LOWE CREEK

Site Information

Site Location:	Mt Hood NF, Forest Road 4671		
Year Installed:	Pre-1987		
Lat/Long:	121°53'55.08"W 44°56'55.13"N	**Watershed Area (mi²):**	6.0
Stream Slope (ft/ft)[1]:	0.0445	**Channel Type:**	Step-pool
Bankfull Width (ft):	23.6	**Survey Date:**	April 5, 2007

[1]Water surface slope extending up to 20 channel widths up and downstream of crossing.

Culvert Information

Culvert Type:	Open-bottom arch	**Culvert Material:**	Annular CMP
Culvert Width:	19 ft	**Outlet Type:**	Hybrid projecting/mitered
Culvert Length:	70 ft	**Inlet Type:**	Hybrid projecting/mitered

Pipe Slope (structure slope): 0.05

Culvert Bed Slope: 0.035

(First hydraulic control upstream of inlet to first hydraulic control downstream of outlet.)

Culvert width as a percentage of bankfull width: 0.81

Alignment Conditions: Appears inline with natural channel.

Bed Conditions: Scoured at upstream end of pipe. Large cobbles to large boulders are creating steps in culvert.

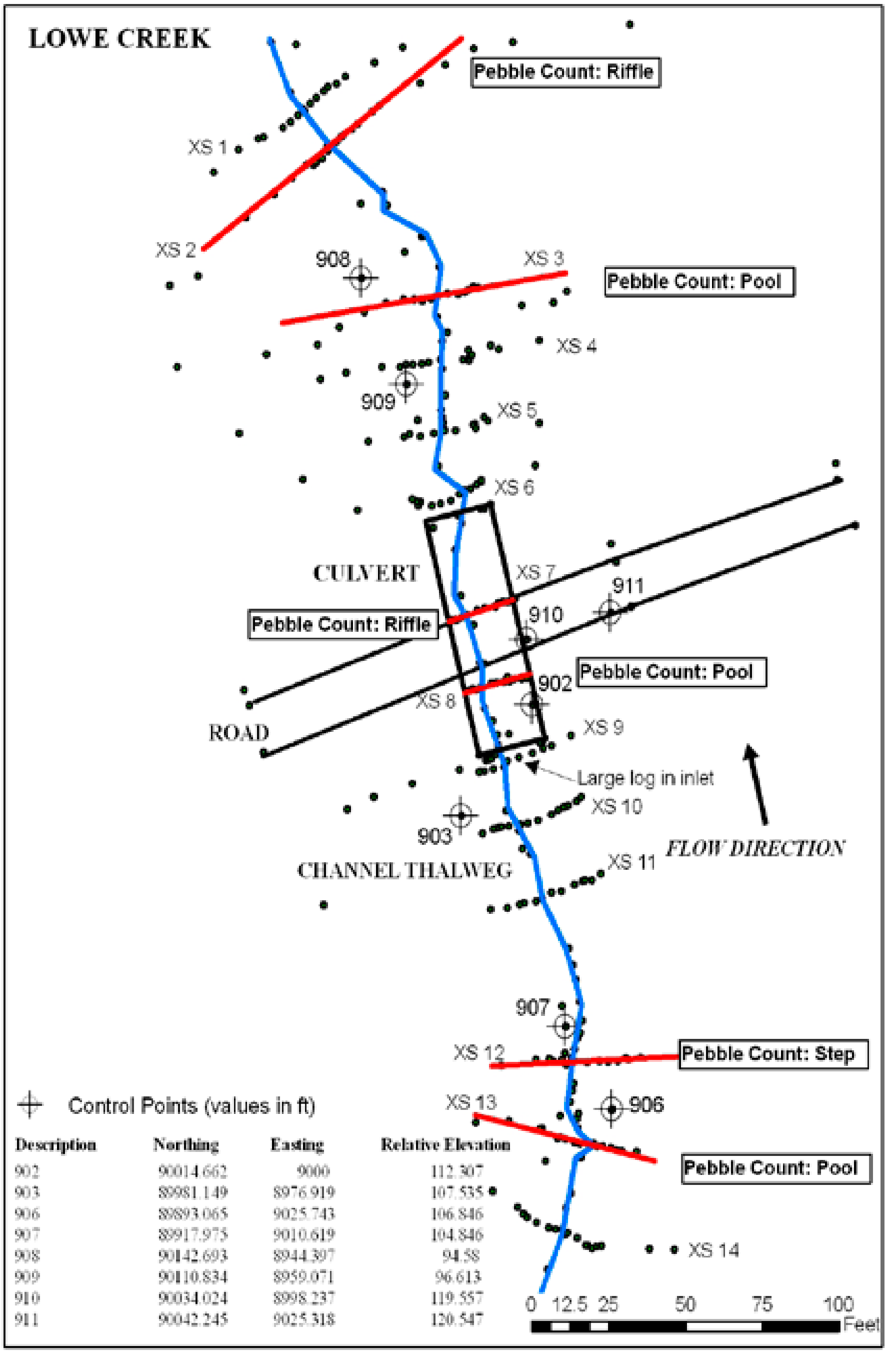
Pipe Condition: Left footing severely undermined at upstream end. May be some piping around sides of pipe where erosion has occurred.

Hydrology

Discharge (cfs) for indicated recurrence interval

25% 2-yr	Q_{bf}[2]	2-year	5-year	10-year	50-year	100-year
35	115	141	227	292	448	520

[2]Bankfull flow estimated by matching modeled water surface elevations to field-identified bankfull elevations.



Description	Northing	Easting	Relative Elevation
902	90014.662	9000	112.307
903	89981.149	8976.919	107.535
906	89893.065	9025.743	106.846
907	89917.975	9010.619	104.846
908	90142.693	8944.397	94.58
909	90110.834	8959.071	96.613
910	90034.024	8998.237	119.557
911	90042.245	9025.318	120.547

Points represent survey points

Figure 1—Plan view map.

HISTORY

The exact installation date is unknown, but the culvert was included in the 1987 Western Federal Lands Highway Division (WFLHD) "Oregon Culvert Fish Passage Survey." The field survey for the WFLHD study was conducted on November 27, 1987. The study describes the culvert as an "open bottom arch with boulders placed inside the barrel." With respect to fish passage, Oregon Department of Fish and Wildlife (ODFW) staff described the culvert as an "excellent open bottom arch installation;" whereas WFLHD staff noted that the culvert was in "fair" condition, the foundation was in "poor" condition, and there was "moderate" outlet scour. The culvert hydraulics were considered "compatible" with the natural stream hydraulics. They go on to note that open-bottom arches with shallow foundations are susceptible to scour and recommend that if foundation requirements cannot be met (i.e., embedment depth), then closed-bottom pipes should be installed.

The following are photos from the WFLHD study:

Culvert inlet.

Typical stream channel.

SITE DESCRIPTION

The Lowe Creek culvert is an open-bottom arch that projects from the roadfill. The culvert is characterized by a deep scour pool at the inlet, primarily concentrated along the left side of the culvert where significant footing scour and undermining has occurred. Downstream of the scour pool, the bed is aggraded and levels off forming a consistent riffle. The channel is against the left side of the culvert for most of its length. There has been deposition of material along the right footing at the inlet. There is a large (greater than 2-foot diameter) log just upstream and inside of the culvert. There is significant erosion at the sides of the culvert at the inlet and outlet.

The upstream representative reach consists of a moderate gradient step-pool channel. The upstream segment sits in a fairly confined and narrow valley. Channel banks are steep with high adjacent terraces that may only be active at infrequent floods. Large boulders and fallen trees line both banks. The reach consists of a series of steps and pools.

The downstream representative reach consists of a series of steep riffles interspersed with pools. A relatively extensive low (active) flood plain exists through this reach. Bed material was finer and there were small log jams.

SURVEY SUMMARY

Fourteen cross sections and a longitudinal profile were surveyed at the Lowe Creek crossing in April 2007 to characterize the culvert, an upstream representative reach, and a downstream representative reach. Representative cross sections in the culvert were taken through the downstream end of the pool and the riffle. One additional cross section was surveyed upstream to characterize the inlet as well as the contraction of flow. Another two cross sections were surveyed downstream of the culvert to characterize the outlet and the expansion of flow.

Four cross sections were surveyed to characterize the upstream representative reach; one at the upstream boundary, one at the downstream boundary, one through a step, and one through a pool. Four cross sections were also surveyed to characterize the downstream representative reach; one at the upstream boundary, one at the downstream boundary, one through a pool, and one through a riffle.

PROFILE ANALYSIS SEGMENT SUMMARY

The profile analysis resulted in a total of eight profile segments. The two consecutive segments downstream of the outlet, though similar in gradient, were not combined in order to separate out the transition area from the downstream representative channel. The culvert consisted of two profile segments, the upstream one extending into the upstream transition area. The upstream culvert segment was compared to two representative profile segments, one in the upstream channel and one in the downstream channel. There was no suitable comparison for the downstream segment in the culvert. The upstream transition segment was compared to a representative profile segment in the downstream channel. The downstream transition segment was compared to two representative profile segments, one in the upstream channel and one in the downstream channel. See figure 2 and table 1.

SCOUR CONDITIONS

Observed conditions

Footing scour – The greatest amount of footing scour is at the upstream end on the left bank where the footing is undermined. The base of the footing is suspended above the bed 2.5 feet at the maximum depth of the scour pool. The lateral extent of scour under the footing reaches 4 feet at one location. Some of this scour may be the result of a large log (greater than 2-foot diameter) located at the inlet. Approximately 40 percent of the footing on the left bank is undermined and all of it is exposed. There is also scour around the sides of the pipe at the inlet and outlet and there may be some piping of flow around the culvert in these areas. The “poor” foundation rating from the WFLHD study and the suggestion regarding foundation requirements suggest that some foundation undermining may have been present in 1987, but likely less than in 2007 or there would have been more mention of it.

Culvert-bed adjustment – The culvert bed has reduced its slope since installation (assuming the culvert bed was constructed at the same gradient as the structure). This flattening appears to be mostly due to scour in the upstream portion of the pipe. There is still streambed material throughout the pipe and no bedrock is present on the bed.

Profile characteristics – The profile has a concave shape through the crossing (figure 2). This shape reflects scour at the inlet region. There is a natural valley transition in this area. Upstream is more confined with higher and less active flood-plain terraces than the downstream reach.

Residual depths – The single culvert residual depth is within the range of residual depths in corresponding profile segments in the natural channel (B and H) (figure 21). The single residual depth in the downstream transition is also within the range of corresponding profile segments in the natural channel (B and H). There was no residual depth in the corresponding profile segment for the upstream transition.

Substrate – Bed-material distributions are similar between the culvert and channel sample sites. The culvert has more coarse material than the downstream channel but similar abundance of coarse material as the upstream channel. The downstream channel has the greatest abundance of fine material. Sorting and skewness values in the culvert are within the range of those in the natural channel (table 7).

Predicted conditions

*Note: As estimated in the model, backwater from the culvert affects portions of the upstream reach (figure 3). The backwater affects the upstream representative reach for the Q_{50} and Q_{100}. For this reason, hydraulic metrics for these flows are not used in the comparisons with culvert values.

Cross-section characteristics – The culvert appears to affect most of the cross-section metrics at the Q_{bf} and above (figures 5 through 9 and 12 through 19). There is a dramatic reduction in top width and an increase in depth as flows rise. The culvert exhibits characteristics of outlet control, with culvert characteristics (i.e., barrel roughness, slope, and area) creating deep subcritical flow throughout most of the barrel length. The flow passes through critical depth near the downstream end. Cross-section characteristics at the upstream transition (F) are impacted by the culvert backwater at higher flows (Q_{50} and Q_{100}). At lower flows, the flow has lower width and greater depth than the corresponding profile segments (A), but this may be due partially to changes in valley confinement. Cross-section characteristics in the downstream transition (C) are mostly within the range of corresponding profile segments (B and H).

Shear stress – The modeling suggests that shear stress is low in the culvert due to backwater conditions that reduce the energy grade. Shear stress near the downstream end of the culvert is high where the flow passes through critical depth (figure 10). Shear stress in the upstream transition (F) is greater than the corresponding profile segment (A) for flows up to the Q_{10} but is less at the Q_{50} and Q_{100} because of backwater effects (figures 10 and 19). Shear stress in the downstream transition (C) is within the range of corresponding profile segments (B and H).

Excess shear – The excess shear analysis shows the culvert as having lower potential for bed mobilization when compared to the upstream and downstream channels (figure 20). This is due to the backwater effect of the culvert that lowers the energy grade and therefore lowers the applied shear available to move material.

Velocity – The modeling suggests that velocity is low in the culvert due to backwater conditions that reduce the energy grade. Velocity near the downstream end of the culvert is high where the flow passes through critical depth (figure 11). Velocity in the upstream transition (F) is similar to the corresponding channel segment (A) at the Q_{10} and below but is lower than the channel at the Q_{50} and Q_{100} (figure 18) due to backwater effects. Velocity in the downstream transition (C) is within the range of corresponding channel segments (B and H) at all modeled flows.

Scour summary

There is severe scour of the left bank footing at the inlet and extending downstream approximately 30 feet. This is a serious maintenance issue that needs to be addressed to ensure that the structural integrity of the crossing is not compromised. This scour may be partially related to culvert capacity, deposition of coarse material upstream of the inlet, and a large (greater than 2-foot diameter) midchannel log just upstream and inside of the culvert. The drop into the scour pool is larger than any drops observed in the reference reaches. This has also resulted in the deposition of material along the right footing at the inlet and the shifting of the channel towards the left. Downstream of the scour pool, the bed is aggraded and levels off forming a consistent riffle.

Bed material at the inlet has likely eroded out and redeposited at the downstream portion of the culvert, contributing to bed flattening.

Modeling suggests that flow geometry and hydraulics are highly impacted by the culvert, especially at high flows that cause backwater within and upstream of the culvert. The culvert appears to be under outlet control at high flows, with the length, roughness, and downstream conditions raising the elevation of the flow through much of the culvert. This condition serves to reduce channel velocity and shear stress through most of the culvert at very high flows (Q_{50} and above). At these flows, the modeling shows flow passing through critical depth near the downstream end of the culvert, with associated high shear stress and velocity that could cause scour at this location. Prior to the inlet scour, which widened the inlet area, the culvert may have exhibited inlet control conditions that contributed to the scour observed in the inlet area. At more frequent flood events, inlet control conditions may still be a concern, especially with respect to the potential for increased scour of the footing at the inlet

There is also significant erosion at the sides of the culvert at the inlet and outlet, possibly a result of flow contraction and expansion. Erosion at the left bank upstream of the inlet is further exacerbated by the coarse material and logs that have deposited upstream of the inlet, thus initiating lateral boundary adjustment.

AOP CONDITIONS

Cross-section complexity – The sum of squared height differences in the culvert cross sections are both within the range of those in the channel cross sections (table 3).

Profile complexity – Vertical sinuosity in the upstream culvert segment (E) is slightly greater than the values in the corresponding channel segments (B and H) (table 4). Vertical sinuosity in the upstream transition segment (F) is slightly greater than the value in the corresponding channel segment (A). Vertical sinuosity in the downstream transition segment (C) is within the range of values in the corresponding channel segments (B and H).

Depth distribution – The upstream culvert cross section has less channel margin habitat than the natural channel but the downstream culvert cross section is within the range of the natural channel (table 5).

Habitat units – Habitat-unit distribution in the culvert is within the range of that found in the natural channel upstream and downstream of the crossing (table 6).

Residual depths – The single culvert residual depth is within the range of residual depths in corresponding profile segments in the natural channel (B and H) (figure 21). The single residual depth in the downstream transition is also within the range of corresponding profile segments in the natural channel (B and H). There was no residual depth in the corresponding profile segment for the upstream transition.

Substrate – Bed-material distributions are similar between the culvert and channel sample sites. The culvert has more coarse material than the downstream channel but similar abundance of coarse material as the upstream channel. The downstream channel has the greatest abundance of fine material. Sorting and skewness values in the culvert are within the range of those in the natural channel (table 7).

Large woody debris – There was one 2- to 3-foot-diameter piece of LWD present at the inlet to the culvert. The piece may have been a contributor to the scour present at the inlet. The representative channel had high LWD abundance (table 8). LWD formed steps and scour pools in the channel outside the crossing and played a primary role in habitat-unit creation and complexity. Features in the culvert did not mimic the role of wood in the natural channel.

AOP summary

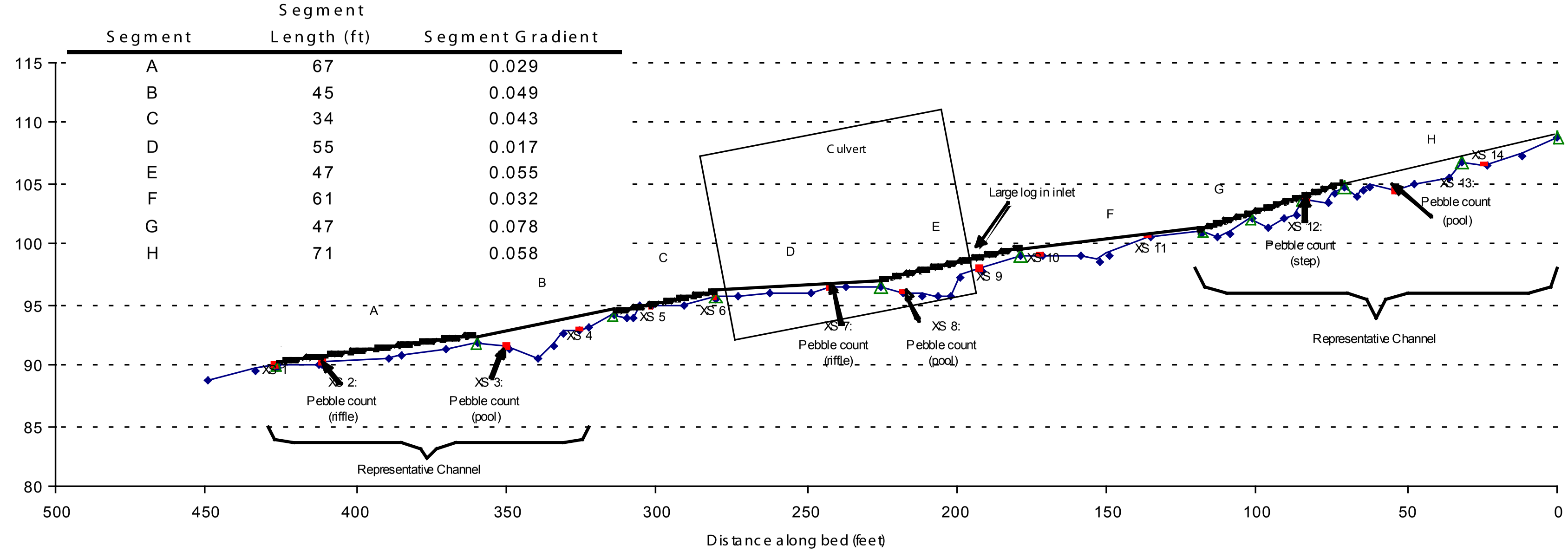
Complexity measures and site observations suggest that this is a good installation with respect to AOP. There is good flow concentration in the culvert that would support fish passage at low flows. The hydraulics at the Q_{bf} and below are unaffected by the backwater effects described earlier and are assumed to be amenable to fish passage. There is also a dry bank along the right side suitable for passage of terrestrial organisms.

DESIGN CONSIDERATIONS

This site is a poor installation with respect to scour but appears to be suitable for AOP. There are serious concerns with the structural integrity of the structure that are primarily related to the undermining of the left-bank footing at the upstream end of the culvert. Additionally, modeling suggests a severe effect on flow geometry and hydraulics at the Q_{50} and above that may create future scour problems within the pipe. This design could be improved by use of a wider culvert with greater capacity to convey high flood flows. It is also clear that the footing depth needs to be increased to extend below the depth of maximum potential scour.

There is also erosion on the sides of the culvert at the inlet and outlet. These areas should be stabilized with rock or concrete (e.g., wing-walls) to prevent erosion around the edges of the pipe.

Regular maintenance of the site is needed to remove woody debris, such as the large log that is located at the inlet and may be contributing to the inlet scour. Based on the presence of log jams in the natural channel, wood transport is common through this portion of Lowe Creek. Maintenance needs to be conducted to manage for this wood or the crossing needs to be made wide enough to convey wood.



Segment	Segment Length (ft)	Segment Gradient
A	67	0.029
B	45	0.049
C	34	0.043
D	55	0.017
E	47	0.055
F	61	0.032
G	47	0.078
H	71	0.058

Figure 2—Lowe Creek longitudinal profile.

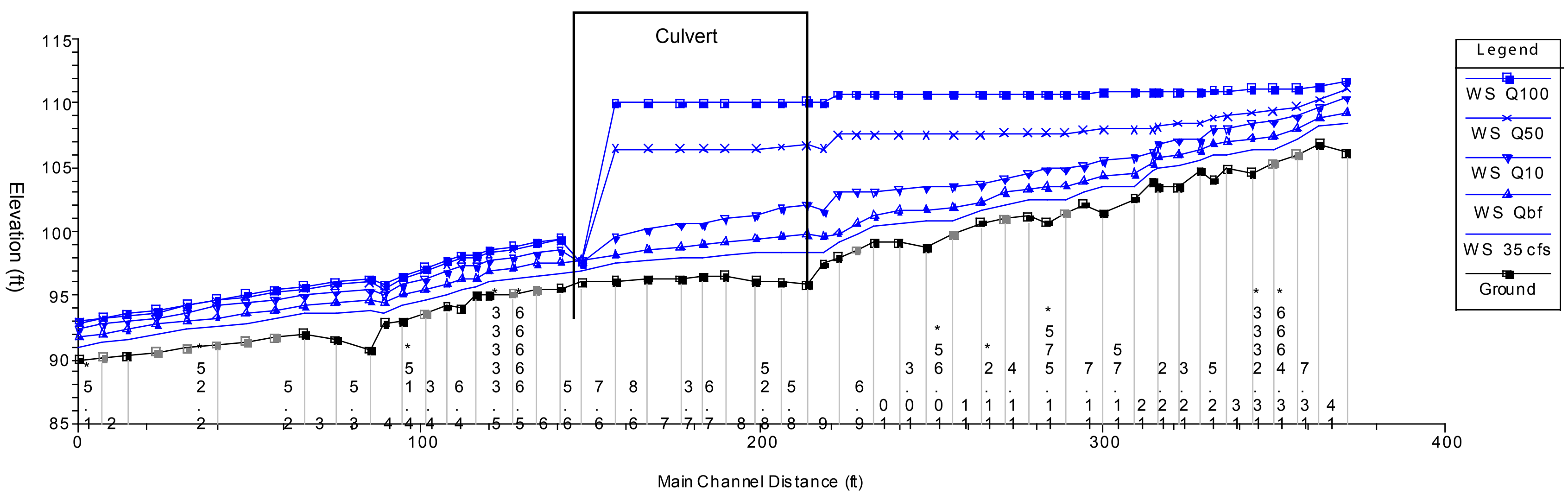
Table 1—Segment comparisons

Culvert Segment	Representative Channel Segment	% Difference in Gradient
E	B	10.7%
E	H	4.9%
Upstream Transition		
F	A	9.7%
Downstream Transition		
C	B	13.4%
C	H	26.3%

Table 2—Summary of segments used for comparisons

Segment	Range of Manning's n values[1]	# of measured XSs	# of interpolated XSs
A	0.1126 – 0.1187	2	7
B	0.1131 – 0.1197	2	5
C	0.1115 – 0.1217	2	5
E	0.0875 – 0.1298	2	6
F	0.1298 – 0.1328	2	5
H	0.1228 – 0.1336	2	6

[1]Obtained using equation from Jarrett (1984): n = 0.39S0.38R-0.16, where S=stream slope; R=hydraulic radius. Jarrett's equation only applied within the following ranges: S = 0.002 to 0.08, R = 0.5 ft to 7 ft. For cross-sections outside these ranges, n was computed either from adjacent sections that fell within the ranges, using the guidance of Arcement and Schneider (1987), or from the HEC-RAS recommendations for culvert modeling.



Stations with decimal values are interpolated cross sections placed along the surveyed profile.

Figure 3—HEC-RAS profile.

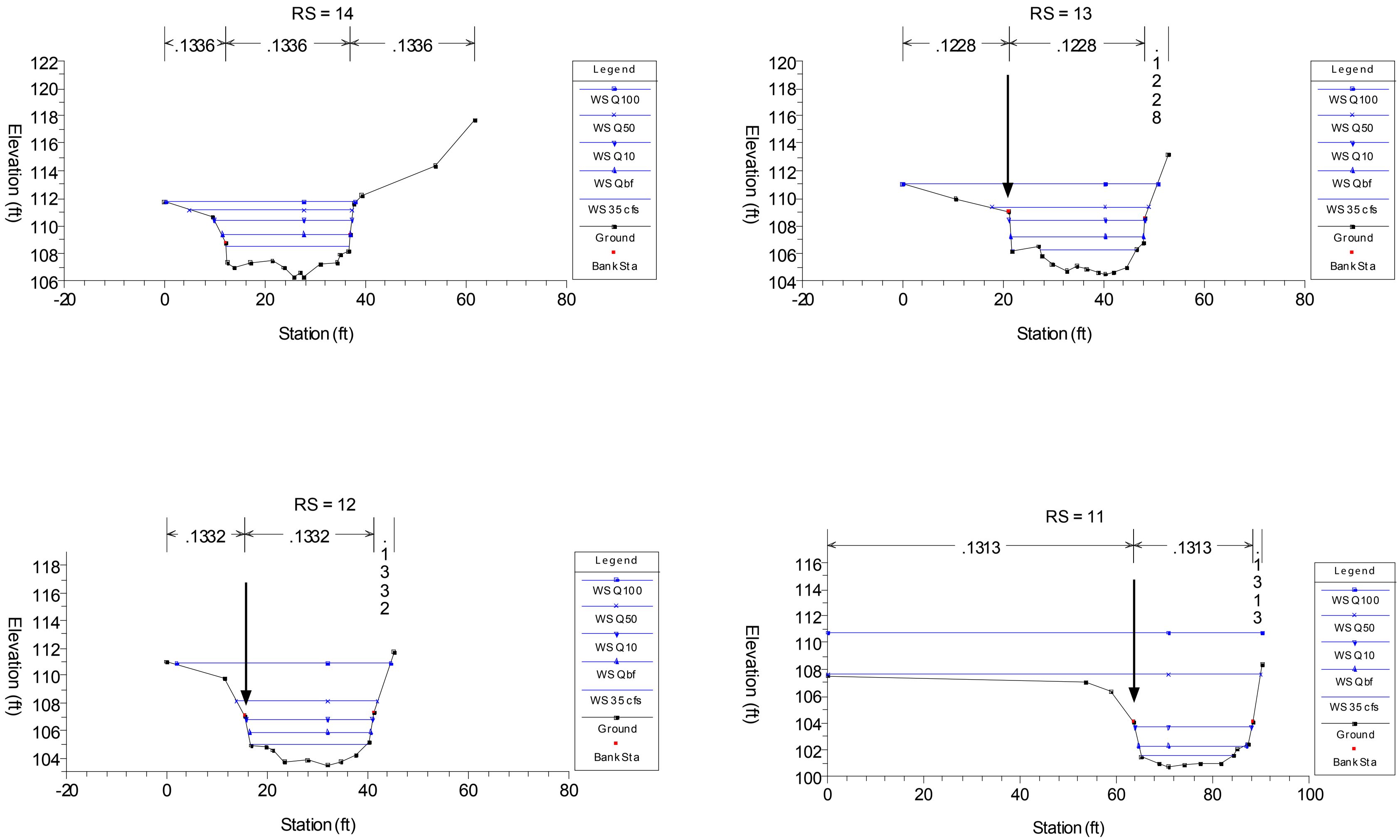
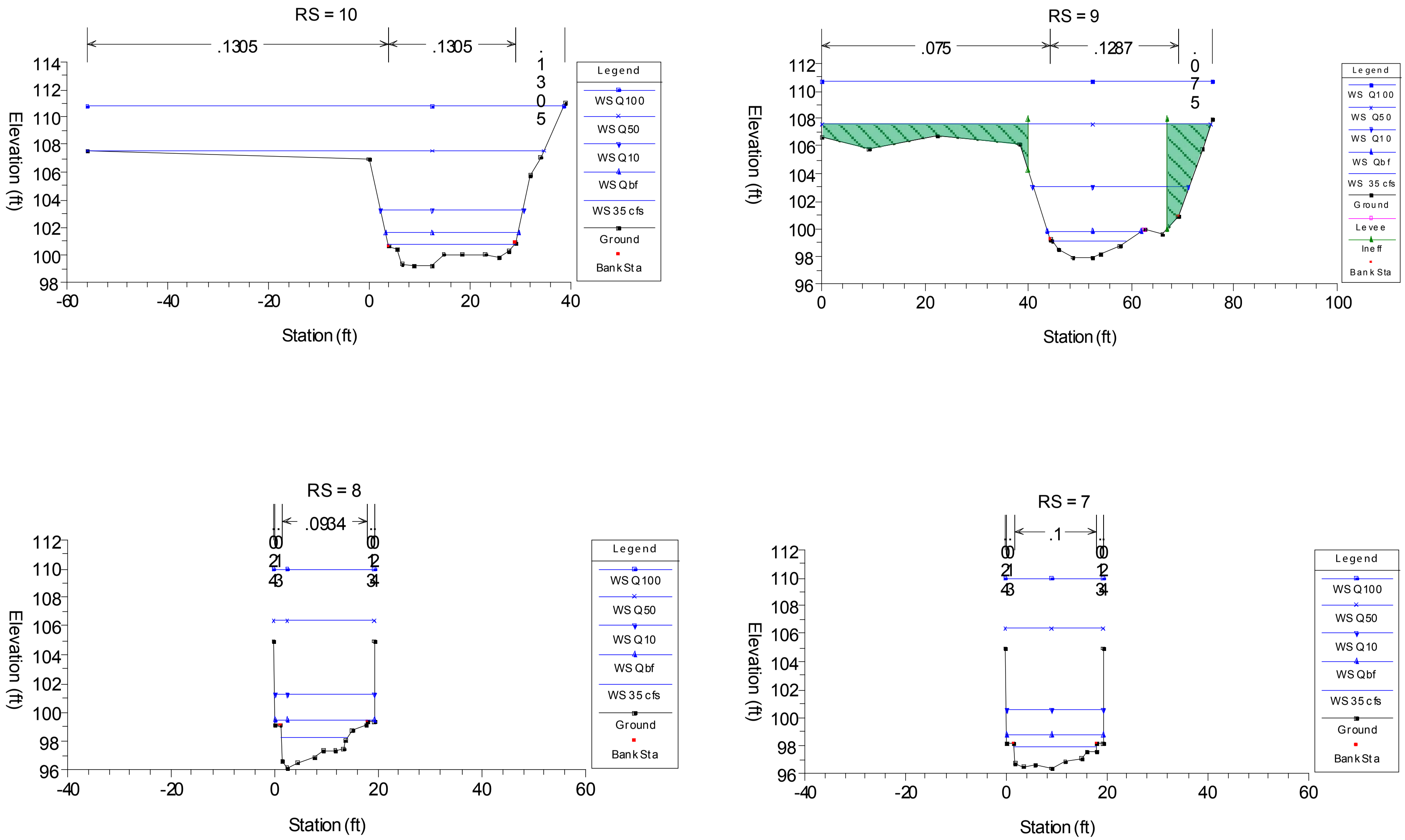


Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points surveyed in as the bankfull channel boundary. Only those points called out in the field and supported by further hydraulic and topographic analyses are marked below.



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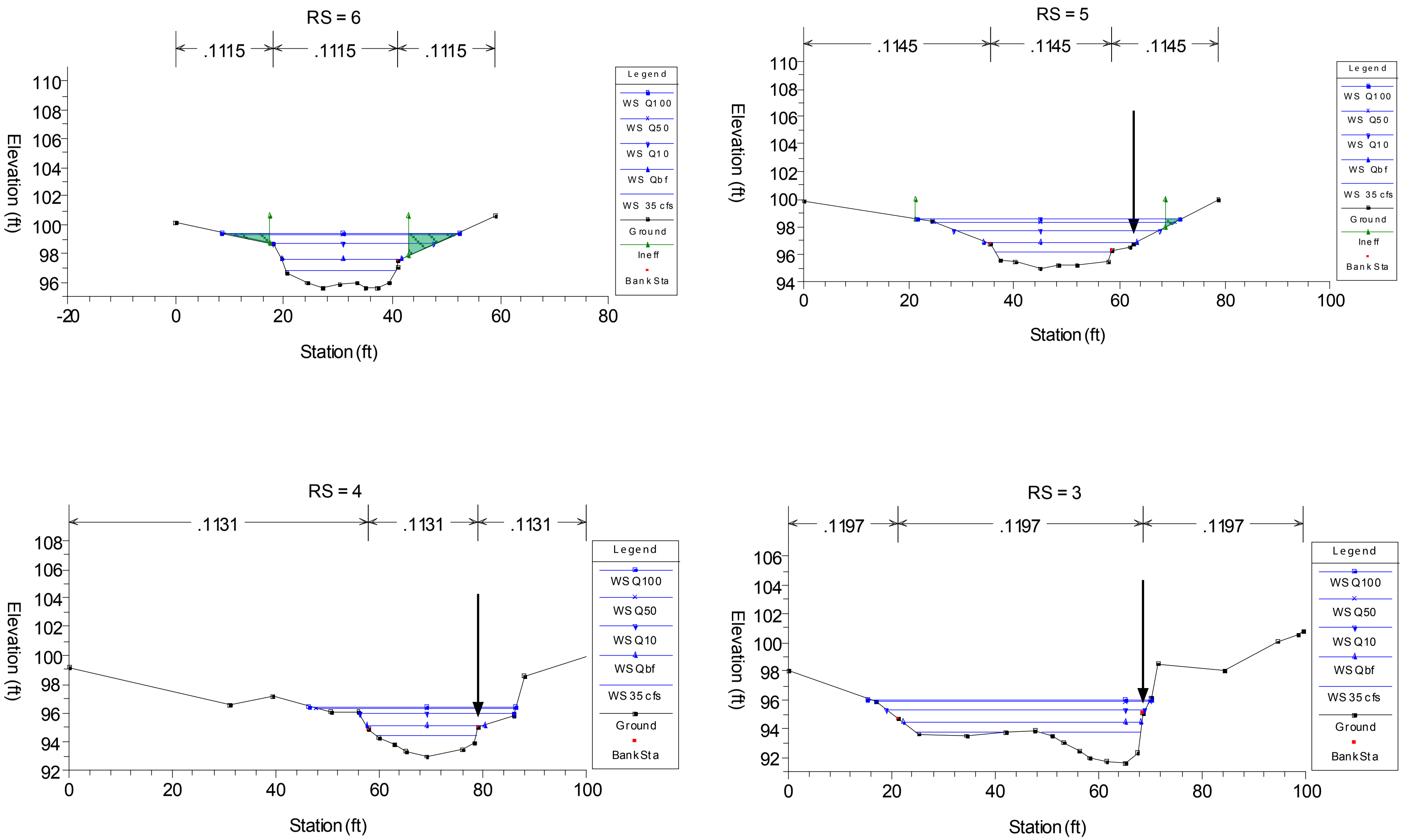

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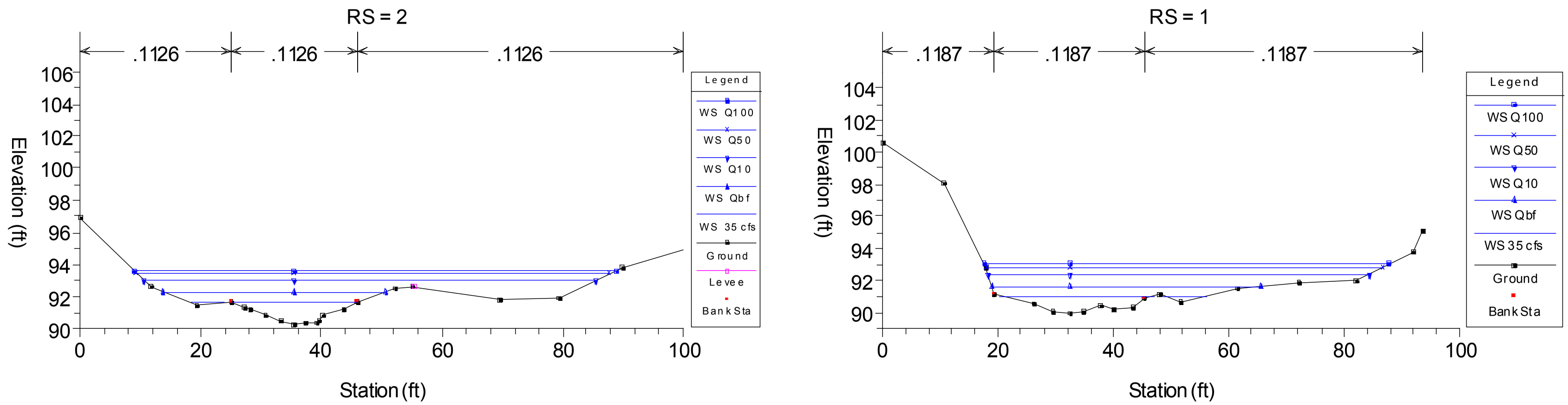

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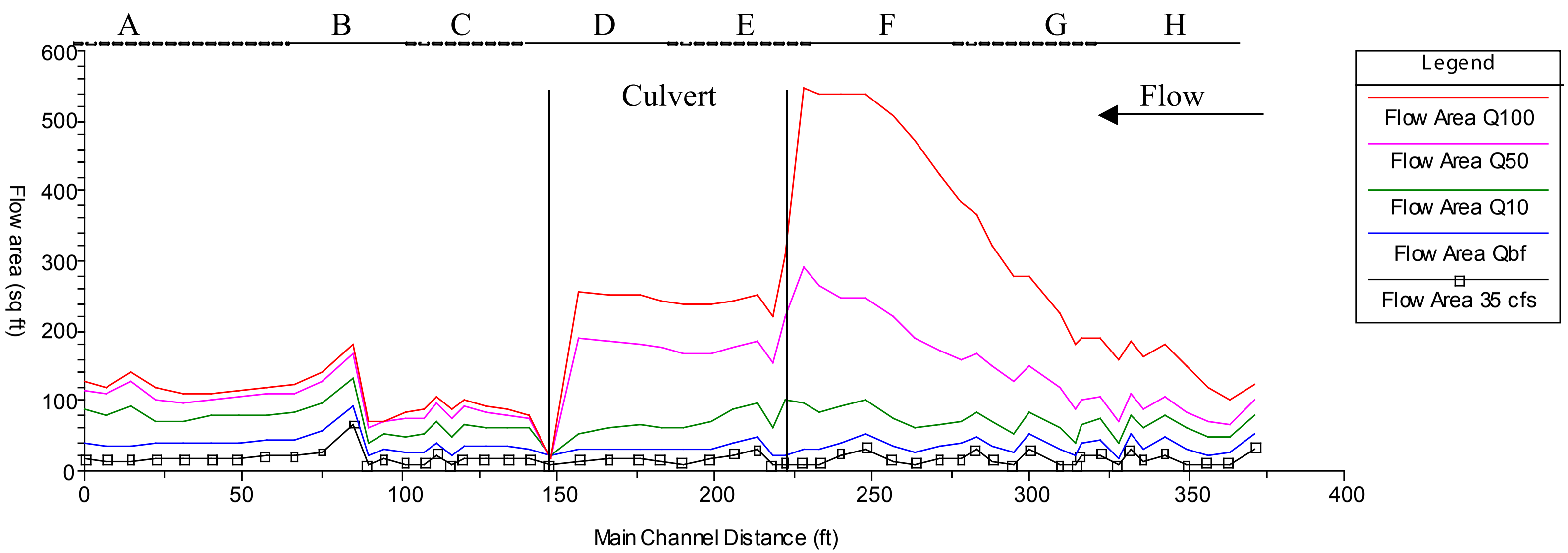


Figure 5—Flow area (total) profile plot.

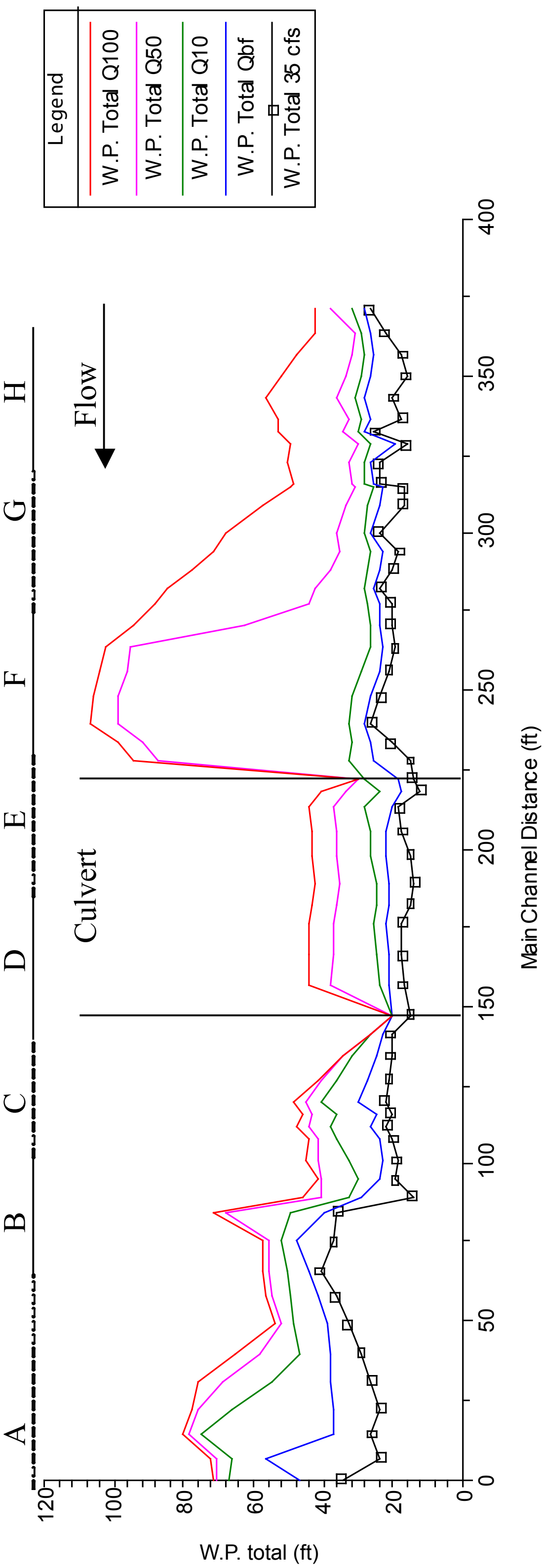


Figure 6—Wetted perimeter.

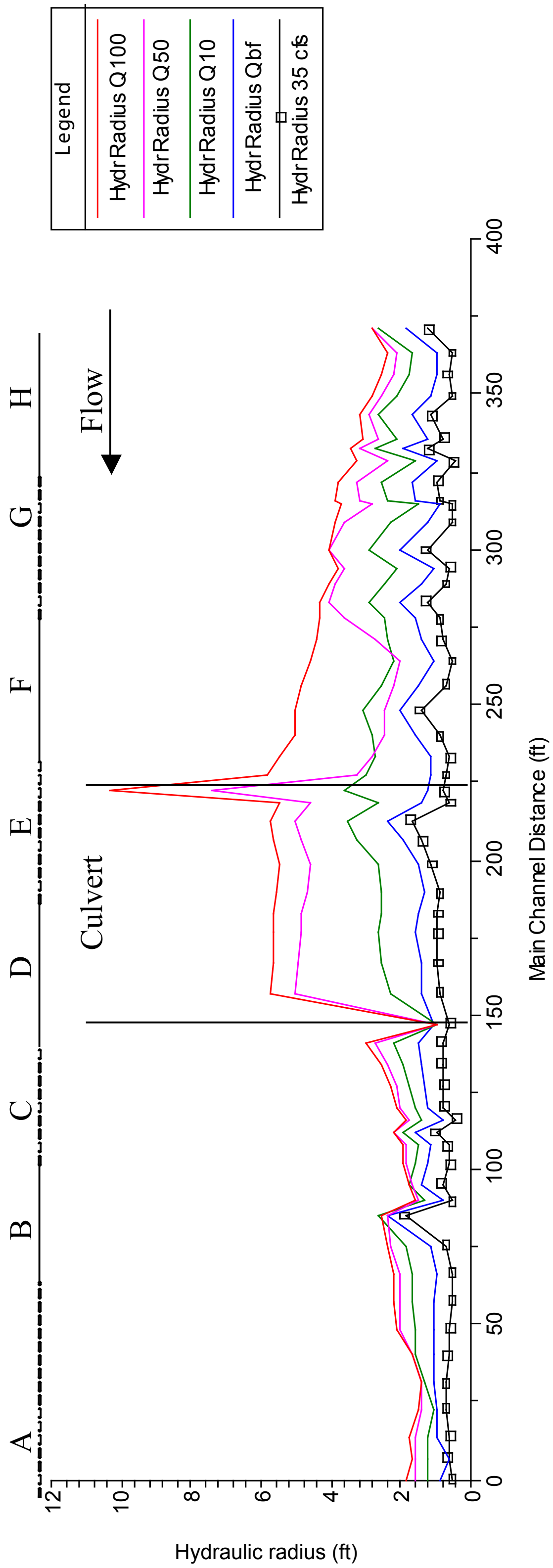


Figure 7—Hydraulic radius.

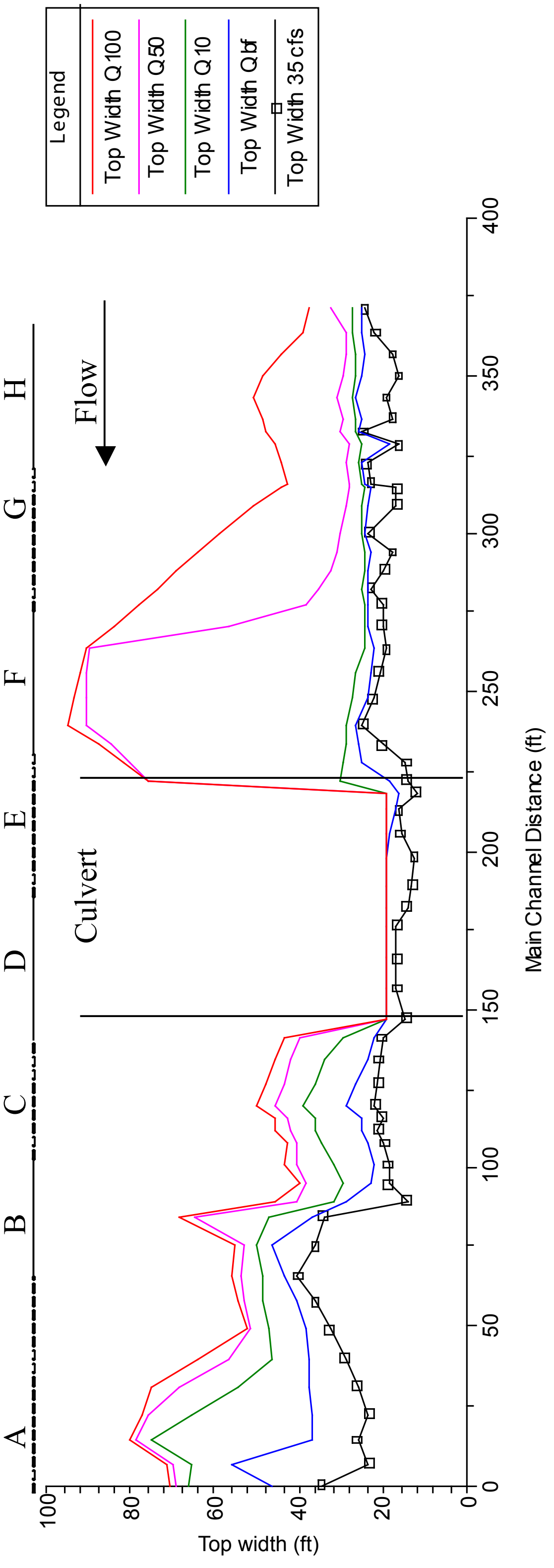


Figure 8—Top width.

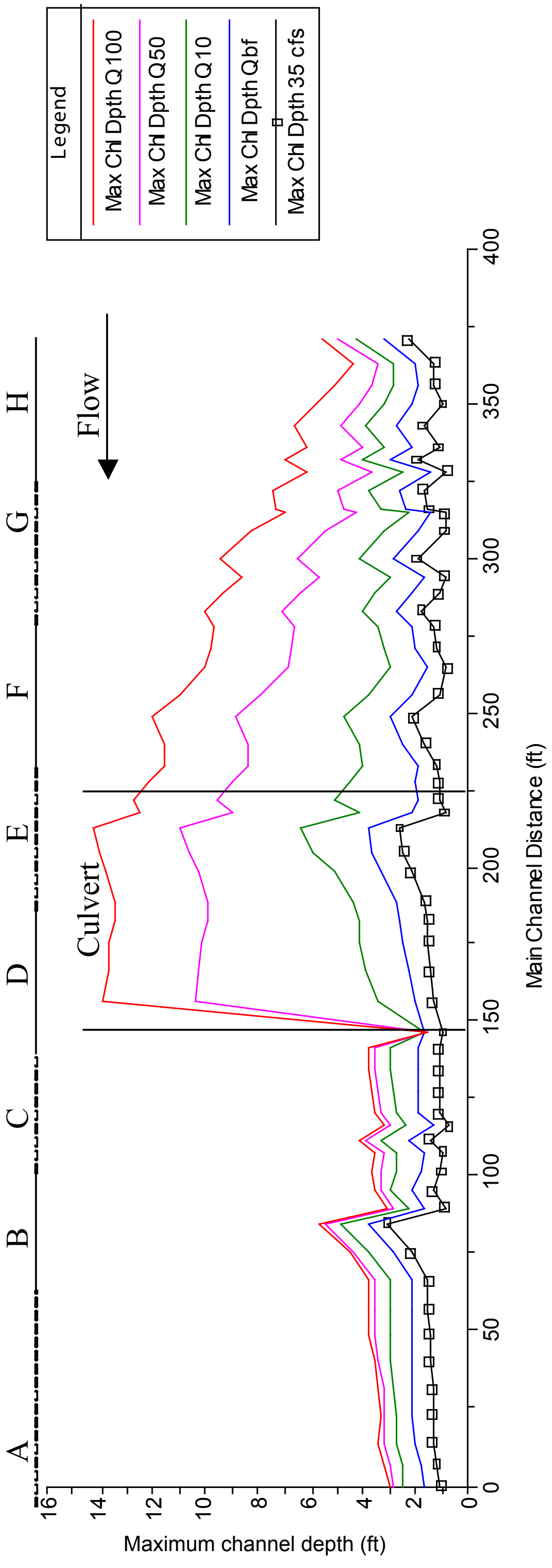
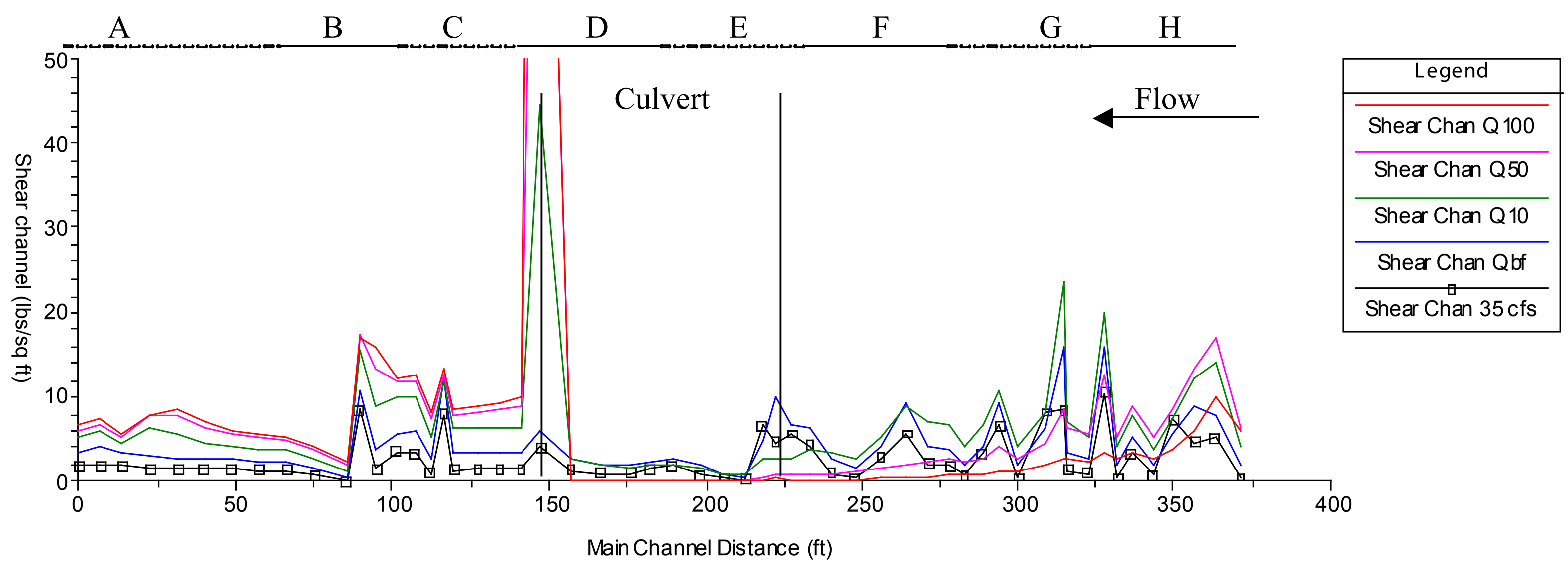


Figure 9—Maximum depth.



Note: Shear at station 6.5 for the Q_{50} and Q_{100} are greater than 50 pounds per square foot and are therefore not shown.

Figure 10—Shear stress (channel) profile.

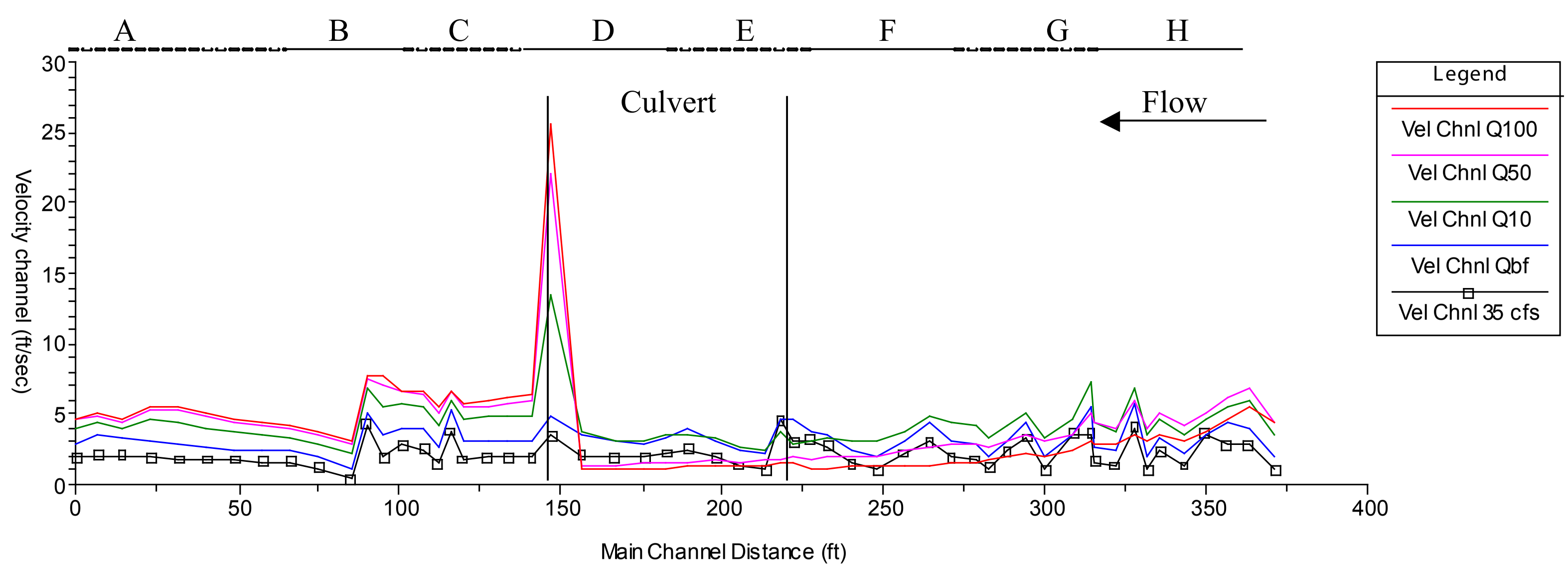
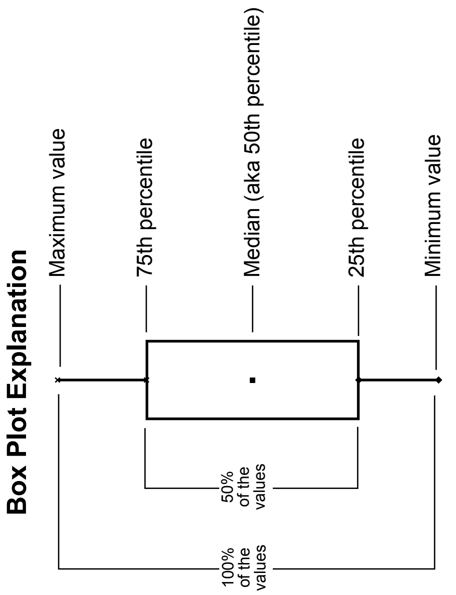


Figure 11—Velocity (channel) profile plot.



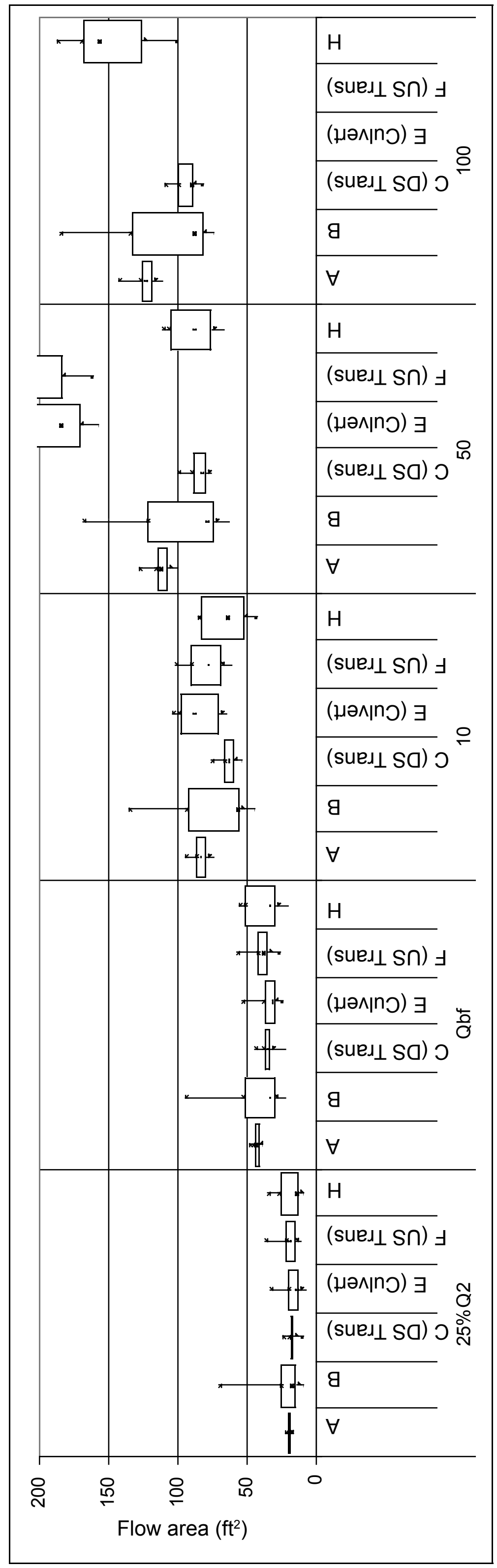


Figure 12—Flow area (total).

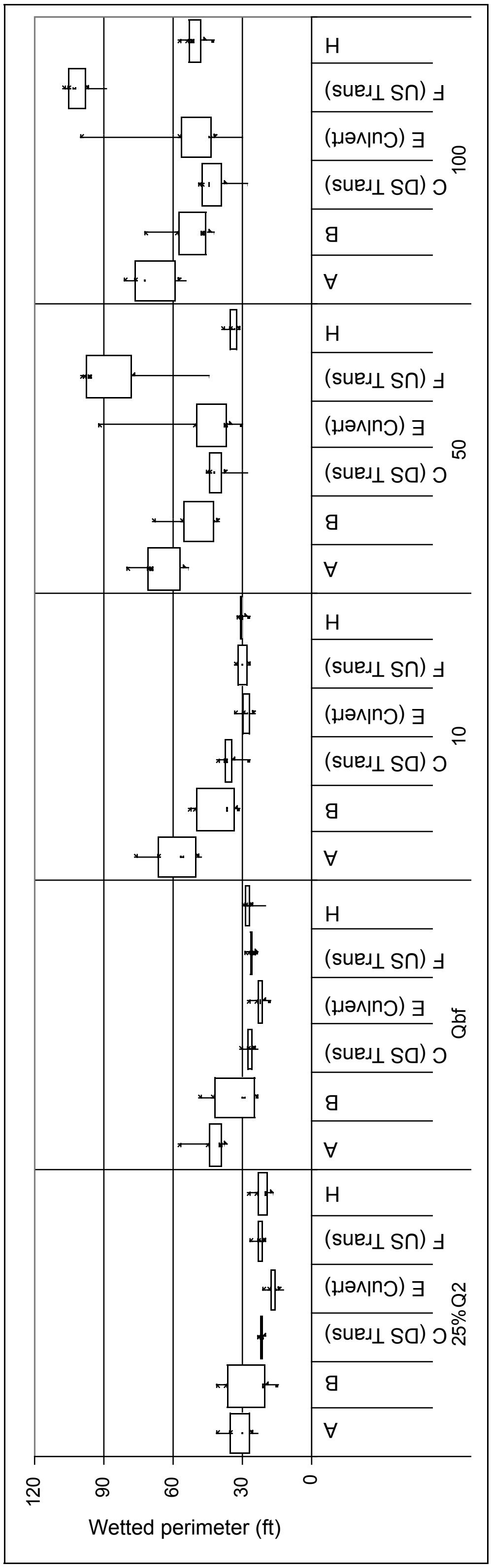


Figure 13—Wetted perimeter.

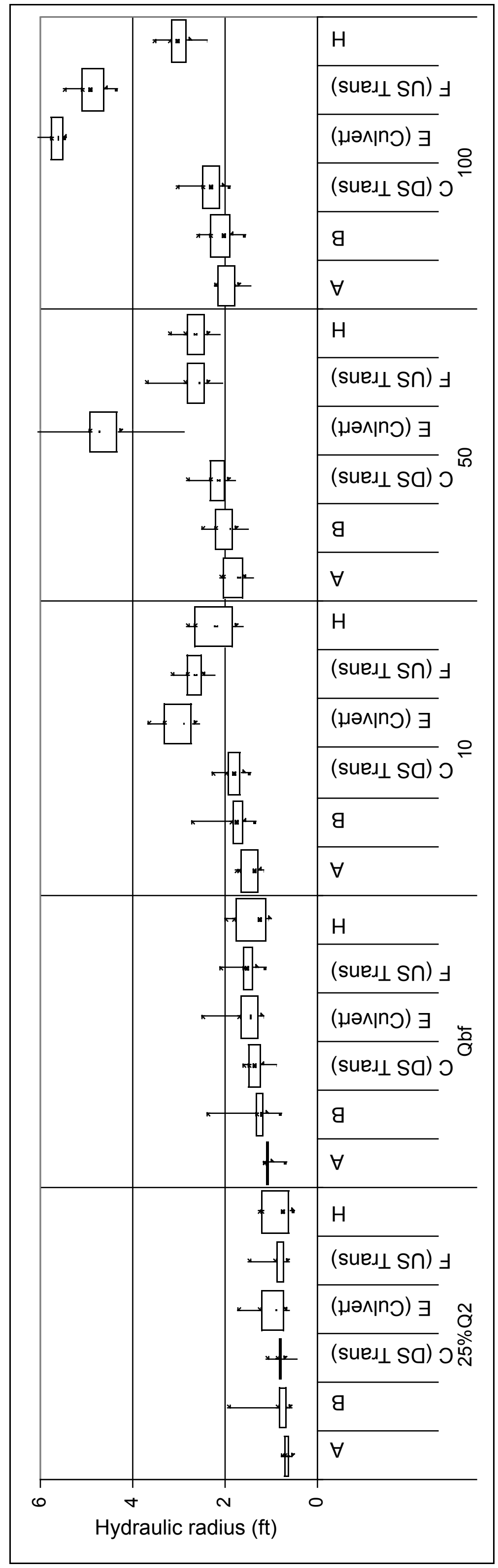


Figure 14—Hydraulic radius.

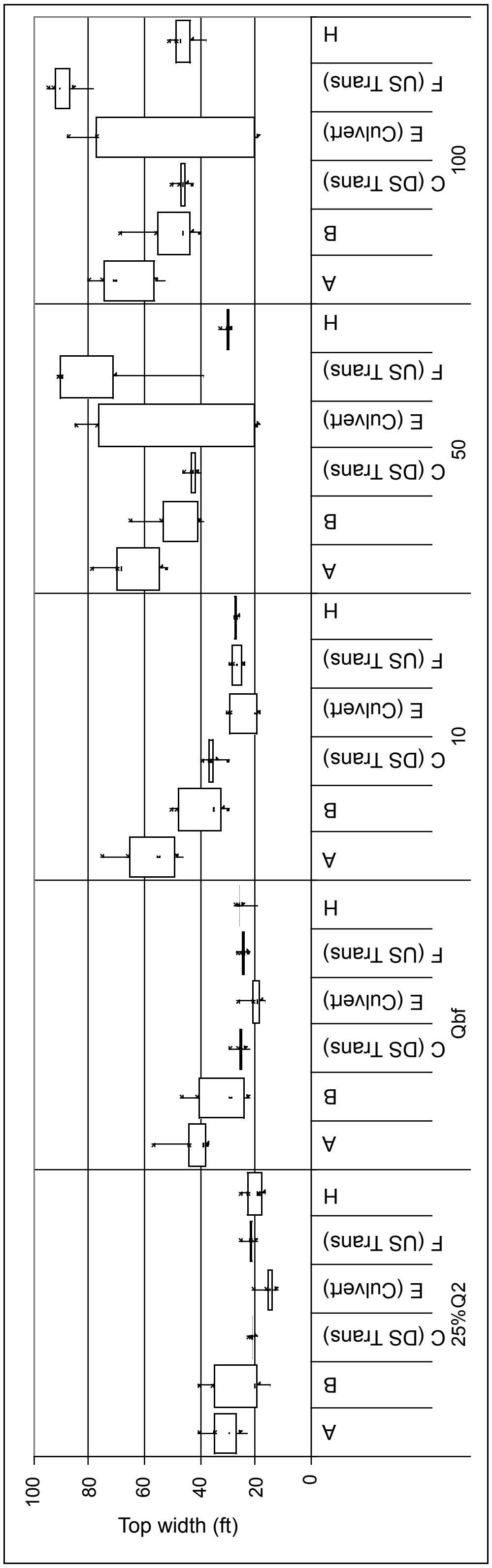


Figure 15—Top width.

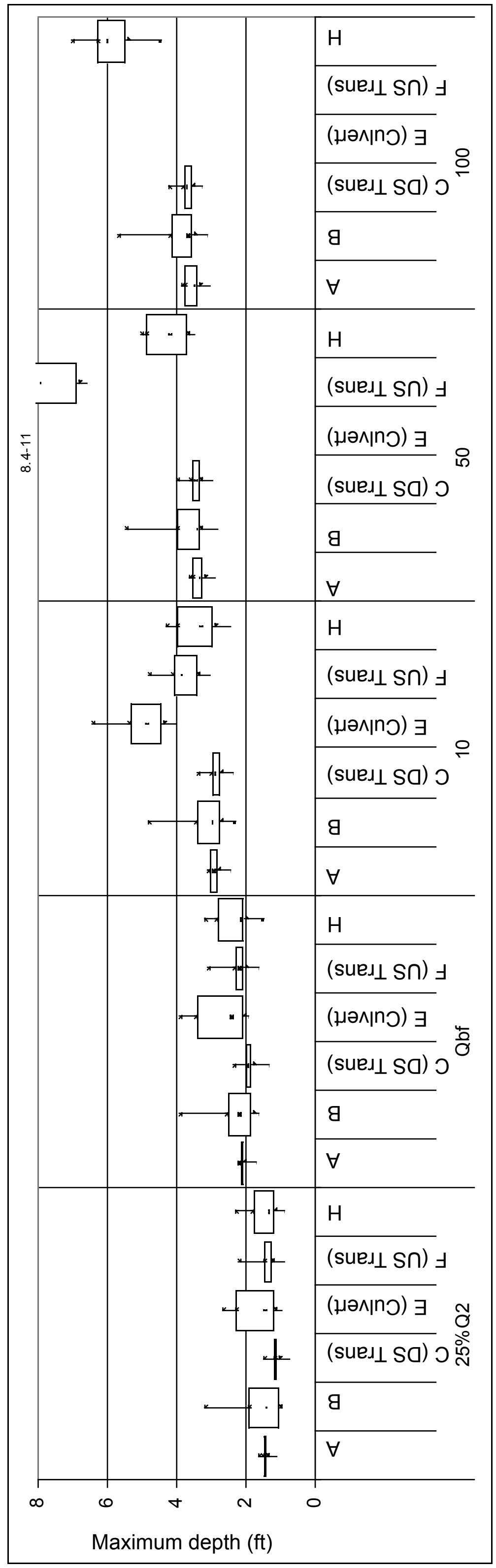


Figure 16—Maximum depth.

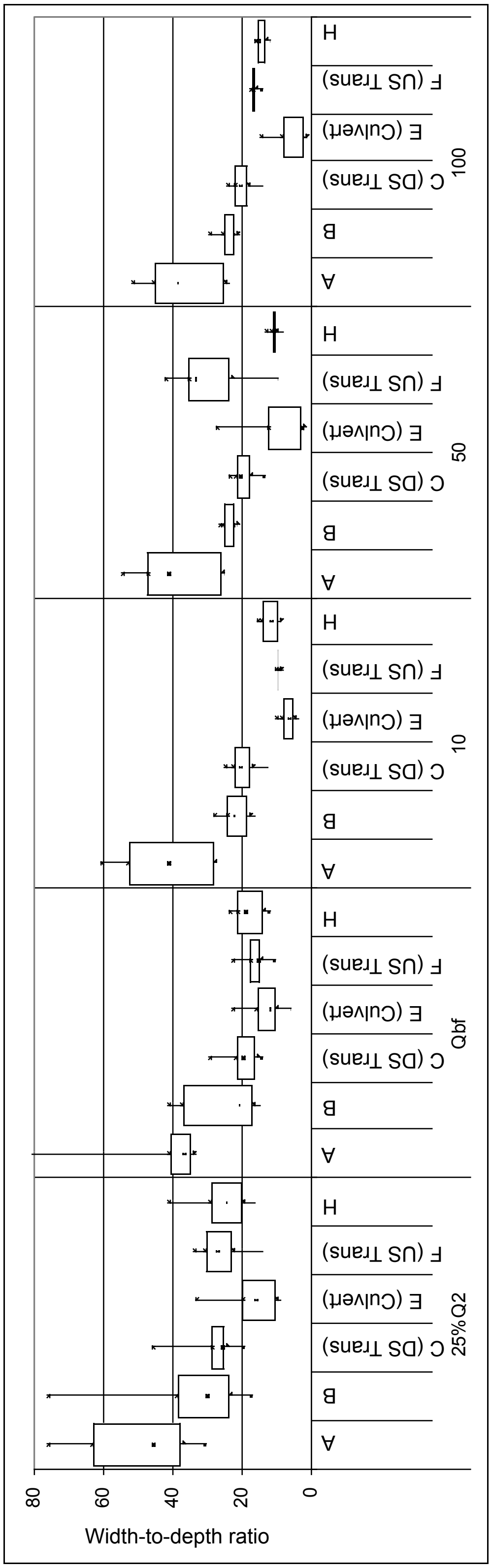


Figure 17—Width-to-depth ratio.

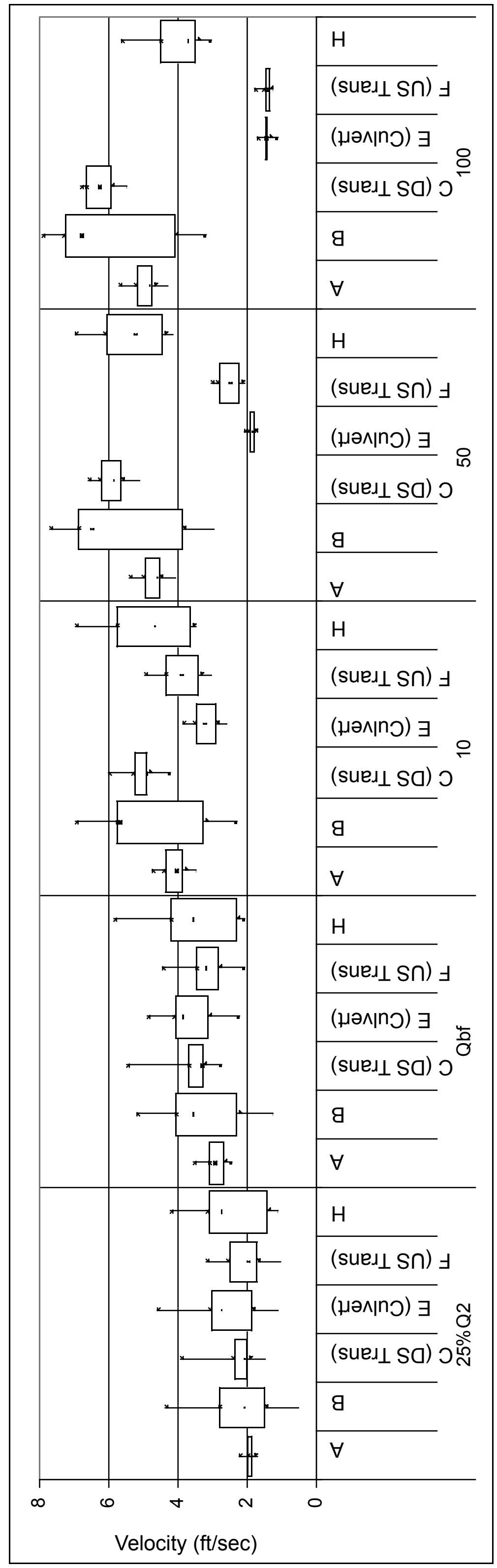


Figure 18—Velocity (channel).

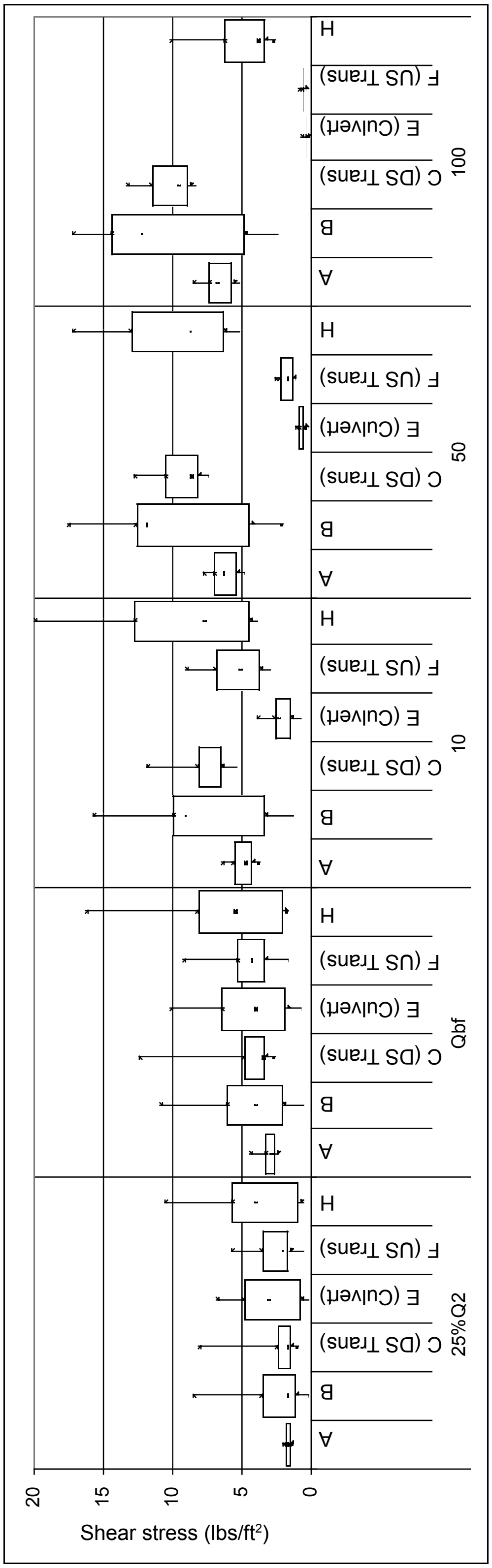
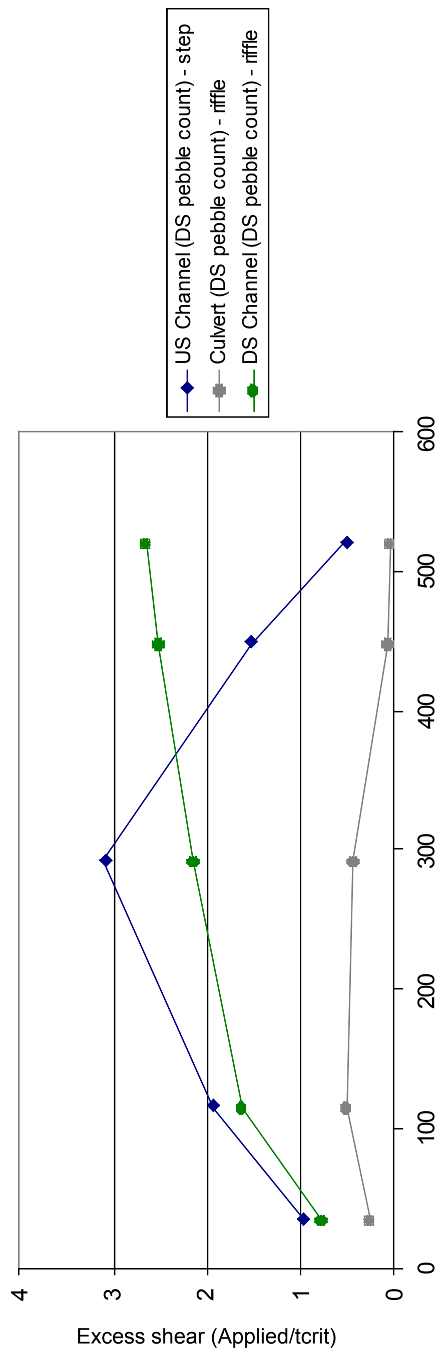


Figure 19—Shear stress (channel).



Excess shear stress is the channel shear divided by the critical shear for bed entrainment of the D_{84} particle size. Values of excess shear greater than 1 indicate bed movement for the D_{84} particle size.

Figure 20—Excess shear stress.

Table 3—Sum of squared height difference

Reach	XS Location	Unit type	Sum of squared height difference	Within range of channel conditions?
Culvert	US	Pool	0.06	Yes
	DS	Riffle	0.03	Yes
Upstream	US	Pool	0.05	
	DS	Step	0.10	
Downstream	US	Pool	0.04	
	DS	Riffle	0.03	

Table 4—Vertical sinuosity

Segment	Location	Vertical Sinuosity (ft/ft)
A	DS channel	1.001
B	DS channel	1.009
C	DS transition	1.007
D	Culvert	1.000
E	Culvert	1.010
F	US transition	1.002
G	US channel	1.016
H	US channel	1.007

Table 5—Depth distribution

Reach	XS Location	25% Q_2	Within range of channel conditions?
Culvert	US	1	No
	DS	2	Yes
Upstream	US	2	
	DS	2	
Downstream	US	3	
	DS	18	

Table 6—Habitat unit composition

Reach	Percent of surface area			
	Pool	Glide	Riffle	Step
Culvert	21%	0%	64%	3%
Upstream Channel	48%	0%	41%	11%
Downstream Channel	16%	0%	75%	2%

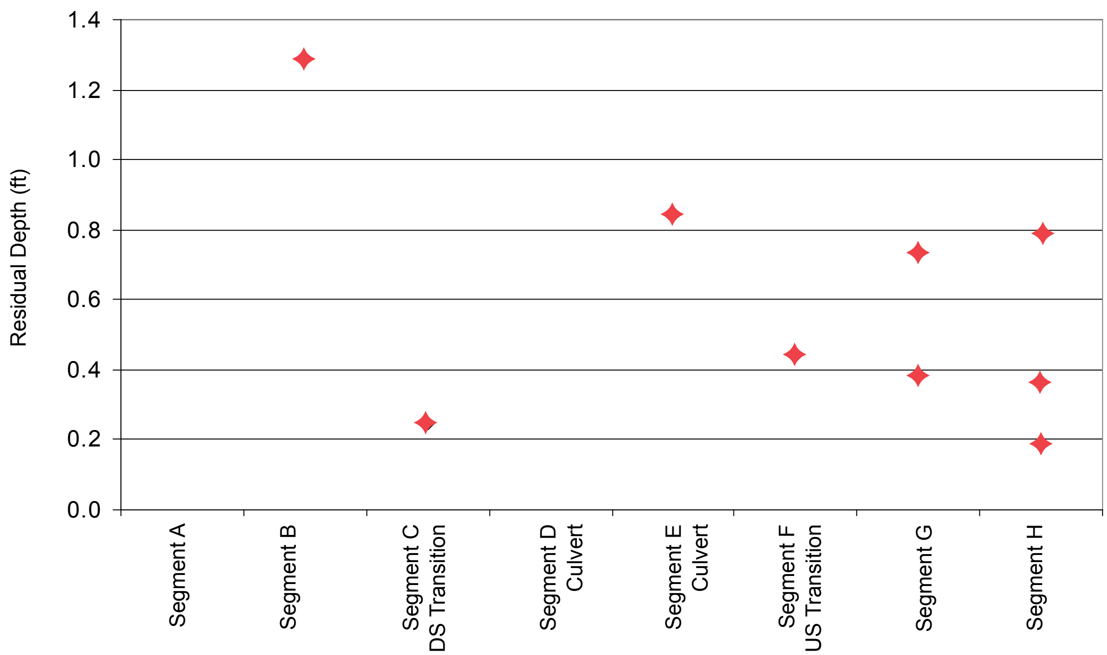


Figure 21—Residual depths.

Table 7—Bed material sorting and skewness

Reach	XS Location	Unit Type	Sorting	Within range of channel conditions?	Skewness	Within range of channel conditions?
Culvert	US	Pool	1.50	Yes	0.13	Yes
	DS	Riffle	1.47	Yes	0.26	Yes
Upstream	US	Pool	1.59		0.12	
	DS	Step	1.25		0.14	
Downstream	US	Pool	1.55		0.31	
	DS	Riffle	2.34		0.37	

Table 8—Large woody debris

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Reach	Pieces/Channel Width
Culvert	0.34
Upstream	3.43
Downstream	4.22

Terminology:

US = Upstream

DS = Downstream

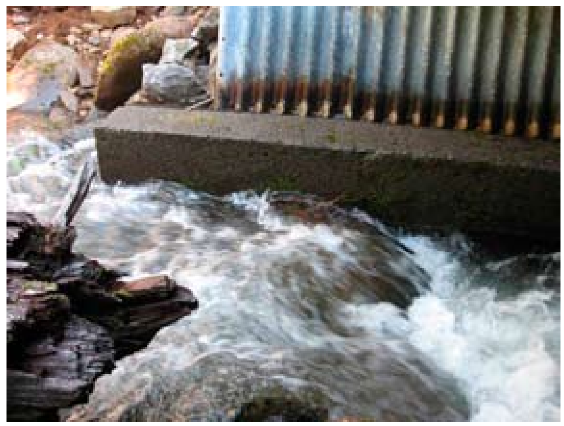
RR = Reference reach

XS = Cross section

View upstream through culvert.

View downstream through culvert.

View downstream of culvert inlet.



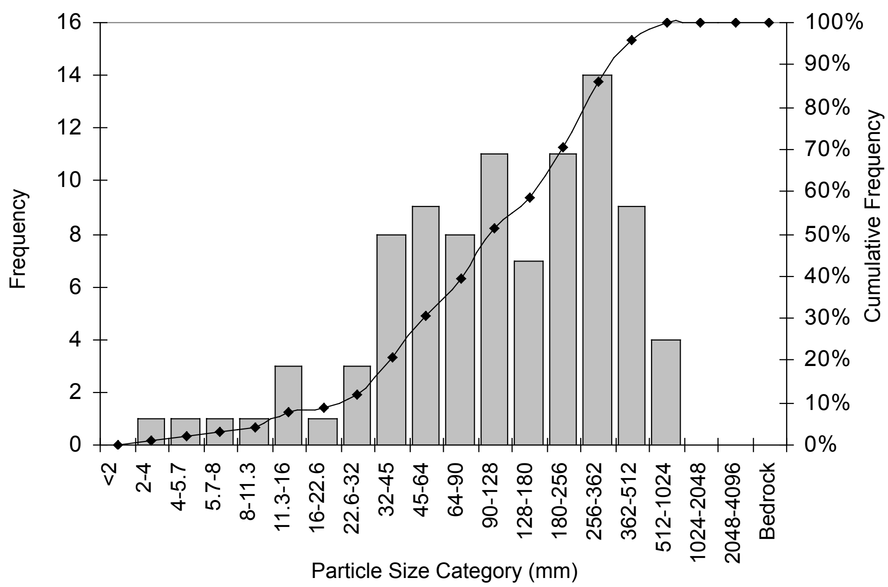
View of undercut left bank footing at upstream end of culvert.

Downstream reference reach.

Upstream reference reach.

Cross Section: Upstream Reference Reach – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	0	0%	0%
very fine gravel	2 - 4	1	1%	1%
fine gravel	4 - 5.7	1	1%	2%
fine gravel	5.7 - 8	1	1%	3%
medium gravel	8 - 11.3	1	1%	4%
medium gravel	11.3 - 16	3	3%	8%
coarse gravel	16 - 22.6	1	1%	9%
coarse gravel	22.6 - 32	3	3%	12%
very coarse gravel	32 - 45	8	9%	21%
very coarse gravel	45 - 64	9	10%	30%
small cobble	64 - 90	8	9%	39%
medium cobble	90 - 128	11	12%	51%
large cobble	128 - 180	7	8%	59%
very large cobble	180 - 256	11	12%	71%
small boulder	256 - 362	14	15%	86%
small boulder	362 - 512	9	10%	96%
medium boulder	512 - 1024	4	4%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



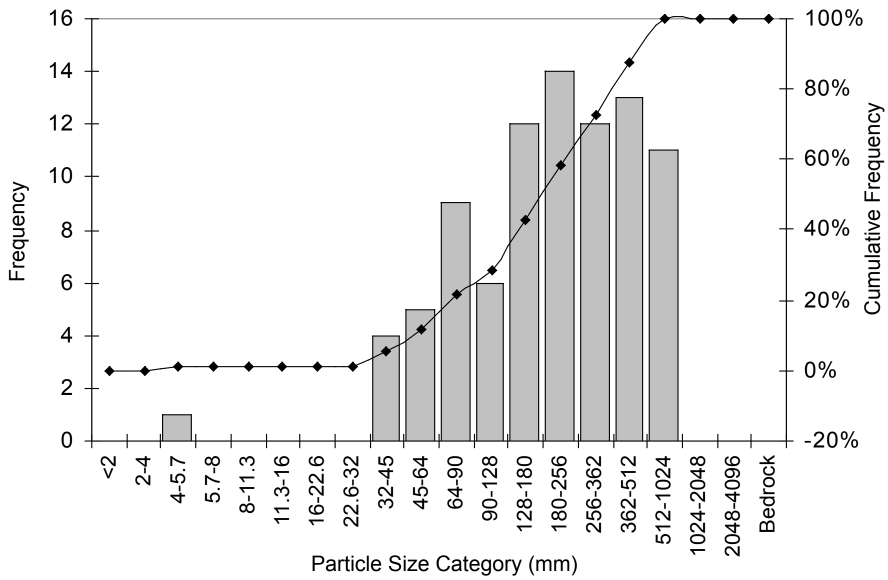
Size Class	Size percent finer than (mm)
D5	13
D16	40
D50	120
D84	349
D95	500
D100	900

Material	Percent Composition
Sand	0%
Gravel	30%
Cobble	40%
Boulder	29%
Bedrock	0%

Sorting Coefficient: 1.59
Skewness Coefficient: 0.12

Cross Section: Upstream Reference Reach – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	0	0%	0%
very fine gravel	2 - 4	0	0%	0%
fine gravel	4 - 5.7	1	1%	1%
fine gravel	5.7 - 8	0	0%	1%
medium gravel	8 - 11.3	0	0%	1%
medium gravel	11.3 - 16	0	0%	1%
coarse gravel	16 - 22.6	0	0%	1%
coarse gravel	22.6 - 32	0	0%	1%
very coarse gravel	32 - 45	4	5%	6%
very coarse gravel	45 - 64	5	6%	11%
small cobble	64 - 90	9	10%	22%
medium cobble	90 - 128	6	7%	29%
large cobble	128 - 180	12	14%	43%
very large cobble	180 - 256	14	16%	59%
small boulder	256 - 362	12	14%	72%
small boulder	362 - 512	13	15%	87%
medium boulder	512 - 1024	11	13%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock		0%	100%



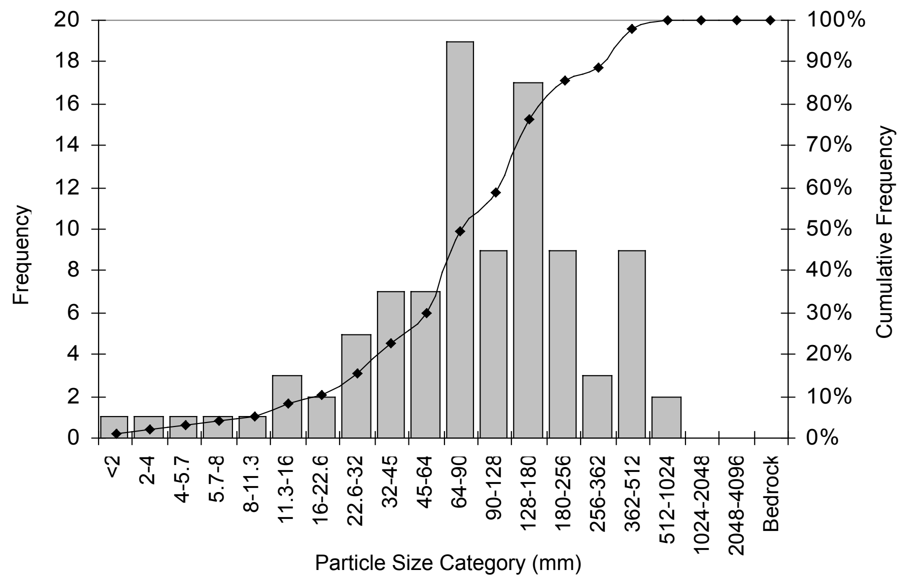
Size Class	Size percent finer than (mm)
D5	43
D16	78
D50	210
D84	500
D95	600
D100	700

Material	Percent Composition
Sand	0%
Gravel	11%
Cobble	47%
Boulder	41%
Bedrock	0%

Sorting Coefficient: 1.25
Skewness Coefficient: 0.14

Cross Section: Culvert – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	1	1%	1%
very fine gravel	2 - 4	1	1%	2%
fine gravel	4 - 5.7	1	1%	3%
fine gravel	5.7 - 8	1	1%	4%
medium gravel	8 - 11.3	1	1%	5%
medium gravel	11.3 - 16	3	3%	8%
coarse gravel	16 - 22.6	2	2%	10%
coarse gravel	22.6 - 32	5	5%	15%
very coarse gravel	32 - 45	7	7%	23%
very coarse gravel	45 - 64	7	7%	30%
small cobble	64 - 90	19	20%	49%
medium cobble	90 - 128	9	9%	59%
large cobble	128 - 180	17	18%	76%
very large cobble	180 - 256	9	9%	86%
small boulder	256 - 362	3	3%	89%
small boulder	362 - 512	9	9%	98%
medium boulder	512 - 1024	2	2%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



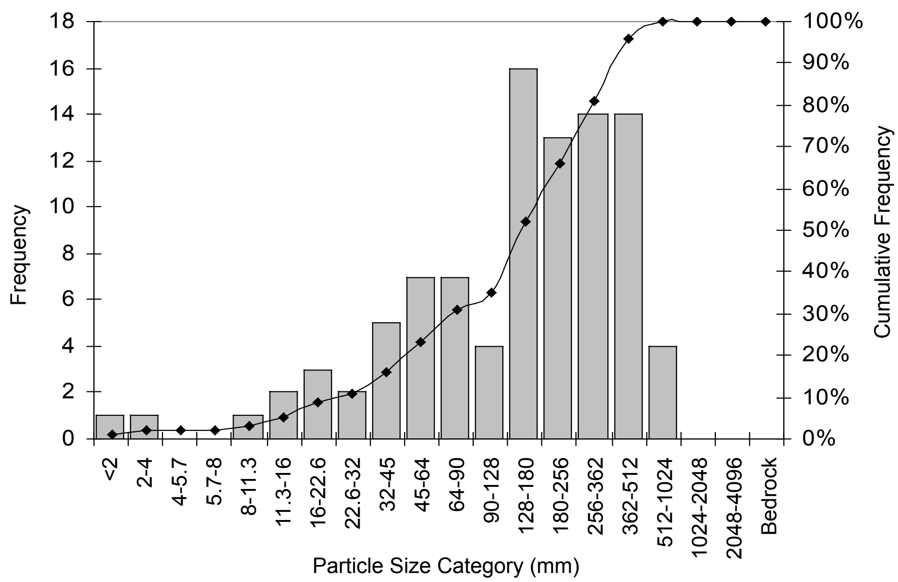
Size Class	Size percent finer than (mm)
D5	12
D16	35
D50	100
D84	236
D95	470
D100	600

Material	Percent Composition
Sand	1%
Gravel	29%
Cobble	56%
Boulder	14%
Bedrock	0%

Sorting Coefficient: 1.50
Skewness Coefficient: 0.13

Cross Section: Culvert – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	1	1%	1%
very fine gravel	2 - 4	1	1%	2%
fine gravel	4 - 5.7	0	0%	2%
fine gravel	5.7 - 8	0	0%	2%
medium gravel	8 - 11.3	1	1%	3%
medium gravel	11.3 - 16	2	2%	5%
coarse gravel	16 - 22.6	3	3%	9%
coarse gravel	22.6 - 32	2	2%	11%
very coarse gravel	32 - 45	5	5%	16%
very coarse gravel	45 - 64	7	7%	23%
small cobble	64 - 90	7	7%	31%
medium cobble	90 - 128	4	4%	35%
large cobble	128 - 180	16	17%	52%
very large cobble	180 - 256	13	14%	66%
small boulder	256 - 362	14	15%	81%
small boulder	362 - 512	14	15%	96%
medium boulder	512 - 1024	4	4%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



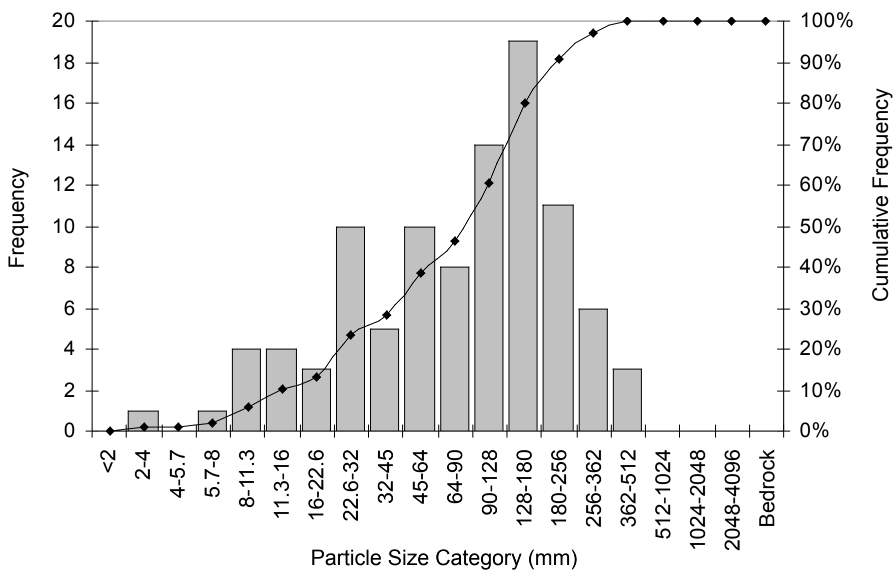
Size Class	Size percent finer than (mm)
D5	18
D16	49
D50	165
D84	382
D95	504
D100	950

Material	Percent Composition
Sand	1%
Gravel	22%
Cobble	43%
Boulder	34%
Bedrock	0%

Sorting Coefficient: 1.47
Skewness Coefficient: 0.26

Cross Section: Downstream Reference Reach – Upstream Pebble Count

Material	Size Range (mm)	Count	Item %	Cumulative %
sand	<2	0	0%	0%
very fine gravel	2 - 4	1	1%	1%
fine gravel	4 - 5.7	0	0%	1%
fine gravel	5.7 - 8	1	1%	2%
medium gravel	8 - 11.3	4	4%	6%
medium gravel	11.3 - 16	4	4%	10%
coarse gravel	16 - 22.6	3	3%	13%
coarse gravel	22.6 - 32	10	10%	23%
very coarse gravel	32 - 45	5	5%	28%
very coarse gravel	45 - 64	10	10%	38%
small cobble	64 - 90	8	8%	46%
medium cobble	90 - 128	14	14%	61%
large cobble	128 - 180	19	19%	80%
very large cobble	180 - 256	11	11%	91%
small boulder	256 - 362	6	6%	97%
small boulder	362 - 512	3	3%	100%
medium boulder	512 - 1024	0	0%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	> 4096	0	0%	100%



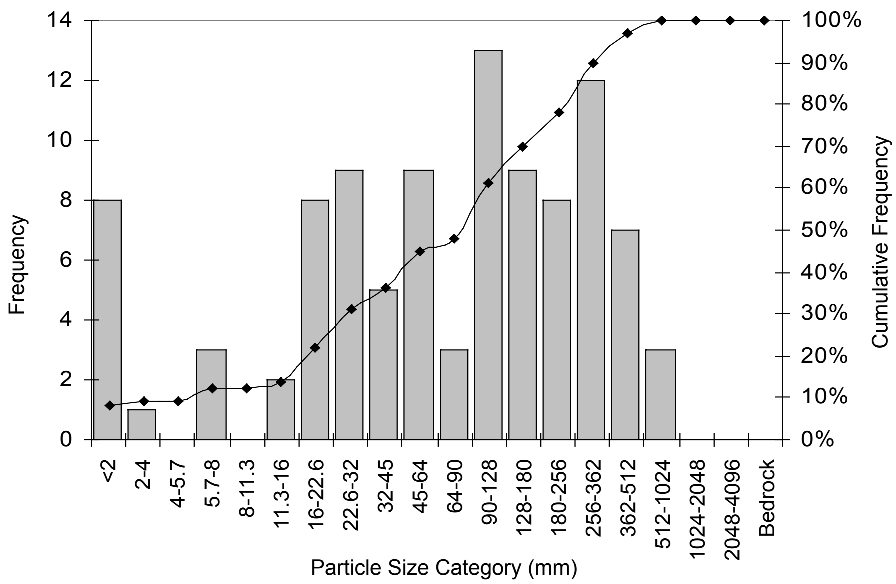
Size Class	Size percent finer than (mm)
D5	11
D16	23
D50	100
D84	210
D95	340
D100	420

Material	Percent Composition
Sand	0%
Gravel	38%
Cobble	53%
Boulder	9%
Bedrock	0%

Sorting Coefficient: 1.55
Skewness Coefficient: 0.31

Cross Section: Downstream Reference Reach – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	8	8%	8%
very fine gravel	2 - 4	1	1%	9%
fine gravel	4 - 5.7	0	0%	9%
fine gravel	5.7 - 8	3	3%	12%
medium gravel	8 - 11.3	0	0%	12%
medium gravel	11.3 - 16	2	2%	14%
coarse gravel	16 - 22.6	8	8%	22%
coarse gravel	22.6 - 32	9	9%	31%
very coarse gravel	32 - 45	5	5%	36%
very coarse gravel	45 - 64	9	9%	45%
small cobble	64 - 90	3	3%	48%
medium cobble	90 - 128	13	13%	61%
large cobble	128 - 180	9	9%	70%
very large cobble	180 - 256	8	8%	78%
small boulder	256 - 362	12	12%	90%
small boulder	362 - 512	7	7%	97%
medium boulder	512 - 1024	3	3%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



Size Class	Size percent finer than (mm)
D5	1
D16	18
D50	100
D84	300
D95	430
D100	750

Material	Percent Composition
Sand	8%
Gravel	37%
Cobble	33%
Boulder	22%
Bedrock	0%

Sorting Coefficient: 2.34
Skewness Coefficient: 0.37