APPENDIX B

DECEMBER 31, 2008 REPORT

DTA **Devine Tarbell & Associates, Inc.**
Consulting Engineers, Scientists, & Regulatory Specialists
An Employee-Owned Company

December 31, 2008

Mr. Raymond L. McCoy
Mail Code ON02MO
Oconee Nuclear Station
7800 Rochester Highway
Seneca, SC 29672

Subject: **Oconee Nuclear Station**
Model Simulation Results for Jocassee Dam Failure Report

Dear Mr. Mc Coy:

The Keowee Hydroelectric Development is owned and operated by Duke Energy Carolinas, LLC (Duke Energy) and is part of the Keowee-Toxaway Project licensed by the Federal Energy Regulatory Commission (FERC) as Project No. 2503-SC. The Keowee-Toxaway Project (Project) includes the Jocassee Pumped Storage Development and the Keowee Development. The FERC regulates the Project and their role includes regulatory oversight of all water retaining structures at both developments. The Oconee Nuclear Station (ONS) is located on Lake Keowee adjacent to the Keowee Dam and tailrace. Based on a request for additional information concerning flooding impacts at ONS from a hypothetical failure of the Jocassee Dam, Devine Tarbell & Associates, Inc. (DTA) was commissioned by Duke Energy to develop a dam breach failure model using the U.S. Army Corps of Engineers (USACE) HEC_RAS v4 unsteady flow program and compare the output from the HEC_RAS model to results from Jocassee Dam failure simulations using the National Weather Service (NWS) DAMBRK model. The emergency action plan (EAP) model was previously developed by Duke Energy and results were submitted to FERC in 1992. DTA was selected to perform this work based on experience with the HEC_RAS and DAMBRK models and development of the 1992 Jocassee EAP dam failure scenarios.

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DTA

1.0 Purpose

Duke Energy requested that DTA develop an unsteady flow model of the Jocassee/Keowee reservoir system using the HEC_RAS program. The HEC_RAS model would be developed from available Digital Elevation Model (DEM) and U.S. Geological Survey (USGS) data using a combination of electronic files and paper maps. The HEC_RAS model is a 1-dimensional dynamic flow model used for estimating inundation due to hypothetical dam failures or to study historic dam failure events. HEC_RAS is a graphical input-based software program that has an available geographic information systems (GIS) interface and post processing tools to support input and review output. The resulting HEC_RAS model would be used to study inundation as the result of a hypothetical failure of the Jocassee rock-filled dam, owned and maintained by Duke Energy.

The scope of this work covers the development of the base geometric data file required for the HEC_RAS model and to run a series of model scenarios that were previously simulated using the 1992 EAP DAMBRK model in September 2008. The purpose of this software conversion is to compare the outputs (resulting flood inundation elevations) of the two software tools while using the same breach parameters used in the 1992 EAP DAMBRK scenarios. The eight scenarios for this study use starting reservoir elevations for Lake Jocassee ranging from 1080 to 1108 feet mean sea level (ft msl) and Lake Keowee reservoir elevations of 796, 797, and 798 ft msl.

Two of the eight scenarios were modeled assuming a bottom of breach elevation at Jocassee Dam of 919 ft msl, as was used in the 1983 analysis for the design of the SSF wall at Oconee. This input parameter differed from the elevation assumed for the FERC EAP analyses, which used a bottom of breach elevation of 800 ft msl, the full reservoir elevation at Lake Keowee.

2.0 Scope/Models

The hydraulic modeling performed in 1992 to develop FERC required EAP inundation mapping was simulated using a "Mainframe" compiled version of the DAMBRK computer program developed by D.L. Fread. Details of the 1992 model input development are outlined in the referenced report and are not repeated in this summary report. The DAMBRK model used a total of seven top widths and 31 cross sections to model the river reach between Jocassee, Keowee, and Hartwell dams. All model scenarios for this project use "Sunny Day" inflow hydrographs.

The HEC_RAS model developed for this review is being constructed in phases, as is typical for 1-dimensional modeling of complex hydraulic channels such as the terrain associated with the Jocassee/Keowee river basin. The model development started using a simple geometric replication of the Keowee River arm of the reservoir that is directly downstream of the Jocassee Dam. DEMs, pre-filling topography, and USGS 1:24,000 topographic maps were used to construct cross sections representing the flow reach between Jocassee Dam and Keowee Dam. Unlike the eight top width cross section limitations in DAMBRK, the HEC_RAS model supports

the input of more complex cross section geometry. This feature was fully utilized by DTA modelers to provide additional reach channel flow and storage definition. Water storage in large tributaries of the Keowee River arm of the reservoir was added to the model using storage compartments similar to the off-channel storage methods used in the DAMBRK model. The initial test version of the HEC_RAS model included a storage compartment controlled by an inline channel structure (weir flow control) to simulate the storage in the Little River arm of the reservoir. This was similar to the method used in the DAMBRK model. As the model was refined, the inline channel structure was replaced using a river branch to simulate the storage area in the Little River arm. This feature is not available in the DAMBRK model.

As part of the refinement of the HEC_RAS model, the river reach downstream of Keowee Dam began with a few simple river cross sections and was developed to include additional cross sections and storage in Lake Hartwell, as needed, to review the downstream routing impacts of the dam breach flood wave.

As stated above, the development of the HEC_RAS model is an ongoing project that requires refinement as scenarios are developed and run. This process is followed to isolate problem areas where instabilities arise due to the complex mathematics that are solved to provide estimates of inundation flood levels. The model results presented in this report represent a 1-dimensional flow model that contains significantly more geometric and hydraulic channel data than is contained in the DAMBRK model (Figure 1).

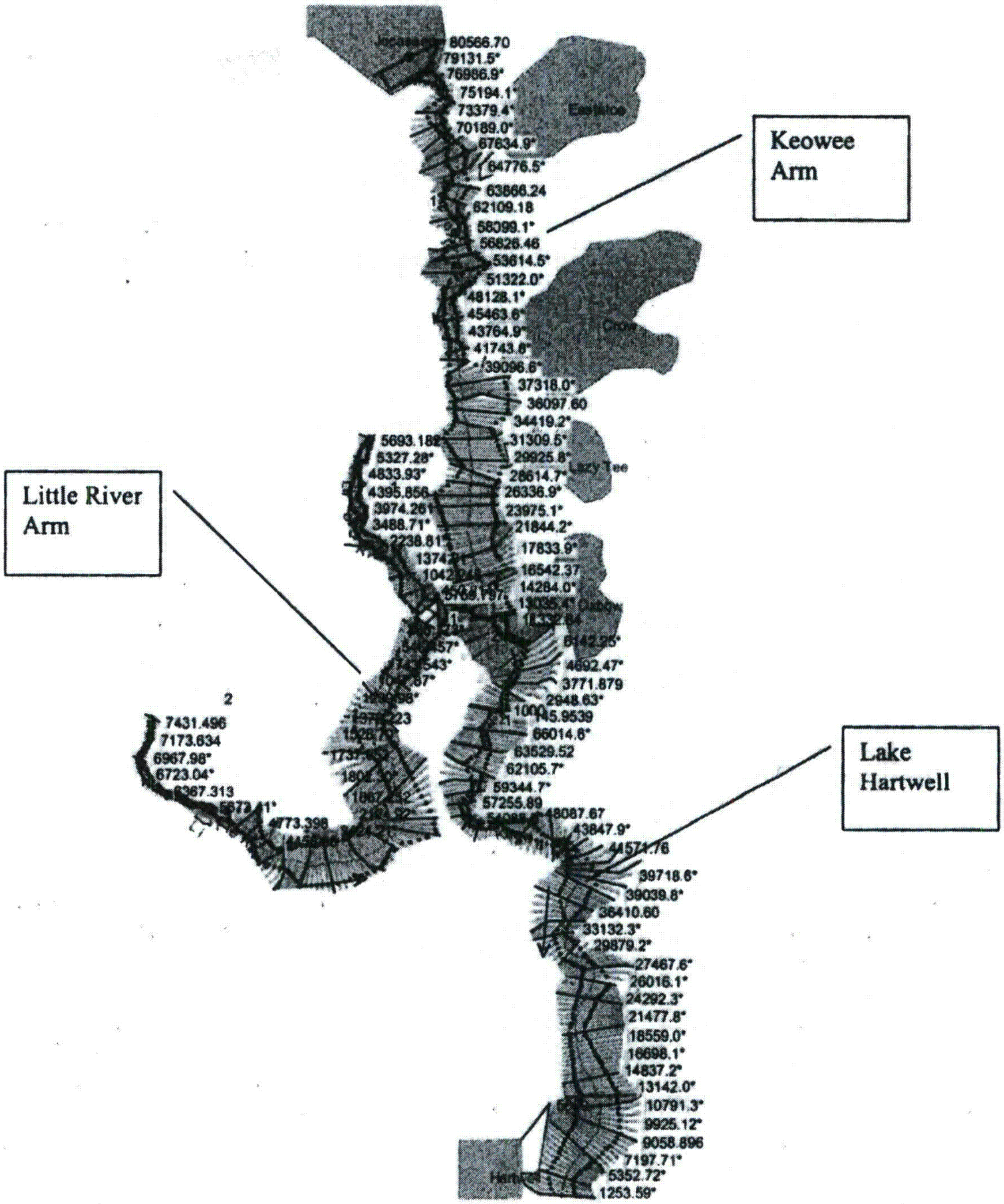


Figure 1 HEC_RAS Model Geometry File

In all HEC_RAS scenarios, the Jocassee Dam failure was simulated in the main rock-filled section by piping starting at elevation 940 ft msl except for two scenarios that included a modified bottom of breach elevation at 919 ft msl. For those two scenarios, a piping failure was assumed to occur at elevation 940 ft msl (Figure 2). No other changes in breach parameters were assumed.

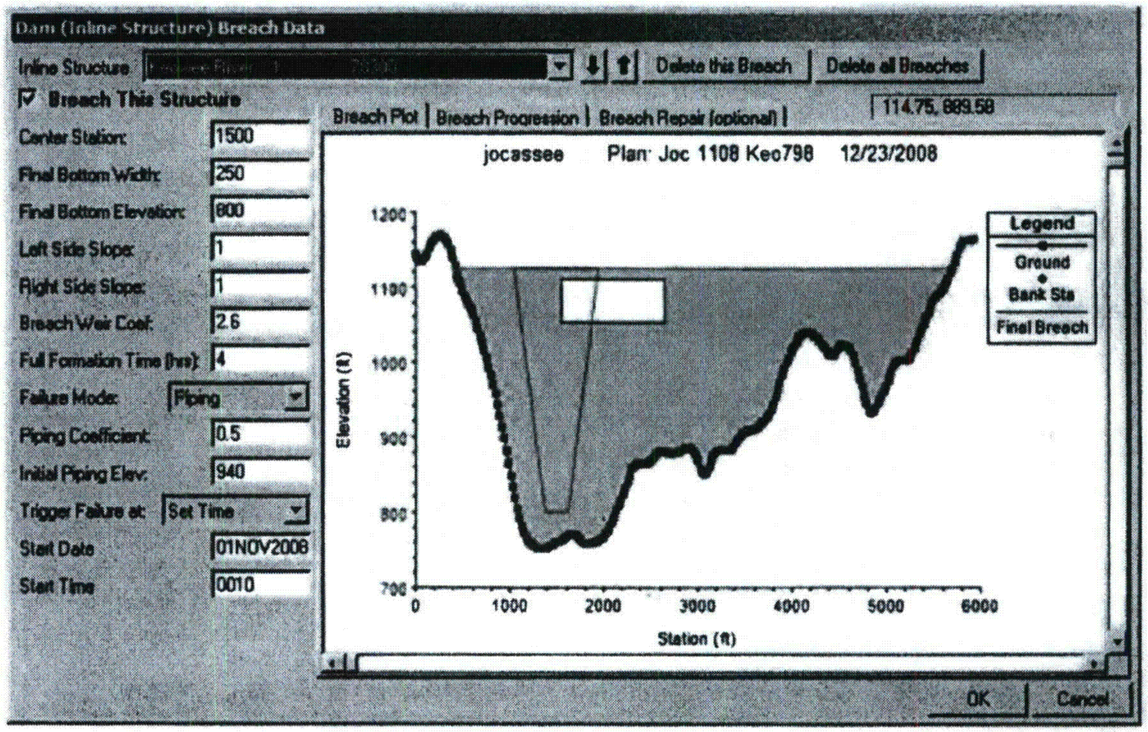


Figure 2 Jocassee Dam Breach Parameters

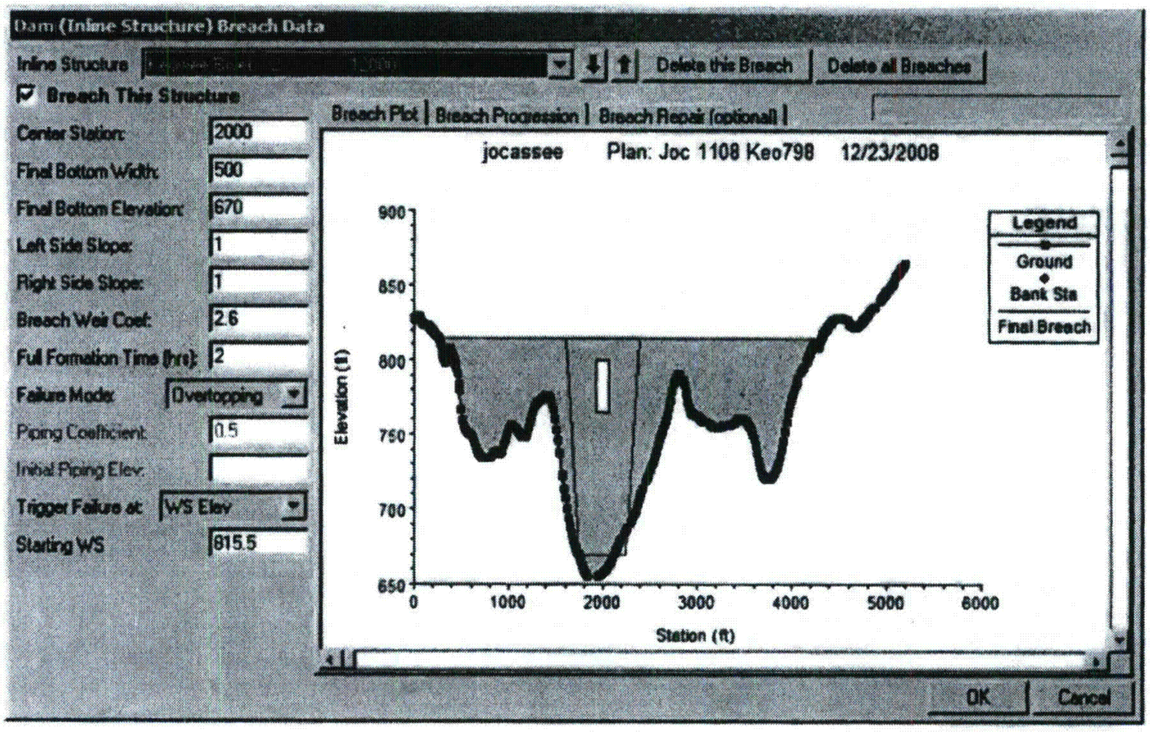


Figure 3 Keowee Dam Breach Parameters

Dam failure parameters used in the EAP analysis were based on FERC guidelines with consideration for generating inundation maps for emergency management planning purposes. The DAMBRK model requires a bottom of breach elevation, side slope, and time to complete failure parameters. HEC_RAS requires the same parameters. Figures 2 and 3 and the following two figures from the 1992 EAP report show the extent of the simulated breach shape for all runs except JOSD22 and JOSD23 (Table 1), which differ in final breach bottom.

Jocassee reservoir storage was input in HEC_RAS as a function of elevation while an area-elevation curve was input in DAMBRK. Table 2 illustrates the storage table used in HEC_RAS.

The Jocassee failure in both models is triggered as a piping failure assuming a linear failure progression over the failure time, in this case 4 hours. Keowee Dam failure is the result of overtopping at a set elevation of 0.5 ft over the top of the dam (815.5 ft) with the breach failure occurring over 2 hours.

Table 1 Definition of DAMBRK Modeled Scenarios

Model Name	DAMBRK Analysis File Name	Jocassee Dam Failure Breach Bottom Elev.	Pond Levels at Lake Keowee/ Lake Jocassee (ft msl)
Restored "1992"	JOSD106	1992 shape	798/1108
"1992" Current Levels	JOSD16	1992 shape	797/1085
Sensitivity Case 2	JOSD21	1992 shape	797/1090
Sensitivity Case 5	JOSD09	1992 shape	796/1080
Sensitivity Case 6	JOSD10	1992 shape	796/1085
Sensitivity Case 1	JOSD15	1992 shape	796/1090
Sensitivity Case 4	JOSD23	1983 shape 919 ft msl	798/1108
Sensitivity Case 3	JOSD22	1983 shape 919 ft msl	797/1090

Table 2 Jocassee Storage Table

Storage Area: Jocassee Volume Elevation Relationship

Plot Table

	Vol-Elev Volume (acre-ft)	Vol-Elev Elevation (ft)
1	0.000	740.000
2	0.100	760.000
3	1650.000	780.000
4	16061.000	820.000
5	237851.000	940.000
6	483103.000	1000.000
7	693303.000	1040.000
8	944600.000	1080.000
9	1013998.000	1090.000
10	1065898.000	1100.000
11	1160298.000	1110.000
12	1237250.000	1120.000

Examples of input cross sections for each of the river reaches in the current model are included as attachments to this submittal. Flow elevations shown in cross sections are for a typical test scenario that was used during the development of the model.

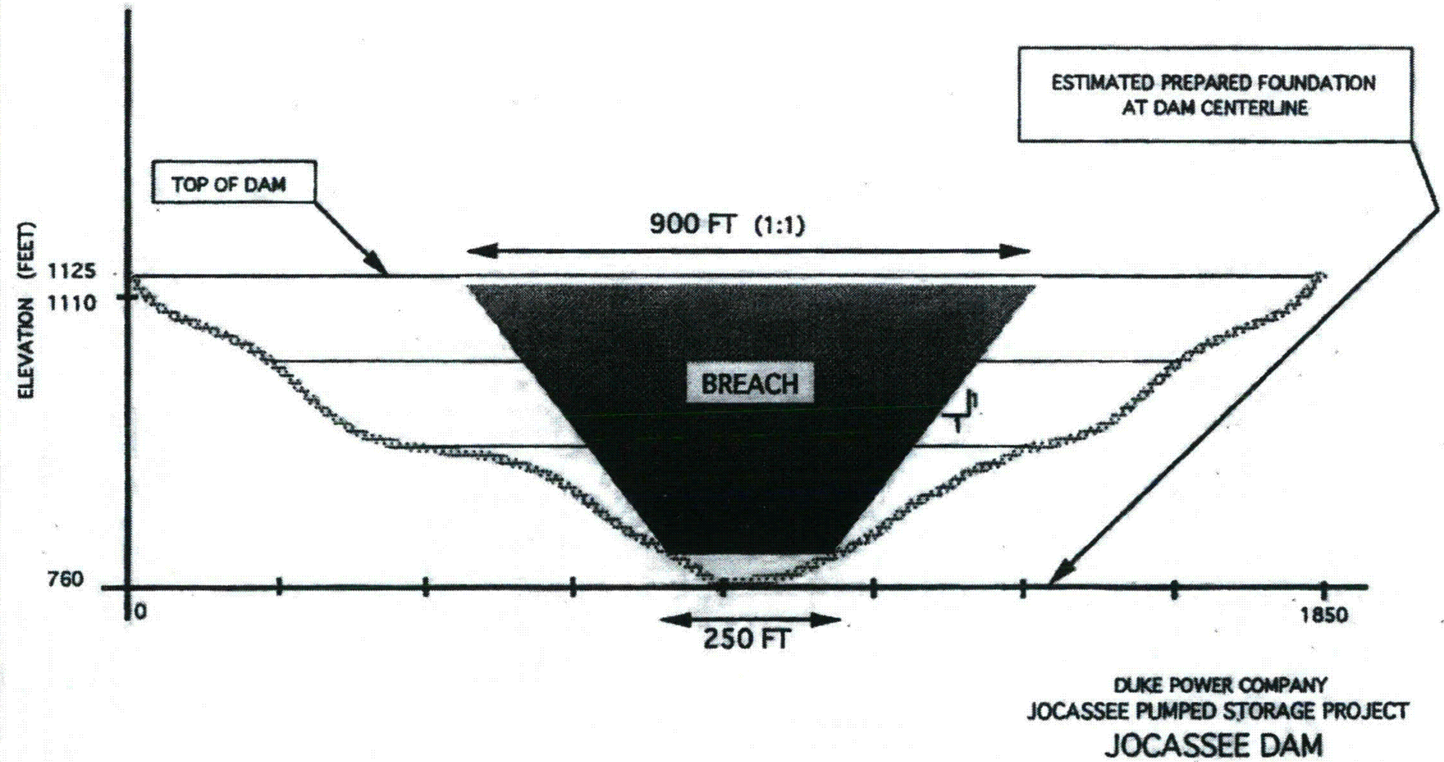

ESTIMATED PREPARED FOUNDATION AT DAM CENTERLINE
TOP OF DAM
900 FT (1:1)
ELEVATION (FEET)
1125
1110
BREACH
760
0
1850
250 FT
DUKE POWER COMPANY
JOCASSEE PUMPED STORAGE PROJECT
JOCASSEE DAM
BREACH PROFILE

Figure 6.1

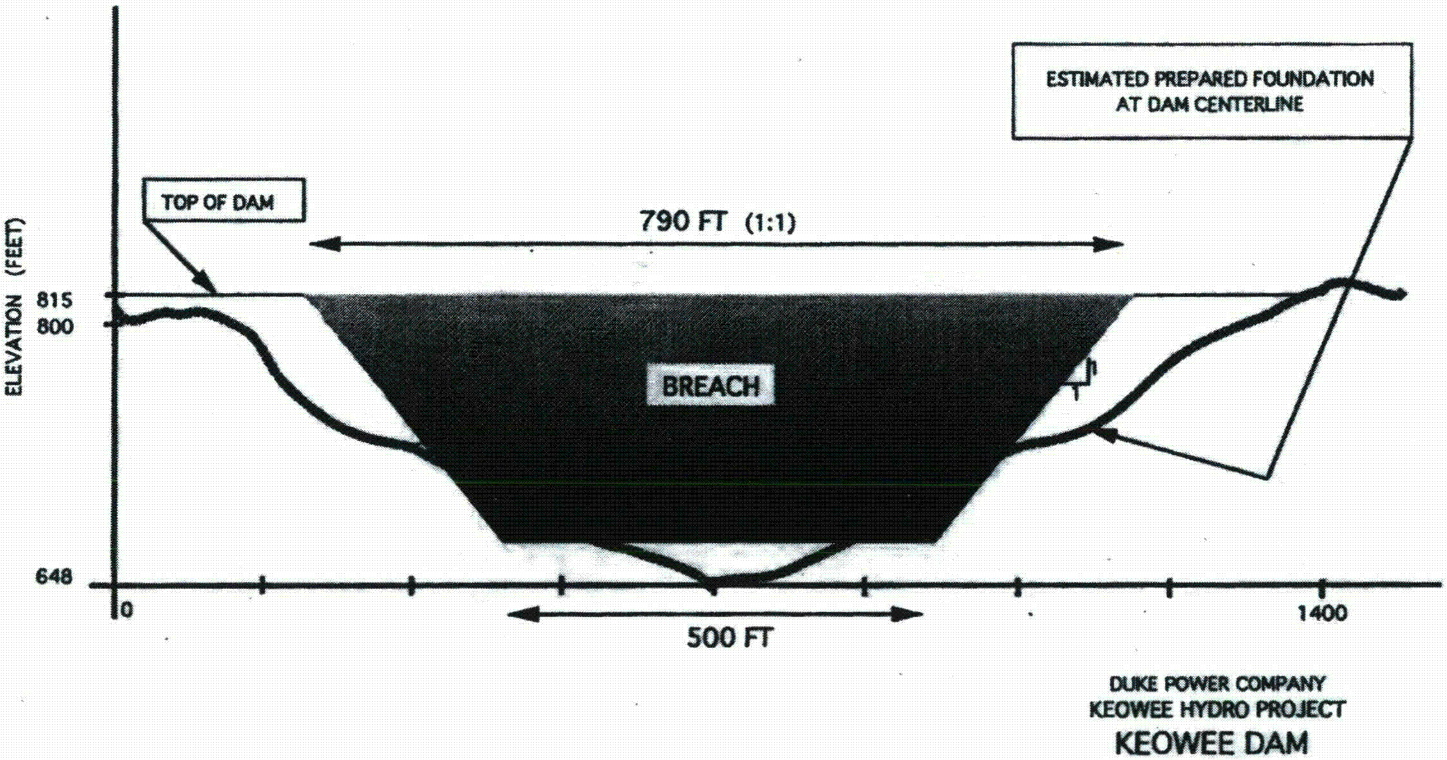

ESTIMATED PREPARED FOUNDATION
AT DAM CENTERLINE
TOP OF DAM
790 FT (1:1)
ELEVATION (FEET)
815
800
BREACH
648
0
1400
500 FT
DUKE POWER COMPANY
KEOWEE HYDRO PROJECT
KEOWEE DAM
BREACH PROFILE

Figure 6.2

3.0 Results of Simulations

The focus of the hydraulic model simulations was on the dam failure water elevations just downstream of Jocassee Dam and upstream and downstream (tailrace area) of Keowee Dam. The area downstream of Keowee Dam is of significant interest due to possible inundation of ONS facilities from dam failure flooding. The results are presented in the tables at the end of this section based on the scenario file name. Table 3 includes columns with both HEC_RAS and DAMBRK cross section data to provide a quick comparison between the flow and water surface elevation at selected cross sections near the dams. It should be noted that for all HEC_RAS scenarios assuming a base of breach elevation of 800 ft msl at Jocassee Dam, the peak flood elevations at Keowee Dam exceed the DAMBRK elevations while the downstream elevations were less than the DAMBRK model estimates. It should also be noted that the Little River arm of Keowee Reservoir reached elevations exceeding the 815 ft msl top of dam elevation but no discharge out of the reservoir was modeled. For this study, only Jocassee and Keowee Dam were simulated to fail. If the Oconee intake canal dike overtops, the discharge would enter the ONS facility near the dry-cast storage yard and the area already being flooded by a breach of Keowee Dam. The impact of this additional water on flood elevations is currently not included in the existing model. DTA recommends this area of the model be reviewed for additional refinement.

Based on the level of development of the HEC_RAS model completed to date, results indicate additional refinements to the HEC_RAS model will be necessary to study the flood impacts of a failure of the Jocassee Dam in a comprehensive manner. To date, only a "Sunny Day" failure has been modeled with two different breaches (Table 3). Ongoing probabilistic risk assessment (PRA) studies are also dependent on using the HEC_RAS model to study the impacts of varying inputs like gate and turbine operations, and analyzing the impact of debris on gate operations. The flexibility and tools available in HEC_RAS permits a modeler to add detail that more realistically simulates the flooding that may be expected from a breach of the Jocassee Dam.

The additional geometry and hydraulic options available in HEC_RAS should be further refined to provide a more realistic and accurate modeling of the breach discharge flows. The key results requested by Duke Energy are discussed in the following subsections.

3.1 Peak Tailwater Level below Keowee Dam

<u>Results</u>

Maximum water levels in the tailrace for all scenarios are less than 796 ft msl.

<u>Contributing Model Factors</u>

The model uses a more defined geometry downstream of Keowee Dam. The ability to define cross sections using more than seven top widths along with using detailed topography from Duke Energy files results in less flow restriction than was used in the DAMBRK model.

Recommendation

Prior to any significant actions based on the model results, additional checks should be done to confirm the model results. The model's handling of backwater entering the Little River arm and resulting rise in reservoir levels should be confirmed. Additional cross sections of the reservoir rim and flow over existing dams and dikes should be reviewed and refined as necessary. Particular emphasis should be on adding more definition to the connecting channel including review of constrictions provided by the highway bridge. No overtopping discharge or dam failure is currently modeled at the Oconee intake dike; therefore, consideration for flow out of the intake canal should be modeled so as to capture the flow input back into the Keowee tailrace.

3.2 Lake Keowee Water Levels upstream of Keowee Dam

Results

Up to 15.5 ft of water is going over both Keowee Dam and the Oconee intake canal dike.

Contributing Model Factors

The model uses a more defined geometry around the connecting canal and upstream of Keowee Dam. The ability to define cross sections using more than seven top widths along with using detailed topography from DEM files results in different flow restrictions and connectivity between the Little River arm than was used in the DAMBRK model. There is very little attenuation of the flood wave between Jocassee and Keowee. The flood wave overtops Keowee at 3 hrs and 20 minutes into the simulation and is above elevation 815 ft msl for approximately 3 hours, including the 2-hour breach formation at Keowee that results in the flood level falling so quickly. The model has additional storage area of Little River Arm as a branch permitting flow from the main branch through the connecting channel and back into the Keowee arm as the breach is formed. No dam failure (or the associated flow) is currently modeled at the intake canal, Little River Dam, or dikes.

Recommendation

Prior to any significant actions based on the model results, additional checks should be done to confirm the model results. The model's handling of backwater entering the Little River arm and resulting rise in reservoir levels should be confirmed. Additional cross sections of the reservoir rim and flow over existing dams and dikes should be reviewed and refined as necessary. Particular emphasis should be on adding more definition to the connecting channel including review of constrictions provided by the highway bridge. No overtopping discharge or dam failure is currently modeled at the Oconee intake dike; therefore, consideration for flow out of the intake canal should be modeled.

3.3 Comparative Results from both HEC_RAS and DAMBRK (Table 3)

3.3.1 Peak Flow out of Jocassee Dam Breach

Generally, HEC_RAS breach flows range from 7% to 25% less than DAMBRK breach discharge flows. This parameter appears to be sensitive to the storage rating curve for Jocassee. The storage curve is directly input in HEC_RAS while DAMBRK uses a reservoir surface area curve and interpolates to develop a storage-elevation curve. Differences in storage at each elevation result in differences in peak discharge. Peak flood wave flows reaching Keowee do not appear to be significantly impacted by the difference in flows released at Jocassee. Both models use a linear breach formation and the same failure time and geometry.

Recommendation

Prior to taking any significant actions based on the model results, additional checks should be done to confirm the model results. Additional sensitivity studies should be performed regarding the sensitivity of HEC_RAS breach discharge to the storage curve and piping breach non-linear formation.

3.3.2 Peak Flow out of Keowee Dam Breach

Generally, HEC_RAS breach flows range from 15% to 20% greater than DAMBRK breach discharge flows. This parameter appears to be sensitive to the reservoir elevation (i.e., storage). The storage curve is input in both models based on the cross sections developed to represent the reservoir area. Differences in storage at each elevation results in differences in peak discharge. Peak breach discharges for both models for the two scenarios that restrict the breach size at Jocassee result in near-equal discharge from both models. Both models use overtopping breach formation and the same failure time and geometry.

Recommendation

Prior to taking any significant actions based on the model results, additional checks should be done to confirm the model results. Additional comparisons should be performed between cross sections and available topography.

Breach times and elevations are approximations limited by the accuracy of the input information and should not be considered absolute numbers due to a variety of unknowns such as breach formation size and time to failure, estimated cross section data representing Lake Keowee and Hartwell, assumed gate operations at Lake Keowee and Lake Hartwell, flood channel roughness coefficients, and the complex geometry of the Lake Keowee reservoir including the connecting canal and multiple dams.

Table 3 Summary of DAMBRK Scenarios

Selected DPC Model Name	Pond levels Lake Keowee/ Lake Jocassee (ft msl)	Jocassee Dam Failure Trapezoid	DAMBRK WS Elev below Jocassee (ft msl)/ Discharge from Jocassee Breach (mcfs)	HEC-RAS WS Elev below Jocassee (ft msl)/ Discharge from Jocassee Breach (mcfs)	DAMBRK WS Elev at Keowee Dam (ft msl)/ Discharge from Keowee Breach (mcfs)	HEC-RAS WS Elev at Keowee Dam (ft msl)/ Discharge from Keowee Breach (mcfs)	DAMBRK Max Tailrace Water Height (ft msl) ONS Yard	HEC-RAS Max Tailrace Water Height (ft msl) ONS Yard
Restored "1992"	798/1108	1992 Shape	887.0/4.5	873.5/4.2	823.5/3.3	831.5/3.98	807.2	793.3
"1992" Current Levels	797/1085DB 798/1085RAS	1992 Shape	877.4/4.0	866.0/3.5	822.3/3.2	830.4/3.7	802.7	787.6
Sensitivity Case 2	797/1090	1992 Shape	879.6/4.1	867.6/3.6	822.5/3.2	830.7/3.7	803.8	788.0
Sensitivity Case 5	796/1080	1992 Shape	875.0/3.9	864.8/3.3	822.0/3.2	829.9/3.6	802.0	785.3
Sensitivity Case 6	796/1085	1992 Shape	877.3/4.1	866.6/3.5	822.3/3.2	830.5/3.6	802.8	787.0
Sensitivity Case 1	796/1090	1992 Shape	879.5/4.1	867.3/3.6	822.5/3.2	830.9/3.7	803.6	788.2
Sensitivity Case 4	798/1108	1983 Shape	843.3/2.2	840.7/1.8	818.4/3.0	822.5/2.9	795.2	771.1
Sensitivity Case 3	797/1090	1983 Shape	835.4/1.9	834.6/1.5	816.9/2.9	820.1/2.8	792.2	766.0

Note: The results from Jocassee PRA HEC_RAS Model scenarios are "Work In Progress" and should not be used for decision making. The HECRAS results for cross sections below Keowee are generally lower than results from the 1992 EAP DAMBRK but DTA recommends additional model refinement and additional scenarios be investigated prior to making budget decisions.

Table 4 Comparison of Model Inputs

Item	HEC_RAS December 2008 Model	2008 DAMBRK Model
Software	HEC_RAS	DAMBRK - PC version
Software version	Version 4.0.0, 3/2008	Rev 4, 8/1991 with modifications for Duke Energy to increase array size and gate options definition of changes in the Law Engineering Catawba Wateree PMF Studies 1991-1992
General Storage Areas	Off-channel storage per maps	Same
Connecting Channel	Used Branch - Cross Section Option to model Little River Arm of Reservoir	Increased array to allow storage at higher Reservoir/FPC areas in Little River Arm Original FPC 'maxed-out'
PMF	Not part of scope of work	Not part of scope of work
Sunny Day Jocassee Level	1108 - Varied per Duke Energy request	Varied per Duke Energy request
Keowee Level	798 - Varied per Duke Energy request	Varied per Duke Energy request
Jocassee Breach Size	Trapz - 250'W/1-1 slopes/El 800 ft msl Piping Failure El 940 ft msl	Trapz - 250'W/1-1 slopes/El 800 ft msl Piping Failure El 940 ft msl
Keowee Dam Failed	Yes - fail at 0.5 ft overtopping of Keowee Dam	Yes - Fail at 0.5 ft overtopping of Keowee Dam
Keowee Dam Breach	Trapz - 500'W/1-1 slopes/El 670 ft msl	Trapz - 500'W/1-1 slopes/El 670 ft msl
Keowee Spillway Curve	4 gate discharge (est. w/head vs. discharge curve)	4 gate discharge (est. w/head vs. discharge curve)
Hartwell Spillway Curve	Estimated from USACE data	Estimated from USACE data

Note: Jocassee Reservoir Area Curve, used in the 1992 analysis and a volume curve is used in HEC_RAS.

This report provides summary results of DAMBRK modeling at the Keowee-Toxaway Project for the scenarios requested by Duke Energy using the 1992 EAP Inundation Model Inputs. Should you have any questions regarding this submittal or require further information, please contact me at (704) 342-7385 or chris.ey@devinetarbell.com.

Sincerely,

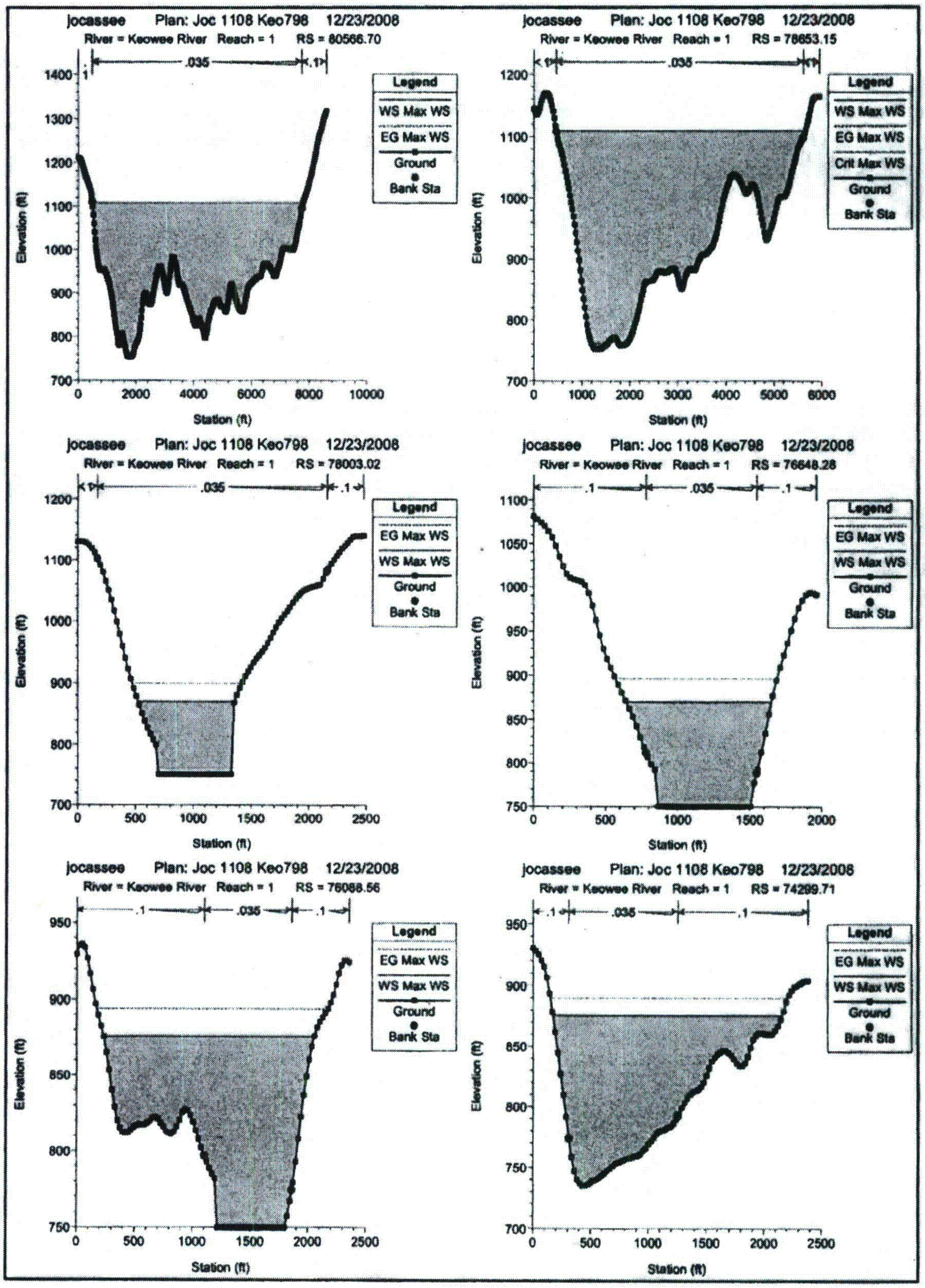
DEVINE TARBELL & ASSOCIATES, INC

J. Christopher Ey, P.E.	Carey Fraser	John Parrish, P.E.
Civil Engineering Manager	Technical Editor	Senior Engineer

JCE/cef
Attachments

cc: C. Ey, DTA
File

ATTACHMENT 1
KEOWEE RIVER ARM 1 & 2 CROSS SECTIONS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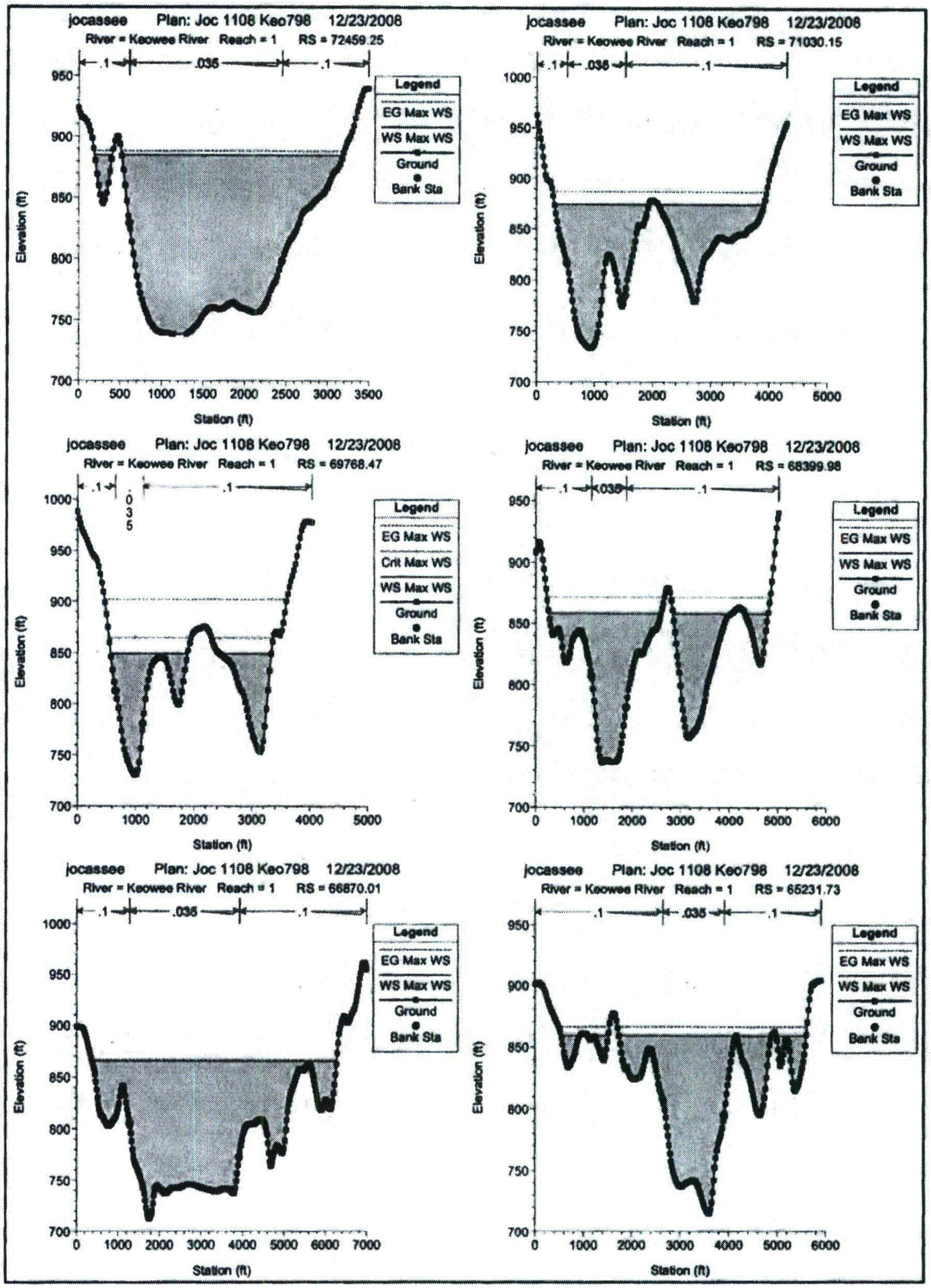
WS Max WS
EG Max WS
Crit Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)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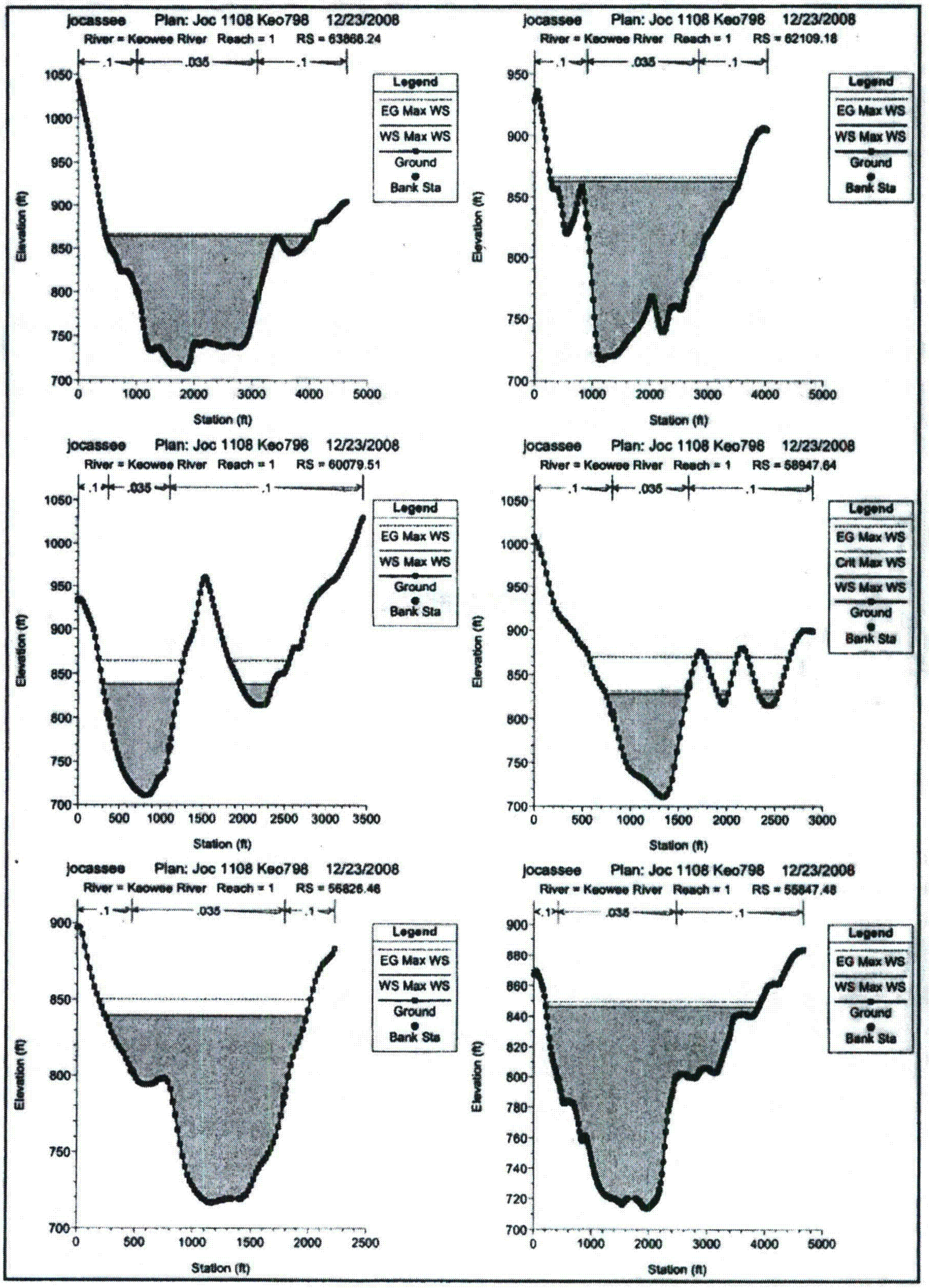
Elevation (ft)
Station (ft)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Ground
Bank Sta
Elevation (ft)
Station (ft)
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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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Crit Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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WS Max WS
Ground
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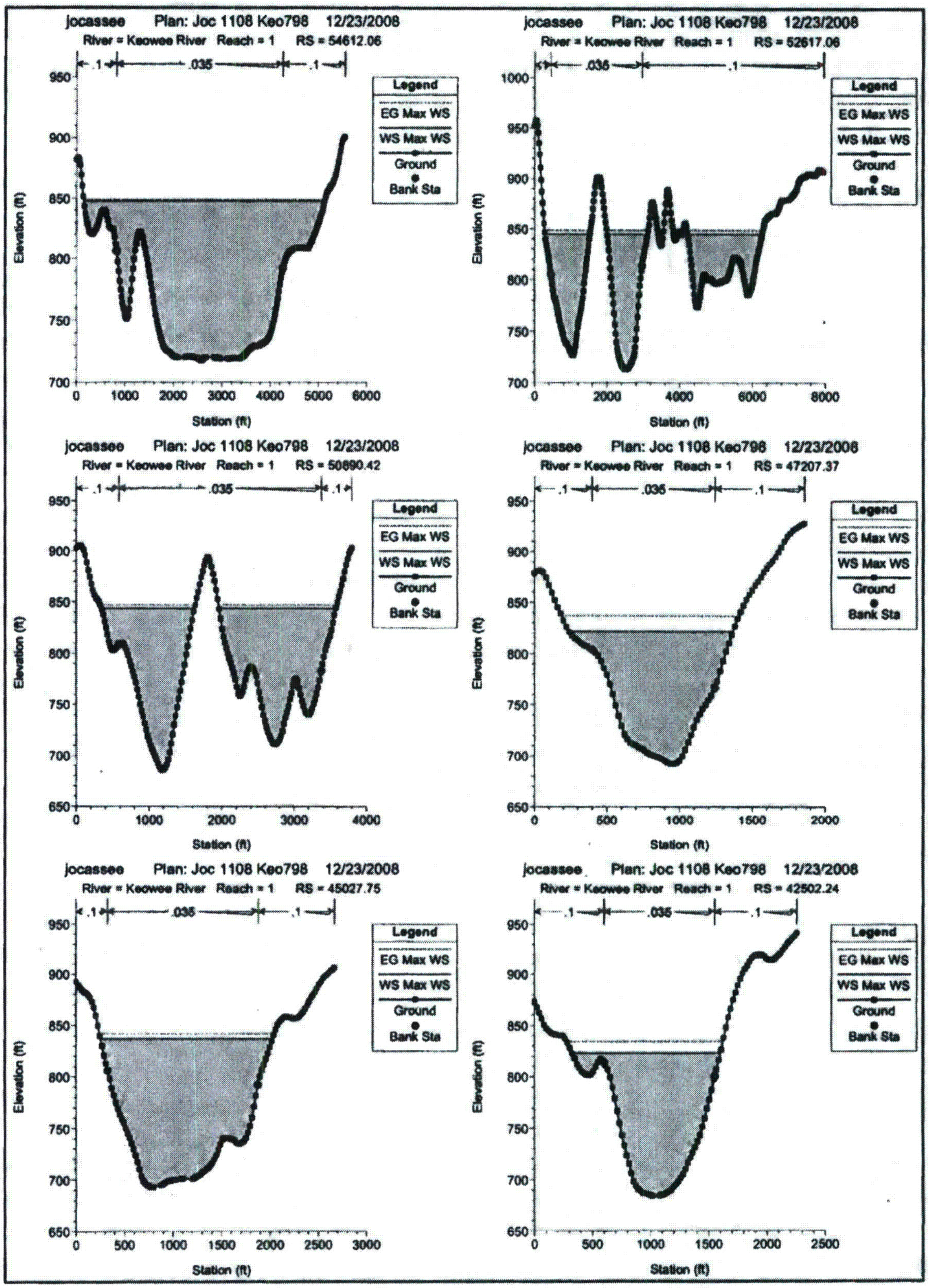
Elevation (ft)
Station (ft)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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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Legend
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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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.1
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WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
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Ground
Bank Sta
Elevation (ft)
Station (ft)
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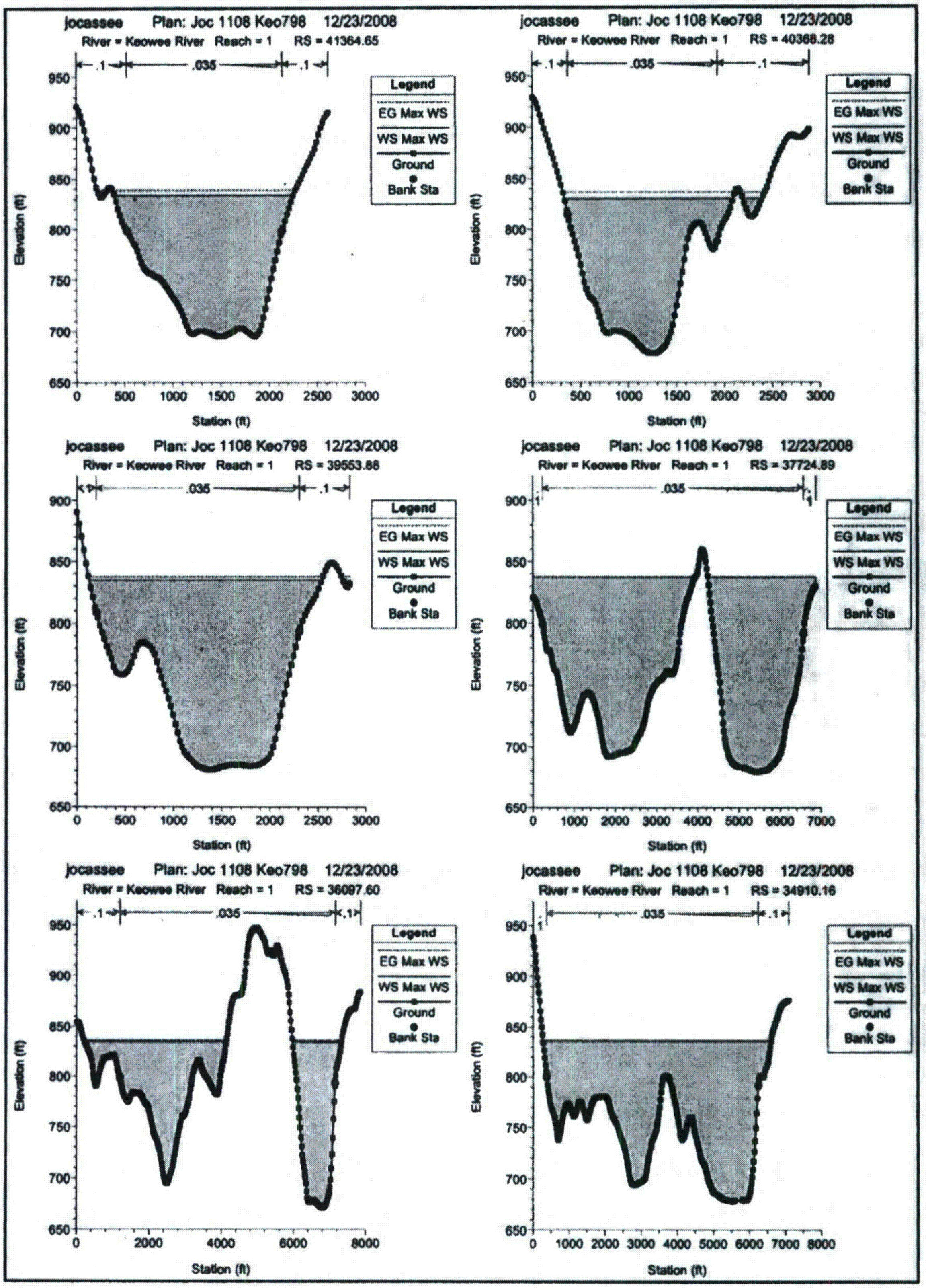
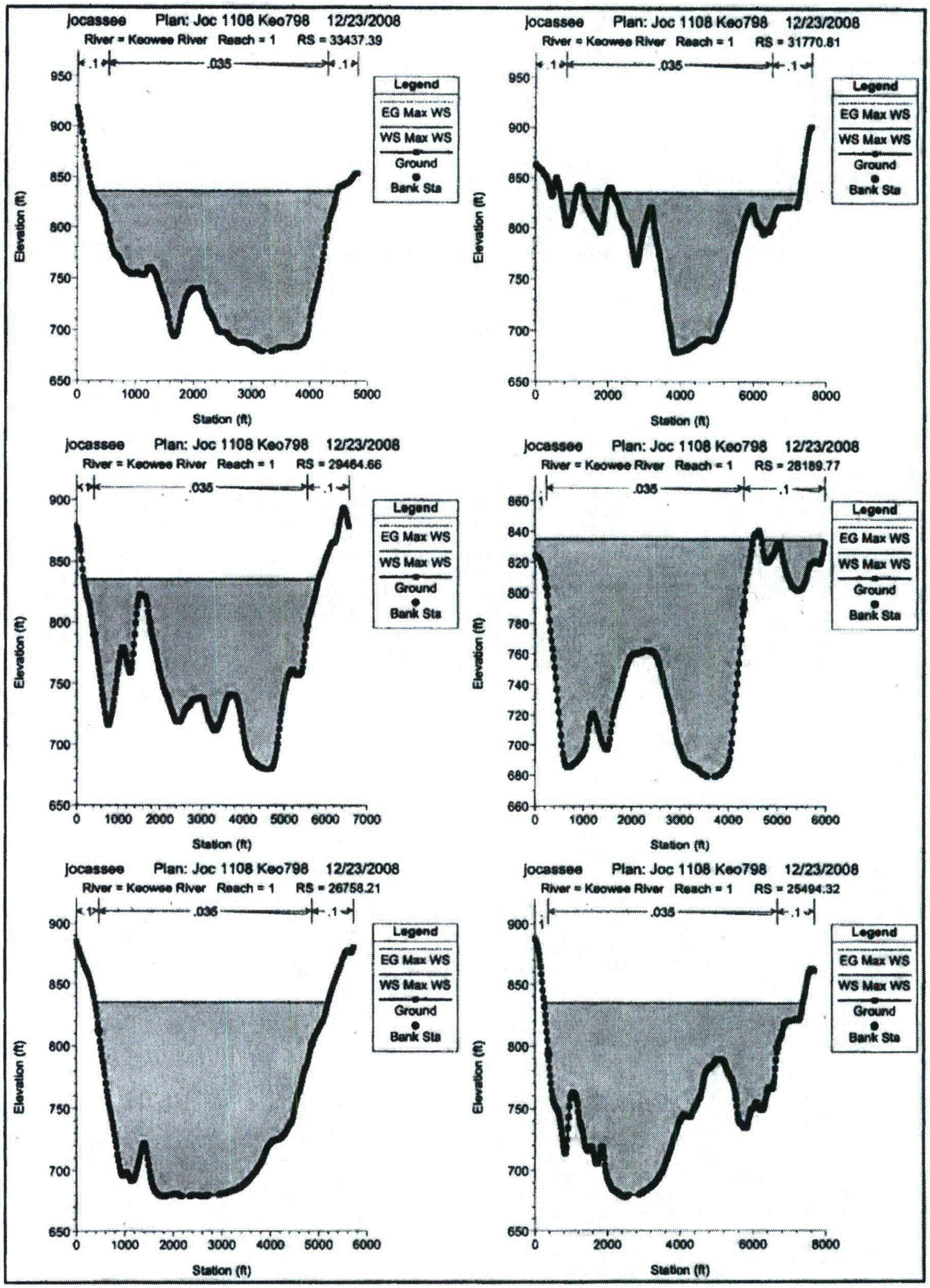
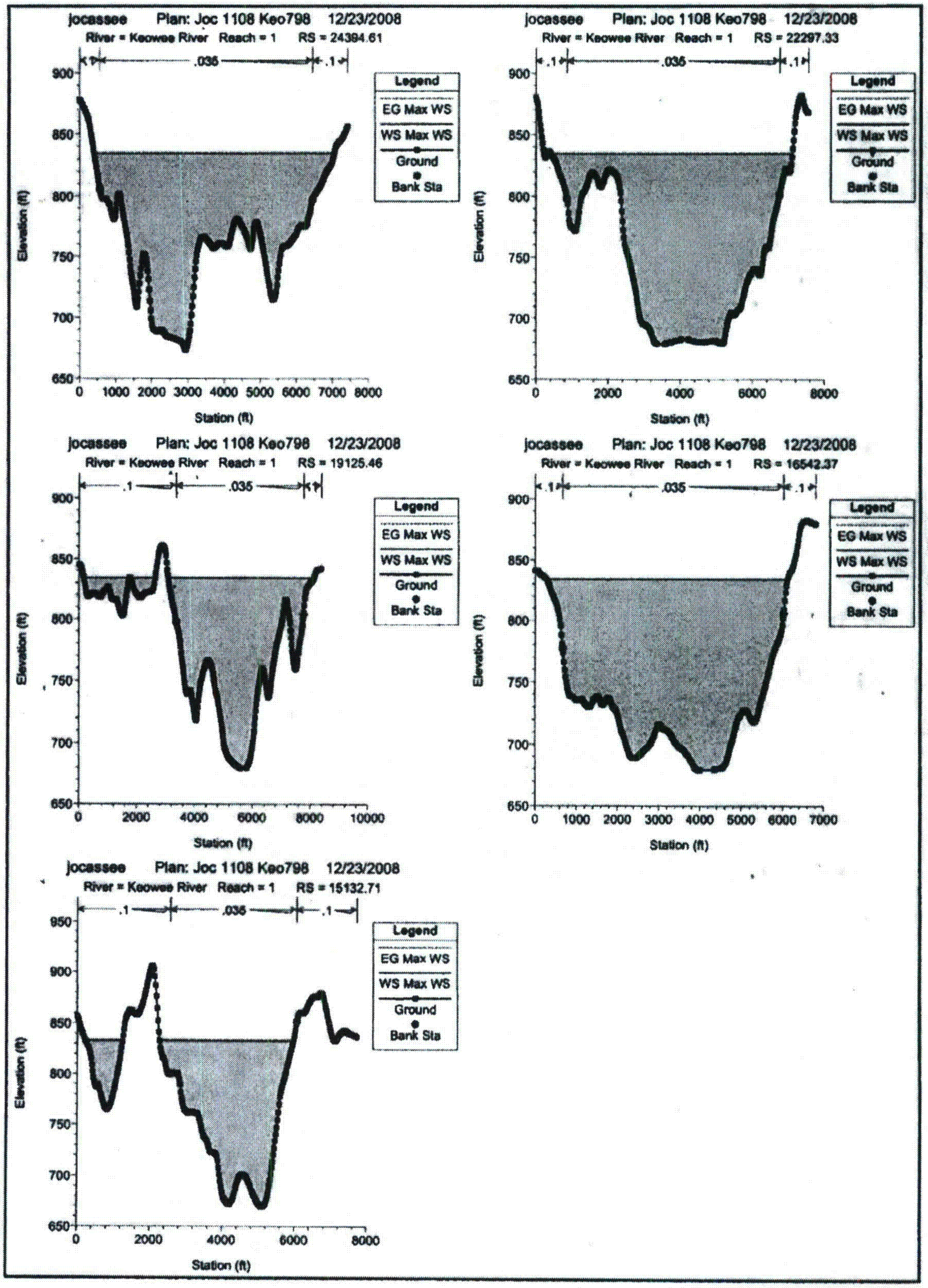
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 42502.24
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 41364.65
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 40368.28
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 39553.88
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 37724.89
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 36097.60
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 34910.16
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)



jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 33437.39
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 31770.81
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 29464.66
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 28189.77
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 26758.21
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 25494.32
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 24394.61
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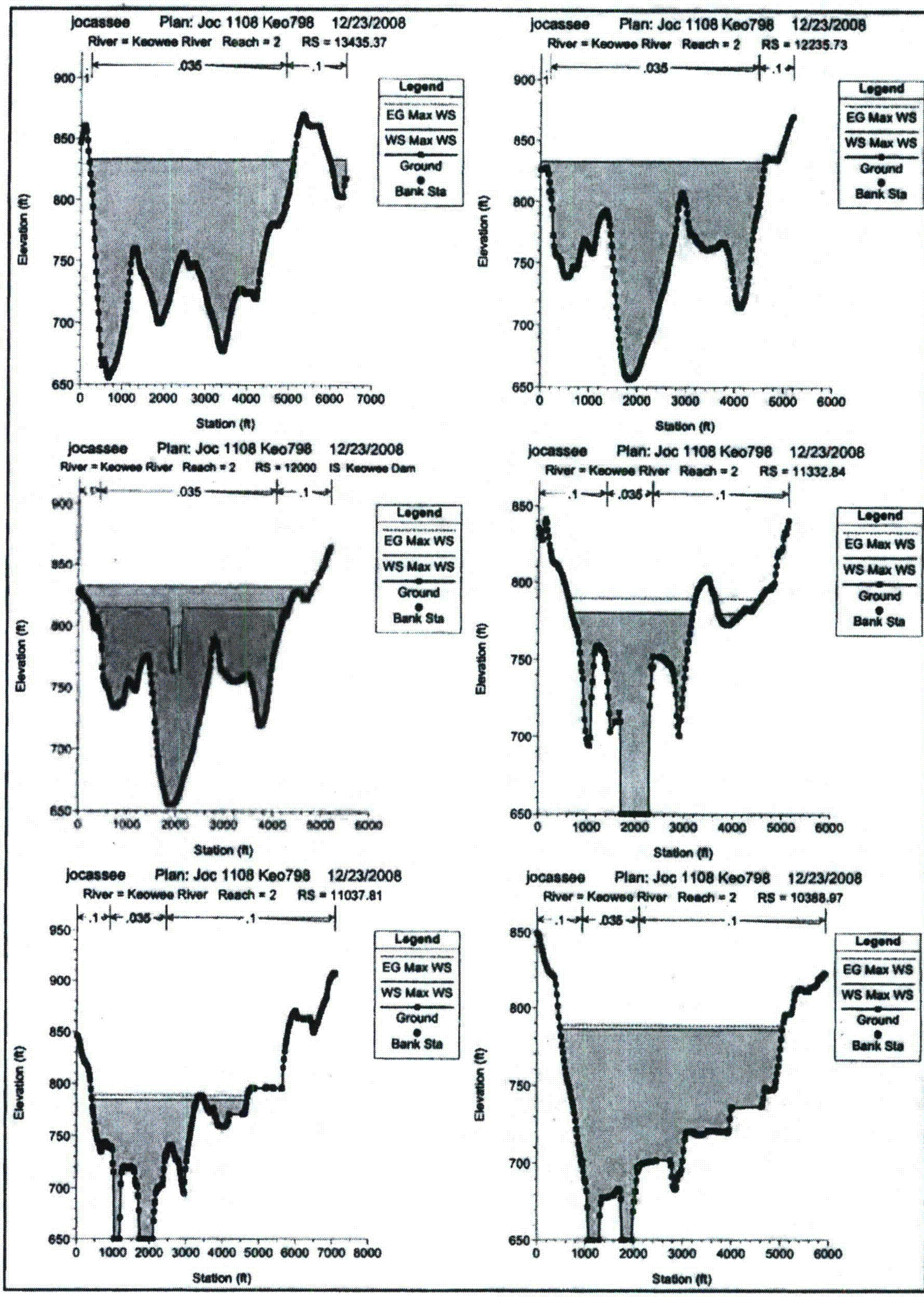
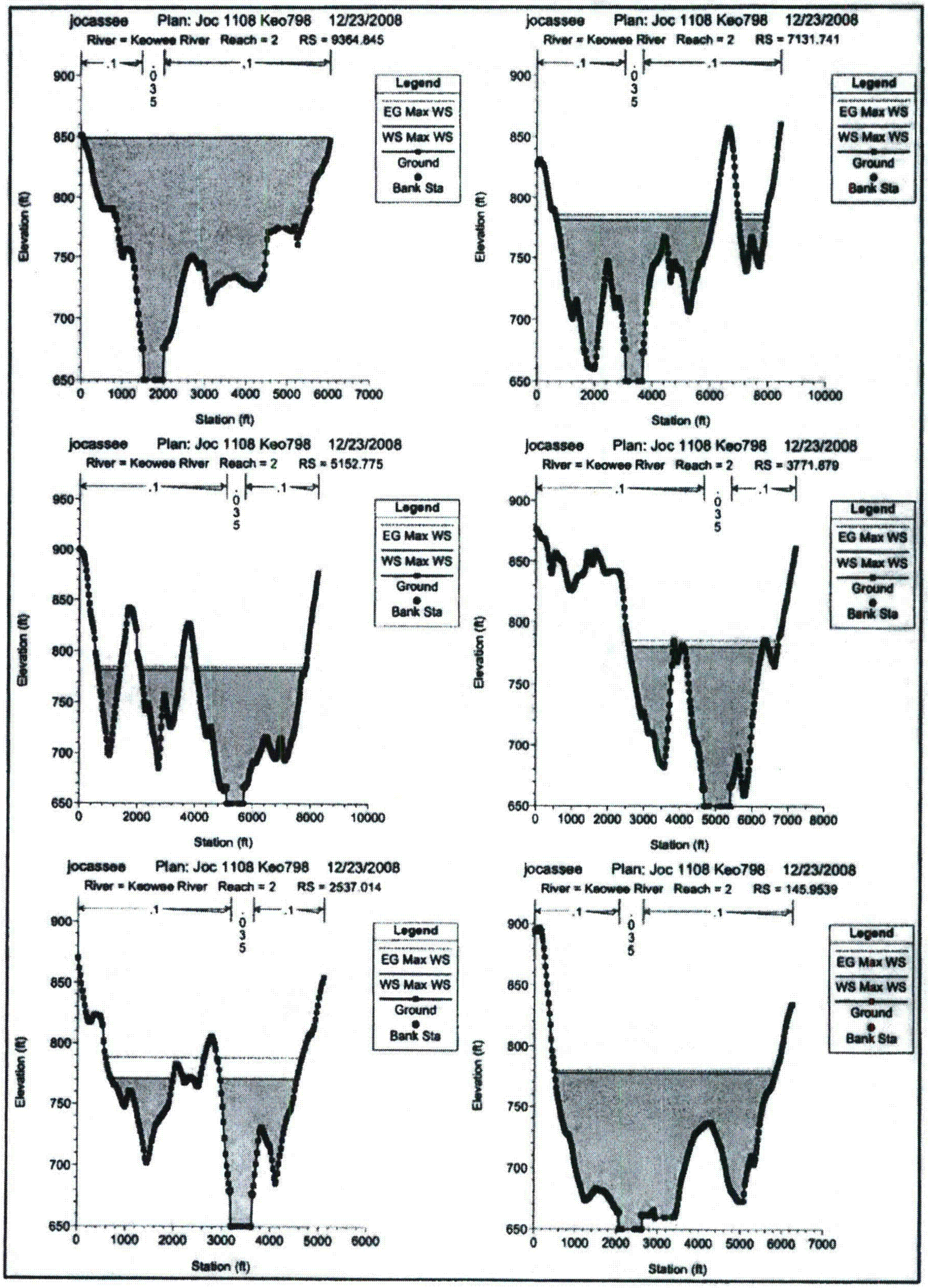
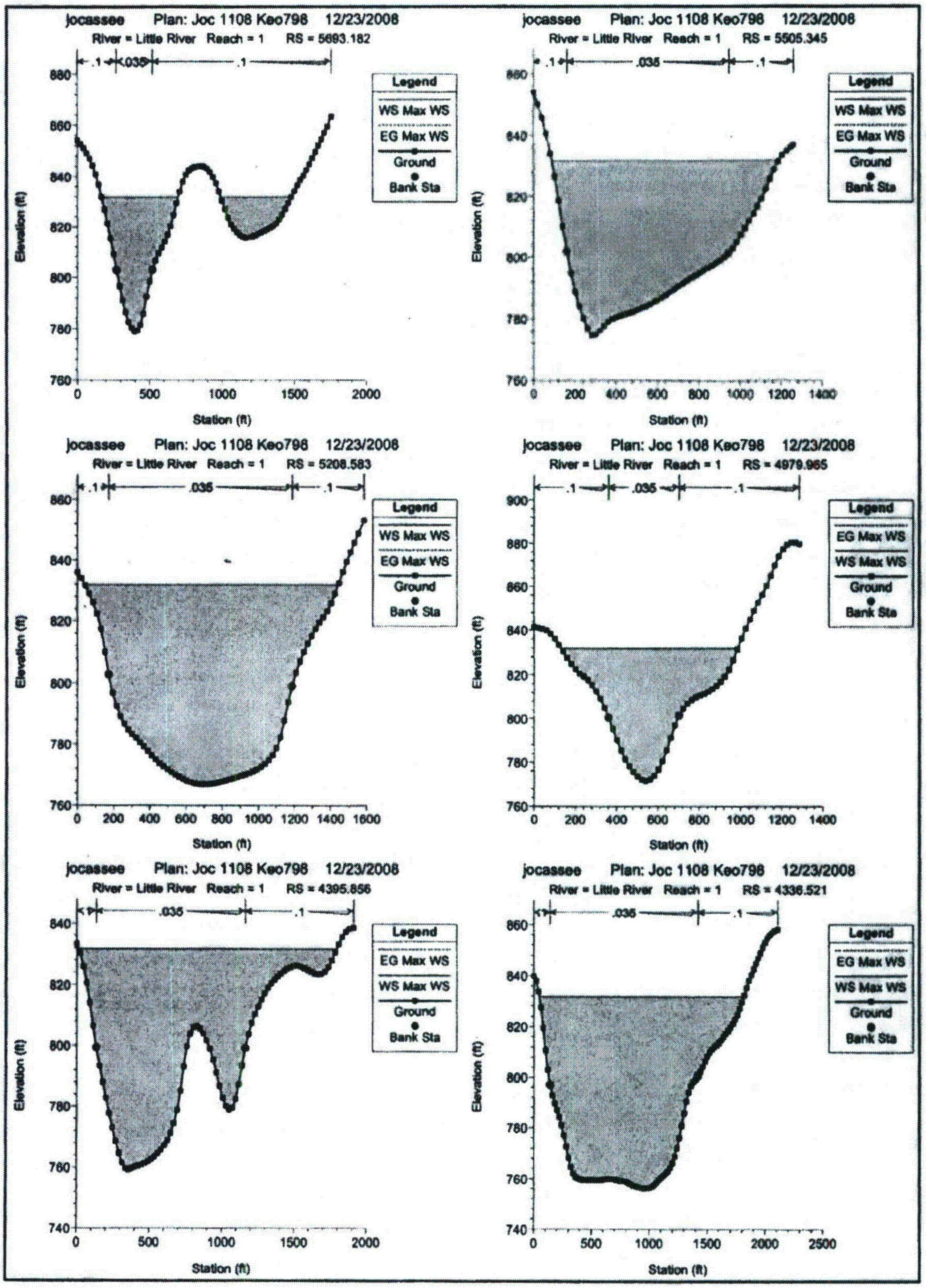
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 22297.33
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 19125.46
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 16542.37
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 1 RS = 15132.71
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

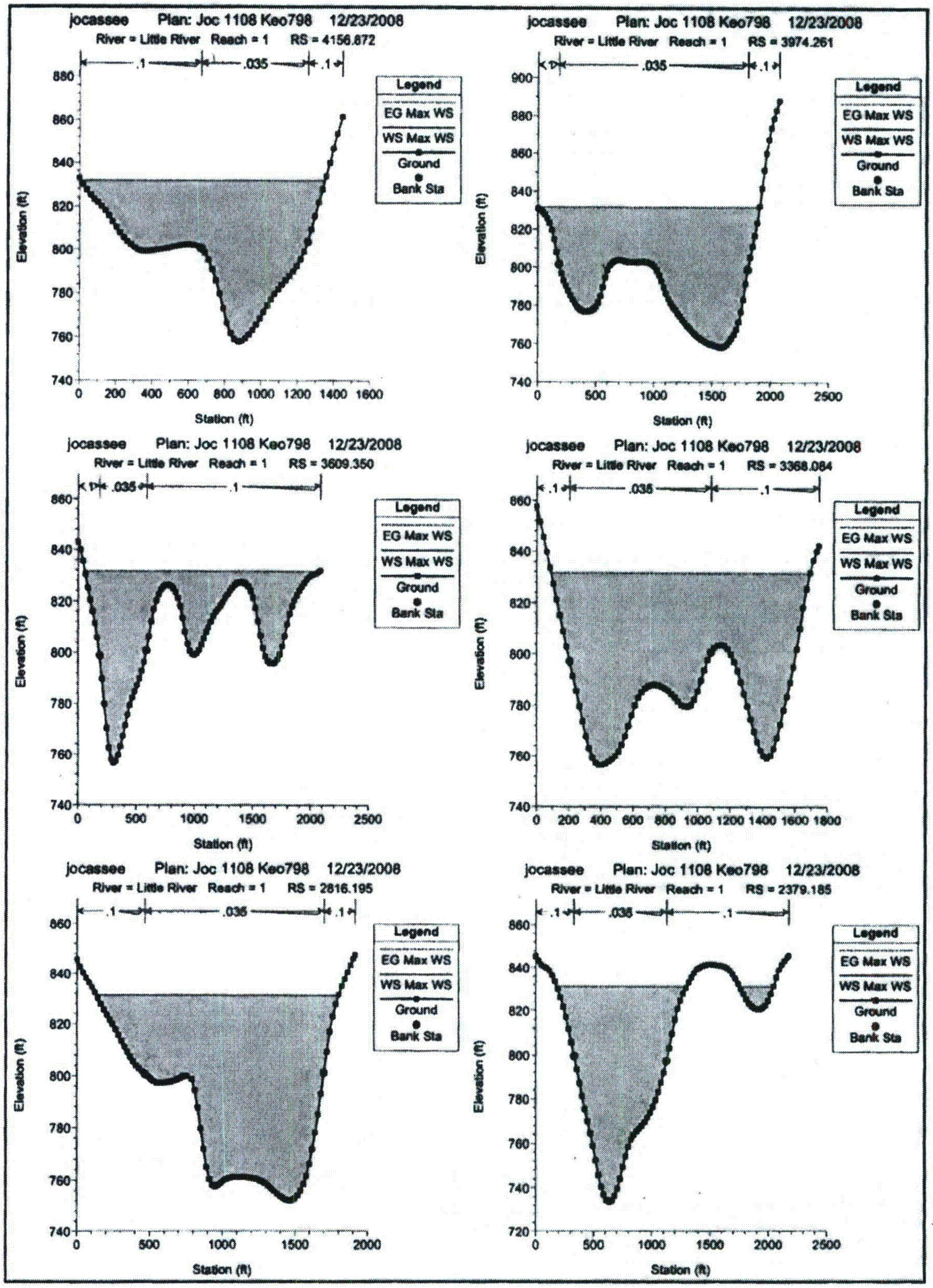

jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 13435.37
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 12235.73
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 12000 IS Keowee Dam
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 11332.84
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 11037.81
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 10388.97
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 9364.845
Elevation (ft)
Station (ft)
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 7131.741
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 5152.775
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 3771.679
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 2537.014
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 2 RS = 145.9539

ATTACHMENT 2
LITTLE RIVER ARM CROSS SECTIONS



jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 5693.182
.1
.035
.1
Legend
WS Max WS
EG Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 5505.345
.1
.035
.1
Legend
WS Max WS
EG Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 5208.583
.1
.035
.1
Legend
WS Max WS
EG Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 4979.965
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 4395.856
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 4336.521
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)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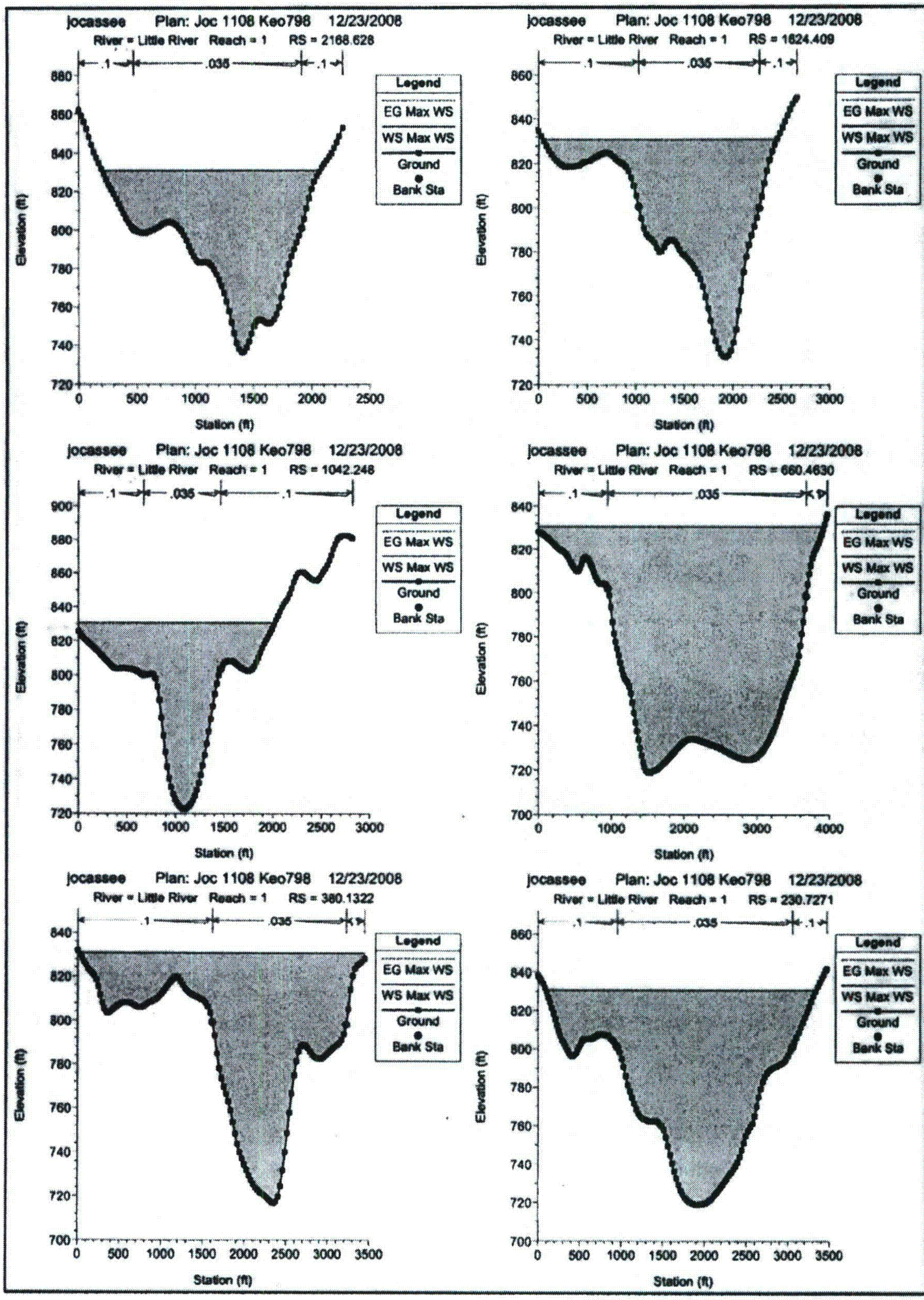
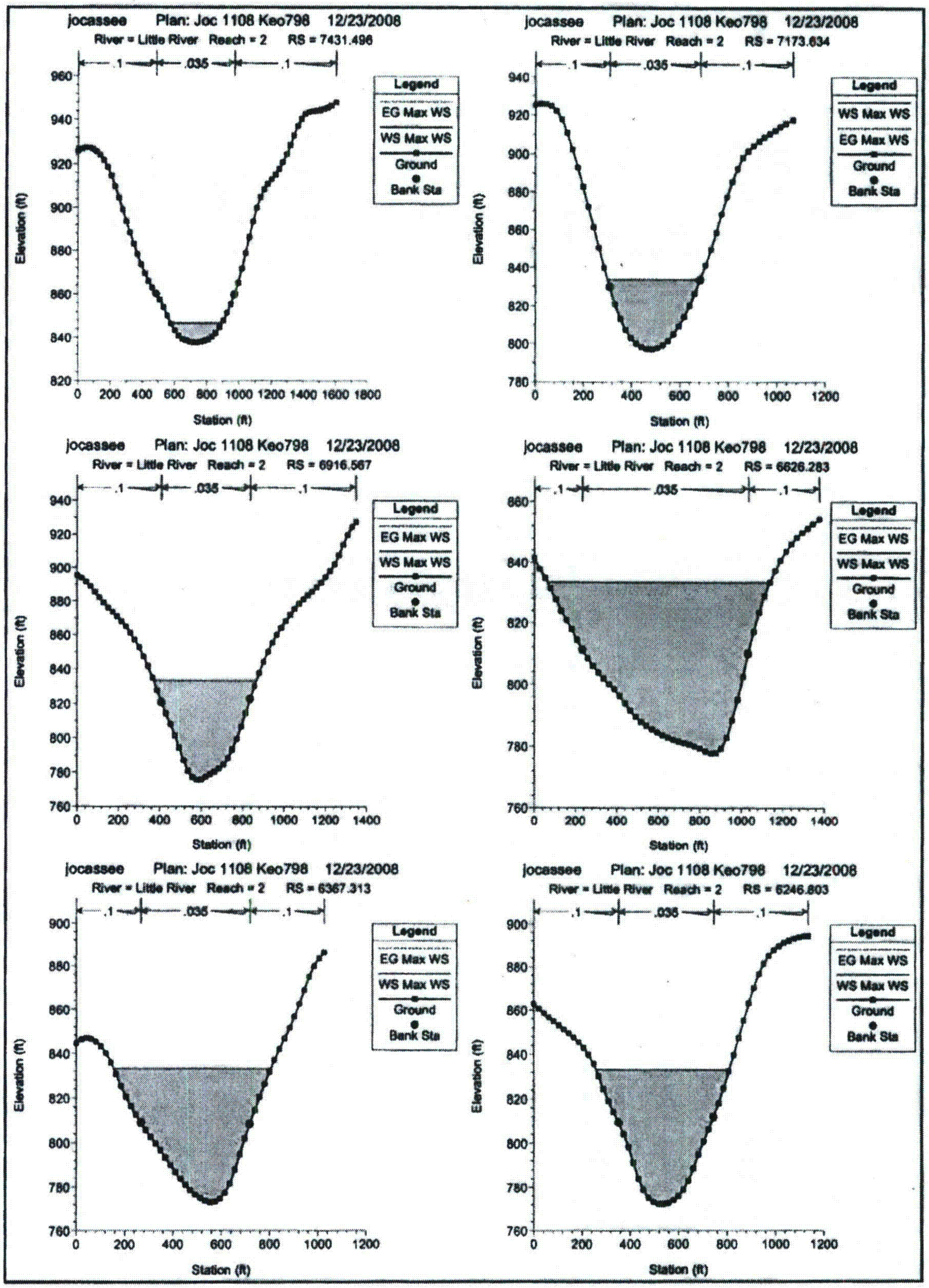
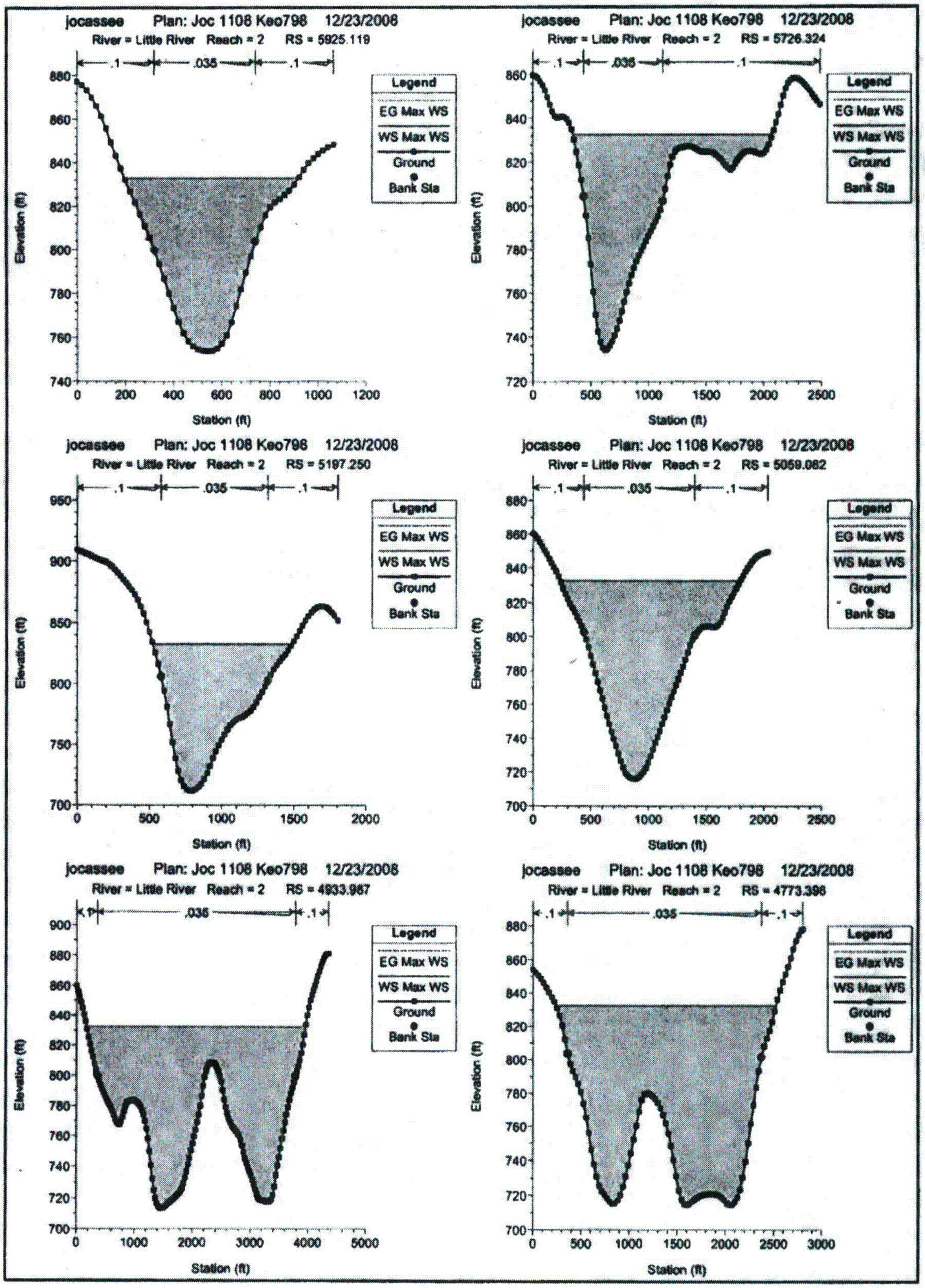
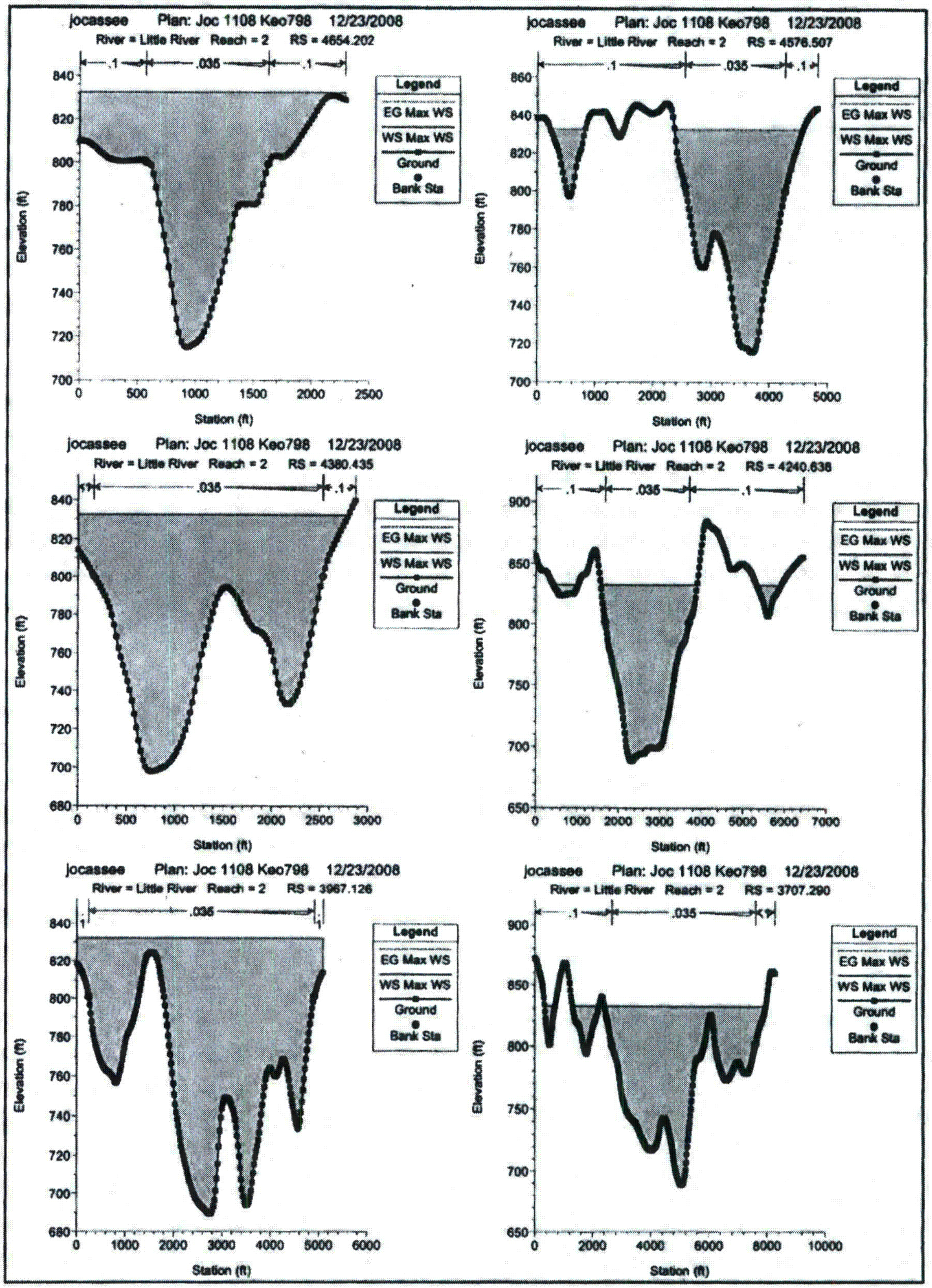
River = Little River Reach = 1 RS = 4156.872
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 3974.261
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 3609.350
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 3368.084
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 2816.195
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 2379.185


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 2168.628
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 1624.409
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 1042.248
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 660.4630
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 380.1322
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 1 RS = 230.7271
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 7431.496
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 7173.634
Legend
WS Max WS
EG Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 6916.567
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 6626.283
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 6367.313
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 6246.803
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 5925.119
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 5726.324
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 5197.250
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 5059.082
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 4933.987
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 4773.398
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)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River = Little River Reach = 2 RS = 4654.202
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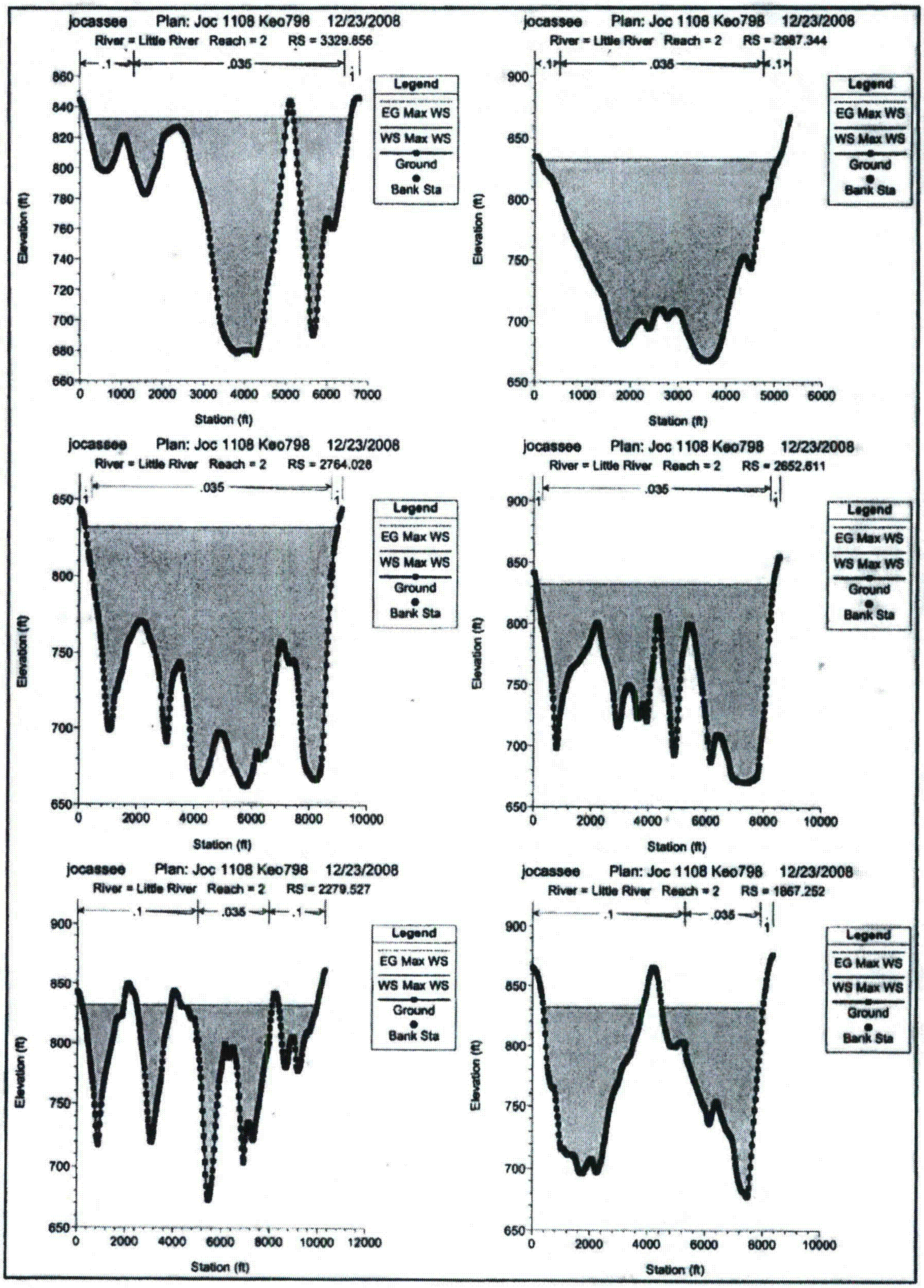
River = Little River Reach = 2 RS = 4576.507
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 4380.435
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 4240.638
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 3967.126
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 3707.290
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)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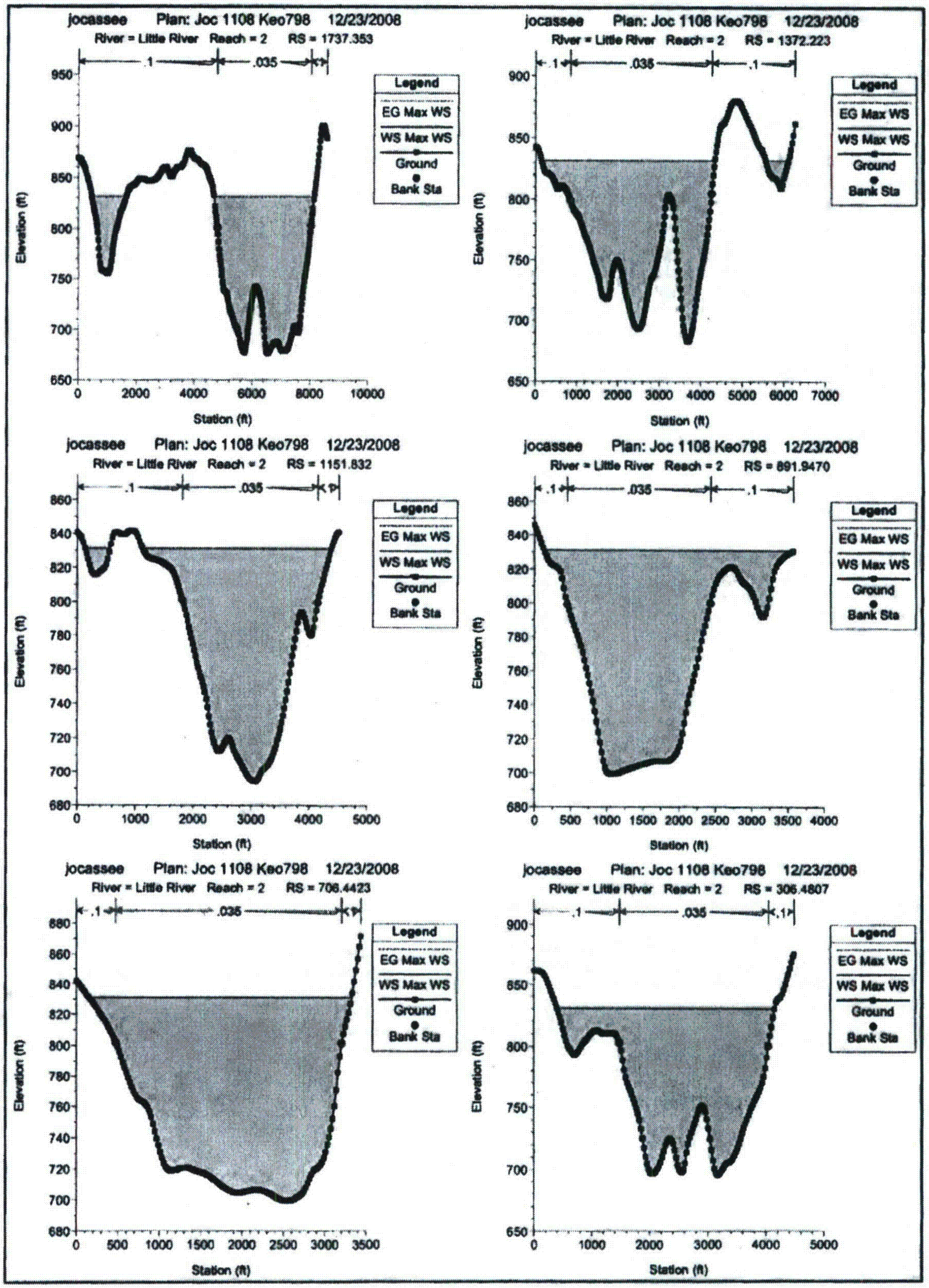
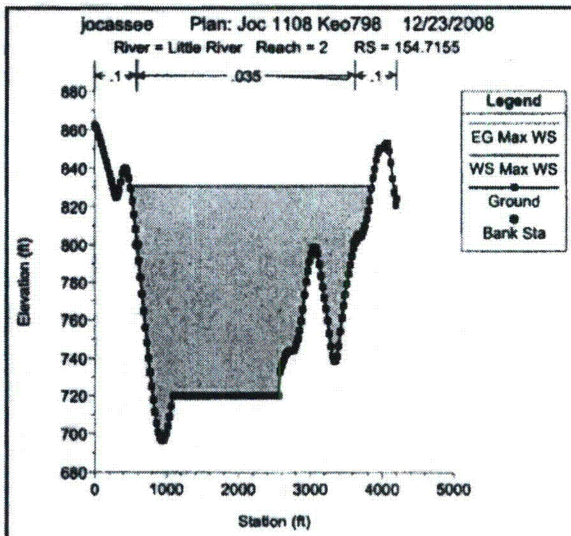
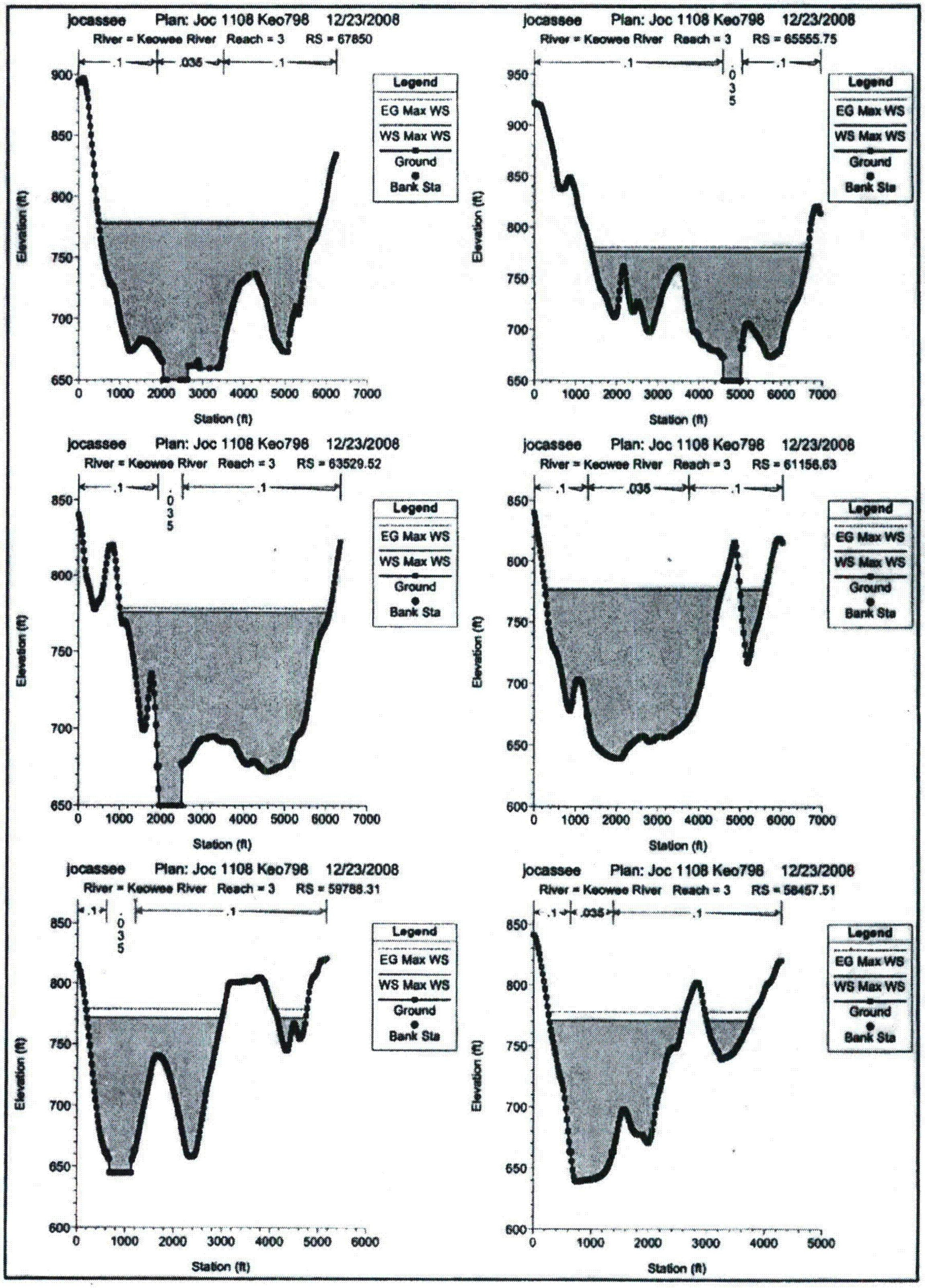
River = Little River Reach = 2 RS = 3329.856
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 2987.344
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 2764.026
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 2652.611
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 2279.527
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 1867.252
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

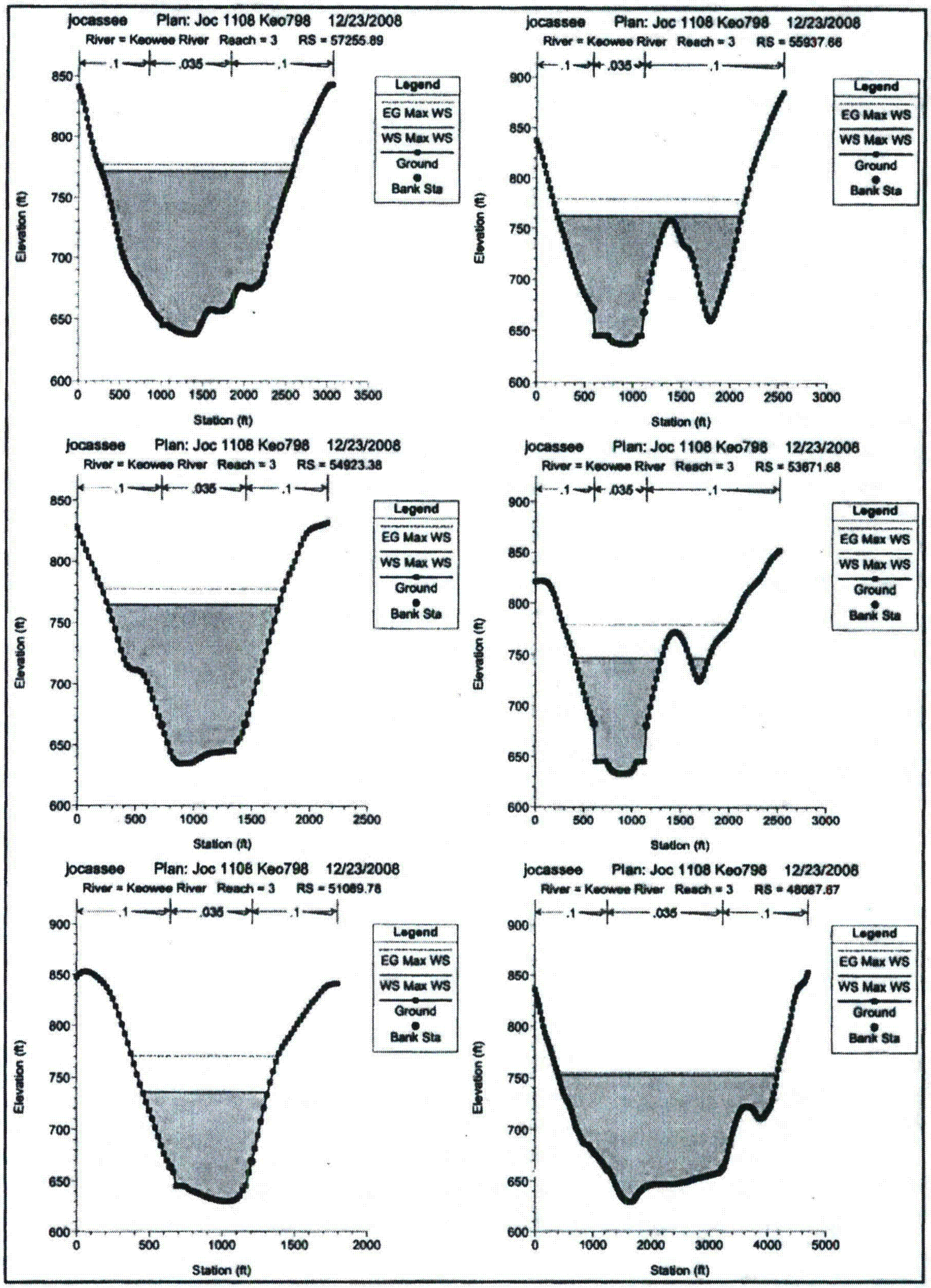

jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 1737.353
.1
.035
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 1372.223
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 1151.832
.1
.035
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 891.9470
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 706.4423
.1
.035
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 306.4807
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)

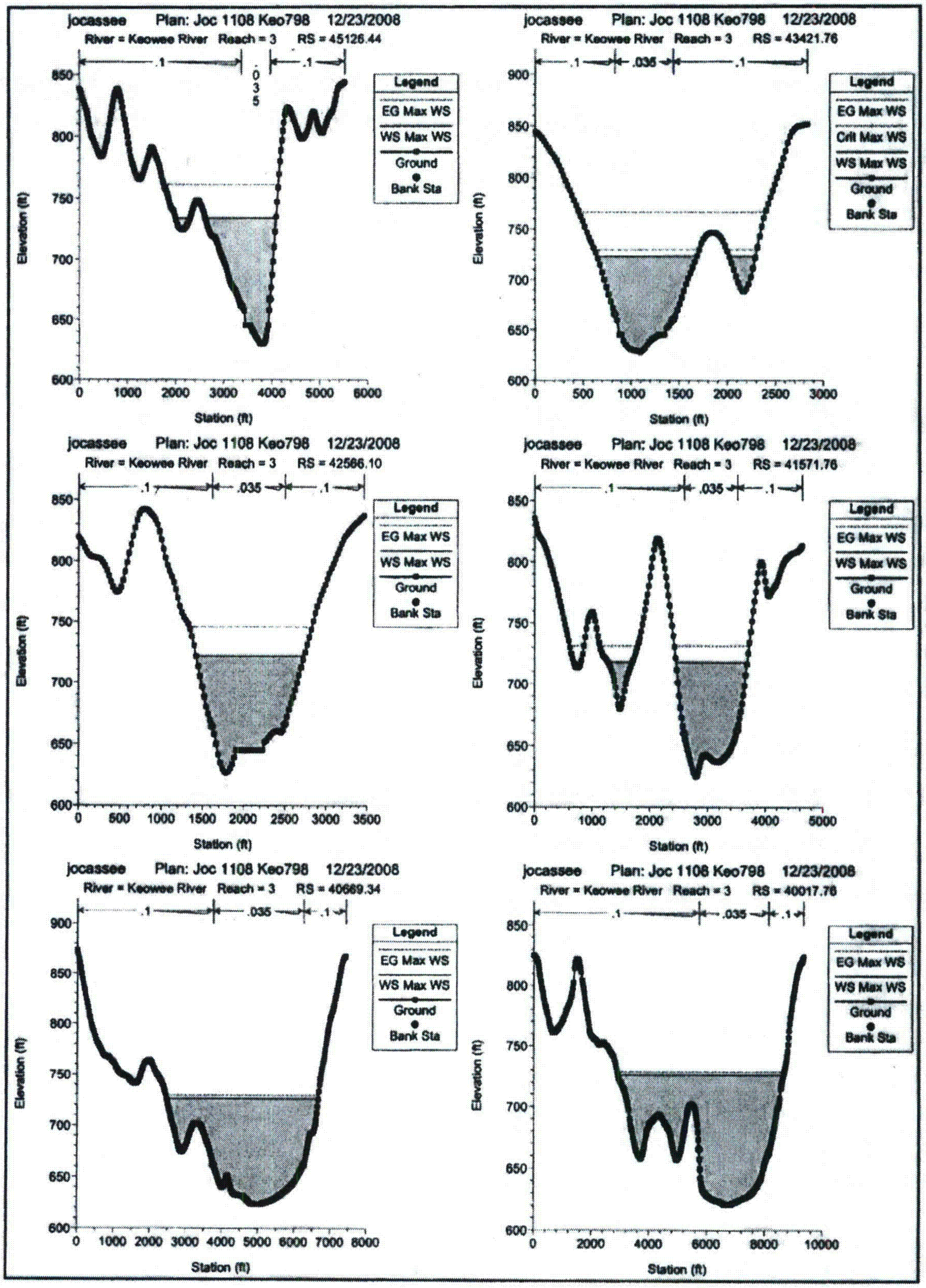

jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Little River Reach = 2 RS = 154.7155
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
880
860
840
820
800
780
760
740
720
700
680
0
1000
2000
3000
4000
5000

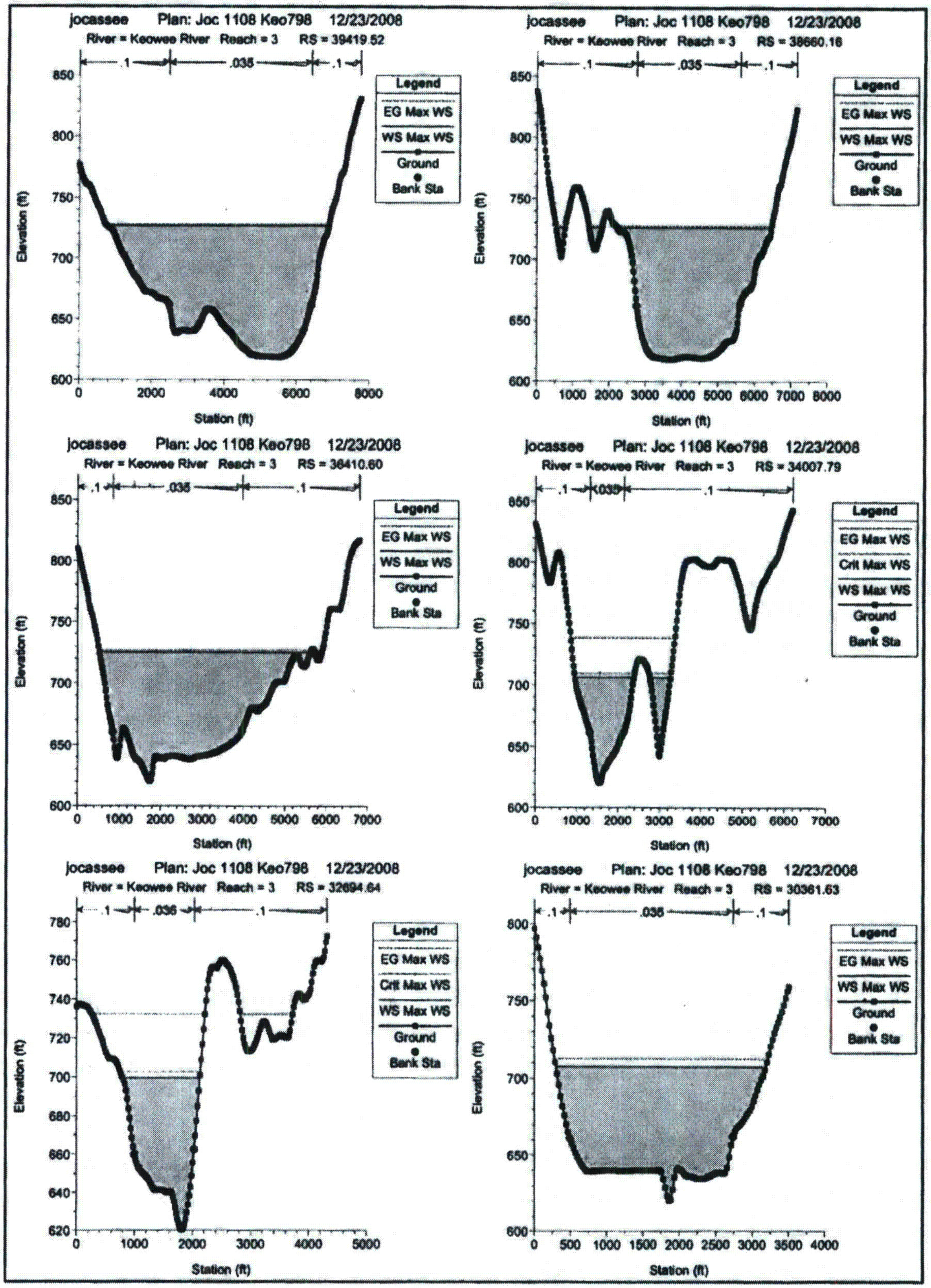
ATTACHMENT 3
RIVER SECTION 3 CROSS SECTIONS

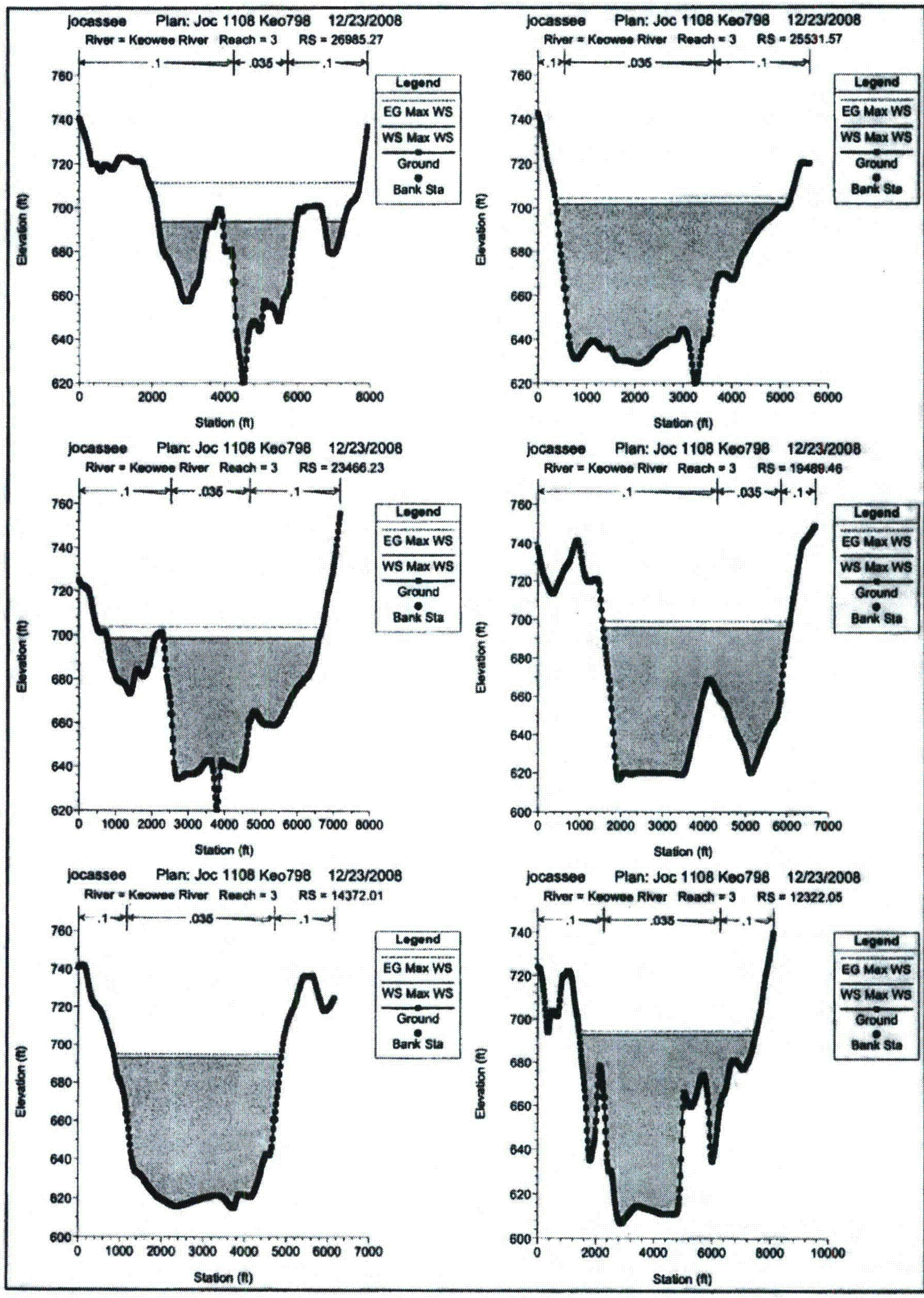


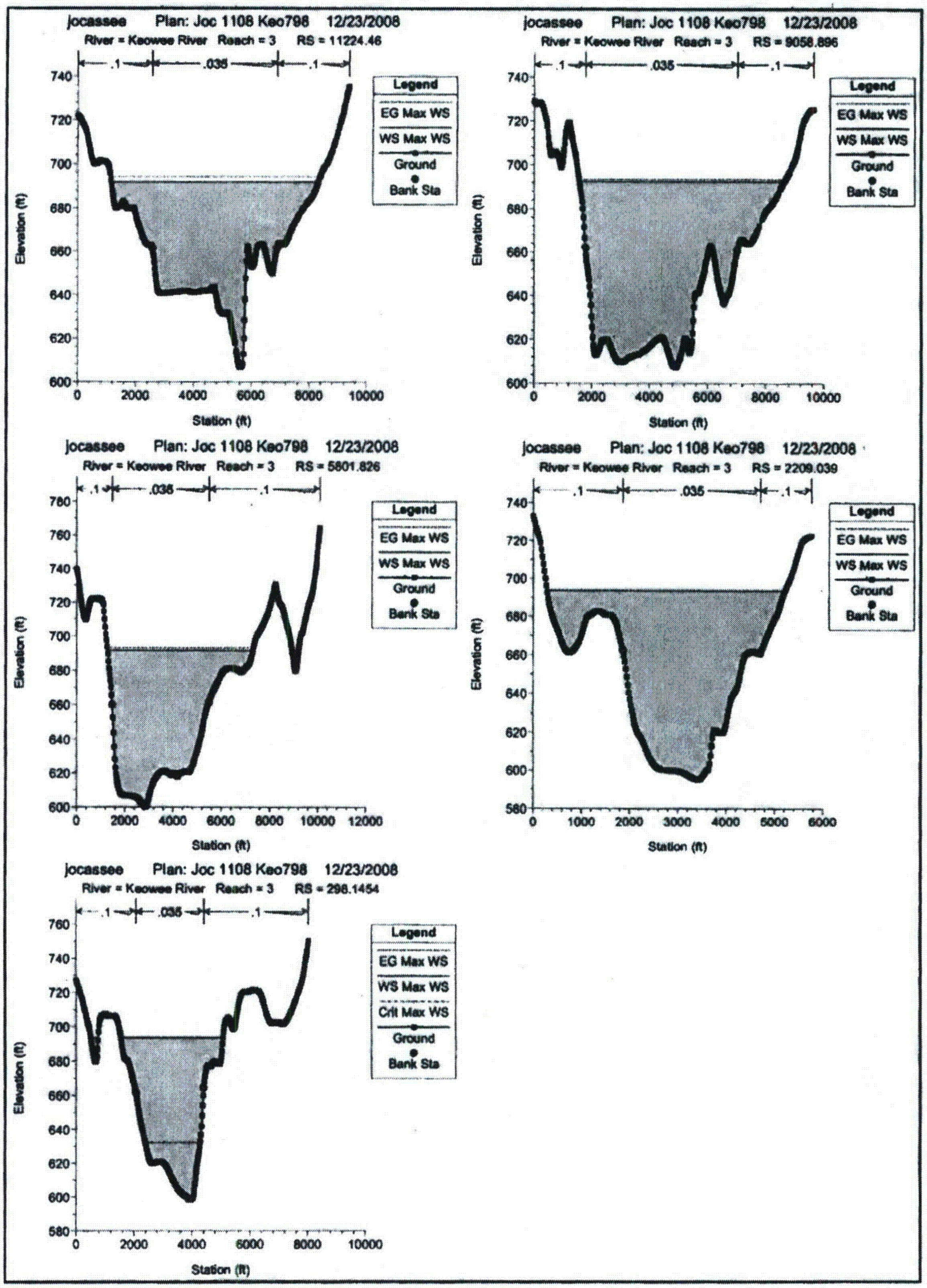
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 67850
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 65555.75
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 63529.52
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 61156.63
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 59788.31
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 58457.51
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 57255.89
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 55937.66
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 54923.38
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 53871.68
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 51089.78
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 48087.67
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 45126.44
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 43421.76
.1
.035
.1
Legend
EG Max WS
Crit Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 42566.10
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 41571.76
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 40669.34
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 40017.76
.1
.035
.1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 39419.52
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 38660.16
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 36410.60
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 34007.79
Crit Max WS
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 32694.64
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 30361.63


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 26985.27
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 25531.57
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 23466.23
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 19489.46
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 14372.01
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 12322.05
.1
.035
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)


jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 11224.46
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 9058.896
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 5801.826
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 2209.039
.1 .035 .1
Legend
EG Max WS
WS Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)
jocassee Plan: Joc 1108 Keo798 12/23/2008
River = Keowee River Reach = 3 RS = 298.1454
.1 .035 .1
Legend
EG Max WS
WS Max WS
Crit Max WS
Ground
Bank Sta
Elevation (ft)
Station (ft)