150528

GALAXY/SPECTRON SITE
ELKTON, MARYLAND

REMOVAL ACTION
FINAL DESIGN REPORT

Prepared For:

THE GALAXY/SPECTRON SITE
WASTE GENERATOR
AND
TRANSPORTER GROUP II

Prepared By:

ADVANCED GEOSERVICES CORP.
Chadds Ford Business Campus
Chadds Ford, Pennsylvania

March 14, 1998 (Revised July 7, 1998)
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1.0 INTRODUCTION

In accordance with the Removal Action Plan (RAP) prepared by Environmental Resources Management, Inc. (ERM) dated August 4, 1995, the Galaxy/Spectron Site Waste Generator and Transporter Group II (the Group), presents this Final (100%) Design for Removal Action (RA) activities at the Galaxy/Spectron Site in Elkton, Maryland (the "Site"). This document represents an extension of the previous design submittals prepared by Advanced GeoServices Corp. (AGC). This Final design represents an 100% state of completion and assumes that the Providence Road Bridge repairs and East Mill Race Stabilization will be completed prior to construction of the RA.

The objective of the RA is to substantially improve water quality in Little Elk Creek (the "Creek") by isolating the Creek from groundwater discharges, stream sediments, seeps and springs which represent potential sources of contamination. This document builds upon the stream isolation concept presented in previous submissions by presenting additional details of the design developed to meet the RAP objectives. Although the design presented is intended to satisfy the requirements of the RA Order, it is also planned to be consistent with and integrated into the final site remedy to be determined by the RI/FS.

The Final Design follows the approach to the RA which was presented in the previous submissions presenting the design in greater detail and addressing specific concerns and suggestions of the USEPA, MDE, the US Department of the Interior (USDOI). Since the 90% Design, several key elements have been further refined. These are discussed below:

- <u>Final Plans for Restoration of Both In-Stream (Benthic) and Riparian Habitat Adjacent to the Site.</u>
  AGC has conducted a detailed stream bed survey for the Little Elk Creek within the limits of the proposed RA activities and has received input from the USDOI, USFWS, USEPA/BTAG on a detailed habitat restoration conceptual plan prepared during November, 1997. The plan was presented to the USEPA/BTAG,

USDOI and USFWS on December 2, 1997. The plan was further discussed during the February 2, 1997 meeting with USEPA/BTAG, USDOI and USFWS. Subsequent comments received from USEPA have been addressed in this document. This information and feedback has been evaluated and incorporated into the 100% design in several ways:

- The grading and configuration of the stream bed has been modified to project existing conditions onto the finished site grades and produce plans that accurately predict post RA flow conditions.

- The dual channel design retains many of the modifications introduced during the 90% Design to allow for increased habitat restoration throughout the project area. Utilizing the services of specialized sub-consultants in the areas of habitat restoration and ecology, the conceptual restoration plan previously provided has been developed into detailed plans and specifications showing how the post-RA habitat will restore or improve upon the habitat currently found at the site.

- The Ecological Assessment has been modified to include several additional elements requested by USEPA/BTAG and USDOI. The assessment report is included in Appendix G.

- Plans for baseline biological monitoring and a long term ecological monitoring plan for the restoration elements of the design have been added (Appendix H).

- <u>Elimination of Pre-Cast Concrete Design Element</u>

  Since submission of the 90% Design, Remediation Contractors interested in performing the RA activities have reviewed and provided comment on the

constructuralabilty of the design. Based on those comments, the design has been modified to eliminate the pre-cast concrete element of the secondary channel. The change represents a return to the concept originally included in the Intermediate (75%) Design. This includes construction of a continuous cast-in-place concrete structural wall along the length of the proposed stream lining. The wall will extend to a typical depth of 3 feet below finished grade and will provide the anchorage and rigidity required for the isolation system. The proposed design change will provide greater flexibility for reproducing the irregularity of the stream bed, reduce the lead time required for material procurement, and eliminate expensive and time consuming rock anchor systems. The cast-in-place wall will allow the single-channel concept to remain as an integral part of the design with the necessary habitat restoration on top of the entire channel width.

- Stabilization of Eastern Mill Race

The 90% Design recommended that stabilization activities be performed in the East Mill Race during the winter of 1997/1998 to prevent continued erosion that could have impacted the current design or the long term integrity of the Removal Action. The USEPA in their letter dated February 5, 1998, directed the Group to begin the stabilization activities immediately. A copy of this letter is provided in Appendix H. These activities have been initiated during finalization of this design and are expected to be complete by the end of March, 1998.

2.0 BACKGROUND

The Galaxy/Spectron Site (the Site) is located off Route 213, north of Elkton, Maryland (Figure 2-1). It is a narrow piece of flat land within the 8.0-acre parcel owned by Paul J. Mraz. The Site was used for solvent recycling and fuel blending from 1962 until 1988. In 1988, the Site was abandoned, with solvents remaining on-site in tanks and drums. In late 1989 and early 1990, the PRP Group conducted a removal action of these materials to mitigate the potential hazards of fire, explosion, or exposure.

Prior to its use as a solvent recycling facility, a paper mill consisting of numerous large buildings occupied the Site. The mill was destroyed by fire in 1954. In 1962, the mill buildings were razed and the solvent recycling facility was built on fill material consisting largely of rubble from the razed buildings. The Site now consists of several standing buildings, empty and decontaminated storage tanks and drums, and remnant process facilities. Old building foundations and related infrastructure exist in and beneath this rubble. In June 1994, the Site was listed on the CERCLA National Priorities List (NPL).

Site operations prior to 1988 have resulted in volatile organic compound (VOC) contamination of Site soils and groundwater. Chlorinated and non-chlorinated VOCs have been detected in the groundwater seeps which enter the Creek along its western bank.

In 1991 the PRP Group entered into an Administration Consent Order (ACO) with the USEPA to determine the feasibility of mitigating seeps and shallow groundwater VOC discharges into the Creek. The objective of this removal action is to achieve target VOC concentrations (State of Maryland surface water quality standards) in the Creek.

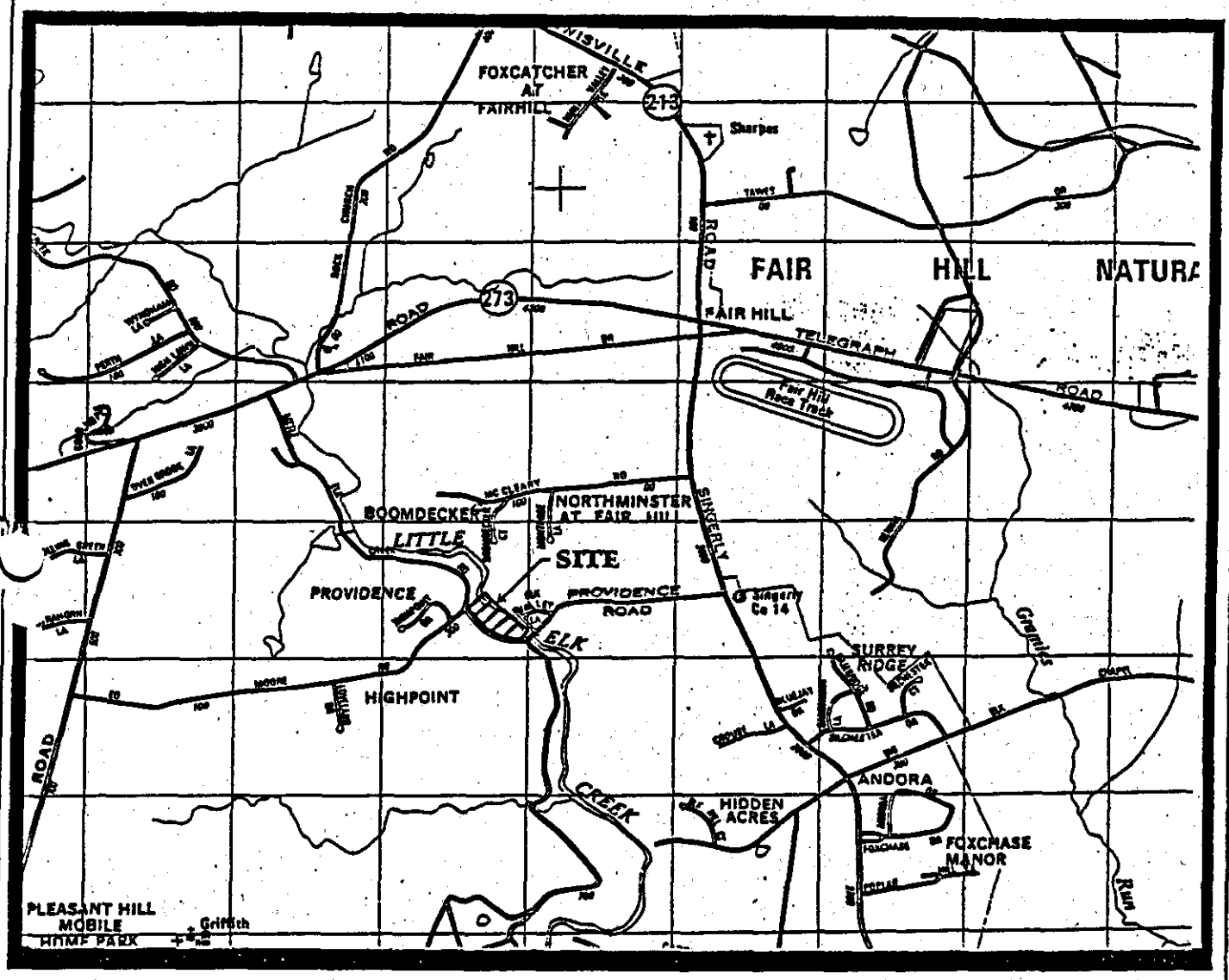
An overburden groundwater extraction and treatment system to mitigate the seeps was envisioned in the ACO. In 1991-92, evaluation of data collected by ERM as part of the extraction system design strongly indicated that the in-stream VOC concentrations were a result not only of the seep/overburden groundwater system discharge, but also involved additional source(s) of VOC mass loading. It was therefore determined that the envisioned shallow groundwater extraction and treatment system would not reduce in-stream VOC concentrations to the acceptable levels required by the ACO.

It was suspected that the additional VOC mass loading to the Creek was the result of Dense Non-Aqueous Phase Liquids (DNAPL) in the Creek sediments and/or discharge of contaminated groundwater from the bedrock. To evaluate the potential presence of DNAPL, and to further define the source and nature of VOC mass loading to the Creek, a Focused Remedial Investigation (FRI) was conducted from May 1993 to May 1994. The FRI followed an USEPA-approved Work Plan which was implemented under the existing ACO.

The FRI consisted of both intrusive and non-intrusive data collection. Limited quantities of free-phase DNAPL was found in the Creek sediments adjacent to the Site and in the bedrock beneath the Site and Creek. The FRI concluded that the overburden and bedrock groundwater flow systems, as well as the DNAPL in the Creek sediments, each provide nearly equal percentages of VOC mass loading to the Creek. Any one of these pathways would provide sufficient VOC concentrations to exceed State of Maryland surface water quality standards. Accordingly, for a removal action to reduce VOC concentrations in the Creek to target levels, a removal action would have to address the VOC mass contributed by each pathway.

The Removal Action Plan (RAP), prepared by the PRP Group in August 1995 and presented to the USEPA and MDE, proposed a stream isolation concept to address these pathways. This concept was further developed in the Conceptual Design Report (AGC, 1996) which was submitted to USEPA and MDE in March 1996. The USEPA approved the Conceptual Design Report in their letter dated May 17, 1996. The 30% and 75% Design Reports were presented to the USEPA and MDE on November 22, 1996 and April 21, 1997, respectively. The 90% Design Report was submitted during

August 1997, and a detailed Habitat Restoration Concept Plan was submitted on December 4, 1997. Following the December 4, 1997 meeting, the USEPA issued a letter requiring the Group to halt its design efforts while they evaluated issues relating to the effectiveness of the RA. After the collection of additional data and numerous meetings with the USEPA, the Group was directed to resume design efforts on in late January, 1998. As a result, the design is being completed under a modified schedule, which will be discussed in Section 6 of this document.



GALAXY / SPECTRON REMOVAL ACTION INTERMEDIATE (90%) DESIGN

ELKTON, MARYLAND

Date: 10/4/96	SITE LOCATION MAP
Scale: N.T.S.	
Drawn By: P.S.G.	
Checked By: T.D.T.	
Project Mgr: P.G.S.	
Dwg No.	

Advanced GeoServices Corp.
Chadds Ford Business Campus, Rts. 202 & 1
Brandywine One, Suite 202
Chadds Ford, Pennsylvania 19317

AR100110

3.0 SITE CONDITIONS

3.1 SITE DESCRIPTION

The Galaxy Spectron Site is shown on the United States Geologic Survey (USGS) Bay View, Maryland quadrangle map. The Site property has frontage along 840 feet of Little Elk Creek (the Creek) which flows from northwest to southeast as shown on the Site Plan, Drawing 1. A dam crosses the Creek near the upstream edge of the Site. Below the downstream edge of the dam and its corresponding plunge pool, the Creek is 40 to 60 feet wide with typically less than 1 foot of water depth at base flow conditions. The Creek bed is highly irregular consisting of boulders infilled with sand and silt. A foot bridge crosses the Creek at approximately the mid point of the Site, providing access between the former production areas and the former facility office on the opposite stream bank. A bridge (Providence Road) crosses the Creek approximately 720 feet downstream of the dam. The Providence Road bridge is 85 feet long with a center pier. The bridge is presently closed because of structural damage to the center pier and is scheduled for repair during the Spring of 1998 by Cecil County. A second dam structure crosses the Creek approximately 320 feet below Providence Road Bridge.

3.2 SITE TOPOGRAPHY

As part of the pre-design investigation activities, Tetra Tech, Inc. of Christiana, Delaware, professional land surveyors licensed in the State of Maryland, performed a detailed topographic and boundary survey and stream channel cross-section survey in early Spring 1996. The mapping area included the Site, and areas 650 ft. upstream of the dam and 1500 ft. downstream of the Providence Road Bridge. National map accuracy precision was 1" = 10' for planimetrics and half foot contour interval (yielding ample detail for planimetrics with vertical precision of a quarter foot contour over 90% of the portions of the Site visible from the air). Tetra Tech, Inc performed an additional detailed survey of the creek bed in the vicinity of the proposed RA during the Fall of 1997. This survey information represents the basis for all of the design drawings. The base map and property boundary survey are shown on the Site Plan, Drawing 1.

As presented on the topographic maps, the topography in the vicinity of the Creek has been strongly influenced by development of the Site. A stone and masonry wall typically 3 to 4 feet high exists along the edge of the Creek bank between the Site and the Creek. Behind the wall, the site grades are relatively uniform. The wall remains intact in some sections, while other sections have fallen down or have been buried. As shown on the Site Plan, topography near the Creek falls from the base of the wall towards the Creek at a 15% to 20% slope. Creek bed grades are irregular because of the boulders covering the bottom. At the opposite bank, grades rise sharply (in some areas nearly vertical) 6 to 8 feet, to a relatively flat top of bank area.

3.3 HYDROLOGIC SETTING

The Little Elk Creek is situated within the Piedmont Physiographic Province. This province is typically drained by streams and creeks with narrow valleys and steep slopes. The drainage area of Little Elk Creek above and including the Site (the "watershed") is approximately 19.8 square miles. The length to width ratio of the watershed is approximately 4:1, indicating that the surface water runoff drains quickly.

A hydrologic evaluation of the Little Elk Creek was performed to determine base flows, and the maximum peak discharges and behavior of the watershed during various flooding events. The determination of peak discharges for various flooding events was necessary in order to calculate maximum flow velocities, flood elevations, and hydraulic forces on the proposed design. Peak discharges were calculated by the following three methods:

1. Regression Equations presented in the U.S. Geological Survey Water-Resources Investigation Report 95-4154 "Technique for Estimating Magnitude and Frequency of Peak Flows in Maryland".

2. Reduction of the 1992 Federal Emergency Management Agency (FEMA) peak discharge data for Little Elk Creek.

3. Flood Hydrograph Package U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC-1), September, 1990.

Details concerning these calculations are included in Appendix A.

The following peak discharges are used in the design. These values are based on the HEC-1 analysis and generally represent the highest peak discharge rates calculated in Appendix A and therefore are the most conservative.

Table 3-1

Flood Frequency (yrs)	Peak Discharge (cfs)
2	2,010
5	3,139
10	4,341
25	5,032
50	6,162
100	7,459
500	12,311*

* Total Rainfall for a 500-year storm was not provided in the references used in the analysis. Therefore the peak discharge calculated from the FEMA data using basin area reduction methods was used for a 500-year storm.

Understanding the behavior of stormwater runoff through the watershed is necessary to determine the length of exposure of the proposed stream improvements to peak discharge, high velocities, scour, and sediment and debris transport. The behavior of a watershed is typically analyzed by developing a discharge hydrograph for a given design storm. Discharge hydrographs for various flood frequencies as well as watershed parameters (i.e., time of concentration, basin lag time, and time to peak discharge) were calculated in conjunction with the peak discharge calculations performed using HEC-1. The following two synthetic hydrograph methods available in HEC-1 were used to develop a runoff hydrograph for a Type II 24-hour rainfall distribution.

1. SCS Synthetic Unit Hydrograph
2. Clark Synthetic Unit Hydrograph

The results of the SCS Synthetic Unit Hydrograph Method are the most conservative and are used in the design. Figure 3-1 presents a discharge hydrograph for a 100-year storm for the watershed. Discharge hydrographs for the other storm events (i.e., 2-year, 5-year, etc.) would show similar curves with peak discharges shown in Table 3-1.

A detailed description of the development of discharge hydrographs is provided in Appendix A.

3.4 HYDRAULIC CONDITIONS

The proposed RA will affect the current hydraulic conditions of the reach of Little Elk Creek between the two existing dams shown on Drawing 1. In order to evaluate these effects, a hydraulic model of existing conditions of Little Elk Creek was developed using the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) Software Package, Version 1.2, April, 1996. This existing conditions model was then modified to predict the changes which would be affected by implementing the RA.

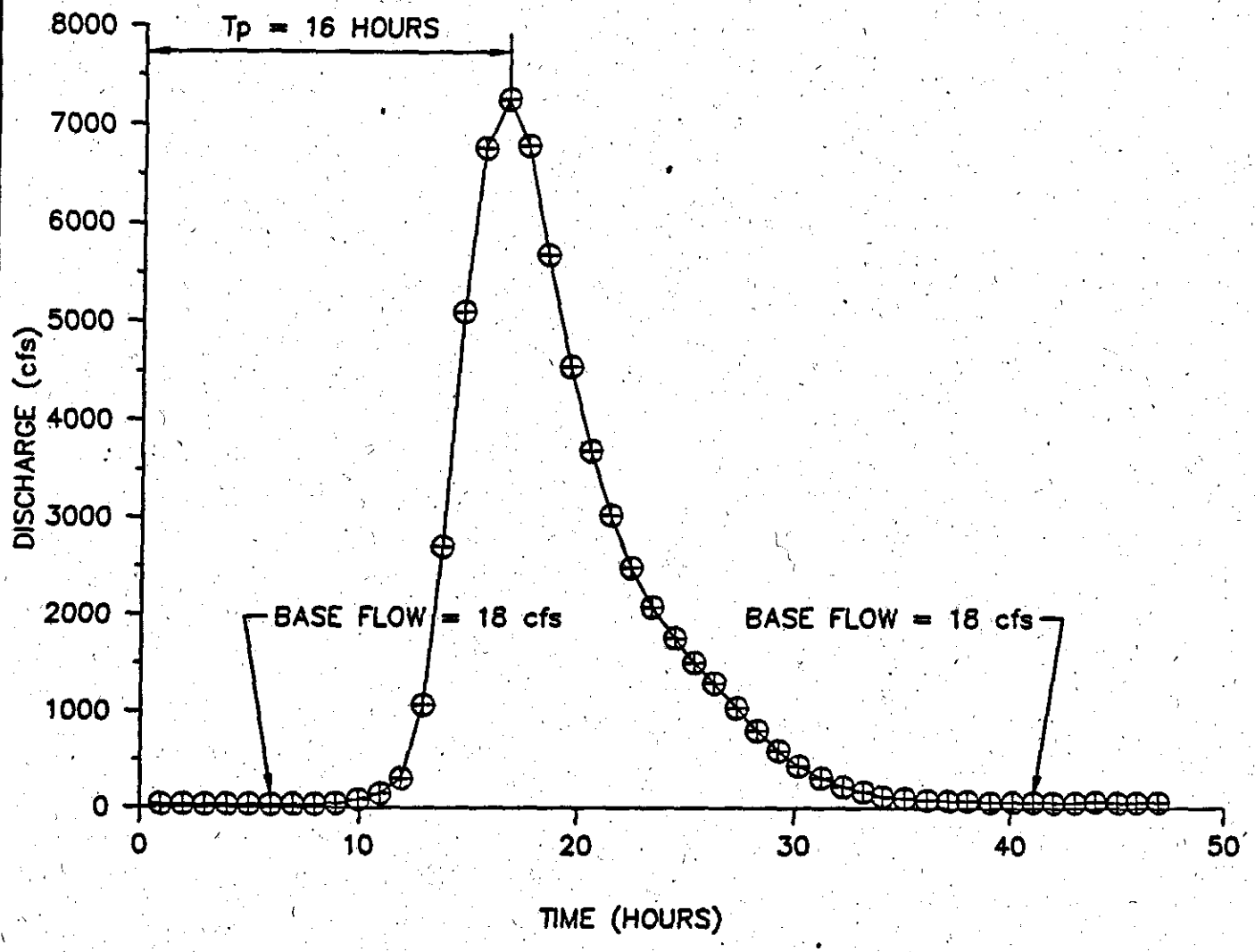
Prior to performing the HEC-RAS hydraulic modeling, AGC reviewed the available data used in the June 16, 1992 Flood Insurance Study for the Town of Elkton, Cecil County Maryland to determine if a hydraulic model of Little Elk Creek had been developed by FEMA. The results of this flood insurance study were based on hydraulic modeling using the U.S. Army Corps of Engineers Hydrologic Engineering Center Water Surface Profiles software (HEC-2 step backwater model), the predecessor to the HEC-RAS software, to model the flow in Little Elk Creek. However, this modeling only extended to the northern corporate limits of Elkton, Maryland (approximately 5 miles downstream of the site). Therefore, AGC developed a model of existing conditions using HEC-RAS software. A comparison of the existing hydraulic conditions to the post RA conditions is provided in Section 4.3. The modeling indicates the Site, and the nearby houses off-site lie within the boundary of the existing pre-RA 100 yr. floodplain. Design modifications have been made to enable the post-RA modelled conditions to be similar to the pre-RA conditions. A detailed description of the hydraulic modeling performed using the HEC-RAS software is provided as Appendix B.

3.5 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The Site is situated in and along the bottom of the Creek valley, in the Piedmont Physiographic Province. It is underlain by fill material, natural sediments, and bedrock. The fill consists primarily of sandy soil containing rubble and demolition debris from the old mill which occupied the Site, and ranges from 1 to 10 feet in thickness across the Site. Below the fill material, alluvial sediments consisting of brown to black sand to silty sand extend from 3-10 feet to bedrock. The bedrock beneath the Site is a metamorphic gneiss of the James Run Formation. Groundwater commonly occurs in joints and fractures, and in weathered zones near the land surface. The depth to the bedrock beneath the Site ranges from approximately 8 to 19 feet (ERM, 1994).

Beneath the Site, shallow groundwater flow in the overburden and fill material is to the east-northeast direction and discharges to the Creek. The FRI has shown that groundwater flow in the shallow bedrock flows toward the Creek. Groundwater flow within the deeper bedrock system may be part of a more regional flow system with an undetermined flow direction expected to be generally eastward (ERM, 1994). Subsequent studies conducted by the Group for the Remedial Investigation indicate that groundwater within the affected area of site flows within an intrabasin flow system, ultimately discharging to Little Elk Creek. Groundwater flow in the overburden unit of the Site is generally to the east/northeast and discharges to the Little Elk Creek. Horizontal gradients are in the range of 0.04 to 0.05 ft/ft. Hydraulic conductivities are highest at the central portion of the Site ranging up to 1×10^{-3} ft/second.

The bedrock flow system discharges to the overburden system and/or to the creek based on upward vertical gradients presented in the FRI (ERM, 1994). As discussed in the FRI, the shallow bedrock ground water flow (to a depth of approximately 50 feet) follows a flow path similar to that of the overburden, eventually discharging to Little Elk Creek.



WATERSHED PARAMETERS

TIME FROM BEGINNING OF STORM TO PEAK DISCHARGE (Tp) = 16 HOURS
BASIN LAG TIME (T_L) = 3.9 HOURS
TIME OF CONCENTRATION (T_C) = 6.5 HOURS

GALAXY / SPECTRON REMOVAL ACTION

ELKTON, MARYLAND

Date: 10/01/96	DISCHARGE HYDROGRAPH 100 – YEAR STORM EVENT
Scale: N.T.S.	
Drawn By: P.S.G.	
Checked By: T.D.T.	Advanced GeoServices Corp Chadds Ford Business Campus, Rts. 202 & 1 Brandywine One, Suite 202 Chadds Ford, Pennsylvania 19317
Project Mgr: T.D.T.	
Dwg No. 95228-14	
Issued:	Project No. 95-228-03 — FIGURE: 3-1

AR100125

4.0 DESIGN OF CHANNEL ISOLATION SYSTEM

The design concept proposed for the RA incorporates the following elements to hydraulically isolate the Little Elk Creek flow from groundwater discharge, sediments, seeps and springs:

- An engineered, single-channel configuration to convey stream channel flows, which has the capability of functioning in a dual-channel mode during construction and maintenance;.

- A stream isolation system to separate groundwater discharge, seeps, springs and sediment from existing creek flow and collect these discharges for subsequent treatment;

- A groundwater treatment system;

- Restoration of existing in-stream and riparian habitat affected by the RA.

As a necessary first step of the RA, and as directed by the USEPA, the Eastern Mill Race, located on the east side of the Spectron Dam, is being stabilized by the Group to provide stable and predictable hydraulic conditions at the northern end of the RA. Plans for this work have been provided to USEPA and MDE under separate cover.

Based on the results of previous investigations, the stream isolation system has been designed to cover approximately 850 feet of Little Elk Creek beginning approximately 120 feet downstream of the Providence Road Bridge and extending upstream to a location between 50 to 75 feet below the upstream dam. The proposed isolation system will include a geomembrane barrier layer that will be protected by a gabion mattress and gabion walls as shown on the design drawings. A collection system will be installed beneath the barrier layer to intercept contaminated groundwater and convey it to an on-site treatment system.

Components of the Final Design are summarized on the Design Drawings and were developed considering key design and construction issues, the criteria outlined in the ACO, and the objectives of the project. Design drawings include the following:

- Drawing 1: Site Plan
- Drawings 2 and 3: Site Preparation Plan
- Drawings 4: Anchor/Cutoff Wall Layout Plan
- Drawings 5 and 6: Channel Base Grading Plan
- Drawing 7: Longitudinal Anchor Wall Profile
- Drawings 8, 9 and 10: Channel Cross-Sections
- Drawing 11: Collection System Layout Plan
- Drawing 12: Gabion Mat Grading Plan
- Drawing 13: Gabion Wall Elevations
- Drawing 14 and 15: Site Restoration Plan
- Drawings 16, 17 and 18: Site Restoration Details
- Drawing 19: Structural Details
- Drawing 20: Construction Details

Calculations supporting the Design are included in Appendix A through C. A description of each design component is provided below:

4.1 DESIGN APPROACH/DESCRIPTION

The Preliminary (30%) Design envisioned a 10-foot wide pre-cast concrete low flow channel to handle base flows while leaving a high flow channel dry until storm events. During meetings held prior to the 75% design with representatives from the USEPA, USDOI, MDE, and USEPA/BTAG, the PRP Group was asked to reconsider the proposed low flow channel for the following reasons:

1. Agency representatives believed that the pre-cast-concrete was too sterile and not likely to be capable of re-establishing a benthic habitat.

2. Agency representatives expressed a desire not to limit base flow to a narrow portion of the stream bottom (i.e., the proposed pre-cast low flow channel).

In response, the Intermediate (75%) Design showed surface water isolation and management being accomplished utilizing dual gabion-lined channels; however, a constructability review determined that the 75% design would be difficult to construct. Therefore, the Pre-final (90%) Design was revised to show a primary channel and temporary secondary channel with precast sections covered by a gabion mat. This was intended to give the same outward appearance as the primary channel and would promote flow across the entire channel width. The 90% Design was provided to several contractors and feedback was requested on the constructability, cost and value. Based on their input, the pre-cast channel sections were eliminated and the design was developed to its final form, presented herein. As shown, a temporary (removable) wall will divide the Little Elk Creek into a primary channel (measuring approximately 50 feet in width) and a secondary channel (measuring about 13 feet in width) during construction and when repairs are required. Both sides of the channel bottom will be lined and covered with a gabion mat. The secondary (non-site side) portion of the channel will have a full flow capacity of about 100 cfs when the temporary dividers are in place.

Following construction, the entire width of the creek will be available for stream flow and the remedy will function as a single channel. The proposed alignment and details are shown on the Design Drawings.

4.2 CHANNEL ISOLATION SYSTEM

The construction of the stream isolation system will include the following components:

- Structural Walls;
- Subbase Grading;
- Collection System;
- Barrier and Protective Layers; and
- System Anchorage.

These components are described in more detail in the following subsection.

4.2.1 Structural Walls

Cast in place concrete walls (structural walls) will be constructed along the eastside of Little Elk Creek (longitudinal wall) and across the proposed channel lining system at the upstream and downstream limits of the remedy and at two intermediate locations (cross stream walls). The walls will provide stability and anchorage for the proposed gabion mat channel lining, and barrier layer components. The types of structural wall, are discussed below.

Longitudinal Wall

A cast-in place concrete wall will be provided along the eastern stream bank. The wall will be aligned as shown on the drawings, and will define the limits of the temporary secondary channel. The top of the longitudinal wall will be flush with the proposed top of the gabion mat and will separate the barrier components of the primary and secondary channels. The longitudinal wall will be designed to hold steel plates, or polyethylene sheets, that will provide separation between the primary and secondary channels, when required, such as during construction or maintenance. During normal operation, flow will occur over the width of both channels as dictated by grading. There will be no separation of flow during normal operation. The gabion mats and barrier layers will be anchored to the wall and the wall will be anchored into bedrock, using steel bars (#8 rebar) grouted in place.

Cross Stream Walls

Cross stream walls will extend the width of the channel, between the site side stream bank and the opposite bank. The upstream and downstream walls will be anchored into bedrock using rock-anchors. Both walls will extend four feet below finished grade and will have the underlying sediment and decomposed pressure grouted. The pressure grouting beneath the downstream wall is intended to provide containment of the potentially contaminated groundwater. The pressure

grouting beneath the upstream wall will minimize the amount of clean water entering the collection system.

A debris interceptor, as presented on the design drawings, will be situated at the upstream wall and extend across the creek. The debris interceptor is intended to slow down, and when possible prevent the movement of large debris across the lined portions of creek. Because of the dynamic/high energy environment of the creek, the debris interceptor has been designed to shear at its anchor bolts before de-stabilizing the cross-stream wall.

Two additional cross channel walls will be constructed at locations between the upstream and downstream cutoff walls for the purpose of dividing the system into separate sections to: provide stability; simplify construction; allow the segregation of groundwater collection areas; and improve performance of the collection system. These walls will extend a uniform depth of 3 feet below finished grade and will be anchored into the underlying rock with steel bars (#8 rebars) grouted in-place.

4.2.2 Subbase Grading

The existing creek bed and banks have highly irregular grades with large rubble and debris, and therefore are unsuitable in their present state for the placement of geosynthetic barrier layer components. Drawings 4 and 5 provide a representation of the proposed base grading for the stream isolation system. This grading was developed to:

- Maintain the existing creek bed topography and bank slopes and minimize encroachments into the existing creek channel which could result in increased flood elevations;
- Provide smooth hydraulic transitions along the Creek alignment;
- Provide a stable base for support of the liner and Gabion mat/wall; and

- Provide habitat diversity.

The grading shown requires that cutting and filling of materials within the footprint of the isolation system be performed. During construction, the amount of grading will be minimized to maintain the natural irregularity existing in Little Elk Creek (which provides a diverse benthic habitat). Some cutting/filling of creek bed and bank materials will be necessary. To minimize and possibly prevent the disposal of excess material and provide suitable materials for construction of the collection system and liner subbase, sediments from structural wall and collection system excavations will be segregated by size and reused. Material between 2 inches and 3/4 inches will be used around the collection system. Material < 3/4 inches will be used for grading the liner subbase. Material > 2 inches will be steam cleaned, sorted based on size, and used in the gabion mats and for site restoration. During construction, grades will be achieved by first removing existing surface rubble, boulders, and debris, and then performing grading of the remaining sediments. If additional materials were required, washed gravel meeting the specified gradation requirements will be placed as necessary to smooth out unacceptable irregularities. The construction of the Gabion wall along the Site frontage will require the construction of a 4-foot wide bench. Excess material produced during the construction of this 4-foot wide bench will be used to grade the slope area between the edge of flow and the bench prior to liner placement.

Construction along the opposite (non-site) stream bank will include both cutting and filling. Excess uncontaminated soil from the non-site areas will be utilized for minor grading and restoration activities outside the limits of the channel.

4.2.3 Collection System

The collection system will collect the isolated groundwater flowing into the affected areas from the creek sediments, overburden and underlying bedrock. Separation of any DNAPL which enters the system will be handled within the sumps, prior to entering the treatment system, as shown on the Design Drawings.

The groundwater collection system will be situated within the prepared subbase and beneath the barrier layer. The collection system will consist of 6-inch diameter corrugated polyethylene pipe with smooth interior walls and perforations. The collection pipe will be placed in a bed of the 3/4-inch to 2-inch gravel generated during subbase grading and excavation for the collection system piping, wrapped in a non-woven geotextile to provide separation and filtration between the gravel and the stream sediments.

The collection system will be divided into three sections with the construction of two midstream cross channel walls, each operating independently of the other. The collection pipe will pass through each cross channel wall, but flow through the pipe will be controlled by a valve. During normal operation, the valves will be closed so that each section will operate independently of each other. However, during construction, the pilot study, and during any significant downtime of the treatment system, the valves will be opened to avoid excessive upward pressure on the liner. The collection system was divided into three sections because the midstream walls will provide additional anchorage of the barrier layer. In the event that a segment of the RA is damaged, this additional anchorage will help maintain stability until the necessary repairs are made.

Two rows of collection pipe will be placed parallel to the creek alignment as shown on the Design Drawings. These pipes will be connected to each other by perforated lateral pipes. The collection pipe will be connected to non-perforated pipe which will carry collected water to the sumps. Head control will be provided in the sumps to maintain full flow in the collection pipes at all times in order to minimize chemical and biological fouling. Clean-outs will be provided at the end of each collection pipe (at the upstream, mid-stream and downstream cutoff walls) to allow access for routine maintenance. Each section will convey water to its own sump. Each sump will have a pump and will convey collected water directly to the treatment system where it will be mixed prior to treatment. As part of O&M practices, a back up pump will be kept on-site in case a pump should break down. A valve will be placed in each manhole to prevent flow into the sump during maintenance. Conveyance piping will be situated within an 8-inch diameter corrugated polyethylene pipe running between the manholes as shown on the design drawing.

A 4-inch diameter corrugated polyethylene collection pipe will be placed along the east creek bank behind the gabion wall and underneath the gabion mat side slope. The elevations of the pipe invert will range between 2 to 3 feet above the lowest elevation of the liner within the creek bed directly adjacent to the collection pipe. This pipe will provide a relief in the build up of upward pressure on the liner if the treatment system is temporarily not in operation. This pipe will also collect surface water runoff as well as groundwater behind and/or underneath the gabion mat/wall. The collected water will discharge into the creek through the gabion wall.

4.2.4 Barrier and Protective Layers

The barrier and protective layer components will be exposed to physical forces created by weather, flow conditions, wildlife, and human factors. The barrier layer component will provide the separation between surface water and groundwater flow in the Creek sediments. Success of the RA is dependent upon the long-term operation and survivability of the barrier layer, therefore making the protective cover a critical component. Key issues considered during the design include:

- velocity resistance;
- permeability (air and liquid);
- abrasion resistance;
- puncture and tear resistance;
- weather/temperature tolerance;
- multi-axial elongation and settlement;
- chemical compatibility;
- biological degradation;
- wildlife impact; and
- vandalism.

4.2.4.1 Barrier Layer

The primary component of the barrier layer will be a geomembrane. A 45 mil scrim reinforced polypropylene geomembrane is proposed for the following reasons:

- it has a low vapor transmission rate (pseudo-permeability), 0.08g/M^2/day;

- it has lower flexural modulus than 60 mil HDPE which permits it greater elongation to conform with the existing stream bed thereby minimizing grading;

- it has higher puncture resistance than 60 mil HDPE; 50 percent higher for standard puncture (ASTM D-4833) and 400 percent higher for large scale hydrostatic puncture (GRI, GM-3);

- it has wide temperature tolerance (flexible at temperatures greater than 40 below zero);

- it's tensile strength with scrim reinforcement is equal to 60 mil HDPE;

- it has lower expansion and contraction rates (less than 15 percent of HDPE or LLDPE); and

- Polypropylene is a member of the polyolefin family (as is HDPE) and is resistant to chlorinated and non-chlorinated compounds at the concentrations observed in the creek.

In addition to the geomembrane, the design specifies that a composite geosynthetic clay liner (GCL) be placed as a secondary barrier layer. The composite member of the GCL is a flexible plastic membrane liner bonded to the non-woven side of a conventional GCL. In this design, the composite GCL will be situated beneath the geomembrane, and the membrane side will be placed face down on the barrier layer subbase. The composite GCL is intended to provide additional protection against puncture and leakage. The membrane on the GCL is intended to prevent hydration of the GCL during installation.

4.2.4.2 Protective Cover

During the design process, AGC considered the following protective cover systems:

1. Gabion mats
2. Concrete
3. Grout filled blankets
4. Stone filled geocells
5. Riprap/Boulders

Based on our analysis of the various materials and required performance criteria, it was determined that the most reliable and durable protection of the barrier layer will be provided by a Gabion mat separated from the geomembrane by a geocushion/geotextile layer. The use of gabions and related materials will enable the necessary habitat restoration to occur both within the stream and in the adjacent transition zone between the stream and the riparian corridor while providing the liner protection which is essential to long term performance. The geocushion (32 oz/sy geotextile) and geotextile (16 oz/sy) will provide protection against abrasion and puncture.

The other protective covers were eliminated for the following reasons:

- Concrete was eliminated due to cost, difficulties in repairing the underlying liner system, resistance to siltation, appearance, and the inability to restore habitat within the creek.

- Grout filled blankets were eliminated due to difficulties in repairing the underlying liner system, resistance to siltation, and the inability to restore habitat within the creek.

- Articulated concrete blocks were eliminated due to cost, contractibility, thickness requirements, the presence of voids and the inability to restore habitat within the creek.

- Stone filled geocells were eliminated due to stability problems and difficulties in achieving design velocities without grouting.

- Riprap boulder covering was eliminated because of the excessive thickness that would be required and potential for shifting that would expose and/or damage the

geomembrane. This was confirmed by discussions with the ecological/restoration experts. Additional thickness would also raise post RA flood elevations

Long-term survivability of Gabion mats is very good when properly installed and Gabions are conducive to siltation and renaturalization of the stream bed. They provide an excellent substrate for the restoration of habitat, which will be further enhanced by backfilling with sand and silt as required by the restoration plans. Maintenance is easier than with most other protective layers (especially concrete channel linings or grout filled blankets) because Gabions can be removed and replaced in sections without compromising the entire system. Additional protection can be provided by grouting of the Gabion basket in potential high-scour zones. Protection against exposure of the underlying barrier layer caused by shifting or movement of the protective stone is provided by the Gabion basket, while the armor-like layer of stone protects against puncture, high flow velocities, scour, abrasion, vandalism, and burrowing wildlife.

4.2.5 System Anchorage

The barrier and protective layers will be continually exposed to hydraulic forces of varying magnitudes. Severe stream flood events may carry large debris such as boulders and tree limbs that may encounter the system, exerting potentially damaging forces on the system components. In order to prevent movement of the protective cover, which may cause abrasions, punctures, tears, and elongation of the barrier layer, both the barrier and protective systems will be continuously anchored around the perimeter as described below:

- The barrier and protective layers will be battened to the concrete structural walls which will be anchored to the underlying bedrock. A continuous strip of geomembrane will be cast into the structural walls and extended across the batten strip. The geomembrane strip will be welded to the barrier layer to provide redundant protection against leakage.

- On the Site side, the barrier and protective systems will be confined under the weight of the Gabion wall. The barrier layer will extend behind the wall to a horizontal anchor trench.

- On the non-site side, the barrier layer will be terminated as shown on the design drawings confined by the weight of the overlying gabion mats and/or walls.

- In addition to the anchorage at the upstream and downstream cutoff walls, two interior cross-walls will be constructed across the creek. The protective cover and barrier layer will also be anchored at these locations. These interior cross-walls will be structurally tied to bedrock using rock anchors.

4.3 CHANGES TO EXISTING HYDRAULIC CONDITIONS

4.3.1 Introduction

The proposed Removal Action imposed a variety of design restraints that required close attention during preparation of the design and a clear understanding of how the changes in one hydraulic conditions would dictate a change in another. While the design required the stream bed elevation to be increased by about one foot, additional design restraints were as follows:

- Minimize, and to the extent practicable, prevent an increase in the 100 year and 500 year flood elevations.

- Select a cover for the proposed barrier layer that will tolerate the dynamic stream conditions and protect it from natural and manmade forces, while minimizing thickness of the cover.

- Provide a post removal action stream bed that provides diverse flow conditions and generally mimics the existing irregularity/flow regimes of the stream bed.

- Provide base flow stream velocities and depths that are condusive to the migration of fish and re-establishment of a benthic habitat.

- Re-establish habitat within and along the stream, including the riparian areas.

In general, these restraints represent conflicting goals. For example, providing the necessary protective cover for the barrier layer will result in a reduction of the stream channel's cross-sectional area that must result in an increase in flood levels and/or an increase in velocities. The design, as presented, balances each of the restraints listed above and provides the following:

- 100 and 500 year flood levels are approximately equal to their current levels, with a slight decrease in flood level at the residential properties and a slight increase in the flood elevations directly upstream of Providence Road Bridge.

- Base flow velocities will experience a slight increase over existing conditions within limited sections of the creek, although in general the increase in base flow velocities from existing to proposed conditions will be less than 0.3 feet per second. The maximum increase will be less than 0.75 feet per second. Based on a review of the data by the ecological design team members, the predicted increases will not impact the migration of fish. Additionally, the stream's physical features are being replicated to provide a post-RA habitat consistent with the pre-RA habitat value.

- In general, little or no grading will be required within the creek; however, within a limited area in the vicinity of the Providence Road Bridge, minor regrading will be necessary to prevent a restriction of flow beneath the bridge.

- Impact to flood levels will be minimized through the removal of the existing foot bridge, the former office building on the east side of the creek, and several small site structures. This improves over bank flow conditions and decreases flood plain elevations.

A complete discussion of the evaluations/modeling performed as part of the design process follows:

4.3.2 Description of Modeling Efforts

Changes to the existing hydraulic conditions of Little Elk Creek due to the implementation of the RA were evaluated by comparing water surface elevations, depths of flow, and flow velocities using the HEC-RAS computer software.

The reach of Little Elk Creek which will contain the proposed gabion-lined channel and associated restored habitat is defined at its upstream and downstream limits by dams. The significance of these dams is that the flow within the reach will be dictated by "upstream control" and any changes in hydraulic conditions as a result of the RA may only be realized within the relatively short reach between these two dams. The HEC-RAS analysis indicates the following regarding changes in water surface elevations, depth of flow, and velocities resulting from the construction of the RA. Appendix B provides a detailed discussion of the hydraulic modeling and comparison for each flow condition.

4.3.3 Water Surface Elevations/Depth of Flow

The change in water surface elevations for base flow and the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events is discussed below.

Base Flow Depth and Elevations

A primary concern expressed during preparation of the design was the depth of flow during base flow conditions following implementation of the RA. As detailed in the analysis contained in Appendix B, minimum base flow water depths are predicted to be approximately equal to their current depths (0.23 feet versus 0.19 feet). Modeling has shown that the average water depth will decrease by approximately 0.7 feet, although the actual decrease will be less because the model can not provide the detail that will be introduced because of the habitat restoration and addition of physical restoration features.

The predicted water surface elevation is as much as 1.3 feet higher, attributed primarily to the 1.0 feet thick gabion mattress. Modeling has shown that the elevations of base flow will not change down stream of the Providence Road bridge. The predicted limits of base flow are plotted on Drawing 12.

Frequency Storms Flow Depth and Elevation

The HEC-RAS modeling of the frequency storm events (2-,5-,10-,50-,100-, and 500- year storms) has shown that, although water surface elevations will increase at some cross-sections and decrease at others, the maximum predicted water surface elevations will be approximately the same before an after construction of the RA remedy. Considering the 100 year storm event, the maximum predicted increase in flood elevations was approximately 9 inches. The maximum increase occurred directly upstream of Providence Road bridge and quickly returned to the existing levels within 350 feet upstream. The difference in the flood elevations is zero in the vicinity of the nearby residence. A plot of the pre-and post RA100-year flood elevations is shown on Drawings 1. As shown, the 100 year water surface elevation is equal to or slightly lower than existing conditions.

4.3.4 Flow Velocities

Although some decrease in velocity at a few locations will result, generally, the average flow velocity will increase within the Creek over the length of the RA. This is because the gabion-lined channel will be somewhat more smoother in comparison to the existing stream bed, with generally a more hydraulically efficient channel. Larger increases in velocity will be experienced within the higher stream flows. Changes in velocity during base flow and during the frequency storms is discussed below:

Velocity of Base Flow

Based on the HEC-RAS analysis, existing base flow velocities within the limit of the proposed RA range from 0.21 ft/sec to 2.2 ft/sec and average about 0.8 ft/sec. Flow velocities within the same reach following the construction of the RA are expected to range from 0.33 ft/sec to 2.95 ft/sec and

average about 1.1 ft/sec. Therefore, the implementation of the RA will only increase the average base flow velocity about 0.3 ft/sec. However, post-RA habitat restoration plans include low velocity, moderate depth areas to facilitate fish passage and re-establish pre-RA habitat conditions.

Velocity of Frequency Storms

The average velocity for existing conditions for the frequency storms was calculated to be about 7.6 ft/sec. The average flow velocity following the implementation of he RA is expected to be about 8.7 ft/sec. Therefore, the implementation of the RA will increase the average velocity in the stream during higher flows by about 1.1 ft/sec.

4.3.5 Conclusions

AGC offers the following conclusions regarding the impact of changes to water surface elevations, depths of flow, and velocities on this reach of Little Elk Creek:

- The banks of the main channel and overbank area within this reach of Little Elk Creek are currently very steep. Because the water surface elevations will be generally unchanged following the construction of the RA, with the steep banks, the lateral extent of flooding due to various events will remain essentially the same.

- The gabion-lined channel will cause a slight increase in flow velocities. However, the flow velocities quickly return to those of existing conditions immediately downstream of the gabion mat.

- The post RA flow depths will generally be slightly lower during all modeled storm events. Habitat restoration will establish variable flow depths and velocities.

The analysis provided above does not fully account for the diverse flow conditions during base flow within the post RA creek which will be provided for by the post RA habitat restoration plan. The HEC-RAS modelling was conducted assuming a roughness coefficient which accounts for the

roughness of the gabion lining while not fully accounting for the full extent of the in-stream habitat restoration features. It will not be possible to fully evaluate the impact on in-stream base flow velocities and base flow depth until the restoration features have been established. However, throughout the design process, the design has been modified to result in post RA base flow conditions which are as close as technically feasible to pre-RA hydraulic conditions.

4.4 ECOLOGIC CONSIDERATIONS AND HABITAT RESTORATION

During performance of the 75% design, the Group performed an ecological assessment of the Little Elk Creek in the vicinity of the proposed RA . The purpose of the ecological assessment was to provide a basis for the evaluation of pre-RA ecological conditions and to use the evaluation to provide post-RA stream and riparian habitat consistent with the pre-RA conditions. The draft ecological assessment was submitted to the USEPA, USDOI, and USFWS in April 1997 and included an evaluation of existing habitat conditions and value. The initial report has been modified to include additional data and to respond to comments received during review of the RA design. The report and supporting information are presented in Appendix G to this report.

The report presented two important pieces of information which will assist in the restoration efforts during implementation of the RA:

1) A ranking of current in-stream habitat value using the USEPA Rapid Bioassessment and Maryland Biologic Stream Survey protocols; and,

2) A ranking of the suitability of the riparian habitat for five species in the area adjacent to the stream. An additional species (mink) was evaluated at the request of the USEPA/BTAG and is included.

The evaluation also contained a review of earlier versions of the proposed Removal Action and ranked the value of the post Removal Action habitat. The current report contains a ranking of the 100% design habitat and will serve as a guide during restoration activities.

The results of the study show that the current in-stream habitat in the immediate vicinity of the site is generally highest immediately below the downstream dam and lowest above the upstream dam. The three sections evaluated within the length of the Removal Action (i.e., between the two dams) represented a transition zone with the in-stream habitat value ranked as intermediate between the upstream and downstream sections.

The benthic and riparian habitat in the vicinity of the site has been strongly influenced by land use both upstream (agricultural) and at the site. A stone and masonry wall 3 to 4 feet in height and completely backfilled extends along the western edge of the Creek bank. Topography in the Creek falls from the base of the wall towards the Creek at a flat to medium slope. At the opposite bank, grades rise sharply 6 to 8 feet, to a fairly flat top of bank area. In addition, the site section is bounded by both an upstream and downstream dam. The upstream dam (a 9 ft. high concrete masonry structure - circa 1832) would have significantly altered the pre-dam stream configuration. The identified sections of the stream are therefore expected to have varying habitat classifications due to these extensive historic alteration.

The evaluation of the predicted post RA conditions contained in the 75% design stage showed that the value of the in-stream habitat with only the proposed gabion mat would be less than the pre-RA conditions until the stream re-naturalization occurs. To improve the scoring in as short a time frame as feasible, several recommendations were made relative to stream restoration including:

- reproducing the diversity of stream flow to include riffle, pool and run areas;
- reestablishing the riparian habitat to increase diversity and quality of the plants; and
- minimize the physical barriers between the in-stream and riparian habitat created by the final conditions.

The 100% design incorporates these recommended design improvements to address ecological habitat concerns and presents detailed restoration plans and specifications for the in-stream and riparian areas. The Restoration Plan presents zones that will be replanted after completion of the

Removal Action, a table presenting the proposed species to be replanted is provided in the specifications.

Comments received from the USEPA/BTAG regarding the detailed conceptual restoration plan were incorporated into the final restoration design plans.

4.5 VOC VAPOR EMISSIONS DURING CONSTRUCTION

Because of the nature of the contaminants present in the sediments and groundwater beneath the portions of Little Elk Creek proposed for remediation, VOC vapor emissions may increase when surface water is removed from the work areas and when intrusive activities such as trenching are performed. In an attempt to predict the impact from the proposed work activities, AGC evaluated the potential for atmospheric VOC/vapor emissions during construction.

The evaluation of possible atmospheric VOC concentrations during the RA was performed using information contained in the Removal Action Design and measured contaminant concentrations from the pre-design investigation and previous sampling at the site. Results of the study are in a report titled Removal Action Evaluation of Potential Atmospheric VOC Releases During Construction, which is attached as Appendix D. The purpose of the report is to evaluate potential in-stream breathing-zone VOC emissions during construction and ambient air conditions in the vicinity of the stream which may exist during construction of the RA.

Based on the report, the construction area breathing zone concentrations are not predicted to exceed the 8-Hour Threshold Limit Value-Time Weighted Average (TLV-TWA) values for any of the contaminants considered. However, since concentrations of VOC's in the work zone may, at times, approach or exceed IDLH (immediately dangerous to life or health) levels for short periods, the Contractor will be required to monitor VOC concentrations throughout periods when the stream bed is dewatered and/or intrusive activities, such as grading and trench excavation, are being performed. When concentrations are observed to exceed allowable limits specified in the Contractor's Health and Safety Plan, workers shall be required to use appropriate personal protection equipment.

An evaluation of potential ambient air concentrations was performed to predict VOC concentrations in the air at locations near the stream where construction of the isolation system is to take place. The purpose of this evaluation was to predict the maximum anticipated concentrations of VOCs expected during construction in areas adjacent to work zones where exposure could occur. Based on a comparison of estimated ambient air concentrations to the health benchmarks as presented in the report (Appendix D), it was determined that the maximum predicted concentrations for methylene chloride and PCE would exceed the ambient air Risk Based Concentration (RBC) values provided by the benchmark. The RBC values are based on a 30-year exposure period and should be adjusted to account for the shorter exposure period during construction, estimated to be on the order of three to six months. The Contractor shall develop, as part of their Work Plan, a contingency plan (including such measures as the use of foam) for addressing potentially high VOC concentrations at nearby residents. The Contractor's plan shall also include real time monitoring of VOC ambient air concentrations. The plan will also include a set of VOC concentration criteria and action levels which will be used to trigger mitigating measures.

4.6 PERMITTING & ARARS

Based on previous discussions with the USEPA, and in accordance with provisions of CERCLA/SARA, it is not anticipated that any formal Federal, State or Local permit applications will be required for the RA work; however, where possible, the work will need to comply with the intent of the applicable permits. The EPA has prepared a table of Applicable and/or Relevant and Appropriate Requirements (ARAR) for the Removal Action. Upon review of the ARARs, some of the issues relating to permitting requirements may change. The Group is evaluating permitting and ARARs as the ARARs are made available, and will incorporate this information into RA-planning. AGC met with the Cecil County Government (i.e., Office of Planning and Zoning, Public Works, Soil Conservation, and Health Department) on August 14, 1996, to introduce the proposed RA and discuss permitting issues. Based on this meeting and discussions with MDE, it is understood that the provisions of the following permits apply to this project:

- A building permit (Planning and Zoning);
- A bridge encroachment permit (Public Works);

- Submission of a Grading Plan and an Erosion and Sediment Control Plan including a description of the proposed sequence of construction to Soil Conservation for a grading and earthworks permit;
- Non-tidal wetlands permit (Soil Conservation);
- NPDES (MDE); and
- Air (MDE).

AGC anticipates that a roadway access or occupancy permit may also be required.

In preparing to implement the East Mill Race stabilization project, AGC submitted a permit application to the Central Regional Chief of Non-tidal Wetlands and Waterways Division of MDE. Although not requesting a permit, the information was provided to the MDE for review. The MDE discussed the project with USEPA and responded formally in their letter dated February 2, 1998, which is contained in Appendix H.

Based on our past project experience, regulatory review and comment relative to non-tidal wetland issues and the acceptance of an Erosion and Sediment Control Plan may prove to be critical tasks in terms of requirements and scheduling. The Non-tidal wetland requirements typically include erosion and sediment control issues and is administered as a dual state and federal program which, to our understanding, is administered through the Cecil County Soil Conservation Services and/or the State Permit Center. Since the work area in the stream is greater than 5,000 square feet, restrictions at the County and State level, will apply. Therefore, the 100% Design will be distributed to the to the Cecil County Department of Public Works, Maryland Department of the Environment (MDE), Maryland Department of Natural Resources (DNR),and Fish and Wildlife Service.

The Erosion and Sediment Control Plan and Non-Tidal Wetlands Permit equivalence review application and local permit equivalency review will be submitted by the Contractor following award of the RA contract. NPDES and air permit applications will be submitted as part of the treatment system piloting and design.

4.7 EASTERN MILL RACE

Bypass channels were commonly used to divert upstream flow around dams to either hydraulically drive equipment, generate energy and/or to provide process water for manufacturing. Remnants of a former mill race around the eastern portion of the upstream dam (Spectron Dam) are very prominent. Portions of the stone/masonry walls of this former mill race are intact, while other portions have been dislodged by ice during the winter of 1996, and were washed forward during subsequent flooding. Concurrent with the preparation of this final design, stabilization of the Eastern Mill Race is being performed. The stabilization activities are intended to prevent further degradation of the mill race and possible negative impact on the function of the RA as currently designed. The plans for the Eastern Mill Race stabilization were included in the 90% Design, and have since been finalized and distributed to the USEPA, MDE and USDOI for their records. The USEPA, in their letter dated February 5, 1998 (included in Appendix H), directed the Group to proceed with the stabilization work immediately.

5.0 GROUNDWATER TREATMENT

5.1 TREATMENT CONCEPT

Once the stream isolation system is in place, water which would normally discharge to the creek from overburden, seeps, bedrock and through stream sediments will be captured by the collection system beneath the liner. This water will flow under gravity to a series of collection sumps. Once the treatment system is operational, contaminated groundwater will be delivered to the system from the sumps, via pumping. It is estimated that the collection system will continuously deliver approximately 25 gallons per minute to the treatment system. This section of the report describes the treatment system as currently envisioned and the process which will be used to complete the design of the system.

An extensive amount of groundwater quality information has been collected at the site to date. The majority of the information was collected to assess VOC concentrations in groundwater and the surface water quality of Little Elk Creek. During the Pre-Design Investigation, AGC collected groundwater, piezometer and surface water samples to supplement earlier data and also to analyzed select samples for inorganic and general wet chemistry parameters to identify compounds or constituents that could foul or otherwise interfere with the proposed groundwater treatment system. Data used to predict influent concentrations included shallow bedrock and overburden well data, as well as data from seeps located along the site-side stream bank, data from in-stream piezometers and data from geoprobe water samples collected from the overburden. During pre-design data analysis, the seeps were considered an expression of overburden groundwater. All monitoring well data is representative of vertically-oriented wells, which may not accurately represent influent concentrations from the horizontally-oriented collection system that will underlie the stream isolation system. AGC evaluated influent concentrations as an approximation of expected concentrations and as a starting point for screening treatment technologies. Since the RA collection system will collect a mixture of contaminants from 3 sources (overburden, bedrock and sediment), the proportions of contaminants from each source and the resultant concentrations cannot be accurately predicted prior to constructing the collection system. The influent Design Basis will be further refined during the pilot

testing proposed in this plan. Table 5-1 presents a summary of VOC data collected during the pre-design investigation and estimated combined groundwater concentrations.

To predict the flux to the creek, VOC data was spatially divided into three sections which correspond to the segments of the stream isolation system. The VOC mass flux (in mg/sec) was calculated for each segment and divided by the total expected influent flow (in l/sec). This produced an average concentration for each of the stream isolation segments, by contaminant. Based on these inputs, a flow-weighted average was calculated for the combined contribution from the three stream isolation segments. Using the estimated high end of the VOC range enabled an initial screening of primary treatment technologies which may be used as the basis for further evaluation once actual system samples have been collected. Conducting this preliminary screening will enable the pilot testing design to be conducted in a reasonable time frame. Some SVOCs have been detected at the site, however, not enough data is available to accurately predict SVOC mass fluxes.

There is far less inorganic and general wet chemistry data than VOC data. Therefore, a more simple averaging routine was used to predict influent concentrations for these parameters. Inorganic and general chemistry mass fluxes were not calculated. Since available inorganic and general chemistry data was limited, the concentrations across a given isolation segment were used to provide the most probable average concentration range, a best estimate and worst case scenario for each parameter. The results of this analysis are provided on Table 5-2.

TABLE 5-1

SELECTED VOC RESULTS

Zone	OB-2	OB-2	OB-4	OB-5	OB-5	OB-5	OB-6	OB-6	OB-6	OB-6	OB-7	Combined
Sample Location	B-5	B-5A	RD-7	MW-11	MW-11	RDGP-22	RAW-1	RAW-2	RDGP-17	RDGP-41	RD-17	Groundwater
Description	OB well	OB well	Stm Pz	OB well	OB well	Geoprobe	Sh. BR	Sh. BR	Geoprobe	Geoprobe	Stm Pz	
Unit	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Methylene chloride			170000									62000
Chloroethane	1000	580	3800	180					12			
1,1,1-Trichloroethane	9700	13000	55000	3200	4500	1300	350	480	3000	41000	430	29000
1,1,2,2-	620		2900	41					10			
1,1-dichloroethane	3100	3700	20000	400	1600	380	19	61	1100	11000	14	
1,2-dichloroethane	830	800	15000		86	17			35			
1,1-dichloroethylene				34		6.4			15			
cis 1,2-dichloroethylene	17000	20000	33000	2500	1400	510	180	320	2200	39000	130	10000
tran 1,2-				68		14						
Chlorobenzene			8100	220		57			20			
Ethylbenzene	530	600	2600	79	200	95			53	4300		
m-xylene (incl p-)	920	1200	3500	470	280	340			120	14000		
p-xylene												
o-xylene	260	320	1100	250	110	150			53	4200		
Tetrachloroethylene	700	830	5900	29	76	63	41	70	32	12000	86	5000
Trichloroethylene	600	800	920	82	560	60	78	110	310	8000	99	9000
Benzene			1100									
Toluene	3000	3600	9100	170	340	270			39	36000		2000
Acetone											1100	
Vinyl chloride	4200	3600		900	760	390			420	7200		
1,2-dichlorobenzene				480		390			320	25000		
1,4-dichlorobenzene										3300		
Chloroform			810									
2-butanone												

Table 5-2
Estimated Influent Concentrations to Treatment System

PARAMETER	AVE RANGE	BEST ESTIMATE	WORST CASE
Inorganics			
ALUMINUM	1240-15000	3500	42200
ARSENIC	9-23	20	23.3
BARIUM	84-378	310	544
CADMIUM	56-100	56	180000?
CALCIUM	130000-150000	140000	281000
CHROMIUM	13-85	25	158
COPPER	50-200	30	527
IRON	54000-95000	60000	491000
LEAD	5-230	20	634
MAGNESIUM	7200-18000	15000	25900
MANGANESE	1650-6050	3500	14800
MERCURY	.25-1.5	1	1.5
NICKEL	14-40	30	219
POTASSIUM	5240-19500	15000	33600
SODIUM	31000-55600	40000	82800
VANADIUM	9-99	50 ?	98.9?
ZINC	280-700	400	1950
General Chemistry			
ALKALINITY	47500-207500	180000	230000
AMMONIA NITROGEN	5135-13050	5500	27000
BIOCHEMICAL OXYGEN DEMAND	37500-235000	145000	730000
CHEMICAL OXYGEN DEMAND	292000-307500	250000	1400000
CHLORIDE	230000-402500	280000	680000
DISSOLVED OXYGEN	2-3	2.5	7
HARDNESS	160000-290000	185000	340000
KJELDAHL NITROGEN	2800-9000	4000	41000
NITRITE NITROGEN	180	180?	360?
OIL AND GREASE	1200-16000	2800	16000
pH*	5.4-6.4	6	7.4
PHOSPHORUS	145-210	155	660
SILICA	16000-24000	18000	38000
SULFATE	14000-38500	20000	47000
SULFIDE	1600-2300	2000	7000
SULFITE	1000-2000	1500	2000
TOTAL DISSOLVED SOLIDS	360000-1270000	600000	2100000
TOTAL ORGANIC CARBON	13300-220500	100000	790000
TOTAL SUSPENDED SOLIDS	179000-1005000	500000	1400000

1. All results are expressed in ug/l except as noted.
2. ? indicates data is limited, therefore, confidence is low.

5.2 DISCHARGE CRITERIA

5.2.1 Vapor - Phase Discharge Criteria

The vapor-phase effluent from the groundwater treatment system must meet the requirements set forth in the Code of Maryland Regulations (COMAR) 26.11.06 and 26.11.15. Federal regulations superceed state regulations, if more stringent.

The above mentioned regulations require an 85 percent removal of volatile emissions if total VOCs exceed 20 lbs/day. An 85 percent removal is to be achieved using Best Available Control Technology for Toxics (T-BACT). Additionally, individual Toxic Air Pollutant (TAP) limits cannot be exceeded. The individual TAPs limits are calculated using formulas contained in COMAR 26.15.08. Emissions must be modeled using one of several methods provied in COMAR 26.15.07. Additionally, particulates, nuisance emissions and/or odors must be controlled.

Controls can be removed if data indicates a downward trend in emissions and a two week period indicates less than 20 lbs/day of total VOCs are being released. If removal of controls is instituted, individual Toxic Air Pollutant (TAP) limits cannot be exceeded.

5.2.2 Liquid - Phase Discharge Criteria

The liquid - phase effluent from the groundwater treatment system must meet the requirements set forth in COMAR 26.08 and 40 CFR 122.

These regulations limit the discharge of total VOCs to a maximum of 100 parts per billion (ppb) as measured at the point of discharge. The acute and chronic exposure limits for fresh water are published in Table 1 of COMAR 26.08.02.03-2D. Specific limits for VOCs and metals are listed on Table 1. The point of compliance for metals can be the end of the discharge pipe or at the edge of

a mixing zone which is limited to one-third of the receiving stream width. The point of compliance will be determined based on pilot testing data.

The discharge criteria will be further developed based on additional data from the pilot test. Prior to initiation of full-scale groundwater treatment, AGC will provide all available groundwater and surface water data to the agencies to develop short-term and long-term discharge criteria for the site in accordance with the RAO.

5.3 PILOT TESTING

The RA consists of a stream liner which will be underlain by a collection system. The water which is collected below the stream isolation system will require extensive treatment before being discharged to Little Elk Creek under the requirements of a NPDES permit or returned to the subsurface via infiltration galleries. Upon completion of the Pre-Design Investigation at the Site, it was apparent that the design of an effective treatment system for groundwater would be difficult due to the presence of a variety of constituents, including Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), metals and various other inorganics from three sources. The design is further complicated by the inability to predict the resultant influent concentrations which will result when these three sources are mixed along the length of the stream containment. Based on this data, the pilot testing and/or treatability studies on the collected groundwater is deemed necessary.

The pilot testing concept was presented to the agencies prior to the 75% Design stage and it was determined that a Pilot Testing Plan would be developed. This section of the Design Report presents a summary of the general scope for a Pilot Testing Plan and a schedule for its implementation. The Group is in the process of evaluating vendors who are qualified to conduct the pilot test, design the long term system and perform operation and maintenance of the system. Once a firm has been selected, the pilot testing plan will be revised and finalized for implementation.

The collection system is designed to collect overburden and shallow bedrock groundwater, as well as dissolved DNAPL from the creek sediments. Estimating collection system influent concentrations

from these sources involves considerable uncertainty. Although the treatment of VOCs is a well understood process, pre-treatment of metals and other potential general chemistry parameters is more difficult. Therefore, sampling of the actual collection system influent, once the collection system has been installed, is considered necessary to provide accurate design data. Water collected prior to the start of piloting may be used for batch and/or treatability testing if deemed necessary. The collection system effluent data will be used to design a pilot and full-scale treatment system which will be capable of meeting discharge criteria which will be established as per the RAO.

5.3.1 Objectives and Scope

The primary objectives of the pilot tests are to evaluate influent flow rates, evaluate influent chemical and physical quality and to test various pre-treatment, treatment, post-treatment and air treatment technologies as necessary to prepare an implementable and successful final treatment system. The collection system is designed to collect only the water which would normally discharge to the stream segment adjacent to the site, not to create any drawdown or stress on the surrounding water bearing units.

The following elements will be evaluated during pilot testing:

- Collection system flow rates (system influent)
- Influent chemical and physical properties/quality
- Pre-treatment technologies.
- Sludge production and carbon usage/production and quality (hazardous or non-hazardous disposal).
- Primary treatment efficiencies/mass transfer from water to air.
- Vapor-phase capture efficiencies/carbon or energy usage.

The Group has interviewed several vendors who are capable of both conducting the pilot testing and designing/implementing a full scale system. Once the vendor is selected, the pilot test plan will be

reviewed by the vendor and the Group and finalized. An implementation schedule is included at the end of this section which will be further refined for submittal with the pilot test plan.

5.3.2 Pilot Testing Tasks

The pilot test will consist of two major tasks; collection system sampling and analysis; and piloting of treatment technologies.

These major tasks are further divided into the following general pilot testing scope-of-work which may be modified upon review by the Group and the pilot testing vendor:

- Collection System Sampling - The collection system will be sampled for a wide variety of parameters including VOCs, SVOCs, inorganics and general chemistry parameters. Batch and/or treatability testing would be performed at this point, if necessary. This data will be used to specify pilot system treatment and pre-treatment methods.

- Equilibrium Modelling - An equilibrium model will be used to determine what types of solids may form when the water from the three segments is combined. The formation of solids could result in fouling to components of the treatment system and could result in the exceedance of discharge criteria. Modifications to the pilot test will be based on the information obtained from the collection system sampling.

- Economic Evaluation of Viable Alternatives - An economic analysis will be performed to evaluate the cost/benefits of various treatment scenarios. The capital and long-term O&M costs will be weighed to determine the best low-cost, effective method of treatment prior to pilot testing. Upon completion of pilot testing, the selected pilot technology will be re-evaluated based on performance

during the pilot. If costs are considerably higher than anticipated, the piloted technology may not be selected as the full-scale treatment system.

- Design and Installation of Pilot System - The conceptual design will be modified, if necessary, based on the results of the collection system sampling, equlibrium modelling and economic evaluation. Upon completion of the pilot treatment system design, the system will be installed in a manner which will allow components to be added, if necessary.

- Evaluation of System Performance - The performance of the pilot system will be monitored by sampling the system effluent at the point of discharge.

- Modify Pilot System (if necessary) - Based on the performance of the initial pilot, modifications may be made or a second pilot test phase may be initiated.

- Evaluation of Modified Pilot System Performance (if necessary) - The performance of the above modifications (if necessary) will be evaluated by collecting additional effluent samples.

5.3.3 Transition from Pilot to Full-Scale System

Upon completion of the pilot testing activities and evaluation period, the final pilot system will be modified as needed to meet long-term, full-scale requirements. It is envisioned that the final full-scale system may only require modifications to the final configuration of the pilot system.

In any case, a final system design will be prepared followed by implementation of the full-scale system.

5.4 DATA EVALUATION

The pilot test analytical data will be used for three main purposes:

1) determining the effectiveness of the pilot technologies;
2) identifying trends in influent and effluent concentrations; and
3) developing parameters for detailed system design.

General trends in influent and effluent quality will be analyzed by graphing concentrations vs. time. This will provide information regarding the range of concentrations which will require treatment. Additionally, the effects of changes in air flow, influent temperature and possibly different equipment configurations can be evaluated.

The pilot will also provide data on chemical usage rates for floculants, coagulants and pH adjustment chemicals (acids and caustics). The rate of sludge and solids generation will also be determined during the pilot evaluation.

5.5 TECHNOLOGIES RETAINED FOR PILOT TESTING

This is a preliminary effort and is not intended to exclude any technologies which the selected vendor may evaluate in preparation for pilot testing.

AGC has conducted an analysis of the data collected to date in order to focus the pilot testing effort. The analysis performed include:

- Water quality equilibrium modeling (mixed water);
- Air stripper efficiency modeling;
- Evaluation of pre-treatment needs;
- Evaluation of VOC treatment needs; and
- Evaluation of off-gas treatment needs.

The results of the equilibrium modeling identified numerous constituents/parameters which will need to be evaluated during pilot testing including: aluminum, iron, manganese, BOD, COD, TSS and others. Equilibrium modeling using the system influent data will be one of the first steps of the pilot test. Results of the air stripper efficiency analysis indicates that air stripping may be a viable technology and should be retained for pilot testing. Options being considered include variable tower and packing configurations and the use of vacuum steam stripping. The use of carbon as a primary and/or polishing treatment is also being considered.

Off gas treatment technologies initially screened include vapor phase carbon, thermal oxidation, catalytic oxidation, regenerative catalytic oxidation and bio-filtration. With the exception of bio-filtration, all technologies are currently retained for pilot consideration.

Technologies for removal of potential foulants and other pre-treatment needs include filtration, setting/clarification, sequestering agents, precipitation and biocides. The need to pilot pre-treatment technologies will be determined based on the results of the collections system sampling and equilibrium modeling.

A brief discussion of some of the possible liquid and vapor phase (off-gas) treatment trains are provided below.

5.5.1 Air Stripping with Liquid-Phase Carbon and Thermal Destruction of Vapor-Phase

The main treatment component in this scenario is an air stripper designed to remove VOCs from the liquid-phase and transfer a high percentage of the VOC mass to the vapor phase. The air would then be treated using a thermal oxidation device which burns the VOCs resulting in safe byproducts including, chlorides, carbon dioxide and water. The VOCs which remain in the liquid-phase (at low concentrations) would then pass through a granular activated carbon polisher before discharge to the stream under the requirements of a NPDES permit, or returned to the subsurface via an infiltration gallery.

5.5.2 Air Stripping with Liquid-Phase and Vapor-Phase Carbon

The main component of this scenario is also an air stripper which will transfer VOCs from the liquid to vapor-phase. However, carbon would be used to remove VOCs from the vapor phase. Low-level VOCs in the liquid-phase would be treated via liquid-phase carbon. Treated water would be discharged as mentioned above.

5.5.3 Carbon Adsorption

The carbon adsorption scenario consists of two, liquid-phase carbon vessels which would be placed in series. Contaminated water would flow through the first bed where most VOCs would be deposited on the carbon before flowing to the second vessel. The second vessel would simply act as a back-up until exhaustion (breakthrough) of the first vessel occurred. At this point, the second vessel would become the lead while the first vessel is replenished and then acts as a lag. The discharge of treated water would be handled as previously discussed.

For each of the above potential treatment scenarios, various pre-treatment technologies will be tested which may include:

- filtration;
- settling/clarification;
- sequestering agents (scale control);
- precipitation; and
- biocides.

Based on the composition of the system influent, a series of pre-treatment/post-treatment elements will be included in the pilot testing.

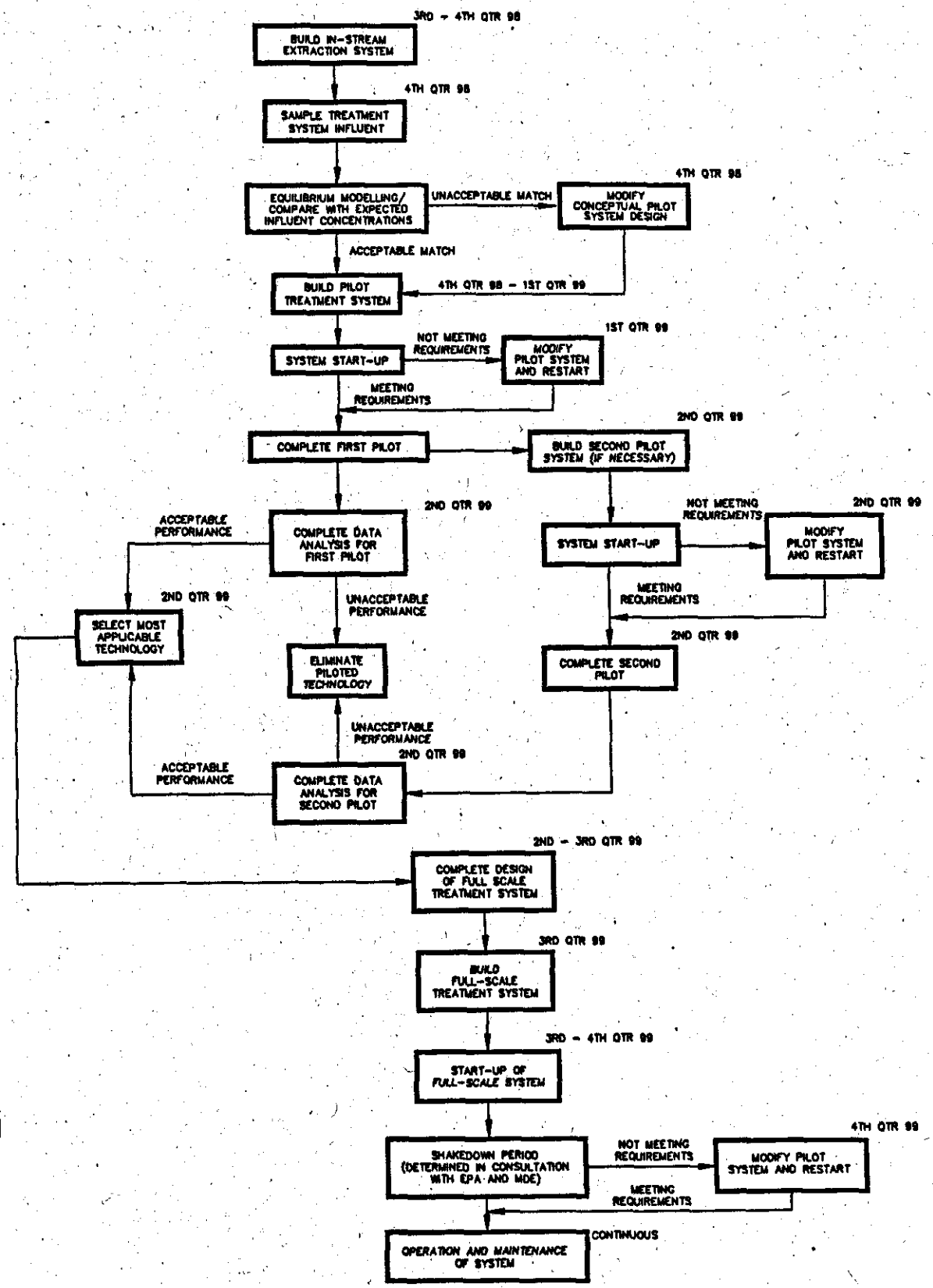
5.6 PILOT TESTING SCHEDULE

The pilot testing activities are scheduled to begin immediately after completion of the stream isolation and collection system installations. Depending on the construction sequencing, sampling of the system influent may begin as early as November 1998. Figure 5-1 is a flow diagram which depicts the general sequence of events which will take place in order to complete the pilot test and implement a full scale system. The pilot testing schedule is provided on Figure 5-2. The stream channel lining portion of the Removal Action will be completed prior to initiation of groundwater treatment system. This will require the passive release of groundwater which would normally discharge to the creek at the down-stream limits of the channel lining. This will allow the groundwater to flow through the sediment in the same manner that lateral flow beneath the stream bed is already occurring. Once the treatment system is fully functional, the passive release of groundwater will be stopped and the Removal Action treatment system will be functional.

5.7 PROJECT TEAM

The successful completion of the pilot testing plan will require the skills and capabilities of individuals from several organizations. The Group is in the process of interviewing several potential subcontractors who specialize in the design, testing and installation and operation of groundwater treatment systems. When selected, the subcontractor will provide input on the following:

- review and revision of the Pilot Test Plan (summarized here);
- sampling of the collection system
- equipment design and selection;
- pilot testing and data analysis;
- modifications to the pilot and full-scale system;
- design of the full-scale system; and
- long-term operation and maintenance (O&M).



Date: 6/30/97	PILOT TESTING AND GROUNDWATER TREATMENT FLOW PATH
Scale: N.T.S	
Drawn By: S.A.C.	Advanced GeoServices Corp. Chadds Ford Business Campus, Rts. 202 & 1 Brandywine One, Suite 202 Chadds Ford, Pennsylvania 19317
Checked By: S.S.C.	
Project Mgr: G.K.R.	
Dwg No. 95227-01	Project No. 95-227-05
Issued:	Figure 5-1

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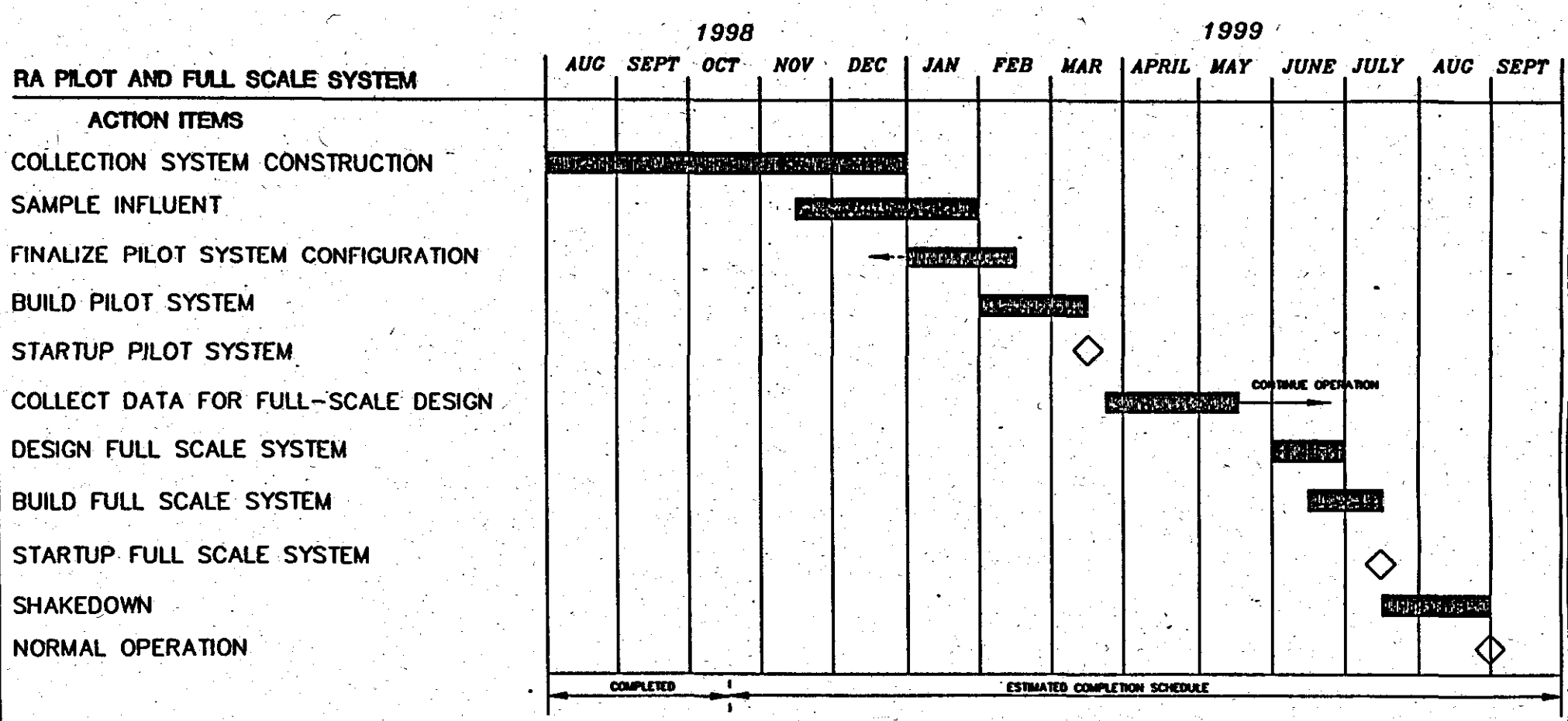
PILOT TESTING / FULL-SCALE SYSTEM IMPLEMENTATION SCHEDULE



NOTES:

◇ INDICATES SIGNIFICANT MILESTONES (START-UPS AND NORMAL OPERATION)

(1)

Date: 7/16/97	IMPLEMENTATION SCHEDULE
Scale: N.T.S.	
Drawn By: V.E.N.	Advanced GeoServices Corp. Chadds Ford Business Campus, Rts. 202 & 1 Brandywine One, Suite 202 Chadds Ford, Pennsylvania 19317
Checked By: B.S.C.	
Project Mgr: W.K.R.	
Dwg No. 95227-03	
Issued:	Project No. 95-227-05 — FIGURE: 5-2

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6.0 ESTIMATED REMOVAL ACTION CONSTRUCTION SCHEDULE

Presented on Figure 6-1 is an updated estimated schedule for the Removal Action Construction. Assumptions and limitations to this schedule are listed below.

- Agency review of the Final design will proceed in accordance with the time frames shown.

- Approval of the Final design will be received no later than April 15, 1998.

- This schedule does not provide for protracted permit/approval negotiations. It is expected, based on previous discussions, that the USEPA will assist in expediting the permit equivalency review process for all State, and Federally required approvals.

- The Removal Action schedule presented in this 100% Design Report is predicated on the following:

  - Procurement of construction materials will begin during late May, 1998;

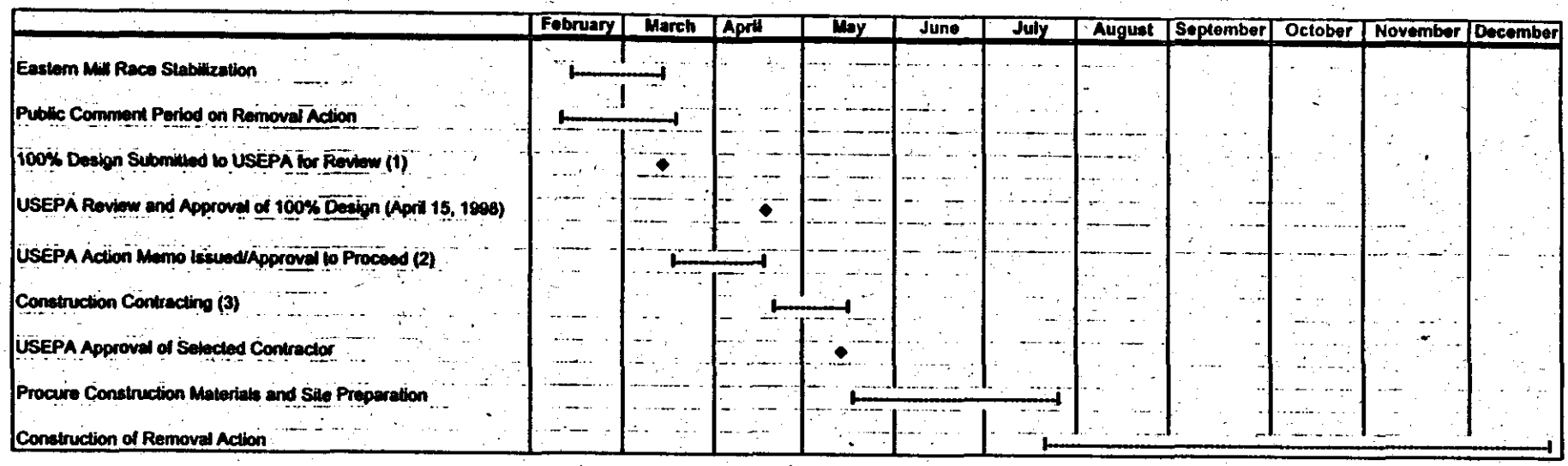
  - Construction will begin during mid summer;

  - Regulatory approvals are obtained on schedule; and

The current schedule also anticipates that the in-stream components of the RA (including groundwater collection components) are constructed on a separate schedule from the groundwater treatment system. Pilot testing of potential groundwater pre-treatment, treatment and air treatment technologies is required, prior to implementing full scale treatment operations.

It is planned that the pilot tests would be conducted using groundwater collected after installation of the in-stream collection components. Although this will delay the initial full-scale start-up of the treatment systems, it is anticipated that the certainty provided by the pilot will shorten the shakedown period for the full-scale system, thereby accelerating the schedule of a fully operational treatment system. The schedule for the pilot testing program is included in Section 5 of this report.

GALAXY/SPECTRON REMOVAL ACTION SCHEDULE



Notes:
(1) 100% Design submitted to USEPA on March 15, 1998.
(2) USEPA review completed and action memo issued on or before April 15, 1998.
(3) The group will submit the name of the selected contractor to USEPA on or before March 15, 1998.
(4) Schedule for pilot testing presented in Section 5.0 of this report.

AR100165

7.0 CONSTRUCTION SPECIFICATIONS

Construction Specifications for the RA are enclosed as Appendix E. Technical specifications are presented in three sections:

Division 1 - General Requirements
Division 2 - Site Work
Division 3 - Concrete

The Construction Quality Assurance Plan (CQAP) is presented in Appendix F.

APPENDIX A

PEAK DISCHARGE CALCULATIONS

APPENDIX A

SUMMARY OF PEAK DISCHARGE CALCULATIONS

The following three methods were used to estimate peak discharge for Little Elk Creek:

- Regression Equations from the U.S. Geological Survey Water - Resources Investigations Report 95-4154 "Technique for Estimating Magnitude and Frequency of Peak Flows in Maryland."

- Reduction of 1992 FEMA peak discharge data of the entire drainage basin of Little Elk Creek presented in the "Flood Insurance Study, Town of Elkton, Maryland, Cecil County", Federal Emergency Management Agency, June 16, 1992.

- Synthetic hydrograph methods in the (HEC-1) Flood Hydrograph Package U.S. Army Corps of Engineers Hydrologic Engineering Center, September, 1990.

Regression Equations

Regression equations developed from Maryland stream gauge data were presented in the U.S. Geological Survey Report (95-4154) for the Piedmont Area of Maryland. The input parameters were the drainage area, A, (19.8 mi^2) and percent forest cover, F, (18.7%). Both areas were determined from USGS Oxford, Pennsylvania; Bay View, Maryland; and Newark West, Delaware quadrangle maps. A reduced copy of these maps showing the drainage area of Little Elk Creek above and including the Site is included as Attachment 1 of this Appendix.

The following equations were used:

$$Q_2 = 451A^{0.635}(F+10)^{-0.266}$$
$$Q_5 = 839A^{0.606}(F+10)^{-0.248}$$
$$Q_{10} = 1{,}210A^{0.589}(F+10)^{-0.242}$$
$$Q_{25} = 1{,}820A^{0.574}(F+10)^{-0.239}$$
$$Q_{50} = 2{,}390A^{0.565}(F+10)^{-0.240}$$
$$Q_{100} = 3{,}060A^{0.557}(F+10)^{-0.241}$$
$$Q_{500} = 5{,}190A^{0.543}(F+10)^{-0.245}$$

Where

Q_2 = Peak discharge for 2-year storm event, etc.

The following peak discharges were calculated from the above equations.

Flood Frequency (yrs)	Peak Discharge (cfs)
2	1,230
5	2,228
10	3,117
25	4,528
50	5,769
100	7,188
500	11,537

Reduction of FEMA Data

The following peak discharge were listed in the "Flood Insurance Study for the Town of Elkton Maryland, Cecil County", June 16, 1992. The drainage area for these discharges is the entire drainage basin (39.6 mi^2) of Little Elk Creek.

Flood Frequency (yrs)	Peak Discharge (cfs)
10	5,400
50	9,800
100	12,200
500	20,000

These peak discharges were reduced for the project drainage area of 19.8 mi^2 by the following formula:

$$\frac{Q_1}{Q_2} = \frac{(A_1)^{0.7}}{(A_2)^{0.7}}$$

Flood Frequency (yrs)	Peak Discharge (cfs)
10	3,336
50	6,033
100	7,510
500	12,311

Synthetic Hydrograph Method (HEC-1)

This method is available through the U.S. Army Corps of Engineers (HEC-1) Flood Hydrograph Package and includes the following four steps:

1. Development of a rainfall distribution.
2. Determination of rainfall losses (i.e., infiltration, evaporation, storage, etc.).
3. Determination of base flow.
4. Development of hydrographs.

These steps are explained below:

1. **Rainfall distribution**

For this analysis, a Type II 24-hour rainfall distribution function was chosen. The distribution curve function for this rainfall event was obtained from the "Design Hydrology and Sedimentology for Small Catchments", Academic Press, Hoon, Barfield and Hayes.

The following total rainfalls for various storm events were provided in the "Water Resource Data, Maryland and Delaware Water Year 1994", U.S. Geological Survey Water Data Report MD-DE 94-1. The total rainfall was reported by county.

Storm Frequency (yrs)	Total Rainfall (in.)
2	3.3
5	4.2
10	5.1
25	5.6
50	6.4
100	7.3

These total rainfalls were distributed over a 24-hour period using the Type II 24-hour distribut function to model a rain event.

2. **Rainfall Losses**

HEC-1 provi

e

Ampt Infiltration Function

- SCS Curve Number

The Uniform, Exponential, and Holtan Models require input parameters which are hard to apply to drainage basin characteristics. The Green and Ampt Function relates soil properties to infiltration rates; however, the data for these relationships is limited.

The SCS Curve Number was used since the loss function has been directly related to SCS soil classification. A review of the "Soil Survey of Cecil County, Maryland",

United States Department of Agriculture Soil Conservation, December 1973, shows that the watershed consists of the following three soil groups:

- Glenelg Silt
- Manor Loam
- Codorus Silt Loam

These soils are moderate to well draining.

Runoff curve numbers for different land uses were provided in the "Technique for Estimating Magnitude and Frequency of Peak Flows in Maryland". A composite curve number (CN) of 78 was calculated from the following Group C curve numbers:

Forest Cover = 73 (Area = 2,368 acres)

Grass Cover = 79 (Area = 10,304 acres)

$$CN = \frac{(73)(2,368 \text{ acres}) + (79)(10,304 \text{ acres})}{(2,368 \text{ acres} + 10,304 \text{ acres})} = 78$$

The CN of 78 is consistent with the values used to develop the regression equations in the "Technique for Estimating Magnitude and Frequency of Peak Flows in Maryland".

3. Base Flow

The base flow or normal flow is the seasonal stream discharge that generally derives from the groundwater and surface water reservoirs in the watershed, in absence of significant surface water runoff contributions. Stream discharge for base flow was field measured at several locations and was found to range from about 10 cubic feet per second (cfs) to 18 cfs. These values were generally consistent with data presented in the Maryland Geological Survey Bulletin 34 "Water Resources and

Estimated Effects of Ground Water Development, Cecil County, Maryland", dated 1988. A value of 18 cfs was used in the HEC-1 analysis.

4. **Hydrograph Calculation**

HEC-1 provides three synthetic unit hydrographs models:

- SCS
- Clark
- Snyder

All three models require the input of a time of concentration (t_c) or a basin lag time (t_l), which is a function of t_c.

The Clark and Snyder models also require the input of coefficients relating to storage capacity of the drainage area. For the Clark Unit Hydrograph Method, this coefficient (R) has been related to t_c in the "Clark Unit Hydrograph and R - Parameter Estimation" by George W. Sabol. Hydrology references provide coefficients for the Snyder Unit Hydrograph; however, these references only provide broad ranges.

A sensitivity analysis was performed for each model to see the effect of varying each parameter (t_c t_l, R) on the resulting peak discharge. The results of this analysis show that these models are very sensitive to the input parameters. Therefore, only the SCS and Clark Methods were used since the value for the storage capacity required for the Snyder Model could not be adequately determined.

Since the SCS and Clark Unit Hydrograph models are based on t_c, several methods were used to calculate the time of concentration of the watershed. The calculated values for t_c are listed below along with the corresponding R Parameter for the Clark Method.

Method	t_c (min.)	R (min)
Kirpich, 1940	305 (5.1 hrs)	327 (5.5 hrs)
USBR Design of Small Dams, 1975	304 (5.1 hrs)	326 (5.4 hrs)
SCS Average Velocity, 1986	278 (4.6 hrs)	298 (5.0 hrs)
SCS Lag Equation, 1972		
3% Average Basin Slope *	503 (8.4 hrs)	540 (9.0 hrs)
4% Average Basin Slope *	436 (7.3 hrs)	468 (7.8 hrs)
5% Average Basin Slope *	390 (6.5 hrs)	419 (7.0 hrs)

*Basin slopes range from about 3% to 5%.

The following table compares the peak discharge for a 100-year flood event based on the various time of concentrations.

	Peak Discharge (cfs)		Time to Peak (hrs)	
t_c (hrs)	SCS Hydrograph	Clark* Hydrograph	SCS	Clark
4.6	9,209	5,646	15.0	16.0
5.1	8,801	5,275	15.0	17.0
6.5	7,459	4,382	16.0	18.0
7.3	6,804	4,018	16.0	19.0
8.4	6,241	3,596	17.0	20.0

*HEC-1 computed a time-area curve for basin discharge.

It is believe that the t_c = 6.5 hours calculated using the SCS Lag Equation, 1972 with an average basin slope of 5% best models the watershed. Unlike the other equations for t_c, the SCS Lag Equation considers the effects of rainfall losses by using the SCS curve number (CN). The length to width ratio of the watershed is about 4:1, indicating that surface runoff drains quickly. Therefore, an average basin slope of 5% was used.

The peak discharges calculated from the SCS Hydrograph Method will be used since these values are more conservative than those calculated using the Clark Hydrograph Method. The discharges for various flood frequency are provided below:

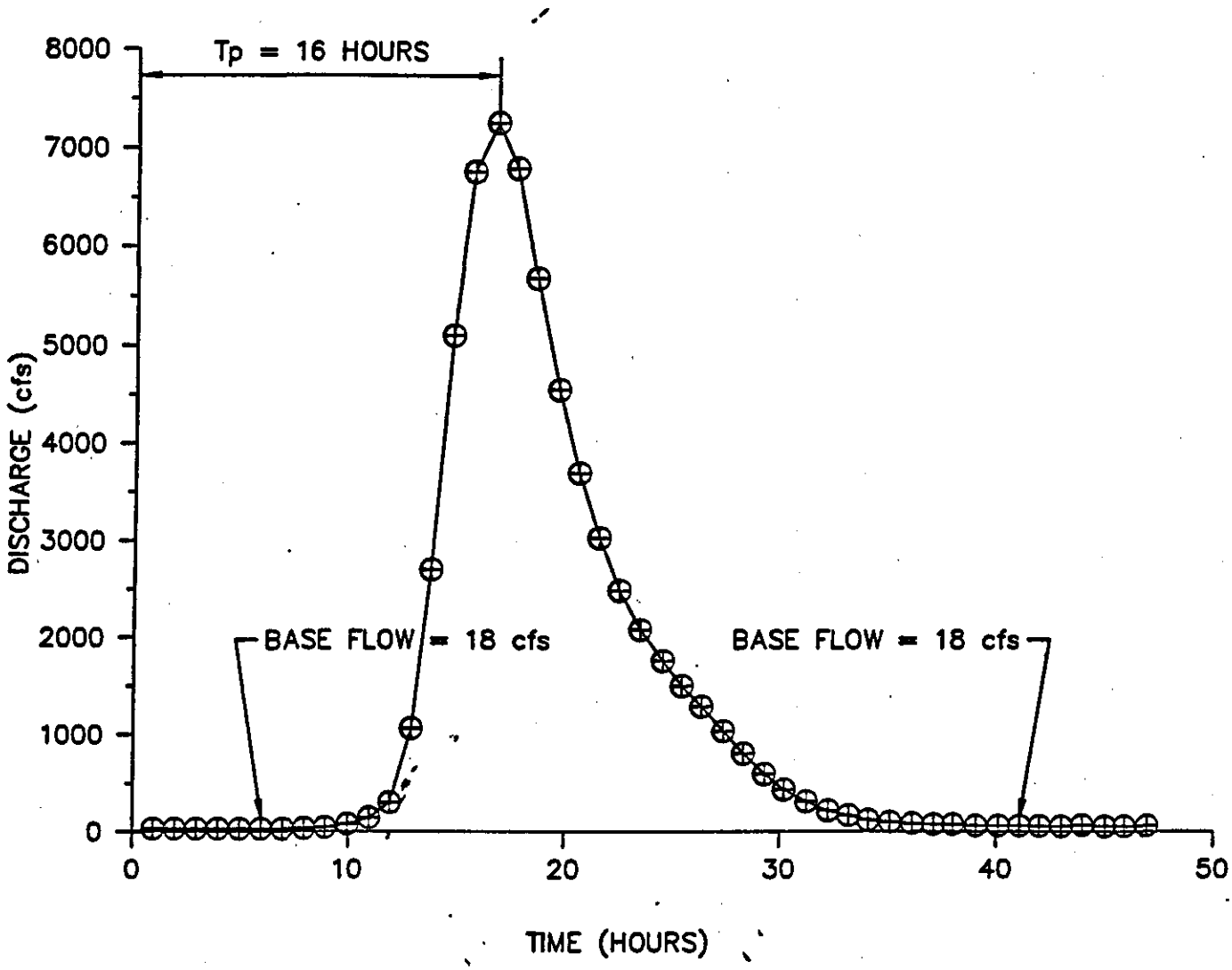
Flood Frequency (yrs)	Peak Discharge (cfs)
2	2,010
5	3,139
10	4,341
25	5,032
50	6,162
100	7,459

Attachment 2 presents a discharge hydrograph for a 100-year storm event based on the SCS Unit Hydrograph Method. Other flooding events would produce similar curves with the peak discharges shown above.

The following table compares the peak discharges calculated using the regression equations, FEMA data, and SCS Unit Hydrograph.

Flood Frequency (yrs)	Peak Discharge (cfs)		
	Regression Equations	FEMA	SCS Unit Hydrograph
2	1,230	NA	2,010
5	2,228	NA	3,139
10	3,117	3,336	4,341
25	4,528	NA	5,032
50	5,769	6,033	6,162
100	7,188	7,510	7,459
500	11,537	12,311	NA

NA = Data Not Available.



WATERSHED PARAMETERS

TIME FROM BEGINNING OF STORM TO PEAK DISCHARGE (T_p) = 16 HOURS
BASIN LAG TIME (T_L) = 3.9 HOURS
TIME OF CONCENTRATION (T_c) = 6.5 HOURS

GALAXY / SPECTRON REMOVAL ACTION

ELKTON, MARYLAND

Date: 10/01/96	DISCHARGE HYDROGRAPH 100 – YEAR STORM EVENT
Scale: N.T.S.	
Drawn By: P.S.G.	
Checked By: T.D.T.	Advanced GeoServices Corp. Chadds Ford Business Campus, Rts. 202 & 1 Brandywine One, Suite 202 Chadds Ford, Pennsylvania 19317
Project Mgr: T.D.T.	
Dwg No. 95228-08	
Issued:	Project No 95-228-02 — ATTACHMENT 2

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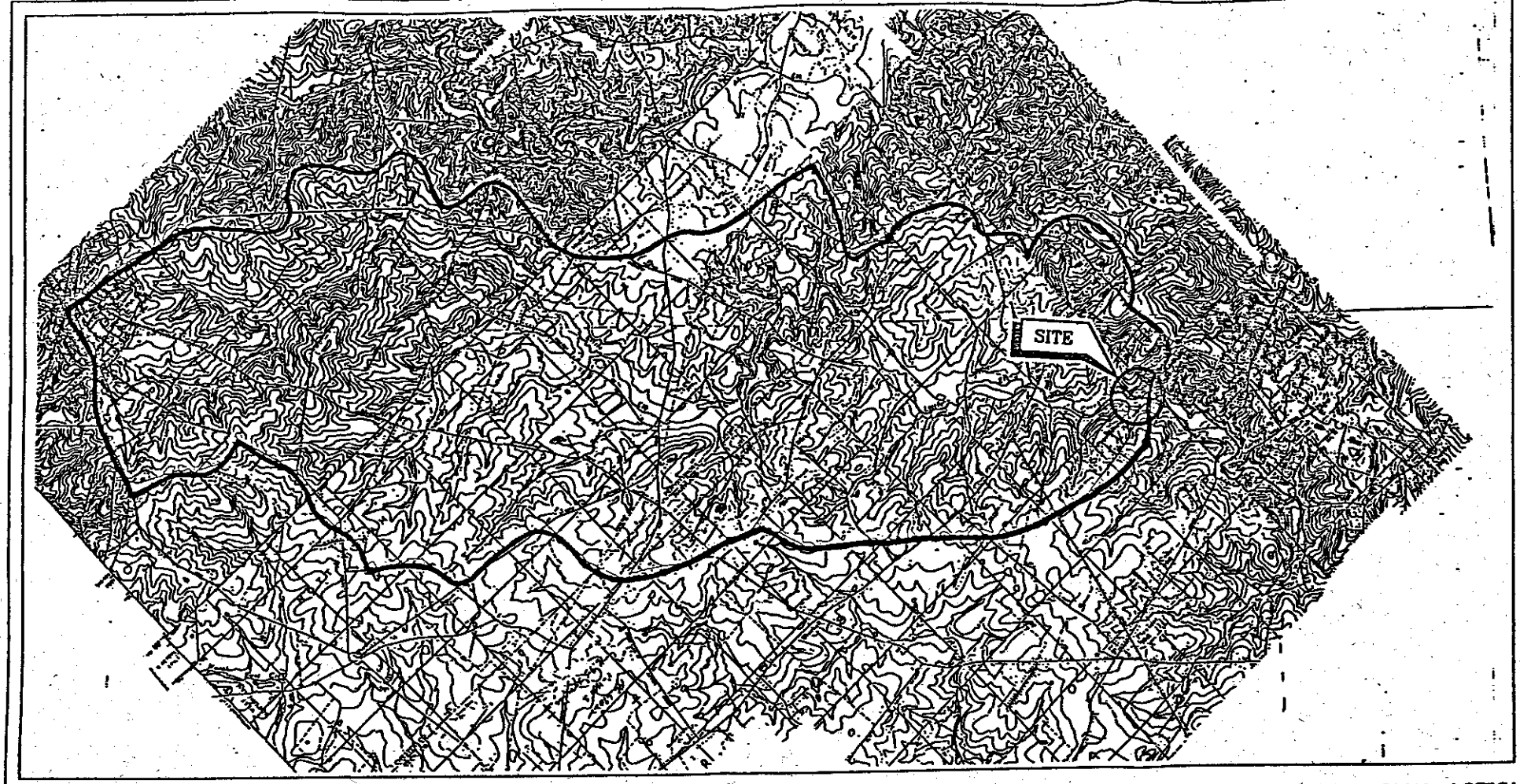

GALAXY / SPECTRON REMOVAL ACTION

Source: United States Geologic Survey (USGS) Oxford Pennsylvania, Bay View Maryland, and Newark West, Delaware quadrangle maps.

Date: 10/07/96	DELINEATION OF WATERSHED
Scale: N.T.S.	
Drawn By: P.S.C.	Advanced GeoServices Corp. Chadds Ford Business Campus, Rts. 202 & 1, Brandywine One, Suite 202, Chadds Ford, Pennsylvania 19317
Checked By: T.D.T.	
Project Mgr: W.K.R.	
Dwg No. 95228-17	
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APPENDIX B

HYDRAULIC MODELING

SUMMARY OF HYDRAULIC MODELING

A review of the June 16, 1992 Flood Insurance Study (FIS) for the Town of Elkton, Cecil County Maryland revealed that no formal hydraulic study (i.e., HEC-2 analysis) was performed for Little Elk Creek upstream of the city limits of Elkton, Maryland. Therefore, AGC as part of the Final (100%) design, performed a hydraulic evaluation of Little Elk Creek in the vicinity of the Site using the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) Software Package, Version 1.2, April, 1996. This software utilizes a steady-state, one dimensional step backwater model to calculate water surface profiles, and is the successor program to HEC-2. This hydraulic evaluation consisted of the creation of an existing conditions model of Little Elk Creek and modifications to this model to predict changes to existing conditions due to the stream isolation concept as proposed at the Final (100%) design stage. The hydraulic modeling included the following tasks:

1. Hydrologic Evaluation of Little Elk Creek watershed.
2. Hydrographic Survey of Little Elk Creek.
3. Hydraulic Modeling of Existing Conditions.
4. Hydraulic Modeling of the Final (100%) Design.

The remainder of this appendix has been formatted as follows:

- Summary of Conclusions
- Brief Description of Flow Conditions of Little Elk Creek at the Site.
- Summary of the Hydrologic Evaluation of Little Elk Creek.
- Hydraulic Modeling of Existing Conditions of Little Elk Creek.
- Hydraulic Modeling of 100% Design.
- Comparison of Results

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SUMMARY OF CONCLUSIONS

The reach of Little Elk Creek which contains the proposed gabion-lined channel is defined at its upstream and downstream limits by dams. The significance of the presence of these dams is that the flow within the reach will be dictated by "upstream control". This means that any changes in hydraulic conditions as a result of the RA will only be realized within the reach bounded by these two dams (i.e., Stations 4+13 to Station 14+74, as shown on Figure B-1).

In general, the HEC-RAS analysis indicates that flow depths resulting from the construction of the RA will be slightly lower than existing conditions. The flow velocities will be slightly higher. This is because the gabion-lined channel will be a smoother surface than the existing stream bed. The water surface elevations will generally remain unchanged. AGC offers the following conclusions regarding the impact of these changes on Little Elk Creek:

- The banks of the main channel and overbank area within this reach of Little Elk Creek are currently very steep. Because the water surface elevations will be generally unchanged following the construction of the RA, with the steep banks, the lateral extent of flooding will remain essentially the same.

- The gabion-lined channel will cause a slight increase in flow velocities. However, the flow velocities quickly return to those of existing conditions immediately downstream of the gabion mat.

- The post RA flow depths will generally be slightly lower during all modeled storm events.

- An increase in flow velocity and decrease in flow depth will have its greatest affect on base flow. The stream restoration activities will include the use of boulder islands and ripple pools (created by placing boulders) in order to braid flow to increase flow depth and therefore, decrease flow velocities.

FLOW CONDITIONS OF LITTLE ELK CREEK AT THE SITE

The reach of Little Elk Creek adjacent to the Galaxy/Spectron Site is bounded at both the upstream and downstream ends by dams. Two bridges, a foot bridge and a highway bridge (Providence Road) span the creek between these dams. These features are shown on Figure B-1 located at the end of this appendix.

Upstream Dam: The upstream dam is a 9 ft. high concrete masonry structure. No significant storage capacity is present in the reservoir behind the upstream dam. This occurs because most of the base stream flow passes through the former "stoplog" portion of the dam rather than over the crest, and the reservoir is virtually filled with sediment. Bypass channels (mill races) were commonly used to divert upstream flow around dams to either hydraulically drive equipment and/or to provide process water for manufacturing. These were probably the primary reasons for originally constructing the dam. Remnants of a former mill race around the eastern portion of the upstream dam are very prominent. Portions of this former mill race are intact, while other portions have been dislodged and washed forward during flooding. The mill race now is an eroded bypass channel with a single timber weir across the race at its upstream juncture with Little Elk Creek. The Group is currently performing stabilization activities to prevent further erosion to the mill race.

Downstream Dam: The downstream dam is a 4 to 5 ft high concrete structure. Under base flow, apart form seepage beneath the dam, all flow occurs around the eastern side of the dam in an eroded bypass channel. A former mill race bypasses the dam to the west. However, a massive steel plate has been placed across the race at its juncture with Little Elk Creek that blocks base flow.

Bridges: The Providence Road bridge spans approximately 85 feet and consists of a concrete deck supported on steel "I" beams. The steel beams are supported at concrete bridge abutments and a center concrete pier. The bridge is presently closed because of structural damage to the center pier. The bridge is scheduled for repair in late winter, early spring of 1998, and the repair will consist of a single span deck with no center pier. It is understood that the existing abutments will remain and

a steel deck will replace the existing concrete deck. Based on discussions with Cecil County Department of Public Works County Roads Department, it is expected that the elevation of the bridge deck and bottom chord will remain the same. The footbridge is a steel truss structure with a wooden deck. This bridge will be removed and not replaced during the RA.

Physical Conditions: The slope of Little Elk Creek between the upstream and downstream dams ranges from 0.004 ft/ft to 0.007 ft/ft. Creek bed grades are irregular because of the boulders covering the bottom. The creek bottom north of the footbridge is heavily lined with boulders and the amount of boulders decreases south of the footbridge. The surface configuration in the vicinity of the Creek has been strongly influenced by development of the Site. A stone and masonry wall typically 3 to 4 feet high was constructed along the western edge of the Creek bank and filling was performed behind the wall to create a relatively uniform site grade. The wall remains intact in some sections, while other sections have fallen down or have been buried. As shown on the Site Plan, topography in the Creek falls from the base of the wall towards the Creek at a flat to medium slope. At the opposite bank, grades rise sharply (in some areas nearly vertical) 6 to 8 feet, to a fairly flat top of bank area.

SUMMARY OF HYDROLOGIC EVALUATION OF LITTLE ELK CREEK

A hydrologic evaluation of the Little Elk Creek was performed to determine base flows, and the maximum peak discharges and behavior of the watershed during various flooding events. A detailed description of this analysis is provided in Appendix A. Based on this evaluation, the following discharges were used for the HEC-RAS modeling. Excluding base flow and the peak discharge for a 500-year storm event, these values are based on the HEC-1 analysis and generally represent the highest peak discharge rates calculated in Appendix A and the most conservative:

Flood Frequency (yrs)	Peak Discharge (CPS)
2	2,010
5	3,139
10	4,341

25	5,032
50	6,162
100	7,459
500	12,311*
Base Flow	18**

* Total Rainfall for a 500-year storm was not provided in the references used in the analysis. Therefore the peak discharge calculated from the FEMA data by basin area reduction procedures (see Appendix A) was used for a 500-year storm.

** Base flow was field measured with a flowmeter on August 2 and August 25, 1996 at several locations and was found to range from about 10 cubic feet per second (CPS) to 18 CPS. These values are generally consistent with data presented in the Maryland Geologic Survey Bulletin 34 "Water Resources and Estimated Effects of Ground Water Development, Cecil County, Maryland", dated 1988.

HYDRAULIC MODELING OF EXISTING CONDITIONS OF LITTLE ELK CREEK

A model of current hydraulic conditions of Little Elk Creek in the vicinity of the Site was developed to determine the water surface elevations and flow velocities at base flow and at the flood levels for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year frequency storms for comparison to those following construction of the RA. The description of the development of this current conditions hydraulic model has been formatted as follows:

- Input Data/Assumptions
- Current Flood Levels

These items are described in more detail below:

Input Data/Assumptions

The following input data/assumptions were used to develop the hydraulic model of current conditions:

- Geometry of Main Channel and Overbank Areas
- Creek Discharge
- Water Surface Boundary Conditions
- Roughness Coefficients and Friction Loss within Main Channel and Overbank Areas
- Expansion/Contraction Coefficients
- Levees
- Ineffective Flow Areas
- Blocked Obstructions
- Modeling at Bridges
- Modeling at Upstream and Downstream Dams

A print out of the input data for the existing conditions model is provided as Attachment C of this appendix (Attachment A and B are referenced later).

Geometry of Main Channel and Overbank Areas

The HEC-RAS software requires the input of stream channel geometry. A total of 38 cross-sections were used in the hydraulic modeling. The locations of these cross-sections are shown on Figure B-1 located at the end of this appendix.

The geometry of the main channel of Little Elk Creek was defined by a detailed topography of the Creek bottom performed within the limits of the proposed RA as well as a survey of 22 cross-sections. These surveys were performed by Tetra Tech of Christiana, Delaware. The cross-sections were located at the existing structures within the Creek (i.e., dams and bridges) and at changes in flow direction and channel geometry. The extent of coverage of the 22 surveyed cross-sections includes the Creek reach from the toe of the downstream dam to the entrance of the former eastern mill race at the upstream dam (approximately 275 ft. upstream of this dam). The survey at each cross-section included, at a minimum, the east and west stream banks, and the stream centerline. Additional points were surveyed as necessary to define structures and abrupt changes in grade.

Topographical data from the base plan mapping performed in March 1996 was used to define the geometry of the left and right overbank areas at each survey location. Cross-sections 0+00 and 25+48, not shown on Figure B-1 due to space limitations, were constructed from USGS maps, site mapping, and interpolation from known survey points.

Creek Discharge

The HEC-RAS software requires the input of a value for creek discharge at the upstream end of the study reach. Additional discharge values can be entered at any cross-section location to model additional runoff. Due to the relatively small size of the drainage area along the reach in comparison with the total area of the watershed, total discharge was assigned at the upstream cross-section.

Water Surface Boundary Condition

As mentioned previously, the HEC-RAS software utilizes a steady-state one-dimensional step backwater model. The backwater model requires the input of a starting water surface elevation at either the last upstream and/or downstream cross-section of the reach. The starting water surface elevation can be a water surface elevation at flooding conditions (if known) or the software can calculate the elevation of normal or critical depth as appropriate. Normal depth is a function of the creek discharge and occurs when flow is uniform (i.e., depth is not increasing or decreasing), and is the state of flow that a channel continually tries to achieve. Critical depth is the depth of flow at minimum energy and typically occurs when flow is over or through structures such as bridges, dams, spillways, and weirs.

Typically, FEMA Flood Insurance Studies that are based on the HEC-2 step backwater model (the predecessor of HEC-RAS) use a downstream starting water surface elevation at the confluence with another body of water (usually a larger body of water) where the flooding elevation is known. The June 16, 1992 Flood Insurance Study (FIS) for the Town of Elkton, Cecil County Maryland used the backwater elevation of the Big Elk Creek. However, as stated previously, the limit of the FIS is about five miles downstream from the Site. Therefore, since there are no larger streams between the limit of the FEMA study and the Site where flooding elevations are known, normal depth of Little Elk Creek was used as a boundary condition at a cross-sections 0+00 and 25+48.

Roughness Coefficients and Friction Loss within Main Channel and Overbank Areas

The HEC-RAS software model divides the cross-sections of a river reach into three component areas: a left overbank, a main channel, and a right overbank. The main channel is the deeper portion of the river which is generally free of trees and heavy brush, and generally experiences higher velocities during discharge. The overbank is the area on both sides of the main channel that is flooded during storm events, but is normally dry during normal or base flow. Flow in the overbank area during flooding is generally more shallow and slower than experienced in the main channel, and because of

the slower and less frequent flow, the overbank is often covered with trees and brush in undeveloped areas.

During the surveying of creek cross-sections, AGC performed a reconnaissance of Little Elk Creek in order to observe and define the main channel and overbank area. The delineation of the main channel and overbank areas was defined in the model as follows:

- The overbank station along the east Creek bank was set at the water surface elevation of an approximate 2.33-year storm event which is typically considered the mean annual flood. The discharge for a mean annual flood was interpolated from the peak discharges calculated in Appendix A.

- The overbank station along the west Creek bank both up-and downstream of the Site was set at the water surface elevation of an approximate 2.33-year storm event.

- The overbank station along the west Creek bank adjacent to the Site was set at the top of the Creek bank. This is because the Site overbank area is almost entirely covered with asphalt pavement.

The HEC-RAS software model uses the Manning Formula to calculate flow velocities and conveyance at each cross-section based on the input discharge. The Manning Formula utilizes a roughness coefficient (Manning's n) to account for friction losses that occur during flow. The following values of Manning's n were used in the model:

- Manning's n values for the main channel ranged from 0.04 to 0.045. These values were obtained from *Open Channel Hydraulics* (French, 1985) and represent bed friction from gravels, cobbles, boulders, high grass, and light brush. These physical features exist along the entire reach of the Creek. A composite Manning's n value 0.037 was used at Providence Road Bridge to account for the masonry abutments.

- Composite Manning's n values were used for the overbank areas. The following typical n values were used to calculate composite values. These values were also obtained from (French, 1985):

  1. 0.013: Asphalt
  2. 0.05: Light brush
  3. 0.08 Trees

The Manning's n values for both the main channel and overbank area are consistent with values used in the 1992 FIS for Little Elk Creek and other creeks in Cecil County.

The HEC-RAS software computes friction loss between each cross-section using one of the following four methods:

- Arithmetic
- Harmonic
- Geometric Mean
- Average Conveyance

Each of these methods is a function of discharge and the conveyance calculated from the Manning Formula. Average conveyance is the default equation in HEC-RAS and was used for the current hydraulic model.

Expansion/Contraction Coefficients

Minor head losses due to changes in channel geometry between cross-sections are calculated using expansion and contraction coefficients. The following values were used:

- Expansion and contraction coefficients of 0.3 and 0.1, respectively were used at stream channel cross-sections.
- Expansion and contraction coefficients of 0.5 and 0.3, respectively were used at the foot bridge and at Providence Road Bridge.

Levees

The levee option in the HEC-RAS software allows for the creation of a left and/or right levee station and elevation on any cross-section. When levees are established, no water can flow to the left (left levee) or to the right (right levee) until the levee elevation is exceeded. This option was used at the former mill races along the study reach of Little Elk Creek to prevent flow in these areas until the

elevation of the upstream control (i.e., timber weir, metal plate, and soil/rubble as described previously) was exceeded.

Ineffective Flow Areas

The HEC-RAS software allows for the modeling of ineffective flow areas. An ineffective flow area is an area in a cross-section that contains water, but the water is not actively being conveyed as flow. The water is included in storage calculations and other wetted cross-section parameters, but is not included as part of the active flow area. This option was used along the main channel in areas of heavy brush and trees.

Blocked Obstructions

The existing houses and site structures were modeled by blocked obstructions. Blocked obstructions permanently block out that portion of the cross-section and therefore, decrease flow and add wetted perimeter when the water comes in contact with the obstruction.

Modeling at Bridges

Two bridges span across Little Elk Creek within the study reach: the bridge at Providence Road and the foot bridge. For modeling purposes, the HEC-RAS software classifies flow at bridges into two types of flow conditions: low flow and high flow. The low flow condition occurs when the water surface is below the highest point on the low chord of the bridge opening. Three types of bridge analysis methods are available in HEC-RAS to model the low flow condition:

1. Energy Method
2. Momentum Method
3. Yarnell Method (Class A flow only)

The energy and momentum methods are the most physically based models, and in general are applicable for the widest range of bridges and flow situations. The Yarnell equation is an empirical

formula and is only applicable for subcritical flow. The modeling of the low flow condition at both bridges is described below.

- Providence Road Bridge: All three methods were analyzed during modeling and the highest energy computed was used. A coefficient of drag (C_d) of 1.5 was used for the momentum method. A pier shape coefficient (k) of 1.25 was used for the Yarnell method.

- Foot bridge: The energy equation was used.

The high flow condition occurs when the water surface is above the deck of the bridge. Under this condition, weir flow occurs over the bridge deck and pressure flow occurs below the bridge deck. In the HEC-RAS software, this flow condition can either be model using the energy method or the pressure and weir flow method. The modeling of the high flow condition for both bridges is described below:

- Providence Road Bridge: The pressure and weir flow method was used in the hydraulic model. A submerged inlet coefficient (C_d) of 0.8 and a weir coefficient of 2.6 was used. Other parameters required for this method were assigned default values available in the HEC-RAS software.

- Foot bridge: The energy equation was used.

Modeling at Upstream and Downstream Dams

The current version of HEC-RAS does not model weirs. Therefore, the upstream and downstream dams were modeled as bridges with culverts.

As mention previously, the upstream dam passes base flow through the former stoplog section. A box culvert was placed at the existing stop log location to model base flow through the dam. Flow around the upstream mill race was modeled using a levee.

Base flow passes around the eastern side of the downstream dam. Higher flows pass over the dam. A box culvert was placed at this location to model flow around the dam.

During the August 1996 field measurements of base flow, surface water elevations were surveyed upstream of both dams. This survey data was used to calibrate the HEC-RAS model at base flow (i.e., to determine the size, Manning's n values, and entrance and exit loss coefficients of the culverts required to pass the base flow at the surveyed surface water elevations).

Current Flood Levels

Water surface elevations at the Site for base flow and the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events were determined using the current hydraulic model. Table B-1 located at the end of this appendix presents a summary of the water surface elevations and other pertinent hydraulic data at these flow conditions. Profiles of base flow, 10-year flow, and 100-year flow are provided as Figures B-2, B-3, and B-4, respectively. Plots of individual site cross-sections showing the various flood levels are provided as Attachment A of this Appendix.

It should be noted that the water surface elevations calculated for the 100-year storm do not match the water surface elevations interpolated from the limits of the flood plain shown on Flood Insurance Rate Map Cecil County Maryland (Unincorporated Areas), Panel 20 of 80, Community Panel Number 2400190020 A, effective date April 4, 1983. These differences can be attributed to the fact that the limits of the FEMA flood plain are based only on an approximate study. The intent of the HEC-RAS modeling was to develop a hydraulic model which is consistent with existing Site conditions for comparison to the post-construction hydraulic conditions, and not to duplicate the results of the FEMA study.

HYDRAULIC MODELING OF FINAL (100%) DESIGN

Modifications to the existing condition model were made to predict the changes to Little Elk Creek as a result of the RA at the Final (100%) design. These changes included the following:

- Stream bed and bank elevations were changed at each cross-section within the proposed RA to reflect the final grading.

- A Manning's n of 0.0222 (Maccaferri) is suggested for gabion-lined channels constructed with carefully sorted stones which are positioned very carefully. Streambed restoration activities are planned to create post RA conditions similar to current conditions. Measures such as ripples pools (formed using boulders) and boulder islands are planned to increase base flow depth and reduce velocity. Also, the stream banks above the base flow water line will be re-vegetated with light brush-like (grassy) plants. A composite Manning's n value of 0.033 was used for the main channel to model the post-construction conditions. A composite Manning's n value of 0.021 was used at Providence Road Bridge to account for the masonry abutments.

- The overbank stations of Little Elk Creek within the proposed RA were moved to the edge of the proposed gabion walls/mats at the left and right creek banks.

- The overbank Manning's n values were adjusted (lowered slightly) along the Site side of the Creek to account for the decrease in vegetation which will result from the implementation of the RA.

- The center pier of the bridge at Providence Road was removed and accordingly, the energy method for modeling low flow at the bridge was used. Based on discussions with Cecil County Public Works County Roads Department, it is understood that the existing bridge at Providence Road will be replaced with a clear span (i.e., no piers) metal grate bridge. If this design scheme is changed and piers are added, an analysis of the effects of the hydraulic forces anticipated following construction of the RA on the proposed piers will have to be performed.

- It is anticipated that several structures will be removed/demolished during the RA. The blocked obstructions of the following structures were removed from the model.

  1. Brick office building along the east side of the Creek
  2. The on-site trailer, small block building, and transformer along the western creek bank.

A print out of the input data for the hydraulic model of the RA at the Final (100%) design stage is provided as Attachment D of this appendix.

Table B-2 located at the end of this appendix presents a summary of the water surface elevations and other pertinent hydraulic data at these flow conditions. Profiles of base flow, 10-year flow, and 100-

year flow are provided as Figures B-5, B-6, and B-7. Plots of individual site cross-sections showing the various flood levels are provided as Attachment B.

COMPARISON OF RESULTS

In general, the HEC-RAS analysis indicates that flow depths resulting from the construction of the RA will be slightly lower than existing conditions. The flow velocities will be slightly higher. This is because the gabion-lined channel will be a smoother surface than the existing stream bed (i.e., has a lower Manning's n value). However, beyond the downstream limit of the gabion mat, the flow depths, velocities, and total energy returned to that of existing conditions. The water surface elevations will generally remain unchanged. A detailed comparison of exiting and post RA water surface elevations, flow velocities, and flow depths for each HEC-RAS coss-section is provided on Table B-3.

TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
2548	18	212	212.13	212.13	212.19	0.04453	1.99	9.06	70.9	0.13
2548	2010	212	216.74		217.03	0.002051	4.58	542.17	202.9	4.74
2548	3139	212	218.11		218.4	0.001642	4.88	857.86	253.34	6.11
2548	4341	212	219.01		219.36	0.001668	5.41	1096.59	273.1	7.01
2548	5032	212	219.52		219.88	0.001616	5.58	1234.67	276.74	7.52
2548	6162	212	220.26		220.65	0.001587	5.9	1442.4	288	8.26
2548	7459	212	221.01		221.45	0.001605	6.29	1668.19	310.54	9.01
2548	12311	212	223.32		223.86	0.001512	7.13	2398.38	320.62	11.32
1748	18	208.64	212.06		212.06	0.000006	0.12	155.86	101.99	3.42
1748	2010	208.64	215.73		215.89	0.000986	3.17	636.18	147.76	7.09
1748	3139	208.64	217.22		217.42	0.000903	3.67	914.8	224.44	8.58
1748	4341	208.64	217.97		218.26	0.001118	4.41	1093.19	250.01	9.33
1748	5032	208.64	218.46		218.78	0.001153	4.69	1217.41	261.05	9.82
1748	6162	208.64	219.17		219.54	0.001201	5.1	1408.74	274.23	10.53
1748	7459	208.64	219.89		220.32	0.001244	5.5	1608.65	279.46	11.25
1748	12311	208.64	222.1		222.7	0.001369	6.7	2279.42	315.19	13.46
1736	18	208.64	212.06		212.06	0.000003	0.1	187.91	101.99	3.42
1736	2010	208.64	215.73		215.87	0.000843	3.02	668.13	147.75	7.09
1736	3139	208.64	217.22		217.41	0.000805	3.54	946.78	224.43	8.58
1736	4341	208.64	217.97		218.24	0.001013	4.28	1125.07	249.98	9.33
1736	5032	208.64	218.46		218.76	0.001054	4.56	1249.17	261.02	9.82
1736	6162	208.64	219.17		219.52	0.00111	4.97	1440.31	274.21	10.53
1736	7459	208.64	219.89		220.3	0.001161	5.38	1639.99	279.44	11.25
1736	12311	208.64	222.1		222.68	0.001303	6.6	2310.03	315.17	13.46
1720	18	208.92	212.05	209.58	212.06	0.000007	0.15	119.56	64.41	3.13
1720	2010	208.92	215.48	213.35	215.83	0.002369	4.9	450.72	113.27	6.56
1720	3139	208.92	216.9	214.36	217.36	0.002242	5.7	661.35	184.95	7.98
1720	4341	208.92	217.51	215.1	218.18	0.002948	6.97	781.21	210	8.59
1720	5032	208.92	217.95	215.54	218.69	0.003041	7.4	878.58	227.18	9.03
1720	6162	208.92	218.64	216.57	219.45	0.003061	7.89	1039.61	242.18	9.72
1720	7459	208.92	219.34	215.91	220.22	0.003052	8.35	1215.01	252.3	10.42
1720	12311	208.92	221.5	219.35	222.6	0.003077	9.75	1798.56	290.98	12.58
1606	18	207.67	212.05	208.49	212.05	0.000004	0.13	139.3	55.77	4.38
1606	2010	207.67	215.07	212.99	215.52	0.002981	5.61	393.21	105.27	7.4
1606	3139	207.67	216.39	214.24	217.04	0.003198	6.83	595.61	191.92	8.72
1606	4341	207.67	216.54	215.01	217.68	0.005496	9.1	625.06	193.45	8.87
1606	5032	207.67	216.94	215.59	218.18	0.005643	9.61	703.2	197.45	9.27
1606	6162	207.67	217.47	215.99	218.91	0.006097	10.5	813.51	212.53	9.8
1606	7459	207.67	217.98	215.99	219.65	0.006668	11.49	922.05	219.67	10.31
1606	12311	207.67	219.85	219.31	221.99	0.006945	13.55	1357.97	247.02	12.18
1538	18	206.5	212.05	207.09	212.05	0.000001	0.09	195.13	54.74	5.55
1538	2010	206.5	215.04	211.95	215.32	0.001663	4.5	514.41	110.13	8.54
1538	3139	206.5	216.39	213.19	216.8	0.002023	5.49	688.99	143.75	9.89
1538	4341	206.5	216.54	214.41	217.26	0.003545	7.37	709.86	144.77	10.04
1538	5032	206.5	216.91	215	217.75	0.003848	7.97	763.75	147.35	10.41
1538	6162	206.5	217.39	215.01	218.44	0.00443	8.95	838.32	160.23	10.89

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TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
1538	7459	206.5	217.82	215.41	219.14	0.005216	10.09	910.89	181.39	11.32
1538	12311	206.5	219.05	218.38	221.45	0.008009	13.78	1152.61	213.65	12.55
1510	18	209.61	212.05	209.87	212.05	0.000011	0.18	101.95	59.72	7.29
1510	2010	209.61	213.82	213.66	215.11	0.014404	9.1	220.77	73.77	9.06
1510	3139	209.61	214.76	214.76	216.53	0.015758	10.7	293.28	82.2	10
1510	4341	209.61	216.48	215	217.12	0.005072	6.89	704	185.73	11.72
1510	5032	209.61	216.85	215.01	217.59	0.005272	7.43	778.23	208.19	12.09
1510	6162	209.61	217.35	215.45	218.26	0.005801	8.34	889.34	238.06	12.59
1510	7459	209.61	217.82	215.99	218.92	0.006278	9.2	1008.32	264.57	13.06
1510	12311	209.61	219.48	217.8	220.97	0.006546	11.14	1505.3	316.28	14.72
1508	18	209.61	212.05	209.87	212.05	0.00001	0.17	105.07	59.97	7.29
1508	2010	209.61	213.82	213.61	215.07	0.013684	8.95	224.46	73.95	9.06
1508	3139	209.61	214.59	214.7	216.5	0.017288	11.09	283.05	80.58	9.83
1508	4341	209.61	216.47	215	217.11	0.005002	6.87	704.91	178.63	11.71
1508	5032	209.61	216.84	215.01	217.58	0.005221	7.42	775.2	195.94	12.08
1508	6162	209.61	217.33	215.43	218.25	0.005815	8.36	876.22	219.01	12.57
1508	7459	209.61	217.76	216	218.9	0.006515	9.33	974.91	237.11	13
1508	12311	209.61	218.47	218.47	220.87	0.012004	13.72	1160.16	277.86	13.71
					Spectron Dam					
1474	18	197.95	200.45	198.21	200.45	0.000028	0.29	62.46	26.07	2.5
1474	2010	197.95	205.91	203.97	206.22	0.003143	4.43	453.84	112.06	7.96
1474	3139	197.95	207.51	204.74	207.89	0.002612	4.95	634.17	113.63	9.56
1474	4341	197.95	208.95	205.45	209.41	0.00239	5.43	799.19	115.06	11
1474	5032	197.95	209.77	205.82	210.26	0.002259	5.63	893.1	115.86	11.82
1474	6162	197.95	210.53	206.39	211.15	0.002509	6.27	982.36	116.62	12.58
1474	7459	197.95	211.31	207.03	212.06	0.002782	6.95	1073.62	117.39	13.36
1474	12311	197.95	215.03	209.09	215.82	0.002171	7.37	1890.55	266.67	17.08
1466	18	195.49	200.45	195.76	200.45	0.000003	0.1	177.32	62.43	4.96
1466	2010	195.49	206.04	200.78	206.15	0.000678	2.67	752.68	120.54	10.55
1466	3139	195.49	207.65	202.05	207.82	0.000793	3.31	947.93	122.15	12.16
1466	4341	195.49	209.1	203.16	209.33	0.000879	3.85	1126.73	123.6	13.61
1466	5032	195.49	209.92	203.52	210.18	0.000901	4.1	1228	124.42	14.43
1466	6162	195.49	210.75	204.08	211.04	0.000947	4.4	1485.02	155.99	15.26
1466	7459	195.49	211.57	204.65	211.93	0.001087	4.91	1615.07	158.75	16.08
1466	12311	195.49	215.21	206.63	215.72	0.001191	5.9	2310.13	260.66	19.72
1463	18	195.5	200.45		200.45	0.000001	0.07	269.45	88.26	4.95
1463	2010	195.5	206.06		206.14	0.000337	2.41	962.26	139.99	10.56
1463	3139	195.5	207.67		207.8	0.000448	3.07	1197.64	148.34	12.17
1463	4341	195.5	209.14		209.31	0.000528	3.6	1416.17	149.92	13.64
1463	5032	195.5	209.96		210.16	0.000555	3.84	1539.82	150.8	14.46
1463	6162	195.5	210.77		211.02	0.000665	4.36	1662.48	151.68	15.27
1463	7459	195.5	211.6		211.92	0.000786	4.9	1788.69	152.57	16.1
1463	12311	195.5	215.24		215.7	0.001031	6.03	2473.11	258.85	19.74
1457	18	195.5	200.45		200.45	0.000002	0.09	202.89	61.69	4.95

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TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
1457	2010	195.5	206.04		206.13	0.000469	2.64	906.14	150.42	10.54
1457	3139	195.5	207.66		207.8	0.00056	3.24	1151.56	152.45	12.16
1457	4341	195.5	209.13		209.31	0.000627	3.74	1376.59	154.29	13.63
1457	5032	195.5	209.95		210.15	0.000645	3.96	1504.1	155.32	14.45
1457	6162	195.5	210.76		211.02	0.000759	4.47	1630.54	156.34	15.26
1457	7459	195.5	211.6		211.91	0.000882	5	1760.81	157.38	16.1
1457	12311	195.5	215.24		215.7	0.001045	6.1	2439.32	217.48	19.74
1446	18	197.77	200.44		200.45	0.000044	0.31	58.38	34.19	2.67
1446	2010	197.77	205.9		206.11	0.001716	3.97	594.03	142.38	8.13
1446	3139	197.77	207.52		207.78	0.001536	4.45	827.53	146.2	9.75
1446	4341	197.77	208.98		209.29	0.001449	4.88	1042.86	148.63	11.21
1446	5032	197.77	209.8		210.13	0.001385	5.05	1165.82	150	12.03
1446	6162	197.77	210.59		210.99	0.001547	5.61	1284.16	151.31	12.82
1446	7459	197.77	211.35		211.88	0.001879	6.45	1406.74	171.56	13.58
1446	12311	197.77	215.07		215.67	0.001463	6.93	2153.14	237.04	17.3
1419	18	199.5	200.38	200.22	200.44	0.013432	1.9	9.48	26.72	0.88
1419	2010	199.5	205.48	204	206.01	0.005262	5.85	348.38	98.4	5.98
1419	3139	199.5	207.06	205.01	207.68	0.004103	6.36	516.31	112.15	7.56
1419	4341	199.5	208.5	205.88	209.19	0.003543	6.8	691.02	134.23	9
1419	5032	199.5	209.34	206.34	210.04	0.003142	6.88	806.53	141.79	9.84
1419	6162	199.5	210.04	207.01	210.89	0.003441	7.59	910.59	153.18	10.54
1419	7459	199.5	210.78	207.73	211.76	0.003674	8.26	1024.12	156.12	11.28
1419	12311	199.5	214.74	210.25	215.59	0.002184	7.92	1821.6	246.33	15.24
1369	18	199	199.56	199.48	199.62	0.020154	2.08	8.66	29.27	0.56
1369	2010	199	205.02	203.38	205.71	0.006029	6.69	305.02	73.32	6.02
1369	3139	199	206.54	204.47	207.42	0.005525	7.62	440.77	101.85	7.54
1369	4341	199	208	205.75	208.96	0.004848	8.09	600.41	123.51	9
1369	5032	199	208.96	206.51	209.84	0.004056	7.92	718.75	124.93	9.96
1369	6162	199	209.62	207.12	210.67	0.004626	8.68	802.49	128.09	10.62
1369	7459	199	210.3	208.26	211.52	0.005245	9.42	896.63	150.59	11.3
1369	12311	199	214.7	210.66	215.47	0.001798	7.07	1898.8	258.52	15.7
1310	18	198	198.64	198.5	198.7	0.013115	1.99	9.05	23.64	0.64
1310	2010	198	204.58	202.9	205.35	0.005957	7.02	286.73	62.21	6.58
1310	3139	198	206.24	204.2	207.11	0.004988	7.67	447.5	98.09	8.24
1310	4341	198	207.76	205.47	208.68	0.004291	8.07	638.14	142.96	9.76
1310	5032	198	208.8	205.99	209.6	0.003417	7.68	792.58	152.6	10.8
1310	6162	198	209.47	207.13	210.39	0.003667	8.34	900.24	174.37	11.47
1310	7459	198	210.19	207.98	211.19	0.003742	8.86	1029.42	183.76	12.19
1310	12311	198	214.6	210.3	215.37	0.001633	7.5	1917.31	224.19	16.6
1184	18	196.86	197.79		197.81	0.00432	1.29	13.93	29.91	0.93
1184	2010	196.86	204.11		204.64	0.004329	5.85	343.83	74.55	7.25
1184	3139	196.86	205.83		206.5	0.003812	6.58	487.61	103.02	8.97
1184	4341	196.86	207.43		208.15	0.003208	6.96	669.32	130.54	10.57
1184	5032	196.86	208.53		209.18	0.002542	6.71	816.71	134	11.67
1184	6162	196.86	209.14		209.94	0.002906	7.47	898.16	134	12.28
1184	7459	196.86	209.77		210.75	0.003275	8.24	982.33	134	12.91

TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
1184	12311	196.86	214.23		215.13	0.001879	7.71	1681.91	165.18	17.37
1170	18	197	197.73		197.76	0.003409	1.27	14.22	26.49	0.73
1170	2010	197	204		204.57	0.004779	6.06	331.74	74.02	7
1170	3139	197	205.73		206.44	0.00407	6.76	473.86	100.3	8.73
1170	4341	197	207.34		208.11	0.003401	7.13	653.7	126.08	10.34
1170	5032	197	208.46		209.15	0.002674	6.87	802.72	134	11.46
1170	6162	197	209.05		209.9	0.003076	7.66	881.78	134	12.05
1170	7459	197	209.65		210.7	0.00349	8.48	963.17	134	12.65
1170	12311	197	214.16		215.1	0.001958	7.89	1666.58	165.13	17.16
1103	18	196.5	197.69		197.69	0.000387	0.61	29.67	32.44	1.19
1103	2010	196.5	203.74		204.28	0.00382	5.88	342.09	66.69	7.24
1103	3139	196.5	205.48		206.18	0.003595	6.75	482.79	93.84	8.98
1103	4341	196.5	207.14		207.89	0.003039	7.13	670.94	142.54	10.64
1103	5032	196.5	208.33		208.97	0.002219	6.67	844.32	148.31	11.83
1103	6162	196.5	208.9		209.69	0.00254	7.42	930.37	152.32	12.4
1103	7459	196.5	209.49		210.46	0.00286	8.18	1021.84	160.52	12.99
1103	12311	196.5	214.26		214.92	0.001104	6.51	2056.81	231.84	17.76
1018	18	196	197.68		197.68	0.000059	0.3	59.07	44.38	1.68
1018	2010	196	203.66		203.99	0.001928	4.58	438.58	74.57	7.66
1018	3139	196	205.42		205.89	0.002056	5.48	574.67	80.68	9.42
1018	4341	196	207.09		207.62	0.00185	5.95	812.09	235	11.09
1018	5032	196	208.37		208.76	0.0012	5.23	1154.61	288.33	12.37
1018	6162	196	209		209.44	0.00126	5.58	1338.2	294	13
1018	7459	196	209.67		210.16	0.001289	5.87	1541.02	324.3	13.67
1018	12311	196	214.46		214.76	0.00041	4.17	3339.55	407.12	18.46
1000	18	194.72	197.68	195.2	197.68	0.000023	0.27	66.44	27.26	2.96
1000	2010	194.72	203.3	200.6	203.87	0.00384	6.06	331.78	56.42	8.58
1000	3139	194.72	204.85	201.9	205.71	0.004501	7.46	421.09	59.28	10.13
1000	4341	194.72	206.24	203.1	207.38	0.004954	8.59	520.23	128.04	11.52
1000	5032	194.72	207.99	203.7	208.65	0.002515	6.91	914.06	317.79	13.27
1000	6162	194.72	208.77	204.67	209.36	0.002128	6.69	1176.06	353.45	14.05
1000	7459	194.72	209.58	205.69	210.12	0.001783	6.43	1484.47	411.98	14.86
1000	12311	194.72	214.46	209.33	214.74	0.000246	3.02	3776.02	489.77	19.74
			Former Location of Footbridge							
993	18	194.66	197.68	195.18	197.68	0.000027	0.29	61.36	25.07	3.02
993	2010	194.66	203.16	200.71	203.82	0.004336	6.51	308.73	56.24	8.5
993	3139	194.66	204.57	201.99	205.63	0.005256	8.24	381.16	58.64	9.91
993	4341	194.66	205.7	203.17	207.22	0.006293	9.91	439.28	61.08	11.04
993	5032	194.66	206.33	203.82	208.09	0.006606	10.64	492.9	132.18	11.67
993	6162	194.66	207.66	204.8	208.89	0.004917	9.32	810.59	291.18	13
993	7459	194.66	209.2	207.9	209.88	0.002375	7.16	1326.96	380.2	14.54
993	12311	194.66	214.35	209.35	214.64	0.000259	3.06	3740.53	496.13	19.69
982	18	194.66	197.68	195.24	197.68	0.000017	0.21	86.36	44.4	3.02
982	2010	194.66	203.21	199.73	203.7	0.002371	5.59	359.93	64.66	8.55

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TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
982	3139	194.66	204.65	201.06	205.46	0.003036	7.19	438.55	68.62	9.99
982	4341	194.66	205.83	202.3	206.99	0.003697	8.67	519.34	108.71	11.17
982	5032	194.66	206.5	202.94	207.81	0.003847	9.26	592.41	162.04	11.84
982	6162	194.66	207.8	203.92	208.68	0.002732	7.82	950.3	262.5	13.14
982	7459	194.66	209.19	204.96	209.84	0.001813	6.93	1367.02	324.52	14.53
982	12311	194.66	214.23	208.92	214.61	0.000451	4.39	3254.71	403.68	19.57
905	18	197.35	197.58	197.58	197.65	0.053069	2.19	8.23	53.32	0.23
905	2010	197.35	202.98	200.78	203.47	0.003474	5.65	358.77	83.88	5.63
905	3139	197.35	204.44	201.85	205.16	0.00363	6.83	464.9	89.32	7.09
905	4341	197.35	205.62	202.82	206.6	0.003957	7.97	556.2	93.49	8.27
905	5032	197.35	206.43	203.34	207.31	0.003596	7.55	684.9	106.58	9.08
905	6162	197.35	207.56	204.16	208.45	0.003137	7.72	858.31	181.01	10.21
905	7459	197.35	208.89	205	209.65	0.002276	7.22	1128.1	232.85	11.54
905	12311	197.35	214.01	208.38	214.53	0.00073	5.36	2579.7	323.35	16.66
854	18	196.5	197.43	196.88	197.43	0.000765	0.64	27.98	47.11	0.93
854	2010	196.5	202.84	200.34	203.3	0.002983	5.46	368.86	83.03	6.34
854	3139	196.5	204.28	201.43	204.98	0.003296	6.72	472.12	88.84	7.78
854	4341	196.5	205.43	202.45	206.4	0.003727	7.92	558.33	92.73	8.93
854	5032	196.5	206.27	202.97	207.12	0.003384	7.42	695.44	103.1	9.77
854	6162	196.5	207.36	203.8	208.28	0.003165	7.81	849.5	176.01	10.86
854	7459	196.5	208.69	204.68	209.52	0.0025	7.61	1109.9	223.64	12.19
854	12311	196.5	214.01	208.22	214.47	0.000878	5.95	2609.74	311.29	17.51
777	18	195.5	197.42	195.88	197.42	0.000071	0.33	55.26	42.92	1.92
777	2010	195.5	202.57	200.07	203.06	0.003348	5.58	360.07	77.29	7.07
777	3139	195.5	203.97	201.31	204.71	0.003687	6.87	458.64	80.95	8.47
777	4341	195.5	205.06	202.32	206.09	0.004245	8.15	536.1	83.17	9.56
777	5032	195.5	205.56	202.84	206.78	0.004606	8.86	572.93	84.69	10.06
777	6162	195.5	206.44	203.65	207.93	0.004903	9.79	638.11	87.33	10.94
777	7459	195.5	207.39	204.51	209.16	0.005147	10.71	709.63	105.6	11.89
777	12311	195.5	213.67	207.38	214.36	0.001405	7.38	2221.28	377.07	18.17
755	18	195	197.42	195.38	197.42	0.000045	0.28	63.7	42.92	2.42
755	2010	195	202.51	199.81	202.98	0.002888	5.5	365.51	78.5	7.51
755	3139	195	203.88	200.95	204.63	0.003444	6.93	453.98	81.33	8.88
755	4341	195	204.9	202.01	205.99	0.004194	8.36	521.46	83.44	9.9
755	5032	195	205.37	202.57	206.67	0.004678	9.17	552.4	85.87	10.37
755	6162	195	206.17	203.41	207.8	0.005186	10.25	606.82	90.77	11.17
755	7459	195	207.02	204.32	209.02	0.005685	11.37	664.52	95.86	12.02
755	12311	195	213.53	207.32	214.32	0.00163	7.55	1924.93	301.76	18.53
742	18	195	197.41	195.65	197.42	0.000063	0.35	51.07	42.65	2.41
742	2010	195	202.48	200.04	202.95	0.002367	5.47	367.33	71.33	7.48
742	3139	195	203.87	201.16	204.57	0.002738	6.7	468.22	73.33	8.87
742	4341	195	204.93	202.16	205.91	0.003333	7.94	546.93	76.31	9.93
742	5032	195	205.42	202.69	206.57	0.003676	8.61	584.75	77.4	10.42
742	6162	195	206.28	203.51	207.67	0.00402	9.44	652.43	79.75	11.28
742	7459	195	207.21	204.38	208.84	0.004319	10.24	728.13	82.74	12.21
742	12311	195	213.23	207.23	214.28	0.001291	7.67	1553.84	247.61	18.23

AR100200

TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
				Providence Road Bridge						
725	18	195.5	197.41	195.75	197.41	0.000025	0.27	66.19	41.67	1.91
725	2010	195.5	202.1	200	202.55	0.002479	5.44	369.81	76.45	6.6
725	3139	195.5	203.49	200.96	204.16	0.002722	6.57	477.85	78.17	7.99
725	4341	195.5	204.64	201.88	205.55	0.003054	7.64	568.21	79.58	9.14
725	5032	195.5	205.17	202.38	206.23	0.003289	8.24	610.93	80.24	9.67
725	6162	195.5	205.97	203.13	207.26	0.003644	9.13	674.89	81.22	10.47
725	7459	195.5	206.8	203.96	208.37	0.003987	10.03	743.47	82.26	11.3
725	12311	195.5	210.99	206.6	212.61	0.002756	10.35	1207.29	165.91	15.49
715	18	195.5	197.41	195.74	197.41	0.00003	0.27	65.89	42.23	1.91
715	2010	195.5	201.69	200	202.29	0.004165	6.22	322.91	74.32	6.19
715	3139	195.5	203.02	201.11	203.87	0.004217	7.43	423.54	77.48	7.52
715	4341	195.5	204.04	202.07	205.21	0.00461	8.68	504.1	79.96	8.54
715	5032	195.5	204.46	202.58	205.85	0.005035	9.46	538.18	80.98	8.96
715	6162	195.5	205.03	203.34	206.8	0.005841	10.72	583.97	82.34	9.53
715	7459	195.5	205.44	204.16	207.77	0.007168	12.3	618.12	83.33	9.94
715	12311	195.5	206.88	206.88	211.4	0.011193	17.14	740.44	86.82	11.38
646	18	195	197.41	195.46	197.41	0.000015	0.22	81.75	42.53	2.41
646	2010	195	201.09	199.64	201.92	0.006255	7.45	286.96	81.45	6.09
646	3139	195	202.6	201.24	203.55	0.004947	8.11	473.03	193.77	7.6
646	4341	195	203.93	202.51	204.84	0.00393	8.3	756.83	231.98	8.93
646	5032	195	204.47	203.08	205.42	0.003805	8.58	886.92	244.06	9.47
646	6162	195	205.26	203.76	206.25	0.003695	9.02	1084.63	260.95	10.26
646	7459	195	205.96	204.43	207.05	0.003789	9.63	1272.83	276.07	10.96
646	12311	195	208.28	206.16	209.62	0.003864	11.31	2066.93	392.17	13.28
562	18	193.5	197.41		197.41	0.000009	0.18	98.14	47.19	3.91
562	2010	193.5	200.43		201.38	0.006354	7.83	257.16	59.29	6.93
562	3139	193.5	201.61	200.49	203.02	0.006955	9.57	362.64	139.85	8.11
562	4341	193.5	202.21	202.21	204.25	0.00903	11.66	461.1	181.8	8.71
562	5032	193.5	202.8	202.8	204.85	0.008379	11.92	572.77	200.5	9.3
562	6162	193.5	203.56	203.56	205.7	0.00799	12.48	734.94	228.53	10.06
562	7459	193.5	204.38	204.38	206.51	0.007364	12.83	934.65	252.98	10.88
562	12311	193.5	206	206	208.99	0.008991	15.93	1387.44	316.88	12.5
479	18	193	197.41		197.41	0.000004	0.14	132.02	49.12	4.41
479	2010	193	199.98		200.86	0.005649	7.56	265.96	55.93	6.98
479	3139	193	199.92	199.81	202.13	0.014303	11.95	262.6	55.75	6.92
479	4341	193	201.41	201.68	203.47	0.009794	11.85	490.13	221.63	8.41
479	5032	193	201.71	202.19	204.04	0.01065	12.76	559.29	234.07	8.71
479	6162	193	202.19	202.85	204.85	0.01155	13.93	676.59	257.81	9.19
479	7459	193	202.68	202.97	205.66	0.012302	15.04	808.49	280.82	9.68
479	12311	193	204.06	205.45	207.94	0.014504	18.29	1271.39	356.67	11.06
465	18	192.74	197.41		197.41	0.000002	0.1	174.69	60.89	4.67
465	2010	192.74	200.19		200.69	0.002785	5.71	351.93	67.35	7.45
465	3139	192.74	200.61		201.67	0.00529	8.25	382.97	81.44	7.87

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TABLE B-1
Hydraulic Data of Existing Conditions

River Sta.	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)	Max Chl Dpth (ft)
465	4341	192.74	198.85	199.99	203.03	0.031291	16.42	264.39	63.89	6.11
465	5032	192.74	199.56	200.57	203.64	0.025696	16.22	310.2	65.37	6.82
465	6162	192.74	200.93	202.42	204.56	0.016919	15.31	412.6	103.4	8.19
465	7459	192.74	201.79	203.05	205.41	0.014639	15.57	618.41	269.88	9.05
465	12311	192.74	203.33	204.61	207.69	0.015407	18.27	1113.02	337.27	10.59
433	18	194	197.41	194.22	197.41	0.000002	0.1	188.88	78.12	3.41
433	2010	194	200.27	197.75	200.56	0.001911	4.39	496.99	112.81	6.27
433	3139	194	200.84	198.73	201.39	0.003153	6.09	561.79	114.52	6.84
433	4341	194	201.24	199.64	202.13	0.004671	7.78	640.2	257.46	7.24
433	5032	194	201.39	200	202.51	0.005692	8.74	679.53	264.09	7.39
433	6162	194	199.24	200.54	203.7	0.038114	17.28	384.1	105.26	5.24
433	7459	194	199.88	201.68	204.6	0.035043	17.81	452.88	110.9	5.88
433	12311	194	202.54	203.78	207.1	0.018941	17.71	921.8	312.17	8.54
413	18	193.5	197.41	194.1	197.41	0.000006	0.12	150.68	98.21	3.91
413	2010	193.5	200.29	198.24	200.5	0.001703	3.8	628.01	239.47	6.79
413	3139	193.5	200.92	198.99	201.27	0.002399	4.97	786.38	257.78	7.42
413	4341	193.5	201.42	199.73	201.94	0.003156	6.1	922.02	290.86	7.92
413	5032	193.5	201.65	200.05	202.27	0.003612	6.72	989.62	307.47	8.15
413	6162	193.5	199.63	200.55	202.59	0.030043	14.13	482.68	194.08	6.13
413	7459	193.5	199.84	201	203.62	0.035478	16.01	526.01	210.77	6.34
413	12311	193.5	201.24	202.8	206.57	0.03219	19.02	776.6	249.75	7.74
				Downstream Dam						
399	18	192.05	192.64	192.63	192.78	0.033847	3.03	5.94	20.1	0.59
399	2010	192.05	196.25	195.21	196.67	0.005064	5.25	383.18	130.26	4.2
399	3139	192.05	197.34	195.91	197.88	0.004535	5.95	527.79	134.95	5.29
399	4341	192.05	198.19	196.57	198.89	0.005032	6.72	645.62	147.83	6.14
399	5032	192.05	198.56	196.91	199.36	0.005173	7.17	701.92	148.84	6.51
399	6162	192.05	199.1	197.44	200.06	0.005484	7.88	782.16	156.95	7.05
399	7459	192.05	199.62	198.09	200.79	0.005825	8.66	873.98	193.62	7.57
399	12311	192.05	201.35	200.05	202.93	0.005878	10.37	1424.3	319.71	9.3
390	18	192.05	192.35	192.31	192.41	0.023942	2.03	8.87	42.09	0.3
390	2010	192.05	196.36	194.67	196.58	0.002119	3.76	534.74	161.42	4.31
390	3139	192.05	197.49	195.28	197.78	0.00202	4.37	718.95	166.83	5.44
390	4341	192.05	198.38	195.84	198.76	0.002132	4.99	869.77	171.64	6.33
390	5032	192.05	198.78	196.15	199.23	0.002254	5.36	939.63	173.82	6.73
390	6162	192.05	199.36	196.6	199.91	0.002425	5.92	1044.95	197.07	7.31
390	7459	192.05	199.94	197.11	200.6	0.002595	6.51	1169.63	232.48	7.89
390	12311	192.05	201.74	198.76	202.71	0.00288	8.07	1783.91	351.42	9.69

AR100202

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
2548	18	212	212.13	212.13	212.19	0.04453	1.99	9.06	70.9	0.13
2548	2010	212	216.74		217.03	0.002051	4.68	542.17	202.9	4.74
2548	3139	212	218.11		218.4	0.001642	4.88	857.86	253.34	6.11
2548	4341	212	219.01		219.36	0.001666	5.4	1097	273.11	7.01
2548	5032	212	219.52		219.88	0.001615	5.58	1235.06	276.75	7.52
2548	6162	212	220.26		220.65	0.001586	5.89	1442.97	288.06	8.26
2548	7459	212	221.01		221.45	0.001604	6.29	1668.5	310.55	9.01
2548	12311	212	223.32		223.86	0.001512	7.13	2398.1	320.62	11.32
1748	18	208.64	212.06		212.06	0.000006	0.12	155.86	101.99	3.42
1748	2010	208.64	215.73		215.89	0.000986	3.17	636.18	147.76	7.09
1748	3139	208.64	217.22		217.42	0.000903	3.67	914.8	224.44	8.58
1748	4341	208.64	217.97		218.26	0.001116	4.41	1093.96	250.11	9.33
1748	5032	208.64	218.46		218.78	0.001152	4.69	1218.15	261.11	9.82
1748	6162	208.64	219.17		219.55	0.001199	5.09	1409.75	274.25	10.53
1748	7459	208.64	219.89		220.32	0.001243	5.49	1609.16	279.47	11.25
1748	12311	208.64	222.1		222.7	0.001369	6.7	2278.92	315.18	13.46
1736	18	208.64	212.06		212.06	0.000003	0.1	187.91	101.99	3.42
1736	2010	208.64	215.73		215.87	0.000843	3.02	668.13	147.75	7.09
1736	3139	208.64	217.22		217.41	0.000805	3.54	946.78	224.43	8.58
1736	4341	208.64	217.97		218.25	0.001011	4.28	1125.83	250.09	9.33
1736	5032	208.64	218.46		218.77	0.001052	4.56	1249.91	261.08	9.82
1736	6162	208.64	219.17		219.53	0.001108	4.97	1441.32	274.24	10.53
1736	7459	208.64	219.89		220.3	0.00116	5.38	1640.5	279.46	11.25
1736	12311	208.64	222.1		222.68	0.001303	6.6	2309.52	315.16	13.46
1720	18	208.92	212.05	209.58	212.06	0.000007	0.15	119.56	64.41	3.13
1720	2010	208.92	215.48	213.35	215.83	0.002369	4.9	450.72	113.27	6.56
1720	3139	208.92	216.9	214.36	217.36	0.002242	5.7	661.35	184.95	7.98
1720	4341	208.92	217.51	215.1	218.18	0.00294	6.97	782.09	210.16	8.59
1720	5032	208.92	217.96	215.54	218.69	0.003034	7.39	879.48	227.33	9.04
1720	6162	208.92	218.64	216.57	219.45	0.003052	7.88	1040.89	242.29	9.72
1720	7459	208.92	219.35	215.91	220.22	0.003048	8.35	1215.68	252.32	10.43
1720	12311	208.92	221.49	219.35	222.6	0.00308	9.76	1797.9	290.97	12.57
1606	18	207.67	212.05	208.49	212.05	0.000004	0.13	139.3	55.77	4.38
1606	2010	207.67	215.07	212.99	215.52	0.002981	5.61	393.21	105.27	7.4
1606	3139	207.67	216.39	214.24	217.04	0.003198	6.83	595.61	191.92	8.72
1606	4341	207.67	216.56	215.01	217.69	0.005427	9.06	628.58	193.63	8.89
1606	5032	207.67	216.96	215.59	218.19	0.005578	9.57	706.71	197.62	9.29
1606	6162	207.67	217.5	215.99	218.92	0.005993	10.44	819.55	212.94	9.83
1606	7459	207.67	218	215.99	219.65	0.006564	11.43	928.16	220.05	10.33
1606	12311	207.67	219.81	219.31	221.98	0.00706	13.62	1349.21	246.56	12.14
1538	18	206.5	212.05	207.09	212.05	0.000001	0.09	195.13	54.74	5.55
1538	2010	206.5	215.04	211.95	215.32	0.001663	4.5	514.41	110.13	8.54
1538	3139	206.5	216.39	213.19	216.8	0.002023	5.49	688.99	143.75	9.89
1538	4341	206.5	216.56	214.41	217.27	0.003509	7.35	712.36	144.89	10.06
1538	5032	206.5	216.92	215	217.76	0.00381	7.94	766.32	147.47	10.42
1538	6162	206.5	217.42	215.01	218.46	0.004366	8.91	842.78	161.09	10.92

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
1538	7459	206.5	217.85	215.41	219.16	0.005143	10.04	916.03	183.08	11.35
1538	12311	206.5	218.8	218.38	221.39	0.008925	14.28	1100.63	205.8	12.3
1510	18	209.61	212.05	209.87	212.05	0.000011	0.18	101.95	59.72	7.29
1510	2010	209.61	213.82	213.66	215.11	0.014411	9.11	220.73	73.76	9.06
1510	3139	209.61	214.76	214.76	216.53	0.015758	10.7	293.28	82.2	10
1510	4341	209.61	216.5	215	217.13	0.005008	6.87	707.43	187.18	11.74
1510	5032	209.61	216.87	215.01	217.6	0.005205	7.4	782.17	209.19	12.11
1510	6162	209.61	217.38	215.45	218.28	0.005696	8.29	896.55	239.79	12.62
1510	7459	209.61	217.86	215.99	218.93	0.006148	9.14	1017.03	266.9	13.1
1510	12311	209.61	219.22	217.8	220.89	0.00756	11.7	1426.13	314.02	14.46
1508	18	209.61	212.05	209.87	212.05	0.00001	0.17	105.07	59.97	7.29
1508	2010	209.61	213.82	213.61	215.07	0.01369	8.96	224.43	73.95	9.06
1508	3139	209.61	214.59	214.7	216.5	0.017288	11.09	283.05	80.58	9.83
1508	4341	209.61	216.51	215	217.11	0.004407	6.49	712.41	181.34	11.75
1508	5032	209.61	216.89	215	217.58	0.004616	7.02	784.56	197.79	12.13
1508	6162	209.61	217.4	215.37	218.25	0.005137	7.93	892.43	222.33	12.64
1508	7459	209.61	217.88	216	218.9	0.005635	8.8	1002.22	243.81	13.12
1508	12311	209.61	219.05	217.8	220.86	0.008164	11.99	1325.58	296.4	14.29
1474	18	197.95	201.48	198.21	201.48	0.000009	0.2	89.82	26.92	3.53
1474	2010	197.95	206.17	203.97	206.44	0.002565	4.16	483.32	112.31	8.22
1474	3139	197.95	207.63	204.74	207.99	0.002441	4.85	647.71	113.75	9.68
1474	4341	197.95	208.93	205.45	209.39	0.002417	5.45	796.37	115.03	10.98
1474	5032	197.95	209.61	205.82	210.12	0.002414	5.75	874.59	115.7	11.66
1474	6162	197.95	210.61	206.39	211.12	0.002533	6.29	979.42	116.59	12.56
1474	7459	197.95	211.46	207.03	212.19	0.002645	6.84	1091.2	117.54	13.51
1474	12311	197.95	215.06	209.09	215.84	0.002153	7.35	1898.18	267.67	17.11
1466	18	195.49	201.48	195.76	201.48	0.000001	0.07	249.58	80.11	5.99
1466	2010	195.49	206.28	200.79	206.38	0.000599	2.57	782.22	120.78	10.79
1466	3139	195.49	207.76	201.99	207.92	0.000758	3.26	961.62	122.26	12.27
1466	4341	195.49	209.08	203.14	209.31	0.000886	3.86	1123.86	123.58	13.59
1466	5032	195.49	209.77	203.51	210.04	0.000946	4.16	1209.16	124.27	14.28
1466	6162	195.49	210.72	204.07	211.01	0.000954	4.41	1481.33	155.92	15.23
1466	7459	195.49	211.71	204.67	212.06	0.001044	4.85	1637.34	159.22	16.22
1466	12311	195.49	215.24	206.66	215.74	0.001182	5.89	2317.13	261.63	19.75
1463	18	195.5	201.48		201.48	0	0.05	368.89	101.58	5.98
1463	2010	195.5	206.3		206.38	0.000307	2.34	996.5	141.96	10.8
1463	3139	195.5	207.78		207.91	0.000431	3.03	1214.14	148.46	12.28
1463	4341	195.5	209.12		209.29	0.000531	3.61	1412.72	149.89	13.62
1463	5032	195.5	209.81		210.01	0.00058	3.9	1517.19	150.64	14.31
1463	6162	195.5	210.75		211	0.000669	4.37	1658.92	151.65	15.25
1463	7459	195.5	211.74		212.05	0.00076	4.84	1809.89	152.72	16.24
1463	12311	195.5	215.27		215.73	0.001024	6.02	2480.01	259.8	19.77
1457	18	195.5	201.48		201.48	0.000001	0.07	286.93	105.28	5.98
1457	2010	195.5	206.29		206.37	0.000414	2.53	946.87	150.18	10.79
1457	3139	195.5	207.78		207.91	0.000534	3.19	1170.37	150.4	12.28

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TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
1457	4341	195.5	209.11		209.29	0.000633	3.75	1370.68	150.59	13.61
1457	5032	195.5	209.8		210.01	0.000681	4.04	1475.4	151.37	14.3
1457	6162	195.5	210.74		211	0.000776	4.52	1618.13	153.65	15.24
1457	7459	195.5	211.73		212.04	0.00087	5	1771.52	156.05	16.23
1457	12311	195.5	215.24		215.72	0.000995	6.24	2429.4	217.67	19.74
1446	18	197.77	201.48	198.48	201.48	0.000011	0.18	105.72	59.55	3.71
1446	2010	197.77	206.17	203.21	206.35	0.001426	3.73	632.1	143.53	8.4
1446	3139	197.77	207.64		207.89	0.001441	4.36	845.12	146.4	9.87
1446	4341	197.77	208.95		209.26	0.001465	4.89	1039.21	148.59	11.18
1446	5032	197.77	209.64		209.98	0.001476	5.16	1141.82	149.74	11.87
1446	6162	197.77	210.56		210.97	0.001561	5.63	1280.32	151.27	12.79
1446	7459	197.77	211.5		212.01	0.001787	6.33	1432.96	172.64	13.73
1446	12311	197.77	215.1		215.7	0.00143	6.86	2159.77	237.43	17.33
1419	18	201	201.43		201.47	0.006218	1.64	10.99	34.98	0.43
1419	2010	201	205.57		206.25	0.003836	6.6	310.6	93.92	4.57
1419	3139	201	206.93		207.77	0.003291	7.43	445.47	104.2	5.93
1419	4341	201	208.1		209.14	0.003128	8.26	573.41	124.2	7.1
1419	5032	201	208.76		209.86	0.002941	8.53	656.39	125.53	7.76
1419	6162	201	209.55		210.83	0.003032	9.26	758.25	134.86	8.55
1419	7459	201	210.48		211.86	0.003238	9.73	893.62	152.14	9.48
1419	12311	201	214.48		215.6	0.001776	9.09	1673.16	245.17	13.48
1369	18	200.5	200.83	200.82	200.93	0.023242	2.48	7.26	33.41	0.33
1369	2010	200.5	204.76	204.32	205.94	0.007319	8.7	231.3	87.92	4.26
1369	3139	200.5	206.21	205.48	207.51	0.005569	9.27	362.37	98.81	5.71
1369	4341	200.5	207.47	206.54	208.91	0.004681	9.85	489.65	107.91	6.97
1369	5032	200.5	208.12	207	209.63	0.004386	10.16	563.97	119	7.62
1369	6162	200.5	208.93	207.7	210.61	0.004308	10.8	660.32	119	8.43
1369	7459	200.5	209.83	208.66	211.63	0.004485	11.31	767.45	125.1	9.33
1369	12311	200.5	214.55	211.67	215.46	0.001369	8.03	1796.78	257.75	14.05
1310	18	199	199.42	199.42	199.55	0.025163	2.91	6.19	23.82	0.42
1310	2010	199	204.79		205.52	0.003447	6.93	305.2	78.71	5.79
1310	3139	199	206.17		207.17	0.00339	8.13	418.63	89.39	7.17
1310	4341	199	207.38		208.61	0.003402	9.13	552.14	127.58	8.38
1310	5032	199	208.07		209.34	0.003229	9.41	644.71	141.24	9.07
1310	6162	199	208.94		210.27	0.003572	9.79	772.68	152.15	9.94
1310	7459	199	209.96		211.26	0.003115	9.88	945.5	182.24	10.96
1310	12311	199	214.47		215.38	0.00124	8.29	1847.42	223.63	15.47
1184	18	198	198.63		198.64	0.000663	0.83	21.75	35.26	0.63
1184	2010	198	204.37		205.08	0.00331	6.76	297.47	67.87	6.37
1184	3139	198	205.72		206.73	0.003423	8.09	399.34	90.51	7.72
1184	4341	198	206.94		208.18	0.003386	9.04	522.44	110.3	8.94
1184	5032	198	207.75		208.93	0.002905	9	632.97	148	9.75
1184	6162	198	208.68		209.85	0.002533	9.05	770.79	148	10.68
1184	7459	198	209.71		210.91	0.00213	8.94	924.45	148	11.71
1184	12311	198	214.17		215.23	0.000891	7.42	1683.28	179.14	16.17

AR100205

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
1170	18	198	198.61		198.63	0.001028	0.96	18.7	34.04	0.61
1170	2010	198	204.34		205.03	0.003196	6.67	301.4	69.02	6.34
1170	3139	198	205.7		206.68	0.003255	7.95	403.97	89.93	7.7
1170	4341	198	206.91		208.12	0.003246	8.92	525.79	109.95	8.91
1170	5032	198	207.71		208.89	0.00282	8.94	634.04	148	9.71
1170	6162	198	208.64		209.81	0.00248	9.03	771.55	148	10.64
1170	7459	198	209.68		210.88	0.002088	8.94	926.24	148	11.68
1170	12311	198	214.16		215.22	0.000878	7.45	1687.7	179.13	16.16
1103	18	198	198.29	198.29	198.42	0.025662	2.95	6.11	23.24	0.29
1103	2010	198	203.88		204.77	0.004199	7.55	266.11	60.91	5.88
1103	3139	198	205.08		206.39	0.004636	9.2	352.39	82.64	7.08
1103	4341	198	206.11		207.81	0.004987	10.58	441.51	91.07	8.11
1103	5032	198	206.79		208.57	0.005205	10.9	508.4	104.01	8.79
1103	6162	198	208.13		209.59	0.003567	10.13	703.73	155.89	10.13
1103	7459	198	209.42		210.72	0.002501	9.38	910.35	165.08	11.42
1103	12311	198	214.29		215.09	0.000667	6.43	2008.21	240.96	16.29
1018	18	197	198.26		198.26	0.000289	0.61	29.51	41.29	1.26
1018	2010	197	203.87		204.42	0.00209	5.96	337.46	65.48	6.87
1018	3139	197	205.1		205.97	0.002575	7.51	418.87	67.41	8.1
1018	4341	197	206.1		207.34	0.003068	8.95	491.58	116.01	9.1
1018	5032	197	206.83		208.1	0.002871	9.17	610.75	215.35	9.83
1018	6162	197	208.43		209.19	0.001441	7.33	1042.54	296.88	11.43
1018	7459	197	209.77		210.39	0.000895	6.3	1455.66	340.58	12.77
1018	12311	197	214.55		214.93	0.000237	4.12	3297.25	417	17.55
1000	18	196.37	198.26		198.26	0.000054	0.39	46.28	35.79	1.89
1000	2010	196.37	203.83		204.38	0.002178	5.97	337.13	67.32	7.46
1000	3139	196.37	205.05		205.92	0.002643	7.49	431.04	88.52	8.68
1000	4341	196.37	206.09		207.26	0.003286	8.77	534.04	116.27	9.72
1000	5032	196.37	206.82		208.03	0.003018	8.99	645.19	199.8	10.45
1000	6162	196.37	208.44		209.15	0.001529	7.28	1105.64	338.78	12.07
1000	7459	196.37	209.86		210.33	0.000867	6.04	1647.94	435.69	13.49
1000	12311	196.37	214.63		214.89	0.000152	3.24	3903.64	490.81	18.26
993	18	196.37	198.26		198.26	0.000048	0.36	49.45	39.14	1.89
993	2010	196.37	203.83		204.36	0.002099	5.88	342.44	68.05	7.46
993	3139	196.37	205.05		205.89	0.002552	7.37	437.51	89.01	8.68
993	4341	196.37	206.09		207.23	0.002927	8.65	540.12	110.97	9.72
993	5032	196.37	206.8		208.01	0.002815	8.97	644.01	195.58	10.43
993	6162	196.37	208.42		209.14	0.001474	7.33	1102.18	338.08	12.05
993	7459	196.37	209.86		210.32	0.00084	6.07	1646.85	435.13	13.49
993	12311	196.37	214.64		214.89	0.000148	3.23	3930.22	497.81	18.27
982	18	196.5	198.26	196.95	198.26	0.00004	0.33	54.14	42.79	1.76
982	2010	196.5	203.86		204.32	0.001755	5.42	371.46	73.17	7.36
982	3139	196.5	205.12		205.83	0.002114	6.78	474.36	91.89	8.62
982	4341	196.5	206.18		207.15	0.002418	7.96	581.65	114.02	9.68
982	5032	196.5	206.9		207.93	0.002339	8.28	683.34	168.81	10.4
982	6162	196.5	208.3		209.12	0.001619	7.66	1025.62	292.59	11.8

AR100206

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
982	7459	196.5	209.71		210.3	0.001002	6.6	1472.57	328.69	13.21
982	12311	196.5	214.48		214.88	0.000297	4.57	3292.45	404.44	17.98
905	18	198	198.19		198.24	0.016513	1.89	9.54	51.13	0.19
905	2010	198	203.71		204.18	0.001844	5.48	369.52	78.99	5.71
905	3139	198	204.95		205.66	0.002166	6.79	470.42	82.9	6.95
905	4341	198	205.97		206.96	0.00249	8.01	556.67	85.92	7.97
905	5032	198	206.63		207.73	0.002504	8.47	614.01	88.52	8.63
905	6162	198	207.9		208.96	0.002038	8.45	825.7	222.85	9.9
905	7459	198	209.41		210.2	0.001292	7.46	1212.76	282.65	11.41
905	12311	198	214.35		214.84	0.000424	5.53	2826.98	368.13	16.35
854	18	197.2	197.44		197.5	0.014136	1.99	9.05	39.94	0.24
854	2010	197.2	203.67		204.08	0.001451	5.11	395.8	77.71	6.47
854	3139	197.2	204.9		205.54	0.001818	6.45	494.21	81.8	7.7
854	4341	197.2	205.91		206.82	0.002167	7.7	578.18	84.72	8.71
854	5032	197.2	206.56		207.59	0.002215	8.19	634.43	87.24	9.36
854	6162	197.2	207.65		208.84	0.002177	8.8	754.33	141.07	10.45
854	7459	197.2	208.84		210.07	0.001988	9.11	979.89	243.36	11.64
854	12311	197.2	214.25		214.8	0.000657	6.93	2677.06	353.46	17.05
777	18	196	197.43		197.43	0.000175	0.55	32.72	36.65	1.43
777	2010	196	203.5		203.95	0.001702	5.41	371.75	72.69	7.5
777	3139	196	204.64		205.38	0.002201	6.91	456.85	75.56	8.64
777	4341	196	205.54		206.62	0.002716	8.33	525.71	77.08	9.54
777	5032	196	206.16		207.38	0.002787	8.88	573.95	78.33	10.16
777	6162	196	207.21		208.62	0.002772	9.55	657.37	80.43	11.21
777	7459	196	208.2		209.84	0.00285	10.34	761.81	183.96	12.2
777	12311	196	213.89		214.72	0.000961	8.16	2190.52	382.41	17.89
755	18	196	197.43		197.43	0.000094	0.46	39.24	35.14	1.43
755	2010	196	203.43		203.91	0.001846	5.56	361.63	67.78	7.43
755	3139	196	204.51		205.32	0.002501	7.22	435.92	69.11	8.51
755	4341	196	205.32		206.54	0.003259	8.86	491.97	69.52	9.32
755	5032	196	205.89		207.3	0.003426	9.51	531.86	69.82	9.89
755	6162	196	206.87		208.53	0.003515	10.34	602	75.23	10.87
755	7459	196	207.75		209.74	0.003766	11.35	671.83	87.83	11.75
755	12311	196	213.57		214.66	0.00131	9.18	1760.63	303.86	17.57
742	18	196	197.42	196.39	197.43	0.000068	0.58	31.15	29.27	1.42
742	2010	196	203.16	201.3	203.87	0.00133	6.73	298.74	63.12	7.16
742	3139	196	204.07	202.58	205.25	0.00175	8.72	359.86	69	8.07
742	4341	196	204.5	203.82	206.43	0.002597	11.15	389.26	69	8.5
742	5032	196	204.97	204.3	207.18	0.002737	11.92	422.12	70	8.97
742	6162	196	206	205.15	208.41	0.002873	12.46	494.65	70	10
742	7459	196	205.98	205.97	209.54	0.004255	15.13	492.93	70	9.98
742	12311	196	213.37	209.03	214.63	0.00068	9.39	1421.8	261.6	17.37
725	18	196	197.42		197.43	0.000035	0.45	40.37	35.97	1.42
725	2010	196	203.3		203.75	0.000767	5.39	372.96	74.27	7.3
725	3139	196	204.3		205.06	0.001068	6.99	448.82	76	8.3

AR100207

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
725	4341	196	204.88		206.08	0.00154	8.8	493.45	77	8.88
725	5032	196	205.11		206.62	0.001852	9.84	511.23	77	9.11
725	6162	196	205.38		207.47	0.002451	11.58	532.05	77	9.38
725	7459	196	204.11	205.1	208.69	0.006697	17.18	434.18	76	8.11
725	12311	196	207.84	207.84	212.36	0.003793	17.06	722.75	84.25	11.84
715	18	196	197.42		197.42	0.000061	0.39	46.66	39.53	1.42
715	2010	196	203.26		203.65	0.001535	5.03	399.78	75.79	7.26
715	3139	196	204.25		204.92	0.002199	6.6	475.47	77.35	8.25
715	4341	196	204.8		205.89	0.003207	8.37	518.44	77.47	8.8
715	5032	196	205.01		206.39	0.003914	9.41	534.66	77.51	9.01
715	6162	196	205.23		207.17	0.005323	11.17	551.67	77.55	9.23
715	7459	196	203.67	204.71	208.32	0.016849	17.31	431	76.85	7.67
715	12311	196	205.97	207.37	212.31	0.015621	20.21	609.1	77.7	9.97
646	18	196.33	197.41		197.42	0.000356	0.76	23.65	27.44	1.08
646	2010	196.33	201.79	201.79	203.33	0.008786	10.35	249.41	95.17	5.46
646	3139	196.33	203.3	203.3	204.61	0.007184	10.06	504.76	206.83	6.97
646	4341	196.33	203.96	203.96	205.51	0.008338	11.25	649.14	228.98	7.63
646	5032	196.33	204.32	204.32	205.98	0.008325	11.78	733.44	236.75	7.99
646	6162	196.33	204.85	204.85	206.68	0.008384	12.57	862.23	247.91	8.52
646	7459	196.33	205.4	205.4	207.41	0.008473	13.38	1001.42	259.43	9.07
646	12311	196.33	207.11	206.83	210.12	0.009708	16.69	1492.33	377.66	10.78
562	18	194.17	197.41		197.41	0.000011	0.19	93.37	47.15	3.24
562	2010	194.17	198.26	199.31	201.72	0.04453	14.92	134.72	49.79	4.09
562	3139	194.17	199.61	200.58	203.26	0.031146	15.33	204.79	55.04	5.44
562	4341	194.17	201.46	202.3	204.43	0.015465	13.9	336.75	127.7	7.29
562	5032	194.17	202.23	202.87	205.02	0.012541	13.67	458.49	182.33	8.06
562	6162	194.17	203.13	203.61	205.81	0.010651	13.78	634.9	211.65	8.96
562	7459	194.17	203.98	204.42	206.6	0.009468	14.02	830.28	245.55	9.81
562	12311	194.17	206.88	206.88	209.08	0.006271	14.03	1717.46	396.05	12.71
479	18	193	197.41		197.41	0.000004	0.14	132.02	49.12	4.41
479	2010	193	199.98		200.86	0.005649	7.56	265.96	55.93	6.98
479	3139	193	199.92	199.81	202.13	0.014303	11.95	262.6	55.75	6.92
479	4341	193	201.41	201.68	203.47	0.009787	11.85	490.35	221.67	8.41
479	5032	193	202.14	202.19	203.97	0.007968	11.51	663.52	255.41	9.14
479	6162	193	202.14	202.85	204.88	0.011899	14.08	665.13	255.71	9.14
479	7459	193	202.67	202.97	205.66	0.012371	15.07	806.04	280.41	9.67
479	12311	193	203.93	205.45	208.09	0.01563	18.61	1227.29	354.31	10.93
465	18	192.74	197.41		197.41	0.000002	0.1	174.69	60.89	4.67
465	2010	192.74	200.19		200.69	0.002785	5.71	351.93	67.35	7.45
465	3139	192.74	200.61		201.67	0.00529	8.25	382.97	81.44	7.87
465	4341	192.74	198.85	199.99	203.03	0.031288	16.42	264.4	63.89	6.11
465	5032	192.74	199.66	200.57	203.57	0.02408	15.88	316.84	65.58	6.92
465	6162	192.74	200.89	202.42	204.58	0.01734	15.42	408.23	100.46	8.15
465	7459	192.74	201.79	203.05	205.41	0.014678	15.58	617.25	269.67	9.05
465	12311	192.74	203.22	204.61	207.84	0.016446	18.71	1076.25	336.18	10.48

TABLE B-2
Hydraulic Data of 100% Design

River Sta	Q Total (cfs)	Min Ch El (ft)	WS Elev (ft)	Crit W.S. (ft)	EG Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Max Chnl Dpth (ft)
433	18	194	197.41	194.22	197.41	0.000002	0.1	188.88	78.12	3.41
433	2010	194	200.27	197.75	200.58	0.001911	4.39	496.99	112.81	6.27
433	3139	194	200.84	198.73	201.39	0.003153	5.09	561.79	114.52	6.84
433	4341	194	201.24	199.64	202.13	0.004671	7.78	640.2	257.46	7.24
433	5032	194	201.39	200	202.51	0.005692	8.74	679.53	264.09	7.39
433	6162	194	199.24	200.54	203.71	0.038236	17.3	383.67	105.22	5.24
433	7459	194	199.87	201.68	204.6	0.035085	17.82	452.68	110.88	5.87
433	12311	194	202.44	203.78	207.25	0.020213	18.12	888.76	311.75	8.44
413	18	193.5	197.41	194.1	197.41	0.000006	0.12	150.68	98.21	3.91
413	2010	193.5	200.29	198.24	200.5	0.001703	3.8	628.01	239.47	6.79
413	3139	193.5	200.92	198.99	201.27	0.002399	4.97	786.38	257.78	7.42
413	4341	193.5	201.42	199.73	201.94	0.003156	6.1	922.02	290.86	7.92
413	5032	193.5	201.65	200.05	202.27	0.003612	6.72	989.62	307.47	8.15
413	6162	193.5	199.62	200.55	202.59	0.030136	14.14	482.1	193.85	6.12
413	7459	193.5	199.84	201	203.62	0.035504	16.01	525.86	210.72	6.34
413	12311	193.5	201.18	202.8	206.66	0.03358	19.28	762.44	245.92	7.68
399	18	192.05	192.64	192.63	192.78	0.033847	3.03	5.94	20.1	0.59
399	2010	192.05	196.25	195.21	196.67	0.005064	5.25	383.18	130.26	4.2
399	3139	192.05	197.34	195.91	197.88	0.004535	5.95	527.79	134.95	5.29
399	4341	192.05	198.19	196.57	198.89	0.005032	6.72	645.62	147.83	6.14
399	5032	192.05	198.56	196.91	199.36	0.005173	7.17	701.92	148.84	6.51
399	6162	192.05	199.1	197.44	200.06	0.005484	7.88	782.16	156.95	7.05
399	7459	192.05	199.62	198.09	200.79	0.005825	8.66	873.98	193.62	7.57
399	12311	192.05	201.35	200.05	202.93	0.005878	10.37	1424.3	319.71	9.3
390	18	192.05	192.35	192.31	192.41	0.023942	2.03	8.87	42.09	0.3
390	2010	192.05	196.36	194.67	196.58	0.002119	3.76	534.74	161.42	4.31
390	3139	192.05	197.49	195.28	197.78	0.00202	4.37	718.95	166.83	5.44
390	4341	192.05	198.38	195.84	198.76	0.002132	4.99	869.77	171.64	6.33
390	5032	192.05	198.78	196.15	199.23	0.002254	5.36	939.63	173.82	6.73
390	6162	192.05	199.36	196.6	199.91	0.002425	5.92	1044.95	197.07	7.31
390	7459	192.05	199.94	197.11	200.6	0.002595	6.51	1169.63	232.48	7.89
390	12311	192.05	201.74	198.76	202.71	0.00288	8.07	1783.91	351.42	9.69

AR100209

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
1748	18	212.06	0.12	3.42	212.06	0.12	3.42	0	0	0
1748	2010	215.73	3.17	7.09	215.73	3.17	7.09	0	0	0
1748	3139	217.22	3.67	8.58	217.22	3.67	8.58	0	0	0
1748	4341	217.97	4.41	9.33	217.97	4.41	9.33	0	0	0
1748	5032	218.46	4.69	9.82	218.46	4.69	9.82	0	0	0
1748	6162	219.17	5.1	10.53	219.17	5.09	10.53	0	-0.01	0
1748	7459	219.89	5.5	11.25	219.89	5.49	11.25	0	-0.01	0
1748	12311	222.1	6.7	13.46	222.1	6.7	13.46	0	0	0
1736	18	212.06	0.1	3.42	212.06	0.1	3.42	0	0	0
1736	2010	215.73	3.02	7.09	215.73	3.02	7.09	0	0	0
1736	3139	217.22	3.54	8.58	217.22	3.54	8.58	0	0	0
1736	4341	217.97	4.26	9.33	217.97	4.26	9.33	0	0	0
1736	5032	218.46	4.56	9.82	218.46	4.56	9.82	0	0	0
1736	6162	219.17	4.97	10.53	219.17	4.97	10.53	0	0	0
1736	7459	219.89	5.38	11.25	219.89	5.38	11.25	0	0	0
1736	12311	222.1	6.6	13.46	222.1	6.6	13.46	0	0	0
1720	18	212.05	0.15	3.13	212.05	0.15	3.13	0	0	0
1720	2010	215.48	4.9	6.56	215.48	4.9	6.56	0	0	0
1720	3139	216.9	5.7	7.96	216.9	5.7	7.96	0	0	0
1720	4341	217.51	6.97	8.59	217.51	6.97	8.59	0	0	0
1720	5032	217.95	7.4	9.03	217.96	7.39	9.04	0.01	-0.01	0.01
1720	6162	218.64	7.89	9.72	218.64	7.88	9.72	0	-0.01	0
1720	7459	219.34	8.35	10.42	219.35	8.35	10.43	0.01	0	0.01
1720	12311	221.5	9.75	12.58	221.49	9.76	12.57	-0.01	0.01	-0.01
1606	18	212.05	0.13	4.38	212.05	0.13	4.38	0	0	0
1606	2010	215.07	5.61	7.4	215.07	5.61	7.4	0	0	0
1606	3139	216.39	6.83	8.72	216.39	6.83	8.72	0	0	0
1606	4341	216.54	9.1	8.87	216.56	9.06	8.89	0.02	-0.04	0.02
1606	5032	216.94	9.61	9.27	216.96	9.57	9.29	0.02	-0.04	0.02
1606	6162	217.47	10.5	9.8	217.5	10.44	9.83	0.03	-0.06	0.03
1606	7459	217.96	11.49	10.31	218	11.43	10.33	0.02	-0.06	0.02
1606	12311	219.85	13.55	12.18	219.81	13.62	12.14	-0.04	0.07	-0.04
1538	18	212.05	0.09	5.55	212.05	0.09	5.55	0	0	0

AR100210

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
1538	2010	215.04	4.5	8.54	215.04	4.5	8.54	0	0	0
1538	3139	216.39	5.49	9.89	216.39	5.49	9.89	0	0	0
1538	4341	216.54	7.37	10.04	216.56	7.35	10.06	0.02	-0.02	0.02
1538	5032	216.91	7.97	10.41	216.92	7.94	10.42	0.01	-0.03	0.01
1538	6162	217.39	8.95	10.89	217.42	8.91	10.92	0.03	-0.04	0.03
1538	7459	217.82	10.09	11.32	217.85	10.04	11.35	0.03	-0.05	0.03
1538	12311	219.05	13.78	12.55	218.8	14.28	12.3	-0.25	0.5	-0.25
1510	18	212.05	0.18	7.29	212.05	0.18	7.29	0	0	0
1510	2010	213.82	9.1	9.06	213.82	9.11	9.06	0	0.01	0
1510	3139	214.76	10.7	10	214.76	10.7	10	0	0	0
1510	4341	216.48	6.89	11.72	216.5	6.87	11.74	0.02	-0.02	0.02
1510	5032	216.85	7.43	12.09	216.87	7.4	12.11	0.02	-0.03	0.02
1510	6162	217.35	8.34	12.59	217.38	8.29	12.62	0.03	-0.05	0.03
1510	7459	217.82	9.2	13.06	217.86	9.14	13.1	0.04	-0.06	0.04
1510	12311	219.48	11.14	14.72	219.22	11.7	14.46	-0.26	0.56	-0.26
1508	18	212.05	0.17	7.29	212.05	0.17	7.29	0	0	0
1508	2010	213.82	8.95	9.06	213.82	8.96	9.06	0	0.01	0
1508	3139	214.59	11.09	9.83	214.59	11.09	9.83	0	0	0
1508	4341	216.47	6.87	11.71	216.51	6.49	11.75	0.04	-0.38	0.04
1508	5032	216.84	7.42	12.08	216.89	7.02	12.13	0.05	-0.4	0.05
1508	6162	217.33	8.36	12.57	217.4	7.93	12.64	0.07	-0.43	0.07
1508	7459	217.76	9.33	13	217.88	8.8	13.12	0.12	-0.53	0.12
1508	12311	218.47	13.72	13.71	219.05	11.99	14.29	0.58	-1.73	0.58
					Spectron Dam					
1474	18	200.45	0.29	2.5	201.48	0.2	3.53	1.03	-0.09	1.03
1474	2010	205.91	4.43	7.96	206.17	4.16	8.22	0.26	-0.27	0.26
1474	3139	207.51	4.95	9.56	207.63	4.85	9.68	0.12	-0.1	0.12
1474	4341	208.95	5.43	11	208.93	5.46	10.98	-0.02	0.02	-0.02
1474	5032	209.77	5.63	11.82	209.61	5.75	11.66	-0.16	0.12	-0.16
1474	6162	210.53	6.27	12.58	210.51	6.29	12.56	-0.02	0.02	-0.02
1474	7459	211.31	6.95	13.36	211.46	6.84	13.51	0.15	-0.11	0.15
1474	12311	215.03	7.37	17.06	215.06	7.35	17.11	0.03	-0.02	0.03

AR100211

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
1468	18	200.45	0.1	4.96	201.48	0.07	5.99	1.03	-0.03	1.03
1466	2010	206.04	2.67	10.55	206.28	2.57	10.79	0.24	-0.1	0.24
1466	3139	207.65	3.31	12.16	207.76	3.26	12.27	0.11	-0.05	0.11
1466	4341	209.1	3.85	13.61	209.08	3.86	13.59	-0.02	0.01	-0.02
1466	5032	209.92	4.1	14.43	209.77	4.16	14.28	-0.15	0.06	-0.15
1466	6162	210.75	4.4	15.26	210.72	4.41	15.23	-0.03	0.01	-0.03
1466	7459	211.57	4.91	16.08	211.71	4.85	16.22	0.14	-0.06	0.14
1466	12311	215.21	5.9	19.72	215.24	5.89	19.75	0.03	-0.01	0.03
1463	18	200.45	0.07	4.95	201.48	0.05	5.98	1.03	-0.02	1.03
1463	2010	206.06	2.41	10.56	206.3	2.34	10.8	0.24	-0.07	0.24
1463	3139	207.67	3.07	12.17	207.78	3.03	12.28	0.11	-0.04	0.11
1463	4341	209.14	3.6	13.64	209.12	3.61	13.62	-0.02	0.01	-0.02
1463	5032	209.96	3.84	14.46	209.81	3.9	14.31	-0.15	0.06	-0.15
1463	6162	210.77	4.36	15.27	210.75	4.37	15.25	-0.02	0.01	-0.02
1463	7459	211.6	4.9	16.1	211.74	4.84	16.24	0.14	-0.06	0.14
1463	12311	215.24	6.03	19.74	215.27	6.02	19.77	0.03	-0.01	0.03
1457	18	200.45	0.09	4.95	201.48	0.07	5.98	1.03	-0.02	1.03
1457	2010	206.04	2.64	10.54	206.29	2.53	10.79	0.25	-0.11	0.25
1457	3139	207.66	3.24	12.16	207.78	3.19	12.28	0.12	-0.05	0.12
1457	4341	209.13	3.74	13.63	209.11	3.75	13.61	-0.02	0.01	-0.02
1457	5032	209.95	3.96	14.45	209.8	4.04	14.3	-0.15	0.08	-0.15
1457	6162	210.76	4.47	15.26	210.74	4.52	15.24	-0.02	0.05	-0.02
1457	7459	211.6	5	16.1	211.73	5	16.23	0.13	0	0.13
1457	12311	215.24	6.1	19.74	215.24	6.24	19.74	0	0.14	0
1446	18	200.44	0.31	2.67	201.48	0.18	3.71	1.04	-0.13	1.04
1446	2010	205.9	3.97	8.13	206.17	3.73	8.4	0.27	-0.24	0.27
1446	3139	207.52	4.45	9.75	207.64	4.36	9.87	0.12	-0.09	0.12
1446	4341	208.98	4.88	11.21	208.95	4.89	11.18	-0.03	0.01	-0.03
1446	5032	209.8	5.05	12.03	209.64	5.16	11.87	-0.16	0.11	-0.16
1446	6162	210.59	5.61	12.82	210.56	5.63	12.79	-0.03	0.02	-0.03
1446	7459	211.35	6.45	13.58	211.5	6.33	13.73	0.15	-0.12	0.15
1446	12311	215.07	6.93	17.3	215.1	6.86	17.33	0.03	-0.07	0.03
1419	18	200.38	1.9	0.88	201.43	1.64	0.43	1.05	-0.26	-0.45

AR100212

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
1419	2010	205.48	5.85	5.98	205.57	6.6	4.57	0.09	0.75	-1.41
1419	3139	207.06	6.36	7.56	206.93	7.43	5.93	-0.13	1.07	-1.63
1419	4341	208.5	6.8	9	208.1	8.26	7.1	-0.4	1.46	-1.9
1419	5032	209.34	6.88	9.84	208.76	8.53	7.76	-0.58	1.65	-2.08
1419	6162	210.04	7.59	10.54	209.55	9.26	8.55	-0.49	1.67	-1.99
1419	7459	210.78	8.26	11.28	210.48	9.73	9.48	-0.3	1.47	-1.8
1419	12311	214.74	7.92	15.24	214.48	9.09	13.48	-0.26	1.17	-1.76
1369	18	199.56	2.08	0.56	200.83	2.48	0.33	1.27	0.4	-0.23
1369	2010	205.02	6.69	6.02	204.76	8.7	4.26	-0.26	2.01	-1.76
1369	3139	206.54	7.62	7.54	206.21	9.27	5.71	-0.33	1.65	-1.83
1369	4341	208	8.09	9	207.47	9.85	6.97	-0.53	1.76	-2.03
1369	5032	206.96	7.92	9.96	208.12	10.16	7.62	-0.84	2.24	-2.34
1369	6162	209.62	8.68	10.62	208.93	10.8	8.43	-0.69	2.12	-2.19
1369	7459	210.3	9.42	11.3	209.83	11.31	9.33	-0.47	1.89	-1.97
1369	12311	214.7	7.07	15.7	214.55	8.03	14.05	-0.15	0.96	-1.65
1310	18	198.64	1.99	0.64	199.42	2.91	0.42	0.78	0.92	-0.22
1310	2010	204.58	7.02	6.58	204.79	6.93	5.79	0.21	-0.09	-0.79
1310	3139	206.24	7.67	8.24	206.17	8.13	7.17	-0.07	0.46	-1.07
1310	4341	207.76	8.07	9.76	207.38	9.13	8.38	-0.38	1.06	-1.38
1310	5032	208.8	7.68	10.8	208.07	9.41	9.07	-0.73	1.73	-1.73
1310	6162	209.47	8.34	11.47	208.94	9.79	9.94	-0.53	1.45	-1.53
1310	7459	210.19	8.86	12.19	209.96	9.88	10.96	-0.23	1.02	-1.23
1310	12311	214.6	7.5	16.6	214.47	8.29	15.47	-0.13	0.79	-1.13
1184	18	197.79	1.29	0.93	198.63	0.83	0.63	0.84	-0.46	-0.3
1184	2010	204.11	5.85	7.25	204.37	6.76	6.37	0.26	0.91	-0.88
1184	3139	205.83	6.58	8.97	205.72	8.09	7.72	-0.11	1.51	-1.25
1184	4341	207.43	6.96	10.57	206.94	9.04	8.94	-0.49	2.08	-1.63
1184	5032	208.53	6.71	11.67	207.75	9	9.75	-0.78	2.29	-1.92
1184	6162	209.14	7.47	12.28	208.68	9.05	10.68	-0.46	1.58	-1.6
1184	7459	209.77	8.24	12.91	209.71	8.94	11.71	-0.06	0.7	-1.2
1184	12311	214.23	7.71	17.37	214.17	7.42	16.17	-0.06	-0.29	-1.2
1170	18	197.73	1.27	0.73	198.61	0.96	0.61	0.88	-0.31	-0.12
1170	2010	204	6.06	7	204.34	6.67	6.34	0.34	0.61	-0.66

AR100213

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
1170	3139	205.73	6.76	8.73	205.7	7.95	7.7	-0.03	1.19	-1.03
1170	4341	207.34	7.13	10.34	206.91	8.92	8.91	-0.43	1.79	-1.43
1170	5032	208.46	6.87	11.46	207.71	8.94	9.71	-0.75	2.07	-1.75
1170	6162	209.05	7.66	12.05	208.64	9.03	10.64	-0.41	1.37	-1.41
1170	7459	209.65	8.48	12.65	209.68	8.94	11.68	0.03	0.46	-0.97
1170	12311	214.16	7.89	17.16	214.16	7.45	16.16	0	-0.44	-1
1103	18	197.69	0.61	1.19	198.29	2.95	0.29	0.6	2.34	-0.9
1103	2010	203.74	5.88	7.24	203.88	7.55	5.88	0.14	1.67	-1.36
1103	3139	205.48	6.75	8.98	205.08	9.2	7.08	-0.4	2.45	-1.9
1103	4341	207.14	7.13	10.64	206.11	10.58	8.11	-1.03	3.45	-2.53
1103	5032	208.33	6.67	11.83	206.79	10.9	8.79	-1.54	4.23	-3.04
1103	6162	208.9	7.42	12.4	208.13	10.13	10.13	-0.77	2.71	-2.27
1103	7459	209.49	8.18	12.99	209.42	9.38	11.42	-0.07	1.2	-1.57
1103	12311	214.26	6.51	17.76	214.29	6.43	16.29	0.03	-0.08	-1.47
1018	18	197.68	0.3	1.68	198.26	0.61	1.26	0.58	0.31	-0.42
1018	2010	203.66	4.58	7.66	203.87	5.96	6.87	0.21	1.38	-0.79
1018	3139	205.42	5.48	9.42	205.1	7.51	8.1	-0.32	2.03	-1.32
1018	4341	207.09	5.95	11.09	206.1	8.95	9.1	-0.99	3	-1.99
1018	5032	208.37	5.23	12.37	206.83	9.17	9.83	-1.54	3.94	-2.54
1018	6162	209	5.58	13	208.43	7.33	11.43	-0.57	1.75	-1.57
1018	7459	209.67	5.87	13.67	209.77	6.3	12.77	0.1	0.43	-0.9
1018	12311	214.46	4.17	18.46	214.55	4.12	17.55	0.09	-0.05	-0.91
1000	18	197.68	0.27	2.96	198.26	0.39	1.89	0.58	0.12	-1.07
1000	2010	203.3	6.06	8.58	203.83	5.97	7.46	0.53	-0.09	-1.12
1000	3139	204.85	7.46	10.13	205.05	7.49	8.68	0.2	0.03	-1.45
1000	4341	206.24	8.59	11.52	206.09	8.77	9.72	-0.15	0.18	-1.8
1000	5032	207.99	6.91	13.27	206.82	8.99	10.45	-1.17	2.08	-2.82
1000	6162	208.77	6.69	14.05	208.44	7.28	12.07	-0.33	0.59	-1.98
1000	7459	209.58	6.43	14.86	209.86	6.04	13.49	0.28	-0.39	-1.37
1000	12311	214.46	3.02	19.74	214.63	3.24	18.26	0.17	0.22	-1.48
					Footbridge					
993	18	197.68	0.29	3.02	198.26	0.36	1.89	0.58	0.07	-1.13

AR100214

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
993	2010	203.16	6.51	8.5	203.83	5.88	7.46	0.67	-0.63	-1.04
993	3139	204.57	8.24	9.91	205.05	7.37	8.68	0.48	-0.87	-1.23
993	4341	205.7	9.91	11.04	206.09	8.65	9.72	0.39	-1.26	-1.32
993	5032	206.33	10.64	11.67	206.8	8.97	10.43	0.47	-1.67	-1.24
993	6162	207.66	9.32	13	208.42	7.33	12.05	0.76	-1.99	-0.95
993	7459	209.2	7.16	14.54	209.86	6.07	13.49	0.66	-1.09	-1.05
993	12311	214.35	3.06	19.69	214.64	3.23	18.27	0.29	0.17	-1.42
982	18	197.68	0.21	3.02	198.26	0.33	1.76	0.58	0.12	-1.26
982	2010	203.21	5.59	8.55	203.86	5.42	7.36	0.65	-0.17	-1.19
982	3139	204.65	7.19	9.99	205.12	6.78	8.62	0.47	-0.41	-1.37
982	4341	205.83	8.67	11.17	206.18	7.96	9.68	0.35	-0.71	-1.49
982	5032	206.5	9.26	11.84	206.9	8.28	10.4	0.4	-0.98	-1.44
982	6162	207.8	7.82	13.14	208.3	7.66	11.8	0.5	-0.16	-1.34
982	7459	209.19	6.93	14.53	209.71	6.6	13.21	0.52	-0.33	-1.32
982	12311	214.23	4.39	19.57	214.48	4.57	17.98	0.25	0.18	-1.59
905	18	197.58	2.19	0.23	198.19	1.89	0.19	0.61	-0.3	-0.04
905	2010	202.98	5.65	5.63	203.71	5.48	5.71	0.73	-0.17	0.08
905	3139	204.44	6.83	7.09	204.95	6.79	6.95	0.51	-0.04	-0.14
905	4341	205.62	7.97	8.27	205.97	8.01	7.97	0.35	0.04	-0.3
905	5032	206.43	7.55	9.06	206.63	8.47	8.63	0.2	0.92	-0.45
905	6162	207.56	7.72	10.21	207.9	8.45	9.9	0.34	0.73	-0.31
905	7459	208.89	7.22	11.54	209.41	7.46	11.41	0.52	0.24	-0.13
905	12311	214.01	5.36	16.66	214.35	5.53	16.35	0.34	0.17	-0.31
854	18	197.43	0.64	0.93	197.44	1.99	0.24	0.01	1.36	-0.69
854	2010	202.84	5.46	6.34	203.67	5.11	6.47	0.83	-0.35	0.13
854	3139	204.28	6.72	7.78	204.9	6.45	7.7	0.62	-0.27	-0.08
854	4341	205.43	7.92	8.93	205.91	7.7	8.71	0.48	-0.22	-0.22
854	5032	206.27	7.42	9.77	206.56	8.19	9.36	0.29	0.77	-0.41
854	6162	207.36	7.81	10.86	207.65	8.8	10.45	0.29	0.99	-0.41
854	7459	208.69	7.61	12.19	208.84	9.11	11.64	0.15	1.5	-0.55
854	12311	214.01	5.95	17.51	214.25	6.93	17.05	0.24	0.98	-0.46
777	18	197.42	0.33	1.92	197.43	0.55	1.43	0.01	0.22	-0.49
777	2010	202.57	5.58	7.07	203.5	5.41	7.5	0.93	-0.17	0.43

AR100215

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
777	3139	203.97	6.87	8.47	204.64	6.91	8.64	0.67	0.04	0.17
777	4341	205.06	8.15	9.56	205.54	8.33	9.54	0.48	0.18	-0.02
777	5032	205.56	8.86	10.06	206.16	8.88	10.16	0.6	0.02	0.1
777	6162	206.44	9.79	10.94	207.21	9.55	11.21	0.77	-0.24	0.27
777	7459	207.39	10.71	11.89	208.2	10.34	12.2	0.81	-0.37	0.31
777	12311	213.67	7.38	18.17	213.89	8.16	17.89	0.22	0.78	-0.28
755	18	197.42	0.28	2.42	197.43	0.46	1.43	0.01	0.18	-0.99
755	2010	202.51	5.5	7.51	203.43	5.56	7.43	0.92	0.06	-0.08
755	3139	203.88	6.93	8.88	204.51	7.22	8.51	0.63	0.29	-0.37
755	4341	204.9	8.36	9.9	205.32	8.86	9.32	0.42	0.5	-0.58
755	5032	205.37	9.17	10.37	205.89	9.51	9.89	0.52	0.34	-0.48
755	6162	206.17	10.25	11.17	206.87	10.34	10.87	0.7	0.09	-0.3
755	7459	207.02	11.37	12.02	207.75	11.35	11.75	0.73	-0.02	-0.27
755	12311	213.53	7.55	18.53	213.57	9.18	17.57	0.04	1.63	-0.96
742	18	197.41	0.35	2.41	197.42	0.58	1.42	0.01	0.23	-0.99
742	2010	202.48	5.47	7.48	203.16	6.73	7.16	0.68	1.26	-0.32
742	3139	203.87	6.7	8.87	204.07	8.72	8.07	0.2	2.02	-0.8
742	4341	204.93	7.94	9.93	204.5	11.15	8.5	-0.43	3.21	-1.43
742	5032	205.42	8.61	10.42	204.97	11.92	8.97	-0.45	3.31	-1.45
742	6162	206.28	9.44	11.28	206	12.46	10	-0.28	3.02	-1.28
742	7459	207.21	10.24	12.21	205.98	15.13	9.98	-1.23	4.89	-2.23
742	12311	213.23	7.67	18.23	213.37	9.39	17.37	0.14	1.72	-0.86
					Providence Road Bridge					
725	18	197.41	0.27	1.91	197.42	0.45	1.42	0.01	0.18	-0.49
725	2010	202.1	5.44	6.8	203.3	5.39	7.3	1.2	-0.05	0.7
725	3139	203.49	6.57	7.99	204.3	6.99	8.3	0.81	0.42	0.31
725	4341	204.64	7.64	9.14	204.88	8.8	8.88	0.24	1.16	-0.26
725	5032	205.17	8.24	9.67	205.11	9.84	9.11	-0.06	1.6	-0.56
725	6162	205.97	9.13	10.47	205.38	11.58	9.38	-0.59	2.45	-1.09
725	7459	206.8	10.03	11.3	204.11	17.18	8.11	-2.69	7.15	-3.19
725	12311	210.99	10.35	15.49	207.84	17.06	11.84	-3.15	6.71	-3.65
715	18	197.41	0.27	1.91	197.42	0.39	1.42	0.01	0.12	-0.49

AR100216

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
715	2010	201.69	6.22	6.19	203.26	5.03	7.26	1.57	-1.19	1.07
715	3139	203.02	7.43	7.52	204.25	6.6	8.25	1.23	-0.83	0.73
715	4341	204.04	8.68	8.54	204.8	8.37	8.8	0.76	-0.31	0.26
715	5032	204.46	9.46	8.96	205.01	9.41	9.01	0.55	-0.05	0.05
715	6162	205.03	10.72	9.53	205.23	11.17	9.23	0.2	0.45	-0.3
715	7459	205.44	12.3	9.94	203.67	17.31	7.67	-1.77	5.01	-2.27
715	12311	206.88	17.14	11.38	205.97	20.21	9.97	-0.91	3.07	-1.41
646	18	197.41	0.22	2.41	197.41	0.76	1.08	0	0.54	-1.33
646	2010	201.09	7.45	6.09	201.79	10.35	5.46	0.7	2.9	-0.63
646	3139	202.6	8.11	7.6	203.3	10.06	6.97	0.7	1.95	-0.63
646	4341	203.93	8.3	8.93	203.96	11.25	7.63	0.03	2.95	-1.3
646	5032	204.47	8.58	9.47	204.32	11.78	7.99	-0.15	3.2	-1.48
646	6162	205.26	9.02	10.26	204.85	12.57	8.52	-0.41	3.55	-1.74
646	7459	205.96	9.63	10.96	205.4	13.38	9.07	-0.56	3.75	-1.89
646	12311	208.28	11.31	13.28	207.11	16.69	10.78	-1.17	5.38	-2.5
562	18	197.41	0.18	3.91	197.41	0.19	3.24	0	0.01	-0.67
562	2010	200.43	7.83	6.93	198.26	14.92	4.09	-2.17	7.09	-2.84
562	3139	201.61	9.57	8.11	199.61	15.33	5.44	-2	5.76	-2.67
562	4341	202.21	11.66	8.71	201.46	13.9	7.29	-0.75	2.24	-1.42
562	5032	202.8	11.92	9.3	202.23	13.67	8.06	-0.57	1.75	-1.24
562	6162	203.56	12.48	10.06	203.13	13.78	8.96	-0.43	1.3	-1.1
562	7459	204.38	12.83	10.88	203.98	14.02	9.81	-0.4	1.19	-1.07
562	12311	206	15.93	12.5	206.88	14.03	12.71	0.88	-1.9	0.21
479	18	197.41	0.14	4.41	197.41	0.14	4.41	0	0	0
479	2010	199.98	7.56	6.98	199.98	7.56	6.98	0	0	0
479	3139	199.92	11.95	6.92	199.92	11.95	6.92	0	0	0
479	4341	201.41	11.85	8.41	201.41	11.85	8.41	0	0	0
479	5032	201.71	12.76	8.71	202.14	11.51	9.14	0.43	-1.25	0.43
479	6162	202.19	13.93	9.19	202.14	14.08	9.14	-0.05	0.15	-0.05
479	7459	202.68	15.04	9.68	202.67	15.07	9.67	-0.01	0.03	-0.01
479	12311	204.06	18.29	11.06	203.93	18.81	10.93	-0.13	0.52	-0.13
465	18	197.41	0.1	4.67	197.41	0.1	4.67	0	0	0
465	2010	200.19	5.71	7.45	200.19	5.71	7.45	0	0	0

AR100217

Table B-3
Comparison of Hydraulic Conditions

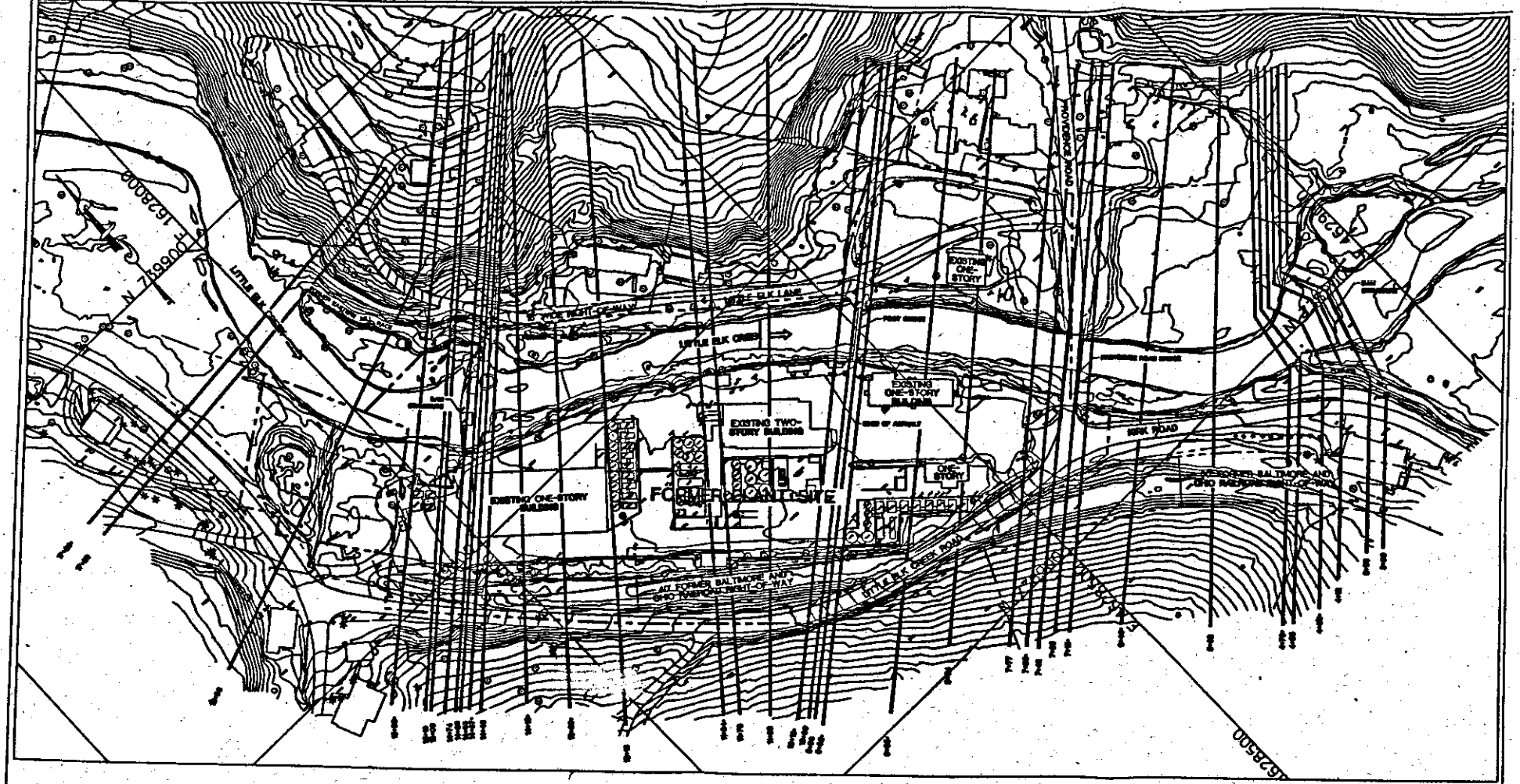
		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Cepth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
465	3139	200.61	8.25	7.87	200.61	8.25	7.87	0	0	0
465	4341	198.85	16.42	6.11	198.85	16.42	6.11	0	0	0
465	5032	199.56	16.22	6.82	199.66	15.88	6.92	0.1	-0.34	0.1
465	6162	200.93	15.31	8.19	200.89	15.42	8.15	-0.04	0.11	-0.04
465	7459	201.79	15.57	9.05	201.79	15.58	9.05	0	0.01	0
465	12311	203.33	18.27	10.59	203.22	18.71	10.48	-0.11	0.44	-0.11
433	18	197.41	0.1	3.41	197.41	0.1	3.41	0	0	0
433	2010	200.27	4.39	6.27	200.27	4.39	6.27	0	0	0
433	3139	200.84	6.09	6.84	200.84	6.09	6.84	0	0	0
433	4341	201.24	7.78	7.24	201.24	7.78	7.24	0	0	0
433	5032	201.39	8.74	7.39	201.39	8.74	7.39	0	0	0
433	6162	199.24	17.28	5.24	199.24	17.3	5.24	0	0.02	0
433	7459	199.88	17.81	5.88	199.87	17.82	5.87	-0.01	0.01	-0.01
433	12311	202.54	17.71	8.54	202.44	18.12	8.44	-0.1	0.41	-0.1
413	18	197.41	0.12	3.91	197.41	0.12	3.91	0	0	0
413	2010	200.29	3.8	6.79	200.29	3.8	6.79	0	0	0
413	3139	200.92	4.97	7.42	200.92	4.97	7.42	0	0	0
413	4341	201.42	6.1	7.92	201.42	6.1	7.92	0	0	0
413	5032	201.65	6.72	8.15	201.65	6.72	8.15	0	0	0
413	6162	199.63	14.13	6.13	199.62	14.14	6.12	-0.01	0.01	-0.01
413	7459	199.84	16.01	6.34	199.84	16.01	6.34	0	0	0
413	12311	201.24	19.02	7.74	201.18	19.28	7.68	-0.06	0.26	-0.06
					Downstream Dam					
399	18	192.64	3.03	0.59	192.64	3.03	0.59	0	0	0
399	2010	196.25	5.25	4.2	196.25	5.25	4.2	0	0	0
399	3139	197.34	5.95	5.29	197.34	5.95	5.29	0	0	0
399	4341	198.19	6.72	6.14	198.19	6.72	6.14	0	0	0
399	5032	198.56	7.17	6.51	198.56	7.17	6.51	0	0	0
399	6162	199.1	7.88	7.05	199.1	7.88	7.05	0	0	0
399	7459	199.62	8.66	7.57	199.62	8.66	7.57	0	0	0
399	12311	201.35	10.37	9.3	201.35	10.37	9.3	0	0	0
390	18	192.35	2.03	0.3	192.35	2.03	0.3	0	0	0

AR100218

Table B-3
Comparison of Hydraulic Conditions

		Existing Conditions			100% Design			Comparison		
River Station	Q Total (cfs)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Max Chnl Depth (ft)	Change in W.S. Elev (ft)	Change in Vel Chnl (ft/s)	Change in Max Chnl Depth (ft)
390	2010	196.36	3.76	4.31	196.36	3.76	4.31	0	0	0
390	3139	197.49	4.37	5.44	197.49	4.37	5.44	0	0	0
390	4341	198.38	4.99	6.33	198.38	4.99	6.33	0	0	0
390	5032	198.78	5.36	6.73	198.78	5.36	6.73	0	0	0
390	6162	199.36	5.92	7.31	199.36	5.92	7.31	0	0	0
390	7459	199.94	6.51	7.89	199.94	6.51	7.89	0	0	0
390	12311	201.74	8.07	9.69	201.74	8.07	9.69	0	0	0

AR100219



* INDICATES MAIN CHANNEL SURVEY POINTS WERE INTERPOLATED.

LEGEND

- EXISTING GROUND CONTOUR
- SITE PROPERTY LINE
- PROPERTY LINE OF ADJOINERS
- EXISTING TREES
- EXISTING CHAIN LINK FENCE
- N739900 E1628000 MARYLAND STATE COORDINATE SYSTEM
- 0+04 CROSS-SECTION LOCATION

120 0 120 240

SCALE IN FEET

GALAXY / SPECTRON REMOVAL ACTION

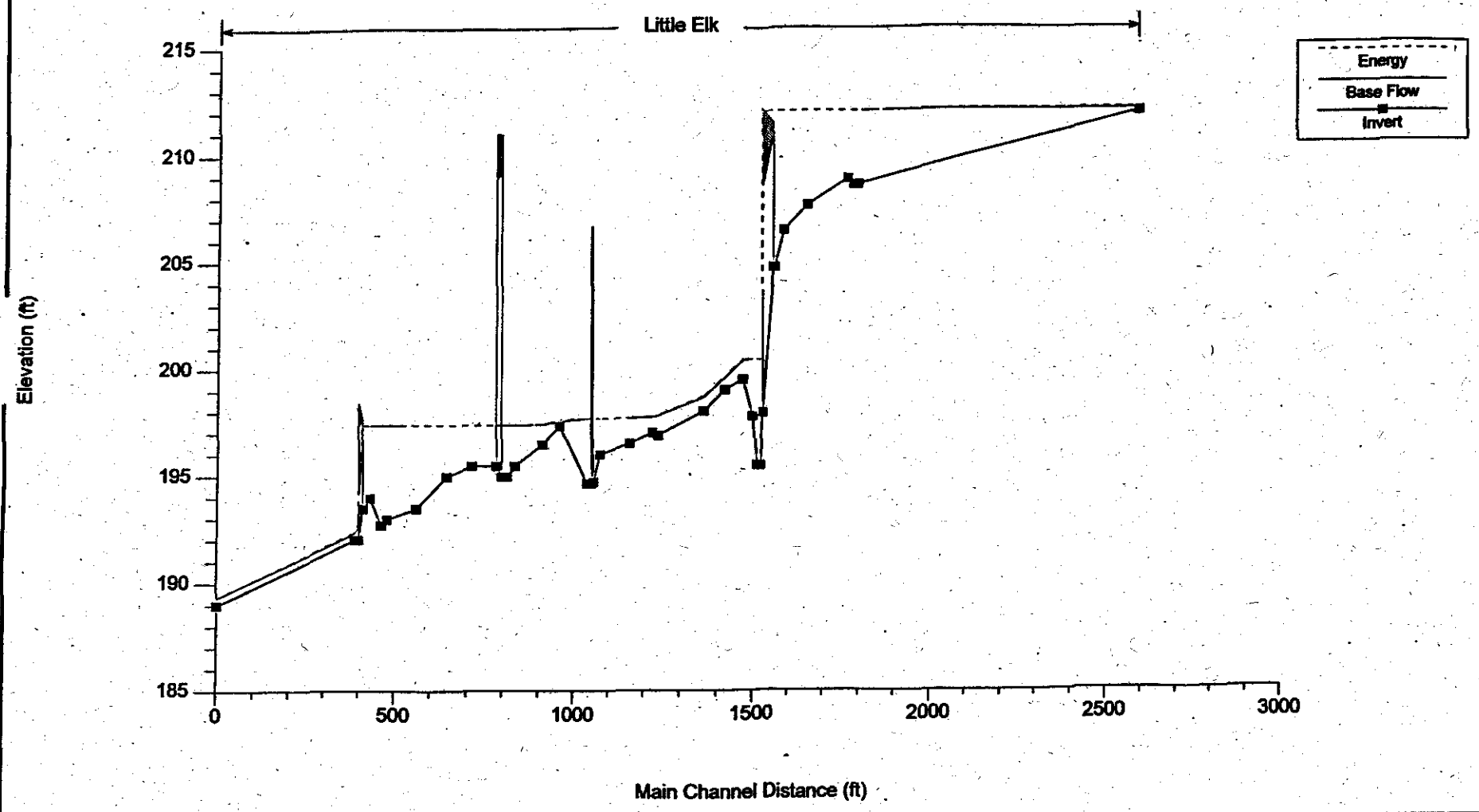
ELKTON, MARYLAND

Date: 3/11/97	HEC-RAS CROSS-SECTION LOCATION PLAN
Scale: 1"=120'	
Drawn By: V.E.N.	Advanced GeoServices Corp. Chadds Ford Business Campus, Rts. 202 & 1 Brandywine One, Suite 202 Chadds Ford, Pennsylvania 19317
Checked By: T.D.T.	
Project Mgr: P.G.S.	
Dwg No. 95228-12	
Issued:	Project No. 95-228-03 FIGURE: B-1

AR100220

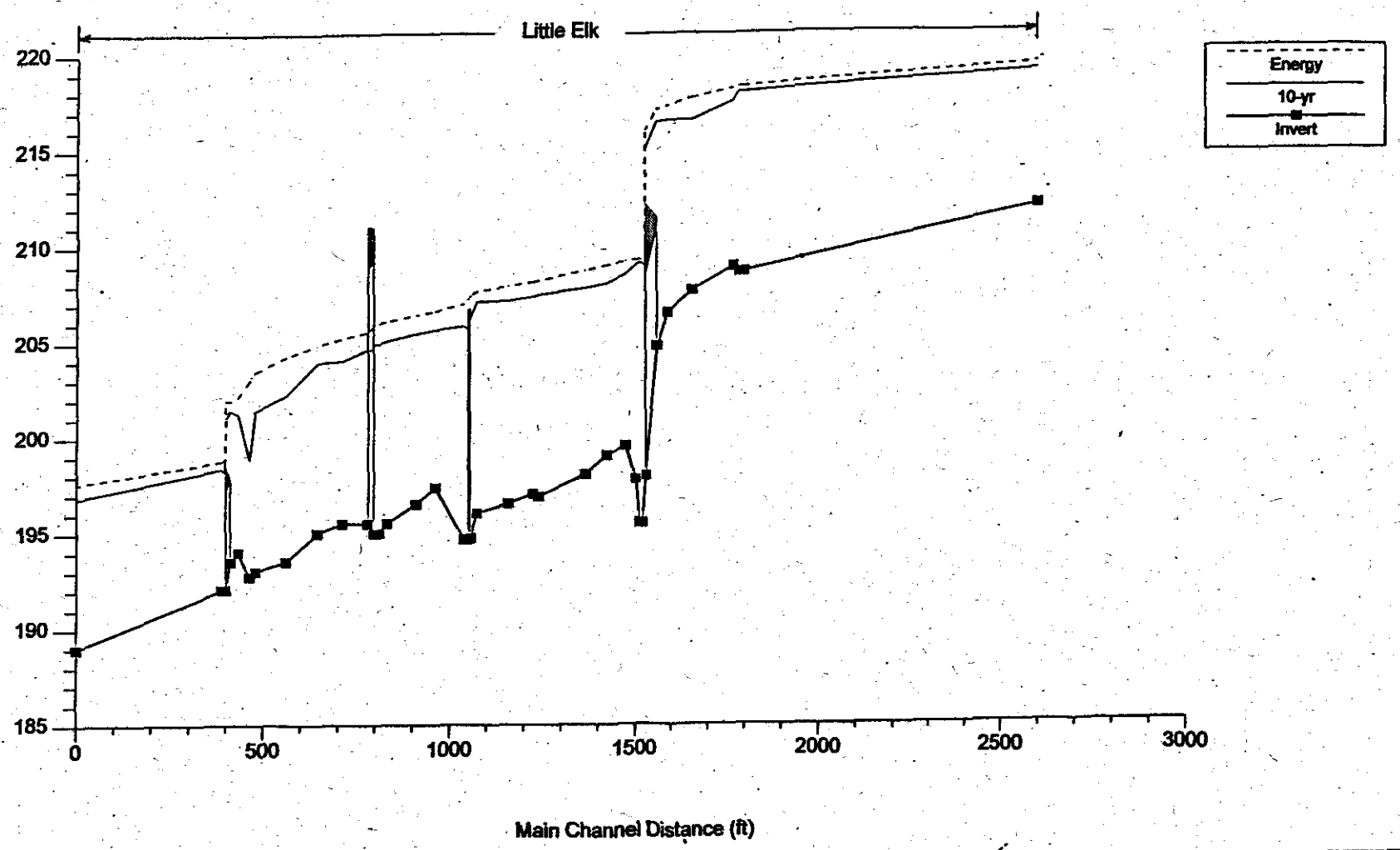
J:\SPECTRON\DRAWINGS\9522803\95228-12.DWG

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Figure B-2 (Base Flow)



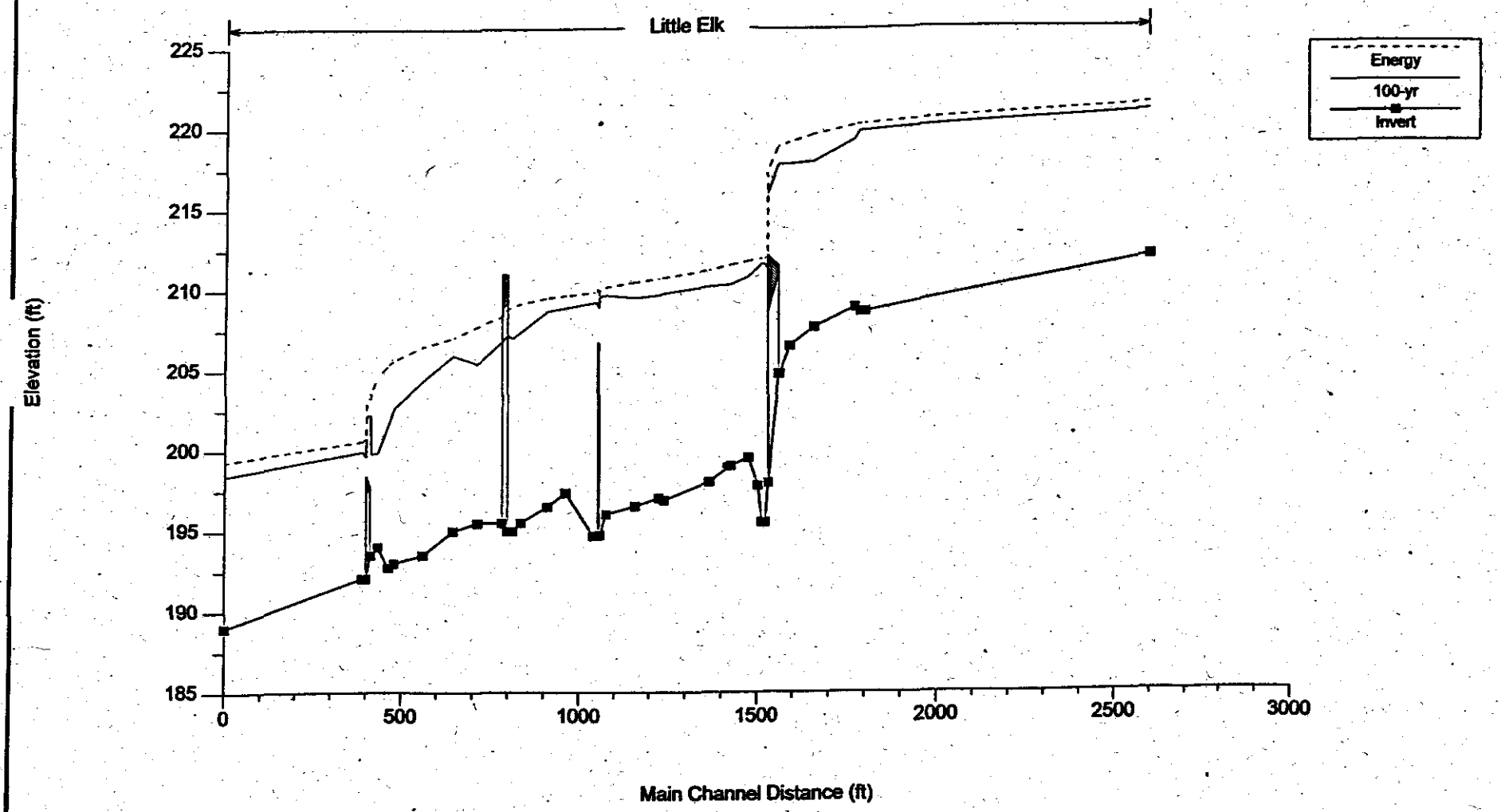
AR100221

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Figure B-3 (10-Year Flow)



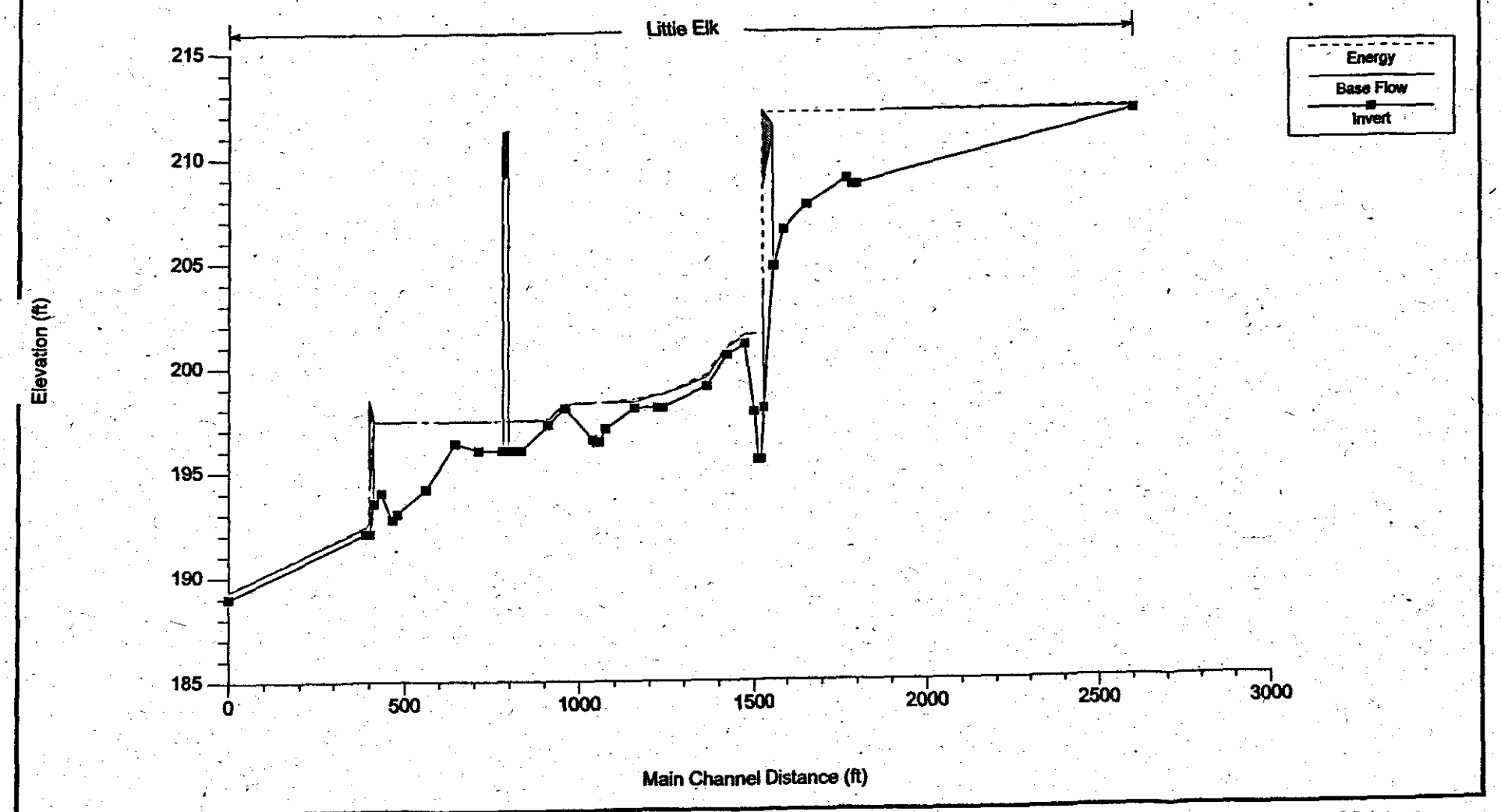
AR100222

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Figure B-4 (100-Year Flow)



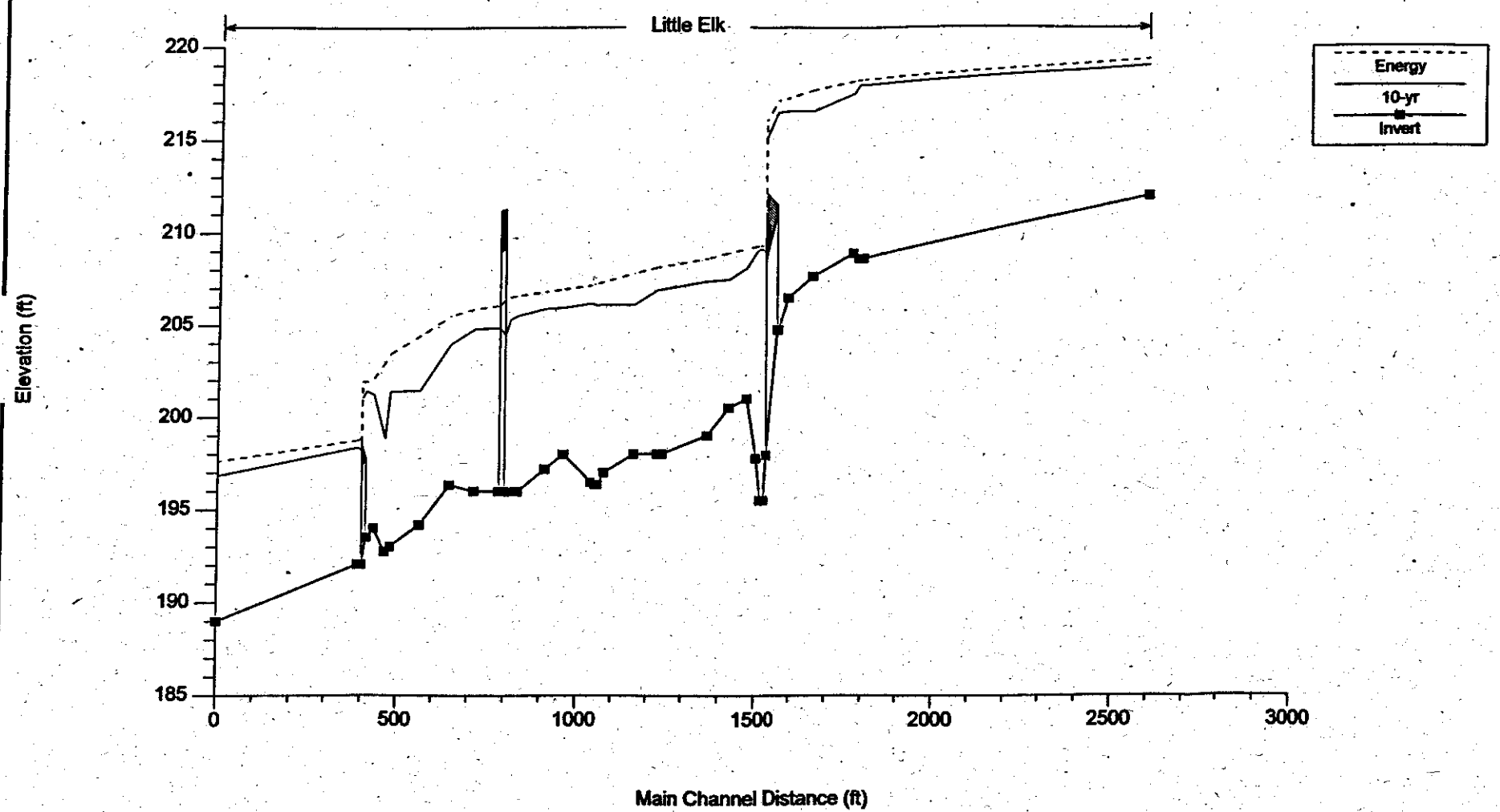
AR100223

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Figure B-5 (Base Flow)



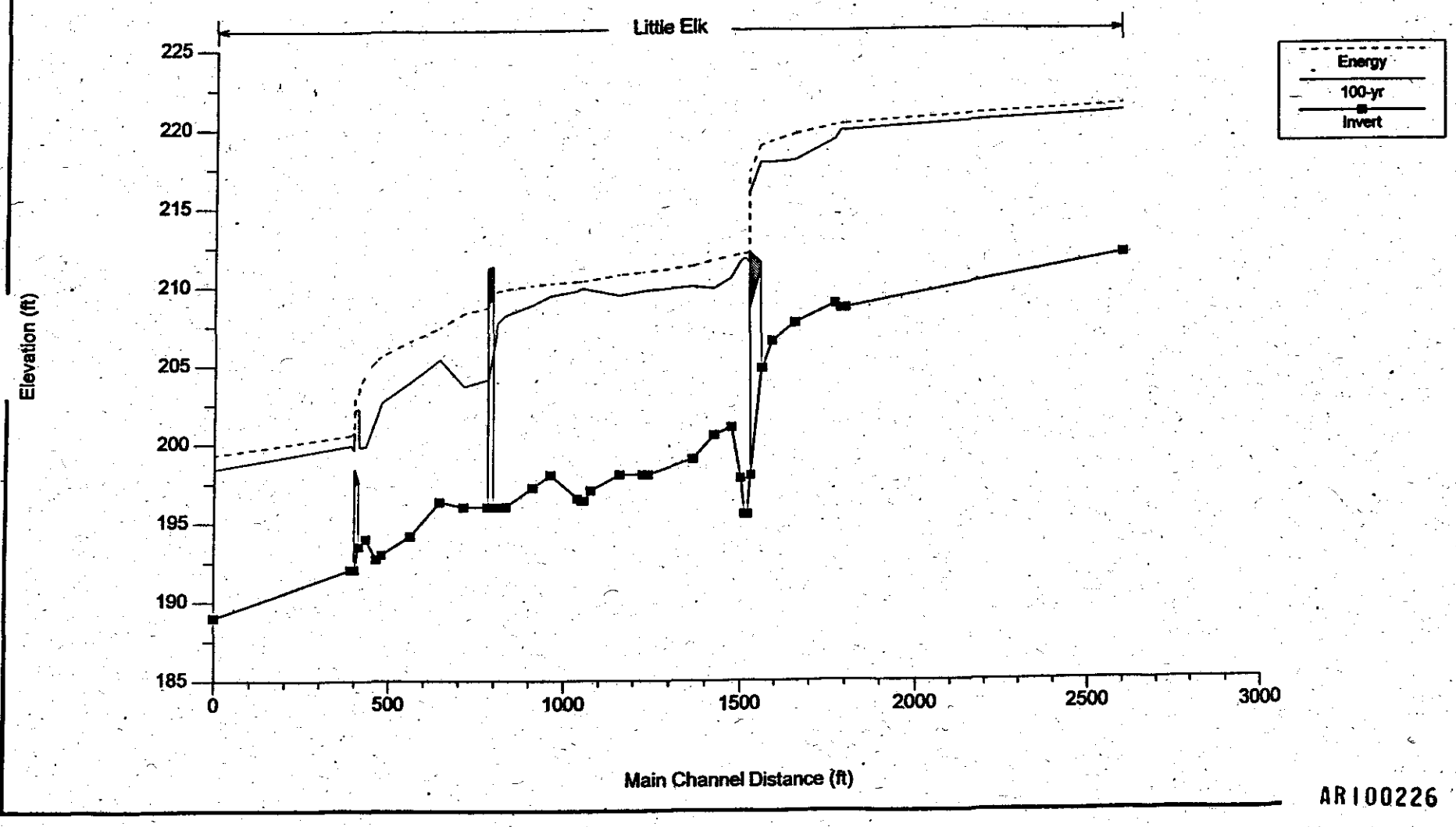
AR100224

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Figure B-6 (10 -Year Flow)



AR100225

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Figure B-7 (100 -Year Flow)



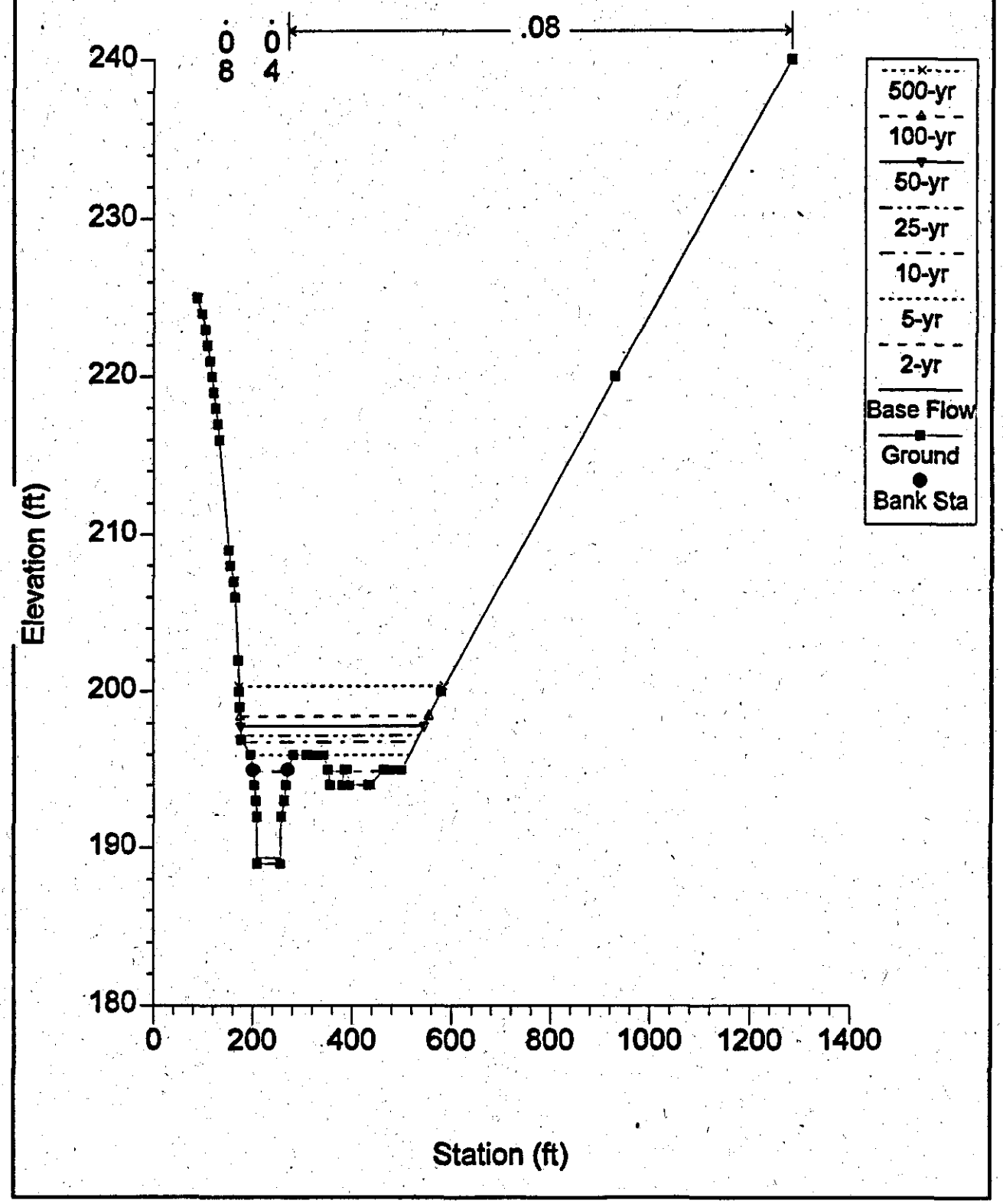
AR100226

ATTACHMENT A

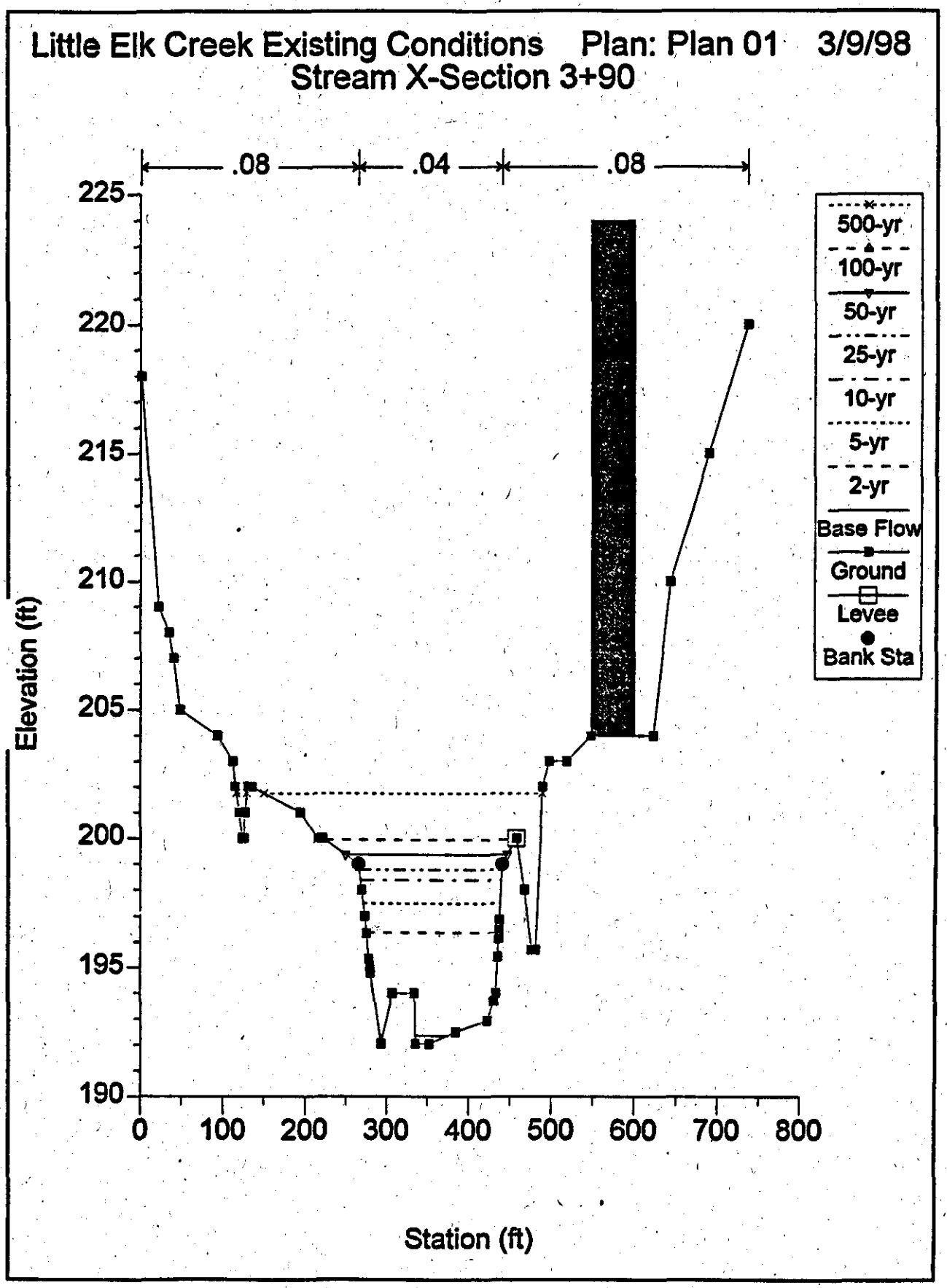
CROSS-SECTION PLOTS

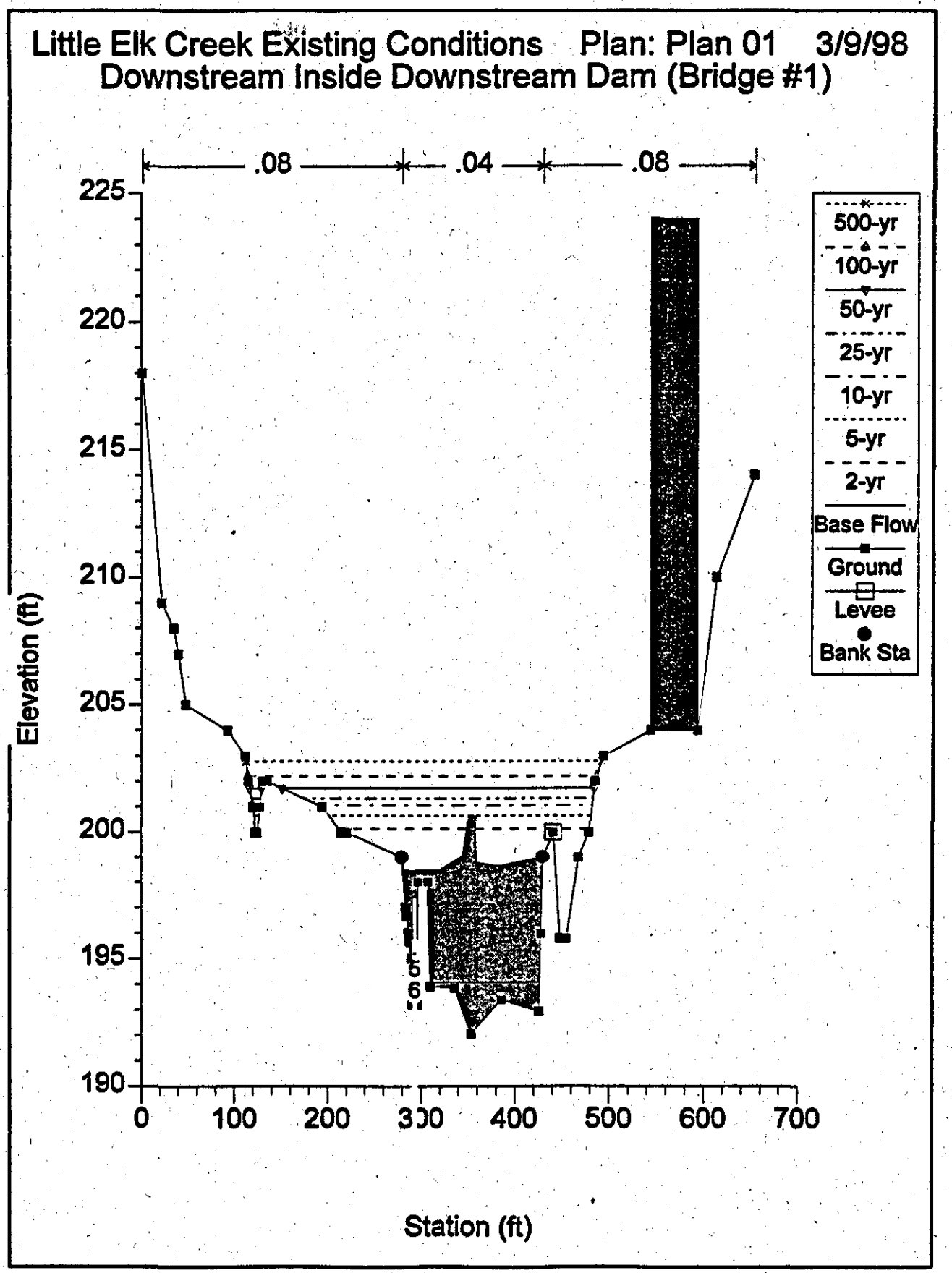
CURRENT CONDITIONS

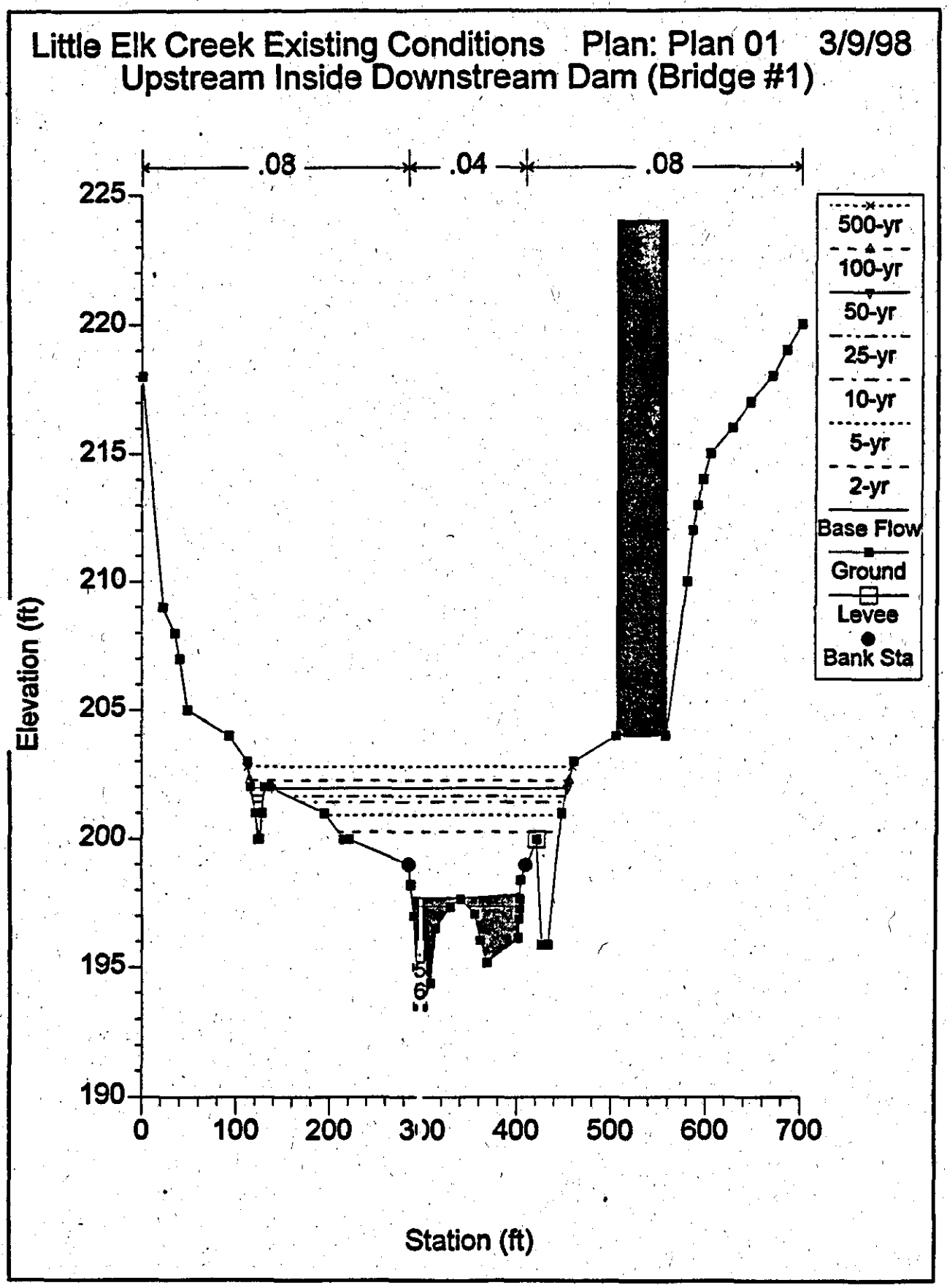
Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 0+00



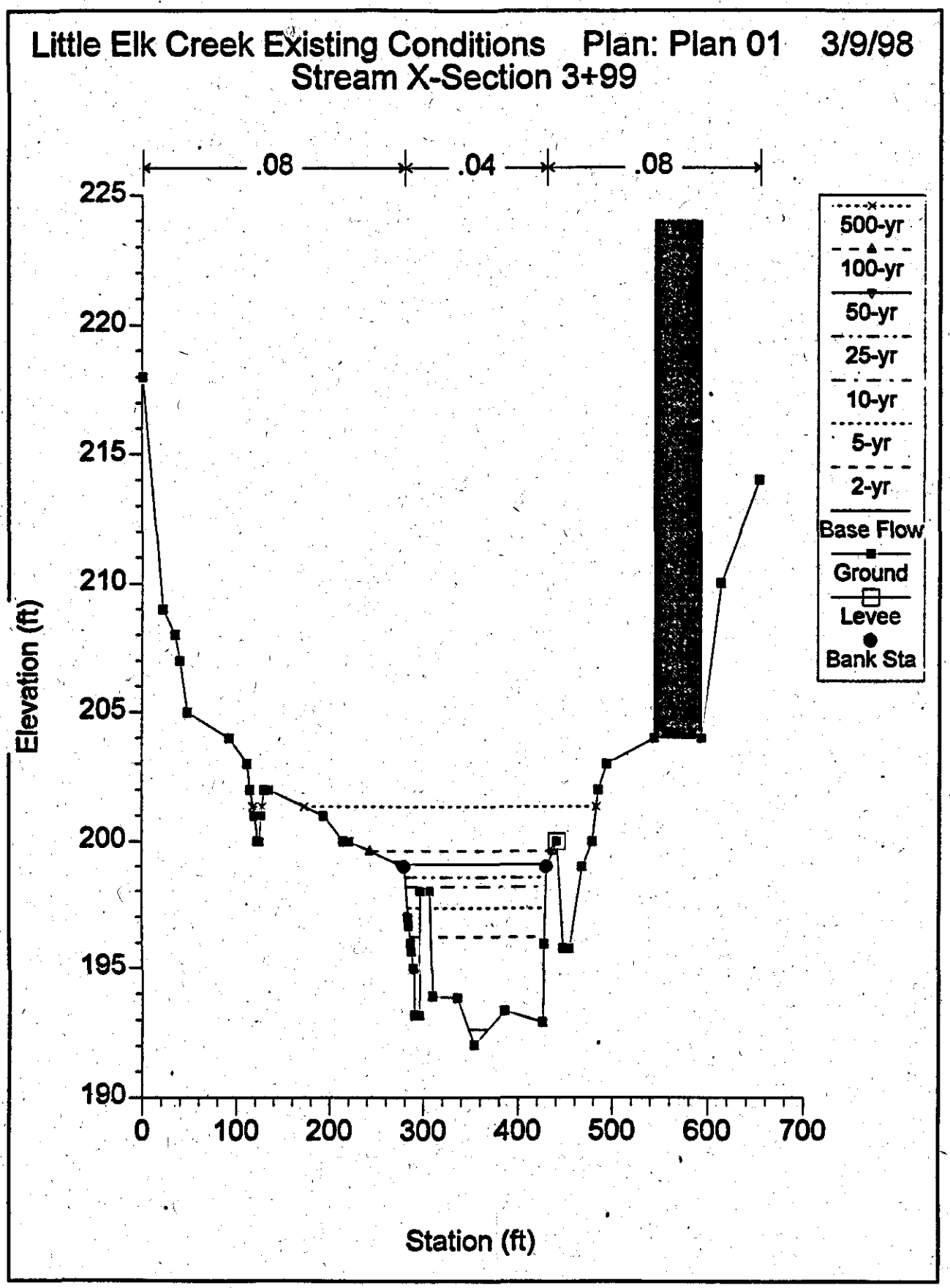
AR100228


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 3+90
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
800
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

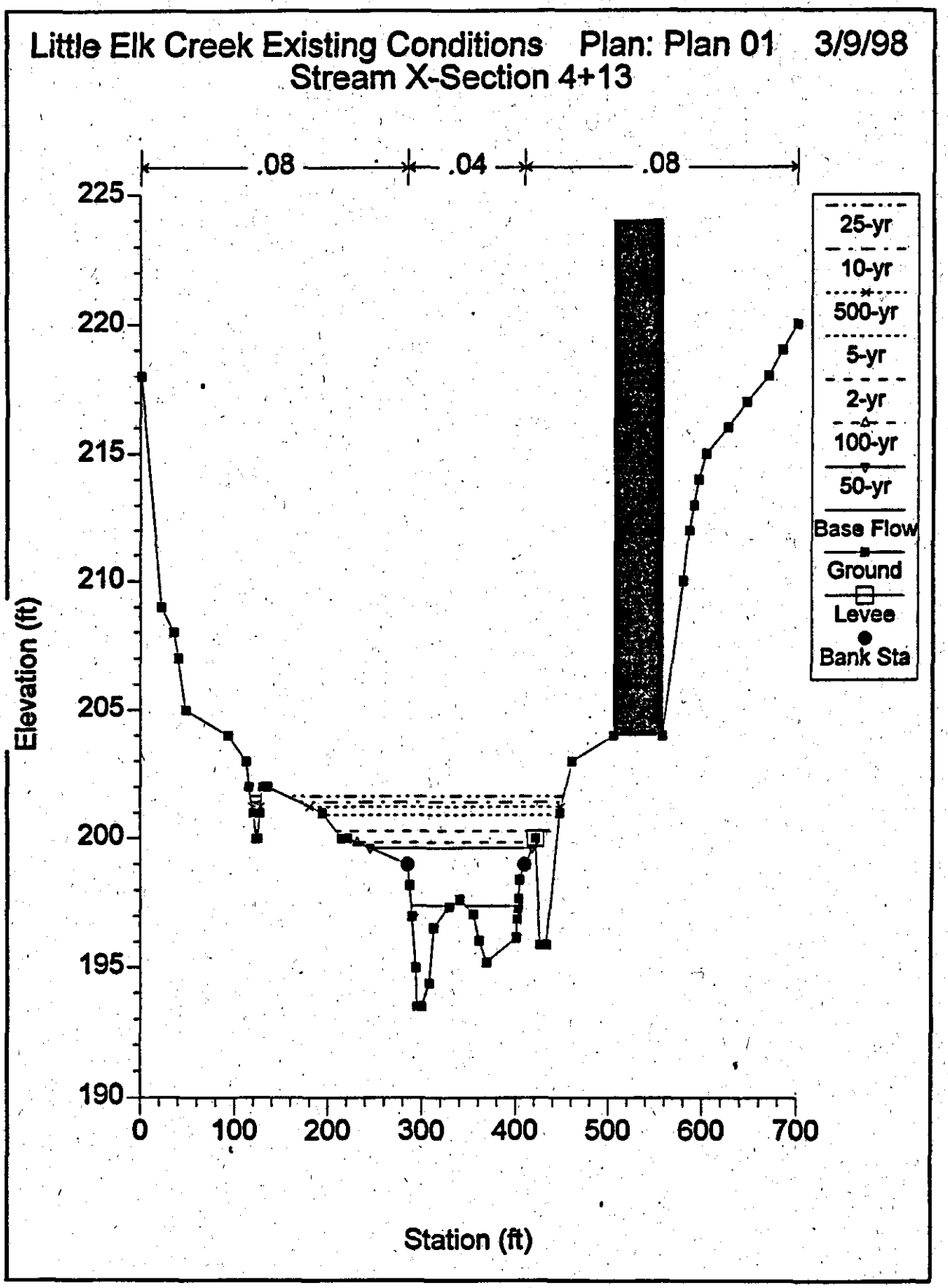

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Downstream Inside Downstream Dam (Bridge #1)
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

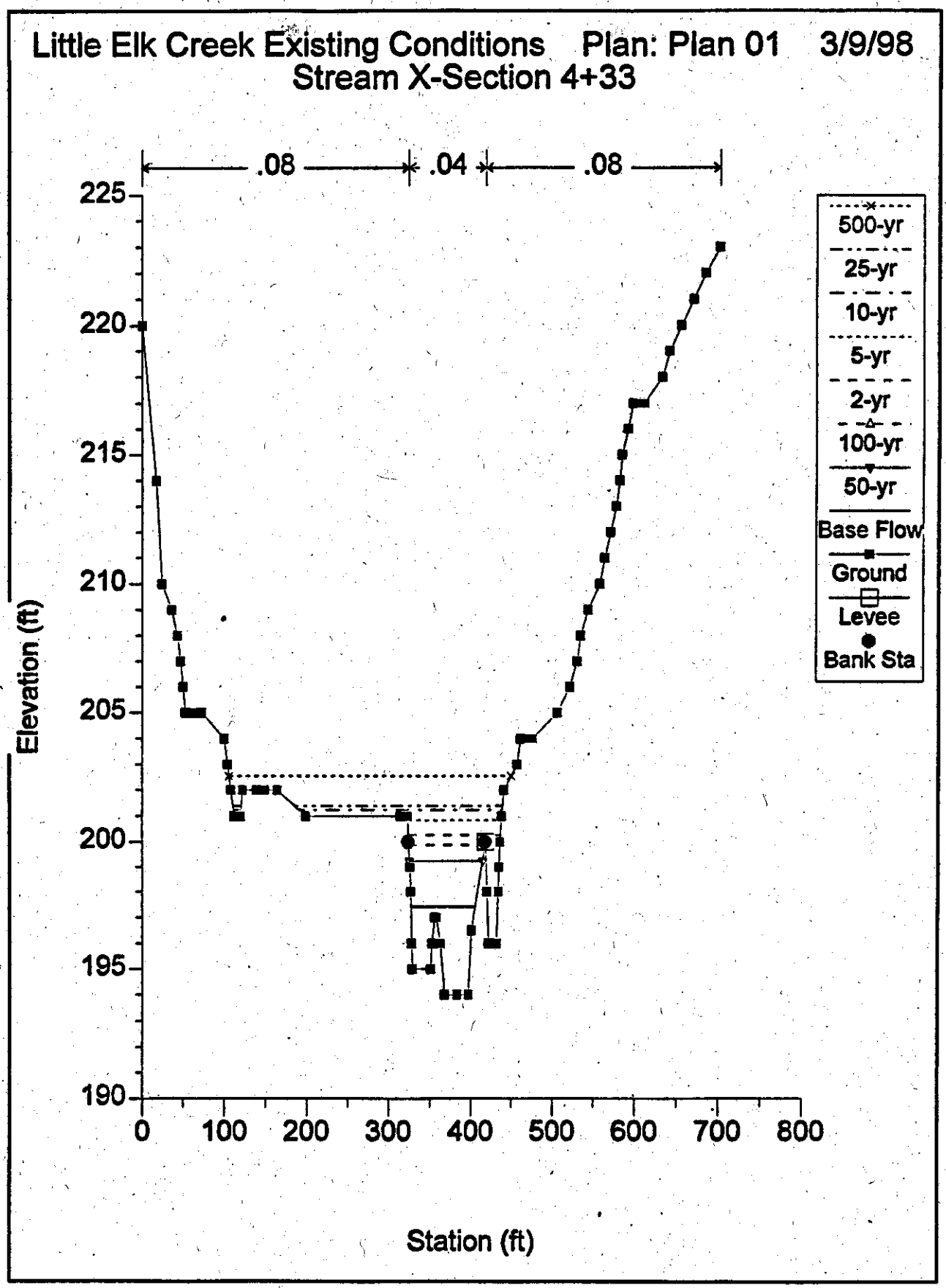

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Upstream Inside Downstream Dam (Bridge #1)
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

AR100231

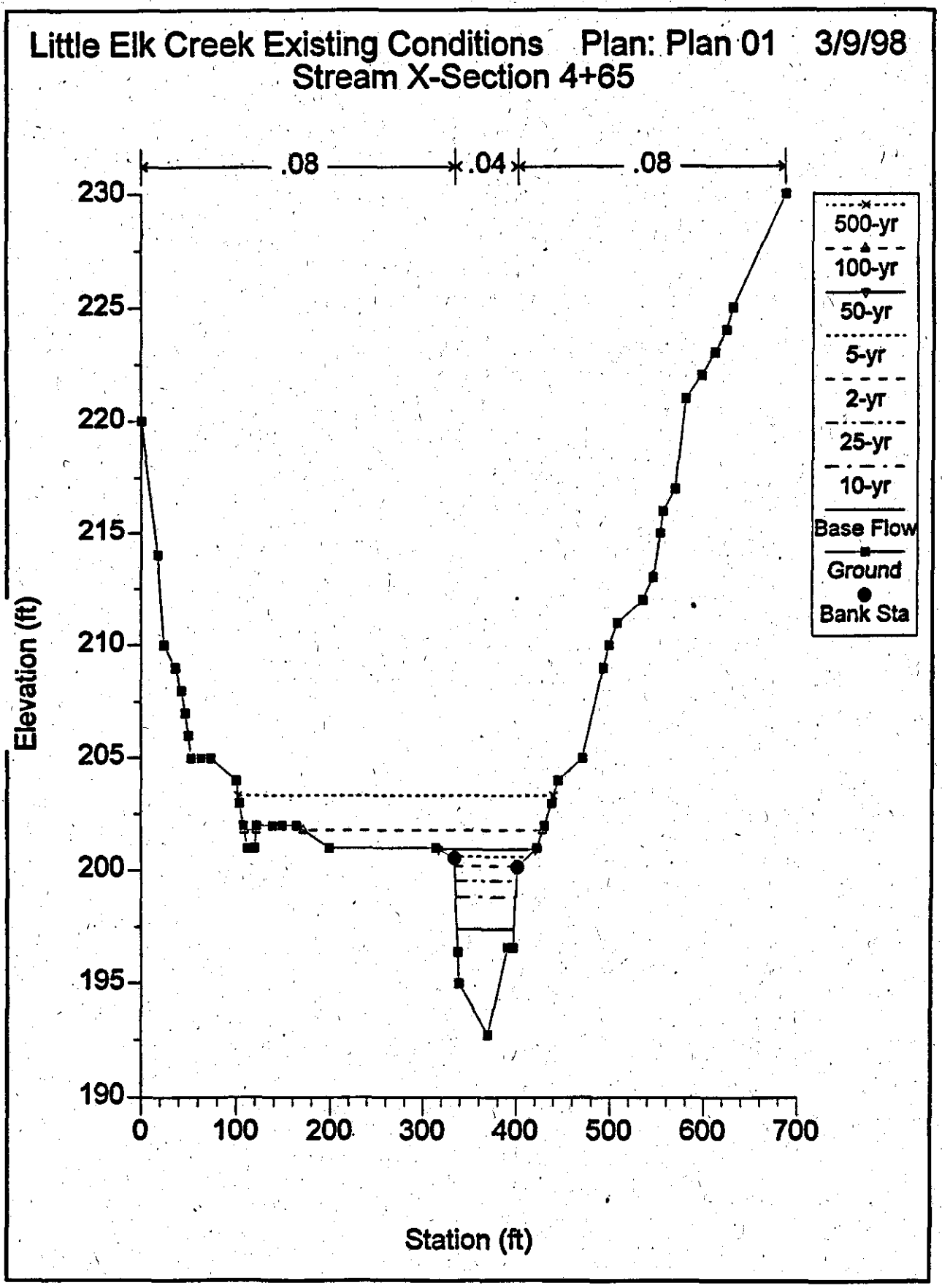

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 3+99
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

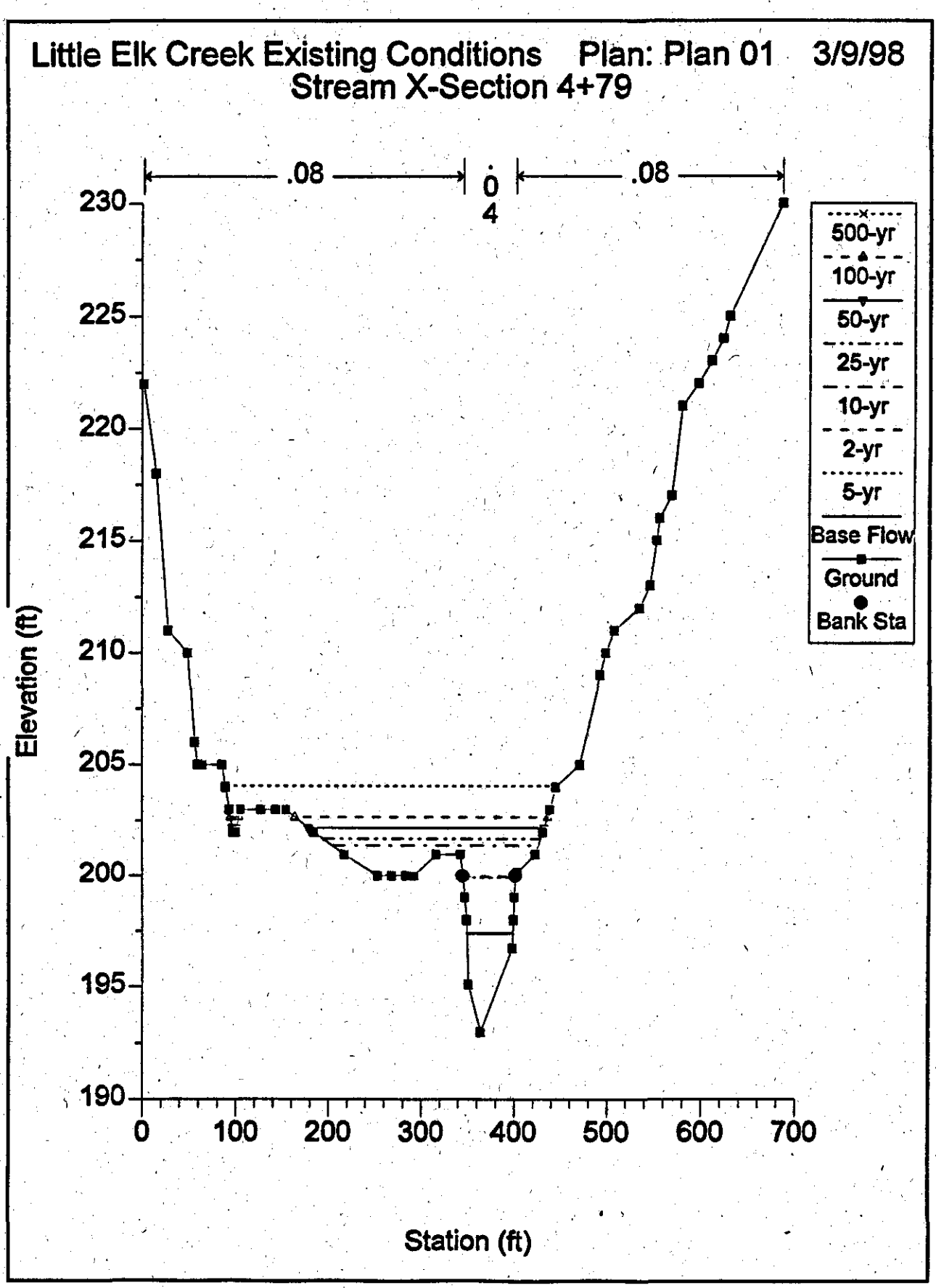
AR100232


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 4+13
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
25-yr
10-yr
500-yr
5-yr
2-yr
100-yr
50-yr
Base Flow
Ground
Levee
Bank Sta

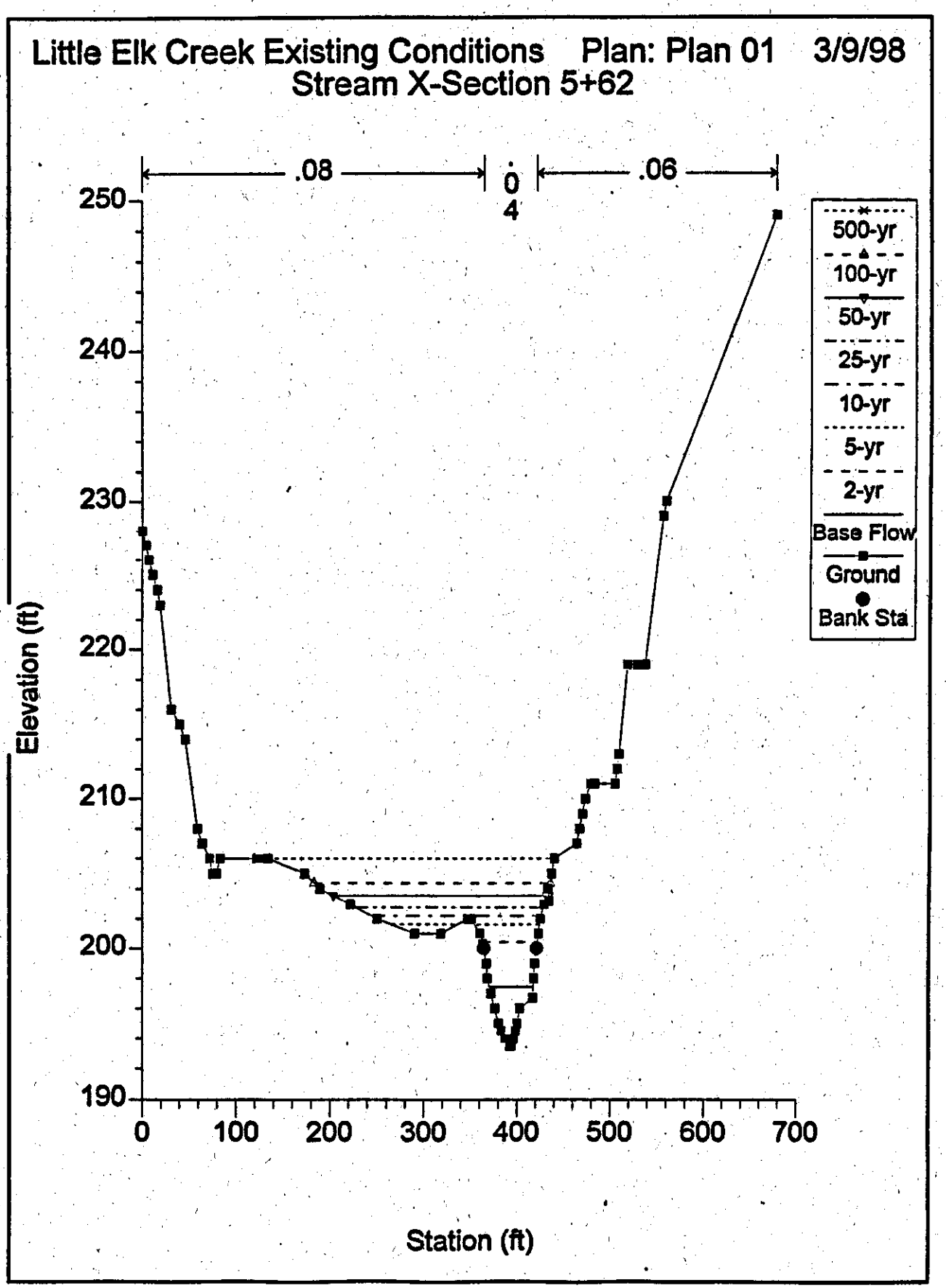

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 4+33
.08
.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
800
Station (ft)
500-yr
25-yr
10-yr
5-yr
2-yr
100-yr
50-yr
Base Flow
Ground
Levee
Bank Sta

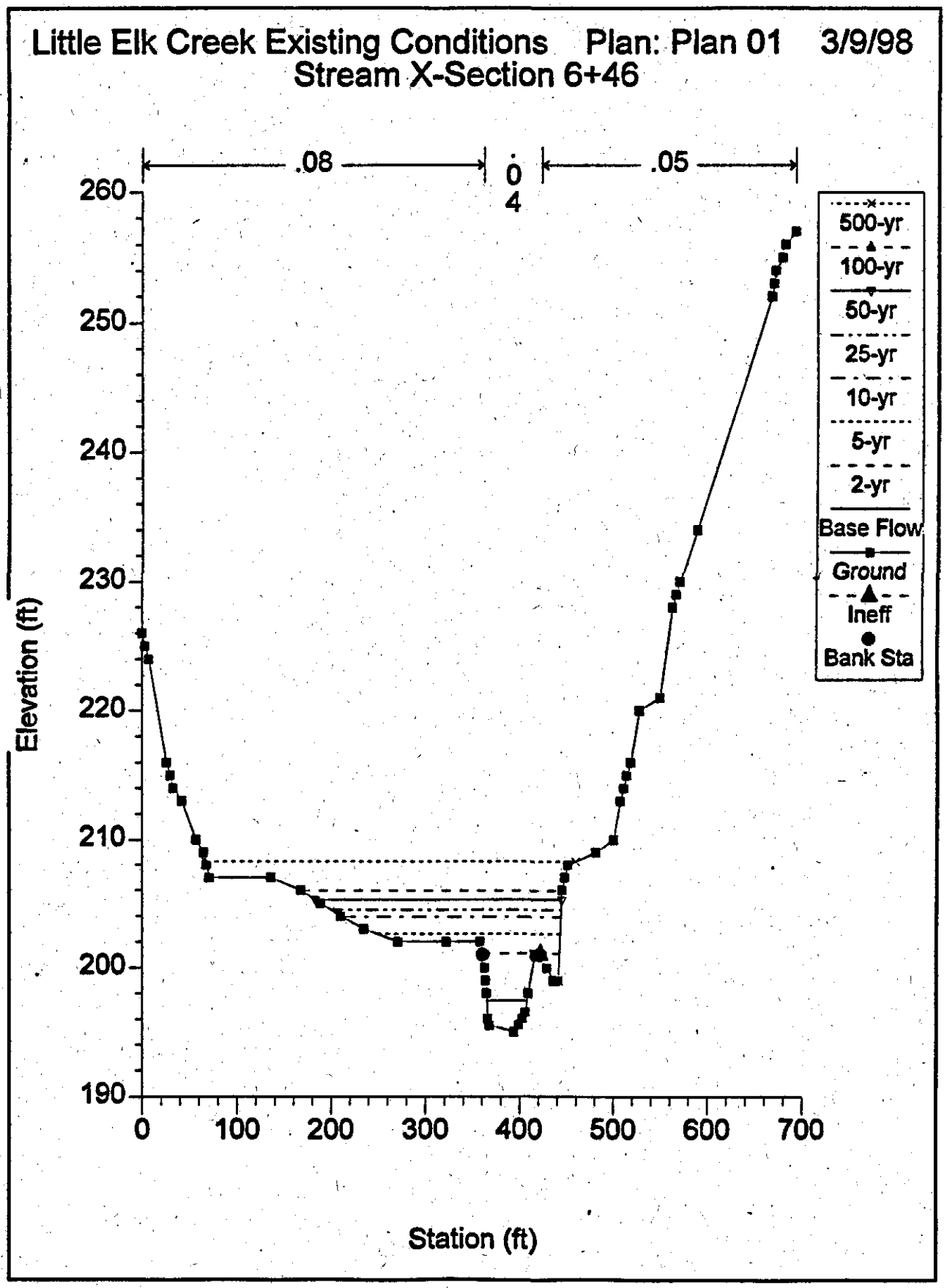
AR100234


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 4+65
.08
.04
.08
230
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
5-yr
2-yr
25-yr
10-yr
Base Flow
Ground
Bank Sta

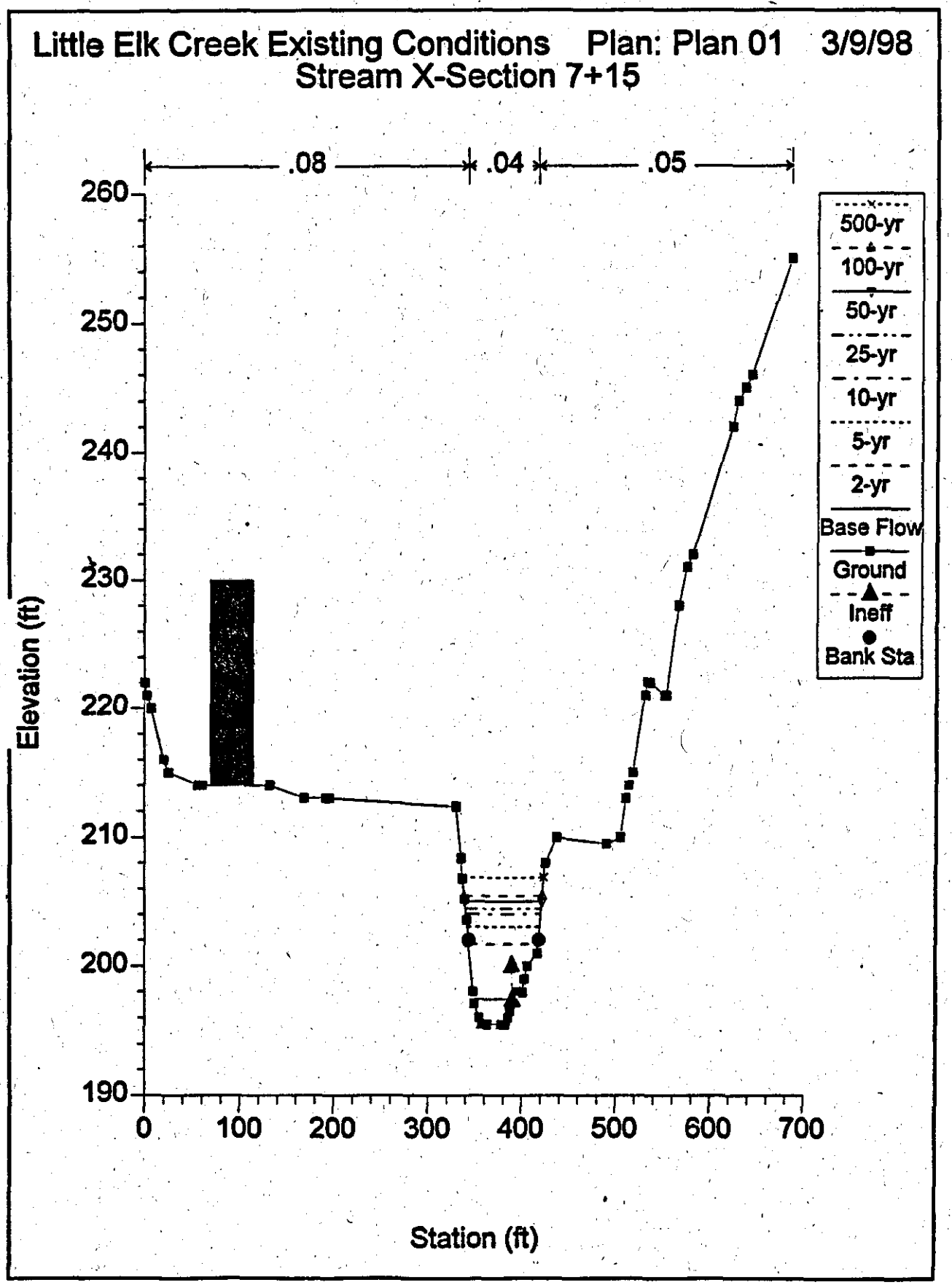

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 4+79
.08
0
4
.08
230
225
220
215
210
205
200
195
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
2-yr
5-yr
Base Flow
Ground
Bank Sta

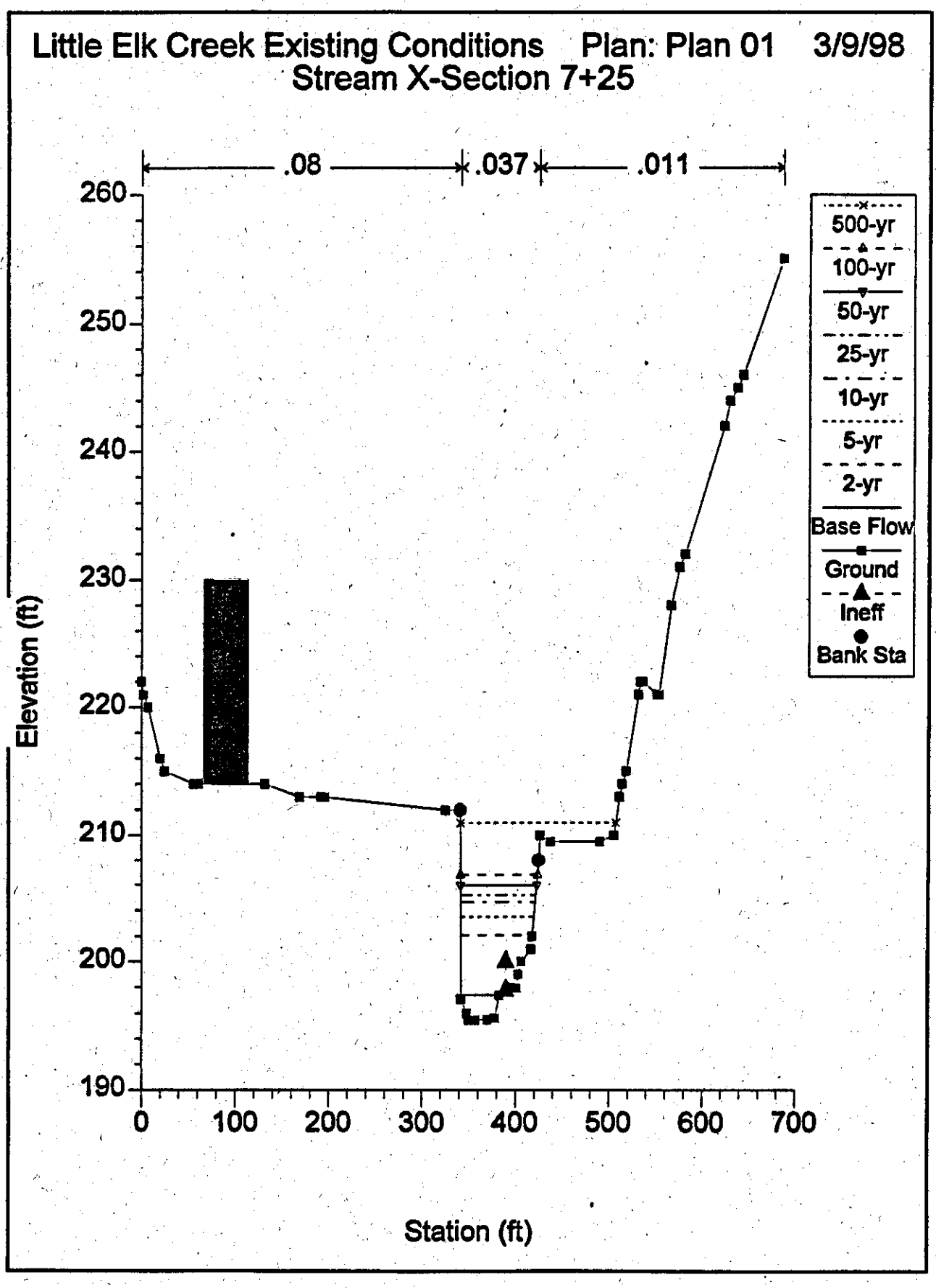
AR100236


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 5+62
.08
0
4
.06
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

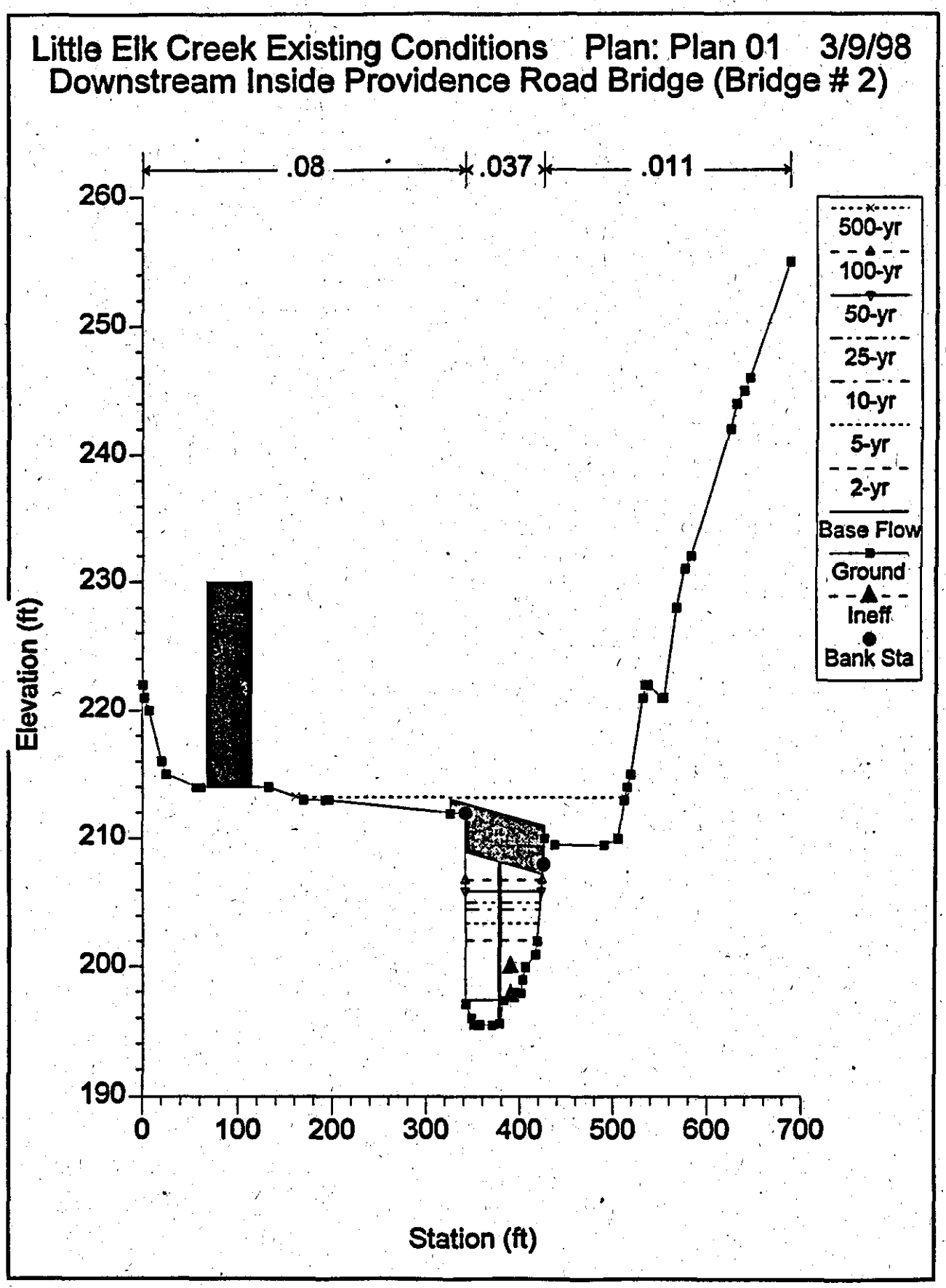

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 6+46
.08
.05
0
4
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

AR100238


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 7+15
.08
.04
.05
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

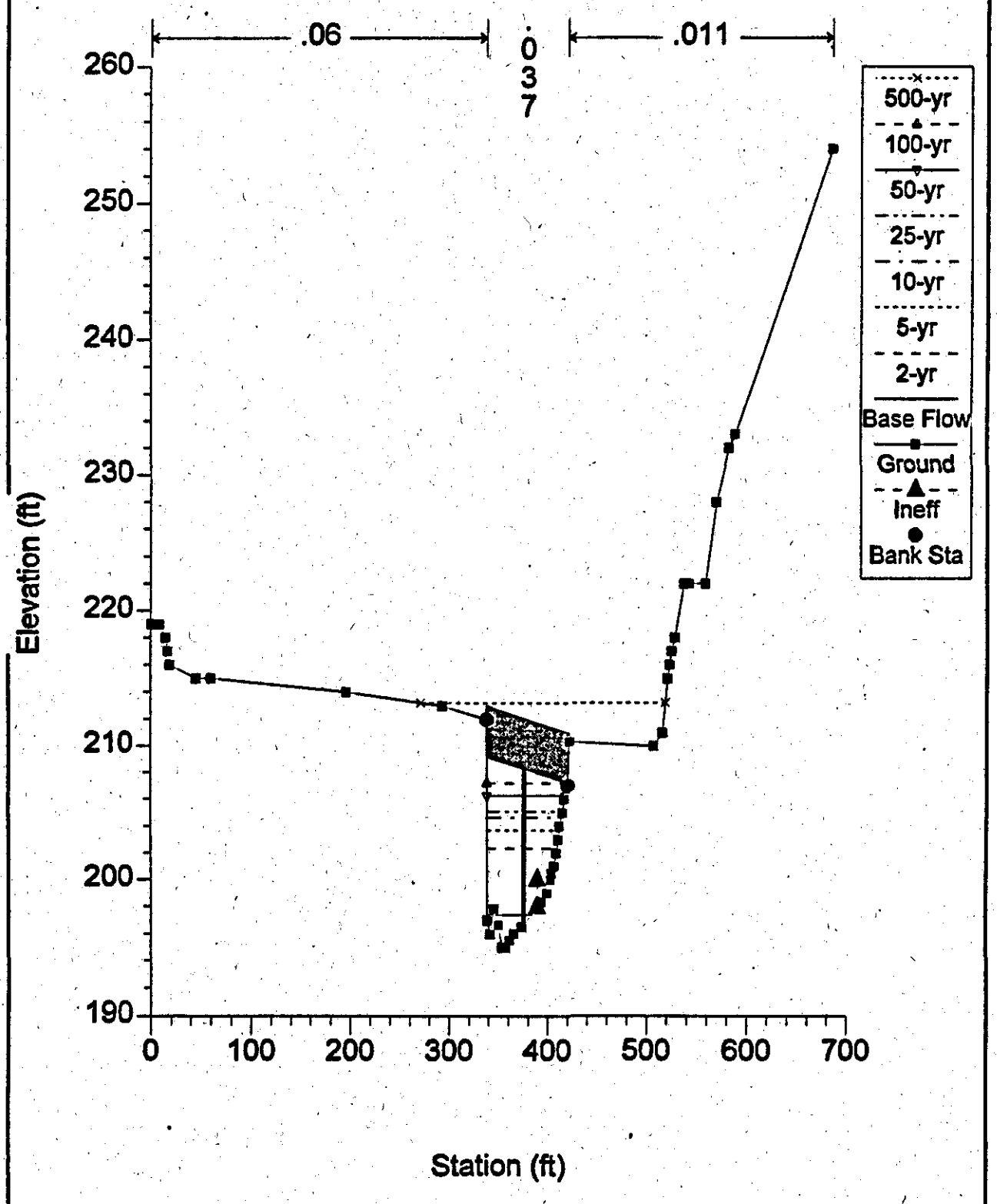

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 7+25
.08
.037
.011
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

AR100240

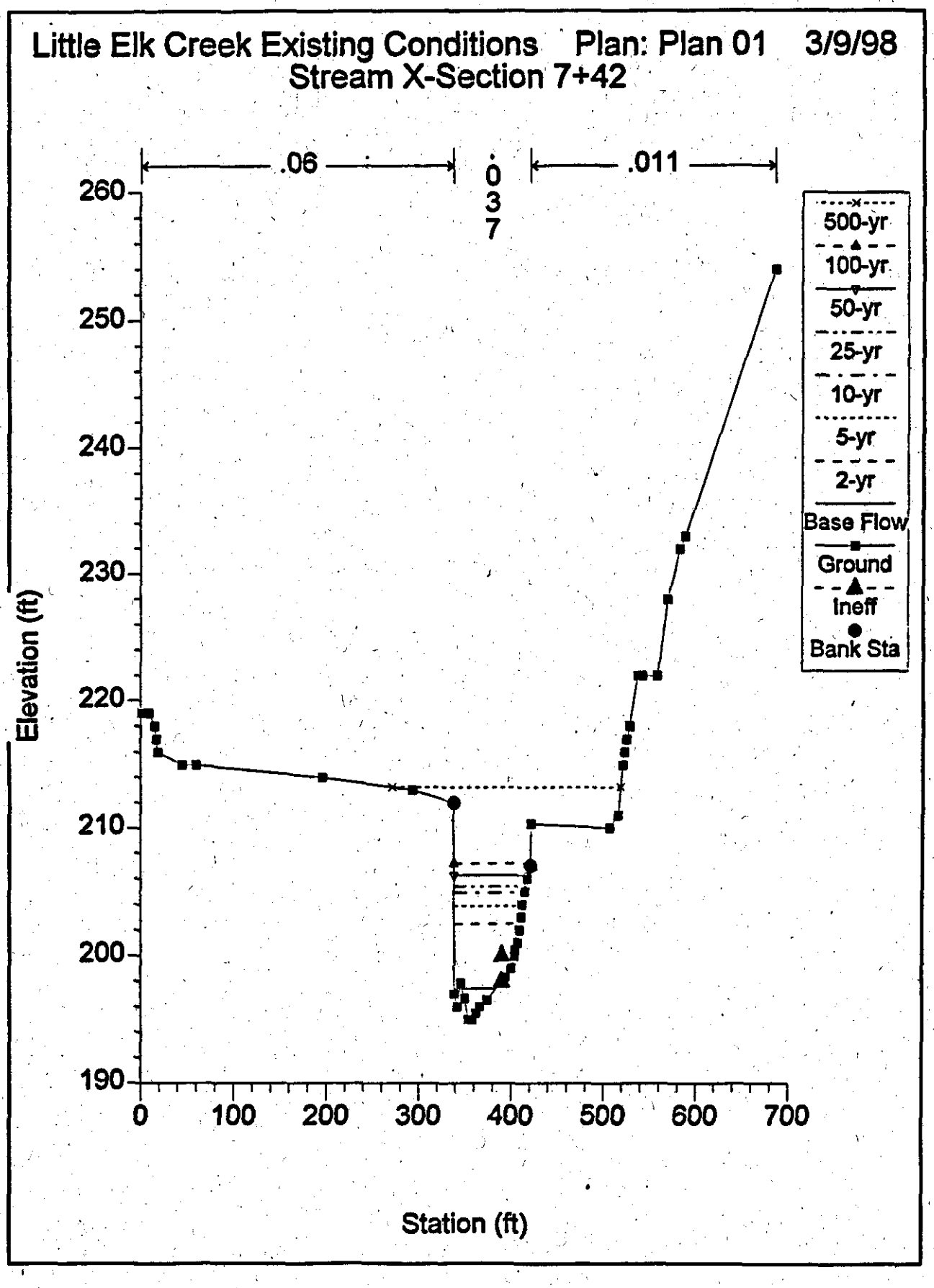

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Downstream Inside Providence Road Bridge (Bridge # 2)
.08
.037
.011
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

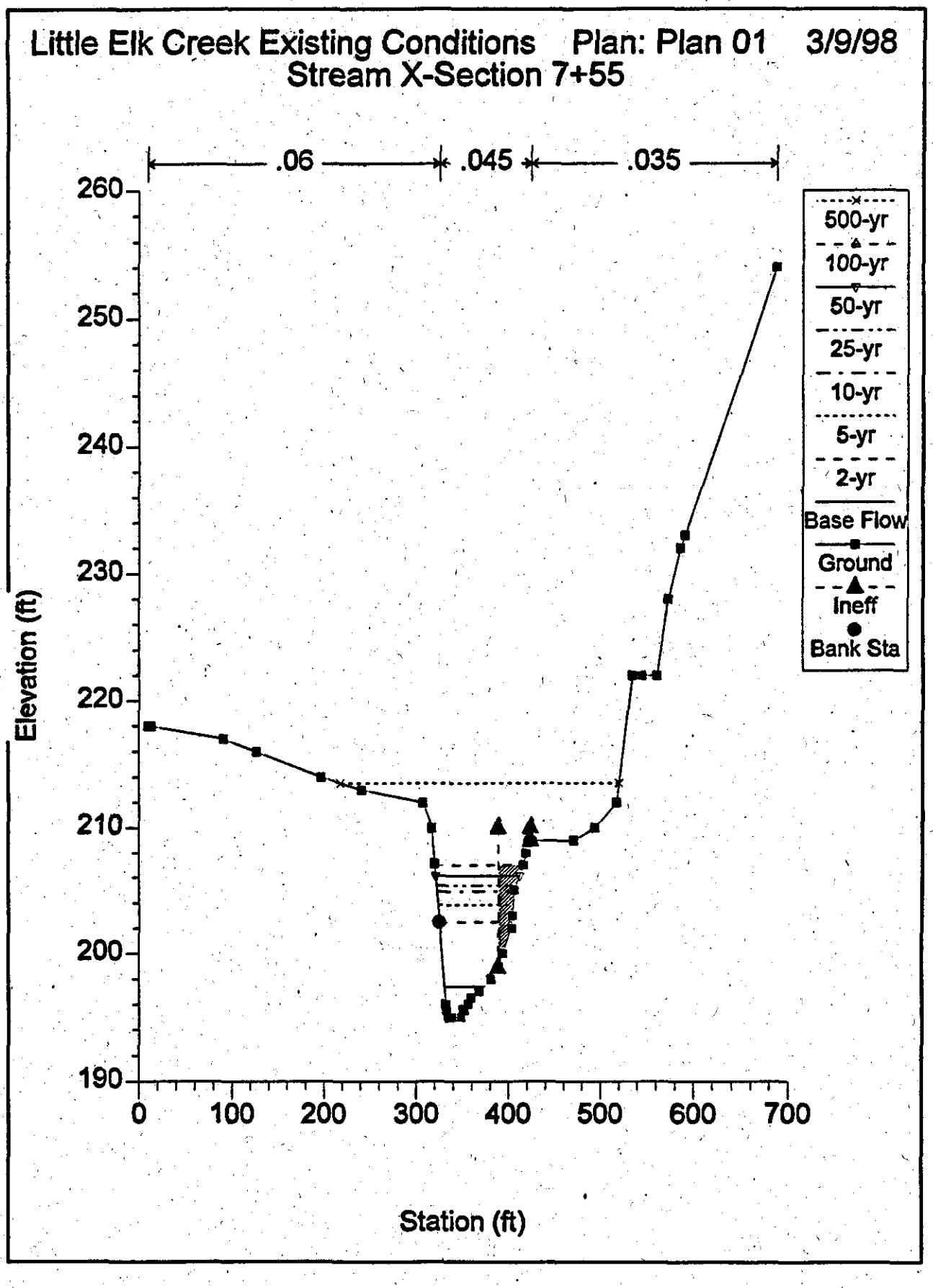
AR100241

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Upstream Inside Providence Road Bridge (Bridge # 2)

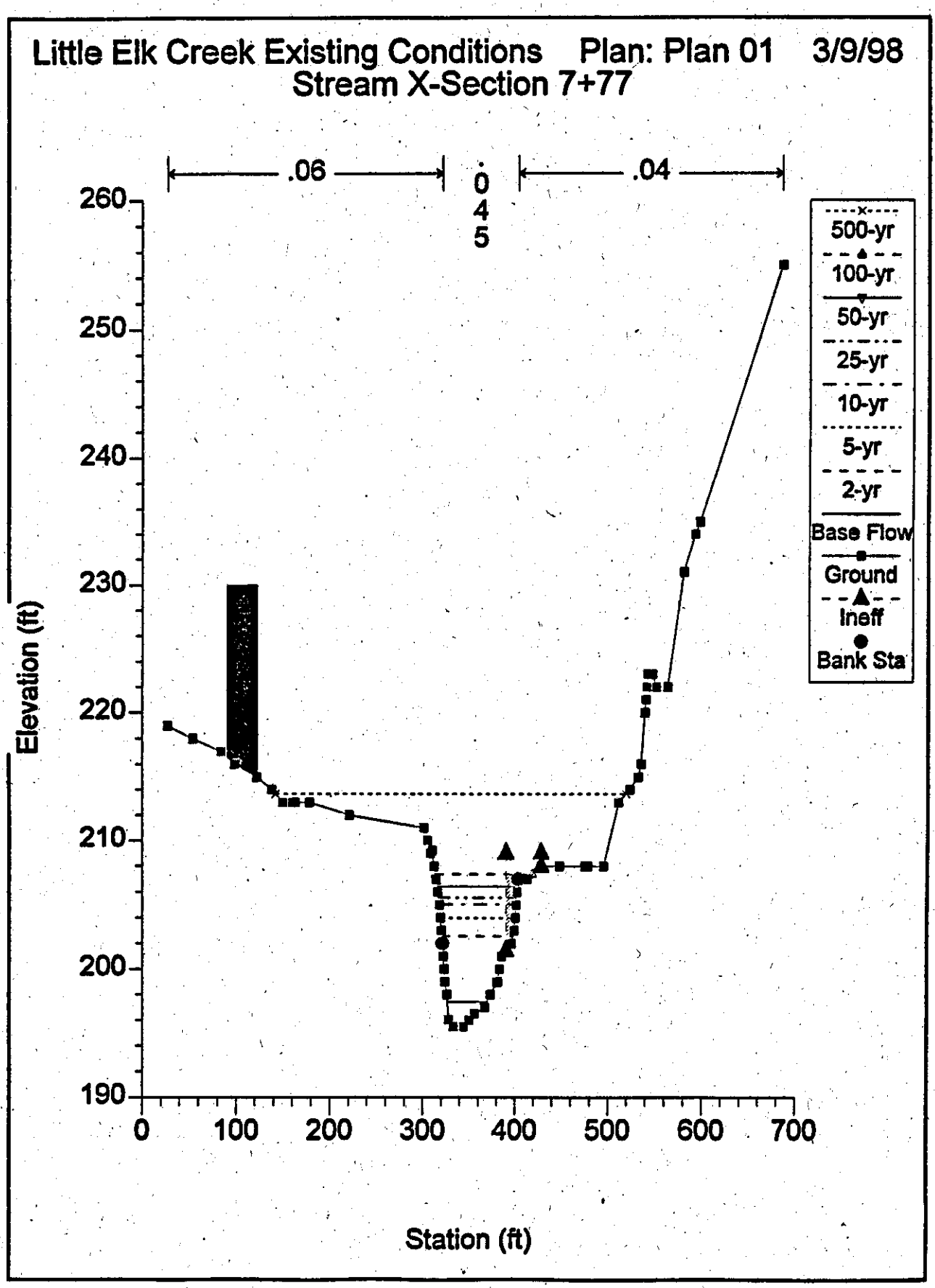


AR100242

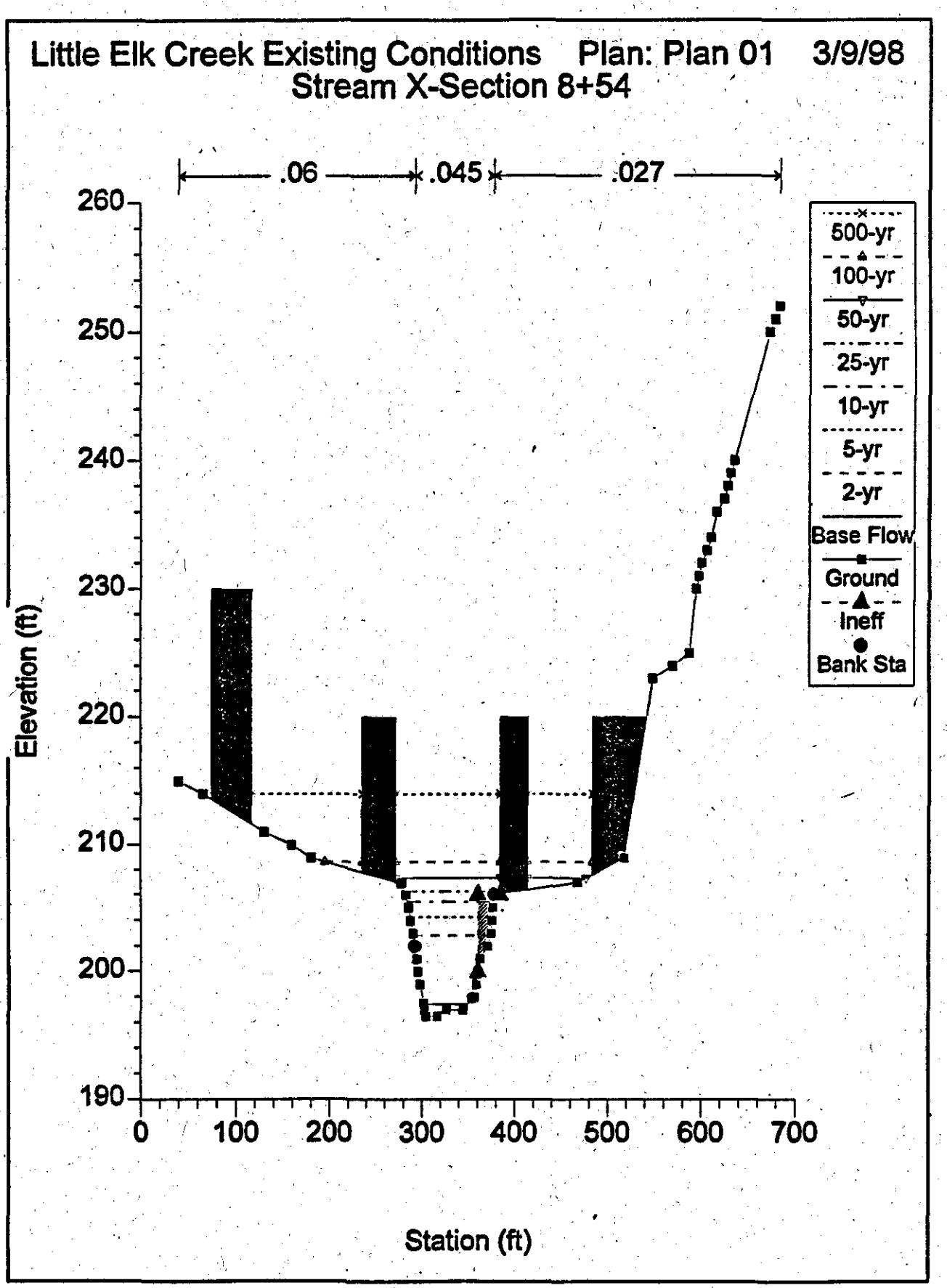

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 7+42
.06
.037
.011
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

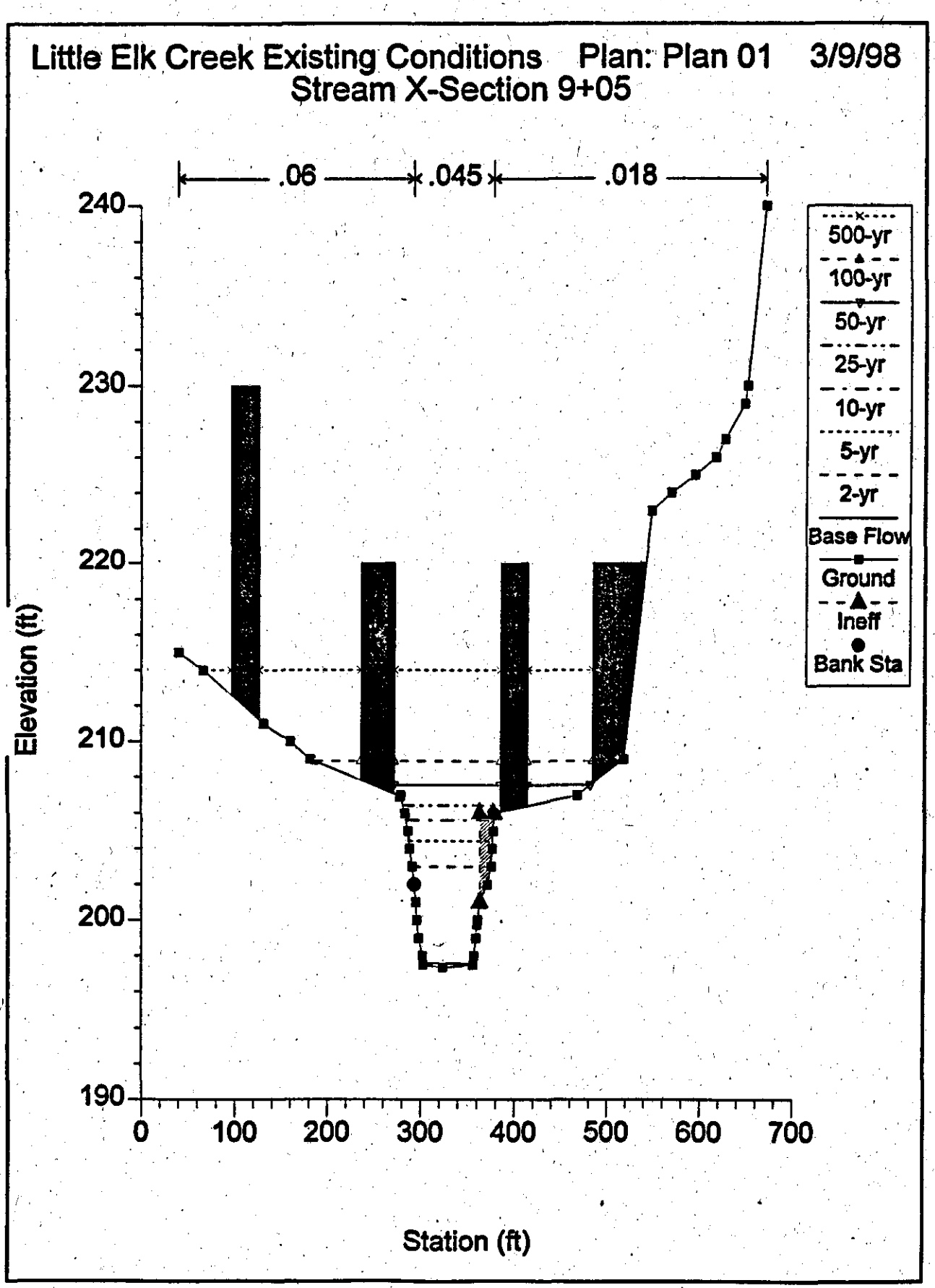

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 7+55
.06
.045
.035
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

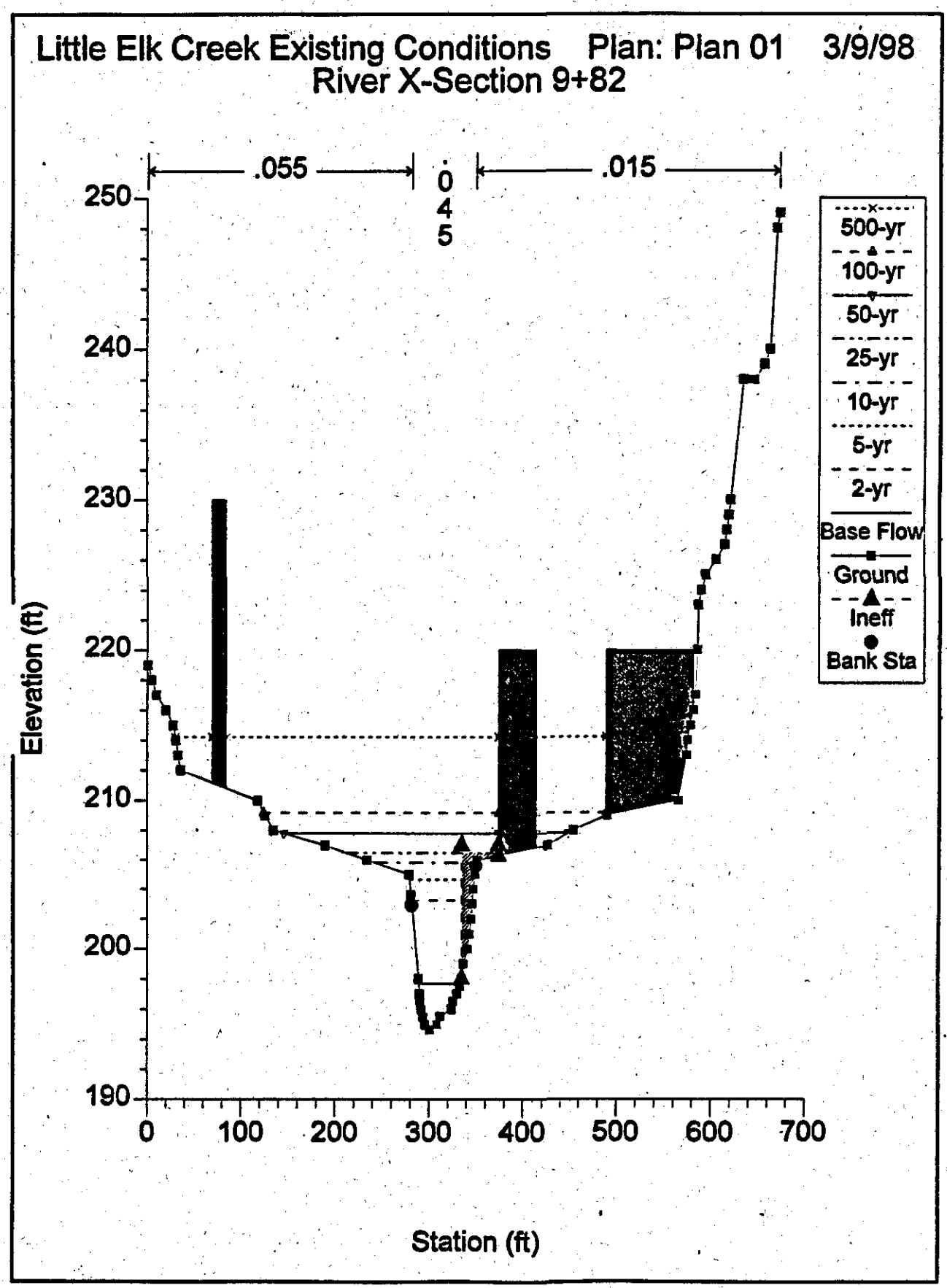
AR100244

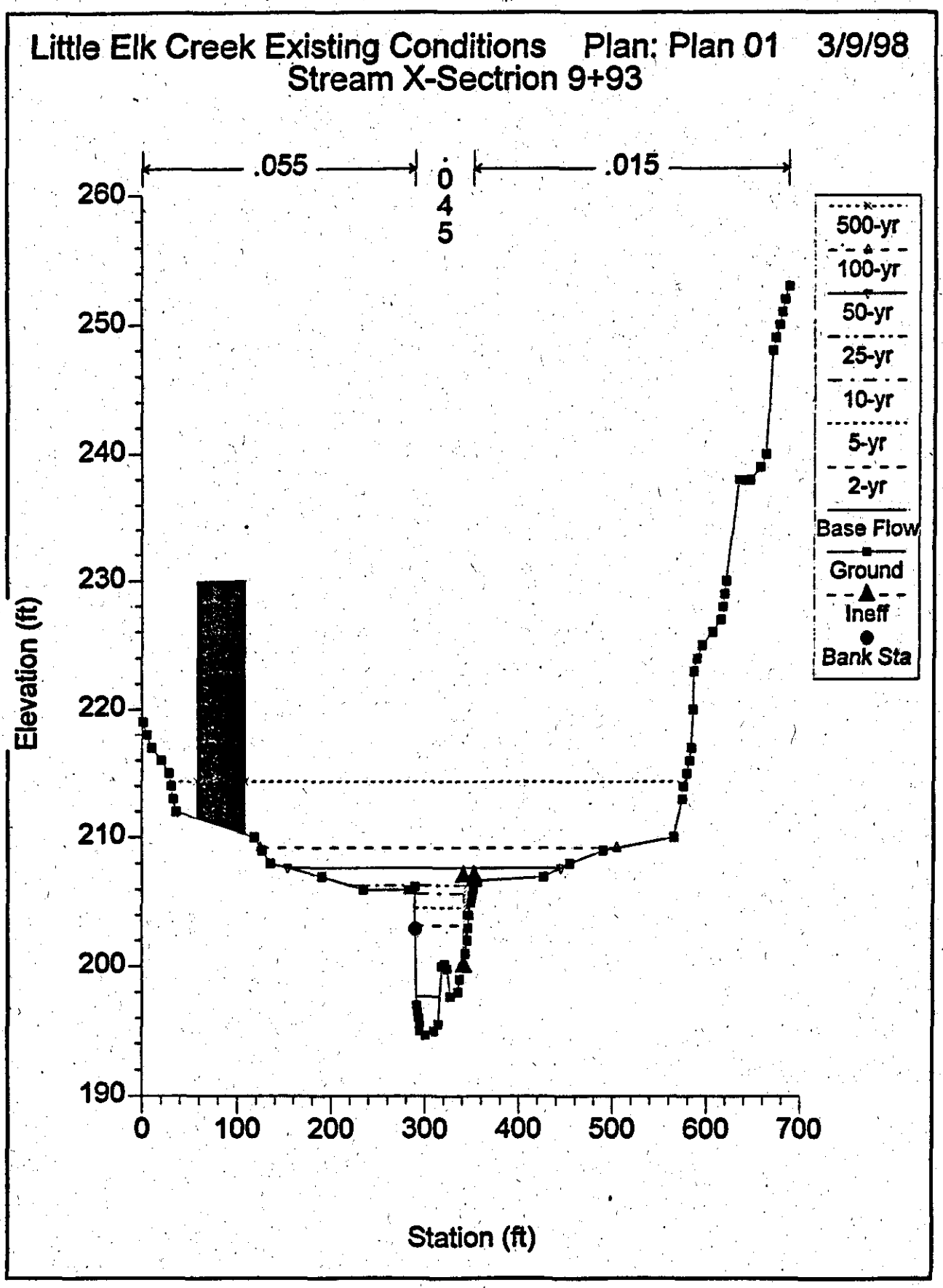

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 7+77
.06
.045
.04
Elevation (ft)
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta

AR100245


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 8+54
.06
.045
.027
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

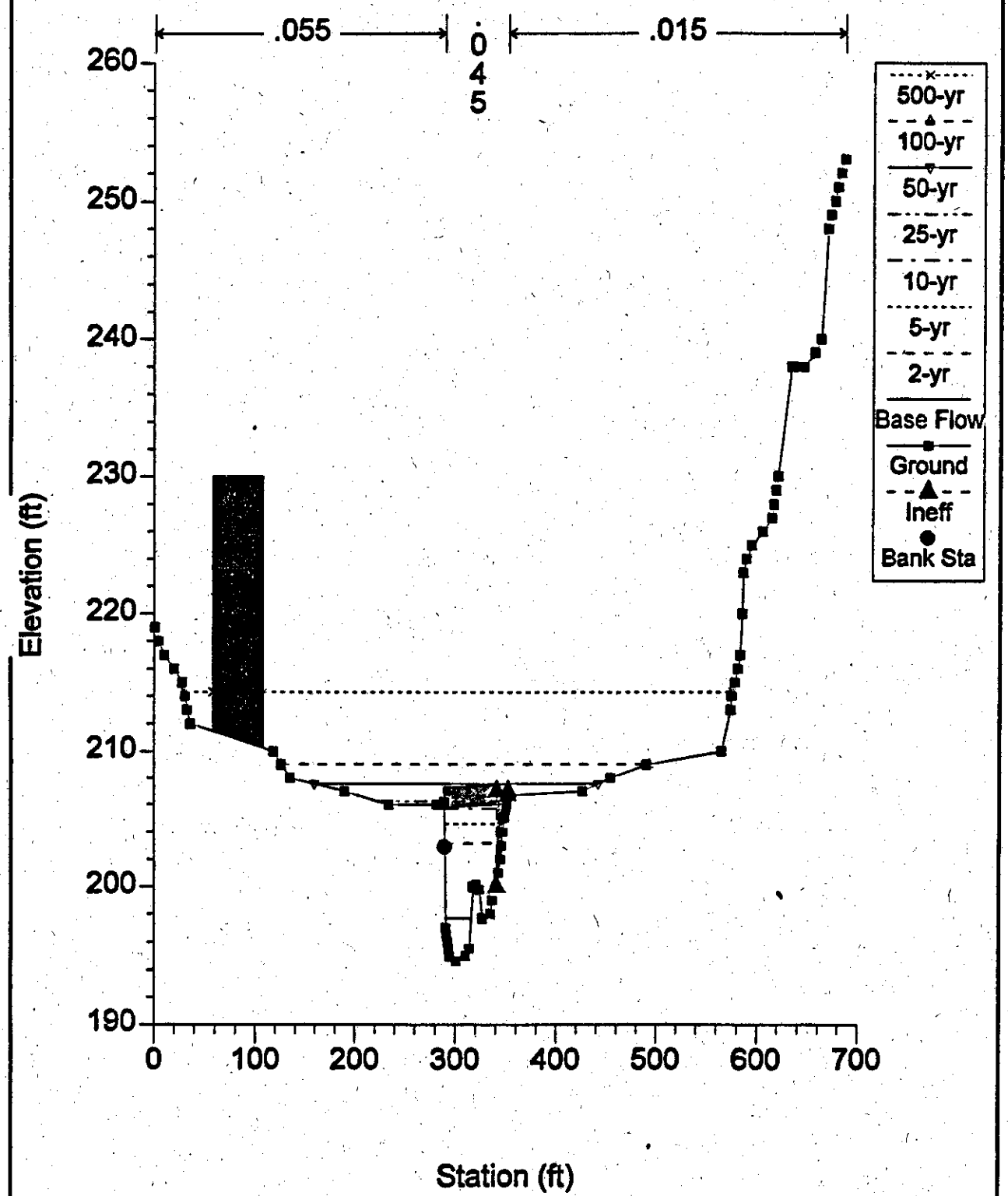

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 9+05
.06
.045
.018
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
River X-Section 9+82
.055
.045
.015
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Sectrion 9+93
.055
.045
.015
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

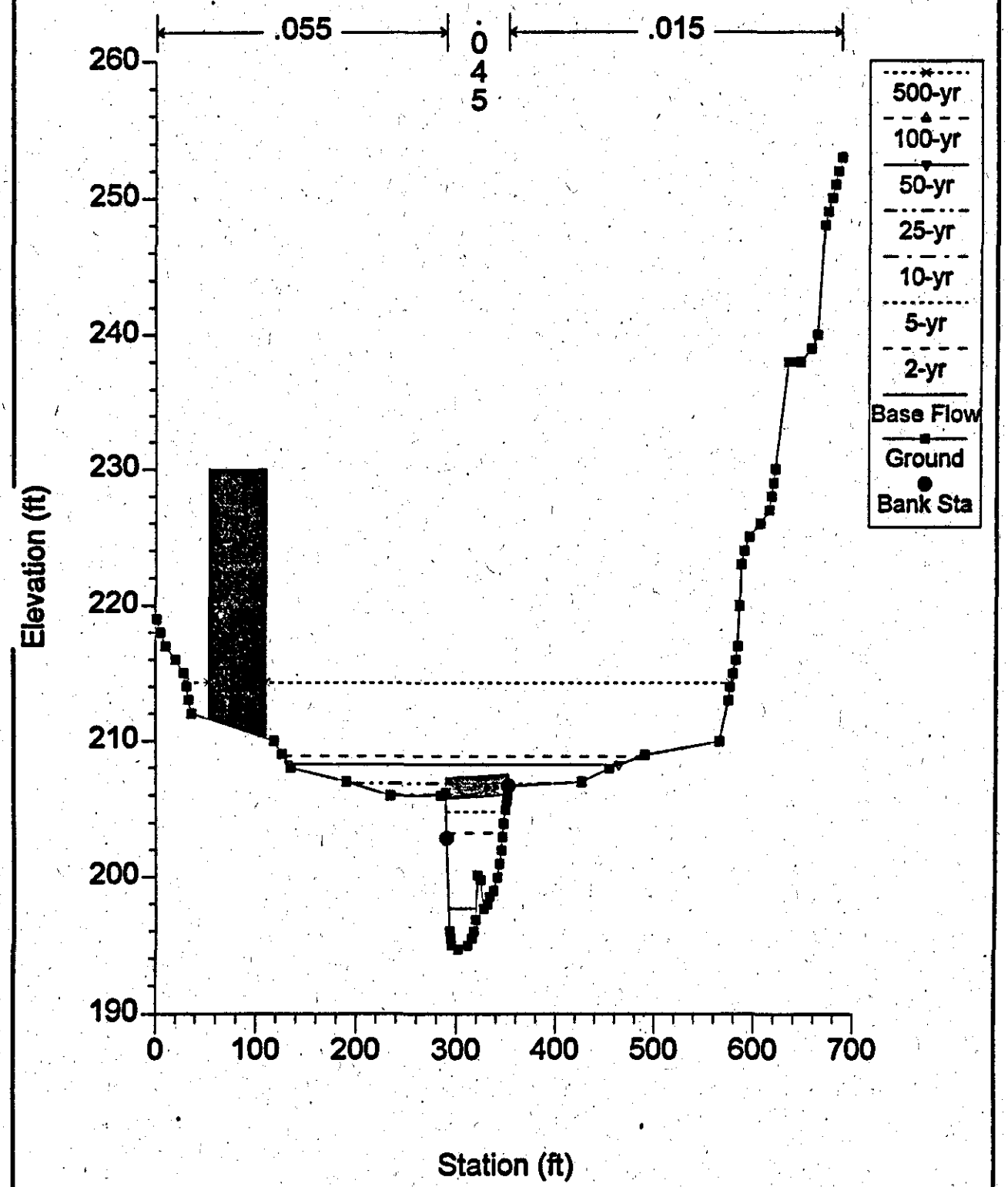
AR100249

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Downstream Inside Footbridge (Bridge # 3)

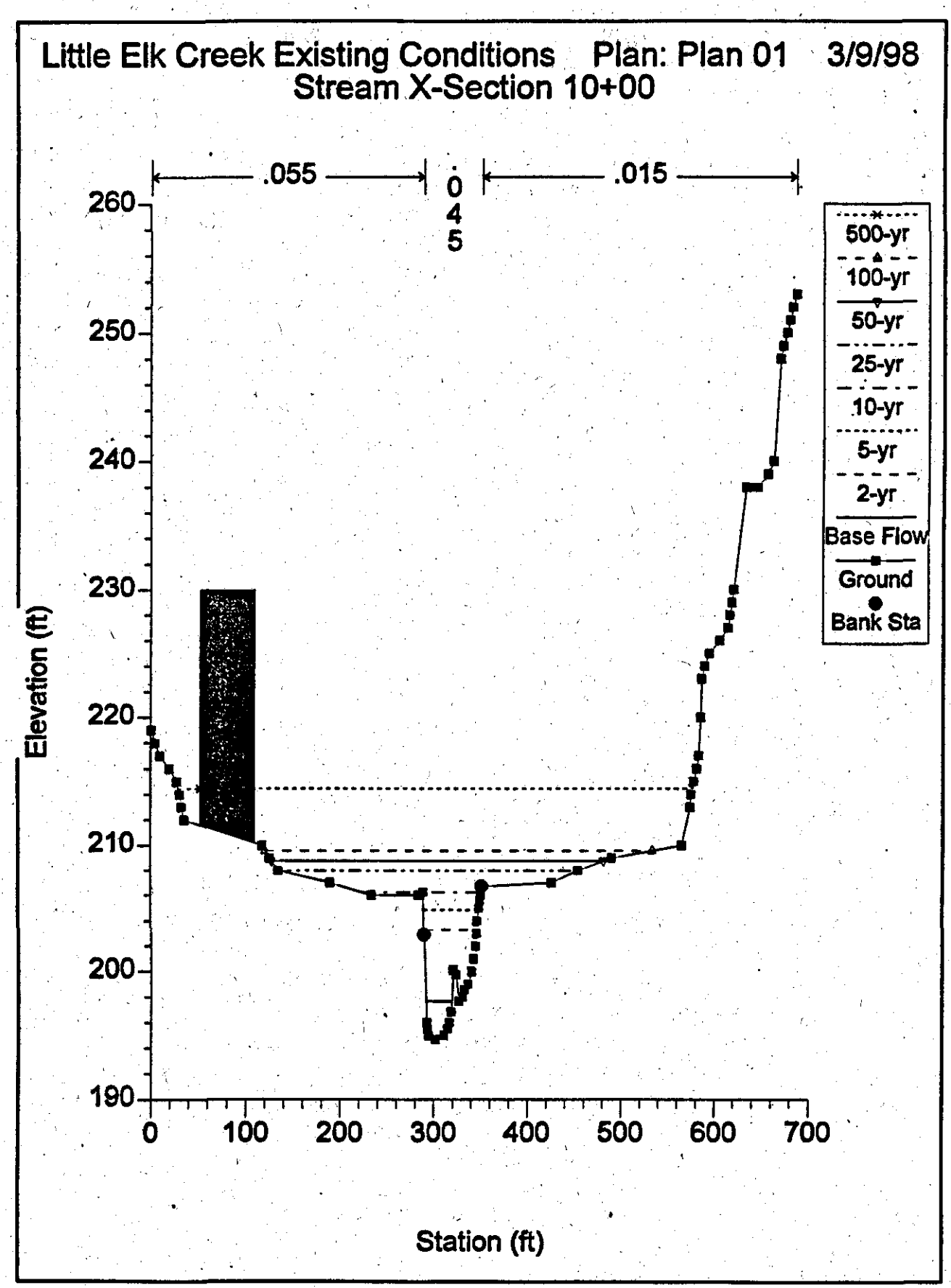


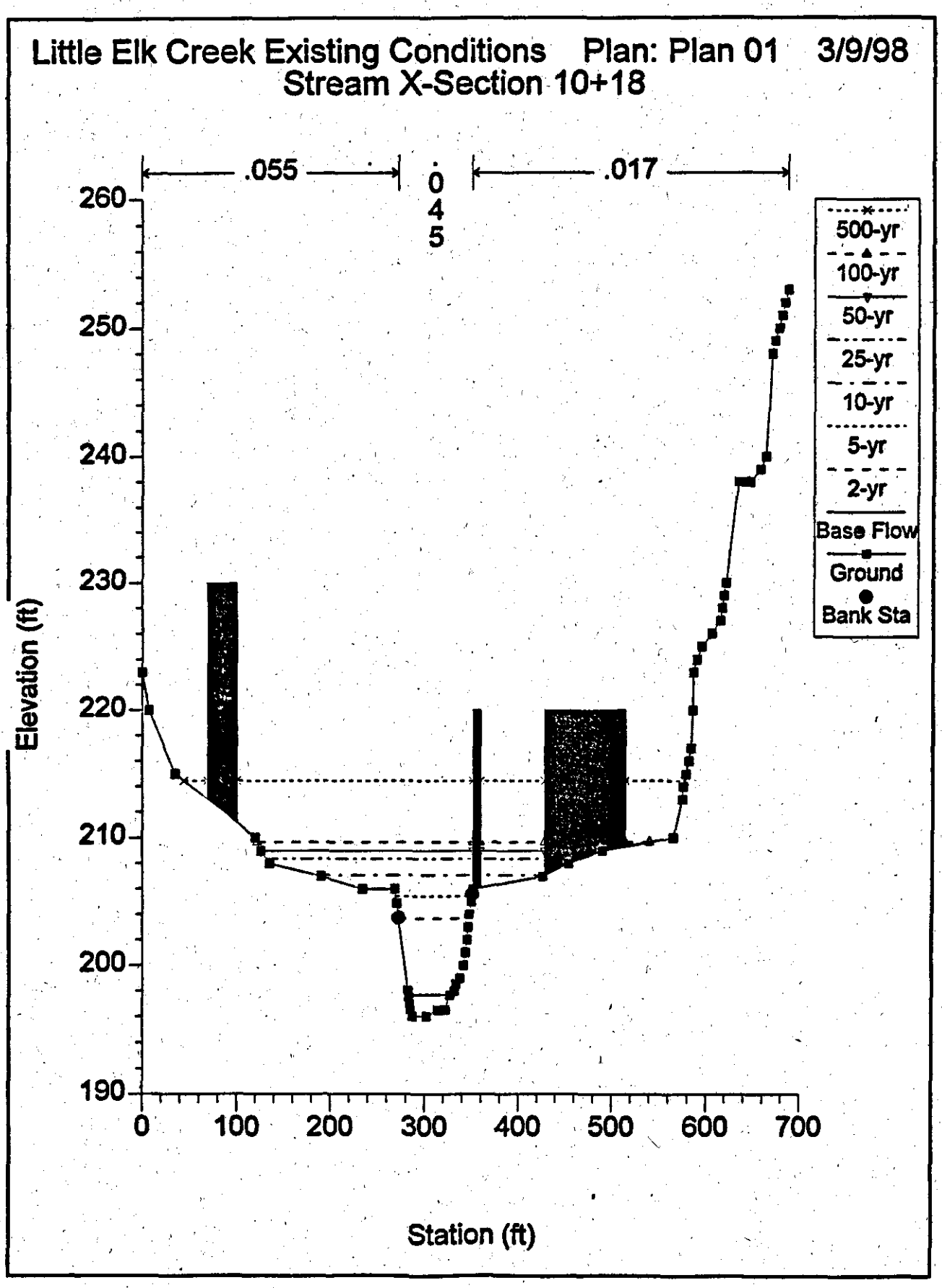
AR100250

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Upstream Inside Footbridge (Bridge # 3)



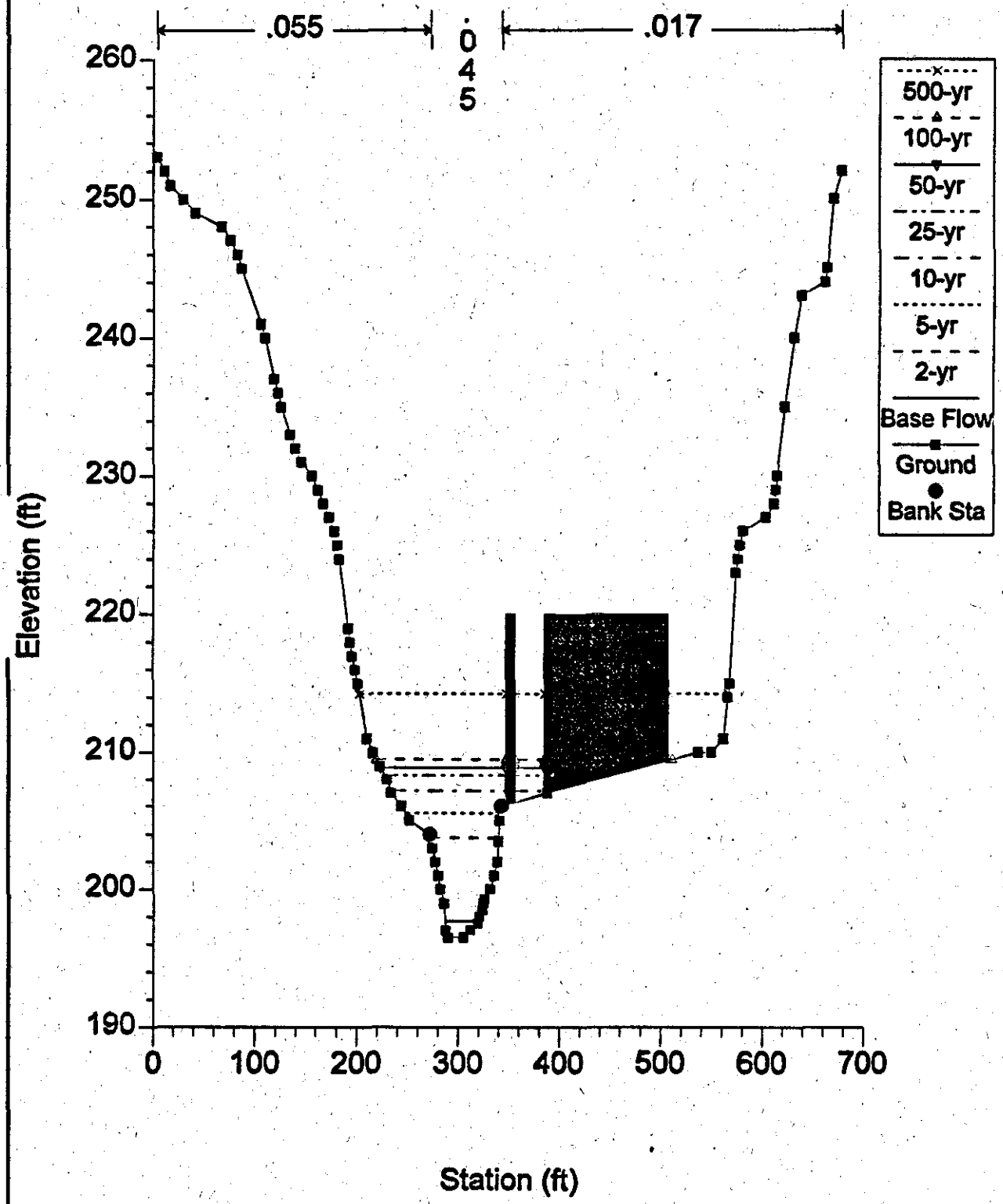
AR100251


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 10+00
.055
.045
.015
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

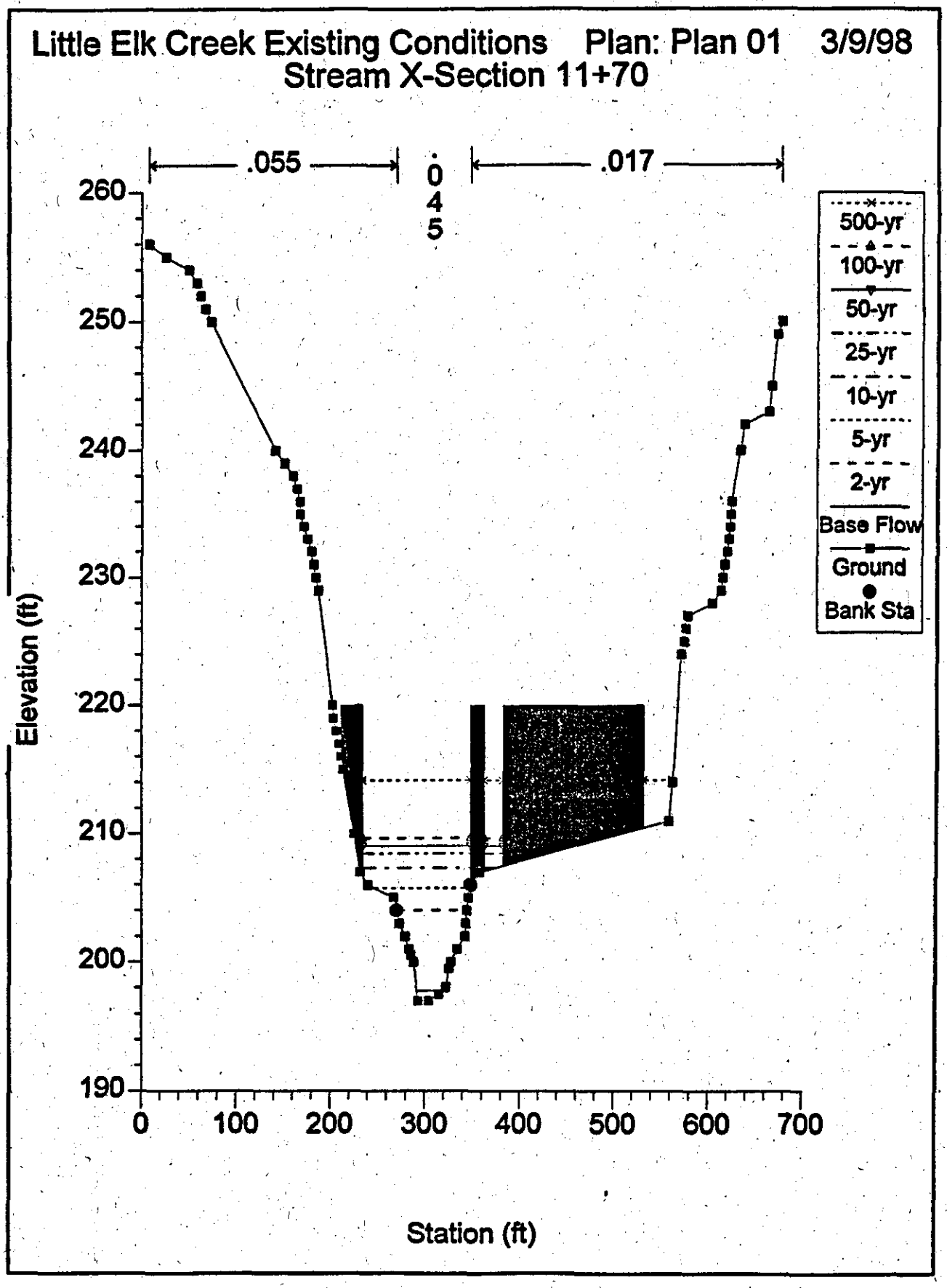

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 10+18
.055
.045
.017
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

AR100253

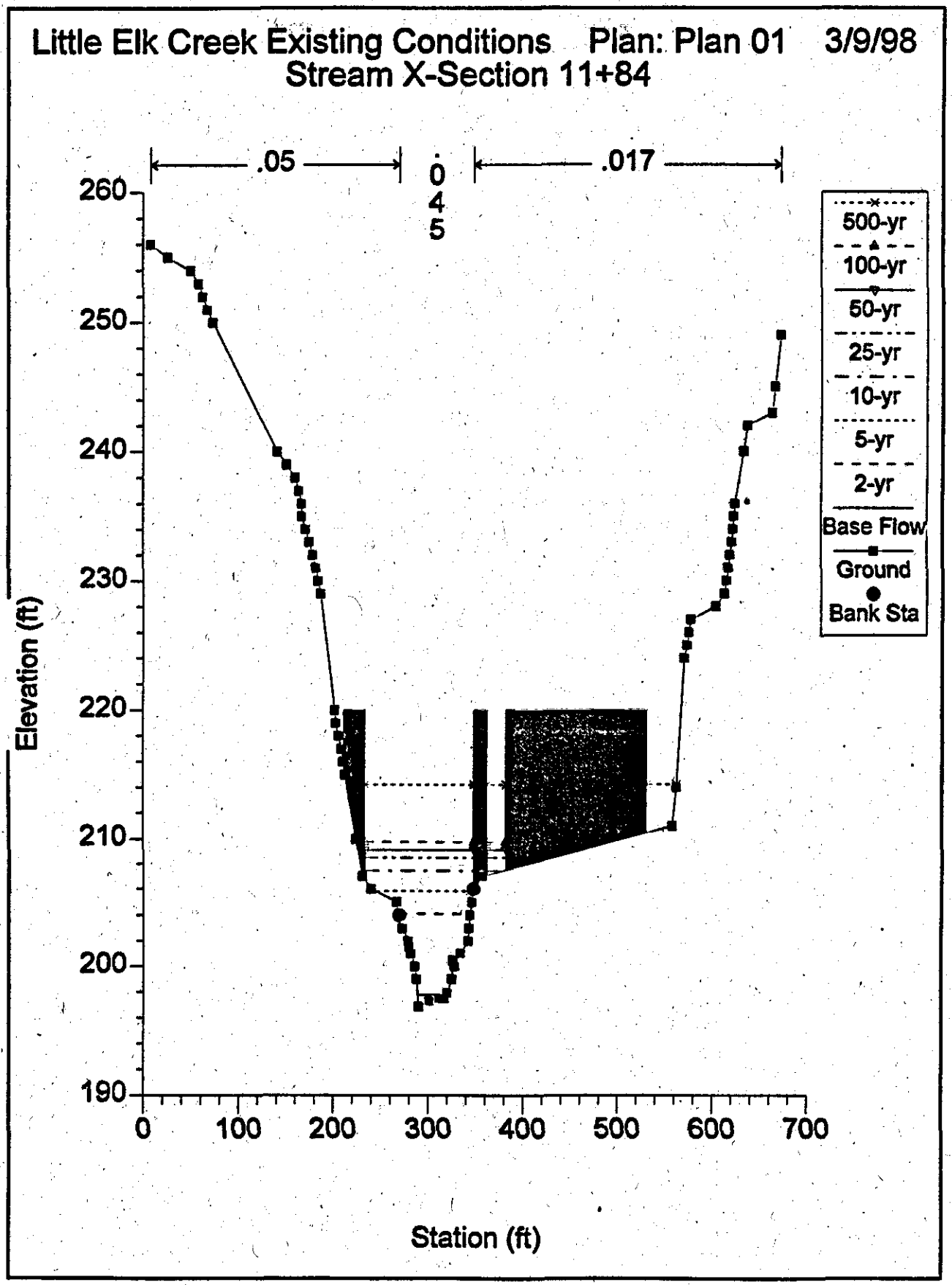
Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Steam X-Section 11+03

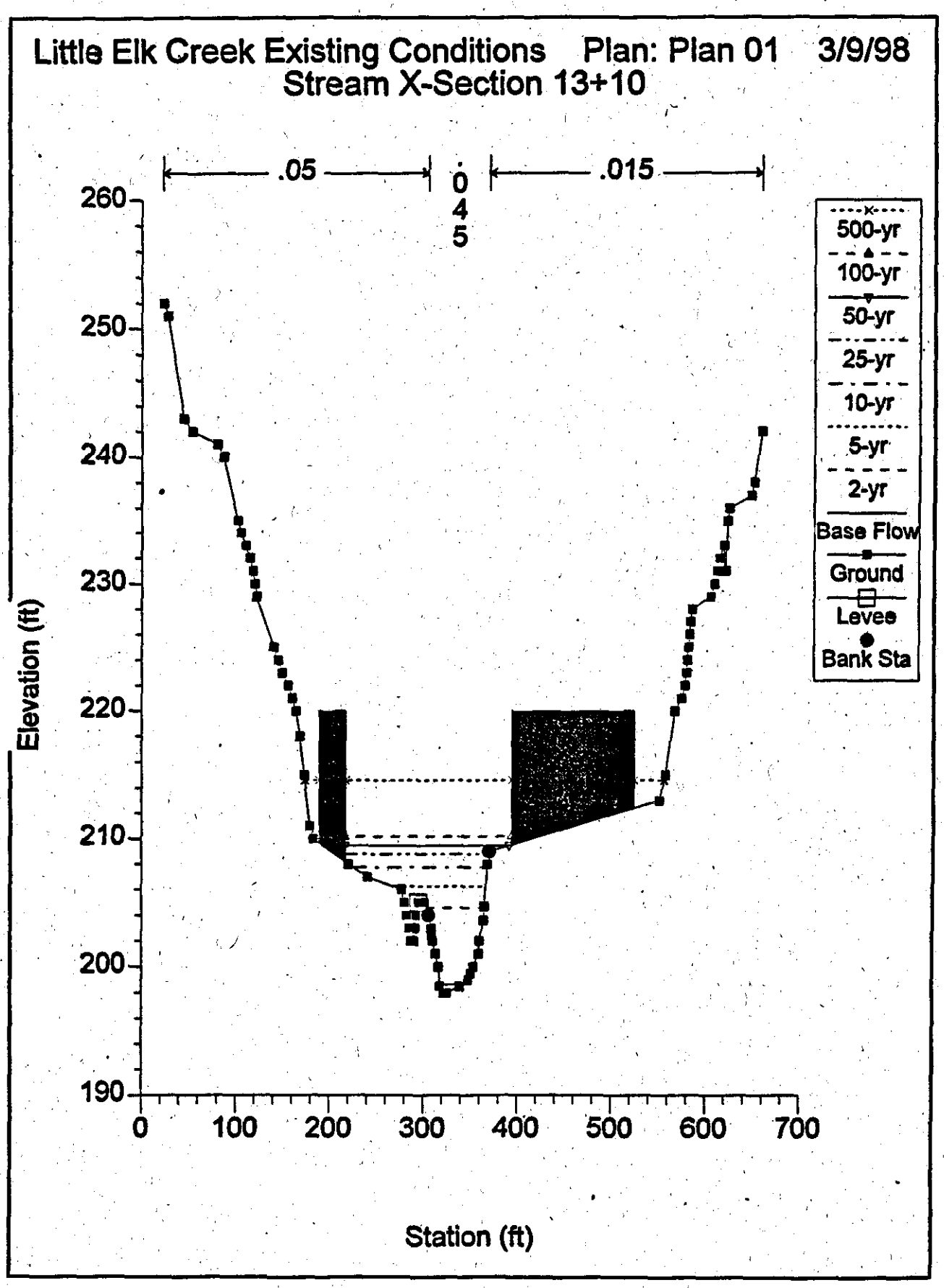


AR100254


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 11+70
.055
045
.017
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

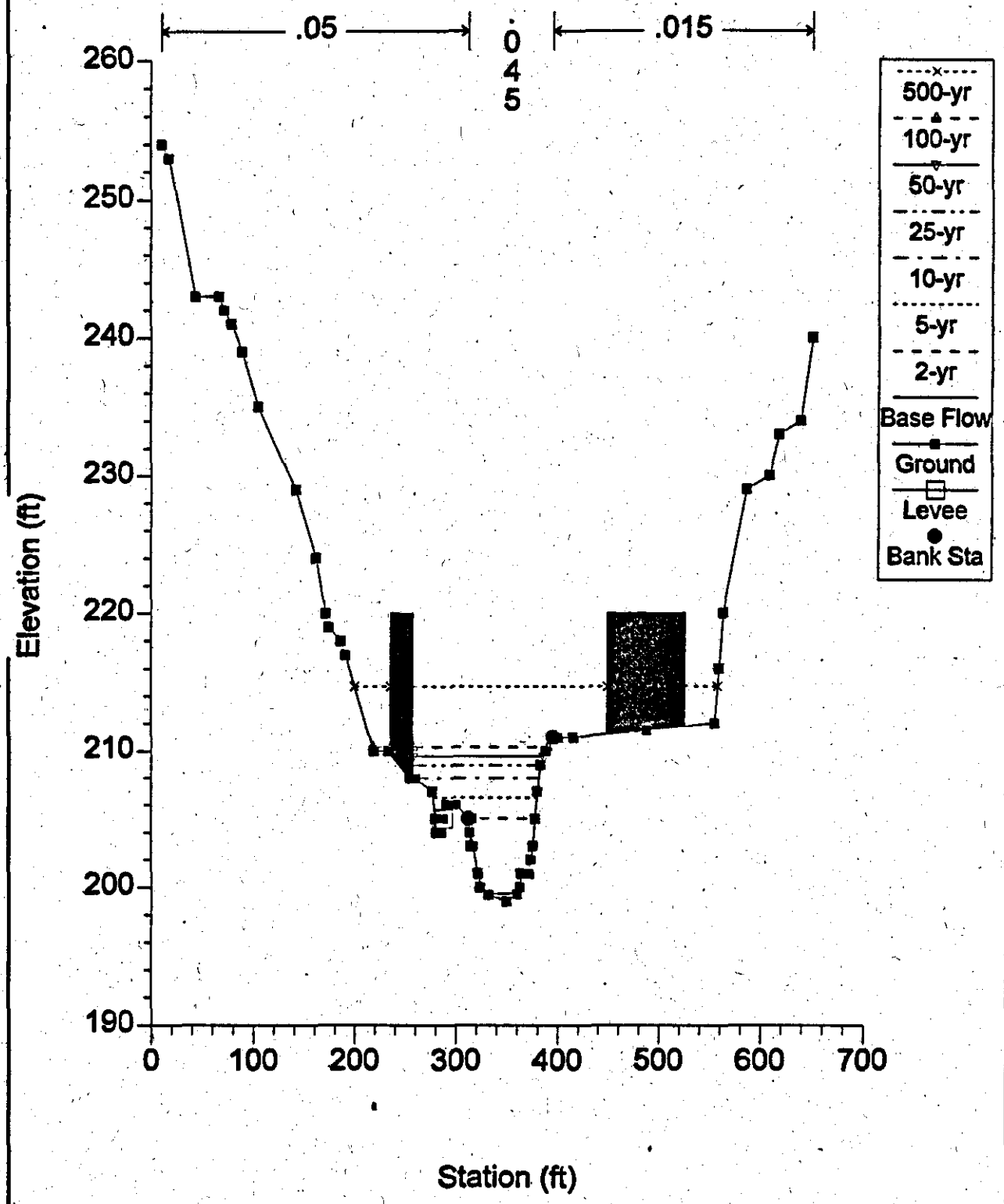
AR100255


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 11+84
.05
.045
.017
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

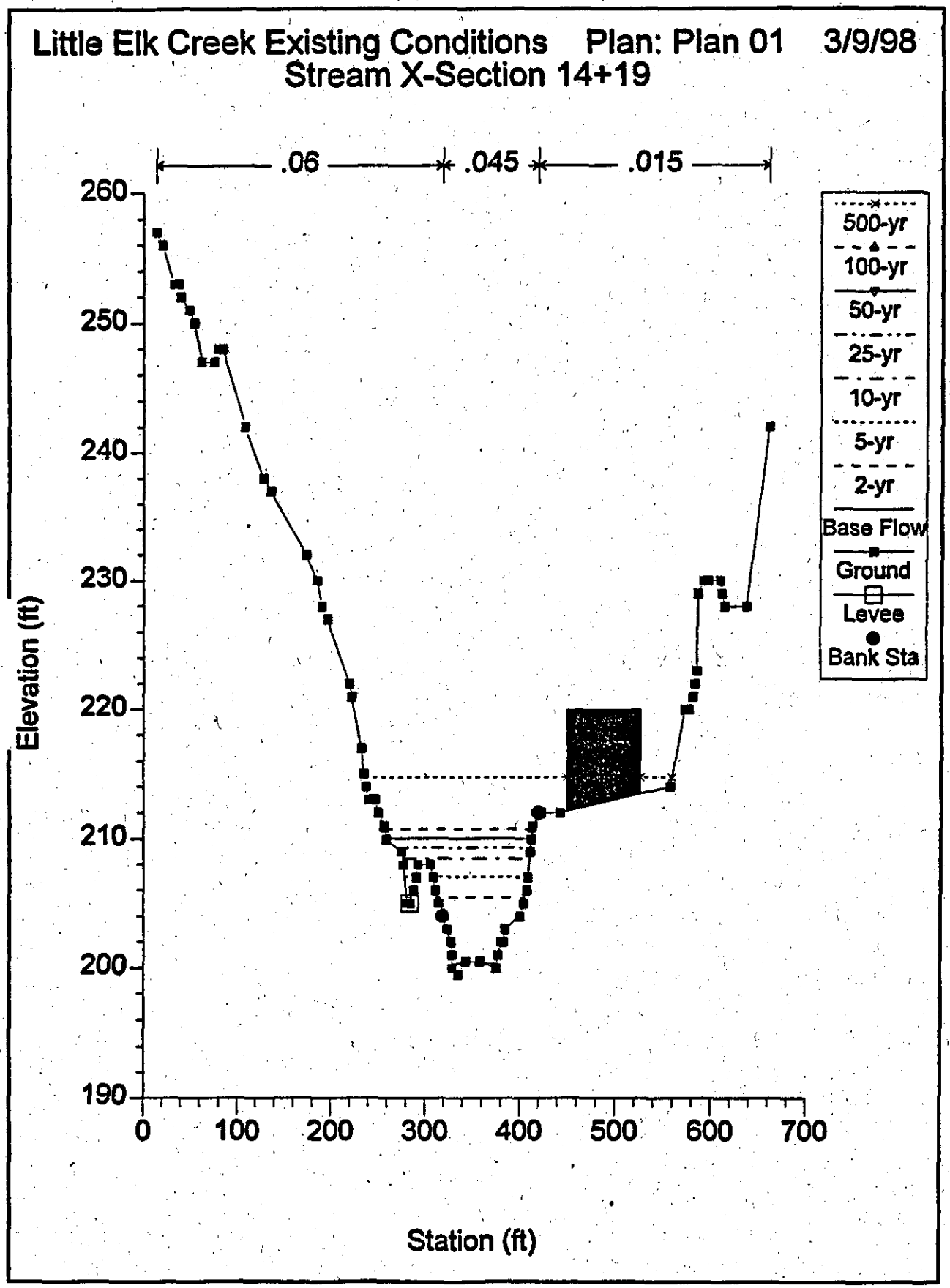

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 13+10
.05
.045
.015
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

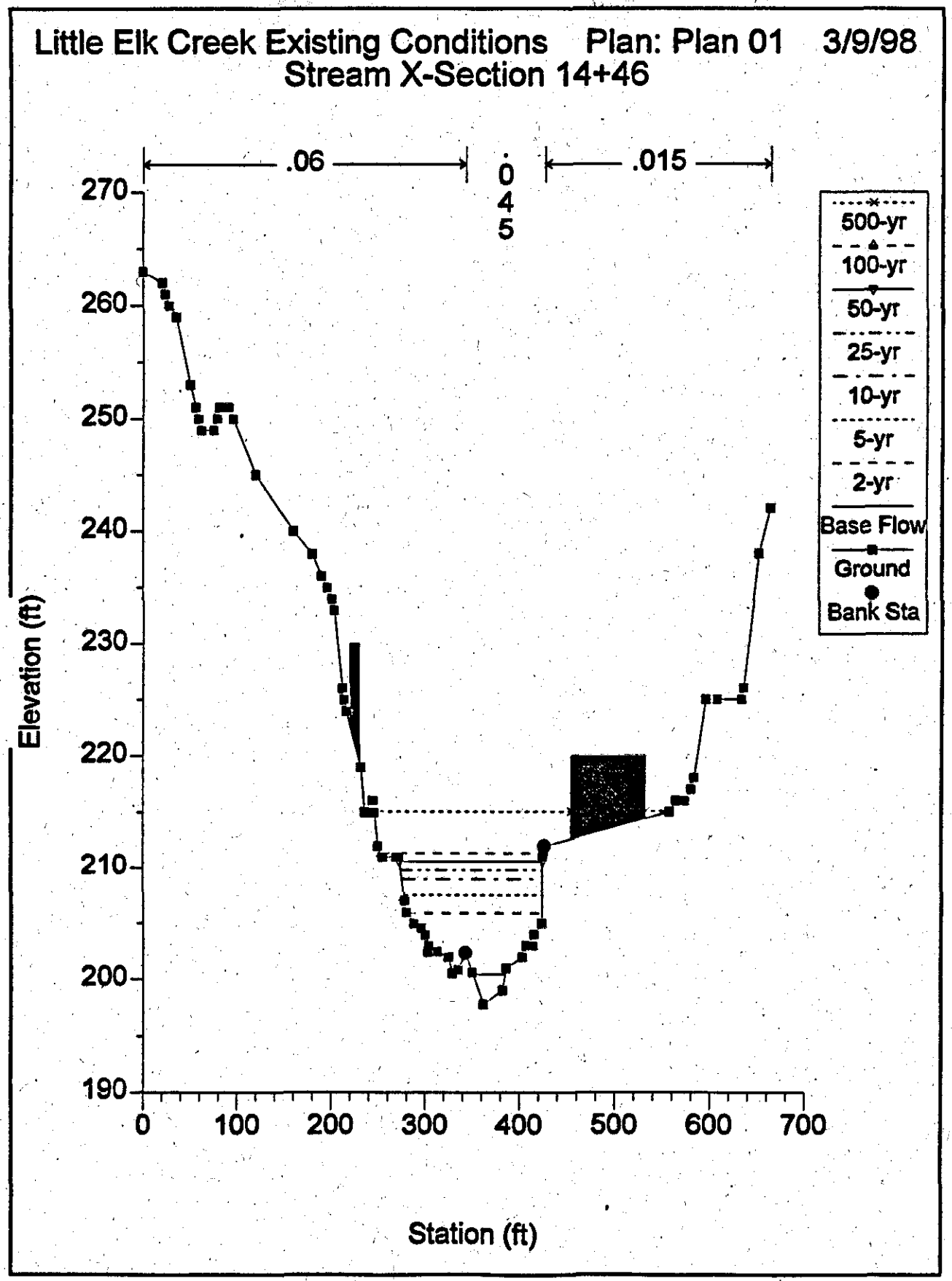
AR100257

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 13+69

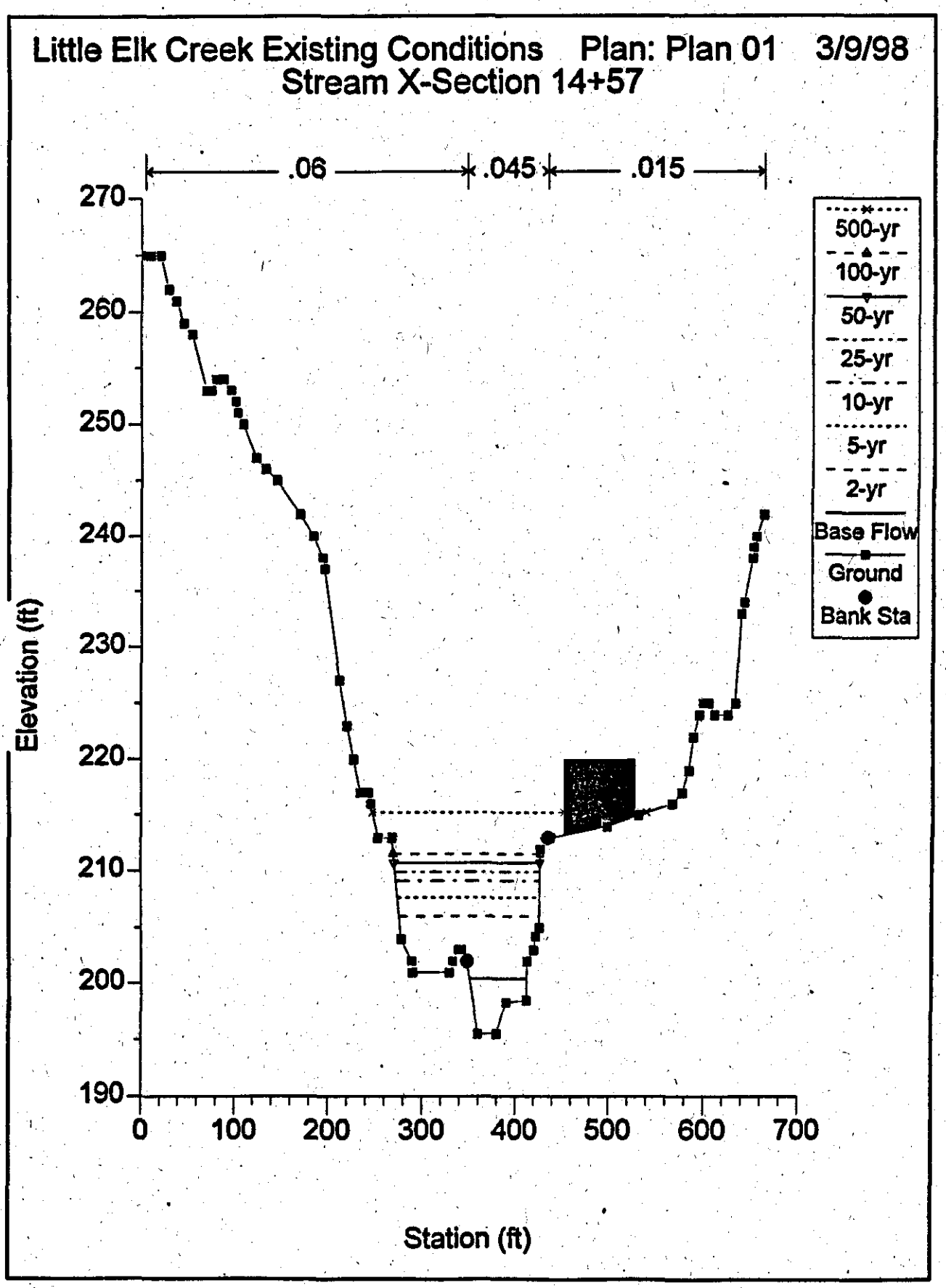


AR100258

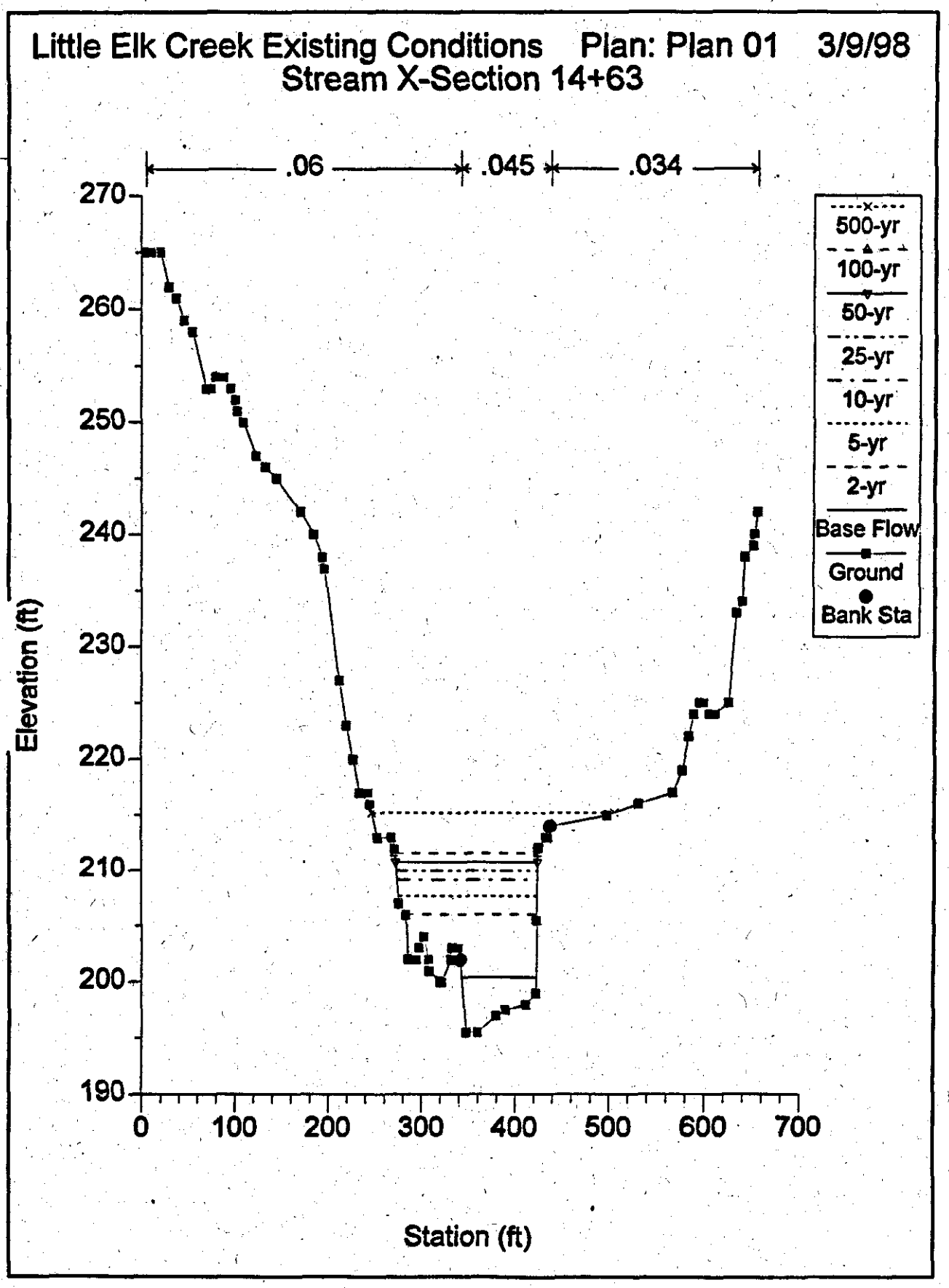

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+19
.06
.045
.015
Elevation (ft)
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

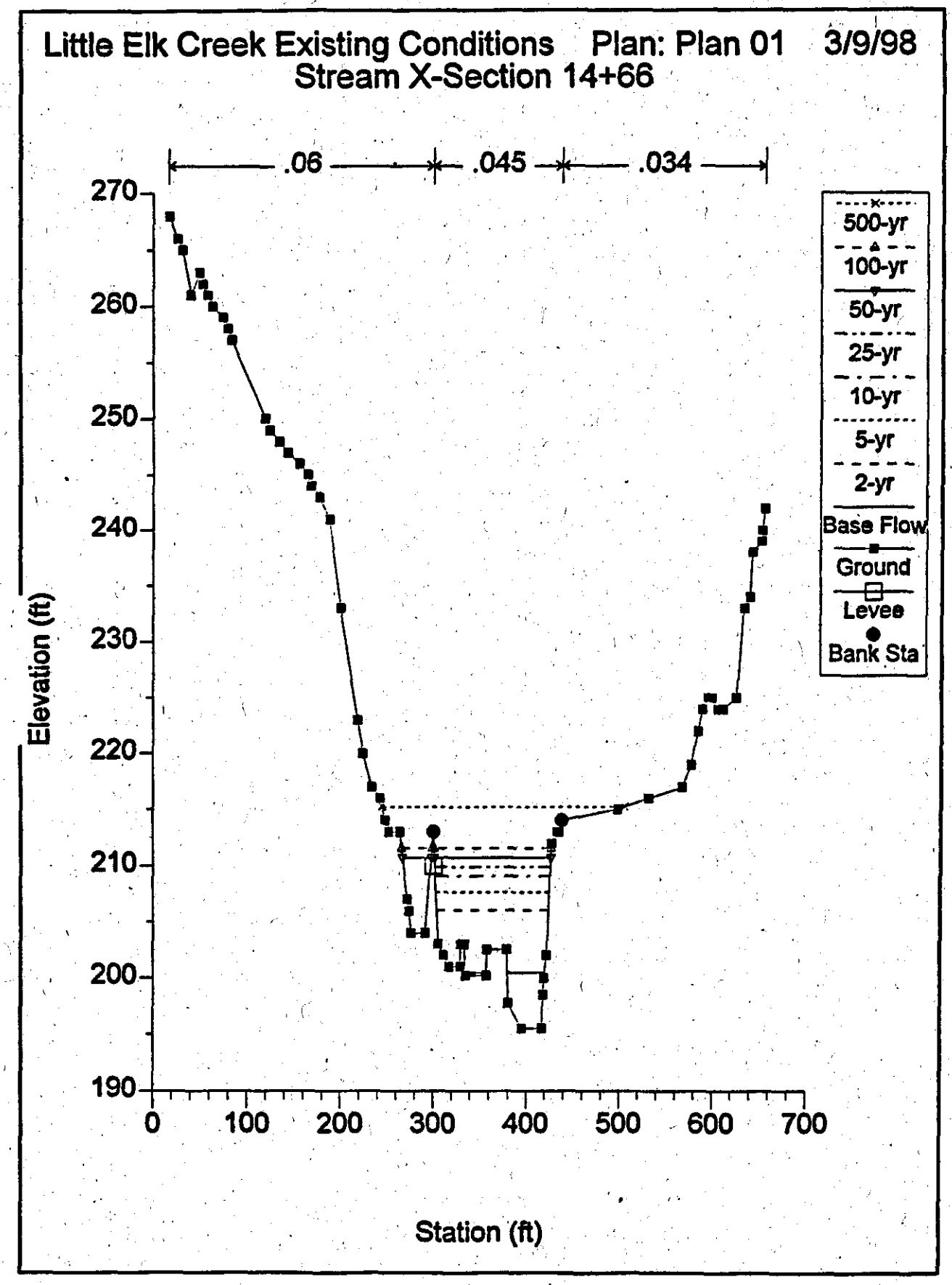

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+46
.06
.045
.015
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
270
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700
Station (ft)

AR100260

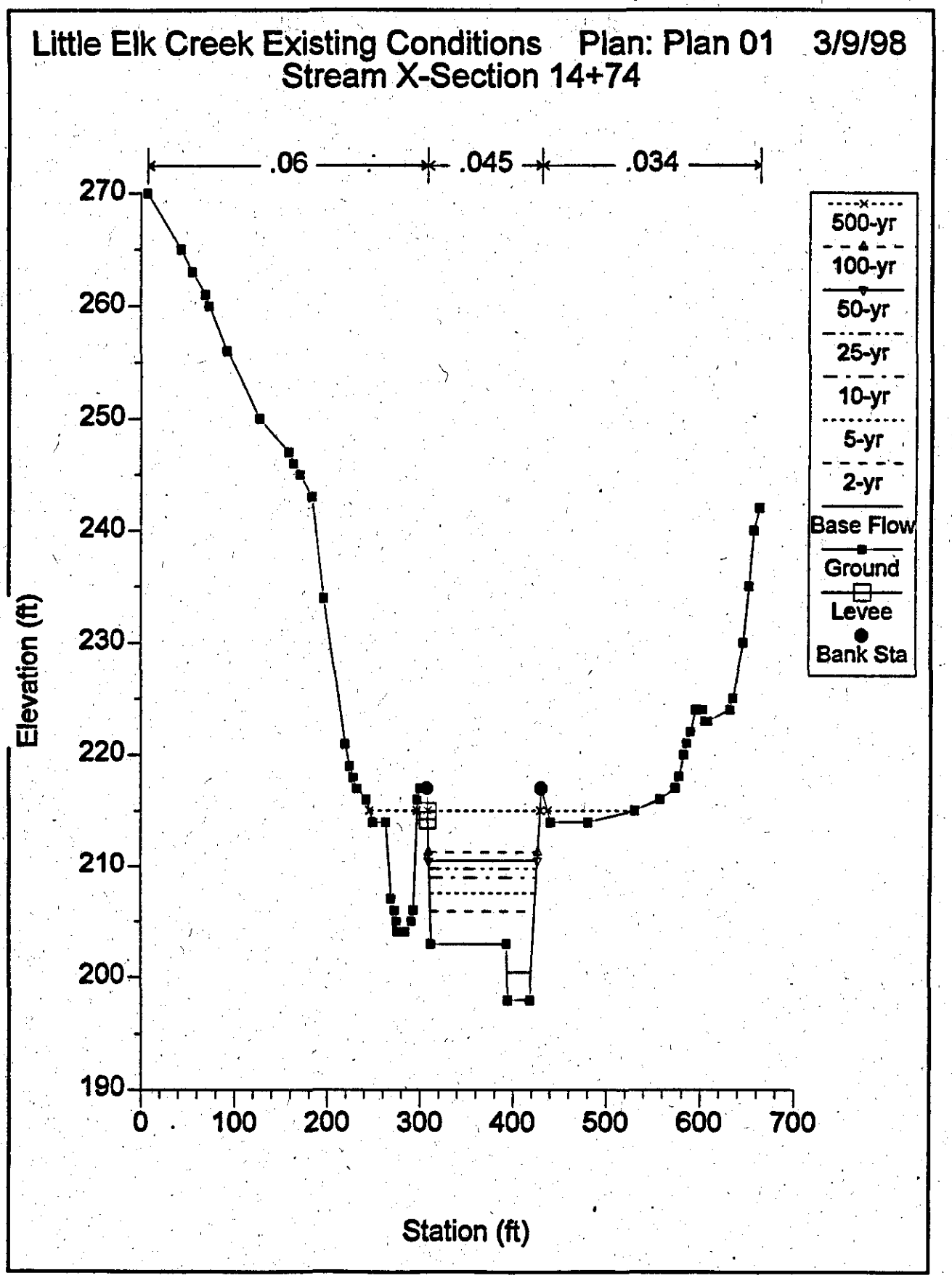

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+57
.06
.045
.015
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

AR100261

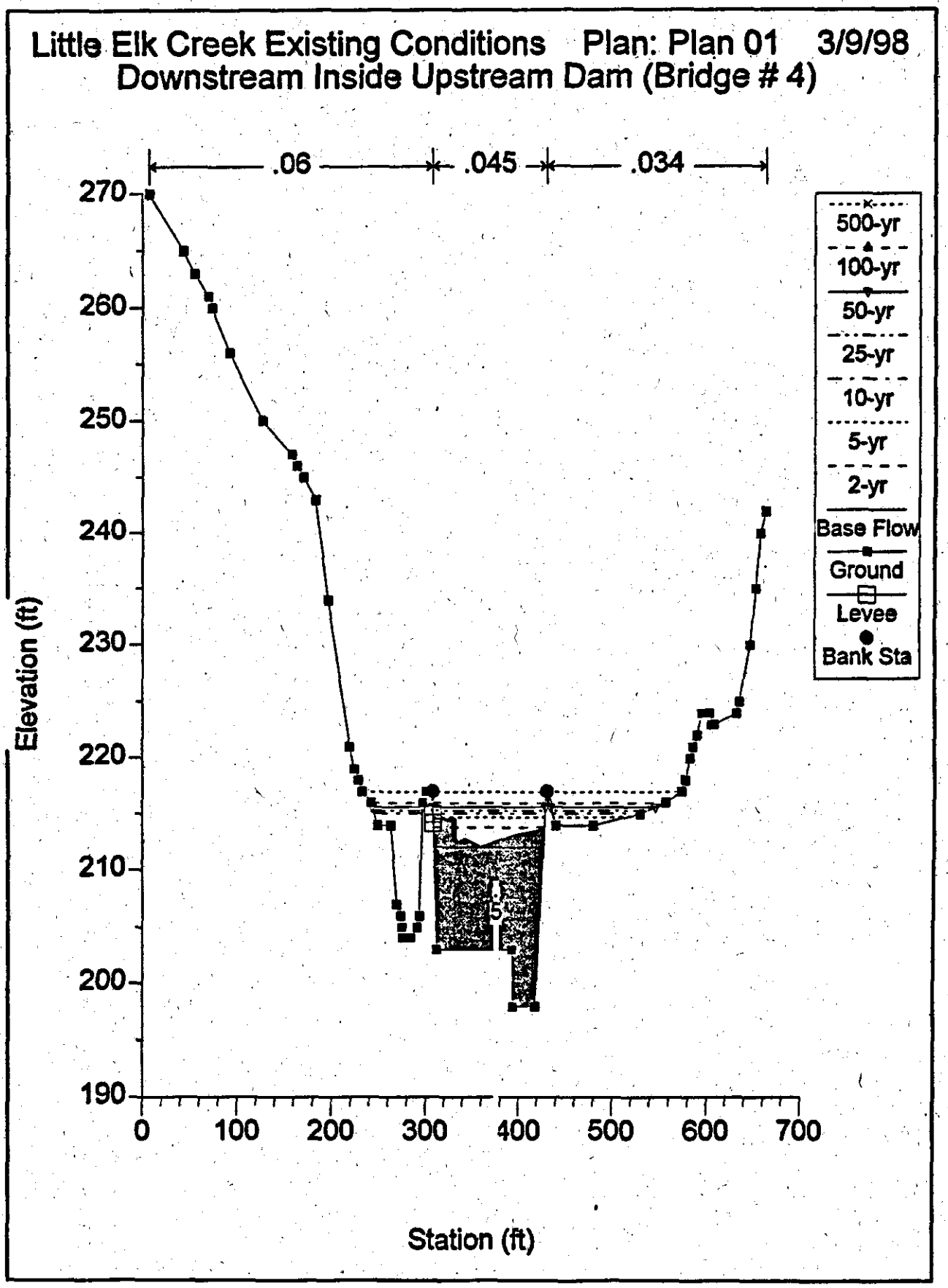

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+63
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+66
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

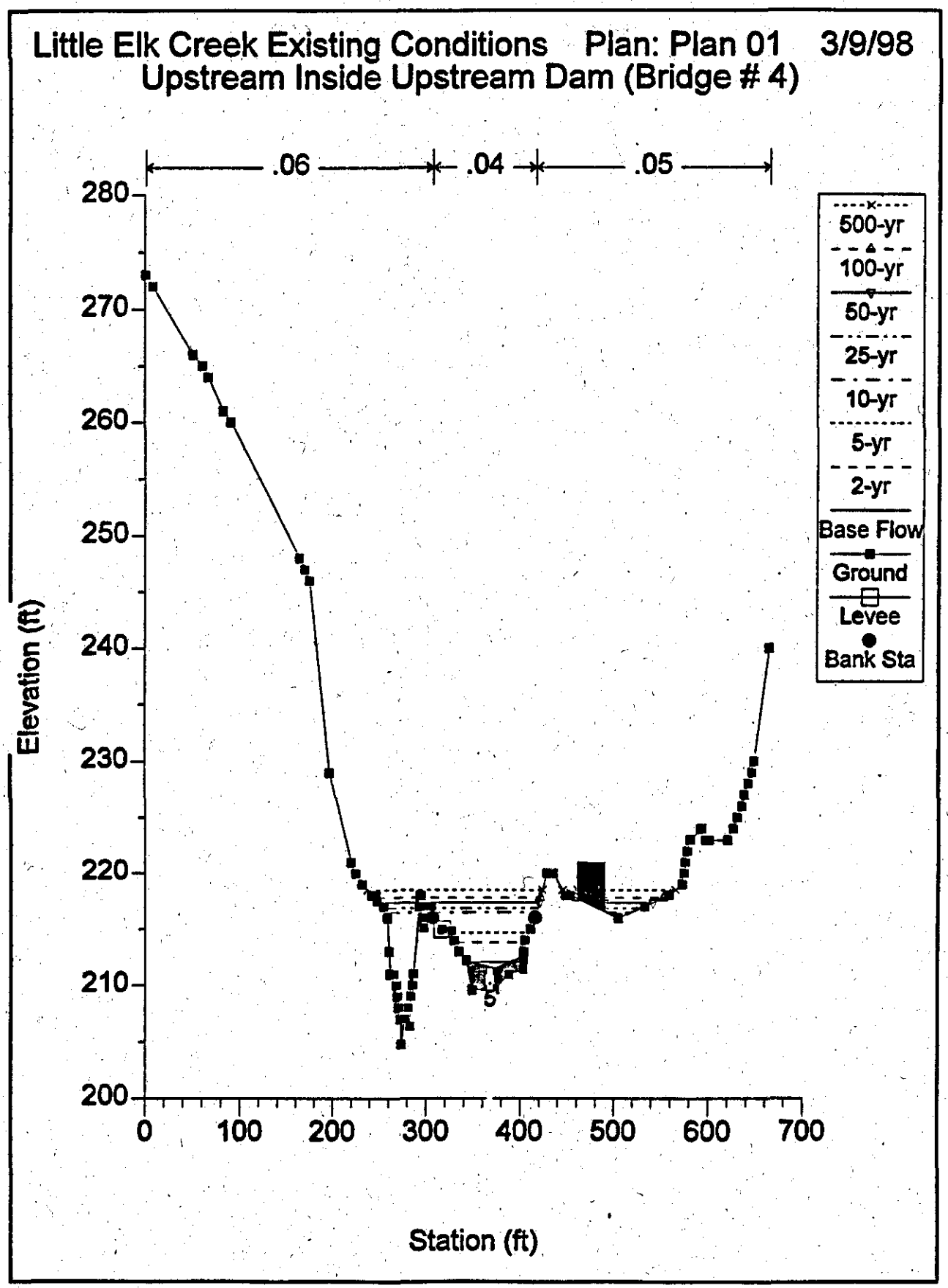
AR100263


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 14+74
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

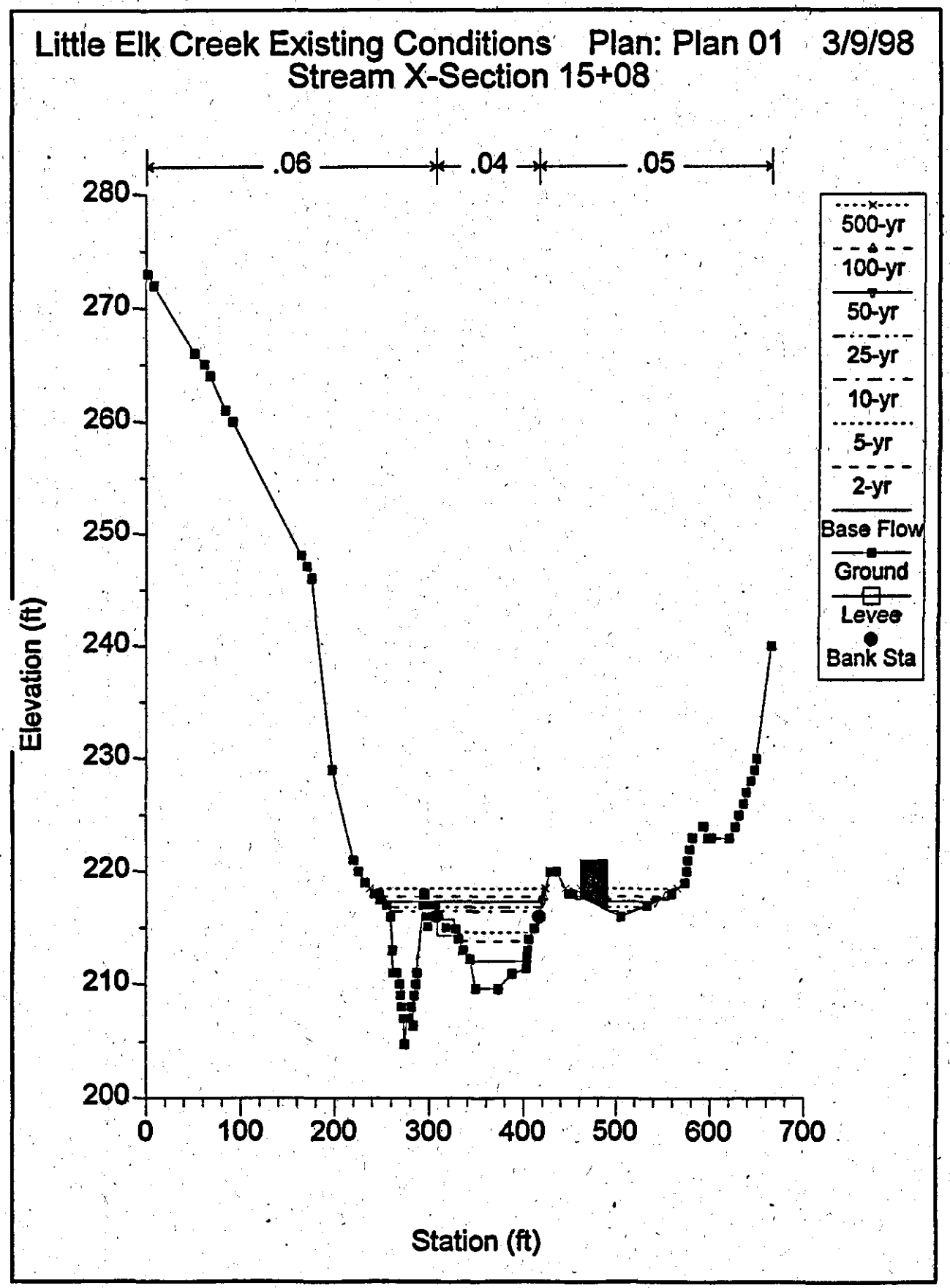
AR100264


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Downstream Inside Upstream Dam (Bridge # 4)
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

AR100265


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Upstream Inside Upstream Dam (Bridge # 4)
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

AR100266


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 15+08
.06
.04
.05
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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270
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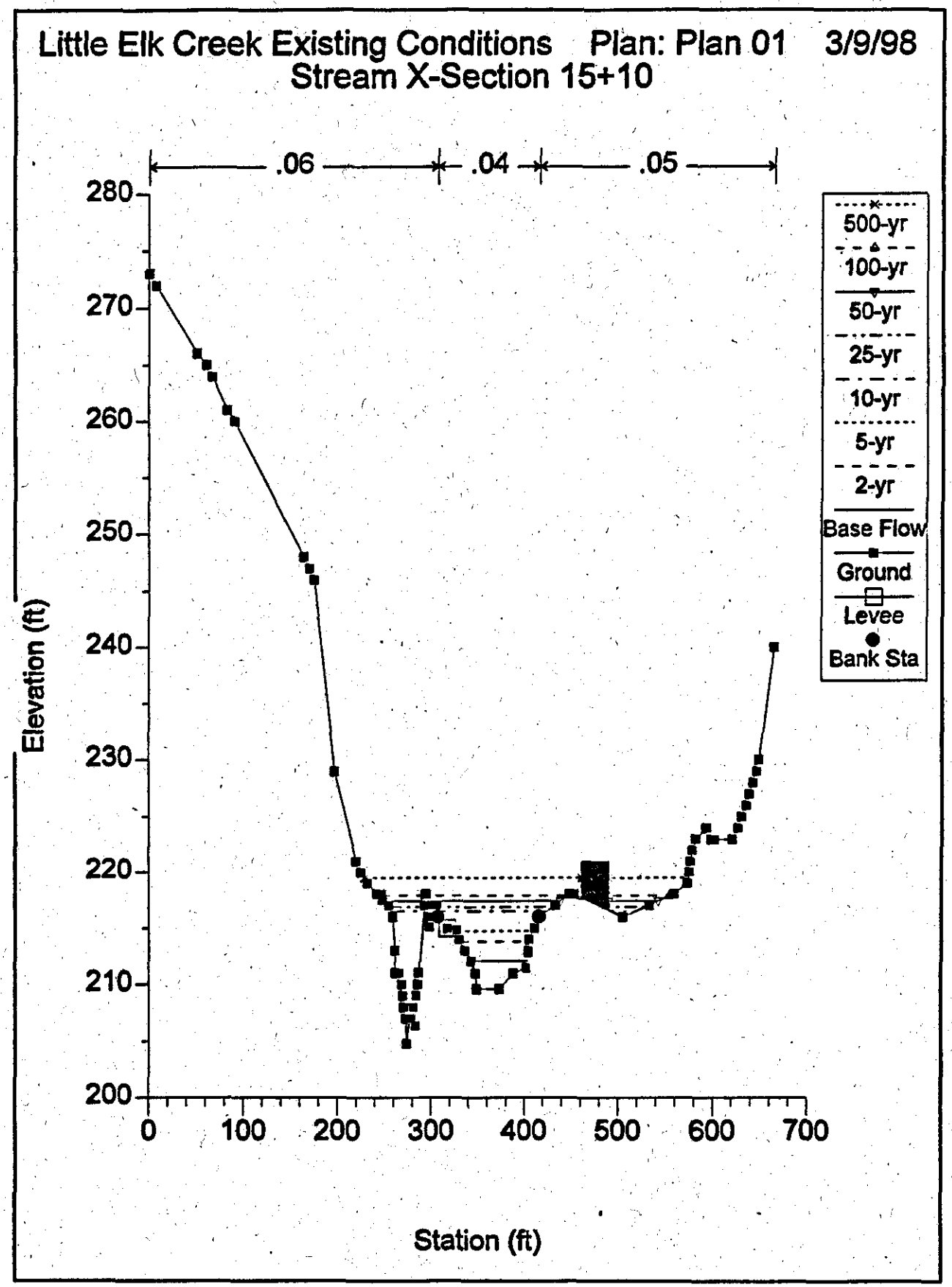
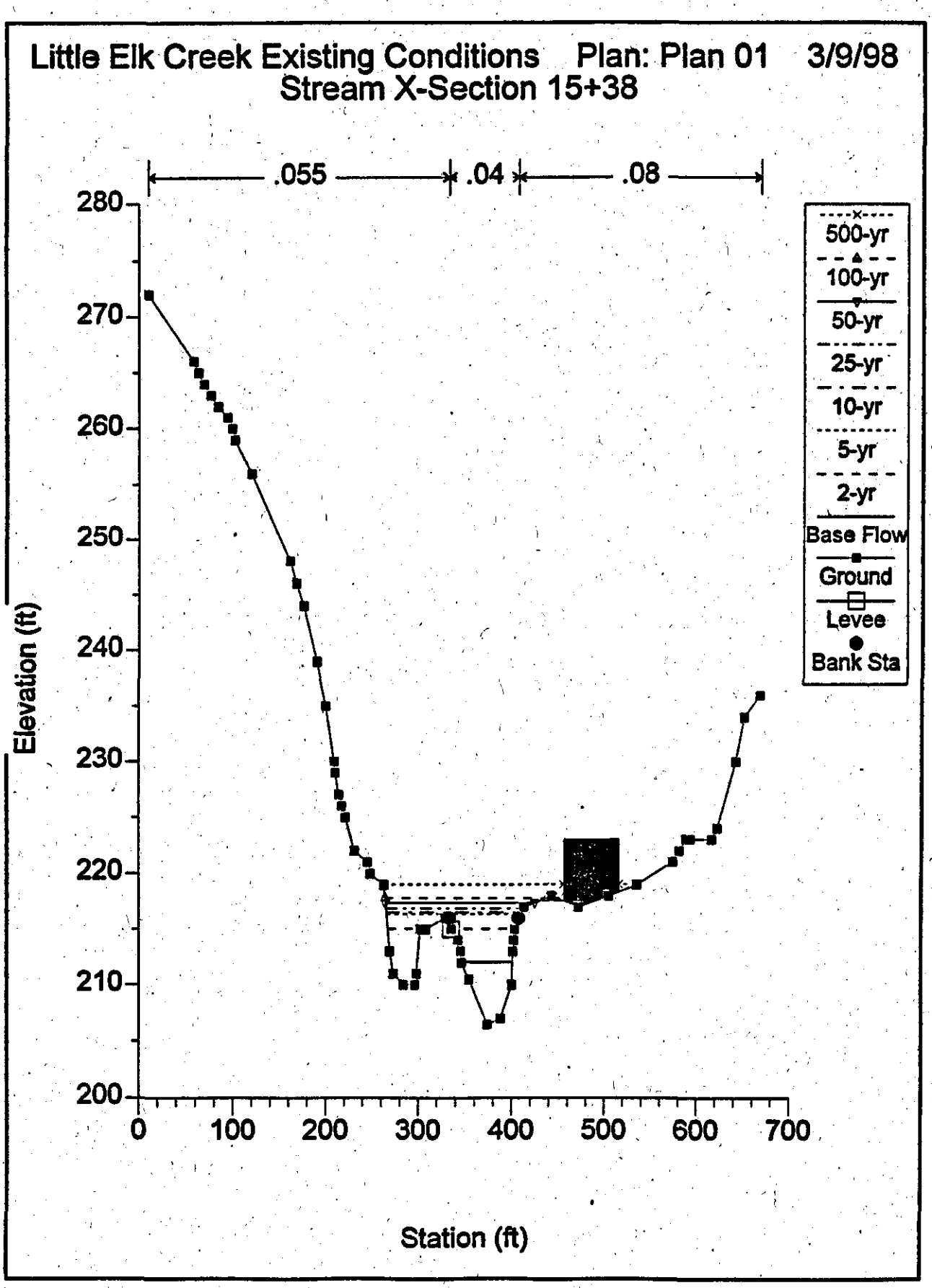
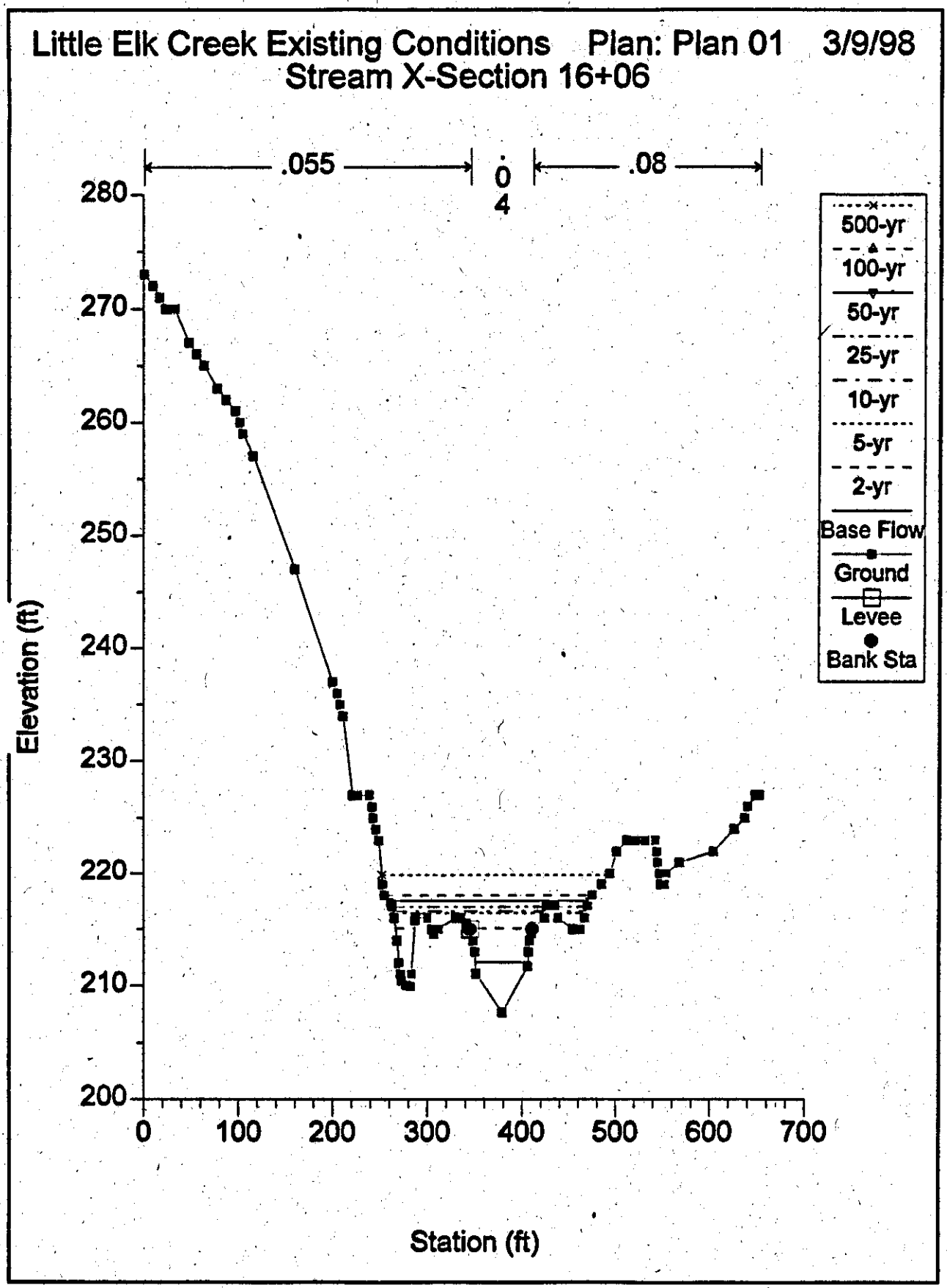
240
230
220
210
200
0
100
200
300
400
500
600
700

AR100267

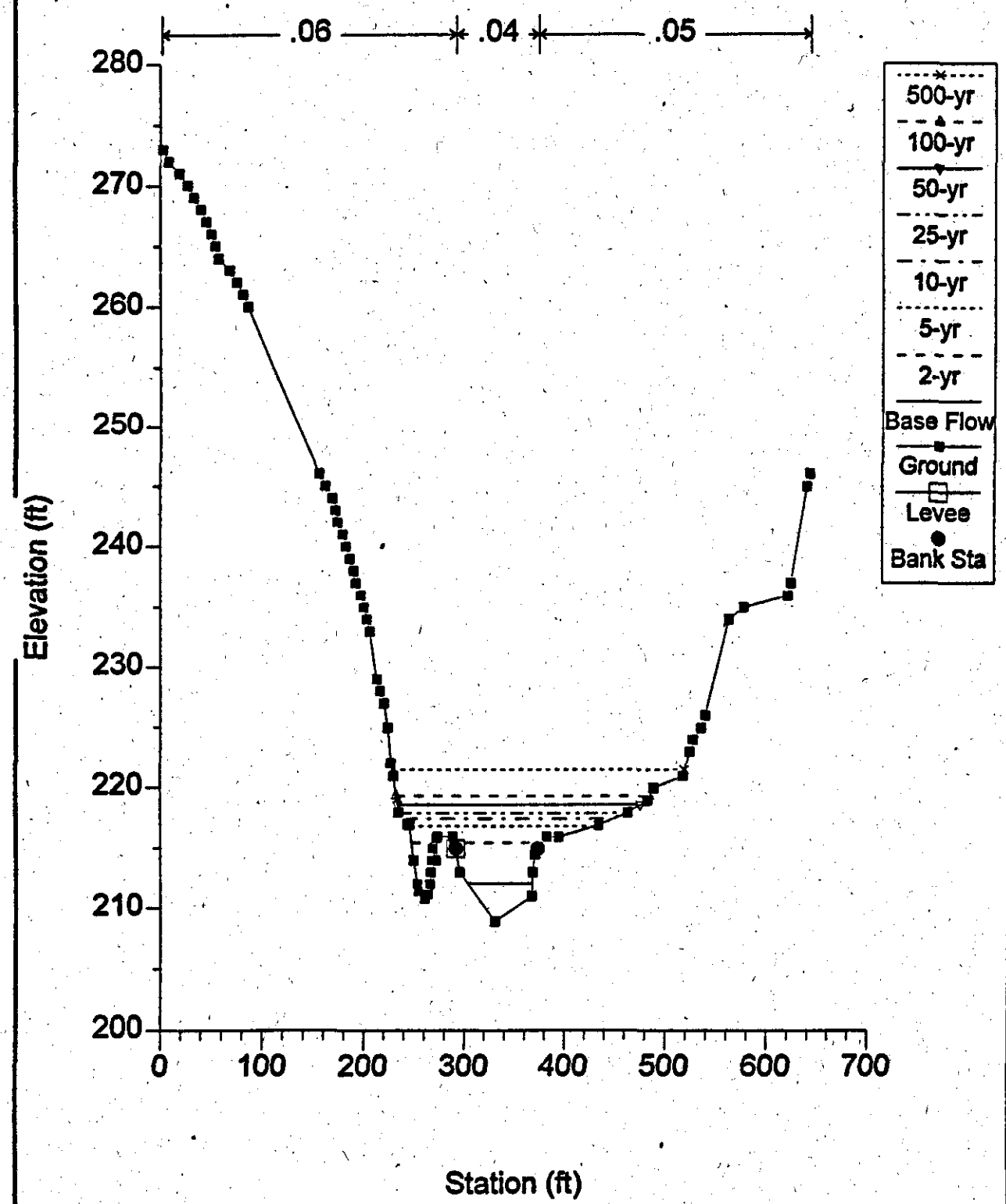

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 15+10
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 15+38
.055
.04
.08
Elevation (ft)
280
270
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

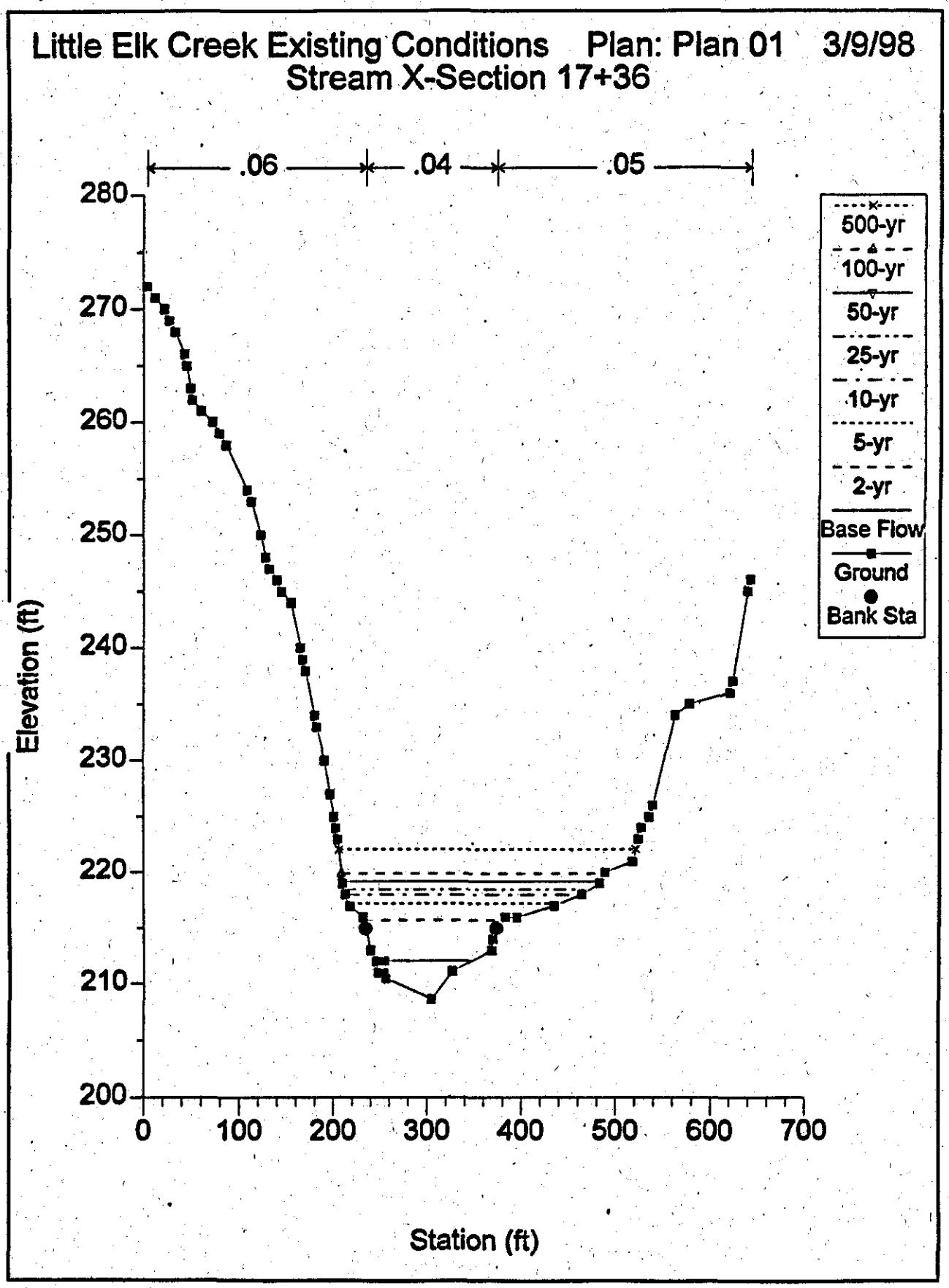

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 16+06
.055
.08
0
4
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

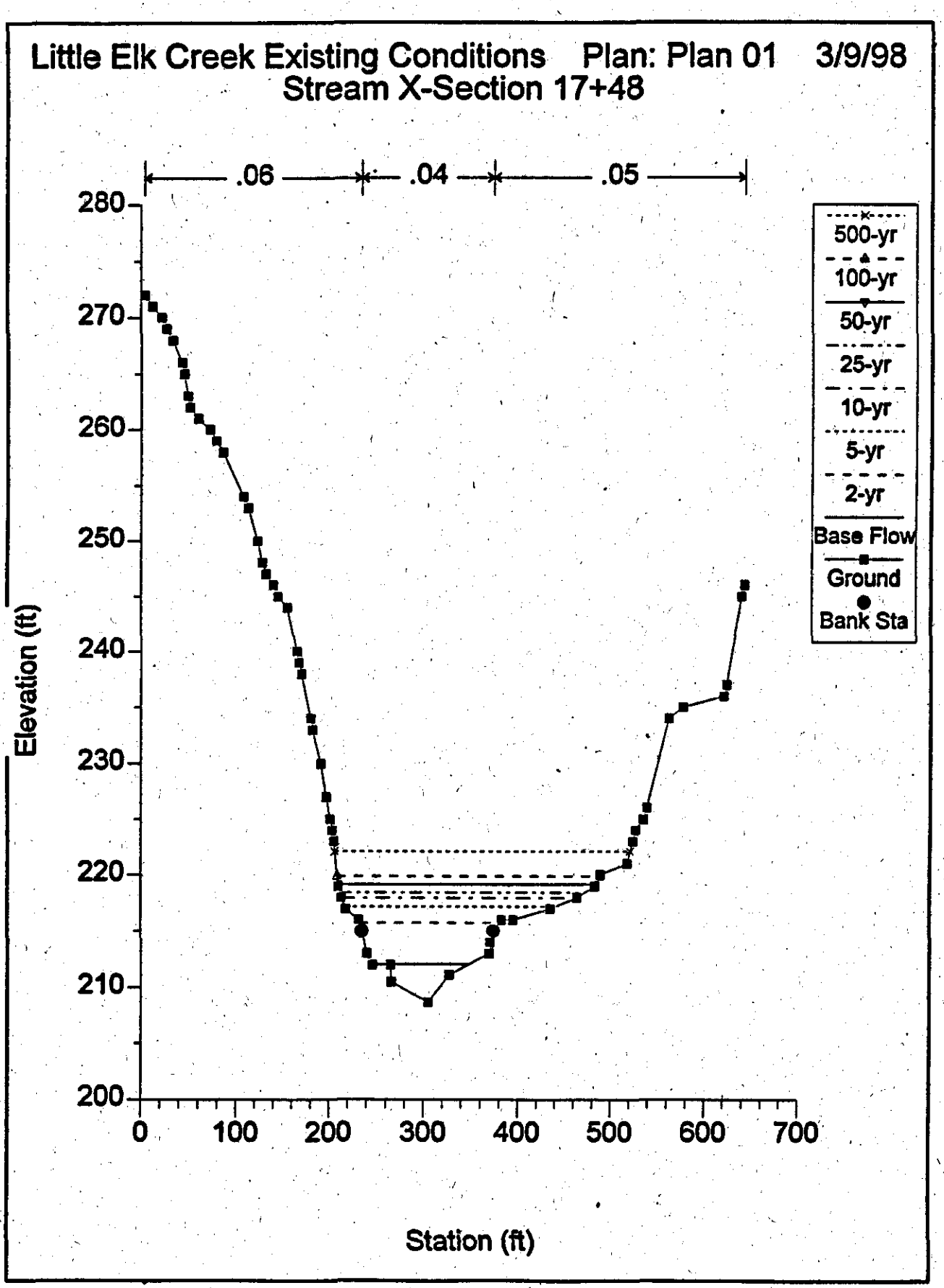
AR100270

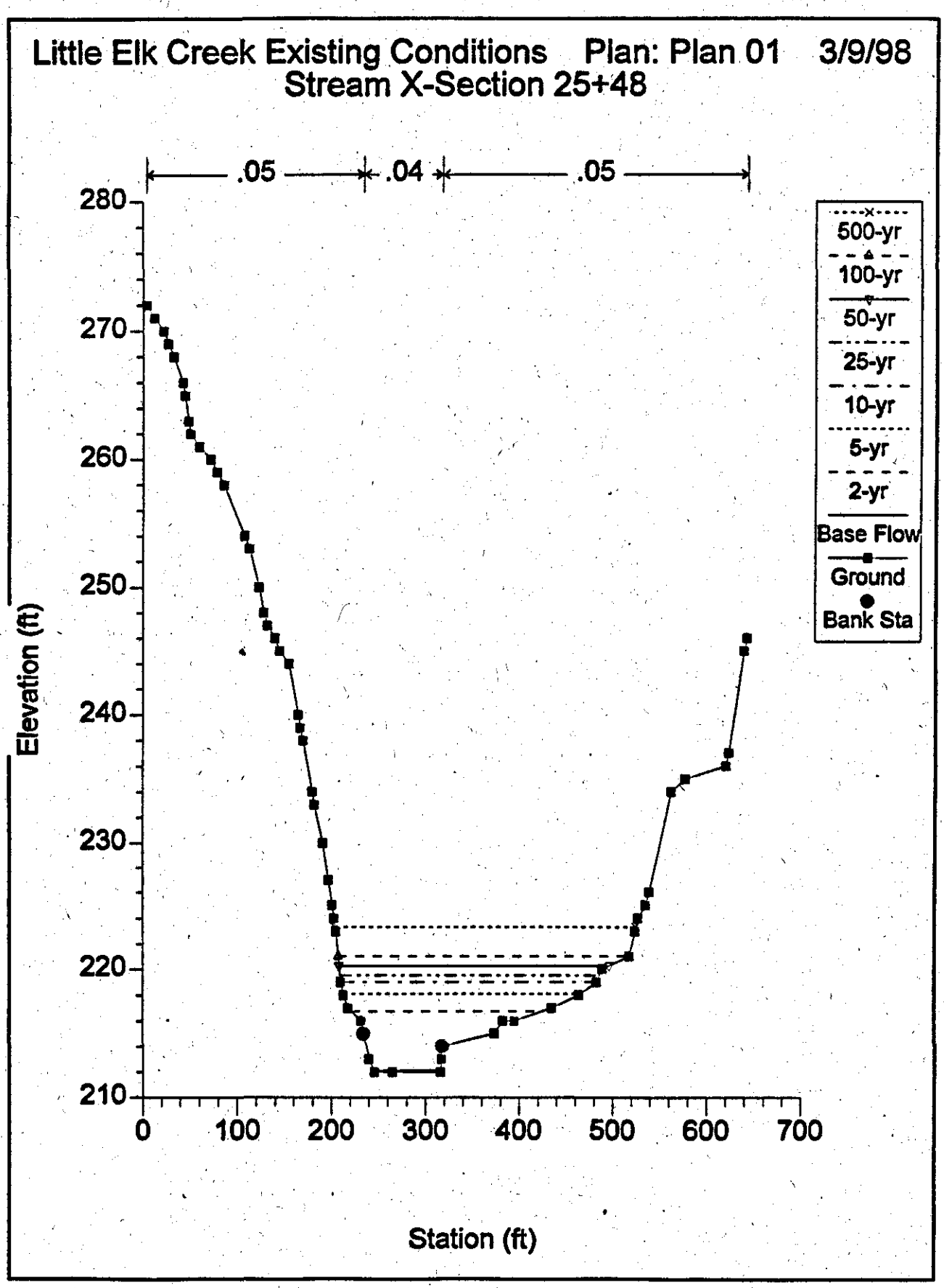
Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 17+20



AR100271


Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 17+36
.06
.04
.05
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700
Station (ft)

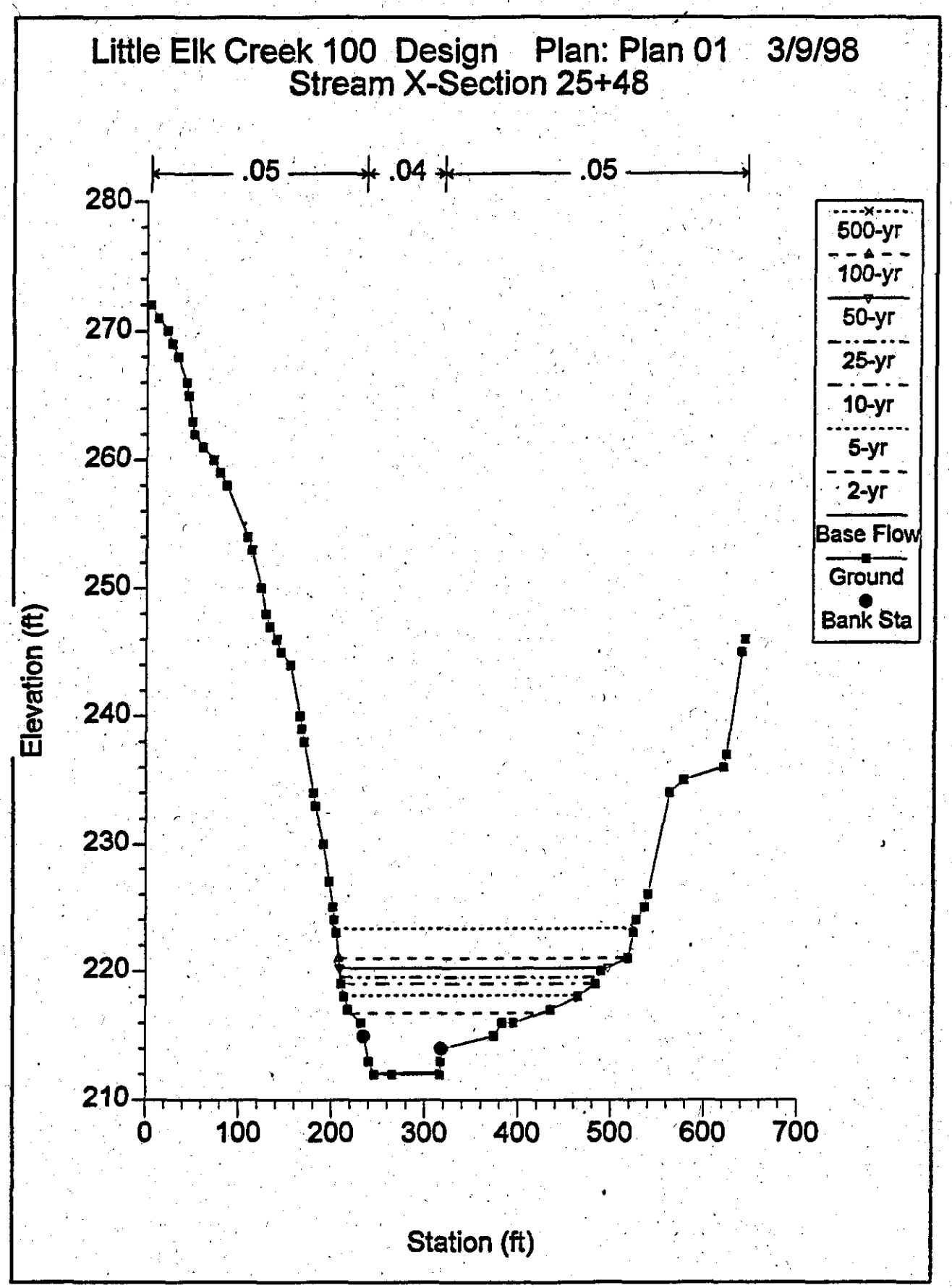

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 17+48
.06
.04
.05
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700
Station (ft)

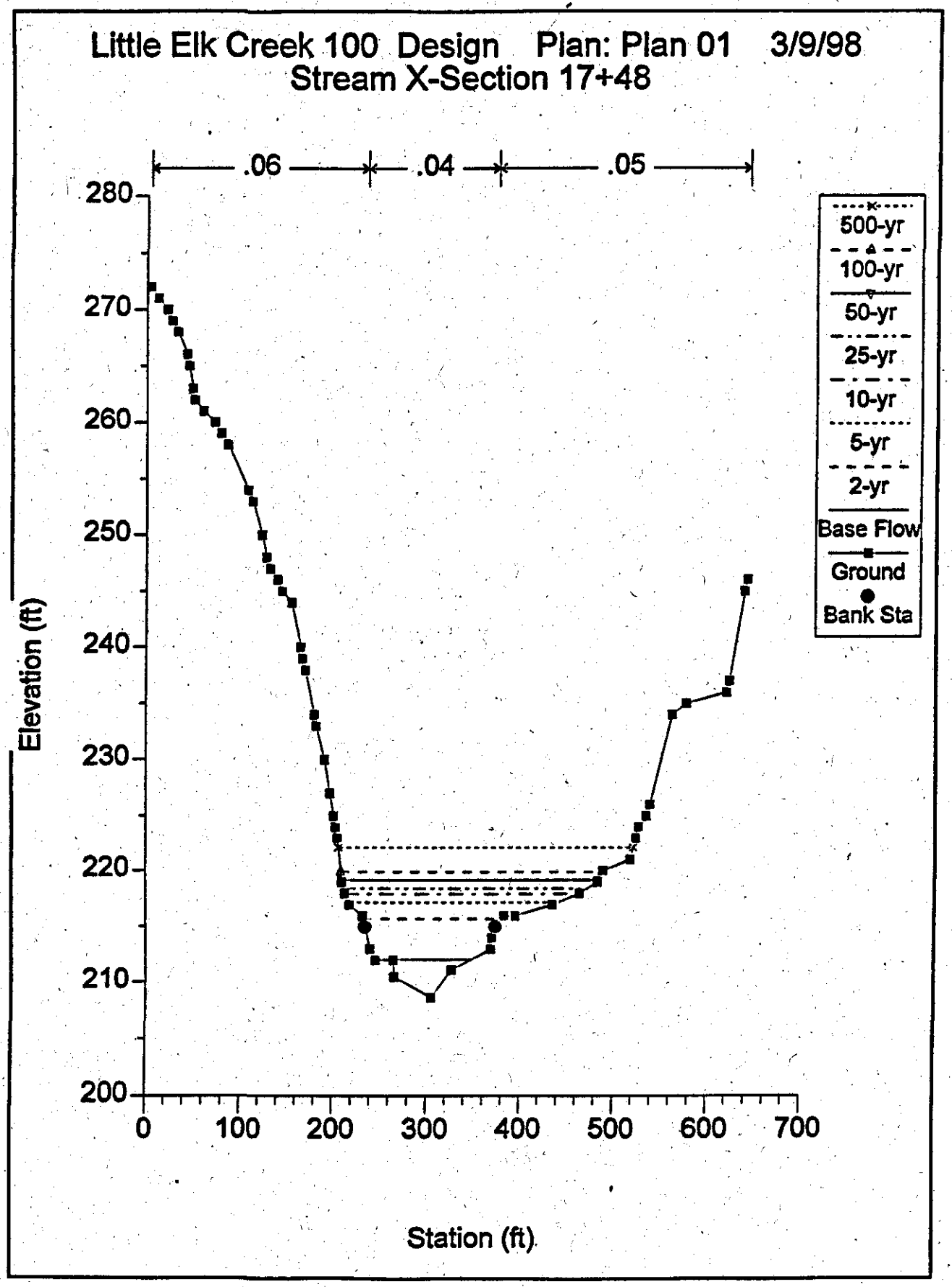

Little Elk Creek Existing Conditions Plan: Plan 01 3/9/98
Stream X-Section 25+48
.05
.04
.05
280
270
260
250
240
230
220
210
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

ATTACHMENT B

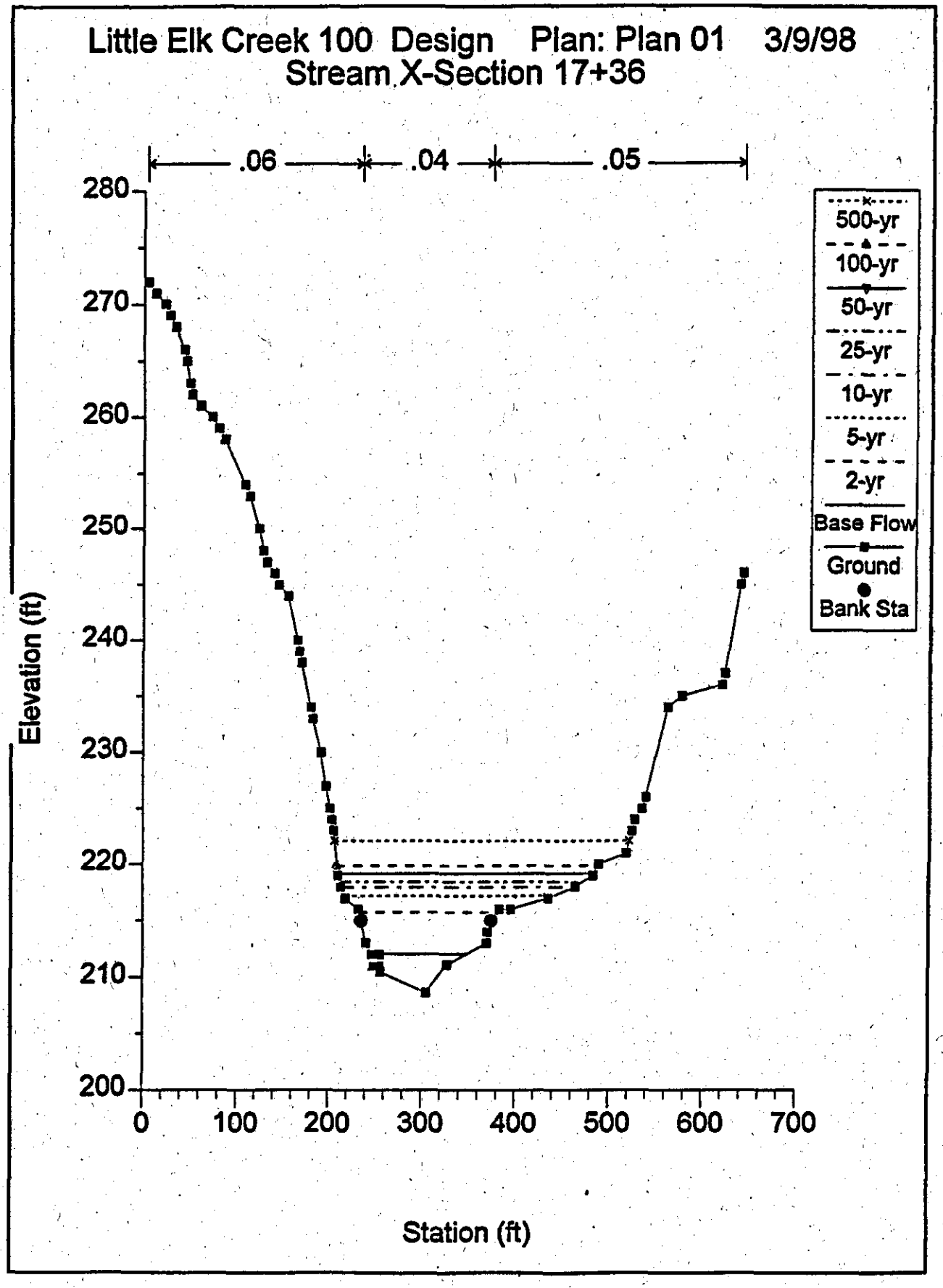
CROSS-SECTION PLOTS

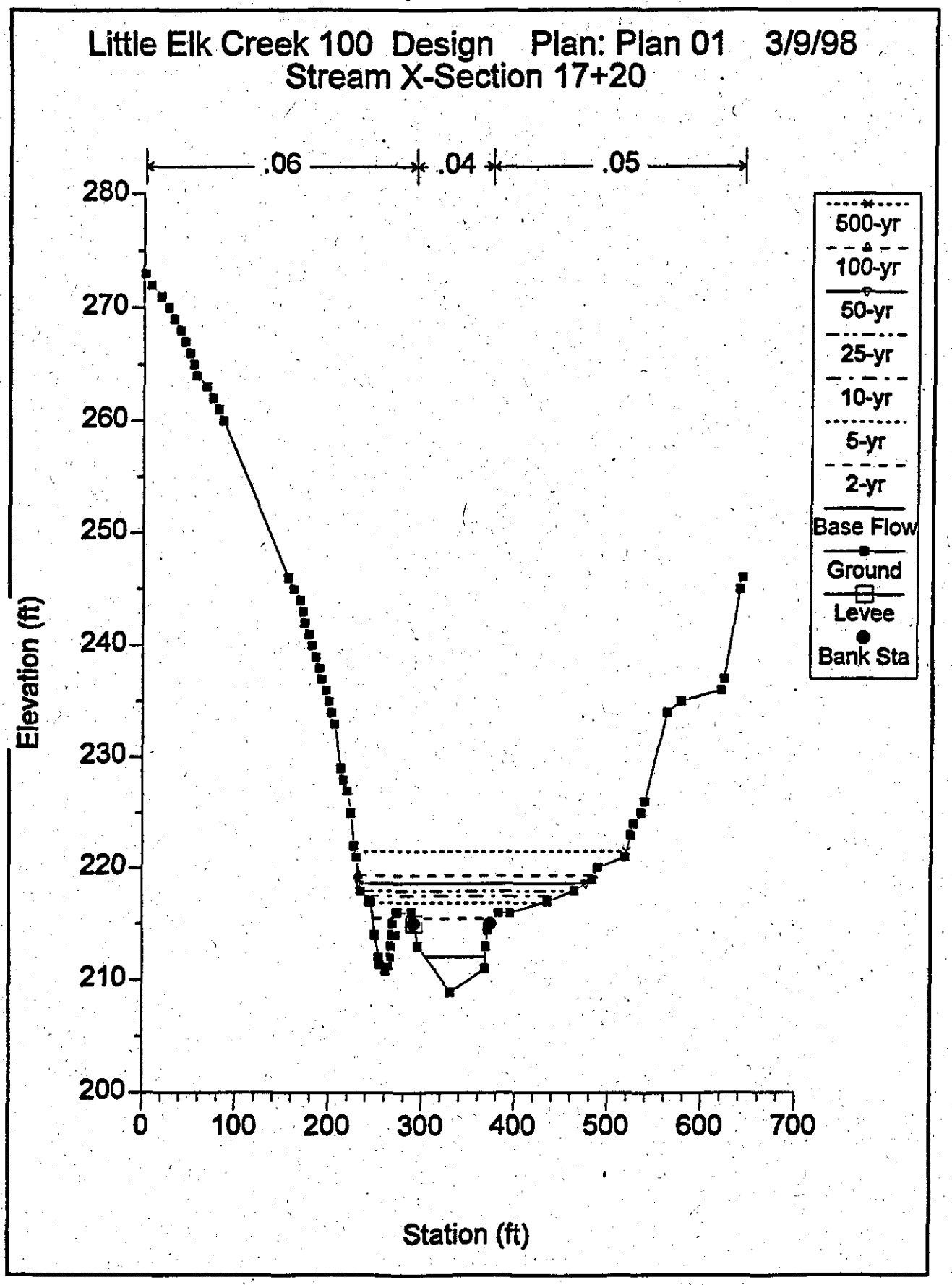
POST RA CONDITIONS

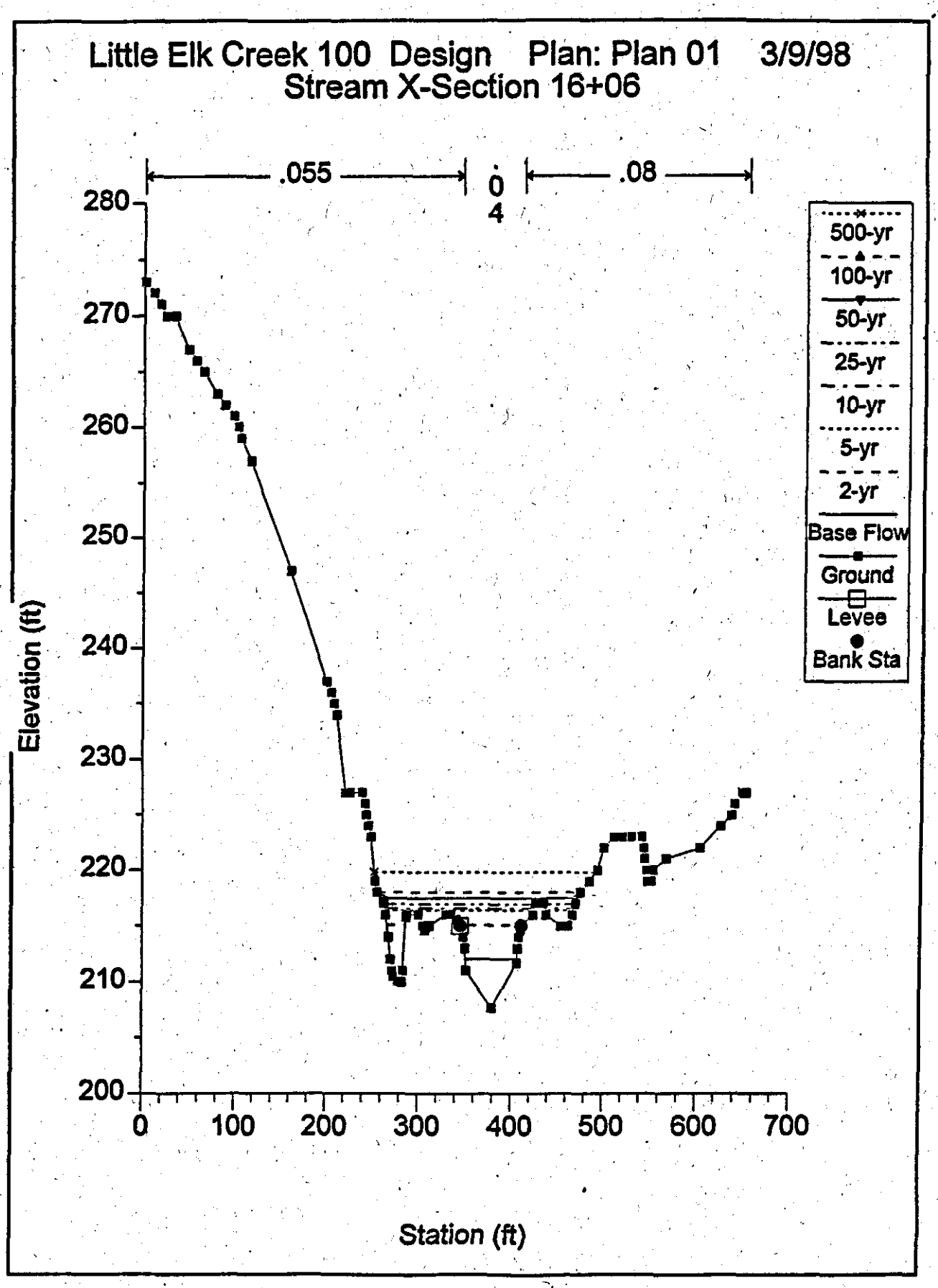

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 25+48
.05
.04
.05
280
270
260
250
240
230
220
210
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

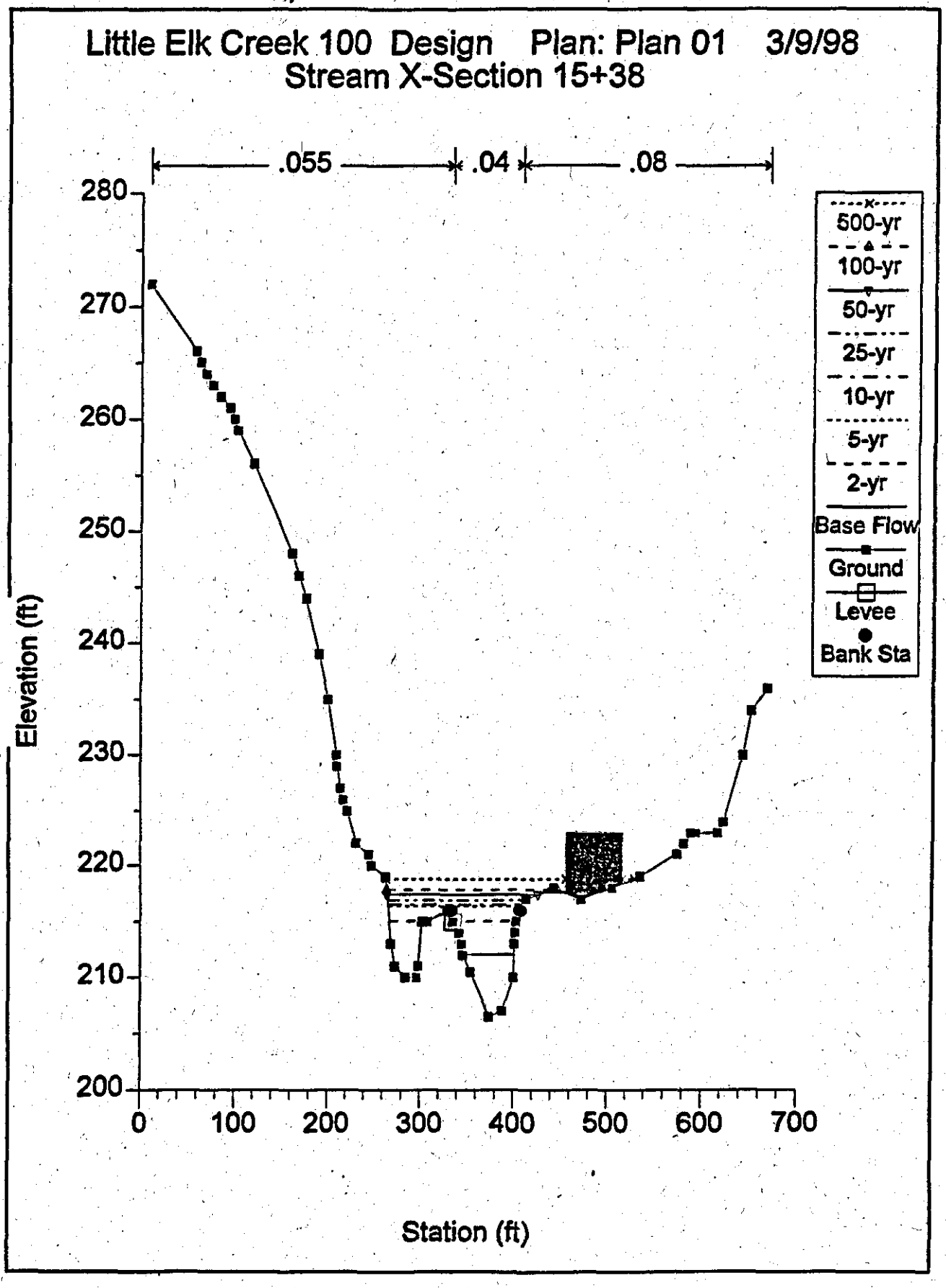

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 17+48
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

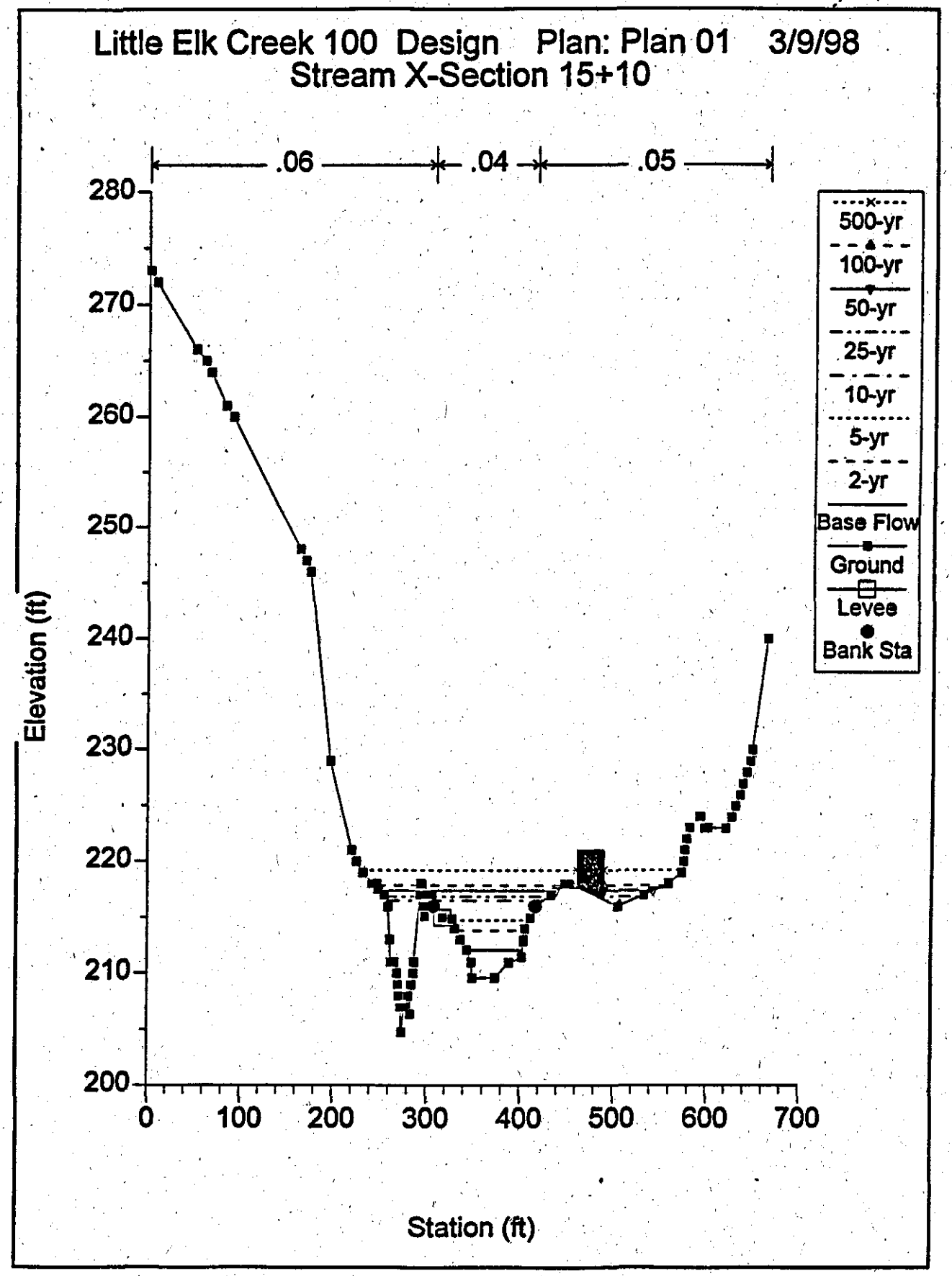
AR100277

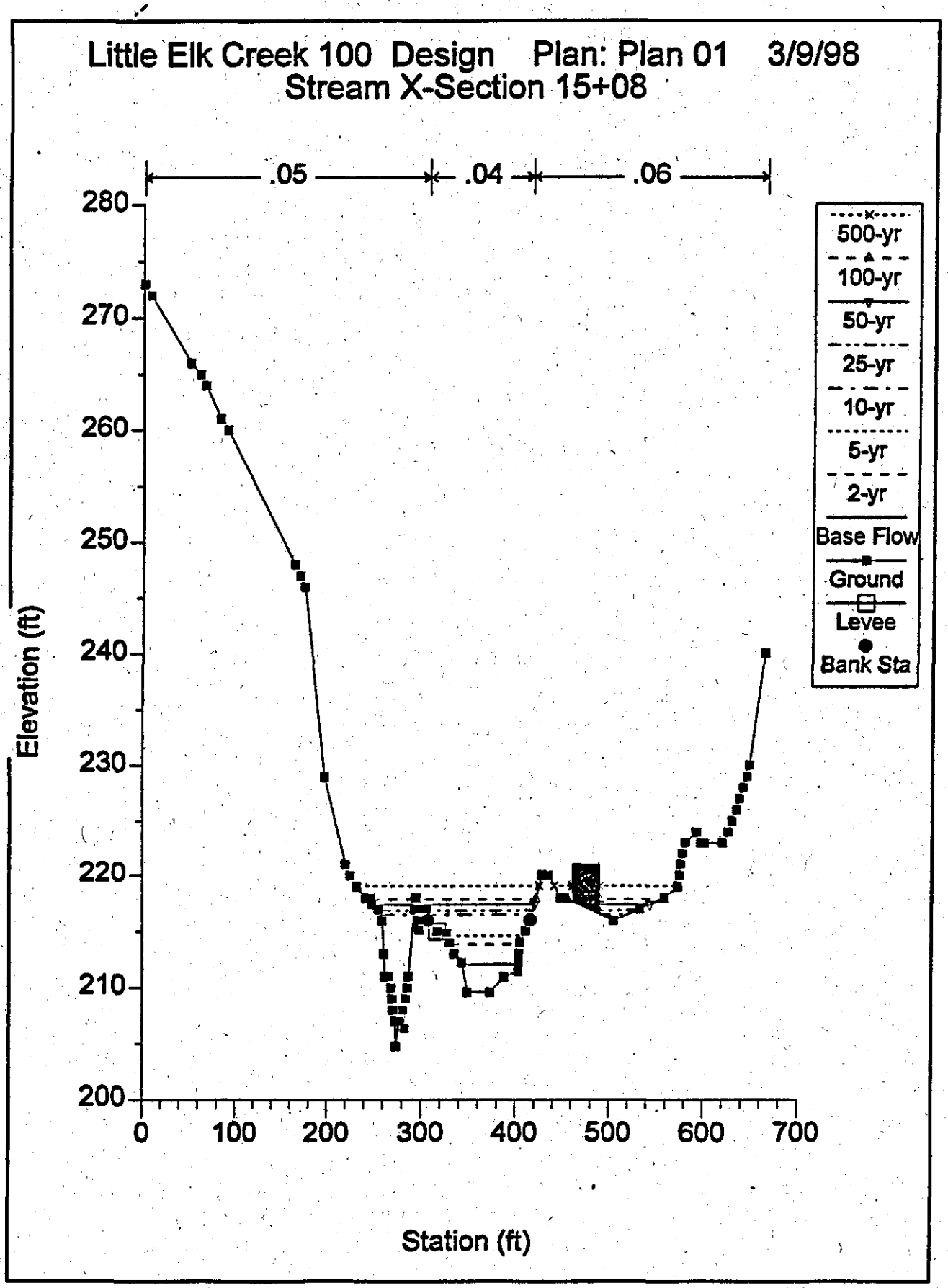

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 17+36
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

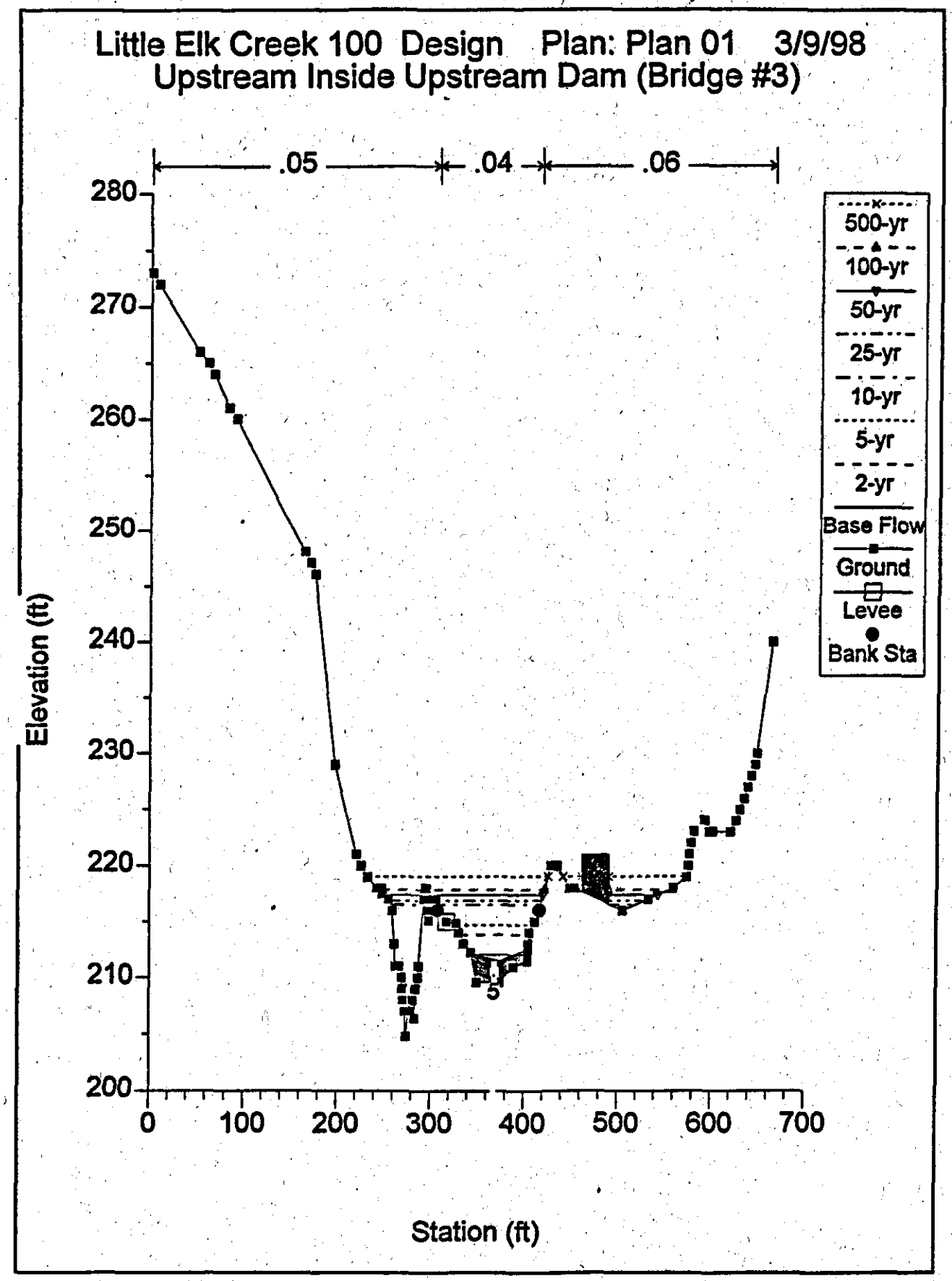

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 17+20
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 16+06
.055
0
4
.08
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta
Elevation (ft)
280
270
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700
Station (ft)

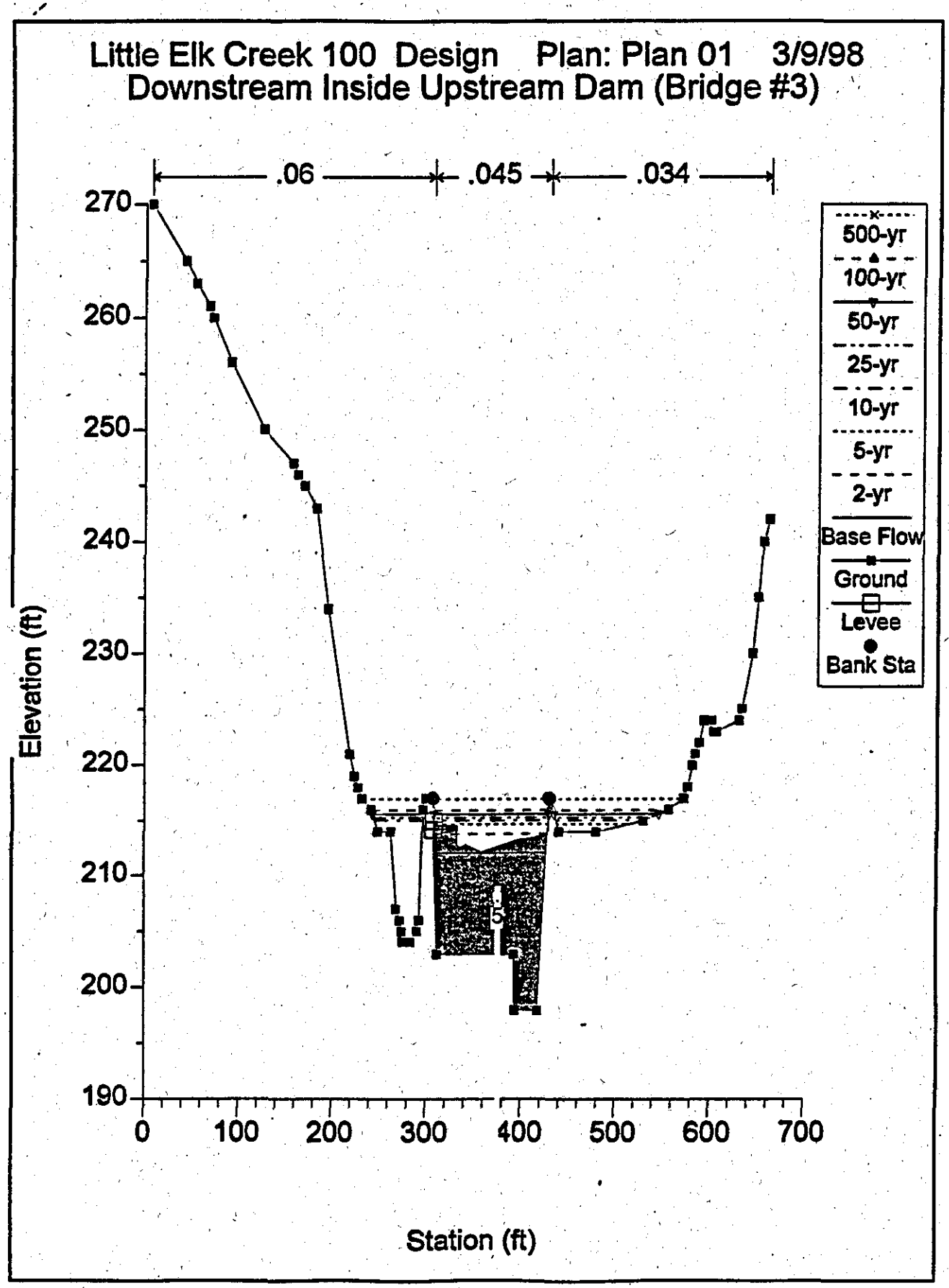

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 15+38
.055
.04
.08
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 15+10
.06
.04
.05
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

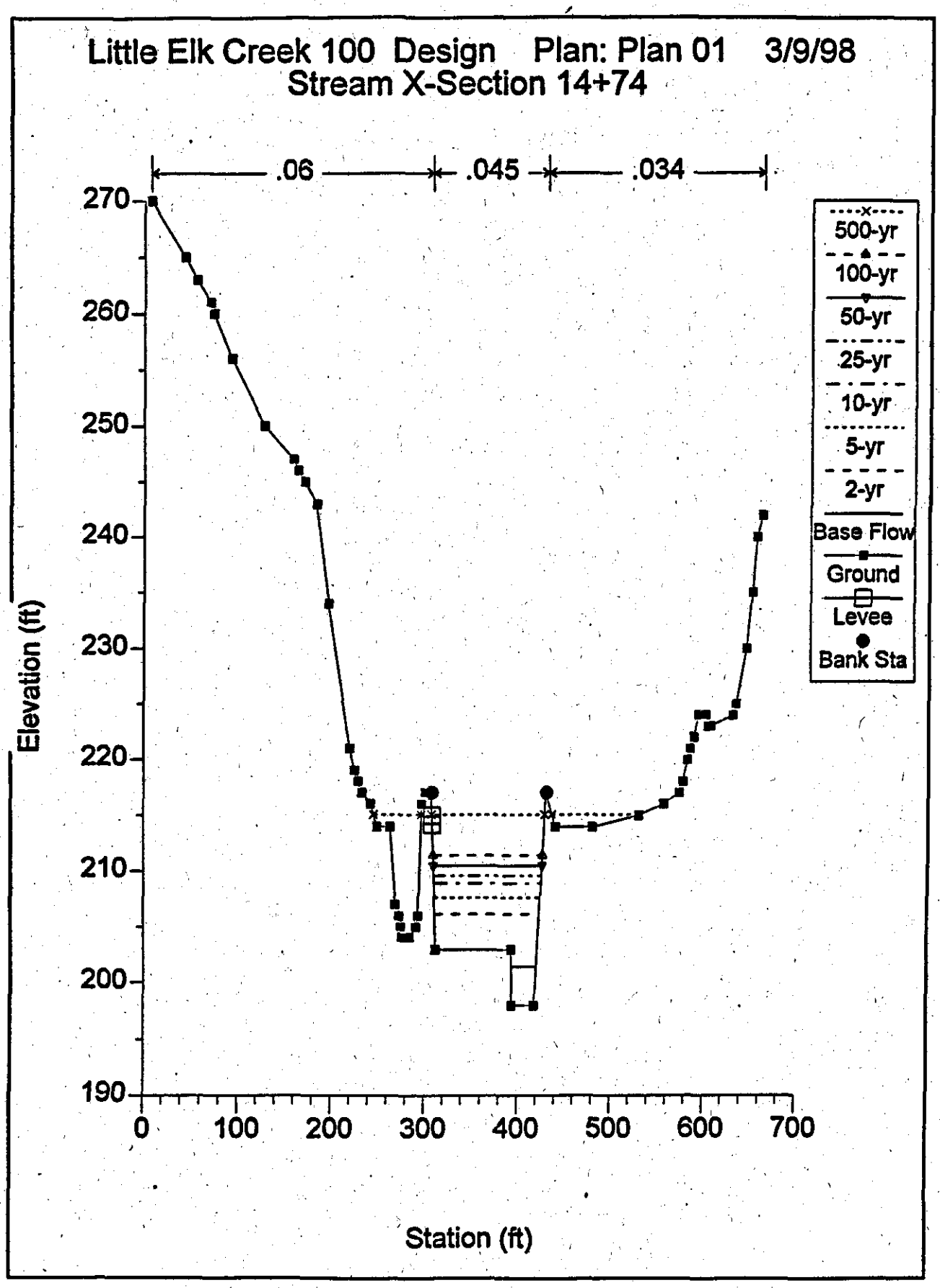

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 15+08
.05
.04
.06
280
270
260
250
240
230
220
210
200
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

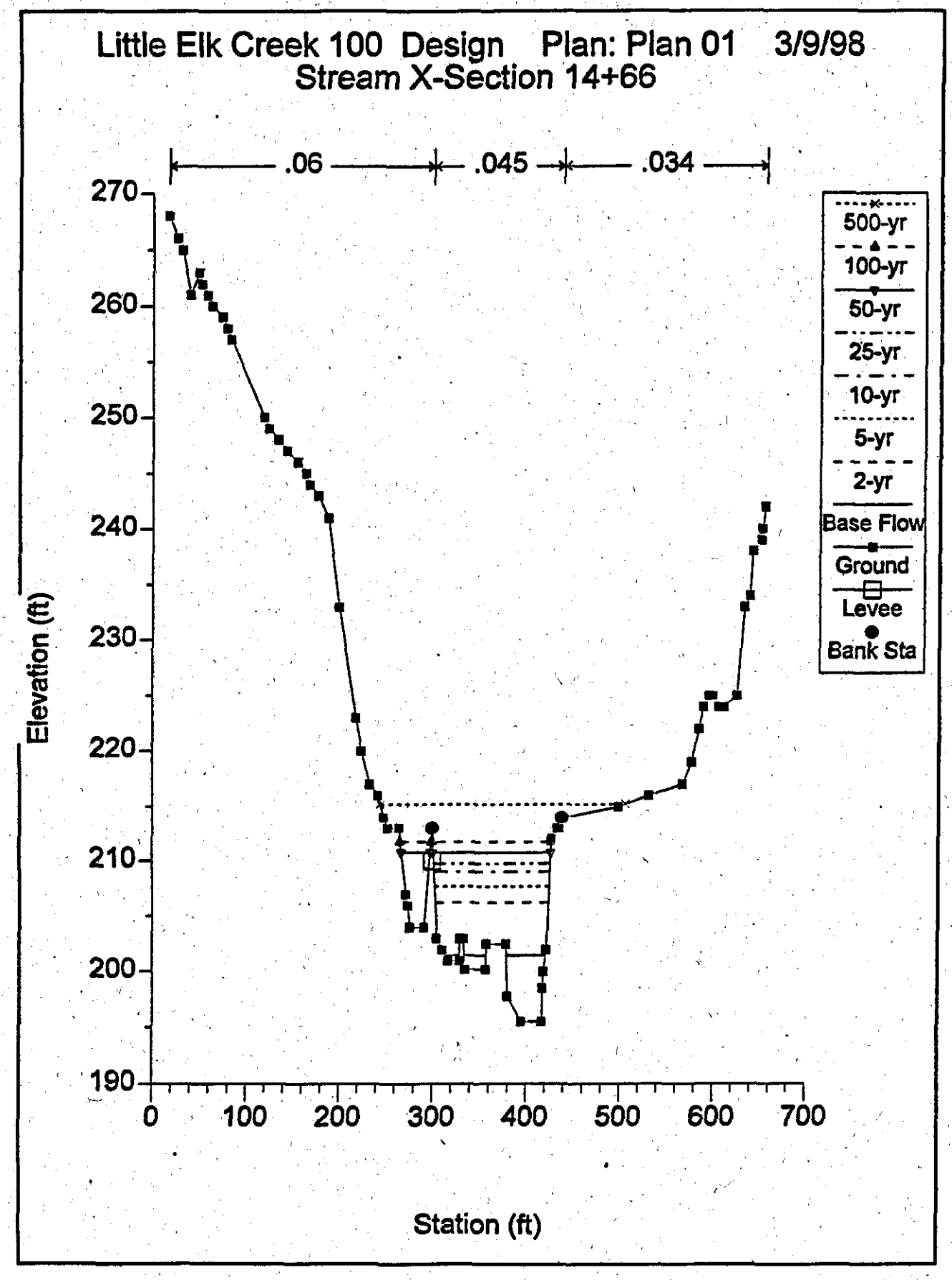

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Upstream Inside Upstream Dam (Bridge #3)
.05
.04
.06
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
280
270
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700
5

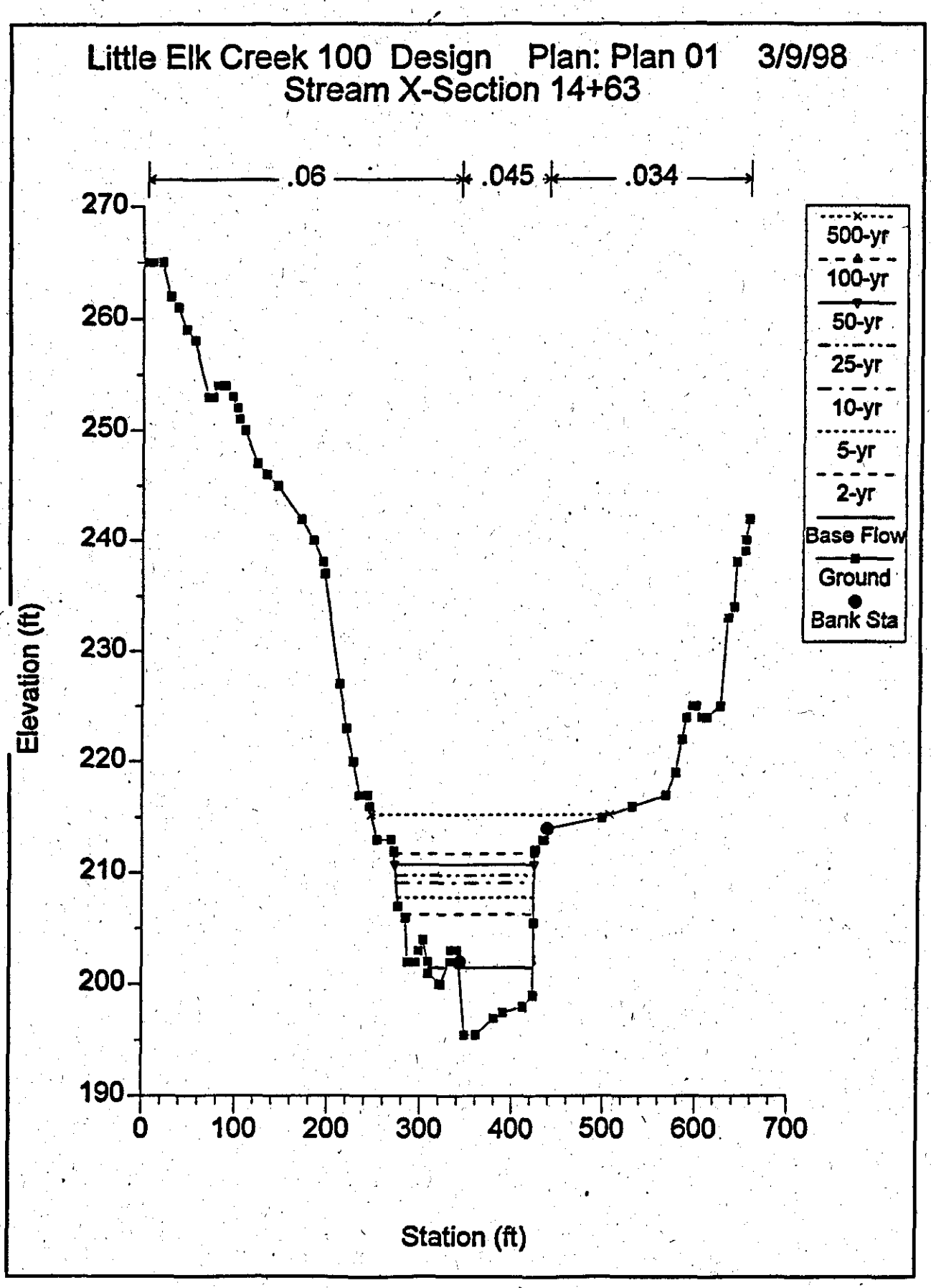
AR100284

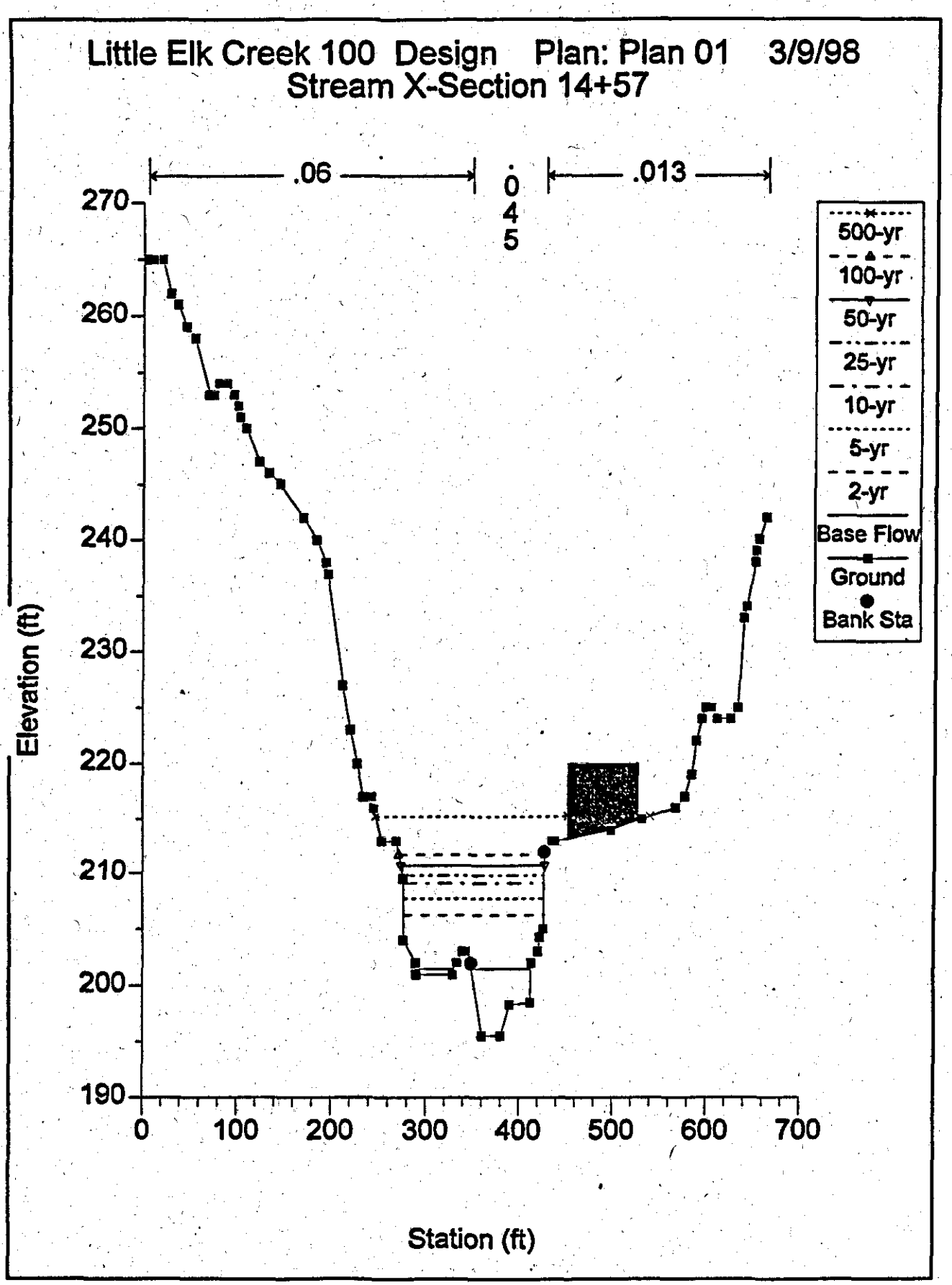

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Downstream Inside Upstream Dam (Bridge #3)
.06
.045
.034
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
270
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

AR100285

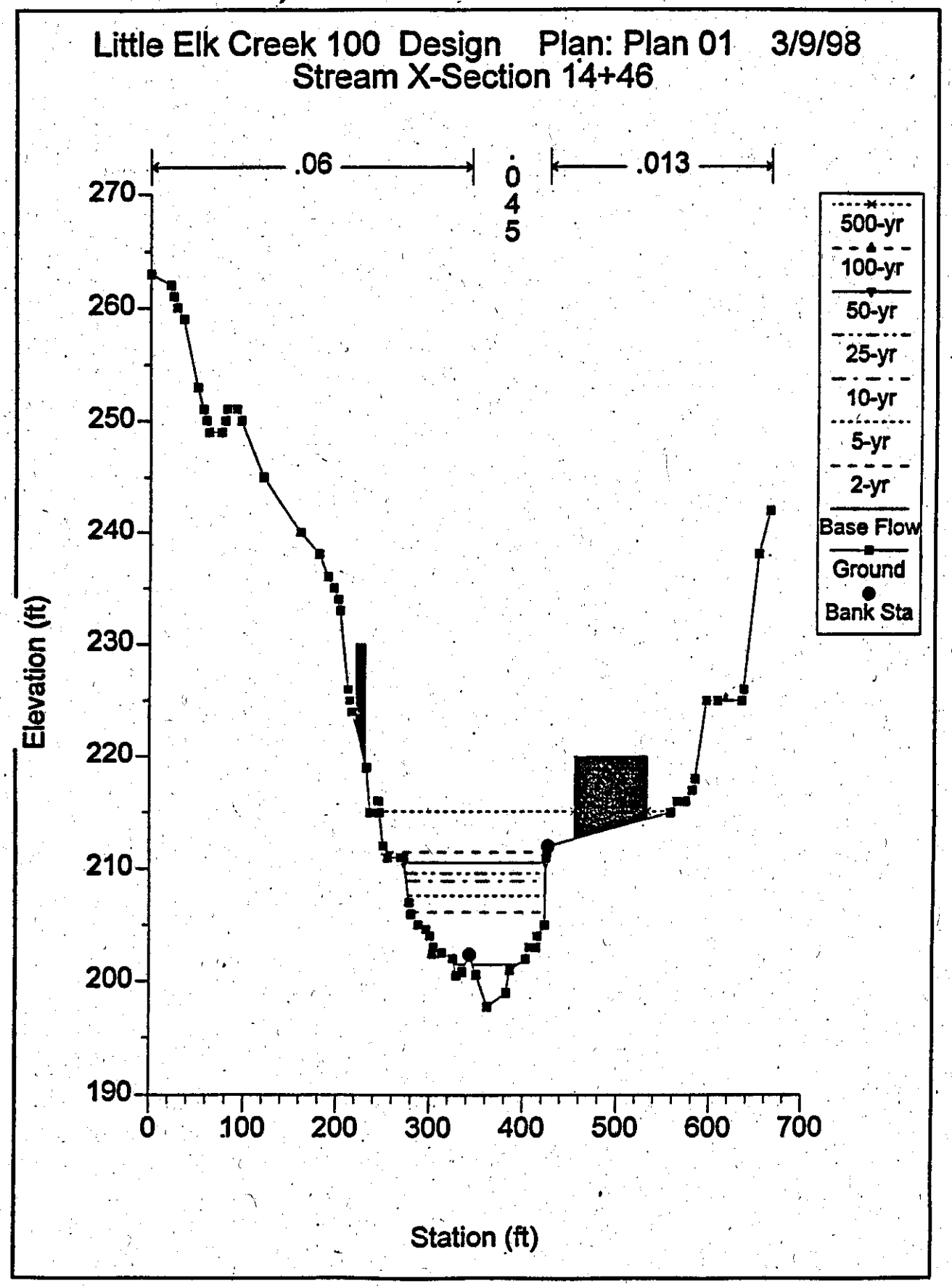

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+74
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+66
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

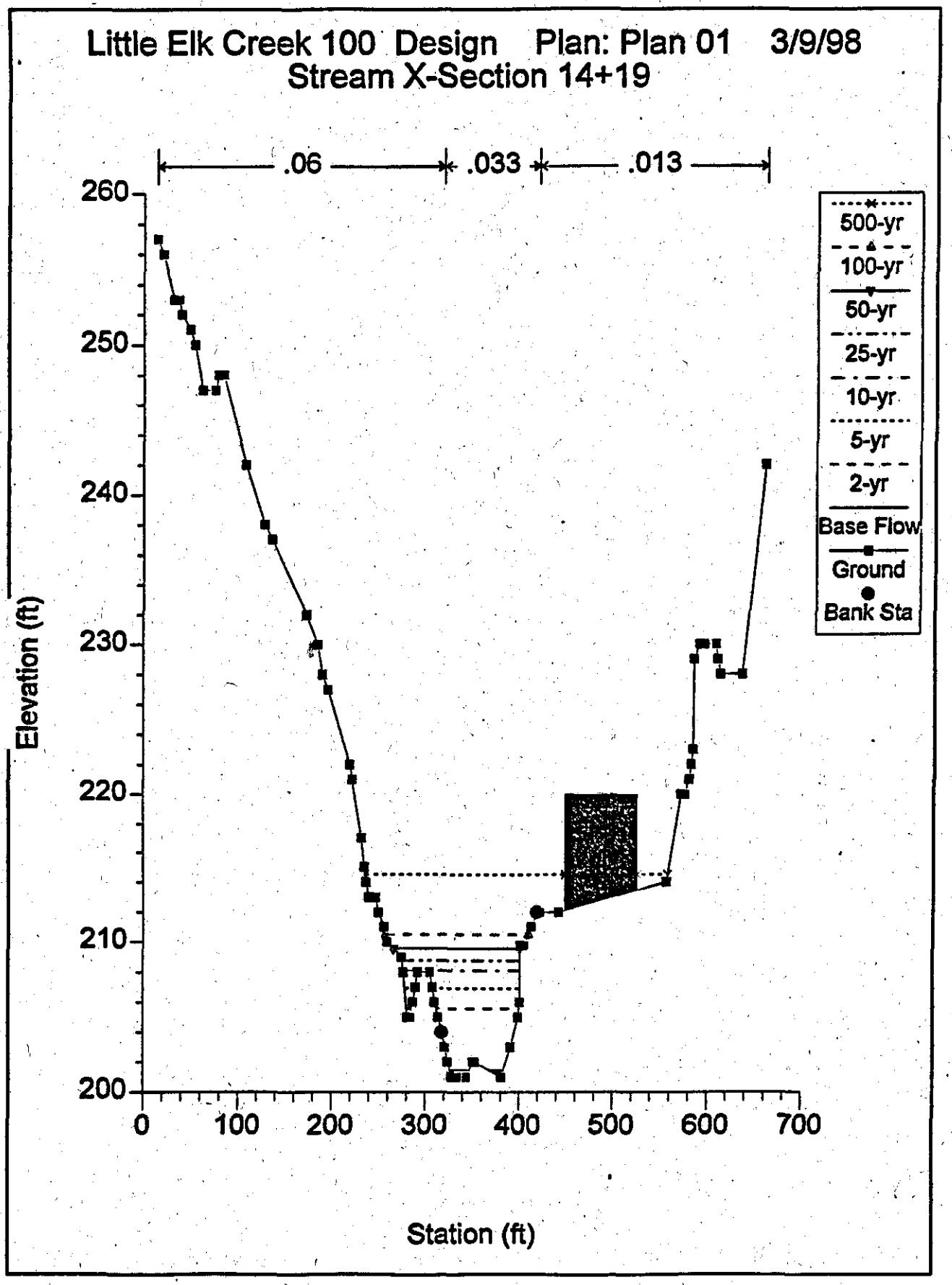

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+63
.06
.045
.034
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+57
.06
.045
.013
270
260
250
240
230
220
210
200
190
Elevation (ft)
0
100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

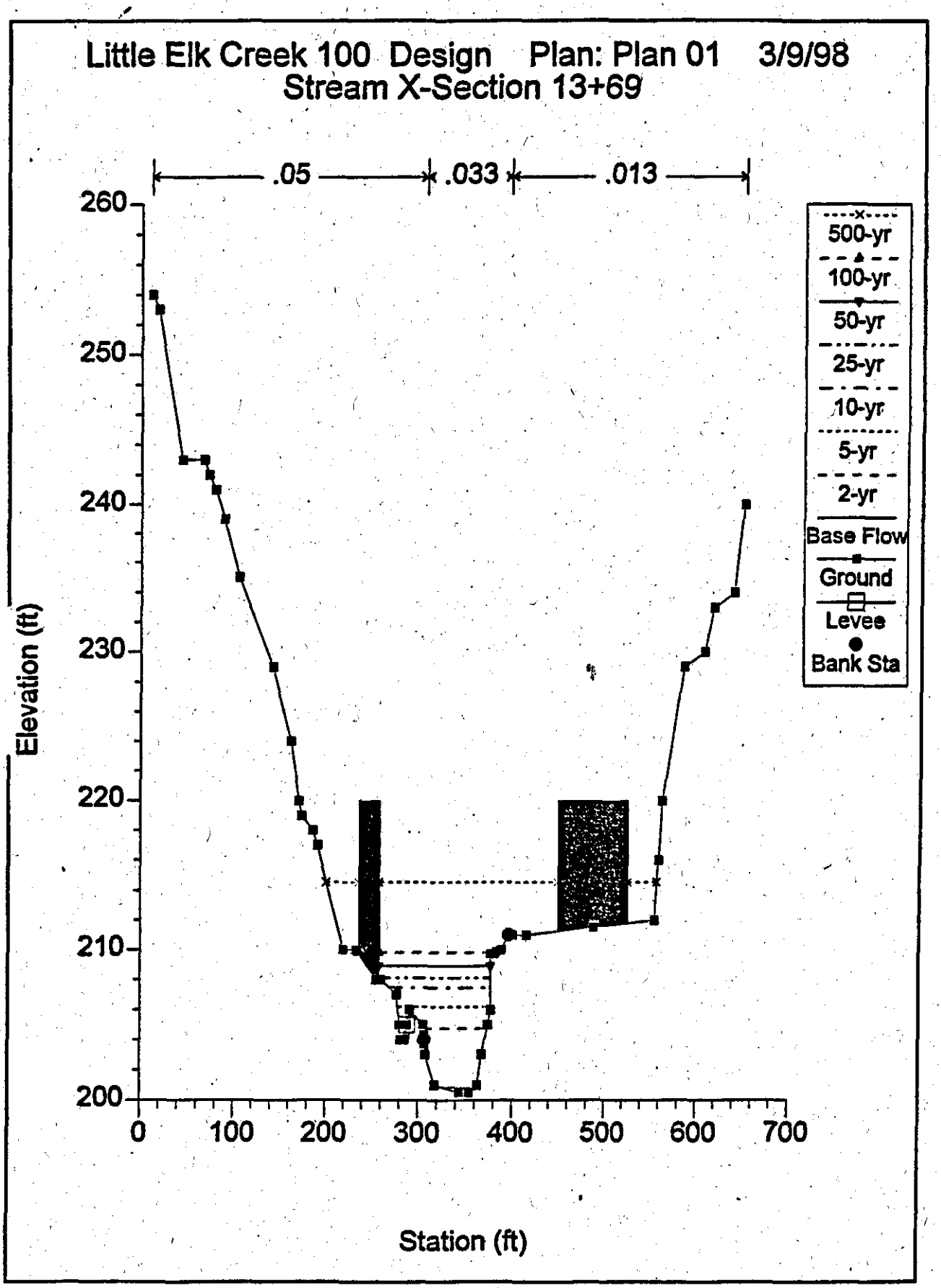
AR100289


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+46
.06
.045
.013
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
270
260
250
240
230
220
210
200
190
0
100
200
300
400
500
600
700

AR100290


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 14+19
.06
.033
.013
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
0
100
200
300
400
500
600
700

AR100291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.013
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Station (ft)
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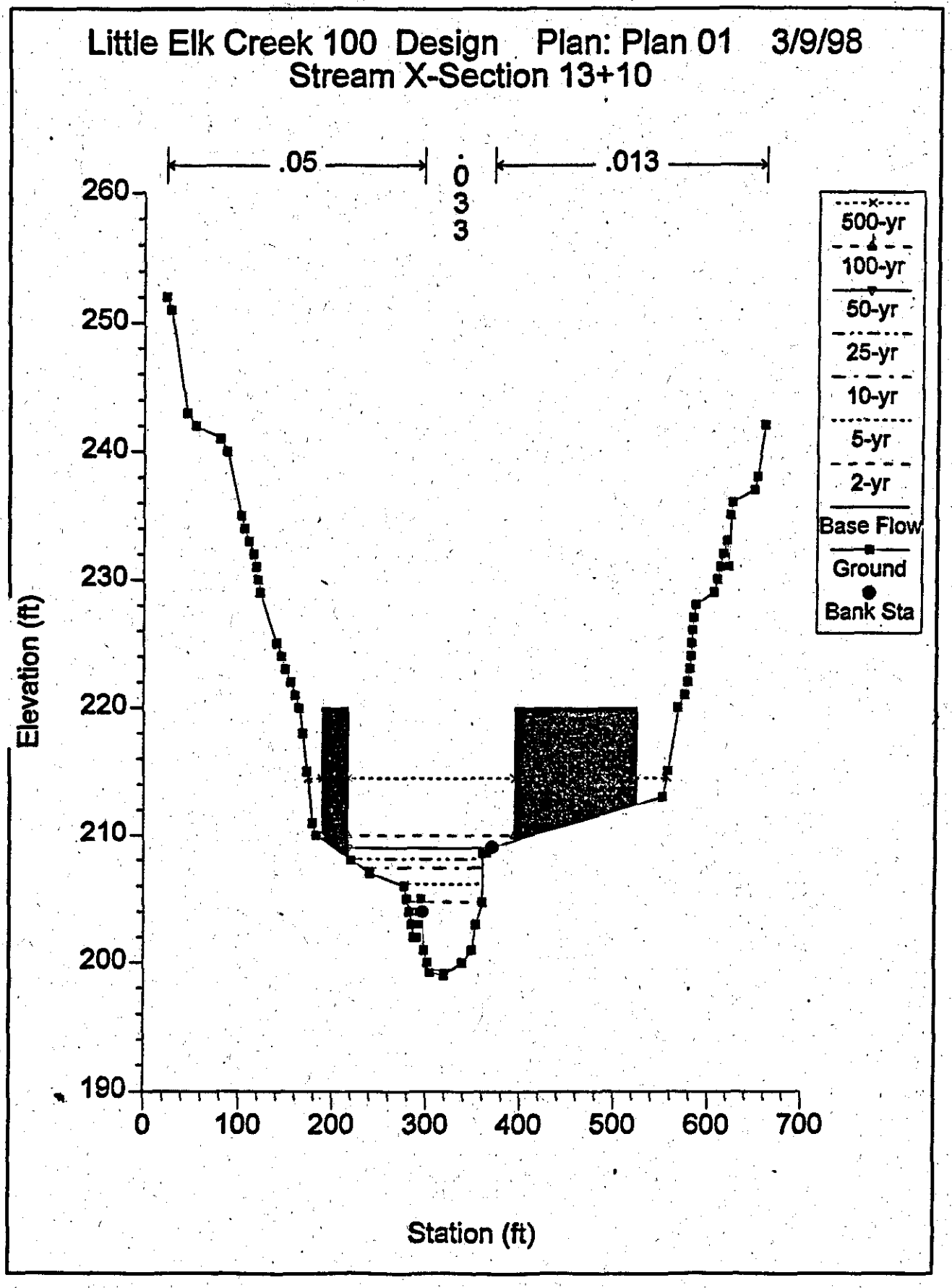
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta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300
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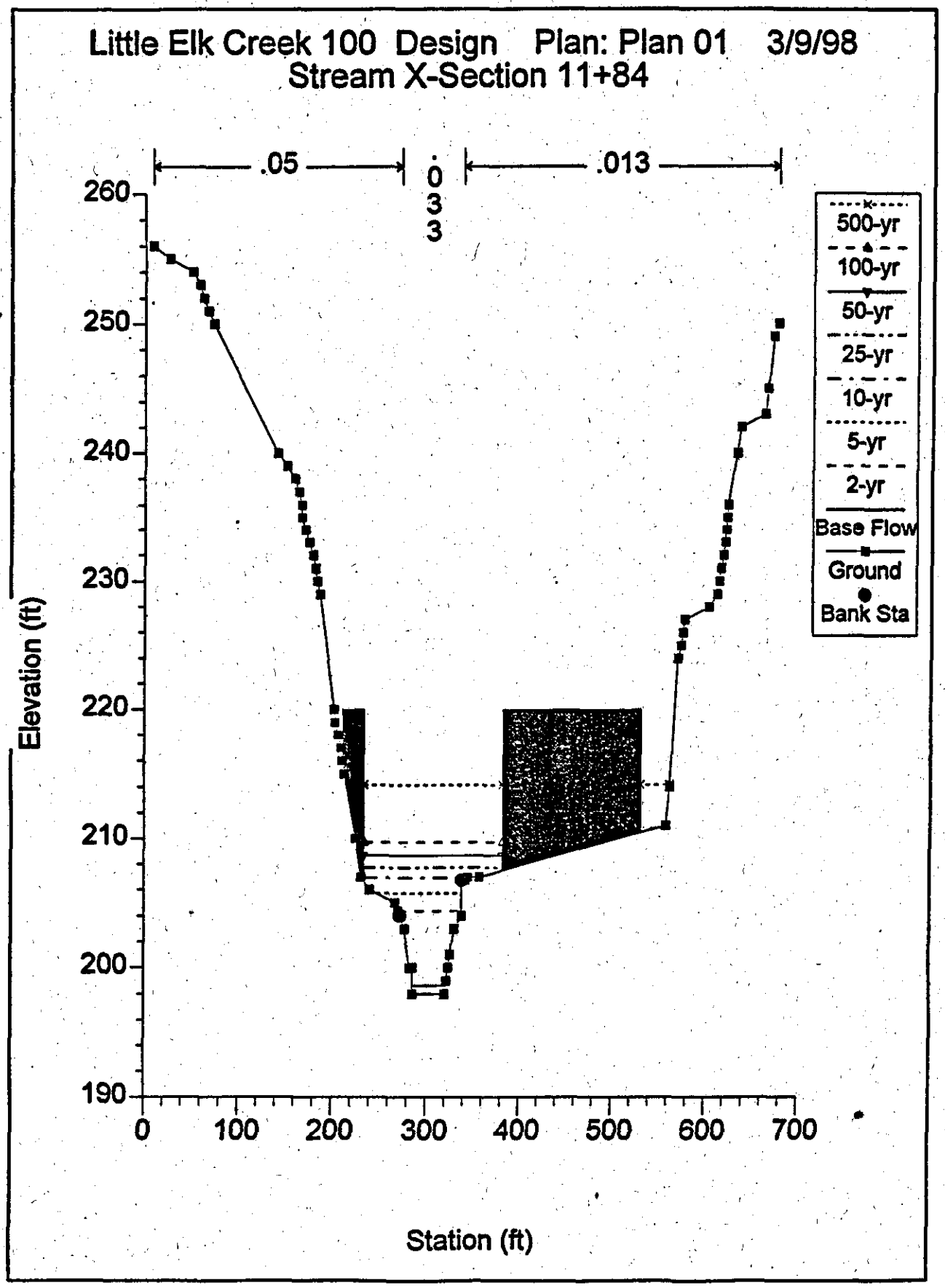
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta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10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
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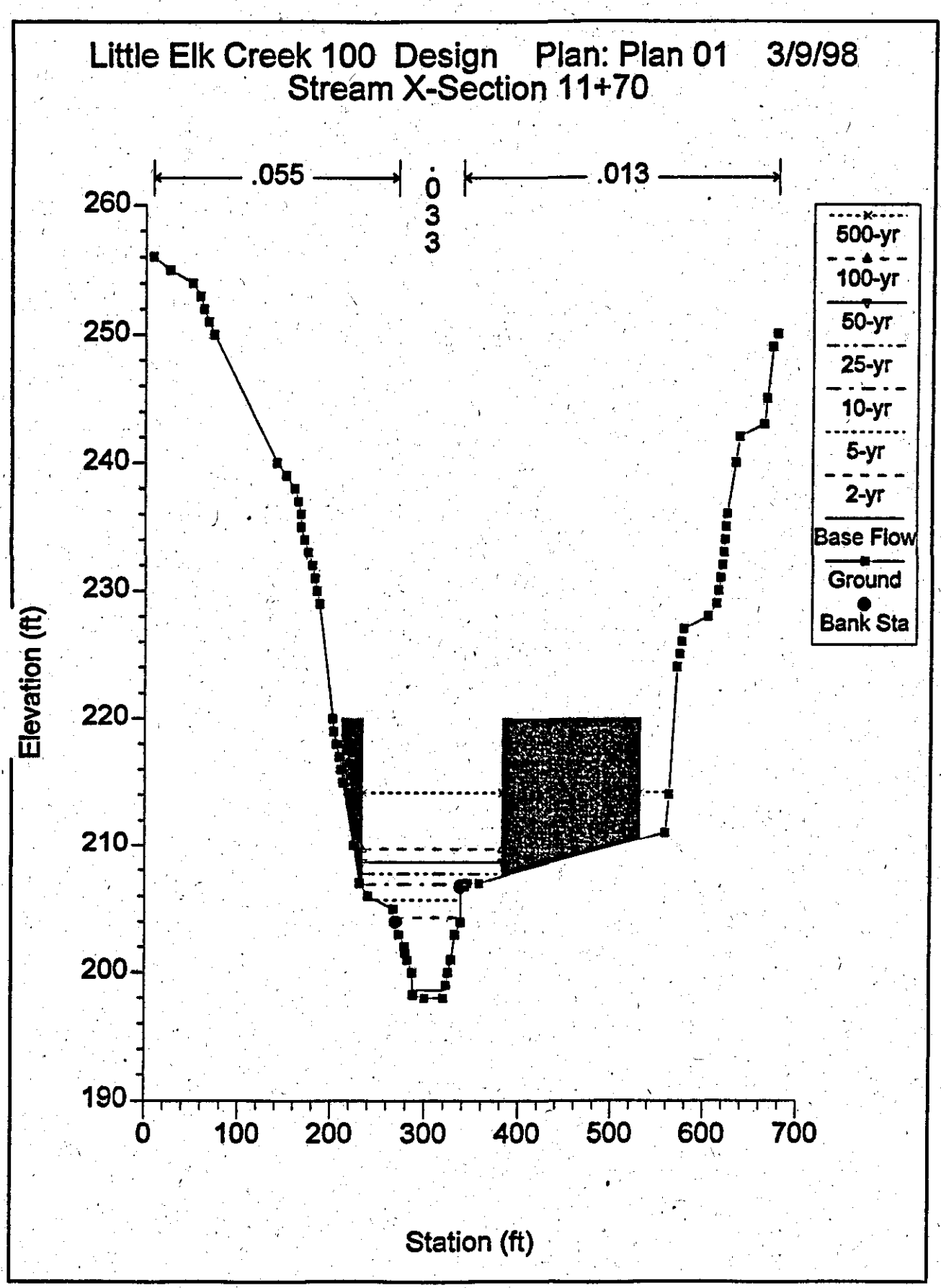
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2-yr
Base Flow
Ground
Bank Sta
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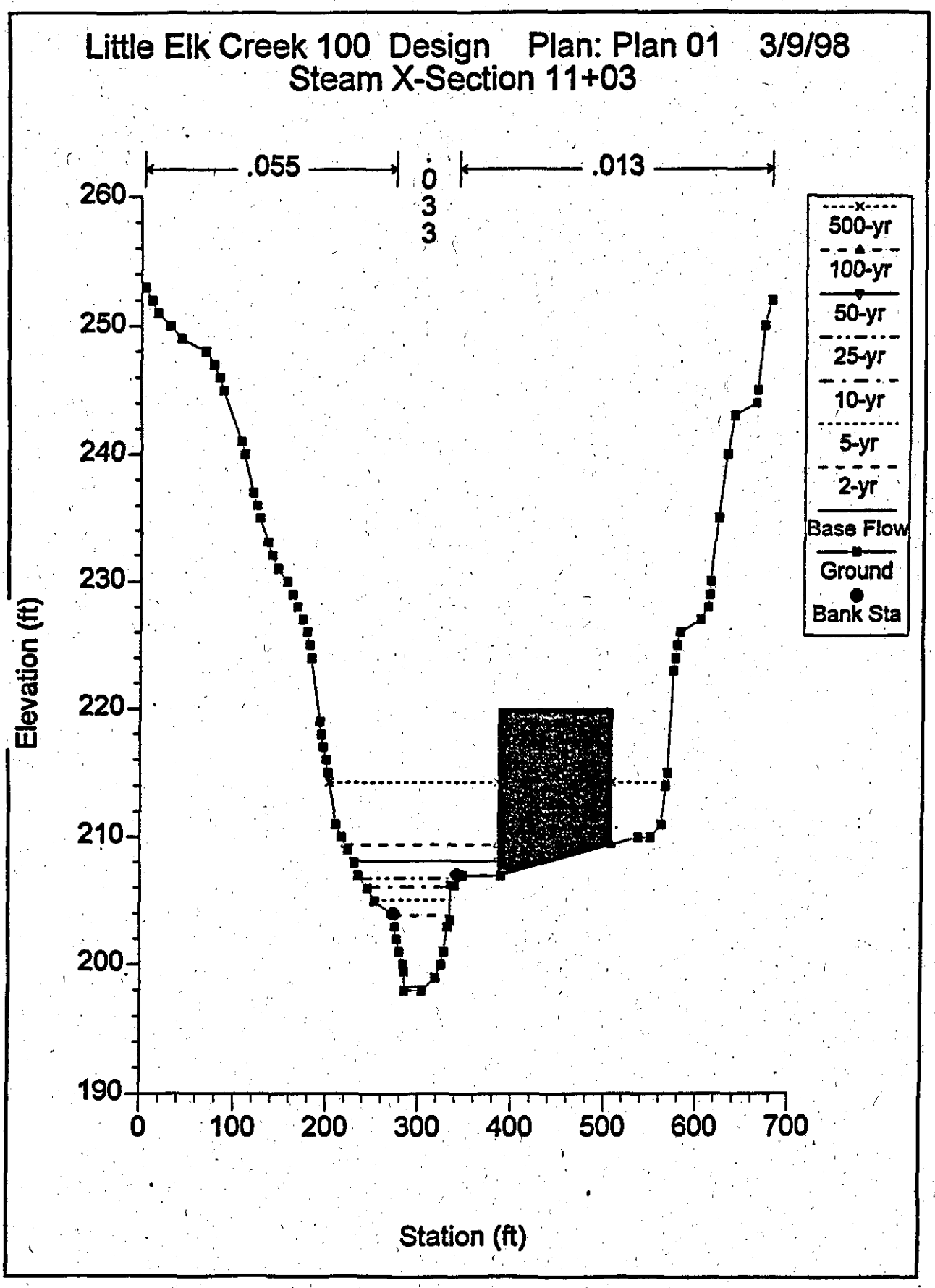
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10-yr
5-yr
2-yr
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Ground
Bank Sta
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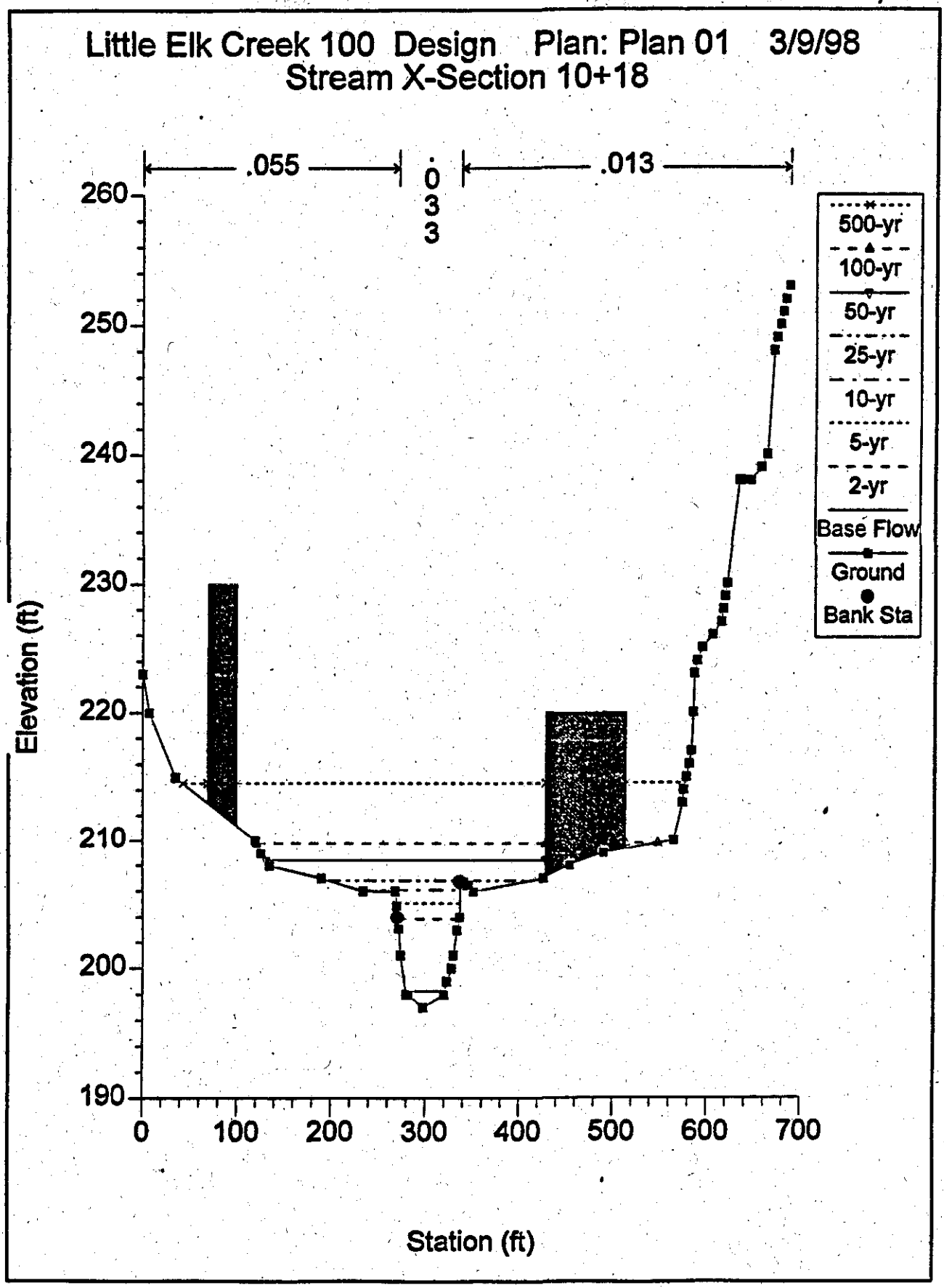
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5-yr
2-yr
Base Flow
Ground
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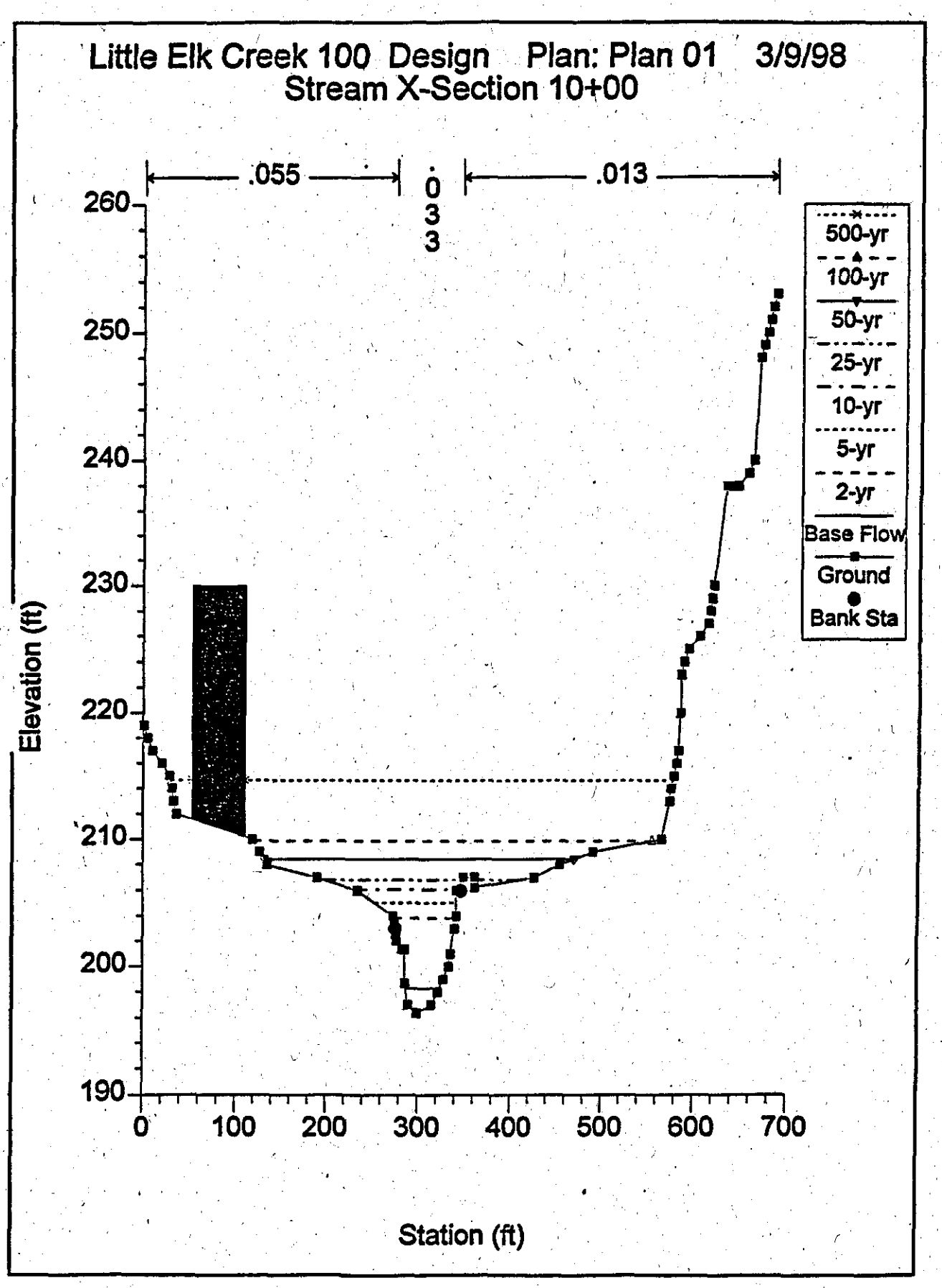
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10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
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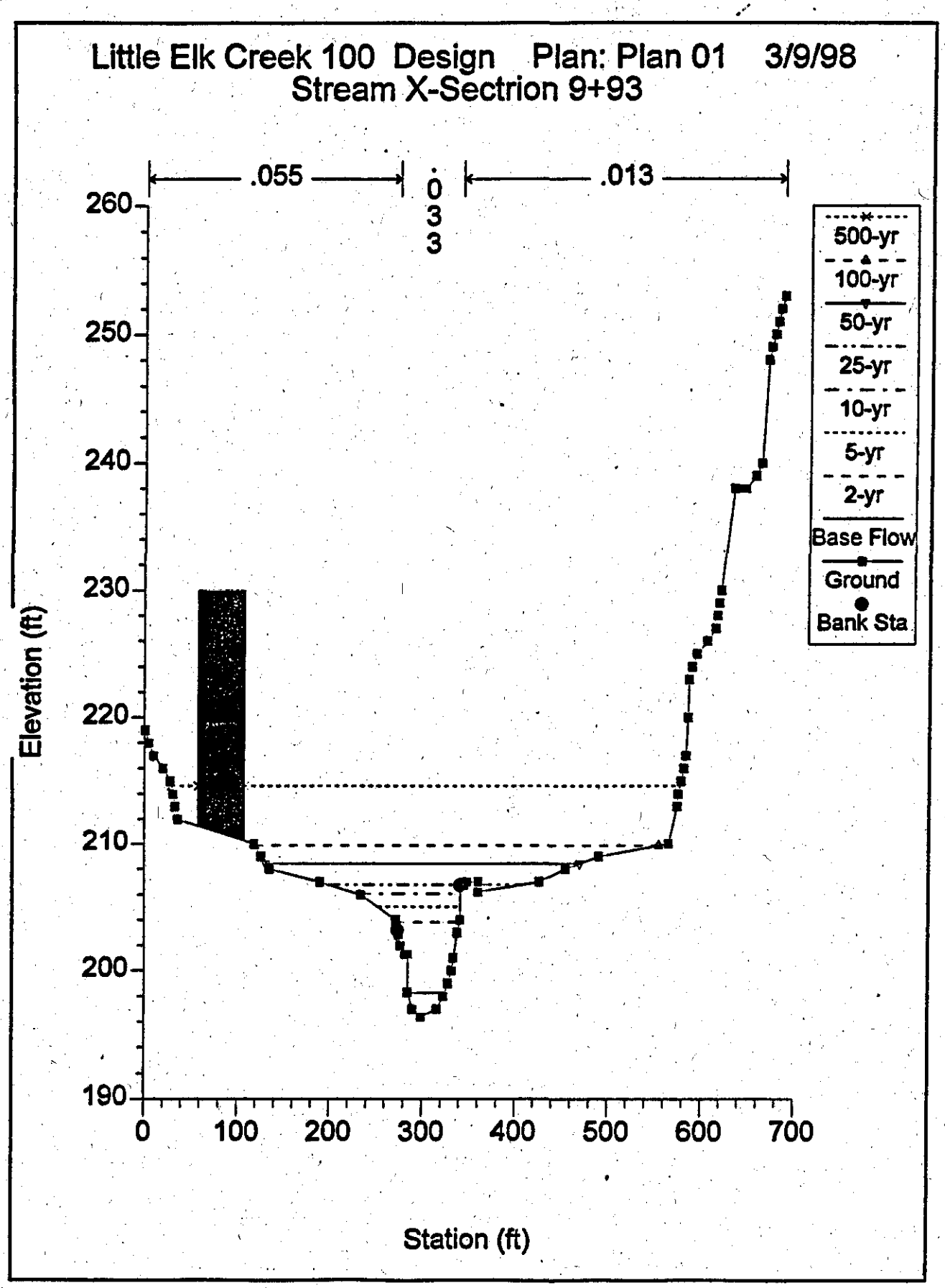
Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Sectrion 9+93
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200
190
Elevation (ft)
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200
300
400
500
600
700
Station (ft)
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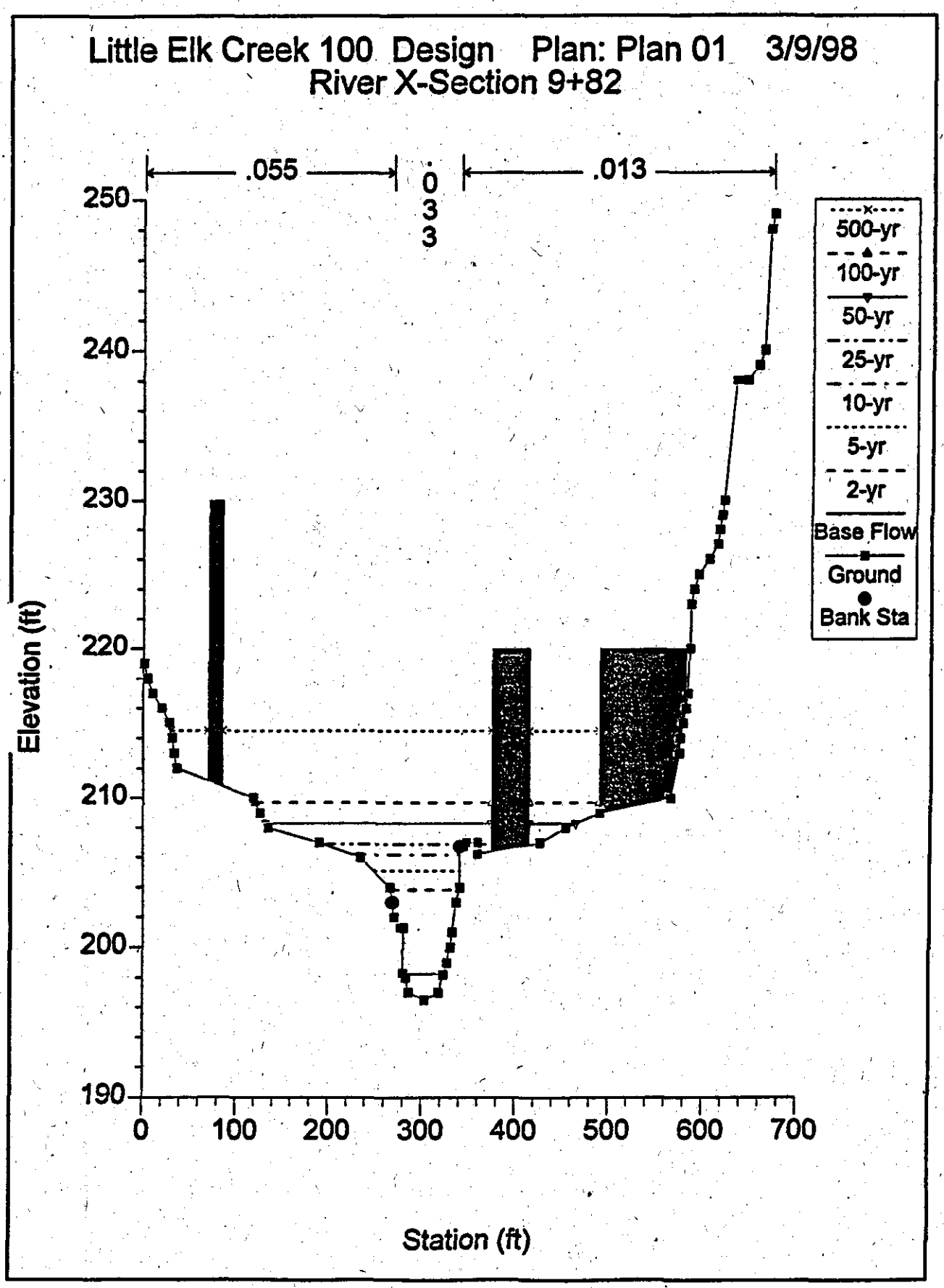
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta

AR100299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River X-Section 9+82
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.013
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220
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200
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Elevation (ft)
0
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200
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400
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Station (ft)
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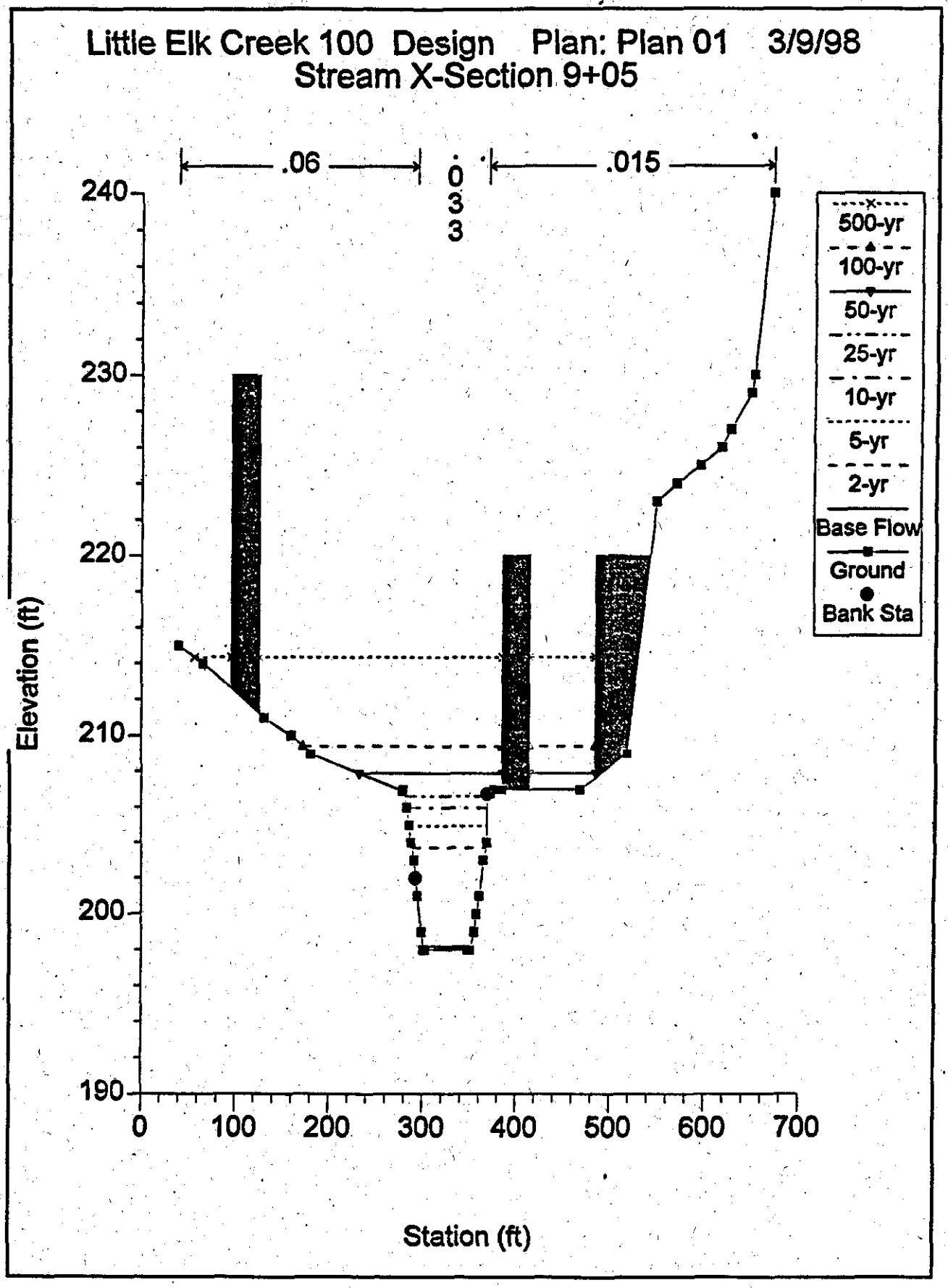
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 9+05
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240
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200
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Elevation (ft)
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100
200
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500
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700
Station (ft)
500-yr
100-yr
50-yr
25-yr
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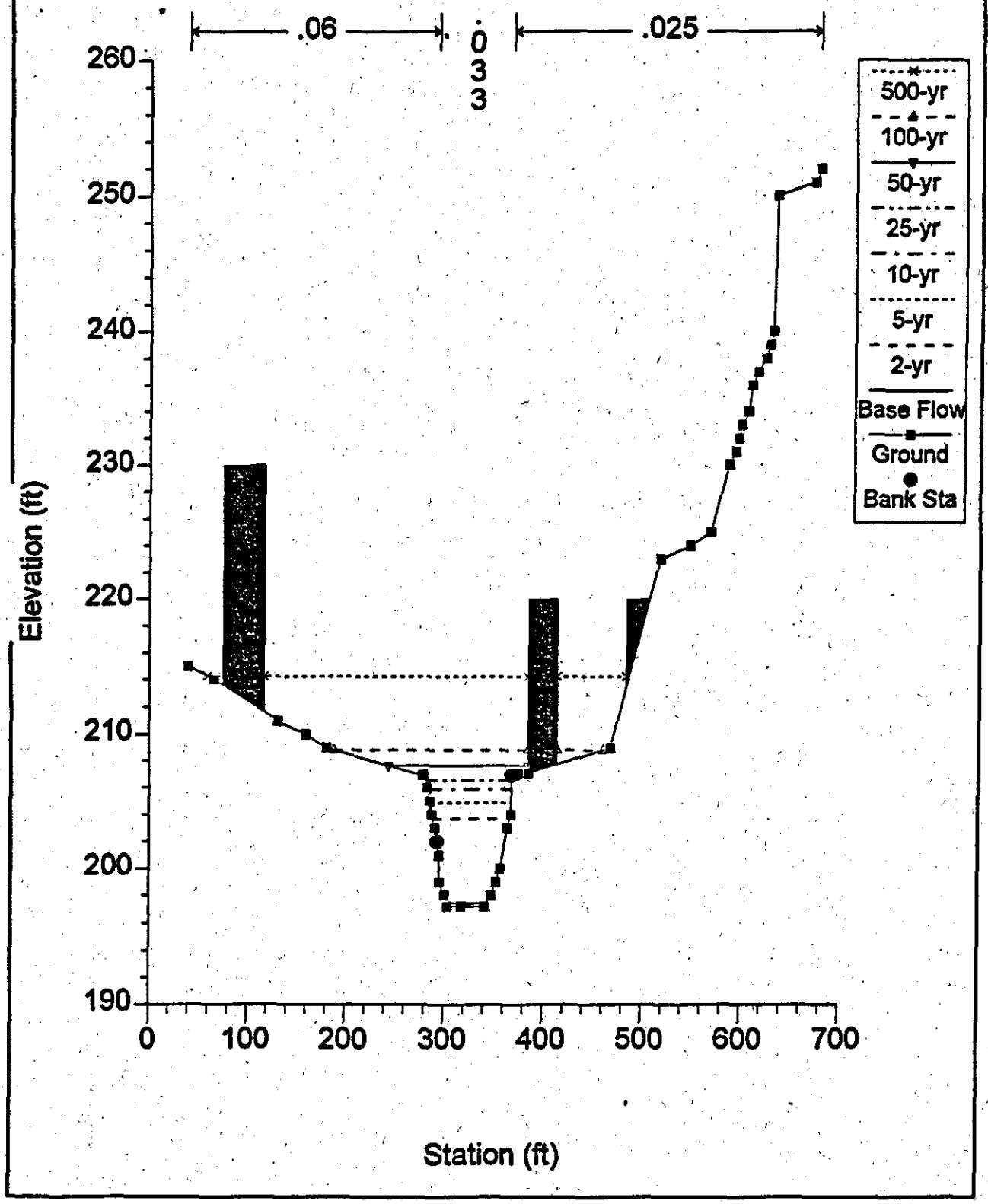
5-yr
2-yr
Base Flow
Ground
Bank Sta

Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 8+54



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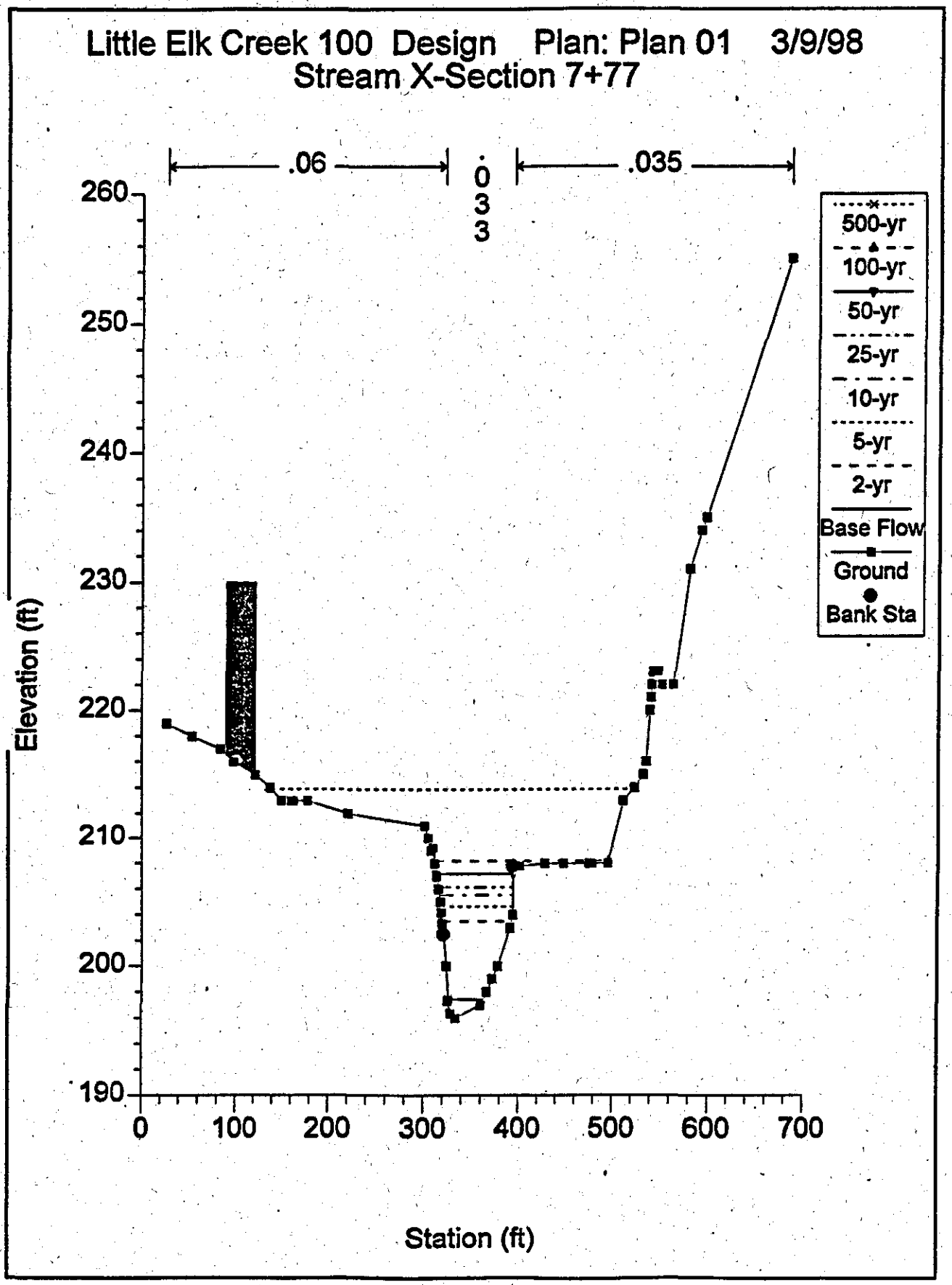
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Stream X-Section 7+77
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.033
.035
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
200
190
0
100
200
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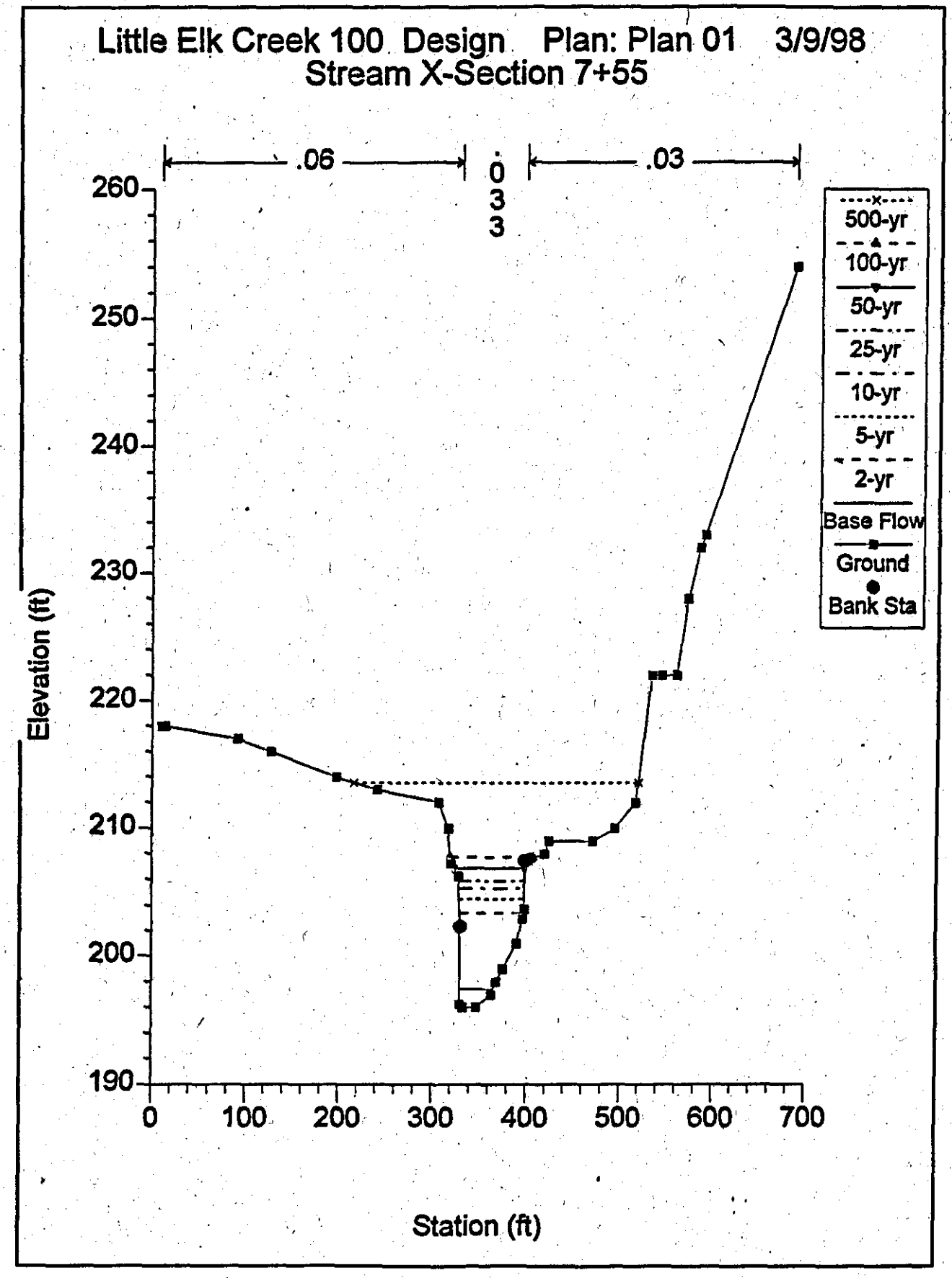
400
500
600
700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Stream X-Section 7+55
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.033
.03
Elevation (ft)
Station (ft)
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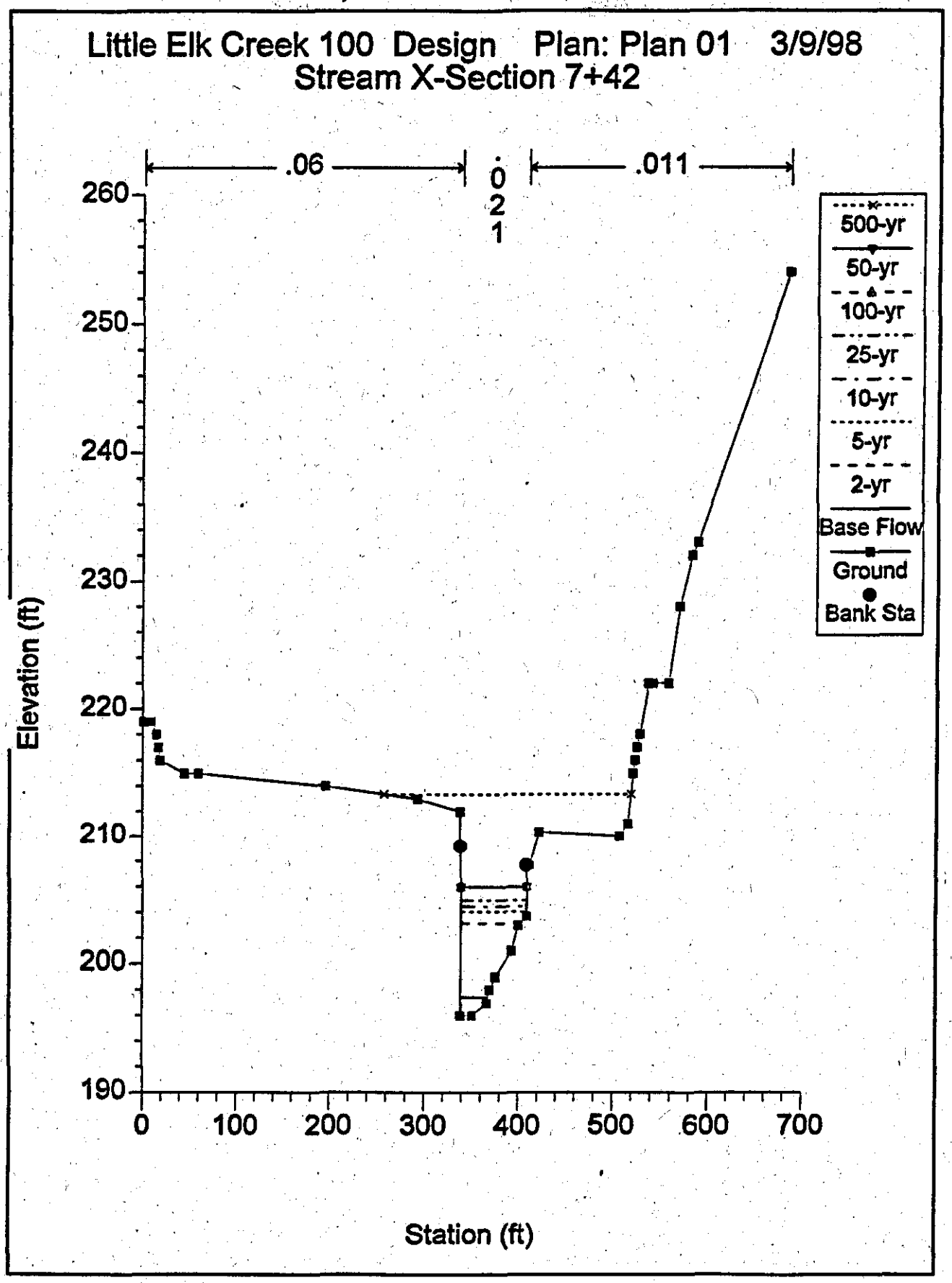
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta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Stream X-Section 7+42
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.021
.011
500-yr
50-yr
100-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
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220
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200
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0
100
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600
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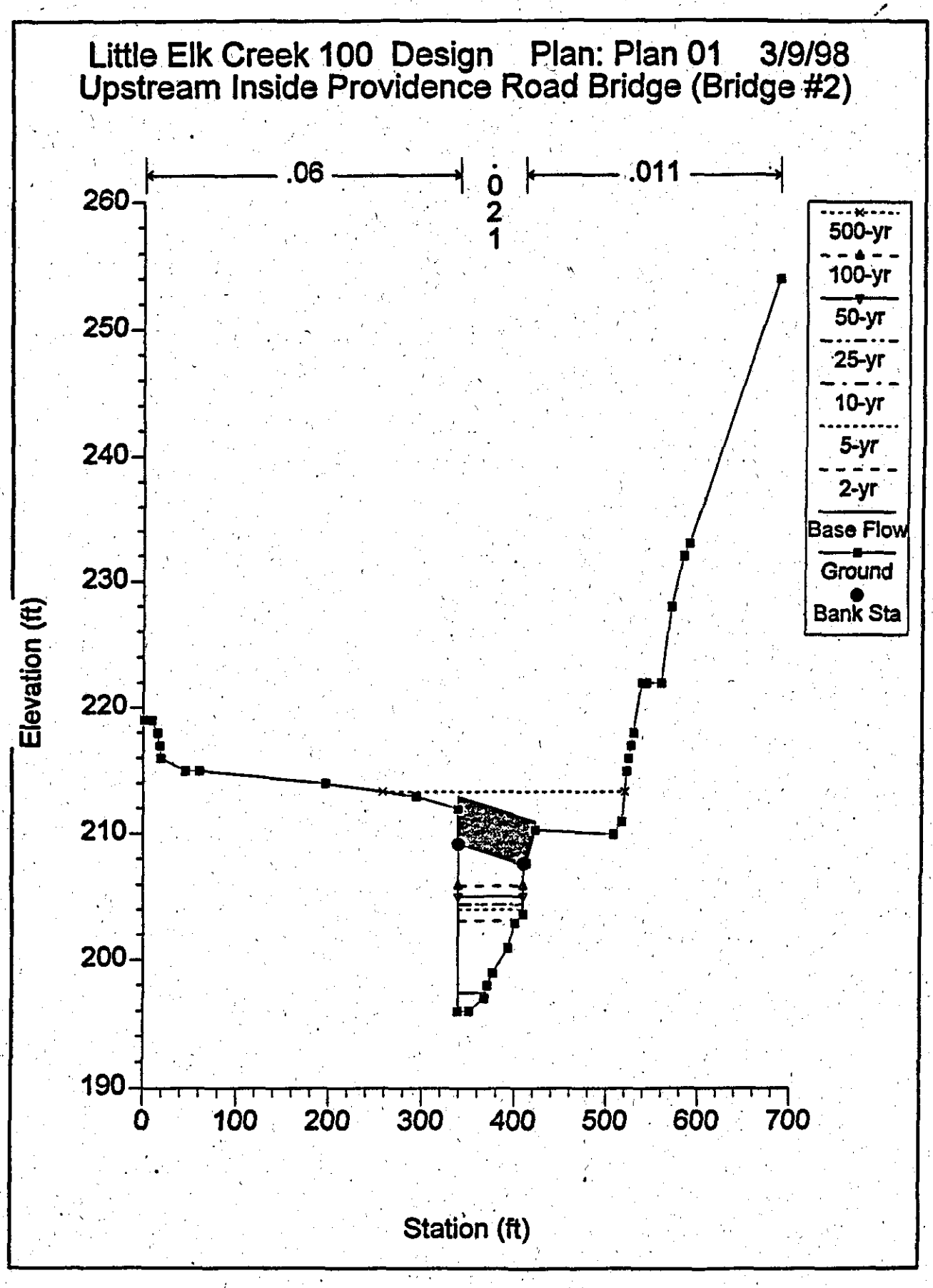
Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Upstream Inside Providence Road Bridge (Bridge #2)
.06
.021
.011
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
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200
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0
100
200
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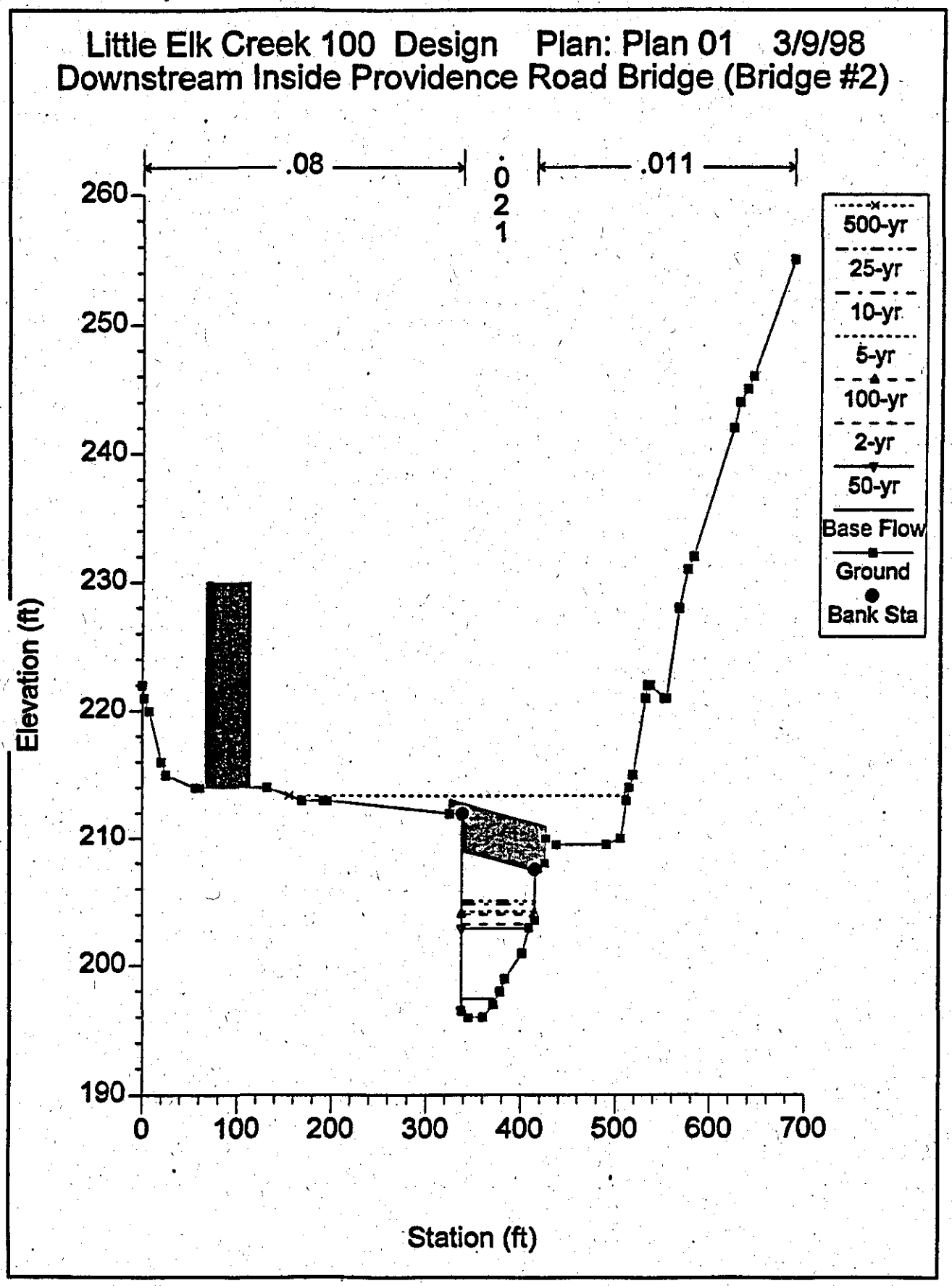
400
500
600
700


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Downstream Inside Providence Road Bridge (Bridge #2)
.08
.021
.011
500-yr
25-yr
10-yr
5-yr
100-yr
2-yr
50-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
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200
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0
100
200
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400
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600
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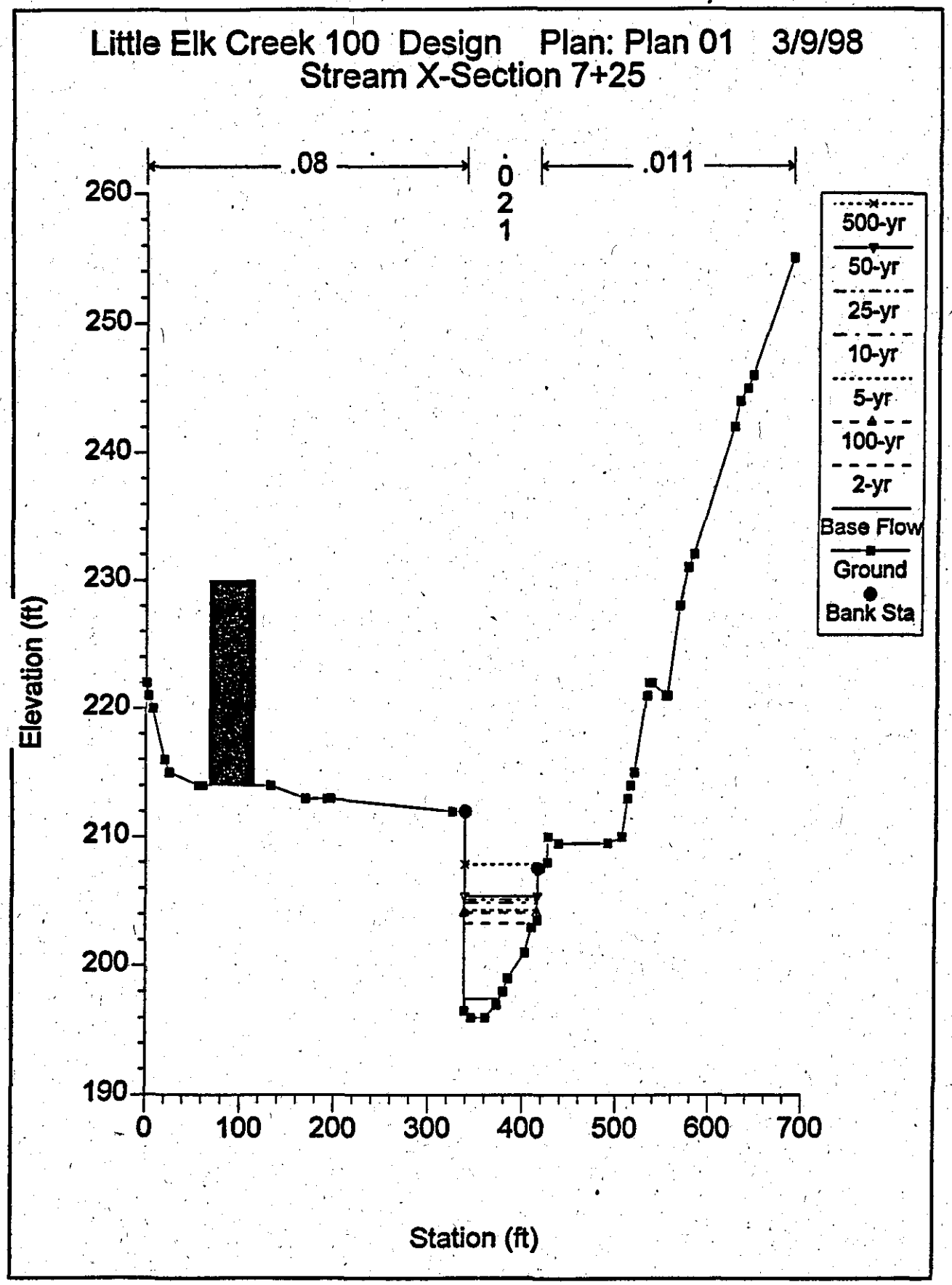
Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 7+25
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.021
.011
500-yr
50-yr
25-yr
10-yr
5-yr
100-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
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0
100
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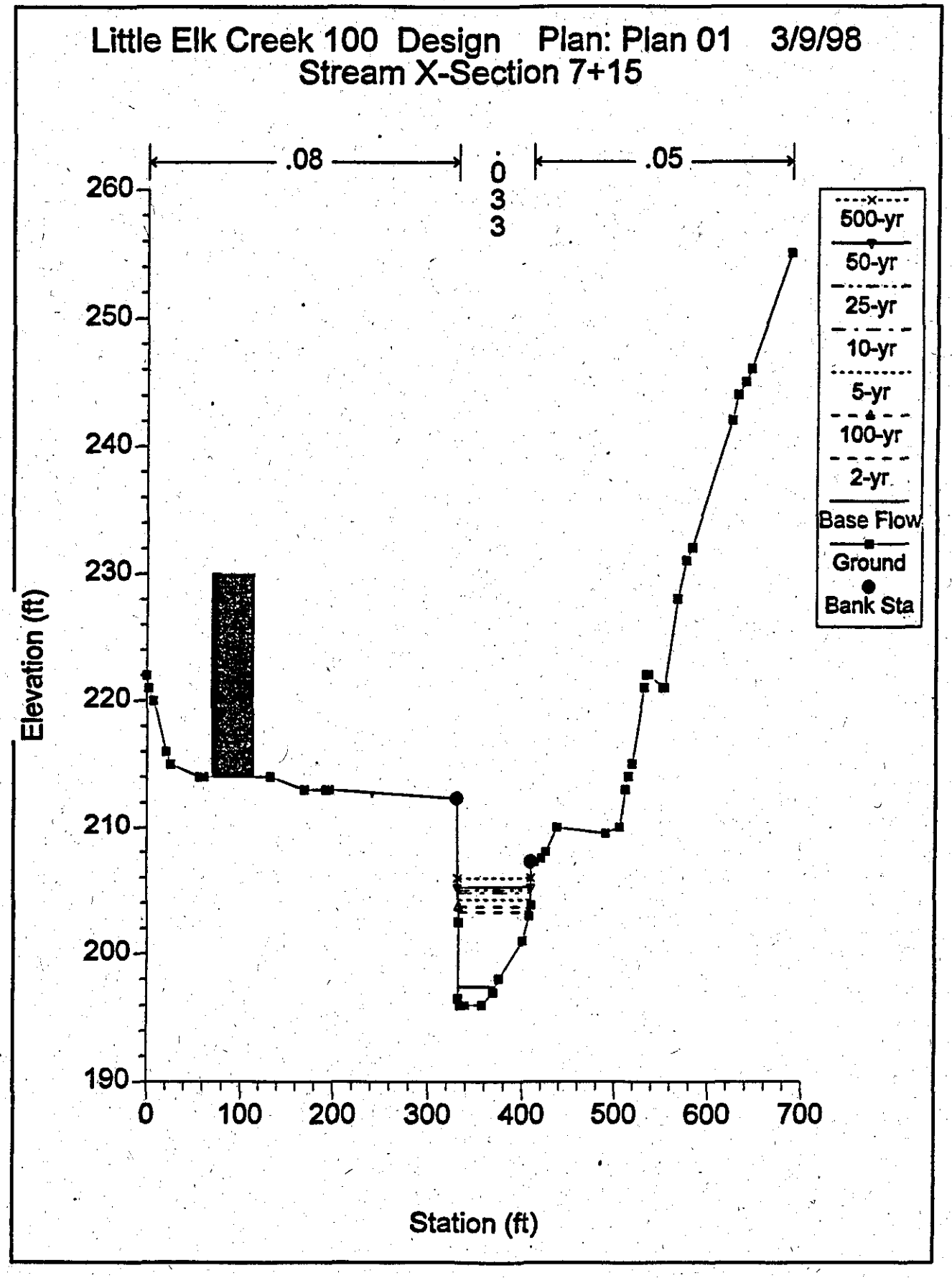
500
600
700

AR100308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Stream X-Section 7+15
.08
.05
0
3
3
500-yr
50-yr
25-yr
10-yr
5-yr
100-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
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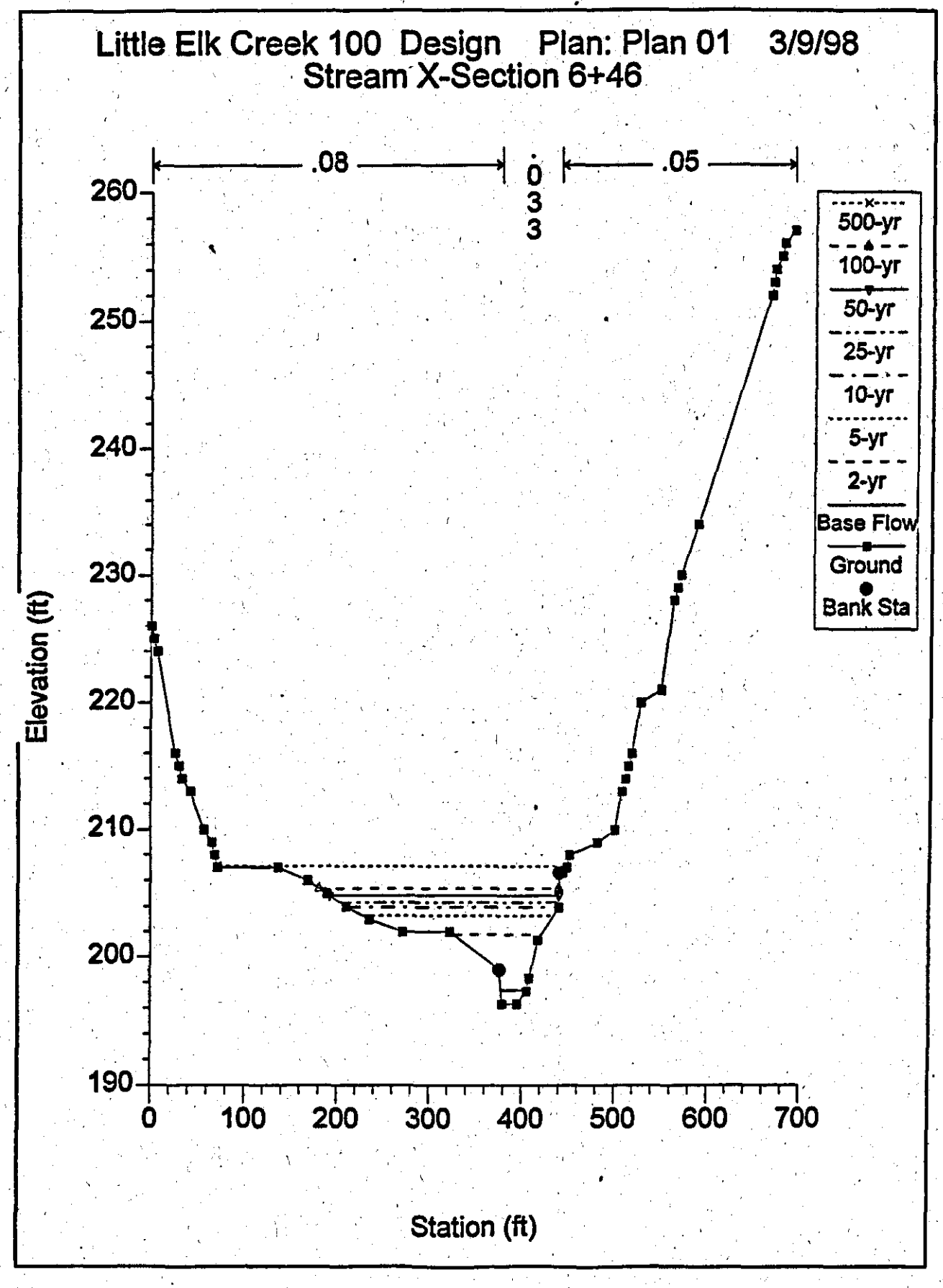
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.033
.05
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50-yr
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10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
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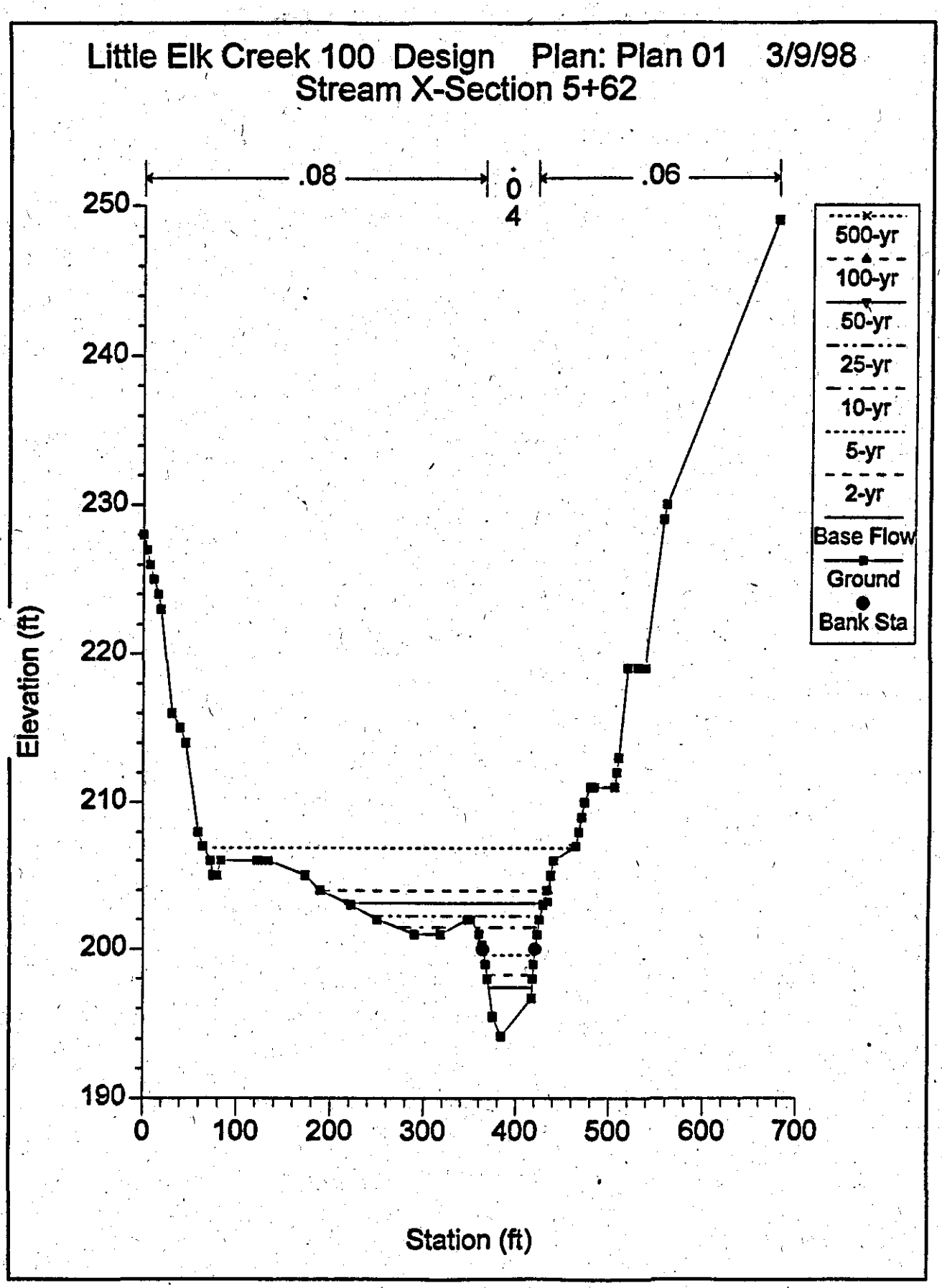
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Stream X-Section 5+62
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0
4
.06
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Elevation (ft)
0
100
200
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400
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Station (ft)
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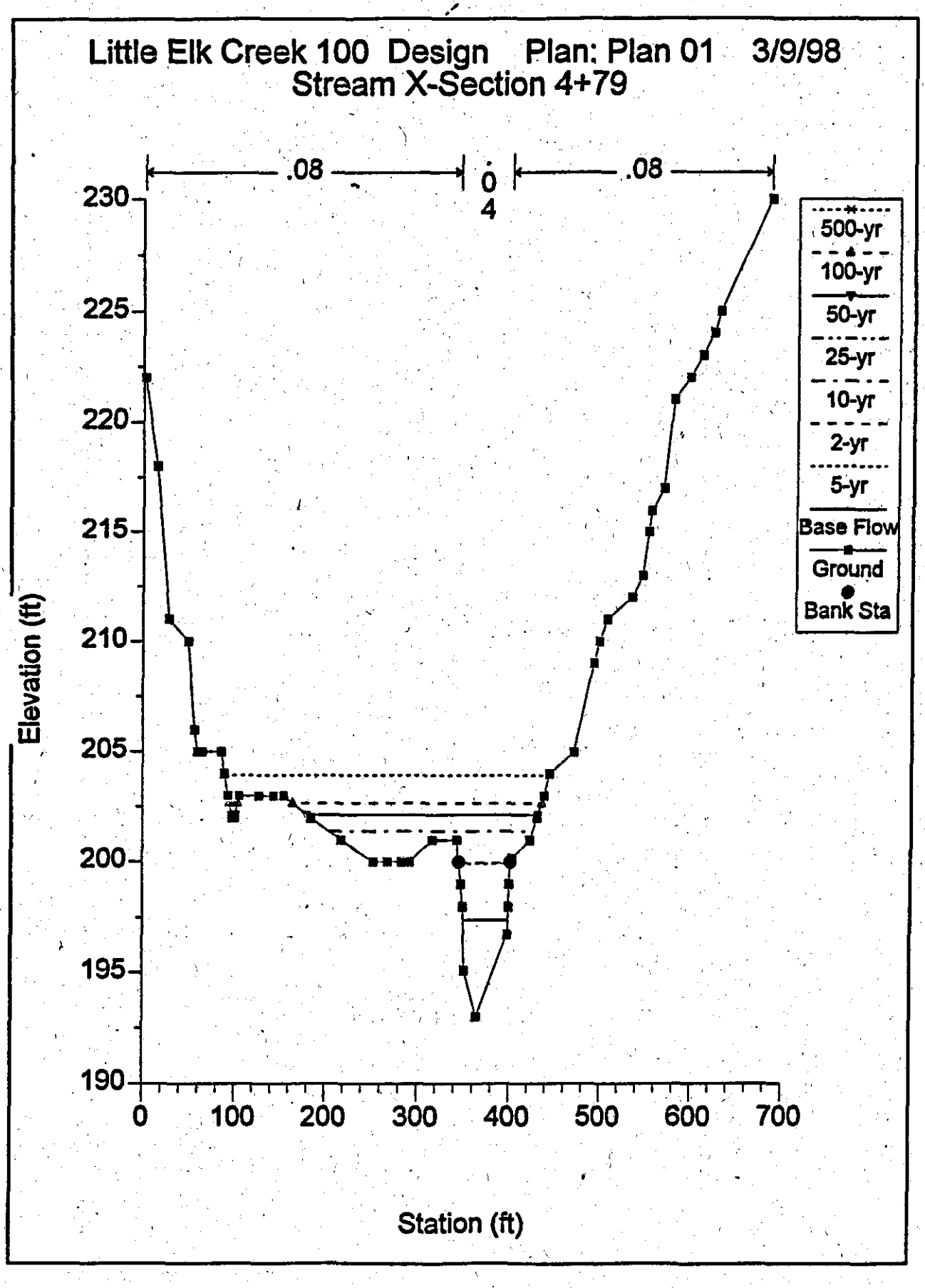
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta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4
.08
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200
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190
Elevation (ft)
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400
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Station (ft)
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100-yr
50-yr
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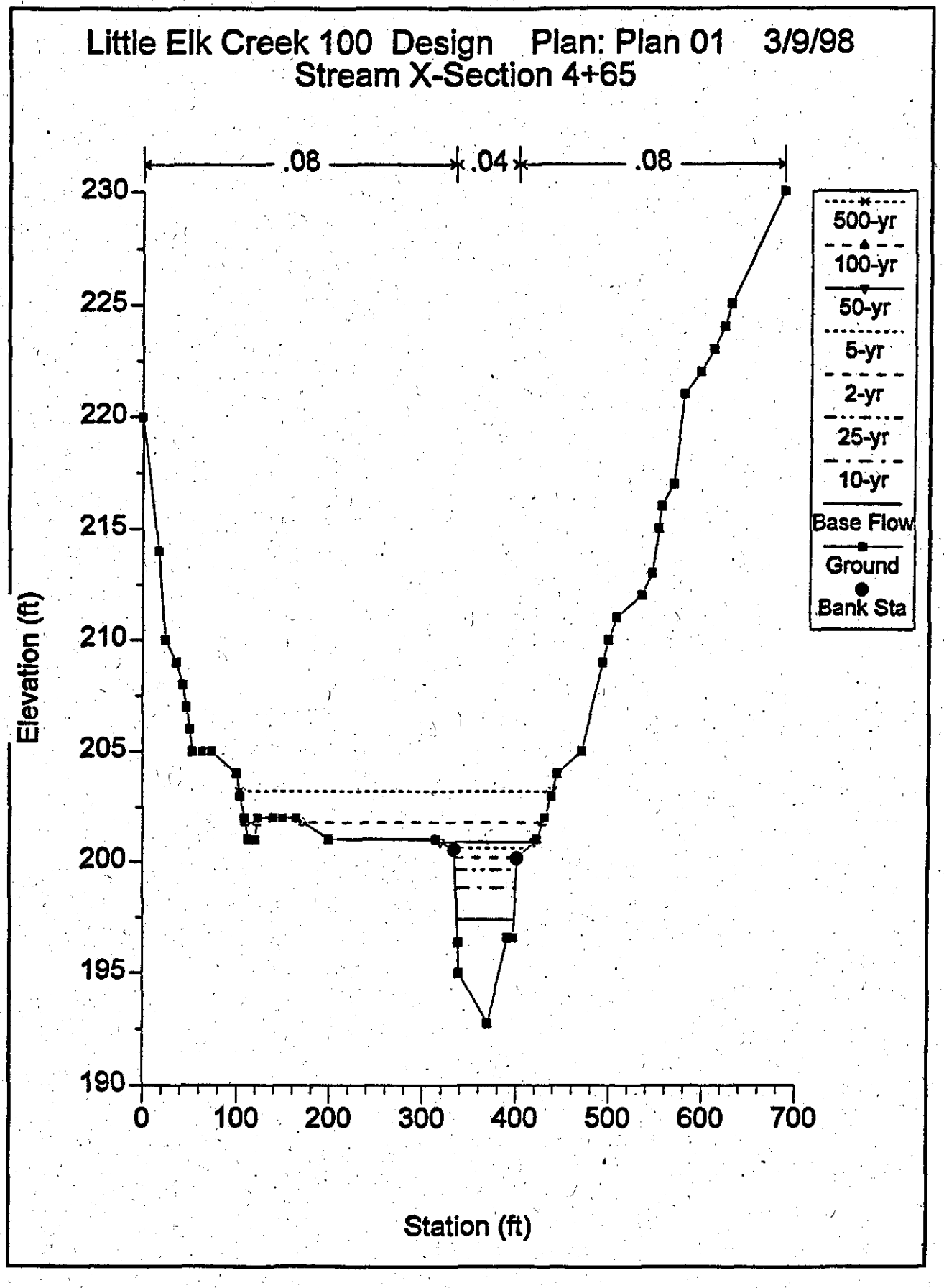
2-yr
5-yr
Base Flow
Ground
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 4+65
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195
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Elevation (ft)
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400
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Station (ft)
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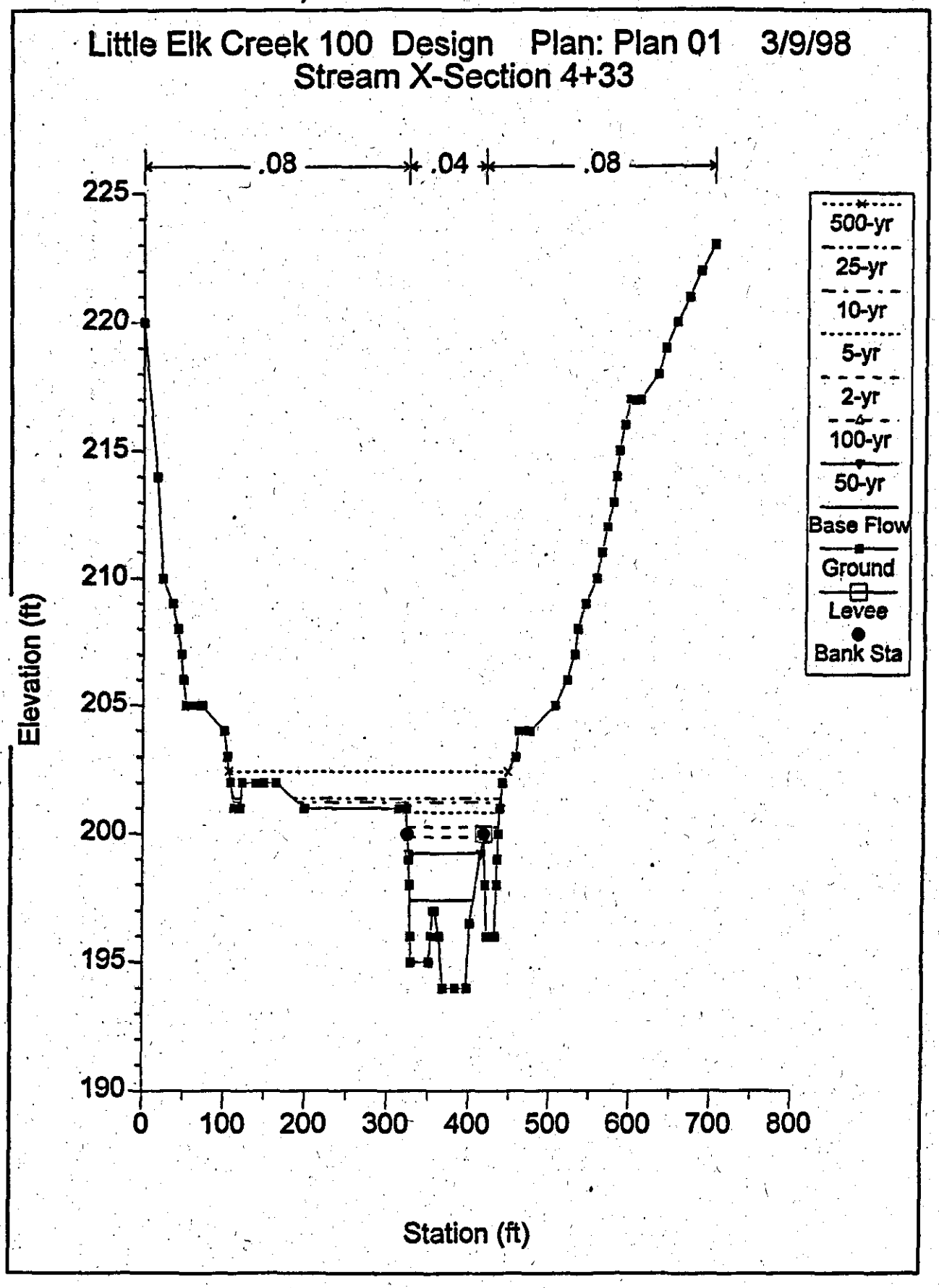
2-yr
25-yr
10-yr
Base Flow
Ground
Bank Sta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Stream X-Section 4+33
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Elevation (ft)
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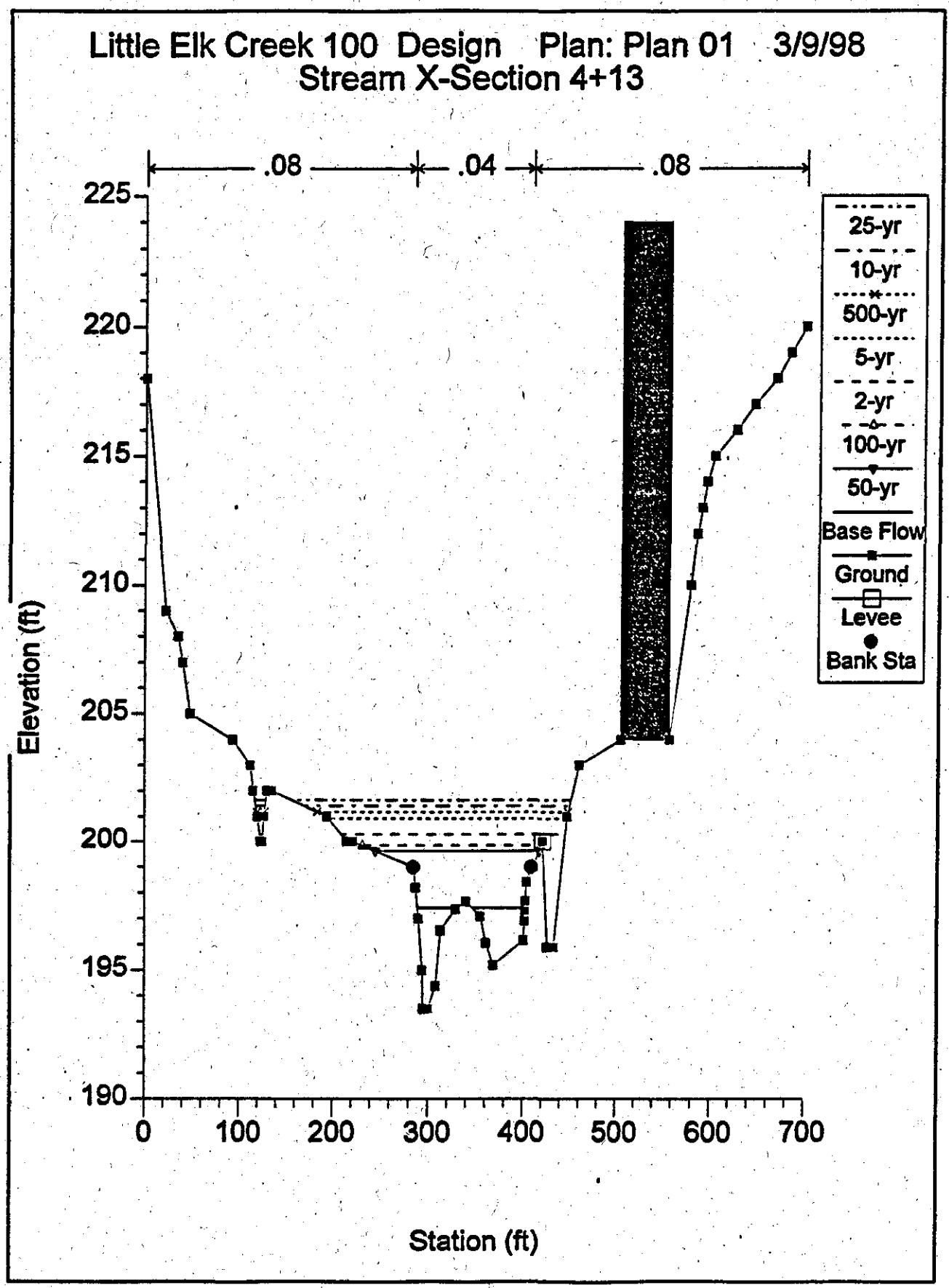
50-yr
Base Flow
Ground
Levee
Bank Sta

AR100314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Stream X-Section 4+13
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Elevation (ft)
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Base Flow
Ground
Levee
Bank Sta

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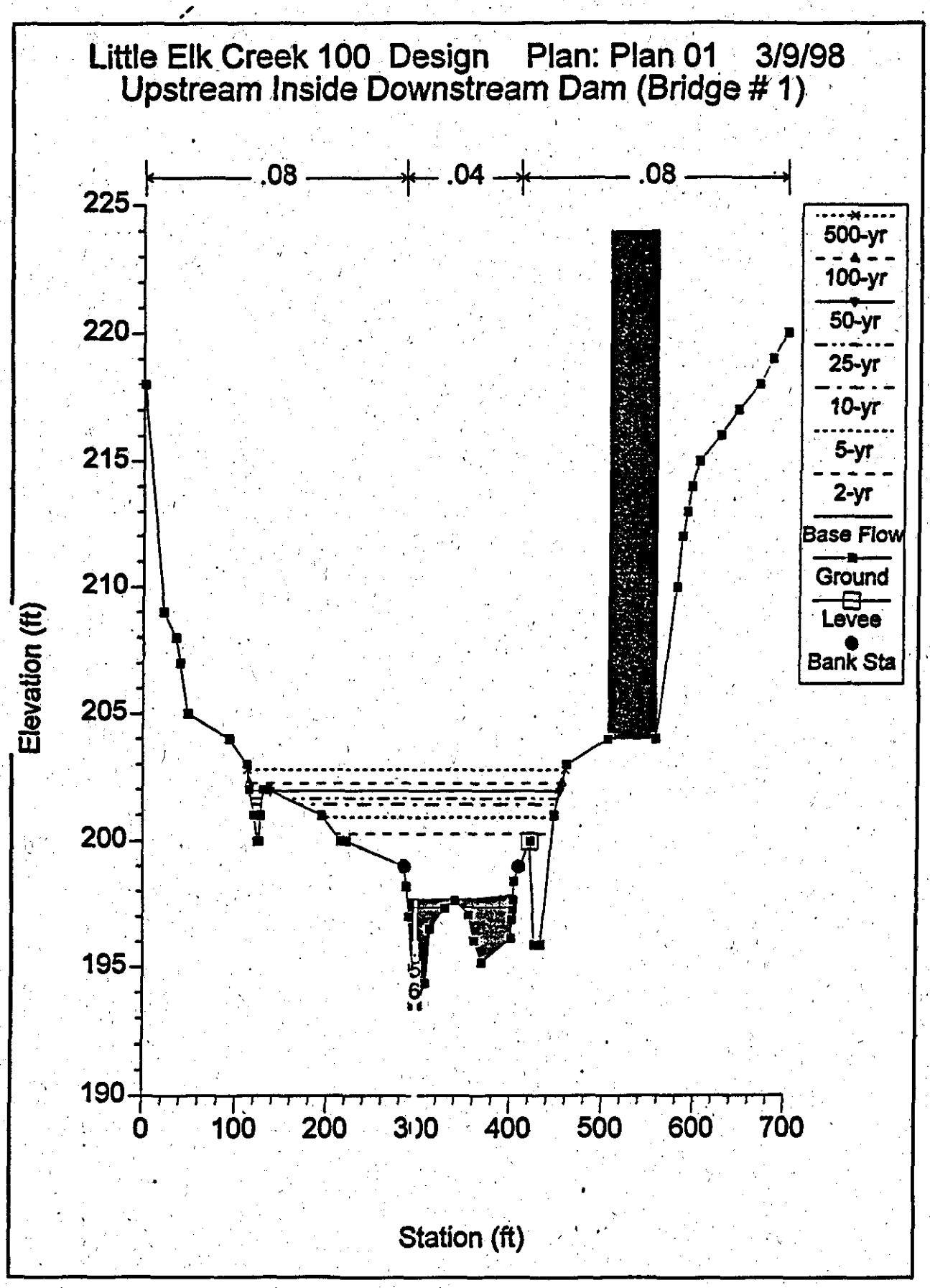
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190
Elevation (ft)
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500
600
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Station (ft)
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2-yr
Base Flow
Ground
Levee
Bank Sta

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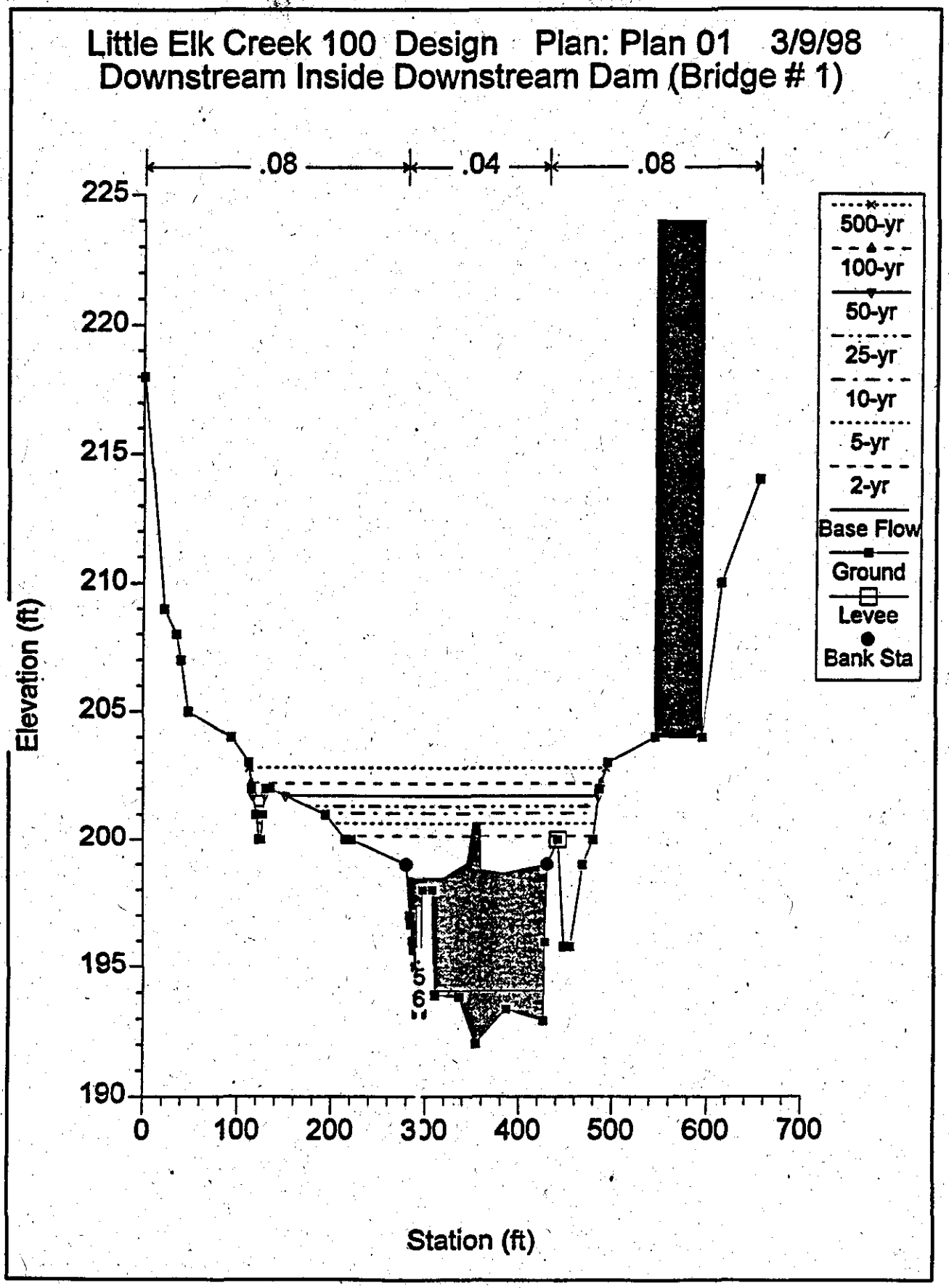
Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Downstream Inside Downstream Dam (Bridge # 1)
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.04
.08
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220
215
210
205
200
195
190
Elevation (ft)
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100
200
300
400
500
600
700
Station (ft)
500-yr
100-yr
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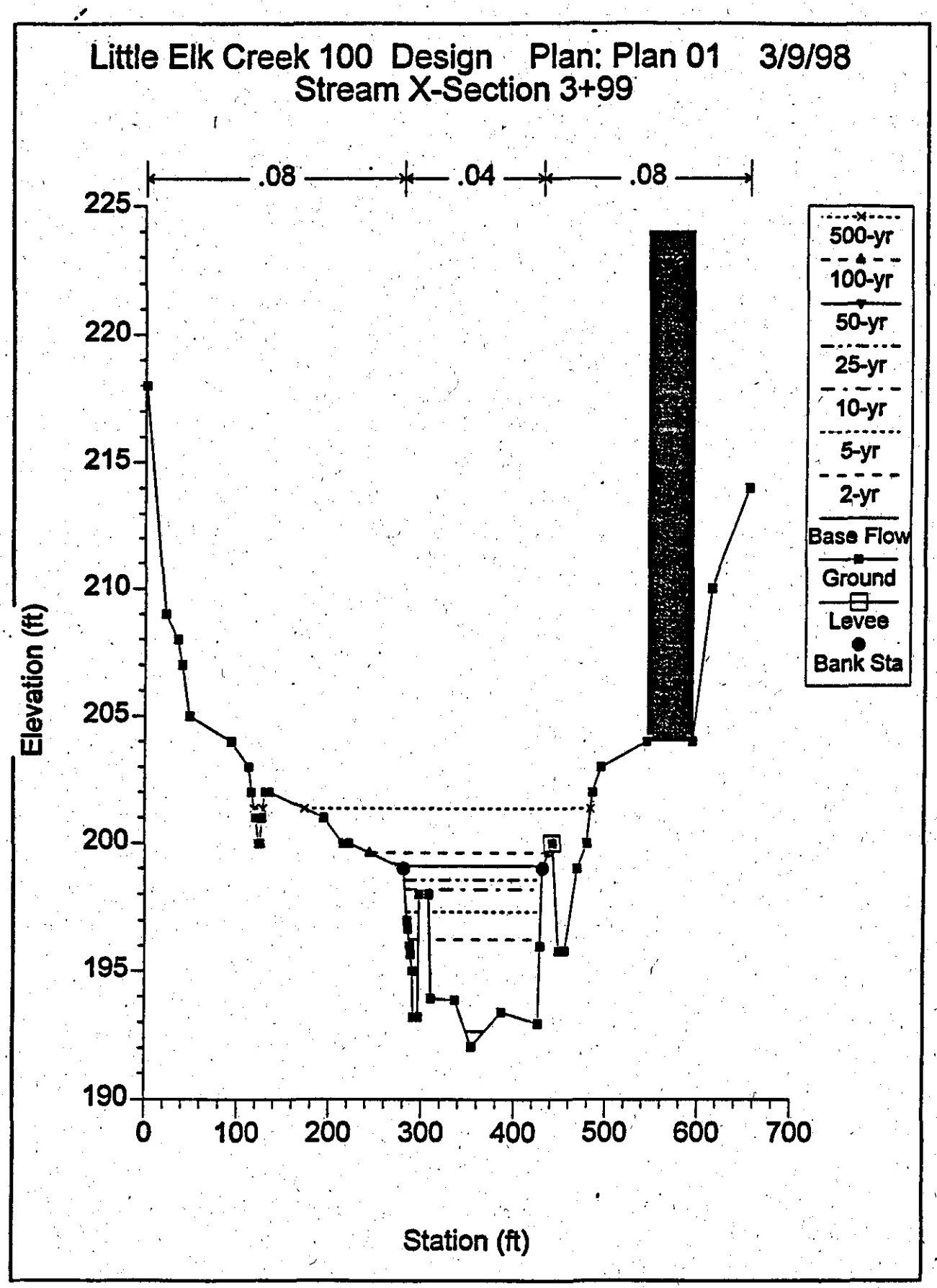
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 3+99
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.04
.08
225
220
215
210
205
200
195
190
Elevation (ft)
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100
200
300
400
500
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Station (ft)
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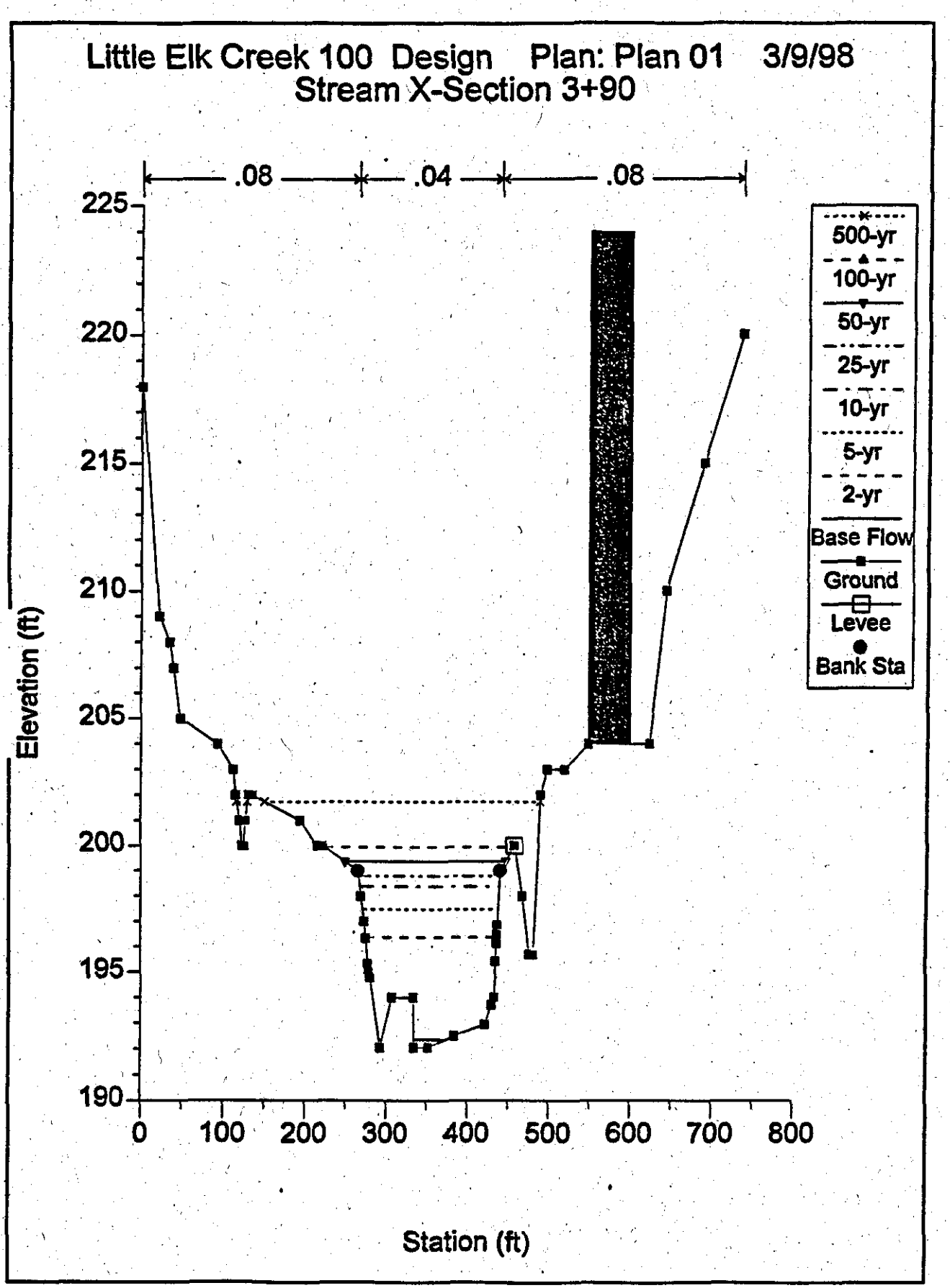
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta


Little Elk Creek 100 Design Plan: Plan 01 3/9/98
Stream X-Section 3+90
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.04
.08
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190
Elevation (ft)
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600
700
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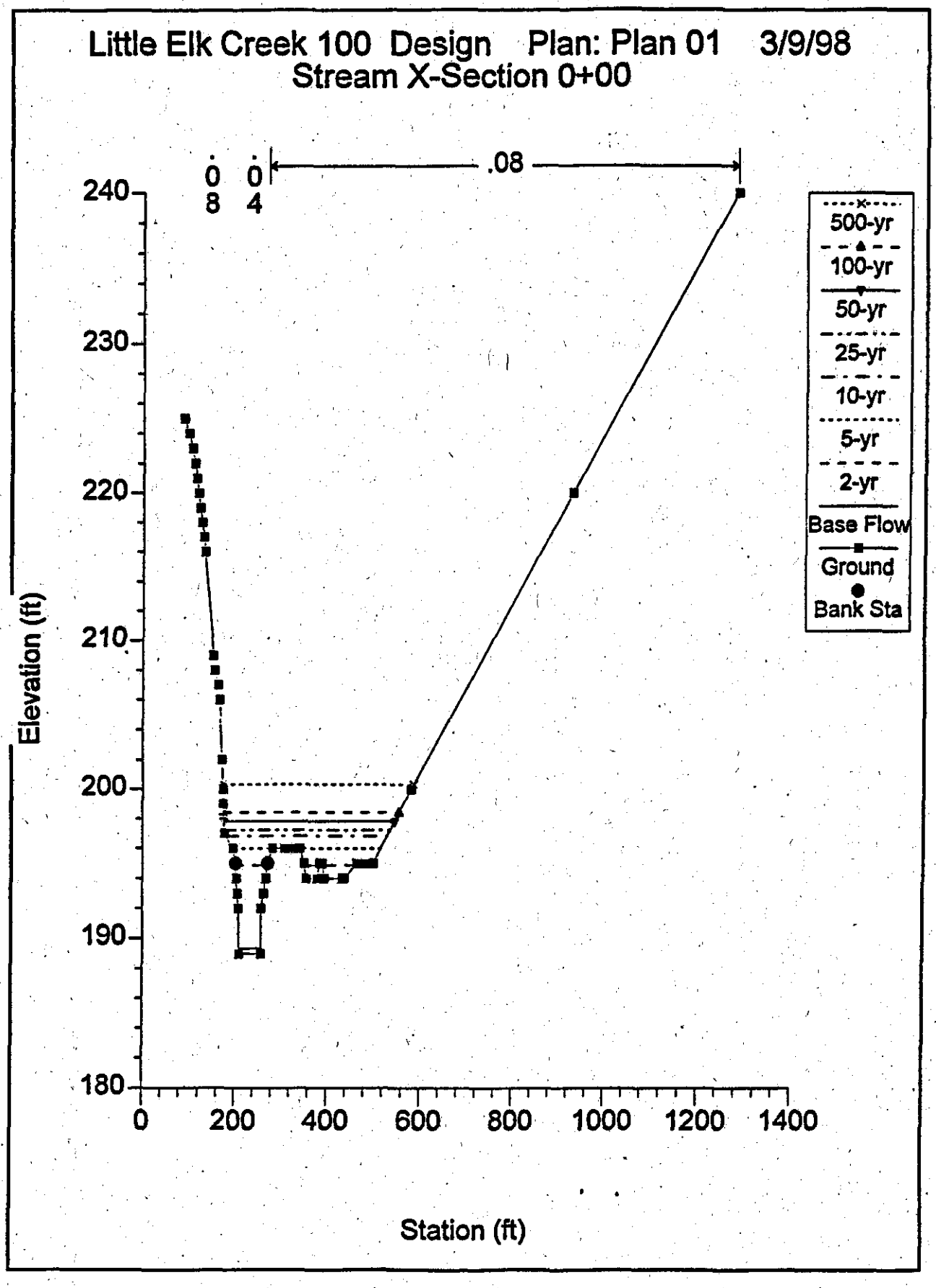
5-yr
2-yr
Base Flow
Ground
Levee
Bank Sta

AR100319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Stream X-Section 0+00
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0.08
0.04
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
Base Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
240
230
220
210
200
190
180
0
200
400
600
800
1000
1200
1400

AR100320

ATTACHMENT C

MODELING DATA

CURRENT CONDITIONS

HEC-RAS Version 1.2 April 1996
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street, Suite D
Davis, California 95616-4687
(916) 756-1104

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Project File : current.prj
Run Date and Time: 3/9/98 10:15:36 AM

Project in English units

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PLAN DATA

Plan Title: Plan 01
Plan File : c:\junk\existing\current.p01

Geometry Title: Plan 01
Geometry File : c:\junk\existing\current.p01

Flow Title : Plan 01
Flow File : c:\junk\existing\current.p01

Plan Summary Information:
Number of: Cross Sections = 39 Mulitple Openings = 0
Culverts = 2 Inline Weirs = 0

Bridges = 2

Computational Information
Water surface calculation tolerance = .01
Critical depth calculaton tolerance = .01
Maximum number of interations = 20
Maximum difference tolerance = .3
Flow tolerance factor = .001

Computational Flow Regime: Mixed Flow

Encroachment Data: None

Flow Distribution Locations: None

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FLOW DATA

Flow Title: flow
Flow File : c:\junk\existing\current.f01

Flow Data (cfs)
****
****
* Reach Riv Sta * PF#1 PF#2 PF#3 PF#4 PF#5 PF#6 PF#7 PF#8 *
****
****
* Little Elk 2548 * 18 2010 3139 4341 5032 6162 7459 12311 *
****
****
Boundary Conditions
****
* Reach Profile * Upstream Downstream *
****
* Little Elk 1 * Normal S = .004 Normal S = .004 *
* Little Elk 2 * Normal S = .004 Normal S = .004 *
* Little Elk 3 * Normal S = .004 Normal S = .004 *
* Little Elk 4 * Normal S = .004 Normal S = .004 *
* Little Elk 5 * Normal S = .004 Normal S = .004 *
* Little Elk 6 * Normal S = .004 Normal S = .004 *
* Little Elk 7 * Normal S = .004 Normal S = .004 *
* Little Elk 8 * Normal S = .004 Normal S = .004 *
****

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GEOMETRY DATA

Geometry Title: existing
Geometry File : c:\junk\existing\current.g01

CROSS SECTION INPUT Reach: Little Elk River Station: 2548
Description: Stream X-Section 25+48

Station Elevation Data, num = 60

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216
235	215	240	213	246	212	265	212	316	212
317	213	318	214	374	215	383	216	395	216
435	217	464	218	483	219	489	220	518	221
524	223	527	224	535	225	539	226	562	234
577	235	620	236	623	237	639	245	642	246

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.05	235	.04	318	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	318	800	800	800	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1748
Description: Stream X-Section 17+48

Station Elevation Data, num = 62

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216

235	215	240	213	246	212	265	212	266	210.5
305	208.64	327	211.14	369	213	370	214	374	215
383	216	395	216	435	217	464	218	483	219
489	220	518	221	524	223	527	224	535	225
539	226	562	234	577	235	620	236	623	237
639	245	642	246						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.06	235	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	374	12	12	12	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1736
Description: Stream X-Section 17+36

Station Elevation Data, num = 64

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216
235	215	240	213	246	212	248	211	254.5	211
255	212	256	210.5	305	208.64	327	211.14	369	213
370	214	374	215	383	216	395	216	435	217
464	218	483	219	489	220	518	221	524	223
527	224	535	225	539	226	562	234	577	235
620	236	623	237	639	245	642	246		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.06	235	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	374	16	16	16	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1720
Description: Stream X-Section 17+20

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.

2	273	8	272	19	271	27	270	33	269
40	268	45	267	50	266	54	265	57	264
68	263	75	262	81	261	86	260	156	246
162	245	169	244	172	243	174	242	179	241
182	240	186	239	190	238	192	237	197	236
200	235	203	234	206	233	213	229	216	228
220	227	224	225	227	222	230	221	235	218
244	217.06	246	217	250	214	254	212	255	211.41
261	210.83	264	211.19	266	212	267	213	268	214
269	215	272	214	273	215.91	274	216	289	216
290	215.35	292	215	296	213	331	208.92	368	211.02
369	213	371	214.5	374	215	383	216	395	216
435	217	464	218	483	219	489	220	518	221
524	223	527	224	535	225	539	226	562	234
577	235	620	236	623	237	639	245	642	246

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
2	.06	292	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
292	374	114	114	114	.1	.3

Left Levee Station= 292 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1606
Description: Stream X-Section 16+06

Station Elevation Data, num = 87

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	10	272	17	271	23	270	27	270
33	270	48	267	56	266	64	265	78	263
87	262	97	261	102	260	105	259	116	257
160	247	200	237	205	236	208	235	211	234
221	227	226	227	239	227	242	226	243	225
246	224	249	223	253	219	255	218	262	217.24
263	217	265	216	268	214	270	212	272	211
273	210.47	278	210.08	282	209.98	283	211	287	215.79
288	216	300	216	305	215	307	214.6	312	215
330	216	335	216	341	215.56	345	215	348	214
350	213	351	211.06	379	207.67	406	211.72	407	213
408	214	410	214.6	411	215	424	216	426	217
435	217	438	216	454	215	462	215	467	216
470	217	475	218	485	219	494	220	501	222
512	223	521	223	531	223	542	223	544	222
545	221	547	220	548	219	552	219	554	220

568	221	604	222	626	224	637	225	640	226
648	227	652	227						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	345	.04	411	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
345	411	68	68	68	.1	.3

Left Levee Station= 345 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1538
Description: Stream X-Section 15+38

Station Elevation Data, num = 60

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
10	272	58	266	63	265	69	264	76	263
84	262	94	261	99	260	102	259	120	256
161	248	168	246	176	244	190	239	200	235
209	230	210	229	214	227	217	226	221	225
231	222	245	221	248	220	263	219	269	213
273	211	284	210	296	210	298	211	302	215
305	215	308	215	329	216	333	216	335	215
342	214	345	213	346	212	354	210.5	374	206.5
388	207	400	210	401	213	402	214	403	215
407	216	413	217	443	218	472	217	505	218
535	219	574	221	581	222	588	223	593	223
616	223	622	224	642	230	651	234	668	236

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
10	.055	333	.04	407	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
333	407	28	28	28	.1	.3

Left Levee Station= 335 Elevation= 215
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
456	516	223

****

CROSS SECTION INPUT Reach: Little Elk River Station: 1510
Description: Stream X-Section 15+10

Station Elevation Data, num = 84

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	8	272	51	266	61	265	67	264
83	261	91	260	164	248	170	247	175	246
197	229	220	221	225	220	232	219	242	218
247	218	248	217.49	255	217	259	216	261	213
262	211	264	211	266	211	269	210	270	209
271	208	273	207	274	204.76	277	207	281	208
283	206.39	284	209	286	210	287	211	293	217
294	218	295	218	296	217	297	216	298	215.14
303	216	304	217	306	217	307	216	317	215
327	214.85	330	214	336	213	343	212.07	348	210.97
349	209.61	373	209.61	388	210.95	402	211.44	403.8	212.84
404	213	405	214	411	215	416	216	433	217
448	218	453	218	505	216	533	217	559	218
573	219	575	220	576	221	578	222	581	223
592	224	593	224	597	223	598	223	601	223
620	223	626	224	630	225	635	226	638	227
642	228	646	229	648	230	664	240		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.06	307	.04	416	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
307	416	2	2	2	.1	.3

Left Levee Station= 317 Elevation= 215

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
461	490	221

****

CROSS SECTION INPUT Reach: Little Elk River Station: 1508

Description: Stream X-Section 15+08

Station Elevation Data, num = 86

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	8	272	51	266	61	265	67	264
83	261	91	260	164	248	170	247	175	246
197	229	220	221	225	220	232	219	242	218
247	218	248	217.49	255	217	259	216	261	213
262	211	264	211	266	211	269	210	270	209
271	208	273	207	274	204.76	277	207	281	208
283	206.39	284	209	286	210	287	211	293	217
294	218	295	218	296	217	297	216	298	215.14
303	216	304	217	306	217	307	216	317	215

327	214.85	330	214	335	213	343	212.24	349	209.61
373	209.61	388	210.95	403	211.44	403.5	212.22	403.8	212.68
403.9	212.84	404	213	405	214	411	215	416	216
428	220	435	220	448	218	453	218	505	216
533	217	559	218	573	219	575	220	576	221
578	222	581	223	592	224	593	224	597	223
598	223	601	223	620	223	626	224	630	225
635	226	638	227	642	228	646	229	648	230
664	240								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.06	307	.04	416	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
307	416	34	34	34	.1	.3

Left Levee Station= 317 Elevation= 215

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
461	490	221

CULVERT INPUT Reach: Little Elk River Station: 1491

Description: Upstream Dam (Bridge # 4)

Distance from Upstream XS = 1

Deck/Roadway Width = 32

Weir Coefficient = 2.6

Bridge Deck/Roadway Skew =

Upstream Deck/Roadway Coordinates, num = 7

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
320	212.24	190	335	212.24	190	350	212.02	190
374	211.53	190	388	212.04	190	403	212.52	190
419	212.52	190						

Downstream Deck/Roadway Coordinates, num = 9

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
300	214.59	190	333	214.59	190	333	212.82	190
336	212.57	190	342	212.83	190	359	212.17	190
382	212.78	190	396	213.22	190	436	213.83	190

Elevation at which weir flow begins =

Maximum allowable submergence for weir flow = .95

Submergence criteria :Broad Crested

Number of Culverts = 1

Culvert Name	Shape	Rise	Span
Culvert #1	Box	1	11

FHWA Chart # 16- Corrugated metal box culvert
FHWA Scale # 2 - Thick wall projecting

Culvert Length	n Value	Entrance Loss Coef	Exit Loss Coef
32	.5	.9	1

Upstream Elevation = 210
Centerline Station = 368
Downstream Elevation = 207.58
Centerline Station = 376

CROSS SECTION INPUT Reach: Little Elk ...River Station: 1474
Description: Stream X-Section 14+74

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
7	270	43	265	55	263	69	261	73	260
92	256	127	250	158	247	163	246	170	245
183	243	196	234	219	221	224	219	228	218
232	217	242	216	249	214	263	214	269	207
273	206	275	205	276	204.1	284	204.1	291	205
293	206	297	216	300	217	307	217	312	203
393	203	394	197.95	418	197.95	430	217	440	214
480	214	530	215	557	216	573	217	577	218
582	220	585	221	589	222	594	224	602	224
604	223	607	223	631	224	634	225	645	230
651	235	656	240	662	242				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
7	.06	307	.045	430	.034

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
307	430	8	8	8	.1	.3

Left Levee Station= 308 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1466
Description: Stream X-Section 14+66

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
17	268	26	266	31	265	40	261	49	263
52	262	58	261	63	260	74	259	79	258
83	257	119	250	124	249	134	248	143	247
155	246	164	245	168	244	177	243	188	241

200	233	218	223	224	220	233	217	242	216
248	214	252	213	264	213	272	207	274	206
276	204	291	204	300	213	305	203	311	202
317	201	329	201	330	203	334	203	335	200.2
357	200.2	358	202.53	379	202.53	380	197.76	395	195.49
417	195.49	418	198.5	419	200	422	202	427	212
433	213	435	213	438	214	498	215	531	216
567	217	577	219	584	222	589	224	595	225
599	225	605	224	611	224	625	225	633	233
639	234	642	238	651	239	652	240	655	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
17	.06	300	.045	438	.034

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
300	438	3	3	3	.1	.3

Left Levee Station= 300 Elevation= 210

CROSS SECTION INPUT Reach: Little Elk River Station: 1463
Description: Stream X-Section 14+63

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
5	265	10	265	20	265	29	262	37	261
46	259	55	258	70	253	75	253	80	254
88	254	96	253	101	252	103	251	109	250
123	247	133	246	145	245	170	242	184	240
194	238	196	237	212	227	220	223	227	220
234	217	241	217	243	217	245	216	253	213
268	213	271	212	276	207	284	206	286	202
295	202	298	203	303	204	308	202	309	201
321	200	322	200	332	202	333	203	339	203
342	202	348	195.5	360	195.5	380	197	390	197.5
412	198	423	199	423.5	205.5	424	212	425	212.11
433	213	435	213	438	214	498	215	531	216
567	217	577	219	584	222	589	224	595	225
599	225	605	224	611	224	625	225	633	233
639	234	642	238	651	239	652	240	655	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
5	.06	342	.045	438	.034

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

342 438 6 6 6 .1 .3

CROSS SECTION INPUT Reach: Little Elk River Station: 1457
Description: Stream X-Section 14+63

Station Elevation Data, num = 68

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
5	265	10	265	20	265	29	262	37	261
46	259	55	258	70	253	75	253	80	254
88	254	96	253	101	252	103	251	109	250
123	247	133	246	145	245	170	242	184	240
194	238	196	237	212	227	220	223	227	220
234	217	241	217	243	217	245	216	253	213
268	213	278	204	289	202	290	201	329	201
333	202	339	203	342	203	348	202	360	195.5
380	195.5	390	198.29	412	198.48	413	202	420	203
422	204.27	426	205	427	212	435	213	438	213
498	214	531	215	567	216	577	217	584	219
589	222	595	224	599	225	605	225	611	224
625	224	633	225	639	233	642	234	651	238
652	239	655	240	663	242				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
5	.06	348	.045	435	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
348	435	11	11	11	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
452	527	220

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CROSS SECTION INPUT Reach: Little Elk River Station: 1446
Description: Stream X-Section 14+46

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	263	21	262	24	261	28	260	35	259
50	253	56	251	59	250	62	249	75	249
79	250	81	251	91	251	96	250	120	245
160	240	180	238	190	236	196	235	201	234
203	233	212	226	214	225	216	224	232	219
236	215	239	215	244	216	245	216	246	215
250	212	255	211	269	211	272	211	278	207

280	206	288	205	296	204.61	300	204	303	202.44
304	203	313	202.51	325	202	329	200.54	335	200.83
343	202.36	350	200.61	362	197.77	382	199	386	201
403	202	407	203	414	203	415	204	423	205
424	211	425	211.44	426	212	557	215	564	216
570	216	573	216	580	217	583	218	595	225
607	225	633	225	635	226	651	238	663	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.06	343	.045	426	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
343	426	27	27	27	.1	.3

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
220	230	230	454	532	220

****

CROSS SECTION INPUT Reach: Little Elk River Station: 1419
Description: Stream X-Section 14+19

Station Elevation Data, num = 80

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
14	257	20	256	32	253	34	253	37	253
40	252	49	251	54	250	62	247	75	247
79	248	84	248	108	242	128	238	136	237
173	232	185	230	190	228	196	227	219	222
222	221	232	217	235	215	237	214	240	213
241	213	247	213	250	212	256	211	259	210
275	209	277	208	281	205	284	205	287	206
290	207	292	208	305	208	308	207	310	206
314	205	318	204	323	203	327	202	328	201
329	200	335	199.5	343	200.5	358	200.5	375	200
376	201	380	202	382	202	384	203	400	204
404	205	407	206	408	207	411	209	412	210
413	211	419	212	422	212	442	212	557	214
572	220	574	220	576	220	580	221	582	222
584	223	585	229	591	230	593	230	596	230
608	230	610	229	613	228	636	228	660	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
14	.06	318	.045	419	.015

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
318 419 50 50 50 .1 .3
Left Levee Station= 284 Elevation= 205
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
449	526	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1369
Description: Stream X-Section 13+69

Station Elevation Data, num = 57

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
11	254	18	253	44	243	67	243	72	242
79	241	89	239	105	235	142	229	162	224
171	220	174	219	186	218	191	217	219	210
233	210	255	208	258	208	260	208	277	207
280	205	281	204	286	204	288	205	291	206
300	206	313	205	314	204	315	203	316	205
317	203	322	201	324	200	332	199.5	350	199
360	199.5	363	200	364	201	372	201	374	202
376	203	378	205	380	207	383	209	388	210
396	211	400	211	415	211	488	211.52	555	212
559	216	563	220	586	229	608	230	618	233
639	234	650	240						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
11	.05	313	.045	396	.015

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
313 396 59 59 59 .1 .3
Left Levee Station= 288 Elevation= 205
Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
236	258	220	449	526	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1310
Description: Stream X-Section 13+10

Station Elevation Data, num = 76

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
23	252	28	251	45	243	54	242	80	241
87	240	102	235	105	234	110	233	115	232

118	231	120	230	122	229	140	225	145	224
149	223	155	222	160	221	164	220	168	218
173	215	179	211	183	210	220	208	240	207
277	206	280	205	282	204	285	203	287	202
290	202	291	203	292	204	295	205	301	205
305	204	308	203	309	202.42	310	202	313	201
316	200	318	198.5	322	198	325	198	339	198.5
348	199	350	199.5	353	200	359	201	360	202
364	203.6	365	204.7	368	208	370	209	551	213
557	215	567	220	574	221	577	222	579	223
580	224	581	225	582	226	583	227	585	228
604	229	608	230	611	231	614	232	618	233
620	231	622	235	624	236	647	237	650	238
658	242								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
23	.05	305	.045	370	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
305	370	126	126	126	.1	.3

Left Levee Station= 295 Elevation= 205

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
189	217	220	394	524	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1184

Description: Stream X-Section 11+84

Station Elevation Data, num = 71

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
8	256	26	255	50	254	58	253	62	252
67	251	73	250	141	240	151	239	160	238
164	237	167	236	167	235	171	234	175	233
179	232	182	231	184	230	187	229	202	220
203	219	206	218	209	217	211	216	213	215
225	210	231	207	240	206	267	205	270	204
273	203	279	202	280	201.55	282	201	286	200
288	199	290	196.86	301	197.31	311	197.5	317	197.5
320	197.92	325	199	326	200.45	328	200	334	201
342	202	343	203	344	204	346	205	348	206
357	207	558	211	562	214	570	224	573	225
575	226	577	227	603	228	612	229	614	230
616	231	618	232	620	233	621	234	622	235

623	236	632	240	636	242	662	243	665	245
671	249								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
8	.05	270	.045	348	.017

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
270	348	14	14	14	.1	.3

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
211	234	220	348	362	220	382	531	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1170
Description: Stream X-Section 11+70

Station Elevation Data, num = 69

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
8	256	26	255	50	254	58	253	62	252
67	251	73	250	141	240	151	239	160	238
164	237	167	236	167	235	171	234	175	233
179	232	182	231	184	230	187	229	202	220
203	219	206	218	209	217	211	216	213	215
225	210	231	207	240	206	267	205	270	204
273	203	279	202	283	201	285	200.5	288	200
293	197	304	197	315	197.5	322	198	325	199.5
327	200	334	201	342	202	343	203	344	204
346	205	348	206	357	207	558	211	562	214
570	224	573	225	575	226	577	227	603	228
612	229	614	230	616	231	618	232	620	233
621	234	622	235	623	236	632	240	636	242
662	243	665	245	671	249	676	250		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
8	.055	270	.045	348	.017

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
270	348	66.9999	66.9999	66.99999	.1	.3

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
211	234	220	348	362	220	382	531	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1103
Description: Steam X-Section 11+03

Station Elevation Data, num = 79

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	253	11	252	17	251	30	250	42	249
68	248	77	247	83	246	87	245	106	241
110	240	119	237	123	236	126	235	135	233
140	232	146	231	156	230	162	229	167	228
173	227	178	226	181	225	183	224	192	219
194	218	196	217	199	216	201	215	210	211
216	210	223	209	230	208	234	207	244	206
252	205	271	204	273	203.97	275	203	278	202
281	201	283	200	286	199	288	197	290	196.5
305	196.5	312	197	319	197.5	321	198	324	198.5
325	199	326	199.28	332	200	336	201	339	202
340	203.5	341	205	343	206	388	207	536	210
549	210	561	211	565	214	567	215	573	223
575	224	577	225	580	226	602	227	610	228
612	229	613	230	621	235	630	240	637	243
660	244	662	245	669	250	677	252		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.055	273	.045	343	.017

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
273	343	84.9999984	.9999984	.99999	.1	.3

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
347	356	220	385	507	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1018
Description: Stream X-Section 10+18

Station Elevation Data, num = 60

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	223	7	220	35	215	120	210	126	209
135	208	190	207	234	206	268	206	270	204.86
272	203.72	282	198	283	197.5	284	197	285	196.5
287	196	302	196	314	196.5	322	196.5	327	197.68
331	198	333	198.56	337	199	341	200	343	201
345	202	346	203	347	204	349	205	350	205.6
351	206	426	207	454	208	490	209	565	210

574	213	575	214	578	215	581	216	583	217
585	220	586	223	589	224	594	225	605	226
614	227	616	228	618	229	620	230	633	238
639	238	645	238	656	239	662	240	669	248
672	249	676	250	679	251	682	252	686	253

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.055	272	.045	350	.017

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
272	350	18	18	18	.3	.5

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
69	100	230	351	359	220	428	514	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1000
Description: Stream X-Section 10+00

Station Elevation Data, num = 69

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	5	218	10	217	20	216	28	215
31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	284	206	286	206
289	206.23	290	202.9	293	196	294	195.5	295	195
302	194.72	311	195	315	195.5	317	196	319	196.84
321	200.13	324	199.79	327	197.68	331	198	333	198.56
337	199	341	200	343	201	345	202	346	203
347	204	349	205	350	205.6	351	206	352	206.7
426	207	454	208	490	209	565	210	574	213
575	214	578	215	581	216	583	217	585	220
586	223	589	224	594	225	605	226	614	227
616	228	618	229	620	230	633	238	639	238
645	238	656	239	662	240	669	248	672	249
676	250	679	251	682	252	686	253		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	290	.045	352	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
290	352	7	7	7	.3	.5

Blocked Obstructions, num = 1

Sta L	Sta R	Elev

****
53 110 230

BRIDGE INPUT Reach: Little Elk River Station: 996.5
Description: Footbridge (Bridge # 3)
Distance from Upstream XS = 1.5
Deck/Roadway Width = 4
Weir Coefficient = 2.6
Bridge Deck/Roadway Skew =
Upstream Deck/Roadway Coordinates, num = 2
Sta. Hi Cord Lo Cord Sta. Hi Cord Lo Cord
****
289 207.28 205.78 352 207.54 206.04
Downstream Deck/Roadway Coordinates, num = 2
Sta. Hi Cord Lo Cord Sta. Hi Cord Lo Cord
****
289 207.28 205.78 352 207.54 206.04
Elevation at which weir flow begins =
Maximum allowable submergence for weir flow = .95
Submergence criteria :Broad Crested

Number of Bridge Coefficient Sets = 1

Low Flow Methods
Energy
Momentum Cd = 0
Yarnell KVal =
W.S. Pro Method CVal =
Selected Low Flow Methods = Energy

High Flow Method
Energy Only

Additional Bridge Parameters
Add Friction component to Momentum
Do not add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the downstream end
Criteria to check for pressure flow = Upstream water surface

CROSS SECTION INPUT Reach: Little Elk River Station: 993
Description: Stream X-Sectrion 9+93

Station Elevation Data, num = 70
Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev.

1	219	5	218	10	217	20	216	28	215
31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	282	206	284	206
286	206	289	206.23	290	202.9	291	197	292	196.5
293	196	294	195.5	295	195	301	194.66	310	195
314	195.5	318	200	321	200.13	324	199.79	327	197.68
335	198	337	199	341	200	343	201	345	202
346	203	347	204	349	205	350	205.6	351	206
352	206.7	426	207	454	208	490	209	565	210
574	213	575	214	578	215	581	216	583	217
585	220	586	223	589	224	594	225	605	226
614	227	616	228	618	229	620	230	633	238
639	238	645	238	656	239	662	240	669	248
672	249	676	250	679	251	682	252	686	253

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	290	.045	352	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
290	352	11	11	11	.3	.5

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
341	352	207

****

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
58	108	230

****

CROSS SECTION INPUT Reach: Little Elk River Station: 982
Description: River X-Section 9+82

Station Elevation Data, num = 64

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	5	218	10	217	20	216	28	215
31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	279	205	281	203.6
282	202.9	289	198	290	197	291	196.5	292	196
294	195.5	296	195	301	194.66	308	195	312	195.5
324	196	326	196.5	330	197	333	197.5	335	198
337	199	341	200	343	201	345	202	346	203
347	204	349	205	350	205.6	351	206	426	207
454	208	490	209	565	210	574	213	575	214
578	215	581	216	583	217	585	220	586	223

589	224	594	225	605	226	614	227	616	228
618	229	620	230	633	238	639	238	645	238
656	239	662	240	669	248	672	249		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	282	.045	350	.015

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
282	350	77	77	77	.3	.5

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
335	374	207

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
70	85	230	374	414	220	489	581	220

CROSS SECTION INPUT Reach: Little Elk River Station: 905
Description: Stream X-Section 8+54

Station Elevation Data, num = 39

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
40	215	66	214	131	211	160	210	181	209
278	206.92	279	207	283	206	286	205	288	204
291	203	293	202	295	201	296	200	298	199
302	198	303	197.5	324	197.35	356	197.5	357	198
359	199	360	199.75	361	200	363	201	371	202
375	203	376	204	377	205	378	206	468	207
518	209	548	223	569	224	594	225	616	226
626	227	647	229	650	230	670	240		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
40	.06	293	.045	378	.018

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
293	378	51	51	51	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
363	378	206

Blocked Obstructions, num = 4

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev

****

96	126	230	236	272	220	385	414	220
484	543	220						

CROSS SECTION INPUT Reach: Little Elk River Station: 854
Description: Stream X-Section 8+54

Station Elevation Data, num = 50

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
40	215	66	214	131	211	160	210	181	209
278	206.92	279	207	283	206	286	205	288	204
291	203	293	202	295	201	296	200	298	199
302	197.5	303	197	305	196.5	317	196.5	327	197
345	197	354	197.9	357	198	359	199	360	199.75
361	200	363	201	371	202	375	203	376	204
377	205	378	206	468	207	518	209	548	223
569	224	587	225	594	230	597	231	600	232
606	233	610	234	616	236	624	237	628	238
631	239	635	240	672	250	678	251	683	252

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
40	.06	293	.045	378	.027

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
293	378	77	77	77	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
361	385	206

****

Blocked Obstructions, num = 4

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
75	117	230	236	272	220	385	414	220
484	543	220						

****

CROSS SECTION INPUT Reach: Little Elk River Station: 777
Description: Stream X-Section 7+77

Station Elevation Data, num = 65

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
27	219	54	218	84	217	98	216	122	215
138	214	150	213	160	213	163	213	178	213
221	212	301	211	305	210	308	209	310	209.22
312	208	314	207	316	206	318	205	319	204

320	203	321	202	322	201	323	200	324	199
326	198	328	196	333	195.5	344	195.5	350	196
356	196.5	367	197	373	198	380	198.97	381	199
383	200	385	201	396	202	399	203	400	204
401	205	402	206	403	207	404	207	413	207
428	208	448	208	475	208	478	208	495	208
511	213	523	214	532	215	535	216	539	220
540	221	541	222	542	223	547	223	551	222
563	222	580	231	592	234	597	235	685	255

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
27	.06	321	.045	403	.04

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
321	403	22	22	22	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
390	428	209

****

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
90	122	230

****

CROSS SECTION INPUT Reach: Little Elk River Station: 755
Description: Stream X-Section 7+55

Station Elevation Data, num = 39

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
10	218	14	218	91	217	127	216	197	214
241	213	307	212	317	210	320	207.2	325	202.53
332	196	333	195.5	335	195	338	195	348	195
350	195.6	352	195.5	356	196	359	196.5	368	197
381	198	390	199	394	200	403	202	404	203
406	205	416	207	419	208	424	209	471	209
494	210	517	212	534	222	544	222	560	222
572	228	585	232	590	233	687	254		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
10	.06	325	.045	424	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
325	424	13	13	13	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
389	424	210

CROSS SECTION INPUT Reach: Little Elk River Station: 742
Description: Stream X-Section 7+42

Station Elevation Data, num = 44

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	9	219	15	218	17	217	19	216
45	215	60	215	196	214	293	213	338	212
339	197	342	196	346	197.84	350	196.66	354	195
358	195	362	195.5	366	196	374	196.5	394	198.33
400	199	403	200	404	200.46	407	201	409	202
411	203	412	204	415	205	417	206	421	207
422	210.33	507	210	516	211	521	215	523	216
525	217	528	218	537	222	542	222	558	222
569	228	582	232	588	233	685	254		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.06	338	.037	421	.011

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
338	421	17	17	17	.3	.5

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
390	685	200

BRIDGE INPUT Reach: Little Elk River Station: 734
Description: Providence Road Bridge (Bridge # 2)
Distance from Upstream XS = 1
Deck/Roadway Width = 15
Weir Coefficient = 2.6
Bridge Deck/Roadway Skew =
Upstream Deck/Roadway Coordinates, num = 4

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
337	211	209.23	338	213.03	209.23	422	210.99	207.19
423	209	207.19						

Downstream Deck/Roadway Coordinates, num = 4

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord

324 211 209.27 325 213.07 209.27 426 211 207.2
427 209 207.2
Elevation at which weir flow begins =
Maximum allowable submergence for weir flow = .95
Submergence criteria :Broad Crested

Number of Piers = 1

Pier Station Upstream= 376 Downstream= 378
Upstream Pier Data, num = 2
Elev. Width Elev. Width
****
194 3 211 3
Downstream Pier Data, num = 2
Elev. Width Elev. Width
****
194 3 211 3

Number of Bridge Coefficient Sets = 1

Low Flow Methods
Energy
Momentum Cd = 1.5
Yarnell KVal = 1.25
W.S. Pro Method CVal =
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Pressure and Weir flow
Submerged Inlet Cd =
Submerged Inlet + Outlet Cd = .8
Max Low Cord =

Additional Bridge Parameters
Add Friction component to Momentum
Add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the downstream end
Criteria to check for pressure flow = Upstream water surface

CROSS SECTION INPUT Reach: Little Elk River Station: 725
Description: Stream X-Section 7+25

Station Elevation Data, num = 47
Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev.

0	222	2	221	7	220	20	216	25	215
56	214	61	214	132	214	169	213	192	213
196	213	325	212	341	212	342	197.1	348	196
350	195.5	357	195.5	370	195.5	378	195.62	383	197.38
395	198	401	197.94	403	199	406	200	417	201
418	202	425	208	426	210	437	209.5	490	209.5
505	210	511	213	514	214	518	215	531	221
533	222	536	222	551	221	553	221	566	228
575	231	581	232	623	242	629	244	637	245
643	246	686	255						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	341	.037	425	.011

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
341	425	69	69	69	.3	.5

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
390	686	200

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
67	114	230

CROSS SECTION INPUT Reach: Little Elk River Station: 715
Description: Stream X-Section 7+15

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	222	2	221	7	220	20	216	25	215
56	214	61	214	132	214	169	213	192	213
196	213	330	212.36	335	208.37	337	206.77	339	205.18
341	203.58	343	201.99	348	198	349	197.1	354	196
357	195.5	363	195.5	378	195.5	383	195.5	385	196
387	196.5	388	197	395	198	401	197.94	403	199
406	200	417	201	418	202	425	208	437	210
490	209.5	505	210	511	213	514	214	518	215
531	221	533	222	536	222	551	221	553	221
566	228	575	231	581	232	623	242	629	244
637	245	643	246	686	255				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value

0	.08	343	.04	418	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
343	418	69	69	69	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
390	686	200

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
69	114	230

CROSS SECTION INPUT Reach: Little Elk River Station: 646
Description: Stream X-Section 6+46

Station Elevation Data, num = 56

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	226	3	225	7	224	26	216	30	215
33	214	42	213	57	210	65	209	68	208
71	207	136	207	168	206	189	205	210	204
235	203	271	202	322	202	358	202	361	201
363	200	364	199	365	198	366	196	368	195.5
394	195	399	195.5	403	196	406	196.5	409	198
416	201	422	201	429	200	436	199	441	199
445	206	448	207	451	208	481	209	500	210
507	213	511	214	514	215	518	216	527	220
549	221	562	228	566	229	570	230	588	234
666	252	668	253	670	254	677	255	680	256
691	257								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	361	.04	422	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
361	422	84	84	84	.1	.3

Ineffective Flow Areas, num = 1

Sta L	Sta R	Elev
422	691	201

CROSS SECTION INPUT Reach: Little Elk River Station: 562
Description: Stream X-Section 5+62

Station Elevation Data, num = 68

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	228	4	227	7	226	11	225	16	224
19	223	31	216	40	215	46	214	59	208
64	207	72	206	75	205	79	205	83	206
122	206	130	206	134	206	173	205	189	204
222	203	250	202	290	201	318	201	347	202
351	202	360	201	363	200.33	364	200	367	199
368	198	372	197	376	196	380	195	383	194.5
387	194	392	193.5	394	193.5	396	194	398	194.5
400	195	403	196	417	196.69	418	198	419	199
421	200	423	201	425	202	429	203	433	204
434	203.22	437	205	440	206	464	207	467	208
470	209	473	210	479	211	483	211	505	211
507	212	509	213	518	219	528	219	537	219
556	229	559	230	677	249				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	364	.04	421	.06

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
364	421	83	83	83	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 479
Description: Stream X-Section 4+79

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
2	222	15	218	28	211	49	210	56	206
59	205	64	205	85	205	89	204	93	203
97	202	100	202	105	203	127	203	143	203
154	203	184	202	217	201	253	200	268	200
283	200	292	200	316	201	342	201	345	200
347	199	349	198	351	195.1	364	193	398	196.74
399	198	400	199	401	200	403	200.16	422	201
430	202	438	203	444	204	470	205	492	209
498	210	507	211	534	212	545	213	552	215
555	216	568	217	579	221	596	222	610	223
622	224	629	225	685	230				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
2	.08	345	.04	401	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
345	401	14	14	14	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 465
Description: Stream X-Section 4+65

Station Elevation Data, num = 47

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	220	17	214	24	210	36	209	43	208
47	207	50	206	53	205	63	205	73	205
100	204	104	203	108	202	112	201	120	201
122	202	139	202	149	202	164	202	199	201
314	201	334	200.54	338	196.39	339	195	370	192.74
391	196.6	397	196.6	401	200.16	422	201	430	202
438	203	444	204	470	205	492	209	498	210
507	211	534	212	545	213	552	215	555	216
568	217	579	221	596	222	610	223	622	224
629	225	685	230						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	334	.04	401	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
334	401	32	32	32	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 433
Description: Stream X-Section 4+33

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	220	17	214	24	210	36	209	43	208
47	207	50	206	53	205	63	205	73	205
100	204	104	203	108	202	112	201	120	201
122	202	139	202	149	202	164	202	199	201
314	201	323	201	324	200	326	199	327	198
328	196	329	195	351	195	353	196	356	197
358	197	363	196	368	194	383	194	397	194
401	196.5	418	200	420	198	422	196	432	196
434	198	435	199	436	200	438	201	441	202
457	203	461	204	469	204	475	204	506	205
521	206	530	207	534	208	543	209	557	210
563	211	570	212	577	213	581	214	584	215
591	216	597	217	603	217	610	217	632	218
641	219	655	220	670	221	684	222	701	223

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	324	.04	418	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
324	418	20	20	20	.1	.3

Right Levee Station= 418 Elevation= 200

CROSS SECTION INPUT Reach: Little Elk River Station: 413
Description: Stream X-Section 4+13

Station Elevation Data, num = 54

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	285	199	287	198.2	290	197
294	195	295	193.5	300	193.5	308	194.38	313	196.53
329	197.36	340	197.65	355	197.08	361	196.05	369	195.2
401	196.16	402	196.91	402.5	197.29	403	197.67	404	198.42
409	199	411	199	421	200	426	195.9	433	195.9
447	201	460	203	505	204	557	204	579	210
585	212	590	213	595	214	603	215	626	216
645	217	668	218	683	219	699	220		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	285	.04	409	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
285	409	14	14	14	.1	.3

Right Levee Station= 421 Elevation= 200
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
505	557	224

CULVERT INPUT Reach: Little Elk River Station: 406
Description: Downstream Dam (Bridge #1)
Distance from Upstream XS = 1
Deck/Roadway Width = 12
Weir Coefficient = 2.6
Bridge Deck/Roadway Skew =
Upstream Deck/Roadway Coordinates, num = 5

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord

****

280	197.72	190	318	197.72	190	346	197.72	190
376	197.78	190	415	197.93	190			

Downstream Deck/Roadway Coordinates, num = 8

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord

****

280	198.46	190	319	198.46	190	345	199.04	190
351	200.64	190	358	200.64	190	359	198.8	190
383	198.65	190	430	198.99	190			

Elevation at which weir flow begins =
Maximum allowable submergence for weir flow = .95
Submergence criteria :Broad Crested

Number of Culverts = 1

Culvert Name	Shape	Rise	Span
Culvert #1	Box	4.1	4.5

FHWA Chart # 16- Corrugated metal box culvert
FHWA Scale # 1 - 90 degree headwall

Culvert Length	n Value	Entrance Loss Coef	Exit Loss Coef
12	.56	.5	1

Upstream Elevation = 193.6
Centerline Station = 297.5
Downstream Elevation = 193.3
Centerline Station = 293.5

CROSS SECTION INPUT Reach: Little Elk River Station: 399
Description: Stream X-Section 3+99

Station Elevation Data, num = 45

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	280	199	284	197	285	196.67
287	196	288	195.67	290	195	291	193.2	296	193.2
297	198	307	198	310	193.92	336	193.86	354	192.05
386	193.38	426	192.94	428	195.97	430	199	441	200
448	195.8	455	195.8	468	199	479	200	485	202
494	203	544	204	593	204	613	210	653	214

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	280	.04	430	.08

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
280 430 9 9 9 .1 .3
Right Levee Station= 441 Elevation= 200
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
544	593	224

CROSS SECTION INPUT Reach: Little Elk River Station: 390
Description: Stream X-Section 3+90

Station Elevation Data, num = 50

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	265	199	269	198	273	197
275	196.33	278	195.33	279	195	280	194.79	293	192.05
307	194	334	194	335	192.05	352	192.05	384	192.5
422	192.94	430	193.71	433	194	435	195.43	436	196.14
436.5	196.49	437	196.85	440	199	457	200	467	198
476	195.7	481	195.7	489	202	497	203	518	203
547	204	622	204	642	210	688	215	735	220

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	265	.04	440	.08

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
265 440 390 390 390 .1 .3
Right Levee Station= 457 Elevation= 200
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
547	599	224

CROSS SECTION INPUT Reach: Little Elk River Station: 0
Description: Stream X-Section 0+00

Station Elevation Data, num = 52

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
88	225	98	224	105	223	110	222	115	221
119	220	122	219	126	218	130	217	133	216
152	209	155	208	163	207	166	206	172	202
174	200	175	199	178	197	197	196	202	195

204	194	207	193	209	192	210	189	257	189
258	192	264	193	268	194	272	195	283	196
308	196	310	196	328	196	339	196	343	196
352	195	356	194	357	194	379	194	385	195
390	195	395	194	433	194	437	194	464	195
481	195	483	195	485	195	500	195	580	200
930	220	1280	240						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
88	.08	202	.04	272	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
202	272	0	0	0	.1	.3

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SUMMARY OF MANNING'S N VALUES

Reach	River Sta.	n1	n2	n3
Little Elk	2548	.05	.04	.05
Little Elk	1748	.06	.04	.05
Little Elk	1736	.06	.04	.05
Little Elk	1720	.06	.04	.05
Little Elk	1606	.055	.04	.08
Little Elk	1538	.055	.04	.08
Little Elk	1510	.06	.04	.05
Little Elk	1508	.06	.04	.05
Little Elk	1491	Culvert		
Little Elk	1474	.06	.045	.034
Little Elk	1466	.06	.045	.034
Little Elk	1463	.06	.045	.034
Little Elk	1457	.06	.045	.015
Little Elk	1446	.06	.045	.015
Little Elk	1419	.06	.045	.015
Little Elk	1369	.05	.045	.015
Little Elk	1310	.05	.045	.015
Little Elk	1184	.05	.045	.017
Little Elk	1170	.055	.045	.017
Little Elk	1103	.055	.045	.017
Little Elk	1018	.055	.045	.017
Little Elk	1000	.055	.045	.015

*Little Elk *	996.5 *	Bridge*	*	*
*Little Elk *	993 *	.055*	.045*	.015*
*Little Elk *	982 *	.055*	.045*	.015*
*Little Elk *	905 *	.06*	.045*	.018*
*Little Elk *	854 *	.06*	.045*	.027*
*Little Elk *	777 *	.06*	.045*	.04*
*Little Elk *	755 *	.06*	.045*	.035*
*Little Elk *	742 *	.06*	.037*	.011*
*Little Elk *	734 *	Bridge*	*	*
*Little Elk *	725 *	.08*	.037*	.011*
*Little Elk *	715 *	.08*	.04*	.05*
*Little Elk *	646 *	.08*	.04*	.05*
*Little Elk *	562 *	.08*	.04*	.06*
*Little Elk *	479 *	.08*	.04*	.08*
*Little Elk *	465 *	.08*	.04*	.08*
*Little Elk *	433 *	.08*	.04*	.08*
*Little Elk *	413 *	.08*	.04*	.08*
*Little Elk *	406 *	Culvert*	*	*
*Little Elk *	399 *	.08*	.04*	.08*
*Little Elk *	390 *	.08*	.04*	.08*
*Little Elk *	0 *	.08*	.04*	.08*

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SUMMARY OF REACH LENGTHS

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* Reach *	River Sta. *	Left *	Channel*	Right *
*Little Elk *	2548 *	800*	800*	800*
*Little Elk *	1748 *	12*	12*	12*
*Little Elk *	1736 *	16*	16*	16*
*Little Elk *	1720 *	114*	114*	114*
*Little Elk *	1606 *	68*	68*	68*
*Little Elk *	1538 *	28*	28*	28*
*Little Elk *	1510 *	2*	2*	2*
*Little Elk *	1508 *	34*	34*	34*
*Little Elk *	1491 *	Culvert*	*	*
*Little Elk *	1474 *	8*	8*	8*
*Little Elk *	1466 *	3*	3*	3*
*Little Elk *	1463 *	6*	6*	6*
*Little Elk *	1457 *	11*	11*	11*
*Little Elk *	1446 *	27*	27*	27*
*Little Elk *	1419 *	50*	50*	50*

*Little Elk *	1369 *	59*	59*	59*
*Little Elk *	1310 *	126*	126*	126*
*Little Elk *	1184 *	14*	14*	14*
*Little Elk *	1170 *	66.99999*	66.99999*	66.99999*
*Little Elk *	1103 *	84.99999*	84.99999*	84.99999*
*Little Elk *	1018 *	18*	18*	18*
*Little Elk *	1000 *	7*	7*	7*
*Little Elk *	996.5 *	Bridge*	*	*
*Little Elk *	993 *	11*	11*	11*
*Little Elk *	982 *	77*	77*	77*
*Little Elk *	905 *	51*	51*	51*
*Little Elk *	854 *	77*	77*	77*
*Little Elk *	777 *	22*	22*	22*
*Little Elk *	755 *	13*	13*	13*
*Little Elk *	742 *	17*	17*	17*
*Little Elk *	734 *	Bridge*	*	*
*Little Elk *	725 *	69*	69*	69*
*Little Elk *	715 *	69*	69*	69*
*Little Elk *	646 *	84*	84*	84*
*Little Elk *	562 *	83*	83*	83*
*Little Elk *	479 *	14*	14*	14*
*Little Elk *	465 *	32*	32*	32*
*Little Elk *	433 *	20*	20*	20*
*Little Elk *	413 *	14*	14*	14*
*Little Elk *	406 *	Culvert*	*	*
*Little Elk *	399 *	9*	9*	9*
*Little Elk *	390 *	390*	390*	390*
*Little Elk *	0 *	0*	0*	0*

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SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

Reach	River Sta.	Contr.	Expan.
*Little Elk *	2548 *	.1*	.3*
*Little Elk *	1748 *	.1*	.3*
*Little Elk *	1736 *	.1*	.3*
*Little Elk *	1720 *	.1*	.3*
*Little Elk *	1606 *	.1*	.3*
*Little Elk *	1538 *	.1*	.3*
*Little Elk *	1510 *	.1*	.3*

```
*Little Elk *  1508  *    .1*    .3*
*Little Elk *  1491  * Culvert*      *
*Little Elk *  1474  *    .1*    .3*
*Little Elk *  1466  *    .1*    .3*
*Little Elk *  1463  *    .1*    .3*
*Little Elk *  1457  *    .1*    .3*
*Little Elk *  1446  *    .1*    .3*
*Little Elk *  1419  *    .1*    .3*
*Little Elk *  1369  *    .1*    .3*
*Little Elk *  1310  *    .1*    .3*
*Little Elk *  1184  *    .1*    .3*
*Little Elk *  1170  *    .1*    .3*
*Little Elk *  1103  *    .1*    .3*
*Little Elk *  1018  *    .3*    .5*
*Little Elk *  1000  *    .3*    .5*
*Little Elk *  996.5 * Bridge*      *
*Little Elk *  993   *    .3*    .5*
*Little Elk *  982   *    .3*    .5*
*Little Elk *  905   *    .1*    .3*
*Little Elk *  854   *    .1*    .3*
*Little Elk *  777   *    .1*    .3*
*Little Elk *  755   *    .1*    .3*
*Little Elk *  742   *    .3*    .5*
*Little Elk *  734   * Bridge*      *
*Little Elk *  725   *    .3*    .5*
*Little Elk *  715   *    .1*    .3*
*Little Elk *  646   *    .1*    .3*
*Little Elk *  562   *    .1*    .3*
*Little Elk *  479   *    .1*    .3*
*Little Elk *  465   *    .1*    .3*
*Little Elk *  433   *    .1*    .3*
*Little Elk *  413   *    .1*    .3*
*Little Elk *  406   * Culvert*      *
*Little Elk *  399   *    .1*    .3*
*Little Elk *  390   *    .1*    .3*
*Little Elk *  0     *    .1*    .3*
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ATTACHMENT D

MODELING DATA

POST RA CONDITIONS

HEC-RAS Version 1.2 April 1996
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street, Suite D
Davis, California 95616-4687
(916) 756-1104

```
X   X XXXXXX  XXXX    XXXX    XX   XXXX
X   X X    X  X    X  X   X X  X
X   X X    X      X  X  X  X  X
XXXXXXX XXXX   X    XXX XXXX   XXXXXX  XXXX
X   X X    X      X  X   X  X    X
X   X X    X  X    X  X  X  X    X
X   X XXXXXX  XXXX    X  X  X  X XXXXX
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PROJECT DATA
Project Title: Little Elk Creek 100 Design
Project File : proposed.prj
Run Date and Time: 3/9/98 10:08:14 AM

Project in English units

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**

PLAN DATA

Plan Title: Plan 01
Plan File : c:\junk\proposed\proposed.p01

Geometry Title: Plan 01
Geometry File : c:\junk\proposed\proposed.p01

Flow Title : Plan 01
Flow File : c:\junk\proposed\proposed.p01

Plan Summary Information:
Number of: Cross Sections = 39 Mulitple Openings = 0
Culverts = 2 Inline Weirs = 0

Bridges = 1

Computational Information
Water surface calculation tolerance = .01
Critical depth calculaton tolerance = .01
Maximum number of interations = 20
Maximum difference tolerance = .3
Flow tolerance factor = .001

Computational Flow Regime: Mixed Flow

Encroachment Data: None

Flow Distribution Locations: None

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FLOW DATA

Flow Title: flow
Flow File : c:\junk\proposed\proposed.f01

Flow Data (cfs)
****
****
* Reach Riv Sta * PF#1 PF#2 PF#3 PF#4 PF#5 PF#6 PF#7 PF#8 *
****
****
* Little Elk 2548 * 18 2010 3139 4341 5032 6162 7459 12311 *
****
****
Boundary Conditions
****
* Reach Profile * Upstream Downstream *
****
* Little Elk 1 * Normal S = .004 Normal S = .004 *
* Little Elk 2 * Normal S = .004 Normal S = .004 *
* Little Elk 3 * Normal S = .004 Normal S = .004 *
* Little Elk 4 * Normal S = .004 Normal S = .004 *
* Little Elk 5 * Normal S = .004 Normal S = .004 *
* Little Elk 6 * Normal S = .004 Normal S = .004 *
* Little Elk 7 * Normal S = .004 Normal S = .004 *
* Little Elk 8 * Normal S = .004 Normal S = .004 *
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GEOMETRY DATA

Geometry Title: proposed
Geometry File : c:\junk\proposed\proposed.g01

CROSS SECTION INPUT Reach: Little Elk River Station: 2548
Description: Stream X-Section 25+48

Station Elevation Data, num = 60

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216
235	215	240	213	246	212	265	212	316	212
317	213	318	214	374	215	383	216	395	216
435	217	464	218	483	219	489	220	518	221
524	223	527	224	535	225	539	226	562	234
577	235	620	236	623	237	639	245	642	246

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.05	235	.04	318	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	318	800	800	800	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1748
Description: Stream X-Section 17+48

Station Elevation Data, num = 62

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216

235	215	240	213	246	212	265	212	266	210.5
305	208.64	327	211.14	369	213	370	214	374	215
383	216	395	216	435	217	464	218	483	219
489	220	518	221	524	223	527	224	535	225
539	226	562	234	577	235	620	236	623	237
639	245	642	246						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.06	235	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	374	12	12	12	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1736
Description: Stream X-Section 17+36

Station Elevation Data, num = 64

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	272	12	271	22	270	27	269	33	268
43	266	45	265	49	263	51	262	60	261
72	260	79	259	86	258	108	254	113	253
123	250	128	248	132	247	140	246	145	245
155	244	165	240	167	239	170	238	180	234
182	233	191	230	197	227	201	225	203	224
205	223	210	219	213	218	218	217	232	216
235	215	240	213	246	212	248	211	254.5	211
255	212	256	210.5	305	208.64	327	211.14	369	213
370	214	374	215	383	216	395	216	435	217
464	218	483	219	489	220	518	221	524	223
527	224	535	225	539	226	562	234	577	235
620	236	623	237	639	245	642	246		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.06	235	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
235	374	16	16	16	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 1720
Description: Stream X-Section 17+20

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.

2	273	8	272	19	271	27	270	33	269
40	268	45	267	50	266	54	265	57	264
68	263	75	262	81	261	86	260	156	246
162	245	169	244	172	243	174	242	179	241
182	240	186	239	190	238	192	237	197	236
200	235	203	234	206	233	213	229	216	228
220	227	224	225	227	222	230	221	235	218
244	217.06	246	217	250	214	254	212	255	211.41
261	210.83	264	211.19	266	212	267	213	268	214
269	215	272	214	273	215.91	274	216	289	216
290	215.35	292	215	296	213	331	208.92	368	211.02
369	213	371	214.5	374	215	383	216	395	216
435	217	464	218	483	219	489	220	518	221
524	223	527	224	535	225	539	226	562	234
577	235	620	236	623	237	639	245	642	246

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
2	.06	292	.04	374	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
292	374	114	114	114	.1	.3

Left Levee Station= 292 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1606
Description: Stream X-Section 16+06

Station Elevation Data, num = 87

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	10	272	17	271	23	270	27	270
33	270	48	267	56	266	64	265	78	263
87	262	97	261	102	260	105	259	116	257
160	247	200	237	205	236	208	235	211	234
221	227	226	227	239	227	242	226	243	225
246	224	249	223	253	219	255	218	262	217.24
263	217	265	216	268	214	270	212	272	211
273	210.47	278	210.08	282	209.98	283	211	287	215.79
288	216	300	216	305	215	307	214.6	312	215
330	216	335	216	341	215.56	345	215	348	214
350	213	351	211.06	379	207.67	406	211.72	407	213
408	214	410	214.6	411	215	424	216	426	217
435	217	438	216	454	215	462	215	467	216
470	217	475	218	485	219	494	220	501	222
512	223	521	223	531	223	542	223	544	222
545	221	547	220	548	219	552	219	554	220

568	221	604	222	626	224	637	225	640	226
648	227	652	227						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	345	.04	411	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
345	411	68	68	68	.1	.3

Left Levee Station= 345 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1538
Description: Stream X-Section 15+38

Station Elevation Data, num = 60

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
10	272	58	266	63	265	69	264	76	263
84	262	94	261	99	260	102	259	120	256
161	248	168	246	176	244	190	239	200	235
209	230	210	229	214	227	217	226	221	225
231	222	245	221	248	220	263	219	269	213
273	211	284	210	296	210	298	211	302	215
305	215	308	215	329	216	333	216	335	215
342	214	345	213	346	212	354	210.5	374	206.5
388	207	400	210	401	213	402	214	403	215
407	216	413	217	443	218	472	217	505	218
535	219	574	221	581	222	588	223	593	223
616	223	622	224	642	230	651	234	668	236

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
10	.055	333	.04	407	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
333	407	28	28	28	.1	.3

Left Levee Station= 335 Elevation= 215
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
456	516	223

CROSS SECTION INPUT Reach: Little Elk River Station: 1510
Description: Stream X-Section 15+10

Station Elevation Data, num = 84

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	8	272	51	266	61	265	67	264
83	261	91	260	164	248	170	247	175	246
197	229	220	221	225	220	232	219	242	218
247	218	248	217.49	255	217	259	216	261	213
262	211	264	211	266	211	269	210	270	209
271	208	273	207	274	204.76	277	207	281	208
283	206.39	284	209	286	210	287	211	293	217
294	218	295	218	296	217	297	216	298	215.14
303	216	304	217	306	217	307	216	317	215
327	214.85	330	214	336	213	343	212.07	348	210.97
349	209.61	373	209.61	388	210.95	402	211.44	403.8	212.84
404	213	405	214	411	215	416	216	433	217
448	218	453	218	505	216	533	217	559	218
573	219	575	220	576	221	578	222	581	223
592	224	593	224	597	223	598	223	601	223
620	223	626	224	630	225	635	226	638	227
642	228	646	229	648	230	664	240		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.06	307	.04	416	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
307	416	2	2	2	.1	.3

Left Levee Station= 317 Elevation= 215

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
461	490	221

CROSS SECTION INPUT Reach: Little Elk River Station: 1508

Description: Stream X-Section 15+08

Station Elevation Data, num = 86

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	273	8	272	51	266	61	265	67	264
83	261	91	260	164	248	170	247	175	246
197	229	220	221	225	220	232	219	242	218
247	218	248	217.49	255	217	259	216	261	213
262	211	264	211	266	211	269	210	270	209
271	208	273	207	274	204.76	277	207	281	208
283	206.39	284	209	286	210	287	211	293	217
294	218	295	218	296	217	297	216	298	215.14
303	216	304	217	306	217	307	216	317	215

327	214.85	330	214	335	213	343	212.24	349	209.61
373	209.61	388	210.95	403	211.44	403.5	212.22	403.8	212.68
403.9	212.84	404	213	405	214	411	215	416	216
428	220	435	220	448	218	453	218	505	216
533	217	559	218	573	219	575	220	576	221
578	222	581	223	592	224	593	224	597	223
598	223	601	223	620	223	626	224	630	225
635	226	638	227	642	228	646	229	648	230
664	240								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.05	307	.04	416	.06

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
307	416	34	34	34	.1	.3

Left Levee Station= 317 Elevation= 215

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
461	490	221

CULVERT INPUT Reach: Little Elk River Station: 1491

Description: Upstream Dam (Bridge #3)

Distance from Upstream XS = 1

Deck/Roadway Width = 32

Weir Coefficient = 2.6

Bridge Deck/Roadway Skew =

Upstream Deck/Roadway Coordinates, num = 7

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
320	212.24	190	335	212.24	190	350	212.02	190
374	211.53	190	388	212.04	190	403	212.52	190
419	212.52	190						

Downstream Deck/Roadway Coordinates, num = 9

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
300	214.59	190	333	214.59	190	333	212.82	190
336	212.57	190	342	212.83	190	359	212.17	190
382	212.78	190	396	213.22	190	436	213.83	190

Elevation at which weir flow begins =

Maximum allowable submergence for weir flow = .95

Submergence criteria :Broad Crested

Number of Culverts = 1

Culvert Name Shape Rise Span
Culvert #1 Box 1 11
FHWA Chart # 16- Corrugated metal box culvert
FHWA Scale # 2 - Thick wall projecting
Culvert Length n Value Entrance Loss Coef Exit Loss Coef
32 .5 .9 1
Upstream Elevation = 210
Centerline Station = 368
Downstream Elevation = 207.58
Centerline Station = 376

CROSS SECTION INPUT Reach: Little Elk River Station: 1474
Description: Stream X-Section 14+74

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
7	270	43	265	55	263	69	261	73	260
92	256	127	250	158	247	163	246	170	245
183	243	196	234	219	221	224	219	228	218
232	217	242	216	249	214	263	214	269	207
273	206	275	205	276	204.1	284	204.1	291	205
293	206	297	216	300	217	307	217	312	203
393	203	394	197.95	418	197.95	430	217	440	214
480	214	530	215	557	216	573	217	577	218
582	220	585	221	589	222	594	224	602	224
604	223	607	223	631	224	634	225	645	230
651	235	656	240	662	242				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
7	.06	307	.045	430	.034

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
307 430 8 8 8 .1 .3
Left Levee Station= 308 Elevation= 215

CROSS SECTION INPUT Reach: Little Elk River Station: 1466
Description: Stream X-Section 14+66

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
17	268	26	266	31	265	40	261	49	263
52	262	58	261	63	260	74	259	79	258
83	257	119	250	124	249	134	248	143	247
155	246	164	245	168	244	177	243	188	241

200	233	218	223	224	220	233	217	242	216
248	214	252	213	264	213	272	207	274	206
276	204	291	204	300	213	305	203	311	202
317	201	329	201	330	203	334	203	335	200.2
357	200.2	358	202.53	379	202.53	380	197.76	395	195.49
417	195.49	418	198.5	419	200	422	202	427	212
433	213	435	213	438	214	498	215	531	216
567	217	577	219	584	222	589	224	595	225
599	225	605	224	611	224	625	225	633	233
639	234	642	238	651	239	652	240	655	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
17	.06	300	.045	438	.034

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
300	438	3	3	3	.1	.3

Left Levee Station= 300 Elevation= 210

CROSS SECTION INPUT Reach: Little Elk River Station: 1463
Description: Stream X-Section 14+63

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
5	265	10	265	20	265	29	262	37	261
46	259	55	258	70	253	75	253	80	254
88	254	96	253	101	252	103	251	109	250
123	247	133	246	145	245	170	242	184	240
194	238	196	237	212	227	220	223	227	220
234	217	241	217	243	217	245	216	253	213
268	213	271	212	276	207	284	206	286	202
295	202	298	203	303	204	308	202	309	201
321	200	322	200	332	202	333	203	339	203
342	202	348	195.5	360	195.5	380	197	390	197.5
412	198	423	199	423.5	205.5	424	212	425	212.11
433	213	435	213	438	214	498	215	531	216
567	217	577	219	584	222	589	224	595	225
599	225	605	224	611	224	625	225	633	233
639	234	642	238	651	239	652	240	655	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
5	.06	342	.045	438	.034

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

342 438 6 6 6 .1 .3

CROSS SECTION INPUT Reach: Little Elk River Station: 1457
Description: Stream X-Section 14+63

Station Elevation Data, num = 69

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
5	265	10	265	20	265	29	262	37	261
46	259	55	258	70	253	75	253	80	254
88	254	96	253	101	252	103	251	109	250
123	247	133	246	145	245	170	242	184	240
194	238	196	237	212	227	220	223	227	220
234	217	241	217	243	217	245	216	253	213
268	213	276	209.5	276	204	289	202	290	201
329	201	333	202	339	203	342	203	348	202
360	195.5	380	195.5	390	198.29	412	198.48	413	202
420	203	422	204.27	426	205	427	212	435	213
438	213	498	214	531	215	567	216	577	217
584	219	589	222	595	224	599	225	605	225
611	224	625	224	633	225	639	233	642	234
651	238	652	239	655	240	663	242		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
5	.06	348	.045	427	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
348	427	11	11	11	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
452	527	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1446
Description: Stream X-Section 14+46

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	263	21	262	24	261	28	260	35	259
50	253	56	251	59	250	62	249	75	249
79	250	81	251	91	251	96	250	120	245
160	240	180	238	190	236	196	235	201	234
203	233	212	226	214	225	216	224	232	219
236	215	239	215	244	216	245	216	246	215
250	212	255	211	269	211	272	211	278	207

280	206	288	205	296	204.61	300	204	303	202.44
304	203	313	202.51	325	202	329	200.54	335	200.83
343	202.36	350	200.61	362	197.77	382	199	386	201
403	202	407	203	414	203	415	204	423	205
424	211	425	211.44	426	212	557	215	564	216
570	216	573	216	580	217	583	218	595	225
607	225	633	225	635	226	651	238	663	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.06	343	.045	426	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
343	426	27	27	27	.1	.3

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
220	230	230	454	532	220

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CROSS SECTION INPUT Reach: Little Elk River Station: 1419
Description: Stream X-Section 14+19

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
14	257	20	256	32	253	34	253	37	253
40	252	49	251	54	250	62	247	75	247
79	248	84	248	108	242	128	238	136	237
173	232	185	230	190	228	196	227	219	222
222	221	232	217	235	215	237	214	240	213
241	213	247	213	250	212	256	211	259	210
275	209	277	208	281	205	284	205	287	206
290	207	292	208	305	208	308	207	310	206
314	205	318	204	321	203	324	202	328	201
334	201	344	201	351	202	353	202	381	201
391	203	399	205	401	206	401	209.75	405	209.75
413	211	419	212	422	212	442	212	557	214
572	220	574	220	576	220	580	221	582	222
584	223	585	229	591	230	593	230	596	230
608	230	610	229	613	228	636	228	660	242

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
14	.06	318	.033	419	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

318 419 50 50 50 .1 .3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
449	526	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1369

Description: Stream X-Section 13+69

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
11	254	18	253	44	243	67	243	72	242
79	241	89	239	105	235	142	229	162	224
171	220	174	219	186	218	191	217	219	210
233	210	255	208	258	208	260	208	277	207
280	205	281	204	286	204	288	205	291	206
305	205	306	204.33	306.5	204	307	203.67	308	203
318	201	344	200.5	354	200.5	363	201	368	203
374	205	377	206	377	209.75	381	209.75	383	209.9
388	210	396	211	400	211	415	211	488	211.52
555	212	559	216	563	220	586	229	608	230
618	233	639	234	650	240				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
11	.05	306.5	.033	396	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
306.5	396	59	59	59	.1	.3

Left Levee Station= 288 Elevation= 205

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
236	258	220	449	526	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1310

Description: Stream X-Section 13+10

Station Elevation Data, num = 69

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
23	252	28	251	45	243	54	242	80	241
87	240	102	235	105	234	110	233	115	232
118	231	120	230	122	229	140	225	145	224
149	223	155	222	160	221	164	220	168	218
173	215	179	211	183	210	220	208	240	207

277	206	280	205	282	204	285	203	287	202
290	202	291	203	292	204	295	205	296	204
298	201	302	200	304	199.25	319	199	339	200
349	201	353	203	360	204.75	360	208.5	364	208.5
367	208.8	370	209	551	213	557	215	567	220
574	221	577	222	579	223	580	224	581	225
582	226	583	227	585	228	604	229	608	230
611	231	614	232	618	233	620	231	622	235
624	236	647	237	650	238	658	242		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
23	.05	296	.033	370	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
296	370	126	126	126	.1	.3

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
189	217	220	394	524	220

****

CROSS SECTION INPUT Reach: Little Elk River Station: 1184
Description: Stream X-Section 11+84

Station Elevation Data, num = 67

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
8	256	26	255	50	254	58	253	62	252
67	251	73	250	141	240	151	239	160	238
164	237	167	236	167	235	171	234	175	233
179	232	182	231	184	230	187	229	202	220
203	219	206	218	209	217	211	216	213	215
225	210	231	207	240	206	267	205	270	204.4
271	204.2	272	204	277	203	283	200	286	200
286	198	320	198	322	199	324	200	326	201
330	203	338	204	338	206.75	342	206.75	345	207
357	207	558	211	562	214	570	224	573	225
575	226	577	227	603	228	612	229	614	230
616	231	618	232	620	233	621	234	622	235
623	236	632	240	636	242	662	243	665	245
671	249	676	250						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
8	.05	272	.033	338	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
272 338 14 14 14 .1 .3
Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
211	234	220	382	531	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1170
Description: Stream X-Section 11+70

Station Elevation Data, num = 68

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
8	256	26	255	50	254	58	253	62	252
67	251	73	250	141	240	151	239	160	238
164	237	167	236	167	235	171	234	175	233
179	232	182	231	184	230	187	229	202	220
203	219	206	218	209	217	211	216	213	215
225	210	231	207	240	206	267	205	270	204
273	203	279	202	280	201.55	282	201	287	200
288	198.25	300	198	320	198	323	199	325	200
328	201	332	203	338	204	338	206.75	342	206.75
345	207	357	207	558	211	562	214	570	224
573	225	575	226	577	227	603	228	612	229
614	230	616	231	618	232	620	233	621	234
622	235	623	236	632	240	636	242	662	243
665	245	671	249	676	250				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
8	.055	270	.033	338	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
270 338 66.9999966.9999966.99999 .1 .3
Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
211	234	220	382	531	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1103
Description: Steam X-Section 11+03

Station Elevation Data, num = 75

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
4	253	11	252	17	251	30	250	42	249
68	248	77	247	83	246	87	245	106	241

110	240	119	237	123	236	126	235	135	233
140	232	146	231	156	230	162	229	167	228
173	227	178	226	181	225	183	224	192	219
194	218	196	217	199	216	201	215	210	211
216	210	223	209	230	208	234	207	244	206
252	205	271	204	273	203.97	274	203	276	202
279	201	283	200	284	199.5	285	198	304	198
318	199	324	200	327	201	331	203	334	203.5
334	206.25	338	206.25	341	207	347	207	388	207
536	210	549	210	561	211	565	214	567	215
573	223	575	224	577	225	580	226	602	227
610	228	612	229	613	230	621	235	630	240
637	243	660	244	662	245	669	250	677	252

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
4	.055	273	.033	341	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
273	341	84.9999	984.9999	84.99999	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
385	507	220

****

CROSS SECTION INPUT Reach: Little Elk River Station: 1018
Description: Stream X-Section 10+18

Station Elevation Data, num = 56

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	223	7	220	35	215	120	210	126	209
135	208	190	207	234	206	268	206	270	204.86
271	203.99	272	203.12	274	201	280	198	282	198
298	197	320	198	323	199	328	200	330	201
334	203	337	204	337	206.75	341	206.75	344	206.5
346	206.5	351	206	426	207	454	208	490	209
565	210	574	213	575	214	578	215	581	216
583	217	585	220	586	223	589	224	594	225
605	226	614	227	616	228	618	229	620	230
633	238	639	238	645	238	656	239	662	240
669	248	672	249	676	250	679	251	682	252
686	253								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value

0	.055	271	.033	337	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

271	337	18	18	18	.1	.3

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
69	100	230	428	514	220

CROSS SECTION INPUT Reach: Little Elk River Station: 1000
Description: Stream X-Section 10+00

Station Elevation Data, num = 64

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	5	218	10	217	20	216	28	215
31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	273	204	274	203.5
275	203	276	202.5	277	202	283	201.36	286	201.36
286	198.69	289	197	299	196.37	314	197	321	198
327	199	333	200	335	201	339	203	341	204
341	206	346	206	349	207	361	207	361	206.25
426	207	454	208	490	209	565	210	574	213
575	214	578	215	581	216	583	217	585	220
586	223	589	224	594	225	605	226	614	227
616	228	618	229	620	230	633	238	639	238
645	238	656	239	662	240	669	248	672	249
676	250	679	251	682	252	686	253		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	275	.033	346	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

275	346	7	7	7	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
53	110	230

CROSS SECTION INPUT Reach: Little Elk River Station: 993
Description: Stream X-Sectrion 9+93

Station Elevation Data, num = 64

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	5	218	10	217	20	216	28	215

31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	272	204	273	203.6
274	203.2	275	202.8	277	202	282	201.3	285	201.3
285	198.3	290	197	299	196.37	316	197	323	198
328	199	332	200	334	201	338	203	341	204
341	206.75	345	206.75	348	207	360	207	360	206.25
426	207	454	208	490	209	565	210	574	213
575	214	578	215	581	216	583	217	585	220
586	223	589	224	594	225	605	226	614	227
616	228	618	229	620	230	633	238	639	238
645	238	656	239	662	240	669	248	672	249
676	250	679	251	682	252	686	253		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	274	.033	341	.013

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
274	341	11	11	11	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
58	108	230

****

CROSS SECTION INPUT Reach: Little Elk River Station: 982
Description: River X-Section 9+82

Station Elevation Data, num = 59

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	5	218	10	217	20	216	28	215
31	214	33	213	36	212	118	210	126	209
135	208	190	207	234	206	266	204	268	203
270	202	277	201.3	280	201.3	280	198.3	283	198
286	197	303	196.5	318	197	323	198.22	327	199
330	200	332	201	336	203	340	204	340	206.75
344	206.75	347	207	359	207	359	206.25	426	207
454	208	490	209	565	210	574	213	575	214
578	215	581	216	583	217	585	220	586	223
589	224	594	225	605	226	614	227	616	228
618	229	620	230	633	238	639	238	645	238
656	239	662	240	669	248	672	249		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.055	268	.033	340	.013

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

268	340	77	77	77	.1	.3

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
70	85	230	489	581	220	374	414	220

CROSS SECTION INPUT Reach: Little Elk River Station: 905
Description: Stream X-Section 8+54

Station Elevation Data, num = 37

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
40	215	66	214	131	211	160	210	181	209
278	206.92	279	207	283	206	286	205	288	204
291	203	293	202	295	201	299	199	301	198
303	198	348	198	351	198	355	199	358	200
361	201	365	203	369	204	369	206.75	373	206.75
376	207	385	207	468	207	518	209	548	223
569	224	594	225	616	226	626	227	647	229
650	230	670	240						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
40	.06	293	.033	369	.015

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

293	369	51	51	51	.1	.3

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
96	126	230	484	543	220	385	414	220

CROSS SECTION INPUT Reach: Little Elk River Station: 854
Description: Stream X-Section 8+54

Station Elevation Data, num = 44

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
40	215	66	214	131	211	160	210	181	209
278	206.92	279	207	283	206	286	205	288	204
291	203	293	202	295	201	296	199	301	198
304	197.2	318	197.2	341	197.2	348	198	353	199
357	200	364	203	368	204	368	206.95	372	206.95
375	207.1	385	207.1	468	209	518	223	548	224
569	225	587	230	594	231	597	232	600	233
606	234	610	236	616	237	624	238	628	239

631 240 635 250 672 251 678 252

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
40	.06	293	.033	368	.025

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
293	368	77	77	77	.1	.3

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
75	117	230	484	543	220	385	414	220

CROSS SECTION INPUT Reach: Little Elk River Station: 777
Description: Stream X-Section 7+77

Station Elevation Data, num = 55

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
27	219	54	218	84	217	98	216	122	215
138	214	150	213	160	213	163	213	178	213
221	212	301	211	305	210	308	209	310	209.22
312	208	314	207	316	206	318	205	319	204.17
320	203.33	321	202.5	324	200	326	197.33	329	196.36
334	196	360	197	366	198	372	199	378	200
391	203	394	204	394	207.8	398	207.8	401	207.8
428	208	448	208	475	208	478	208	495	208
511	213	523	214	532	215	535	216	539	220
540	221	541	222	542	223	547	223	551	222
563	222	580	231	592	234	597	235	685	255

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
27	.06	321	.033	394	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
321	394	22	22	22	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
90	122	230

CROSS SECTION INPUT Reach: Little Elk River Station: 755
Description: Stream X-Section 7+55

Station Elevation Data, num = 35

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
10	218	14	218	91	217	127	216	197	214
241	213	307	212	317	210	320	207.2	328	206.25
330	202.36	330	196.22	333	196	347	196	363	197
368	198	375	199	390	201	396	203	398	203.7
398	207.45	402	207.45	405	207.7	419	208	424	209
471	209	494	210	517	212	534	222	544	222
560	222	572	228	585	232	590	233	687	254

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
10	.06	330	.033	398	.03

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
330	398	13	13	13	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 742
Description: Stream X-Section 7+42

Station Elevation Data, num = 36

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	219	9	219	15	218	17	217	19	216
45	215	60	215	196	214	293	213	338	212
338	209.22	339	209.22	339	196	351	196	367	197
370	198	376	199	393	201	400	203	409	203.7
409	207.7	412	207.7	422	210.33	507	210	516	211
521	215	523	216	525	217	528	218	537	222
542	222	558	222	569	228	582	232	588	233
685	254								

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.06	339	.021	409	.011

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
339	409	17	17	17	.2	.4

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
339	340	197	408	409	204.7

BRIDGE INPUT Reach: Little Elk River Station: 734
Description: Providence Road Bridge (Bridge #2)
Distance from Upstream XS = 1
Deck/Roadway Width = 15

Weir Coefficient = 2.6
Bridge Deck/Roadway Skew =
Upstream Deck/Roadway Coordinates, num = 4

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
337	211	209.23	338	213.03	209.23	422	210.99	207.19
423	209	207.19						

Downstream Deck/Roadway Coordinates, num = 4

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
324	211	209.27	325	213.07	209.27	426	211	207.2
427	209	207.2						

Elevation at which weir flow begins =
Maximum allowable submergence for weir flow = .95
Submergence criteria :Broad Crested

Number of Bridge Coefficient Sets = 2

Low Flow Methods
Energy
Momentum Cd =
Yarnell KVal = 1.25
W.S. Pro Method CVal =
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Pressure and Weir flow
Submerged Inlet Cd =
Submerged Inlet + Outlet Cd = .8
Max Low Cord =

Low Flow Methods
Energy
Momentum Cd = 2
Yarnell KVal = 1.25
W.S. Pro Method CVal =
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Pressure and Weir flow
Submerged Inlet Cd =
Submerged Inlet + Outlet Cd = .8
Max Low Cord =

Additional Bridge Parameters

Add Friction component to Momentum
Add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the downstream end
Criteria to check for pressure flow = Upstream water surface

CROSS SECTION INPUT Reach: Little Elk River Station: 725
Description: Stream X-Section 7+25

Station Elevation Data, num = 45

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	222	2	221	7	220	20	216	25	215
56	214	61	214	132	214	169	213	192	213
196	213	325	212	338	212	338	196.5	345	196
360	196	372	197	379	198	384	199	402	201
409	203	415	203.55	415	207.55	418	207.6	425	208
426	210	437	209.5	490	209.5	505	210	511	213
514	214	518	215	531	221	533	222	536	222
551	221	553	221	566	228	575	231	581	232
623	242	629	244	637	245	643	246	686	255

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	338	.021	415	.011

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
338	415	69	69	69	.2	.4

Blocked Obstructions, num = 3

Sta L	Sta R	Elev	Sta L	Sta R	Elev	Sta L	Sta R	Elev
67	114	230	338	339	197.5	414	415	204.55

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CROSS SECTION INPUT Reach: Little Elk River Station: 715
Description: Stream X-Section 7+15

Station Elevation Data, num = 45

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	222	2	221	7	220	20	216	25	215
56	214	61	214	132	214	169	213	192	213
196	213	330	212.36	332	202.5	332	196.5	334	196
339	196	357	196	369	197	375	198	400	201
407	203	409	203.83	409	207.25	413	207.25	420	207.5
425	208	437	210	490	209.5	505	210	511	213
514	214	518	215	531	221	533	222	536	222
551	221	553	221	566	228	575	231	581	232

623 242 629 244 637 245 643 246 686 255

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	330	.033	409	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
330	409	69	69	69	.1	.3

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
69	114	230

****

CROSS SECTION INPUT Reach: Little Elk River Station: 646
Description: Stream X-Section 6+46

Station Elevation Data, num = 48

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	226	3	225	7	224	26	216	30	215
33	214	42	213	57	210	65	209	68	208
71	207	136	207	168	206	189	205	210	204
235	203	271	202	322	202	376	199	376	199
379	196.33	395	196.33	405	197.33	408	198.33	417	201.33
440	203.93	440	206.6	444	206.6	448	207	451	208
481	209	500	210	507	213	511	214	514	215
518	216	527	220	549	221	562	228	566	229
570	230	588	234	666	252	668	253	670	254
677	255	680	256	691	257				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	376	.033	440	.05

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
376	440	84	84	84	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 562
Description: Stream X-Section 5+62

Station Elevation Data, num = 59

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	228	4	227	7	226	11	225	16	224
19	223	31	216	40	215	46	214	59	208
64	207	72	206	75	205	79	205	83	206
122	206	130	206	134	206	173	205	189	204

222	203	250	202	290	201	318	201	347	202
351	202	360	201	363	200.33	364	200	367	199
369	198	375	195.46	384	194.17	417	196.69	418	198
419	199	421	200	423	201	425	202	429	203
433	204	434	203.22	437	205	440	206	464	207
467	208	470	209	473	210	479	211	483	211
505	211	507	212	509	213	518	219	528	219
537	219	556	229	559	230	677	249		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	364	.04	421	.06

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
364	421	83	83	83	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 479
Description: Stream X-Section 4+79

Station Elevation Data, num = 53

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
2	222	15	218	28	211	49	210	56	206
59	205	64	205	85	205	89	204	93	203
97	202	100	202	105	203	127	203	143	203
154	203	184	202	217	201	253	200	268	200
283	200	292	200	316	201	342	201	345	200
347	199	349	198	351	195.1	364	193	398	196.74
399	198	400	199	401	200	403	200.16	422	201
430	202	438	203	444	204	470	205	492	209
498	210	507	211	534	212	545	213	552	215
555	216	568	217	579	221	596	222	610	223
622	224	629	225	685	230				

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
2	.08	345	.04	401	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
345	401	14	14	14	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 465
Description: Stream X-Section 4+65

Station Elevation Data, num = 47

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.

0	220	17	214	24	210	36	209	43	208
47	207	50	206	53	205	63	205	73	205
100	204	104	203	108	202	112	201	120	201
122	202	139	202	149	202	164	202	199	201
314	201	334	200.54	338	196.39	339	195	370	192.74
391	196.6	397	196.6	401	200.16	422	201	430	202
438	203	444	204	470	205	492	209	498	210
507	211	534	212	545	213	552	215	555	216
568	217	579	221	596	222	610	223	622	224
629	225	685	230						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	334	.04	401	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
334	401	32	32	32	.1	.3

CROSS SECTION INPUT Reach: Little Elk River Station: 433
Description: Stream X-Section 4+33

Station Elevation Data, num = 70

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
0	220	17	214	24	210	36	209	43	208
47	207	50	206	53	205	63	205	73	205
100	204	104	203	108	202	112	201	120	201
122	202	139	202	149	202	164	202	199	201
314	201	323	201	324	200	326	199	327	198
328	196	329	195	351	195	353	196	356	197
358	197	363	196	368	194	383	194	397	194
401	196.5	418	200	420	198	422	196	432	196
434	198	435	199	436	200	438	201	441	202
457	203	461	204	469	204	475	204	506	205
521	206	530	207	534	208	543	209	557	210
563	211	570	212	577	213	581	214	584	215
591	216	597	217	603	217	610	217	632	218
641	219	655	220	670	221	684	222	701	223

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
0	.08	324	.04	418	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
324	418	20	20	20	.1	.3

Right Levee Station= 418 Elevation= 200

CROSS SECTION INPUT Reach: Little Elk River Station: 413
Description: Stream X-Section 4+13

Station Elevation Data, num = 54

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	285	199	287	198.2	290	197
294	195	295	193.5	300	193.5	308	194.38	313	196.53
329	197.36	340	197.65	355	197.08	361	196.05	369	195.2
401	196.16	402	196.91	402.5	197.29	403	197.67	404	198.42
409	199	411	199	421	200	426	195.9	433	195.9
447	201	460	203	505	204	557	204	579	210
585	212	590	213	595	214	603	215	626	216
645	217	668	218	683	219	699	220		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	285	.04	409	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
285	409	14	14	14	.1	.3

Right Levee Station= 421 Elevation= 200

Blocked Obstructions, num = 1

Sta L	Sta R	Elev
505	557	224

CULVERT INPUT Reach: Little Elk River Station: 406
Description: Downstream Dam (Bridge # 1)
Distance from Upstream XS = 1
Deck/Roadway Width = 12
Weir Coefficient = 2.6
Bridge Deck/Roadway Skew =
Upstream Deck/Roadway Coordinates, num = 5

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
280	197.72	190	318	197.72	190	346	197.72	190
376	197.78	190	415	197.93	190			

Downstream Deck/Roadway Coordinates, num = 8

Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord	Sta.	Hi Cord	Lo Cord
280	198.46	190	319	198.46	190	345	199.04	190
351	200.64	190	358	200.64	190	359	198.8	190

383 198.65 190 430 198.99 190
Elevation at which weir flow begins =
Maximum allowable submergence for weir flow = .95
Submergence criteria :Broad Crested

Number of Culverts = 1

Culvert Name Shape Rise Span
Culvert #1 Box 4.1 4.5
FHWA Chart # 16- Corrugated metal box culvert
FHWA Scale # 1 - 90 degree headwall
Culvert Length n Value Entrance Loss Coef Exit Loss Coef
12 .56 .5 1
Upstream Elevation = 193.6
Centerline Station = 297.5
Downstream Elevation = 193.3
Centerline Station = 293.5

CROSS SECTION INPUT Reach: Little Elk River Station: 399
Description: Stream X-Section 3+99

Station Elevation Data, num = 45

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	280	199	284	197	285	196.67
287	196	288	195.67	290	195	291	193.2	296	193.2
297	198	307	198	310	193.92	336	193.86	354	192.05
386	193.38	426	192.94	428	195.97	430	199	441	200
448	195.8	455	195.8	468	199	479	200	485	202
494	203	544	204	593	204	613	210	653	214

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	280	.04	430	.08

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
280 430 9 9 9 .1 .3
Right Levee Station= 441 Elevation= 200
Blocked Obstructions, num = 1
Sta L Sta R Elev
****
544 593 224

CROSS SECTION INPUT Reach: Little Elk River Station: 390
Description: Stream X-Section 3+90

Station Elevation Data, num = 50

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
1	218	22	209	35	208	40	207	48	205
93	204	112	203	115	202	120	201	123	200
125	200	127	201	130	202	135	202	194	201
215	200	221	200	265	199	269	198	273	197
275	196.33	278	195.33	279	195	280	194.79	293	192.05
307	194	334	194	335	192.05	352	192.05	384	192.5
422	192.94	430	193.71	433	194	435	195.43	436	196.14
436.5	196.49	437	196.85	440	199	457	200	467	198
476	195.7	481	195.7	489	202	497	203	518	203
547	204	622	204	642	210	688	215	735	220

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
1	.08	265	.04	440	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
265	440	390	390	390	.1	.3

Right Levee Station= 457 Elevation= 200
Blocked Obstructions, num = 1

Sta L	Sta R	Elev
547	599	224

****

CROSS SECTION INPUT Reach: Little Elk River Station: 0
Description: Stream X-Section 0+00

Station Elevation Data, num = 52

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
88	225	98	224	105	223	110	222	115	221
119	220	122	219	126	218	130	217	133	216
152	209	155	208	163	207	166	206	172	202
174	200	175	199	178	197	197	196	202	195
204	194	207	193	209	192	210	189	257	189
258	192	264	193	268	194	272	195	283	196
308	196	310	196	328	196	339	196	343	196
352	195	356	194	357	194	379	194	385	195
390	195	395	194	433	194	437	194	464	195
481	195	483	195	485	195	500	195	580	200
930	220	1280	240						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
88	.08	202	.04	272	.08

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
202	272	0	0	0	.1	.3

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SUMMARY OF MANNING'S N VALUES

Reach	River Sta.	n1	n2	n3
Little Elk	2548	.05	.04	.05
Little Elk	1748	.06	.04	.05
Little Elk	1736	.06	.04	.05
Little Elk	1720	.06	.04	.05
Little Elk	1606	.055	.04	.08
Little Elk	1538	.055	.04	.08
Little Elk	1510	.06	.04	.05
Little Elk	1508	.05	.04	.06
Little Elk	1491	Culvert		
Little Elk	1474	.06	.045	.034
Little Elk	1466	.06	.045	.034
Little Elk	1463	.06	.045	.034
Little Elk	1457	.06	.045	.013
Little Elk	1446	.06	.045	.013
Little Elk	1419	.06	.033	.013
Little Elk	1369	.05	.033	.013
Little Elk	1310	.05	.033	.013
Little Elk	1184	.05	.033	.013
Little Elk	1170	.055	.033	.013
Little Elk	1103	.055	.033	.013
Little Elk	1018	.055	.033	.013
Little Elk	1000	.055	.033	.013
Little Elk	993	.055	.033	.013
Little Elk	982	.055	.033	.013
Little Elk	905	.06	.033	.015
Little Elk	854	.06	.033	.025
Little Elk	777	.06	.033	.035
Little Elk	755	.06	.033	.03
Little Elk	742	.06	.021	.011
Little Elk	734	Bridge		

*Little Elk *	725	*	.08*	.021*	.011*
*Little Elk *	715	*	.08*	.033*	.05*
*Little Elk *	646	*	.08*	.033*	.05*
*Little Elk *	562	*	.08*	.04*	.06*
*Little Elk *	479	*	.08*	.04*	.08*
*Little Elk *	465	*	.08*	.04*	.08*
*Little Elk *	433	*	.08*	.04*	.08*
*Little Elk *	413	*	.08*	.04*	.08*
*Little Elk *	406	*	Culvert*	*	*
*Little Elk *	399	*	.08*	.04*	.08*
*Little Elk *	390	*	.08*	.04*	.08*
*Little Elk *	0	*	.08*	.04*	.08*

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SUMMARY OF REACH LENGTHS

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* Reach	* River Sta.	* Left	* Channel*	Right *
*Little Elk *	2548	* 800*	800*	800*
*Little Elk *	1748	* 12*	12*	12*
*Little Elk *	1736	* 16*	16*	16*
*Little Elk *	1720	* 114*	114*	114*
*Little Elk *	1606	* 68*	68*	68*
*Little Elk *	1538	* 28*	28*	28*
*Little Elk *	1510	* 2*	2*	2*
*Little Elk *	1508	* 34*	34*	34*
*Little Elk *	1491	* Culvert*	*	*
*Little Elk *	1474	* 8*	8*	8*
*Little Elk *	1466	* 3*	3*	3*
*Little Elk *	1463	* 6*	6*	6*
*Little Elk *	1457	* 11*	11*	11*
*Little Elk *	1446	* 27*	27*	27*
*Little Elk *	1419	* 50*	50*	50*
*Little Elk *	1369	* 59*	59*	59*
*Little Elk *	1310	* 126*	126*	126*
*Little Elk *	1184	* 14*	14*	14*
*Little Elk *	1170	*66.99999*	66.99999*	66.99999*
*Little Elk *	1103	*84.99999*	84.99999*	84.99999*
*Little Elk *	1018	* 18*	18*	18*
*Little Elk *	1000	* 7*	7*	7*
*Little Elk *	993	* 11*	11*	11*
*Little Elk *	982	* 77*	77*	77*

*Little Elk *	905 *	51*	51*	51*
*Little Elk *	854 *	77*	77*	77*
*Little Elk *	777 *	22*	22*	22*
*Little Elk *	755 *	13*	13*	13*
*Little Elk *	742 *	17*	17*	17*
*Little Elk *	734 *	Bridge*	*	*
*Little Elk *	725 *	69*	69*	69*
*Little Elk *	715 *	69*	69*	69*
*Little Elk *	646 *	84*	84*	84*
*Little Elk *	562 *	83*	83*	83*
*Little Elk *	479 *	14*	14*	14*
*Little Elk *	465 *	32*	32*	32*
*Little Elk *	433 *	20*	20*	20*
*Little Elk *	413 *	14*	14*	14*
*Little Elk *	406 *	Culvert*	*	*
*Little Elk *	399 *	9*	9*	9*
*Little Elk *	390 *	390*	390*	390*
*Little Elk *	0 *	0*	0*	0*

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SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

Reach	River Sta.	Contr.	Expan.
*Little Elk *	2548 *	.1*	.3*
*Little Elk *	1748 *	.1*	.3*
*Little Elk *	1736 *	.1*	.3*
*Little Elk *	1720 *	.1*	.3*
*Little Elk *	1606 *	.1*	.3*
*Little Elk *	1538 *	.1*	.3*
*Little Elk *	1510 *	.1*	.3*
*Little Elk *	1508 *	.1*	.3*
*Little Elk *	1491 *	Culvert*	*
*Little Elk *	1474 *	.1*	.3*
*Little Elk *	1466 *	.1*	.3*
*Little Elk *	1463 *	.1*	.3*
*Little Elk *	1457 *	.1*	.3*
*Little Elk *	1446 *	.1*	.3*
*Little Elk *	1419 *	.1*	.3*
*Little Elk *	1369 *	.1*	.3*
*Little Elk *	1310 *	.1*	.3*

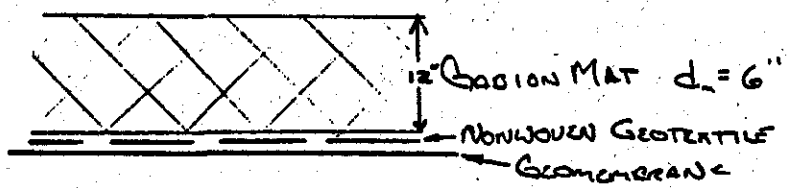
*Little Elk *	1184	*	.1*	.3*
*Little Elk *	1170	*	.1*	.3*
*Little Elk *	1103	*	.1*	.3*
*Little Elk *	1018	*	.1*	.3*
*Little Elk *	1000	*	.1*	.3*
*Little Elk *	993	*	.1*	.3*
*Little Elk *	982	*	.1*	.3*
*Little Elk *	905	*	.1*	.3*
*Little Elk *	854	*	.1*	.3*
*Little Elk *	777	*	.1*	.3*
*Little Elk *	755	*	.1*	.3*
*Little Elk *	742	*	.2*	.4*
*Little Elk *	734	*	Bridge*	*
*Little Elk *	725	*	.2*	.4*
*Little Elk *	715	*	.1*	.3*
*Little Elk *	646	*	.1*	.3*
*Little Elk *	562	*	.1*	.3*
*Little Elk *	479	*	.1*	.3*
*Little Elk *	465	*	.1*	.3*
*Little Elk *	433	*	.1*	.3*
*Little Elk *	413	*	.1*	.3*
*Little Elk *	406	*	Culvert*	*
*Little Elk *	399	*	.1*	.3*
*Little Elk *	390	*	.1*	.3*
*Little Elk *	0	*	.1*	.3*

****

APPENDIX C

DESIGN CALCULATIONS

CALCULATION OF VELOCITY BENEATH GABION MAT



RESIDUAL VELOCITY ON BED (BENEATH GABION MAT) = V_b

$$V_b = \frac{1}{n_F}\left(\frac{d_m}{2}\right)^{2/3} i \quad \text{(MacCaferri)}$$

WHERE:

n_F = MANNINGS COEFFICIENT = 0.020

d_m = AVERAGE DIMENSION OF ROCK = 0.5 ft

i = CHANNEL SLOPE = 0.0043 ft/ft

$$V_b = \left(\frac{1}{0.020}\right)\left(\frac{0.5\ ft}{2}\right)^{2/3}(0.0043)^{1/2}$$

$$V_b = 1.3\ fps$$

ALTHOUGH A GEOMEMBRANE AND GROUNDWATER COLLECTION SYSTEM, THE BED VELOCITY CAN BE COMPARED TO THE ALLOWABLE VELOCITY DERIVED FROM THE FOLLOWING EQUATION

$$V_c = (16.1)(d)^{1/2}$$

WHERE d = SOIL PARTICLE SIZE IN FT

SHEET 1 OF 2	PROJECT NO. 95-228-02	PROJECT NAME GALAXY SPECTRON CHANNEL LINING
BY PGS	DATE 7/24/96	DESCRIPTION GABION STABILITY CALCULATIONS
CHK. BY TDt	DATE 10-6-96	

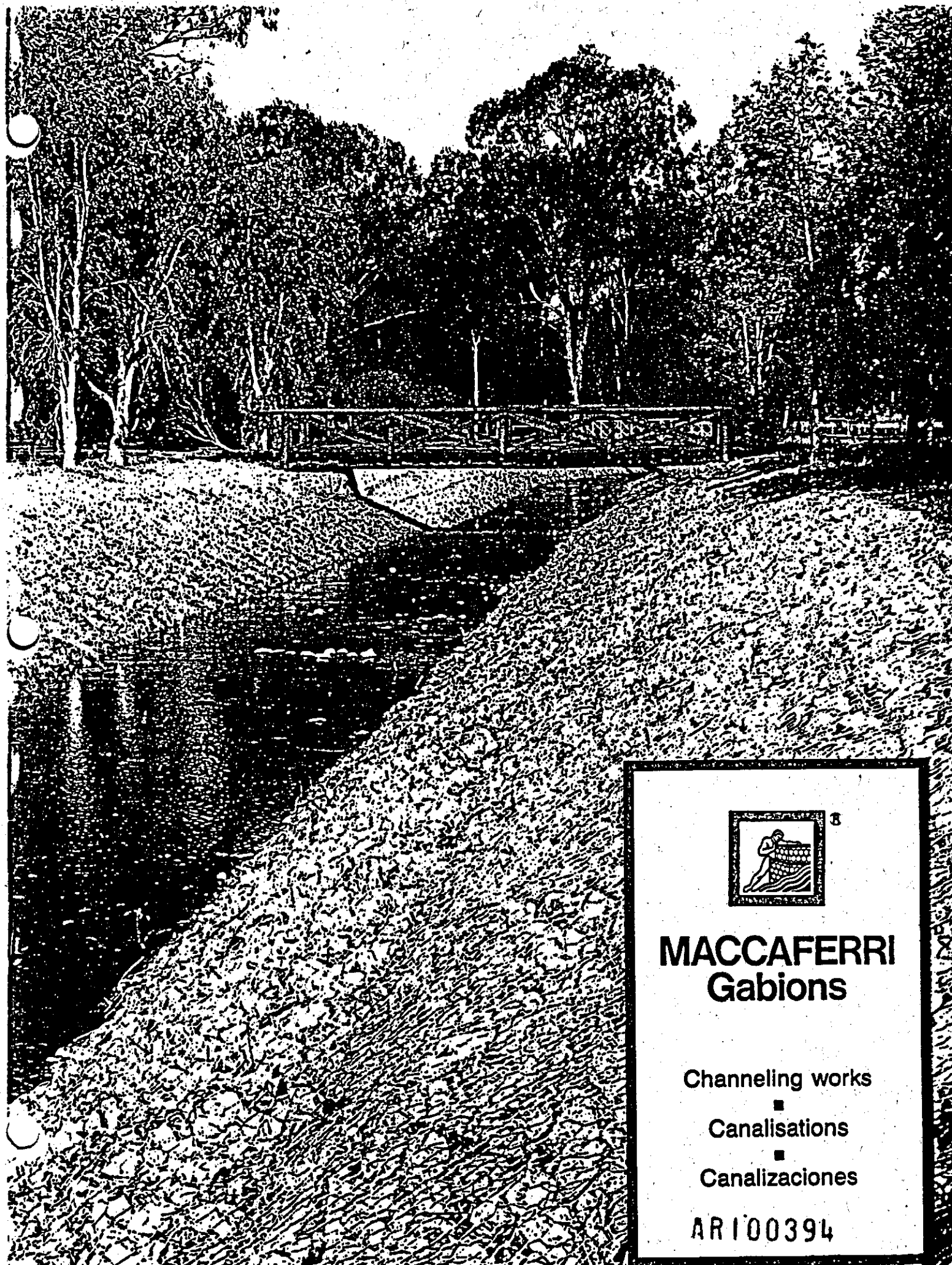
CALCULATION OF VELOCITY BENEATH GABION MAT (Cont.)

FOR THIS EVALUATION OF CRITICAL VELOCITY ASSUME THAT STREAM BED IS COARSE SAND OR $d > 2.0$ mm = 0.006654

THEREFORE $V_c = (16.1)(0.0066 ft)^{1/2}$

$V_c = 1.3$ fps

AS SHOWN, $V_b = V_c$ THEREFORE, EVEN WITHOUT A GEOMEMBRANE LAYER, THE STREAM BED (WHICH IS COMPRISED OF GRAVEL, COBBLES AND BOULDERS) WOULD BE STABLE.



MACCAFERRI Gabions

Channeling works

▪

Canalisations

▪

Canalizaciones

AR100394

"Critical velocity" is the velocity at which the revetment will remain stable without movement of the fill, while «limit velocit» is that which is still acceptable although there is some deformation of the Reno mattress due to movement of the stones within the compartments (table 2).
It is essential for the longevity of the revetment that the mesh be protected against corrosion: Reno mattresses and gabions are therefore manufactured from meshes with a heavy zinc coating which complies with the strictest international standards.
However, when the lining is subjected to polluted or aggressive water, the risk of corrosion is increased, and Reno mattress and/or gabions made from wire which has been coated with both zinc and PVC, offering high resistance to chemicals, abrasion and ageing, should be used.

On entend par «vitesse critique» la vitesse maximale supportable par le revêtement sans provoquer le déplacement de la pierraille de remplissage et par «vitesse limite» celle, encore acceptable, qui engendre de légères déformations dues à l'entassement de la pierraille dans le matelas Reno (tableau 2).
Nous fournissons ici aussi le tableau 3 qui montre quelques valeurs indicatives de la vitesse limite au fond des cours d'eau naturels.
La protection du grillage contre la corrosion est d'une importance vitale pour la durée du revêtement; c'est pourquoi les matelas Reno et les gabions sont constitués d'un grillage métallique galvanisé conformément aux plus sévères normes internationales.
Toutefois, nous conseillons en présence d'eaux polluées, ou de toute façon agressives, c'est-à-dire là où la corrosion est particulièrement forte, de recourir aux matelas Reno et/ou aux gabions galvanisés sous gaine PVC, insensibles aux attaques chimiques, aux phénomènes d'abrasion et à l'usure.

Por «velocidad crítica» se entiende la velocidad máxima que puede soportar el revestimiento sin que se produzcan movimientos de las piedras en el interior del colchón y, por «velocidad límite», la velocidad, aún aceptable, que determina deformaciones reducidas debido al amontonamiento de las piedras en el colchón Reno (tabla 2).
Para mayor comodidad, se agrega la tabla 3 con algunos valores indicativos de la velocidad límite en el fondo de los cursos de agua naturales.
La protección de la red contra la corrosión es de vital importancia para la duración del revestimiento; por esta razón, los colchones Reno y los gaviones están formados por una red metálica fuertemente galvanizada, en conformidad con las más rigurosas normas internacionales.
Sin embargo, en el caso de aguas contaminadas o corrosivas, es decir, donde el problema de la corrosión es más agudo, es aconsejable la utilización de colchones Reno y/o gaviones galvanizados y revestidos con una capa de PVC altamente resistente a los agentes químicos, los fenómenos abrasivos y al envejecimiento.

Tab. 2 - Indicative Reno mattress and gabion thicknesses in relation to water velocities

Tab. 2 - Epaisseurs approximatives des revêtements en matelas Reno et en gabions en fonction de la vitesse du courant

Tab. 2 - Espesores indicativos de los revestimientos en colchones Reno y en gaviones en función de la velocidad de la corriente

Type Type Tipo	Thickness Epaisseur Espesor m	Filling stones Pierraille de remplissage Pedrisco de relleno Stone size Granulométrie Dimensiones mm	d_{50}	Critical velocity (*) Vitesse critique (*) Velocidad crítica (*) m/s	Limit velocity (*) Vitesse limite (*) Velocidad límite (*) m/s
Reno mattresses Matelas Reno Colchones Reno	0.15-0.17	70-100	0.085	3.5	4.2
		70-150	0.110	4.2	4.5
	0.23-0.25	70-100	0.085	3.8	5.5
		70-150	0.120	4.5	6.1
	0.30	70-120	0.100	4.2	5.5
		100-150	0.125	5.0	6.4
Gabions Gabions Gaviones	0.50	100-200	0.150	5.8	7.6
		120-250	0.190	6.4	8.0

(*) The values of velocity reported were obtained experimentally for Froude numbers ≤ 1 (see pag. 33); values > have to be intended purely indicative and approximated.

(*) Les valeurs des vitesses indiquées sont tirées expérimentalement des nombres de Froude ≤ 1 (voir page 33); les valeurs > 1 sont purement indicatives.

(*) Los valores de velocidad indicados han sido calculados experimentalmente para números de Froude ≤ 1 (pág. 33); para valores > 1, deben considerarse como puramente indicativos y muy en general.

Tab. 3 - Limiting velocities at bed level for various soils

Tab. 3 - Valeurs indicatives de vitesse limite au fond

Tab. 3 - Valores indicativos de la velocidad límite en el fondo

Bed material / Matériaux constituant le lit / Material del cauce			Velocity / Vitesse / Velocidad m/s	
			A	B
Fine sand. (*)	Sable fin(*)	Arena fina	0.45	0.75
Sandy clay. (*)	Terrain argileux-sablonneux (*)	Terreno arcilloso-arenoso	0.55	0.75
Soft clays	Terrain argileux-vaseux	Terreno arcilloso-limoso	0.60	0.90
Mude	Limons normaux	Limos normales	0.75	1.05
Coarse sand	Gravier fin	Grava fina	0.75	1.50
Medium clay	Argile compacte	Arcilla compacta	1.15	1.50
Gravel	Gravier ordinaire	Grava gruesa	1.20	1.85
Shingle	Cailloux et galets	Guijarros y pedrisco	1.50	1.70
Hard clay	Schistes argileux	Arcillas-esquistosas	1.85	1.85

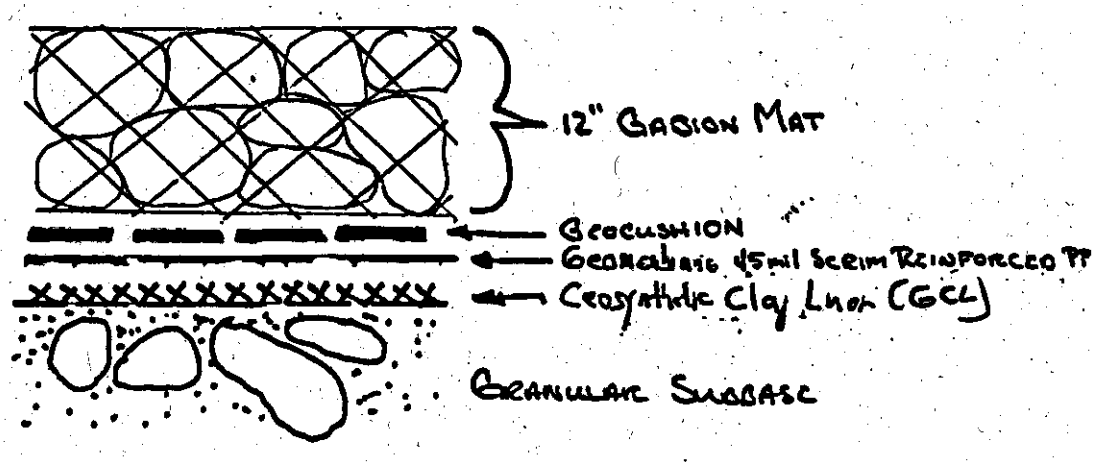
A = No material carried in suspension
B = Colloidal material carried in suspension
(*) = Non-colloidal

A = Courant sans transport de matériau colloïdal
B = Courant avec transport de matériau colloïdal en suspension
(*) = Non colloïdal

A = Sin transporte de material coloidal
B = Con transporte de material coloidal
(*) = No coloidal

GEOMEMBRANE CALCULATIONS

PROPOSED LINER CROSS-SECTION



CALCULATION OF WATER VAPOR TRANSMISSION 8

The following calculation determines the water transmission from above the liner to below the liner. This calculation assumes that the maximum depth of water on the liner will be less than 12 inches. Although under high flow conditions, the depth of water will be greater; this greater depth will only be a temporary condition. The following W.V.T calculation has been based on this assumption.

CALCULATION OF WATER VAPOR TRANSMISSION (cont.)

KNOWN: MANUFACTURERS WVT VALUE FOR 45 mil PPL = 0.08 g/m²/d.

OR $k_{pseudo} = 2 \times 10^{-13}$ cm/sec.

MAXIMUM FLUID HEAD = 12 INCHES

MAXIMUM WATER LEAKAGE

$$Q = k_{pseudo}\, i\, A = k_{pseudo} \frac{\Delta H}{t} A$$

$$Q = (2.0 \times 10^{-13}\ \text{cm/s})\left(\frac{\text{ft}}{30.48\ \text{cm}}\right)\left(\frac{86{,}400\ \text{sec}}{\text{day}}\right)\left(\frac{12''}{.045''}\right)\left(\frac{43560\ \text{ft}^2}{\text{Acre}}\right)$$

$$Q = 0.007\ \text{ft}^3/\text{acre-day}\ (7.48\ \text{gal/ft}^3)$$

$$Q = 0.05\ \text{gal/acre-day}$$

RELATIVE TO DE MINIMUS LEAKAGE (1 gal/Acre-day)

$$Q = 0.05\ \text{gal/acre-day} \ll 1\ \text{gal/Acre-day}$$

FACTOR OF SAFETY

$$FS = Q_{allowable}/Q_{actual} = 1.0/0.05$$

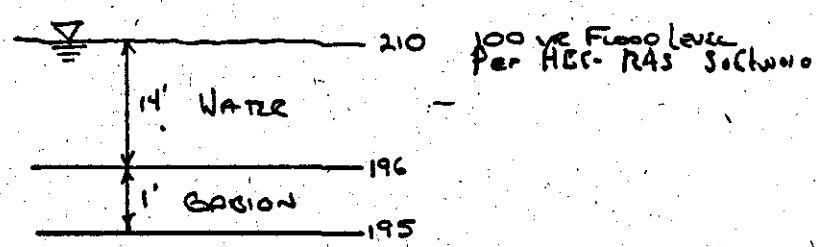
$$FS = 20.0$$

REFERENCES: RICHARDSON G.N. AND KOERNER, R.M. (1988) GEOSYNTHETIC DESIGN GUIDANCE FOR HAZARDOUS WASTE LANDFILL CELLS AND SURFACE IMPOUNDMENTS

AR100397

PUNCTURE RESISTANCE

PUNCTURE RESISTANCE HAS BEEN EVALUATED ASSUMING FLOOD-LEVELS EQUAL TO THE 100 YEAR FLOOD PLAN.



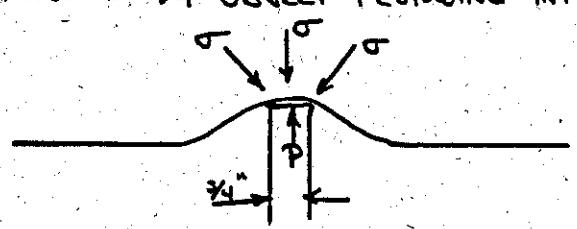
OVERBURDEN LOAD $\sigma_v = \sum_{i=1}^{n} H_i V_i$

$\sigma_v = (15\ ft)(62.4\ pcf) + (1\ ft)(140\ pcf)$

$\sigma_v = 1{,}076\ psf$

PUNCTURE FORCE APPLIED

ASSUME 3/4 OBJECT PROTRUDING INTO GEOMEMBRANE



$P = \sigma A = \sigma\ \tfrac{1}{4}\pi D^2$

$P = (1{,}076\ psf)\left(\tfrac{1}{4}\pi(3/4)^2\right)\left(1\ ft^2/144\ in^2\right)$

$P = 3.3\ lbs$

AR100398

Puncture Resistance (cont.)

Puncture Resistance of Geomembrane, $T_{Punc} \geq 185$ lbs *

*Based on Manufacturer's Published Values

$$FS = T_{Punc} / P = 185 \text{ lbs} / 3.3 \text{ lbs} = 56$$

AR100399

ADVANCED GEOSERVICES CORP.

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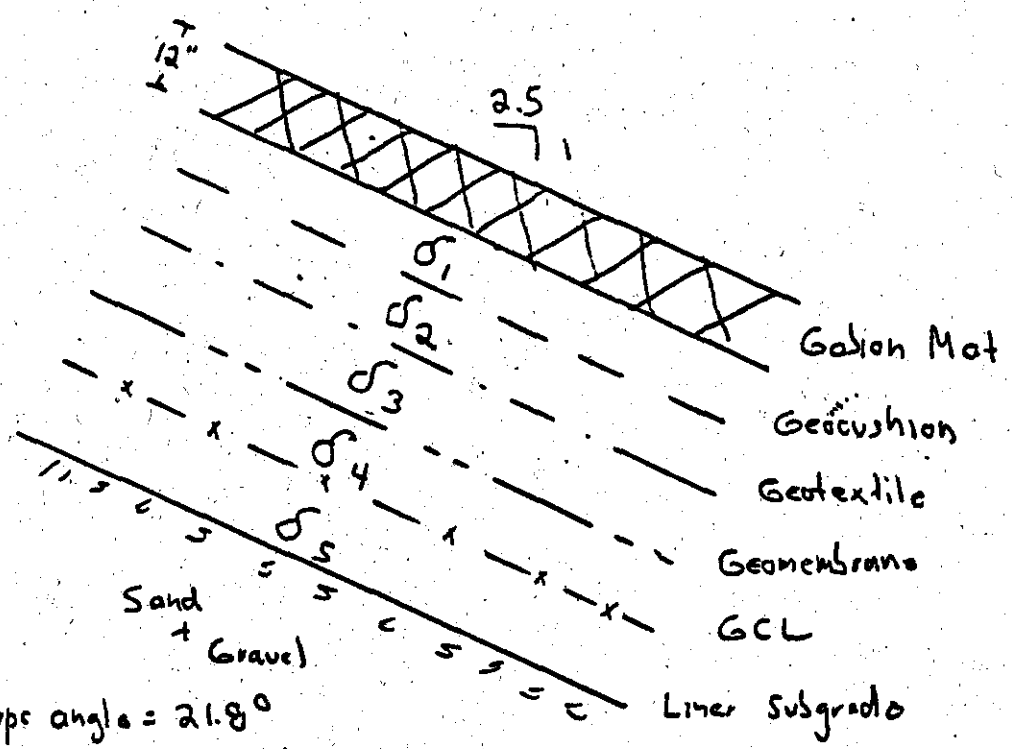
Calculation of Gabion Mat Stability



Slope angle = 21.8°

Slope Length 20' (Worst Case)

- Assumptions

Geosynthetic Interface Friction Angles

		Typical Range	Value Used
Gabion Mat to Geocushion	δ_1	Not Available	Assumed to act as one
Geocushion to Geotextile	δ_2	Not Available	Assumed to act as
Geotextile to Geomembrane	δ_3	12° to 18°	12°
Geomembrane to GCL	δ_4	12° to 18°	12°
GCL to Soil	δ_5	18° to 20°	18°
Soil Friction Angle	ϕ	28° to 34°	32°

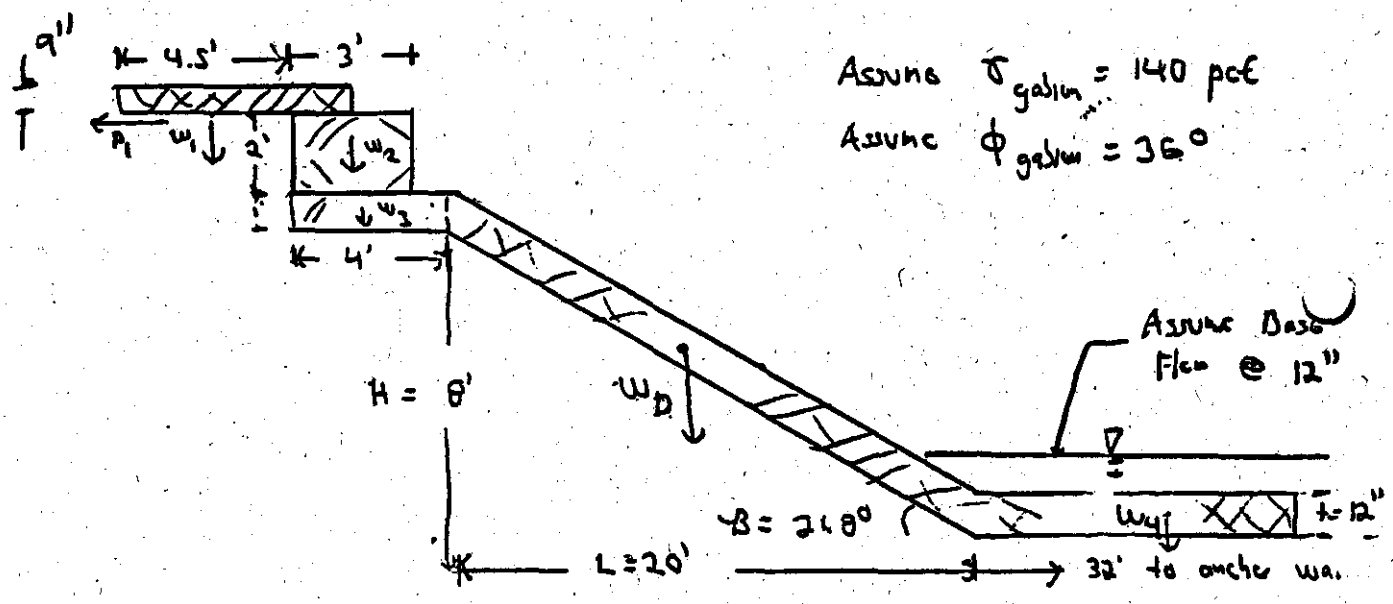
AR100408

SHEET 1 OF 1 PROJECT NO. 95-228-05 PROJECT NAME Galaxy / Spectron
BY TDT DATE 3/12/98 DESCRIPTION Gabion Mat Stability
CHK. BY DATE

Calculation of Gabion Mat Stability (Cont)

The liner system will be evaluated to determine the factor of safety against the sliding of the gabion mat. The gabion mat will slide if the passive resistance of the weakest interface is exceeded. The weakest interface is σ_3 and σ_4.

- Evaluating slope along site-side of creek. Assume lowest wall



Assume γ_{gabion} = 140 pcf
Assume ϕ_{gabion} = 36°

- Driving Force (W_D)

$$W_D = \left(\frac{H}{\sin\beta}\right)(t)(\gamma_{gabion}) = \underline{3{,}016 \text{ lb/ft width}}$$

- Passive Force from W_1

$$P_{W_1} = (6')(0.75')(140 \text{ pcf})(\tan 12°) = \underline{134 \text{ lb/ft width}}$$

- Passive Force from W_D

$$P_{W_D} = (3{,}016)(\cos 21.8°)(\tan 12°) = \underline{595 \text{ lb/ft width}}$$

AR100401

Calculation of Gabion Mat Stability (Cont)

- Passive Force From W_2

$$Pw_2 = (2')(3')(140\ pcf)(\tan 12°) = \underline{179\ lb/ft\ width}$$

- Passive Force From W_3

$$Pw_3 = (1')(4')(140\ pcf)(\tan 12°) = \underline{119\ lb/ft\ width}$$

- Passive Force From W_4

$$Pw_4 = (32')(1')(140\ pcf - 62.4\ pcf)\tan 12° + (62.4\ pcf)(2')(\tan 12°)$$

$$\underline{Pw_4 = 554\ lb/ft\ width}$$

or

$$Pw_4 = (0.5)(1')^2(140\ pcf - 62.4\ pcf)\left(\frac{1+\sin 36°}{1-\sin 36°}\right) + (0.5)(62.4\ pcf)(2')^2$$

$$\underline{Pw_4 = 212\ lb/ft\ width}$$

- Factor of Safety Against Sliding ($Pw_4 = 270\ lb/ft\ width$)

$$F.S. = \frac{\Sigma\ Resisting\ Forces}{\Sigma\ Opposing\ Forces}$$

$$F.S. = \frac{(Pw_1 + Pw_2 + Pw_3 + Pw_4)\cos 21.8° + Pw_D}{W_D \sin 21.8}$$

$$\boxed{F.S. = 1.0 \quad \text{Marginal}}$$

- Factor of Safety Against Sliding ($Pw_4 = 554\ lb/ft\ width$)

$$\boxed{F.S. = 1.3 \quad \text{ok}}$$

AR100402

Gabion Wall Stability Calculations

The following calculations evaluate the stability of the proposed gabion walls along the west and east creek banks.

Assumptions

$\gamma_{soil} = 125$ pcf

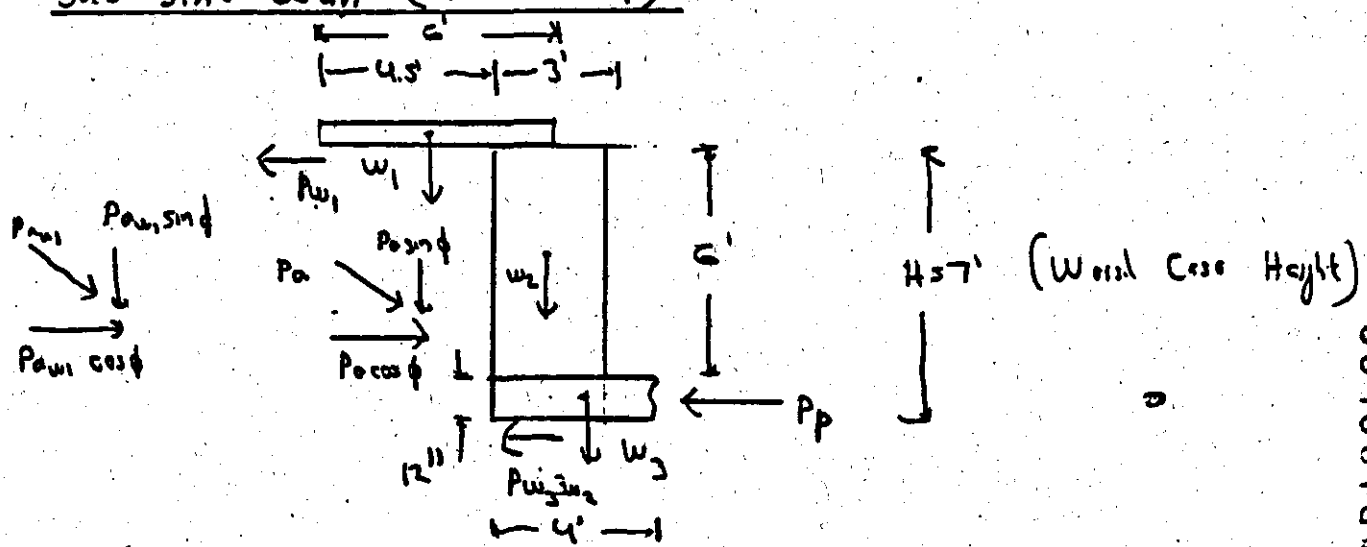
$\phi_{soil} = 32°$

$\gamma_{gabion} = 140$ pcf

$\phi_{gabion} = 36°$

No Better of Gabion Baskets

Site Side Wall (West Bank)



AR100403

SHEET 1 OF 6 PROJECT NO. 95.228-03 PROJECT NAME Galaxy / Spectrum
BY TDT DATE 3/12/98 DESCRIPTION Gabion Wall Calculations
CHK. BY DATE

Gabion Wall Stability Calculations (cont)

- Calculating Earth Pressures

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = 0.31$$

$$P_a = \frac{1}{2}\gamma_{soil} H^2 K_a = 941 \text{ lb/ft wall}$$

$$P_a \cos\phi = 798 \text{ lb/ft wall}$$

$$P_a \sin\phi = 499 \text{ lb/ft wall}$$

- Calculating Surcharge Pressure

$$P_{a_{w1}} = (0.75')(140 \text{ pcf})(7') = 735 \text{ lb/ft wall}$$

$$P_{a_{w1}} \cos\phi = 623 \text{ lb/ft wall}$$

$$P_{a_{w1}} \sin\phi = 389 \text{ lb/ft wall}$$

- Calculating Wall Weight

$$w_1 = (0.75')(140 \text{ pcf})(6') = 630 \text{ lb/ft wall}$$

$$w_2 = (6')(3')(140 \text{ pcf}) = 2{,}520 \text{ lb/ft wall}$$

$$w_3 = (4')(1')(140 \text{ pcf}) = 560 \text{ lb/ft wall}$$

Calculating Passive Pressure

$$K_p = \frac{1+\sin\phi}{1-\sin\phi} = 3.9$$

$$P_p = \left[\frac{1}{2}\gamma_{gabion} H^2 K_p\right] \cos 21.8^\circ = 250 \text{ lb/ft wall}$$

AR100404

- Factor of Safety Against Sliding

$$F.S. = \frac{\Sigma \text{ Resisting Forces}}{\Sigma \text{ Opposing Forces}}$$

$$F.S. = \frac{P_p + (W_1 + W_2 + W_3)\tan 12^\circ + (P_a \sin\phi \tan 12^\circ + P_{a_{w_1}} \sin\phi \tan 12^\circ)\tan 12^\circ}{P_a \cos\phi + P_{a_{w_1}} \cos\phi}$$

$$F.S. = \frac{1{,}078}{1{,}421} = 0.75$$

$\boxed{F.S. = 0.75 \text{ No Good}}$

- Factor of Safety Against Overturning

$$F.S. = \frac{\Sigma \text{ Resisting Moments}}{\Sigma \text{ Opposing Moments}}$$

$$F.S. = \frac{(W_1)(4.5) + (W_2)(1.5) + (W_3)(2') + (W_1 \tan 12^\circ)(7')}{(P_a \cos\phi)(2.33') + (P_{a_{w_1}} \cos\phi)(3.5')}$$

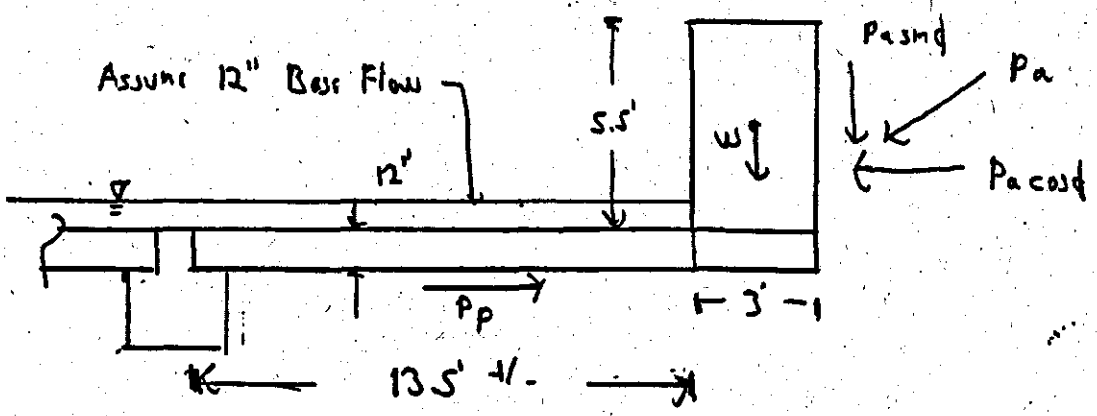
$\boxed{F.S. = 2.1 \text{ ok}}$

Wall Fails in sliding. Additional calculations and design modifications will be issued as an addendum to the 100% Design Report.

AR100405

East Bank Wall

Excluding Providence Road Bridge, the worst case wall is 6.5' high



- Calculating Active Pressures

From Before; $K_a = 0.31$

$P_a = \frac{1}{2}\gamma_{soil} H^2 K_a = (\frac{1}{2})(125)(6.5)^2(0.31) = 811$ lb/ft wall

$P_a \sin\phi = (811)(\sin 32°) = 430$ lb/ft·wall

$P_a \cos\phi = (811)(\cos 32°) = 688$ lb/ft·wall

- Calculating Passive Pressures

From Before; $K_p = 3.9$

$P_p = \frac{1}{2}\gamma_{gabion} H^2 K_p + \frac{1}{2}\gamma_{water} H^2$

$P_p = (\frac{1}{2})(140-62.4)(1)^2(3.9) + (0.5)(62.4)(2)^2 = 276$ lb/ft w

or

$P_p = [(140-62.4)(1) + (62.4)(2')](+3.5')(\tan 12°) = 581$ lb/ft

AR100406

- Wall Weight

$$W = (6.5')(3')(140\ pcf) = 2730\ lb/ft\ wall$$

- Factor of Safety Against Sliding

$$F.S. = \frac{(W \tan 12^\circ) + (P_a \sin\phi \tan 12^\circ) \tan 12^\circ + P_p}{P_a \cos\phi}$$

For $P_p = 276$ lb/ft wall

$$\boxed{F.S. = 1.3 \quad ok}$$

For $P_p = 581$ lb/ft wall

$$\boxed{F.S. = 1.7 \quad ok}$$

- Factor of Safety Against Overturning

$$F.S. = \frac{(W)(1.5')}{(P_a \cos\phi)(2.2')} =$$

$$\boxed{F.S. = 2.7 \quad ok}$$

AR100407

- Factor of Safety Against Sliding (Ignoring Passive Pressure)

$$F.S. = \frac{(W \tan 12^\circ) + (P_a \sin\phi \tan 12^\circ) \tan 12^\circ}{P_a \cos\phi}$$

$$\boxed{F.S. = 0.87 \quad \text{Not Good}}$$

Wall will fail if passive pressures are ignored. Addition calculations and design will be provided as an addendum to the 100% Design Report.

East Bank Wall At Providence Road Bridge

Additional calculations and design will be provided as an addendum to the 100% Design Report for details regarding the gabion wall around the bridge.

AR100408

Collection System Geotextile Design Calculations

The collection system beneath the liner will consist of a perforated pipe surrounded by Coarse Aggregate (3/4 inches to 2 inches). This aggregate will be wrapped in a geotextile filter fabric.

Assumptions:

1. The drainage system is designed to collect water. Therefore, it is imperative that the geotextile not become clogged. The design will favor permeability.
2. Flow conditions will be steady-state and uni-direction
3. Effective confining stress on the geotextile will be low due to the shallow depth of the collection system

⇒ Soil Retention Requirements

Based on test borings performed at the site, the overburden material generally consists of a fine sand with some gravel and silt.

Three sediment samples were obtained during the pre-design investigation for grain-size analysis. The following are the results of this testing:

SA-1

Gravel: 53%
Sand: 44%
Fines: 3%

SA-3

Gravel: 12%
Sand: 83%
Fines: 5%

SA-2

Gravel: 61%
Sand: 35%
Fines: 4%

These samples were obtained from the upper 6 inches of sediment in the Elk Creek with a sampling trowel; therefore, the percent fines may be low.

AR100409

From the attached grain-size distribution curves, the follow Linear Coefficients of Uniformity were determined:

$$C_u' = \sqrt{\frac{d_{100}'}{d_0'}}$$

SA-1

$$C_u' = \sqrt{\frac{200}{0.2}} = 31.6 \; ; \quad d_{50}' = 6.9 \text{ mm}$$

SA-2

$$C_u' = \sqrt{\frac{200}{0.59}} = 18.4 \; ; \quad d_{50}' = 10.0 \text{ mm}$$

SA-3

$$C_u' = \sqrt{\frac{10}{0.41}} = 4.9 \; ; \quad d_{50}' = 2.0 \text{ mm}$$

Addition grain-size analysis testing was performed by ERM for the FRI. The samples used for this testing were taken at depths ranging from 8' to 12' from test borings performed at the site. A review of the test boring logs indicates that these samples are natural overburden materials. The depths of these samples correspond to about 2' to 6' below the elevation of the stream bed.

The results of this testing is summarized below:

Gravel:	3.2%	to 32%
Sand:	44.2%	to 61.2%
Silt:	9.9%	to 34.8%
Clay:	4.7%	to 20.9%

These results indicate that the fines (silt and clay) are non-plastic.

AR100410

From the attached grain-size distribution curves, the following Linear Coefficients of Uniformity were determined:

$$Cu' = \sqrt{\frac{d'_{100}}{d'_0}}$$

Top-1 (8.0')

$$Cu' = \sqrt{\frac{0.85}{0.03}} = 5.3 \quad ; \; d'_{50} = 0.17 \text{ mm}$$

Top-1 (10.0')

$$Cu' = \sqrt{\frac{5.0}{0.007}} = 26.7 \quad ; \; d'_{50} = 0.17 \text{ mm}$$

Top-2 (8.0')

$$Cu' = \sqrt{\frac{0.5}{0.028}} = 4.2 \quad ; \; d'_{50} = 0.12 \text{ mm}$$

Top-2 (10.0')

$$Cu' = \sqrt{\frac{10.0}{0.055}} = 13.5 \quad ; \; d'_{50} = 0.75 \text{ mm}$$

Top-3 (10.0')

$$Cu' = \sqrt{\frac{0.8}{0.008}} = 10.0 \quad ; \; d'_{50} = 0.08 \text{ mm}$$

Top-3 (12.0')

$$Cu' = \sqrt{\frac{100}{0.01}} = 100.0 \quad ; \; d'_{50} = 1.0 \text{ mm}$$

AR100411

Finding the average Cu' by dropping the high and the low Cu'

$$Cu' = \frac{4.9 + 18.4 + 31.6 + 5.3 + 26.7 + 13.5 + 10.0}{7}$$

Use $Cu' = 15.8$

Assuming low confining stress

$$O_{95} \leq \frac{9}{Cu'} d'_{50}$$

Considering that the overburden soils are predominantly sand, the average d_{50} was found from the range of d_{50}' between 5 mm and 0.08 mm

$$d_{50}' = \frac{2.0 + 0.17 + 0.17 + 0.12 + 0.75 + 0.08 + 1.0}{7}$$

Use $d_{50}' = 0.61$ mm

$$O_{95} \leq \frac{9}{15.8}(0.61)$$

$$O_{95} \leq 0.35 \text{ mm}$$

Maximum Allowable Opening Size = O_{95} = 0.35 mm
U.S. Sieve 50

AR100412

⇒ Permeability Requirements

ERM determined the following range of permeability (K) for the overburden soils:

- $K = 3.6 \times 10^{-7}$ ft/sec
- $K = 9.3 \times 10^{-5}$ ft/sec
- $K = 1.0 \times 10^{-4}$ ft/sec
- $K = 8.2 \times 10^{-6}$ ft/sec
- $K = 2.5 \times 10^{-6}$ ft/sec
- $K = 6.8 \times 10^{-5}$ ft/sec

Droping the high and low and finding the average

$$K_{overburden} = \frac{9.3 \times 10^{-5} + 8.2 \times 10^{-6} + 2.5 \times 10^{-6} + 6.8 \times 10^{-5}}{4}$$

Use $K_{overburden} = 4.3 \times 10^{-5}$ ft/sec

$$4.3 \times 10^{-5} \text{ ft/sec} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \equiv 1.3 \times 10^{-3} \text{ cm/sec}$$

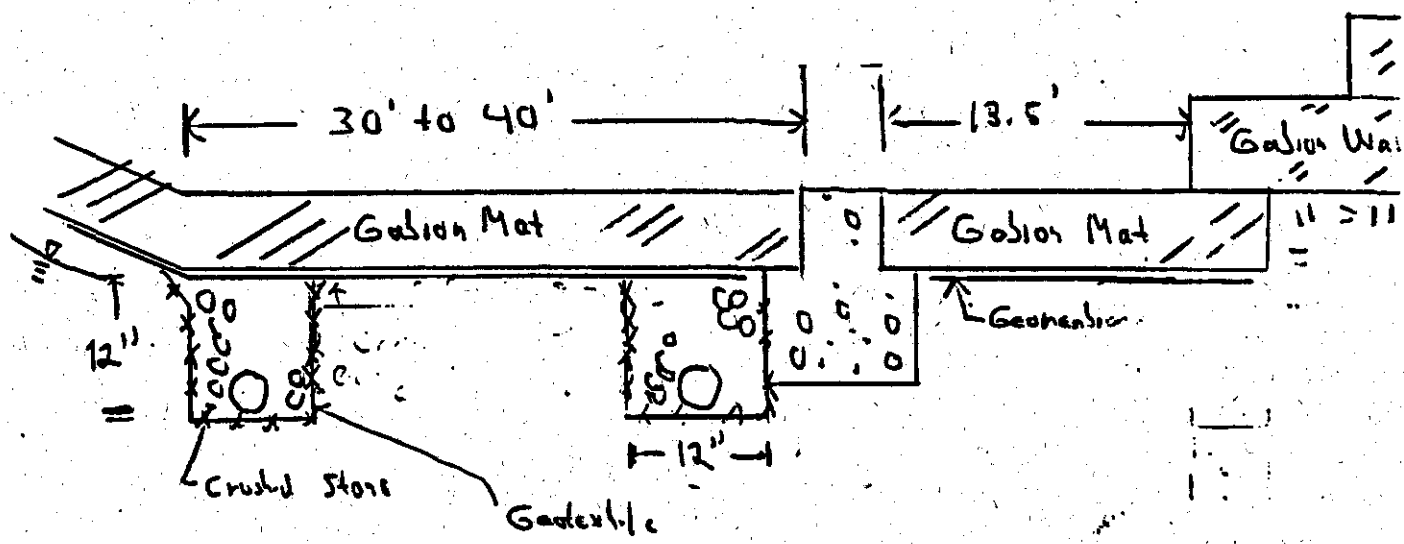
Use $K_{overburden} = 1.3 \times 10^{-3}$ cm/sec

The geotextile should have a permeability greater than the permeability of the soil

Therefore

$$\boxed{K_{geotextile} \geq 1.3 \times 10^{-3} \text{ cm/sec}}$$

AR100413



The RA is divided into three areas for collection. The follow flow rates have been calculated for these areas assuming a negligible groundwater flow component from the overburden along the east bank.

Area 1: 5.45 gpm (50 ft wide)
Area 2: 5.37 gpm (45 ft wide)
Area 3: 8.49 gpm (40 ft wide)

These flows equal the following flow per unit length of creek.

Area 1: $5.45 \frac{gal}{min} \times \frac{1\ min}{60\ sec} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{1}{50\ ft - 13.5\ ft} = 3.9 \times 10^{-4}\ ft^3/sec/$

Area 2: $5.37 \frac{gal}{min} \times \frac{1\ min}{60\ sec} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{1}{45\ ft - 13.5\ ft} = 3.8 \times 10^{-4}\ ft^3/sec/ft$

Area 3: $8.49 \frac{gal}{min} \times \frac{1\ min}{60\ sec} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{1}{40\ ft - 13.5\ ft} = 7.1 \times 10^{-4}\ ft^3/sec/ft$

Calculating required geotextile permittivity using $q = 7.1 \times 10^{-4}$ ft³/sec/ft

$$q = KiA$$

$$q = K \frac{\Delta h}{t} A$$

$$\frac{K}{t} = \frac{q}{\Delta h A} = \frac{7.1 \times 10^{-4} \text{ ft}^3/\text{sec}/\text{ft}}{[(1\text{ft})(1\text{ft})]}$$

$$\psi_{req} = 7.1 \times 10^{-4} \text{ sec}^{-1}/\text{ft}$$

Checking against allowable perittivity of available woven and non-woven geotextiles

$$F.S. = \frac{\psi_{allow}}{\psi_{req}}$$

$$\psi_{allow} = \psi_{ult} \left(\frac{1}{FS_{SCB} \times FS_{CR} \times FS_{IN} \times FS_{CC} \times FS_{BC}} \right)$$

From Designing with Geosynthetics, third Edition, Robert M Koerner

Factor of Safety Soil Clogging and Binding (FS_{SCB}) = 3.0
Factor of Safety Creep Reduction Voids (FS_{CR}) = 3.0
Factor of Safety Intrusion into Voids (FS_{IN}) = 1.2
Factor of Safety Chemical Clogging (FS_{CC}) = 1.3
Factor of Safety Biological Clogging (FS_{BC}) = 1.3

Assuming Pressure Flow

Choose Nicolon Filterweave 40/10 Woven Geotextile or Similar

AOS = U.S. Sieve No. 40; $K = 2.8 \times 10^{-2}$ cm/sec; $\psi_{ult} = 0.95$ sec⁻¹

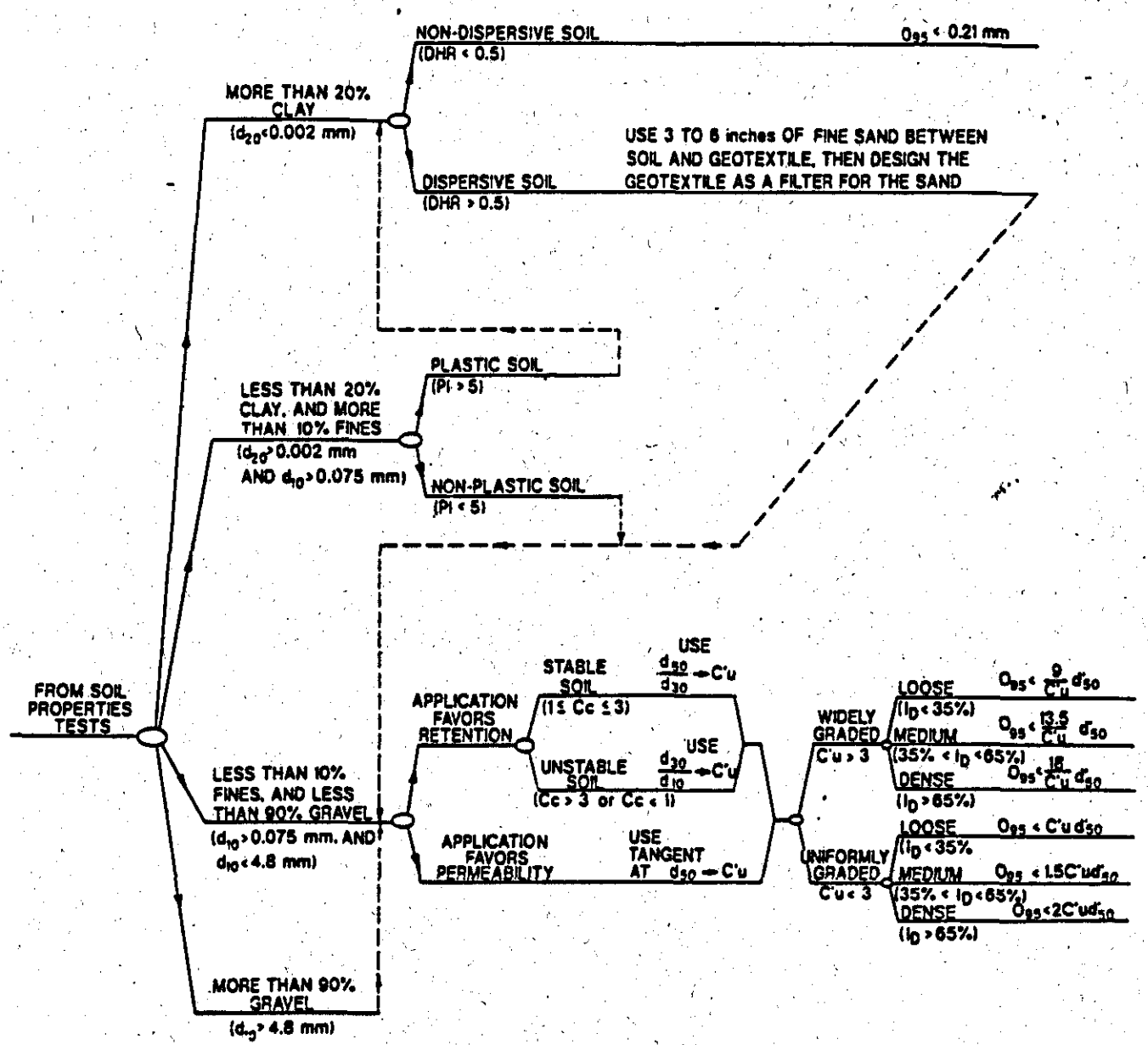
$$\psi_{allow} = \psi_{ult} \left(\frac{1}{(3.0)(3.0)(1.2)(1.3)(1.3)} \right) = 0.05$$

$$F.S. = \frac{\psi_{allow}}{\psi_{req}} = \frac{0.05}{7.10 \times 10^{-4}} = 70.4 \text{ ok}$$

AR100415

SHEET 7 OF 7 PROJECT NO. 95-228-03 PROJECT NAME Galaxy / Spectron
BY T.D.T DATE 1-9-97 DESCRIPTION Collection System Geotextile Calculations
CHK. BY PGS DATE 3-25-97

SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES:

d_x is the particle size of which x percent is smaller

$C'u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above: and d'_{50} is the midpoint of this line.

$Cc = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

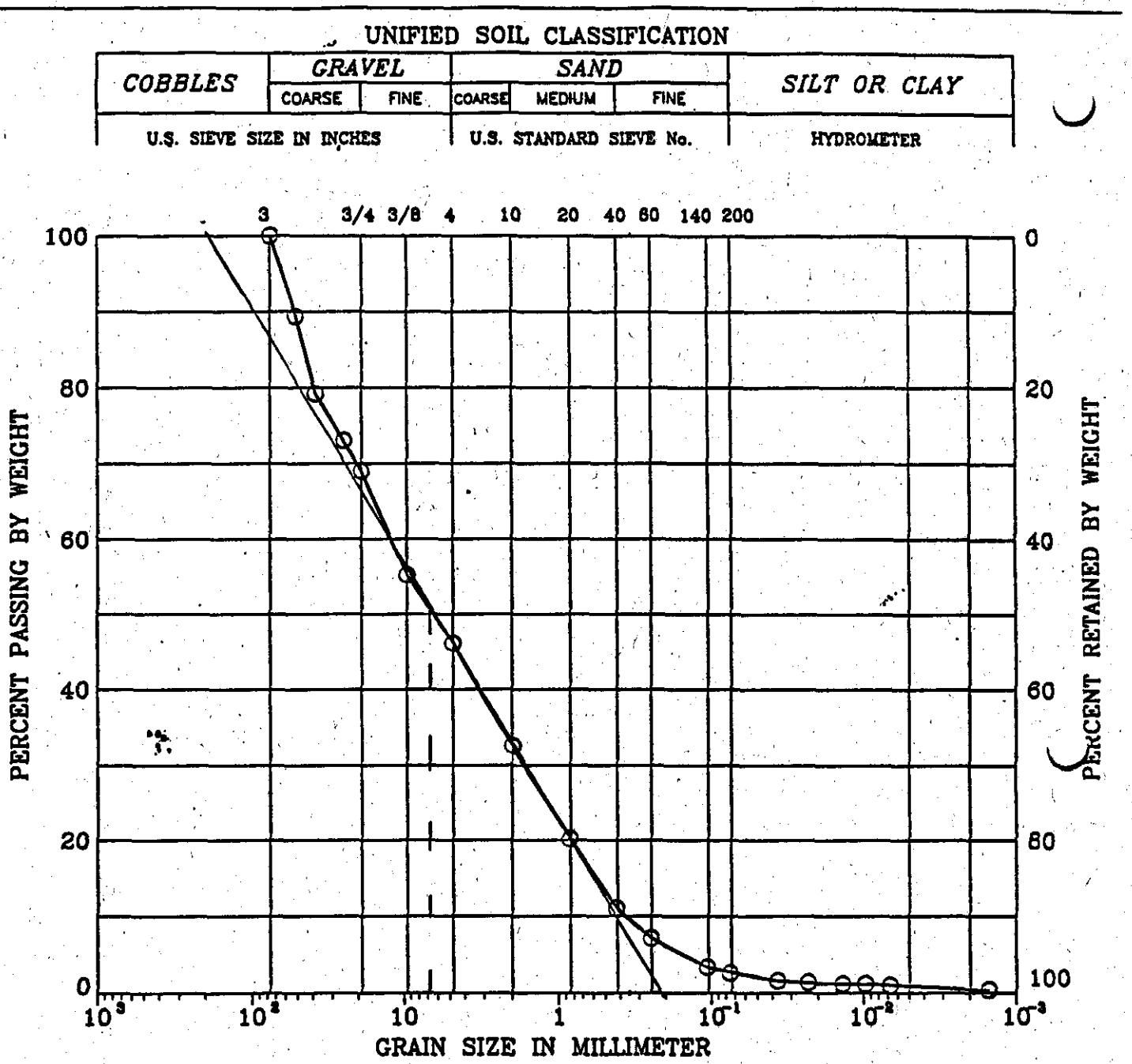
I_D is the relative denisty of the soil

PI is the plasticity index of the soil

DHR is the double-hydrometer ratio of the soil

Portions of this flow chart modified from Giroud (1988)

AR100416

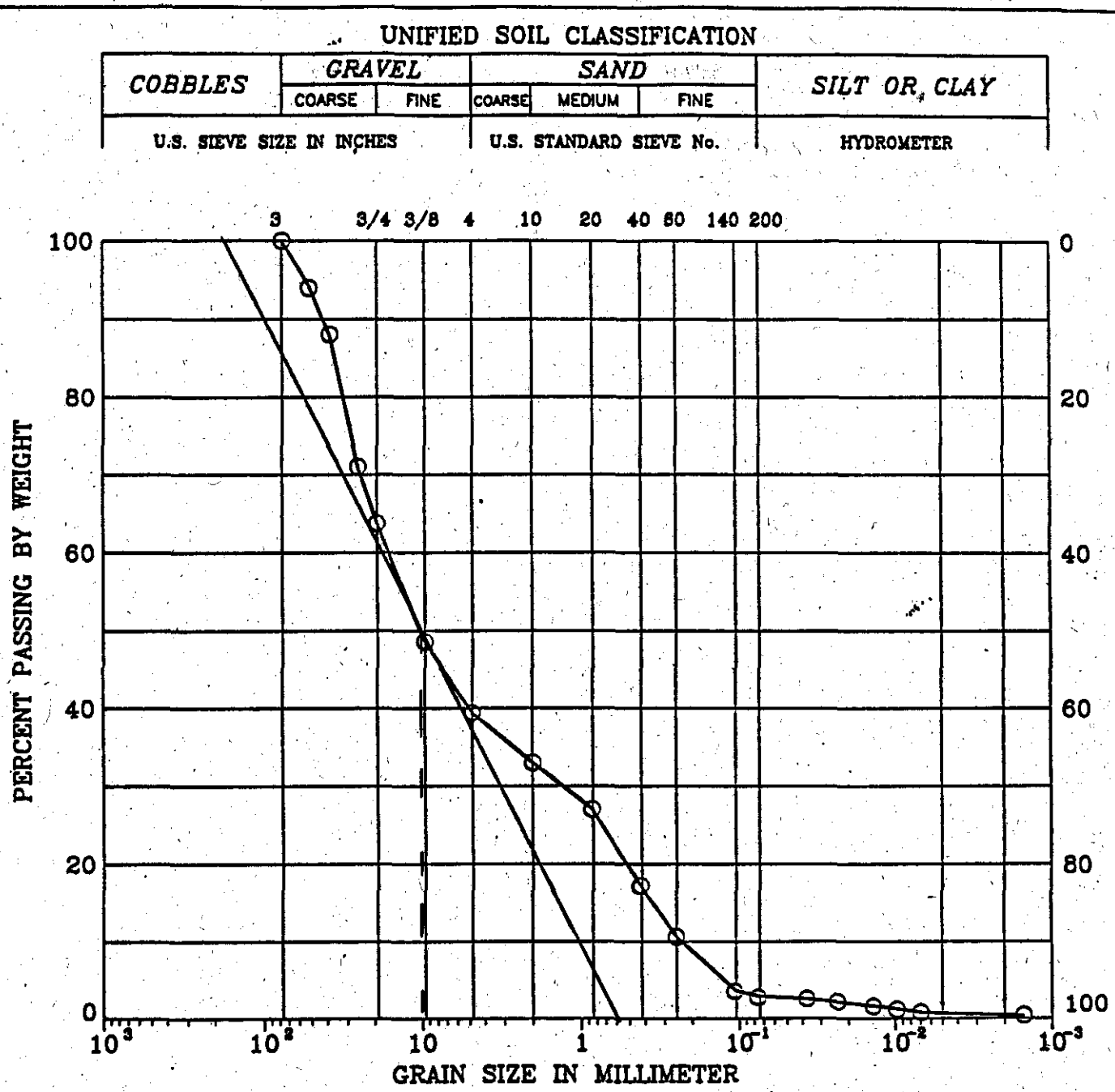


SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
O	SA-1				MULTICOLORED POORLY GRADED GRAVEL WITH SAND (GP)

Remark :

Project No. 94104	GALAXY SPECTRON, MARYLAND
Valley Forge Laboratories, Inc.	GRAIN SIZE DISTRIBUTION 9/23/96

AR100417



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
O	SA-2				MULTICOLORED POORLY GRADED GRAVEL WITH SAND (GP)

Remark :

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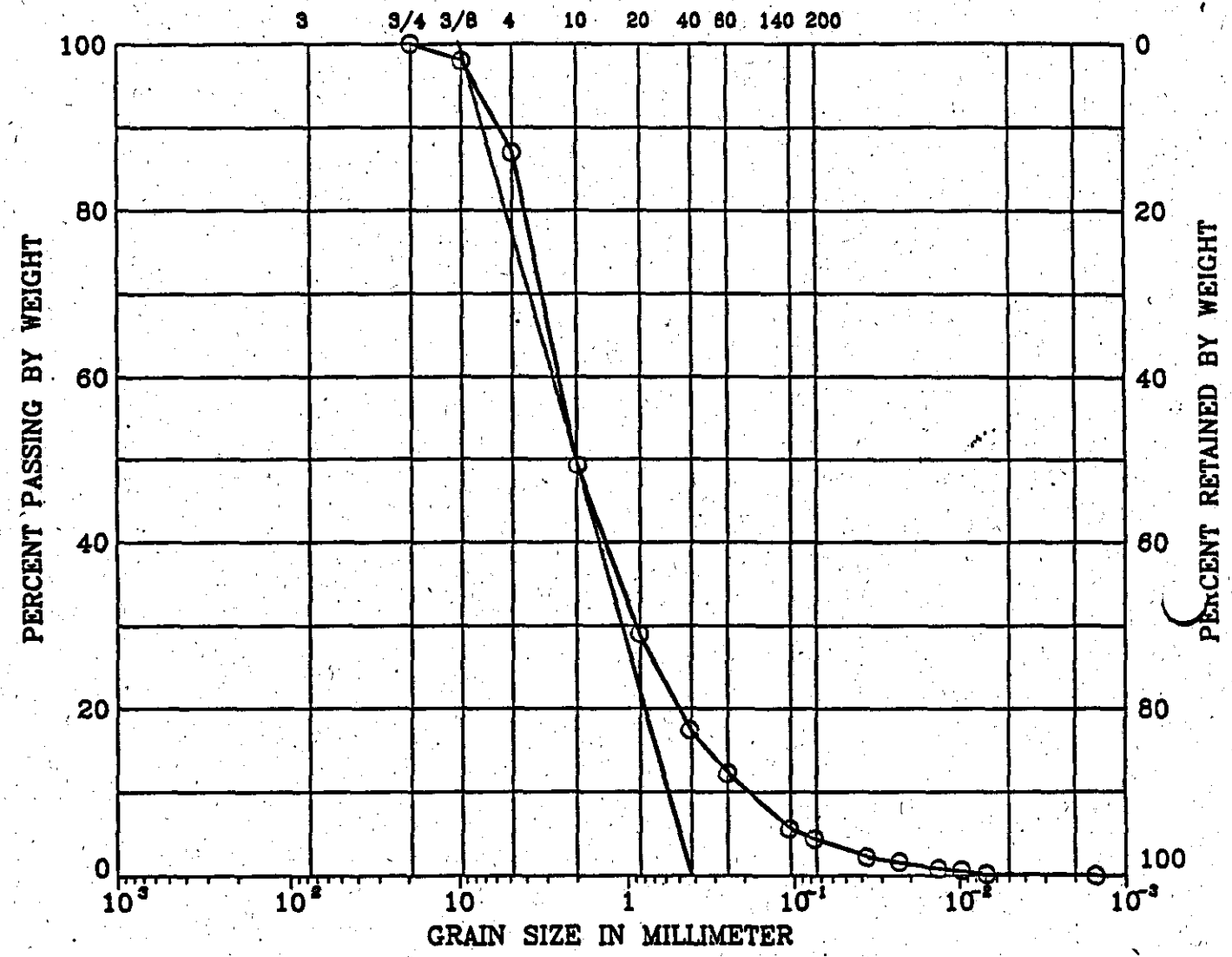
Valley Forge Laboratories, Inc.	GRAIN SIZE DISTRIBUTION . 9/23/96

AR100418

UNIFIED SOIL CLASSIFICATION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN INCHES			U.S. STANDARD SIEVE No.			HYDROMETER

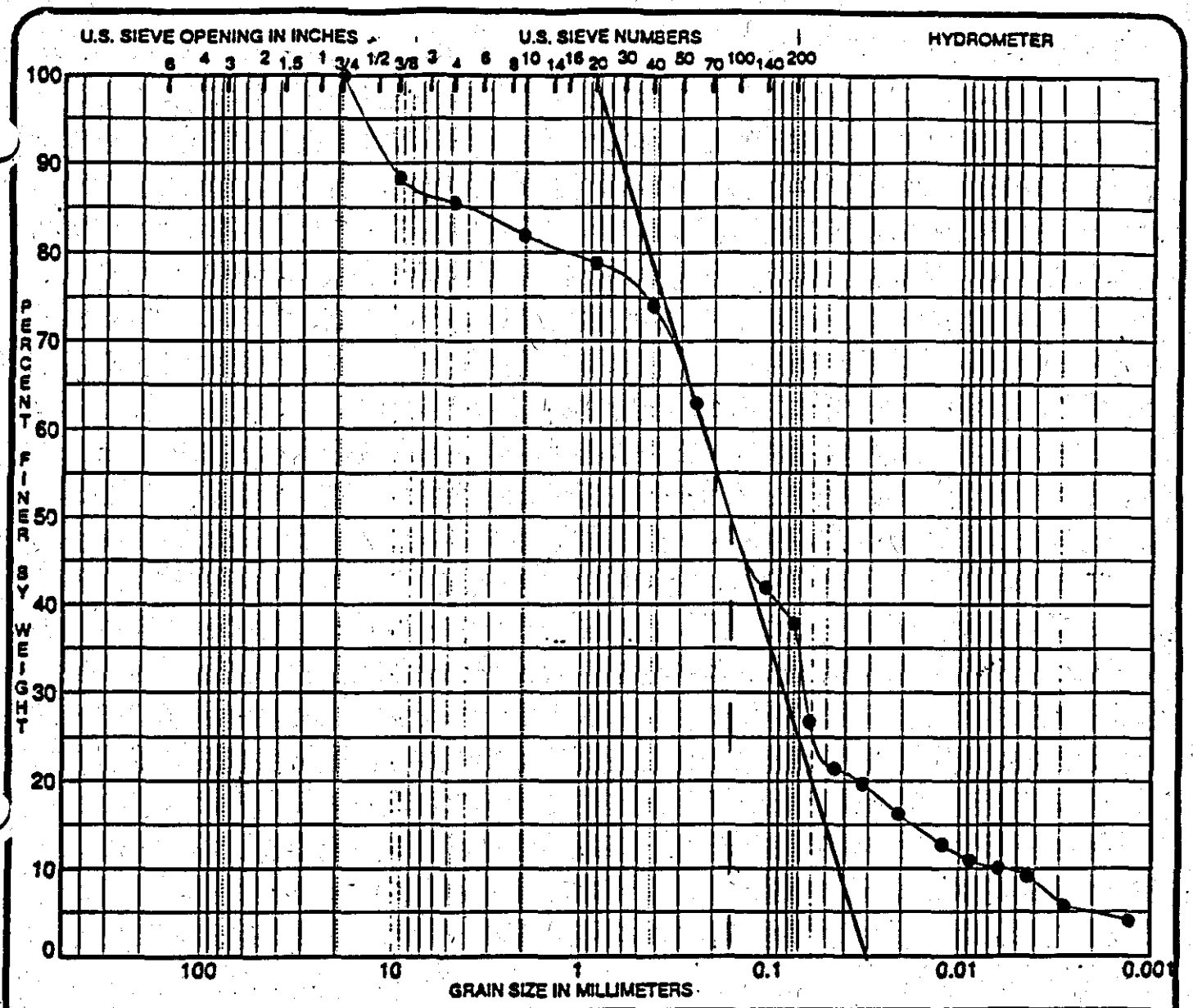


SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
O	SA-3				MULTICOLORED WELL GRADED SAND (SW)

AR100419

Remark :

Project No. 94104	GALAXY SPECTRON, MARYLAND
Valley Forge Laboratories, Inc.	GRAIN SIZE DISTRIBUTION 9/23/96



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 1	8.0	Silty SAND (SM)	19					

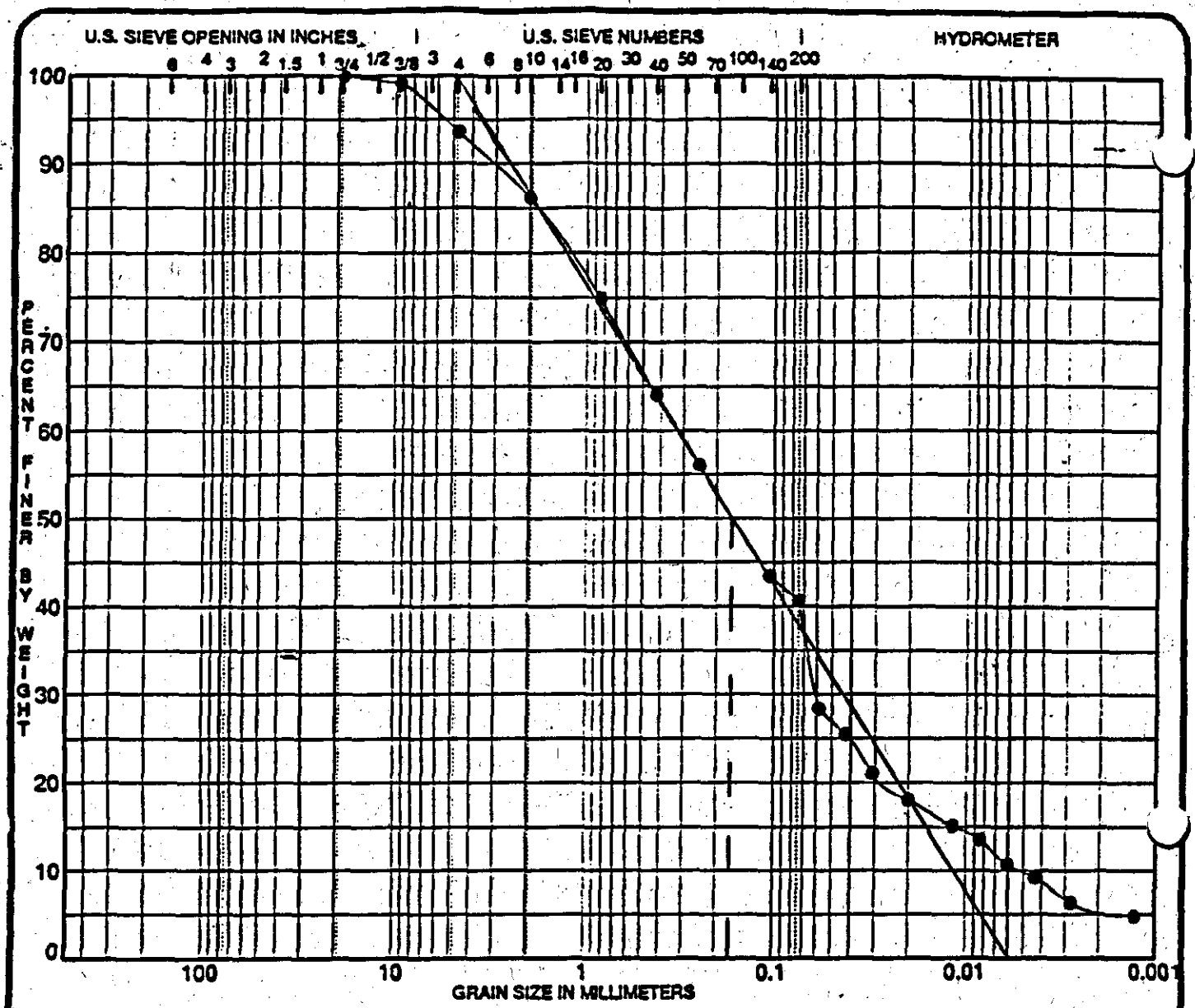
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 1	8.0	19.00	0.22	0.066	0.0060	14.5	47.7	28.3	9.5

PROJECT Spectron - JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

The ERM Group
Exton, Pennsylvania

AR100420



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 1	10.0	Silty SAND (SM)	14					

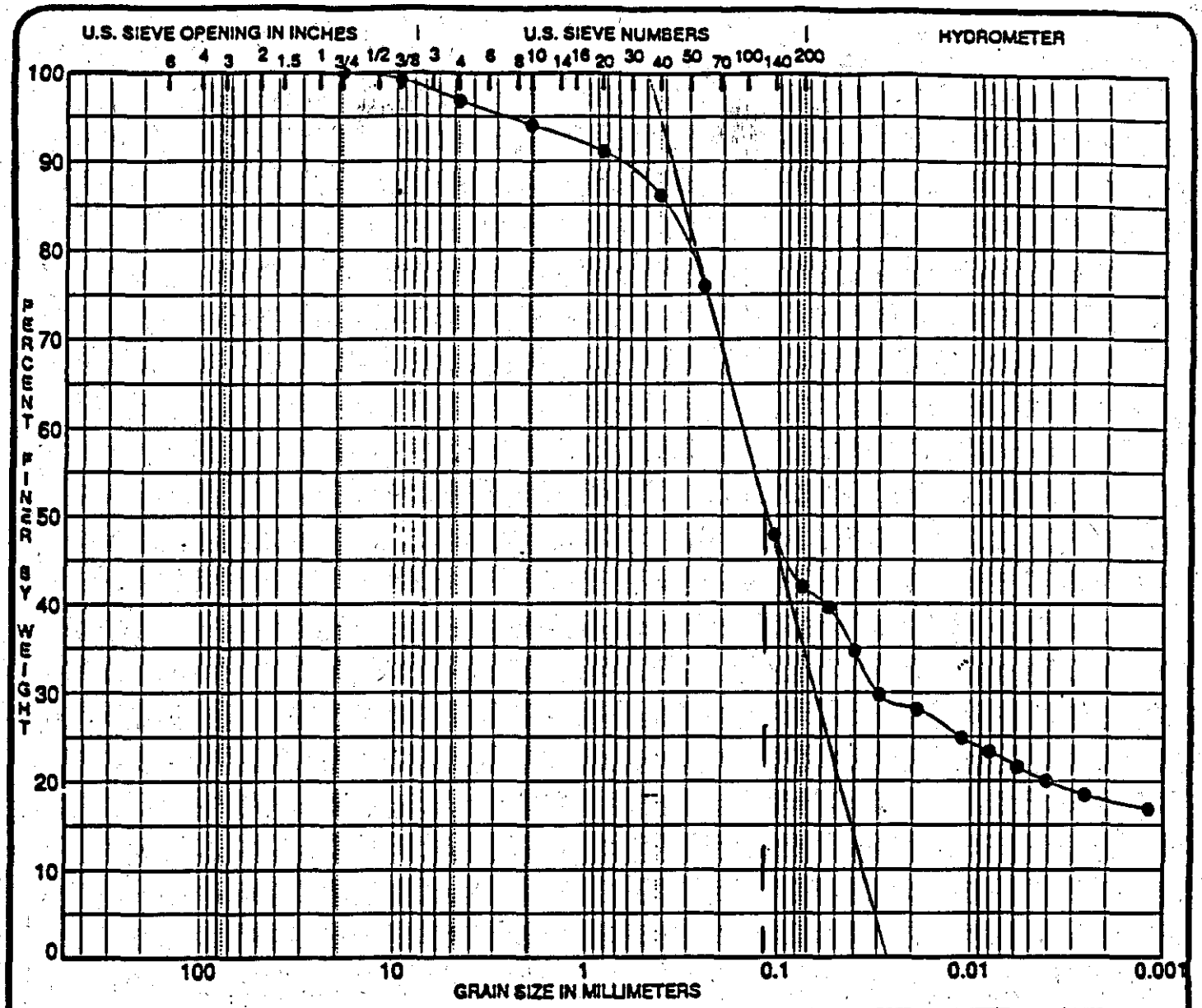
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 1	10.0	19.00	0.32	0.061	0.0052	6.4	53.0	30.8	9.8

PROJECT Spectron - JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

The ERM Group
Exton, Pennsylvania

AR100421



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 2	8.0	Silty SAND (SM)	28					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 2	8.0	19.00	0.15	0.030		3.2	54.9	21.0	20.9

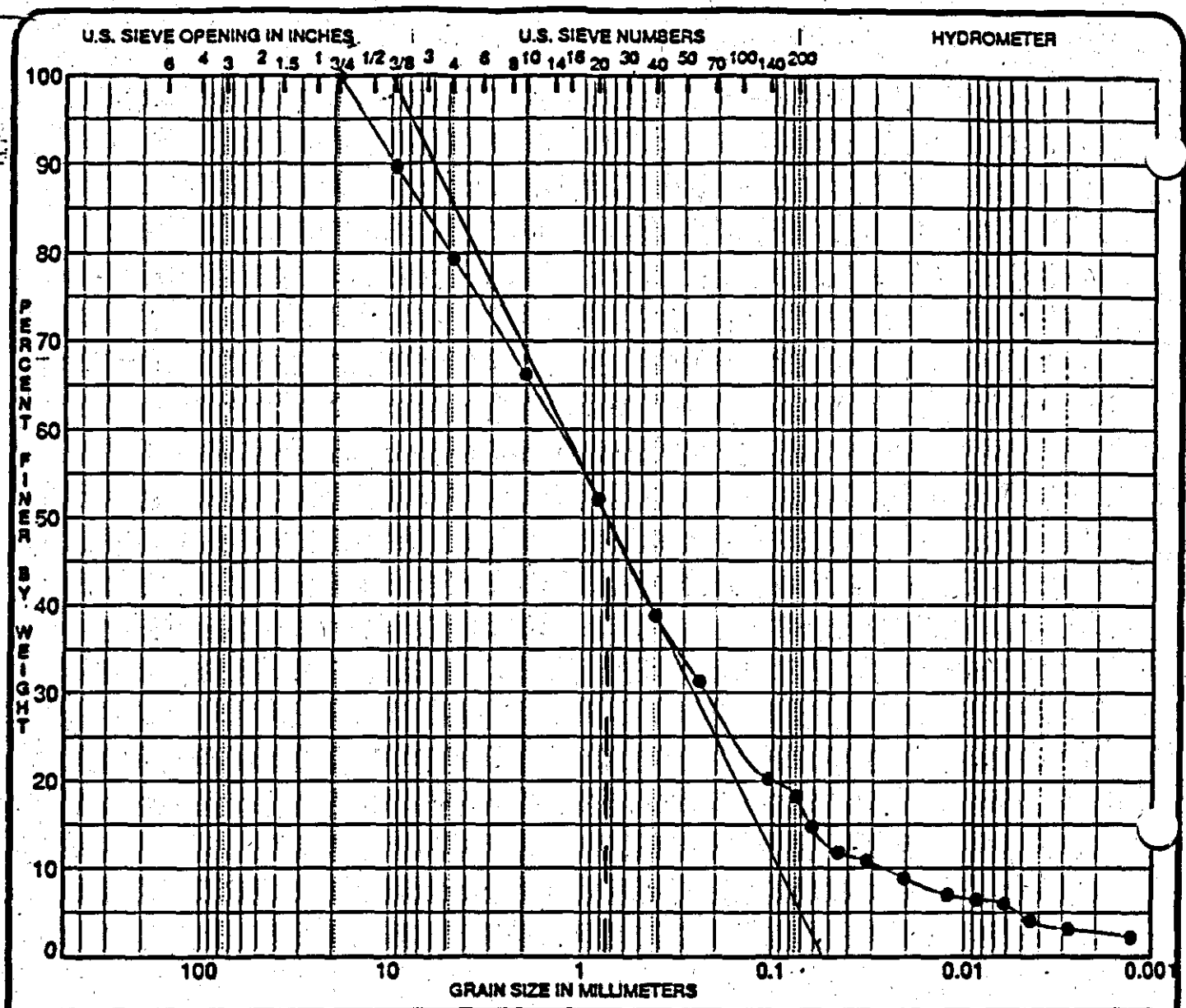
PROJECT Spectron -

JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

The ERM Group
Exton, Pennsylvania

AR100422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 2	10.0	Silty SAND w/Gravel (SM)	14	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 2	10.0	19.00	1.37	0.226	0.0268	20.6	61.2	13.5	4.7

PROJECT Spectron - JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

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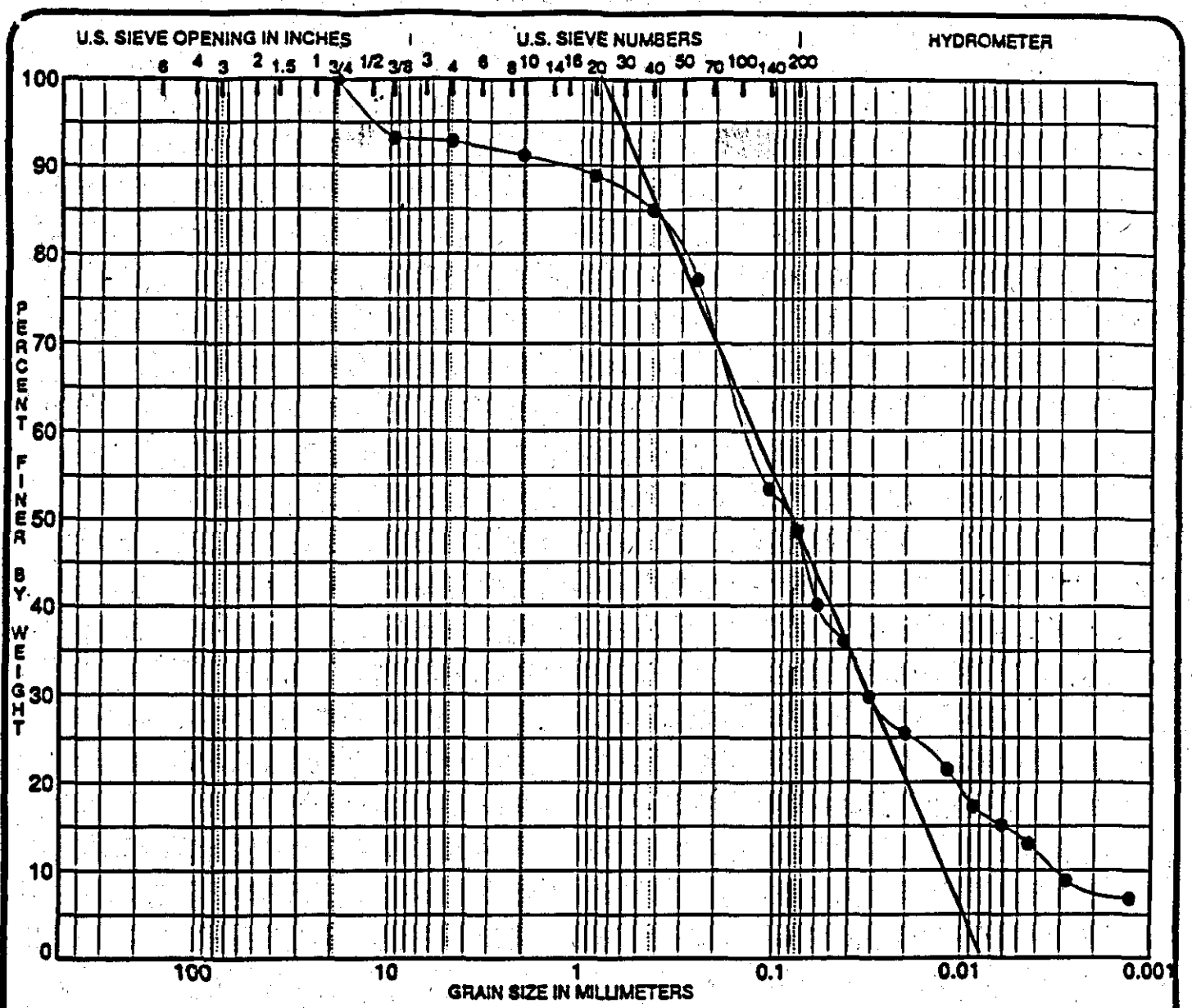
AR100423



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 3	10.0	Silty SAND (SM)	26					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 3	10.0	19.00	0.13	0.032	0.0032	7.2	44.2	34.8	13.8

PROJECT Spectron -

JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

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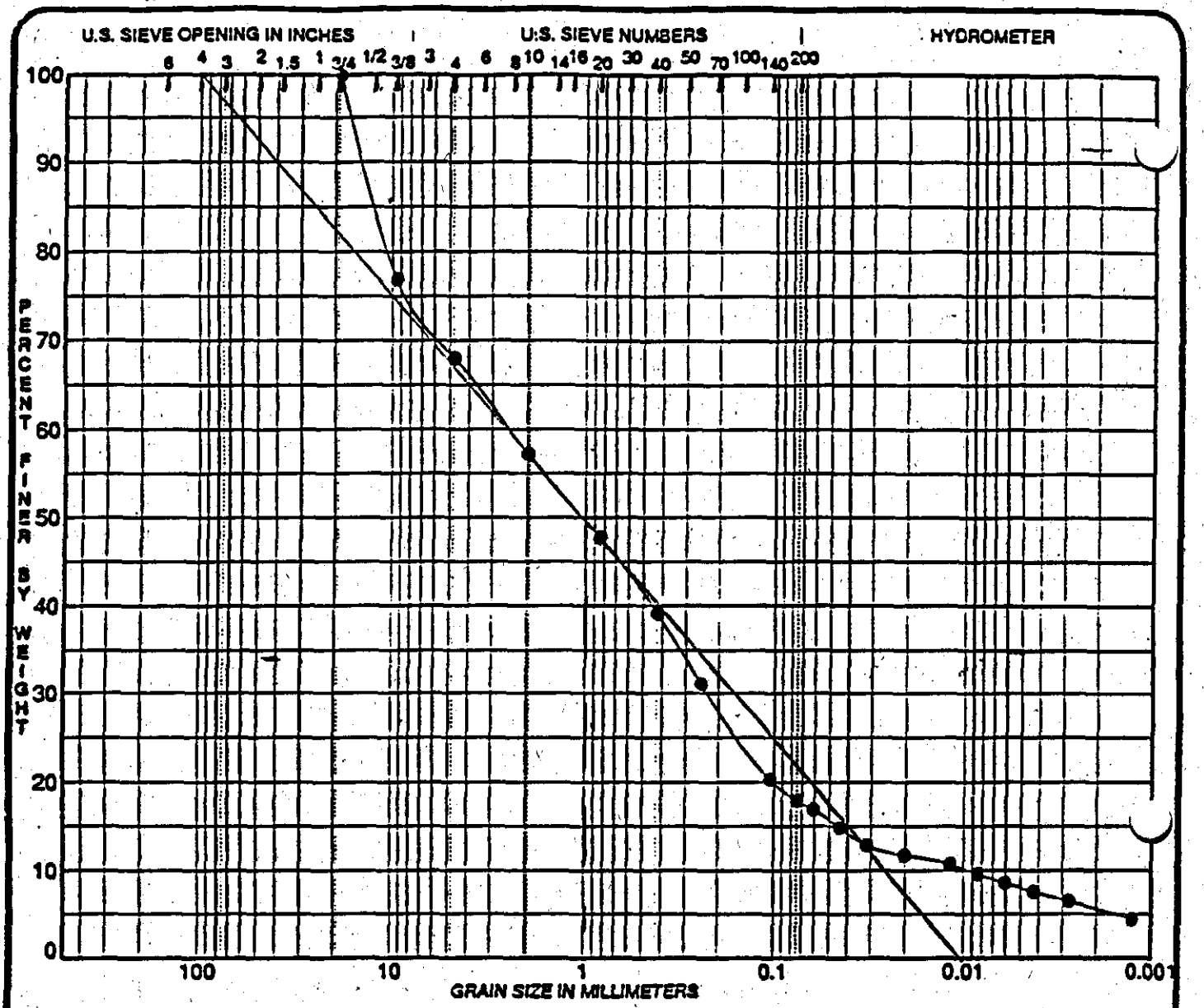
AR100424



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	TOP 3	12.0	Silty SAND w/Gravel (SM)	12	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	TOP 3	12.0	19.00	2.50	0.229	0.0096	32.0	50.1	9.9	8.0

PROJECT Spectron -

JOB NO. 949-06-07-01
DATE 6/30/93

GRADATION CURVES - ASTM

The ERM Group
Exton, Pennsylvania

1R100425

Collection System Calculations

→ Required Area of Pipe Perforations

In order to maintain a constant hydraulic gradient in the crushed stone (i.e., AASHTO No. 57 stone) and through the pipe perforations, the area of pipe perforation per length of pipe should be equal or exceed the hydraulic conductivity (K) of the crushed stone.

Based on the attached grain size analysis and typical hydraulic conductivity values, K for the stone is assumed to be equal to 0.16 ft/sec.

For a 1 ft length of 6" ϕ pipe

Surface Area, $A_s = \pi (6''/12)(1\,ft) = 1.57\ ft^2$

The flow rate (Q) through the crushed stone for $A_s = 1.57$

Flow Rate, $Q = (1.57\,ft^2)(0.16\,ft/sec) = 0.25\ cfs$

Using the orifice equation and solving for the area of the orifice (A_o) for 1 foot of pipe.

$$Q/A_o = C_v\sqrt{2gh}$$

where

$C_v = 0.98$
$g = 32.2\ ft/sec^2$
$h = 2\ ft$

$$A_o = \frac{Q}{C_v\sqrt{2gh}}$$

AR100426

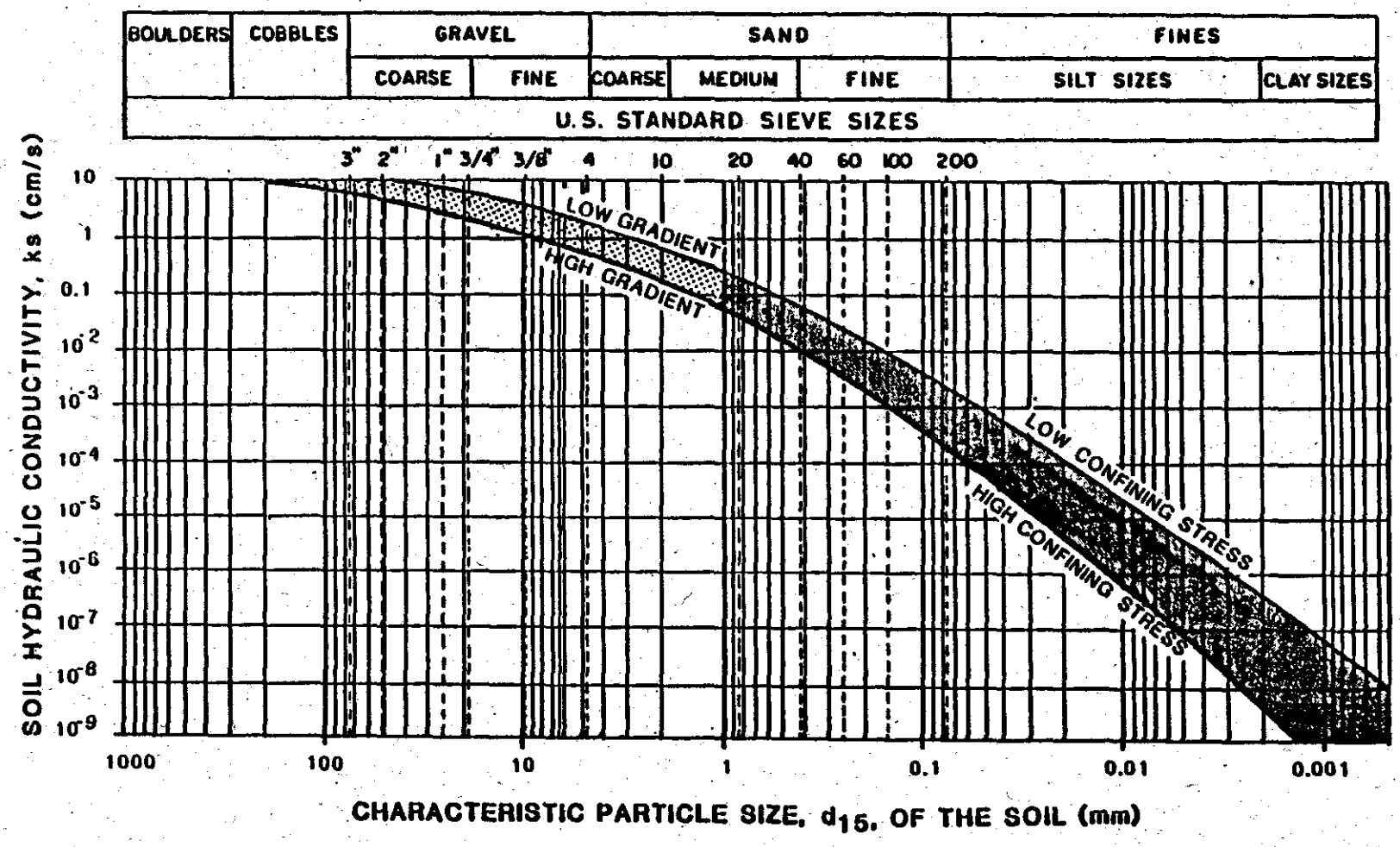
$$A_o = \frac{0.25\ ft^3/sec}{(0.98)\sqrt{(2)(32.2)(2)}} = 0.022\ ft^2/ft\ of\ pipe$$

$$A_o = 0.022\ \frac{ft^2}{ft} \times \frac{1\ ft}{12\ in} \times \frac{(12\ in)^2}{1\ ft^2} = 0.27\ in^2/in$$

Required perforations = 0.3 in^2/inch of pipe

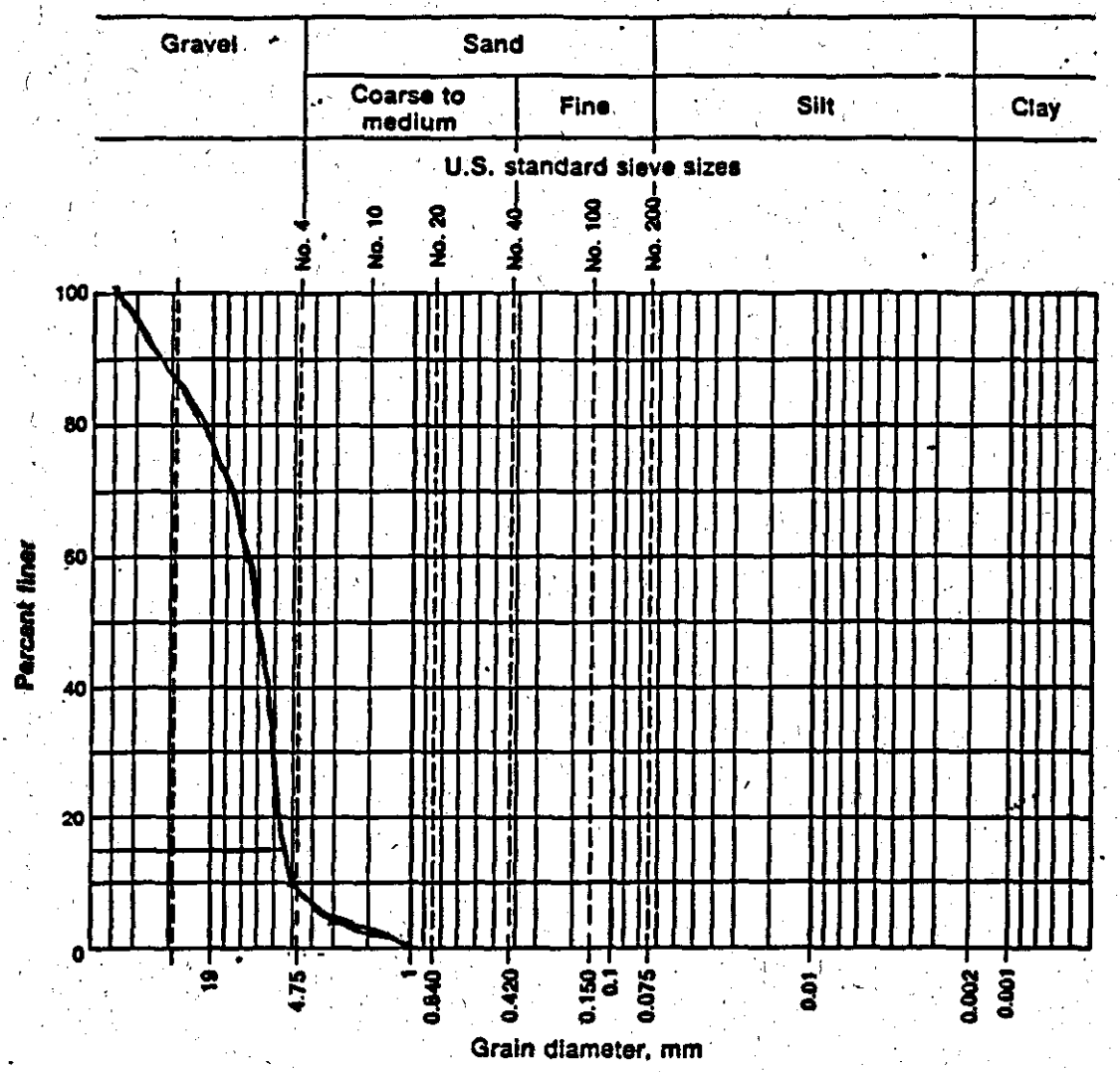
AR100427

TYPICAL HYDRAULIC CONDUCTIVITY VALUES



K_s AASHTO No. 57 = 5 cm/sec or 0.16 ft/sec

AR100428



Grain Size Distribution Curve AASHTO No. 57 Stone

$d_{15} = 6.4$ mm

Calculation Sheet for OB-1						
Q	0.00025	l/sec				
Average Concentration by Parameter						
Parameter	MW-9*				Total Conc.	Ave. Conc.
Meth. Cl.					0	0
TCA	2.8				2.8	2.8
DCE	22				22	22
TCE	0.025				0.025	0.025
PCE	0.028				0.028	0.028
Toluene	11				11	11
					Total VOCs	35.853
					Tot.ID Comp.	71.2
1. All concentrations are expressed in milligrams/liter (mg/l)						
2. * = Concentration Data from ERM 6/92 Sampling Event (mg/l)						
3. Blank Spaces Indicate the Result was Blank Qualified and not used.						
4. Overburben Velocity is from ERM FRI						
Flux = Q*C (average)						
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	2.50E-04	0	0.00E+00			
TCA	2.50E-04	2.8	7.00E-04			
DCE	2.50E-04	22	5.50E-03			
TCE	2.50E-04	0.025	6.25E-06			
PCE	2.50E-04	0.028	7.00E-06			
Toluene	2.50E-04	11	2.75E-03			
		Total Flux	8.96E-03			
Calculation Sheet for OB-2						
Q	0.095	l/sec				
Average Concentration by Parameter						
Parameter	MW-3*	B-5	SP-2	SP-3	Total Conc.	Ave. Conc.
Meth. Cl.	44		2.6		46.6	23.300
TCA	47	9.7	10.5	160	227.2	56.8
DCE	52	17	4.7	33	106.7	26.675
TCE	3.4	0.6	3	14	21	5.25
PCE	8.2	0.7	1.5	30	40.4	10.5
Toluene	4	3	3.3	13	23.3	5.825
					Total VOCs	127.950
					Tot.ID Comp.	495.38
1. All concentrations are expressed in milligrams/liter (mg/l)						
2. * = Concentration Data from ERM 6/92 Sampling Event (mg/l)						
3. Seep-3 Concentration Data from Laboratory Confirmation Sample (mg/l)						
4. B-5 Concentration is from AGC 8/96 Sampling Event (mg/l)						
5. Seep-2 Data from Vironex Field GC Data (mg/l)						
6. Blank Spaces Indicate the Result was Blank Qualified and not used.						
7. Overburben Velocity is from ERM FRI						

Flux = Q*C (average)	(OB-2 Con't)					
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	9.50E-02	23.300	2.21E+00			
TCA	9.50E-02	56.8	5.40E+00			
DCE	9.50E-02	26.675	2.53E+00			
TCE	9.50E-02	5.25	4.99E-01			
PCE	9.50E-02	10.1	9.60E-01			
Toluene	9.50E-02	5.825	5.53E-01			
		Total Flux	1.22E+01			
Calculation Sheet for OB-3						
Q	1.01E-01	l/sec				
Average Concentration by Parameter						
Parameter	MW-10*	SP-4	SP-5		Total Conc.	Ave. Conc.
Meth. Cl.	740	19.1	2.6		761.7	253.900
TCA	46	21	12.5		79.5	26.500
DCE	36	13.6	8.3		57.9	19.300
TCE	0	1.7	0.19		1.89	0.630
PCE	8.4	0.76	0.14		9.3	3.100
Toluene	12	4.1	3		19.1	6.367
					Total VOCs	309.797
					Tot.ID Comp.	1040.87
1. All concentrations are expressed in milligrams/liter (mg/l)						
2. * = Concentration Data from ERM 12/91Sampling Event (mg/l)						
3. Seep Data from Vironex Field GC (mg/l)						
4. Overburben Velocity is from ERM FRI						
Flux = Q*C (average)						
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	1.01E-01	253.900	2.56E+01			
TCA	1.01E-01	26.500	2.68E+00			
DCE	1.01E-01	19.300	1.95E+00			
TCE	1.01E-01	0.630	6.36E-02			
PCE	1.01E-01	3.100	3.13E-01			
Toluene	1.01E-01	6.367	6.43E-01			
		Total Flux	3.13E+01			

Calculation Sheet for OB-4						
Q	0.00946	l/sec				
Average Concentration by Parameter						
Parameter	MW-12*	SP-5			Total Conc.	Ave. Conc.
Meth. Cl.		2.6			2.6	2.600
TCA	0.64	12.5			13.14	6.570
DCE	0.76	8.3			9.06	4.530
TCE	0.12	0.19			0.31	0.155
PCE	0.43	0.14			0.57	0.285
Toluene	0.28	3			3.28	1.640
					Total VOCs	15.78
					Tot.ID Comp.	36.19
1. All concentrations are expressed in milligrams/liter (mg/l)						
2. * = Concentration Data from ERM 6/92 Sampling Event (mg/l)						
3. Seep Data from Vironex Field GC (mg/l)						
4. Blank Spaces Indicate the Result was Blank Qualified and not used.						
5. *Overburben Velocity is from ERM FRI*						
Flux = Q*C (average)						
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	9.46E-03	2.600	2.46E-02			
TCA	9.46E-03	6.570	6.22E-02			
DCE	9.46E-03	4.530	4.29E-02			
TCE	9.46E-03	0.155	1.47E-03			
PCE	9.46E-03	0.285	2.70E-03			
Toluene	9.46E-03	1.640	1.55E-02			
		Total Flux	1.49E-01			
Calculation Sheet for OB-5						
Q	0.00189	l/sec				
Average Concentration by Parameter						
Parameter	MW-11*	SP-6	GPs		Total Conc.	Ave. Conc.
Meth. Cl.		4.2	4.42		8.62	4.310
TCA	3.2	8.8	27.6		12	4.000
DCE	1.4	2.8	13.55		4.2	1.400
TCE	0.082	0.59	6.26		0.672	0.224
PCE	0.029	0.181	3.39		0.21	0.070
Toluene	0.17	0.678	5.23		0.848	0.283
					Total VOCs	10.287
					Tot.ID Comp.	160.07

1. All concentrations are expressed in milligrams/liter (mg/l)						
2.* = Concentration Data from Laboratory Confirmatory Sample (mg/l)						
3. Seep Data from Vironex Field GC (mg/l)						
4. GPs are an Average of the Geoprobe Data from Vironex (mg/l)						
5. Blank Spaces Indicate the Result was Blank Qualified and not used.						
6. Overburben Velocity is from ERM FRI						
Flux = Q*C (average)	(OB-5 Con't)					
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	1.89E-03	4.310	8.15E-03			
TCA	1.89E-03	4.000	7.56E-03			
DCE	1.89E-03	1.400	2.65E-03			
TCE	1.89E-03	0.224	4.23E-04			
PCE	1.89E-03	0.070	1.32E-04			
Toluene	1.89E-03	0.283	5.34E-04			
		Total Flux	1.94E-02			
Calculation Sheet for OB-6						
Q	0.074	l/sec				
Average Concentration by Parameter						
Parameter	SP-7	GPs			Total Conc.	Ave. Conc.
Meth. Cl.	1.9	1.31			3.21	1.605
TCA	12.9	11.58			24.48	8.160
DCE	7	6.13			13.13	4.377
TCE	1.27	1.1			2.37	0.790
PCE	0.224	0.29			0.514	0.171
Toluene	0.629	0.58			1.209	0.403
					Total VOCs	15.506
					Tot.ID Comp.	44.91
1. All concentrations are expressed in milligrams/liter (mg/l)						
2. Seep Data from Vironex Field GC (mg/l)						
3. GPs are an Average of the Geoprobe Data from Vironex (mg/l)						
4. Overburben Velocity is estimated for OB-6 from ERM FRI Data						
Flux = Q*C (average)						
Mass Flux by Parameter						
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)			
Meth. Cl.	7.40E-02	1.605	1.19E-01			
TCA	7.40E-02	8.160	6.04E-01			
DCE	7.40E-02	4.377	3.24E-01			
TCE	7.40E-02	0.790	5.85E-02			
PCE	7.40E-02	0.171	1.27E-02			
Toluene	7.40E-02	0.403	2.98E-02			
		Total Flux	1.15E+00			

Total Overburden Flux to Stream by Parameter						
Parameter			Cum. Flux			
Meth. Cl.			2.80E+01			
TCA			8.75E+00			
DCE			4.86E+00			
TCE			6.23E-01			
PCE			1.29E+00			
Toluene			1.25E+00			
		Total Flux	4.48E+01		4.48E+01	

Calculation Sheet for BR-1							
Q	0.237	l/sec					
Average Concentration by Parameter							
Parameter	VW-1*				Total Conc.	Ave. Conc.	
Meth. Cl.	1.68				1.68	1.680	
TCA	0				0	0.000	
DCE	0.45				0.45	0.450	
TCE	11.55				11.55	11.550	
PCE	1.46				1.46	1.460	
Toluene	0.14				0.14	0.140	
					Total VOCs	15.280	
					Tot. ID Comp.	26.51	
1. All concentrations are expressed in milligrams/liter (mg/l)							
2.* = Concentration Data from ERM FRI Report (mg/l)							
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC							
Flux = Q*C (average)							
Mass Flux by Parameter							
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)				
Meth. Cl.	2.37E-01	1.680	3.98E-01				
TCA	2.37E-01	0.000	0.00E+00				
DCE	2.37E-01	0.450	1.07E-01				
TCE	2.37E-01	11.550	2.74E+00				
PCE	2.37E-01	1.460	3.46E-01				
Toluene	2.37E-01	0.140	3.32E-02				
		Total Flux	3.62E+00				
Calculation Sheet for BR-2							
Q	0.009	l/sec					
Average Concentration by Parameter							
Parameter	VW-2	VW-1*			Total Conc.	Ave. Conc.	
Meth. Cl.	4000	1.68			4001.68	2,000.840	
TCA	380	0			380	190.000	
DCE	10	0.45			10.45	5.225	
TCE	74	11.55			85.55	42.775	
PCE	68	1.46			69.46	34.730	
Toluene	25	0.14			25.14	12.570	
					Total VOCs	2,286.140	
					Tot. ID Comp.	4786	
1. All concentrations are expressed in milligrams/liter (mg/l)							
2. VW-2 Concentration Data from AGC 8/96 Sampling Event (mg/l)							
3.* = Concentration Data from ERM FRI Report (mg/l)							
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC							

Flux = Q*C (average)		(BR-2 con't)					
Mass Flux by Parameter							
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)				
Meth. Cl.	9.00E-03	2,000.840	1.80E+01				
TCA	9.00E-03	190.000	1.71E+00				
DCE	9.00E-03	5.225	4.70E-02				
TCE	9.00E-03	42.775	3.85E-01				
PCE	9.00E-03	34.730	3.13E-01				
Toluene	9.00E-03	12.570	1.13E-01				
		Total Flux	2.06E+01				
Calculation Sheet for BR-3							
Q	0.0002	l/sec					
Average Concentration by Parameter							
Parameter	VW-2	VW-1*			Total Conc.	Ave. Conc.	
Meth. Cl.	4000	1.68			4001.68	2,000.840	
TCA	380	0			380	190.000	
DCE	10	0.45			10.45	5.225	
TCE	74	11.55			85.55	42.775	
PCE	68	1.46			69.46	34.730	
Toluene	25	0.14			25.14	12.570	
					Total VOCs	2,286.140	
					Tot. ID Comp.	4786	
1. All concentrations are expressed in milligrams/liter (mg/l)							
2.* = Concentration Data from ERM FRI Report (mg/l)							
3. VW-2 Concentration Data from AGC 8/96 Sampling Event (mg/l)							
4. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC							
Flux = Q*C (average)							
Mass Flux by Parameter							
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)				
Meth. Cl.	2.00E-04	2,000.840	4.00E-01				
TCA	2.00E-04	190.000	3.80E-02				
DCE	2.00E-04	5.225	1.05E-03				
TCE	2.00E-04	42.775	8.56E-03				
PCE	2.00E-04	34.730	6.95E-03				
Toluene	2.00E-04	12.570	2.51E-03				
		Total Flux	4.57E-01				

Calculation Sheet for BR-4							
Q	0.009	l/sec					
Average Concentration by Parameter							
Parameter	VW-2	AW-1*			Total Conc.	Ave. Conc.	
Meth. Cl.	4000	202.49			4202.49	2,101.245	
TCA	380	13.87			393.87	196.935	
DCE	10	2.37			12.37	6.185	
TCE	74	8.16			82.16	41.080	
PCE	68	19.94			87.94	43.970	
Toluene	25	5.58			30.58	15.290	
					Total VOCs	2,404.705	
					Tot. ID Comp.	4786	
1. All concentrations are expressed in milligrams/liter (mg/l)							
2. VW-2 Concentration Data from AGC 8/96 Sampling Event (mg/l)							
3.* = Concentration Data from ERM FRI Report (mg/l)							
4. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC							
Flux = Q*C (average)							
Mass Flux by Parameter							
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)				
Meth. Cl.	9.00E-03	2,101.245	1.89E+01				
TCA	9.00E-03	196.935	1.77E+00				
DCE	9.00E-03	6.185	5.57E-02				
TCE	9.00E-03	41.080	3.70E-01				
PCE	9.00E-03	43.970	3.96E-01				
Toluene	9.00E-03	15.290	1.38E-01				
		Total Flux	2.16E+01				
Calculation Sheet for BR-5							
Q	0.18	l/sec					
Average Concentration by Parameter							
Parameter	AW-1*				Total Conc.	Ave. Conc.	
Meth. Cl.	202.49				202.49	202.490	
TCA	13.87				13.87	13.870	
DCE	2.37				2.37	2.370	
TCE	8.16				8.16	8.160	
PCE	19.94				19.94	19.940	
Toluene	5.58				5.58	5.580	
					Total VOCs	252.410	
					Tot. ID Comp.	353.44	

Mass in Surface Water Calculations

Cross Section # 1419

Weighted Concentrations (mg/l)

Parameter	SW-10	W. Factor	W. Conc.	SW-11*	W. Factor	W. Conc.	SW-12	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0	3	0	0	6	0	0	1	0	0.00E+00
TCA	0	3	0	0	6	0	0	1	0	0.00E+00
DCE	0.0018	3	0.0054	0.01	6	0.06	0.0026	1	0.0026	6.80E-03
TCE	0.0008	3	0.0024	0.0018	6	0.0108	0.0006	1	0.0006	1.38E-03
PCE	0.0001	3	0.0003	0	6	0	0.00017	1	0.00017	4.70E-05
Toluene	0.0003	3	0.0009	0	6	0	0.00016	1	0.00016	1.06E-04

1. * = Laboratory Confirmatory Data Concentration (mg/l)
2. Other Data from Vironex Field GC (mg/l)
3. Velocity from Stream Flow Data Collected the day of Sampling
4. Stream Concentrations are Weighted based on Stream Flow Data

(Cross Section # 1419) Total Wt. 8.33E-03

Q= 508.94 l/sec VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	508.94	0.00E+00	0.00E+00
TCA	508.94	0.00E+00	0.00E+00
DCE	508.94	6.80E-03	3.46E+00
TCE	508.94	1.38E-03	7.02E-01
PCE	508.94	4.70E-05	2.39E-02
Toluene	508.94	1.06E-04	5.39E-02
		Total Flux=	4.24E+00
		Calc. Seg. Flux=	3.60E+00

AR100438

Cross Section # 1018

Weighted Concentrations (mg/l)

Parameter	SW-7	W. Factor	W. Conc.	SW-8*	W. Factor	W. Conc.	SW-9	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.352	0.2	0.0704	0.071	4.35	0.30885	0	5.45	0	3.79E-02
TCA	0.344	0.2	0.0688	0.041	4.35	0.17835	0	5.45	0	2.47E-02
DCE	0.322	0.2	0.0644	0.02	4.35	0.087	0.003	5.45	0.01635	1.68E-02
TCE	0.038	0.2	0.0076	0.005	4.35	0.02175	0.001	5.45	0.00545	3.48E-03
PCE	0.102	0.2	0.0204	0.009	4.35	0.03915	0.001	5.45	0.00545	6.50E-03
Toluene	0.064	0.2	0.0128	0.006	4.35	0.0261	0.0004	5.45	0.00218	4.11E-03

1. * = Laboratory Confirmatory Data Concentration (mg/l)
2. Other Data from Vironex Field GC (mg/l)
3. Velocity from Stream Flow Data Collected the day of Sampling
4. Stream Concentrations are Weighted based on Stream Flow Data

Total Wt. 9.35E-02

(Cross Section # 1018)

Q= 508.94 l/sec

VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	508.94	3.79E-02	1.93E+01
TCA	508.94	2.47E-02	1.26E+01
DCE	508.94	1.68E-02	8.54E+00
TCE	508.94	3.48E-03	1.77E+00
PCE	508.94	6.50E-03	3.31E+00
Toluene	508.94	4.11E-03	2.09E+00
		Total Flux=	4.76E+01
		Calc. Seg. Flux=	3.60E+01

AR100439

Cross Section # 755

Weighted Concentrations (mg/l)

Parameter	SW-4	W. Factor	W. Conc.	SW-5	W. Factor	W. Conc.	SW-6	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.294	1	0.294	0.13	4	0.52	0	5	0	8.14E-02
TCA	0.841	1	0.841	0.089	4	0.356	0	5	0	1.20E-01
DCE	0.62	1	0.62	0.07	4	0.28	0.01	5	0.05	9.50E-02
TCE	0.15	1	0.15	0.012	4	0.048	0.003	5	0.015	2.13E-02
PCE	0.038	1	0.038	0.026	4	0.104	0.004	5	0.02	1.62E-02
Toluene	0.027	1	0.027	0.012	4	0.048	0.001	5	0.005	8.00E-03

1. All Data from Vironex Field GC (mg/l)
2. Velocity from Stream Flow Data Collected the day of Sampling
3. Stream Concentrations are Weighted based on Stream Flow Data

Total Wt. 3.42E-01

(Cross Section # 755)

Q= 508.94 l/sec

VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	508.94	8.14E-02	4.14E+01
TCA	508.94	1.20E-01	6.09E+01
DCE	508.94	9.50E-02	4.83E+01
TCE	508.94	2.13E-02	1.08E+01
PCE	508.94	1.62E-02	8.24E+00
Toluene	508.94	8.00E-03	4.07E+00
		Total Flux=	1.74E+02
		Calc. Seg. Flux=	1.74E+02
		0	

AR100440

Cross Section # 715

Weighted Concentrations (mg/l)

Parameter	SW-1	W. Factor	W. Conc.	SW-2	W. Factor	W. Conc.	SW-3	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.151	0.2	0.0302	0.078	4	0.312	0	5.8	0	3.42E-02
TCA	0.272	0.2	0.0544	0.032	4	0.128	0	5.8	0	1.82E-02
DCE	0.265	0.2	0.053	0.036	4	0.144	0.006	5.8	0.0348	2.32E-02
TCE	0.025	0.2	0.005	0.007	4	0.028	0.002	5.8	0.0116	4.46E-03
PCE	0.026	0.2	0.0052	0.016	4	0.064	0.004	5.8	0.0232	9.24E-03
Toluene	0.016	0.2	0.0032	0.006	4	0.024	0.001	5.8	0.0058	3.30E-03

1. All Data from Vironex Field GC (mg/l)
2. Velocity from Stream Flow Data Collected the day of Sampling
3. *Stream Concentrations are Weighted based on Stream Flow Data*

Total Wt. 9.26E-02

(Cross Section # 715)

Q= 508.94 l/sec

VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	508.94	3.42E-02	1.74E+01
TCA	508.94	1.82E-02	9.28E+00
DCE	508.94	2.32E-02	1.18E+01
TCE	508.94	4.46E-03	2.27E+00
PCE	508.94	9.24E-03	4.70E+00
Toluene	508.94	3.30E-03	1.68E+00
		Total Flux=	4.71E+01
		Calc. Seg. Flux=	4.71E+01
		0	

AR100441

Cross Section # 646

Weighted Concentrations (mg/l)

Parameter	SW-13	W. Factor	W. Conc.	SW-14	W. Factor	W. Conc.	SW-20	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.219	2.5	0.5475	0.069	7	0.483	0.238	0.5	0.119	1.15E-01
TCA	0.133	2.5	0.3325	0.022	7	0.154	0.245	0.5	0.1225	6.09E-02
DCE	0.078	2.5	0.195	0.011	7	0.077	0.121	0.5	0.0605	3.33E-02
TCE	0.009	2.5	0.0225	0.003	7	0.021	0.016	0.5	0.008	5.15E-03
PCE	0.02	2.5	0.05	0.007	7	0.049	0.024	0.5	0.012	1.11E-02
Toluene	0.008	2.5	0.02	0.002	7	0.014	0.02	0.5	0.01	4.40E-03

1. All Data from Vironex Field GC (mg/l)
2. Velocity from Stream Flow Data Collected the day of Sampling
3. Stream Concentrations are Weighted based on Stream Flow Data

(Cross Section # 646) Total Wt. 2.30E-01

Q= 282.74 l/sec VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	282.74	1.15E-01	3.25E+01
TCA	282.74	6.09E-02	1.72E+01
DCE	282.74	3.33E-02	9.40E+00
TCE	282.74	5.15E-03	1.46E+00
PCE	282.74	1.11E-02	3.14E+00
Toluene	282.74	4.40E-03	1.24E+00
		Total Flux=	6.50E+01
		Calc. Seg. Flux=	6.50E+01
		0	

AR100442

Cross Section # 562

Weighted Concentrations (mg/l)

Parameter	SW-15	W. Factor	W. Conc.	SW-16	W. Factor	W. Conc.	SW-22*	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.256	4.2	1.0752	0.097	5.2	0.5044	0.097	0.6	0.0582	1.64E-01
TCA	0.219	4.2	0.9198	0.039	5.2	0.2028	0.14	0.6	0.084	1.21E-01
DCE	0.103	4.2	0.4326	0.018	5.2	0.0936	0.083	0.6	0.0498	5.76E-02
TCE	0.013	4.2	0.0546	0.003	5.2	0.0156	0.011	0.6	0.0066	7.68E-03
PCE	0.021	4.2	0.0882	0.009	5.2	0.0468	0.016	0.6	0.0096	1.45E-02
Toluene	0.01	4.2	0.042	0.002	5.2	0.0104	0.014	0.6	0.0084	6.08E-03

1. * = Laboratory Confirmatory Data Concentration (mg/l)
2. Other Data from Vironex Field GC (mg/l)
3. Velocity from Stream Flow Data Collected the day of Sampling
4. Stream Concentrations are Weighted based on Stream Flow Data

(Cross Section # 562) Total Wt. 3.70E-01

Q= 282.74 l/sec VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	282.74	1.64E-01	4.63E+01
TCA	282.74	1.21E-01	3.41E+01
DCE	282.74	5.76E-02	1.63E+01
TCE	282.74	7.68E-03	2.17E+00
PCE	282.74	1.45E-02	4.09E+00
Toluene	282.74	6.08E-03	1.72E+00
		Total Flux=	1.05E+02
		Calc. Seg. Flux=	1.06E+02

AR100443

Cross Section # 479

Weighted Concentrations (mg/l)

Parameter	SW-24	W. Factor	W. Conc.	SW-41	W. Factor	W. Conc.	SW-42	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.181	0.2	0.0362	0.154	2.3	0.3542	0.024	7.5	0.18	5.70E-02
TCA	0.127	0.2	0.0254	0.068	2.3	0.1564	0.014	7.5	0.105	2.87E-02
DCE	0.072	0.2	0.0144	0.058	2.3	0.1334	0.006	7.5	0.045	1.93E-02
TCE	0.009	0.2	0.0018	0.008	2.3	0.0184	0.002	7.5	0.015	3.52E-03
PCE	0.02	0.2	0.004	0.007	2.3	0.0161	0.005	7.5	0.0375	5.76E-03
Toluene	0.007	0.2	0.0014	0.006	2.3	0.0138	0.001	7.5	0.0075	2.27E-03

1. All Data from Vironex Field GC (mg/l)
2. Velocity from Stream Flow Data Collected the day of Sampling
3. Stream Concentrations are Weighted based on Stream Flow Data

Total Wt. 1.17E-01

(Cross Section # 479)

Q= 282.74 l/sec

VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	282.74	5.70E-02	1.61E+01
TCA	282.74	2.87E-02	8.11E+00
DCE	282.74	1.93E-02	5.45E+00
TCE	282.74	3.52E-03	9.95E-01
PCE	282.74	5.76E-03	1.63E+00
Toluene	282.74	2.27E-03	6.42E-01
		Total Flux=	3.30E+01
		Calc. Seg. Flux=	3.30E+01
		0	

AR100444

Cross Section # 433

Weighted Concentrations (mg/l)

Parameter	SW-26*	W. Factor	W. Conc.	SW-28	W. Factor	W. Conc.	SW-29	W. Factor	W. Conc.	Final Conc.
Meth. Cl.	0.079	1.5	0.1185	0.148	4.5	0.666	0.154	4	0.616	1.40E-01
	0.077	1.5	0.1155	0.085	4.5	0.3825	0.086	4	0.344	8.42E-02
DCE	0.044	1.5	0.066	0.048	4.5	0.216	0.047	4	0.188	4.70E-02
TCE	0.007	1.5	0.0105	0.007	4.5	0.0315	0.007	4	0.028	7.00E-03
PCE	0.012	1.5	0.018	0.017	4.5	0.0765	0.017	4	0.068	1.63E-02
Toluene	0.01	1.5	0.015	0.005	4.5	0.0225	0.005	4	0.02	5.75E-03

1. * = Laboratory Confirmatory Data Concentration (mg/l)
2. Other Data from Vironex Field GC (mg/l)
3. Velocity from Stream Flow Data Collected the day of Sampling
4. Stream Concentrations are Weighted based on Stream Flow Data

Total Wt. 3.00E-01

(Cross Section # 433)

Q= 282.74 l/sec

VOC Conc.

Parameter	Q (l/sec)	Ave. Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	282.74	1.40E-01	3.96E+01
TCA	282.74	8.42E-02	2.38E+01
DCE	282.74	4.70E-02	1.33E+01
TCE	282.74	7.00E-03	1.98E+00
PCE	282.74	1.63E-02	4.59E+00
Toluene	282.74	5.75E-03	1.63E+00
		Total Flux=	8.49E+01
		Calc. Seg. Flux=	8.60E+01

AR100445

Piezometer Mass Flux Calculations					
Piezometer Mass Flux = Q*C (average)					
("OB-4" Con't)					
"OB-4L"PZFlux=	0.07	mg/sec			
BRFlux=(6.58*0.20)+(45.4*0.5)					
"OB-4L"BRFlux=	24.02	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-4L"SEDFlux=	-23.95	mg/sec			
Calculation Sheet for "OB-5" Sediment Flux					
Q=(.20*.80)+(.3*.25)		0.235	l/sec		
PZ (ave.)=	5.32				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
PZ-23*	20				
PZ-5*	0.002				
RD-6	0.002				
RD-5	1.68				
RD-4	4.9				
Total VOCs	26.58				
Ave. VOCs	5.32				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2.* = Concentration Data from ERM FRI Report (mg/l)					
3. All other concentration data from AGC Pre-design Investigation					
4. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					
Piezometer Mass Flux Calculations					
Piezometer Mass Flux = Q*C (average)					
"OB-5"PZFlux=	1.25	mg/sec			
BRFlux=(6.58*0.80)+(.244*0.25)					
"OB-5"BRFlux=	5.325	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-5"SEDFlux=	-4.08	mg/sec			

1. All concentrations are expressed in milligrams/liter (mg/l)
2.* = Concentration Data from ERM FRI Report (mg/l)
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC

Flux = Q*C (average) (BR-5 Con't)

Mass Flux by Parameter

Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	1.80E-01	202.490	3.64E+01
TCA	1.80E-01	13.870	2.50E+00
DCE	1.80E-01	2.370	4.27E-01
TCE	1.80E-01	8.160	1.47E+00
PCE	1.80E-01	19.940	3.59E+00
Toluene	1.80E-01	5.580	1.00E+00
		Total Flux	4.54E+01

Calculation Sheet for BR-6

Q	0.2	l/sec

Average Concentration by Parameter

Parameter	VW-3*	AW-2*	Total Conc.	Ave. Conc.
Meth. Cl.	0.77	6.76	7.53	3.765
TCA	5.89	1.9	7.79	3.895
DCE	30.94	0	30.94	15.470
TCE	13.53	0.44	13.97	6.985
PCE	3.67	0.84	4.51	2.255
Toluene	0.96	0.11	1.07	0.535
			Total VOCs	32.905
			Tot. ID Comp.	78.15

1. All concentrations are expressed in milligrams/liter (mg/l)
2.* = Concentration Data from ERM FRI Report (mg/l)
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC

Flux = Q*C (average)

Mass Flux by Parameter

Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)
Meth. Cl.	2.00E-01	3.765	7.53E-01
TCA	2.00E-01	3.895	7.79E-01
DCE	2.00E-01	15.470	3.09E+00
TCE	2.00E-01	6.985	1.40E+00
PCE	2.00E-01	2.255	4.51E-01
Toluene	2.00E-01	0.535	1.07E-01
		Total Flux	6.58E+00

Calculation Sheet for BR-7							
Q	0.3	l/sec					
Average Concentration by Parameter							
Parameter	RAW-1	RAW-2			Total Conc.	Ave. Conc.	
Meth. Cl.	0	0			0	0.000	
TCA	0.35	0.48			0.83	0.415	
DCE	0.18	0.32			0.5	0.250	
TCE	0.078	0.11			0.188	0.094	
PCE	0.041	0.07			0.111	0.056	
Toluene	0	0			0	0.000	
					Total VOCs	0.815	
					Tot. ID Comp.	1.73	
1. All concentrations are expressed in milligrams/liter (mg/l)							
2. RAW-1 and RAW-2 Concentration Data from AGC 8/96 Sampling Event (mg/l)							
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC							
Flux = Q*C (average)							
Mass Flux by Parameter							
Parameter	Q (l/sec)	Conc. (mg/l)	Flux (mg/sec)				
Meth. Cl.	3.00E-01	0.000	0.00E+00				
TCA	3.00E-01	0.415	1.25E-01				
DCE	3.00E-01	0.250	7.50E-02				
TCE	3.00E-01	0.094	2.82E-02				
PCE	3.00E-01	0.056	1.67E-02				
Toluene	3.00E-01	0.000	0.00E+00				
		Total Flux	2.44E-01				
Total Bedrock Flux to Stream by Parameter							
Parameter			Cum. Flux				
Meth. Cl.			7.49E+01				
TCA			6.92E+00				
DCE			3.81E+00				
TCE			6.39E+00				
PCE			5.12E+00				
Toluene			1.40E+00				
		Total Flux	9.86E+01		9.86E+01		

Calculation Sheet for "OB-1" Sediment Flux					
Q=.237*.75	0.178	l/sec			
PZ (ave.)=	2.25	mg/l			
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
PZ-2*	0.006				
PZ-22*	1.76				
PZ-21*	0				
RD-12	0.067				
RD-11	11.64				
RD-10	0.056				
Total VOCs	13.53				
Ave. VOCs	2.25				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2.* = Concentration Data from ERM FRI Report (mg/l)					
3. All other concentration data from AGC Pre-design Investigation					
4. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					
Piezometer Mass Flux Calculations					
Piezometer Flux = Q*C (average)					
"OB-1"PZ Flux=	0.40	mg/sec			
BRFlux= 3.62*.75					
"OB-1"BRFlux=	2.72	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-1SEDFlux=	-2.31	mg/sec			
Calculation Sheet for "OB-2" Sediment Flux					
Q=.237*.25+.009+.0002*.60		0.07	l/sec		
PZ (ave.)=	300.75				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
PZ-17	1.35				
PZ-17	2.1				
PZ-11	0.48				
PZ-12	290				
PZ-6	68				
PZ-8	8.6				
PZ-3	326				
PZ-3	1468				
PZ-10	119.7				
PZ-7	554				
PZ-19	470				
Total VOCs	3308.23				
Ave.VOCs	300.75				

("OB-2" Con't)

1. All concentrations are expressed in milligrams/liter (mg/l)
2. All Concentration Data from ERM FRI Report (mg/l)
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC

Piezometer Mass Flux Calculations

Piezometer Mass Flux = Q*C (average)

"OB-2" PZ Flux=	20.56	mg/sec

BRflux= (3.62*.25)+20.6+(.457*.60)

"OB-2"BRFlux=	21.78	mg/sec

SEDFlux=PZFlux-BRFlux

"OB-2"SEDFlux=	-1.22	mg/sec

Calculation Sheet for "OB-3" Sediment Flux

Q=(.0002*.40)+(.009*.75)		0.007	l/sec
PZ (ave.)=	700.3		

Piezometer Average Concentration (mg/l)

Sample ID	Conc. (mg/l)
PZ-14	5.2
PZ-18	180
PZ-15	816
PZ-13	1800
Total VOCs	2801.2
Ave. VOCs	700.3

1. All concentrations are expressed in milligrams/liter (mg/l)
2. All Concentration Data from ERM FRI Report (mg/l)
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC

Piezometer Mass Flux Calculations

Piezometer Mass Flux = Q*C (average)

"OB-3"PZ Flux=	4.78	mg/sec

BRFlux=(.457*.40)+(21.6*.75)

"OB-3"BRFlux=	16.38	mg/sec

SEDFlux=PZFlux-BRFlux

"OB-3"SEDFlux=	-11.60	mg/sec

Calculation Sheet for "OB-4" (UpperPortion)					
Q=(.009*.25)+(.18*.50)		0.092	l/sec		
PZ (ave.)=	1257.67				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
PZ-25*	164				
PZ-16*	5600				
PZ-16*	816				
RD-9	44				
RD-8	648				
RD-7	274				
Total VOCs	7546.00				
Ave. VOCs	1257.67				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2.* = Concentration Data from ERM FRI Report (mg/l)					
3. All other concentration data from AGC Pre-design Investigation					
4. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					
Piezometer Mass Flux Calculations					
Piezometer Mass Flux = Q*C (average)					
"OB-4U"PZFlux=	116.02	mg/sec			
BRFlux=	(21.6*0.25)+(45.4*0.5)				
"OB-4U"BRFlux=	28.10	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-4U"SEDFlux=	87.92	mg/sec			
Calculation Sheet for "OB-4" (Lower Portion)					
Q=(.18*.50)+(.20*.20)		0.13	l/sec		
PZ (ave.)=	0.54				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
PZ-4	0.4				
PZ-26	0.67				
Total VOCs	1.07				
Ave. VOCs	0.54				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2. All Concentration Data from ERM FRI Report (mg/l)					
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					

Piezometer Mass Flux Calculations					
Piezometer Mass Flux = Q*C (average)					
"OB-7"PZFlux=	0.19	mg/sec			
BRFlux=.244					
"OB-7"BRFlux=	0.244	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-7"SEDFlux=	-0.06	mg/sec			
Total Cum. PZ Flux=	**143.51**	**mg/sec**			
Total Cum.SED Flux=	**44.77**	**mg/sec**			

Calculation Sheet for "OB-6"					
Q=(.30*.75)		0.225	l/sec		
PZ (ave.)=	1.07				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
RD-3	0.004				
RD-2	0.966				
RD-1	3				
RD-13	0.645				
RD-14	0.757				
Total VOCs	5.37				
Ave. VOCs	1.07				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2. All concentration data from AGC Pre-design Investigation					
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					
Piezometer Mass Flux Calculations					
Piezometer Mass Flux = Q*C (average)					
"OB-6"PZFlux=	0.24	mg/sec			
BRFlux=(.244*0.75)					
"OB-6"BRFlux=	0.183	mg/sec			
SEDFlux=PZFlux-BRFlux					
"OB-6"SEDFlux=	0.06	mg/sec			
Calculation Sheet for "OB-7"					
Q=.30		0.3	l/sec		
PZ (ave.)=	0.62				
Piezometer Average Concentration (mg/l)					
Sample ID	Conc. (mg/l)				
RD-15	0.271				
RD-16	0.304				
RD-17	0.786				
RD-17	0.68				
RD-17	0.852				
RD-18	0.697				
RD-18	0.768				
Total VOCs	4.36				
Ave. VOCs	0.62				
1. All concentrations are expressed in milligrams/liter (mg/l)					
2. All concentration data from AGC Pre-design Investigation					
3. Velocity Data Developed using K and I Values from ERM FRI and A as Developed from AGC					

APPENDIX D

ODOR EMISSIONS ANALYSIS

ROCKY MOUNTAIN

RMBI

BUSINESS INNOVATIONS

SPECTRON/GALAXY SITE
ELKTON, MARYLAND

REMOVAL ACTION
EVALUATION OF POTENTIAL ATMOSPHERIC VOC RELEASES DURING CONSTRUCTION

Prepared By:
John Haasbeek
Rocky Mountain Business Innovations, Inc.
September 8, 1997

1 Introduction

This document presents estimates of atmospheric VOC concentrations related to the planned Removal Action (RA) at the Galaxy/Spectron Superfund site. The RA is intended to mitigate discharge of VOCs to the Little Elk Creek, and is currently in the design phase. This document has been prepared at the request of Advanced GeoServices Corp (AGC), and is intended to provide guidance related to the need for mitigative measures during the RA. The objectives of this analysis are to:

1. develop a conceptual model of potential atmospheric discharges of VOCs from the Little Elk Creek sediments during construction activities;

2. develop a mathematical model to estimate the resulting atmospheric concentrations in the breathing zone and surrounding areas; and

3. evaluate the range of results and describe the uncertainties associated with the estimates.

This analysis is based on existing site investigation data and RA preliminary design information presented in the following documents:

- Focused Remedial Investigation Work Plan. ERM. May 7, 1993.
- Removal Action Plan. ERM. August 4, 1995.
- Removal Action Conceptual Design Report. AGC. March 1, 1996.
- Removal Action Pre-Design Investigation Summary Report. AGC. November 22, 1996.
- Removal Action Draft Intermediate (75%) Design Report. AGC. April 3, 1997.

Section 2 of this document presents a brief site background. Sections 3 and 4 present the conceptual and mathematical models, respectively. Physical and chemical data used are given in Section 5, and the calculations and estimates of atmospheric concentrations are provided in Section 6. Section 7 presents the conclusions and recommendations of the analysis.

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2 Site Background

The Galaxy/Spectron site is a former solvent recycling and fuel blending facility occupying approximately 5 acres adjacent to the Little Elk Creek north of Elkton, Maryland. Details of the site history and prior investigative activities are skipped herein for brevity, but can be obtained from previous site reports. Previous investigations have shown the presence of various chlorinated and non-chlorinated VOCs in ground water, surface water, soils, and sediments at the site. The constituents of concern (COCs) identified at the site are 1,1,1 trichloroethane (1,1,1 TCA), cis-1,2 dichloroethylene (cis-1,2 DCE), methylene chloride, tetrachloroethylene (PCE), trichloroethylene (TCE), and toluene. Table 1 summarizes field-GC results for VOCs taken from piezometers located within the stream channel. The overburden segments referred to on the table are discussed in Section 6. Table 2 summarizes the VOC results by construction segments, also discussed in Section 6.

During previous investigations, Dense Non-Aqueous Phase Liquids (DNAPLs) were discovered in the sediments of Little Elk Creek. These DNAPLs, along with contaminated surface seeps and contaminated ground water discharge, have caused exceedences of Maryland State water quality standards in Little Elk Creek. The objective of the RA is to divert the discharge of VOCs into the creek in order to achieve the State water quality criteria. This will be accomplished using collection systems for seeps and contaminated ground water, and a mechanical isolation system for the creek sediments. The isolation system consists of a cast-in-place concrete structure with ground water cutoff walls that will convey the Little Elk Creek streamflow while eliminating contact with the contaminated sediments.

During construction of the proposed RA, the contaminated stream sediments will be exposed for a short period of time. During this time period, the release of VOCs from the sediments will divert to the atmosphere, creating a new potential transport pathway both within the creek bed and offsite. The purpose of this analysis is to evaluate that potential transport pathway, and to estimate the potential atmospheric concentrations of each of the COCs during the RA construction. Following completion of the construction activities, the atmospheric pathway will be eliminated by the presence of the cast-in-place concrete structure.

Table 1 - Average Overburden VOC Concentrations

	*Overburden Segment**						
Compound	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1,1,1-TCA	7,425	76,127	44,539	90,247	4,582	627	317
cis 1,2-DCE	740	NA	NA	25,378	671	212	90
Methylene Chloride	676	958,060	213,701	968,892	2,313	493	90
PCE	166	23,110	21,720	10,776	681	78	80
TCE	281	NA	NA	2,215	173	86	41
Toluene	1	NA	NA	7,126	22	1	0

All concentrations are ug/L
Concentration averages provided by AGG (transmittal dated 8/20/97).
* - Segment locations indicated on Figure 4. Segment 1 is upstream, segment 7 is downstream.

Table 2 - Average VOC Concentrations By Construction Segment

	*Construction Segment**		
Compound	*1*	*2*	*3*
1,1,1-TCA	41,776	67,393	1,842
cis 1,2-DCE	740	25,378	324
Methylene Chloride	479,368	591,297	965
PCE	11,638	16,248	280
TCE	281	2,215	100
Toluene	1	7,126	8

All concentrations are ug/L
Averages calculated by giving equal weight to each overburden segment listed in Table 1
* - Segment locations indicated on Figure 4.
Segment 1 is upstream, segment 3 is downstream.

3 Conceptual Model

There are three primary elements in the conceptual model for volatilization from stream sediments at the site. These elements (depicted in Figure 1) are:

1. the source of VOCs, which consists of VOCs dissolved in interstitial water within the stream bed (note – although DNAPL was observed directly in one location, all other locations showed VOC concentrations at 10% or less of solubility);

2. unsaturated soils and sediments of the stream channel which lie above the VOC source and through which the volatilized constituents must travel; and

3. the near-surface atmosphere into which volatilizing VOCs are discharged.

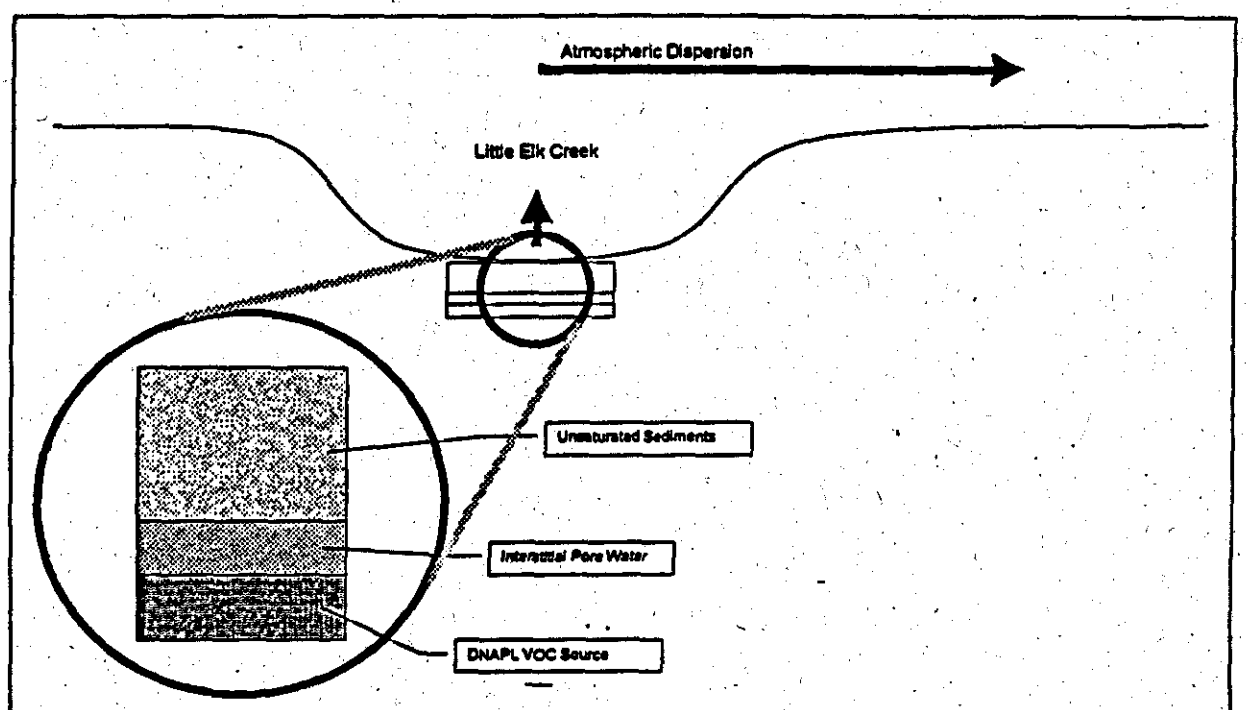

Figure 1 – Conceptual Model

The depiction in Figure 1 is a generalized model of the vertical cross-section within and above the stream channel. The strength of the source, and the thickness and properties of the unsaturated zone vary over the length of the channel. These variations are accounted for in the calculations (presented in Section 6). The discussion of the conceptual model and derivation of the mathematical model are based on the generalized model presented in Figure 1.

The first element (the VOC source) exists as VOC constituents dissolved in ground water. The strength of the source is represented by the measured ground water concentrations in different segments of the stream channel. The release of VOCs from the aqueous phase into the soil vapor in the unsaturated zone occurs by volatilization and is governed by Henry's law and the measured Henry's constants for each individual compound.

Once VOC vapors have entered the pore vapor space, they will migrate upwards toward the surface through the unsaturated bed sediments. This process is governed by Fick's First Law of dispersion, which describes the movement of gases through diffusion due to concentration gradients. The concentration gradient is defined by the difference in concentrations at the surface of the VOC source and at the ground surface, and by the thickness of the unsaturated zone.

VOC vapors diffusing upward through the unsaturated zone are entrained in the atmosphere when they reach the ground surface. A gaussian dispersion algorithm is used to estimate the resulting atmospheric concentrations in areas adjacent to the stream. For areas within the stream channel, a simplified box model will be used to estimate the resulting breathing zone concentrations.

Details on the mathematical formulation for each of these steps are given in the next section.

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4 Mathematical Model

The mathematical model for this site is derived from basic principals of physics and chemistry. Where possible, references are given for other authors who have used these same derivations, but it is important to understand that no specialized modeling codes or empirical calculations are included herein. The only exception is the gaussian dispersion used to estimate ambient air concentrations – the derivation of the mathematical model for gaussian dispersion is referenced rather than providing it in full.

Receptor Concentrations

The derivation of the mathematical model for this site begins with the estimation of atmospheric concentrations. There are two mathematical representations used herein; one for the breathing zone and one for areas adjacent to the stream channel (referred to as "ambient air"). In both cases, the source of VOCs to the atmosphere is represented by a ground-level area source with a given mass flux rate of each compound (Figure 2).

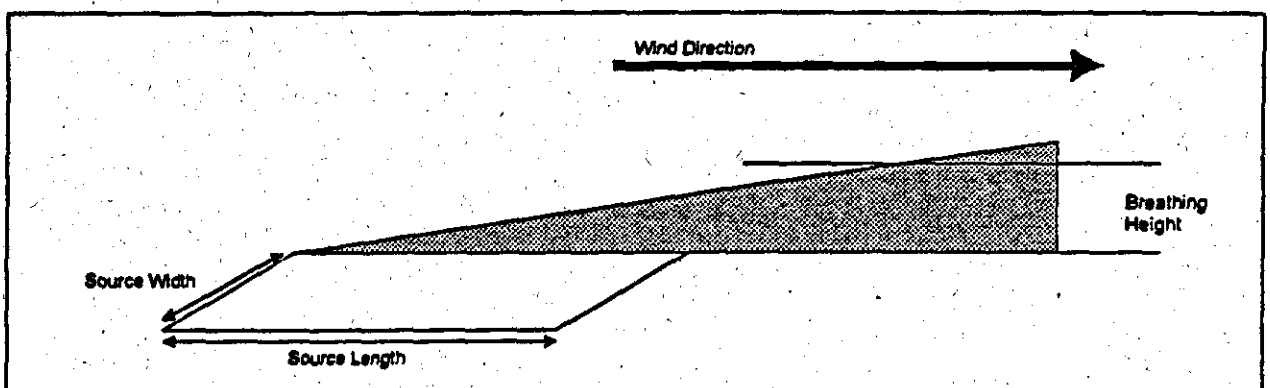

Figure 2 – Ground Level Area Source

Ambient Air Concentrations

The most widely used mathematical models for estimating ambient air concentrations resulting from a horizontal area source are based on the theory of gaussian dispersion. This is an empirical method that has been extensively calibrated to field data, primarily by the US EPA. In fact, the required atmospheric dispersion modeling techniques given in the Guideline on Air Quality Models (US EPA, 1986) use the gaussian dispersion technique. These models determine a concentration factor (χ/Q) based on a unit flux rate (1 $g/m^2/sec$). The concentration factor is generally a function of wind speed, atmospheric stability, downwind and crosswind distance, and height above ground surface. A detailed description of the development and calibration of a gaussian dispersion algorithm is provided by Turner (1970).

Details on the model calculations of χ/Q for this site are provided in Section 6. For the remainder of the derivation, the relationship between ambient air concentrations and the source mass flux rate are given as:

$$C_{a,i} = F_i * \chi/Q \qquad (1)$$

where

$C_{a,i}$ = ambient air concentration of compound i (mg/m^3)

F_i = mass flux of compound i at the ground surface ($mg/m^2/sec$)

χ/Q = model-determined concentration factor ((mg/m^3)/($mg/m^2/sec$))

Breathing Zone Concentrations

The breathing zone is defined as the zone between the ground surface and the average height of a human receptor. Concentrations in this zone resulting from mass vapor flux at the surface are estimated using a simple mixing model. This model is based on a mass balance performed within a control volume of air in the breathing zone as shown in Figure 3 (Zannetti, 1990). The length of the control volume into which the vapor flux disperses is defined by the wind speed. The resulting air volume is derived as follows:

$$V_{cv} = W * H * u * t \qquad (2)$$

where

V_{cv} = volume of the control volume (m^3)

W = width of the source area (m)

H = breathing height (m)

u = wind speed (m/sec)

t = elapsed time (sec)

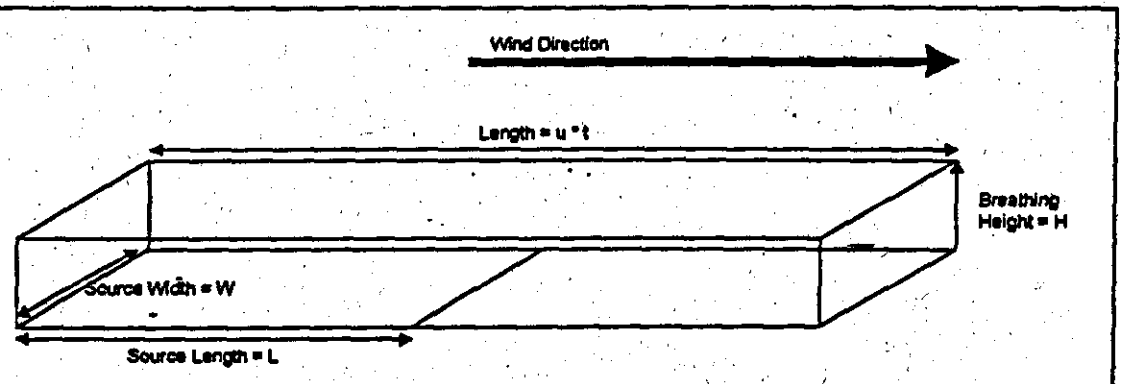

Figure 3 – Breathing Zone Mixing Model

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The mass discharged into the control volume is derived as:

$$M_i = F_i * W * L * t \quad (3)$$

where

M_i = mass of compound i discharged into the control volume (mg)

L = length of the source area in the direction of the wind (m)

The fully mixed concentration in the breathing zone is calculated as the mass in the control volume divided by the volume of the control volume:

$$C_{b,i} = M_i / V_{cv}$$

$$C_{b,i} = [F_i * W * L * t] / [W * H * u * t]$$

$$C_{b,i} = [F_i * L] / [H * u] \quad (4)$$

Mass Flux at the Surface

The movement of vapors from the subsurface source to the ground surface is driven by the concentration gradient as defined by Fick's First Law of diffusion (US EPA, 1988):

$$F_i = D_{e,i} * dC_i/dz \quad (5)$$

where

$D_{e,i}$ = effective diffusion coefficient of compound i in the soil matrix (m^2/sec)

dC_i/dz = vertical concentration gradient of compound i (mg/m^4)

The concentration gradient is calculated as follows:

$$dC_i/dz = [{}^0C_{v,i} - {}^1C_{v,i}] / h \quad (6)$$

where

${}^0C_{v,i}$ = vapor concentration of compound i just above the source (mg/m^3)

${}^1C_{v,i}$ = vapor concentration of compound i just above the ground surface (mg/m^3)

h = thickness of unsaturated zone (m)

In reality, the vapor concentration just above the ground source will not be equal to zero since the atmospheric dispersion does not completely remove the vapors immediately. However, assuming a ground-level vapor concentration of zero simplifies the model and produces conservative estimates of the volatilization rate. Therefore, we assume that ${}^1C_{v,i}$ is equal to zero for the purpose of determining the vapor concentration gradient.

The effective diffusion coefficient is related to the air diffusion coefficient of a vapor by an empirical relationship (US EPA, 1988) describing the tortuosity of the vapor space in the soil matrix:

$$D_{e,i} = D_{a,i} * [n_a^{3.33} / n^2] \quad (7)$$

where

$D_{a,i}$ = air diffusion coefficient for compound i (m^2/sec)

n_a = air-filled porosity of the soil (m^3/m^3)

n = total porosity of the soil (m^3/m^3)

Therefore, the mass flux may be simplified as follows:

$$F_i = D_{a,i} * [n_a^{3.33} / n^2] * [{}^0C_{v,i} - {}^1C_{v,i}] / h \quad (8)$$

Vapor Concentrations at the Source

The equilibrium between the dissolved and vapor phases is governed by Henry's Law (US EPA, 1988):

$${}^0C_{v,i} = H'_i * C_{aq,i} * 1000\ l/m^3 \quad (9)$$

where

H'_i = dimensionless Henry's constant for compound i

$C_{aq,i}$ = *measured ground water concentration of compound i*

Summary

The equations derived above can be combined for the two desired endpoints, as summarized in the following matrix:

Receptor Type	
Breathing Zone Concentration	*Ambient Air Concentration*
$C_{b,i} = [D_{a,i} * [n_a^{3.33} / n^2] * H'_i * 1000 * C_{aq,i} * L] / [h * H * u]$	$C_{a,i} = [D_{a,i} * [n_a^{3.33} / n^2] * H'_i * 1000 * C_{aq,i} * \chi/Q] / h$

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5 Physical and Chemical Data

The physical parameters used in the site model are provided in Table 3. Note that some of the physical parameters are provided as a range of values – the ranges are evaluated in Section 6 below. The chemical parameters used for each compound are provided in Table 4.

Table 3 – Physical Parameter Values

Parameter	*Symbol*	*Units*	*Value*	*Source*
breathing height	H	m	2	(1)
wind speed	U	m/s	3.5	(2)
source area length	L	m	Varies	(3)
source area width	W	m	Varies	(3)
unsaturated zone thickness	h	m	0.15 – 1	(3)
total porosity	n	m^3/m^3	0.3	(4)
air-filled porosity	na	m^3/m^3	0.1 - 0.2	(4)
temperature	T	°C	25.4	(5)
temperature	T	°K	303.4	

(1) - US EPA, 1996a
(2) - based on mean July wind speeds for 1987 through 1994 from NOAA data for Wilmington WSO
(3) - 90% Design
(4) - professional estimate
(5) - based on mean daily July temperatures for 1987 through 1996 from NOAA data for Wilmington WSO

Table 4 – Chemical Parameter Values

—	*Air Diffusion Coefficient* m^2/sec	*Henry's Law Coefficient* -
1,1,1-TCA	7.80E-06	7.05E-01
cis 1,2-DCE	7.36E-06	1.67E-01
Methylene Chloride	1.01E-05	8.98E-02
PCE	7.20E-06	7.54E-01
TCE	7.90E-06	4.22E-01
Toluene	8.70E-06	2.72E-01

Values taken from the Soil Screening Guidance (US EPA, 1996b).

6 Calculations

During the implementation of the Removal Action, portions of the Little Elk creek will be dewatered and exposed for construction activities. Details of the construction sequence and activities can be found in the 90% Design. The construction will be completed in three phases, as depicted on Figure 4. The three construction segments are characterized by different model inputs with respect to calculation of expected atmospheric VOC concentrations. Only one construction segment will be open at any time – the mathematical model was therefore applied to each construction segment individually. Table 5 shows the model inputs by construction segment.

Table 5 – Construction Segment Parameter Values

Parameter	*Segment 1*	*Segment 2*	*Segment 3*
Average Width (m)	30	20	20
Length (m)	80	80	100
Area (m^2)	2400	1600	2000

Appendix A shows the output from the SCREEN3 model used to determine χ/Q values. The SCREEN3 model was developed by the US EPA for use in determining screening level ambient air concentrations from point, area, and volume sources. The model was executed using an area source with dimensions for each construction segment as indicated in Table 5. The average wind speed was combined with worst-case stability conditions to determine the maximum possible short-term downwind concentrations in the critical wind direction. The ambient concentrations reported in Table 9 are based on a 1-hour averaging period.

Table 6 shows the estimated ground level fluxes for each constituent for each of the three construction segments, given in terms of flux per unit area. Table 7 shows these fluxes converted using the approximate area of each construction segment. Table 7 also shows the estimated total flux of VOCs into the creek by construction segment taken from the Pre-Design Investigation Summary Report. The previously calculated flux values represent the estimated flux of VOCs from ground water and sediments into the creek under natural conditions, and are not directly comparable to the estimated volatilization fluxes under construction conditions. However, as a point of reference, there is strong similarity between the magnitude of the fluxes calculated based on volatilization, and those previously calculated based on ground water discharge to the creek.

Table 8 shows estimated breathing zone concentrations and Table 9 shows estimated downwind ambient concentrations for each constituent by construction segment. Appendix B shows an illustrated calculation of TCE concentrations for construction segment 2.

The calculations shown in Tables 8 and 9 were performed using an unsaturated zone thickness of 0.6 m (2 ft), and an air-filled porosity of 0.2. These values are the most likely average values for these parameters.

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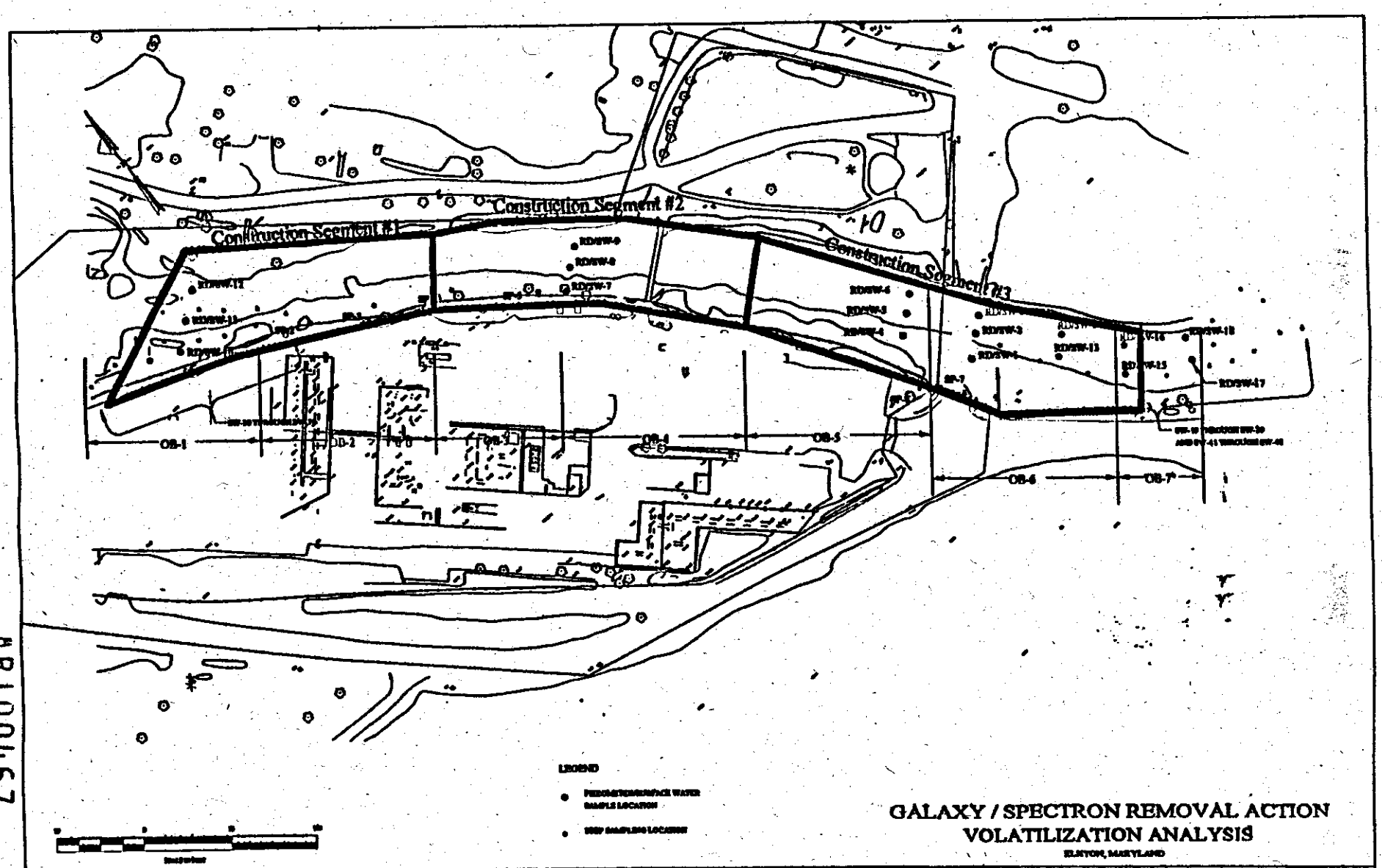

FIGURE 4: OVERBURDEN AND CONSTRUCTION SEGMENTS

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Table 6 - Calculated Fluxes

Compound	Construction Segment 1	2	3
1,1,1-TCA	2.00E-02	3.23E-02	8.82E-04
cis 1,2-DCE	7.92E-05	2.72E-03	3.47E-05
Methylene Chloride	3.79E-02	4.67E-02	7.63E-05
PCE	5.50E-03	7.68E-03	1.32E-04
TCE	8.16E-05	6.43E-04	2.90E-05
Toluene	2.06E-07	1.47E-03	1.58E-06

All fluxes are $mg/m^2/sec$

Table 7 - Comparison to Previous Flux Estimates

Compound	Construction Segment 1	2	3
Segment Area (m^2)	2400	1600	2000
1,1,1-TCA	4.80E+01	5.16E+01	1.76E+00
cis 1,2-DCE	1.90E-01	4.35E+00	6.94E-02
Methylene Chloride	9.09E+01	7.47E+01	1.53E-01
PCE	1.32E+01	1.23E+01	2.64E-01
TCE	1.96E-01	1.03E+00	5.81E-02
Toluene	9.09E+01	7.47E+01	1.53E-01
Total	2.43E+02	2.19E+02	2.46E+00
PDI Estimate[1]	3.32E+01	1.52E+02	2.84E+00

All fluxes are mg/sec

1 - Pre-Design Investigation estimate of natural flux into stream from bedrock and overburden discharge

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Table 8 - Estimated Breathing Zone Concentrations

Compound	Construction Segment		
	1	2	3
1,1,1-TCA	2.29E-01	3.69E-01	1.26E-02
cis 1,2-DCE	9.05E-04	3.11E-02	4.96E-04
Methylene Chloride	4.33E-01	5.34E-01	1.09E-03
PCE	6.29E-02	8.78E-02	1.89E-03
TCE	9.33E-04	7.35E-03	4.15E-04
Toluene	2.36E-06	1.68E-02	2.26E-05

All concentrations are mg/m^3

Table 9 - Estimated Maximum Ambient Air Concentrations

Compound	Construction Segment		
	1	2	3
1,1,1-TCA	4.12E-02	4.45E-02	1.22E-03
cis 1,2-DCE	1.63E-04	3.74E-03	4.78E-05
Methylene Chloride	7.80E-02	6.44E-02	1.05E-04
PCE	1.13E-02	1.06E-02	1.82E-04
TCE	1.68E-04	8.86E-04	4.00E-05
Toluene	4.24E-07	2.02E-03	2.18E-06

All concentrations are mg/m^3
Concentrations calculated perpendicular to stream channel

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7 Summary and Conclusions

Table 10 summarizes the ranges of estimated concentrations for the breathing zone and the ambient air adjacent to the stream channel.

Table 10 – Summary of Estimated Concentration Ranges

Compound	*Daily Average Breathing Zone Concentration Range (mg/m³)*	*Hourly Average Ambient Air (100m) Concentration Range (mg/m³)*
1,1,1-TCA	0.01 - 0.4	0.001 - 0.04
cis 1,2-DCE	0.0005 - 0.03	0.00005 - 0.004
Methylene Chloride	0.001 - 0.5	0.0001 - 0.08
PCE	0.002 - 0.09	0.0002 - 0.01
TCE	0.0004 - 0.007	0.00004 - 0.0009
Toluene	0.000002 - 0.02	0.0000004 - 0.002

The results presented here do not account for other background sources of VOCs, and represent only the contribution of volatilization from the subsurface. Other background concentrations should be added to these results to estimate the concentrations that will be observed in the field.

The breathing zone concentration estimates show that the highest concentrations are seen consistently in construction segment 2. A review of the overburden segment VOC data in Table 1 show that overburden segment numbers 2 and 4 have somewhat higher methylene chloride concentrations than the averages for the construction segments shown in Table 2. The same is true for the other COCs. Actual concentrations observed in the field should be higher while working in these segments than the averages would indicate. However, the difference is not great, and is not more than a factor of 2.

The volatilization estimates provided by this analysis are dependent on the ground water data collected, and thus are subject to change as the source term changes. Based on the planned collection of ground water during the construction of the remedy, and the significant time period which has elapsed since the last major sampling effort, the actual ground water concentrations are expected to be lower than the older data would suggest. This will cause a concomitant reduction in the estimated atmospheric concentrations.

For comparison purposes, Table 11 lists the ACGIH TLV-TWA values and the EPA Region 3 ("Roy's List") Risk Based Concentrations (RBCs) for ambient air for the constituents of concern. The RBCs were developed to be protective of long-term exposures, while the TLV-TWAs are specifically relevant to worker exposures. The inclusion of these values herein does not imply that they are appropriate targets for the proposed removal action. However, they are provided as a reference point by which to assess the magnitude of the estimated concentrations provided in Tables 8, 9, and 10.

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Table 11 – Health Benchmarks

Compound	*8-Hour TLV-TWA** (mg/m³)*	*Ambient Air RBC* (mg/m³)*
1,1,1-TCA	1910	1.0
cis 1,2-DCE	793	0.037
Methylene Chloride	174	0.0038
PCE	170	0.0031
TCE	269	0.001
Toluene	188	0.42

* - EPA Region III Risk-Based Concentration Guidance, April 30, 1996.
** - National Library of Medicine MEDLARS (RTECS) accessed July 27, 1997.

The RBC values are based on a 30-year exposure period and should be adjusted to account for the shorter exposure period during construction prior to comparison to the estimated ambient concentrations. Based on a preliminary comparison of the estimated concentrations to the health benchmarks presented, it is apparent that the worker protection benchmarks are significantly higher than the estimated breathing zone concentrations. The RBC values (unadjusted) are comparable to the estimated ambient concentrations, and the adjusted RBC values will probably be higher.

8 References

Turner, D. B., 1970. Workbook of Atmospheric Dispersion Estimates. EPA, Research Triangle Park, NC.

US EPA, 1986. *Guideline on Air Quality Models*. EPA-450/2-78-027R. EPA, Research Triangle Park, NC.

US EPA, 1988. Superfund Exposure Assessment Manual. OSWER Directive 9285.5-1. Office of Solid Waste and Emergency Response, Washington, DC.

US EPA, 1996a. *Exposure Factors Handbook (Review Draft)*. Government Institutes, Inc., Rockville, MD.

US EPA, 1996b. Soil Screening Level Guidance. OSWER Publication 9355.4-23. Office of Solid Waste and Emergency Response, Washington, DC.

Zannetti, P., 1990. Air Pollution Modeling – Theories, Computational Models, and Available Software. Van Nostrand, Reinhold, New York, NY.

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9 Appendix A – SCREEN Model Results

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  ***  SCREEN3 MODEL RUN  ***
  *** VERSION DATED 96043 ***

 Spectron Site - Construction Segment 1

 SIMPLE TERRAIN INPUTS:
    SOURCE TYPE                    =        AREA
    EMISSION RATE (G/(S-M**2))     =     1.00000
    SOURCE HEIGHT (M)              =       .0000
    LENGTH OF LARGER SIDE (M)      =     80.0000
    LENGTH OF SMALLER SIDE (M)     =     30.0000
    RECEPTOR HEIGHT (M)            =      2.0000
    URBAN/RURAL OPTION             =       RURAL
 THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

    ANGLE RELATIVE TO LONG AXIS =      90.0000


 BUOY. FLUX =     .000 M**4/S**3;  MOM. FLUX =     .000 M**4/S**2.

 *** STABILITY CLASS  6 ONLY ***
 *** ANEMOMETER HEIGHT WIND SPEED OF   3.50 M/S ONLY ***

 ***********************************
 *** SCREEN AUTOMATED DISTANCES ***
 ***********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

   DIST     CONC              U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB    (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----   -----  -----  ------  ------  -------
    10.   .2989E+05    6      3.5    3.5  10000.0     .00     90.
   100.   .2026E+07    6      3.5    3.5  10000.0     .00     90.
   200.   .1484E+07    6      3.5    3.5  10000.0     .00     90.

 MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
    85.   .2059E+07    6      3.5    3.5  10000.0     .00     90.

      ****************************************
      *** SUMMARY OF SCREEN MODEL RESULTS ***
      ****************************************

  CALCULATION         MAX CONC    DIST TO   TERRAIN
   PROCEDURE         (UG/M**3)    MAX (M)    HT (M)
 --------------     -----------   -------   -------
 SIMPLE TERRAIN      .2059E+07      85.        0.


 ****************************************************
 ** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
 ****************************************************
```


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 ***  SCREEN3 MODEL RUN  ***
 *** VERSION DATED 96043 ***

Spectron Site - Construction Segment 2

SIMPLE TERRAIN INPUTS:
   SOURCE TYPE                =        AREA
   EMISSION RATE (G/(S-M**2)) =     1.00000
   SOURCE HEIGHT (M)          =       .0000
   LENGTH OF LARGER SIDE (M)  =     80.0000
   LENGTH OF SMALLER SIDE (M) =     20.0000
   RECEPTOR HEIGHT (M)        =      2.0000
   URBAN/RURAL OPTION         =       RURAL
THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

   ANGLE RELATIVE TO LONG AXIS =     90.0000


BUOY. FLUX =     .000 M**4/S**3;  MOM. FLUX =     .000 M**4/S**2.

*** STABILITY CLASS  6 ONLY ***
*** ANEMOMETER HEIGHT WIND SPEED OF   3.50 M/S ONLY ***

**********************************
*** SCREEN AUTOMATED DISTANCES ***
**********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST     CONC            U10M   USTK  MIX HT   PLUME  MAX DIR
   (M)   (UG/M**3)   STAB  (M/S)  (M/S)   (M)    HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
    10.   4453.        6     3.5    3.5 10000.0     .00     90.
   100.   .1353E+07    6     3.5    3.5 10000.0     .00     90.
   200.   .9892E+06    6     3.5    3.5 10000.0     .00     90.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
    84.   .1378E+07    6     3.5    3.5 10000.0     .00     90.

     ****************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ****************************************

 CALCULATION         MAX CONC    DIST TO   TERRAIN
  PROCEDURE         (UG/M**3)    MAX (M)    HT (M)
 --------------    -----------   -------   -------
 SIMPLE TERRAIN     .1378E+07      84.        0.


*****************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
*****************************************************
```


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 ***  SCREEN3 MODEL RUN  ***
 *** VERSION DATED 96043 ***

Spectron Site - Construction Segment 3

SIMPLE TERRAIN INPUTS:
   SOURCE TYPE                  =        AREA
   EMISSION RATE (G/(S-M**2))   =     1.00000
   SOURCE HEIGHT (M)            =       .0000
   LENGTH OF LARGER SIDE (M)    =    100.0000
   LENGTH OF SMALLER SIDE (M)   =     20.0000
   RECEPTOR HEIGHT (M)          =      2.0000
   URBAN/RURAL OPTION           =       RURAL
THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

   ANGLE RELATIVE TO LONG AXIS =      90.0000


BUOY. FLUX =     .000 M**4/S**3;  MOM. FLUX =     .000 M**4/S**2.

*** STABILITY CLASS  6 ONLY ***
*** ANEMOMETER HEIGHT WIND SPEED OF   3.50 M/S ONLY ***

**********************************
*** SCREEN AUTOMATED DISTANCES ***
**********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST     CONC              U10M   USTK  MIX HT   PLUME  MAX DIR
   (M)   (UG/M**3)   STAB   (M/S)  (M/S)    (M)   HT (M)   (DEG)
-------  ----------  ----   -----  -----  ------  ------  -------
    10.   4453.        6     3.5    3.5 10000.0     .00     90.
   100.   .1353E+07    6     3.5    3.5 10000.0     .00     90.
   200.   .9892E+06    6     3.5    3.5 10000.0     .00     90.

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND    10. M:
    84.   .1378E+07    6     3.5    3.5 10000.0     .00     90.

     ****************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ****************************************

 CALCULATION        MAX CONC    DIST TO   TERRAIN
  PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
--------------    -----------   -------   -------
SIMPLE TERRAIN      .1378E+07      84.        0.


****************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
****************************************************
```


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10 Appendix B – Example Calculations

Sample calculations for TCE in construction segment 2:

C_{aq} = 2,215 µg/L (average from piezometers – see Table 2)

= 2.215 mg/L

^0C_v = C_{aq} * H' * 1000 L/m³

= 2.215 mg/L * 0.422 * 1000 L/m³

= 934.7 mg/m³

F = D_a * [$n_a^{3.33}/n^2$] * [^0C_v/h]

= 7.9×10^{-6} m²/sec * [$0.2^{3.33}/0.3^2$] * 934.7 mg/m³ * [1/0.6 m]

= 6.43×10^{-4} mg/m²-sec

C_{bz} = [F * L] / [H * u]

= [6.43×10^{-4} mg/m²-sec * 80 m] / [2 m * 3.5 m/sec]

= 7.35×10^{-3} mg/m³ (compare to 7.35×10^{-3} mg/m³ in Table 8)

C_{amb} = F * χ/Q

= 6.43×10^{-4} mg/m²-sec * 0.138×10^{7} µg-m²-sec/g-m³ * 1 g/10^6 µg

= 8.88×10^{-4} mg/m³ (compare to 8.86×10^{-4} mg/m³ in Table 9)

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Summary of Potential Atmospheric VOC Concentrations During RA Construction

Compound of Concern	In Stream Values: Daily Ave. Conc. in Breathing Zone	In Stream Values: TLV-TWA (8 - Hour)	In Stream Values: IDLH (ppm) (Instant)	Ambient Air (Residential Exposure) Values: Hourly Ave. Ambient Air Conc. Range	Ambient Air (Residential Exposure) Values: Ambient Air RBC Concentration Case 1	Ambient Air (Residential Exposure) Values: 10X RBC Conc. Case 2	Ambient Air (Residential Exposure) Values: 50X RBC Conc. Case 3	Approx. Odor Threshold (ppm)	Comments / Observations
1,1,1 TCA	0.01 - 0.04	1910	700	0.001 - 0.04	1	10	50	0.120 - 0.400	Odor observed before risk is exceeded
cis 1,2 DCE	0.0005 - 0.03	793	1000	0.00005 - 0.004	0.037	0.37	1.85	0.02	Odor observed before risk is exceeded
Meth. Chloride	0.001 - 0.5	174	2300	0.0001 - 0.08	0.0038	0.038	0.19	0.30	Risk is exceeded before odor is observed in all cases
PCE	0.002 - 0.09	170	300	0.0002 - 0.01	0.0031	0.031	0.155	0.005 - 0.027	Risk is only exceeded in Case 1
TCE	0.0004 - 0.007	269	1000	0.00004 - 0.0009	0.001	0.01	0.05	0.025 - 0.050	Odor observed before risk is exceeded
Toluene	0.000002 - 0.02	188	500	0.0000004 - 0.002	0.42	4.2	21	0.01	Odor observed before risk is exceeded
Vinyl Chloride		1*	ND		0.000021	0.00021	0.00105	0.260 - 4.0	
1,1 DCE		ND*	ND		0.000036	0.00036	0.0018	0.190 - 0.500	
1,1 DCA		100*	3000		0.52	5.2	26		
Xylene		100*	900		7.3	73	365		
Chlorobenzene		75*	1000		0.021	0.21	1.05	0.0001 - 0.003	

1. All air concentrations are expressed in mg/m3 unless otherwise indicated.
2. Hourly Average Ambient Air Concentration Range is reported for a distance of 100 m from the source.
3. 8 - Hour TLV - TWA concentrations are from National Library of Medicine MEDLARS (RTECS) accessed July 27, 1997.
4. Ambient Air RBCs are from EPA Region III Risk-Based Concentration Guidance, April 30, 1996.
5. Odor Threshold data from Handbook of Toxic and Hazardous Chemicals and Carcinogens, 3rd Edition, Marshall Sittig, 1991.
6. Immediately Dangerous to Life and Health (IDLH) values from NIOSH Pocket Guide to Chemical Hazards, June 1994.
7. ND for IDLH or TLV-TWA indicates a concentration has not been determined for that compound.
8. * indicates TLV-TWA for OSHA exposure limits as published in NIOSH Pocket Guide to Chemical Hazards, June 1994.
9. Mass flux was not determined for Vinyl Chloride, 1,1-DCE, 1,1-DCA, Xylene and Chlorobenzene, therefore, Column 2 and 5 values are not present.

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APPENDIX E

CONSTRUCTION SPECIFICATIONS

DIVISION 1

GENERAL REQUIREMENTS

TABLE OF CONTENTS

DIVISION 1: GENERAL REQUIREMENTS

Section 01010: Summary of Work

Section 01039: Coordination and Meetings

Section 01050: Field Engineering

Section 01300: Submittals

Section 01545: Health and Safety

Section 01550: Construction Facilities and Temporary Controls

Section 01600: Materials and Equipment

Section 01700: Demobilization/Project Closeout

DIVISION 2: SITE WORK

Section 02060: Demolition

Section 02110: Site Clearing

Section 02115: Erosion and Sediment Control

Section 02220: Earthwork

Section 02225: Collection System Containment Piping

Section 02229: Boulder and Rubble Removal

Section 02277: Gabions

Section 02715: Water Management

Section 02733: Groundwater Collection System

Section 02749: Composite Geosynthetic Clay Layer

Section 02751: Geocushion

Section 02753: Geocomposite Polypropylene Geomembrane

Section 02831: Fencing

Section 02936 Habitat Restoration

DIVISION 3: CONCRETE

Section 03300: Cast-In-Place Concrete

Section 03412: Rock Anchors

SECTION 01010

SUMMARY OF WORK

PART 1: GENERAL

1.1 Description

This section includes the following items:

A. Scope of work
B. Description of Project Documents
C. Project objective
D. Work included
E. Permits and agency approvals
F. Contractor's use of site and premises
G. Construction quality assurance (CQA) requirements
H. Sequence of work

1.2 Scope of Work

Work to be performed is identified in the Contract Documents (i.e., Bidding Document, Project Drawings, these Specifications, Construction Quality Assurance Plan, and written directives from the Owner or Engineer) and generally includes all stream channel improvements including collection systems, and manholes/sumps and containment piping for the conveyance piping. Construction/installation of pumping, conveyance piping and treatment facilities are beyond the scope of this RA contract scope. The Contractor shall furnish all expertise, supervision, equipment, materials, and labor necessary for the performance of the work and shall furnish and do everything necessary to make the work satisfactory, complete, neat, and finished. All incidental, minor and miscellaneous items, work, or materials for which no payment is specifically provided and any items,

work, or materials not included in the Contract Documents which are necessary to complete the indicated intent of the project and project objective and to maintain and repair the work shall be done and furnished by the Contractor at the Contractor's expense.

1.3 Description of Project Documents

Documents (Contract Documents) to be followed under this Contract shall be the Bidding Document, all approved drawings (Project Drawings), specifications (Specifications), and Construction Quality Assurance Plan (CQAP) included herein and any directives issued by the Owner or the Engineer in accordance with the Contract Document. Project Drawings show the location, details, and dimensions of the work contemplated. There shall be no deviation from the Project Drawings or Specifications unless approved and authorized in writing by the Engineer, the Owner, or Construction Manager.

Wherever references are made to other specifications, standards, or requirements, it shall be understood that the latest version is intended and shall apply, except as otherwise specified or when the Specifications, standards or requirements may be in conflict with applicable laws, ordinances, rules or regulations.

1.4 Project Objective

The objective of this project is to physically separate the surface water flow in the Little Elk Creek from the subsurface dense non-aqueous phase liquid (DNAPL) impacted subsurface flow and to isolate, collect, and treat the DNAPL-impacted subsurface flow (permanent treatment system installation is not part of this contract). This objective shall be accomplished by isolating the surface water flow in the creek, constructing a groundwater cutoff wall at the downstream limit of the remedy, installing a groundwater collection system, installing a barrier layer along the stream bed, and installing a protective cover within in the creek channel over the barrier layer, and reconstructing the riparian and stream habitat.

1.5 Work Included

The project work includes, but is not limited to, the following major work items to be performed by the Contractor. Note that these items are in general order of performance; however, it is anticipated that these activities will be performed in stages and in low and high flow work areas. The actual sequence of work shall be proposed by the Contractor and approved by the Engineer as specified in section 1.9 of this section.

- Mobilization of all necessary labor, materials, equipment, and field facilities for the proper completion of the work.

- Preparation of required project documents (i.e., submittals) as specified in these Specifications and obtaining of necessary permits, approvals, licenses, or other documents necessary to perform the specified work.

- Preparation and implementation of a Health and Safety Program including, but not limited to, work area and personnel monitoring.

- Preparation and implementation of an ambient air quality monitoring plan for on-site air quality during construction and ambient air quality outside the work area.

- Establishment of vertical and horizontal survey control and surveying of construction operations to establish locations and elevations shown on the Project Drawings.

- Mobilization and operation of facilities necessary to manage and treat, and dispose of (if necessary), water removed from within the construction areas.

- Construction of temporary or permanent fencing and establishment of Site control (i.e., controlled access to the Site).

- Demolition of the footbridge structure and abutments and staging and disposal, where applicable, of the demolition material.

- Implementation of procedures to control turbidity in surface water leaving the project area.

- Installation of water flow management features for the controlled management and diversion of surface water flow around the work zones.

- Installation of longitudinal wall and lined secondary channel and east stream bank erosion protection.

- Segregation of excavated stream bed materials based on particle size.

- Diversion of steam flow around primary channel using secondary channel.

- Removal of boulders, rubble, and other debris from the stream channel and embankments and minor grading of the primary channel to accept the overlying groundwater collection and barrier systems.

- Installation of the cross stream structural walls, the groundwater collection system, and the barrier layer.

- Installation of the primary channel gabion structures and surficial habitat restoration features.

- Re-establishment of stream flow in the primary channel.

- Re-establishment and restoration of the project area in accordance with these Specifications and federal, state, and local regulations.

- Demobilization of all mobilized labor, equipment, materials, field facilities, and any materials generated by the work activities that are to be removed from the Site according to the Specifications.

- All other ancillary work required for the completion of the project including, but not limited to, dust control, surface and groundwater management, erosion control, site clearing, and establishing and maintaining the work area.

- Contractor to supply one-year guarantee on workmanship to repair any deficiencies in installation and restoration.

1.6 Permits, ARARs, and Agency Approvals

Although permits are not required for projects under CERCLA, the project must comply with the substantive requirements of applicable federal, state, or local regulations including the project ARARs list prepared by USEPA. It shall be expressly understood that nothing in these Specifications shall relax or modify any permit equivalency, stipulation or condition; and that it is the Contractor's responsibility to comply with all regulatory requirements affecting the work, including any and all environmental requirements.

The Contractor shall be responsible for obtaining and complying with any and all local permits necessary to perform the work. This may include, but not be limited to:

- sediment control permits;
- traffic and highway permits;
- off-site disposal or transportation permits;

- permits for work within Little Elk Creek;
- temporary discharge permit for work area water; and
- air emission permit for Contractors' temporary water treatment system.

1.7 Contractor's Use of Site and Premises

The Contractor's access to the Owner's property is limited to the project work area as identified in the Project Drawings. The Contractor shall use the work area for the sole purpose of performing the specified activities and not for unrelated storage, recreation, non-site related activities, or other unapproved activities.

1.8 Construction Quality Assurance Requirements

All work will be monitored and tested, where specified, by a Construction Quality Assurance (CQA) Monitor in accordance with the requirements of the Construction Quality Assurance Plan (CQAP). The Contractor shall be aware of all testing activities outlined in the CQAP and shall account for these activities in the construction schedule. The Contractor shall be responsible for cooperating with the CQA Monitor during all testing and monitoring activities. The Contractor shall provide equipment and labor to assist the CQA Monitor in sampling, if requested, and shall also provide access to all areas requiring monitoring or testing. The Contractor shall repair any damage to finished work cause by the CQA Monitor's sampling or testing activities.

The Contractor (and its subcontractors, suppliers, manufacturers, etc.) shall abide by all qualification requirements identified in the CQAP. The Contractor will be held to high standards for the quality and performance of the proposed work.

1.9 Sequence of Work

The sequence of work presented in Section 1.6 of these Specifications provides a generalized description of how construction activities are expected to proceed. The actual sequences should be developed by the Contractor for review and discussions with the Engineer and should be developed in a manner intended to optimize efficiency, minimize excess handling of material and generation of potentially contaminated water or solids, and minimize disruption of previous and future work activities, while being sensitive to surrounding environmental concerns.

PART 2: PRODUCTS

Not Used

PART 3: EXECUTION

3.1 General

The Contractor shall execute all work in accordance with the requirements of the Project Documents.

3.2 Familiarization

Prior to implementing any work described in these Specifications, the Contractor shall become thoroughly familiar with the Site, the existing Site conditions, and all portions of the work falling within the appropriate section of the Specifications.

Prior to implementing any of the work, the Contractor shall carefully inspect the previously installed work to verify that the previous work is complete to the point where the installation of succeeding work may commence without adverse impact. If the Contractor has any concerns regarding the

previously installed work, it should immediately notify the Engineer verbally and within 48 hours in writing.

3.3 Use of Explosives

No explosives may be used within the limits of the Site.

3.4 Public Water Supply

The Contractor is required to supply all potable and non-potable water required for the work and for consumption by all on-site personnel. There is not a public water supply available at the Site.

3.5 Relocation and Protection of Existing Utilities

The Contractor shall protect and/or support all existing utilities that are endangered by its operations and the cost for these activities will be taken to be included in the total contract price except as specified herein.

3.6 Protection of Work

The Contractor shall use all means necessary to protect all prior work resulting from man-made or natural occurrences (such as flooding), including all materials and completed work of other Sections. In the event of damage to work performed by the Contractor prior to the Owner's acceptance of the work, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the Owner, Engineer, and the CQA Monitor, and at no additional cost to the Owner.

PART 4: MEASUREMENT AND PAYMENT

4.1 Measurement

Measurement of specific work tasks are included in the applicable sections of this Specification.

4.2 Payment

Payment of specific work tasks are included in the applicable sections of this Specification.

SECTION 01039

COORDINATION AND MEETINGS

PART 1: GENERAL

1.1 Description

This section pertains to the coordination and scheduling of work activities, CQA activities, submittals, and project meetings such that the project is operated in an efficient and orderly manner.

1.2 Related Sections

A. Section 01010 - Summary of Work

B. Section 01700 - Contract Closeout

1.3 Coordination

The Contractor shall ensure that work is performed in an organized manner such that the duration, effectiveness, and safety of the work activities is optimized. Coordination includes, but is not limited to, the proper selection of equipment, materials, and labor to perform the intended task and the coordination of work activities within the Site such that work, traffic, staging, and support areas are utilized effectively and not compromised. It is noted that most of the work activities will occur in Little Elk Creek, a stream that is subject to sudden and unexpected flooding that can be detrimental to the project. Therefore, comprehensive monitoring and emergency response responsibilities will be borne by the Contractor and addressed in Work Plans prepared by the Contractor.

The Contractor shall be aware that the construction quality assurance monitoring will be required during or at the completion of many of the Contractor's work activities and these monitoring events may impact the anticipated schedule including requiring the Contractor to perform additional work or to remove completed work and replace with acceptable in accordance with these Specifications and the Construction Quality Assurance Plan.

1.4 Preconstruction Meetings

At least one month prior to initiation of work, the Engineer will schedule a preconstruction meeting. The Contractor, Owner, Engineer, CQA Monitor and all necessary representatives of each of these parties shall attend the meeting. The agenda for the meeting will be developed by the Engineer and should include items of significance that could impact the project such as:

1. Construction schedule and work sequencing
2. Designation of responsible personnel
3. Construction quality control requirements
4. Construction Quality Assurance (CQA) procedures and protocols
5. Procedures for processing field decisions and change orders
6. Procedures for processing Applications for Payment
7. Submittal procedures and requirements
8. Handling of record documents
9. Use of the premises
10. Permits and approvals
11. Office, work and storage areas
12. Equipment deliveries and priorities
13. Safety, first aid, and security
14. Working hours

The meeting minutes shall be recorded by the Construction Manager with copies of the minutes submitted to all parties in attendance within three (3) days of the meeting.

1.5 Progress Meetings

Progress meetings shall be held at the Site in the temporary facilities on a weekly basis. The meetings shall be run by the Construction Manager and the Contract Manager shall be responsible for making all necessary arrangements for the meeting including, but not limited to, advising all parties of the meeting time and place, ensuring that adequate meeting facilities are available, and preparing a meeting agenda.

No later than three (3) working days after each progress meeting date, the Construction Manager shall distribute copies of the meeting minutes to each party present and to other parties who should have been present. The minutes shall accurately reflect the topics discussed at the meeting with emphasis on conflicts raised and decisions made. The Engineer and Owner shall have the final decision as to the adequacy of the meeting minutes and all parties in attendance shall have the opportunity to rebut any discrepancies in the meeting minutes by submitting said discrepancies to the Contractor in writing within one (1) week of receipt of the meeting minutes.

In the event that the frequency of the progress meetings is deemed to be inadequate by the Contractor, the Engineer, and the Owner, the frequency may be changed to a mutually acceptable interval.

PART 2: PRODUCTS

Not Used

PART 3: EXECUTION

Not Used

PART 4: MEASUREMENT AND PAYMENT

Not Used

SECTION 01050

FIELD ENGINEERING

PART 1: GENERAL

1.1 Description

The work covered by this section shall include, but not be limited to, establishing survey control points, surveying existing conditions, providing survey control during construction, and providing final "as-built" documentation.

The Contractor shall provide an independent registered Land Surveyor licensed in the State of Maryland to provide survey control for each stage of the project and to provide survey "as-built" documentation for various components of the project. The Contractor shall furnish all expertise, supervision, labor, materials, and equipment necessary to perform the project surveying as specified herein, as shown on the Project Drawings, and in accordance with the Construction Quality Assurance Plan (CQAP).

1.2 Related Sections

A. Section 01300 - Submittals
B. Section 01700 - Contract Closeout
C. Section 02110 - Site Clearing
D. Section 02115 - Erosion and Sediment Control
E. Section 02210 - Earthwork
F. Section 02225 - Collection System Containment Piping
G. Section 02277 - Gabions
H. Section 02733 - Groundwater Collection System
I. Section 02749 - Composite Geosynthetic Clay Layer

J. Section 02751 - Geocushion

K. Section 02755 - Polypropylene Geomembrane

L. Section 02831 - Fencing

M. Section 03300 - Cast-in-Place Concrete

1.3 Qualification of Surveyor

The Contractor shall provide a registered Land Surveyor licensed in the State of Maryland and acceptable to the Owner and the Engineer. The Surveyor, in the opinion of the Owner and the Engineer, shall have a proven record of successful performance on projects of similar magnitude. Prior to acceptance by the Owner and the Engineer, the Surveyor will be required to submit a resume describing the qualifications of the licensed Surveyor, the survey crew chief, and other key personnel, and make a commitment to be responsive and timely during the RA.

1.4 Submittals

The Contractor shall submit to the Engineer the name, address, and telephone number of the Surveyor and the Surveyor's qualifications at least 14 days prior to the start of the survey work. The Contractor shall also submit to the Engineer a Survey Plan including project staffing, scheduling, and the type of equipment the Surveyor intends to use in the field and in the office (i.e., EDM, computer software) to complete the project for review and approval by the Engineer prior to the start of survey work.

1.5 Project Record Drawings

The Contractor or Contractor's surveyor shall maintain a complete and accurate account of survey work as work progresses (Project Record Drawings). This account shall, at a minimum, consist of progress drawings of all work performed throughout the project. The progress drawings shall be a copy of the Project Drawings with field changes and work progress indicated. The Contractor shall

allow the Owner, Engineer and the CQA Monitor to inspect the drawings at any time. At the end of the project, the Contractor shall submit a complete set of the progress drawings and the surveyor's log of control and survey work to the Engineer for its use in preparing the final report of construction activities.

1.6 Survey Requirements

The Surveyor shall locate survey control points prior to starting site work and shall protect these points at all times during the Project. The Contractor shall immediately report, in writing, to the Engineer any survey control point which is in discrepancy or which is lost, destroyed, or requires relocation. The Contractor shall replace each lost or destroyed permanent survey control point at no additional cost to the Owner.

The Surveyor shall locate and clearly mark in the field all site property boundaries. The Surveyor shall immediately notify the Engineer of any discrepancy between the boundary location shown on the Project Drawings and the location indicated by the documents used by the Surveyor to locate the boundaries.

The surveyor shall maintain lines and grades and locate the work utilizing recognized engineering survey practices. A complete and accurate log of control and survey work must be maintained. Also, all survey control points on the Project Drawings shall be included in the Surveyor's documentation. The surveyor shall cooperate with independent surveyors representing the CQA Monitor in their tasks of assuring the accuracy of the project survey layout/documentation. Cooperation shall include site meetings, provision of survey data and resolution of discrepancies that may be disclosed.

The survey instruments used shall be capable of reading to a precision of 0.01 ft and with a setting accuracy of 10 seconds.

1.7 Survey for Quantity Estimates

The survey by the Contractor, upon review and acceptance by the Owner, Engineer and CQA Monitor, shall be used to determine pay quantities for many of the individual work activities. The Contractor shall advise the Engineer and the CQA Monitor when such quantity surveying is to be performed such that all parties may monitor the surveying.

PART 2: PRODUCTS

The Surveyor shall provide, at a minimum, "as-built" documentation, signed and sealed by the Surveyor, for the following components.

1. The initial work area (including property boundaries and pertinent site features) documenting original site conditions.
2. Areas of clearing and disturbance.
3. The final elevations of the stream bed, groundwater collection, and barrier layers including all components.
4. The final elevations and locations of the gabion structures.
5. The location of groundwater collecting piping and sumps.
6. The location and elevations of the structural/cast-in-place walls.
7. All other items that the Contractor requires to complete its work and establish pay quantities.
8. All the reasonable items requested by the Engineer and the CQA Monitor to verify that the Contractor's work meets the requirements of the Project Drawings and Specifications.

The Surveyor shall submit the "as-built" documentation for review to the Owner (4 copies) with the request for final payment or at the completion of the applicable phase of work.

2.2 Daily Reports

The Contractor shall prepare a Daily Report detailing any and all work and health and safety activities that were performed. The Daily Report shall be prepared by the end of the following work day and two copies each shall be submitted to the Owner, Engineer, and the CQA Monitor within this time period.

PART 3: EXECUTION

Not Used

PART 4: MEASUREMENT AND PAYMENT

4.1 Measurement

Surveying and related field engineering work and documentation shall not be measured.

4.2 Payment

No itemized payment shall be made for surveying and related work. The Contractor shall include in its bid price any and all costs it estimates for the completion of surveying and related tasks.

SECTION 01300

SUBMITTALS

PART 1: GENERAL

1.1 Description

The work covered by this section includes, but is not limited to, the submittals required during the duration of the project and the procedures that the Contractor shall use in providing the submittals.

1.2 Related Sections

All sections of this Specification

1.3 Project Record Documents

The Contractor shall keep on Site at all times for review by the Owner, Engineer, and CQA Monitor one copy of all documents, materials, photographs, and related project records that have been submitted to the Owner, Engineer, or CQA Monitor. The Contractor shall also keep on Site at all times an updated copy of the submittal register for review.

The Contractor shall ensure that the submittal register and all project documents on file at the Site are complete, accurate, legible, and are kept in a separate and marked location accessible to all authorized personnel.

PART 2: PRODUCTS

2.1 Submittal Register

Upon award of the project and review of all Contract Documents including, but not limited to, the Project Drawings and Specifications, the Contractor shall prepare a submittal register for review and approval by the Owner and the Engineer. The submittal register shall be submitted no later than 14 days after award of the contract. The submittal register shall include all submittal items listed in the Specifications and shall also provide the following items, at a minimum:

1. Project name
2. Contractor's project or reference number
3. Submittal title and description of item
4. Submittal reference number sequentially numbered
5. Date item was submitted
6. Number of copies submitted
7. Parties who received the submittal
8. Whether response is required by parties who received the submittal
9. Whether submittal is part of the original submittal register or an addition
10. Cite section of specification as involved with the submittal.

The submittal register shall include blank entries for future addition of submittals that were not anticipated. Upon addition of additional line items in the submittal register, the Contractor shall re-submit an updated submittal register for review and approval by the Engineer and the Owner.

2.2 Submittal References

The following is a partial list of submittals related to the project. The Contractor shall provide a complete list of submittals as specified in this section of the Specifications.

1. Meeting Minutes
   - Daily Reports
   - Weekly or Monthly Progress Reports
   - Material Certifications
2. Field Engineering Qualifications and Project Record Drawings *
3. Site Specific Health and Safety Plan and all related submittals *
4. Material Specifications *
5. Payment Requisitions *
6. Project Record Documents upon project closeout
7. Demolition Plan *
8. Erosion and Sediment Control Plan *
9. Site Clearing Plan *
10. Water Management Plan *
11. Air Monitoring Plan *
12. Site Specific Contingency Plan (Monitoring/Emergency Response) *
13. Construction Quality Control Plan *

* Denotes submittals that must be provided prior to start of work and should be subsections within the Contractor's Comprehensive Removal Action Work Plan.

PART 3: EXECUTION

3.1 Submittal Procedures

Submittals shall be made by the Contractor to the parties indicated in the applicable sections of the Specifications. A submittal cover sheet or transmittal sheet shall accompany each submittal and shall include all information specified in these Specifications. The submittal shall be hand-delivered with the transmittal cover sheet being signed by the recipient in the presence of the deliverer. In lieu of hand delivering, the Contractor may send the submittal via certified mail.

PART 4: MEASUREMENT AND PAYMENT

Not Used

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