COMBINED AQUATICS WORKING GROUP

CAWG 3 FLOW-RELATED HABITAT-LOWER BASIN WETTED PERIMETER

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EXECUTIVE SUMMARY

The CAWG 3 Study Plan, *Determine Flow Related Physical Habitat in Bypass Reaches,* had the primary objective of identifying how flow affects habitat for aquatic species in the bypass reaches below project facilities.

For the purpose of evaluating rearing and spawning habitat, streams were divided into two groups, those with diversions that were operated throughout the year (mid-sized to large streams), and those with seasonal diversions that are operated only during the runoff season (small streams). PHABSIM (Milhous et al. 1989) was used to evaluate the continuously diverted streams, while the wetted perimeter methodology (Randolph 1984, Nelson 1989, Lohr 1993) was applied to the seasonally diverted streams.

This report provides the results of wetted perimeter habitat and passage analyses for seasonally diverted streams in the lower basin. These streams are tributary to the San Joaquin River downstream of Mammoth Pool Dam or to Big Creek. Results were provided for seasonally diverted streams above Mammoth Pool Dam in SCE (2003a). Results for continuously diverted streams where PHABSIM was applied will be presented in a subsequent report. Also included in the PHABSIM report, will be the results of depth suitability analyses performed for Bolsillo and Rock creeks. These studies were dependent on the development of habitat suitability criteria for project streams.

The streams evaluated in this report include Rancheria, Pitman, Balsam, Adit 8, and Ely creeks. The CAWG elected not to conduct studies on Ross Creek, as this stream goes dry in the summer months, even during wet years and does not support habitat for fish. All transects used in conducting the wetted perimeter analysis were selected in the field with the concurrence of the CAWG representatives present. As with all of the small streams where the wetted perimeter method was applied, there is essentially no storage of water behind these small stream diversions. Therefore, there is no opportunity to store water for release later in the year, after natural flows have diminished to base levels.

Both the wetted perimeter inflection point method and passage analyses are usually based on stream riffles, which are affected more by flow changes than other areas of streams (Lohr 1993, Thompson 1972). For habitat analyses, riffles are important areas for food production, as well. Because the physical characteristics of riffles are more sensitive to changes in flow than most other habitat types, maintenance of acceptable flows in riffles preserves food production potential, and protects habitat value in other stream habitats for fish and macroinvertebrates, as well. For passage analyses, riffles are the shallowest habitats, and thus the most likely to impede fish passage at low flow levels (Thompson 1972).

The inflection flows based upon the wetted perimeter analysis ranged from 0.4 to 0.8 cfs above the diversions and 0.4 to 0.6 cfs below the diversions. The flows at the inflection points were similar above and below the diversion for all streams. The flows at the

inflection points are consistent with the small size of these channels, most being less than 10 feet wide. The results of the wetted perimeter analysis were confirmed by using three analytical approaches, which generally provided similar results.

The flows needed to meet fish passage criteria were estimated for each stream. These flows ranged from 0.7 to 3.6 cfs above the diversions and 1.6 to 2.5 cfs below the diversions. However, in Pitman Creek above the diversion and Rancheria Creek below the energy dissipater, the passage flow observed at one transect that was substantially higher than those observed at the other transects. Additional analysis at these transects indicated that highest minimum passage flows could potentially be reduced to 2.8 and 2.0 cfs, respectively.

1.0
INTRODUCTION

The main purpose of this report is to present the methods and results for flow-related habitat studies conducted on five streams with seasonal diversions in the Lower Basin during the 2003 field season and to provide a brief summary of progress under the CAWG 3 study plan. Results of the depth suitability analysis are reported in the PHABSIM report. The Lower Basin streams are tributary to the San Joaquin River or Big Creek, as defined by the CAWG 3 Study Plan (SCE 2001). Flow related habitat studies for Upper Basin small streams were completed in 2002 and presented in the CAWG 3 Report (SCE 2003a).

Flow related habitat studies were completed in 2003 for five Lower Basin streams: Rancheria Creek, Pitman Creek, Balsam Creek, Adit 8 Creek, and Ely Creek, (Figure CAWG 3-1). Ross Creek, a sixth stream, was considered for analysis. Ross Creek was omitted from the analysis as it is dry in the summer months, even in wet years, and does not supply suitable permanent habitat for fish. Water is diverted from these small streams during the runoff season, typically from April into July. The diversions are not operated during the remainder of the year and the streamflows are thus unaffected for most of the year. These streams were evaluated using the Wetted Perimeter approach, as described in the CAWG 3 Study Plan (SCE 2001). For each stream, fish passage conditions were analyzed to determine the streamflows needed to allow adult trout to move up and downstream past typical riffles within the stream channel. The methods used for this evaluation are described in Section 3.4. The information provided in this report will be used in coordination with other instream flow studies, as well as studies of fish, amphibians, riparian zones, geomorphology, recreation and others, to evaluate project effects and to develop flow recommendations to be included as part of the new license applications for the Big Creek ALP Projects.

2.0 STUDY OBJECTIVES

2.1 STUDY IMPLEMENTATION

This study was implemented as part of the CAWG 3 study plan. The CAWG 3 plan identified two primary approaches to evaluate potential project effects on flow-related habitat. One approach focuses on larger streams that are diverted throughout the year. In these streams, the PHABSIM model was selected for use (SCE 2001). The other approach focused on smaller streams that are diverted primarily during the run off period. In these streams a wetted perimeter analysis was selected for use. The potential of diversions to affect fish passage was also identified as a potential issue. This report addresses the second study approach for the Lower Basin small streams. The following components of the CAWG 3 study plan have been completed and some were reported previously.

2.1.1 PREVIOUSLY COMPLETED WETTED PERIMETER STUDY ELEMENTS

- All bypass stream segments were divided into study reaches based on the major channel types present (as determined by CAWG 1 Characterize Stream and Reservoir Habitats). These reaches were summarized along with the mesohabitats present in each in the CAWG 1 Characterize Stream and Reservoir Habitats (Habitat Inventory) Report (SCE 2003b).

- Recommendations were made to the CAWG as to the reaches and habitat types to be represented and the number of transects to be measured and modeled. These results were presented to the CAWG for approval. After some discussion and refinement, the study reaches and the number of transects within each reach were approved by the CAWG (July 2002 CAWG meeting notes). The CAWG Transect Selection Team (CTST) subsequently visited each reach and placed transects to represent the habitat type within that reach.

- Results of wetted perimeter and fish passage studies on six upper basin small streams were reported in the CAWG 3 2002 report (SCE 2003a).

2.1.2 STUDY ELEMENTS COMPLETED IN 2003

- Report on results of 2002 Flow Related Habitat studies (SCE 2003a)

- Collection of data on 32 transects on five lower basin streams

- Data reduction and analysis of data collected above, reported in this document.

- Collection of field data for all PHABSIM transects on project medium and large streams (to be reported in the PHABSIM report, in preparation)

- Collection of field data for HSC verification studies on PHABSIM streams (to be reported separately in an HSC report, in preparation)

2.1.3 OUTSTANDING STUDY ELEMENTS

The remaining elements in the CAWG 3 are described below.

- Complete depth suitability analysis for Rock and Bolsillo creeks. This will be provided in the subsequent PHABSIM report.
- Complete PHABSIM analysis for mid-sized and large project streams. This will be provided in the subsequent PHABSIM report.
- Complete stranding analysis for all project streams. This will be provided in a subsequent Stranding Analysis report.
- In consultation with the CAWG, evaluate how flow changes resulting from project operations may affect native fish and aquatic species.

3.0 METHODS

3.1 AGENCY CONSULTATION

The study design and workplan were developed in consultation with resource agency personnel and other stakeholders at several meetings and field visits. The procedures used are outlined in the CAWG 3 study plan (SCE 2001). In the process of developing the CAWG 3 study plan and implementing the ALP relicensing studies, the Licensee worked closely with resource agencies and other stakeholders to develop the objectives and methods for the flow-related habitat assessment. The study plan was approved by the Plenary.

The methods used in this study followed those agreed upon in the Big Creek ALP process CAWG 3 Study Plan (SCE 2001). As part of the CAWG 3 study plan, it was agreed that the wetted perimeter approach would be used to assess habitat for the small, seasonally diverted streams.

In September 2002, ENTRIX presented an overview of the wetted perimeter studies conducted in 2002 and discussed the transect selection approach for the 2003 studies. At the January 2003 CAWG meeting, ENTRIX identified the 32 transects selected for wetted perimeter studies to be completed during the 2003 field season. Transects were selected as outlined in the CAWG 3 study plan to evaluate flow related habitat. Based on the site visit, the wetted perimeter approach was selected for five of the six streams. Ross Creek was removed from consideration, as it was dry in summer.

3.2 STUDY SITE AND TRANSECT SELECTION

As outlined in the CAWG 3 Study Plan (SCE 2001), the preliminary Rosgen Level I evaluation (August 2001) and mesohabitat typing conducted in 1999-2001 (Table CAWG 3-1) was used as the basis for selecting the channel segments and habitat units to be represented in the Wetted Perimeter studies.

Prior to field visits by the CAWG Transect Selection Team (CTST), preliminary habitat units were randomly selected within each of the preliminary Rosgen Level I channel types. Five or six habitat units were randomly selected based upon the results of habitat inventory studies (SCE 2003b). Riffles are the preferred habitat type for wetted perimeter transect placement because they are very responsive to changes in flow. In some reaches, however, riffles were (a) absent, (b) represented a very small proportion of the total reach length, or (c) were present but contained hydraulic features which could not be accurately modeled. Runs were used in place of riffles, where necessary, because these habitat types are also very responsive to changes in flow and are commonly thought of as “flooded riffles”. The candidate study sites were inspected by an experienced instream flow specialist to screen out any non-representative sites or areas that could not be modeled. The remaining sites were retained for inspection and final transect selection by the CTST.

All members of the CAWG were invited to participate in the site review and transect selection process. The CTST generally included representatives from SCE, the USFS, CDFG and SWRCB, although not all members were present at all sites (Table CAWG 3-2). The CTST toured each of the preliminary study sites to gain an impression of the stream characteristics. During the site review, large sections of the stream were examined. The candidate sites were inspected and the group then selected specific habitat units for sampling. Transects were placed such that the location was representative of the characteristics of the unit. Transects were not placed in areas where hydraulic models could not be calibrated. The site name, transect designations, and habitat types selected for the wetted perimeter study in each stream are presented in Table CAWG 3-3. The locations of sampling sites used for this study are shown in Figures CAWG 3-2 through CAWG 3-4.

Adit 8 Creek is created from leakage from Tunnel 2 and hence it was not possible to place reference transects upstream of this diversion. This diversion allows SCE to move water from Tunnel 5, which normally conveys water from Shaver Lake to Powerhouse 2A, to Tunnel 2, which conveys water from Dam 4 to Powerhouse 2. This diversion has not been operated in many years, either as a diversion or to transfer water between the tunnels.

Above the diversion, the stream is dry most of the year; while water below the diversion comes from tunnel leakage. Three transects were selected below the diversion (Figure CAWG 3-3), and the CTST agreed that the necessity of a Wetted Perimeter study in those circumstances was questionable. However, the full CAWG felt that an evaluation of habitat in Adit 8 Creek was necessary, so the studies were conducted.

In Balsam Creek, a total of 6 transects were selected. Three transects were selected above the diversion (Figure CAWG 3-2). The most downstream of these three transects was placed below another small domestic water diversion for Camp Sierra, which caused some flow variation between transects during the study. Another three transects were selected below the diversion; two near the confluence with Big Creek and one a half mile upstream, near the Camp Sierra swimming hole.

Three transects were selected on Ely Creek below Ely Diversion, near Canyon Road (Figure CAWG 3-3). The most downstream transect, located below the Road, had different flows than the other two transects at the high calibration flow due to a side channel which became active at high flow. Only two transects were placed above the diversion because other suitable transect locations could not be found.

In Pitman Creek, a total of six transects were established: three transects were placed upstream and three transects were placed downstream of the diversion. The area upstream of the diversion was dissimilar to the area downstream of the diversion. While the stream is wide and open upstream of the diversion, with a gravel and cobble dominant substrate, the area downstream of the diversion is a succession of bedrock cascades, bedrock chutes, and step pools. The CTST acknowledged the difference, but elected to pursue data collection and analysis at the time. The three transects upstream of the diversion were placed in a classic riffle habitat (Figure CAWG 3-2).

Below the diversion, in the absence of other more appropriate habitat types, two pocket waters and a bedrock sheet habitat were selected for transect placement. Two of these transects were placed upstream of the Huntington Lake Road. The third transect was placed just downstream of the diversion. A side channel became active at high flow at the most downstream transect, which resulted in a difference in calibration flows between this transect and the adjacent one.

Rancheria Creek does not have a diversion, but SCE has the potential to impact the stream flow with an Energy Dissipater operated when the Portal Powerhouse generator trips (goes offline) in an emergency. This can result in higher flows downstream of the structure. A total of nine transects were located on Rancheria Creek: three transects upstream of the Energy Dissipater, and six downstream. Three transects were placed downstream of the Energy Dissipater in each Rosgen Level 1 channel type present, A and B (Figure CAWG 3-4). Three transects above the Energy Dissipater were placed in B channel.

The CTST decided that it was not necessary to conduct wetted perimeter studies in Ross Creek as the stream is intermittent, even in wet years.

3.3 Transect Installation and Data Collection

The wetted perimeter method evaluates changes in wetted perimeter with changes in stream flow. Wetted perimeter is the distance along the stream bottom from one water edge to the other along a transect established perpendicular to the direction of stream flow. Usually wetted perimeter analyses focus on riffles (Lohr 1993). To accomplish this analysis it is necessary to know the bed profile and the location of the left and right water edges at a series of flow levels. To facilitate this analysis, SCE elected to use the PHABSIM models developed by USFWS to simulate water surface elevations at different flow levels. Because of this, the field measurement procedures used for the wetted perimeter data collection follow those described for use in PHABSIM studies (Trihey and Wegner 1981).

Each transect selected by the CTST was marked with headpins. The headpins were installed at the time of selection to facilitate relocation of the transects during spring 2003, when the first set of measurements were to be taken.

For each cross section, the relative elevation of the headpins and bed profile were surveyed using standard surveying techniques (Trihey and Wegner 1981). Elevations were established relative to a temporary benchmark installed for this purpose. Stage measurements were made at three flow levels. In addition, mean column velocities and depths were measured at several points along each transect. These data were used to provide information regarding the velocities present at the measurement flows for each transect. This information is provided in Appendix A of this report.

In the performance of this study, several conventions were adopted to facilitate the collection of quality data and timely reduction of those data. These included:

1. All survey loops were closed in the field (±0.02 ft).

2. All headpins and water surface elevations were referenced to benchmarks allowing relocation of headpins, etc.

3. More than two water surface elevations were surveyed for transects with rapidly varying flow conditions.

4. Water surface elevations were checked before and after transect measurements to identify any change in discharge during the data collection.

5. Discharges were computed in the field prior to leaving the site.

6. The distance of right headpin was established for each transect and matched in subsequent tape placements to facilitate the collection of point velocity measurements at different calibration flows.

After head pin elevations had been established, transects were surveyed to provide bed profiles for input into the IFG-4a stage-discharge model (Milhaus et al. 1989). While surveying the bed profile, we also surveyed the water surface elevation, water surface slope, and stage of zero flow. The stage of zero flow is defined as "the water surface elevation at a cross section when the flow reaches zero. This is either the lowest point of the bed or the pool water surface when no flow occurs" (Hardy 2002).

Measurements were taken at various times during the natural runoff period with the objective of collecting measurements over a range of flows wider than could be obtained through operation of Project facilities alone. The flow measurements taken were used to develop stage-discharge models. Project operations were modified, as necessary, during the study to provide the flows needed to develop reliable stage-discharge relationship.

Discharge was measured within each study site at three calibration flows. In streams where transects were more distant from each other, discharge was measured near each transect. Flow measurements were collected at locations with the best characteristics for a good flow measurement. These were typically not located on the wetted perimeter analysis transects selected by the CAWG. Locations with uniform depth and velocity profiles, preferably runs or pool tails, were selected for calibration discharge measurements. An attempt was made to collect measurements at a minimum of 15 to 20 verticals for each transect, but because of the small size of the channels, this was not always possible. In these cases, we placed as many verticals as possible at 0.2 ft spacing.

At each habitat transect, stage-discharge measurements were collected at three flow levels. At each flow level, depths and velocity measurements were collected at 5 to 10 points across the channel, as described in the CAWG 3 Study Plan (SCE 2001). Depths were measured to the nearest 0.05 ft and velocity to the nearest 0.01-ft per second (fps). The spacing and number of verticals per transect depended on the cross-section profile and complexity of the velocity distribution along each transect. The specific location at which measurements were taken were replicated at each flow level by matching the distance from the left bank headpin.

3.4 MODELING AND ANALYSIS

The data collected at the study transects were used to develop stage-discharge models which were used for the wetted perimeter and fish passage analyses. Stage-discharge predictions were developed using the IFG-4a regression of the PHABSIM program. This model regresses the logarithm of discharge against the logarithm of water surface elevation minus the stage at zero flow.

The stage-discharge models were used to predict water surface elevations at a series of unmeasured discharges. On some occasions, to complete our analyses, it was necessary to model discharges either higher or lower than the range of flows that were measured in the field. These instances are noted in the results section of this report and the relevant limitations of the model, if any, are discussed.

WETTED PERIMETER ANALYSIS

The wetted perimeter inflection point method is usually based on stream riffles, which are affected more by flow changes than other areas of streams (Lohr 1993). Riffles are important sites for production of invertebrate fish-food organisms (Hynes 1970). Leathe and Nelson (1986) found that the carrying capacity of the stream for fish is proportional to fish-food producing areas and that riffle wetted-perimeter is a reliable index of food producing areas. Because the physical characteristics of riffles are more sensitive to changes in flow than most other habitat types, maintenance of acceptable flows in riffles often preserves other stream habitats for fish and macroinvertebrates, as well.

From zero flow, wetted perimeter increases rapidly with small increases in flow until water reaches the sides of the channel. At the point where the instantaneous rate of change in wetted perimeter with increasing discharge decreases, an inflection point occurs on a plot of wetted perimeter versus discharge. A typical wetted perimeter versus discharge curve has either one or two prominent inflection points. Flow recommendations are made at stream discharges equal to or greater than the discharge at the inflection point, where flows are judged sufficient to maintain existing aquatic invertebrate communities. When two inflection points occur in the wetted perimeter curve, the upper inflection point is assumed to represent flows providing optimal stream conditions (Nelson 1989). Using this technique, ultimate selection of a flow recommendation is usually also based on professional judgment relative to the biological potential of the specific stream.

The stage-discharge model for each transect was used in conjunction with the bed profile to develop a wetted perimeter versus flow relationship for each transect. This relationship was plotted, along with the instantaneous rate of change in the wetted perimeter vs. flow relationship to assist in determining the inflection points. In determining the inflection flow, we evaluated both of the above referenced curves. We also used the PHABSIM model to look at how the water filled the channel at different flow levels and the flow where the water reached the toe of the banks was also selected as an inflection flow. These three analytical techniques generally resulted in similar results, but there were some transects where one method differed substantially from the other two. To select the final inflection point for each transect, we selected the median of the three flow estimates. In our analysis, however, emphasis was placed on the instantaneous rate of change curve, as the inflection point of this curve can be more clearly identified. The flows at which these inflection points occur serve as the basis for identifying the recommended flow levels in this analysis.

The wetted perimeter analysis for the study streams covers a broad range of flows, approaching and sometimes exceeding bank-full flow. The wetted perimeter method is intended, however, to assess the flow levels that provide adequate habitat conditions under baseflow conditions. It is not intended to assess habitat conditions under flood conditions (Lohr 1993). Inflection points in the range of flood flows are not appropriate flow levels for maintaining habitat during the summer months.

FISH PASSAGE ANALYSIS

SCE used the channel geometry and stage-discharge model at each transect to evaluate the flows needed for fish passage. The passage flows were based on Thompson's (1972) depth and velocity criteria for the passage of adult trout. Thompson's criteria call for a minimum depth of 0.4 ft and a maximum water velocity less than four feet per second (fps) to be passable. In this study, for transects to be considered passable, these criteria must be met over a minimum of 25 percent of the wetted channel width, with at least a contiguous 10 percent of the channel width meeting the depth and velocity criteria. This analysis was completed for each transect, and the average of the resulting passage flows of all transects in that stream reach was the recommended passage flow, as described by Thompson (1972). The recommended passage flow is intended to estimate the instream flow required for passage through the typical shallower habitats present, in the absence of other structural barriers to passage (i.e., drops, dams, weirs, or substantial debris jams). The structural barriers present in project streams were assessed during the habitat inventory and are included in the CAWG 14 Fish Passage Report (SCE 2004).

4.0
RESULTS

4.1 MODEL CALIBRATION RESULTS

Field measurements at stream transect locations were collected from April to September of 2003. Stream channel cross-sections and measured water surface elevations at the transect locations are provided in Appendix B. In order to develop a stage-discharge relationship three calibration discharge measurements were taken at each transect. Flows in the individual stream reaches varied with watershed size, geographic orientation, snow melt pattern and the time at which the measurements were taken. The lowest calibration flows were observed on Ely Creek and Adit 8 Creek, while the highest calibration flows were found on Rancheria Creek. Low calibration flows ranged from 0.2 to 2.1 cfs. Middle flows ranged between 1.0 and 10.6 cfs. High flows ranged from 2.4 to 15.1 cfs (Table CAWG 3-4).

The IFG-4a stage-discharge regression method was used for each of the 32 transects. Modeling of the stage discharge relationships was highly successful and acceptable water surface simulations were obtained for all transects through this method. All of the mean errors of the stage discharge relationships were less than five percent. Milhaus et al. (1989) describe a stage discharge relationship with a mean error of less than 10 percent as “good”, and one with a mean error of less than five percent as “excellent”. For all but four transects, simulated water surface elevations from the model were within 0.03 feet of the measured water surface elevations at each measured flow (Appendix C). At the remaining four transects the largest observed error was 0.05 feet.

4.2 WETTED PERIMETER VERSUS FLOW RELATIONSHIPS ON SEASONALLY DIVERTED STREAMS

Wetted perimeter versus flow relationships were developed for each of the 29 transects on streams where wetted perimeter analysis was to be applied [wetted perimeter relationships were not developed for the three transects on Rock Creek where the food availability approach was to be applied]. Eleven of these transects were located upstream of diversions while 18 transects were located downstream of the diversions. Plots of wetted perimeter versus flow and the rate of change in wetted perimeter with flow are provided for each transect in Appendix B. This appendix also provides cross sectional profiles of the transects with the flow that fills the channel bottom depicted on them. The flows for the inflection points determined by the three methods (rate of change in wetted perimeter vs. flow (RCvQ), wetted perimeter vs. flow (WPvQ) and where the water fills the channel bottom (Bed Elevation)) are shown in Table CAWG 3-5.

ADIT 8 CREEK

Three transects were placed on Adit 8 Creek below the diversion. The average inflection flow for these three transects is 0.4 cfs. The flows at the inflection points of the three transects below the diversion were 0.3 cfs at two transects and 0.7 cfs at the third. There was good correspondence in the inflection flows determined by the three methods at these transects. The only difference occurred at BD-HGR-1, where the inflection of RCvQ function was at 0.5 cfs, rather than at 0.3 cfs as indicated for the WPvQ and bed elevation methods. A review of the cross-section profiles with the flows at the inflection points overlain on the cross sections, indicates that these flows fill the channel bottom. This is an important consideration, as the underlying concept of the wetted perimeter analysis is that by filling the channel bottom in riffle areas, a high amount of area suitable for food production is maintained. As previously described, no transects were placed above the diversion on Adit 8 Creek for comparison purposes as the stream is dry above the diversion. The flow in Adit 8 Creek is the result of tunnel leakage.

BALSAM CREEK

Transects were placed above and below the diversion on Balsam Creek. The flows at the inflection points for the three transects on Balsam Creek above the diversion ranged from 0.3 to 0.5 cfs, with an average of 0.4 cfs. At these transects the three methods used to determine the inflection flow demonstrated less agreement. For all three transects, the WPvQ function had inflection points at 0.3 cfs, while the RCvQ functions had inflection points at 0.5 cfs. A review of the cross sectional profiles and stage discharge relationship indicated that the flow that filled the bottom of the channel was 0.1 cfs for cross sections AD-HGR-2 and AD-HGR-7 and one cfs for AD-HGR-1. Based on this information, an average of 0.4 cfs appears to be an appropriate flow for Balsam Creek above the diversion.

On Balsam Creek below the diversion, the inflection point flows for the three transects were 0.3 for BD-HGR-2, 0.5 for BD-HGR-3 and 0.9 for BD-HGR-1, with an average of 0.6 cfs. There was good agreement between the WPvQ, RCvQ, and cross-sectional profile examination for all three transects. The inflection point flow below the diversion is slightly higher than the inflection flow above the diversion. This is likely due to the influence of transect BD-HGR-1. This transect was located in Camp Sierra and has experienced some influence from the development. This transect was considerably wider and had a lower gradient than the other transects, resulting in its higher inflection flow. If this transect is ignored, the inflection flow below Balsam Diversion is similar to that above Balsam Diversion.

ELY CREEK

The average flow at the inflection points for the two transects upstream of the diversion on Ely Creek was 0.6 cfs, with 0.3 cfs at one transect and 0.9 cfs at the other. At each transect, the inflection points of the WPvQ and RCvQ functions occurred at the same flow. Evaluation of the channel cross section found that the channel bottom on both transects were filled at a flow of 0.3 cfs. Thus while the indicated flow level is 0.6 cfs, a flow of 0.3 cfs may provide sufficient water to fill the riffles and support invertebrate production.

Ely Creek below the diversion had an average inflection flow of 0.5 cfs, with a range at the three transects of 0.3 to 0.7 cfs. All three methods had similar inflection points, with one exception. At BD-HGR-4, the bed elevation flow indicated that 0.8 cfs would be needed to fill the channel, while the other two methods indicated a flow of 0.3 cfs was appropriate. The median flow was selected as the appropriate flow for this transect. At BD-HGR-1, the WPvQ curve had two inflection points, one at 0.3 cfs and one at 0.7 cfs. The inflection point at 0.7 cfs was selected because it was more consistent with the RCvQ function. The inflection flow for Ely Creek below the diversion appears to be very comparable to that for Ely Creek above the Diversion.

PITMAN CREEK

Transects were placed above and below the diversion on Pitman Creek, although these areas differ markedly in structure, as do the transects representing these areas. On Pitman Creek above the diversion, the average inflection flow was 0.8 cfs for the three transects above the diversion. The three methods resulted in different inflection flows at AD-HGR-2 – ranging from 0.3 to 0.9 cfs. The RCvQ and WPvQ functions agreed more closely for this transect, while the bed elevation method provided the higher 0.9 cfs flow. The three methods agreed within 0.2 cfs at the other two transects.

For Pitman Creek below the diversion the average inflection flow of the three transects was 0.5 cfs. The RCvQ and WPvQ functions agreed closely at all transects, but the bed elevation method diverged from these methods at two of the three transects. The bed elevation method resulted in a lower flow than the other methods at BD-POW-3 and a higher flow than the other methods at BD-BRS-8.

While the inflection flows above and below Pitman Diversion differ, this difference is not surprising. These two areas are quite different morphologically, as described in Section 3.2. The area above the diversion is wider and has a lower gradient, and thus the higher flow level would be anticipated. The area below the diversion is steep and narrow, consisting of bedrock sheet flow, bedrock chutes, with a few pools interspersed. This habitat provides little in the way of invertebrate production aside from Simuliids and other organisms that can withstand very high, constant velocities.

RANCHERIA CREEK

Rancheria Creek is not diverted, but the flow of Ward Tunnel may be shunted into the creek on rare occasions if there is an emergency trip of the Portal Powerhouse generator. Thus this section of stream may receive very high flows on rare occasions. These flows enter the creek at an energy dissipater. Transects were placed above and below the dissipater. Above the energy dissipater, inflection flows averaged 0.5 cfs for the three transects. The three methods provided consistent results for all three transects.

Below the energy dissipater, the average of the inflection flows at the six transects (there were two channel types in this section) was 0.4 cfs. Again the three methods provided consistent results for all transects, generally differing by less than 0.1 cfs and never more than 0.2 cfs.

4.2.1 INFLECTION POINTS OUTSIDE RANGE OF EXTRAPOLATION

For four transects in this study, the inflection points occur at flows lower than the usually accepted limits for extrapolation of the model (0.4 times the lowest measured flow (Milhaus et al. 1989)). These transects are summarized in Table CAWG 3-6. The results from these transects may not provide the same level of reliability as those from transects where the inflection point is within the normally accepted range of extrapolation. In three of the four cases, the flows are only slightly beyond the range of accepted extrapolation (<0.2 cfs) and thus are likely reliable. At one transect in Balsam Creek below the diversion (BD-HGR-2), the lowest calibration flow was 2.1 cfs providing a lower extrapolation range of 0.8 cfs. The inflection flow of 0.3 cfs was well beyond the range of extrapolation. If this transect were eliminated from consideration, the inflection flow for Balsam Creek below the diversion would increase from 0.6 cfs to 0.7 cfs.

4.3 FISH PASSAGE

This analysis provides an estimate of the flow needed to provide fish passage upstream through representative shallow habitats, typically riffles. The flow necessary for fish passage was based on the channel cross sections and the water surface elevations. as discussed in Section 3.4 of this report. The information provided here is discussed in conjunction with structural barriers in CAWG 14 (SCE 2004), to provide a more complete description of passage issues in each stream.

ADIT 8

Adit 8 Creek was found to contain no fish during fish population surveys conducted in 2002 (SCE 2003c). Therefore providing a minimum passage flow is unwarranted. Additionally, Adit 8 Creek is created by leakage from Tunnel 2. SCE has no way of regulating flow in Adit 8 Creek. These factors were discussed during the transect selection process, but the CAWG felt that evaluation of this stream was necessary. On Adit 8 Creek the minimum passage flow ranged from 0.6 to 2.4 cfs for the three transects providing a passage flow of 1.6 cfs (derived from the average of the transects, see Section 3.4) (Table CAWG 3-7).

BALSAM CREEK

For Balsam Creek above the diversion, Transect AD-HGR-2 was not used in the passage analysis because of backwater effects from a downstream control. The minimum passage flows at the remaining two transects were 0.1 and 1.8 cfs, with an average flow of 1.0 cfs. On Balsam Creek below the diversion, passage flows ranged from 0.5 to 4.25 cfs. This resulted in an average passage flow for this reach of 2.5 cfs. For transect BD-HGR-3 which had the highest passage flow based on the criteria, passage would likely be possible at two cfs. At two cfs, the depth criteria would be met over a contiguous 20 percent of the channel width, a width of 1.8 ft. If this were taken into account, the average passage flow recommendation would be 1.8 cfs for Balsam Creek below the diversion.

ELY CREEK

On Ely Creek above the diversion, flows of 0.9 and 1.4 cfs were indicated for passage at the individual transects, for an average passage flow of 1.2 cfs. On Ely below the diversion, passage flows at the three transects range from 1.2 to 3.75 cfs, with an average of 2.4 cfs.

PITMAN CREEK

On Pitman Creek the average passage flow was 3.6 cfs above the diversion and 2.5 cfs below the diversion. As previously discussed in Section 3.2, the channel above the diversion was different than that below the diversion. Above the diversion, the channel had a much lower gradient, an alluvial substrate, a broader cross section and was less confined than the channel below the diversion. Below the diversion, the channel was much steeper, with predominantly bedrock substrate. Pitman Creek below the diversion has numerous falls and bedrock sheet habitats that would likely make migration along any distance of stream impossible, due to drops at the falls, and shallow depths and high velocities in bedrock sheet areas. The analysis presented below, does not account for these types of barriers, although the discussion of transect BD-BRS-8 below, provides an excellent example of the passage problems associated with bedrock sheet habitats. These are discussed in more detail in the CAWG 14 Fish Passage report (SCE 2004 in prep.)

For Pitman Creek above the diversion, the minimum passage flows at the three transects ranged between 1.2 and 6.6 cfs. The passage flow of 6.6 cfs was associated with transect LGR-1, which is a low-gradient riffle habitat. At this transect, the water surface elevations showed a relatively small response to increasing flow conditions. The higher passage flow is required because the channel is wide and flat, causing the water to spread thinly across the channel as the flow increases. The PHABSIM model calculates a wet channel width of 24.9 ft at one cfs, growing to a width of 34.0 ft at 6.6 cfs. This is caused by a flat bedrock sheet on the left bank. Due to this wide and flat condition, the minimum passage flow increases to 6.6 cfs before satisfying the criterion of 25 percent of the total wetted-width exhibiting a passable depth. At a flow of 5.4 cfs the minimum contiguous width criterion is satisfied with 11.8 percent of the channel width being passable. At this flow, the total passable width of the channel is 23.2 percent of the total channel width, just slightly below the 25 percent criterion. Given the wide nature of the channel, this means 7.8 ft of the channel would be passable at a flow of 5.4 cfs, with four ft being contiguous. Fish would likely be able to pass upstream under these conditions. At AD-HGR-2, which requires a flow of three cfs to meet the channel width criteria, a flow of 1.8 cfs would provide passage over 24.4 percent of the channel with a contiguous passage width of 2.3 feet. Using the alternate minimum passage flows for LGR-1 and HGR-2, the average minimum passage flow for Pitman Creek above the diversion would be 2.8 cfs, rather than 3.6 cfs indicated by a strict interpretation of the study criteria.

On Pitman Creek below the diversion, the minimum passage flows at the three transects ranged between 0.2 and 7.1 cfs. The high passage flow of 7.1 cfs was associated with transect BRS-8, and is required because the stream channel consists of bedrock with a shallowly sloping bedrock shelf along the right bank. This creates a stage-discharge relationship with a very shallow slope, indicating that depth increases slowly as a function of flow. Therefore, the higher flow is required to provide sufficient depth across the channel for fish passage. This transect exhibited velocities greater than four fps across the channel at the middle calibration flow (4.5 cfs). For both the high- and mid-flow conditions, the velocities at stations where depths were greater than 0.4 feet were above 4.6 fps (Appendix A Table A-4). The model results show that where the water depth is sufficient for passage, the velocities are too high. This indicates that this transect would be impassible at any flow simulated. The other two transects on Pitman Creek below the diversion were placed in pocket water habitat types, due to the lack of riffles in this steep canyon reach. At these transects backwaters created by downstream hydraulic controls resulted in passage flows of 0.2 cfs. Thus in Pitman Creek downstream of the diversion, the passage flow analysis provides limited insight into the flow levels required for passage. However, in this reach of stream, passage flows are largely irrelevant. As described in Section 3.2 and in the Habitat Inventory Report (SCE 2003b), this reach is very steep, with predominantly bedrock sheet and cascade habitat types, with some pools interspersed. The structural barriers in this reach would prevent fish from moving more than 100-200 feet in most areas, regardless of flow level.

RANCHERIA CREEK

Rancheria Creek had average passage flows of 2.7 cfs above the energy dissipater and 2.4 cfs below the energy dissipater. These transects were placed in classic riffle habitats, except for two transects below the dissipater (BED-RUN-1 and BED-SRN-2) which were runs and were not included in the analysis as they were not representative of typical passage impediments.

On Rancheria Creek above the energy dissipater (AED), the minimum passage flows at the three transects range between 0.7 and five cfs. The high passage flow of five cfs is located at transect AED-46. The channel bottom at this transect is uneven, with several boulders creating rises along the cross section. These “spikes” in the channel bottom split up the deep portions of the channel, and prevented a contiguous 10 percent of the channel width to meet Thompson’s depth criterion until the minimum passage flow was increased to five cfs. At a flow of 3.25 cfs, the total percent passable across the width of the channel is 26.7 percent, with a contiguous percentage of nine percent. Using this minimum passage flow of 3.25 for AED-46, the average minimum passage flow for Rancheria Creek AED would drop to 2.1 cfs from 2.7 cfs.

On Rancheria Creek below the energy dissipater, the minimum passage flows ranged from 0.3 to 3.75 cfs. At transect BED-LGR-4, adequate passage conditions would be available at two cfs, rather than the 3.5 cfs indicated by a strict interpretation of the study criteria. The two cfs flow would provide a total of 3.3 feet of passable width in an active channel a little over 14 feet wide. This means passage would be met at 23 percent of the channel width. The contiguous width more than 0.4 feet deep would be 1.1 feet, or 8.5 percent of the channel width. This certainly provides a sufficient width of stream for trout to move upstream through. If this flow is suitable for passage, the average passage flow for Rancheria Creek below the energy dissipater would be two cfs.

5.0 CONCLUSIONS

This report provides the results of flow-related habitat analyses for seasonally diverted streams in the Lower Basin. Specifically these streams included: Rancheria Creek, Pitman Creek, Balsam Creek, Adit 8 Creek, and Ely Creek. Transects for evaluating flow related habitat on these streams were selected by the CTST in fall 2002. The CTST agreed that studies on Ross Creek were unnecessary as this stream goes dry in the summer, even during wet years. Wetted perimeter and fish passage analyses were conducted for each of these streams.

The inflection flows based upon the wetted perimeter analysis ranged 0.4 to 0.8 cfs above the diversions and 0.4 to 0.6 cfs below the diversions. The flows at the inflection points were similar above and below the diversion for all streams. The greatest difference occurred at Pitman Creek, which had different channel characteristics above and below the diversion. The flows at the inflection points are consistent with the small size of these channels, most being less than 10 feet wide. The results of the wetted perimeter analysis were confirmed by using three analytical approaches. These approaches generally provided similar results.

Minimum flows for fish passage were estimated for each stream. Passage flows ranged from 0.7 to 3.6 cfs above the diversions and 1.6 to 2.5 cfs below the diversions. In two stream reaches, passage flows that were unusually high relative to other transects prompted a closer evaluation. At these transects additional analysis suggested that lower streamflows for passage might be appropriate. These are Pitman Creek above the diversion, and Rancheria Creek below the diversion. Taking these additional analyses into account, passage flows for Pitman Creek above the diversion would be reduced from 3.6 to 2.8 cfs. On Rancheria Creek below the energy dissipater passage flows would be decreased from 2.4 to 2.0 cfs when a revised flow estimate for one transect is incorporated.

There is no consistent pattern in the relationship of required flows above or below the diversions for either the wetted perimeter or passage analyses. Two streams had higher wetted perimeter flows above the diversion and two had lower wetted perimeter flows above the diversion. Passage flow requirements were higher above the diversion in three streams and lower above the diversion in Balsam Creek. The lack of a consistent pattern is indicative of the similarity of the channel types in which the transects were placed above and below the diversions (except Pitman Creek). It might be expected that the channels below the diversions would be wider, given that they drain a greater portion of the watershed, however, these are first order tributaries and the watersheds are small. Thus the runoff (accretion) from upland areas between the diversion and the transects downstream of the diversion may be relatively small. Additionally, the diversions are placed at locations on the streams where the gradient begins to pick up. Thus the channels below the diversions might be expected to be narrower from that perspective.

The results of these studies will be used in conjunction with an assessment of the management goals and the results of other studies for these streams, to develop flow recommendations for the FERC license applications. Resource management considerations include those for the individual streams, the basin as a whole, and the Big Creek ALP Hydroelectric system. Among the other study results to be considered are those from other instream flow studies, as well as studies of fish, amphibians, riparian zones, geomorphology, recreation and others.

6.0
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TABLES

Table CAWG 3-1. Rosgen Level 1 Channel Types for Lower Basin Small Streams.

Stream	Reach	Geomorphology Rosgen Typing 2000-2001
Adit 8 Creek		Aa+
Balsam Creek	AD	Aa+
	BD	Aa+
Ely Creek	AD	Aa+
	BD	Aa+
Pitman Creek	AD	G
	BD	Aa+/G
Rancheria Creek	AED	B
	BED	A/B

Table CAWG 3-2. CAWG Transect Selection Team (CTST) Members Present during Transect Selection.

			Participants									
Stream	**Reach**	**Date**	**Steve Rowan, SCE**	**Wayne Allen, SCE**	**Dennis Smith, USFS**	**Phil Strand, USFS**	**Julie Means, CDFG**	**Britt Fecko, SWRCB**	**Larry Wise, ENTRIX**	**Coralie Dayde, ENTRIX**	**Wiley Taylor, ENTRIX**	**Jason Coburn, ENTRIX**
Adit 8 Creek	Below Diversion	7/29/2002	X	X		X			X	X	X	
Ross Creek	Above Diversion	7/30/2002		X		X	X	X	X	X	X	
Ross Creek	Below Diversion	7/30/2002		X		X	X	X	X	X	X	
Ely Creek	Above Diversion	7/31/2002		X		X			X		X	
Ely Creek	Below Diversion	7/31/2002		X		X			X		X	
Balsam Creek	Above Diversion	7/31/2002		X		X			X		X	
Balsam Creek	Below Diversion	7/31/2002		X		X			X		X	
Pitman Creek	Above Diversion	8/1/2002		X		X	X		X	X	X	
Pitman Creek	Below Diversion	8/1/2002		X		X	X		X	X	X	
Rancheria Creek	Above Energy Dissipater	10/25/2002			X		X		X	X		X
Rancheria Creek	Below Energy Dissipater	10/25/2002		X	X		X		X	X		X

Table CAWG 3-3. Site Names and Transect Designations for Wetted Perimeter Study.

Site Name	Transect Designation	Habitat Type[1]
Adit 8 Creek	BD-LGR-5	LGR
	BD-HGR-1	HGR
	BD-HGR-6	HGR
Balsam Creek Above Diversion	AD-HGR-2	HGR
	AD-HGR-1	HGR
	AD-HGR-7	HGR
Balsam Creek Below Diversion	BD-HGR-3	HGR
	BD-HGR-2	HGR
	BD-HGR-1	HGR
Ely Creek Above Diversion	AD-RUN-1	RUN
	AD-SRN-2	SRN
Ely Creek Below Diversion	BD-HGR-4	HGR
	BD-HGR-1	HGR
	BD-HGR-2	HGR
Pitman Creek Above Diversion	AD-HGR-2	HGR
	AD-LGR-1	LGR
	AD-LGR-3	LGR
Pitman Creek Below Diversion	BD-POW-3	POW
	BD-BRS-8	BRS
	BD-POW-6	POW
Rancheria Creek Above Energy Dissipater	AED-HGR-1	HGR
	AED-HGR-2	HGR
	AED-HGR-4	HGR
Rancheria Creek Below Energy Dissipater	BED-RUN-1	RUN
	BED-SRN-2	SRN
	BED-LGR-3	LGR
	BED-LGR-5	LGR
	BED-LGR-4	LGR
	BED-HGR-2	HGR

[1] LGR – Low Gradient Riffle, HGR – High Gradient Riffle, SPO – Step Pool, SRN – Step Run, RUN – Run, POW – Pocket Water, BRS – Bedrock Sheet

Table CAWG 3-4. Flows Measured During Data Collection at Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect	Low	Middle	High
Adit 8 Below Diversion	BD-LGR-5	0.17	1.02	3.75
	BD-HGR-1,BD- HGR-6	0.24	0.95	5.32
Balsam Creek Above Diversion	AD-HGR-2	0.94	3.58	4.90
	AD-HGR-1, AD-HGR-7	1.26	3.12	6.24
Balsam Creek Below Diversion	BD-HGR-3, BD-HGR-2	2.11	3.65	5.60
	BD-HGR-1	1.84	3.55	4.97
Ely Creek Above Diversion	All	0.32	1.02	2.37
Ely Creek Below Diversion	BD-HGR-4	0.51	2.35	3.24
	BD-HGR-1, BD-HGR-2	0.51	1.98	3.01
Pitman Creek Above Diversion	All	0.17	3.94	13.82
Pitman Creek Below Diversion	BD-POW-3	0.64	4.49	10.76
	BD-BRS-8	0.64	4.49	11.90
	BD-POW-6	0.20	3.74	11.04
Rancheria Creek Above Energy Dissipater	All	1.10	8.49	12.62
Rancheria Creek Below Energy Dissipater	All	0.90	5.55	15.11

Table CAWG 3-5. Flow at the Inflection Points for Wetted Perimeter Analysis, Lower Basin Streams.

Site Name	Transect	Rate of Change	WP vs Q	Bed Profile		Median
Adit 8 Creek	BD-LGR-5	0.3	0.3	0.3		0.3
	BD-HGR-1	0.5	0.3	0.3		0.3
	BD-HGR-6	0.7	0.7	0.7		0.7
					Average	**0.4**
Balsam Creek Above Diversion	AD-HGR-2	0.5	0.3	0.1		0.3
	AD-HGR-1	0.5	0.3, 1.7	1.0		0.5
	AD-HGR-7	0.5	0.3, 1.1	0.1		0.5
					Average	**0.4**
Balsam Creek Below Diversion	BD-HGR-3	0.5	0.5	0.5		0.5
	BD-HGR-2	0.3	0.3	0.2		0.3
	BD-HGR-1	0.9	0.7	0.9		0.9
					Average	**0.6**
Ely Creek Above Diversion	AD-RUN-1	0.3	0.3	0.3		0.3
	AD-SRN-2	0.9	0.9	0.3		0.9
					Average	**0.6**
Ely Creek Below Diversion	BD-HGR-4	0.3	0.3	0.8		0.3
	BD-HGR-1	0.7	0.3, 0.7	0.8		0.7
	BD-HGR-2	0.5	0.5	0.5		0.5
					Average	**0.5**
Pitman Creek Above Diversion	AD-HGR-2	0.5	0.3	0.9		0.5
	AD-LGR-1	0.3, 1.3	0.3, 1.3	1.3		1.3
	AD-LGR-3	0.7	0.5	0.5		0.5
					Average	**0.8**
Pitman Creek Below Diversion	BD-POW-3	0.5	0.5	0.2		0.5
	BD-BRS-8	0.4	0.3	0.9		0.4
	BD-POW-6	0.6	0.6	0.6		0.6
					Average	**0.5**
Rancheria Creek Above Energy Dissipater	AED-HGR-1	0.3	0.3	0.7		0.3
	AED-HGR-2	0.5	0.5	0.5		0.5
	AED-HGR-4	0.7	0.7	0.8		0.7
					Average	**0.5**
Rancheria Creek Below Energy Dissipater	BED-RUN-1	0.5	0.3	0.3		0.3
	BED-SRN-2	0.3	0.3	0.3		0.3
	BED-LGR-3	0.5	0.7	0.6		0.6
	BED-LGR-5	0.4	0.4	0.5		0.4
	BED-LGR-4	0.4	0.4	0.4		0.4
	BED-HGR-2	0.6	0.6	0.7		0.6
					Average	**0.4**

TableCAWG 3-6. Inflection Point, Lowest Extrapolation Flow, and Lowest Observed Flow for Selected Transects.

Stream	Transect	Rate of Change	WP vs Q	Bed Profile	Lower Limit of Extrapolation	Lowest Observed Flow
Balsam Creek Below Diversion	BD-HGR-3	0.5	0.5	0.5	0.8	2.1
Balsam Creek Below Diversion	BD-HGR-2	0.3	0.3	0.2	0.8	2.1
Rancheria Creek Above Energy Dissipater	AED-HGR-1	0.3	0.3	0.7	0.4	1.1
Rancheria Creek Below Energy Dissipater	BED-SRN-2	0.3	0.3	0.3	0.4	0.9

Table CAWG 3-7. Minimum Passage Flows for Adult Trout, Based on Wetted Perimeter Transects.

	Above Diversion / Energy Dissipater				Below Diversion / Energy Dissipater			
Stream	**Transect**	**Passage Flow (cfs)**	**% Passable of Total Width**	**% Contiguous and Passable**	**Transect**	**Passage Flow (cfs)**	**% Passable of Total Width**	**% Contiguous and Passable**
Adit 8	NA				BD-LGR-5	1.8	78.6	78.6
					BD-HGR-1	0.6	38.9	19.4
					BD-HGR-6	2.4	30.4	16.1
					Average:	**1.6**		
Balsam	AD-HGR-2	NA - STZ 0.5 ft higher than thalweg			BD-HGR-3	4.25	29.7	22.5
	AD-HGR-1	1.8	33.3	33.3	BD-HGR-2	0.5	39.4	39.4
	AD-HGR-7	0.1	26.4	26.4	BD-HGR-1	2.75	41.4	13.3
	Average:	**1.0**			***Average:***	**2.5**		
Ely	AD-RUN-1	0.9	42.0	42.0	BD-HGR-4	3.75	31.0	31.0
	AD-SRN-2	1.4	34.1	34.1	BD-HGR-1	2.25	30.5	10.5
					BD-HGR-2	1.2	40.0	40.0
	Average:	**1.2**			***Average:***	**2.4**		
Pitman	AD-HGR-2	3	35.5	35.5	BD-POW-3	0.2	33.3	33.3
	AD-LGR-1	6.6	28.6	11.5	BD-BRS-8	7.1	39.6	28.3
	AD-LGR-3	1.2	35.5	19.6	BD-POW-6	0.2	25.6	25.6
	Average:	**3.6**			***Average:***	**2.5**		
Rancheria	AED-HGR-1	2.25	35.0	14.5	BED-RUN-1	NA - not representative		
	AED-HGR-2	0.7	25.0	20.8	BED-SRN-2	NA - not representative		
	AED-HGR-4	5	46.2	13.0	BED-LGR-3	0.6	25.7	18.6
					BED-LGR-5	3.75	27.2	18.1
					BED-LGR-4	3.5	27.2	12.8
					BED-LGR-2	1.8	25.3	25.3
	Average:	**2.7**			***Average:***	**2.4**		

FIGURES

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APPENDIX A

MEASURED VELOCITIES AND DEPTHS AT WETTED PERIMETER TRANSECTS

CAWG 3 Appendix A Table A-1. Measured Depths and Velocities for Adit 8.

Site	Transect	Discharge (cfs)			Station	Velocity (fps)			Depth (feet)		
		Hi Q	Mid Q	Low Q		Hi Q	Mid Q	Low Q	Hi Q	Mid Q	Low Q
Adit 8 Below Diversion	LGR-5	3.75	1.02	0.17	10.1	0.66	0.28	0.00	0.40	0.30	0.15
					10.5	2.33	0.51	0.06	0.50	0.35	0.10
					11.1	3.38	1.65	0.76	0.60	0.35	0.10
					11.7	4.99	3.11	*	0.50	0.35	*
					12.0	3.57	2.58	*	0.25	0.25	*
	HGR-1	5.32	0.95	0.24	10.7	1.02	0.63	0.31	0.70	0.30	0.30
					11.1	6.30	0.94	1.21	0.70	0.40	0.40
					11.7	4.21	1.75	0.00	0.70	0.25	0.10
					12.3	3.99	*	*	0.50	*	*
	HGR-6	5.32	0.95	0.24	20.6	2.05	*	*	0.70	*	*
					21.0	1.73	0.59	*	0.60	0.20	*
					21.6	3.40	2.51	1.46	0.60	0.18	0.10
					22.2	4.29	2.79	1.48	0.55	0.20	0.15
					22.6	4.84	2.43	1.99	0.40	0.30	0.10

* Insufficient depth for measurement

cfs = cubic feet per second
fps = feet per second

CAWG 3 Appendix A Table A-2. Measured Depths and Velocities for Balsam Creek.

Site	Transect	Discharge (cfs)			Station	Velocity (fps)			Depth (feet)		
		Hi Q	Mid Q	Low Q		Hi Q	Mid Q	Low Q	Hi Q	Mid Q	Low Q
Balsam Creek Above Diverson	HGR-2	4.90	3.58	0.94	5.0	0.10	0.47	0.32	1.05	0.90	0.75
					6.0	0.26	0.21	0.11	0.90	0.70	0.45
					7.0	0.85	0.39	0.39	1.10	0.60	0.30
					8.3	1.00	0.26	0.08	1.05	0.85	0.70
					9.3	1.98	2.71	0.89	0.90	0.70	0.50
					10.3	0.16	0.15	0.10	0.35	0.70	0.55
	HGR-1	6.24	3.12	1.26	14.1	0.42	0.22	*	0.45	0.20	0.05
					21.6	2.09	2.02	1.06	0.70	0.50	0.40
					23.5	1.08	*	*	0.20	*	*
					25.5	0.63	0.92	0.56	0.55	0.35	0.20
					26.2	0.82	0.73	0.64	0.55	0.30	0.15
	HGR-7	6.24	3.12	1.26	14.1	1.05	0.23	*	0.40	0.20	0.05
					15.7	1.55	0.55	0.08	0.55	0.40	0.30
					17.3	1.68	2.18	1.78	0.75	0.60	0.45
					18.5	2.35	2.23	2.00	1.00	0.80	0.70
					19.7	0.56	0.18	0.24	0.75	0.60	0.50
Balsam Creek Below Diverson	HGR-3	5.60	3.65	2.11	10.4	0.83	0.02	0.25	0.35	0.30	0.20
					11.9	2.66	2.81	0.00	0.35	0.20	0.10
					13.9	1.96	1.10	1.24	0.45	0.25	0.20
					16.4	0.78	0.90	1.27	0.45	0.30	0.20
					17.4	0.97	1.24	0.54	0.55	0.40	0.30
	HGR-2	5.60	3.65	2.11	19.2	0.30	0.22	0.12	0.70	0.55	0.50
					20.0	2.30	0.39	0.32	0.60	0.50	0.45
					20.4	3.70	2.84	0.84	0.60	0.50	0.45
					20.7	3.19	1.97	3.21	0.70	0.50	0.30
					21.7	1.56	5.37	1.61	1.00	0.75	0.50
					22.0	4.70	**	**	0.90	**	**
	HGR-1	4.97	3.55	1.84	8.3	2.09	1.56	1.78	0.60	0.40	0.20
					9.2	2.69	2.17	2.69	0.50	0.40	0.30
					10.6	2.20	1.22	*	0.40	0.20	*
					12.1	2.29	1.81	1.52	0.80	0.65	0.50
					13.2	0.49	0.50	0.56	0.70	0.55	0.40

* Insufficient depth for measurement
** No measurement taken

cfs = cubic feet per second
fps = feet per second

CAWG 3 Appendix A Table A-3. Measured Depths and Velocities for Ely Creek.

Site	Transect	Discharge (cfs)			Station	Velocity (fps)			Depth (feet)		
		Hi Q	Mid Q	Low Q		Hi Q	Mid Q	Low Q	Hi Q	Mid Q	Low Q
Ely Creek Above Diversion	RUN-1	2.37	1.02	0.32	9.7	0.92	0.54	0.83	0.60	0.50	0.25
					10.3	0.78	0.48	1.04	0.55	0.50	0.20
					11.1	0.94	0.57	1.26	0.60	0.50	0.20
					11.7	0.89	0.61	0.90	0.60	0.50	0.15
					12.1	0.82	0.45	*	0.60	0.40	*
	SRN-2	2.37	1.02	0.32	10.6	0.48	0.50	0.15	0.60	0.50	0.35
					11.5	0.55	0.71	0.39	0.50	0.40	0.30
					13.5	0.32	0.38	0.50	0.50	0.30	0.20
					15.0	0.41	0.46	0.00	0.40	0.30	0.10
					17.5	0.52	0.14	*	0.40	0.25	0.05
Ely Creek Below Diversion	HGR-4	3.24	2.35	0.51	8.4	2.03	1.71	*	0.45	0.35	*
					9.0	1.91	1.30	0.37	0.40	0.45	0.20
					9.6	1.82	2.44	*	0.45	0.40	*
					10.5	3.42	1.56	*	0.40	0.50	*
					13.5	0.04	0.01	0.20	0.30	0.30	0.20
	HGR-1	3.01	1.98	0.51	15.6	**	0.14	*	**	0.20	*
					15.2	2.40	0.15	0.91	0.55	0.40	0.30
					13.1	1.18	0.25	1.61	0.60	0.55	0.20
					10.0	3.87	0.72	2.37	0.25	0.25	0.20
					6.1	1.72	0.26	*	0.25	0.20	*
	HGR-2	3.01	1.98	0.51	12.0	1.21	0.46	1.60	0.75	0.40	0.30
					11.5	0.75	0.27	1.51	0.80	0.55	0.30
					10.7	0.94	0.27	1.96	0.50	0.45	0.10
					10.0	2.81	0.53	*	0.35	0.30	*
					7.4	1.81	0.57	0.00	0.40	0.20	0.10

* Insufficient depth for measurement
** No measurement taken

cfs = cubic feet per second
fps = feet per second

CAWG 3 Appendix A Table A-4. Measured Depths and Velocities for Pitman Creek.

Site	Transect	Discharge (cfs)				Velocity (fps)			Depth (feet)		
		Hi Q	Mid Q	Low Q	Station	Hi Q	Mid Q	Low Q	Hi Q	Mid Q	Low Q
Pitman Creek Above Diversion	HGR-2	13.82	3.94	0.17	79.4	0.66	0.31	*	0.30	0.20	*
					78.4	0.87	0.82	*	0.65	0.40	*
					77.4	2.16	1.81	0.03	0.80	0.60	0.20
					76.4	3.54	2.94	0.95	0.80	0.60	0.20
					75.4	1.91	3.09	0.00	0.70	0.55	0.15
					74.6	3.10	3.51	*	0.20	0.10	*
	LGR-1	13.82	3.94	0.17	38.8	0.96	0.48	*	0.35	0.15	*
					48.4	1.01	*	*	0.20	*	*
					50.5	1.53	1.21	*	0.40	0.20	0.05
					52.8	3.00	2.13	1.16	0.40	0.25	0.10
					54.8	2.02	1.51	0.38	0.50	0.25	0.10
					66.3	1.88	0.41	*	0.50	0.15	*
					66.8	2.71	1.65	*	0.50	0.15	*
					67.8	1.68	0.95	*	0.50	0.20	*
	LGR-3	13.82	3.94	0.17	46.0	1.03	0.23	*	0.80	0.50	0.05
					47.0	0.22	0.40	*	0.65	0.40	*
					48.0	0.91	1.25	0.80	0.55	0.50	0.10
					50.0	2.87	2.70	0.75	0.60	0.60	0.15
					51.0	2.11	1.64	*	0.85	0.55	0.05
					52.0	1.02	1.84	*	0.80	0.40	*
Pitman Creek Below Diversion	POW-3	10.76	4.49	0.64	2.00	0.00	0.02	-0.10	1.15	0.70	0.20
					2.55	0.33	0.55	0.14	1.45	1.10	0.55
					3.00	**	**	2.73	**	**	0.65
					3.55	1.22	0.48	0.06	1.40	1.00	0.55
					4.55	1.94	2.38	-0.54	1.25	0.80	0.30
					5.55	2.54	1.15	-0.55	1.10	0.70	0.25
					6.55	1.15	0.89	**	1.25	0.40	**
	BRS-8	11.90	4.49	0.64	26.0	3.07	3.24	1.76	0.5	0.3	0.10
					26.5	5.48	4.82	2.66	0.5	0.4	0.10
					27.0	5.76	4.64	3.35	0.6	0.4	0.15
					28.0	5.59	5.11	*	0.5	0.35	0.05
					29.0	5.57	5.44	*	0.45	0.2	*
	POW-6	11.04	3.74	0.20	27.0	0.65	0.59	*	1.20	0.75	0.05
					28.0	1.22	0.42	0.29	1.60	0.90	0.20
					28.2	**	0.65	0.00	**	1.20	0.45
					29.0	2.27	1.33	0.06	1.50	1.10	0.30
					30.0	2.39	1.58	*	1.40	0.90	0.05
					30.8	2.43	1.12	**	0.90	0.55	**

* Insufficient depth for measurement
** No measurement taken

cfs = cubic feet per second
fps = feet per second

CAWG 3 Appendix A Table A-5. Measured Depths and Velocities for Rancheria Creek.

Site	Transect	Discharge (cfs) Hi Q	Discharge (cfs) Mid Q	Discharge (cfs) Low Q	Station	Velocity (fps) Hi Q	Velocity (fps) Mid Q	Velocity (fps) Low Q	Depth (feet) Hi Q	Depth (feet) Mid Q	Depth (feet) Low Q
Rancheria Creek Above Energy Dissipator	AED-HGR-1	12.62	8.49	1.10	11.5	0.82	1.15	2.05	0.90	0.70	0.30
					14.4	1.92	2.20	1.02	0.90	0.50	0.30
					15.7	2.29	1.91	1.43	0.80	0.55	0.20
					17.0	1.82	2.11	0.75	0.80	0.65	0.30
					18.2	2.41	1.98	0.83	0.70	0.55	0.20
					19.7	2.41	2.11	*	0.50	0.25	*
					31.0	1.73	0.89	**	0.40	0.30	**
	AED-HGR-2	12.62	8.49	1.10	13.6	4.74	2.62	*	0.60	0.40	*
					15.0	3.71	1.58	0.43	0.80	0.60	0.25
					20.4	1.25	0.25	1.28	0.70	0.55	0.30
					21.4	2.50	3.08	1.15	0.80	0.80	0.50
					22.9	1.77	0.86	0.04	0.80	0.65	0.50
	AED-HGR-4	12.62	8.49	1.10	12.0	3.12	2.10	0.74	0.80	0.50	0.25
					14.9	1.10	0.72	1.09	0.90	0.60	0.40
					17.1	2.15	2.31	0.65	0.65	0.45	0.25
					20.0	0.22	0.33	*	0.55	0.30	*
					23.0	0.35	1.32	*	0.50	0.40	*
Rancheria Creek Below Energy Dissipator	BED-RUN-1	15.11	5.55	0.90	12.2	0.61	0.05	0.01	1.50	1.20	0.80
					15.0	0.46	0.04	0.00	1.40	1.05	0.65
					16.0	3.79	1.95	*	0.60	0.15	*
					17.0	3.94	3.16	1.92	0.80	0.60	0.20
					19.0	1.34	0.19	0.03	1.20	0.80	0.45
					22.0	0.49	*	*	0.80	*	*
	BED-SRN-2	15.11	5.55	0.90	5.4	1.44	0.70	0.00	0.80	0.40	0.10
					6.4	2.00	1.36	*	0.50	0.15	*
					7.4	1.16	0.55	0.00	0.90	0.50	0.10
					11.0	**	0.25	0.10	**	0.95	0.50
					13.5	1.06	0.57	0.47	1.80	0.90	0.50
					15.6	0.71	*	*	0.80	*	*
	BED-LGR-3	15.11	5.55	0.90	9.5	3.69	2.42	0.80	0.90	0.60	0.40
					10.5	3.96	2.85	1.89	0.90	0.55	0.30
					11.5	2.40	0.59	0.48	1.10	0.60	0.40
					12.2	1.34	1.04	*	0.50	0.15	*
					15.5	2.57	1.85	0.26	0.90	0.60	0.40
	BED-LGR-5	15.11	5.55	0.90	12.0	1.01	0.89	0.63	0.70	0.35	0.20
					13.0	1.51	0.48	0.00	0.80	0.50	0.40
					15.0	2.11	1.80	0.96	0.70	0.50	0.30
					17.0	2.65	1.39	1.19	0.70	0.50	0.25
					19.0	0.70	0.12	0.06	0.80	0.50	0.30
	BED-LGR-4	15.11	5.55	0.90	11.5	2.05	0.43	*	0.60	0.20	*
					13.5	2.14	2.03	0.19	0.65	0.45	0.25
					14.7	1.23	2.46	0.31	0.80	0.50	0.30
					15.7	**	**	1.71	**	**	0.30
					16.4	2.88	1.15	0.54	0.80	0.40	0.20
					19.0	0.49	1.68	0.19	0.55	0.40	0.20
	BED-HGR-2	15.11	5.55	0.9	15.7	1.68	1.15	*	0.70	0.15	0.05
					16.7	0.38	1.05	*	0.60	0.20	0.05
					19.5	0.99	1.35	1.49	0.90	0.60	0.30
					20.5	2.25	1.76	0.61	0.90	0.60	0.35
					22.0	0.88	1.41	1.48	1.00	0.60	0.35

* Insufficient depth for measurement
** No measurement taken

cfs = cubic feet per second
fps = feet per second

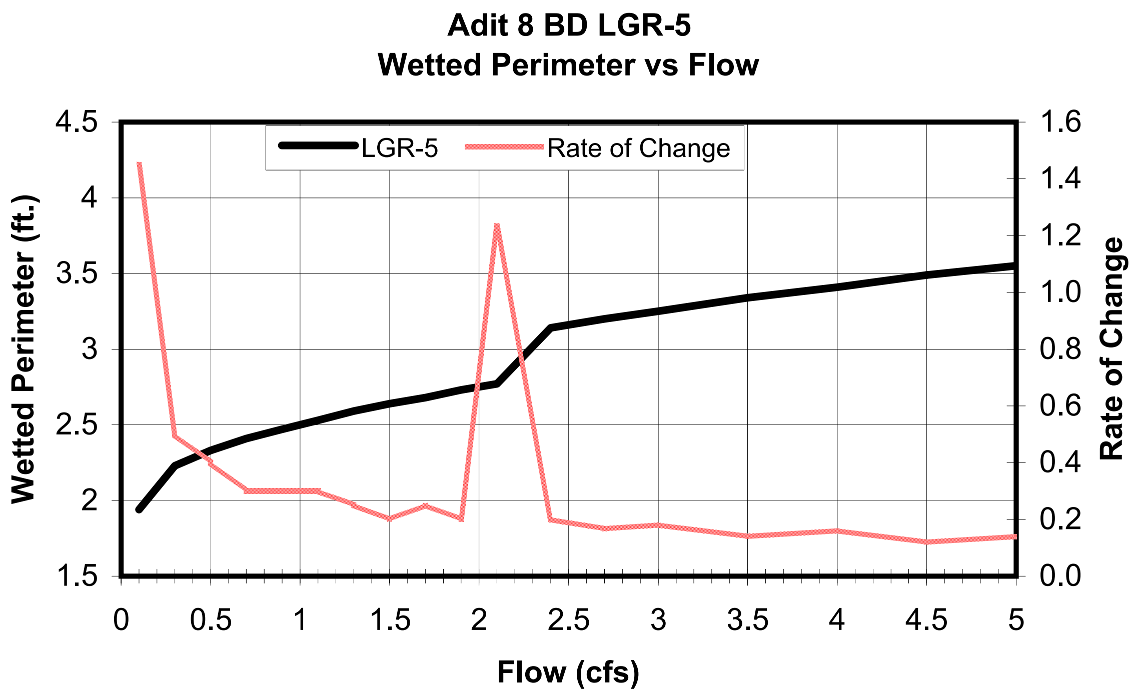
APPENDIX B

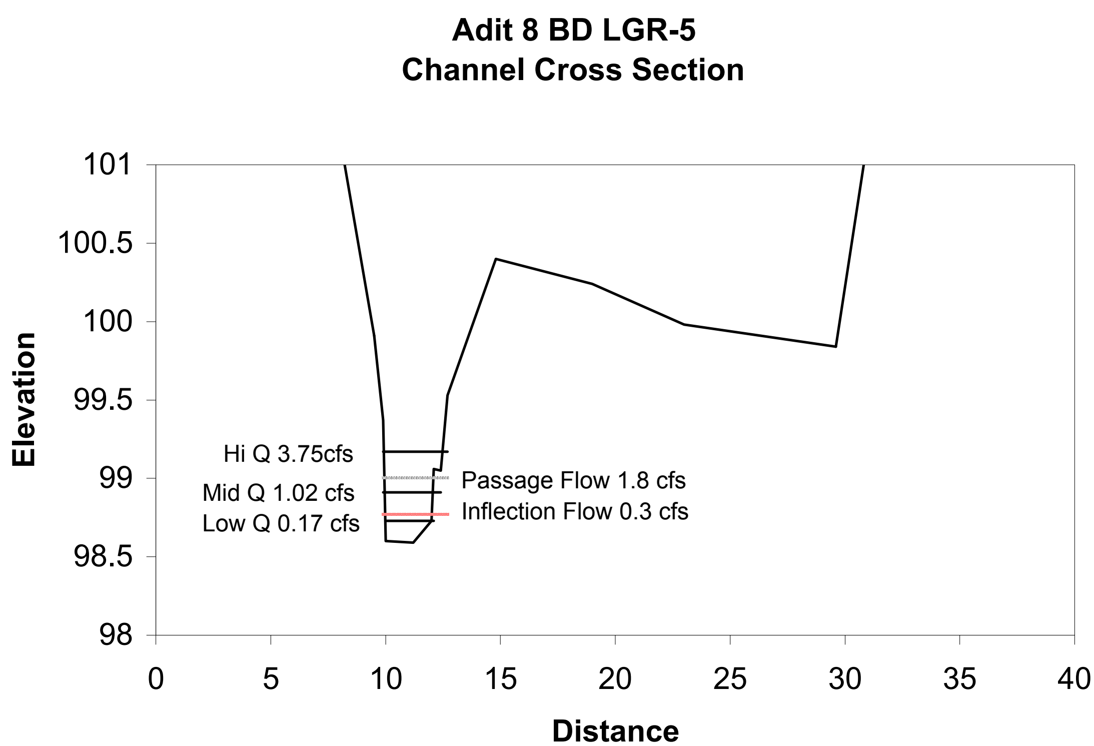
WETTED PERIMETER VS. FLOW PLOTS

AND

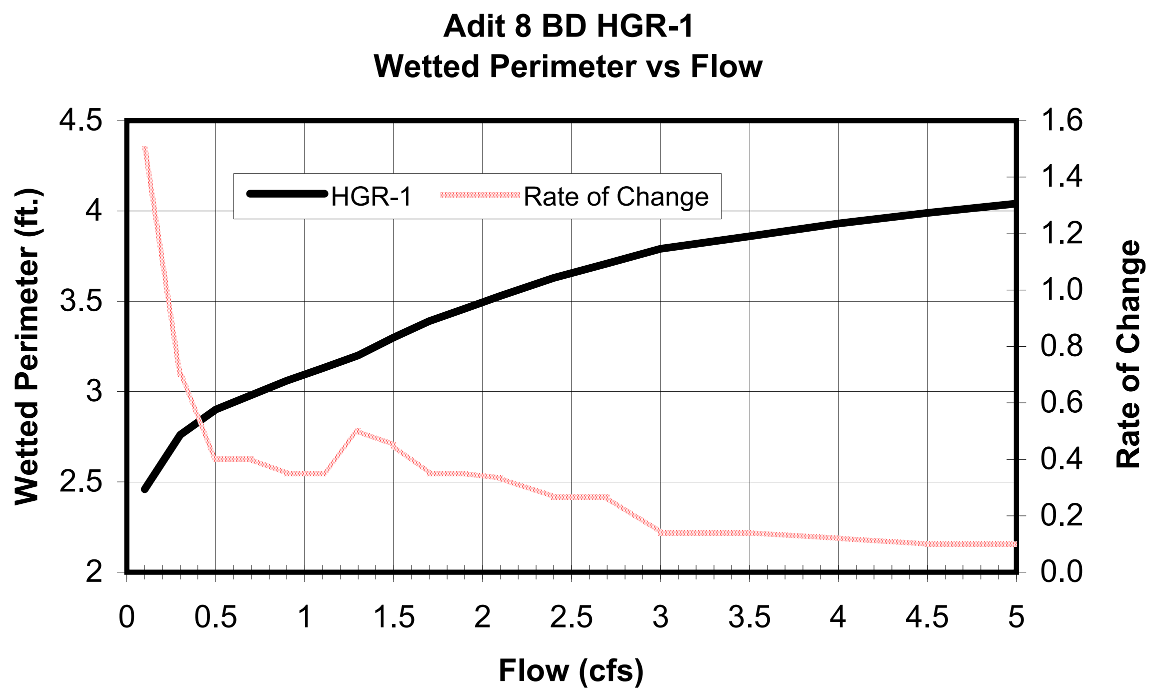
TRANSECT PROFILES AND MEASURED WATER SURFACE ELEVATIONS

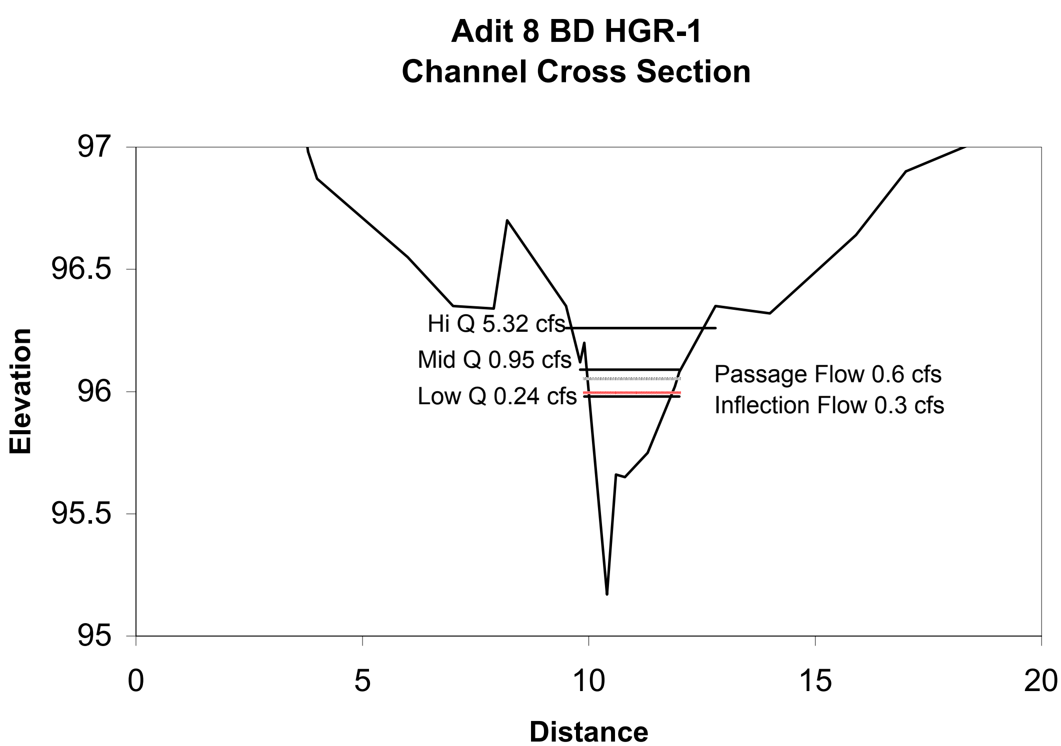
The figures in this appendix are presented one page per transect. The figure at the top of each page presents the wetted perimeter vs. flow relationship for the transect and the instantaneous rate of change in the wetted perimeter vs. flow relationship. The figure at the bottom of each page shows the channel profile, the measured water surface elevations during data collection and the water surface elevation at the flow providing passage for adult trout. The shaded bar underneath the cross section profile indicates the approximate area where passage would be possible.





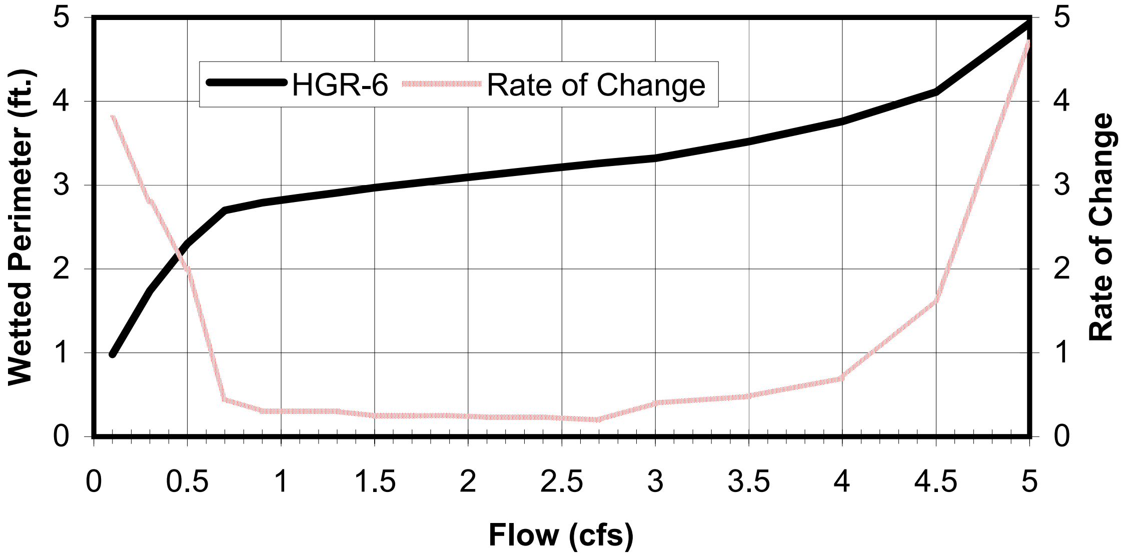
CAWG 3 Appendix B Figure B-1. Wetted perimeter and channel cross-section plots for Adit 8 BD-LGR-5.



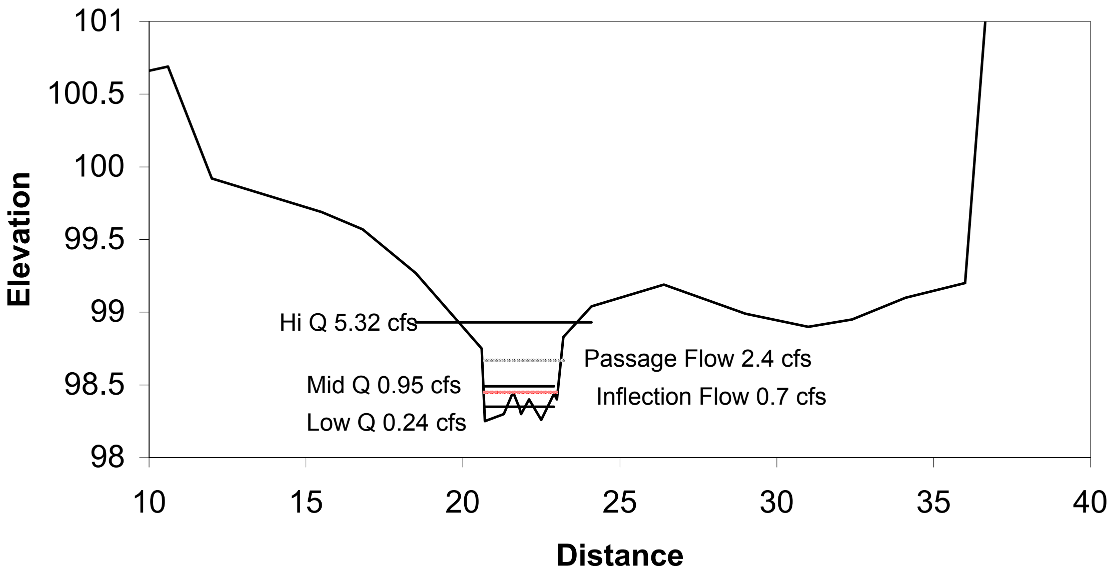


CAWG 3 Appendix B Figure B-2. Wetted perimeter and channel cross-section plots for Adit 8 BD-HGR-1.

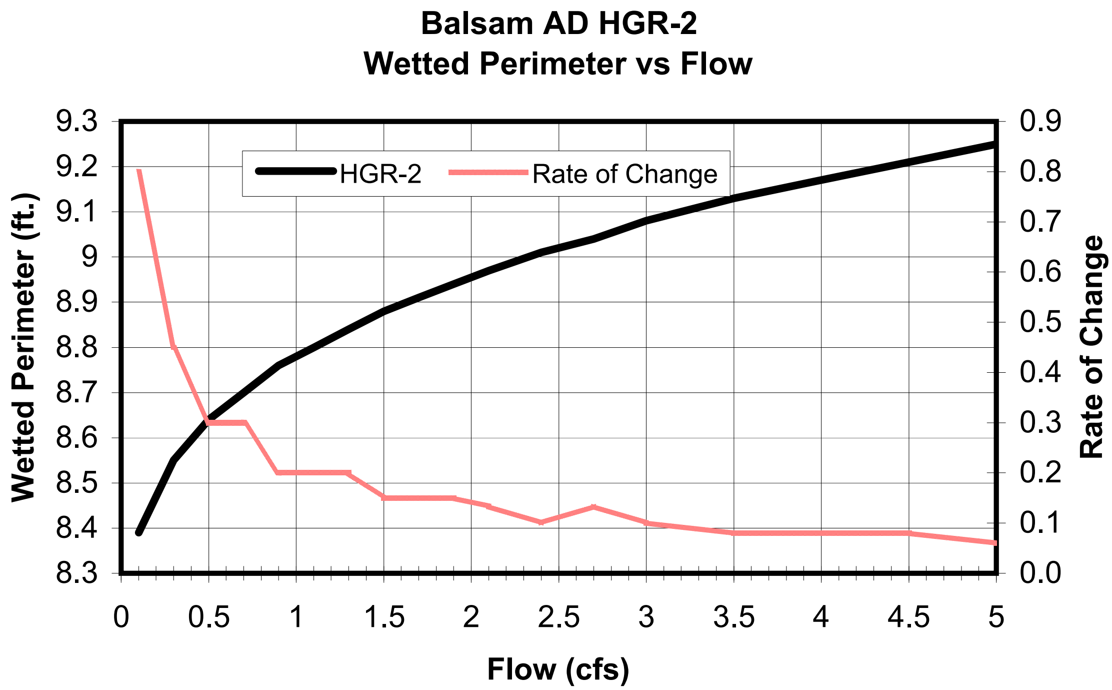
Adit 8 BD HGR-6
Wetted Perimeter vs Flow

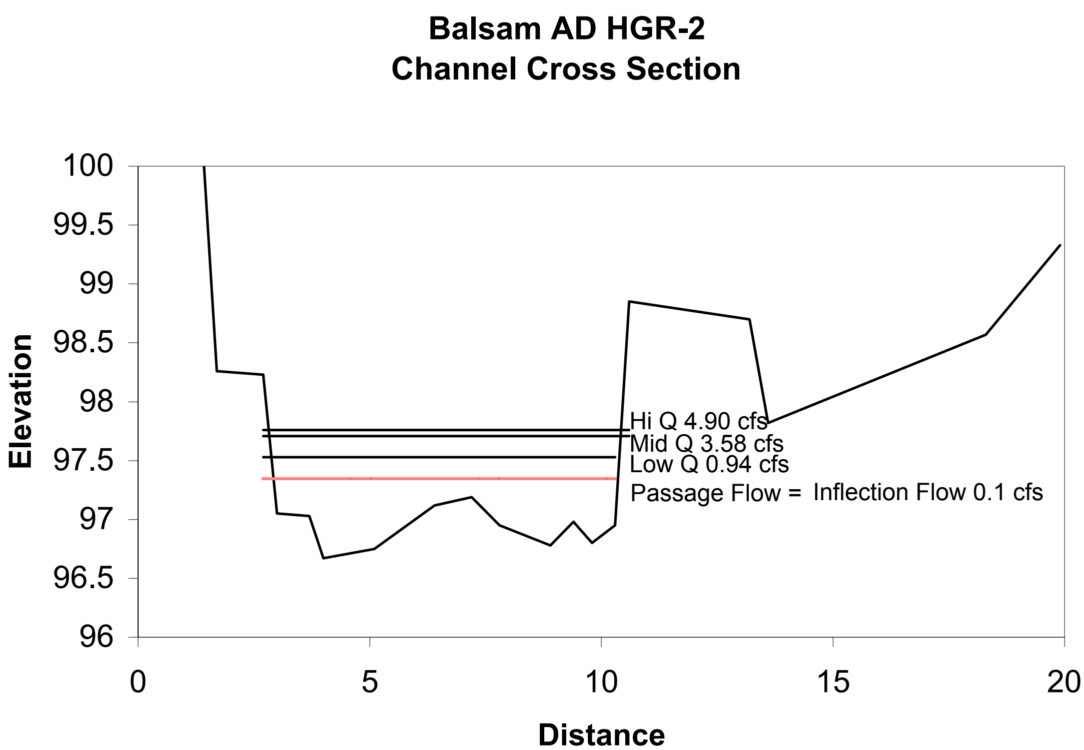


Adit 8 BD HGR-6
Channel Cross Section

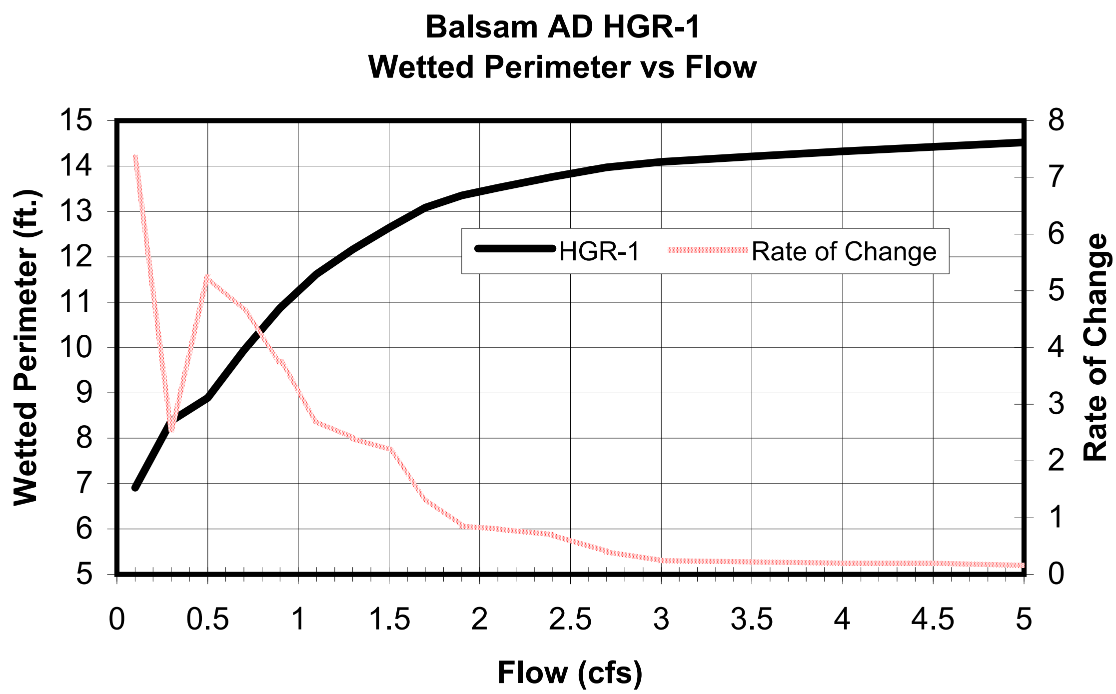


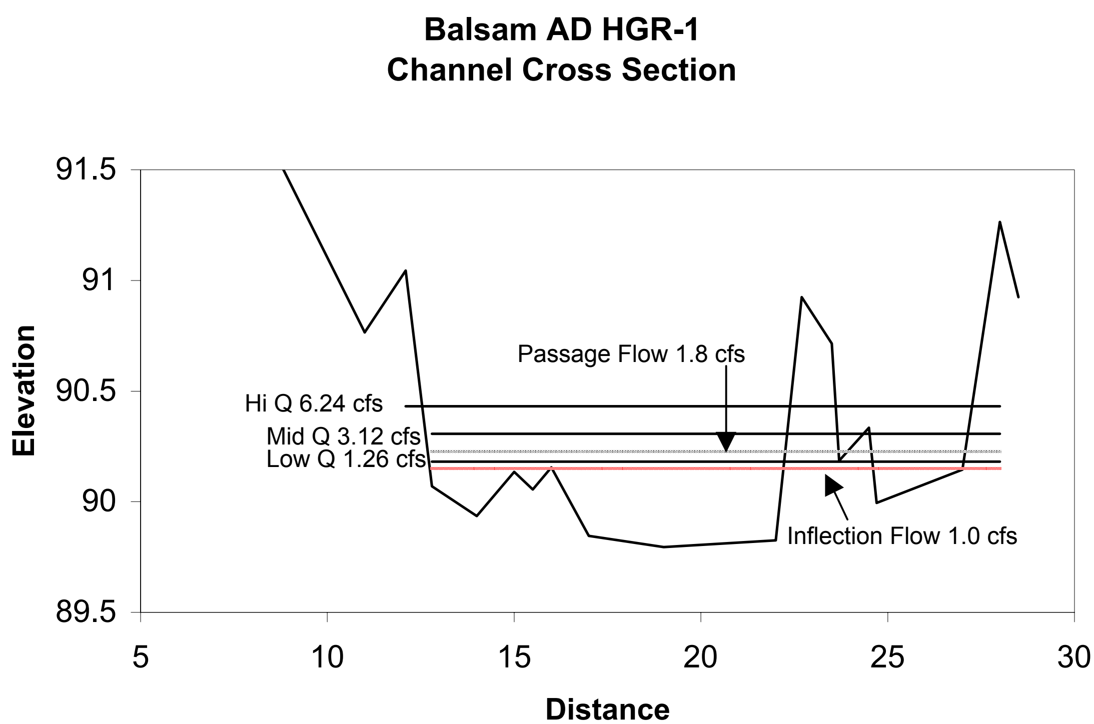
CAWG 3 Appendix B Figure B-3. Wetted perimeter and channel cross-section plots for Adit 8 BD-HGR-6.



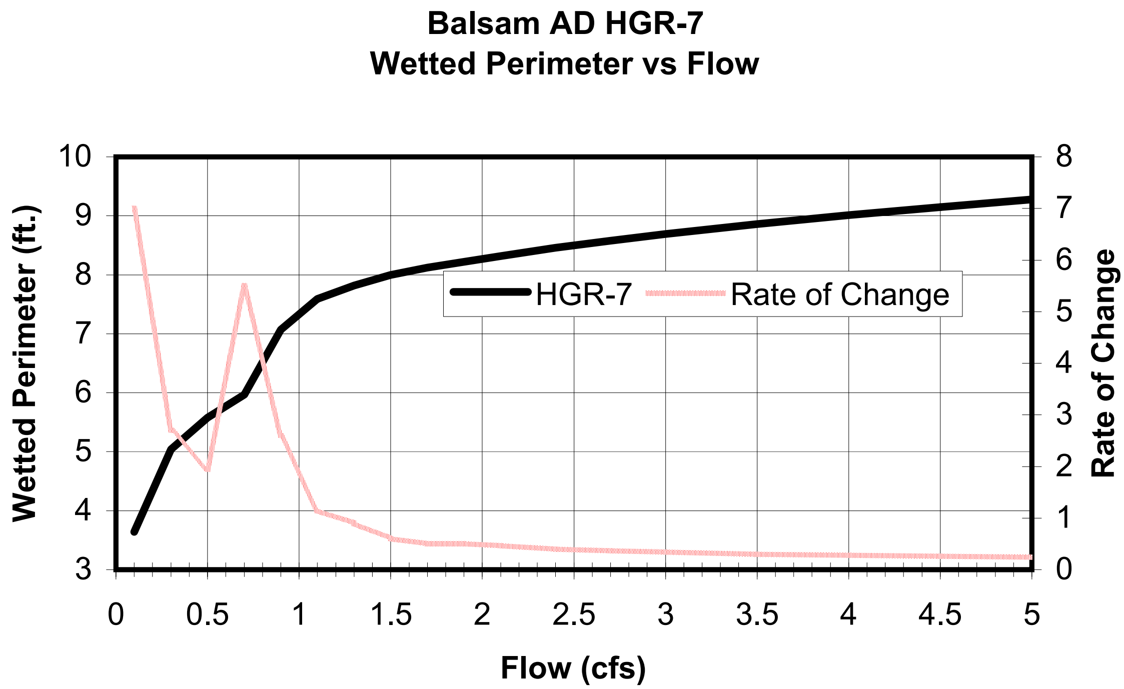


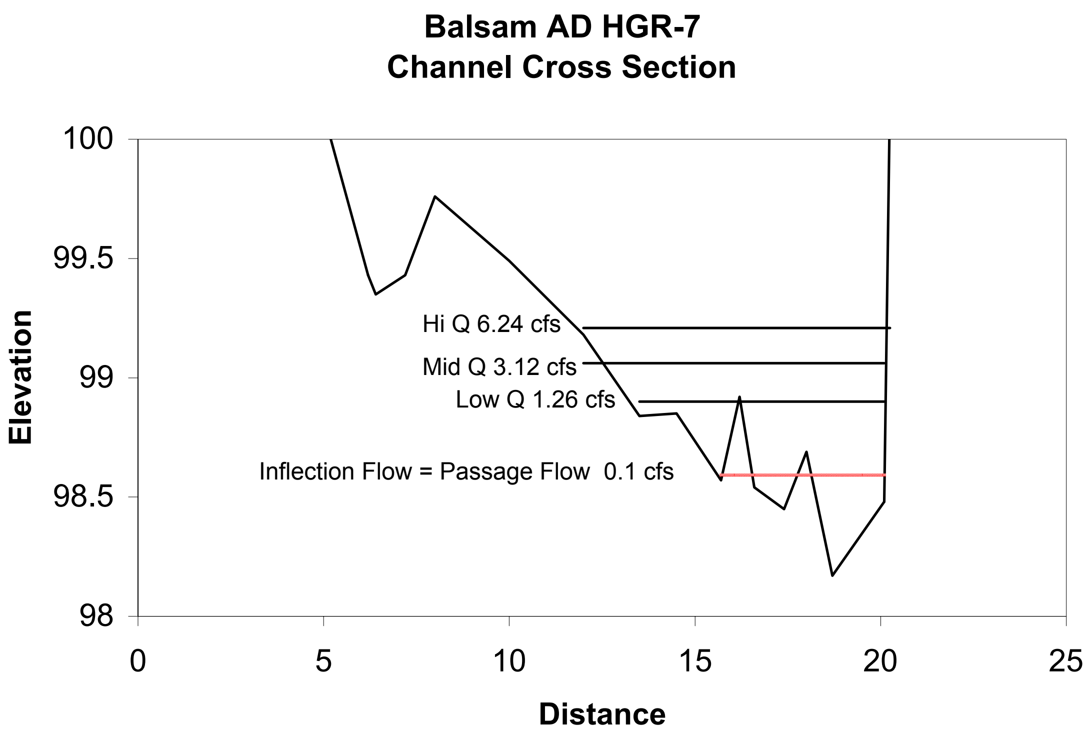
CAWG 3 Appendix B Figure B-4. Wetted perimeter and channel cross-section plots for Balsam AD-HGR-2.



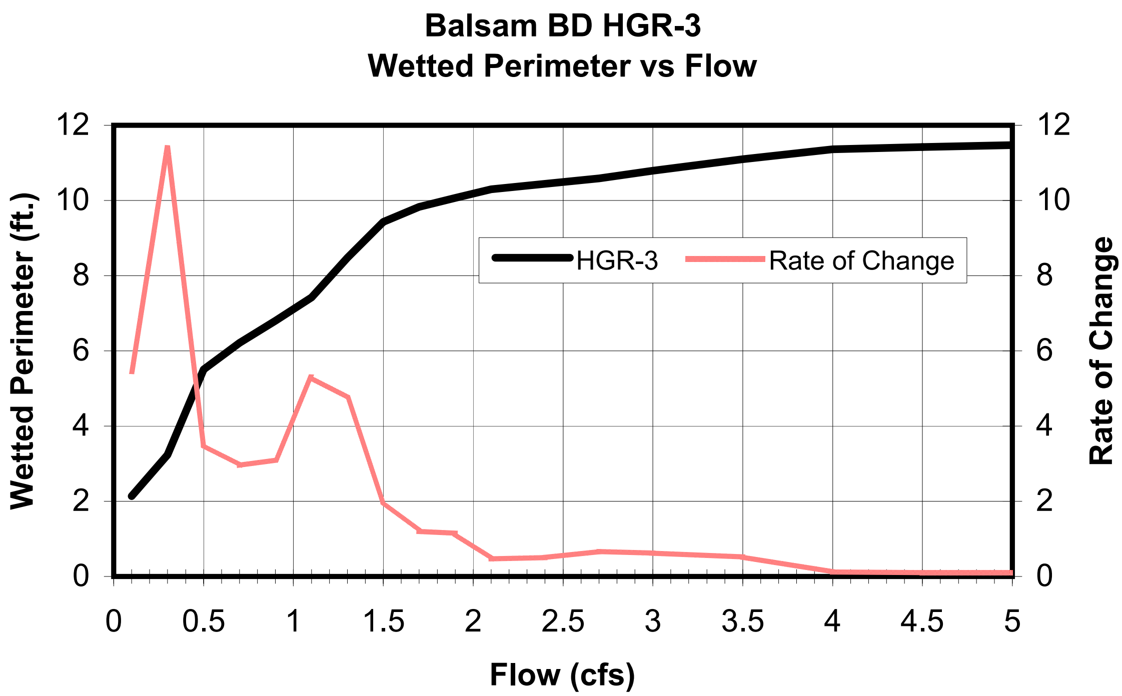


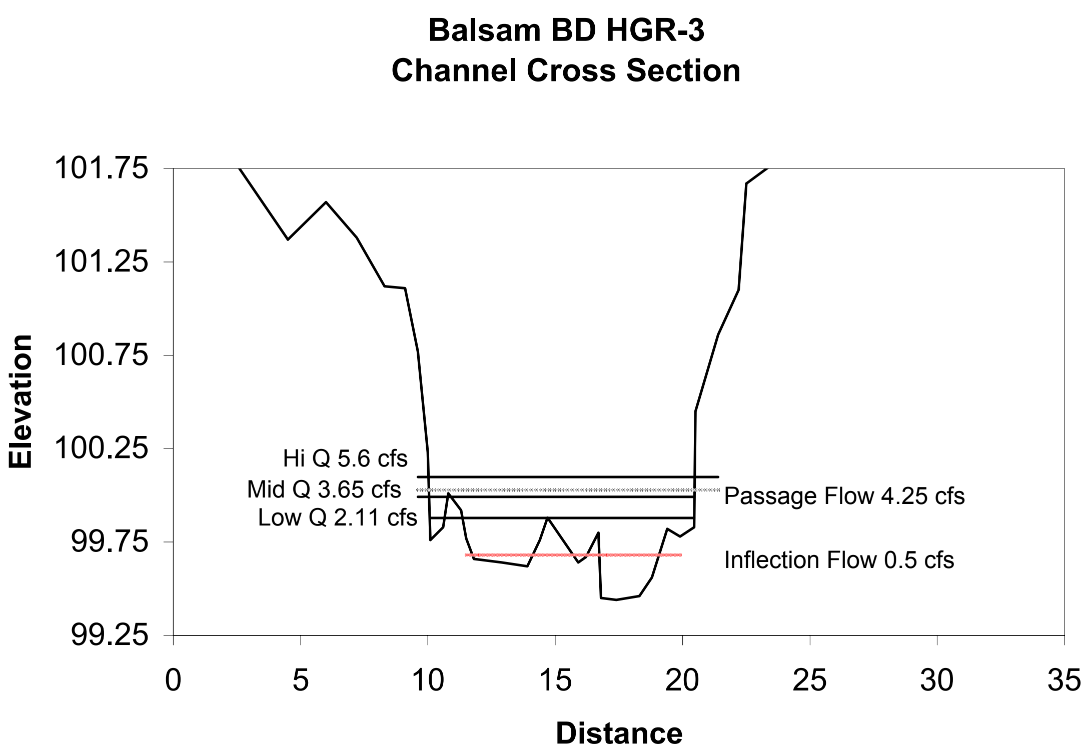
CAWG 3 Appendix B Figure B-5. Wetted perimeter and channel cross-section plots for Balsam AD-HGR-1.



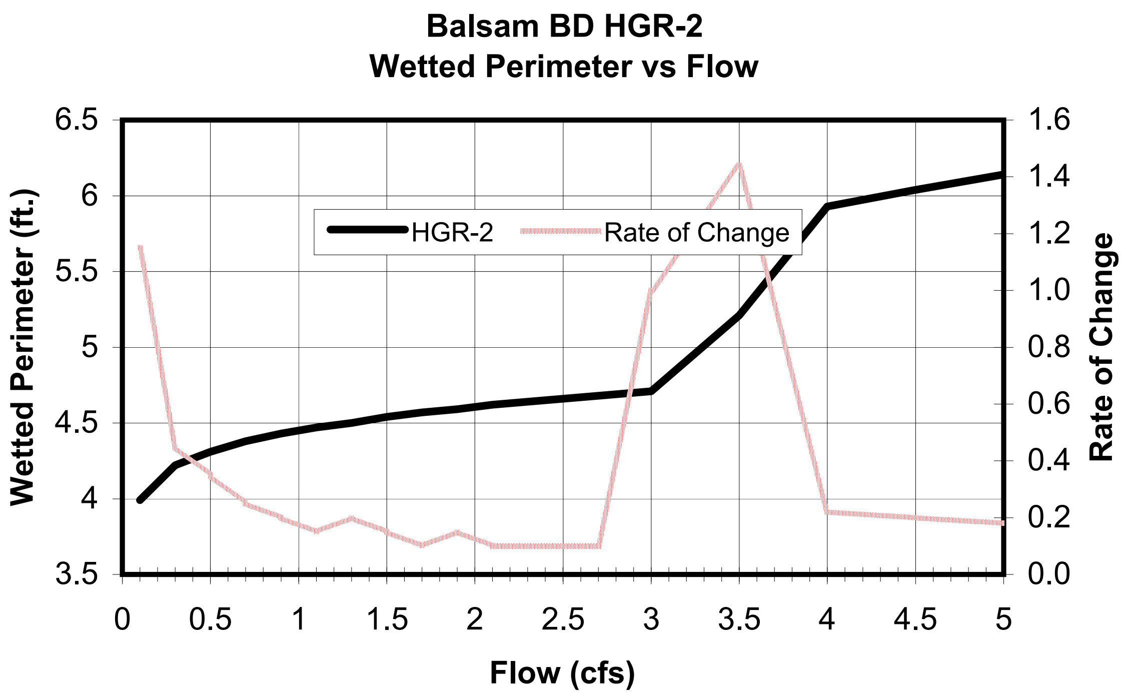


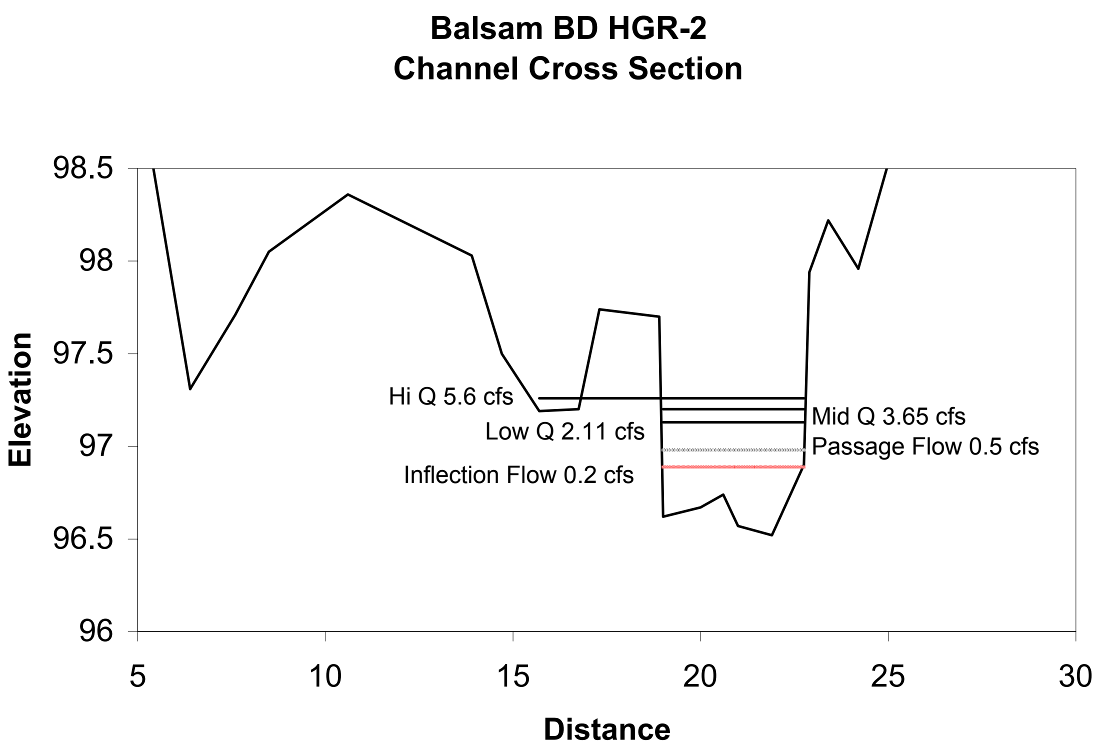
CAWG 3 Appendix B Figure B-6. Wetted perimeter and channel cross-section plots for Balsam AD-HGR-7.



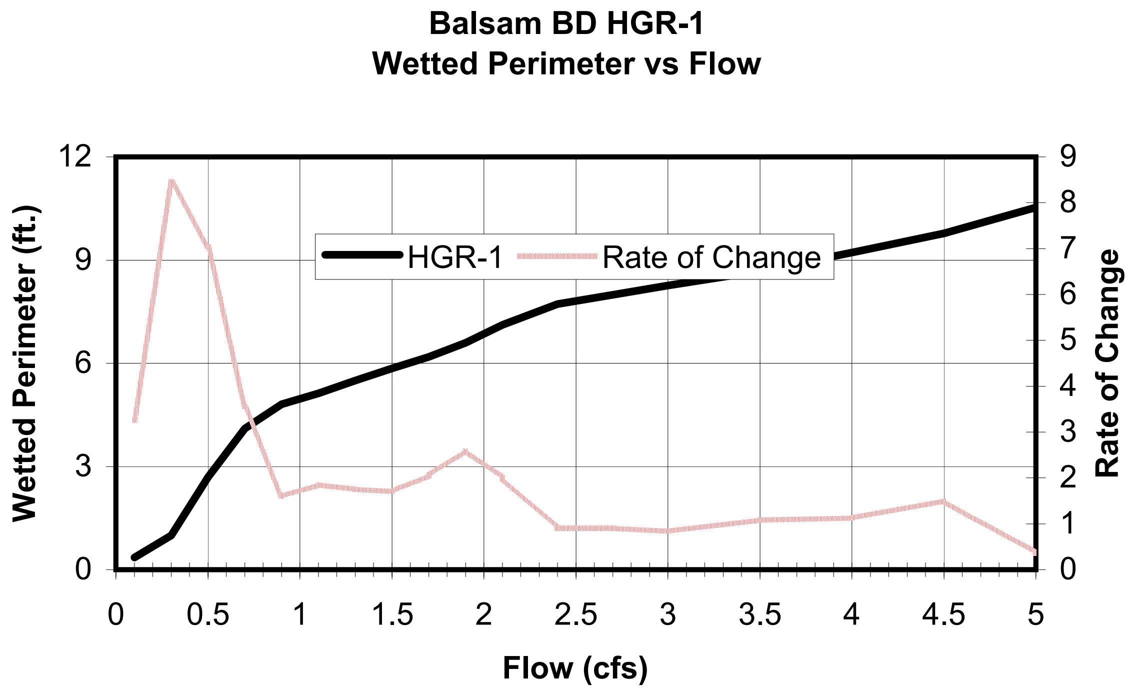


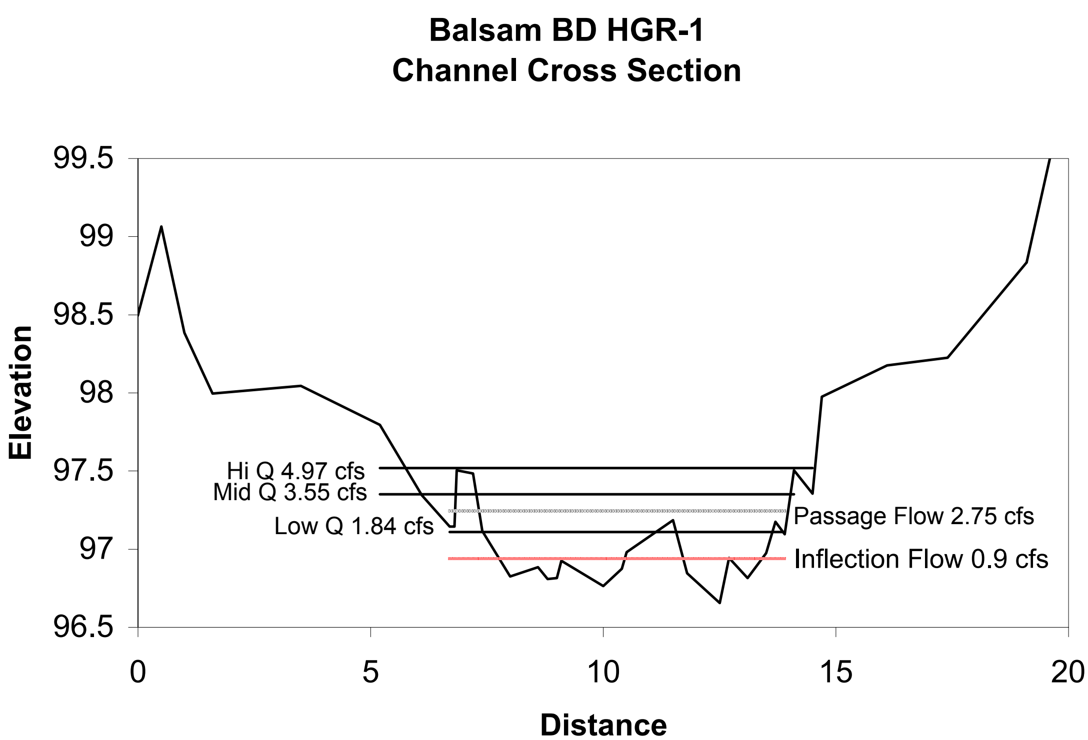
CAWG 3 Appendix B Figure B-7. Wetted perimeter and channel cross-section plots for Balsam BD-HGR-3.



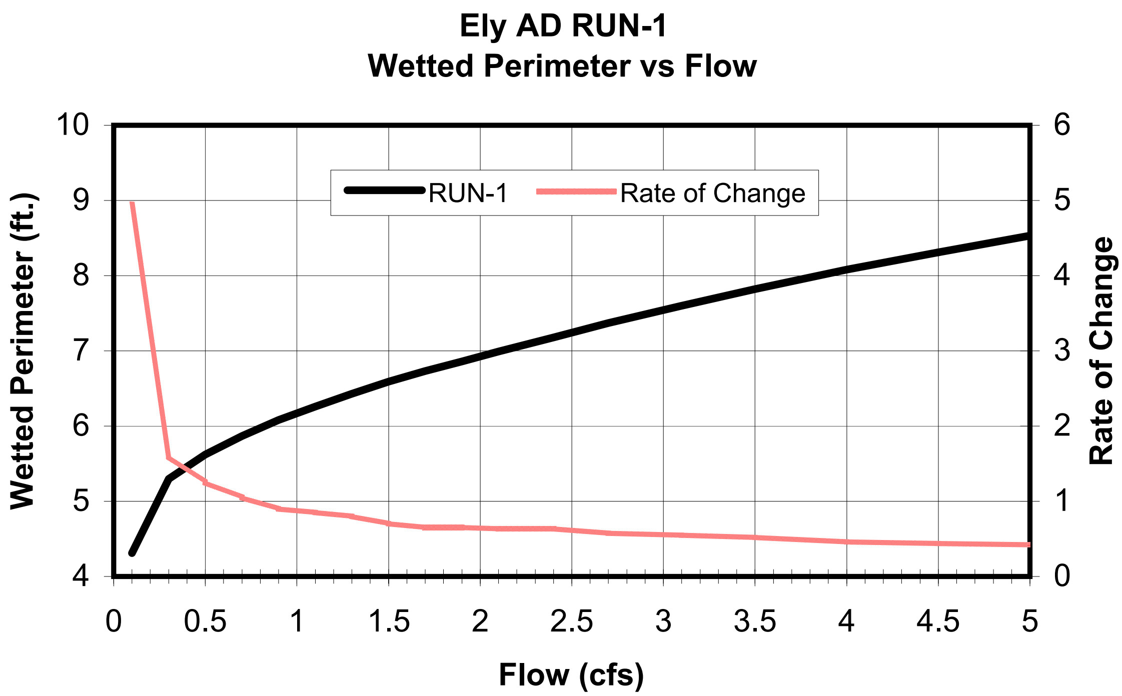


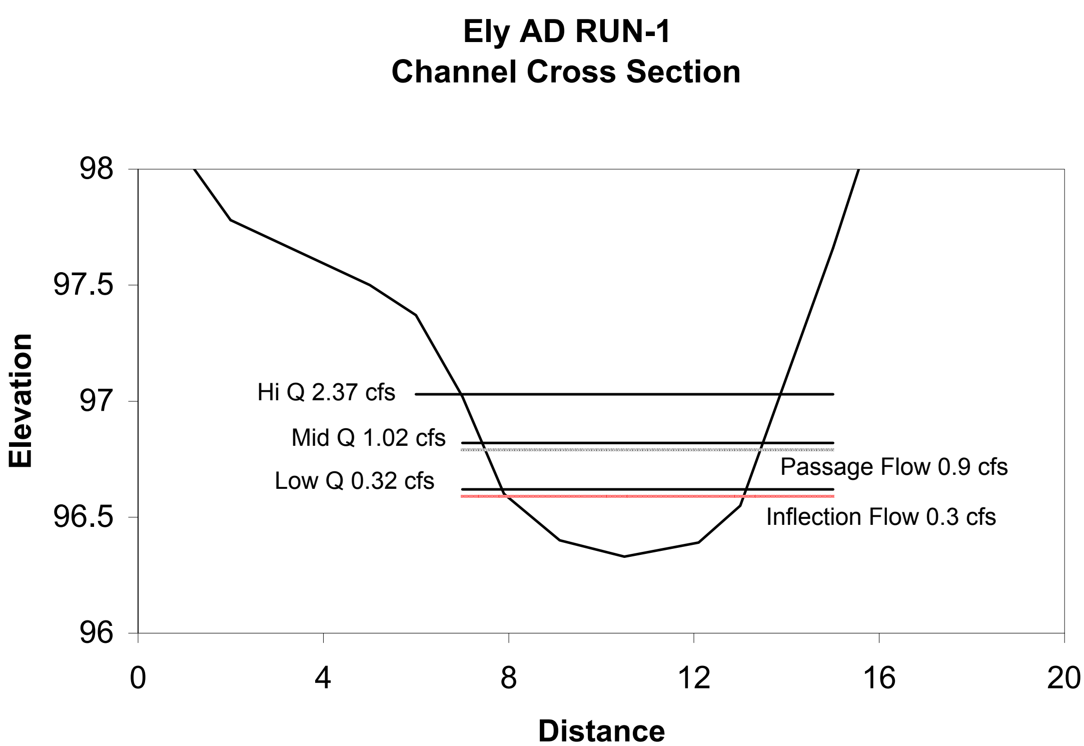
CAWG 3 Appendix B Figure B-8. Wetted perimeter and channel cross-section plots for Balsam BD-HGR-2.





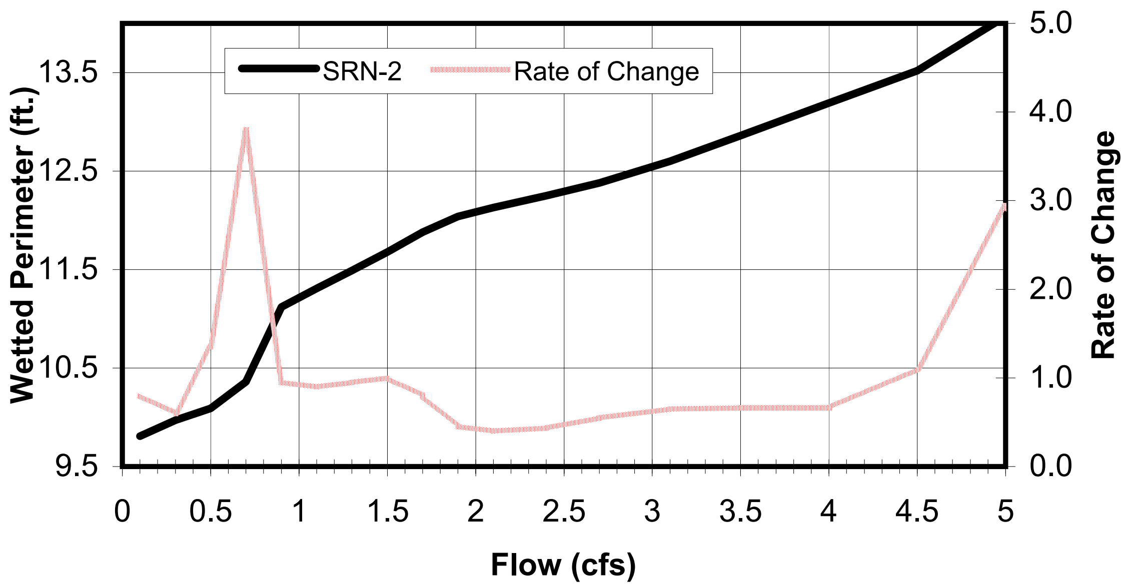
CAWG 3 Appendix B Figure B-9. Wetted perimeter and channel cross-section plots for Balsam BD-HGR-1.



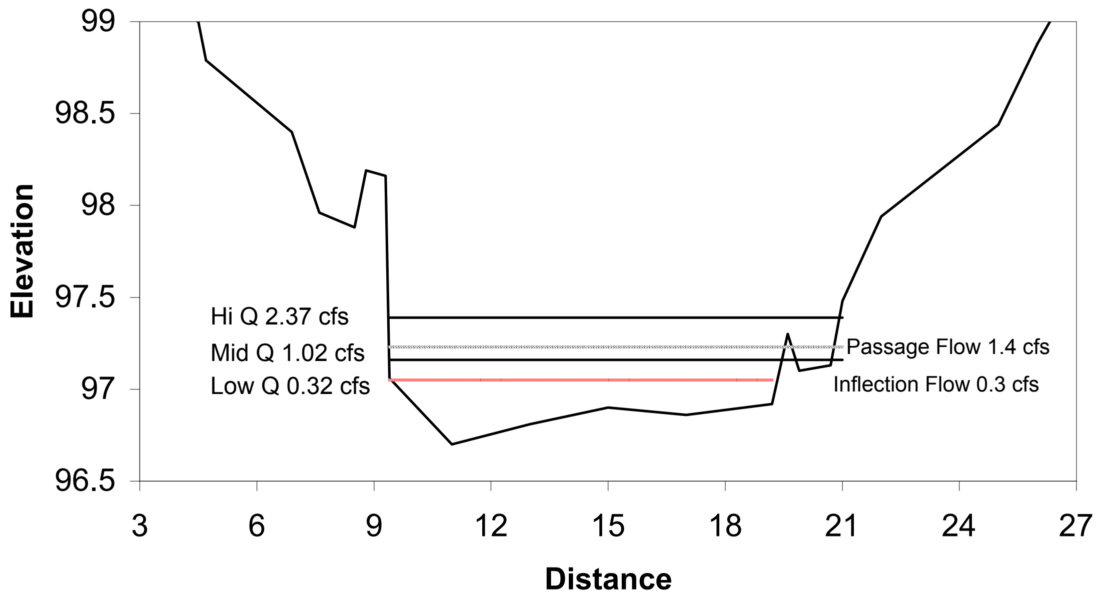


CAWG 3 Appendix B Figure B-10. Wetted perimeter and channel cross-section plots for Ely AD-RUN-1.

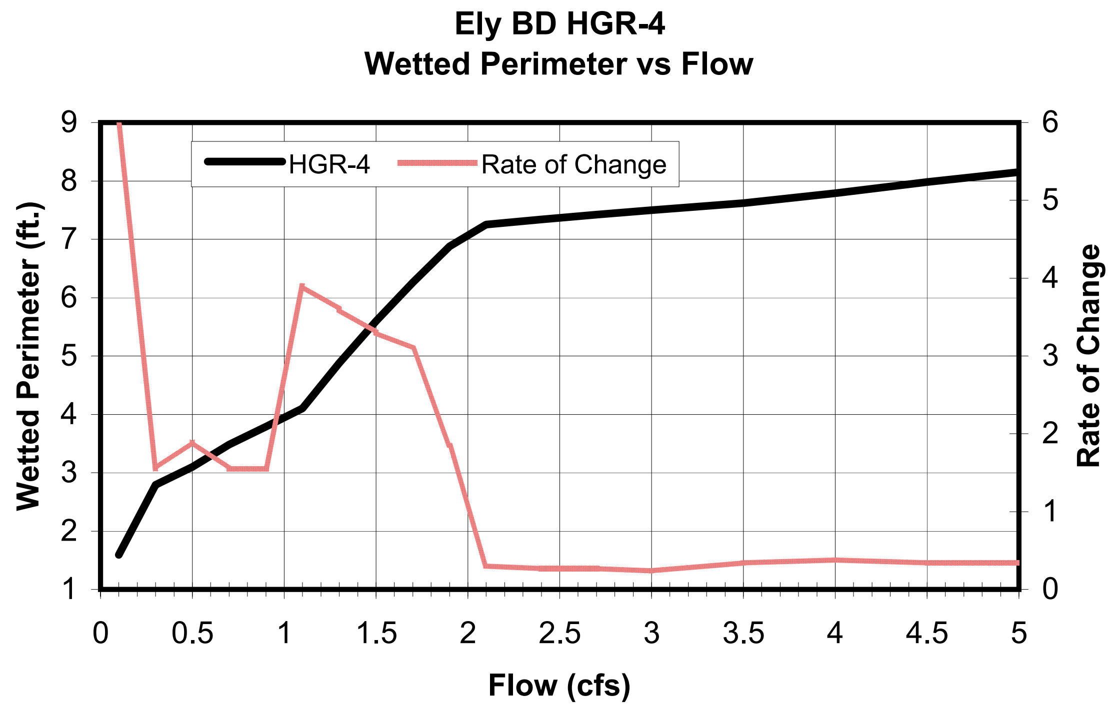
Ely AD SRN-2
Wetted Perimeter vs Flow

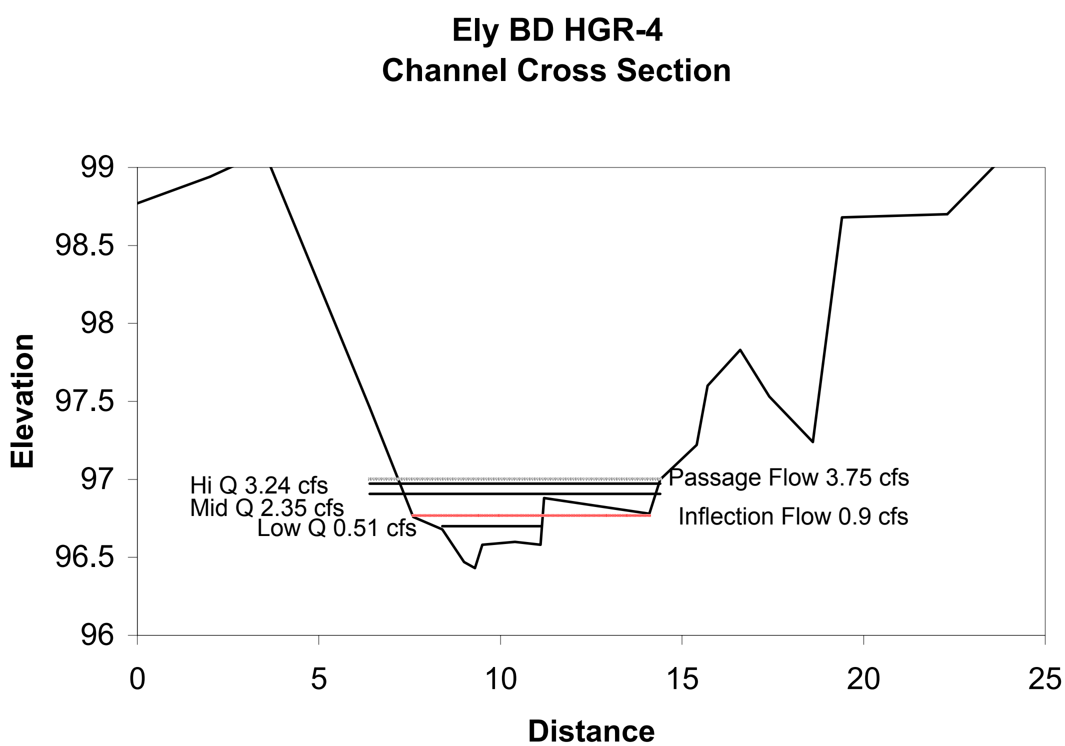


Ely AD SRN-2
Channel Cross Section

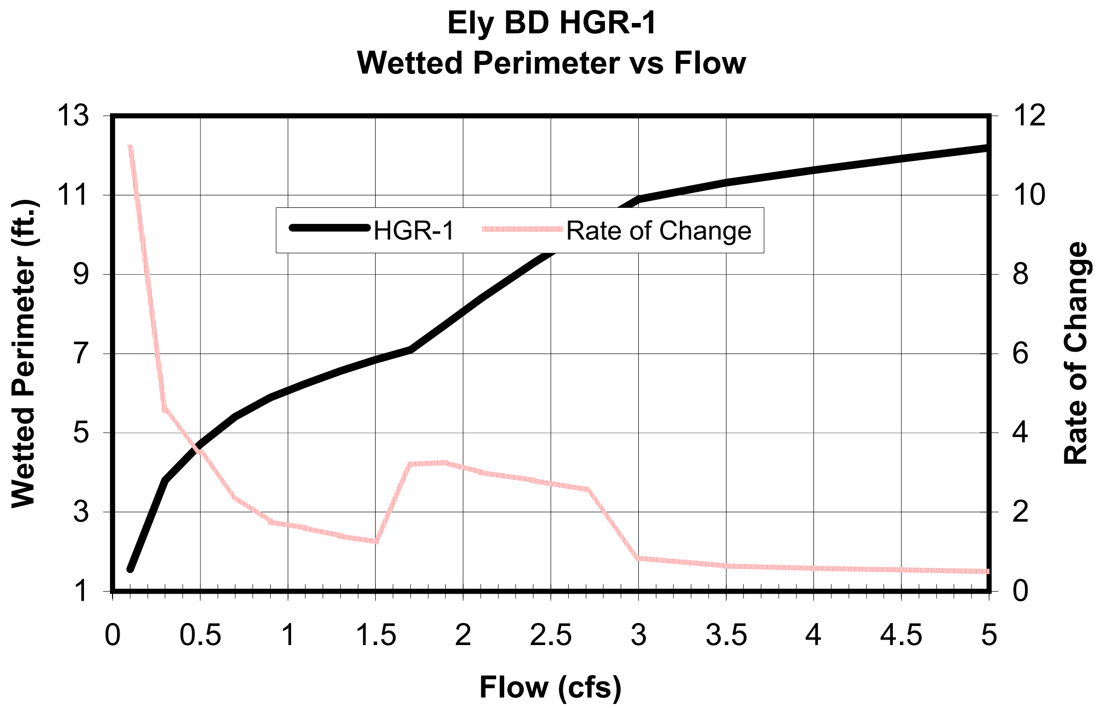


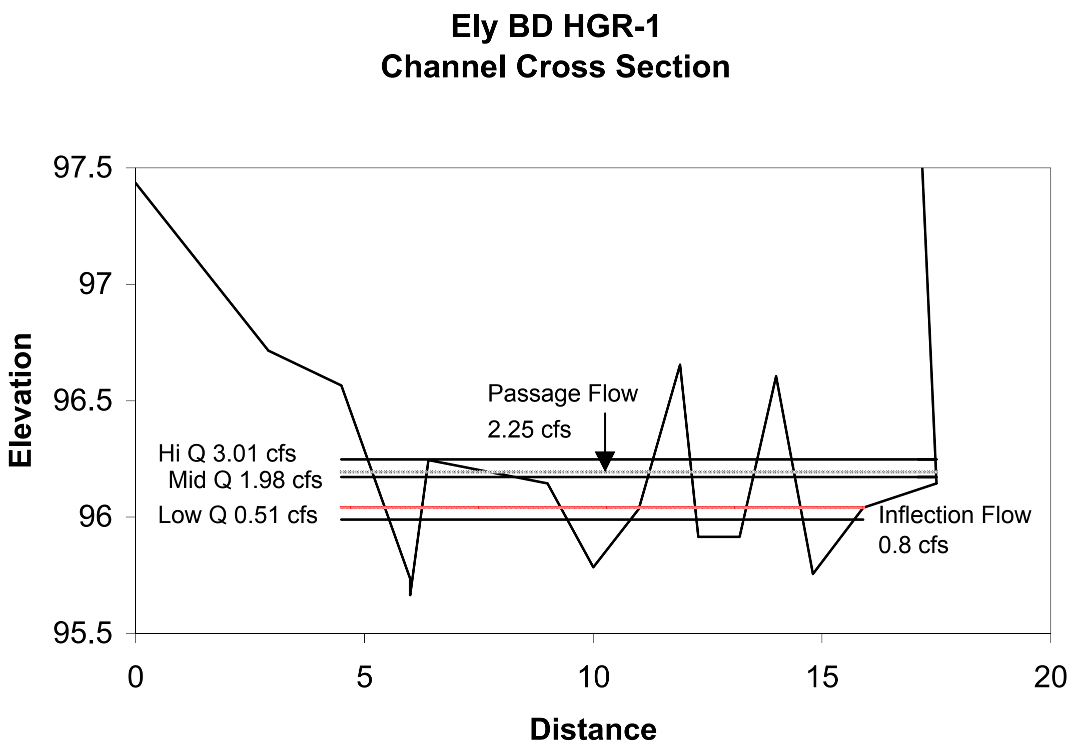
CAWG 3 Appendix B Figure B-11. Wetted perimeter and channel cross-section plots for Ely AD-SRN-2.



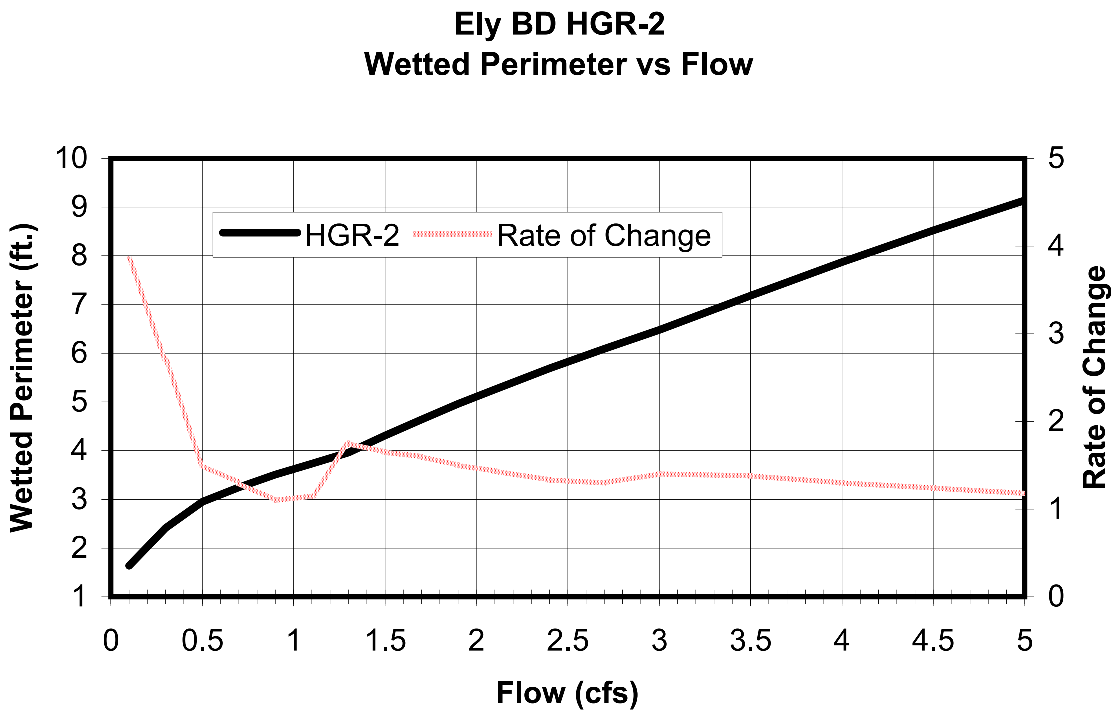


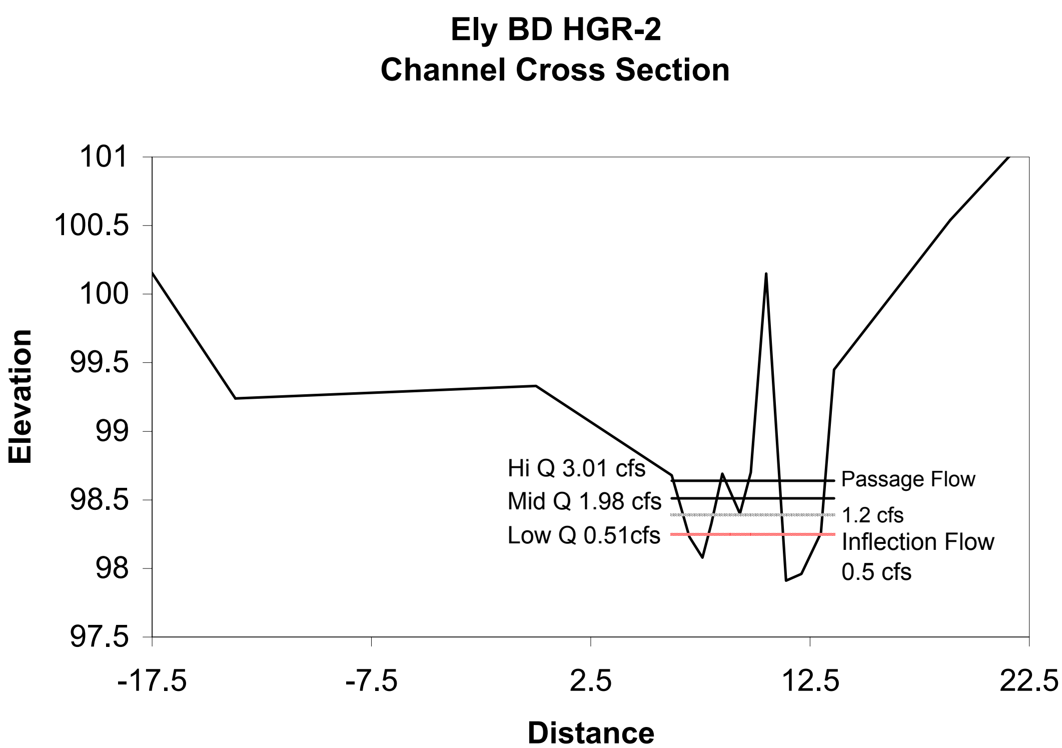
CAWG 3 Appendix B Figure B-12. Wetted perimeter and channel cross-section plots for Ely BD-HGR-4.



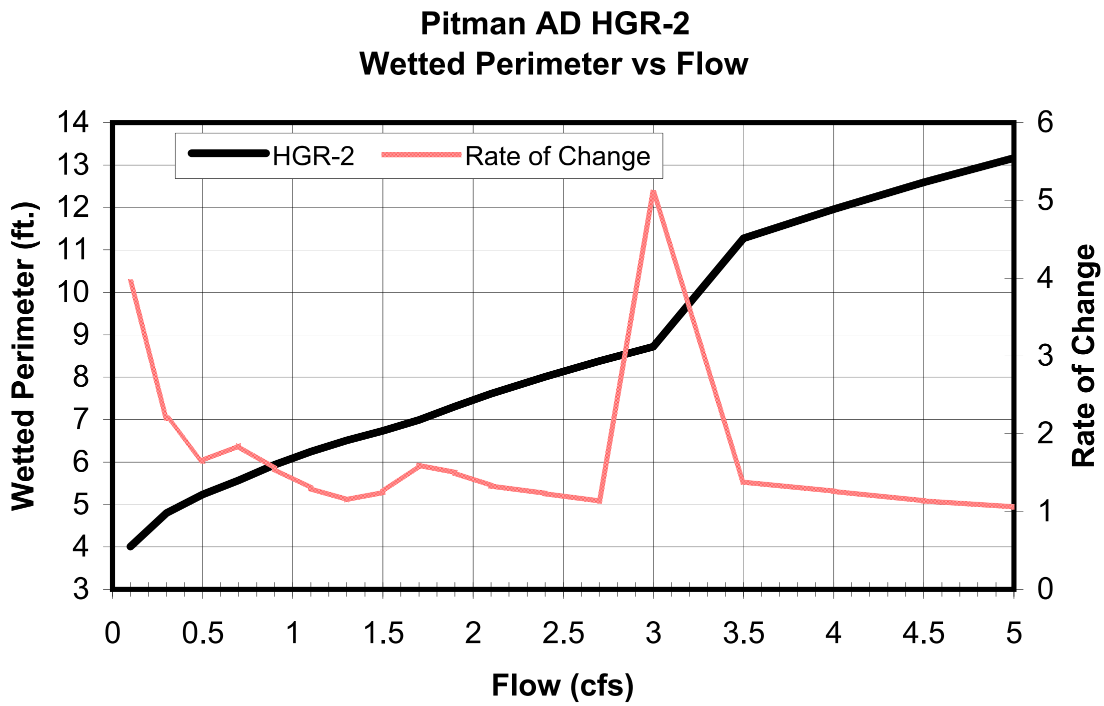


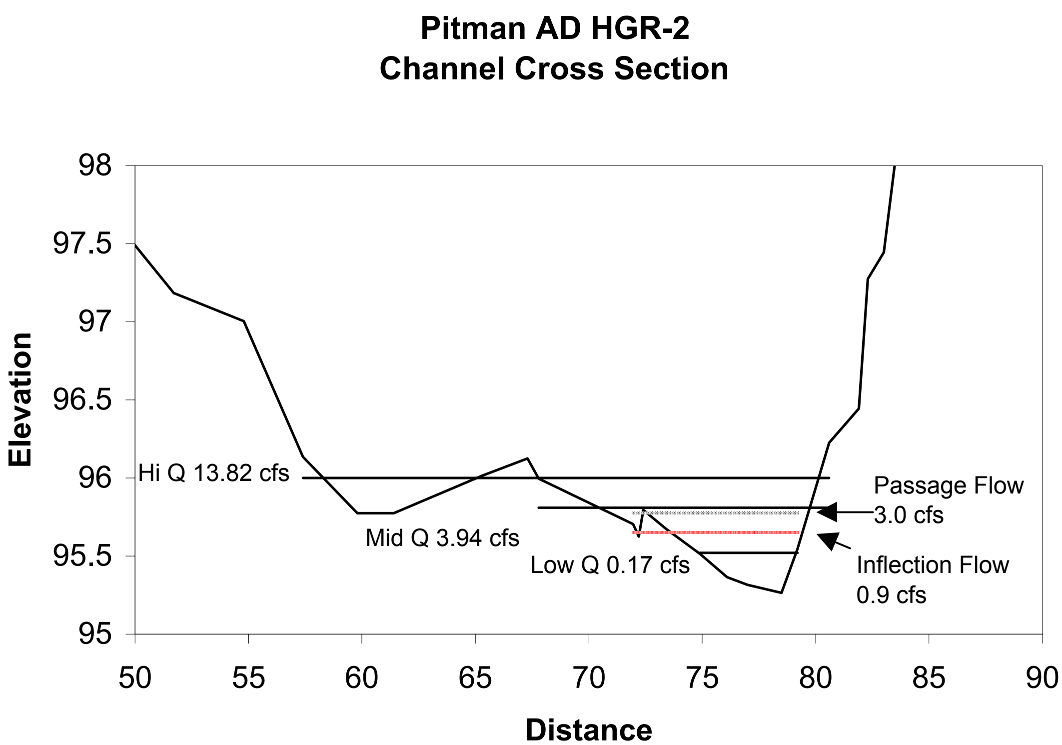
CAWG 3 Appendix B Figure B-13. Wetted perimeter and channel cross-section plots for Ely BD-HGR-1.



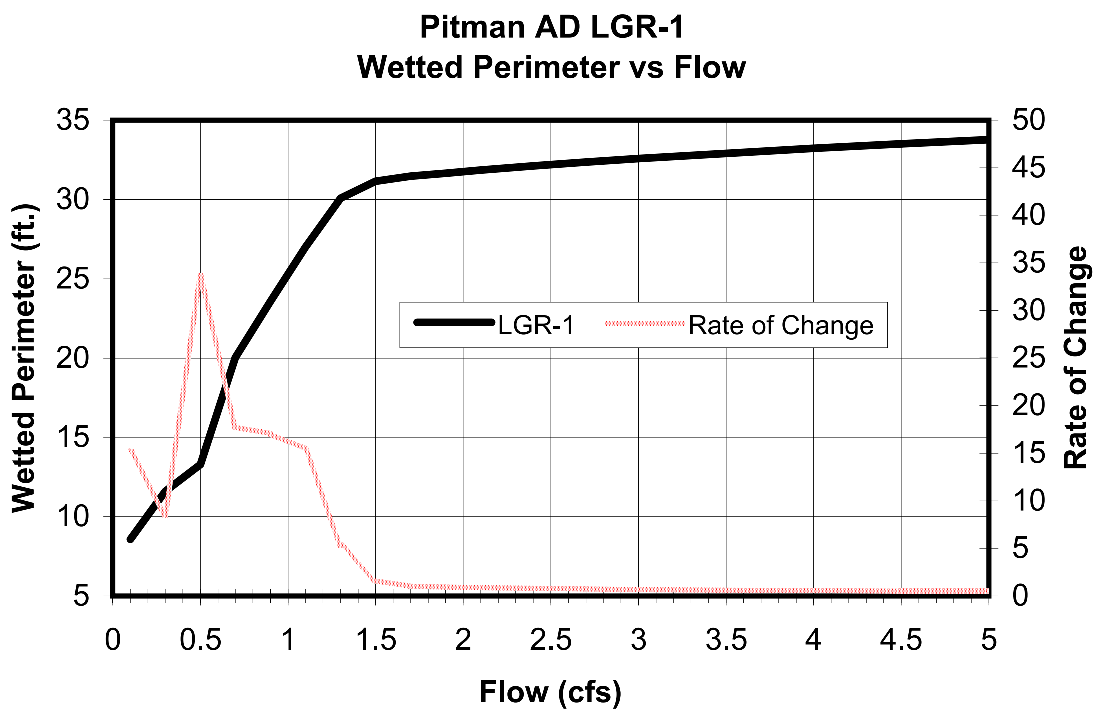


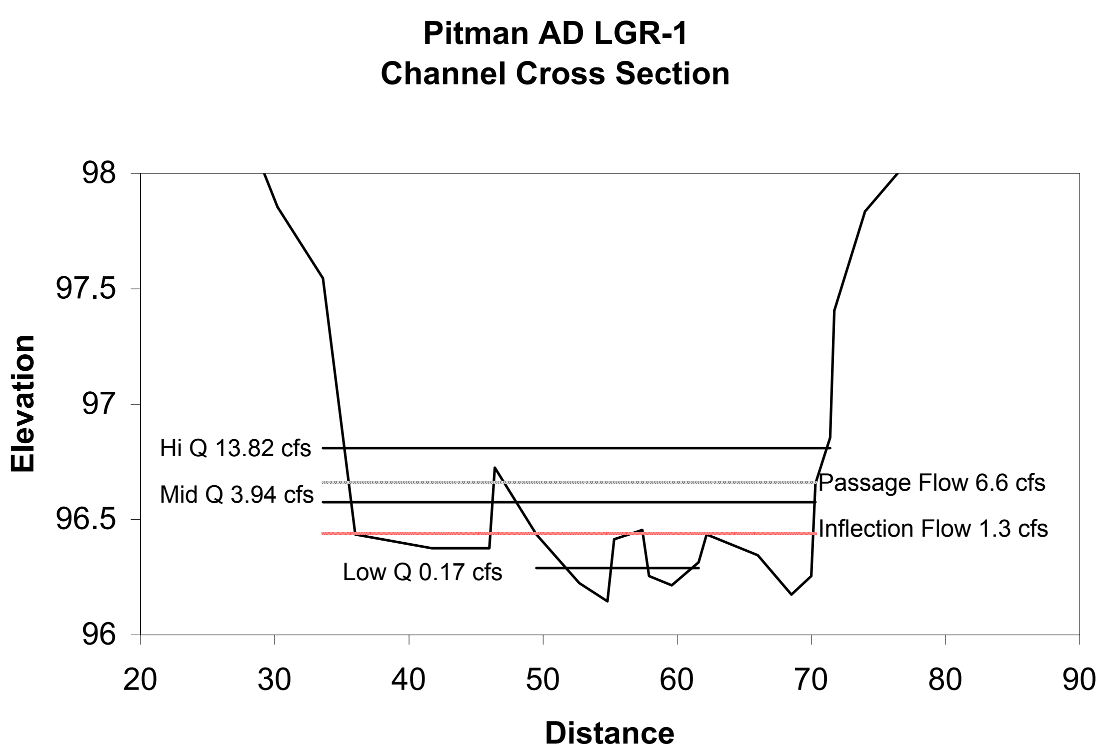
CAWG 3 Appendix B Figure B-14. Wetted perimeter and channel cross-section plots for Ely BD-HGR-2.



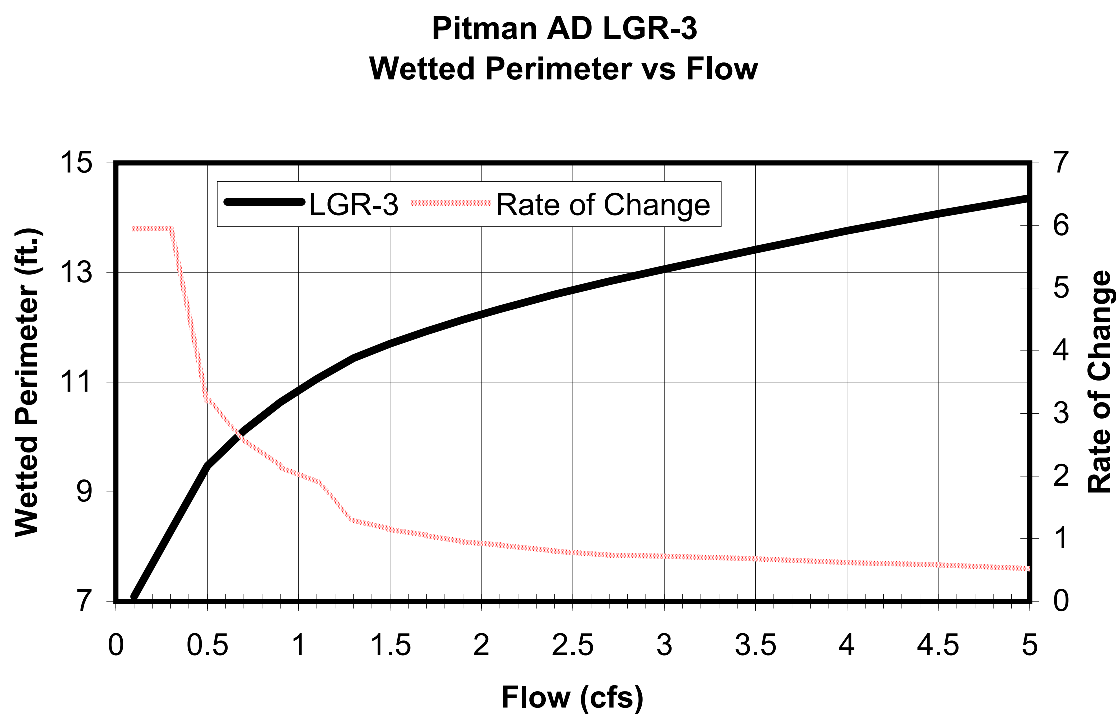


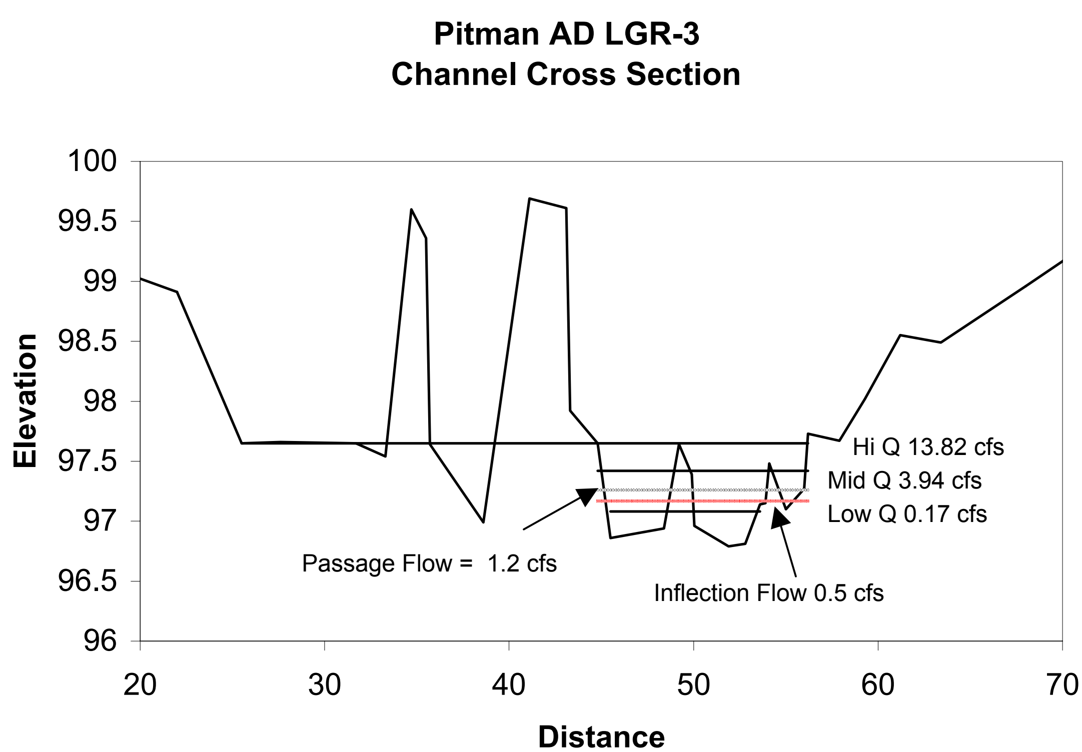
CAWG 3 Appendix B Figure B-15. Wetted perimeter and channel cross-section plots for Pitman AD-HGR-2.



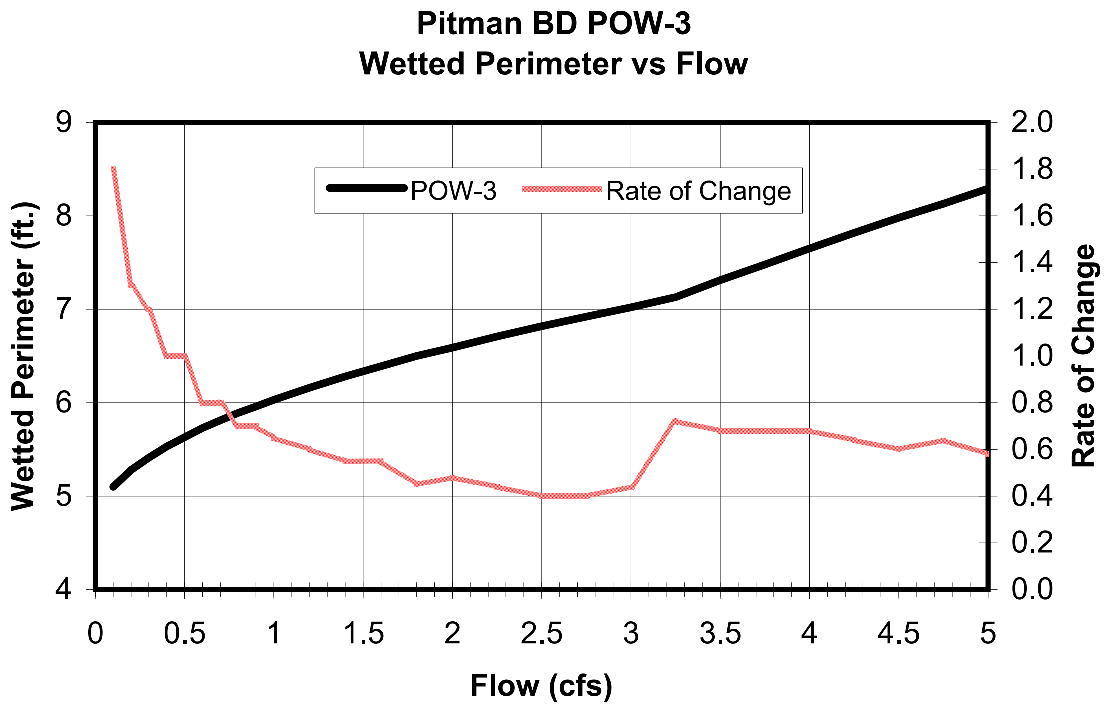


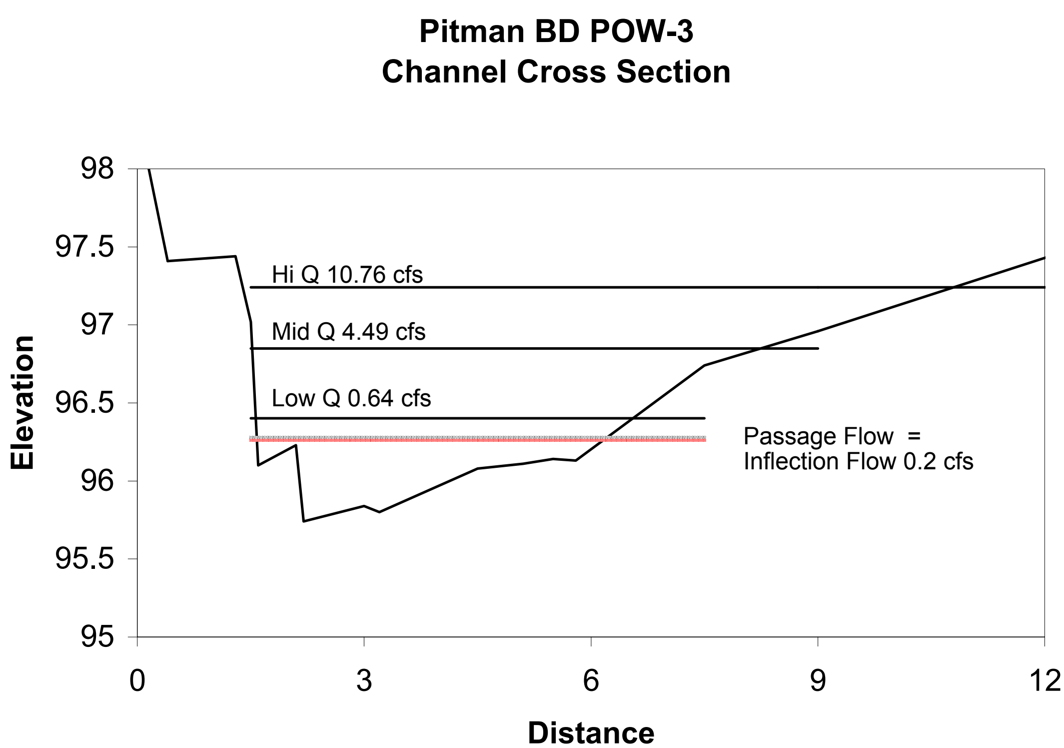
CAWG 3 Appendix B Figure B-16. Wetted perimeter and channel cross-section plots for Pitman AD-LGR-1.



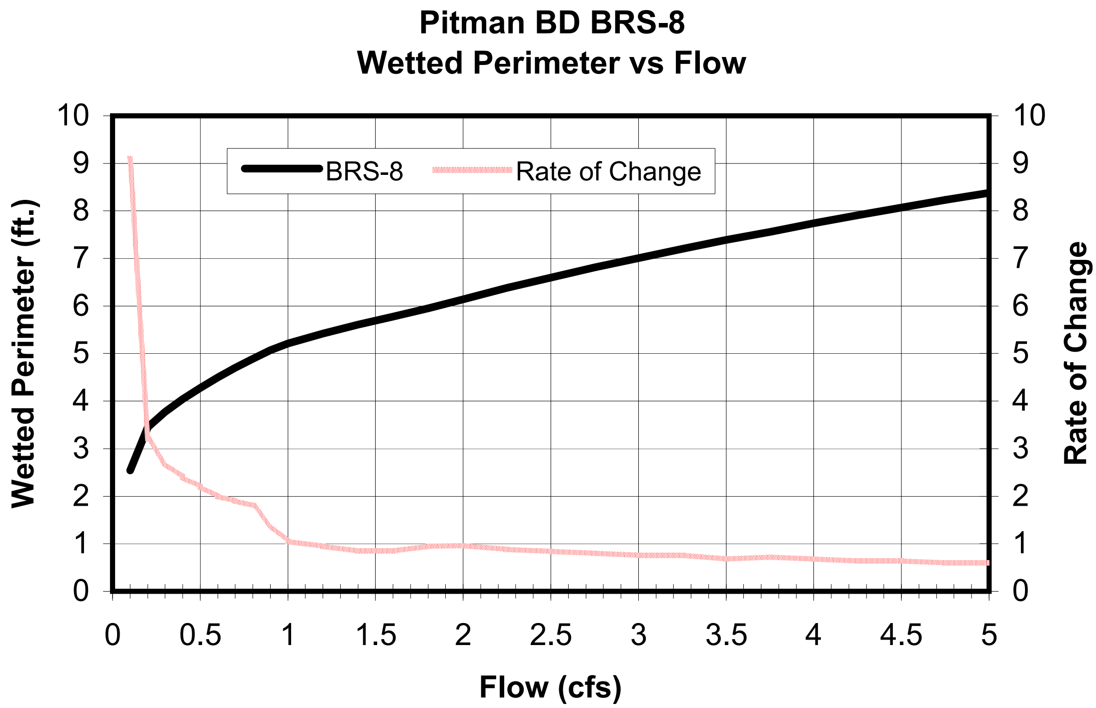


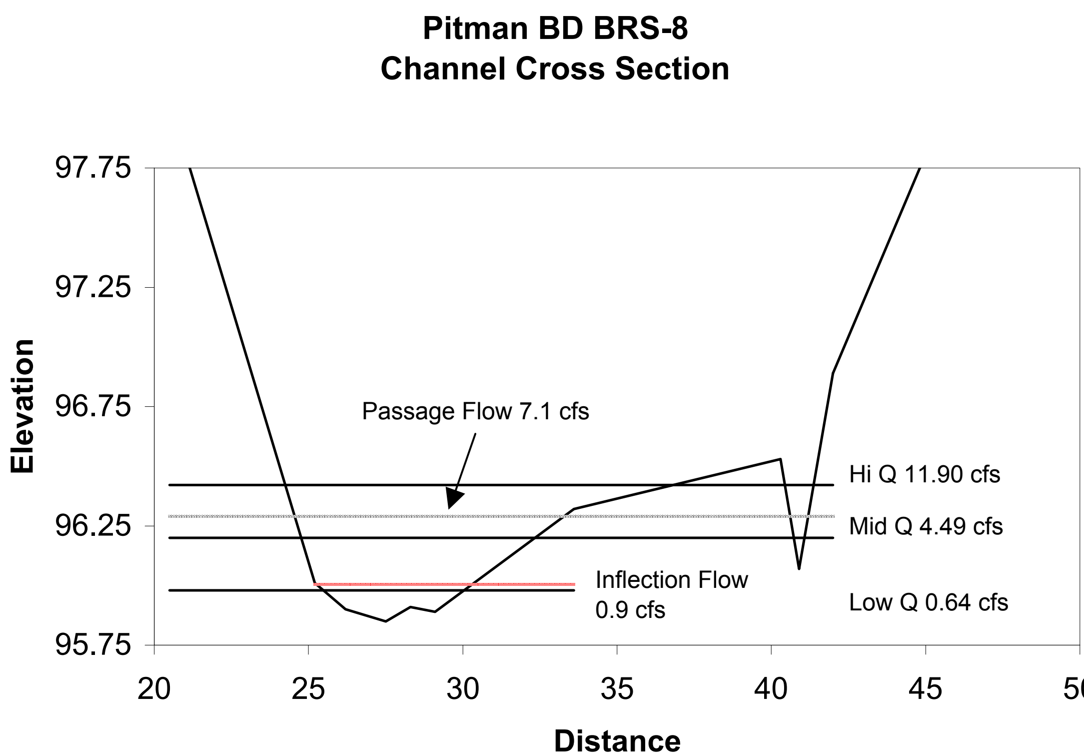
CAWG 3 Appendix B Figure B-17. Wetted perimeter and channel cross-section plots for Pitman AD-LGR-3.



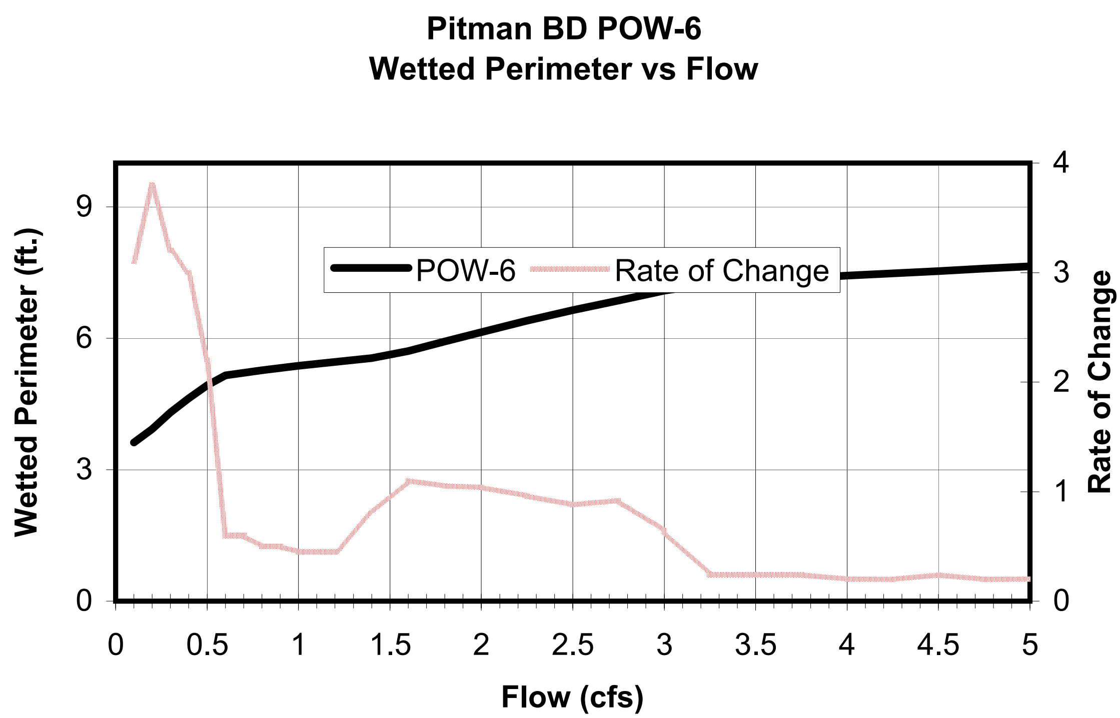


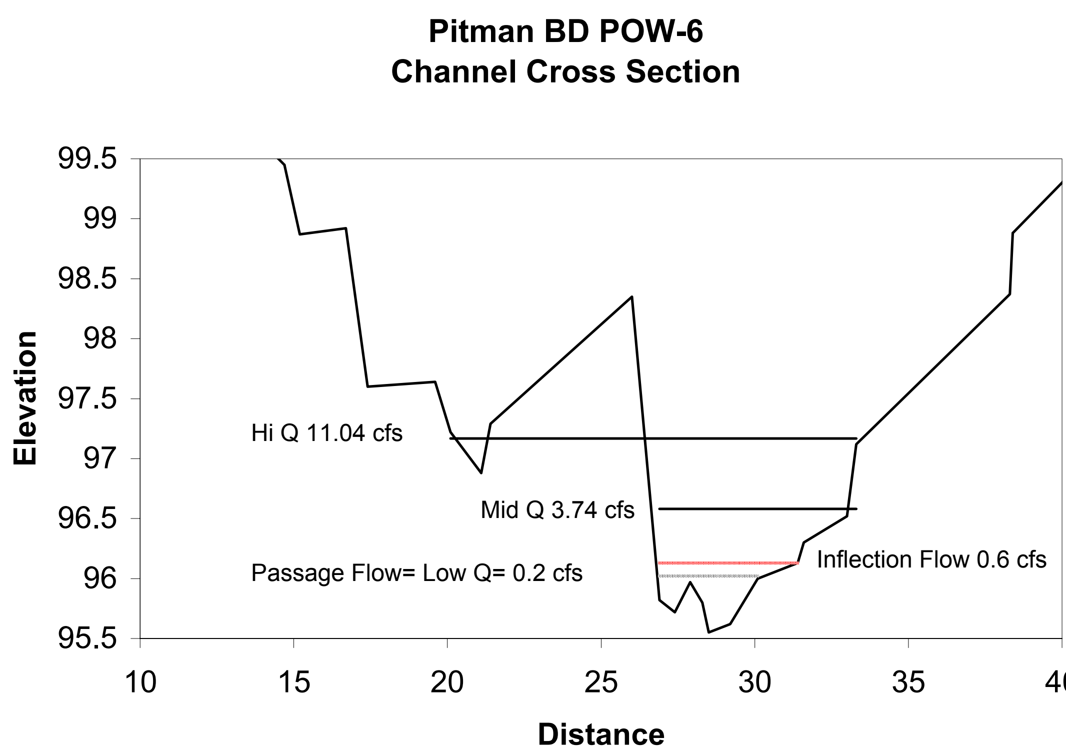
CAWG 3 Appendix B Figure B-18. Wetted perimeter and channel cross-section plots for Pitman BD-POW-3.



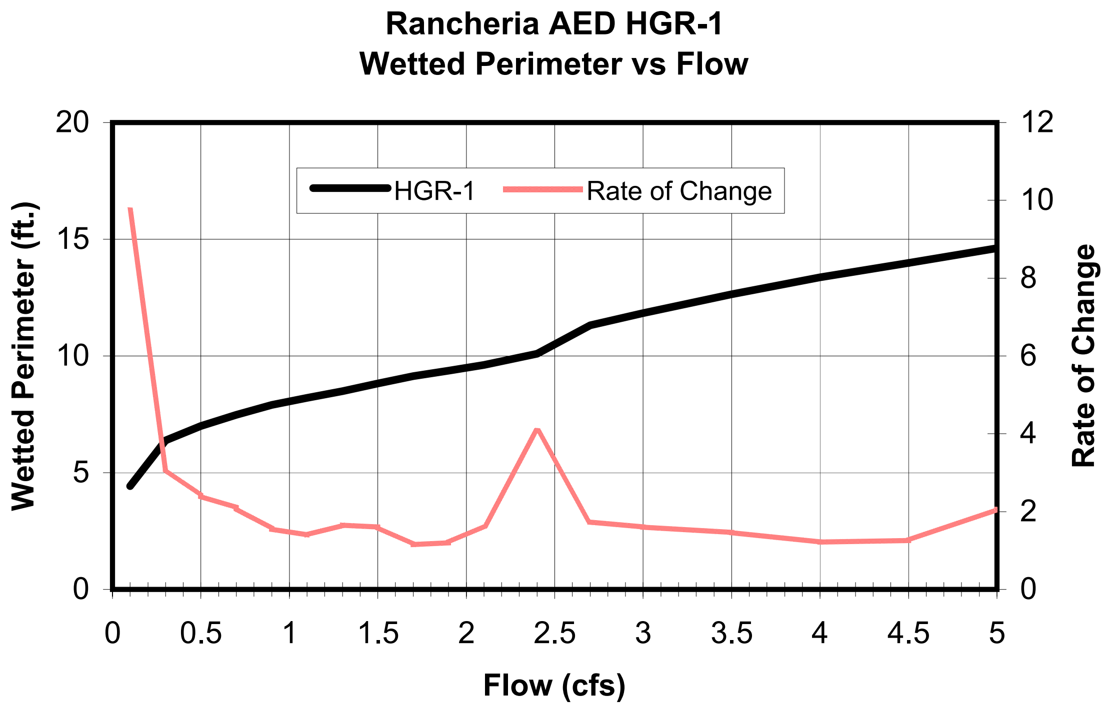


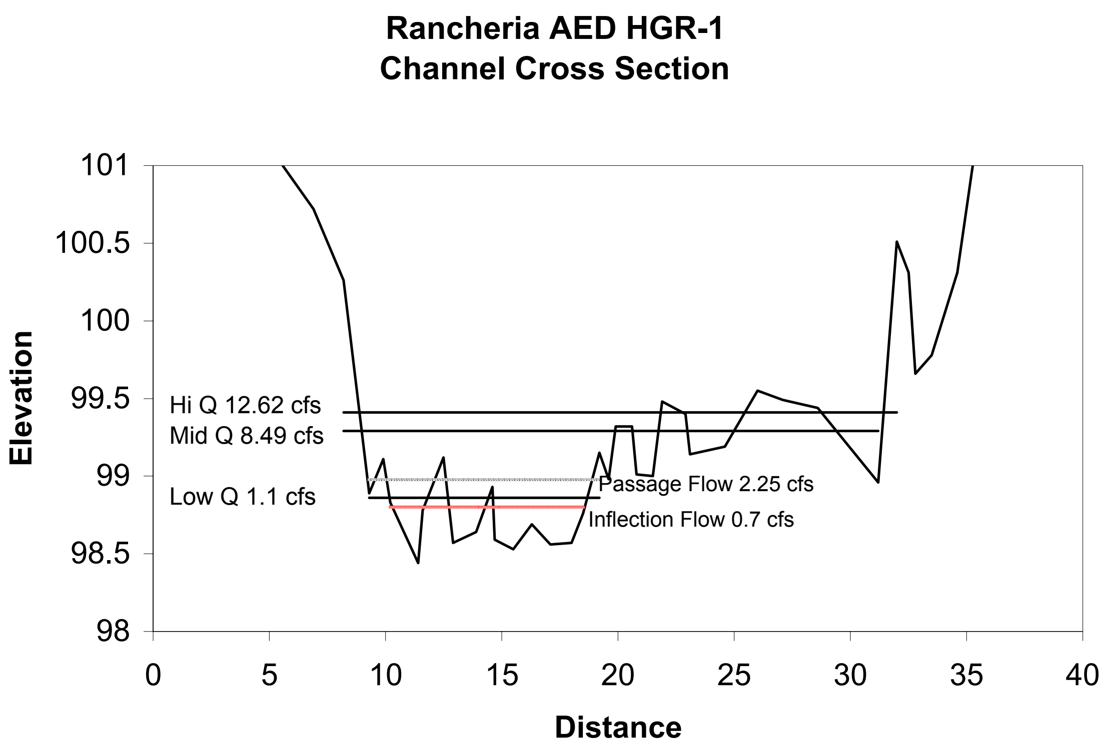
CAWG 3 Appendix B Figure B-19. Wetted perimeter and channel cross-section plots for Pitman BD-BRS-8.



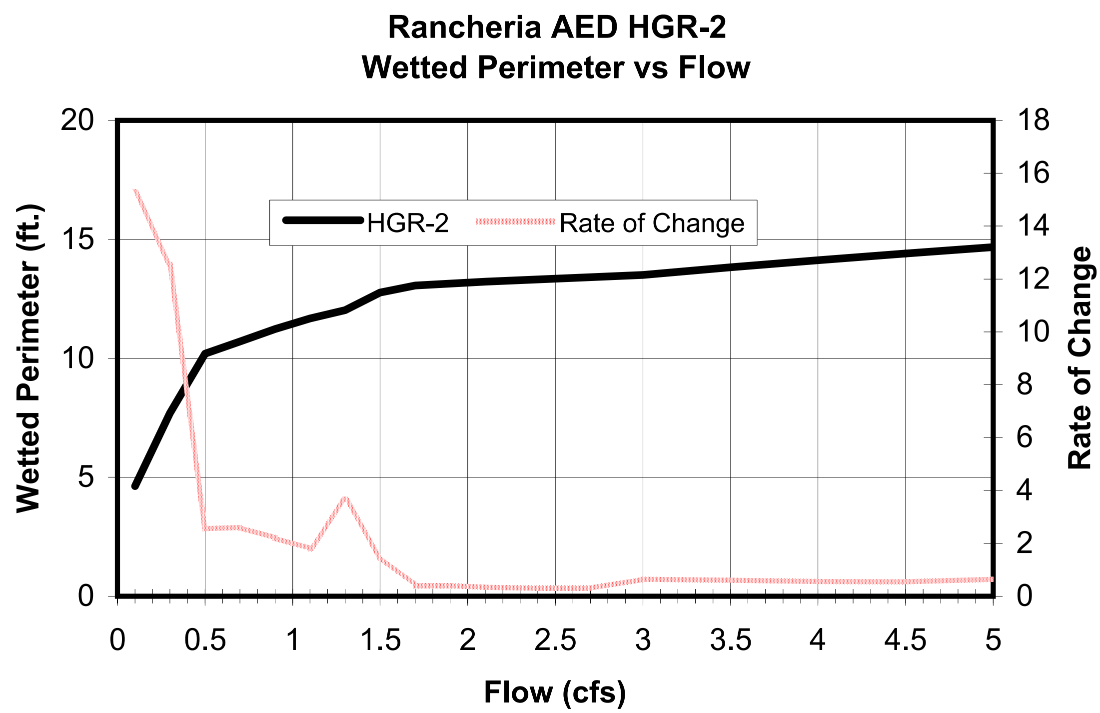


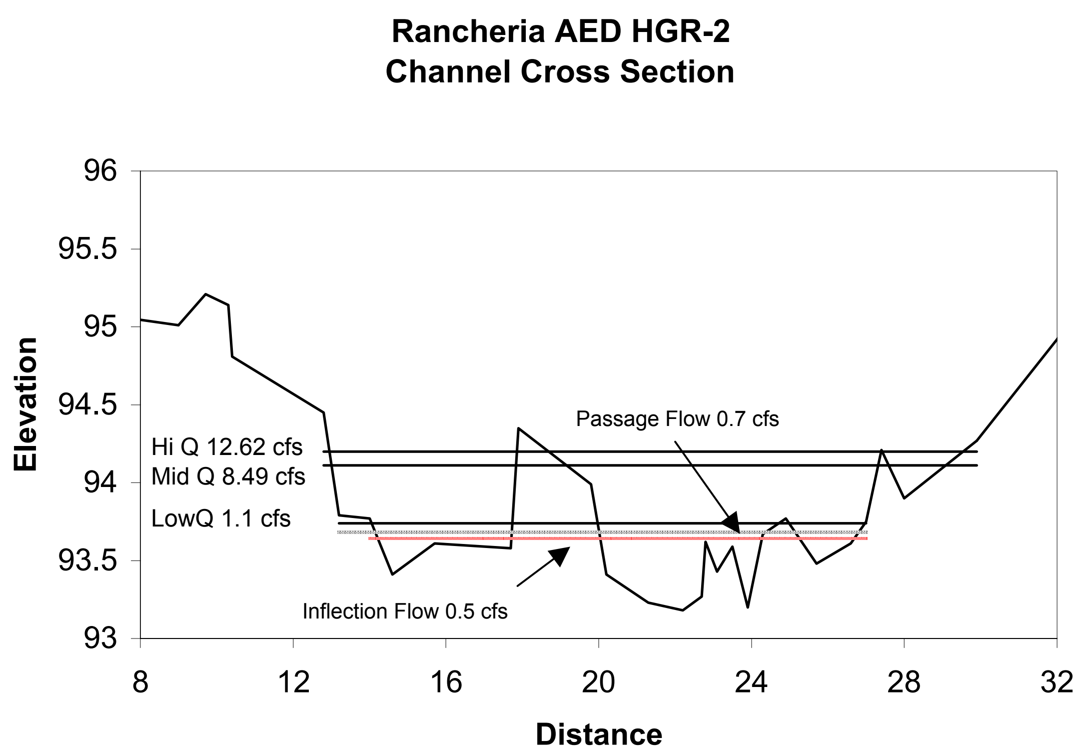
CAWG 3 Appendix B Figure B-20. Wetted perimeter and channel cross-section plots for Pitman BD-POW-6.



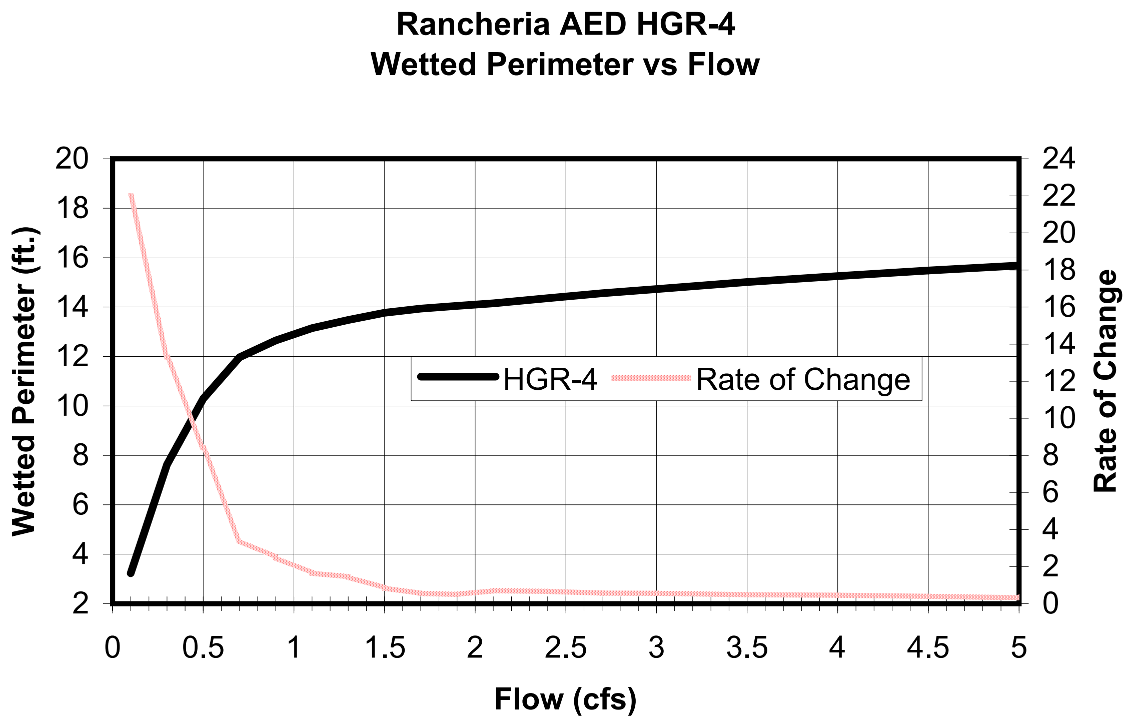


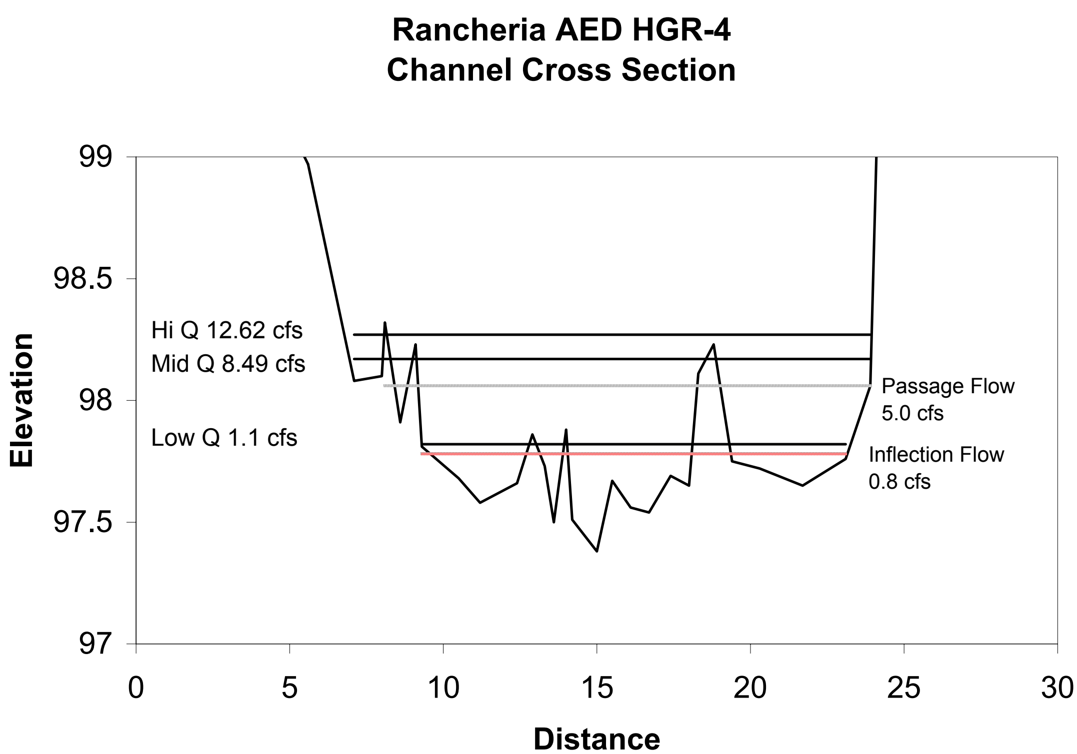
CAWG 3 Appendix B Figure B-21. Wetted perimeter and channel cross-section plots for Rancheria AED-HGR-1.



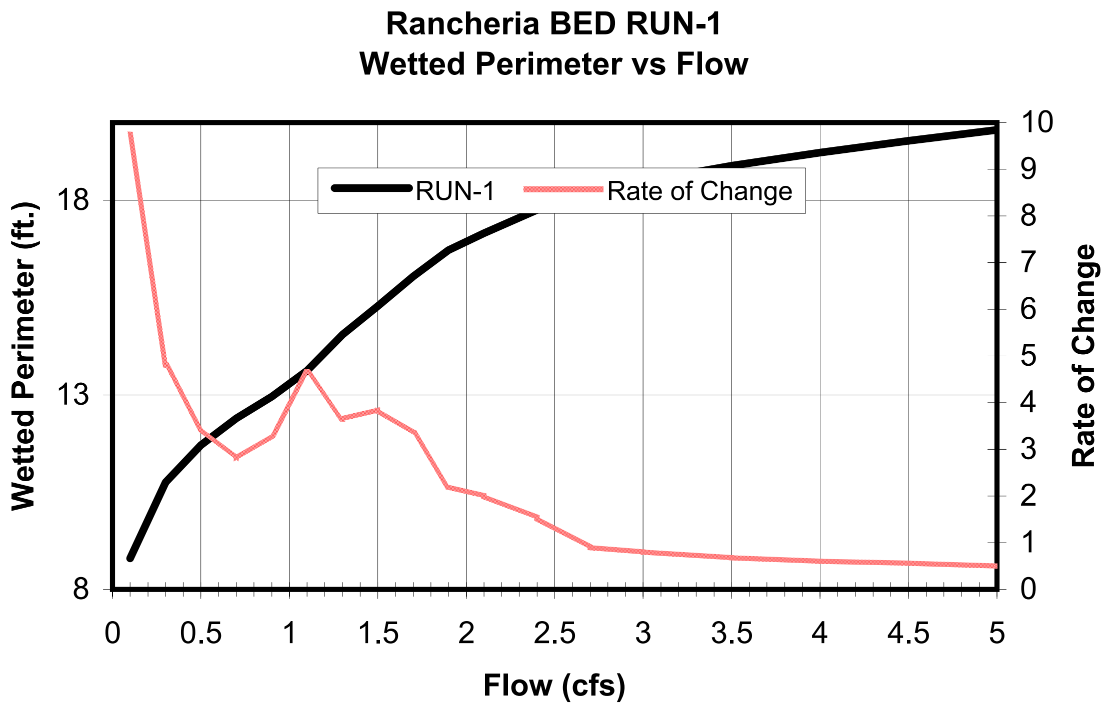


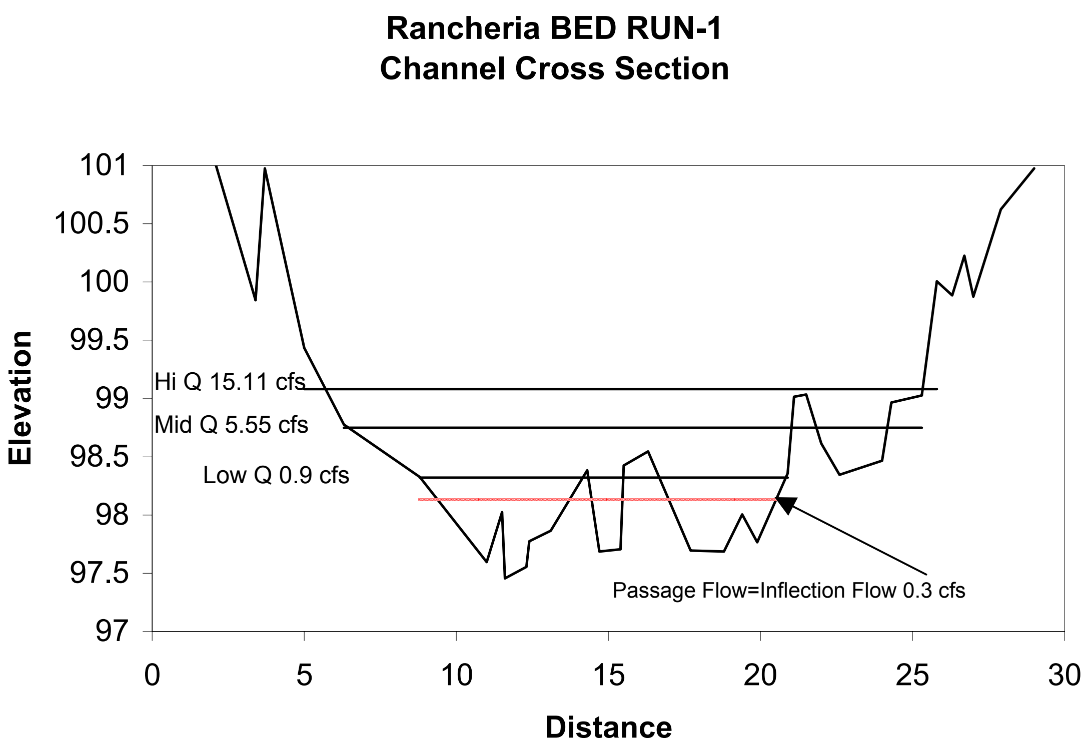
CAWG 3 Appendix B Figure B-22. Wetted perimeter and channel cross-section plots for Rancheria AED-HGR-2.



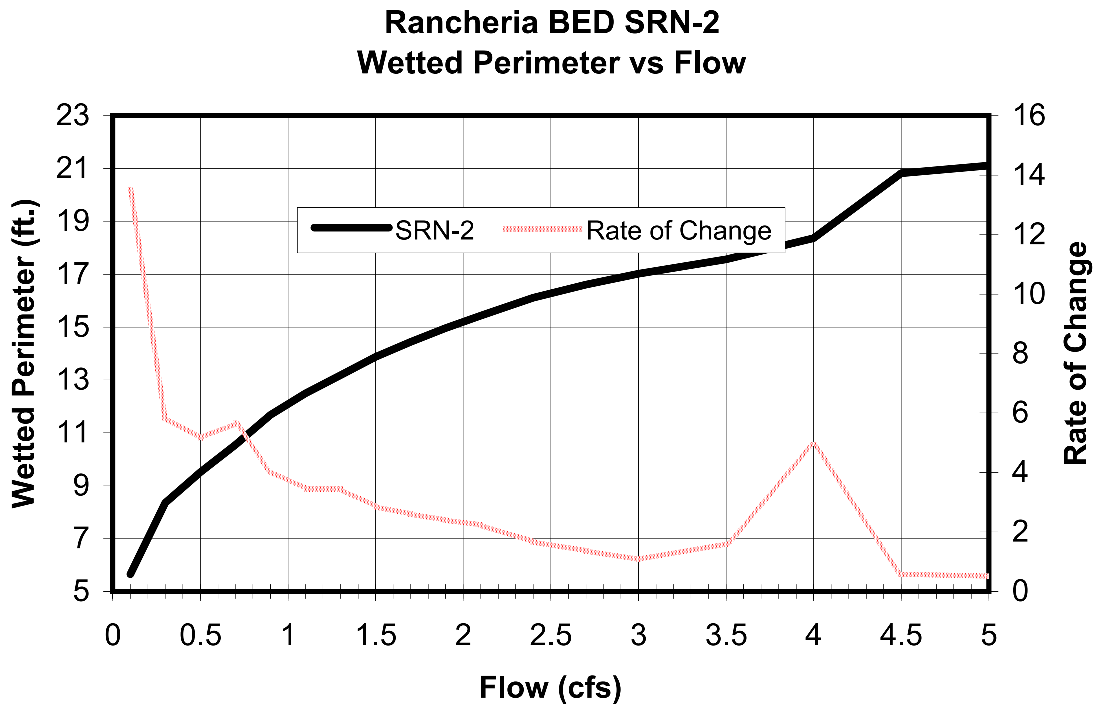


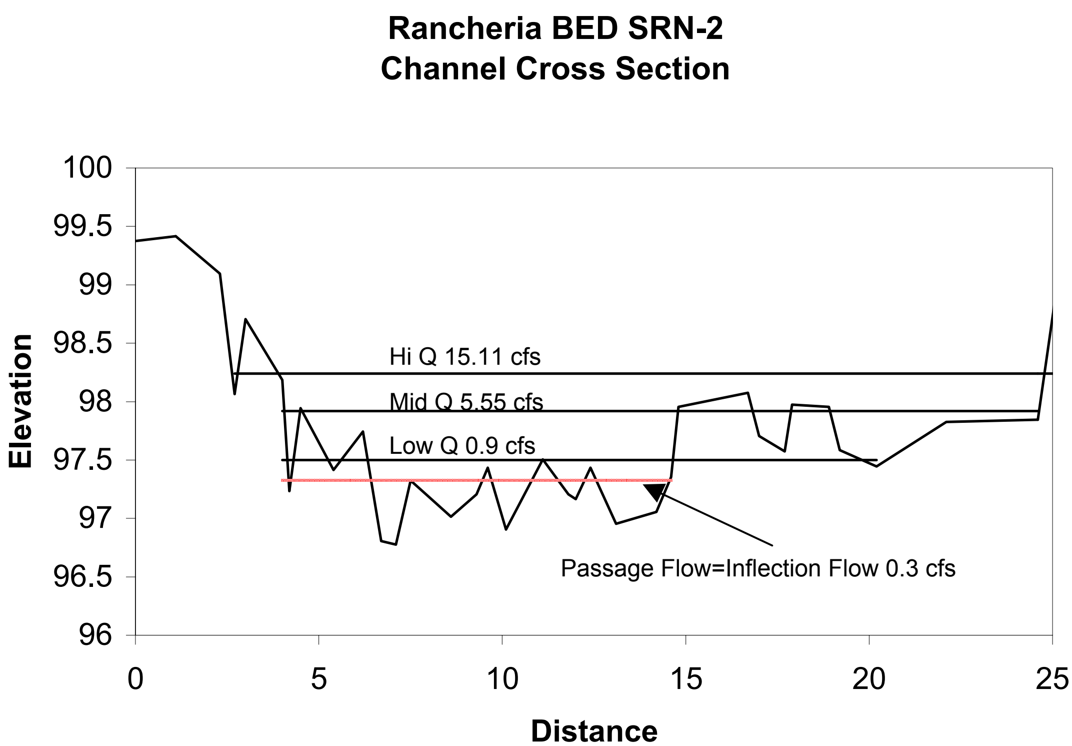
CAWG 3 Appendix B Figure B-23. Wetted perimeter and channel cross-section plots for Rancheria AED-HGR-4.



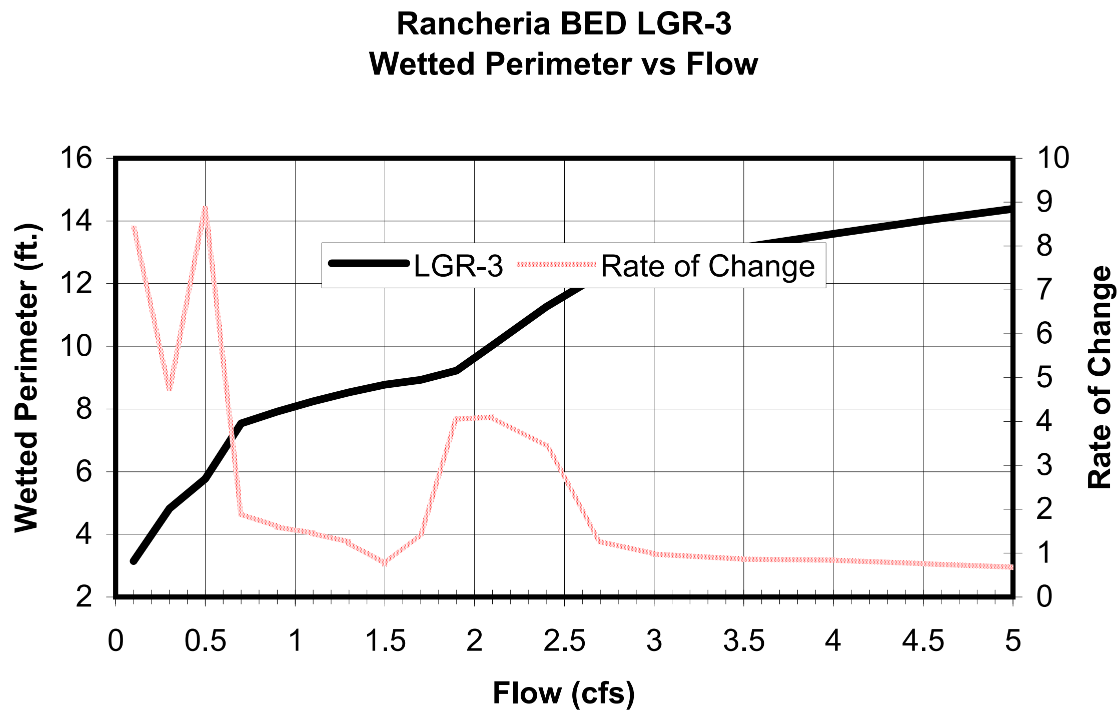


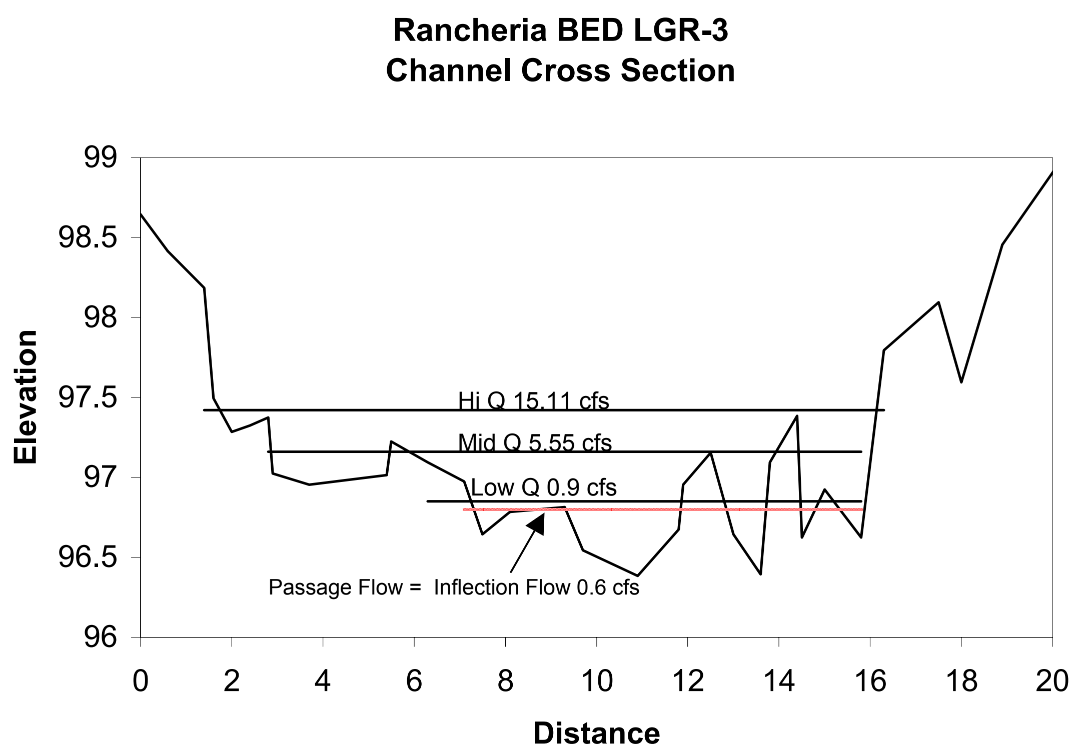
CAWG 3 Appendix B Figure B-24. Wetted perimeter and channel cross-section plots for Rancheria BED-RUN-1.



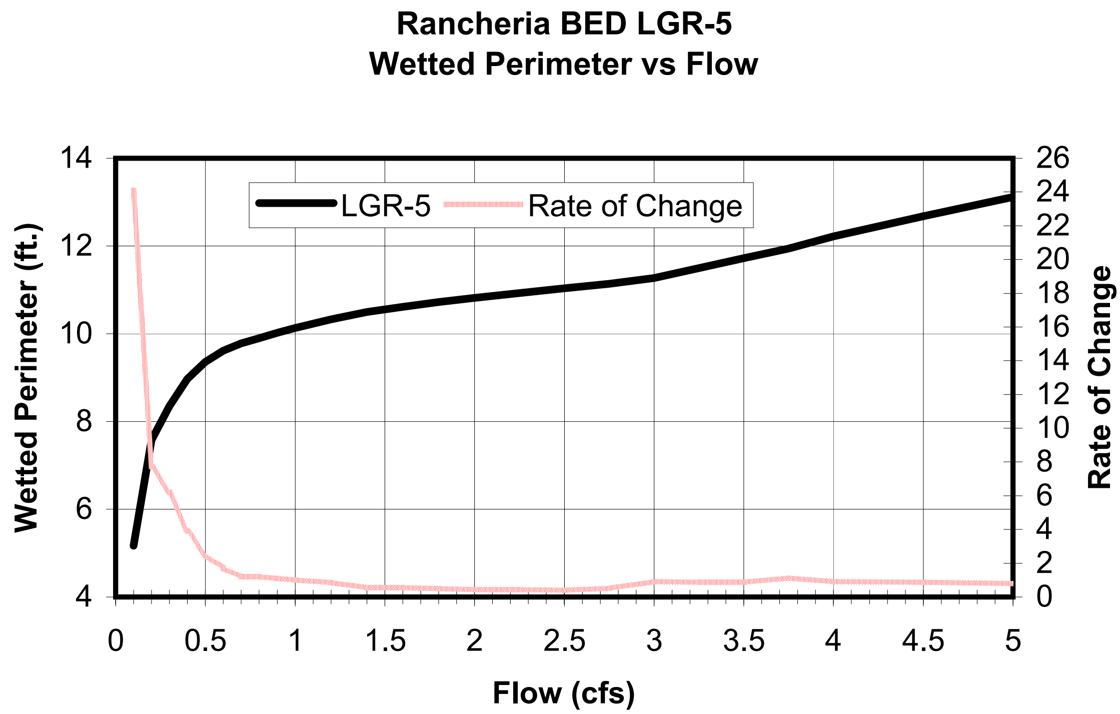


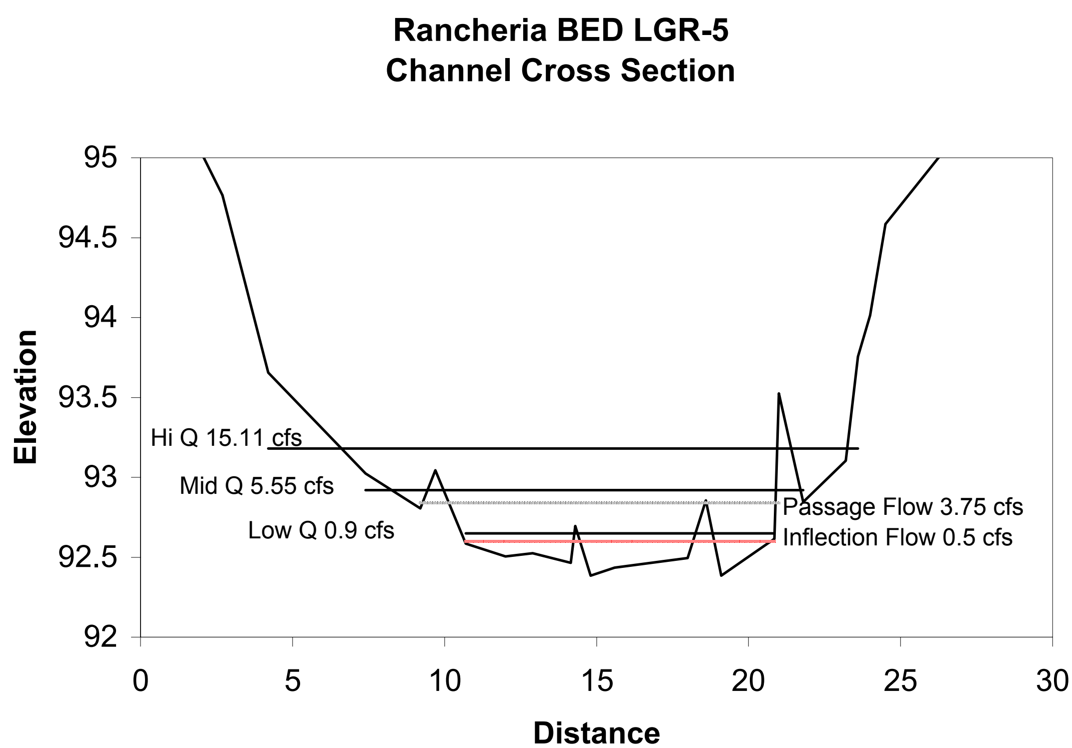
CAWG 3 Appendix B Figure B-25. Wetted perimeter and channel cross-section plots for Rancheria BED-SRN-2.



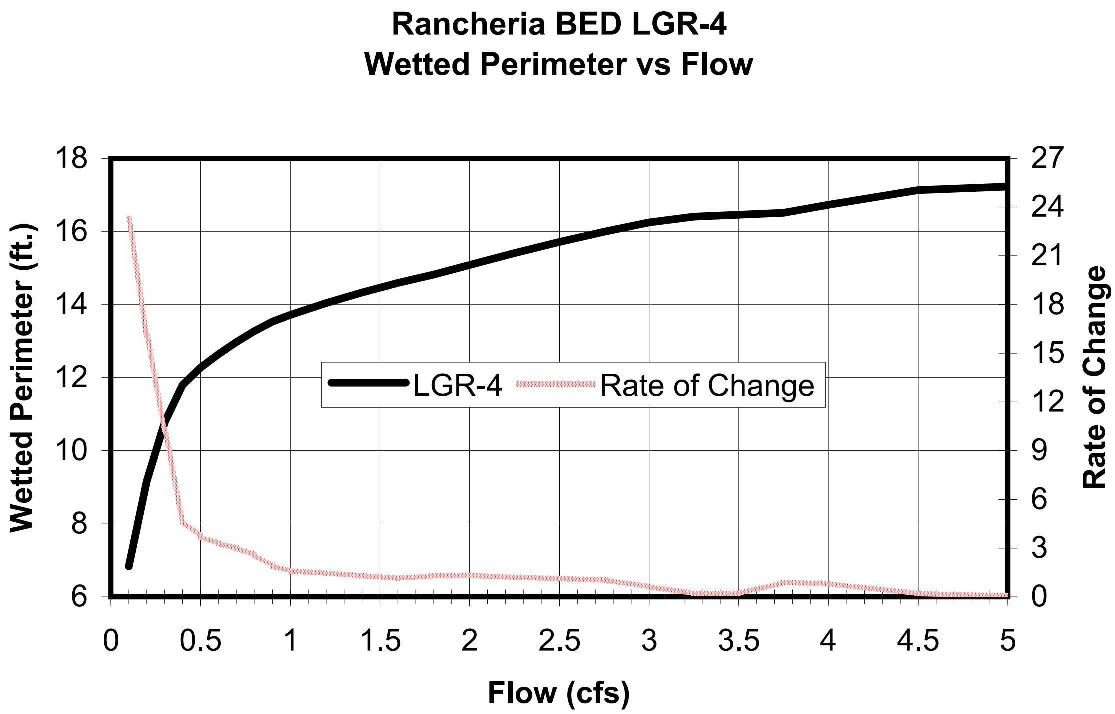


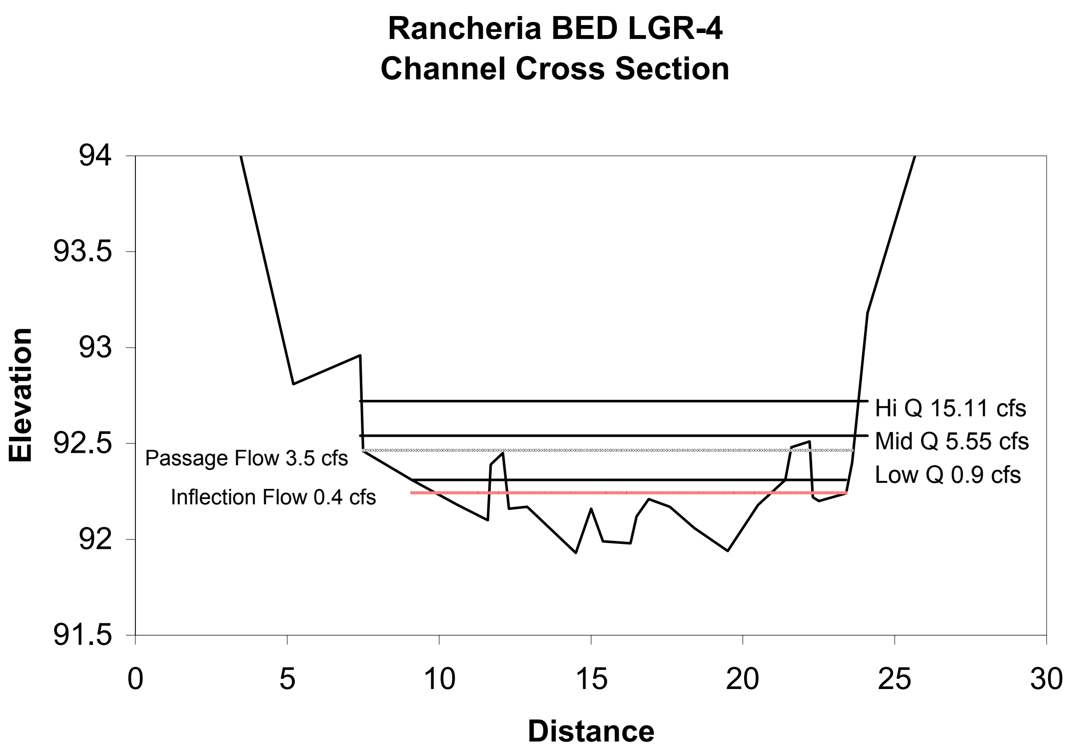
CAWG 3 Appendix B Figure B-26. Wetted perimeter and channel cross-section plots for Rancheria BED-LGR-3.



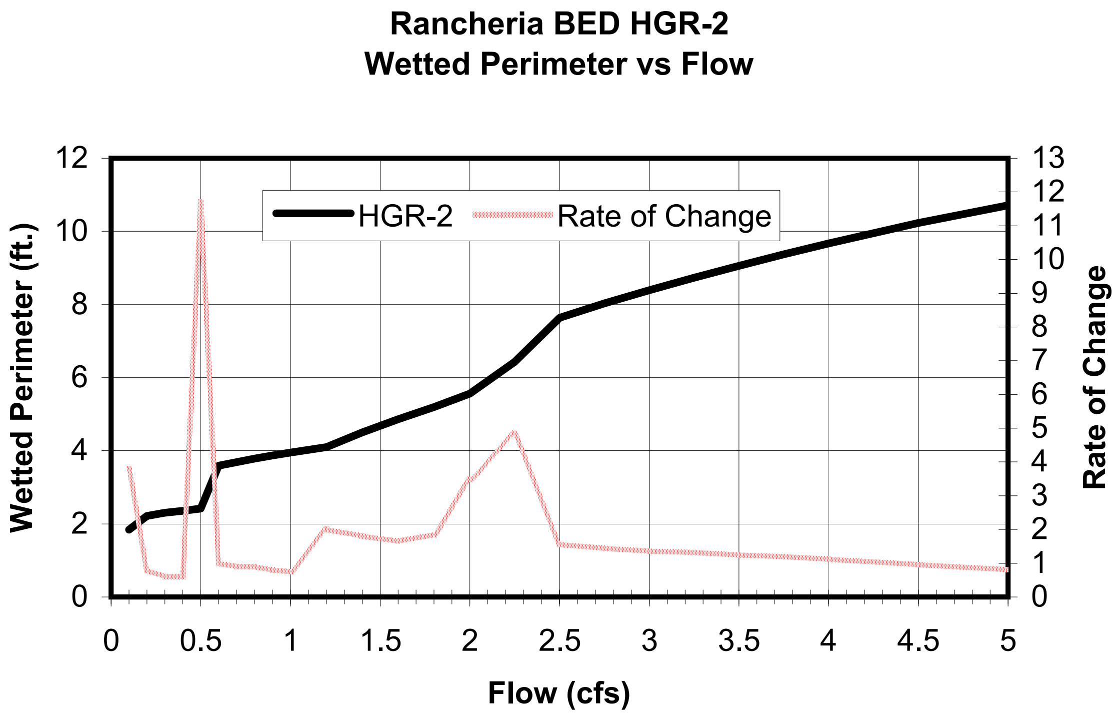


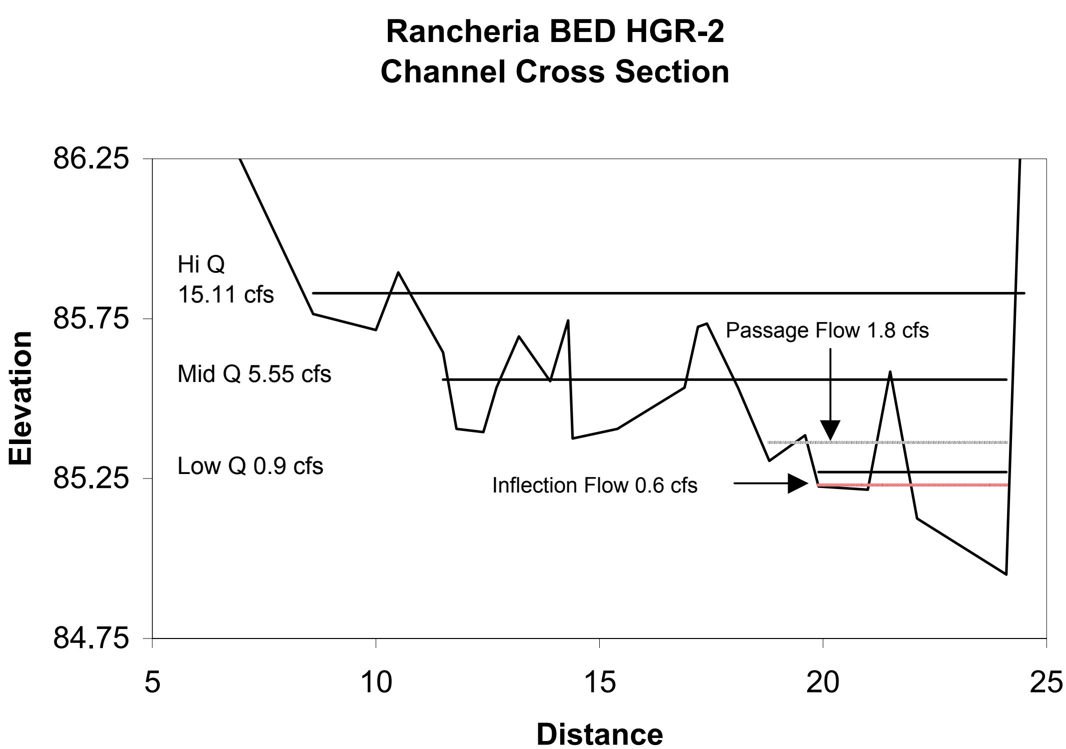
CAWG 3 Appendix B Figure B-27. Wetted perimeter and channel cross-section plots for Rancheria BED-LGR-5.





CAWG 3 Appendix B Figure B-28. Wetted perimeter and channel cross-section plots for Rancheria BED-LGR-4.





CAWG 3 Appendix B Figure B-29. Wetted perimeter and channel cross-section plots for Rancheria BED-HGR-2.

APPENDIX C

MODEL CALIBRATION RESULTS

CAWG 3 Appendix C Table C-1. Stage Discharge Method and Model Calibration for Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect Designation[1]	Stage-Discharge Method	Flow (cfs)	Measured WSE	Simulated WSE	Stage at Zero Flow	Mean Error
Adit 8 Below Diversion	BD-LGR-5	IFG-4a	3.75	99.17	99.17	98.59	0.33
			1.02	98.91	98.91		
			0.17	98.73	98.73		
	BD-HGR-1	IFG-4a	5.32	96.26	96.26	95.17	2.06
			0.95	96.09	96.09		
			0.24	95.98	95.98		
	BD-HGR-6	IFG-4a	5.32	98.93	98.93	98.25	1.75
			0.95	98.49	98.49		
			0.24	98.35	98.35		

[1] HGR - High Gradient Riffle, LGR - Low Gradient Riffle
cfs = cubic feet per second

CAWG 3 Appendix C Table C-2. Stage Discharge Method and Model Calibration for Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect Designation[1]	Stage-Discharge Method	Flow (cfs)	Measured WSE	Simulated WSE	Stage at Zero Flow	Mean Error
Balsam Creek Above Diversion	AD-HGR-2	IFG-4a	4.90	97.76	97.76	97.13	0.52
			3.58	97.71	97.71		
			0.94	97.53	97.53		
	AD-HGR-1	IFG-4a	6.24	90.43	90.43	89.80	1.08
			3.12	90.31	90.31		
			1.26	90.18	90.18		
	AD-HGR-7	IFG-4a	6.24	99.21	99.21	98.20	0.36
			3.12	99.06	99.06		
			1.26	98.90	98.90		
Balsam Creek Below Diversion	BD-HGR-3	IFG-4a	5.60	100.10	100.10	99.44	0.48
			3.65	99.99	99.99		
			2.11	99.88	99.88		
	BD-HGR-2	IFG-4a	5.60	97.26	97.26	96.52	0.03
			3.65	97.20	97.20		
			2.11	97.13	97.13		
	BD-HGR-1	IFG-4a	4.97	97.52	97.52	96.66	0.08
			3.55	97.35	97.35		
			1.84	97.11	97.11		

[1] HGR - High Gradient Riffle
cfs = cubic feet per second

CAWG 3 Appendix C Table C-3. Stage Discharge Method and Model Calibration for Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect Designation[1]	Stage-Discharge Method	Flow (cfs)	Measured WSE	Simulated WSE	Stage at Zero Flow	Mean Error
Ely Creek Above Diversion	AD-RUN-1	IFG-4a	2.37	97.02	97.04	96.33	7.98
			0.94	96.83	96.81		
			0.32	96.62	96.63		
	AD-SRN-2	IFG-4a	2.37	97.39	97.41	97.01	4.35
			0.94	97.16	97.15		
			0.32	97.05	97.05		
Ely Creek Below Diversion	BD-HGR-4	IFG-4a	3.24	96.97	96.97	96.48	0.76
			2.35	96.91	96.91		
			0.51	96.70	96.70		
	BD-HGR-1	IFG-4a	3.01	96.25	96.25	95.67	0.99
			1.98	96.17	96.17		
			0.51	95.99	95.99		
	BD-HGR-2	IFG-4a	3.01	98.64	98.64	98.03	0.07
			1.98	98.51	98.51		
			0.51	98.25	98.25		

[1] RUN - Run, SRN - Step Run, HGR - High Gradient Riffle,
cfs = cubic feet per second

CAWG 3 Appendix C Table C-4. Stage Discharge Method and Model Calibration for Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect Designation[1]	Stage-Discharge Method	Flow (cfs)	Measured WSE	Simulated WSE	Stage at Zero Flow	Mean Error
Pitman Creek Above Diversion	AD-HGR-2	IFG-4a	13.82	96.00	96.00	95.27	0.54
			3.94	95.81	95.81		
			0.17	95.52	95.52		
	AD-LGR-1	IFG-4a	13.82	96.81	96.81	96.15	0.17
			3.94	96.58	96.58		
			0.17	96.29	96.29		
	AD-LGR-3	IFG-4a	13.82	97.65	97.65	96.79	0.15
			3.94	97.42	97.42		
			0.17	97.08	97.08		
Pitman Creek Below Diversion	BD-POW-3	IFG-4a	10.76	97.24	97.24	96.12	0.11
			4.49	96.85	96.85		
			0.64	96.40	96.40		
	BD-BRS-8	IFG-4a	11.90	96.42	96.42	95.85	0.44
			4.49	96.20	96.20		
			0.64	95.98	95.98		
	BD-POW-6	IFG-4a	11.04	97.13	97.17	95.89	4.75
			3.74	96.61	96.58		
			0.20	96.02	96.02		

[1] HGR - High Gradient Riffle, LGR - Low Gradient Riffle, POW - Pocket Water, BRS - Bedrock Sheet
cfs = cubic feet per second

CAWG 3 Appendix C Table C-5. Stage Discharge Method and Model Calibration for Lower Basin Wetted Perimeter Transects.

Stream and Site	Transect Designation[1]	Stage-Discharge Method	Flow (cfs)	Measured WSE	Simulated WSE	Stage at Zero Flow	Mean Error
Rancheria Creek Above Energy Dissipater	AED-HGR-1	IFG-4a	12.62	99.41	99.41	98.44	0.44
			8.49	99.29	99.29		
			1.10	98.86	98.86		
	AED-HGR-2	IFG-4a	12.62	94.20	94.20	93.18	0.79
			8.49	94.11	94.11		
			1.10	93.74	93.74		
	AED-HGR-4	IFG-4a	12.62	98.27	98.27	97.38	0.64
			8.49	98.17	98.17		
			1.10	97.82	97.82		
Rancheria Creek Below Energy Dissipater	BED-RUN-1	IFG-4a	15.11	99.08	99.08	97.46	0.57
			5.55	98.75	98.75		
			0.90	98.32	98.32		
	BED-SRN-2	IFG-4a	15.11	98.24	98.24	96.78	0.62
			5.55	97.92	97.92		
			0.90	97.50	97.50		
	BED-LGR-3	IFG-4a	15.11	97.42	97.42	96.39	0.71
			5.55	97.16	97.16		
			0.90	96.85	96.85		
	BED-LGR-5	IFG-4a	15.11	93.18	93.18	92.39	0.67
			5.55	92.92	92.92		
			0.90	92.65	92.65		
	BED-LGR-4	IFG-4a	15.11	92.72	92.72	91.93	0.22
			5.55	92.54	92.54		
			0.90	92.31	92.31		
	BED-HGR-2	IFG-4a	15.11	85.82	85.83	84.95	1.99
			5.55	85.57	85.56		
			0.90	85.27	85.27		

[1] RUN - Run, SRN - Step Run, HGR - High Gradient Riffle, LGR - Low Gradient Riffle
cfs = cubic feet per second