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Bell Bend Project Site: Supplemental Field Assessments for PPL Riverlands

Prepared for:

PPL Bell Bend Nuclear Power Plant
Salem Township, Luzerne County, PA

Prepared by:

LandStudies
315 North Street
Lititz, Pa 17543
(717)-627-4440

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I. INTRODUCTION

Additional field assessments of Walker Run and three other streams at the Bell Bend project site were completed in the fall of 2009. Prior to this additional field work, fisheries surveys, habitat assessments, and macroinvertebrate surveys had been completed on Walker Run, and were published earlier in 2009. This report will present the assessment findings for North Branch Canal Outlet Channel at the PPL Riverlands Property,

The field assessments completed in the fall of 2009 on the outlet channel for the North Branch Canal include:

- Substrate embeddedness assessments on two reaches.
- Habitat assessments on two reaches.
- Macroinvertebrate community assessments or two reaches.

The following report describes the findings of these field assessments.

II. METHODS

A. Substrate Embeddedness and Characterization. A substrate embeddedness and characterization survey was conducted on two reaches on the outlet channel of the north branch canal at Riverlands (Figure 1) in the fall of 2009.

At each stream reach, seven transects were established across the stream and perpendicular to the stream flow. The seven transects were located at 25-ft increments over the 150-ft stretch of stream reach. Up to nine survey points were located across each transect, depending on the stream width. Substrate embeddedness and substrate characterizations were made visually at each survey point across the transect. If the stream was wide enough to accommodate nine survey points per transect, then each stream reach would have 63 substrate embeddedness and 63 substrate characterization measurements.

Substrate embeddedness assessments were made visually using the protocols established in Platts, Megahan, and Minshall (1983)[1]. A 150-ft reach of stream was selected at random within each of the seven stream regions. A tape measure was used to establish the seven transects at 25-ft intervals along the 150-ft reach of stream. The survey points along each transect were selected at equal intervals across the stream at each transect. A view bucket with a 9-in diameter Plexiglas bottom was used to observe the stream substrate at survey points with sufficient water depth; otherwise, the substrate was viewed without a view bucket.

[1] Platts, W.S., W.F. Megahan and W.G. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT-138, USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Embeddedness is defined as the degree to which sand, silt, and clay particles (collectively referred to as fines) surround or cover larger gravel, cobble, and boulder materials in the bottom of the stream. The percentage of fines surrounding these coarser particles is visually estimated as a percentage, and an embeddedness rating is derived from this percentage as follows[2]:

Rating	Description
5	< 5 percent of gravel, cobble, and boulder particles covered by fine sediments
4	5 to 25 percent of gravel, cobble, and boulder particles covered by fine sediments
3	25 to 50 percent of gravel, cobble, and boulder particles covered by fine sediments
2	50 to 75 percent of gravel, cobble, and boulder particles covered by fine sediments
1	> 75 percent of gravel, cobble, and boulder particles covered by fine sediments

We determined embeddedness ratings intermediate between these numbers based on the visually estimated percentage of fines surrounding the gravel cobble and boulder particles. A visually estimated percentage of 40 percent, for instance, would be noted with an embeddedness rating of 3.4. Substrate embeddedness is a significant predictor of wild trout abundance in streams, as streams with low embeddedness (i.e., a high embeddedness rating number) have conditions conducive to trout spawning success.

Substrate composition was determined visually by estimating the percent of the viewed area of substrate composed of each of the following substrate size classes[1,3]:

Substrate Class	Size Range
Boulder	> 12 inches
Rubble	10 to 12 inches
Cobble	2.5 to 10 inches
Gravel	3/32 to 2.5 inches
Sand	< 3/32 inches
Silt and Clay	< 0.08/32 inches (visually identified)

B. Stream Habitat Assessments. Visual habitat assessments were performed at two reaches of the north branch canal outlet channel at Riverlands during the fall of 2009. The low gradient habitat assessment field methodology, in the EPA's Rapid Bioassessment Protocols (RBP)[4], was utilized for these stream habitat assessments.

[2] Sylte, T. L. and J. C. Fischenich. 2002. Techniques for measuring substrate embeddedness. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-36), U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.
[3] Clean Water Services. 2000. Tualatin River Basin Rapid Stream Assessment Technique (RSAT). Watersheds 2000 Field Methods. Clean Water Services, Watershed Management Division, Hillsboro, Oregon.
[4] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

The RBP evaluates ten habitat quality parameters on a 0 to 20 scale, with scores of 16 to 20 indicating optimal habitat quality, scores of 11 to 15 indicating suboptimal habitat quality, scores of 6 to 10 indicating marginal habitat quality, and scores of 0 to 5 indicating poor habitat quality. The location of the two assessment reaches are shown in Figure 1. The ten habitat quality parameters in the RBP protocols are defined on the following page.

C. Macroinvertebrate community surveys. Macroinvertebrate community surveys were performed in two reaches on the north branch canal outlet channel at Riverlands in the fall of 2009. A 500-micron mesh D-frame net (12-inch width) was used to collect stream macroinvertebrates from four separate riffle or run locations within each sampling reach. The four sampling locations were selected to include the spectrum of habitat conditions in each reach. At each reach, the four separate location samples were composited into one sample to provide a stream reach characterization. The locations of the macroinvertebrate community sampling reaches are shown in Figure 1.

Macroinvertebrate samples from each reach were preserved in isopropyl alcohol in the field. Samples were sorted into vials in the laboratory using a 5X illuminated magnifying lamp. All samples were sorted completely. Organisms were identified to the genus level using a stereo microscope, except for midge larvae (Family Chironomidae), nematodes (Phylum Nematoda), and segmented worms (Class Oligochaeta).

Each taxonomic group of macroinvertebrate organisms (typically at the genus level) has a pollution tolerance value published in the scientific literature. Tolerance values range from 0 (no tolerance to pollution) to 10 (high tolerance to pollution). Tolerance values in this study were averaged across those published in three literature sources.[5] Pollution tolerance values were utilized to calculate the Hilsenhof Biotic Index[6], which provides a single index of the water quality of a stream reach based on the pollution tolerance of the macroinvertebrates collected there. Hilsenhof Biotic Index scores of 0 to 4.5 indicate good water quality, while scores of 8.5 to 10 indicate very poor water quality and intermediate scores indicate fair to poor water quality.

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[5] (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

[6] Hilsenhof, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist, vol. 20: 31-39.

Table 1. Habitat Quality Parameters used in the North Branch Canal Outlet Channel Stream Habitat Assessment

Habitat Quality Parameter	Definition[7]
Epifaunal Substrate and Available Cover	Includes the relative quantity and variety of natural structures in the stream, such as cobble, large rocks, fallen trees, logs and branches, and undercut banks that are available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
Pool Substrate Characterization	Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom.
Pool Variability	Rates the overall mixture of pool types found in streams: large-shallow, large-deep, small shallow, and small-deep. Streams with the majority of pools being either small-shallow or absent have poor habitat quality.
Sediment Deposition	Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of sediment deposition. Streams with heavy deposits of sediments with pools almost absent have poor habitat quality.
Channel Flow Status	The degree to which the stream channel is filled with water. Streambeds with very little water and present mostly as standing water have poor channel flow status.
Channel Alteration	The degree to which the stream has been channelized, dredged, or stabilized with shoring structures.
Channel Sinuosity	The degree of sinuosity evaluates the meandering of the stream, with high sinuosity indicative of optimal habitat quality.
Bank Stability	An evaluation of whether the streambanks are eroded. Signs of erosion include crumbling, unvegetated banks with exposed tree roots and exposed soil.
Vegetative Protection of Streambanks	Measures the amount of vegetative protection for the streambanks and immediate riparian zone.
Riparian Vegetation Zone Width	Measures the width of natural vegetation from the edge of the streambank out through the riparian zone.

[7] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Figure 1. Habitat assessment, sediment embeddedness, and macroinvertebrate sampling locations on the outlet channel of the north branch canal.

III. FINDINGS

A. Substrate Embeddedness and Characterization – Outlet Channel of the North Branch Canal. Two reaches of stream of the north branch canal outlet channel at Riverlands were surveyed for substrate embeddedness and composition (Table 2). The lower (downstream reach nearer the Susquehanna River) had low stream embeddedness, with an embeddedness rating of 3.2. The stream substrate was dominated by gravel and cobble, which comprised an average of 57 percent of the bottom. The lower reach was a combination of run and riffle habitats, and had an average stream width of 2.3 ft and an average water depth of 0.2 ft.

The upper reach of the stream was just below the weir of the discharge canal. This reach was typically run habitat, with an average stream width of 4.3 ft and an average water depth of 0.3 ft. This reach had high substrate embeddedness, with an average embeddedness rating of 1.6 (Table 2). The stream substrate was dominated by a combination of silt and gravel, with sand and clay also present. Gravel and cobble comprised an average of 24.2 percent of the stream bottom.

Table 2. Substrate embeddedness and stream morphometric and substrate characteristics for the North Branch Canal Outlet Channel at Riverlands.

Stream Station	Transect No.	Stream Width (ft)	Average Water Depth (ft)	Habitat Type	Dominant Substrate Type	Median Embeddedness (%)	Transect Embeddedness Rating	Percent Fines*	Median Percent Silt and Clay	Median Percent Sand (< 3/32")	Median Percent Gravel (3/32" to 2.5")	Median Percent Cobble (2.5" to 10")	Median Percent Rubble (10" to 12")	Median Percent Boulder (> 12")
Stream from Discharge Canal - Lower Reach														
DCS-L	TA	2.5	0.14	Run	gravel/cobble	42.5	3.3	26.3%	5.0%	42.5%	35.0%	17.5%	0.0%	0.0%
DCS-L	TB	1.9	0.24	Riffle	gravel/cobble	30.0	3.7	18.8%	5.0%	27.5%	45.0%	22.5%	0.0%	0.0%
DCS-L	TC	1.8	0.24	Run	cobble/gravel	52.5	2.8	26.3%	10.0%	32.5%	32.5%	25.0%	0.0%	0.0%
DCS-L	TD	2.1	0.17	Riffle	gravel/cobble	32.5	3.6	17.5%	5.0%	25.0%	35.0%	30.0%	0.0%	0.0%
DCS-L	TE	2.6	0.20	Riffle	gravel	37.5	3.5	17.5%	5.0%	25.0%	52.5%	15.0%	0.0%	0.0%
DCS-L	TF	2.4	0.28	Run	cobble/sand	45.0	3.2	22.5%	7.5%	30.0%	20.0%	37.5%	0.0%	5.0%
DCS-L	TG	2.7	0.29	Run	sand/gravel	72.5	2.1	40.0%	12.5%	55.0%	20.0%	12.5%	0.0%	0.0%
DCS-L	**7**	**2.3**	**0.22**	**Run/Riffle**	**gravel/cobble**	**44.6**	**3.2**	**24.1%**	**7.1%**	**33.9%**	**34.3%**	**22.9%**	**0.0%**	**0.7%**
Stream from Discharge Canal - Upper Reach														
DCS-U	TA	5.2	0.42	Run	silt	100.0	1.0	92.5%	85.0%	15.0%	0.0%	0.0%	0.0%	0.0%
DCS-U	TB	3.1	0.20	Run	sand	100.0	1.0	56.3%	22.5%	67.5%	7.5%	0.0%	0.0%	0.0%
DCS-U	TC	3.7	0.50	Run	silt/clay	100.0	1.0	96.3%	92.5%	7.5%	0.0%	0.0%	0.0%	0.0%
DCS-U	TD	4.8	0.55	Run	silt	100.0	1.0	93.8%	87.5%	12.5%	0.0%	0.0%	0.0%	0.0%
DCS-U	TE	2.9	0.04	Riffle	gravel	15.0	4.5	6.3%	0.0%	12.5%	65.0%	22.5%	0.0%	0.0%
DCS-U	TF	6.5	0.36	Run	gravel	90.0	1.4	18.8%	10.0%	17.5%	65.0%	10.0%	0.0%	0.0%
DCS-U	TG	3.6	0.19	Run	silt	100.0	1.0	90.0%	80.0%	20.0%	0.0%	0.0%	0.0%	0.0%
DCS-U	**7**	**4.3**	**0.32**	**Run**	**silt/gravel**	**86.4**	**1.6**	**64.8%**	**53.9%**	**21.8%**	**19.6%**	**4.6%**	**0.0%**	**0.0%**

* *Percent fines (particles < 1.0 mm) calculated as the sum of the median percent silt and clay and 1/2 the median percent sand.*

B. Habitat Assessments – Outlet Channel for the North Branch Canal. Two stream reaches in the outlet channel of the north branch canal at Riverlands were assessed for habitat quality using the EPA RBP methods. The habitat assessment scores for these reaches were 7.5 and 6.3, both in the marginal habitat quality category (Table 3). Habitat quality in the lower reach was rated slightly higher, but still in the marginal habitat quality category.

Habitat quality in the Riverlands stream from the discharge canal was rated marginal because of poor epifaunal substrate, pool substrate, pool variability, channel alteration, vegetative protection, riparian vegetation zone width, and channel sinuosity. Additionally, habitat quality was marginal in the lower reach because of bank stability, and marginal in the upper reach because of sediment deposition and channel flow status.

Table 3. Habitat assessment scores for the two reaches on the outlet channel of the north branch canal at Riverlands

Habitat Category	DC-Main Lower	DC-Main Upper	Scoring Descriptions
Epifaunal substrate / available cover	9	2	
Pool substrate characterization	6	7	
Pool variability	4	6	Optimal: 20 to 16
Sediment deposition	15	3	Suboptimal: 15 to 11
Channel flow status	13	10	Marginal: 10 to 6
Channel alteration	6	6	Poor: 5 to 0
Channel sinuosity	5	5	
Bank stability	4	12	
Vegetative protection	4	6	
Riparian vegetation zone width	9	6	
Average Score:	**7.5**	**6.3**	

C. Macroinvertebrate Community Surveys – Outlet Channel for the North Branch Canal. The macroinvertebrate community was surveyed at two reaches or the north branch canal outlet channel (Figure 1). A total of 28 macroinvertebrate taxa were collected from the Riverlands stream (Table 4) comprised of 1,322 individuals. The macroinvertebrate community was dominated by sow bugs (*Caecidotea*, 25 %), moths (*Neocataclysta*, 21 %), midges (Chironomidae, 15 %), and flatworms (*Phagocata*, 10 %). These four taxonomic groups constituted about 71 % of the macroinvertebrate community in the Riverlands stream. This type of dominance typically indicates fair to poor water quality conditions.

The macroinvertebrate community metrics also indicate that the Riverlands stream has fair to poor water quality (Table 5). The two reaches are similar in their macroinvertebrate community metrics, with Hilsenhof Biotic Index values of 6.3 and 6.5 for the upper and lower reaches respectively.

Table 4. Macroinvertebrates collected from the North Branch Canal Outlet Channel, with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	DC Stream-Upper	DC Stream-Lower	Tolerance Value
Acariformes					6.0
Hoplonemertea	Tetrastemmatidae	*Prostoma*		3	7.7
Tricladida	Planariidae	*Dugesia*	16		7.4
Tricladida	Planariidae	*Phagocata*	4	128	7.2
Hirudinida	Erpobdellidae		3		10.0
Hirudinida	Glossiphoniidae	*Helobdella*	4		6.0
Oligochaeta			9	11	8.3
Amphipoda	Hyalellidae	*Hyalella*			4.7
Amphipoda	Gammaridae	*Crangonyx*	53	32	5.6
Amphipoda	Gammaridae	*Gammarus*	3	80	6.2
Isopoda	Asellidae	*Caecidotea*	176	156	6.2
Bivalvia	Sphaeridae	*Pisidium*	11	9	6.6
Gastropoda	Physidae	*Physa*	52	6	7.7
Gastropoda	Lymnaeidae	*Fossaria*			7.0
Gastropoda	Hydrobidae	*Amnicola*			7.0
Gastropoda	Planorbidae	*Helisoma*			6.5
Megaloptera	Sialidae	*Sialis*			3.3
Lepidoptera	Pyraulidae	*Neocataclysta*	196	88	5.5
Odonata	Aeshnidae	*Aeshna*			5.5
Odonata	Aeshnidae	*Boyeria*			3.4
Odonata	Calopterygidae	*Calopteryx*			6.8
Odonata	Coenagrionidae	*Enallagma*	18		8.3
Odonata	Cordulegastridae	*Cordulegaster*			2.8
Odonata	Gomphidae	*Gomphus*			4.1
Coleoptera	Elmidae	*Dubiraphia*	1		5.9
Coleoptera	Elmidae	*Optioservus*			4.5
Coleoptera	Elmidae	*Stenelmis*			6.0
Coleoptera	Dryopidae	*Helichus*			5.5
Coleoptera	Hydrophilidae	*Hydrobius*			4.7
Coleoptera	Dytiscidae	*Agabus*			5.1
Coleoptera	Dytiscidae	*Hydroporus*	1		4.9
Diptera	Ceratopogonidae	*Bezzia*			5.1
Diptera	Ceratopogonidae	*Ceratopogon*		1	4.9
Diptera	Ceratopogonidae	*Culicoides*	2		8.6
Diptera	Ceratopogonidae	*Palpomyia*	1		6.0
Diptera	Ceratopogonidae	*Probezzia*			5.0

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 4 (continued). Macroinvertebrates collected from the North Branch Canal Outlet Cl with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	Downstream Upper	Downstream Lower	Tolerance Value
Diptera	Chironomidae		57	140	7.3
Diptera	Empididae	*Hemerodromia*			6.6
Diptera	Culicidae	*Anopheles*			8.0
Diptera	Culicidae	*Psorphora*			8.0
Diptera	Ephydridae				6.0
Diptera	Psychodidae	*Pericoma*			4.0
Diptera	Ptychopteridae	*Ptychoptera*			4.0
Diptera	Simuliidae	*Prosimulium*			3.8
Diptera	Simuliidae	*Simulium*		1	6.2
Diptera	Tipulidae	*Dicranota*			2.7
Diptera	Tipulidae	*Hexatoma*		1	2.5
Diptera	Tipulidae	*Limnophila*			3.9
Diptera	Tipulidae	*Pedicia*			4.4
Diptera	Tipulidae	*Pseudolimnophila*		2	2.3
Diptera	Tipulidae	*Tipula*		3	5.6
Diptera	Stratiomyidae	*Allognasta*			7.0
Diptera	Stratiomyidae	*Odontimyia*	1		7.0
Diptera	Tabanidae	*Chrysops*			5.0
Diptera	Tabanidae	*Tabanus*		1	4.3
Ephemeroptera	Caenidae	*Caenis*			5.4
Ephemeroptera	Heptageniidae	*Maccaffertium*			4.0
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*			1.7
Ephemeroptera	Leptophlebiidae	*Leptophlebia*			3.3
Plecoptera	Chloroperlidae	*Haploperla*			1.3
Plecoptera	Capniidae	*Allocapnia*			3.4
Plecoptera	Nemouridae	*Soyedina*			2.5
Trichoptera	Dipseudopsidae	*Phylocentropus*			5.0
Trichoptera	Hydropsychidae	*Cheumatopsyche*		40	5.5
Trichoptera	Hydropsychidae	*Hydropsyche*			5.8
Trichoptera	Hydropsychidae	*Diplectrona*			3.2
Trichoptera	Limnephilidae	*Hydatophylax*			2.5
Trichoptera	Limnephilidae	*Pycnopsyche*			3.7
Trichoptera	Molannidae	*Molanna*			6.0
Trichoptera	Philopotamidae	*Chimarra*		8	4.1
Trichoptera	Philopotamidae	*Dolophilodes*			0.6
Trichoptera	Phryganeidae	*Ptilostomis*	4		4.8
Trichoptera	Psychomyiidae	*Lype*			2.9
		Total Organisms per Sample:	612	710	= 8,264

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 5. Macroinvertebrate community metrics for the North Branch Canal Outlet Channel, including the Hilsenhof biotic index.

Benthic Community Metric	DC Stream-Upper	DC Stream-Lower
Hilsenhof Biotic Index (scores defined below)	6.3	6.5
Number of Intolerent Taxa (tolerance values < 3.0)	0	2
Number of EPT Taxa	1	2
EPT Ratio	0.7%	6.8%
Percent Ephemeroptera Taxa	0.0%	0.0%
Percent Plecoptera Taxa	0.0%	0.0%
Percent Trichoptera Taxa	0.7%	6.8%
EPT to Diptera Ratio	0.07	0.32

Hilsenhof Biotic Index Score Definitons for Water Quality:
Scores of 0 to 4.5 are rated good
Scores of 4.51 to 6.5 are rated fair
Scores of 6.51 to 8.5 are rated poor
Scores of 8.51 to 10.0 are rated very poor

IV. SUMMARY – NORTH BRANCH CANAL OUTLET CHANNEL

The outlet channel originates from regulated flow out of the north branch canal weir. Seepage and overflow from the north branch canal just downstream of the weir also contribute flow to the outlet channel. The channel flows through a relatively flat area, where stream banks are low to moderate in height. Further downstream, however, the channel is entrenched with high and eroding stream banks that have developed from a headcut. Photographs of the Riverlands stream are provided in the Appendix.

The substrate embeddedness and composition survey found fair to poor habitat conditions (high substrate embeddedness, gravel and cobble substrate about 24 percent) in the upper reach of the north branch canal outlet channel stream. The downstream (lower) reach, however, had good substrate conditions, with the substrate dominated by cobble and gravel (57 percent) and with substrate embeddedness relatively low.

The habitat quality was found to be marginal in the habitat assessment surveys of the upper and lower reaches of the outlet channel. Macroinvertebrate community surveys showed fair to poor water quality in both reaches, as determined using the macroinvertebrate biotic index. Even though substrate embeddedness was low and gravel/cobble substrate composition was high in the lower reach, the macroinvertebrate community was fair to poor across all the community metrics. This may be caused by poor water quality in the stream.

These surveys collectively indicate marginal habitat conditions in the Unnamed Tributary.

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APPENDIX

Photographs of the North Branch Canal Outlet Channel

Habitat Assessments, Macroinvertebrate Sampling,
and Substrate Embeddedness Surveys

Outlet Channel of the North Branch Canal

Stream facing downstream towards the Susquehanna River (left)
and upstream towards the North Branch Canal (right).

Outlet Channel of the North Branch Canal

Facing upstream.

Substrate in riffle.

Outlet Channel of the North Branch Canal

Substrate downstream in the outlet channel.

Substrate in riffle.

Outlet Channel of the North Branch Canal

Stream facing upstream (left) and downstream (right). A tributary joins the main channel in the photo on the right. This water is seeping through the earthen dam at the North Branch Canal.

Outlet Channel of the North Branch Canal

Substrate characteristic of the upstream section of the outlet channel.

Silt causes turbid water in the upstream section of the outlet channel.

Outlet Channel of the North Branch Canal

Substrate characteristic of the upstream section of the outlet channel.

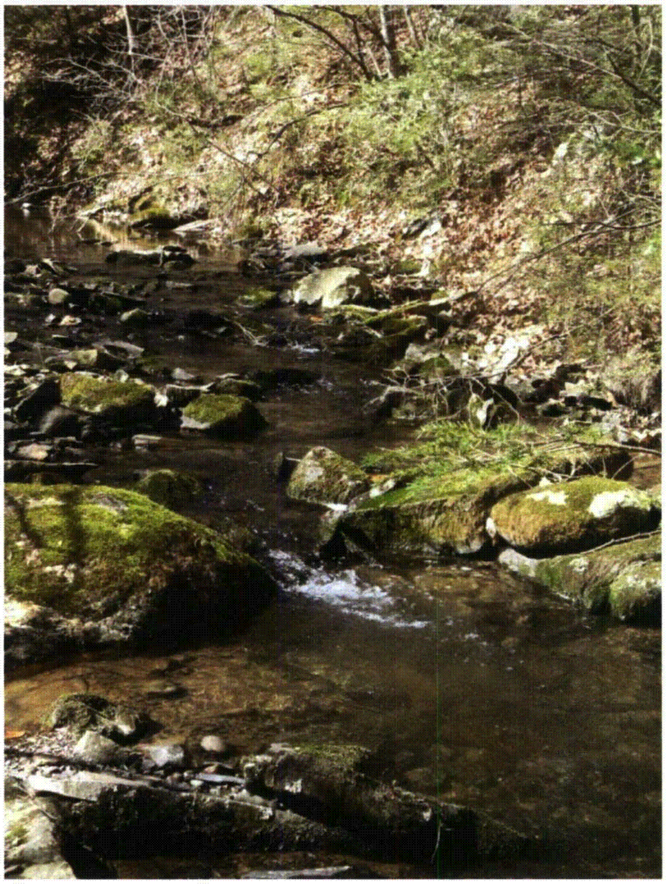
Silt causes turbid water in the upstream section of the outlet channel.

Outlet Channel of the North Branch Canal

Stream channel just below weir.

Weir that controls the water level in the canal and the amount of flow in the outlet channel.

Bell Bend Project Site: Supplemental Field Assessments for the Walker Run Watershed



Prepared for:

PPL Bell Bend Nuclear Power Plant
Salem Township, Luzerne County, PA

Prepared by:

LandStudies
315 North Street
Lititz, Pa 17543
(717)-627-4440

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I. INTRODUCTION

Additional field assessments of Walker Run and its tributaries at the Bell Bend project site were completed in the fall of 2009. Prior to this additional field work, fisheries surveys, habitat assessments, and macroinvertebrate surveys had been completed on Walker Run, and were published earlier in 2009.

The additional field assessments completed in the fall of 2009 at the Bell Bend project site included:

- A substrate embeddedness assessment of seven reaches of Walker Run, two reaches of the Unnamed Tributary, and two reaches of Unnamed Tributary 2.
- Continuous water level and stream temperature recorders (data logging pressure transducers) were installed at ten sites on Walker Run, four sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2.
- A habitat assessment of four reaches of the Unnamed Tributary and two reaches of Unnamed Tributary 2.
- Macroinvertebrate community assessments of four reaches on the Unnamed Tributary and two reaches on Unnamed Tributary 2.
- Field water quality analyses at six sites on Walker Run, two sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2.
- Laboratory water quality analyses at ten sites on Walker Run, two sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2.

The following report describes the findings of these additional field assessments on Walker Run, the Unnamed Tributary, and Unnamed Tributary 2.

II. METHODS

A. Substrate Embeddedness and Characterization. A substrate embeddedness and characterization survey was conducted at seven reaches on Walker Run (Figure 1), two reaches of the Unnamed Tributary (Figure 2), and two reaches of Unnamed Tributary 2 (Figure 2) in the fall of 2009.

At each stream reach, seven transects were established across the stream and perpendicular to the stream flow. The seven transects were located at 25-ft increments over the 150-ft stretch of stream reach. Up to nine survey points were located across each transect, depending on the stream width. Substrate embeddedness and substrate characterizations were made visually at each survey point across the transect. If the stream was wide enough to

accommodate nine survey points per transect, then each stream reach would have 63 substrate embeddedness and 63 substrate characterization measurements.

Substrate embeddedness assessments were made visually using the protocols established in Platts, Megahan, and Minshall (1983)[1]. A 150-ft reach of stream was selected at random within each of the seven stream regions. A tape measure was used to establish the seven transects at 25-ft intervals along the 150-ft reach of stream. The survey points along each transect were selected at equal intervals across the stream at each transect. A view bucket with a 9-in diameter Plexiglas bottom was used to observe the stream substrate at survey points with sufficient water depth; otherwise, the substrate was viewed without a view bucket.

Embeddedness is defined as the degree to which sand, silt, and clay particles (collectively referred to as fines) surround or cover larger gravel, cobble, and boulder materials in the bottom of the stream. The percentage of fines surrounding these coarser particles is visually estimated as a percentage, and an embeddedness rating is derived from this percentage as follows[2]:

Rating	Description
5	< 5 percent of gravel, cobble, and boulder particles covered by fine sediments
4	5 to 25 percent of gravel, cobble, and boulder particles covered by fine sediments
3	25 to 50 percent of gravel, cobble, and boulder particles covered by fine sediments
2	50 to 75 percent of gravel, cobble, and boulder particles covered by fine sediments
1	> 75 percent of gravel, cobble, and boulder particles covered by fine sediments

Embeddedness ratings intermediate between these numbers were determined based on the visually estimated percentage of fines surrounding the gravel cobble and boulder particles. A visually estimated percentage of 40 percent, for instance, would be noted with an embeddedness rating of 3.4. Substrate embeddedness is a significant predictor of wild trout abundance in streams, as streams with low embeddedness (i.e., a high embeddedness rating number) have conditions conducive to trout spawning success.

Substrate composition was determined visually by estimating the percent of the viewed area of substrate composed of each of the following substrate size classes[1,3]:

[1] Platts, W.S., W.F. Megahan and W.G. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT-138, USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah.
[2] Sylte, T. L. and J. C. Fischenich. 2002. Techniques for measuring substrate embeddedness. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-36), U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.
[3] Clean Water Services. 2000. Tualatin River Basin Rapid Stream Assessment Technique (RSAT). Watersheds 2000 Field Methods. Clean Water Services, Watershed Management Division, Hillsboro, Oregon.

Substrate Class	Size Range
Boulder	> 12 inches
Rubble	10 to 12 inches
Cobble	2.5 to 10 inches
Gravel	3/32 to 2.5 inches
Sand	< 3/32 inches
Silt and Clay	< 0.08/32 inches (visually identified)

B. Stream Habitat Assessments. Visual habitat assessments were performed at four reaches of the Unnamed Tributary and two reaches of Unnamed Tributary 2 during the fall of 2009. The low gradient habitat assessment field methodology, in the EPA's Rapid Bioassessment Protocols (RBP)[4], was utilized for these stream habitat assessments.

The RBP evaluates ten habitat quality parameters (Table 1) on a 0 to 20 scale, with scores of 16 to 20 indicating optimal habitat quality, scores of 11 to 15 indicating suboptimal habitat quality, scores of 6 to 10 indicating marginal habitat quality, and scores of 0 to 5 indicating poor habitat quality. The location of the six habitat assessment reaches are shown in Figure 2. The ten habitat quality parameters in the RBP protocols are defined on the following page.

C. Macroinvertebrate community surveys. Macroinvertebrate community surveys were performed in four reaches on the Unnamed Tributary and two reaches on Unnamed Tributary 2 in the fall of 2009. A 500-micron mesh D-frame net (12-inch width) was used to collect stream macroinvertebrates from four separate riffle or run locations within each sampling reach. The four sampling locations were selected to include the spectrum of habitat conditions in each reach. At each reach, the four separate location samples were composited into one sample to provide a stream reach characterization. The locations of the macroinvertebrate community sampling reaches are shown in Figure 2.

Macroinvertebrate samples from each reach were preserved in isopropyl alcohol in the field. Samples were sorted into vials in the laboratory using a 5X illuminated magnifying lamp. All samples were sorted completely. Organisms were identified to the genus level using a stereo microscope, except for midge larvae (Family Chironomidae), nematodes (Phylum Nematoda), and segmented worms (Class Oligochaeta).

Each taxonomic group of macroinvertebrate organisms (typically at the genus level) has a pollution tolerance value published in the scientific literature. Tolerance values range from 0 (no tolerance to pollution) to 10 (high tolerance to pollution). Tolerance values in this study were averaged across those published in three literature sources.[5] Pollution tolerance values

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[4] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

[5] (1) Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams," 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) Benthic Maroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and

were utilized to calculate the Hilsenhof Biotic Index[6], which provides a single index of the water quality of a stream reach based on the pollution tolerance of the macroinvertebrates collected there. Hilsenhof Biotic Index scores of 0 to 4.5 indicate good water quality, while scores of 8.5 to 10 indicate very poor water quality and intermediate scores indicate fair to poor water quality.

Table 1. Habitat Quality Parameters used in the Walker Run Watershed Stream Habitat Assessments

Habitat Quality Parameter	Definition[7]
Epifaunal Substrate and Available Cover	Includes the relative quantity and variety of natural structures in the stream, such as cobble, large rocks, fallen trees, logs and branches, and undercut banks that are available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
Pool Substrate Characterization	Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom.
Pool Variability	Rates the overall mixture of pool types found in streams: large-shallow, large-deep, small shallow, and small-deep. Streams with the majority of pools being either small-shallow or absent have poor habitat quality.
Sediment Deposition	Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of sediment deposition. Streams with heavy deposits of sediments with pools almost absent have poor habitat quality.
Channel Flow Status	The degree to which the stream channel is filled with water. Streambeds with very little water and present mostly as standing water have poor channel flow status.
Channel Alteration	The degree to which the stream has been channelized, dredged, or stabilized with shoring structures.
Channel Sinuosity	The degree of sinuosity evaluates the meandering of the stream, with high sinuosity indicative of optimal habitat quality.
Bank Stability	An evaluation of whether the streambanks are eroded. Signs of erosion include crumbling, unvegetated banks with exposed tree roots and exposed soil.
Vegetative Protection of Streambanks	Measures the amount of vegetative protection for the streambanks and immediate riparian zone.
Riparian Vegetation Zone Width	Measures the width of natural vegetation from the edge of the streambank out through the riparian zone.

Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

[6] Hilsenhof, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist, vol. 20: 31-39.

[7] Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

D. Continuous water level and stream temperature recorders. Continuous water level and stream temperature recorders (data logging pressure transducers, Solinst leveloggers model 3001) were installed at ten sites on Walker Run, four sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2. The location of the water level and stream temperature recorders are shown in Figure 3. The recorders at installation sites 1, 2, 4, 5, 7, 8, 9, 10, 11, 15, and 16 are located at culverts, bridges or pipes. These instruments were located at these constrictions to provide the most accurate flow calculation. HEC-RAS was used to generate known flow profiles through the project site, which were then used to generate a rating curve and equation to calculate flow based on stage. This calculation was calibrated and verified in the field using a pigmy meter to measure flow at each station. Flow was calculated at Stations 4, 8, and 11. These stations were chosen based on the reliability of the measurements and the stability of the control section for flow calculation. HEC-RAS data was also available to generate rating curves for these stations.

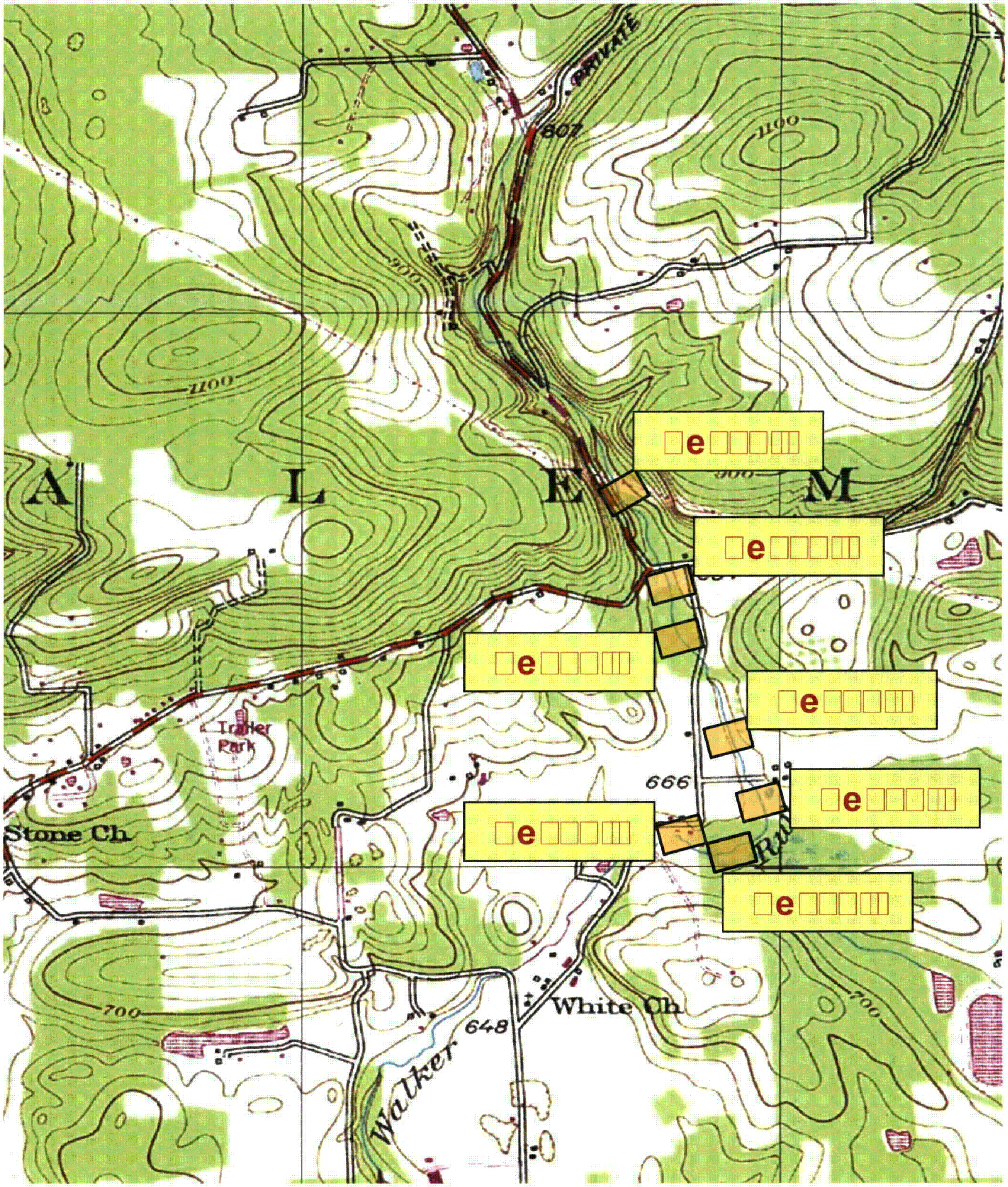
These pressure transducers record the pressure above their installation point in a stream, which includes the pressure from overlying water as well as atmospheric pressure. A barologger (barometric pressure transducer, Solinst) was installed on-site to provide atmospheric pressure data to be subtracted from the data collected by the stream pressure transducers.

The pressure transducers collect stream water temperature and pressure data at 10-minute intervals, and have sufficient datalogging memory to allow for data downloads every 3 months. The transducers were installed on November 3rd and 4th, 2009. Data was downloaded December 10th, 2009, March 3rd and 4th, 2010, April 22nd, 2010 and June 28th, 2010. The data was downloaded using the software provided with all Solinst devices (version 3.4). The data was compiled in Microsoft Excel in 10 minute and 1 hour formats. Due to the large quantity of information processed, the 1 hour data was used to generate Figures 4 through 10.

E. Water quality monitoring. Field water quality analyses were completed at six sites on Walker Run (sites 2, 4, 5, 7, 9, and 10), two sites on the Unnamed Tributary (11 and 12) and two sites on Unnamed Tributary 2 (15 and 16). Laboratory water quality analyses were completed at ten sites on Walker Run (1-10), two sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2. The site locations for these analyses are shown in Figure 3.

Water quality data and samples were collected during a baseflow period in December 2009. Field water quality measurements included pH, dissolved oxygen, water temperature, and conductivity. These measurements were made with a YSI model pH100 EcoSense pH meter, and a YSI model 650 MDS water quality sonde. Calibrations were made with fresh pH calibration solutions (pH 4 and pH 10) and conductivity calibration solution (1000 μS/cm). Dissolved oxygen was calibrated using the air saturation technique.

Water samples were collected for spectrophotometric analyses (YSI model 9500 photometer) of alkalinity, turbidity, ammonia, nitrite, nitrate, and orthophosphate. These samples were collected during baseflow conditions, and the samples were analyzed within 24 hours of collection.



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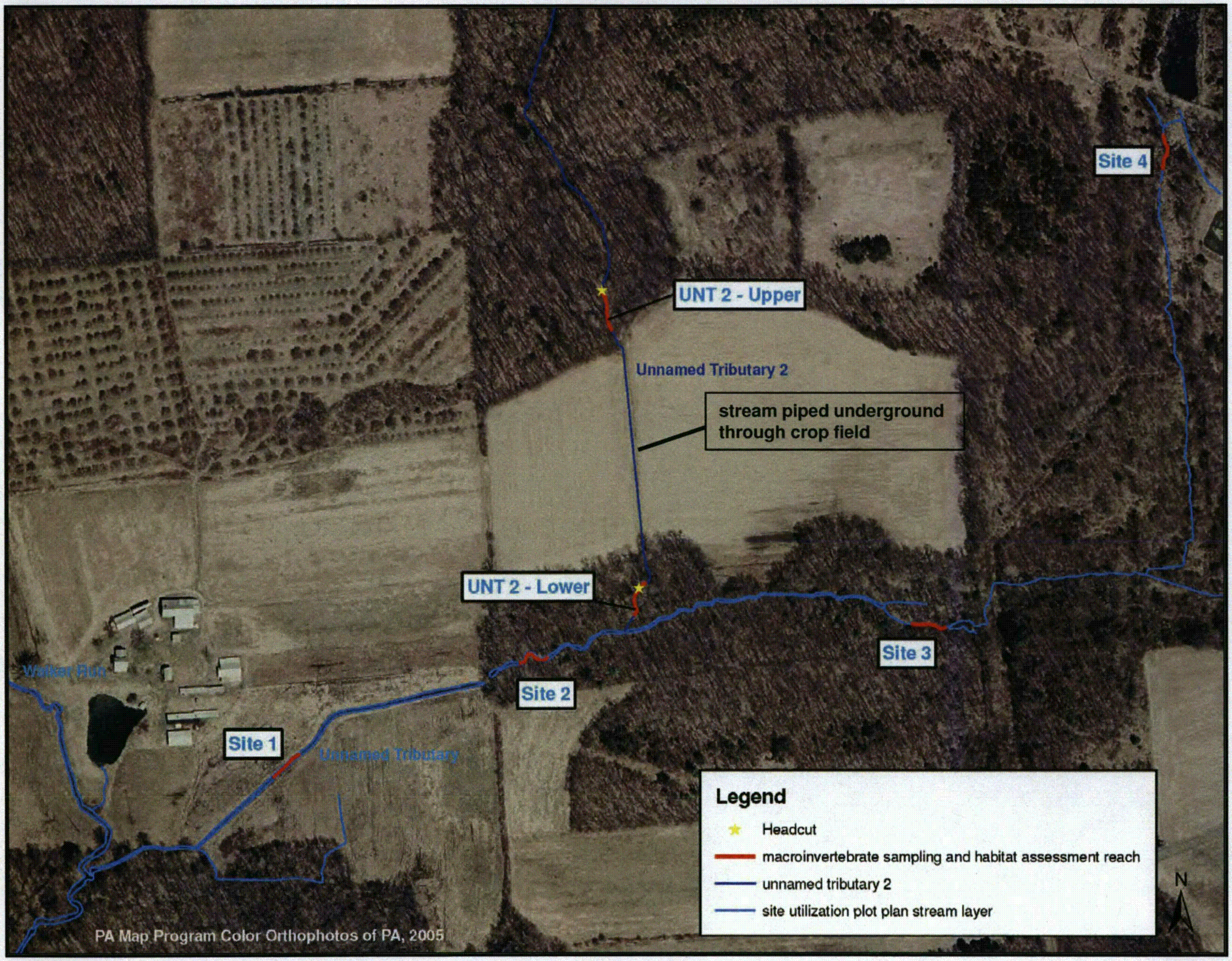
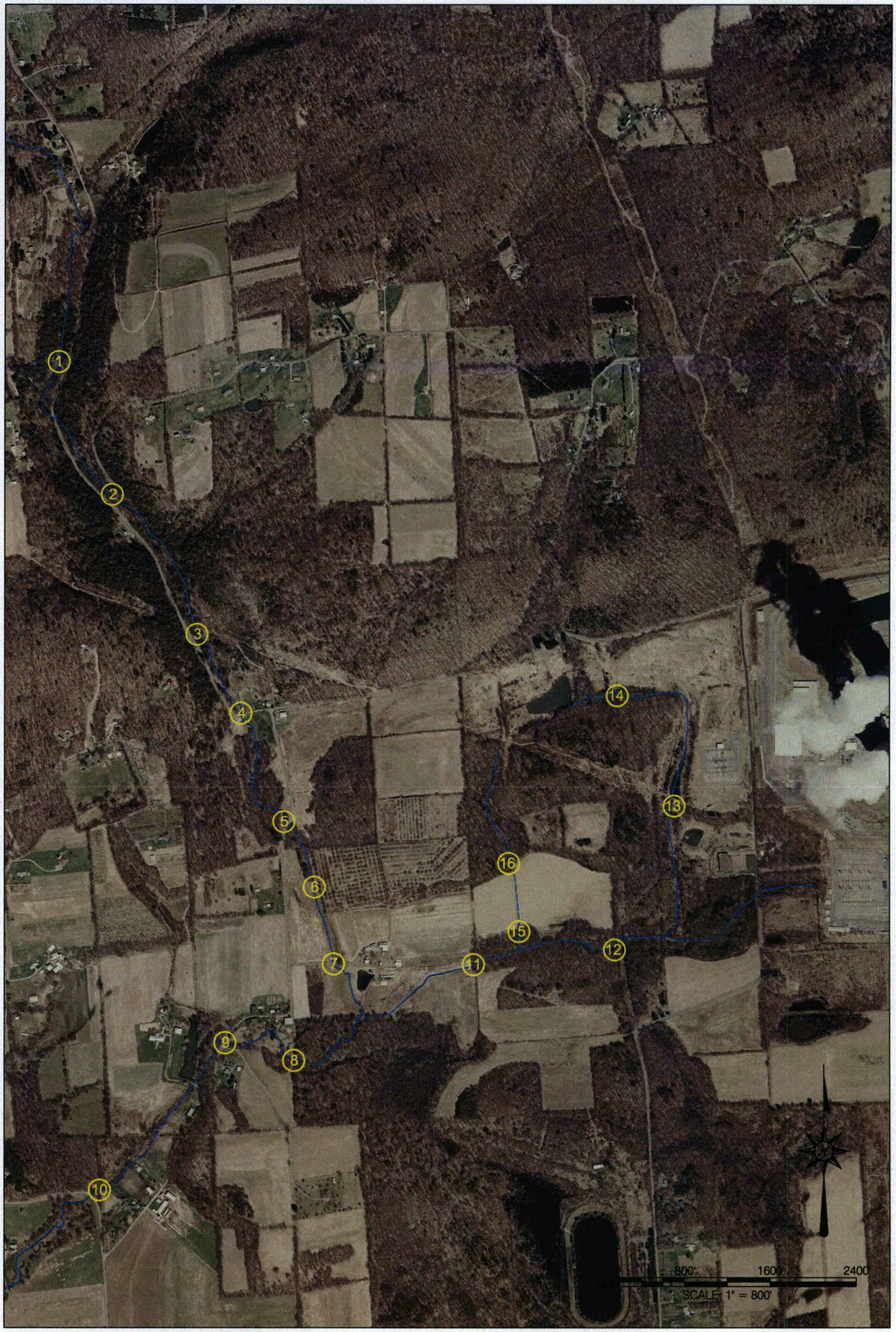
r e e es o er

LandStudies
315 North Street
Lititz, Pa 17543
(717)-627-4440

Figure 2. Habitat assessment, sediment embeddedness, and macroinvertebrate sampling locations on the Unnamed Tributary and Unnamed Tributary 2.





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Project: **Bell Bend Nuclear Power Plant**
Salem Township
Luzerne County, PA

Map: **Figure 3 Pressure Transducer Location Map**

LandStudies
315 NORTH STREET
Lititz, Pennsylvania 17543
tel: (717) 627-4440
fax: (717) 627-4660
e-mail: Land@Landstudies.com
website: www.landstudies.com
"Integrating Natural Resource Management with Land Planning"

III. FINDINGS

A. Substrate Embeddedness and Characterization – Walker Run. Seven reaches were surveyed on Walker Run to characterize substrate embeddedness and composition (Table 2). Of these seven reaches, two were shallow pools (average stream width of 8.1 and 9.6 ft; average water depth of 0.5 and 0.3 ft), one reach was a deep pool (beaver dam backwater; average stream width of 16.1 ft and average water depth of 2.2 ft), two reaches were runs (average stream width of 6.2 and 9.2 ft; average water depth of 0.5 and 0.4 ft), and two reaches were riffles (average stream width of 11.3 and 7.1 ft; average water depth of 0.3 and 0.3 ft). In most cases, there was a combination of habitat types over the 150-ft reach length.

Within the surveyed section of Walker Run, substrate embeddedness was very high (poor habitat conditions) from Reach 3 (upstream of the upper North Market Street crossing) to the most downstream reach that was surveyed (Reach 7 – upstream of the lower North Market Street crossing). Substrate embeddedness ratings ranged from 1.4 to 1.0 in this section of Walker Run. The gravel and cobble component of the stream substrate in this section of stream ranged from 0 percent to 19.7 percent of the bottom (Table 2). The dominant substrate component in this section of Walker Run was sand and silt.

The section of Walker Run from Reach 2 (just downstream of Beach Grove Road) to Reach 1 (about 1,000 ft upstream of Beach Grove Road) had much lower substrate embeddedness, with embeddedness ratings of 3.2 and 3.8 respectively (Table 2). The gravel and cobble component of the stream substrate in this section of stream ranged from 61.1 percent to 66.4 percent of the bottom. The dominant substrate component in these two reaches of Walker Run was gravel and cobble.

Substrate Embeddedness and Characterization – the Unnamed Tributary. Two reaches of the Unnamed Tributary were surveyed for substrate embeddedness and composition (Table 2). Both reaches had high substrate embeddedness (embeddedness ratings of 1.0 for each), and each reach had less than 1 percent of the substrate comprised of gravel and cobble. Sand and silt dominated the substrate in both reaches.

The average stream width of these two reaches was 2.8 ft and 2.3 ft, with average water depths of 0.09 ft and 0.10 ft (Table 2). Both reaches were run habitats.

Substrate Embeddedness and Characterization – Unnamed Tributary 2. Two reaches of Unnamed Tributary 2 were surveyed for substrate embeddedness and composition (Table 3). The upper section (UNT2-U in Table 3) is located in the forested area north of the crop field. Unnamed Tributary 2 is directed through a pipe under the crop field, and discharges into the forested area south of the crop field (the lower section, UNT2-L in Table 3).

Table 2. Substrate embeddedness and stream morphometric and substrate characteristics for Walker Run and the Unnamed Tributary.

Stream Station	Transect No.	Stream Width (ft)	Average Water Depth (ft)	Habitat Type	Dominant Substrate Type	Median Embeddedness (%)	Transect Embeddedness Rating	Percent Fines*	Median Percent Silt and Clay	Median Percent Sand (< 3/32")	Median Percent Gravel (3/32" to 2.5")	Median Percent Cobble (2.5" to 10")	Median Percent Rubble (10" to 12")	Median Percent Boulder (> 12")
REACH 1: UPSTREAM OF BEACH GROVE ROAD														
S1	TA	10.5	0.15	Riffle	cobble/gravel	18.0	4.3	7.5%	0.0%	15.0%	25.0%	60.0%	0.0%	0.0%
S1	TB	13.6	0.24	Riffle	cobble/gravel	30.0	3.7	17.5%	10.0%	15.0%	30.0%	40.0%	0.0%	0.0%
S1	TC	19.5	0.24	Riffle	cobble/gravel	25.0	3.9	15.0%	5.0%	20.0%	40.0%	40.0%	0.0%	0.0%
S1	TD	10.3	0.29	Riffle	gravel/cobble	20.0	4.2	15.0%	5.0%	20.0%	25.0%	20.0%	0.0%	0.0%
S1	TE	9.2	0.43	Shallow Pool	cobble/sand	60.0	2.5	17.5%	5.0%	25.0%	10.0%	40.0%	0.0%	0.0%
S1	TF	8.1	0.20	Riffle	gravel/cobble	15.0	4.5	7.5%	0.0%	15.0%	40.0%	30.0%	0.0%	0.0%
S1	TG	7.8	0.32	Glide	cobble/gravel	30.0	3.7	30.0%	20.0%	20.0%	20.0%	45.0%	0.0%	0.0%
S1	**7**	**11.3**	**0.27**	**Riffle**	**cobble/gravel**	**28.3**	**3.8**	**15.7%**	**6.4%**	**18.6%**	**27.1%**	**39.3%**	**0.0%**	**0.0%**
REACH 2: JUST DOWNSTREAM OF BEACH GROVE ROAD														
S2	TA	11.0	0.16	Riffle	cobble/gravel	35.0	3.5	40.0%	32.5%	15.0%	35.0%	40.0%	0.0%	0.0%
S2	TB	8.5	0.13	Riffle	gravel/cobble	30.0	3.7	35.0%	25.0%	20.0%	50.0%	30.0%	0.0%	0.0%
S2	TC	6.0	0.24	Riffle	gravel/cobble	40.0	3.4	15.0%	0.0%	30.0%	35.0%	30.0%	0.0%	0.0%
S2	TD	5.8	0.38	Riffle	cobble/sand	50.0	2.9	17.5%	0.0%	35.0%	15.0%	30.0%	0.0%	0.0%
S2	TE	7.0	0.34	Riffle	gravel/cobble	45.0	3.2	16.3%	5.0%	22.5%	37.5%	30.0%	0.0%	0.0%
S2	TF	5.0	0.26	Riffle	gravel/cobble	22.5	4.1	7.5%	0.0%	15.0%	50.0%	25.0%	0.0%	0.0%
S2	TG	6.4	0.36	Shallow Pool	silt/sand	75.0	1.9	62.5%	50.0%	25.0%	5.0%	15.0%	0.0%	0.0%
S2	**7**	**7.1**	**0.27**	**Riffle**	**gravel/cobble**	**42.5**	**3.2**	**27.7%**	**16.1%**	**23.2%**	**32.5%**	**28.6%**	**0.0%**	**0.0%**
REACH 3: UPSTREAM OF UPPER MARKET STREET CROSSING														
S3	TA	8.5	0.15	Shallow Pool	sand/silt	90.0	1.4	57.5%	30.0%	55.0%	10.0%	0.0%	0.0%	0.0%
S3	TB	7.4	0.19	Run	sand/gravel	70.0	1.7	30.0%	10.0%	40.0%	25.0%	0.0%	0.0%	0.0%
S3	TC	7.3	0.55	Shallow Pool	sand	85.0	1.5	20.0%	5.0%	30.0%	5.0%	0.0%	15.0%	0.0%
S3	TD	8.3	0.63	Pool	rubble/silt	100.0	1.0	10.0%	10.0%	0.0%	0.0%	0.0%	90.0%	0.0%
S3	TE	10.2	0.66	Shallow Pool	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S3	TF	8.2	0.44	Shallow Pool	silt/sand	100.0	1.0	80.0%	70.0%	20.0%	10.0%	0.0%	0.0%	0.0%
S3	TG	6.5	0.75	Shallow Pool	silt	100.0	1.0	70.0%	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S3	**7**	**8.1**	**0.48**	**Shallow Pool**	**sand/silt**	**92.1**	**1.2**	**52.5%**	**42.1%**	**20.7%**	**7.1%**	**0.0%**	**15.0%**	**0.0%**
REACH 4: CHANNELIZED SEGMENT ABOVE ACCESS ROAD														
S7	TA	7.8	0.79	Pool/Backwater	sand/silt	100.0	1.0	75.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%
S7	TB	8.9	0.73	Run	sand/silt	100.0	1.0	50.0%	30.0%	40.0%	0.0%	0.0%	0.0%	0.0%
S7	TC	7.4	0.46	Run	sand/silt	100.0	1.0	50.0%	30.0%	40.0%	0.0%	0.0%	35.0%	0.0%
S7	TD	5.9	0.34	Run	sand/gravel	72.5	2.1	25.0%	0.0%	50.0%	12.5%	0.0%	0.0%	0.0%
S7	TE	4.4	0.61	Run	sand/gravel	100.0	1.0	36.3%	5.0%	62.5%	10.0%	0.0%	5.0%	0.0%
S7	TF	4.3	0.45	Riffle	sand/gravel	87.5	1.4	33.8%	2.5%	62.5%	15.0%	10.0%	7.5%	0.0%
S7	TG	4.5	0.20	Riffle	sand/gravel	70.0	2.2	22.5%	0.0%	45.0%	30.0%	20.0%	0.0%	0.0%
S7	**7**	**6.2**	**0.51**	**Run**	**sand/silt/gravel**	**90.0**	**1.4**	**41.8%**	**16.8%**	**50.0%**	**9.6%**	**4.3%**	**6.8%**	**0.0%**
REACH 5: BACKWATER SEGMENT ABOVE BEAVER POND														
S6	TA	15.0	2.26	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TB	14.5	1.91	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TC	21.5	1.73	Pool/Backwater	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
S6	TD	16.0	2.46	Pool/Backwater	silt/sand	100.0	1.0	95.0%	90.0%	10.0%	0.0%	0.0%	0.0%	0.0%
S6	TE	14.5	2.31	Pool/Backwater	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S6	TF	16.0	2.39	Pool/Backwater	silt	100.0	1.0	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
S6	TG	15.4	2.32	Pool/Backwater	silt/sand	100.0	1.0	95.0%	90.0%	10.0%	0.0%	0.0%	0.0%	0.0%
S6	**7**	**16.1**	**2.20**	**Pool/Backwater**	**silt/sand**	**100.0**	**1.0**	**92.1%**	**84.3%**	**15.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Table 2 (continued). Substrate embeddedness and stream morphometric and substrate characteristics for Walker Run and the Unnamed Tributary.

Stream Station	Transect No.	Stream Width (ft)	Average Water Depth (ft)	Habitat Type	Dominant Substrate Type	Median Embeddedness (%)	Transect Embeddedness Rating	Percent Fines*	Median Percent Silt and Clay	Median Percent Sand (< 3/32")	Median Percent Gravel (3/32" to 2.5")	Median Percent Cobble (2.5" to 10")	Median Percent Rubble (10" to 12")	Median Percent Boulder (> 12")
REACH 6: FORESTED AREA UPSTREAM OF LOWER MARKET STREET CROSSING														
S5	TA	9.1	0.27	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TB	9.5	0.35	Shallow Pool	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TC	9.5	0.32	Shallow Pool	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S5	TD	8.2	0.36	Shallow Pool	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S5	TE	8.6	0.41	Shallow Pool	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S5	TF	13.0	0.33	Shallow Pool	sand/silt	100.0	1.0	67.5%	35.0%	65.0%	0.0%	0.0%	0.0%	0.0%
S5	TG	9.0	0.26	Shallow Pool	sand/silt	100.0	1.0	62.5%	25.0%	75.0%	0.0%	0.0%	0.0%	0.0%
S5	**7**	**9.6**	**0.33**	**Shallow Pool**	**sand/silt**	**100.0**	**1.0**	**67.1%**	**34.3%**	**65.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
REACH 7: UPSTREAM OF LOWER MARKET STREET CROSSING														
S4	TA	7.7	0.24	Riffle	rubble/cobble	70.0	2.2	11.3%	10.0%	2.5%	2.5%	12.5%	20.0%	0.0%
S4	TB	7.9	0.32	Run	silt/cobble	100.0	1.0	60.0%	50.0%	20.0%	0.0%	25.0%	0.0%	0.0%
S4	TC	7.5	0.44	Run	cobble/sand	100.0	1.0	22.5%	15.0%	15.0%	0.0%	20.0%	0.0%	0.0%
S4	TD	10.3	0.35	Run	sand/silt	100.0	1.0	47.5%	30.0%	35.0%	0.0%	0.0%	0.0%	0.0%
S4	TE	8.3	0.45	Run	cobble/sand	85.0	1.5	20.0%	5.0%	30.0%	0.0%	37.5%	15.0%	0.0%
S4	TF	12.1	0.43	Shallow Pool	sand/rubble	100.0	1.0	42.5%	15.0%	55.0%	0.0%	0.0%	20.0%	0.0%
S4	TG	10.5	0.78	Pool	cobble/sand	90.0	1.4	27.5%	20.0%	15.0%	0.0%	40.0%	0.0%	0.0%
S4	**7**	**9.2**	**0.43**	**Run**	**cobble/sand**	**92.1**	**1.3**	**33.0%**	**20.7%**	**24.6%**	**0.4%**	**19.3%**	**7.9%**	**0.0%**
UNNAMED TRIBUTARY SITE 2: DOWNSTREAM FORESTED SECTION														
S8	TA	2.3	0.08	Run	sand/silt	100.0	1.0	71.3%	42.5%	57.5%	0.0%	0.0%	0.0%	0.0%
S8	TB	3.0	0.11	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S8	TC	2.9	0.08	Run	sand/silt	100.0	1.0	73.8%	47.5%	52.5%	0.0%	0.0%	0.0%	0.0%
S8	TD	2.7	0.07	Run	sand/silt	100.0	1.0	66.3%	32.5%	67.5%	0.0%	0.0%	0.0%	0.0%
S8	TE	2.7	0.09	Run	sand/silt	100.0	1.0	68.8%	37.5%	62.5%	0.0%	0.0%	0.0%	0.0%
S8	TF	2.9	0.08	Run	sand/silt	100.0	1.0	71.3%	42.5%	57.5%	0.0%	0.0%	0.0%	0.0%
S8	TG	3.2	0.10	Run	sand/silt	100.0	1.0	67.5%	35.0%	65.0%	0.0%	0.0%	0.0%	0.0%
S8	**7**	**2.8**	**0.09**	**Run**	**sand/silt**	**100.0**	**1.0**	**69.8%**	**39.6%**	**60.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
UNNAMED TRIBUTARY SITE 3: UPSTREAM FORESTED SECTION OF UNNAMED TRIBUTARY														
S9	TA	3.4	0.07	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S9	TB	2.3	0.14	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
S9	TC	2.3	0.14	Run	sand/silt	100.0	1.0	52.5%	15.0%	75.0%	5.0%	0.0%	0.0%	0.0%
S9	TD	1.6	0.10	Run	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S9	TE	2.2	0.10	Run	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S9	TF	2.4	0.05	Run	sand/silt	100.0	1.0	57.5%	25.0%	65.0%	0.0%	0.0%	0.0%	0.0%
S9	TG	2.0	0.07	Run	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
S9	**7**	**2.3**	**0.10**	**Run**	**sand/silt**	**100.0**	**1.0**	**63.6%**	**30.0%**	**67.1%**	**0.7%**	**0.0%**	**0.0%**	**0.0%**

** Percent fines (particles < 1.0 mm) calculated as the sum of the median percent silt and clay and 1/2 the median percent sand.*

Table 3. Substrate embeddedness and stream morphometric and substrate characteristics for Unnamed Tributary 2.

Stream Station	Transect No.	Stream Width (ft)	Average Water Depth (ft)	Habitat Type	Dominant Substrate Type	Median Embeddedness (%)	Transect Embeddedness Rating	Percent Fines*	Median Percent Silt and Clay	Median Percent Sand (< 3/32")	Median Percent Gravel (3/32" to 2.5")	Median Percent Cobble (2.5" to 10")	Median Percent Rubble (10" to 12")	Median Percent Boulder (> 12")
Unnamed Tributary 2 - Lower Reach														
UNT2-L	TA	1.5	0.11	Run	sand	100.0	1.0	60.0%	20.0%	80.0%	0.0%	0.0%	0.0%	0.0%
UNT2-L	TB	1.9	0.16	Run	sand	100.0	1.0	60.0%	20.0%	80.0%	0.0%	0.0%	0.0%	0.0%
UNT2-L	TC	2.0	0.13	Run	sand	100.0	1.0	57.5%	20.0%	75.0%	10.0%	0.0%	0.0%	0.0%
UNT2-L	TD	1.6	0.07	Run	sand/clay	100.0	1.0	90.0%	80.0%	20.0%	0.0%	0.0%	0.0%	0.0%
UNT2-L	TE	2.5	0.18	Run	silt/clay	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
UNT2-L	TF	1.5	0.22	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
UNT2-L	TG	2.0	0.19	Run	sand	100.0	1.0	61.3%	22.5%	77.5%	0.0%	0.0%	0.0%	0.0%
UNT2-L	**7**	**1.9**	**0.15**	**Run**	**sand**	**100.0**	**1.0**	**69.1%**	**38.9%**	**60.4%**	**1.4%**	**0.0%**	**0.0%**	**0.0%**
Unnamed Tributary 2 - Upper Reach														
UNT2-U	TA	2.1	0.17	Run	sand/silt	100.0	1.0	72.5%	45.0%	55.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TB	1.9	0.29	Run	sand/silt	100.0	1.0	70.0%	40.0%	60.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TC	1.4	0.26	Run	sand/silt	100.0	1.0	75.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TD	3.1	0.17	Run	silt/sand	100.0	1.0	77.5%	55.0%	45.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TE	4.7	0.19	Run	silt/sand	100.0	1.0	85.0%	70.0%	30.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TF	2.7	0.21	Run	sand/silt	100.0	1.0	65.0%	30.0%	70.0%	0.0%	0.0%	0.0%	0.0%
UNT2-U	TG	2.1	0.24	Run	sand/silt	100.0	1.0	78.8%	57.5%	42.5%	0.0%	0.0%	0.0%	0.0%
UNT2-U	**7**	**2.6**	**0.22**	**Run**	**sand/silt**	**100.0**	**1.0**	**74.8%**	**49.6%**	**50.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

* *Percent fines (particles < 1.0 mm) calculated as the sum of the median percent silt and clay and 1/2 the median percent sand.*

Both reaches had high substrate embeddedness (embeddedness ratings of 1.0 for each), and each reach had less than 2 percent of the substrate comprised of gravel and cobble. Sand and silt dominated the substrate in both reaches.
The average stream width of these two reaches was 2.6 ft and 1.9 ft, with average water depths of 0.22 ft and 0.15 ft (Table 3). Both reaches were run habitats.

B. Habitat Assessments – the Unnamed Tributary. Four reaches of the Unnamed Tributary were assessed for habitat quality using the EPA's Rapid Bioassessment Protocols. The habitat assessment scores for these four reaches ranged from 6.2 to 11.0, with three of the reaches categorized as having marginal stream habitat quality and the fourth reach (Site 4 - the most upstream site – see Figure 2) having stream habitat quality at the low end of the suboptimal range (Table 4).

Habitat quality in the Unnamed Tributary was rated marginal to just suboptimal because of poor epifaunal substrate, pool variability, and channel sinuosity. Pool substrate, sediment deposition, and vegetative protection were also poor in the middle two reaches of the Unnamed Tributary. Other habitat quality parameters were typically suboptimal in the Unnamed Tributary.

Habitat Assessments – Unnamed Tributary 2. Two reaches the Unnamed Tributary were assessed for habitat quality, also using the EPA RBP methods. The habitat assessment scores for these reaches were 6.6 and 9.8, both in the marginal habitat quality category (Table 5). Habitat quality in the upper reach of Unnamed Tributary 2 was rated higher, but still in the marginal habitat quality category.

Habitat quality in Unnamed Tributary 2 was rated marginal because of poor epifaunal substrate, pool substrate, pool variability, sediment deposition, vegetative protection, and channel sinuosity. Additionally, habitat quality was marginal in the lower reach of Unnamed Tributary 2 because of channel flow status, bank stability, and riparian vegetation zone width.

Table 4. Habitat assessment scores for the four sites on the Unnamed Tributary to Walker Run.

Habitat Category	Site 1	Site 2	Site 3
Epifaunal substrate / available cover	2	0	1
Pool substrate characterization	11	6	6
Pool variability	2	0	0
Sediment deposition	16	1	3
Channel flow status	2	6	11
Channel alteration	9	11	14
Channel sinuosity	6	7	6
Bank stability	14	12	12
Vegetative protection	16	7	9
Riparian vegetation zone width	18	12	16
Average Score:	**9.6**	**6.2**	**7.8**

Habitat Category	Site 4
Epifaunal substrate / available cover	4
Pool substrate characterization	11
Pool variability	1
Sediment deposition	15
Channel flow status	13
Channel alteration	15
Channel sinuosity	5
Bank stability	14
Vegetative protection	16
Riparian vegetation zone width	16
Average Score:	**11.0**

Scoring Descriptions

Optimal: 20 to 16
Suboptimal: 15 to 11
Marginal: 10 to 6
Poor: 5 to 0

Table 5. Habitat assessment scores for the two reaches on Unnamed Tributary 2.

Habitat Category	UNT-2 LR	UNT-2 UR	Scoring Descriptions
Epifaunal substrate / available cover	3	7	
Pool substrate characterization	6	7	
Pool variability	1	2	Optimal: 20 to 16
Sediment deposition	7	9	Suboptimal: 15 to 11
Channel flow status	8	13	Marginal: 10 to 6
Channel alteration	11	15	Poor: 5 to 0
Channel sinuosity	6	7	
Bank stability	8	14	
Vegetative protection	7	8	
Riparian vegetation zone width	9	16	
Average Score:	**6.6**	**9.8**	

C. Macroinvertebrate Community Surveys – the Unnamed Tributary. The macroinvertebrate community was surveyed at four reaches of the Unnamed Tributary (Figure 2). A total of 49 macroinvertebrate taxa were collected from the Unnamed Tributary (Table 6) comprised of 4,652 individuals. The macroinvertebrate community in the Unnamed Tributary was dominated by pill clams (*Pisidium,* 28 %), scuds (*Hyalella,* 22 %), freshwater worms (Oligochaeta, 12 %), and midges (Chironomidae, 8 %). These four taxonomic groups constituted over 70 % of the macroinvertebrate community in the Unnamed Tributary. Dominance of the macroinvertebrate community by just a few taxa that are all pollution tolerant typically indicates fair to poor water quality conditions.

The macroinvertebrate community metrics rate the Unnamed Tributary as fair to poor water quality. The most downstream reach (Site 1 – see Figure 2) has poor water quality as indicated by the Hilsenhof Biotic Index (Table 7). This is corroborated by the other metrics, particularly the number of EPT taxa (Ephemeroptera, Plecoptera, Trichoptera), the EPT to Diptera ratio, and the number of intolerant taxa. The Hilsenhof Biotic Index incorporates pollution tolerance values for each macroinvertebrate taxon, and is utilized here as the primary community metric for interpretation of water quality in the stream. The other community metrics provide secondary water quality interpretations.

The other three upstream reaches on the Unnamed Tributary have fair water quality as indicated by the Hilsenhof Biotic Index (Table 7). The reach with the best water quality as indicated by this metric is Reach 3 (Site 3 – see Figure 2). This interpretation is supported by other community metrics, particularly the EPT to Diptera ratio.

Macroinvertebrate Community Surveys –Unnamed Tributary 2. The macroinvertebrate community was surveyed at two reaches of Unnamed Tributary 2 (Figure 2). A total of 25 macroinvertebrate taxa were collected from Unnamed Tributary 2 (Table 6) comprised of 2,290 individuals. The macroinvertebrate community in Unnamed Tributary 2 was dominated by midges (Chironomidae, 65 %) and pill clams (*Pisidium,* 17 %). These two taxonomic groups constituted about 82 % of the macroinvertebrate community in Unnamed Tributary 2. This type of dominance indicates fair to poor water quality conditions.

The macroinvertebrate community metrics also indicate that Unnamed Tributary 2 has fair to poor water quality (Table 7). The two reaches are similar in their macroinvertebrate community metrics, with Hilsenhof Biotic Index values of 6.7 and 6.4 for the upper and lower reaches respectively.

Table 6. Macroinvertebrates collected from the Unnamed Tributary and Unnamed Tributary 2, with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	UNT-Site 1	UNT-Site 2	UNT-Site 3	UNT-Site 4	UNT2-Upper	UNT2-Lower	Tolerance Value
Acariformes						1			6.0
Hoplonemertea	Tetrastemmatidae	*Prostoma*							7.7
Tricladida	Planariidae	*Dugesia*							7.4
Tricladida	Planariidae	*Phagocata*							7.2
Hirudinida	Erpobdellidae								10.0
Hirudinida	Glossiphoniidae	*Helobdella*	1	54		2			6.0
Oligochaeta			152	144	12	249	4	12	8.3
Amphipoda	Hyalellidae	*Hyalella*	1	356	60	601			4.7
Amphipoda	Gammaridae	*Crangonyx*							5.6
Amphipoda	Gammaridae	*Gammarus*							6.2
Isopoda	Asellidae	*Caecidotea*			1	176			6.2
Bivalvia	Sphaeridae	*Pisidium*	261	512	32	505	80	304	6.6
Gastropoda	Physidae	*Physa*	64	1	6	30			7.7
Gastropoda	Lymnaeidae	*Fossaria*				1			7.0
Gastropoda	Hydrobidae	*Amnicola*	1			1			7.0
Gastropoda	Planorbidae	*Helisoma*	2			1			6.5
Megaloptera	Sialidae	*Sialis*				1			3.3
Lepidoptera	Pyraulidae	*Neocataclysta*						1	5.5
Odonata	Aeshnidae	*Aeshna*	1	1					5.5
Odonata	Aeshnidae	*Boyeria*		4					3.4
Odonata	Calopterygidae	*Calopteryx*	1	3	18	1			6.8
Odonata	Coenagrionidae	*Enallagma*	47			1			8.3
Odonata	Cordulegastridae	*Cordulegaster*			1				2.8
Odonata	Gomphidae	*Gomphus*		2					4.1
Coleoptera	Elmidae	*Dubiraphia*		98	2				5.9
Coleoptera	Elmidae	*Optioservus*		4					4.5
Coleoptera	Elmidae	*Stenelmis*		1	3				6.0
Coleoptera	Dryopidae	*Helichus*			2				5.5
Coleoptera	Hydrophilidae	*Hydrobius*				5			4.7
Coleoptera	Dytiscidae	*Agabus*	13						5.1
Coleoptera	Dytiscidae	*Hydroporus*							4.9
Diptera	Ceratopogonidae	*Bezzia*				2			5.1
Diptera	Ceratopogonidae	*Ceratopogon*				2	1	2	4.9
Diptera	Ceratopogonidae	*Culicoides*					3		8.6
Diptera	Ceratopogonidae	*Palpomyia*							6.0
Diptera	Ceratopogonidae	*Probezzia*		73			4	6	5.0

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 6 (continued). Macroinvertebrates collected from the Unnamed Tributary and Unnamed Tributary 2, with their pollution tolerance values.

ORDER/CLASS	FAMILY	GENUS	UNT-Site 1	UNT-Site 2	UNT-Site 3	UNT-Site 4	UNT2-Upper	UNT2-Lower	Tolerance Value
Diptera	Chironomidae		45	84	202	63	864	624	7.3
Diptera	Empididae	*Hemerodromia*			28				6.6
Diptera	Culicidae	*Anopheles*	7						8.0
Diptera	Culicidae	*Psorphora*	1						8.0
Diptera	Ephydridae			1					6.0
Diptera	Psychodidae	*Pericoma*			1			3	4.0
Diptera	Ptychopteridae	*Ptychoptera*					9	5	4.0
Diptera	Simuliidae	*Prosimulium*					21	16	3.8
Diptera	Simuliidae	*Simulium*			1				6.2
Diptera	Tipulidae	*Dicranota*					3	4	2.7
Diptera	Tipulidae	*Hexatoma*					2		2.5
Diptera	Tipulidae	*Limnophila*			2		3	7	3.9
Diptera	Tipulidae	*Pedicia*					1		4.4
Diptera	Tipulidae	*Pseudolimnophila*		4	6		14	13	2.3
Diptera	Tipulidae	*Tipula*			17		1	7	5.6
Diptera	Stratiomyidae	*Allognasta*			2				7.0
Diptera	Stratiomyidae	*Odontimyia*							7.0
Diptera	Tabanidae	*Chrysops*		4	3				5.0
Diptera	Tabanidae	*Tabanus*					10	5	4.3
Ephemeroptera	Caenidae	*Caenis*				1			5.4
Ephemeroptera	Heptageniidae	*Maccaffertium*		7	132				4.0
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*		21	72	4			1.7
Ephemeroptera	Leptophlebiidae	*Leptophlebia*					9	40	3.3
Plecoptera	Chloroperlidae	*Haploperla*			1				1.3
Plecoptera	Capniidae	*Allocapnia*					7	16	3.4
Plecoptera	Nemouridae	*Soyedina*					27	6	2.5
Trichoptera	Dipseudopsidae	*Phylocentropus*						5	5.0
Trichoptera	Hydropsychidae	*Cheumatopsyche*		19	148	7			5.5
Trichoptera	Hydropsychidae	*Hydropsyche*		2					5.8
Trichoptera	Hydropsychidae	*Diplectrona*					2		3.2
Trichoptera	Limnephilidae	*Hydatophylax*		3					2.5
Trichoptera	Limnephilidae	*Pycnopsyche*					54	84	3.7
Trichoptera	Molannidae	*Molanna*					3		6.0
Trichoptera	Philopotamidae	*Chimarra*		1	232				4.1
Trichoptera	Philopotamidae	*Dolophilodes*			4				0.6
Trichoptera	Phryganeidae	*Ptilostomis*	6	2		5	4	4	4.8
Trichoptera	Psychomyiidae	*Lype*		1					2.9
		Total Organisms per Sample:	603	1,402	988	1,659	1,126	1,164	= 8,264

Tolerance Values range from 0 (species is highly intolerant of pollution) to 10 (species is highly tolerant of pollution).

Tolerance values were averaged across those derived from three literature sources: (1) "Development of a Benthic Index of Biotic Integrity for Maryland Streams, 1998, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-98-3, Maryland Department of Natural Resources, (2) "Maryland Biological Stream Survey 2000-2004, New Biological Indicators to Better Assess the Condition of Maryland Streams, 2005, Chesapeake Bay and Watershed Programs, CBWP-MANTA-EA-05-13, Maryland Department of Natural Resources, and (3) "Benthic Macroinvertebrates in Freshwaters - Taxa Tolerance Values, Metrics, and Protocols, 2002, S.M. Mandaville, prepared for Soil and Water Conservation Society of Metro Halifax, Halifax, Nova Scotia.

Animals were identified in the laboratory; organisms were discarded once identified.

Table 7. Macroinvertebrate community metrics for UNT1 and UNT2, including the Hilsenhof biotic index.

Benthic Community Metric	UNT-Site 1	UNT-Site 2	UNT-Site 3	UNT-Site 4	UNT2-Upper	UNT2-Lower
Hilsenhof Biotic Index (scores defined below)	7.3	6.0	5.1	6.1	6.7	6.4
Number of Intolerent Taxa (tolerance values < 3.0)	0	4	5	1	4	3
Number of EPT Taxa	1	8	6	4	7	6
EPT Ratio	1.0%	4.0%	59.6%	1.0%	9.4%	13.3%
Percent Ephemeroptera Taxa	0.0%	2.0%	20.6%	0.3%	0.8%	3.4%
Percent Plecoptera Taxa	0.0%	0.0%	0.1%	0.0%	3.0%	1.9%
Percent Trichoptera Taxa	1.0%	2.0%	38.9%	0.7%	5.6%	8.0%
EPT to Diptera Ratio	0.11	0.34	2.25	0.25	0.11	0.22

Hilsenhof Biotic Index Score Definitons for Water Quality:
Scores of 0 to 4.5 are rated good
Scores of 4.51 to 6.5 are rated fair
Scores of 6.51 to 8.5 are rated poor
Scores of 8.51 to 10.0 are rated very poor

D. <u>Water Level and Stream Temperature Monitoring.</u> The continuous water level and stream temperature recorders were installed at ten sites on Walker Run, four sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2 (see Figure 3 for installation locations). These recorders were installed and began logging data on November 4th & 5th, 2009. The barologger was also installed and began logging data on November 4, 2009. The barologger data is used to compensate the pressure transducer data with air pressure. The set-up pages for these 16 pressure transducers are provided in Appendix G. Example data from Site11 after compensation for air pressure from the barologger is provided in Appendix A. The following paragraphs summarize the temperature, stream stage, and flow data collected between November 5, 2009 and June 22, 2010.

Temperature followed a diurnal fluctuation pattern at all sensor locations throughout the study period. Due to stream size, the tributaries consistently demonstrated greater variations of daily temperature than Walker Run. The temperatures in Walker Run during this time period approach 0 °C between December 2009 and February 2010 with a warmer period during a precipitation event on January 24th, 2010. Between November 2009 and February 2010, all the sensors stayed within a range of approximately 5 °C at any given time. Beginning in March 2010, the daily temperature variation between reaches began to increase to approximately 15 °C. Sensors indicated that most storm events resulted in a cooling effect on the stream temperature immediately following the storm event, especially within the unnamed tributaries. This cooling effect is most evident during the storm events in April and May 2010. Site 12 indicates wide temperature variability during warm weather, prior to canopy cover establishment. Once the canopy cover becomes established during early May 2010, Site 12 becomes less influenced by the diurnal fluctuation and less variable. See figures 4, 5, and 6 for a graph of stream temperatures at each station on Walker Run, the unnamed tributary, and the unnamed tributary 2 during the study period.

The stream stage for Walker Run decreased at a very moderate rate between November 2009 and June 2010, with the exception of periodic precipitation and snowmelt events. The most drastic example of a precipitation and melt event is evident on January 26, 2010. This precipitation event, while not the largest, produced the highest stream stages because of the combination with snow melt. March 1, 2010 was the beginning of another snow melt event which lasted until approximately March 15, 2010. This event is reflected in the temperature, stage and flow graphs for all the sensors. Precipitation events after May 20, 2010 do not exhibit as large of a response in stream stage as earlier precipitation events. This could be caused by the amount of vegetative cover and increased evapotranspiration rates present during the growing season and absent during the winter months. See figures 7, 8, and 9 for a graph on stream stage at each station on Walker Run, the unnamed tributary, and the unnamed tributary 2 during the study period. Low stream stage readings at Site 2 (figure 7) are a result of transducer setup. The transducer was installed in a riffle location and could not be set at the bottom of the thalweg, meaning the sensor cannot measure the lowest stream flows.

The flow data for Stations 4, 8 and 11 can be found in Figure 10. These stations were chosen based on the reliability of the measurements and the stability of the control section for flow calculation. HEC-RAS data was also available to generate rating curves for these stations. A flow balance was set up using Sites 4, 8 and 11 to determine if the system is a losing or gaining system.

Equation 1: *Outflow Station – Inflow Station₁ – Inflow Station₂ = Net Gain (or Loss)*
Following this equation, Station 8 was used as the outflow station while Station 4 and Station 11 were used as the inflow stations. The flow balance suggests that Walker Run is a slightly losing stream; however a full statistical analysis has not been conducted to determine if this is significant. The flow balance yielded an average of -0.33 cfs with a median flow of -0.37 cfs between November 4th, 2009 and June 28th, 2010. Sources of error and variability in the data collection and analysis include the field measurement of flow, field measurement of stage, the HEC-RAS modeling of the system, the development of the regression equations as well as the seasonal variability of the channel size and roughness. See figure 10 for a graph of stream flow at the stations throughout the study period.

Station 9 and Station 10 demonstrate the amount of sediment transported by Walker Run. Between 4/22/10 and 6/28/10, these transducers became isolated in fluvial sediment deposits. No other sensors in the study area indicated any depositional sediment around or near the sensors. The land uses adjacent to the streams are unlikely contributors of sediment to the stream system. Much of the land adjacent to the stream is forested. Some agricultural areas are present but were fallow in 2010 with crop residue and weed cover. There also was no known construction near the streams during the study period that could have contributed sediment. Likely sources of sediment include stream bank erosion and sediment transported after the beaver dam was removed on April 12th, 2010. The data collected from Sites 9 and 10 has been disregarded after 4/22/10, the last known successful data download.

Figure 4 : Stream Temperature of Walker Run at Bell Bend Nuclear Power Plant

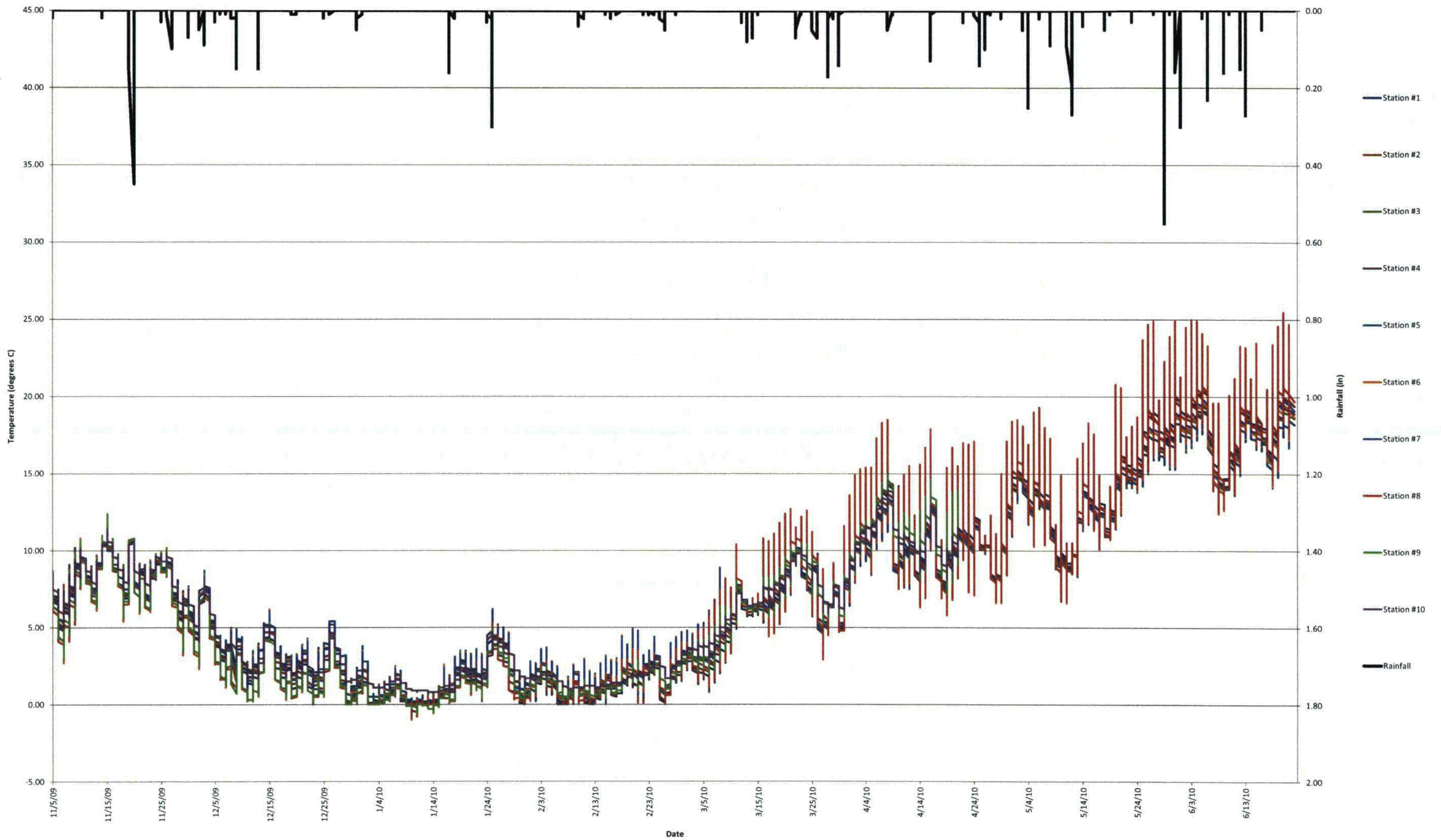
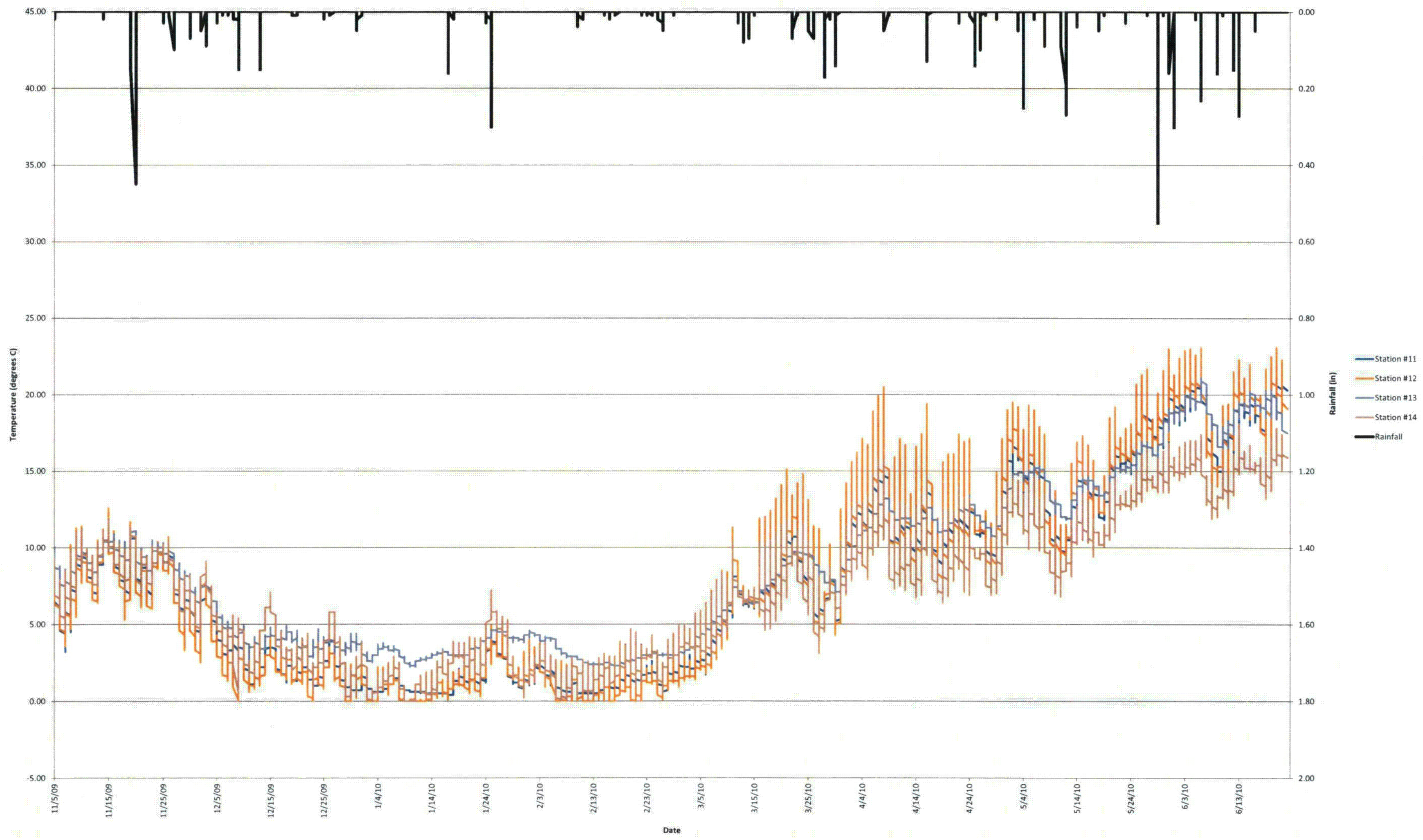


Figure 5 : Stream Temperature of the Unnamed Tributary to Walker Run at Bell Bend Nuclear Power Plant



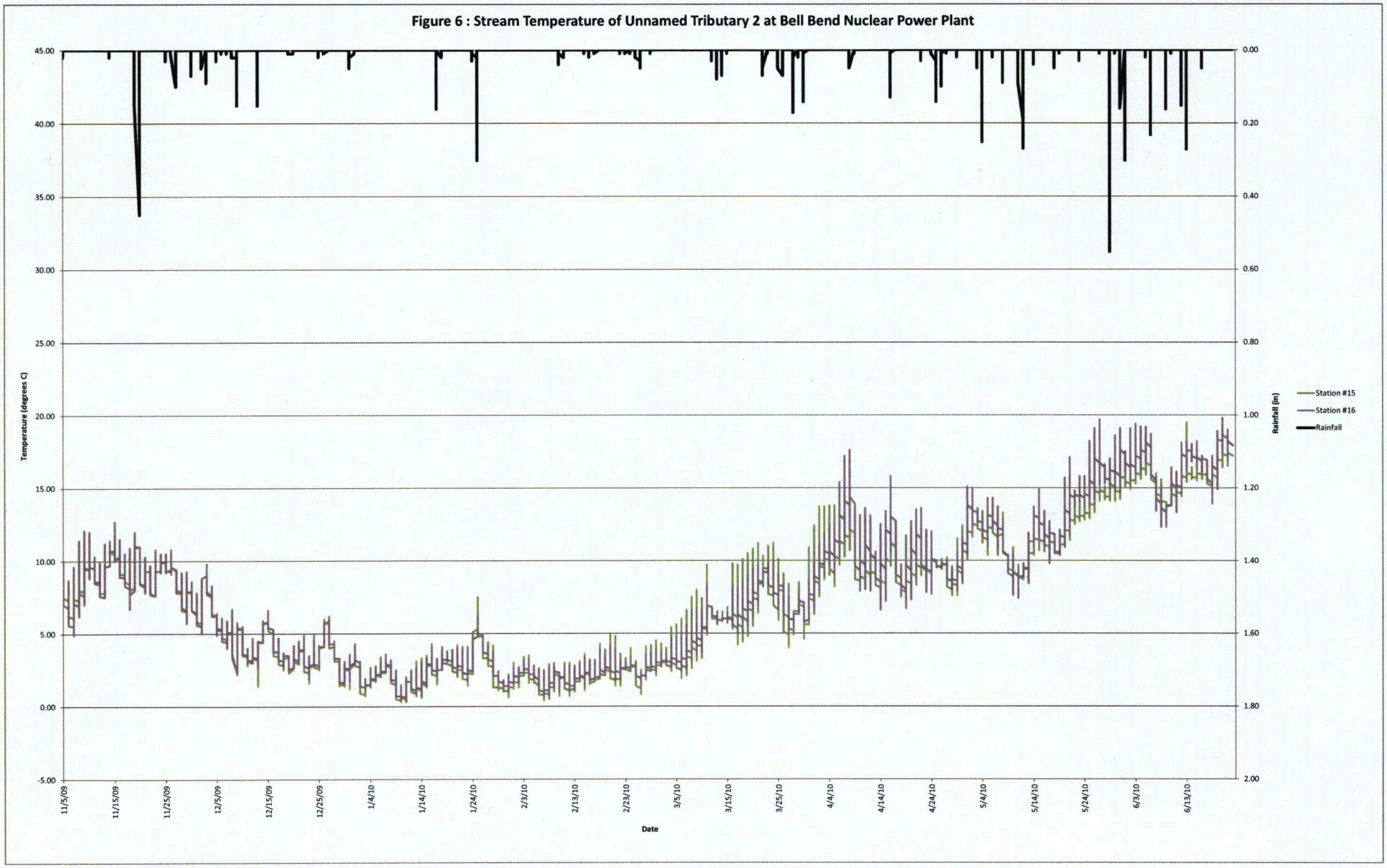


Figure 6 : Stream Temperature of Unnamed Tributary 2 at Bell Bend Nuclear Power Plant
Temperature (degrees C)
Rainfall (in)
Date
Station #15
Station #16
Rainfall

Figure 7 : Stream Stage of Walker Run at Bell Bend Nuclear Power Plant

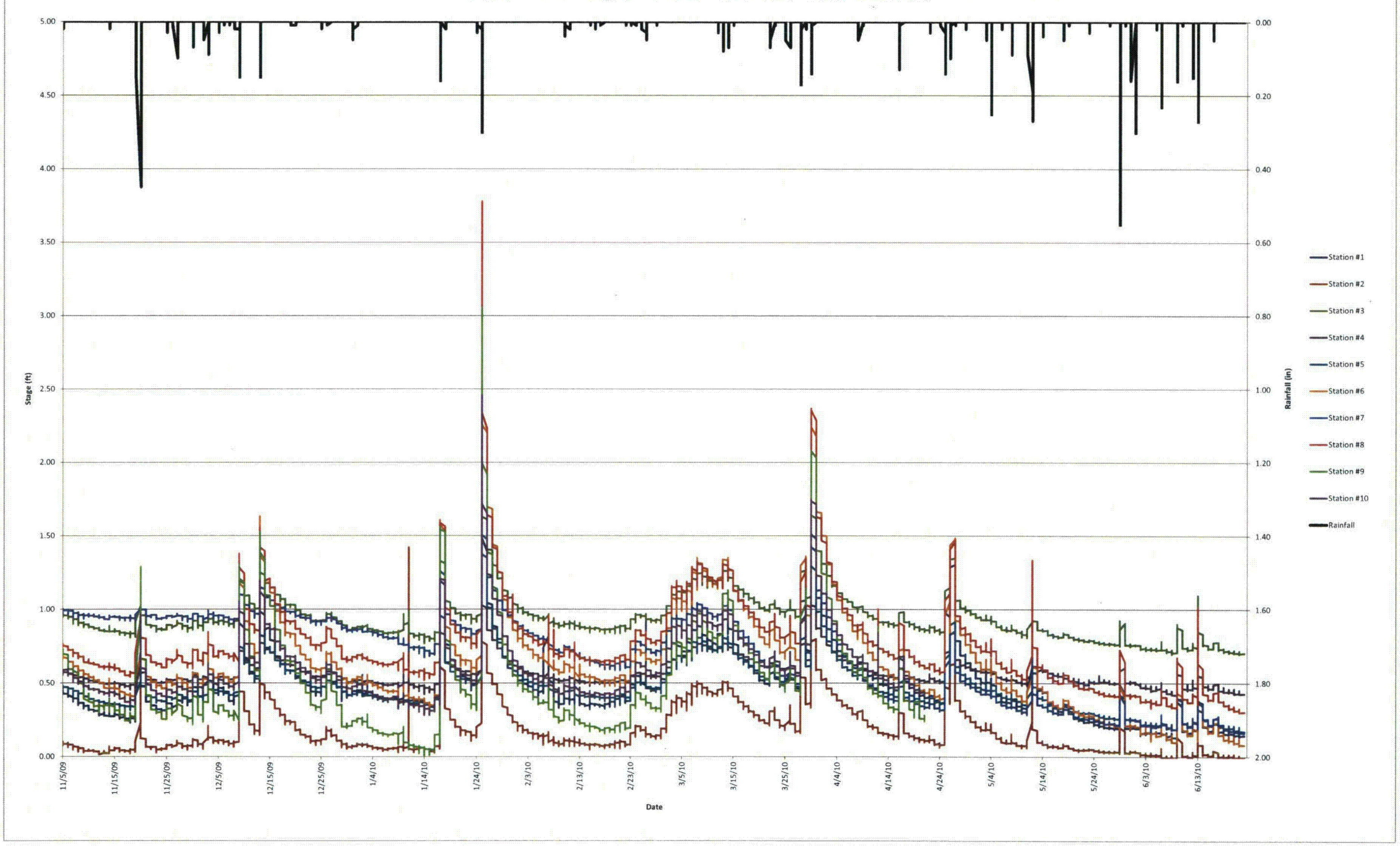


Figure 8 : Stream Stage at the Unnamed Tributary to Walker Run at Bell Bend Nuclear Power Plant

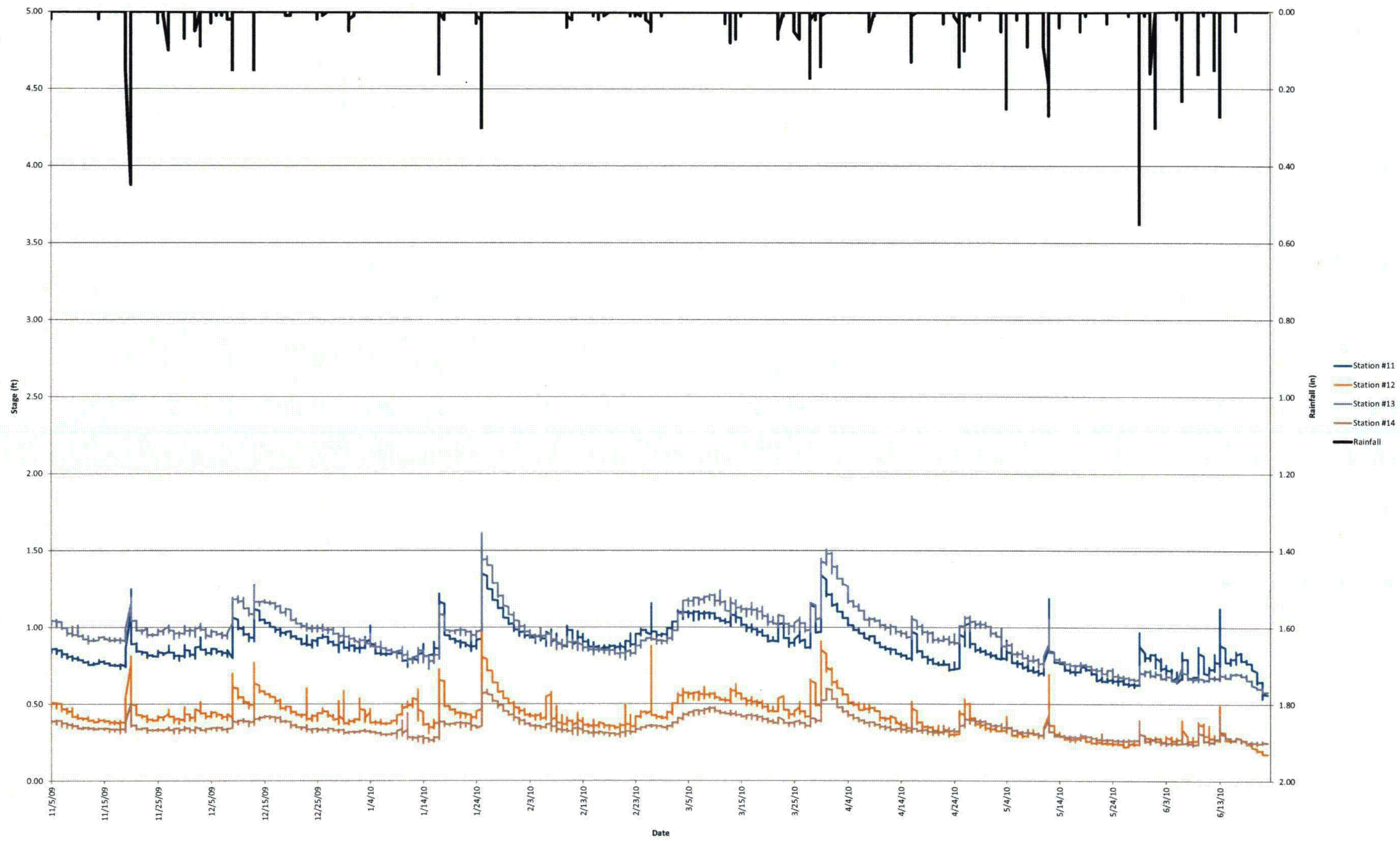


Figure 9 : Stream Stage at Unnamed Tributary 2 at Bell Bend Nuclear Power Plant

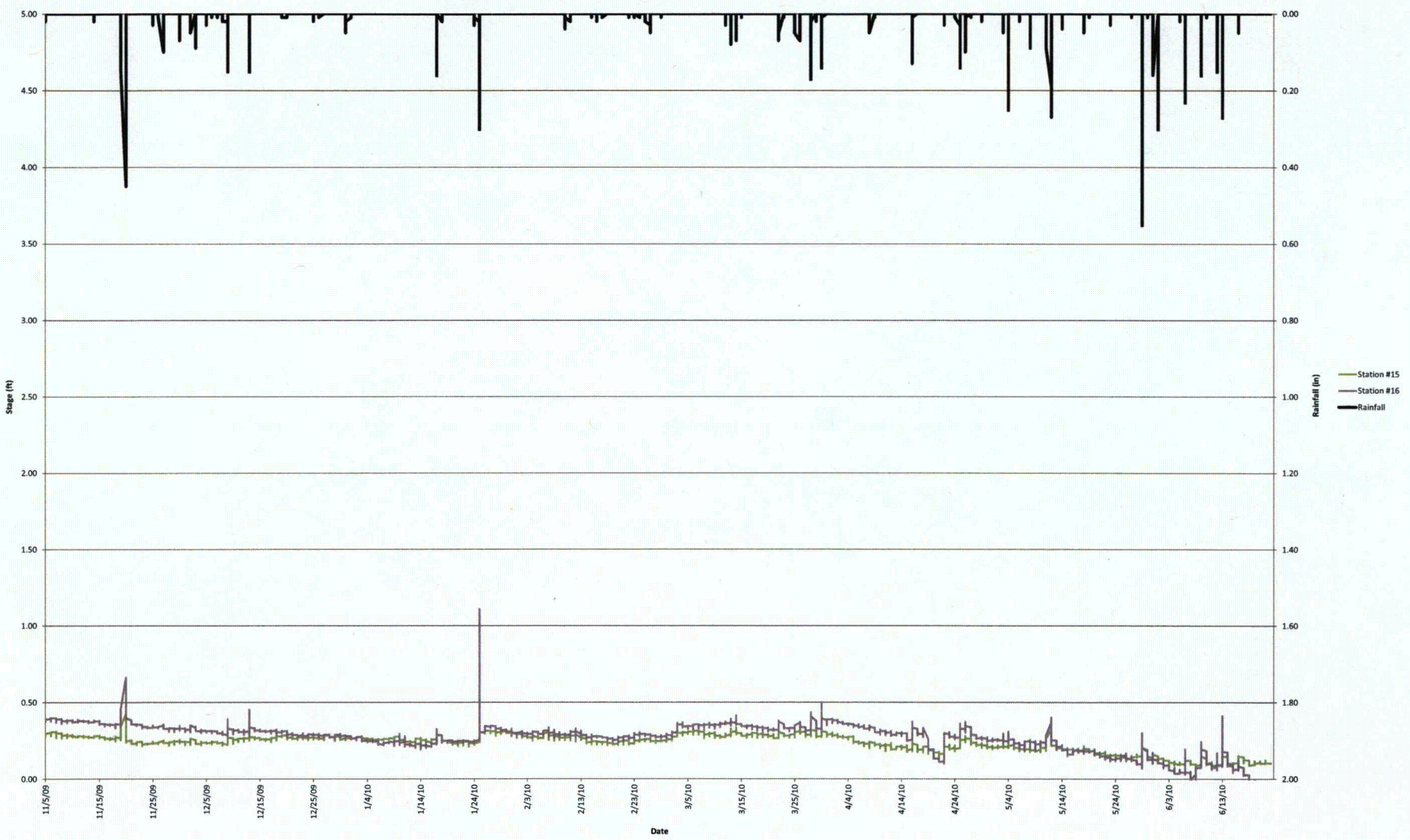
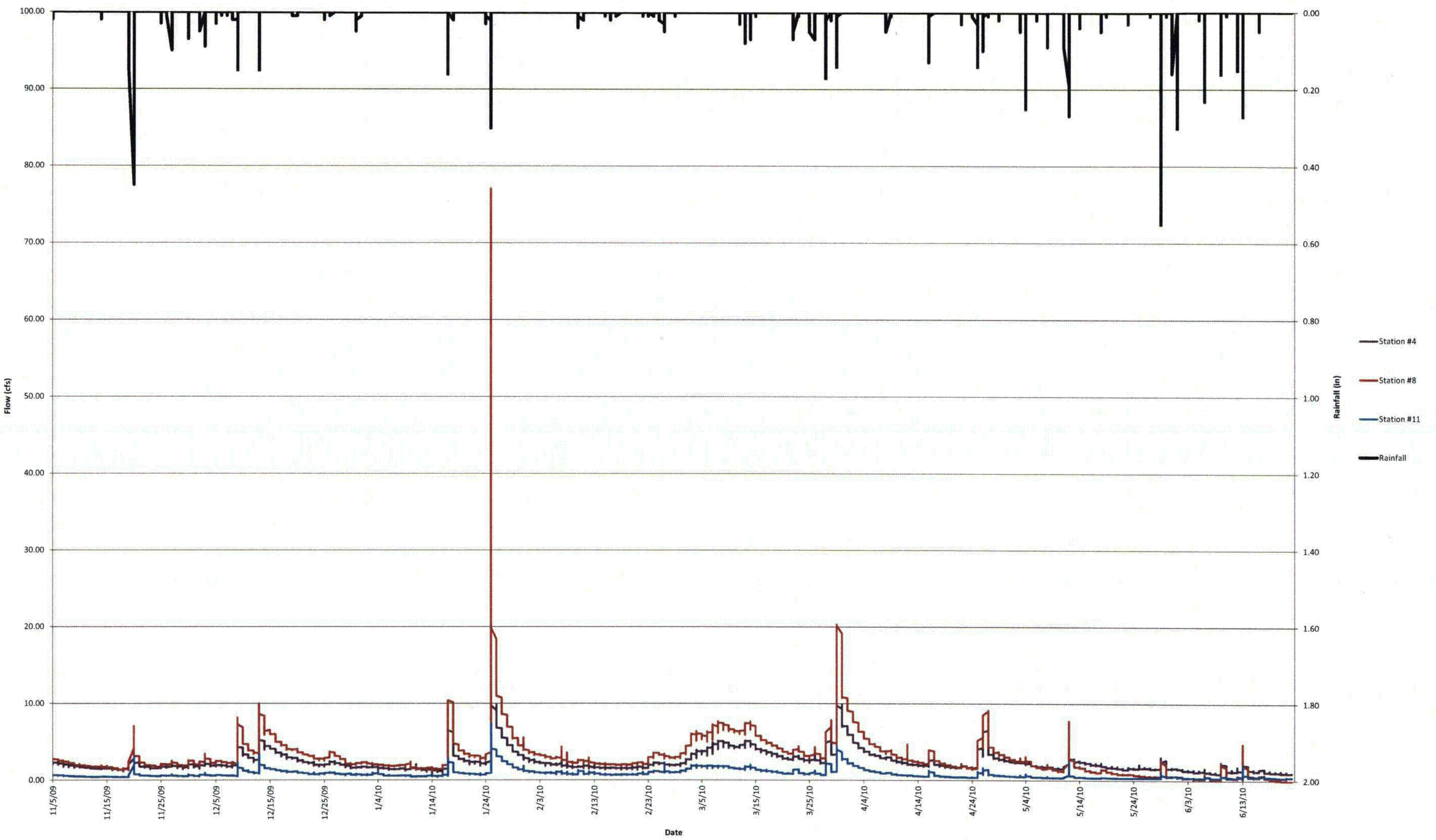


Figure 10 : Stream Flow at Walker Run and the Unnamed Tributaries at Bell Bend Nuclear Power Plant



F. Water Quality Field Data. Field water quality results for the six monitored sites on Walker Run, two sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2 are shown in Table 8b. The site locations for this monitoring are shown in Figure 3. These data were collected during a baseflow period in December 2009. Field water quality measurements included pH, dissolved oxygen, water temperature, and conductivity.

pH in Walker Run (sites 2 through 10 in Table 8b) ranged from 6.8 to 7.0, and dissolved oxygen ranged from 13.8 to 14.1 mg/L, both narrow ranges in the data. Water temperature in Walker Run ranged from 2.6 to 3.3 °C, which likely reflects the different times of day the field measurements were taken. These data are all typical of streams at this time of year.

Specific conductivity fell within a relatively narrow range of 93 to 120 μS/cm, and increased within this range as you move downstream in Walker Run. Specific conductivity is a measure of how well water can conduct an electrical current. Conductivity increases as the concentrations of negatively and positively charged ions dissolved in the water increases. Specific conductivity is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution. The specific conductivity measured in Walker Run is low.

pH measured at two sites in the Unnamed Tributary (sites 11 and 12 in Table 8b) was 7.2 and 7.3, with dissolved oxygen concentrations of 13.3 and 14.0 mg/L. Water temperature was 2.7 and 3.2 °C, all typical values for streams in December. Specific conductivity in the Unnamed Tributary was substantially higher than the other two streams, with levels of 288 and 314 μS/cm (Table 8b). The cause for the higher specific conductivity in the Unnamed Tributary is not known.

pH measured at two sites in Unnamed Tributary 2 (sites 15 and 16 in Table 8b) was 6.3 and 6.5, with dissolved oxygen concentrations of 11.7 and 13.1 mg/L. Water temperature was 4.4 and 5.8 °C. pH was somewhat lower in Unnamed Tributary 2 compared to the other two streams, as was dissolved oxygen. This likely reflects the intermittent underground flow of Unnamed Tributary 2. Water temperature in Unnamed Tributary 2 was higher than the other two streams, also reflecting the intermittent underground flow of Unnamed Tributary 2. Specific conductivity in Unnamed Tributary 2 was 110 and 68 μS/cm (Table 8b), reflecting more closely the specific conductivity of Walker Run.

Water Quality– Laboratory Data – Walker Run. Laboratory water quality analyses were completed at ten sites on Walker Run, two sites on the Unnamed Tributary, and two sites on Unnamed Tributary 2 (Table 8a). Water quality samples were collected during a baseflow period in December 2009. Water samples were collected for spectrophotometric analyses of alkalinity, turbidity, ammonia, nitrite, nitrate, and orthophosphate.

Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from acid mine drainage, rainfall or wastewater. Alkalinity refers

Table [illegible] Laboratory Water Quality Data for three streams at the Bell Bend [illegible] December 2009

DATE	SITE	TIME (hrs)	CONDITION	[illegible]	ALKALINITY (mg/L [illegible])	[illegible] ([illegible])	AMMONIA (mg/L-N)	NITRITE (mg/L-N)	NITRATE (mg/L-N)	[illegible] PHOSPHATE (mg/L [illegible])
12/08/09	1	1455	baseflow	present	25	0	0.04	0.006	0.695	0.09
12/08/09	2	1505	baseflow	present	20	0	0.07	0.004	0.605	0.07
12/08/09	3	1515	baseflow	present	30	0	0.01	0.002	0.905	0.07
12/08/09	4	1440	baseflow	present	25	0	0.01	0.002	0.760	0.05
12/08/09	5	1430	baseflow	present	25	0	0.01	0.003	0.780	0.06
12/08/09	6	1420	baseflow	present	35	4	0.03	0.002	0.650	0.05
12/08/09	7	1410	baseflow	present	15	0	0.01	0.001	0.745	0.06
12/08/09	8	1400	baseflow	present	20	0	0.02	0.004	0.705	0.01
12/08/09	9	1352	baseflow	present	15	0	0.02	0.002	0.650	0.07
12/08/09	10	1340	baseflow	present	5	4	0.02	0.002	0.695	0.03
12/08/09	11	1555	baseflow	present	50	4	0.03	0.005	0.204	0.05
12/08/09	12	1610	baseflow	present	60	2	0.02	0.005	0.257	0.07
12/08/09	15	1540	baseflow	present	30	8	0.03	0.004	0.177	0.12
12/08/09	16	1620	baseflow	present	70	2	0.02	0.001	0.189	0.07

Table [illegible] Water Quality Field Data for three streams at the Bell Bend [illegible] December 2009

DATE	SITE	TIME (hrs)	CONDITION	[illegible]	DISSOLVED OXYGEN (mg/L)	[illegible] TEMPERATURE (°C)	[illegible] CONDUCTANCE (µS/cm)
12/10/09	2	1640	baseflow	6.93	14.10	3.03	96
12/10/09	4	1630	baseflow	7.00	14.02	3.10	93
12/10/09	5	1615	baseflow	6.90	14.12	2.79	96
12/10/09	7	1540	baseflow	6.81	14.10	3.35	100
12/10/09	9	1605	baseflow	6.88	13.84	2.68	116
12/10/09	10	1455	baseflow	6.94	14.00	2.61	120
12/10/09	11	1501	baseflow	7.23	14.01	2.67	288
12/10/09	12	1420	baseflow	7.30	13.35	3.22	314
12/10/09	15	1435	baseflow	6.54	13.09	4.44	110
12/10/09	16	1400	baseflow	6.25	11.68	5.77	68

to the ability of water to resist changes in pH. These buffering materials are primarily bicarbonate (HCO_3), and carbonate (CO_3), and occasionally hydroxide (OH^-).

Alkalinity in Walker Run ranged from 5 to 35 mg/L $CaCO_3$, with levels higher and relatively constant (20 to 35 mg/L $CaCO_3$) from the upstream end of Walker Run downstream to site 6 (Table 8a). Site 6 is located just downstream from the forested area at the upper North Market Street crossing (see Figure 3 for locations). These levels are typical for streams. Alkalinity further downstream in Walker Run, from site 7 through site 10, was lower and ranged from 5 to 20 mg/L $CaCO_3$, indicating a lower ability of the stream to resist changes in pH due to acidic pollution.

Turbidity was low in Walker Run, which is expected during baseflow conditions. Ammonia was low (0.01 to 0.03 mg/L) at all Walker Run sites except the two most upstream sites (sites 1 and 2), where levels were 0.04 to 0.07 mg/L. This could reflect land use practices further upstream from these sites in the Walker Run watershed. Nitrite levels were all low in Walker Run, ranging from 0.001 to 0.006 mg/L. Nitrate levels were also low in Walker Run, ranging from 0.61 to 0.91 mg/L.

Orthophosphate concentrations in Walker Run ranged from 0.01 to 0.09 mg/L. The majority of the sites exhibited elevated concentrations of orthophosphate from 0.05 to 0.09 mg/L, with the exception of sites 8 and 10 where concentrations were 0.01 and 0.03 mg/L. Orthophosphate concentrations are typically higher in winter, notwithstanding seasonal inputs to the stream), because there is slowed biological uptake of nutrients due to low temperature reductions in metabolic rates.

Water Quality – Laboratory Data – the Unnamed Tributary. Laboratory water quality analyses were completed at two sites on the Unnamed Tributary (sites 11 and 12; see Figure 3). Alkalinity in the Unnamed Tributary was 50 and 60 mg/L $CaCO_3$, which was higher than in Walker Run (Table 8a). These levels indicate a high ability of the stream to resist changes in pH due to acidic pollution.

Turbidity was low in the Unnamed Tributary, which is expected during baseflow conditions. Ammonia was low (0.02 and 0.03 mg/L) at the two sites, and nitrite levels were also low (0.005 mg/L). Nitrate levels (0.20 and 0.26 mg/L) were also low in the Unnamed Tributary, and were lower than in Walker Run.

Orthophosphate concentrations in the Unnamed Tributary were 0.05 and 0.07 mg/L, similar to concentrations found at most sites in Walker Run.

Water Quality – Laboratory Data – Unnamed Tributary 2. Laboratory water quality analyses were completed at two sites on Unnamed Tributary 2 (sites 15 and 16; see Figure 3). Alkalinity in Unnamed Tributary 2 was 30 and 70 mg/L $CaCO_3$, which was similar to the Unnamed Tributary (Table 8a). These levels indicate a moderate to high ability of the stream to resist changes in pH due to acidic pollution.

Turbidity was low in Unnamed Tributary 2, which is expected during baseflow conditions (Table 8a). Ammonia was low (0.02 and 0.03 mg/L) at the two sites, and nitrite levels were also low (0.004 and 0.001 mg/L). Nitrate levels (0.18 and 0.19 mg/L) were very low in Unnamed Tributary 2, and were lower than either Walker Run or the Unnamed Tributary.

Orthophosphate concentrations in Unnamed Tributary 2 were 0.07 and 0.12 mg/L, which are higher than most concentrations found in Walker Run and the Unnamed Tributary. The 0.12 mg/L concentrations were found in the lower reach of Unnamed Tributary 2 (site 15; see figure 3), potentially reflecting inputs from the crop field. It is not known whether drain tiles in the field contribute flow to the stream before it reaches the forested lower reach.

IV. SUMMARIES – STREAMS AT THE BELL BEND PROJECT SITE

A. Walker Run. The substrate embeddedness and composition survey found poor habitat conditions (high substrate embeddedness, low gravel and cobble substrate composition) in Walker Run from Reach 3 (upstream of the upper North Market Street crossing) to the most downstream survey reach. The dominant substrate component in this segment of Walker Run was sand and silt. Photographs of the stream and substrate in this segment of Walker Run are provided in Appendix D (pages 15 through 49). Photograph locations in Appendix D refer to the station and transect numbers provided in Table 2, which cross-reference the stream reaches shown on the map in Figure 1.

The upstream segment of Walker Run, from Reach 2 (just downstream of the Beach Grove Road crossing) to Reach 1 (about 1,000 ft upstream of Beach Grove Road) had good habitat conditions. Stream embeddedness was much lower, and the gravel and cobble component dominated the substrate and was over three times higher than in the downstream segment of Walker Run. Photographs of the stream and substrate in this segment of Walker Run are provided in Appendix D (pages 1 through 14).

Additional photographs of Walker Run habitat are provided in Appendix E (pages 1 through 12). These photographs show the stream at locations where the water level and stream temperature recorders were installed. Photograph locations in Appendix E reference the sites shown on the map in Figure 3.

These habitat quality findings parallel those in the habitat assessment surveys, macro-invertebrate surveys, and spawning gravel surveys of Walker Run completed in April 2009[8]. In those surveys, the three surveyed reaches of Walker Run upstream of Beach Grove Road all had optimal to suboptimal habitat quality scores from habitat assessments, while the three reaches downstream from Beach Grove Road had marginal habitat quality scores. The macroinvertebrate surveys in the April 2009 study showed Hilsenhof Biotic Index scores of 2.6 to 2.8 for the four upstream reaches, indicating good water quality (which includes the reach just downstream from Beach Grove Road), and biotic index scores of 4.1 and 5.8 for the two downstream reaches, indicating fair water quality. The spawning gravel findings from the April

[8] LandStudies, Inc. 2009. Walker Run Surveys: Wild Trout Habitat Assessment. Prepared for PPL Bell Bend Nuclear Power Plant, Salem Township, Luzerne County, Pennsylvania. May 2009.

2009 survey paralleled the macroinvertebrate findings in the April 2009 survey, and also paralleled the substrate embeddedness findings of this present study.

The ten water level and stream temperature recorders installed in Walker Run have provided continuous data temperature and water depth data. Photographs of Walker Run at these ten installation sites (site locations shown in Figure 3) are provided in Appendix E (pages 1 through 12). Walker Run's daily temperature fluctuation was smaller than the unnamed tributaries. Stream temperature monitoring demonstrated a diurnal fluctuation in temperature with a maximum recorded temperature of 25.5 °C at Station 8 on 6/20/2010. Stations 9 and 10 were disabled due to sediment at the time of the maximum water temperatures. The two most downstream transducers became perched on sediment deposits indicating significant stream bank erosion within Walker Run. The stage data indicates that Walker Run had continuous flow during the study period and the flow data suggests that it is a flow balanced system for the majority of the study period.

Water quality monitoring in this study provides a single day snapshot for Walker Run, and does not capture seasonal or annual variability. Several findings, however, are noteworthy from this snapshot monitoring. Specific conductivity was low throughout Walker Run, and was lowest in the upstream segment of the stream. This indicates that dissolved solids are low in the stream. Alkalinity is low in the downstream reaches of Walker Run (sites 7 through 10 in Figure 3), indicating a poor ability to buffer the stream from acidic pollution. This low alkalinity segment of Walker Run begins at the access road to the project site from North Market Street and extends to the most downstream reach that was monitored.

Ammonia concentrations were high at the two most upstream monitoring sites (sites 1 and 2; see Figure 3). These high ammonia concentrations likely reflect upstream watershed land uses. Orthophosphate concentrations were elevated throughout Walker Run. These high concentrations may also reflect watershed land use inputs of orthophosphate. Additional water quality monitoring across seasons and hydrologic events (baseflow and stormflow conditions) would be needed to better understand these nutrient conditions in Walker Run.

B. Unnamed Tributary. The Unnamed Tributary is a small, narrow stream with an average width of about 2.5 ft and an average water depth, at the time of sampling, of 0.1 ft. The stream begins in the northern part of the project area and flows eastward through a forested area (site 14 in Figure 3). It then turns 90° to the south and enters a pond formed by impounding the stream. The stream then flows through a forested and emergent wetland area (site 4 in Figure 2; site 13 in Figure 3). Further downstream, the Unnamed Tributary turns west and flows through a forested area (sites 2 and 3 in Figure 2). Unnamed Tributary 2 joins the stream in this forested area. The stream then flows through an emergent wetland area (site 1 in Figure 2), where it is partially influenced by the backwater from a beaver dam on Walker Run. The Unnamed Tributary joins Walker Run just upstream of the beaver dam.

Photographs of the Unnamed Tributary at sites 1 through 4 (site locations shown in Figure 2) are provided in Appendix B.

The substrate embeddedness and composition survey found poor habitat conditions (very high substrate embeddedness, gravel and cobble substrate typically absent) in the two surveyed reaches of the Unnamed Tributary. The substrate was almost entirely composed of sand and silt. Photographs of the stream and substrate in this segment of Walker Run are provided in Appendix D (pages 50 through 63). Photograph locations in Appendix D refer to the station and transect numbers provided in Table 2, which cross-reference the stream sites shown on the map in Figure 2.

The habitat quality in was found to be marginal in the habitat assessment surveys of four reaches in the Unnamed Tributary (photographs provided in Appendix B). Macroinvertebrate community surveys showed fair to poor water quality as determined using the macroinvertebrate biotic index. These two surveys, in conjunction with the substrate embeddedness and composition survey, all indicate marginal to poor habitat conditions in the Unnamed Tributary.

The four water level and stream temperature recorders installed in the Unnamed Tributary provided continuous data on the variability in water depths and temperature. Photographs of the Unnamed Tributary at these four recorder installation sites (site locations shown in Figure 3) are provided in Appendix E (pages 13 through 17). Temperature within the Unnamed Tributary has a greater daily fluctuation than Walker Run due to its smaller size and had a maximum temperature of 23.1 °C on 6/20/10 at Station 12. The cooling effect of storm events plays a much greater role in the Unnamed Tributary than it does in Walker Run. The stage and flow data for the Unnamed Tributary indicates that it had continuous flow during the study period.

Water quality in the Unnamed Tributary was generally typical of streams. The Unnamed Tributary did exhibit high specific conductivity and high alkalinity when compared to the other three streams monitored in this study. Orthophosphate concentrations were high in the Unnamed Tributary, as they were in the other three streams monitored in this study.

C. Unnamed Tributary 2. Unnamed Tributary 2 is small, narrow stream with an average width of about 2.2 ft and an average water depth, at this time of year, of 0.2 ft. Unnamed Tributary 2 is unique among the four streams surveyed in this study, as it has two stream segments that flow underground. There are headcuts in both the upper and lower reaches of Unnamed Tributary 2 that are documented in Figure 2 and in the photographs in Appendix C. These photographs reference the stream locations shown in Figure 2. Unnamed Tributary 2 is also unique in that it is piped underneath a crop field between the upper and lower reaches (see Figure 2).

The substrate embeddedness and composition survey found poor habitat conditions (very high substrate embeddedness, gravel and cobble substrate typically absent) in the two reaches of Unnamed Tributary 2. The substrate was almost entirely composed of sand and silt. Photographs of the substrate in Unnamed Tributary 2 are provided in Appendix C.

The stream habitat quality was found to be marginal in the habitat assessment surveys of two reaches in Unnamed Tributary 2. Macroinvertebrate community surveys showed fair to poor water quality as determined using the macroinvertebrate biotic index. These two surveys, in

conjunction with the substrate embeddedness and composition survey, all indicate marginal to poor habitat conditions in Unnamed Tributary 2.

The two water level and stream temperature recorders installed in Unnamed Tributary 2 provided continuous data on the variability in water depths and temperature. Photographs of Unnamed Tributary 2 at these two recorder installation sites (site locations shown in Figure 3) are provided in Appendix E (pages 18 through 19). Temperature within the Unnamed Tributary 2 has a greater daily fluctuation than Walker Run due to its smaller size and had a maximum temperature of 19.8 °C on 6/20/10 at Station 16. The pipe that connects the teardrop wetland to the Unnamed Tributary cools the water before it enters the unnamed tributary. The stage data indicates that the Unnamed Tributary 2 had continuous flow during the study period.

Water quality in Unnamed Tributary 2 was somewhat different than in Walker Run and the Unnamed Tributary. The lower pH and dissolved oxygen, and higher stream temperature, likely reflect the intermittent underground flow of Unnamed Tributary 2.

Nitrate levels (0.18 and 0.19 mg/L) were very low in Unnamed Tributary 2, and were lower than in either Walker Run or the Unnamed Tributary. Orthophosphate concentrations in Unnamed Tributary 2 were higher than most concentrations found in Walker Run and the Unnamed Tributary, with the highest orthophosphate concentration possibly reflecting inputs from the crop field.

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