Indirect Measurement Summary

Long Creek near Langley, Arkansas
Ouchita River Basin
Miscellaneous Site

Q= 13,000 ft^3/s

Flood of June 11, 2010

Type of measurement: Slope Area

Location of site: A miscellaneous site on Long Creek 3,700 feet upstream from Little Missouri River and 1200 feet downstream of the first low water crossing that is encountered on the Forest Service Road 512-2 leading from County Road 4 (AKA USFS Road 73) Lat N 34˚23’15”, Long W 93˚53’40”. This site was selected because it was a fairly straight reach that was as far downstream as possible without getting into the backwater from the Little Missouri.

3 of the 20 flood fatalities came from a camp area which was approximately 7,000 feet upstream of the indirect reach. The car that the 3 people were sleeping in and subsequently washed away came to rest at the downstream cross section of the indirect reach.

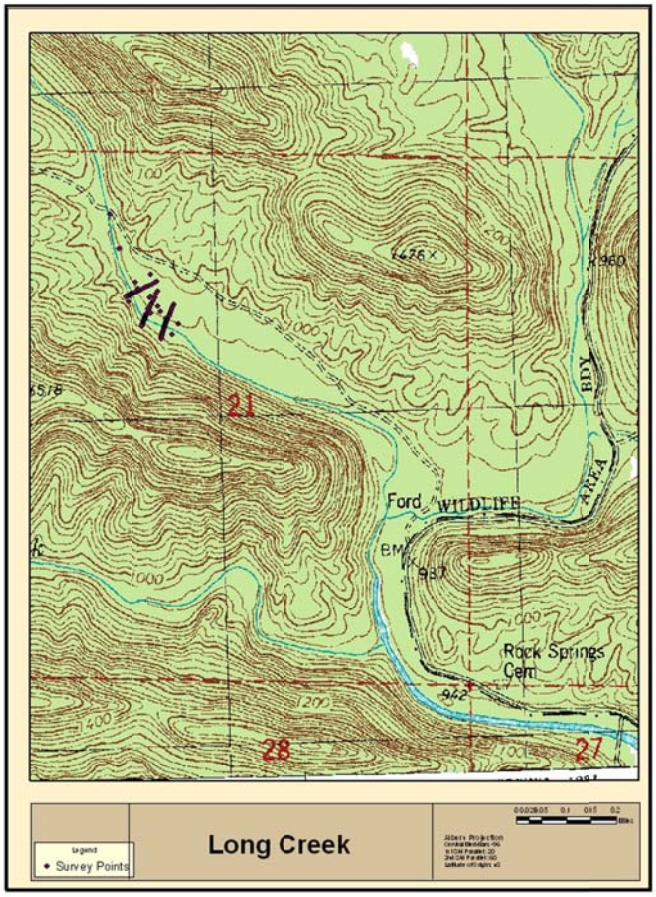
The site is Approximately 6.06 miles northwest of Langley, Arkansas, 12.87 miles southwest of Norman, Arkansas, and 29.7 miles east of Cove, Arkansas.

Survey of site: Site was selected on Tuesday June 15, 2010 by Robert Holmes during reconnaissance of the flood area. High water marks were flagged on the morning of June 17, 2010 by Robert Holmes, Ferrell Killian, Aaron Pugh, and Jonathon Gillip. A survey commenced on June 17, 2010 by Ferrell Killian, Aaron Pugh, and Jonathon Gillip. The initial occupation point (OC-1 and also known as TP-1 in data logger notes) was a rebar driven into ground in the riprap area to the southeast of the low water bridge that is 1200 feet upstream of the indirect reach. An arbitrary Northing/Easting of 5000/5000 was assumed with an elevation of 100. The azimuth was established with a compass bearing of magnetic north. After the point was vacated by the total station survey, a Trimble GPS unit was setup to occupy the point for several hours to establish the true horizontal and vertical position of each survey point. The UTM Zone 15 NAD 83 and NAVD 88 location of OC1 is as follows:

Elevation NAVD88	Northing (UTM Feet)	Easting (UTM Feet)	
973.05	12486287.31	1370239.51	OC1

The Survey of the indirect measurement site was made using a Sokkia Set 3c 3-second total station, serial number 23110.

The stream reach of the indirect was on a slight bend, as such, SAM was not used for longitudinal stationing of the HWM or Cross sections. Rather, a baseline was chosen in ARC to assign stationing to all HWM and cross sections.



Map of Surveyed Indirect Reach and Cross Sections

Discharge and Gage Height: 13,000 cfs. No Gage Height as this is a miscellaneous site.

Drainage area: 10.7 mi^2 . This was determined by subtracting 0.264 mi2 (determined by Robert Holmes using GIS) from the value for mouth of Long Creek (10.93 mi2 (at Little Missouri River) as determined by Albert Rea of the USGS using NHD Plus.

Unit Discharge: 1,215 cfs/mi^2. Crippen and Bue (1977) envelope curve for this region (Region 8) is below, with this flood approximately plotted.

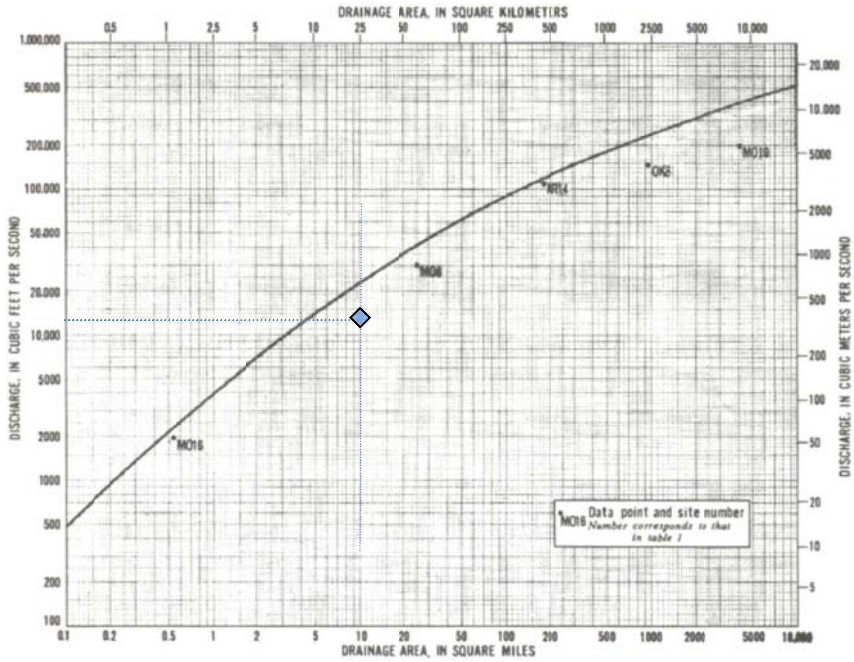


FIGURE 10.—Peak discharge versus drainage area, and envelope curve for region 8.

Nature of flood: This flood was a flash flood of extreme nature. As much as 7 inches of rain fell in a very short period of time starting just before or at midnight on June 10. Rates of rise at the USGS streamgage on the Little Missouri River 10 miles downstream were as much as 8 ft/hour. Anecdotal accounts of the rates of rise on the Little Missouri River from survivors in the Albert Pike Campground indicate as much as 3 feet in a few minutes. It is fully conceivable that the rates of rise on Long Creek would be even faster. The Ouachita mountains are a known "flood hotspot" in the United States due to their steep topography and proximity to the Gulf of Mexico (GOM) moisture source. Moisture-laden air masses travel north from the GOM over the Coastal plain with Orographic lifting occurring as the mass meets the Ouachita mountains of southwestern Arkansas. The orographic lifting can produce intense rainfall. The intense rainfall on steep slopes results in large peak streamflows.

Field conditions: The indirect reach is on a slight bend with nearly uniform boundary roughness through the reach. A baseline was chosen in ARC and all longitudinal stationing for the cross sections and HWM were chosen from that base line. Each of the three cross sections was subdivided into 2 subsections: 1) the main channel, which included the two bank areas with the trees, and 2) the left overbank, which is a panhandle subsection of the total cross section. XS1 is the most upstream cross section, XS2 is the middle cross section, and XS3 is the most downstream cross section.

Videos documenting the Field Conditions are:

M4H01872.MP4
M4H01873.MP4

M4H01875.MP4

The left overbank is forested with grass. The forest is of medium density and appears that it may have been burned at one time in the recent past. The left overbank is fairly uniform in roughness, with some thinning of tree density as one heads upstream from XS3 to XS1. Based on engineering judgment, a value for n = 0.07 was assigned the left overbank area.

Left Overbank area near XS3, looking upstream. Note trail went parallel to stream.

Left Overbank at XS 2 looking downstream

The main channel is treed on both banks with a gravel/cobble bed for the low water channel. There are some intermittent boulders in this reach. The right bank rises into the bluff on the right valley wall. A composite n value of 0.051 was selected for the main channel based on engineering judgement, weighting of n values from channel width, and comparison of the indirect reach with photos from Barnes (1967, http://pubs.usgs.gov/wsp/wsp_1849/pdf/wsp_1849.pdf).

From left bank to right bank at the dozer track to pull out car. This is approximately 50 to 100 feet downstream of XS3

On left bank of XS 2 looking from LB to RB

The high water marks on the left bank were of generally fair to good condition. The right bank was a bluff which contained mostly poor high water marks due to the high velocities.

Right Bank High Water Marks

Mark Name	Station	MSL Elev	Elevation
RH-1-P	86.0	961.5	88.4
RH-2-F	330.0	966.5	93.5
RH-3-P	549.0	963.7	90.7

Left Bank High Water Marks

Mark Name	Station	MSL Elev	Elevation
LH-2-G	0.0	968.4	95.4
LH-1-F	69.0	968.0	95.0
LH-3-G	241.0	966.6	93.6
LH-4-G	241.0	966.3	93.2
LH-5-G	330.0	966.1	93.0
LH-6-G	330.0	965.9	92.8
LH-7-F	357.0	965.5	92.4
LH-8-F	401.0	965.2	92.2
LH-9-G	443.0	965.1	92.1
LH-10-G	523.0	964.6	91.6
LH-11-G	672.0	963.8	90.7

Computations:

SAM 2.1 was used to process the Total Station Survey data and ready it for input into the SAC program (Slope Area Computation). Baseline stationing was computed by hand as SAM 2.1 analysis incorrectly computed the baseline distancing . The discharge computed for this measurement was 13,000 cfs. The reach was slightly expanding from X1 to X2 and nearly uniform from X2 to X3. Following are the output diagnostics from SAC.

Reach	dH,fall (ft)	length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
X1 - X2	2.10	244.	13441.	8	2.273	0.958	0.000	-0.152	#
X2 - X3	1.40	219.	12427.	4	1.459	0.979	0.000	-0.081	#
X1 - X3	3.50	463.	13006.	6	3.727	0.967	0.000	-0.122	

Definitions:
Spread: the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF: friction head which is the sum of Q*Q*L/(K1*K2) over subreaches
L: reach length; K1, upstream section conveyance;
K2: downstream section conveyance
CX: the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC: velocity head change in contracting section divided by friction head
RX: velocity head change in expanding section divided by friction head

Sensitivity Analysis

Sensitivity analysis was conducted on the n values for the main channel and overbank whereby the n values were allowed to vary +/- 10%., resulting in a variation of -9% to +11.5% in streamflow from the accepted value of 13,000 ft^3/s.

Evaluation:

Use 13,000 cfs and consider it fair reliability. The indirect is graded at fair, missing the good measurement designation mainly because of the limited high water marks. Other supporting reasons for this evaluation are as follows:

1. The high water marks were flagged and surveyed within 4 days of the flood. A few good marks were found on the left bank, with the majority of marks were either fair or poor.
2. There was a slight expansion from XS1 to XS2. However, this location was the best available. The survey reach likely should have gone downstream for one more cross section, however, given the time constraints, this was not possible and there was concern of backwater from the Little Missouri River.
3. The computation diagnostics are fair to good. There is some minor expansion through this reach with Spread values of 8% between X1 to X2 and 4% between X2 to X3.
4. There is little evidence that the reach cross section main channel has changed much during the flood. The channel is remarkably stable. The left overbank had minor erosion/deposition of sands, gravels, and fines from the ground being bare from construction. The impact to any cross sectional change is negligible.
5. There is no evidence that this flood was a debris flow based on evidence left behind such as scouring and deposition.

Previous computations:

None

Remarks:

Responses to Rodney Southard comments (Southard comments in regular text and response in *italics*):

1. GPS equipment was used to establish vertical and horizontal control at the point of origin for the indirect survey. Suggest documenting the coordinates of this point in the indirect report and water surface elevations used in the analyses. It would be beneficial to translate all points to real world coordinates for future reference.

   I added the UTM and NAVD88 values for OC-1 in the summary. All the points were already translated into real world coordinates in the file "Long_Survey_Data.xls" .

2. Cross section 1 has a station reference distance of 115 for the SAC input. The high water mark profile plot shows cross section 1 at station 262 and the corresponding water surface elevation of 93.85 ft which was used in the SAC input file. The water surface elevation for a section reference distance of 115 is 95.2 ft. Should the water surface elevation of 95.2 ft at cross section 1 be used for the SAC computations? Velocities at cross section 1 abnormally high compared to other cross sections, maybe due to water surface elevation used. Diagnostics between cross section 1 and 2 are also poor between cross sections 1 and 2.

   I made an alteration to the longitudinal stationing and have redone the stationing for both high water marks and cross sections. New water surface elevations for each cross section were determined. Velocity at XS1 is higher than XS2 and XS3, but not abnormally so.

3. Suggest obtaining a cross section downstream to improve analyses and additional high water marks on right bank. Only three high water marks on right bank with one mark six foot lower than on left floodplain. Additional marks on right valley wall would be beneficial.

   Cross section on right bank greatly expands (right bank bluff deviates from the channel) thus, no additional cross section will be obtained as it will likely not improve the analysis. Regarding additional high water marks on the right bank, the right bank is a bluff and the velocity was high. As such, limited high water marks were left from the flood, with most being of poor quality.

4. Plan view of cross sections indicates a sharp bend in channel between cross sections one and two. If not, then are some of the cross sections skewed to the channel? Are section reference distances straight lined or do they follow the main channel?

   I have revisited the longitudinal stationing of the indirect.

5. Indirect rated poor due to reach and limited data, which is appropriate.

   I have upgraded the measurement quality to fair. When I redid the longitudinal base line, it vastly improved the computation diagnostics. In addition, the high water marks along the left bank align very well.

6. Computational table and cross sectional properties table in summary write-up does not match for the same SAC run. One table is from one analyses and the second table is from another analyses with different inputs. Not sure which computation is considered final.

   I have removed the cross sectional properties table as this information is in the SAC output.

Computed By: Robert R. Holmes, Jr. PhD, P.E., D.WRE
National Flood Specialist
Date: August 2, 2010
Revised: September 14, 2010

Check/Review By: Rodney Southard

Date: August 26, 2010

Re-Review By: Rodney Southard
Date: September 15, 2010

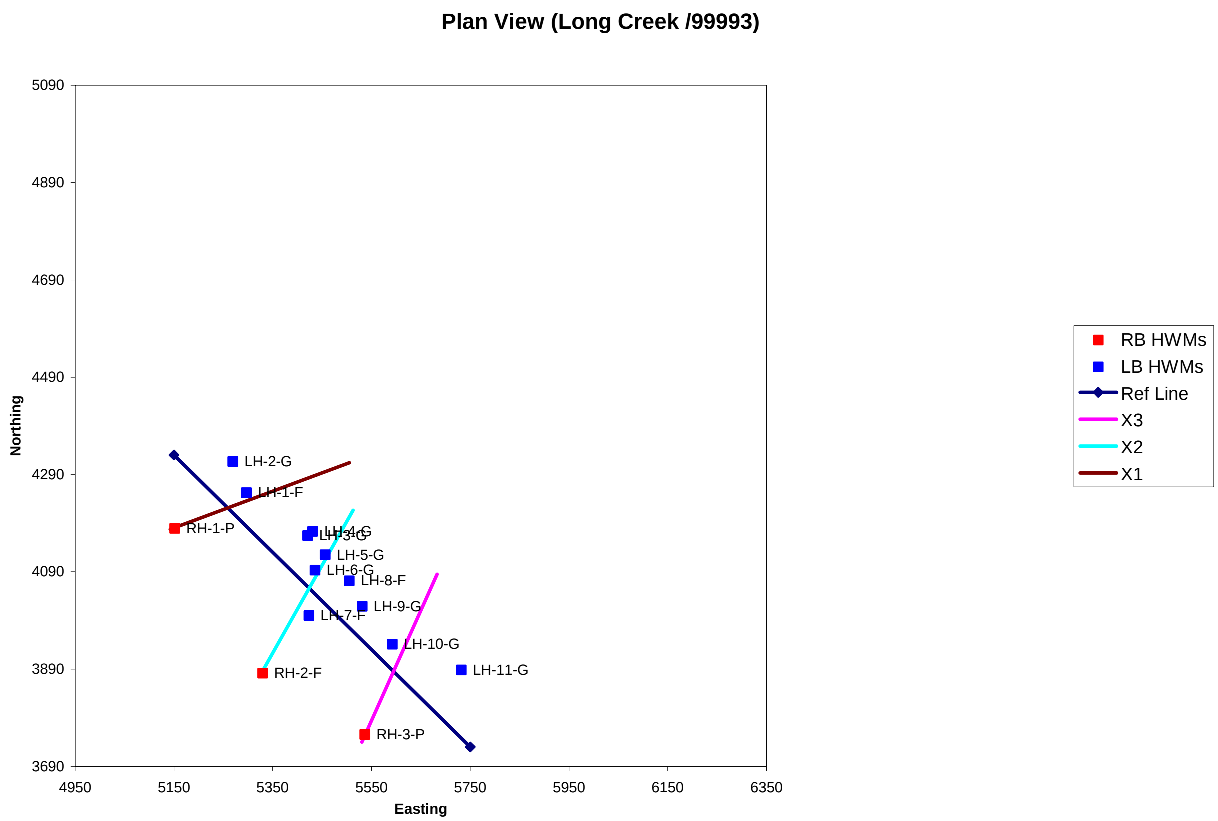
Approval: Mark E. Smith
Surface Water Specialist,
Central Water Science Field Team
Date: January 21, 2011

Appendix

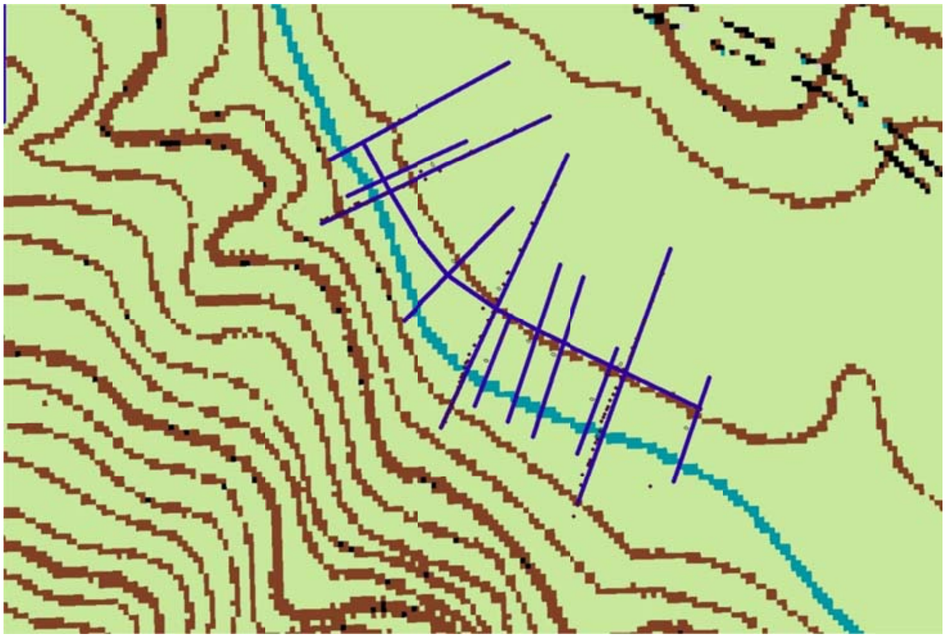
Long Creek near Langley, Arkansas

Flood of June 11, 2010

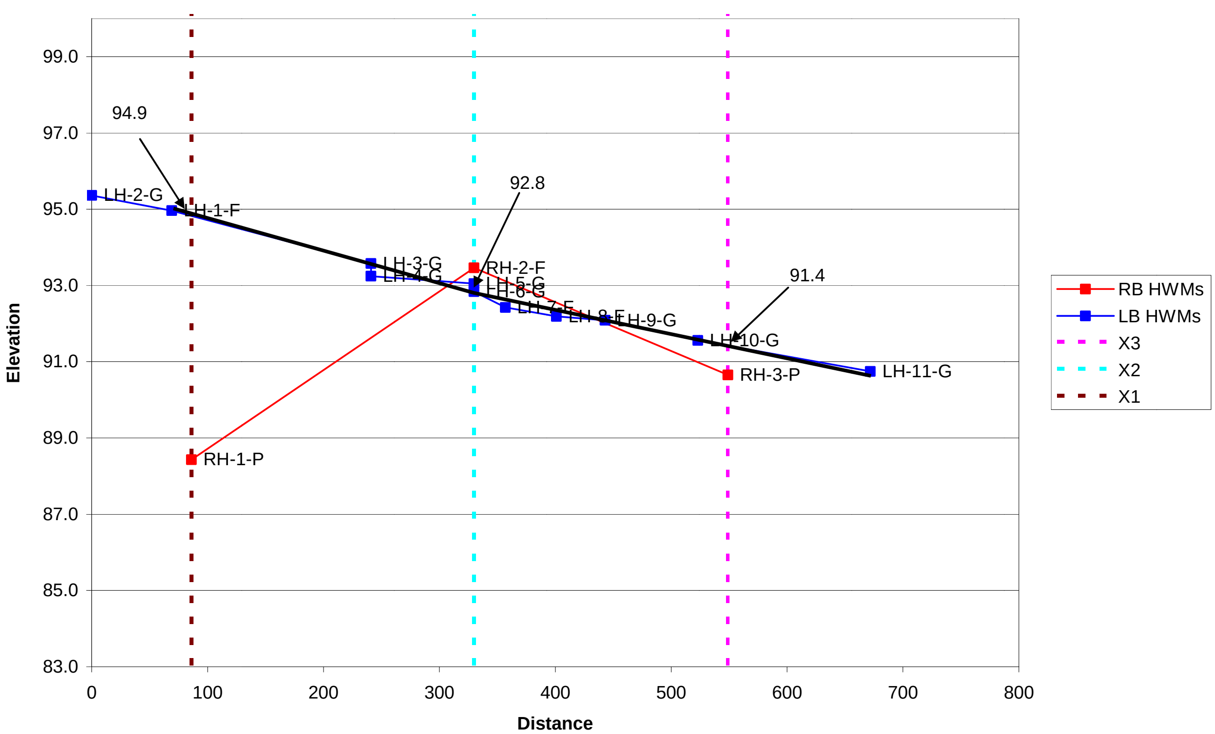
Graphs from SAM



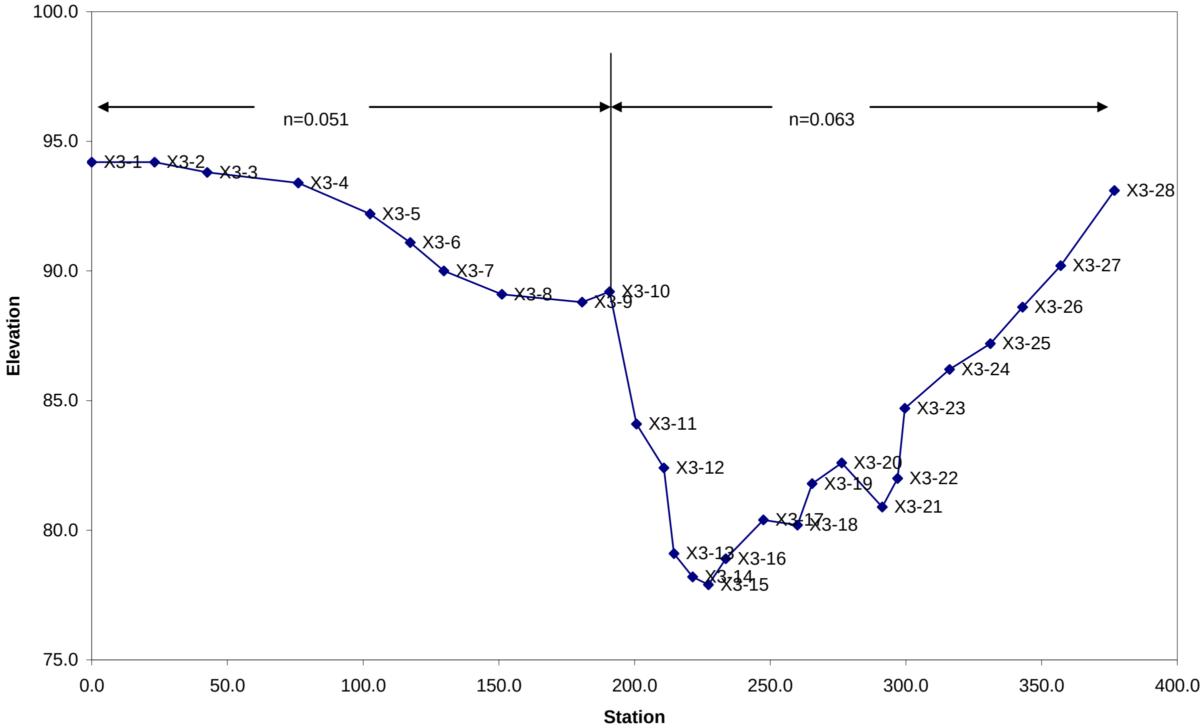
Note: these are printed in Plan View from SAM, due to stream curvature, longitudinal stationing computed from ARC see below:



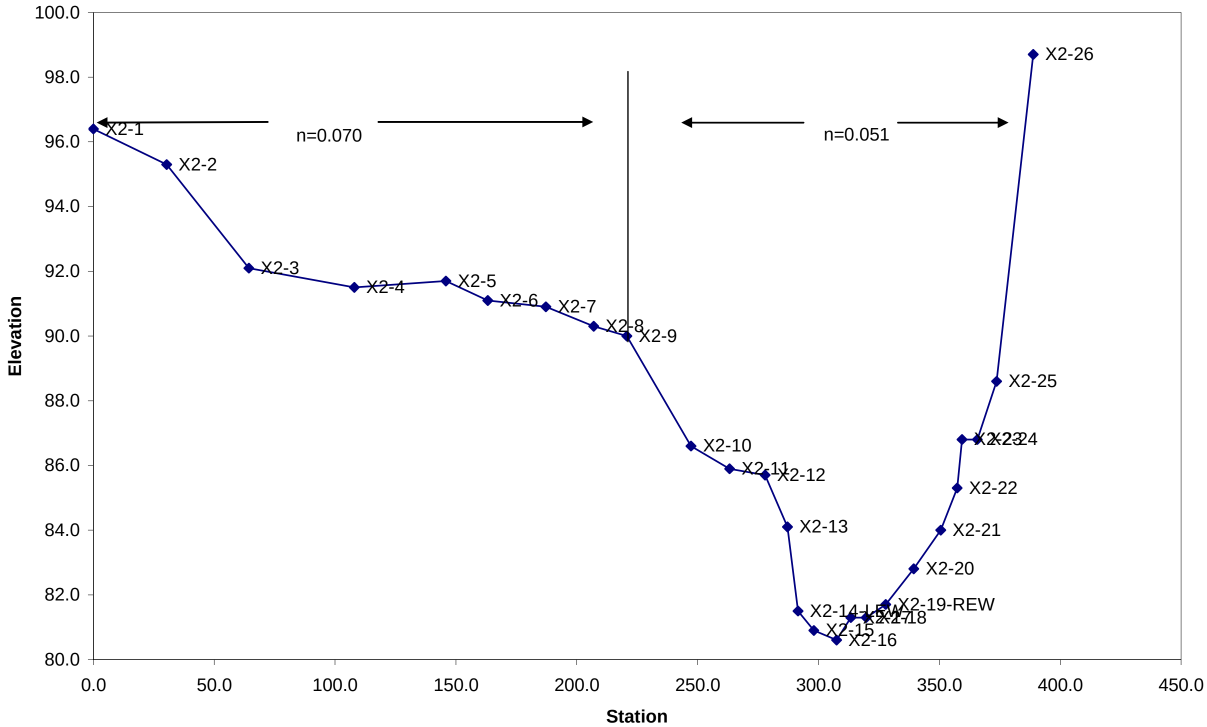
High Water Marks Profile (Long Creek /99993)



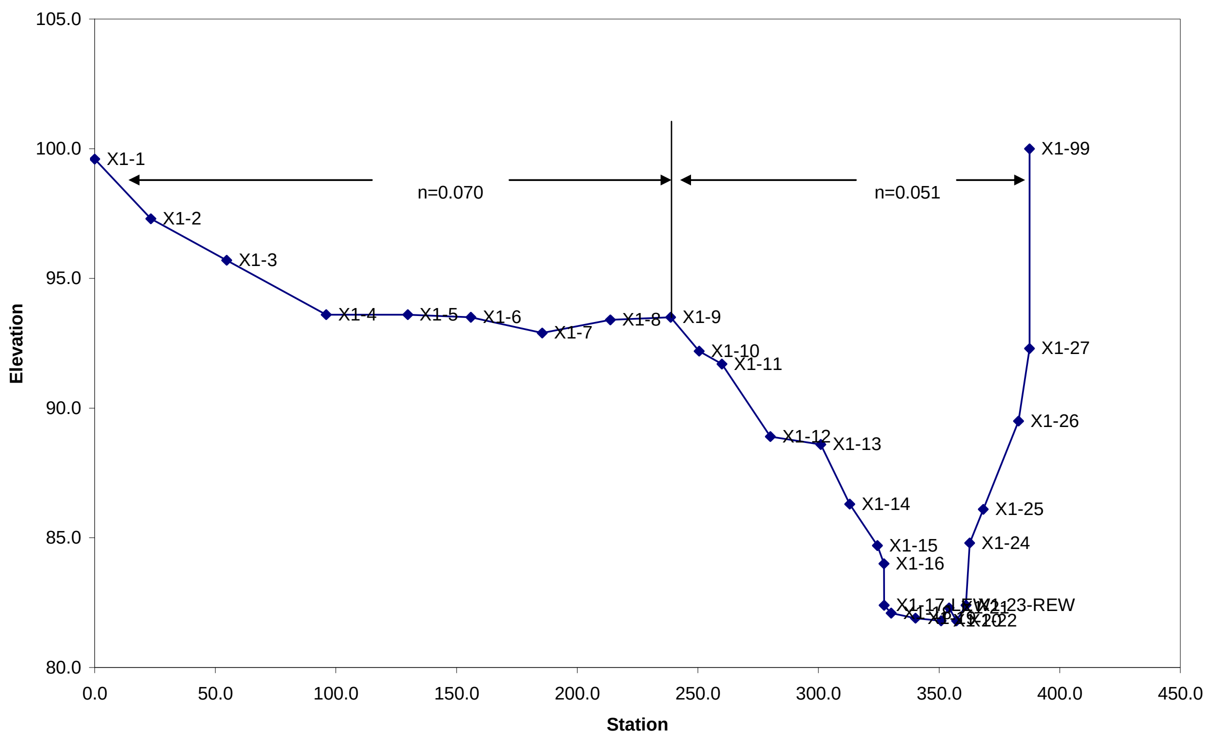
Cross Section X3



Cross Section X2



Cross Section X1



Roughness Estimates

Main Channel

Main channel was determined from a combination of engineering judgment, photo comparison with Barnes (1967), and by doing a weighted (by width) estimate of the main channel composite n value.

The main channel had brush and trees on the left shore (44 ft in width), a rock and gravel bed low water channel (38 ft in width) and a treed/brush right shore (25 ft in width).
The left shore was estimated to be n= 0.060.
The right shore was estimated to be n = 0.060.
The low water channel was estimated to be 0.031. This was based on published n values in Chow (1959) and engineering judgement.

A weighted value of n for the main channel is 0.063.

Width(W)	n	W*n
44’	0.060	2.65
38	0.031	1.18
25’	0.060	1.50
101		5.32

$$n_c = 5.32/101 = 0.053$$

For this indirect, a n value of 0.051 was used for the main channel. This was based on engineering judgment, weighting of n values from channel width (above), examination of photos from Barnes (1967, http://pubs.usgs.gov/wsp/wsp_1849/pdf/wsp_1849.pdf), and review of the sensitivity analysis data.

SAC INPUT DATA

```
T1        SAC/WSPRO Input for Long Creek   (99993)
T2
Q
WS        91.4
XS   X3   549
GR        0,94.2 23.2,94.2 42.6,93.8 76.1,93.4 102.6,92.2 117.4,91.1 129.7,90
GR        151.1,89.1 180.7,88.8 190.8,89.2 200.7,84.1 210.8,82.4 214.5,79.1
GR        221.4,78.2 227.2,77.9 233.6,78.9 247.5,80.4 260,80.2 265.4,81.8
GR        276.3,82.6 291.3,80.9 296.9,82 299.6,84.7 316.1,86.2 331.1,87.2
GR        343,88.6 357,90.2 376.8,93.1
N         0.070  0.051
SA        190.8
HP 4 X3    91.4
XS   X2   330
GR        0,96.4 30.3,95.3 64.3,92.1 107.9,91.5 145.9,91.7 163.2,91.1
GR        187.2,90.9 207,90.3 220.7,90 247.3,86.6 263.2,85.9 277.9,85.7
GR        287.2,84.1 291.5,81.5 298.1,80.9 307.5,80.6 313.4,81.3 319.7,81.3
GR        327.8,81.7 339.4,82.8 350.6,84 357.4,85.3 359.4,86.8 365.7,86.8
GR        373.7,88.6 388.9,98.7
N         0.070  0.051
SA        220.7
HP 4 X2    92.8
XS   X1   86
GR        0,99.6 23.3,97.3 54.7,95.7 96,93.6 129.8,93.6 155.9,93.5 185.5,92.9
GR        213.7,93.4 238.7,93.5 250.5,92.2 260,91.7 280.1,88.9 301,88.6
GR        313,86.3 324.4,84.7 327.1,84 327.2,82.4 330.1,82.1 340.2,81.9
GR        350.9,81.8 354.1,82.3 357.2,81.8 361.1,82.4 362.7,84.8 368.3,86.1
GR        382.9,89.5 387.5,92.3 387.5,100
N         0.070  0.051
SA        238.7
HP 4 X1     94.9
```

SAC OUTPUT

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
X1 - X2	2.10	244.	13441.	8	2.273	0.958	0.000	-0.152	#
X2 - X3	1.40	219.	12427.	4	1.459	0.979	0.000	-0.081	#
X1 - X3	3.50	463.	13006.	6	3.727	0.967	0.000	-0.122	

Definitions:

Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss

HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance

CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)

RC, velocity head change in contracting section divided by friction head

RX, velocity head change in expanding section divided by friction head

ER, warnings, *-fall <' 0.5ft, @-conveyance ratio exceeded, #-reach too short error, 1-negative or 0 fall

******, terms that can not be computed because' of strong expansion in reach

CROSS SECTION PROPERTIES

I.D. X3 Velocity head 1.33ft Discharge 13006.cfs
Ref.distance 549.ft Q/K 0.0071 Alpha 1.123

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	91.40	0.070	147.4	77.4	77.5	1.90	4.816	3.	2.7	0.35
2	91.40	0.051	1341.3	174.4	179.2	7.48	149.948	97.	9.4	0.60
Total	91.40	---	1489.	252.	257.	5.80	154.763	100.	8.7	0.63

I.D. X2 Velocity head 1.46ft Discharge 13006.cfs
Ref.distance 330.ft Q/K 0.0075 Alpha 1.243

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	92.80	0.070	239.1	163.8	163.9	1.46	6.546	4.	2.4	0.35
2	92.80	0.051	1255.4	159.3	162.7	7.72	143.212	96.	9.9	0.62
Total	92.80	---	1494.	323.	327.	4.58	149.758	100.	8.7	0.71

Definitions:

n, Manning's coefficient of roughness Q/K = discharge/conveyance

F, Froude number F = Ki*Q/(K*A sqrt(g*(Ai/TWi)); Q, discharge; A, total cross-section area; g, acceleration of gravity; Ai, sub-section area; TWi, sub-section top width

SAC -USGS slope-area program Ver 97-01 page 2

long creek

SAC/WSPRO Input for Long Creek (99993)

CROSS SECTION PROPERTIES

I.D. X1 Velocity head 1.79ft Discharge 13006.cfs

Ref.distance 86.ft Q/K 0.0101 Alpha 1.260

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	94.90	0.070	231.7	168.3	168.3	1.38	6.104	5.	2.6	0.40
2	94.90	0.051	1130.0	148.8	156.4	7.23	123.401	95.	11.0	0.70
Total	94.90	---	1362.	317.	325.	4.19	129.505	100.	9.6	0.81

Definitions:

n, Manning's coefficient of roughness Q/K = discharge/conveyance

F, Froude number F = Ki*Q/(K*A sqrt(g*(Ai/TWi)); Q, discharge; A, total cross-section area; g, acceleration of gravity; Ai, sub-section area; TWi, sub-section top width