Chavis Park, Garner Branch Stream Restoration Project

For

North Carolina Department of Environment
and Natural Resources
Division of Water Quality Wetland Program
Stream and Riparian Area Restoration
Raleigh, North Carolina

February 26, 2002

Prepared By:

Natural Areas Ecosystem Management 10015 Wright Road Harvard IL 60033

Appalachian Environmental Services PO Box 52 Webster NC 28788

Becky L. Ward Consulting 1512 Eglantyne Court Raleigh NC 27613

Garner Branch Stream Restoration Project
Chavis Park Raleigh, NC
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Garner Branch Stream Restoration Project

Chavis Park, Raleigh North Carolina

Introduction

The Wetlands Restoration Program identified the Garner Branch project in 1999 for a design project. Garner Branch was investigated from the Confluence with Walnut Creek to the origin of the stream at Lenoir Street. After submittal of preliminary findings to WRP final design/build plans were prepared for the reach of Garner Branch from Martin Luther King Boulevard to Lenoir Street approximately 1,830 linear feet. Two short segments of tributaries within the Chavis Park boundaries were also included in this project. The first location is approximately 250 linear feet of tributary just upstream of Station 55+00. The second tributary is located just above Station 63+00 and is approximately 120 feet in length. Therefore the total project stream length included in this submittal is approximately 2,200 linear feet.

Project Location

The project is located on Garner Branch within the limits of Chavis Park. Chavis Park is a very old & established park located in downtown Raleigh, North Carolina. The park is an urban park located approximately one mile south east of the state capitol building in downtown Raleigh. The upstream limit of the project is Lenoir Street and the lower limit is Martin Luther King Boulevard.

Problem Statement

Unstable Channel Configuration:

The channel has incised over the years through out the park. Based on the tributary plan, profile, and dimensions, the stream was classified as a G4c type. A G type stream is generally described as an entrenched "gully step/pool channel with low width-to-depth ratios on moderate gradients. Isolated short reaches of the channel did exhibit other Rosgen stream Characteristics, but the G4c appears to be the most representative of the typical stream condition. The existing channel pattern throughout the stream is causing further instability in the steep banks due to the erosion occurring at the toe. In much of the stream the floodplains are too high, not allowing for frequent storm water access. The existing stream above station 64+00 was classified as an E4 stream. The existing pattern in this region is also causing extensive erosion on high banks within bends.

Poor Water Quality:

The water quality in the stream is impacted both by the urban environment and by the sediment caused by eroding banks. The watershed is comprised of downtown Raleigh. The stream receives sediment starved storm water being released through a concrete culvert at the origin of the project. Further along the stream length sediment is being released from continually eroding banks. Bank Erosion Hazard Indexes were completed for eleven locations along the stream reach. The values ranged from moderate to very high with an average index of 32 (High).

An environmental assessment was preformed on the stream with these results. Bioclassification ratings were Poor as EPT Taxa were few and Biotic Index values were high, indicative of poor water quality. Tolerance values for individual benthic

mocroinvertebrate species varried from 0 to 10, with the higher numbers indicating more tolerant species found in polluted conditions.

Bed Features:
The bed of the stream is featureless throughout much of its length. There are several rock nick points that are controlling the grade of the channel especially in the lower reaches below station 59+00.

Vegetation:
The vegetation that is present in the channel is primarily non-native species. The vegetation ranges from very sparse to vigorous vegetation communities. Bank vegetation protection is poor. The existing stream riparian vegetation is low. The park maintains mowed grass almost to the top of bank along the stream.

Habitat:
The stream has poor habitat. The urban watershed characteristics create storm events that have large peak discharges that occur quickly and produce high velocities. Abundant in-stream cover is not present and fines are currently embedding the channel.

Project Goals and Objectives
The objective of this stream restoration project is to improve the water quality, riparian quality and stability of the stream. Restoring the natural flow pattern of the stream and stabilizing the steep channel banks will accomplish this. Long-term stabilization will be accomplished by planting the riparian area with native vegetation.

- Reduce bank erosion by adjustment of the existing channel pattern or by bio-engineered methods.
- Improve water quality by reducing erosion and by increasing the connectivity between the channel and floodplain.
- Stabilize the bankfull elevation along the reach.
- Enhance in stream habitat by placing structures, overhanging vegetation and removal of aggressive species.
- Enhance riparian corridor with native vegetative species to improve the function and aesthetic value.
- Slope and vegetate the stream banks so that they are more resistant to flooding.
- Plant native trees, bushes and ground cover that will stabilize the stream banks, shade the stream, and provide wildlife cover and food.

Watershed Conditions
Garner Branch a tributary of Walnut Creek is located in Downtown Raleigh. The main channel begins just south of East Cabarrus Street and continues south through primarily residential neighborhoods and Chavis Park until it enters Walnut Creek just west of State Street. This project will only include work on Garner Branch from Lenoir Street to Martin Luther King Boulevard. The watershed is approximately 347 acres (0.54 square miles) to our point of interest at Martin Luther King Boulevard.

The watershed basin has a western boundary located primarily along Rock Quarry Road and Cumberland Street. The northern boundary extends almost to New Bern Avenue and the eastern limit is approximately defined by Chavis Way. The southern watershed boundary is Martin Luther King Boulevard.

The watershed contributing stormwater runoff to Garner Branch is very urban and fully developed. The current zoning and planimetric maps from the City of Raleigh show three-quarters of the watershed development consists primarily of residential high density properties. Land usage in the upper north-eastern quarter of the watershed supports dense developments of downtown city offices, businesses and industrial facilities.

The soils in the watershed basin are identified in the Wake County North Carolina Soil Survey published by the US Department of Agriculture Soil Conservation Service. These soils consist primarily of Cecil and Appling Sandy Loam in the upland areas and Worsham Sandy Loam and Wehadkee soils in the floodplains adjacent to the stream.

Cecil soils are identified in the survey for the segment of the tributary that extends north of Martin Luther King Boulevard within the stream corridor, floodplains, and most of the adjacent watershed upland area. Cecil soils are characterized with fair infiltration rates, rapid surface runoff, and a moderate to very severe hazard of further erosion.

Stream Reference Reach Site

Brookhaven Park in Raleigh was used as the reference reach channel for the stream plan form design from station 64+00 through station 69+00. The reference reach site was surveyed by NC State in 1998. The reference reach is a stream type C4. The watershed size for the reference reach is 0.14 square miles. The watershed area for the project site at station 64+00 is 0.14 square miles.

Stream Restoration Plan

The stream work being proposed consists of stream bank stabilization, in-stream structures, stream plan form adjustments and storm drainage retrofits. The existing non-native and nuisance vegetation along the steep stream banks will be cleared along the entire 2,200 linear feet and replanted with native species that will be sensitive to the park setting and visibility concerns. In-stream structures are proposed to establish additional bedform and provide better habitat. Some bio-technical practices are proposed in areas where the banks are steep and severely eroded.

The proposed work will be preformed within the confines of the existing incised channel. At locations where possible the banks will be sloped back to stable slopes before re-vegetation. The tops of these banks now functioning as a terrace are 12 to 25 feet in height along the stream length. Sanitary sewer lines, park asphalt walkways, roadways, and park shelter buildings are located in close proximity to these terrace edges. Park pedestrian bridges, a very old stone bridge, and utility lines cross the creek. No utilities except for storm water discharge point sources into the creek are proposed to be changed during construction. All existing bridges will remain in place. A cross vane will be placed down stream of the stone bridge set at the elevation of the existing footings to

assist in re-establishing the channel grade through the bridge structure. The City of Raleigh will be performing repairs necessary to this stone bridge and footings.

From station 52+60 to station 62+00 the work will primarily consist of stream bank stabilization and re-grading of the stream floodplain. The floodplain will be reworked to allow for more frequent stormwater access. A "W" Vane structure will be placed just upstream of the Martin Luther King culverts to help direct the flow into both barrels. A second rock vane will be installed between the "W" Vane and the existing upstream bedrock to assist in redirecting the flow away from the reconstructed bank. At station 55+50 the existing in-stream island will be cut down and will be replanted with wetland vegetation.

At station 64+00 through 69+00 the stream will be re-meandered through the floodplain. Where the floodplain is restricted it will be widened to obtain more pattern and assist with bankfull as well as large stormwater flows. The proposed channel was designed based on the Rosgen method. The only parameter that could not be consistently obtained in this reach is the belt width. Due to the close proximity of Chavis Way to the north and utility lines to the south the required belt width stayed at the low end of the range or below. The morphological characteristics of the existing, proposed and reference reach is shown in the table below.

Variables	Existing Channel	Proposed Reach	Reference Reach
Stream type	E4	C4	C4
Drainage Area (Sq. Mile)	0.14 Urban	0.14 Urban	0.14 rural
Bankfull width (Wbkf)	12 ft 16-24	23 ft 21-25	12.8 ft 10-15.6
Bankfull mean depth (dbkf)	1.55 ft. 1.4-2.0	1.2 ft. 1.1-1.3	0.67 ft 0.55-0.8
Width/depth ratio (Wbkf/dbkf)	7.7	19 18-21	19.4 18.2-20.6
Bankfull Cross Sectional Area (Abkf)	18.6 sq ft	25 sq ft	8.6 sq ft 5.5-11.8
Bankfull Mean Velocity (Vbkf)	5.7 ft/sec	4.2 ft/sec	3.5 ft/sec
Bankfull Discharge, cfs (Qbkf)	107	115	30
Bankfull Maximum depth (dmax)	3.0-3.8 ft	1.76 ft 1.65-1.98	1.1 1-1.2
Max driff/dbkf ratio	2.2	1.6 1.5-1.8	1.64 1.5-1.8
Low bank Height to max dbkf	1.2	1.0 0.9-1.1	1.0 0.9-1.1
Width of flood prone area (Wfpa)	52-57 ft	52 ft 40-63	27 ft 19-33

Entrenchment ratio (Wfpa/Wbkf)	4.5	2.2 1.9-2.5	2.6 1.9-3.3
Meander length (Lm)	96 ft.	80ft 70-108	47 ft
Ratio of meander length to bankfull width (Lm/Wbkf)	8 4-6	3.5 3.0-4.7	3.7 3.0-4.7
Radius of Curvature (Rc)	20 8-31	32 23-40	23.5 12-35
Ratio of radius of curvature to bankfull width (Rc/Wbkf)	1.67	1.4 1.1-1.6	1.8 1.0-2.7
Belt width (Wblt)	37 ft 19-50	43 ft 35-50	34.5 ft 28-41
Meander width ratio (Wblt/Wbkf)	3.0	1.9 1.5-2.2	2.7 2.2-3.2
Sinuosity (stream length /valley distance) (k)	1.05	1.1	1.7
Valley slope (ft/ft)	0.0054	0.0054	0.027
Average slope Savg= (Svalley /k)	0.0052	.0049	0.016
Pool Slope (Spool)	0.001	0.004 0- 0.009	0.001 0-.003
Ratio of pool slope to average slope (spool/Sbkf)	.14	0.06 0- 0.18	0.06 0- 0.18
Maximum pool depth (dpool)	2.8 ft	3.5 ft 3.3-3.9	2.0 ft 1.9-2.2
Ratio of pool depth to average bankfull depth (dpool/dbkf)	1.8	2.98 2.8-3.3	2.98 2.8-3.3
Pool width (Wpool)	10 ft	17 ft 15-20	9.8 ft 8.4-11.3
Ration of pool width to bankfull width (Wpool/Wbkf)	0.83	0.76 0.65-0.88	0.76 0.65-0.88
Ratio of pool area to bankfull area	1.2	1.12 1.1-1.2	1.12 1.1-1.2
Pool to pool spacing (p-p)	69 ft 44-95	64 ft 50-78	45 ft 40-50
Ration of p-p spacing to bankfull width (p-p/Wbkf)	6	2.8 2.4-3.1	3.5 3.1-3.9

Materials:	Existing	Proposed	Reference
Particle Size distribution of channel material			
D16	0.35 mm	0.35 mm	0.74 mm
D35	1.1	1.1	4.4
D50	3.0	3.0	16
D84	11.5	11.5	70
D95	23	23	100
Particle Size distribution of bar material			
D16	0.54 mm	0.54 mm	Not Available
D35	1.2	1.2	
D50	2.4	2.4	
D84	12	12	
D95	22	22	
Largest size particle at the toe (lower third) of bar	2.0 inches	2.0 inches	

Sediment Transport Validation (Based on Bankfull shear Stress)	Existing	Proposed
Calculated value	0.50	0.34
Value from Shield Diagram (lb/sq.ft.)	0.38	0.38
Critical dimensionless shear stress	0.0216	0.0216
Miminum mean dbkf calculated using critical dimensionless shear stress equations	1.2 ft	1.2 ft

Storm Drainage Retrofits:

There is currently four existing pipes that discharge stormwater into Garner Branch and one location in which two existing swales discharge water at the top of the bank causing erosion. Each retrofit is described below for existing and proposed conditions.

Retrofit "A"

An existing 24 inch diameter corrugated plastic pipe currently discharges water from the parking lot into the creek. The pipe exits the slope of the existing stream bank approximately 15 feet above the stream invert. No storm drainage system records were available to determine the connection of the system. The drainage basin is approximately 2.3 acres consisting of impervious roadways & parking lots, park grounds, and apartment land use.

The existing system proposed to be retrofitted will provide for treatment of the parking lot stormwater within a constructed grass swale approximately 50 feet in length. Currently this stormwater enters a piped system and directly discharges to the stream.

The stormwater discharge from the parking lot, along with the overland flow, will be collected into a yard inlet located at the top of the stream bank. After entering the inlet the stormwater will continue through a series of pipes and a junction box transitioning the stormwater down the bank approximately 15 feet in elevation. The pipe will then discharge at the channel elevation in between two proposed rock vanes. The existing 24 inch CPP will be connected to the yard inlet if it is determined in the field that this pipe collects water from sources other than the parking lot inlet that is shown to be retrofitted in this plan.

Retrofit "B"

A 18" RCP discharges to the stream just upstream of the aerial sanitary sewer crossing directly across from the swimming pool. The headwall and concrete apron are approximately 3-4 feet above the existing channel. A large scour has occurred and is advancing past the headwall.

The proposed retrofit will include a junction box placed within the stable channel bank. The junction box will provide for a drop in elevation so that the proposed outlet pipe can be lowered to the existing channel elevation. The pipe will be extended outside of the scour and the end stabilized.

Retrofit "C"

A 15" pipe discharges stormwater from the inlet on Cape Avenue to the top of the stream bank in the park. The 15" pipe crosses under the park asphalt bike trail and over the existing sanitary sewer line which are both located in close proximity to the existing stream top of bank. The pipe end sections are currently separated.

Investigations were made to pull the existing system back to allow for the water to flow through an open channel however the existing bike trail was a concern for the parks department. They were concerned with potential hazards with water on the trail. Also a sanitary sewer upgrade is planned for the park which is just in the conceptual stages. The sewer may be relocated in this area. The proposed retrofit includes extending the existing 15" pipe into a junction box located at the top of the bank and dropping the elevation through the structure to the stream invert elevation. The pipe outlet into the stream will be tied into the vegetated geogrids proposed to be placed at the channel bottom.

Retrofit "D"

Two existing swales exist on either side of the existing park shelter. This area is all grassed. The swales are currently discharging over the top of the bank and causing erosion of already unstable steep banks. The water that enters these swales travel approximately 250 feet over grassed park land before they get to this point.

To prevent this point discharge the proposed retrofit will include the installation of two yard inlets and 15" pipe that will collect the overland flow and transfer it down to the stream. We have not increased the impervious area or changed the land use in any way. The retrofit is proposed to convert an unstable point discharge at the existing top of bank to a more stable discharge point at the stream bottom.

Retrofit "E"

An existing 18 inch corrugated metal pipe originates at a curb inlet in Chavis Way. The CMP currently discharges out of an unstable bank. The pipe is very damaged and falling apart in sections.

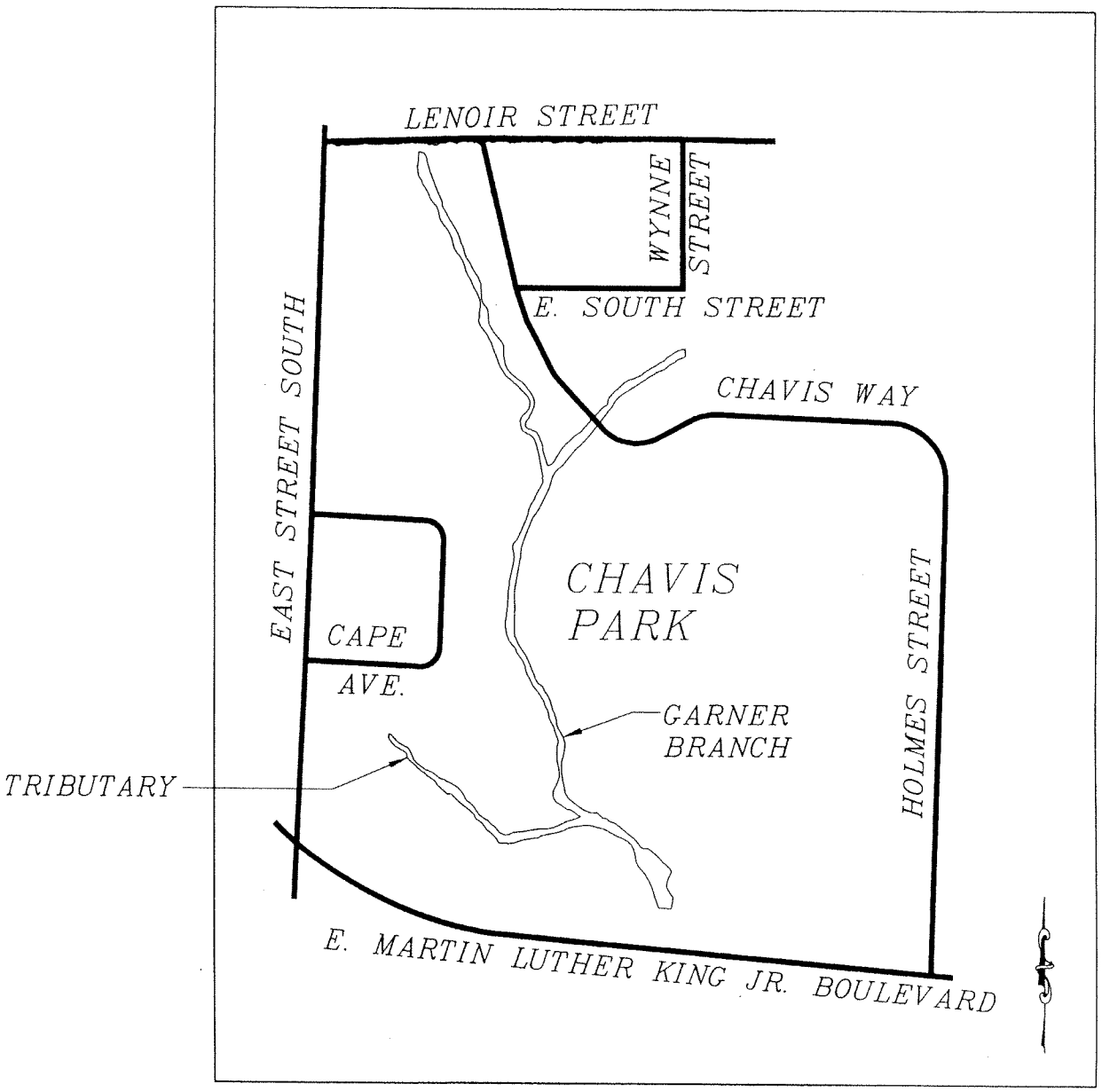
The proposed retrofit will relocate the discharge point of the 18 inch pipe onto a reconstructed flood plain. The pipe will discharge in the direction of flow of the stream. The new pipe will be an 18"RCP with a stabilized outlet.

Riparian Restoration

Low growing woody species will be planted on the steep banks of the incised channel. These species will be planted as bare rooted or potted stock during he dormant season. As much as possible existing established large trees tat are on site will be avoided. Riparian species were chosen to be aesthetically pleasing and to benefit wildlife by providing food or habitat. Only native species will be used to re-vegetate the riparian zone. A selection of the folowing species will be used at this site:
Red Chokeberry (aronia arbutifolia), American Beautyberry (Callicarpa americana), Buttonbush (Cephalanthus occidentalis), Silky Dogwood (Cornus amomum), Witch Hazel (Hamamelis virginiana), Winterberry (Ilex, verticillata), Dog-hobble (Leucothoe fontanesiana), Spicebush (Lindera benzoin), Common Elderberry (Sambucus canadensis), Flowering Dogwood (Cornus rugosa). All flower species will be planted 3 to 4 feet apart, bush species 4-8 feet apart and trees will be planted 10-15 feet apart.

Chavis Park Downtown Raleigh, North Carolina

Garner Branch Location Map
within
Chavis Park, Raleigh North Carolina



LOCATION MAP

NOT TO SCALE

US Geological Survey Quadrangle Map
Raleigh East & West, NC
Scale 1"= 2,000'

Garner Branch Chavis Park Raleigh, North Carolina

Culvert Under Lenoir Street Upstream Project Limit

Over Widened Stream Segment Just Downstream of the Culvert

Garner Branch Chavis Park Raleigh, North Carolina

Stream Reach Upstream of Stone Bridge

Rock Outcrop Just Upstream of Culverts Under MLK Blvd.

Garner Branch Chavis Park Raleigh, North Carolina

Chavis Park Stone Bridge

Supporting Stream Calculations

Existing Channel Discharges:

$A = 18.58$
$w = 12$
$d = 1.55$

$D_{84} = 11.5\ mm \times \frac{.45}{12} = 0.04\ ft$

$\approx R = 1.55$ Relative Roughness $= \frac{1.55}{.04} = 38 \Rightarrow \frac{v}{u*} = 11.7$

$\Rightarrow N = .025$

$$Q = \frac{1.486}{N}(A)(R)^{2/3}(S)^{.5}$$

$$= \frac{1.486}{.025}(18.58)(1.55)^{.667}(.0052)^{.5}$$

$Q = 107\ cfs$

Proposed Channel:

existing $(k) = 1.05$

$\frac{SL}{VL} = k \quad \frac{SL}{k} = VL \quad = \frac{560}{1.05} = VL = 533\ ft$

$SL = VL \cdot k = 533(1.1) = 586\ ft$

New stream slope $= \frac{2.91}{586} = .0049$ w/ Adj. Sinuousity

$$Q = \frac{1.486}{n}(A)(R)^{2/3}(S)^{.5}$$

$$Q = \frac{1.486}{.025}(25.3)(1.15)^{.667}(.0049)^{.5}$$

$Q = 115\ cfs.$

Sediment Transpat Calculations

Sampk #2

T_{ci} = cutical dumensional shear stress

d_i = D_{50} of bed material (pavement) = 11.3 mm

d_{50} = D_{50} of bar material (sub-pavement) = 2.4 mm

$$\gamma_{ci} = 0.0834 \left(\frac{d_i}{d_{50}}\right)^{-.872}$$

$$= .0834 \left(\frac{11.3}{2.4}\right)^{-.872}$$

$$\gamma_{ci} = 0.0216$$

D_i = largest particle bar = 2.0" = 0.167 ft

entrainment:

$$d = \frac{(T_{ci})\,1.65\,(D_i)}{S} \qquad S = .0052$$

$$d = \frac{.0216\,(1.65)(.167)}{.0052}$$

$d = 1.15$ ft = 1.2 ft ≈ 14 inches

New Stream Slope = 0.0049 ft/ft

$$d = \frac{.0216\,(1.65)(.167)}{.0049}$$

$d \approx 1.2$ ft ok

Cross Section #1
Inner Berm
Width= 12'
Bankfull Cross Section
Bankfull Elevation 92.36

Station	Elevation	Elevation from Bankfull	Incremental Avg.Height Ft.	Incremental Distance Ft.	Incremental Area Sq.Ft.
49.4	92.36	0			
			0.58	1.60	0.93
51	91.2	1.16			
			1.13	2.00	2.25
53	91.27	1.09			
			1.48	1.70	2.51
54.7	90.5	1.86			
			2.05	3.30	6.76
58	90.12	2.24			
			2.46	1.30	3.19
59.3	89.69	2.67			
			1.34	2.20	2.94
61.5	92.36	0			

Total Area 18.58 Sq. Feet

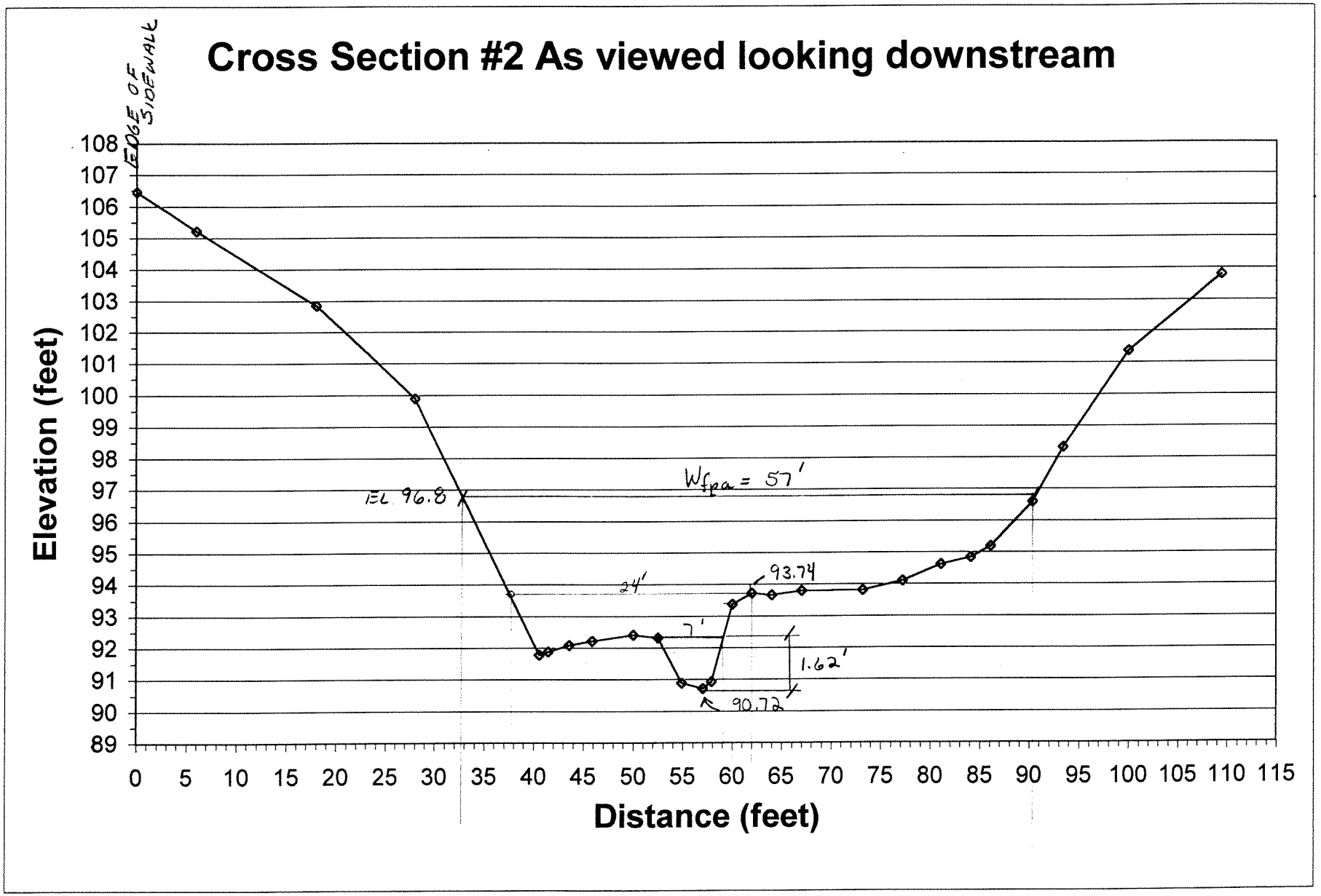
$d_{bkf} = 1.55$ ft.

Width = 16'
Bankfull Cross Section
Bankfull Elevation 93.48

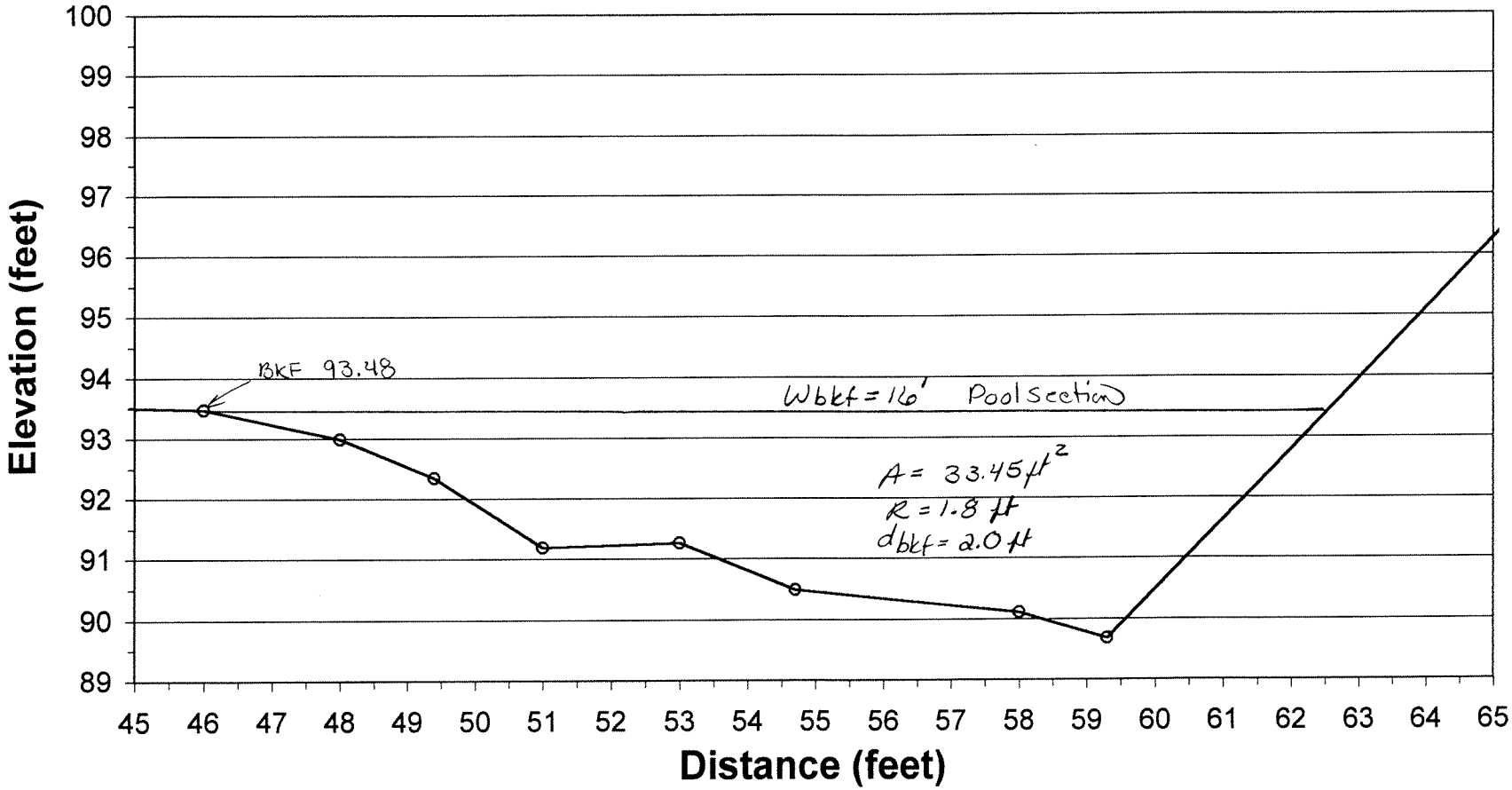
Station	Elevation	Elevation from Bankfull	Incremental Avg.Height Ft.	Incremental Distance Ft.	Incremental Area Sq.Ft.
46	93.48	0			
			0.24	2.00	0.48
48	93	0.48			
			0.80	1.40	1.12
49.4	92.36	1.12			
			1.70	1.60	2.72
51	91.2	2.28			
			2.25	2.00	4.49
53	91.27	2.21			
			2.60	1.70	4.41
54.7	90.5	2.98			
			3.17	3.30	10.46
58	90.12	3.36			
			3.58	1.30	4.65
59.3	89.69	3.79			
			1.90	2.70	5.12
62	93.48	0			

Total Area 33.45 Sq. Feet

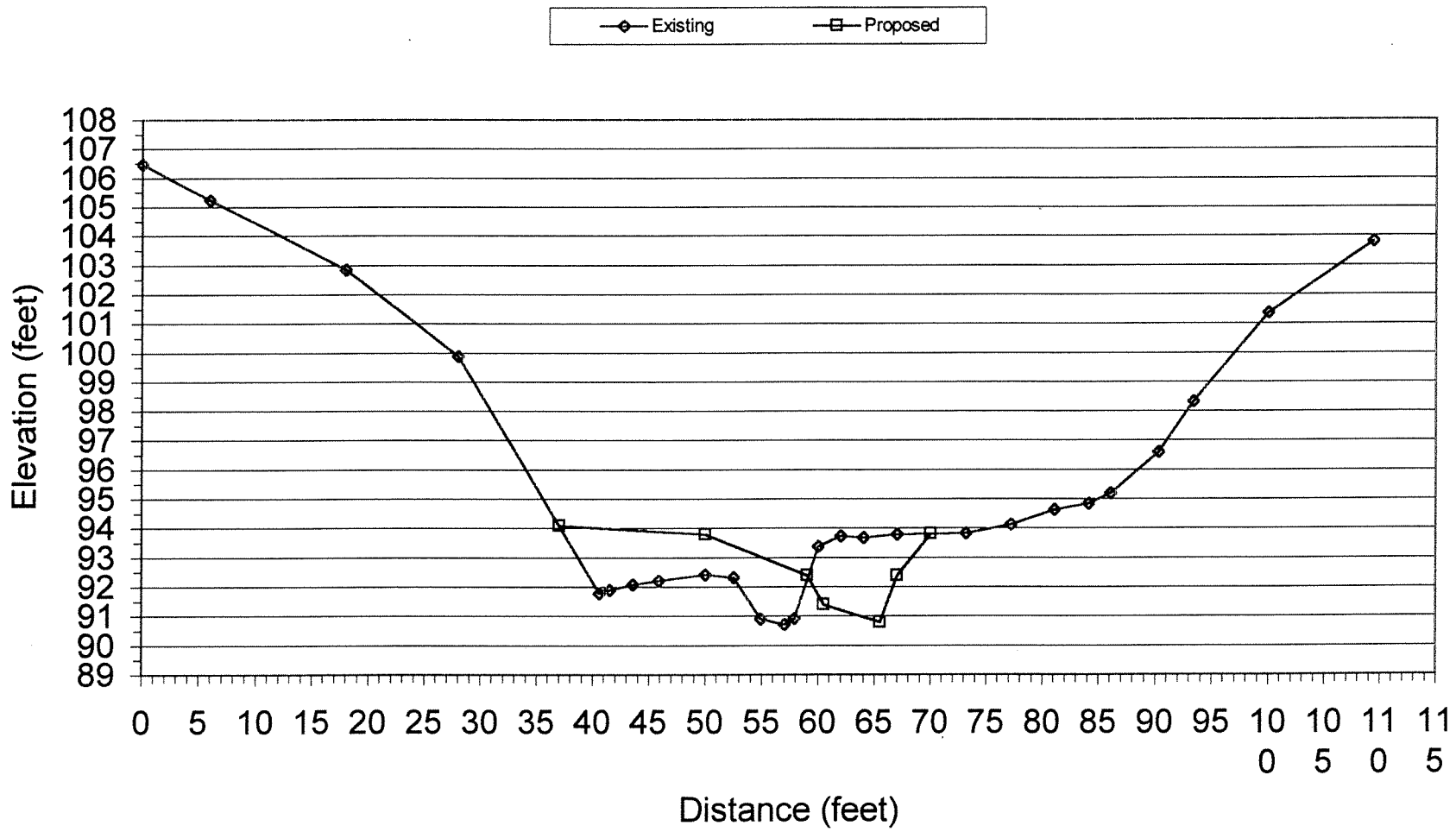
$d_{bkf} = \frac{33.45}{16} = 2.09$ ft.


Cross Section #2 As viewed looking downstream
EDGE OF SIDEWALK
Elevation (feet)
Distance (feet)
EL 96.8
W_{fpa} = 57'
24'
93.74
7'
1.62'
90.72
108
107
106
105
104
103
102
101
100
99
98
97
96
95
94
93
92
91
90
89
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115

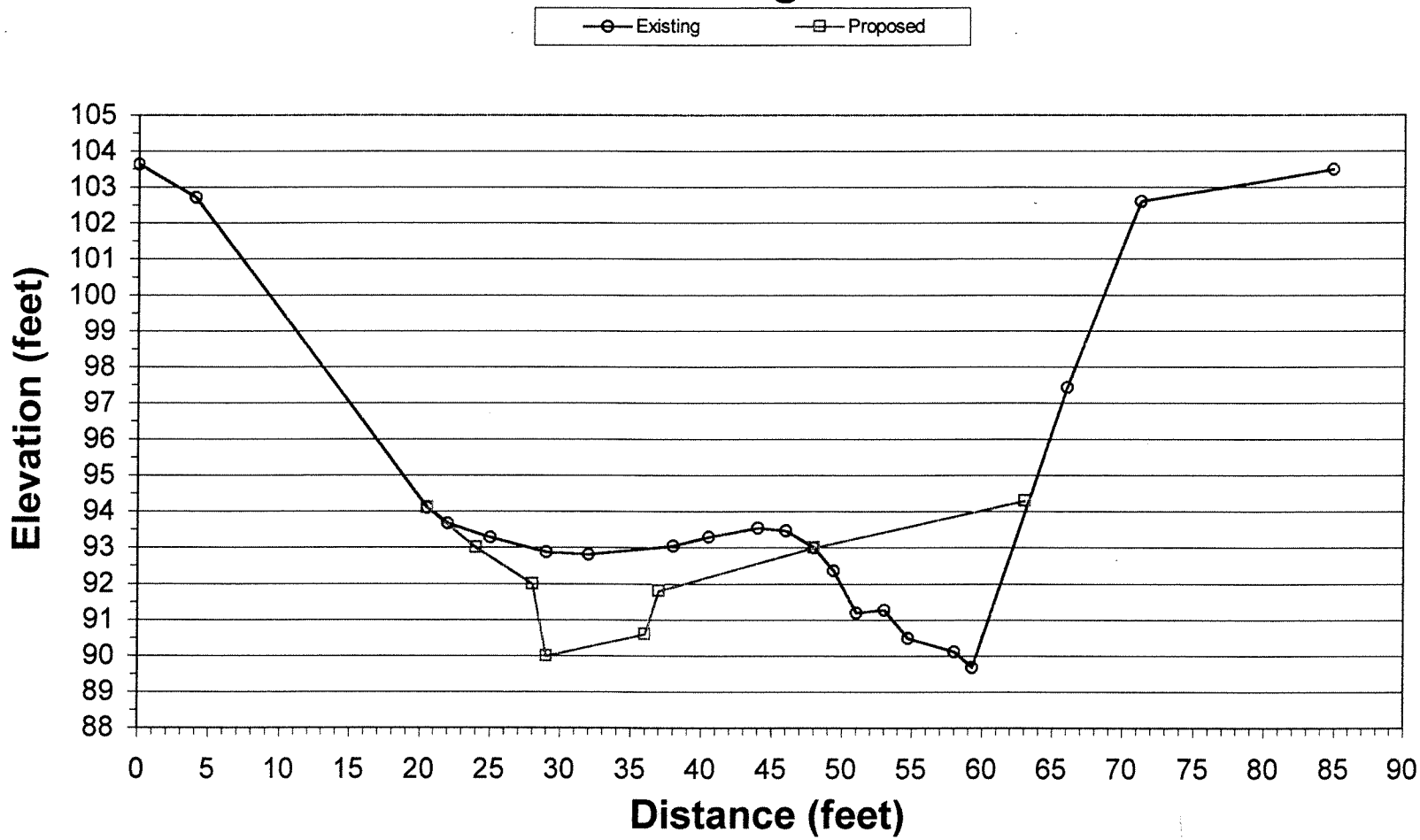
Chavis Park Cross Section #1 as viewed looking downstream



Cross Section Station 68+20
As viewed looking downstream



Chavis Park Cross Section Station 66+10
As viewed looking downstream



Pavement Samples

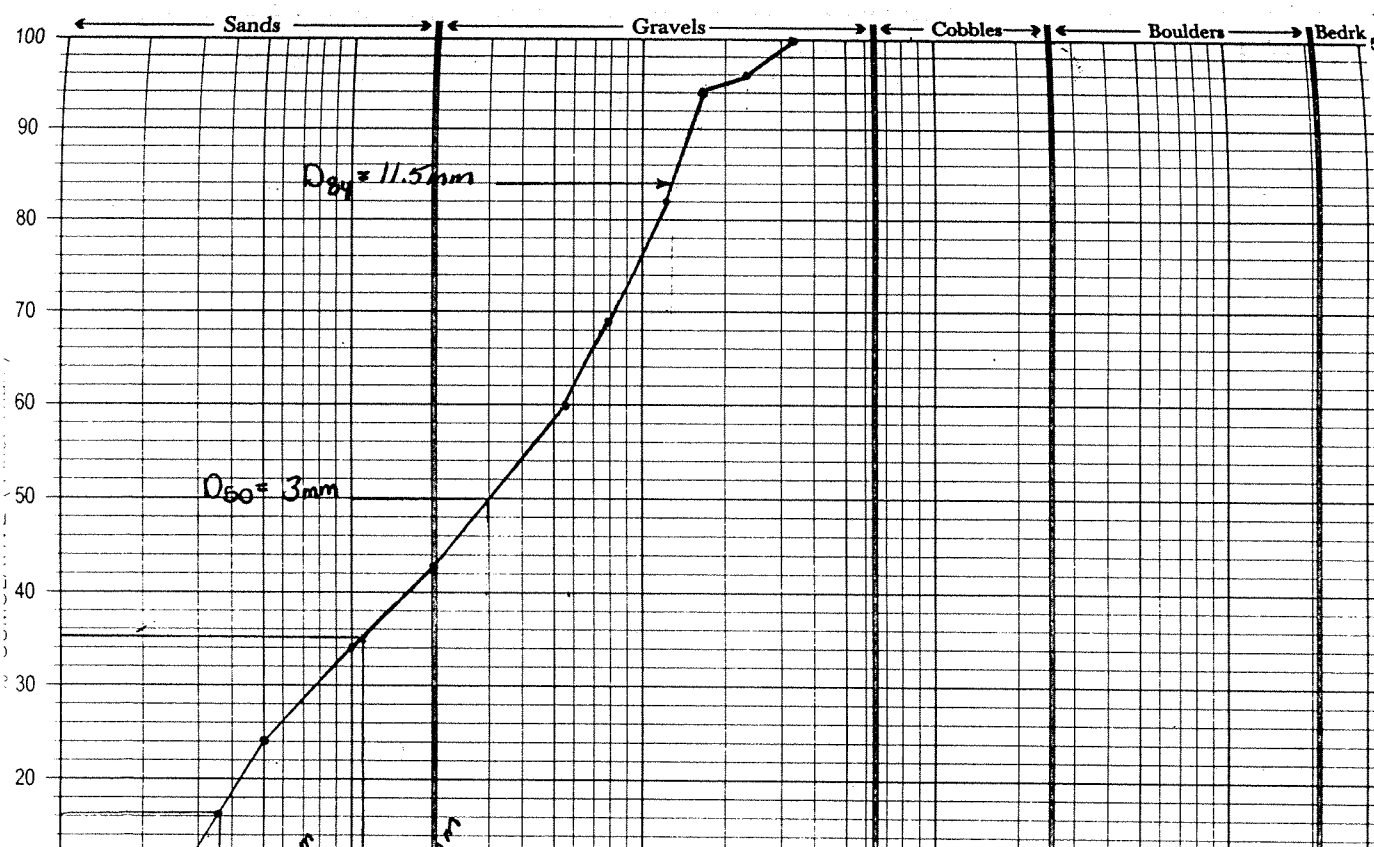
PEBBLE COUNT

Site: Chaw's Park Upper Reach Reach: along entire Reach of Stream
Party: B&B Ward Date: 3-9-01 approx 700'

Inches	PARTICLE	Millimeters		PARTICLE COUNT 1 2 3	TOT #	ITEM %	% CUM
	Silt / Clay	< .062	S/C				
	Very Fine	.062 - .125	SAND				
	Fine	.125 - .25	SAND	𝍸 𝍸 I	11	11	11
	Medium	.25 - .50	SAND	𝍸 𝍸 III	13	13	24
	Coarse	.50 - 1.0	SAND	𝍸 𝍸	10	10	34
.04 - .08	Very Coarse	1.0 - 2	SAND	𝍸 IIII	9	9	43
.08 - .16	Very Fine	2 - 4	GRAVEL	𝍸	5	5	48
.16 - .22	Fine	4 - 5.7	GRAVEL	𝍸 𝍸 II	12	12	60
.22 - .31	Fine	5.7 - 8	GRAVEL	𝍸 IIII	9	9	69
.31 - .44	Medium	8 - 11.3	GRAVEL	𝍸 𝍸 III	13	13	82
.44 - .63	Medium	11.3 - 16	GRAVEL	𝍸 𝍸 II	12	12	94
.63 - .89	Coarse	16 - 22.6	GRAVEL	II	2	2	96
.89 - 1.26	Coarse	22.6 - 32	GRAVEL	IIII	4	4	100
1.26 - 1.77	Very Coarse	32 - 45	GRAVEL				
1.77 - 2.5	Very Coarse	45 - 64	GRAVEL				
2.5 - 3.5	Small	64 - 90	COBBLE				
3.5 - 5.0	Small	90 - 128	COBBLE				
5.0 - 7.1	Large	128 - 180	COBBLE				
7.1 - 10.1	Large	180 - 256	COBBLE				
10.1 - 14.3	Small	256 - 362	BOULDER				
14.3 - 20	Small	362 - 512	BOULDER				
20 - 40	Medium	512 - 1024	BOULDER				
40 - 80	Large-Vry Large	1024 - 2048	BOULDER				
	Bedrock		BEDRK				
				TOTALS →			

PEBBLE COUNT — Reach: — Date: — TOT # | ITEM % | % CUM

PEBBLE COUNT — Reach: — Date: — TOT # | ITEM % | % CUM



GAGE:
Reach: Chaw's Park Upper Reach

PEBBLE COUNT DATA

No:
Date: 3-

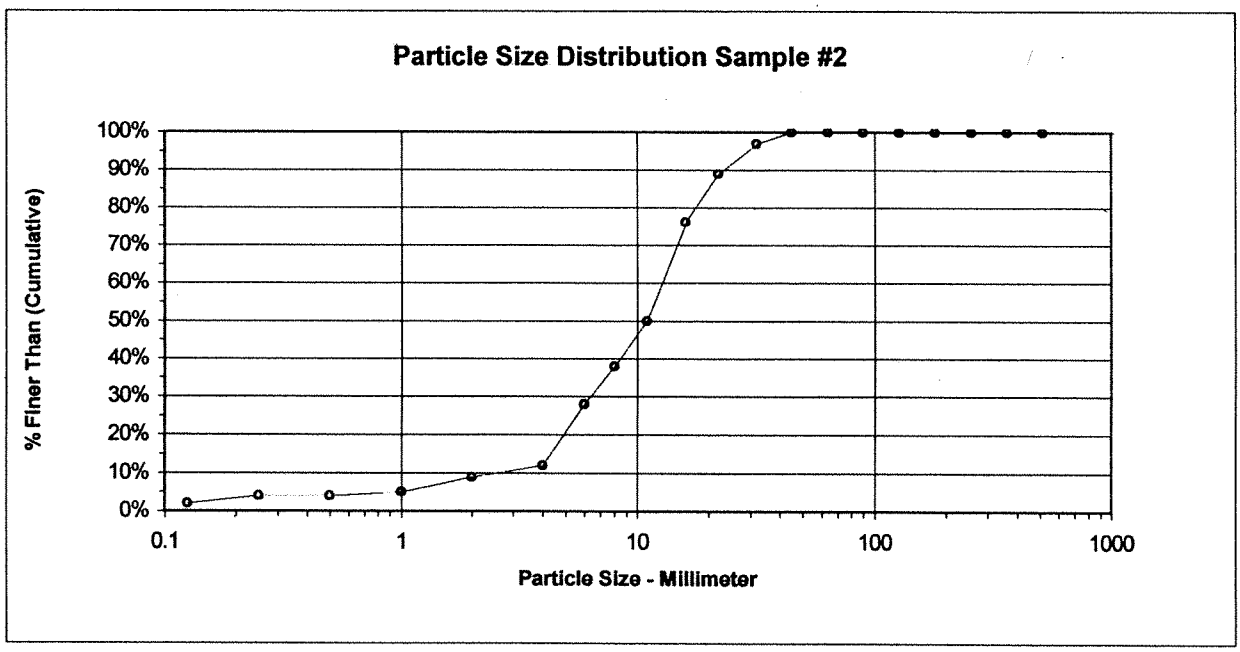
64

THE [illegible]

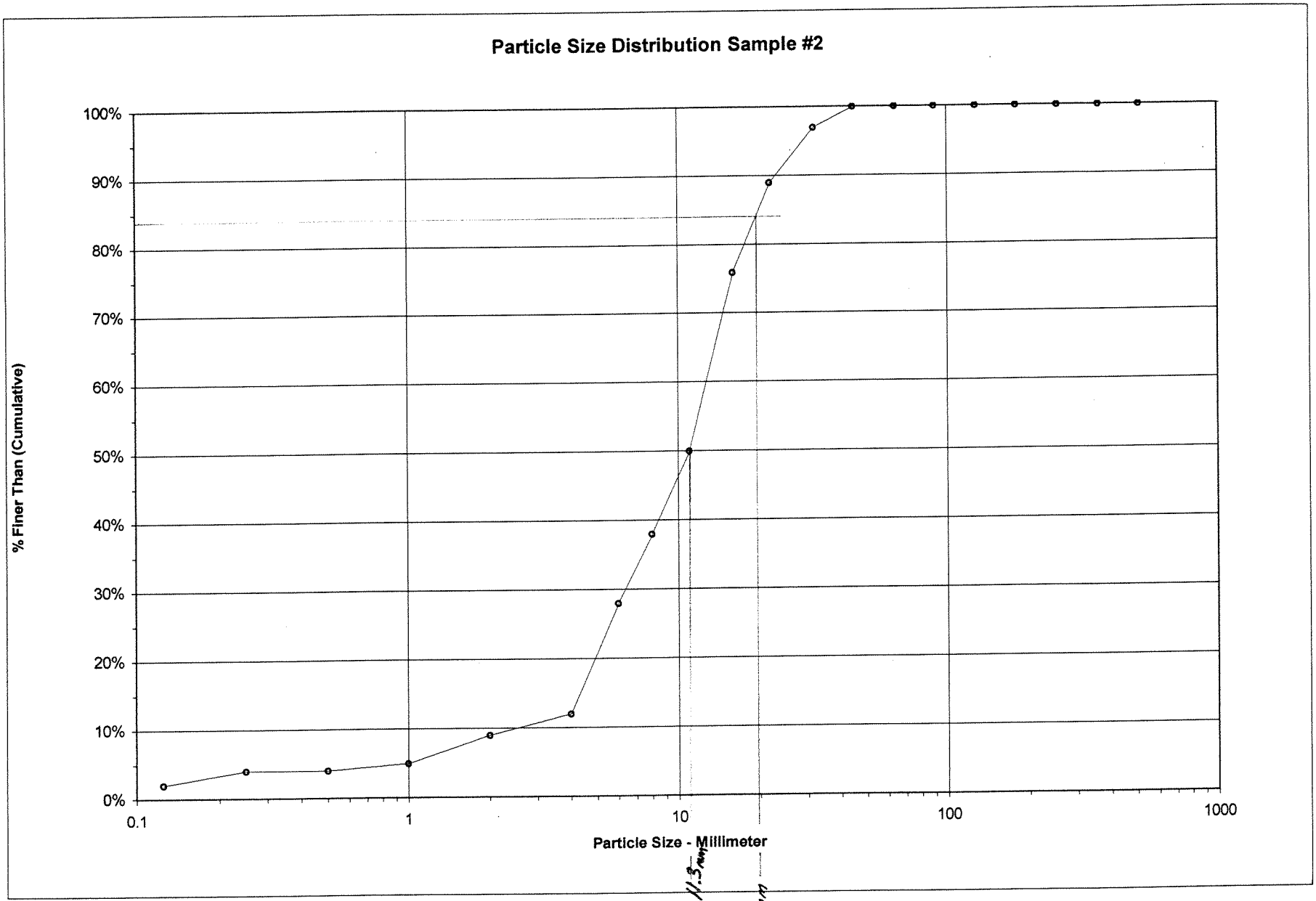
Pebble Count

Pavement Sample
Largest Dia Particle = 2.0"

PEBBLE COUNT								
Site: Chavis Park, Pavement Sample #2 at upper end,						Date: 4/19/2001		
Party: Becky Ward, Bob Ward						Reach: Garner Branch		
Particle Counts								
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0		0	0%	0%
	Very Fine	.062 - .125	S	2	0	2	2%	2%
	Fine	.125 - .25	A	2	0	2	2%	4%
	Medium	.25 - .50	N	0	0	0	0%	4%
	Coarse	.50 - 1.0	D	1	0	1	1%	5%
.04 -.08	Very Coarse	1.0 - 2.0	S	4	0	4	4%	9%
.08 - .16	Very Fine	2.0 - 4.0		3	0	3	3%	12%
.16 - .22	Fine	4.0 - 5.7	G	16	0	16	16%	28%
.22 - .31	Fine	5.7 - 8.0	R	10	0	10	10%	38%
.31 - .44	Medium	8.0 - 11.3	A	12	0	12	12%	50%
.44 - .63	Medium	11.3 - 16.0	V	26	0	26	26%	76%
.63 - .89	Coarse	16.0 - 22.6	E	13	0	13	13%	89%
.89 - 1.26	Coarse	22.6 - 32.0	L	8	0	8	8%	97%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	3	0	3	3%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0	0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	**100**	**0**	**100**	**100%**	**100%**



Sample #2 Chart 7



Sub-pavement Sample

Location: Sample #2 located in upper reach of Garner Branch

Largest Particle on bar =======> 2 inches

Sieve Size	Sieve Size (mm)	Sieve Weight (Lbs)	Sieve +Sample Weight (Lbs)	Sieve +Sample Weight (Lbs)	Sieve +Sample Weight (Lbs)	Sieve +Sample Weight (Lbs)	Total Weight (Lbs)	Cumulative Weight (Lbs)
1 inch	25	1.23	1.625				0.395	0.395
3/4 inch	19	1.245	2.15				0.905	1.3
1/2 inch	12.5	1.21	2.755				1.545	2.845
3/8 inch	9.5	1.225	2.375	1.26			1.185	4.03
No. 4	4.75	1.145	2.925	1.82			2.455	6.485
No. 8	2.36	1.07	2.555	1.91			2.325	8.81
No. 16	1.18	0.955	1.89	1.84	1.57	1.15	2.63	11.44
No. 30	0.6	0.9	2.33	1.66	1.535		2.825	14.265
No. 50	0.3	0.815	2.455	1.59			2.415	16.68
No. 100	0.15	0.775	1.16				0.385	17.065
No. 200	0.075	0.765	0.865				0.1	17.165
Passing 200	<0.075	1.08	1.11				0.03	17.195

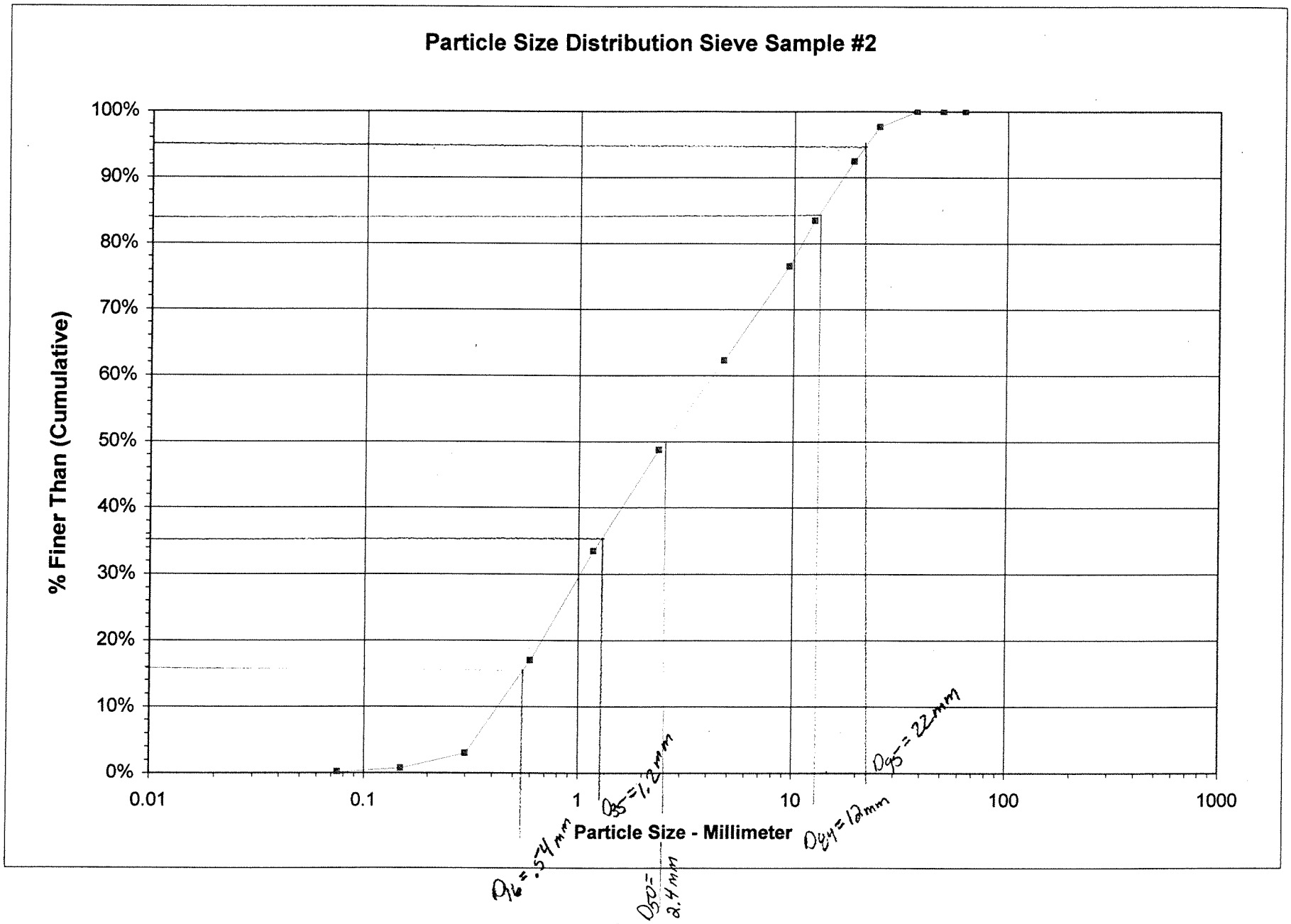
Bar Material

Sieve Sample

Site: Chavis Park, Sub-Pavement Sample #2 In upper reach of park

Party: Becky Ward, Bob Ward

Inches	Sieve Size	Millimeter < #200	S/C	Wt. Retained (lbs) 0.03	% Passing 0.17%	% Cumulative 0.17%	
0.0029	#200	0.0750	S	0.1	0.58%	0.76%	0.15
0.0059	#100	0.150	A	0.385	2.24%	3.00%	0.3
0.0117	#50	0.30	N	2.415	14.04%	17.04%	0.6
0.0234	#30	0.60	D	2.825	16.43%	33.47%	1.18
0.0469	#16	1.18	S	2.63	15.30%	48.76%	2.36
0.0937	#8	2.36	G	2.325	13.52%	62.29%	4.75
0.187	#4	4.75	R	2.455	14.28%	76.56%	9.5
0.374	3/8"	9.50	A	1.185	6.89%	83.45%	12.5
0.5	1/2"	12.50	V	1.545	8.99%	92.44%	19
0.748	3/4"	19.0	E	0.905	5.26%	97.70%	25
0.9843	1"	25.0	L	0.395	2.30%	100.00%	37.5
1.4764	1 1/2"	37.5	S	0	0.00%	100.00%	50
1.9685	2"	50.0		0	0.00%	100.00%	63
2.5	2 1/2"	63.0	C	0	0.00%	100.00%	
			O	0	0.00%	100.00%	
			B	0	0.00%	100.00%	
			L	0	0.00%	100.00%	
			B	0	0.00%	100.00%	
			L	0	0.00%	100.00%	
			D	0	0.00%	100.00%	
			R	0	0.00%	100.00%	
	Bedrock		BDRK	0	0.00%	100.00%	
			Totals	**17.195**	**100%**	**100%**	


Particle Size Distribution Sieve Sample #2
% Finer Than (Cumulative)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
Particle Size - Millimeter
D16 = .54 mm
D35 = 1.2 mm
D50 = 2.4 mm
D84 = 12mm
D95 = 22mm

Supporting Storm Drainage Calculations

Retrofit "A"

Drainage Area = 2.3Ac.

Calculate Composite "C"

Impervious Area	= (1/3) 2.3 x 0.95	=	0.73
Park area	= (1/3) 2.3 x 0.25	=	0.19
Apartments	= (1/3) 2.3 x 0.60	=	0.46
			1.38 / 2.3 = 0.60

t_c = 5 min - 7.22 in/hr. Composite "C"

$Q = CIA$
$= 0.60(7.22)(2.3)$
$Q = 9.96$ cfs.

Length of pipe 45' - 1' Drop

Slope = $\frac{1}{45} = 0.0222$

Q_c = 17 cfs ✓ ok > 10 cfs. design

Place 15' Drop. Inlet - yard inlet (YI-1)

80 LF PIPE Slope = $\frac{6}{80} = 7.5\%$

Drainage Area to yard inlet = 8.78 Ac

Composite "C"

Park = 5.0 Ac	= 5.0(.25) =	1.25
Impervious = 1.68 Ac	1.68(.95) =	1.596
Apartment = 2.1 Ac	2.1(.60) =	1.26
		4.106 / 8.78 = 0.47

$Q = CIA$
$= 0.47(7.22)(8.78)$
$Q = 29.8$ cfs.

Use 24" because can be set at as little as 2% and still will work when an 18" would love to be set at a minimum 7.5% slope to handle the flows.

Retrofit "A" Continued -

Check - Orifice Equation and determine openings per yard inlet -

$$Q = C_D A \sqrt{2gh}$$

$C_D = 0.60$
A = Cross sectional Area = $3.75\,ft^2$
g = $32.2\,ft/sec^2$
h = Driving head = 6" = .5 ft

openings use all 4 sides

$A = (2.5 \times .75)$ 4 sides = $7.50\,ft^2$

$$Q = 0.60(7.50)\sqrt{2(32.2)(.75)}$$

$Q = 31.27$ cfs. ✓ ok. $Q_D = 30$ cfs.

Design Rip Rap outlet Protection:

18" RCP. State Erosion Control Manual Figure 8.06a

$La = 9.5'$
$D_{50} = .3' = 4"$ Use Class A rip Rap.

Storm Drainage Retrofit - B

Determine Discharge to system:

Drainage Area = 2.5 Ac

60% Impervious	1.5 Ac x .95	= 1.43
40% Park	1.0 Ac x .25	= .25
		1.68 / 2.5 = .67 = Composite "C"

$Q = CIA$
$= .67(7.22)(2.5) = 12.1$ cfs.

Determine minimum slope of 18" RCP needs to be at 1.5% to carry anticipated water

Rip Rap. outlet Protection - 8.06b - Erosion Control Manual -
$La = 12$ ft.
Use Class II Rip Rap because discharging into main Channel.
Place JB to transition grade to lower elevation JB-1

Retrofit "C"

Drainage Area = 1.2 AC
C = .60
I = 7.22 T_C = 5 min

Q = CIA
= 1.2(.6)(7.22)
= 5.2 cfs.

Existing System 15" @ 11.4% slope Q_c = 24 cfs ✓ ok

Minimum Slope to carry ≈ 6 cfs.

Need to have at least a 1% slope Q_c = 7 cfs ✓ ok
Place Junction Box 6-5' depth (JB-2)

Determine Rip Raps - Outlet Protection - Figure 8.06b
State Erosion Control Manual

L_a = 2'

Use Class II because of Channel 15" thk.

New Storm Drainage System at Existing Park Shelter
Station 64+00

System is being added to transition point source locations at top of bank to discharge at the channel bottom location.

Determine Discharge to YI-2

Both flow through approx. 250' of parkland before enter new system.

A = 1.85 Ac
Residential = .925 x .60 = .56
Park = .925 x .25 = .23
.79/1.85 = .43 = C
Q = CIA = .43(1.85)(7.22) = 5.74 cfs.

Determine Discharge to YI-3

A = .41 Ac
area is all park land C = .25

Q = CIA = .41(.25)(7.22) = .74 cfs.

Check capacity of 15" pipe outlet from YI-2

Q_D = 6 cfs.

Need to have slope (minimum) = 1% to have a capacity of 7%.

Look at Orifice Equation for Inlet capacity -

Std opening - 2.5 x .5 x 4 sides = Area = 2.5

$Q = C_D A \sqrt{2gh}$ $C_D = 0.60$

A = Crossectional Area = 2.5 ft²

$Q = 0.6(2.5)\sqrt{2(32.2)(.5)}$ $g = 32.2$ ft/s²

h = driving head = .5 ft.

Q = 8.5 cfs.

Therefore minimum openings = 2.5 x .5 high all four sides. Both inlets

Rip Rap outlet Protection: Figure 8.06b

$L_a = 8'$

Storm Drainage Retrofit "E"

Drainage Area = 2.6 Ac.
Area is all Residential $C = .6$

$Q = CIA$
$= .6(7.22)(2.6) = 11.3$ cfs.

Determine Minimum Slope on 18" pipe for Capacity - 1.5% - yields Q_c = 14 cfs.

Determine Rip Rap Outlet Protection -

$L_a = 12$

Project:	Chavis Park Storm Drainage Retrofits										
Location:	Downtown Raleigh, North Carolina										
Date:	02/14/2002										
By:	Becky Ward Consulting										
			Mannings Equation:								
			Q=1.486/n*A*R^2/3*S^1/2								
			V=1.486/n*R^2/3*S^1/2								
			Conveyance K*= (1.486/n)*A*R^2/3								
			Qc= S^1/2*K* Pipe capacity								

Pipe Segment Calculations									**Pipe Segment Calculations Conti**		
			Pipe	Pipe						full flow pipe	"Q"design
			elevation	elevation	Pipe					capacity	flow
Pipe segment			invert in	invert out	Length		Slope (ft/ft	Pipe area	conveyanc	cfs	cfs
From - To	D (in)	D (ft)				n	S	Ap	K*	Qc	Qd
Park MLK	18	1.5			45	0.012	0.100	1.707	113.8	35.99	10.00
New Yinlet	24	2			80	0.012	0.075	3.142	245.1	67.12	30.00
Rep HW	18	1.5			25	0.012	0.015	1.707	113.8	13.94	12.00
Exst Cape	15	1.25			100	0.012	0.114	1.227	70.1	23.67	5.50
New cape	15	1.25			20	0.012	0.010	1.227	70.1	7.01	5.50
YI-2	15	1.25			50	0.012	0.020	1.227	70.1	9.91	6.00
YI-3	15	1.25			30	0.012	0.033	1.227	70.1	12.73	7
Chavis way	18	1.5			70	0.012	0.070	1.707	113.8	30.11	12.00

Bank Erosion Potential Data

Wildland Hydrology **Field Data Form** **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Charis Park Date: 4-19-01

Xsec. No. Sta 11+00 N-Bnk Crew: B&B. Ward

Location/Note: #1

Bank *Height* ~~(Ft)~~ 50" = 4.2'

Bankfull Height ~~(Ft)~~ 18" = 1.5'

Root Density (%) 6" depth - density = 40%

Bank *Angle* (degrees) 80°

Surface Protection (%) 5%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	10
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	8.0-9.0	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS						16.8				9.0		10
		5-9.5		10-19.5		20-29.5		30-39.5		40-45		46-50
Numerical Adjustments	None											

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

None

BEHI 35.8 - High

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Chavis Park Date: 4-19-01

Xsec. No. Sta 70+00 S-Bnk Crew: B & B. Ward

Location/Note: #2

Bank *Height* (ft) 20'

Bankfull Height (ft) 1.6'

Root Density (%) 10-12" root depth density = 30%

Bank *Angle* (degrees) 30-45°

Surface Protection (%) 50% boulders / 50% grass

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	(>2.8)	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-(.05)	8.0-(9.0)	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	(30-54)	(4.0-5.9)	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9 (3)	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	(80-100)	1.0-1.9 (1.4)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		1.4		3		4				9		10
		5-9.5		10-19.5		(20-29.5)		30-39.5		40-45		46-50
Numerical Adjustments	None											

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW
BOULDERS: BANK EROSION POTENTIAL LOW
COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT
Soil w/ rip-rap
Gave
GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND
SAND: ADJUST VALUES UP BY 10 POINTS
SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE
NO

BEHI 27.4 moderate w/ Rip Rap - Adj. to Low

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name: Garner Branch - Chavis Park Date: 4-19-01

Xsec. No: Sta 66+20 S-BNK Crew: B & B. Ward

Location/Note: #3 Large tree Roots exposed

Bank *Height* (ft) 20'

Bankfull Height (~~ft~~) 16"

Root Density (%) 12-14" depth - 50% density

Bank *Angle* (degrees) 90°

Surface Protection (%) 20%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	(>2.8)	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-(.05)	8.0-(9.0)	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-(54)	4.0-(5.9)	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-(90)	6.0-(7.9)	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS						5.9		14.9		9		10
		5-9.5		10-19.5		20-29.5		(30-39.5)		40-45		46-50
Numerical Adjustments	None											

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

NONE

BEHI 39.8 - High

Picture was (#2) taken

Wildland Hydrology *Field Data Form* *1999RAM*

BANK EROSION POTENTIAL

Stream Name Garner Branch - Charis Park Date: 4-19-01

Xsec. No. Sta 65+20 N-Bnk Crew: B&B. Ward

Location/Note: #4

Bank *Height* (ft) 9'

Bankfull Height (ft) 14" = 1.2'

Root Density (%) 10" depth - 60%

Bank *Angle* (degrees) 70-90°

Surface Protection (%) 80%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	(>2.8)	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05 .09	8.0-9.0 8.3	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79 60	2.0-3.9 (3)	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-(7.9)	91-119	8.0-9.0	>119	10
Surface Prot. (%)	(80)-100	(1.0)-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		1.0		3				7.9		18.5		10
		5-9.5		10-19.5		20-29.5		(30-39.5)		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

None

BEHI 30.4 - High

Wildland Hydrology **Field Data Form** **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Brand. - Charis Park Date: 4-19-01

Xsec. No. Sta. 69+50 S-BNK Crew: B & B Ward

Location/Note: #3

Bank *Height* (ft) 18'

Bankfull Height (ft) 16" = 1.3'

Root Density (%) 12" depth, 40%

Bank *Angle* (degrees) 120°

Surface Protection (%) 20%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	(>2.8)	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-(.05)	8.0-(9.0)	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54 40	4.0-5.9 (4.5)	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	(>119)	(10)
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29 28	6.0-7.9 (7)	10-15	8.0-9.0	<10	10
TOTALS						4.5		7		9		20
		5-9.5		10-19.5		20-29.5		30-39.5		(40-45)		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

NOTE

BEHI 40.5 - Very High

Picture (#2) Taken.

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Charis Park Date: 4-19-01

Xsec. No. Sta. 63+00 E-BNK Crew: BJB Ward

Location/Note: #10

Bank *Height* (ft) 25'

Bankfull Height (ft) 18" = 1.5'

* *Root* Density (%) 6" by surface plants plus 2-3' for tree roots D = 85%

Bank *Angle* (degrees) 60-70°

Surface Protection (%) 95%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	(8.0-9.0)	<.05	10
Root Density (%)	(80-100)	(1.0-1.9)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9 (5)	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9 (1.5)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		2.5				5				8		10
		5-9.5		10-19.5		(20-29.5)		30-39.5		40-45		46-50
Numerical Adjustments	None											

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

NONE

BEHI 25.5 Moderate

upstream of historic bridge

picture #3

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name: Garner Branch - Chavis Park Date: 4-19-01

Xsec. No.: Sta 61+00 E-BNK Crew: B & B Ward

Location/Note: 7

Bank *Height* (ft) 12-15'

Bankfull Height (ft) 17" = 1.4

Root Density (%) 18"-24" Density = 80%

Bank *Angle* (degrees) 60-70°

Surface Protection (%) 90%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	(8.0)-9.0	<.05	10
Root Density (%)	80-100	(1.0)-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	(4.0)-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9 (1.5)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		2.5				4				8		10
		5-9.5		10-19.5		(20-29.5)		30-39.5		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW
BOULDERS: BANK EROSION POTENTIAL LOW
COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT
GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND
SAND: ADJUST VALUES UP BY 10 POINTS
SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE
NONE

BEHI 24.5 - Moderate

Picture #11 TAKEN

Wildland Hydrology | Field Data Form | 1999RAM

BANK EROSION POTENTIAL

Stream Name: Garner Branch - Charis Park Date: 4-19-01

Xsec. No.: Sta 58+50 W-Bnk Crew: B&B Ward

Location/Note: #8

Bank *Height* (ft) 15'

Bankfull Height (ft) 14" = 1.2'

Root Density (%) 3-4' trees & shrubs, 6" w/ surface vegetation Density = 5

Bank *Angle* (degrees) 80-90°

Surface Protection (%) 90%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	8.0-9.0	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-(5.9)	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9 (3.3)	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS				3.3		5.9		14				10
		5-9.5		10-19.5		20-29.5		(30-39.5)		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

None

BEHI 33.2 - High

Picture #5

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Chavis Park Date: 4-19-01

Xsec. No. Sta 56+50 W-Bnk Crew: B&B Ward

Location/Note: #9

Bank *Height* (ft) 12'

Bankfull Height (ft) 18" = 1.5'

Root Density (%) 8" = .67' D = 40%

Bank *Angle* (degrees) 80-110

Surface Protection (%) 10%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	(8.0-9.0)	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9 (5)	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0 (8.5)	>119	10
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	(8.0-9.0)	<10	10
TOTALS						5				25.5		10
		5-9.5		10-19.5		20-29.5		30-39.5		(40-45)		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

None

BEHI 40.5 - Very High

Took pictures 20

Wildland Hydrology | **Field Data Form** | **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Chavis Park Date: 4-19-01

Xsec. No. Sta. 55+00 S-BNK Crew: B&B Ward

Location/Note: #10

Bank *Height* (ft) 17"

Bankfull Height (ft) RWR 11 / 30%

Root Density (%) 18" roots (shrubs) plus 6-8" surface plants D = 70%

Bank *Angle* (degrees) 60°

Surface Protection (%) 90%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	8.0-9.0	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9 (1.5)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		1.5		3.9		4.0				9.0		10
		5-9.5		10-19.5		20-29.5		30-39.5		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW
BOULDERS: BANK EROSION POTENTIAL LOW
COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT
GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND
SAND: ADJUST VALUES UP BY 10 POINTS
→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

None

BEHI 28.4 - Moderate

took picture #7

Wildland Hydrology — **Field Data Form** — **1999RAM**

BANK EROSION POTENTIAL

Stream Name Garner Branch - Chavis Park Date: 4-19-01

Xsec. No. Sta 54+50 E-BNK Crew: B&B Ward

Location/Note: #11

Bank *Height* (ft) 12'

Bankfull Height (ft) 11" - 1.3'

Root Density (%) 2-3' density = 70%

Bank *Angle* (degrees) 60°

Surface Protection (%) 90-95%

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	(10)
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	(6.0-7.9)	0.14-.05	8.0-9.0	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	(4.0-5.9)	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9 (1.5)	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS		1.5		2.5		4		6				10
		5-9.5		10-19.5		(20-29.5)		30-39.5		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

SAND: ADJUST VALUES UP BY 10 POINTS

→ SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

NONE

BEHI 24 - Moderate