PINE CREEK

Site Information

Site Location:	Willamette NF, Road 21		
Year Installed:	Circa 1999		
Lat/Long:	122°27"21.67"W 43°33'16.38"N	**Watershed Area (mi^2):**	1.91
Stream Slope (ft/ft)[1]:	0.062	**Channel Type:**	Step-pool
Bankfull Width (ft):	13	**Survey Date:**	March 21 2007

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

Culvert Information

Culvert Type:	Pipe arch	**Culvert Material:**	Annular CMP
Culvert Width:	13	**Outlet Type:**	Mitered
Culvert Length:	60 ft	**Inlet Type:**	Mitered

Pipe Slope (structure slope): 0.05

Culvert Bed Slope: 0.038

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

Culvert width as a percentage of bankfull width: 1.03

Alignment Conditions: Inlet appears to be further south than natural channel alignment. Bank scour on right bank upstream of inlet may be partially related to alignment.

Bed Conditions: Large cobble/boulder steps in upstream end of pipe.

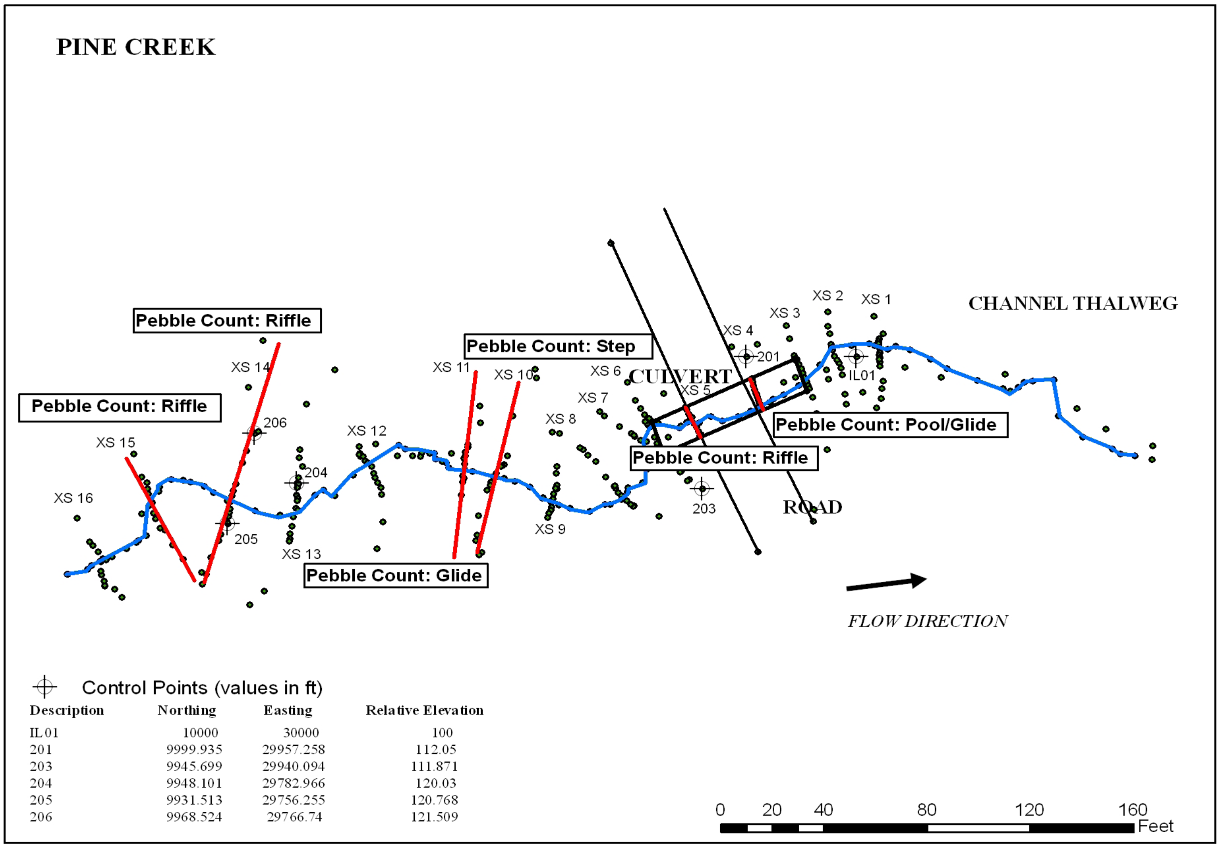
Pipe Condition: Structure joints open in places on culvert walls. Cannot see pipe bottom.

Hydrology

Discharge (cfs) for indicated recurrence interval

25% 2-yr	2-year	Q_{bf}[2]	5-year	10-year	50-year	100-year
15	58	65	91	113	165	188

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



Points represent survey points

Figure 1—Plan view map.

Culvert Scour Assessment

HISTORY

The Pine Creek culvert was installed in 1999. Bed material was placed inside the culvert during construction. The gradation used was similar to the upstream channel. Pebble counts following construction revealed similar D_{84} and D_{16}, and low D_{50} compared to the upstream channel. Very few fines were present. No bed material sorting, bedform construction, or bank construction was performed.

As for horizontal alignment, the culvert was centered in the existing channel. For vertical alignment, the pipe was placed intermediate between the upstream and downstream profiles.

Following construction, about 50 percent of the placed bed material scoured out of the structure but sediments redeposited within the pipe, raising the bed to near the constructed-bed elevation. In addition, channel sediment that aggraded upstream of the culvert transported through the structure.

No significant maintenance has occurred at the site since construction.

The above information was furnished by Kim Johansen, USFS.

An assessment of nearby stream gauges suggests that nothing more than a 5-year recurrence interval event has occurred in the region since construction.

Pine Creek culvert post construction (Fall 1999, Kim Johansen, U.S. Forest Service).

The previous culvert at this site 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 December 1, 1987. The previous culvert was a 7.5-foot-diameter corrugated metal pipe with an additional 36-inch-diameter pipe installed for flood relief. Oregon Department of Fish and Wildlife (ODFW) staff rated the previous culvert as a "good" installation for fish passage but WFLHD staff noted high velocities (nearly double that of the natural channel) and a 2- to 3-foot-deep scour hole, and considered the pipe to not be a good installation for fish passage.

The following are photos of the previous culvert from the WFLHD study:

Culvert inlet.

Typical stream channel.

SITE DESCRIPTION

The Pine Creek culvert is a large bottomless arch mitered to conform to the roadfill. The site is characterized by a high-gradient step-pool/cascade channel extending approximately 50 feet upstream of the inlet. The high gradient flattens out as it enters the culvert. A steep riffle/step at the entrance transitions into a relatively flat scour pool along the right footing. Grade drops off again downstream of the outlet, which soon enters the broader flood plain of the Middle Fork Willamette River.

Two upstream representative reaches were identified at the site; a lower gradient upper one and a steeper lower one. A long cascade and wood jam separate representative reach one (downstream) from representative reach two (upstream). Below this cascade, representative reach one consists of a series of steps and pools. Large fallen trees are present through this reach, generally along the banks and flood plain. Gradient through this reach is much higher than that found through the culvert or in representative reach two.

Upstream of the cascade, reference reach two runs through a series of riffles, pools, and steps. As a flatter reach, this segment of channel is wider with bars of gravels and some cobbles. A similar flood-plain surface exists as that found in the lower representative reach. Large fallen trees also line the banks and have a small influence in the channel.

SURVEY SUMMARY

Sixteen cross sections and a longitudinal profile were surveyed along Pine Creek in March 2007 to characterize the culvert and two upstream reference reaches. In the culvert, representative cross sections were taken along a step and through a pool. Two additional cross sections were 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.

Representative cross sections in representative reach one were taken through a step and a pool. An additional two sections were taken to characterize the upstream and downstream boundaries of the reach. Representative cross sections in representative reach two were also taken through a step and a pool. An additional two sections were taken to characterize the upstream and downstream boundaries of the reach.

PROFILE ANALYSIS SEGMENT SUMMARY

The profile analysis resulted in a total of 10 profile segments. Two segments with similar gradients upstream of the inlet were not combined in order to separate out the inlet transition segment for analysis. The culvert consisted of two profile segments. The downstream segment in the culvert had comparable gradient to two representative profile segments in the upstream channel. There was no suitable comparison segment for the upstream segment in the culvert. The upstream transition segment had comparable gradient to two representative profile segments in the upstream channel. The downstream transition segment had comparable gradient to three upstream representative segments. See figure 2 and table 1.

SCOUR CONDITIONS

Observed conditions

Footing scour – At least half and possibly as much as all of the originally placed material was scoured out of the pipe after construction. At the time of the survey there was scour to the culvert base at the inlet. The culvert base was exposed for 4 feet. The scour was concentrated on the left bank. The thalweg was along the left edge of the pipe at the inlet (for 10 feet) and along the right edge in the downstream half of the pipe.

Culvert-bed adjustment – Most, if not all, of the original bed material installed in the culvert has scoured out (see photo of post-construction conditions in History section). Bed material has aggraded adjacent to the scour pool along the right bank and through the lower two-thirds of the pipe resulting in a relatively flat bed. The slope of the culvert bed has been reduced through scour and aggradation (assuming the original culvert bed was constructed at the same slope as the structure).

Profile characteristics – The profile has a concave shape through the crossing, with the maximum concavity focused near the inlet (figure 2). This shape reflects the inlet scour and upstream channel incision combined with aggradation in the downstream portion of the channel and downstream of the outlet.

Residual depths – The upstream culvert segment (C) residual depth is greater than any residual depth found in the natural channel (figure 21). This is the location of inlet scour. Residual depth in the downstream portion of the culvert (B) is within the range of residual depths in corresponding profile segments (G and J). Residual depth in the downstream transition segment (A) is within or above the range of depths in corresponding profile segments in the natural channel (G, H, and J). Residual depth in the upstream transition segment (D) is within the range of depths in corresponding profile segments in the natural channel (E and H).

Substrate – The bed material distribution in the riffle in the culvert is similar to the bed material in the step in representative channel reach one (downstream) but coarser than the riffles in representative channel reach two (upstream). The bed material distribution in the glide in the culvert is similar to the glide in representative channel reach one. Culvert bed material sorting values diverge only slightly from the range of values found in the natural channel (table 7). Pebble count data is provided at the end of this summary.

Predicted conditions

Cross-section characteristics – Hydraulic modeling estimates that the culvert reduces flow area, top width, and wetted perimeter but increases hydraulic radius and depth (figures 5 through 7 and 12 through 19). These impacts are apparent even at the lowest modeled flow (25 percent Q_2). Flow geometry in the upstream transition (D) remains mostly within the range of corresponding profile segments (E and H) at all flows. The downstream transition segment (A) exhibits greater depths and lower wetted perimeter than corresponding profile segments (G, H, and J).

Shear stress – Shear stress in the culvert and in the upstream transition segment (D) spikes to higher values than in corresponding profile segments (figures 10 and 19). Shear stress in the downstream transition (A) has a wider range than that found in corresponding profile segments (G, H, and J).

Excess shear – Modeling suggests that excess shear in the culvert is mostly within the range (or slightly lower) than the excess shear in the natural channel (figure 20).

Velocity – Velocity in the culvert and in the upstream transition segment (D) spikes to higher values than in corresponding profile segments (figures 11 and 18). Velocity in the downstream transition (A) has a wider range than that found in corresponding profile segments (G, H, and J).

Scour summary

Originally placed material scoured out of the pipe after construction. There is currently scour to the culvert base at the upstream end (inlet) of the culvert. There has been aggradation in the downstream portion of the culvert. The bed has therefore adjusted to a flatter slope than what was originally constructed (assuming the original culvert bed was constructed at the same gradient as the structure). Hydraulic modeling indicates high shear stress and velocity within the culvert, indicating potential risk of continued scour during high flow events.

The culvert appears to have most likely been placed lower in the profile than the original stream. This could relate to channel adjustments from the previous culvert or may also be a result of restrictions in height imposed by the current road prism. The change in profile has caused upstream incision. Deposition of coarse material upstream of the culvert may be due to culvert backwater during a high flood event (possible debris plugging). Subsequent lateral boundary adjustment has occurred in response to this deposited material and has resulted in the lateral migration of the channel in the right bank direction. This has altered the culvert alignment, creating a sharp bend at the inlet that contributes to inlet scour.

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 culvert and transition segments are within the range of those in the channel segments (table 4).

Depth distribution – The upstream culvert cross section (riffle) has a depth-distribution value within the range of channel conditions but the downstream culvert cross section (glide) has a value less than channel conditions (table 5).

Habitat units – The culvert has more glide habitat and less pool and riffle habitat than the natural channel (table 6).

Residual depths – The upstream culvert segment (C) residual depth is greater than any residual depth found in the natural channel (figure 21). This is the location of inlet scour. Residual depth in the downstream portion of the culvert (B) is within the range of residual depths in corresponding profile segments (G and J). Residual depth in the downstream transition segment (A) is within or above the range of depths in corresponding profile segments in the natural channel (G, H, and J). Residual depth in the upstream transition segment (D) is within the range of depths in corresponding profile segments in the natural channel (E and H).

Substrate – The bed-material distribution in the riffle in the culvert is similar to the bed material in the step in representative channel reach one (downstream) but coarser than the riffles in representative channel reach two (upstream). The bed-material distribution in the glide in the culvert is similar to the glide in representative channel reach one. Culvert bed material sorting values diverge only slightly from the range of values found in the natural channel (table 7). Pebble count data is provided at the end of this summary.

Large woody debris – There was no LWD present in the culvert (table 8). The representative channel had moderate LWD abundance. 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

Site observations and complexity measures indicate that this site is moderately suitable for AOP. There is flow concentration that would allow for passage during low flows and there is some coarse material that would create velocity refuge at higher flows. The high velocity spikes indicated in the hydraulic modeling could potentially limit fish passage at high flows. The thalweg runs along the culvert edge for much of the length, limiting the roughness and associated velocity refuge that is found in the natural channel outside the crossing. There is an exposed bank on the left bank of the culvert for terrestrial organism passage, but no bank exists along most of the right bank.

DESIGN CONSIDERATIONS

Inlet scour, upstream incision, and upstream lateral boundary adjustment could likely have been reduced by raising the invert elevation of the culvert bed; however, this may have required raising the elevation of the road prism at considerable expense. Adding stable, embedded boulders into the culvert bed would reduce risk of scour to the culvert base, which is currently occurring. Use of an open-bottom arch at this location would allow for the construction of stable bed elements while not significantly reducing culvert capacity. Creation of continuous banks along both culvert walls would reduce the smooth wall-based flow currently occurring along much of the length and would also benefit terrestrial organism passage.

Segment	Segment Length (ft)	Segment Gradient
A	43	0.045
B	52	0.038
C	18	0.022
D	50	0.077
E	93	0.074
F	19	0.223
G	70	0.034
H	21	0.061
I	14	0.014
J	16	0.038

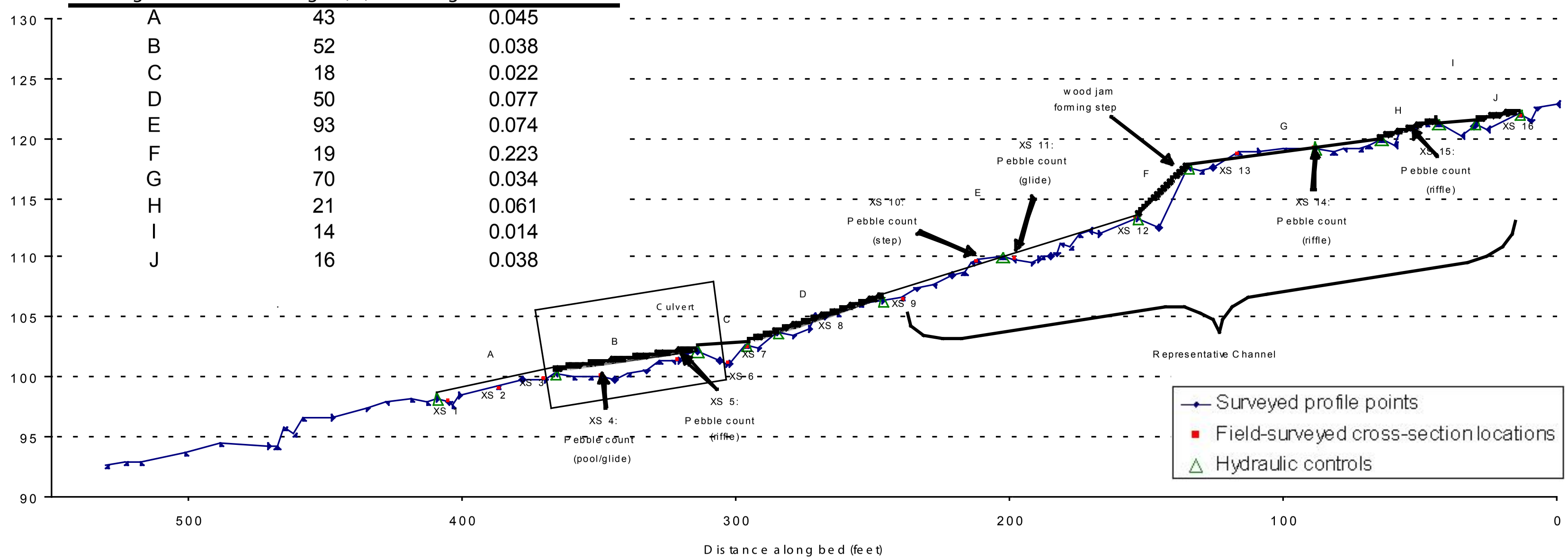


Figure 2—Pine Creek longitudinal profile.

Table 1—Segment comparisons

Culvert Segment	Representative Channel Segment	% Difference in Gradient
B	G	12.6%
B	J	0.6%
Upstream Transition		
D	E	3.6%
D	H	21.2%
Downstream Transition		
A	G	25.7%
A	H	25.4%
A	J	15.4%

Table 2—Summary of segments used for comparisons

Segment	Range of Manning's n values[1]	# of measured XSs	# of interpolated XSs
A	0.1273 – 0.1321	3	6
B	0.0987 – 0.1284	2	7
D	0.1527	2	7
E	0.1527 – 0.1578	4	9
G	0.1117 – 0.1147	2	7
H	0.1099 – 0.1117	1	3
J	0.1102 – 0.1107	1	2

[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.

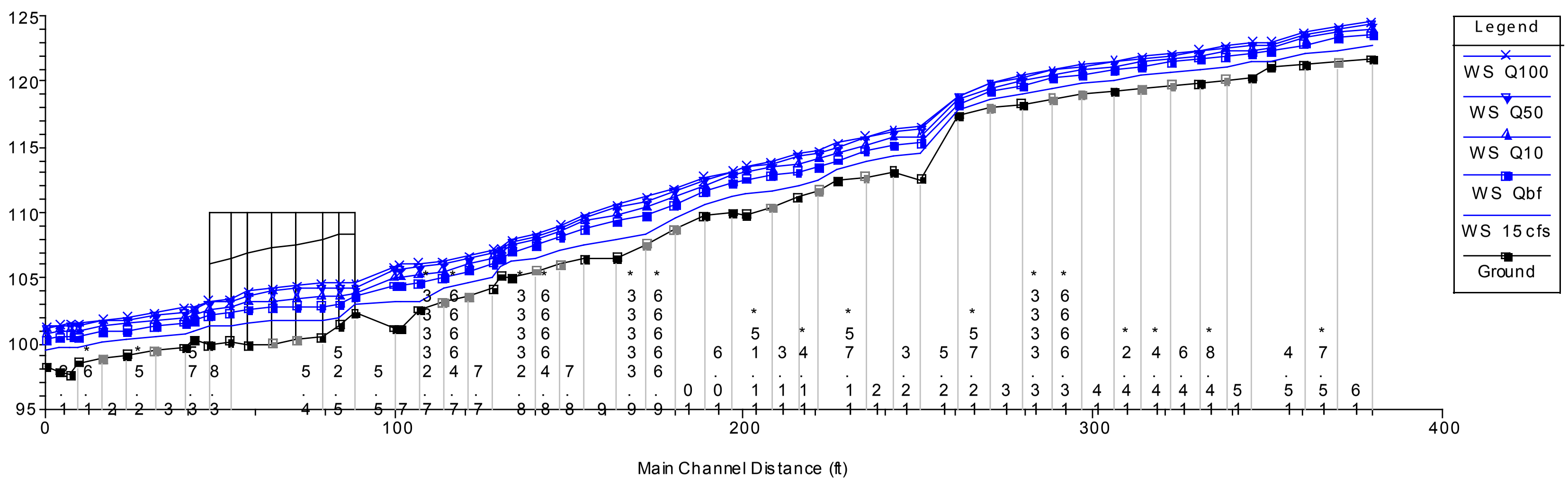


Figure 3—HEC-RAS profile.

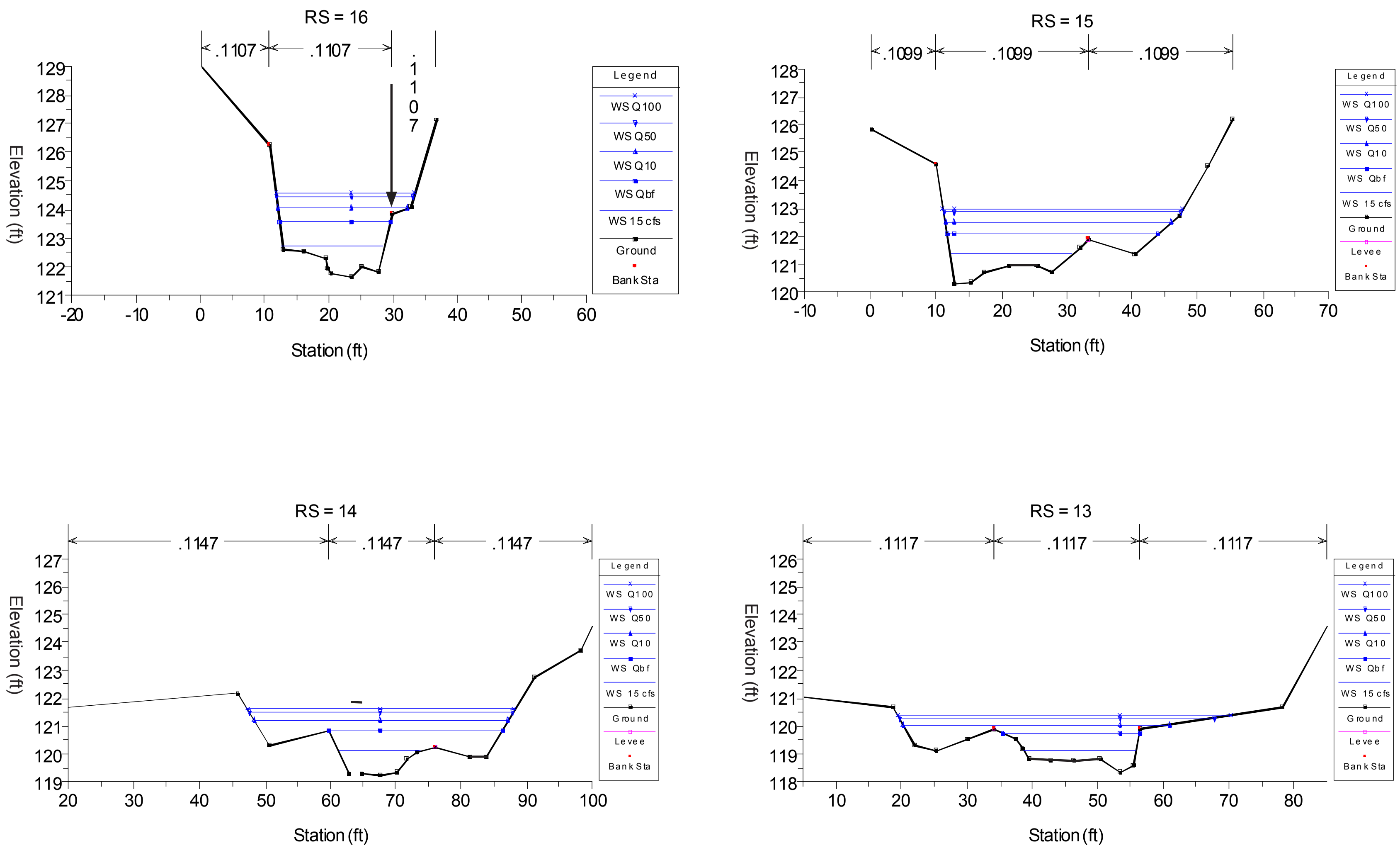
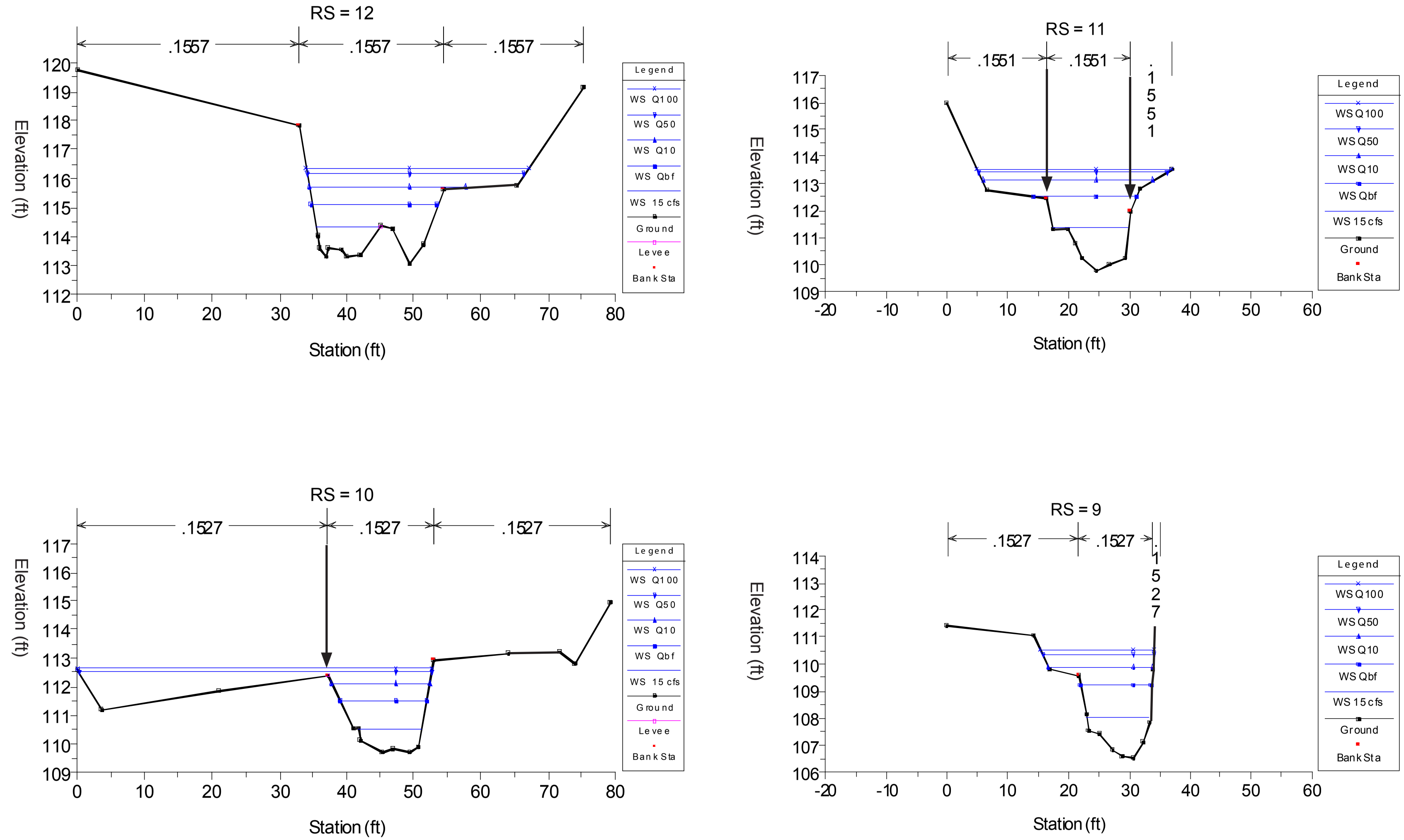


Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points identified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



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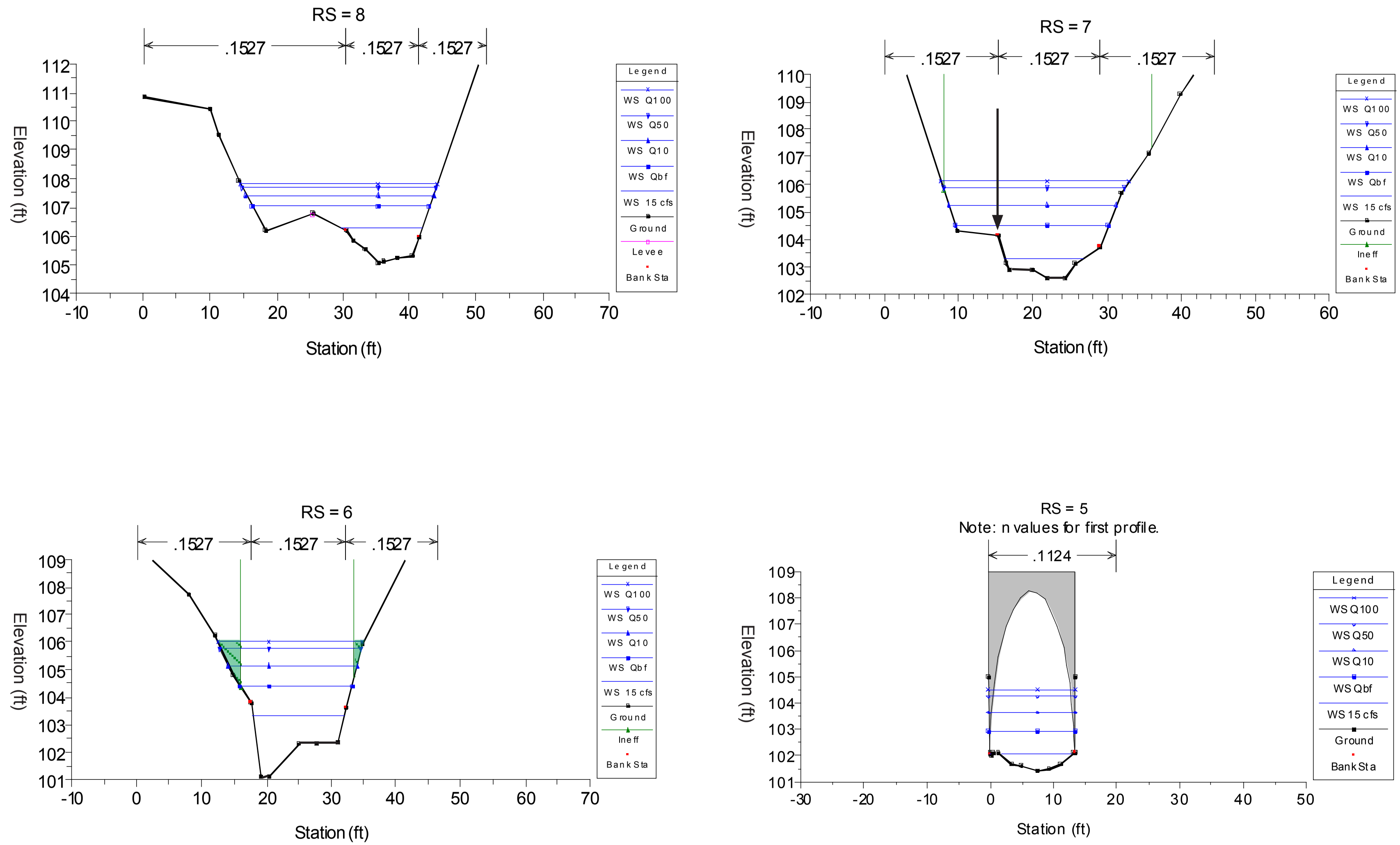

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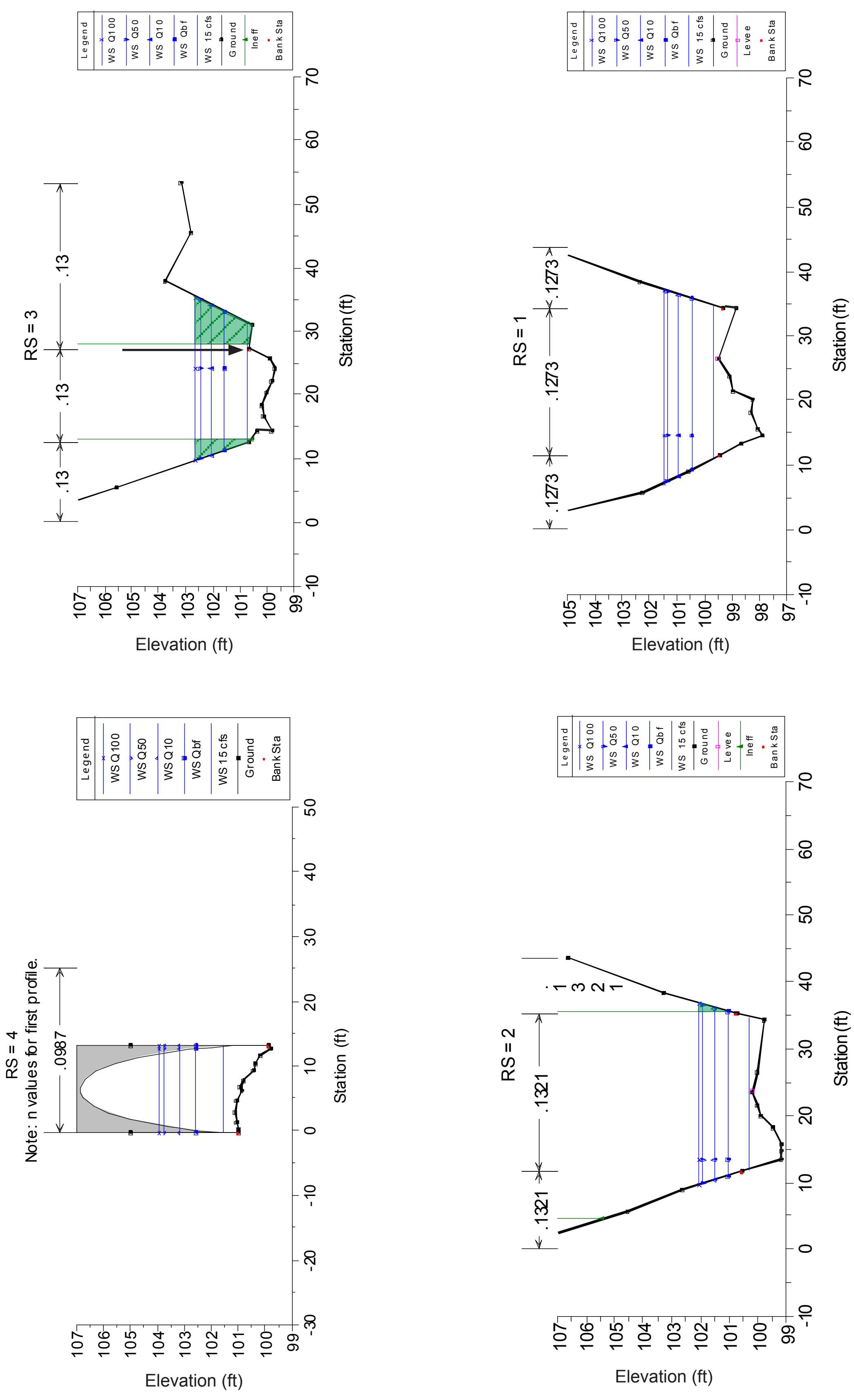

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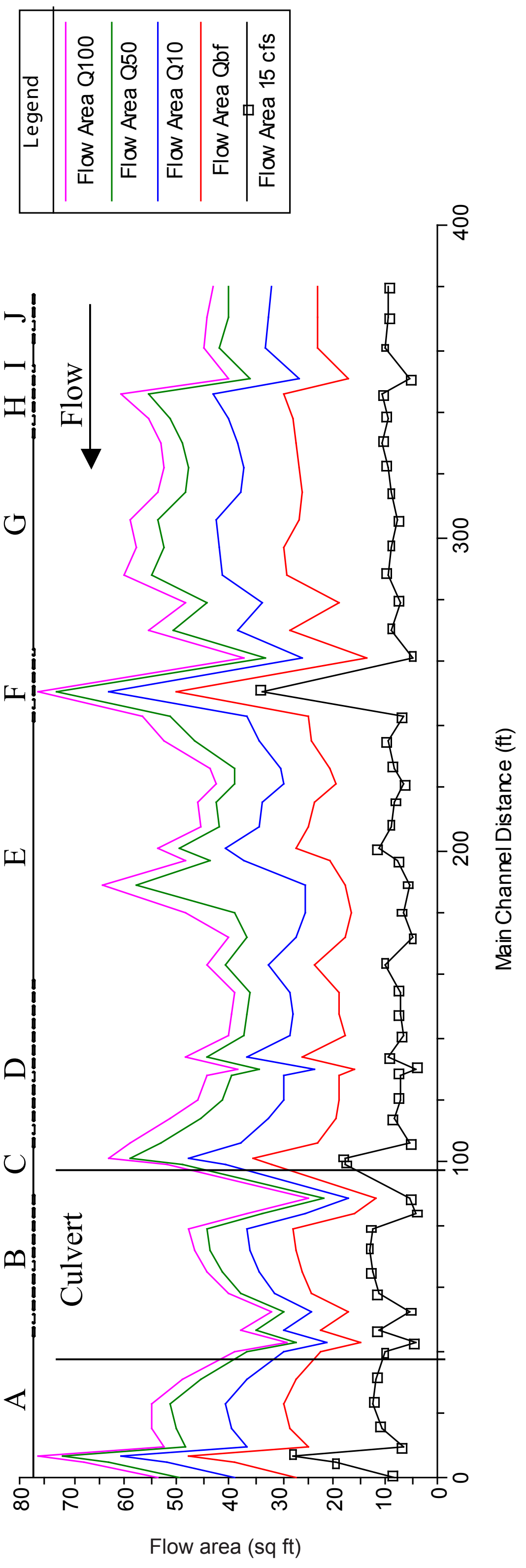


Figure 5—Flow area (total) profile plot.

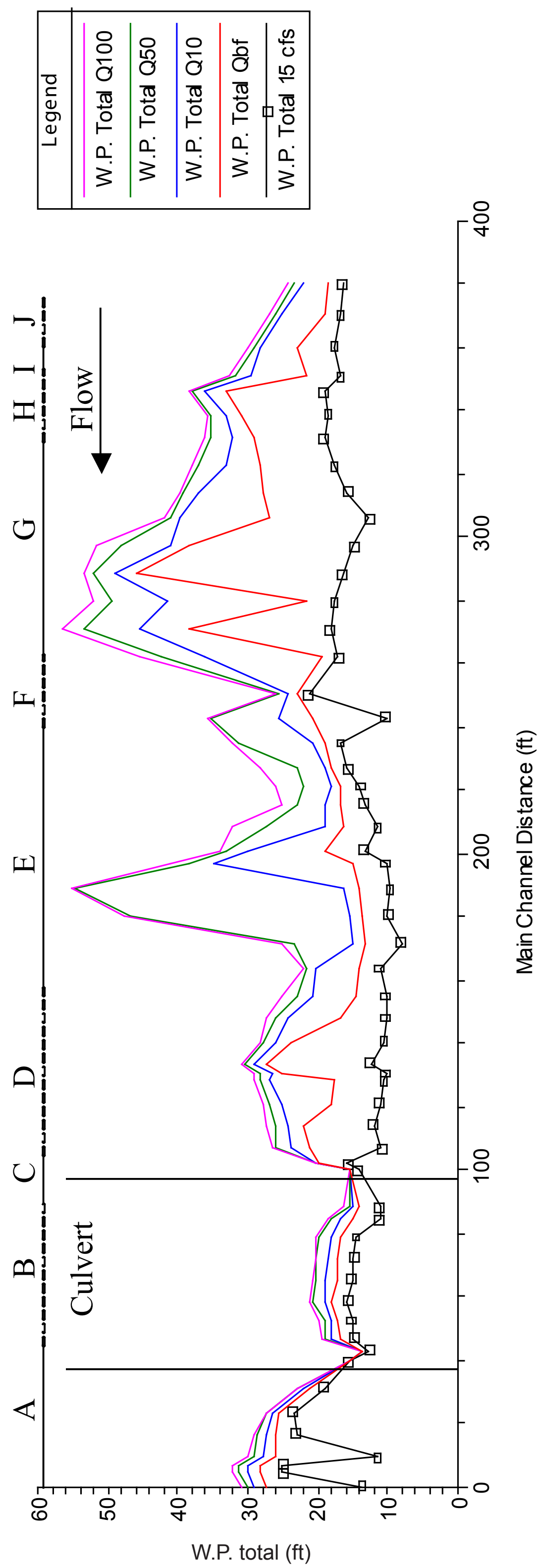


Figure 6—Wetted perimeter.

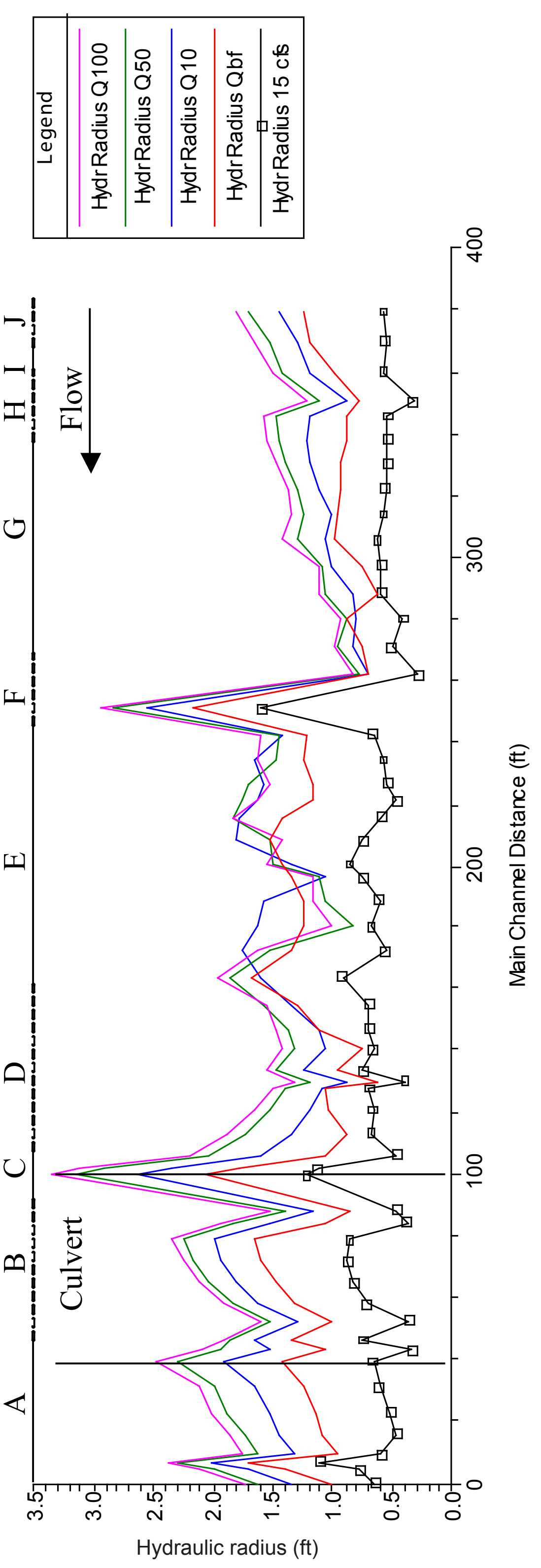


Figure 7—Hydraulic radius.

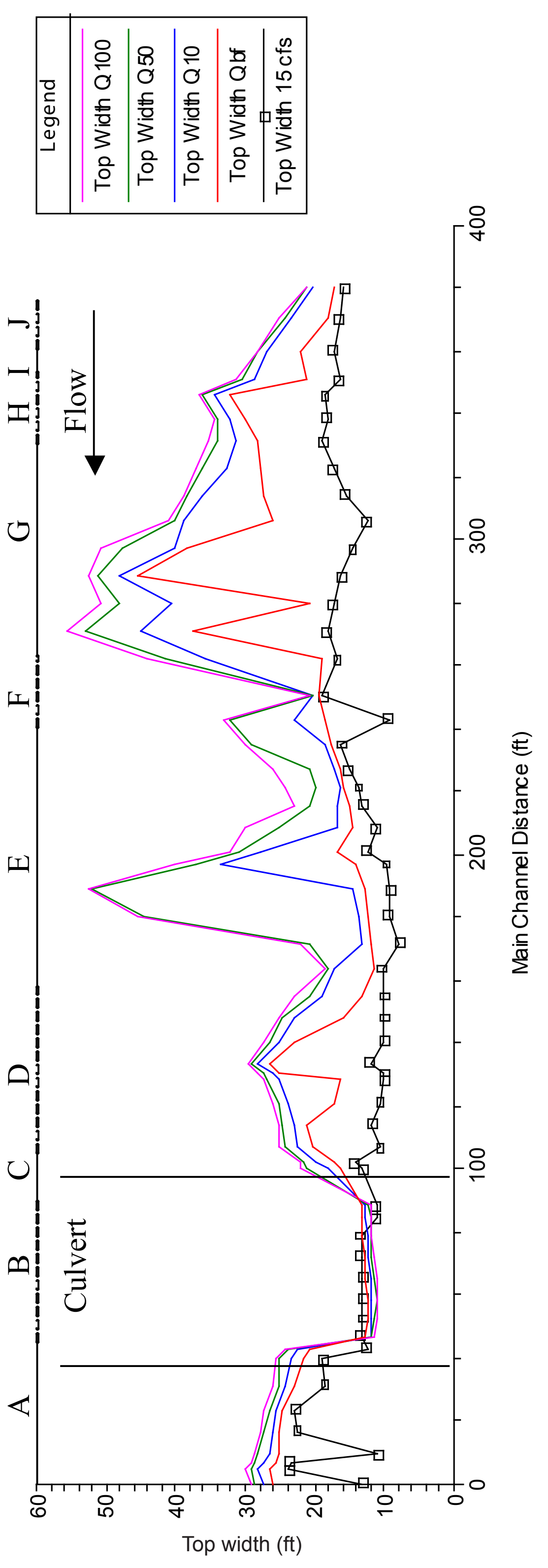


Figure 8—Top width.

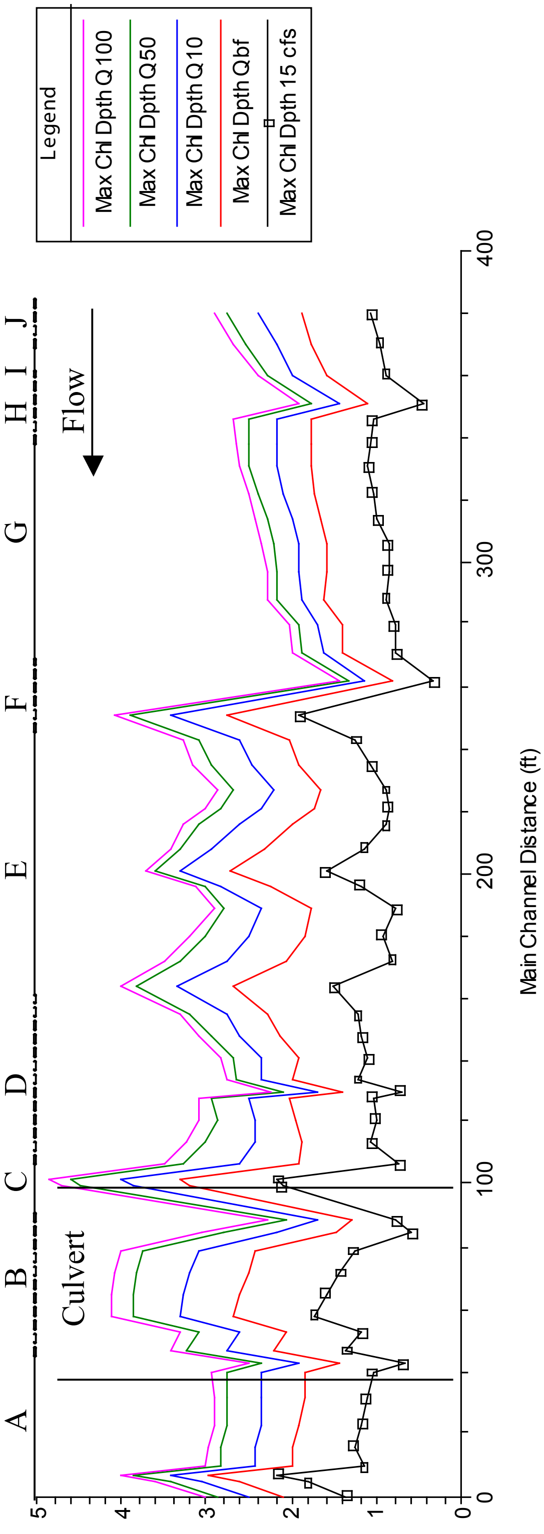


Figure 9—Maximum depth.

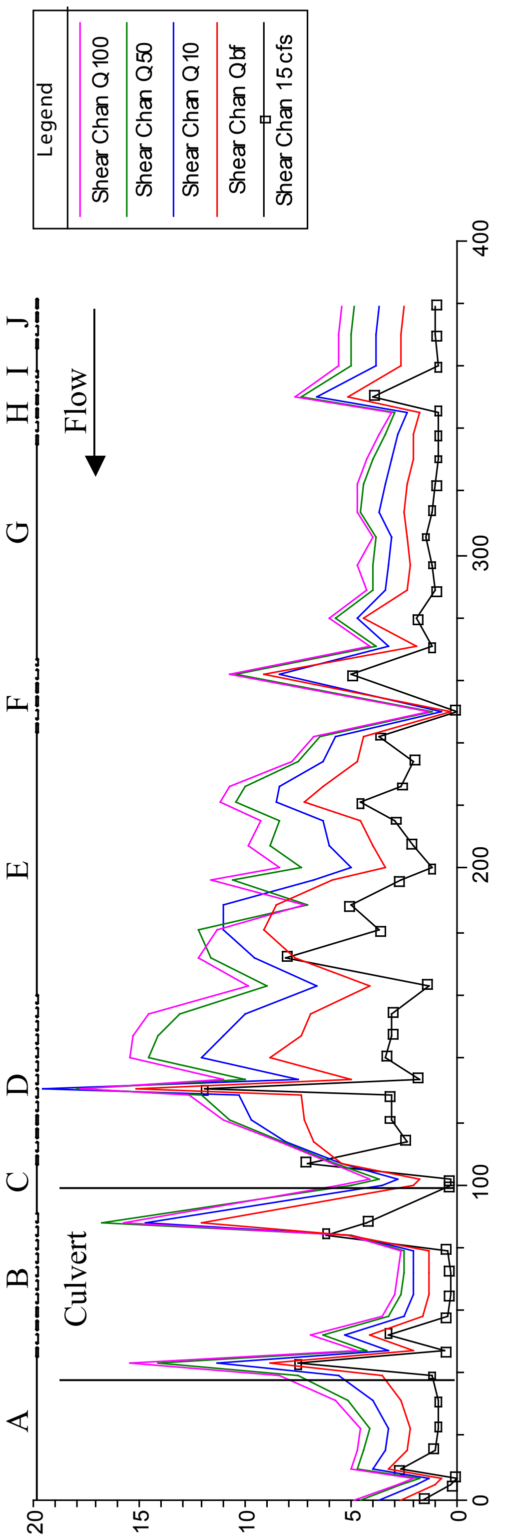


Figure 10—Shear stress (channel) profile.

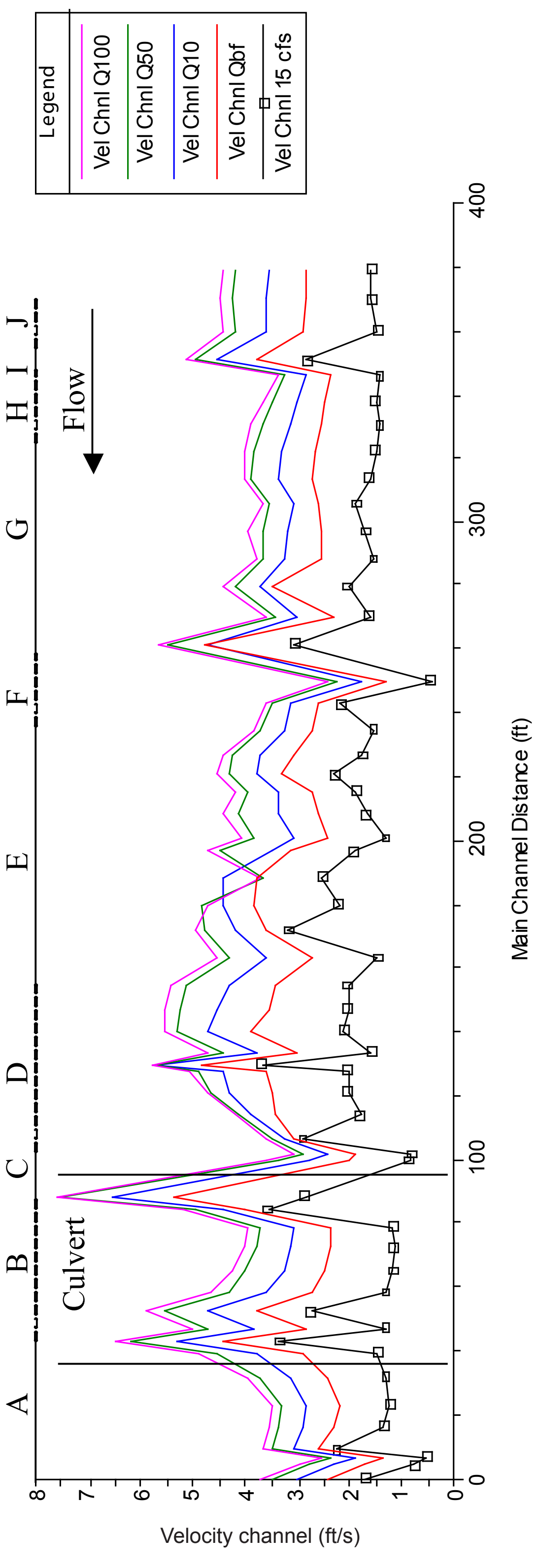
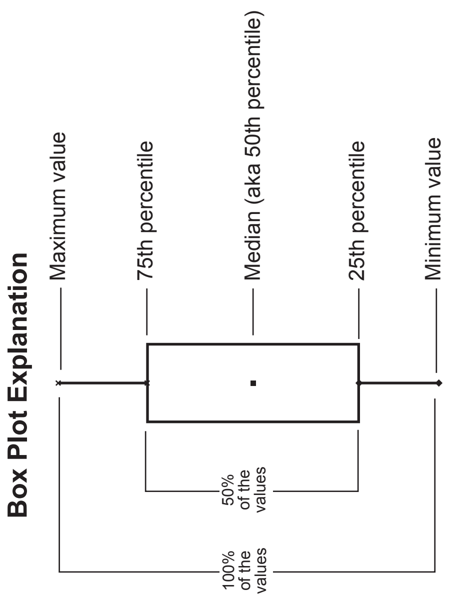


Figure 11—Velocity (channel) profile plot.



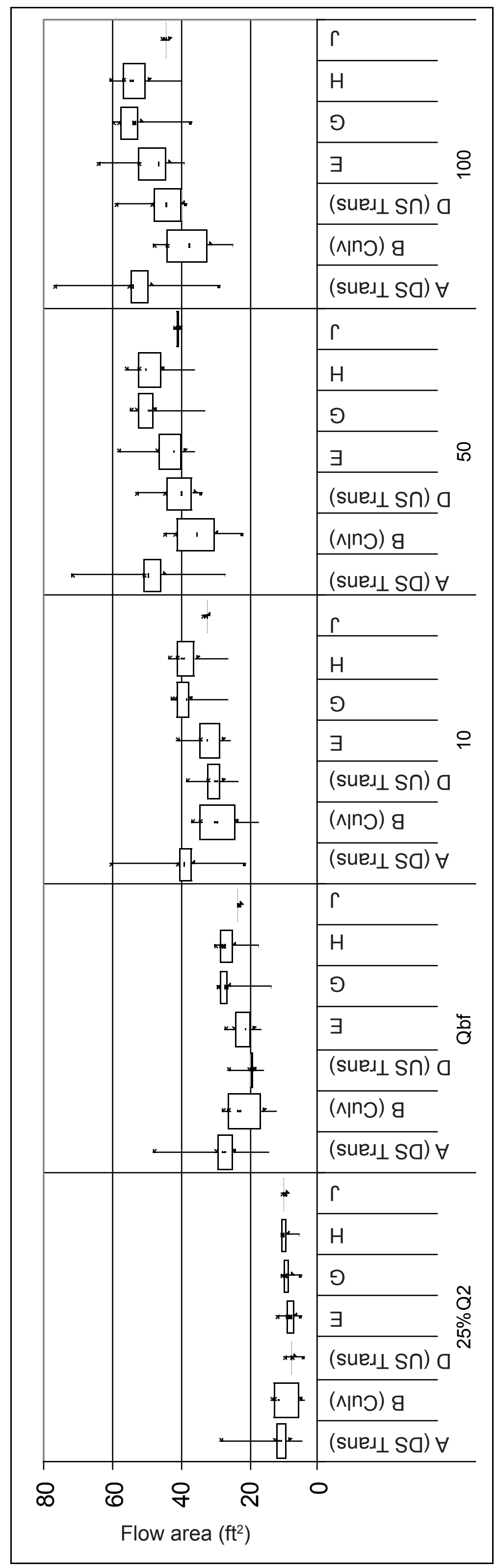


Figure 12—Flow area (total).

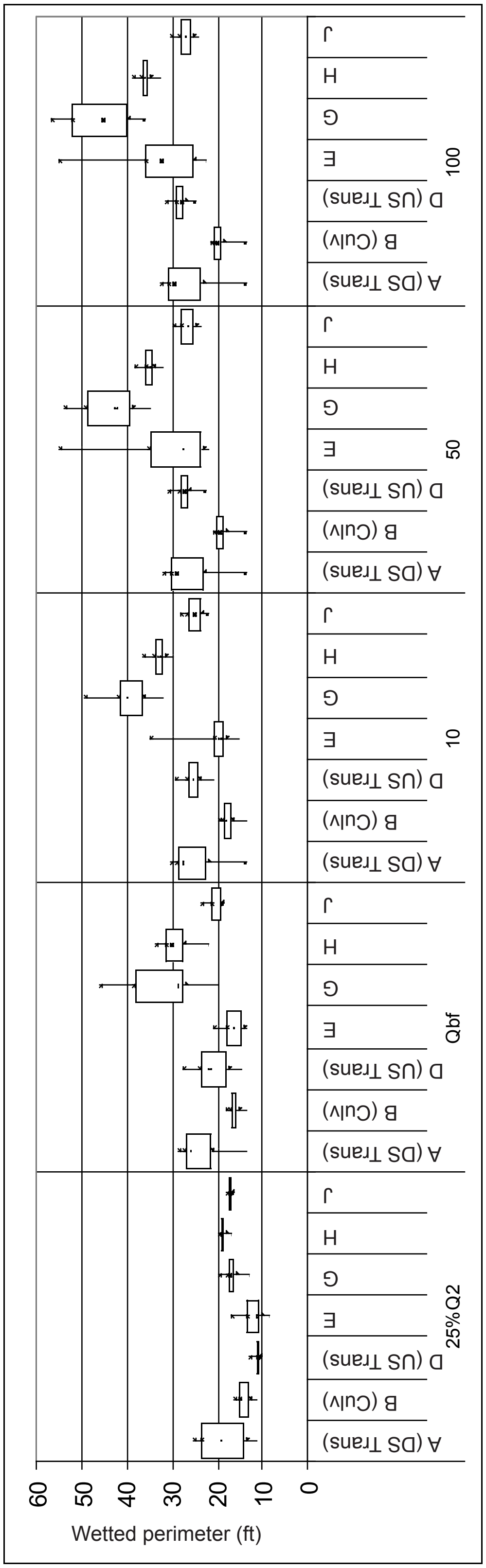


Figure 13—Wetted perimeter.

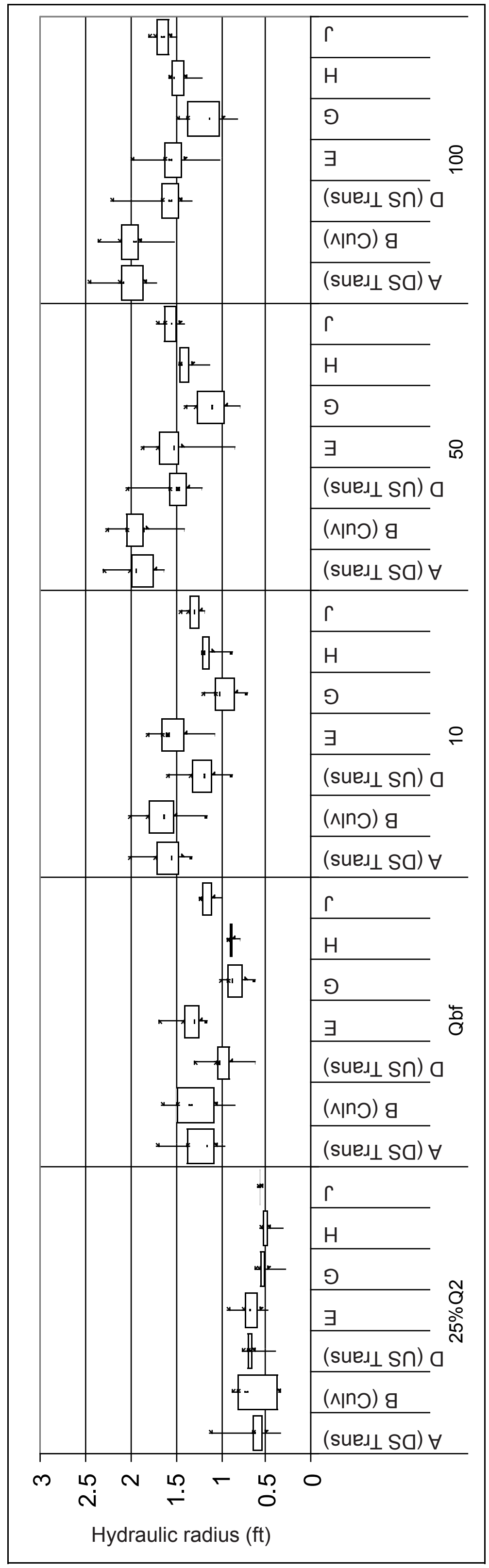


Figure 14—Hydraulic radius.

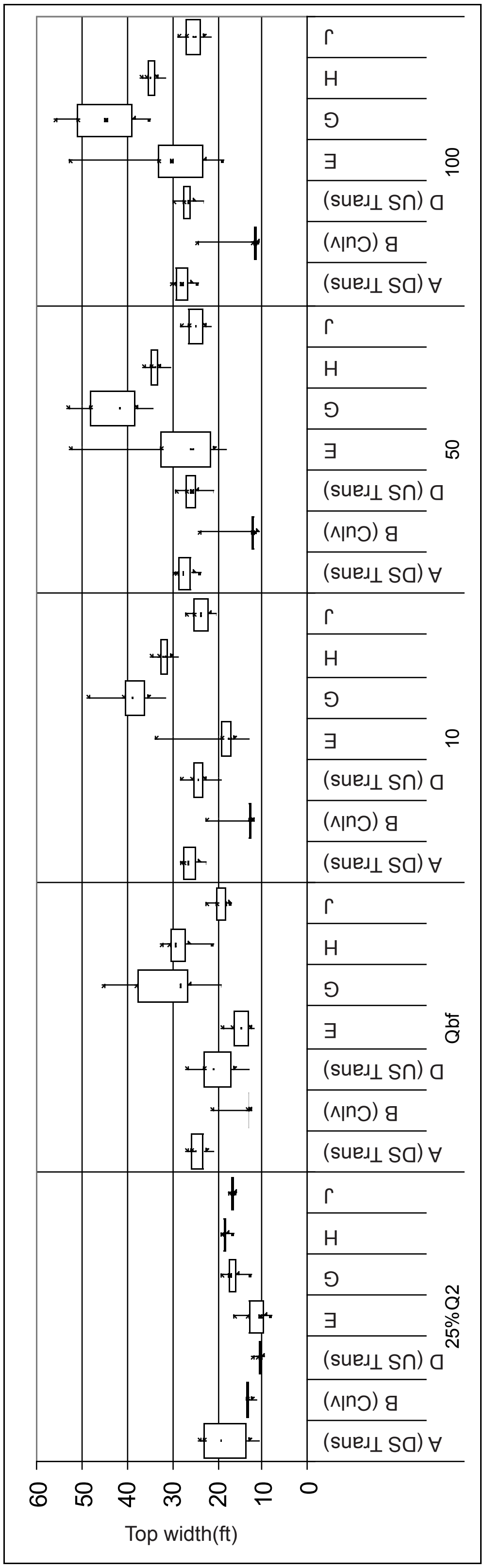


Figure 15—Top width.

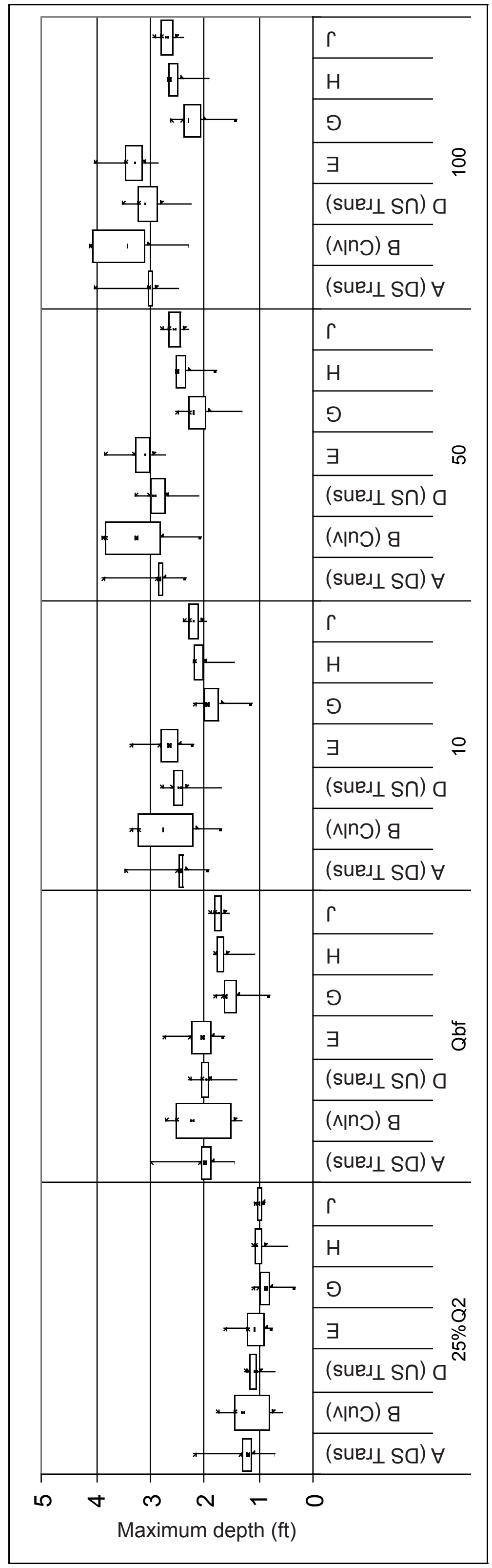


Figure 16—Maximum depth.

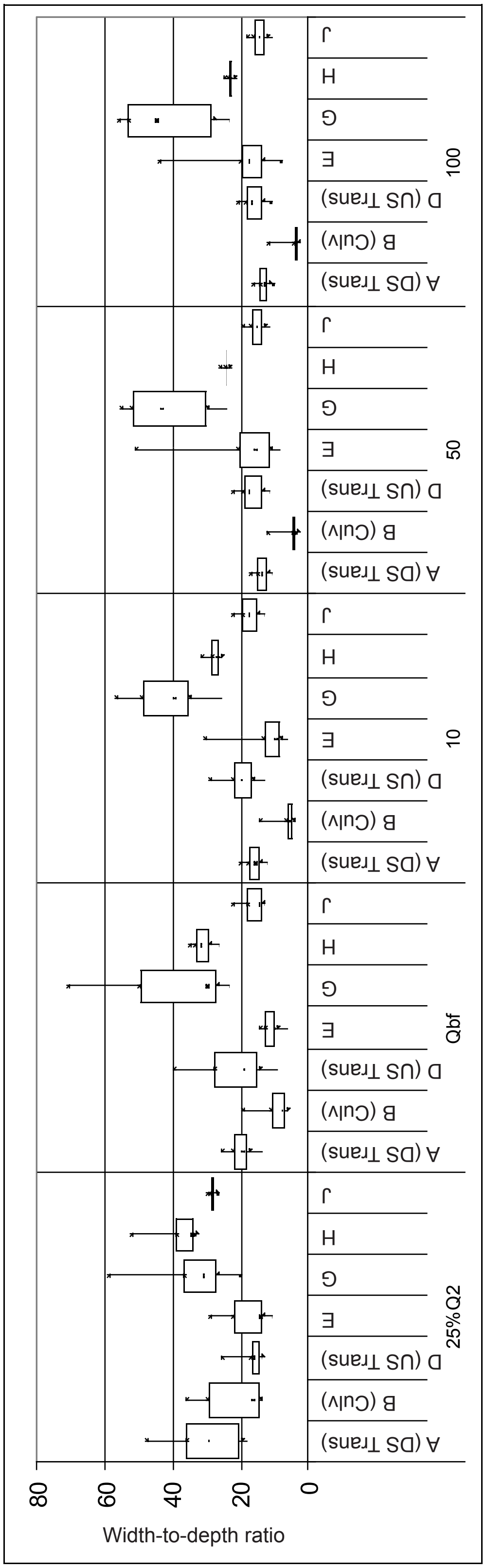


Figure 17—Width-to-depth ratio.

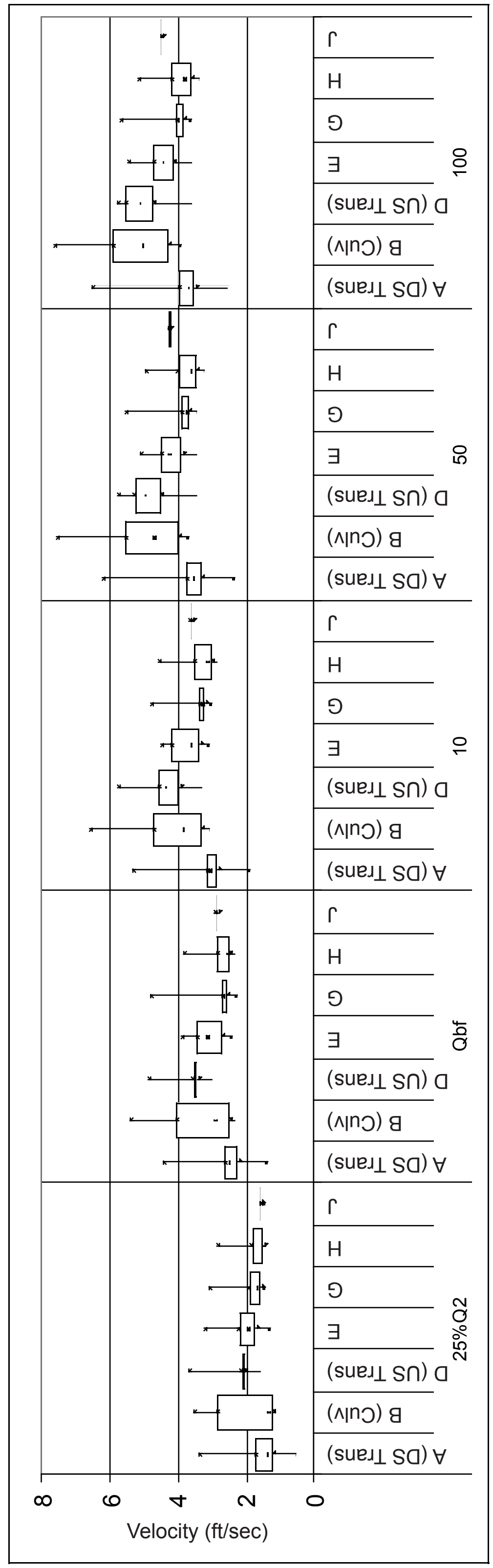


Figure 18—Velocity (channel).

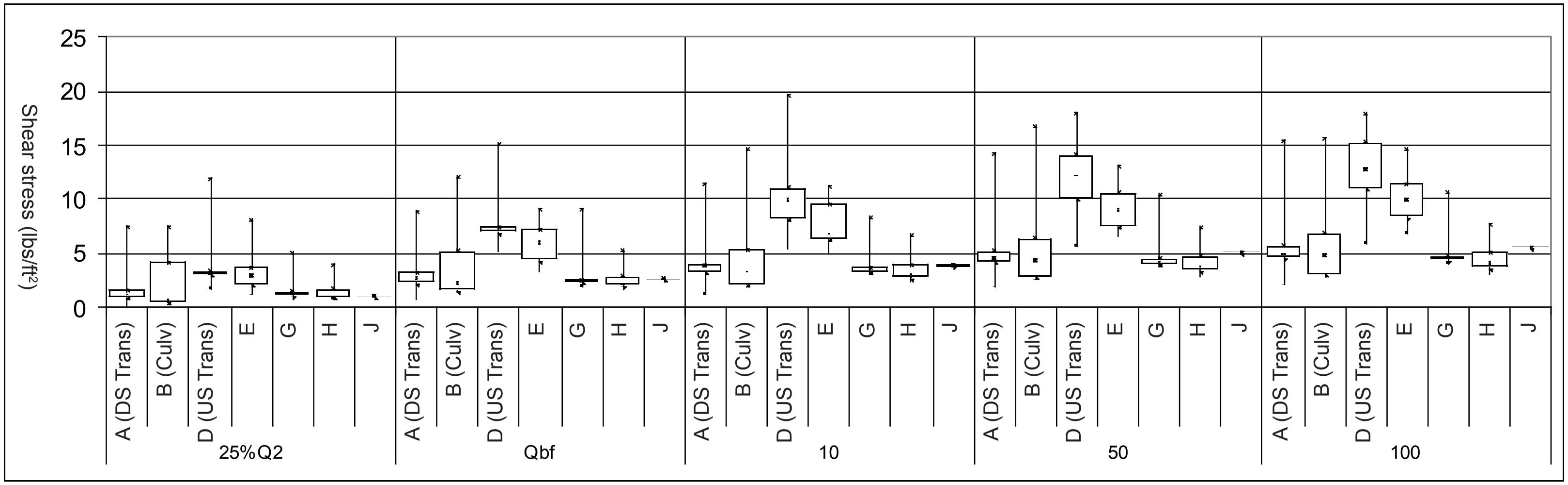
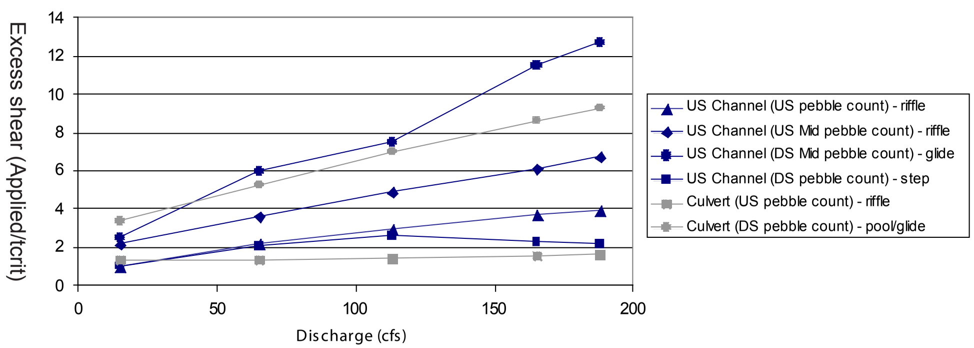


Figure 19—Shear stress (channel).



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	Riffle	0.03	Yes
	DS	Pool/glide	0.03	Yes
Upstream (2-US)	US	Riffle	0.02	
	DS	Riffle	0.02	
Upstream (1-DS)	US	Glide	0.08	
	DS	Step	0.04	

Table 4—Vertical sinuosity

Segment	Location	Vertical Sinuosity (ft/ft)
A	DS transition	1.008
B	Culvert	1.003
C	Culvert	1.013
D	US transition	1.010
E	US channel	1.009
F	US channel	1.059
G	US channel	1.003
H	US channel	1.018
I	US channel	1.011
J	US channel	1.005

Table 5—Depth distribution

Reach	XS Location	25% Q_2	Within range of channel conditions?
Culvert	US	6	Yes
	DS	0	No
Upstream (2-US)	US	23	
	DS	18	
Upstream (1-DS)	US	1	
	DS	2	

Table 6—Habitat unit composition

Reach	Percent of surface area			
	Pool	Glide	Riffle	Step
Culvert	22%	41%	38%	0%
Upstream Channel (2-US)	36%	0%	63%	1%
Upstream Channel (1-DS)	49%	0%	46%	4%

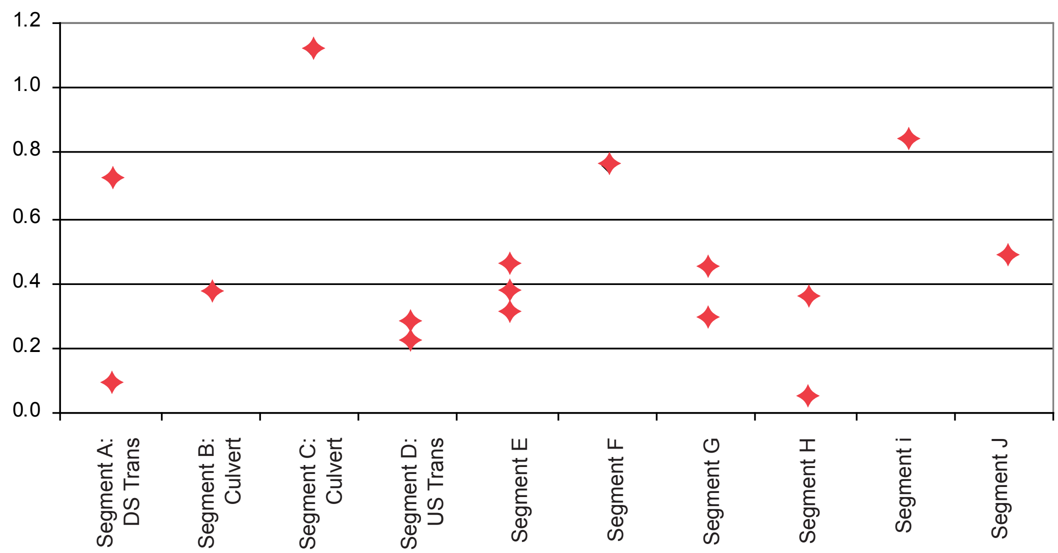


Figure 21—Residual depths.

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	Riffle	1.57	No	0.33	Yes
	DS	Pool/glide	2.02	No	0.18	Yes
Upstream (2-US)	US	Riffle	1.81		0.03	
	DS	Riffle	1.92		-0.08	
Upstream (1-DS)	US	Glide	2.01		-0.10	
	DS	Step	1.92		0.49	

Table 8. Large woody debris

Reach	Pieces/Channel Width
Culvert	0
Upstream (2-US)	1.34
Upstream (1-DS)	1.17

Terminology:

US = Upstream

DS = Downstream

RR = Reference reach

XS = Cross section

View upstream through culvert.

View downstream towards culvert inlet.

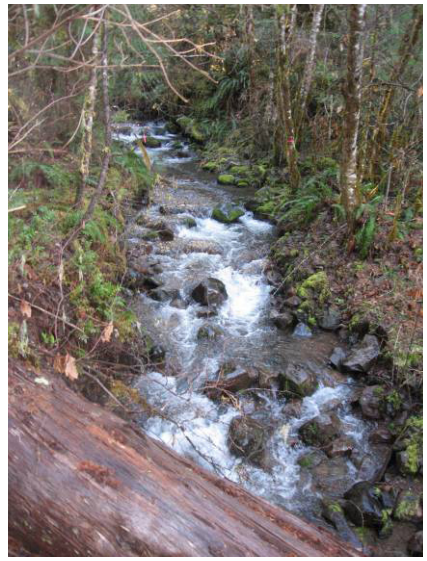
View downstream from roadway.

View upstream from roadway.

Upstream reference reach 2 (upstream).

Upstream reference reach 2 (upstream) – downstream pebble count (riffle).

Upstream reference reach 2 (upstream) – downstream pebble count (pool tail-out).



View of upstream reference reach 1 (downstream).

Upstream reference reach 1 (downstream) – downstream pebble count (step).

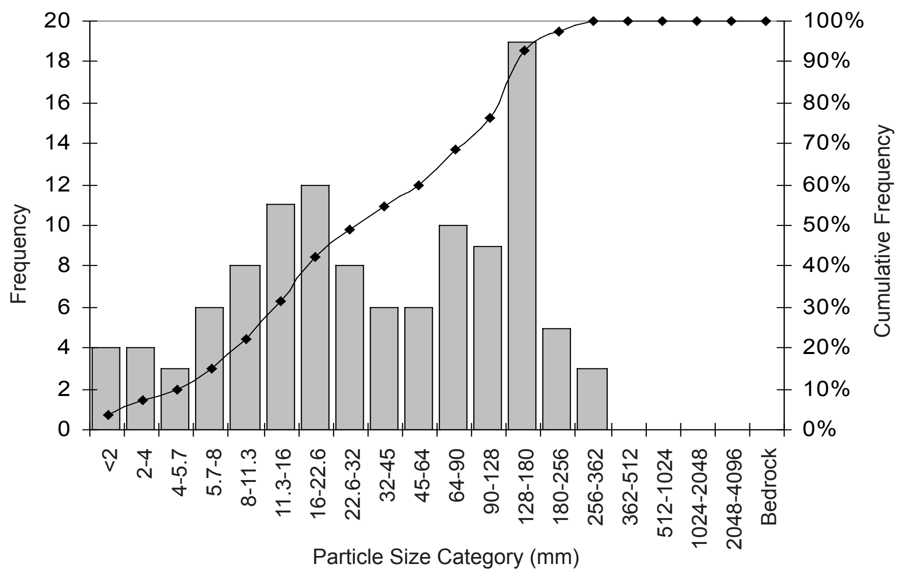
Upstream reference reach 1 (downstream) – upstream pebble count (between steps).

View downstream towards inlet.

View upstream from within culvert.

Cross Section: Upstream Reference Reach 2 – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	4	4%	4%
very fine gravel	2 - 4	4	4%	7%
fine gravel	4 - 5.7	3	3%	10%
fine gravel	5.7 - 8	6	5%	15%
medium gravel	8 - 11.3	8	7%	22%
medium gravel	11.3 - 16	11	10%	32%
coarse gravel	16 - 22.6	12	11%	42%
coarse gravel	22.6 - 32	8	7%	49%
very coarse gravel	32 - 45	6	5%	54%
very coarse gravel	45 - 64	6	5%	60%
small cobble	64 - 90	10	9%	68%
medium cobble	90 - 128	9	8%	76%
large cobble	128 - 180	19	17%	93%
very large cobble	180 - 256	5	4%	97%
small boulder	256 - 362	3	3%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



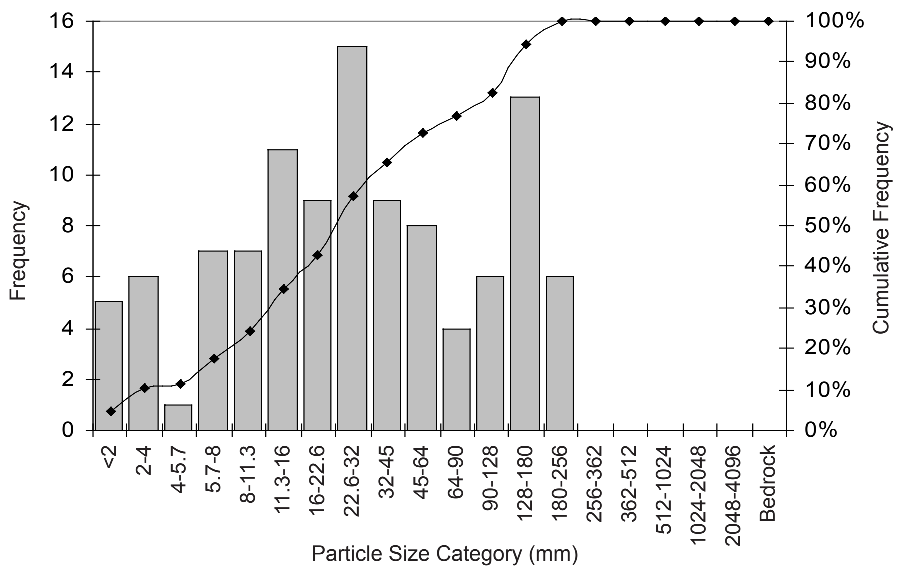
Size Class	Size percent finer than (mm)
D5	3.65
D16	10
D50	34
D84	139.6
D95	190
D100	290

Material	Percent Composition
Sand	4%
Gravel	56%
Cobble	38%
Boulder	3%
Bedrock	0%

Sorting Coefficient: 1.81
Skewness Coefficient: 0.03

Cross Section: Upstream Reference Reach 2 – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	5	5%	5%
very fine gravel	2 - 4	6	6%	10%
fine gravel	4 - 5.7	1	1%	11%
fine gravel	5.7 - 8	7	7%	18%
medium gravel	8 - 11.3	7	7%	24%
medium gravel	11.3 - 16	11	10%	35%
coarse gravel	16 - 22.6	9	8%	43%
coarse gravel	22.6 - 32	15	14%	57%
very coarse gravel	32 - 45	9	8%	65%
very coarse gravel	45 - 64	8	7%	73%
small cobble	64 - 90	4	4%	77%
medium cobble	90 - 128	6	6%	82%
large cobble	128 - 180	13	12%	94%
very large cobble	180 - 256	6	6%	100%
small boulder	256 - 362	0	0%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



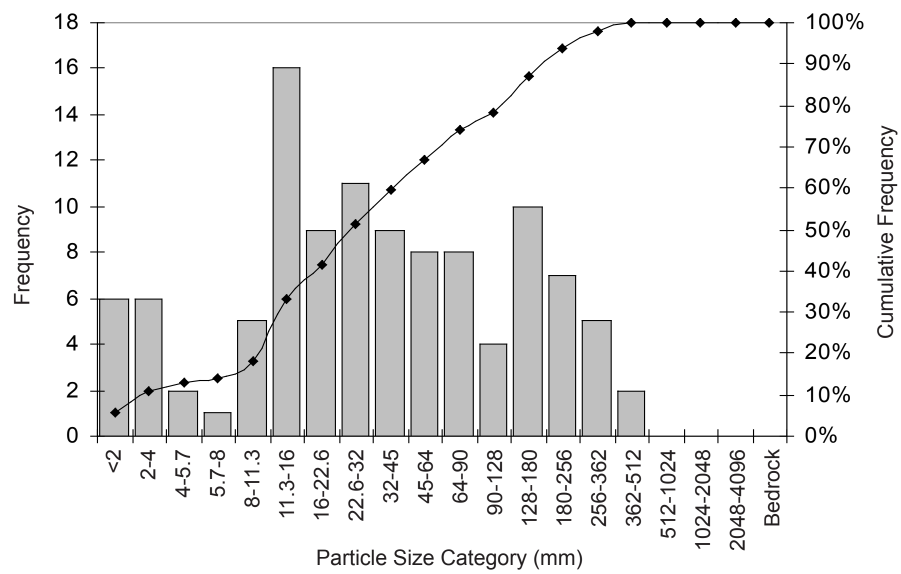
Size Class	Size percent finer than (mm)
D5	3
D16	8
D50	25
D84	130
D95	194
D100	250

Material	Percent Composition
Sand	5%
Gravel	68%
Cobble	27%
Boulder	0%
Bedrock	0%

Sorting Coefficient: 1.92
Skewness Coefficient: -0.08

Cross Section: Upstream Reference Reach 1 – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	6	6%	6%
very fine gravel	2 - 4	6	6%	11%
fine gravel	4 - 5.7	2	2%	13%
fine gravel	5.7 - 8	1	1%	14%
medium gravel	8 - 11.3	5	5%	18%
medium gravel	11.3 - 16	16	15%	33%
coarse gravel	16 - 22.6	9	8%	41%
coarse gravel	22.6 - 32	11	10%	51%
very coarse gravel	32 - 45	9	8%	60%
very coarse gravel	45 - 64	8	7%	67%
small cobble	64 - 90	8	7%	74%
medium cobble	90 - 128	4	4%	78%
large cobble	128 - 180	10	9%	87%
very large cobble	180 - 256	7	6%	94%
small boulder	256 - 362	5	5%	98%
small boulder	362 - 512	2	2%	100%
medium boulder	512 - 1024	0	0%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



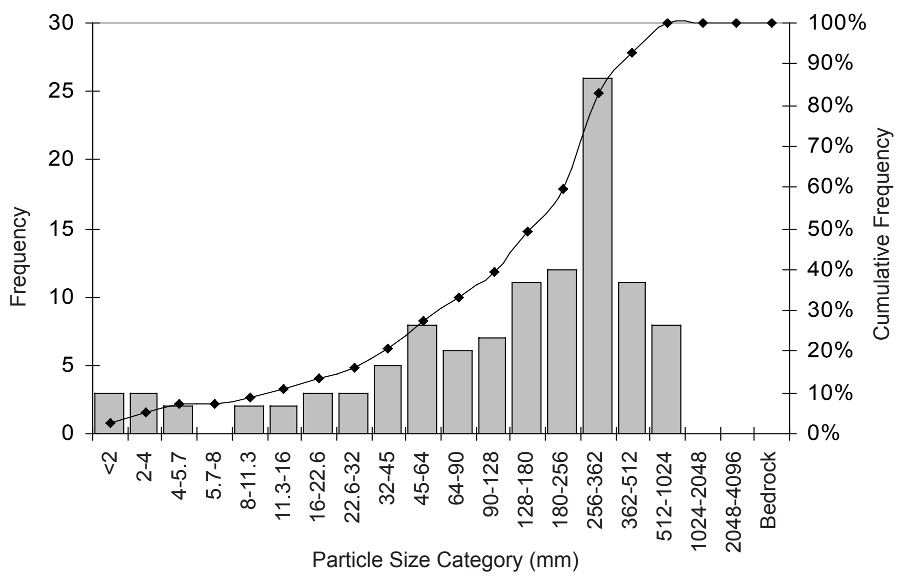
Size Class	Size percent finer than (mm)
D5	2
D16	11
D50	30
D84	160
D95	286
D100	450

Material	Percent Composition
Sand	6%
Gravel	61%
Cobble	27%
Boulder	6%
Bedrock	0%

Sorting Coefficient: 2.01
Skewness Coefficient: -0.10

Cross Section: Upstream Reference Reach 1 – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	3	3%	3%
very fine gravel	2 - 4	3	3%	5%
fine gravel	4 - 5.7	2	2%	7%
fine gravel	5.7 - 8	0	0%	7%
medium gravel	8 - 11.3	2	2%	9%
medium gravel	11.3 - 16	2	2%	11%
coarse gravel	16 - 22.6	3	3%	13%
coarse gravel	22.6 - 32	3	3%	16%
very coarse gravel	32 - 45	5	4%	21%
very coarse gravel	45 - 64	8	7%	28%
small cobble	64 - 90	6	5%	33%
medium cobble	90 - 128	7	6%	39%
large cobble	128 - 180	11	10%	49%
very large cobble	180 - 256	12	11%	60%
small boulder	256 - 362	26	23%	83%
small boulder	362 - 512	11	10%	93%
medium boulder	512 - 1024	8	7%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



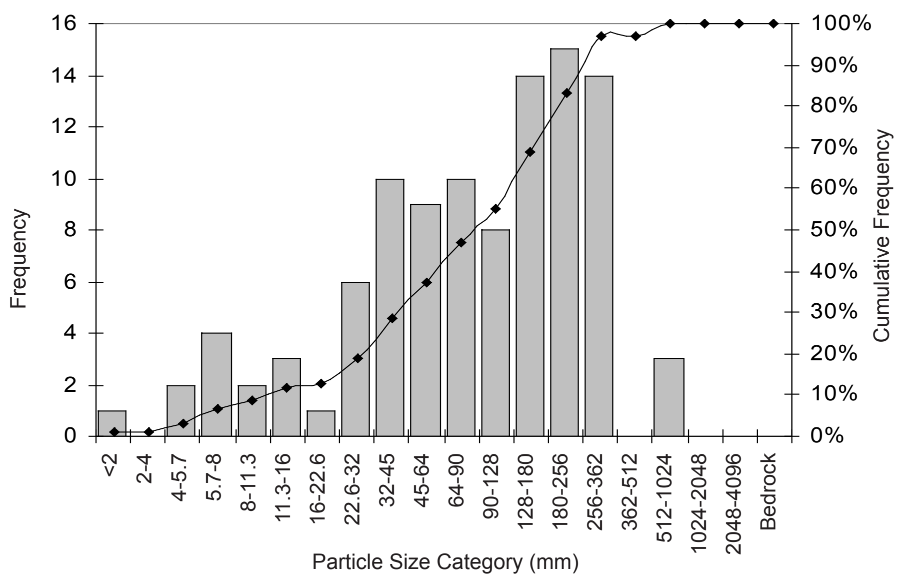
Size Class	Size percent finer than (mm)
D5	5
D16	33.8
D50	190
D84	385
D95	529
D100	560

Material	Percent Composition
Sand	3%
Gravel	25%
Cobble	32%
Boulder	40%
Bedrock	0%

Sorting Coefficient: 1.92
Skewness Coefficient: 0.49

Cross Section: Culvert – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	1	1%	1%
very fine gravel	2 - 4	0	0%	1%
fine gravel	4 - 5.7	2	2%	3%
fine gravel	5.7 - 8	4	4%	7%
medium gravel	8 - 11.3	2	2%	9%
medium gravel	11.3 - 16	3	3%	12%
coarse gravel	16 - 22.6	1	1%	13%
coarse gravel	22.6 - 32	6	6%	19%
very coarse gravel	32 - 45	10	10%	28%
very coarse gravel	45 - 64	9	9%	37%
small cobble	64 - 90	10	10%	47%
medium cobble	90 - 128	8	8%	55%
large cobble	128 - 180	14	14%	69%
very large cobble	180 - 256	15	15%	83%
small boulder	256 - 362	14	14%	97%
small boulder	362 - 512	0	0%	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%



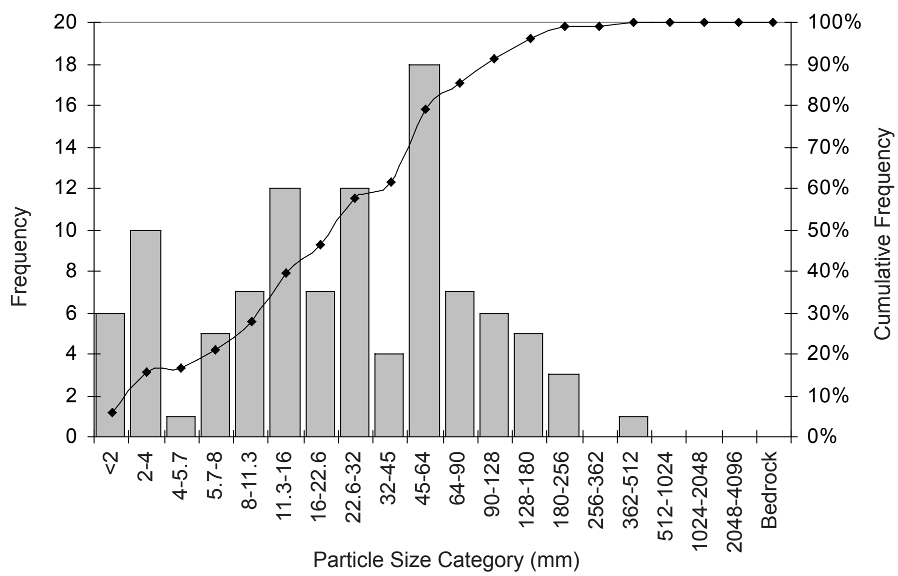
Size Class	Size percent finer than (mm)
D5	8
D16	30
D50	110
D84	258
D95	300
D100	540

Material	Percent Composition
Sand	1%
Gravel	36%
Cobble	46%
Boulder	17%
Bedrock	0%

Sorting Coefficient: 1.57
Skewness Coefficient: 0.33

Cross Section: Culvert – Downstream Pebble Count

Material	Size Range (mm)	Count	Item %	Cumulative %
sand	<2	6	6%	6%
very fine gravel	2 - 4	10	10%	15%
fine gravel	4 - 5.7	1	1%	16%
fine gravel	5.7 - 8	5	5%	21%
medium gravel	8 - 11.3	7	7%	28%
medium gravel	11.3 - 16	12	12%	39%
coarse gravel	16 - 22.6	7	7%	46%
coarse gravel	22.6 - 32	12	12%	58%
very coarse gravel	32 - 45	4	4%	62%
very coarse gravel	45 - 64	18	17%	79%
small cobble	64 - 90	7	7%	86%
medium cobble	90 - 128	6	6%	91%
large cobble	128 - 180	5	5%	96%
very large cobble	180 - 256	3	3%	99%
small boulder	256 - 362	0	0%	99%
small boulder	362 - 512	1	1%	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	1
D16	5
D50	25
D84	81
D95	159
D100	420

Material	Percent Composition
Sand	6%
Gravel	73%
Cobble	20%
Boulder	1%
Bedrock	0%

Sorting Coefficient: 2.02
Skewness Coefficient: 0.18