Yuba River
New Colgate Powerhouse Reach
Draft Hydraulic Calibration Results

Model Used

The hydraulic model for the New Colgate Powerhouse Reach PHABSIM study was calibrated by HDR using RHABSIM 3.0 (Riverine Habitat Simulation), a commercial software program written by Thomas R. Payne and Associates of Arcata, California. RHABSIM is a commercial version of the PHABSIM computer model (Milhous et al. 1984).

Model Files

The following RHABSIM files are associated with the New Colgate Powerhouse Reach:
DSNCPHR.RHB

Modeling Methods

Water Surface Elevations (WSE)

Hydraulic modeling procedures appropriate to the study site and level of data collection were used for modeling WSEs and velocities across each of the 20 cross sections comprising the study reach plus 1 additional Ramping Study transect. For WSEs, these procedures included the development of stage-discharge rating curves using Log/Log regression (IFG4), Manning's formula (MANSQ) and Step-backwater (WSP), direct comparison of results, and selection of the most appropriate and accurate method. Data file construction, calibration, and simulation followed standard procedures and guidelines outlined in Milhous et al. 1989 and Waddle 2001.

Modeling Guidelines

PHABSIM modeling guidelines considered for the New Colgate Powerhouse Reach were as follows:

- To determine whether the IFG4 model accurately predicts measured values:
    1. The beta value (a measure of the change in channel roughness with changes in streamflow) must be between 2.0 and 4.5;
    2. The mean error in calculated versus given discharges must be less than 10 percent;
    3. There must be no more than a 25 percent difference for any calculated versus given discharge; and
    4. There must be no more than a 0.1-foot difference between measured and simulated WSEs.
    5. To determine whether the MANSQ model accurately predicts measured values, the second through fourth of the above criteria must be met, and the beta value parameter

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used by MANSQ must be within the range of 0.0 to 0.5. The first IFG4 criterion is not applicable to MANSQ.

6. To determine accuracy of predictions of the WSP model, model predicted water surfaces are compared to field measured values across all measured flows. Manning's N values should be consistent between transects within a study site.

Habitat Summary for New Colgate Powerhouse Reach

A hydraulic model was developed for the 20 Instream flow transects, plus 1 additional ramping transect, for a total of 21 transects on the New Colgate Powerhouse Reach on the Yuba River above Englebright Reservoir. Meso-habitats represented in this reach are presented in Table 1. Final transect locations are presented in Figure 1.

Table 1. Habitat frequency based on video-mapped data and target transects for the New Colgate Powerhouse Reach of the Yuba River.

PHABSIM Habitat	Number	Number Frequency	Potential # Target Transects
High gradient riffles	0	0%	0
Low gradient riffles	4	12%	3
Runs/Step-Runs	6	18%	3
Glides	4	12%	2
Pocket Water	0	0%	0
Pools	11	33%	5
Rapids	8	24%	4
Total	**33**	**100%**	**17**[1]

[1] The transect target is based on mesohabitat, but does not take into account of differences between mesohabitats. While the target number is the baseline goal, additional transects were selected to more accurately represent the variability within the reach.

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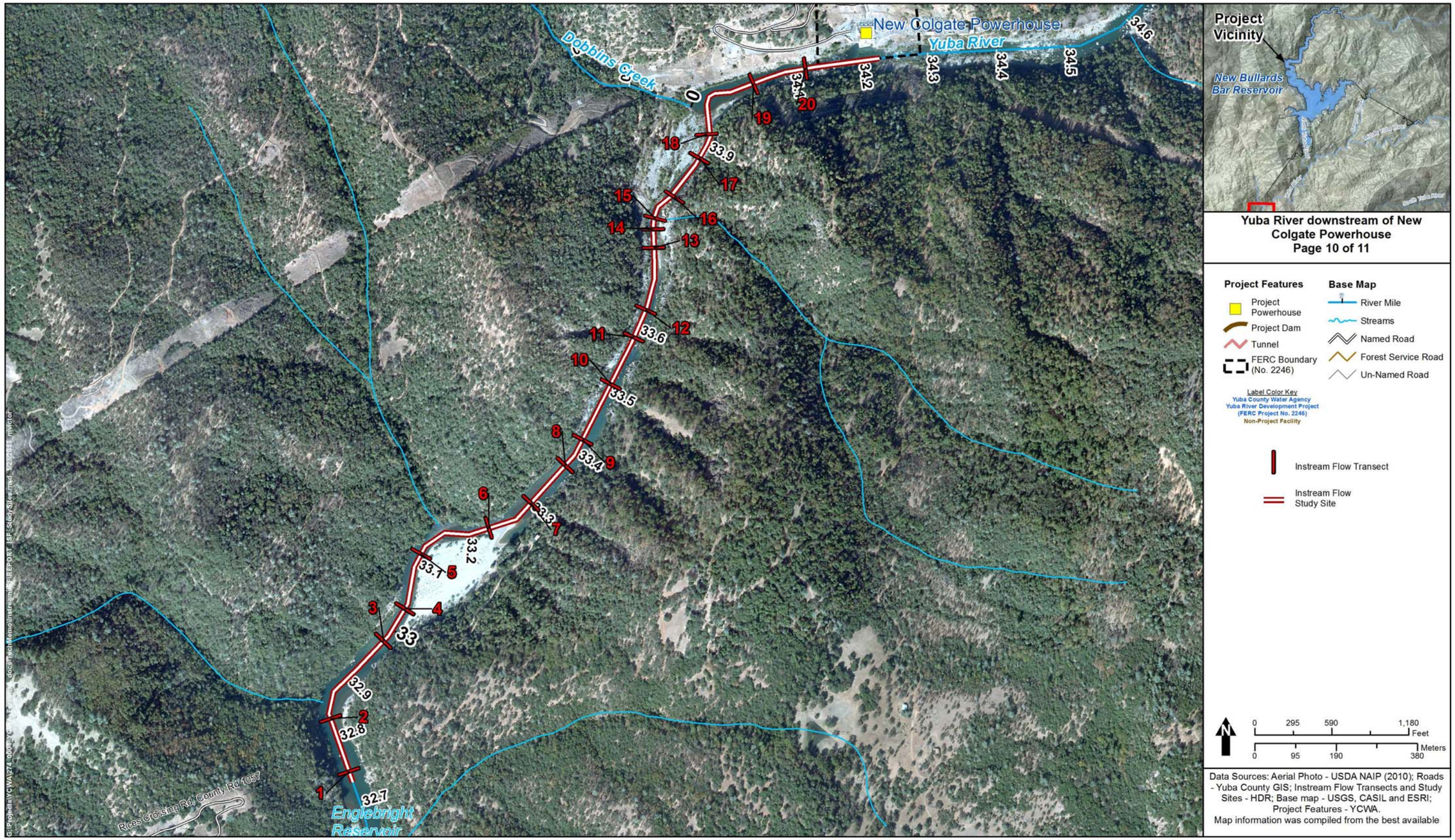

Figure 1. PHABSIM transects in the New Colgate Powerhouse Reach.

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Calibration Summary for New Colgate Powerhouse Reach

The New Colgate model was associated with a four stage discharge pairs, and primary velocity calibration set at full channel flow of 3749 cubic feet per second (cfs). When velocities couldn't be safely measured at 3749 cfs, they were measured at 1529 cfs, 640 cfs, or even 253 cfs. Each transect in the site had one velocity set measured, which is consistent with the "one-velocity" method.

Stage/discharge regressions were developed using four main channel calibration discharges: 3749 cfs, 1529 cfs 640 cfs and 253 cfs. Table 2 summarizes modeling statistics for each transect and modeling method, while Table C-1, in Appendix C, summarize the given calibration stage and the modeled stages for each flow, at each transect, using all modeling methods used on a given transect.

Cross Sections

One limitation of 1D hydraulic flow models is that a single water surface must be used for the entirety of each transect at a given flow. When a transect involves more than one significantly different water surface, RHABSIM will over-or underwater parts of the transect, depending on what water surface elevation is used. In order to create the most realistic representation of wetted area and water depths, two transects had part of their bed shifted. The perched pool/backwater on the right bank ascending of Transect T-06 and T-R3 were lowered. Also, at the highest simulation discharge (i.e., 9372 cfs), two transects, T-11 and T-12 had water surfaces slightly higher than the measured topography. Additional stations, based on the nearby slope, were added to increase the bank height on these two transect to prevent overbank flow at the highest simulated flow. Detailed notes describing overbank conditions at each transect and the addition of topographic stations have been included in Appendix B. Cross sectional profiles with measured WSEs have been included in Appendix A.

Calibration Details for New Colgate Powerhouse Reach

Stage/Discharge Calibration

- All transects in the study site were calibrated using both Log/Log and MANSQ.
- 4 groups of transects were modeled using WSP. These groups generally represented pool and run dominated sections of the reach.
  - T-01 to T-04
  - T-07 to T-10
  - T-16 to T-17
  - T-19 to T-20
- For model calibration, WSEs were selected within the range of field collected data only.

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- The water surface longitudinal profile, cross-sectional geometry and a realistic rating curve fit were considered when choosing the primary modeling method.
- WSP was selected on T-01 to T-04, T07 to T10, T-16 to T-17, and T-19 to T-20, with log/log stage elevations entered for the most downstream transect of each group.
- MANSQ was selected as the primary calibration method on T-05 and T-14, based on the modeling guidelines outlined above.
- All Log/Log betas were between 2.0 and 4.5, except for T-07, T-08, T-09 and T-10.
  - T-07 had Log/Log beta of 1.85, but had a much lower mean error than MANSQ, so was used for calibrating Step-Backwater on T-07 through T-10
- All transects but one had MANSQ betas inside the range of 0.0 to 5.0.
  - T-07's beta = -0.286. A negative beta value is typically indicative of a riffle with high gradient
- 18 out of 21 MANSQ mean errors were less than 10 percent, and the only transects selected for MANSQ, T-05 and T-14, the errors were less than 3.8 percent.
- Both MANSQ and Log/Log mean errors can be seen in Table 2. No mean error values are available for the WSP routine. Refer to Table C-1 and C-2 in the Appendix for a comparison of measured versus modeled WSEs.
- All calculated discharges were within 10 percent of given discharges.
- Velocity measurements were modeled at the highest flow possible for each transects.
  - High-High Flow: T-01 to T-05, T-07 to T-12, T-16, and T-19 to T-20.
  - High Flow: T-14, T-15, and T-18
  - Mid Flow: T-06 and T-13
  - Low Flow: T-17
  - None: T-R3

    T-R3 was selected only for the ramping study. Velocities were not collected at any calibration flow.

Table 2. Percent Mean Error for Stage/Discharge Relationships[1].

	T-20	T-19	T-18	T-17	T-16	T-15	T-14	T-13	T-12	T-11	T-10
Log/Log	5.538	5.273	1.679	1.042	5.143	2.584	1.136	1.257	2.537	1.606	5.225
MANSQ	8.508	7.811	2.576	4.977	6.312	4.791	3.214	6.736	4.876	12.611	7.185
MANSQ BETA	0.563	0.572	0.081	0.313	0.322	0.398	0.371	0.256	0.193	0.133	0.426
Log/Log	4.623	5.036	5.103	3.692	10.710	3.407	5.660	3.852	1.096	1.435	
MANSQ	6.405	6.602	29.719	4.631	14.631	3.137	1.968	6.207	7.038	4.991	
MANSQ BETA	0.425	0.330	-0.286	0.174	0.294	0.471	0.3721	0.102	0.489	0.357	

[1] Mean error not available for the WSP routine in RHABSIM.

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Velocity Calibration

All transect velocity measurements were collected at the highest target flow possible for that transect. Limiting physical parameters included deep swift water to deep to safely wade or deep water with entrained air which limited ADCP data collection.

- Velocity measurements were modeled at the highest flow possible for each transect.
  - High-High Flow (3749 cfs): T-01 through T-05, T-07 through T-12, T-16, T-19, and T-20.
  - High Flow (1529 cfs): T-14, T15, and T-18
  - Mid Flow (640 cfs): T-06 and T-13
  - Low Flow (253 cfs): T-17

Table 3, Table 4 and Table 5 provide the velocity adjustment factor (VAF) for each calibration flow on each transect. VAF is the index of the difference between the requested simulation discharge and computed discharge derived from the velocity simulations (Waddle 2001). These velocity adjustments are used to prevent the model from over or under estimating the discharge at flows other than the velocity calibration discharge. Graphical representations of this can be found in Figure 2, Figure 3 and Figure 4.

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Table 3. Velocity adjustment factors (VAF).

Transect	1			Transect	2			Transect	3 (R1)		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
92.84	101.2	968.98	0.1044	92.83	101.2	1672.17	0.0605	92.81	101.2	273	0.3707
93.39	253	1203.04	0.2103	93.39	253	1887.37	0.134	93.4	253	440.8	0.574
94.22	640	1625.72	0.3937	94.24	640	2245.59	0.285	94.3	640	810.3	0.7898
95.37	1529	2328.31	0.6567	95.43	1529	2806.02	0.5449	95.59	1529	1627.95	0.9392
97.1	3749	3616.77	1.0366	97.24	3749	3773.14	0.9936	97.57	3749	3787.18	0.9899
99.71	9372.5	6021.94	1.5564	99.98	9372.5	5466.58	1.7145	100.64	9372.5	8901.58	1.0529
Transect	**4**			**Transect**	**5**			**Transect**	**6 (R2)**		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
92.66	101.2	692.02	0.1462	93.84	101.2	1547.29	0.0654	96.74	101.2	266.98	0.3791
93.47	253	1002.15	0.2525	94.64	253	1797.54	0.1407	97.41	253	442.72	0.5715
94.59	640	1508.16	0.4244	95.77	640	2187.44	0.2926	98.27	640	725.44	0.8822
96.01	1529	2271.12	0.6732	97.22	1529	2756.44	0.5547	99.27	1529	1151.61	1.3277
97.98	3749	3533.84	1.0609	99.25	3749	3696.7	1.0141	100.57	3749	1939.91	1.9326
100.72	9372.5	5667.72	1.6537	102.11	9372.5	5303.98	1.7671	102.25	9372.5	3490.42	2.6852
Transect	**R3**			**Transect**	**7**			**Transect**	**8**		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
96.79	101.2	152.74	0.6625	89.87	101.2	446.13	0.2268	89.78	101.2	816.51	0.1239
97.57	253	322	0.7857	90.38	253	652.75	0.3876	90.45	253	1114.09	0.2271
98.63	640	684.39	0.9351	91.23	640	1092.64	0.5857	91.45	640	1632.91	0.3919
99.93	1529	1412.61	1.0824	92.54	1529	1965.92	0.7778	92.78	1529	2459.47	0.6217
101.69	3749	2965.44	1.2642	94.7	3749	3892.96	0.963	94.69	3749	3883.65	0.9653
104.06	9372.5	6119.84	1.5315	98.32	9372.5	8239.8	1.1375	97.44	9372.5	6373.5	1.4705

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Table 4. Velocity adjustment factors (cont.)

Transect	9			Transect	10			Transect	11		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
89.88	101.2	1337.73	0.0757	89.79	101.2	1764.88	0.0573	85.79	101.2	106.78	0.9478
90.42	253	1545.54	0.1637	90.43	253	1977.73	0.1279	86.74	253	326.14	0.7757
91.32	640	1926.03	0.3323	91.51	640	2348.65	0.2725	88.04	640	864.05	0.7407
92.72	1529	2584.45	0.5916	93.01	1529	2909.82	0.5255	89.69	1529	1891.73	0.8083
95.06	3749	3879.66	0.9663	95.19	3749	3799.58	0.9867	91.98	3749	3874.55	0.9676
99.01	9372.5	6421.22	1.4596	98.24	9372.5	5204.34	1.8009	95.15	9372.5	7547.53	1.2418
Transect	**12**			**Transect**	**13 (R4)**			**Transect**	**14**		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
86.41	101.2	337.58	0.2998	89.26	101.2	237.39	0.4263	90.8	101.2	539.16	0.1877
87.26	253	591.04	0.4281	89.98	253	363.93	0.6952	91.45	253	735.18	0.3441
88.54	640	1093.02	0.5855	91	640	645.83	0.991	92.38	640	1069.48	0.5984
90.28	1529	2016.1	0.7584	92.31	1529	1243.3	1.2298	93.59	1529	1595.49	0.9583
92.89	3749	3874.77	0.9675	94.16	3749	2439.81	1.5366	95.33	3749	2497.37	1.5012
96.78	9372.5	7615.58	1.2307	96.77	9372.5	4728.72	1.982	97.83	9372.5	4063.73	2.3064
Transect	**15**			**Transect**	**16 (R5)**			**Transect**	**17 (R6)**		
WSL	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**	**WSL**	**Calibration Flow**	**Calculated Flow**	**VAF**
90.74	101.2	513.13	0.1972	90.68	101.2	485.08	0.2086	90.54	101.2	140.64	0.7196
91.66	253	698.85	0.362	91.54	253	793.91	0.3187	91.48	253	213.08	1.1873
92.89	640	980.89	0.6525	92.76	640	1357.26	0.4715	92.8	640	341.35	1.8749
94.42	1529	1383.84	1.1049	94.34	1529	2302.57	0.664	94.48	1529	547.08	2.7948
96.55	3749	2044.94	1.8333	96.55	3749	4004.79	0.9361	96.73	3749	909.28	4.123
99.25	9372.5	3080.03	3.043	99.6	9372.5	7003.24	1.3383	99.69	9372.5	1557.33	6.0183

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Table 5. Velocity adjustment factors (cont.)

Transect	18 (R7)			Transect	19			Transect	20		
WSL	Calibration Flow	Calculated Flow	VAF	WSL	Calibration Flow	Calculated Flow	VAF	WSL	Calibration Flow	Calculated Flow	VAF
94.96	101.2	206.49	0.4901	94.03	101.2	1739.65	0.0582	93.97	101.2	1456.67	0.0695
95.62	253	383.12	0.6604	94.5	253	1975.73	0.1281	94.47	253	1640.28	0.1542
96.65	640	761.39	0.8406	95.15	640	2330.64	0.2746	95.19	640	1920	0.3333
98.15	1529	1542.45	0.9913	96	1529	2828.85	0.5405	96.13	1529	2316.41	0.6601
100.51	3749	3301.53	1.1355	97.18	3749	3604.1	1.0402	97.5	3749	2938.09	1.276
104.25	9372.5	7256.76	1.2916	98.85	9372.5	4841.5	1.9359	99.46	9372.5	3927.99	2.3861

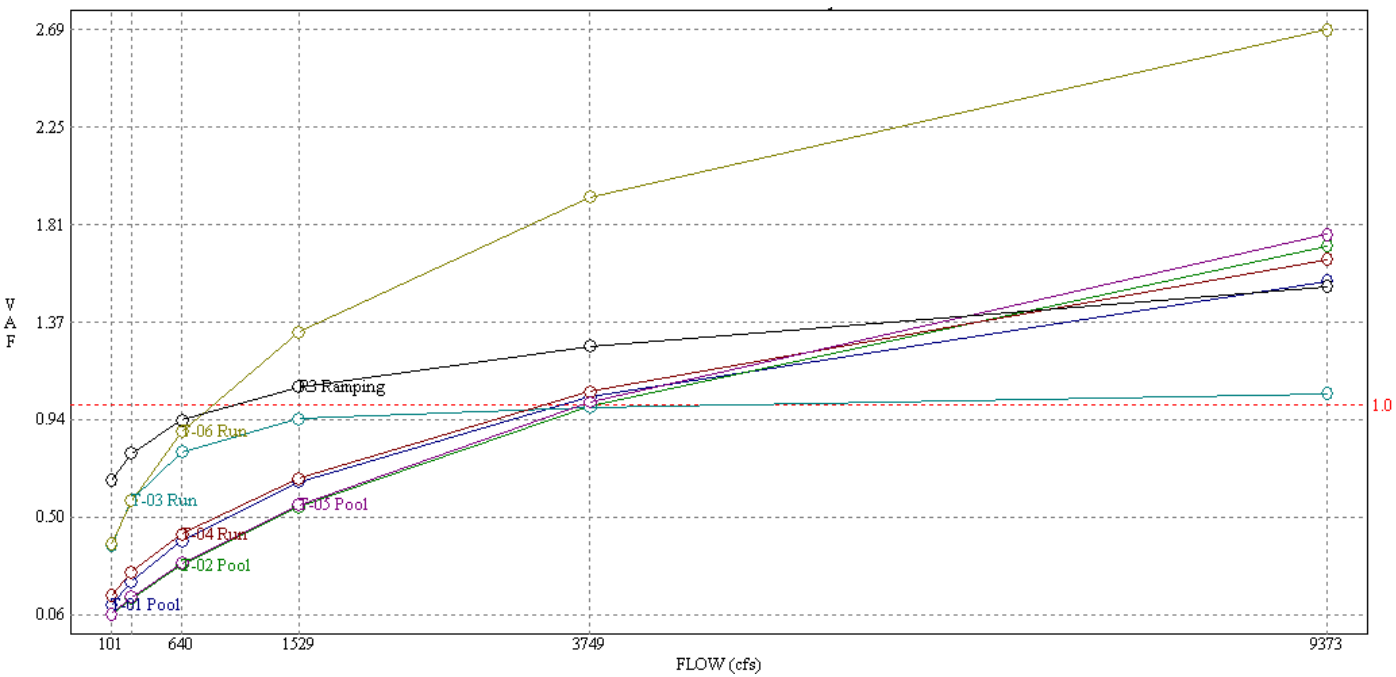

Figure 2. Velocity adjustment factor by Flow (T-01 to T-06, plus T-R3)

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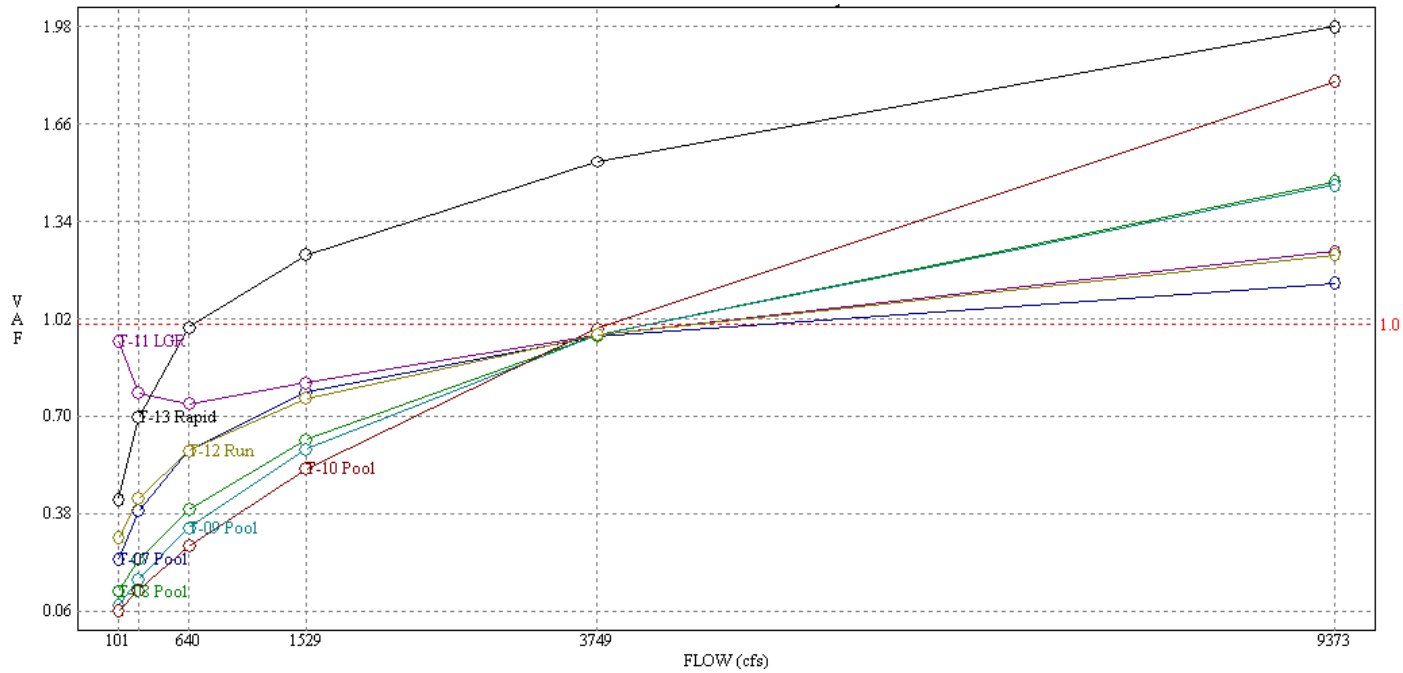

Figure 3. Velocity adjustment factor by Flow (T-07 to T-13(R4))

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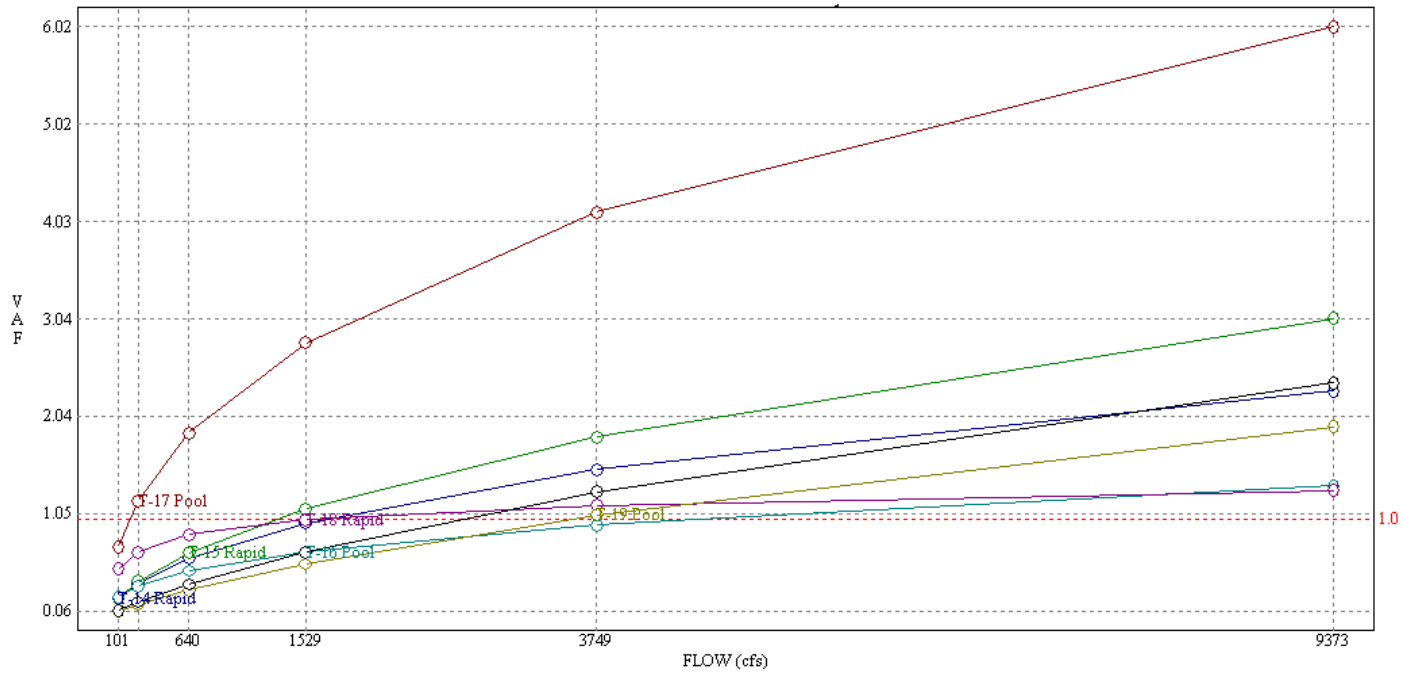

Figure 4. Velocity adjustment factor by Flow (T-14 to T-20)

Target Discharge and Field Discharge

Discharge, like water surface elevation, is used to calibrate stage/discharge relationships in the PHABSIM hydraulic models. Modeled discharges used in the Log/Log and MANSQ routines were modified slightly from best estimates to improve model calibration. Discharge selections were within the range of flows observed during data collection if the average discharge for the day was not used. Average daily discharge calculated from all field measurements are summarized below in Table 6.

Table 6. Target and measured flows for the New Colgate Powerhouse Reach.

Transect	Type	Discharge							
		Low - Target 100 cfs		Mid - Target 600 cfs		High - Target 1,570 cfs		High High - Target 3,260 cfs	
		Measured (cfs)	Method	Measured (cfs)	Method	Measured (cfs)	Method	Measured (cfs)	Method
1	Pool	--	--	--	--	--	--	3629	ADCP/ Swoffer
2	Pool	--	--	--	--	--	--	3795	ADCP/ Swoffer
3(R1)	Run	--	--	--	--	--	--	3738	ADCP/ Swoffer
4	Run	--	--	--	--	--	--	3376	ADCP/ Swoffer
5	Pool	--	--	--	--	--	--	3766	ADCP/ Swoffer
6(R2)	Run	--	--	689	ADCP/ Swoffer	--	--	--	--
7	Pool	--	--	--	--	--	--	3669	ADCP/ Swoffer
8	Pool	--	--	--	--	--	--	3877	ADCP/ Swoffer
9	Pool	--	--	--	--	--	--	3755	ADCP/ Swoffer
10	Pool	--	--	--	--	--	--	3802	ADCP/ Swoffer
11	LGR	--	--	--	--	--	--	3726	ADCP/ Swoffer
12	Run	--	--	--	--	--	--	3746	ADCP/ Swoffer
13(R4)	Rapid	--	--	640	ADCP/ Swoffer	--	--	--	--
14	Rapid	--	--	--	--	2005	ADCP/ Swoffer	--	--
15	Rapid	--	--	--	--	1399	ADCP/ Swoffer	--	--
16(R5)	Pool	--	--	--	--	--	--	3848	ADCP/ Swoffer
17(R6)	Pool	261	Swoffer	--	--	--	--	--	--
18(R7)	Rapid	--	--	--	--	1659	ADCP/ Swoffer	--	--
19	Pool	--	--	--	--	--	--	3635	ADCP/ Swoffer

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Table 6. (continued)

Transect	Type	Discharge							
		Low - Target 100 cfs		Mid - Target 600 cfs		High - Target 1,570 cfs		High High - Target 3,260 cfs	
		Measured (cfs)	Method	Measured (cfs)	Method	Measured (cfs)	Method	Measured (cfs)	Method
20	Pool	--	--	--	--	--	--	N/A	--
Q1	Below T-19	214.0	Swoffer	--	--	--	--	--	--
Q2	Below T-19	265.0	Swoffer	--	--	--	--	--	--
Q3	Below T-19	230.0	Swoffer	--	--	--	--	--	--
Q4	Below T-19	260.0	Swoffer	--	--	--	--	--	--
Q5	Below T-19	197.0	Swoffer	--	--	--	--	--	--
Q6	Below T-19	250.0	Swoffer	--	--	--	--	--	--
Q7	Below T-17	231.0	Swoffer	--	--	--	--	--	--
Q8	Below T-17	291.0	Swoffer	--	--	--	--	--	--
Q9	Below T-17	443.0	Swoffer	--	--	--	--	--	--
Q10	Below T-17	422.0	Swoffer	--	--	--	--	--	--
Q11	Below T-17	286.0	Swoffer	--	--	--	--	--	--
Given Flow Averages using best transects		**253**	(Q1 to Q4, Q6(R2) to Q8, and Q11)	**640**	(T-13(R4))	**1529**	(T-15 and T-18(R7))	**3749**	(T-01 to T-03(R1), T-05, T-07 to T-12, T-16(R5), and T-19)

References

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Appendix A
New Colgate Powerhouse Reach Cross Sectional Profiles and Photos

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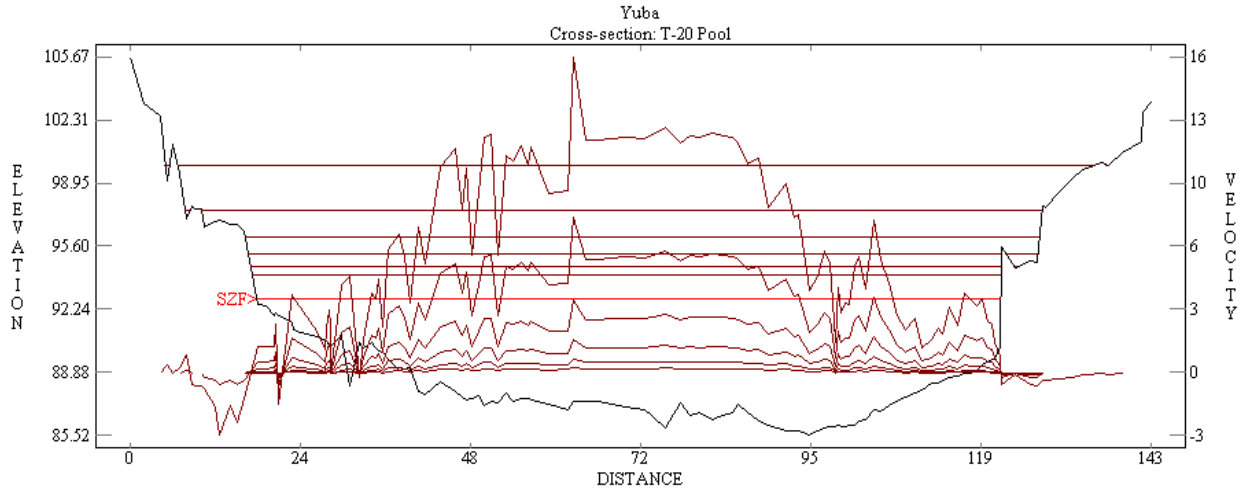

Figure A-1. Transect 20 (Pool).

Figure A-2. Transect 20-right bank to left bank at High Flow (1529 cfs).

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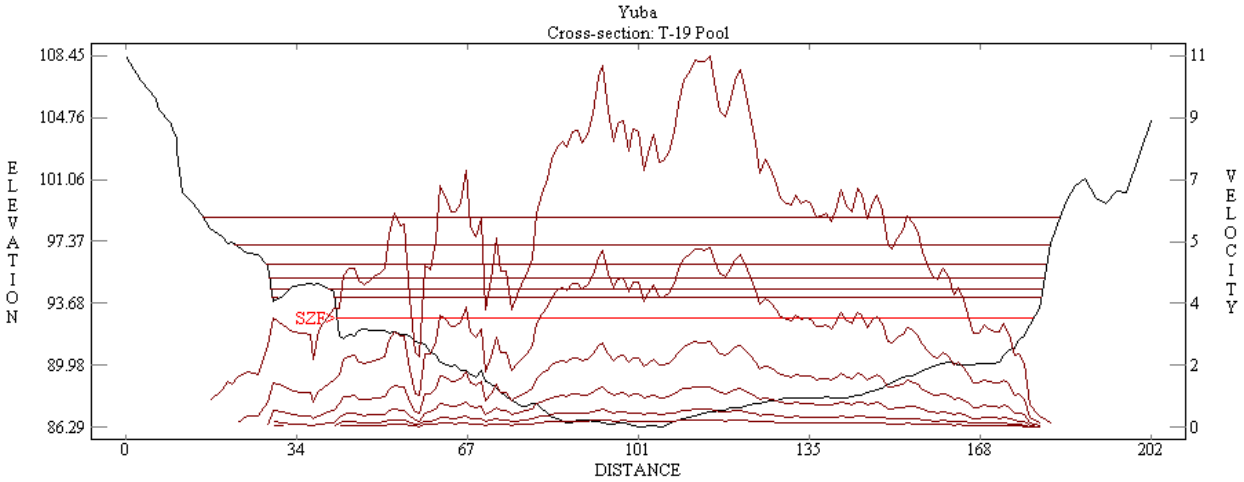

Figure A-3. Transect 19 (Pool).

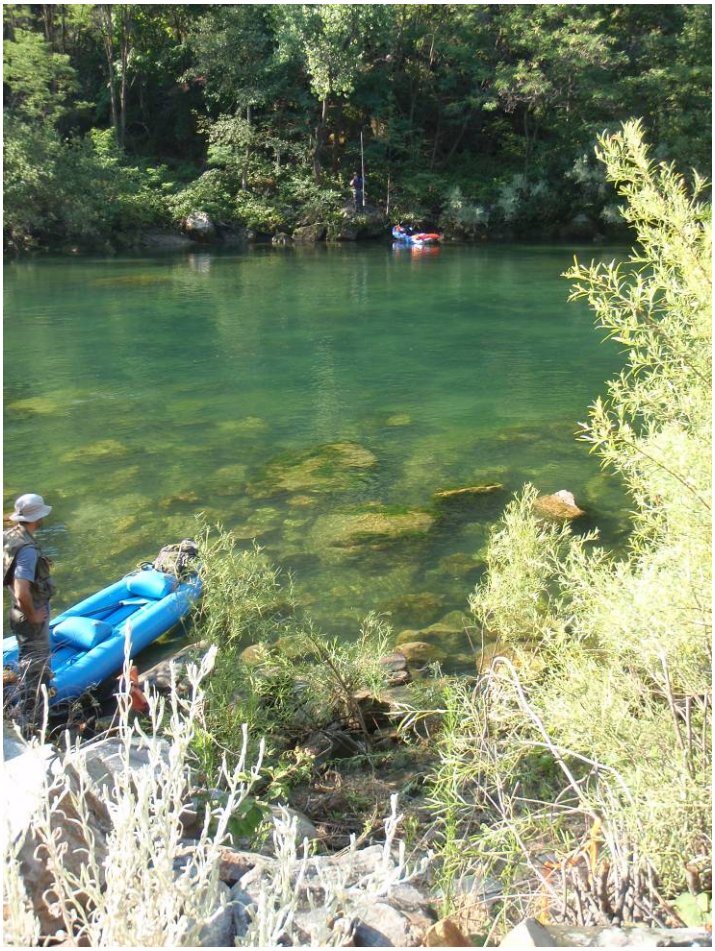

Figure A-4. Transect 19-looking right bank to left bank at Mid Flow (640 cfs).

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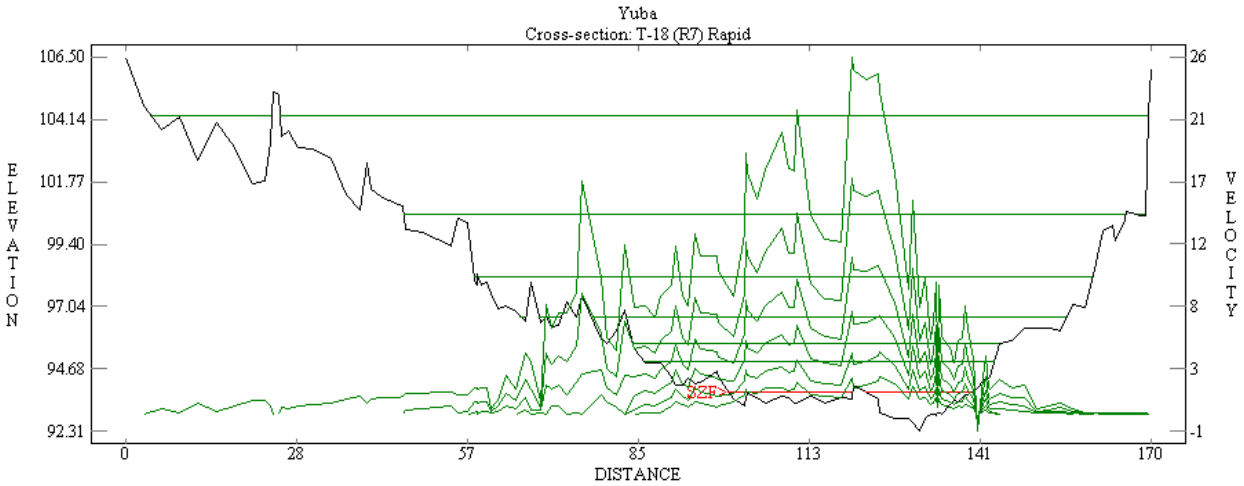

Figure A-5. Transect 18 (R7) (Rapid)

Figure A-6. Transect 18 (R7)-looking left bank to right bank at High Flow (~1500 cfs).

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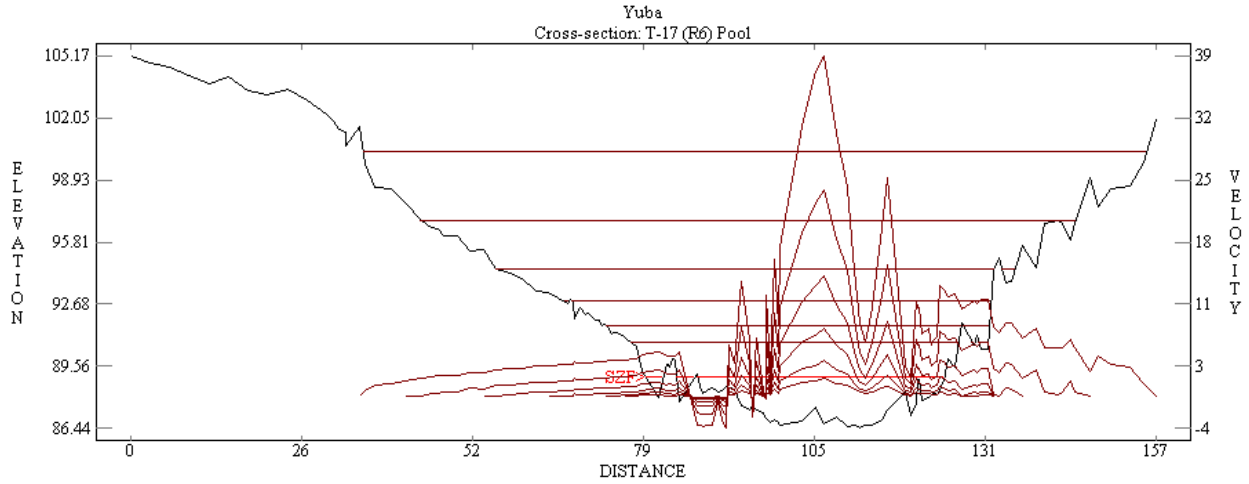

Figure A-7. Transect 17 (R6) (Pool)

Figure A-8. Transect 17 (R6)-looking from right to left at High Flow (~1,500 cfs)

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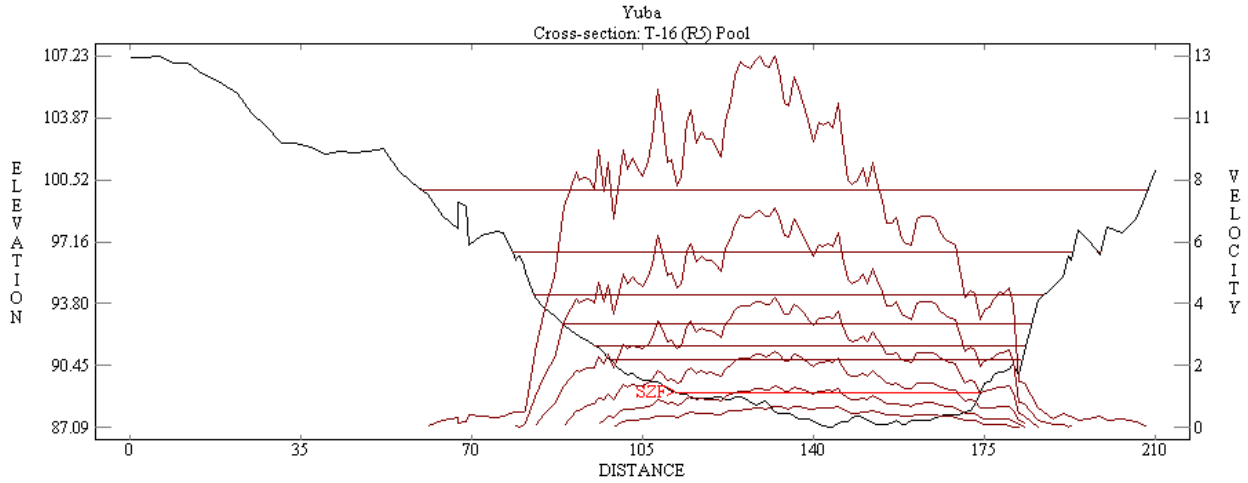

Figure A-9. Transect 16 (R5) (Pool)

Figure A-10. Transect 16 (R5)-looking from left bank towards right bank at Low Flow (253 cfs)

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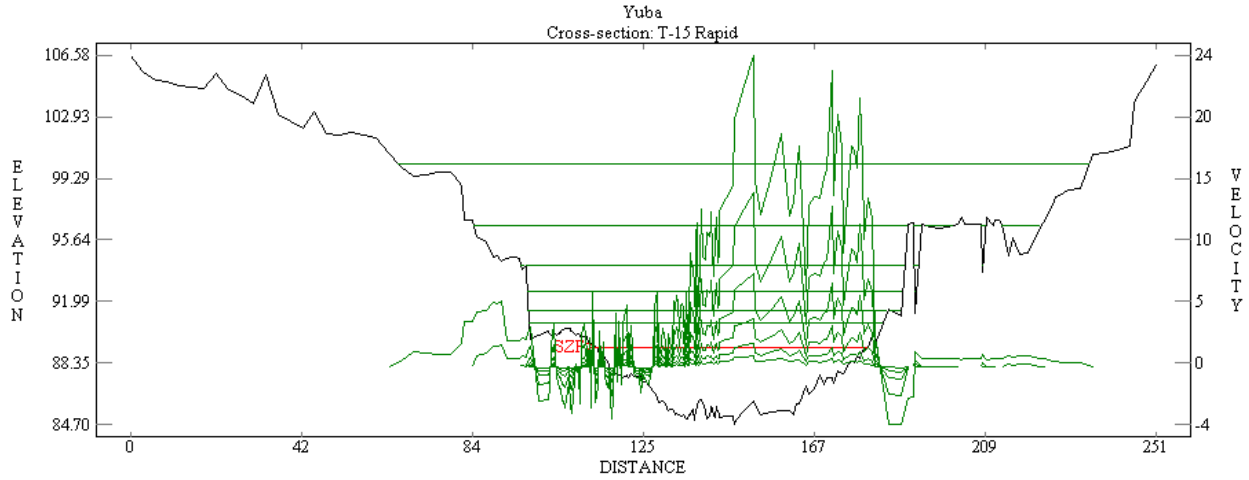

Figure A-11. Transect 15 (Rapid)

Figure A-12. Transect 15-looking from left bank towards right bank at High Flow (1529 cfs)

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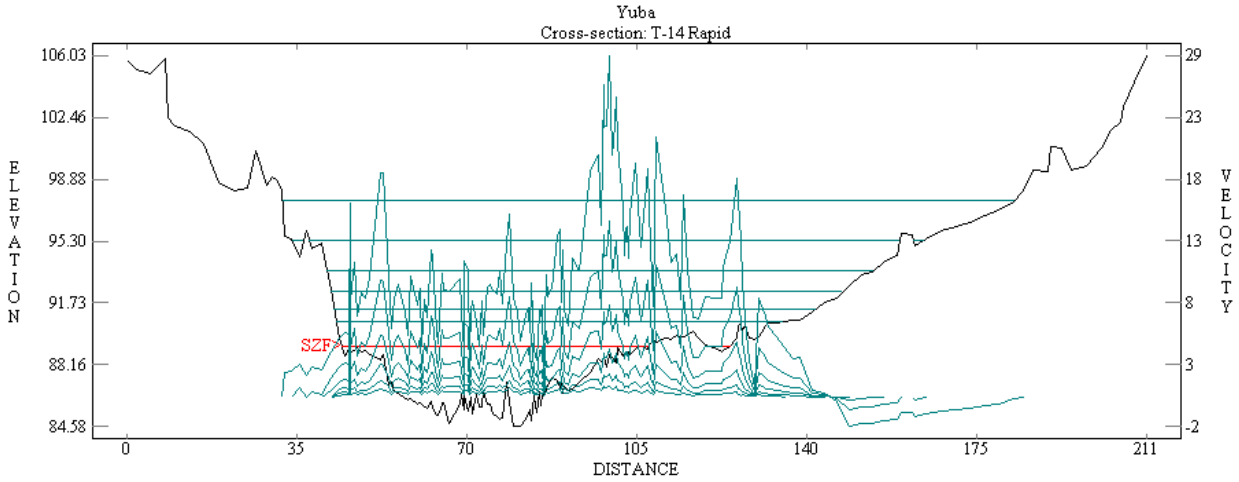

Figure A-13. Transect 14 (Rapid)

Figure A-14. Transect 14-looking from left bank towards right bank at High Flow (1529 cfs)

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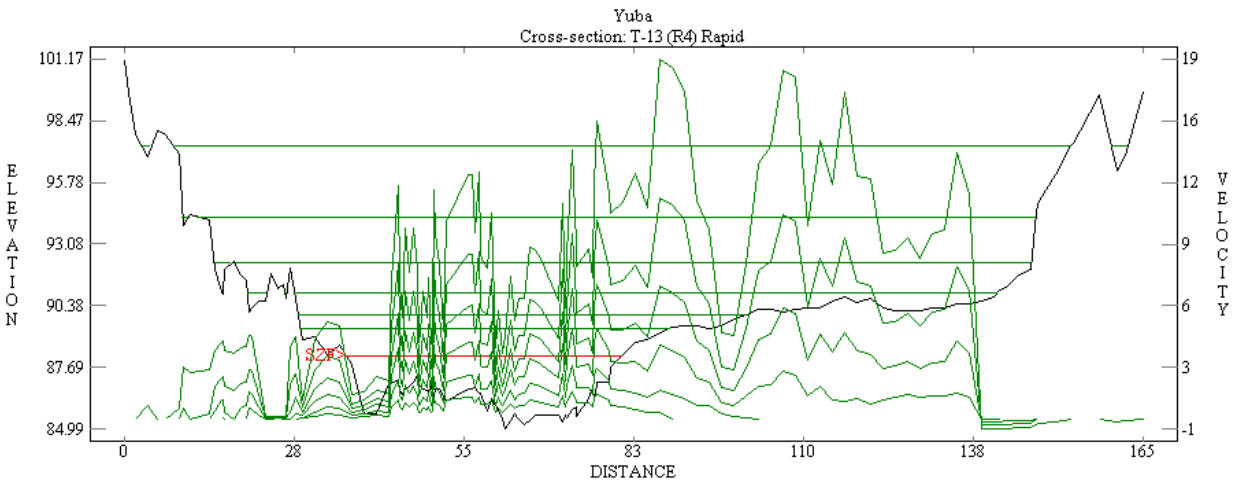

Figure A-15. Transect 13 (R4) (Rapid)

Figure A-16. Transect 13 Right-looking from left bank to right bank at High Flow (1529 cfs)

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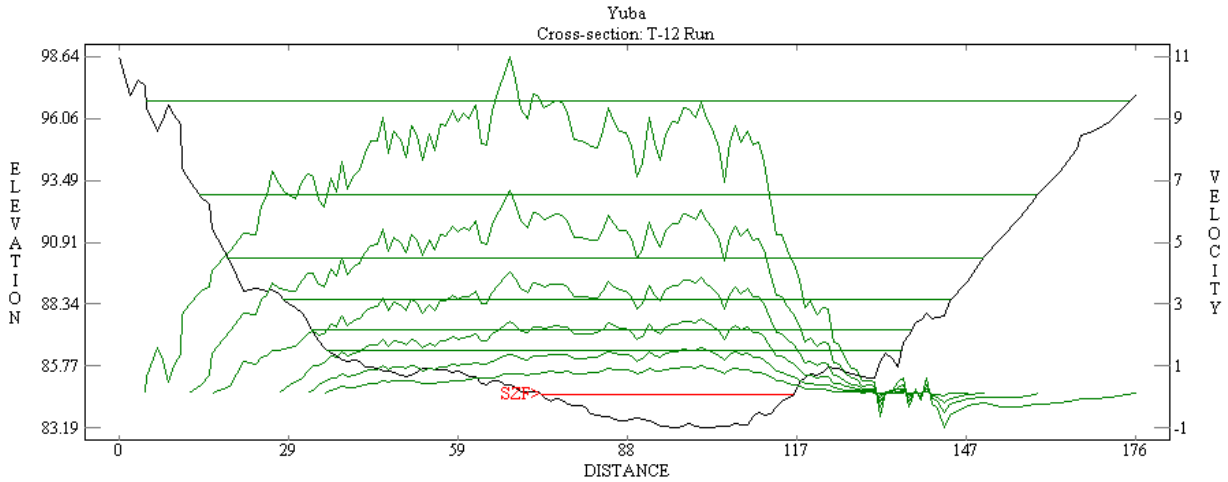

Figure A-17. Transect 12 (Run)

Figure A-18. Transect 12-looking from left bank towards right bank at Low Flow (253 cfs)

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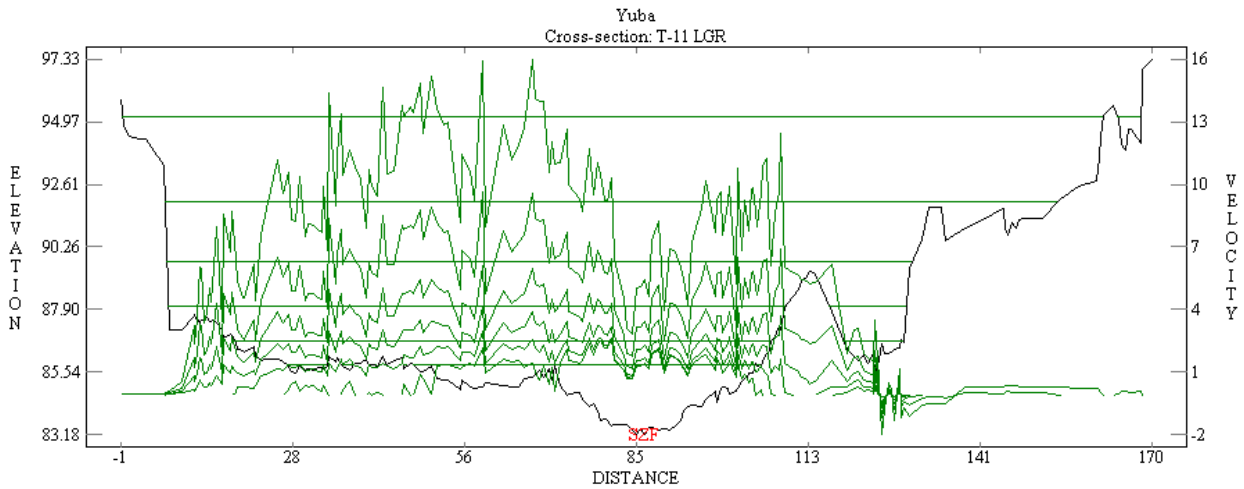

Figure A-19. Transect 11 (Low gradient riffle)

Figure A-20. Transect 11-looking from left bank towards right bank at Low Flow (253 cfs)

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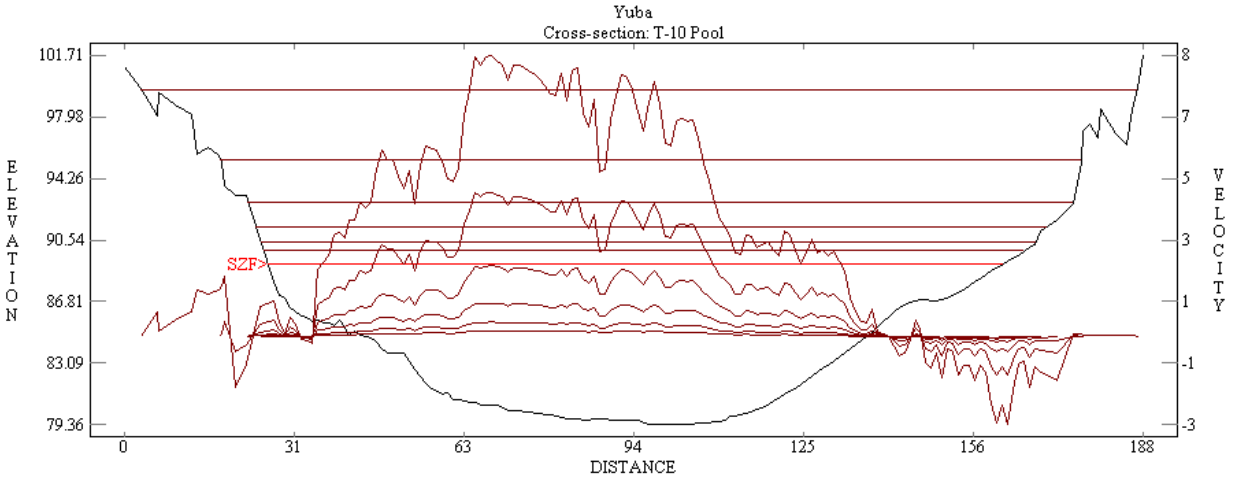

Figure A-21. Transect 10 (Pool)

Figure A-22. Transect 10-looking from downstream right bank at Low Flow (253 cfs)

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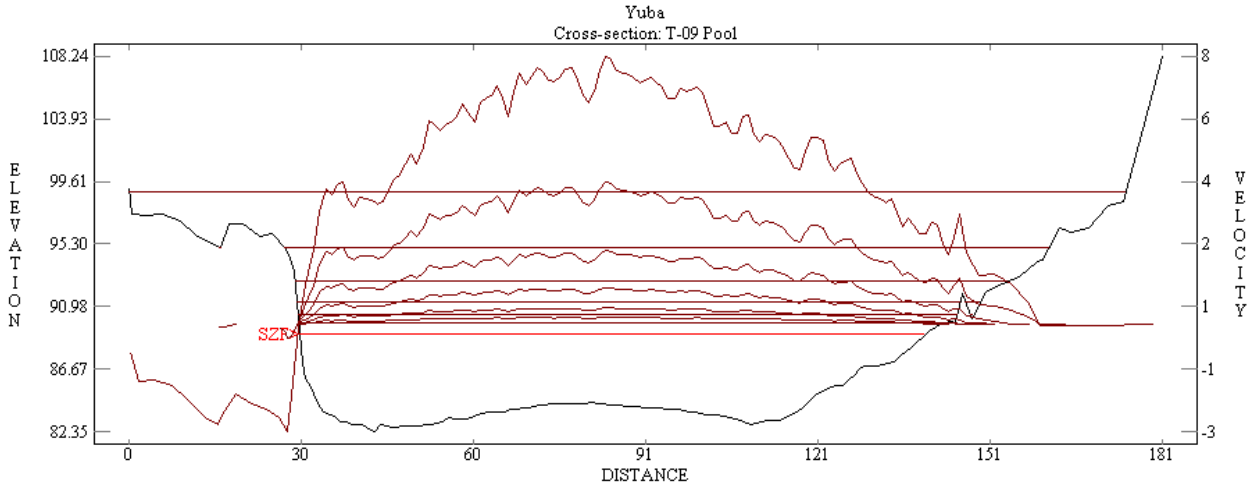

Figure A-23. Transect 09 (Pool)

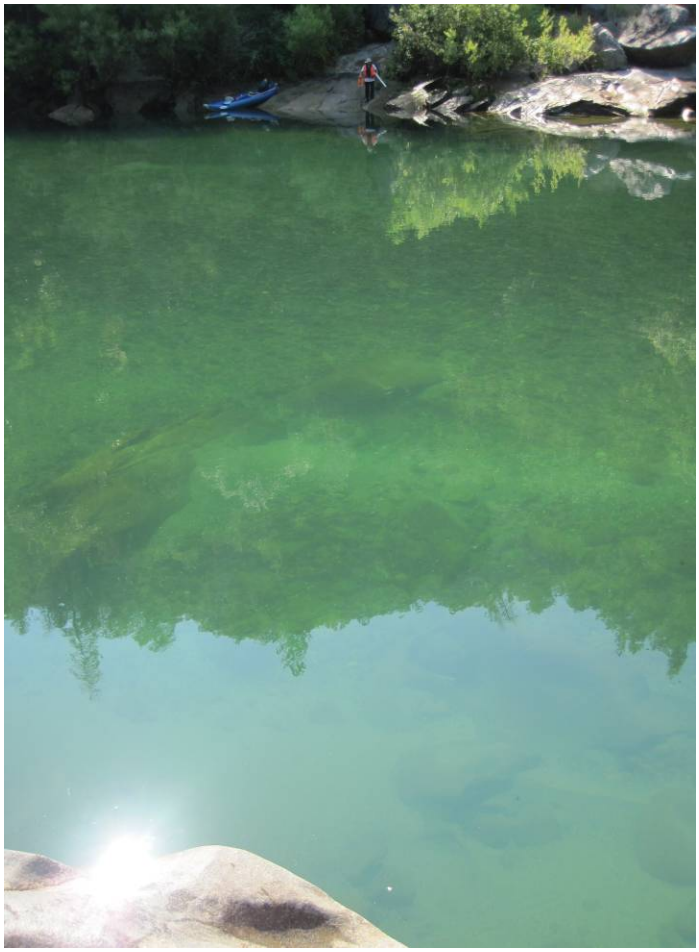

Figure A-24. Transect 09-looking from left bank towards right bank at Mid Flow (640 cfs)

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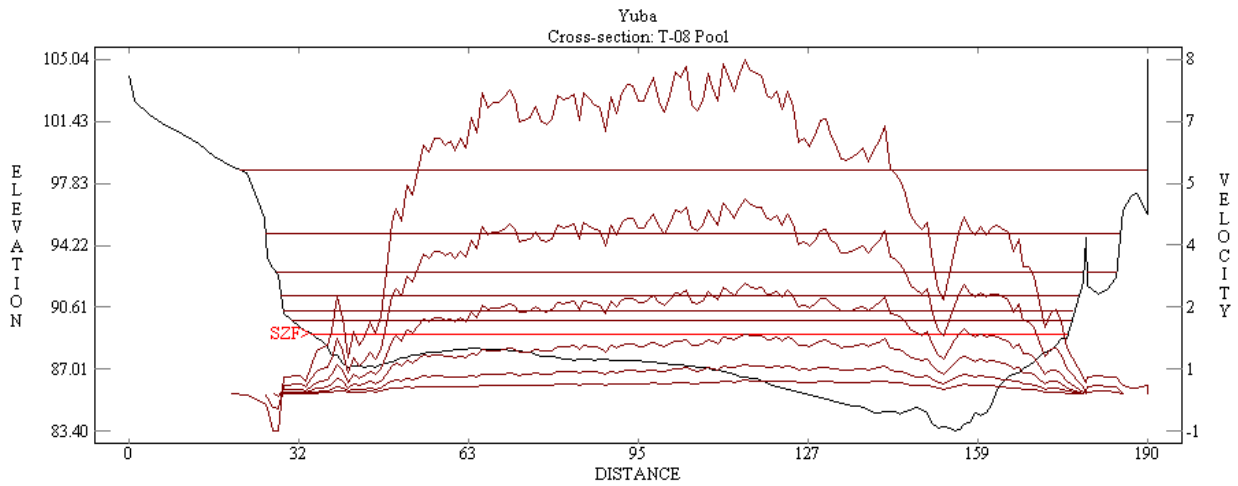

Figure A-25. Transect 08 (Pool)

Figure A-26. Transect 08-looking from left bank towards right bank at Low Flow (253 cfs)

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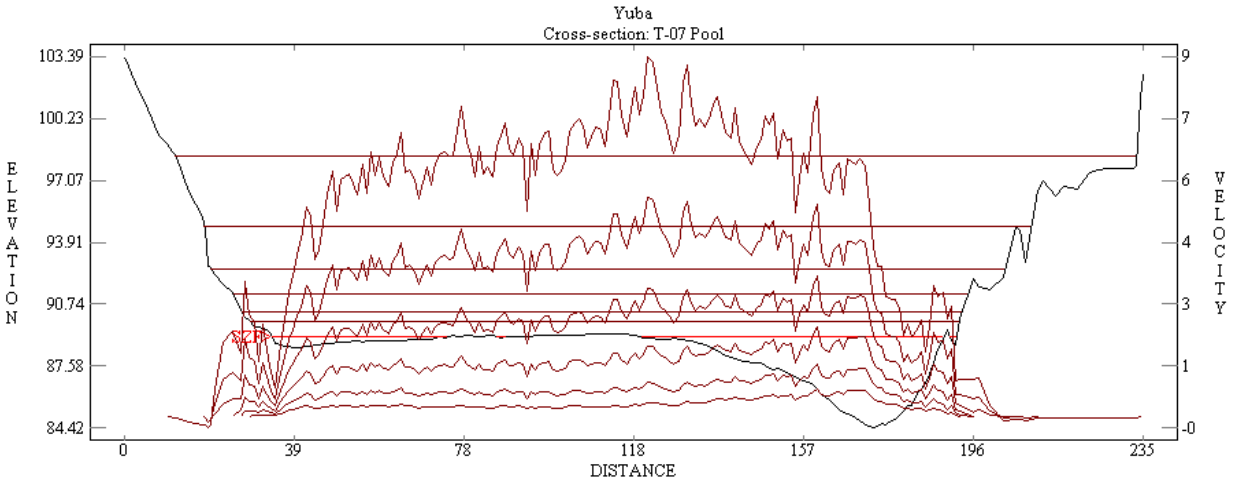

Figure A-27. Transect 07 (Pool)

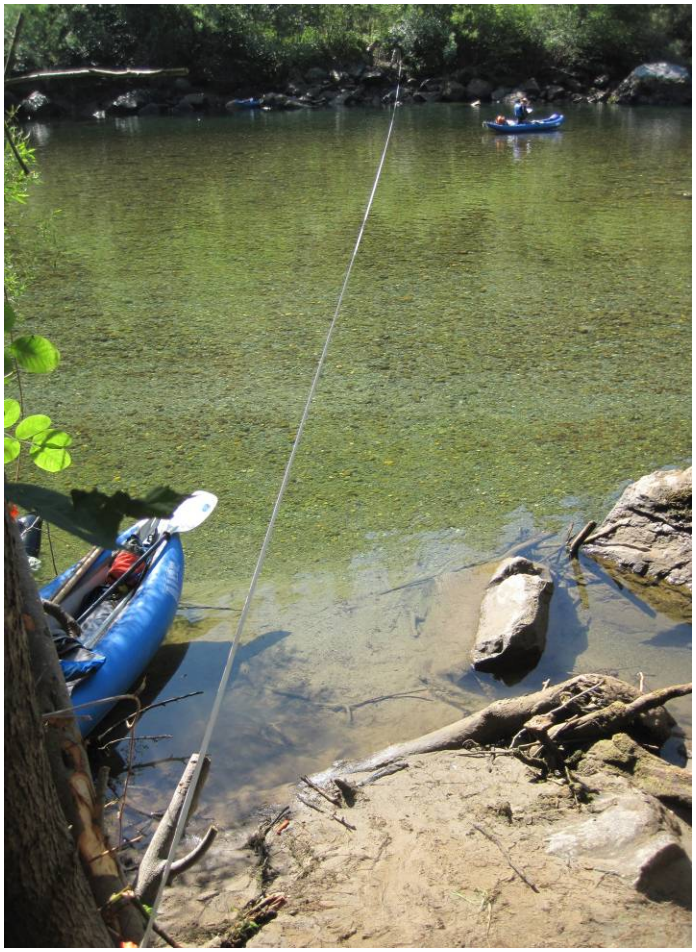

Figure A-28. Transect 07-looking from left bank towards right bank at Low Flow (253 cfs)

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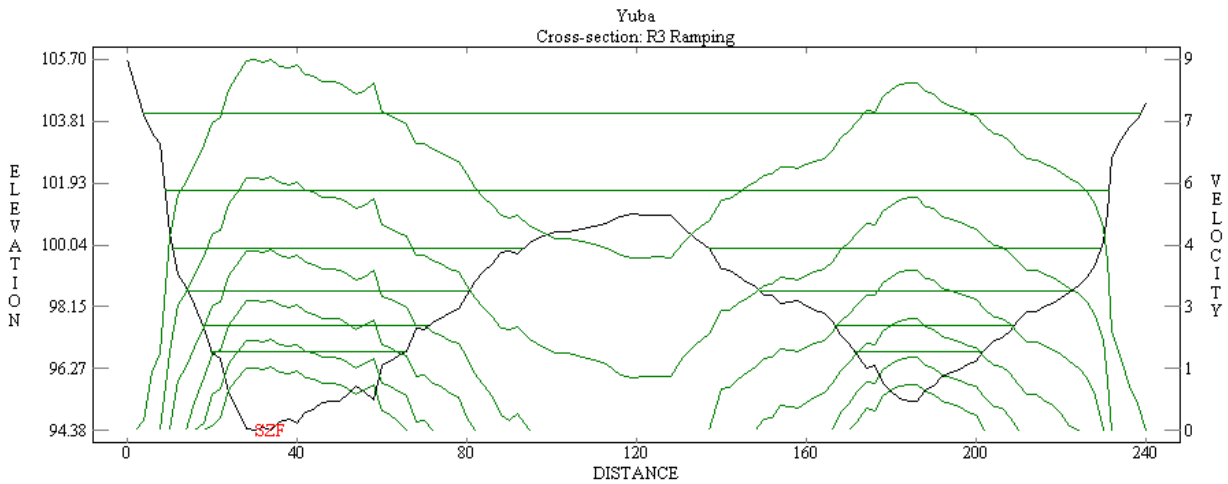

Figure A-29. Transect R3 (Run)

Figure A-30. Transect R3-looking from right bank to left bank at High-High Flow (~3200 cfs)

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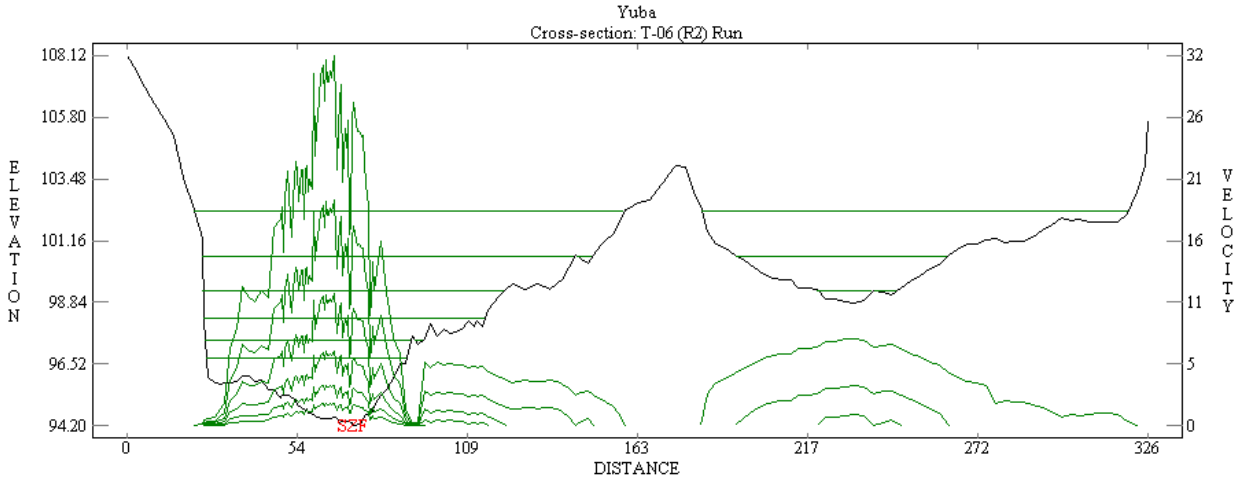

Figure A-31. Transect 06 (R2) (Run)

Figure A-32. Transect 06 (R2)-looking from right bank towards left bank at High Flow (1529 cfs)

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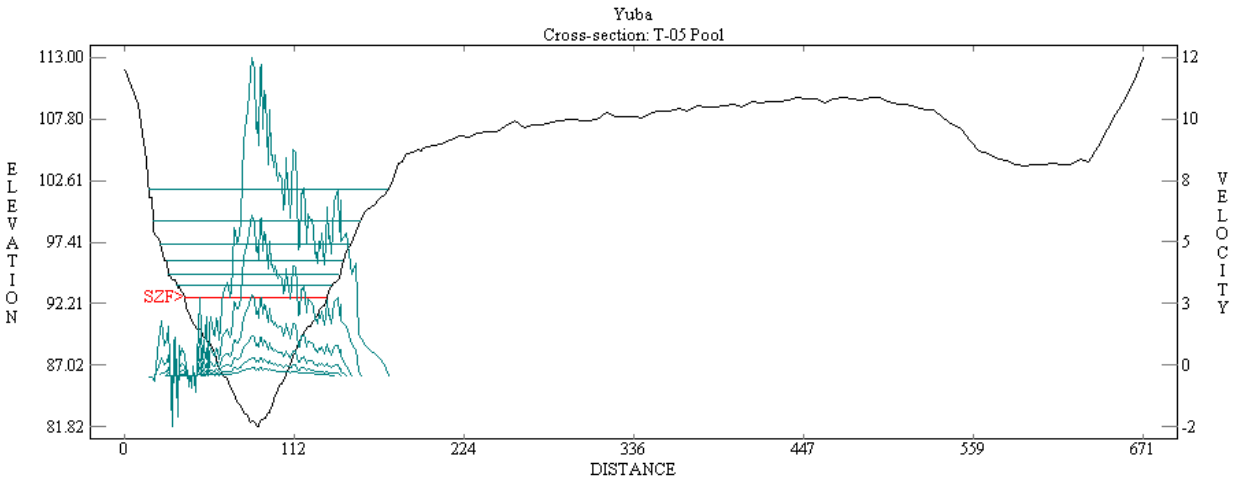

Figure A-33. Transect 05 (Pool)

Figure A-34. Transect 05-looking from left bank towards right bank at Low Flow (253 cfs)

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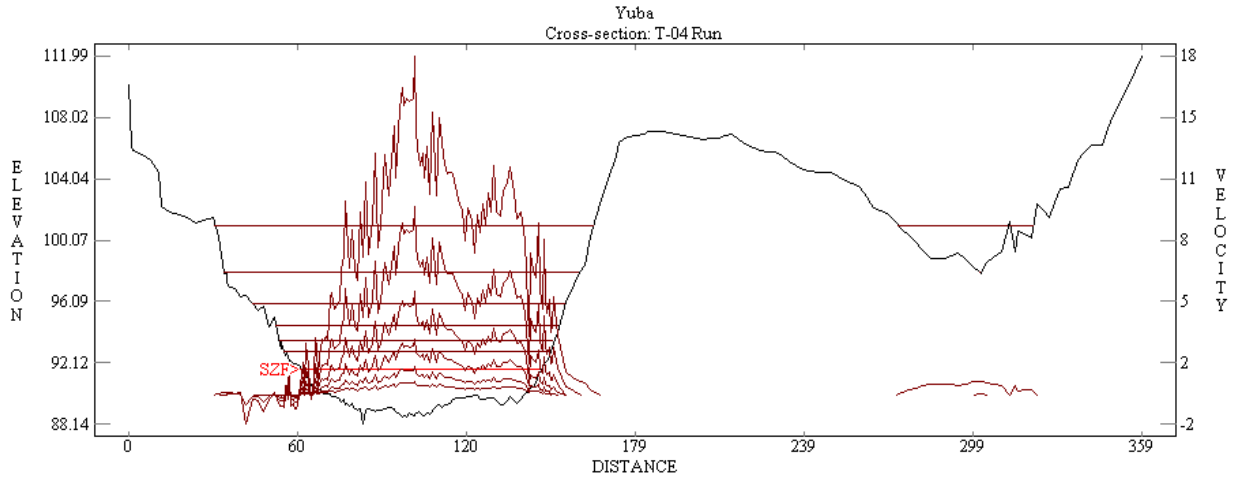

Figure A-35. Transect 04 (Run)

Figure A-36. Transect 04-looking from left bank to right bank at Low Flow (253 cfs)

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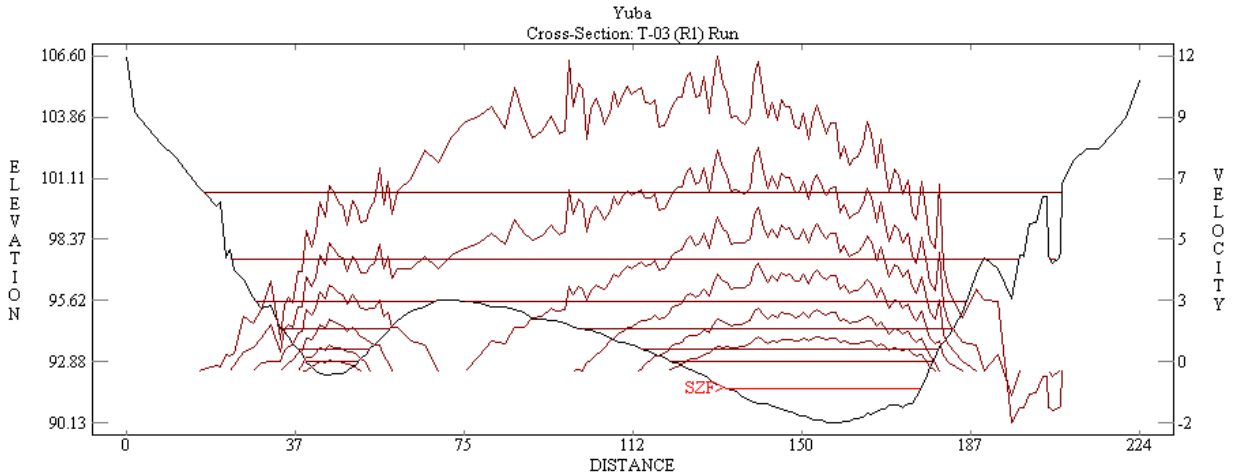

Figure A-37. Transect 03 (R1) (Run)

Figure A-38. Transect 03-looking from left bank to right bank at Low Flow (253 cfs)

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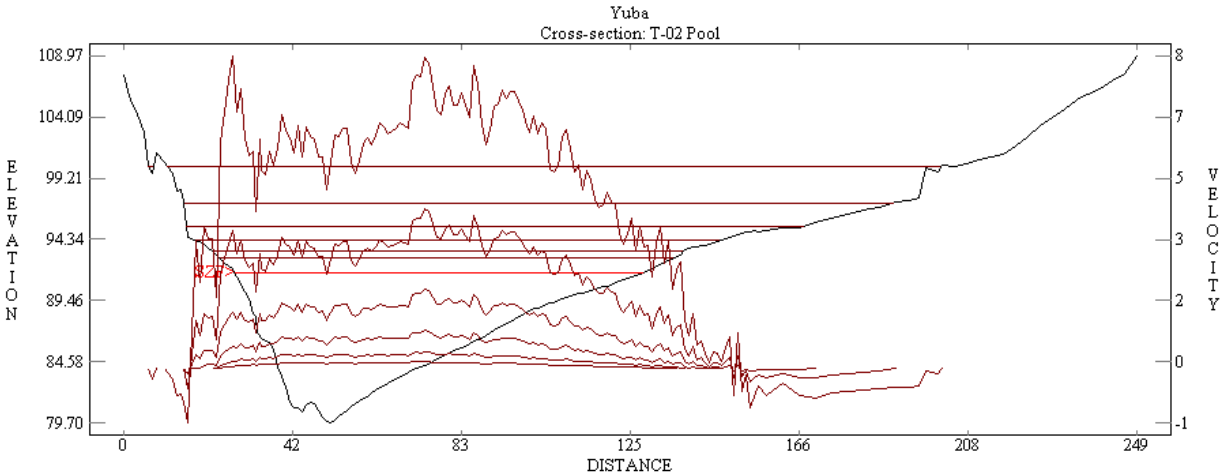

Figure A-39. Transect 02 (Pool)

Figure A-40. Transect 02-looking from left bank towards right bank at Low Flow (253 cfs)

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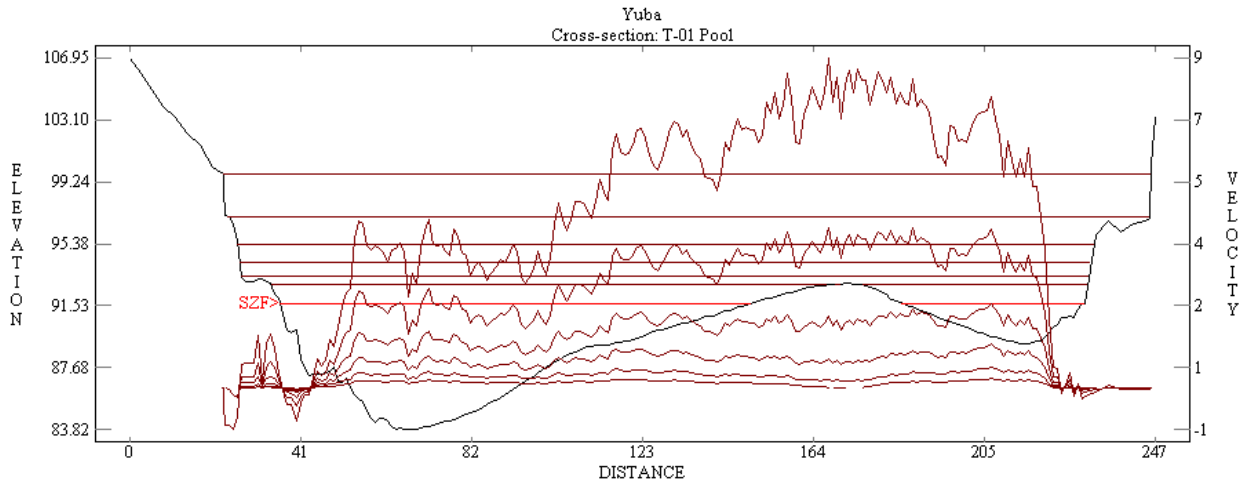

Figure A-41. Transect 01 (Pool)

Figure A-42. Transect 01-looking from left bank towards right bank at Low Flow (253 cfs)

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Appendix B
New Colgate Powerhouse Reach Cross Section Adjustments

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T-01

- Station 39.0 and 42.0, borrowed adjacent N values to release flow through cell at other simulation flows.

T-02

- No changes.

T-03 (R1)

- No changes.

T-04

- Adjusted SZF to 91.69 based knowledge of the transect and professional judgment of model accuracy.

T-05

- Stations 142.5-152.5: Adjusted roughness, based on nearby cells, to dampen a velocity spike.

T-06 (R2)

- Stations 0.0 to 26.0 and 95.0 to end: Adjusted roughnesses, based on nearby cells, to decrease velocity troughs.
- Conducted a bedshift on the right side of the channel so a consistent water surface elevation for the entire transect would generate appropriate depths.

T-R3

- Removed farthest right point of profile data to prevent overbank flow at 2.5*[High-High Flow] discharge.
- Conducted a bedshift on the right side of the channel so a consistent water surface elevation for the entire transect would generate appropriate depths.

T-07

- No changes.

T-08

- No changes.

T-09

- No changes.

T-10

- No changes.

T-11

- Extended left bank 0.5’ to prevent overbank flow at 2.5*[High-High Flow] discharge.

T-12

- Extended left bank 4.5’ to prevent overbank flow at 2.5*[High-High Flow] discharge.

T-13 (R4)

- Raised SZF from 87.37 to 88.20 to increase residual depth, based on knowledge of the transect and professional judgment.

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- Stations 26.0-27.0: Adjusted roughness to remove unrealistic negative velocities.
- Stations 120.8-122.8: Adjusted roughness to remove unrealistic velocity trough.

T-14

- Stations 129.64-130.54: Made roughness values positive to remove unrealistic negative velocity spike.

T-15

- Raised SZF from 88.99 to 89.30, based on knowledge of the transect and professional judgment, to improve model accuracy and performance.
- Stations 95.50- 97.50: Adjusted roughness to decrease velocity spike.
- Station 102.65: Adjusted roughness to decrease velocity trough.
- Stations 102.00, 104.76, 105.09, 105.27, and 107.28: Adjusted roughness to dampen negative velocity spikes.

T-16 (R5)

- No changes.

T-17 (R6)

- Stations 86.66-88.17: Adjusted roughness to dampen negative velocity spike.
- Stations104.95-106.06 and 114.90-118.60: Adjusted roughness to dampen velocity spikes.

T-18 (R7)

- Stations 118.16-122.32: Adjusted roughness to dampen velocity spike.

T-19

- No changes.

T-20

- An incomplete velocity set was collected, so parts of this transect were only depth calibrated.

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Appendix C
New Colgate Powerhouse Reach
Water Surface Elevation Comparison Tables

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Table C-1. Measured and Modeled WSEs.

Transect R1 (T-03)				Transect R2 (T-06)				Transect (R3)				Transect R4 (T-13)			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**
253	93.41	93.4	93.3	**253**	97.5	97.41	97.24	**253**	97.62	97.57	97.57	**253**	89.97	89.98	89.78
640	94.25	94.3	94.35	**640**	98.21	98.27	98.2	**640**	98.53	98.63	98.64	**640**	91.03	91	91.02
1529	95.7	95.59	95.69	**1529**	99.07	99.27	99.37	**1529**	99.95	99.93	99.94	**1529**	92.32	92.31	92.36
3749	97.5	97.57	97.49	**3749**	100.75	100.57	100.74	**3749**	101.72	101.69	101.71	**3749**	94.14	94.16	94.13
Transect R5 (T-16)				**Transect R6 (T-17)**				**Transect R7 (T-18)**							
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**				
253	91.48	91.53	91.54	**253**	91.63	91.63	91.48	**253**	95.61	95.62	95.61				
640	92.77	92.69	92.76	**640**	92.81	92.82	92.8	**640**	96.65	96.65	96.72				
1529	94.36	94.25	94.34	**1529**	94.47	94.42	94.48	**1529**	98.22	98.15	98.21				
3749	96.4	96.57	96.55	**3749**	96.75	96.78	96.73	**3749**	100.44	100.51	100.43				

Table C-2. Differences Between Measured and Modeled WSEs.

Transect R1 (T-03)				Transect R2 (T-06)				Transect (R3)				Transect R4 (T-13)			
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**
253	93.41	-0.01	**-0.11**	**253**	97.5	-0.09	**-0.26**	**253**	97.62	-0.05	-0.05	**253**	89.97	0.01	**-0.19**
640	94.25	0.05	0.10	**640**	98.21	0.06	-0.01	**640**	98.53	0.10	**0.11**	**640**	91.03	-0.03	-0.01
1529	95.7	**-0.11**	-0.01	**1529**	99.07	**0.20**	**0.30**	**1529**	99.95	-0.02	-0.01	**1529**	92.32	-0.01	0.04
3749	97.5	0.07	-0.01	**3749**	100.75	**-0.18**	-0.01	**3749**	101.72	-0.03	-0.01	**3749**	94.14	0.02	-0.01
Transect R5 (T-16)				**Transect R6 (T-17)**				**Transect R7 (T-18)**							
Q	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**	**Q**	**Cal Stage**	**Log/Log**	**MANSQ**				
253	91.48	0.05	0.06	**253**	91.63	0.00	**-0.15**	**253**	95.61	0.01	0.00				
640	92.77	-0.08	-0.01	**640**	92.81	0.01	-0.01	**640**	96.65	0.00	0.07				
1529	94.36	**-0.11**	-0.02	**1529**	94.47	-0.05	0.01	**1529**	98.22	-0.07	-0.01				
3749	96.4	**0.17**	**0.15**	**3749**	96.75	0.03	-0.02	**3749**	100.44	0.07	-0.01				

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