DRAFT

# *FINAL DRAINAGE REPORT POWERS BOULEVARD – STATE HIGHWAY 83 AND SHOUP ROAD IMPROVEMENTS*

***CDOT PROJECT STU M240-081***
***September 10, 2003***

Submitted to
COLORADO DEPARTMENT OF TRANSPORTATION
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# DRAINAGE CERTIFICATION:

I hereby certify that this report for the drainage design for Powers Boulevard North Extension was prepared by me (or under my direct supervision) in accordance with the provisions of the Colorado Department of Transportation Drainage Design Manual, and was designed to comply with the provisions thereof. I understand that the Colorado Department of Transportation does not and will not assume liability for drainage facilities designed by others.

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State of Colorado
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# INTRODUCTION

### *Project Location*

This drainage report presents a supplement to the final drainage report for Powers Boulevard North Extension from Briargate Parkway to State Highway 83 (Sta. 603+85.80 to Sta. 760+67.08) located within the limits of the City of Colorado Springs, El Paso County, Colorado as shown in Figure 1: Vicinity Map. This extension is known as CDOT Project STU R200-107. This first supplemental report amended prior information presented in the "Final Drainage Report Powers Boulevard North Extension" (Reference 9) for drainage structures north of Powers Boulevard Sta. 721+00. These changes were made due to the realignment of State Highway 83, associated entrance and exit ramps, and revisions in the hydraulic grade line criteria. This current report continues with the design of the interchange of Powers Boulevard and State Highway 83, and also includes the realignment of Shoup Road with State Highway 83. This portion of construction is known as CDOT Project STU M240-081.

### *Site Location and Description*

The Colorado Department of Transportation (CDOT) is extending Powers Boulevard to the northwest through Sections 16, 21, 22, 26, 27 and 35 of Township 12 South, Range 66 West of the 6th Principal Meridian. The extension traverses gentle rolling prairie grasslands and will cross a north tributary of Pine Creek, the main tributary of Kettle Creek, and the upper tributary of the Elkhorn Basin. Also included in this construction is the realignment of State Highway 83 from the Powers Boulevard intersection to the Shoup Road intersection. State Highway 83 is within the upper tributary of the Elkhorn Basin and then crosses over Black Squirrel Creek. The soils in the project area are predominantly Peyton and Pring soils. See Figure 2: Soil Classification Map. The Natural Resources Conservation Services (NRCS) of El Paso County (Reference 12) refers to these types of soil as hydrologic soil type B, which are relatively poor draining soils with high runoff potential.

Construction of the entire Powers Boulevard project is planned in two phases. Phase I will consist of construction for parts of the mainline roadway and ramps from north of Briargate Parkway to realigned State Highway 83. In addition, ramps and a revised intersection to Old Ranch Road will be constructed in the Phase I project. Phase II will consist of roadway construction for the mainline Powers Boulevard between Briargate Parkway and Union Boulevard and near Old Ranch Road.

Construction of the Powers Boulevard and State Highway 83 intersection will occur in three stages. Stage I (Pre-Interim Condition) will consist of construction of Powers Boulevard to Sta. 749+00, the beginning of the northbound off ramp (Ramp E) and the beginning of the southbound on ramp (Ramp F). The first supplemental drainage report described the drainage structures involved in this first stage of construction.

Stage II (Interim Condition) will consist of realigning State Highway 83 from Powers Boulevard to Shoup Road and the completion of Ramp E and F from Powers Boulevard to State Highway 83. This supplemental drainage report will describe the drainage structures involved in this second stage of construction. Stage III (Ultimate Condition) will consist of continuing Powers Boulevard north, the southbound off ramp (Ramp G) and the northbound on ramp (Ramp H). The first supplemental drainage report analyzed both conditions, interim and ultimate, to size drainage structures for the worst case scenario within the first stage of construction within the Elkhorn Basin. This supplemental drainage report will continue to use this analysis for the interim condition for the Elkhorn Basin at the State Highway 83 and Powers Boulevard intersection. A separate analysis for the Black Squirrel Creek Basin will be shown in this drainage report. An additional drainage report (to be published separately) will describe the drainage structures involved in the third stage of construction.

# HYDROLOGIC AND HYDRAULIC ANALYSIS

*Basin Description*

The Interim Condition of the Powers Boulevard and State Highway 83 intersection and the realignment of State Highway 83 and Shoup Road is within two drainage basins: Elkhorn Basin and Black Squirrel Creek Basin. For the Elkhorn Basin, the interim drainage areas and ultimate drainage areas are shown for both basins in Figure 3: Elkhorn Basin Intermediate Drainage Basin Map and Figure 4: Elkhorn Basin Ultimate Drainage Basin Map. For the Black Squirrel Creek basin, the drainage areas are shown on Figure 5: Black Squirrel Creek Basin Map.

**Elkhorn Basin**

Elkhorn Basin is located in northern El Paso County. The Elkhorn Basin flows relatively west toward Monument Creek and eventually into the Arkansas River Basin. Elkhorn's headwaters are within the intersection of the Powers Boulevard mainline and realigned State Highway 83. There is currently no Drainage Basin Planning Study (DBPS) for the Elkhorn Drainage Basin (FOMO3400).

The Elkhorn Basin is bounded by the Black Squirrel Basin to the north and Kettle Creek Basin to the south. A semiarid climate exists within the basin. The basin covers an area of roughly 3.5 square miles and has an elevation range of 6940 to 7040 feet. See Appendix A: Hydrology - Rational Basin Calculations for Elkhorn Basin for hydrology.

**Black Squirrel Creek Basin**

Black Squirrel Creek Basin is in northern El Paso County and has a majority of the area within the Black Forest area. Black Squirrel Creek flows southwest towards Monument Creek and eventually into the Arkansas River Basin. A DBPS (Reference 2) was completed in January 1989 for the basin (FOMO3600).

The Black Squirrel Creek Basin is bounded by several other basin, with West and East Cherry Creek to the north and east, Kettle Creek and Elkhorn to the south and east, and Smith Creek, Monument Branch, and Middle Tributary along the west. A majority of the basin is forested while about a third is pasture or rangeland. The total basin area is approximately 10.3 square miles and has an elevation range or 6500 to 7500 feet. See Appendix B: Hydrology - Rational Basin Calculations for Black Squirrel Creek Basin for hydrology.

*Channel Description*

**Elkhorn**

Elkhorn is a small tributary to Monument Creek. Powers Boulevard crosses Elkhorn in the upper portions of the basin. The majority of the area is small swales, with non-existent flood plains.

**Black Squirrel Creek**

Black Squirrel Creek is a small to medium sized tributary to Monument Creek. State Highway 83 currently crossed Black Squirrel Creek just north of Shoup Road. The creek, within the project area, is a deep narrow channel with minimal vegetation on the channel bottom and well-vegetated side slopes.

### *Precipitation*

Northern El Paso County can be described in general as high plains and foothills, with total precipitation amounts of a semi-arid region. The average annual precipitation varies from a low of 8 inches to a high of 20 inches in the higher elevations. Winters are generally cold and dry with precipitation in the form of snow. Winter storms typically track from the west to the east and the majority of the snowfall occurs in the higher mountains to the west and snowpack in the basin is generally light, therefore springtime runoff is generally light. The majority of precipitation occurs during the months of May through September from convective thunderstorms. During the summer months intense thunderstorms occur, sometimes of cloudburst intensity. Normal annual precipitation for Colorado Springs is 13.2 inches, with the normal maximum monthly amount of 2.4 inches occurring in July.

### *Flood History*

Recorded flood histories for the Elkhorn and Black Squirrel Creek Basins do not exist. The Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for El Paso County and Incorporated Areas shows a 100-year floodplain for Black Squirrel Creek Basin and no designated regulated floodplains within the Elkhorn Basin, as shown on Figure 6: Flood Insurance Rate Map (FIRM).

### *Design Frequency*

The design frequency is based on CDOT criteria (Table 7.2 on page 7-8 of the CDOT Drainage Design Manual-Reference 5) for multilane roads in urban areas. The 100-year storm event was used for the project, due to the urbanization of the area, for the major storm. The 5-year storm is used for any minor storm systems. Culvert outlet scour protection and channel lining are based upon the 10-year storm.

### *Design Discharge*

#### Method of Analysis

The hydrology for this project is analyzed for the design storm using two methods as recommended by both the CDOT Drainage Design Manual (Reference 5) and the City of Colorado Springs and El Paso County Drainage Criteria Manual (City DCM) (Reference 3). The Rational Method is used for drainage basins less than 160 acres in size. U.S. Army Corps of Engineers HEC-HMS computer model program utilizing the SCS Unit Hydrograph Method was utilized for drainage basins greater than the 160 acres.

#### Run-off Coefficients

Rational Method coefficients are from Table 5-1 on page 5-8 of the City DCM (Reference 1). The 10-year storm C values were used for the 5-year storm as per the manual's recommendations. The SCS curve numbers were also taken from the City DCM (Reference 3).

#### Time of Concentration

The Time of Concentration ($t_c$) for both the Rational Method and the SCS Method were taken from the CDOT Drainage Design Manual page 7-11 (Reference 5). The time of concentration consists of the initial time (the time runoff is sheet flowing) and the travel time (time runoff is in a channel). A minimum $t_c$ of 5 minutes was used due to urban area, as per CDOT Drainage Design Manual page 7-13 (Reference 5).

**Rainfall Intensity and Depth**

The rainfall intensity curves for the Rational Method were taken from the City DCM Figure 5-1 (Reference 3). Rainfall intensities of 2.96 inches and 4.4 inches for the 10-year and 100-year storm were used for the SCS method, based on the 24-hour Type IIA storm distribution. These values were taken from the City DCM Figure 5-4d and Figure 5-4e (Reference 3).

## EXISTING STRUCTURES

*Drainage Structures*

An effort has been made to maintain as many existing drainage structures as possible. This has been done by either adding to or extending structures or by modifications to the structure itself. In some cases, the existing structure was undersized and could not handle the major storm event properly. In this case, the structure was replaced or abandoned for an alternative structure in a different location. Within this supplemental project area, the existing 15-foot corrugated metal underpass culvert under State Highway 83 north of Shoup Road will have to be replaced, due to being undersized and not allowing a habitat corridor for the Prebles Meadow Jumping Mouse (PMJM). The replacement is called out as a bridge in the DBPS (Reference 2).

*Other Utilities*

Other utilities that may be encountered include but are not limited to water distribution, sanitary sewer, gas and electrical lines. These utilities have been examined on a case by case basis and will be avoided where feasible and/or relocated. Any relocation of these utilities has and will continue to be coordinated with the respective utility contact.

## DESIGN DISCUSSION

*Introduction*

The criteria has been established by reviewing the most stringent requirement of the City DCM (Reference 3) and CDOT Drainage Design Manual (Reference 5). The appropriate design storm was used to size the storm drain system based on the design frequency discussed above.

*Roadside Ditches*

Roadside ditches are designed using the Manning's Equation for open channel flow. Flexible linings for erosion protection were designed using Federal Highway Administration (FHWA) "Design of Roadside Channels with Flexible Lining" (Reference 8). Ditches were sized using the worst-case scenario hydrology for the interim or the ultimate condition, where appropriate.

*Inlets and Storm Sewer Systems*

Inlet spacing is based on the road surface area required to generate enough runoff to reach either gutter capacity, given the allowable spread, or the ditch capacity given the allowable depth for the design storm. The inlet efficiency and inlet sizing are calculated using *Haestad Methods'* FlowMaster design software for the Type C close mesh grate inlets and the Type R curb opening inlets.

Storm sewer systems were designed using *Haestad Methods'* StormCAD design software. The system is sized using the 100-year storm with the hydraulic grade line (HGL) remaining inside the storm drain system. The 100-year storm HGL is shown on the construction plans. The storm systems were based on a worst-case scenario hydrology for the interim and ultimate conditions, where appropriate.

***Energy Dissipators***

Energy dissipators will be used to reduce flow velocities of storm water at various locations, as noted. Riprap plunge pools at culvert outfalls are based FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). These are used to reduce the exit velocity.

In cases where the exit velocity is greater than the allowable 16 feet per second as per CDOT Criteria Manual (Reference 5), an internal energy dissipator is used to create tumbling flow within the circular culvert. Energy is dissipated by having a series of internal rings inside the culvert, reducing the diameter of the culvert and causing either full flow or tumbling flow. The abrupt change in flow regime, causes an increase in flow area and a reduction in velocity to discharge the same quantity of flow. This internal energy dissipator is based on FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7) and the American Concrete Pipe Association (APWA) "Concrete Pipe Handbook" (Reference 1).

Open channel drop structures are used to reduce elevation of a channel in a controlled area, keeping the main portion of the channel at a non-eroding slope. Two types of drop structures are found within this project. The first is a straight drop structure, where the elevation change occurs in a vertical drop. The flow impacts the floor of the drop structure at a pre-determined distance from the vertical drop. Floor blocks are placed downstream of the impact point to create a hydraulic jump in the flow. To complete the process, an end sill is placed at the end of this structure.

The second type of drop structure is a sloping drop, where a steep slope is used drop elevation, forcing supercritical flow. A stilling basin is created at the bottom of the drop to force a hydraulic jump before an end sill completes the structure. Both of these structures are based on FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7) and Denver Regional Council of Governments (DRCOG) "Urban Storm Drainage Criteria Manual, Volume 2" (Reference 6).

## RECOMMENDED DESIGN

The recommended improvements due to the construction of Powers Boulevard are shown on the construction drawing set of CDOT Project No. STU M240-081. A brief description of each improvement in the supplemental project area is listed below.

***Kettle Creek Basin***

A continuation of the roadside ditches along Ramp E and Ramp F will take flow towards the existing inlets in CDOT Project STU R200-107. This continuation includes the underdrains as noted. The flow from these ditches was accounted for in the design of each of these existing inlets. Please refer to URS "Final Drainage Report – Supplemental Powers Boulevard North Extension Sta. 721+00 to Sta. 749+00" (Reference 10).

***Elkhorn Basin***

*See Appendix C: Hydraulics - Ditch Capacity / Lining for Elkhorn Basin, Appendix D: Hydraulics - Culvert Design for Elkhorn Basin, Appendix E: Hydraulics - Multiple Drop Structure Design For Elkhorn Basin, and Appendix F: Hydraulics - Inlet / Storm System Design for Elkhorn Basin for calculations on the following systems.*

**Line SE**

At the upper portion of the Elkhorn Basin, near the intersection of the proposed State Highway 83 and the State Highway 83 Access Road, a series of inlets will be used to direct flow from the median towards the right ditch. The downstream inlet is set at 10 feet above the zero percent cross-slope (where the cross-slope transfers from a super-elevation to a normal crown) of Proposed State Highway 83, as per CDOT Drainage Criteria Manual (Reference 5).

**STR-231**

At the intersection of Ramp E and the proposed State Highway 83, a culvert will bring flow from the left ditch over to the right ditch. In the ultimate condition, with Ramp H being constructed, a berm at the top of the cut slope will direct flow down to this culvert. The beginning of this berm is shown at the upstream portion of the culvert. The culvert size is designed for the ultimate condition flow.

**Line SC and SD**

To bring the headwaters of the Elkhorn Basin under Ramp E, a significant elevation drop has to occur from the existing ground. In addition, there is no well-defined channel for the Elkhorn basin at this upstream location. A series of Type D inlets are designed in conjunction with articulated concrete blocks and a berm to form a sump area for the flow to be collected. The inlets were designed with a clogging factor and redundancy. The flow will be dropped through the inlets and out a culvert to a lower elevation to travel under Ramp E.

The outfall of the culvert, due to the slope and flow, has an exit velocity higher than the 16 feet per second allowable by CDOT Drainage Criteria Manual (Reference 5) without any internal reduction. An internal energy dissipator was designed to reduce the exit velocities to acceptable levels, as per FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). A riprap plunge pool continues this process.

The flow from line SC and SD will combine with the interceptor ditch along the top of Ramp E cut slope. The interceptor ditch is used to keep as much drainage area in the Elkhorn Basin as possible, while also reducing the possibility of erosion along the cut slope.

**STR-114**

A culvert will take storm water from the right side of Ramp E to the left side. A riprap plunge pool is designed to reduce velocities to non-erosive levels.

**Drop Structure Area**

To continue the Elkhorn Basin under future Powers Boulevard, a series of drop structures are needed. The upstream drop structures are vertical drops with floor blocks, as per FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). Boulders were used instead of the typical concrete foundation to maintain a more appealing natural look. Grouted riprap and 4:1(horizontal to vertical) side slopes complete the structure.

The downstream drop structure is a grouted sloping boulder drop on a 4:1 horizontal to vertical slope, as per FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). A plunge pool at the bottom of the structure causes a hydraulic jump to complete the structure.

**STR-410**

A concrete box culvert will take flow under both the future Powers Boulevard and Ramp F. In the interim condition, only about half of the ultimate box culvert will be installed. A continuation of the box culvert will take the Elkhorn Basin under Powers Boulevard in the ultimate condition. A trapezoidal channel will be installed in the same alignment and profile as the future box culvert during the interim condition.

The box culvert is sized for the ultimate condition. During the ultimate condition, other culverts will be connected to the future box culvert to take flow from future Powers Boulevard and future ramps.

**Line SB**

A type C inlet will take flow from the northwest side of the proposed State Highway 83. This inlet will also take the discharge from the existing corrugated metal pipe (CMP) under the existing State Highway 83. A type R inlet will take flow from the median of proposed State Highway 83 near the turn lane to Ramp F. Both of these will discharge into STR-410.

**Elkhorn Basin Channel**

STR-410 will discharge into the proposed trapezoidal channel. To drain, a minimal slope will be used for this channel, until the southern portion of the project where the flow will discharge into the historical channel.

**Line SA**

At the southern end of the project, a series of type R inlets will collect flow along the median and discharge into the existing ditch along Old State Highway 83. The downstream inlet is set 10 feet upstream of the zero percent cross-slope of proposed State Highway 83, as per CDOT Drainage Criteria Manual (Reference 5).

***Black Squirrel Creek Basin***

*See Appendix G: Hydraulics - Ditch Capacity/ Lining for Black Squirrel Creek Basin, Appendix H: Hydraulics - Culvert Design for Black Squirrel Creek Basin, Appendix I: Hydraulics – Channel Improvements for Black Squirrel Creek, and Appendix J: Hydraulics - Inlet / Storm System Design for Black Squirrel Creek Basin for calculations on the following systems.*

**Line SF and SG**

A series of type R inlets accepts flow from the median along proposed State Highway 83 north of the intersection with State Highway 83 Access Road. A type D inlet takes flow from the right ditch and, combining with the median flow discharges into the left ditch. This flow then flows down the left ditch of the State Highway 83 Access Road and then into the existing east ditch along the existing State Highway 83. The proposed discharge is within five percent of the historic flow at this point.

**STR-703 and STR-708**

A pair of culverts takes flow from the left ditch of State Highway 83 Access Road to the right ditch, back from the right ditch to the left ditch, and then along the existing ditch of the existing State Highway 83.

**Left Roadside Ditch Sta. 258+00**

The left ditch of proposed State Highway 83 from the highpoint at Sta. 251+00 to Sta. 258+00 discharges into the existing ditch of existing State Highway 83. The proposed flow is less than historic, due to a portion of the historic drainage area being intercepted by the right ditch of proposed State Highway 83.

**Line SI**

A flared end section takes ditch flow from the right side of Shoup Road to the left side. This flow, in combination with the left ditch, will discharge into Black Squirrel Creek upstream of the proposed bridge. The outfall of the culvert, due to the slope and flow, has an exit velocity higher than the 16 feet per second allowable by CDOT Drainage Criteria Manual (Reference 5) without any internal reduction. An internal energy dissipator was designed to reduce the exit velocities to acceptable levels, as per FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). The outfall will be in the proposed Black Squirrel Creek channel bottom.

**Sheetflow along right side Sta. 270+00**

Due to the fill condition of proposed State Highway 83 on the right side from Sta. 270+00 to the end of construction at Sta. 298+49, no roadside ditch will be used. The two existing culverts taking flow from the left side of proposed State Highway 83 to the right will be removed. The existing ditch along the right side, outside of the right-of-way will have sheet flow from proposed State Highway 83 that will be less than historic, due to the removal of the existing culverts.

**Line SH**

A roadside ditch will take flow along the left side of proposed State Highway 83 and discharge into Black Squirrel Creek through a Type D inlet and storm system. The outfall of the culvert, due to the slope and flow, has an exit velocity higher than the 16 feet per second allowable by CDOT Drainage Criteria Manual (Reference 5) without any internal reduction. An internal energy dissipator was designed to reduce the exit velocities to acceptable levels, as per FHWA "Hydraulic Design of Energy Dissipators for Culverts and Channels" (Reference 7). The outfall will be in the proposed Black Squirrel Creek channel bottom.

**Black Squirrel Creek Bridge and Drop Structures**

The existing 15-foot corrugated metal underpass culvert will be replaced with a single-span bridge, as per the recommendations of the Black Squirrel Creek DBPS (Reference 2). With a low chord of 6891.89 feet, there will be over 25 feet of freeboard over the 100-year water surface elevation. No scour is anticipated as there are no piers or abutments in the channel area, nor is there any contraction.

Buried riprap protection with vegetation will be used to guide the Black Squirrel Creek into and through the proposed bridge. Vegetated gabions will replace the existing concrete slope paving in the 2:1 horizontal to vertical area. A series of small drop structures (maximum of 3.5' in height) will be used to drop the channel bottom to existing grade. The drops will be used for habitat improvement and will be installed with as minimum excavation as possible. The furthest downstream drop will be used to prevent possible headcutting of the abutments of the bridge. A small 1-foot by 1-foot key low flow opening will continue the average daily flow through the drop structures.

## EROSION CONTROL

Best Management Practices (BMPs) will be utilized to minimize erosion during construction and are shown on the construction drawing set of CDOT Project No. STU M240-081 in accordance with CDOT Erosion Control and Stormwater Quality Guide (Reference 4). BMPs will be utilized as deemed necessary by the contractor and/or engineer and are not limited to the measures shown on the construction drawing set. The contractor shall minimize the amount of area disturbed during all construction activities. All materials shall conform to the CDOT Standard Specifications for Road and Bridge Construction.

In general the following shall be applied in developing the sequence of major activities:

1. Install downslope and sideslope perimeter BMPs before the land disturbing activity occurs.
2. Do not disturb an area until it is necessary for the construction activity to proceed.
3. Cover or stabilize as soon as possible.
4. Time the construction activities to reduce the impacts from seasonal climatic changes or weather events.
5. The construction of filtration BMPs should wait until the end of the construction project when upstream drainage areas have been stabilized.
6. Do not remove the temporary perimeter controls until after all upstream areas are stabilized.

### *Drainage Ditches*

The roadside ditches will have 6:1, 4:1 and 3:1 side slopes with a typical 4' bottom width. The ditches will be seeded with native grasses to match those that exist at the site now. Plastic soil retention blanket shall be installed in drainage ditches where noted. The minimum shear stress allowable is 3.00 pounds per square foot. Straw soil retention blankets shall be installed in the remainder of the drainage ditches where noted. Erosion bales or logs shall be installed in drainage ditches where noted. The maximum spacing between bales/logs should be such that the toe of the upstream bale/log is at the same elevation as the top of the downstream bale/log. Erosion bales/logs shall remain in place until all construction is complete and/or "finally stabilized". Bales/logs shall be inspected frequently and, if needed, repair/replacement made promptly. At this time, the bales/logs shall be removed from the ditches. All material shall be installed per manufacture's installation instructions.

### *Slopes*

Plastic soil retention blanket shall be installed where noted on slopes 3:1 or steeper facing south or west. Mulching with mulch tackifier shall be installed where noted on slopes 3:1 or steeper facing north or east. Silt fence shall be installed at the toe of fill slopes where noted on a level contour. Erosion logs shall be installed on slopes greater than ten feet in height where noted to reduce runoff length. The erosion logs shall be installed on a level contour. Disturbed surfaces shall be left in a roughened condition at all times with horizontal depressions approximately 2" to 4" deep, spaced 4" to 6" apart. Silt fence shall remain in place until all construction is complete and/or "finally stabilized". At this time, the silt fence shall be removed from the slopes. All material shall be installed per manufacture's installation instructions.

### *Stockpiles/Mobilizations/Winter Shutdown*

Soils stockpiled for more than 30 days shall be mulched with mulch tackifier and native seeding within 14 days of stockpile construction. After any mobilization and prior to any winter shutdown, all disturbed slopes not completed shall be mulched with mulch tackifier and native seeding shall be required.

### *Inlet and Outlet Protection*

Storm Drain Inlet Protection shall be provided at all storm inlets where noted. All material shall be installed per manufacture's installation instructions. Permanent riprap plunge pools shall be installed at outlets where noted to dissipate energy to a non-eroding velocities ($d_{50}$ noted). Erosion control geotextile shall be installed as bedding. All material shall be installed per manufacture's installation instructions. A concrete apron will be used at STR-410 to help establish a normal flow regime.

*Concrete Washout*

A concrete washout structure shall be installed for cleaning concrete trucks. The concrete washout structure shall be bermed such that water can only evaporate or infiltrate from the structure. The concrete washout structure shall be periodically cleaned out of residue and concrete.

*Erosion Control Supervisor and Maintenance*

The erosion control supervisor shall be a person other than the superintendent. The erosion control supervisor shall inspect at least every 14 days and after any precipitation or snowmelt event that causes surface erosion. At sites where construction has been completed but a vegetative cover has not established, these inspections must occur at least once per month.

All erosion control measures shall remain in place until all construction is complete and/or "finally stabilized". "Finally Stabilized" means that all disturbed areas have been either built on, paved, or a uniform vegetative cover has been established with a density of at least 70 percent of pre-disturbance levels, or equivalent permanent, physical erosion reduction methods have been employed. Any areas not meeting this equivalent shall be repaired according to the BMPs and re-seeded at no additional cost. Re-seeding alone shall not qualify. Accumulated sediment and debris shall be removed when the sediment level reaches one half the height of the BMP or at any time that sediment or debris adversely impacts the function of the BMP. The Contractor shall remove all sediment, mud, and construction debris that may accumulate in any public right of ways not designated before hand as a result of this construction project. All repairs, removals, and replacements stated above shall be conducted in a timely manner.

## ANTICIPATED CONSTRUCTION PERMITS

Construction permitting is required by many agencies, depending on the location, type, and magnitude of construction activity. Below is a summary of some of the anticipated construction permits required prior to construction. **This list is meant to be a helpful starting point and is no way all inclusive of the construction permits required.** A pre-construction meeting with local/city/county departments is key to a successful beginning. A point of contact for each permit is a good way to insure that the permit is acquired, compliance is kept, and periodic inspections are completed as required. Not included in this list is local or special permits needed (e.g. grading permit, construction dewatering, waste generation and disposal, fuel and oil storage, chemical handling, wildlife protection, cultural resources, etc.)

*Colorado's Stormwater General Permit for Construction Activities*

A stormwater permit is required for any construction activity that disturbs at least one acre of land (or is part of a larger common plan of development or sale that will disturb at least one acre). The development is considered a "small construction site" if it will disturb one to five acres, or a "large construction site" if it will disturb five acres or more. A "large construction site" is required to obtain coverage under the "Stormwater General Permit for Construction Activities" through CDHPE. A "small construction site" can obtain a permit by either applying for coverage under the "R-Factor Waiver", a state-designated qualifying local program, or the "Stormwater General Permit for Construction Activities". A "Stormwater Management Plan" (SWMP) is required for any permit, but does not qualify for the application solely. Inspection and maintenance are major keys in the implementation of this permit.

It is anticipated that the construction of this site will require this permit.

*Floodplain Development Permit*

All construction in federally designated floodplain areas must obtain a "Floodplain Development Permit" from the local Floodplain Administrator. Construction includes, but is not limited to: any structures, fill, excavation, utilities or bank stabilization.

It is anticipated that the construction of the bridge and proposed channel improvements in the Black Squirrel Creek floodplain will require this permit. El Paso County Floodplain Administrator is Kevin Stilson and can be reached at (719) 327-2906.

*404 Permit*

Permits for Section 404 of the Clean Water Act are needed for the discharge of dredged or fill material into waters of the United States from the U.S. Army Corps of Engineers (USACE). Waters of the U.S. can include rivers, streams, tributaries, and wetlands.

It is anticipated that the construction within Black Squirrel Creek will require this permit. The U.S. Army Corps of Engineer office for this project will be the Albuquerque Distrist's Southern Colorado Rgulatory Office in Pueblo at (719) 543-9459.

*Others*

**Colorado Demolition Permit**

Any demolition or dismantling activity during construction requires a "Demolition Permit Application Form" from the Colorado Department of Public Health and Environment (CDPHE), due to the possibility of asbestos.

It is anticipated that this permit will not be required.

**Air Pollution Emission Notice – Land Development**

An "Air Pollution Emission Notice" (APEN) for land development is required from the CDPHE when the project is over 25 acres or takes more that six months to reach completion. The permit application for land development activities must include a "Fugutive Dust Control Plan". The dust control plan addresses how dust will be kept to a minimum at the site.

It is anticipated that given the length of construction of this project, this permit may be required.

**Air Pollution Emission Notice – Hot Mix Asphalt and Concrete Batching**

An "Air Pollution Emission Notice" (APEN) for either hot mix asphalt or concrete batching is required from the CDPHE for new plants, including portable sources.

It is anticipated that the construction of the bridge could use or employ a portable batch plant and may require this permit.

## REFERENCES

1. American Concrete Pipe Association. 1998. Concrete Pipe Handbook.

2. "Black Squirrel Creek Drainage Basin Planning Study", January, 1989. Prepared by URS.

3. "City of Colorado Springs/El Paso County Drainage Criteria Manual" Sept. 1987, Revised November 1991, Revised October 1994.

4. CDOT. 1995 (June) Erosion Control and Stormwater Quality Guide.

5. CDOT. 1995 (July). Drainage Criteria Manual.

6. Denver Regional Council of Governments. 1969 (March). Urban Storm Drainage Criteria Manual, Volume 2.

7. Federal Highway Administration (FHWA). September 1983. *Hydraulic Design of Energy Dissipators for Culverts and Channels.* Hydraulic Engineering Circular No. 14.

8. Federal Highway Administration (FHWA). April 1988. *Design of Roadside Channel with Flexible Lining.* Hydraulic Engineering Circular No. 15.

9. Final Drainage Report Powers Boulevard North Extension Sta. 603+85.80 to Sta. 760+67.08 (Briargate Parkway to State Highway 83). January 30, 2002. Prepared by URS.

10. Final Drainage Report – Supplemental Powers Boulevard North Extension Sta. 721+00 to Sta. 749+00 (Briargate Parkway to State Highway 83). August 29, 2002. Prepared by URS.

11. Flood Insurance Rate Study for El Paso County, Colorado and Incorporated Areas. Federal Emergency Management Agency, revised March 17, 1997.

12. Soils Survey of El Paso County Area, Natural Resources Conservation Services of Colorado.

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# FIGURES

**Figure 1: Vicinity Map**

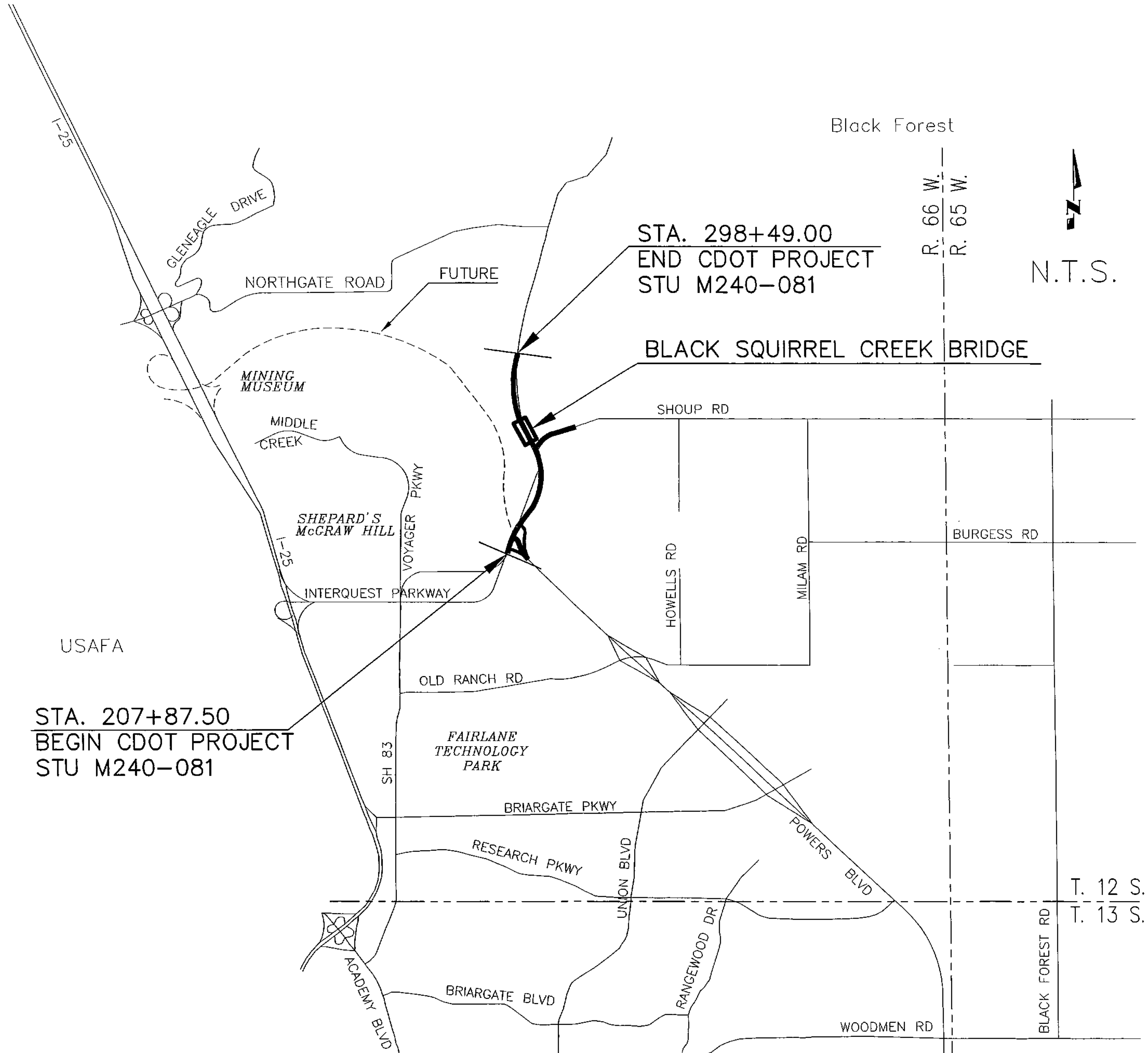


FIGURE 1

VICINITY MAP

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42618\CAD\DESIGN\HYDRO\DRAINAGE REPORT\XHBT-VICINITY.DWG

**Figure 2: Soil Classification Map**

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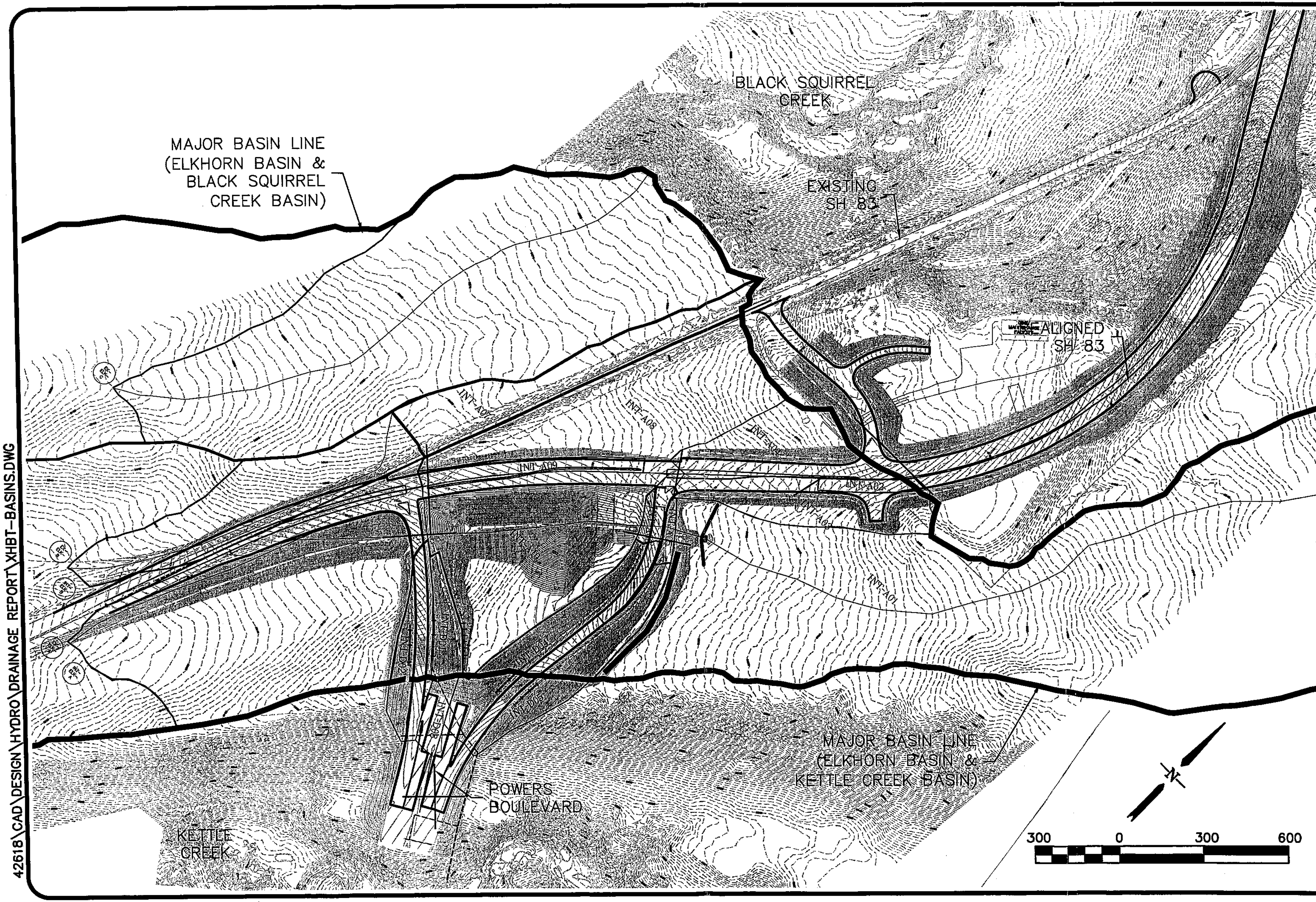
SOIL CLASSIFICATION MAP

FIGURE 2

**Figure 3: Elkhorn Basin Intermediate Drainage Basin Map**

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# ELKHORN BASIN INTERIM CONDITION BASIN MAP

FIGURE 3


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**Figure 4: Elkhorn Basin Ultimate Drainage Basin Map**

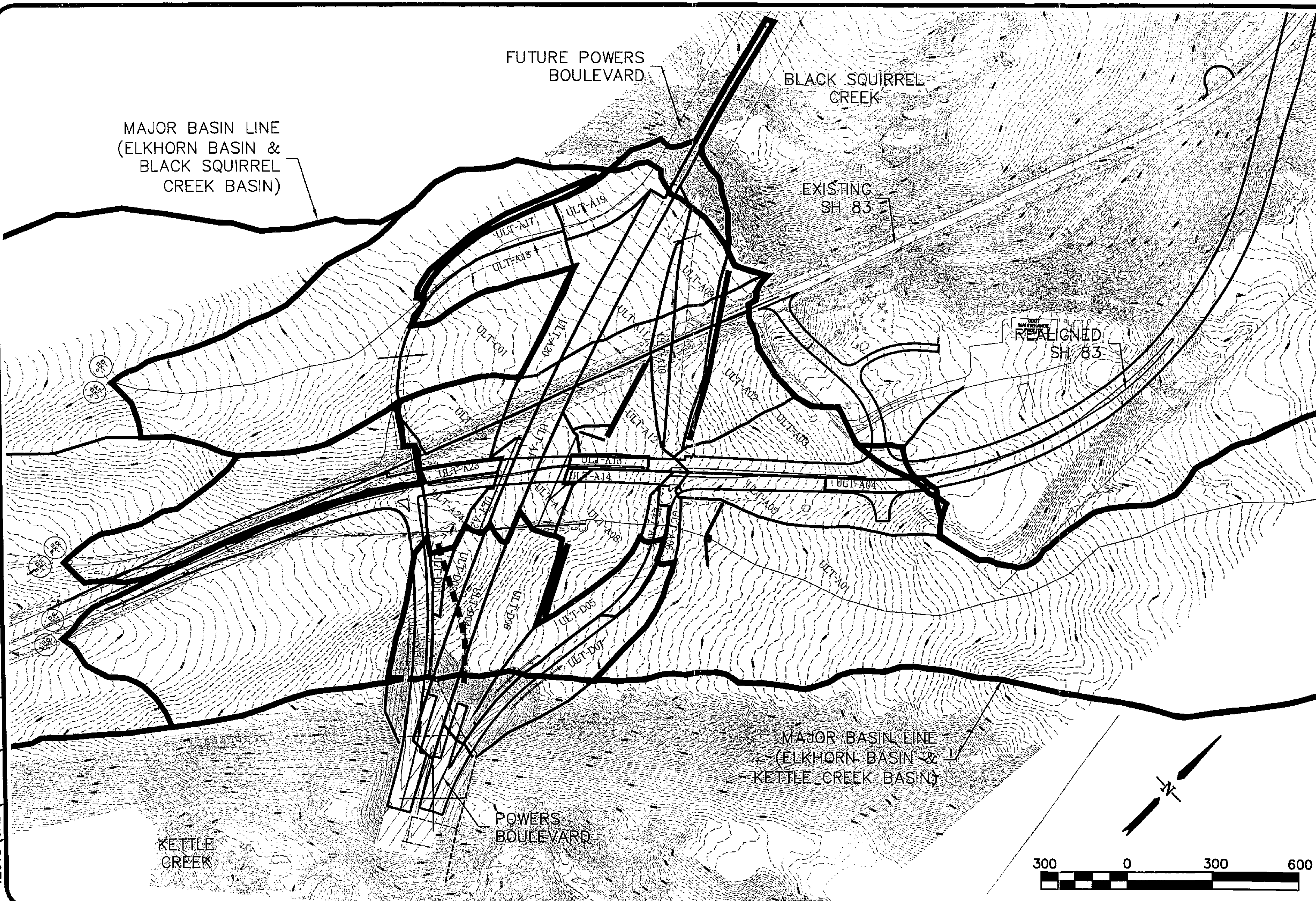


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FIGURE 4

# ELKHORN BASIN ULTIMATE CONDITION BASIN MAP

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**Figure 5: Black Squirrel Creek Basin Map**

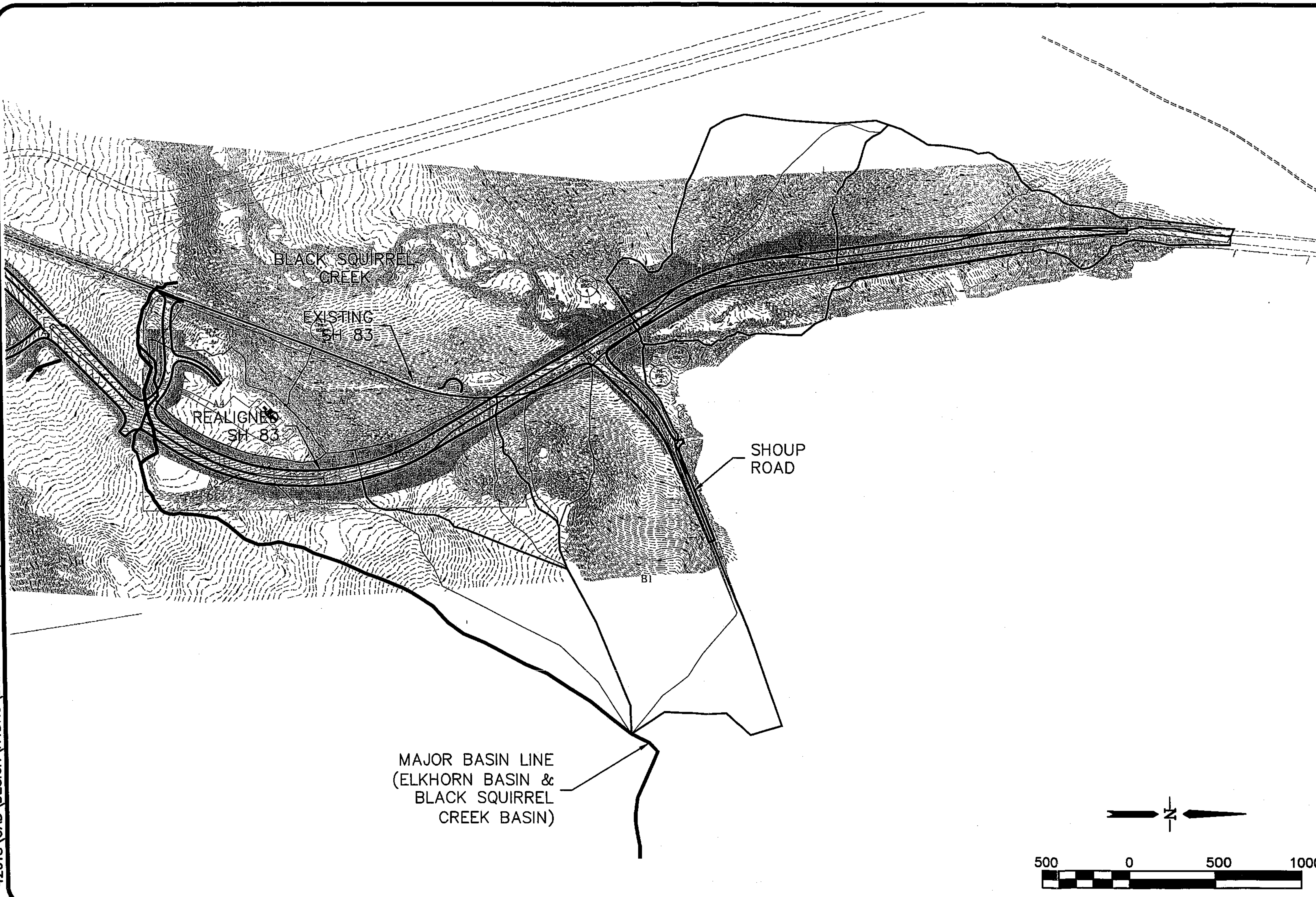


FIGURE 5

# BLACK SQUIRREL CREEK BASIN MAP


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**Figure 6: Flood Insurance Rate Map**

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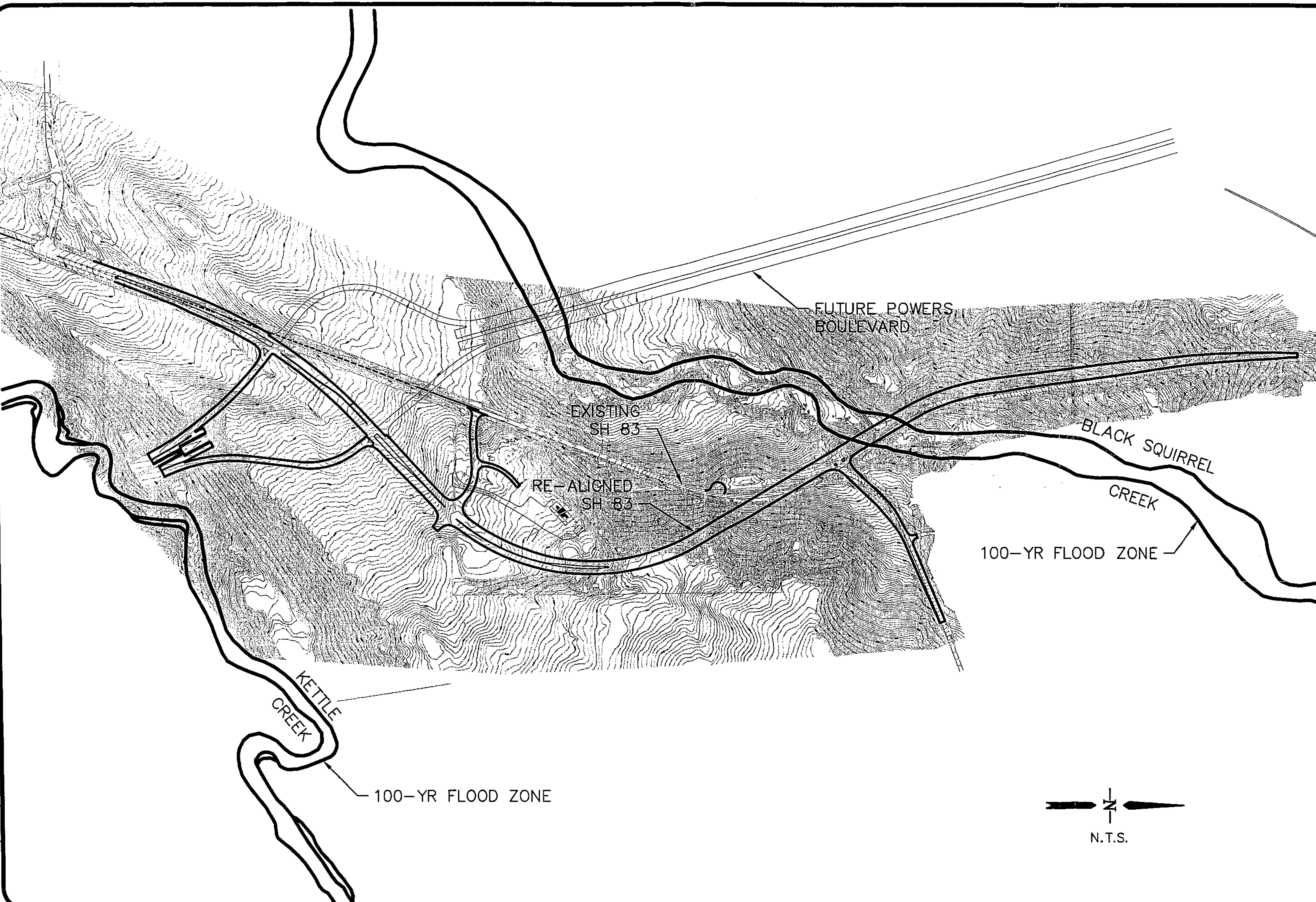


FIGURE 6

# FLOOD INSURANCE RATE MAP


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# APPENDIX

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## Appendix A: Hydrology - Rational Basin Calculations for Elkhorn Basin

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT - REGION 2 Project Name: POWERS B. & SH 83 INT.

Project/Calculation Number: 6700042 500.02

Title: RATIONAL CALCS FOR REDESIGN OF INTERCHANGE

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: ~~6-7-02~~ 7-7-02 EDE

Checked by: W. Alspach Date: 8 JUL 02

Description and Purpose:

- CALC RATIONAL BASINS FOR DRAINAGE IMPROVEMENTS TO INT.
- DECIDE WHICH COND. TO DESIGN TO — INTERMEDIATE OF ULTIMATE CONDITION.

Design bases/references/assumptions:

- CDOT DRAINAGE MANUAL
- SEE INCLUDED INTRODUCTION.

Remarks/conclusions:

Checked, all OK.

Calculation Approved by: ______

Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

**URS**

Page ____ of ____

Job: POWERS BOULEVARD | Project No. 67000425 00.02 | Sheet ____ of ____

Description: + STATE HIGHWAY 83 | Computed by: EPE | Date: 7-7-02

Checked by ______ | Date ______

Reference

## INTRODUCTION

"CDOT - DRAINAGE MANUAL"

- SECTION 7.4.4 STATES THE RATIONAL METHOD TO BE USED ✓ FOR BASINS LESS THAN 160 ACRES AND ESPECIALLY IN URBAN AREAS.
- SECTION 7.3.3 STATES THE 100-YEAR STORM TO BE USED ✓ FOR CROSS-DRAINAGE & STORM-DRAINS. 10-YEAR STORM FOR OUTLET PROTECTION.
- SECTION 8.2 STATES PERMANENT ROADSIDE DITCH LININGS ✓ TO BE BASED ON 10-YEAR STORM. ALSO STATES A MINIMUM OF 1' FREEBOARD FOR OPEN CHANNELS.
- SECTION 7.4.4 HAS A C VALUE FOR RATIONAL FOR PAVEMENT OF 0.90 (10) + 0.93 (100-YEAR) ALSO HAS C VALUE OF 0.05 (10-YEAR) + 0.20 (100-YEAR) FOR SANDY LAWNS, 0.20 + 0.40 (10+100) FOR CLAYEY SOIL LAWNS.
- COLO. SPGS. DRAINAGE CRITERIA MANUAL (SECT. 5.2.3) SHOWS PAVEMENT 0.90 (10) + 0.95 (100) AND 0.25 (10) + 0.35 (100) FOR LAWNS
- PREVIOUS WORK ON PROJECT USED CSDCM VALUES ∴ WE WILL CONTINUE TO USE THE NUMBERS FROM CS (NOTE: PROBABLY CONSERVATIVE).
- ATTACHED SPREADSHEET USES A WEIGHTED AVERAGE FOR C VALUES.
- ATTACHED SPREADSHEET USES THE INITIAL TIME OF CONCENTRATION FORMULA FOUND IN CDOT SECTION 7.4.3. BASED ON $C_{10}$ AVG.
- ATTACHED SPREADSHEET USES THE CHANNEL TIME IN CDOT SECTION 7.4.3 BASED ON AVG. VELOC OF 5 FPS (CONS.)
- ALSO USES CSDCM INTENSITY CURVE IN SECTION 5.2.3 FOR 5-YEAR, 10-YEAR + 100-YEAR

NOTE: OTHER STORMS WILL BE CALCULATED (EXPANDED) LATER. PURPOSE OF THIS IS TO SIZE MAJOR STRUCTURES FIRST. THEN COME BACK FOR OUT-LET AND LINING CALCS.

- NARRATIVE ON FOLLOWING SHEETS CORRESPOND TO LARGE BASIN MAPS.

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Job POWERS BOULEVARD | Project No. 67000042500.02 | Sheet 1 of ____
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Reference

- REVIEWING ORIGINAL CALCS SHOWS ERROR IN BASIN AREA.
- NEED TO REDO CALCS FOR BOX CULVERT.

FOR INTERIM CONDITION: (RAMP E + F, STATE HWY 83)

- INFLOW FOR BOX/PIPE UNDER RAMP E – BASIN INT-AØ1 – $Q_{100}$ = 111 cfs
- INLET/PIPE ON SH 83 @ 235+00 – BASIN INT-AØ2 – $Q_{100}$ = 3 cfs
- DITCH ALONG SH83 (NB) @ 240+00 TO 230+00 ⇒ BASIN INT-AØ2 & INT-AØ3 (CALLED INT-AC1) – $Q_{100}$ = ~~10.3~~ 11 cfs ✓
- DITCH ALONG SH83 (SB) @ 240+00 TO 230+00 – BASIN INT-AØ4 – $Q_{100}$ = 9 cfs
- PIPE UNDER SH 83 @ 230+00 – BASIN INT-AØ4 – $Q_{100}$ = 9 cfs
- ~~DITCH~~ +INLET @ RAMP E (NORTHSIDE) @ 114+00 – BASIN INT-AØ2, INT-AØ3, INT-AØ4 & INT-AØ5 (CALLED INT-AC2) – $Q_{100}$ = 20 cfs ✓
- DITCH + INLET @ RAMP E (~~NORTH~~ SOUTH SIDE) @ 114+00 – ~~1 cfs~~ BASIN INT-AØ6 – 1 cfs
- TOTAL FLOW IN BOX UNDER RAMP E – BASIN INT-AØ1 THRU INT-AØ6 (CALLED INT-AC3) – ~~140~~ cfs ~~128~~ 128 ✓

* FLOW ALONG TOP OF SLOPE ON RAMP E (RIGHTSIDE) – (CALLED INT-AØ1-A) – $Q_{100}$ = 11 cfs
(OVERESTIMATED HOPEFULLY, DUE TO LACK OF KNOWLEDGE ON BERM)

- FLOW TO CROSS OVER OLD SH 83 @ 222+00 LT. – BASIN INT-AØ8 – $Q_{100}$ = 14 cfs ✓
- FLOW TO INLET @ OLD SH83 @ 222+00 LT. – BASIN INT-AØ7 & INT-AØ8 – (CALLED INT-AC4) – 22 cfs
- FLOW AT MEDIAN INLET @ SH83 @ 222+00 – BASIN INT-AØ9 – $Q_{100}$ = 8 cfs
- ~~TOTAL~~ FLOW ENTERING BOX UNDER RAMP F – INT-AØ1 THRU INT-AØ6 & INT-A1... (CALLED INT-AC5) – $Q_{100}$ = ~~125~~ 155 cfs 136 ✓
- TOTAL FLOW IN BOX – INT AØ1 THRU – INT-A1Ø – (CALLED INT-AC...
$Q_{100}$ = ~~141~~ cfs ~~153~~ 156 ✓

× FLOW ALONG TOP OF SLOPE ON RAMP E (RIGHT SIDE) – (CALLED INT-A1ØA)
$Q_{100}$ = 7 cfs ✓

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Reference

CHECKING FLOWS LEAVING THE PROJECT DOWNSTREAM

EX-ELK-A $Q_{100}$ = 156 cfs ✓
EX-ELK-B $Q_{100}$ = 12 cfs ✓
EX-ELK-C $Q_{100}$ = 40 cfs ✓

INT-ELK-A $Q_{100}$ = 157 cfs ✓ (LESS THAN 5% INCR.)
INT ELK-B $Q_{100}$ = 15 cfs ✓ (3 cfs INCREASE)

THERE IS NO CHANGES TO EX-ELK-C DURING THE INTERMEDIATE SITUATION.

FLOWS LEAVING ELKHORN INTO KETTLE

- DITCH FLOW ALONG (AND PIPE ACROSS) RAMP F RT. - BASIN INT-DØ1 - $Q_{100}$ = 2 cfs ✓
- DITCH FLOW ALONG RAMP F LT. - BASIN INT-DØ1 + INT-DØ2 = ~~Q100~~ (CALLED INT-DC1) = ~~7cfs~~ 11 cfs ✓
- MEDIAN FLOW ALONG POWERS @ 750+00 TO 747+00 - BASIN INT-DØ3 - $Q_{100}$ = 4 cfs ✓
- DITCH FLOW ALONG RAMP E LT. + PIPE ACROSS - BASIN INT-DØ4 - $Q_{100}$ = 8 cfs ✓
- DITCH FLOW ALONG RAMP E. RT - BASIN INT-DØ5 - $Q_{100}$ = 10 cfs ✓
- TOTAL FLOW LEAVING POWERS @ KETTLE BRIDGE ON RT. - BASIN INT-DØ3 THRU INT-DØ5 (CALLED INT-DC2) $Q_{100}$ = 22 cfs ✓

FOR SECOND INTERIM CONDITION W/ RAMP G + H IN ADD. TO ABOVE

DUE TO THE LOW POINTS AT THE NORTH END OF RAMPS G+H SOME CONVEYANCE ALONG POWERS ULTIMATE TO THE BOX CULVERT SOUTH OF STATE HIGHWAY 83 WILL OCCUR AND ALSO SOME CONVEYANCE UNDER THE FUTURE BRIDGE @ STATE HIGHWAY 83 AND POWERS ULTIMATE, THEREFORE, THIS INTERIM CONDITION (AS FAR AS THIS PROJECT IS CONCERNED) CAN BE TREATED AS THE ULTIMATE. ✓

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Reference

ULTIMATE CONDITION: (POWERS MAINLINE BUILT IN ADDITION TO ALL RAMPS ABOVE)

- FLOW ENTERING BOX/PIPE @ RAMP E – (SAME AS INT-A01) – ULT-A01 – $Q_{100}$ = 111 cfs ✓
- FLOW ALONG TOP OF SLOPE ON RAMP E (RIGHTSIDE) – (SAME AS INT-A01-A, CALLED ULT-A01-A) – $Q_{100}$ = 11 cfs ✓
- FLOW ALONG TOP OF SLOPE ON RAMP N (RT.) – BASIN ULT-A02 – $Q_{100}$ = 4 cfs ✓
- DITCH FLOW ALONG SH83 (LT) 240+00 TO 230+00 – BASIN ULT-A03 – (SAME AS INT-A04) – $Q_{100}$ = 9 cfs ✓
- INLET/PIPE ON SH83 @ 235+00 – BASIN ULT-A04 (SAME AS INT-A02) – $Q_{100}$ = 3 cfs ✓

FLOW IN PIPE ON SH83 @ 230+00 – BASIN ULT-A02 + ULT-A03 (CALLED ULT-AC01) – $Q_{100}$ = 11 cfs ✓

- FLOW IN DITCH ON SH83 (RT) 240+00 TO 230+00 – BASIN ULT-A04 + ULT-A05 (CALLED ULT-AC02) – $Q_{100}$ = 11 cfs (same as INT-AC1)
- INLET @ RAMP E (RT) @ 114+00 – BASIN ULT-A02 – ULT-A06 (CALLED ULT-AC03) – $Q_{100}$ = 21 cfs ✓
- INLET/DITCH @ RAMP E (LT) @ 114+00 – BASIN ULT-A07 (SAME AS INT-A06) – $Q_{100}$ = 1 cfs ✓
- TOTAL FLOW IN BOX UNDER RAMP E – BASIN ULT-A01 TO ULT-A07 (CALLED ULT-AC04) – $Q_{100}$ = 129 cfs ✓
- FLOW ENTERING BOX UNDER POWERS – BASIN ULT-A01 TO ULT-A08 (CALLED ULT-AC05) – $Q_{100}$ = 132 cfs ✓
- FLOW IN DITCH ALONG RAMP H (RT) AND PIPE – ULT-A09 – $Q_{100}$ = 13 cfs ✓
- FLOW IN DITCH ALONG RAMP H (LT) – ULT-A10 – $Q_{100}$ = 2 cfs ✓
- FLOW IN DITCH ALONG POWERS (RT) – 760+00 TO 767+00 – BASIN ULT-A09 THRU ULT-A11 (CALLED ULT-AC06) – $Q_{100}$ = 23 cfs ✓
- FLOW IN SLOPE PAVING ON POWERS (RT) @ 760+00 – BASIN ULT-A12 – $Q_{100}$ = 4 cfs ✓
- FLOW ENTERING PIPE @ POWERS (RT) @ 760+00 – BASIN ULT-A09 THRU ULT-A12 (CALLED ULT-AC07) – $Q_{100}$ = 27 cfs ✓
- FLOW IN INLET @ MEDIAN SH83 227+00 – BASIN ULT-A13 – $Q_{100}$ = 3 cf
- FLOW @ BRIDGE SH83 (RT) 227+00 – BASIN ULT-A14 – $Q_{100}$ = 1 cfs ✓

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Reference

- FLOW ~~IN~~ DITCH @ POWERS (RT.) 756+00 – BASIN ULT-A15 – $Q_{100}$ = 5 cfs
- COMBINED TOTAL FLOW IN PIPE @ POWERS (RT.) 756+00 – BASIN ULT-A09 THRU ULT-A15 – ~~...~~ (CALLED ULT-AC08) – $Q_{100}$ = 32 cfs
- COMBINED TOTAL FLOW IN BOX @ POWERS (RT.) 756+00 (BASIN ULT-A01 THRU ULT-A15 (CALLED ULT-AC09) – $Q_{100}$ = 151 cfs
- MEDIAN DITCH FLOW IN POWERS @ 755+00 (BASIN ULT-A16) $Q_{100}$ = 22 cfs

- DITCH FLOW ALONG RAMP G (LT) 507+00 TO 512+00 – BASIN ULT-A17 $Q_{100}$ = 2 cfs
- DITCH FLOW ALONG RAMP G (RT) 507+00 TO 512+00 – BASIN ULT-A18 $Q_{100}$ = 7 cfs
- DITCH FLOW ALONG RAMP G (LT) 512+00 TO 518+00 – BASIN ULT-A19 $Q_{100}$ = 8 cfs
- PIPE FLOW UNDER RAMP G @ 512+00 – BASIN ULT-A17 + ULT-A19 (CALLED ULT-AC10) $Q_{100}$ = 10 cfs
- DITCH FLOW ON POWERS (LT.) 760+00 TO 768+00 – BASIN ULT-A17 THRU ULT-A20 (CALLED ULT-AC11) $Q_{100}$ = 17 cfs
- FLOW IN DITCH @ POWERS (LT) 755+00 – BASIN ULT-A21 – $Q_{100}$ = 1 cfs
- TOTAL FLOW IN PIPE @ POWERS (LT) 755+00 – BASIN ULT-A17 THRU ULT-A21 (CALLED ULT-AC12) $Q_{100}$ = 17 cfs
- TOTAL FLOW IN BOX @ POWERS (LT) 755+00 – BASIN ULT-A01 THRU ULT-A21 (CALLED ULT-AC13) $Q_{100}$ = ~~174~~ 171 cfs
- FLOW @ RAMP G (RT) 502+00 – BASIN ULT-A22 – $Q_{100}$ = 6 cfs
- MEDIAN FLOW @ SH 83 222+00 – BASIN ULT-A23 – $Q_{100}$ = 3 cfs
- FLOW @ RAMP F @ 411+00 (RT) – BASIN ULT-A24 – $Q_{100}$ =
- TOTAL FLOW IN PIPE @ RAMP F (RT) 411+00 – BASIN ULT-A22 THRU ULT-A24 (CALLED ULT-AC14) $Q_{100}$ = 10 cfs
- TOTAL FLOW IN BOX @ RAMP F LEAVING PIPE – BASIN ULT-A01 THRU ULT-A24 (CALLED ULT-AC15) – $Q_{100}$ = 175

EX-ELK-A (PRIOR) $Q_{100}$ = 156 cfs ✓
ULT-ELK-A $Q_{100}$ = 179 cfs ✓

15% INC.
(23 cfs up.)

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Reference

EX-ELK-B $Q_{100}$ = 12 cfs ✓
ULT-ELK-B $Q_{100}$ = 16 cfs ✓ (4 cfs increase).

- FLOW UNDER RAMP G @ 505+00 - BASIN ULT-C01
- $Q_{100}$ = 0 cfs

EX-ELK-C $Q_{100}$ = 40 cfs ✓
ULT-ELK-C $Q_{100}$ = 27 cfs ✓

FLOW LEAVING ELKHORN INTO KETTLE

- DITCH FLOW ALONG RAMP F (LT) - BASIN ULT-D01 - $Q_{100}$ = 1 cfs
- DITCH FLOW + PIPE ALONG POWERS (LT) 750+00 TO 750+00 - BASIN ULT-D01 + ULT-D02 - ~~$Q_{100}$~~ (CALLED ULT-DC1) - $Q_{100}$ = 2 cfs
- DITCH FLOW ALONG RAMP F (LT) - BASIN ULT-D01 THRU ULT-D03 (CALLED ULT-DC2) - $Q_{100}$ = 10 cfs
- DITCH MEDIAN FLOW + PIPE ALONG POWERS - 747+00 TO 755+00 - BASIN ULT-D04 - $Q_{100}$ = 14 cfs
- DITCH FLOW ALONG RAMP E (LT) - BASIN ULT D05 - $Q_{100}$ = 6 cfs
- DITCH FLOW ALONG POWERS (RT) 747+00 TO 755+00 - BASIN ULT-D05 + ULT-D06 (CALLED ULT-DC3) $Q_{100}$ = 15 cfs
- DITCH FLOW ALONG RAMP E (RT) - BASIN ULT-D07 - $Q_{100}$ = (SAME AS ULT-D05) - $Q_{100}$ = 10 cfs
- TOTAL FLOW LEAVING POWERS (RT) - BASIN ULT-D05 THRU ULT-D07 (CALLED ULT-DC4) - $Q_{100}$ = 22 cfs ✓

CONCLUSION:

THE ULTIMATE CONDITION IS LARGER THAN INTERIM ~~EXISTING~~ CONDITIONS IN MOST CASES EXCEPT FOR FLOW AROUND RAMP F AND SH 83. THERE PIPES WILL NEED TO BE SIZED FOR INTERIM CONDITION. ?

≤ 300'

Powers Boulevard and State Highway 83 Interchange
Final Drainage Calculation for Interim Condition
Average Channel Velocity 5 ft/s
Average Slope 0.02 ft/ft (If Elevations are used, this will be ignored)
Note: Q2, Q5 & Q10 are based on C10, Q25, Q50 & Q100 are based on C100 ✓

| Basin | Total Area sf | Total Area acres | Surface Type 1 C10 | Surface Type 1 C100 | Surface Type 1 Area | Surface Type 2 C10 | Surface Type 2 C100 | Surface Type 2 Area | Surface Type 3 C10 | Surface Type 3 C100 | Surface Type 3 Area | Average C10 | Average C100 | Initial Length ft | True Initial Length ft | Channel flow Length ft | True Channel Length ft | High Point Elevation | Low Point Elevation | Average Slope | Total Tc | I100 in/hr | Q100 cfs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INT-A01 | 3452244 | 79.25 | 0.25 | 0.35 | 3452244 | | | | | | | 0.25 | 0.35 | 4641.00 | 300.00 | | 4341.00 | 7050.00 | 6880.00 | 0.037 ✓ | 32.33 | 4.01 | 111.23 ✓ |
| INT-A02 | 15986 | 0.37 | 0.90 | 0.95 | 15986 | | | | | | | 0.90 | 0.95 | 60.00 | 60.00 | 320.00 | 320.00 | 6901.00 | 6890.00 | 0.029 ✓ | 5.00 | 9.00 | 3.14 |
| INT-A03 | 121474 | 2.79 | 0.90 | 0.95 | 28557 | 0.26 | 0.35 | 92917 | | | | 0.40 | 0.49 | 260.00 | 260.00 | 660.00 | 660.00 | 6915.00 | 6877.00 | 0.041 | 15.30 | 5.90 | 8.08 |
| INT-A04 | 125111 | 2.87 | 0.90 | 0.95 | 36434 | 0.25 | 0.35 | 88677 | | | | 0.44 | 0.52 | 150.00 | 150.00 | 640.00 | 640.00 | 6895.00 | 6880.00 | 0.019 | 14.35 | 6.13 | 9.24 |
| INT-A05 | 17645 | 0.41 | 0.90 | 0.95 | 5444 | 0.25 | 0.35 | 12201 | | | | 0.45 | 0.54 | 100.00 | 100.00 | 100.00 | 100.00 | 6880.00 | 6873.00 | 0.035 | 8.33 | 7.83 | 1.70 |
| INT-A06 | 10973 | 0.25 | 0.90 | 0.95 | 4536 | 0.25 | 0.35 | 6437 | | | | 0.52 | 0.60 | 150.00 | 150.00 | | 0.00 | 6876.00 | 6870.00 | 0.040 | 8.39 | 7.83 | 1.18 |
| INT-A07 | 160843 | 3.69 | 0.90 | 0.95 | 22261 | 0.25 | 0.35 | 138582 | | | | 0.34 | 0.43 | 50.00 | 50.00 | 1200.00 | 1200.00 | 6875.00 | 6861.00 | 0.011 | 13.68 | 6.36 | 10.17 |
| INT-A08 | 309540 | 7.11 | 0.90 | 0.95 | 22425 | 0.25 | 0.35 | 287115 | | | | 0.30 | 0.39 | 800.00 | 300.00 | 530.00 | 1030.00 | 6898.00 | 6861.00 | 0.028 | 21.92 | 5.04 | 14.09 |
| INT-A09 | 40682 | 0.93 | 0.90 | 0.95 | 40682 | | | | | | | 0.90 | 0.95 | 50.00 | 50.00 | 800.00 | 800.00 | 6879.00 | 6864.00 | 0.018 | 5.00 | 9.00 | 7.99 — |
| INT-A10 | 362161 | 8.31 | 0.90 | 0.95 | 51004 | 0.25 | 0.35 | 311157 | | | | 0.34 | 0.43 | 250.00 | 250.00 | 530.00 | 530.00 | 6878.00 | 6854.00 | 0.031 | 17.19 | 5.60 | 20.23 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| INT-AC1 | 137460 | 3.16 | 0.90 | 0.95 | 15986 | 0.40 | 0.49 | 121474 | | | | 0.46 | 0.54 | 260.00 | 260.00 | 660.00 | 660.00 | 6915.00 | 6877.00 | 0.041 | 14.22 | 6.13 | 10.53 — |
| INT-AC2 | 280216 | 6.43 | 0.46 | 0.54 | 137460 | 0.44 | 0.52 | 125111 | 0.45 | 0.54 | 17645 | 0.45 | 0.54 ✓ | 260.00 | 260.00 | 800.00 | 800.00 | 6915.00 | 6873.00 | 0.040 | 15.04 | 5.90 | 20.31 — |
| INT-AC3 | 3743433 | 85.94 | 0.25 | 0.35 | 3452244 | 0.45 | 0.54 | 280216 | 0.52 | 0.60 | 10973 | 0.27 | 0.36 | 4641.00 | 300.00 | 250.00 | 4591.00 | 7050.00 | 6830.00 | 0.045 | 31.67 | 4.08 | 127.83 — |
| INT-A01A | 272679 | 6.26 | 0.25 | 0.35 | 272679 | | | | | | | 0.25 | 0.35 | 950.00 | 300.00 | | 650.00 | 6910.00 | 6880.00 | 0.032 | 20.93 | 5.15 | 11.28 — |
| INT-AC4 | 470383 | 10.80 | 0.34 | 0.43 | 160843 | 0.30 | 0.39 | 309540 | | | | 0.31 | 0.41 | 800.00 | 300.00 | 530.00 | 1030.00 | 6898.00 | 6861.00 | 0.028 | 21.59 | 5.04 | 22.15 — |
| INT-AC5 | 4105594 | 94.25 | 0.27 | 0.36 | 3743433 | 0.34 | 0.43 | 362161 | | | | 0.27 | 0.37 | 4641.00 | 300.00 | 1050.00 | 5391.00 | 7050.00 | 6820.00 | 0.040 | 34.80 | 3.87 | 135.23 — |
| INT-AC6 | 4616659 | 105.98 | 0.90 | 0.95 | 40682 | 0.31 | 0.41 | 470383 | 0.27 | 0.37 | 4105594 | 0.28 | 0.38 | 4641.00 | 300.00 | 1050.00 | 5391.00 | 7050.00 | 6820.00 | 0.040 | 34.60 | 3.87 | 155.67 — |
| INT-A10A | 159597 | 3.66 | 0.25 | 0.35 | 159597 | | | | | | | 0.25 | 0.35 | 600.00 | 300.00 | | 300.00 | 6878.00 | 6854.00 | 0.040 | 18.34 | 5.45 | 6.99 — |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| EX-ELK-A | 5490195 | 126.04 | 0.90 | 0.95 | 78908 | 0.25 | 0.35 | 5411287 | | | | 0.26 | 0.36 | 6955.00 | 300.00 | | 6655.00 | 7050.00 | 6827.00 | 0.032 | 40.65 | 3.45 | 155.94 |
| EX-ELK-B | 235367 | 5.40 | 0.90 | 0.95 | 37763 | 0.25 | 0.35 | 197604 | | | | 0.35 | 0.45 | 1365.00 | 300.00 | | 1065.00 | 6867.00 | 6830.00 | 0.027 | 20.87 | 5.15 | 12.42 |
| EX-ELK-C | 1128497 | 25.91 | 0.25 | 0.35 | 1128497 | | | | | | | 0.25 | 0.35 | 2125.00 | 300.00 | | 1825.00 | 6887.00 | 6840.00 | 0.022 | 27.21 | 4.42 | 40.08 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| INT-ELK-A | 5246568 | 120.44 | 0.28 | 0.38 | 4616659 | 0.26 | 0.38 | 629909 | | | | 0.28 | 0.38 | 6955.00 | 300.00 | | 6655.00 | 7050.00 | 6827.00 | 0.032 | 40.21 | 3.45 | 156.67 |
| INT-ELK-B | 257306 | 5.91 | 0.90 | 0.95 | 59358 | 0.25 | 0.35 | 197948 | | | | 0.40 | 0.49 | 1365.00 | 300.00 | | 1065.00 | 6867.00 | 6830.00 | 0.027 | 19.81 | 5.30 | 15.29 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| INT-D01 | 35682 | 0.82 | 0.25 | 0.35 | 35682 | | | | | | | 0.25 | 0.35 | 50.00 | 50.00 | 375.00 | 375.00 | 6855.00 | 6837.00 | 0.042 | 8.20 | 7.83 | 2.24 — |
| INT-D02 | 72131 | 1.66 | 0.90 | 0.95 | 35966 | 0.25 | 0.35 | 36165 | | | | 0.57 | 0.65 | 50.00 | 50.00 | 630.00 | 630.00 | 6860.00 | 6831.00 | 0.043 | 6.39 | 8.61 | 9.26 |
| INT-D03 | 21740 | 0.50 | 0.90 | 0.95 | 21740 | | | | | | | 0.90 | 0.95 | 50.00 | 50.00 | 200.00 | 200.00 | 6840.00 | 6835.00 | 0.020 | 5.00 | 9.00 | 4.27 |
| INT-D04 | 107749 | 2.47 | 0.90 | 0.95 | 15443 | 0.25 | 0.35 | 92306 | | | | 0.34 | 0.44 | 50.00 | 50.00 | 900.00 | 900.00 | 6875.00 | 6833.00 | 0.044 | 9.10 | 7.44 | 8.02 |
| INT-D05 | 114792 | 2.64 | 0.90 | 0.95 | 27045 | 0.25 | 0.35 | 87747 | | | | 0.40 | 0.49 | 50.00 | 50.00 | 900.00 | 900.00 | 6875.00 | 6833.00 | 0.044 | 8.61 | 7.83 | 10.14 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| INT-DC1 | 107813 | 2.48 | 0.25 | 0.35 | 35682 | 0.57 | 0.65 | 72131 | | | | 0.47 | 0.55 | 50.00 | 50.00 | 630.00 | 630.00 | 6860.00 | 6831.00 | 0.043 | 7.26 | 8.22 | 11.19 |
| INT-DC2 | 244281 | 5.61 | 0.90 | 0.95 | 21740 | 0.34 | 0.44 | 107749 | 0.40 | 0.49 | 114792 | 0.42 | 0.51 | 50.00 | 50.00 | 900.00 | 900.00 | 6876.00 | 6833.00 | 0.044 | 8.47 | 7.83 | 22.30 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |

$Q = C i A$

Must be ≥ 5 min ✓

Powers Boulevard and State Highway 83 Interchange
Final Drainage Calculation for Ultimate Condition
Average Channel Velocity 5 ft/s
Average Slope 0.02 ft/ft (If Elevations are used, this will be ignored)
Note: Q2, Q5 & Q10 are based on C10, Q25, Q50 & Q100 are based on C100

| Basin | Total Area sf | Total Area acres | Surface Type 1 C10 | Surface Type 1 C100 | Surface Type 1 Area | Surface Type 2 C10 | Surface Type 2 C100 | Surface Type 2 Area | Surface Type 3 C10 | Surface Type 3 C100 | Surface Type 3 Area | Average C10 | Average C100 | Initial Length ft | True Initial Length ft | Channel flow Length ft | True Channel Length ft | High Point Elevation | Low Point Elevation | Average Slope | Total Tc | i100 in/hr | Q100 cfs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ULT-A01 | 3452244 | 79.25 | 0.25 | 0.35 | 3452244 | | | | | | | 0.25 | 0.35 | 4641.00 | 300.00 | | 4341.00 | 7050.00 | 6880.00 | 0.037 | 32.33 | 4.01 | 111.23 |
| ULT-A02 | 112635 | 2.59 | 0.25 | 0.35 | 112635 | | | | | | | 0.25 | 0.35 | 650.00 | 300.00 | | 350.00 | 6886.00 | 6880.00 | 0.009 | 29.44 | 4.24 | 3.84 |
| ULT-A03 | 125111 | 2.87 | 0.90 | 0.95 | 36434 | 0.25 | 0.35 | 88677 | | | | 0.44 | 0.52 | 150.00 | 150.00 | 640.00 | 640.00 | 6895.00 | 6880.00 | 0.019 | 14.35 | 6.13 | 9.24 |
| ULT-A04 | 15986 | 0.37 | 0.90 | 0.95 | 15986 | | | | | | | 0.90 | 0.95 | 60.00 | 60.00 | 320.00 | 320.00 | 6901.00 | 6890.00 | 0.029 | 5.00 | 9.00 | 3.14 |
| ULT-A05 | 121474 | 2.79 | 0.90 | 0.95 | 28557 | 0.25 | 0.35 | 92917 | | | | 0.40 | 0.49 | 260.00 | 260.00 | 660.00 | 660.00 | 6915.00 | 6877.00 | 0.041 | 15.30 | 5.90 | 8.08 |
| ULT-A06 | 17645 | 0.41 | 0.90 | 0.95 | 5444 | 0.25 | 0.35 | 12201 | | | | 0.45 | 0.54 | 100.00 | 100.00 | 100.00 | 100.00 | 6880.00 | 6873.00 | 0.035 | 8.33 | 7.83 | 1.70 |
| ULT-A07 | 10973 | 0.25 | 0.90 | 0.95 | 4536 | 0.25 | 0.35 | 6437 | | | | 0.52 | 0.60 | 150.00 | 150.00 | | 0.00 | 6876.00 | 6870.00 | 0.040 | 8.39 | 7.83 | 1.18 |
| ULT-A08 | 115243 | 2.65 | 0.90 | 0.95 | 15479 | 0.25 | 0.35 | 99764 | | | | 0.34 | 0.43 | 150.00 | 150.00 | 200.00 | 200.00 | 6880.00 | 6865.00 | 0.043 | 11.42 | 6.82 | 7.77 |
| ULT-A09 | 127741 | 2.93 | 0.90 | 0.95 | 50238 | 0.25 | 0.35 | 77503 | | | | 0.51 | 0.59 | 50.00 | 50.00 | 750.00 | 750.00 | 6875.00 | 6853.00 | 0.028 | 8.11 | 7.83 | 13.45 |
| ULT-A10 | 33195 | 0.76 | 0.25 | 0.35 | 33195 | | | | | | | 0.25 | 0.35 | 50.00 | 50.00 | 650.00 | 650.00 | 6880.00 | 6853.00 | 0.039 | 9.33 | 7.44 | 1.98 |
| ULT-A11 | 125339 | 2.88 | 0.90 | 0.95 | 59132 | 0.25 | 0.35 | 66207 | | | | 0.56 | 0.63 | 175.00 | 175.00 | 750.00 | 750.00 | 6861.00 | 6843.00 | 0.019 | 13.27 | 6.36 | 11.59 |
| ULT-A12 | 52957 | 1.22 | 0.90 | 0.96 | 8125 | 0.25 | 0.35 | 44832 | | | | 0.35 | 0.44 | 275.00 | 275.00 | 100.00 | 100.00 | 6880.00 | 6843.00 | 0.099 | 11.18 | 6.82 | 3.67 |
| ULT-A13 | 15682 | 0.36 | 0.90 | 0.95 | 15682 | | | | | | | 0.90 | 0.95 | 250.00 | 250.00 | | 0.00 | 6880.00 | 6875.00 | 0.020 | 5.00 | 9.00 | 3.08 |
| ULT-A14 | 3295 | 0.08 | 0.90 | 0.95 | 3295 | | | | | | | 0.90 | 0.95 | 75.00 | 75.00 | | 0.00 | 6876.00 | 6872.00 | 0.053 | 5.00 | 9.00 | 0.65 |
| ULT-A15 | 42817 | 0.98 | 0.90 | 0.95 | 25202 | 0.25 | 0.35 | 17615 | | | | 0.63 | 0.70 | 150.00 | 150.00 | 225.00 | 225.00 | 6847.00 | 6839.00 | 0.021 | 9.07 | 7.44 | 5.14 |
| ULT-A16 | 121600 | 2.79 | 0.90 | 0.95 | 121600 | | | | | | | 0.90 | 0.95 | 50.00 | 50.00 | 1500.00 | 1500.00 | 6865.00 | 6839.00 | 0.017 | 7.23 | 8.22 | 21.80 |
| ULT-A17 | 40933 | 0.94 | 0.25 | 0.35 | 40933 | | | | | | | 0.25 | 0.35 | 50.00 | 50.00 | 450.00 | 450.00 | 6865.00 | 6850.00 | 0.030 | 9.29 | 7.44 | 2.45 |
| ULT-A18 | 50603 | 1.16 | 0.90 | 0.95 | 26349 | 0.25 | 0.35 | 24254 | | | | 0.59 | 0.66 | 50.00 | 50.00 | 450.00 | 450.00 | 6865.00 | 6850.00 | 0.030 | 6.19 | 8.61 | 6.63 |
| ULT-A19 | 72907 | 1.67 | 0.90 | 0.95 | 39129 | 0.25 | 0.35 | 33778 | | | | 0.60 | 0.67 | 125.00 | 125.00 | 425.00 | 425.00 | 6861.00 | 6850.00 | 0.020 | 9.73 | 7.44 | 8.37 |
| ULT-A20 | 95947 | 2.20 | 0.25 | 0.35 | 95947 | | | | | | | 0.25 | 0.35 | 150.00 | 150.00 | 775.00 | 775.00 | 6870.00 | 6843.00 | 0.029 | 16.21 | 5.75 | 4.43 |
| ULT-A21 | 19490 | 0.45 | 0.25 | 0.35 | 19490 | | | | | | | 0.25 | 0.35 | 50.00 | 50.00 | 275.00 | 275.00 | 6843.00 | 6840.00 | 0.009 | 12.46 | 6.59 | 1.03 |
| ULT-A22 | 93342 | 2.14 | 0.90 | 0.95 | 16979 | 0.25 | 0.35 | 76363 | | | | 0.37 | 0.46 | 375.00 | 300.00 | | 75.00 | 6871.00 | 6861.00 | 0.027 | 17.34 | 5.60 | 5.51 |
| ULT-A23 | 13487 | 0.31 | 0.90 | 0.95 | 13487 | | | | | | | 0.90 | 0.95 | 100.00 | 100.00 | 200.00 | 200.00 | 6872.00 | 6864.00 | 0.027 | 5.00 | 9.00 | 2.65 |
| ULT-A24 | 41296 | 0.95 | 0.90 | 0.95 | 12334 | 0.25 | 0.35 | 28962 | | | | 0.44 | 0.53 | 150.00 | 150.00 | 150.00 | 150.00 | 6870.00 | 6856.00 | 0.050 | 9.28 | 7.44 | 3.73 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| ULT-A01-A | 272679 | 6.26 | 0.25 | 0.35 | 272679 | | | | | | | 0.25 | 0.35 | 950.00 | 300.00 | | 650.00 | 6910.00 | 6880.00 | 0.032 | 20.93 | 5.15 | 11.28 |
| ULT-AC01 | 237746 | 5.46 | 0.25 | 0.35 | 112635 | 0.44 | 0.52 | 125111 | | | | 0.35 | 0.44 | 650.00 | 300.00 | | 350.00 | 6886.00 | 6880.00 | 0.009 | 26.13 | 4.51 | 10.88 |
| ULT-AC02 | 137460 | 3.16 | 0.90 | 0.95 | 15986 | 0.40 | 0.49 | 121474 | | | | 0.46 | 0.54 | 260.00 | 260.00 | 660.00 | 660.00 | 6916.00 | 6877.00 | 0.041 | 14.22 | 6.13 | 10.53 |
| ULT-AC03 | 392851 | 9.02 | 0.35 | 0.44 | 237746 | 0.46 | 0.54 | 137460 | 0.45 | 0.54 | 17645 | 0.39 | 0.48 | 650.00 | 300.00 | 350.00 | 700.00 | 6886.00 | 6873.00 | 0.013 | 23.32 | 4.82 | 20.95 |
| ULT-AC04 | 3856068 | 88.52 | 0.39 | 0.48 | 392851 | 0.25 | 0.35 | 3452244 | 0.52 | 0.60 | 10973 | 0.27 | 0.36 | 4641.00 | 300.00 | 250.00 | 4591.00 | 7050.00 | 6875.00 | 0.036 | 32.98 | 4.01 | 129.27 |
| ULT-AC05 | 3971311 | 91.17 | 0.27 | 0.36 | 3856068 | 0.34 | 0.43 | 115243 | | | | 0.27 | 0.37 | 4641.00 | 300.00 | 400.00 | 4741.00 | 7050.00 | 6865.00 | 0.037 | 33.29 | 3.94 | 131.50 |
| ULT-AC06 | 286275 | 6.57 | 0.51 | 0.59 | 127741 | 0.25 | 0.35 | 33195 | 0.56 | 0.63 | 125339 | 0.50 | 0.58 | 175.00 | 175.00 | 750.00 | 750.00 | 6861.00 | 6843.00 | 0.019 | 14.42 | 6.13 | 23.33 |
| ULT-AC07 | 339232 | 7.79 | 0.50 | 0.58 | 286275 | 0.35 | 0.44 | 52957 | | | | 0.48 | 0.56 | 175.00 | 175.00 | 750.00 | 750.00 | 6861.00 | 6843.00 | 0.019 | 14.88 | 6.13 | 26.63 |
| ULT-AC08 | 401026 | 9.21 | 0.48 | 0.56 | 339232 | 0.90 | 0.95 | 18977 | 0.63 | 0.70 | 42817 | 0.51 | 0.59 | 175.00 | 175.00 | 1100.00 | 1100.00 | 6861.00 | 6839.00 | 0.017 | 15.79 | 5.90 | 32.15 |
| ULT-AC09 | 4372337 | 100.38 | 0.27 | 0.38 | 3856068 | 0.51 | 0.59 | 401026 | | | | 0.28 | 0.38 | 4641.00 | 300.00 | 600.00 | 4941.00 | 7050.00 | 6825.00 | 0.043 | 32.79 | 4.01 | 151.12 |
| ULT-AC10 | 113840 | 2.61 | 0.25 | 0.35 | 40933 | 0.60 | 0.67 | 72907 | | | | 0.47 | 0.56 | 125.00 | 125.00 | 425.00 | 425.00 | 6861.00 | 6850.00 | 0.020 | 11.81 | 6.82 | 9.91 |
| ULT-AC11 | 260390 | 5.98 | 0.47 | 0.56 | 113840 | 0.59 | 0.66 | 50603 | 0.25 | 0.35 | 95947 | 0.41 | 0.50 | 125.00 | 125.00 | 1200.00 | 1200.00 | 6861.00 | 6843.00 | 0.014 | 16.96 | 5.75 | 17.22 |
| ULT-AC12 | 279880 | 6.43 | 0.41 | 0.50 | 260390 | 0.25 | 0.35 | 19490 | | | | 0.40 | 0.49 | 125.00 | 125.00 | 1475.00 | 1475.00 | 6861.00 | 6840.00 | 0.013 | 18.24 | 5.45 | 17.17 |
| ULT-AC13 | 4773817 | 109.59 | 0.28 | 0.38 | 4372337 | 0.90 | 0.95 | 121600 | 0.40 | 0.49 | 279880 | 0.30 | 0.40 | 4641.00 | 300.00 | 800.00 | 5141.00 | 7050.00 | 6823.00 | 0.042 | 33.16 | 3.94 | 171.34 |

Powers Boulevard and State Highway 83 Interchange
Final Drainage Calculation for Ultimate Condition
Average Channel Velocity 5 ft/s
Average Slope 0.02 ft/ft (If Elevations are used, this will be ignored)
Note: Q2, Q5 & Q10 are based on C10, Q25, Q50 & Q100 are based on C100

| Basin | Total Area sf | Total Area acres | Surface Type 1 C10 | Surface Type 1 C100 | Surface Type 1 Area | Surface Type 2 C10 | Surface Type 2 C100 | Surface Type 2 Area | Surface Type 3 C10 | Surface Type 3 C100 | Surface Type 3 Area | Average C10 | Average C100 | Initial Length ft | True Initial Length ft | Channel flow Length ft | True Channel Length ft | High Point Elevation | Low Point Elevation | Average Slope | Total Tc | I100 in/hr | Q100 cfs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ULT-AC13 | 4773817 | 109.59 | 0.28 | 0.38 | 4372337 | 0.90 | 0.95 | 121600 | 0.40 | 0.49 | 279880 | 0.30 | 0.40 | 4641.00 | 300.00 | 800.00 | 5141.00 | 7050.00 | 6823.00 | 0.042 | 33.16 | 3.94 | 171.34 |
| ULT-AC14 | 148125 | 3.40 | 0.37 | 0.46 | 93342 | 0.90 | 0.95 | 13487 | 0.44 | 0.53 | 41296 | 0.44 | 0.52 | 375.00 | 300.00 | 325.00 | 400.00 | 6871.00 | 6855.00 | 0.023 | 17.62 | 5.60 | 9.98 |
| ULT-AC15 | 4921942 | 112.99 | 0.30 | 0.40 | 4773817 | 0.44 | 0.52 | 148125 | | | | 0.31 | 0.40 | 4641.00 | 300.00 | 1050.00 | 5391.00 | 7050.00 | 6820.00 | 0.040 | 34.08 | 3.87 | 175.20 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| ULT-ELK-A | 5581286 | 128.13 | 0.31 | 0.40 | 4921942 | 0.26 | 0.36 | 659344 | | | | 0.30 | 0.40 | 6955.00 | 300.00 | | 6655.00 | 7050.00 | 6827.00 | 0.032 | 39.71 | 3.52 | 178.53 |
| ULT-ELK-B | 259245 | 5.95 | 0.90 | 0.95 | 71107 | 0.25 | 0.35 | 188138 | | | | 0.43 | 0.51 | 1365.00 | 300.00 | | 1065.00 | 6867.00 | 6830.00 | 0.027 | 19.15 | 5.30 | 16.23 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| ULT-C01 | 114600 | 2.63 | 0.90 | 0.95 | 11178 | 0.25 | 0.35 | 103422 | | | | 0.31 | 0.41 | 600.00 | 300.00 | | 300.00 | 6877.00 | 6863.00 | 0.023 | 20.21 | 5.15 | 5.54 |
| ULK-ELK-C | 735791 | 16.89 | 0.31 | 0.41 | 114600 | 0.25 | 0.35 | 621191 | | | | 0.26 | 0.36 | 2125.00 | 300.00 | | 1825.00 | 6887.00 | 6840.00 | 0.022 | 26.97 | 4.51 | 27.36 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| ULT-D01 | 9540 | 0.22 | 0.25 | 0.35 | 9540 | | | | | | | 0.25 | 0.35 | 75.00 | 75.00 | 175.00 | 175.00 | 6851.00 | 6845.00 | 0.024 | 10.86 | 7.05 | 0.54 |
| ULT-D02 | 28893 | 0.66 | 0.25 | 0.35 | 28893 | | | | | | | 0.25 | 0.35 | 100.00 | 100.00 | 400.00 | 400.00 | 6855.00 | 6836.00 | 0.034 | 11.90 | 6.82 | 1.58 |
| ULT-D03 | 72131 | 1.66 | 0.90 | 0.95 | 35966 | 0.25 | 0.35 | 36165 | | | | 0.57 | 0.65 | 50.00 | 50.00 | 630.00 | 630.00 | 6860.00 | 6831.00 | 0.043 | 6.39 | 8.61 | 9.26 |
| ULT-D04 | 71015 | 1.63 | 0.90 | 0.95 | 71015 | | | | | | | 0.90 | 0.95 | 100.00 | 100.00 | 700.00 | 700.00 | 6844.00 | 6834.00 | 0.013 | 5.81 | 9.00 | 13.94 |
| ULT-D05 | 76433 | 1.75 | 0.90 | 0.95 | 15443 | 0.25 | 0.35 | 60990 | | | | 0.38 | 0.47 | 50.00 | 50.00 | 900.00 | 900.00 | 6875.00 | 6833.00 | 0.044 | 8.79 | 7.83 | 6.47 |
| ULT-D06 | 122192 | 2.81 | 0.90 | 0.95 | 49651 | 0.25 | 0.35 | 72541 | | | | 0.51 | 0.59 | 125.00 | 125.00 | 700.00 | 700.00 | 6843.00 | 6833.00 | 0.012 | 13.82 | 6.36 | 10.59 |
| ULT-D07 | 114792 | 2.64 | 0.90 | 0.95 | 27045 | 0.25 | 0.35 | 87747 | | | | 0.40 | 0.49 | 50.00 | 50.00 | 900.00 | 900.00 | 6875.00 | 6833.00 | 0.044 | 8.61 | 7.83 | 10.14 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| ULT-DC1 | 38433 | 0.88 | 0.25 | 0.35 | 38433 | | | | | | | 0.25 | 0.35 | 100.00 | 100.00 | 400.00 | 400.00 | 6855.00 | 6838.00 | 0.034 | 11.90 | 6.82 | 2.11 |
| ULT-DC2 | 110564 | 2.54 | 0.25 | 0.35 | 38433 | 0.57 | 0.65 | 72131 | | | | 0.46 | 0.55 | 100.00 | 100.00 | 675.00 | 675.00 | 6856.00 | 6831.00 | 0.031 | 10.44 | 7.05 | 9.76 |
| ULT-DC3 | 198625 | 4.56 | 0.38 | 0.47 | 76433 | 0.51 | 0.59 | 122192 | | | | 0.46 | 0.55 | 125.00 | 125.00 | 700.00 | 700.00 | 6843.00 | 6833.00 | 0.012 | 14.82 | 6.13 | 15.28 |
| ULT-DC4 | 313417 | 7.20 | 0.46 | 0.55 | 198625 | 0.40 | 0.49 | 114792 | | | | 0.44 | 0.53 | 125.00 | 125.00 | 800.00 | 800.00 | 6843.00 | 6832.00 | 0.012 | 15.67 | 5.90 | 22.35 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |
| | | 0.00 | | | | | | | | | | 0.00 | 0.00 | | 0.00 | | 0.00 | | | 0.020 | 5.00 | 9.00 | 0.00 |

DRAFT

**Appendix B: Hydrology - Rational Basin Calculations for Black Squirrel Creek Basin**

# CALCULATION COVER SHEET

Client: CDOT REGION 2 Project Name: SHOUP/SH83 ~~21710832~~

Project/Calculation Number: 21710832 . 00004

Title: HYDROLOGY CALCS FOR BLACK SQUIRREL BASIN

Total Number of Pages (including cover sheet): ____________

Total Number of Computer Runs: ____________

Prepared by: RYAN WEAVER Date: 2/9/03

Checked by: E. DANNY ELSNER Date: 2/11/03

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Description and Purpose: RATIONAL CALCULATIONS FOR BLACK SQUIRREL BASIN FOR HYDRAULICS

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Design Basis/References/Assumptions
- CDOT DRAINAGE CRITERIA MANUAL
- CITY OF COLO. SPGS. DRAINAGE CRITERIA MANUAL

---

Remarks/Conclusions/Results:

MINOR CHANGES NOTED.

Calculation Approved by: ______________________
Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

**URS**

Page ____ of ____

| | | | |
|---|---|---|---|
| Job | SH83 & Shoup Road | Project No. | 21710831 |
| Description | Drainage - Hydrology Basins | Computed by | RGW |
| | | Checked by | SDE |

Sheet ____ of ____

Date 02/10/03

Date 2/11/03

Reference

Existing

Basin A

✓1A → Flows to DP1.4 (existing culvert)

✓2A → Flows N in ditch E side of SH83 to culvert at DP1.5; also from 1A

3A → Flows S in ditch E side of SH83 to culvert at DP ~~1.6~~ 1.7

DP1 → Combined flow from DP1.5 & DP ~~1.6~~ 1.7

Basin B

✓1B → Flows N, then W in ditch S of Shoup Rd to DP2.1

✓2B → Flows W, then N in ditch E of SH83 to DP2.2

✓3B → Flows W in ditch N of Shoup Rd; then N to DP 2.4 (Black Squirrel Creek)

✓DP 2.3 → Combined flow from 1B & 2B

✓DP 2 → Combined flow from DP 2.4 & DP 2.3

Basin C

✓1C → Flows S in ditch on W side of SH83 to culvert at DP3.1

✓2C → Flows S in ditch on W side of SH83 to culvert at DP3.2

✓3C → Flows S to Black Squirrel Creek (sheet flow); also from 1C & 2C

✓DP3 → Combined flow from 1C, 2C, & 3C into Black Squirrel Creek

Basin D

✓1D → Flows SE, then S in ditch on W side of SH83 to DP4

✓DP 4 → Flow from 1D; DP4 is low point with no culvert/inlet

Proposed

Basin A

✓A1 → Flows to proposed ditch, then S to DP1.1

✓A2 → Flows along curb S to DP1.2

✓A3 → Flows from cut slope and pavement to DP1.3 along proposed ditch

✓A4 → Flows SW to DP 1A; also flows from DP1.1, DP1.2, & DP1.3

✓A5 → Flows N in ditch E side of existing 83 to culvert at DP1.5; also from A1-A4

✓A6 → Flows from proposed pavement to DP ~~1.7~~ 1.6 along proposed ditch

✓A7 → Flows W, then S in ditch E side of existing 83 to DP ~~1.6~~ 1.7; also from A6

DP1 → Combined flow from DP1.5 & DP ~~1.6~~ 1.7

Basin B

B1 → Flows N, then W in proposed ditch S of Shoup Rd to DP2.1

B2 → Flows W, then N in proposed ditch E of proposed SH83 to DP2.2

B3 → Flows W in ditch N of Shoup Rd, then N to DP2.4 (Black Squirrel Creek)

DP2.3 → Combined flow from DP2.4 & DP2.3

(Proposed Basin B Continued)

DP 2 → Combined flow from DP2.4 & DP2.3

Basin C

C1 → Sheet flow from proposed SH83 E into Black Squirrel Creek

DP3 → Flow from C1 into Black Squirrel Creek

Basin D

D1 → Flows from slope and proposed SH83 to proposed ditch flowing S to DP4

DP4 → Flow from D1

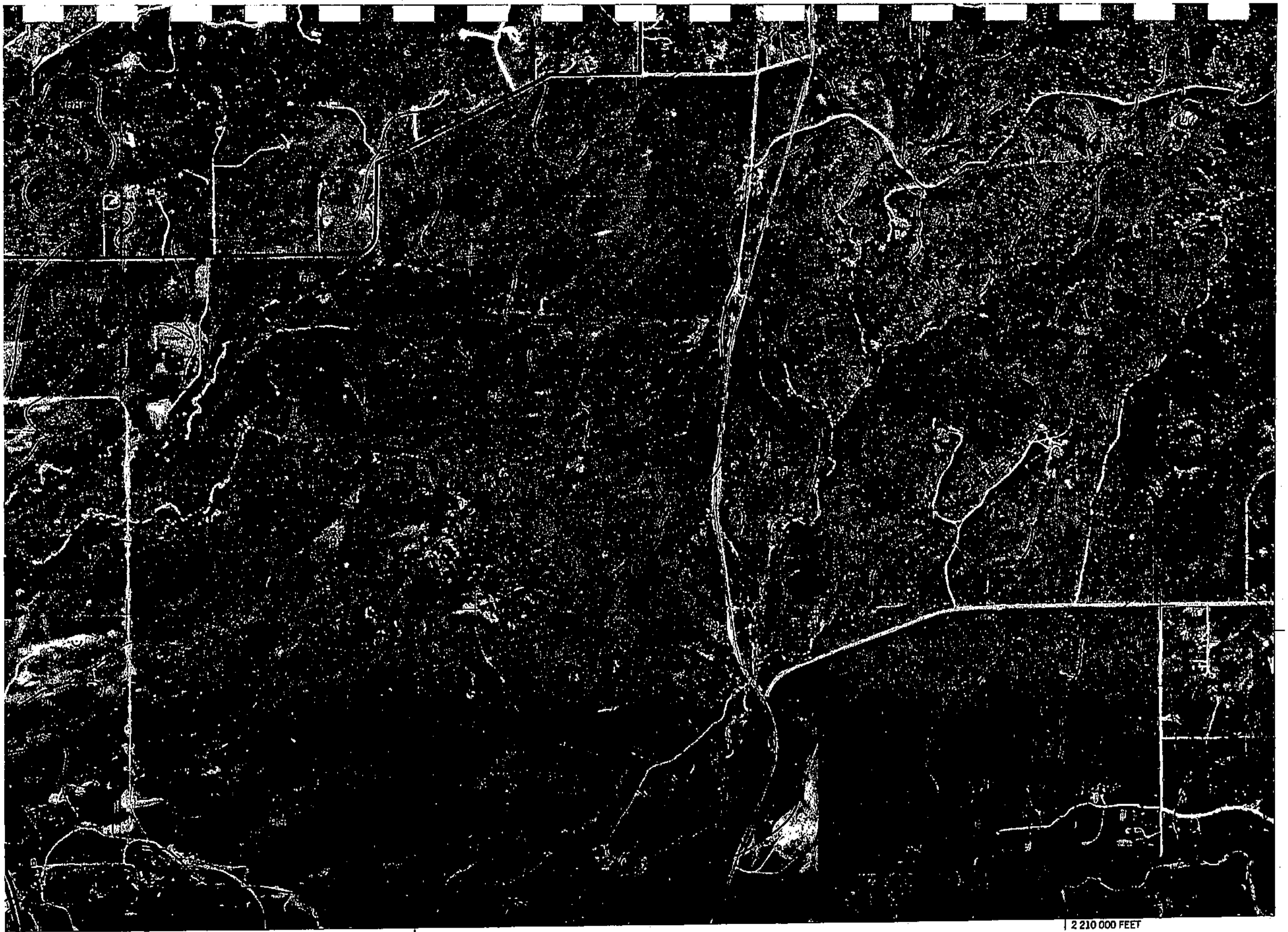
**URS**

| | | | |
|---|---|---|---|
| Job SH83 & Shoup Road | Project No. 21710831 | Page ___ of ___ | |
| | | Sheet ___ of ___ | |
| Description Drainage - Hydrology | Computed by REW | Date 02/07/03 | |
| Hydrologic Soil Types | Checked by EDE | Date 2/11/03 | |

Reference

Soil Survey of El Paso County Area, Colorado
- Map Sheet 1 of 37
  - Mostly type 93 soils → Tomah-Crowfoot loamy sands, 8-15% slopes
  - Some type 71 soils → Pring coarse sandy loam, 3-8% slopes
  - Some type 69 soils → Peyton-Pring complex, 8-15% slopes
- Soil and Water Features Table 16.
  - 93: Hydrologic Group B
  - 71: Hydrologic Group B
  - 69: Hydrologic Group B

xerox site!




*(Joins sheet 8)*

1
2 Miles
5000
10000 Feet
Scale 1:24000

SHEET NO. 1 OF 37

**URS**

Page ____ of ____

| | | | |
|---|---|---|---|
| Job: SH83 & Shoup Road | Project No. 21710831 | Sheet ____ of ____ | |
| Description: Drainage - Hydrology Runoff Coefficients | Computed by RGW | Date 02/07/03 | |
| | Checked by EDE | Date 2/11/03 | |

Reference

City of Colorado Springs and El Paso County Drainage Criteria Manual:

| | AB Soils 10 yr | AB Soils 100 yr |
|---|---|---|
| Undeveloped Pasture | 0.25 | 0.35 |
| Streets (Paved) | 0.90 | 0.95 |
| Streets (Gravel) | 0.80 | 0.85 |
| Roofs | 0.90 | 0.95 |

CDOT Drainage Manual: (NOT USED)

| | 10 yr | 100 yr |
|---|---|---|
| Lawns (Sandy Soil) | 0.05 | 0.20 |
| Lawns (Clayey Soil) | 0.20 | 0.40 |
| Streets (Paved) | 0.90 | 0.93 |
| Streets (Gravel) | 0.35 | 0.65 |
| Roofs | 0.90 | 0.90 |

Runoff coefficients from the City/County Drainage Criteria Manual are consitantly higher than those from CDOT Drainage Manual. To be conservative, the coefficients from the City/County Drainage Criteria Manual will be used for design. ✓

Maximum 300' Initial channel length will be used. This meets City/County criteria for developed and CDOT criteria for urban. ✓

**Table 7.4 Recommended Runoff Coefficients and Percent Impervious**

| Land Use or Surface Characteristics | Percent Impervious | Frequency | | | |
|---|---|---|---|---|---|
| | | 2 | 5 | 10 | 100 |
| Business: | | | | | |
| Commercial Areas | 95 | .87 | .87 | .88 | .89 |
| Neighborhood Areas | 70 | .60 | .65 | .70 | .80 |
| Residential: | | | | | |
| Single-Family | | .40 | .45 | .50 | .60 |
| Multi-Unit (detached) | 50 | .45 | .50 | .60 | .70 |
| Multi-Unit (attached) | 70 | .60 | .65 | .70 | .80 |
| ½ Acre Lot or Larger | | .30 | .35 | .40 | .60 |
| Apartments | 70 | .65 | .70 | .70 | .80 |
| Industrial: | | | | | |
| Light Areas | 80 | .71 | .72 | .76 | .82 |
| Heavy Areas | 90 | .80 | .80 | .85 | .90 |
| Parks, Cemeteries: | 7 | .10 | .10 | .35 | .60 |
| Playgrounds: | 13 | .15 | .25 | .35 | .65 |
| Schools: | 50 | .45 | .50 | .60 | .70 |
| Railroad Yard Areas: | 40 | .40 | .45 | .50 | .60 |
| Undeveloped Areas: | | | | | |
| Historic Flow Analysis, Greenbelt, Agricultural: | 2 | See | Lawns | | |
| Offsite Flow Analysis: (when land use not defined) | 45 | .43 | .47 | .55 | .65 |
| Streets: | | | | | |
| Paved | 100 | .87 | .88 | .90 | .93 |
| Gravel | 13 | .15 | .25 | .35 | .65 |
| Drive and Walks: | 96 | .87 | .87 | .88 | .89 |
| Roofs: | 90 | .80 | .85 | .90 | .90 |
| Lawns, Sandy Soil: | 0 | .00 | .01 | .05 | .20 |
| Lawns, Clayey Soil: | 0 | .05 | .10 | .20 | .40 |

Note: These Rational Formula coefficients may not be valid for large basins.

Source: Urban Storm Drainage Criteria Manual (UDFCD, 1969).

**TABLE 5-1**

**RECOMMENDED AVERAGE RUNOFF COEFFICIENTS AND PERCENT IMPERVIOUS**

| LAND USE OR SURFACE CHARACTERISTICS | PERCENT IMPERVIOUS | "C" FREQUENCY 10 A&B* | 10 C&D* | 100 A&B* | 100 C&D* |
|---|---|---|---|---|---|
| Business | | | | | |
| Commercial Areas | 95 | 0.90 | 0.90 | 0.90 | 0.90 |
| Neighborhood Areas | 70 | 0.75 | 0.75 | 0.80 | 0.80 |
| Residential | | | | | |
| 1/8 Acre or less | 65 | 0.60 | 0.70 | 0.70 | 0.80 |
| 1/4 Acre | 40 | 0.50 | 0.60 | 0.60 | 0.70 |
| 1/3 Acre | 30 | 0.40 | 0.50 | 0.55 | 0.60 |
| 1/2 Acre | 25 | 0.35 | 0.45 | 0.45 | 0.55 |
| 1 Acre | 20 | 0.30 | 0.40 | 0.40 | 0.50 |
| Industrial | | | | | |
| Light Areas | 80 | 0.70 | 0.70 | 0.80 | 0.80 |
| Heavy Areas | 90 | 0.80 | 0.80 | 0.90 | 0.90 |
| Parks and Cemeteries | 7 | 0.30 | 0.35 | 0.55 | 0.60 |
| Playgrounds | 13 | 0.30 | 0.35 | 0.60 | 0.65 |
| Railroad Yard Areas | 40 | 0.50 | 0.55 | 0.60 | 0.65 |
| Undeveloped Areas | | | | | |
| Historic Flow Analysis-Greenbelts, Agricultural | 2 | 0.15 | 0.25 | 0.20 | 0.30 |
| Pasture/Meadow | 0 | 0.25 | 0.30 | 0.35 | 0.45 |
| Forest | 0 | 0.10 | 0.15 | 0.15 | 0.20 |
| Exposed Rock | 100 | 0.90 | 0.90 | 0.95 | 0.95 |
| Offsite Flow Analysis (when land use not defined) | 45 | 0.55 | 0.60 | 0.65 | 0.70 |
| Streets | | | | | |
| Paved | 100 | 0.90 | 0.90 | 0.95 | 0.95 |
| Gravel | 80 | 0.80 | 0.80 | 0.85 | 0.85 |
| Drive and Walks | 100 | 0.90 | 0.90 | 0.95 | 0.95 |
| Roofs | 90 | 0.90 | 0.90 | 0.95 | 0.95 |
| Lawns | 0 | 0.25 | 0.30 | 0.35 | 0.45 |

* Hydrologic Soil Group

EDE
2/11/03

Highway 83 and Shoup Road
ary Drainage - EXISTING
e Channel Velocity 5 ft/s
age Slope 0.02 ft/ft (If Elevations are used, this will be ignored)
Q2, Q5 & Q10 are based on C10, Q25, Q50 & Q100 are based on C100

| n | Total Area sf | Total Area acres | Surface Type 1 C10 | Surface Type 1 C100 | Surface Type 1 Area | Surface Type 2 C10 | Surface Type 2 C100 | Surface Type 2 Area | Surface Type 3 C10 | Surface Type 3 C100 | Surface Type 3 Area | Average C10 | Average C100 | Initial Length ft | True Initial Length ft | Channel flow Length ft | True Channel Length ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DP1.4) | 1941107 | 44.56 | 0.25 | 0.35 | 1915281 | 0.90 | 0.95 | 17771 | 0.80 | 0.85 | 8055 | 0.26 | 0.36 | 1050.00 | 300.00 | 2867.00 | 3617.00 |
| | 280791 | 6.45 | 0.25 | 0.35 | 258730 | 0.90 | 0.95 | 13641 | 0.80 | 0.85 | 8420 | 0.30 | 0.39 | 155.00 | 155.00 | 1253.00 | 1253.00 |
| (DP1.4+2A) | 2221898 | 51.01 | 0.25 | 0.35 | 2174011 | 0.90 | 0.95 | 31412 | 0.80 | 0.85 | 16475 | 0.26 | 0.36 | 1050.00 | 300.00 | 3919.00 | 4669.00 |
| DP1.7) | 878809 | 20.17 | 0.25 | 0.35 | 872315 | 0.90 | 0.95 | 6494 | 0.80 | 0.85 | 0 | 0.25 | 0.35 | 572.00 | 300.00 | 1696.00 | 1968.00 |
| 7+DP1.5) | 3100707 | 71.18 | 0.25 | 0.35 | 3046326 | 0.90 | 0.95 | 37906 | 0.80 | 0.85 | 16475 | 0.26 | 0.36 | 1050.00 | 300.00 | 3919.00 | 4669.00 |
| DP2.1) | 1435125 | 32.95 | 0.25 | 0.35 | 1399964 | 0.90 | 0.95 | 35161 | 0.80 | 0.85 | 0 | 0.27 | 0.36 | 342.00 | 300.00 | 2298.00 | 2340.00 |
| DP2.2) | 332365 | 7.63 | 0.25 | 0.35 | 332365 | 0.90 | 0.95 | 0 | 0.80 | 0.85 | 0 | 0.25 | 0.35 | 255.00 | 255.00 | 970.00 | 970.00 |
| (DP2.1+DP2.2) | 1767490 | 40.58 | 0.25 | 0.35 | 1732329 | 0.90 | 0.95 | 35161 | 0.80 | 0.85 | 0 | 0.26 | 0.36 | 342.00 | 300.00 | 2298.00 | 2340.00 |
| 2.4) | 66677 | 1.53 | 0.25 | 0.35 | 58048 | 0.90 | 0.95 | 8629 | 0.80 | 0.85 | 0 | 0.33 | 0.43 | 59.00 | 59.00 | 782.00 | 782.00 |
| P2.3+DP2.4) | 1834167 | 42.11 | 0.25 | 0.35 | 1790377 | 0.90 | 0.95 | 43790 | 0.80 | 0.85 | 0 | 0.27 | 0.36 | 342.00 | 300.00 | 2298.00 | 2340.00 |
| 3.1) | 76856 | 1.76 | 0.25 | 0.35 | 76856 | 0.90 | 0.95 | 0 | 0.80 | 0.85 | 0 | 0.25 | 0.35 | 335.00 | 300.00 | 750.00 (Seems high) | 785.00 |
| 3.2) | 705554 | 16.20 | 0.25 | 0.35 | 689610 | 0.90 | 0.95 | 15944 | 0.80 | 0.85 | 0 | 0.26 | 0.36 | 522.00 | 300.00 | 723.00 | 945.00 |
| | 512990 | 11.78 | 0.25 | 0.35 | 439225 | 0.90 | 0.95 | 73765 | 0.80 | 0.85 | 0 | 0.34 | 0.44 | 52.00 | 52.00 | 3652.00 | 3652.00 |
| G+DP3.1+DP3.2) | 1295400 | 29.74 | 0.25 | 0.35 | 1205691 | 0.90 | 0.95 | 89709 | 0.80 | 0.85 | 0 | 0.30 | 0.39 | 335.00 | 300.00 | 2229.00 | 2264.00 |
| | 979086 | 22.48 | 0.25 | 0.35 | 969771 | 0.90 | 0.95 | 9315 | 0.80 | 0.85 | 0 | 0.26 | 0.36 | 350.00 | 300.00 | 1596.00 | 1646.00 |

| n | High Point Elevation | Low Point Elevation | Average Slope | Initial Tc | Channe Tc | Total Tc | i2 in/hr | Q2 cfs | i5 in/hr | Q5 cfs | i10 in/hr | Q10 cfs | i25 in/hr | Q25 cfs | i50 in/hr | Q50 cfs | i100 in/hr | Q100 cfs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DP1.4) | 7025.00 | 6898.00 | 0.032 | 18.42 | 12.06 | 30.48 | 1.76 | 20.25 | 2.42 | 27.87 | 2.83 | 32.52 | 3.63 | 57.89 | 4.12 | 65.61 | 4.31 | 68.70 |
| | 6891.00 | 6865.00 | 0.018 | 15.22 | 4.18 | 19.39 | 2.25 | 4.32 | 3.09 | 5.94 | 3.61 | 6.93 | 4.64 | 11.79 | 5.26 | 13.36 | 5.51 | 13.99 |
| (DP1.4+2A) | 7025.00 | 6865.00 | 0.032 | 18.35 | 15.56 | 33.92 | 1.67 | 22.37 | 2.29 | 30.79 | 2.67 | 35.92 | 3.44 | 63.54 | 3.90 | 72.01 | 4.08 | 75.40 |
| DP1.7) | 6993.00 | 6865.00 | 0.056 | 15.38 | 6.56 | 21.94 | 2.14 | 10.98 | 2.94 | 15.11 | 3.43 | 17.63 | 4.41 | 31.53 | 5.00 | 35.74 | 5.23 | 37.42 |
| 7+DP1.5) | 7025.00 | 6865.00 | 0.032 | 18.41 | 15.56 | 33.97 | 1.67 | 30.94 | 2.29 | 42.57 | 2.67 | 49.67 | 3.44 | 88.13 | 3.90 | 99.88 | 4.08 | 104.58 |
| DP2.1) | 7025.00 | 6885.00 | 0.053 | 15.49 | 7.80 | 23.29 | 2.04 | 17.85 | 2.80 | 24.56 | 3.27 | 28.66 | 4.21 | 50.53 | 4.77 | 57.27 | 4.99 | 59.96 |
| DP2.2) | 6986.00 | 6885.00 | 0.082 | 12.56 | 3.23 | 15.80 | 2.52 | 4.80 | 3.46 | 6.60 | 4.04 | 7.70 | 5.19 | 13.87 | 5.89 | 15.72 | 6.16 | 16.46 |
| (DP2.1+DP2.2) | 7025.00 | 6885.00 | 0.053 | 15.55 | 7.80 | 23.35 | 2.04 | 21.74 | 2.80 | 29.91 | 3.27 | 34.90 | 4.21 | 61.76 | 4.77 | 70.00 | 4.99 | 73.29 |
| 2.4) | 6914.00 | 6857.00 | 0.068 | 5.81 | 2.61 | 8.42 | 3.23 | 1.65 | 4.44 | 2.27 | 5.18 | 2.65 | 6.67 | 4.36 | 7.55 | 4.95 | 7.91 | 5.18 |
| P2.3+DP2.4) | 7025.00 | 6885.00 | 0.053 | 15.50 | 7.80 | 23.30 | 2.04 | 22.78 | 2.80 | 31.34 | 3.27 | 36.57 | 4.21 | 64.51 | 4.77 | 73.12 | 4.99 | 76.56 |
| 3.1) | 7020.00 | 6993.00 | 0.025 | 20.32 | 2.62 | 22.93 (seems high) | 2.09 | 0.92 | 2.87 | 1.27 | 3.35 | 1.48 | 4.30 | 2.66 | 4.88 | 3.01 | 5.11 | 3.15 |
| 3.2) | 7014.00 | 6925.00 | 0.071 | 14.04 | 3.15 | 17.19 | 2.37 | 10.17 | 3.27 | 14.00 | 3.81 | 16.33 | 4.90 | 28.84 | 5.55 | 32.69 | 5.81 | 34.23 |
| | 7022.00 | 6857.00 | 0.045 | 6.20 | 12.17 | 18.37 | 2.31 | 9.34 | 3.18 | 12.85 | 3.71 | 14.99 | 4.76 | 24.48 | 5.40 | 27.74 | 5.65 | 29.05 |
| G+DP3.1+DP3.2) | 7020.00 | 6857.00 | 0.064 | 14.07 | 7.55 | 21.62 | 2.14 | 18.74 | 2.94 | 25.79 | 3.43 | 30.09 | 4.41 | 51.35 | 5.00 | 58.20 | 5.23 | 60.94 |
| | 7042.00 | 6874.00 | 0.086 | 13.32 | 5.49 | 18.81 | 2.31 | 13.29 | 3.18 | 18.29 | 3.71 | 21.34 | 4.76 | 38.09 | 5.40 | 43.17 | 5.65 | 45.21 |

Highway 83 and Shoup Road
ary Drainage - PROPOSED
rage Channel Velocity 5 ft/s
rage Slope 0.02 ft/ft (If Elevations are used, this will be ignored)
Q2, Q5 & Q10 are based on C10, Q25, Q50 & Q100 are based on C100

should be close to 155 ? (2A)

| sin | Total Area sf | Total Area acres | Surface Type 1 C10 | Surface Type 1 C100 | Surface Type 1 Area | Surface Type 2 C10 | Surface Type 2 C100 | Surface Type 2 Area | Surface Type 3 C10 | Surface Type 3 C100 | Surface Type 3 Area | Average C10 | Average C100 | Initial Length ft | True Initial Length ft | Channel flow Length ft | True Channel Length ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ( ) | 1304142 | 29.94 | 0.25 | 0.35 | 1304142 | 0.90 | 0.95 | 0 | 0.80 | 0.85 | 0 | 0.25 | 0.35 | 1050.00 | 300.00 | 2533.00 | 3283.00 |
| ( ) | 43270 | 0.99 | 0.25 | 0.35 | 0 | 0.90 | 0.95 | 43270 | 0.80 | 0.85 | 0 | 0.90 | 0.95 | 40.00 | 40.00 | 1124.00 | 1124.00 |
| (1.3) | 167633 | 3.85 | 0.25 | 0.35 | 84424 | 0.90 | 0.95 | 83209 | 0.80 | 0.85 | 0 | 0.57 | 0.65 | 103.00 | 103.00 | 1298.00 | 1298.00 |
| | 379978 | 8.72 | 0.25 | 0.35 | 351396 | 0.90 | 0.95 | 8055 | 0.80 | 0.85 | 20527 | 0.29 | 0.39 | 101.00 | 101.00 | 1249.00 | 1249.00 |
| (+1.1+1.2+1.3) | 1895023 | 43.50 | 0.25 | 0.35 | 1739962 | 0.90 | 0.95 | 134534 | 0.80 | 0.85 | 20527 | 0.30 | 0.40 | 1050.00 | 300.00 | 3080.00 | 3830.00 |
| | 277261 | 6.37 | 0.25 | 0.35 | 255954 | 0.90 | 0.95 | 13641 | 0.80 | 0.85 | 7666 | 0.30 | 0.39 | 74.00 | 74.00 | 1253.00 | 1253.00 |
| (A5+1.4) | 2172284 | 49.87 | 0.25 | 0.35 | 1995916 | 0.90 | 0.95 | 148175 | 0.80 | 0.85 | 28193 | 0.30 | 0.40 | 1050.00 | 300.00 | 4132.00 | 4882.00 |
| (1.6) | 108235 | 2.48 | 0.25 | 0.35 | 47363 | 0.90 | 0.95 | 60872 | 0.80 | 0.85 | 0 | 0.62 | 0.69 | 103.00 | 103.00 | 790.00 | 790.00 |
| | 355209 | 8.15 | 0.25 | 0.35 | 348715 | 0.90 | 0.95 | 6494 | 0.80 | 0.85 | 0 | 0.26 | 0.36 | 331.00 | 300.00 | 472.00 | 503.00 |
| 1.6+1.7) | 2635728 | 60.51 | 0.25 | 0.35 | 2391994 | 0.90 | 0.95 | 215541 | 0.80 | 0.85 | 28193 | 0.31 | 0.40 | 1050.00 | 300.00 | 4132.00 | 4882.00 |
| 1) ADD 1.7 (A7+1.6) | | | | | | | | | | | | | | | | | |
| (2.1) | 1439180 | 33.04 | 0.25 | 0.35 | 1375000 | 0.90 | 0.95 | 64180 | 0.80 | 0.85 | 0 | 0.28 | 0.38 | 342.00 | 300.00 | 2274.00 | 2316.00 |
| (2 | 834155 | 19.15 | 0.25 | 0.35 | 785026 | 0.90 | 0.95 | 49129 | 0.80 | 0.85 | 0 | 0.29 | 0.39 | 572.00 | 300.00 | 1166.00 | 1438.00 |
| (+2.2) | 2273335 | 52.19 | 0.25 | 0.35 | 2160026 | 0.90 | 0.95 | 113309 | 0.80 | 0.85 | 0 | 0.28 | 0.38 | 342.00 | 300.00 | 2274.00 | 2316.00 |
| (2.4) | 86543 | 1.99 | 0.25 | 0.35 | 61411 | 0.90 | 0.95 | 25132 | 0.80 | 0.85 | 0 | 0.44 | 0.52 | 59.00 | 59.00 | 757.00 | 757.00 |
| 2.4) | 2359878 | 54.18 | 0.25 | 0.35 | 2221437 | 0.90 | 0.95 | 138441 | 0.80 | 0.85 | 0 | 0.29 | 0.39 | 342.00 | 300.00 | 2610.00 | 2652.00 |
| | 699364 | 16.06 | 0.25 | 0.35 | 509488 | 0.90 | 0.95 | 189876 | 0.80 | 0.85 | 0 | 0.43 | 0.51 | 39.00 | 39.00 | 3664.00 | 3664.00 |
| | 1576166 | 36.18 | 0.25 | 0.35 | 1515527 | 0.90 | 0.95 | 60639 | 0.80 | 0.85 | 0 | 0.28 | 0.37 | 335.00 | 300.00 | 3096.00 | 3131.00 |

| sin | High Point Elevation | Low Point Elevation | Average Slope | Initial Tc | Channe Tc | Total Tc | i2 in/hr | Q2 cfs | i5 in/hr | Q5 cfs | i10 in/hr | Q10 cfs | i25 in/hr | Q25 cfs | i50 in/hr | Q50 cfs | i100 in/hr | Q100 cfs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ( ) | 7025.00 | 6895.00 | 0.036 | 17.92 | 10.94 | 28.86 | 1.83 | 13.70 | 2.52 | 18.85 | 2.94 | 21.99 | 3.78 | 39.59 | 4.28 | 44.86 | 4.48 | 46.98 |
| ( ) | 6927.00 | 6896.00 | 0.027 | 1.71 | 3.75 | 5.45 | 3.71 | 3.32 | 5.10 | 4.56 | 5.96 | 5.32 | 7.66 | 7.23 | 8.68 | 8.19 | 9.09 | 8.57 |
| (1.3) | 6928.00 | 6887.00 | 0.029 | 7.00 | 4.33 | 11.32 | 2.87 | 6.33 | 3.95 | 8.71 | 4.61 | 10.16 | 5.93 | 14.78 | 6.72 | 16.75 | 7.04 | 17.54 |
| | 6942.00 | 6898.00 | 0.033 | 10.22 | 4.16 | 14.39 | 2.60 | 6.64 | 3.57 | 9.14 | 4.17 | 10.67 | 5.36 | 18.21 | 6.07 | 20.64 | 6.36 | 21.61 |
| (+1.1+1.2+1.3) | 7025.00 | 6898.00 | 0.031 | 17.77 | 12.77 | 30.54 | 1.76 | 23.13 | 2.42 | 31.84 | 2.83 | 37.14 | 3.63 | 62.91 | 4.12 | 71.30 | 4.31 | 74.66 |
| | 6900.00 | 6865.00 | 0.026 | 9.35 | 4.18 | 13.52 | 2.68 | 5.07 | 3.69 | 6.98 | 4.30 | 8.14 | 5.53 | 13.85 | 6.27 | 15.70 | 6.57 | 16.44 |
| (A5+1.4) | 7025.00 | 6865.00 | 0.031 | 17.76 | 16.27 | 34.03 | 1.64 | 24.61 | 2.25 | 33.87 | 2.63 | 39.52 | 3.38 | 66.98 | 3.83 | 75.91 | 4.01 | 79.48 |
| (1.6) | 6928.00 | 6906.00 | 0.025 | 6.81 | 2.63 | 9.44 | 3.10 | 4.74 | 4.27 | 6.52 | 4.98 | 7.61 | 6.40 | 10.93 | 7.25 | 12.39 | 7.59 | 12.97 |
| | 6930.00 | 6865.00 | 0.081 | 13.52 | 1.68 | 15.20 | 2.52 | 5.37 | 3.46 | 7.39 | 4.04 | 8.63 | 5.19 | 15.29 | 5.89 | 17.32 | 6.16 | 18.14 |
| 1.6+1.7) | 7025.00 | 6865.00 | 0.031 | 17.59 | 16.27 | 33.87 | 1.67 | 31.15 | 2.29 | 42.87 | 2.67 | 50.02 | 3.44 | 84.16 | 3.90 | 95.38 | 4.08 | 99.86 |
| (2.1) | 7025.00 | 6885.00 | 0.054 | 15.20 | 7.72 | 22.92 | 2.09 | 19.22 | 2.87 | 26.45 | 3.35 | 30.86 | 4.30 | 53.59 | 4.88 | 60.73 | 5.11 | 63.59 |
| (2 | 6993.00 | 6885.00 | 0.062 | 14.30 | 4.79 | 19.09 | 2.25 | 12.41 | 3.09 | 17.07 | 3.61 | 19.92 | 4.64 | 34.23 | 5.26 | 38.80 | 5.51 | 40.62 |
| (+2.2) | 7025.00 | 6885.00 | 0.054 | 15.14 | 7.72 | 22.86 | 2.09 | 30.74 | 2.87 | 42.30 | 3.35 | 49.35 | 4.30 | 85.35 | 4.88 | 96.73 | 5.11 | 101.29 |
| (2.4) | 6914.00 | 6857.00 | 0.070 | 4.97 | 2.52 | 7.49 | 3.37 | 2.94 | 4.64 | 4.05 | 5.41 | 4.72 | 6.96 | 7.25 | 7.89 | 8.22 | 8.26 | 8.60 |
| 2.4) | 7025.00 | 6857.00 | 0.057 | 14.73 | 8.84 | 23.57 | 2.04 | 31.80 | 2.80 | 43.76 | 3.27 | 51.06 | 4.21 | 87.76 | 4.77 | 99.46 | 4.99 | 104.14 |
| | 7022.00 | 6857.00 | 0.045 | 4.78 | 12.21 | 16.99 | 2.44 | 16.72 | 3.36 | 23.01 | 3.92 | 26.84 | 5.04 | 41.51 | 5.71 | 47.04 | 5.98 | 49.26 |
| | 7020.00 | 6874.00 | 0.043 | 16.49 | 10.44 | 26.93 | 1.91 | 18.98 | 2.62 | 26.11 | 3.06 | 30.47 | 3.94 | 53.14 | 4.46 | 60.22 | 4.67 | 63.06 |

DRAFT

**Appendix C: Hydraulics - Ditch Capacity / Lining for Elkhorn Basin**

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT REGION 2 Project Name: 6700042 500.02

Project/Calculation Number: ~~CALC /CHECK DITCH FLOW~~ POWERS BOULEVARD

Title: CALC / CHECK DITCH FLOW

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 7-8-02

Checked by: DANNA JUDISH Date: 7/9/02

Description and Purpose:
CALC DITCH FLOW CAPACITY AND CHECK FOR CHANGES.

Design bases/references/assumptions:
- FLOW MASTER
- CDOT DRAINAGE CRITERIA MANUAL

Remarks/conclusions:
See Comments ON calc Sheets

Calculation Approved by: ______
Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

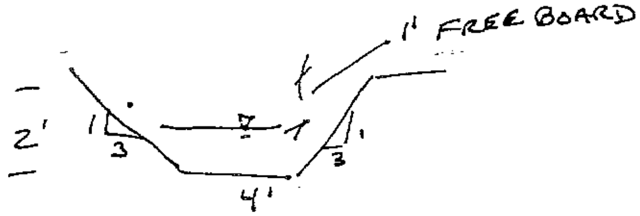
URS

| | | | |
|---|---|---|---|
| Job: POWERS BOULEVARD + | Project No. 62000 42500.02 | Page ___ of ___ | Sheet 1 of ___ |
| Description: STATE HIGHWAY 83 | Computed by: EDE | Date: 7-8-02 | |
| DITCH FLOW | Checked by: | Date: | |

Reference

* ASSUMPTION : ALL DITCHES WILL BE GRASS-LINED
$n = 0.035$

TYPICAL DITCH




WORST CASE SCENARIO IS 0.5% SLOPE
GIVES A MAX Q = 16.2 cfs

ANY FLOW BELOW THIS WILL FIT IN DITCH W/ FREEBOARD

PLACES TO REVIEW

1. RAMP E (RT) FROM SH83 TO BOX ENTRANCE (21 cfs)

2. POWERS (LT) ~~FROM AND FROM~~
+ RAMP G (RT) LOW POINT TO POWERS
+ THEN DOWN TO SH83 (17 cfs)

3. POWERS MEDIAN (CT.) FROM BLACK SQUIRREL CREEK
TO SH83 (22 cfs)

3A. POWERS MEDIAN FROM SH83 TO KETTLE (14 cfs)

4. POWER (RT) FROM RAMP H TO SH 83 (23 cfs)

SOL'N

✓ 1.) MAKE SAME DITCH W/ MIN. SLOPE OF 0.85%
FOR RAMP E (RT)

✓ 2.) START DITCH @ MIN SLOPE OF 0.55% FROM
LOW POINT TILL YOU MATCH INTO POWERS GRADE.

3.) CHECK OUT MEDIAN FLOW SEPERATE.

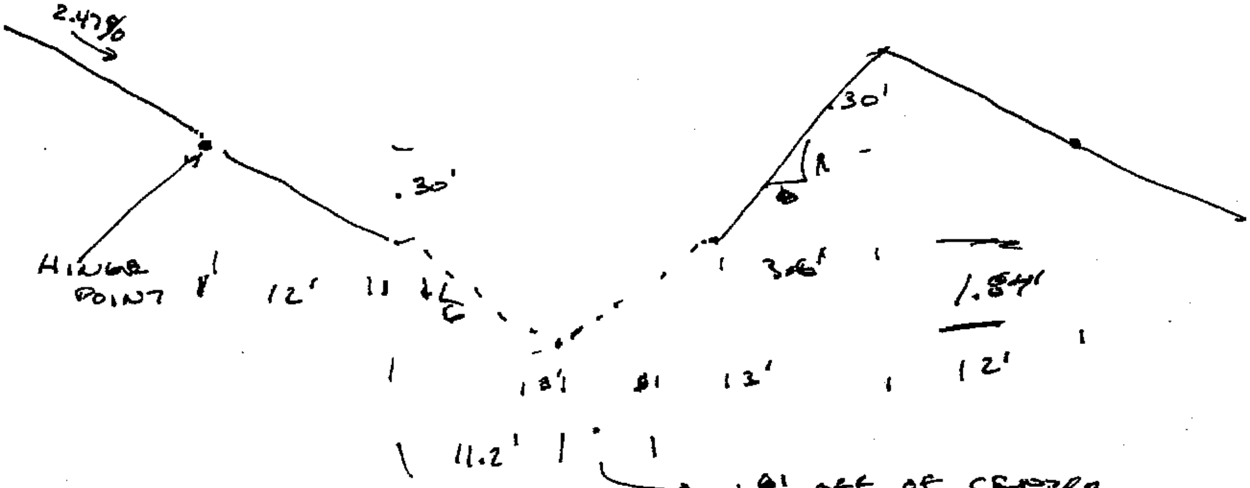
3A.)

4.) MAX FLOW IN CHANNEL IS 18.5 cfs ∴ Need
inlets along this in FUTURE.

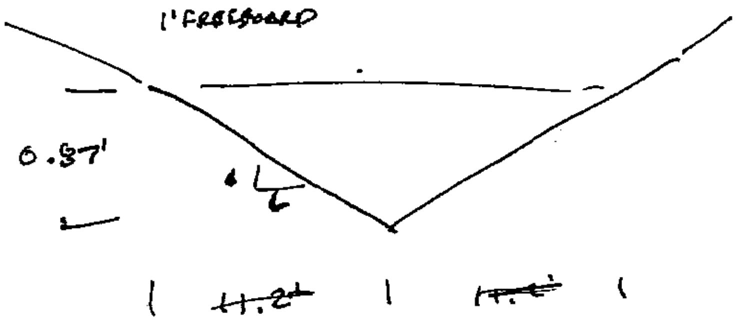
URS

| | | | |
|---|---|---|---|
| Job POWERS BOULEVARD + | Project No. 61000425000.02 | Page ___ of ___ | |
| Description STATE HIGHWAY 83 | Computed by SDS | Sheet 2 of ___ | |
| DITCH FLOW | Checked by ___ | Date 7-8-02 | |
| | | Date ___ | |
| | | | Reference |

MEDIAN FLOWS




REDRAW:




MAX FLOW IN CENTER IS 10.5 cfs

SO WE WILL NEED INLETS IN MEDIAN BOTH NORTH AND SOUTH OF SH 83

FOR INTERIM CONDITION. SIZE INLET FOR 10.5 cfs WITH ~~10.5~~ 11.5 cfs max pipe in

11.5 pipe flow future (inlets to be determined)

10.5 median flow

inlet to be placed now

22cfs - 10.5cfs = 11.5cfs to inlet

Channel

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Typical Ditch Flc |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Form |
| Solve For | Discharge |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Depth | 1.00 | ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |

| Results | | |
|---|---|---|
| Discharge | 16.22 | cfs |
| Flow Area | 7.0 | ft² |
| Wetted Perim | 10.32 | ft |
| Top Width | 10.00 | ft |
| Critical Depth | 0.67 | ft |
| Critical Slope | 0.023267 | ft/ft |
| Velocity | 2.32 | ft/s |
| Velocity Head | 0.08 | ft |
| Specific Energ | 1.08 | ft |
| Froude Numb | 0.49 | |
| Flow Type | Subcritical | |

TYPICAL DITCH

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Typical Ditch Flc |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Formι |
| Solve For | Discharge |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 008500 | ft/ft |
| Depth | 1.00 | ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |

| Results | | |
|---|---|---|
| Discharge | 21.15 | cfs |
| Flow Area | 7.0 | ft² |
| Wetted Perimι | 10.32 | ft |
| Top Width | 10.00 | ft |
| Critical Depth | 0.78 | ft |
| Critical Slope | 0.022378 | ft/ft |
| Velocity | 3.02 | ft/s |
| Velocity Head | 0.14 | ft |
| Specific Enerç | 1.14 | ft |
| Froude Numbι | 0.64 | |
| Flow Type | Subcritical | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Typical Ditch Flc |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Formı |
| Solve For | Discharge |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005500 | ft/ft |
| Depth | 1.00 | ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |

| Results | | |
|---|---|---|
| Discharge | 17.01 | cfs |
| Flow Area | 7.0 | ft² |
| Wetted Perimı | 10.32 | ft |
| Top Width | 10.00 | ft |
| Critical Depth | 0.69 | ft |
| Critical Slope | 0.023104 | ft/ft |
| Velocity | 2.43 | ft/s |
| Velocity Head | 0.09 | ft |
| Specific Energ | 1.09 | ft |
| Froude Numb | 0.51 | |
| Flow Type | Subcritical | |

# Worksheet
## Worksheet for Triangular Channel

| Project Description | |
|---|---|
| Worksheet | Median Flow |
| Flow Element | Triangular Char |
| Method | Manning's Forr |
| Solve For | Discharge |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 009200 | ft/ft |
| Depth | 0.87 | ft |
| Left Side Slope | 6.00 | H : V |
| Right Side Slope | 6.00 | H : V |

| Results | | |
|---|---|---|
| Discharge | 10.52 | cfs |
| Flow Area | 4.5 | ft² |
| Wetted Perim | 10.58 | ft |
| Top Width | 10.44 | ft |
| Critical Depth | 0.72 | ft |
| Critical Slope | 0.025576 | ft/ft |
| Velocity | 2.32 | ft/s |
| Velocity Head | 0.08 | ft |
| Specific Energ | 0.95 | ft |
| Froude Numb | 0.62 | |
| Flow Type | Subcritical | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp E Sta. 114 RT 1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 010500 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 11.70 | cfs |

← AVE slope

← $Q_{100}$ ⇒ BASIN ULT-AQ1-A

| Results | | |
|---|---|---|
| Depth | 0.64 | ft |
| Flow Area | 3.8 | ft² |
| Wetted Perim | 8.06 | ft |
| Top Width | 7.85 | ft |
| Critical Depth | 0.56 | ft |
| Critical Slope | 0.017957 | ft/ft |
| Velocity | 3.08 | ft/s |
| Velocity Head | 0.15 | ft |
| Specific Energ | 0.79 | ft |
| Froude Numb | 0.78 | |
| Flow Type | Subcritical | |

← Depth → TOTAL DEPTH = 2 FT ok✓

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp E Sta. 114 RT |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 010500 | ft/ft ← MAX SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 5.50 | cfs ← $Q_{10}$ BASIN ULT-A&A |

| Results | | |
|---|---|---|
| Depth | 0.43 | ft |
| Flow Area | 2.2 | ft² |
| Wetted Perim | 6.69 | ft |
| Top Width | 6.55 | ft |
| Critical Depth | 0.35 | ft |
| Critical Slope | 0.020248 | ft/ft |
| Velocity | 2.45 | ft/s ← velocity |
| Velocity Head | 0.09 | ft |
| Specific Energ | 0.52 | ft |
| Froude Numb | 0.74 | |
| Flow Type | Subcritical | |

$$R = \frac{2.2}{6.69} = 0.33 \text{ ft}$$

$$\tau = \gamma R S$$

$$= (62.4 \text{ lb/ft}^3)(0.33 \text{ ft})(.0105 \tfrac{\text{ft}}{\text{ft}})$$

$$= .22 \text{ lb/ft}^2$$

Class C Veg. $\tau = 1.00$ max

ok!

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | SH 83 Sta. 221 RT 10 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 028200 | ft/ft ← AVE. SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 21.40 | cfs ← $Q_{100}$ → BASIN ULT-AC03 |

| Results | | |
|---|---|---|
| Depth | 0.68 | ft ← Depth |
| Flow Area | 4.1 | ft² |
| Wetted Perim | 8.30 | ft |
| Top Width | 8.08 | ft |
| Critical Depth | 0.78 | ft |
| Critical Slope | 0.016413 | ft/ft |
| Velocity | 5.21 | ft/s |
| Velocity Head | 0.42 | ft |
| Specific Enerç | 1.10 | ft |
| Froude Numb | 1.29 | |
| Flow Type | Supercritical | |

Total Depth = 2ft OK ✓

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | SH 83 Sta. 221 RT 1i |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 113000 | ft/ft ← MAX SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 11.60 | cfs ← $Q_{10}$ BASIN ULT-AC03 |

| Results | | |
|---|---|---|
| Depth | 0.33 | ft |
| Flow Area | 1.7 | ft² |
| Wetted Perim | 6.10 | ft |
| Top Width | 5.99 | ft |
| Critical Depth | 0.55 | ft |
| Critical Slope | 0.017981 | ft/ft |
| Velocity | 6.99 | ft/s ← velocity |
| Velocity Head | 0.76 | ft |
| Specific Energ | 1.09 | ft |
| Froude Numb | 2.34 | |
| Flow Type | Supercritical | |

$R = \frac{1.7}{6.10} = 0.28\ ft$

$\tau = \gamma R S$

$= (62.4\ \frac{lb}{ft^3})(0.28 ft)(.113 ft/ft)$

$= 1.97\ lb/ft^2$

normal curlex blanket > $\tau = 2.00\ lb/ft^2$

CLOSE BUT OK!

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | SH 83 Sta. 221 LT 10( |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 018900 | ft/ft ← AVG SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 9.50 | cfs ← $Q_{100}$ BASIN ULT-4Φ3 |

| Results | | |
|---|---|---|
| Depth | 0.49 | ft ← Depth |
| Flow Area | 2.7 | ft² |
| Wetted Perim | 7.09 | ft |
| Top Width | 6.93 | ft |
| Critical Depth | 0.49 | ft |
| Critical Slope | 0.018545 | ft/ft |
| Velocity | 3.55 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Enerç | 0.69 | ft |
| Froude Numb | 1.01 | |
| Flow Type | Supercritical | |

Total Depth = 2ft OK ✓

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | SH 83 Sta. 221 LT 1( |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 020700 | ft/ft ← MAX SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 5.30 | cfs ← $Q_{10}$ BASIN ULT-A03 |

| Results | | |
|---|---|---|
| Depth | 0.34 | ft |
| Flow Area | 1.7 | ft² |
| Wetted Perim | 6.18 | ft |
| Top Width | 6.07 | ft |
| Critical Depth | 0.35 | ft |
| Critical Slope | 0.020374 | ft/ft |
| Velocity | 3.06 | ft/s ← velocity |
| Velocity Head | 0.15 | ft |
| Specific Energ | 0.49 | ft |
| Froude Numb | 1.01 | |
| Flow Type | Supercritical | |

$R = \frac{1.7}{6.18} = 0.28$ ft

$\tau = \gamma R S$

$= (62.4 \frac{lb}{ft^3})(0.28 ft)(0.0207 \frac{ft}{ft})$

$= 0.36$ lb/ft²

CLASS C Vegetation $\tau = 1.00$ max

ok!

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp F Sta. 410 RT 1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | | |
|---|---|---|---|
| Mannings Coeffic | 0.030 | | |
| Slope | 063600 | ft/ft | ← AVE SLOPE |
| Left Side Slope | 3.00 | H : V | |
| Right Side Slope | 3.00 | H : V | |
| Bottom Width | 4.00 | ft | |
| Discharge | 7.20 | cfs | ← $Q_{100}$ = BASIN INT- A10A |

| Results | | | |
|---|---|---|---|
| Depth | 0.30 | ft | ← Depth |
| Flow Area | 1.5 | ft² | |
| Wetted Perim | 5.89 | ft | |
| Top Width | 5.79 | ft | |
| Critical Depth | 0.42 | ft | |
| Critical Slope | 0.019378 | ft/ft | |
| Velocity | 4.93 | ft/s | |
| Velocity Head | 0.38 | ft | |
| Specific Energ | 0.68 | ft | |
| Froude Numb | 1.73 | | |
| Flow Type | Supercritical | | |

Total Depth = 2ft ok ✓

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp f Sta. 410 RT 1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 142900 | ft/ft ← MAX SLOPE |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 3.40 | cfs ← $Q_{10}$ - BASIN INT-A10A |

| Results | | |
|---|---|---|
| Depth | 0.15 | ft |
| Flow Area | 0.7 | ft² |
| Wetted Perim | 4.97 | ft |
| Top Width | 4.92 | ft |
| Critical Depth | 0.26 | ft |
| Critical Slope | 0.021972 | ft/ft |
| Velocity | 4.98 | ft/s ← velocity |
| Velocity Head | 0.39 | ft |
| Specific Energ | 0.54 | ft |
| Froude Numb | 2.36 | |
| Flow Type | Supercritical | |

$$R = \frac{0.7}{4.97} = 0.14\ ft$$

$$\tau = \gamma R S$$

$$= \left(62.4 \frac{lb}{ft^3}\right)(0.14\ ft)\left(.1429 \frac{ft}{ft}\right)$$

$$= 1.25\ lb/ft^2$$

due to temp situation

CLASS G Veg. $\tau = 1.00$

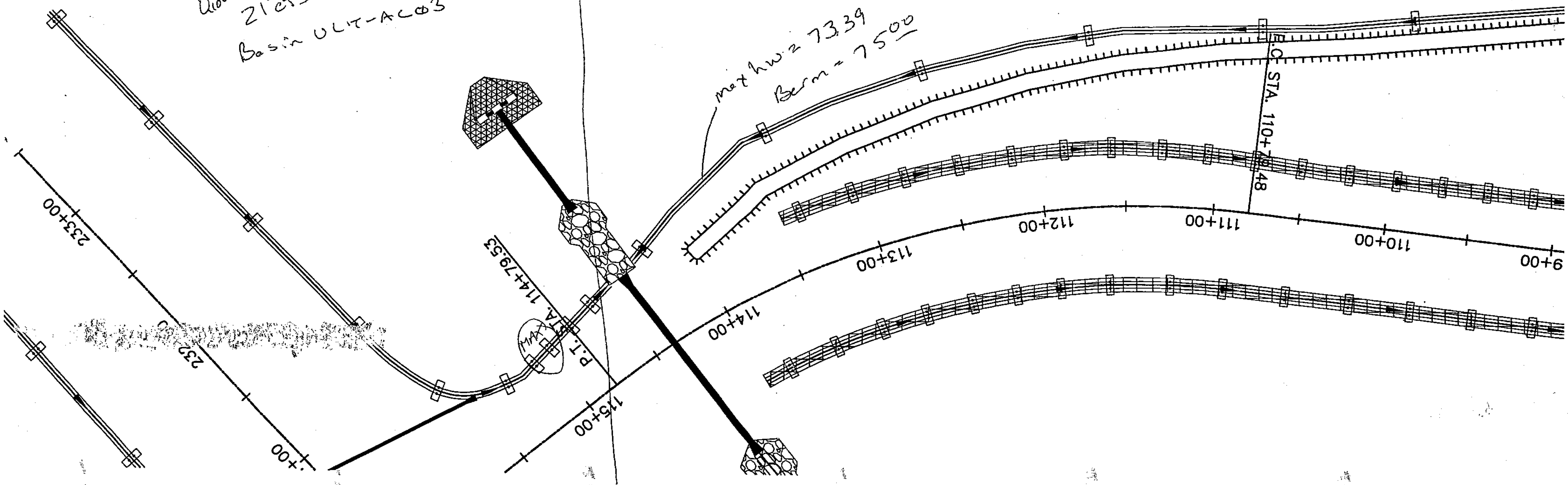
OK. for short duration

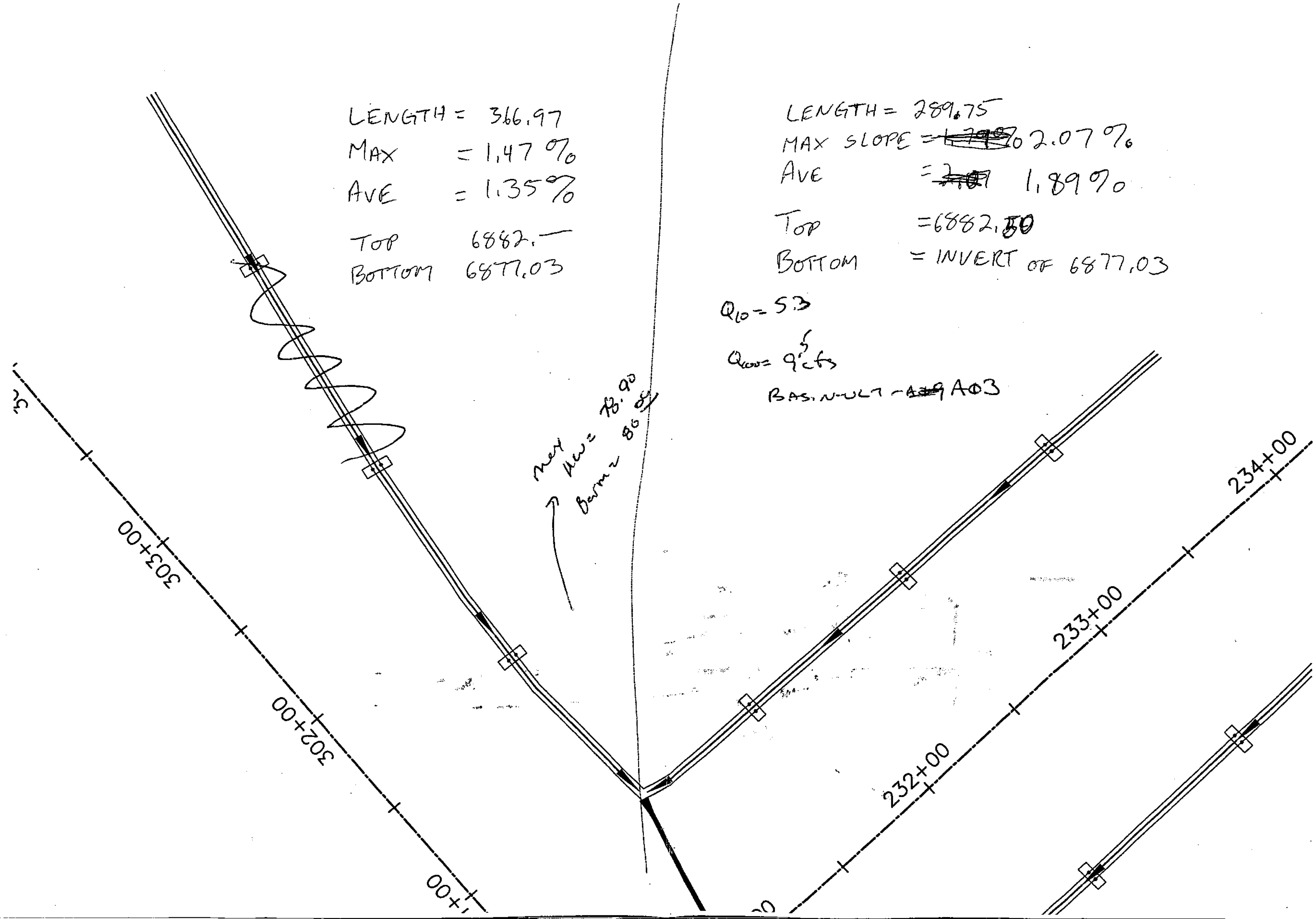
| | | |
|---|---|---|
| LENGTH | 453. | |
| MAX | 11.30% | |
| AVE | 2.82% | |
| TOP | 6882.50 | |
| BOTTOM | 6869.73 | |

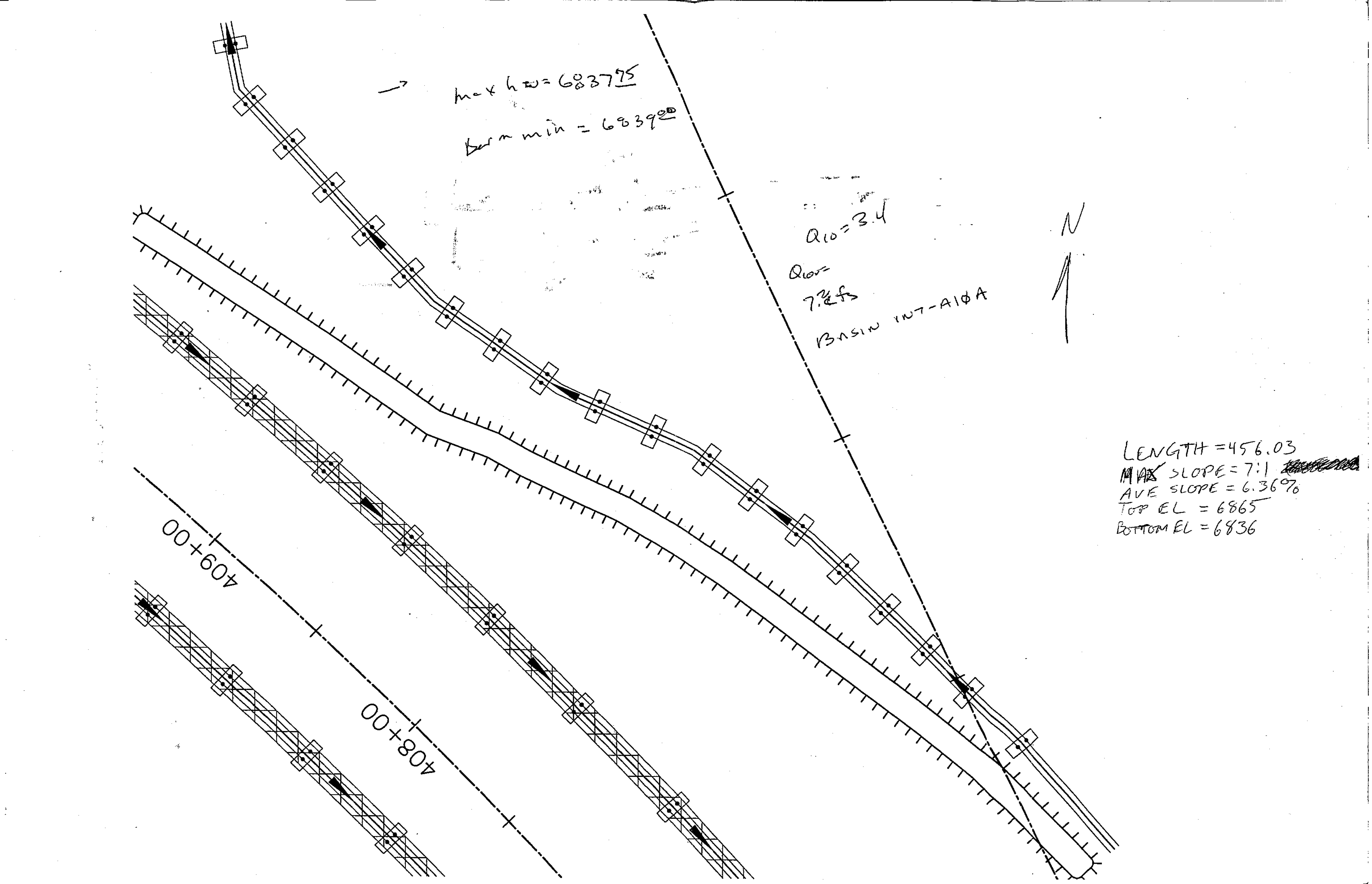
| | | |
|---|---|---|
| LENGTH | 595.35 | |
| MAX | 1.05% | |
| AVE | 1.05% | |
| TOP | 6876.00 | |
| BOTTOM | 6869.73 | |

Q10 = 5.5
Q100 = 7 cfs
Basin ULT-A01-A

Q10 = 11.6
Q100 = 21 cfs
Basin ULT-AC03




LENGTH = 366.97
MAX = 1.47 %
AVE = 1.35 %
TOP 6882.—
BOTTOM 6877.03
LENGTH = 289.75
MAX SLOPE = 2.07 %
AVE = 1.89 %
TOP = 6882.50
BOTTOM = INVERT OF 6877.03
Q10 = 5.3
Q100 = 9.5 cfs
BASIN-ULT-A03
Max HW =
Berm ≈
303+00
302+00
232+00
233+00
234+00


max hw = 6837.75
Berm min = 6839.00
Q10 = 3.4
Q100 =
7.2 cfs
BASIN INT-A10A
N
LENGTH = 456.03
MAX SLOPE = 7:1
AVE SLOPE = 6.36%
TOP EL = 6865
BOTTOM EL = 6836
409+00
408+00

DRAFT

**Appendix D: Hydraulics - Culvert Design for Elkhorn Basin**

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT  Project Name: POWERS + SH83

Project/Calculation Number: 6742500.02

Title: ELKHORN BASIN CULVERTS UNDER POWERS, RAMP E + RAMP F

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: JASON MEHLHOP  Date: 7-8-02

Checked by: DANNY ELSNER  Date: 7-9-02

Description and Purpose:

- INVERTS FOR FUTURE BOX CULVERTS UNDER POWERS, RAMP E, + RAMP F FOR ELKHORN BASINS.

Design bases/references/assumptions:

- ALIGNMENTS, PROFILES FOR POWERS, RAMP E + RAMP F
- CULVERT SIZES FOR EARLIER CALCS
  BASED ON FLOWS FOR EARLIER CALCS

Remarks/conclusions:

Calculation Approved by: [signature] 8-13-02
Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

**URS**

Page ____ of ____

Job POWERS BOULEVARD Project No. 67-00042500.02 Sheet 1 of ____

Description ELKHORN BOX CULVERT CALC'S Computed by JJM Date 7/8/02

Checked by EDE Date 7-9-02

Reference

755+55.85 (INT POWER ALIGN + BOX ALIGN)

758+00 EL = 6845.55

℄ EL @ 755+55.85 = 6845.55 − 0.0092×(758+00 − 755+55.85)
6845.55 − 2.246
6843.30

FLOW = ℄ − .30' − 1.87' (SEE PAGE 2)

MEDIAN 6841.13

EDGE OF SHOULDER = ℄ − 1.43' − 2.0' (SEE PAGE 2)
= 6839.87

BOX CULVERT BASED ON EDGE OF SHOULDER
95' R OF CL

INVERT @ EDGE OF SHOULDER FOR BOX =
6839.87 − 2' (COVER) − .67 (BOX THICKNESS) − 4' (BOX HEIGHT)

6833.20

SEE PAGE 2 FOR DRAWING

@ 100.92 R BOX STOPS W/ INV = 6833.23

@ 115.03 R WING WALLS STOPS W/ INV = 6833.30

**URS**

Page ___ of ___

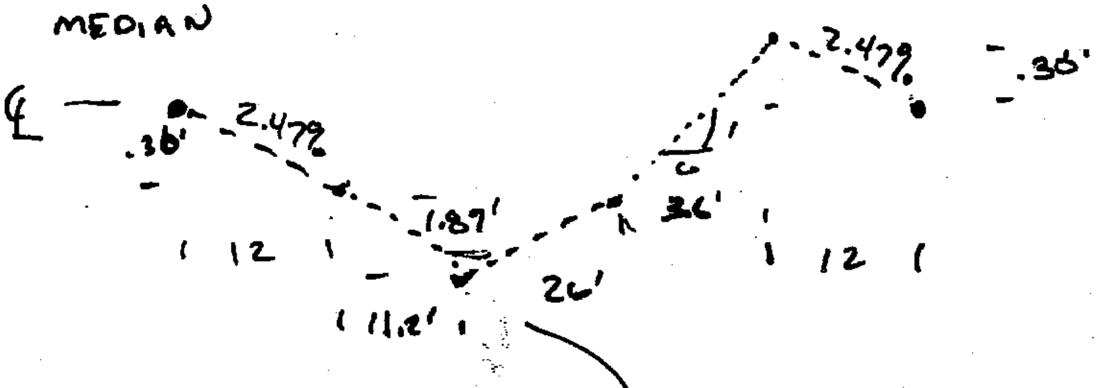
Job Powers Boulevard — Project No. 67-00042500.02 — Sheet 2 of ___

Description Elkhorn Box Culvert Calc's — Computed by JJM — Date 7/8/02

Checked by EDS — Date 7-9-02

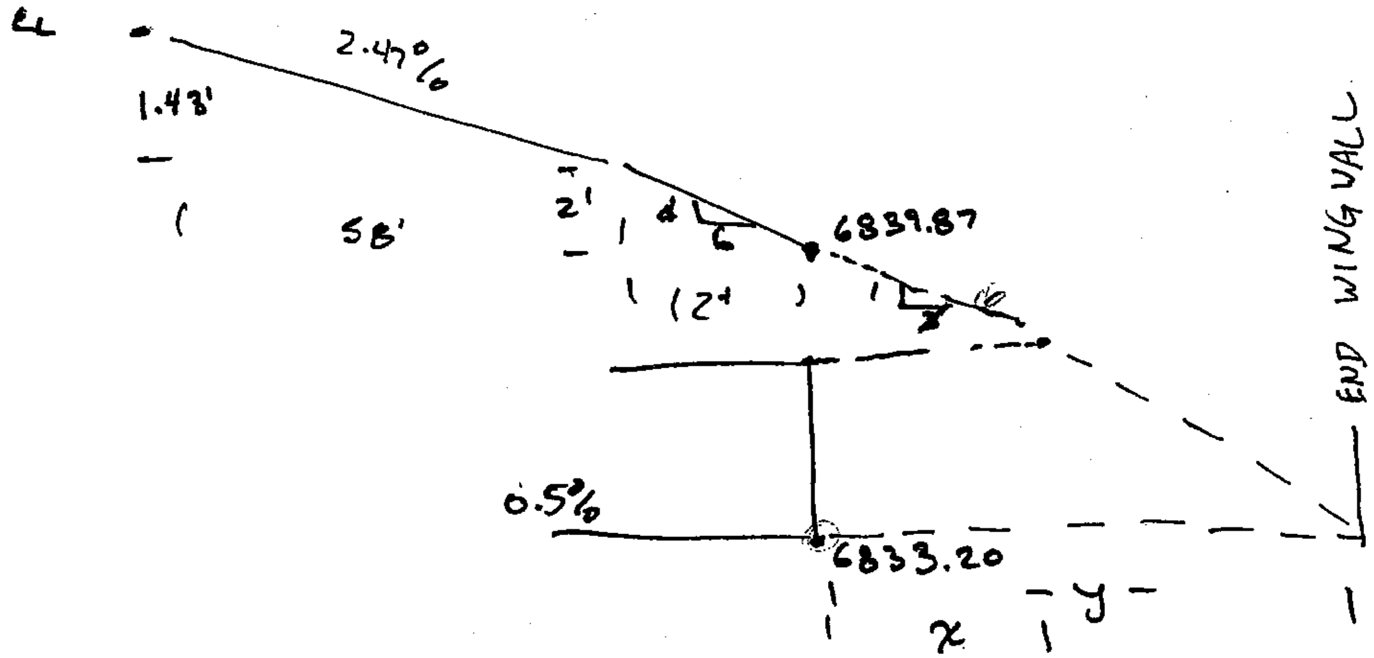
Reference

MEDIAN




∴ FL = ℄ − .30' − 1.87'

EDGE OF SHOULDER




$\therefore\ 6833.20 + 4' + .67' + .005x = 6839.87 - x/6$

$.172x = 2$

$x = 11.63'$

∴ @ 106.63' box stops.

INV = 6833.2

URS

Page ____ of ____

Job POWERS BOULEVARD
Project No. 67-00042500.02
Sheet 3 of ____

Description ELKHORN BOX CULVERT CALC'S
Computed by JSM
Date 7/8/02

Checked by CPZ
Date 7-9-02

Reference

FOR WINGWALLS

$\therefore 6833.20 + \cancel{y}(.005) = 6831.97 - \cancel{y}/\cancel{3}6$

~~.338~~ 172 y = 6.77

y = ~~20.03'~~ 39.36'

~~115.03'~~ 134.36' from CL end of wing walls

INV = 68~~33.30~~ 33.40

URS

Job POWERS BOULEVARD — Project No. 67-00042500.02 — Page ____ of ____ — Sheet 4 of ____

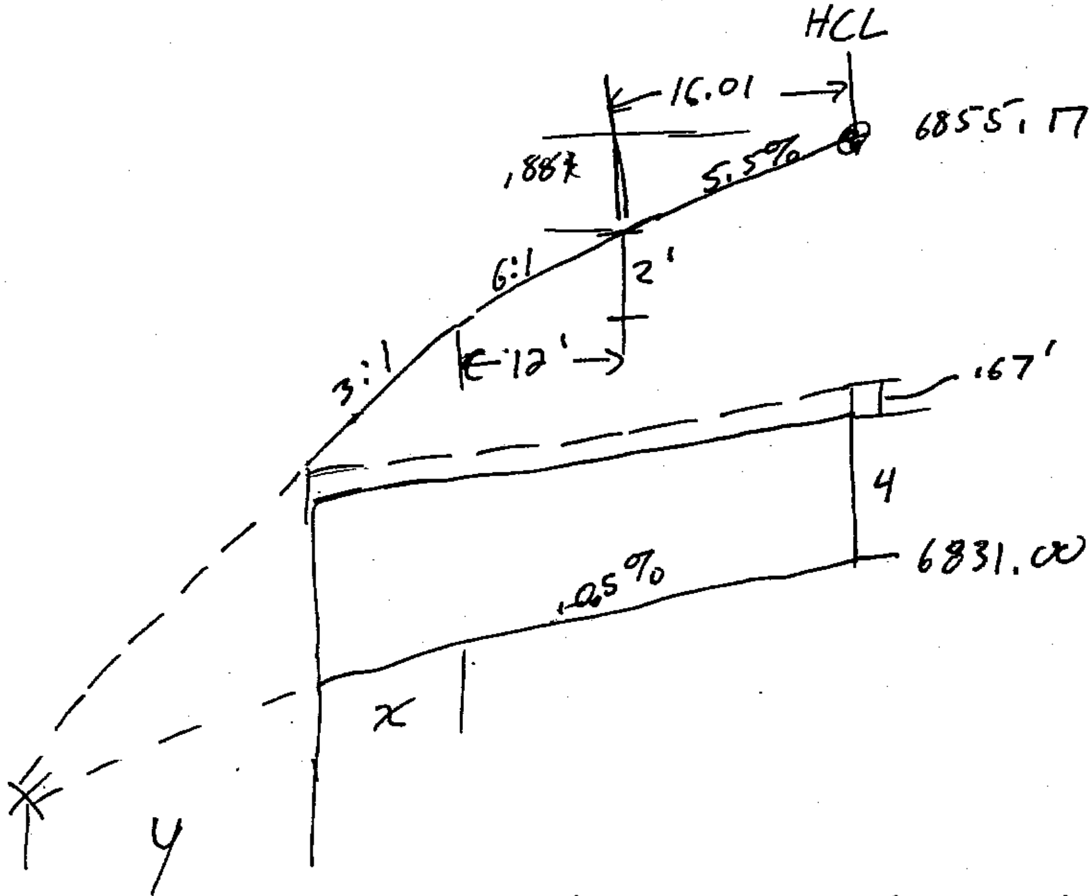
Description ELKHORN BOX CULVERT CALC'S — Computed by JJM — Date 7/9/02

Checked by GDE — Date 7-9-02

Reference

INV IN @ WING WALLS = 6833.30

INV @ INT OF BOX + RAMP F ALIGNMENTS =
(RAMP F STA. 40+66.29) 6833.30 − .005(459.26) = 6831.00




$$\therefore\ 6855.17 - .881 - 2 - x/3 = 6831.00 - (28.01 + x)(.005) + 4.67$$
$$.328x = 16.76$$
$$x = 51.10$$
∴ INV of BOX STOP = 6830.60

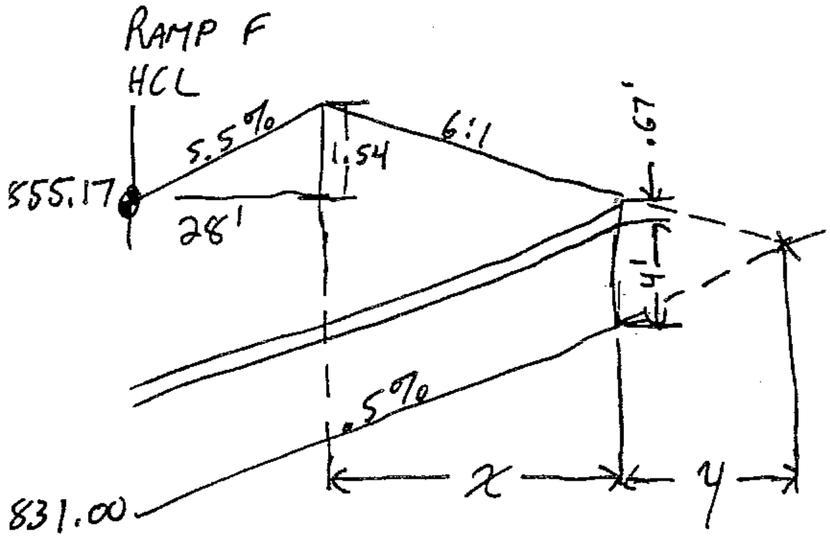
$$6830.60 - .005y = 6830.60 + 4.67 - y/3$$
$$.328y = 4.67$$
$$y = 14.24$$

∴ INV @ WINGWALL = 6830.53
(43.35' L)

**URS**

| | | | |
|---|---|---|---|
| | | Page ___ of ___ | |
| Job POWERS BOULEVARD | Project No. 67-00042500.02 | Sheet 5 of ___ | |
| Description ELKHORN BOX CULVERT CALC'S | Computed by SJM | Date 7/9/02 | |
| | Checked by [illegible] | Date 7-9-02 | |

Reference




$$6855.17 + 1.54 - x/6 = 6831 + .005(28 + x) + 4.67$$

$$.172x = 20.90$$ ✓

$$x = 121.51$$ ✓

∴ INV OF BOX STOP = 6831.75 ✓

$$6831.75 + .005y = 6831.75 + 4.67 - y/6$$

$$.172y = 4.67$$

$$y = 27.15$$ ✓

∴ INV @ WINGWALL = 6831.89 ✓
(176.66 R)

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS BOULEVARD | Project No. 67000042500.02 | Page ___ of ___ | |
| Description: BOX CULVERT CALCS. RAMP E | Computed by: EDE | Sheet 1 of ___ | Date 7-8-02 |
| | Checked by: JSM | | Date ___ |

Reference

DISTANCE FROM BOX/WING = ~~400.00~~ 382.20'
TO RAMP E STA. 114+38.22

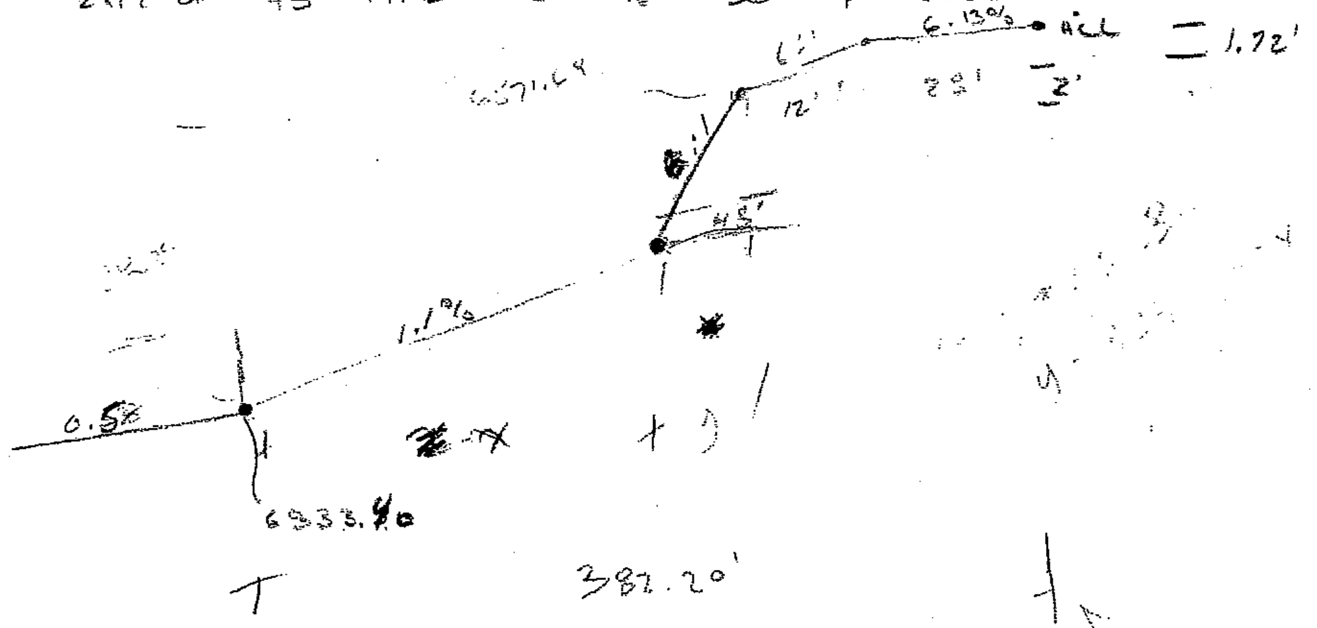
ELEVATION @ BOX/WING = 6833.~~30~~40

EL @ RAMP F STA. 114+38.22 = 6875.41

SUPER @ 113+80 = 8%  ∴ SUPER @ 114+38.22 = 6.13%
SUPER @ 115+75 = 1.75%

$1.75 + \frac{(8-1.75)}{(113+80 - 115+75)}(114+38.22 - 113+75)$

- RUN CHANNEL FROM ENT OF BOX CULVERT TO EXIT OF 48" PIPE @ 1.1% SO $F_r$ = 0.80




$6833.40 + .011x = 6875.41 - 1.72' - 2' - [(382.20) - x - 40]/6$

$18.74 = .156x$

$x = 120.13$

∴ EXIT OF 48" RCP = 6834.72 ±

y = 222.07'

EPS = 262.07' AWAY FROM E

**URS**

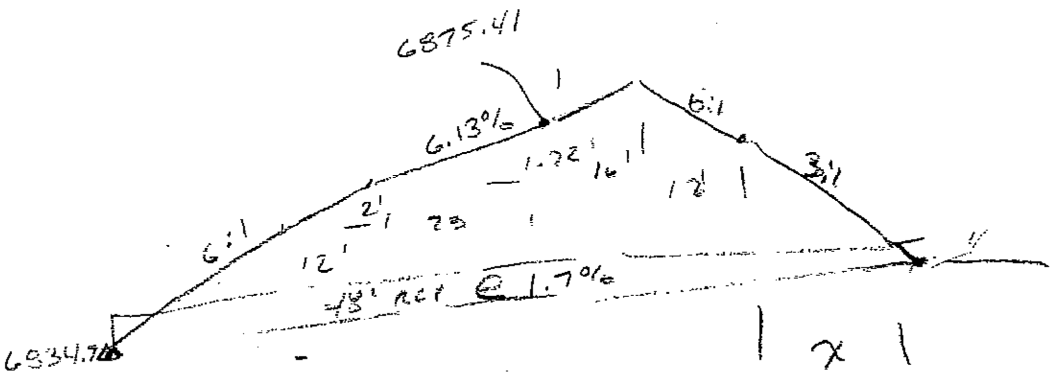
Page ____ of ____

Job: POWERS BOULEVARD — Project No. 67000425000.02 — Sheet 2 of ____

Description: BOX CULVERT CALC. RAMPS — Computed by: EDE — Date: 7-8-02

Checked by: SJM — Date: ____

Reference




* 222.07' *

$6875.41 - 16(.063) - 2' - 8/3 = 6834.72 + (222.07 + 12 + 28 + 16 + 12 + x)(.0$

$34.77' = .350x$

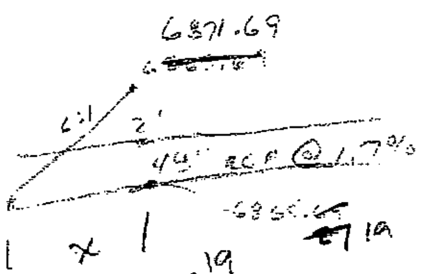
$99.34 = x$

∴ INV = 6841.34  PIPE @ 127.34' FROM ℄

NOT GOING TO WORK. TOO DEEP

☆ INSTEAD SET DOWNSTREAM INVERT TO HAVE 2' COVER UNDER SHOULDER. ∴ INV = 6875.41 − 28'(.0613) − 12/6 − 2' − 4' − ~~.42~~ .5'

= 6865.~~65~~ ~~27~~ @ SHOULDER
65.19




∴ 6871.69 − 8/6 = 6865.~~27~~ 19 − x(.017)

.150x

x = 40"
~~42.8~~
43.33

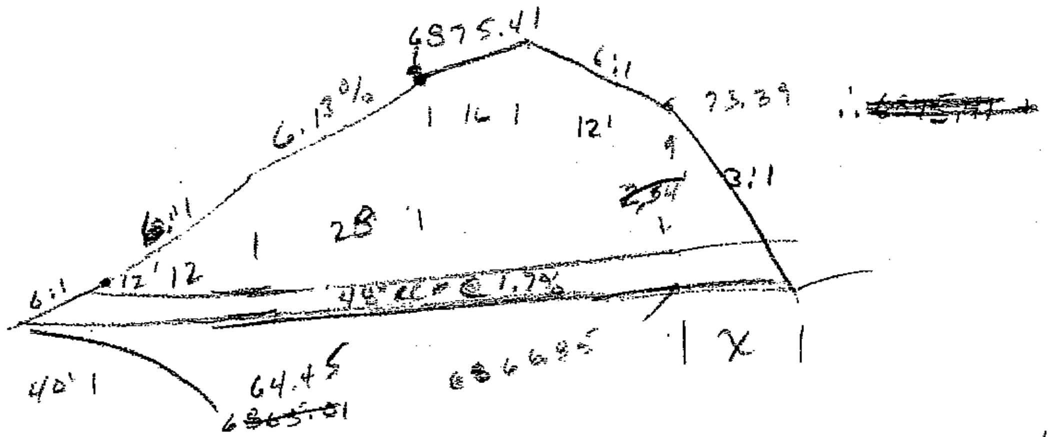
INV = 686~~5.01~~ ~~4.54~~ ~~2.27~~ 64.45

@ ~~80'~~ AWAY FROM ℄
~~82.8'~~
83.33'

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS BOULEVARD | Project No. 6700042500.02 | Page ___ of ___ | |
| Description: BOX CULVERT CALC RAMP E | Computed by EDE | Sheet 3 of ___ | Date 7-9-02 |
| | Checked by JJM | | Date ___ |

Reference




$\therefore$ 6875.41 + 16(.0613) − 12/6 − x/3 = ~~6865.01~~ 6864.45 + (~~40~~ 43.53 + 12 + 28 + 16 + 12 + x)(.017)

8.05 ~~7.64~~ = .350 x

x = ~~21.84~~ 23.00'

$\therefore$ INV = 68~~67.21~~ 66.73 @ ~~49.5~~ 51' AWAY FROM ℄

URS

Job: POWDER BOULEVARD + SH 83 RAMP & DITCH / BERM

Project No. 67000242522.02 | Page ___ of ___ | Sheet 1 of 1

Computed by EDE | Date 7-10-02

Checked by ___ | Date ___

Reference

BY EARLIER CALCS 51' RT @ 114+33.22
EL = 6866.73

SLOPE MAX IS 1.75% (3.24 ft/s Fr = 0.85)

∴ WORKING AWAY FROM SH83

114+00.00 = 6867.40 (DITCH IS LOWER THAN RD)
113+50 = 6868.287 BLEND OUT!
113+00 = 6869.165 ~~BLEND OUT~~!
112+50 = 6870.042
112+00 = 6870.920
111+50 = 6871.~~80~~ 77
111+00 = 6872.685
110+50 = 6873.~~56~~ 57
110+00 = 6874.~~49~~ 40
109+50 = 6875.~~32~~ 27
109+00 = 6876.~~20~~ 15
TRY 108+50 = 6877.~~08~~ 02 (WON'T FIT.)

HW @ CULVERT = 66.73
+ 6.84 (FROM CALCULATION)
+ 1' (FREEBOARD MIN)
74.57

HW BERM = 6875

WORKING TOWARDS SH83

ASSUME MAX V = 7 ft/s (LINING) = 9%

114+50 = 6867.79
115+00 = 6872.29
115+50 = 6876.79 (EL: GRADE 77 SO HOLD NORMAL)

**URS**

Job POWERS BOULEVARD — Project No. 67000012500.02 — Page ___ of ___ — Sheet 1 of 1

Description + SH83 — Computed by EDE — Date 7-10-02

RAMP F DITCH / BERM — Checked by ___ — Date ___

Reference

BY EARLIER CALLS 410+67.34 149.51' RT

IOL = 6831.89

4:1 SLOPE GIVES 7 ft/s (LINING)

HOLD TOP.

WORKING AWAY FROM SH83

~~410+50~~
~~411+00 6840.06~~
~~410+00~~
~~410+50 = 6852.56~~
~~410+00~~

410+50 = 6836.23
410+00 = 6848.73
409+50 = 6852.98 (EXIST 2' DITCH)
409+00 = 6852.80
408+50 = 6859.76

redo!

406+00 = 6865.02

STRAIGHT GRADE = 7.5%

V = 4.57 ft/s (GRASS)

410+50 = 6833.~~89~~ .19
410+00 = 683~~7.64~~ 6.94
409+50 = 68~~41.39~~ 0.69
409+00 = 684~~5.14~~ 4.44 406+00 = 6865~~.02~~ 6.94
408+50 = 6848.~~89~~ .19
408+00 = 685~~2.64~~ 1.94
407+50 = 685~~6.39~~ 5.69
407+00 = 68~~60.14~~ 59.44
406+50 = 6863.~~89~~ .19

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Upstream Channel for 4 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 017500 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 11.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.59 | ft |
| Flow Area | 3.4 | ft² |
| Wetted Perim | 7.72 | ft |
| Top Width | 7.53 | ft |
| Critical Depth | 0.54 | ft |
| Critical Slope | 0.024674 | ft/ft |
| Velocity | 3.24 | ft/s |
| Velocity Head | 0.16 | ft |
| Specific Energ | 0.75 | ft |
| Froude Numb | 0.85 | |
| Flow Type | Subcritical | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ditch from SH83 to Ramp |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 090000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 21.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.54 | ft |
| Flow Area | 3.0 | ft² |
| Wetted Perim | 7.39 | ft |
| Top Width | 7.21 | ft |
| Critical Depth | 0.78 | ft |
| Critical Slope | 0.022400 | ft/ft |
| Velocity | 6.99 | ft/s |
| Velocity Head | 0.76 | ft |
| Specific Energ | 1.30 | ft |
| Froude Numb | 1.91 | |
| Flow Type | Supercritical | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Temp Ditch on R |
| Flow Element | Trapezoidal Char |
| Method | Manning's Formu |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 075000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 7.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.31 | ft |
| Flow Area | 1.5 | ft² |
| Wetted Perim | 5.93 | ft |
| Top Width | 5.83 | ft |
| Critical Depth | 0.41 | ft |
| Critical Slope | 0.026496 | ft/ft |
| Velocity | 4.66 | ft/s ✓ |
| Velocity Head | 0.34 | ft |
| Specific Energ | 0.64 | ft |
| Froude Numb | 1.62 | |
| Flow Type | Supercritical | |

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS BOULEVARD | Project No. 61000242500.02 | Page ___ of ___ | |
| | | Sheet 1 of ___ | |
| Description: @ STATE HIGHWAY 83 | Computed by: EDE | Date: 7-12-02 | |
| RAMP H CALCS | Checked by: | Date: | |
| | | Reference | |

FROM EARLIER CALCS
115+00 = 6872.29
115+50 = 6895.27 } RAMP E

11 cfs max in culvert under SH 83

CAN RUN a 24" RCP at 0.25% SLOPE WITH

SET UPSTREAM INVERT @ 231+00

ASSUME 6880 WILL BE HELD AROUND CORNER

∴ INV ≈ 6876.00 UPSTREAM

@ 115+50 = 6875.69 / ~~[illegible]~~ CLOSE ENOUGH
∴ ~~115+25=~~

SO PIPE GOES FROM

DOWN RAMP E 115+50 46' RT = 6875.29
UP SH83 231+03.14 46' LT = 6876.20

NEED TO SET SCREEN @ 6880.20

ALSO INV UP IS @ RAMP H 300+80.25 29.05' RT
RUN @ 7% UP.

SH83
∴ 231+00.00 = 6876.20 ~~3+00~~
231+50 = 6879.48 } DON'T NEED [illegible]

**URS**

Page ____ of ____

Job POWERS BOULEVARD Project No. 67000042500.02 Sheet 2 of ____

Description + STATE HIGHWAY 83 Computed by EDE Date 7-12-02

RAMP H CALCS Checked by ________ Date ________

Reference

RAMP H

1.5%

| | | |
|---|---|---|
| 301+00 | = 6876.50 | |
| 301+50 | = 6877.25 | |
| 302+00 | = 6878.00 | |
| 302+50 | = 6878.75 | |
| 303+00 | = 6879.50 | |
| 303+50 | = 6880.25 | |
| 304+00 | = 6881.00 | |
| 304+50 | = 6881.75 | |
| 305+00 | = 6882.50 | (USE EX.) |
| 305+50 | = 6883.25 | (USE EX.) |
| 306+00 | = 6884.00 | (USE EX.) |
| 306+50 | = 6884.75 | ~~closest 1.5%~~ |
| 307+00 | = 6885.50 | |
| 307+50 | 6886.10 | (HOLD EXISTING) |

# Culvert Calculator Report
# 24" RCP for SH83 near Ramp E

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 5.00 ft | Headwater Depth/Height | 0.96 |
| Computed Headwater Elev: | 2.92 ft | Discharge | 11.00 cfs |
| Inlet Control HW Elev. | 2.80 ft | Tailwater Elevation | 0.54 ft |
| Outlet Control HW Elev. | 2.92 ft | Control Type | Outlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 1.00 ft | Downstream Invert | 0.00 ft |
| Length | 200.00 ft | Constructed Slope | 0.005000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | M2 | Depth, Downstream | 1.19 ft |
| Slope Type | Mild | Normal Depth | 1.22 ft |
| Flow Regime | Subcritical | Critical Depth | 1.19 ft |
| Velocity Downstream | 5.65 ft/s | Critical Slope | 0.005386 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 2.92 ft | Upstream Velocity Head | 0.47 ft |
| Ke | 0.50 | Entrance Loss | 0.23 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 2.80 ft | Flow Control | Unsubmerged |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | SH83 (lt) near Rai |
| Flow Element | Trapezoidal Chan |
| Method | Manning's Formul |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 070000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 9.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.36 | ft |
| Flow Area | 1.8 | $ft^2$ |
| Wetted Perim | 6.27 | ft |
| Top Width | 6.16 | ft |
| Critical Depth | 0.48 | ft |
| Critical Slope | 0.025457 | ft/ft |
| Velocity | 4.93 | ft/s |
| Velocity Head | 0.38 | ft |
| Specific Energ | 0.74 | ft |
| Froude Numb | 1.60 | |
| Flow Type | Supercritical | |

# Worksheet
# Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp H Ditch (top of s |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 015000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 4.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.35 | ft |
| Flow Area | 1.8 | ft² |
| Wetted Perim | 6.22 | ft |
| Top Width | 6.11 | ft |
| Critical Depth | 0.29 | ft |
| Critical Slope | 0.029079 | ft/ft |
| Velocity | 2.25 | ft/s |
| Velocity Head | 0.08 | ft |
| Specific Ener | 0.43 | ft |
| Froude Numb | 0.74 | |
| Flow Type | Subcritical | |

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT REGION 2 Project Name: POWERS B. + SH 83 INT.

Project/Calculation Number: 6700042500.02

Title: BOX CULVERT FOR ELKHORN BASIN UNDER RAMP E

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 7-7-02

Checked by: DANNA JUDISH Date: 7/9/02

---

Description and Purpose:

- SIZE BOX CULVERT FOR ULTIMATE CONDITIONS UNDER ~~RAMP~~ RAMP E

---

Design bases/references/assumptions:

- RATIONAL CALCS
- ~~SEE~~ FLOWMASTER + CULVERT MASTER
- CDOT DRAINAGE MANUAL
- SEE INCLUDED INTRODUCTION

---

Remarks/conclusions:

See Comments on Calc Sheets

Calculation Approved by: ______________________

Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
| --- | --- | --- |
| | | |
| | | |
| | | |

Project Manager/Date

**URS**

Page ____ of ____

Job POWERS BOULEVARD + SH83 INT Project No. 67000425000Z Sheet 1 of ____

Description ____ Computed by EDE Date 7-7-02

BOX CULVERT UNDER RAMP E Checked by ____ Date ____

Reference

ASSUMPTION: – HISTORIC FLOWS UPSTREAM (BOX SIZED FOR FUTURE ...)

- WORST SITUATION IS ULTIMATE CONDITION.)
- FLOW ENTERING BOX / EXITING BOX IS 129 cfs (WILL PROBABLY SLOPE PAVE FLOWS INTO ENTRANCE OR INLET WILL BE CLOSE TO ENTRANCE ∴ TOTAL FLOW SHOULD BE USED).
- NEED TO FIND BOX CULVERT WITH MAX VELOCITY LEAVING @ 16 fps (CDOT Section 9.2.2.3) with GREATEST SLOPE AND WITHIN HW/D (CDOT SECTION 9.2.2.1).

  THIS WILL HELP TO LOWER WATER DOWN TO POWERS BOX CULVERT AND LOSE SOME OF THE ENERGY IN THE BOX.
- ASSUME 250' IN LENGTH.
- CULVERT MASTER AND FLOWMASTER WILL BE USED TO HELP.

DITCH AT ~~POWERS~~ RAMP E ~~LT.~~ RT IS ~~6877~~ 6876 ∴ BOX TOP SHOULD BE AT ~~6869~~. MAX HW = 6876 (TO BE CALC'D AFTER SLOPE)

FIRST TRY:

48" PIPE (RCP): MAX SLOPE = 1.7% FOR HW/D = 1.7

$V_{exit}$ ≈ 15.68 fps. (INLET CONTROLED)

SECOND TRY:

4'×3' BOX: FOR INLET CONTROLED HW/D = 2.02 NOT ACCEPTABLE.

THIRD TRY:

6'×4' BOX: (INLET CONTROL) MAX SLOPE = 2.2% FOR HW/D = 0.97 $V_{exit}$ = 15.89 fps (over sized and not much slope gained).

**URS**

Page ____ of ____

Job POWERS BOULEVARD + SH83 INT. Project No. 67600042500.02 Sheet 2 of ____

Description ____ Computed by SDE Date 7-7-02

BOX CULVERT UNDER RAMP E. Checked by ____ Date ____

Reference

FOR 8TH YR 54" PIPE (RCP): (OUTLET CONTROL) MAX SLOPE = 1.8%
FOR HW/D = 1.28 Vexit = 15.96 fps
(NOT MUCH SLOPE GAINED FOR INCREASE IN PIPE).

SOL'N 48" PIPE @ MAX SLOPE 1.7%
VERIFY HW DOES NOT EXCEED
ROADWAY.

# Culvert Calculator Report
# 48" RCP for Ramp E

Solve For: Headwater Elevation

| Culvert Summary | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,876.00 ft ✓ | Headwater Depth/Height | 1.71 ✓ |
| Computed Headwater Elev: | 6,875.84 ft | Discharge | 129.00 cfs ✓ |
| Inlet Control HW Elev. | 6,875.84 ft | Tailwater Elevation | 6,867.06 ft |
| Outlet Control HW Elev. | 6,875.39 ft | Control Type | Inlet Control |

| Grades | | | |
|---|---|---|---|
| Upstream Invert | 6,869.00 ft | Downstream Invert | 6,864.75 ft |
| Length | 250.00 ft ✓ | Constructed Slope | 0.017000 ft/ft ✓ |

| Hydraulic Profile | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.49 ft |
| Slope Type | Steep | Normal Depth | 2.44 ft |
| Flow Regime | Supercritical | Critical Depth | 3.40 ft |
| Velocity Downstream | 15.68 ft/s | Critical Slope | 0.007593 ft/ft |

| Section | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 1 | | |

| Outlet Control Properties | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,875.39 ft | Upstream Velocity Head | 1.99 ft |
| Ke | 0.50 | Entrance Loss | 1.00 ft |

| Inlet Control Properties | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,875.84 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 12.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

1st TRY + SOL'N

# Culvert Calculator Report
## 4'x3' Box for Ramp E

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,876.00 ft | Headwater Depth/Height | 2.02 |
| Computed Headwater Elev: | 6,875.06 ft | Discharge | 129.00 cfs |
| Inlet Control HW Elev. | 6,875.06 ft | Tailwater Elevation | 6,866.31 ft |
| Outlet Control HW Elev. | 6,874.16 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,869.00 ft | Downstream Invert | 6,864.00 ft |
| Length | 250.00 ft | Constructed Slope | 0.020000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.03 ft |
| Slope Type | Steep | Normal Depth | 2.00 ft |
| Flow Regime | Supercritical | Critical Depth | 3.00 ft |
| Velocity Downstream | 15.89 ft/s | Critical Slope | 0.010864 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 4 x 3 ft | Rise | 3.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,874.16 ft | Upstream Velocity Head | 1.80 ft |
| Ke | 0.20 | Entrance Loss | 0.36 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,875.06 ft | Flow Control | Submerged |
| Inlet Type | 90° headwall w 45° bevels | Area Full | 12.0 ft² |
| K | 0.49500 | HDS 5 Chart | 10 |
| M | 0.66700 | HDS 5 Scale | 2 |
| C | 0.03140 | Equation Form | 2 |
| Y | 0.82000 | | |

2nd TRY

# Culvert Calculator Report
# 6'x4' Box for Ramp E

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,876.00 ft | Headwater Depth/Height | 0.97 |
| Computed Headwater Eleva | 6,872.89 ft | Discharge | 129.00 cfs |
| Inlet Control HW Elev. | 6,872.83 ft | Tailwater Elevation | 6,865.81 ft |
| Outlet Control HW Elev. | 6,872.89 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,869.00 ft | Downstream Invert | 6,863.50 ft |
| Length | 250.00 ft | Constructed Slope | 0.022000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 1.35 ft |
| Slope Type | Steep | Normal Depth | 1.34 ft |
| Flow Regime | Supercritical | Critical Depth | 2.43 ft |
| Velocity Downstream | 15.89 ft/s | Critical Slope | 0.004041 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 6.00 ft |
| Section Size | 6 x 4 ft | Rise | 4.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,872.89 ft | Upstream Velocity Head | 1.22 ft |
| Ke | 0.20 | Entrance Loss | 0.24 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,872.83 ft | Flow Control | Unsubmerged |
| Inlet Type | 90° headwall w 45° bevels | Area Full | 24.0 ft² |
| K | 0.49500 | HDS 5 Chart | 10 |
| M | 0.66700 | HDS 5 Scale | 2 |
| C | 0.03140 | Equation Form | 2 |
| Y | 0.82000 | | |

3rd TRY

# Culvert Calculator Report
## 54" RCP for Ramp E

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,876.00 ft √ | Headwater Depth/Height | 1.28 |
| Computed Headwater Elev: | 6,873.76 ft | Discharge | 129.00 cfs |
| Inlet Control HW Elev. | 6,873.61 ft | Tailwater Elevation | 6,865.81 ft |
| Outlet Control HW Elev. | 6,873.76 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,868.00 ft | Downstream Invert | 6,863.50 ft |
| Length | 250.00 ft | Constructed Slope | 0.018000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.28 ft |
| Slope Type | Steep | Normal Depth | 2.22 ft |
| Flow Regime | Supercritical | Critical Depth | 3.34 ft |
| Velocity Downstream | 15.96 ft/s | Critical Slope | 0.005292 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.50 ft |
| Section Size | 54 inch | Rise | 4.50 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,873.76 ft | Upstream Velocity Head | 1.61 ft |
| Ke | 0.50 | Entrance Loss | 0.81 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,873.61 ft | Flow Control | Transition |
| Inlet Type | Square edge w/headwall | Area Full | 15.9 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

4Th TRY

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Ramp E to Powers Channel for |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 6.00 | ft |
| Discharge | 132.00 | cfs |

Why not 129cfs

| Results | | |
|---|---|---|
| Depth | 2.31 | ft |
| Flow Area | 35.1 | ft² |
| Wetted Perim | 25.01 | ft |
| Top Width | 24.44 | ft |
| Critical Depth | 1.71 | ft |
| Critical Slope | 0.017695 | ft/ft |
| Velocity | 3.76 | ft/s |
| Velocity Head | 0.22 | ft |
| Specific Energ | 2.53 | ft |
| Froude Numb | 0.55 | |
| Flow Type | Subcritical | |

TAIL-WATER CONDITION

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT - REGION 2 Project Name: POWERS B. + SH83 INT.

Project/Calculation Number: 67000425??.02

Title: BOX CULVERT FOR ELKHORN BASIN UNDER POWERS + RAMP F

Total number of pages (including cover sheet): ________

Total number of computer runs: ________

Prepared by: E. DANNY ELLNER Date: 7-7-02

Checked by: W ASPATCH Date: 9 JUL 02

---

Description and Purpose:

- SIZE BOX CULVERT FOR ULTIMATE CONDITIONS UNDER POWERS + RAMP F (COMBINED TOGETHER)

---

Design bases/references/assumptions:

- RATIONAL CALCS
- STORMCAD, FLOWMASTER, CULVERT MASTER.
- CDOT DRAINAGE MANUAL
- SEE INCLUDED INTRODUCTION

---

Remarks/conclusions:

SEE COMMENTS.

Calculation Approved by: ______________________

Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

URS

Page ____ of ____

Job POWER + SH 83 INT.
Project No. 6700042500.02
Sheet 1 of ____

Description
Computed by SDE
Date 7-7-02

BOX CULVERT CALCS. FOR ELKHORN
Checked by WA
Date 9 JUL 02

Reference

ASSUMPTION:

- WORST SITUATION IS ULTIMATE CONDITION ✓
- FLOW ENTERING BOX @ POWERS 755+00 RT. IS 132 cfs (BASED ON RATIONAL CALCS.) ✓
- FLOW LEAVING BOX @ ~~POWER~~ RAMP F 410+50 LT. IS 175 cfs (BASED ON RATIONAL CALCS) ✓
- DUE TO LARGE CUTS @ POWERS AND DOWNSTREAM GRADES TO CATCH UP TO SLOPE ON BOX AND DOWNSTREAM GRADE ASSUMED TO BE 0.58% ✓
- FROM PROFILE AND PROJECTED GRADES AS OF THIS DATE, DITCH ON RT. OF POWERS HAS LOW POINT OF 6838 AND MAX HEAD WATER OF ELEV. 6842.
- LOW PROFILE BOX AS ASSUMED TO BE BEST OPTION (OR MULTIPLE PIPES.

- CULVERT MASTER AND FLOW MASTER WILL BE USED TO HELP (STORMCAD ALSO)
  - ASSUME 2' COVER ABOVE BOX CULVERT AND DITCH.
  - ∴ TOP OF BOX IS 6836. ✓
  - ASSUME BOX LENGTH IS AROUND 200'

FIRST TRY:

7'x4' BOX. GIVES OUTLET CONTROL (BARELY) WITH & HW/D = 0.865 (ASSUMPTION - 200 BIG!)

NOTE: DOWNSTREAM ELEV ≈ 6827.5 & CATCH POINT IS AROUND 1500' DOWNSTREAM & TRY TO REDUCE INVERT TO CATCH FASTER AND USE FOR PIPE.

SECOND TRY:

36" RCP PIPES: WITH USING PIPES WE COULD CHANGE ASSUMPTION AND BRING TOP OF PIPE UP TO 6839 (BECAUSE WE CAN HAVE DITCH BLEND IN AND NOT USE AN INLET.) ☺

# URS

Page ____ of ____

Job POWERS + SH 83. INT. Project No. 67004 2500.02 Sheet 2 of ____

Description ____ Computed by EDE Date 7-7-02

BOX CULVERT CALCS. FOR ELKHORN Checked by ____ Date ____

Reference

NEED 3 36" RCP PIPES. OUTLET CONTROL (BARELY)
WITH A HW/D = ~~THE~~ 1.12
DOWNSTREAM INVERT = 6832. (BETTER)
ISSUES = 3 PIPES NOT TOO GOOD WITH CONNECTIONS.

THIRD TRY:
48" RCP PIPES: 2 PIPES NEED, OUTLET CONTROLED
WITH A HW/D = 0.93
DOWNSTREAM INVERT = 6831.

FORTH TRY:
6'x4' BOX WITH THE SAME ASSUMPTION OF TOP OF
BOX WITH (6839.) OUTLET CONTROL (BARELY)
WITH A HW/D = 0.99 (MIGHT STILL BE TOO BIG)
DOWNSTREAM INVERT = 6830.5

→ MIGHT WANT TO CHECK LOSSES DUE
TO ENTRANCE AND CHECK UPSTREAM.

STORM CAD SHOWS THAT AS FLOW INCREASES
HGL WITHIN PIPE:

LOOKS THIS COULD BE A GOOD SOL'N TO HELP
WITH FUTURE CONNECTIONS.

SOL'N:

6'x4' BOX @ 0.50% AT MIN
COVER @ POWERS RT.
w/ DITCH FLOW SLOPE INTO
ENTRANCE.

# Culvert Calculator Report
# 7'x4' Box Culvert

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,842.00 ft | Headwater Depth/Height | 0.89 |
| Computed Headwater Elev< | 6,834.56 ft | Discharge | 132.00 cfs |
| Inlet Control HW Elev. | 6,834.51 ft | Tailwater Elevation | 6,830.03 ft |
| Outlet Control HW Elev. | 6,834.56 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,831.00 ft | Downstream Invert | 6,827.50 ft |
| Length | 700.00 ft | Constructed Slope | 9.758571 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositeS1S2 | Depth, Downstream | 2.53 ft |
| Slope Type | Steep | Normal Depth | 0.17 ft |
| Flow Regime | N/A | Critical Depth | 2.23 ft |
| Velocity Downstream | 7.45 ft/s | Critical Slope | 0.003636 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 7.00 ft |
| Section Size | 7 x 4 ft | Rise | 4.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,834.56 ft | Upstream Velocity Head | 1.11 ft |
| Ke | 0.20 | Entrance Loss | 0.22 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,834.51 ft | Flow Control | Unsubmerged |
| Inlet Type | 90° headwall w 45° bevels | Area Full | 28.0 ft² |
| K | 0.49500 | HDS 5 Chart | 10 |
| M | 0.66700 | HDS 5 Scale | 2 |
| C | 0.03140 | Equation Form | 2 |
| Y | 0.82000 | | |

? Is this the correct condition for this location?

1st TRY

Title: Elkhorn Culvert for Powers and SH83
...\cad\design\hydr\culverts\elkhornculvert.cvm
07/07/02 09:32:21 AM



URS

Project Engineer: E. Danny Elsner
CulvertMaster v2.0 [2.005]

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Downstream Channel for 7 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 7.00 | ft |
| Discharge | 175.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 2.53 | ft |
| Flow Area | 43.4 | $ft^2$ |
| Wetted Perim | 27.89 | ft |
| Top Width | 27.27 | ft |
| Critical Depth | 1.90 | ft |
| Critical Slope | 0.017052 | ft/ft |
| Velocity | 4.03 | ft/s |
| Velocity Head | 0.25 | ft |
| Specific Energ | 2.79 | ft |
| Froude Numb | 0.56 | |
| Flow Type | Subcritical | |

# Culvert Calculator Report
## 36" RCP Pipes

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,842.00 ft | Headwater Depth/Height | 1.12 |
| Computed Headwater Eleva | 6,838.87 ft | Discharge | 132.00 cfs |
| Inlet Control HW Elev. | 6,838.81 ft | Tailwater Elevation | 6,834.10 ft |
| Outlet Control HW Elev. | 6,838.87 ft | Control Type | Outlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,835.50 ft | Downstream Invert | 6,832.00 ft |
| Length | 700.00 ft | Constructed Slope | 0.005000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | M2 | Depth, Downstream | 2.16 ft |
| Slope Type | Mild | Normal Depth | 2.30 ft |
| Flow Regime | Subcritical | Critical Depth | 2.16 ft |
| Velocity Downstream | 8.07 ft/s | Critical Slope | 0.005769 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.00 ft |
| Section Size | 36 inch | Rise | 3.00 ft |
| Number Sections | 3 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,838.87 ft | Upstream Velocity Head | 0.89 ft |
| Ke | 0.20 | Entrance Loss | 0.18 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,838.81 ft | Flow Control | Transition |
| Inlet Type | Beveled ring, 33.7° bevels | Area Full | 21.2 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | B |
| C | 0.02430 | Equation Form | 1 |
| Y | 0.83000 | | |

2nd TRY

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Downstream Channel for |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 13.00 | ft |
| Discharge | 175.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 2.10 | ft |
| Flow Area | 44.9 | ft² |
| Wetted Perim | 30.30 | ft |
| Top Width | 29.78 | ft |
| Critical Depth | 1.51 | ft |
| Critical Slope | 0.017388 | ft/ft |
| Velocity | 3.90 | ft/s |
| Velocity Head | 0.24 | ft |
| Specific Energ | 2.33 | ft |
| Froude Numb | 0.56 | |
| Flow Type | Subcritical | |

# Culvert Calculator Report
## 48" RCP Pipes

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,842.00 ft | Headwater Depth/Height | 0.92 |
| Computed Headwater Eleva | 6,838.20 ft | Discharge | 132.00 cfs |
| Inlet Control HW Elev. | 6,838.06 ft | Tailwater Elevation | 6,833.30 ft |
| Outlet Control HW Elev. | 6,838.20 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,834.50 ft | Downstream Invert | 6,831.00 ft |
| Length | 700.00 ft | Constructed Slope | 0.005000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.35 ft |
| Slope Type | Steep | Normal Depth | 2.35 ft |
| Flow Regime | Supercritical | Critical Depth | 2.45 ft |
| Velocity Downstream | 8.60 ft/s | Critical Slope | 0.004377 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 2 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,838.20 ft | Upstream Velocity Head | 1.04 ft |
| Ke | 0.20 | Entrance Loss | 0.21 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,838.06 ft | Flow Control | Unsubmerged |
| Inlet Type | Beveled ring, 33.7° bevels | Area Full | 25.1 ft² |
| K | 0.00180 | HDS 5 Chart | 3 |
| M | 2.50000 | HDS 5 Scale | B |
| C | 0.02430 | Equation Form | 1 |
| Y | 0.83000 | | |

3rd TRY

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Downstream Channel for |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 175.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 2.30 | ft |
| Flow Area | 44.0 | ft² |
| Wetted Perim | 28.93 | ft |
| Top Width | 28.37 | ft |
| Critical Depth | 1.68 | ft |
| Critical Slope | 0.017194 | ft/ft |
| Velocity | 3.97 | ft/s |
| Velocity Head | 0.25 | ft |
| Specific Energ | 2.54 | ft |
| Froude Numb | 0.56 | |
| Flow Type | Subcritical | |

# Culvert Calculator Report
## 6'x4' Box Culvert

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,842.00 ft | Headwater Depth/Height | 0.99 |
| Computed Headwater Elev: | 6,837.95 ft | Discharge | 132.00 cfs ✓ |
| Inlet Control HW Elev. | 6,837.89 ft | Tailwater Elevation | 6,833.12 ft |
| Outlet Control HW Elev. | 6,837.95 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,834.00 ft | Downstream Invert | 6,830.50 ft |
| Length | 700.00 ft | Constructed Slope | 0.005000 ft/ft |

will energy be dissipater required?

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositeS1S2 | Depth, Downstream | 2.62 ft |
| Slope Type | Steep | Normal Depth | 2.29 ft |
| Flow Regime | N/A | Critical Depth | 2.47 ft |
| Velocity Downstream | 8.40 ft/s | Critical Slope | 0.004057 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 6.00 ft |
| Section Size | 6 x 4 ft | Rise | 4.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,837.95 ft | Upstream Velocity Head | 1.23 ft |
| Ke | 0.20 | Entrance Loss | 0.25 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,837.89 ft | Flow Control | Unsubmerged |
| Inlet Type | 90° headwall w 45° bevels | Area Full | 24.0 ft² |
| K | 0.49500 | HDS 5 Chart | 10 |
| M | 0.66700 | HDS 5 Scale | 2 |
| C | 0.03140 | Equation Form | 2 |
| Y | 0.82000 | | |

Same question as 1st Try.

4TH TRY + SOL'N

# Worksheet
## Worksheet for Trapezoidal Channel

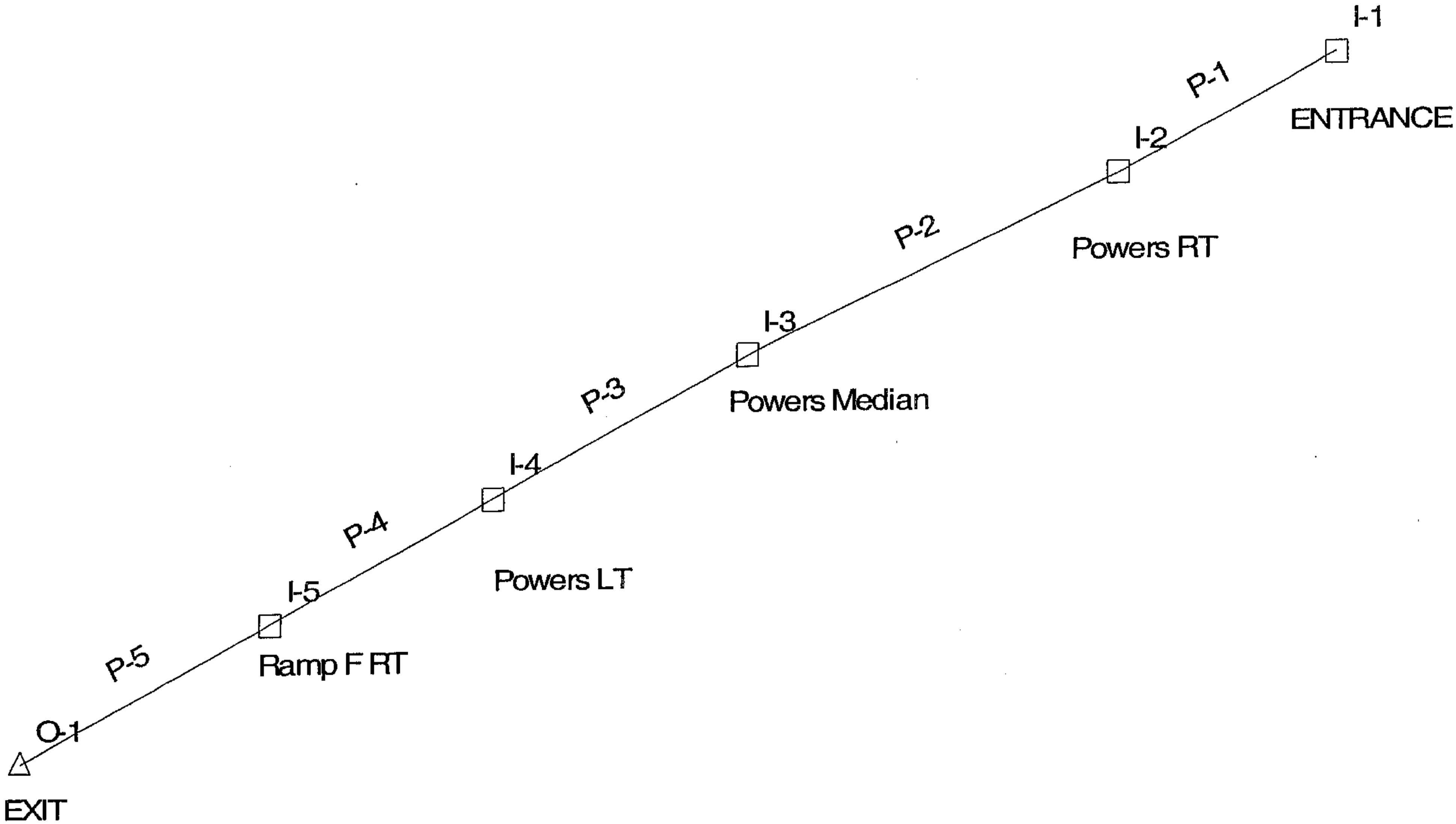
| Project Description | |
|---|---|
| Worksheet | Downstream Channel for 6 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.035 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 6.00 | ft |
| Discharge | 175.00 | cfs ✓ |

| Results | | |
|---|---|---|
| Depth | 2.62 | ft |
| Flow Area | 43.2 | ft² |
| Wetted Perim | 27.62 | ft |
| Top Width | 26.98 | ft |
| Critical Depth | 1.98 | ft |
| Critical Slope | 0.017020 | ft/ft |
| Velocity | 4.05 | ft/s |
| Velocity Head | 0.25 | ft |
| Specific Energ | 2.88 | ft ✓ |
| Froude Numb | 0.56 | ✓ |
| Flow Type | Subcritical | ✓ |

THIS IS SIGNIFICANTLY LESS THAN THE STORMCAD COMPUTED EXIT VELOCITY FROM THE 6'x 4" BOX (10.08 fps). WILL A HYD. JUMP OCCUR? IF SO NEED TO CONSIDER OUTLET DETAILS: ENERGY DISSIPATOR.

**Scenario: Base**

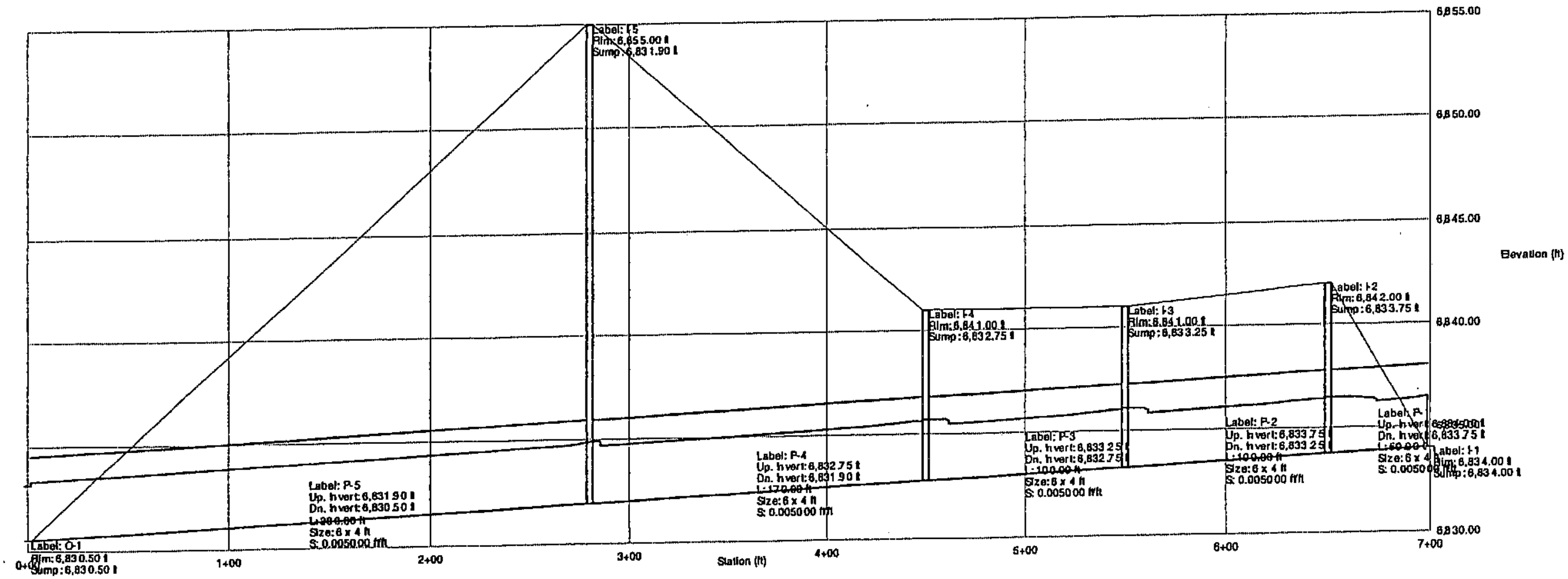


# Scenario: Base

# DOT Report

| Label | -Node- Upstream Downstream | Upstream Inlet Area (acres) | Upstream Inlet CA (acres) | Upstream Calculated System CA (acres) | -Ground- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Section Discharge Capacity (cfs) | -Section- Shape Size | Length (ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1 | I-1 | 0.00 | 0.00 | 0.00 | 6,834.00 | 6,836.47 | 0.004242 | 132.00 | Box | 50.00 | 8.48 | |
| | I-2 | | | | 6,842.00 | 6,836.49 | 0.005000 | 219.05 | 6 x 4 ft | | | |
| P-2 | I-2 | 0.00 | 0.00 | 0.00 | 6,842.00 | 6,836.45 | 0.004874 | 151.00 | Box | 100.00 | 9.07 | |
| | I-3 | | | | 6,841.00 | 6,836.11 | 0.005000 | 219.05 | 6 x 4 ft | | | |
| P-3 | I-3 | 0.00 | 0.00 | 0.00 | 6,841.00 | 6,836.07 | 0.004879 | 161.00 | Box | 100.00 | 9.27 | |
| | I-4 | | | | 6,841.00 | 6,835.72 | 0.005000 | 219.05 | 6 x 4 ft | | | |
| P-4 | I-4 | 0.00 | 0.00 | 0.00 | 6,841.00 | 6,835.68 | 0.004978 | 171.00 | Box | 170.00 | 9.57 | |
| | I-5 | | | | 6,855.00 | 6,834.92 | 0.005000 | 219.05 | 6 x 4 ft | | | |
| P-5 | I-5 | 0.00 | 0.00 | 0.00 | 6,855.00 | 6,834.88 | 0.004947 | 175.00 | Box | 280.00 | 10.08 | |
| | O-1 | | | | 6,830.50 | 6,833.31 | 0.005000 | 219.05 | 6 x 4 ft | | | |

# Scenario: Base




Title: Elkhorn Culvert Calculation
...\cad\design\hydr\culverts\elkhornculvert.stm
07/07/02 10:27:18 AM

URS Corporation


Project Engineer: E. Danny Elsner
StormCAD v4.1.1 [4.2014]

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT - REGION 2 Project Name: 6700042500.02

Project/Calculation Number: POWERS + SH 83 INTERCHANGE

Title: WINGWALL CALCULATIONS

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 9-19-02

Checked by: W. Alspach Date: 25 Sep 02

Description and Purpose: DESIGN WINGWALLS FOR INTERIM AND ULTIMATE CONDITIONS FOR ELKHORN BASIN CULVERT.

Design bases/references/assumptions: - CDOT DRAINAGE MANUAL (INCL.)
- SKEW ANGLE (AUTOCAD)

Remarks/conclusions:

Calculation Approved by: ______

Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

- Use headwalls parallel to roadway if result is less than 50.

Headwalls with Bevels

- Increase the efficiency of metal pipe.
- Provide embankment stability.
- Provide embankment erosion protection.
- Provide protection from buoyancy.
- Shorten the required structure length.
- Reduce maintenance damage.

Improved Inlets

- Shall be considered for culverts which will operate in inlet control.
- Can increase the hydraulic performance of the culvert, but may also add to the total culvert cost.

End Sections

All cross culverts and side drains shall be installed with end sections unless other types of end treatments are proven more appropriate.

- Are available for corrugated metal, concrete, and plastic pipes.
- They retard embankment erosion and incur less damage from maintenance activities.
- May improve projecting metal pipe entrances by increasing hydraulic efficiency, reducing the accident hazard, and improving their appearance.
- They are hydraulically equal to a headwall, but can be equal to a bevelled or side-tapered entrance if a flared, enclosed transition takes place before the barrel.

Wingwalls

- Are used to retain the roadway embankment to avoid a projecting culvert barrel.
- Are used where the side slopes of the channel are unstable.
- Are used where the culvert is skewed to the normal channel flow.

should nearly match the final ground elevation. For irrigation structures, the k height should be above the design discharge water surface elevation.

- A wingwall flare angle of from 20 to 40 degrees normally provides a hydraulically efficient inlet condition for the culvert. Use of the recommended values for $\theta_a$ or $\theta_b$ given in Table 9-4 and k will generally effect a smooth flow transition from channel to culvert, and keep the spill cone out of the projected jet of flow.

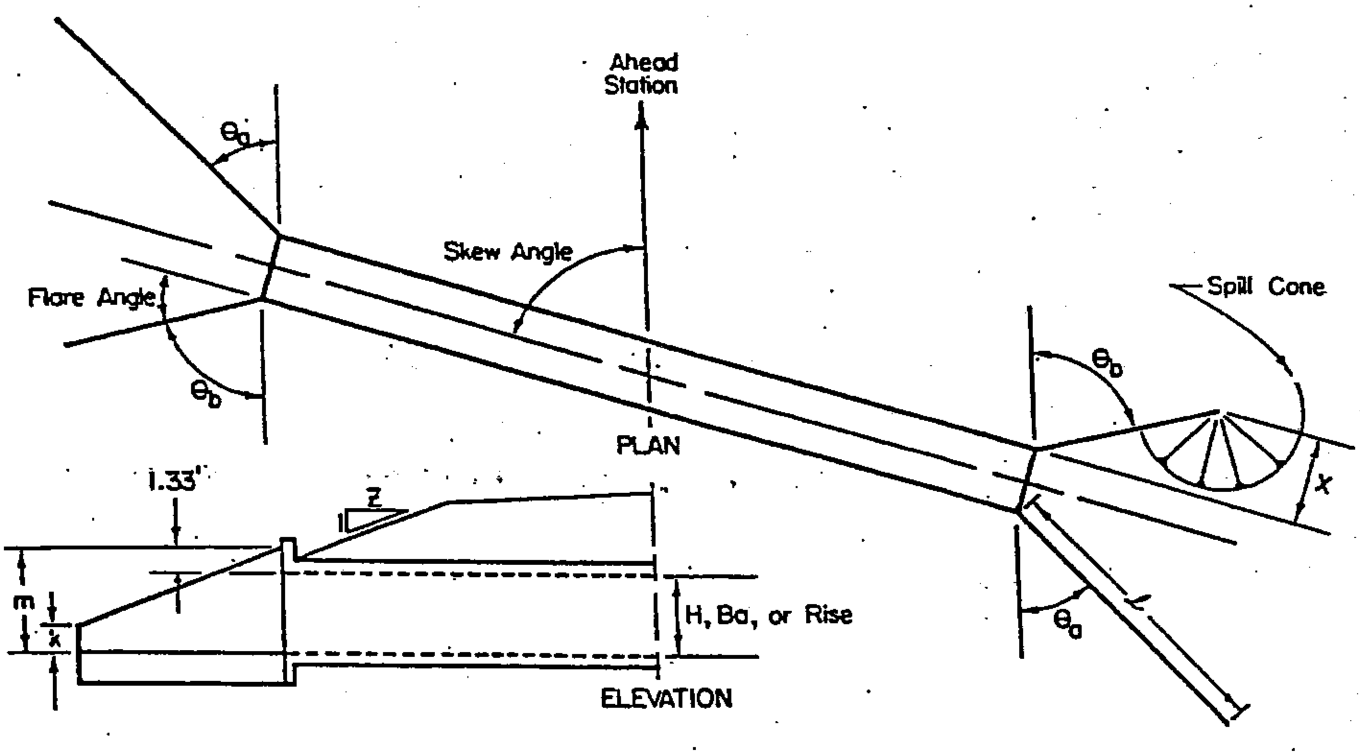



Figure 9-9 Layout of Wingwalls

- A plan showing site contours or spot elevations is often helpful when laying out the final wingwall geometry, especially when the wingwalls must conform to a distinct channel.

- Allow a spill cone slope of 1.5:1 or flatter at the wingwall ends to assure that the main flow jet, roughly defined by the culvert width, does not impinge on the spill cone.

- Culvert headwalls shall be perpendicular to the culvert centerline unless excessive cost or aesthetics favors a skewed headwall. A wide culvert with a small skew angle usually justifies the skewed headwall as discussed in the section for headwalls.

Aprons

- Shall be used to reduce scour from high headwater depths or from approach velocity in the channel.
- Shall extend at least one pipe diameter upstream.
- Shall not protrude above the normal streambed elevation.
- Concrete aprons shall be used at the outlet of culvert with wingwalls and at both inlet and outlet if culvert also serves as a stockpass.
- Concrete aprons should be considered at the outlet for scour protection.
- If scour damage is anticipated, a concrete apron should be placed between the wingwalls. Toe walls are required on all wingwalls except when a concrete apron is used. Toe walls are placed on the end of the apron as shown in the CDOT M & S Standards.

### 9.2.3.4 Safety Considerations

Traffic Safety

Traffic shall be protected from culvert ends as follows:

Small culverts (30" in diameter or less) shall use an end section or a sloped headwall.

Culverts greater than 30" in diameter shall receive one of the following treatments:

**URS**

Page ____ of ____

Job: POWERS + SH 83 | Project No. 6900042500.02 | Sheet 1 of ____
Description: WINGWALLS | Computed by: EDE | Date: 9-25-02
Checked by: W. Alspach | Date: 25 Sep 02

Reference

ramp F box culvert skew = 88.13° rt.

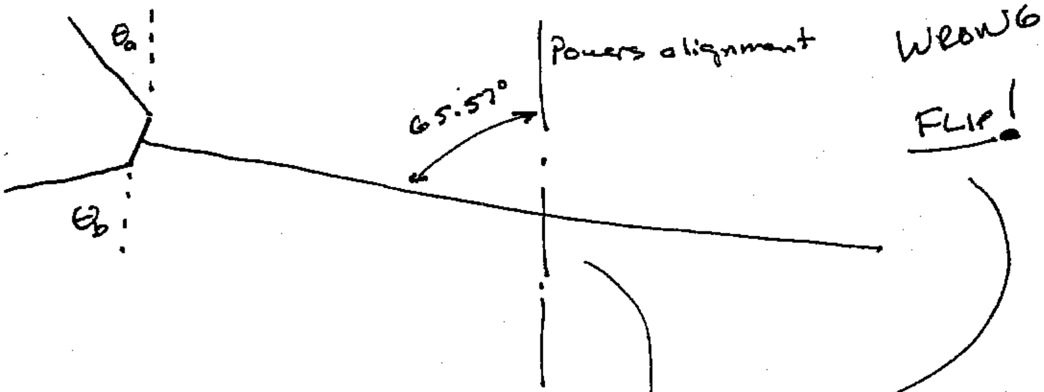
powers box culvert skew = 65.57° rt

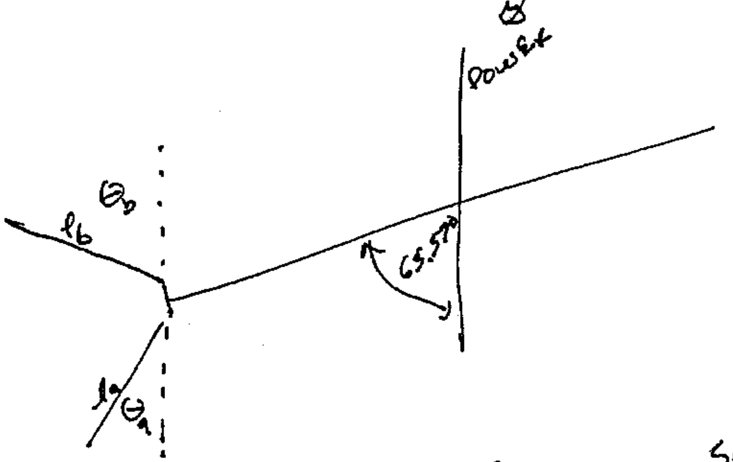
for POWERS $\theta$ (skew) = 65.57° RT

$\frac{(65.57-60)}{(70-60)}(45-40)+40 = 42.8°$ $\theta_a$ ✓

LINEAR INTERPOLATION FROM TABLE 9-4

$\frac{(65.57-60)}{(70-60)}(80-90)+90 = 84.4°$ $\theta_b$ ✓




rise = 4'

K = ½ [4] − 1 = 1'

m = [4'] + 1.33' = ~~6.33'~~ 5.33

Z = 6 (INSIDE POWERS

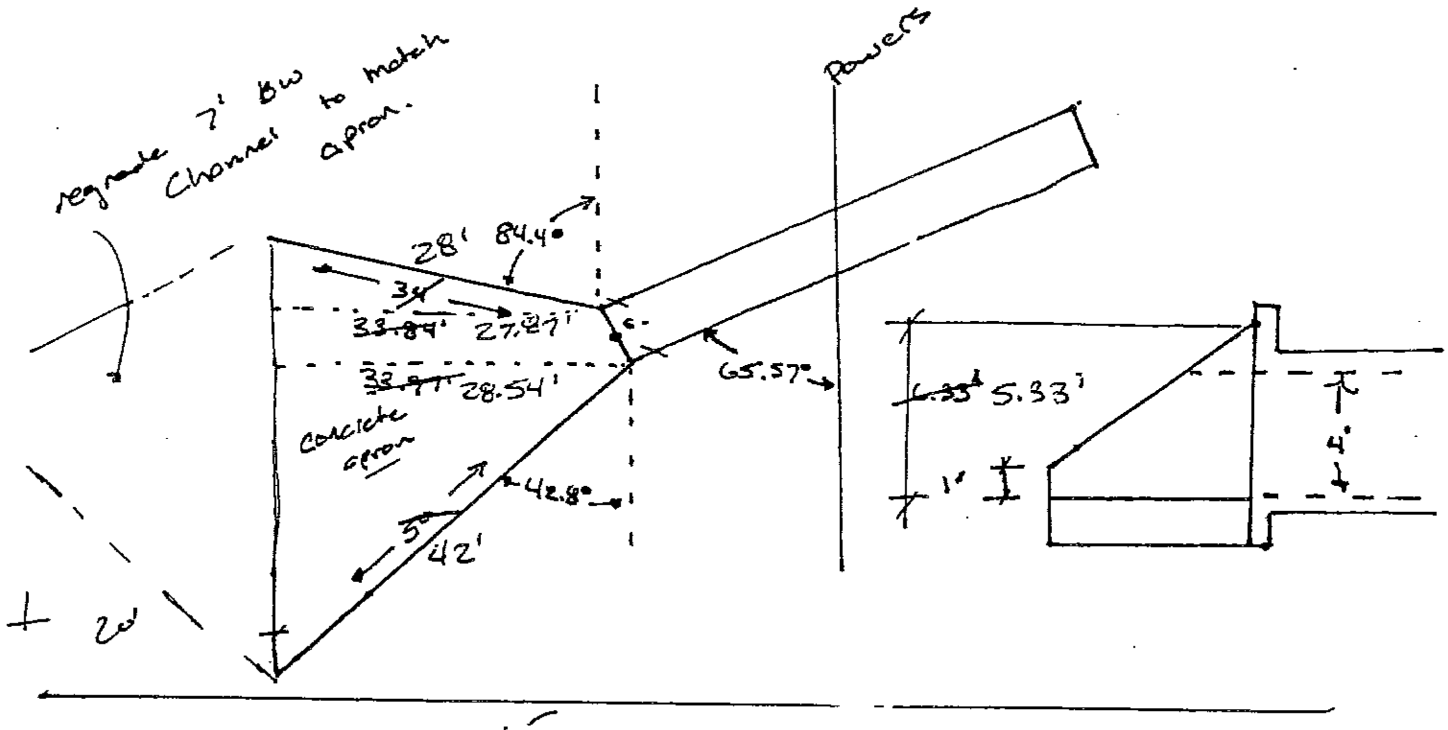
$l_a = \frac{6[~~6.33'~~ 5.33 - 1']}{\sin 42.8°}$ = ~~47.1'~~ 38.2 ✓ ⇒ ~~50'~~ 42' round (4' incr.)

$l_b = \frac{6[~~6.33'~~ 5.33 - 1']}{\sin 84.4°}$ = ~~32.1'~~ 26.1 ✓ ⇒ ~~34'~~ 28' (~~4'~~ 2' incr.)

**URS**

Job: POWERS + SH83 | Project No. 67000425000.02 | Page ___ of ___ | Sheet 2 of ___
Description: WINGWALLS | Computed by: EPE | Date ___
Checked by: W. Alspach | Date: 25 Sep 02
Reference

POWERS REDRAW!




$k = 1'$ $m = \cancel{6.33}$ 5.33' $z = 6$ (on upstream)
$z = 3$ (on downstream)

$\theta$ = skew = 88.13°

$$\theta_a = \frac{(88.13-80)}{(90-80)}(60-50)+50 = 58.1°$$

$$\theta_b = \frac{(88.13-80)}{(90-80)}(60-70)+70 = 61.9°$$

UPSTREAM

$$l_a = \frac{6[\cancel{6.33}\ 5.33' - 1']}{\sin 58.1°} = \cancel{37.7}\ 30.6 \Rightarrow \cancel{38}\ 34'$$ (4 incr.)

$$l_b = \frac{6[\cancel{6.33}\ 5.33 - 1']}{\sin 61.9°} = \cancel{36.3'}\ 29.5 \Rightarrow \cancel{38'}\ 30'$$ (4 incr.)

DOWNSTREAM

$$l_a = \frac{3[\cancel{6.33}\ 5.33' - 1']}{\sin 58.1°} = \cancel{18.8'}\ 15.3 \Rightarrow \cancel{20'}\ 16'$$ (2' incr.)

$$l_b = \frac{3[\cancel{6.33}\ 5.33' - 1']}{\sin 61.9°} = \cancel{18.1'}\ 14.7 \Rightarrow \cancel{20'}\ 16'$$ (2' incr.

**URS**

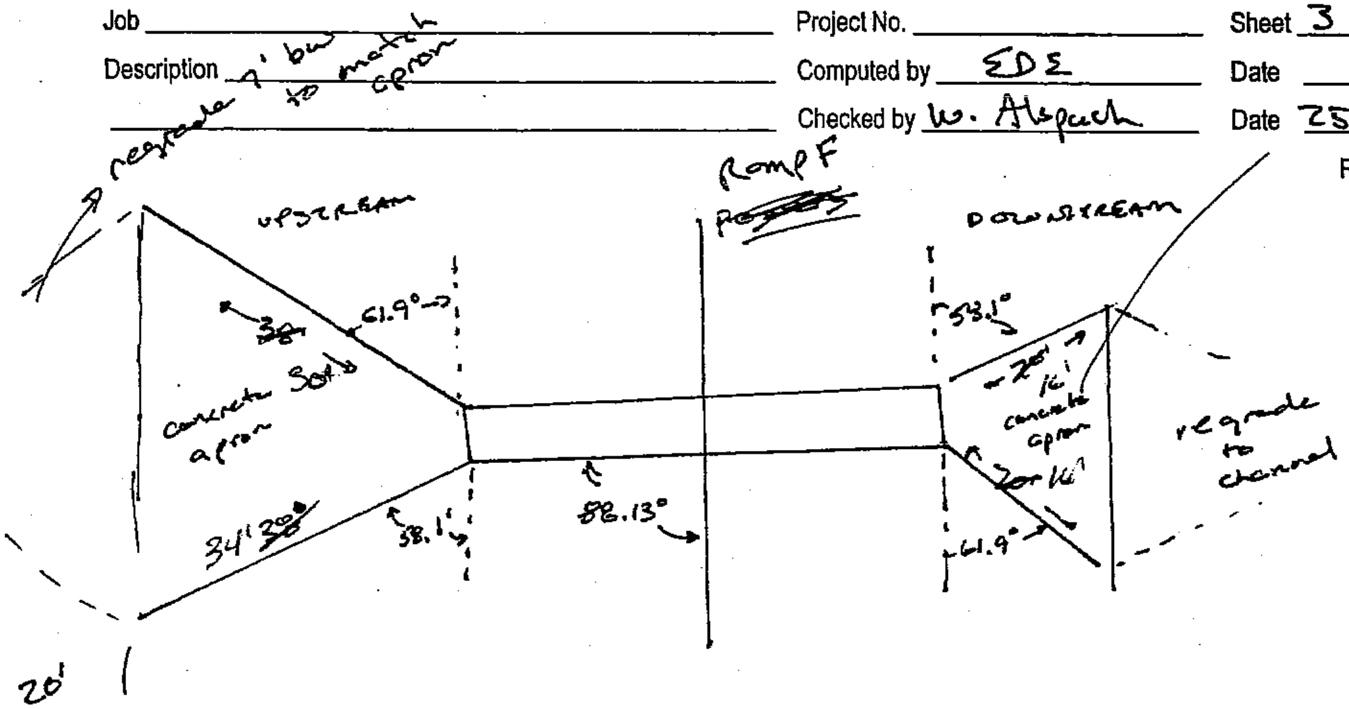
Page ____ of ____

Job ____ Project No. ____ Sheet 3 of ____

Description ____ Computed by EDE Date ____

Checked by W. Alspach Date 25 Sep03

Reference



# Culvert Calculator Report
## 24" RCP FES for SH83 near Ramp F - FINAL

Solve For: Headwater Elevation    HW10    ALLOWABLE=2.0

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,865.13 ft | Headwater Depth/Height | 1.61 |
| Computed Headwater Eleva | 6,864.35 ft | Discharge | 23.00 cfs ← MAX DISCHARGE (BASIN INT-A09) |
| Inlet Control HW Elev. | 6,861.13 ft | Tailwater Elevation | 6,851.13 ft ← FROM STORMCAD |
| Outlet Control HW Elev. | 6,864.35 ft | Control Type | Entrance Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,861.13 ft | Downstream Invert | 3,850.30 ft |
| Length | 138.95 ft | Constructed Slope | 21.668442 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | CompositePressureProfileS1S2 | Depth, Downstream | 3,000.83 ft |
| Slope Type | N/A | Normal Depth | 0.20 ft |
| Flow Regime | N/A | Critical Depth | 1.71 ft |
| Velocity Downstream | 7.32 ft/s | Critical Slope | 0.009682 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,864.35 ft | Upstream Velocity Head | 1.01 ft |
| Ke | 0.50 | Entrance Loss | 0.50 ft |

(FES (WORST CASE SCENARIO ACCORDING TO CULVERTMASTER)

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,861.13 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
## 24" RCP for SH83 near Ramp E - FINAL

ALLOWABLE = 2.0

Solve For: Headwater Elevation    HW/D = 2.0

| Culvert Summary | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,880.97 ft | Headwater Depth/Height | 0.97 |
| Computed Headwater Elev: | 6,878.90 ft | Discharge | 11.00 cfs ← MAX DISCHARGE (BASIN ULT - ACDI) |
| Inlet Control HW Elev. | 6,878.77 ft | Tailwater Elevation | 6,876.30 ft |
| Outlet Control HW Elev. | 6,878.90 ft | Control Type | Entrance Control |

INV + DEPTH

| Grades | | | |
|---|---|---|---|
| Upstream Invert | 6,876.97 ft | Downstream Invert | 6,875.30 ft |
| Length | 172.11 ft | Constructed Slope | 0.009703 ft/ft |

| Hydraulic Profile | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 0.99 ft |
| Slope Type | Steep | Normal Depth | 0.99 ft |
| Flow Regime | Supercritical | Critical Depth | 1.19 ft |
| Velocity Downstream | 7.07 ft/s | Critical Slope | 0.005386 ft/ft |

| Section | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

| Outlet Control Properties | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,878.90 ft | Upstream Velocity Head | 0.50 ft |
| Ke | 0.50 | Entrance Loss | 0.25 ft |

FES (WORST CASE SCENARIO ACCORDING TO CULVERTMASTER)

| Inlet Control Properties | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,878.77 ft | Flow Control | Unsubmerged |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Discharge Channel from SH: |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 21.00 | cfs |

← WORST CASE SLOPE

← MAX DISCHARGE (BASIN ULT-AC03)

| Results | | |
|---|---|---|
| Depth | 1.00 | ft |
| Flow Area | 8.0 | $ft^2$ |
| Wetted Perim | 12.23 | ft |
| Top Width | 11.98 | ft |
| Critical Depth | 0.74 | ft |
| Critical Slope | 0.016724 | ft/ft |
| Velocity | 2.63 | ft/s |
| Velocity Head | 0.11 | ft |
| Specific Energ | 1.11 | ft |
| Froude Numb | 0.57 | |
| Flow Type | Subcritical | |

# Culvert Calculator Report
## 48" RCP for Ramp E - FINAL

Solve For: Headwater Elevation

HW/D=1.7 ALLOWABLE=1.7

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,873.39 ft | Headwater Depth/Height | 1.71 |
| Computed Headwater Eleva | 6,873.43 ft | Discharge | 129.00 cfs |
| Inlet Control HW Elev. | 6,873.43 ft | Tailwater Elevation | 6,866.43 ft |
| Outlet Control HW Elev. | 6,872.98 ft | Control Type | Inlet Control |

MAX DISCHARGE (BASIN ULT-AC04)

INV + DEPTH

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,866.59 ft | Downstream Invert | 6,864.59 ft |
| Length | 117.80 ft | Constructed Slope | 0.016978 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.62 ft |
| Slope Type | Steep | Normal Depth | 2.44 ft |
| Flow Regime | Supercritical | Critical Depth | 3.40 ft |
| Velocity Downstream | 14.82 ft/s | Critical Slope | 0.007593 ft/ft |

LESS THAN 16 fps

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,872.98 ft | Upstream Velocity Head | 1.99 ft |
| Ke | 0.50 | Entrance Loss | 1.00 ft |

FES (WORST CASE SCENARIO ACCORDING TO CULVERT MASTER)

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,873.43 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 12.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Discharge Channel from |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 008000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 7.00 | ft |
| Discharge | 132.00 | cfs |

← MAX DISCHARGE (BASIN ULT-AC04)

| Results | | |
|---|---|---|
| Depth | 1.84 | ft |
| Flow Area | 26.5 | ft² |
| Wetted Perim | 22.20 | ft |
| Top Width | 21.74 | ft |
| Critical Depth | 1.64 | ft |
| Critical Slope | 0.013033 | ft/ft |
| Velocity | 4.98 | ft/s |
| Velocity Head | 0.39 | ft |
| Specific Energ | 2.23 | ft |
| Froude Numb | 0.80 | |
| Flow Type | Subcritical | |

# Culvert Calculator Report
## 6'x4' Box Culvert - INTERIM

Solve For: Headwater Elevation

*HW/D = 1.5*

*ALLOWABLE = 1.5*

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,837.75 ft | Headwater Depth/Height | 1.10 |
| Computed Headwater Eleva | 6,836.14 ft | Discharge | 135.00 cfs |
| Inlet Control HW Elev. | 6,835.79 ft | Tailwater Elevation | 6,832.96 ft |
| Outlet Control HW Elev. | 6,836.14 ft | Control Type | Entrance Control |

*MAX INFLOW @ RAMP F (BASIN INT-ACS)*

*OUTLET = DEPTH*

**Grades**

*INTERIM INV.*

| | | | |
|---|---|---|---|
| Upstream Invert | 6,831.75 ft | Downstream Invert | 6,830.60 ft |
| Length | 229.26 ft | Constructed Slope | 0.005016 ft/ft |

*INTERIM LENGTH*

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.32 ft |
| Slope Type | Steep | Normal Depth | 2.32 ft |
| Flow Regime | Supercritical | Critical Depth | 2.51 ft |
| Velocity Downstream | 9.69 ft/s | Critical Slope | 0.004074 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 6.00 ft |
| Section Size | 6 x 4 ft | Rise | 4.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,836.14 ft | Upstream Velocity Head | 1.25 ft |
| Ke | 0.50 | Entrance Loss | 0.63 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,835.79 ft | Flow Control | Unsubmerged |
| Inlet Type | 30 to 75° wingwall flares | Area Full | 24.0 ft² |
| K | 0.02600 | HDS 5 Chart | 8 |
| M | 1.00000 | HDS 5 Scale | 1 |
| C | 0.03470 | Equation Form | 1 |
| Y | 0.86000 | | |

# Culvert Calculator Report
## 6'x4' Box Culvert - FINAL

Solve For: Headwater Elevation

EDGE OF SHOULDER

ALLOWABLE ≤1.5

### Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,840.22 ft | Headwater Depth/Height | 1.08 |
| Computed Headwater Eleva | 6,837.45 ft | Discharge | 132.00 cfs |
| Inlet Control HW Elev. | 6,837.11 ft | Tailwater Elevation | 6,832.96 ft |
| Outlet Control HW Elev. | 6,837.45 ft | Control Type | Entrance Control |

← MAX INFLOW @ POWERS (BASIN ULT-AC Φ5)

OUTLET + DEPTH

### Grades

FUTURE INV.

| | | | |
|---|---|---|---|
| Upstream Invert | ~~6,833.13~~ ft | Downstream Invert | 6,830.60 ft |
| Length | 506.19 ft | Constructed Slope | 0.004998 ft/ft |

FUTURE LENGTH

### Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.29 ft |
| Slope Type | Steep | Normal Depth | 2.29 ft |
| Flow Regime | Supercritical | Critical Depth | 2.47 ft |
| Velocity Downstream | 9.62 ft/s | Critical Slope | 0.004057 ft/ft |

### Section

| | | | |
|---|---|---|---|
| Section Shape | Box | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 6.00 ft |
| Section Size | 6 x 4 ft | Rise | 4.00 ft |
| Number Sections | 1 | | |

### Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,837.45 ft | Upstream Velocity Head | 1.23 ft |
| Ke | 0.50 | Entrance Loss | 0.62 ft |

### Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,837.11 ft | Flow Control | Unsubmerged |
| Inlet Type | 30 to 75° wingwall flares | Area Full | 24.0 ft² |
| K | 0.02600 | HDS 5 Chart | 8 |
| M | 1.00000 | HDS 5 Scale | 1 |
| C | 0.03470 | Equation Form | 1 |
| Y | 0.86000 | | |

# Worksheet
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | Discharge Channel from |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 7.00 | ft |
| Discharge | 175.00 | cfs |

→ MAX DISCHARGE (BASIN ULT-AC15)

| Results | | |
|---|---|---|
| Depth | 2.36 | ft |
| Flow Area | 38.7 | ft² |
| Wetted Perim | 26.44 | ft |
| Top Width | 25.86 | ft |
| Critical Depth | 1.90 | ft |
| Critical Slope | 0.012528 | ft/ft |
| Velocity | 4.52 | ft/s |
| Velocity Head | 0.32 | ft |
| Specific Energ | 2.67 | ft |
| Froude Numb | 0.65 | |
| Flow Type | Subcritical | |

DRAFT

## Appendix E: Hydraulics - Multiple Drop Structure Design For Elkhorn Basin

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT - REGION 2 Project Name: POWERS / SH83

Project/Calculation Number: 67000042 500.02

Title: POWERS / SH83 WEIR / DROP STRUCTURE NEAR RAMP E

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 9-26-02

Checked by: W. Alspach Date: 27 Sep 02

Description and Purpose: - DESIGN WEIR / DROP STRUCTURE FOR ELKHORN BASIN NEAR RAMP E (NEED TO DROP AROUND 20' TO BRING DRAINAGE UNDER RAMP E.

Design bases/references/assumptions:
- CDOT DRAINAGE CRITERIA MANUAL
- QA'D RATIONAL CALCS
- HEC-15
- TRI-LOCK INFO
- CONCRETE PIPE HANDBOOK
- ASSUMED INV @ 48" FES UNDER RAMP E

Remarks/conclusions:

Calculation Approved by: ______
Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| 1 | Change max to 22fps (TYPE 2 change) | W. Alspach 2 Oct 02 |
| | | |
| | | |

Project Manager/Date

**URS**

| | | | |
|---|---|---|---|
| Job POWERS / SH83 | Project No. 6900042500.02 | Page ____ of ____ | |
| | | Sheet 1 of ____ | |
| Description WEIR / DROP STRUCTURE | Computed by SDE | Date 9-25-02 | |
| | Checked by W. Alspach | Date 27 Sep 02 | |
| | | Reference | |

USING THE INV @ THE 48" FES AS A STARTING POINT
INV= 6866.73

ASSUME 20' UP TO INV OUT. OF PIPE

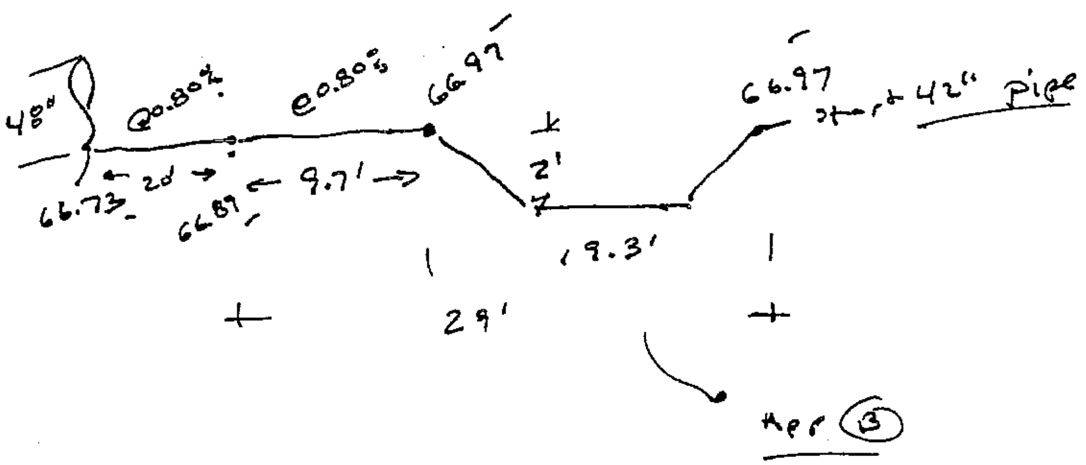
MAX DISCHARGE IN CHANNEL = $Q_{100}$ = 129 cfs
(BASIN ULT-AC04)
USING A 5 fps MAXIMUM GIVES A SLOPE OF 0.80% AND A DEPTH OF 1.82'
APP. (A)

∴ INV OUT OF PIPE = 66.73
+20 (.008)
6866.89 ✓

ASSUMPTION IS USE INTERNAL ENERGY DISSAPATOR TO LET MAX SLOPE

FORGOT PLUNGE POOL
~~END PLUNGE POOL @ 48" RCP~~

PLUNGE POOL WILL START @ 66.89 (20' AWAY)



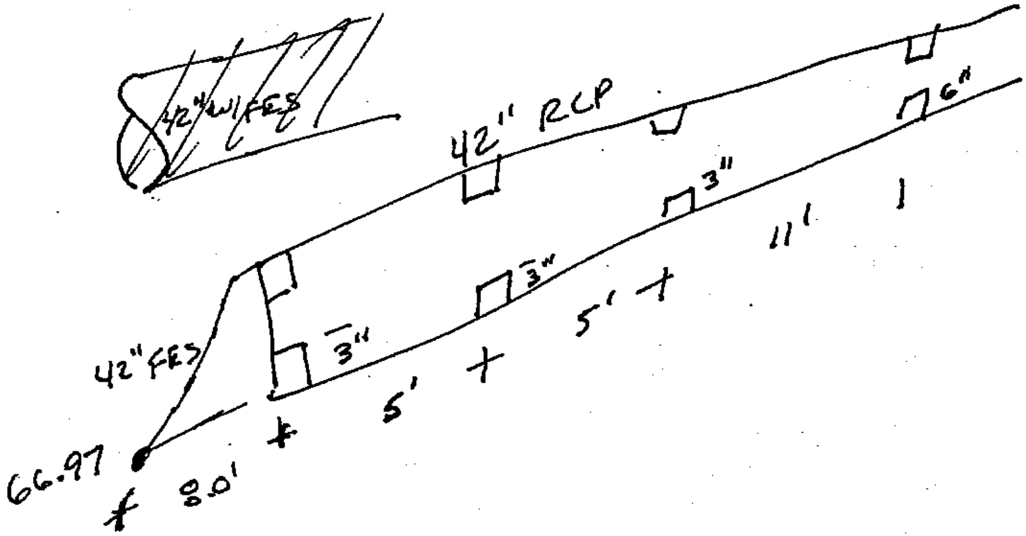
**URS**

| | | | |
|---|---|---|---|
| | | Page ____ | of ____ |
| Job: Powers / SH83 | Project No. 67000 42500.02 | Sheet 2 | of ____ |
| Description: WEIR / DROP STRUCTURE | Computed by EDE | Date 9-25-02 | |
| | Checked by W. Alspach | Date 27 Sep 02 | |
| | | Reference | |

* ASSUME ~~MAX SLOPE~~ MIN SIZE PIPE W/ FULL FLOW DISSAPATORS TO MAINTAIN EXIT VELOCITY OF 16 fps.

∴ A 42" PIPE W/ INTERNAL DISSAPTORS

SEE APP. (C)




SLOPE OF 42" RCP WILL BE MAXIMIZED TO GAIN ELEVATION.

TRY 3 DIFF. VELOCITIES

| | | |
|---|---|---|
| (D) | 20 fps ✓ | SLOPE = 3.25% |
| (E) | 25 fps ✓ | SLOPE = 6.00% |
| (F) | 30 fps ✓ | SLOPE = 9.75% |

use thickened walls!

NEED TO ~~CHECK~~ THE ADVANTAGE TO WEIGH THE VELOCITY VS. THE GAIN IN ELEVATION.

Note 22 fps is max allowed by CDOT ✓

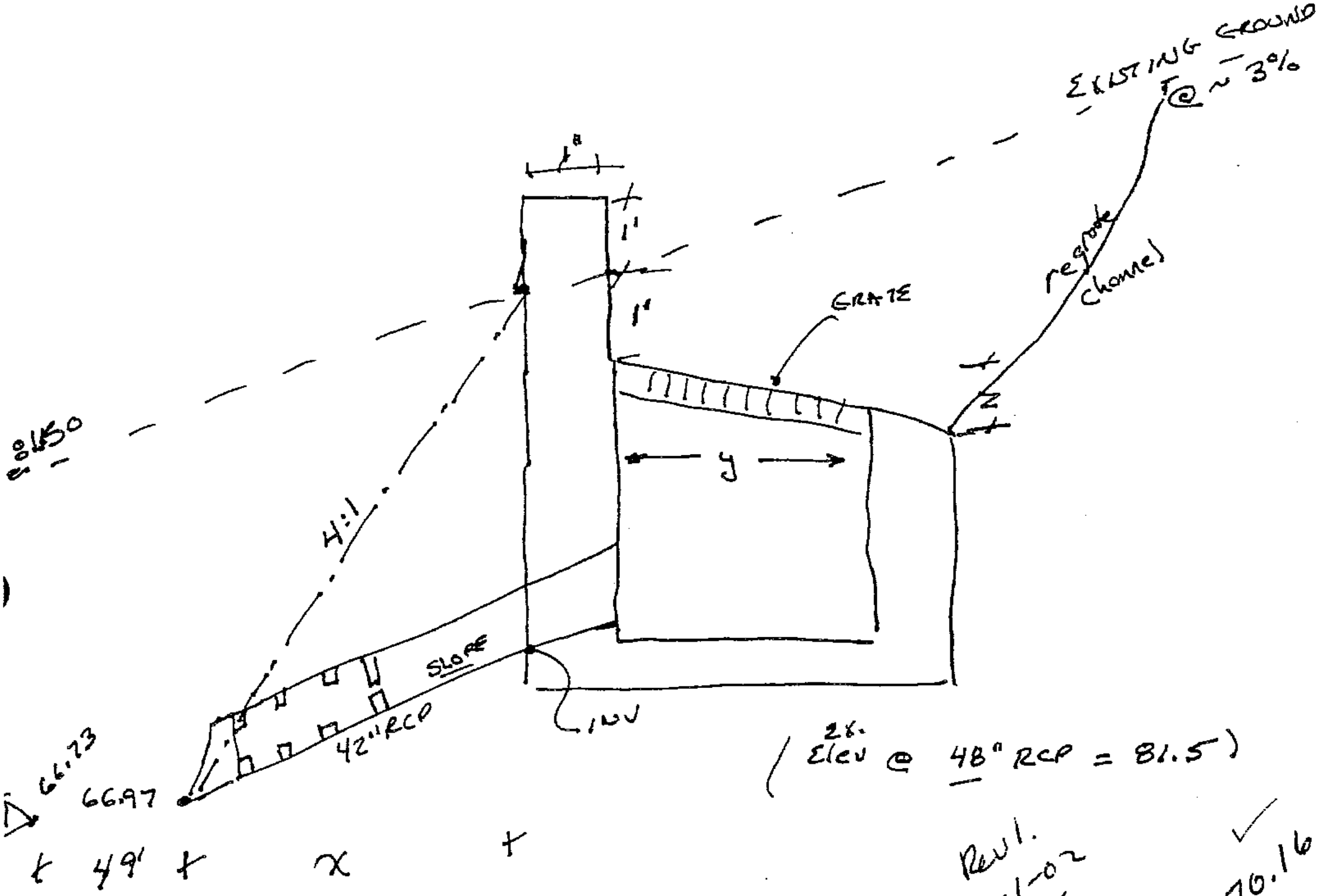
∴ slope = 4.25% → (K) ✓

Rev ~~10-1-02~~ 10/1 EDE

WA 2 Oct 02

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS / SH83 | Project No. 6900042500.02 | Page ___ of ___ | Sheet 3 of ___ |
| Description: WEIR / DROP STRUCTURE | Computed by: EDE | Date: 9-25-02 | |
| | Checked by: W. Alspach | Date: 27 Sep 02 | |
| | | Reference | |




$\therefore 66.97 + x/4 = 81.5 + (49 + x)(.03)$

$.22x = 16$

$x = 72.7 \approx 75'$

$\therefore$ GROUND = 85

Rev 1. 10-1-02 EDE
4.25% ⇒ INV = 70.16 ✓
H = 14.84 still OK!

| | | |
|---|---|---|
| 3.25% ⇒ | INV = 69.41 | H = 85 − 69.41 = 15.59' |
| 6.00% ⇒ | INV = 71.47 | H = 85 − 71.47 = 13.53' |
| 9.75% ⇒ | INV = 74.28 | H = 85 − 74.28 = 10.72' |

TYPICAL STRUCTURES COME IN 5', 10' & 15' FOR H
USE 6.00% TO MIN. VELOCITY BUT BE IN H = 15'

**URS**

Page ____ of ____

Job: POWERS / SH83 — Project No. 6200042500.02 — Sheet 4 of ____

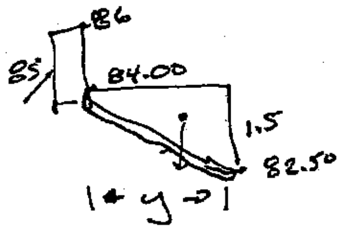
Description: WEIR / DROP STRUCTURE — Computed by: EDS — Date: 9-25-02

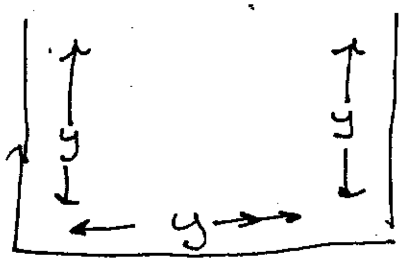
Checked by: W. Alspach — Date: 27 Sep 02

Reference

FOR THE WEIR, ASSUME Z (FROM ORIGINAL DRAWING = 1.5', ALSO ASSUME A ~~BOX~~ SQUARE BOX.

∴ TO CALCULATE y ASSUME MAX DEPTH WILL BE 1.5' above weir @ 82.50' ∴ WS = 82.5+1.5 = ~~83~~ 84.0




∴ weir length = y + 1/3 y + 1/3 y

(1/3 is using centroid theory)

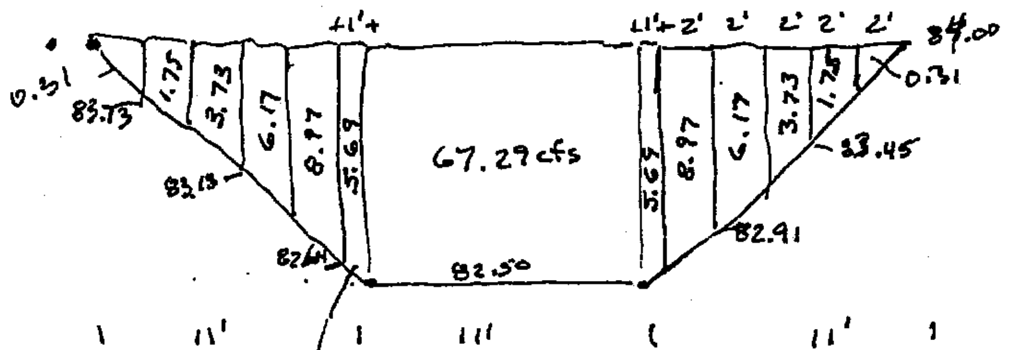
∴ weir length = 5/3 y

(G) w = 18.14 = 5/3 y  y = 10.8 = 11' round

(H) ∴ w = 18.33 gives a depth of 1.49'

QUICK CHECK FOR ASSUMPTION OF CENTROID

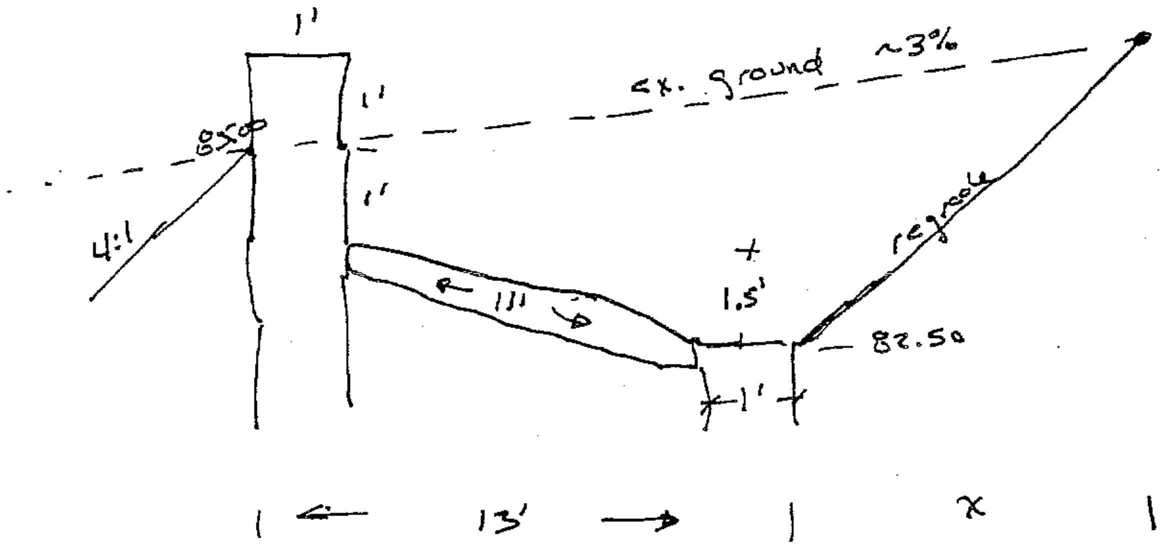
* DO IN PIECES




∴ SUM = 120.53 cfs conservative OK!

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS / SHB3 | Project No. 67000 42500.02 | Page ___ of ___ | |
| Description: WEIR / DROP STRUCTURE | Computed by: SDE | Sheet 5 of ___ | Date 9-25-02 |
| | Checked by: W. Alspach | | Date 27 Sep 02 |
| | | Reference | |




try some slopes

∴ @ 4%

85.00 + (13 + x)(.03) = 82.50 + .04x

2.89 = .01x

x = 289 ← way too long

try a 10:1 (10% slope)

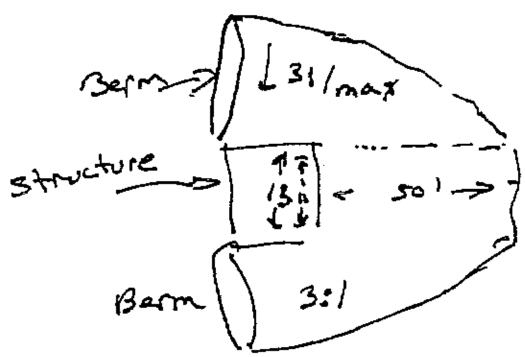
85.00 + (13 + x)(.03) = 82.50 + .10x

2.89 = .07x

x = 41.3' better

Say = x = 50' at 10:1

velocities will be high 9 fps (I)
rip rap to be used




TOTAL DISTANCE = 20'
29'
75'
13'
50'

FROM ...

# URS

Job: POWERS /5483 | Project No. 67000 42500.02 | Page ___ of ___ | Sheet 6 of ___
Description: WEIR / DROP STRUCTURE | Computed by: EDE | Date: 9-26-01
Checked by: W. Alspach | Date: 27Sep02
Reference

TRY CONCRETE BLOCK REVETMENT FOR RIPRAP

CHECK COSTS (ESTIMATED OFF CDOT NUMBERS)

ASSUME 50' x 50' AREA FOR SIMPLICITY = 2500 SF

USING \$50 /SQ YD FOR REVETMENT

CBR = $\frac{2500\ SF}{} \times \frac{1\ SY}{9\ SF} \times \frac{\$50}{SY}$ = ~~\$~~ \$13,889 ✓

RIPRAP ASSUMING $d_{50}$ = 12" (GUESS)
∴ THICKNESS = 2'
2500 SF × 2' × $\frac{1\ CY}{27\ SF} \times \frac{\$41}{CY}$ = \$7,593 ✓

TRY $d_{50}$ = 24" (MAX. GUES
THICKNESS = 4'
2500 SF × 4' × $\frac{1\ CY}{27\ CF} \times \frac{\$45}{CY}$ = \$16,667 ✓

QUICK ESTIMATE ON SIZE (FROM CSDCM)

$$\frac{V S^{0.17}}{(S_s - 1)^{0.66}} = \frac{(9.07)(.10)^{0.17}}{(2.5-1)^{0.66}} = 4.69$$

TYPE H ($d_{50}$=18")

C.B.R. COULD BE COST. EQUIV. AS LONG AS IT'S AROUND \$50/SQ.YD.

HOWARD WAGNER GAVE AN INST. COST OF \$5.00/SF OR \$45/SQ.YD. (PURSUE C.B.R.)

**URS**

Page ____ of ____

Job: POWERS / SH83
Project No. 67000042500.02
Sheet 7 of ____

Description: WEIR / DROP STRUCTURE
Computed by: EDE
Date: 9-26-02

Checked by: W. Alspach
Date: 27 Sep 02

Reference

FROM ~~AE~~ AMERICAN EXCELSIOR COMPANY PUBLICATION "HYDRAULIC STABILITY OF TRI-LOCK 4010 REVETMENT IN HIGH VELOCITY FLOW"

A MANNINGS N = 0.03 WAS AVERAGED

A VELOCITY OF 10 - 16 fps FOR THE 4" (SMALLEST) WAS SHOWN TO BE STABLE.

FLOWMASTER SHOWS A VELOCITY OF 10.97 fps. STABLE. (J)

* WILL DESIGN WEIR BOX STRUCTURAL ON SEPERATE CALCS.

**URS**

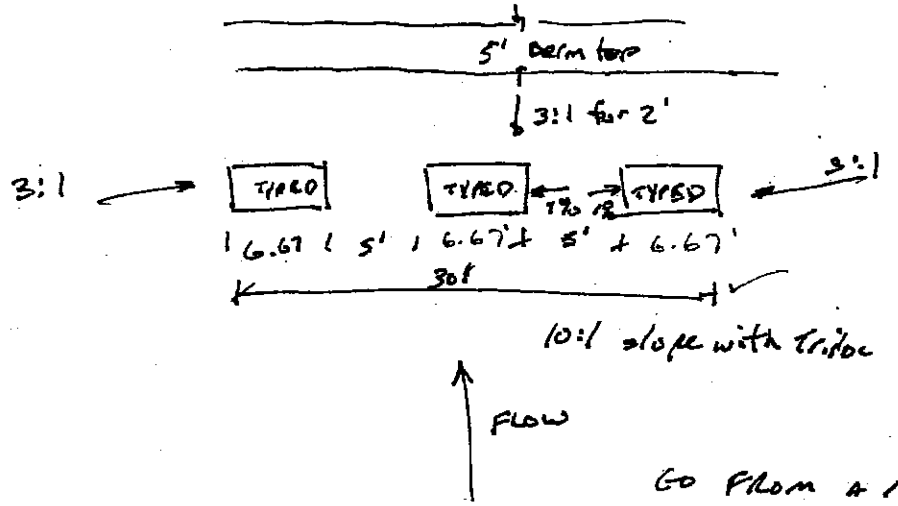
| | | | | | |
|---|---|---|---|---|---|
| | | | | Page ___ | of ___ |
| Job | POWERS BOULEVARD | Project No. | 6700042500.02 | Sheet 86 | of ___ |
| Description | WEIR DROP STRUCTURE | Computed by | EDE | Date | 10-1-02 |
| | | Checked by | W Alspach | Date | 2 OCT 02 |

REVISION 1

Reference

- TRY TO CHANGE WEIR STRUCTURE TO 3 each TYPE D INLETS

- ASSUMED BASIN ULT-A01 = 111 cfs ✓
- ASSUME MINIMUM THREE TYPE D INLETS
  ∴ 111 / 3 = 37 cfs per INLET ✓
- ASSUME MAX PONDING DEPTH = 1FT

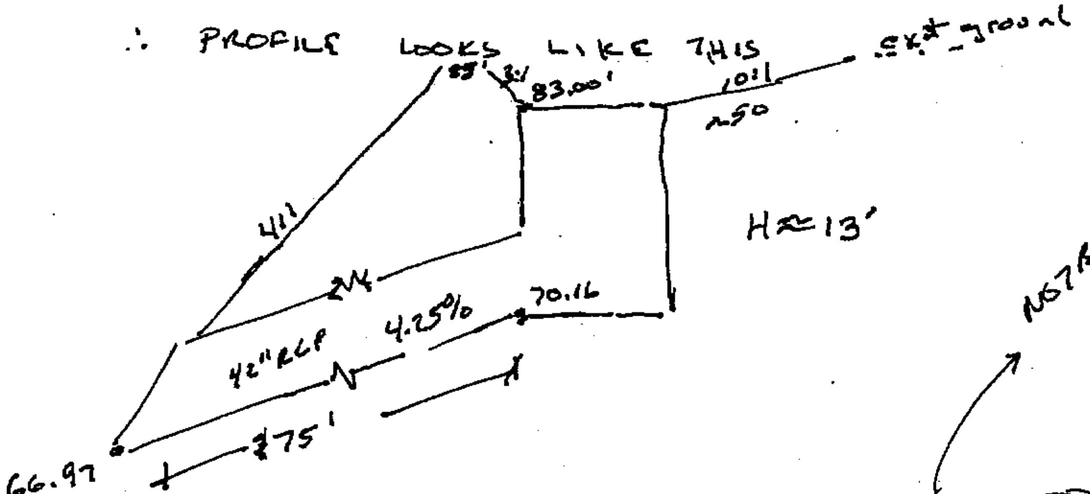



GO FROM A 10' BW TO 30' BW

(ASSUMPTION: 5' SEPERATION WILL GIVE ENOUGH SEPERATION FOR INFLUENCE.

3 TYPE D INLETS WILL GIVE A DEPTH OF 0.84' ✓ OK! (L)

∴ PROFILE LOOKS LIKE THIS




NOTE 10' BW is WORST CASE SCENARIO.

CHECK TRILOC w/ 10' BW (M)
V = 11.64 OK.

Redo with 6:1 due to R.O.W.

URS

Page ____ of ____

Job: POWERS BOULEVARD — Project No. 6700042500.02 — Sheet 9 of ____

Description: WEIR/DROP STRUCTURE — Computed by: EDE — Date: 10-1-02

Checked by: W. Alspach — Date: 2 OCT 02

Reference

PIPES FROM SIDE INLETS WILL HAVE 37 cfs
TRY TO HAVE 18" RCP AT MAX VEL OF 22 fps
TO MINIMIZE CHANGING STRUCTURE.

SLOPE OF 10% GIVES A VELOCITY OF 21.62 fps
OK. (N) ✓

NEED TO SET INV ON SIDE INLETS SO
HEADWATER NEEDED INTO 18" IS BELOW
GRATE SO AS NOT TO INFLUENCE GRATE. ✓

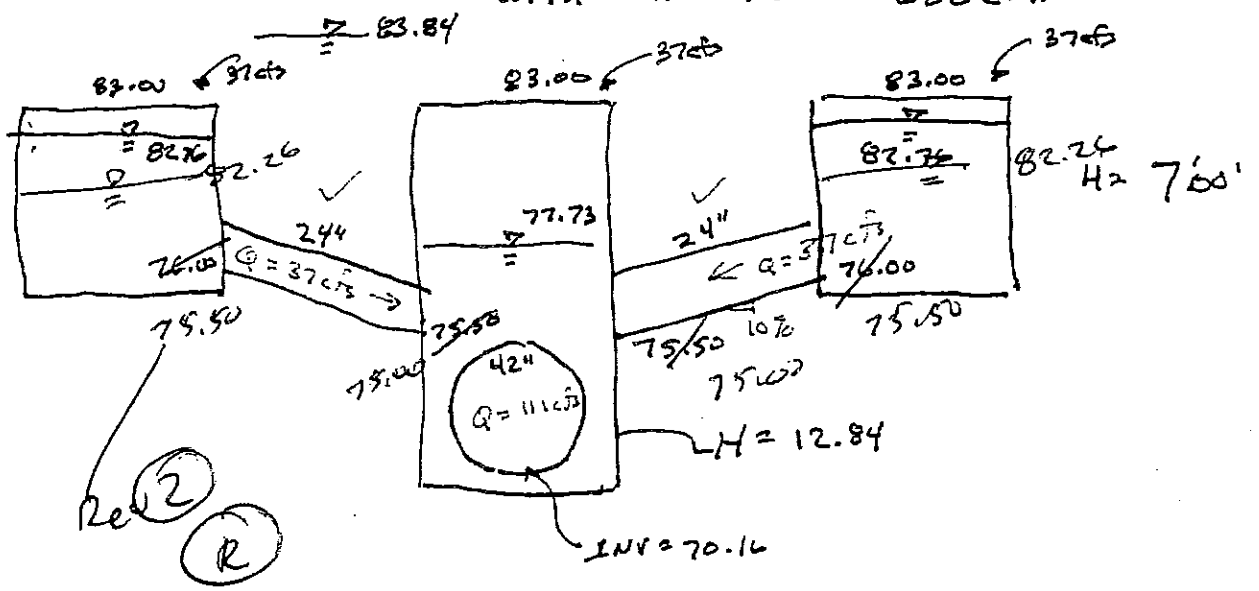
* NOT POSSIBLE (HEADWATER ELEV HIGHER
THAN INLET)! (O)

NEED TO CHECK HEADWATER IN 42" RCP. (P)

HW = 6877.73 ✓

TRY 24" PIPE AS HIGH AS POSSIBLE ✓

GIVES
INV OUT = 6876.~~00~~ 75.50
INV IN = 6875.~~50~~ 75.00 (Q)
WITH A HW = 6882.76



# Worksheet
## Worksheet for Trapezoidal Channel

(A)

| Project Description | |
|---|---|
| Worksheet | Discharge Channel for Weir/Drop |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 008000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 7.00 | ft |
| Discharge | 129.00 | cfs ✓ ← (BASIN ULT-AC04) |

| Results | | |
|---|---|---|
| Depth | 1.82 | ft ✓ |
| Flow Area | 26.0 | ft² |
| Wetted Perim | 22.03 | ft |
| Top Width | 21.58 | ft |
| Critical Depth | 1.62 | ft |
| Critical Slope | 0.013076 | ft/ft |
| Velocity | 4.95 | ft/s ✓ ← LESS THAN 5fps |
| Velocity Head | 0.38 | ft |
| Specific Energ | 2.20 | ft |
| Froude Numb | 0.79 | |
| Flow Type | Subcritical ✓ | |

## Plunge Pool Design

Weir Drop Plunge Pool — BASIN ULT-A01

111.00 Q (cfs)

21.84 Tailwater (in) — DOWNSTREAM DEPTH

**Box Culvert**

Height (in)
Width (in)

**Circular**

42 Diameter (in)

**Circular**

42.00 Normal Depth (in) — FULL FLOW

| | | | |
|---|---|---|---|
| 4.84 | Q/D^(2.5) | Rounded | 5.00 |
| 0.52 | TW/D | Rounded | 0.50 |
| 0.87 | Yo/D | | 1.00 |

36.54 Brink Depth (in)

0.60 TW/yo **LOW TAILWATER DEPTH**

1280 Brink Area (sq in)
12.49 Brink Velocity (fps)

25.29 Equivalent Brink Depth (in)
1.52 Froude

Rip Rap Sizing

| Type | d50 (in) | dmax (in) | d50/Ye | Hs/Ye | Hs (in) | Hs/d50 | 2<Hs/d50<4 |
|---|---|---|---|---|---|---|---|
| VL | 6 | 12 | 0.24 | 1.24 | 31.46 | 5.24 | BAD |
| L | 9 | 15 | 0.36 | 0.92 | 23.16 | 2.57 | OK ✓ |
| M | 12 | 21 | 0.47 | 0.63 | 15.85 | 1.32 | BAD |
| H | 18 | 30 | 0.71 | N/A | #VALUE! | #VALUE! | #VALUE! |
| VH | 24 | 42 | 0.95 | N/A | #VALUE! | #VALUE! | #VALUE! |

Rip Rap

| Type | d50 (in) | dmax (in) | Hs (in) |
|---|---|---|---|
| L | 9 | 15 | 23.16 — round to ~~2ft~~ 2' |

| **Dissapator Length** | | | **Apron Length** | | | **Thickness of Approach** | | | **Thickness of Basin** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19.30 | 10*hs (ft) | Max (ft) | 9.65 | 5*hs (ft) | Max (ft) | 2.25 | 3*d50 (ft) | Max (ft) | 1.50 | 2*d50 (ft) | Max (ft) |
| 10.50 | 3*Wo (ft) | **19.30** | 3.50 | Wo (ft) | **9.65** (round to 9.7') | 2.50 | 2*dmax (ft) | **2.50** | 1.88 | 1.5*dmax (ft) | **1.88** |



(B)

**Riprap Quantities**

| | |
|---|---|
| Hs (ft) | 1.93 |
| W (ft) | 3.50 |
| thickness approach (ft) | 2.50 |
| thickness basin (ft) | 1.88 |
| dissapator length (ft) | 19.30 |
| apron length (ft) | 9.65 |
| channel bottom (ft) | 7.00 |
| tailwater (ft) | 1.82 |

Channel Bottom must be larger than W

| Areas | (ft^3) | length (ft) | width (ft) | depth (ft) |
|---|---|---|---|---|
| A | 46.19 | 3.86 | 4.79 | 2.50 |
| B | 189.22 | 15.44 | 6.54 | 1.88 |
| C | 126.65 | 9.65 | 7.00 | 1.88 |
| D | 634.56 | 9.50 | 13.36 | 2.50 |
| E | 412.50 | 11.58 | 9.50 | 1.88 |
| F | 676.78 | 13.51 | 13.36 | 1.88 |

Total (cy) 77

# CONCRETE PIPE HANDBOOK

Published by
AMERICAN CONCRETE PIPE ASSOCIATION
222 West Las Colinas Blvd., Suite 641
Irving, Texas 75039-5423
(972) 506-7216

$31.50 (U.S.)

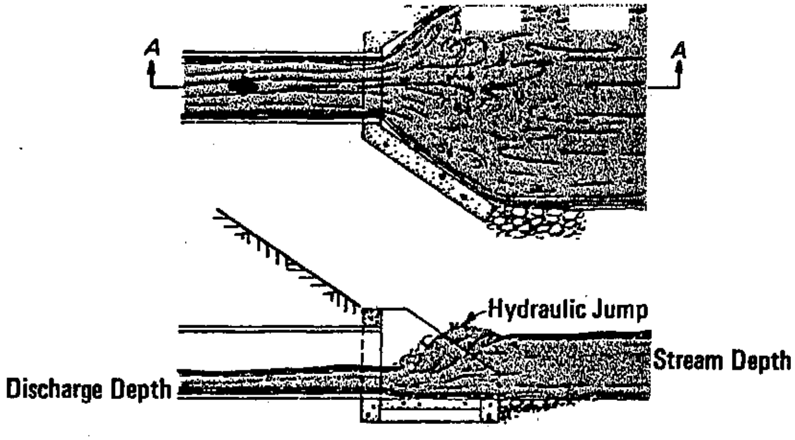



**Figure 5.25.** Transformation of Kinetic to Potential Energy by Hydraulic Jump and Flow Distribution.

## INTERNAL ENERGY DISSIPATORS

Research conducted in the 1960's at Virginia Polytechnic Institute and State University, VPI, on the use of roughness elements in open channels established that excess energy in storm water flowing down steep drainage channels could be dissipated by constructing roughness elements within the channel. Since culverts operating under inlet control simulate open channel flow, application of this type of internal energy dissipation to culverts would result in more efficient utilization of the culvert barrel and reduced outlet velocities.

In 1969, the American Concrete Pipe Association contracted with VPI to investigate and determine the feasibility and applicable design procedures for using roughness elements as energy dissipators of **free surface flow** in circular concrete pipe culverts, and the results were published in 1971.

Research was based on free surface flow, therefore, full capacity of the pipe was not realized. This necessitated an increase in pipe size within the length of the culvert in which the roughness elements were placed. Based on the laboratory and field observations during this initial research, subsequent tests were conducted for **full flow** conditions occurring near the outlet end at maximum design discharge. By eliminating the criteria of free surface flow and allowing the culvert to approach full flow, it was found velocity reduction could be effected without an increase in pipe size. The results of this later research and design procedures were published in 1972.

high velocities associated with culverts on what are considered steep slopes, the culverts were operating under inlet control. Accordingly, the flow characteristics were observed to be one of critical flow at the entrance of the pipe with the flow accelerating down the length of the pipe until the first ring, or roughness element, was reached. At that point a hydraulic jump was formed, with extreme turbulence. The flow then encountered another roughness element while still in an agitated condition from the first and this pattern of action was repeated until a cyclic condition was reached, where the flow conditions over the roughness elements were uniform. Generally, this cyclic action was attained after the second or third element. An early conclusion was that a maximum of five rings were necessary to achieve consistent results. The agitated flow is called tumbling flow and is characterized by a greater depth over the element than before it, a fall into a valley between the elements, and a form resembling a hydraulic jump shortly before the next element. When one cycle is completed, the flow tumbles into the next cycle until the outlet is reached. Tumbling flow can only be established and maintained under less than full flow conditions, *Figure 5.26*.

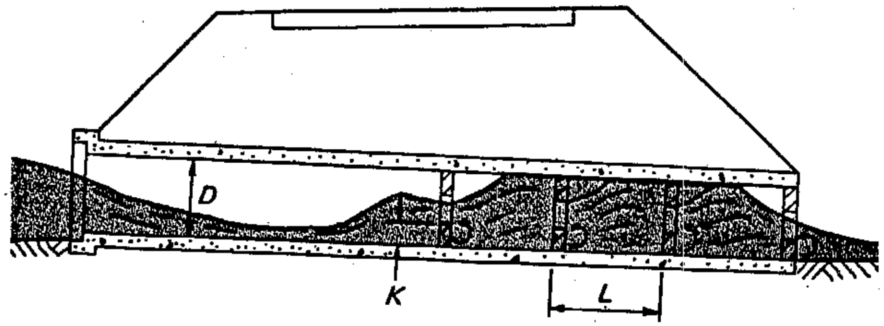



**Figure 5.26.** Internal Energy Dissipators with Tumbling Flow.

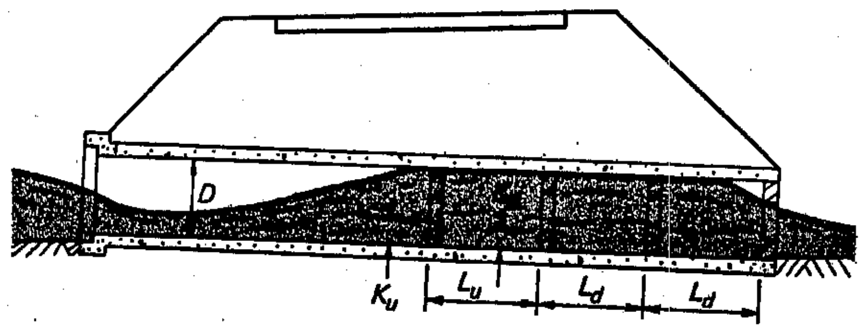



**Figure 5.27.** Internal Energy Dissipators with Full Flow.

During the VPI research on open channel flow, it was observed that if one large dissipator element was placed upstream a large hydraulic jump was created and maintained by smaller downstream elements. ACPA research validated this observation for pipe flow at maximum design discharges and concluded that three small rings preceded by one large ring at twice the small ring spacing would maintain full flow at slopes greater than 4 percent, *Figure 5.27*.

## DESIGN PROCEDURES AND CRITERIA

Based on the test results, the following design procedures and criteria for full flow and free surface flow are presented.

### Full Flow

1. Select required pipe size in accordance with the appropriate design procedures presented in *Chapter 3*.
2. Determine outlet velocity per *Chapter 3*.
3. Select a ring height for the three downstream elements within a range determined by:

$$0.06 \leq \frac{K_d}{D} \leq 0.09 \qquad (5.21)$$

Where: $K_d$ = ring height of the downstream elements, inches
$D$ = pipe diameter, inches

4. Select a ring height for the single upstream element within the range determined by:

$$0.12 \leq \frac{K_u}{D} \leq 0.18 \qquad (5.22)$$

Where: $K_u$ = ring height of the single upstream element, inches

5. Select a spacing for the three downstream elements as determined by:

$$L_d \approx \frac{1.5D}{12} \qquad (5.23)$$

Where: $L_d$ = Spacing of the downstream elements, feet

6. Select a spacing for the single upstream element as determined by:

$$L_u \approx \frac{3.0D}{12} \qquad (5.24)$$

Where: $L_u$ = spacing of the single upstream element, feet

7. Determine the hydraulic cross-sectional area in square feet at the last downstream element.
8. Determine the outlet velocity by dividing the design discharge by the cross-sectional area of flow determined previously.

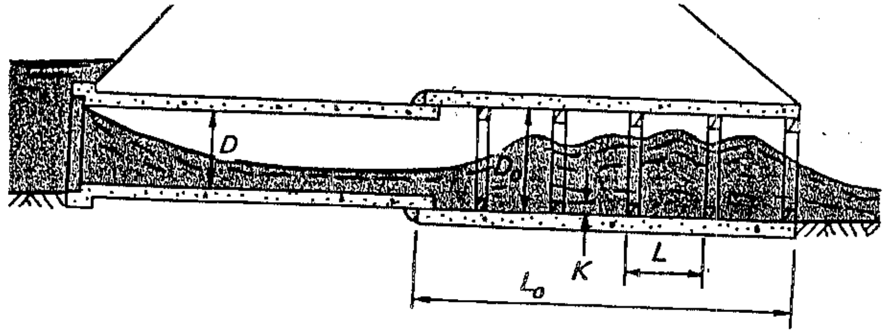



**Figure 5.28.** Internal Energy Dissipators with Free Surface Flow.

### Free Surface Flow

If full flow design reduces outlet velocity to an acceptable level, free surface flow design, *Figure 5.28*, is not required. However, if the outlet velocity is not acceptable, continue with free surface flow design as follows:

1. Select an outlet pipe diameter within the range determined by:

$$\left[\frac{Q^2}{3.22}\right]^{1/5} \leq D_0 \leq \left[\frac{Q^2}{1.42}\right]^{1/5} \qquad (5.25)$$

Where: $D_0$ = outlet pipe diameter, feet
$Q$ = design flow, cubic feet per second

2. Select a ring height for the elements within the range determined by:

$$1.2 \leq \frac{K}{D_0} \leq 1.8 \qquad (5.26)$$

Where: $K$ = ring height of the elements, inches

3. Select a ring spacing for the five elements within the range determined by:

$$1.5 \leq \frac{L}{D_0} \leq 2.5 \qquad (5.27)$$

Where: $L$ = spacing of the elements, feet

4. Determine the approximate length of the outlet pipe by:

$$L_0 \approx 5L \qquad (5.28)$$

Where: $L_0$ = length of the outlet pipe, feet

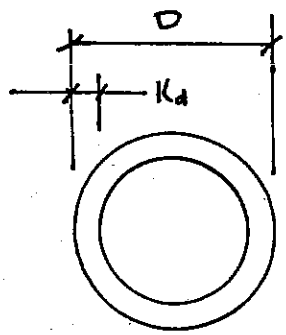
5. Determine hydraulic cross-sectional area at last dissipator ring based upon critical depth as presented in *Chapter 3*.
6. Determine the outlet velocity by dividing the design discharge by the cross-sectional area of flow determined in the previous step.

(C)

Checked WA 27Sep02

# Internal Energy Dissipators

Weir Drop Structure




Equations taken from the ACPA Concrete Pipe Handbook Chapter 5, 1998.
Note: There is two types of Tumbling Flow (Full Flow and Free Surface Flow)
Full Flow should be checked first, then Free Surface Flow

| | | |
|---|---|---|
| Q (cfs) | 111 | Design flow ← BASIN ULT-API |
| D (in) | 42 | Diameter of outlet pipe |

| Full Flow | | | |
|---|---|---|---|
| Min Kd (in) | 2.52 | Minimum ring height of the downstream elements | 0.06*D ✓ |
| Max Kd (in) | 3.78 | Maximum ring height of the downstream elements | 0.09*D ✓ |
| Kd (in) | 3 | Chosen Kd between min and max | 0.06<Kd<0.09 (Kd/D) |
| | OK | | |
| Min Ku (in) | 5.04 | Minimum ring height of the single upstream element | 0.12*D |
| Max Ku (in) | 7.56 | Maximum ring height of the single upstream element | 0.18*D |
| Ku (in) | 6 | Chosen Ku between min and max | 0.12<Ku/D<0.18 |
| | OK | | |
| Ld (ft) | 5 | Spacing of the downstream elements ✓ | 1.5*D/12 (rounded) ✓ |
| Lu (ft) | 11 | Spacing of the single upstream element ✓ | 3.0*D/12 (rounded) ✓ |
| Area (ft^2) | 7.07 | Hydraulic cross-sectional area at last ring | pi*((D-2*Kd)/12)^2)/4 |
| **V (fps)** | **15.7** | **Outlet velocity** | Q/A |

✓ less than 16 fps

| Free Surface Flow (NOT USED) | | | |
|---|---|---|---|
| Min Do (ft) | 5.21 | Minimum outlet pipe diameter | ((Q^2)/3.22)^(1/5) |
| Max Do (ft) | 6.13 | Maximum outlet pipe diameter | ((Q^2)/1.42)^(1/5) |
| Do (ft) | 5.5 | Chosen Do between min and max | ((Q^2)/3.22)^(1/5)<Do<((Q^2)/1.42)^(1/5) |
| | OK | | |
| M:in K (in) | 6.6 | Minimum ring height of elements | 1.2*Do |
| Max K (in) | 9.9 | Maximum ring height of elements | 1.8*Do |
| K (in) | 8 | Chosen K between min and max | 1.2<K/Do<1.8 |
| | OK | | |
| Min L (ft) | 8.25 | Minimum spacing of the elements | 1.5*Do |
| Max L (ft) | 13.75 | Maximum spacing of the elements | 2.5*Do |
| L (ft) | 10 | Chosen L between min and max | 1.5<L/Do<2.5 |
| | OK | | |
| Lo (ft) | 50 | Length of the outlet pipe | 5*L |
| Using Flowmaster find critical depth, area at critical depth, and velocity at critical depth | | | |
| Diameter (in) | 50.00 | | |
| Q (cfs) | 111 | | |
| dc (ft) | 3.16 | Critical Depth from Flowmaster | |
| Area (ft^2) | 11.1 | Area at Critical Depth from Flowmaster | |
| **V (fps)** | **10** | **Velocity at Critical Depth from Flowmaster** | |

# Worksheet
## Worksheet for Circular Channel

(D)

| Project Description | |
|---|---|
| Worksheet | 42" RCP for Weir |
| Flow Element | Circular Channel |
| Method | Manning's Formul |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.013 | |
| Slope | 032500 | ft/ft |
| Diameter | 42 | in |
| Discharge | 111.00 | cfs ← BASIN ULT-A01 |

| Results | | |
|---|---|---|
| Depth | 1.98 | ft |
| Flow Area | 5.6 | ft² |
| Wetted Perime | 5.96 | ft |
| Top Width | 3.47 | ft |
| Critical Depth | 3.18 | ft |
| Percent Full | 56.5 | % |
| Critical Slope | 0.010644 | ft/ft |
| Velocity | 19.79 | ft/s ← 20 fps max |
| Velocity Head | 6.09 | ft |
| Specific Energ: | 8.07 | ft |
| Froude Numbe | 2.75 | |
| Maximum Disc | 195.10 | cfs |
| Discharge Full | 181.37 | cfs |
| Slope Full | 0.012173 | ft/ft |
| Flow Type | ;upercritical | |

# Worksheet
## Worksheet for Circular Channel

(51)

| Project Description | |
|---|---|
| Worksheet | 42" RCP for Weir Drop |
| Flow Element | Circular Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.013 | |
| Slope | 060000 | ft/ft ✓ |
| Diameter | 42 | in |
| Discharge | 111.00 | cfs ← BASIN ULT-A01 |

| Results | | |
|---|---|---|
| Depth | 1.65 | ft |
| Flow Area | 4.4 | $ft^2$ |
| Wetted Perime | 5.29 | ft |
| Top Width | 3.49 | ft |
| Critical Depth | 3.18 | ft |
| Percent Full | 47.1 | % |
| Critical Slope | 0.010644 | ft/ft |
| Velocity | 24.94 | ft/s ✓ ← 25 fps max |
| Velocity Head | 9.67 | ft |
| Specific Energ | 11.32 | ft |
| Froude Numbe | 3.90 | |
| Maximum Disc | 265.09 | cfs |
| Discharge Full | 246.43 | cfs |
| Slope Full | 0.012173 | ft/ft |
| Flow Type | Supercritical | |

# Worksheet
## Worksheet for Circular Channel

(F)

| Project Description | |
|---|---|
| Worksheet | 42" RCP for Weir Drop |
| Flow Element | Circular Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.013 | |
| Slope | 097500 | ft/ft ✓ |
| Diameter | 42 | in |
| Discharge | 111.00 | cfs ← Basin ULT-A01 |

| Results | | |
|---|---|---|
| Depth | 1.44 | ft |
| Flow Area | 3.7 | ft² |
| Wetted Perime | 4.87 | ft |
| Top Width | 3.44 | ft |
| Critical Depth | 3.18 | ft |
| Percent Full | 41.1 | % |
| Critical Slope | 0.010644 | ft/ft |
| Velocity | 29.83 | ft/s ✓ ← 30 fps max |
| Velocity Head | 13.83 | ft |
| Specific Energ | 15.27 | ft |
| Froude Numbe | 5.06 | |
| Maximum Disc | 337.92 | cfs |
| Discharge Full | 314.14 | cfs |
| Slope Full | 0.012173 | ft/ft |
| Flow Type | Supercritical | |

# Worksheet
## Worksheet for Sharp Crested Rectangular Weir

(G)

| Project Description | |
|---|---|
| Worksheet | Weir Drop w/ 1.5' Depth |
| Type | Sharp Crested Rectangul |
| Solve For | Crest Length |

| Input Data | | | |
|---|---|---|---|
| Discharge | 111.00 | cfs | ← BASIN ULT-A01 ✓ |
| Headwater Elevatic | ,884.00 | ft | ✓ |
| Crest Elevation | ,882.50 | ft | ✓ ← 1.5' DEPTH |
| Tailwater Elevation | ,874.97 | ft | |
| Discharge Coefficie | 3.33 | US | |
| Number of Contrac | 0 | | |

| Results | | | |
|---|---|---|---|
| Crest Length | 18.14 | ft | ← WEIR LENGTH NEEDED ✓ |
| Headwater Height Abov | 1.50 | ft | |
| Tailwater Height Above | -7.53 | ft | |
| Flow Area | 27.2 | ft² | |
| Velocity | 4.08 | ft/s | |
| Wetted Perimeter | 21.14 | ft | |
| Top Width | 18.14 | ft | |

# Worksheet
## Worksheet for Sharp Crested Rectangular Weir

(4)

| Project Description | |
|---|---|
| Worksheet | Weir Drop w/ 1.5' Depth |
| Type | Sharp Crested Rectangul |
| Solve For | Headwater Elevation |

| Input Data | | |
|---|---|---|
| Discharge | 111.00 | cfs |
| Crest Elevation | ,882.50 | ft |
| Tailwater Elevation | ,874.97 | ft |
| Discharge Coefficic | 3.33 | US |
| Crest Length | 18.33 | ft |
| Number of Contrac | 0 | |

← BASIN U27-A01

← 4=11'

| Results | | |
|---|---|---|
| Headwater Elevation | ,883.99 | ft |
| Headwater Height Abov | 1.49 | ft |
| Tailwater Height Above | -7.53 | ft |
| Flow Area | 27.3 | ft² |
| Velocity | 4.06 | ft/s |
| Wetted Perimeter | 21.31 | ft |
| Top Width | 18.33 | ft |

← 1.49' DEPTH

# Worksheet
## Worksheet for Trapezoidal Channel

(1)

| Project Description | |
|---|---|
| Worksheet | Channel into We |
| Flow Element | Trapezoidal Cha |
| Method | Manning's Formu |
| Solve For | Channel Depth |

| Input Data | | | |
|---|---|---|---|
| Mannings Coeffic | 0.040 | | ← RIPRAP ✓ |
| Slope | 100000 | ft/ft | ← 10:1 DROP |
| Left Side Slope | 3.00 | H : V | |
| Right Side Slope | 3.00 | H : V | ← WEIR OF 11' + 1' WALL ON EITHER SIDE |
| Bottom Width | 13.00 | ft | |
| Discharge | 111.00 | cfs | ← BASIN ULT-A01 |

| Results | | |
|---|---|---|
| Depth | 0.80 | ft |
| Flow Area | 12.2 | ft² |
| Wetted Perimi | 18.03 | ft |
| Top Width | 17.77 | ft |
| Critical Depth | 1.19 | ft |
| Critical Slope | 0.024070 | ft/ft |
| Velocity | 9.07 | ft/s ✓ |
| Velocity Head | 1.28 | ft |
| Specific Energ | 2.07 | ft |
| Froude Numb | 1.93 | |
| Flow Type | Supercritical | |

# Worksheet
## Worksheet for Trapezoidal Channel

(3)

| Project Description | |
|---|---|
| Worksheet | Channel into Weir (tri-lo |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

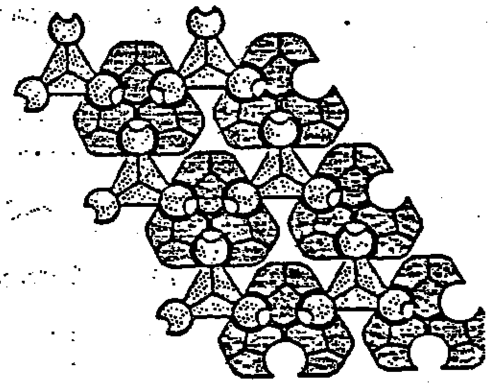
| Input Data | | | |
|---|---|---|---|
| Mannings Coeffic | 0.030 | | ← TRI-LOCK ✓ |
| Slope | 100000 | ft/ft | ← 10:1 DROP ✓ |
| Left Side Slope | 3.00 | H : V | |
| Right Side Slope | 3.00 | H : V | |
| Bottom Width | 13.00 | ft | ← WEIR 11' +1' WALL ON EITHER SIDE ✓ |
| Discharge | 111.00 | cfs | ← BASIN ULT-A01 |

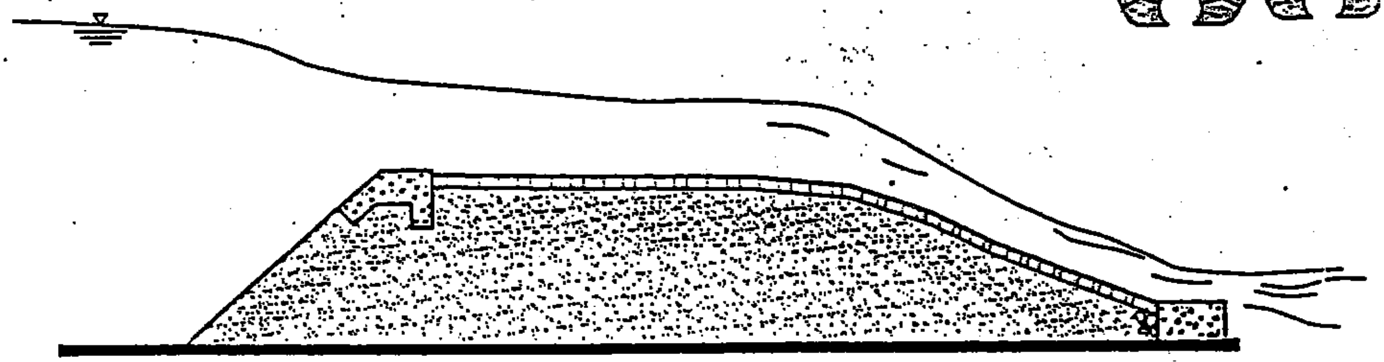
| Results | | | |
|---|---|---|---|
| Depth | 0.67 | ft | |
| Flow Area | 10.1 | ft² | |
| Wetted Perim | 17.26 | ft | |
| Top Width | 17.04 | ft | |
| Critical Depth | 1.19 | ft | |
| Critical Slope | 0.013540 | ft/ft | |
| Velocity | 10.97 | ft/s | ← BETWEEN 10 fps AND 16 fps (4" TRI-LOCK OK) ✓ |
| Velocity Head | 1.87 | ft | |
| Specific Energ | 2.54 | ft | |
| Froude Numb | 2.51 | | |
| Flow Type | Supercritical | | |

# HYDRAULIC STABILITY OF TRI-LOCK 4010 REVETMENT IN HIGH VELOCITY FLOW

*Prepared For:*

American Excelsior Company
850 Avenue H East
Arlington, TX 76011





*Prepared By:*

Resource Consultants & Engineers, Inc.
3665 JFK Parkway
Bldg. 2, Suite 300
Fort Collins, CO 80525

Project Number 92-857
February 1993

RCE RESOURCE CONSULTANTS & ENGINEERS, INC
A KLH Engineering Group Company

Table 3.2. Summary of Key Hydraulic Parameters.

| Test Number | Embankment Slope (ft/ft) | Typical Depth (ft) | Maximum Velocity (ft/s) | Maximum Energy Slope $S_f$ (ft/ft) | Maximum Shear Stress $\tau_o$ (lb/ft$^2$) | Manning's n Values | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Crest | Slope | |
| TL-1A | 0.20 | 0.35 | 9.7 | 0.20 | 4.8 | 0.026 | 0.035 | Stable |
| TL-2A | 0.20 | 0.61 | 15.0 | 0.20 | 7.6 | 0.026 | 0.035 | At stability threshold |
| TL-3A | 0.20 | 1.01 | 15.8 | 0.115 | 7.4 | 0.028 | 0.032 | At stability threshold |
| TL-1B | 0.50 | 0.26 | 11.6 | 0.50 | 8.1 | 0.026 | 0.038 | Failed |

# 4. SELECTION OF TRI-LOCK BLOCK

The selection of the proper Tri-Lock System, 4", 6", or 8" is affected by site or project conditions such as soil permeability, flow or wave intensity, soil compaction and slope or grade conditions.

Generally acceptable guidelines are:

4010 (Nominal 4" Tri-Lock)
Flow - 10-16 fps
Wave - 4' Height

4015 (Nominal 6" Tri-Lock)
Flow - 16-20 fps
Wave - 7' Height

4020 (Nominal 8" Tri-Lock)
Contact American Excelsior Specialist

# Worksheet
## Worksheet for Circular Channel

(K)

| Project Description | |
|---|---|
| Worksheet | 42" RCP for Weir Drop |
| Flow Element | Circular Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.013 | |
| Slope | 042500 | ft/ft |
| Diameter | 42 | in |
| Discharge | 111.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.82 | ft |
| Flow Area | 5.1 | ft² |
| Wetted Perime | 5.64 | ft |
| Top Width | 3.50 | ft |
| Critical Depth | 3.18 | ft |
| Percent Full | 52.1 | % |
| Critical Slope | 0.010644 | ft/ft |
| Velocity | 21.92 | ft/s |
| Velocity Head | 7.47 | ft |
| Specific Energ; | 9.29 | ft |
| Froude Numbe | 3.21 | |
| Maximum Disc | 223.10 | cfs |
| Discharge Full | 207.40 | cfs |
| Slope Full | 0.012173 | ft/ft |
| Flow Type | Supercritical | |

# Worksheet
## Worksheet for Ditch Inlet In Sag

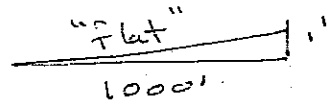
(L)

| Project Description | |
|---|---|
| Worksheet | Type D Inlets at W |
| Type | Ditch Inlet In Sag |
| Solve For | Spread |

| Input Data | | |
|---|---|---|
| Discharge | 37.00 | cfs |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 1,000.00 | H : V |
| Bottom Width | 4.00 | ft |
| Grate Width | 3.42 | ft |
| Grate Length | 5.67 | ft |
| Local Depression | 0.0 | in |
| Local Depression \ | 0.00 | ft |
| Grate Type | ) mm (P-1-7/8") | |
| Clogging | 30.0 | % |

← 111 cfs / 3 inlets (BASIN ULT-AP1 ✓

← ESTIMATE FOR FLAT BOTTOM ON ONE SIDE ✓




| Results | | |
|---|---|---|
| Spread | 142.75 | ft ✓ |
| Depth | 0.84 | ft ← PONDING DEPTH |
| Wetted Perimeter | 142.89 | ft |
| Top Width | 142.75 | ft |
| Open Grate Area | 12.2 | ft² |
| Active Grate Weir Le | 16.13 | ft |

# Worksheet
## Worksheet for Trapezoidal Channel

(M)

| Project Description | |
|---|---|
| Worksheet | Channel into Weir (tri-lo |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | | |
|---|---|---|---|
| Mannings Coeffic | 0.030 | | |
| Slope | 100000 | ft/ft | ← 10% |
| Left Side Slope | 3.00 | H : V | |
| Right Side Slope | 3.00 | H : V | |
| Bottom Width | 10.00 | ft | ← 10' B.W. |
| Discharge | 111.00 | cfs | ← BASIN ULT-A01 |

| Results | | | |
|---|---|---|---|
| Depth | 0.77 | ft | |
| Flow Area | 9.5 | $ft^2$ | |
| Wetted Perim | 14.90 | ft | |
| Top Width | 14.64 | ft | |
| Critical Depth | 1.36 | ft | |
| Critical Slope | 0.013314 | ft/ft | |
| Velocity | 11.64 | ft/s | ← LESS THAN 16 fps |
| Velocity Head | 2.10 | ft | |
| Specific Energ | 2.88 | ft | |
| Froude Numb | 2.54 | | |
| Flow Type | Supercritical | | |

# Worksheet
## Worksheet for Circular Channel

(N)

| Project Description | |
|---|---|
| Worksheet | Side Pipes for Type D Inlets a ✓ |
| Flow Element | Circular Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.013 | ✓ |
| Slope | 100000 ft/ft | ← 10% ✓ |
| Diameter | 18 in | ← MIN SIZE ✓ |
| Discharge | 37.00 cfs | ← 111 cfs / 3 ✓ |

| Results | | |
|---|---|---|
| Depth | 1.34 | ft |
| Flow Area | 1.7 | ft² |
| Wetted Perime | 3.70 | ft |
| Top Width | 1.02 | ft |
| Critical Depth | 1.53 | ft |
| Percent Full | 87.2 | % |
| Critical Slope | 0.105437 | ft/ft |
| Velocity | 21.62 | ft/s ← LESS THAN 22fps ✓ |
| Velocity Head | 7.26 | ft |
| Specific Energ | 8.60 | ft |
| Froude Numbe | 2.95 | |
| Maximum Disc | 37.95 | cfs |
| Discharge Full | 35.28 | cfs |
| Slope Full | 0.110000 | ft/ft |
| Flow Type | Supercritical | |

# Culvert Calculator Report
## 18" RCP between Type D inlets at weir

(6)

Solve For: Headwater Elevation

INLET RIM

| Culvert Summary | | | |
|---|---|---|---|
| Allowable HW Elevation | 83.00 ft | Headwater Depth/Height | 12.25 |
| Computed Headwater Eleva | 89.38 ft | Discharge | 37.00 cfs ← 111 cfs/3 ✓ |
| Inlet Control HW Elev. | 89.38 ft | Tailwater Elevation | 75.00 ft ← GUESS |
| Outlet Control HW Elev. | 85.84 ft | Control Type | Inlet Control |

OUTSIDE INLET! ✓

LOWEST POSSIBLE

| Grades | | | |
|---|---|---|---|
| Upstream Invert | 71.00 ft | Downstream Invert | 70.50 ft |
| Length | 5.00 ft | Constructed Slope | 0.100000 ft/ft |

| Hydraulic Profile | | | |
|---|---|---|---|
| Profile | PressureProfile | Depth, Downstream | 4.50 ft |
| Slope Type | N/A | Normal Depth | N/A ft |
| Flow Regime | N/A | Critical Depth | 1.50 ft |
| Velocity Downstream | 20.94 ft/s | Critical Slope | 0.119703 ft/ft |

| Section | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 1.50 ft |
| Section Size | 18 inch | Rise | 1.50 ft |
| Number Sections | 1 | | |

| Outlet Control Properties | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 85.84 ft | Upstream Velocity Head | 6.81 ft |
| Ke | 0.50 | Entrance Loss | 3.41 ft |

| Inlet Control Properties | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 89.38 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 1.8 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
## 42" RCP for weir

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,883.00 ft | Headwater Depth/Height | 2.16 |
| Computed Headwater Eleva | 6,877.73 ft | Discharge | 111.00 cfs |
| Inlet Control HW Elev. | 6,877.73 ft | Tailwater Elevation | 6,868.79 ft |
| Outlet Control HW Elev. | 6,876.75 ft | Control Type | Inlet Control |

INLET RIM — CALC HEADWATER — BASIN ULT-A01

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,870.16 ft | Downstream Invert | 6,866.97 ft |
| Length | 75.00 ft | Constructed Slope | 0.042533 ft/ft |

ACTUAL — ACTUAL

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.14 ft |
| Slope Type | Steep | Normal Depth | 1.82 ft |
| Flow Regime | Supercritical | Critical Depth | 3.18 ft |
| Velocity Downstream | 18.05 ft/s | Critical Slope | 0.010644 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.50 ft |
| Section Size | 42 inch | Rise | 3.50 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,876.75 ft | Upstream Velocity Head | 2.27 ft |
| Ke | 0.50 | Entrance Loss | 1.14 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,877.73 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 9.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
## 24" RCP between Type D inlets at weir - trial

Solve For: Headwater Elevation

RIM ELEV

### Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,883.00 ft | Headwater Depth/Height | 3.38 |
| Computed Headwater Eleva | 6,882.76 ft | Discharge | 37.00 cfs |
| Inlet Control HW Elev. | 6,882.76 ft | Tailwater Elevation | 6,877.73 ft |
| Outlet Control HW Elev. | 6,881.23 ft | Control Type | Inlet Control |

111 cfs / 3 inlets

COMP. HW OF MAIN INLET

BELOW RIM ELEV.

### Grades

| | | | |
|---|---|---|---|
| Upstream Invert | 6,876.00 ft | Downstream Invert | 6,875.50 ft |
| Length | 5.00 ft | Constructed Slope | 0.100000 ft/ft |

### Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | CompositePressureProfileS1S2 | Depth, Downstream | 1.61 ft |
| Slope Type | N/A | Normal Depth | 1.02 ft |
| Flow Regime | N/A | Critical Depth | 1.94 ft |
| Velocity Downstream | 13.66 ft/s | Critical Slope | 0.023483 ft/ft |

### Section

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

### Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,881.23 ft | Upstream Velocity Head | 2.20 ft |
| Ke | 0.50 | Entrance Loss | 1.10 ft |

### Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,882.76 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
# 24" RCP between Type D inlets at weir - FINAL

R

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,883.00 ft | Headwater Depth/Height | 3.38 |
| Computed Headwater Elev: | 6,882.26 ft | Discharge | 37.00 cfs |
| Inlet Control HW Elev. | 6,882.26 ft | Tailwater Elevation | 6,877.73 ft |
| Outlet Control HW Elev. | 6,881.10 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,875.50 ft | Downstream Invert | 6,875.00 ft |
| Length | 5.00 ft | Constructed Slope | 0.100000 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | PressureProfile | Depth, Downstream | 1.61 ft |
| Slope Type | N/A | Normal Depth | 1.02 ft |
| Flow Regime | N/A | Critical Depth | 1.94 ft |
| Velocity Downstream | 13.66 ft/s | Critical Slope | 0.023483 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 2.00 ft |
| Section Size | 24 inch | Rise | 2.00 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,881.10 ft | Upstream Velocity Head | 2.20 ft |
| Ke | 0.50 | Entrance Loss | 1.08 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,882.26 ft | Flow Control | Submerged |
| Inlet Type | Square edge w/headwall | Area Full | 3.1 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Worksheet
## Worksheet for Trapezoidal Channel

(5)

| Project Description | |
|---|---|
| Worksheet | Channel into Weir (tri-lo |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 166667 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 10.00 | ft |
| Discharge | 111.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 0.67 | ft |
| Flow Area | 8.0 | ft² |
| Wetted Perim | 14.23 | ft |
| Top Width | 14.02 | ft |
| Critical Depth | 1.36 | ft |
| Critical Slope | 0.013314 | ft/ft |
| Velocity | 13.81 | ft/s |
| Velocity Head | 2.97 | ft |
| Specific Energ | 3.63 | ft |
| Froude Numb | 3.22 | |
| Flow Type | Supercritical | |

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT REGION 2 Project Name: 67000042500.02

Project/Calculation Number: POWERS / SH83 INTERCHANGE

Title: WATERFALL AREA DESIGN

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 9-23-02

Checked by: W. ALSPACH Date: 25 SEP 02

Description and Purpose: TO DESIGN WATERFALL AREA WITH PROVEN DROP STRUCTURES.

Design bases/references/assumptions:
- CDOT DESIGN MANUAL
- QA'D FLOWS
- QA'D DROP STRUCTURE SPREADSHEET
- QA'D GROUTED BOULDER DROP.
- ASSUMPTION: ROCK DROPS INSTEAD OF CONCRETE.

Remarks/conclusions:

Calculation Approved by: ______

Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
| --- | --- | --- |
| | | |
| | | |
| | | |

Project Manager/Date

31.14'

ASSUMPTIONS: • THE UPPER END OF THE WATERFALL AREA IS SET BY THE 48" RCP UNDER RAMP E (INV OUT = 6864.45' (PREV. CALCS)) ✓

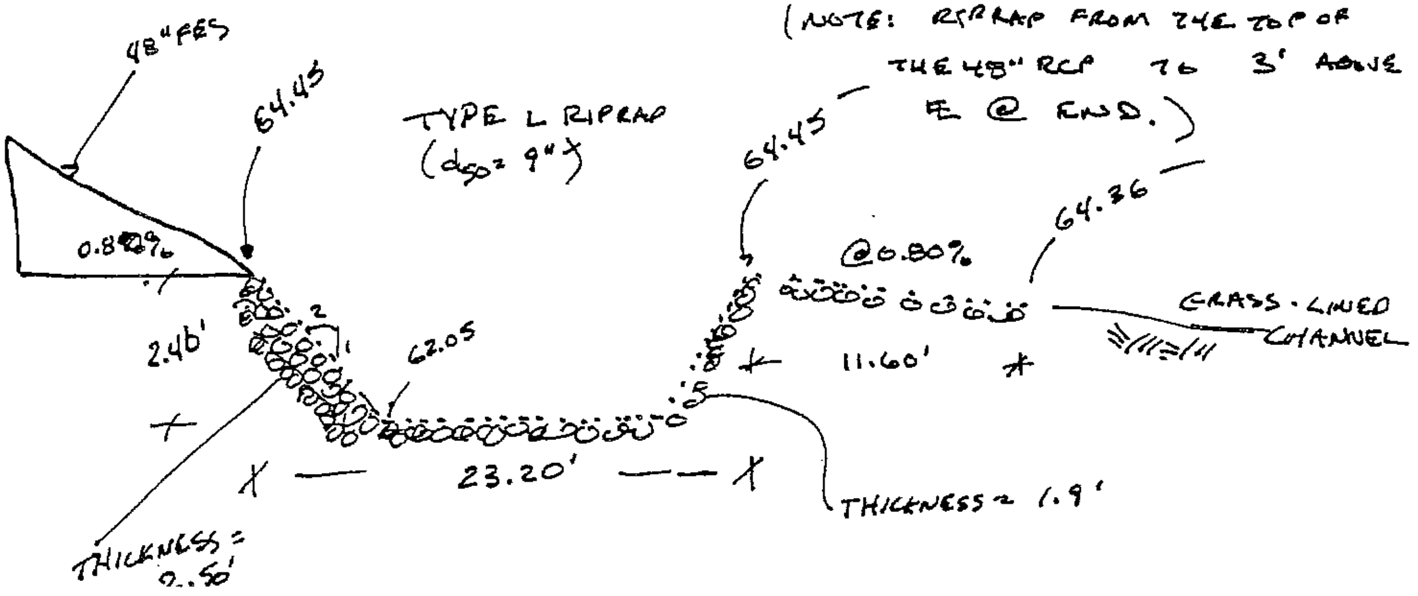
• THE LOWER END OF THE WATERFALL AREA IS SET BY THE FUTURE 6'x4' RCBC UNDER POWERS (INV IN @ WINGWALL = 6833.31' (PREV. CALCS)) ✓

• THE WATERFALL WILL CONSIST OF 2 DIFFERENT AREAS, THE UPPER AREA WILL HAVE VERTICAL DROPS, THE LOWER AREA WILL HAVE A SLOPED DROP. THE CHANGE WILL BE ROUGHLY AT THE ELEV OF POWERS (IE. ~~NOT A~~ LOWER PART IS NOT HIGHLY VISIBLE TO POWERS). ✓

• THE DESIGN FLOW WILL BE A $Q_{100}$ (ULTIMATE) = 132 cfs (FROM PREVIOUS CALCS). ✓

STARTING FROM THE TOP, A PLUNGEPOOL WILL BE NEEDED OUT OF THE 48" RCP. THE WIDTH OF A 48" FES IS 7' AT THE ~~BOTTOM~~ ∴ A 7' BOTTOM WIDTH WILL BE USED. (129 cfs is the Q @ EXIT)

USING APPENDIX (A). A PLUNGE POOL @ THE 48" WILL BE



URS

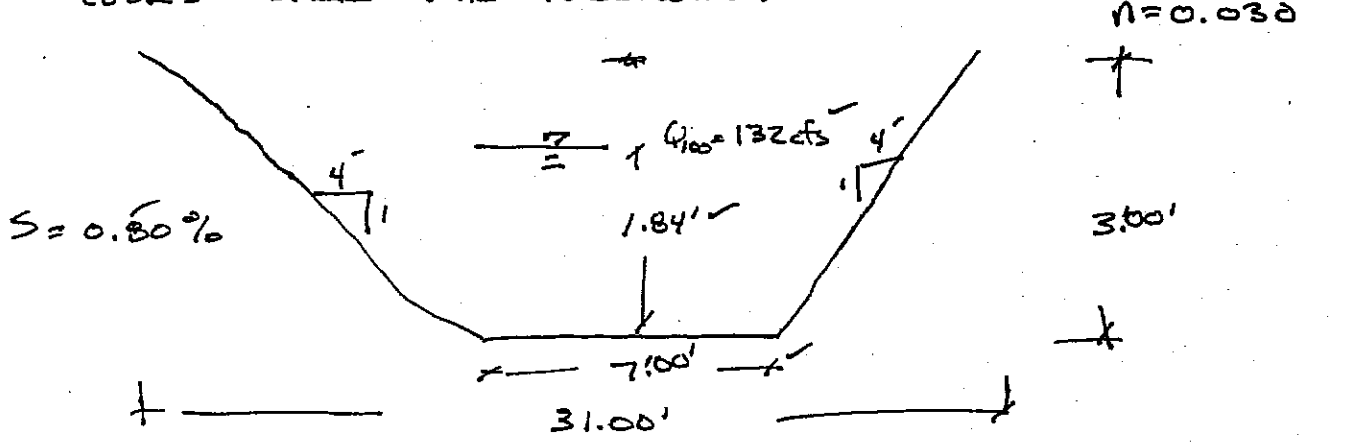
Job POWERS / SH 83 Project No. 67000042500.02 Page ____ of ____ Sheet 2 of ____

Description WATERFALL AREA DESIGN Computed by EDE Date 9-20-02

Checked by W. Alspach Date 25Sep02

Reference

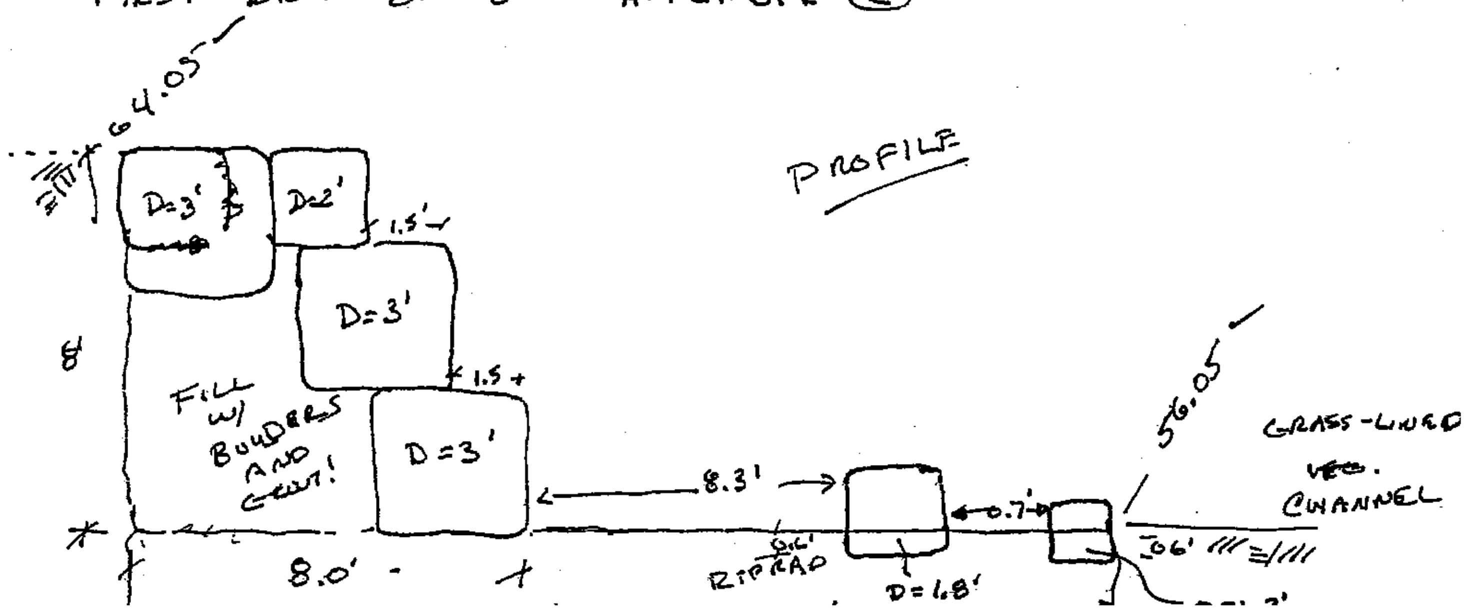
USING A 7' BOTTOM WIDTH WITH 4:1 SIDE SLOPES A CHANEL X-SECTION FOR THE GRASS LINED CHANNEL LOOKS LIKE THE FOLLOWING:




FROM FLOW MASTER, APPENDIX (B) THE $V_{100}$ = 4.98 ft/s AND $F_r$ = 0.80. BOTH ACCEPTABLE FOR GRASS-LINED CHANNELS.

(THIS X-SECTION WILL BE USED AS A DEFAULT THRU THE WATER FALL AREA.)

FROM THE END OF THE PLUNGE POOL THIS GRASS-LINED CHANNEL WILL GO 38.54' @ 0.80% TO INV OF 6864.05 AND START THE BEGINNING OF THE FIRST DROP OF 8' APPENDIX (C)



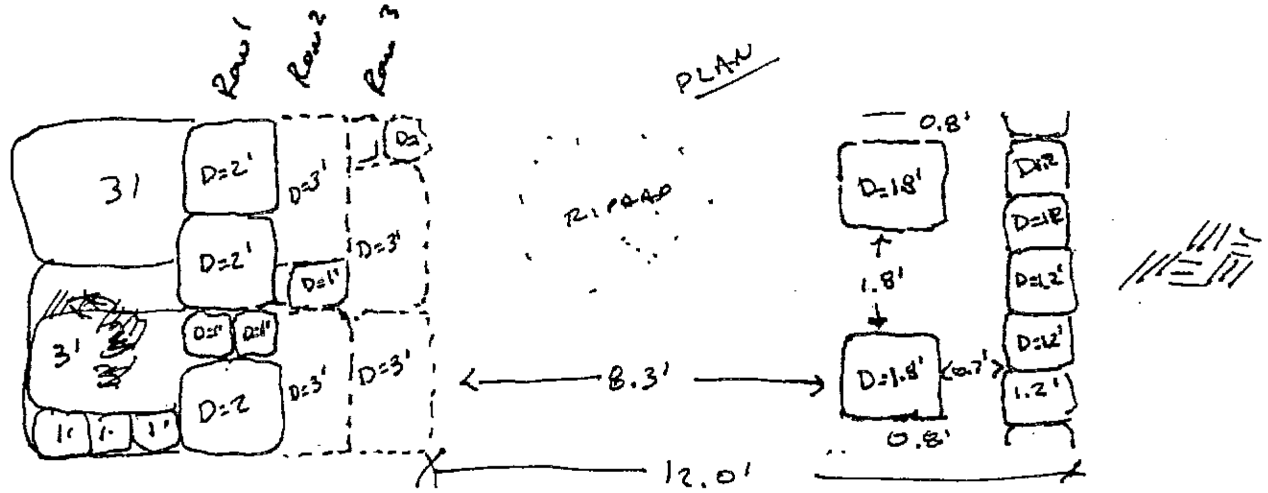
URS

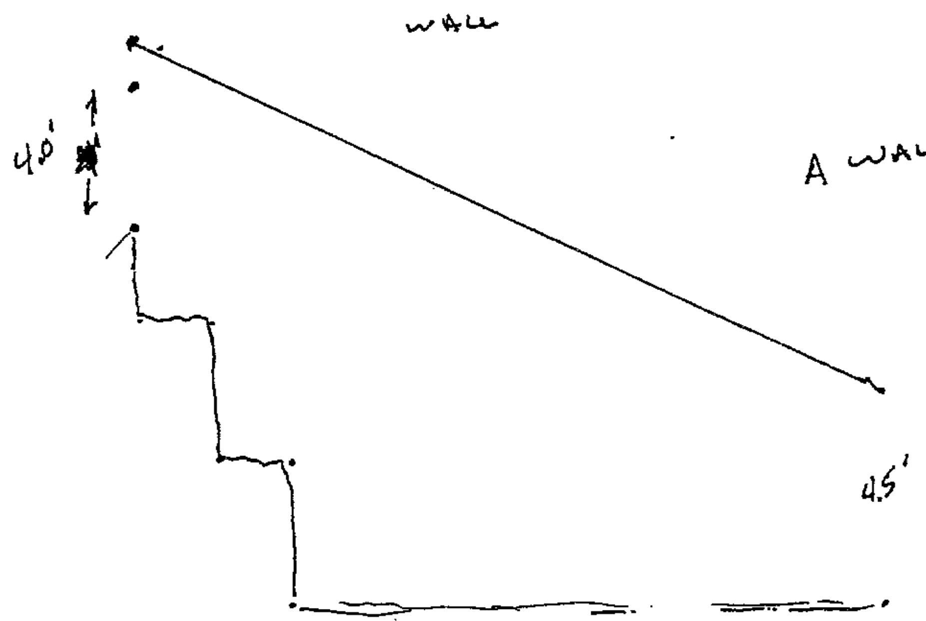
Job POWERS / SH83 | Project No. 67000 42500.02 | Page ___ of ___
Sheet 3 of ___

Description WATERFALL AREA DESIGN | Computed by EDE | Date 9-20-02

Checked by W. Alspach | Date 25 Sep 02

Reference



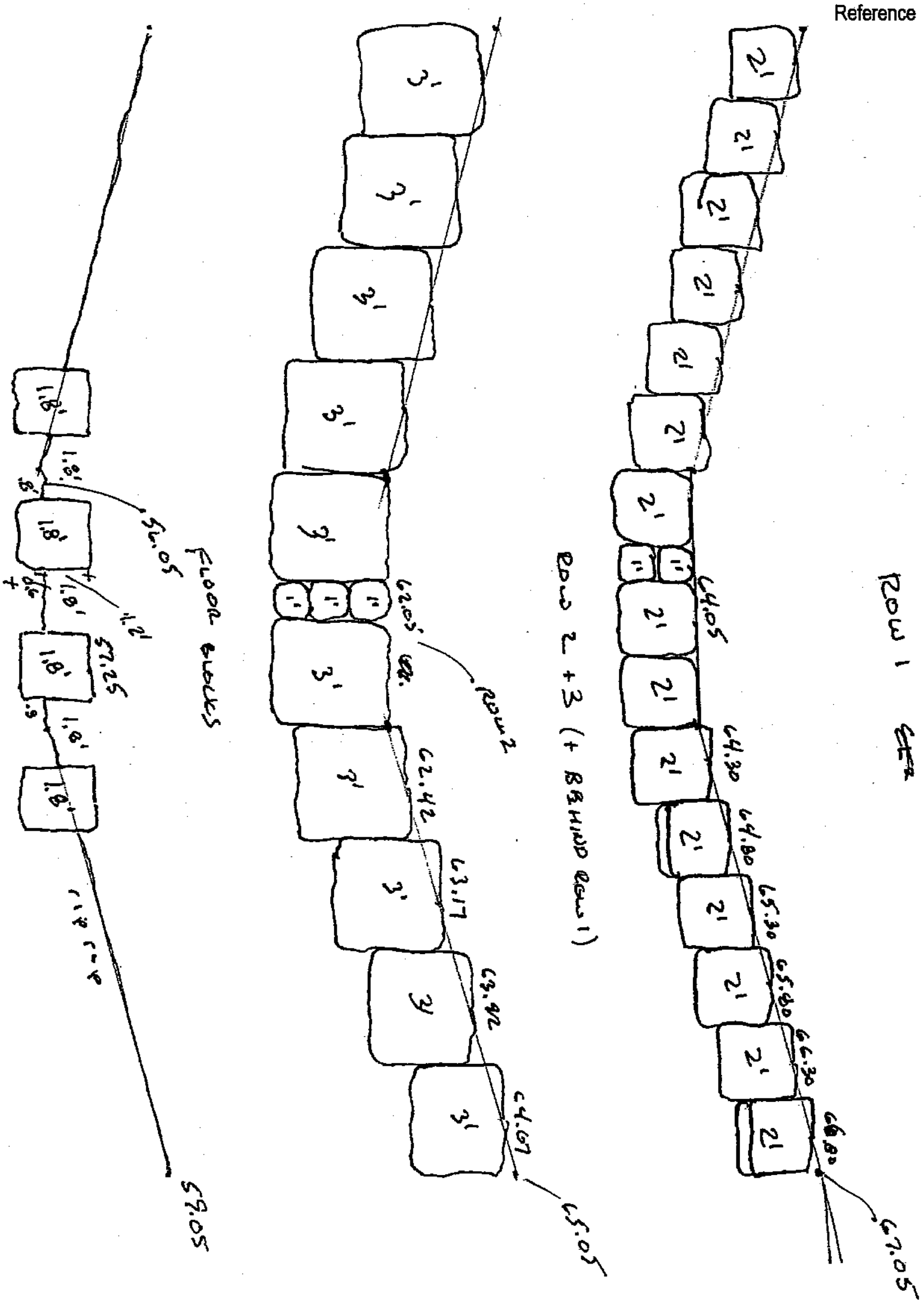

A WALL WOULD HIDE THIS

TRY SPREADING OUT THE DROP!

**URS**

| | | | |
|---|---|---|---|
| Job: POWERS / SH®3 | Project No. 67000 42500.02 | Page ___ of ___ | |
| Description: WATER FALL AREA DESIGN | Computed by: SDE | Sheet 4 of ___ | Date 9-20-02 |
| | Checked by: W. Alspach | | Date 25 Sep 02 |

Reference



**URS**

| | | | |
|---|---|---|---|
| Job: POWER / SH83 | Project No. 67000425000.02 | Page ___ of ___ | |
| Description: WATERFALL AREA DESIGN | Computed by: EDE | Sheet 5 of ___ | Date: 9-20-02 |
| | Checked by: W. Alspach | | Date: 25 Sep 02 |

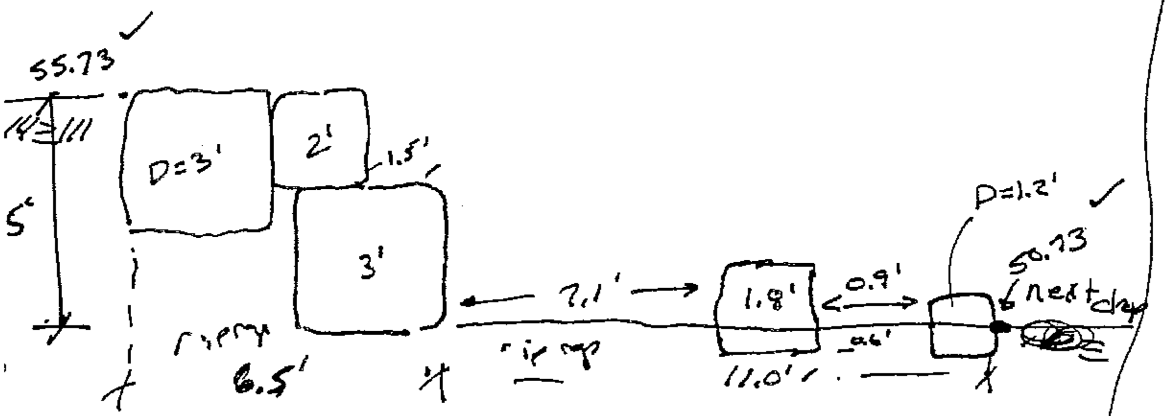
Reference

THE GRASS-LINED CHANNEL WILL CONTINUE FOR 40' FROM END OF 8' DROP STRUCTURE

$\therefore$ 56.05 − 40 (.008) = 55.73' ✓

5' DROP APPENDIX (D)

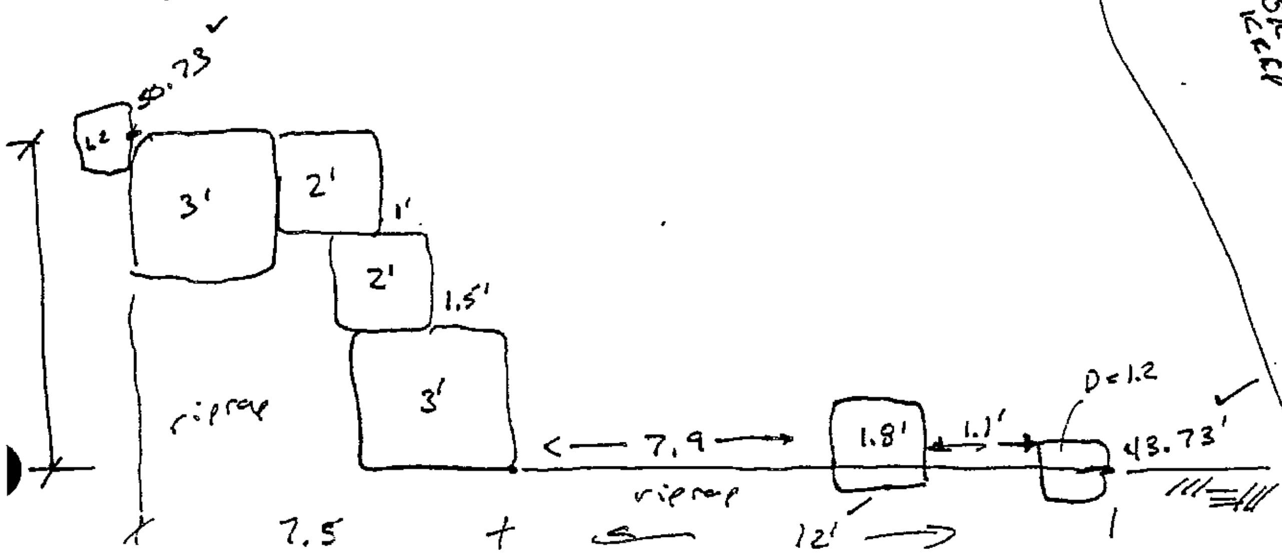
PROFILE

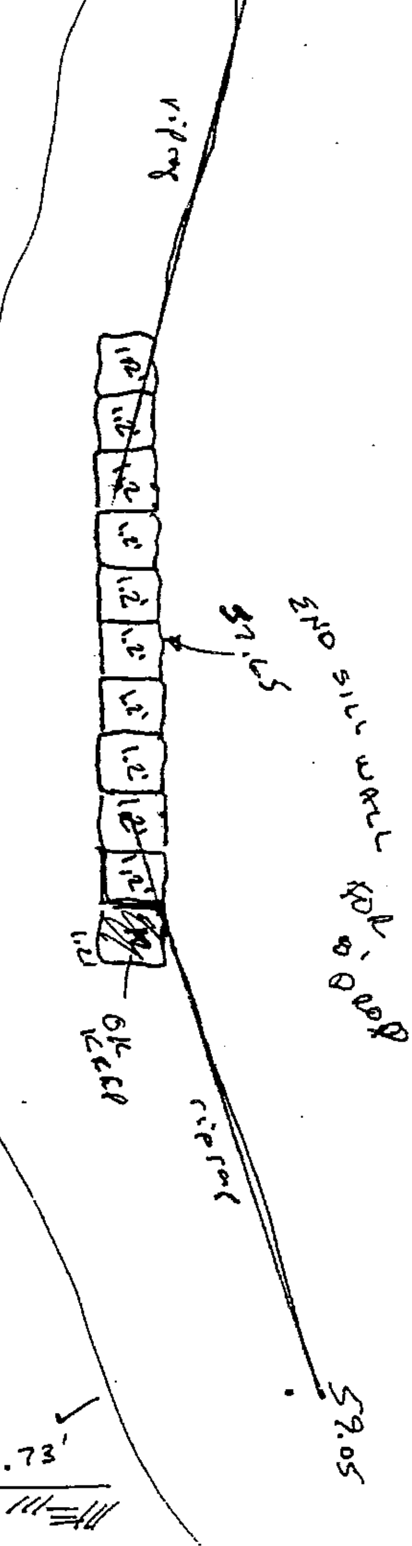



Use same layout

7' DROP APPENDIX (E)

THE 7' DROP WILL FOLLOW RIGHT BEHIND THE 5' DROP.



**URS**

| | | | |
|---|---|---|---|
| Job POWERS /SH83 | Project No. 6100042500.02 | Page ___ of ___ | Sheet 6 of ___ |
| Description WATERFALL AREA DESIGN | Computed by EDE | | Date 9-20-02 |
| | Checked by W. Alspach | | Date 25 Sep 02 |

Reference

FROM THE END OF THE 7' DROP USE A NATURAL CHANNEL @ 0.80% FOR 15'

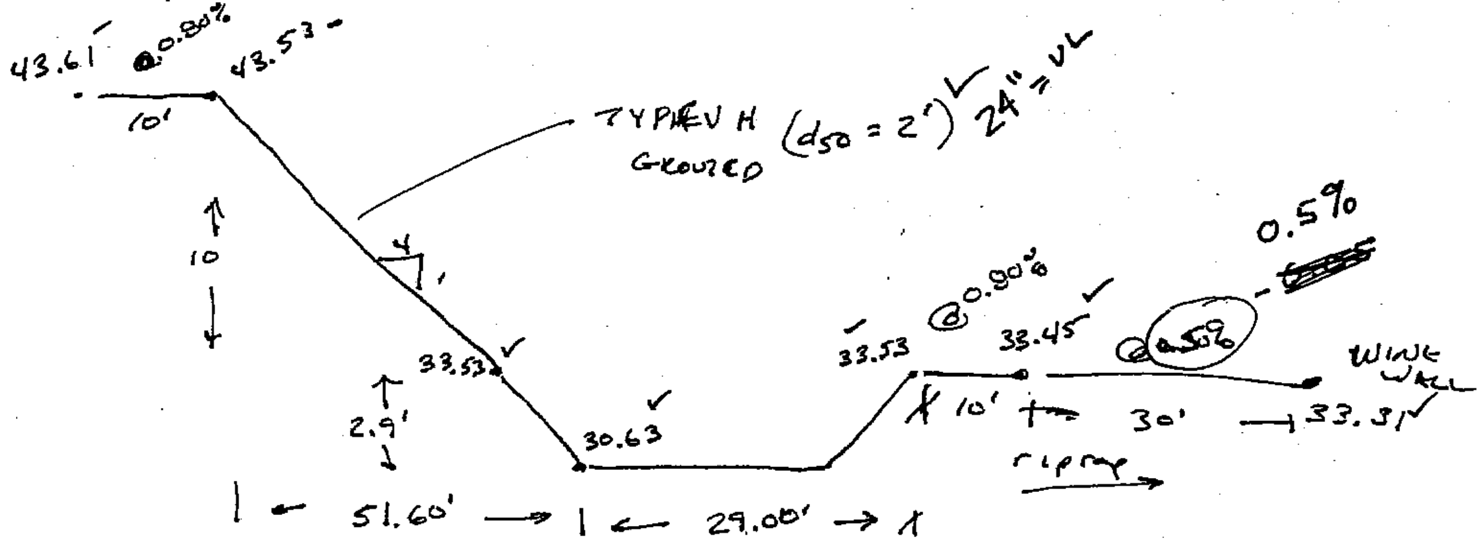
∴ 43.73 − 15 × (.008) = 43.61 ✓

THE ℄ OF POWERS @ BOX CULVERT = 43.59

∴ A GROUTED RIPRAP BOULDER DROP WILL BE USED FROM HERE.

APPENDIX (F)

A 10' DROP @ 4:1 W/ PLUNGE POOL




FROM AUTOCAD, THE DISTANCE BETWEEN ~~TOP~~ 48" FES TO WING WALL IS 315.94'

QUICK CHECK.

| | |
|---|---|
| 23.20' | (PLUNGE POOL) |
| 11.60' | (APRON) |
| 38.54' | (GRASS CHANNEL) |
| 8.00' | (ROCK DROP) |
| 12.00' | (DROP POOL) |
| 40.00' | (GRASS CHANNEL) |
| 6.50' | (ROCK DROP) |
| 11.00' | (DROP POOL) |

(CONT.) →

URS

Job POWERS /SH83 — Project No. 6700042500.02 — Page ___ of ___

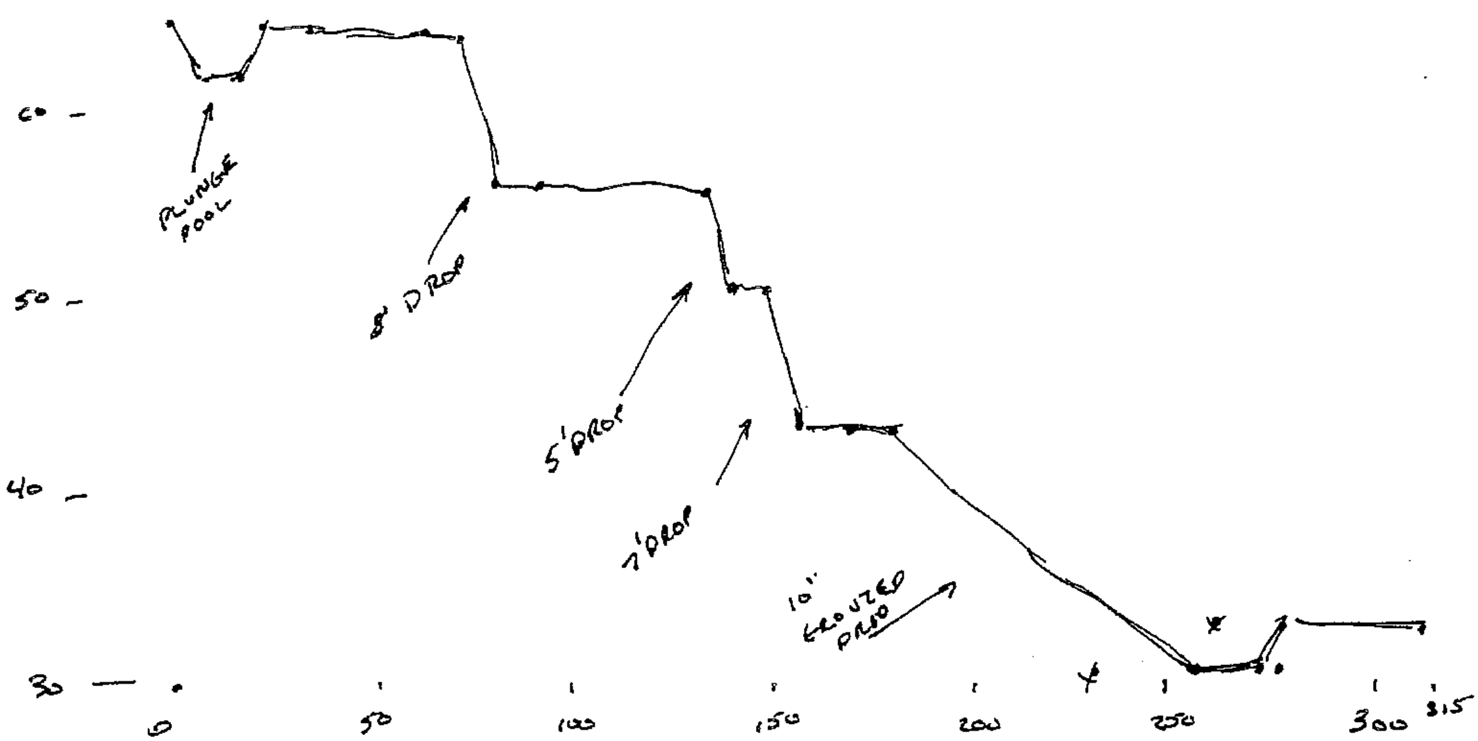
Description WATERFALL AREA DESIGN — Computed by EDE — Sheet 7 of ___ — Date 9-23-02

Checked by ___ — Date ___

Reference

(CONT.)

| | |
|---|---|
| 7.50' | (ROCK DROP) |
| 12.00' | (DROP POOL) |
| 15.00' | (GRASS CHANEL) |
| 10.00' | (APPROACH) |
| 51.60' | (GROUTED SLOP DROP) |
| 27.00' | (PLUNGE POOL AREA) |
| 10.00' | (APRON) |
| 30.00' | (APPROACH TO WINGWALL) |
| 315.94' | (OK!) |



## Plunge Pool Design

Ramp E 48" RCP exit

129.00 Q (cfs)

22.08 Tailwater (in)

**Box Culvert**
Height (in)
Width (in)

**Circular**
48 Diameter (in)

**Circular**
29.28 Normal Depth (in)

| | | | |
|---|---|---|---|
| 4.03 | Q/D^(2.5) | Rounded | 4.00 |
| 0.46 | TW/D | Rounded | 0.50 |
| 0.71 | Yo/D | | 0.50 |

34.08 Brink Depth (in)

0.65 TW/yo — **LOW TAILWATER DEPTH**

1374 Brink Area (sq in)
13.52 Brink Velocity (fps)

26.21 Equivalent Brink Depth (in)
1.61 Froude

Rip Rap Sizing

| Type | d50 (in) | dmax (in) | d50/Ye | Hs/Ye | Hs (in) | Hs/d50 | 2<Hs/d50<4 |
|---|---|---|---|---|---|---|---|
| VL | ~~6~~ | 12 | 0.23 | 1.42 | 37.28 | 6.21 | BAD |
| L | 9 | 15 | 0.34 | 1.06 | 27.73 | 3.08 | OK |
| M | 12 | 21 | 0.46 | 0.76 | 19.79 | 1.65 | BAD |
| H | 18 | 30 | 0.69 | 0.36 | 9.39 | 0.52 | BAD |
| VH | 24 | 42 | 0.92 | N/A | #VALUE! | #VALUE! | #VALUE! |

Rip Rap

| Type | d50 (in) | dmax (in) | Hs (in) |
|---|---|---|---|
| L | 9 | 15 | 27.73 |

**Dissapator Length**

| | | Max (ft) |
|---|---|---|
| 23.11 | 10*hs (ft) | |
| 12.00 | 3*Wo (ft) | 23.11 |

**Apron Length**

| | | Max (ft) |
|---|---|---|
| 11.55 | 5*hs (ft) | |
| 4.00 | Wo (ft) | 11.55 |

**Thickness of Approach**

| | | Max (ft) |
|---|---|---|
| 2.25 | 3*d50 (ft) | |
| 2.50 | 2*dmax (ft) | 2.50 |

**Thickness of Basin**

| | | Max (ft) |
|---|---|---|
| 1.50 | 2*d50 (ft) | |
| 1.88 | 1.5*dmax (ft) | 1.88 |

**Riprap Quantities**

| | |
|---|---|
| Hs (ft) | 2.31 |
| W (ft) | 4.00 |
| thickness approach (ft) | 2.50 |
| thickness basin (ft) | 1.88 |
| dissapator length (ft) | 23.11 |
| apron length (ft) | 11.55 |
| channel bottom (ft) | 7.00 ✓ |
| tailwater (ft) | 1.84 |

Channel Bottom must be larger than W

| Areas | (ft^3) | length (ft) | width (ft) | depth (ft) |
|---|---|---|---|---|
| A | 63.54 | 4.62 | 5.50 | 2.50 |
| B | 242.60 | 18.48 | 7.00 | 1.88 |
| C | 151.63 | 11.55 | 7.00 | 1.88 |
| D | 768.56 | 10.30 | 14.92 | 2.50 |
| E | 535.51 | 13.86 | 10.30 | 1.88 |
| F | 905.03 | 16.17 | 14.92 | 1.88 |

Total (cy) 99

# Worksheet
## Worksheet for Trapezoidal Channel

(B)

| Project Description | |
|---|---|
| Worksheet | Trapezoidal Channe |
| Flow Element | Trapezoidal Channe |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coeffic | 0.030 | |
| Slope | 008000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 7.00 | ft |
| Discharge | 132.00 | cfs |

| Results | | |
|---|---|---|
| Depth | 1.84 | ft |
| Flow Area | 26.5 | ft² |
| Wetted Perim | 22.20 | ft |
| Top Width | 21.74 | ft |
| Critical Depth | 1.64 | ft |
| Critical Slope | 0.013033 | ft/ft |
| Velocity | 4.98 | ft/s |
| Velocity Head | 0.39 | ft |
| Specific Energ | 2.23 | ft |
| Froude Numb | 0.80 | |
| Flow Type | Subcritical | |

~~**Drop Structure with Floor Blocks**~~

Bennett Ranch Channel 6' Drop ?

| | | | |
|---|---|---|---|
| Q (cfs) | 132 | | |
| Normal depth (ft) | 1.84 | Yo | |
| Normal Velocity (fps) | 5.00 | Vo | |
| Drop height (ft) | 8.00 | Hd | |
| Slope of Channel (ft/ft) | 0.008 | Ss | |
| | 1.68 | ft^1/2/sec | |
| Specific Head (ft) | 2.23 | | |
| Critical depth (ft) | 1.49 | Yc | |
| Min height tailwater (ft) | 3.19 | Y3 | |
| Vert. Dist (Crest-Tailwater) (ft) | -6.16 | H2 | |
| Vert. Dist (Crest-Floor) (ft) | -9.35 | Ho | |
| | 7.63 | Lf | |
| | 6.25 | Lt | |
| | 7.78 | Ls | |
| Horz. Dist (Wall-striking pt.) (ft) | 7.71 | L1 | |
| Horz. Dist (striking pt.-block) (ft) | 1.19 | L2 | |
| Horz. Dist (block-end of basin) (ft) | 3.11 | L3 | |
| Total length of basin (ft) | 12.00 | Lb | |
| Floor Blocks height (ft) | 1.19 | | |
| Width Blocks (ft) | 0.59 | | |
| Spacing between Blocks (ft) | 0.59 | | |
| End Sill Height (ft) | 0.59 | | |
| Sidewall Height (ft) | 4.46 | | |

Check to see if Drop Size within parameters

| | | | |
|---|---|---|---|
| Min Drop | (Hd/Yc) | 1.49 | OK |
| Max Drop | 15*(Hd/Yc) or 15' | 15.00 | OK |

**NOTE**

Line upstream channel with riprap 5.00 feet with VL Type Riprap from headwall.

Bottom width of basin should be equal to the spillway notch .

Crest of spillway should be at same elevation as approach channel.

D

## ~~Drop Structure with Floor Blocks~~

Bennett Ranch Channel 6' Drop

| | | |
|---|---|---|
| Q (cfs) | 132 | |
| Normal depth (ft) | 1.84 | Yo |
| Normal Velocity (fps) | 5.00 | Vo |
| Drop height (ft) | 5.00 | Hd |
| Slope of Channel (ft/ft) | 0.008 | Ss |
| | 1.68 | ft^1/2/sec |
| Specific Head (ft) | 2.23 | |
| Critical depth (ft) | 1.49 | Yc |
| Min height tailwater (ft) | 3.19 | Y3 |
| Vert. Dist (Crest-Tailwater) (ft) | -3.16 | H2 |
| Vert. Dist (Crest-Floor) (ft) | -6.35 | Ho |
| | 6.35 | Lf |
| | 4.65 | Lt |
| | 6.64 | Ls |
| Horz. Dist (Wall-striking pt.) (ft) | 6.49 | L1 |
| Horz. Dist (striking pt.-block) (ft) | 1.19 | L2 |
| Horz. Dist (block-end of basin) (ft) | 3.32 | L3 |
| Total length of basin (ft) | 11.00 | Lb |
| Floor Blocks height (ft) | 1.19 | |
| Width Blocks (ft) | 0.59 | |
| Spacing between Blocks (ft) | 0.59 | |
| End Sill Height (ft) | 0.59 | |
| Sidewall Height (ft) | 4.46 | |

Check to see if Drop Size within parameters

| | | | |
|---|---|---|---|
| Min Drop | (Hd/Yc) | 1.49 | **OK** |
| Max Drop | 15*(Hd/Yc) or 15' | 15.00 | **OK** |

**NOTE**

Line upstream channel with riprap 5.00 feet with VL Type Riprap from headwall.

Bottom width of basin should be equal to the spillway notch .

Crest of spillway should be at same elevation as approach channel.

2

## ~~Drop Structure with~~ Floor Blocks

Bennett Ranch Channel 6' Drop

| | | |
|---|---|---|
| Q (cfs) | 132 | |
| Normal depth (ft) | 1.84 | Yo |
| Normal Velocity (fps) | 5.00 | Vo |
| Drop height (ft) | 7.00 | Hd |
| Slope of Channel (ft/ft) | 0.008 | Ss |
| | 1.68 | ft^1/2/sec |
| Specific Head (ft) | 2.23 | |
| Critical depth (ft) | 1.49 | Yc |
| Min height tailwater (ft) | 3.19 | Y3 |
| Vert. Dist (Crest-Tailwater) (ft) | -5.16 | H2 |
| Vert. Dist (Crest-Floor) (ft) | -8.35 | Ho |
| | 7.22 | Lf |
| | 5.76 | Lt |
| | 7.41 | Ls |
| Horz. Dist (Wall-striking pt.) (ft) | 7.32 | L1 |
| Horz. Dist (striking pt.-block) (ft) | 1.19 | L2 |
| Horz. Dist (block-end of basin) (ft) | 3.50 | L3 |
| Total length of basin (ft) | 12.00 | Lb |
| Floor Blocks height (ft) | 1.19 | |
| Width Blocks (ft) | 0.59 | |
| Spacing between Blocks (ft) | 0.59 | |
| End Sill Height (ft) | 0.59 | |
| Sidewall Height (ft) | 4.46 | |

Check to see if Drop Size within parameters

| | | | |
|---|---|---|---|
| Min Drop | (Hd/Yc) | 1.49 | **OK** |
| Max Drop | 15*(Hd/Yc) or 15' | 15.00 | **OK** |

**NOTE**

Line upstream channel with riprap 5.00 feet with VL Type Riprap from headwall.
Bottom width of basin should be equal to the spillway notch .
Crest of spillway should be at same elevation as approach channel.

F

~~Grouted Sloping Boulder Drop Structure~~

USAFA Kettle Creek Estimated Drop Structure

## INFORMATION INPUT

| | | |
|---|---|---|
| Q (cfs) | 132 | Q |
| Normal depth (ft) @ crest | 1.84 | Yo |
| Normal Velocity (fps) @ crest | 5.00 | Vo |
| Drop height (ft) | 10.00 | **Hd** |
| Slope of Channel (ft/ft) | 0.008 | Sc |
| Channel Width (ft) | 7.00 | B1 |
| Crest Width (ft) | 7.00 | B2 |
| Drop Slope (H:V) | 4.00 | **Z** |
| Downstream Velocity (fps) @ tw | 5.00 | V2 |
| Tailwater Depth (ft) | 1.84 | tw |
| Side slopes in basin (H:V) | 4.00 | Ss |

## ESTIMATED INPUT

| | | |
|---|---|---|
| Estimated d1 (ft) | [redacted] | d1 (est) |
| % Diff. For Spec. Head | 1.0% | **Estimate OK** |

**Note: Vary d1 (depth at toe) to within 1% of the specific head calced at toe.**

**MAJOR STORM**

100-year

| | | | | |
|---|---|---|---|---|
| Specific Head (ft) @ crest | 2.23 | Hc | Yo + (Vo^2)/2g | |
| Specific Head (ft) @ toe | 12.23 | Ht | Hc + Hd | (assumes no head loss through sloped drop) |
| Estimated Area (ft^2) @ toe | 4.83 | A(est) | d1(est)*(b2+Ss*d1(est)) | (assumes sideslopes in basin and crest width) |
| Estimated Velocity (fps) @ toe | 27.31 | V(est) | Q/A(est) | |
| Estimated Specific Head (ft) @ toe | 12.11 | H (est) | d1(est) + (V(est)^2)/2g | |
| Depth (ft) @ toe | 0.53 | d1 | | |
| Area (ft^2) @ toe | 4.83 | A1 | d1*(b2+Ss*d1) | |
| Velocity (fps) @ toe | 27.31 | V1 | Q/A1 | |
| Frounde number @ toe | 6.61 | Fr1 | V1/((g*d1)^(1/2)) | |
| Depth (ft) @ hydraulic jump | 4.70 | d2 | d1*((1+8*Fr1^2)^(1/2)-1)/2 | |
| Length (ft) of hydraulic jump | **28.89** | **Lb** | Lookup Lb/d2 * d2 | (vlookup for Fr1 for Lb/d2) |
| Basin (ft) depression below channel | **2.86** | **B** | d2-tw | |
| Length (ft) of drop slope | **51.43** | **La** | (Hd+B)*Z | |
| Length (ft) of upstream protection | **4.46** | **Lu** | 2*Hc | |
| Total Length (ft) | 84.77 | L(total) | Lb+La+Lu | |
| RipRap Type (ft) | 24" 2.00 | d50 | **TYPE VH** | (1.5 for Hd<3, 2.0 for Hd>3) |
| Grout Thickness (ft) | 1.50 | Dg | | (1.0 for Hd<3, 1.5 for Hd>3) |

NOTE: Install 10 feet of buried riprap (minimum) downstream.

DRAFT

**Appendix F: Hydraulics - Inlet / Storm System Design for Elkhorn Basin**

**EXHIBIT 5.3-1**
**URS Greiner**
**CALCULATION COVER SHEET**

Client: CDOT REGION 2 Project Name: POWERS BOULEVARD

Project/Calculation Number: 21710830.00004

Title: SH83 REDESIGN INLET CALCULATIONS

Total number of pages (including cover sheet): ______

Total number of computer runs: ______

Prepared by: E. DANNY ELSNER Date: 12-SEPT 02

Checked by: W. ALSPACH Date: 16 Sep 02

Description and Purpose: - CALCULATE GUTTER CAPACITY FOR MEDIAN ALONG SH83 REDESIGN.
- PLACE INLETS AT PROPER LOCATION FOR SPREAD
- CALC ℄ ELEVATIONS OF INLET

Design bases/references/assumptions:
- PREV. WAID RATIONAL CALCS
- CDOT DRAINAGE MANUAL
- FLOW MASTER

Remarks/conclusions: See calc sheets, all items resolved w/ Danny Elsner
WA 16 Sep 02

Calculation Approved by: ______
Project Manager/Date

| Revision No.: | Description of Revision: | Approved by: |
|---|---|---|
| | | |
| | | |
| | | |

Project Manager/Date

**URS**

Page ____ of ____

Job: POWERS BOULEVARD | Project No. 67000412500.02 | Sheet 1 of ____

Description: INLETS ALONG SH83 FOR SH83 / POWERS INTERCHANGE | Computed by: EDS | Date: 9-3-02

Checked by: W. Alspach | Date: 16Sep02

Reference

SH 83 MEDIAN INLET

FROM CAD USE STA 221+90.00 9.00' R

(GIVES ENOUGH ROOM BACK TO SBR. INLET).

CROSS SLOPE IS 4.3% Rc

MIN SLOPE IN AREA IS 1.75%

ELE ℄ = 6864.52

− 8' × .043

− ~~1"~~ ← 2"

~~6864.09~~ ← FL EL.

64.01 ✓

Revised see (D)

OTHER INLET WILL BE AT 213+35 (0% SLOPE)

+10

= 213+45.00 ← 14.82' LT

℄ ELE 6843.41 0.26%

CROSS SLOPE IS 0.~~25~~%

6843.41

+ 15.82 × .0026

− 2"/12 ← median

6843.~~37~~ 28 ← FL EL. ✓

* CAN ONLY HAVE 4' IN TRAVEL LANE ∴ ONLY 5' TOTAL W/ GUTTER.

SO MAXIMUM CFS BEFORE INLET IS **2.37 cfs** ← (APP. A)

FROM RATIONAL CALCS $t_c$ WAS 5 min AND $i_{100}$ = 8.78

∴ WE CAN USE AREAS TO FIGURE OUT WHEN INLET IS NEEDED.

$C_{100}$ = 0.95

URS

Job Powers Boulevard Project No. 67600425000.02 Page ___ of ___ Sheet 2 of ___

Description ~~INLETS ALONG SH83~~ Computed by EDE Date 9-4-02

for SH83 / Powers Interchange Checked by W Alspach Date 16 Sep 02

Reference

$Q = CIA$

$\therefore A = \frac{Q}{CI} = \frac{2.37 \text{ cfs}}{.95 (8.78 \text{ in/hr})} = 0.28 \text{ acres}$

for first inlet, best use is 15' for 88% efficient APP. (B)

$(1-0.88)(2.37 \text{cfs})$

bypass = $\frac{0.29 \text{ cfs}}{(C \, SA)}$ = 0.03 acres (bypassed

$\therefore$ next inlet can only have 0.25 acre $(0.28 - 0.03 = 0.25)$

NOTE: MANY INLETS WILL BE USED!
TRY CHANGING MEDIAN CTG TO 2' GUTTER

THIS GIVES 4.39 cfs maximum APP. (C)

$A = \frac{4.38}{.95(8.78)} = 0.53 \text{ acres}$

Why the difference in p.er. eng.? WA 16 Sep 02

for first inlet, best use is ~~18~~ 15' inlet @ ~~100%~~ 97% APP (D)

(~~no clogging~~

$\therefore$ 0.14 cfs bypass = $\frac{.14}{(.95)(8.78)}$ = 0.02 acres

0.53 acres would actually get to the other side of the bridge. ~~be~~

* BECAUSE THESE ARE TURN LANES, CAN GO TO A MAX HEIGHT of 0.5(?). inches or feet?

**URS**

Page ____ of ____

| | | |
|---|---|---|
| Job POWERS BOULEVARD | Project No. 67000042500.02 | Sheet 3 of ____ |
| Description ~~INLETS ALONG SH 83~~ | ~~Computed by~~ EDE | ~~Date~~ 9-4-02 |
| FOR SH83 / POWERS INTERCHANGE | Checked by W. Alspach | Date 16 Sep 02 |

Reference

THIS GIVES A MAX OF ~~9.80~~ 14.33 cfs. APP. (E)

RATIONAL CALC SHOWS A MAX OF 7.79 cfs ✓

SLOPE @ 221+90 IS 2.45%

APP. (F)

ACTUAL DEPTH IS 0.39' SPREAD = 7.14'
(5.14 IN ~~TRAFFIC~~ TURN LANE

A 15' INLET HERE
WOULD BE ~~79%~~ 92% ✓ EFFICIENT APP. (G)

EXCESS (BYPASS ~~1.65~~ 0.61 cfs) WILL FLOW PAST INLET INTO DITCHES ON SOUTHERN PORTION OF ROAD.

---

FOR DOWNSTREAM INLET @ 2~~1~~3+45.00 w/
CROSS SLOPE IS 0.25% @ 2.5% SLOPE

THIS GIVES A MAX Q = ~~1.66~~ 0.81 cfs IN THE ROAD

AREA FLOWING TO THESE INLETS IS 56' × 800' = 44800 sf ✓
= 1.03 ac

$Q = (0.95)(8.78)(1.03) = 8.58$ cfs ✓
c i A

~~NEXT INLET WILL HAVE TO HAVE BYPASS + ADDITIONAL AREA TO LAST INLET = 1.66 cfs 0.81~~

~~TRY 100' UPSTREAM Q into inlet = 1.09 cfs~~
~~$\frac{(100 \times 56)}{43560} \times (8.78) \times (0.95) = 1.07$ cfs~~

~~bypass < 1.66 cfs − 1.07 cfs = 0.59 cfs max.~~

REDO!

~~[illegible]~~ ← more colorful

**URS**

| | | | | | |
|---|---|---|---|---|---|
| Job | POWERS BOULEVARD | Project No. | 67000042500.02 | Sheet 4 of | |
| Description | ~~INLETS ALONG SH83~~ FOR SH83 / POWERS INTERCHANGE | Computed by | EDS | Date | 9-10-02 |
| | | Checked by | W Alspach | Date | 16 Sep 02 |

Page ___ of ___

Reference

CROSS SLOPE @ 214+45 = 2.75% @ 2.5% SLOPE (ROAD)

~~GUTTER CAPACITY = 5.49 cfs~~

~~15' INLET @ THIS LOCATION GIVES 4.83 cfs INTERCEPTED w/ BYPASS of 0.66 cfs~~

~~* JUST EXCEEDS BYPASS FLOW MAX. BUT VERY CLOSE TRY WORKING UP A BIT.~~

~~$\frac{5.49 \text{ cfs}}{(0.95)(8.78)} = 0.66 \text{ ac}$ THIS GIVES A TOTAL OF 0.66 ac + 0.13 ac = 0.79 ac~~

redo

~~THIS LEAVES 0.24 ac. = 187' x 56'~~

~~TRY INLET 200' UP 216+45 CROSS SLOPE IS 4.3% @ 2.5% SLOPE (ROAD)~~

~~AREA = $\frac{450' \times 56'}{43560}$ = 0.58 acre~~

REDO!

~~Q = (0.95)(8.78)(0.58) = 4.84 cfs~~

GUTTER CAPACITY @ 213+45 IS 0.82 cfs
∴ CAN ONLY GO AROUND 50' - 75' UP TO NEXT INLET

TRY 50' 213+95
AREA WITH DIRECT SLOPE INTO INLET IS
$\frac{(50)(56)}{43560}$ (8.78)(0.95) = 0.54 cfs

0.06 acre.

MAX BYPASS = 0.82 - 0.54 = 0.28 cfs

↑ Capacity ↑ $Q_{Area}$ ↑ Excess gutter capacity

**URS**

Page ____ of ____

Job: POWERS BOULEVARD — Project No. 67000425 00.02 — Sheet 5 of ____

Description: ~~INLETS ALONG SH83~~ FOR SH83 / POWERS / INTERCHANGE — Computed by: ~~EDE~~ — Date: ~~9-10-02~~

Checked by: W. Alopuch — Date: 16 Sep 02

Reference

CROSS SLOPE @ 213+95 = 1.56%

GUTTER CAPACITY = 1.81 cfs

A 10' INLET WILL HAVE A BYPASS OF 0.3 cfs
OK!

TRY NEXT INLET 150' UP @ 215+45

0.19 acre — $Q_{DIRECT} = \frac{150 \times 56}{43560}(8.78)(0.95) = 1.61$ cfs

MAX BYPASS = 1.81 cfs − 1.61 = 0.20 cfs

CROSS SLOPE @ 215+45 = 4.3% (FULL SUPER)

GUTTER CAPACITY = 5.23 cfs

$AREA = \frac{5.23}{(0.95)(8.78)} = 6.63$ acre

6.63
+ 0.19
+ 0.06
6.88 acres

STILL HAVE 1.03 − 0.88 = 0.15 acres left

SET ONE LAST INLET 200 UP @ 217+45
AND CALC DOWN!

$Q = \frac{(22100-21745)(56)}{43560}(0.95)(8.78) = 3.81$ cfs

APP. (H) + (I)

TRY ~~10'~~ 5' INLET — ~~2.93~~ 2.16 cfs captured, ~~0.88~~ 1.65 cfs bypass } @ 217+45

NOW 215+45

$Q_{DIRECT} = \frac{(200)(56)}{43560}(0.95)(8.78) = 2.14$ cfs
+ ~~0.88~~ 1.65 bypass
3.79 ~~3.02~~ cfs

**URS**

Job: POWERS BOULEVARD — Project No. 67000 42500.02 — Page ___ of ___ — Sheet 6 of ___

Description: INLETS ALONG SH83 FOR SH83 / POWERS INTERCHANGE — Computed by: EDE — Date: 9-10-02

Checked by: W. Alspach — Date: 16 Sep 02

Reference

TRY 15' INLET = ~~5.00~~ 3.79 cfs captured, ~~0.02~~ 0.00 cfs bypass } @ 215+45 — APP. (J)+(K)

NOW 213+95

Q direct = 1.61 + ~~0.02~~ bypass = 1.61 cfs

A 10' INLET = ~~1.53~~ 1.61 cfs captured, ~~0.08~~ 0 cfs bypass } @ 213+95 — APP. (L)+(M)

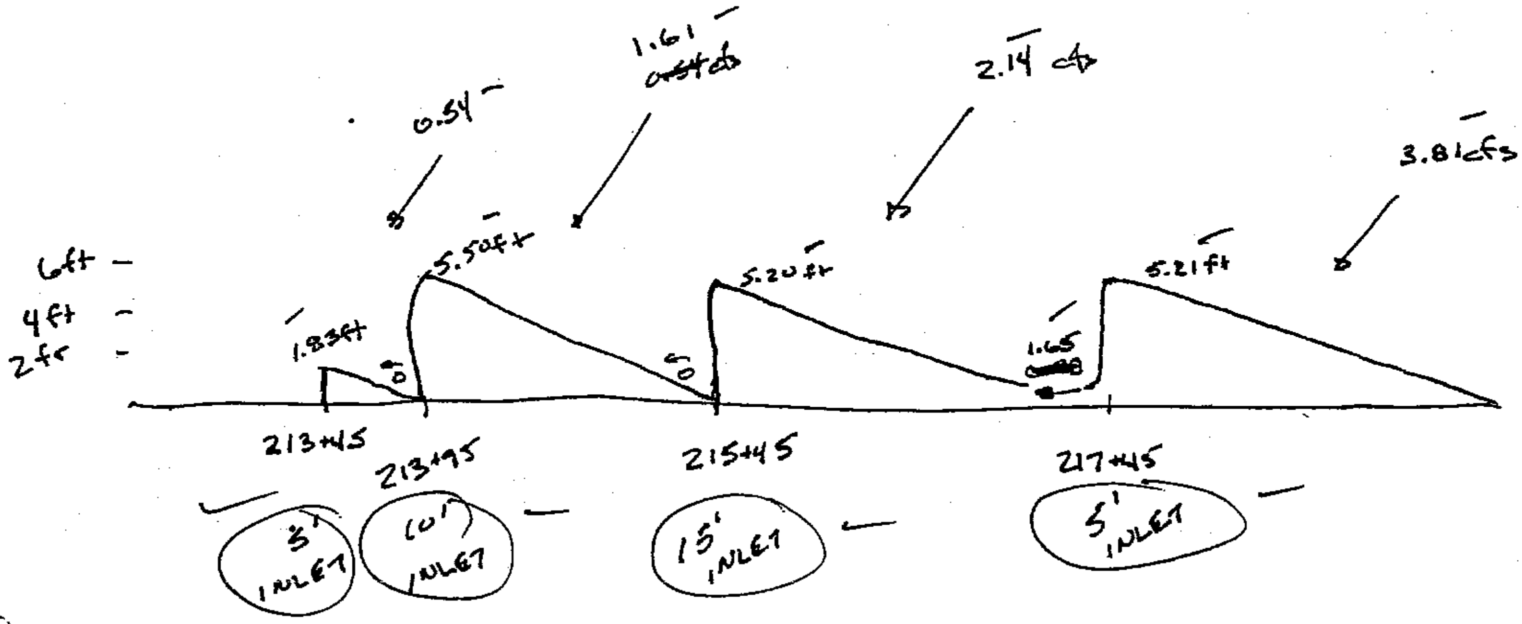
NOW 213+45

Q direct = 0.54 cfs + ~~0.08~~ 0 bypass = ~~0.62~~ 0.54 cfs

A 10' INLET = 0.62 captured @ 213+35, Ø bypass — APP. (N)+(O)

---

CHECK SPREAD GRAPHICALLY



**URS**

| | | |
|---|---|---|
| | | Page ____ of ____ |
| Job Powers Boulevard | Project No. 6700042500.02 | Sheet 7 of ____ |
| Description ~~Inlets along SH83~~ For SH83/ Powers Interchange | Computed by EDE | Date 9-10-02 |
| | Checked by W. Alspach | Date 16 Sep 02 |
| | | Reference |

NEED ELEVATION

213+95 ℄ EL = 6844.66
+ 16 x 1.56%
−2"/12
6844.74 ✓

215+45 ℄ EL = 6848.41
+ 16 x 4.3%
−2"/12
6848.93 ✓

217+45 ℄ EL = 6853.41
+ 16 x 4.3%
−2"/12
6853.93 ✓

# Worksheet
## Worksheet for Gutter Section

(A)

**Project Description**

| | |
|---|---|
| Worksheet | Maximum Gutter Spread (SH8 |
| Type | Gutter Section |
| Solve For | Discharge |

**Input Data**

| | | |
|---|---|---|
| Slope | 017500 | ft/ft ✓ |
| Gutter Width | 1.00 | ft |
| Gutter Cross Slo| | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft ✓ |
| Spread | 5.00 | ft |
| Mannings Coeffic | 0.013 | |

**Results**

| | | |
|---|---|---|
| Discharge | 2.37 | cfs ✓ |
| Flow Area | 0.6 | $ft^2$ |
| Depth | 0.26 | ft |
| Gutter Depress | 0.5 | in |
| Velocity | 4.25 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

(B)

**Project Description**

| | |
|---|---|
| Worksheet | First Inlet along SH83 at Intercl |
| Type | Curb Inlet On Grade |
| Solve For | Efficiency |

**Input Data**

| | | |
|---|---|---|
| Discharge | 2.37 | cfs |
| Slope | 017500 | ft/ft |
| Gutter Width | 1.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 043000 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 15.00 | ft |
| Local Depression | 1.0 | in |
| Local Depression \ | 15.00 | ft |

**Results**

| | | |
|---|---|---|
| Efficiency | 0.88 | |
| Intercepted Flow | 2.08 | cfs |
| Bypass Flow | 0.29 | cfs |
| Spread | 5.00 | ft |
| Depth | 0.26 | ft |
| Flow Area | 0.6 | ft² |
| Gutter Depression | 0.5 | in |
| Total Depression | 1.5 | in |
| Velocity | 4.25 | ft/s |
| Equivalent Cross Slo | 047046 | ft/ft |
| Length Factor | 0.69 | |
| Total Interception Ler | 21.71 | ft |

# Worksheet
## Worksheet for Gutter Section

(1)

| Project Description | |
|---|---|
| Worksheet | Maximum 2' Gutter Spread (SH8 |
| Type | Gutter Section |
| Solve For | Discharge |

| Input Data | | |
|---|---|---|
| Slope | 017500 | ft/ft |
| Gutter Width | 2.00 | ft ✓ |
| Gutter Cross Slo | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft |
| Spread | 6.00 | ft |
| Mannings Coeffic | 0.013 | |

| Results | | |
|---|---|---|
| Discharge | 4.38 | cfs ✓ |
| Flow Area | 0.9 | ft² |
| Depth | 0.34 | ft |
| Gutter Depress | 1.0 | in |
| Velocity | 5.12 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

D

| Project Description | |
|---|---|
| Worksheet | Inlet (w/ 2' gutter) along SH83 at Interc |
| Type | Curb Inlet On Grade |
| Solve For | Efficiency |

| Input Data | | |
|---|---|---|
| Discharge | 4.38 | cfs |
| Slope | 017500 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 043000 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 15.00 | ft |
| Local Depression | 1.0 | in |
| Local Depression \ | 2.00 | ft |

| Results | | |
|---|---|---|
| Efficiency | 0.97 | |
| Intercepted Flow | 4.24 | cfs |
| Bypass Flow | 0.14 | cfs |
| Spread | 6.00 | ft |
| Depth | 0.34 | ft |
| Flow Area | 0.9 | ft² |
| Gutter Depression | 1.0 | in |
| Total Depression | 2.0 | in |
| Velocity | 5.13 | ft/s |
| Equivalent Cross Slo | 102392 | ft/ft |
| Length Factor | 0.85 | |
| Total Interception Ler | 17.62 | ft |

# Worksheet
## Worksheet for Gutter Section

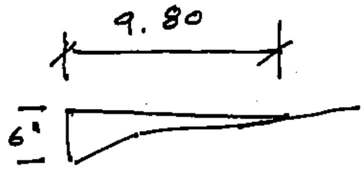
(5)

Project Description

| | |
|---|---|
| Worksheet | Maximum 2' Gutter Height (SH8: |
| Type | Gutter Section |
| Solve For | Discharge |

Input Data

| | | |
|---|---|---|
| Slope | 017500 | ft/ft ✓ |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo| | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft |
| Spread | 9.80 | ft ✓ |
| Mannings Coeffic | 0.013 | |




Results

| | | |
|---|---|---|
| Discharge | 14.33 | cfs ✓ |
| Flow Area | 2.1 | ft² |
| Depth | 0.50 | ft |
| Gutter Depress | 1.0 | in |
| Velocity | 6.68 | ft/s |

# Worksheet
## Worksheet for Gutter Section

F

**Project Description**

| | |
|---|---|
| Worksheet | Gutter Depth @ sta 221+90 (SH8 |
| Type | Gutter Section |
| Solve For | Spread |

**Input Data**

| | | |
|---|---|---|
| Slope | 024500 | ft/ft ✓ |
| Discharge | 7.79 | cfs from Rational Calc. |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo; | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft |
| Mannings Coeffic | 0.013 | |

**Results**

| | | |
|---|---|---|
| Spread | 7.14 | ft ✓ |
| Flow Area | 1.2 | ft² |
| Depth | 0.39 | ft ✓ |
| Gutter Depres: | 1.0 | in |
| Velocity | 6.62 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

(6)

| Project Description | |
|---|---|
| Worksheet | Inlet SH83 sta. 221 |
| Type | Curb Inlet On Grac |
| Solve For | Efficiency |

| Input Data | | |
|---|---|---|
| Discharge | 7.79 | cfs |
| Slope | 024500 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 043000 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 15.00 | ft |
| Local Depression | 3.0 | in |
| Local Depression \ | 2.00 | ft |

| Results | | |
|---|---|---|
| Efficiency | 0.92 | |
| Intercepted Flow | 7.18 | cfs |
| Bypass Flow | 0.61 | cfs — To ditches on south portion of road |
| Spread | 7.14 | ft |
| Depth | 0.39 | ft |
| Flow Area | 1.2 | ft² |
| Gutter Depression | 1.0 | in |
| Total Depression | 4.0 | in |
| Velocity | 6.62 | ft/s |
| Equivalent Cross Slo | 149158 | ft/ft |
| Length Factor | 0.76 | |
| Total Interception Ler | 19.81 | ft |

# Worksheet
## Worksheet for Gutter Section

(H)

| Project Description | |
|---|---|
| Worksheet | Gutter Depth @ sta 217+45 (SH83 @ |
| Type | Gutter Section |
| Solve For | Spread |

| Input Data | | |
|---|---|---|
| Slope | 025000 | ft/ft |
| Discharge | 3.81 | cfs |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo| | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft |
| Mannings Coeffic | 0.013 | |

| Results | | |
|---|---|---|
| Spread | 5.21 | ft |
| Flow Area | 0.7 | ft² |
| Depth | 0.30 | ft |
| Gutter Depress | 1.0 | in |
| Velocity | 5.74 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

(I)

**Project Description**

| | |
|---|---|
| Worksheet | Inlet SH83 sta. 217 |
| Type | Curb Inlet On Grac |
| Solve For | Efficiency |

**Input Data**

| | | |
|---|---|---|
| Discharge | 3.81 | cfs |
| Slope | 025000 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 043000 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 5.00 | ft |
| Local Depression | 3.0 | in |
| Local Depression \ | 2.00 | ft |

**Results**

| | | |
|---|---|---|
| Efficiency | 0.57 | |
| Intercepted Flow | 2.16 | cfs |
| Bypass Flow | 1.65 | cfs |
| Spread | 5.21 | ft |
| Depth | 0.30 | ft |
| Flow Area | 0.7 | ft² |
| Gutter Depression | 1.0 | in |
| Total Depression | 4.0 | in |
| Velocity | 5.74 | ft/s |
| Equivalent Cross Slo | 173503 | ft/ft |
| Length Factor | 0.37 | |
| Total Interception Ler | 13.48 | ft |

# Worksheet
## Worksheet for Gutter Section

| Project Description | |
|---|---|
| Worksheet | Gutter Depth @ sta 215+45 (SH83 @ |
| Type | Gutter Section |
| Solve For | Spread |

| Input Data | | |
|---|---|---|
| Slope | 025000 | ft/ft |
| Discharge | 3.79 | cfs |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo| | 083300 | ft/ft |
| Road Cross Slop | 043000 | ft/ft |
| Mannings Coeffic | 0.013 | |

| Results | | |
|---|---|---|
| Spread | 5.20 | ft |
| Flow Area | 0.7 | ft² |
| Depth | 0.30 | ft |
| Gutter Depres: | 1.0 | in |
| Velocity | 5.73 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

(K)

| Project Description | |
| --- | --- |
| Worksheet | Inlet SH83 sta. 21E |
| Type | Curb Inlet On Grac |
| Solve For | Efficiency |

| Input Data | | |
| --- | --- | --- |
| Discharge | 3.79 | cfs |
| Slope | 025000 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 043000 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 15.00 | ft |
| Local Depression | 3.0 | in |
| Local Depression \ | 2.00 | ft |

| Results | | |
| --- | --- | --- |
| Efficiency | 1.00 | |
| Intercepted Flow | 3.79 | cfs |
| Bypass Flow | 0.00 | cfs |
| Spread | 5.20 | ft |
| Depth | 0.30 | ft |
| Flow Area | 0.7 | ft² |
| Gutter Depression | 1.0 | in |
| Total Depression | 4.0 | in |
| Velocity | 5.73 | ft/s |
| Equivalent Cross Slo | 173680 | ft/ft |
| Length Factor | 1.12 | |
| Total Interception Ler | 13.44 | ft |

# Worksheet
## Worksheet for Gutter Section

(L.)

| Project Description | |
| --- | --- |
| Worksheet | Gutter Depth @ sta 213+95 (SH83 @ |
| Type | Gutter Section |
| Solve For | Spread |

| Input Data | | |
| --- | --- | --- |
| Slope | 025000 | ft/ft |
| Discharge | 1.61 | cfs |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo; | 083300 | ft/ft |
| Road Cross Slop | 015600 | ft/ft |
| Mannings Coeffic | 0.013 | |

| Results | | |
| --- | --- | --- |
| Spread | 5.51 | ft |
| Flow Area | 0.4 | ft² |
| Depth | 0.22 | ft |
| Gutter Depress | 1.6 | in |
| Velocity | 4.33 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

(M)

| Project Description | |
|---|---|
| Worksheet | Inlet SH83 sta. 21: |
| Type | Curb Inlet On Grac |
| Solve For | Efficiency |

| Input Data | | |
|---|---|---|
| Discharge | 1.61 | cfs ✓ |
| Slope | 025000 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 015600 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 10.00 | ft ✓ |
| Local Depression | 3.0 | in |
| Local Depression \ | 2.00 | ft |

| Results | | |
|---|---|---|
| Efficiency | 1.00 | |
| Intercepted Flow | 1.61 | cfs ✓ |
| Bypass Flow | 0.00 | cfs ✓ |
| Spread | 5.51 | ft |
| Depth | 0.22 | ft |
| Flow Area | 0.4 | ft² |
| Gutter Depression | 1.6 | in |
| Total Depression | 4.6 | in |
| Velocity | 4.33 | ft/s |
| Equivalent Cross Slo | 185915 | ft/ft |
| Length Factor | 1.11 | |
| Total Interception Ler | 9.00 | ft |

# Worksheet
## Worksheet for Gutter Section

N

| Project Description | |
|---|---|
| Worksheet | Gutter Depth @ sta 213+45 (SH83 @ |
| Type | Gutter Section |
| Solve For | Spread |

| Input Data | | |
|---|---|---|
| Slope | 025000 | ft/ft |
| Discharge | 0.54 | cfs |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slo| | 083300 | ft/ft |
| Road Cross Slop | 002600 | ft/ft |
| Mannings Coeffic | 0.013 | |

| Results | | |
|---|---|---|
| Spread | 1.83 | ft |
| Flow Area | 0.1 | $ft^2$ |
| Depth | 0.15 | ft |
| Gutter Depress | 1.9 | in |
| Velocity | 3.87 | ft/s |

# Worksheet
## Worksheet for Curb Inlet On Grade

| Project Description | |
|---|---|
| Worksheet | Inlet SH83 sta. 21: |
| Type | Curb Inlet On Grac |
| Solve For | Efficiency |

| Input Data | | |
|---|---|---|
| Discharge | 0.54 | cfs |
| Slope | 025000 | ft/ft |
| Gutter Width | 2.00 | ft |
| Gutter Cross Slope | 083333 | ft/ft |
| Road Cross Slope | 002600 | ft/ft |
| Mannings Coefficie | 0.013 | |
| Curb Opening Len | 5.00 | ft |
| Local Depression | 3.0 | in |
| Local Depression \ | 2.00 | ft |

| Results | | |
|---|---|---|
| Efficiency | 0.99 | |
| Intercepted Flow | 0.54 | cfs |
| Bypass Flow | 3.34e-3 | cfs |
| Spread | 1.83 | ft |
| Depth | 0.15 | ft |
| Flow Area | 0.1 | ft² |
| Gutter Depression | 1.9 | in |
| Total Depression | 4.9 | in |
| Velocity | 3.87 | ft/s |
| Equivalent Cross Slo | 208333 | ft/ft |
| Length Factor | 0.94 | |
| Total Interception Ler | 5.32 | ft |

**URS**

| | | | |
|---|---|---|---|
| Job POWERS BOULEVARD | Project No. 67-425009.02 | Page ____ of ____ | |
| | | Sheet ____ of ____ | |
| Description MOVED TYPE R | Computed by SSM | Date 10/3/02 | |
| NEAR 222+00 | Checked by ____ | Date ____ | |

Reference (P)

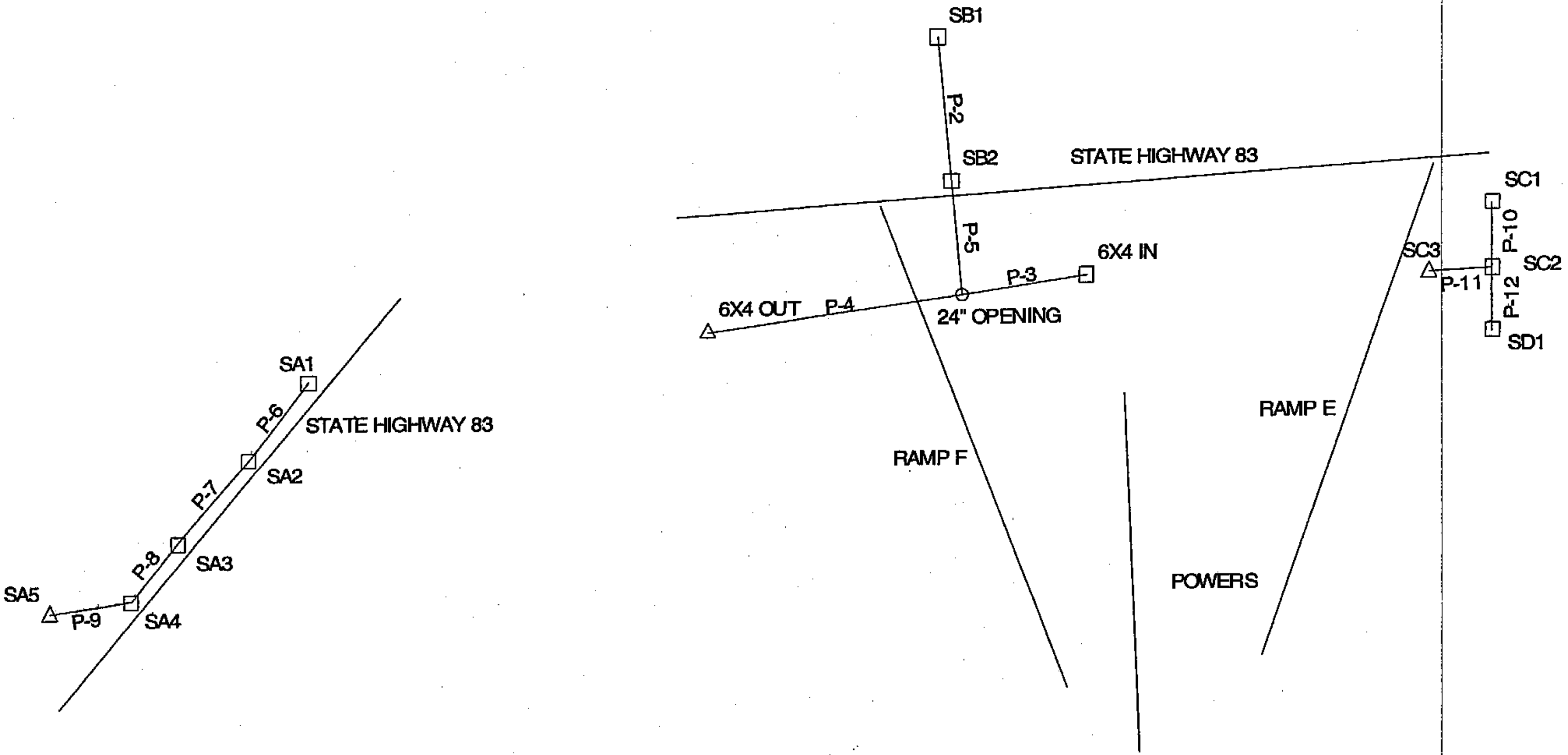
NEW STA: 222+1.51' 10' RT

ASSUMED: 2' GUTTER
4.3% SUPER
HCL = 6864.81

FL EL = 6864.81 − 8(.043) − 2" = 6864.30 ✓

∴ TOP EL = 6864.80 ✓

# Scenario: Base




Title: SH83 and Powers Interchange
...\hydr\sh83 interchange\sh83 interchange.stm
10/07/02 09:36:04 AM

**URS Corporation**


Project Engineer: E. Danny Elsner
StormCAD v4.1.1 [4.2014]

# DOT Report

| Label | -Node- Upstream Downstream | Upstream Inlet Area (acres) | Upstream Inlet CA (acres) | Upstream Calculated System CA (acres) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Section Discharge Capacity (cfs) | -Section- Shape Size | Length (ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-2 | SB1 | 10.80 | 4.43 | 4.43 | 6,861.13 | 6,861.15 | 6,862.85 | 0.051158 | 22.78 | Circular | 138.48 | 13.11 | |
| | SB2 | | | | 6,864.80 | 6,850.77 | 6,851.61 | 0.074957 | 61.93 | 24 inch | | | |
| P-5 | SB2 | 0.93 | 0.88 | 5.24 | 6,864.80 | 6,850.47 | 6,852.27 | 0.115786 | 26.83 | Circular | 154.65 | 8.77 | |
| | 24" OPENIN | | | | 6,835.39 | 6,832.45 | 6,834.49 | 0.116521 | 77.22 | 24 inch | | | |
| P-3 | 6X4 IN | 101.26 | 40.50 | 40.50 | 6,831.75 | 6,831.75 | 6,834.54 | 0.004475 | 158.36 | Box | 60.11 | 9.07 | |
| | 24" OPENIN | | | | 6,835.39 | 6,831.45 | 6,834.49 | 0.004991 | 218.85 | 6 x 4 ft | | | |
| P-4 | 24" OPENIN | N/A | N/A | 45.74 | 6,835.39 | 6,831.45 | 6,834.47 | 0.004936 | 178.47 | Box | 169.15 | 10.15 | |
| | 6X4 OUT | | | | 6,830.60 | 6,830.60 | 6,833.45 | 0.005025 | 219.60 | 6 x 4 ft | | | |
| P-6 | SA1 | 0.46 | 0.43 | 0.24 | 6,854.43 | 6,850.10 | 6,850.65 | 0.024754 | 2.15 | Circular | 184.50 | 3.18 | |
| | SA2 | | | | 6,849.43 | 6,845.49 | 6,846.18 | 0.024986 | 16.60 | 18 inch | | | |
| P-7 | SA2 | 0.26 | 0.25 | 0.68 | 6,849.43 | 6,845.19 | 6,846.12 | 0.028656 | 5.78 | Circular | 139.12 | 7.26 | |
| | SA3 | | | | 6,845.24 | 6,840.56 | 6,841.12 | 0.033281 | 19.16 | 18 inch | | | |
| P-8 | SA3 | 0.19 | 0.18 | 0.86 | 6,845.24 | 6,840.06 | 6,841.10 | 0.020781 | 7.22 | Circular | 43.63 | 7.50 | |
| | SA4 | | | | 6,843.78 | 6,838.60 | 6,839.27 | 0.033463 | 19.21 | 18 inch | | | |
| P-9 | SA4 | 0.06 | 0.06 | 0.92 | 6,843.78 | 6,838.30 | 6,839.54 | 0.005612 | 7.67 | Circular | 71.70 | 5.29 | |
| | SA5 | | | | 6,837.94 | 6,837.94 | 6,839.01 | 0.005021 | 7.44 | 18 inch | | | |
| P-10 | SC1 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,875.50 | 6,877.44 | 0.025232 | 37.00 | Circular | 5.00 | 12.77 | |
| | SC2 | | | | 6,883.00 | 6,875.00 | 6,876.61 | 0.100000 | 71.53 | 24 inch | | | |
| P-12 | SD1 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,875.50 | 6,877.44 | 0.025232 | 37.00 | Circular | 5.00 | 12.77 | |
| | SC2 | | | | 6,883.00 | 6,875.00 | 6,876.61 | 0.100000 | 71.53 | 24 inch | | | |
| P-11 | SC2 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,870.16 | 6,874.25 | 0.012173 | 111.00 | Circular | 67.00 | 11.54 | |
| | SC3 | | | | 6,867.31 | 6,867.31 | 6,873.43 | 0.042537 | 207.49 | 42 inch | | | |

100-YEAR

# Inlet Report

| Label | Calculated Station (ft) | Rim Elevation (ft) | Sump Elevation (ft) | Area (acres) | Inlet C | Time of Concentration (min) | Inlet CA (acres) | Local Rational Flow (cfs) | Carryover Rational Flow (cfs) | Curb Opening Length (ft) | Inlet | Inlet Location | Clogging Factor (%) | Headloss Method | Hydraulic Grade Line In (ft) | Hydraulic Grade Line Out (ft) | Gutter Ditch Depth (ft) | Gutter Ditch Spread (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6X4 IN | 2+29 | 6,831.75 | 6,831.75 | 101.26 | 0.40 | 34.08 | 40.50 | 158.36 | 0.00 | N/A | Generic Default 100% | In Sag | 0.0 | HEC-22 Ener | 6,831.75 | 6,831.75 | 0.00 | 0.00 |
| SA1 | 4+39 | 6,854.43 | 6,850.10 | 0.46 | 0.95 | 5.00 | 0.43 | 3.84 | 0.00 | 5.00 | Curb CDOT Type R | On Grade | 0.0 | HEC-22 Ener | 6,850.65 | 6,850.65 | 0.31 | 5.23 |
| SA2 | 2+54 | 6,849.43 | 6,845.19 | 0.26 | 0.95 | 5.00 | 0.25 | 2.19 | 1.68 | 15.00 | Curb CDOT Type R | On Grade | 0.0 | HEC-22 Ener | 6,846.18 | 6,846.12 | 0.31 | 5.25 |
| SA3 | 1+15 | 6,845.24 | 6,840.06 | 0.19 | 0.95 | 5.00 | 0.18 | 1.60 | 0.00 | 10.00 | Curb CDOT Type R | On Grade | 0.0 | HEC-22 Ener | 6,841.18 | 6,841.10 | 0.22 | 5.48 |
| SA4 | 0+72 | 6,843.78 | 6,838.30 | 0.06 | 0.95 | 5.00 | 0.06 | 0.50 | 0.00 | 5.00 | Curb CDOT Type R | On Grade | 0.0 | HEC-22 Ener | 6,839.61 | 6,839.54 | 0.15 | 1.79 |
| SB1 | 4+62 | 6,861.13 | 6,861.13 | 10.80 | 0.41 | 21.59 | 4.43 | 22.78 | 0.00 | N/A | Generic Default 100% | In Sag | 0.0 | HEC-22 Ener | 6,861.13 | 6,861.13 | 0.00 | 0.00 |
| SB2 | 3+24 | 6,864.80 | 6,850.47 | 0.93 | 0.95 | 5.00 | 0.88 | 7.82 | 0.00 | 15.00 | Curb CDOT Type R | On Grade | 0.0 | HEC-22 Ener | 6,852.45 | 6,852.27 | 0.39 | 7.15 |
| SC1 | 0+72 | 6,883.00 | 6,875.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | N/A | Grate CDOT Type D | In Sag | 30.0 | HEC-22 Ener | 6,877.44 | 6,877.44 | 0.00 | 0.00 |
| SC2 | 0+67 | 6,883.00 | 6,870.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | N/A | Grate CDOT Type D | In Sag | 30.0 | HEC-22 Ener | 6,874.43 | 6,874.25 | 0.00 | 0.00 |
| SD1 | 0+72 | 6,883.00 | 6,875.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | N/A | Grate CDOT Type D | In Sag | 30.0 | HEC-22 Ener | 6,877.44 | 6,877.44 | 0.00 | 0.00 |

100-YEAR

# Inlet Report

| Capture Efficiency (%) | External CA (acres) | External Time of Concentration (min) | Description |
|---|---|---|---|
| 100.0 | 0.00 | 0.00 | RATIONAL BASIN ULT-AC15 - ACRES AT INLETS SB1 AND SB2 (WORST CASE SCENARIO)□□INLET US |
| 56.2 | 0.00 | 0.00 | 355'X56' FOR AREA |
| 100.0 | 0.00 | 0.00 | 200'X56' AREA |
| 100.0 | 0.00 | 0.00 | 150'X56' AREA |
| 99.7 | 0.00 | 0.00 | 50'X56' AREA□□10' UP FROM 0% CROSS SLOPE |
| 100.0 | 0.00 | 0.00 | BASIN -INT-AC4 (WORST CASE SCENARIO)□□INLET BEING USED FOR FES. |
| 91.9 | 0.00 | 0.00 | RATION BASIN INT-A09 (WORST CASE SCENARIO) |
| 100.0 | 0.00 | 0.00 | 1/3 of Basin ULT-A01 |
| 100.0 | 0.00 | 0.00 | 1/3 of Basin ULT-A01 |
| 100.0 | 0.00 | 0.00 | 1/3 of Basin ULT-A01 |

100-YEAR

# Scenario: Base

## DOT Report

| Label | -Node- Upstream Downstream | Upstream Inlet Area (acres) | Upstream Inlet CA (acres) | Upstream Calculated System CA (acres) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Section Discharge Capacity (cfs) | -Section- Shape Size | Length (ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-2 | SB1 | 10.80 | 4.43 | 4.43 | 6,861.13 | 6,861.15 | 6,862.55 | 0.055123 | 15.11 | Circular | 138.48 | 11.35 | |
| | SB2 | | | | 6,864.80 | 6,850.77 | 6,851.44 | 0.074957 | 61.93 | 24 inch | | | |
| P-5 | SB2 | 0.93 | 0.88 | 5.31 | 6,864.80 | 6,850.47 | 6,852.00 | 0.086710 | 18.01 | Circular | 154.65 | 13.51 | |
| | 24" OPENIN | | | | 6,835.39 | 6,832.45 | 6,833.11 | 0.116521 | 77.22 | 24 inch | | | |
| P-3 | 6X4 IN | 101.26 | 40.50 | 40.50 | 6,831.75 | 6,831.75 | 6,833.87 | 0.004602 | 105.05 | Box | 60.11 | 7.91 | |
| | 24" OPENIN | | | | 6,835.39 | 6,831.45 | 6,833.76 | 0.004991 | 218.85 | 6 x 4 ft | | | |
| P-4 | 24" OPENIN | N/A | N/A | 45.81 | 6,835.39 | 6,831.45 | 6,833.75 | 0.004877 | 118.53 | Box | 169.15 | 8.97 | |
| | 6X4 OUT | | | | 6,830.60 | 6,830.60 | 6,832.71 | 0.005025 | 219.60 | 6 x 4 ft | | | |
| P-6 | SA1 | 0.46 | 0.43 | 0.29 | 6,854.43 | 6,850.10 | 6,850.59 | 0.024986 | 1.70 | Circular | 184.50 | 3.37 | |
| | SA2 | | | | 6,849.43 | 6,845.49 | 6,845.98 | 0.024986 | 16.60 | 18 inch | | | |
| P-7 | SA2 | 0.26 | 0.25 | 0.68 | 6,849.43 | 6,845.19 | 6,845.94 | 0.029468 | 3.84 | Circular | 139.12 | 6.43 | |
| | SA3 | | | | 6,845.24 | 6,840.56 | 6,841.02 | 0.033281 | 19.16 | 18 inch | | | |
| P-8 | SA3 | 0.19 | 0.18 | 0.86 | 6,845.24 | 6,840.06 | 6,840.91 | 0.021638 | 4.79 | Circular | 43.63 | 6.71 | |
| | SA4 | | | | 6,843.78 | 6,838.60 | 6,839.13 | 0.033463 | 19.21 | 18 inch | | | |
| P-9 | SA4 | 0.06 | 0.06 | 0.92 | 6,843.78 | 6,838.30 | 6,839.22 | 0.005075 | 5.09 | Circular | 71.70 | 4.68 | |
| | SA5 | | | | 6,837.94 | 6,837.94 | 6,838.81 | 0.005021 | 7.44 | 18 inch | | | |
| P-10 | SC1 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,875.50 | 6,877.44 | 0.025232 | 37.00 | Circular | 5.00 | 12.77 | |
| | SC2 | | | | 6,883.00 | 6,875.00 | 6,876.61 | 0.100000 | 71.53 | 24 inch | | | |
| P-12 | SD1 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,875.50 | 6,877.44 | 0.025232 | 37.00 | Circular | 5.00 | 12.77 | |
| | SC2 | | | | 6,883.00 | 6,875.00 | 6,876.61 | 0.100000 | 71.53 | 24 inch | | | |
| P-11 | SC2 | 0.00 | 0.00 | 0.00 | 6,883.00 | 6,870.16 | 6,874.25 | 0.012173 | 111.00 | Circular | 67.00 | 11.54 | |
| | SC3 | | | | 6,867.31 | 6,867.31 | 6,873.43 | 0.042537 | 207.49 | 42 inch | | | |

10-YEAR

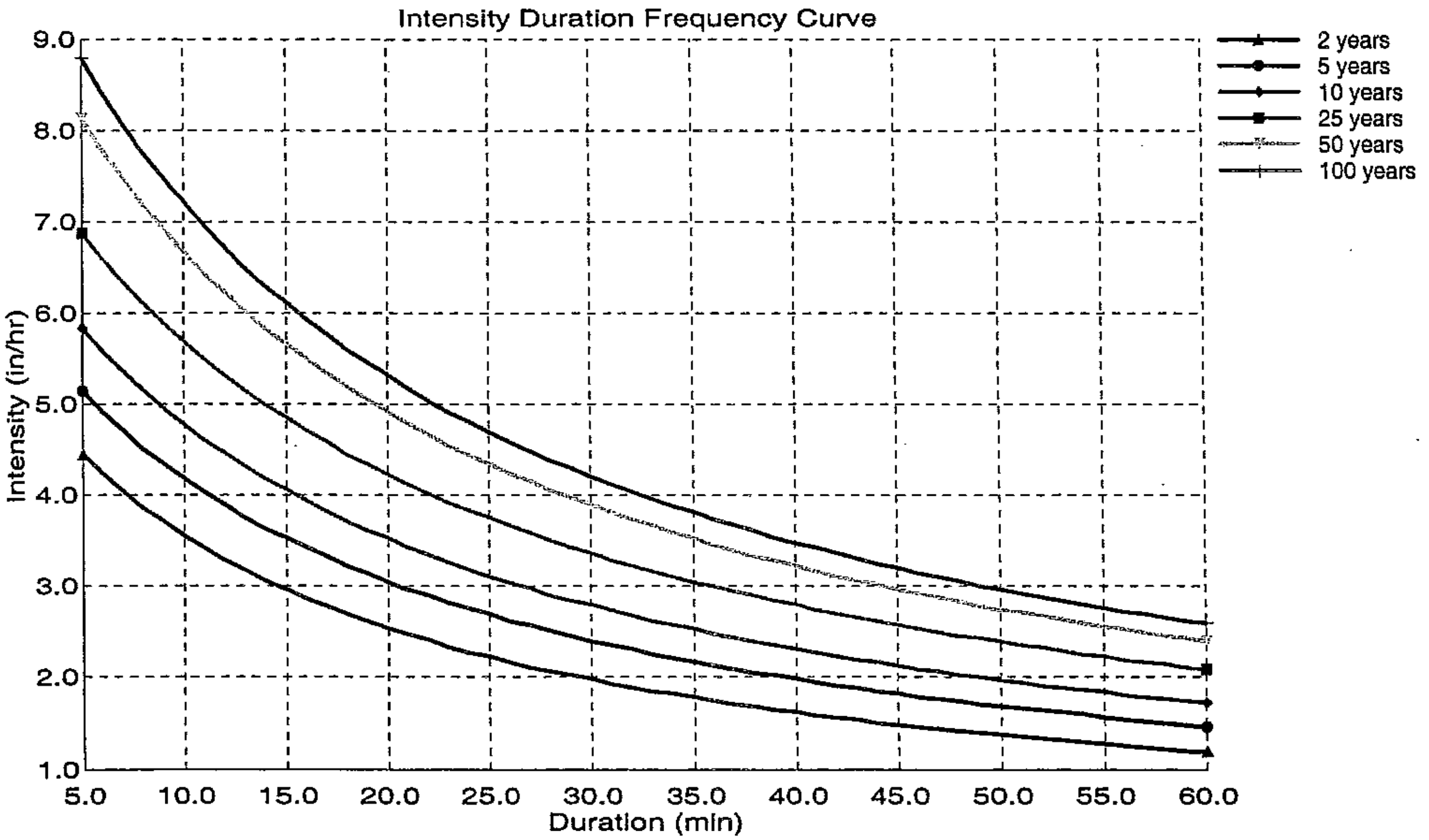
# Rainfall Table

| Return Periods | | | | | | |
|---|---|---|---|---|---|---|
| Durations | 2 year | 5 year | 10 year | 25 year | 50 year | 100 year |
| 5 min | 4.45 | 5.14 | 5.83 | 6.88 | 8.13 | 8.78 |
| 6 min | 4.24 | 4.91 | 5.58 | 6.60 | 7.79 | 8.42 |
| 7 min | 4.05 | 4.71 | 5.36 | 6.35 | 7.48 | 8.08 |
| 8 min | 3.87 | 4.52 | 5.15 | 6.11 | 7.19 | 7.77 |
| 9 min | 3.71 | 4.35 | 4.96 | 5.89 | 6.93 | 7.48 |
| 10 min | 3.56 | 4.19 | 4.79 | 5.69 | 6.68 | 7.21 |
| 11 min | 3.42 | 4.04 | 4.62 | 5.50 | 6.45 | 6.97 |
| 12 min | 3.30 | 3.90 | 4.47 | 5.32 | 6.23 | 6.73 |
| 13 min | 3.18 | 3.77 | 4.32 | 5.16 | 6.03 | 6.52 |
| 14 min | 3.07 | 3.65 | 4.19 | 5.00 | 5.84 | 6.31 |
| 15 min | 2.97 | 3.53 | 4.06 | 4.85 | 5.67 | 6.12 |
| 16 min | 2.87 | 3.42 | 3.94 | 4.71 | 5.50 | 5.94 |
| 17 min | 2.78 | 3.32 | 3.83 | 4.58 | 5.34 | 5.77 |
| 18 min | 2.70 | 3.23 | 3.72 | 4.46 | 5.19 | 5.61 |
| 19 min | 2.62 | 3.14 | 3.62 | 4.34 | 5.05 | 5.46 |
| 20 min | 2.54 | 3.05 | 3.53 | 4.23 | 4.92 | 5.32 |
| 21 min | 2.47 | 2.97 | 3.44 | 4.13 | 4.79 | 5.18 |
| 22 min | 2.41 | 2.90 | 3.35 | 4.02 | 4.67 | 5.05 |
| 23 min | 2.34 | 2.83 | 3.27 | 3.93 | 4.56 | 4.93 |
| 24 min | 2.28 | 2.76 | 3.19 | 3.84 | 4.45 | 4.81 |
| 25 min | 2.23 | 2.69 | 3.12 | 3.75 | 4.35 | 4.70 |
| 26 min | 2.17 | 2.63 | 3.05 | 3.67 | 4.25 | 4.59 |
| 27 min | 2.12 | 2.57 | 2.98 | 3.59 | 4.16 | 4.49 |
| 28 min | 2.07 | 2.51 | 2.91 | 3.51 | 4.07 | 4.39 |
| 29 min | 2.02 | 2.46 | 2.85 | 3.44 | 3.98 | 4.30 |
| 30 min | 1.98 | 2.40 | 2.79 | 3.37 | 3.90 | 4.21 |
| 31 min | 1.93 | 2.35 | 2.73 | 3.30 | 3.82 | 4.12 |
| 32 min | 1.89 | 2.31 | 2.68 | 3.24 | 3.74 | 4.04 |
| 33 min | 1.85 | 2.26 | 2.63 | 3.17 | 3.67 | 3.96 |
| 34 min | 1.82 | 2.22 | 2.58 | 3.11 | 3.60 | 3.88 |
| 35 min | 1.78 | 2.17 | 2.53 | 3.06 | 3.53 | 3.81 |
| 36 min | 1.75 | 2.13 | 2.48 | 3.00 | 3.46 | 3.74 |
| 37 min | 1.71 | 2.09 | 2.44 | 2.95 | 3.40 | 3.67 |
| 38 min | 1.68 | 2.05 | 2.39 | 2.89 | 3.34 | 3.61 |
| 39 min | 1.65 | 2.02 | 2.35 | 2.84 | 3.28 | 3.54 |
| 40 min | 1.62 | 1.98 | 2.31 | 2.80 | 3.22 | 3.48 |
| 41 min | 1.59 | 1.95 | 2.27 | 2.75 | 3.17 | 3.42 |
| 42 min | 1.56 | 1.92 | 2.23 | 2.70 | 3.12 | 3.37 |
| 43 min | 1.53 | 1.88 | 2.20 | 2.66 | 3.07 | 3.31 |
| 44 min | 1.51 | 1.85 | 2.16 | 2.62 | 3.02 | 3.26 |
| 45 min | 1.48 | 1.82 | 2.13 | 2.58 | 2.97 | 3.21 |
| 46 min | 1.46 | 1.79 | 2.09 | 2.54 | 2.92 | 3.16 |
| 47 min | 1.44 | 1.77 | 2.06 | 2.50 | 2.88 | 3.11 |
| 48 min | 1.41 | 1.74 | 2.03 | 2.46 | 2.83 | 3.06 |
| 49 min | 1.39 | 1.71 | 2.00 | 2.43 | 2.79 | 3.01 |
| 50 min | 1.37 | 1.69 | 1.97 | 2.39 | 2.75 | 2.97 |
| 51 min | 1.35 | 1.66 | 1.94 | 2.36 | 2.71 | 2.93 |
| 52 min | 1.33 | 1.64 | 1.91 | 2.32 | 2.67 | 2.89 |
| 53 min | 1.31 | 1.61 | 1.89 | 2.29 | 2.63 | 2.85 |
| 54 min | 1.29 | 1.59 | 1.86 | 2.26 | 2.60 | 2.81 |
| 55 min | 1.27 | 1.57 | 1.84 | 2.23 | 2.56 | 2.77 |
| 56 min | 1.25 | 1.55 | 1.81 | 2.20 | 2.53 | 2.73 |
| 57 min | 1.24 | 1.53 | 1.79 | 2.17 | 2.49 | 2.69 |

# Rainfall Table

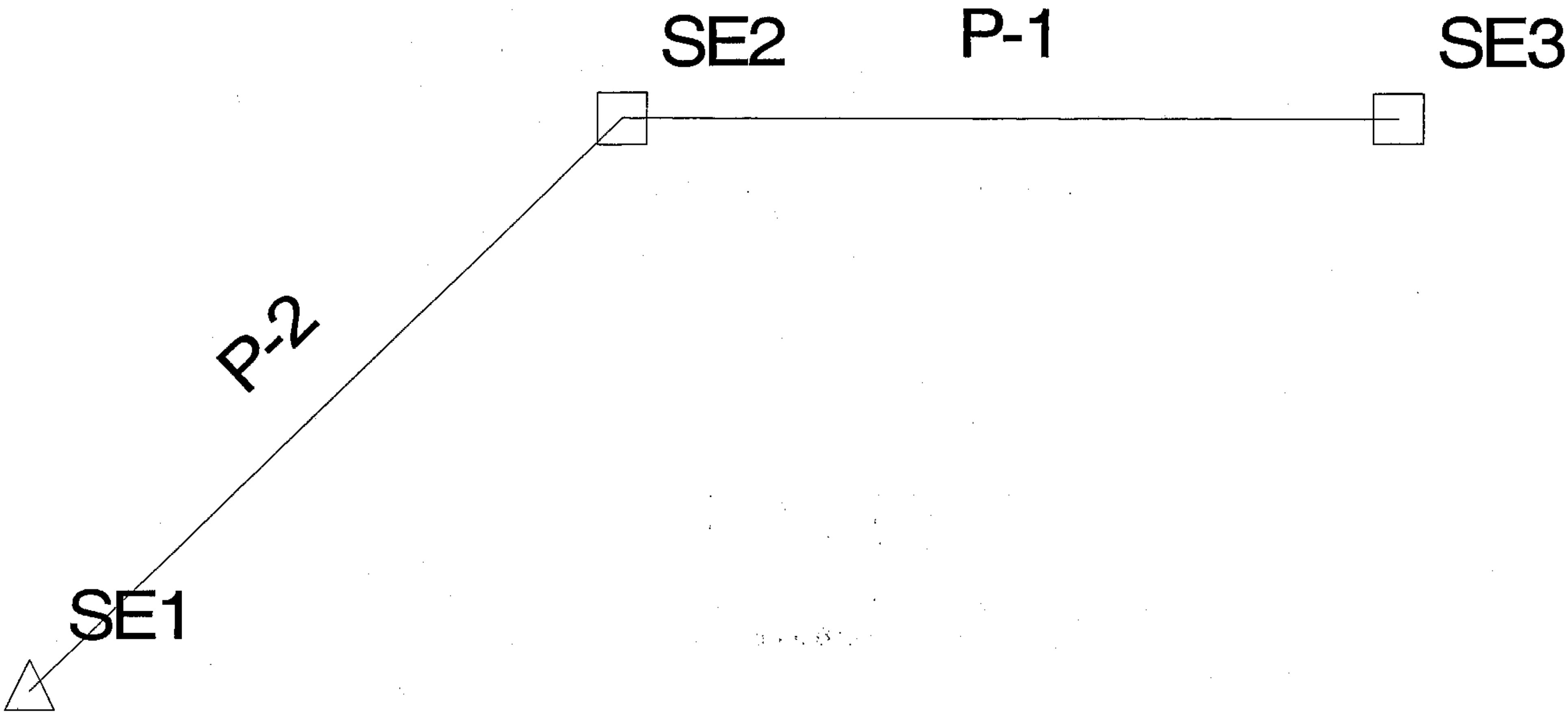
| Return Periods | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Durations | 2 year | 5 year | 10 year | 25 year | 50 year | 100 year |
| 58 min | 1.22 | 1.51 | 1.76 | 2.14 | 2.46 | 2.66 |
| 59 min | 1.20 | 1.49 | 1.74 | 2.12 | 2.43 | 2.62 |
| 60 min | 1.19 | 1.47 | 1.72 | 2.09 | 2.40 | 2.59 |

Rainfall Intensities are in (in/hr)



Intensity Duration Frequency Curve
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Intensity (in/hr)
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
Duration (min)
2 years
5 years
10 years
25 years
50 years
100 years

Scenario: Base



# Scenario: Base

## DOT Report

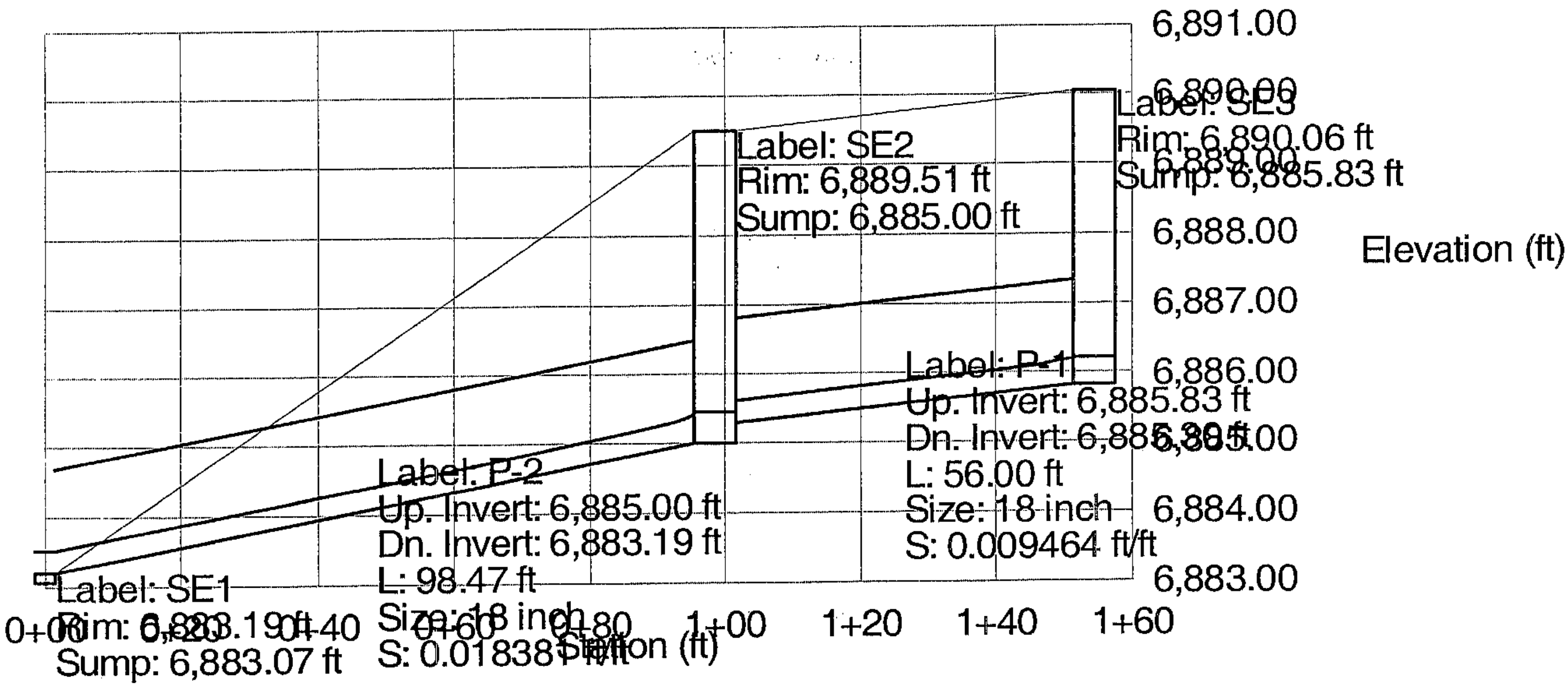
| Label | -Node- Upstream Downstream | -Section- Shape Size | Length (ft) | Upstream Calculated System CA (acres) | System Flow Time (min) | System Intensity (in/hr) | Section Discharge Capacity (cfs) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -Cover- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-2 | SE2 | Circular | 98.47 | 0.28 | 5.28 | 5.04 | 1.44 | 6,889.51 | 6,885.00 | 3.01 | 6,885.45 | 0.017105 | 4.20 | |
| | SE1 | 18 inch | | | | | 14.24 | 6,883.19 | 6,883.19 | -1.50 | 6,883.51 | 0.018381 | | |
| P-1 | SE3 | Circular | 56.00 | 0.21 | 5.00 | 5.10 | 1.07 | 6,890.06 | 6,885.83 | 2.73 | 6,886.22 | 0.009060 | 3.36 | |
| | SE2 | 18 inch | | | | | 10.22 | 6,889.51 | 6,885.30 | 2.71 | 6,885.63 | 0.009464 | | |

## Scenario: Base

# DOT Report 2

| Label | Rim Elevation (ft) | Sump Elevation (ft) | Area (acres) | Inlet C | Time of Concentration (min) | Local Rational Flow (cfs) | Carryover Rational Flow (cfs) | Curb Opening Length (ft) | Inlet | Inlet Location | Gutter Width (ft) | Gutter Cross Slope (ft/ft) | Clogging Factor (%) | Gutter Ditch Depth (ft) | Gutter Ditch Spread (ft) | Capture Efficiency (%) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE3 | 6,890.06 | 6,885.83 | 0.22 | 0.95 | 5.00 | 1.07 | 0.00 | 10.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.20 | 3.83 | 100.0 | |
| SE2 | 6,889.51 | 6,885.00 | 0.08 | 0.95 | 5.00 | 0.39 | 0.00 | 5.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.14 | 1.68 | 100.0 | |

**Profile**
**Scenario: Base**




Title: Powers/SH83/Shoup
q:\cad\design\hydr\stormcad\upper elkhorn (se).stm
09/09/03 09:09:05 AM

**URS Corporation**


Project Engineer: E. Danny Elsner
StormCAD v4.1.1 [4.2014]

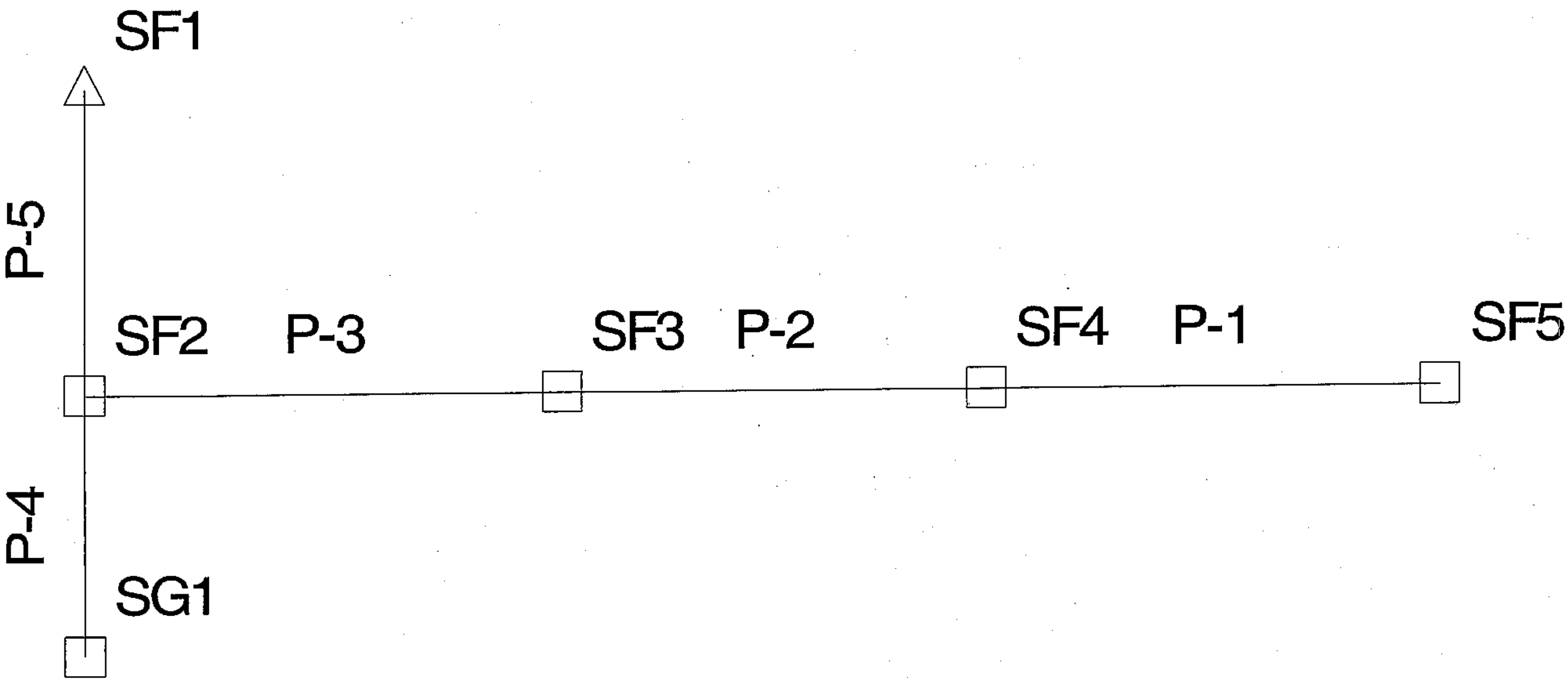
DRAFT

## Appendix G: Hydraulics - Ditch Capacity/ Lining for Black Squirrel Creek Basin

DRAFT

**Appendix J: Hydraulics - Inlet / Storm System Design for Black Squirrel Creek Basin**

**Scenario: Base**



# Scenario: Base

# DOT Report

| Label | -Node- Upstream Downstream | -Section- Shape Size | Length (ft) | Upstream Calculated System CA (acres) | System Flow Time (min) | System Intensity (in/hr) | Section Discharge Capacity (cfs) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -Cover- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-5 | SF2 | Circular | 88.80 | 12.5503 | 28.99 | 2.49 | 32.73 | 6,896.80 | 6,888.08 | 5.72 | 6,889.94 | 0.004953 | 7.15 | |
| | SF1 | 36 inch | | | | | 46.95 | 6,887.64 | 6,887.64 | -3.00 | 6,889.48 | 0.004955 | | |
| P-3 | SF3 | Circular | 170.85 | 1.5788 | 7.08 | 4.68 | 8.68 | 6,902.63 | 6,897.63 | 3.50 | 6,898.77 | 0.040178 | 9.02 | |
| | SF2 | 18 inch | | | | | 22.80 | 6,896.80 | 6,889.58 | 5.72 | 6,890.22 | 0.047117 | | |
| P-2 | SF4 | Circular | 159.68 | 1.2067 | 6.73 | 4.75 | 7.67 | 6,907.46 | 6,902.46 | 3.50 | 6,903.53 | 0.024823 | 7.66 | |
| | SF3 | 18 inch | | | | | 17.69 | 6,902.63 | 6,897.93 | 3.20 | 6,898.62 | 0.028369 | | |
| P-1 | SF5 | Circular | 416.75 | 0.5053 | 5.00 | 5.10 | 3.82 | 6,920.01 | 6,915.01 | 3.50 | 6,915.76 | 0.029338 | 4.01 | |
| | SF4 | 18 inch | | | | | 18.01 | 6,907.46 | 6,902.76 | 3.20 | 6,903.61 | 0.029394 | | |
| P-4 | SG1 | Circular | 70.41 | 10.4790 | 28.86 | 2.50 | 26.40 | 6,895.60 | 6,890.27 | 2.33 | 6,891.93 | 0.014921 | 9.10 | |
| | SF2 | 36 inch | | | | | 109.27 | 6,896.80 | 6,888.38 | 5.42 | 6,889.45 | 0.026843 | | |

# Scenario: Base

# DOT Report 2

| Label | Rim Elevation (ft) | Sump Elevation (ft) | Area (acres) | Inlet C | Time of Concentration (min) | Local Rational Flow (cfs) | Carryover Rational Flow (cfs) | Curb Opening Length (ft) | Inlet | Inlet Location | Gutter Width (ft) | Gutter Cross Slope (ft/ft) | Clogging Factor (%) | Gutter Ditch Depth (ft) | Gutter Ditch Spread (ft) | Capture Efficiency (%) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF4 | 6,907.46 | 6,902.46 | 0.4100 | 0.95 | 5.00 | 3.56 | 0.44 | 5.00 | Curb CDOT Type R | On Grade | 2.00 | 0.083 | 0.0 | 0.31 | 4.06 | 56.2 | |
| SF5 | 6,920.01 | 6,915.01 | 0.2670 | 0.95 | 5.00 | 2.32 | 0.00 | 5.00 | Curb CDOT Type R | On Grade | 2.00 | 0.083 | 0.0 | 0.30 | 3.86 | 80.8 | |
| SF3 | 6,902.63 | 6,897.63 | 0.1600 | 0.95 | 5.00 | 1.39 | 1.76 | 5.00 | Curb CDOT Type R | On Grade | 2.00 | 0.083 | 0.0 | 0.28 | 3.56 | 59.4 | |
| SF2 | 6,896.80 | 6,888.08 | 0.2237 | 0.95 | 5.00 | 1.94 | 1.28 | 10.00 | Curb CDOT Type R | On Grade | 2.00 | 0.083 | 0.0 | 0.30 | 3.84 | 96.9 | |
| SG1 | 6,895.60 | 6,890.27 | 29.9400 | 0.35 | 28.86 | 47.00 | 0.00 | N/A | Generic Default 100% | In Sag | 0.00 | 0.020 | 0.0 | 0.00 | 0.00 | 100.0 | |

# Scenario: Base

# DOT Report

| Label | -Node- Upstream Downstream | -Section- Shape Size | Length (ft) | Upstream Inlet Area (acres) | Upstream Inlet Rational Coefficient | Upstream Inlet CA (acres) | Upstream Calculated System CA (acres) | System Flow Time (min) | System Intensity (in/hr) | Section Discharge Capacity (cfs) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -Cover- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-5 | SF2 | Circular | 88.80 | 0.2237 | 0.95 | 0.2125 | 12.5393 | 29.01 | 4.43 | 57.24 | 6,896.80 | 6,888.08 | 5.72 | 6,890.95 | 0.006519 | 8.74 | |
| | SF1 | 36 inch | | | | | | | | 46.95 | 6,887.64 | 6,887.64 | -3.00 | 6,890.09 | 0.004955 | | |
| P-3 | SF3 | Circular | 170.85 | 0.1600 | 0.95 | 0.1520 | 1.4955 | 6.88 | 8.40 | 13.89 | 6,902.63 | 6,897.63 | 3.50 | 6,899.01 | 0.042972 | 8.01 | |
| | SF2 | 18 inch | | | | | | | | 22.80 | 6,896.80 | 6,889.58 | 5.72 | 6,891.74 | 0.047117 | | |
| P-2 | SF4 | Circular | 159.68 | 0.4100 | 0.95 | 0.3895 | 1.1295 | 6.58 | 8.51 | 11.58 | 6,907.46 | 6,902.46 | 3.50 | 6,903.76 | 0.024807 | 8.90 | |
| | SF3 | 18 inch | | | | | | | | 17.69 | 6,902.63 | 6,897.93 | 3.20 | 6,898.81 | 0.028369 | | |
| P-1 | SF5 | Circular | 416.75 | 0.2670 | 0.95 | 0.2536 | 0.4719 | 5.00 | 9.07 | 5.53 | 6,920.01 | 6,915.01 | 3.50 | 6,915.92 | 0.029203 | 4.40 | |
| | SF4 | 18 inch | | | | | | | | 18.01 | 6,907.46 | 6,902.76 | 3.20 | 6,903.90 | 0.029394 | | |
| P-4 | SG1 | Circular | 70.41 | 29.9400 | 0.35 | 10.4790 | 10.4790 | 28.86 | 4.45 | 47.00 | 6,895.60 | 6,890.27 | 2.33 | 6,892.50 | 0.024900 | 7.70 | |
| | SF2 | 36 inch | | | | | | | | 109.27 | 6,896.80 | 6,888.38 | 5.42 | 6,891.05 | 0.026843 | | |

# Scenario: Base

## DOT Report 2

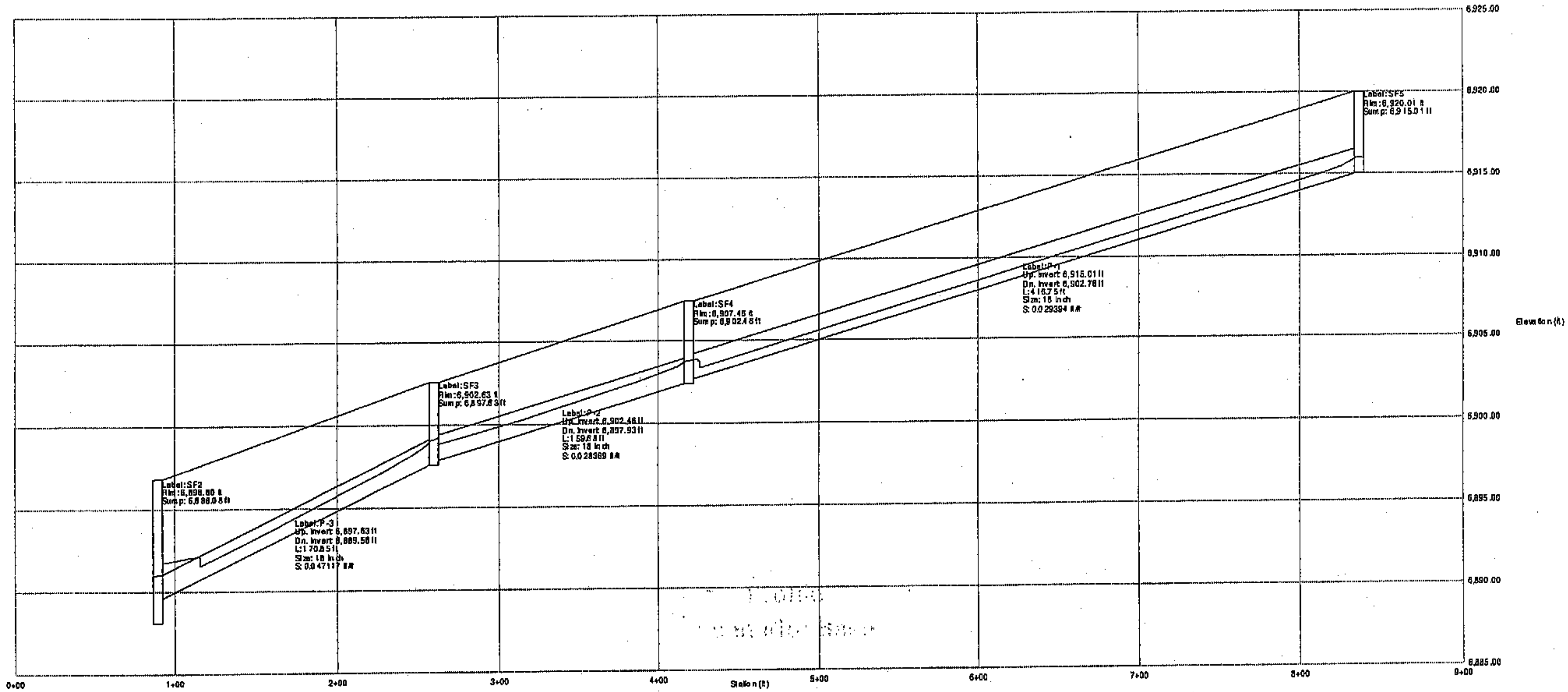
| Label | Rim Elevation (ft) | Sump Elevation (ft) | Area (acres) | Inlet C | Time of Concentration (min) | Local Rational Flow (cfs) | Carryover Rational Flow (cfs) | Curb Opening Length (ft) | Inlet | Inlet Location | Gutter Width (ft) | Gutter Cross Slope (ft/ft) | Clogging Factor (%) | Gutter Ditch Depth (ft) | Gutter Ditch Spread (ft) | Capture Efficiency (%) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF4 | 6,907.46 | 6,902.46 | 0.4100 | 0.95 | 5.00 | 2.00 | 0.08 | 5.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.25 | 3.12 | 71.6 | |
| SF5 | 6,920.01 | 6,915.01 | 0.2670 | 0.95 | 5.00 | 1.30 | 0.00 | 5.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.24 | 3.07 | 94.0 | |
| SF3 | 6,902.63 | 6,897.63 | 0.1600 | 0.95 | 5.00 | 0.78 | 0.59 | 5.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.21 | 2.54 | 78.9 | |
| SF2 | 6,896.80 | 6,888.08 | 0.2237 | 0.95 | 5.00 | 1.09 | 0.29 | 10.00 | Curb CDOT Type R | On Grad | 2.00 | 0.083 | 0.0 | 0.22 | 2.73 | 100.0 | |
| SG1 | 6,895.60 | 6,890.27 | 29.9400 | 0.35 | 28.86 | 26.40 | 0.00 | N/A | Generic Default 100% | In Sag | 0.00 | 0.020 | 0.0 | 0.00 | 0.00 | 100.0 | |

# Scenario: Base

## DOT Report

| Label | -Node- Upstream Downstream | -Section- Shape Size | Length (ft) | Upstream Calculated System CA (acres) | System Flow Time (min) | System Intensity (in/hr) | Section Discharge Capacity (cfs) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -Cover- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-5 | SF2 | Circular | 88.80 | 12.5393 | 29.01 | 4.43 | 57.24 | 6,896.80 | 6,888.08 | 5.72 | 6,890.95 | 0.006519 | 8.74 | |
| | SF1 | 36 inch | | | | | 46.95 | 6,887.64 | 6,887.64 | -3.00 | 6,890.09 | 0.004955 | | |
| P-3 | SF3 | Circular | 170.85 | 1.4955 | 6.88 | 8.40 | 13.89 | 6,902.63 | 6,897.63 | 3.50 | 6,899.01 | 0.042972 | 8.01 | |
| | SF2 | 18 inch | | | | | 22.80 | 6,896.80 | 6,889.58 | 5.72 | 6,891.74 | 0.047117 | | |
| P-2 | SF4 | Circular | 159.68 | 1.1295 | 6.58 | 8.51 | 11.58 | 6,907.46 | 6,902.46 | 3.50 | 6,903.76 | 0.024807 | 8.90 | |
| | SF3 | 18 inch | | | | | 17.69 | 6,902.63 | 6,897.93 | 3.20 | 6,898.81 | 0.028369 | | |
| P-1 | SF5 | Circular | 416.75 | 0.4719 | 5.00 | 9.07 | 5.53 | 6,920.01 | 6,915.01 | 3.50 | 6,915.92 | 0.029203 | 4.40 | |
| | SF4 | 18 inch | | | | | 18.01 | 6,907.46 | 6,902.76 | 3.20 | 6,903.90 | 0.029394 | | |
| P-4 | SG1 | Circular | 70.41 | 10.4790 | 28.86 | 4.45 | 47.00 | 6,895.60 | 6,890.27 | 2.33 | 6,892.50 | 0.024900 | 7.70 | |
| | SF2 | 36 inch | | | | | 109.27 | 6,896.80 | 6,888.38 | 5.42 | 6,891.05 | 0.026843 | | |

# Profile
## Scenario: Base

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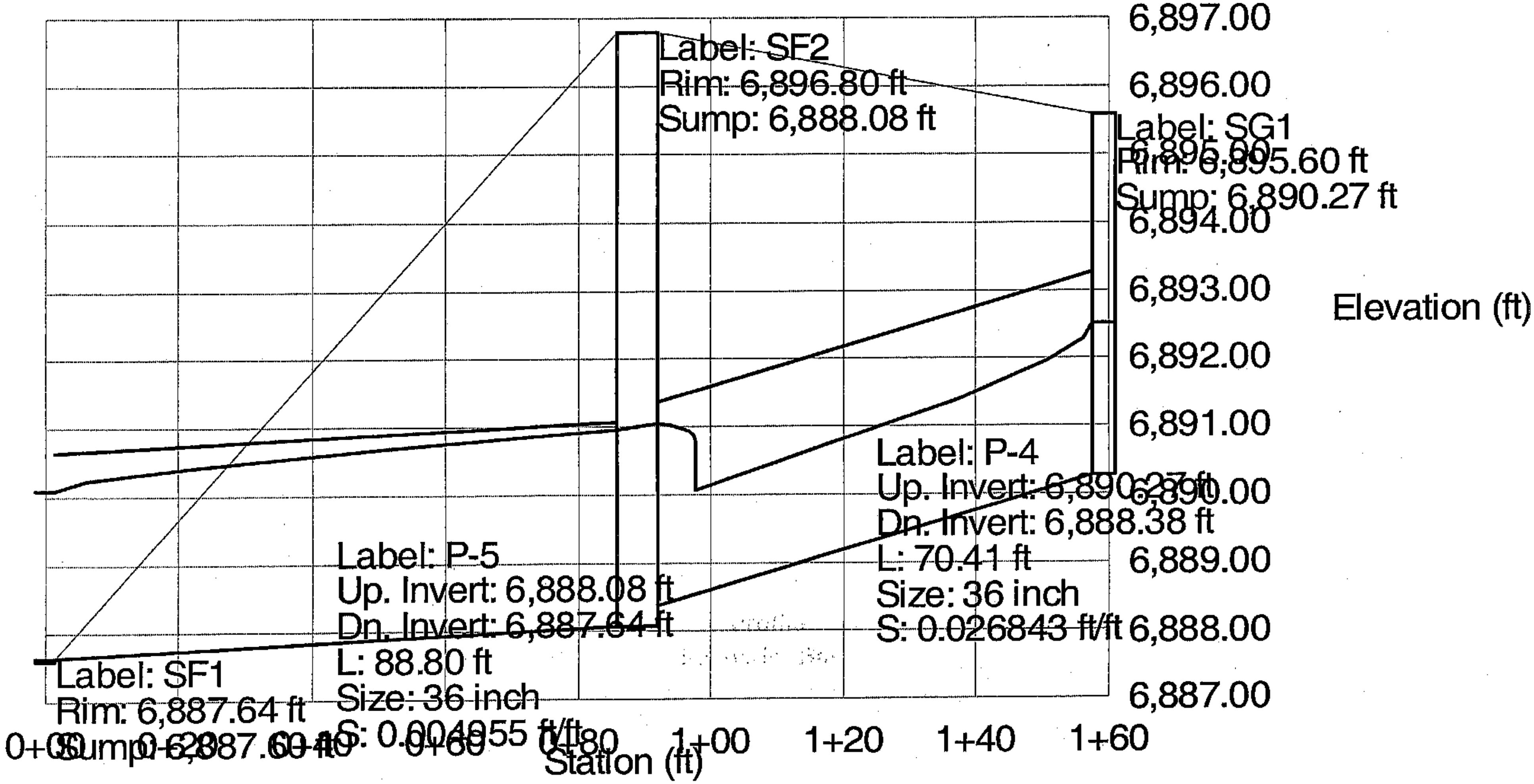
08/27/03 10:28:01 AM

URS Corporation

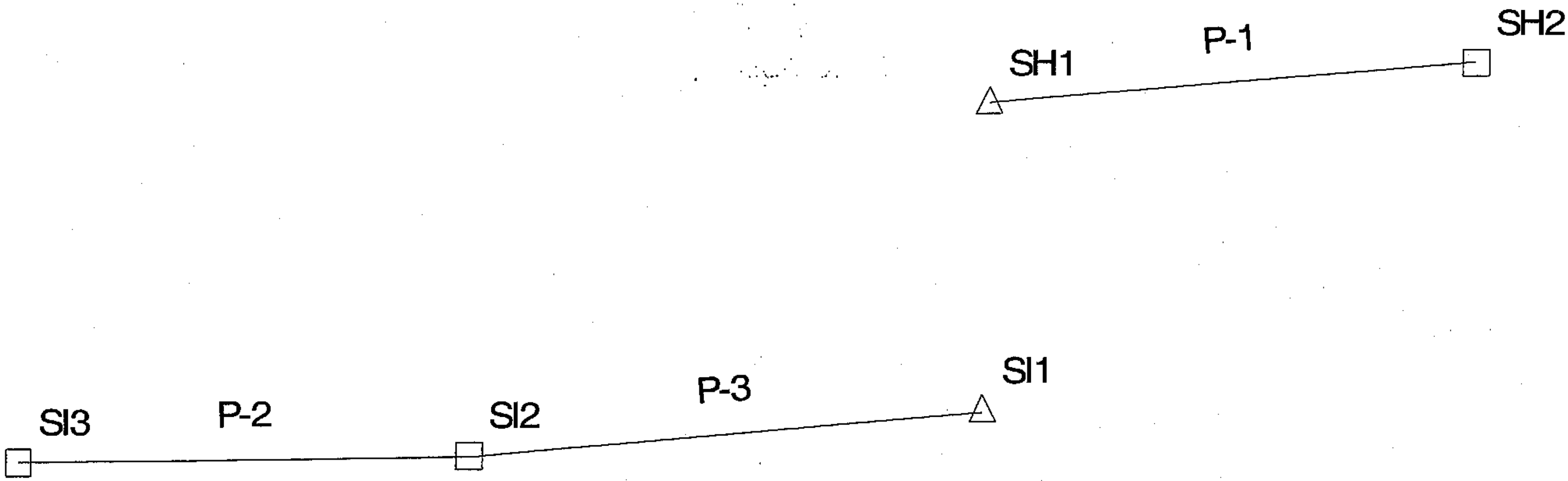


Project Engineer: R. Weaver
StormCAD v4.1.1 [4.2014]

**Profile**
**Scenario: Base**



**Scenario: Base**



# Scenario: Base

# DOT Report

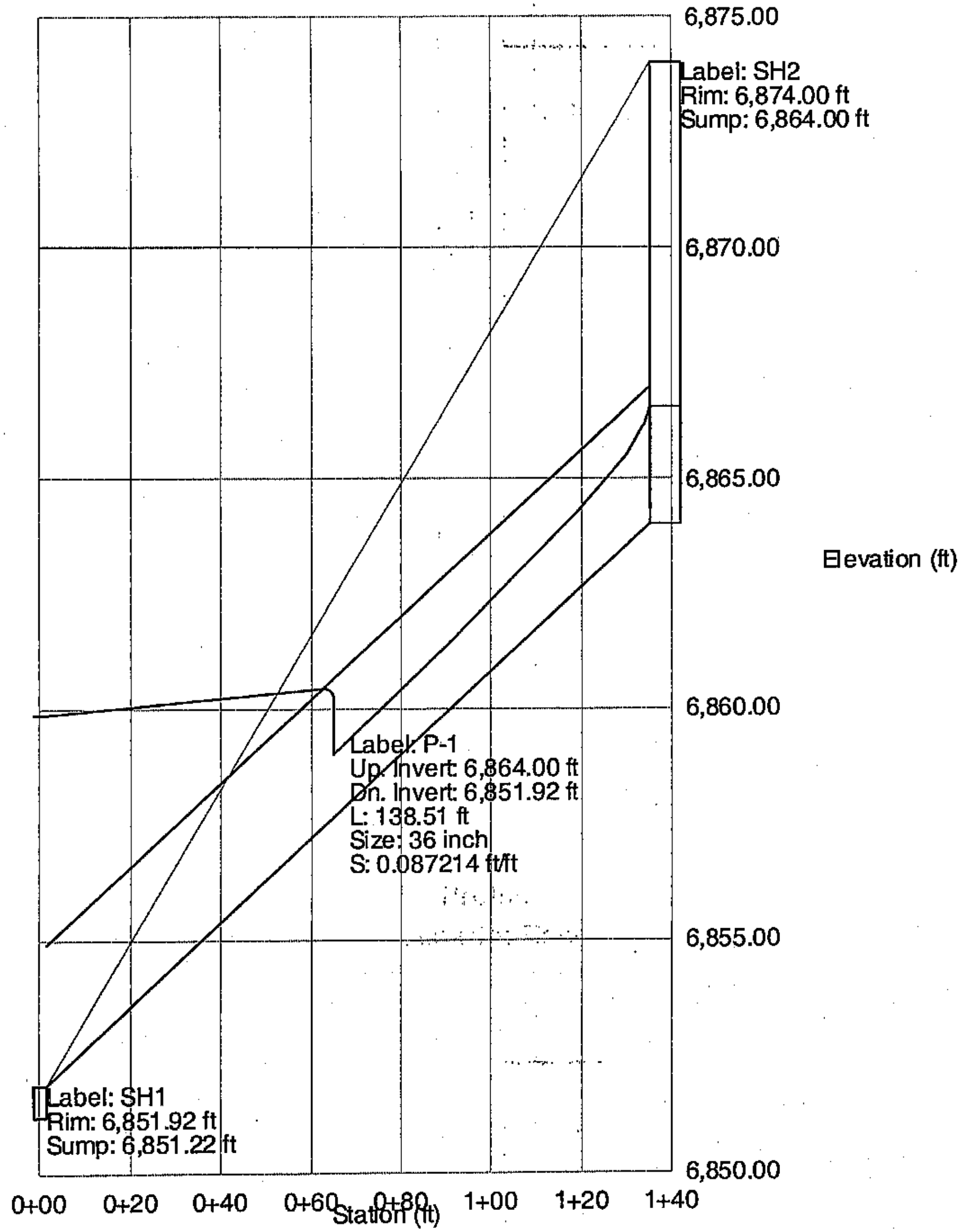
| Label | -Node- Upstream Downstream | -Section- Shape Size | Length (ft) | Upstream Calculated System CA (acres) | System Flow Time (min) | System Intensity (in/hr) | Section Discharge Capacity (cfs) | -Ground- Upstream Downstream (ft) | -Invert- Upstream Downstream (ft) | -Cover- Upstream Downstream (ft) | -HGL- Upstream Downstream (ft) | -Slope- Energy Constructed (ft/ft) | Average Velocity (ft/s) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1 | SH2 | Circular | 138.51 | 13.39 | 26.93 | 4.69 | 63.24 | 6,874.00 | 6,864.00 | 7.00 | 6,866.56 | 0.050117 | 9.40 | |
| | SH1 | 36 inch | | | | | 196.96 | 6,851.92 | 6,851.92 | -3.00 | 6,859.88 | 0.087214 | | |
| P-3 | SI2 | Circular | 143.18 | 20.87 | 23.00 | 5.17 | 108.72 | 6,882.17 | 6,870.49 | 7.68 | 6,873.64 | 0.065071 | 9.44 | |
| | SI1 | 48 inch | | | | | 442.68 | 6,856.89 | 6,856.89 | -4.00 | 6,864.79 | 0.094985 | | |
| P-2 | SI3 | Circular | 152.37 | 19.83 | 22.86 | 5.19 | 103.67 | 6,886.00 | 6,885.24 | -3.24 | 6,888.32 | 0.045277 | 18.15 | |
| | SI2 | 48 inch | | | | | 442.33 | 6,882.17 | 6,870.79 | 7.38 | 6,872.19 | 0.094835 | | |

# Scenario: Base

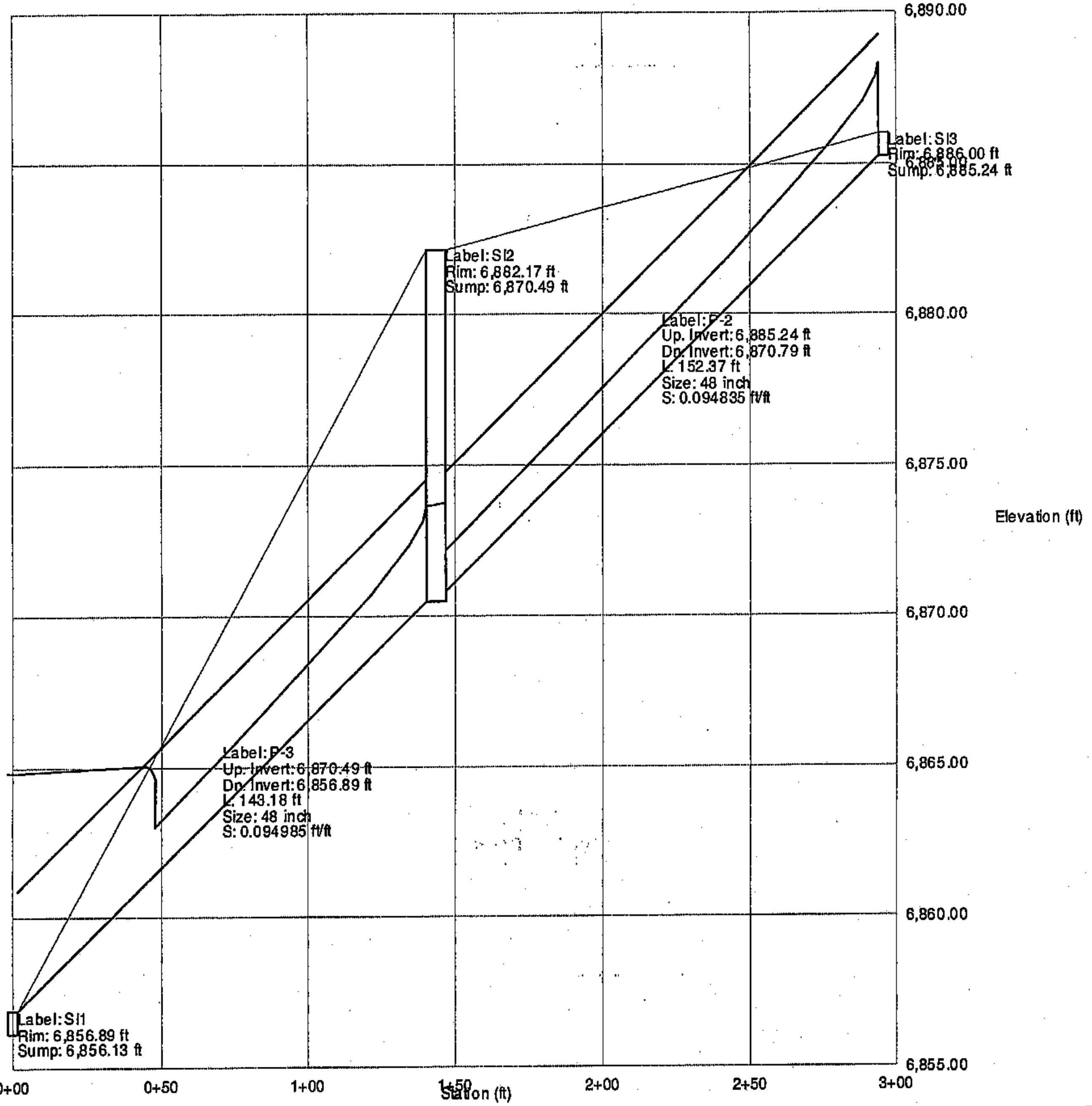
# DOT Report 2

| Label | Rim Elevation (ft) | Sump Elevation (ft) | Area (acres) | Inlet C | Time of Concentration (min) | Local Rational Flow (cfs) | Carryover Rational Flow (cfs) | Curb Opening Length (ft) | Inlet | Inlet Location | Gutter Width (ft) | Gutter Cross Slope (ft/ft) | Clogging Factor (%) | Gutter Ditch Depth (ft) | Gutter Ditch Spread (ft) | Capture Efficiency (%) | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SI3 | 6,886.00 | 6,885.24 | 52.19 | 0.38 | 22.86 | 103.67 | 0.00 | N/A | Generic Default 100% | In Sag | 2.00 | 0.083 | 0.0 | 0.00 | 0.00 | 100.0 | |
| SI2 | 6,882.17 | 6,870.49 | 1.99 | 0.52 | 7.49 | 8.54 | 0.00 | N/A | Grate CDOT Type D | In Sag | 0.00 | 0.020 | 30.0 | 0.41 | 20.64 | 100.0 | |
| SH2 | 6,874.00 | 6,864.00 | 36.18 | 0.37 | 26.93 | 63.24 | 0.00 | N/A | Grate CDOT Type D | In Sag | 0.00 | 0.020 | 30.0 | 1.57 | 78.44 | 100.0 | |

# Profile
## Scenario: Base



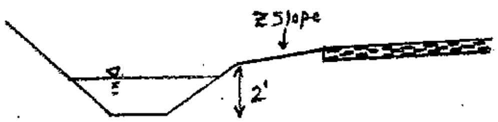
# Profile
## Scenario: Base



# Ditch Sizing - DRH-DP1.1
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DRH-DP1.1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| | Input Data | | |
|---|---|---|---|
| | Mannings Coefficient | 0.030 | |
| In. | Slope | 0.005000 | ft/ft |
| | Left Side Slope | 3.00 | H : V |
| | Right Side Slope | 4.00 | H : V |
| | Bottom Width | 4.00 | ft |
| 100 | Discharge | 46.98 | cfs → Basin A1 |




| Results | | |
|---|---|---|
| Depth | 1.51 | ft < 2' |
| Flow Area | 14.0 | ft² |
| Wetted Perimeter | 15.01 | ft |
| Top Width | 14.57 | ft |
| Critical Depth | 1.17 | ft |
| Critical Slope | 0.014805 | ft/ft |
| Velocity | 3.35 | ft/s |
| Velocity Head | 0.17 | ft |
| Specific Energy | 1.68 | ft |
| Froude Number | 0.60 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DLH-DP1.3
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DLH-DP1.3 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Min. Slope | 0.005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 17.54 | cfs → Basin A3 |

| Results | | |
|---|---|---|
| Depth | 0.94 | ft < 2' |
| Flow Area | 6.8 | ft² |
| Wetted Perimeter | 10.82 | ft |
| Top Width | 10.56 | ft |
| Critical Depth | 0.68 | ft |
| Critical Slope | 0.017036 | ft/ft |
| Velocity | 2.57 | ft/s |
| Velocity Head | 0.10 | ft |
| Specific Energy | 1.04 | ft |
| Froude Number | 0.56 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DRV-DP1.4
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DRV-DP1.4 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| | Input Data | | |
|---|---|---|---|
| | Mannings Coefficient | 0.030 | |
| Min. | Slope | 0.005000 | ft/ft |
| | Left Side Slope | 4.00 | H : V |
| | Right Side Slope | 3.00 | H : V |
| | Bottom Width | 4.00 | ft |
| 100 | Discharge | 74.66 | cfs → DP1.4 Basins A1, A2, A3, A4 |

| Results | | |
|---|---|---|
| Depth | 1.67 | ft < 2' |
| Flow Area | 19.8 | ft² |
| Wetted Perimeter | 17.64 | ft |
| Top Width | 17.11 | ft |
| Critical Depth | 1.48 | ft |
| Critical Slope | 0.013893 | ft/ft |
| Velocity | 3.78 | ft/s |
| Velocity Head | 0.22 | ft |
| Specific Energy | 2.09 | ft |
| Froude Number | 0.62 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DLH-DP1.6
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DLH-DP1.6 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Slope | 0.005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 12.97 | cfs → Basin A6 |

| Results | | |
|---|---|---|
| Depth | 0.80 | ft < 2' |
| Flow Area | 5.5 | ft² |
| Wetted Perimeter | 9.86 | ft |
| Top Width | 9.63 | ft |
| Critical Depth | 0.58 | ft |
| Critical Slope | 0.017819 | ft/ft |
| Velocity | 2.37 | ft/s |
| Velocity Head | 0.09 | ft |
| Specific Energy | 0.89 | ft |
| Froude Number | 0.55 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DRS-DP2.1
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DRS-DP2.1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Slope | 0.005000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 63.59 | cfs → Basin B1 |

| Results | | |
|---|---|---|
| Depth | 1.74 | ft < 2' |
| Flow Area | 17.5 | ft² |
| Wetted Perimeter | 16.67 | ft |
| Top Width | 16.18 | ft |
| Critical Depth | 1.36 | ft |
| Critical Slope | 0.014201 | ft/ft |
| Velocity | 3.62 | ft/s |
| Velocity Head | 0.20 | ft |
| Specific Energy | 1.94 | ft |
| Froude Number | 0.61 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DRH-DP2.2
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DRH-DP2.2 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Slope | 0.005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 40.62 | cfs → Basin B2 |

| Results | | |
|---|---|---|
| Depth | 1.41 | ft < 2' |
| Flow Area | 12.6 | ft² |
| Wetted Perimeter | 14.27 | ft |
| Top Width | 13.87 | ft |
| Critical Depth | 1.08 | ft |
| Critical Slope | 0.015108 | ft/ft |
| Velocity | 3.22 | ft/s |
| Velocity Head | 0.16 | ft |
| Specific Energy | 1.57 | ft |
| Froude Number | 0.60 | |
| Flow Type | Subcritical | |

# Ditch Sizing - DLH-DP4
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | DLH-DP4 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Slope | 0.005000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 67.37 | cfs → Basin D1 |

| Results | | |
|---|---|---|
| Depth | 1.79 | ft < 2' |
| Flow Area | 18.3 | ft² |
| Wetted Perimeter | 17.01 | ft |
| Top Width | 16.50 | ft |
| Critical Depth | 1.40 | ft |
| Critical Slope | 0.014089 | ft/ft |
| Velocity | 3.68 | ft/s |
| Velocity Head | 0.21 | ft |
| Specific Energy | 2.00 | ft |
| Froude Number | 0.62 | |
| Flow Type | Subcritical | |

# Channel Lining - DRH-DP1.1
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DRH-DP1.1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Max Slope | 0.030000 | ft/ft |
| Left Side Slope | 3.00 | H : V |
| Right Side Slope | 4.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 21.99 | cfs → Basin A1 |

| Results | | |
|---|---|---|
| Depth | 0.66 | ft |
| Flow Area | 4.2 | ft² |
| Wetted Perimeter | 8.84 | ft |
| Top Width | 8.65 | ft |
| Critical Depth | 0.78 | ft |
| Critical Slope | 0.016483 | ft/ft |
| Velocity | 5.23 | ft/s |
| Velocity Head | 0.42 | ft |
| Specific Energy | 1.09 | ft |
| Froude Number | 1.32 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^3)(4.2\ ft^2 / 8.84\ ft)(0.03\ ft/ft)$

$= 0.89\ lb/ft$

Class C Vegetation is sufficient

# Channel Lining - DLH-DP1.3
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DLH-DP1.3 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Max Slope | 0.030000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 10.16 | cfs → Basin A3 |

| Results | | |
|---|---|---|
| Depth | 0.44 | ft |
| Flow Area | 2.4 | ft² |
| Wetted Perimeter | 7.21 | ft |
| Top Width | 7.08 | ft |
| Critical Depth | 0.50 | ft |
| Critical Slope | 0.018495 | ft/ft |
| Velocity | 4.17 | ft/s |
| Velocity Head | 0.27 | ft |
| Specific Energy | 0.71 | ft |
| Froude Number | 1.25 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ \text{lb/ft}^2)(2.4\ \text{ft}^2 / 7.21\ \text{ft})(0.03\ \text{ft/ft})$

$= 0.62\ \text{lb/ft}$

Class C Vegetation is sufficient

# Channel Lining - DRV-DP1.4
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DRV-DP1.4 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Max. Slope | 0.057000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 37.14 | cfs |

→ DP1.4 Basins A1, A2, A3, A4

| Results | | |
|---|---|---|
| Depth | 0.74 | ft |
| Flow Area | 4.9 | ft² |
| Wetted Perimeter | 9.38 | ft |
| Top Width | 9.17 | ft |
| Critical Depth | 1.03 | ft |
| Critical Slope | 0.015298 | ft/ft |
| Velocity | 7.63 | ft/s |
| Velocity Head | 0.91 | ft |
| Specific Energy | 1.64 | ft |
| Froude Number | 1.85 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ \text{lb/ft}^3)(4.9\ \text{ft}^2 / 9.38\ \text{ft})(0.057\ \text{ft/ft})$

$= 1.86\ \text{lb/ft}^2$

Channel Lining is needed

# Channel Lining - DLH-DP1.6
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DLH-DP1.6 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Max Slope | 0.035000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| ?10 Discharge | 7.61 | cfs → Basin A6 |

| Results | | |
|---|---|---|
| Depth | 0.36 | ft |
| Flow Area | 1.9 | ft² |
| Wetted Perimeter | 6.62 | ft |
| Top Width | 6.52 | ft |
| Critical Depth | 0.42 | ft |
| Critical Slope | 0.019350 | ft/ft |
| Velocity | 4.02 | ft/s |
| Velocity Head | 0.25 | ft |
| Specific Energy | 0.61 | ft |
| Froude Number | 1.32 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^2)(1.9\ ft^2 / 6.62\ ft)(0.035\ ft/ft)$

$= 0.63\ lb/ft$

Class C Vegetation is sufficient

→ SEE DITCH CURL WORKSHEET FOR ADDITIONAL CHANNEL LINING CALCS IN BASIN A6

# Channel Lining - DLH-DP1.6 - ditch curl
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DLH-DP1.6 - ditch curl |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| max. Slope | 0.080000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| Discharge | 7.61 | cfs → Basin A 6 |

| Results | | |
|---|---|---|
| Depth | 0.29 | ft |
| Flow Area | 1.4 | ft² |
| Wetted Perimeter | 6.08 | ft |
| Top Width | 6.00 | ft |
| Critical Depth | 0.42 | ft |
| Critical Slope | 0.019350 | ft/ft |
| Velocity | 5.33 | ft/s |
| Velocity Head | 0.44 | ft |
| Specific Energy | 0.73 | ft |
| Froude Number | 1.93 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^3)(1.4\ ft^2 / 6.08\ ft)(0.08\ ft/ft)$

$= 1.15\ lb/ft$

Channel Lining is required

## Channel Lining - DRS-DP2.1
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DRS-DP2.1 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| | Input Data | | |
|---|---|---|---|
| | Mannings Coefficient | 0.030 | |
| max | Slope | 0.046500 | ft/ft |
| | Left Side Slope | 3.00 | H : V |
| | Right Side Slope | 4.00 | H : V |
| | Bottom Width | 4.00 | ft |
| $Q_{10}$ | Discharge | 30.86 | cfs → Basin B1 |

| Results | | |
|---|---|---|
| Depth | 0.71 | ft |
| Flow Area | 4.6 | ft² |
| Wetted Perimeter | 9.16 | ft |
| Top Width | 8.95 | ft |
| Critical Depth | 0.93 | ft |
| Critical Slope | 0.015702 | ft/ft |
| Velocity | 6.73 | ft/s |
| Velocity Head | 0.70 | ft |
| Specific Energy | 1.41 | ft |
| Froude Number | 1.66 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^2)(4.6\ ft^2 / 9.16\ ft)(0.0465\ ft/ft)$

$= 1.46\ lb/ft$

Channel Lining is needed

# Channel Lining - DRH-DP2.2
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DRH-DP2.2 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| | Input Data | | |
|---|---|---|---|
| | Mannings Coefficient | 0.030 | |
| Max | Slope | 0.035000 | ft/ft |
| | Left Side Slope | 4.00 | H : V |
| | Right Side Slope | 3.00 | H : V |
| | Bottom Width | 4.00 | ft |
| 110 | Discharge | 19.92 | cfs → Basin B2 |

| Results | | |
|---|---|---|
| Depth | 0.61 | ft |
| Flow Area | 3.7 | ft² |
| Wetted Perimeter | 8.42 | ft |
| Top Width | 8.24 | ft |
| Critical Depth | 0.74 | ft |
| Critical Slope | 0.016721 | ft/ft |
| Velocity | 5.37 | ft/s |
| Velocity Head | 0.45 | ft |
| Specific Energy | 1.05 | ft |
| Froude Number | 1.41 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^2)(3.7\ ft^2 / 8.42\ ft)(0.035\ ft/ft)$

$= 0.96\ lb/ft^2$

Class C Vegetation is sufficient

# Channel Lining - DLH-DP4
## Worksheet for Trapezoidal Channel

| Project Description | |
|---|---|
| Worksheet | 10yr DLH-DP4 |
| Flow Element | Trapezoidal Channel |
| Method | Manning's Formula |
| Solve For | Channel Depth |

| Input Data | | |
|---|---|---|
| Mannings Coefficient | 0.030 | |
| Max Slope | 0.100000 | ft/ft |
| Left Side Slope | 4.00 | H : V |
| Right Side Slope | 3.00 | H : V |
| Bottom Width | 4.00 | ft |
| $Q_{10}$ Discharge | 32.55 | cfs → Basin D1 |

| Results | | |
|---|---|---|
| Depth | 0.60 | ft |
| Flow Area | 3.6 | ft² |
| Wetted Perimeter | 8.34 | ft |
| Top Width | 8.17 | ft |
| Critical Depth | 0.96 | ft |
| Critical Slope | 0.015585 | ft/ft |
| Velocity | 8.99 | ft/s |
| Velocity Head | 1.25 | ft |
| Specific Energy | 1.85 | ft |
| Froude Number | 2.38 | |
| Flow Type | Supercritical | |

$\tau = \gamma R S$

$= (62.4\ lb/ft^2)(3.6\ ft^2 / 8.34\ ft)(0.10\ ft/ft)$

$= 2.69\ lb/ft$

Channel Lining is needed

# URS

Page ____ of ____

Job SH83 & Shoup Road | Project No. 21710831 | Sheet ____ of ____

Description Hydraulics | Computed by RGW | Date 03/20/03

Freeboard for sharp bend | Checked by ____ | Date ____

Reference

From City/County Drainage Criteria Manual

10-15 :

$$\text{additional } H = \frac{CV^2W}{gR}$$

C = 1.0 (supercritical)
V = average velocity (fps)
W = width at level water surface
g = 32.2 ft/sec²
R = centerline radius

$$H = \frac{1.0\,(4.02)^2(6.52)}{32.2\,(25)} = 0.13'$$

Depth in 10-yr storm = 0.36'
(FlowMaster 10yr DLH-DP1.6 Worksheet)

0.36' + 0.13' = 0.49'
0.49' will not fill the 2' deep ditch so 1' of freeboard will be provided

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## Appendix H: Hydraulics - Culvert Design for Black Squirrel Creek Basin

# Culvert Calculator Report
## STR. 703 (100-year)

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,881.41 ft | Headwater Depth/Height | 1.35 |
| Computed Headwater Elev¿ | 6,880.35 ft | Discharge | 74.66 cfs |
| Inlet Control HW Elev. | 6,880.35 ft | Tailwater Elevation | 6,877.31 ft |
| Outlet Control HW Elev. | 6,880.31 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,875.62 ft | Downstream Invert | 6,875.22 ft |
| Length | 79.70 ft | Constructed Slope | 0.005019 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | M2 | Depth, Downstream | 2.71 ft |
| Slope Type | Mild | Normal Depth | 3.05 ft |
| Flow Regime | Subcritical | Critical Depth | 2.71 ft |
| Velocity Downstream | 9.36 ft/s | Critical Slope | 0.006189 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.50 ft |
| Section Size | 42 inch | Rise | 3.50 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,880.31 ft | Upstream Velocity Head | 1.16 ft |
| Ke | 0.50 | Entrance Loss | 0.58 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,880.35 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 9.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
# STR. 708 (100-year)

Solve For: Headwater Elevation

**Culvert Summary**

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,889.29 ft | Headwater Depth/Height | 1.35 |
| Computed Headwater Eleva | 6,888.23 ft | Discharge | 74.66 cfs |
| Inlet Control HW Elev. | 6,888.23 ft | Tailwater Elevation | 6,885.21 ft |
| Outlet Control HW Elev. | 6,888.19 ft | Control Type | Inlet Control |

**Grades**

| | | | |
|---|---|---|---|
| Upstream Invert | 6,883.50 ft | Downstream Invert | 6,883.12 ft |
| Length | 75.88 ft | Constructed Slope | 0.005008 ft/ft |

**Hydraulic Profile**

| | | | |
|---|---|---|---|
| Profile | M2 | Depth, Downstream | 2.71 ft |
| Slope Type | Mild | Normal Depth | 3.05 ft |
| Flow Regime | Subcritical | Critical Depth | 2.71 ft |
| Velocity Downstream | 9.36 ft/s | Critical Slope | 0.006189 ft/ft |

**Section**

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 3.50 ft |
| Section Size | 42 inch | Rise | 3.50 ft |
| Number Sections | 1 | | |

**Outlet Control Properties**

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,888.19 ft | Upstream Velocity Head | 1.16 ft |
| Ke | 0.50 | Entrance Loss | 0.58 ft |

**Inlet Control Properties**

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,888.23 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 9.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

# Culvert Calculator Report
## SI3 (100-year)

Solve For: Headwater Elevation

### Culvert Summary

| | | | |
|---|---|---|---|
| Allowable HW Elevation | 6,893.69 ft | Headwater Depth/Height | 1.33 |
| Computed Headwater Elev: | 6,890.56 ft | Discharge | 101.29 cfs |
| Inlet Control HW Elev. | 6,890.47 ft | Tailwater Elevation | 6,883.50 ft |
| Outlet Control HW Elev. | 6,890.56 ft | Control Type | Entrance Control |

### Grades

| | | | |
|---|---|---|---|
| Upstream Invert | 6,885.25 ft | Downstream Invert | 6,881.50 ft |
| Length | 160.00 ft | Constructed Slope | 0.023438 ft/ft |

### Hydraulic Profile

| | | | |
|---|---|---|---|
| Profile | S2 | Depth, Downstream | 2.02 ft |
| Slope Type | Steep | Normal Depth | 1.91 ft |
| Flow Regime | Supercritical | Critical Depth | 3.05 ft |
| Velocity Downstream | 15.96 ft/s | Critical Slope | 0.005762 ft/ft |

### Section

| | | | |
|---|---|---|---|
| Section Shape | Circular | Mannings Coefficient | 0.013 |
| Section Material | Concrete | Span | 4.00 ft |
| Section Size | 48 inch | Rise | 4.00 ft |
| Number Sections | 1 | | |

### Outlet Control Properties

| | | | |
|---|---|---|---|
| Outlet Control HW Elev. | 6,890.56 ft | Upstream Velocity Head | 1.51 ft |
| Ke | 0.50 | Entrance Loss | 0.75 ft |

### Inlet Control Properties

| | | | |
|---|---|---|---|
| Inlet Control HW Elev. | 6,890.47 ft | Flow Control | N/A |
| Inlet Type | Square edge w/headwall | Area Full | 12.6 ft² |
| K | 0.00980 | HDS 5 Chart | 1 |
| M | 2.00000 | HDS 5 Scale | 1 |
| C | 0.03980 | Equation Form | 1 |
| Y | 0.67000 | | |

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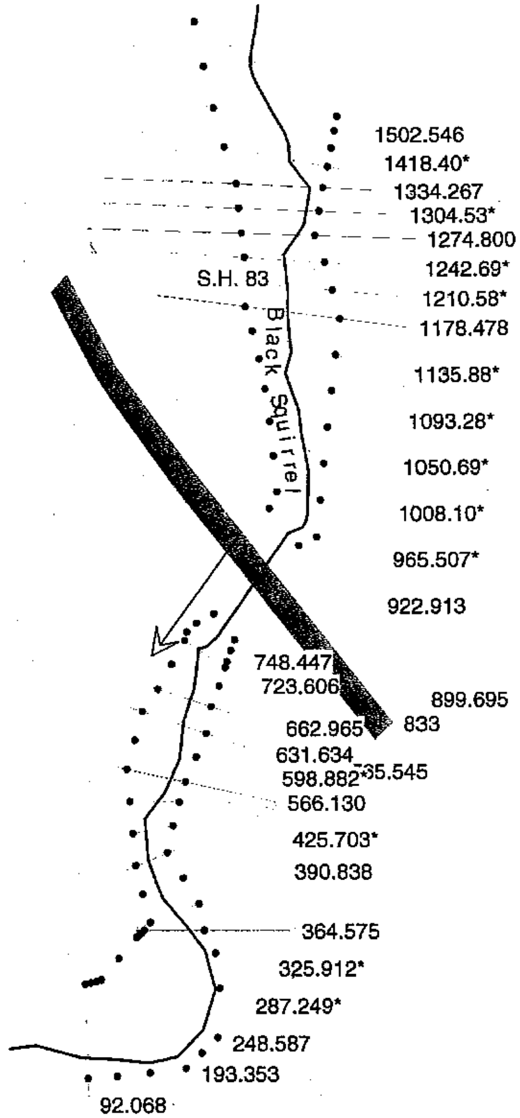
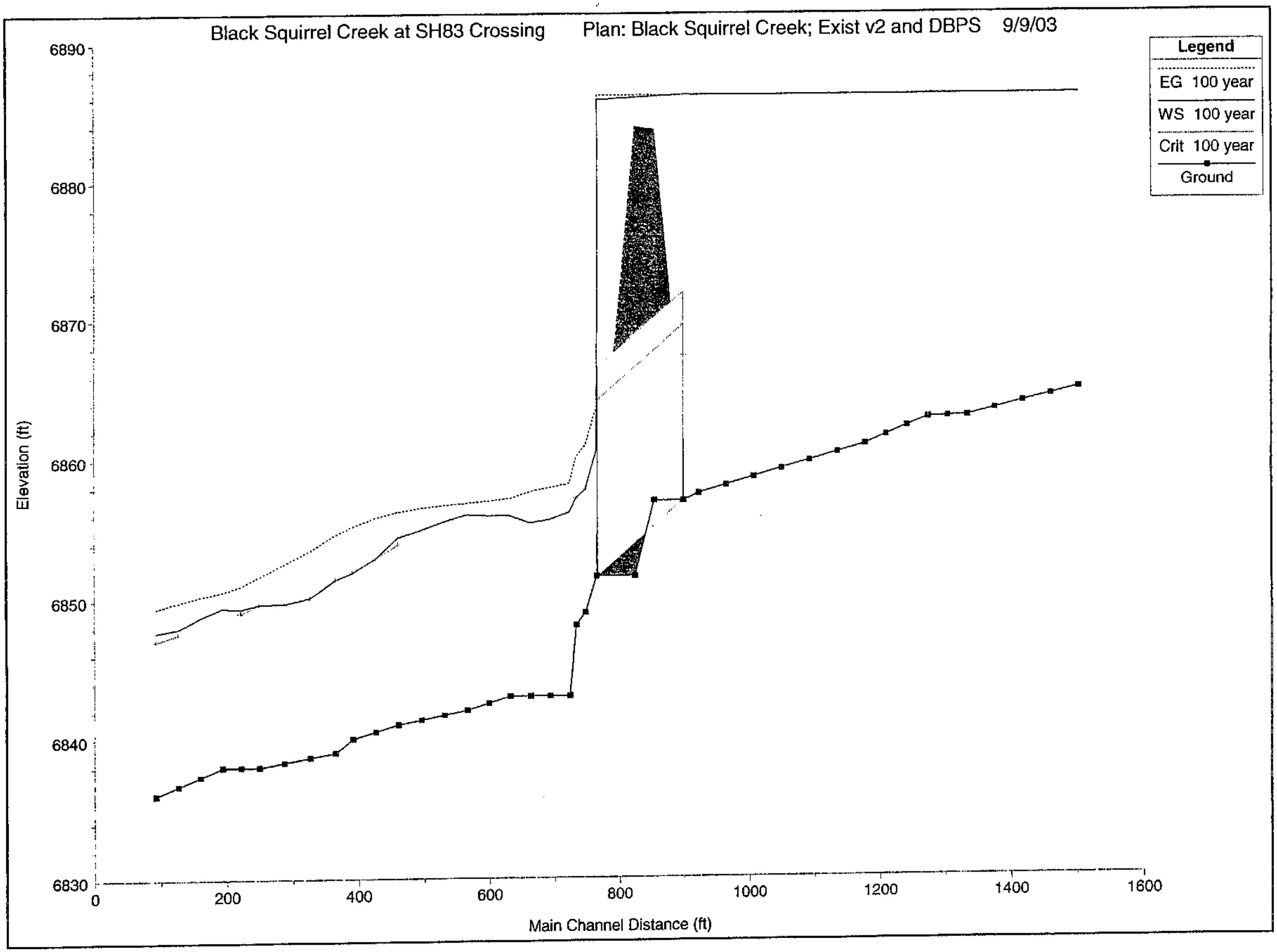
## Appendix I: Hydraulics – Channel Improvements for Black Squirrel Creek


1502.546
1418.40*
1334.267
1304.53*
1274.800
1242.69*
S.H. 83
1210.58*
1178.478
Black Squirrel
1135.88*
1093.28*
1050.69*
1008.10*
965.507*
922.913
748.447
723.606
899.695
833
662.965
631.634
598.882*
35.545
566.130
425.703*
390.838
364.575
325.912*
287.249*
248.587
193.353
92.068

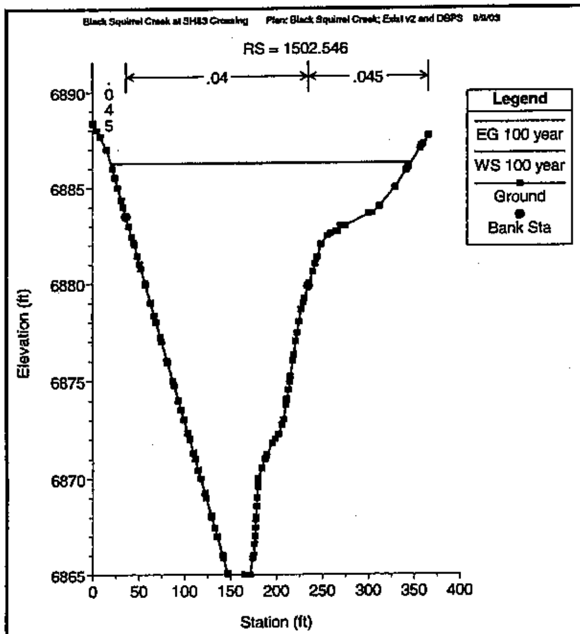

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Elevation (ft)
Main Channel Distance (ft)
6890
6880
6870
6860
6850
6840
6830
0
200
400
600
800
1000
1200
1400
1600

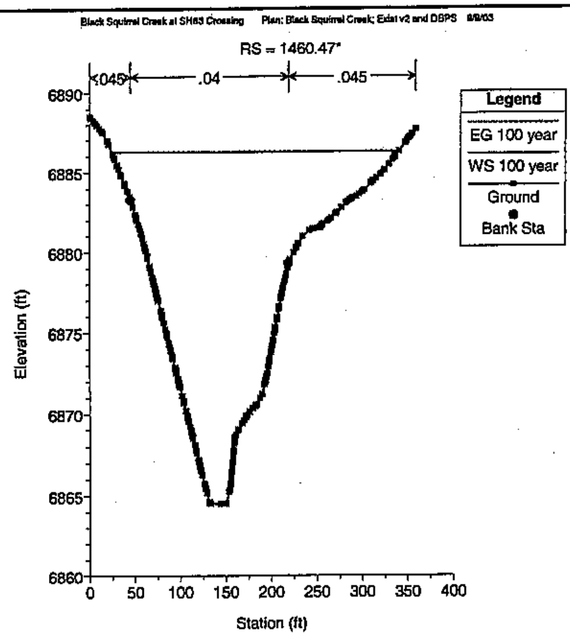
HEC-RAS Plan: EXISTING 2 River: Black Squirrel Reach: S.H. 83 Profile: 100 year

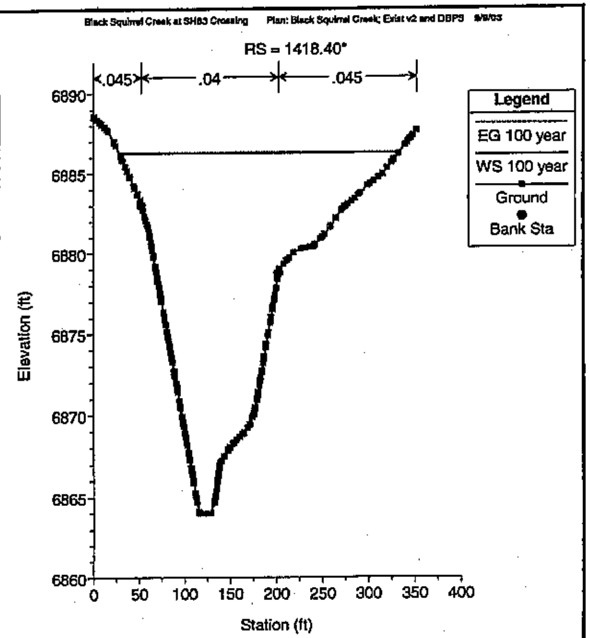
| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.H. 83 | 1502.546 | 100 year | 4400.00 | 6865.00 | 6886.27 | | 6886.31 | 0.000058 | 1.58 | 3017.58 | 327.04 | 0.08 |
| S.H. 83 | 1460.47 | 100 year | 4400.00 | 6864.50 | 6886.26 | | 6886.30 | 0.000062 | 1.69 | 2898.48 | 315.80 | 0.08 |
| S.H. 83 | 1418.40 | 100 year | 4400.00 | 6864.00 | 6886.25 | | 6886.30 | 0.000066 | 1.80 | 2792.42 | 304.72 | 0.08 |
| S.H. 83 | 1376.33 | 100 year | 4400.00 | 6863.50 | 6886.24 | | 6886.30 | 0.000070 | 1.93 | 2699.23 | 293.54 | 0.08 |
| S.H. 83 | 1334.267 | 100 year | 4400.00 | 6863.00 | 6886.23 | | 6886.29 | 0.000075 | 2.06 | 2619.42 | 282.49 | 0.09 |
| S.H. 83 | 1304.59 | 100 year | 4400.00 | 6862.96 | 6886.24 | | 6886.29 | 0.000064 | 1.97 | 2981.57 | 335.90 | 0.08 |
| S.H. 83 | 1274.800 | 100 year | 4400.00 | 6862.91 | 6886.25 | | 6886.28 | 0.000045 | 1.71 | 3591.58 | 360.52 | 0.07 |
| S.H. 83 | 1242.691 | 100 year | 4400.00 | 6862.27 | 6886.24 | | 6886.28 | 0.000050 | 1.77 | 3404.90 | 364.82 | 0.07 |
| S.H. 83 | 1210.58 | 100 year | 4400.00 | 6861.64 | 6886.24 | | 6886.28 | 0.000054 | 1.78 | 3250.66 | 368.70 | 0.07 |
| S.H. 83 | 1178.478 | 100 year | 4400.00 | 6861.00 | 6886.24 | | 6886.28 | 0.000056 | 1.73 | 3205.72 | 329.57 | 0.07 |
| S.H. 83 | 1135.86 | 100 year | 4400.00 | 6860.42 | 6886.24 | | 6886.27 | 0.000045 | 1.63 | 3531.31 | 361.22 | 0.07 |
| S.H. 83 | 1093.28 | 100 year | 4400.00 | 6859.83 | 6886.24 | | 6886.27 | 0.000037 | 1.54 | 3872.90 | 390.93 | 0.06 |
| S.H. 83 | 1050.69 | 100 year | 4400.00 | 6859.25 | 6886.24 | | 6886.27 | 0.000031 | 1.46 | 4231.84 | 422.58 | 0.06 |
| S.H. 83 | 1008.16 | 100 year | 4400.00 | 6858.67 | 6886.24 | | 6886.26 | 0.000026 | 1.39 | 4607.23 | 452.81 | 0.05 |
| S.H. 83 | 965.207 | 100 year | 4400.00 | 6858.08 | 6886.24 | | 6886.26 | 0.000022 | 1.32 | 4998.71 | 481.91 | 0.05 |
| S.H. 83 | 922.919 | 100 year | 4400.00 | 6857.50 | 6886.25 | | 6886.26 | 0.000019 | 1.26 | 5402.97 | 507.74 | 0.05 |
| S.H. 83 | 899.899 | 100 year | 4400.00 | 6857.00 | 6886.25 | 6867.45 | 6886.26 | 0.000018 | 1.19 | 6104.07 | 608.20 | 0.04 |
| S.H. 83 | 833.2 | [illegible] | Culvert | | | | | | | | | |
| S.H. 83 | 765.546 | 100 year | 4400.00 | 6851.60 | 6860.67 | 6860.67 | 6863.82 | 0.012499 | 14.64 | 323.30 | 54.93 | 0.96 |
| S.H. 83 | 748.447 | 100 year | 4400.00 | 6849.00 | 6857.82 | 6857.82 | 6861.01 | 0.013052 | 14.43 | 313.50 | 51.74 | 0.97 |
| S.H. 83 | 733.959 | 100 year | 4400.00 | 6848.12 | 6857.21 | 6857.21 | 6860.18 | 0.012791 | 13.95 | 327.36 | 59.00 | 0.96 |
| S.H. 83 | 723.606 | 100 year | 4400.00 | 6843.00 | 6856.17 | | 6858.24 | 0.007879 | 11.58 | 389.05 | 62.27 | 0.74 |
| S.H. 83 | 693.285 | 100 year | 4400.00 | 6843.00 | 6855.67 | | 6857.96 | 0.008785 | 12.16 | 364.37 | 56.27 | 0.79 |
| S.H. 83 | 662.965 | 100 year | 4400.00 | 6843.00 | 6855.43 | | 6857.69 | 0.008596 | 12.08 | 364.61 | 49.50 | 0.78 |
| S.H. 83 | 631.634 | 100 year | 4400.00 | 6843.00 | 6855.97 | | 6857.21 | 0.003899 | 8.99 | 506.06 | 80.69 | 0.55 |
| S.H. 83 | 598.882 | 100 year | 4400.00 | 6842.50 | 6855.86 | | 6857.04 | 0.003319 | 8.51 | 558.09 | 89.77 | 0.51 |
| S.H. 83 | 566.130 | 100 year | 4400.00 | 6842.00 | 6856.05 | | 6856.87 | 0.002440 | 7.59 | 648.16 | 97.17 | 0.44 |
| S.H. 83 | 530.943 | 100 year | 4400.00 | 6841.67 | 6855.58 | | 6856.74 | 0.003787 | 9.11 | 556.72 | 93.42 | 0.53 |
| S.H. 83 | 495.756 | 100 year | 4400.00 | 6841.33 | 6854.96 | | 6856.54 | 0.005597 | 10.73 | 487.49 | 90.99 | 0.63 |
| S.H. 83 | 460.569 | 100 year | 4400.00 | 6841.00 | 6854.44 | 6853.93 | 6856.29 | 0.007059 | 11.78 | 456.79 | 91.26 | 0.67 |
| S.H. 83 | 425.703 | 100 year | 4400.00 | 6840.50 | 6852.93 | 6852.93 | 6855.88 | 0.011428 | 14.05 | 344.09 | 71.72 | 0.86 |
| S.H. 83 | 390.838 | 100 year | 4400.00 | 6840.00 | 6851.94 | 6851.94 | 6855.23 | 0.014017 | 14.61 | 308.96 | 55.18 | 0.95 |
| S.H. 83 | 364.575 | 100 year | 4400.00 | 6839.00 | 6851.44 | 6851.44 | 6854.64 | 0.012660 | 14.44 | 317.48 | 64.90 | 0.91 |
| S.H. 83 | 325.912 | 100 year | 4400.00 | 6838.67 | 6850.15 | 6850.15 | 6853.51 | 0.015190 | 14.72 | 298.94 | 44.99 | 1.01 |
| S.H. 83 | 287.249 | 100 year | 4400.00 | 6838.33 | 6849.72 | 6849.72 | 6852.60 | 0.015331 | 13.63 | 322.72 | 56.38 | 1.00 |
| S.H. 83 | 248.587 | 100 year | 4400.00 | 6838.00 | 6849.68 | 6849.68 | 6851.68 | 0.016871 | 11.35 | 387.83 | 99.93 | 1.01 |
| S.H. 83 | 220.9 | 100 year | 4400.00 | 6838.00 | 6849.37 | 6849.08 | 6851.04 | 0.013106 | 10.38 | 423.94 | 104.67 | 0.91 |
| S.H. 83 | 193.353 | 100 year | 4400.00 | 6838.00 | 6849.45 | | 6850.61 | 0.007804 | 8.61 | 511.01 | 112.89 | 0.71 |
| S.H. 83 | 159.591 | 100 year | 4400.00 | 6837.33 | 6848.79 | | 6850.28 | 0.009618 | 9.79 | 449.50 | 95.57 | 0.80 |
| S.H. 83 | 125.829 | 100 year | 4400.00 | 6836.67 | 6847.95 | 6847.57 | 6849.87 | 0.012384 | 11.10 | 396.27 | 84.47 | 0.90 |
| S.H. 83 | 92.069 | 100 year | 4400.00 | 6836.00 | 6847.70 | 6847.05 | 6849.44 | 0.010010 | 10.59 | 423.49 | 99.89 | 0.83 |

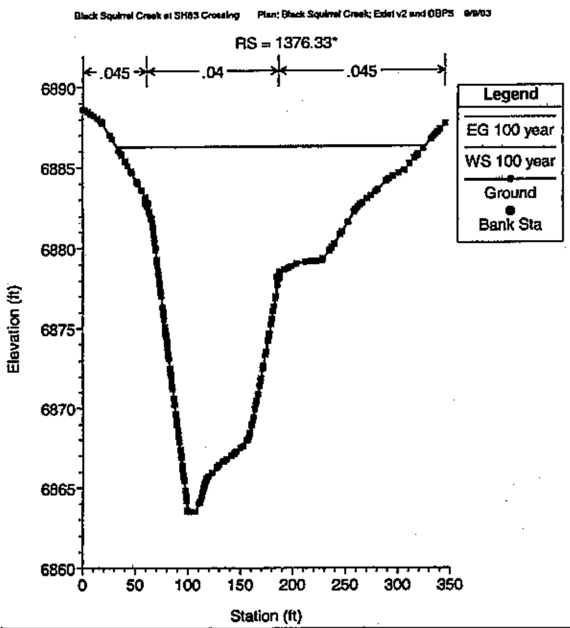
HEC-RAS Plan: EXISTING 2 River: Black Squirrel Reach: S.H. 83 Profile: 100 year

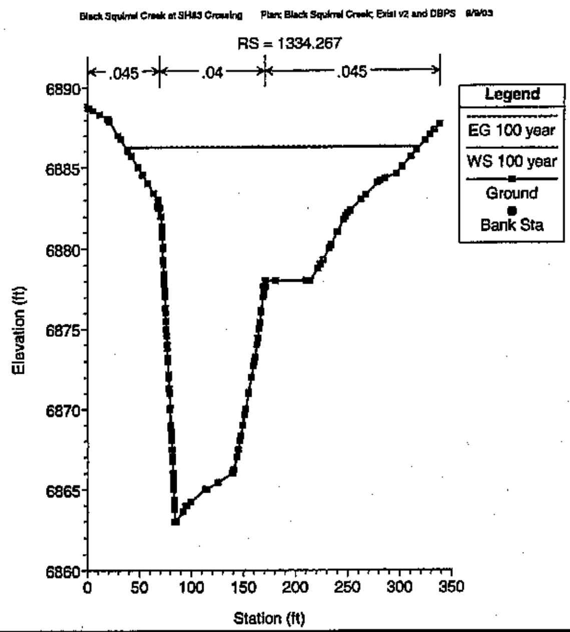
| Reach | River Sta | Profile | E.G. Elev (ft) | W.S. Elev (ft) | Vel Head (ft) | Frctn Loss (ft) | C & E Loss (ft) | Q Left (cfs) | Q Channel (cfs) | Q Right (cfs) | Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S.H. 83 | 1502.546 | 100 year | 6886.31 | 6886.27 | 0.04 | 0.00 | 0.00 | 7.18 | 4233.65 | 159.17 | 327.04 |
| S.H. 83 | 1460.47* | 100 year | 6886.30 | 6886.26 | 0.04 | 0.00 | 0.00 | 10.07 | 4153.00 | 236.93 | 315.80 |
| S.H. 83 | 1418.40* | 100 year | 6886.30 | 6886.25 | 0.05 | 0.00 | 0.00 | 13.47 | 4052.44 | 334.09 | 304.72 |
| S.H. 83 | 1376.335 | 100 year | 6886.30 | 6886.24 | 0.05 | 0.00 | 0.00 | 17.44 | 3930.52 | 452.04 | 293.54 |
| S.H. 83 | 1334.267 | 100 year | 6886.29 | 6886.23 | 0.06 | 0.00 | 0.00 | 22.29 | 3778.50 | 599.21 | 282.49 |
| S.H. 83 | 1304.53* | 100 year | 6886.29 | 6886.24 | 0.05 | 0.00 | 0.00 | 246.98 | 3413.74 | 739.28 | 335.90 |
| S.H. 83 | 1274.800 | 100 year | 6886.28 | 6886.25 | 0.03 | 0.00 | 0.00 | 769.65 | 2825.38 | 804.97 | 360.52 |
| S.H. 83 | 1242.69* | 100 year | 6886.28 | 6886.24 | 0.04 | 0.00 | 0.00 | 346.19 | 3124.44 | 929.37 | 364.82 |
| S.H. 83 | 1210.58* | 100 year | 6886.28 | 6886.24 | 0.04 | 0.00 | 0.00 | 79.33 | 3266.19 | 1054.48 | 368.70 |
| S.H. 83 | 1178.478 | 100 year | 6886.28 | 6886.24 | 0.04 | 0.00 | 0.00 | 5.88 | 3225.17 | 1168.95 | 329.57 |
| S.H. 83 | 1135.88* | 100 year | 6886.27 | 6886.24 | 0.03 | 0.00 | 0.00 | 19.45 | 3063.63 | 1316.92 | 361.22 |
| S.H. 83 | 1093.28* | 100 year | 6886.27 | 6886.24 | 0.03 | 0.00 | 0.00 | 39.95 | 2893.21 | 1466.84 | 390.93 |
| S.H. 83 | 1050.69* | 100 year | 6886.27 | 6886.24 | 0.02 | 0.00 | 0.00 | 65.62 | 2714.55 | 1619.83 | 422.58 |
| S.H. 83 | 1008.10* | 100 year | 6886.26 | 6886.24 | 0.02 | 0.00 | 0.00 | 98.09 | 2526.87 | 1775.04 | 452.81 |
| S.H. 83 | 965.507* | 100 year | 6886.26 | 6886.24 | 0.02 | 0.00 | 0.00 | 136.37 | 2329.15 | 1934.47 | 481.91 |
| S.H. 83 | 922.913 | 100 year | 6886.26 | 6886.25 | 0.01 | 0.00 | 0.00 | 182.14 | 2119.99 | 2097.87 | 507.74 |
| S.H. 83 | 899.695 | 100 year | 6886.26 | 6886.25 | 0.01 | | | 744.47 | 1615.15 | 2040.38 | 608.20 |
| S.H. 83 | 839 | | Culvert | | | | | | | | |
| S.H. 83 | 765.545 | 100 year | 6863.82 | 6860.67 | 3.15 | 0.22 | 0.00 | 318.75 | 4080.41 | 0.84 | 54.93 |
| S.H. 83 | 748.447 | 100 year | 6861.01 | 6857.82 | 3.19 | 0.19 | 0.07 | 67.60 | 4332.41 | | 51.74 |
| S.H. 83 | 733.939 | 100 year | 6860.18 | 6857.21 | 2.97 | 0.10 | 0.27 | 88.83 | 4311.17 | | 59.00 |
| S.H. 83 | 723.606 | 100 year | 6858.24 | 6856.17 | 2.07 | 0.25 | 0.02 | 32.10 | 4367.90 | | 62.27 |
| S.H. 83 | 693.285* | 100 year | 6857.96 | 6855.67 | 2.29 | 0.26 | 0.01 | 4.93 | 4395.07 | | 56.27 |
| S.H. 83 | 662.965 | 100 year | 6857.69 | 6855.43 | 2.26 | 0.17 | 0.31 | 0.39 | 4399.61 | | 49.50 |
| S.H. 83 | 631.634 | 100 year | 6857.21 | 6855.97 | 1.24 | 0.12 | 0.05 | 41.54 | 4358.46 | | 80.69 |
| S.H. 83 | 598.882* | 100 year | 6857.04 | 6855.96 | 1.08 | 0.09 | 0.08 | 179.18 | 4220.82 | | 89.77 |
| S.H. 83 | 566.130 | 100 year | 6856.87 | 6856.05 | 0.83 | 0.10 | 0.03 | 408.98 | 3991.02 | | 97.17 |
| S.H. 83 | 530.943* | 100 year | 6856.74 | 6855.58 | 1.16 | 0.16 | 0.04 | 543.72 | 3856.29 | | 93.42 |
| S.H. 83 | 495.756* | 100 year | 6856.54 | 6854.96 | 1.58 | 0.21 | 0.03 | 647.77 | 3752.23 | | 90.99 |
| S.H. 83 | 460.569 | 100 year | 6856.29 | 6854.44 | 1.86 | 0.31 | 0.11 | 743.94 | 3656.06 | | 91.26 |
| S.H. 83 | 425.703* | 100 year | 6855.88 | 6852.93 | 2.95 | 0.44 | 0.03 | 175.11 | 4224.89 | | 71.72 |
| S.H. 83 | 390.838 | 100 year | 6855.23 | 6851.94 | 3.29 | 0.35 | 0.03 | 30.21 | 4369.79 | | 55.18 |
| S.H. 83 | 364.575 | 100 year | 6854.64 | 6851.44 | 3.21 | 0.54 | 0.02 | 41.62 | 4358.38 | | 64.90 |
| S.H. 83 | 325.912* | 100 year | 6853.51 | 6850.15 | 3.36 | 0.59 | 0.14 | | 4400.00 | | 44.99 |
| S.H. 83 | 287.249* | 100 year | 6852.60 | 6849.72 | 2.89 | 0.62 | 0.27 | | 4400.00 | | 56.38 |
| S.H. 83 | 248.587 | 100 year | 6851.68 | 6849.68 | 2.00 | 0.41 | 0.10 | | 4400.00 | | 99.93 |
| S.H. 83 | 220.97* | 100 year | 6851.04 | 6849.37 | 1.67 | 0.27 | 0.16 | | 4400.00 | | 104.67 |
| S.H. 83 | 193.353 | 100 year | 6850.61 | 6849.45 | 1.15 | 0.29 | 0.03 | | 4400.00 | | 112.89 |
| S.H. 83 | 159.591* | 100 year | 6850.28 | 6848.79 | 1.49 | 0.37 | 0.04 | | 4400.00 | | 95.57 |
| S.H. 83 | 125.829* | 100 year | 6849.87 | 6847.95 | 1.91 | 0.37 | 0.05 | | 4400.00 | | 84.47 |
| S.H. 83 | 92.068 | 100 year | 6849.44 | 6847.70 | 1.73 | | | 22.37 | 4377.63 | | 99.89 |

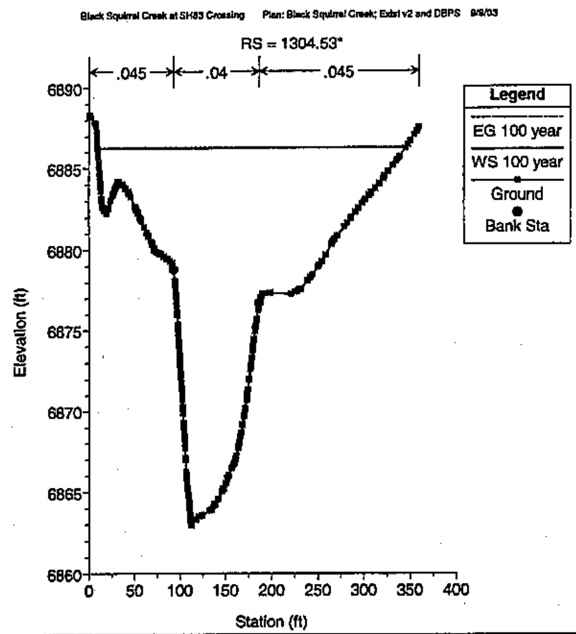

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1502.546
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta

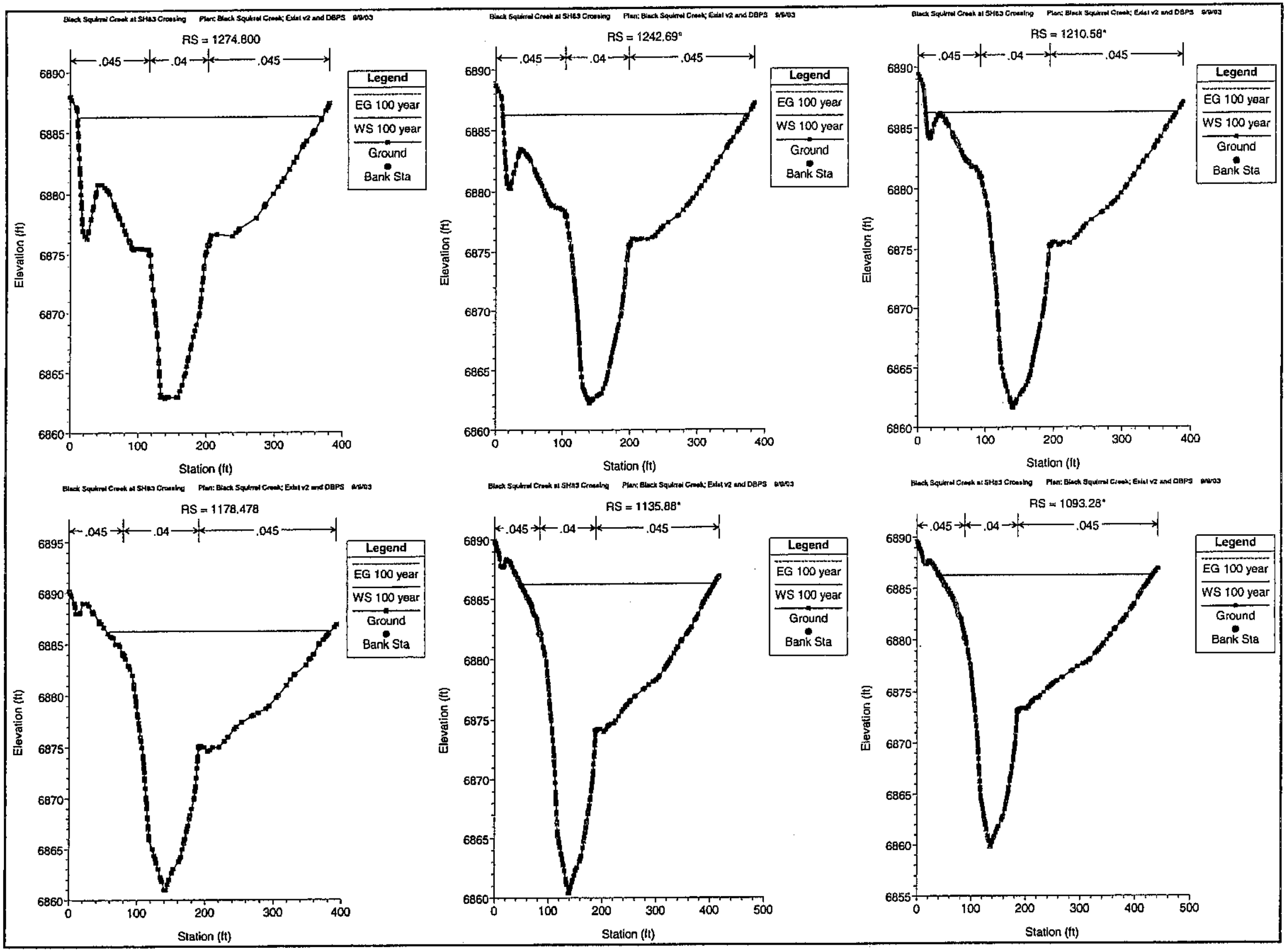

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1460.47*
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1418.40*
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta

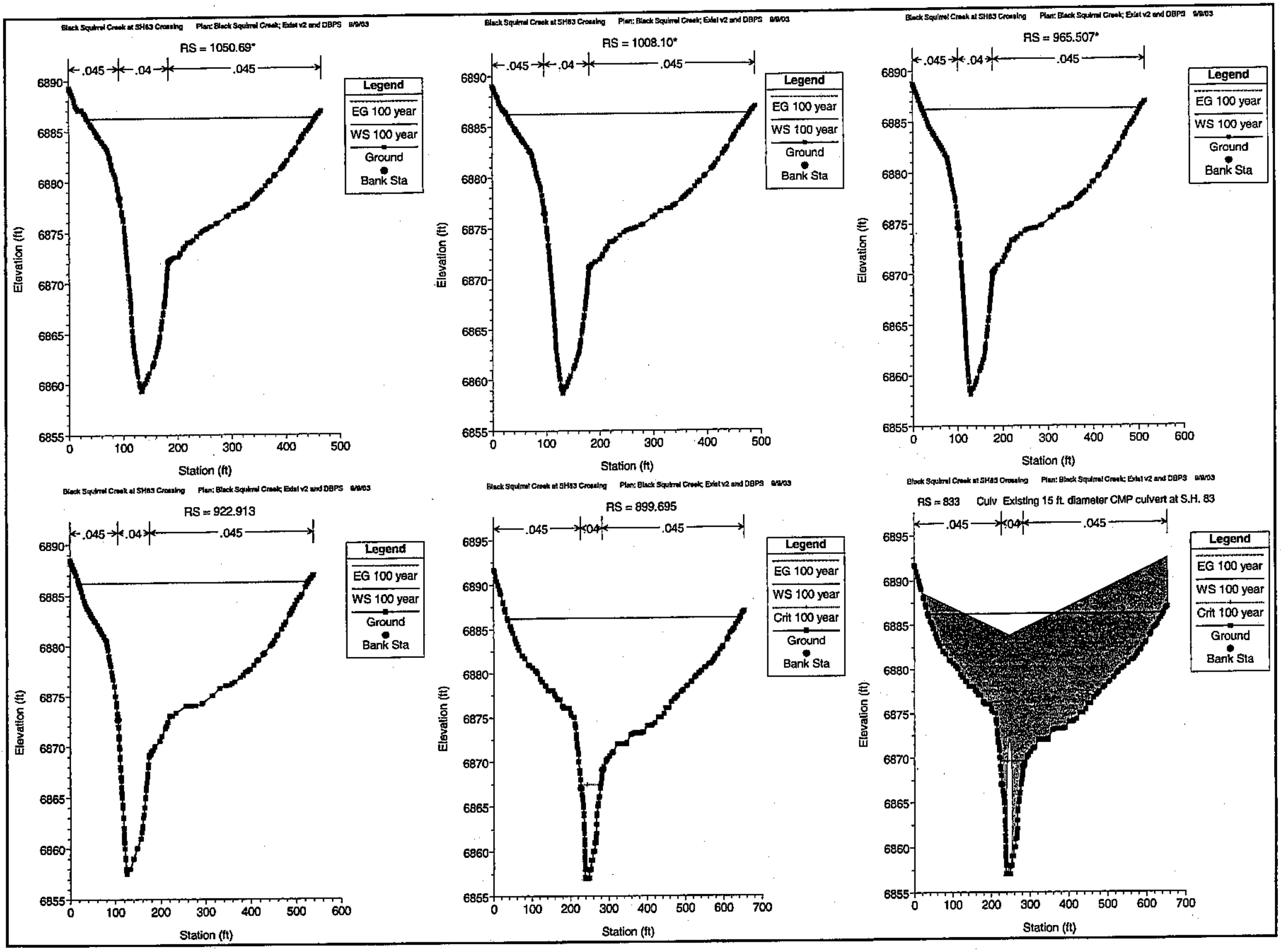

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1376.33*
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta

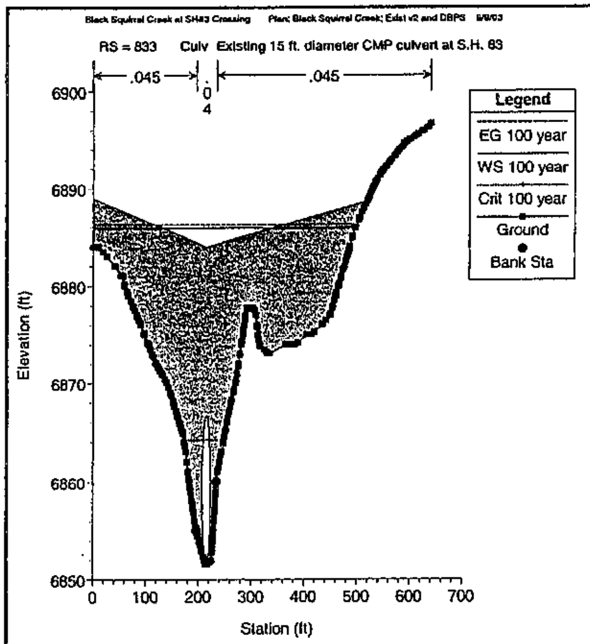

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1334.267
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta

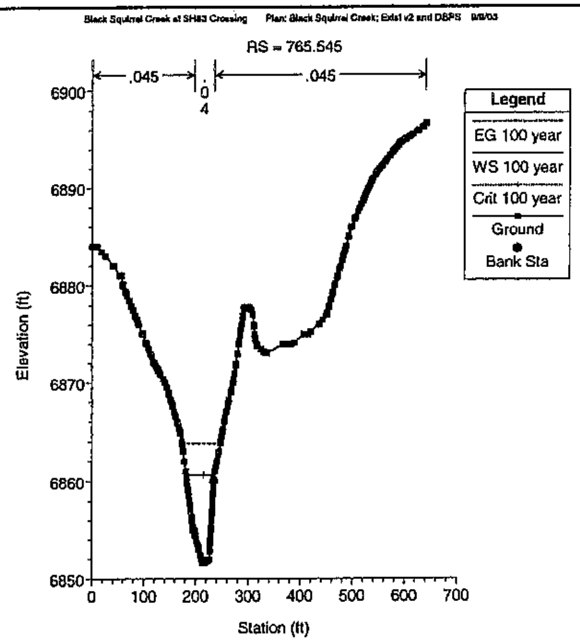

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1304.53*
.045
.04
.045
Elevation (ft)
Station (ft)
Legend
EG 100 year
WS 100 year
Ground
Bank Sta

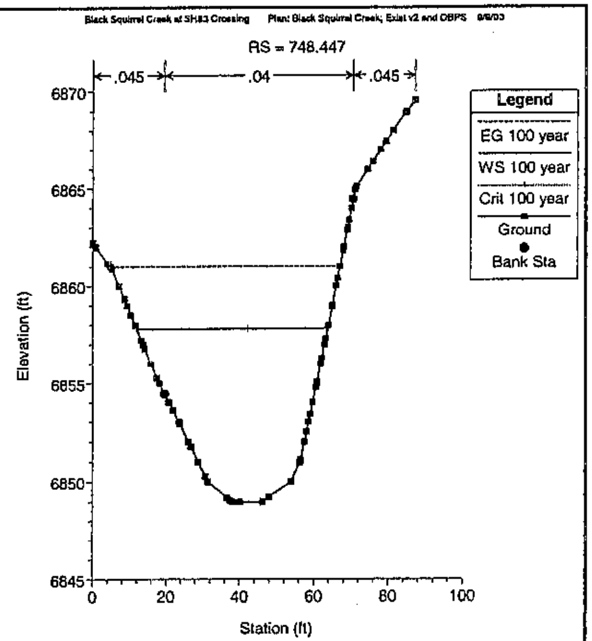


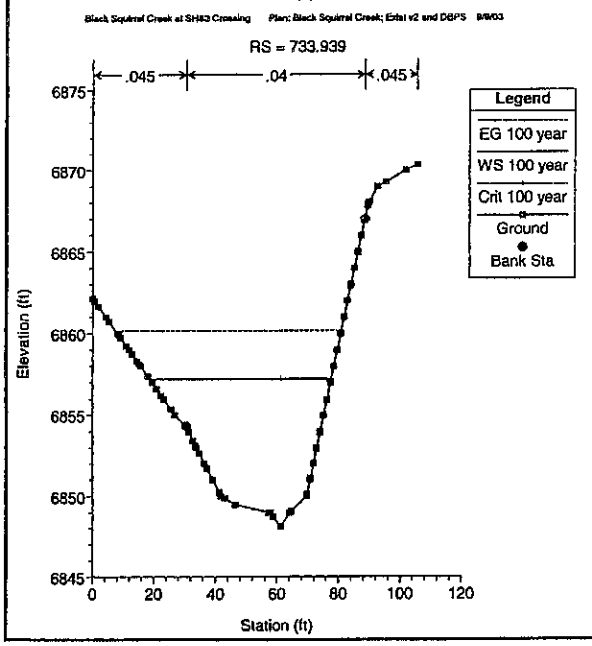
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1274.800
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6860 6865 6870 6875 6880 6885 6890
Station (ft)
0 100 200 300 400
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1242.69*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6860 6865 6870 6875 6880 6885 6890
Station (ft)
0 100 200 300 400
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1210.58*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6860 6865 6870 6875 6880 6885 6890
Station (ft)
0 100 200 300 400
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1178.478
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6860 6865 6870 6875 6880 6885 6890 6895
Station (ft)
0 100 200 300 400
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1135.88*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6860 6865 6870 6875 6880 6885 6890
Station (ft)
0 100 200 300 400 500
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1093.28*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6855 6860 6865 6870 6875 6880 6885 6890
Station (ft)
0 100 200 300 400 500

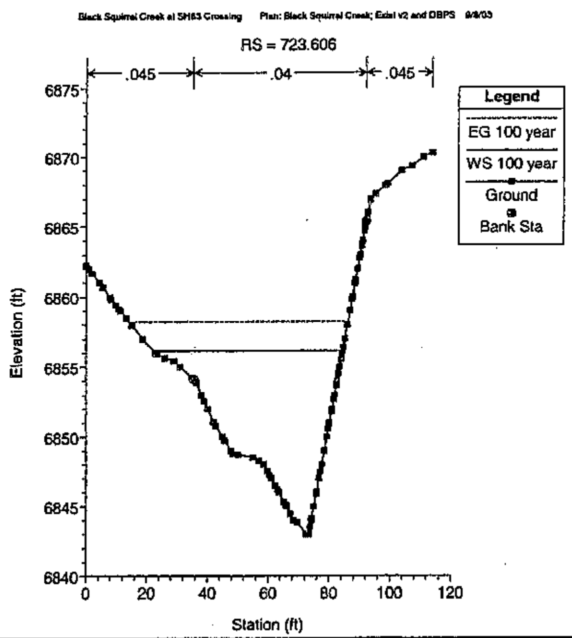

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1050.69*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 1008.10*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 965.507*
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 922.913
.045 .04 .045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 899.695
.045 .04 .045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 833 Culv Existing 15 ft. diameter CMP culvert at S.H. 83
.045 .04 .045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

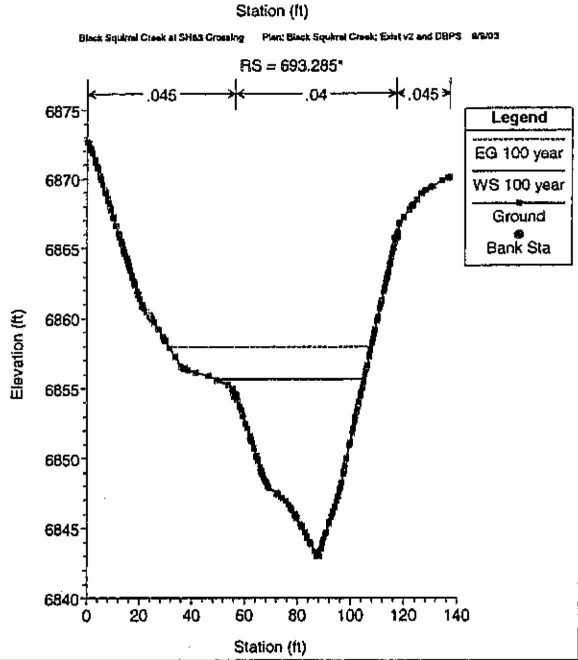

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 833 Culv Existing 15 ft. diameter CMP culvert at S.H. 83
.045
0
4
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

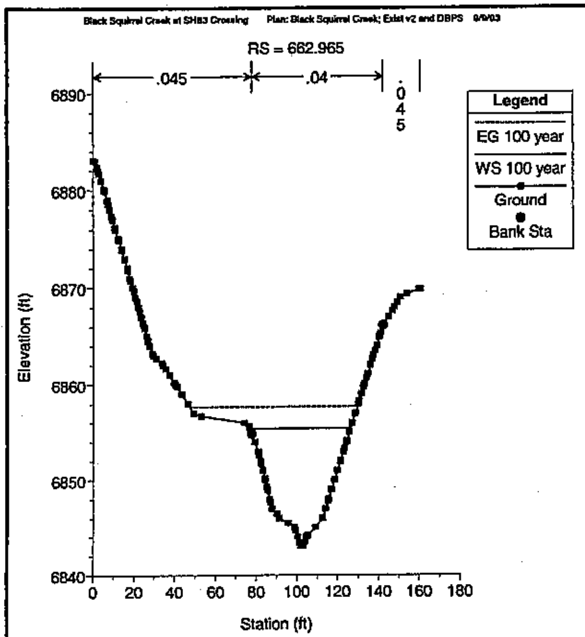

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 765.545
.045
0
4
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

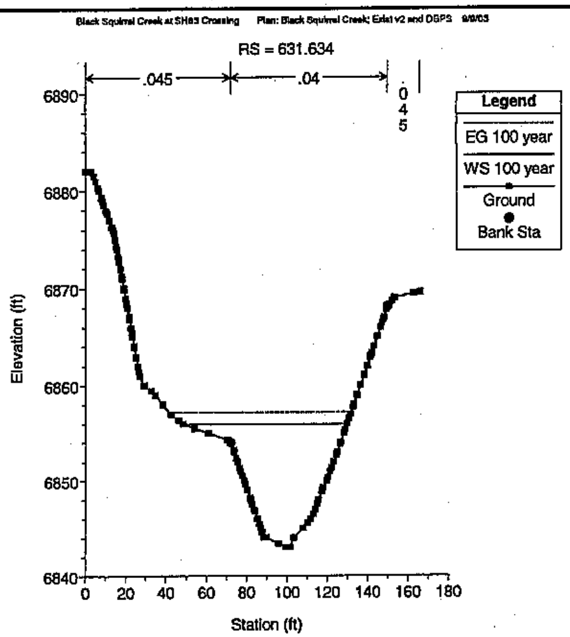

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 748.447
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

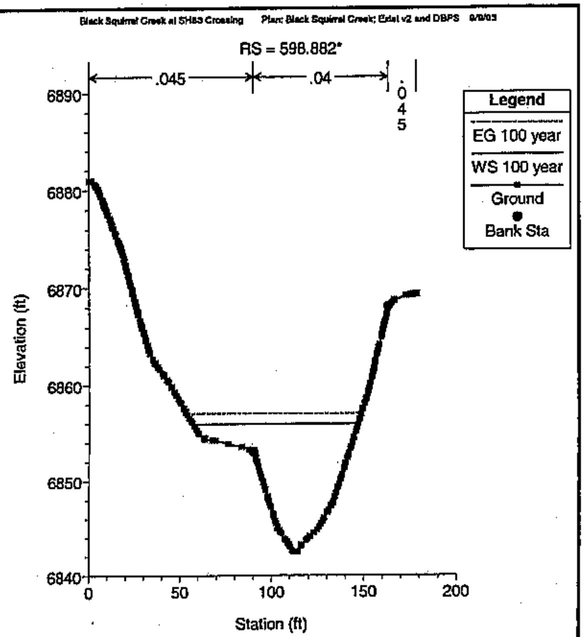

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 733.939
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

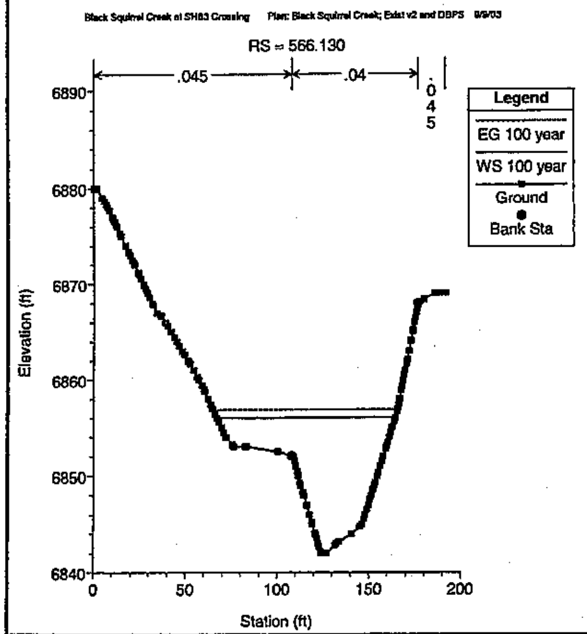

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 723.606
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

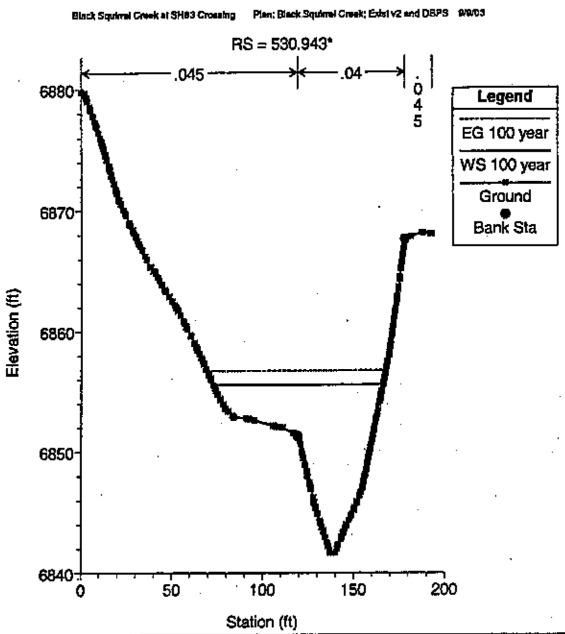

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Exist v2 and DBPS 9/9/03
RS = 693.285*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

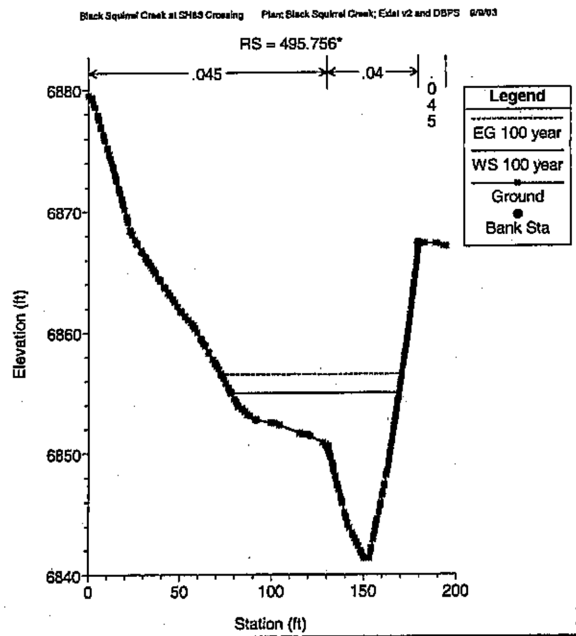

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 662.965
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
6890
Station (ft)
0
20
40
60
80
100
120
140
160
180

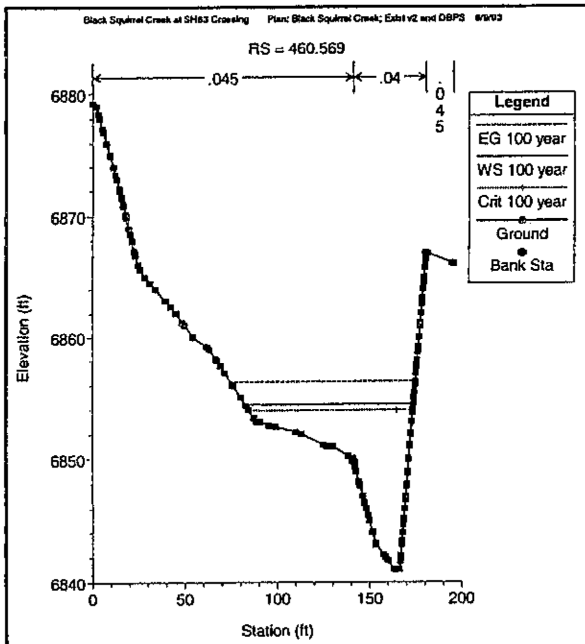

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 631.634
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
6890
Station (ft)
0
20
40
60
80
100
120
140
160
180

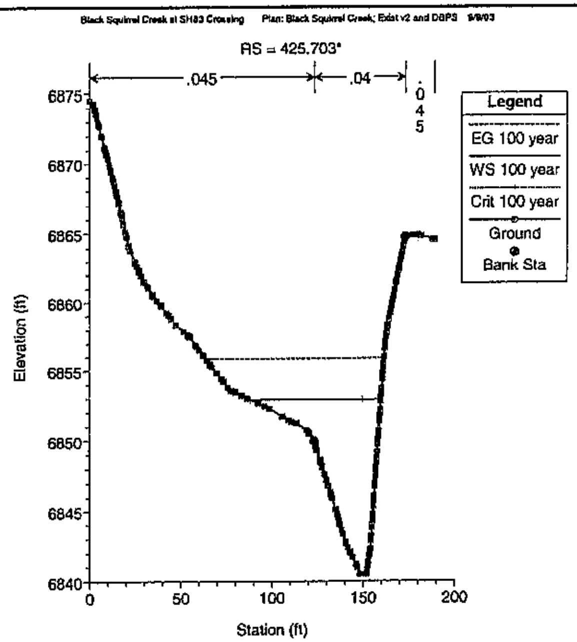

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 598.882*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
6890
Station (ft)
0
50
100
150
200

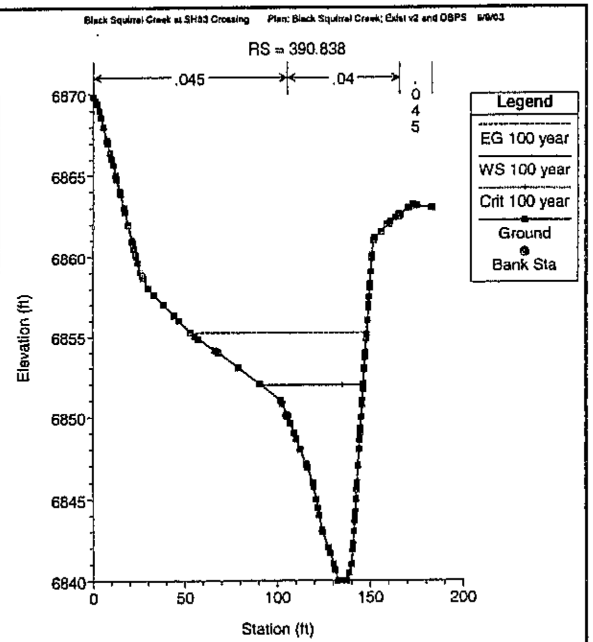

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 566.130
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
6890
Station (ft)
0
50
100
150
200

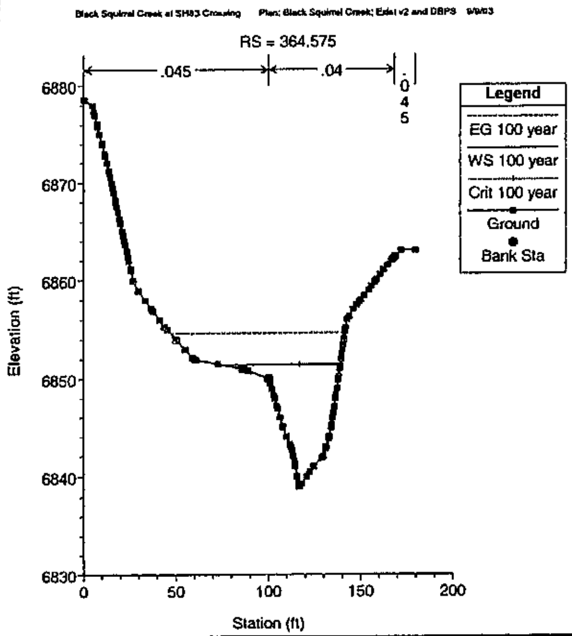

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 530.943*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
Station (ft)
0
50
100
150
200

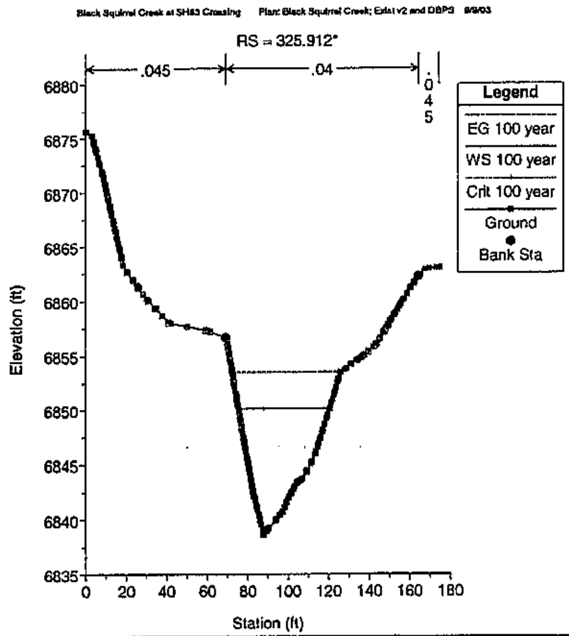

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 495.756*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
Station (ft)
0
50
100
150
200

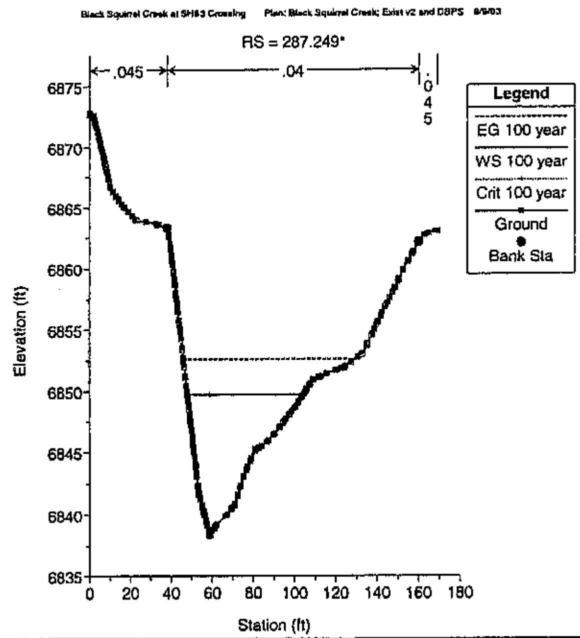

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 460.569
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6840
6850
6860
6870
6880
Station (ft)
0
50
100
150
200

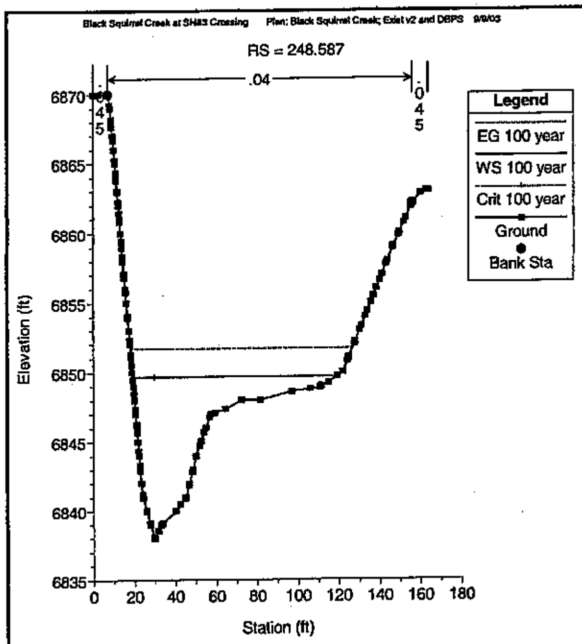

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 425.703*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6840
6845
6850
6855
6860
6865
6870
6875
Station (ft)
0
50
100
150
200

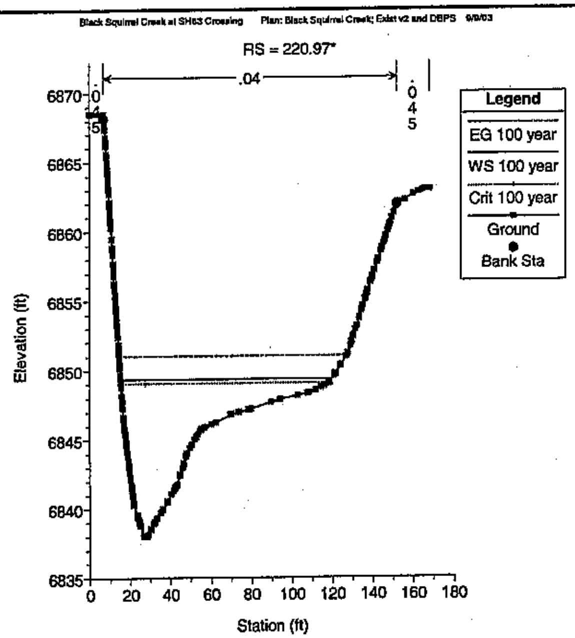

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 390.838
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6840
6845
6850
6855
6860
6865
6870
Station (ft)
0
50
100
150
200

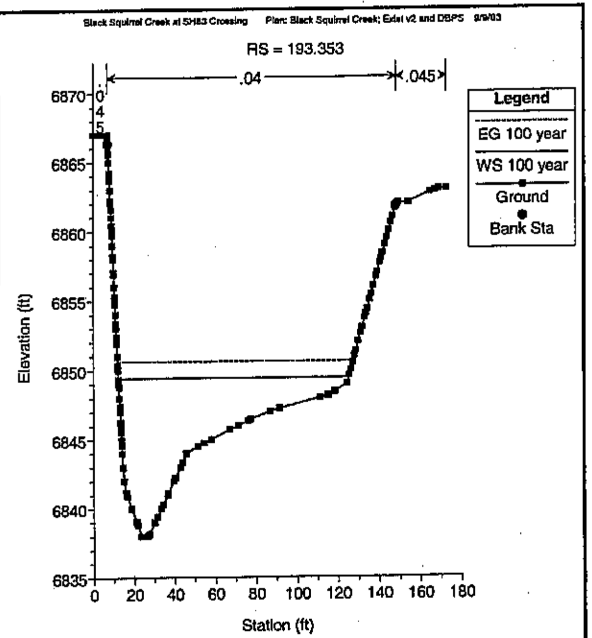

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 364.575
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6830
6840
6850
6860
6870
6880
Station (ft)
0
50
100
150
200

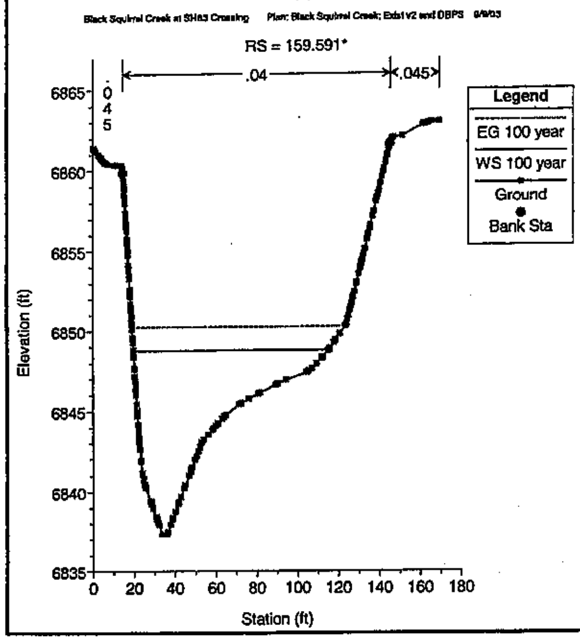

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 325.912*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6835
6840
6845
6850
6855
6860
6865
6870
6875
6880
Station (ft)
0
20
40
60
80
100
120
140
160
180

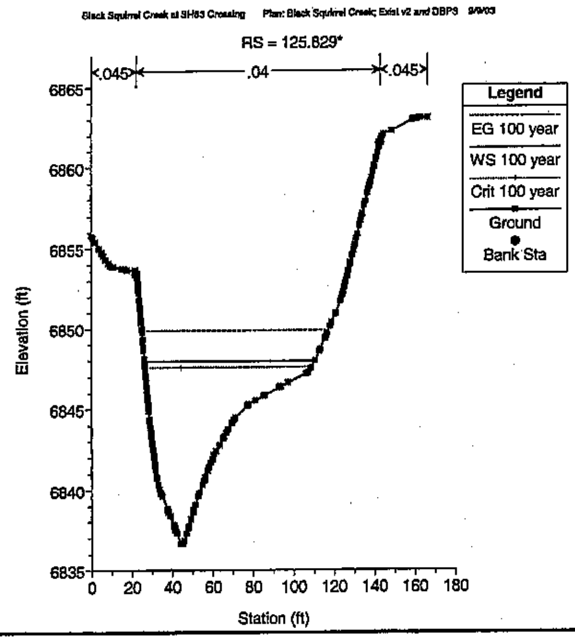

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Exist v2 and DBPS
RS = 287.249*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6835
6840
6845
6850
6855
6860
6865
6870
6875
Station (ft)
0
20
40
60
80
100
120
140
160
180

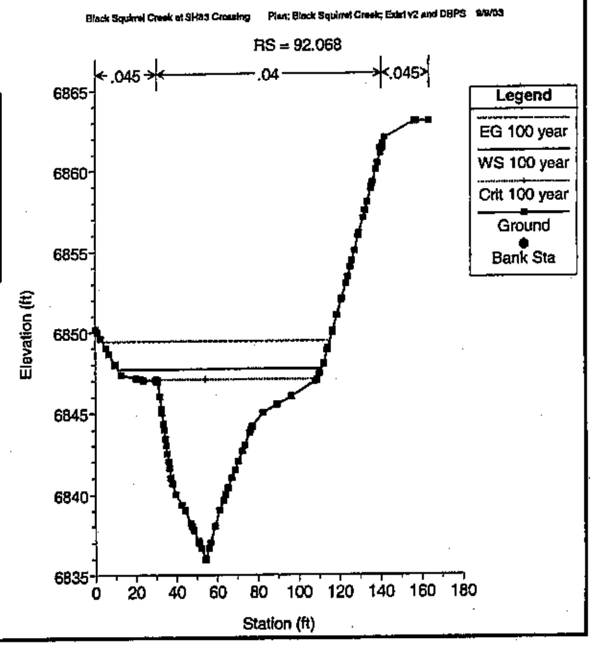

Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 248.587
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

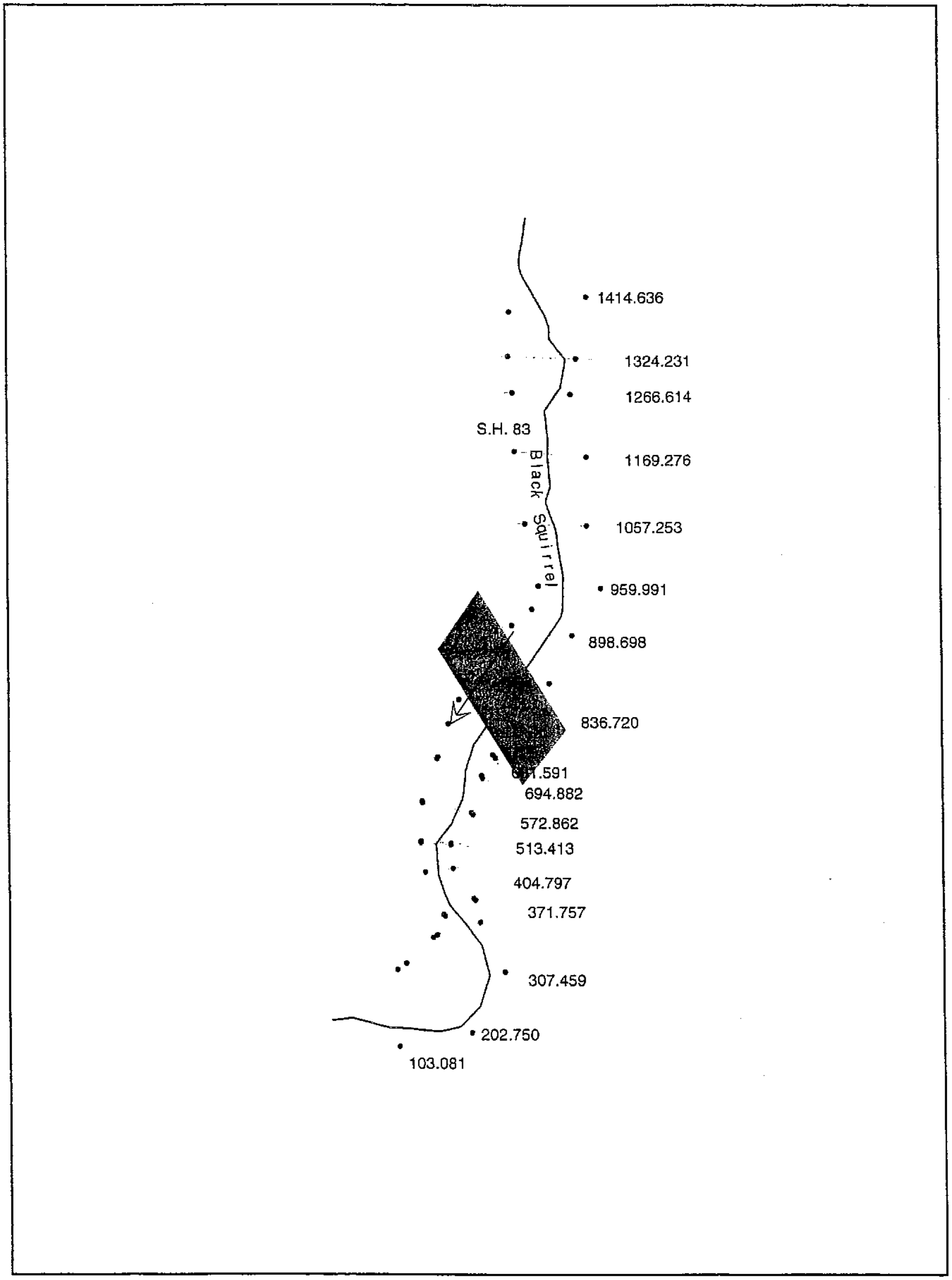

Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 220.97*
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

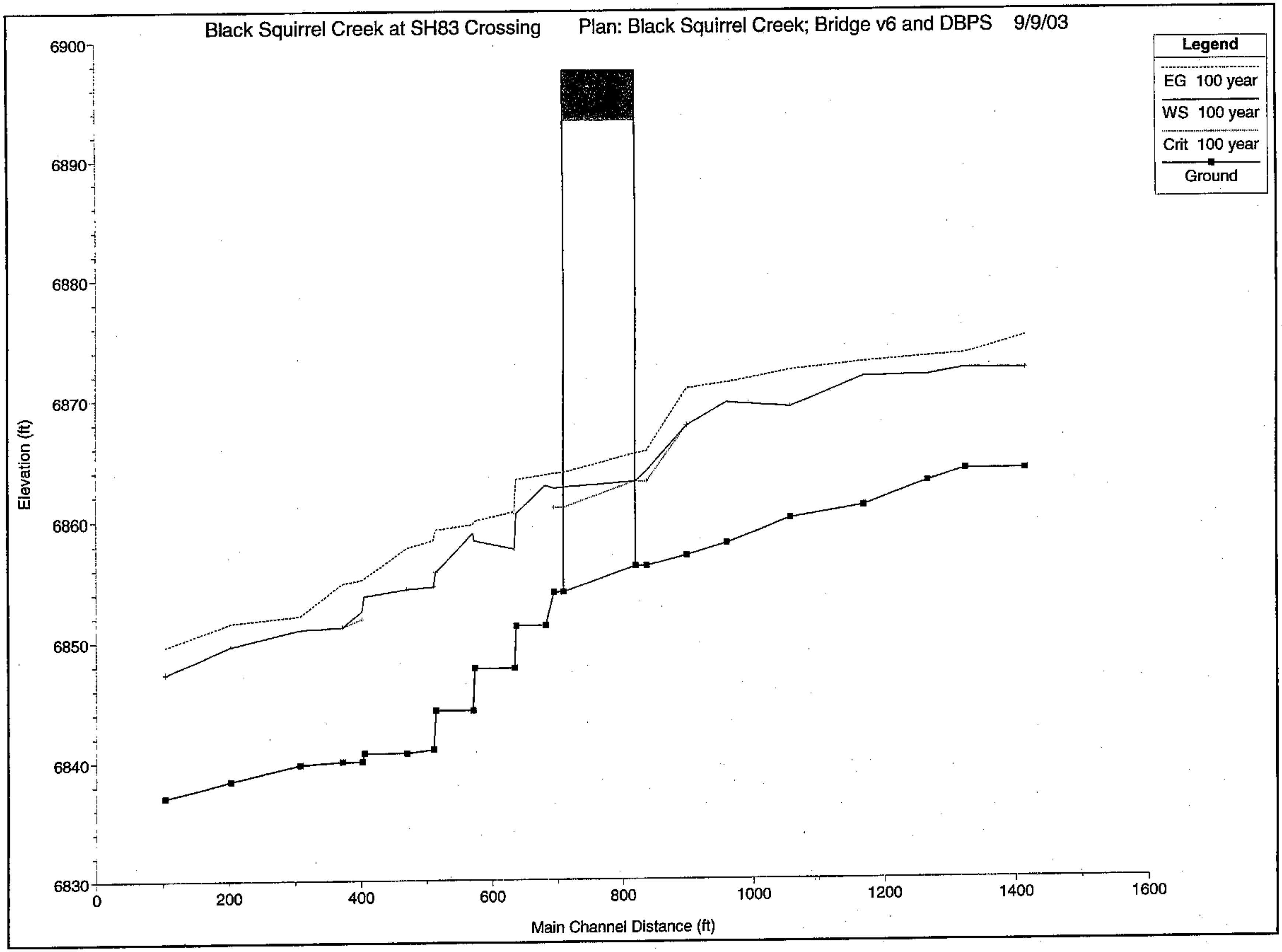

Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 193.353
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 159.591*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 125.829*
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing   Plan: Black Squirrel Creek; Exist v2 and DBPS   9/9/03
RS = 92.068
.045
.04
.045
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


1414.636
1324.231
1266.614
S.H. 83
Black Squirrel
1169.276
1057.253
959.991
898.698
836.720
694.882
572.862
513.413
404.797
371.757
307.459
202.750
103.081

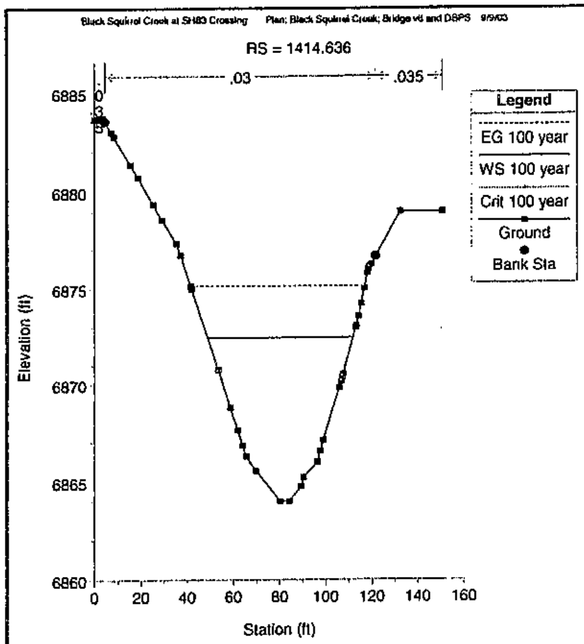

Black Squirrel Creek at SH83 Crossing
Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Elevation (ft)
6900
6890
6880
6870
6860
6850
6840
6830
0
200
400
600
800
1000
1200
1400
1600
Main Channel Distance (ft)

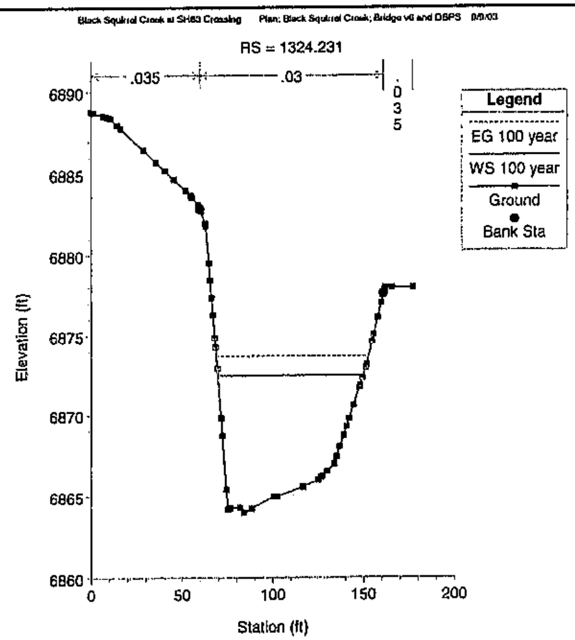
HEC-RAS Plan: Version 6 River: Black Squirrel Reach: S.H. 83 Profile: 100 year

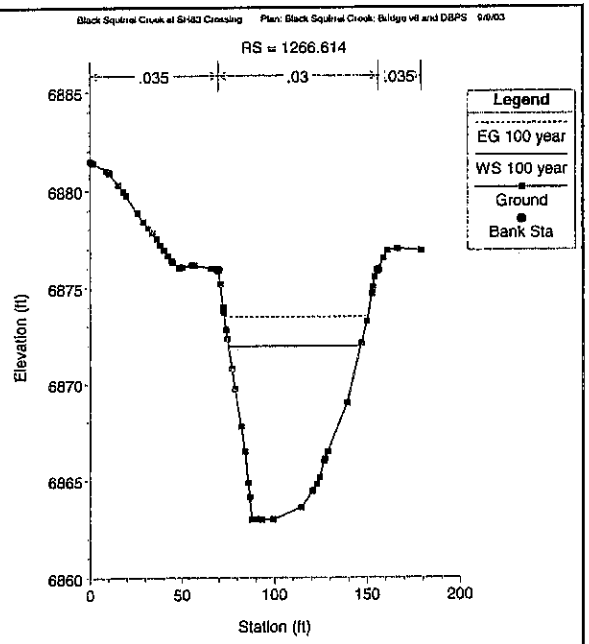
| Reach | River Sta | Profile | E.G. Elev (ft) | W.S. Elev (ft) | Vel Head (ft) | Frctn Loss (ft) | C & E Loss (ft) | Q Left (cfs) | Q Channel (cfs) | Q Right (cfs) | Top Width (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S.H. 83 | 1414.636 | 100 year | 6875.16 | 6872.46 | 2.69 | 0.42 | 0.44 | | 4400.00 | | 62.94 |
| S.H. 83 | 1324.231 | 100 year | 6873.72 | 6872.51 | 1.21 | 0.20 | 0.03 | | 4400.00 | | 80.04 |
| S.H. 83 | 1266.614 | 100 year | 6873.49 | 6871.95 | 1.54 | 0.31 | 0.09 | | 4400.00 | | 71.20 |
| S.H. 83 | 1169.276 | 100 year | 6873.09 | 6871.86 | 1.23 | 0.49 | 0.19 | | 4400.00 | | 73.33 |
| S.H. 83 | 1057.253 | 100 year | 6872.41 | 6869.30 | 3.11 | 0.53 | 0.42 | | 4400.00 | | 50.70 |
| S.H. 83 | 959.991 | 100 year | 6871.37 | 6869.67 | 1.69 | 0.34 | 0.14 | | 4398.90 | 1.10 | 64.96 |
| S.H. 83 | 898.698 | 100 year | 6870.89 | 6867.75 | 3.14 | 0.40 | 0.44 | | 4400.00 | | 50.12 |
| S.H. 83 | 836.720 | 100 year | 6865.64 | 6863.96 | 1.67 | 0.11 | 0.07 | | 4400.00 | | 81.13 |
| S.H. 83 | 766 | | Bridge | | | | | | | | |
| S.H. 83 | 694.882 | 100 year | 6863.81 | 6862.52 | 1.29 | 0.03 | 0.12 | | 4400.00 | | 85.78 |
| S.H. 83 | 681.591 | 100 year | 6863.65 | 6862.78 | 0.88 | 0.14 | 0.20 | | 4400.00 | | 76.34 |
| S.H. 83 | 636.472 | 100 year | 6863.32 | 6860.49 | 2.83 | 0.02 | 0.02 | 0.00 | 4400.00 | | 58.92 |
| S.H. 83 | 633.687 | 100 year | 6860.64 | 6857.63 | 3.02 | 0.31 | 0.43 | | 4400.00 | | 51.10 |
| S.H. 83 | 572.862 | 100 year | 6859.90 | 6858.32 | 1.58 | 0.00 | 0.26 | 2.97 | 4397.03 | | 66.74 |
| S.H. 83 | 570.305 | 100 year | 6859.63 | 6858.93 | 0.70 | 0.13 | 0.28 | 5.17 | 4394.83 | | 73.07 |
| S.H. 83 | 519.413 | 100 year | 6859.22 | 6855.72 | 3.51 | 0.02 | 0.04 | 211.68 | 4188.32 | | 46.18 |
| S.H. 83 | 510.304 | 100 year | 6858.38 | 6854.52 | 3.86 | 0.32 | 0.13 | 71.48 | 4328.52 | | 39.65 |
| S.H. 83 | 469.296 | 100 year | 6857.76 | 6854.33 | 3.43 | 0.27 | 0.58 | 217.23 | 4182.77 | | 47.86 |
| S.H. 83 | 404.797 | 100 year | 6855.25 | 6853.77 | 1.48 | 0.01 | 0.11 | 209.26 | 4190.74 | | 62.44 |
| S.H. 83 | 401.253 | 100 year | 6855.13 | 6852.50 | 2.63 | 0.21 | 0.10 | 50.18 | 4349.82 | | 55.47 |
| S.H. 83 | 371.757 | 100 year | 6854.82 | 6851.17 | 3.65 | 0.30 | 0.76 | 5.27 | 4394.73 | | 41.82 |
| S.H. 83 | 307.459 | 100 year | 6852.12 | 6851.00 | 1.12 | 0.51 | 0.08 | | 4400.00 | | 89.60 |
| S.H. 83 | 202.750 | 100 year | 6851.53 | 6849.64 | 1.89 | 0.91 | 0.04 | | 4400.00 | | 109.52 |
| S.H. 83 | 103.081 | 100 year | 6849.63 | 6847.34 | 2.29 | | | | 4400.00 | | 81.46 |

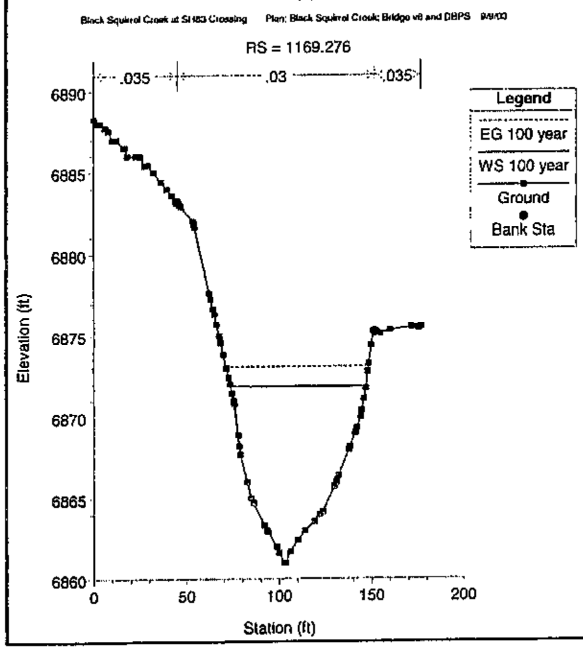
HEC-RAS Plan: Version 6 River: Black Squirrel Reach: S.H. 83 Profile: 100 year

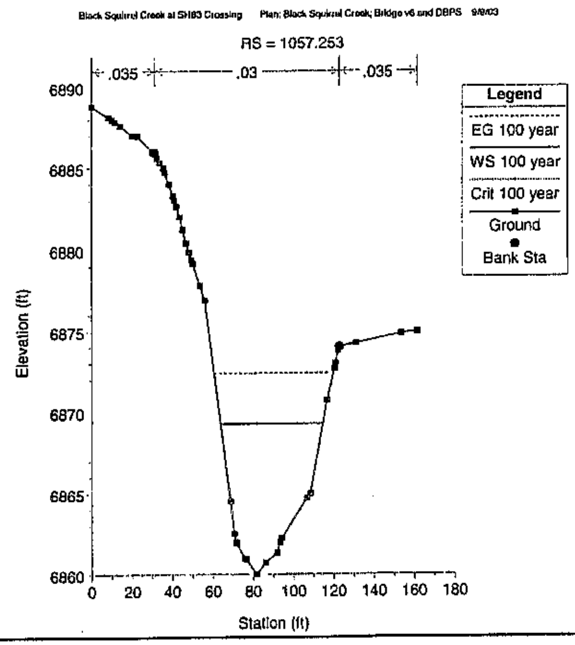
| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.H. 83 | 1414.536 | 100 year | 4400.00 | 6864.00 | 6872.46 | 6872.46 | 6875.16 | 0.008084 | 13.17 | 334.18 | 62.94 | 1.01 |
| S.H. 83 | 1324.231 | 100 year | 4400.00 | 6864.00 | 6872.51 | | 6873.72 | 0.003033 | 8.83 | 498.23 | 80.04 | 0.62 |
| S.H. 83 | 1268.614 | 100 year | 4400.00 | 6863.00 | 6871.95 | | 6873.49 | 0.003821 | 9.96 | 441.86 | 71.20 | 0.70 |
| S.H. 83 | 1169.276 | 100 year | 4400.00 | 6861.00 | 6871.86 | | 6873.09 | 0.002715 | 8.89 | 495.21 | 73.33 | 0.60 |
| S.H. 83 | 1057.259 | 100 year | 4400.00 | 6860.00 | 6869.30 | 6869.30 | 6872.41 | 0.008246 | 14.15 | 310.92 | 50.70 | 1.01 |
| S.H. 83 | 959.991 | 100 year | 4400.00 | 6858.00 | 6869.67 | | 6871.37 | 0.003819 | 10.45 | 421.97 | 64.96 | 0.71 |
| S.H. 83 | 898.696 | 100 year | 4400.00 | 6857.00 | 6867.75 | 6867.75 | 6870.89 | 0.008539 | 14.21 | 309.57 | 50.12 | 1.01 |
| S.H. 83 | 836.720 | 100 year | 4400.00 | 6856.16 | 6863.96 | 6863.09 | 6865.64 | 0.005012 | 10.37 | 424.17 | 81.13 | 0.80 |
| S.H. 83 | 750 | | Bridge | | | | | | | | | |
| S.H. 83 | 694.882 | 100 year | 4400.00 | 6854.00 | 6862.52 | 6860.97 | 6863.81 | 0.003508 | 9.11 | 482.90 | 85.78 | 0.68 |
| S.H. 83 | 681.591 | 100 year | 4400.00 | 6851.22 | 6862.78 | | 6863.65 | 0.001654 | 7.51 | 585.60 | 76.34 | 0.48 |
| S.H. 83 | 636.472 | 100 year | 4400.00 | 6851.22 | 6860.49 | 6860.49 | 6863.32 | 0.008537 | 13.50 | 325.95 | 58.92 | 1.01 |
| S.H. 83 | 633.687 | 100 year | 4400.00 | 6847.72 | 6857.63 | 6857.56 | 6860.64 | 0.007891 | 13.94 | 315.75 | 51.10 | 0.99 |
| S.H. 83 | 572.862 | 100 year | 4400.00 | 6847.72 | 6858.32 | | 6859.90 | 0.003602 | 10.09 | 437.48 | 66.74 | 0.68 |
| S.H. 83 | 570.305 | 100 year | 4400.00 | 6844.22 | 6858.93 | | 6859.63 | 0.001034 | 6.74 | 656.84 | 73.07 | 0.38 |
| S.H. 83 | 519.413 | 100 year | 4400.00 | 6844.22 | 6855.72 | 6855.72 | 6859.22 | 0.007722 | 15.34 | 306.28 | 46.18 | 0.93 |
| S.H. 83 | 510.304 | 100 year | 4400.00 | 6841.00 | 6854.52 | 6854.52 | 6858.38 | 0.008357 | 15.88 | 286.15 | 39.65 | 0.98 |
| S.H. 83 | 489.298 | 100 year | 4400.00 | 6840.72 | 6854.33 | 6854.33 | 6857.76 | 0.007544 | 15.17 | 309.87 | 47.86 | 0.93 |
| S.H. 83 | 404.797 | 100 year | 4400.00 | 6840.72 | 6853.77 | | 6855.25 | 0.002671 | 9.97 | 469.27 | 62.44 | 0.58 |
| S.H. 83 | 401.254 | 100 year | 4400.00 | 6840.00 | 6852.50 | 6851.85 | 6855.13 | 0.006029 | 13.07 | 346.01 | 55.47 | 0.85 |
| S.H. 83 | 371.757 | 100 year | 4400.00 | 6840.00 | 6851.17 | 6851.17 | 6854.82 | 0.008214 | 15.35 | 288.32 | 41.82 | 0.99 |
| S.H. 83 | 307.459 | 100 year | 4400.00 | 6839.75 | 6851.00 | | 6852.12 | 0.002997 | 8.49 | 518.18 | 89.60 | 0.62 |
| S.H. 83 | 202.750 | 100 year | 4400.00 | 6838.41 | 6849.64 | 6849.64 | 6851.53 | 0.009465 | 11.03 | 398.88 | 109.52 | 1.02 |
| S.H. 83 | 103.061 | 100 year | 4400.00 | 6837.00 | 6847.34 | 6847.34 | 6849.63 | 0.008740 | 12.14 | 362.49 | 81.46 | 1.01 |

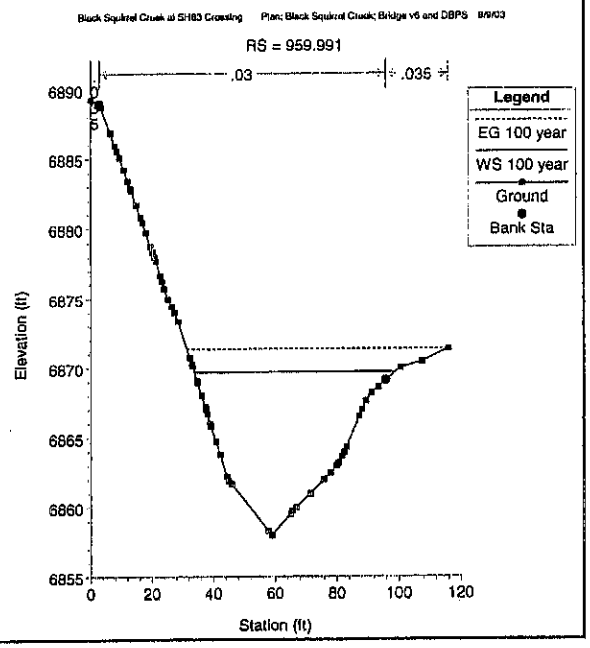

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 1414.636
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

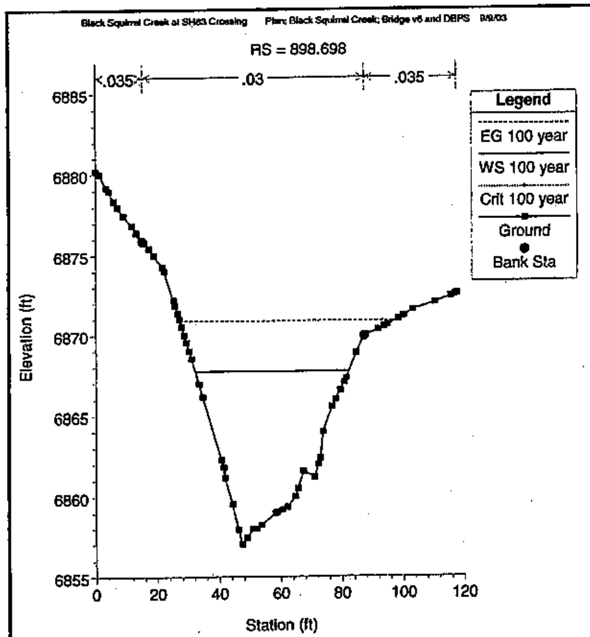

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 1324.231
.035
.03
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

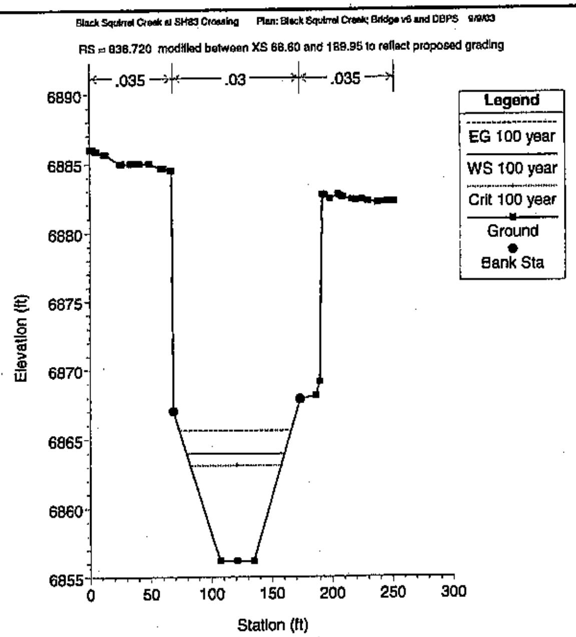

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 1266.614
.035
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

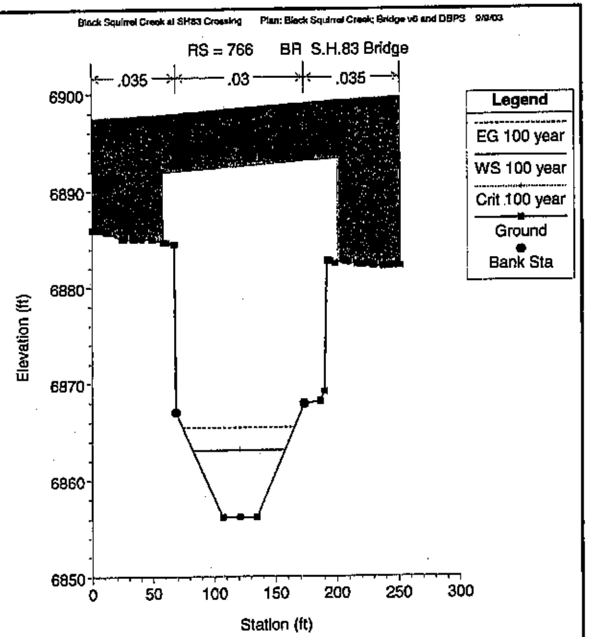

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 1169.276
.035
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

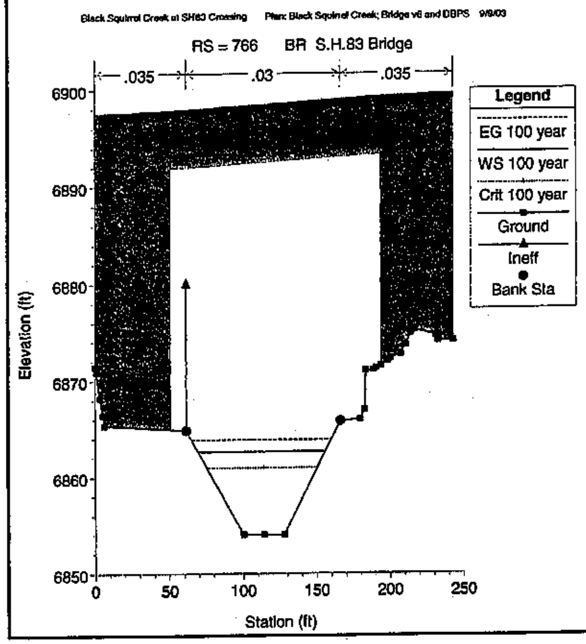

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 1057.253
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

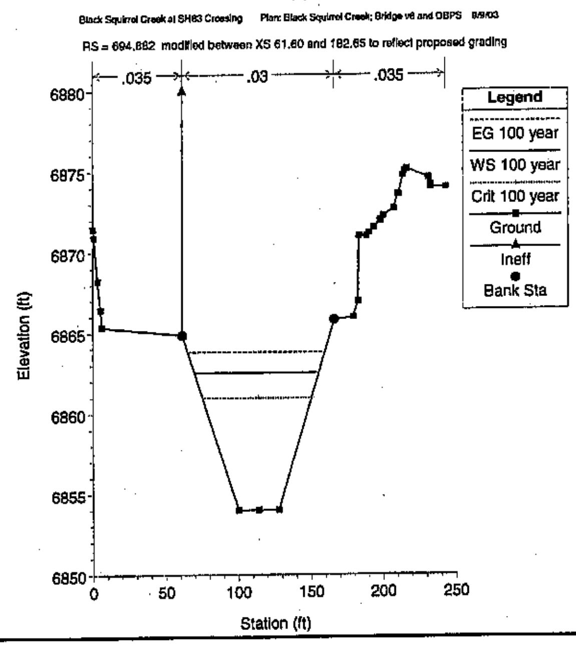

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 959.991
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

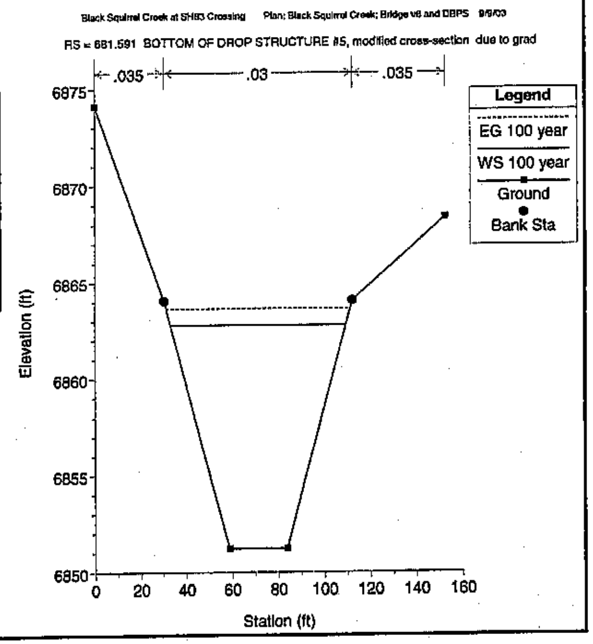

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 898.698
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

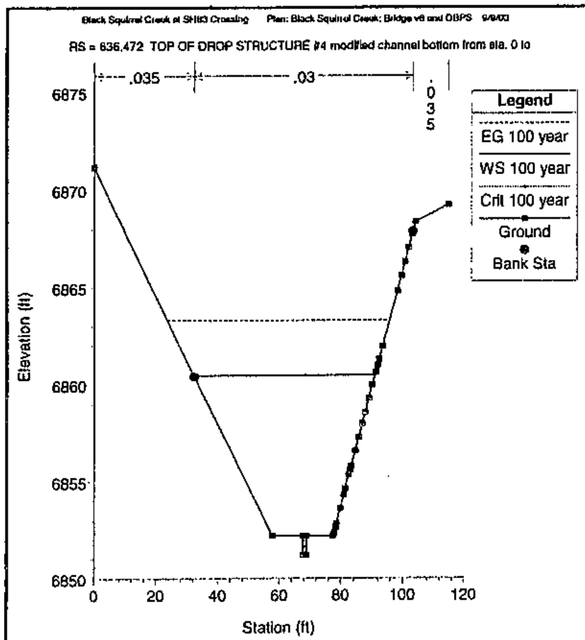

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 836.720 modified between XS 68.60 and 189.95 to reflect proposed grading
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

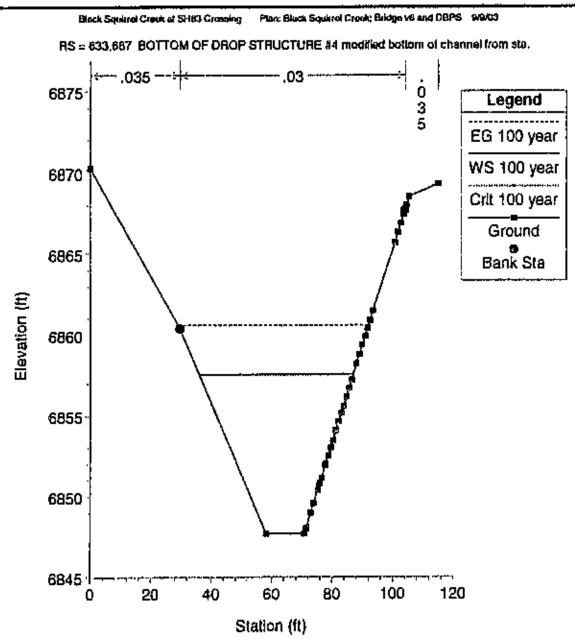

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 766 BR S.H.83 Bridge
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

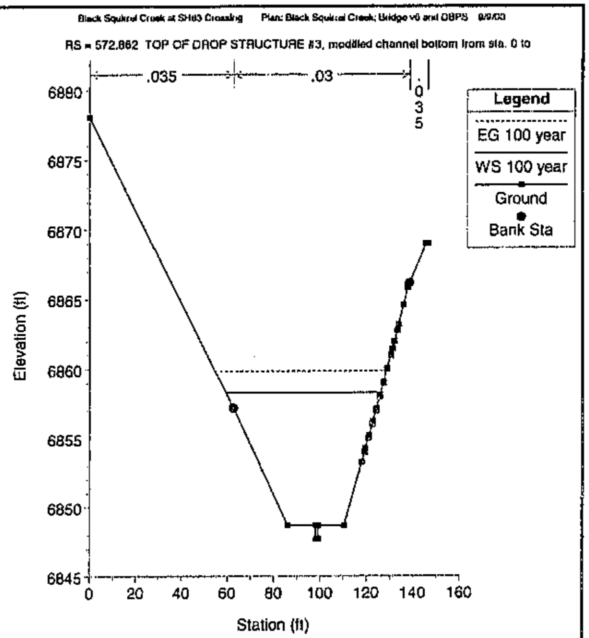

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 766 BR S.H.83 Bridge
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

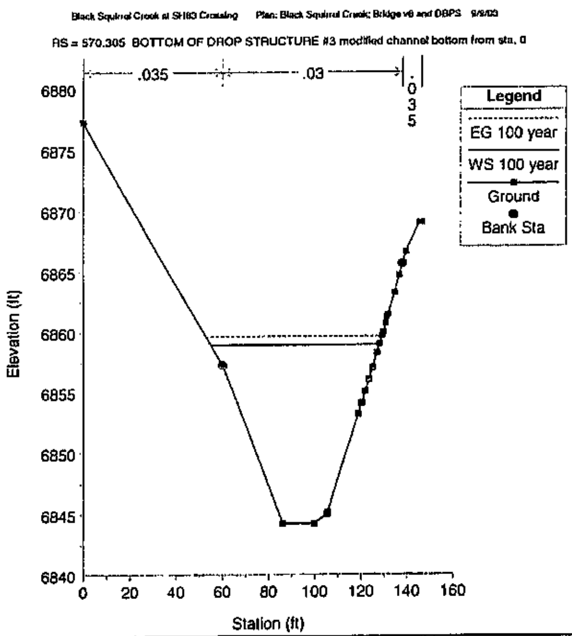

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 694.882 modified between XS 61.60 and 182.65 to reflect proposed grading
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

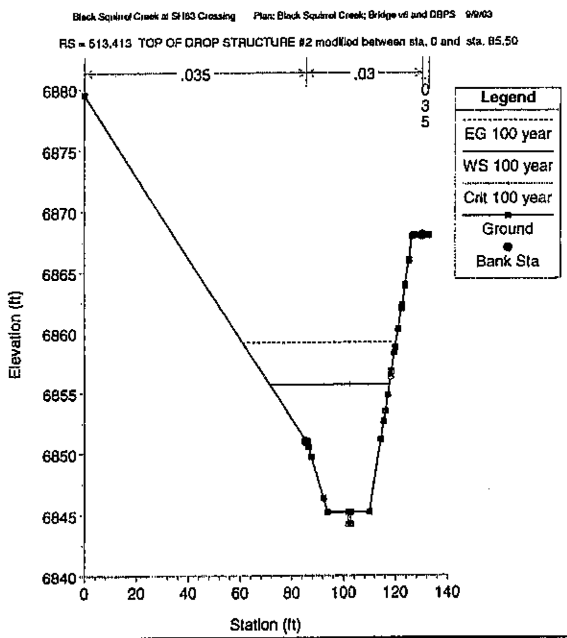

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 681.591 BOTTOM OF DROP STRUCTURE #5, modified cross-section due to grad
.035
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

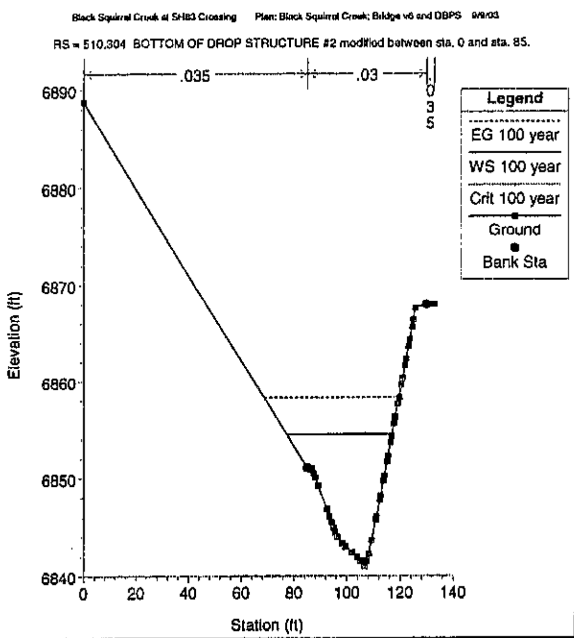

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 636.472 TOP OF DROP STRUCTURE #4 modified channel bottom from sta. 0 to
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

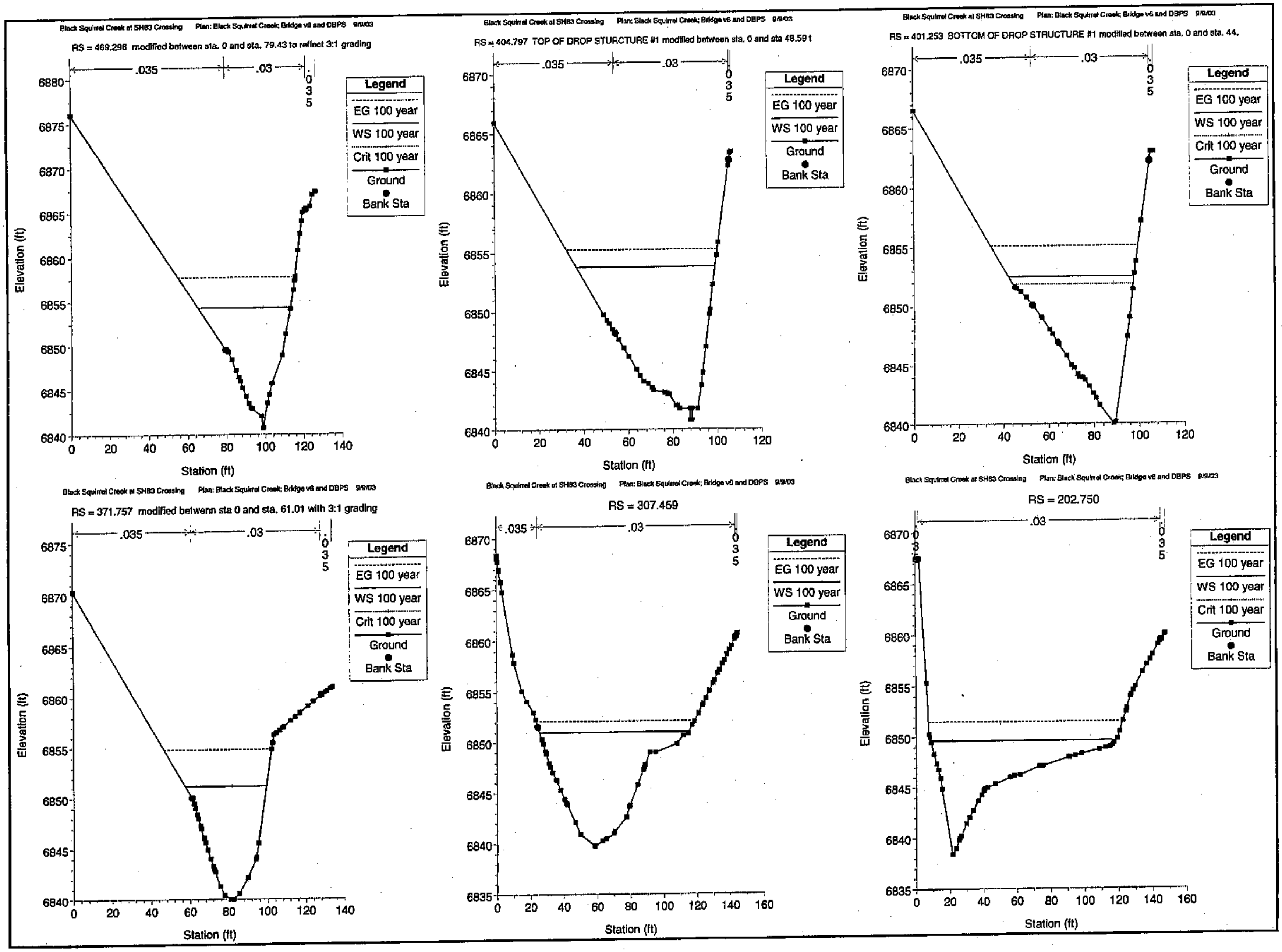

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 633.667 BOTTOM OF DROP STRUCTURE #4 modified bottom of channel from sta.
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)

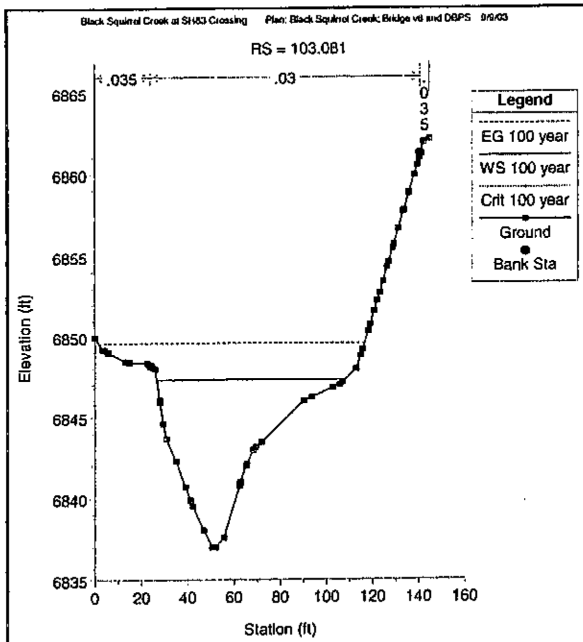

Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 572.862 TOP OF DROP STRUCTURE #3, modified channel bottom from sta. 0 to
.035
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 570.305 BOTTOM OF DROP STRUCTURE #3 modified channel bottom from sta. 0
.035
.03
.035
Legend
EG 100 year
WS 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 513.413 TOP OF DROP STRUCTURE #2 modified between sta. 0 and sta. 85.50
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 510.304 BOTTOM OF DROP STRUCTURE #2 modified between sta. 0 and sta. 85.
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 469.298 modified between sta. 0 and sta. 79.43 to reflect 3:1 grading
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 404.797 TOP OF DROP STURCTURE #1 modified between sta. 0 and sta 48.59 t
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 401.253 BOTTOM OF DROP STRUCTURE #1 modified between sta. 0 and sta. 44.
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 371.757 modified betwenn sta 0 and sta. 61.01 with 3:1 grading
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 307.459
Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v6 and DBPS 9/9/03
RS = 202.750
.035
.03
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Black Squirrel Creek at SH83 Crossing Plan: Black Squirrel Creek; Bridge v8 and DBPS 9/9/03
RS = 103.081
.035
.03
.035
Legend
EG 100 year
WS 100 year
Crit 100 year
Ground
Bank Sta
Elevation (ft)
6865
6860
6855
6850
6845
6840
6835
0
20
40
60
80
100
120
140
160
Station (ft)