Silas Creek
Stream Restoration Project
Winston-Salem, North Carolina

Mitigation Plan

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

Prepared By:

BUCK ENGINEERING

1347 Harding Place
Suite 100
Charlotte, North Carolina 28204
Phone: 704.334.4454
Fax: 704.334.4492
www.buckengineering.com

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Shawn Wilkerson
Project Manager

Karen J. Missell
Project Scientist

Executive Summary

In 2003, the North Carolina Ecosystem Enhancement Program (EEP, formerly the Wetlands Restoration Program) restored 4,287 linear feet of stream along three reaches of Silas Creek and one reach of Buena Vista Branch in Winston-Salem, North Carolina. The reaches are located in Shaffner Park. These streams are tributaries to Muddy Creek (USGS Hydrologic Unit 03040102) and are in the Yadkin River basin.

The existing stream channels had low sinuosity and varying levels of incision due to historic channelization. The stream restoration design was based on natural channel design principals and considered differences in drainage area, adjacent land uses, upstream impoundments, and future development potential. The design addressed the channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships. When considering design alternatives, every effort was made to create a stable meandering channel with bankfull stage located at the existing floodplain elevation. Where valley or development restrictions did not allow for new channel pattern to be established, the existing incised channels were enhanced by excavating new floodplain benches and installing structures to improve bed features and control channel grade.

The project included enhancement of three reaches on Silas Creek. An additional 114 feet of channel was created on the Buena Vista Branch. A summary of existing and restored reach lengths with restoration design approaches is provided in the table below.

Reach	Existing Length (ft)	Restored Length (ft)	Restoration Approach
Silas Reach 1	999	999	Instream structures installed to change channel dimension and profile over time and cut new floodplain at bankfull elevation. Priority 3 restoration of incised channel.
Silas Reach 2	897	897	Instream structures installed to change channel dimension and profile over time and cut new floodplain at bankfull elevation. Priority 3 restoration of incised channel.
Silas Reach 3	1771	1771	Instream structures installed to change channel dimension and profile over time and cut new floodplain at bankfull elevation. Priority 3 restoration of incised channel.
Buena Vista	668	782	Change dimension, pattern, and profile. Priority 2/3 restoration.
Total	**4,335**	**4,449**	

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1 Introduction

1.1 Project Goals

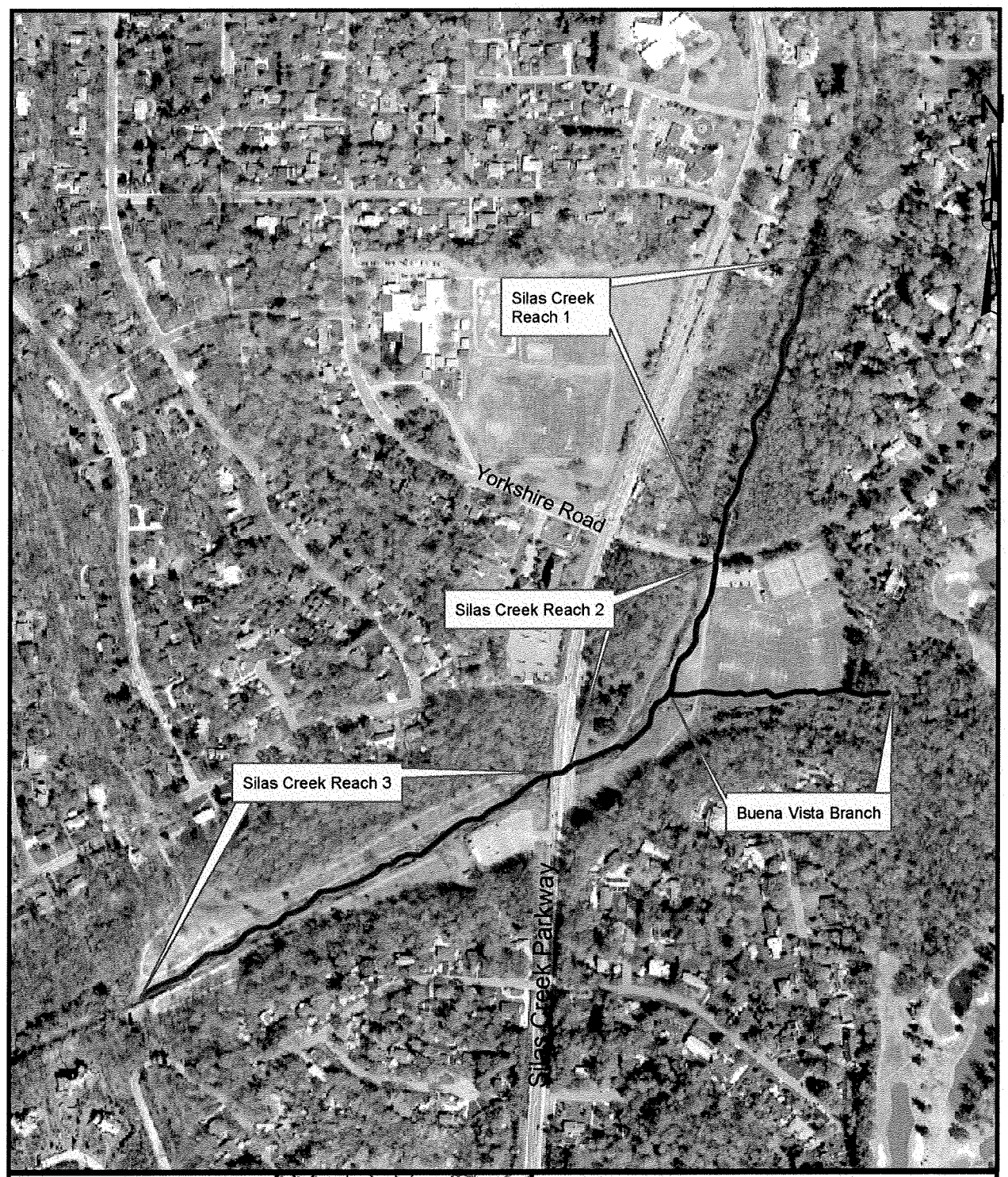
The Silas Creek Stream Restoration Project is one component in the enhancement of the Silas Creek watershed. The overall goal is to improve the water quality, habitat, and stability within this urban watershed. As in many developed watersheds, the increase of peak flow events, loss of floodplains and adjacent wetlands, and conventional engineering of streams has caused a substantial loss of the ecological value and has resulted in degraded water quality. By stabilizing channels, preserving and installing riparian buffers, enhancing habitat structure, allowing natural storage capacity for storm flows, and constructing necessary storm water treatment BMPs, the overall watershed health can be restored to Silas Creek.

The objectives of the Silas Creek stream restoration project are to enhance the Silas Creek watershed by:

- Restoring 4,449 LF of channel dimension, pattern, and profile to the extent possible considering the project constraints, watershed characteristics, and data from reference reaches in similar watersheds;
- Improving floodplain functionality by matching floodplain elevation with bankfull stage therefore increasing watershed attenuation and reducing peak flows;
- Establishment of native floodplain vegetation which will allow treatment of diffuse storm flow and nutrient uptake while establishing part of a wildlife corridor in the watershed;
- Improving the natural aesthetics of the stream corridor; and,
- Improving the water quality in the Silas Creek watershed by reducing bank erosion, increasing nutrient storage and uptake, and increasing the dissolved oxygen of the system.

1.2 Project Location

The project site is located in the city of Winston-Salem in the urban Piedmont physiographic region (figure 1.1). The topography is characterized by gently rolling hills and wide alluvial valleys with a dendritic stream pattern.



Forsyth County

NorthCarolina
Ecosystem Enhancement Program

Figure 1.1: Silas Creek Location Map
Winston Salem, NC
Forsyth County

0 500 1,000 Feet

2 Summary

2.1 Project Description and Watershed

The overall drainage area for the project watershed is 7.2 square miles. The project is divided into 3 reaches on Silas Creek and one reach on the Buena Vista Branch based on drainage area, construction sequence, and road crossings (Figure 2.1). Reach 1 is from the point where Silas Creek enters Shaffner Park to Yorkshire Road. Reach 2 is from Yorkshire Road to Silas Creek Parkway and Reach 3 is from Silas Creek Parkway to the point where Silas Creek flows out of Shaffner Park (Figure 2.1). The project reach lengths and their respective drainage areas are listed in Table 2.1.

Table 2.1 Project Reaches with Existing Lengths and Drainage Areas.

Reach Name and Location	Existing Length (ft)	Drainage Area (mi^2)
Silas Reach 1	999	5.4
Silas Reach 2	897	5.4-7.2
Silas Reach 3	1771	7.2
Buena Vista	668	1.4
Total	**4,335**	

2.2 Methodologies

Buck Engineering used natural channel design principles and considered differences in drainage area, adjacent land uses, and future development potential to redesign the stream to the highest level of restoration within the given constraints. The design addressed the channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships. When considering design alternatives, every effort was made to create a stable meandering channel with bankfull stage located at the existing floodplain elevation. Where valley or development restrictions did not allow for new channel pattern to be established, the existing incised channels were enhanced by excavating new floodplain benches at the bankfull stage and installing structures to improve bed features and control channel grade.

This process included extensive planning beginning with the existing condition survey. Field data collected included: longitudinal profile and cross sections, bed material analysis, valley morphology, stream classification, channel stability assessment, channel

evolution, riparian conditions, water quality impacts, and photographs. Other data analyzed included watershed analysis and land use survey (historical and present). The second step in the planning process was an analysis of stream potential and restoration alternatives (priority levels of restoration, urban considerations, and built-out scenarios). Design procedures were conducted concurrently with planning. These included reference reach analysis, verification of bankfull using the rural and urban Piedmont regional curves, restored channel morphology design (channel dimension, pattern, and profile), sediment transport analysis, structure design and placement, streambank stabilization/bioengineering, design of an erosion and sediment control plan, flood impact analysis, and completion of design plans. Finally, Buck Engineering conducted construction management including field layout, construction supervision, preparation of the as-built survey, and collection of photographs.

2.3 Plan View

See separate set of plan sheets included (Figure 2.1)

2.4 Points of Contact

Design Firm:

Buck Engineering
Point of Contact – Mr. Shawn Wilkerson (swilkerson@buckengineering.com)
1347 Harding Place, Suite 100
Charlotte, North Carolina 28204
(704) 334-4454 x101
Fax (704) 334-4492

Construction Firm:

North State Environmental, Inc
Point of Contact – Darrell Westmoreland (darrell@nsenv.com)
2889 Lowery St. Suite B
Winston Salem, NC 27101
336-725-2010
Fax (336) 375-1801

NC EEP Project Manager:

Point of Contact – Mr. Jeff Jurek (Jeff.Jurek@ncmail.net)
1619 Mail Service Center
Raleigh, North Carolina 27699-1619
(919) 733-5208
Fax (919) 733-5321

3 Success Criteria

Environmental components monitored in this project are those that allow an evaluation of channel stability and riparian survivability. Specifically, the success of channel modification, erosion control, seeding, and woody vegetation plantings will be evaluated. This will be accomplished through the following activities for 5 years after the project is built.

3.1 Dimension

Nine permanent cross-sections were established on Silas Creek for a total of 5 riffles and 4 pools. Two permanent cross-sections, a riffle and a pool, were established on Buena Vista. Each cross-section is marked on both banks with permanent pins set in concrete to establish the exact transect used. A common benchmark is used for cross-sections to facilitate easy comparison of year-to-year data. The as-built cross-section survey includes points measured at all breaks in slope, including top of bank, bankfull, and thalweg. In the future, points will be measured at all breaks and slope, as well as at three foot intervals across the section. This will ensure that points are taken at the same locations each year. Riffle cross-sections will be classified using the Rosgen stream classification system (Figures 2.1a-d).

Success Criteria: Minor changes such as settling, increase in vegetative density, deposition along the banks, decrease in width/depth ratio, and a decrease in cross sectional area may occur. Such changes are indicative of the stream moving towards stability. Larger shifts in cross-sectional area should be evaluated to determine if they represent a movement toward a more unstable condition such as down-cutting, erosion, bank failure and mitigation strategies should be developed.

3.2 Pattern and Profile

A longitudinal profile was completed after construction and will be repeated every two years for a total of five years (for a total of 4 times). Measurements include thalweg, water surface, bankfull, and top of low bank. Each measurement is taken at the head of feature, e.g. riffle, run, pool, and glide, and the maximum pool depth. Cross section pins shall serve as permanent benchmarks. The survey is also used to calculate sinuosity.

Success Criteria: The as-built longitudinal profiles should show that the bedform features are remaining stable, e.g., they are not aggrading or degrading over the 5-year period. Short term aggradation/degradation may occur depending on the peak annual discharge. The gravel bed pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed in "E" and "Bc" type channels. The pattern should not change and there should be no change in sinuosity. The pool/riffle sequence should also remain constant.

3.3 Bed Material Analysis

Annual pebble counts will be performed on all gravel-bed project reaches based on the percent of pools and riffles.

Success Criteria: Established D50 and D85 should increase in coarseness in riffles, and increase fineness in pools.

3.4 Photo Reference Sites

Photographs used to evaluate restored sites will be made with a 35-mm camera using slide film or a digital camera. Reference sites were photographed after construction and will be taken once a year for at least 5 years following construction. Reference sites were marked with wooden stakes and were located on as-built drawings.

Longitudinal reference photos: Photographs will be taken looking downstream at delineated locations (figure 2.1). Reference photo locations were marked and described for future reference. Points are close enough together to provide an overall view of the reach. When modifications of stream position have to be made due to obstructions or other reasons, the position will be noted along with any landmarks and the same position used in the future.

Lateral reference photos: Reference photo transects will be taken at each permanent cross-section. Photographs will show both banks at each cross-section. The water line will be located in the lower edge of the frame and as much of the bank as possible included in each photo. Photographers should make an effort to consistently maintain the same area in each photo over time. These locations were also marked with wooden stakes.

Success Criteria: Photographs will be used to qualitatively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

3.5 Vegetation Survival Plots

Survival of live stakes and bare root woody vegetation will be evaluated using two plots, one along Silas Creek and the other along Buena Vista Branch. Evaluations of live stake and bare root woody vegetation survival will continue for at least 5 years. When

vegetation does not survive a determination will be made as to the need for replacement; in general if greater than 25% die, replacement will be done.

Success Criteria: The interim measure of vegetative success will be the survival of at least 320 3-year old planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260 5-year old planted trees per acre at the end of year five of the monitoring period. In addition, for the five year monitoring period, the presence of volunteer facultative softwood species such as red maple, sweet gum, and loblolly pine will be limited to less than 10% each of the total number of trees utilized to determine success. These trees may contribute more than 10% of the total trees on the site, but they will not constitute more than 10% each of the 260 trees per acre.

3.6 Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate monitoring will be conducted by the NC Division of Water Quality.

4 Monitoring Schedule and Methods

Monitoring will be conducted annually for five years. Buck Engineering conducted the as-built survey in October 2003 and annual surveys will be conducted in October starting in 2004 and ending in 2008.

The cross sections will be surveyed each year using a Total Station or level between the permanent cross section pins. During each monitoring event, points in each cross-section survey should be taken at breaks in slope and at each three foot interval. This will ensure that points are taken in the same locations along the cross-sections each year. This will include a photo of each cross section taken from the upstream side looking downstream ensuring both banks are visible in the photograph.

The longitudinal survey will be done using a Total Station or level for the first year and then every two years for a total of four times (As-built is completed, then October 2004, 2006, and 2008).

The photographs will be taken every year. They include the cross sections listed above as well as longitudinal photographs taken from the photo locations listed on the plan view. These supplement the cross section photos to ensure the entire reach is covered.

Vegetation survival plots will be counted annually. The plots for both bare root plantings and live stakes are listed on the plan view. For success criteria, the 3-year period is through October 2006, and the 5-year period is through September 2008.

5 Mitigation

5.1 Mitigation Proposal

The following table lists the proposed mitigation available after completing the project.

Table 5.1 Proposed Mitigation.

Reach	Restored Length (ft)	Category
Silas Reach 1	999	Enhancement I
Silas Reach 2	897	Enhancement I
Silas Reach 3	1771	Enhancement I
Buena Vista	782	Restoration
Total	**4,449**	

5.2 Design Summary

For each stream reach in the Silas Creek watershed project, the proposed natural channel design is the highest level of restoration feasible given the valley type, stream type, land use and urban constraints. For the incised reaches, selection of restoration type follows Rosgen's priority restoration approaches for incised streams (Rosgen, 1997) with the overriding objective of re-establishing contact between the channel and a floodplain. For the purposes of this discussion the four Rosgen restoration approaches have been defined below in order of decreasing priority:

- Priority 1 – Re-establish the channel on a previous floodplain (e.g., raise channel elevation); meander new channel to achieve dimension, pattern, and profile characteristic of a stable stream for the particular valley type; fill or isolate existing incised channel.
- Priority 2 – Establish a new floodplain for the existing bankfull elevation (e.g., excavate a new floodplain); meander channel to achieve dimension, pattern, and profile characteristic of a stable stream for the particular valley type; fill or isolate existing incised channel.
- Priority 3 – Establish a new floodplain at the existing bankfull elevation (e.g., using bankfull benches); leave existing channel in place; use in-stream structures to dissipate energy through a step/pool channel type.

- Priority 4 – Stabilize the channel in place using in-stream structures and bioengineering to decrease streambed and streambank erosion.

5.3 Silas Creek Reach 1, 2 and 3

Silas Creek is constrained throughout the project area by a combination of sewer lines, walking paths, soccer fields, footbridges, and road crossings. As a result of these constraints, relocation of the Silas Creek channel was not feasible. The proposed natural channel design for the Silas Creek reaches was based on a combination of a Rosgen Priority 3 and Priority 4 techniques. This approach was intended to allow for better bankfull-floodplain connectivity, encourage positive changes to occur in the channel cross-section and to create diversity in bedform.

Bankfull benches were excavated intermittently along both sides of the channel to create a new active floodplain or increase the size of existing active floodplains. This design approach increased entrenchment ratios along the reach, thus reducing near bank stresses during large flows and allowing for sediment to be stored outside of the channel. In conjunction with benching, cross vanes and constructed riffles were used throughout the existing channel to set and control grade as well as encourage narrowing and steepening of the riffles. Below the culverts, step-pool structures were used to raise the bed elevation, thus increasing overall channel slope and increasing aeration and coarsening of riffle substrate. Double wing deflectors were constructed to narrow the low flow channel where it is over-wide as well as stabilize the existing banks by reducing near bank stress. J-hook and single vanes and root wads were used to stabilize the banks on the outside of meander bends. All of these structures were spaced to mimic the pool to pool spacing ratio of the Silas Creek reference reach. The spacing of these structures allows Silas Creek to dissipate energy through this series of steps thus decreasing shear stresses and bank erosion (figure 2.1).

By installing cross-vanes, constructed riffles, wing deflectors, and j-hook vanes, Silas Creek's form will change with time. It is expected that diversity in bedform will allow for coarsening of riffles and deepening of pools thus improving habitat and aeration. The various structures will encourage the bankfull channel to narrow decreasing the width to depth ratio over time and increasing the efficiency of the channel. So, although Table 5.2 below does not show direct change in many of the design parameters, by locating structures above the bed elevation, the channel will quickly aggrade in the riffle sections and deepen in the pool sections. This will allow, as seen in the as-built survey, for smaller riffle cross-sections and larger riffle cross-sections as well as a more varied profile.

Table 5.2 Natural Channel Design Parameters for Silas Creek (Reaches 1,2,&3 are represented by the same dataset).

Parameters		Existing Reaches 1,2,&3	Design Reaches 1,2,&3
Rosgen Stream Type		B4c	B4c
Drainage Area (sq mi)		7.2	7.2
Reach Length (ft)		3667	3667
Dimension	Bankfull Width (ft)	40	40
	Bankfull Mean Depth (ft)	3.5	3.5
	Width/Depth Ratio (ft)	11.7	11.7
	Bankfull Area (sq ft)	138	138
	Bankfull Mean Velocity (ft/sec)	4.35	4.35
	Bankfull Discharge (cfs)	600	600
	Bankfull Max Depth (ft)	4.5	4.5
	Width of Floodprone Area (ft)	68-272	120-272
	Entrenchment Ratio	1.7-6.8	3.0-6.8
	Max Pool Depth (ft)	6.8	6.8
	Ratio of Max Pool Depth to Bankfull Depth	1.2	1.2
	Pool Width (ft)	35.25	35.25
	Ratio of Pool Width to Bankfull Width	0.9	0.9
	Pool to Pool Spacing (ft)	82-189	72 - 144
	Ratio of Pool to Pool Spacing to Bankfull Width	2-4.8	2 - 4
	Bank Height Ratio	1.6	1.0
Pattern	Meander Length (ft)	N/A*	N/A*
	Meander Length Ratio	N/A*	N/A*
	Radius of Curvature (ft)	N/A*	N/A*
	Radius of Curvature Ratio	N/A*	N/A*
	Meander Belt Width (ft)	N/A*	N/A*
	Meander Width Ratio	N/A*	N/A*
	Sinuosity	1.03	1.03
Profile	Valley Slope (ft/ft)	0.0029	0.0029
	WS Slope (ft/ft)	0.0025	0.0025
	Pool Slope (ft/ft)	0.0005	0.0005
	Ratio of pool slope to WS slope	0.19	0.19
	Riffle Slope	0.0028	0.0028
	Riffle Slope Ratio	1.12	1.12

5.4 Buena Vista

The proposed natural channel design for Buena Vista Branch was based on a combination of a Rosgen Priority 2 and Priority 3 approach. A new meandering E4 channel was constructed from Station 10+00 to 16+00 at a lower elevation than the existing terrace. A floodplain was excavated along both sides of the channel. The rest of Buena Vista Branch was left at its existing location because of the presence of sewer lines, adjacent soccer fields, and pedestrian footbridge crossings. Constructed riffles, rock vanes and root wads were used to stabilize the new and existing channel.

At the downstream end of the project, Buena Vista Branch was highly incised as a result of a head-cut moving up from Silas Creek. This section was stepped down to the bed elevation of Silas Creek using a step/pool structure. The step/pool design has been modified from earlier designs to minimize the drop between steps (<= 0.5 ft) and prevent piping.

Table 5.3. Natural channel design parameters for Buena Vista Branch.

Parameters		Existing	Design
Rosgen Stream Type		E4	E4
Drainage Area (sq mi)		1.4	1.4
Reach Length (ft)		668	782
Dimension	Bankfull Width (ft)	14.5	17.6
	Bankfull Mean Depth (ft)	2.11	1.8
	Width/Depth Ratio	6.86	10
	Bankfull Area (sq ft)	30.6	32.2
	Bankfull Max Depth (ft)	3.21	2.6
	Width of Floodprone Area (ft)	20-119	60-160
	Entrenchment Ratio	1.4 - 8.2	3.4 – 9.1
	Max Pool Depth (ft)	2.76	3.4
	Ratio of Max Pool Depth to Bankfull Depth	1.3	1.9
	Pool Width (ft)	15.8	22.9
	Ratio of Pool Width to Bankfull Width	1.09	1.3
	Pool to Pool Spacing (ft)	45 - 160	60 - 100
	Ratio of Pool to Pool Spacing to Bankfull Width	3.1 - 11	3.5 - 6
	Bank Height Ratio	1.8	1.0
Pattern	Meander Length (ft)	72-105	120 - 200
	Meander Length Ratio	5-7.2	7 - 11
	Radius of Curvature (ft)	25-100	32 - 53
	Radius of Curvature Ratio	1.7-6.9	2.0 - 3.0
	Meander Belt Width (ft)	15.4-23.8	53 - 88
	Meander Width Ratio	1.1-1.6	3 - 5
	Sinuosity	1.09	1.22
Profile	Valley Slope (ft/ft)	0.0111	0.011
	WS Slope (ft/ft)	0.0107	0.009
	Pool Slope (ft/ft)	0.0025	0.0034
	Ratio of Pool Slope to WS Slope	0.23	0.38

5.5 Riparian Restoration Design

A combination of native herbaceous and woody vegetation was planted in the riparian buffer along Silas Creek. The buffer width ranged between 15 and 25 feet depending on space restrictions due to park boundaries. This buffer width is in accordance with the City of Winston-Salem's stream buffer recommendations (1999) which include a variance stating that a stream buffer shall not exceed 25% of the available land space on publicly owned property with a "cross sectional land space" less then 400 feet. In addition, areas around utilities in the buffer zone were left free of woody vegetation to a

minimum length of 10 feet and a maximum length of 30 feet. These clearings also act as public access areas along with a path (10-15 feet wide) leading to and from the footbridge. All access areas may need to be periodically maintained by the City of Winston-Salem (Winston-Salem 1999).

Native plantings included live stakes and brush mattresses on the stream banks, bare root woody vegetation in the riparian buffer, 2 inch caliper B&B trees along the floodplain banks, and riparian seeding within the buffer. Species planted are listed in table 5.4.

Table 5.4. Vegetation Planted.

B&B Trees

River Birch	Betula nigra
Sycamore	Platanus occidentalis
Willow Oak	Quercus phellos
Red Oak	Quercus rubra
Flowering Dogwood	Cornus florida
Black Tupelo	Nyssa sylvatica

Live Stakes

Silky Willow	Salix sericea
Silky Dogwood	Cornus amomum

Bare Root Woody Vegetation

River Birch	Betula nigra
Shagbark Hickory	Carya ovata
Sycamore	Platanus occidentalis
Willow Oak	Quercus phellos
Southern Sugar Maple	Acer floridanum
Red Chokeberry	Aronia arbutifolia
Common Pawpaw	Asimina triloba
Ironwood	Carpinus caroliniana
Spicebush	Lindera benzoin

5.6 Mitigation Credit

The mitigation credit proposal will be completed by the NC Ecosystem Enhancement Program. Buck Engineering has provided a plan view showing reaches and sub-reaches for their use.

6 Maintenance and Contingency Plans

Future maintenance concerns noted during monitoring shall be reported to the NCEEP Project Manager.

7 References

City of Winston-Salem, NC, Stormwater Management Division. 1999. *Why are our Stream Banks "growing up" in Winston-Salem?* Available from World Wide Web: (http://www.ci.Winston-Salem.nc.us/stormwater/why_are_stream_banks.htm)

Clinton, D. R., G. D. Jennings, W. A. Harman, J. M. Patterson, L. O. Slate, and J. Williams. 1999. North Carolina reference stream channel morphology relationships. In: Olson, D. S., and J. P. Potyondy (Eds.). Wildland Hydrology, Proc. AWRA Specialty Conf., Bozeman, MT. pp. 393-400.

Doll, Barbara A., Dani E. Wise-Frederick, Carolyn M. Buckner, Shawn D. Wilkerson, William A. Harman and Rachel E. Smith. 2000. Hydraulic Geometry Relationships for Urban Streams Throughout the Piedmont of North Carolina. Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association Summer Symposium. Portland, Oregon. Dates: September 28-31, 2000. pp: 299-304.

Dunne, T. and L. B. Leopold, 1978. Water in Environmental Planning. New York: W. H. Freeman and Company.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream Corridor Restoration: Principles, Processes and Practices. National Technical Information Service, Springfield, VA.

Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith, 1999. Bankfull Hydraulic Geometry Relationships for North Carolina Streams. Wildland Hydrology. AWRA Symposium Proceedings. Edited by: D.S. Olsen and J.P. Potyondy. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

Harman, W.A., June 2001. Smith and Austin Creeks Stream Mitigation Plan and Design Wake Forest, North Carolina prepared for the North Carolina Department of Environment and Natural Resources Wetlands Restoration Program. Buck Engineering, Cary, NC.

Harmel, R. D., C. T. Haan, and R. C. Dutnell. 1999. Evaluation of Rosgen's streambank erosion potential assessment in Northeastern Oklahoma. Journal AWRA 35(1):113-121.

Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Jelenevski, P., June 2001. Smith and Austin Creeks Riparian Restoration Design (Draft) prepared for the North Carolina Department of Environment and Natural Resources Wetlands Restoration Program. Soil and Environmental Consultants, Inc., Raleigh, NC.

Jennings, G. D., and W. A. Harman. 2000. Stream corridor restoration experiences in North Carolina. ASAE Paper 002012, ASAE Annual International Meeting, Milwaukee, WI. Am. Soc. Agr. Eng., St. Joseph, MI.

Leopold, L. B., M. G. Wolman and J. P. Miller. 1992. Fluvial Processes in Geomorphology. Dover Publications, Inc. New York, NY.

Leopold, L.B., 1994. A View of the River. Harvard University Press, Cambridge, Mass.

North Carolina Division of Water Quality. 1997. Standard Operating Procedures Biological Monitoring. North Carolina Department of Environment and Natural Resources, Raleigh, NC.

North Carolina Division of Water Quality. 2000. Benthic Macroinvertebrate Monitoring Protocols for Compensatory Stream Restoration Projects. North Carolina Department of Environment and Natural Resources, Raleigh, NC.

Patterson, J. M., D. R. Clinton, W. A. Harman, G. D. Jennings, and L. O. Slate. 1999. Development of streambank erodibility relationships for North Carolina stream. In: Olson, D. S., and J. P. Potyondy (Eds.). Wildland Hydrology, Proc. AWRA Specialty Conf., Bozeman, MT. pp. 117-123.

Rinaldi, M. and P.A. Johnson, 1997. Stream Meander Restoration. Journal of the American Water Resources Association 33:855-866.

Rosgen, D. L. 1994. A classification of natural rivers. Catena 22:169-199.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colo.

Rosgen, D.L., 1998. The Reference Reach - a Blueprint for Natural Channel Design. Draft Presented at ASCE Conference on River Restoration in Denver Colorado - March, 1998. ASCE. Reston, VA.

Schafale, M.P. and A.S. Weakley, 1990. Classification of the Natural Communities of North Carolina. Third Approximation. NCDEHNR Natural Heritage Program, Raleigh, NC.

Wilkerson, S.D., Karl G. Linden, James D. Bowen, Craig J. Allan. 1998. Development and Analysis of Hydraulic Geometry Relationships for the Urban Piedmont of North Carolina. University of North Carolina at Charlotte.

Williams, G.P., 1986. River Meander and Channel Size. Journal of Hydrology 88:147-164.

Wilson, M.P. 1983. Erosion of Banks Along Piedmont Urban Streams. Water Resources Research Institute of the University of North Carolina.

Wolman, M.G., 1954. A Method of Sampling Course River-Bed Material. Transactions of American Geophysical Union 35: 951-956.

Silas Creek
Cross Section Summary

Silas Creek

SR3

Cross Section 1 –Pool	Photo Point 85-86
Cross Section 2 –Pool	Photo Point 87-88
Cross Section 3 –Riffle	Photo Point 89-90

SR2

Cross Section 4 –Riffle	Photo Point 91-92
Cross Section 5 –Pool	Photo Point 93-94
Cross Section 6 –Riffle	Photo Point 95-96

SR1

Cross Section 7 –Pool	Photo Point 97-98
Cross Section 8 –Pool	Photo Point 99-100
Cross Section 9 –Riffle	Photo Point 101-102

Buena Vista Branch

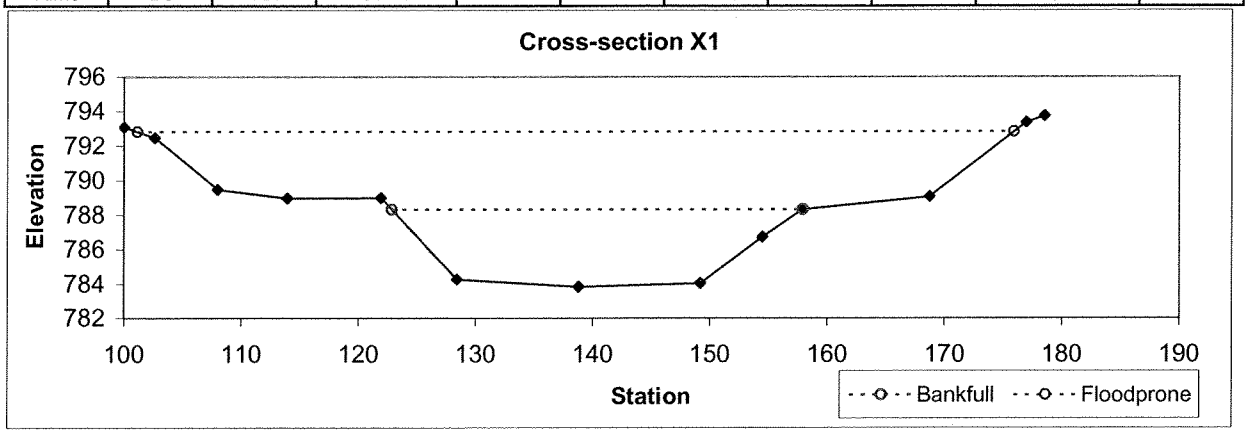
BVB

Cross Section 1 – Rifle	Photo Point 109-110
Cross Section 2 – Pool	Photo Point 111-112

Notes:

1. All cross sections are marked on each bank by permanent pins set in concrete.
2. All pins are shown on the plan views (with North Carolina State plane and elevation coordinates) and are marked with wooden stakes with orange flagging tape.
3. Photo point locations are shown on the plan views and are marked with wooden stakes with orange flagging tape.

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	120	35.09	3.42	4.5	10.27	2.1	2.1	788.32	793.08

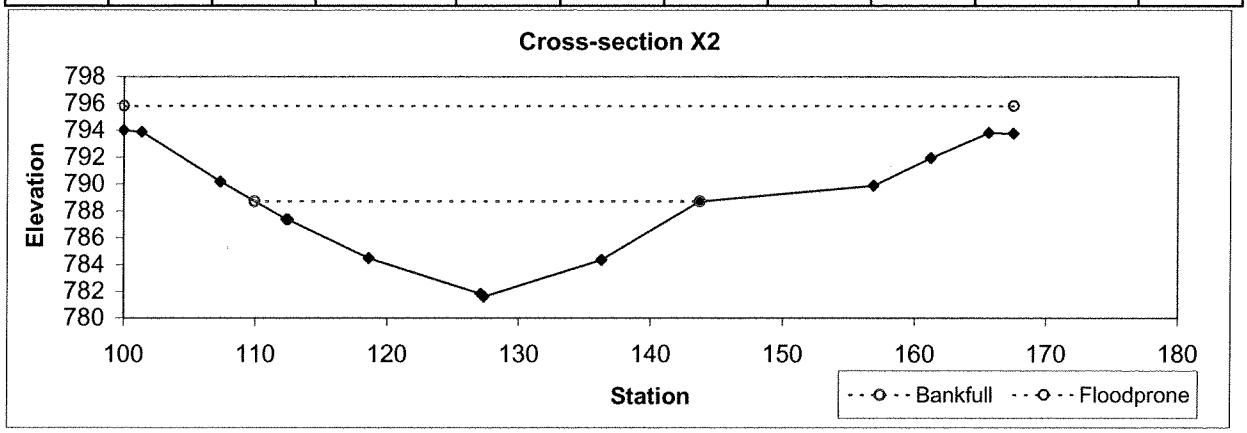


Pt #	North	East	Elevation	Note	Station
535	858179.9	1612523	793.0772	X1LBMON	100
536	858182.2	1612522	792.4601	X1TOP	102.619
537	858187	1612520	789.4635	X1TOE	107.9904
538	858192.4	1612517	788.9637	X1	113.9022
539	858199	1612512	788.9809	X1LBKFL	121.9013
540	858204.7	1612509	784.2493	X1LCHNL	128.4169
541	858213.5	1612504	783.8209	X1TW	138.8105
543	858222.5	1612499	784.0227	X1RCHNL	149.2188
544	858228	1612498	786.7033	X1RIB	154.4725
545	858230.6	1612495	788.3179	X1RBKFL	157.9085
546	858240.5	1612491	789.0581	X1TOE	168.75
547	858247.9	1612487	793.3656	X1TOP	176.954
548	858249.3	1612487	793.7237	X1RBMON	178.5204

Bankfull Line	
Station	Elevation
122.81	788.32
157.91	788.32

Floodprone Line	
Station	Elevation
101.11	792.81
175.91	792.81

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		135.4	33.77	4.01	7.1	8.42	1.7	2	788.71	793.82

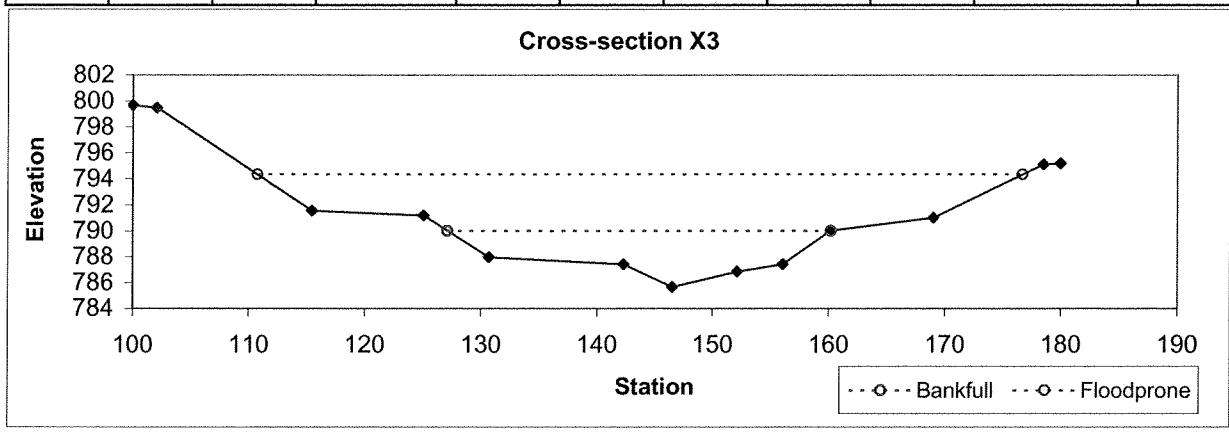


Pt #	North	East	Elevation	Note	Station
453	858260.3	1612686	794.014	X2LBMON	100
454	858261.4	1612685	793.8766	X2TOP	101.382
455	858266.8	1612683	790.1689	X2	107.3381
456	858271.1	1612680	787.3724	X2TOE	112.3512
457	858271.2	1612680	787.3404	X2LBKFL	112.5217
458	858277.4	1612679	784.4642	X2LCHNL	118.6349
459	858284.7	1612674	781.8116	X2TW	127.137
467	858288.1	1612680	781.6151	X2MAXPO	127.3759
461	858292.7	1612670	784.3453	X2RCHNL	136.2683
462	858299.2	1612666	788.7147	X2RBKFL	143.7153
463	858311	1612660	789.8746	X2TOE	156.9067
464	858314.8	1612658	791.9378	X2	161.2306
465	858318.4	1612655	793.8155	X2TOP	165.6296
466	858320	1612654	793.7601	X2RBMON	167.5006

Bankfull Line	
Station	Elevation
109.94	788.71
143.72	788.71

Floodprone Line	
Station	Elevation
100	795.81
167.5	795.81

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	82.8	33.08	2.5	4.34	13.22	2.2	2	790	795.2

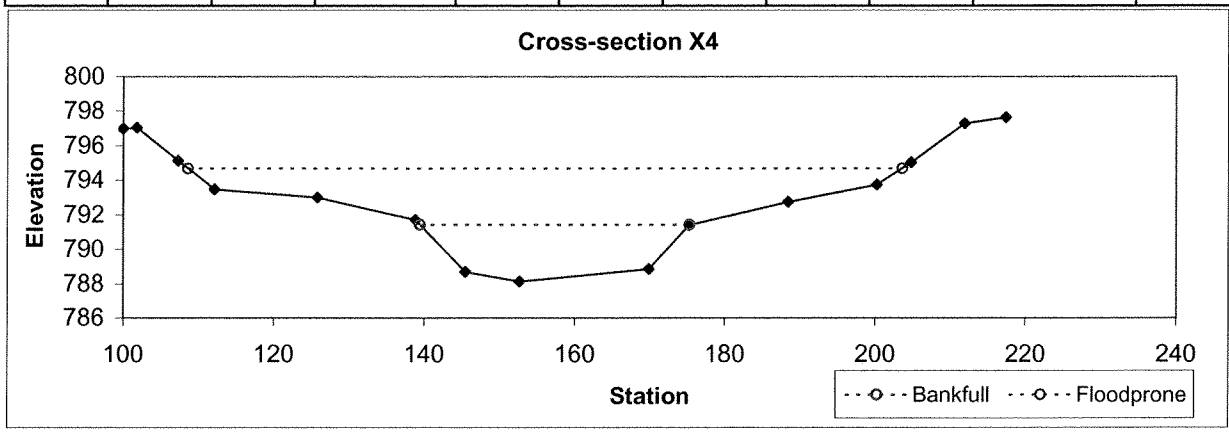


Pt #	North	East	Elevation	Note	Station
403	858571.2	1613279	799.6801	X3RBMON	100
402	858572.9	1613278	799.4704	X3TOP	102.0547
401	858585.5	1613273	791.5616	X3TOE	115.4429
400	858593.6	1613268	791.175	X3LBKFL	125.0646
399	858598.6	1613265	787.9516	X3	130.6886
398	858608.8	1613260	787.4076	X3	142.2982
396	858612.3	1613258	785.6679	X3TW	146.5153
395	858616.9	1613254	786.8567	X3	152.1108
394	858620.2	1613252	787.4272	X3	156.0089
393	858623.4	1613249	790.0047	X3RBKFL	160.1842
392	858631.3	1613246	791.0008	X3TOE	169.0074
391	858639.6	1613241	795.1173	X3TOB	178.4812
390	858640.6	1613240	795.2014	X3LBMON	179.9481

Bankfull Line	
Station	Elevation
127.11	790
160.18	790

Floodprone Line	
Station	Elevation
110.74	794.34
176.7	794.34

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	86.9	35.79	2.43	3.27	14.73	2.7	2.7	791.41	797.04

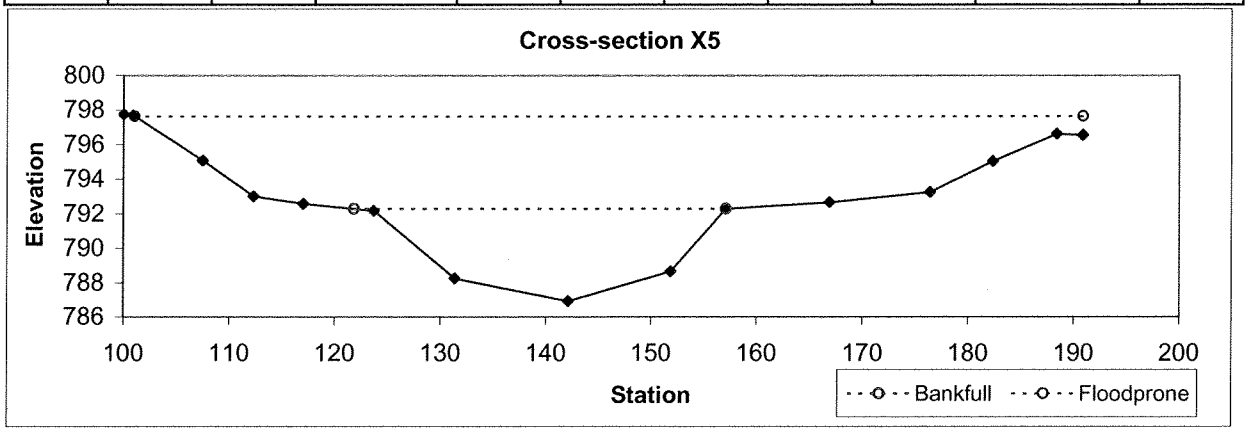


Pt #	North	East	Elevation	Note	Station
1921	858894.9	1613782	796.989	X4 LMON	100
1920	858895.6	1613780	797.0435	X4 TOP	101.8332
1919	858898.1	1613775	795.1265	X4	107.2653
1918	858899.9	1613771	793.4633	X4 TOE	112.1059
1917	858907.3	1613759	792.9999	X4	125.8455
1916	858912.4	1613747	791.6926	X4 LBKFL	138.8304
1915	858916.6	1613742	788.6765	X4 LCHNL	145.4644
1913	858921.1	1613736	788.1315	X4 TW	152.7098
1912	858929.1	1613721	788.842	X4 RCHNL	169.8543
1911	858931.4	1613716	791.4064	X4 RBKFL	175.2479
1910	858939.2	1613705	792.7439	X4	188.4145
1909	858944.9	1613695	793.7405	X4 TOE	200.2662
1908	858947.7	1613691	795.0251	X4	204.8274
1907	858952	1613686	797.2766	X4 TOP	211.9187
1906	858954.7	1613681	797.6284	X4 RMON	217.3696

Bankfull Line	
Station	Elevation
139.46	791.41
175.25	791.41

Floodprone Line	
Station	Elevation
108.56	794.68
203.61	794.68

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		119.8	35.27	3.4	5.36	10.39	1.8	2.5	792.27	796.62

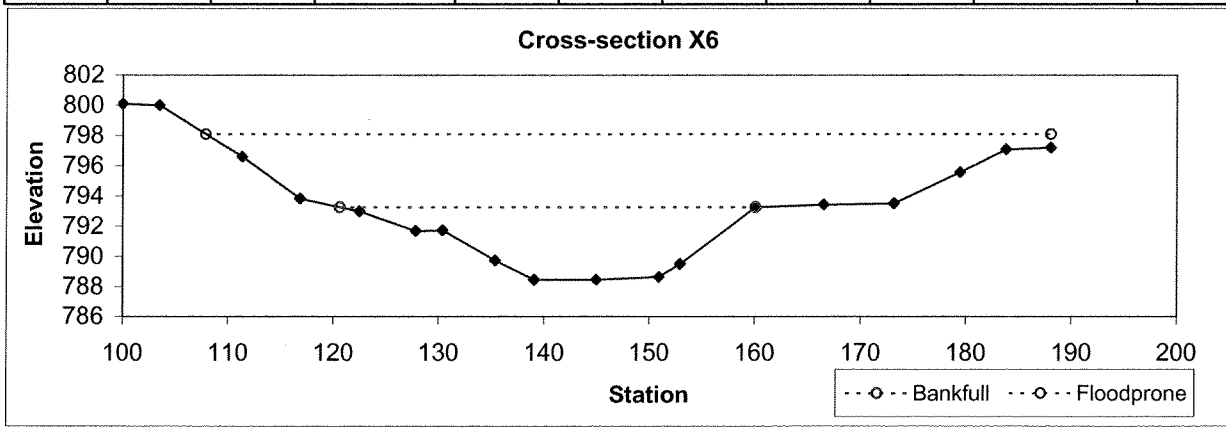


Pt #	North	East	Elevation	Note	Station
1939	859015.8	1613823	797.7401	X5 LMON	100
1938	859016.1	1613822	797.6844	X5 TOP	100.8857
1937	859018.5	1613816	795.0667	X5	107.5112
1936	859020.3	1613811	792.9919	X5 TOE	112.2833
1935	859021.9	1613807	792.5657	X5	117.0449
1934	859021.4	1613799	792.158	X5 LBKFL	123.7048
1933	859026	1613793	788.2296	X5 LCHNL	131.3716
1931	859030.8	1613783	786.9155	X5 TW	142.1228
1930	859037.6	1613776	788.6442	X5 RCHNL	151.8445
1929	859040.4	1613771	792.2725	X5 RBKFL	157.1061
1927	859045.7	1613763	792.6487	X5	166.909
1926	859051.6	1613755	793.2467	X5 TOE	176.4046
1925	859055.1	1613750	795.0279	X5	182.3739
1924	859058.3	1613745	796.6204	X5 TOP	188.4181
1923	859059.3	1613743	796.5314	X5 RMON	190.9047

Bankfull Line	
Station	Elevation
121.83	792.27
157.11	792.27

Floodprone Line	
Station	Elevation
101.02	797.63
190.9	797.63

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	115.7	39.47	2.93	4.82	13.46	1.8	2	793.26	797.2



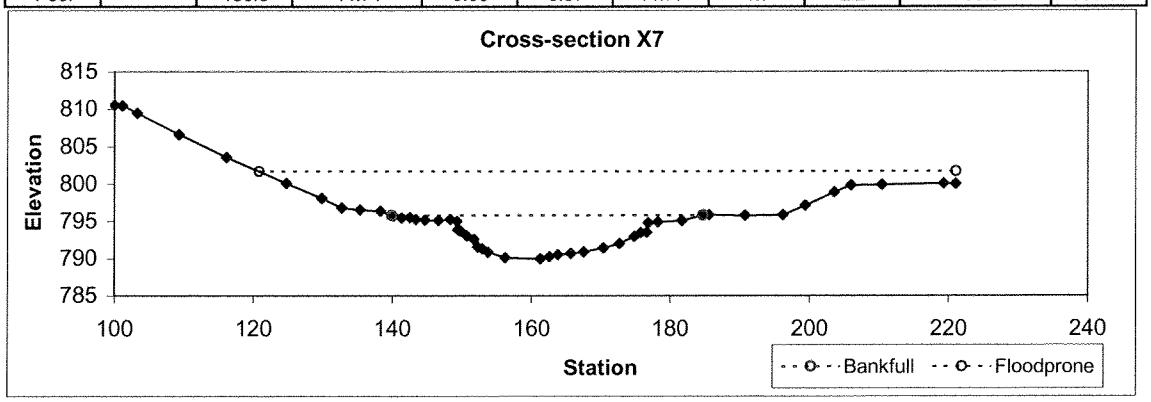
Pt #	North	East	Elevation	Note	Station
1961	859163.1	1613895	800.083	X6 LMON	100
1960	859164.7	1613892	799.9951	X6 TOP	103.4704
1959	859168	1613885	796.5904	X6	111.3662
1958	859170.5	1613880	793.8286	X6 TOE	116.8627
1957	859172.9	1613875	792.973	X6	122.5085
1956	859175.8	1613871	791.6834	X6	127.8782
1955	859177	1613868	791.7329	X6 LBKFL	130.3945
1954	859179.8	1613864	789.716	X6 TOE	135.4065
1953	859182	1613861	788.4384	X6 LCHNL	139.0816
1951	859185.9	1613856	788.4518	X6 TW	145.0021
1950	859188.2	1613851	788.6331	X6 RCHNL	150.9557
1949	859188.5	1613849	789.4886	X6 TOE	152.9582
1946	859190.8	1613842	793.2613	X6 RBKFL	160.0778
1945	859192.8	1613836	793.4185	X6	166.5508
1944	859194.7	1613829	793.5162	X6 TOE	173.1504
1943	859197.6	1613824	795.5747	X6	179.4423
1942	859199.6	1613820	797.0827	X6 TOP	183.8044
1941	859201.9	1613816	797.2011	X6 RMON	188.0396

Bankfull Line	
Station	Elevation
120.61	793.26
160.08	793.26

Floodprone Line	
Station	Elevation
107.9	798.08
188.04	798.08

Cross-section Data:

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		135.5	44.74	3.03	5.87	14.77	1.7	2.2	795.8	800.05

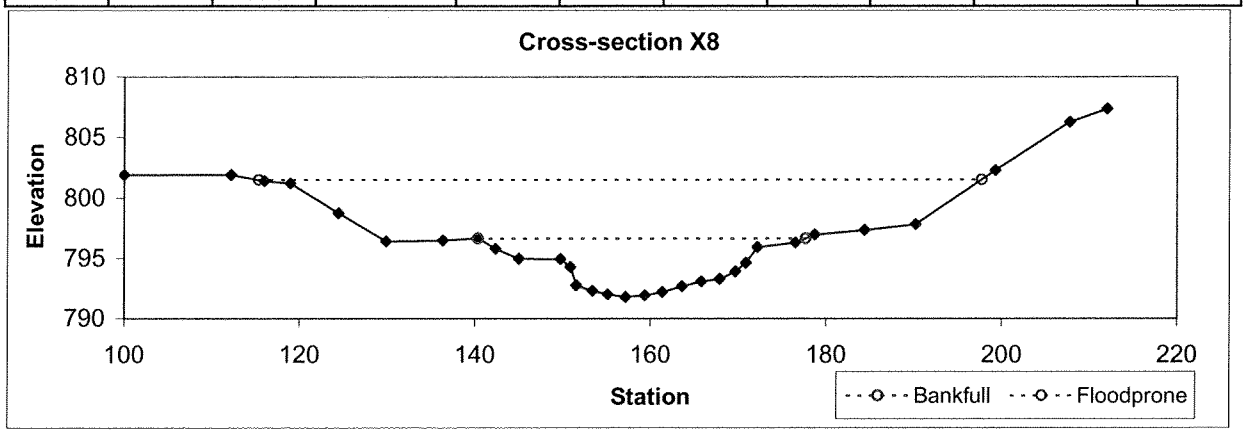


Pt #	North	East	Elevation	Note	Station
2675	859911.5	1614010	810.5368	X7RPIN	100
2674	859910.9	1614011	810.4303	X7	101.0923
2673	859909.8	1614012	809.4452	X7	103.237
2672	859907.3	1614018	806.6361	X7	109.2909
2671	859904.9	1614024	803.584	X7	116.0965
2670	859901.6	1614032	800.0816	X7	124.7221
2669	859900.5	1614037	798.0853	X7	129.843
2668	859899.6	1614040	796.7652	X7	132.6584
2667	859898.7	1614043	796.5091	X7	135.3198
2666	859897.5	1614045	796.3263	X7 RBKF	138.2746
2665	859896.3	1614047	795.7142	X7	140.2005
2664	859895.9	1614048	795.4358	X7	141.3447
2663	859895.5	1614049	795.4761	X7	142.4667
2662	859894.9	1614050	795.222	X7	143.3395
2661	859894.1	1614051	795.1466	X7	144.6912
2660	859893	1614053	795.0845	X7	146.6193
2659	859892	1614054	795.2149	X7	148.3296
2658	859891.1	1614055	794.9622	X7	149.2839
2657	859891	1614055	793.8392	X7	149.4097
2656	859890.8	1614055	793.6967	X7	149.8388
2655	859890.1	1614056	793.0525	X7 REWW	150.7291
2654	859889.4	1614057	792.5739	X7	151.7359
2653	859889.3	1614057	791.5435	X7	152.2465
2652	859889	1614058	791.3381	X7	152.9405
2651	859888.6	1614059	790.861	X7	153.7762
2650	859887.3	1614061	790.1131	X7 TW	156.2571
2649	859887.8	1614066	789.9316	X7	161.2551
2648	859887.4	1614068	790.2401	X7	162.5986
2647	859886.9	1614069	790.4982	X7	163.8501
2646	859886.7	1614071	790.6631	X7	165.6561
2645	859886.2	1614072	790.8947	X7	167.576
2644	859885.8	1614075	791.3898	X7	170.3818
2643	859885.7	1614078	792.0167	X7	172.7111
2642	859885.1	1614080	792.9572	X7 LEW	174.8254
2641	859885	1614081	793.4616	X7	175.7326
2640	859884.8	1614082	793.5191	X7	176.6212
2639	859884.7	1614082	794.798	X7	176.8505
2638	859884.5	1614083	794.8717	X7	178.2106
2637	859883.2	1614086	795.0689	X7	181.6887
2636	859882.1	1614089	795.8045	X7 BKF	184.6575
2635	859881.5	1614090	795.8247	X7	185.5699
2634	859881.6	1614095	795.7489	X7	190.7245
2633	859880	1614101	795.8242	X7	196.1918
2632	859878.8	1614103	797.0801	X7	199.3436
2631	859878	1614108	798.8781	X7	203.6029
2630	859877.7	1614110	799.7848	X7	205.9838
2629	859876.2	1614114	799.8551	X7	210.4278
2628	859874.4	1614123	800.0513	X7	219.2799
2627	859873.6	1614125	799.9962	X7LPIN PC	221.0286

Bankfull Line	
Station	Elevation
139.92	795.8
184.66	795.8

Floodprone Line	
Station	Elevation
120.79	801.68
221.03	801.68

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		98.9	37.31	2.65	4.84	14.08	2.1	2.2	796.65	801.9

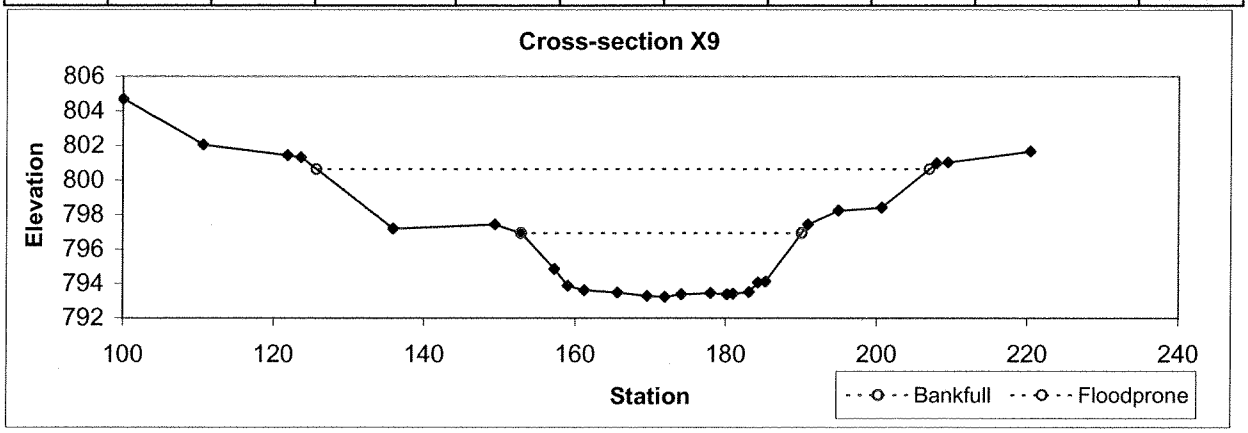


Pt #	North	East	Elevation	Note	Station
2527	860088.8	1614203	801.8979	X8 EOP	100
2528	860092.2	1614191	801.8888	X8 BM	112.2216
2529	860093.1	1614187	801.4033	X8	116.0089
2530	860094.1	1614184	801.2088	X8 HT	118.9344
2531	860095.5	1614179	798.7352	X8	124.4479
2532	860096.4	1614174	796.3964	X8 LT	129.8781
2533	860098.1	1614167	796.491	X8 LT	136.3834
2534	860099	1614163	796.658	X8 BKF	140.3448
2535	860099.3	1614161	795.8002	X8	142.3545
2536	860099.9	1614159	794.9755	X8	145.0432
2537	860101.3	1614154	794.9408	X8	149.753
2538	860101.2	1614153	794.2751	X8	150.8921
2539	860101.4	1614152	792.7728	X8 LEW	151.552
2540	860102	1614151	792.3173	X8	153.4082
2541	860102.2	1614149	792.0309	X8	155.1136
2542	860102.6	1614147	791.8099	X8 TW	157.1681
2543	860103.4	1614145	791.9401	X8	159.3831
2544	860103.9	1614143	792.2062	X8	161.3565
2545	860104.5	1614141	792.6947	X8	163.5993
2546	860105.1	1614139	793.0882	X8 REW	165.8078
2548	860105.7	1614137	793.2804	X8	167.9122
2549	860106.2	1614135	793.8945	X8	169.7058
2550	860106.7	1614134	794.6103	X8	170.9028
2551	860106.8	1614133	795.9169	X8	172.1991
2552	860107.5	1614128	796.3061	X8	176.5166
2553	860108.3	1614126	796.9616	X8 BKF	178.7198
2554	860112.3	1614121	797.3251	X8	184.4023
2555	860115.3	1614116	797.799	X8 FP	190.2025
2556	860116.2	1614107	802.2728	X8	199.3233
2557	860117.8	1614099	806.2583	X8	207.8042
2558	860119.3	1614095	807.3481	X8 BM	212.0465

Bankfull Line	
Station	Elevation
140.36	796.65
177.67	796.65

Floodprone Line	
Station	Elevation
115.33	801.49
197.73	801.49

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	106.3	37.17	2.86	3.7	12.99	2.3	2.2	796.93	801.64

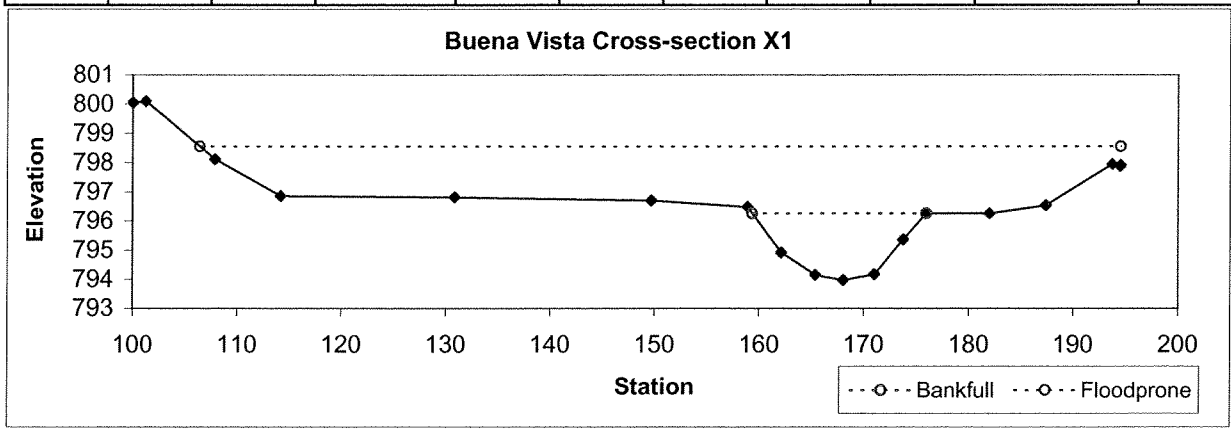


Pt #	North	East	Elevation	Note	Station
2585	860351.1	1614155	804.6829	X9	100
2584	860348.5	1614166	802.0472	X9	110.6358
2583	860345.4	1614176	801.4353	X9 BM	121.8264
2582	860344.4	1614178	801.3098	X9 MT	123.6222
2581	860338.2	1614189	797.1949	X9 LT	135.8903
2580	860334.6	1614202	797.4265	X9	149.3276
2579	860333.4	1614205	796.9282	X9 BKF	152.8529
2578	860333.1	1614210	794.8501	X9	157.2439
2577	860332.4	1614211	793.874	X9 REW	159.055
2576	860332	1614213	793.6086	X9	161.2028
2575	860331.5	1614218	793.4794	X9	165.6514
2574	860330.6	1614222	793.2807	X9	169.5728
2573	860329.8	1614224	793.2346	X9 TW	171.928
2572	860329.3	1614226	793.3829	X9	174.0644
2571	860328.2	1614230	793.453	X9	177.97
2570	860327.9	1614232	793.3682	X9	180.1749
2569	860327.6	1614233	793.405	X9	180.9489
2568	860327.1	1614235	793.5145	X9	183.0989
2566	860326.7	1614236	794.0578	X9	184.2897
2565	860326.3	1614237	794.1108	X9 LEW	185.2619
2564	860324.8	1614242	797.4337	X9 BKF	190.8543
2563	860323.9	1614246	798.2368	X9 LT	194.9285
2562	860322.3	1614252	798.3969	X9 LT	200.6405
2561	860320	1614259	800.9706	X9 HT	207.8992
2560	860319.4	1614260	801.0236	X9 BM	209.4568
2559	860316.7	1614271	801.6432	X9	220.3605

Bankfull Line	
Station	Elevation
152.84	796.93
190.01	796.93

Floodprone Line	
Station	Elevation
125.66	800.63
206.93	800.63

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	24.9	16.64	1.5	2.29	11.09	1.7	5.3	796.26	797.94

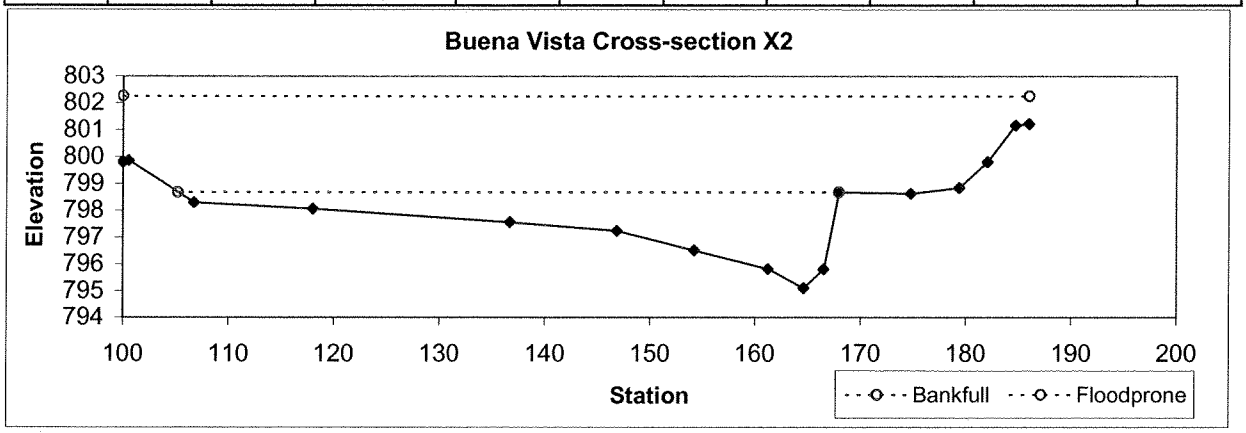


Pt #	North	East	Elevation	Note	Station
1693	858955.3	1614054	800.0408	X1 RMON	100
1720	858955.2	1614054	800.0439	X1 RMON	100.0315
1719	858954.3	1614053	800.0938	X1 TOP	101.2598
1718	858948.2	1614049	798.109	X1	107.9073
1717	858943	1614046	796.8527	X1 TOE	114.1899
1716	858932.4	1614033	796.8023	X1	130.8487
1715	858920.6	1614018	796.6974	X1	149.6997
1714	858915.9	1614010	796.4719	X1 BKFL	158.9074
1713	858914.8	1614006	794.9167	X1	162.1197
1712	858912.4	1614004	794.1454	X1 RCHNL	165.3987
1710	858910.6	1614002	793.9638	X1 TW	168.0628
1709	858908.4	1614000	794.1718	X1 LCHNL	171.0254
1708	858906.3	1613998	795.3593	X1	173.7823
1707	858904.6	1613997	796.2554	X1 BKFL	175.991
1706	858900.5	1613993	796.2625	X1	181.9967
1705	858896.7	1613989	796.5307	X1 TOE	187.3854
1704	858893.3	1613983	797.9437	X1 TOP	193.7251
1694	858892.7	1613983	797.8788	X1 LMON I	194.4824
1703	858892.6	1613983	797.908	X1 LMON	194.5282

Bankfull Line	
Station	Elevation
159.35	796.26
175.99	796.26

Floodprone Line	
Station	Elevation
106.44	798.55
194.53	798.55

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		85.2	62.72	1.36	3.58	46.17	1.3	1.4	798.67	799.87

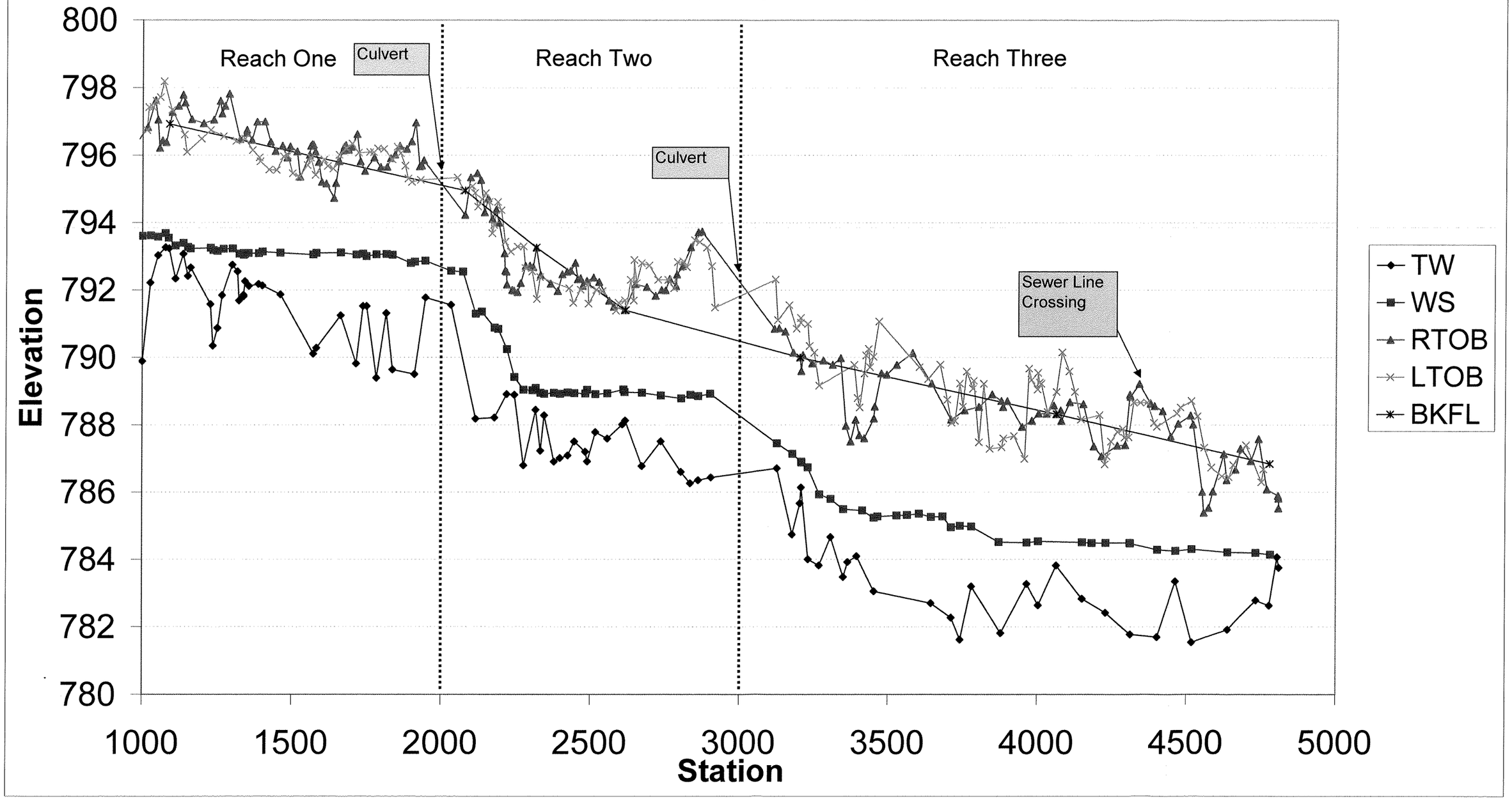


Pt #	North	East	Elevation	Note	Station
1737	858875.9	1614262	799.7852	X2 LMON	100
1698	858875.9	1614262	799.8253	X2 LMON I	100.0066
1736	858876.5	1614262	799.8653	X2 TOP	100.5545
1735	858882.6	1614263	798.2859	X2TOE	106.7375
1734	858893.9	1614265	798.057	X2	118.0428
1733	858912.4	1614267	797.5546	X2	136.6903
1732	858922.5	1614268	797.2313	X2 BKFL	146.8559
1731	858929.9	1614269	796.5104	X2	154.2137
1730	858936.9	1614268	795.8121	X2 LCHNL	161.2217
1728	858940.3	1614268	795.0905	X2 TW	164.6086
1727	858942.3	1614267	795.7976	X2 RCHNL	166.5039
1726	858943.8	1614264	798.6746	X2 BKFL	167.9369
1725	858950.6	1614265	798.6285	X2	174.761
1724	858955.2	1614266	798.8468	X2 TOE	179.3815
1723	858957.9	1614267	799.8031	X2	182.0554
1722	858960.6	1614266	801.1658	X2 TOP	184.7115
1699	858961.8	1614266	801.2311	X2 RMON	185.9387
1721	858961.8	1614266	801.2102	X2 RMON	185.9694

Bankfull Line	
Station	Elevation
105.22	798.67
167.94	798.67

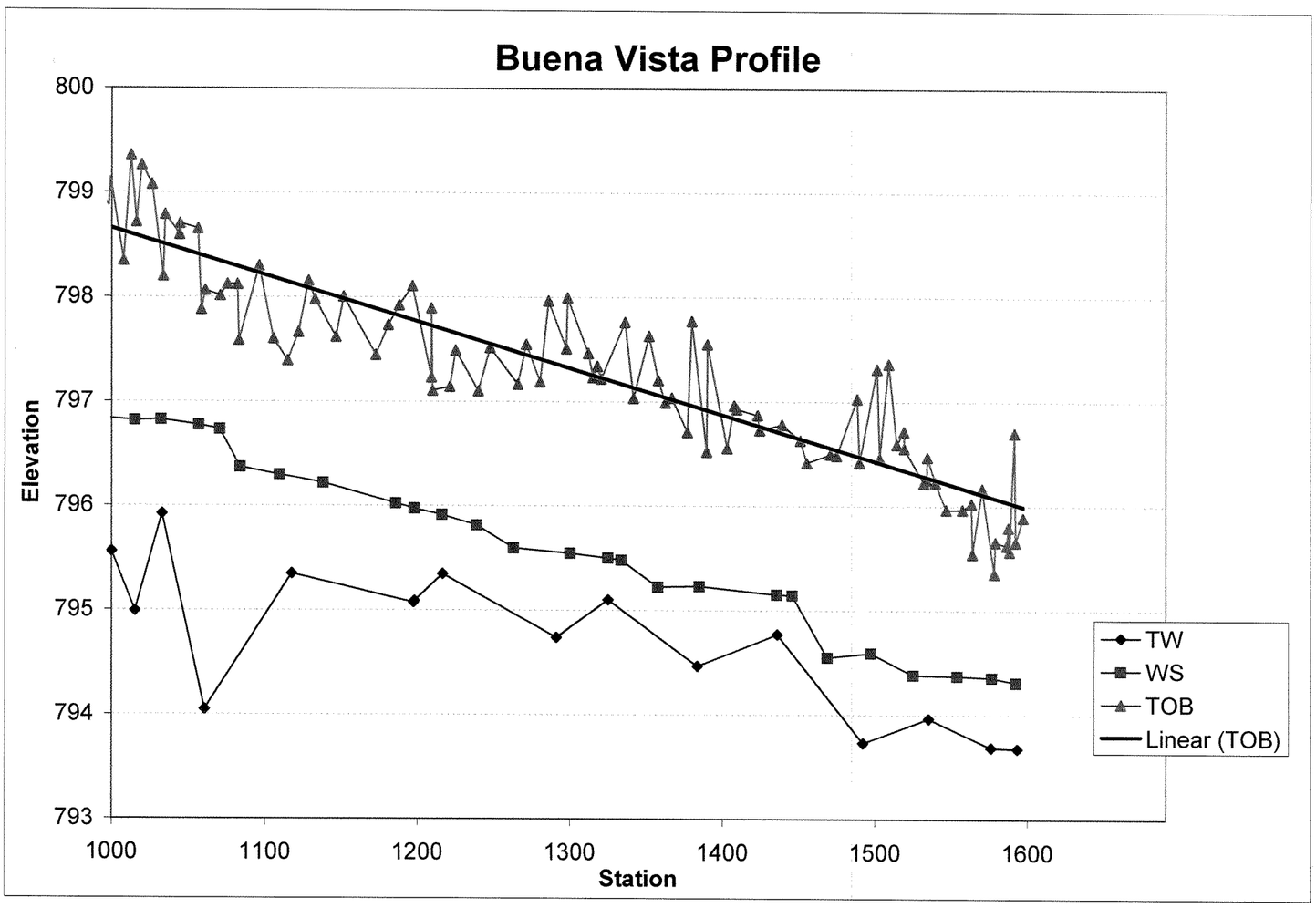
Floodprone Line	
Station	Elevation
100	802.26
185.97	802.26

Silas Creek Profile



Silas Creek Longitudinal Profile Survey Data

Descriptor	TW	Descriptor	WS	Descriptor	RTOB	Descriptor	RTOB	Descriptor	LTOB	Descriptor	LTOB		BKFL	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation			
1000	789.8883	1000.156	793.6008	966.6205	796.7883	2510.494	792.3691	1014.26	796.7383	3206.285	791.0287		1089.2	796.93
1026.664	792.2186	1027.554	793.6181	973.7378	796.3522	2528.862	792.2405	1020.34	797.4277	3206.421	791.175		2079.11	794.954
1052.418	793.0272	1052.054	793.5779	990.4554	796.494	2562.294	791.6872	1034.161	797.4278	3230.222	790.9961		2318.4	791.26
1077.396	793.2619	1076.889	793.6848	1016.614	796.8324	2578.587	791.5077	1043.958	797.6102	3235.41	790.3411		2616.8	791.4
1089.237	793.2346	1087.483	793.5473	1042.852	797.6357	2614.554	791.4064	1058.74	797.7216	3251.508	790.1428		3204.3	790
1110.928	792.3372	1110.365	793.3163	1051.358	797.0558	2650.402	792.179	1071.703	798.1885	3268.491	789.1718		4063.5	788.32
1136.744	793.0711	1137.053	793.3967	1057.305	796.2169	2688.195	792.0928	1097.752	797.3438	3385.774	789.7845			
1151.999	792.4147	1152.076	793.2749	1066.63	796.4399	2717.48	791.8289	1139.416	796.6148	3397.126	788.8002			
1161.242	792.6656	1161.166	793.232	1078.82	796.3861	2737.543	792.0039	1147.684	796.0998	3404.166	788.5201			
1227.696	791.5782	1227.827	793.2473	1099.216	797.2816	2751.137	791.9951	1196.457	796.4963	3420.052	789.5258			
1235.388	790.3499	1236.96	793.1804	1120.163	797.4626	2765.035	792.3321	1226.735	796.7488	3425.37	790.0605			
1250.885	790.8763	1250.468	793.1591	1135.064	797.791	2786.81	792.1169	1270.391	796.5662	3434.361	790.256			
1266.213	791.8443	1270.849	793.2224	1141.924	797.5621	2789.711	792.4629	1312.674	796.4325	3438.664	789.716			
1300.352	792.7473	1301.357	793.228	1164.054	797.0696	2808.547	792.7071	1341.752	796.4935	3449.983	790.0228			
1317.822	792.5484	1324.135	793.0741	1203.489	796.9467	2836.373	793.2731	1367.492	796.158	3468.495	791.0665			
1322.848	791.6858	1338.652	793.0423	1237.965	797.0539	2860.963	793.7199	1390.66	795.9381	3569.094	790.0593			
1337.965	791.8099	1338.91	793.0951	1258.879	797.616	2872.845	793.7385	1393.977	795.825	3604.026	789.7172			
1338.206	791.8548	1342.283	793.0725	1264.854	797.2357	3118.144	790.8507	1423.316	795.5769	3632.435	789.3623			
1343.242	792.2602	1354.519	793.0971	1275.565	797.4639	3133.506	790.8645	1448.525	795.5648	3673.827	789.7892			
1355.973	792.1221	1389.465	793.0901	1289.402	797.8234	3154.427	790.7698	1471.616	795.966	3697.586	788.7489			
1388.226	792.178	1401.894	793.1408	1325.16	796.4802	3181.6	790.1428	1485.423	795.9923	3712.527	788.0655			
1401.57	792.1349	1461.222	793.1047	1347.61	796.6849	3204.467	790.0047	1502.004	795.467	3723.04	788.1217			
1461.758	791.87	1571.631	793.0525	1348.535	796.7533	3208.342	789.5989	1522.973	795.3624	3739.408	789.2322			
1572.18	790.1131	1581.968	793.1001	1365.675	796.4537	3213.897	790.0794	1551.198	795.7081	3749.951	788.5461			
1582.585	790.2864	1663.821	793.1094	1382.855	796.997	3245.026	789.8259	1562.919	795.9258	3762.237	789.5863			
1663.496	791.2446	1716.13	793.0519	1409.05	797.0021	3281.936	789.9137	1577.903	795.4157	3783.285	789.0799			
1715.494	789.8196	1738.731	793.0737	1428.227	796.4008	3313.543	789.7879	1607.275	795.8724	3786.244	789.3124			
1738.564	791.5242	1750.123	793.0022	1444.258	796.1257	3340.452	789.9794	1619.143	795.6813	3803.829	787.4843			
1750.795	791.5251	1783.47	793.0542	1467.782	796.2885	3358.494	787.977	1637.632	795.604	3819.602	789.2219			
1783.545	789.3971	1817.185	793.0654	1483.579	795.9329	3373.901	787.5068	1657.932	796.0164	3840.16	787.2904			
1816.942	791.311	1837.341	793.0414	1493.691	796.2641	3390.581	788.1533	1680.699	796.2109	3879.551	787.3404			
1837.872	789.6429	1898.354	792.802	1517.195	796.1126	3403.132	787.6988	1700.751	796.3506	3885.902	787.6003			
1911.609	789.5081	1912.113	792.8393	1526.998	795.3599	3420.137	787.6043	1722.828	796.0787	3921.408	787.6712			
1947.742	791.7777	1946.803	792.8672	1558.452	796.0155	3452.348	788.1944	1760.103	796.0977	3956.55	786.9923			
2033.076	791.5609	2033.078	792.5699	1563.12	796.2804	3454.842	788.5455	1773.325	796.0934	3971.246	789.6721			
2115.834	788.1845	2072.675	792.5461	1567.156	796.3263	3476.593	789.5304	1786.826	796.2045	3979.394	789.3333			
2179.222	788.2172	2116.016	791.2923	1571.445	796.3166	3494.525	789.4918	1807.954	796.1912	3999.677	789.0526			
2220.078	788.9146	2135.958	791.3552	1577.889	796.1099	3527.775	789.7819	1836.293	795.8779	4001.216	789.5466			
2245.514	788.8951	2179.214	790.8851	1589.004	795.8032	3580.779	790.1349	1852.197	796.2526	4006.578	789.261			
2276.302	786.797	2191.224	790.8462	1599.172	795.2117	3645.274	789.23	1863.197	796.0632	4012.35	789.2232			
2316.517	788.4518	2220.35	790.2466	1614.837	795.1617	3710.712	788.1604	1878.606	795.6944	4033.703	788.3833			
2332.862	787.2328	2245.659	789.4191	1640.755	794.7305	3755.841	788.4336	1888.951	795.3137	4063.102	788.9809			
2345.664	788.2866	2276.49	789.0433	1646.701	795.1776	3803.833	788.537	1901.015	795.211	4081.724	790.1561			
2378.583	786.9099	2306.496	789.0289	1658.063	795.8227	3847.425	788.9089	1930.562	795.275	4105.544	789.5926			
2398.358	787.0146	2316.921	789.0993	1670.128	796.1443	3878.415	788.7147	2053.171	795.3398	4124.265	788.9804			
2424.466	787.0912	2332.864	788.9545	1674.634	796.2559	3884.438	788.5345	2074.214	794.9544	4144.211	788.1591			
2446.648	787.5105	2345.525	788.9226	1679.673	796.3074	3898.725	788.7128	2103.143	795.0851	4205.709	788.2958			
2483.659	787.2022	2378.158	788.9508	1688.846	796.1636	3948.383	787.9426	2112.231	794.8812	4223.972	786.8263			
2489.897	786.9155	2398.27	788.9217	1698.632	796.2499	3981.44	788.1253	2122.388	794.4761	4231.224	787.0647			
2517.142	787.7892	2424.288	788.9621	1717.616	796.6306	4003.771	788.3386	2135.385	794.6994	4244.768	787.5079			
2557.293	787.5967	2446.512	788.9433	1728.657	795.8192	4030.021	788.3356	2148.474	794.8825	4266.603	787.7962			
2607.574	788.0132	2483.411	788.9306	1743.891	795.5392	4054.43	788.5823	2160.393	794.6186	4284.714	787.8823			
2616.798	788.1315	2489.762	789.0455	1774.768	795.9326	4062.501	788.3179	2170.267	793.6853	4290.421	787.6227			
2672.709	786.7791	2517.227	788.9142	1797.064	795.6527	4077.051	788.4313	2176.663	793.9317	4304.507	787.6325			
2736.005	787.5141	2557.085	788.9366	1818.758	795.6526	4079.13	788.1221	2189.094	794.6173	4320.841	788.6654			
2803.938	786.6036	2610.6	789.0551	1830.722	795.9145	4107.434	788.6757	2200.92	794.3681	4343.097	788.6638			
2835.288	786.2679	2614.353	788.9777	1844.563	796.0211	4151.633	788.6183	2214.14	793.4266	4365.072	788.6664			
2861.977	786.359	2672.682	788.9562	1860.571	796.2812	4186.664	787.3588	2232.767	793.1385	4388.282	788.0639			
2904.749	786.4391	2735.919	788.8747	1884.178	796.1926	4212.994	787.0701	2254.949	793.2872	4397.628	787.9462			
3127.087	786.7112	2804.567	788.7902	1900.431	796.414	4266.369	787.3854	2275.071	793.2935	4465.908	788.3433			
3178.442	784.7424	2835.733	788.8929	1914.075	796.9705	4293.019	787.4023	2281.46	792.6513	4478.126	788.5212			
3204.275	785.6679	2861.623	788.858	1927.232	795.672	4308.668	788.8992	2304.016	792.5499	4515.152	788.7162			
3208.352	786.1417	2901.137	788.9289	1934.219	795.6949	4310.727	788.8375	2319.868	791.7329	4536.305	788.2638			
3232.333	784.0005	3127.323	787.4547	1940.818	795.8534	4340.323	789.2168	2330.662	792.3808	4559.512	787.325			
3269.038	783.8183	3178.727	787.1433	2079.11	794.2277	4376.908	788.6349	2428.318	792.0537	4583.042	786.7354			
3307.559	784.6664	3209.155	786.9117	2097.76	795.3434	4390.316	788.5624	2442.215	791.6159	4617.374	786.4771			
3349.986	783.4744	3210.233	786.8858	2119.84	795.4693	4417.391	788.409	2466.361	792.0097	4641.231	786.4471			
3364.916	783.9184	3230.572	786.7388	2132.39	795.2687	4445.164	787.6594	2491.814	792.158	4655.714	786.8075			
3394.972	784.0962	3269.283	785.9342	2144.633	794.3048	4470.65	788.0417	2493.487	791.5997	4698.828	787.3981			
3453.08	783.0495	3307.454	785.7981	2156.432	794.7277	4512.362	788.2874	2519.541	792.0074	4750.361	786.3			
3644.091	782.6988	3349.921	785.4954	2171.011	794.1104	4521.373	788.0169	2539.743	791.9691	4756.639	786.6835			
3711.483	782.2709	3413.945	785.4566	2183.778	794.3869	4553.168	786.0131	2585.534	791.3865					
3741.521	781.6181	3452.929	785.2373	2193.015	793.9982	4558.839	785.3904	2593.608	791.6237					
3779.994	783.1957	3465.067	785.279	2212.083	793.0924	4574.622	785.5322	2614.682	791.6926					
3878.206	781.8116	3528.958	785.3088	2214.199	792.5735	4588.777	786.0219	2619.332	791.4123					
3964.726	783.2706	3564.112	785.3203	2218.199	792.5427	4623.51	787.1323	2633.958	792.302					
4003.29	782.637	3603.571	785.362	2220.188	792.1654	4633.623	786.359	2644.228	791.6881					
4063.475	783.8209	3644.258	785.2618	2237.277	791.9996	4664.767	786.672	2646.013	792.8947					
4149.149	782.8286	3682.708	785.2756	2243.339	791.9831	4680.745	787.2936	2653.862	792.2028					
4227.792	782.4123	3711.4	784.956	2255.563	791.9373	4715.163	786.9283	2671.174	792.8021					
4311.45	781.7713	3741.068	784.9986	2266.063	792.2085	4740.725	787.5824	2695.963	792.7339					
4399.83	781.6967	3779.556	784.9794	2282.206	792.7164	4768.667	786.0857	2725.389	792.3023					
4461.71	783.3439	3871.264	784.5153	2296.637	792.7238	4777.98	786.8408	2759.398	792.3019					
4517.282	781.5389	3965.016	784.4996	2307.269	792.6789	4805.73	785.8957	2779.917	792.0558					
4636.584	781.9118	4002.761	784.5411	2318.235	793.2613	4807.475	785.8146	2791.918	792.829					
4732.183	782.7812	4149.273	784.5083	2333.233	792.4474	4807.694	785.5184	2810.856	792.8549					
4777.054	782.6278	4181.055	784.486	2366.02	792.1871			2822.959	792.6816					
4802.925	784.0649	4227.737	784.4895	2390.305	791.9678			2849.719	793.4805					
4808.502	783.7517	4309.023	784.4922	2405.046	792.4682			2865.362	793.4259					
		4310.839	784.4733	2421.494	792.5428			2889.128	793.2636					
		4400.41	784.2871	2433.072	792.572			2906.424	792.7083					
		4461.988	784.2557	2448.467	792.8058			2916.365	791.4845					
		4517.293	784.3053	2456.728	792.3202			3120.921	792.3125					
		4636.588	784.2087	2466.618	792.3504			3129.217	791.109					
		4731.51	784.1959	2473.9	792.1255			3167.374	791.5501					
		4780.174	784.1421	2487.742	792.2725			3191.748	790.8544					


Buena Vista Profile
800
799
798
797
796
795
794
793
Elevation
1000
1100
1200
1300
1400
1500
1600
Station
TW
WS
TOB
Linear (TOB)

Buena Vista Longitudinal Profile Survey Data

Descriptor TW	
Station	Elevation
100	795.5602
115.204	794.9911
132.808	795.9222
160.503	794.0469
217.405	795.3493
297.383	795.0743
297.991	795.0905
316.472	795.3481
391.179	794.7405
425.176	795.1019
483.551	794.4655
535.895	794.7722
591.979	793.7316
635.115	793.9638
676.083	793.6883
693.199	793.6764

Descriptor = WS	
Station	Elevation
99.7111	796.8337
115.0009	796.8159
132.0769	796.8227
156.7692	796.771
170.4425	796.7306
183.6451	796.3678
209.4187	796.2944
238.0119	796.2169
285.5812	796.0242
297.8415	795.9739
315.9873	795.9144
338.8743	795.8131
363.1067	795.5955
400.2471	795.5462
424.9656	795.5016
433.7121	795.4821
457.6303	795.2255
484.7561	795.2319
535.4812	795.1518
545.6537	795.1455
568.6727	794.5508
597.0367	794.5938
625.047	794.3803
653.8532	794.3719
676.5451	794.3567
692.1093	794.3108

Descriptor = TOB	
Station	Elevation
90.3041	799.0554
98.0853	798.8732
99.2902	799.1406
107.7903	798.3462
112.6946	799.3569
116.1233	798.7134
119.5905	799.2633
126.2972	799.0761
133.5513	798.2007
134.8498	798.7877
144.1999	798.5955
144.6153	798.7013
156.251	798.6532
158.4254	797.8793
160.9528	798.0634
170.7662	798.0133
175.4927	798.1248
182.0664	798.1224
182.9005	797.5843
196.1426	798.2975
205.3837	798.9999
205.4233	797.6003
214.4827	798.9374
214.7293	797.3908
221.929	797.664
228.3913	798.1561
232.6286	797.9764
246.3023	797.618
251.4604	798.0043
272.5557	797.4444
280.725	797.7316
283.2359	797.0114
287.8966	797.922
296.0812	798.6746
296.5503	798.1064
309.0735	797.2313
309.0883	797.8928
309.7803	797.1044
321.1866	797.1419
324.9714	797.4898
339.8831	797.0983
347.7223	797.5154
365.9355	797.163
371.3819	797.5482
380.5451	797.1878
386.0894	797.9646
397.8003	797.5061
398.5857	797.9955
412.1623	797.4632
415.2571	797.231
417.9493	797.3407
420.526	797.2172
436.3219	797.7609

Descriptor TOB (Cont	
Station	Elevation
441.79	797.0319
451.8769	797.6297
458.0679	797.206
462.558	796.9908
466.8404	797.0365
477.0225	796.709
479.8915	797.7722
489.6984	796.5194
490.1743	797.5512
503.056	796.5547
507.6761	796.9639
509.2234	796.93
523.0004	796.8724
524.2793	796.729
538.9177	796.7796
551.0018	796.6318
555.2808	796.4155
570.6237	796.4985
574.6422	796.4839
588.2136	797.0277
589.7334	796.4179
601.2715	797.3161
602.9326	796.4575
608.8715	797.3641
614.257	796.5938
618.9718	796.7181
619.1607	796.5568
632.0307	796.2244
633.9013	796.2554
634.3057	796.4719
639.6837	796.2272
646.7288	795.9689
657.321	795.9704
663.2627	796.0287
663.8352	795.5439
670.209	796.169
678.1055	795.3544
678.9475	795.6587
686.1802	795.6235
687.4228	795.7991
688.2536	795.5689
691.3717	796.7032
692.193	795.6565
697.0636	795.8924

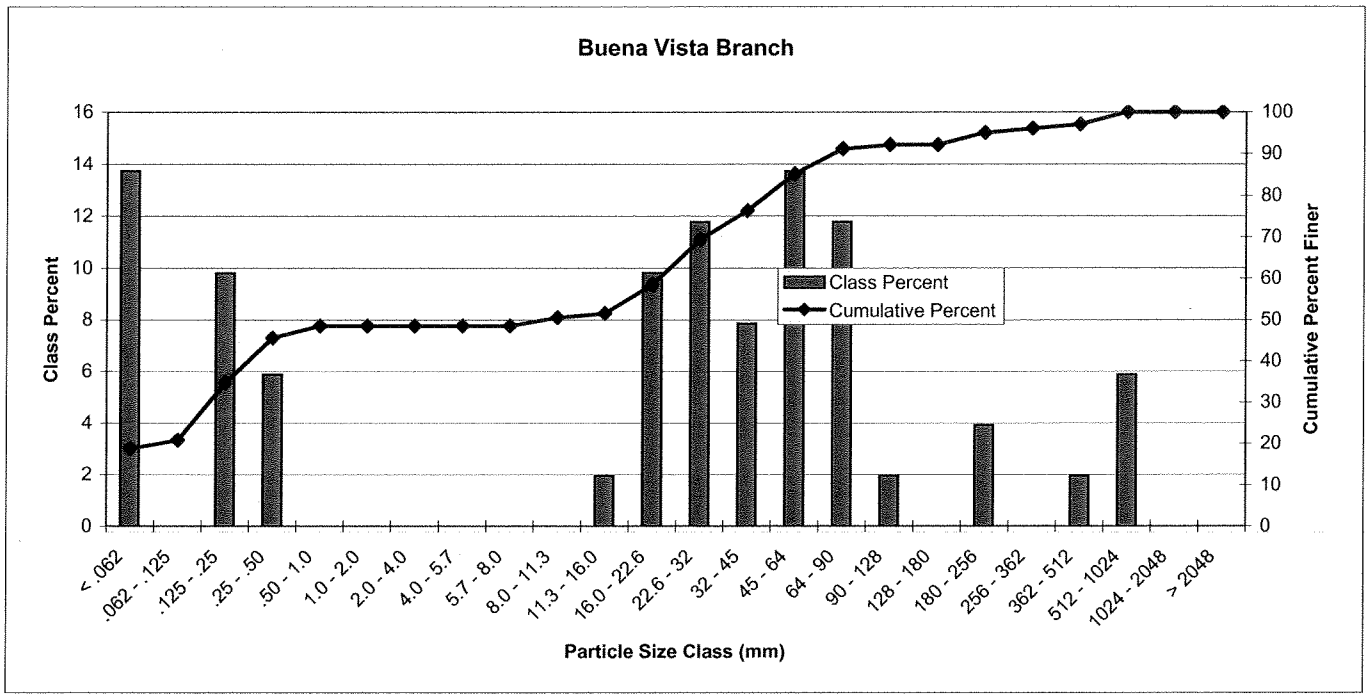
PEBBLE COUNT DATA SHEET

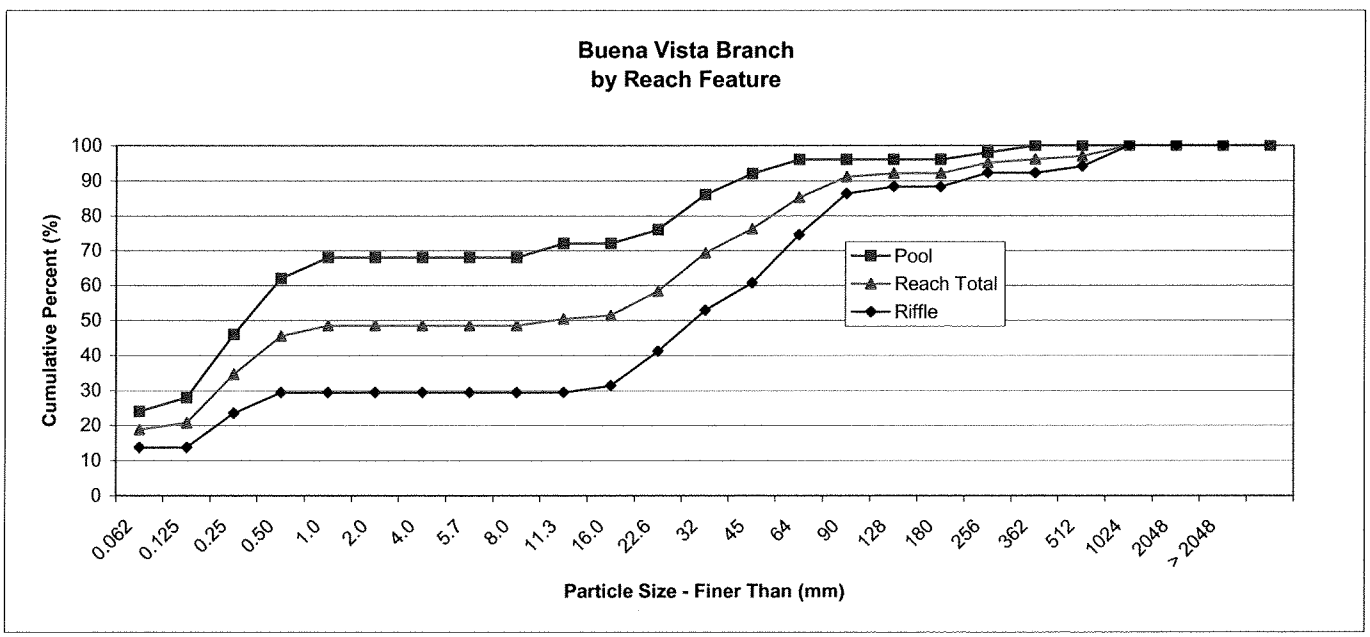
SITE OR PROJECT:	SILAS CREEK
REACH/LOCATION:	BUENA VISTA BRANCH
DATE COLLECTED:	7/30/2003
FIELD COLLECTION BY:	JBP
DATA ENTRY BY:	SEG

SEDIMENT ANALYSIS DATA SHEET

			PARTICLE CLASS WEIGHT (g)			Reach Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Pool	Total	Class %	% Cum
SILT/CLAY	Silt / Clay	< .062	7.0	12.0	19.00	18.81	18.81
SAND	Very Fine	.062 - .125		2.0	2.00	1.98	20.79
	Fine	.125 - .25	5.0	9.0	14.00	13.86	34.65
	Medium	.25 - .50	3.0	8.0	11.00	10.89	45.54
	Coarse	.50 - 1.0		3.0	3.00	2.97	48.51
	Very Coarse	1.0 - 2.0					48.51
GRAVEL	Very Fine	2.0 - 4.0					48.51
	Fine	4.0 - 5.7					48.51
	Fine	5.7 - 8.0					48.51
	Medium	8.0 - 11.3		2.0	2.00	1.98	50.50
	Medium	11.3 - 16.0	1.0		1.00	0.99	51.49
	Coarse	16.0 - 22.6	5.0	2.0	7.00	6.93	58.42
	Coarse	22.6 - 32	6.0	5.0	11.00	10.89	69.31
	Very Coarse	32 - 45	4.0	3.0	7.00	6.93	76.24
	Very Coarse	45 - 64	7.0	2.0	9.00	8.91	85.15
COBBLE	Small	64 - 90	6.0		6.00	5.94	91.09
	Small	90 - 128	1.0		1.00	0.99	92.08
	Large	128 - 180					92.08
	Large	180 - 256	2.0	1.0	3.00	2.97	95.05
BOULDER	Small	256 - 362		1.0	1.00	0.99	96.04
	Small	362 - 512	1.0		1.00	0.99	97.03
	Medium	512 - 1024	3.0		3.00	2.97	100.00
	Large-Very Large	1024 - 2048					100.00
BEDROCK	Bedrock	> 2048					100.00
		Totals:	51.0	50.0	101.00	100	100

Channel materials	
D_{16} =	<0.062mm
D_{35} =	0.26mm
D_{50} =	10.48mm
D_{84} =	61.55mm
D_{95} =	254.73mm


Buena Vista Branch
Class Percent
Cumulative Percent
Class Percent
Cumulative Percent Finer
Particle Size Class (mm)
< .062
.062 - .125
.125 - .25
.25 - .50
.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
256 - 362
362 - 512
512 - 1024
1024 - 2048
> 2048


Buena Vista Branch
by Reach Feature
Cumulative Percent (%)
Pool
Reach Total
Riffle
Particle Size - Finer Than (mm)
0.062
0.125
0.25
0.50
1.0
2.0
4.0
5.7
8.0
11.3
16.0
22.6
32
45
64
90
128
180
256
362
512
1024
2048
> 2048

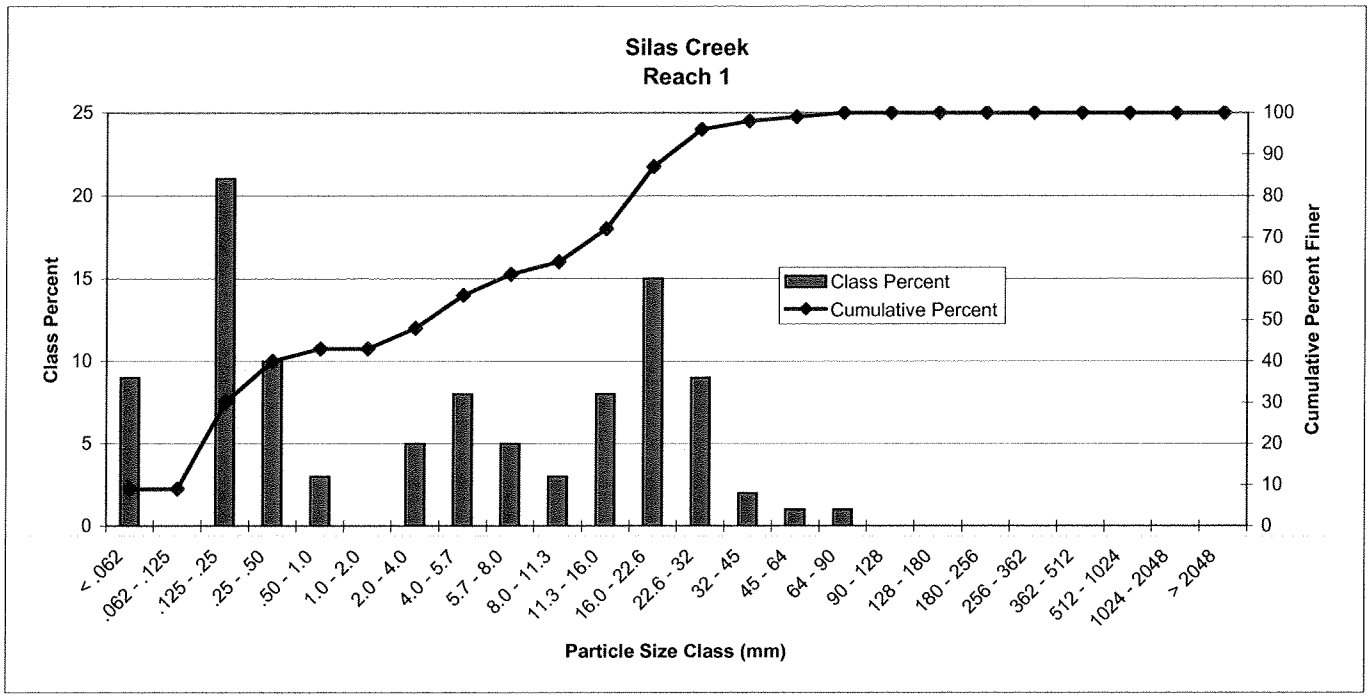
PEBBLE COUNT DATA SHEET

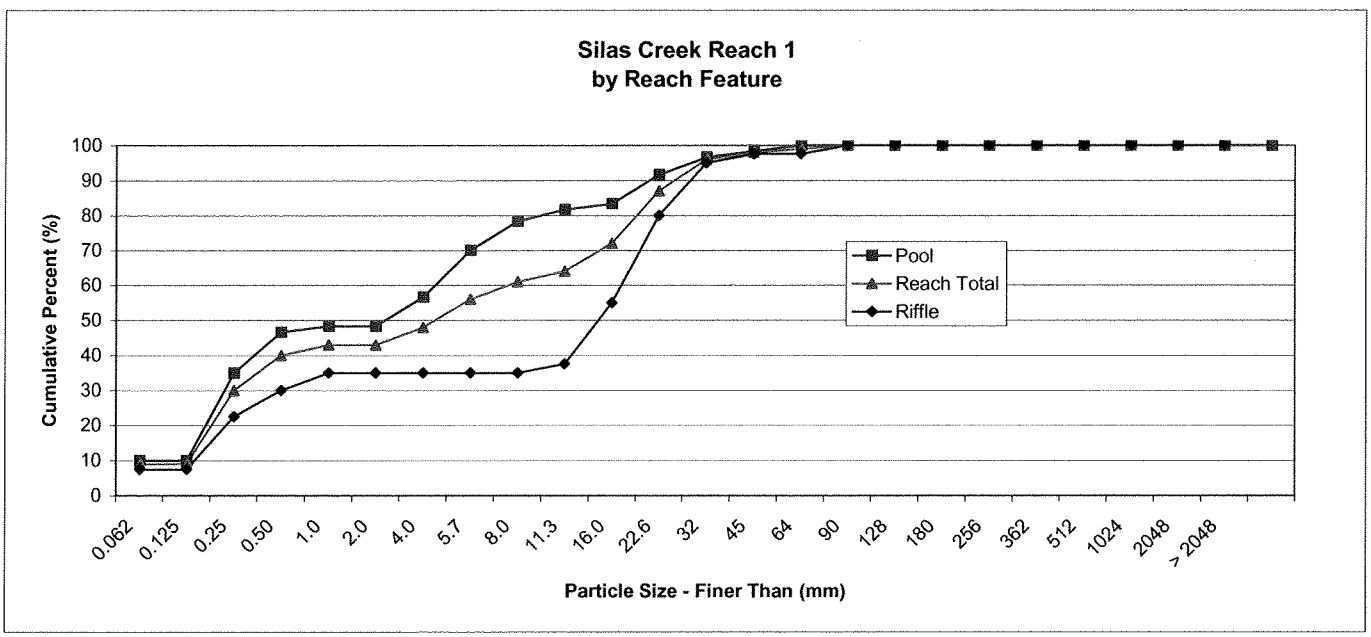
SITE OR PROJECT:	SILAS CREEK
REACH/LOCATION:	REACH 1
DATE COLLECTED:	2/9/2004
FIELD COLLECTION BY:	JBP
DATA ENTRY BY:	EEG

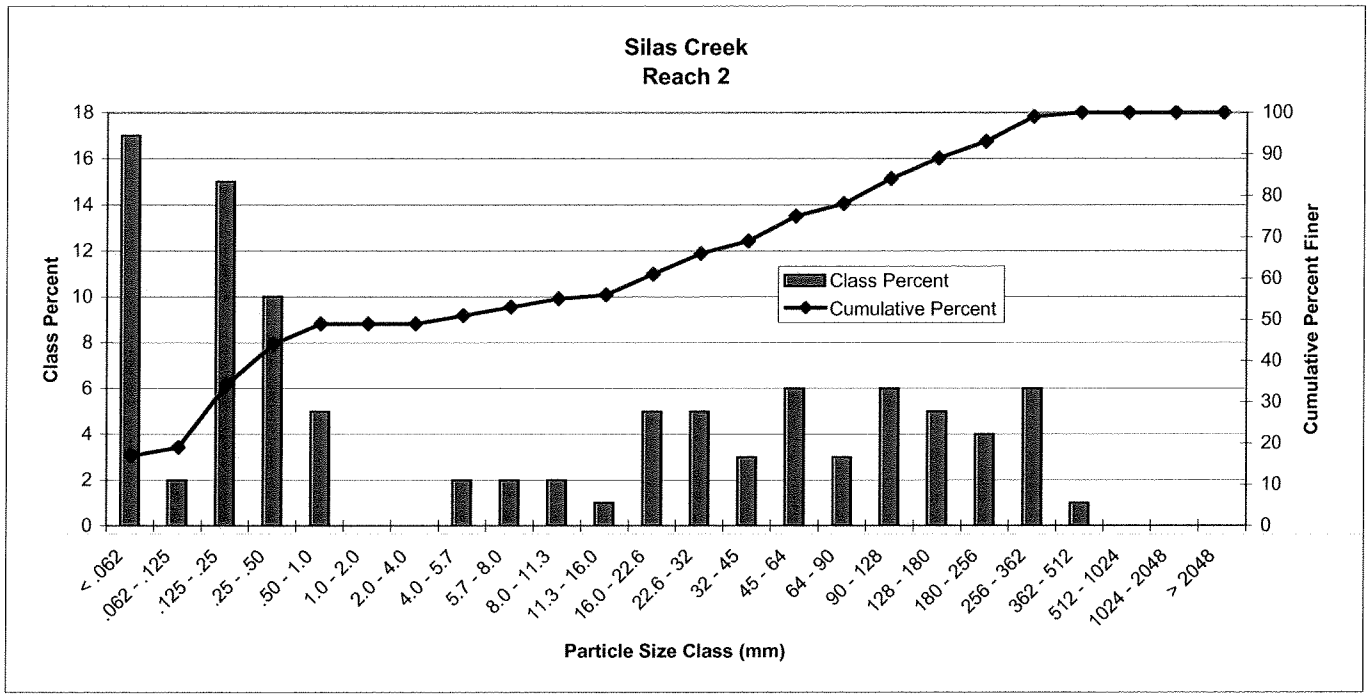
SEDIMENT ANALYSIS DATA SHEET

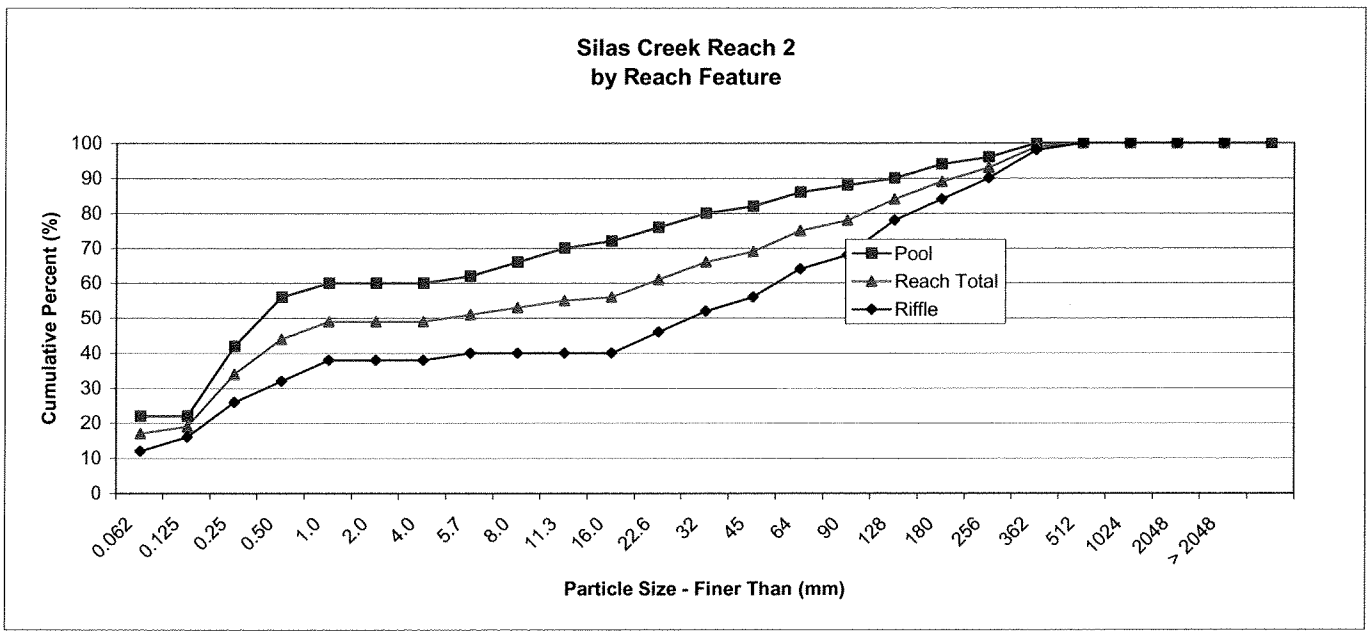
			PARTICLE CLASS WEIGHT (g)			Reach Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Pool	Total	Class %	% Cum
SILT/CLAY	Silt / Clay	< .062	3	6	9.00	9.00	9.00
SAND	Very Fine	.062 - .125					9.00
	Fine	.125 - .25	6	15	21.00	21.00	30.00
	Medium	.25 - .50	3	7	10.00	10.00	40.00
	Coarse	.50 - 1.0	2	1	3.00	3.00	43.00
	Very Coarse	1.0 - 2.0					43.00
GRAVEL	Very Fine	2.0 - 4.0		5	5.00	5.00	48.00
	Fine	4.0 - 5.7		8	8.00	8.00	56.00
	Fine	5.7 - 8.0		5	5.00	5.00	61.00
	Medium	8.0 - 11.3	1	2	3.00	3.00	64.00
	Medium	11.3 - 16.0	7	1	8.00	8.00	72.00
	Coarse	16.0 - 22.6	10	5	15.00	15.00	87.00
	Coarse	22.6 - 32	6	3	9.00	9.00	96.00
	Very Coarse	32 - 45	1	1	2.00	2.00	98.00
	Very Coarse	45 - 64		1	1.00	1.00	99.00
COBBLE	Small	64 - 90	1		1.00	1.00	100.00
	Small	90 - 128					100.00
	Large	128 - 180					100.00
	Large	180 - 256					100.00
BOULDER	Small	256 - 362					100.00
	Small	362 - 512					100.00
	Medium	512 - 1024					100.00
	Large-Very Large	1024 - 2048					100.00
BEDROCK	Bedrock	> 2048					100.00
		Totals:	40.0	60.0	100.00	100	100

Channel materials	
D_{16} =	0.17mm
D_{35} =	0.38mm
D_{50} =	4.43mm
D_{84} =	21.28mm
D_{95} =	30.96mm


Silas Creek
Reach 1
Class Percent
Cumulative Percent
Class Percent
Cumulative Percent Finer
Particle Size Class (mm)
< .062
.062 - .125
.125 - .25
.25 - .50
.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
256 - 362
362 - 512
512 - 1024
1024 - 2048
> 2048


Silas Creek Reach 1
by Reach Feature
Pool
Reach Total
Riffle
Cumulative Percent (%)
Particle Size - Finer Than (mm)
0.062
0.125
0.25
0.50
1.0
2.0
4.0
5.7
8.0
11.3
16.0
22.6
32
45
64
90
128
180
256
362
512
1024
2048
> 2048


Silas Creek
Reach 2
Class Percent
Cumulative Percent
Class Percent
Cumulative Percent Finer
Particle Size Class (mm)
< .062
.062 - .125
.125 - .25
.25 - .50
.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
256 - 362
362 - 512
512 - 1024
1024 - 2048
> 2048


Silas Creek Reach 2
by Reach Feature
Cumulative Percent (%)
Pool
Reach Total
Riffle
Particle Size - Finer Than (mm)
0.062
0.125
0.25
0.50
1.0
2.0
4.0
5.7
8.0
11.3
16.0
22.6
32
45
64
90
128
180
256
362
512
1024
2048
> 2048

PEBBLE COUNT DATA SHEET

SITE OR PROJECT:	SILAS CREEK
REACH/LOCATION:	Reach 2
DATE COLLECTED:	8/8/2003
FIELD COLLECTION BY:	JBP
DATA ENTRY BY:	SEG

SEDIMENT ANALYSIS DATA SHEET

			PARTICLE CLASS WEIGHT (g)			Reach Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Pool	Total	Class %	% Cum
SILT/CLAY	Silt / Clay	< .062	6.0	11.0	17.00	17.00	17.00
SAND	Very Fine	.062 - .125	2.0		2.00	2.00	19.00
	Fine	.125 - .25	5.0	10.0	15.00	15.00	34.00
	Medium	.25 - .50	3.0	7.0	10.00	10.00	44.00
	Coarse	.50 - 1.0	3.0	2.0	5.00	5.00	49.00
	Very Coarse	1.0 - 2.0					49.00
GRAVEL	Very Fine	2.0 - 4.0					49.00
	Fine	4.0 - 5.7	1.0	1.0	2.00	2.00	51.00
	Fine	5.7 - 8.0		2.0	2.00	2.00	53.00
	Medium	8.0 - 11.3		2.0	2.00	2.00	55.00
	Medium	11.3 - 16.0		1.0	1.00	1.00	56.00
	Coarse	16.0 - 22.6	3.0	2.0	5.00	5.00	61.00
	Coarse	22.6 - 32	3.0	2.0	5.00	5.00	66.00
	Very Coarse	32 - 45	2.0	1.0	3.00	3.00	69.00
	Very Coarse	45 - 64	4.0	2.0	6.00	6.00	75.00
COBBLE	Small	64 - 90	2.0	1.0	3.00	3.00	78.00
	Small	90 - 128	5.0	1.0	6.00	6.00	84.00
	Large	128 - 180	3.0	2.0	5.00	5.00	89.00
	Large	180 - 256	3.0	1.0	4.00	4.00	93.00
BOULDER	Small	256 - 362	4.0	2.0	6.00	6.00	99.00
	Small	362 - 512	1.0		1.00	1.00	100.00
	Medium	512 - 1024					100.00
	Large-Very Large	1024 - 2048					100.00
BEDROCK	Bedrock	> 2048					100.00
		Totals:	50.0	50.0	100.00	100	100

Channel materials	
D_{16} =	<0.062
D_{35} =	0.28mm
D_{50} =	4.85mm
D_{84} =	128.00mm
D_{95} =	291.33mm

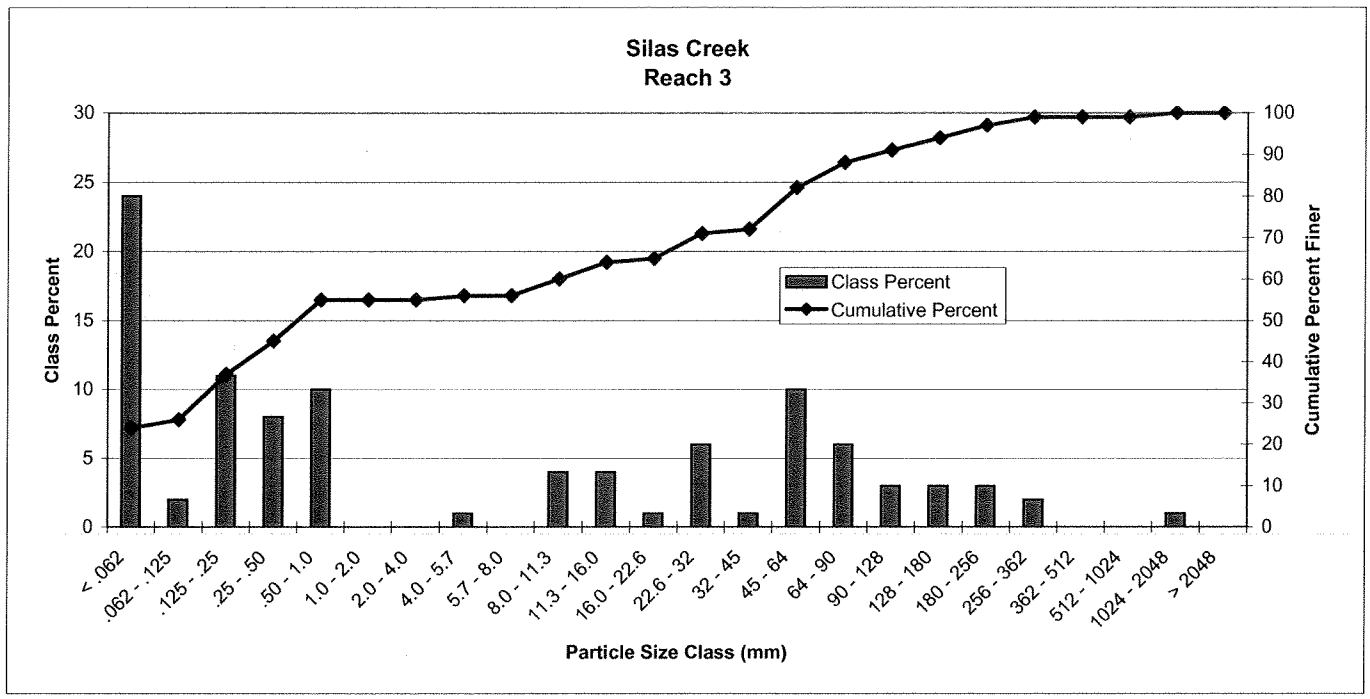
PEBBLE COUNT DATA SHEET

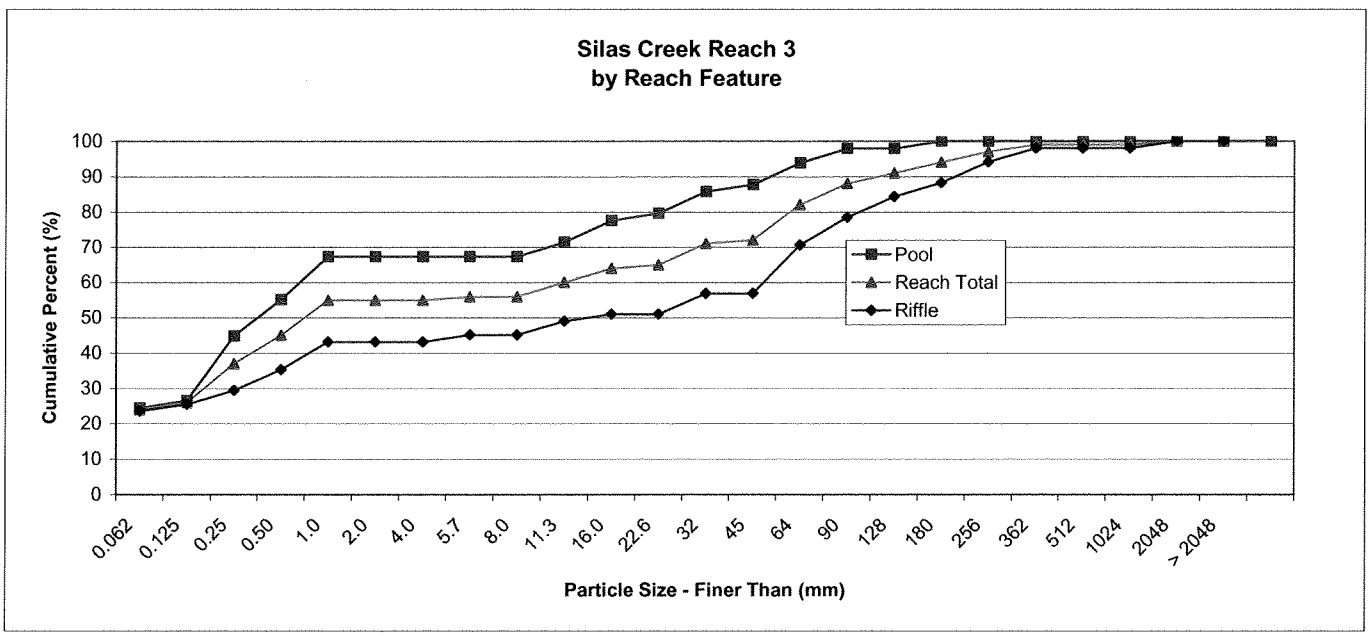
SITE OR PROJECT:	Silas Creek
REACH/LOCATION:	Reach 3
DATE COLLECTED:	7/29/2003
FIELD COLLECTION BY:	JBP
DATA ENTRY BY:	SEG

SEDIMENT ANALYSIS DATA SHEET

			PARTICLE CLASS WEIGHT (g)			Reach Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Pool	Total	Class %	% Cum
SILT/CLAY	Silt / Clay	< .062	12.0	12.0	24.00	24.00	24.00
SAND	Very Fine	.062 - .125	1.0	1.0	2.00	2.00	26.00
	Fine	.125 - .25	2.0	9.0	11.00	11.00	37.00
	Medium	.25 - .50	3.0	5.0	8.00	8.00	45.00
	Coarse	.50 - 1.0	4.0	6.0	10.00	10.00	55.00
	Very Coarse	1.0 - 2.0					55.00
GRAVEL	Very Fine	2.0 - 4.0					55.00
	Fine	4.0 - 5.7	1.0		1.00	1.00	56.00
	Fine	5.7 - 8.0					56.00
	Medium	8.0 - 11.3	2.0	2.0	4.00	4.00	60.00
	Medium	11.3 - 16.0	1.0	3.0	4.00	4.00	64.00
	Coarse	16.0 - 22.6		1.0	1.00	1.00	65.00
	Coarse	22.6 - 32	3.0	3.0	6.00	6.00	71.00
	Very Coarse	32 - 45		1.0	1.00	1.00	72.00
	Very Coarse	45 - 64	7.0	3.0	10.00	10.00	82.00
COBBLE	Small	64 - 90	4.0	2.0	6.00	6.00	88.00
	Small	90 - 128	3.0		3.00	3.00	91.00
	Large	128 - 180	2.0	1.0	3.00	3.00	94.00
	Large	180 - 256	3.0		3.00	3.00	97.00
BOULDER	Small	256 - 362	2.0		2.00	2.00	99.00
	Small	362 - 512					99.00
	Medium	512 - 1024					99.00
	Large-Very Large	1024 - 2048	1.0		1.00	1.00	100.00
BEDROCK	Bedrock	> 2048					100.00
		Totals:	51.0	49.0	100.00	100	100

Channel materials	
D_{16} =	<0.062mm
D_{35} =	0.23mm
D_{50} =	0.75mm
D_{84} =	72.67mm
D_{95} =	205.33mm


Silas Creek
Reach 3
Class Percent
Cumulative Percent
Class Percent
Cumulative Percent Finer
Particle Size Class (mm)
< .062
.062 - .125
.125 - .25
.25 - .50
.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
256 - 362
362 - 512
512 - 1024
1024 - 2048
> 2048


Silas Creek Reach 3
by Reach Feature
Cumulative Percent (%)
Pool
Reach Total
Riffle
Particle Size - Finer Than (mm)
0.062
0.125
0.25
0.50
1.0
2.0
4.0
5.7
8.0
11.3
16.0
22.6
32
45
64
90
128
180
256
362
512
1024
2048
> 2048

Silas Creek
Photo Log

Silas Creek

Reach 1 – Photos 67-90 (Long 23-28, X1-X3)

Reach 2 – Photos 40-66, 91-96 (Long 14-22, X4-X6)

Reach 3 – Photos 1-39, 97-102 (Long 1-13, X7-X9)

Vegetation Plot 1- Photo 113

Buena Vista Branch

BVB – Photos 103-112 (BVB Long 1-6, BVB X1-X2)

Vegetation Plot BV- Photo 114

Notes:
1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and orange flagging tape. For channel points, the stake is set up on the most accessible bank at that same station.
3. Photo locations include longitudinal photos, cross sections, and vegetation plots.

	
Photo 1-Long 1 (Downstream)	Photo 2-Long 1 (Across)
	
Photo 3-Long 1 (Upstream)	Photo 4-Long 2 (Downstream)
	
Photo 5-Long 2 (Across)	Photo 6-Long 2 (Upstream)

	
Photo 7-Long 3 (Downstream)	Photo 8-Long 3 (Across)
	
Photo 9-Long 3 (Upstream)	Photo 10-Long 4 (Downstream)
	
Photo 11-Long 4 (Across)	Photo 12-Long 4 (Upstream)

	
Photo 13-Long 5 (Downstream)	Photo 14-Long 5 (Across)
	
Photo 15-Long 5 (Upstream)	Photo 16-Long 6 (Downstream)
	
Photo 17-Long 6 (Across)	Photo 18-Long 6 (Upstream)

	
Photo 19-Long 7 (Across)	Photo 20-Long 7 (Upstream)
	
Photo 21-Long 7 (Across)	Photo 22-Long 8 (Upstream)
	
Photo 23-Long 8 (Across)	Photo 24-Long 8 (Upstream)

	
Photo 25-Long 9 (Downstream)	Photo 26-Long 9 (Across)
	
Photo 27-Long 9 (Upstream)	Photo 28-Long 10 (Downstream)
	
Photo 29-Long 10 (Across)	Photo 30-Long 10 (Upstream)

Photo 31-Long 11 (Downstream)

Photo 32-Long 11 (Across)

Photo 33-Long 11 (Upstream)

Photo 34-Long 12 (Downstream)

Photo 35-Long 12 (Across)

Photo 36-Long 12 (Upstream)

	
Photo 37-Long 13 (Downstream)	Photo 38-Long 13 (Across)
	
Photo 39-Long 13 (Upstream)	Photo 40-Long 14 (Downstream)
	
Photo 41-Long 14 (Across)	Photo 42-Long 14 (Upstream)

	
Photo 43-Long 15 (Downstream)	Photo 44-Long 15 (Across)
	
Photo 45-Long 15 (Upstream)	Photo 46-Long 16 (Downstream)
	
Photo 47-Long 16 (Across)	Photo 48-Long 16 (Upstream)

	
Photo 49-Long 17 (Downstream)	Photo 50-Long 17 (Across)
	
Photo 51-Long 17 (Upstream)	Photo 52-Long 18 (Downstream)
	
Photo 53-Long 18 (Across)	Photo 54-Long 18 (Upstream)

	
Photo 55-Long 19 (Downstream)	Photo 56-Long 19 (Across)
	
Photo 57-Long 19 (Upstream)	Photo 58-Long 20 (Downstream)
	
Photo 59-Long 20 (Across)	Photo 60-Long 20 (Upstream)

Photo 61-Long 21 (Downstream)

Photo 62-Long 21 (Across)

Photo 63-Long 21 (Upstream)

Photo 64-Long 22 (Downstream)

Photo 65-Long 22 (Across)

Photo 66-Long 22 (Upstream)

Photo 67-Long 23 (Downstream)

Photo 68-Long 23 (Across)

Photo 69-Long 23 (Upstream)

Photo 70-Long 24 (Downstream)

Photo 71-Long 24 (Across)

Photo 72-Long 24 (Upstream)

	
Photo 73-Long 25 (Downstream)	Photo 74-Long 25 (Across)
	
Photo 75-Long 25 (Upstream)	Photo 76-Long 26 (Downstream)
	
Photo 77-Long 26 (Across)	Photo 78-Long 26 (Upstream)

Photo 79-Long 27 (Downstream)

Photo 80-Long 27 (Across)

Photo 81-Long 27 (Upstream)

Photo 82-Long 28 (Downstream)

Photo 83-Long 28 (Across)

Photo 84-Long 28 (Upstream)

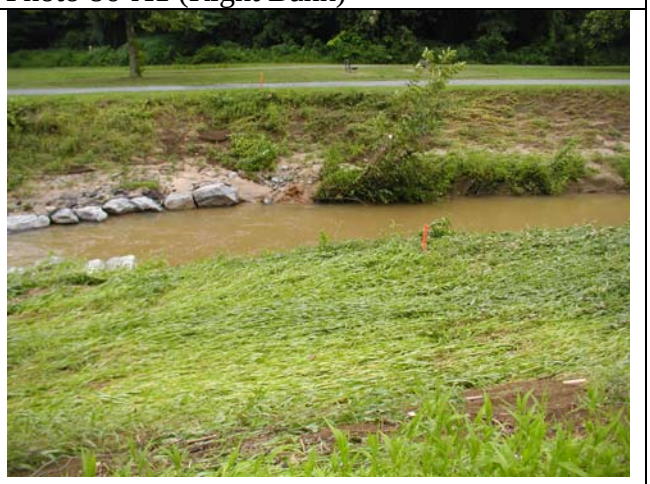
	
Photo 85-X1 (Left Bank)	Photo 86-X1 (Right Bank)
	
Photo 87-X2 (Left Bank)	Photo 88-X2 (Right Bank)
	
Photo 89-X3 (Left Bank)	Photo 90-X3 (Right Bank)

	
Photo 91-X4 (Left Bank)	Photo 92-X4 (Right Bank)
	
Photo 93-X5 (Left Bank)	Photo 94-X5 (Right Bank)
	
Photo 95-X6 (Left Bank)	Photo 96-X6 (Right Bank)

	
Photo 97-X7 (Left Bank)	Photo 98-X7 (Right Bank)
	
Photo 99-X8 (Left Bank)	Photo 100-X8 (Right Bank)
	
Photo 101-X9 (Left Bank)	Photo 102-X9 (Right Bank)

Photo 103-BVB Long 1

Photo 104- BVB Long 2

Photo 105- BVB Long 3

Photo 106- BVB Long 4

Photo 107- BVB Long 5

Photo 108- BVB Long 6

Photo 109- BVB X1 (Left Bank)

Photo 110- BVB X1 (Right Bank)

Photo 111- BVB X2 (Left Bank)

Photo 112- BVB X2 (Right Bank)

Photo 113- Vegetation Plot 1 (Silas Creek) looking downstream

Photo 114- Vegetation Plot BV (Buena Vista Branch) looking downstream

Silas Creek
Vegetation Survival Plots

Live Stakes

Plot	Photo Point (#)	Planted (stakes)	Year 1 (stakes)	Year 2 (stakes)	Year 3 (stakes)	Year (stakes)	Year 5 (stakes)
1		**71**					
BV		**45**					

Bare Root Plantings

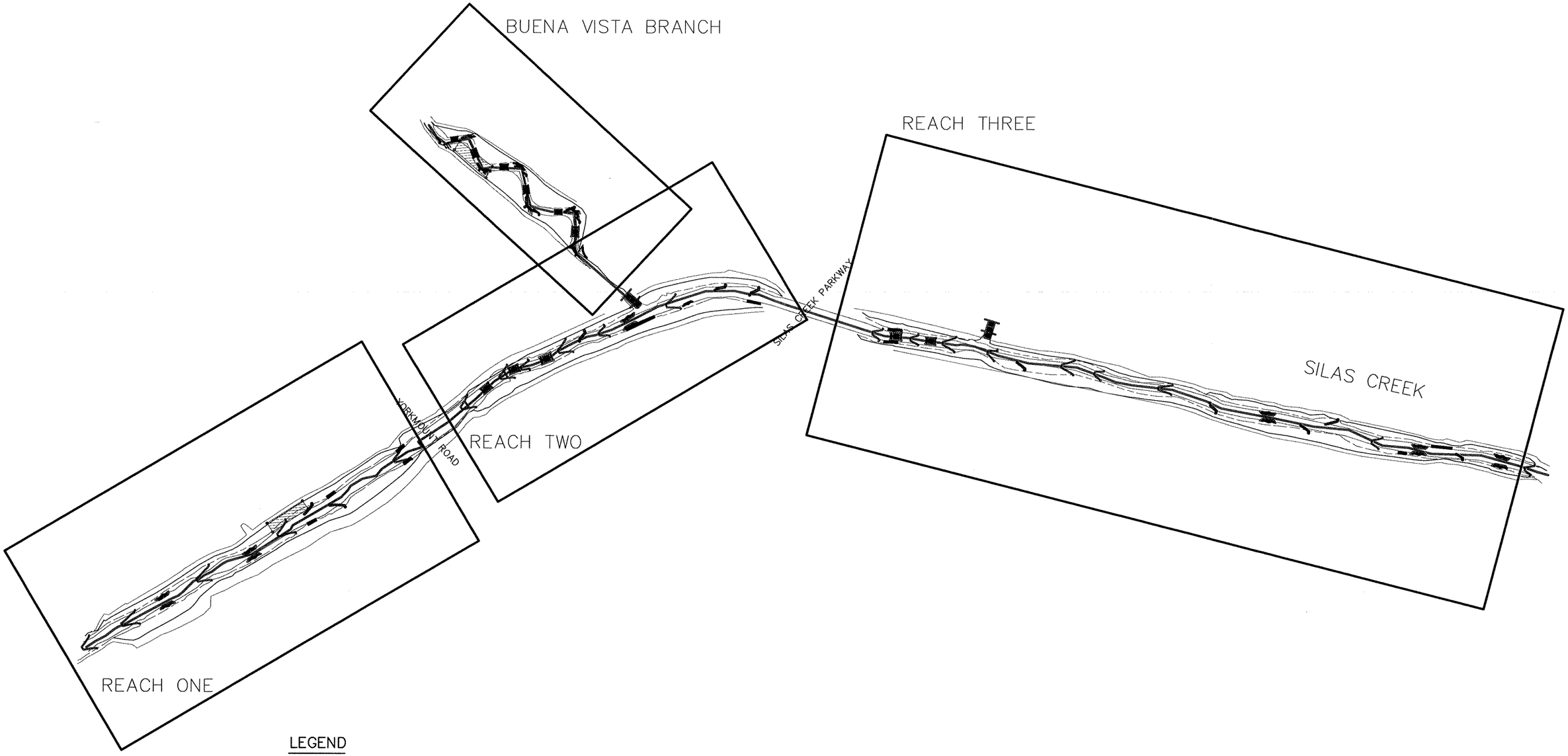
Plot	Photo Point (#)	Planted (Total Stems)	Year 1 (stems)	Year 2 (stems)	Year 3 (stems)	Year 4 (stems)	Year 5 (stems)
1		**37**					
BV		**30**					

Bare Root Plantings By Species

Plot 1	**Planted (stems)**	**Year 1 (stems)**	**Year 2 (stems)**	**Year 3 (stems)**	**Year 4 (stems)**	**Year 5 (stems)**
Sycamore	3					
Ironwood	7					
Spicebush	3					
Willow Oak	4					
River Birch	5					
PawPaw	2					
Shagbark Hickory	6					
Southern Sugar Maple	3					
Red Chokeberry	4					
Plot BV						
Sycamore	5					
Ironwood	4					
Spicebush	2					
Willow Oak	2					
River Birch	3					
PawPaw	2					
Shagbark Hickory	3					
Southern Sugar Maple	4					
Red Chokeberry	5					

Notes:

1. All plots are shown on the plan views. All plot corners are marked with wooden stakes with orange flagging tape.
3. Photo point locations are shown on the plan views and marked with wooden stakes with orange flagging tape.
4. Use successive columns for survivability from year to year.



LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD
- (P) PHOTO LOCATION
- CROSS SECTION LOCATION

0 120 240 360 feet

Silas Creek

Figure 2.1a: Overall As-Built Plan View

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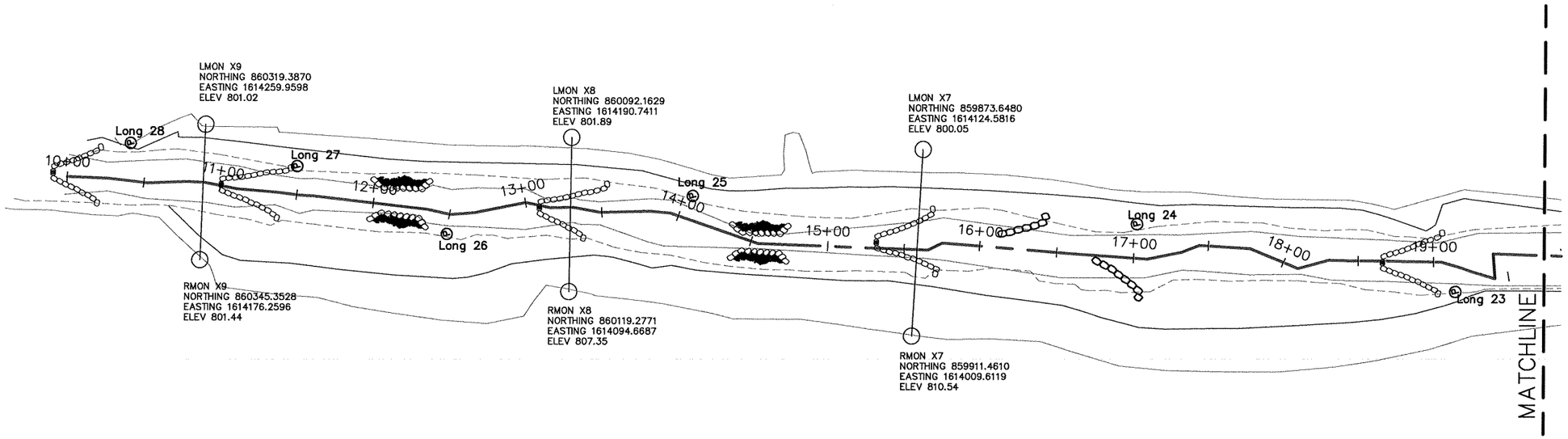
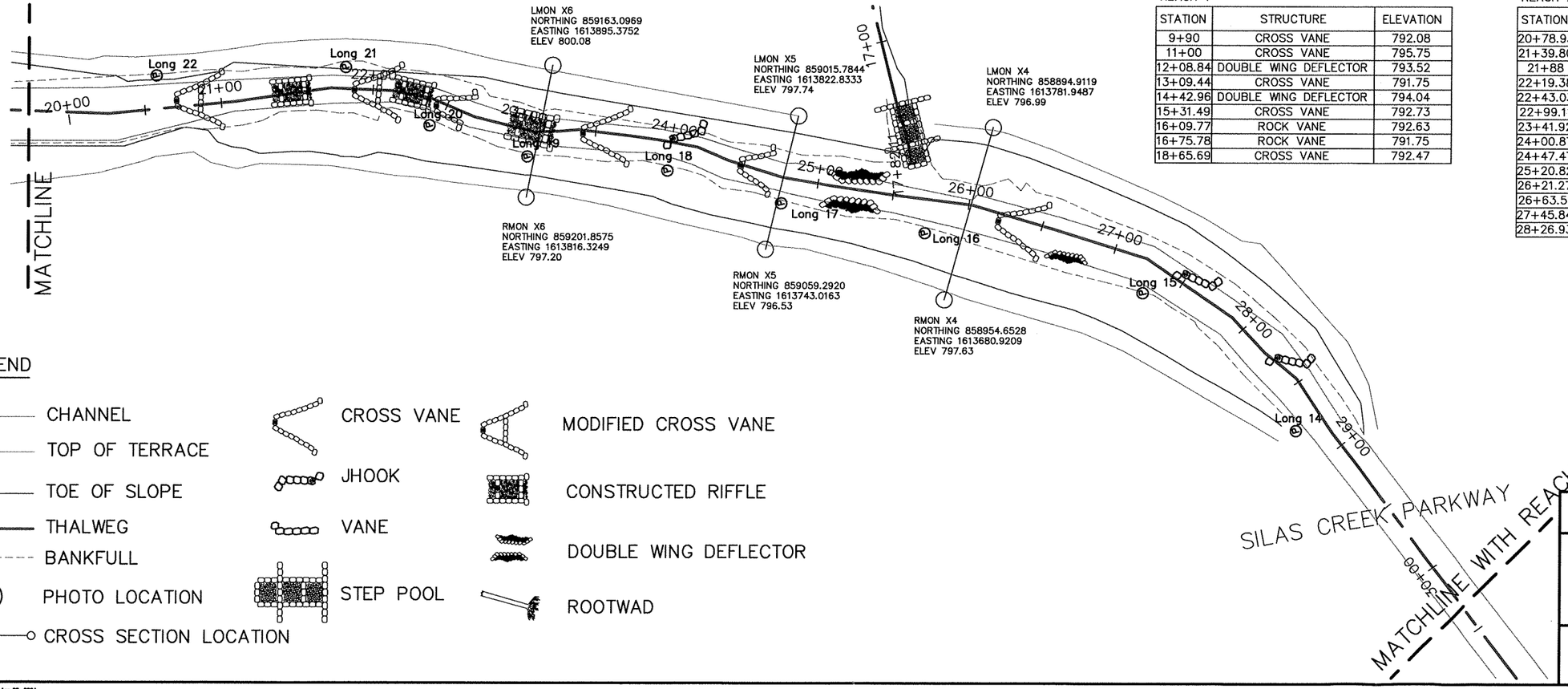
L:\Projects\00760\Surveys\ADJUSTED\asbuilt.dwg Apr 02, 2004

REACH ONE



REACH TWO



REACH 1

STATION	STRUCTURE	ELEVATION
9+90	CROSS VANE	792.08
11+00	CROSS VANE	795.75
12+08.84	DOUBLE WING DEFLECTOR	793.52
13+09.44	CROSS VANE	791.75
14+42.96	DOUBLE WING DEFLECTOR	794.04
15+31.49	CROSS VANE	792.73
16+09.77	ROCK VANE	792.63
16+75.78	ROCK VANE	791.75
18+65.69	CROSS VANE	792.47

REACH 2

STATION	STRUCTURE	ELEVATION
20+78.93	MODIFIED CROSS VANE	792.15
21+39.80	CONSTRUCTED RIFFLE	791.13
21+88	MODIFIED CROSS VANE	790.45
22+19.38	CONSTRUCTED RIFFLE	790.07
22+43.03	CROSS VANE	789.09
22+99.11	CONSTRUCTED RIFFLE	787.94
23+41.92	CROSS VANE	788.31
24+00.87	ROCK VANE	788.15
24+47.47	CROSS VANE	788.14
25+20.82	DOUBLE WING DEFLECTOR	788.54
26+21.27	CROSS VANE	788.32
26+63.51	SINGLE WING DEFLECTOR	789.03
27+45.84	ROCK VANE	788.61
28+26.93	ROCK VANE	787.07

LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD

0 40 80 120 feet

Silas Creek

Figure 2.1b: Reach One And Two As-Built Plan View

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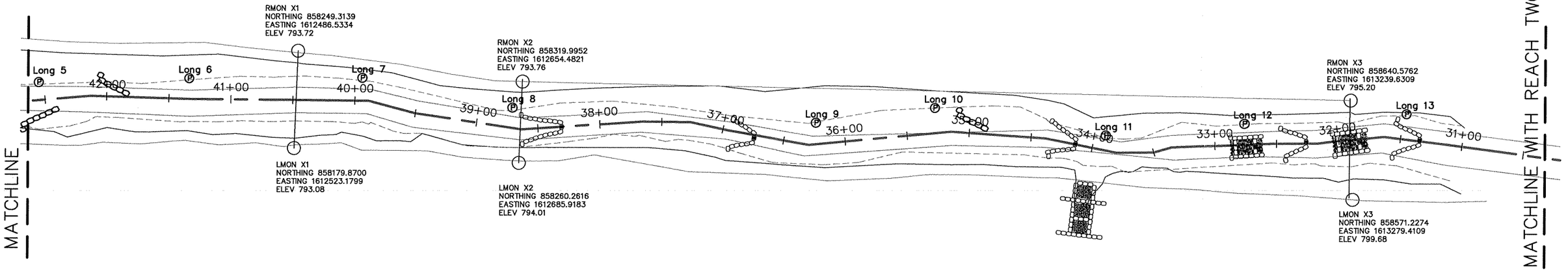

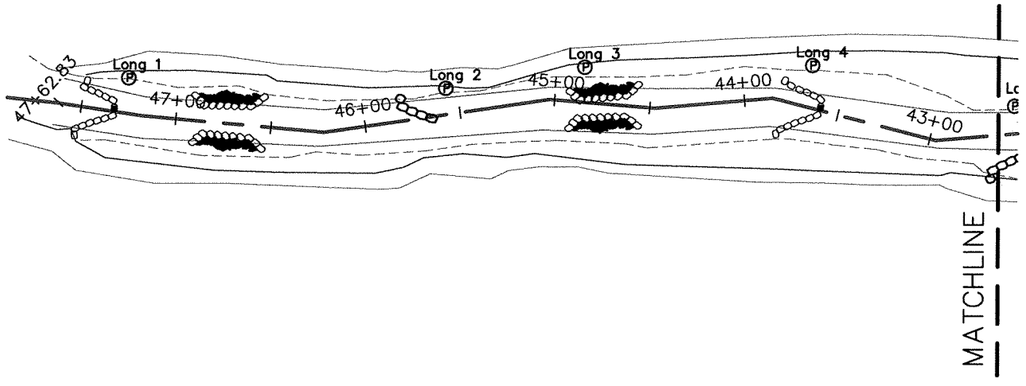

REACH 3

STATION	STRUCTURE	ELEVATION
31+34.02	CROSS VANE	787.20
31+38.48	CONSTRUCTED RIFFLE	787.56
32+26.57	CROSS VANE	786.36
32+67.73	CONSTRUCTED RIFFLE	785.63
33+03.85	CROSS VANE	785.33
3400.60	STEP POOL	790.83
34+13.87	CROSS VANE	785.05
34+85.30	ROCK VANE	784.58
35+91.97	CROSS VANE	784.72
36+73.13	CROSS VANE	784.61
38+31.02	CROSS VANE	784.39
39+61.18	ROCK VANE	784.34
40+91.25	DOUBLE WING DEFLECTOR	784.14
41+87.49	ROCK VANE	784.44
42+39.77	ROCK VANE	783.77
43+60.98	CROSS VANE	783.99
44+62.93	DOUBLE WING DEFLECTOR	784.24
45+64.10	ROCK VANE	782.40
46+57.84	DOUBLE WING DEFLECTOR	783.54
47+33.13	CROSS VANE	782.95

LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD

0 40 80 120 feet

Silas Creek

Figure 2.1c: Reach Three As-Built Plan View

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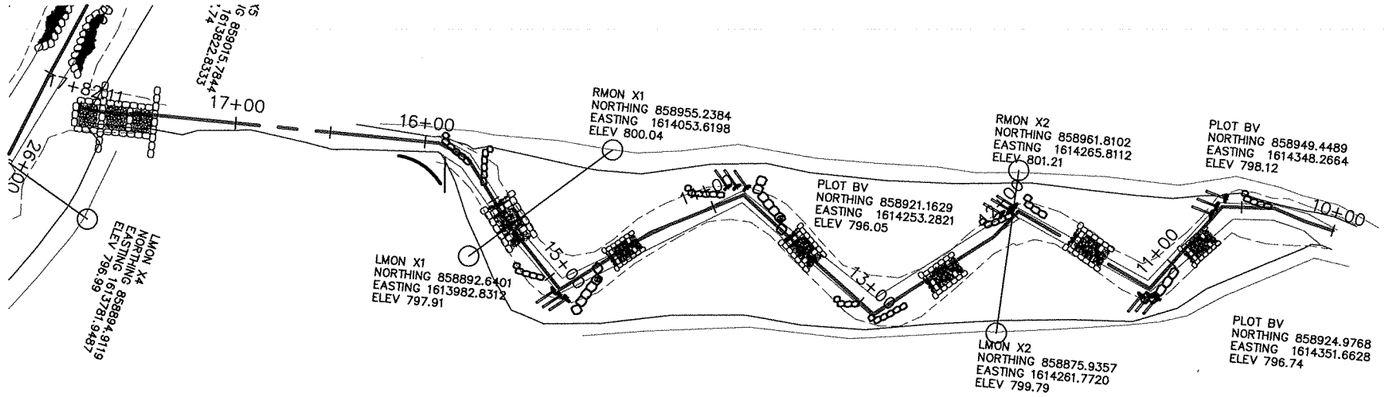

BUENA VISTA

STATION	STRUCTURE	ELEVATION
10+33.83	ROCK VANE	796.09
10+76.47	CONSTRUCTED RIFFLE	796.29
11+02.39	ROCK VANE	795.62
11+45.86	CONSTRUCTED RIFFLE	795.83
12+03.67	ROCK VANE	795.23
12+37.72	CONSTRUCTED RIFFLE	795.38
12+73.15	ROCK VANE	795.15
13+00.60	ROCK VANE	794.57
13+33.96	CONSTRUCTED RIFFLE	794.99
13+58.42	J-HOOK	794.79
13+91.89	ROCK VANE	794.82
14+42.46	CONSTRUCTED RIFFLE	794.47
14+71.09	J-HOOK	794.39
15+02.10	ROCK VANE	794.31
15+23.78	CONSTRUCTED RIFFLE	793.98
15+70.66	ROCK VANE	796.20
15+89.51	ROCK VANE	795.41
17+77.78	STEP POOL	789.41

LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- (P) PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD

0 40 80 120 feet

0 40 80 120 feet

Silas Creek

Figure 2.1d: Buena Vista As-Built Plan View

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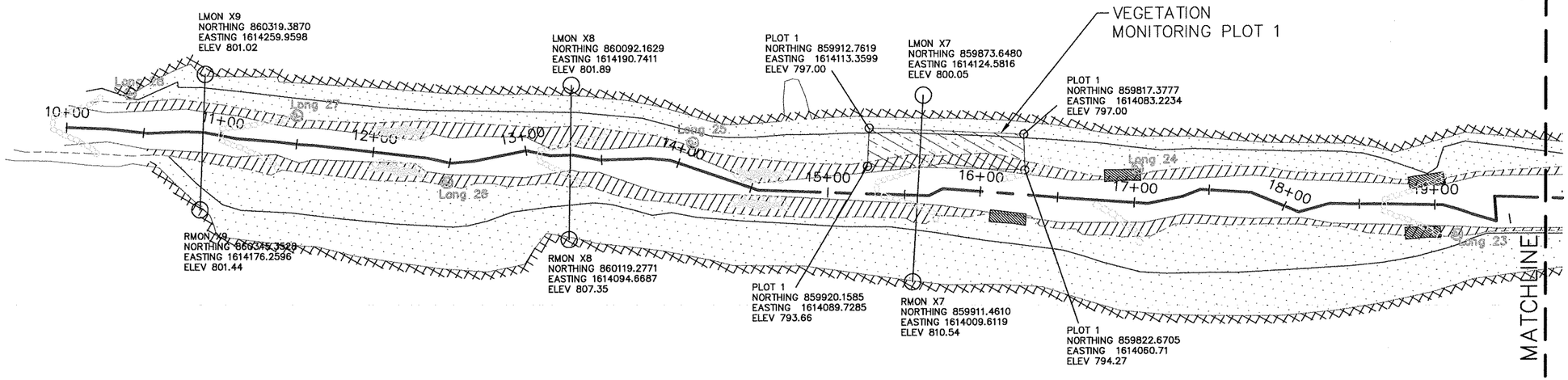
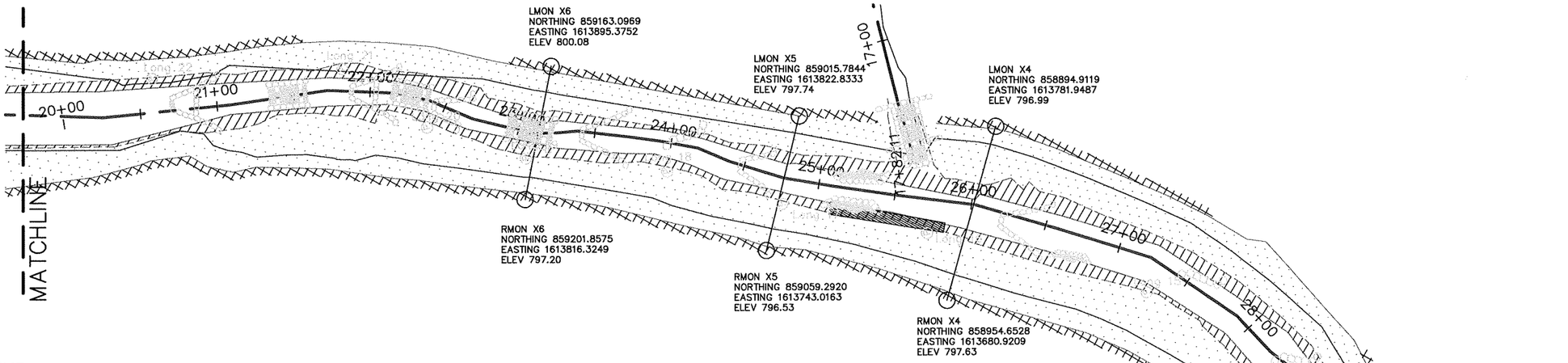
REACH ONE

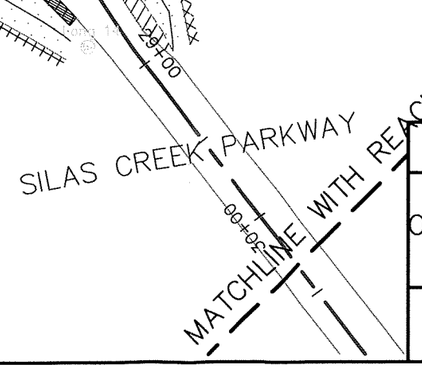


REACH TWO



LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD
- BMP PLANTINGS
- 2" CALIPER B&B PLANTING ZONE
- RIPARIAN SEED MIX, BARE ROOT WOODY VEGETATION
- LIVE STAKING
- BRUSH MATTRESS



0 40 80 120 feet

Silas Creek

Figure 2.1e: Reach One And Two Vegetation As-Built Plan View

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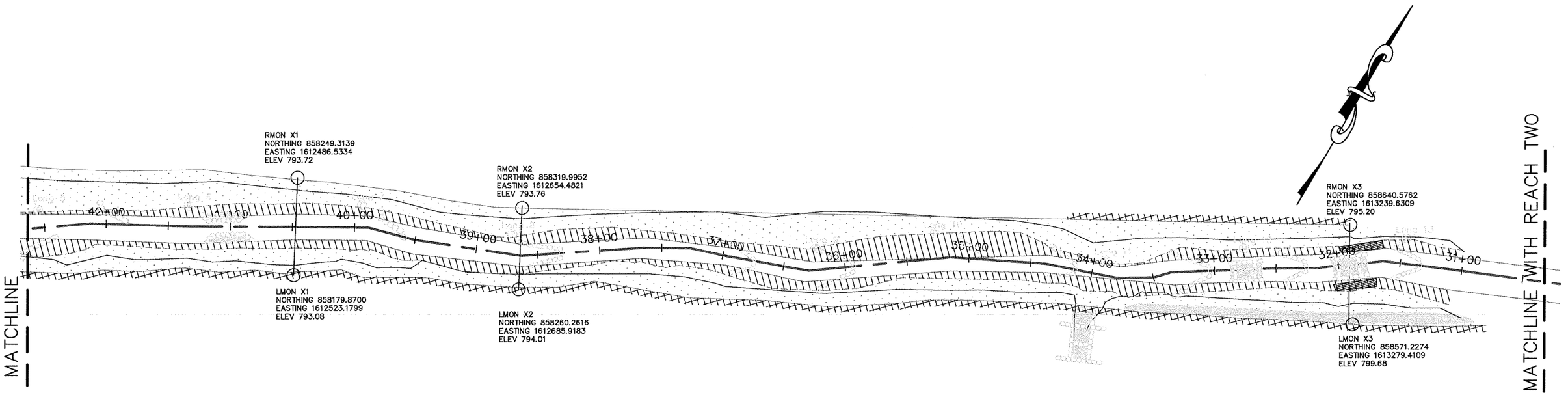

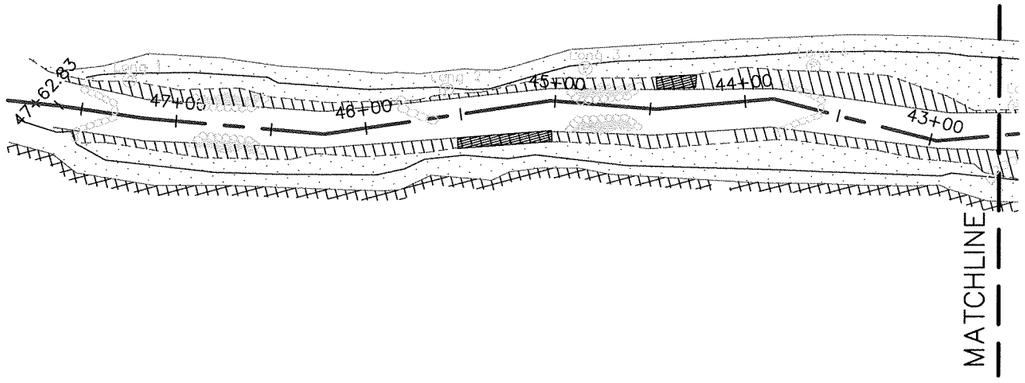

LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- Ⓟ PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD
- BMP PLANTINGS
- 2" CALIPER B&B PLANTING ZONE
- RIPARIAN SEED MIX, BARE ROOT WOODY VEGETATION
- LIVE STAKING
- BRUSH MATTRESS

0 40 80 120 feet

Silas Creek

Figure 2.1f: Reach Three Vegetation As-Built Plan View

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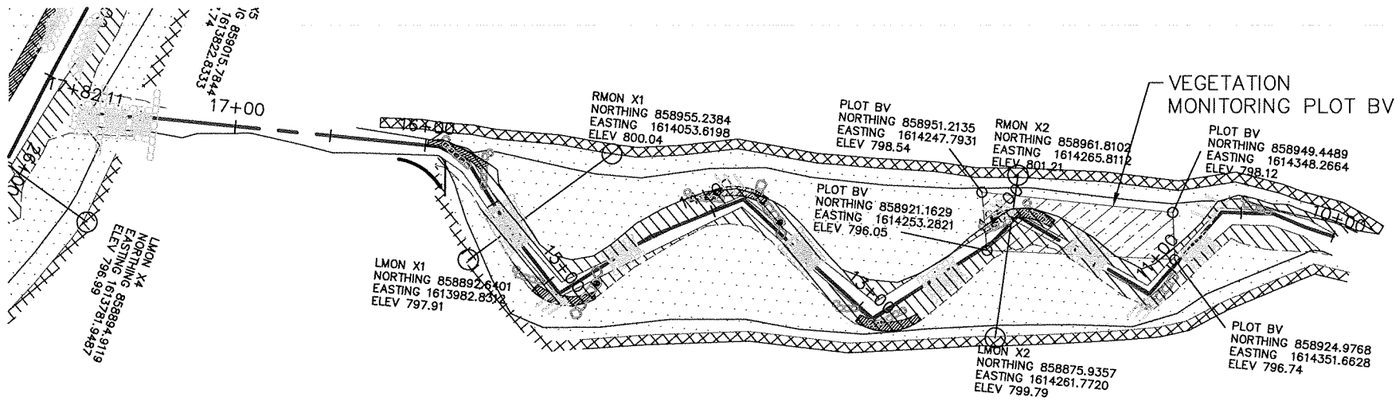

LEGEND

- CHANNEL
- TOP OF TERRACE
- TOE OF SLOPE
- THALWEG
- BANKFULL
- (P) PHOTO LOCATION
- CROSS SECTION LOCATION
- CROSS VANE
- JHOOK
- VANE
- STEP POOL
- MODIFIED CROSS VANE
- CONSTRUCTED RIFFLE
- DOUBLE WING DEFLECTOR
- ROOTWAD
- BMP PLANTINGS
- 2" CALIPER B&B PLANTING ZONE
- RIPARIAN SEED MIX, BARE ROOT WOODY VEGETATION
- LIVE STAKING
- BRUSH MATTRESS

0 40 80 120 feet

Silas Creek

Figure 2.1g: Buena Vista Vegetation As-Built Plan View

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