WOOD RODGERS

February 9, 2006

David T. Price, P.E., County Engineer
Washoe County Community Development
Engineering Department
1001 E. 9th Street
Reno, Nevada 89520

Dear Mr. Price:

We are writing this letter on behalf of our client, CB Maddox. Thank you for giving us the opportunity to sit down with you and Kris Klein to discuss the drainage issues relating to the Wedge Meadows Subdivision ("Wedge Meadows") and the construction of Wedge Parkway and Arrowcreek Parkway. Per our April 25th, 2005 meeting I am writing you this letter to clarify what we feel are possible solutions to the drainage issues created by the re-alignment of Wedge Parkway and the placement of related culverts.

As you are aware, the *Preliminary Whites Creek Basin Management Study* prepared by Cella Barr Associates (the Study) was adopted by Washoe County as the guide for development and dealing with the hydrology in the Whites Creek Basin when this area was under the County's jurisdiction. According to the Study, any development within Reaches 2, 3, and 4 of Whites Creek would be required to design drainage structures to convey 3000 cfs for the 100 year event. This approach was instituted to allow for each of those three Reaches to convey all anticipated flows in case two of the Reaches were obstructed.

As you are aware, during the tentative map phase of Wedge Meadows, a large flood channel was required along the westerly side of Arrowcreek Parkway[1] (the Channel). The Channel was designed to accommodate 3000cfs, the amount of water historically indicated in the Study to reach our site in Reach 2. After the tentative map for Wedge Meadows was approved, Wedge Parkway was realigned, Arrowcreek Parkway was constructed and three culverts were placed across Wedge Parkway. As we have only recently determined pursuant to an engineering study, additional flows from Reach 3 have been redirected to our site on the east side of Arrowcreek Parkway far in excess of the historical flows. Based on our study, the additional flows across Wedge Meadows may actually prevent and otherwise adversely impact development of portions of the subdivision as approved by the County. In our opinion, CB Maddox should not be required to modify approved and completed drainage improvements due to these additional flows.

In order to resolve the problem, we recommend and our client requests that the County and the Regional Transportation Commission agree to promptly complete the following:

1. A full hydraulic study of Reach 3 from the apex of the fan at Shadow Ridge Park to downstream of the crossing of Whites Creek Lane. This hydraulic study should be prepared to model Reaches 2,3, and 4 to determine: (i) the amount of

[1] Note that Arrowcreek Parkway was called Wedge Parkway until its realignment, which occurred with the addition of Arrowcreek Parkway.

flow which can actually be conveyed by each Reach; and (ii) the amount of mixing of each Reach's flow which historically occurred. This study would better define the actual flows reaching the downstream properties and further define the capacity required for the drainage structures in each Reach. This information could then be used to reconstruct the existing culverts crossing Wedge Parkway to return the historic drainage condition.

2. Reconstruct the existing culverts and drainage improvements to return the drainage condition prior to the construction of the realigned Wedge Parkway and the addition of Arrowcreek Parkway.

I have attached the memo and analysis prepared by Wood Rodgers which we previously submitted to your office for review. I appreciate your time and consideration in finding a solution to these issues. We will be available for a meeting in an effort to resolve this matter. Since time is of the essence, we would ask you to advise us of your position or schedule a meeting with us sometime between now and February 20, 2006.

If you have any questions, concerns or have any time available to meet on this issue and discuss the solution, please feel free to contact me at 823-4063.

Sincerely,

Cary D. Chisum, P.E.
Principal
Wood Rodgers, Inc.

cc: Gregory H. Krause Executive Director, Regional Transportation Commission

WOOD RODGERS

April 26, 2005

To: Kristine Klein, P.E.
From: Mary Horvath, P.E.
CC: Cary Chisum, P.E.; CB Maddox

This memo is essentially the same as the one submitted to Washoe County in July 2004 with minor revisions for increased clarity. It is meant to outline the assessment by Wood Rodgers of the hydraulic conditions of Reach 3 of Whites Creek in the vicinity of the Arrowcreek/Wedge Parkway intersection prior the construction of the roadways. This was done to estimate the quantity of flow that would have reached the Phase VI Wedge Meadows property pre-construction in the statistical 100-year flood event defined as 3000 cfs within Reach 3 of Whites Creek. This memorandum references the figures I provided in the July 29th meeting with representatives from CB Maddox, Wood Rodgers, Washoe County and the City of Reno. I have also provided the figures with this memorandum.

The analysis included two steps:

1) Examination and replication of the pre- and post-project conditions modeling effort of Reach 3 completed for the design of the Wedge and Arrowcreek Parkways.
2) Re-creation of a pre-conditions HEC-RAS model to better understand the flow dynamics up and downstream of Wedge Parkway to estimate the quantity of flow in the 3000 cfs event within Reach 3 of Whites Creek that would have reached the Wedge Meadows Phase VI project site without the construction of the roads.

Step 1) The pre-construction hydraulic conditions of the Reach 3 were analyzed by HLA and WRC Nevada for the design of the three multi-cell box culverts beneath Wedge Parkway for the conveyance of Reach 3. The findings are presented in the reports "Special Assessment District #23, Arrowcreek Parkway Hydraulic Report Whites Creek Branches 1, 2, and 3" submitted by HLA in 1997, and "Wedge Parkway Extension Hydraulic Report Whites Creek Branch 3" submitted by WRC Nevada in 1997. Pre- and post-project HEC-RAS hydraulic models were generated for a stretch of Reach 3 extending from approximately 500 feet upstream to just downstream of the then-proposed Wedge Parkway alignment. The models' results showed that the construction of the roadway with three multi-cell box culverts would not increase the water surface elevation above existing conditions in the 3000 cfs event. Neither the model nor the report addresses the flowpaths of the flood in either the existing or post-construction conditions. The HEC-RAS models presented in the reports allow the flow to spread throughout each cross section. HEC-RAS, a one-dimensional flow model, does not consider physical features such as ridges and high ground and allows flow to spread at the computed water surface elevation across the cross section unless directed by the placement of levees, ineffective flow area or blocked obstructions. None of these features were utilized in the Reach 3 model. No analysis was completed to determine the flow response and split flow computation over or around the high ground or ridges represented in the cross sections.

It is our opinion that the cross section placement and orientation in WRC's existing conditions model do not accurately depict flood flow conditions. The cross sections are aligned so that from left to right looking downstream they extend from high to low elevations so that the majority of the flow area is in the right, or southern, portions of the cross sections. As a result of this distortion, the main flow path of Reach 3 along the left side of the floodplain (that was observed flowing during the early summer of 2004) is modeled to be dry or near dry in the 3000 cfs event.

However, since this is what was used for the roadway design, we first used this model for evaluation of Reach 3. Because we could not locate a digital copy of the HEC-RAS model, we replicated the cross sections from the printouts within the WRC report and ran the model with 3000 cfs steady flow. The results matched WRC's results within 0.10 feet for each cross section. We used the flow distribution option within HEC-RAS to compute the quantity of flow within subdivisions of each cross section. The results are presented in Figures 1 through 10. Figures 1 through 9 show the cross sections going from upstream to downstream with the approximate flow distribution (orientation is from left to right looking downstream). Figure 10 shows the plan-view layout of the pre-project WRC model with the numerical flow distribution shown in red for each cross section. The majority of the 3000 cfs is distributed within the right or southern portions of the cross sections in cross sections 9 through 2. Cross section 1 is shorter than 2 through 9 so that it cuts off the flow paths within the southern portions of floodplain, forcing the majority of the flow to be within the center of the cross section and putting more water in the left side and forcing the floodplain to extend to the north.

To analyze the effect of the roadway and culvert construction, we re-created the post-conditions HEC-RAS model with the three culverts using the existing topography available from the City of Reno DataNavigator and the alignment of the cross sections from the WRC report. Because the alignment of Wedge Parkway travels up the alluvial fan from north to south, the lowest part of the road is near its intersection with Arrowcreek Parkway. The WRC report states that because the upstream portion of the roadway is at-grade, approximately 500 cfs would weir over the roadway in the southern stretch of Wedge Parkway in the 3000 cfs event. We also believe that there are discrepancies with this evaluation. Wedge Parkway was not constructed completely at-grade in this section; water would have to pond to depths of near a foot before weiring over the road. The shallow sheet flow on the alluvial fan would instead most likely flow north to the culverts that were constructed at the lowpoint of the roadway just south of the intersection of Wedge Parkway with Arrowcreek Parkway. To simulate this, we neglected the subtraction of the 500 cfs from the 3000 cfs in our post-construction model.

A multi-cell box was constructed approximately 500 feet south of the intersection of Arrowcreek and Wedge Parkways to perpetuate the alignment of the main channel and overflow culverts were placed north of the main channel. According to our replication of the WRC pre-project modeling, this is not where the majority of the flow was conveyed in pre-construction conditions. Figures 11 through 14 show the recreated post-construction cross sections of the crossing of Wedge Parkway with the flow distribution of the culverts shown in Figure 11. In the 3000 cfs event, the farthest left culvert conveys 1096 cfs. This flow plus a portion of that conveyed by the middle culvert will flow directly to the Phase VI Wedge Meadows site. We believe that the placement of the culverts effectively changed the course of a large portion of the Reach 3 flood. Previously, according to the WRC pre-construction model, the majority of the flow was conveyed along the right or southern portion of the floodplain. The construction of the roadway and culverts forces the flow to be concentrated in the north and directs a large quantity to flow directly north to flow to the Phase VI site. Even if 500 cfs were to weir over the southern portion of the roadway, the northern and middle culvert would still convey a large portion of the 3000 cfs.

A one-dimensional steady state model is not an optimal way to analyze flow on an alluvial fan that can change course with each major storm event. However, if any credibility was given to the analysis at the time of the construction, it is unclear why the culverts were clustered near the low point of the road but the not the major flow paths of the reach.

Step 2) As stated above, we do not agree with the cross section placement of the WRC model which favors flow concentration within the right portions of the cross sections. Although the alignment according to WRC better supports our argument, we feel it is necessary to more accurately model the reach with HEC-RAS based on the pre-construction topography. Our goal is to better estimate how much flow would have left reach 3 and commingled with Reach 2 and impacted Wedge Meadows in the 3000 cfs flood prior the construction of the roadways.

We built our own models from pre-construction topography to better analyze the pre-project conditions. We first looked at the area just downstream of Whites Creek Road, since this is a major area of Reach 2 and Reach 3 flow mingling. The topography presented within the WRC and HLA reports does not completely cover this section of Whites Creek Reach 3. However, it does include the area near the then proposed Arrowcreek Parkway where there was a short ridge that divided Reach 2 and Reach 3 before the construction of Arrowcreek Parkway. We cut the cross sections with existing topography from the City of Reno DataNavigator web site supplemented with the topography in the HLA report for the area bordering the then-proposed Arrowcreek Parkway. We ran the model with a steady-state flow of 3000 cfs and put a lateral weir along the left side at the elevation of the short ridge dividing Reach 2 and Reach 3 allowing flow to split out of the model according to the elevations of the ridge. The results of the model, labeled as Upper Three (for the upstream portion of Reach 3) are shown in Figures 15 through 24. Figure 15 shows the HEC-RAS results with the split flow analysis. Figure 16 shows the profile of the model with the lateral weir shown in dark gray. The water surface elevation is higher than the lateral weir allowing approximate 225 cfs to leave the Reach 3 and flow north to Reach 2. Figures 17 through 24 depict the cross sections with the 3000 cfs water surface elevation, again showing that flow is higher than the left side of the channel, allowing overflow. Figure 25 shows the alignment of the cross sections on the Reach 3 fan downstream of Whites Creek Road.

We then examined the portion of Reach 3 where the next split is likely to occur, near the small irrigation ditch than runs through the reach approximately 600 feet upstream of Wedge Meadows Parkway. We utilized the topography within the HLA/WRC reports for pre-construction conditions to delineate a short reach, labeled Middle Three (for the middle portion of Reach 3). The cross sections were delineated close to the alignment of the pre-project WRC cross sections but more parallel to the contours across the fan so that the elevations are more even across the sections. To estimate the spread of the flow, we inserted temporary artificial levees along the right and left sides of the main channel in the cross sections to confine flow where the main channel has adequate conveyance. The results of the modeling are shown in Figure 26 with a flow of 2775 cfs, representing the 3000 cfs run minus the 225 cfs that was computed to leave the reach in the "Upper Three" model. The cross sections are shown in Figures 27 through 30. As evident in the cross sections, the artificial levee separating flow in the main channel from the right portion of the floodplain was overwhelmed; the 2775 cfs spreads along the fan to the south. The modeling also suggests that the flood is confined along the left side and little or no flow breaks out of the channel to the north along the irrigation ditch alignment.

We continued the pre-construction model of Reach 3 with three additional cross sections near the alignment of Wedge Meadows, again aligning the cross sections similarly to WRC's but more parallel to the contours across the fan. This model was labeled "Lower Three" for the lower portion of Reach 3. Because flow breaks out to the right upstream of this area, flow was allowed to spread across the right portion of the cross sections. Artificial levees were placed along the high points of the cross section to the left of the main channel representing the relatively significant ridge to the north of the main channel, disallowing flow from spreading to the left unless these high points are overwhelmed. The results of the model are presented in Figure 26 with a flow of 2775 cfs. The cross sections are shown in Figures 31 through 33. The computed water surface elevations do not overwhelm the ridge to the right of the channel.

The cross section alignment of the middle and lower HEC-RAS models of Reach 3 is shown in Figure 34 and the computed floodplain is shown in blue. The computed floodplain matches that of WRC's closely with one significant exception. We did not find any evidence of flow overwhelming the ridge just the north of the main channel with discharges of 2775 cfs upstream and through the alignment of Wedge Parkway. Flow is confined to the main channel and to the floodplain to the south. As stated above, HEC-RAS is a less than optimum method to analyze flow on an alluvial fan. Large runoff events can carry high loads of debris and sediment and carve new flow paths in unexpected places. However, this current analysis more accurately represents flood conditions then previous efforts. The current analysis does show that the majority of a 3000 cfs event on Whites Creek Reach 3 would be conveyed within the main channel with significant breakout to the south and minimal breakout to the north, delivering minimal flow to the Wedge Meadows Unit VI site. The construction of the Wedge Parkway roadway and the two multi-cell box culverts north of the main channel altered the general direction of the flow to the area of Wedge Meadows Phase VI, diverting a large percentage of the flow to the north of the main channel.

The pertinent conclusions to these analyses are:

1) The HLA/WRC hydraulic analysis of the crossing of Wedge and Arrowcreek Parkways showed that the construction of Wedge and Arrowcreek Parkways with the crossings would not raise 100-year water surface elevations above pre-project conditions. The analysis did not investigate the pre- or post-project flowpaths or how the placements of the culverts would alter the flowpaths. According to the replication of the pre-project HEC-RAS modeling efforts, the majority of the 3000 cfs flow in pre-project conditions was conveyed within main channel of Reach 3 of Whites Creek with significant breakout out to the south and minimal breakout to the north.
2) The construction of Wedge Parkway and the placement of the culverts forces a large majority of a 3000 cfs flood to flow to the north where it did not go in pre-project conditions.
3) Only approximately 225 cfs would have flowed to Reach 2 and subsequently to Unit VI of Wedge Meadows with a 3000 cfs flood in Reach 3 prior the construction of Wedge and Arrowcreek Parkways.

The following is a list of figures included with this memo:

Figures 1-9: Cross sections of WRC's pre-project HEC-RAS model of Reach 3 of Whites Creek showing the 3000 cfs flow distribution as computed by HEC-RAS (replicated by Wood Rodgers).
Figure 10: Plan view of HEC-RAS cross section placement within WRC's pre-project model showing 3000 cfs flow distribution as computed by HEC-RAS (replicated by Wood Rodgers).
Figures 11-14: WRC's post-project HEC-RAS model cross sections showing the 3000 cfs flow distribution through the culverts as computed by HEC-RAS (replicated by Wood Rodgers).
Figure 15: Tabular results of Wood Rodgers pre-project HEC-RAS model of section of Reach 3 of Whites Creek from just downstream of Whites Creek roadway crossing (Upper Three) showing flow breaking from Reach 3 to Reach 2.
Figure 16: Profile of Wood Rodger's pre-project HEC-RAS model of section of Reach 3 of Whites Creek from just downstream of Whites Creek road crossing showing lateral weir between Reach 3 and Reach 2.
Figures 17-24: Cross sections of Wood Rodgers pre-project HEC-RAS model of section of Reach 3 of Whites Creek from just downstream of Whites Creek road crossing.
Figure 25: Plan view of Wood Rodgers pre-project HEC-RAS model of section of Reach 3 of Whites Creek from just downstream of Whites Creek road crossing.
Figure 26: Tabular results of Wood Rodgers pre-project HEC-RAS model of Reach 3 of Whites Creek near alignment of Wedge Parkway.
Figures 27-33: Cross sections of Wood Rodgers pre-project HEC-RAS model of Reach 3 of Whites Creek near alignment of Wedge Parkway.
Figure 34: Plan view of Wood Rodgers pre-project HEC-RAS model of Reach 3 of Whites Creek near alignment of Wedge Parkway.

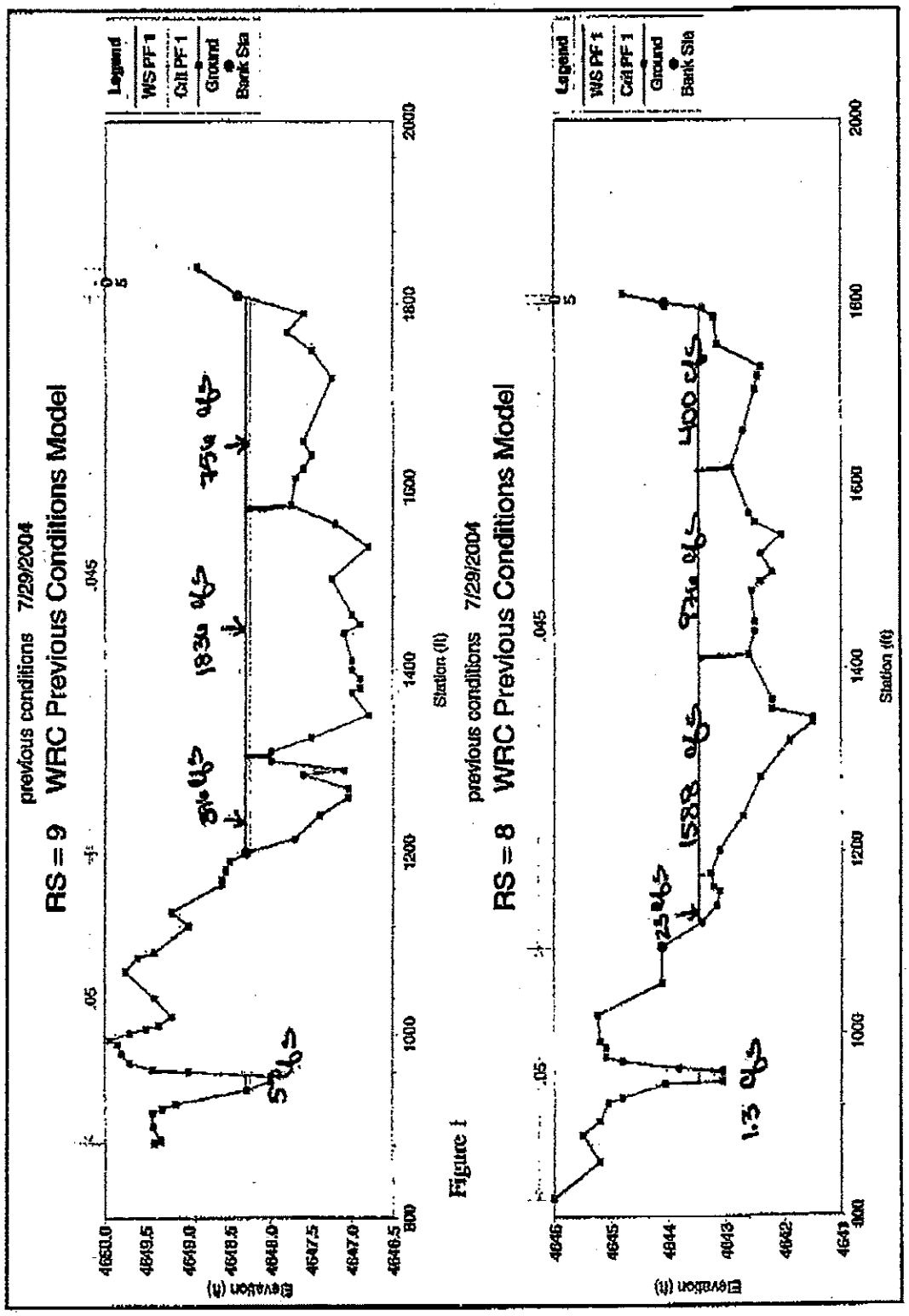


Figure 1

Figure 2

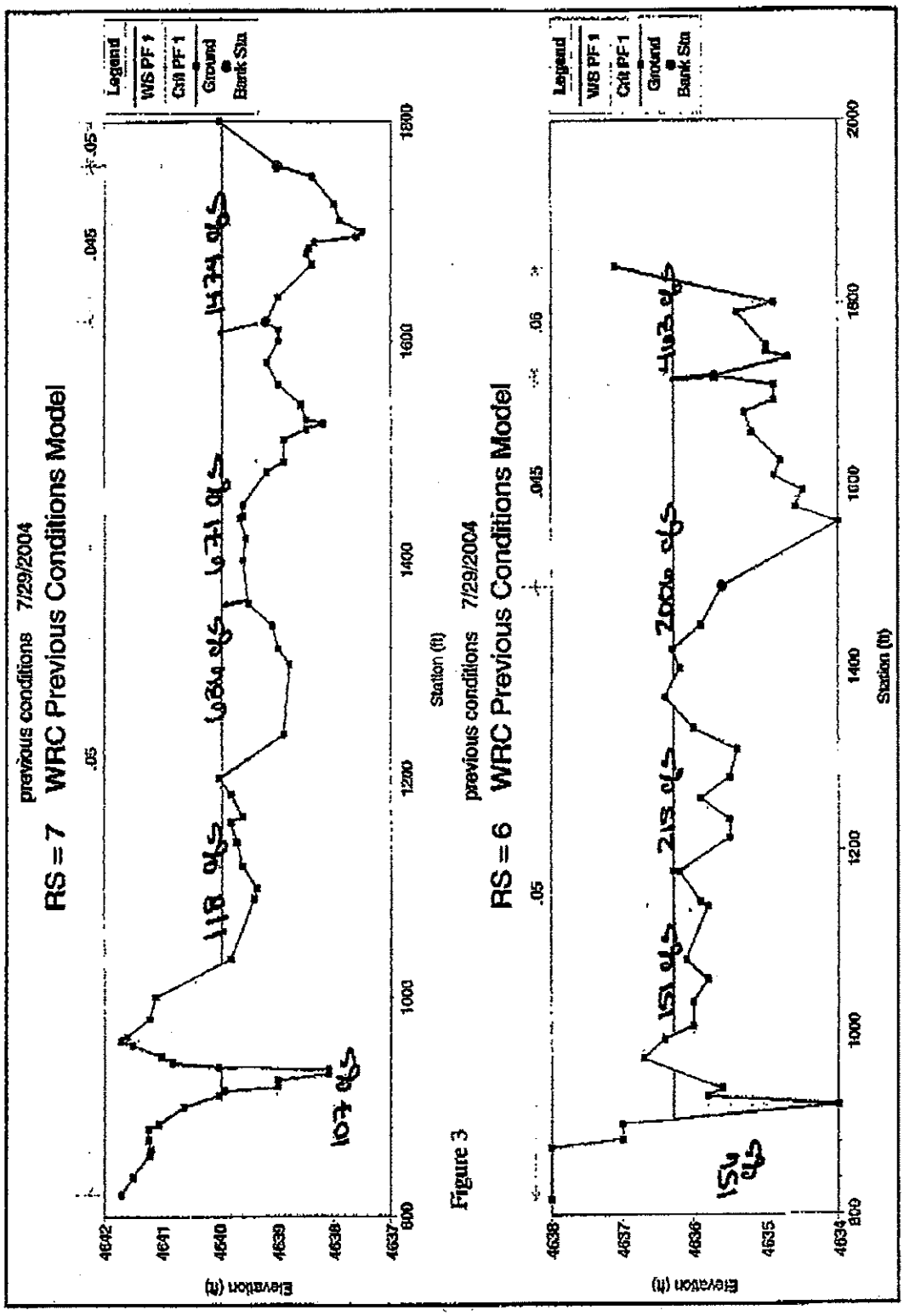


Figure 3

Figure 4

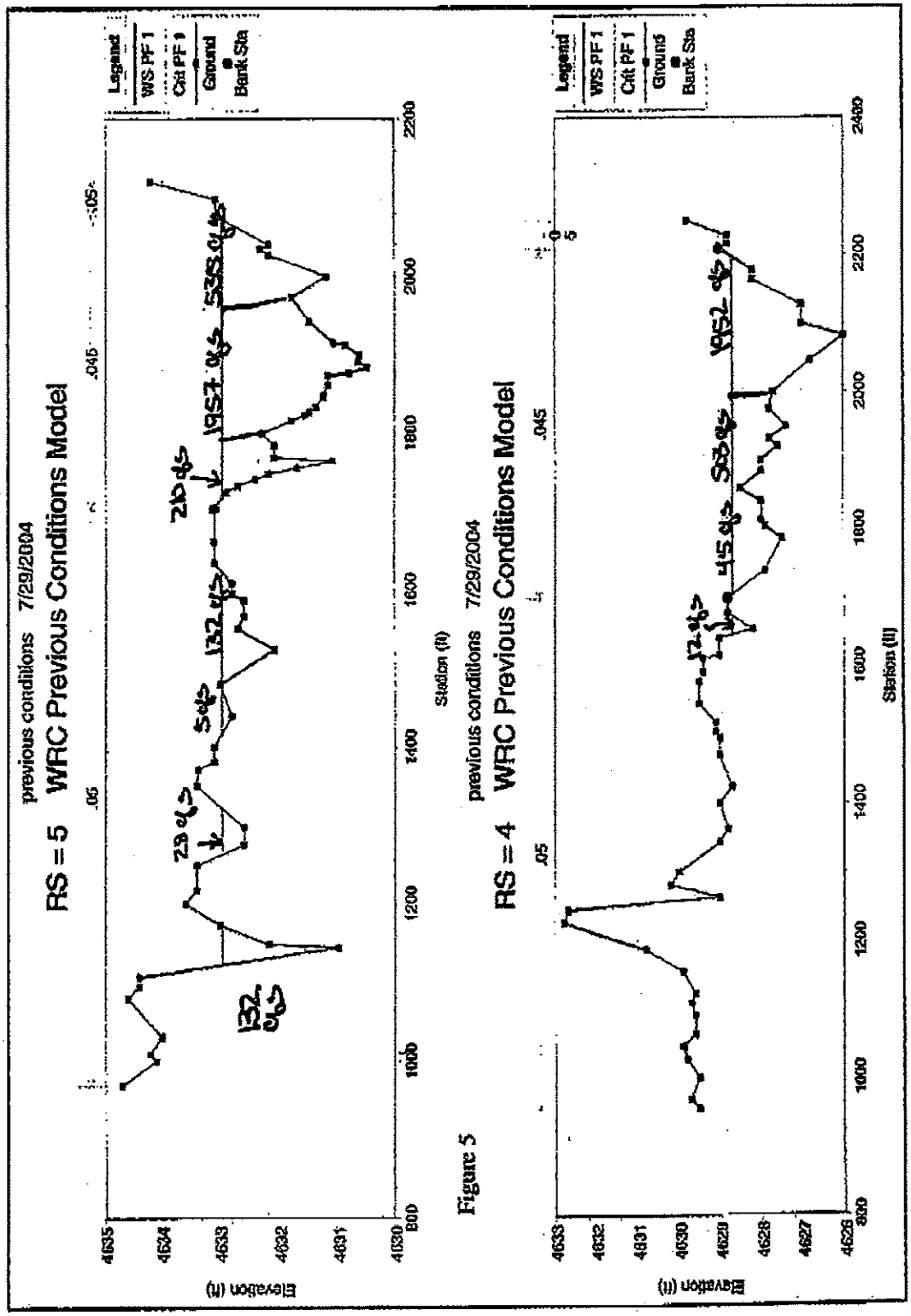


Figure 5

Figure 6

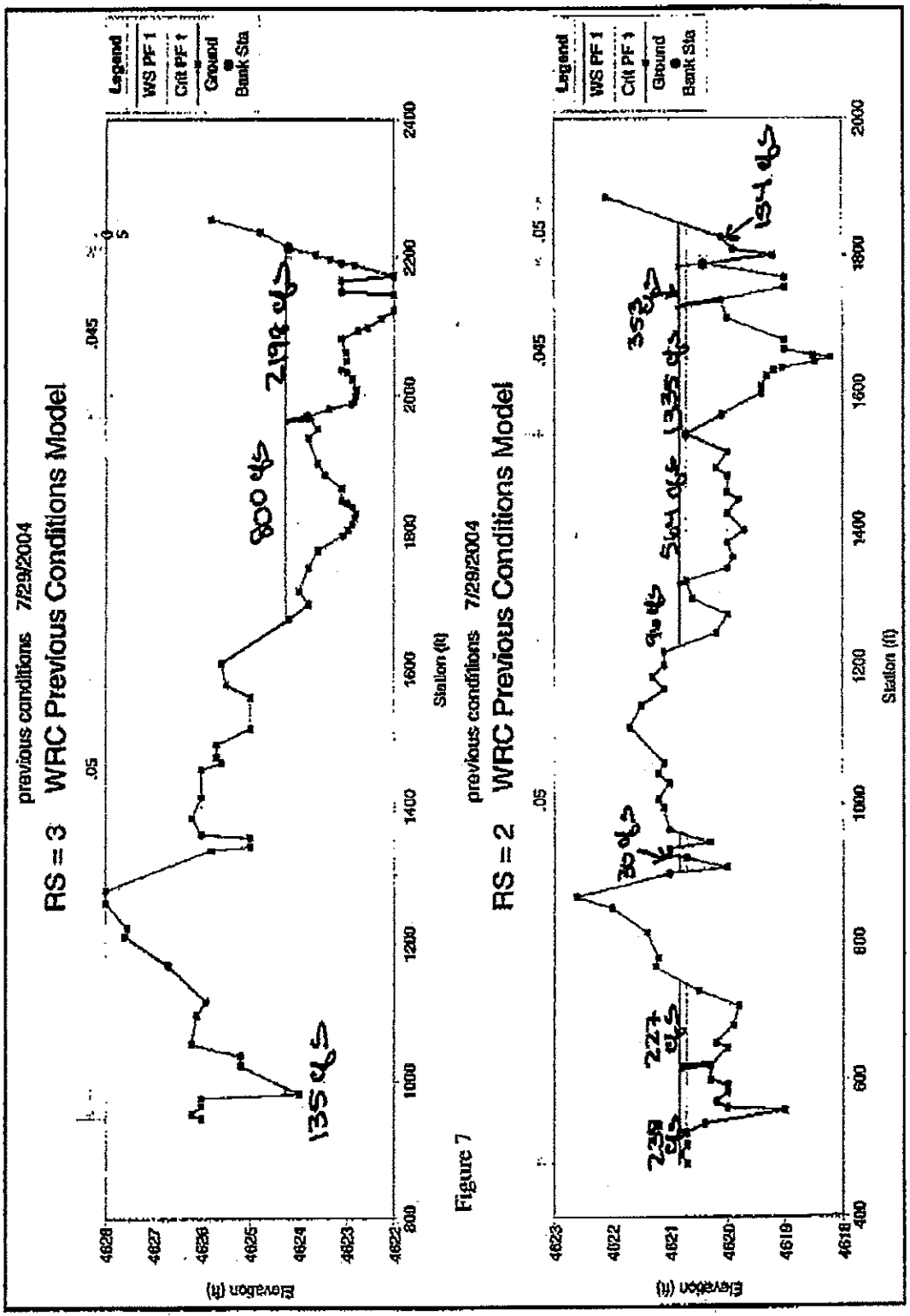


Figure 7

Figure 8

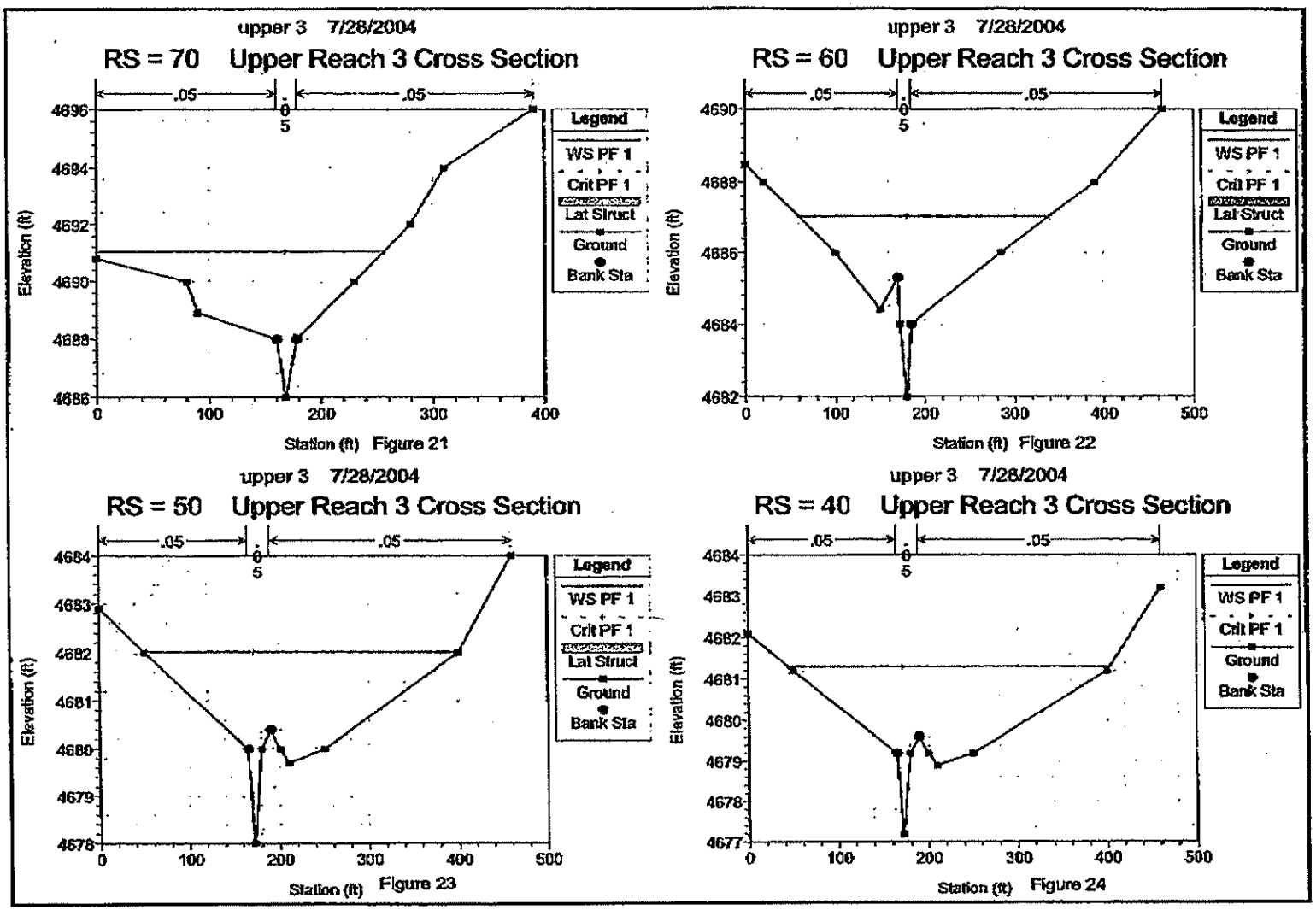


Figure 21 Figure 22 Figure 23 Figure 24

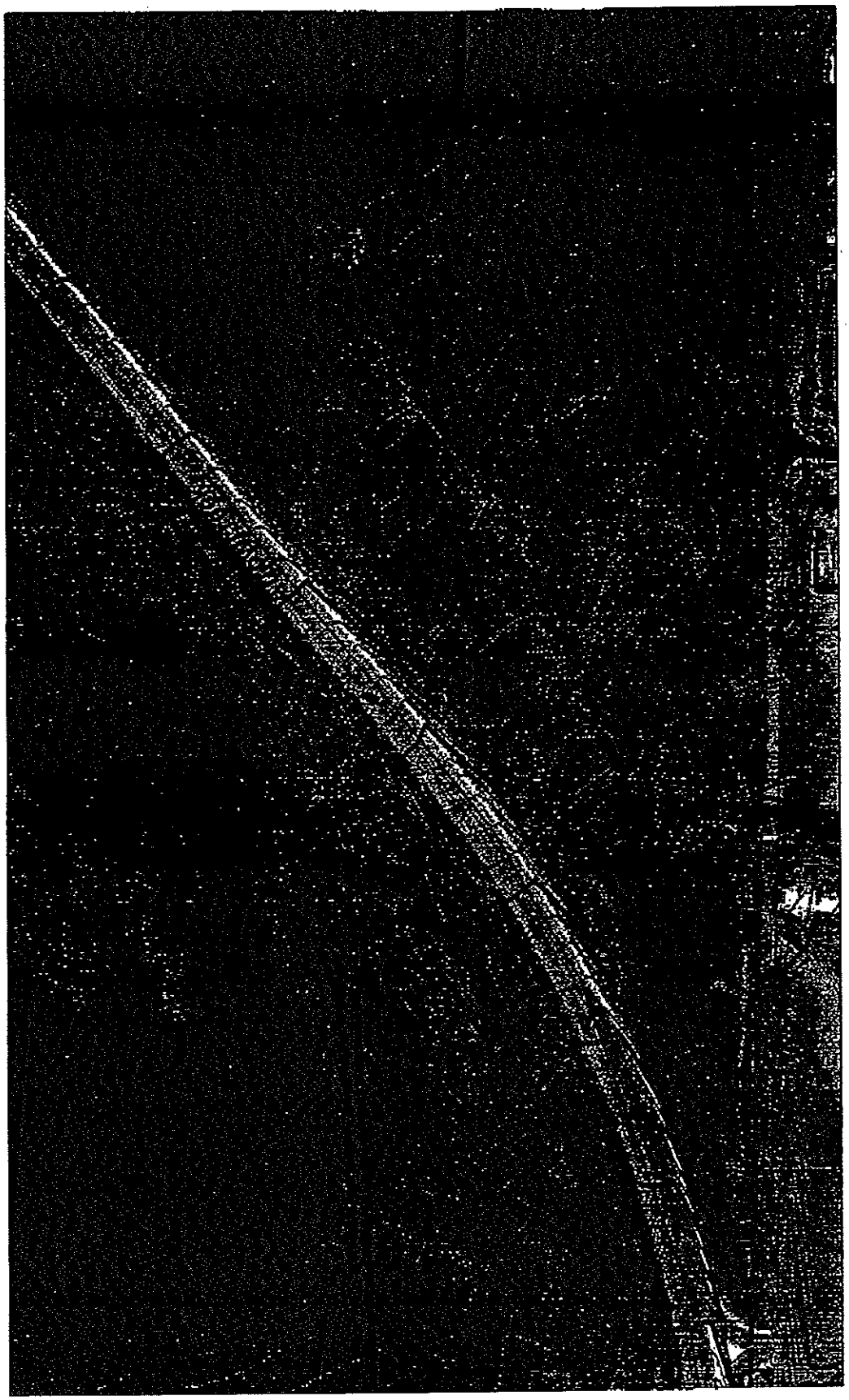


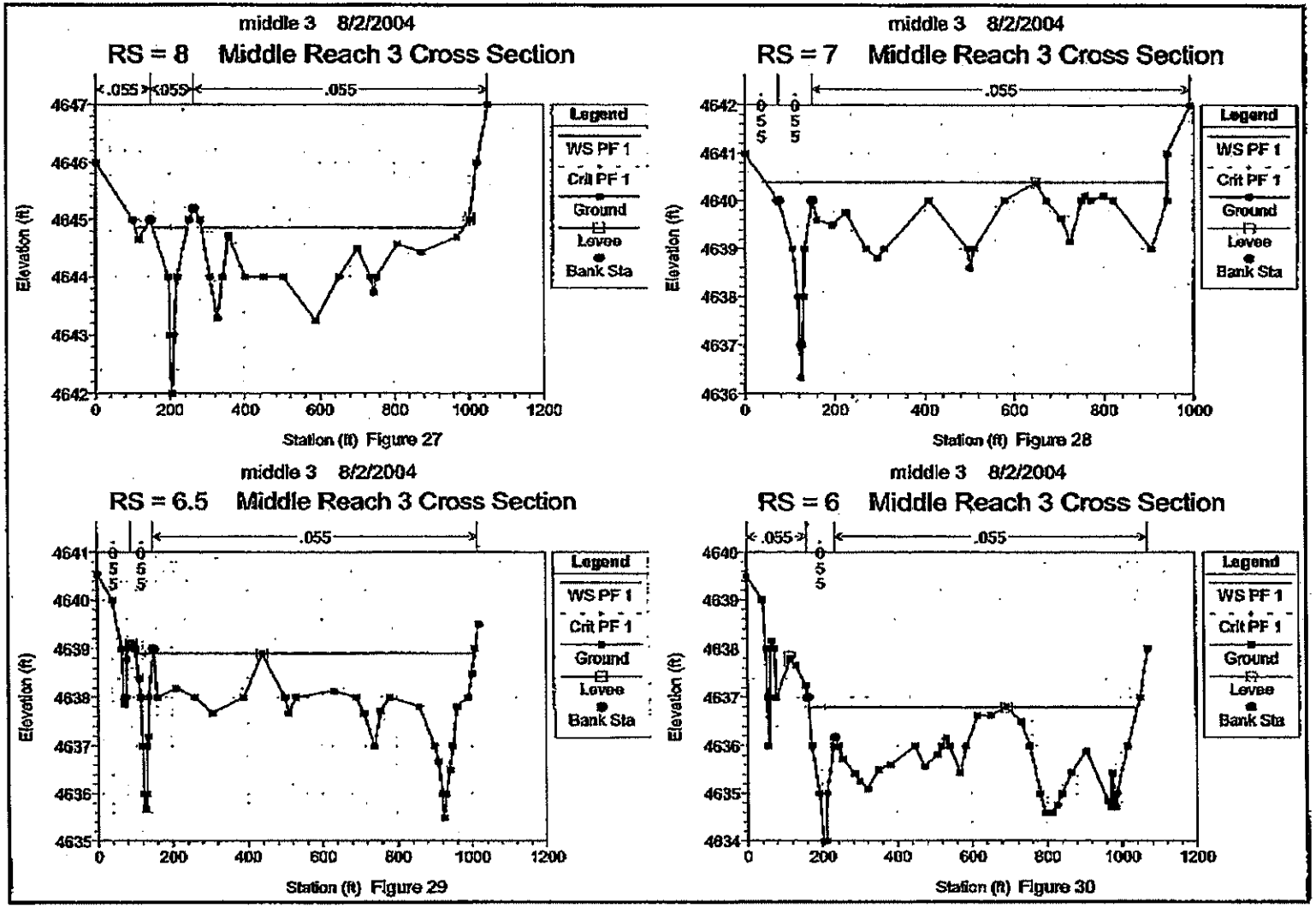
Figure 26: Pre-construction Middle and Lower Reach 3 HEC-RAS Results

HEC-RAS Plan: middle3 River: Reach 3 Reach: Middle Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Middle	8	PF 1	2775	4642	4644.88	4644.88	4645.22	0.046206	4.91	588.35	824.74	0.98
Middle	7	PF 1	2775	4636.33	4640.39	4640.39	4640.63	0.023355	5.31	736.74	894.04	0.77
Middle	6.5	PF 1	2775	4635.67	4638.91	4638.91	4639.04	0.011338	3.32	939.87	904.46	0.52
Middle	6	PF 1	2775	4634	4636.8	4636.8	4636.93	0.009852	3.49	959.75	878.17	0.5

HEC-RAS Plan: lower3 River: Whites Creek Reach: lower 3 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
lower 3	3.5	PF 1	2775	4629	4630.67	4630.52	4630.98	0.025677	4.4	620.44	679.01	0.76
lower 3	2.5	PF 1	2775	4623.1	4625.44	4625.36	4625.78	0.032686	5.65	594.4	642.42	0.89
lower 3	1.5	PF 1	2775	4618	4620.4	4620.38	4620.69	0.035065	4.93	653.45	918.22	0.88


middle 3 8/2/2004
RS = 8 Middle Reach 3 Cross Section
.055
.055
.055
Legend
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft) Figure 27
middle 3 8/2/2004
RS = 7 Middle Reach 3 Cross Section
.055
Legend
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft) Figure 28
middle 3 8/2/2004
RS = 6.5 Middle Reach 3 Cross Section
.055
Legend
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft) Figure 29
middle 3 8/2/2004
RS = 6 Middle Reach 3 Cross Section
.055
.055
Legend
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft) Figure 30

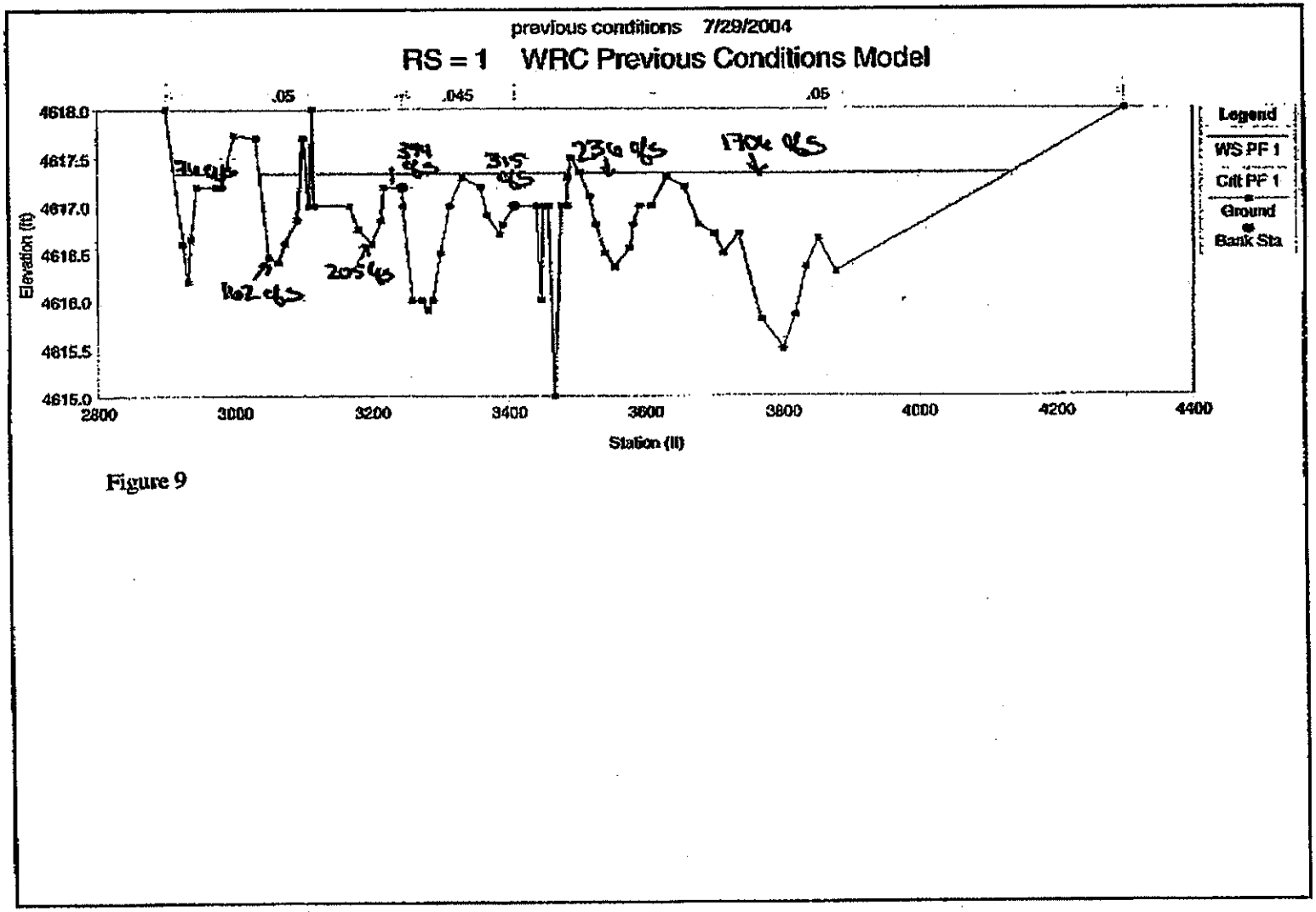
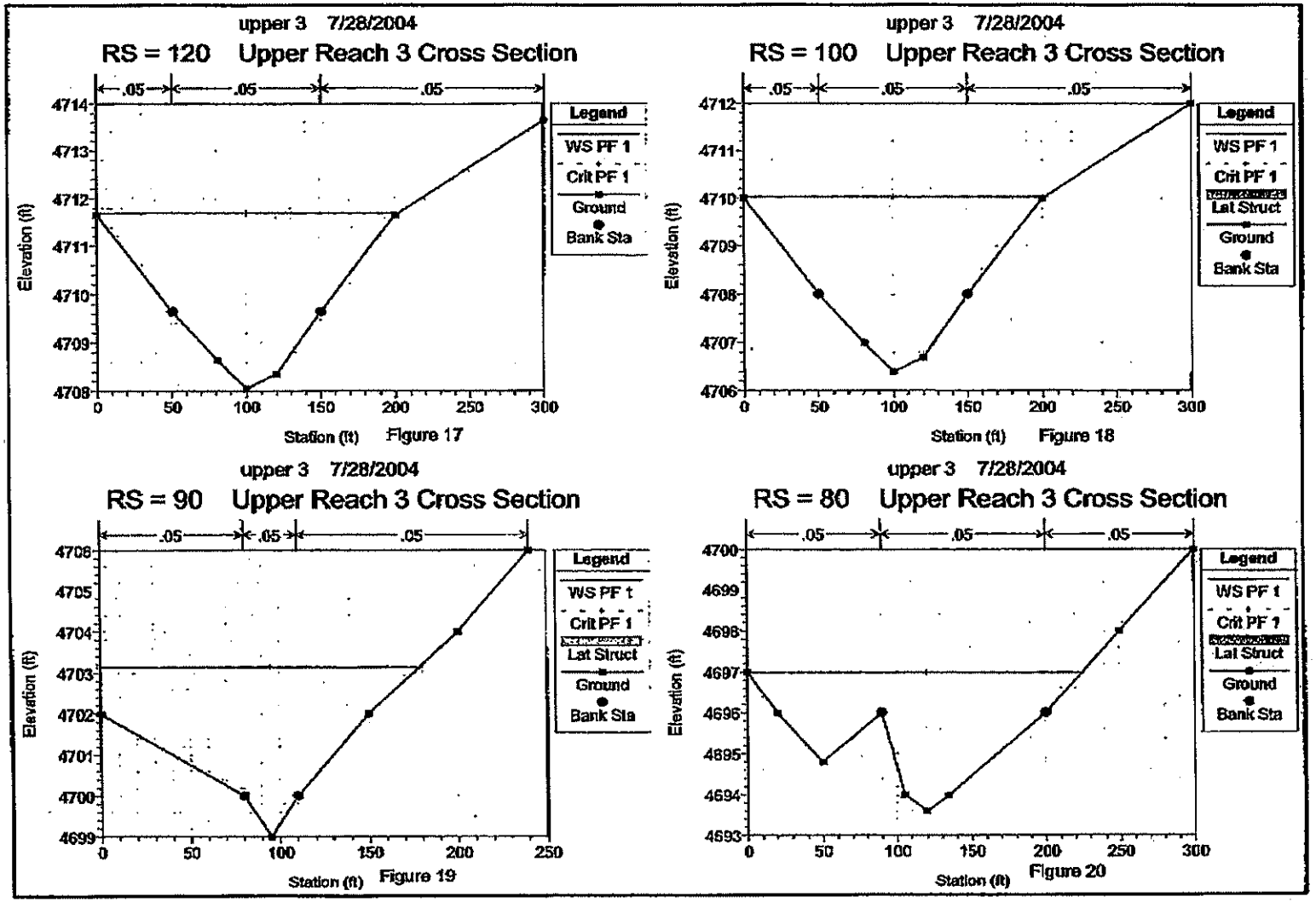


Figure 9


upper 3 7/28/2004
RS = 120 Upper Reach 3 Cross Section
.05
.05
.05
Legend
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Figure 17
upper 3 7/28/2004
RS = 100 Upper Reach 3 Cross Section
Legend
WS PF 1
Crit PF 1
Lat Struct
Ground
Bank Sta
Station (ft)
Figure 18
upper 3 7/28/2004
RS = 90 Upper Reach 3 Cross Section
Station (ft)
Figure 19
upper 3 7/28/2004
RS = 80 Upper Reach 3 Cross Section
Station (ft)
Figure 20

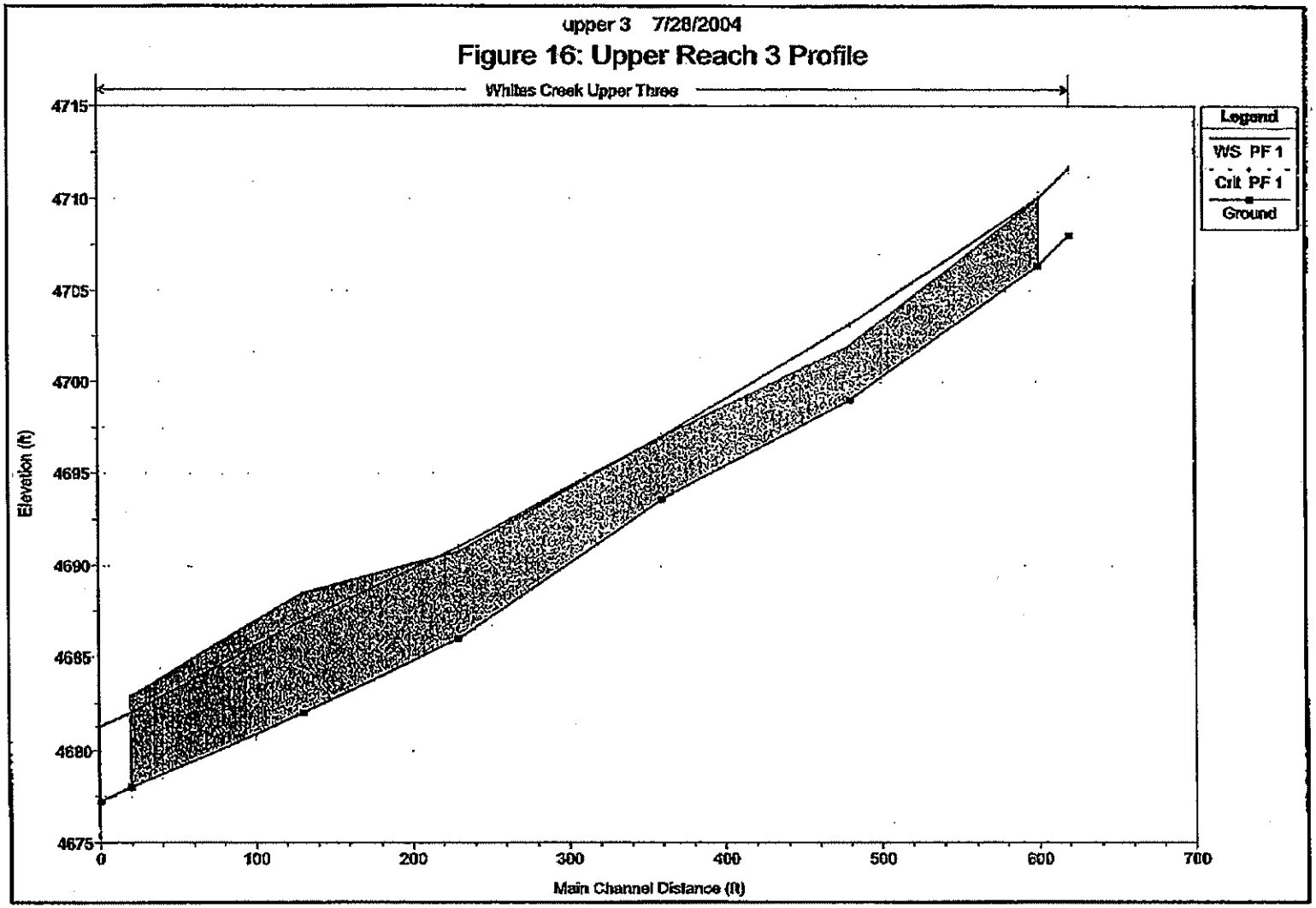

upper 3 7/28/2004
Figure 16: Upper Reach 3 Profile
Whites Creek Upper Three
Legend
WS PF 1
Crit PF 1
Ground
Elevation (ft)
4715
4710
4705
4700
4695
4690
4685
4680
4675
0
100
200
300
400
500
600
700
Main Channel Distance (ft)

Figure 15: Pre-construction Upper Reach 3 HEC-RAS Results

HEC-RAS Plan: up3 River: Whites Creek Reach: Upper Three Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper Three	120	PF 1	3000.00	4708.05	4711.69	4711.69	4712.73	0.020372	8.68	397.74	202.05	0.89
Upper Three	100	PF 1	3000.00	4708.40	4710.04	4710.04	4711.08	0.020372	8.69	397.74	202.05	0.89
Upper Three	99		Lat Struct									
Upper Three	90	PF 1	2879.81	4699.00	4703.14	4703.14	4704.17	0.020766	10.12	382.36	178.52	0.93
Upper Three	80	PF 1	2764.83	4693.60	4696.99	4696.99	4697.86	0.024007	8.05	387.87	224.47	0.83
Upper Three	70	PF 1	2760.69	4686.00	4691.04	4691.04	4691.81	0.016769	10.17	441.87	256.11	0.89
Upper Three	60	PF 1	2748.94	4682.00	4687.02	4687.02	4687.75	0.021907	10.25	440.58	279.04	0.93
Upper Three	50	PF 1	2748.94	4676.00	4682.01	4682.01	4682.65	0.026480	8.86	458.12	351.13	0.88
Upper Three	40	PF 1	3000.00	4677.20	4681.30	4681.30	4681.96	0.026131	9.09	469.32	358.65	0.98

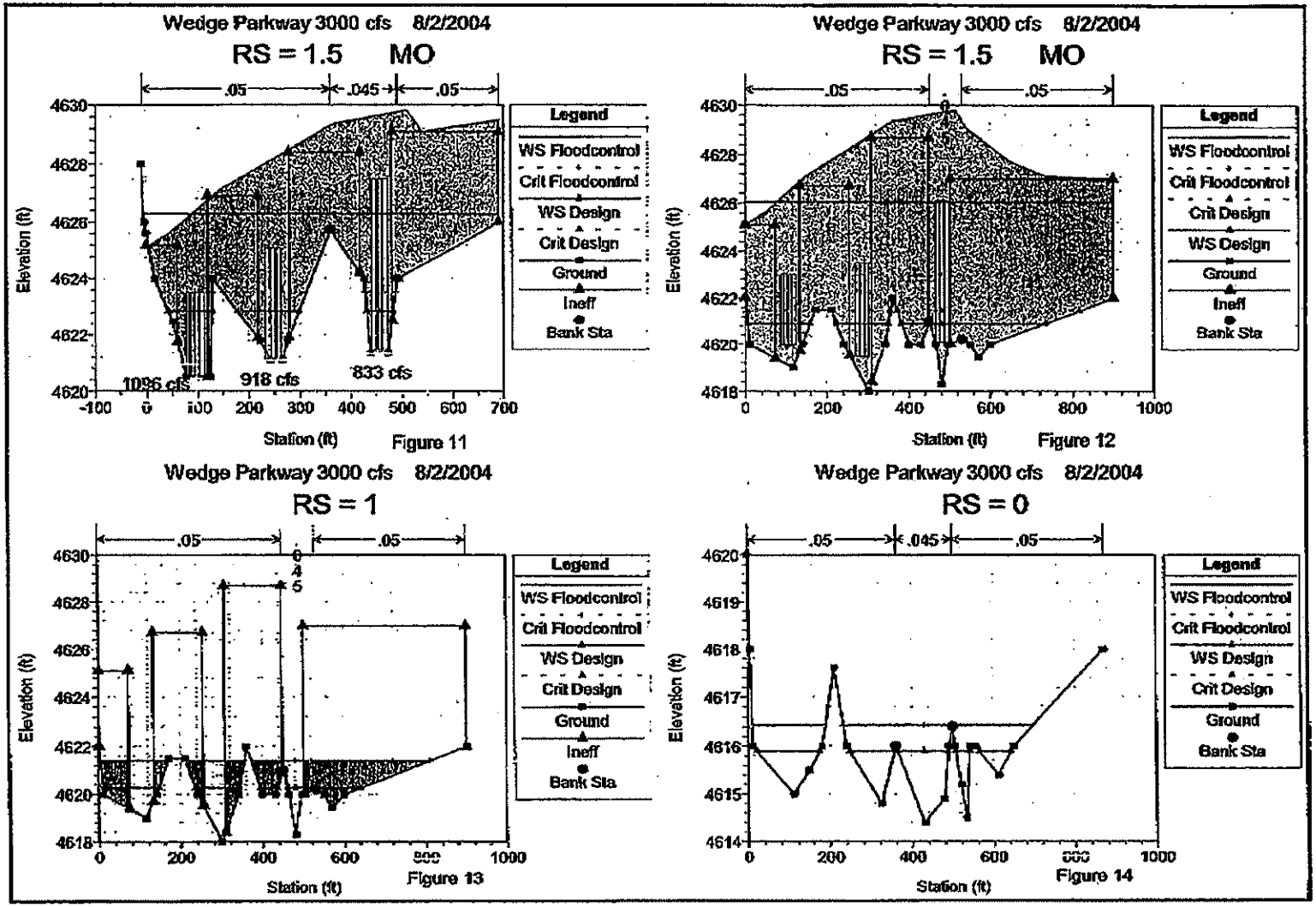
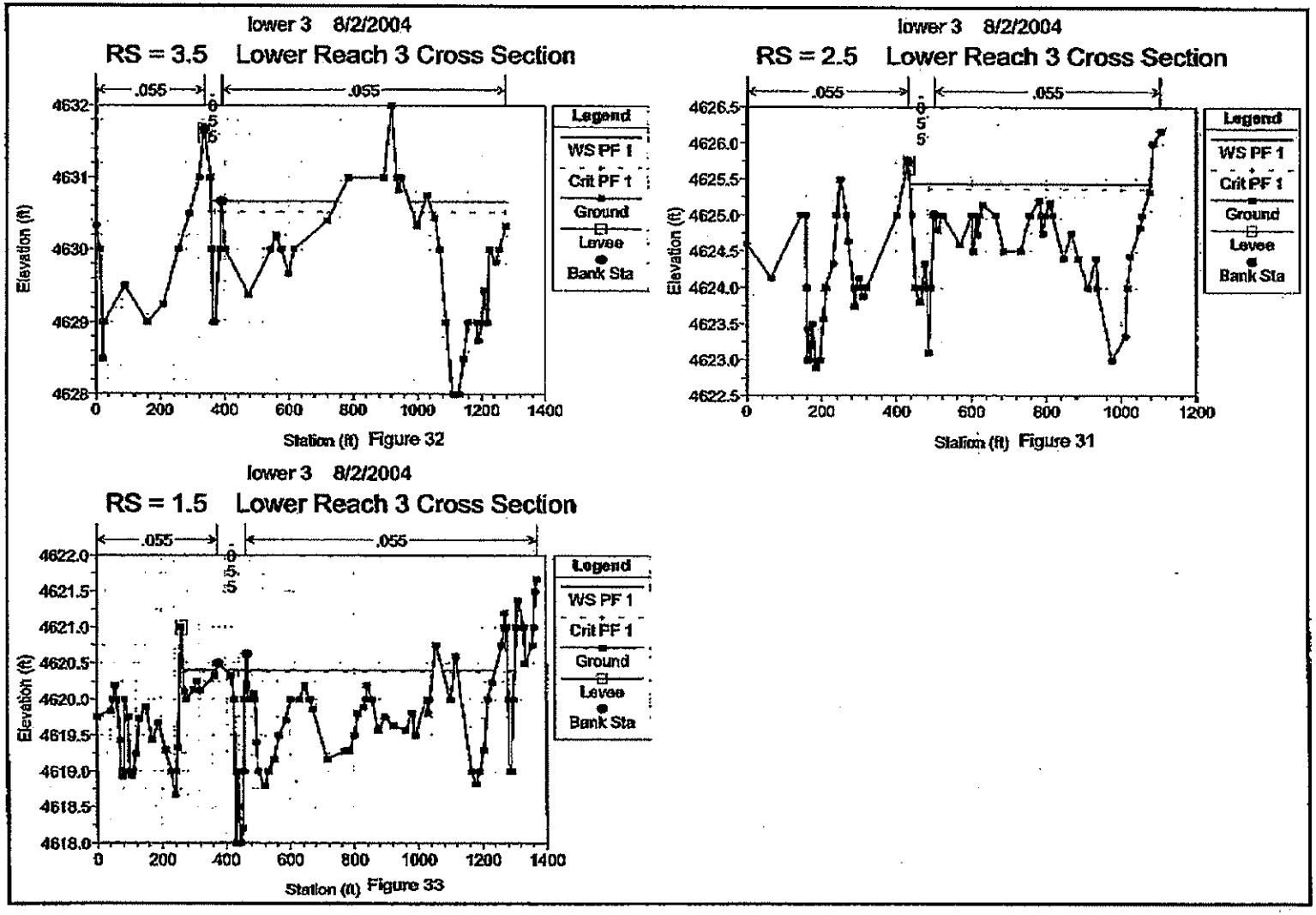

Wedge Parkway 3000 cfs 8/2/2004
RS = 1.5 MO
.05
.045
.05
Elevation (ft)
Station (ft)
1096 cfs
918 cfs
833 cfs
Legend
WS Floodcontrol
Crit Floodcontrol
WS Design
Crit Design
Ground
Ineff
Bank Sta
Figure 11
Wedge Parkway 3000 cfs 8/2/2004
RS = 1.5 MO
Figure 12
Wedge Parkway 3000 cfs 8/2/2004
RS = 1
Figure 13
Wedge Parkway 3000 cfs 8/2/2004
RS = 0
Figure 14

Figure 10 WRC Flow Distribution

1586 cfs Distributed Flow in HEC-RAS Cross-Section

WRC Existing Condition Model


lower 3 8/2/2004
RS = 3.5 Lower Reach 3 Cross Section
.055
.055
0.05
Legend
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
lower 3 8/2/2004
RS = 2.5 Lower Reach 3 Cross Section
Figure 32
Figure 31
lower 3 8/2/2004
RS = 1.5 Lower Reach 3 Cross Section
Figure 33