reed	
End / Upstream End at Red Barn Bridge / Indian Meadow Creek Alluvial Fan		920.7												