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WRIA - Stillaguamish Model Calibration

This document briefly describes the steps taken to calibrate water surface level and velocity model calibrations for the four sites on the North Fork Stillaguamish. Following the description of the approach, proposed changes to original data are described for each transect, coupled with graphical model output of observed versus predicted calibration velocities as well as the full range of modeled velocities. If you are referring back to the original data sheets as a reference, use the Coordinate Table provided for each site to relate specific verticals (e.g., "V4") to the correct X-coordinate (i.e., distance from left head pin).

Water Surface Level Modeling

The first step in model calibration was the selection of the appropriate stage of zero flow (SZF) for each transect. The recorded minimum bed elevation (i.e., thalweg) was used whenever it exceeded the SZF of the next transect downstream. The first transect SZF is always set equal to the thalweg elevation. If the thalweg elevation is lower than the next downstream SZF (e.g., in the case of a deep pool upstream of a riffle), then SZF was set equal to the downstream SZF.

The PhabWin model provides three choices for the calibration of the water surface level (WSL) at each transect. These include the basic stage discharge regression (StageQ), Manning's stage discharge (MSQ) and Water Surface Profile (WSP), a step-backwater modeling approach. The first two choices operate independently on a transect by transect basis, while WSP is used across multiple transects, beginning with a hydraulic control point at the downstream end. Longitudinal profiles were reviewed for all simulated flows to ensure logical consistency in the results, i.e., that water flows downhill from transect to transect at all modeled flows. In most cases, the StageQ proved adequate for modeling the WSL. Improving performance of the WSL model was achieved through subtle changes in the recorded WSL. The default selection is the average of the observed right bank (RB) and left bank (LB) elevations. Changes to the WSL value at a transect was strictly limited to the range between the observed LB and RB values.

Velocity Modeling

The objective of velocity modeling was to achieve a realistic velocity profile for each transect while minimizing differences between the observed and predicted velocities at calibration discharges. Without the benefit of direct involvement in data collection or knowledge of site-specific conditions, adjustments to original data were made using the modeler's best professional judgment. Also, given the 20-year lapse between data collection and modeling, greater emphasis was based on the achievement of a realistic velocity distribution than on fidelity to all observed data points. That being said, changes to original data were nevertheless within reasonable guidelines as described below.

Numerous data collection errors/inconsistencies are evident at most study sites. For example, it is very common to have observed velocities at points that should be dry at a given calibration discharge according to the recorded bed elevation and recorded WSL. The opposite case (i.e., zero velocity in a 'wet' cell) is also persistent, but more easily explained by measurement

difficulties at shallow depths and/or actual zero-velocity conditions. It is possible that the field crew mapped the bed elevation and initial WSL on separate occasions, leading to a persistent discrepancy.

In most cases, a 3-velocity regression was adequate to calibrate the model with minor changes to specific data points. However, some sites feature less usual hydraulic conditions, such as higher velocities at lower discharges for several, typically adjacent, verticals. In cases where subtle changes to original data were insufficient to improve model performance, 1-velocity and 2-velocity models were applied for different flow ranges. These are noted below.

Following an overall review of the observed velocity profiles, a 3-velocity model was initially evaluated for all transects. Results were reviewed on a point-by-point basis. Prediction errors (i.e., observed minus predicted) less than 0.2 feet per second (fps) or less than 20% were ignored. In other words, a 0.2 fps error was permitted regardless of the magnitude of the observed velocity, while a 20% error was permitted at all velocities. This standard is consistent with the Department of Ecology/WDFW study "Walla Walla River Fish Habitat Analysis Using the Instream Flow Incremental Methodology", December 2002. Changes to original data were limited to the same standard, i.e., 0.2 fps or 20%.

In some cases, bed elevations were adjusted slightly to account for the problem noted above, i.e., observed velocities in 'dry' cells, particularly if the recorded bed elevation revealed a steep stream margin where slight measurement errors may have been amplified. In general, most changes were made to observed velocities rather than bed elevations.

Following calibration changes, the model was used to simulate a full range of flows to identify illogical predictions at low or high extremes, e.g., velocity spikes that do not make sense relative to the rest of the velocity profile. These cases are most prevalent along the stream margin, for example, where very low velocities may be observed at the lowest (Q1) or intermediate (Q2) discharge, coupled with a very high velocity at the high discharge (Q3). This problem is exacerbated by the measurement errors noted above, in that the effect of a slight error in bed-elevation (Z) is amplified for shallow verticals (i.e., where WSL-Z is small). If changes within the standard range did not remove model artifacts such as high velocity spikes, very low observed velocities (e.g, 0.15 fps) at Q1 or Q2 were occasionally eliminated from the dataset, allowing the model to provide estimates of velocity for these lower discharges, while eliminating erratic spikes in the profile. Such cases are carefully noted below.

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Contents of this packet

For each study site, this document contains the following information:

1. The first table includes a list of changes made to original data at each transect. Changes are noted by the "station i.d." (i.e., transect vertical) in question, e.g., "V14". See #2 (below) for vertical coordinates.
2. The second table provides an easy way to relate the vertical number (e.g., V14) to an x-coordinate along the transect. These coordinates are taken from the original data sheets.
3. The third table provides a listing of selected calibration details for each transect as requested by Ecology. Note that the information provided is somewhat different for 1-flow, 2-flow and 3-flow velocity models. In the 1-flow case, all stage-discharge calibration results are taken from the WSL model using BestQ rather than from the velocity model which applies ComputedQ. These cells are shaded in gray for ease of reference.
4. Finally, two graphs are provided for each transect. The first graph shows the observed velocities and calibration velocities. The second graph shows the full range of simulated velocities.

Weighted Usable Area (WUA) results have been provided in spreadsheet format to Ecology. WUA File Name: WUA_compiled.xls

Site List:

1. Stillaguamish Mainstem at Arlington
2. North Fork at Wiersma Bar
3. North Fork near Oso
4. North Fork near Hazel
5. North Fork at Blue Slough
6. North Fork near Arlington
7. South Fork at Byle's Farm near Arlington
8. South Fork at Chappel Rd.
9. South Fork at Marten Creek
10. Squire Creek
11. Canyon Creek
12. Pilchuck Creek
13. Jim Creek below 4 mi. bridge
14. Jim Creek at mouth near Arlington
15. Jim Creek near Arlington – fish passage site

Stillaguamish Mainstem Calibration

2-flow model since only two sets of data.

Transect 1	No changes

Transect 2

V2	Z << WSL. Let model prdict velocities.
V3	Eliminate Q2 (.74)
V4	Eliminate Q2 (1.83)
V5	Adjust Q1 down 20% to 2.82, Q2 up 20% to 3.49
V24	Change Q2 from 1.42 to 1.70.
V25	Eliminate Q2 (.24). Z>WSL.

Transect 3

Best Q too low. CalcQ>2500. Set Best Q to 2500.

V4,5,36	No observed velocities despite WSL>Z at Q1 or Q2. Allow model to predict.

Transect 4

V10	Reduce Q2 from 1.49 to 1.19.

Transect 5

V4	Eliminate Q1 (.07) to remove high peak.

Transect 6

V3,29,30	Z<<WSL. Let model predict velocities.

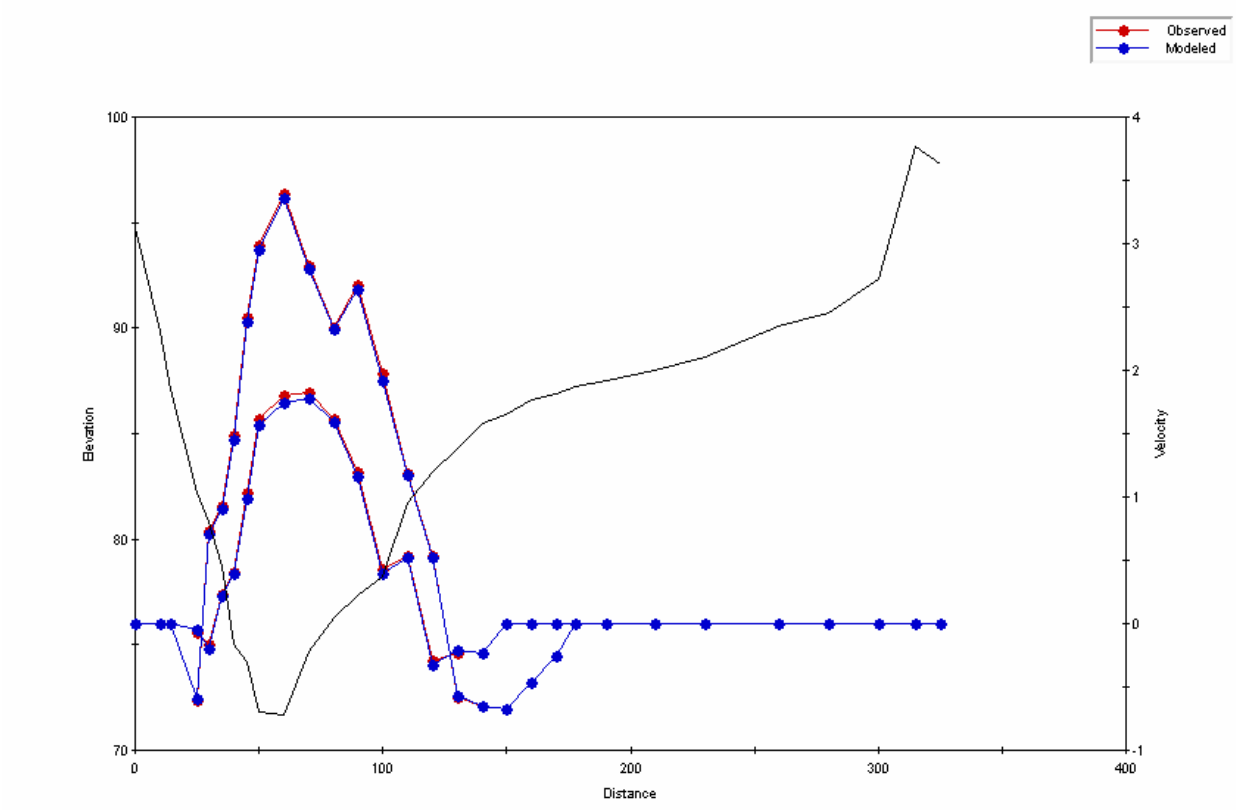
Stillaguamish Mainstem

Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
1	0	0	0	0	0	0
2	10	10	4.5	6	2	4.5
3	14	20	7.5	15	6	10
4	25	25	15	20	16	15
5	30	40	20	25	24	20
6	35	60	30	29	32	25
7	40	80	40	31	40	30
8	45	100	50	40	48	35
9	50	120	60	50	56	40
10	60	140	70	60	64	45
11	70	160	80	70	72	50
12	80	180	90	80	80	55
13	90	200	100	90	88	60
14	100	220	110	100	96	65
15	110	240	120	110	104	70
16	120	260	130	120	112	75
17	130	280	140	130	120	80
18	140	300	150	140	128	85
19	150	320	160	150	136	90
20	160	340	170	160	144	95
21	170	360	180	170	152	100
22	178	380	190	180	160	108
23	190	400	200	190	165	116
24	210	420	210	200	170	126
25	230	440	220	210	175	136
26	260	444	230	220	180	146
27	280	450	240	230	185	156
28	300	460	250	240	190	166
29	315	470	260	252	200	176
30	325	480	270	260	210	186
31		481	280	270	220	198
32			290	280	230	210
33			300	288	240	220
34			320	296	250	230
35			340	304	280	250
36			350.5	312	284	270
37			357	320	300	293
38			369	330	308	303
39				340		
40				350		
41				360		
42				372		
43				374.5		
44				377		

Mainstem

Transect (model)	**1**	**2**	**3**	**4**	**5**	**6**
WSL model	StQ	StQ	StQ	StQ	StQ	WSP
Velocities used	2	2	2	2	2	2
Discharge	1003	865	940	900	1008	965
	2222	1887	2329	2361	2273	2365
Stage	85.82	86.83	87.64	88.16	88.31	88.33
	87.09	87.47	88.57	89.22	89.3	89.41
Plotting Stage	14.12	5.13	2.94	3.16	3.31	3.33
	15.39	5.77	3.87	4.22	4.3	4.41
Ratio of Measured vs. Predicted Discharge						
	1	1	1	1	1	1
	1	1	1	1	1	1
Mean Error of stage/discharge relationship for calculated Q						
	0	0	0	0	0	0
Mean Error of stage/discharge relationship for given Q						
	0	0	0	0	0	0
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF						
A=	0.6677	0.1852	0.3694	0.4103	0.358	0.3867
B =	0.1084	0.1507	0.303	0.3	0.3216	0.3133
SZF =	71.7	81.7	84.7	85	85	85
Beta coefficient log/log discharge/stage relationship						
	9.228	6.637	3.3	3.332	3.109	3.192

Transect 1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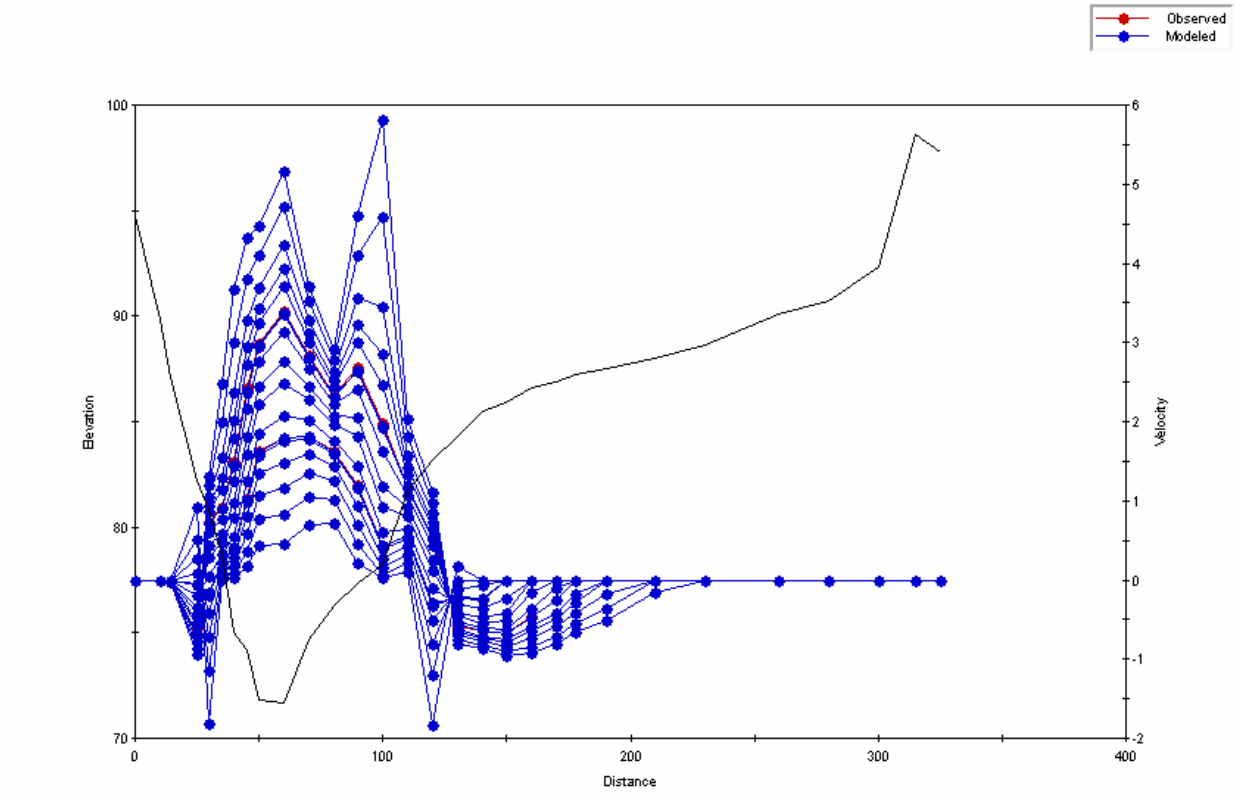
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Modeled
Elevation
Velocity
Distance
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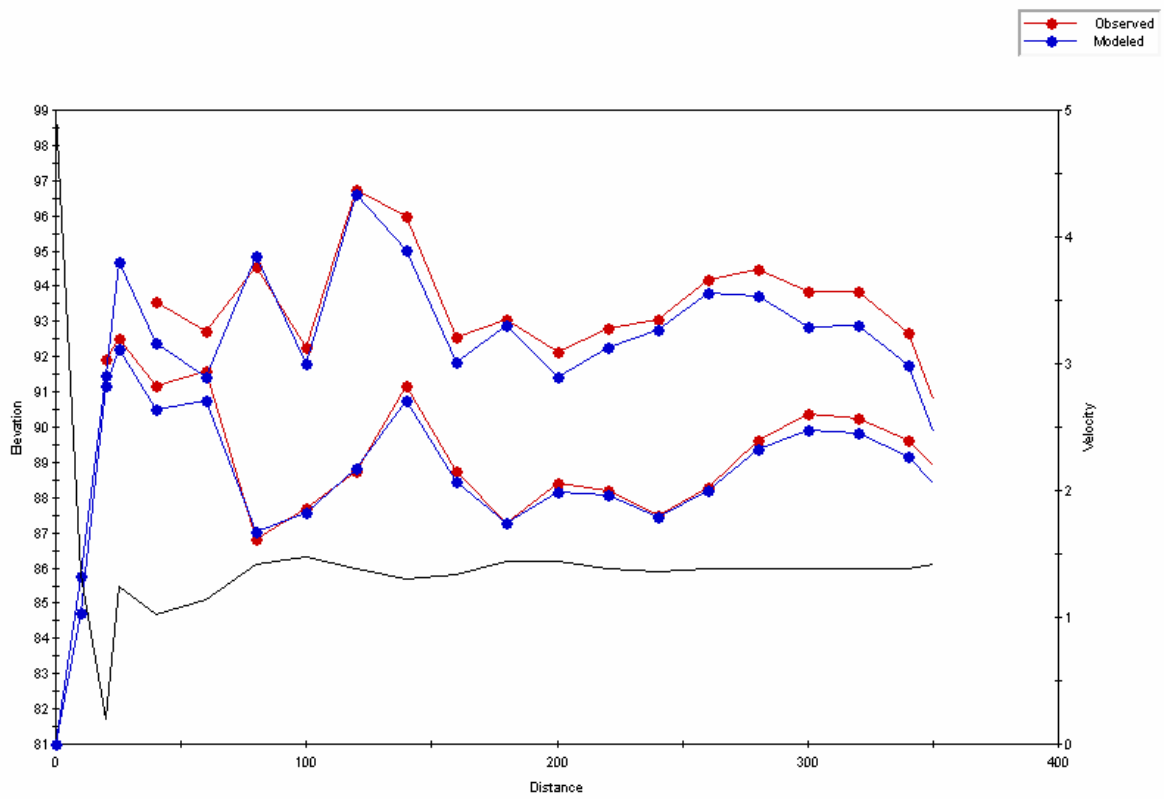
Transect 2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Elevation
Velocity
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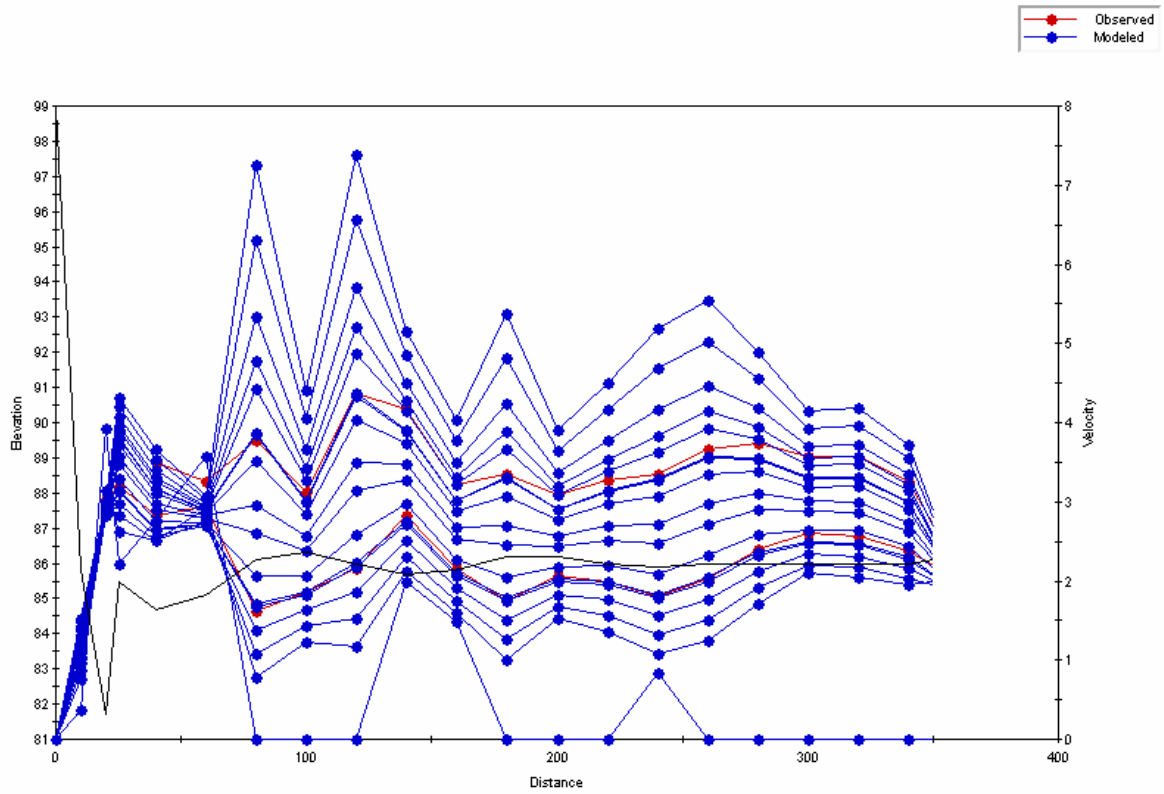
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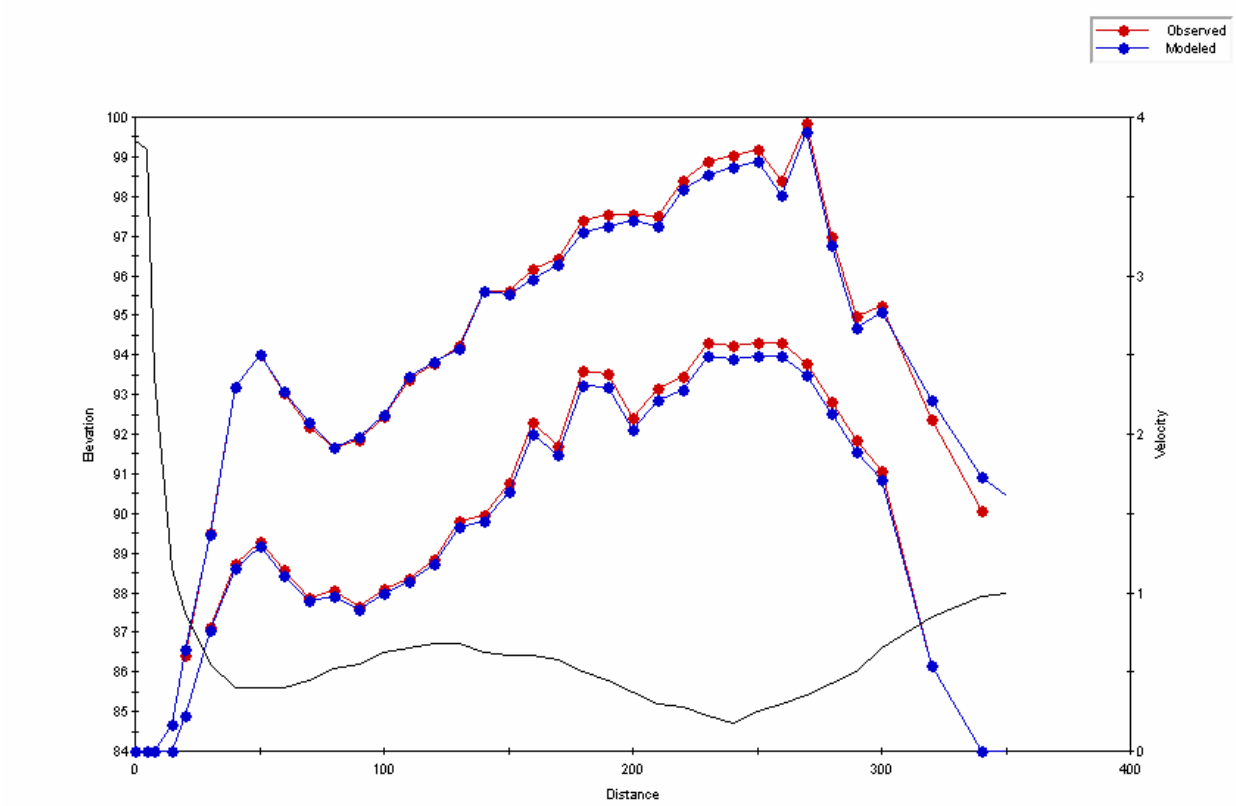
Velocity
Distance

Transect 3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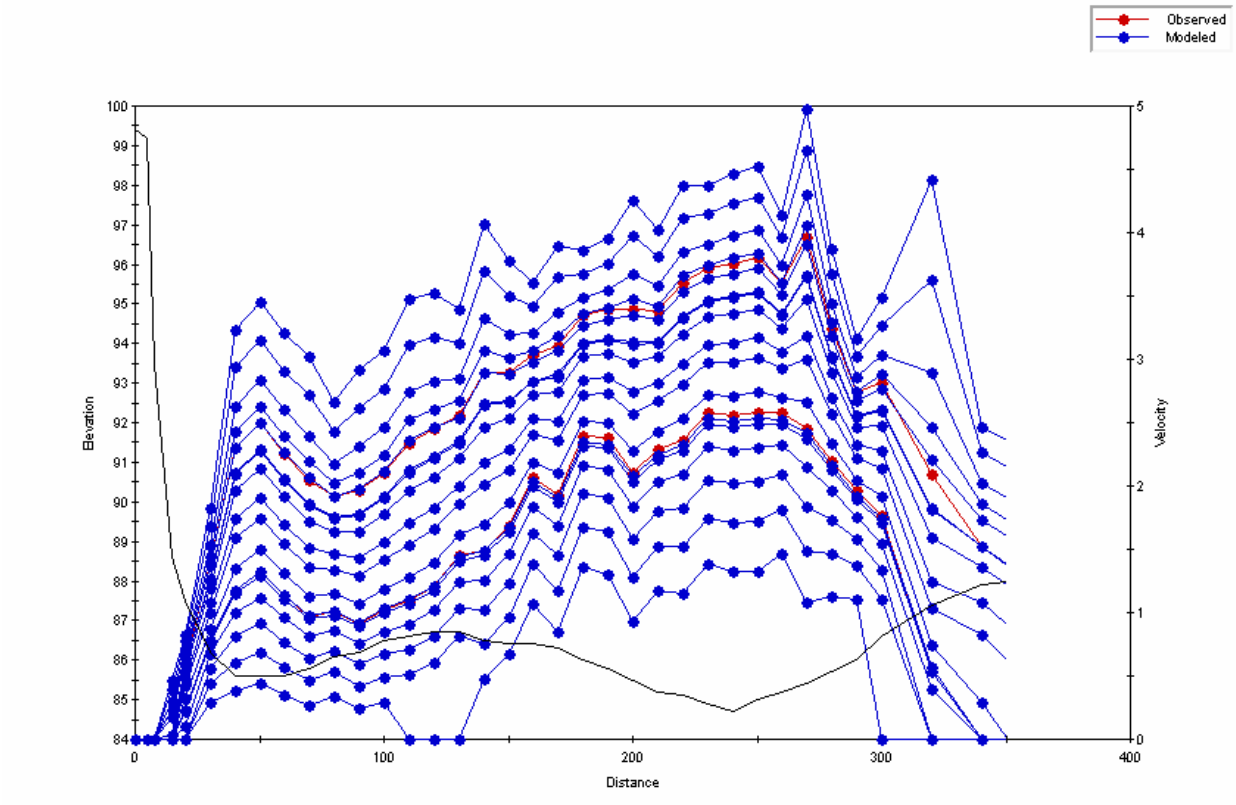
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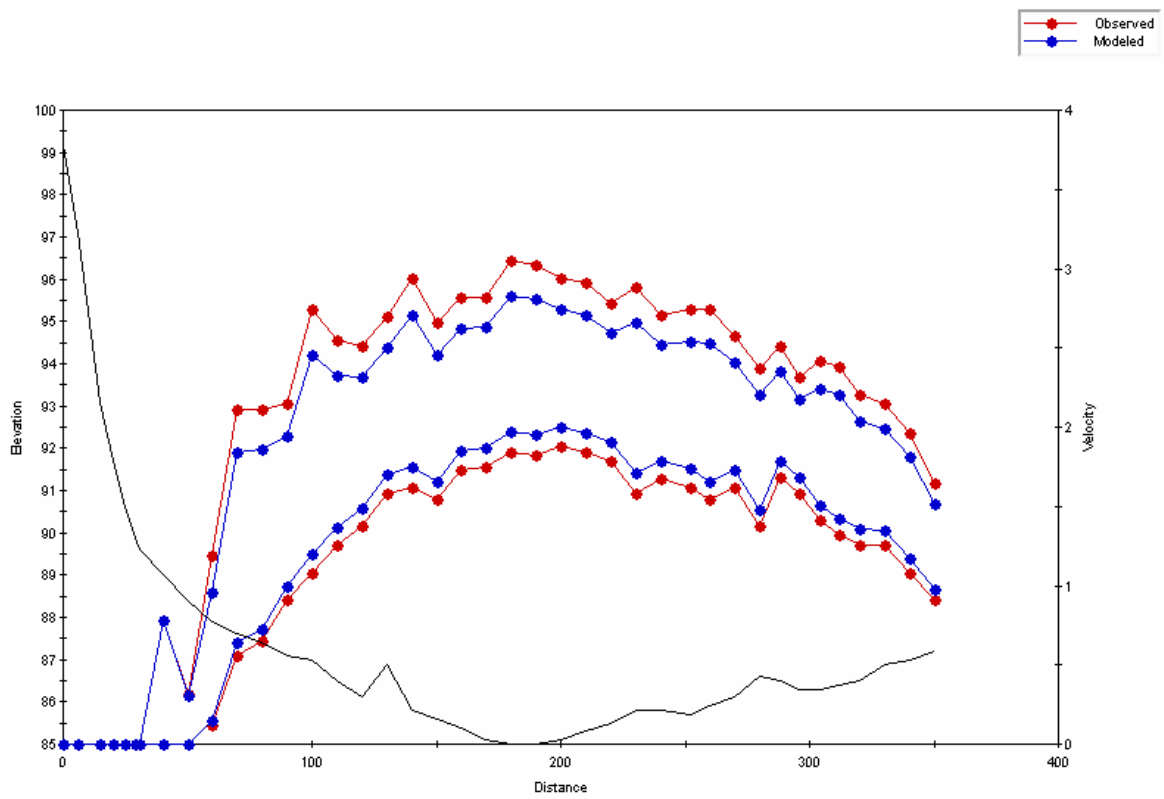
Transect 4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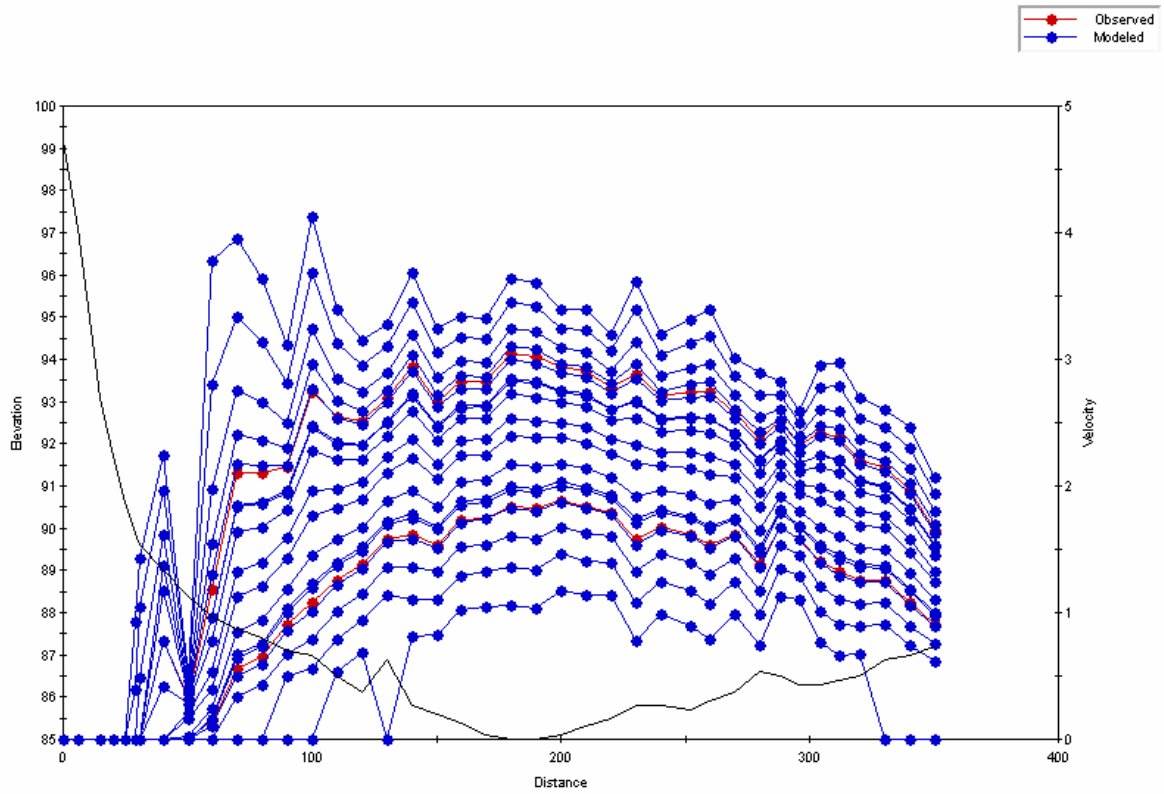
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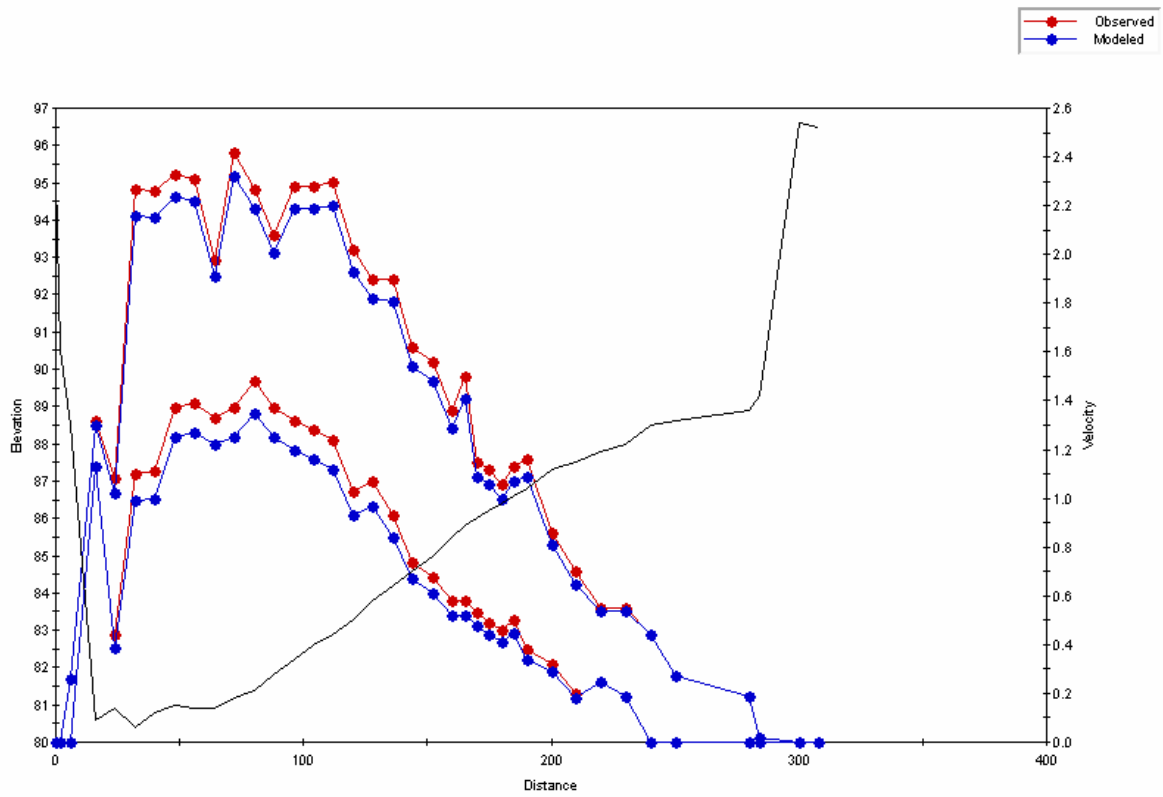
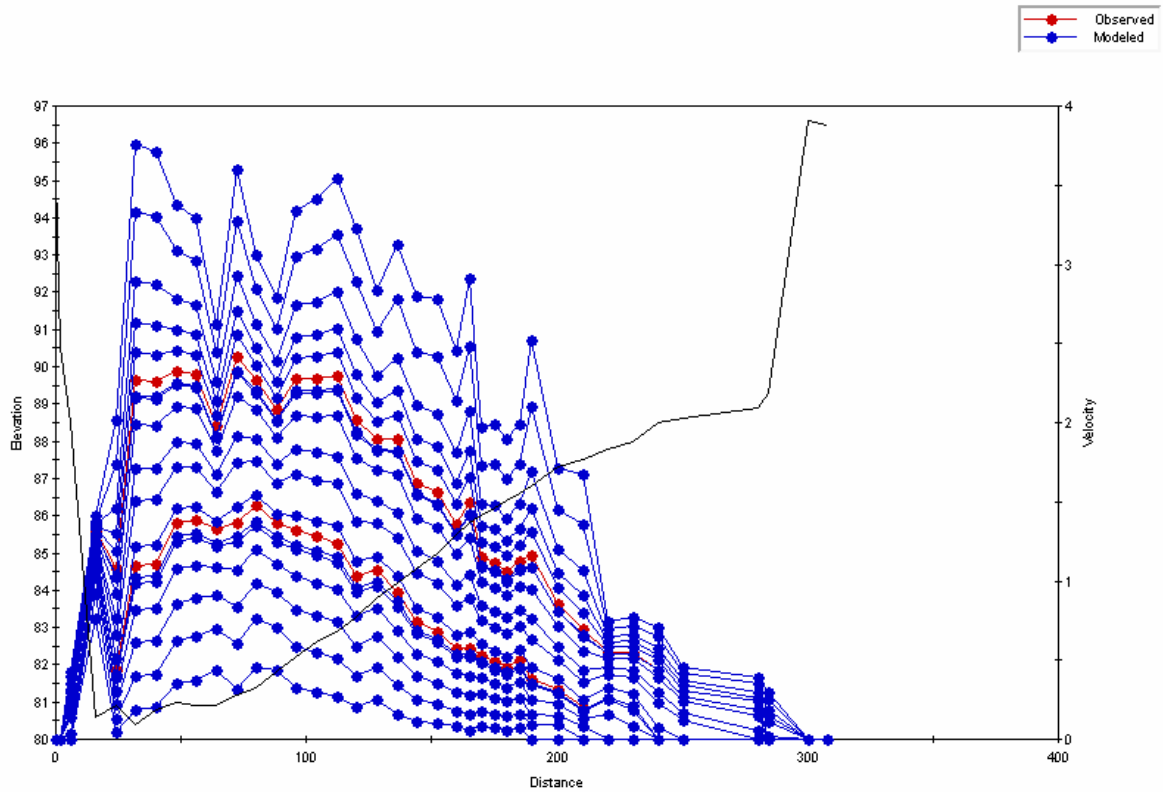
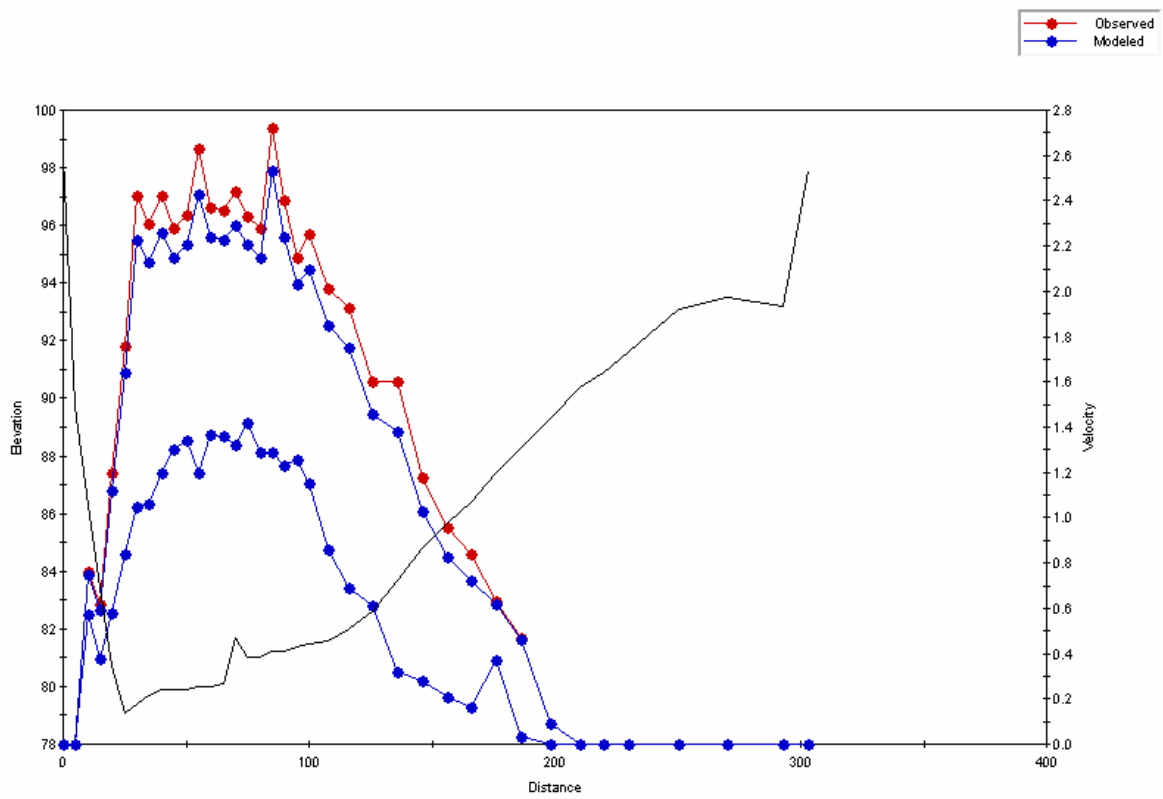
Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 6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Modeled
Elevation
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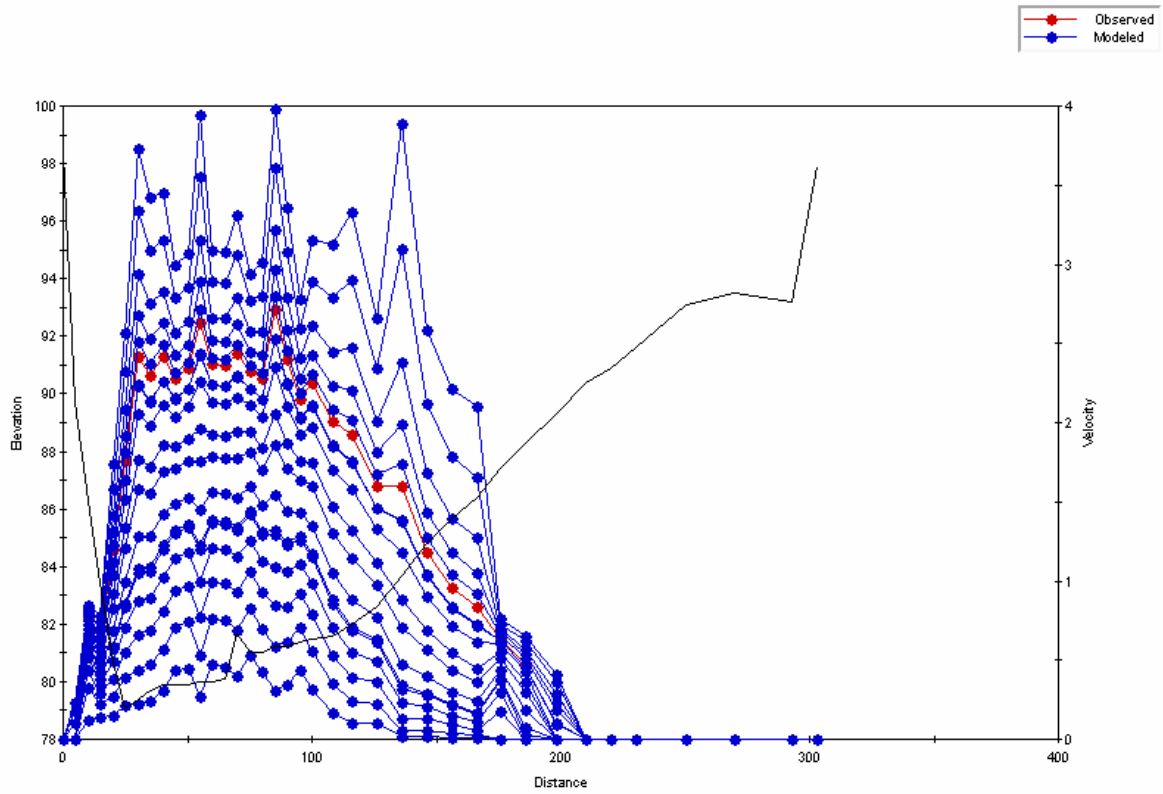
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NF at Wiersma's Bar calibrations

Transect 1

V3	Observed vel=0 at Q1 and Q2, but WSL>Z. left alone. Possible side channel. Let model predict.
V4-6	Obs=0 at Q1, but WSL>>Z. Left alone, allowed model to fill in. Probable occluded side channel.
V6	Changed Q3 from 2.94 to 2.44 to control high spike.
V11	Changed Q3 down 20% to 3.42 to shave very high peak.
V12	Changed Q1 from .41 to .61
V38	Eliminated Q1 (.524) measurement. Makes no sense with zeroes at Q2 and Q3.

Transect 2

V10	Changed Q2 from 0.02 to 0.22. Q3 down 20% to 2.70.
V9	Obs=0 but WSL>Z. Allowed model to predict.
V27	Changed Q1 from 1.65 to 1.32
V28	Eliminated Q2 (1.36). No reasonable adjustment produced sufficient correction for this case.

Transect 3

V6	Changed Q2 from .156 to .356. Changed Q3 from 3.28 to 2.62
V33	Deleted Q3 (-.687) -- bed elev 1.5 ft higher than WSL!

Transect 4

NOTE: T4 is former T5

V17-19	Elminated Q2 (0.1), (0.1), (0.13) for verts 17-19
V10	Set Z at Q10 to 95.20
V20	Q2 from 2.29 to 1.83 (20%)
V32	Q2 from 3.33 to 3.99

Transect 5

V9	Elminated Q2 (.025) to control spike >20 ft/sec

Transect 6

V27-30	Adjusted Q3 downward 20% to reduce high spiking.
V25,27,28	Eliminated Q1 (.313), (.215), (.199)

Transect 7

V25	Adjusted Q1 from 1.13 to 0.9 for better fit

NF Stillaguamish - Wiersma's Bar

Station ID	Distance from Bank						
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
1	0	0	0	0	0	0	0
2	3	10	10	12	8	10	6
3	6	20	20	24	22	18	10
4	10	26	30	34	30	24	16
5	14	32	40	50	40	27	24
6	20	44	50	65	50	30	32
7	27	50	60	80	53	40	40
8	36	57	65	95	63	50	50
9	42	65	70	100	73	60	60
10	50	70	75	110	83	70	70
11	60	80	80	120	93	80	80
12	70	85	85	130	100	90	90
13	80	90	90	140	108	100	100
14	85	95	95	150	116	110	110
15	90	100	100	155	124	120	120
16	95	105	105	160	132	130	130
17	100	110	110	170	140	140	140
18	105	115	115	180	148	150	150
19	110	120	120	190	156	160	160
20	115	125	125	200	164	170	170
21	120	130	130	205	172	180	180
22	125	135	135	210	180	190	190
23	130	140	140	215	188	200	200
24	135	145	145	220	200	210	210
25	140	150	150	225	210	220	220
26	145	155	155	230	220	230	230
27	150	160	160	235	230	240	240
28	155	165	165	240	240	250	250
29	160	170	170	245	250	260	260
30	165	174	175	250	260	270	270
31	170	180	180	255	270	280	280
32	175	185	186	260	280	289	290
33	180		187	265	290	300	295
34	185		195	270	300	310	300
35	190			275	311	340	307
36	195			280	315		313
37	200			285	322		321
38	206			290			326
39	207			295			
40	210			300			
41				305			
42				310			
43				315			
44				320			
45				325			
46				330			
47				335			

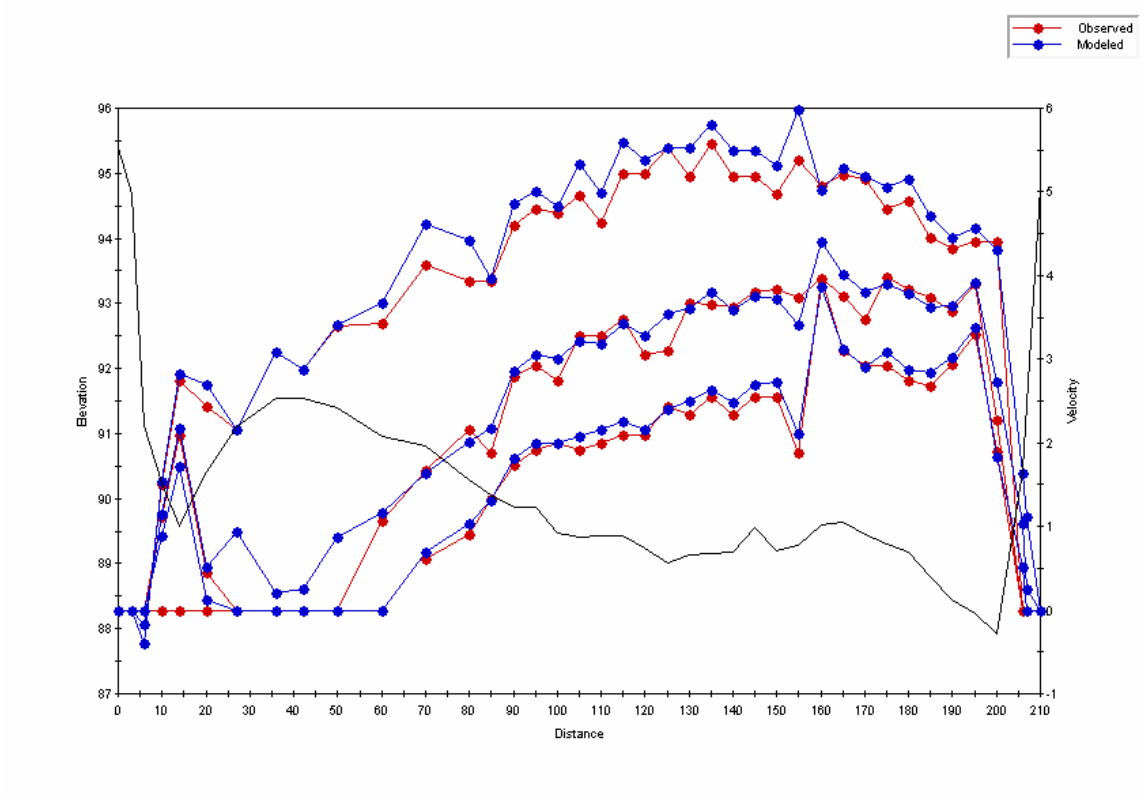
NF Stillaguamish - Wiersma's Bar

Station ID	Distance from Bank						
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
48				340			
49				345			
50				348			
51				352			
52				369			

NF Wiersma

Transect (model)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	3	3	3	3	3	3
Discharge	477	532	540	492	506	556	518
	999	931	1022	1023	1114	1146	1221
	2483	2754	2689	2694	2685	2472	2579
Stage	90.85	91.1	91.1	93.48	93.99	94.46	95.31
	91.54	91.76	91.8	94.18	94.8	95.1	95.94
	92.75	93.03	93.19	95.26	95.95	96.14	96.69
Plotting Stage	2.92	3.17	3.17	1.72	1.81	2.08	1.82
	3.61	3.83	3.87	2.42	2.62	2.72	2.45
	4.82	5.1	5.26	3.5	3.77	3.76	3.2
Ratio of Measured vs. Predicted Discharge							
	0.99	1.04	1	1.03	1.017	0.98	1
	1.03	0.94	1	0.94	0.97	1.03	1.01
	0.99	1.03	1	1.03	1.02	0.99	1
Mean Error of stage/discharge relationship for calculated Q							
	1.78	4.17	0.25	3.84	2.32	2.1	0.53
Mean Error of stage/discharge relationship for given Q							
	1.77	3.58	2.77	0.12	3.76	1.11	0.58
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF							
A=	0.444	0.5292	0.4354	0.1309	0.1182	0.1675	0.2019
B =	0.3046	0.287	0.3155	0.4175	0.4395	0.3975	0.3516
SZF =	87.93	87.93	87.93	91.76	92.18	92.38	93.49
Beta coefficient log/log discharge/stage relationship							
	3.28	3.49	3.17	2.4	2.28	2.52	2.85

Transect 1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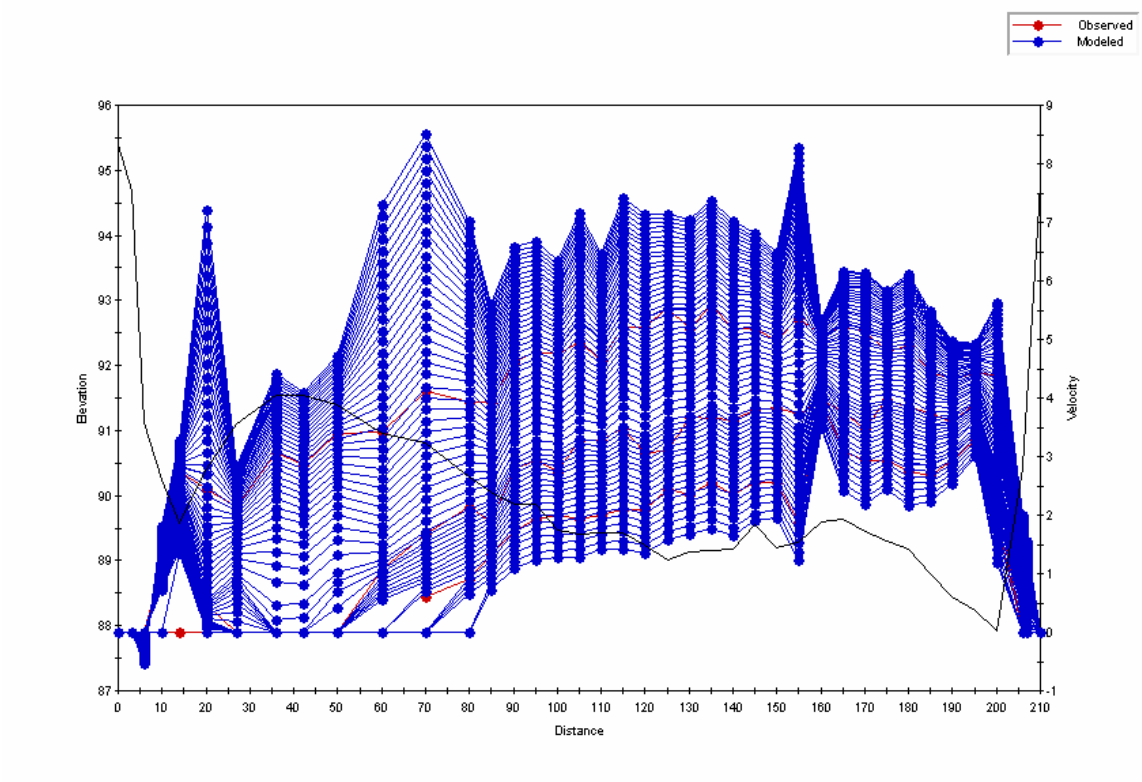
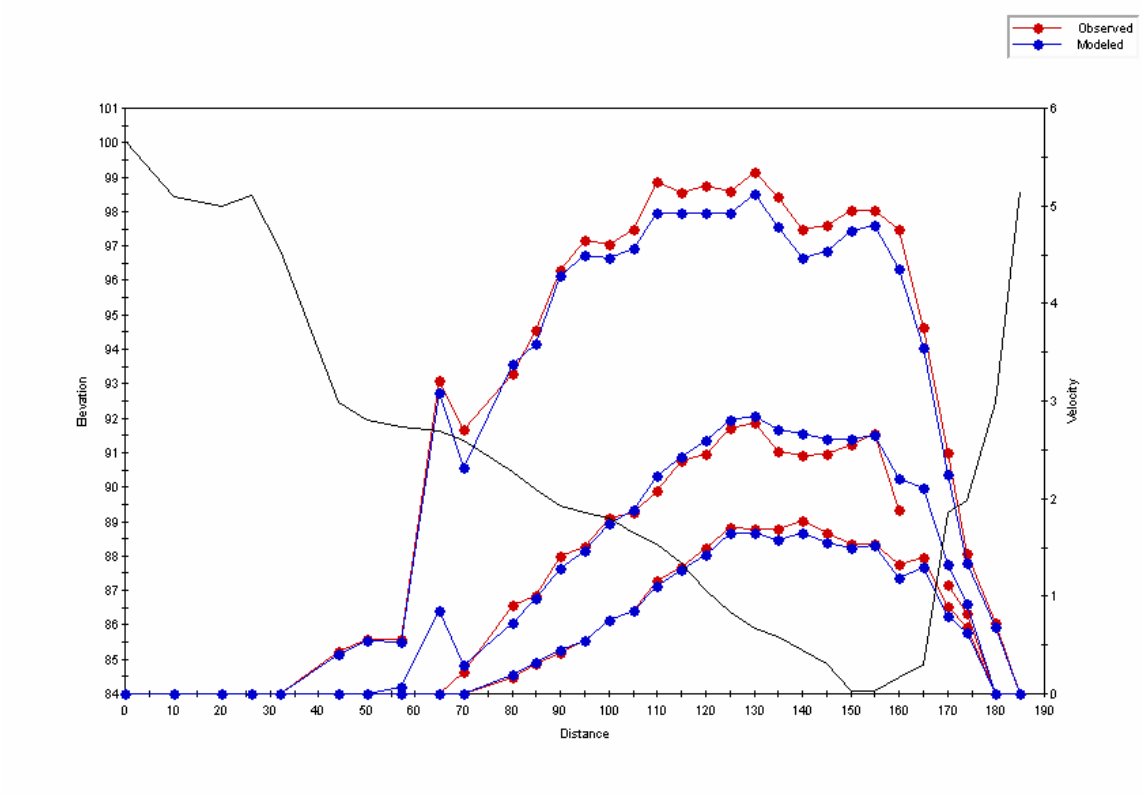
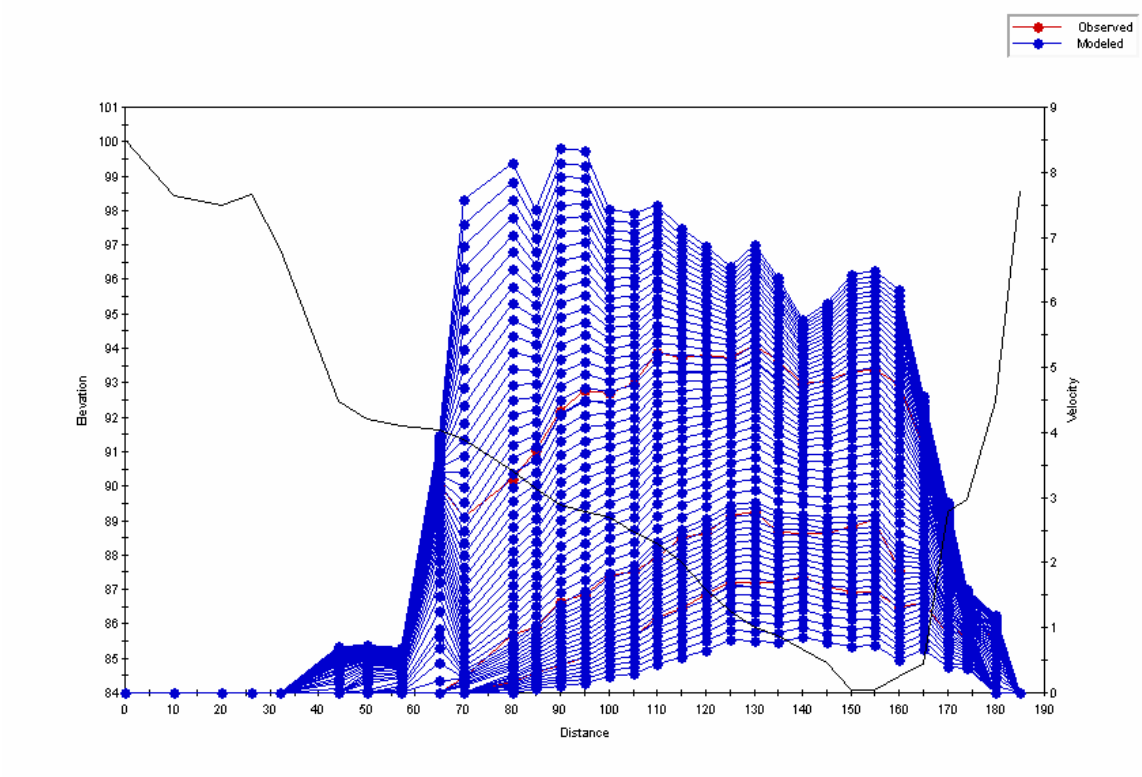
Modeled
Elevation
Velocity
Distance

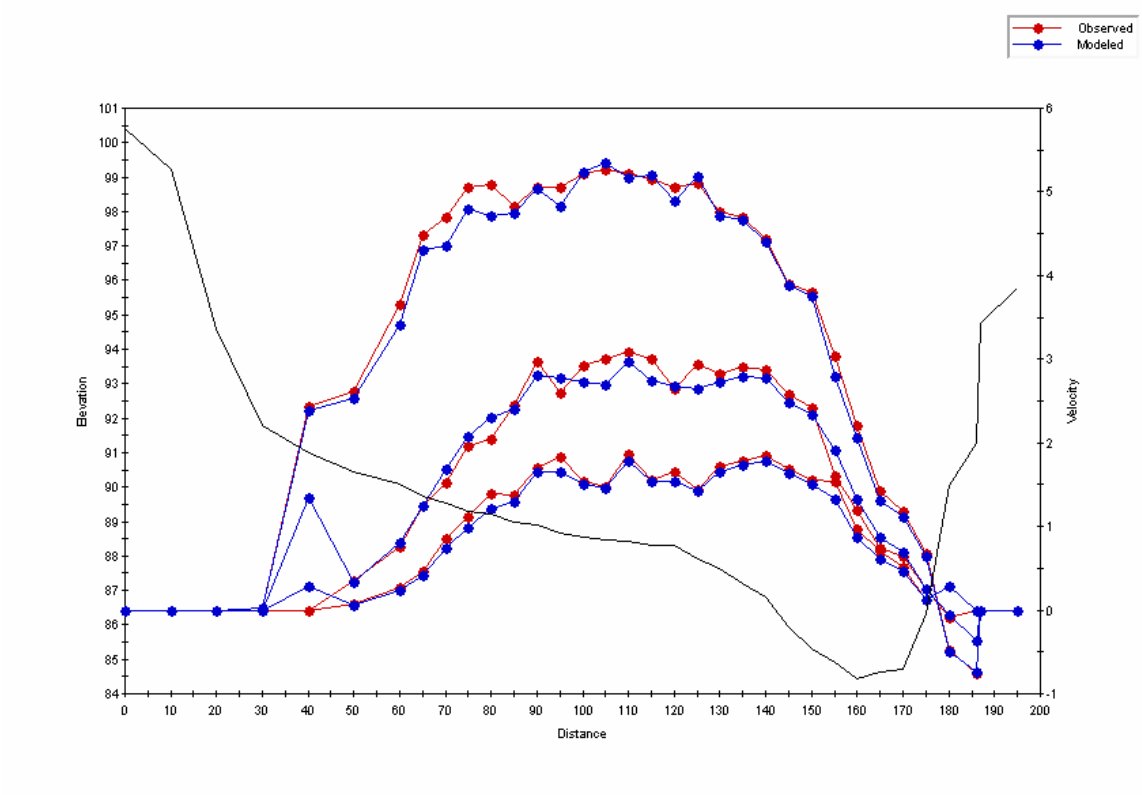

Observed
Modeled
Elevation
Velocity
Distance

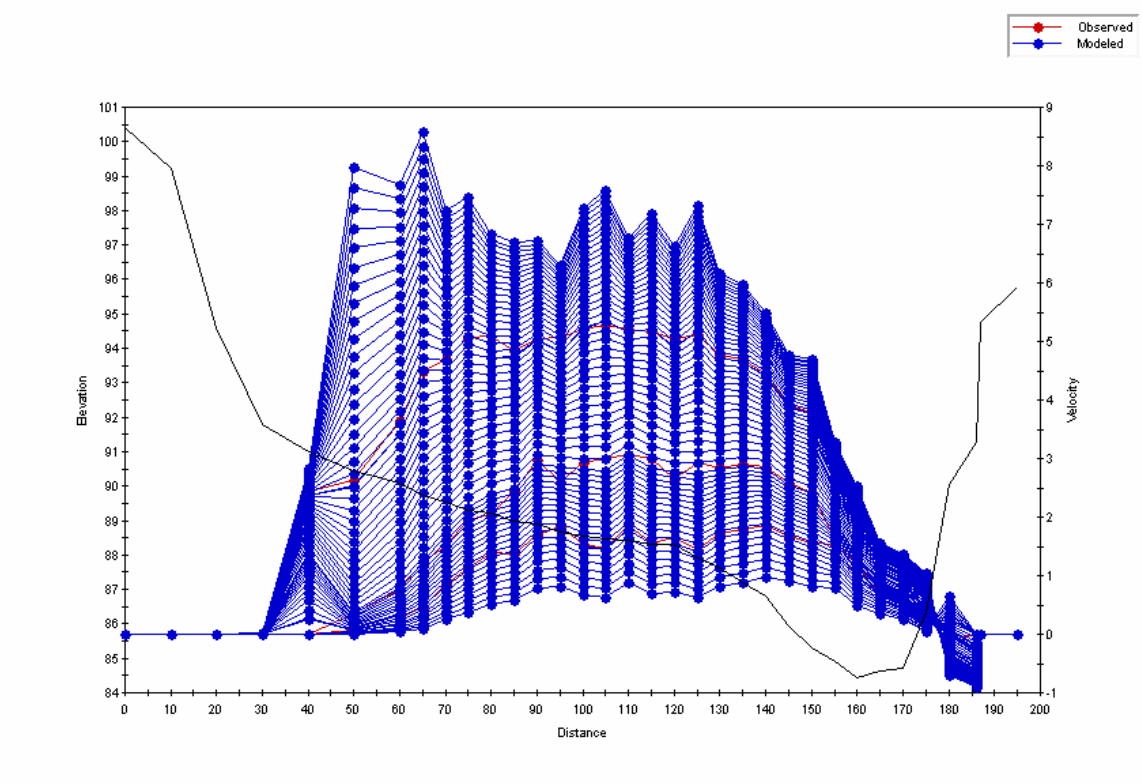
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

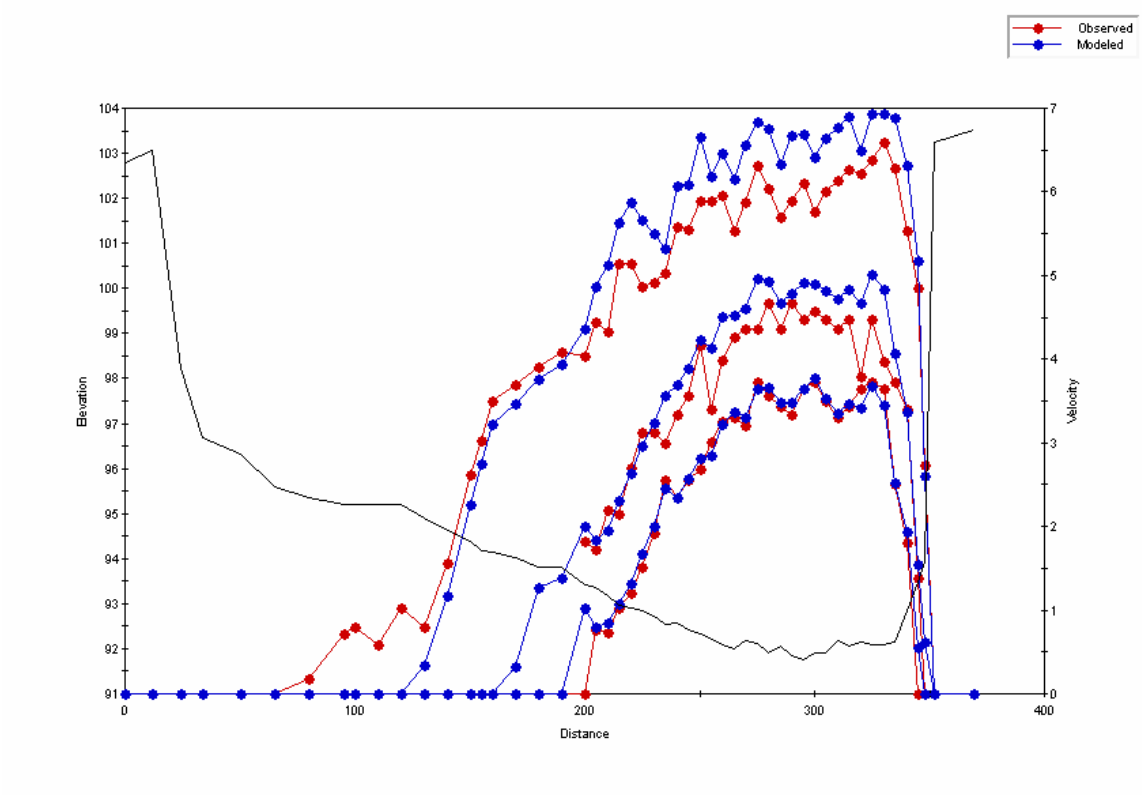

Observed
Modeled
Elevation
Velocity
Distance

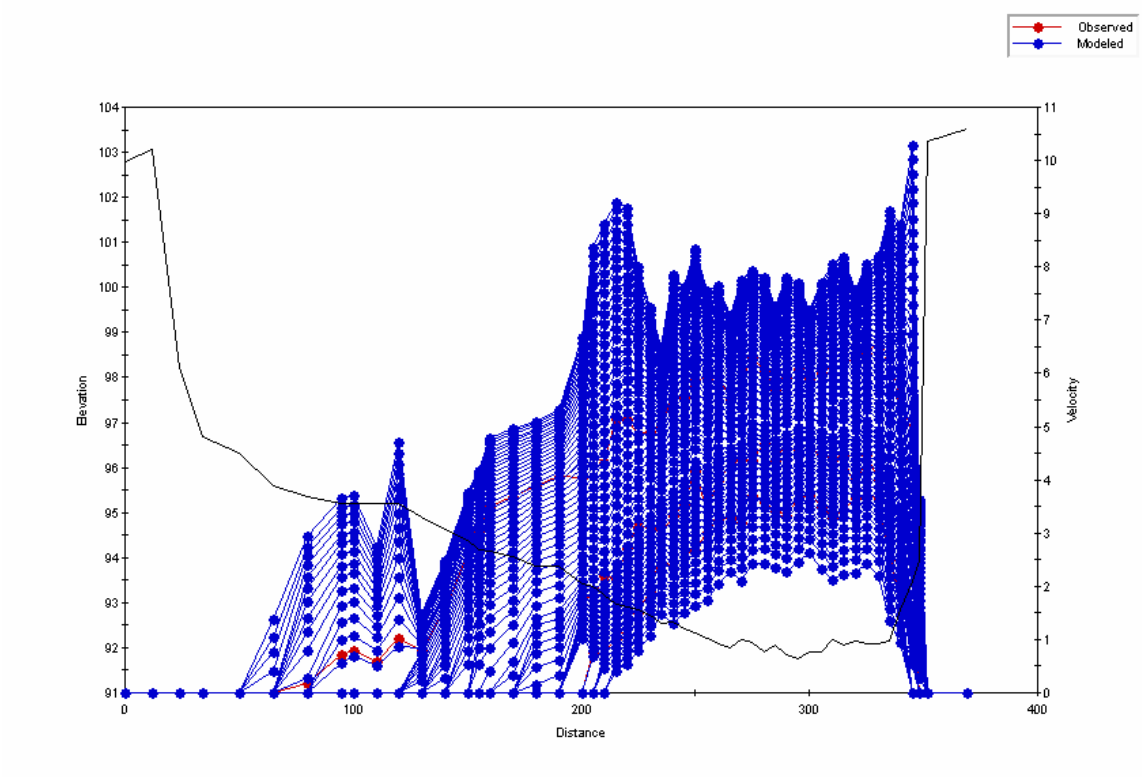
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

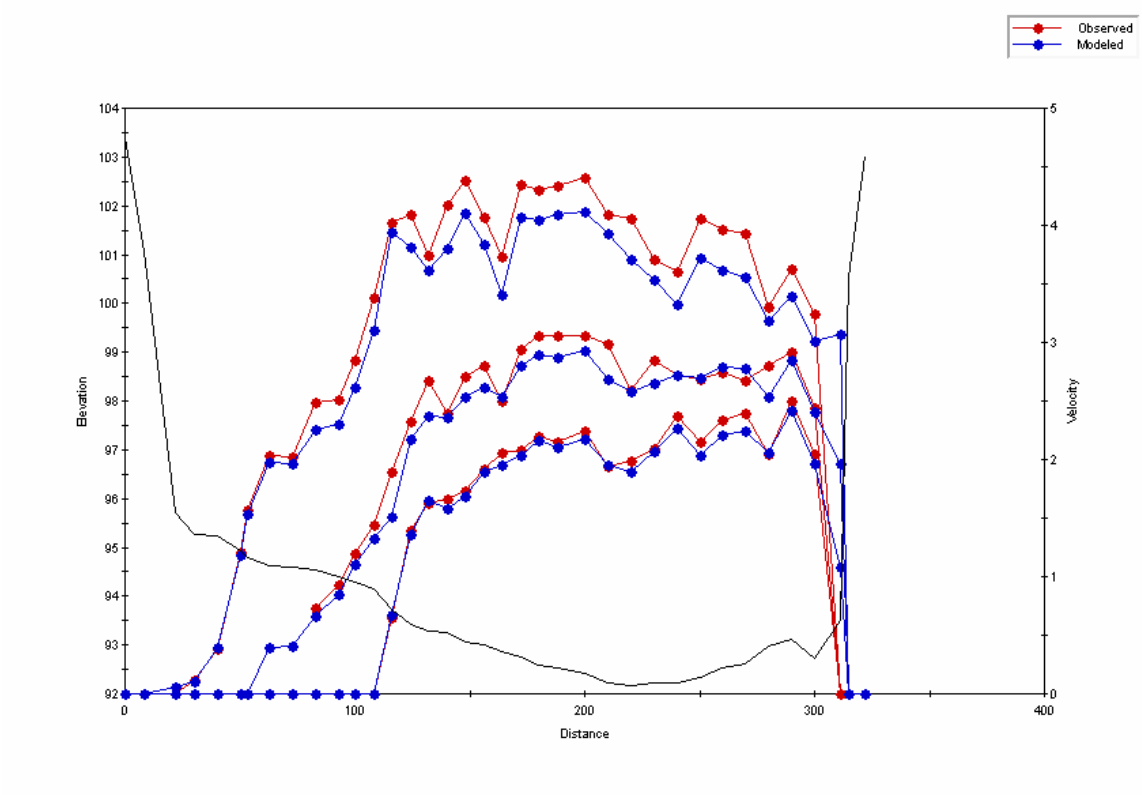

Observed
Modeled
Elevation
Velocity
Distance

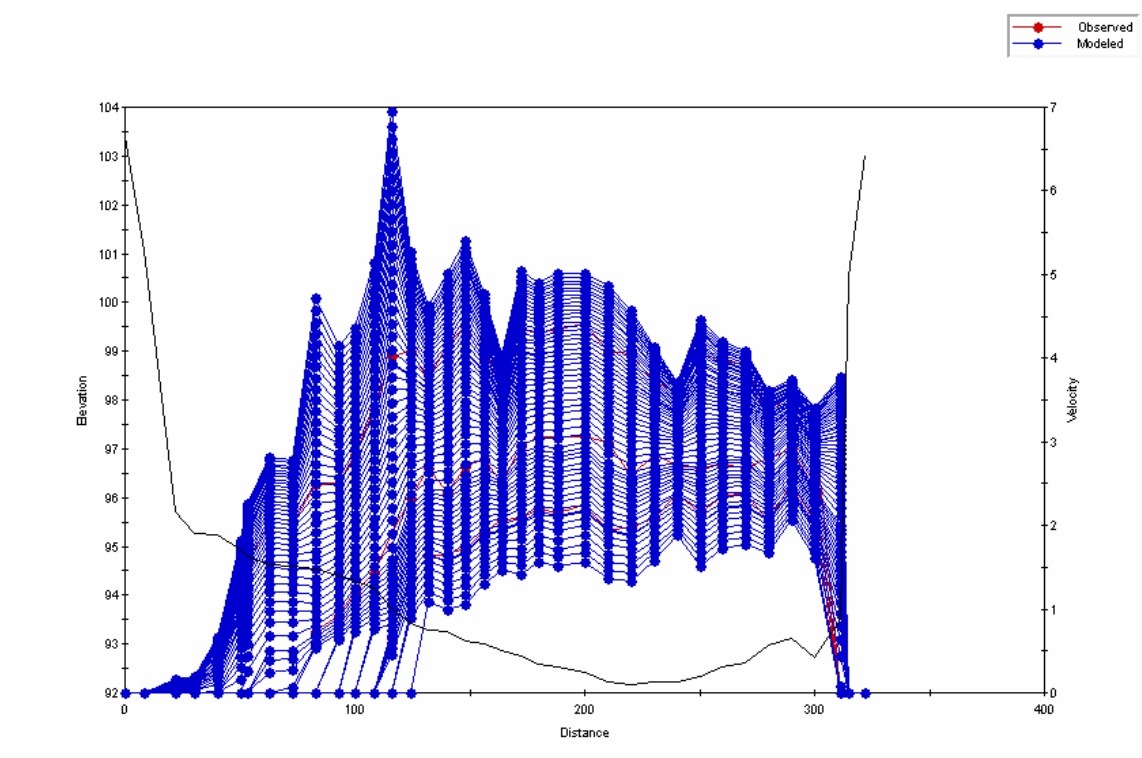
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

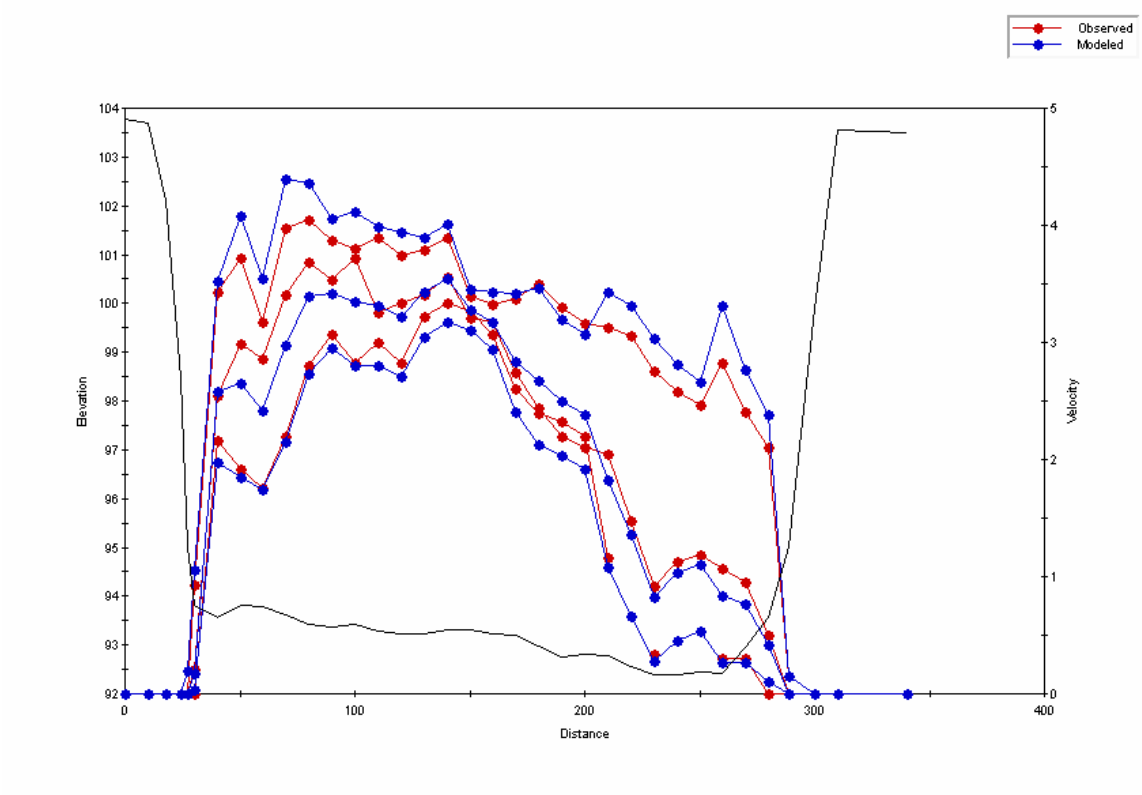

Observed
Modeled
Elevation
Velocity
Distance

Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 6


Observed
Modeled
Elevation
Velocity
Distance
104
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100
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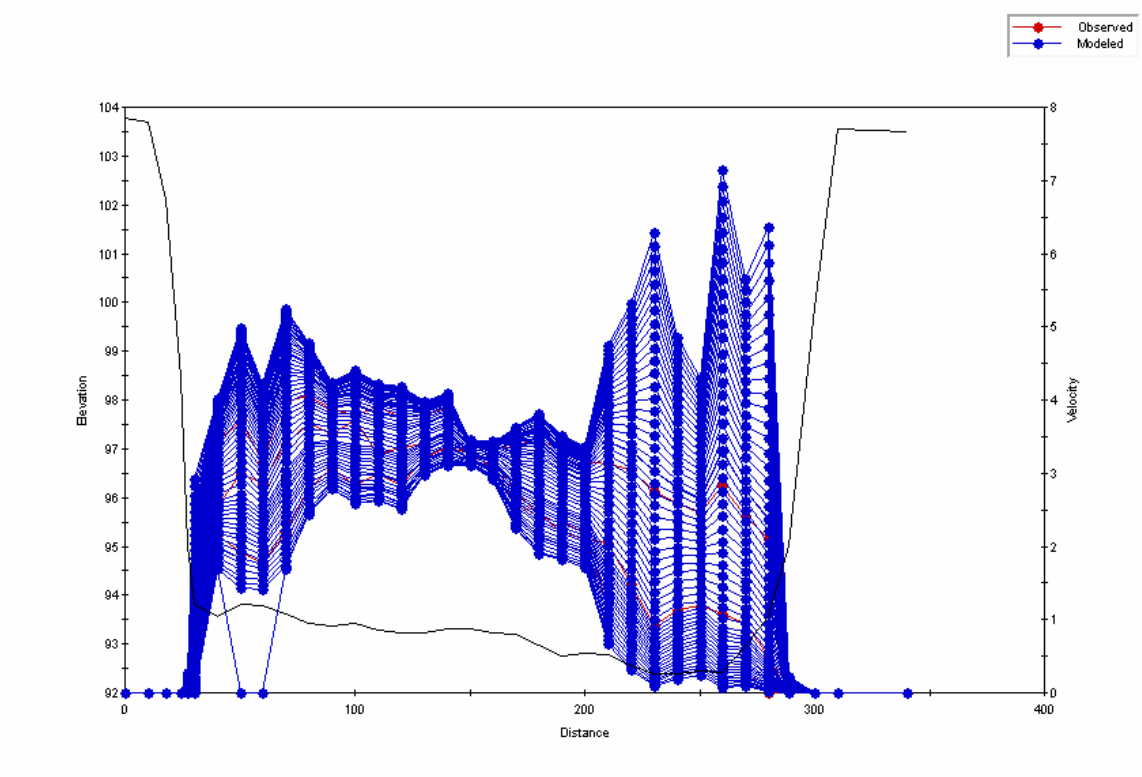
300
400


Observed
Modeled
Elevation
Velocity
Distance
104
103
102
101
100
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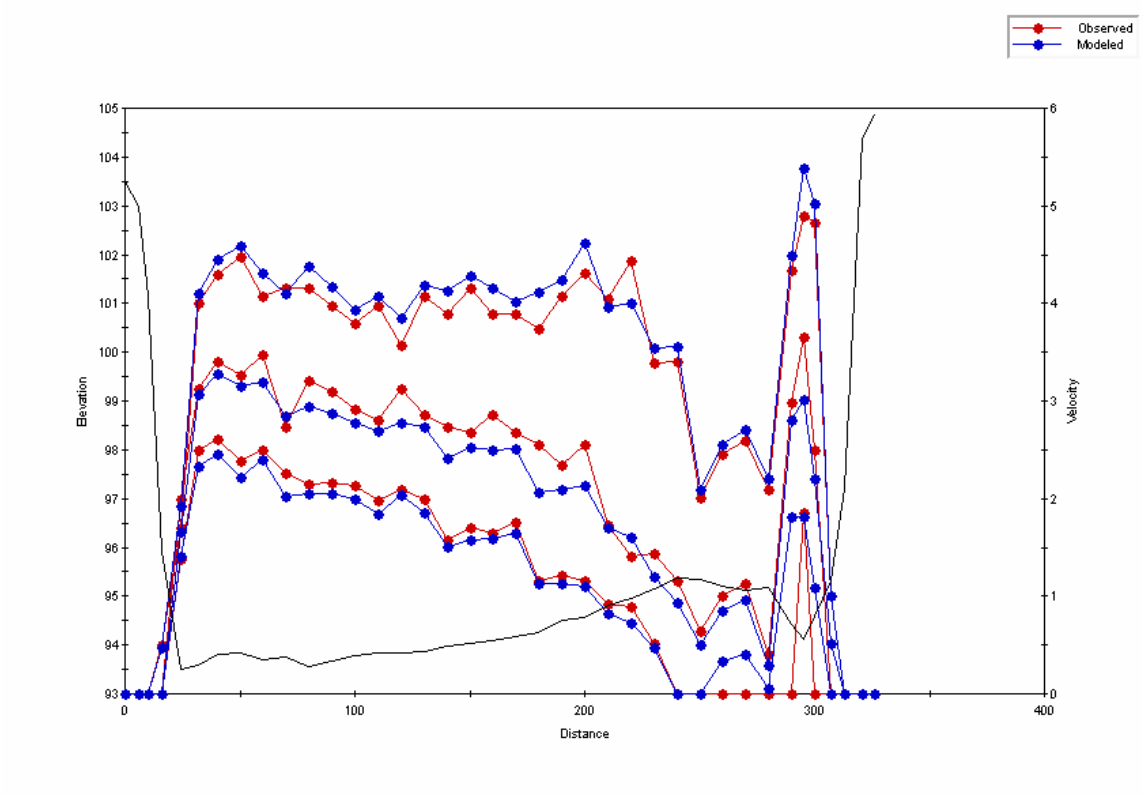
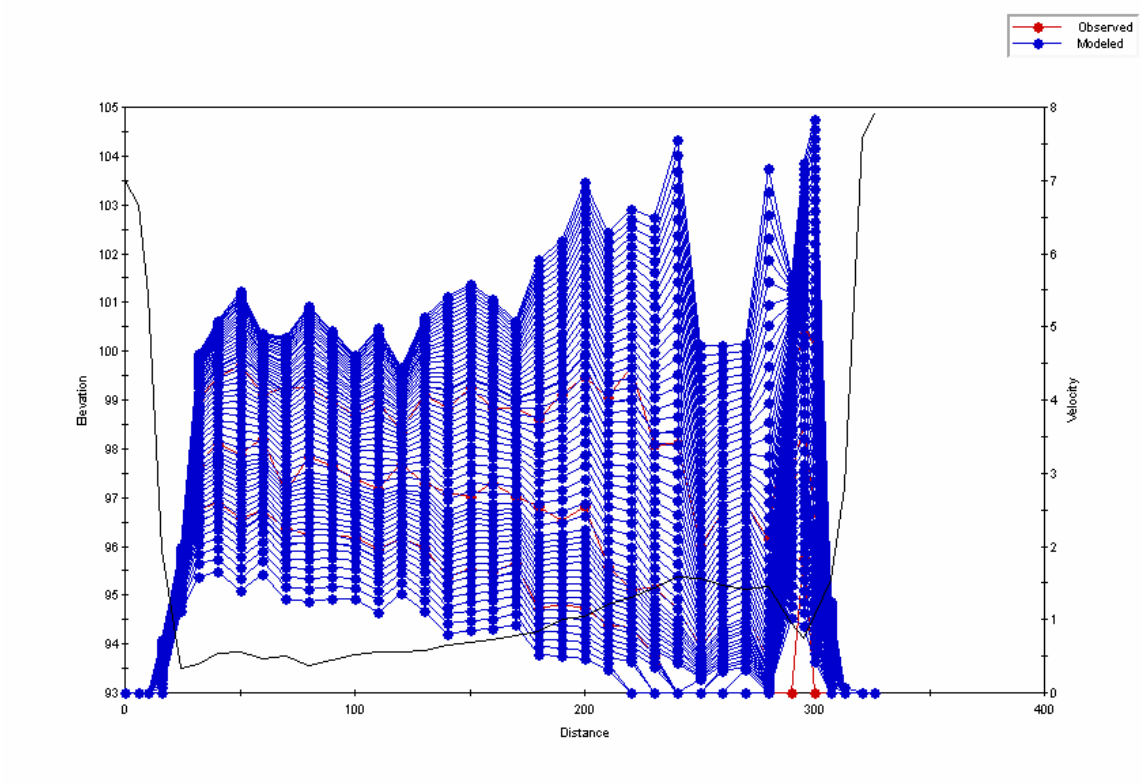
0
100
200
300
400

Transect 7


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

North Fork - Oso

Transect 1

V7 Changed z from 92.61 to 92.63

Several other slight errors in WSL vs Z not corrected since datasheet so full of errors. Let model predict for channel edge verticals where observed = 0 but Z below WSL.

V34-44 Eliminated Q1 (1.54), (1.74), (1.44), (1.34), (.85), (.63), (.38), (.41), (.42), (.32), (.69) values. Odd observations between observed vels and depth. For example, depth of 0.04 feet with velocity 0.63.

Transect 2

V3 Changed z from 92.91 to 92.90

V34 Let model predict Q2

V32,33 Eliminate Q2 (2.00), (1.00) vels.

Transect 3

V8 Changed Z to 93.81 since no observed vels and on a steep channel margin.

V9 Eliminated Q2 (.31)

V26 Change Q2 to 3.97

V12 Change Q1 from 0.51 to 0.71

Transect 4

Very unusual hydraulics at this site. Stark change in profile between calibration flows. Used 3 models. **Changed Best Q for Q1 to 435.**

1-flow Q1 from 150-700 cfs

2-flow Q2,3 from 700-1500

1-flow Q3 from 1500-3500

V22 Change Q2 from 5.94 to 4.75; Q3 from 4.44 to 5.32

V23 Change Q3 from 4.23 to 5.07

Transect 5

Two models. 3-flow from 150-1500. 1-flow Q3 from 1500-3500.

Appears that Q3 best Q may be 10% higher than value used.

V41 Change Q2 to 4.34 from 4.54; Q3 from 4.00 to 4.8

V34 Eliminate Q2 (1.58)

V35 Eliminate Q3 (2.34)

V18,19 Eliminate Q2 (.18), (.27) to control spike >20 ft/sec

Transect 6

V39 Change Q2 from 1.47 to 1.76

V5 Change Q2 from .44 to .64, Q3 from 1.5 to 1.2, to control very high spike.

NF Stillaguamish - Oso

Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
1	0	0	0	0	0	0
2	10	8	12	4	2	15
3	20	20	20	13.5	6	16
4	50	26	30	20	12	18
5	73	32	53	26	20	20
6	80	36	65	34	28	25
7	93	40	70	40	38	30
8	95	44	81	50	42	35
9	100	48	88	60	52	40
10	105	52	98	70	65	45
11	110	56	108	80	72	50
12	115	60	118	90	100	55
13	120	64	128	100	115	60
14	125	68	138	105	119	65
15	130	73	148	110	120	70
16	134	78	153	115	130	75
17	138	83	158	120	140	80
18	142	88	163	125	150	85
19	146	93	168	130	160	90
20	150	98	173	135	170	95
21	153	103	177	140	175	100
22	156	108	181	145	178	105
23	159	113	185	150	183	110
24	162	118	189	155	185	115
25	165	123	193	160	190	120
26	168	128	197	165	195	125
27	171	133	201	170	200	130
28	174	138	205	175	205	135
29	177	148	209	180	210	140
30	180	158	213	188	215	145
31	184	168	218	193	220	150
32	188	178	225	210	225	155
33	192	183	236		230	160
34	196	188	240		235	165
35	200	192.5	250		240	170
36	205	198	264		245	175
37	210	223			250	180
38	215				255	185
39	220				260	190
40	225				265	195
41	230				270	200
42	235				275	210.5
43	240				280	
44	245				283	
45	250				286	
46	255					
47	260					

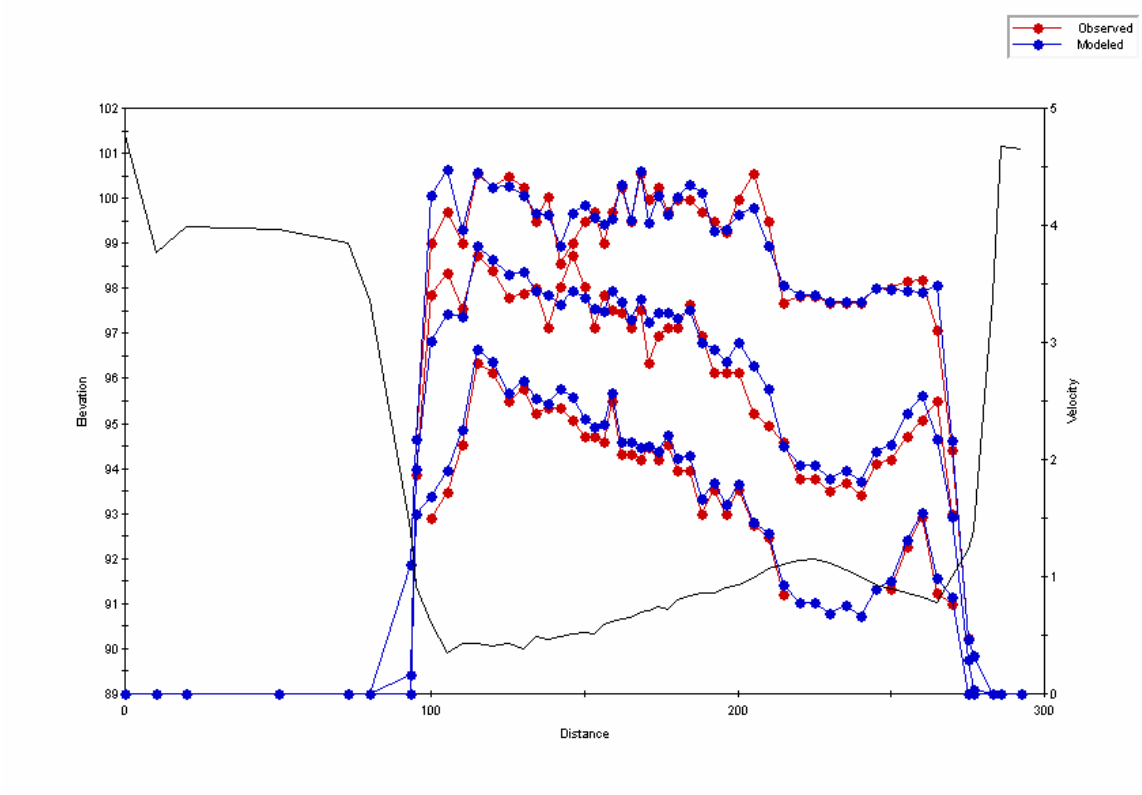
NF Stillaguamish - Oso

Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
48	265					
49	270					
50	275					
51	277					
52	283					
53	286					
54	292.5					

NF Oso

Transect (model)	**1**	**2**	**3**	**4a**	**4b**	**4c**	**5a**	**5b**	**6**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	3	3	1	2	1	3	1	3
Discharge	365	390	526	435		435	335	382	369
	868	869	896	905	982	905	864	905	945
	1539	1476	1456	1550	1737	1550	1559	1550	1538
Stage	92.03	92.23	93.12	93.68		93.68	93.59	93.715	94.79
	92.61	92.91	93.06	94.5	94.66	94.5	94.32	94.55	95.51
	93.2	93.51	93.81	95.25	95.25	95.25	94.95	95.3	96.06
Plotting Stage	2.3	2.17	3.06	2.84		2.84	2.75	2.875	2.51
	2.61	2.85	3	3.66	3.82	3.66	3.48	3.71	3.23
	3.2	3.45	3.75	4.41	4.41	4.41	4.11	4.46	3.78
Ratio of Measured vs. Predicted Discharge									
	0.98	1	0.73	1.000		1.000	0.987	0.986	0.99
	1.05	1.01	1.33	1.000	1	1.000	1.031	1.033	1.04
	0.97	0.99	1.03	1.000	1	1.000	0.982	0.981	0.98
Mean Error of stage/discharge relationship for calculated Q									
	3.13	0.82	21.43	NA	0	NA	2.03	NA	2.68
Mean Error of stage/discharge relationship for given Q									
	1.54	0.74	3.02	0.01	0.01	0.01	2.16	2.16	0.7
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF									
A=	0.314	0.2719	0.4246		0.6749		0.6023		0.464
B =	0.3152	0.3478	0.3003		0.2516		0.2606		0.2849
SZF =	90	90.06	90.06		90.84		90.84		92.28
Beta coefficient log/log discharge/stage relationship									
	3.17	2.88	3.33	2.887	3.974	2.887	3.837	3.202	3.51

Transect 1


Observed
Modeled
Elevation
Velocity
Distance
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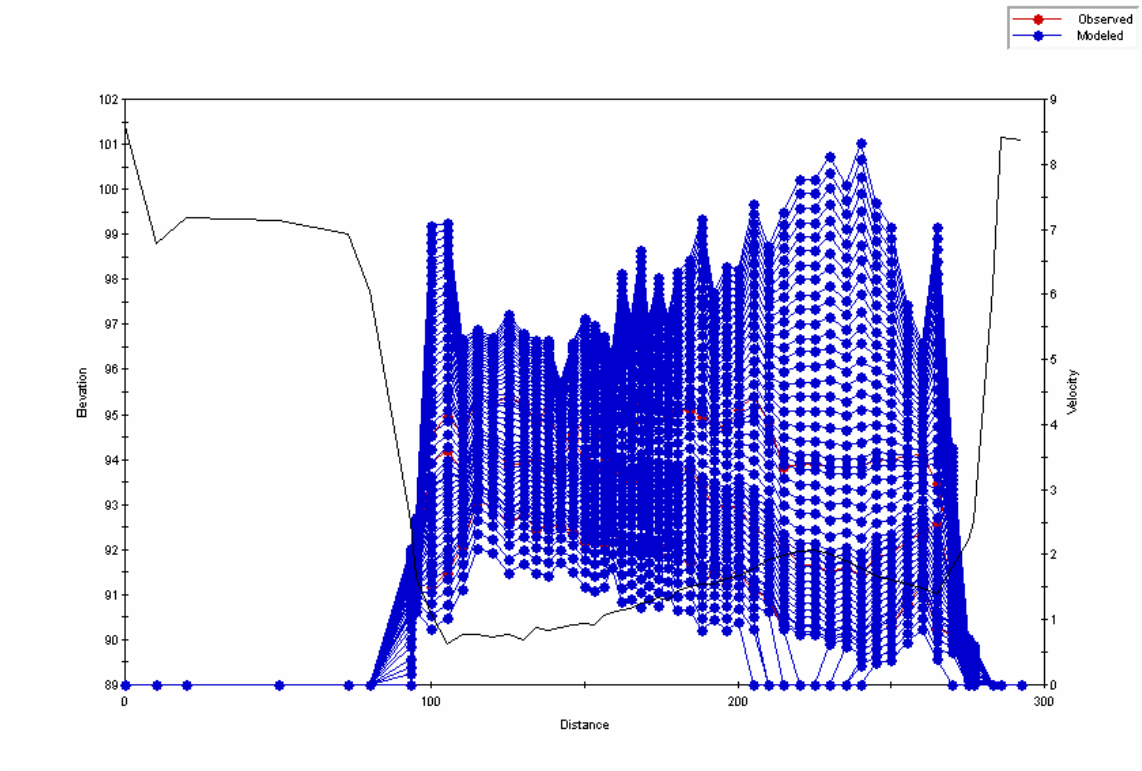
Observed
Modeled
Elevation
Velocity
Distance
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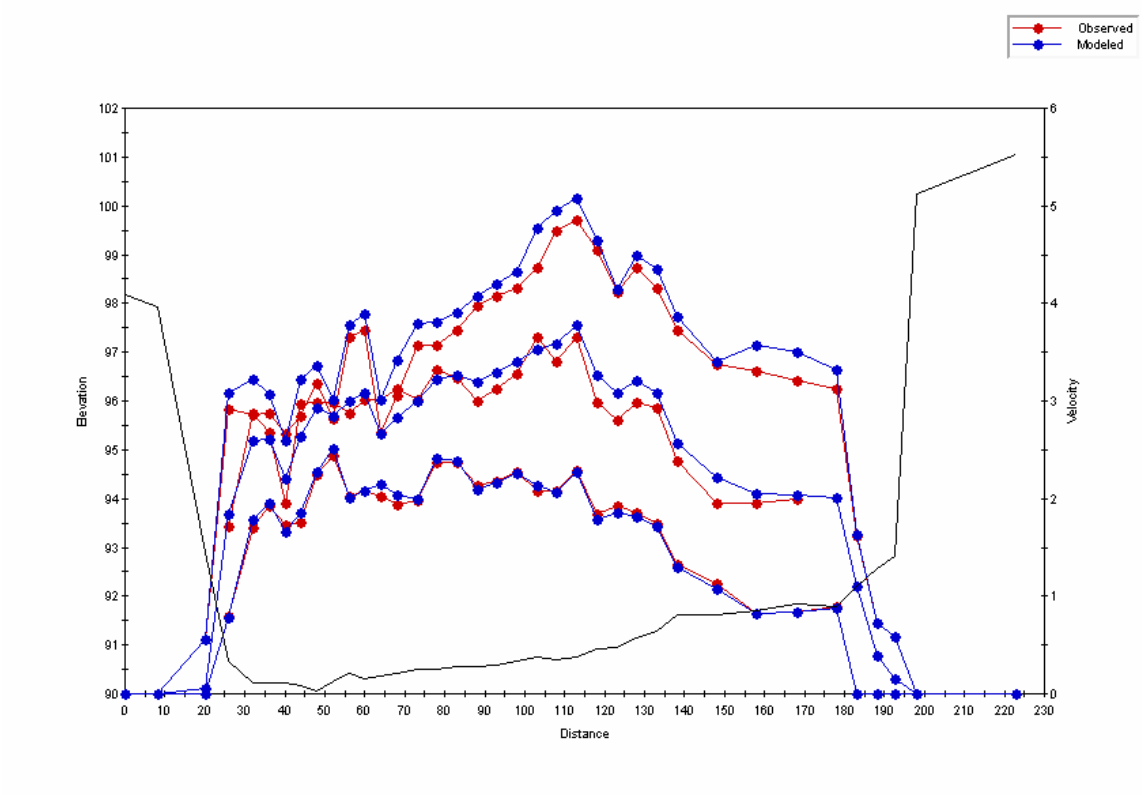
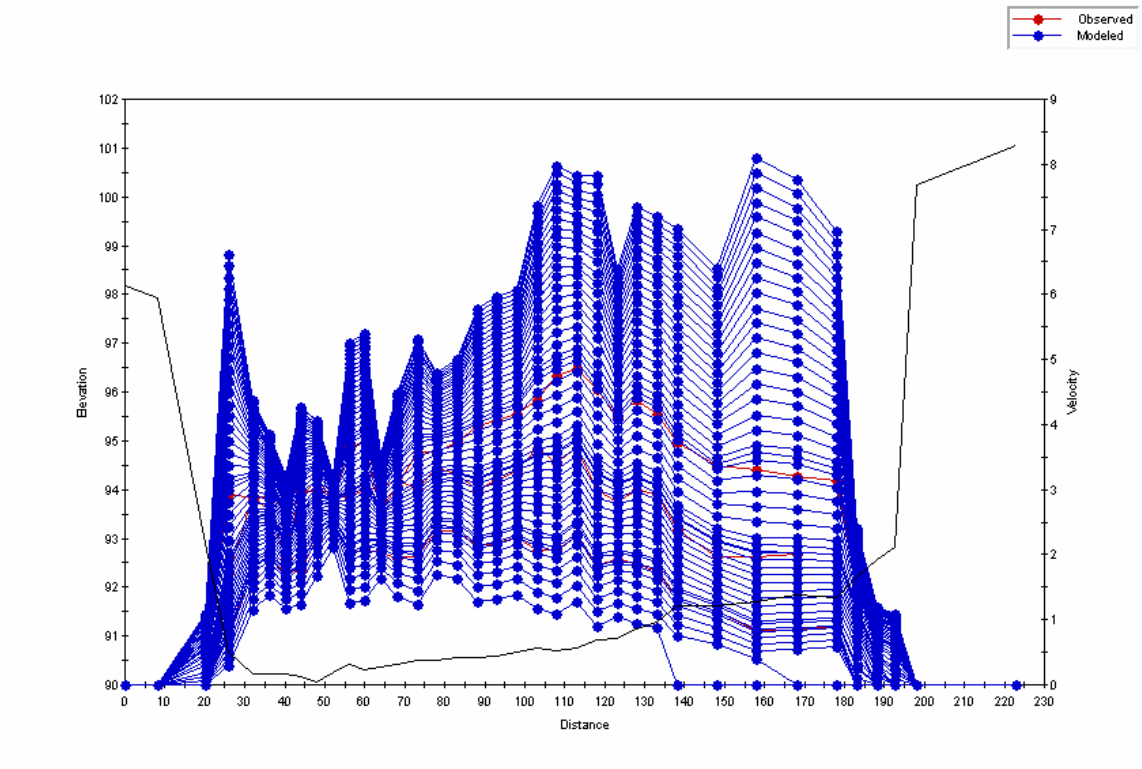
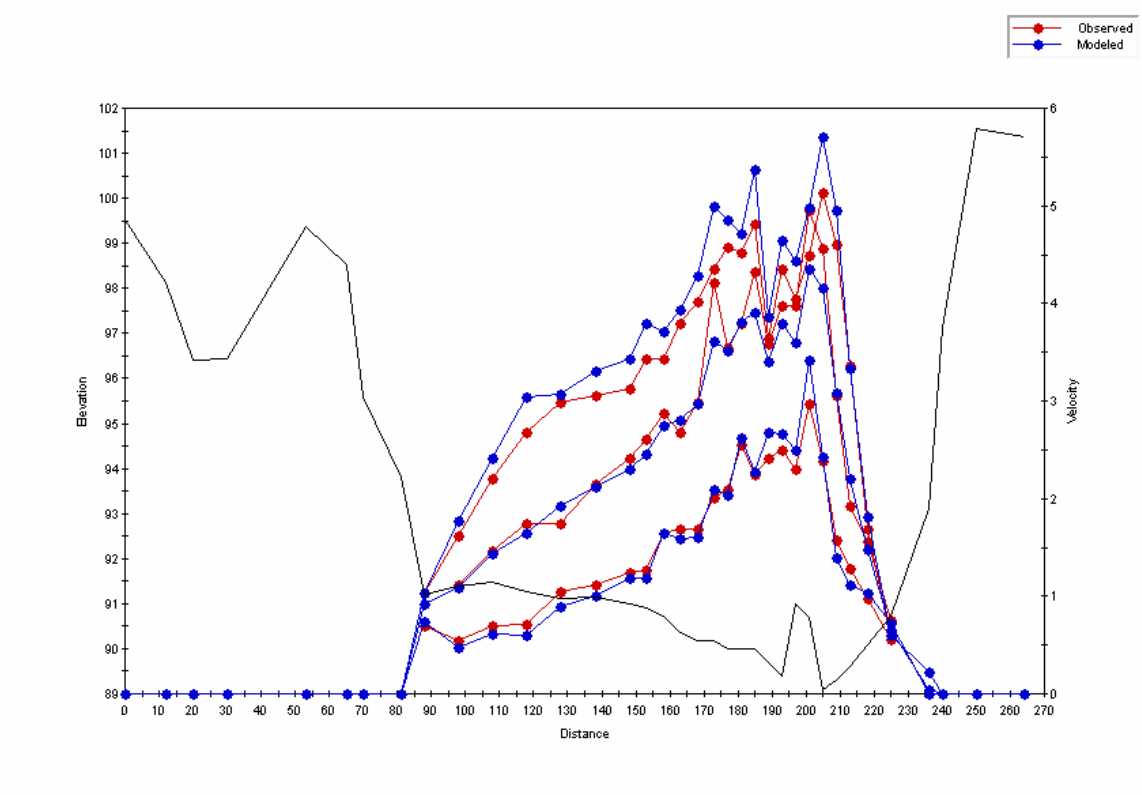
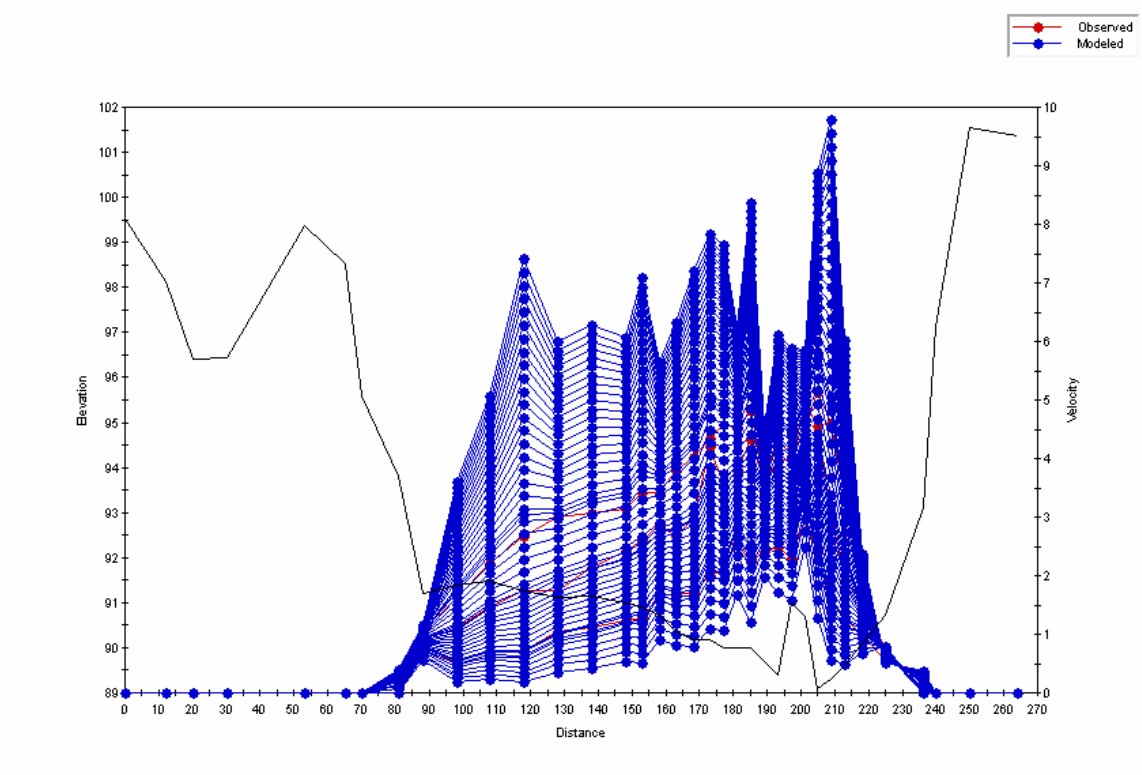
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

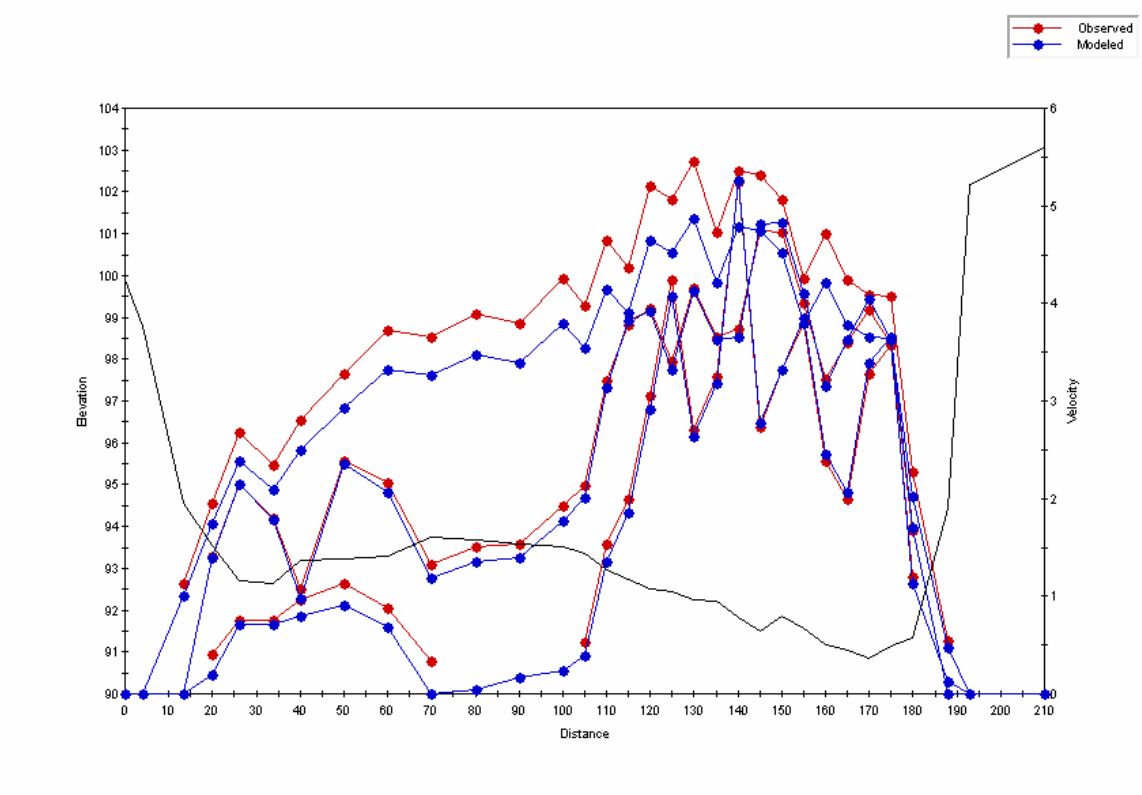

Observed
Modeled
Elevation
Velocity
Distance

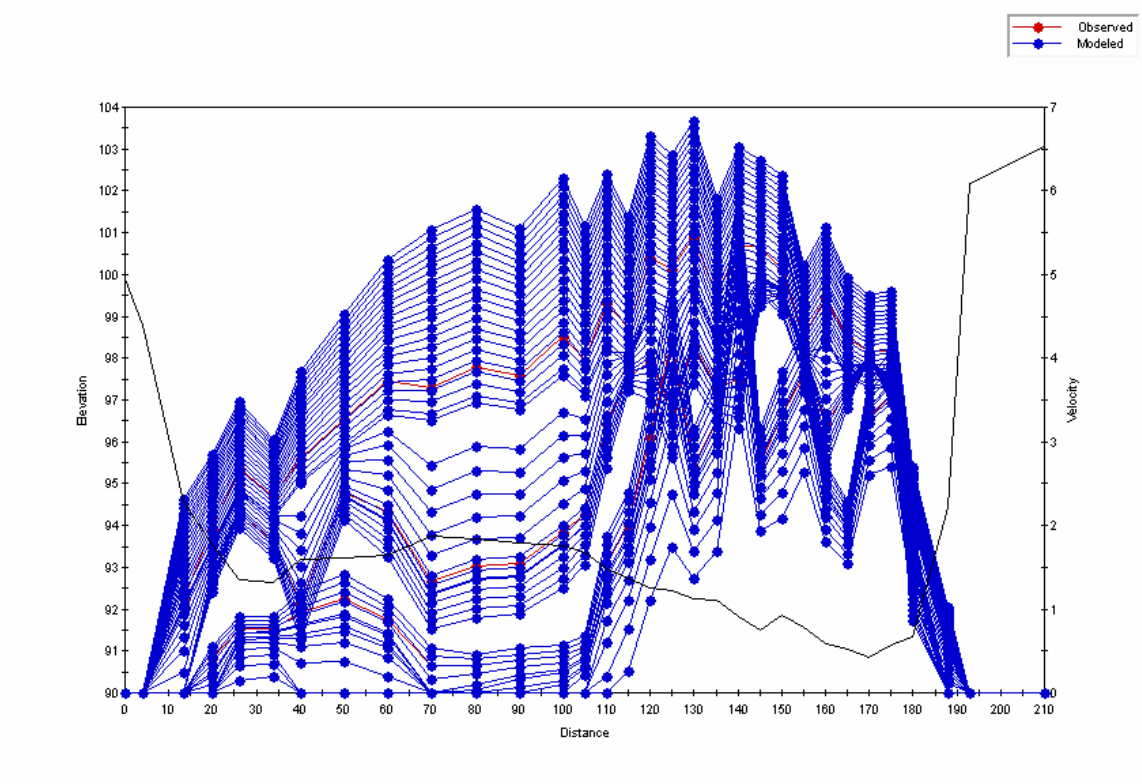
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

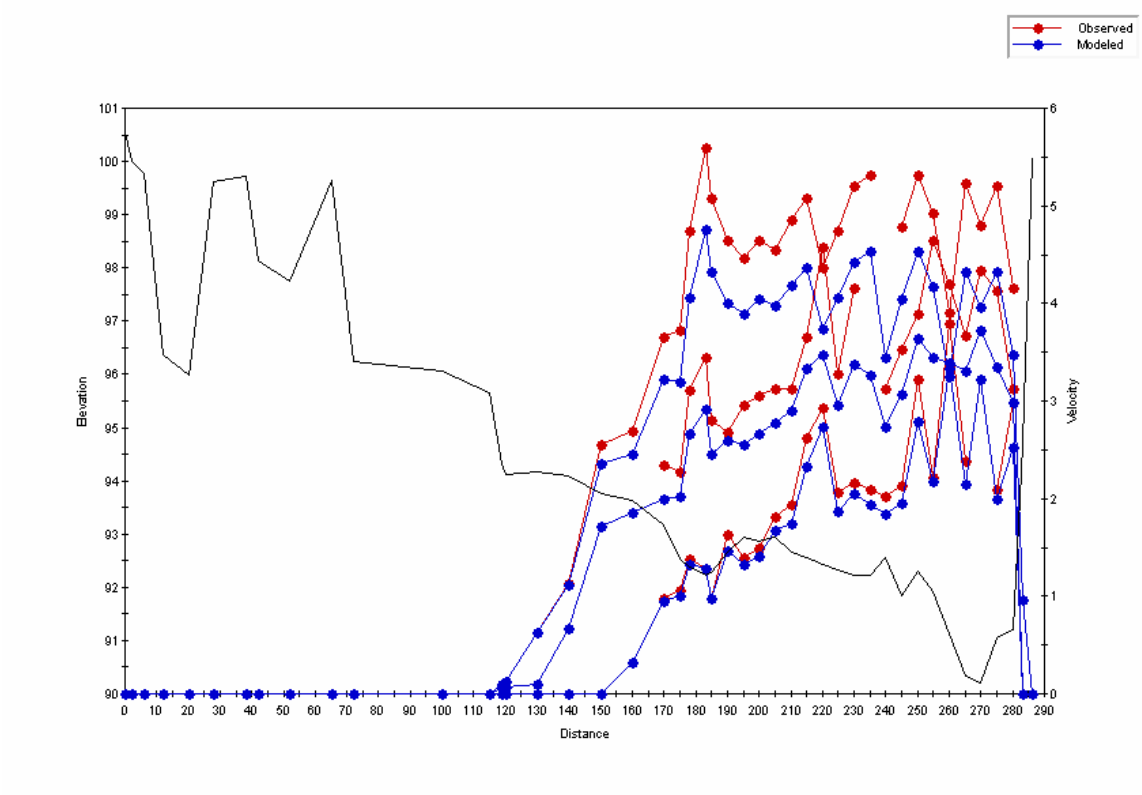

Observed
Modeled
Elevation
Velocity
Distance

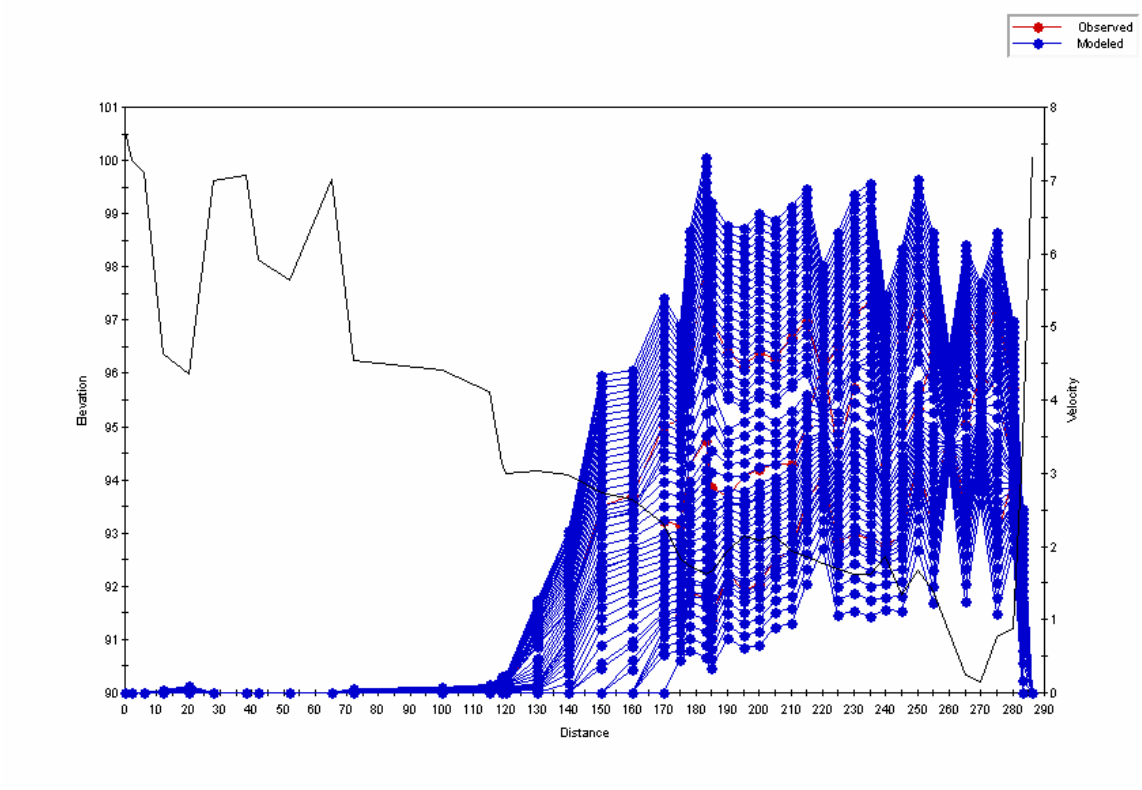
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

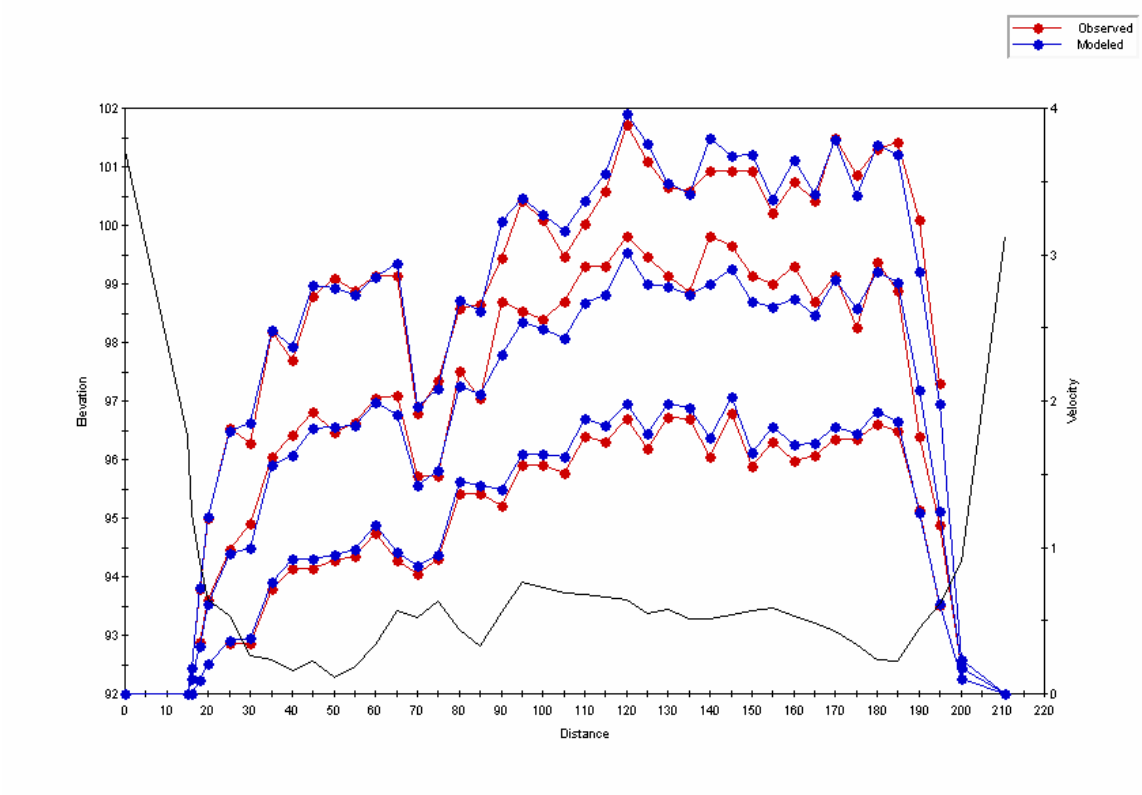

Observed
Modeled
Elevation
Velocity
Distance

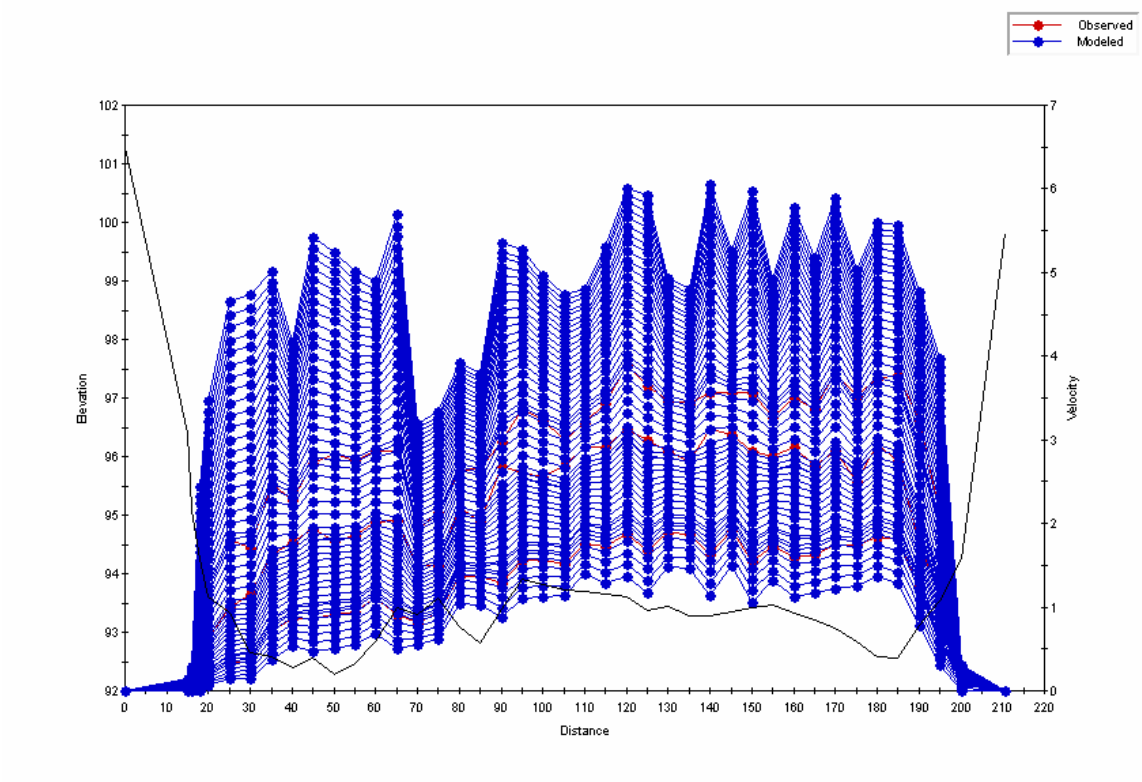
Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 6


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

NF Hazel Calibrations

Transect 1

Very poor data set. Left bank sidechannel bed elevation is a few feet below the WSL, but no flows recorded at Q1 or Q2. See data sheet for numerous notations.
Chose to artificially raise bed elevation in sidechannel to just above the WSL at Q2. Eliminated recorded velocities within the channel at Q3. Allowed model to predict velocities.
For most of data set Q2 vels > Q3. Two models used. 2-flow Q1/Q2 from 100-999 cfs. 1-flow Q3 from 1000-2500 cfs.

V4-8	Set Z to 90.61
V14	Reduce Q3 20% to 1.19 to eliminate high peak.
V42	Reduce Q3 to 1.38 to eliminate high peak.
V43	Eliminated Q3 (.86) since Z is 3 feet above WSL.

Transect 2

V18	Change Q2 from 0.73 to 0.53
V19,20	Eliminate Q1s (.09), (.14). Change Q2 at V20 to 0.91 from 1.11

Transect 3

Split into two models. 100-999 as 3-flow. 1000-2500 as 1-flow Q3.

V18	Reduce Q3 from 2.83 to 2.54
V11	Reduce Q3 from 3.89 to 3.8; eliminate Q1
V12	Eliminate Q1 (.90)

Transect 4

Two models. 1-flow Q1 from 100-999 cfs. 1-flow Q3 from 1000-2500.

V39	Change Z to 90.1.

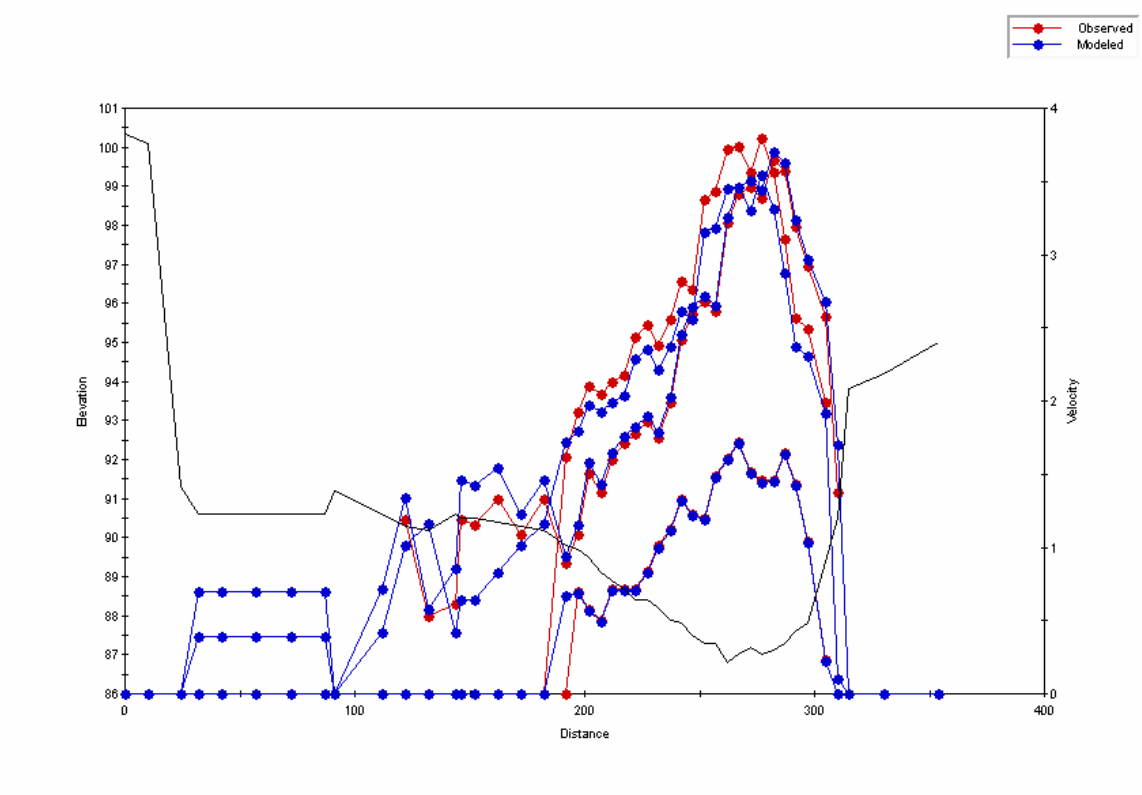
Coordinate Table: NF Stillaguamish - Hazel Slide

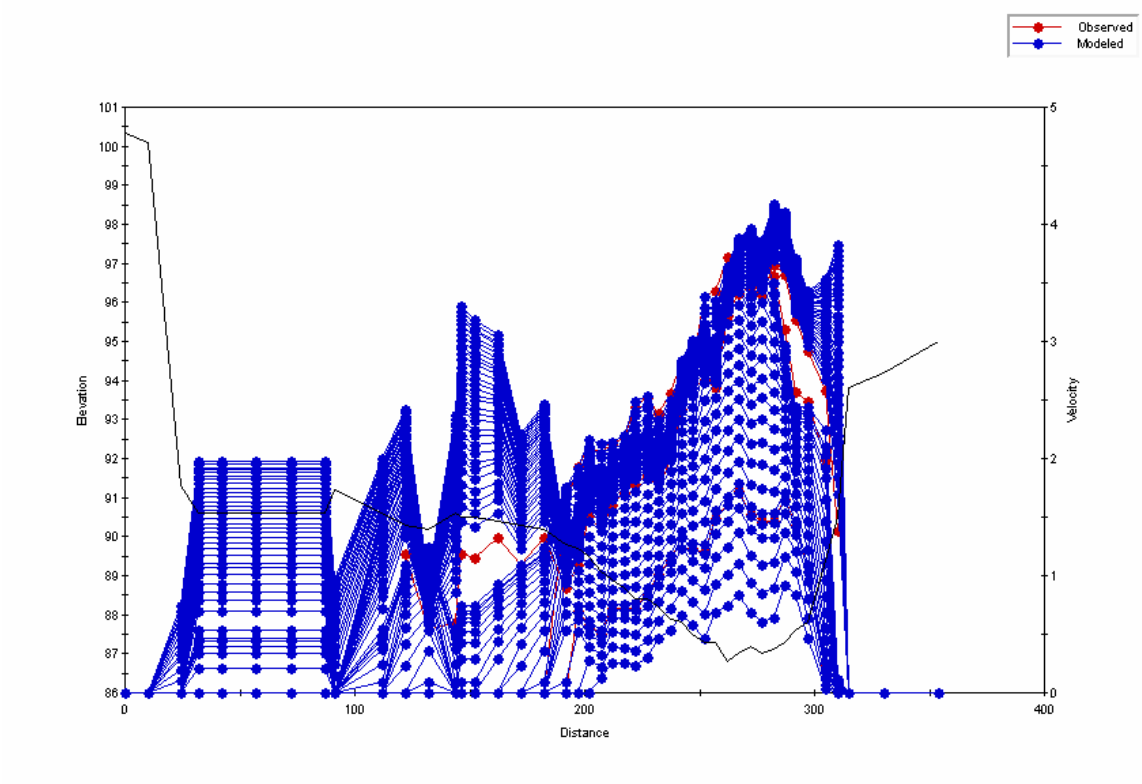
Station ID	Distance from Bank Transect 1	Transect 2	Transect 3	Transect 4
1	0	0	0	0
2	10	5	30	22
3	24	7	40	24
4	32	14	65	26
5	42	30	95	30
6	57	45	119	35
7	72	60	130	40
8	87	80	140	45
9	91	100	150	48
10	112	120	160	53
11	122	140	170	58
12	132	149	180	63
13	144	160	190	68
14	146	175	195	73
15	152	180	200	78
16	162	190	205	83
17	172	200	210	88
18	182	205	215	93
19	192	210	218	98
20	197	215	221	103
21	202	220	224	108
22	207	225	227	113
23	212	230	231	118
24	217	235	234	120.5
25	222	240	237	123
26	227	245	240	125.5
27	232	250	243	130
28	237	255	247	132.5
29	242	260	250	135
30	247	265	253	137.5
31	252	270	256	140
32	257	275	259	142.5
33	262	280	262	145
34	267	285	265	147.5
35	272	290	270	150
36	277	295	272.5	152.5
37	282	297	277	155
38	287	300		157.5
39	292	309		160
40	297			165
41	305			168
42	310			178
43	315			188
44	330			198
45	354			208
46				218
47				229

NF Hazel

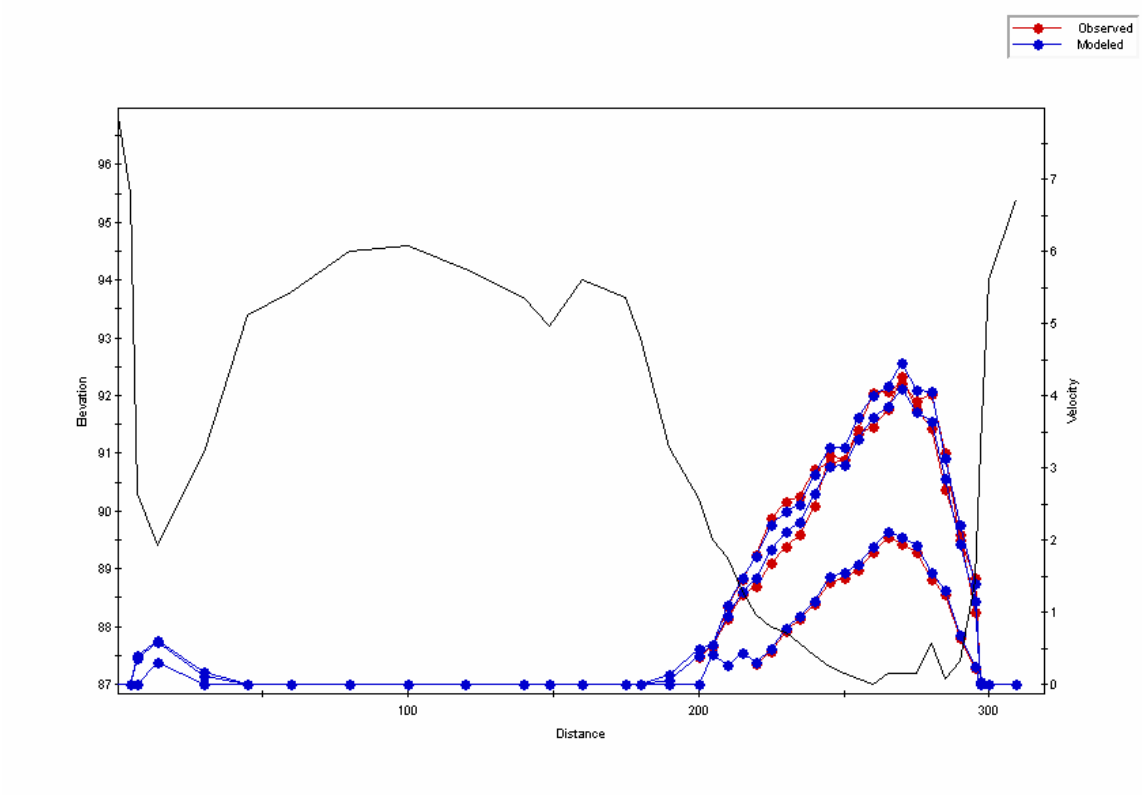
Transect (model)	**1a**	**1b**	**2**	**3a**	**3b**	**4a**	**4b**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	2	1	3	3	1	1	1
Discharge	284	278	264	237	278	278	278
	843	870	846	824	870	870	870
		1000	990	892	1000	1000	1000
Stage	90.02	90.02	90.11	90.22	90.24	90.46	90.46
	90.52	90.605	91.13	91.37	91.51	91.65	91.65
		90.88	91.36	91.68	91.68	91.855	91.855
Plotting Stage	3.22	3.22	3.11	2.22	2.24	2.16	2.16
	3.72	3.805	4.13	3.37	3.51	3.35	3.35
		4.08	4.36	3.68	3.68	3.555	3.555
Ratio of Measured vs. Predicted Discharge							
	1	0.957	1	0.985	1.001	0.999	0.999
	1	1.162	1.03	1.092	0.991	1.007	1.007
		0.899	0.97	0.93	1.009	0.993	0.993
Mean Error of stage/discharge relationship for calculated Q							
	0	NA	2.11	5.86	NA	NA	NA
Mean Error of stage/discharge relationship for given Q							
	9.89	9.89	0.47	0.63	0.63	0.5	0.5
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF							
A=	0.1524		0.7637	0.3			
B =	0.1324		0.2516	0.3651			
SZF =	86.8	86.8	87	88	88	88.3	88.3
Beta coefficient log/log discharge/stage relationship							
	7.552	5.668	3.98	2.739	2.563	2.581	2.581

Transect 1


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 2


Observed
Modeled
Elevation
Velocity
Distance
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90
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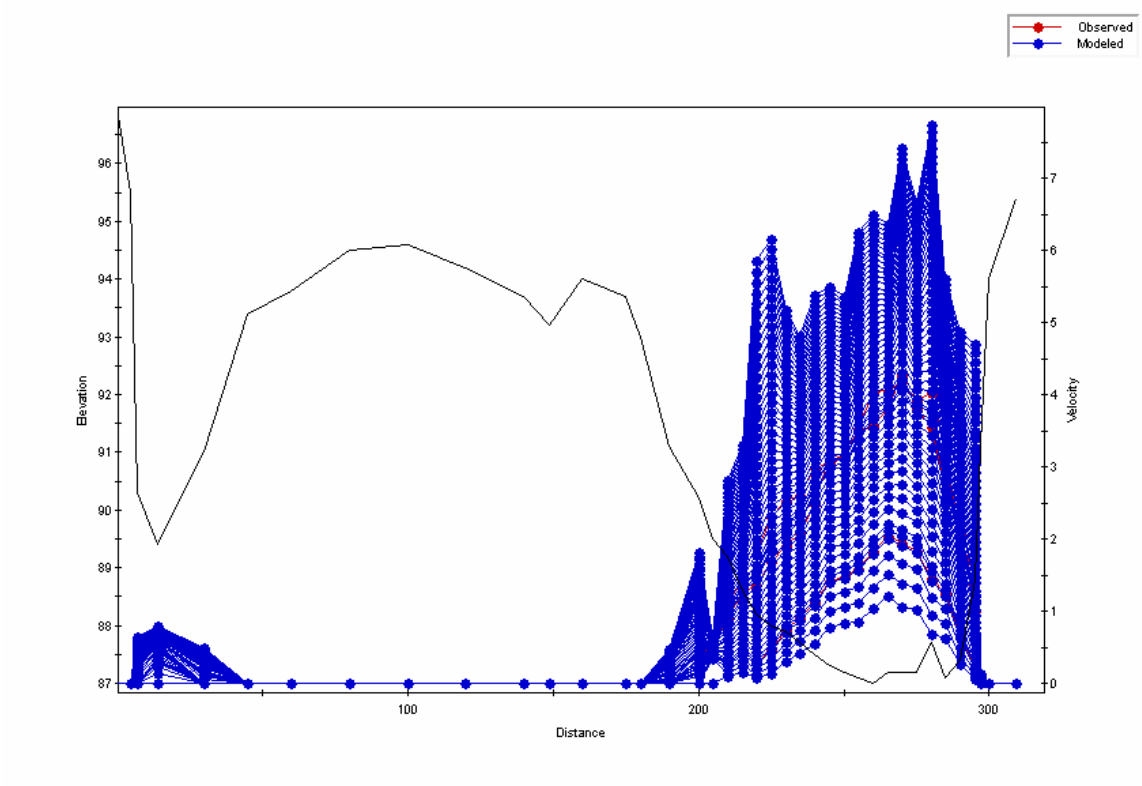
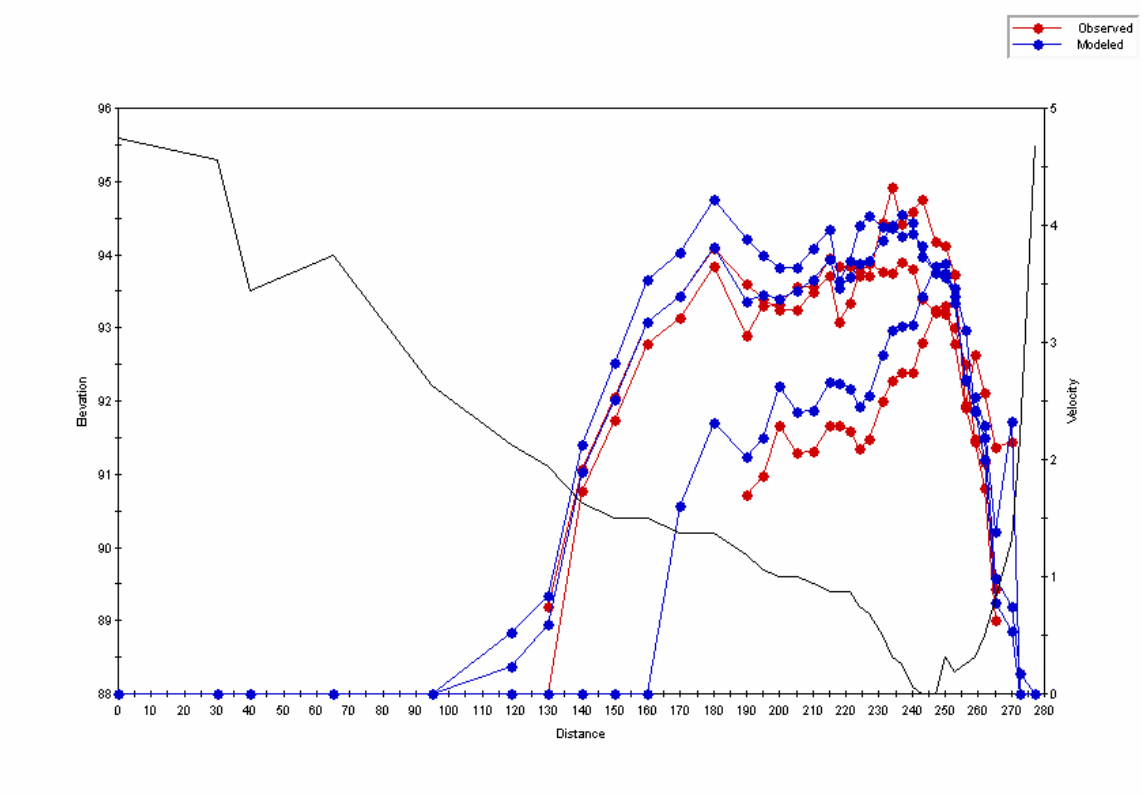
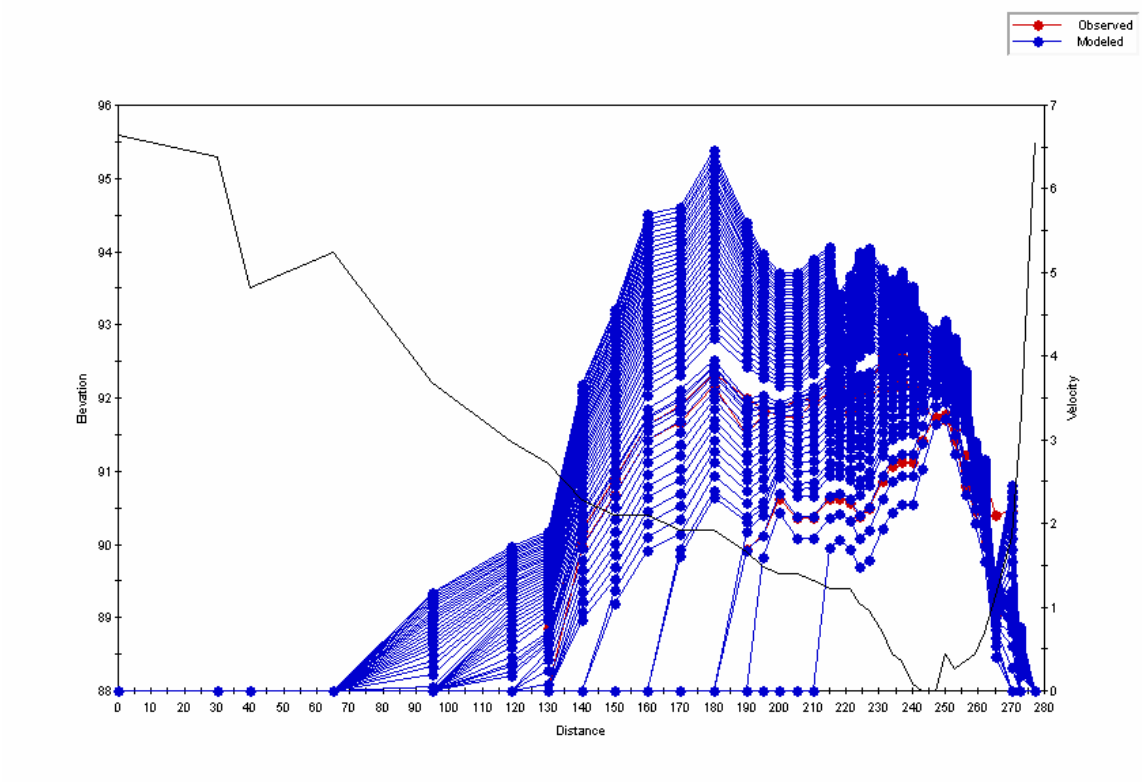
87
7
6
5
4
3
2
1
0
100
200
300

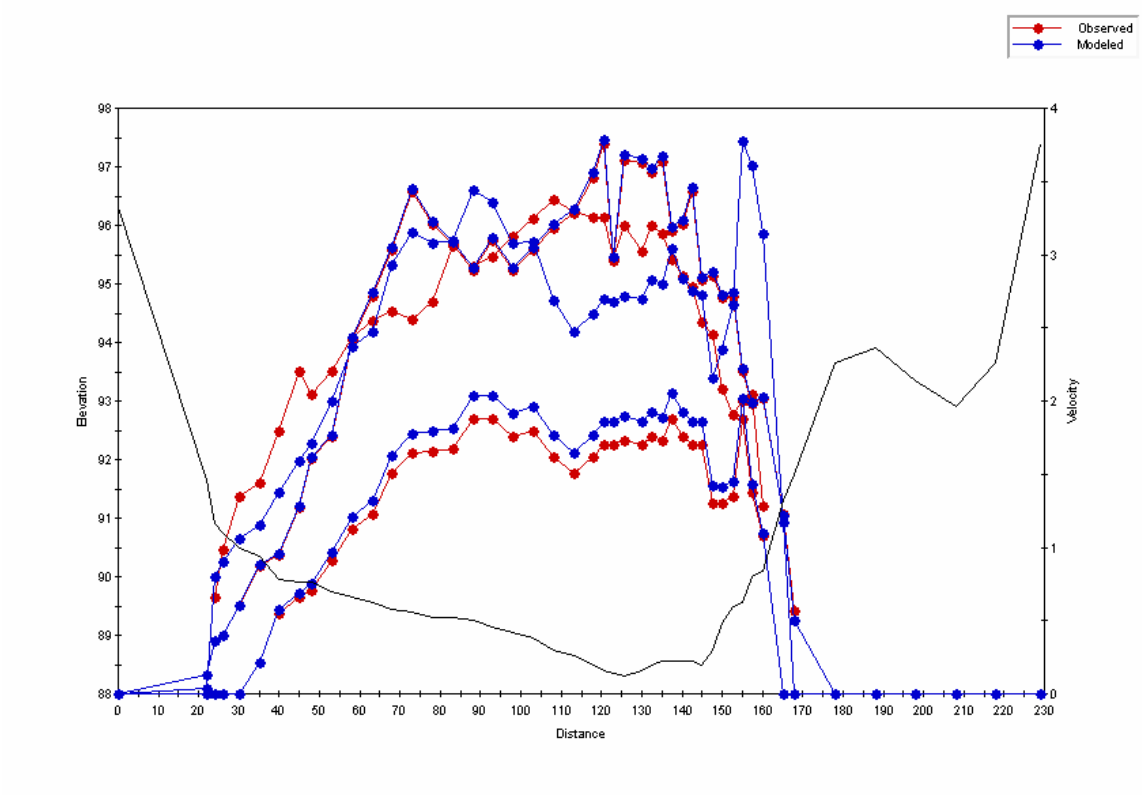

Observed
Modeled
Elevation
Velocity
Distance
96
95
94
93
92
91
90
89
88
87
7
6
5
4
3
2
1
0
100
200
300

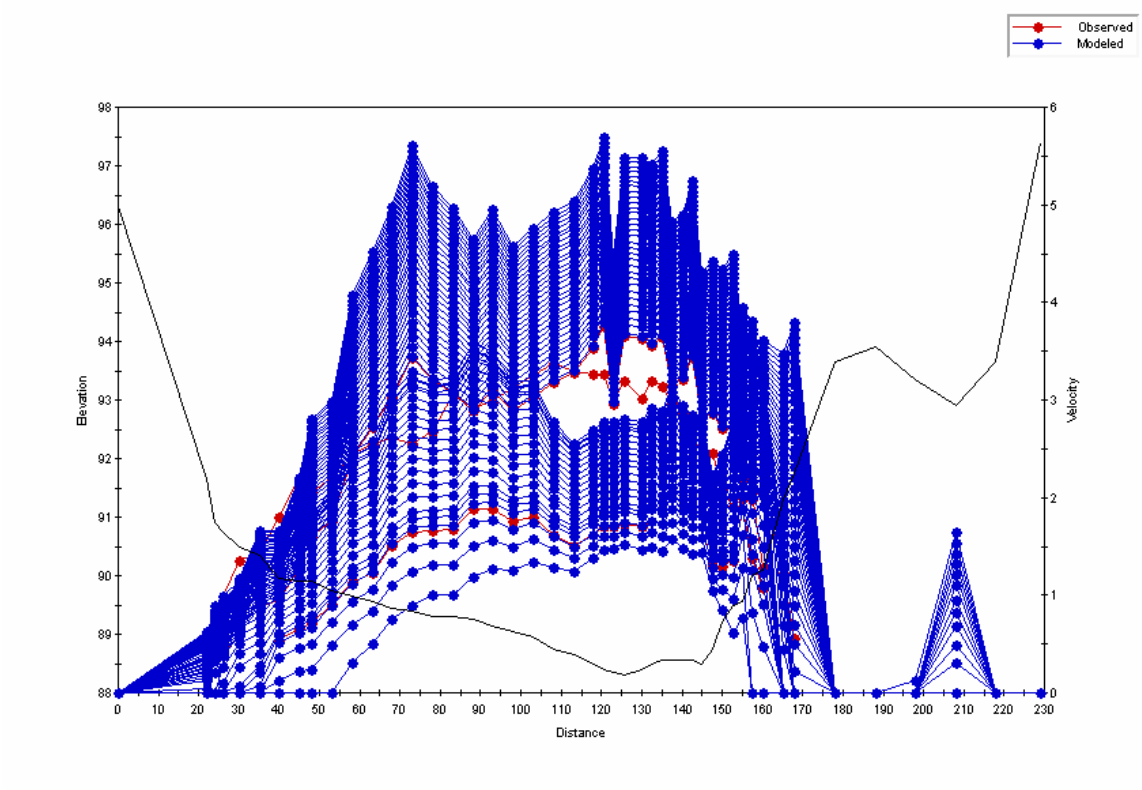
Transect 3


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 4


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

NF Blue Slough Calibrations

Best Q for High Q does not make sense. Changed to 925 cfs - average of computed Q at same transects as identified in original field sheets.

Transect 1

V4	Eliminated Q3 (-.24) since Z >> WSL. Indeterminate data error.
V8	Change Q1 from 0.8 to 0.6, Q2 from 0.41 to 0.61.
V14	Change Q1 down 20% to 1.69.
V23	Change Q1 down 20% to 2.01 and Q2 up 20% to 2.45.
V24	Change Q1 down 20% to 2.54 and Q2 up 20% to 3.02.
V29, 30, 33	Eliminate Q1 (.275), (.561), (.239) to control high peaks.
V30	Change Q3 down from 3.8 to 3.04.

Transect 2

Broke into 2 1-flow models due to poor fit. 50-500 cfs using Q1. 501-2500 cfs using Q3.

Transect 3

V9	Eliminate observed 0.0 at Q2 and allow model to estimate.
V11,12	Eliminate Q1 (.183), (.309) to reduce high spike.

Transect 4

Split into two models due to poor performance at high velocities. 50-1000 3-vel model. 1001-2500 1-flow Q3.

V12	Eliminate Q1 (.159) and Q2 (.331).

Transect 5

Split into 2 1-flow models. 50-500 1-vel Q1; 501-2500, 1-vel Q3.

Transect 6

V9	Let model predict Q1 since Z << WSL.
V24	Eliminate Q1 (.172) and Q2 (.377) to control very high spike.
V23	Change Q3 from 3.8 to 3.04.

Transect 7

V26	Set Z to 94.55. Steep bank area. No observed velocities.
V13	Eliminate Q1 (.28)to control spike.
V11	Eliminate Q2 (.25) to get rid of very high spike.

Transect 8

V8	Change Z to 94.55
V18	Change Q2 to 2.43.
V25-27	Eliminate Q1 (.289), (.228), (.115) to control spikes.

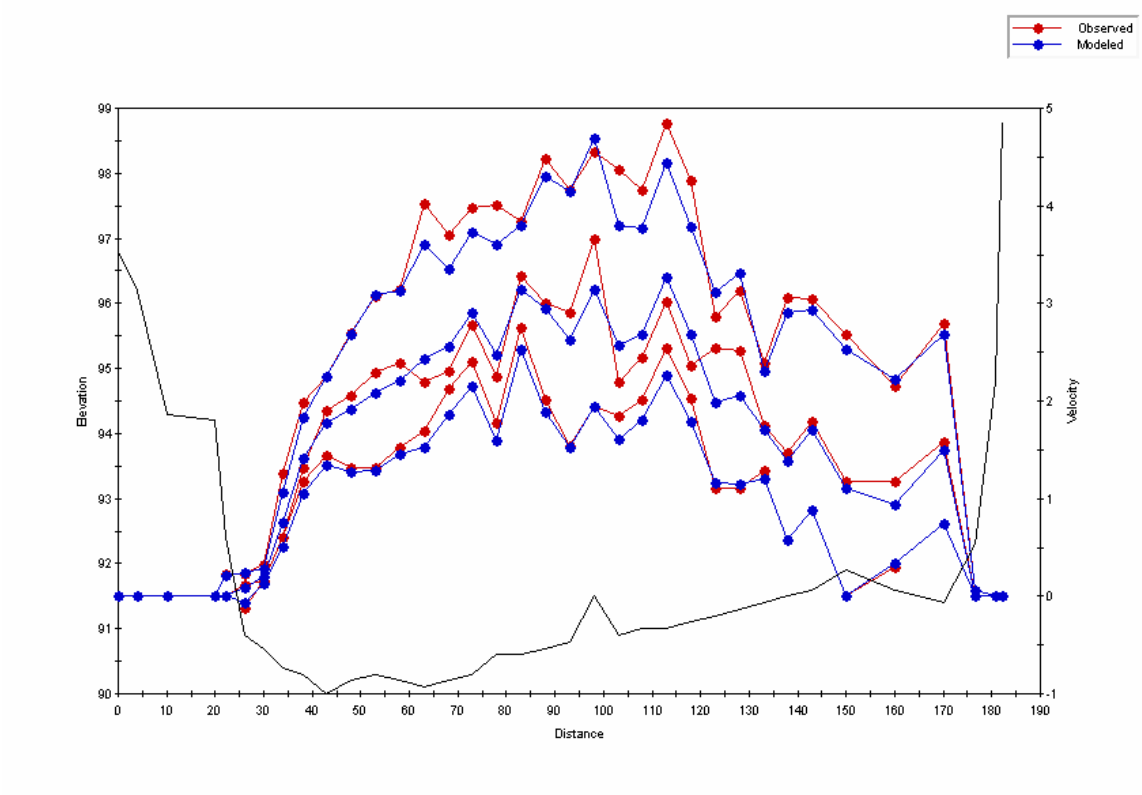
Coordinate Table: NF Stillaguamish - Blue Slough

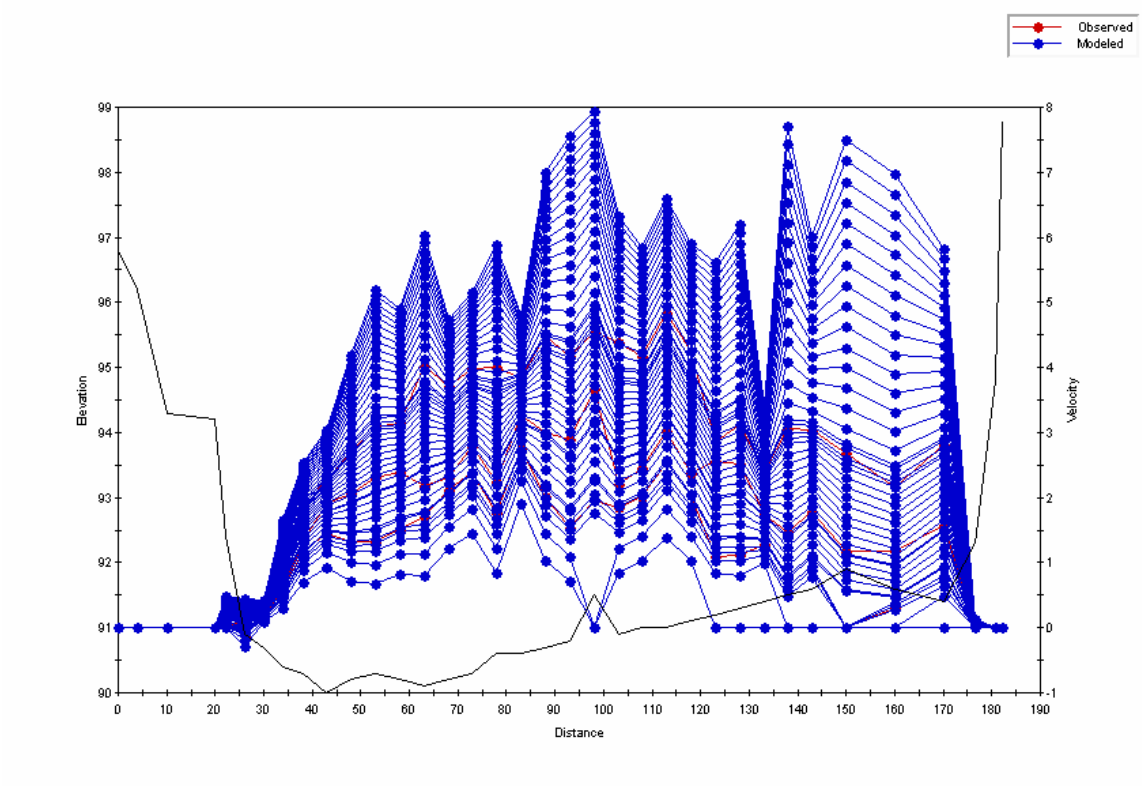
Vertical (V)	Distance from Bank							
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8
1	0	0	0	0	0	0	0	0
2	4	20	20	18	20	12	12	16
3	10	26	36	40	38	30	26	30
4	20	32	50	46	55	50	40	46
5	22	42	65	60	70	65	55	60
6	26	55	80	75	85	80	70	75
7	30	70	95	90	100	95	85	90
8	34	80	102.5	105	115	103	95	100
9	38	90	110	120	120	115	100	110
10	43	100	120	130	127	125	105	115
11	48	110	130	140	130	130	110	120
12	53	120	135	150	135	135	115	125
13	58	130	140	155	140	140	120	129
14	63	135	145	160	145	145	125	135
15	68	140	150	165	150	150	130	140
16	73	145	155	170	155	155	134	144
17	78	150	160	175	160	160	138	147
18	83	155	165	180	165	165	142	150
19	88	160	170	185	170	170	146	153
20	93	165	175	190	175	175	150	156
21	98	175	180	195	180	180	154	159
22	103	185	186	200	185	185	158	162
23	108	195	186.1	205	190	190	162	165
24	113	210	191	210	195	195	166	169
25	118	220		215	200	200	170	173
26	123	230.3		218.5	205	204	181	178
27	128			219	210	207.2	183	183
28	133			222	215		186.2	193
29	138			224	220			196
30	143			228	226			200
31	150				230			215
32	160				233			
33	170				244.5			
34	176.5							
35	180.7							
36	182.2							

NF Blue Slough

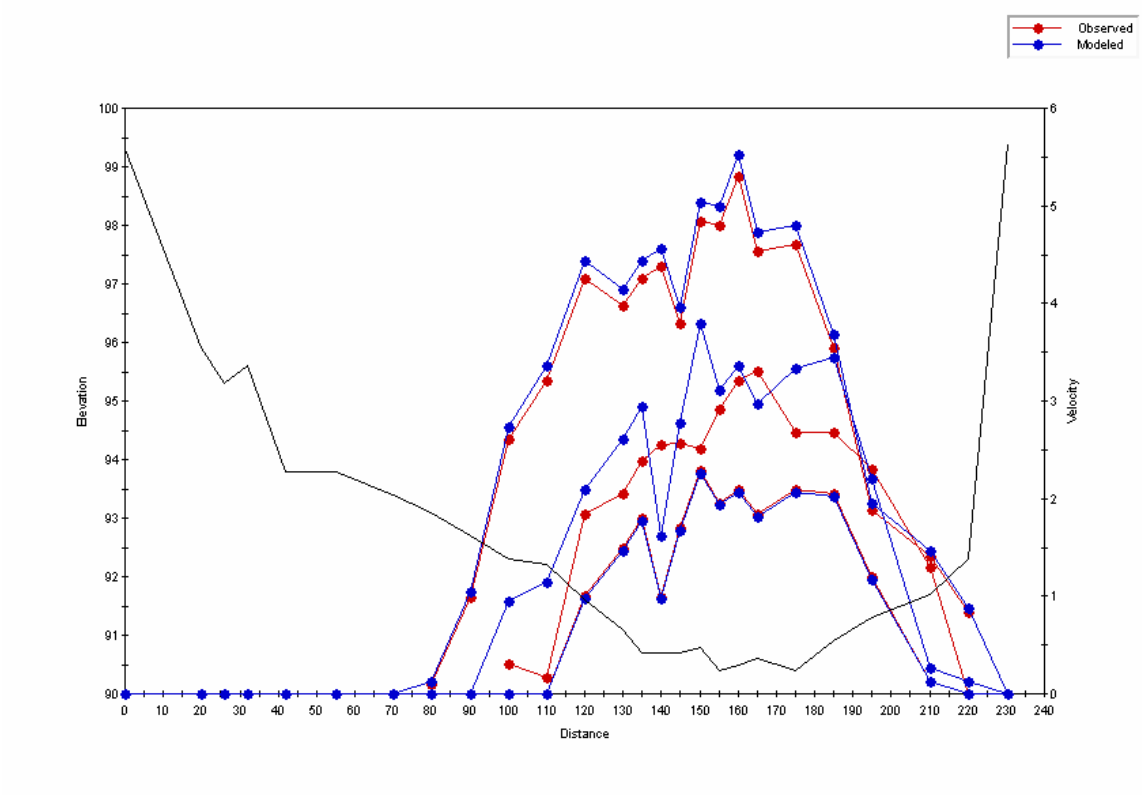
Transect (model)	**1**	**2a**	**2b**	**3**	**4a**	**4b**	**5a**	**5b**	**6**	**7**	**8**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	1	1	3	3	1	1	1	3	3	3
Discharge	160	182	182	191	186	182	240	240	195	177	179
	447	442	442	442	455	442	442	442	427	460	445
	983	925	925	951	886	925	925	925	974	915	881
Stage	91.59	92.125	92.125	92.26	92.38	92.35	92.91	92.91	92.95	93	93.03
	92.36	92.55	92.55	92.87	92.95	92.965	93.31	93.31	93.61	93.69	93.73
	93.02	93.18	93.18	93.56	93.71	93.695	94	94	94.32	94.57	94.63
Plotting Stage	1.59	1.725	1.725	1.86	1.98	1.95	2.21	2.21	2.25	2.3	2.33
	2.36	2.15	2.15	2.47	2.55	2.565	2.61	2.61	2.91	2.99	3.03
	3.02	2.78	2.78	3.16	3.31	3.295	3.3	3.3	3.62	3.87	3.93
Ratio of Measured vs. Predicted Discharge											
	1.02	0.952	0.952	1.01	0.959	0.988	0.981	0.981	1.03	0.96	0.96
	0.94	1.095	1.095	0.99	1.086	1.025	1.034	1.034	0.94	1.09	1.08
	1.04	0.959	0.959	1.01	0.96	0.987	0.986	0.986	1.03	0.96	0.96
Mean Error of stage/discharge relationship for calculated Q											
	4.01	NA	NA	0.85	5.47	NA	NA	NA	3.84	5.6	4.81
Mean Error of stage/discharge relationship for given Q											
	0.86	6.01	6.01	0.51	1.67	1.67	2.23	2.23	0.3	2.51	1.82
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF											
A=	0.263			0.3292	0.3479				0.4746	0.4407	0.4194
B =	0.3562			0.3302	0.3299				0.2966	0.3167	0.3282
SZF =	90	90.4	90.4	90.4	90.4	90.4	90.7	90.7	90.7	90.7	90.7
Beta coefficient log/log discharge/stage relationship											
	2.8	3.392	3.392	3	3.031	3.101	3.351	3.351	3.4	3.2	3.1

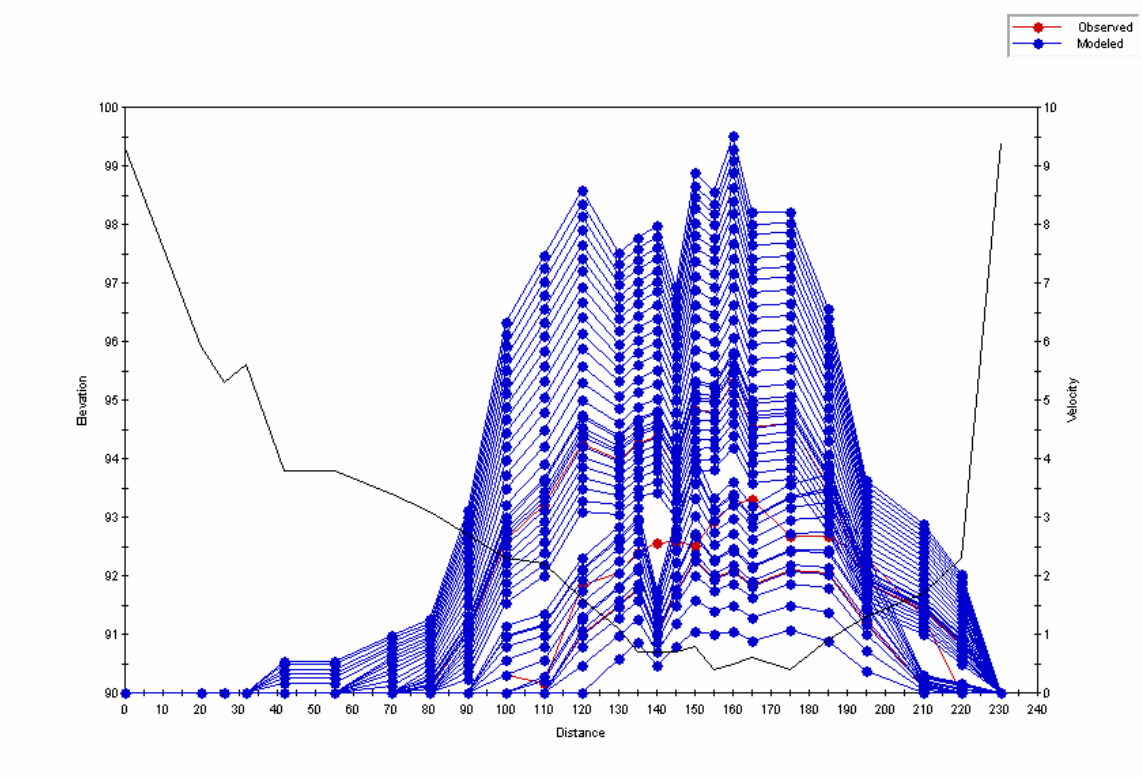
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

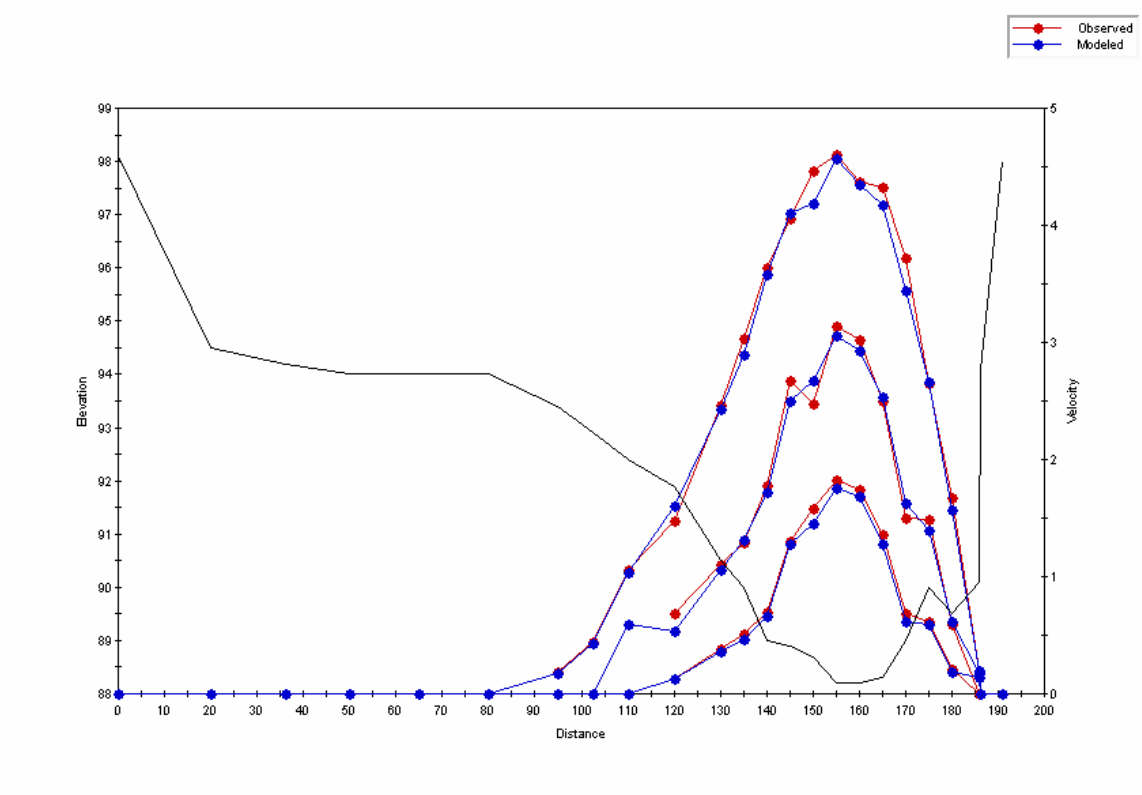

Observed
Modeled
Elevation
Velocity
Distance

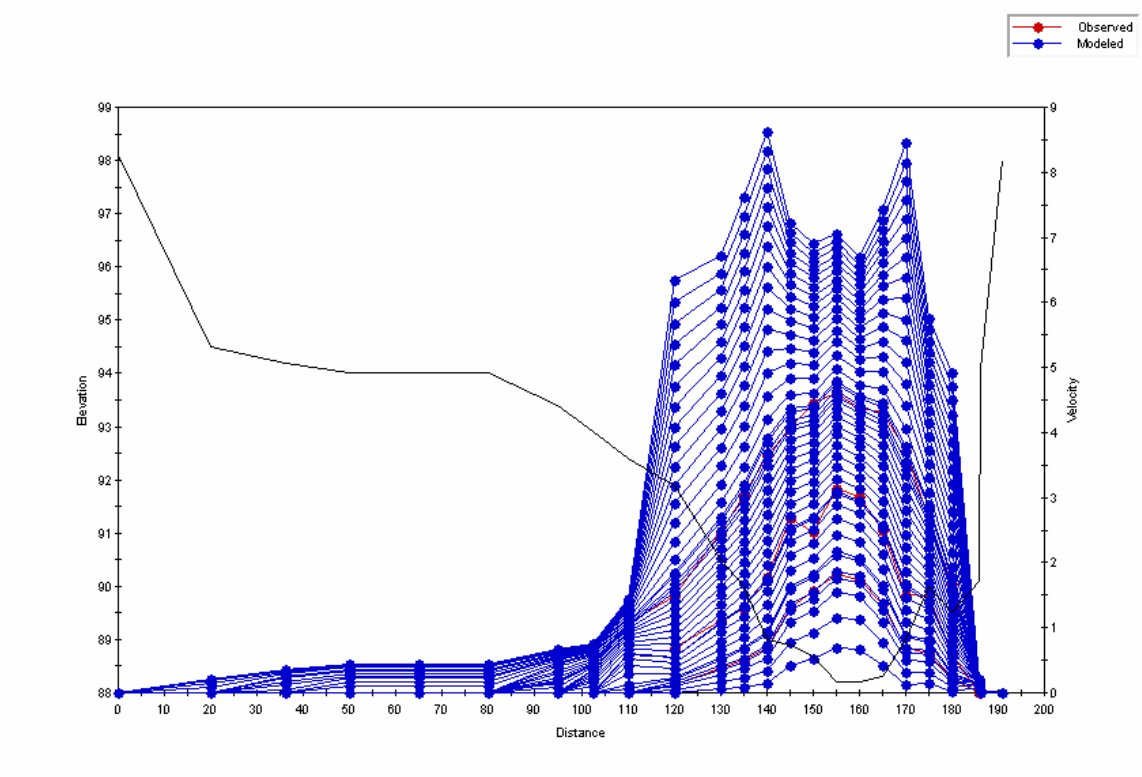
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

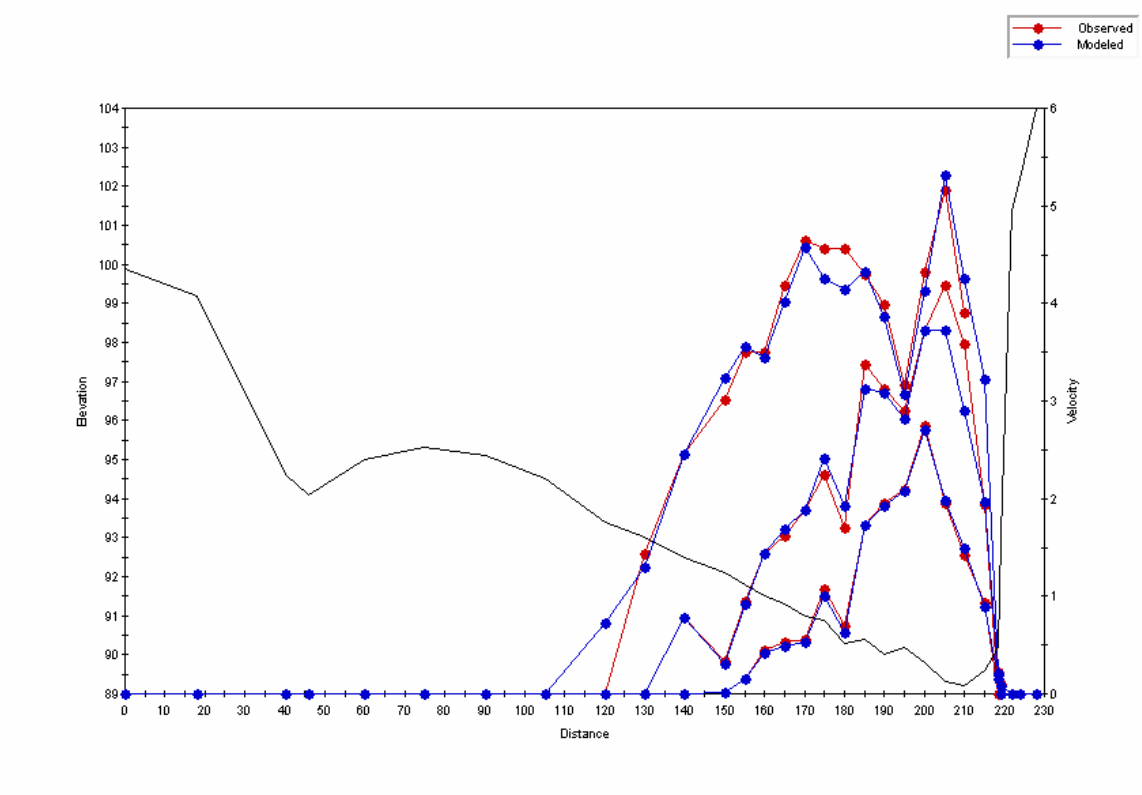

Observed
Modeled
Elevation
Velocity
Distance

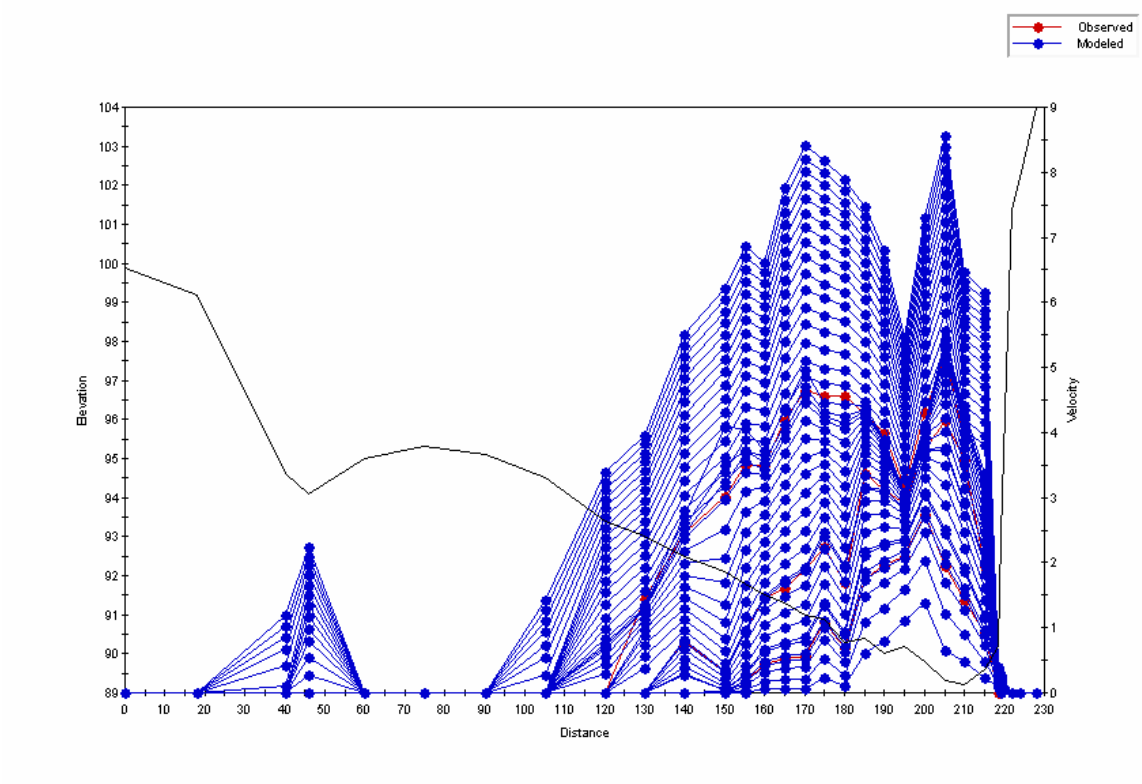
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

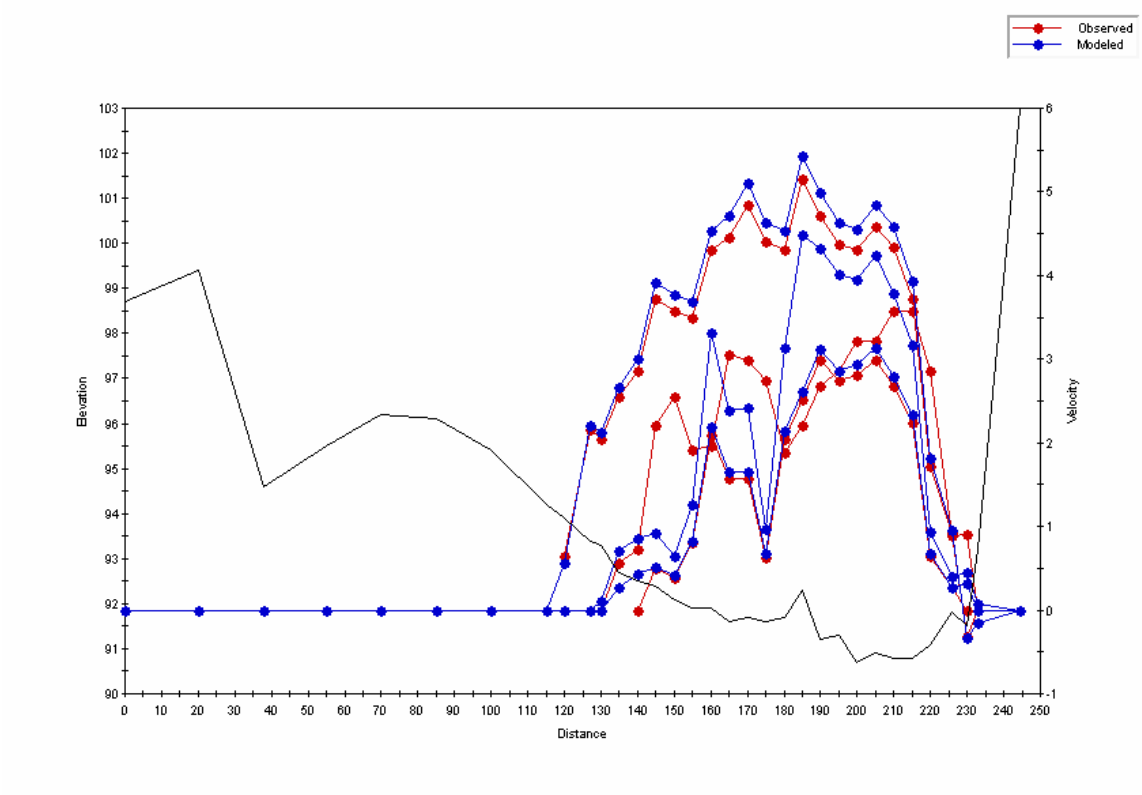

Observed
Modeled
Elevation
Velocity
Distance

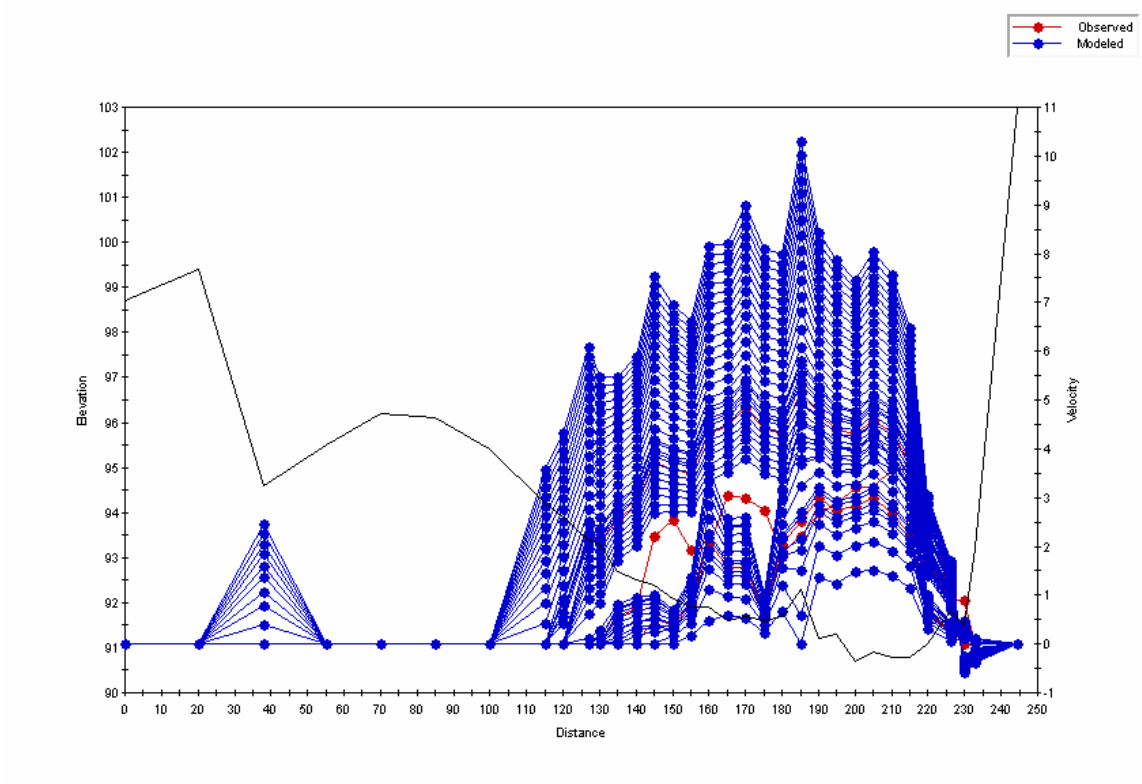
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

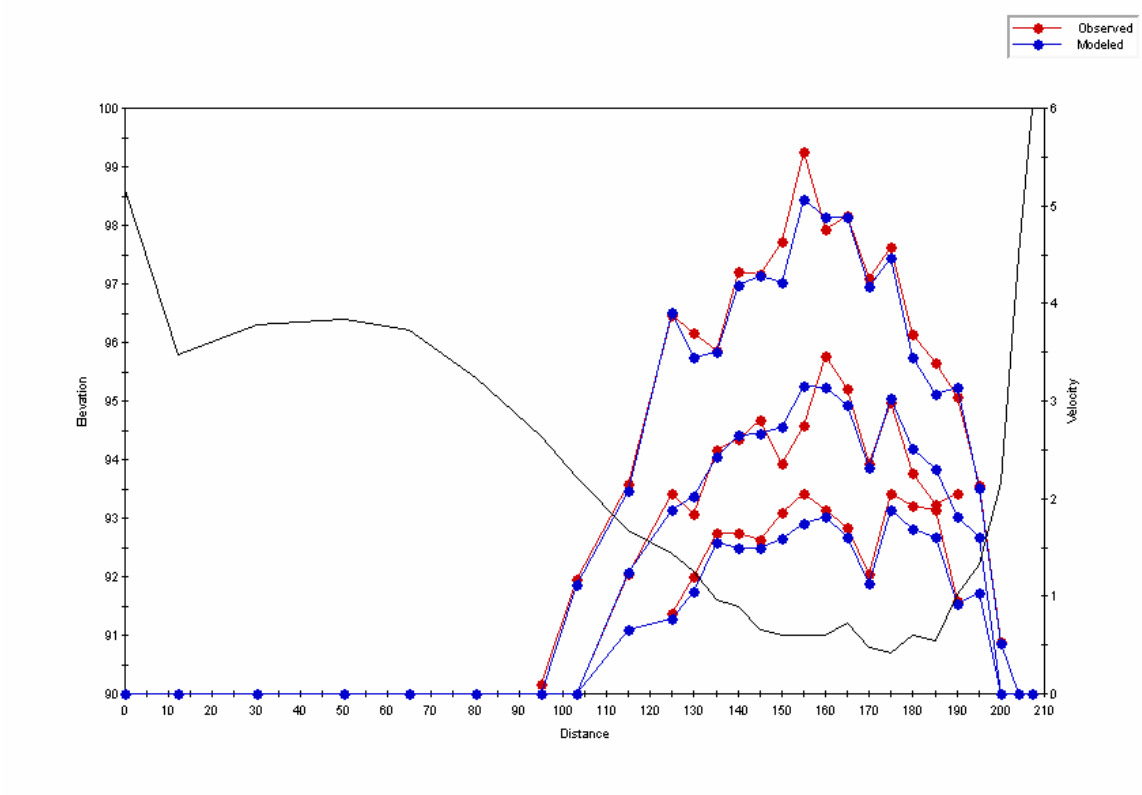

Observed
Modeled
Elevation
Velocity
Distance

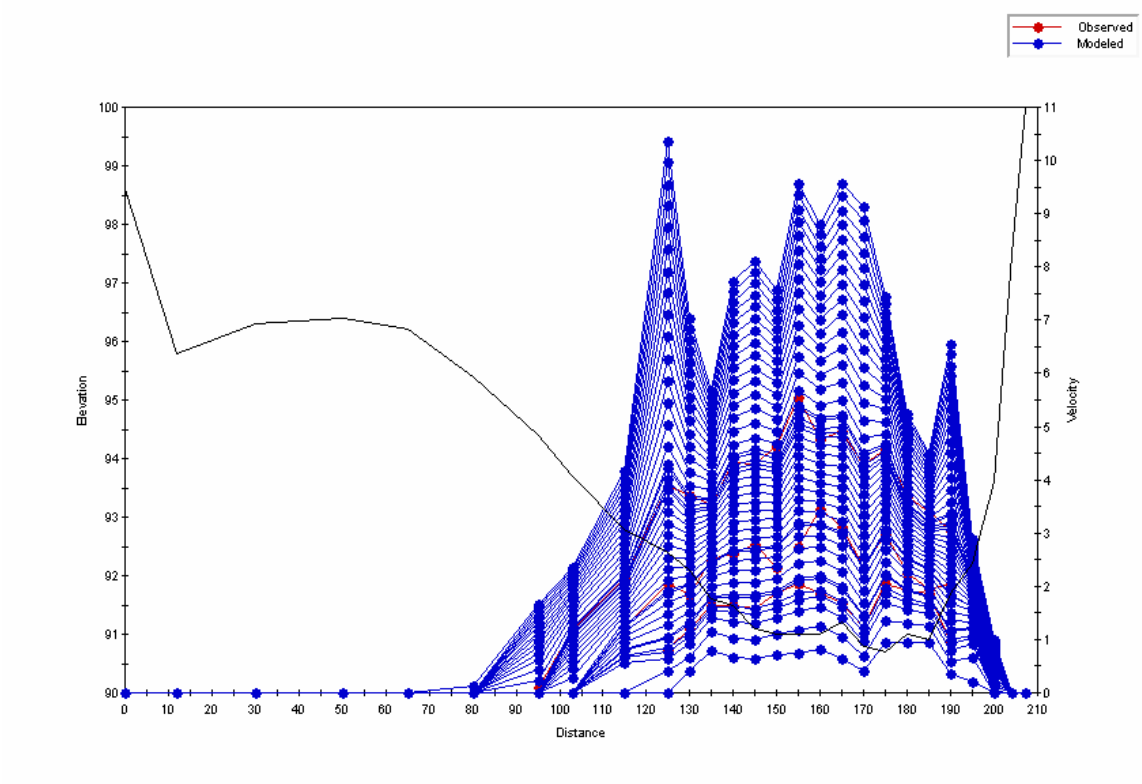
Transect 5


Observed
Modeled
Elevation
Velocity
Distance

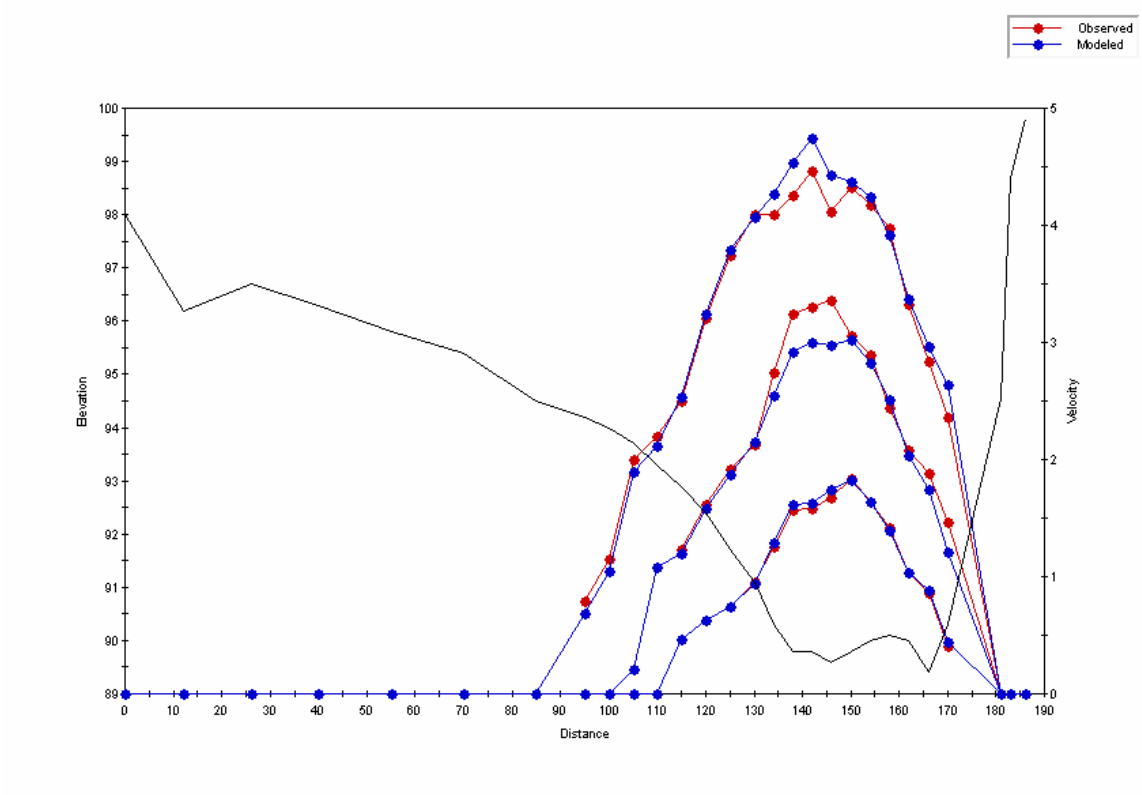

Observed
Modeled
Elevation
Velocity
Distance

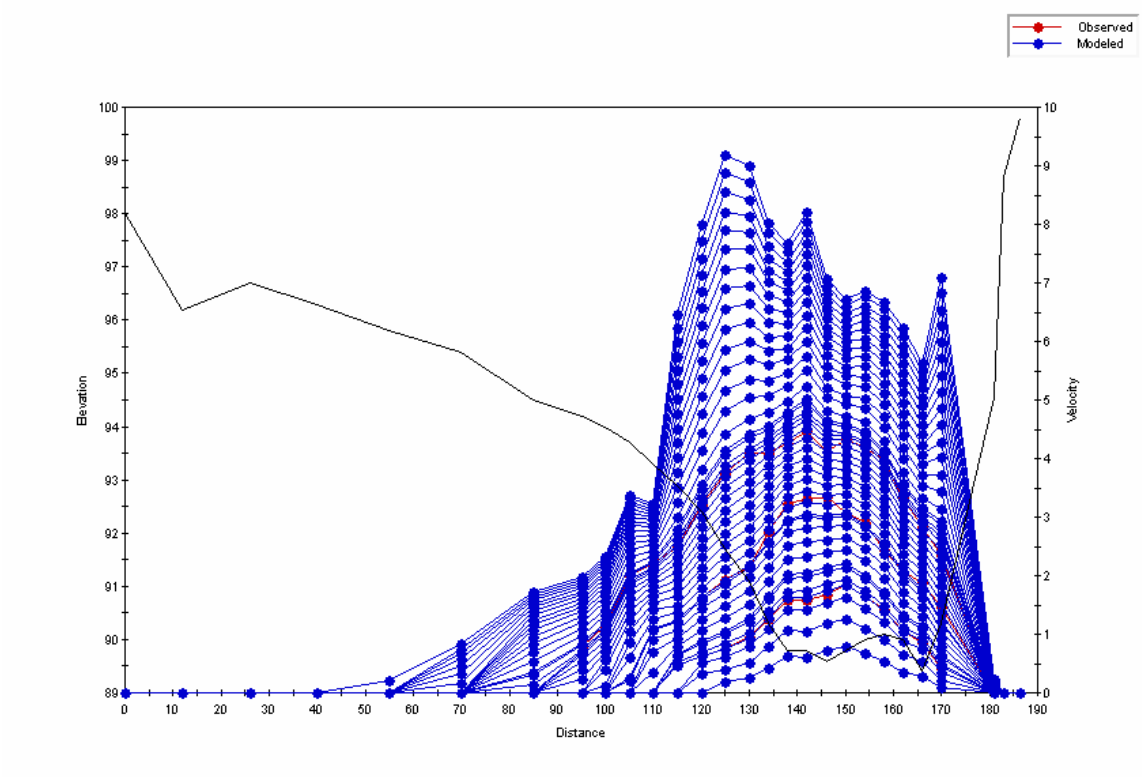
Transect 6


Observed
Modeled
Elevation
Velocity
Distance

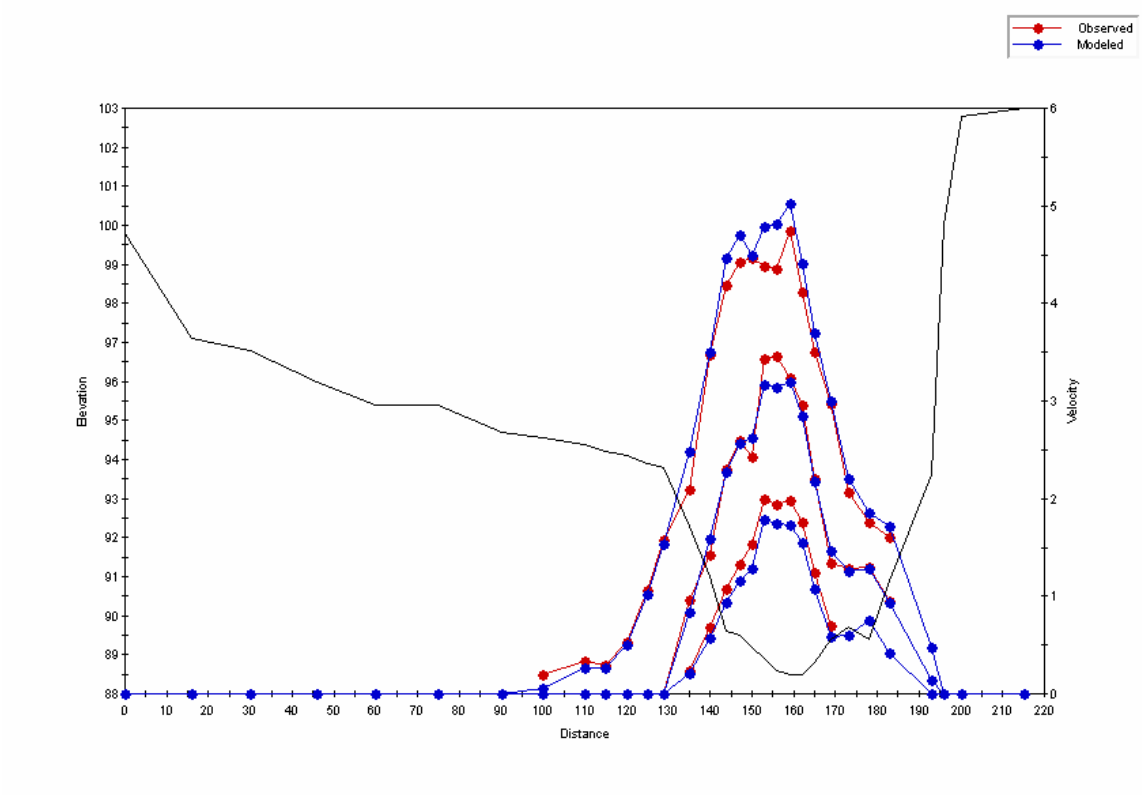

Observed
Modeled
Elevation
Velocity
Distance

Transect 7


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 8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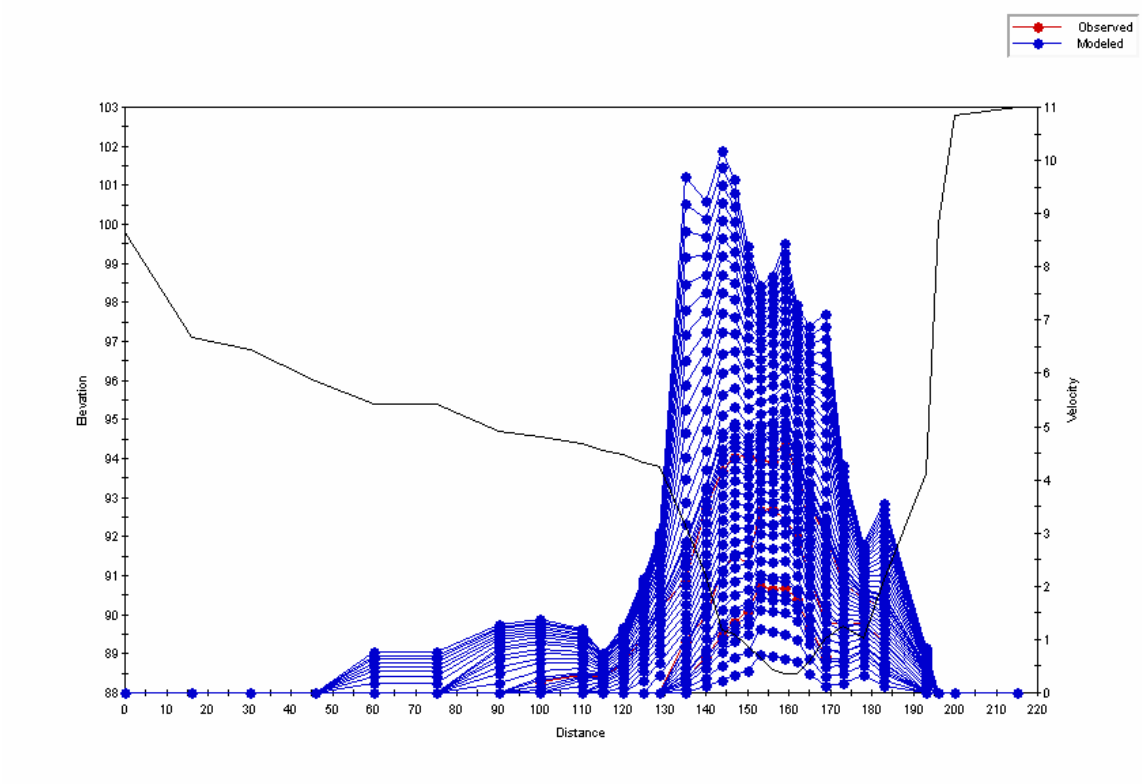

Observed
Modeled
Elevation
Velocity
Distance

Steward and Associates
120 Avenue A, Suite D
Snohomish, Washington 98290
Tel (360)862-1255 / Fax (360)563-0393
www.stewardandassociates.com

South Fork near Arlington Calibration

Transect 1
Set BestQ1 to 465. Not consistent with 518.

V4	Eliminate Q2 (.074)
V5	Increase Q2 20% to 1.76
V30	Change Q2 from 1.26 to 1.46

Transect 2

V30	Change from 0.32 to 0.52

Transect 3
Set Best Q1 to 465
Set Best Q3 to 1850
2-flow model (Q1&Q2) 100-1500cfs. i-flow Q3 from 1500-3800.

V35	Change Z to 84.0.
V36	Change Z to 84.1

Transect 4

V39,40	Eliminate Q2 (.100), (.100)

Transect 5
BestQ3 significantly lower than CalcQ, but prediction erros within 20% so did not change.

V28	Eliminate Q1(.184)

Transect 6
Very strange transect. CalcQ1 is over 700, while BestQ1 only 518. However, WSL calibration much better with Best Q as 518.
Split into three models. 2-vel Q1Q2 from 100-1700. 2-vel Q2Q3 from 1700-2400. 1-vel Q3 from 2400-3800.

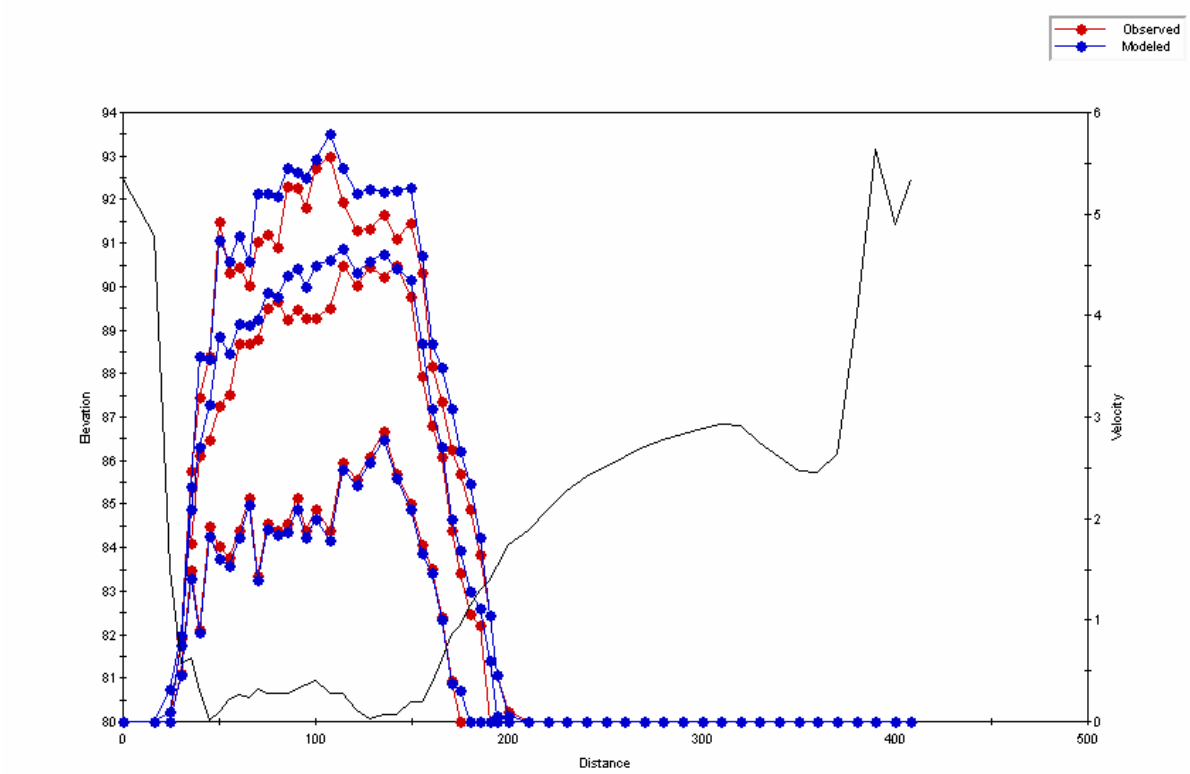
Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
1	0	0	0	0	0	0
2	16	13	3.5	13	12	18
3	24	22	4	18	22	22
4	30	25	7	22	26	26
5	35	30	12	30	30	30
6	40	35	17	35	35	34
7	45	40	22	40	40	38
8	50	45	27	45	45	42
9	55	50	32	50	50	46
10	60	55	37	55	55	50
11	65	60	42	60	63	54
12	70	65	47	65	71	58
13	75	70	52	70	79	62
14	80	75	55	75	87	66
15	85	80	60	80	95	70
16	90	85	65	85	103	75
17	95	90	70	92	111	80
18	100	95	75	99	119	85
19	107	100	80	105	127	90
20	114	105	85	113	135	95
21	121	110	90	120	143	100
22	128	115	95	128	151	105
23	135	122	100	136	159	110
24	142	129	105	144	165	115
25	149	136	110	152	171	123
26	155	143	117	160	179	131
27	160	150	124	168	187	139
28	165	155	131	176	195	145
29	170	160	138	184	200	150
30	175	170	145	192	205	155
31	180	176	150	200	210	160
32	185	180	155	210	215	165
33	190	190	160	220	220	170
34	194	200	170	230	225	175
35	200	210	172	240	230	180
36	210	220	180	250	235	185
37	220	230	190	260	240	190
38	230	240	200	270	245	195
39	240	250	210	280	255	199
40	250	260	220	290	265	200
41	260	270	230	300	275	205
42	270	280	240	310	285	210
43	280	290	250	320	295	215
44	290	300	260	325	305	220
45	300	310	270	332	315	225

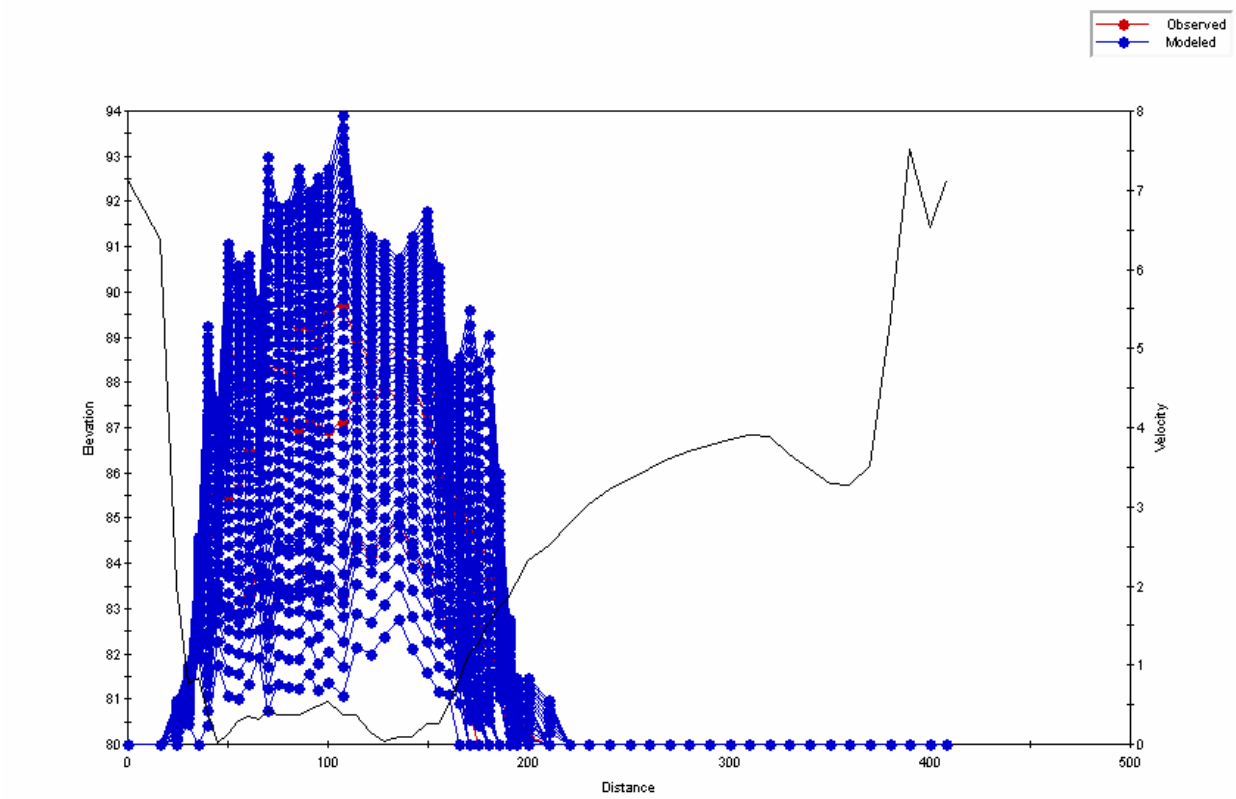
46	310	320	280	340	325	230
47	320	330	290	345	330	235
48	330	340	300	350	340	240
49	340	350	310	351.5	345	246
50	350	360	320		350.5	
51	360	370	330			
52	370	380	340			
53	380	390	350			
54	390	400	360			
55	400	405	370			
56	408	410	380			
57		416.5	390			
58			400			
59			410			
60			420			
61			430			
62			438.5			

SF Arlington

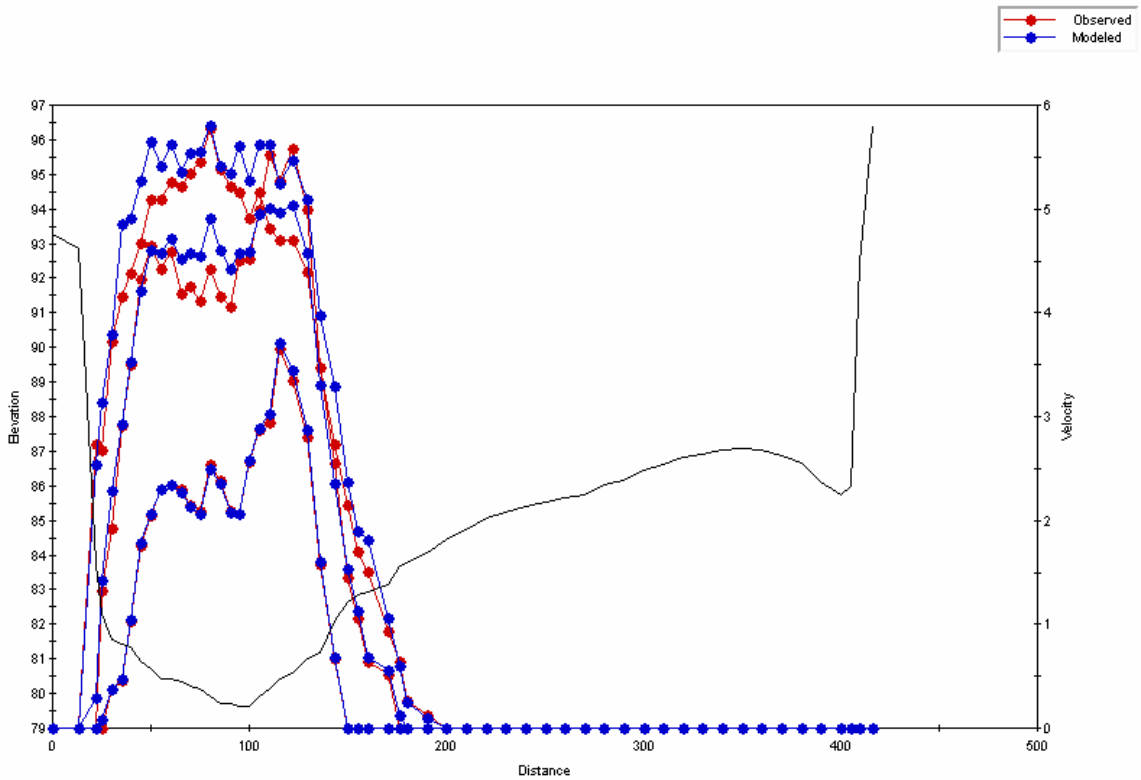
Transect (model)	**1**	**2**	**3a**	**3b**	**4**	**5**	**6a**	**6b**	**6c**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	3	2	1	3	3	2	2	1
Discharge	481	518	489	465	531	514	737		735
	1531	1664	1690	1690	1706	1780	1901	1901	1690
	2273	2253		1850	2670	2742		2476	2390
Stage	82.33	82.45	83.47	83.335	83.63	83.64	83.74		83.73
	83.52	83.74	84.6	84.6	85.2	85.38	85.6	85.6	85.53
	84.09	84.35		84.69	85.81	85.86		86.24	86.24
Plotting Stage	2.3	2.42	1.96	1.825	2.12	2.13	2.23		2.22
	.3.49	3.71	3.09	3.09	3.69	3.87	4.09	4.09	4.02
	4.06	4.32		3.18	4.3	4.35		4.73	4.73
Ratio of Measured vs. Predicted Discharge									
	1	0.99	1	1.001	1.01	1.02	1	1	1.012
	1.01	1.05	1	0.99	0.94	0.91	1	1	0.946
	0.99	0.96		1.01	1.05	1.08			1.045
Mean Error of stage/discharge relationship for calculated Q									
	0.74	3.43	0	NA	3.99	6.15	0	0	NA
Mean Error of stage/discharge relationship for given Q									
	1.3	1.06	0.67	0.67	0.21	1.58	3.75	3.75	3.75
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF									
A=	0.2412	0.2135	0.2018		0.1288	0.1351	0.3258	0.643	
B =	0.3649	0.3877	0.3671		0.4473	0.4428	0.6401	0.55	
SZF =	0.8003	80.03	81.51		81.51	81.51	81.51	81.51	
Beta coefficient log/log discharge/stage relationship									
	2.74	2.58	2.724	2.471	2.24	2.26	1.562	1.818	1.517

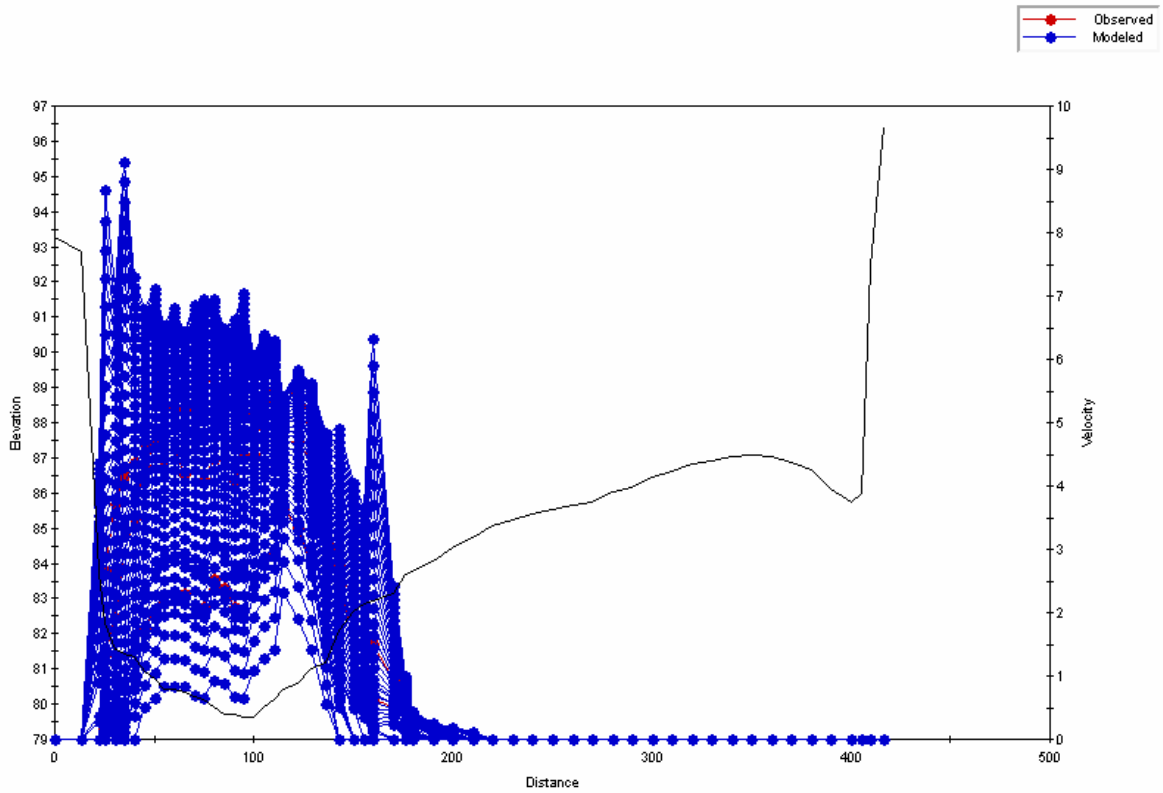
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

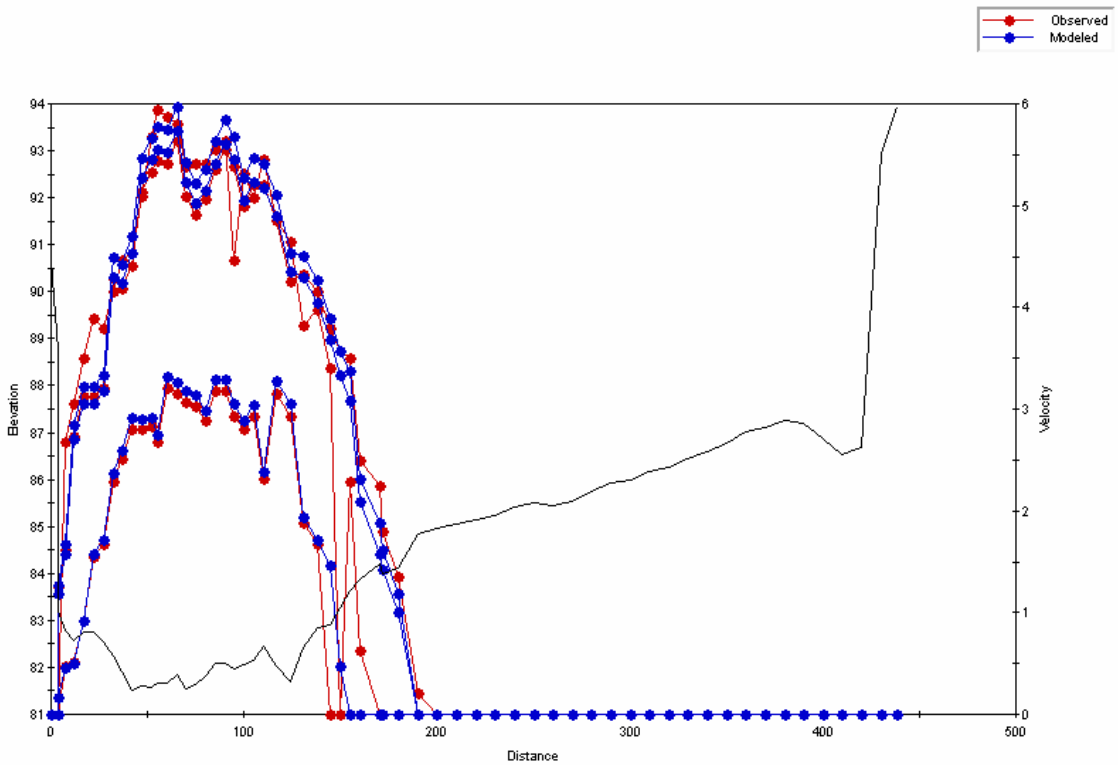

Observed
Modeled
Elevation
Velocity
Distance

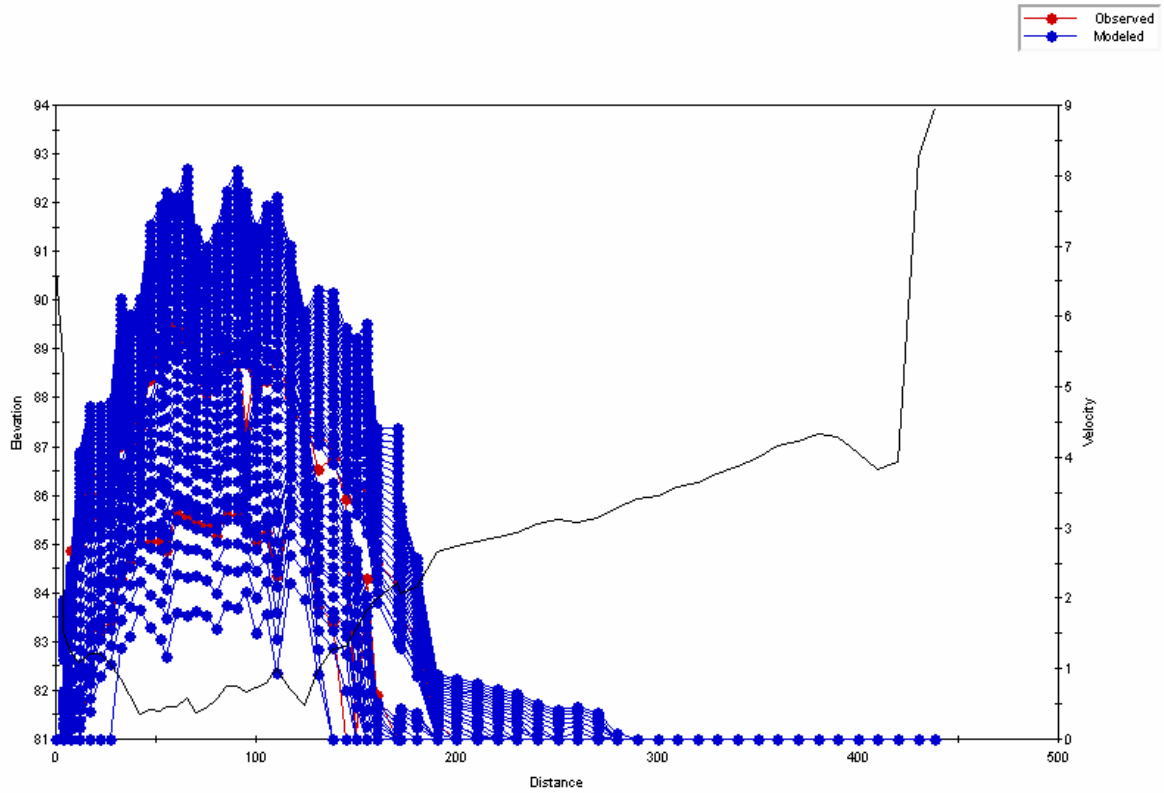
Transect


Observed
Modeled
Elevation
Velocity
Distance

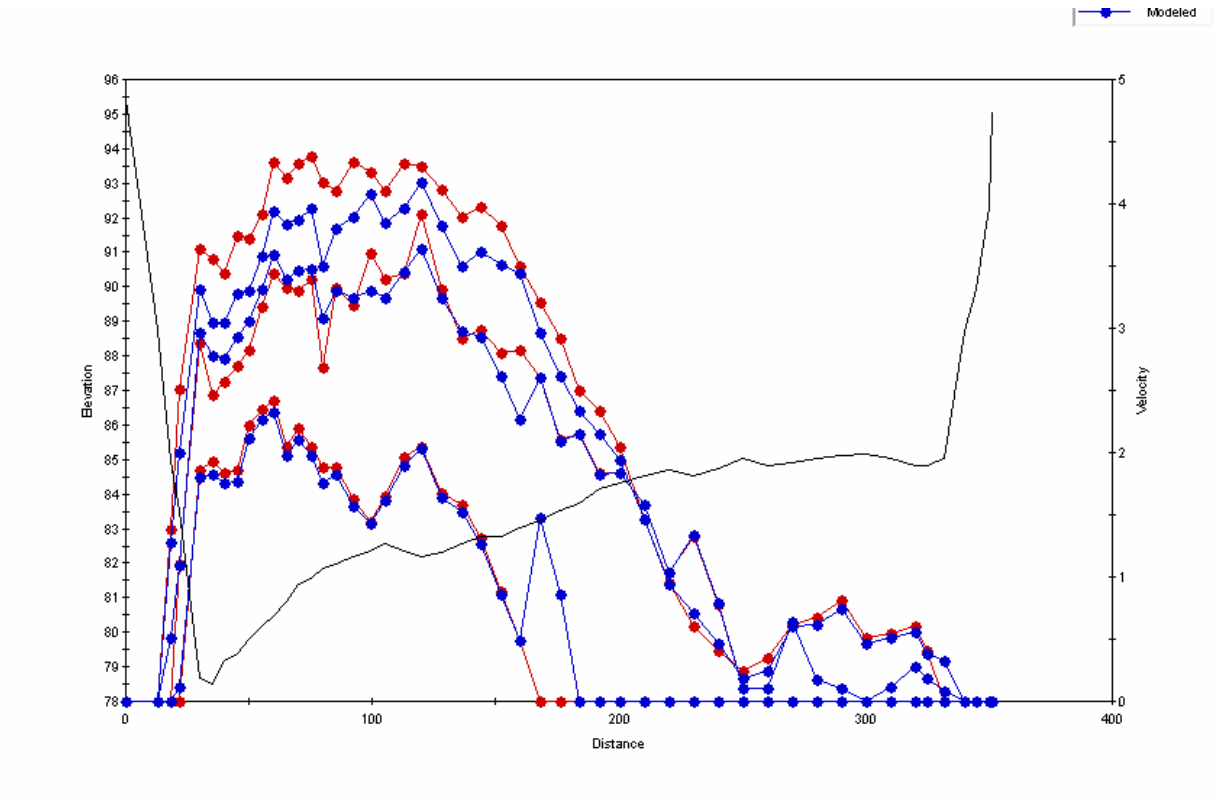

Observed
Modeled
Elevation
Velocity
Distance

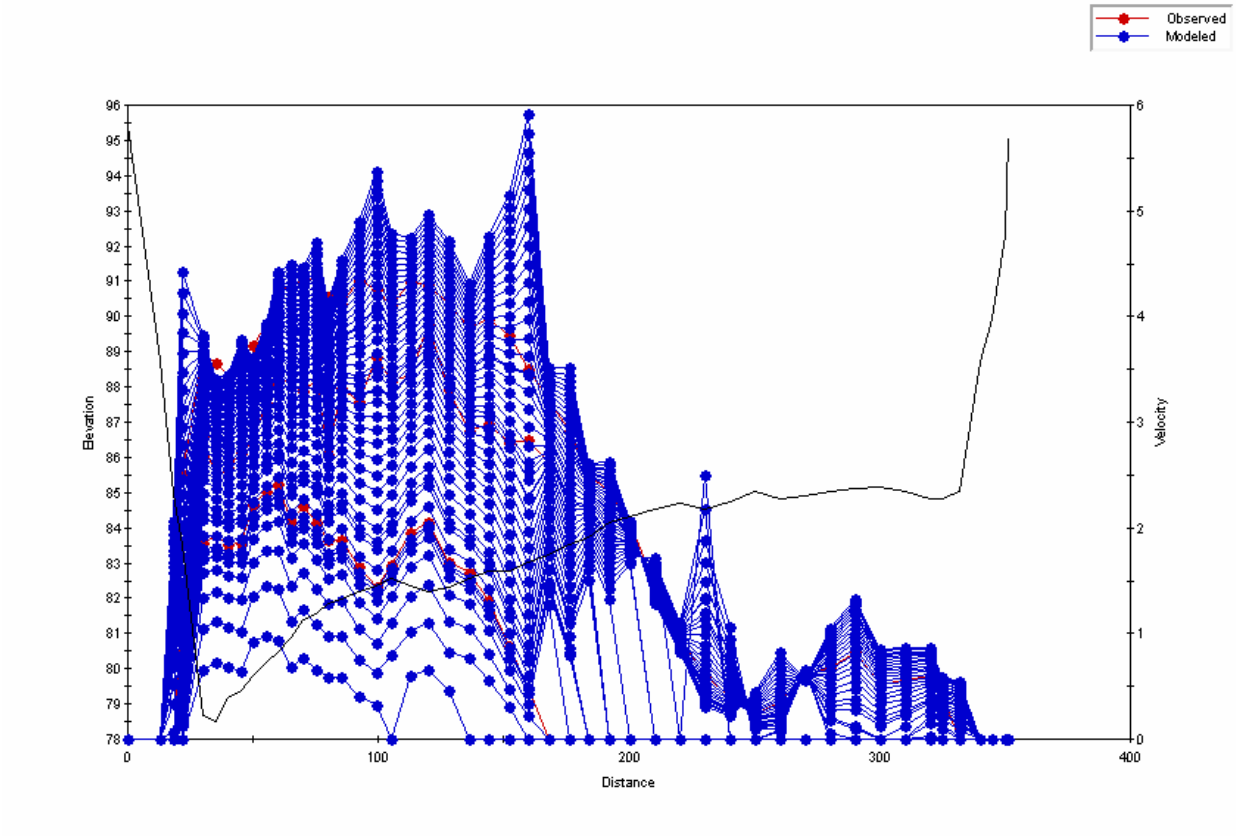
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

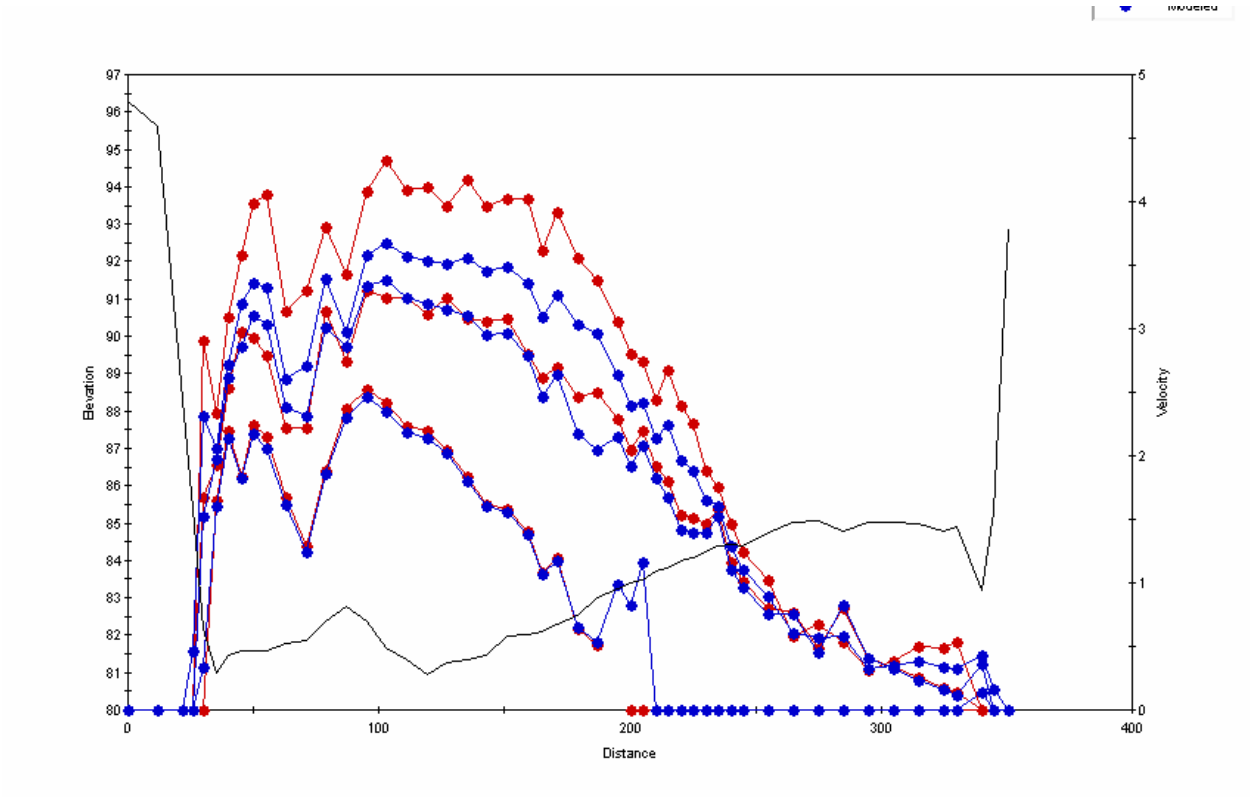

Observed
Modeled
Elevation
Velocity
Distance

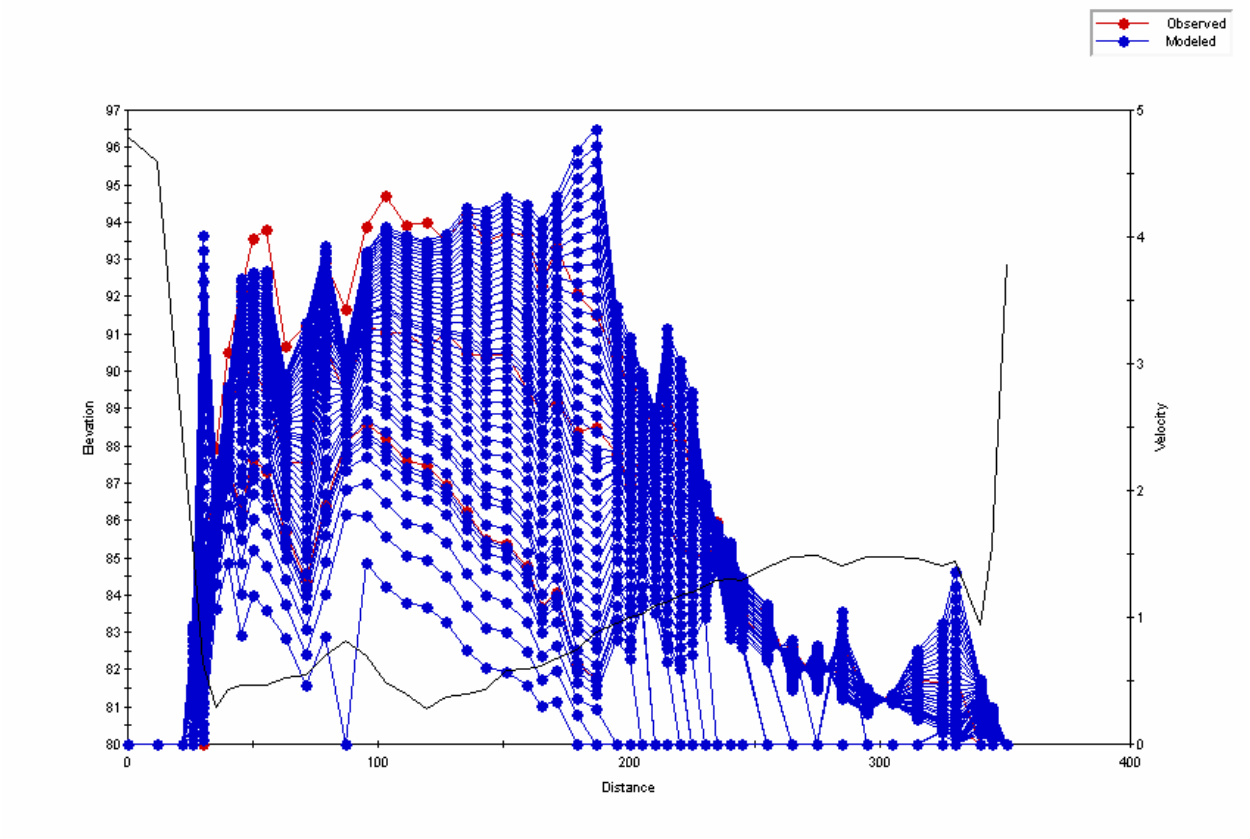
Transect 4


Modeled
Elevation
Velocity
Distance

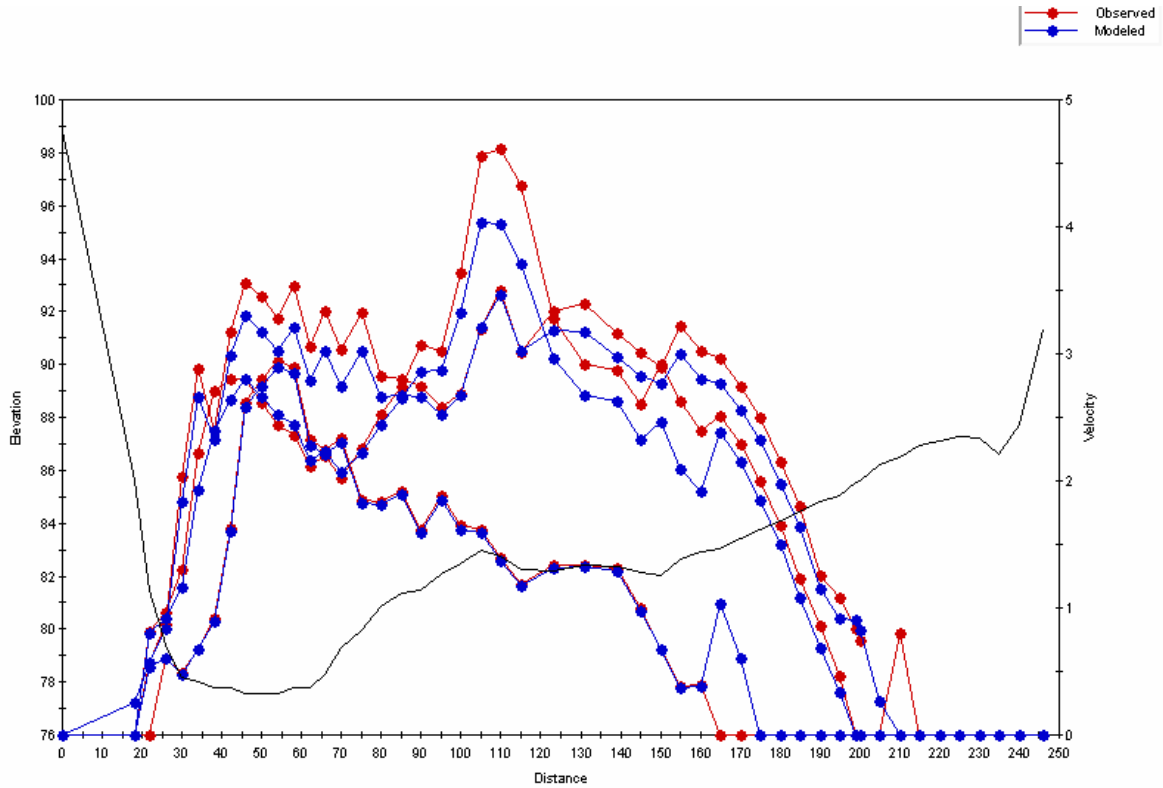

Observed
Modeled
Elevation
Velocity
Distance

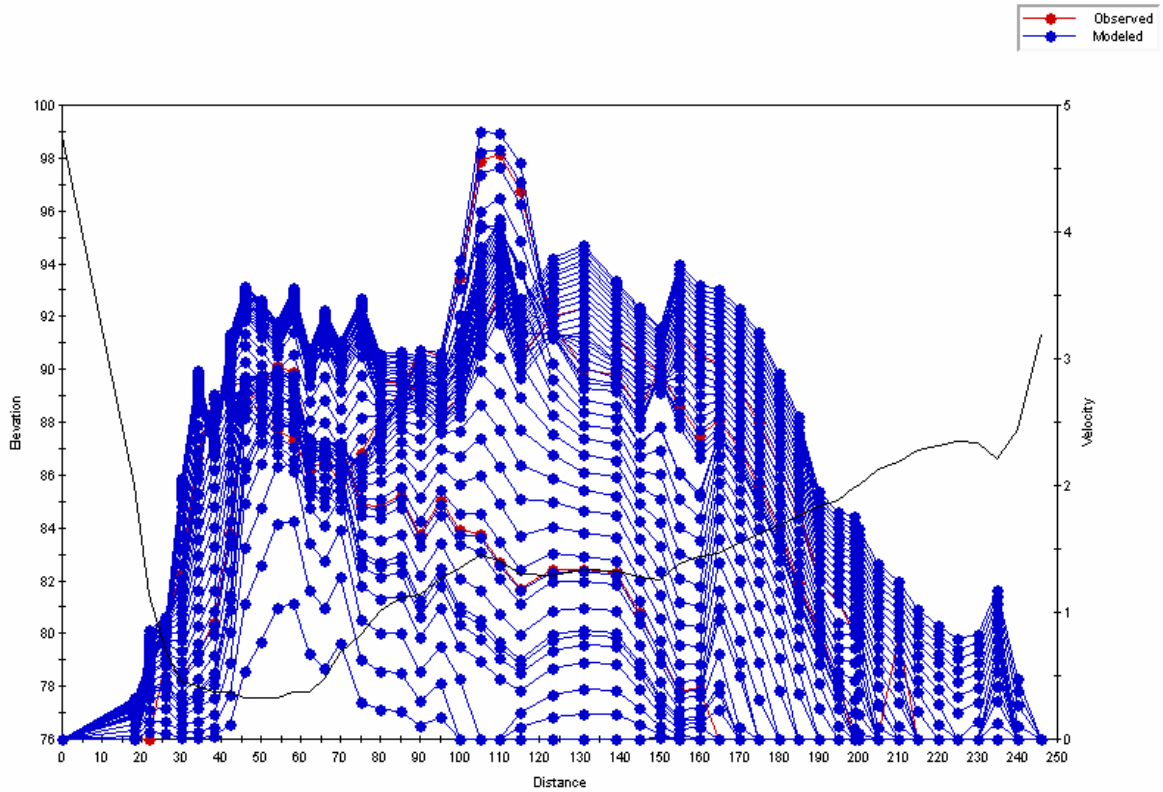
Transect 5


Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 6


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

South Fork at Chappel Road

Two-flow model at all transects

Transect 1

Best Q1 too far off CalcQ for good model fit. Set BestQ to 365 for this transect.

V4-6,19-22	Z<WSL, though shallow. Let model predict velocities.
V17	Increase Q1 20% to 0.3. Decrease Q2 20% to 2.10.
V18	Increase Q1 20% to 0.25. Decrease Q2 20% to 2.05.

Transect 2

V18,19	Z<WSL. Let model predict.
V9	Missing Q1. Let model predict.
V6	Increase Q1 from 0.5 to 0.7.

Transect 3

V23,25	Z<WSL. Let model predict.
V15	Decrease Q1 20% to 1.61. Increase Q2 20% to 2.30.

Transect 4

V3-9,13	Z<WSL. Let model predict.
V14,15	Eliminate Q1s (.29), (.15).
V28	Eliminate Q1(.56). Decrease Q2 20% to 2.62.
V30	Add 0.2 to Q1 to 0.64. Decrease Q2 20% to 1.68.
V27	Decrease Q1 to 1.54. Increase Q2 to 1.68.
V24	Decrease Q2 10% to 5.34
V25	Decrease Q2 10% to 5.29
V26	Decrease Q2 20% to 4.12
V21	Decrease Q2 10% to 5.01

Transect 5

V29	Eliminate Q1(.22)

Transect 6

No changes.

Transect 7

V10	Decrease Q2 by 0.2 to control spike.
V14	Decrease Q2 by 0.2 to control spike.

SF Stillaguamish- Chappel Road

Station ID	Distance from Bank						
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
1	0	0	0	0	0	0	0
2	22	6	1	10	10	16	10
3	28	12	3	12	20	29	26
4	34	18	10	20	30	40	36
5	40	24	17	30	40	50	43
6	46	30	24	40	50	60	50
7	52	37	31	40.2	60	70	57
8	58	44	38	50	70	80	64
9	64	51	45	60	74	90	71
10	70	58	52	70	80	100	78
11	76	65	59	80	90	107	85
12	82	72	66	87	100	114	92
13	88	79	73	94	107	121	99
14	94	86	80	101	114	128	106
15	101	93	87	108	121	135	113
16	107	99	94	115	128	142	120
17	113	105	101	122	135	149	127
18	119	111	108	129	142	156	134
19	125	117	115	136	149	163	141
20	131	123	122	143	156	170	148
21	137	129	129	150	163	177	155
22	143	136	136	157	170	184	162
23	150	146	143	164	177	191	169
24	160	150	154	171	185	198	176
25	170	160	160	178	192	205	183
26	180	170	170	185	199	212	189
27	190	190	180	192	206	219	190
28	196		190	199	213	223	195
29			205	206	220	223.5	201
30				213	227	230	
31				220	235.5		
32				228	239		
33				230	242		
34				240			

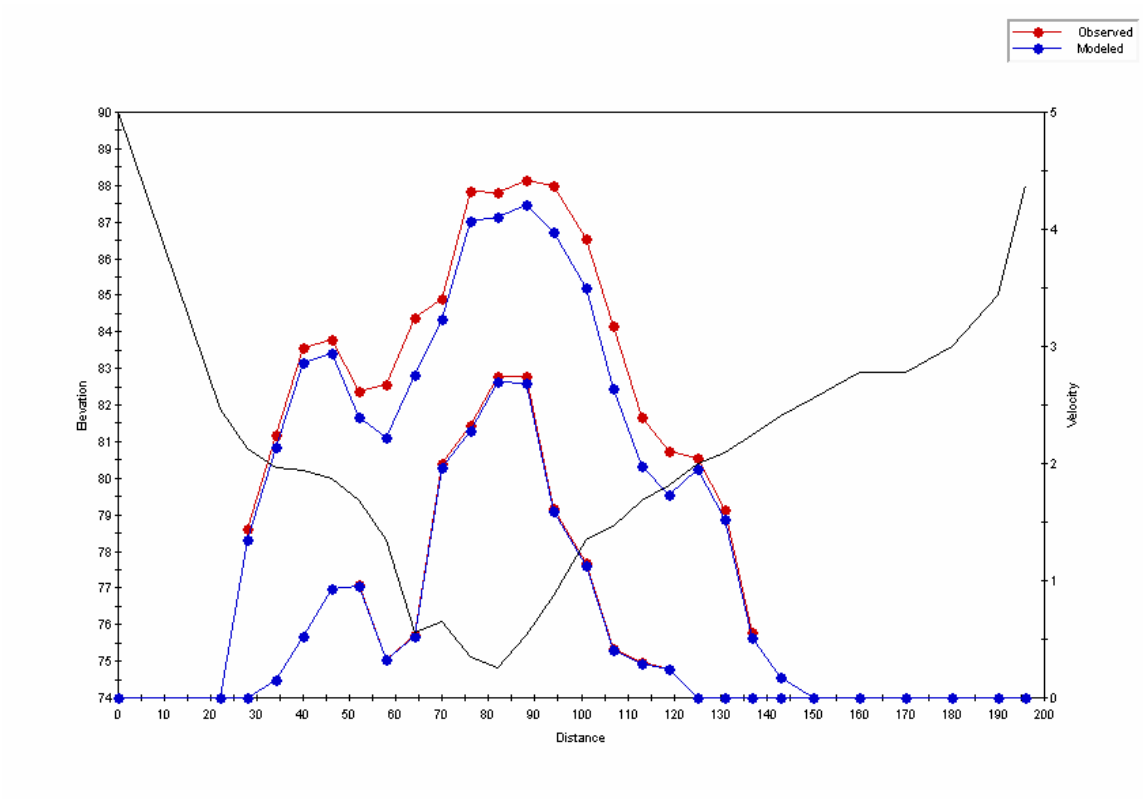
SF Stillaguamish- Chappel Road

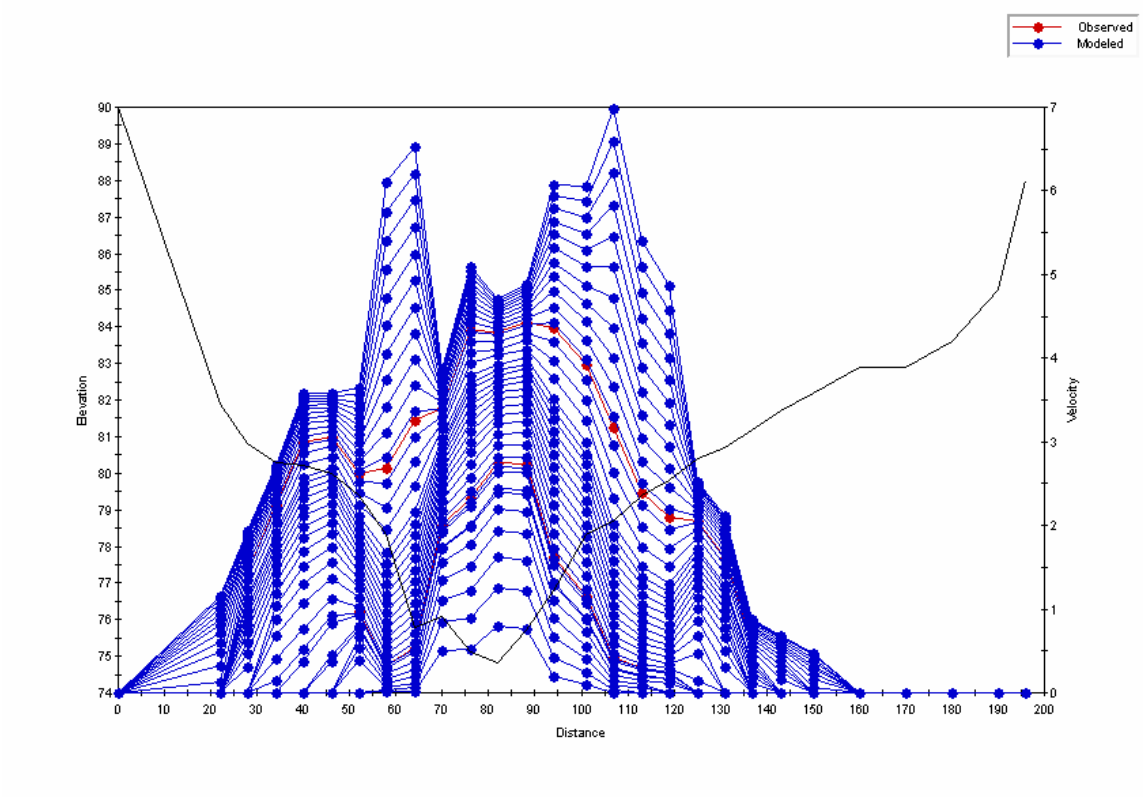
Station ID	Distance from Bank						
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
35				250			

SF Chappel

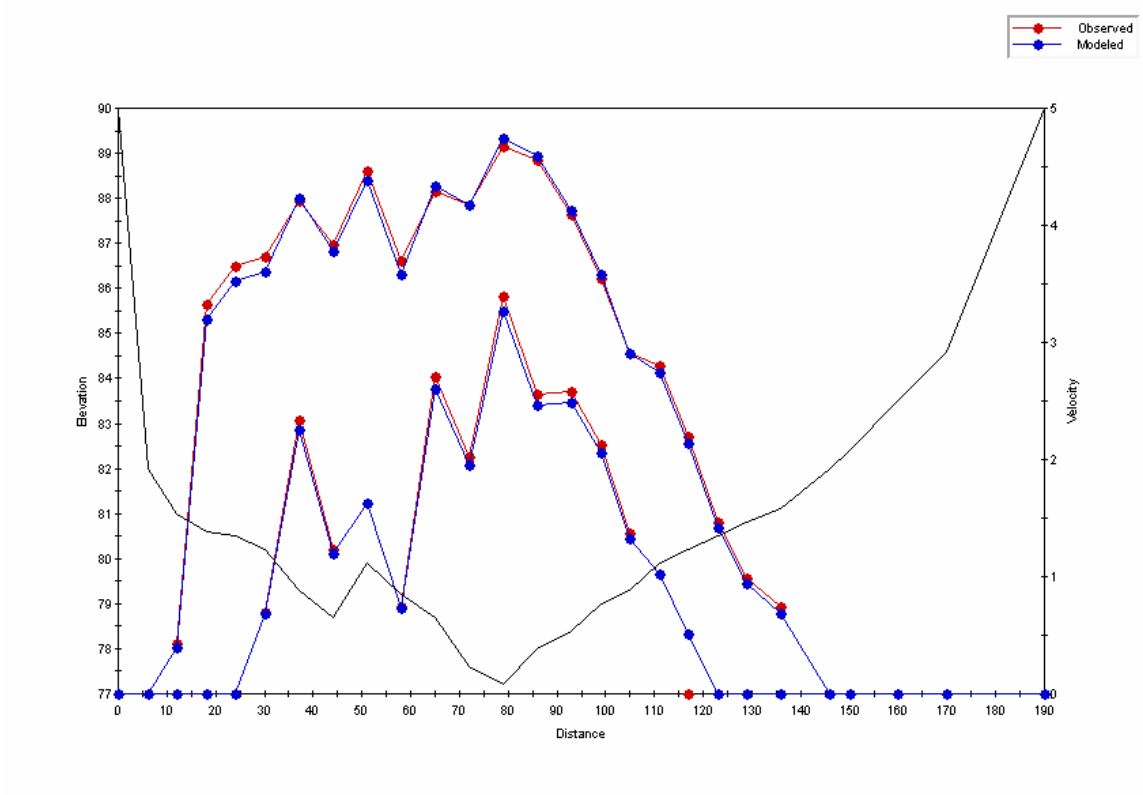
Transect (model)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	2	2	2	2	2	2	2
Discharge	366	286	274	274	285	293	285
	1341	1268	1225	951	1163	1280	1210
Stage	80.29	80.43	80.71	82.38	82.98	83.27	83.84
	81.91	812.13	82.3	83.21	84.34	84.9	85.38
Plotting Stage	5.49	3.23	3.51	1.98	2.18	2.47	2.64
	7.11	4.93	5.1	2.81	3.54	4.1	4.18
Ratio of Measured vs. Predicted Discharge							
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
Mean Error of stage/discharge relationship for calculated Q							
	0	0	0	0	0	0	0
Mean Error of stage/discharge relationship for given Q							
	0	0	0	0	0	0	0
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF							
A=	0.1696	0.6485	0.8636	0.4072	0.3097	0.3499	0.4381
B =	0.199	0.2839	0.2497	0.2817	0.3451	0.344	0.3178
SZF =	74.8	77.2	77.2	80.8	80.8	80.8	81.2
Beta coefficient log/log discharge/stage relationship							
	5.025	3.523	4.004	3.55	2.897	2.907	3.147

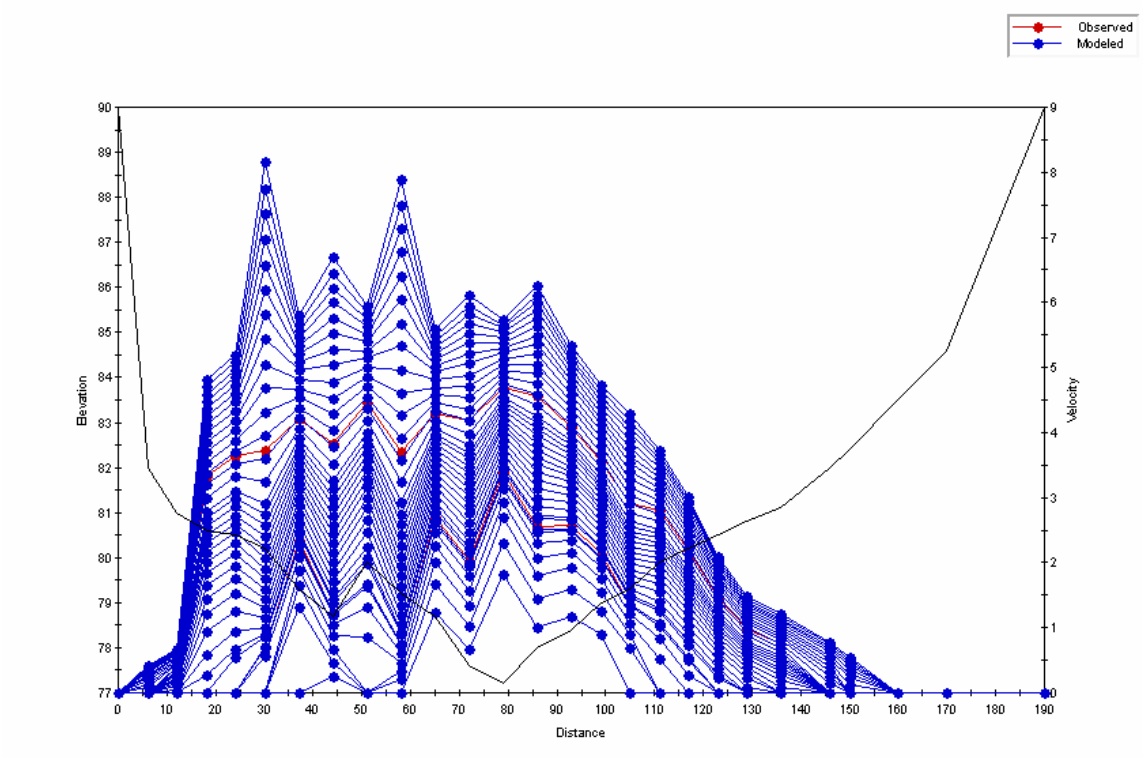
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

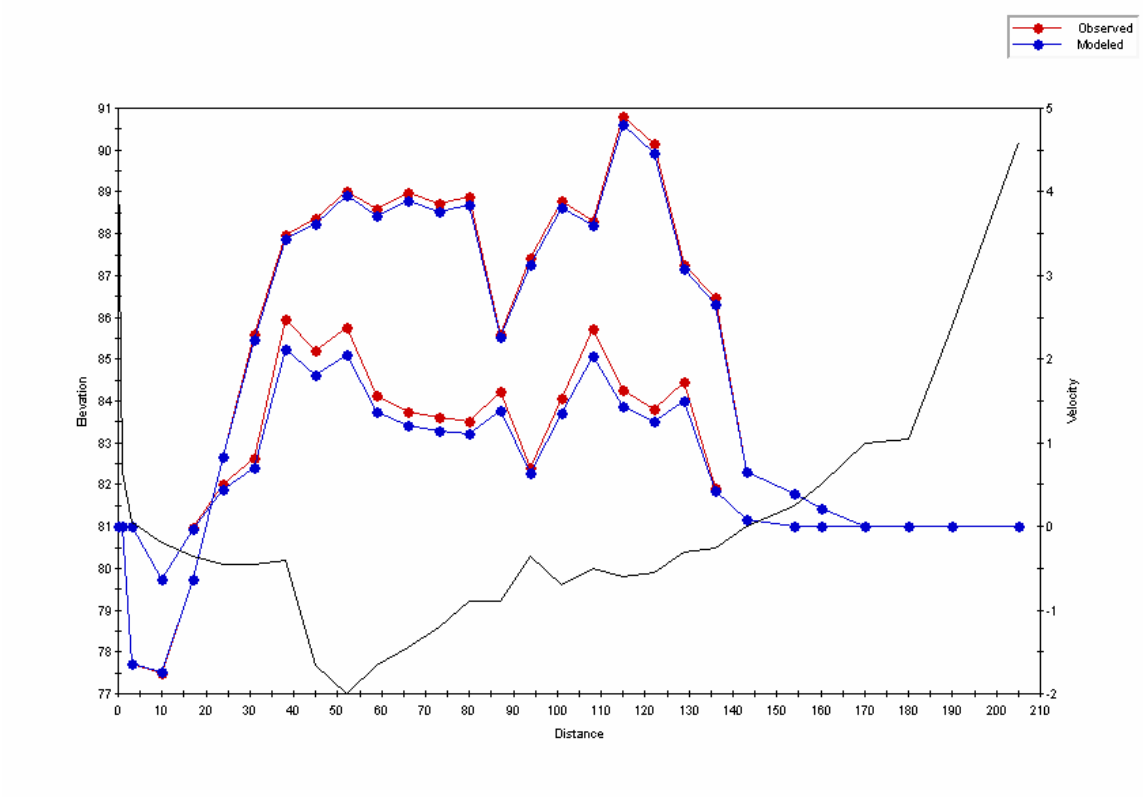

Observed
Modeled
Elevation
Velocity
Distance

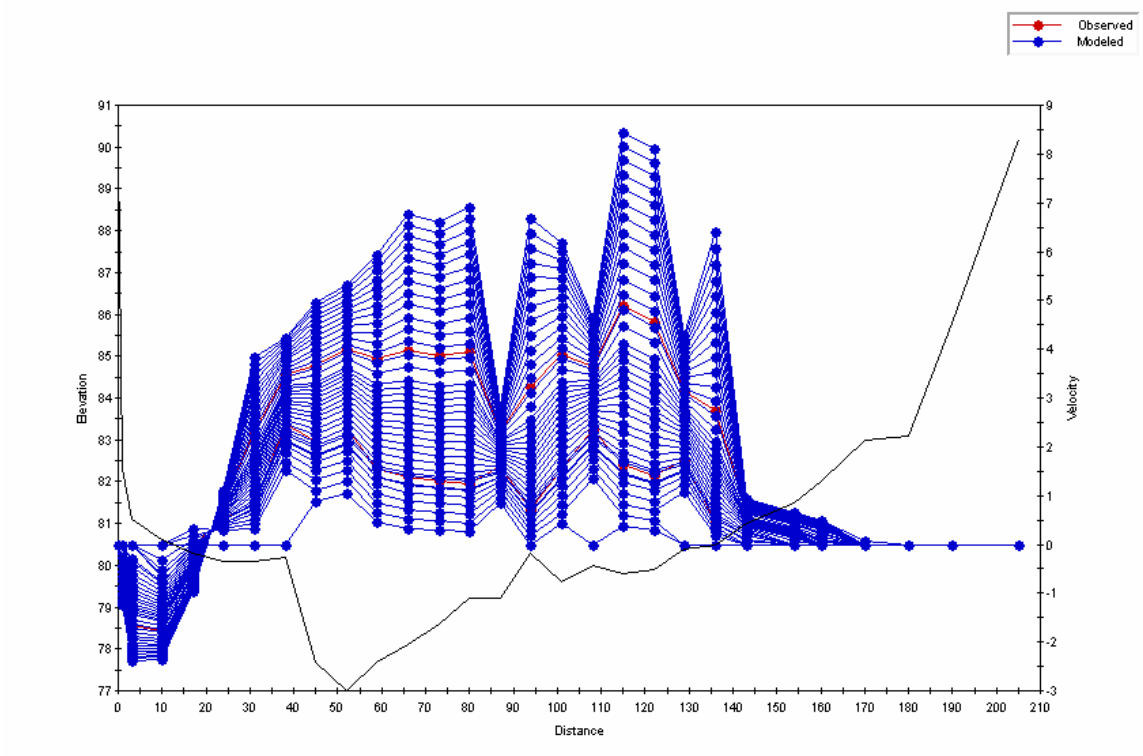
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

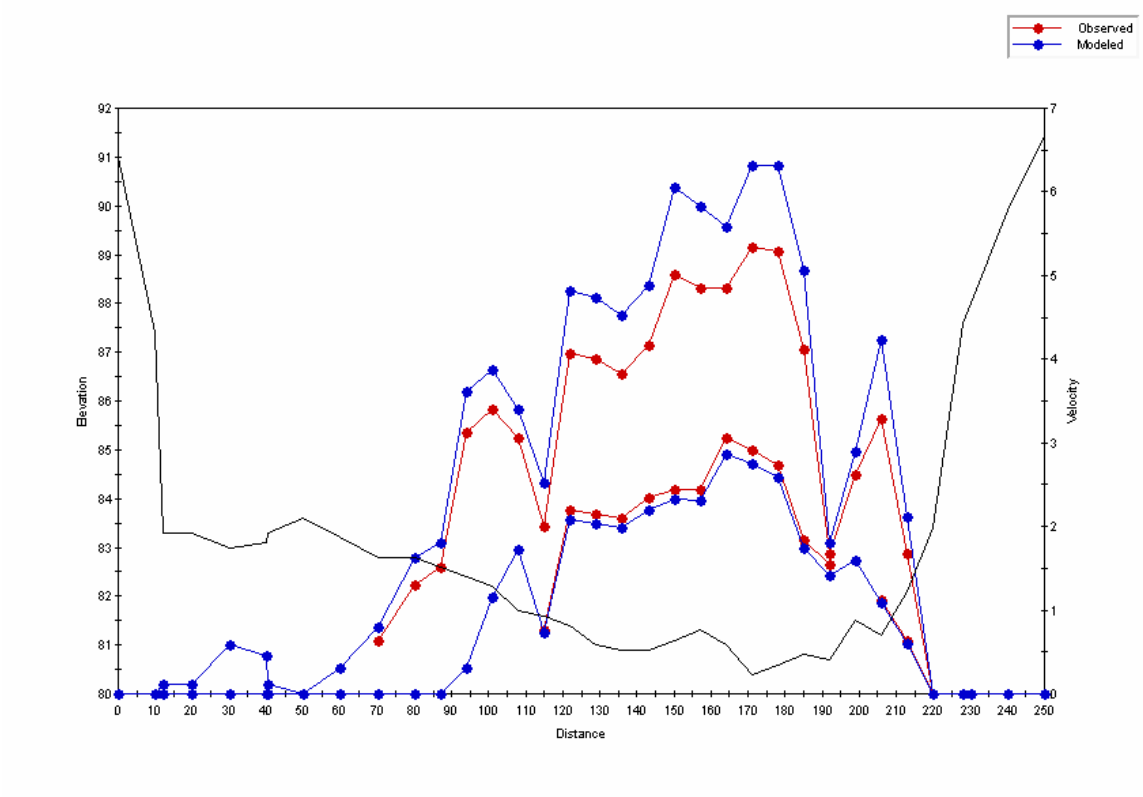

Observed
Modeled
Elevation
Velocity
Distance

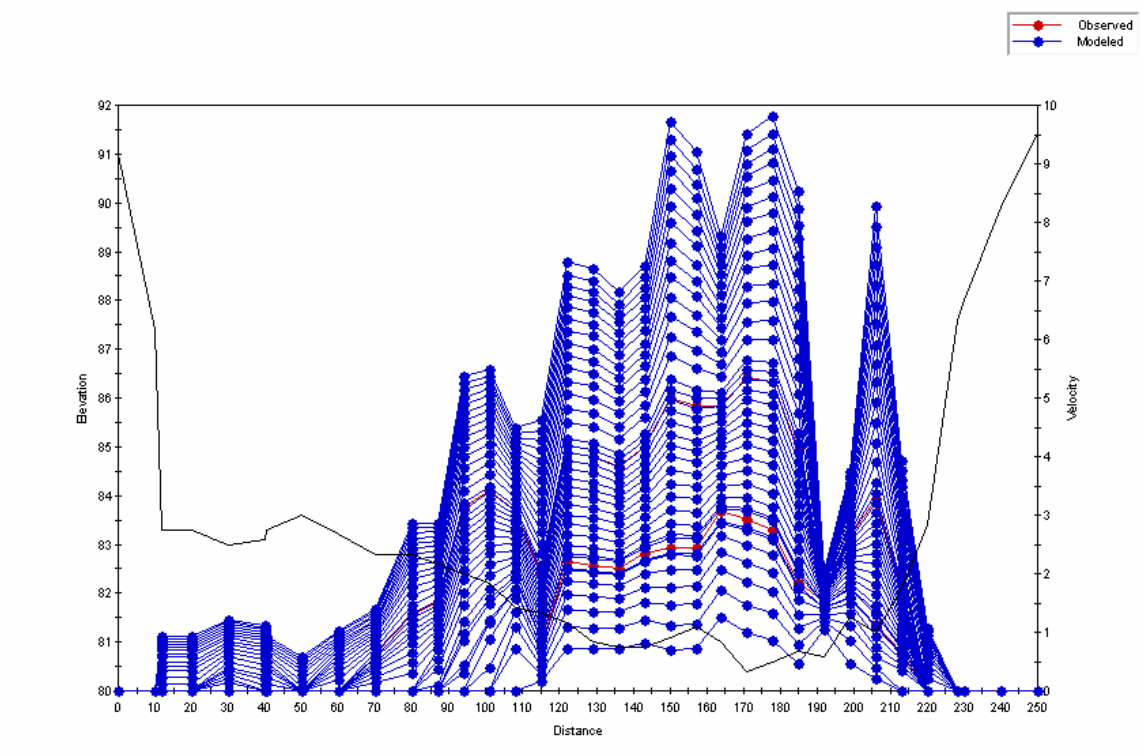
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

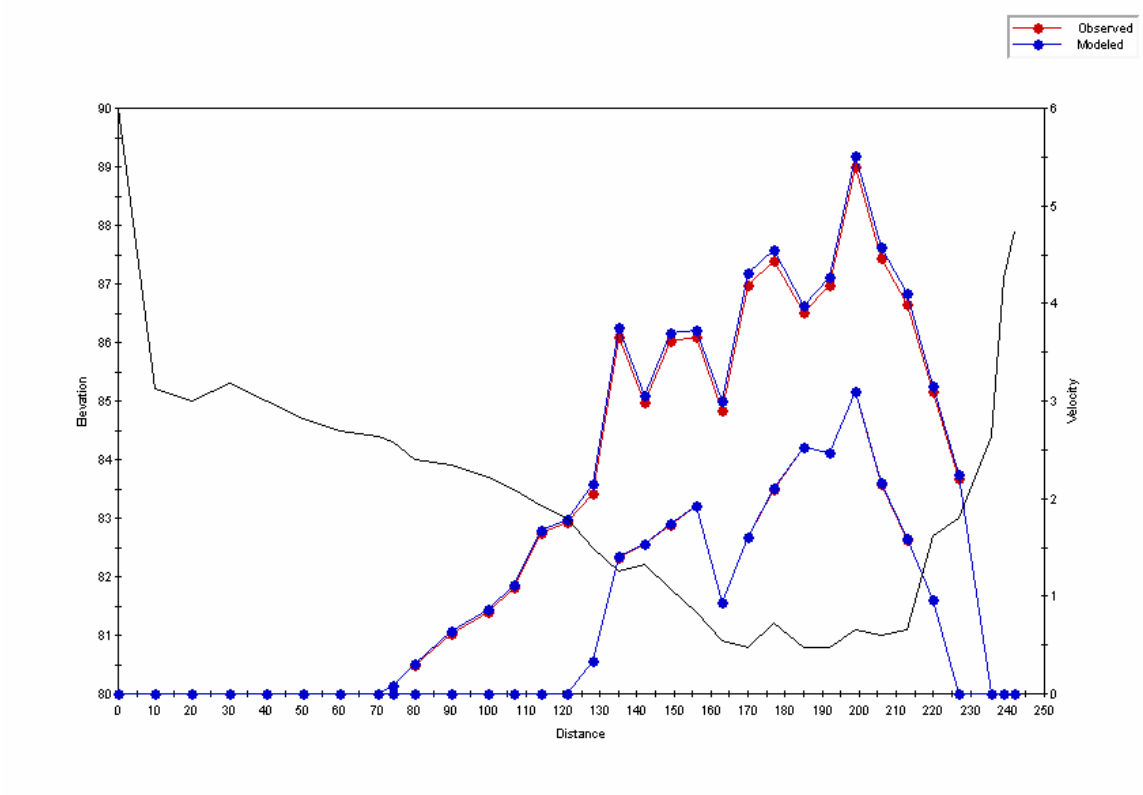

Observed
Modeled
Elevation
Velocity
Distance

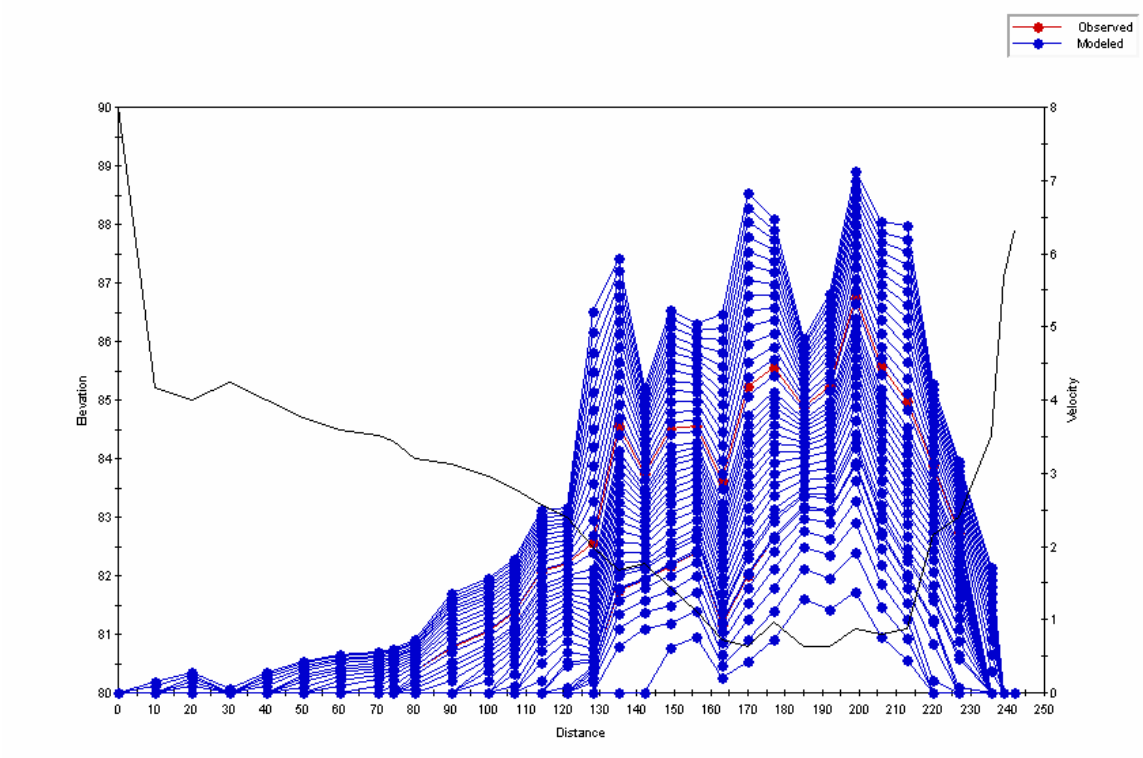
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

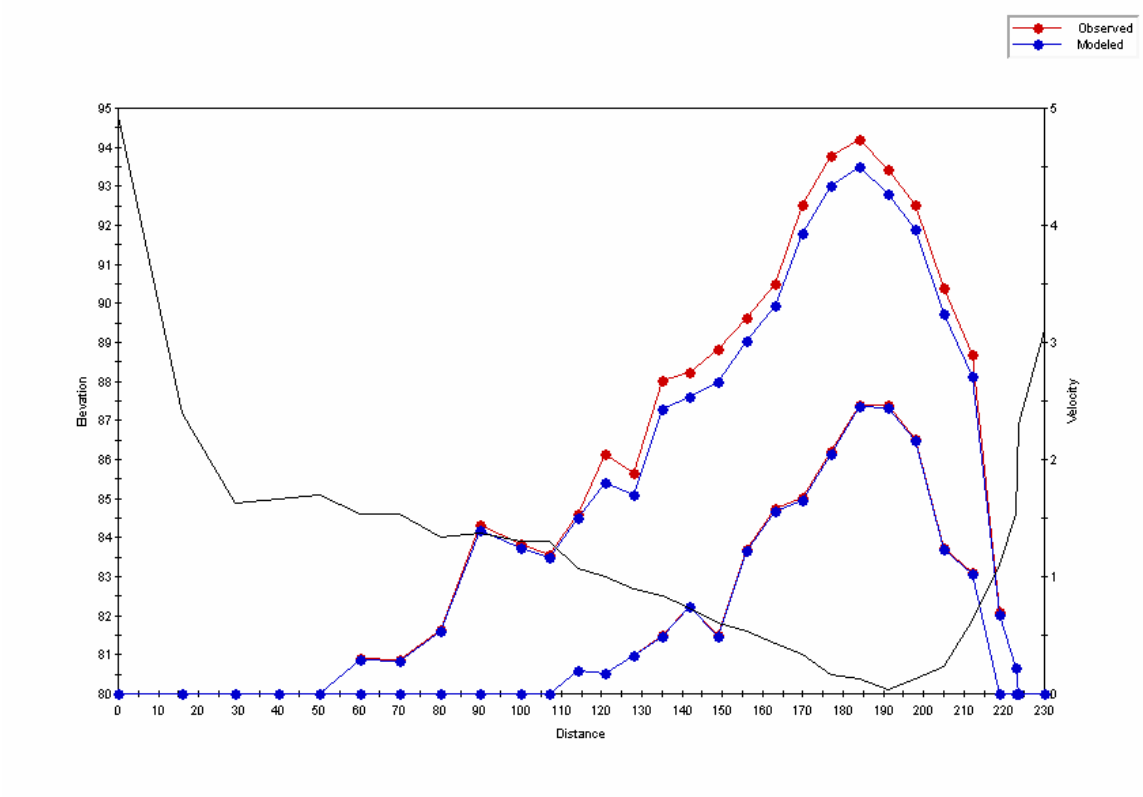

Observed
Modeled
Elevation
Velocity
Distance

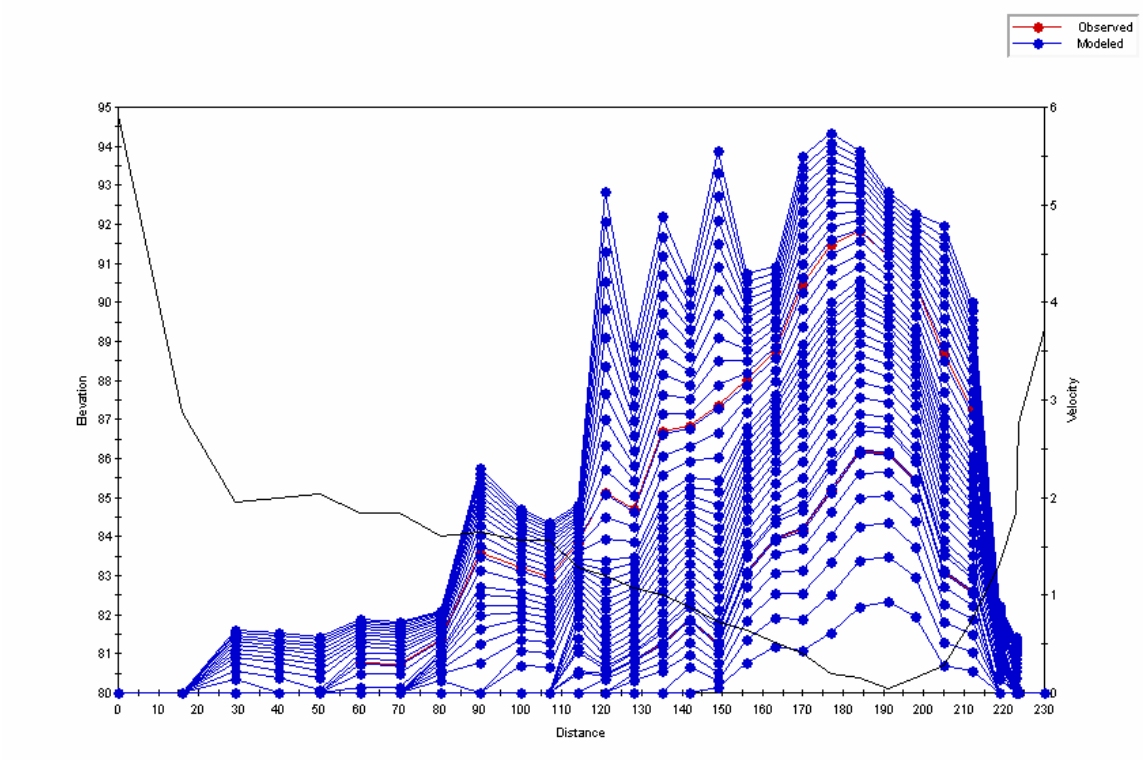
Transect 5


Observed
Modeled
Elevation
Velocity
Distance

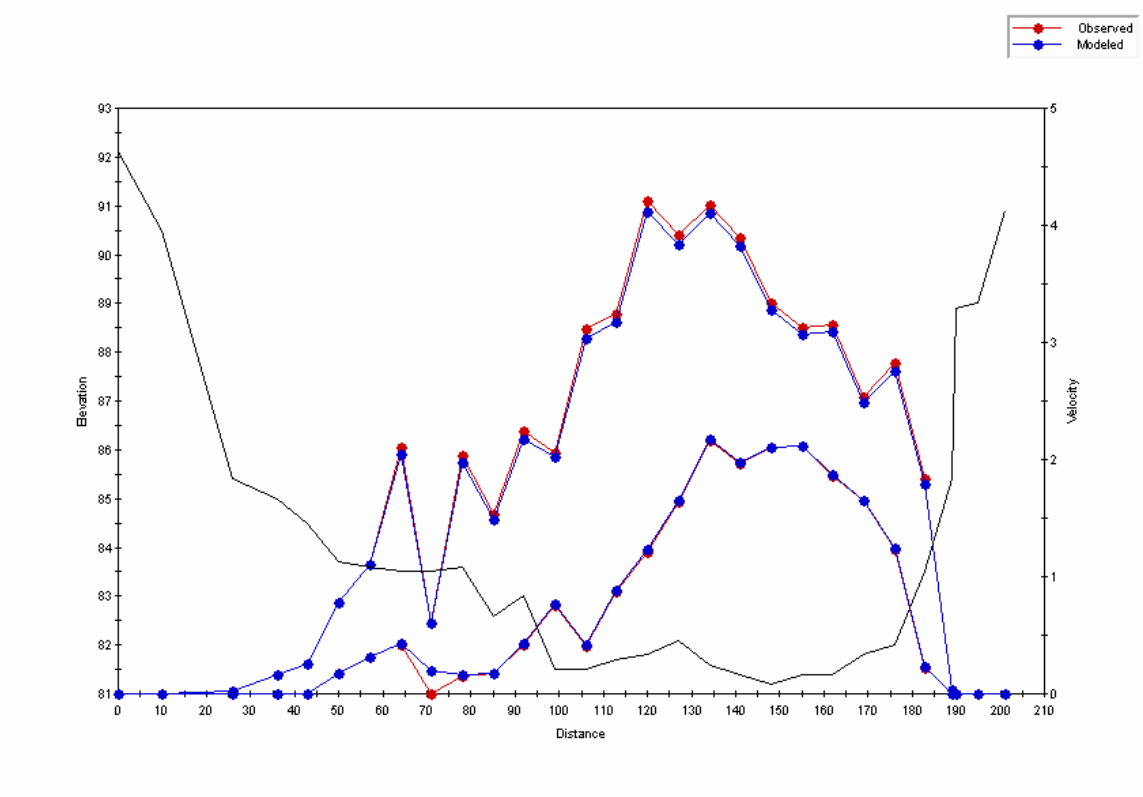

Observed
Modeled
Elevation
Velocity
Distance

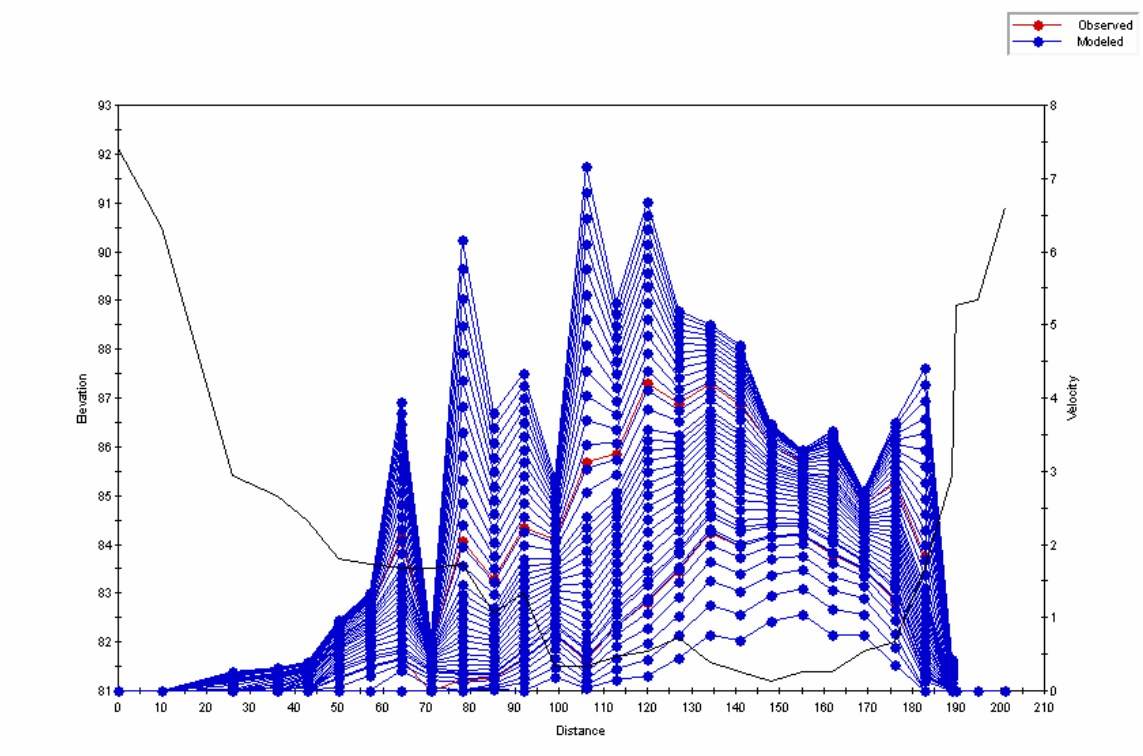
Transect 6


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 7


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

South Fork – Marten's Calibration

Transect 1

V7	Eliminate Q2 (.185)
V15	Reduce Q2 20% to 2.79. Increase Q3 20% to 3.38
V19	Reduce Q2 20% to 2.70.
V23	Increase V23 20% to 2.87
V25	Decrease Q2 20% to 3.11
V32	Increase Q3 20% to 2.90
V33	Decrease Q2 by 0.2 to 2.24
V34	Decrease Q2 20% to 1.57; Eliminate Q1 (.135)
V35	Eliminate Q2 (.208)
V36	Eliminate Q1 (.278)

Transect 2

V8,9	Eliminate Q1 (.056), (.146).

Transect 3

V11	Eliminate Q2 (.262)
V13	Eliminate Q2 (.484)
V14	Increase Q2 to 1.44
V15,16	Eliminate Q1; note ? Marks on data sheet
V16	Reduce Q3 20% to 2.39
V17,18	Eliminate Q1 (.372), (.273)
V18	Reduce Q3 20% to 2.86

Transect 4

CalcQ substantiall higher at Q1 and Q3 than Best Q. Set BestQ1 to 120.
Split into two 1-vel models. 40-300 cfs Q1. 301-1000 cfs Q3.
Channel change at approx 300 cfs.

Transect 5

V11	Eliminate Q2 (.135) to remove very high spike.
V16	Reduce Q1 0.2 to .79
V21	Increase Q2 20% to 2.00

Transect 6

Split into two 1-vel models. 40-300 cfs Q1. 301-1000 cfs Q3.

Transect 7

Described as mid-riffle with boulders.
Split into two models. 40-300 cfs Q1 and Q2. 301-1000 cfs Q3.

V23	Decrease Q1 to 0.94.

Transect 8

Split into two models. 40-300 cfs Q1 and Q2. 301-1000 cfs Q3.

V6	Elminate Q1 (.383)
V19	Decrease Q1 0.2 to 0.96
V20	Decrease Q2 20% to 2.70
V29	Decrease Q2 20% to 1.70

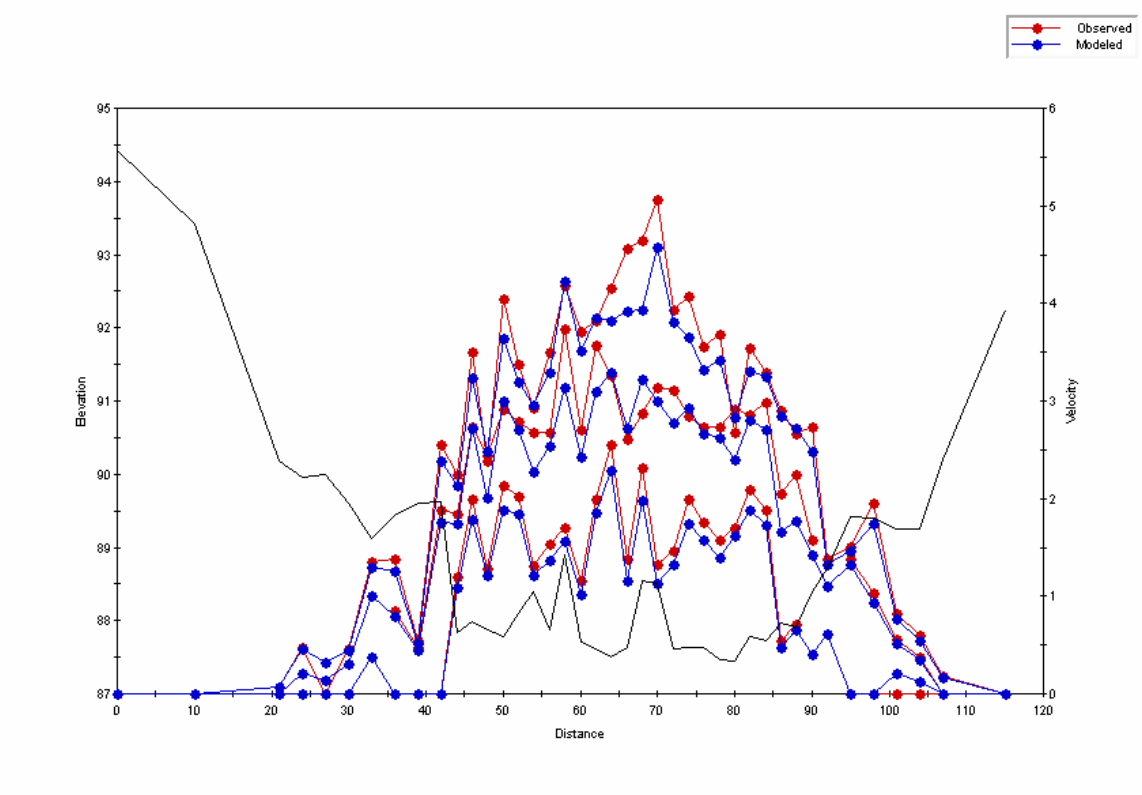
SF Stillaguamish above Marten Creek

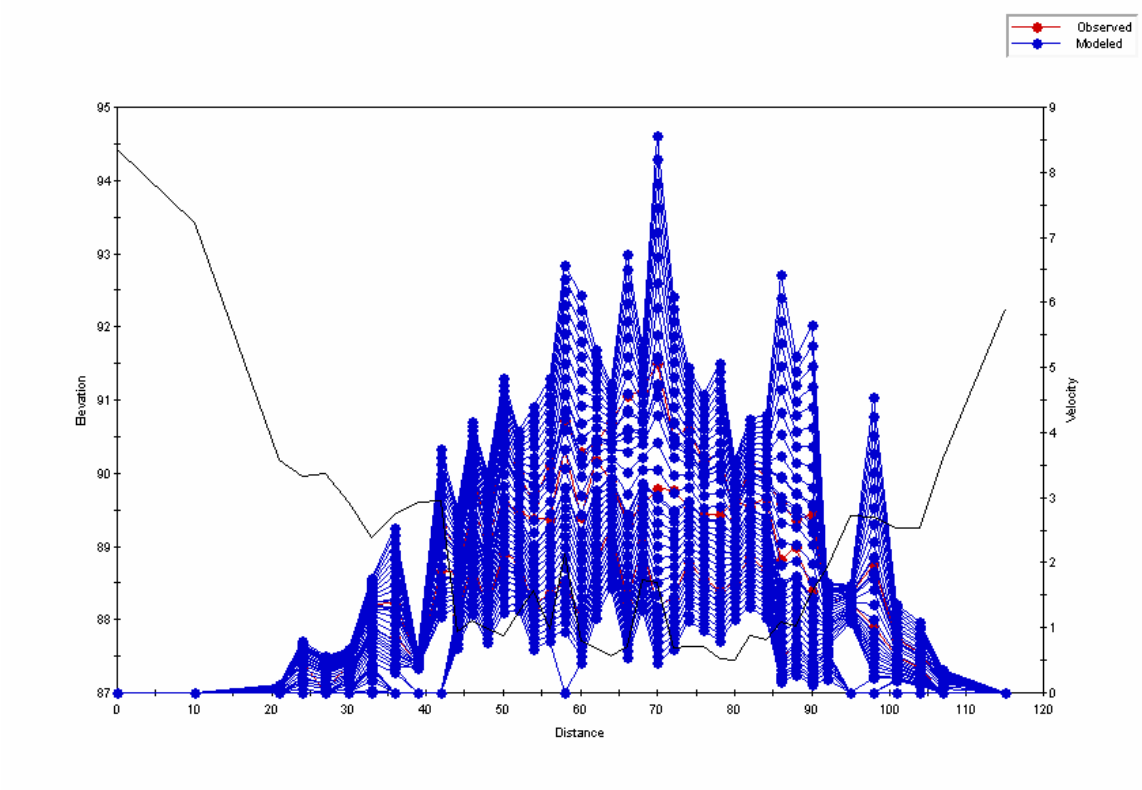
Station ID	Distance from Bank							
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8
1	0	0	0	0	0	0	0	0
2	10	10	7	10	5	10	11	10
3	21	13	15	14	10	20	14	18
4	24	20	18	18	15	25	18	22
5	27	24	22	22	20	30	22	26
6	30	28	26	26	25	35	26	30
7	33	32	30	30	30	40	30	33
8	36	36	34	34	35	44	34	36
9	39	39	38	38	40	48	37	39
10	42	42	42	42	42	52	40	42
11	44	45	46	45	45	56	43	45
12	46	48	49	49	48	59	46	48
13	48	51	52	53	51	62	49	51
14	50	54	55	56	54	65	52	54
15	52	57	58	59	57	68	55	57
16	54	60	61	62	60	71	58	60
17	56	63	64	64	63	73	61	63
18	58	66	67	66	66	75	64	66
19	60	69	70	68	69	77	67	69
20	62	72	73	70	72	79	70	72
21	64	75	75	72	75	81	73	75
22	66	78	77	74	78	83	76	78
23	68	81	79	76	80	85	79	81
24	70	84	81	78	82	87	82	84
25	72	87	83	80	84	89	85	87
26	74	90	85	82	86	91	88	90
27	76	94	87	84	88	93	92	93
28	78	98	90	86	90	95	96	96
29	80	103	93	88	92	97	100	99
30	82	104	96	90	94	99	105	102
31	84	109	99	92	96	101	112	105
32	86		102	94	98	103	118	109
33	88		105	96	100	105	133	113
34	90		109	98	102	107		117
35	92		117	100	104	109		127
36	95			102	107	113		129
37	98			104	112	115		
38	101			106	117	116		
39	104			110	125	120		
40	107			114	135			
41	115			115				

SF Marten

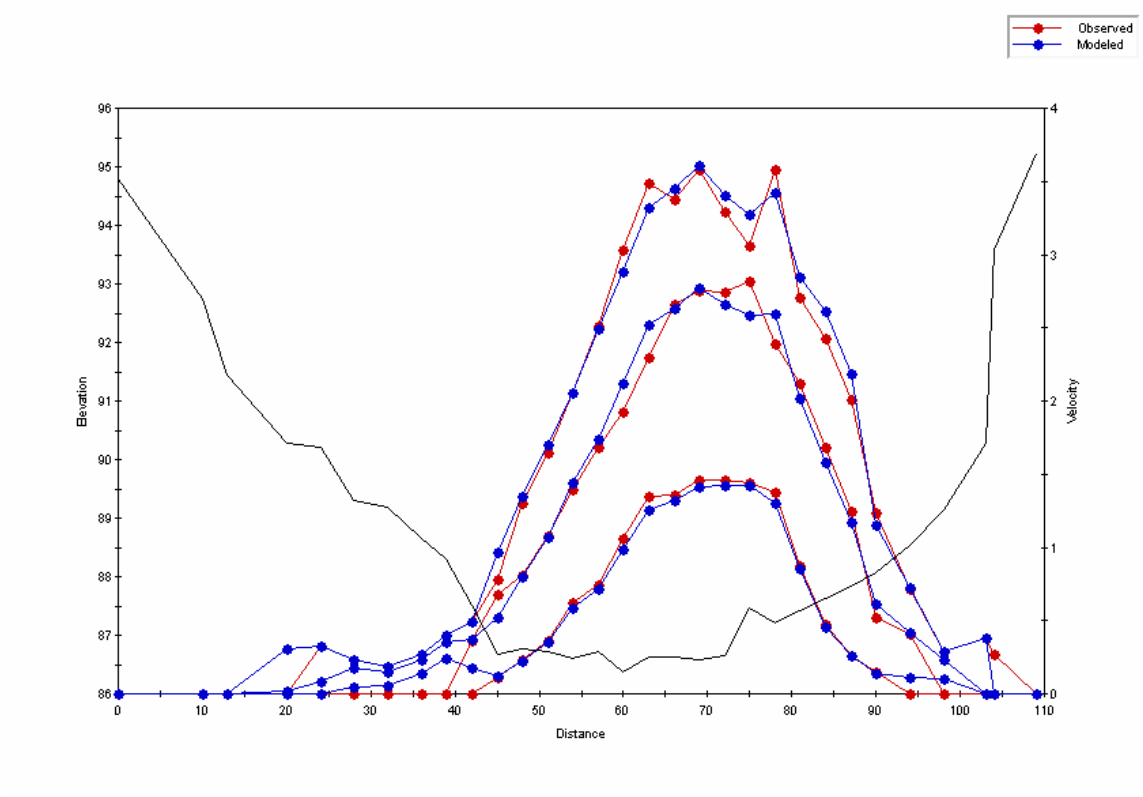
Transect (model)	**1**	**2**	**3**	**4a**	**4b**	**5**	**6a**	**6b**	**7a**	**7b**	**8a**	**8b**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	3	3	1	1	3	1	1	2	1	2	1
Discharge	112	102	97	120	120	104	102	102	108	102	129	120
	318	294	294	301	301	287	301	301	297	301	368	301
	517	475	494	555	555	466	483	483		483		555
Stage	89.38	89.45	89.44	90.545	90.545	91.87	91.89	91.89	92.9	92.805	93.57	93.425
	90.2	90.28	90.37	91.2	91.2	92.68	92.665	92.665	93.58	93.6	94.42	94.14
	90.67	90.72	90.77	91.69	91.69	93.04	93.03	93.03		94.05		94.8
Plotting Stage	1.93	2	1.99	2.105	2.105	2.63	2.65	2.65	1.57	1.475	2.14	1.995
	2.75	2.83	2.92	2.76	2.76	3.44	3.425	3.425	2.25	2.27	2.99	2.71
	3.22	3.27	3.32	3.25	3.25	3.8	3.79	3.79		2.72		3.37
Ratio of Measured vs. Predicted Discharge												
	1	1.01	1.02	1.009	1.009	1.01	1.006	1.006	1	1.002	1	0.993
	0.99	0.98	0.93	0.977	0.977	0.95	0.98	0.98	1	0.992	1	1.017
	1.01	1.01	1.05	1.015	1.015	1.04	1.015	1.015		1.006		0.99
Mean Error of stage/discharge relationship for calculated Q												
	0.68	1.21	4.55	NA	NA	3.28	NA	NA	0	NA	0	NA
Mean Error of stage/discharge relationship for given Q												
	0.4	0.36	0.75	1.56	1.56	1.67	1.37	1.37	0.56	0.56	1.09	1.09
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF												
A=	0.3954	0.4526	0.4636			0.8301			0.296		0.4552	
B =	0.336	0.3215	0.3201			0.249			0.356		0.3186	
SZF =	87.45	87.45	87.45	88.44	88.44	89.24	89.24	89.24	91.33	91.33	91.43	91.43
Beta coefficient log/log discharge/stage relationship												
	2.976	3.11	3.12	3.513	3.513	4.02	4.321	4.321	2.807	2.535	3.139	2.926

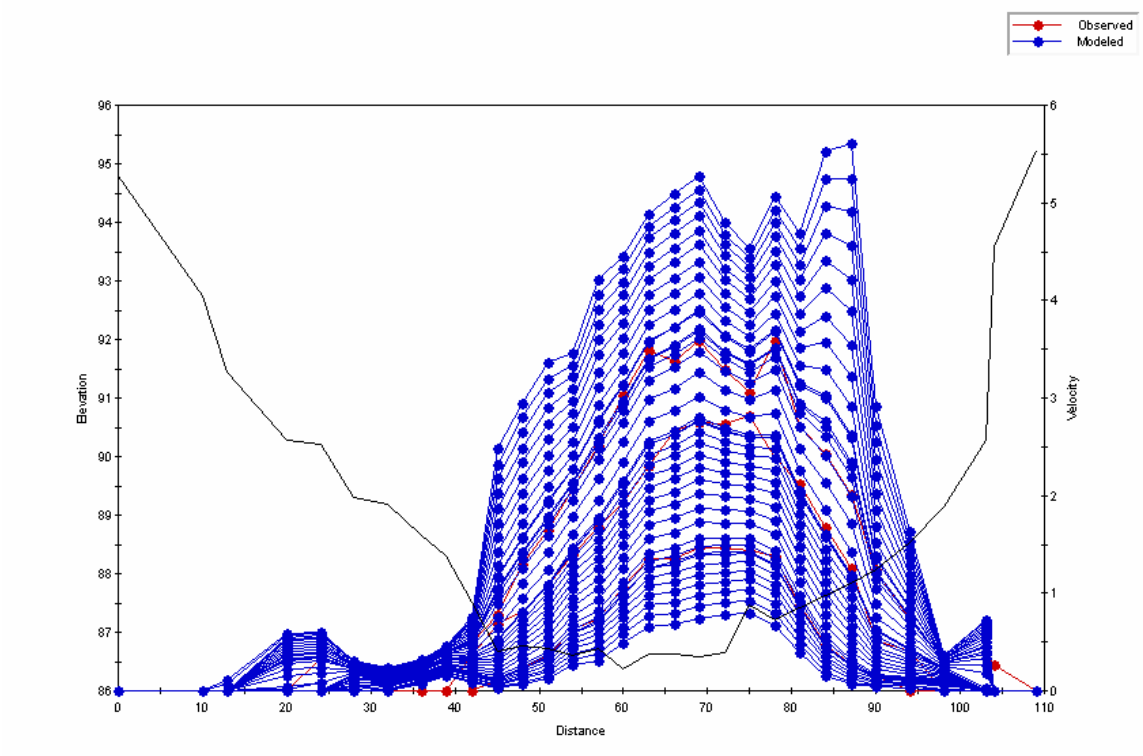
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

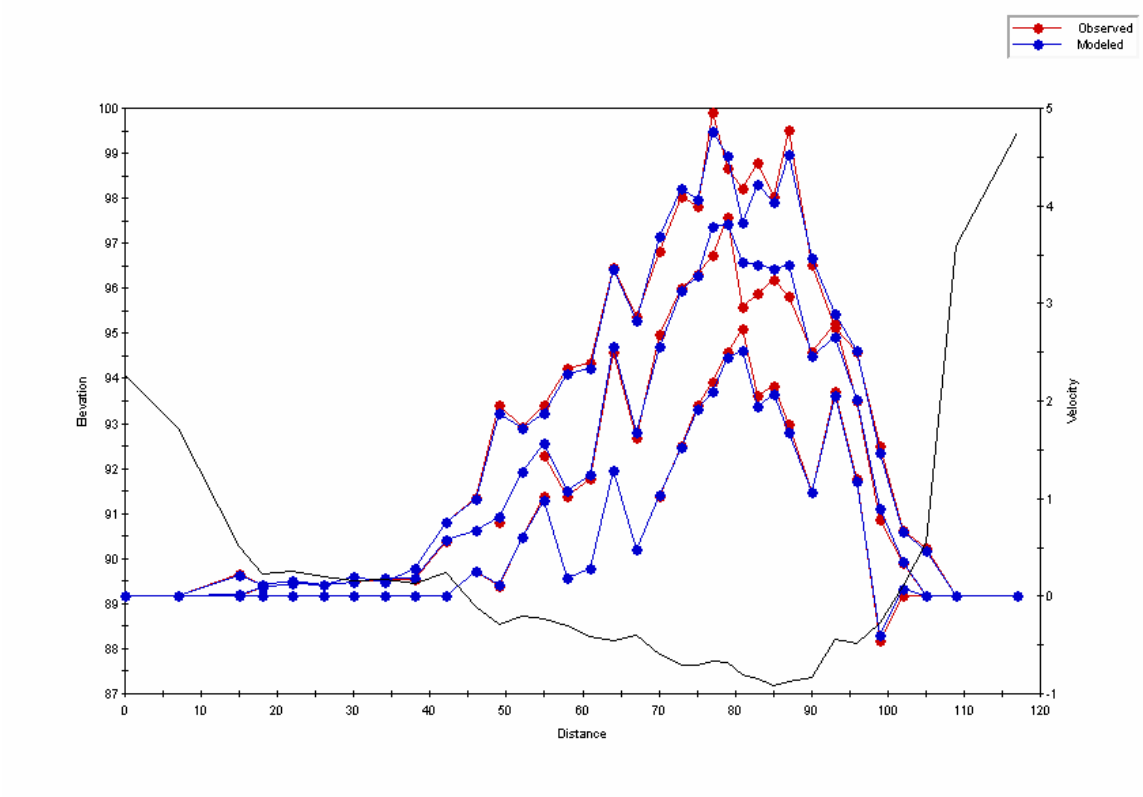

Observed
Modeled
Elevation
Velocity
Distance

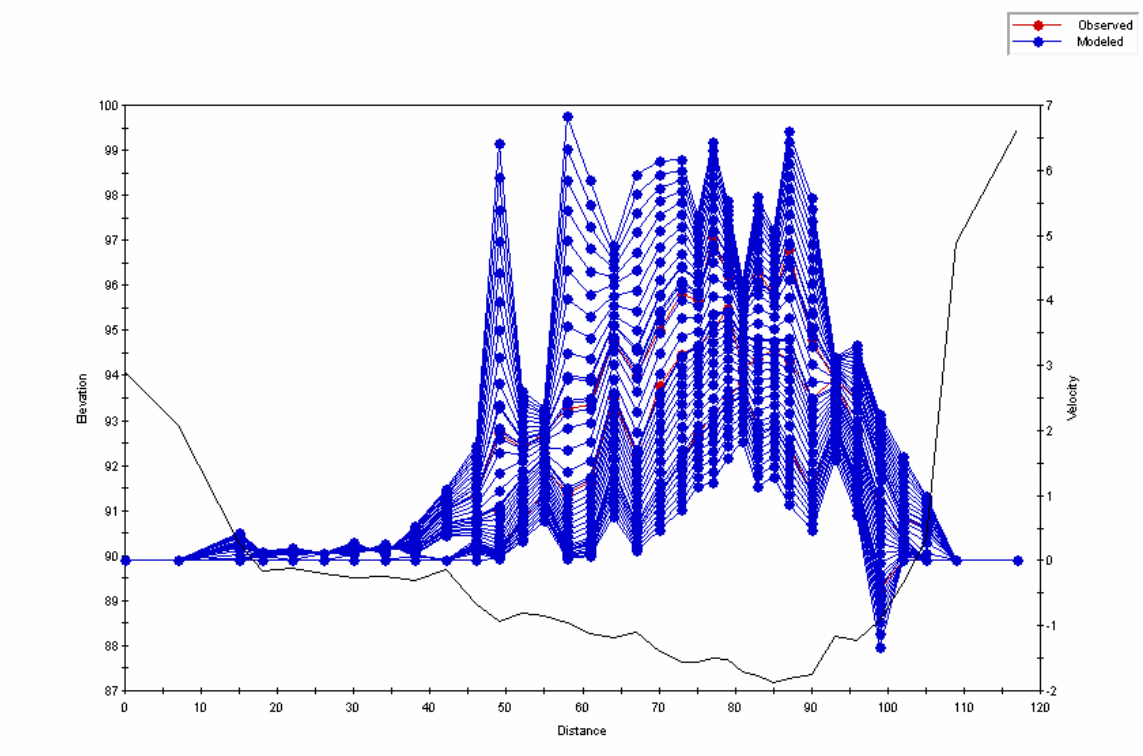
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

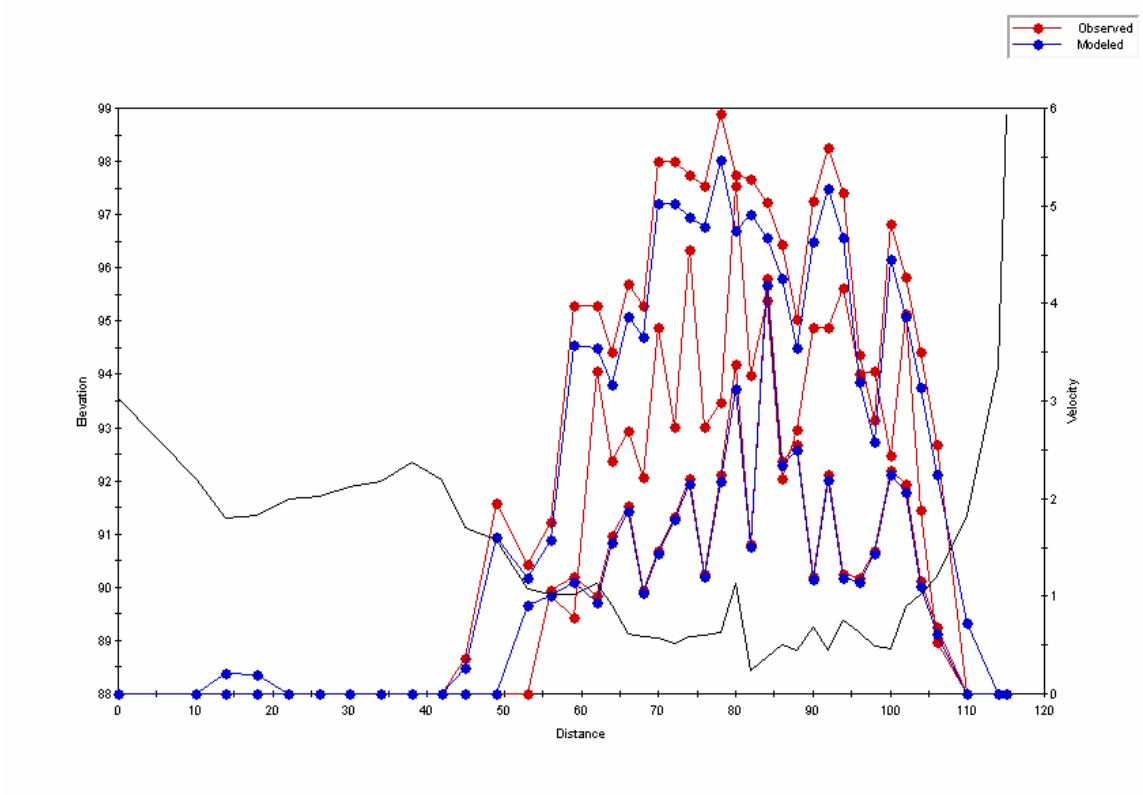

Observed
Modeled
Elevation
Velocity
Distance

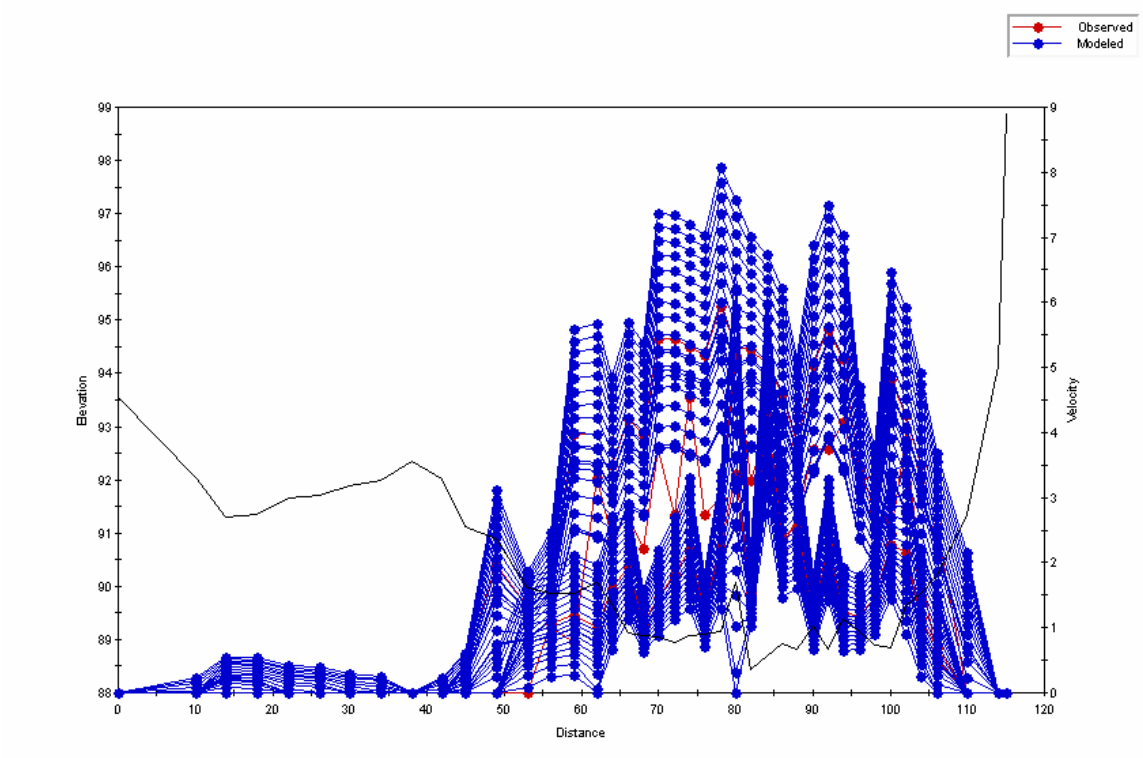
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

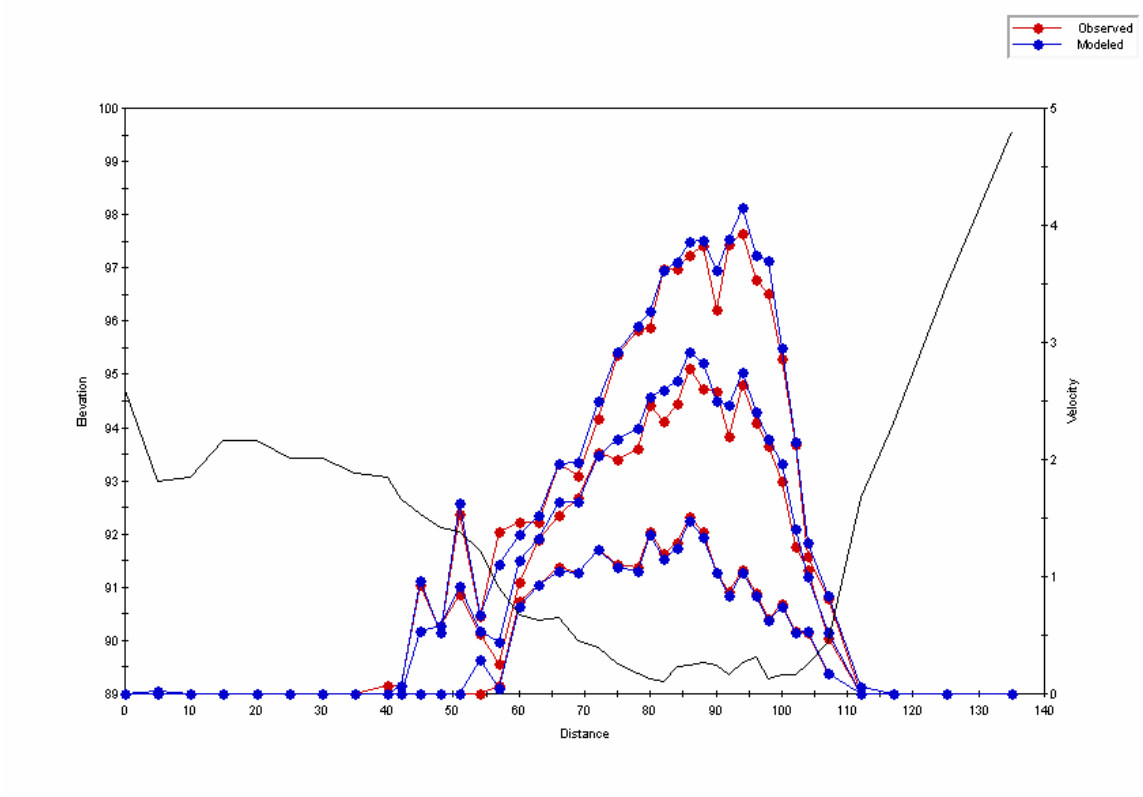

Observed
Modeled
Elevation
Velocity
Distance

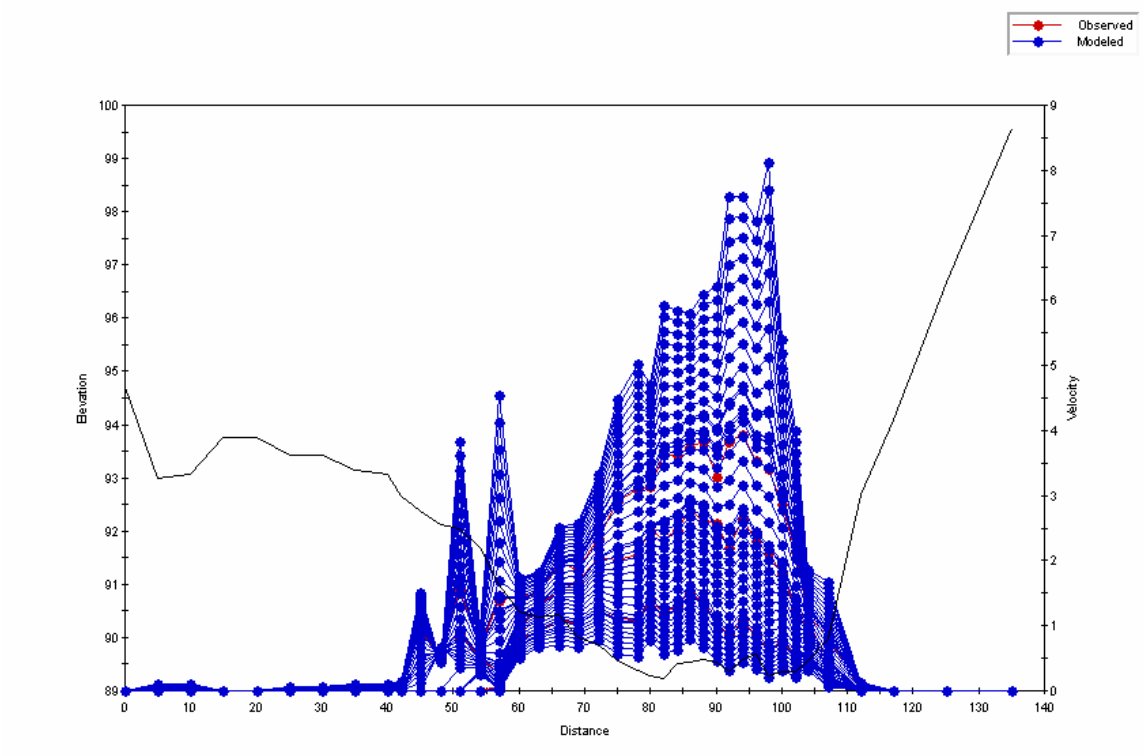
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

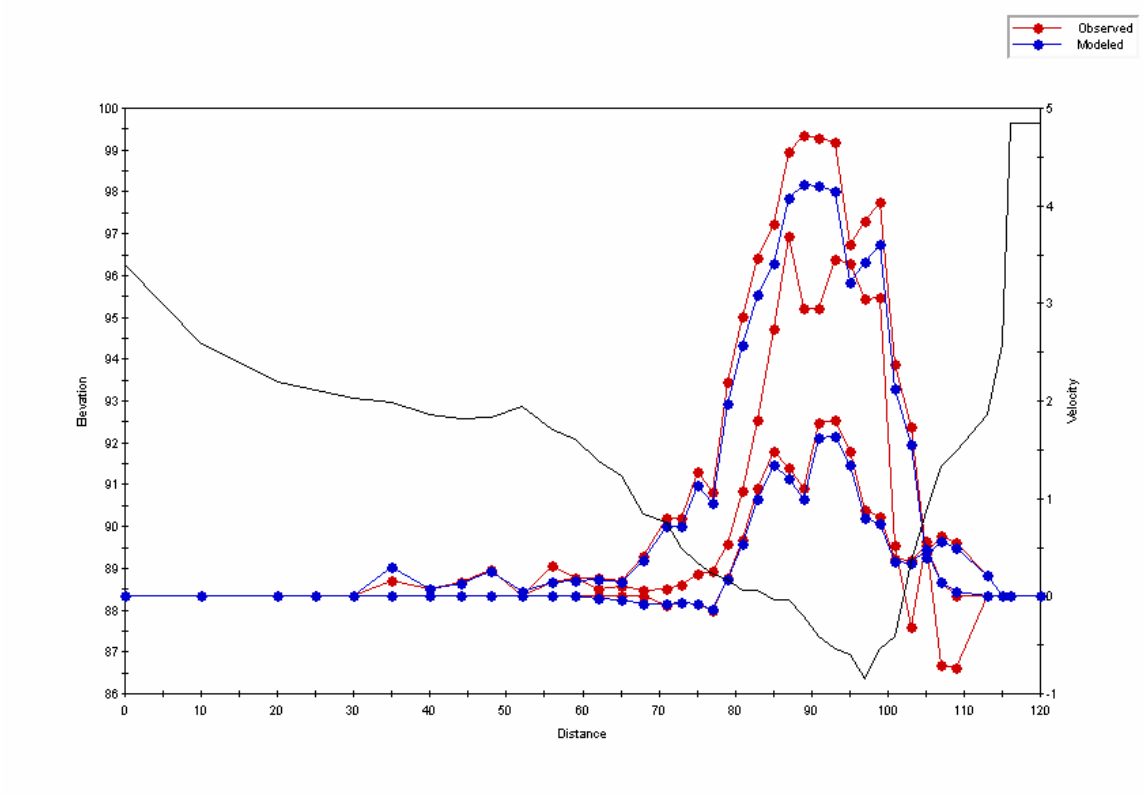

Observed
Modeled
Elevation
Velocity
Distance

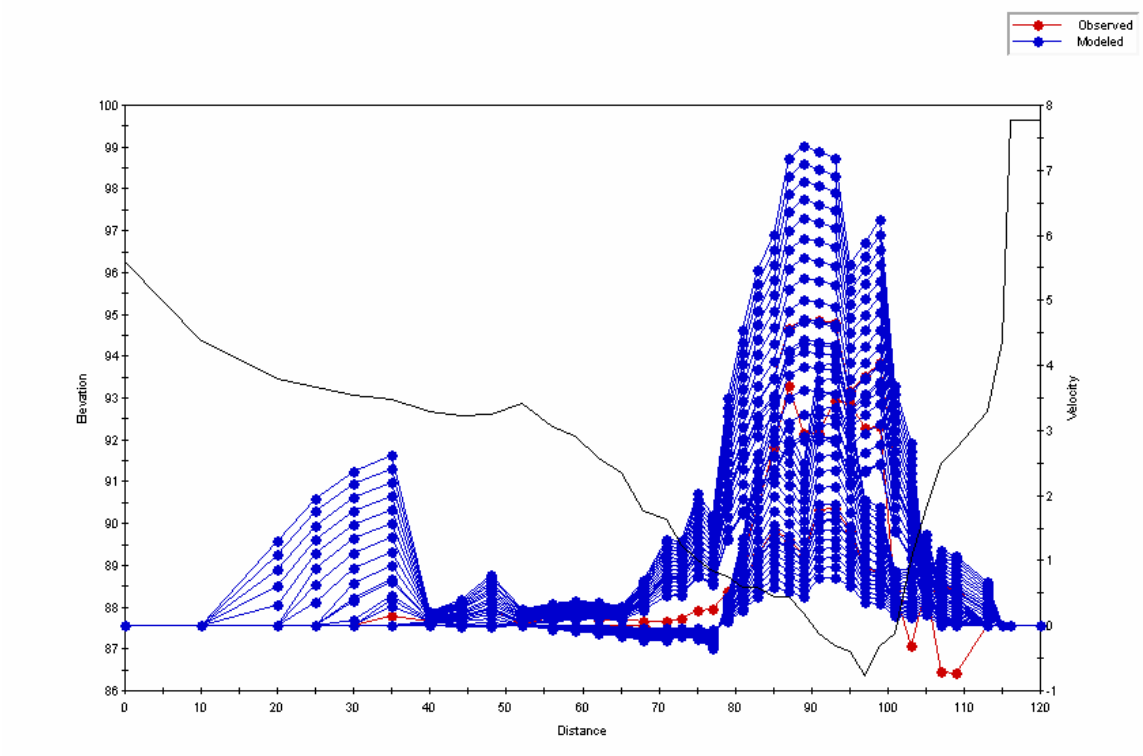
Transect 5


Observed
Modeled
Elevation
Velocity
Distance

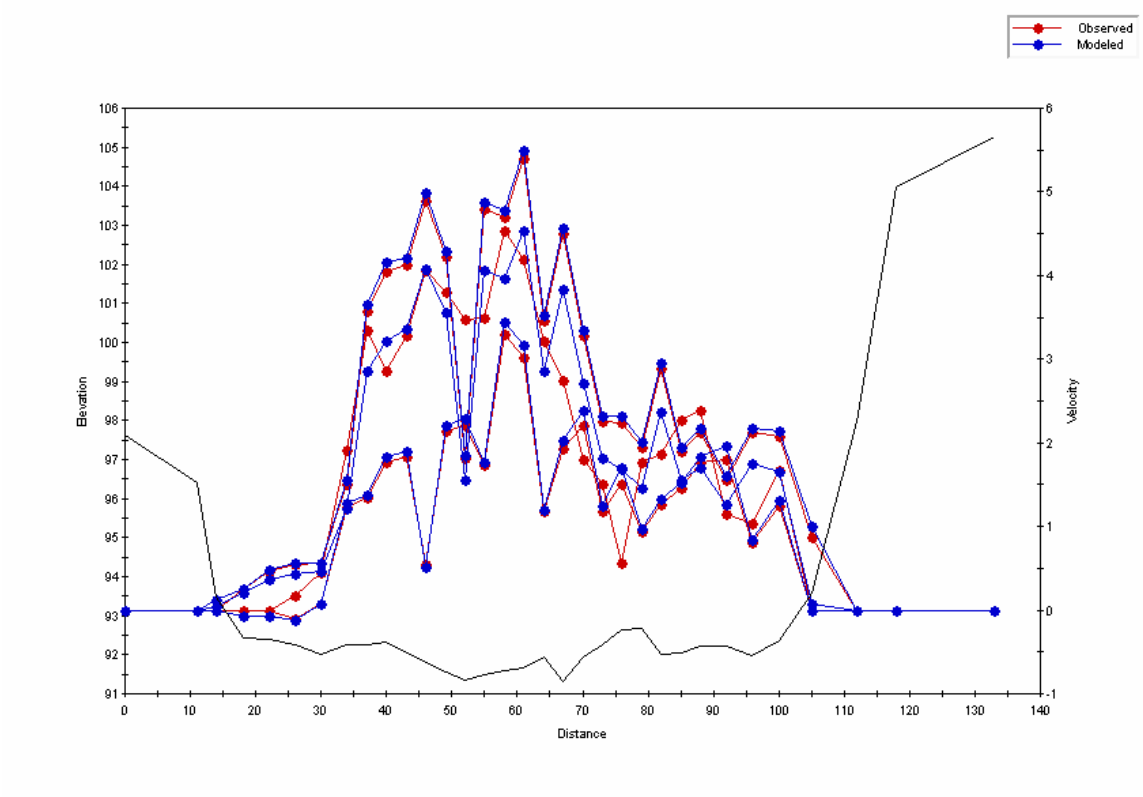

Observed
Modeled
Elevation
Velocity
Distance

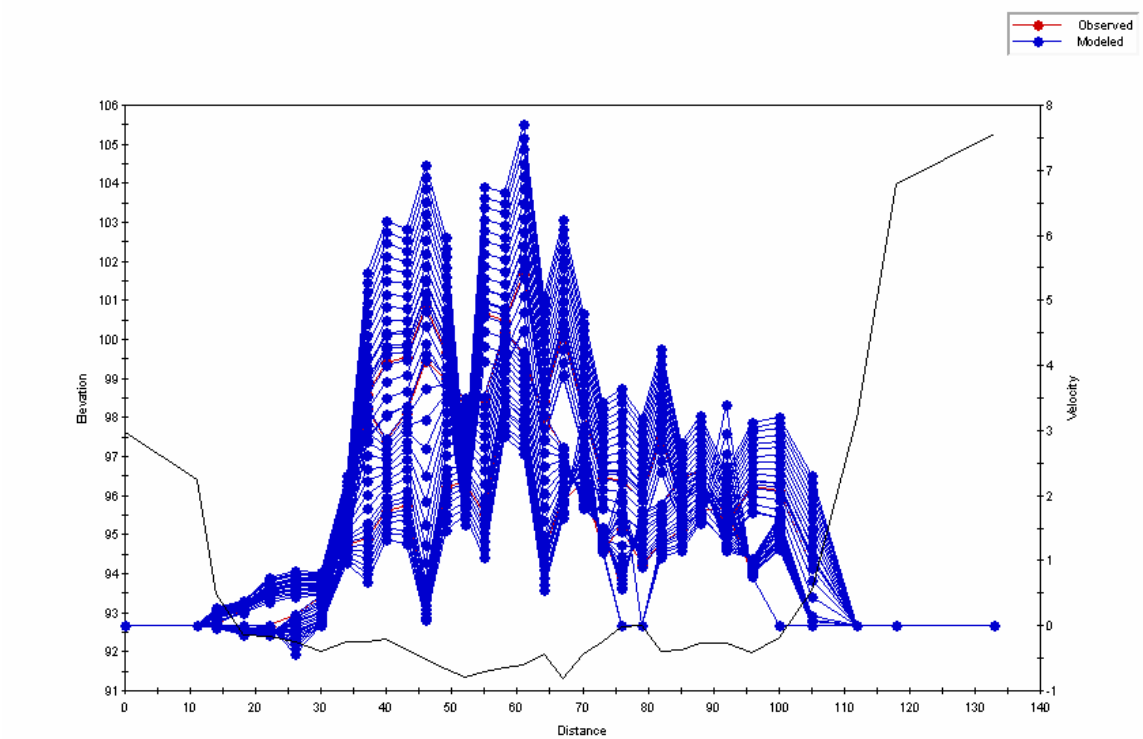
Transect 6


Observed
Modeled
Elevation
Velocity
Distance

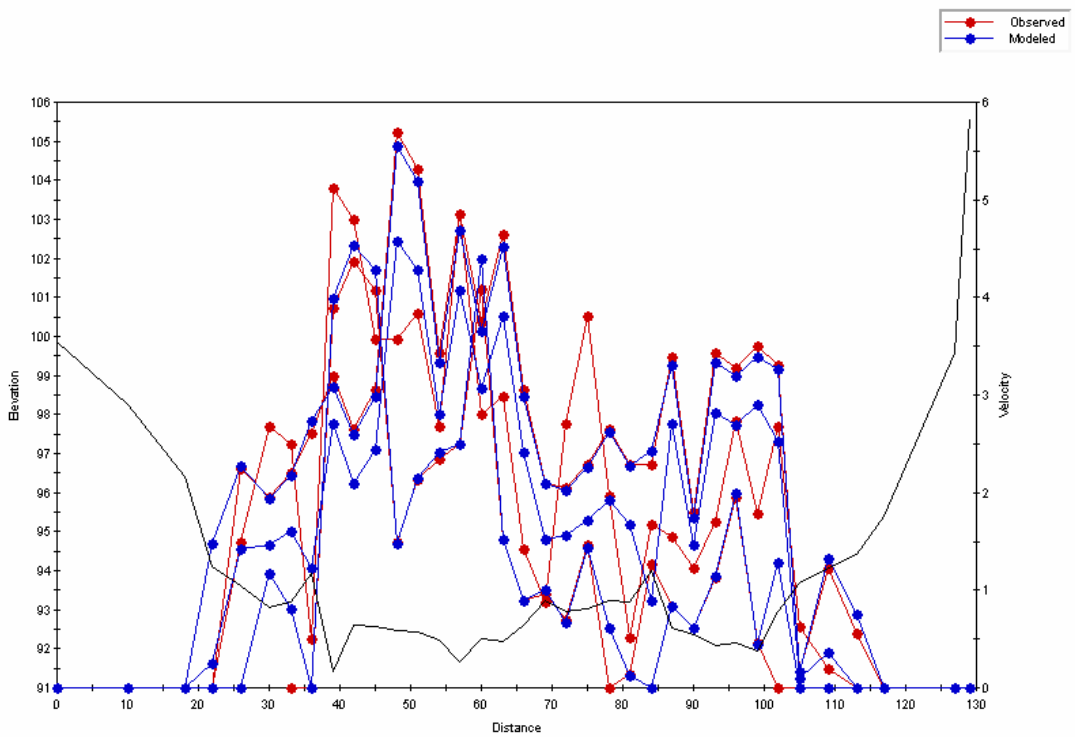

Observed
Modeled
Elevation
Velocity
Distance

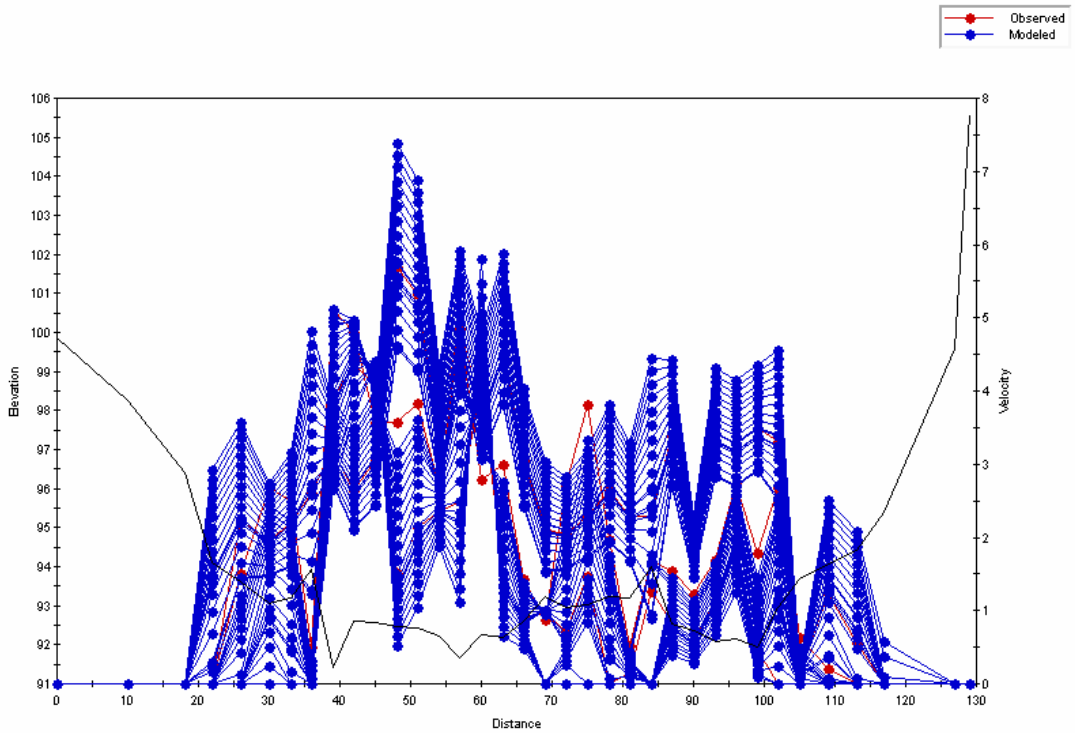
Transect 7


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 8


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Squire Creek Calibrations

Transect 1
V7 Change Q2 from 1.25 to 1.05

Transect 2
V6 Changed Q2 from 1.13 to 1.03
V18 Changed Q2 from 1.38 to 1.18
V26 Changed Q1 from 0.02 to 0.12 to control spike at high vels
V27 Changed Q2 from 0 to 0.01 since Z below WSL

Transect 3
Split into two 1-vel models. 20-150 using Q1. 151-900 using Q3.

Transect 4
Set WSLs to RB, LB,LB for Q1, Q2, Q3 respectively to improve WSL fit.
Went to two 1-vel models. 20-150 using Q1. 151-900 using Q3. Check VAFs - a bit poor at high end.

Transect 5
Set WSLs to RB, LB, LB for Q1, Q2, Q3 respectively to improve fit.

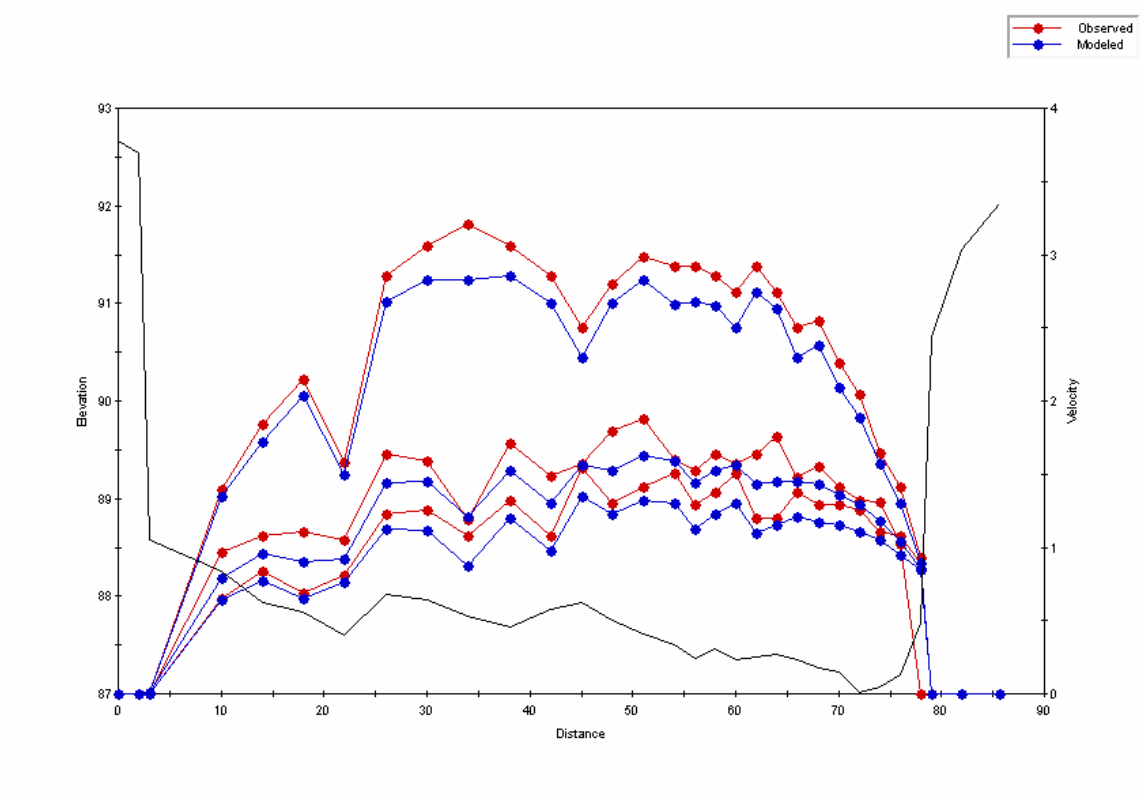
Squire

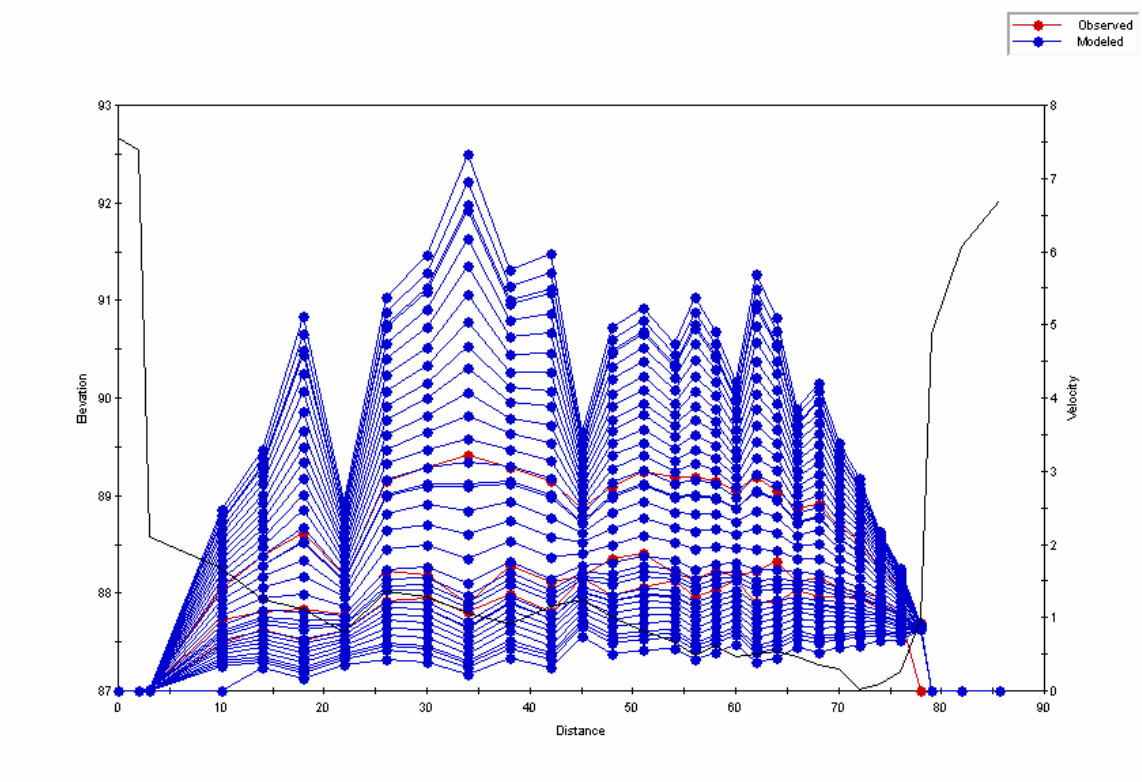
Station ID	Distance from Bank				
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
1	0	0	0	0	-2
2	2	1.9	6	12	-1.9
3	3	2	6.5	15	0
4	10	4	10	20	4
5	14	6	13	26	8
6	18	8	16	32	10
7	22	10	18	36	12
8	26	12	20	40	16
9	30	14	22	42	18
10	34	16	24	44.3	20
11	38	18	25.5	46	29.5
12	42	20	27	48	34.5
13	45	22	28.5	50	37.5
14	48	24	30	52	41.5
15	51	26	31.5	54	43.8
16	54	28	33	56	47.5
17	56	30	34.5	58	50.5
18	58	32	36	60	52.5
19	60	34	37.5	62	57
20	62	36	39	64	61
21	64	38	41	66	65
22	66	40	43	68	69.1
23	68	42	45	70	74.1
24	70	44	48	72	76
25	72	46	53	74	78
26	74	48	60	76	80
27	76	50	70	78	82
28	78	53.5	87.3	80	84
29	79	60		82	86
30	82	70		84	88
31	85.6	91.3		86	90
32				88	92
33				94	94
34				96.2	96
35					98
36					100
37					102
38					104
39					106
40					108
41					110
42					112
43					114
44					117
45					119
46					127.2

Squire Crk

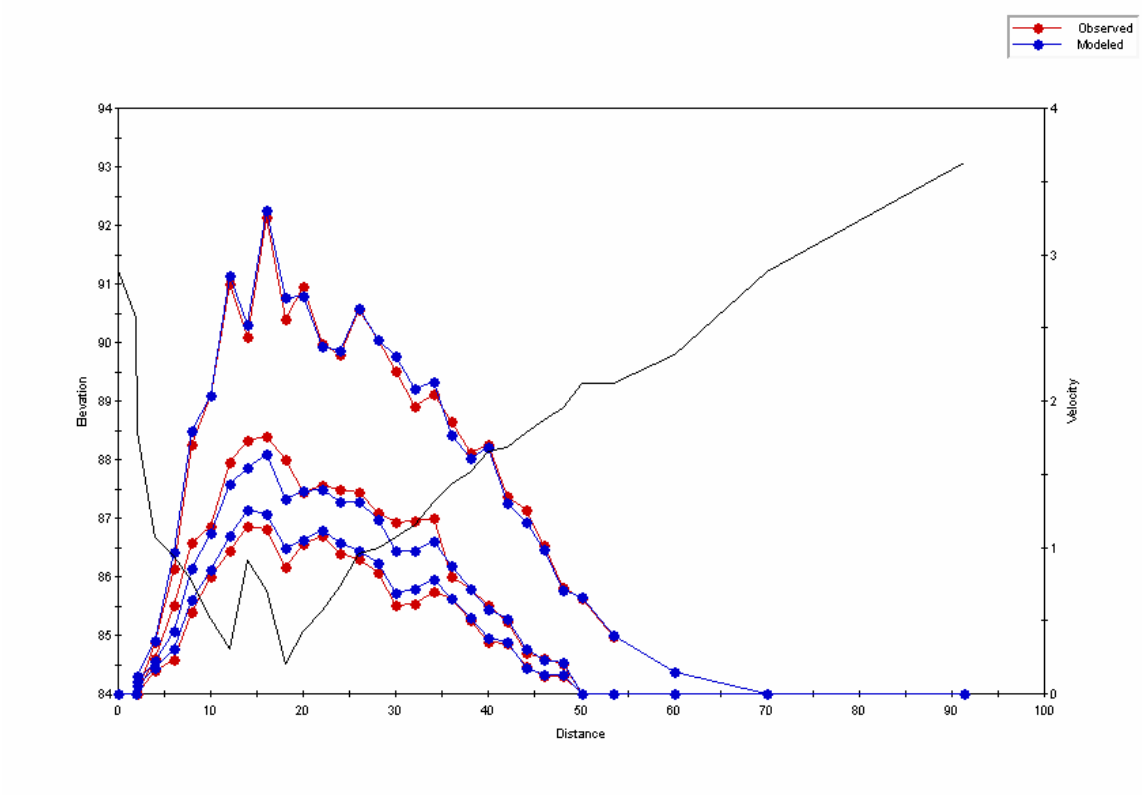
Transect (model)	**1**	**2**	**3a**	**3b**	**4a**	**4b**	**5a**	**5b**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	3	3	1	1	1	1	1	1
Discharge	98	83	91	91	91	91	91	91
	144	144	130	130	130	130	130	130
	336	317	324	324	324	324	324	324
Stage	88.84	88.96	89.01	89.01	89.49	89.49	90.92	90.92
	89.1	89.27	89.275	89.275	89.81	89.81	91.11	91.11
	89.59	89.92	89.965	89.965	90.35	90.35	91.66	91.66
Plotting Stage	1.82	1.94	1.99	1.99	1.59	1.59	1.64	1.64
	2.08	2.25	2.255	2.255	1.91	1.91	1.83	1.83
	2.57	2.9	2.945	2.945	2.45	2.45	2.38	2.38
Ratio of Measured vs. Predicted Discharge								
	1.04	0.98	1.021	1.021	1.072	1.072	1.008	1.008
	0.94	1.04	0.97	0.97	0.887	0.887	0.989	0.989
	1.02	0.99	1.01	1.01	1.052	1.052	1.003	1.003
Mean Error of stage/discharge relationship for calculated Q								
	4.02	2.56	NA	NA	NA	NA	NA	NA
Mean Error of stage/discharge relationship for given Q								
	3.05	4.89	2.07	2.07	8.15	8.15	0.72	0.72
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF								
A=	0.5185	0.5092						
B =	0.2763	0.3014						
SZF =	87.02	87.02	87.02	87.02	87.9	87.9	89.28	89.28
Beta coefficient log/log discharge/stage relationship								
	3.62	3.32	3.268	3.268	2.979	2.979	3.422	3.422

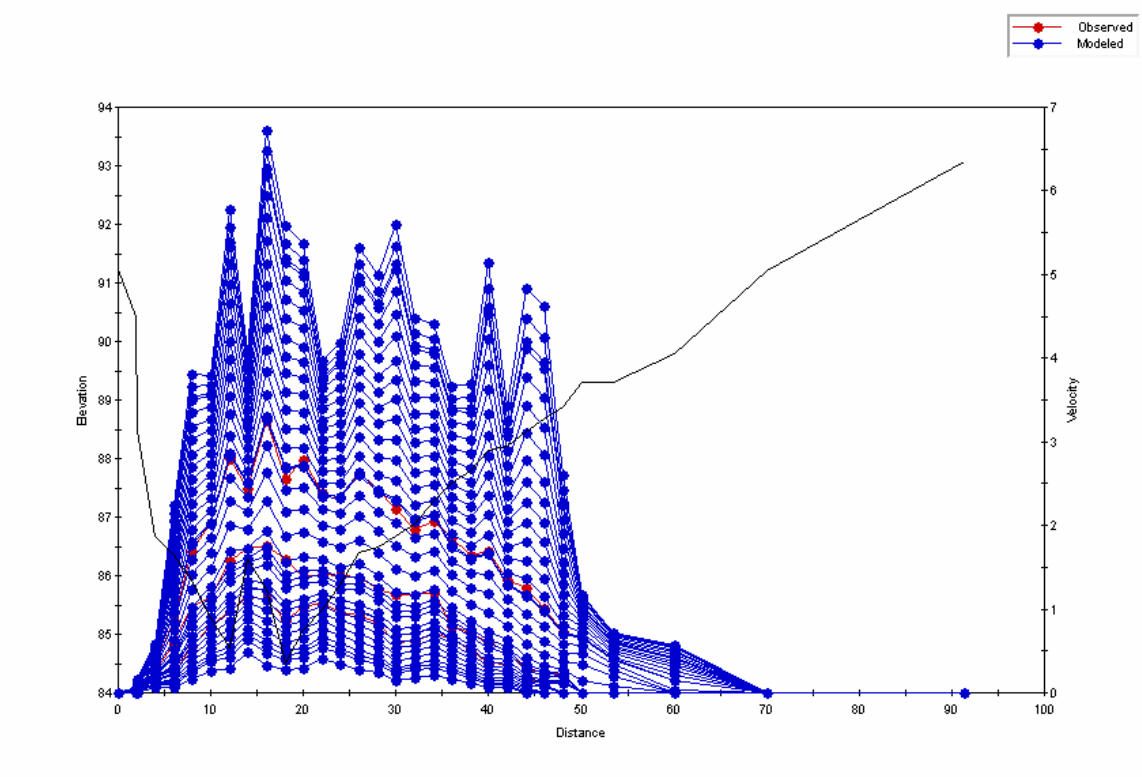
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

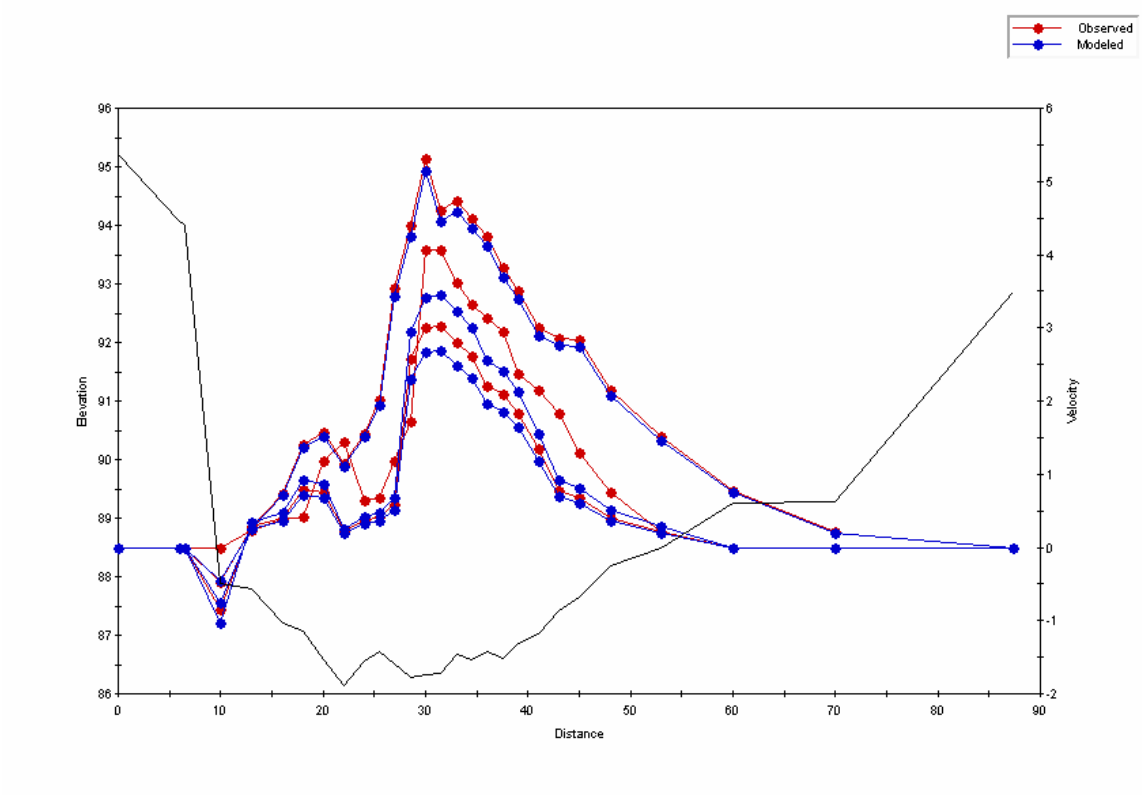

Observed
Modeled
Elevation
Velocity
Distance

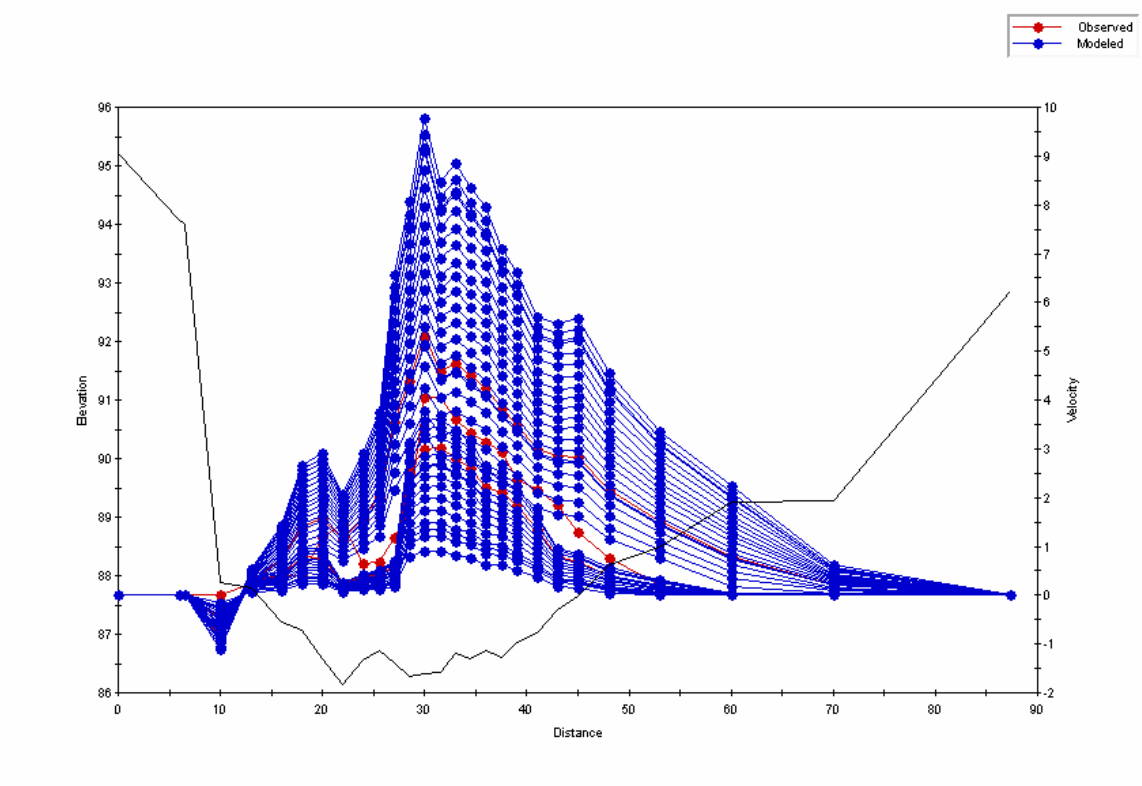
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

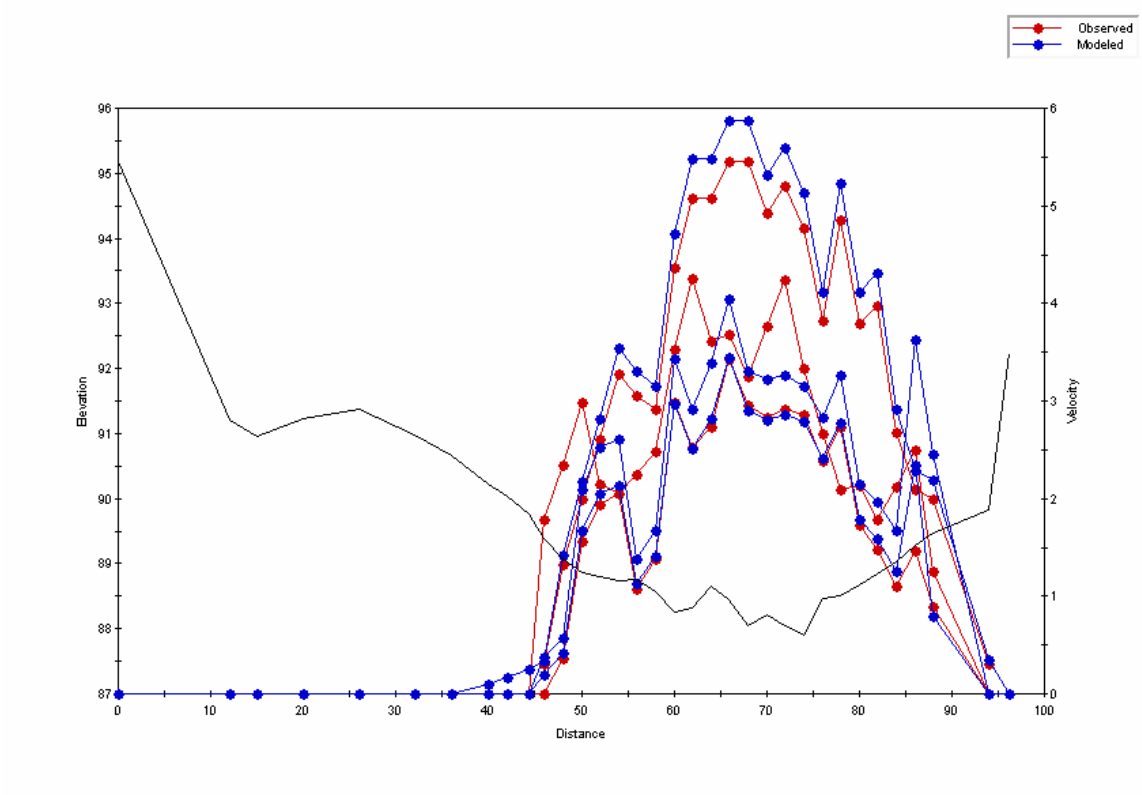

Observed
Modeled
Elevation
Velocity
Distance

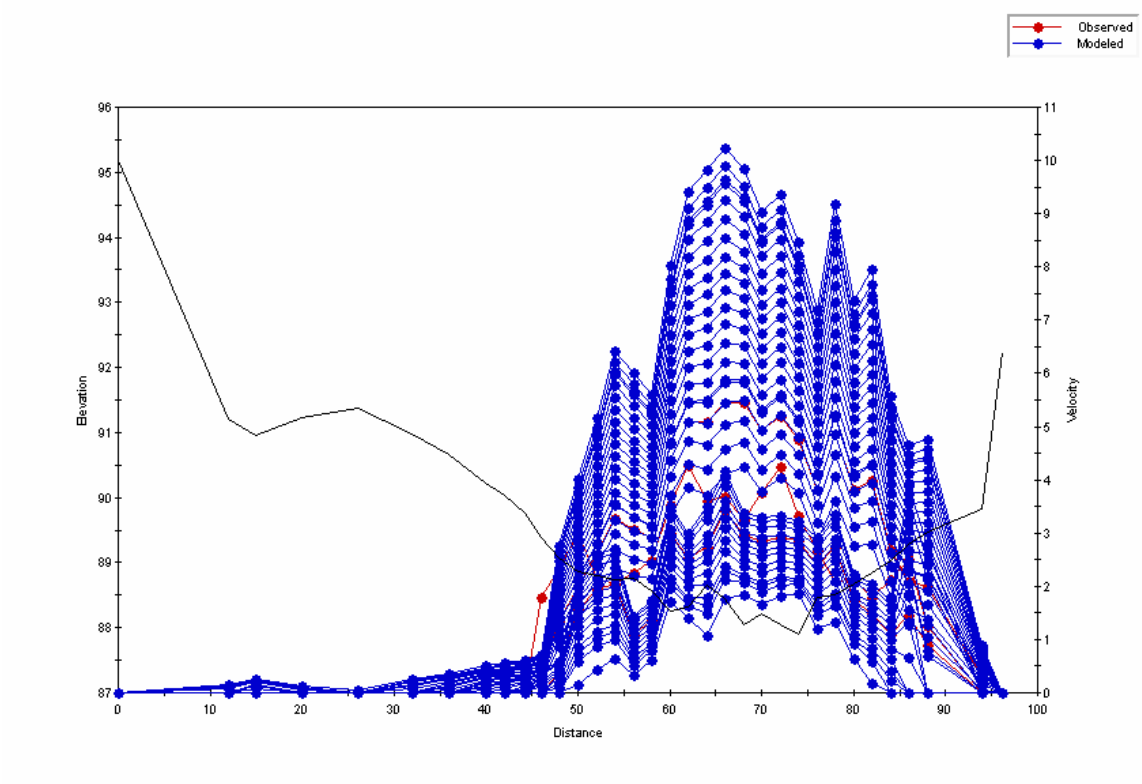
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

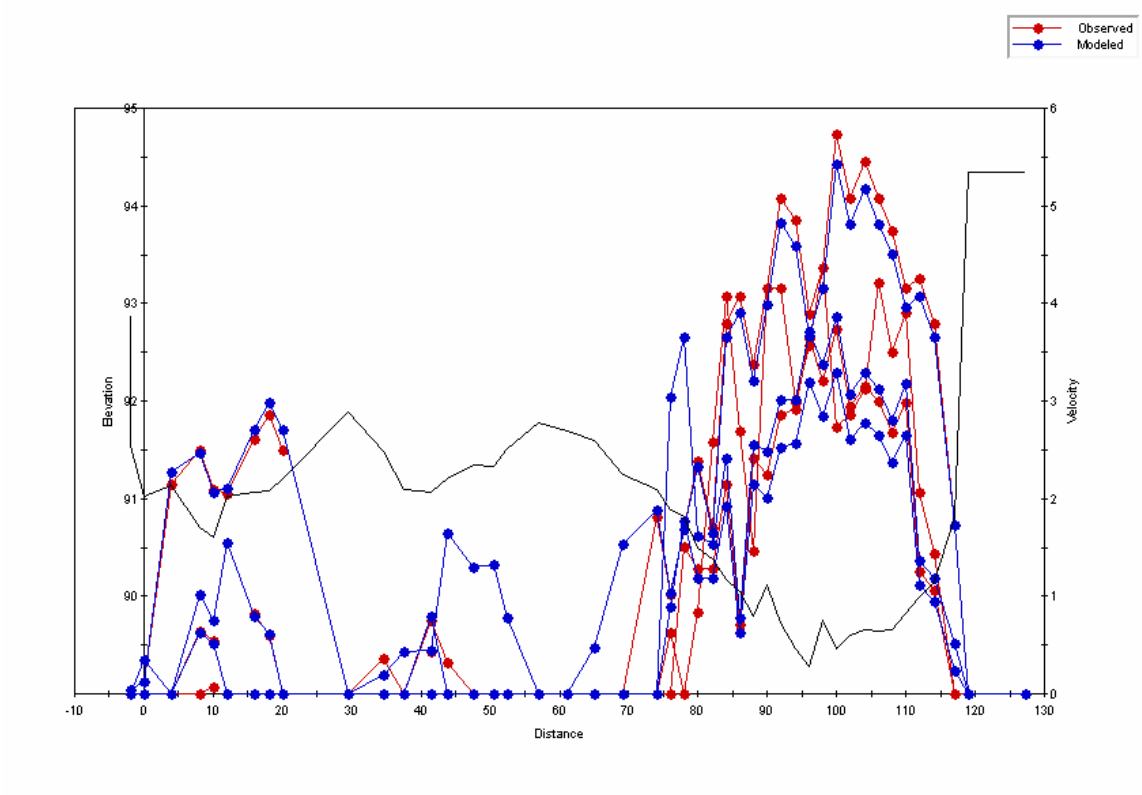

Observed
Modeled
Elevation
Velocity
Distance

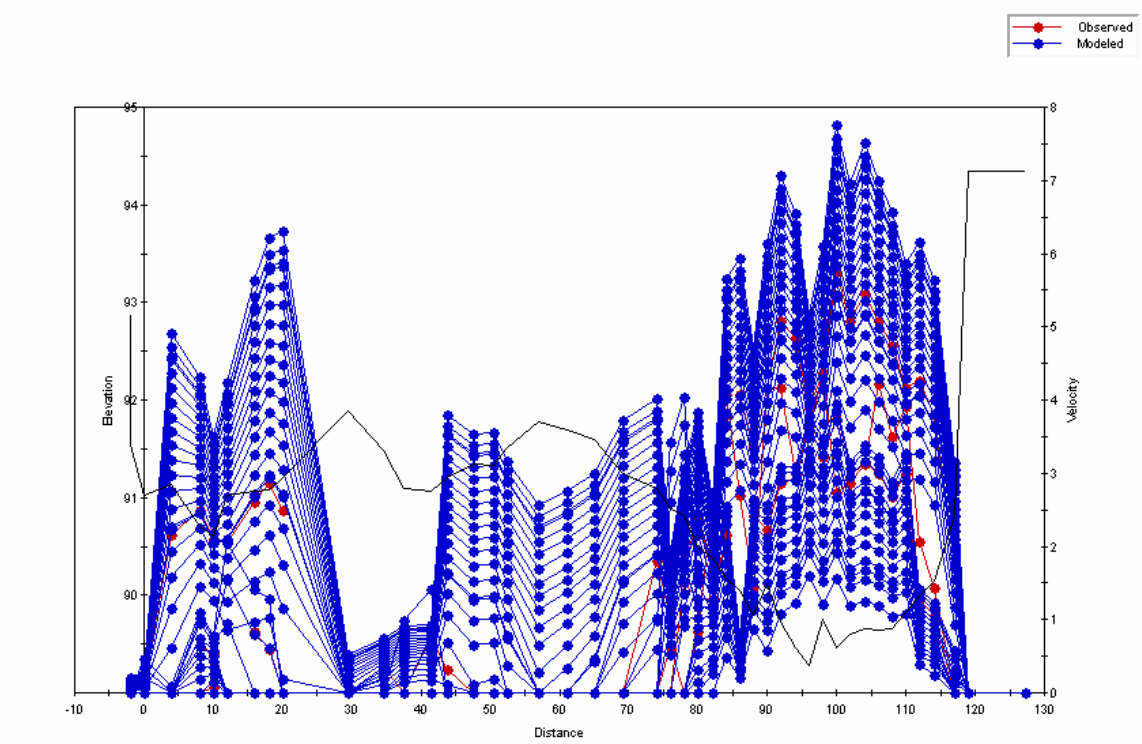
Transect 4


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Canyon Calibrations

Each transect had three calibration sets but at four different velocities. As discussed, transects 1 & 2 were modeled using calibration discharges of 114, 338 and 756 cfs, while transects 3-5 were modeled with discharges of 114, 338 and 453 cfs. For the time being, all transects were modeled over the same range of flows, despite the calibration flow range difference. Note that the highest modeled flow (1300 cfs) is only slightly higher than the 2.5 threshold for extrapolation at transects 3-5.

Data at this transect were very erratic and the channel very irregular. All but one transect were broken up into a combination of 1-flow and 2-flow models.

Transect 1

1-flow Q1 from 40-250 cfs. 2-flow Q2Q3 from 250-800 cfs. 1-flow Q3 from 800-1300 cfs.

V10	Raise Q2 20% to 1.25
V13	Raise Q1 up 0.2 to 0.25, Q2 down 20% to 2.5, Q3 up 20% to 3.12
V16	Q1 set n=.03 to control spike.
V22	Q1 set n=.02 to control spike

Transect 2

3-vel model

V8	Q2 up 0.2 to 0.75
V10	Q2 up 20% to 1.41, Q3 down 20% to 3.58
V12	Raise Q2 20% to 3.76
V13	Q3 down 16% to 5.00
V16	Raise Q1 by 0.2 to 0.36, Q2 down 20% to 1.58
V17	Raise Q2 0.2 to 0.85
V18	Raise Q1 0.2 to 0.54, Q2 down 20% to 1.15, Q3 up 20% to 1.28
V20	Raise Q3 0.2 to 0.7
V21	Eliminate Q3 (.15)
V22	Eliminate Q2 (.06)

Transect 3

2-vel Q1Q2 from 40-600 cfs. 1-vel Q3 from 600-1300.

V25	Raise Q3 from 0 to 0.2
V15	Decrease Q3 20% to 3.7

Transect 4

2-vel Q1Q2 from 40-600 cfs. 1-vel Q3 from 600-1300.

	Q2 velocity despite Z>>WSL. Reduced WSL to 94.5 from 95.5,
T17	increase Q2 0.2 to 1.0, Q3 down 20% to 1.8
T25	Eliminate Q2 (0.09)

Transect 5

1-vel Q1 from 40-250. 2-vel Q2Q3 from 250-600 cfs. 1-vel Q3 from 600-1300 cfs.

V10	Q1 down 20% to 2.45
V11	Q2 up 20% to 2.8
V12	Q2 up 20% to 1.81

V14	Q2 up 20% to 1.48
V18	Q1 down 20% to 2.45. Q2 up 0.2 to 0.89

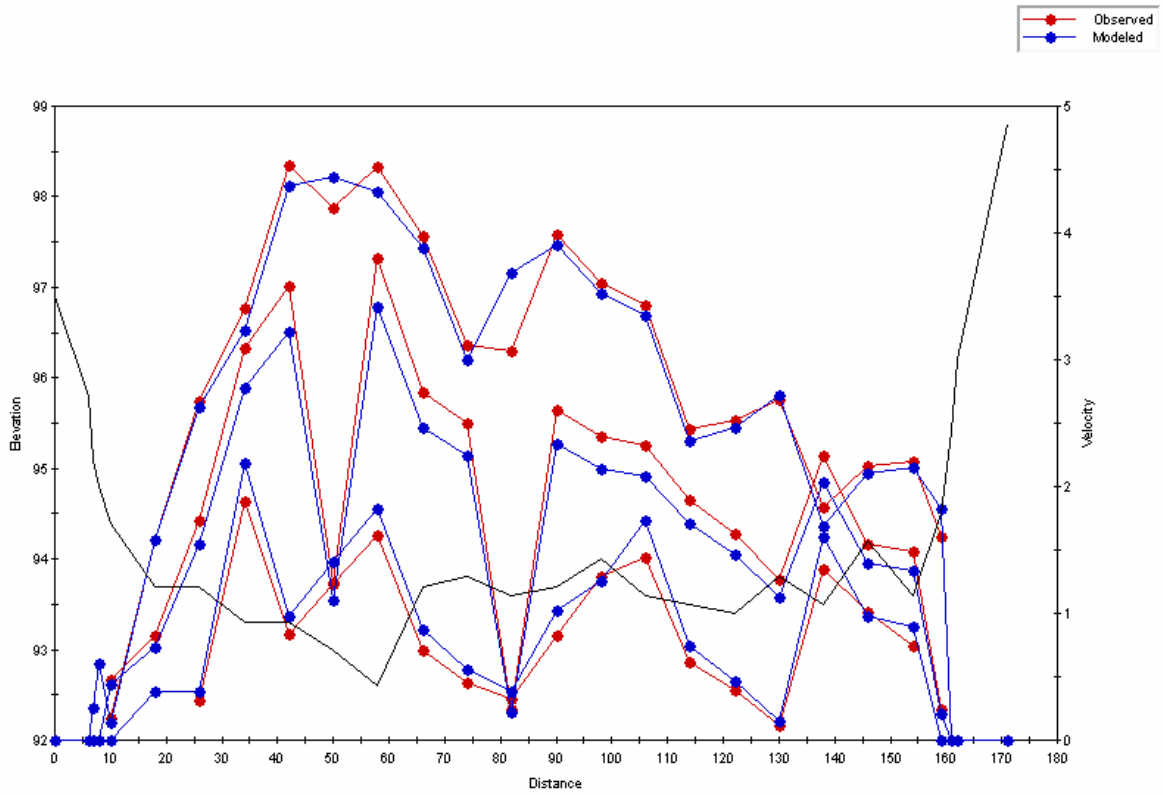
Canyon Creek

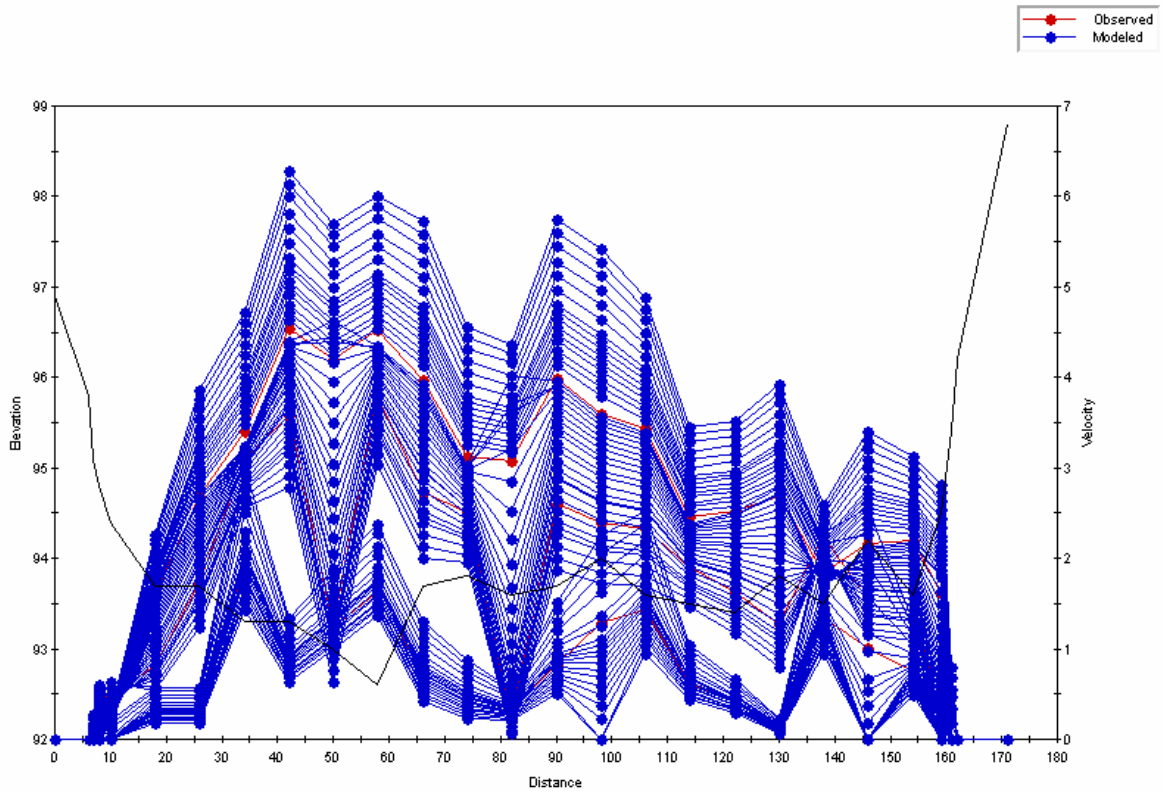
Station ID	Distance from Bank				
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
1	0	0	0	0	0
2	6	10	8	8	14
3	7	20	12	19	24
4	8	24	17	25	30
5	10	28	21	30	35
6	18	36	22	35	40
7	26	44	25	40	45
8	34	52	30	45	50
9	42	60	35	50	55
10	50	68	40	55	60
11	58	76	45	60	65
12	66	84	50	65	70
13	74	92	55	70	75
14	82	100	60	75	80
15	90	108	65	80	85
16	98	116	70	85	90
17	106	124	75	88	95
18	114	132	80	90	100
19	122	140	85	92	105
20	130	148	90	95	110
21	138	156	95	100	125
22	146	164	100	105	
23	154	172	105	110	
24	159	183	110	115	
25	161		115	120	
26	162		120	125	
27	171		125	130	
28			130	136	
29			135	146	
30			140		
31			143		
32			150		
33			156		

Canyon Creek

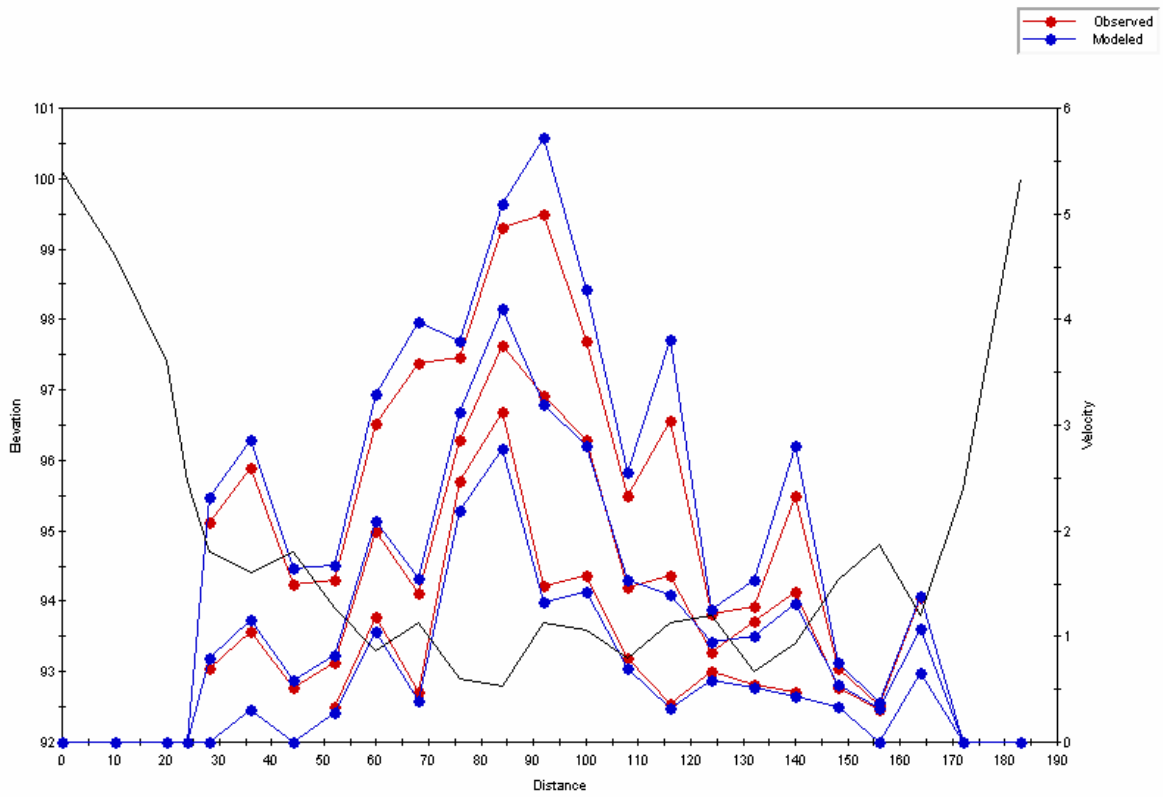
Transect (model)	**1a**	**1b**	**1c**	**2**	**3a**	**3b**	**4a**	**4b**	**5a**	**5b**	**5c**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	1	2	1	3	2	1	2	1	1	2	1
Discharge	114		114	128	130	114	114	114	95		95
	338	341	338	319	370	338	320	338	338	305	338
	756	704	756	727		453		453	453	413	453
Stage	94.325		94.325	94.51	94.67	94.62	94.79	94.795	94.78	95.88	94.78
	94.76	94.67	94.76	95.02	95.22	95.22	95.62	95.485	95.88	96.11	95.88
	95.235	95.09	95.235	95.69		95.46		95.735	96.2		96.2
Plotting Stage	1.725		1.725	1.71	1.87	1.82	1.99	2.695	1.88	2.98	1.88
	2.16	2.07	2.16	2.22	2.42	2.42	2.82	3.385	2.98	3.21	2.98
	2.635	2.49	2.635	2.89		2.66		3.635	3.3		3.3
Ratio of Measured vs. Predicted Discharge											
	0.975		0.975	0.98	1	0.992	1	0.995	1.001		1.001
	1.057	1	1.057	1.03	1	1.032	1	1.022	0.994	1	0.994
	0.971	1	0.971	0.98		0.977		0.984	1.005	1	1.005
Mean Error of stage/discharge relationship for calculated Q											
	NA	0	NA	2.2	0	NA	0	NA	NA	0	NA
Mean Error of stage/discharge relationship for given Q											
	3.64	3.64	3.64	2.66	2.08	2.08	0.38	0.38	0.38	0.38	0.38
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF											
A=		0.4685		0.3918	0.5632		0.4005			0.7299	
B =		0.2547		0.3026	0.2465		0.3384			0.2459	
SZF =	92.6	92.6	92.6	92.8	92.8	92.8	92.8	92.8	92.9	92.9	92.9
Beta coefficient log/log discharge/stage relationship											
	4.474	3.925	4.474	3.31	4.056	3.677	2.955	4.649	2.77	4.067	2.77

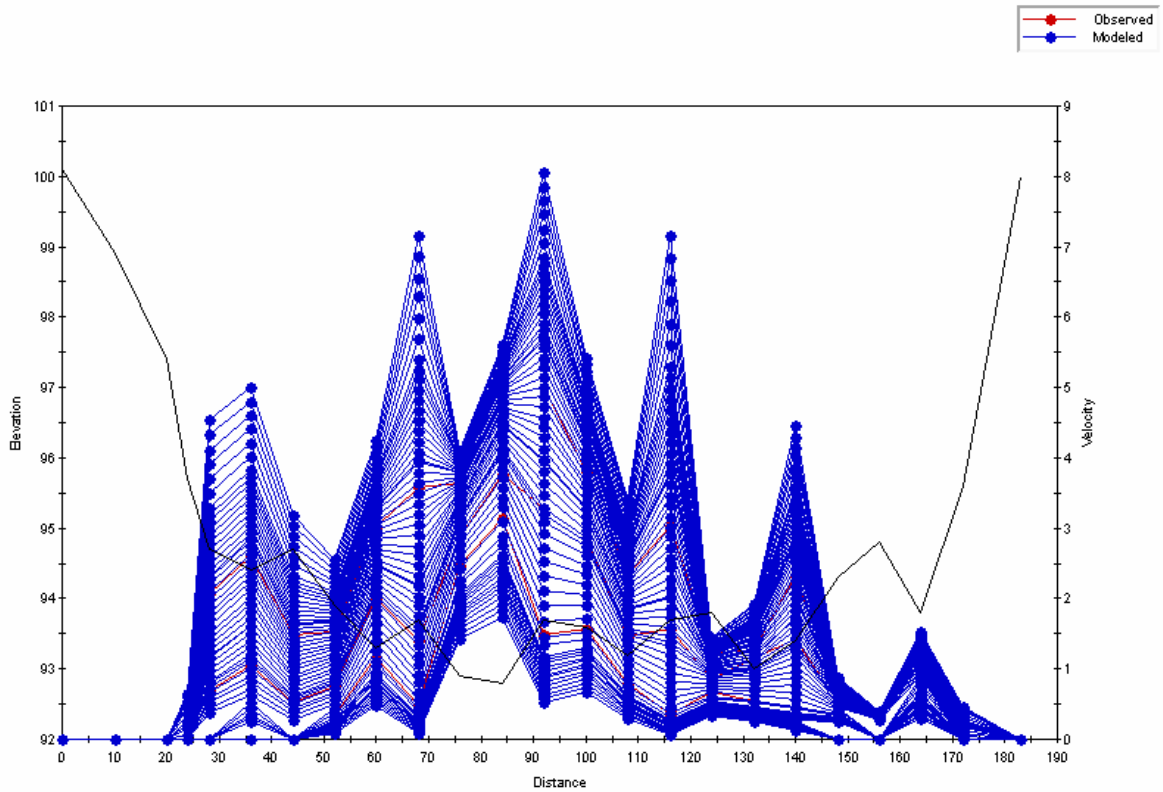
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

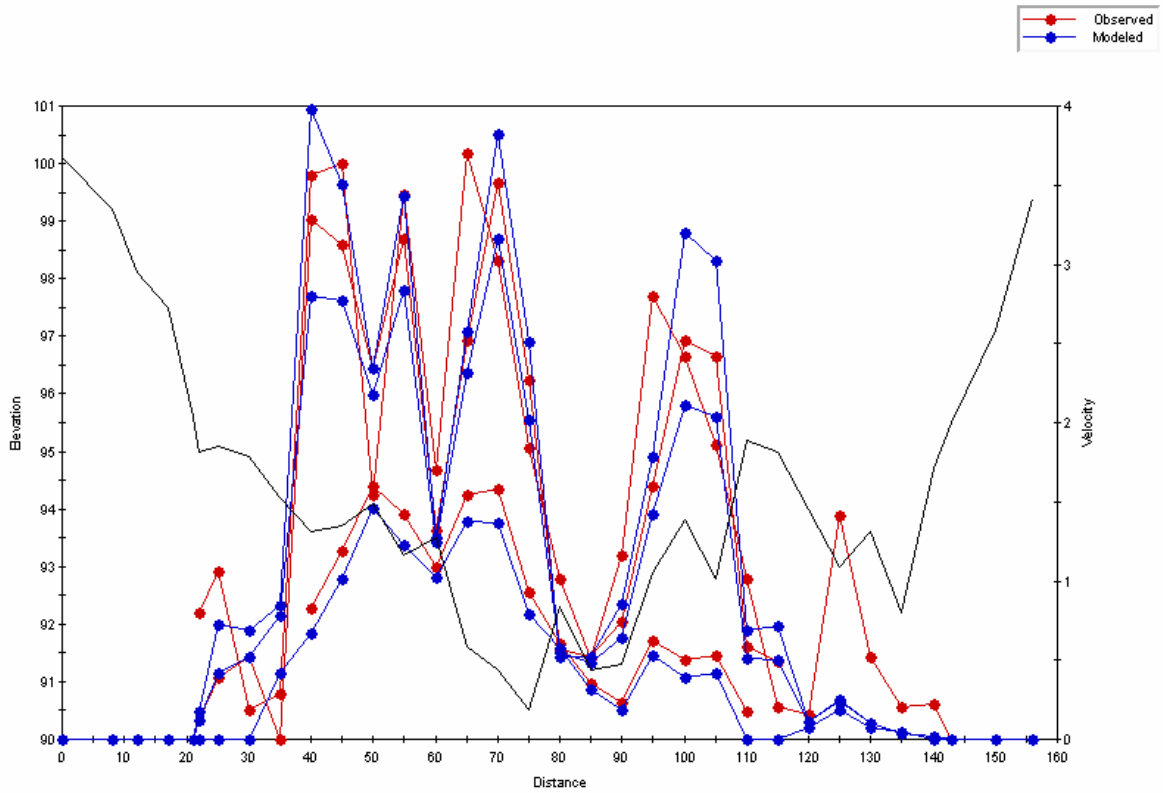

Observed
Modeled
Elevation
Velocity
Distance

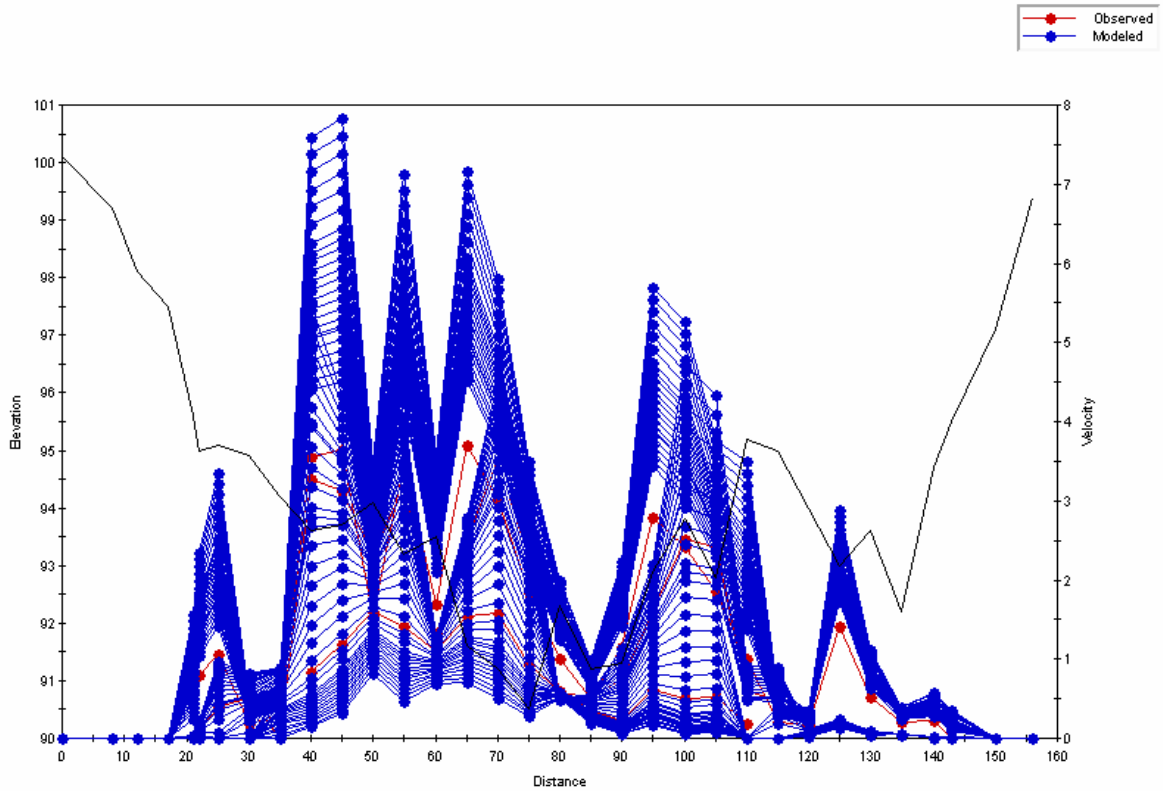
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

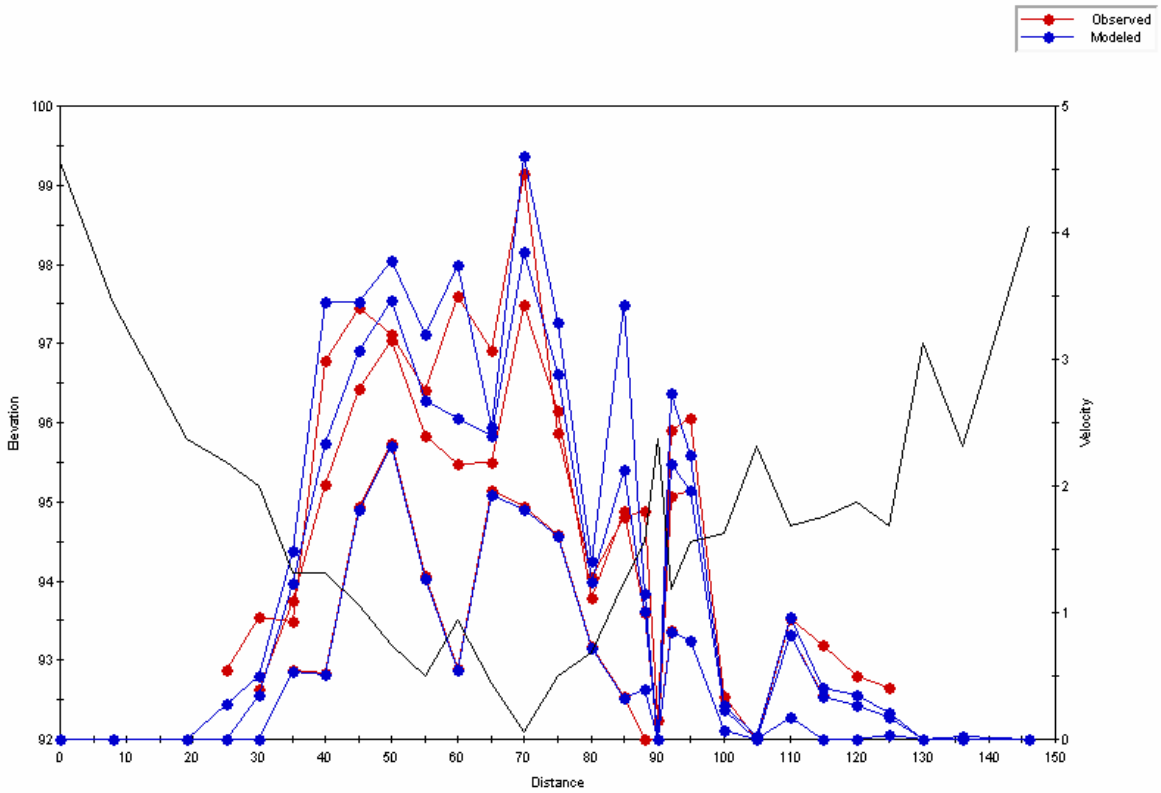

Observed
Modeled
Elevation
Velocity
Distance

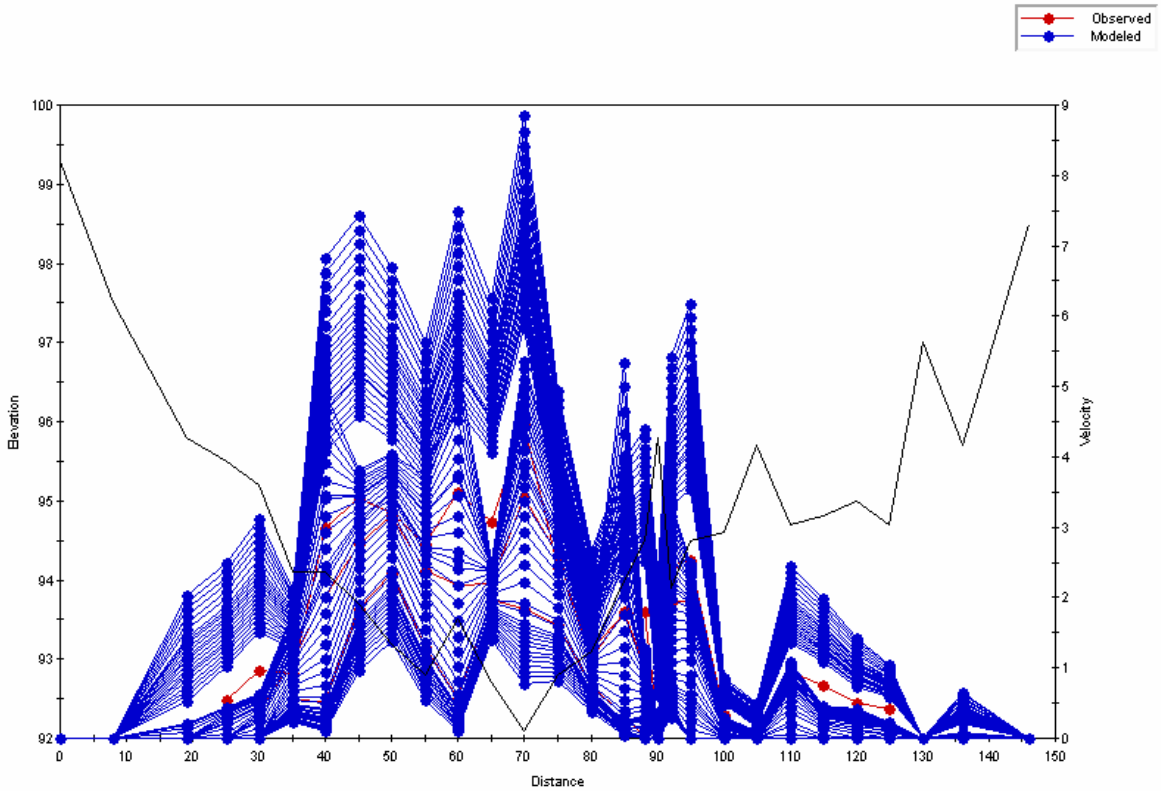
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

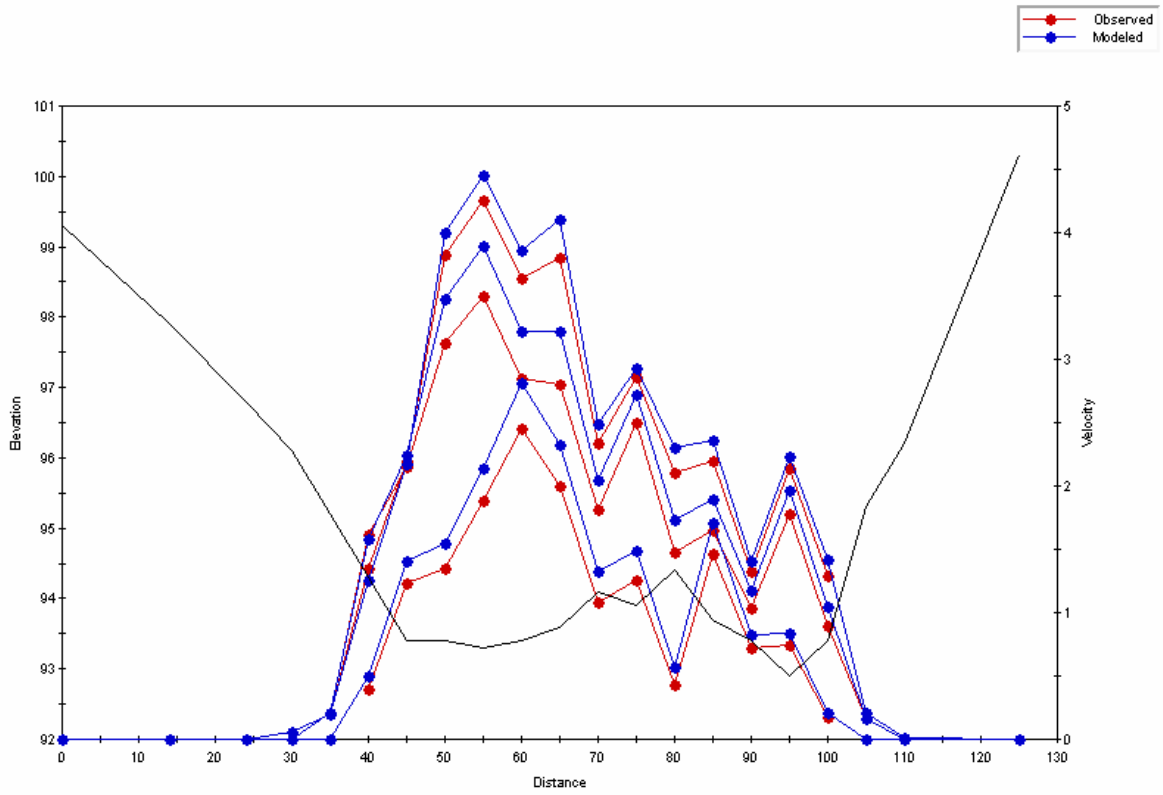

Observed
Modeled
Elevation
Velocity
Distance

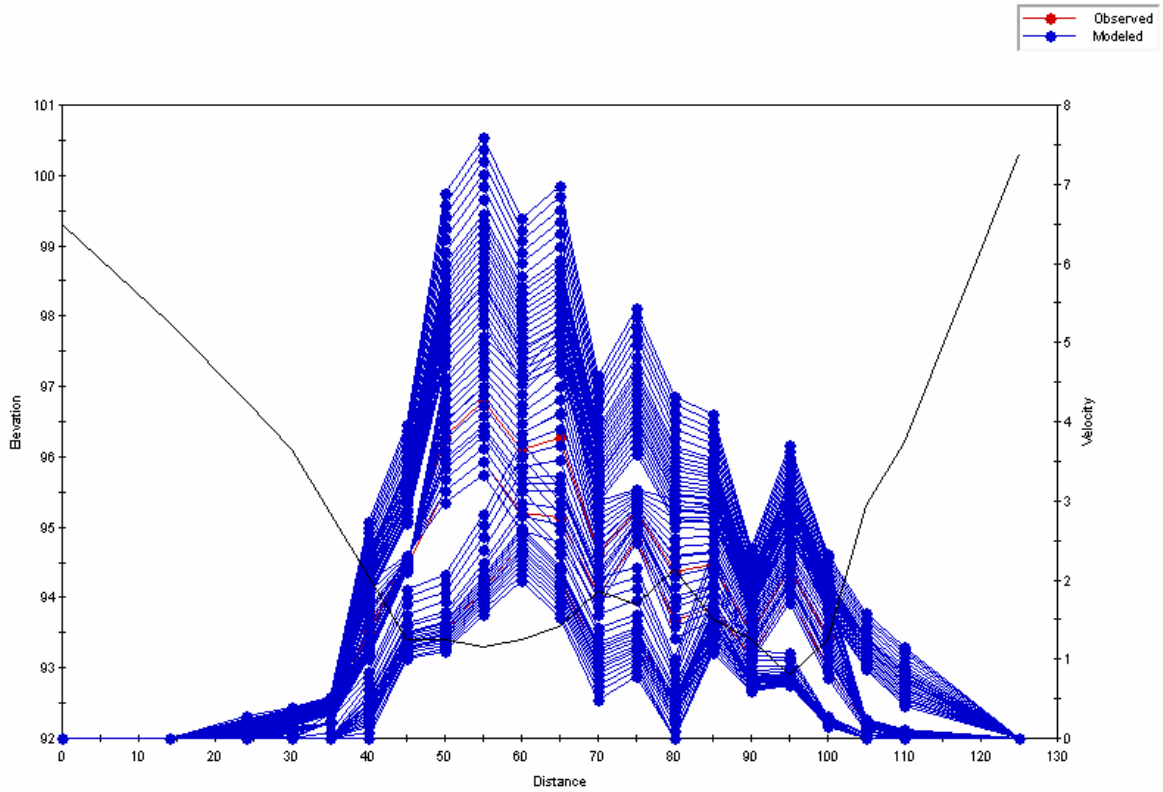
Transect 4


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Pilchuck Creek Calibrations

Consistent with the USGS report, Transect 1 was not included in the study. Remaining transects were re-numbered accordingly. I initially modeled the transect to identify potential reasons for omission since none are provided elsewhere. Significant discrepancies between the bed elevation and water surface level (WSL) are prevalent in this transect, as well as a very unusual hydraulic profile. I concur that the site should not be included in the analysis.

The Pilchuck Creek site has several transects that feature unusual/complex hydraulics that do not perform well in a 3-velocity modeling framework. Transects 4 and 5 (previously numbered 5 and 6), for example, feature significant portions of the transect where velocities at Q3 are lower or roughly equal to those measured at Q2. After testing several possible combinations of 1-flow, 2-flow and 3-flow models and examining performance as measured by prediction error as well as the VAF distribution, a 2-flow model was selected for the entire range of simulated flows.

In addition, the Best Q estimates provided on the data sheets and in the USGS reports do not conform well to Calculated Q estimates at several transects. In some cases, a discrepancy >25% was evident. I adjusted BestQ estimates accordingly to attain a better fit with observed data.

Original Transect 1 not included, as per notes in USGS report. All transects renumbered.
Adjusted distances and weighting to ensure correct proportions by transect.

Transect 1 (formerly Transect 2)
Set Best Q1 to 32 cfs
Set Best Q3 to 289

V7	Eliminate Q3 (0.106)
V14	Raise Q1 0.2 to 0.58
V15	Reduce Q3 20% to 3.57
V16	Reduce Q3 20% to 3.8. Change Z to 91.4. Q1 up 0.2 to 0.9.
V18	Increase Q1 20% to 1.45
V20	Increase Q1 20% to 1.44.
V22	Increase Q1 to 1.42
V26	Decrease Q3 10% to 4.79.
V31	Q1 down 20% to 1.92. Q2 up 20% to 2.21.

Transect 2
Two models. 2-flow Q1Q2 from 20-250 cfs. 1-flow Q3 from 251-1000.

V17	Reduce Q3 by 20% to 1.81. Q2 up 0.2 to 1.11.
V41,42	Eliminate Q2 (0.18, 0.34)

Transect 3
Extremely poor fit with any choice of model. Unusual hydraulic distribution. Three 1-flow models across different flow ranges used.
Q1 20-75 cfs. Q2 76-300 cfs. Q3 301-1000 cfs.

V35-38	Eliminate Q1 to remove very high spiking (.13,.11, .12,.3).
V40	Reduce Q1 0.2 to 0.8.
V41	Reduce Q1 20% to 0.99.
V47	**Q3 Z=100.5, but WSL=93.13. Deleted velocity at Q3.

Transect 4
2-velocity model from 20-1000 cfs using Q1Q3.

V39	Eliminate Q1 (.29)
V40	Eliminate Q1 (.82, note odd error notation in data sheet)
V41	Increase Q1 20% to 1.55

Transect 5
2-vel model Q1Q2 from 20-1000 cfs.

Pilchuck Creek

Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
1	0	0	0	0	0	0
2	1	3	12	3	2	10
3	6	6	24	10	8	15
4	9	10	28	16	12	19
5	11	13	32	19	18	24
6	13	16	36	22	24	30
7	14	19	40	26	30	35
8	16	22	44	30	34	40
9	18	25	50	34	38	45
10	20	28	54	38	42	48
11	22	31	58	42	46	52
12	24	34	62	46	50	56
13	26	37	66	50	54	60
14	28	40	70	54	58	64
15	30	43	74	58	62	66
16	32	46	76	62	66	68
17	34	49	79	66	70	70
18	36	52	82	70	74	72
19	38	55	85	74	78	74
20	40	58	88	78	80	76
21	42	61	91	82	82.5	78
22	44	64	94	86	85	80
23	46	67	97	90	87.5	82
24	48	70	98.5	92	90	84
25	50	73	100	94	92.5	86
26	52	76	101.5	96	95	88
27	54	79	103	98	97.5	90
28	56	81	104.5	100	100	92
29	58	84	106	102	102.5	94
30	60	87	107.5	104	105	96
31	62	90	109	106	107.5	98
32	64	93	110.5	108	110	100
33	66	95	112	110	112.5	102
34	67	98	113.5	112	115	104
35	68	101	115	114	117.5	106
36	70	105	116.5	116	120	108
37	72	110	118	118	122.5	110
38	75	122	119.5	120	125	112
39	80		121	122	127.5	114
40	85		124	124	130	116
41	92		127	126	132.5	118
42			130	128	135	120
43			132	130	137.5	122
44			135	132	140	125
45			140	134	142	129
46			144	138	142.5	130
47				141	145	
48				148		

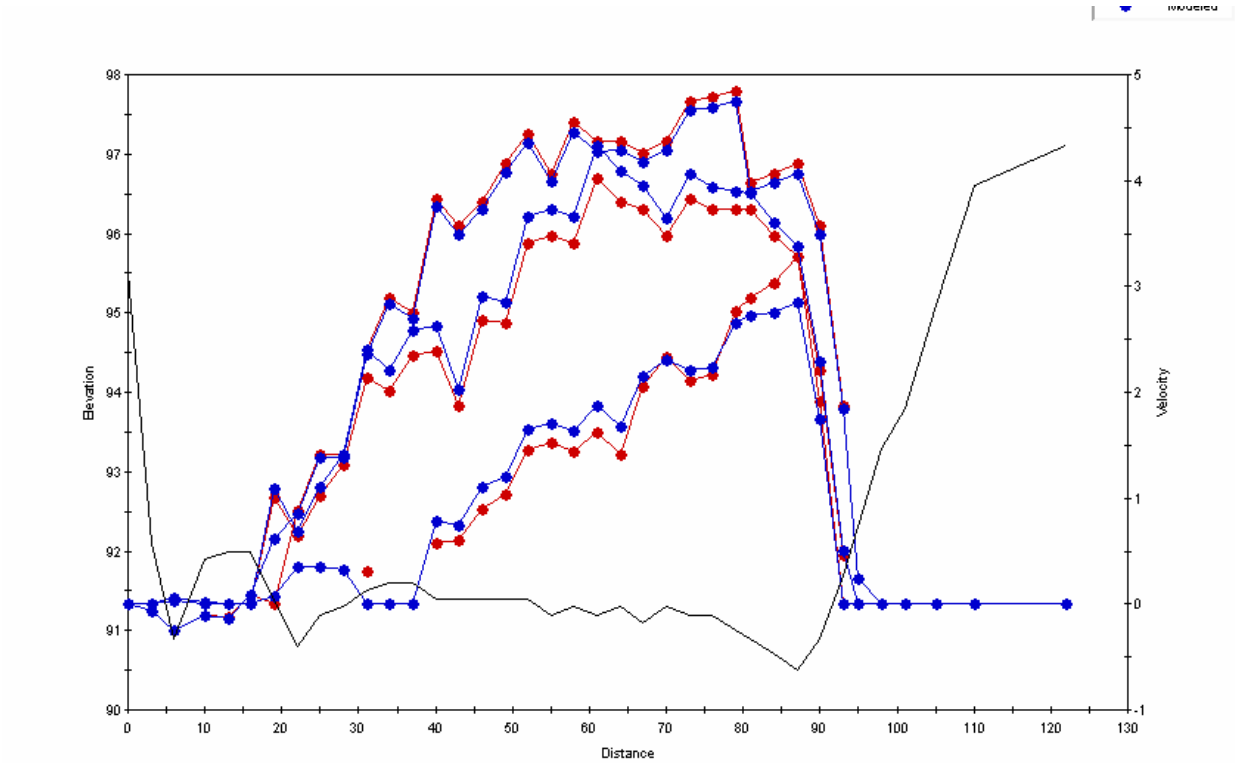
Pilchuck Creek

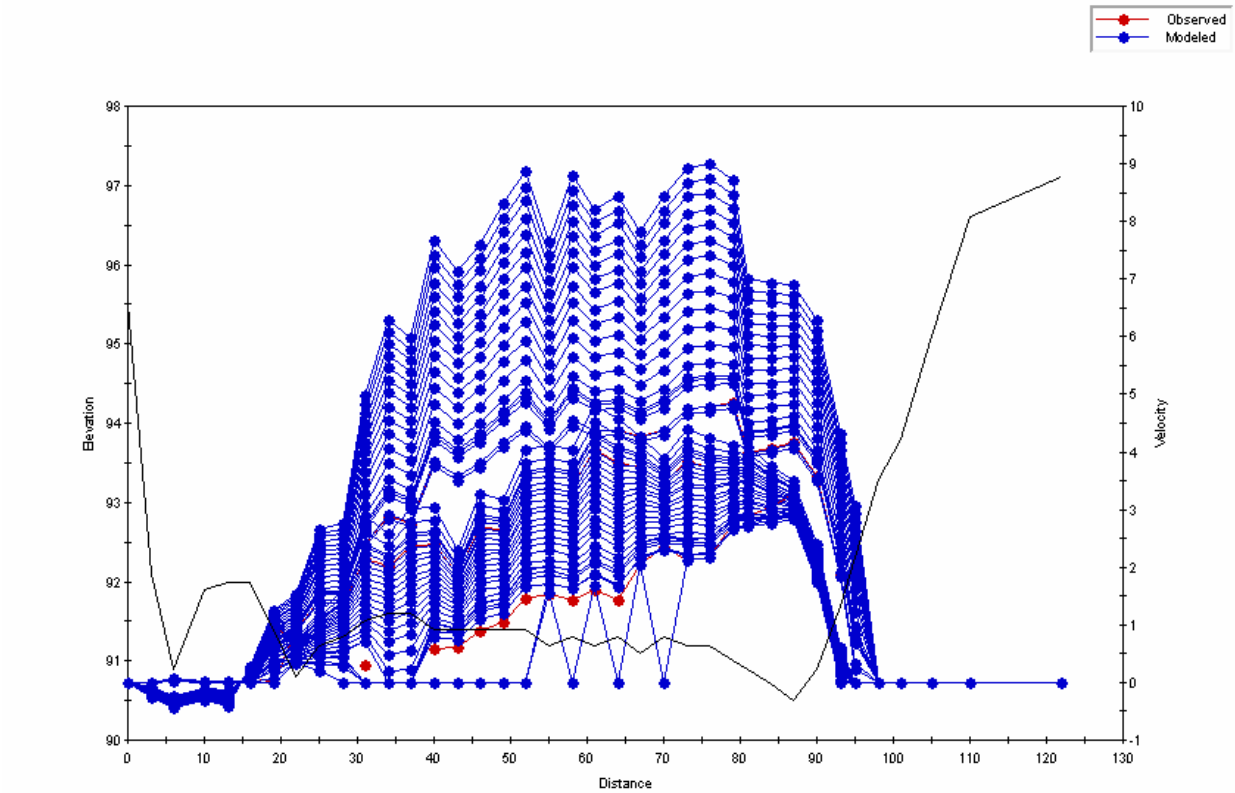
Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
49				156		

Pilchuck Crk

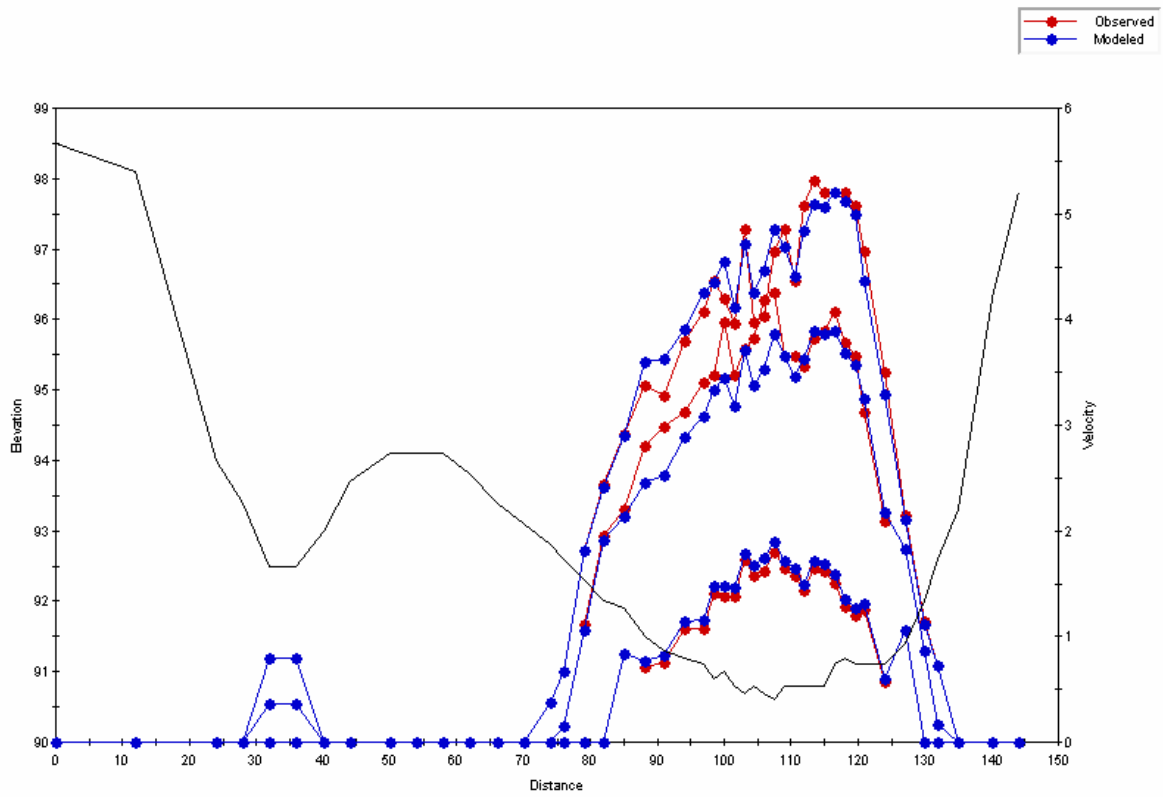
Transect (model)	**1a**	**1b**	**2**	**3a**	**3b**	**3c**	**4**	**5**
WSL model	StQ	StQ	StQ	StQ	StQ	StQ	StQ	StQ
Velocities used	2	1	3	1	1	1	2	2
Discharge	14	32	48	52	52	52	45	49
	182	205	230	205	205	205		231
		289	356	363	363	363	350	
Stage	91.18	91.415	91.94	92.055	92.055	92.055	92.34	92.34
	92.09	92.15	92.65	92.81	92.81	92.81		93.31
		92.32	92.94	93.16	93.16	93.16	93.52	
Plotting Stage	0.68	0.915	1.34	1.455	1.455	1.455	1.24	1.24
	1.59	1.65	2.05	2.21	2.21	2.21		2.21
		1.82	2.34	2.56	2.56	2.56	2.42	
Ratio of Measured vs. Predicted Discharge								
	1	1.002	0.99	1.011	1.011	1.011	1	1
	1	0.983	1.03	0.96	0.96	0.96	1	1
		1.015	0.98	1.031	1.031	1.031		
Mean Error of stage/discharge relationship for calculated Q								
	0	NA	1.63	NA	NA	NA	0	0
Mean Error of stage/discharge relationship for given Q								
	1.13	1.13	0.78	2.73	2.73	2.73	0.57	1.3
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF								
A=	0.2775		0.4615				0.3572	0.2903
B =	0.3353		0.2754				0.3266	0.3729
SZF =	90.5		90.6				91.1	91.1
Beta coefficient log/log discharge/stage relationship								
	2.982	3.183	3.63	3.405	3.405	3.405	3.062	2.682

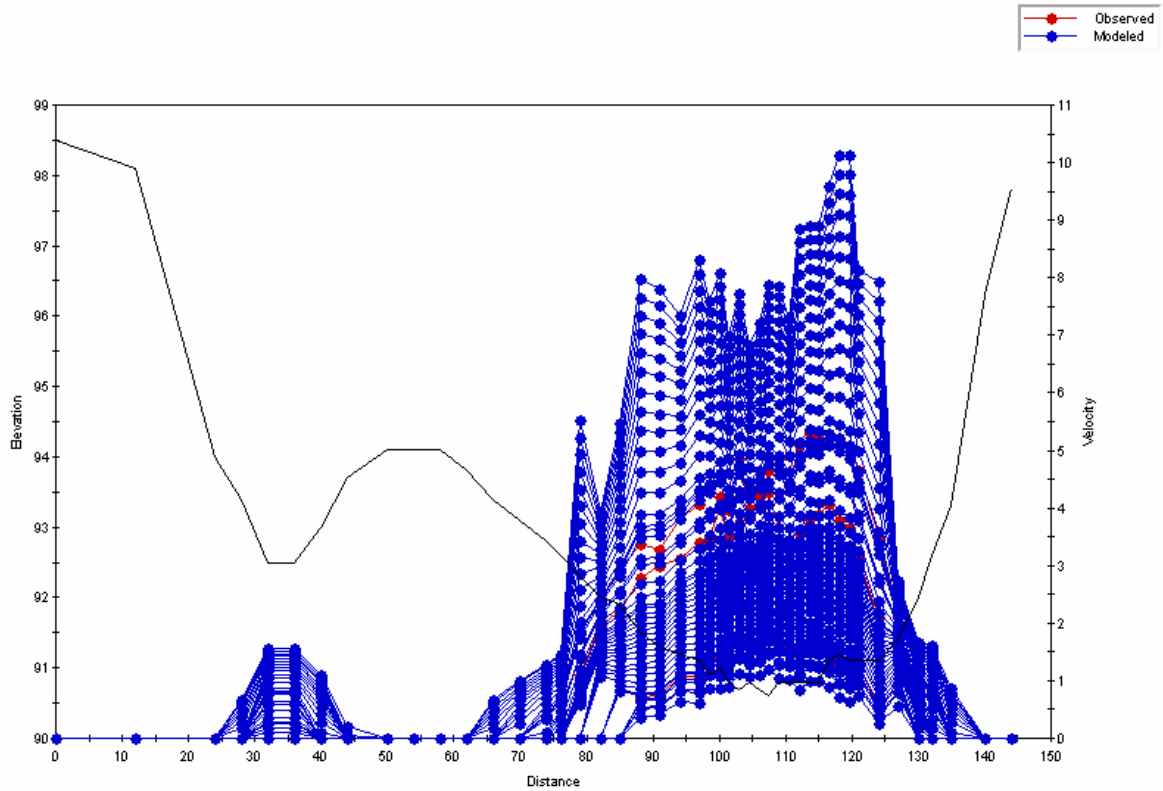
Transect 1


Elevation
Velocity
Distance

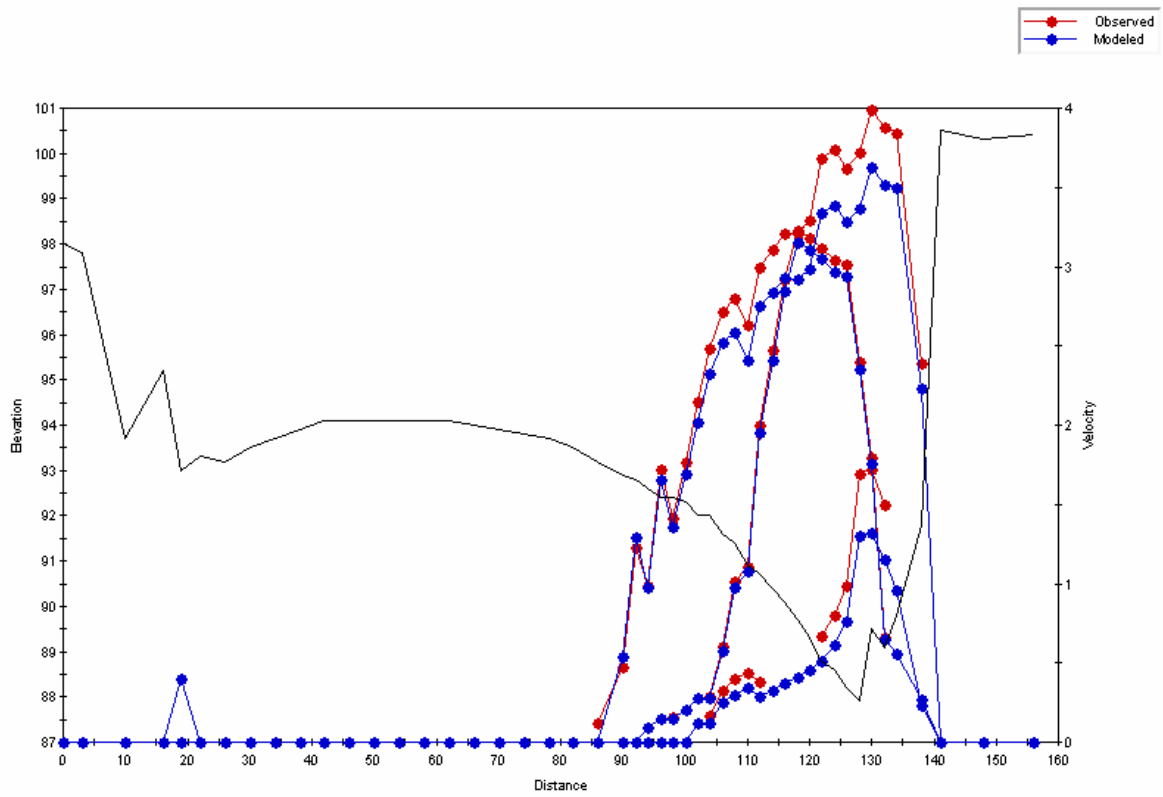

Observed
Modeled
Elevation
Velocity
Distance

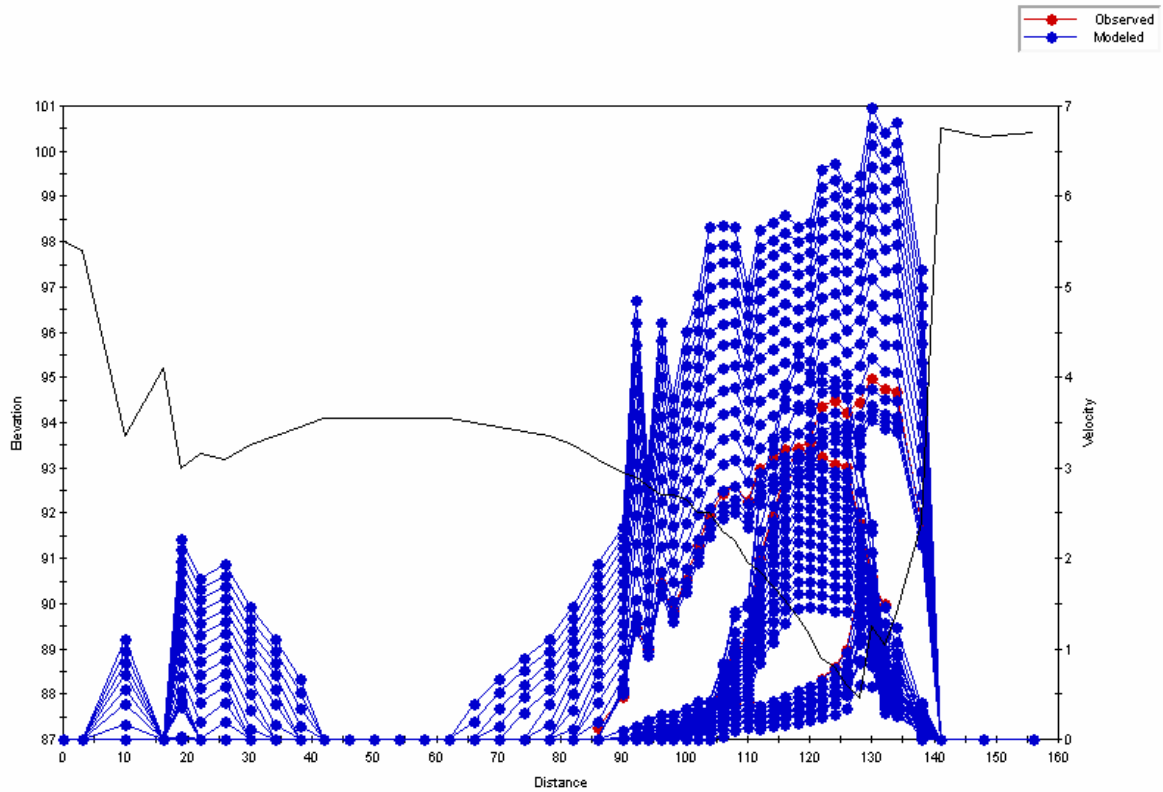
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

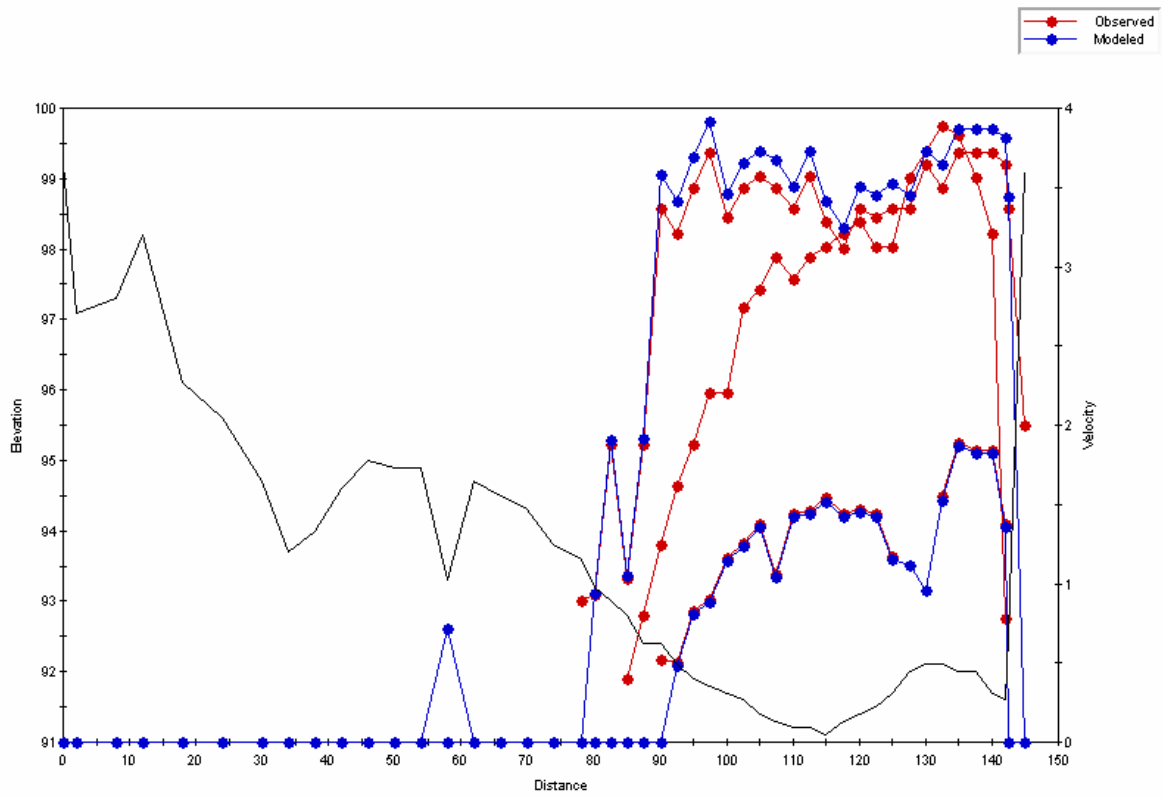

Observed
Modeled
Elevation
Velocity
Distance

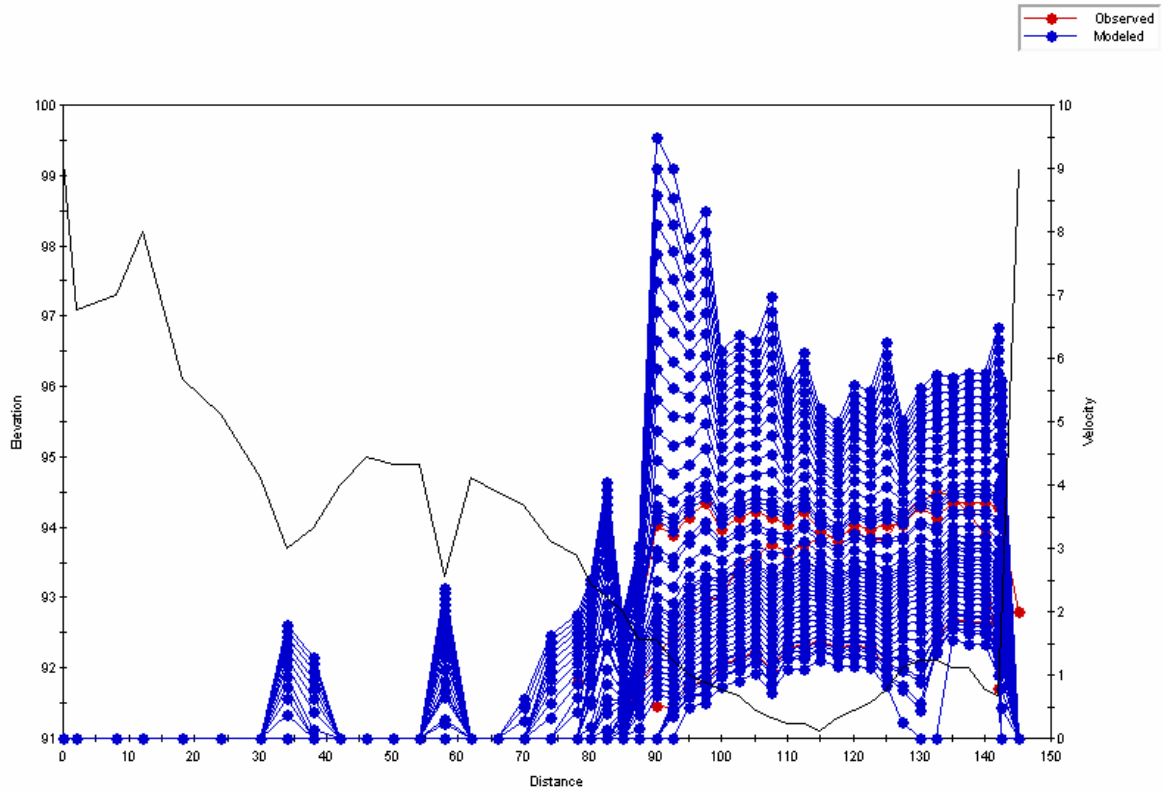
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

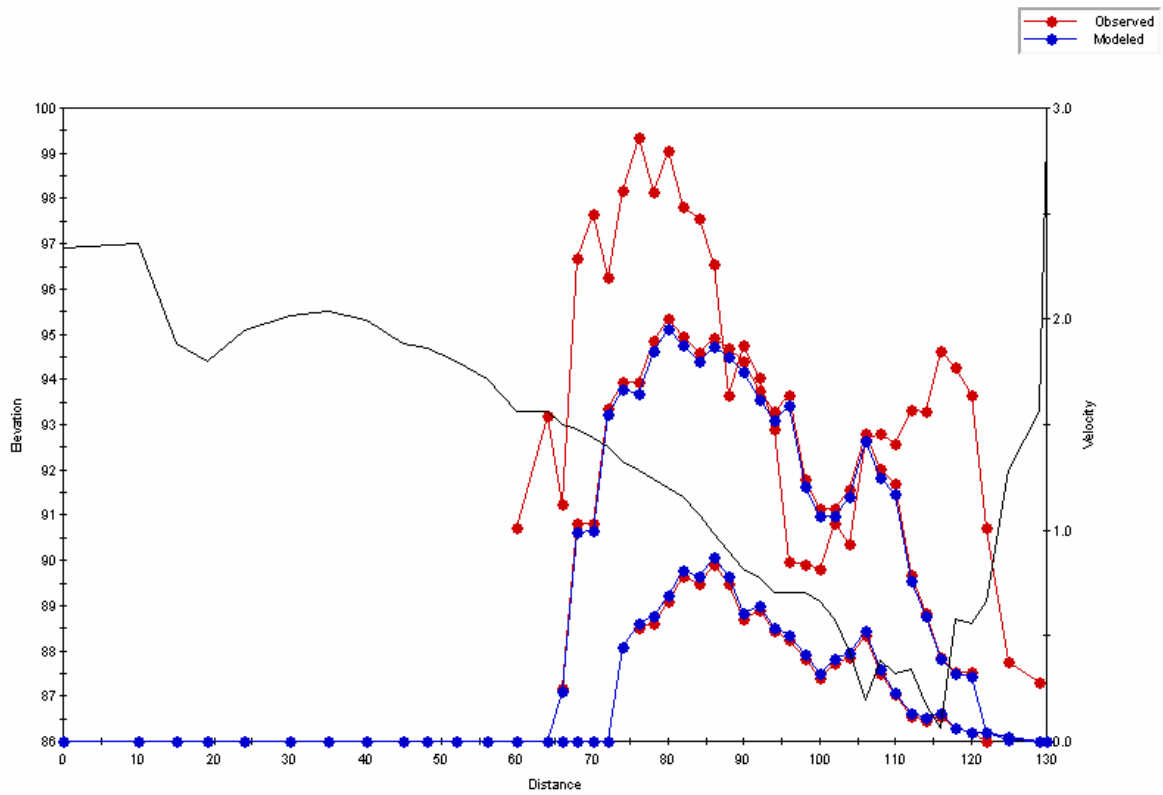

Observed
Modeled
Elevation
Velocity
Distance

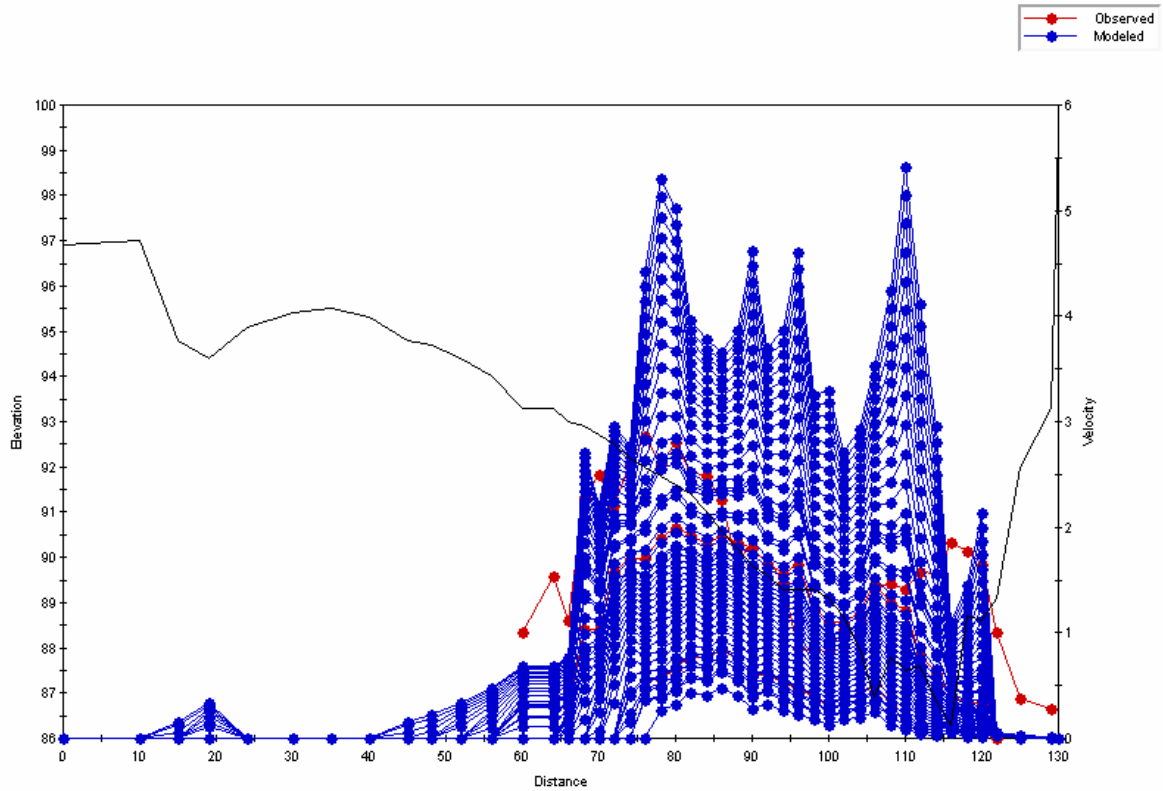
Transect 4


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Jim Creek below 4-mile bridge

Transect 1
No changes

Transect 2
3-vel model not a good fit. 1-vel models perform poorly here in terms of VAF.
Used 2-vel model with Q2 and Q3. Note that Q1 and Q2 very similar. Good profile. Good VAFs.

V4,6,24,26	Z<WSL but no vel. Let model interpolate.

Transect 3
Very odd siet with no vels in thalweg area for Q1 or Q2.
Used 2-vel model with Q2 and Q3.

V13-15	Decrease Q2 0.1 for all verticals.
V16-25	Decrease Q2 0.2 for all verticals.
V29	Increase Q2 by 0.2 to 0.26 to control spiking.

Transect 4

V14	Eliminate Q2 (.142) to control spiking.
V15	Reduce Q3 20% to 3.04
V16	Reduce Q3 20% to 3.72
V17	Increase Q2 0.2 to 1.21
V18	Increase Q2 0.2 to 1.59
V21	Increase Q10.2 to 1.55
V26	Increase Q2 0.2 to 1.34

Transect 5
Similar to Transect 3 with no vels in thalweg.
Used 2-vel Q1Q3. 3-vel model way off.
Limit N to max 0.2 to control erratic simulation at a few verticals.

V5,8,10,13,15,17,18,22	Decrease Q1 by 0.2
V7	Decrease Q1 by 20% to 1.58
V27,28	Eliminate Q2 (.075), (.043) to control spikes.

Transect 6
Used teo 1-vel models Q1 from 15-100 cfs, Q3 from 101-750. Very good VAFs.

Transect 7
Best Q3 too low for good simulation. Set to CalcQ of 385.
No other adjustments

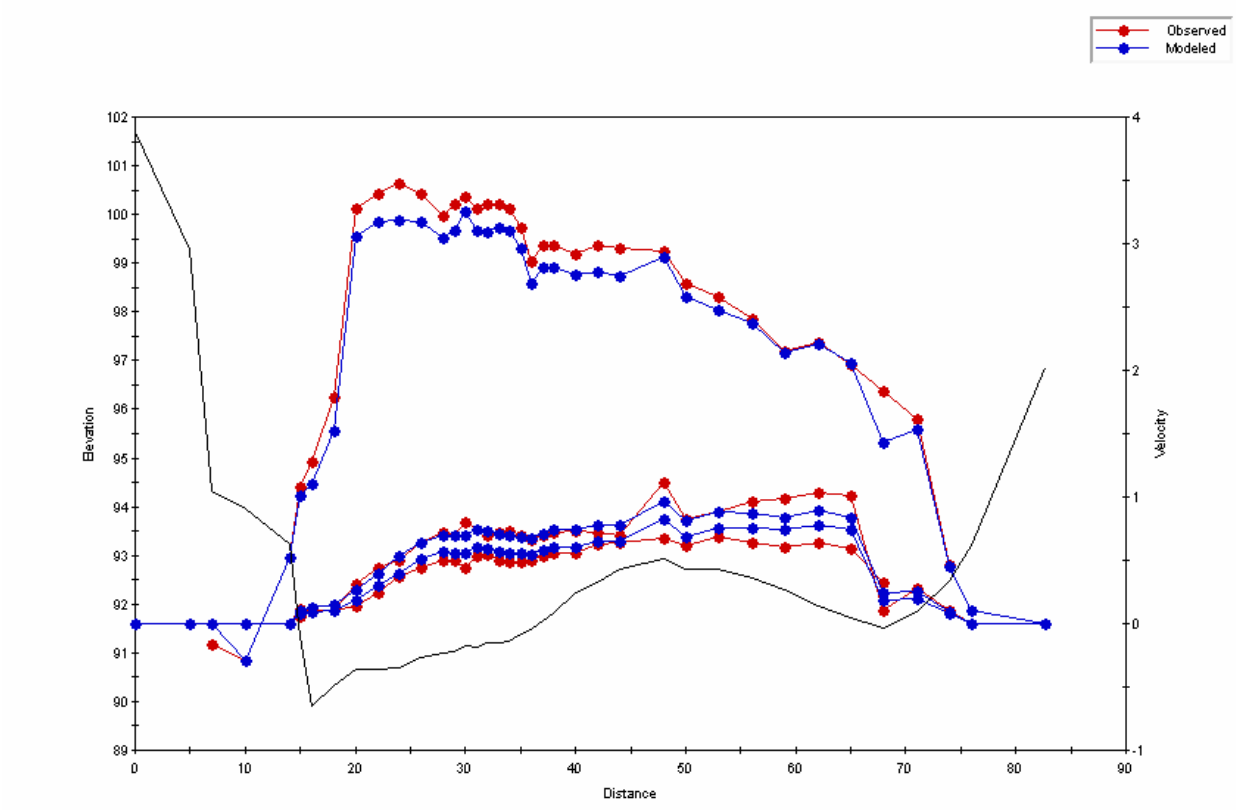
Jim Creek near 4 mi

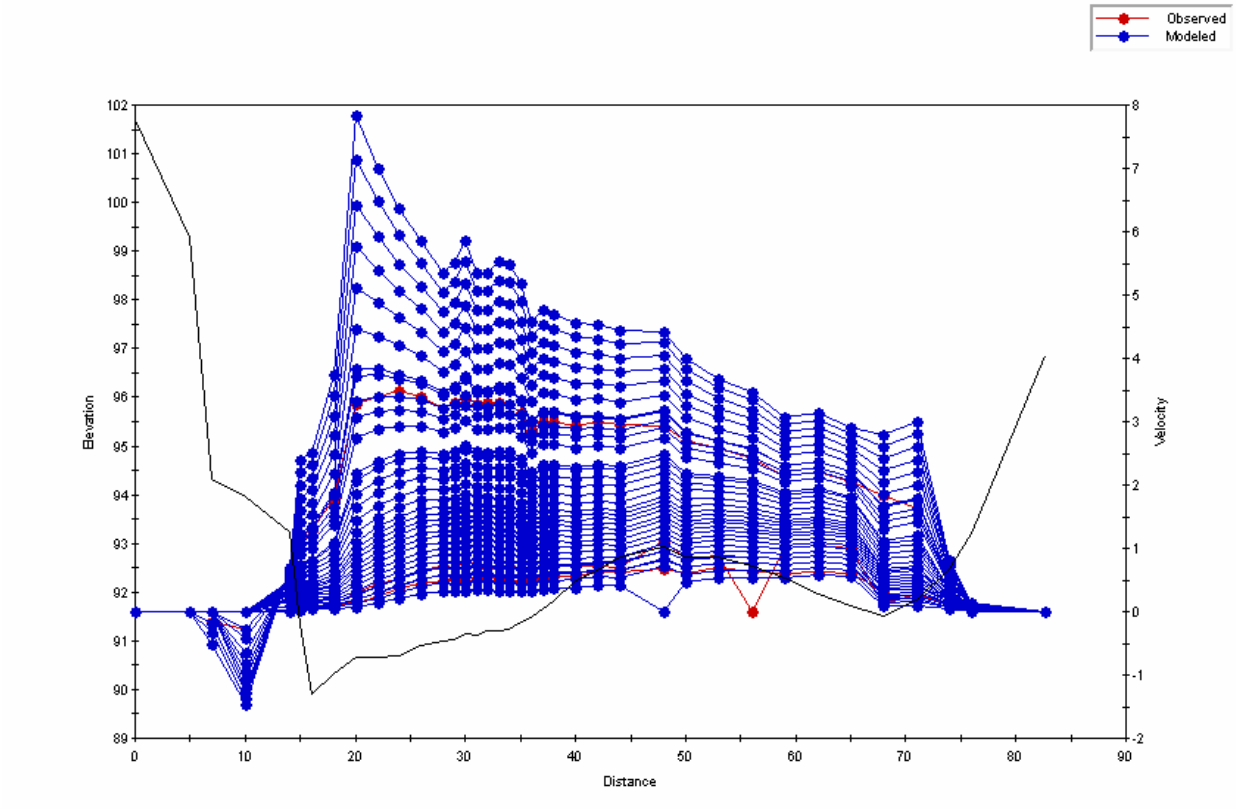
Station ID	Distance from Bank						
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
1	0	0	0	0	0	0	0
2	5	3	4	5	4	4	6
3	7	4	6	8.5	7	6	8
4	10	6	8	10	10	8	14
5	14	8	10	11	12	9.5	18
6	15	10	12	12	14	10	21
7	16	12	14	14	16	12	24
8	18	14	16	17	18	14	27
9	20	16	18	20	20	16	30
10	22	18	20	23	22	18	33
11	24	20	22	26	24	20	36
12	26	22	24	28	26	22	39
13	28	24	26	29.5	28	24	42
14	29	26	28	34	30	26	44
15	30	28	30	38	32	28	46
16	31	30	32	42	34	30	48
17	32	32	33	46	36	32	50
18	33	34	34	48	38	34	52
19	34	36	35	50	40	36	54
20	35	38	36	52	42	40	56
21	36	40	37	54	44	44	58
22	37	42	38	56	46	48	60
23	38	44	40	58	50	52	63
24	40	46	42	60	54	56	66
25	42	47	44	62	57	60	69
26	44	50	46	65	59	64	72
27	48	55	48	68	60	68	75
28	50	60	50	71	64	72	78
29	53		54	73	70	75	81
30	56		58	75	75	77.5	84
31	59		61	80	77.5	80	87
32	62		62.5	90.5		82.5	90
33	65		65			85	92.6
34	68		72			87.5	94
35	71					90	100
36	74					92.5	116
37	76					95	
38	82.6					100	
39						106.1	

Jim_4mi

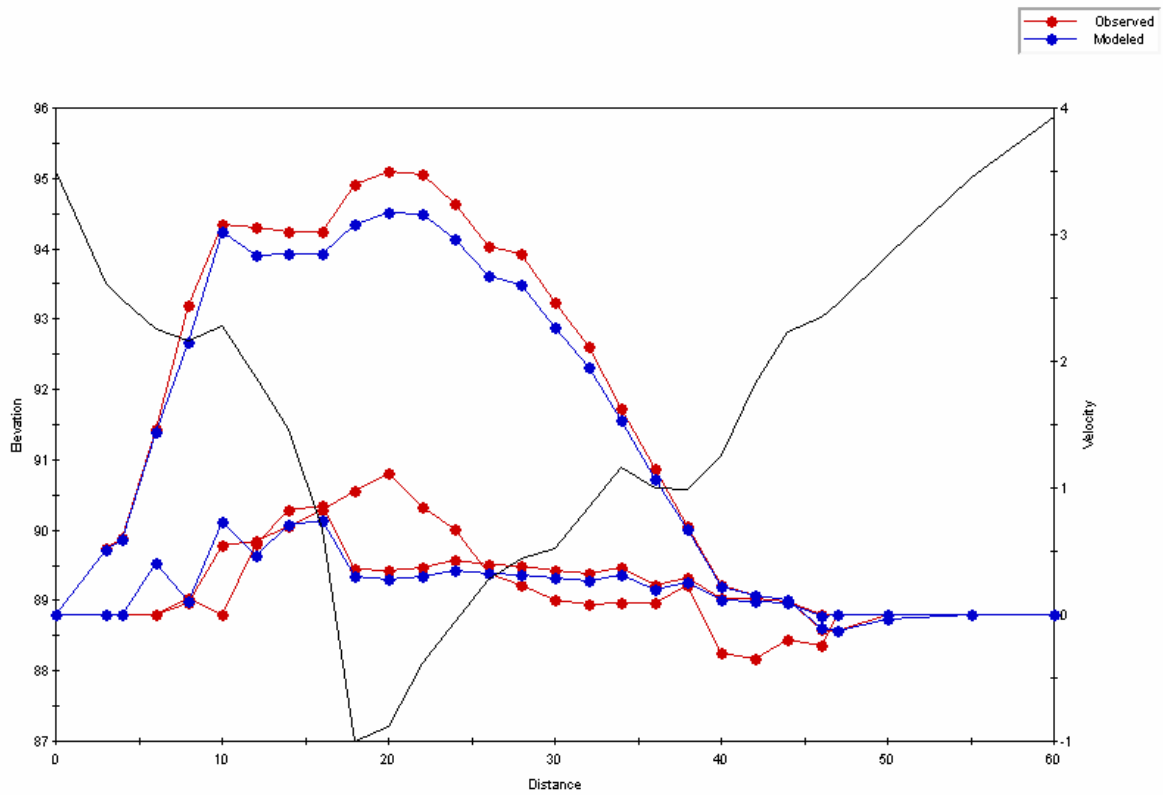
Transect (model)	**1**	**2**	**3**	**4**	**5**	**6a**	**6b**	**7**
WSL model	WSP	WSP	WSP	StQ	StQ	StQ	StQ	StQ
Velocities used	3	2	2	3	2	1	1	3
Discharge	29	40		31	35	34	34	31
	48		42	43		46	46	47
	350	358	335	305	325	328	328	385
Stage	93.02	93.03		93.09	93.81	94.19	94.19	95.8
	93.23		93.23	93.24		94.33	94.33	95.97
	94	94.08	94.04	94.09	94.75	95.52	95.52	96.82
Plotting Stage	3.1	3.11		1.11	1.43	0.91	0.91	1.21
	3.31		2.68	1.26		1.05	1.05	1.38
	4.08	4.16	3.49	2.11	2.37	2.24	2.24	2.23
Ratio of Measured vs. Predicted Discharge								
	1.04	1		1.06	1	1.028	1.028	1.06
	0.95		1	0.93		0.967	0.967	0.93
	1.01	1	1	1.02	1	1.005	1.005	1.02
Mean Error of stage/discharge relationship for calculated Q								
	3.32	0	0	5.15	0	NA	NA	4.79
Mean Error of stage/discharge relationship for given Q								
	9.07	NA	NA	5.79	3.02	2.23	2.23	6.54
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF								
A=	0.21647	0.1908	0.1669	0.4373	0.6441			0.5421
B =	0.1084	0.1325	0.1268	0.2758	0.2253			0.2382
SZF =	89.92	89.92	90.55	91.98	92.38	93.28	93.28	94.59
Beta coefficient log/log discharge/stage relationship								
	9.222	7.545	7.885	3.63	4.439	2.542	2.542	4.2

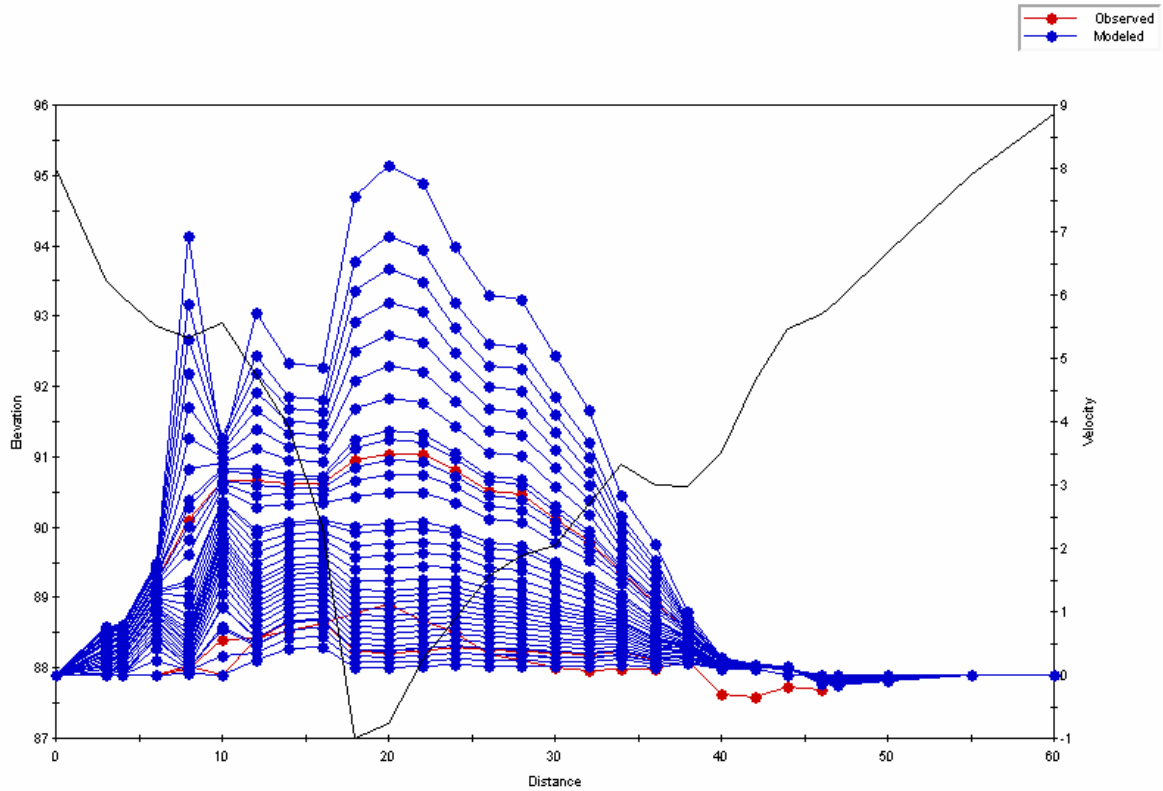
Transect 1


Observed
Modeled
Elevation
Velocity
Distance

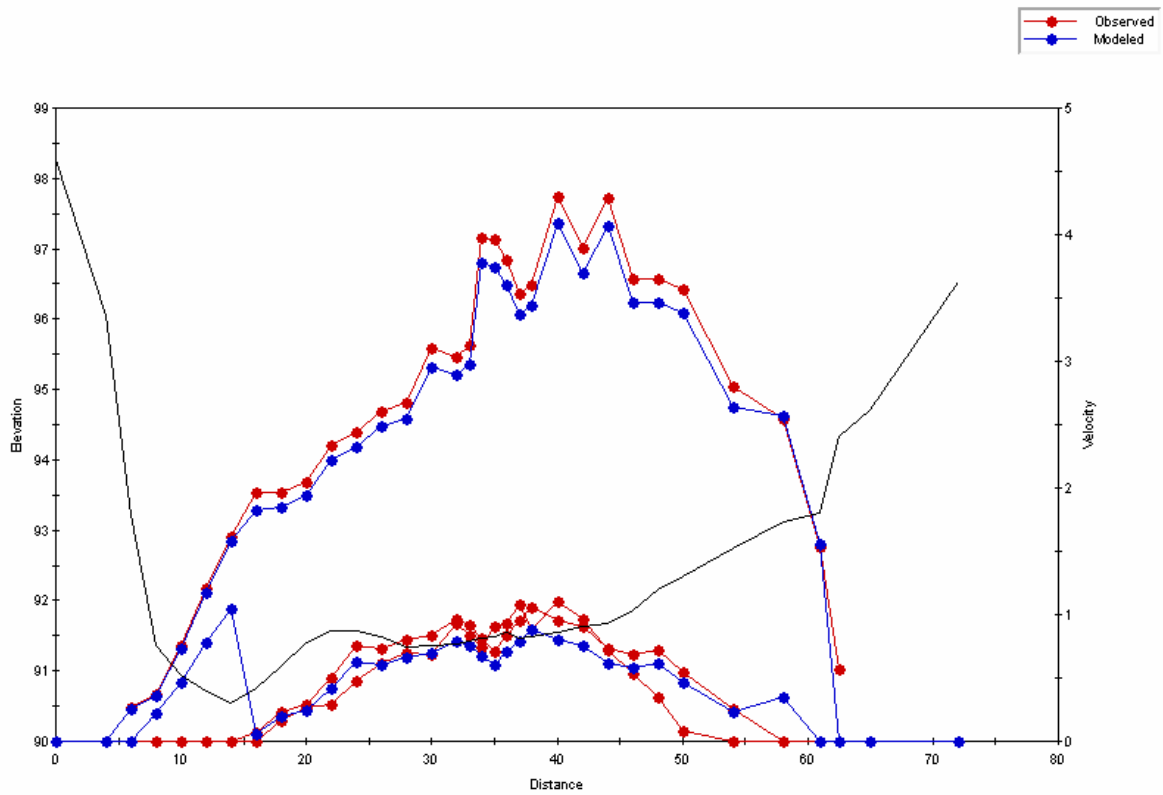

Observed
Modeled
Elevation
Velocity
Distance

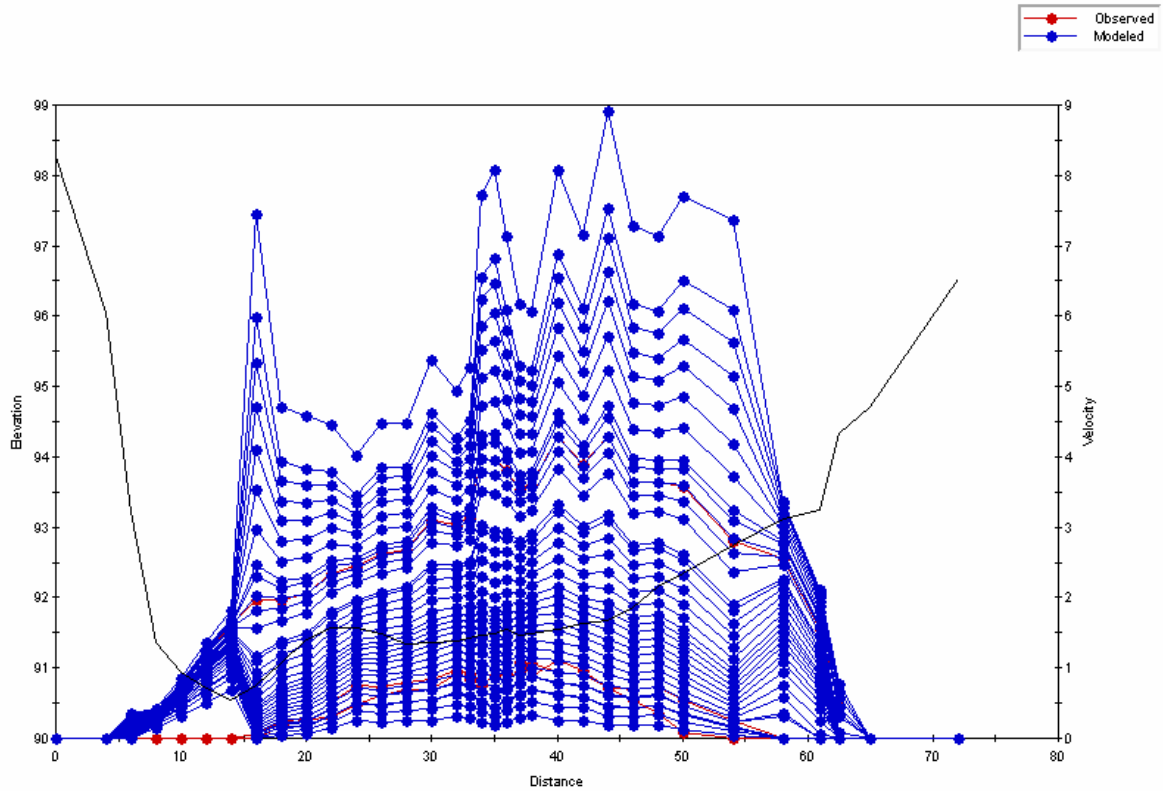
Transect 2


Observed
Modeled
Elevation
Velocity
Distance

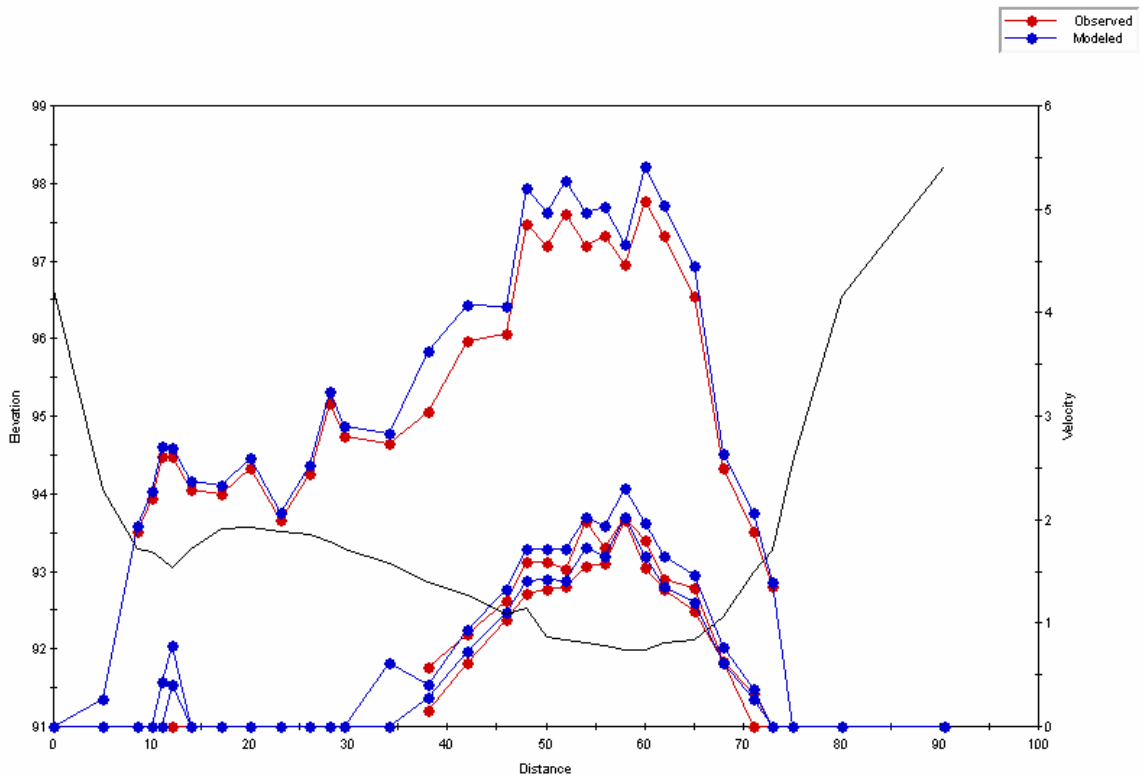

Observed
Modeled
Elevation
Velocity
Distance

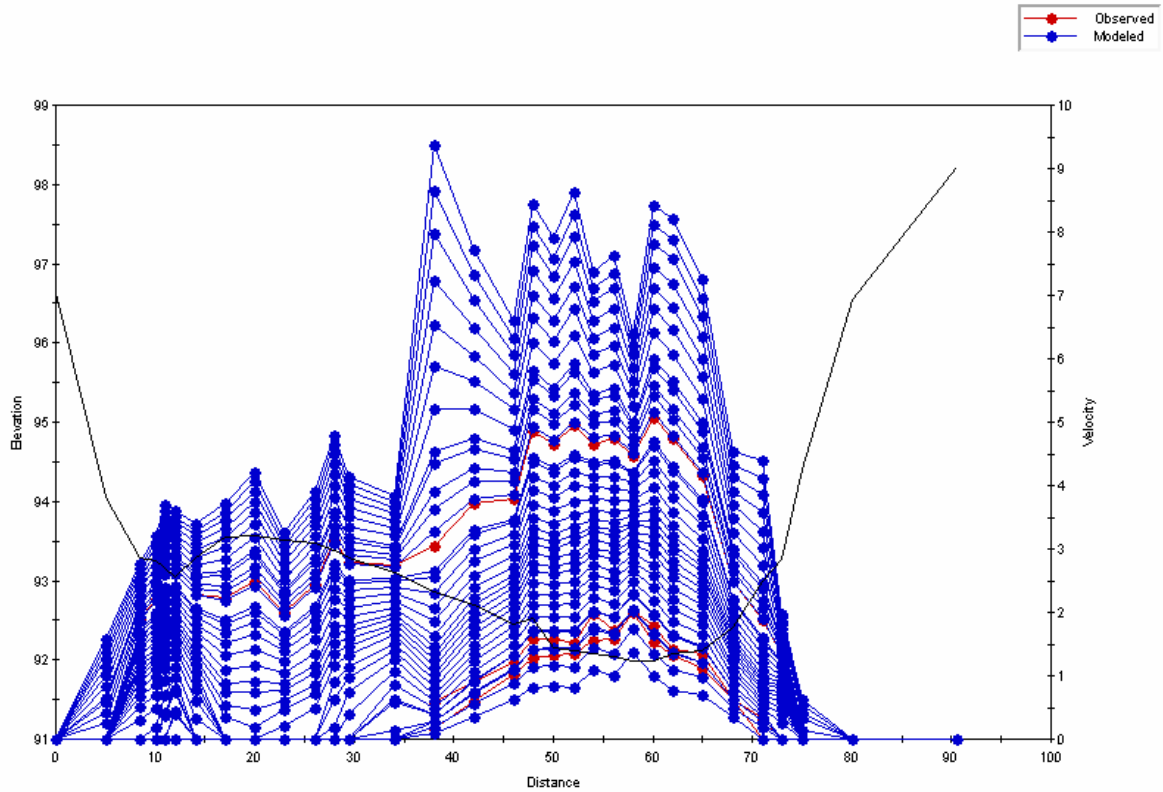
Transect 3


Observed
Modeled
Elevation
Velocity
Distance

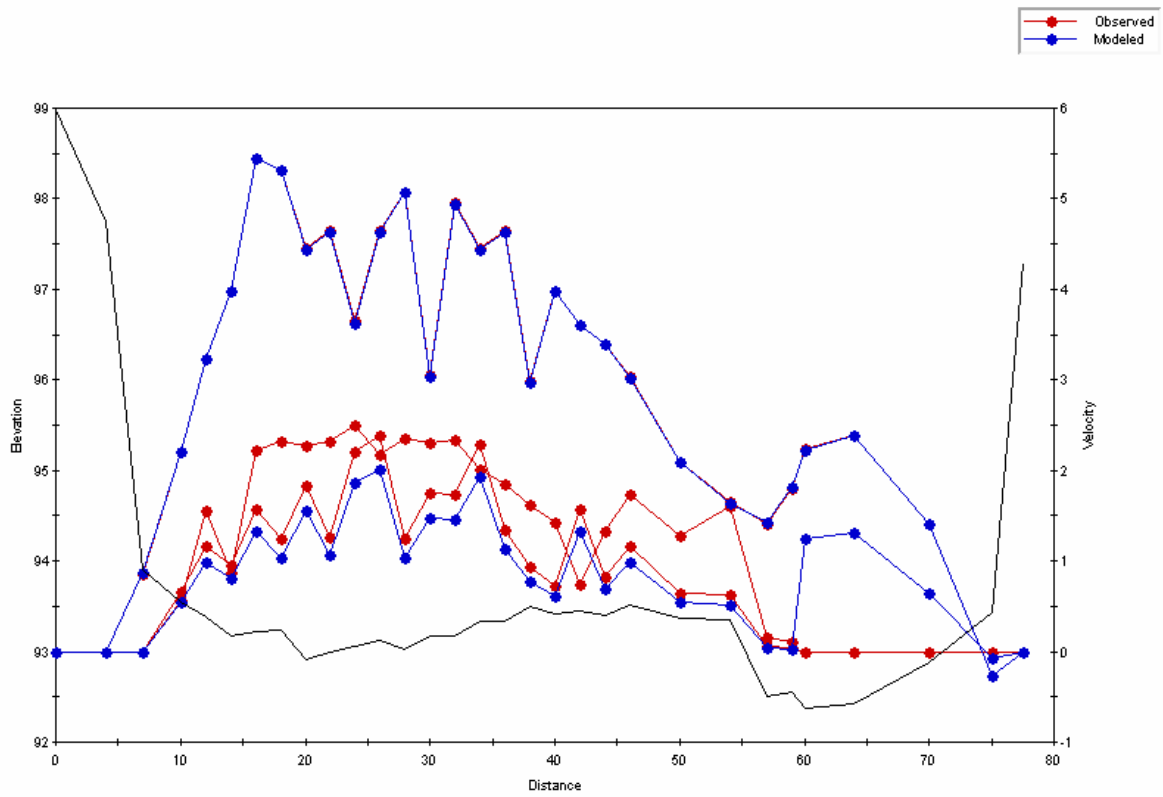

Observed
Modeled
Elevation
Velocity
Distance

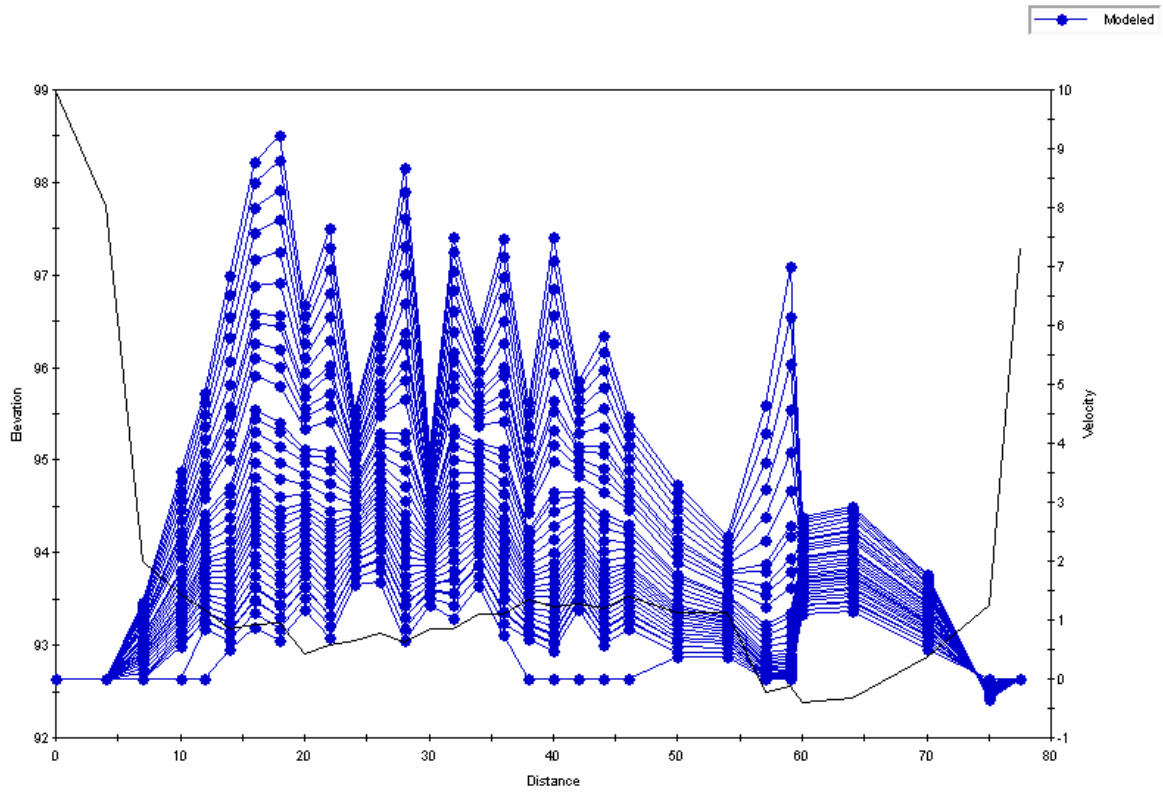
Transect 4


Observed
Modeled
Elevation
Velocity
Distance

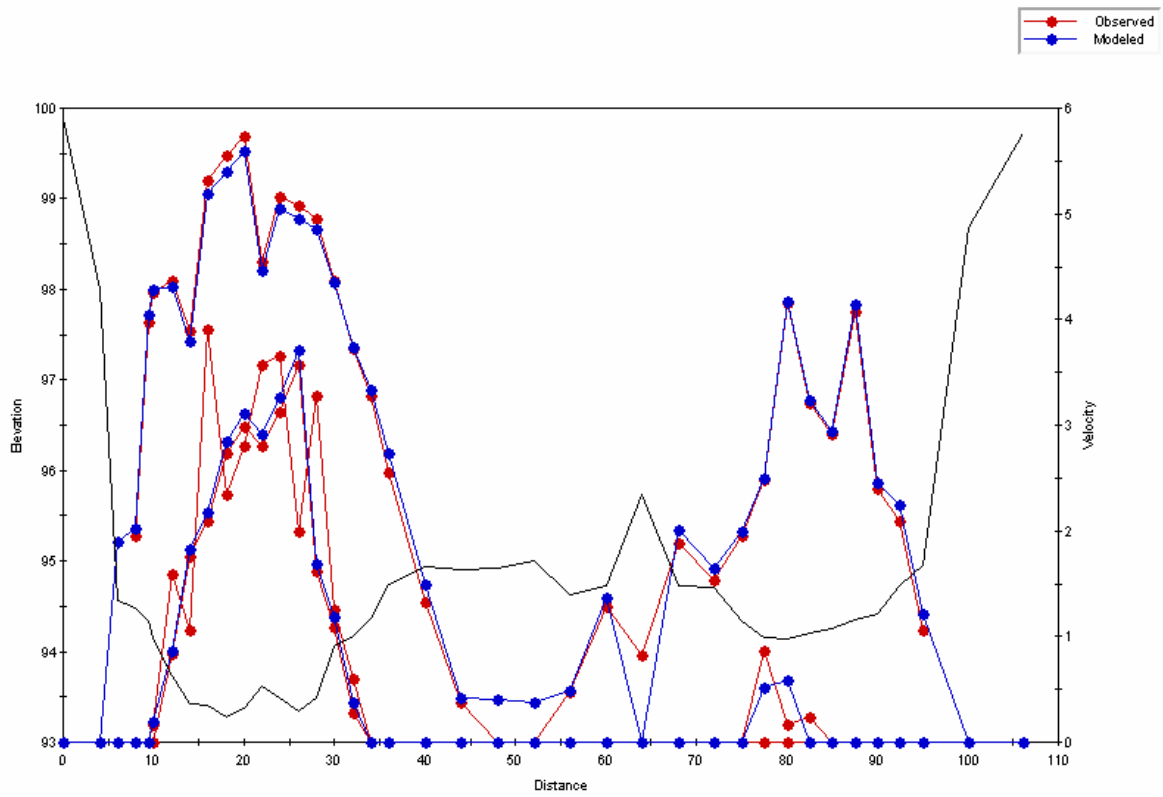

Observed
Modeled
Elevation
Velocity
Distance

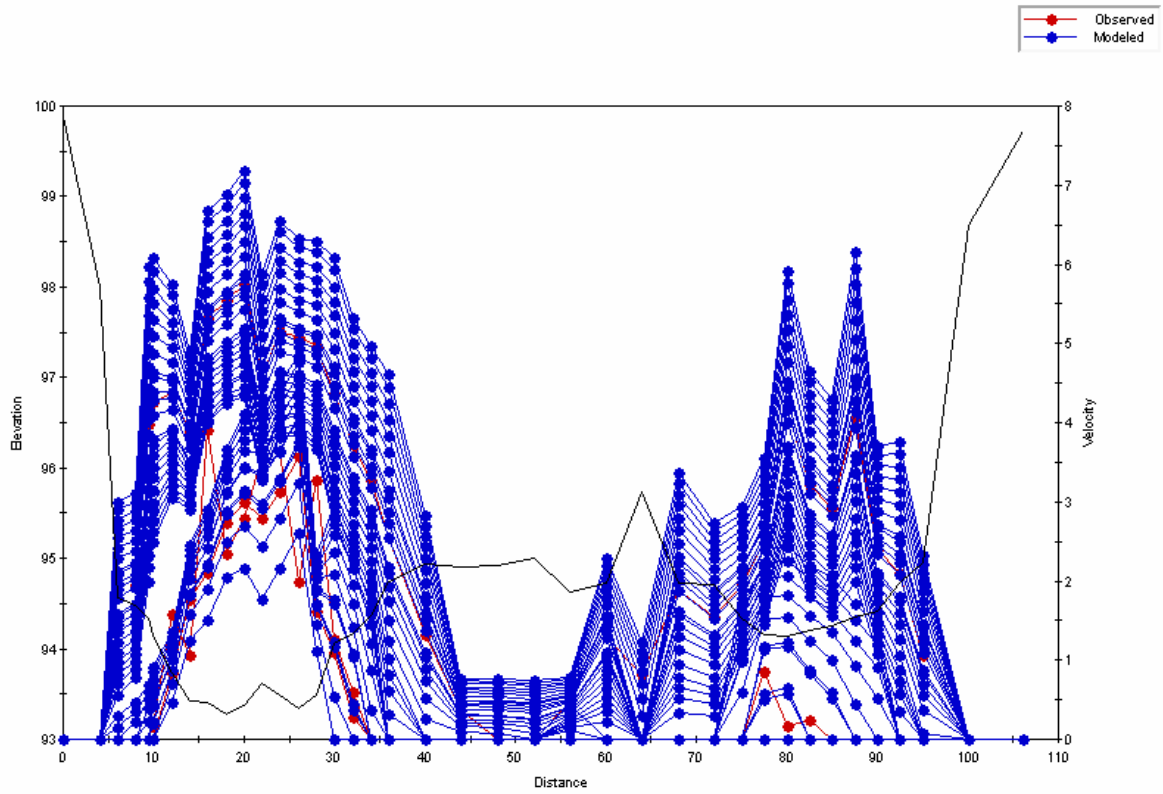
Transect 5


Observed
Modeled
Elevation
Velocity
Distance

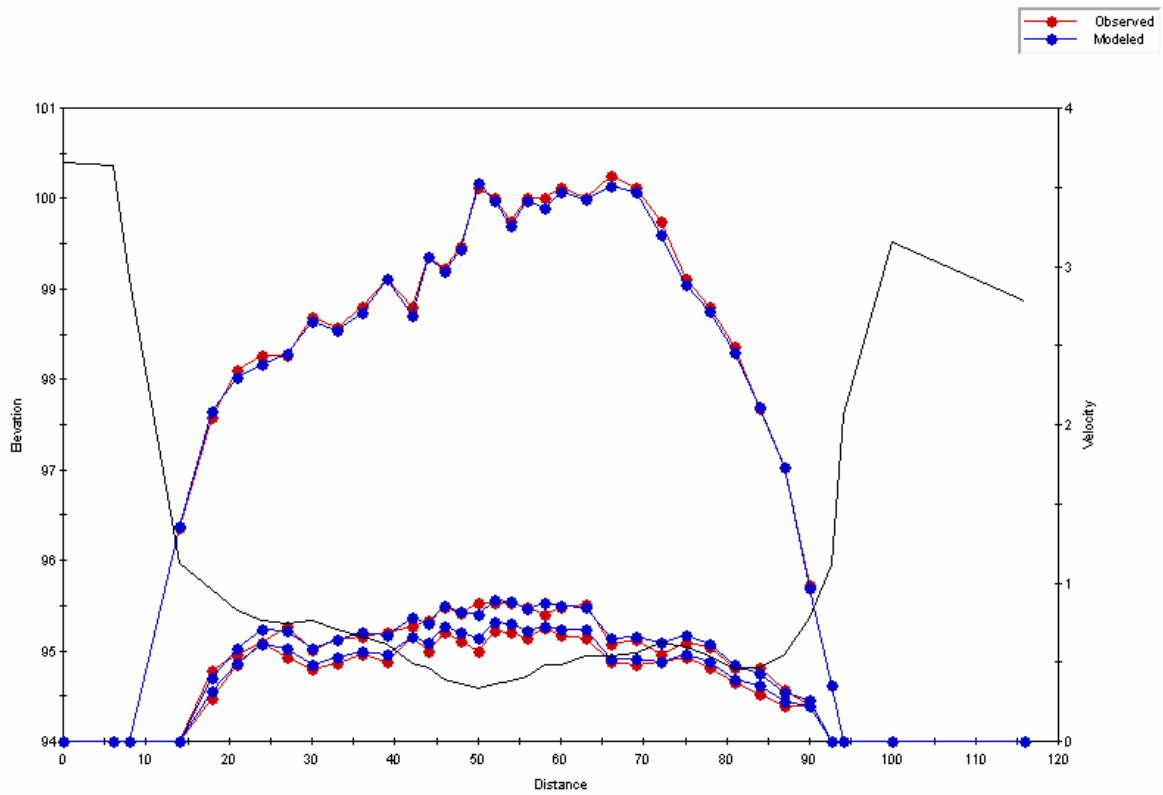

Modeled
Elevation
Velocity
Distance

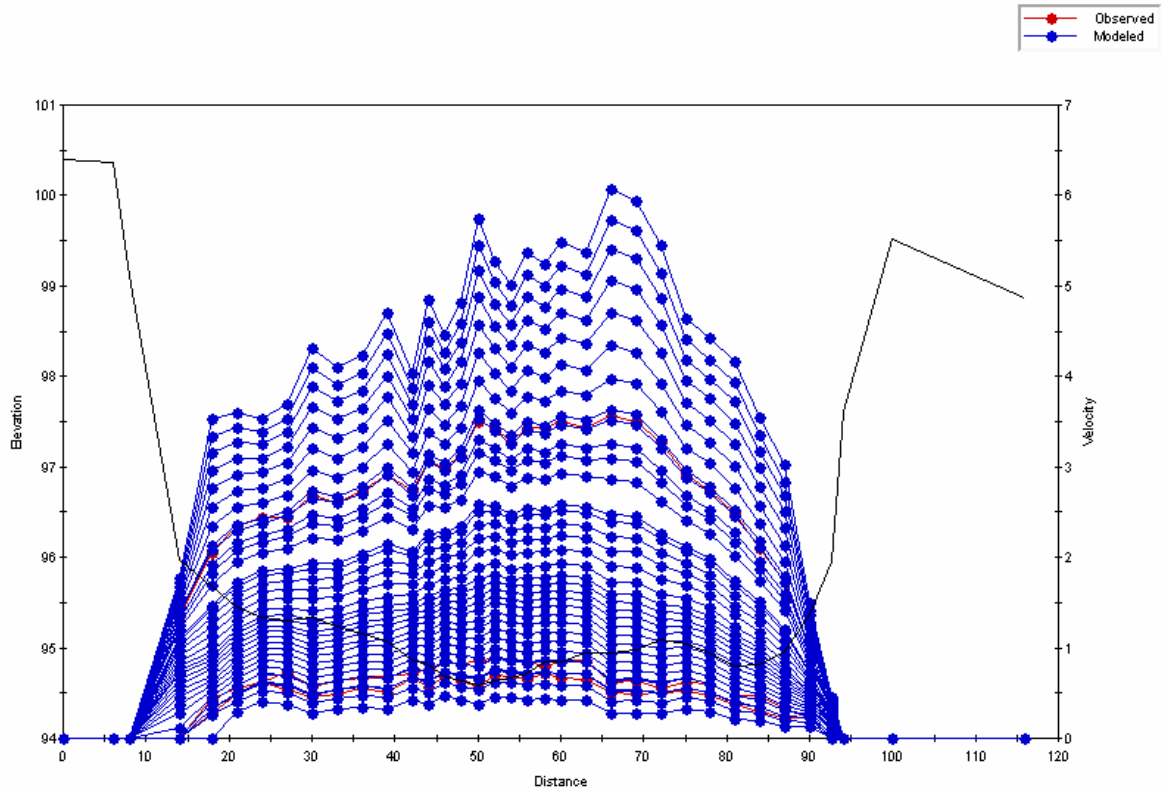
Transect 6


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 7


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Jim Creek at Mouth Calibrations

Eliminated Transect 7 as discussed
Used WSP model to calibrate transects 3-5 for WSL. StageQ produced poor fit with water running uphill between transects 4 and 3 at low flows and 5 & 4 at high flows.
Best Q1 for Transects 1-3 set to 17 cfs.
Best Q3 for all transects changed to 491. Average of all CalcQs. Same method as noted on data sheets, but calculation different.

Transect 1
Applied 2-flow Q1Q2 from 15-100 cfs. 2-flow Q2Q3 from 100-500. 1-flow Q3 from 500-1300.

Transect 2
2-flow Q1Q2 from 15-100. 2-flow Q2Q3 from 100-1300

V13	Q1 down 20% to 1.91, Q2 up 20% to 2.16
V14	Q1 down 20% to 2.06
V16	Q1 down 20% to 2.6, Q2 up 20% to 3.5
V17	Q1 down 20% to 2.48, Q2 up 20% to 2.75
V18	Q1 down 20% to 1.79
V19	Q1 up 0.2 to 1.46

Transect 3
3-flow to 500 cfs. 1-flow Q3 from 500-1300, at break in channel geometry.

Transect 4

V17	Q2 up 0.2 to 0.72, Q3 down 20% to 3.88
V18	Q1 up 0.2 to 0.55. Q3 down 20% to 4.04
V21	Q3 down to 5.55
V25	Q1 down 0.2 to 1.68
V26	Q1 down 0.2 to 1.64
V27	Q1 down 0.2 to 1.8
V28	Q1 down 0.2 to 1.8

Transect 5
1-vel Q2 from 15-100 cfs, 2-vel Q2Q3 from 100-1300 cfs.

V14	Eliminate Q2 (.330) . Q3 down 20% to 4.85
V15	Q3 down to 5.45

Transect 6

V10	Q3 down 20% to 3.11
V13	Q1 down to 1.09
V14	Q1 down to 1.16
V15	Q1 down to 1.54
V13-15	Delete Q2 (.323), (.465), (1.14) - standard adjustments insufficient

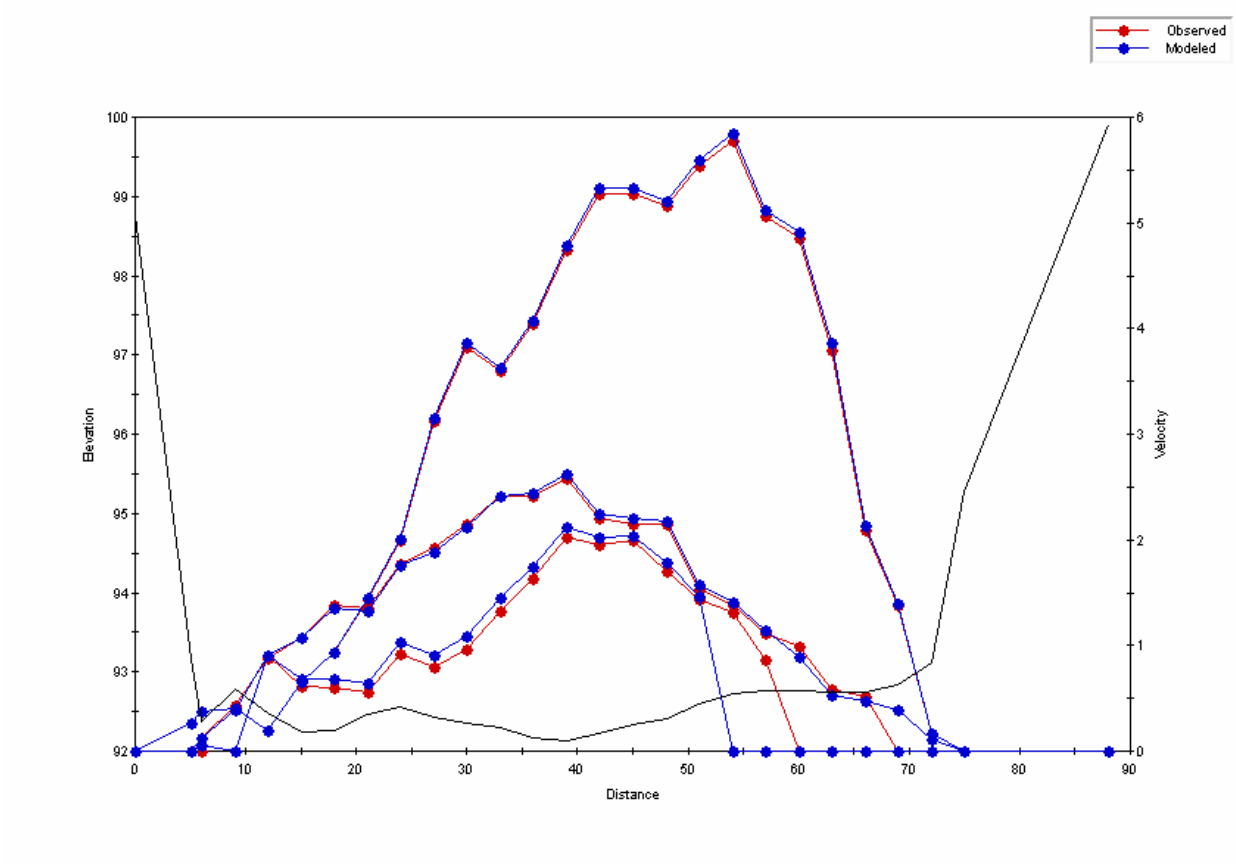
Jim Creek at Mouth

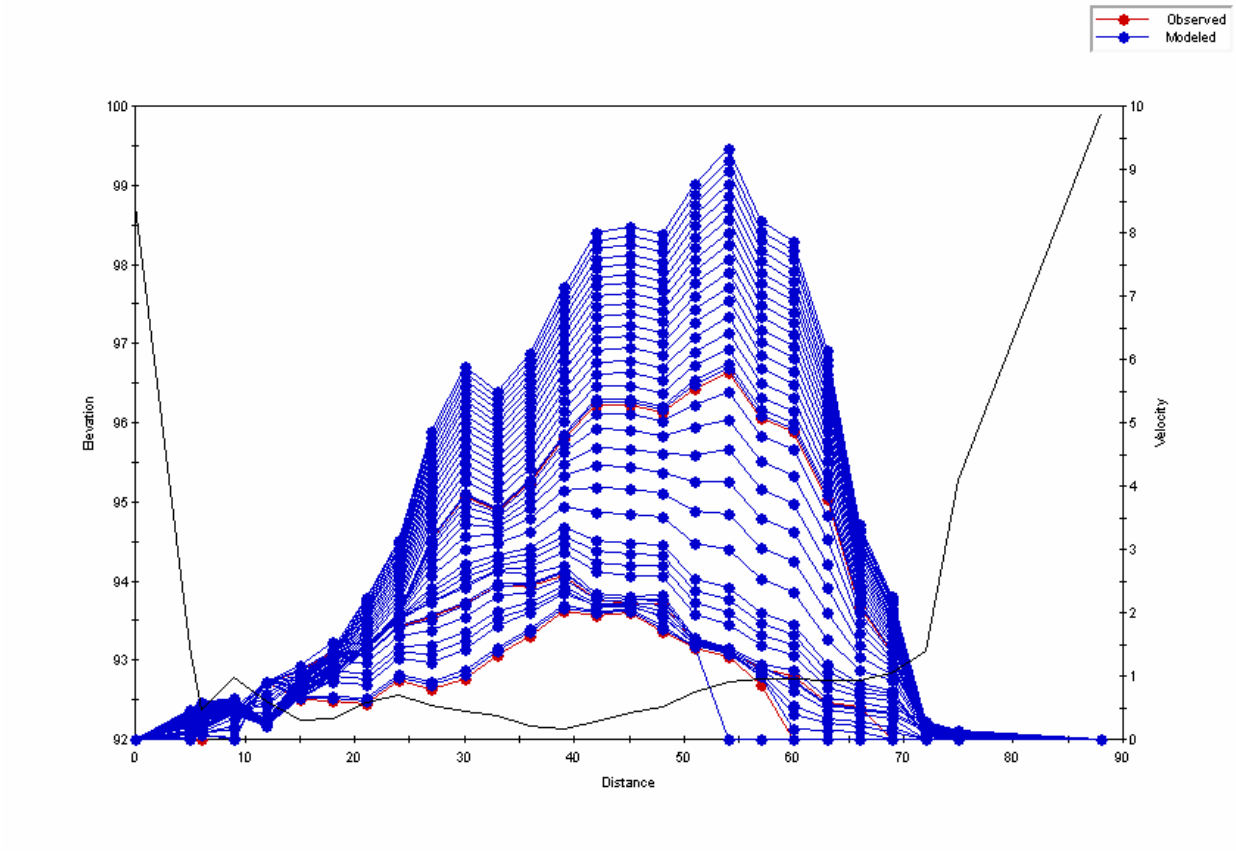
Station ID	Distance from Bank					
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
1	0	0	0	0	0	0
2	5	4	12	4	10	10
3	6	12	21	8	19	18
4	9	18	24	14	24	21
5	12	26	30	26	28	24
6	15	34.5	36	30	34	28
7	18	35	38	36	40	32
8	21	36	40	40	46	36
9	24	38.5	42	44	50	40
10	27	41	44	48	55	44
11	30	43.5	46	52	57.5	47
12	33	46	48	56	60	50
13	36	48.5	50	60	63.5	52
14	39	51	52	62	65	54
15	42	53.5	54	64	66.5	56
16	45	56	56	67	68	58
17	48	58.5	58	68.5	69.5	60
18	51	61	60	70	71	62
19	54	63.5	62	71.5	72.5	63
20	57	66	64	73	74	64
21	60	68.5	66	74.5	75.5	65
22	63	71	68	76	77	66
23	66	73.5	70	77.5	78.5	67
24	69	76	72	79	80	68
25	72	78.5	74	80.5	81.5	69
26	75	80	76	82	83	70
27	88	80.2	78	83.5	84.5	72
28		88.9	79	85	86	74
29			81	86.5	87.5	76
30			83.6	88	89	78
31				89.5	90.5	80
32				91	92	82
33				92.5	93.5	84
34				94	95	85
35				95.5	96.5	87.5
36				97	98	90
37				98	102.8	92.5
38				98.7		95
39						97.5

Jim_Mouth

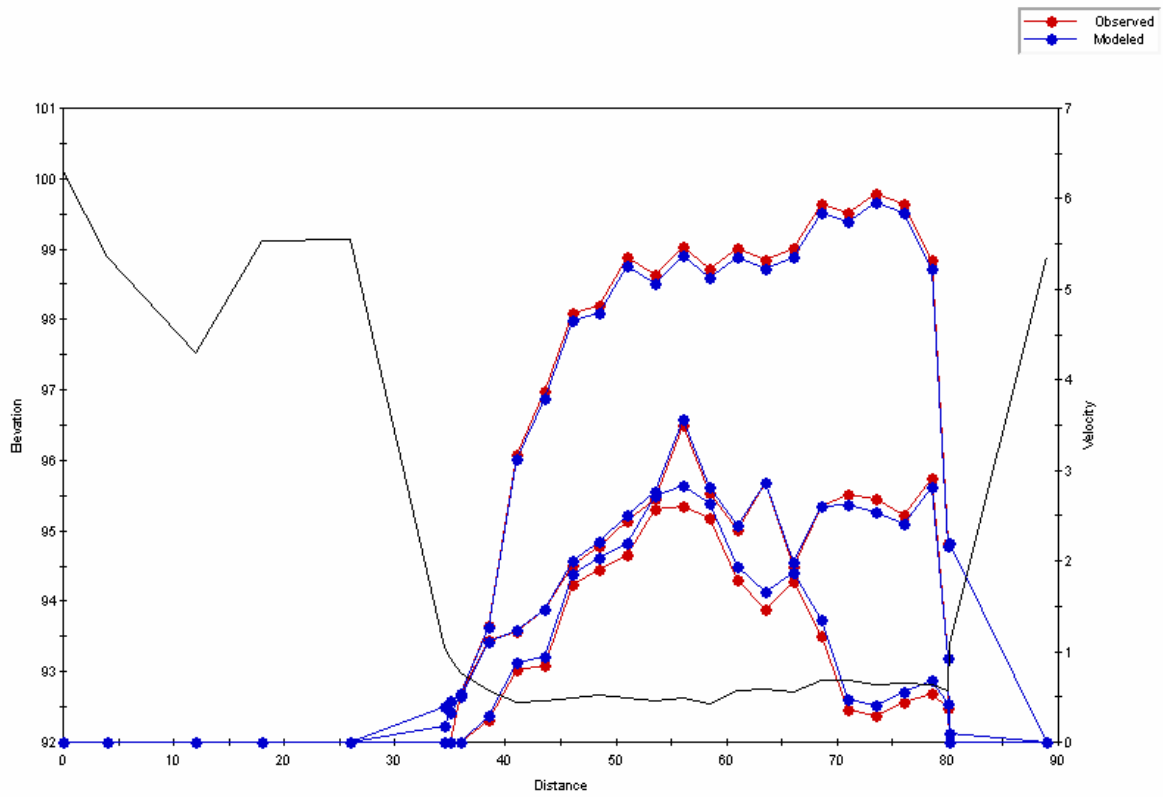
Transect (model)	**1a**	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4**	**5a**	**5b**	**6**
WSL model	StQ	StQ	StQ	StQ	StQ	WSP	WSP	WSP	WSP	WSP	StQ
Velocities used	2	2	1	2	2	3	1	3	1	2	3
Discharge	13		17	14		19	17	33			37
	78	78	71	76	76	74	71	72	69	69	66
		486	491		495	487	491	485		484	478
Stage	92.59		92.64	92.91		93.25	93.25	93.3			94.04
	93.24	93.24	93.16	93.47	93.47	93.98	93.96	94		94.1	94.42
		94.81	94.81		95.04	95.49	95.49	95.58		95.82	96.12
Plotting Stage	0.46		0.51	0.37		0.68	0.68	0.73			1.01
	1.11	1.11	1.03	0.93	0.93	1.41	1.39	1.42		1.53	1.39
		2.68	2.68		2.5	2.92	2.92	3.01		3.25	3.09
Ratio of Measured vs. Predicted Discharge											
	1		0.998	1		1.097	1.078	1.19			1.07
	1	1	1.003	1	1	0.831	0.86	0.72		1	0.92
		1	0.999		1	1.097	1.075	1.17		1	1.03
Mean Error of stage/discharge relationship for calculated Q											
	0	0		0	0	12.65		22.87		0	
Mean Error of stage/discharge relationship for given Q											
	0.2	0.2	0.2	2.61	2.61	10.01	10.01	NA	NA	NA	0.71
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF											
A=	0.1268	0.136		0.88	0.955	0.1854		0.1269		0.2962	0.2224
B =	0.4979	0.4817		0.5451	0.5261	0.4522		0.525		0.3875	0.4282
SZF =	92.13	92.13	92.13	92.54	92.54	92.57	92.57	92.57	92.57	92.57	93.03
Beta coefficient log/log discharge/stage relationship											
	2.008	2.076	2.027	1.835	1.9	2.211	2.31	1.91		2.581	2.34

Transect 1


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 2


Observed
Modeled
Elevation
Velocity
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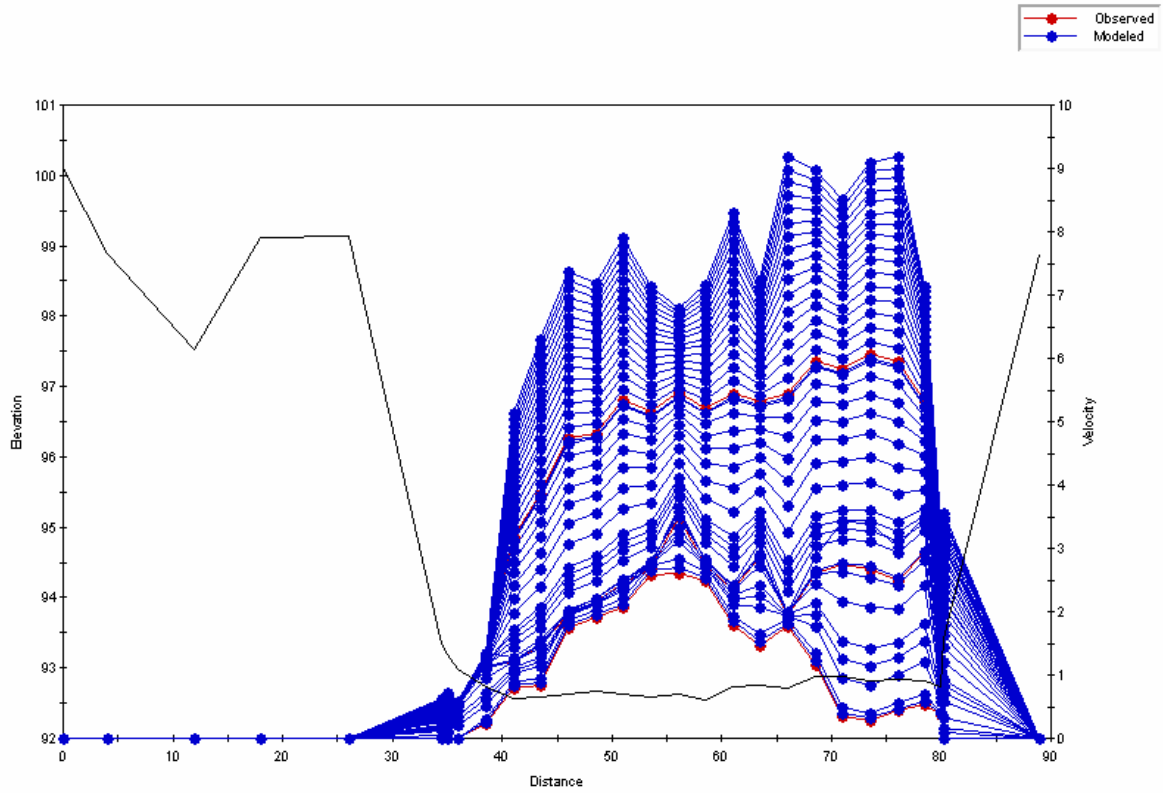
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Modeled
Elevation
Velocity
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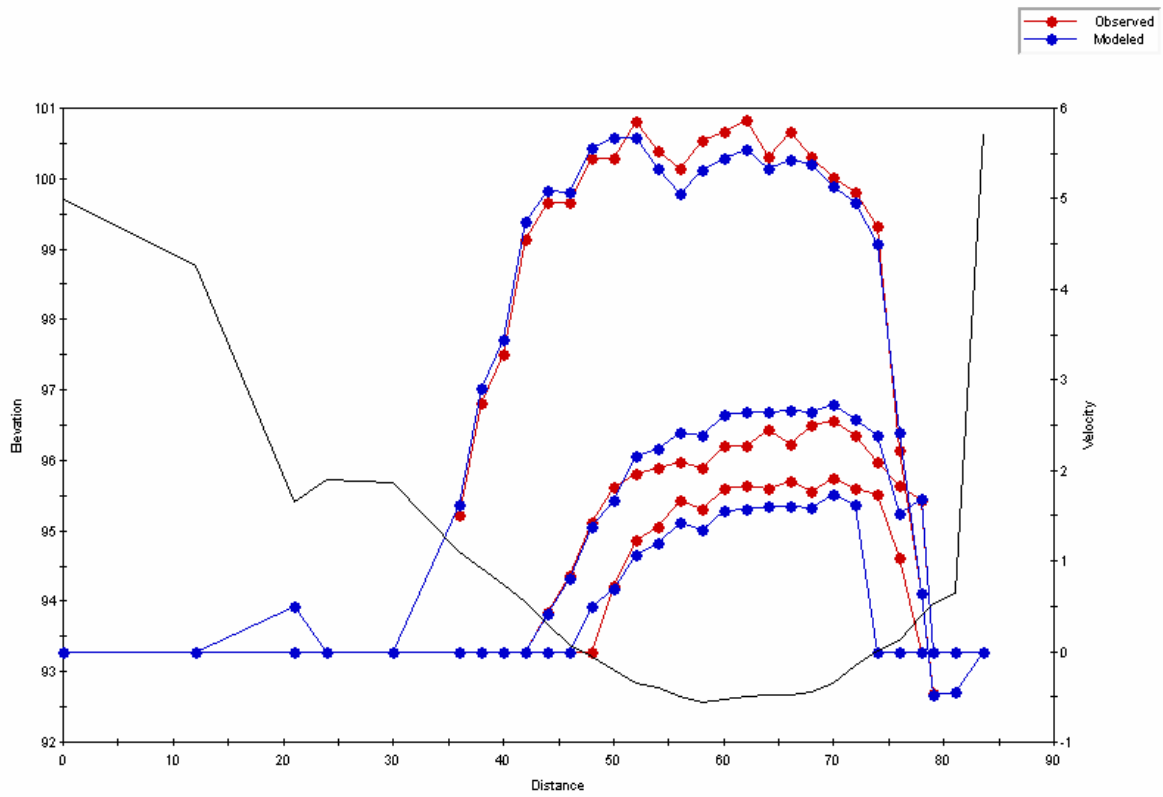
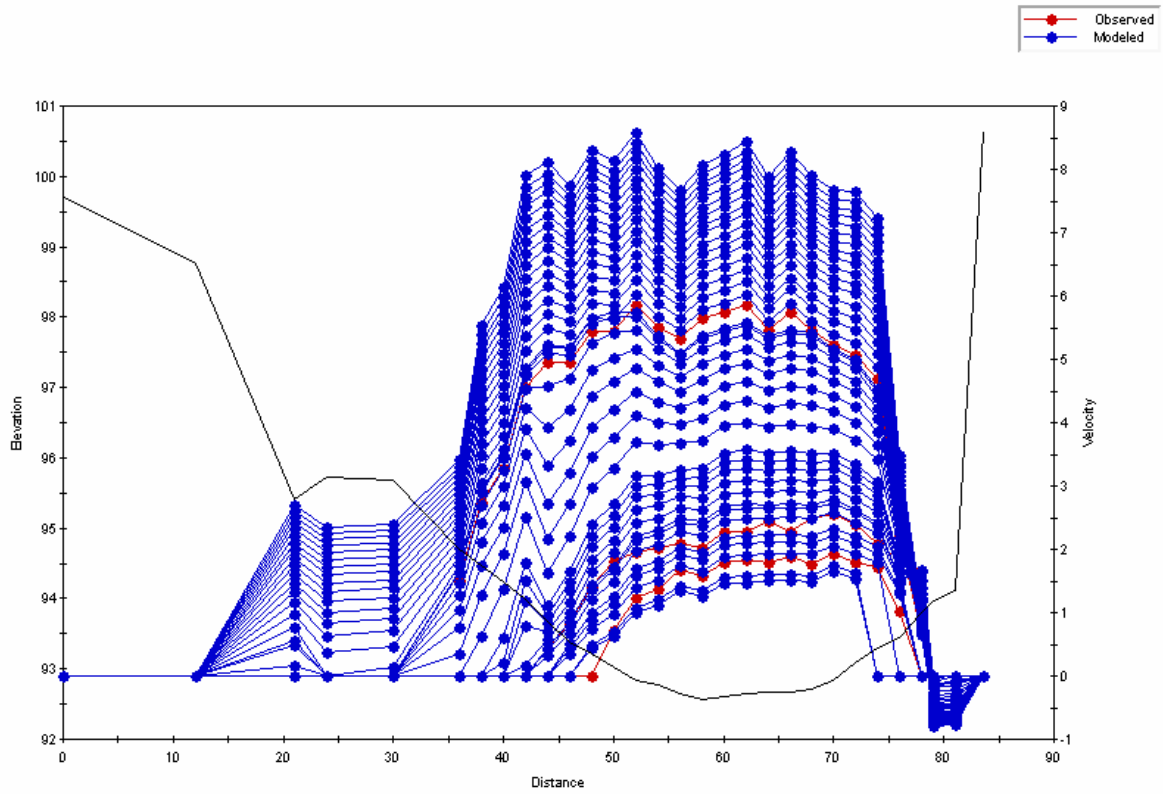
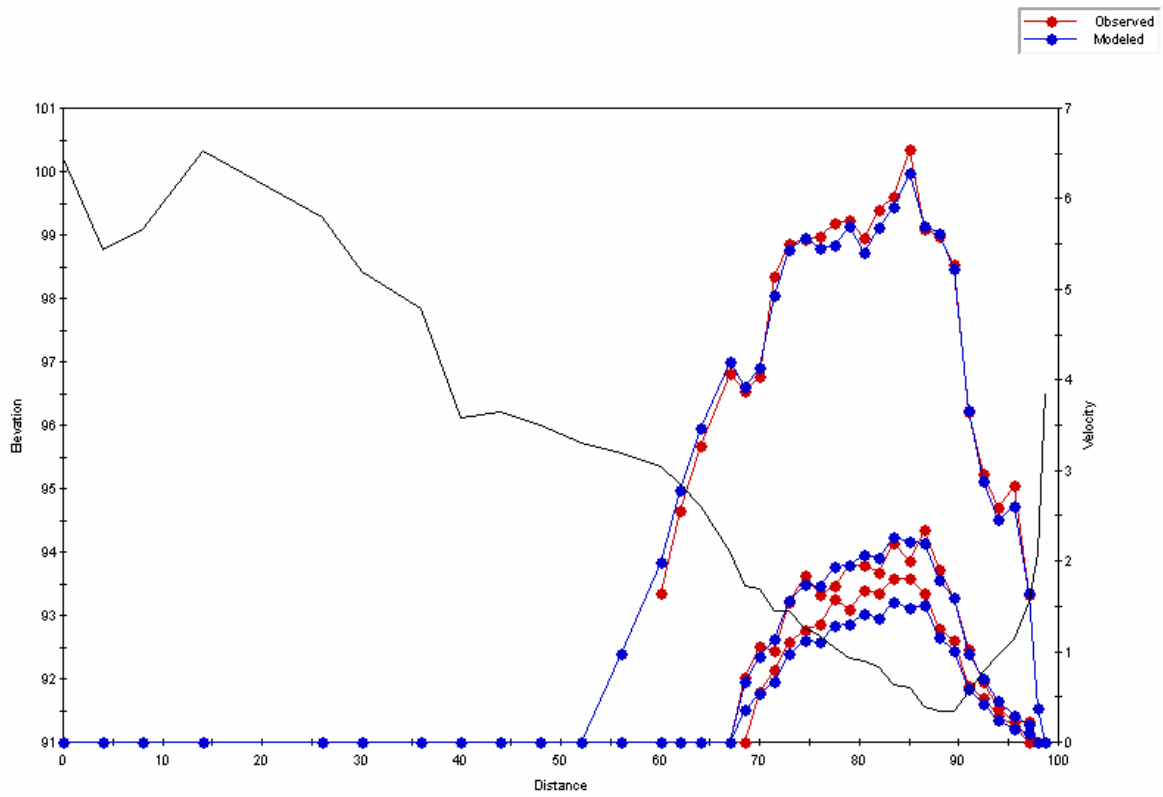
Transect 3


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 4


Observed
Modeled
Elevation
Velocity
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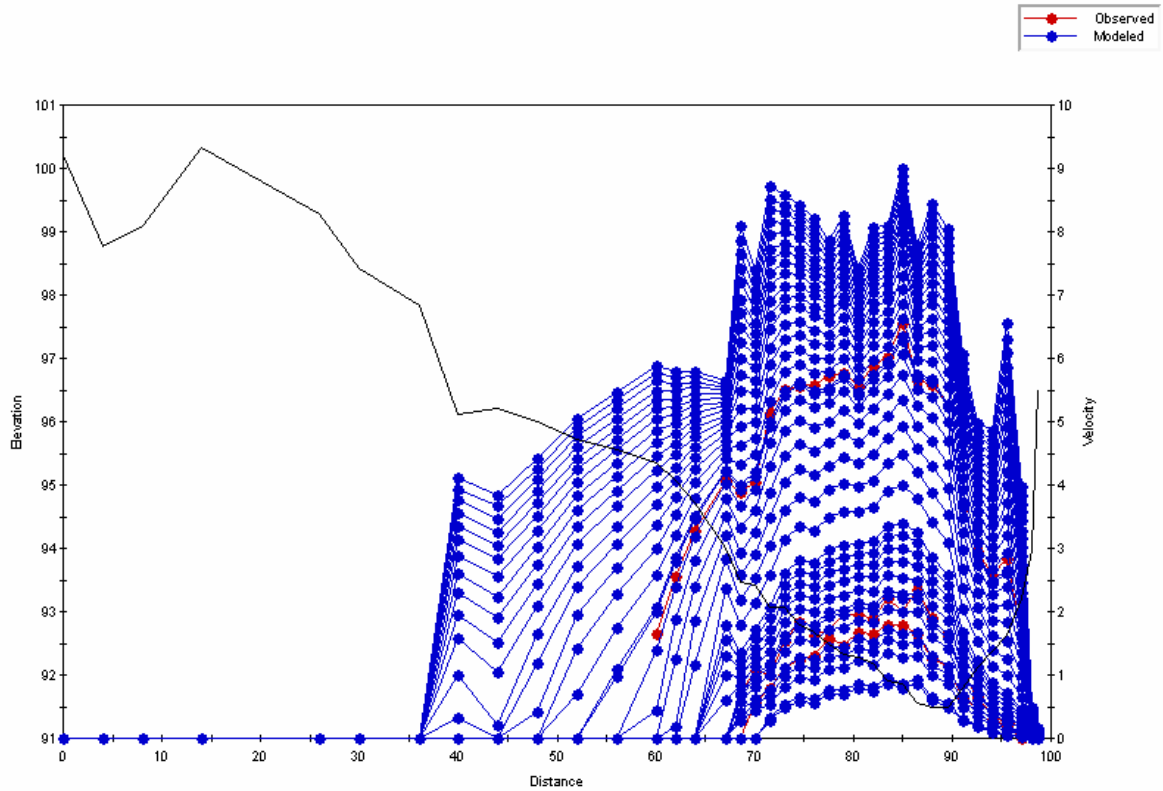
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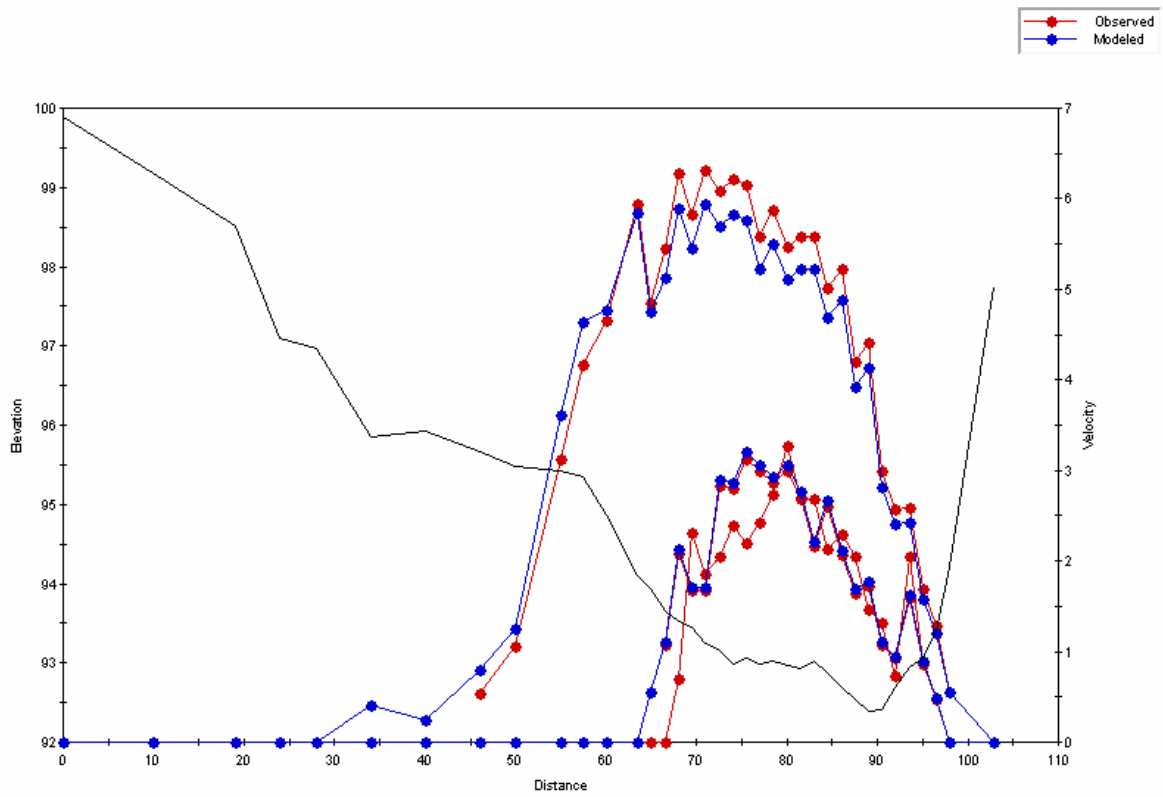
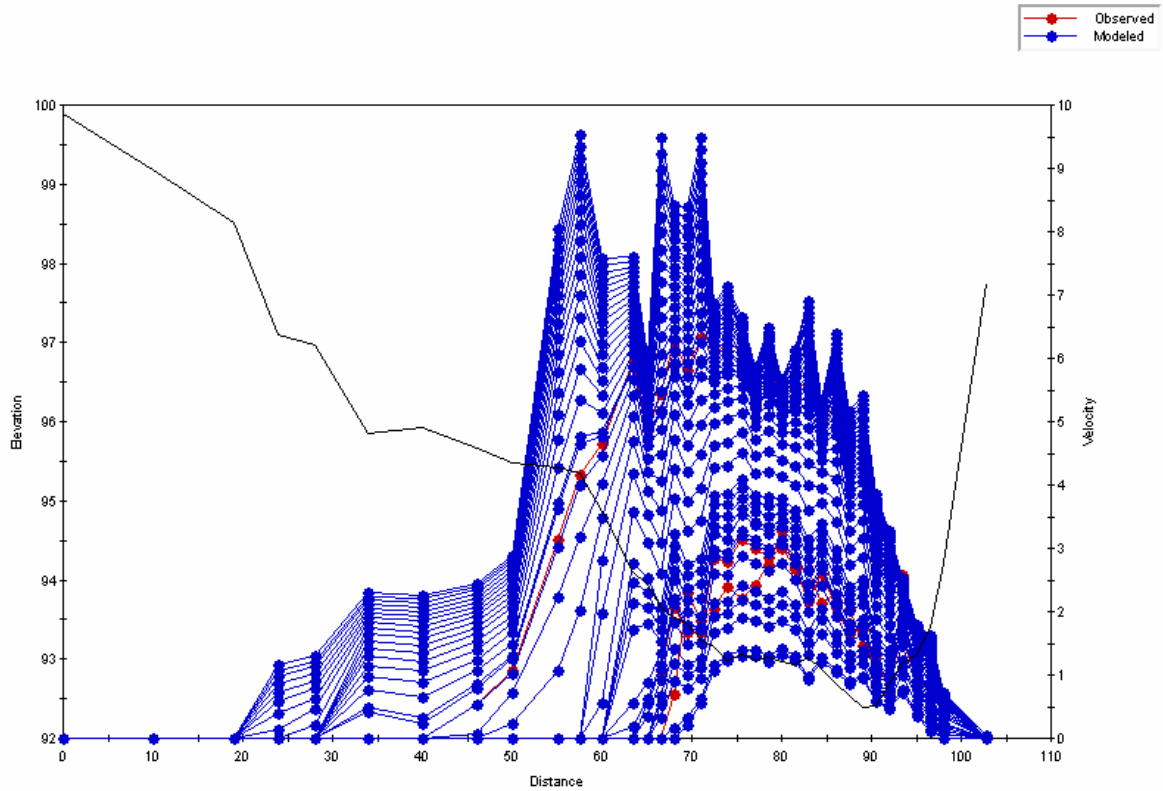
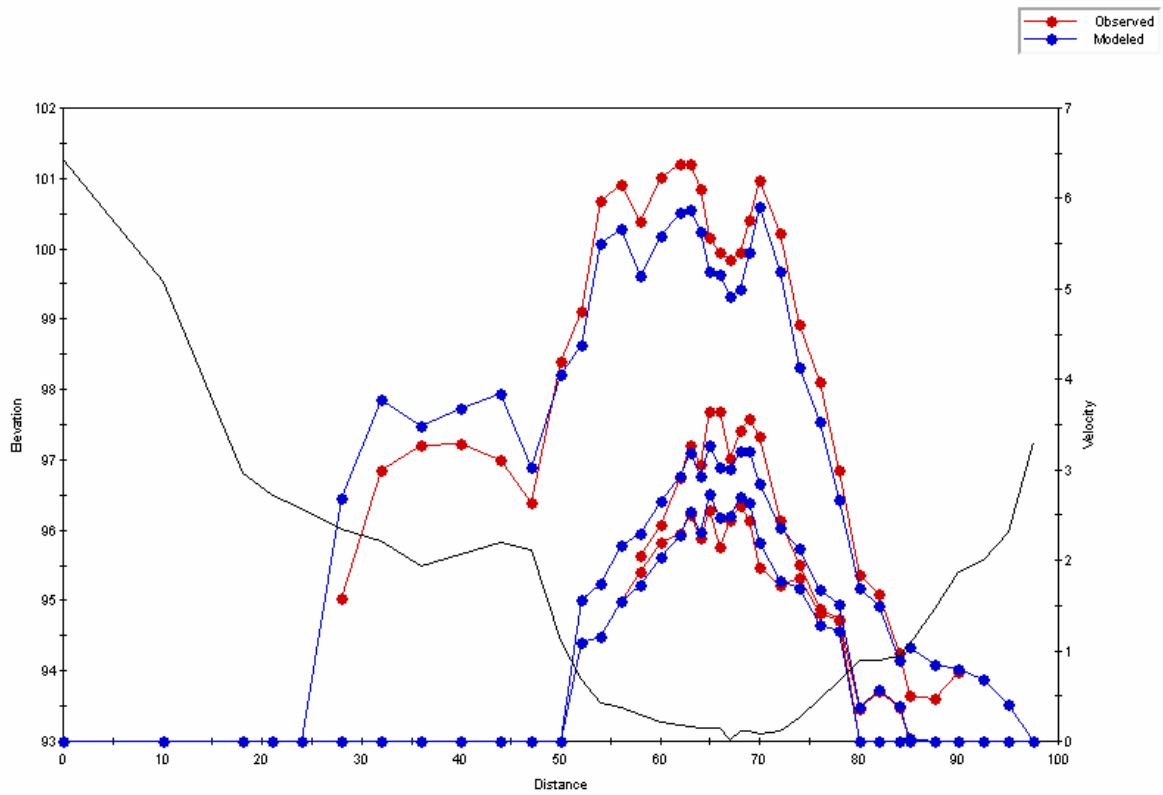
Modeled
Elevation
Velocity
Distance

Transect 5


Observed
Modeled
Elevation
Velocity
Distance


Observed
Modeled
Elevation
Velocity
Distance

Transect 6


Observed
Modeled
Elevation
Velocity
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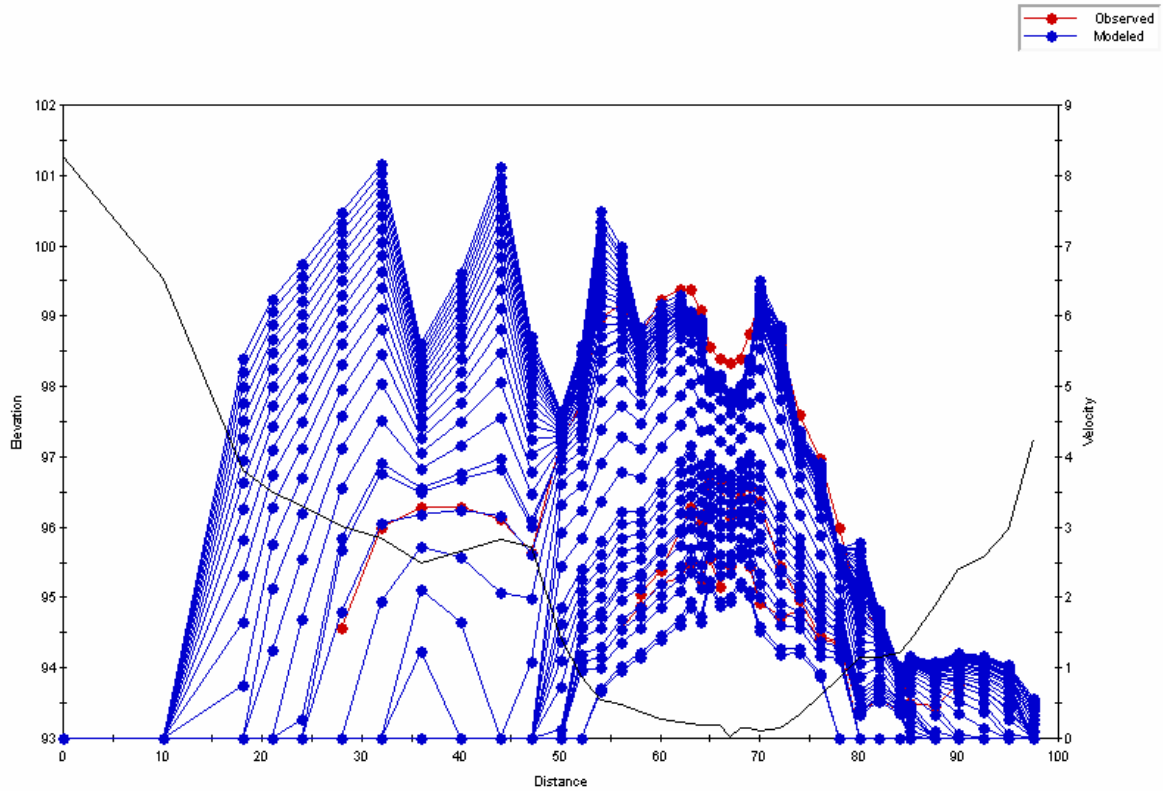
Observed
Modeled
Elevation
Velocity
Distance

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Jim Creek Fish Passage Site

Fish passage transect
Best Q3 way off of CalcQ. Since emphasis is on passage, used only Q1 and Q2 to calibrate WSL model.
1-vel Q1 model used for velocity if velocity issue is deemed relevant.
Simulated from 10-200 cfs.

Our approach to passage analysis follows the same guidelines as the USGS report. These call for quantification of stream widths by discharge with minimum depths of 0.6, 0.8 and 1.0 ft. Furthermore, we identified threshold discharge levels at each critical depth that provide 10% continuous passable width and 25% aggregate passable width. Due to the shape of the channel at the transect, all passable depth cells are continuous, i.e., 10% continuous width and 10% aggregate width are synonymous in this case.

We applied two quantitative approaches to perform the analysis. The "WUA Method" utilizes the Habitat program module to quantify passability. We created a two-transect "site" by duplicating the passage transect 1-ft further upstream. Channel condition and velocity preferences were fixed as 1.0. The depth suitability curves for the 0.6, 0.8 and 1.0 criteria depths were set to zero from a depth of 0 to 0.599, 0.799, and 0.999, respectively; at or above the criteria depth, suitability is set to 1.0. In other words, we constructed depth suitability curves with a binary step-function. All weighting factors were set to 1.0. The resulting WUA results are calculated as sq.ft./1000 ft., then divided by 1000 to attain passable width for each depth for discharges of 10-200 cfs. The results below include discharges from 10-100 cfs only since the 25% passability criteria is exceeded for all criteria depths at a discharge less than 100 cfs. Bed elevation for verticals at the site were spaced 2-ft apart across the entire transect (with the exception of the last few verticals near the right bank). As a result, passable width increases in multiples of 2 ft due to the manner in which the model defines computational cells.

The second method utilized the water surface levels generated by the WSL model to compute the depth at each vertical at each discharge. To provide somewhat finer passage-width discrimination within the constraints imposed by 2 ft spacing between verticals, we divided the transect into 1-ft cells by assuming that depth between two observed verticals follows a linear relationship. In this way, we artificially doubled the number of computational cells, providing a finer-scale estimate of passage width at each discharge.

In the result tables (below), we provide results for both methods and for all three criteria depths. We applied color formatting to the results table to indicate exceedence of the 10% (blue) and 25% (green) of wetted width thresholds.

Jim Creek at Arlington - Fish Passage

Transect (model)		**1**
WSL model		StQ
Velocities used		1
Discharge		37
		194
		600
Stage		93.4
		94.27
		95.68
Plotting Stage		0.8
		1.67
		3.08
Ratio of Measured vs. Predicted Discharge		
		0.96
		1.095
		0.952
Mean Error of stage/discharge relationship for calculated Q		
		NA
Mean Error of stage/discharge relationship for given Q		
		5.96
Stage/discharge relationship (S vs. Q) S=A*Q**B+SZF		
	A=	
	B =	
	SZF =	92.6
Beta coefficient log/log discharge/stage relationship		
		2.073

Jim Creek Passage

Summary Table

Critical discharge for 10% and 25% passable depth

	WUA method		WSL method	
	10%	25%	10%	25%
0.6 ft	23 cfs	32 cfs	19 cfs**	28 cfs
0.8 ft	48 cfs	54 cfs	49 cfs	62 cfs
1.0 ft	76 cfs	92 cfs	77 cfs	94 cfs

** 10% criterion exceeded at 19 cfs, but below 10% for flows of 20-23 cfs

		Thresholds		**WUA Method**			**WSL Method**		
Discharge (cfs)	**Wetted width**	10%	25%	Depth0.6	Depth0.8	Depth1.0	Depth0.6	Depth0.8	Depth1.0
10	28	2.8	7.0						
11	28	2.8	7.0						
12	28	2.8	7.0						
13	28	2.8	7.0						
14	28	2.8	7.0						
15	28	2.8	7.0						
16	28	2.8	7.0						
17	28	2.8	7.0						
18	28	2.8	7.0						
19	28	2.8	7.0	2			3		
20	34	3.4	8.5	2			3		
21	34	3.4	8.5	2			3		
22	34	3.4	8.5	2			3		
23	34	3.4	8.5	4			3		
24	34	3.4	8.5	4			4		
25	34	3.4	8.5	4			4		
26	34	3.4	8.5	4			4		
27	34	3.4	8.5	8			4		
28	34	3.4	8.5	8			9		
29	34	3.4	8.5	8			9		
30	34	3.4	8.5	8			9		
31	34	3.4	8.5	8			9		
32	34	3.4	8.5	12			9		
33	34	3.4	8.5	12			11		
34	34	3.4	8.5	12			11		
35	34	3.4	8.5	12			11		
36	34	3.4	8.5	12			11		
37	34	3.4	8.5	16	2		16	3	
38	40	4.0	10.0	16	2		16	3	
39	42	4.2	10.5	16	2		16	3	
40	42	4.2	10.5	16	2		16	3	
41	42	4.2	10.5	16	2		16	3	
42	42	4.2	10.5	18	4		17	3	
43	42	4.2	10.5	18	4		17	4	
44	42	4.2	10.5	18	4		17	4	

		Thresholds		WUA Method			WSL Method		
Discharge (cfs)	**Wetted width**	10%	25%	Depth0.6	Depth0.8	Depth1.0	Depth0.6	Depth0.8	Depth1.0
45	42	4.2	10.5	18	4		17	4	
46	42	4.2	10.5	18	4		17	4	
47	42	4.2	10.5	18	4		17	4	
48	42	4.2	10.5	18	8		17	4	
49	46	4.6	11.5	18	8		19	9	
50	46	4.6	11.5	18	8		19	9	
51	46	4.6	11.5	18	8		19	9	
52	46	4.6	11.5	18	8		19	9	
53	46	4.6	11.5	18	8		19	9	
54	46	4.6	11.5	20	12		19	9	
55	46	4.6	11.5	20	12		19	9	
56	46	4.6	11.5	20	12		20	11	
57	46	4.6	11.5	20	12		20	11	
58	46	4.6	11.5	20	12		20	11	
59	46	4.6	11.5	20	12		20	11	
60	46	4.6	11.5	20	12		20	11	
61	46	4.6	11.5	26	16	2	20	11	
62	52	5.2	13.0	26	16	2	27	16	3
63	52	5.2	13.0	26	16	2	27	16	3
64	52	5.2	13.0	26	16	2	27	16	3
65	52	5.2	13.0	26	16	2	27	16	3
66	52	5.2	13.0	26	16	2	27	16	3
67	52	5.2	13.0	26	16	2	27	16	3
68	52	5.2	13.0	26	18	4	27	17	3
69	52	5.2	13.0	26	18	4	27	17	4
70	52	5.2	13.0	26	18	4	27	17	4
71	52	5.2	13.0	26	18	4	27	17	4
72	52	5.2	13.0	26	18	4	27	17	4
73	52	5.2	13.0	26	18	4	27	17	4
74	52	5.2	13.0	26	18	4	27	17	4
75	52	5.2	13.0	26	18	4	27	17	4
76	52	5.2	13.0	28	18	8	28	17	4
77	57.5	5.8	14.4	28	18	8	28	19	9
78	57.5	5.8	14.4	28	18	8	28	19	9
79	57.5	5.8	14.4	28	18	8	28	19	9
80	57.5	5.8	14.4	28	18	8	28	19	9
81	57.5	5.8	14.4	28	18	8	28	19	9
82	57.5	5.8	14.4	28	18	8	28	19	9
83	57.5	5.8	14.4	29	20	12	28	19	9
84	57.5	5.8	14.4	29	20	12	28	19	9
85	57.5	5.8	14.4	30	20	12	29	20	11
86	57.5	5.8	14.4	30	20	12	29	20	11
87	57.5	5.8	14.4	30	20	12	29	20	11
88	57.5	5.8	14.4	30	20	12	29	20	11

		Thresholds		WUA Method			WSL Method		
Discharge (cfs)	**Wetted width**	10%	25%	Depth0.6	Depth0.8	Depth1.0	Depth0.6	Depth0.8	Depth1.0
89	57.5	5.8	14.4	30	20	12	29	20	11
90	57.5	5.8	14.4	30	20	12	29	20	11
91	57.5	5.8	14.4	30	20	12	29	20	11
92	57.5	5.8	14.4	34	26	16	29	20	11
93	57.5	5.8	14.4	34	26	16	29	20	11
94	57.5	5.8	14.4	34	26	16	34	27	16
95	57.5	5.8	14.4	34	26	16	34	27	16
96	57.5	5.8	14.4	34	26	16	34	27	16
97	57.5	5.8	14.4	34	26	16	34	27	16
98	57.5	5.8	14.4	34	26	16	34	27	16
99	57.5	5.8	14.4	34	26	16	34	27	16
100	57.5	5.8	14.4	34	26	16	34	27	16