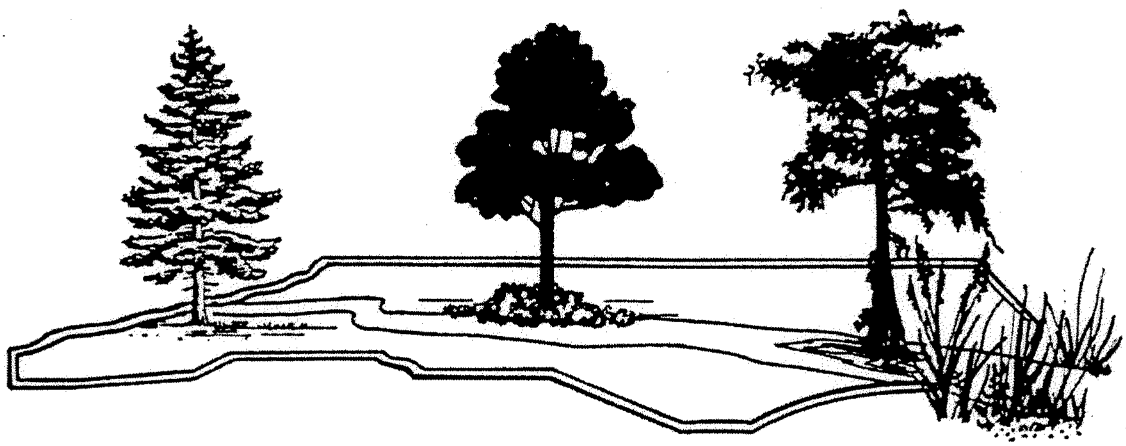
FINAL DESIGN CRITERIA
AND
REFERENCE REACH ASSESSMENT

HOMINY SWAMP CREEK
WILSON RECREATION PARK
WILSON, NORTH CAROLINA



N.C. Wetlands Restoration Program

NCDENR DWQ

PREPARED BY:

KCI
ASSOCIATES OF NC

NOVEMBER 17, 2000

HOMINY SWAMP CREEK
WILSON RECREATION PARK STREAM RESTORATION

FINAL DESIGN CRITERIA

INTRODUCTION

The portion of Hominy Swamp Creek located within the Wilson Recreation Park was identified as a potential stream restoration/mitigation site by the North Carolina Department of Environment and Natural Resources Wetlands Restoration Program (WRP).

Phase I of this project consisted of a detailed study of the portion of the Hominy Swamp Watershed contributing to the project site. This phase involved the documentation and evaluation of the watershed conditions. Phase I of the project was completed in October 1999 with the submittal of the Hominy Swamp Creek Watershed Management Plan. Based upon the conclusions derived from the watershed evaluation, this plan recommended specific watershed controls, BMPs, and storm water retrofits that could be applied in the watershed to stabilize and restore water quality integrity. Restoration of the Hominy Swamp Creek stream section within the Wilson Recreation Park was included as a recommended action.

Phase II of the project focused on the stream restoration within Wilson Recreation Park and included a detailed site survey and evaluation to document existing site conditions and constraints. This evaluation included a preliminary analysis of existing site hydrologic and geomorphic conditions. A site constraint evaluation, documentation of existing riparian buffers, and a constructibility evaluation were also completed. The findings of this evaluation resulted in the development of a Preliminary Stream Evaluation and Design Criteria Report that was completed in November 1999.

PURPOSE

The purpose of this project memorandum is to present final project design criteria based on fluvial geomorphologic parameters, a site constraint evaluation, approved riparian buffer revegetation parameters, and a sediment transport analysis. The goal is to integrate all of the appropriate information and establish the criteria upon which the restoration design will be based.

DESIGN CRITERIA

Morphology

The morphologic design criteria were developed using an analog design or reference reach methodology. An analog design strategy involves using data derived from a channel similar to the project stream when features of the project stream are no longer useful due to disturbance. The objective is to base design improvements of a channel in an undesirable condition upon observed desirable conditions within a similar channel type. Channel dimensions, pattern and profile are measured on a stable reference site and used to develop quantitative dimensionless ratios from which the restoration design is based.

A Level II Stream Classification, according to the methodologies outlined in Applied River Morphology (Rosgen, 1996), was performed on a selected reference reach. For this project, the selected reference site is located directly north of Airport Road and to south of the Wilson Airport (See Site/Reference Watershed Graphic). Selection of this site is appropriate due to its close proximity to the subject site, location within the same watershed as the project site and similarity of geographic characteristics (i.e., geology, landscape position, topographic relief, watershed landuse and land cover) of the project site.

The stream section that flows through the project site was also assessed and surveyed to provide for a general classification based on fluvial geomorphic principles. The stream section in the project site was identified as a modified "E5" channel type. As urban streams have oftentimes been altered and in many cases do not exhibit the typical characteristics of "natural channels," all the classification parameters may not fall within certain limits for a given stream type, thus the modified status.

The morphologic design criteria established for the proposed restoration of the project site is provided in Appendix 1 – Morphologic Design Criteria.

Constraints

A detailed survey was conducted to document existing site characteristics that could affect stream restoration on the subject site. Utilities, structures, slope stability problems, and construction access and staging were the key elements examined. (See Appendix 2 – Site Constraints.)

Riparian Buffers

Criteria for the re-establishment and maintenance of riparian buffer and streambank vegetation were developed based upon established bioengineering principles and the project guidelines previously approved by the interested parties. (See Appendix 3 – Riparian Buffer Criteria.)

Sediment Transport Analysis

An evaluation of the expected sediment transport characteristics of the project site was completed. The evaluation consists of 1) a determination of critical dimensionless shear stress (based on the Shields formula), 2) an analysis of critical depth, and 3) a sediment discharge estimate. Based on the evaluation results, it is expected that the proposed restoration will be competent in terms of sediment transport and will achieve a state of equilibrium in the section of Hominy Swamp Creek located within the project site. (See Appendix 4 – Sediment Transport Analysis.)

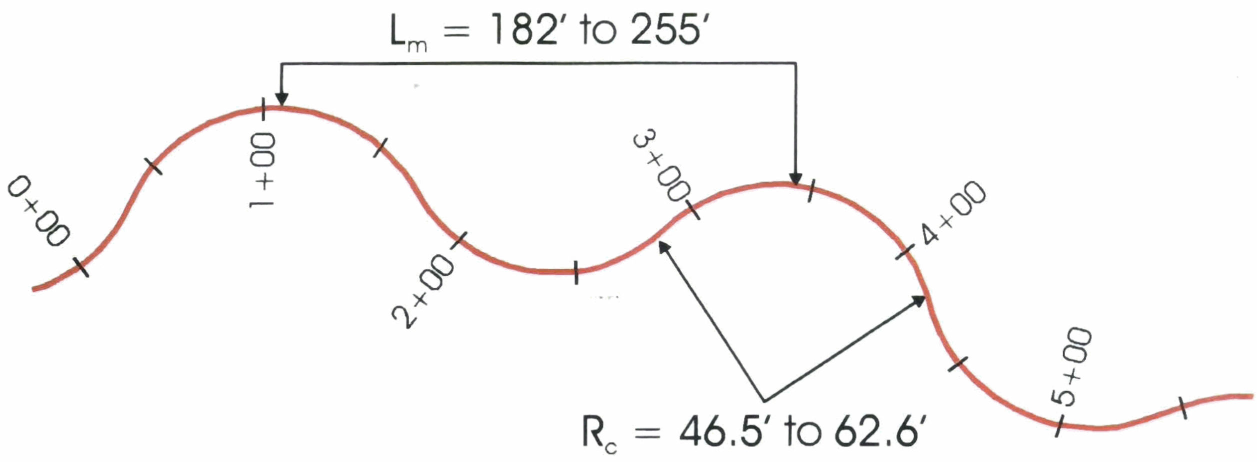
CONCLUSION

The evaluated potential of successfully restoring stream channel characteristics of the Wilson Recreation Park Site to a condition that will facilitate improved water quality is good. The approved riparian revegetation parameters will also contribute to improvements in both habitat and water quality. The existing constraints place some limitations on restoration activities; however they do not eliminate the overall potential of using the project site.

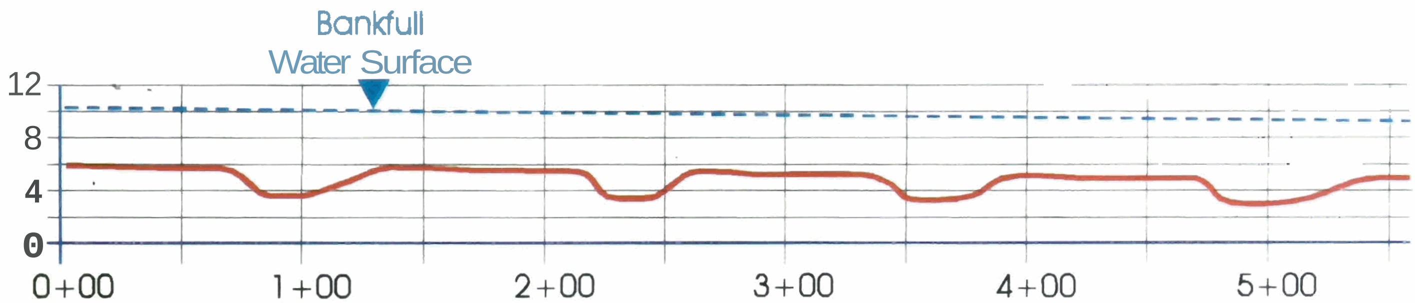
Appendix 1 –
Morphological Design Criteria

MORPHOLOGICAL DESIGN CRITERIA

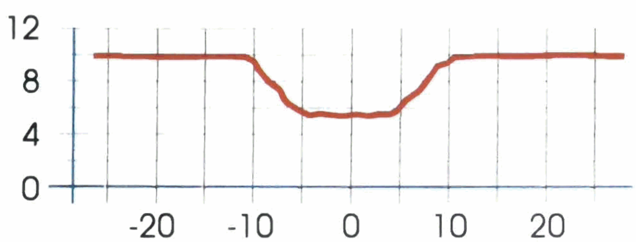
	Variables	Project Site Existing Channel	Reference Reach	Project Site Restored Reach
	Stream Type	E5 (Modified)	E5	E5
	Drainage Area (mi^2)	5.4	1.03	5.4
	Bankfull Width (W_{bkf})	25.5'	11.9'	20.2'
	Bankfull Mean Depth (d_{bkf})	2.74'	1.61'	2.73'
	Bankfull Cross-Sectional Area (A_{bkf}) (ft^2)	70	19.2	55
	Width/Depth Ratio (W_{bkf}/d_{bkf})	9.3	7.4	7.4
	Bankfull Max Depth (d_{mbkf})	4.68'	2.11'	4.30'
	Width of Floodprone Area (W_{fpa})	> 100'	>45'	> 100'
	Entrenchment Ratio (ER)	> 4.0	>2.2	> 5.0
	Channel Materials (D50) (mm)	Fine Sand	V. Fine Sand	Fine Sand
	Water Surface Slope (S)	0.0015	0.0015	0.0014
	Sinuosity (K)	1.1	1.41	1.2
Dimension	Pool Depth (dp)	5.18 – 6.78'	2.46' – 3.55'	5.4 – 6.6
	Riffle Depth (dr)	3.88 – 5.08'	1.55' – 2.18'	3.9 – 4.7
	Ratio - Max. Pool Depth:Mean Bkf. Depth	2.47	2.2	2.2
	Bankfull mean velocity (u) (ft./sec.)	2.94	2.43	3.38
	Bankfull discharge (Q) (CFS)	205.5	46.6	200
Pattern	Meander Length (L_m)	114 – 170'	107 – 150'	182 – 255'
	Radius of Curvature (R_c)	43' – 135'	27.35' - 36.9'	46.5 – 62.6'
	Belt Width (W_{blt})	92'	92'	85'
	Meander Width Ratio (MWR)	3.6	7.7	4.2
	Ratio- Rad. of Curv.:Bkf Width (R_c/W_{bkf})	1.9 – 5.9	2.3 – 3.1	2.3 – 3.1
	Ratio- Meander Length:Bkf Width (L_m/W_{bkf})	4.5 – 6.7	9.0 – 12.6	9.0 – 12.6
Profile	Valley Slope (ft./ft.)	0.0017	0.0021	0.0017
	Water Surface Slope (ft./ft.)	0.0015	0.0015	0.0014
	Riffle Slope (ft./ft.)	0.0016	0.0018	0.0015
	Pool Slope (ft./ft.)	0.0003	0.0007	0.0007
	Pool to Pool Spacing (ft.)	167.0'	69.56'	91.0 – 127.5
	Pool Length (ft.)	26 – 38'	20' – 29'	35 – 49'
	Ratio - Pool Slope:Water Surface Slope	0.20	0.47	0.47
	Ratio - Pool to Pool Spacing:Bkf width	6.55	5.9	4.5 – 6.3



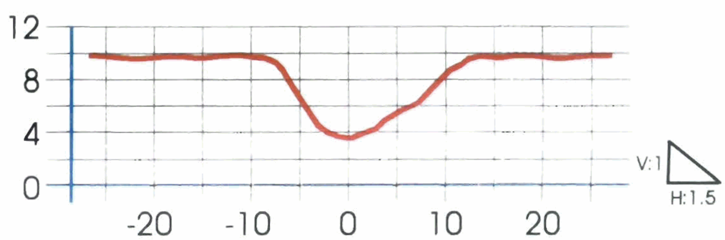
Tvpical Planform



Tvpical Profile



Typical Cross-Section
Riffle



Typical Cross-Section
Pool

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TYPICAL GEOMORPHIC DIMENSIONS

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SITE AND REFERENCE WATERSHEDS

North
NOT TO SCALE

- STREAMS
- SITE WATERSHED
- PROJECT SITE
- REFERENCE REACH WATERSHED

REFERENCE REACH

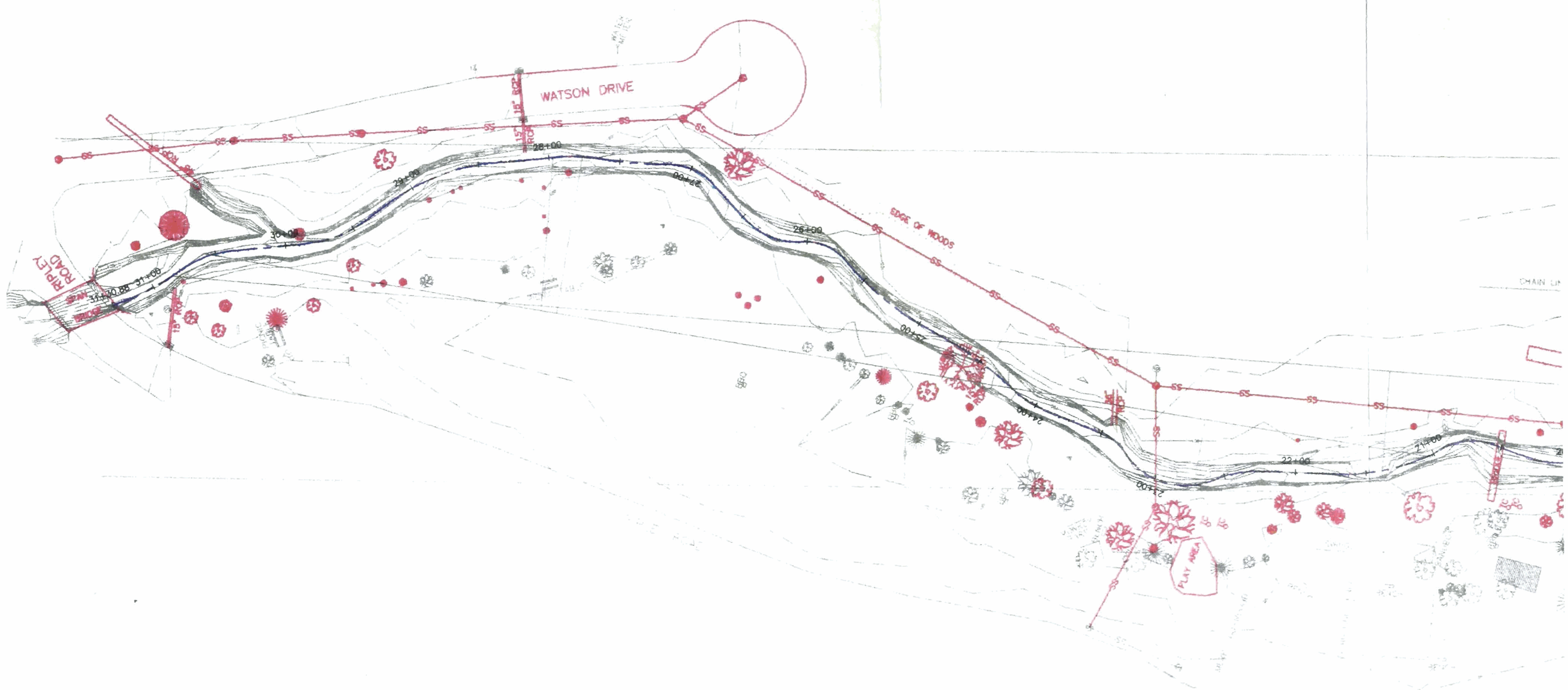
DEGRADED STREAM WITHIN WILSON RECREATION PARK

Appendix 2 –
Site Constraints

SITE CONSTRAINTS

For the purpose of this design criteria, all identified site constraints within fifty feet (50') of the top of banks of the existing channel were highlighted in red on the following graphics. The site constraint table provided below identifies the constraints, their approximate location on the project site, the impact on restoration, and any proposed courses of action or treatments.

Site Constraint	Location (Sta.)	Impact on Restoration	Proposed Action/Treatment
15" RCP	30+90	Water Quality	Cutback Pipe and stabilize outfall as necessary.
8 Trees	30+00 to 31+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
48" RCP	30+30	Water Quality	Stabilize outfall as necessary.
7 Trees	29+00 to 30+00	Lateral Confinement	Avoid all trees in this section.
SS Line	27+00 to 31+30	Lateral Confinement	Avoid sanitary sewer.
Watson Drive	27+00 to 31+30	Lateral Confinement	Avoidance, change stream plan, and stabilize.
15" RCP	28+20	Water Quality	Cutback Pipe and stabilize outfall as necessary.
12 Trees	25+00 to 29+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
SS Line	23+00 to 27+00	Lateral Confinement	Avoid sanitary sewer. Site grading shall not encroach within 10' of SS line.
15" RCP	24+40	Water Quality	Cutback Pipe and stabilize outfall as necessary.
36" RCP	23+40	Water Quality	Stabilize outfall as necessary.
8 Trees	23+00 to 25+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
SS Line perpendicular to channel	23+00	Profile/Grading Limitations	Stabilize the channnel bed and pipe with grade control and/or instream pipe protection if necessary.
10 Trees	21+00 to 23+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
Play Area	22+80	No anticipated impact.	Treat as sensitive area. Avoid during all site operations.
Pedestrian Bridge	21+50	Hydraulic Impacts	Bridge will be removed during construction. A crossing location will be provided for replacement bridge if desired. Bridge replacement is not included as a component of the restoration.
6 Trees	19+00 to 21+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
SS Line	19+50 to 23+00	Lateral Confinement	Avoid sanitary sewer.
Gravel Path	17+50 to 20+50	Lateral Confinement	Avoid gravel path.
SS Line crosses under the channel	18+00 to 19+50	Profile/Grading Limitations	Stabilize the channnel bed and pipe with grade control and/or instream pipe protection if necessary.
14 Trees	14+00 to 19+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
Pedestrian Bridge	16+50	Hydraulic Impacts	Bridge will be removed during construction. A crossing location will be provided for replacement bridge if desired. Bridge replacement is not included as a component of the restoration.
Parking Lot	15+50 to 13+00	Lateral Confinement	Avoidance where possible. Structural protection if necessary.
2 Pipes	14+20/10+35	Water Quality	Cutback Pipes and stabilize outfalls as necessary.
5 Trees	10+00 to 14+00	Lateral Confinement	Avoid all trees when possible. All trees < 4" DBH shall be salvaged and replanted.
SS Line	10+50 to 18+00	Lateral Confinement	Avoid sanitary sewer.
SS Line crosses under the channel	10+50	Profile/Grading Limitations	Stabilize the channnel bed and pipe with grade control and or instream pipe protection if necessary.
Train Trestles	10+00/13+00	Hydraulics/Structural	No structural analysis will be done to determine the integrity of the existing trestles. Designer can assume no liability for the trestle performance. Structural protection (ie. stone riprap) will be applied as necessary.
Culverts	10+00/31+30	Profile/X-section Limitations	Proposed profile must match existing inverts.



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SITE CONSTRAINTS

LEGEND

SS

SANITARY SEWER LINE

UPSTREAM SECTION

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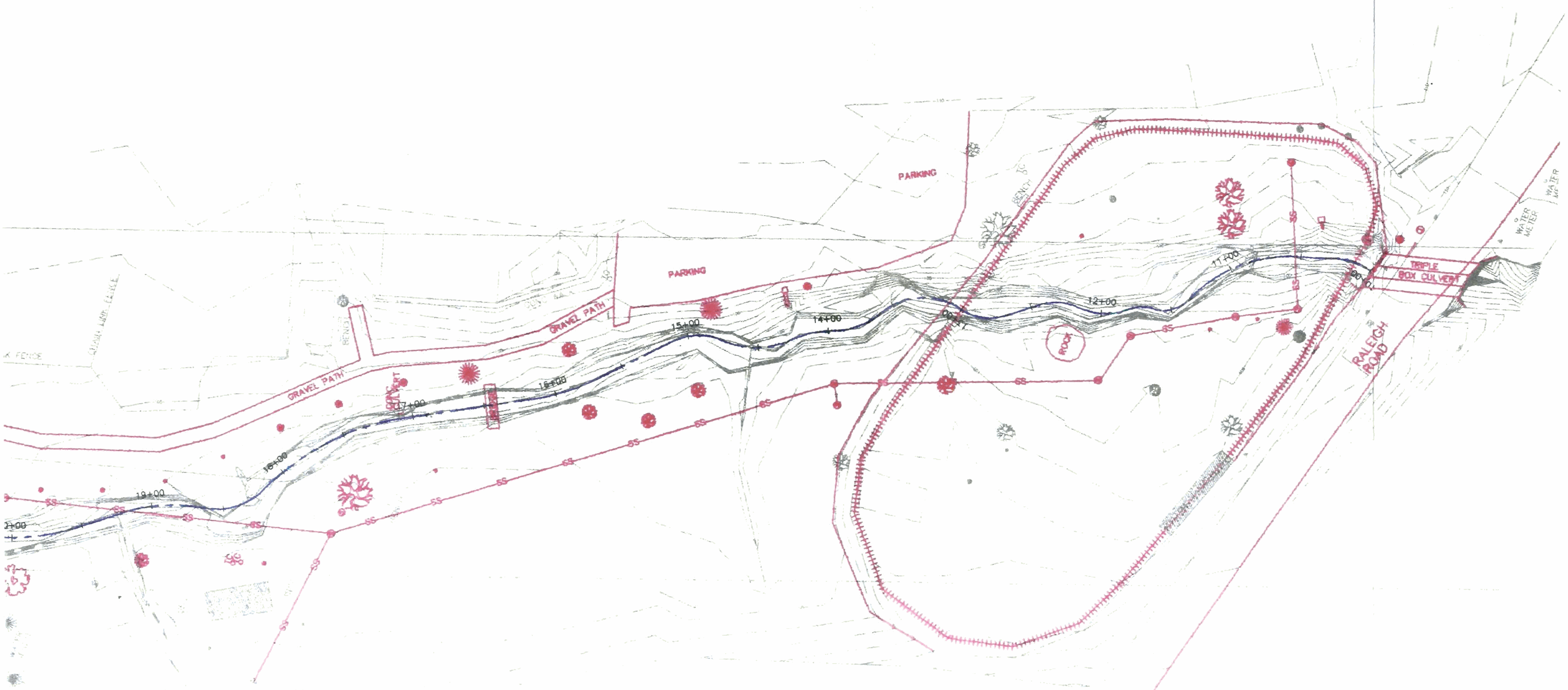

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SITE CONSTRAINTS

LEGEND

——SS—— SANITARY SEWER LINE

DOWNSTREAM SECTION

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Appendix 3 –
Riparian Buffer Criteria

RIPARIAN BUFFER CRITERIA

RIPARIAN BUFFER ZONE	VEGETATION		MAINTENANCE		
	TYPE	COMPOSITION	METHOD	FREQUENCY	TIME OF YEAR
A - Unmowed Herbaceous Buffer: **Left Bank** Station 10+00 to 17+43 Station 22+00 to 31+30 **Right Bank** Station 10+00 to 10+10	Grasses	Redtop (*Agrostis alba*) Lovegrass (*Eragrostis spectabilis*) Hard Fescue Cultivar (*Festuca spp.*) Bahia Grass Rye Grain	Mechanically with a mower to a minimum height of 6 inches.	Twice a year.	Once in May and once in August.
B - Unmowed Shrub Buffer: **Left Bank** Station 17+43 to 19+09 Station 20+53 to 22+00 **Right Bank** Station 12+91 to 14+35 Station 16+72 to 17+98 Station 25+09 to 31+30	Grasses	See Zone "A" composition	Mechanically with a mower to a minimum height of 6 inches.	Twice a year.	Once in May and once in August.
	Shrubs	Red Chokeberry (*Aronia arbutifolia*) Witch-Hazel (*Hamamelis virginiana*) Silky Dogwood (*Cornus amomum*)	Pruning by hand of all dead wood and up to 20% of new growth.	Once a year after one full calendar year.	Late fall.
C - Riparian Deciduous Buffer: **Left Bank** Station 19+09 to 20+53 **Right Bank** Station 10+00 to 12+91 Station 14+35 to 16+72 Station 17+98 to 23+03	Grasses	See Zone "A" composition	Mechanically with a mower to a minimum height of 6 inches.	Twice a year.	Once in May and once in August.
	Shrubs	See Zone "B" composition	Pruning by hand of all dead wood and up to 20% of new growth.	Once a year after one full calendar year.	Late fall.
	Trees	Red Maple (*Acer rubrum*) American Sycamore (*Platanus occidentalis*) River Birch (*Betula nigra*) Green Ash (*Fraxinus pennsylvanica*) Flowering Dogwood (*Cornus florida*)	Pruning by hand of all dead wood.	Once a year after one full calendar year.	Late fall.
			Replacement of deficient stakes and/or wires.	As needed.	During Year 1.
			Removal of stakes and wires.	N/A	Mandatory after 1 full calendar year.
			Removal of all dead or diseased vegetation considered beyond treatment.	As needed.	N/A
Stream Zone: ***(all areas inside the top of banks)***	Grasses	Zone "A" Grass composition Plus: Rough Bluegrass (*Poa palustris*) and Korean or Kobe Lespedeza	By hand with a string trimmer to a minimum height of 6 inches.	Twice a year.	Once in May and once in August.
	Live and Dormant Stakes	Silky Dogwood (*Cornus amomum*) Black Willow (*Salix nigra*) Bankers Willow (*Salix cotteti*) American Elderberry (*Sambucus canadensis*) Red-Osier Dogwood (*Cornus stolonifera*)	Pruning by hand to a minimum plant height of 3' and aerial coverage of 60 percent.	Once a year after two full calendar years.	Late fall.

Vegetation maintenance may be performed on a less frequent and/or intensive basis than indicated in the guidelines. However, vegetation maintenance may not be done on a more frequent or intensive basis than indicated.

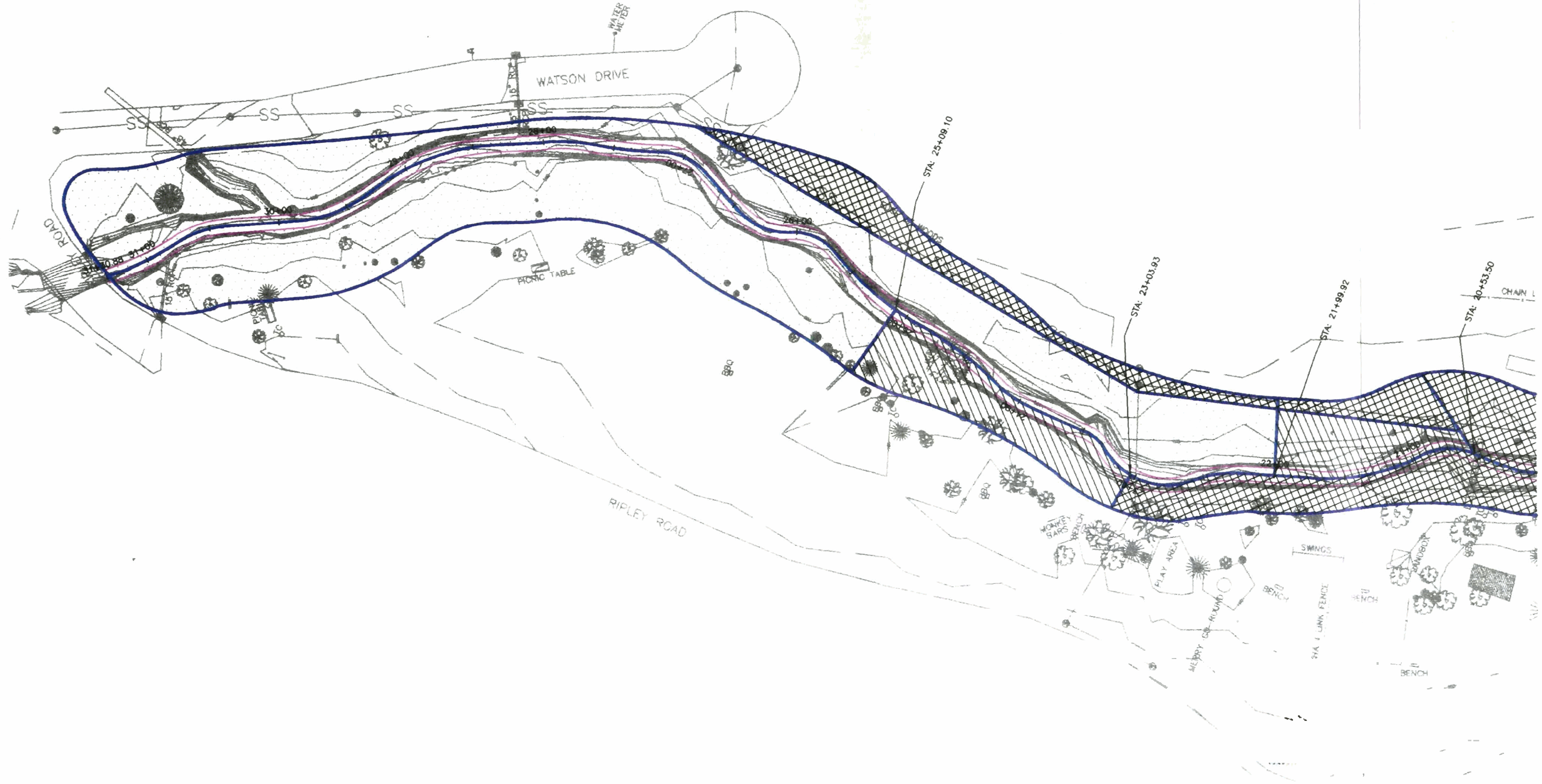
RIPARIAN BUFFER CRITERIA (Continued)

VEGETATION TYPE	LOCATION	SPACING		
		OMS	IMS	PLACEMENT
Herbaceous	All disturbed areas	N/A	N/A	All disturbed areas
Dormant Cuttings/Stakes	Stream banks	2'	2'	Random
Shrubs	Buffer Zones B & C	8.3'	10'	Random
Trees	Buffer Zone C	8.3'	15'	Random

An overall minimum spacing distance (OMS), that stipulates the minimum distance between any two plants regardless of species, is utilized to ensure that adequate room is provided for the use of park maintenance equipment.

An individual minimum spacing distance (IMS), that stipulates the minimum distance between any two plants of the same species, is utilized to assist in achieving appropriate plant species coverage and diversity.

Within the OMS and IMS guidelines, the placement of all woody vegetation, including the various dormant cutting species, should be done in a random manner so that a natural riparian buffer appearance is achieved.



PROPOSED RIPARIAN BUFFERS

LEGEND

"A" UNMOWE HERBACEOUS BUFFER

"B" UNMOWED SHRUB BUFFER

"C" DECIDUOUS BUFFER

UPSTREAM SECTION

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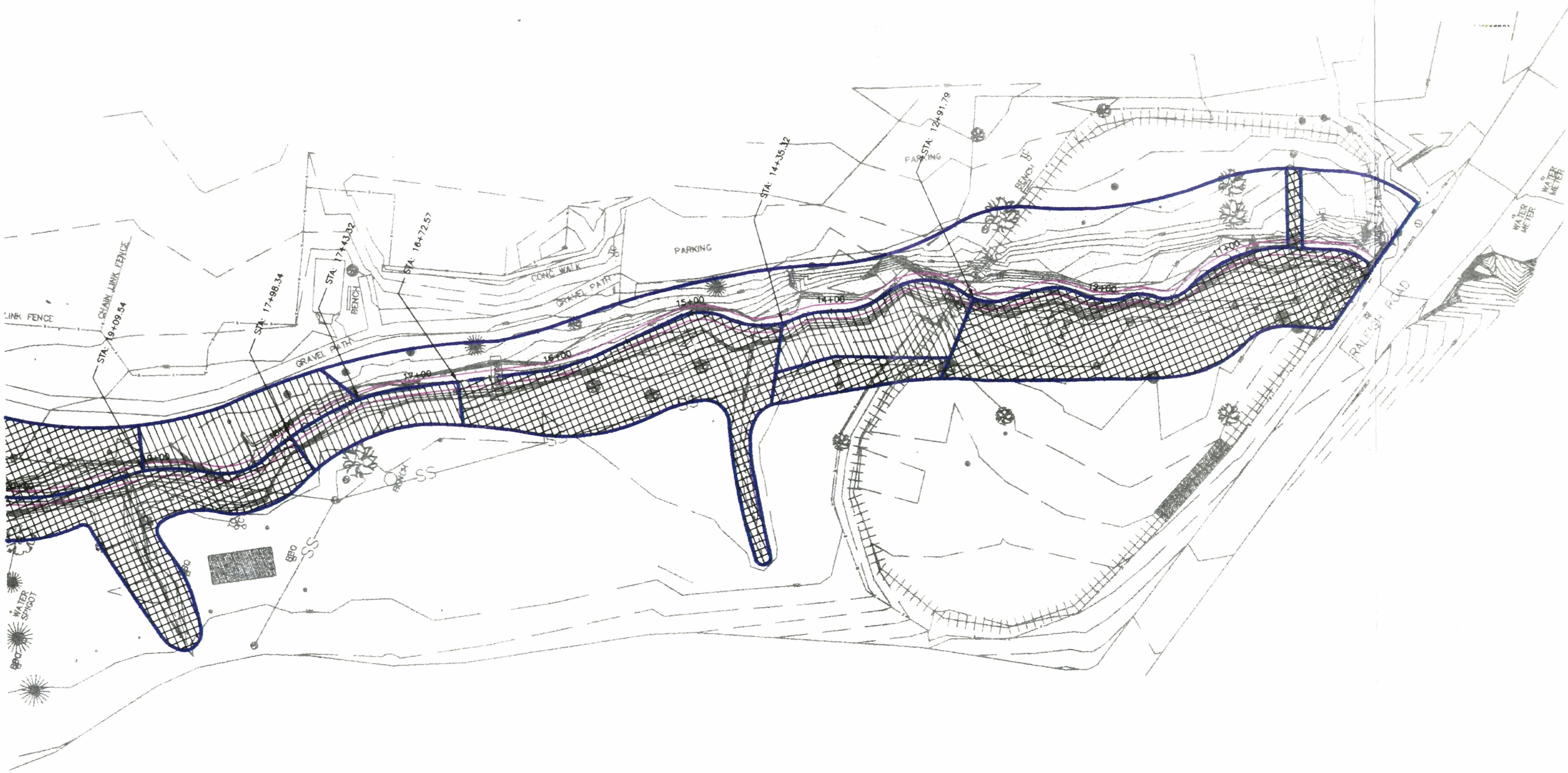

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PROPOSED RIPARIAN BUFFERS

LEGEND

"A" UNMOWED HERBACEOUS BUFFER

"B" UNMOWED SHRUB BUFFER

"C" DECIDUOUS BUFFER

DOWNSTREAM SECTION

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Appendix 4 –
Sediment Transport Analysis

SEDIMENT TRANSPORT ANALYSIS

To determine the critical dimensionless shear stress, τ_{CR}, Shields formula was used. This technique is most appropriate for a coastal sand bed stream (the entrainment calculations used in a Rosgen Level III assessment are intended for use in gravel bed streams only).

$\tau_{CR} = Fs\ (\rho_s - \rho)\ g\ D$ (Shields, A. (1936) Anwendung der Ahnlickkeitsmechanik und der Turbulenzforschung auf die Geschiebebewegung)

Fs (entrainment function) = 0.056
ρ_s (sediment density) = 162.6 lbs/ft^3
ρ (fluid density) = 62.4 lbs/ft^3
g (gravitation acceleration) = 32.37 f/s^2
D (D_{50} particle size) = 6.56 E-4 ft

τ_{CR} = 0.056 (162.6 – 62.4) 32.37 * 6.56 E-4

τ_{CR} = 0.12

By referring to the Shields curve of the *threshold of motion* it can estimated that an 8mm grain diameter could be entrained under these conditions. Using the empirical relationship:

$D = R*S_o / 0.0924$

This computation can be compared with the minimum stable particle size for the subject channel.

D = 0.648 m * 0.0014 / 0.0924 = 9.8 E-3 m = 9.8 mm

As the largest particles encountered during bed material sampling were approximately 6mm, this would dictate that this stream is capable of entraining a large amount of the available sediment from the bed and banks. The resulting scour has led to increased bank failures and the addition of excess sediment into the system. In turn, this sediment is deposited closely downstream (due to the flashy nature of this system) forming large dunes and mid-channel bars on the project site. Stabilization of eroding banks will reduce sediment input to the system. A decrease in cross-sectional area in widened sections will increase velocity and sediment transport in these local areas.

The following table is provided as a gauge of sediment transport characteristics in the subject stream. The d_e:d relationship is 1.02, which closely correlates to the expected ratio for stable sediment transport. As the channel adjusts to the hydrologic regime, it can be expected that considering these characteristics, an equilibrium in terms of sediment transport will be achieved.

0.12	Critical Shear Stress
0.0197 ft	Largest Particles from Sample
0.0014	Water Surface Slope
2.786 ft	Bankfull Depth Required (d_e)
2.730 ft	Proposed Bankfull Mean Depth (d)

As the stream bed consists primarily of sand size particles, a large portion of the transported sediment is carried in suspension (as compared to a larger portion of the transported material in gravel streams consisting of bedload). An estimate of suspended sediment discharge has been included as a means to understand the magnitude of sediment that will be transported by the restored system.

$$v_{fs} = \frac{(\rho_s - \rho)\, g\, D^2}{18\, \mu} = [(2650m - 1000m)\, 9.81 * (2\ E\text{-}4\ (m))^2] / 18\ (1.14\ E\text{-}3\ kg/m\ s)$$

v_{fs} = 0.0316 m/s

R = 0.65 m

$u_* = (g\, R\, S_o)^2 = (9.81 * 0.65 * 0.0014)^2 = 7.97\ E\text{-}5$ m/s

$y_r = 0.04$; @ y=0.1 u = 2.5 (7.97E-5) ln (30 * 0.1 / .0004) = 1.78 E-3 m/s

C (sediment concentration) = 0.0028 $[(0.04(0.83\text{-}0.1)/0.1(0.83\text{-}0.04)]^{6.3\ E\text{-}6}$ = 2.8 E-3

Δq_s = C u * dy = 2.8 E-5 * 1.78 E-3 * 0.2 = 9.97 E-9 m^3/m s

ΔQ_s = 0.667 * 100 * Δq_s = 6.65 E-7 m^3/s = 2.39 E-5 ft^3/s

y	ΔQ_s	
0.9	4.92 E-7 m^3/s	1.77 E-5 ft^3/s
0.7	8.09 E-7 m^3/s	2.91 E-5 ft^3/s
0.5	7.83 E-7 m^3/s	2.81 E-5ft^3/s
0.3	7.46 E-7 m^3/s	2.68 E-5 ft^3/s
0.1	6.65 E-7 m^3/s	2.39 E-5 ft^3/s

Therefore, the estimated total suspended sediment discharge is 3.49 E-6 m^3/s or 1.26 E-4 ft^3/s.

In conclusion, the provided sediment transport data is based on a combination of collected data, dimensional analysis, and simplified theoretical equations. It is a best estimate, as many attempts have been unsuccessful in developing a rational theory to deduce sediment transport. The computations are based on collected data at a specific moment; and as river systems are dynamic, it is difficult to accurately predict responses to varying conditions. The proposed channel restoration, based on the data and computations, should be competent in terms of sediment transport and a state of equilibrium should be attained.