Attachment A

CEQA Addendum #11 and Cultural Resources Reports

ADDENDUM TO THE ENVIRONMENTAL IMPACT REPORT FOR THE STATE ROUTE 4 BYPASS PROJECT

ADDENDUM #11: SPECIFIC TO SEGMENTS 2/3 – BALFOUR ROAD INTERCHANGE, PHASE 1

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Table of Contents

1 Introduction 1

2 Project Description 2

2.1 Purpose and Need 2

2.2 Previous Environmental Analysis Process 2

2.3 Project Description Modifications 3

3 Impact Analysis 6

3.1 Summary of Project Impacts Addressed in the FEIR 6

3.2 Air Quality 6

3.3 Biological Resources 14

3.4 Cultural Resouces 22

3.5 Hazardous Materials 23

3.6 Noise 25

3.7 Traffic 27

3.8 Visual Resources 30

4 Conclusion 31

Figures

Figure 1: Project Site and Vicinity

Figure 2: Proposed Project Improvements

Figure 3: PG&E Relocations

Figure 4: Deer Creek Daylighting Improvements

Figure 5: Off-site Improvements at Sellers Avenue

Figure 6: California Greenhouse Gas Forecast

Appendices

Appendix A: Mitigation Monitoring and Reporting Program

Appendix B: Air Quality Report

Appendix C: Biological Resources Assessment

Appendix D: Archaeological Survey and Cultural Resources Assessment

Appendix E: Preliminary Site Investigation Report

Appendix F: Noise Assessment

1 Introduction

1.1 REASONS FOR THIS ADDENDUM

This document is an Addendum to the Final Environmental Impact Report (FEIR) certified in December 1994 for the State Route 4 (SR-4) Bypass Project (Project) located in the cities of Antioch and Brentwood and unincorporated areas of eastern Contra Costa County. The Project is a 3-segment, 12.4 mile combination freeway/expressway/conventional highway which is being constructed in phases. **Figure 1** shows the general location of the Project.

The SR-4 Bypass FEIR (1994) included the acquisition of sufficient right-of-way at the Balfour Road intersection to accommodate an interchange in the future, however the traffic analysis prepared at that time did not show the need for an interchange at this location until after the horizon year (2010). Current traffic forecasts now demonstrate a need for an interchange at this location.

In 2011, the Bypass Authority prepared Addendum #10 to the FEIR, which evaluated the detailed design elements of an interchange at the Balfour Road location. Addendum #10 provided the analysis necessary under the California Environmental Quality Act (CEQA) to determine if the proposed design of the Balfour Road interchange would result in any potential impacts that were not analyzed in the original 1994 FEIR. The analysis included two phases of construction, Phase 1 and Phase 2. The Phase 2 improvements will not be needed until 4-lanes are constructed between Balfour Road and Marsh Creek Road, which is anticipated to occur beyond the 20-year design period of Phase 1.

Since 2011 and the approval of Addendum #10, several changes to design of the Phase 1 interchange improvements at Balfour Road have occurred. These changes include revised ramp alignments, revised alignment of the existing SR-4 travel lanes approaching the Balfour Road interchange, two clear-spanning bridge structures to avoid work within Deer Creek, two additional retaining walls to avoid right-of-way acquisition from the adjacent properties in the vicinity of the Project area, and off-site improvements necessary to remove an oil pipeline pump station from within the interchange area. **Figure 2** illustrates the SR-4/Balfour Road interchange configuration evaluated in this Addendum #11. The analysis completed in Addendum #10 for the Phase 2 improvements of the SR-4/Balfour Road interchange has not been modified, and is not discussed further in this report.

1.2 CEQA BASIC FOR THIS ADDENDUM

This Addendum was prepared in conformance with CEQA and CEQA Guidelines §15164. State CEQA Guidelines §15164(a) requires that the lead agency or responsible agency prepare an Addendum to a previously certified EIR "if some changes or additions are necessary but none of the conditions described in Section 15162 calling for preparation of a subsequent EIR have occurred". An Addendum need not be circulated for public review per CEQA Guidelines §15164(c) but can be included or attached to the FEIR or adopted negative declaration.

As analyzed in Section 3 of this document, the Phase 1 improvements for the Balfour Road interchange would not result in any new significant environmental effects or substantial increases in the severity of previously identified significant impacts. Consequently, major revisions to the

previous FEIR are not required, and none of the conditions listed in §15162(a) have occurred. Therefore, the appropriate level of analysis for the proposed Project revision is an Addendum to the FEIR. This conclusion is based on the analysis provided in this document and information in the FEIR.

1.3 INTENDED USES OF THIS ADDENDUM

An Addendum to an FEIR is an informational document used in the planning and decision-making process. The intent of this Addendum to the FEIR is to provide the Bypass Authority with additional information regarding the Project's potential environmental impacts that was not available at the time of the certification of the FEIR.

2 Project Description

This section provides a description of the Project evaluated in the FEIR and the modifications proposed by the SR-4 Bypass Authority.

2.1 PURPOSE AND NEED

The primary purpose of the State Route 4 Bypass Project, as described in the FEIR, is to "improve regional circulation through eastern Contra Costa County and provide a more balanced distribution of current and future traffic over the local road network in this area".

2.2 PREVIOUS ENVIRONMENTAL ANALYSIS PROCESS

The SR-4 Bypass Authority (Bypass Authority) has served as the CEQA lead agency for the Project. In October 1993, the Bypass Authority released for public review the SR-4 Bypass Project draft EIR. A 60-day public review period began on November 2, 1993, and closed on January 3, 1994. A Final EIR was prepared in November 1994 and included responses to comments received on the draft EIR. On November 21 and December 8, 1994, the Bypass Authority held public hearings on the Bypass Project and supporting environmental documents. The Bypass Authority approved the Bypass Project and certified the FEIR on December 13, 1994. Since that time ten Addenda and one supplemental EIR have been prepared and adopted by the Bypass Authority, as discussed below.

- December 13, 1994 - An Addendum was prepared to address a proposed modification to the connection from Marsh Creek Road to existing SR-4.
- November, 1997 - A second Addendum was prepared to consider the effects of a variety of long-range area planning projects on the preferred alternative alignment for Segment 3. This Addendum was certified by the Authority in November 1997.
- December, 1998 - A third Addendum was prepared to address the modified construction phasing plan which involved construction of Segment 2 as a first phase.
- January, 2003 - A fourth Addendum was prepared to address modifications to the Lone Tree Way Interchange.
- November, 2003 - A fifth Addendum was prepared to address modifications to Segment 1 of the Bypass.

- October 2004 - A Supplemental EIR was prepared to evaluate proposed refinements to the alignment of Segment 3.
- May 2006 - A sixth Addendum was prepared to evaluate proposed relocations of an existing Chevron pipeline.
- November 2007 - A seventh Addendum was prepared to evaluate the Sand Creek Road Interchange.
- April 2009 – An eighth Addendum was prepared to evaluate the Mokelumne Trail Bicycle/Pedestrian Overcrossing.
- June 2011 – A ninth Addendum was prepared to evaluate the SR-4/SR-160 Freeway Connector
- August 2011 – A tenth Addendum was prepared to evaluate construction of an interchange at Balfour Road consisting of two phases (Phase 1 and Phase 2).[1]

The four-volume 1993 draft EIR for the Bypass Project, together with the 1994 FEIR volume, the ten Addenda, and the Supplemental EIR now comprise the approved EIR and environmental record for the SR-4 Bypass Project. Once completed, this Addendum will be added to the environmental record.

2.3 PROJECT DESCRIPTION MODIFICATIONS

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) jointly propose to widen SR-4 from San Jose Avenue (PM 34.9) to approximately 3,400 feet south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road in the City of Brentwood in Contra Costa County.

The first phase (Phase 1) would include the construction of the following:

- Divided four-lane Freeway from San Jose Avenue Undercrossing to 2,000 feet north of Balfour Road. The freeway then transitions to a two-lane expressway south of Balfour Road Interchange.
- Four-lane wide undercrossing bridge structure over Balfour Road to serve bidirectional two-lane freeway traffic and two entrance loop ramps. This structure would serve only eastbound (EB) traffic in future phases.
- Four-lane wide bridge structure over Deer Creek for SR-4 freeway lanes. It would serve bidirectional traffic in Phase 1
- Two-lane bridge structure over Deer Creek for EB loop on-ramp
- EB SR-4 Diagonal off-ramp
- EB SR-4 Loop on-ramp

[1] This report updates the assessment of the Phase 1 interchange improvements at Balfour Road and supersedes the Phase 1 analysis included in Addendum #10. The Phase 2 interchange improvements at Balfour Road are not considered in this updated assessment of the design changes.

- Westbound (WB) SR-4 diagonal on-ramp that will be in an interim location and moved further to the east in the ultimate configuration
- WB SR-4 diagonal off-ramp
- WB SR-4 loop on-ramp
- Widening of Balfour Road to up to six lanes within the interchange area

Other improvements would include two new traffic signals for the ramp intersections, ramp metering, lighting, drainage improvements, and utility relocations.

Relocation of PG&E Towers

A Pacific Gas & Electric (PG&E) overhead transmission line runs along the eastern side of the Bypass. Construction of the interchange will require relocation of two towers from their current locations adjacent to Balfour Road to new locations approximately 250 feet and 120 feet to the north respectively, as shown in **Figure 3**. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the Bypass and required coordination with public utilities and/or private operators during construction to allow for relocation as needed without disruption to existing service. Impacts associated with the utility relocation were addressed in the 1994 FEIR and are addressed in this Addendum pursuant to California Public Utilities Commission General Order 131-D filing requirements.

Deer Creek Daylighting

Deer Creek is an intermittent stream in its upper reaches but becomes perennial where it is detained in the Contra Costa County Flood Control Basin, approximately ¾-mile west of the SR-4/Balfour Road intersection. From this point Deer Creek flows through an 84-inch concrete pipe toward the SR-4/Balfour Road intersection. A small portion (approximately 250 feet long) north of Balfour Road and west of State Route 4 flows through an open ditch before re-entering an 84-inch non-reinforced concrete pipe to pass under State Route 4. East of State Route 4 Deer Creek flows mainly through an open ditch eventually draining to Marsh Creek and on to the San Joaquin River.

Addendum #10 had evaluated extension of the existing 84-inch pipe culverts along Deer Creek with removal of the open ditch portion in the northwest quadrant of the interchange. The revised Phase 1 interchange improvements now include construction of an eastbound SR-4 clear span bridge over Deer Creek and an eastbound SR-4 loop on-ramp bridge in the north/west quadrant of the SR-4/Balfour Road intersection. This loop on-ramp would cross over on a clear span structure the portion of Deer Creek that flows in an open ditch. In this same area, approximately 200 feet of Deer Creek which flows in a pipe would be removed and replaced with an open ditch configuration, daylighting the creek. The daylighted portion of Deer Creek would be vegetated to maintain consistency with the surrounding natural environment. Some rock slope protection will be needed to prevent channel erosion near the pipe culvert exits into the channel. The remaining portion of the pipe within the interchange limits to the south would be replaced with reinforced concrete pipe and connected to the existing pipeline that flows under Balfour Road (see **Figure 4**).

OFF-SITE IMPROVEMENTS

Removal of the Kinder Morgan Brentwood Pump Station

As part of Phase 1 of the SR-4/Balfour Road interchange, a new eastbound SR-4 off-ramp would be constructed in the northwest quadrant of the SR-4/Balfour Road intersection. Construction of this new off-ramp makes it necessary for Kinder Morgan Energy Partners (Kinder Morgan) to remove an existing oil pipeline pump station (the Brentwood Booster Station) at this location. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the Project and required coordination with public utilities and/or private operators during construction to allow for relocation, as needed, without disruption to existing service. Addendum #10 evaluated the relocation of the Brentwood Booster Station approximately 400 feet to the west to accommodate the proposed on- and off-ramps associated with the interchange.

Since Addendum #10 was completed, additional evaluation and coordination with Kinder Morgan has occurred, which determined that relocating the Brentwood Booster Station is no longer necessary. Rather, the Phase 1 improvements now include removal of the pump station. To maintain oil pipeline pumping capacity two off-site Kinder Morgan system upgrades are necessary. The first system upgrade would occur at an existing Concord Pump Station, located at Arnold Industrial Way and Solano Way in Concord, California (approximately 20 miles northwest from the Project area). Terminal and substation transformers at the Concord Pump Station would be replaced to allow for increased pumping capacity. No physical expansion of the Concord Pump Station would be needed.

The second off-site Kinder Morgan system upgrade would include the modification of an existing oil pipeline access point between Brentwood Boulevard and Sellers Avenue (approximately 2.8 miles southeast from the Project area) and associated truck access along an East Contra Costa Irrigation District (ECCID) canal (see **Figure 5**). A Drag Reducing Additive (DRA) would be injected approximately once per week into the oil pipeline access point known as the Brentwood Boulevard Junction replacing similar DRA injections at the current Brentwood Booster Station. This would require a truck to either enter the area from Brentwood Boulevard, or to enter from Sellers Avenue, and traverse across the maintenance roadway along the ECCID canal. An asphalt concrete roadway would be constructed replacing the existing unpaved maintenance roadway to support the weekly truck trip delivering the DRA. This would require up to one foot of excavation throughout the maintenance road, including at conforms to paved roadways at each end. Additionally, up to one foot of trenching would occur across the maintenance road to maintain an existing water hook-up for irrigation activities associated with the adjacent farmlands. All work would occur within previously disturbed artificial fill associated with elevated maintenance access and paved roadways. No physical expansion of the valve lot for the Brentwood Boulevard Junction would occur.

3 Impact Analysis

3.1 SUMMARY OF PROJECT IMPACTS ADDRESSED IN THE FEIR

The environmental impacts of building the SR-4/Balfour Road interchange are comparable, if not the same, as the impacts of the Project evaluated in the 1994 FEIR. The level of significance of impacts resulting from this modification would not result in any new impacts that were not previously disclosed, nor has the environmental baseline in the Project area changed since the 1994 FEIR, such that new impacts would be created.

The following environmental categories were specifically examined in the context of the modifications to the design discussed above:

- Air Quality and Climate Change
- Biological Resources
- Cultural Resources
- Hazardous Materials
- Noise
- Traffic
- Visual Resources

For these categories, additional analysis has been conducted and the results are discussed below. All other environmental categories examined in the FEIR have been assessed and found not to have any material change from what has already been presented in the draft and final EIR. All mitigation measures adopted in the 1994 FEIR continue to remain in effect and are incorporated by reference in this Addendum. Modifications to the previously adopted mitigation are required for some environmental resource topics, such as noise and air quality. Refinements pursuant to the adopted East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Planning (HCP/NCCP), which lists specific actions that the U.S. Fish and Wildlife Service (USFWS) and the member cities and county have adopted for all development affecting covered species. A refined Mitigation Monitoring and Reporting Program (MMRP) is included as **Appendix A** of this Addendum.

The off-site improvements at the Concord Pump Station are minor equipment alterations at an existing facility, and do not constitute a change that would affect any of the environmental topics considered under CEQA. As such, the Concord Pump Station improvements are not discussed further in this Addendum.

3.2 AIR QUALITY

3.2.1 PRIOR FEIR ANALYSIS

As discussed in Section G of the 1994 FEIR, federal air quality regulations classified the Bay Area as a non-attainment zone for ozone and carbon monoxide, while state regulations classified the Bay Area as non-attainment for ozone, carbon monoxide, and particulate matter (PM) smaller than 10 microns in size.

The FEIR identified significant unavoidable adverse effects resulting from Project implementation. Construction of the entire Project would result in increased emissions that would exceed Bay Area Air Quality Management District (BAAQMD) criteria. Construction activities would temporarily generate substantial amounts of criteria air pollutants including nitrous oxide and PM smaller that 10 microns in size. Over the long term, the Project would hinder regional efforts to attain transportation performance standards set forth in the California Clean Air Act (CCCA), such as decreasing vehicles miles traveled, increasing ridership per vehicle, and achieving no net increase in vehicle emissions.

Mitigation measures to reduce construction period and long term effects of the Project are discussed in the FEIR. Such measures include dust abatement programs during the construction phase, developing high occupancy vehicle (HOV) lanes, and encouraging mixed-use development. However, the FEIR concluded that impacts related to the formation of ozone in the wider region, and attaining the transportation standards described above would remain significant.

3.2.2 UPDATED ANALYSIS

As part of the efforts to prepare Addendum #10 in 2011, the Bypass Authority conducted an Air Quality analysis to evaluate existing and future emissions associated with the preliminary design elements of the Balfour Road interchange. The air quality analysis concluded that the Project would not result in substantially more severe impacts than those described in the 1994 FEIR (refer to **Appendix B**). The discussion below summarizes the air quality impacts for the updated Project compared to those identified in the FEIR. For the purposes of this current Addendum, the results of the 2011 analysis were evaluated to ensure applicability to today's current conditions and future forecasts.

Increase in Emissions

Impact II.G.2 in the FEIR states "Development of the Project would result in an increase in emissions over those expected under the no-project scenario. This increase would exceed BAAQMD significance criteria and would be a significant impact." This impact was based on projections of future motor vehicle traffic in the East County area and resulting emissions in forecast years of 2000 and 2010. It was found that the Project, by diverting some person-trips from transit mode to auto mode and by increasing the lengths of other trips (relative to the no-project case), would result in an increase in vehicle miles traveled.

The described Impact II.G.2 was due to the creation of a new transportation corridor and not dependent on the presence or design of a single interchange within that corridor. The Project would not be anticipated to divert trips nor increase regional trip lengths. The revised Traffic Operations Report (TOR) prepared for the Project by *Fehr & Peers* (August, 2013) found that the Project would have beneficial impacts to traffic levels of service on roadways in the Project area. The 2013 TOR also concluded that traffic congestion without the proposed SR-4/Balfour Road interchange improvements would result in unacceptable levels of service on roadways in the Project area. Based on the projected traffic conditions, the Project would be expected to result in reduced air pollutant emissions through reduced congestion when compared to the no-project condition. The proposed Balfour Road interchange would not result in a substantially more severe impact than that described in the 1994 FEIR.

California Clean Air Act

Impact III.G.5 in the FEIR states "Development of the Project would hinder regional efforts to attain the transportation performance standards set forth in the CCCA. This would be a significant impact." This impact was based on CCCA transportation performance standards. For state ozone non-attainment areas the transportation performance standards were:

- Substantially reduce the rate of increase in passenger vehicle trips and miles traveled;
- Achieve 1.5 average vehicle ridership during the commute period by 1999; and
- Achieve no net increase in vehicle emissions after 1997.

The Project was found to hinder efforts to meet the first two of these performance standards by increasing the number of vehicle trips and vehicle miles traveled over the no-project case and by diverting person trips off transit and onto the road network. It should be noted that the effective dates of the performance standards in question have already passed.

At this time, the Project is included in the Regional Transportation Plan (RTP) for the Bay Area and the 2013 Transportation Improvement Plan (TIP). The current RTP for the Bay Area, known as Plan Bay Area, was adopted by the Metropolitan Transportation Commission (MTC) on July 18, 2013 and was approved by U.S. Department of Transportation (DOT) on August 12, 2013. The 2013 TIP is the most current conforming TIP, which was adopted by MTC on July 18, 2013 and approved by the Federal Transit Administration (FTA), and the Federal Highway Administration (FHWA) on August 12, 2013.

The Project (Project Reference No. 230206) and TIP ID CC-070053 is included in the regional emissions analysis conducted by MTC for Plan Bay Area and the 2013 TIP. This conformity analysis addresses the national 8-hour ozone standard, national carbon monoxide (CO) standard, and the national 24-hour fine PM ($PM_{2.5}$) standard. This analysis found that the plan and, therefore, the individual projects contained in the plan, are conforming projects, and will have air quality impacts consistent with those identified in the Bay Area State Implementation Plan (SIP) for achieving the National Ambient Air Quality Standards (NAAQS). MTC has used the latest planning assumptions for the purpose of preparing this conformity analysis. Regional on-road motor vehicle emissions for future years are estimated using MTC's travel demand forecast model (Travel Model One), which estimates vehicle activity in the Bay Area, in conjunction with the Air Resources Board 's (ARB) latest model for determining motor vehicle emissions (EMFAC2011).

The U.S. DOT issued its approval of the conformity determination for the Transportation 2040 Plan on August 12, 2013. The conformity finding means that the total motor vehicle emissions projected for the Plan Bay Area 2040 and 2013 TIP are within the emissions budgets established in the SIP, and that transportation control measures are implemented in a timely fashion. This conformity finding puts the nine-county region in conformity with SIP and all transportation-related federal air quality requirements.

Based on the inclusion of the Project in the RTP and TIP, emissions generated from the operation of the Project would be considered less than significant.

Construction Emissions

Impact III.G.1 in the FEIR states "Construction activities would temporarily generate substantial amounts of criteria pollutants, particularly NOx and PM_{10}. This would be a significant impact." Construction emissions of NOx from the Project were considered likely to be substantial, due to its scale (nine miles of new roadway and over four miles of improved roadway), extensive amounts of equipment and material, and a considerable number of construction workers needed. Similarly, substantial emission of PM_{10} were considered likely due to the scale of the Project, the extent of earth movement, and the extent of truck traffic over unpaved surfaces.

The nature of construction of the Phase 1 Balfour Road interchange improvements would not result in construction-period emissions being more intense or in closer proximity to receptors than that described in the 1994 FEIR. Since 1994, emission standards for on-road vehicles and off-road construction equipment have become more stringent through state and federal regulation. Current emission rates for vehicles and equipment are substantially below those in 1994. Standard construction practices for dust control that have been established by the regional air district have at the same time become more restrictive. Therefore, the Project would not result in a substantially more severe construction-period impact than that described in the 1994 FEIR.

The 1994 FEIR proposed standard mitigation measures designed to reduce construction-period impacts to a level that is less than significant. Current standard mitigation measures for construction include additional measures not included in the 1994 FEIR.

The BAAQMD CEQA Guidelines provide feasible control measures for construction emissions. Measures to reduce PM_{10}, $PM_{2.5}$, and diesel PM from construction are recommended to ensure that short-term health impacts to nearby sensitive receptors are avoided. Current standards and practices include the following additional measures, which the Caltrans currently adds to all construction contracts. Although Caltrans is not awarding the construction contract for the SR-4/Balfour Road interchange improvements, CCTA will ensure that the Caltrans standards and practices are included, given that the improvements are on a state highway.

- All exposed surfaces (e.g., parking areas, staging areas, soil piles, graded areas, and unpaved access roads) shall be watered two times per day;
- All haul trucks transporting soil, sand, or other loose material off-site shall be covered;
- All visible mud or dirt track-out onto adjacent public roads shall be removed using wet power vacuum street sweepers at least once per day. The use of dry power sweeping is prohibited;
- All vehicle speeds on unpaved roads shall be limited to 15 mph;
- All roadways, driveways, and sidewalks to be paved shall be completed as soon as possible. Building pads shall be laid as soon as possible after grading unless seeding or soil binders are used;
- Idling times shall be minimized either by shutting equipment off when not in use or reducing the maximum idling time to 5 minutes (as required by the California airborne toxics control measure Title 13, Section 2485 of California Code of Regulations [CCR]). Clear signage shall be provided for construction workers at all access points;

- All construction equipment shall be maintained and properly tuned in accordance with manufacturer's specifications. All equipment shall be checked by a certified visible emissions evaluator; and
- Post a publicly visible sign with the telephone number and person to contact at the lead agency regarding dust complaints. This person shall respond and take corrective action within 48 hours.

Caltrans special provisions and standard specifications will include the requirement to minimize or eliminate dust through application of water or dust palliatives. The following construction dust and equipment exhaust emissions measures are consistent with the BAAQMD CEQA Guidelines for basic and enhanced control measures and shall be implemented when practical, during all phases of construction work:

- AQ-1: The Project will follow Caltrans Standard Specification Sections 14-9.01 and 14-9.02, which address the requirements of the local air pollution control district (BAAQMD) and dust control and dust palliative application, respectively.
- AQ-2: The Project will implement all feasible respirable PM (PM_{10}) control measures required by BAAQMD.

Newer or modified construction emission control measures would be included with the Project to be consistent with current practices. The Project changes would not affect the determinations made in the FEIR, and the impacts would not be more severe than those described in the 1994 FEIR.

Off-site Improvements

The off-site improvements at the Kinder Morgan Brentwood Boulevard Junction would require minor excavation (up to one foot) along the length of the ECCID maintenance road in order to construct an asphalt concrete access road. Approximately once per week, a truck would enter the junction valve lot from Brentwood Boulevard or Seller Avenue, and traverse across the maintenance roadway to inject the DRA into the pipeline. Neither of these activities would result in significant contributions to construction or operational emissions associated with the Project. As such, these minor Project changes would not create any impacts more severe than those described in the 1994 FEIR, and no additional mitigation measures would be required.

3.2.3 POTENTIAL IMPACTS NOT PREVIOUSLY ADDRESSED

The effects of the Project on greenhouse gases (GHG) emissions and climate change were not discussed in the 1994 FEIR. Since that time GHG emissions and climate change have been added as a CEQA topic that needs to be analyzed as part of the Project's environmental clearance.

A project's potential to result in significant impacts is based on standards of significance derived from the CEQA Guidelines Appendix G. As such, a project's global climate change impact is considered significant if it meets the following criteria:

- Generates GHG emissions, either directly or indirectly, that may have a significant impact on the environment.
- Conflicts with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of GHGs.

GHG emissions for transportation projects can be divided into those produced during construction and those produced during operation of the new improvements. Construction GHG emissions include indirect emissions produced as a result of material processing, emissions produced by onsite construction equipment, and emissions arising from traffic delays due to construction. These emissions would be produced at different levels throughout the construction phase; their frequency and occurrence can be reduced through innovations in plans and specifications and by implementing better traffic management during construction phases. In addition, with innovations such as longer pavement life, improved traffic management plans, and changes in materials, the GHG emissions produced during construction can be reduced to some degree by longer intervals between maintenance and rehabilitation events.

With respect to construction-related GHG impacts, BAAQMD does not have an adopted threshold of significance for construction-related GHG emissions. However, as recommended in BAAQMD's CEQA Air Quality Guidelines, GHG emissions that would occur during construction have been quantified (see **Table 1**), and a determination has been made as to the significance of these construction-generated GHG emissions in relation to meeting Assembly Bill 32 (AB 32) GHG

reduction goals, as required by the Public Resources Code, Section 21082.2. The Phase 1 interchange improvements once completed would reduce delay and improve traffic flow through the SR-4/Balfour Road intersection, possibly reducing carbon dioxide (CO_2) emissions.

Table 1 Carbon Dioxide (CO2) Construction Emissions (Metric Tons per Day)

Project Phases	CO_2 (lbs/day)
Grubbing/Land Clearing	3,980.3
Grading/Excavation	6,171.2
Drainage/Utilities/Sub-Grade	5,747.0
Paving	3,968.2
Maximum (pounds/day)	6,171.2
Total (metric tons/construction project)	625.8

Illingworth & Rodkin, 2014

Adverse Contribution to Climate Change

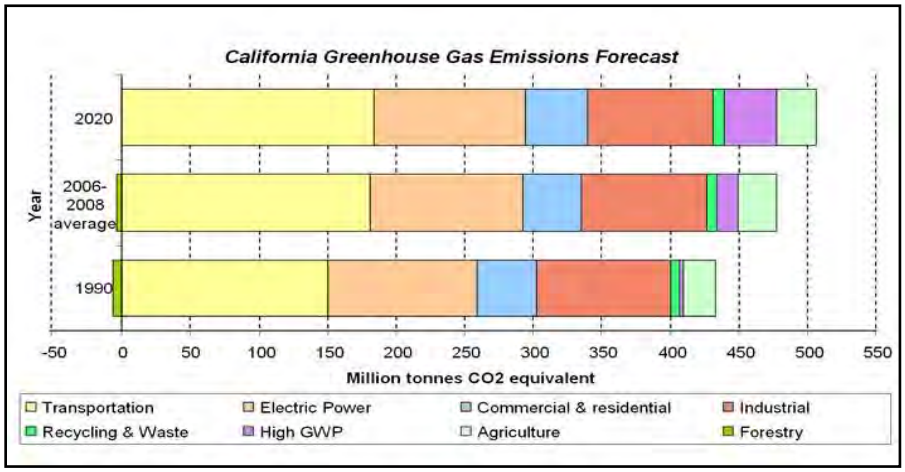
An individual project does not generate enough GHG emissions to significantly influence global climate change. Rather, global climate change is a cumulative impact. This means that a project may contribute to a potential impact through its *incremental* change in emissions when combined with the contributions of all other sources of GHG.[2] In assessing cumulative impacts, it must be determined if a project's incremental effect is "cumulatively considerable" (CEQA Guidelines

2 This approach is supported by the AEP: *Recommendations by the Association of Environmental Professionals on How to Analyze GHG Emissions and Global Climate Change in CEQA Documents* (March 5, 2007), as well as the South Coast Air Quality Management District (Chapter 6: The CEQA Guide, April 2011) and the US Forest Service (Climate Change Considerations in Project Level NEPA Analysis, July 13, 2009).

sections 15064(h)(1) and 15130). To make this determination, the incremental impacts of the project must be compared with the effects of past, current, and probable future projects. To gather sufficient information on a global scale of all past, current, and future projects in order to make this determination is a difficult, if not impossible, task.

The AB 32 Scoping Plan mandated by AB 32 contains the main strategies California will use to reduce GHG emissions. As part of its supporting documentation for the Draft Scoping Plan, ARB released the GHG inventory for California (see **Figure 6**, forecast last updated: October 28, 2010). The forecast is an estimate of the emissions expected to occur in the year 2020 if none of the foreseeable measures included in the Scoping Plan were implemented. The base year used for forecasting emissions is the average of statewide emissions in the GHG inventory for 2006, 2007, and 2008.

Figure 6. California Greenhouse Gas Forecast



Source: http://www.arb.ca.gov/cc/inventory/data/forecast.htm

The Project is included in the 2013 RTP and 2013 TIP, which contain adopted strategies for GHG emissions from transportation sources. Specifically, RTP reference number 230550, "Climate Initiatives Program," is an adopted 5-year program for the Bay Area region involving outreach and education, promotion of safe routes to school, bike-sharing, and funding for electric vehicles. The adopted TIP also demonstrates that the region will remain below all approved "vehicle emission budgets" through the RTP study year.

Existing (2013), design year (2020), and horizon year (2040) CO_2 emissions were estimated under Project and no-project conditions using the latest CT-EMFAC version 5 model based on EMFAC2011 for vehicles in Contra Costa County.[3] Traffic volumes and peak commute period speeds were obtained from the 2013 Traffic Operations Report (TOR) prepared for the Project. The speeds and vehicle miles traveled (VMT) used in the emissions model are shown in **Table 2**.

[3] The CT-EMFAC version 5 model only projects the emission rates up to the 2035 year. These 2035 emission rates were used to calculate the 2040 emissions.

Table 2 shows GHG emissions expressed in metric tons per day of CO_2. GHG emissions are presented with the Pavley and Low Carbon Fuel Standard (LCFS) requirements. With the implementation of the Phase 1 interchange improvements there will be a shift in the VMT from the off-peak period to the peak period and an increase in the average speeds during the peak period.

Table 2 Carbon Dioxide (CO_2) Emissions (Metric Tons per Day)

	Balfour Road		State Route 4		Total Metric Tons	Difference between Existing and Future	Difference between Project and No-Build
	VMT	Average Speed	VMT	Average Speed			
Existing	14,621	30	68,473	40	37.64	--	--
2020 No-Project	20,092	30	78,409	40	35.87	-1.77	--
2020 Project	20,645	45	106,168	65	44.28	6.64	8.41
2040 No-Project	23,104	30	103,820	40	44.68	7.04	--
2040 Project	24,606	45	151,428	65	56.38	18.74	11.70

Source: Illingworth & Rodkin, 2014

These computed CO_2 emissions are only useful for a comparison between alternatives. The numbers are not necessarily an accurate reflection of what the true CO_2 emissions will be because CO_2 emissions are dependent on other factors that are not part of the model, such as the fuel mix (EMFAC2011 model emission rates are only for direct engine-out CO_2 emissions, not full fuel cycle; fuel cycle emission rates can vary dramatically depending on the amount of additives like ethanol and the source of the fuel components), rate of acceleration, and the aerodynamics and efficiency of the vehicles. This analysis does not evaluate the changes in CO_2 emissions translated throughout the entire Bay Area transportation network. That type of analysis was conducted at the regional transportation plan level as previously discussed. The Project was included in the planned network that was evaluated in the regional transportation plan.

If VMT was analyzed over a broader geographic area, there would be very little difference between future conditions with or without the Project. Without the Project, there would be higher traffic volumes on other roads that run roughly parallel to SR-4. Under the Project condition, there are higher volumes on SR-4 itself and lower volumes on those parallel routes. But since the evaluation only looks at SR-4 in isolation, it doesn't see the broader effects of the Project on other routes. If these routes where taken into consideration, it is likely that, because there would be no increase in VMT, there would be lower GHG emissions. The 2013 TOR concludes that the Project would have beneficial impacts to traffic levels of service on roadways in the Project area. The 2013 TOR also concludes that traffic congestion at the SR-4/Balfour Road intersection without the Project would operate at unacceptable levels. The Project would therefore be expected to result in reduced GHG emissions through reduced congestion.

With respect to construction-related GHG impacts, BAAQMD does not have an adopted threshold of significance for construction-related GHG emissions. However, as recommended in BAAQMD's CEQA Guidelines, GHG emissions that would occur during construction would be less-than significant when comparing these construction-generated GHG emission impacts in relation to meeting AB 32 GHG reduction goals, as required by the Public Resources Code, Section 21082.2. The Project impacts related to GHG emissions would be less than significant.

3.3 BIOLOGICAL RESOURCES

3.3.1 PRIOR FEIR ANALYSIS

The 1994 FEIR identified possible effects of the Project on habitats, wetlands, and species of concern, and the potential for direct effects on these species relative to harm or harassment resulting from construction activities. The FEIR included 14 significant, unavoidable effects to biological resources that would potentially occur despite implementation of the proposed mitigation measures.

Construction of the Project was found to adversely impact riparian corridors, such as Deer Creek, which runs through the SR-4/Balfour Road interchange area. The potential loss or degradation of the riparian habitats would be significant because of their local and regional scarcity, possible classification as Waters of the U.S., continuing depletion, and increased threats to dependent species of concern. Following the certification of the FEIR in 1994, a Biological Opinion (BO) was issued by the USFWS for construction of a 2-lane expressway through the Segment 2 limits.

A wetland delineation was prepared in 1998 for the entire State Route 4 Bypass Project area, and was verified by the U.S. Army Corps of Engineers (USACE) in 1999. The wetland delineation verification was valid for a period of five years, and expired on April 27, 2004. Reverification of the wetland delineation is currently underway for the areas encompassing the SR-4/Balfour Road interchange.

No new plants or wildlife have been recorded in the Project area since the 1999 study. However, one species, the California tiger salamander, was upgraded to a federal listing of threatened in 2004.

The HCP/NCCP for East Contra Costa County was developed in consultation with the USFWS and adopted in July 2007. The HCP/NCCP establishes a coordinated process for permitting and mitigating the incidental take of endangered species identified in the plan. This process creates an alternative to the current project-by-project approach. Rather than individually surveying, negotiating, and securing mitigation and permit coverage, project proponents typically receive an endangered species permit by paying a fee/dedicating land and performing limited surveys and avoidance measures. A Supplemental EIR prepared in 2004 for Segment 3 of the Project included revisions to the MMRP to reflect the HCP/NCCP's new mitigation language for biological resources. Further refinements to the MMRP were made as part of this addendum in order to accurately reflect the HCP/NCCP process, which does not require individual consultation with federal agencies and the issuance of a BO. The refined MMRP is included as **Appendix A**.

3.3.2 UPDATED ANALYSIS

A biological assessment was conducted by RCL Ecology in 2011 as a part of the Addendum #10 efforts of the SR-4/Balfour Road Interchange Project. Since that time, additional botanical and general biological surveys were conducted in April and September 2013, and June 2014 to evaluate existing biological conditions in the interchange area. In June 2014, a biological survey was conducted of the area of the off-site Kinder Morgan improvements. The assessment conducted in 2011 for Addendum #10, in combination with the updated surveys in 2013 and 2014, are being used to support an application for participation in the HCP/NCCP in order to receive an "Incidental Take" permit for federal and State listed species. The assessment and surveys also address biological resources as required by the California Environmental Quality Act (CEQA), and assist in determining if the Project will require permits from other agencies such as the U.S. Army Corps of Engineers (USACE), California Department of Fish Game (CDFG) or the Regional Water Quality Control Board (RWQCB). The biological assessment and updated 2014 surveys are included as **Appendix C**.

The SR-4/Balfour Road interchange area lies in a nearly flat annual grassland surrounded by urban development. Much of the area within the freeway right-of-way has been previously disturbed during construction of the existing Balfour Road intersection, realignment of Concord Avenue, and construction of the Kinder Morgan facilities. The existing daylighted section of Deer Creek in the northwest quadrant of the SR-4/Balfour Road intersection is the only waterway within the Project area. Deer Creek is an intermittent stream originating in the hills west of the Project area. It is intermittent in its upper reaches but becomes perennial where it is detained in the Water Quality ponds approximately ¾-mile west of the Project area. From that point, Deer Creek primarily flows through underground pipe under Balfour Road and State Route 4. East of SR-4 Deer Creek flows to Marsh Creek which flows to the San Joaquin River. Drainage from the Project area flows into Deer Creek through drop structures within engineered bio swales along SR-4. Runoff from Project construction will utilize the existing drainage system, and drainage improvements would include drainage inlets, drainage pipes, bioswales, pipe underdrain, and rock slope protection.

Biological surveys confirmed that breeding habitat exists within the Project area for the western burrowing owl (*Athene cunicularia hypugaea*), San Joaquin kit fox (*Vulpes macrotis mutica*), California red-legged frog (*Rana Draytonii*), California tiger salamander (*Ambystoma californiense*), and the white-tailed kite (*Elanus leucurus*). Potential habitat also occurs for other protected species such as the pallid bat (*Antrozous pallidus*), western red bat (*Lasiurus blossevillii*) and state protected birds like the Swainson's hawk (*Buteo swainsoni*) and golden eagle (*Aquila chrysaetos*).

To address potential biological impacts related to the Balfour Road interchange improvements, standard conservation measures included in the HCP/NCCP and the 1994 FEIR will be required, as outlined below. The required mitigation for any incidental take of endangered species will be formalized in the HCP/NCCP permit application.

Wetlands and Water Features

The approximate 250 foot long daylighted section of Deer Creek within the northwestern quadrant of the Project area is a channelized waterway with shallow pools. This section of creek is approximately 55 feet wide at top of bank (TOB) and approximately 25 feet wide at ordinary high water (OHW). Trees consist of saplings and mature Fremont cottonwood (*Populus fremontii)* and red willow (*Salix laevigata*). Shrubs consist of California rose (*Rosa californica*) and blue

elderberry (*Sambucus mexicana*). Herbaceous and wetland species consist of broad-leaved pepperweed (*Lepidium latifolium*), narrow-leaved cattail (*Typha angustifolia*), red-tinge bulrush (*Scirpus macrocarpus*), and purple flat sedge (*Cyperus rotundus*).

Central Valley Fall Run Chinook Salmon (*Oncorhynchus tschawytschai)* are known to spawn in the Marsh Creek system. Salmon have been observed near the Balfour Road crossing of Marsh Creek, over a mile east of the Project area. Fish passage is blocked at the end of the low flow culvert, as well as through a grade control weir structure located approximately ¾ mile from the Project area. Thus, the Project is not expected to have any effect on Central Valley Fall Run Chinook Salmon, or any other special-status fish species.

The two clear span bridges proposed for the new SR-4 on- and off-ramps would cross the daylighted portions of Deer Creek. While this design avoids any direct impacts to the waters, the bridges will require some tree removal and will shade approximately 0.38-acres of riparian cover under the new bridges. The Project would also daylight approximately 200 feet of Deer Creek that is currently culverted/piped. This is anticipated to have a beneficial effect to the area, as the daylighting of the creek would create additional habitat when compared to existing conditions.

Construction of the SR-4/Balfour Road interchange would result in a net increase the amount of impervious paved surfaces in the immediate area. This additional impervious area could prevent runoff from naturally dispersing and infiltrating into the ground, resulting in increased concentrated flow. The additional flow has the potential to transport an increased amount of sediment and pollutants to waterways and water resources, adversely impacting the water quality of Deer Creek.

Construction would involve substantial grading and earth moving activities, stockpiling of soils, and the loading, unloading, and transport of excavated and fill material. Rainfall could carry loose soils into adjacent waterways, resulting in increased sedimentation and adverse effects to water quality. Concentrated flow due to grading in some areas will increase the potential for erosion and for sediment transport into the adjacent areas. Construction equipment debris and fuel could also further degrade the quality of storm water runoff if fueling activity and maintenance products are not handled properly. This contamination could impact nearby waterways, including Deer Creek.

As the Project will directly and indirectly impact portions of Deer Creek—a jurisdictional water feature—the following federal, State and regional permits will be required: Federal USACE 404- (Fill of waters and wetlands); State RWQCB 401 – (Water Quality Certification), State CDFG 1602- Streambed Alteration Agreement, Caltrans' National Pollutant Discharge Elimination System (NPDES) permit and Storm Water Management Plan (SWMP), and the East Contra County Habitat Conservancy (Incidental Take Permit). Conditions stipulated within each of the aforementioned permits would ensure that no adverse impacts to water quality would occur as a result of the Project.

San Joaquin Kit Fox

The San Joaquin kit fox is a federally endangered and state listed threatened species. The San Joaquin kit fox is endemic to California and has known range in Alameda and Contra Costa counties. It is extremely rare and sparsely distributed due to habitat loss and the constriction of

dispersal corridors. Dens are generally located in open areas with grass or grass and scattered brush. San Joaquin kit foxes maintain multiple dens and den use varies for breeding dispersal and temporary shelter.

Although ground squirrel burrows occur within the Project area for the Balfour Road interchange and off-site improvements, none appear to be of suitable size (e.g. 5-inches in diameter or greater) to serve as kit fox dens. However, to ensure that the Project will not affect the species, a kit fox preconstruction survey will be required prior to the start of work.

Preconstruction Surveys

Prior to any ground disturbance related to covered activities, a USFWS/CDFG-approved biologist will conduct a preconstruction survey of the Project area. The survey will establish the presence or absence of San Joaquin kit foxes and/or suitable dens and evaluate use by kit foxes in accordance with USFWS survey guidelines (USFWS, 1999). Preconstruction surveys will be conducted within 30 days of ground disturbance. The biologist will survey the proposed Project disturbance footprint plus a 250-radius from the perimeter of footprint to identify San Joaquin kit foxes and/or suitable dens. The status of all dens will be determined and mapped. Written results of preconstruction surveys will be submitted to USFWS within 5 working days after survey completion and before the start of ground disturbance. If San Joaquin kit foxes and/or suitable dens are identified in the survey area, the avoidance and minimization measures described below will be implemented.

Avoidance and Minimization Measures

If a San Joaquin kit fox is discovered in the proposed Project disturbance footprint, the den will be monitored for 3 days by a USFWS/CDFG-approved biologist using a tracking medium or an infrared beam camera to determine if the den is currently being used. Unoccupied dens will be destroyed immediately to prevent subsequent use.

If a natal den or pupping den is found, USFWS and CDFG will be notified immediately. The den will not be destroyed until the pups and adults have vacated and then only after further consultation with USFWS and CDFG.

If kit fox activity is observed at the den during the initial monitoring period, the den will be monitored for an additional 5 consecutive days from the time of the first observation to allow any resident animals to move to another den while den use is actively discouraged. For dens other than natal or pupping dens, use of the den can be discouraged by partially plugging the entrance with soil such that any resident animal can easily escape. Once the den is determined to be unoccupied, it may be excavated under the direction of the biologist. Alternately, if the animal is still present after 5 or more consecutive days of plugging and monitoring, the den may have to be excavated when, in the judgment of a biologist, it is temporarily vacant (i.e. during the animals' normal foraging activities).

Construction Monitoring

If dens are identified in the survey area outside the proposed Project disturbance footprint, exclusion zones around each den entrance or cluster of entrances will demarcated. The configuration of exclusion zones should be circular, with a radius measured outward from the

den entrance(s). No covered activities will occur within the exclusion zones. Exclusion zone radii for known dens will be at least 100 feet and will be demarcated with staking and flagging that encircles each den or cluster of dens but does not prevent access to the den by kit fox.

California Red-legged Frog (CRLF) and California Tiger Salamander (CTS)

The California red-legged frog (CRLF) is a federally threatened species and a California species of special concern. The California tiger salamander (CTS) is a federally and State listed threatened species.

The existing daylighted section of Deer Creek within the interchange area may serve as a breeding site for both CRLF and CTS and adjacent areas are potential aestivation habitats. While visual surveys at the site were negative for CRLF larvae, adult CTS and larvae, and other amphibians, a large splash was heard at the pool in this section. The splash would indicate the presence of either bullfrog or CRLF. Therefore, the agencies will be notified in advance of construction for potential removal of CRLF per HCP/NCCP protocols.

As required by the HCP/NCCP, proper written notification will be provided to USFWS, CDFG, and the Implementing Entity at least 30 days prior to disturbance of potential habitat in order to provide an opportunity for these agencies to translocate any individuals of these species. The agencies in turn are required to notify the proponent within 14 days of their intent to translocate the species. The agencies will then be allowed 45 days to translocate individuals from the date the first written notification was submitted by the Project proponent (or a longer period agreed to by the Project proponent, USFWS, and CDFG).

Western Burrowing Owl

Western Burrowing owl is designated as California Species of Special Concern. The Western Burrowing owl prefers open, flat, or sloped grasslands and requires burrows for nesting and wintering habitat, but will also nest in artificial structures such as open pipes, concrete rubble piles, and small, dry culverts.

Two burrowing owls were observed in the northwest quadrant or the Project area during a survey conducted in November 2014, and three other sites exhibited sign of burrowing owls (regurgitated pellets and prey remains). Therefore, passive eviction techniques will be used to clear the area of owls before the start of the nesting season (February 1) so that the Project will have no effect on the western burrowing owl.

Preconstruction Surveys

Prior to any ground disturbance related to covered activities, a USFWS/CDFW-approved biologist will conduct a preconstruction survey in areas identified in the planning surveys as having potential burrowing owl habitat. The surveys will establish the presence or absence of western burrowing owl and /or habitat features and evaluate use by owls in accordance with CDFW survey guidelines (CDFW, 1993).

On the parcel where the activity is proposed, the biologist will survey the proposed disturbance footprint and a 500-foot radius from the perimeter of the proposed footprint to identify burrows and owls. Surveys would take place near sunrise or sunset in accordance with CDFW guidelines. All burrow or burrowing owls will be identified and mapped. Surveys will take place no more than 30 days prior to destruction. During the breeding season (February 1-August 31),

surveys will document whether burrowing owls are nesting in or directly adjacent to disturbance areas. During the nonbreeding season (September 1-January 31), surveys will document whether burrowing owls are using habitat in or directly adjacent to any disturbance area. Survey results will be valid only for the season (breeding or nonbreeding) during which the survey is conducted.

Avoidance and Minimization Measures

If burrowing owls are found during breeding season (February 1-August 31), the Project proponent would avoid all nest sites that could be disturbed by Project construction during the remainder of the breeding season or while the nest is occupied by adults or young. Avoidance would include establishment of a non-disturbance buffer zone (described below).

Construction may occur during the breeding season if a qualified biologist monitors the nest and determines that the birds have not begun egg-lying and incubation or that the juveniles from the occupied burrows have fledged. During the nonbreeding season (September 1-January 31), the Project proponent would avoid the owls and the burrows they are using if possible. Avoidance will include the establishment of a buffer zone.

If occupied burrows are not avoided, passive relocation would be implemented. Owls would be excluded from burrows within a 160-foot buffer zone by installing one-way doors in burrow entrances. These doors would be in place for 48 hours prior to installing one-way doors in burrow entrances and prior to excavation. The Project area will be monitored daily for one week to confirm that the owl(s) have abandoned the burrow. Whenever possible, burrows would be excavated using hand tools and refilled to prevent reoccupation (CDFW, 1995). Plastic tubing or similar structure would be inserted in the tunnels during excavation to maintain an escape route for any owls inside the burrow.

White-Tailed Kite

The white-tailed kite is classified as Fully Protected by the state. White-tailed kites breed in lowland grasslands, agriculture, wetlands, oak-woodland and savannah habitats, and riparian areas associated with open areas. Fremont cottonwoods within the daylighted portion of Deer Creek are large enough to furnish nesting habitat for the white-tailed kite. Therefore, preconstruction nest surveys will be conducted for the white-tailed kite if construction is planned to occur within the nesting season (February 1-August 31).

Preconstruction Surveys

If Project construction is scheduled to start during the breeding season (February 1- August 31), preconstruction surveys should be conducted within the Project area and a 300-foot buffer, by a qualified biologist no more than two weeks prior to equipment or material staging, or surface-disturbing activities. If no active nests are found within the survey area, no further mitigation is necessary.

Avoidance and Minimization Measures

If active nests (i.e. nests in the egg laying, incubating, nestling, or fledgling stages) are found within 300 feet of the Project area, non-disturbance buffers should be established at a distance sufficient to minimize disturbance based on the nest location, topography, cover, the nesting pair's tolerance to disturbance, and duration of potential disturbance. No work should occur

within the non-disturbance buffers until the young have fledged as determined by a qualified biologist, Buffer size should be determined in cooperation with the CDFG and the USFWS. If buffers are established and it is determined that Project activities are resulting in nest disturbance, work should cease immediately, and the CDFG and the USFWS should be contacted for further guidance.

Pallid and Western Red Bat

The pallid and western red bats are listed as CDFW Special Concern species. The pallid bat prefers to roost in buildings, caves and other structures not present in the Project area but may forage in the habitat adjacent to the SR-4/Balfour Road intersection. The red bat is a riparian obligate and may roost and forage along the daylighted section of Deer Creek.

Preconstruction Surveys

Preconstruction surveys of the trees within the riparian area will be conducted in advance of construction to detect bat roosting.

Avoidance and Minimization Measures

If roosting is found protective fencing will be erected to prevent disturbance to the roost site. The fence location will be monitored by the biological monitor to ensure it stays secure for the duration of Project work.

State Protected Birds

Several birds with potential to occur in the Project area are listed on the state watch list, or are of state special concern. These include birds of prey, the merlin, Cooper's hawk, Swainson's hawk, golden eagle, and loggerhead shrike; as well as a songbird – the California horned lark.

Preconstruction Surveys

If Project construction is scheduled to begin during the breeding season (February 1- August 31), preconstruction surveys for special-status bird species will be conducted within the Project area and a 300-foot buffer, by a qualified biologist no more than two weeks prior to equipment or material staging, or surface-disturbing activities. If no active nests are found within the survey area, no further mitigation is necessary.

Avoidance and Minimization Measures

If active nests (i.e. nests in the egg laying, incubating, nestling or fledgling stages) are found within 300 feet of the Project footprint, non-disturbance buffers should be established at a distance sufficient to minimize disturbance based on the nest location, topography, cover, the nesting pair's tolerance to disturbance and duration of potential disturbance. No work should occur within the non-disturbance buffers until the young have fledged as determined by a qualified biologist. Buffer size should be determined in cooperation with the CDFW and the USFWS. If buffers are established and it is determined that Project activities are resulting in nest disturbance, work should cease immediately and CDFW and USFWS should be contacted for further guidance.

General Avoidance and Minimization Measures

In addition to the standard HCP/NCCP conservation measures outlined above, the following general measures shall be followed during Project construction.

- Prior to the start of construction, ESA fence will be installed by the contractor as shown on the plans to protect portions of Deer Creek during construction activity. A biological monitor will inspect the fence to ensure correct depth and placement and monitor the fencing to ensure that it remains during construction activity.
- A biological monitor should be on site during all construction activity near the waters and riparian habitat to ensure implementation of, and compliance with all avoidance measures.
- The biological monitor will conduct Worker Environmental Awareness Training for all construction crews and contractors. The education training should be conducted prior to starting work on the Project and upon the arrival of any new workers. The training should include a review of sensitive areas and avoidance and minimization measures to be employed to protect the covered and no take species. A record of all personnel trained during the Project should be maintained for compliance verification.
- Staging areas and access routes through the Project will be reviewed by the biological monitor to ensure that they do not impact any sensitive areas.

Off-site Improvements

A biological study of the area encompassing the off-site improvements at the Kinder Morgan Brentwood Boulevard Junction was prepared by RCL Ecology in September, 2014. The study included a pedestrian survey of the area conducted on May 23, 2014. The survey consisted of walking the roadsides and adjacent areas out to a distance of approximately 500 feet where possible. The maintenance road lies within a farmed area of irrigated row crops and is essentially composed of bare ground from the road to the canal, and from the road to the adjacent field. A few California ground squirrel burrows occur along the concrete edge of the canal and a small area on the north side of the road at its intersection with Sellers Avenue. A small grove of mature eucalyptus trees occurs on the north side of the road near Brentwood Boulevard.

All burrows were closely examined for signs of use by burrowing owls as well as San Joaquin kit fox, and the canal was examined for use by California red-legged frog and California tiger salamander. All trees were surveyed with binoculars for use by tree-nesting birds with specific emphasis on use by protected raptors such as the Swainson's hawk and golden eagle.

No signs of burrowing owls (white-wash, regurgitated pellets, feathers or prey parts) were found. No use by San Joaquin kit fox (scat, tracks) was found, and all burrows were less than the minimum size of 5-inches in circumference in order to be habitat for the kit fox. No amphibians were found in the canal. No nests were found within the eucalyptus trees and no special-status plants occur on the area.

While not present currently, burrowing owls, kit fox and tree nesting birds could move onto the area at a later date. Therefore, preconstruction surveys will be required for these species per agency protocols, as previously described.

3.4 CULTURAL RESOUCES

3.4.1 PRIOR FEIR ANALYSIS

The 1994 FEIR analyzed the potential of the Project to disrupt or adversely affect a prehistoric or historic archaeological site or property of historic or cultural significance. Cultural resources study for the Project consisted of a detailed review of the previously completed archival literature review of the Project right-of-way and an onsite surface archaeological reconnaissance. The supporting cultural reports for the 1994 FEIR did not identify cultural resources in the vicinity of the Project Area; however, only the 1992 SR-4 alignment north of Balfour Road was surveyed. South of Balfour Road, the proposed SR-4 alignment was inaccessible at the time of the survey. Because of differences between the 1992 SR-4 and the current SR-4 alignment, the majority of the Project area was not surveyed in 1992 (see Figure 8 of the Archaeological Survey and Cultural Resources Assessment prepared for the Project, included as **Appendix D** of this addendum).

Although no archaeological or subsurface cultural resources of significance or potential significance were observed along the segments of the Project accessible to field surveys conducted for the 1994 FEIR, the document determined that impacts to undiscovered prehistoric resources could occur through implementation of the Project. Mitigation measures to reduce construction period and long term effects of the Project are discussed in the FEIR. Such measures include archaeological monitoring, suspending work in the event archaeological resources are discovered, development of an excavation plan, and the preparation of an historic property and architectural survey reports should any of the adjacent structures qualify for protection under the National Register of Historic Places and be altered, relocated, or demolished by construction of the Project. However, the FEIR concluded that any impacts related to potential historic resources adjacent to the Project would remain significant.

3.4.2 UPDATED ANALYSIS

An Archaeological Survey and Cultural Resources Assessment were conducted for the SR4/Balfour Road interchange area by William Self Associates in 2014. A field survey of the area was conducted, which covered those areas not previously covered as a part of the 1994 FEIR. Pedestrian surveys of the area were conducted on September 4 and 5, 2014. During the course of the surveys, no cultural materials were observed. A search of the California Historic Resources Information System (CHRIS) records for the area was conducted, and indicates that no prehistoric cultural resources have been recorded within 1-mile of the SR-4/Balfour Road interchange area.[4]

One historic cultural resource is reported by the Northwest Information Center (NWIC) within the study area, a mine adit associated with the Brentwood Coal Company. However, detailed mapping of the location of this resource revealed that it is actually outside of the study area. No NRHP-listed or other local, state, or federally listed or recognized properties are known to exist in the study area. Coordination with the Native American Heritage Commission (NAHC) indicated that no Native American cultural resources are present in the PAL.

The likelihood of encountering potentially significant cultural resources within the area is low. However, should any previously undiscovered historic or prehistoric resources be found during construction, work would stop, in accordance with CEQA regulations, until such time that the

[4] The records search covered a one-mile radius surrounding the Project area.

resource can be evaluated by a qualified archaeologist and appropriate mitigative action take as determined necessary by the lead agency. In the event that Native American human remains or funerary objects are discovered, the provisions of California Health and Safety Code Section 7050.5(b) would be followed. Section 5097.98 and 5097.99 of the Public Resources Code also call for "protection to Native American human burials and skeletal remains from vandalism and inadvertent destruction."

The Project changes would not affect the determinations made in the 1994 FEIR, and the impacts would not be more severe than those described in the 1994 FEIR. No further discussion or mitigation is required as part of this Addendum.

Off-site Improvements

A separate records search was conducted for the off-site improvements, and indicates that no prehistoric cultural resources have been recorded within the off-site Project area. Two historic cultural resources are within ¼ mile of the off-site Project area. Historic railroad tracks run parallel with Brentwood Boulevard west of the off-site Project area. The East Contra Costa Irrigation District Main Canal Complex is located 2.5 miles west of the Project area. This resource includes the main canal itself, a one-mile concrete ditch adjacent to the south side of the off-site Project area, and six pumping stations. The main canal is the only component of this resource in the immediate vicinity of the project area.

Given that there no work is occurring to the railroad or in the canal, and no modifications to the canal or to associated buildings and utilities would occur, there would be no impact to any known historic resources. Furthermore, all excavation activities associated with the Kinder Morgan off-site improvements would be shallow and within previously disturbed soils, thus the likelihood of encountering unknown cultural resources during the construction is low. Adherence to California Health and Safety Code Section 7050.5(b) would be followed, as previously described. No further discussion or mitigation is required as part of this Addendum.

3.5 HAZARDOUS MATERIALS

3.5.1 PRIOR FEIR ANALYSIS

The 1994 FEIR identified potential locations in the Project area that could contain hazardous wastes left by former property users. At the time, the zoning along the Project right-of-way allowed agricultural uses and well-head activities associated with a small oil field in the Sand Creek Area. The FEIR concluded that there were six locations where hazardous wastes could be present. These included a shooting range, two debris yards, a series of oil wells, a crude oil storage facility, and an electrical transformer site. The FEIR included mitigation measures requiring a comprehensive investigation of soil quality at the sites to be conducted by the County Department of Public Works. The mitigation measures reduced the potential impacts to less-than-significant levels.

The 1994 FEIR also contemplated the potential relocation of utilities as part of construction of the Bypass and required coordination with public utilities and/or private operators during construction to allow for relocation as needed without disruption to existing service.

3.5.2 UPDATED ANALYSIS

None of the six sites listed in the 1994 FEIR are located within the SR-4/Balfour Road interchange area. A Preliminary Site Investigation (PSI) Report was prepared by Geocon, Inc. in June, 2014 (included as **Appendix E**). The PSI found that excavated soils would be classified as non-hazardous based on lead and chromium levels. Pesticides, arsenic, and petroleum hydrocarbons were found at concentrations less than the construction exposure Environmental Screening Levels (ESLs), but near or at residential and industrial/commercial ESLs.

The Kinder Morgan Brentwood Booster Station is located within the interchange area on the northwest corner of the SR-4/Balfour Road Bypass intersection. Kinder Morgan owns and operates a 10-inch-diameter petroleum pipeline and booster pump facility that transports refined petroleum products (i.e., gasoline, diesel, and jet fuels) from the Kinder Morgan Concord Station in Concord, California, to the Kinder Morgan Bradshaw Terminal in Stockton, California.

As previously discussed, the Phase 1 interchange improvements would remove the Brentwood Booster Station. Independent of the interchange improvements, Kinder Morgan is working with the Regional Water Quality Control Board (RWQCB) to address groundwater contamination at the Brentwood Booster Station. During 2010/2011, Kinder Morgan conducted sampling activities to characterize and address groundwater impacts. Kinder Morgan has accepted responsibility for the petroleum hydrocarbon impacts at this site and is working under RWQCB oversight to investigate, and remediate if necessary, impacts to the satisfaction of RWQCB. The sampling, characterization, and remediation activities are already occurring and will continue under the oversight of the RWQCB (the lead agency), independent of Project construction.

Following removal of the facility, the remediation work will continue until the contamination is addressed to the satisfaction of the RWQCB. The contamination therefore does not present a potential future hazard to the Bypass Authority or to Caltrans (the eventual owner of the interchange facility), as the RWQCB is already directing the remediation pursuant to state laws governing the characterization and remediation of contaminants.

No construction period impacts exist, since the depth to groundwater is beyond the limits of work for the Balfour Road interchange where any construction workers would be potentially affected. Furthermore, pollutant levels in the soils are below the construction exposure ESLs.

The Phase 1 interchange improvements would not affect the determinations made in the 1994 FEIR, and the impacts would not be more severe than those described in the 1994 FEIR. No further discussion or mitigation is required as part of this Addendum.

Off-site Improvements

The off-site improvements would require shallow excavation work (up to one foot) along an existing unpaved maintenance access roadway. There are two documented hazardous materials release sites located approximately one mile northwest of the off-site improvement Project area. Cleanup has been completed at both of these sites and both are considered closed. The nearest potential hazardous materials site is a historic pipeline owned by Chevron, located at the intersection of Oak Street and Walnut Boulevard in Brentwood; approximately 1.25 miles

northwest of the off-site improvement area. No remediation actions have occurred to date, the site is undergoing preliminary evaluation to determine if crude oil from the historic pipeline is present.[5]

Given that there are no documented release sites or contaminants in the Project area, and that the work proposed is relatively small scale, the off-site improvements would have no impacts related to hazardous materials.

3.6 NOISE

3.6.1 PRIOR FEIR ANALYSIS

The 1994 FEIR concluded that development of the Project would result in significant impacts related to noise. Specifically, the FEIR concluded that construction activities would temporarily increase ambient noise levels in the area, and that development of the Project would create operational noise levels exceeding compatibility guidelines for residential uses. Following the certification of the FEIR, residential development projects were required to construct their own sound barriers sufficient to mitigate potential future noise impacts to a less-than-significant level. The cities of Antioch and Brentwood have diligently implemented this requirement for all of the residential subdivisions that have been built and are being proposed along the SR-4 right-of-way.

Mitigation measures outlined in the FEIR included open space buffers, sound barriers, and installation of noise insulation for existing residences. The FEIR did not provide any guidance as to the proposed location or height of the recommended noise barriers.

3.6.2 UPDATED ANALYSIS

In accordance with the FEIR mitigation measures, a noise analysis was conducted as part of Addendum #10 to determine existing and future noise levels associated with the operation of the existing Balfour intersection and the proposed interchange improvements (included as **Appendix F**). The analysis was conducted using the local City of Brentwood standard, based on the A-weighted scale (dBA), which reflects the normal hearing sensitivity range of the human ear, and also includes the day-night average sound pressure level (Ldn); the average noise level over a 24-hour period with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The City of Brentwood standard is based on a 24-hour average that includes a penalty of 10 dBA added to nighttime noise (Ldn). The results of the 2011 noise modeling indicate that year 2020 traffic noise levels would not exceed the City of Brentwood's 60 dBA Ldn threshold at Summerset residences. No noise abatement mitigation is required for the Project.

Updated noise modeling was conducted by Illingworth and Rodkin in 2014. Traffic noise levels assuming Phase 1 conditions were modeled with Federal Highway Administration's Traffic Noise Model (TNM v. 2.5). The traffic noise model was calibrated to measured conditions documented during the noise monitoring survey made during the 2011 update, and then used to calculate 2020 traffic noise levels with and without the Phase 1 improvements. As indicated in Table 2, 2020 traffic noise levels calculated assuming the construction of the Phase 1 Project improvements are

[5] State Water Resources Control Board, 2014. Available: http://geotracker.waterboards.ca.gov/map/?CMD=runreport&myaddress=balfour+road. Accessed 9/30/2014.

predicted to range from 52 to 60 dBA L_{dn} at Summerset residences. The calculated noise levels assuming the Phase 1 improvements are 1 to 2 dBA less than the noise levels calculated as part of the 2011 Addendum. The reduction in noise levels at Summerset residences is due to a decrease in traffic volumes (2020 traffic conditions relative to 2015 traffic conditions) and the shift in the eastbound travel lanes further west and away from the Summerset residences. Year 2020 traffic noise levels would not exceed the City of Brentwood's 60 dBA L_{dn} threshold at Summerset residences, and no additional mitigation is required.

Additionally, following the certification of the 1994 FEIR, residential development projects were required to construct their own sound barriers sufficient to mitigate potential future noise impacts to a less-than-significant level. The cities of Antioch and Brentwood have diligently implemented this requirement for all the residential subdivisions proposed along the SR-4 right-of-way, thus limiting the impacts of any potential increases in noise in the area.

The following construction activities are required to be done at night due to impacts to traffic. This list is not meant to be all encompassing; however, the nighttime construction will be limited to just essential activities:

- Placement of temporary concrete barrier and temporary traffic stripes along State Route 4 and Balfour Road as construction staging occurs
- Construction of the center pier columns for the eastbound SR-4 bridge over Balfour Road
- Placement of pre-cast girders for the eastbound SR-4 bridge over Balfour Road
- Several pavement conforms at ramps and along Balfour Road

Construction of the proposed improvements would result in temporary noise increases at sensitive receptors in the vicinity of the Project. Construction-period noise reduction measures (Mitigation Measure III.F.1 in the 1994 FEIR) were updated in 2003 as part of a Supplemental EIR prepared by the Bypass Authority, and would apply to the current Project:

- The majority of noise-generating activities at the construction site or in areas adjacent to the construction site associated with the Project in any way would be restricted to the hours of 7:00 a.m.to 6:00 p.m., Monday through Friday, and 8:00 a.m. to 5:00 p.m. on Saturdays. Nighttime construction will be limited to just essential activities. No construction activities should occur Sundays or holidays. Equip all internal combustion engine driven equipment with intake and exhaust mufflers which are in good condition and appropriate for the equipment.
- Unnecessary idling of internal combustion engines should be strictly prohibited.
- Avoid staging of construction equipment within 200 feet of residences and locate all stationary noise-generating construction equipment, such as air compressors and portable power generators, as far as practical from existing noise sensitive receptors. Construct temporary barriers to screen stationary noise generating equipment when located in areas adjoining noise sensitive land uses.
- Utilize "quiet" air compressors and other stationary noise sources where technology exists. Route all construction traffic to and from the Project site via designated truck routes. Prohibit construction related heavy truck traffic in residential areas where feasible. Prohibit construction truck traffic in the Project vicinity during non-allowed hours.

- Notify adjacent residents to the Project site of the construction schedule in writing.
- Designate a "noise disturbance coordinator" who would be responsible for responding to any local complaints about construction noise. The disturbance coordinator would determine the cause of the noise complaint (e.g., starting too early, bad muffler, etc.) and would require that reasonable measures warranted to correct the problem be implemented. Conspicuously post a telephone number for the disturbance coordinator at the construction site and include it in the notice sent to neighbors regarding the construction schedule (the City should be responsible for designating a noise disturbance coordinator and the individual Project sponsor should be responsible for posting the phone number and providing construction schedule notices).

These measures remain in effect for all Project-related construction work.

The construction of the Project would not result in a substantially more severe impact than described in the 1994 FEIR. No additional mitigation is required to reduce the temporary noise increases due to Project construction activities.

Off-site Improvements

The off-site improvements would require minor excavation work (up to one foot), as well as one weekly truck trip to deliver the DRA. Given the minimal excavation work and infrequency of additional truck trips, the noise generated from these activities would be minimal, infrequent and not result in any substantial change in noise levels in this area.

3.7 TRAFFIC

3.7.1 PRIOR FEIR ANALYSIS

The 1994 FEIR analyzed potential impacts of the SR-4 Bypass Project on traffic and transportation in the Project area. The FEIR concluded that the general impact of the Project was beneficial to traffic levels of service on roadways in the Project area. However, there were several locations where levels of service would worsen as a result of the Project. The FEIR included three significant, unavoidable effects that would potentially occur despite implementation of the proposed mitigation measures.

3.7.2 UPDATED ANALYSIS

A Traffic Operations Report (TOR) for the Phase 1 SR-4/Balfour Road interchange improvements was prepared by Fehr & Peers in August, 2013 (included as **Appendix G**). The report documents existing and future (2020 and 2040) traffic conditions within the study area. Traffic operations were analyzed to determine the improvements that would best serve anticipated traffic growth through the study area. Year 2020 represents the opening year while 2040 represents the design year. Study intersections analyzed include: Balfour Road/Cortona Way, Balfour Road/SR-4, and Balfour Road/Summerset Drive. Under future conditions (once the Project is in place), two freeway mainline section north and south of Balfour Road were analyzed along SR-4. In addition, seven freeway ramps were analyzed.

The TOR concludes that the interchange improvements would have beneficial impacts to traffic levels of service on roadways in the study area. The TOR also concludes that traffic levels of service (LOS) at the Balfour Road/SR-4 intersection would operate at unacceptable levels without the Project. The discussion below summarizes the TOR analysis for conditions with and without the Project.

No-Project Conditions

Under the no-project conditions, the SR-4/Balfour Road intersection would remain as a two lane expressway with an at-grade intersection at Balfour Road. The study intersections were analyzed based on projected traffic volumes for 2020 and 2040 under the no-project scenario.

Table 3 summarizes year 2020 and 2040 study intersection LOS under the no-project scenario. As shown in **Table 3** below, the SR-4/Balfour Road intersection is projected to operate at unacceptable LOS E during AM peak hours in 2020 and at LOS F during AM peak hours in 2040.

During the PM peak hour, the SR-4 Balfour Road intersection is projected to drop from LOS D in year 2020 to LOS E in year 2040. Additionally, the Balfour Road/Cortona Way intersection is projected to drop from LOS C in 2020 to LOS E in 2040 during both AM and PM peak periods.

Table 3 Intersection LOS Summary for the No-Project Scenario

Year 2020 No-Project Scenario				
Intersection	Control	Peak Hour	Delay (sec)	LOS
Balfour Rd/Cortona Way	Signal	AM	32	C
		PM	34	C
Balfour Rd/SR-4	Signal	AM	65	E
		PM	52	D
Balfour Rd/Summerset Dr	Signal	AM	6	A
		PM	9	A
Year 2040 No-Project Scenario				
Intersection	Control	Peak Hour	Delay (sec)	LOS
Balfour Rd/Cortona Way	Signal	AM	63	E
		PM	61	E
Balfour Rd/SR-4	Signal	AM	105	F
		PM	75	E
Balfour Rd/Summerset Dr	Signal	AM	7	A
		PM	10	A

Source: Fehr & Peers, 2013

Phase 1 Project Conditions

The Project would generally include a four lane freeway (two mixed flow lanes in each direction) from the Lone Tree Way interchange to south of the Balfour Road interchange. The freeway cross section would transition south of the Balfour Road interchange to a two-lane expressway. The freeway off-ramps at Balfour Road would each be one lane, transitioning to three lanes at the ramp termini intersections. The ramp termini intersections would be signalized.

The intersection analysis assumes that signal timing improvements would be implemented as traffic volumes in the study area continue to increase. As shown in **Table 4** below, the study intersections are projected to improve substantially compared to the no-project conditions, and would operate at acceptable LOS C or better during both AM and PM peak hours under both 2020 and 2040 scenarios at all study intersections.

Table 4 Phase 1 - Intersection LOS Summary for the Project

Year 2020 Project Scenario				
Intersection	Control	Peak Hour	Delay (sec)	LOS
Balfour Rd/Cortona Way	Signal	AM	21	C
		PM	22	C
Balfour Rd/SR-4 EB Ramps	Signal	AM	13	B
		PM	14	B
Balfour Rd/SR-4 WB Off-Ramp/WB Loop On-Ramp	Signal	AM	4	A
		PM	6	A
Balfour Rd/Summerset Dr	Signal	AM	4	A
		PM	5	A
Year 2040 Project Scenario				
Intersection	Control	Peak Hour	Delay (sec)	LOS
Balfour Rd/Cortona Way	Signal	AM	33	C
		PM	28	C
Balfour Rd/SR-4 EB Ramps	Signal	AM	17	B
		PM	15	B
Balfour Rd/SR-4 WB Off-Ramp/WB Loop On-Ramp	Signal	AM	4	A
		PM	6	A
Balfour Rd/Summerset Dr	Signal	AM	5	A
		PM	5	A

Source: Fehr & Peers, 2013

The construction of the Project would not result in a substantially more severe impact than described in the 1994 FEIR. No additional mitigation is required.

Off-site Improvements

The off-site improvements would require some minor excavation work (up to one foot), as well as one weekly truck trip to deliver the DRA. Given the minimal construction work required, and infrequency of additional traffic (once per week), traffic related impacts would be minimal and not significant.

3.8 VISUAL RESOURCES

3.8.1 PRIOR FEIR ANALYSIS

At the time the 1994 FEIR was prepared, the area adjacent to Balfour Road was primarily undeveloped agricultural land. Views of Mt. Diablo and intervening hills could be seen to the west from Balfour Road. The FEIR identified significant and unavoidable visual impacts as a result of Project construction, as it would be visible from adjacent residential areas either already developed or under consideration for development and could affect views from outlying areas by introducing a roadway into the previously undeveloped landscape.

Mitigation measures addressing the impacts to the existing visual character of the area included various landscaping techniques, as seen in Mitigation Measure III.D.1 and III.D.2.

3.8.2 UPDATED ANALYSIS

Since the adoption of the 1994 FEIR, several new land developments have been constructed in the area of the SR-4/Balfour Road intersection. The Brentwood Medical Center, a large medical facility, is located southwest quadrant of the intersection. New high-density townhomes are located to the northwest, and single-family residences are located to the east. Visual simulations of the Balfour Road interchange were prepared as part of the Addendum #10 analyses, with representative viewpoints along the north side of Balfour Road, looking west towards Mt. Diablo. The simulations confirmed that existing views of Mt. Diablo and the intervening hills are partially obstructed by landscaping and commercial development along Balfour Road. The simulations also show that Mt. Diablo and the intervening hills will continue to be partially obstructed by the interchange, although the ridgeline of Mt. Diablo will remain visible. Addendum #10 concluded that construction of the Balfour Road interchange would not result in any new significant environmental effects or substantial increases in the severity of the previously identified visual impacts identified in the 1994 SR-4 Bypass Project FEIR.

Since the visual impact analysis for Addendum #10, there have been no changes in the visual resources and types of viewers within the Project area. When compared to the visual simulations prepared in 2011, the proposed Phase 1 interchange improvements include equal numbers of elevated ramp and bridge structures, with minor shifts (less than 20 feet) in the alignments of each; two clear-spanning bridge structures that would be at a similar elevation as the structures previously proposed; and similar areas of total roadway/paved surface improvements. With the construction of Phase 1 of the SR-4/Balfour Road interchange, views of the visual resources from the Project area (namely Mt. Diablo and other hillsides) would experience the same level of visual

intrusion and obstruction of these views when compared to the Project that was evaluated in Addendum #10. The Project design changes do not propose any new structures or roadway improvements that would change the conclusions of the previously completed visual impact analyses.

The Project would not result in any new significant environmental effects or increase the severity of impacts to visual resources previously identified in the 1994 FEIR.

Off-site Improvements

The off-site improvements would require some minor excavation work (up to one foot), and the application of an aggregate gravel base over an existing maintenance road. Given the minimal construction work required and no change in topography, this work would not result in any visual impact.

4 Conclusion

Construction of Phase 1 of the SR-4/Balfour Road interchange and associated off-site improvements would not result in any new significant environmental effects or substantial increases in the severity of the previously identified significant effects of the 1994 FEIR.

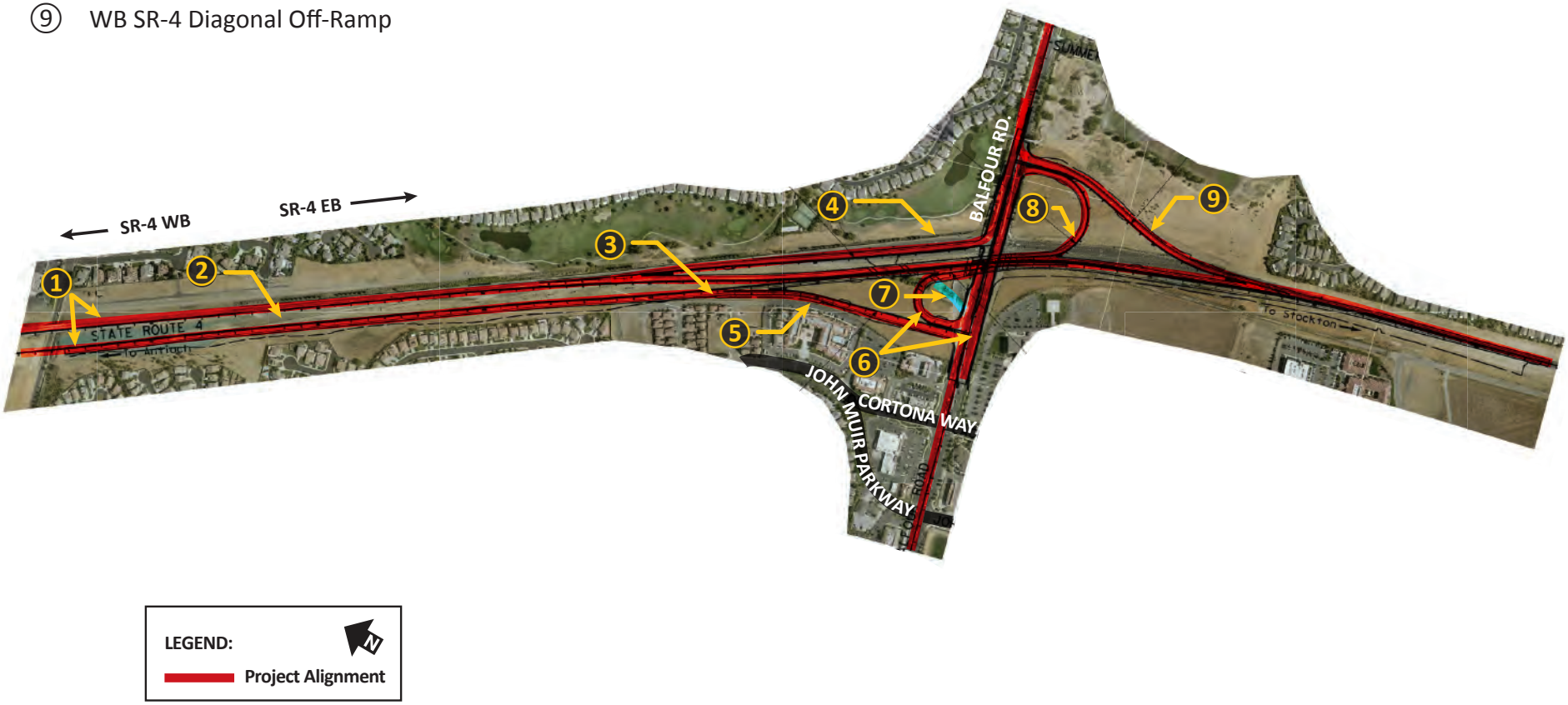
None of the conditions described in §15162 of the CEQA Guidelines requiring for the preparation of a subsequent FEIR have occurred. Therefore, this Addendum to the 1994 FEIR is an appropriate level of environmental review for the construction of Phase 1 of the SR-4/Balfour Road interchange, as identified in §15164 of the CEQA Guidelines.

Project Site & Vicinity

Figure 1

Source: Quincy Engineering, 2014

① Separate EB/WB Travel Lanes
② Remove Existing SR-4 Crossover
③ EB SR-4 Crossover
④ WB SR-4 On-Ramp
⑤ EB SR-4 Diagonal Off-Ramp
⑥ EB SR-4 Loop On-Ramp
⑦ Proposed Daylighted Portion of Deer Creek
⑧ WB SR-4 Loop On-Ramp
⑨ WB SR-4 Diagonal Off-Ramp



Proposed Project Improvements

Figure 2

Source: Quincy Engineering, 2014

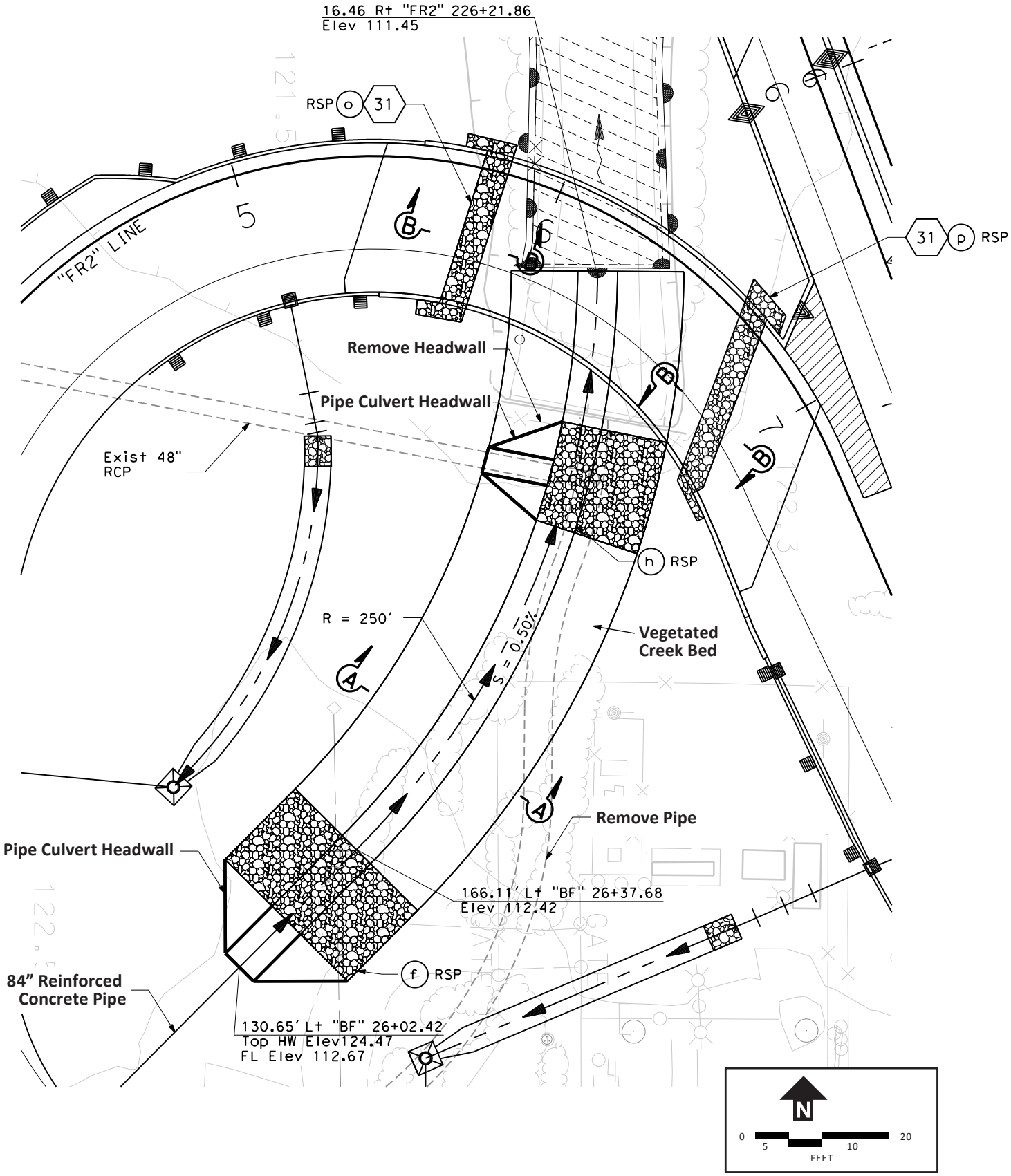
LEGEND:

- TCE
- TCE

PG&E Relocations

Figure 3

Source: Quincy Engineering, 2014



Deer Creek Daylighting Improvements

Figure 4

Source: Quincy Engineering, 2014

LEGEND:

To be demolished

To be relocated

Offsite Improvements at Sellers Avenue

Figure 5

Source: Quincy Engineering, 2014

Cultural Resources

Reports

October 5th, 2014

Jennifer Gallerani
CirclePoint
1814 Franklin Street, Suite 1000
Oakland, CA 94612

RE: Records Search and Native American Heritage Commission Consultation for Off-Site Kinder Morgan Improvements Along ECCID Canal, Brentwood, Contra Costa County, California.

Dear Ms. Gallerani:

In accordance with our agreement, William Self Associates, Inc. (WSA) has implemented a record search and Native American Heritage Commission (NAHC) consultation for the Off-Site Kinder Morgan Improvements Along an East Contra Costa Irrigation District (ECCID) Canal in the City of Brentwood, Contra Costa County (Figures 1-3, All figures located in Appendix A). This project represents one of two off-site improvements associated with the SR-4/Balfour Road Bypass Project (WSA 2014). At this time, no excavation into native soil is planned. Instead, grading and trenching associated with the project are planned within artificial fill. Should project plans change, an archaeological survey of the site is recommended. Given that no significant cultural resources were identifed within the project area during the records search or the NAHC consultation, our response will be in a letter format rather than a stand-alone assessment report. Therefore, only limited background information on the cultural setting of the area is included.

Project Description and Location

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) jointly propose to widen SR-4 from San Jose Avenue (PM 34.9) to approximately 3,400 feet south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road in the City of Brentwood in Contra Costa County (SR-4/Balfour Interchange Project). As part of this undertaking, Off-Site Kinder Morgan Improvements Along the East Contra Costa District (ECCID) Canal (project) will also be implemented.

Off-site Improvements

Off-Site Kinder Morgan Improvements Along ECCID Canal

This project proposes an off-site Kinder Morgan system upgrade would include the modification of an existing oil pipeline access point between Brentwood Boulevard and Sellers Avenue (approximately 2.8 miles southeast from the Project area) and associated truck access along an East Contra Costa Irrigation District (ECCID) canal (see Figure 3). A Drag Reducing Additive (DRA) would be injected approximately once per week into the oil pipeline access point known as the Brentwood Boulevard Junction replacing similar DRA injections at the current Brentwood Booster Station. This would require a truck to either enter the area from Brentwood Boulevard, or to enter from Seller Avenue, and traverse across the maintenance roadway along the ECCID canal. An asphalt concrete roadway will be constructed replacing the existing unpaved maintenance roadway to support the weekly truck trip delivering the DRA. This would require up to one foot of excavation throughout the maintenance road, including at conforms to paved roadways at each end. Additionally, up to one foot of trenching would occur across the maintenance road to maintain an existing water hook-up for irrigation activities associated with the adjacent farmlands. All work would occur within previously disturbed artificial fill associated with elevated maintenance access and paved roadways. No physical expansion of the valve lot for the Brentwood Boulevard Junction would occur.

Environment

The project area is situated on the western margin of California's Central Valley, one of two principal grassland communities that exist in California (the second being the coastal grassland that covers middle-elevation hillsides from San Francisco to southern Oregon). Together these grasslands are known as the Pacific Prairie. The following discussion is largely based on Brown (1985). Annual precipitation in the region averages 20 to 30 inches with precipitation concentrated in the fall, winter, and spring months. This climate is much like that found in the Mediterranean with mild, rainy winters and hot, dry summers. After the first rain at the end of October or early November, the vegetation becomes green and remains green, but not growing, until late February, when the grasses begin to grow rapidly. By early May, the grasses have usually changed to a dry golden-color, and stay that way until fall.

Temperatures in the summer are high, often reaching over 38° C (100° F). The combination of this climate and the arable soils of the Central Valley have proven irresistible to farmers, and the extensive agricultural use of the area has resulted in the disappearance of much of the original grassland community. Grasslands persist, but the dominant species are completely different from those found 150 years ago by settlers.

Prior to Euroamerican contact, the Native Americans used fire to manage native flora and fauna, maintaining grassland and chaparral by periodic burning. In prehistoric times, animals such as pronghorn sheep, antelope, tule elk, mule deer, black-tail deer, and grizzly bear occupied the area. Today, animal life within the region is similarly diverse but favors small, herbivorous mammals, especially voles, pocket gophers, ground squirrels, and pocket mice. The larger, open areas of the surrounding hills are home to some larger animals including deer, coyote, rabbit, skunk, opossum, raccoon, and a number of birds including red-tailed hawks and turkey vultures.

Cultural Setting

Ethnography

At the time of historic contact with the Spanish missionaries and explorers, the SR-4/ Balfour Road Interchange project area was within the Bay Miwok territory, near the border with the Northern Valley Yokuts territory (Heizer and Whipple 1971; Milliken 1995). The Miwok comprised a group of people united by language but broken into tribal groups (independent political entities such as the Volvon), each occupying defined territories over which they controlled access to natural resources.

The arrival of the Spanish in the San Francisco Bay Area in 1775 led to the rapid demise of native populations, including the Bay Miwok and Yokuts. Diseases introduced by early expeditions and missionaries killed a large number of local peoples, exemplified by a mass burial of 18 individuals adjacent to the Hotchkiss Mound site near Oakley (Heizer 1954).

With abandonment of the mission system and Mexican takeover in the 1840s, numerous ranchos were established. The few remaining Indians were then forced by necessity to work on the ranchos. The native way of life in much of northern California had undergone many transformations as a result of missionization, introduction to new resources, land uses such as agriculture, a new form of worship and ideology, limited access to territories and resources that used to be theirs, and severe population decline. For further ethnographic information on the Bay Miwok and Yokuts, refer to Levy (1978), Bennyhoff (1977), and Milliken (1995).

Prehistory

Research into local prehistoric cultures began in the early 1900s with the work of N. C. Nelson as he documented the shellmounds along the San Francisco Bay shore and adjacent coast which provided the basis for the first model of cultural succession in Central California (Nelson 1909; Moratto 1984:227). Throughout the early 20th century, professional archaeological investigations produced seriation sequences based on artifact assemblages from sites in the Central Valley and Sacramento Delta. These sequences were later refined to create the Central California

Taxonomic System (CCTS) (Fredrickson 1973; Hughes 1994:1). The CCTS was used and improved upon extensively throughout the second half of the 20th century.

Most recently, Milliken et al. (2007:99-123) developed what they term a "hybrid system" for the San Francisco Bay Area, Milliken et al.'s (2007) San Francisco Bay Area Cultural Sequence combining the Early-Middle-Late Period temporal sequence with the pattern-aspect-phase cultural sequence. This framework includes six time periods between 8000 B.C. and post-A.D. 1550. No archaeological evidence dating to pre-8000 B.C. has been located in the Bay Area. For more details on this sequence refer to SR-4/Balfour Road Interchange Letter Report (WSA 2014).

Regional History

The history of northern California, Contra Costa County, and the project area in particular, can be divided into several periods of influence: Spanish Period in California (1769-1821); Mexican Period (1822-1848); and the American Period (1848-present). Due to its location 40 miles (64 kilometers) east of San Francisco, the project area was largely isolated from the Spanish and Mexican periods of California. Therefore, events associated with the Spanish and Mexican periods, and cultural remains from those periods, are not expected to be reflected in the project area. For a point of reference on these periods see the SR-4/Balfour Roak Interchange Letter Report (WSA 2014). A brief description of the American Period is described below. For a full discussion see WSA (2014).

American Period (1848 - present)

In 1836, John Marsh purchased the Rancho de Los Meganos, in present day East Contra Costa County. Marsh thus became the first Anglo-American to settle in Contra Costa County (Emanuels 1993:204). Marsh lived on the property from 1838 until his death in 1856.

After a series of events, Marsh's rancho was finally acquired by James T. Sanford in 1871. Sanford, who held an interest in the Brentwood Coal Company, sold a few acres of the Marsh property to the San Pablo and Tular Railroad, otherwise keeping it intact (1993:199). The discovery of coal on the northern slopes of Mt. Diablo in 1848 drew settlers to the region; however, by the mid-1880s when the coal boom was over, the mining "boom towns" were abandoned (Kyle 1990:62-63).

After Sanford lost the property to the Savings and Loan Company in 1878, a group of Scottish investors, Balfour-Guthrie Investment Company, bought Rancho Los Meganos from the Savings and Loan Society in 1900. In 1910, Balfour, Guthire and Co. established a demonstration farm to

begin experimenting with irrigation in the Brentwood area (Jensen 2008: 41). After 1910, Balfour, Guthrie and Co. was known as Brentwood Irrigated Farms.

In 1912 the Balfour-Guthrie acquired a permit to divert water from Indian Slough and built an irrigation system throughout its agricultural lands (Hohlmayer 1991a). This irrigation system would later merge with other local irrigation projects to become the East Contra Costa Irrigation District in 1926 (Hohlmayer 1991b). The development of this irrigation system changed the land use in the area from cattle, grain, and alfalfa production to dairy farms, orchards (walnuts, cherries, almonds, apricots, peaches, and plums), and vineyards (Hohlmayer 1991b). In 1924, Balfour-Guthrie sold a portion of the Rancho Los Meganos to the Samuel Henry Cowell family, a family of early California industrialists.

The Cowell ownership of Rancho Los Meganos resulted in few, if any, significant changes to the area. It continued to be used primarily for pastureland and limited agriculture as it is to the present day. The Brentwood Irrigated Farms continued as a packing and distribution firm after the sub-division of the property in the 1920s and 1930s.

Site Specific History

Settlement of the project area began in the mid-1830s, when José Noriega and his wife, Manuela Fenendez, took possession of the Rancho de Los Meganos (sand dunes ranch) soon after their arrival in 1834. The parcel Noriega claimed was four leagues long and three leagues wide (approximately 17,000 acres), extending east from the foot of Mount Diablo to the mouth of the San Joaquin River. Noriega sold his rancho to Dr. John Marsh just three years later. No standing architectural remains or archaeological materials from this period are known to exist within the project area. Noriega's original claim would have included the project area, and the 1861 Los Meganos Rancho Plat (Figure 4) shows the project area to be inside the formal boundary of the Rancho. No structures are located in the immediate vicinity of the project area, a mile to the east a road labeled "Road to Marsh's House" runs roughly northwest to southeast.

The 1871 *Topographical Map of Contra Costa County* (Britton and Rey 1871) shows no structures in the project area. A mile west of the project area, a southwest to northeast trending road leads from the estate of John Marsh in the southwest to points in the northeast, toward San Pablo Bay. A mile to the southeast a series of unlabeled roads follows the edge of the Mount Diablo foothills.

The 1938 Official Contra Costa County Map shows ten subdivisions of the Brentwood Irrigated Farms. The project area is depicted within subdivision 9 (Figure 5). To the west of the project area, outside of the Brentwood Irrigated Farms property, small farms stretched along the east side of the railroad line and close to canal systems. The Main Canal, just south of the project area

is visible in this map, as is the trajectory of the railroad, which runs northwest to southeast just west of the project area. No structures appear in the project area on the early twentieth-century USGS topographic maps.

The project area remained an unincorporated agricultural area until 1948, when the City of Brentwood was incorporated. Today, the region is a mix of small farms, cattle ranches and rapidly expanding urban development. Although still rural, a tremendous period of growth and development continues as developers make large purchases of land in eastern Contra Costa County, especially in Brentwood and Oakley. The mild climate, vast network of waterways within the Delta region, and moderately priced housing, attracts new residential development, which is rapidly replacing small farms and grazing lands. Today, a mixture of open space and residential developments borders the project area.

Results of the Records Search

Staff at the Northwest Information Center (NWIC) of the California Historical Resources Information System (CHRIS) at Sonoma State University in Rohnert Park, California conducted a records search on behalf of WSA on September 3, 2014 (File No. 14-0264). The records search included a review of the State of California Office of Historic Preservation Historic Properties Directory with summary information from the National Register, State Registered Landmarks, Historic Points of Interest, the *California Inventory of Historic Resources* (1976), and the *Revised Preliminary Historic Resources Inventory Contra Costa County California* (1989). Other references included base maps, historic maps, and literature for Contra Costa County on file at the NWIC. The historic maps examined included the 1861 Rancho Los Meganos Plat Map, 1871 *Topographical Map of Contra Costa County* (Britton and Rey 1871), and the 1938 Contra Costa County Map. The records search covered a 1/4-mile radius surrounding the project area.

Previous Studies

Fourteen overview reports have been prepared that include the project area within their study area (S-595, 848, 1978, 2458, 5208, 9462, 9583, 9795, 11826, 16660, 18217, 20395, 32596, and 33600) (Table 1).

Table 1. Overview Reports that include the Project Area

Study #	Author	Date	Title
S-595	Ronald F. King	1974	A Report on the Status of Generally Available Data Regarding Archaeological, Ethnographic, and Historical Resources within a Five Mile Wide Corridor through Portions of Colusa, Yolo, Solano, and Contra Costa Counties, California.

Study #	Author	Date	Title
S-848	David A. Fredrickson	1977	A Summary of Knowledge of the Central and Northern California Coastal Zone and Offshore Areas, Vol. III, Socioeconomic Conditions, Chapter 7: Historical & Archaeological Resources.
S-1978	Anthony V. Aiello	1960	The Islands of Contra Costa
S-2458	Suzanne Marie Ramiller, Neil Ramiller, Roger Werner, and Suzanne Stewart	1981	Overview of Prehistoric Archaeology for the Northwest Region, California Archaeological Sites Survey.
S-5208	Gregory Greenway, William E. Soule	1977	Sacramento-San Joaquin Delta Investigations: Cultural Resources Reconnaissance.
S-9462	Teresa Ann Miller	1977	Identification and Recording of Prehistoric Petroglyphs in Marin and Related Bay Area Counties
S-9583	David W. Mayfield	1978	Ecology of the Pre-Spanish San Francisco Bay Area
S-9795	Thomas Lynn Jackson	1986	Late Prehistoric Obsidian Exchange in Central California
S-11826	Dorothea J. Theodoratus et al.	1980	Montezuma I and II Cultural Resources.
S-16660	Jeffrey B. Fentress	1992	Prehistoric Rock Art of Alameda and Contra Costa Counties, California
S-18217	Glenn Gmoser	1996	Cultural Resource Evaluations for the Caltrans District 04 Phase 2 Seismic Retrofit Program, Status Report: April 1996
S-20395	Donna L. Gillette	1998	PCNs of the Coast Ranges of California: Religious Expression or the Result of Quarrying?
S-32596	Randall Milliken, Jerome King, and Patricia Mikkelsen	2006	The Central California Ethnographic Community Distribution Model, Version 2.0, with Special Attention to the San Francisco Bay Area, Cultural Resources Inventory of Caltrans District 4 Rural Conventional Highways
S-33600	Jack Meyer, Jeff Rosenthal	2007	Geoarchaeological Overview of the Nine Bay Area Counties in Caltrans District 4.

Five archaeological studies have been conducted within the project area (S-12300, 13256, 17993, 23674, 034234) (Table 2).

Table 2 Cultural Resources Studies Conducted within the Project Area

Study #	Author	Date	Title
S-12300	Michael J. Moratto et al.	1990	Final Cultural Resources Assessment Report, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California, Phase 1: Survey, Inventory, and Preliminary Evaluation of Cultural Resources
S-13256	Allan G. Bramlette, et al.	1991	Archaeological Resources Inventory for Los Vaqueros Water Conveyance Alignments, Contra Costa County, California.

Study #	Author	Date	Title
S-017993	Brian Hatoff, Barb Voss, Sharon Waechter, Stephen Wee, and Vance Bente	1995	Cultural Resources Inventory Report for the Proposed Mojave Northward Expansion Project
S-23674	Michael Moratto, et al.	1995	Archaeological Investigations, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California (Volume I, II, III, IV, V).
S-034234	Colin I. Busby	2007	Archaeological Resources Assessment Report, Brentwood Business Park, City of Brentwood, Contra Costa County (letter report).

Seven archaeological studies have been conducted within a 1/4-mile radius of the project area (S-10508, 23629, 33028, 33545, 34842, 34865, 34866) (Table 3).

Table 3 Cultural Resources Studies Conducted Within 1/4-Mile of the Project Area

Study #	Author	Date	Title
S-10508	G. James West	1982	Class II Archaeological Survey, Kellogg Unit Reformulation, Contra Costa County, California
S-23629	Eric W. Ritter	1973	Archaeological Survey of the Proposed Brentwood - McDonald Island Gas Line in Central California
S-33028	Ric Windmiller	2006	Mission Grove, Cultural Resources Inventory, Brentwood, Contra Costa County, California
S-33545	National Park Service	1994	Draft Comprehensive Management and Use Plan and Environmental Impact Statement, Juan Bautista de Anza National Historic Trail, Arizona and California
S-34842	Suzanne Baker and Laurence Shoup	2007	EBART Transit Corridor EIR/EIS, Historic Resources Evaluation Report: East Contra Costa Irrigation District Main Canal System, eBART Project, Contra Costa County, California
S-34865	Suzanne Baker and Laurence Shoup	2007	Draft, eBART Transit Corridor EIR/EIS, Positive Archaeological Survey Report: eBART Project, Contra Costa County, California (Union Pacific Mococo Line Alternative)
S-34866	Laurence H. Shoup	2007	EBART Transit Corridor EIR/EIS, Historic Resources Evaluation Report: San Pablo & Tulare Railroad/Central Pacific Railroad (Southern Pacific Railroad/Union Pacific Railroad), eBART Project, Contra Costa County, California

Known Cultural Resources

Results of the record search indicated that no prehistoric cultural resources have been recorded within the project area. Two other historic cultural resources (P-07-0000813 and P-07-002914) are within the 1/4-mile search radius. No prehistoric cultural resources have been recorded within the 1/4-mile search radius.

Table 4 Cultural Resources Identified in or Within 1/4-Mile of the APE

Resource	Description	Proximity to Project
P-07-813 (CA-CCO-733H)	Central, Southern, Union Pacific RR/San Pablo and Tulare RR and warehouse complex	RR. runs parallel with Brentwood Blvd., at the west end of project area.
P-07-2914	East Contra Costa Irrigation District Main Canal Complex; Other - A/HC-161	2.5 miles W. of project area (pumping station); canal runs adjacent to project area on south side.

P-07-813 (CA-CCO-733H) is an historic railroad line, located at the west end of the project area. At different times, the tracks were utilized by the San Pablo-Tulare, Southern Pacific, Central Pacific, and Union Pacific railroads. The line was built by the San Pablo and Tulare Railroad between 1876 and 1878 through Eastern Contra Costa County and connected East Contra Costa County with the San Francisco Bay Region, from which it was previously isolated. As noted by Shoup (2007), "the railroad established connections, cemented economic and social ties, and ended localized isolation." The segment closest to the west end of the project area was likely built between 1876-1878, and saw improvements, as railroad technologies improved and changed. No bridges or features of the railroad are located in the vicinity of the project area. In Shoup's 2007 evaluation of a portion of CA-CCO-813 that extends near the project area, he noted that the railroad qualifies for the NRHP under Criteria A [association with a pattern of events that makes the property potentially significant] due to its importance in the economic and social history of the region. However, because the rail line lacks integrity, Shoup did not recommend it as eligible for listing (Shoup 2007).

P-07-2914 is he ECCID Main Canal Complex. The canal is oriented east-west in the project area and is located directly adjacent to and south of the project area. This resource includes the Main Canal itself, a one-mile concrete ditch, and six pumping stations. The Main Canal is the only component of this resource in the immediate vicinity of the project area. The Main Canal is concrete, trapezoidal in shape, and between 12-18 ft. wide. Pumping Station #5 is located approximately 600 ft. to the west of the west end of the project area. The system was built between 1913 and 1919 and is visible on the 1938 map of Contra Costa County and was erected by the Balfour, Guthrie Company (Figure 5) (Baker 2007). Baker argues that the ECCID Main Canal Complex may be eligible for listing on the CRHR under Criterion 1 and the NRHP under Criteria A due to its importance to the economic and social history of the region, and notes that all six pumping stations are largely intact as originally construction, although there have been changes to some of the windows on the south sites of the buildings, but retain enough integrity to be recommended to the NRHP and the CRHR. As of this writing, the ECCID Main Canal Complex is not listed on either of these registers.

No National Register of Historic Places or other local, state, or federally listed or recognized properties are known to exist in the project area.

Summary of Native American Consultation

WSA contacted Debbie Pilas-Treadway at the Native American Heritage Commission (NAHC) on August 29th, 2014 to request information on known Native American traditional or cultural properties within the project area, and to request a list of individuals or groups with cultural affiliation to the project area.

No response was received from the NAHC by mid-September, so a second request for information was sent on September 22nd, 2014. As of this writing, no response has been received. Copies of this requests are provided in Appendix B.

Recommendations

The results of the record search and NAHC consultation indicate that the likelihood of encountering potentially significant cultural resources within the project area is low. However, should any previously undiscovered historic or prehistoric resources be found during construction, work should stop, in accordance with CEQA regulations, until such time that the resource can be evaluated by a qualified archaeologist and appropriate mitigative action taken as determined necessary by the City or County Lead Agency.

In the event that Native American human remains or funerary objects are discovered, the provisions of the California Health and Safety Code should be followed. Section 7050.5(b) of the California Health and Safety Code states:

In the event of discovery or recognition of any human remains in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent remains until the coroner of the county in which the human remains are discovered has determined, in accordance with Chapter 10 (commencing with Section 27460) of Part 3 of Division 2 of Title 3 of the Government Code, that the remains are not subject to the provisions of Section 27492 of the Government Code or any other related provisions of law concerning investigation of the circumstances, manner and cause of death, and the recommendations concerning treatment and disposition of the human remains have been made to the person responsible for the excavation, or to his or her authorized representative, in the manner provided in Section 5097.98 of the Public Resources Code.

The County Coroner, upon recognizing the remains as being of Native American origin, is responsible to contact the Native American Heritage Commission within 24 hours. The Commission has various powers and duties to provide for the ultimate disposition of any Native

American remains, as does the assigned Most Likely Descendant. Sections 5097.98 and 5097.99 of the Public Resources Code also call for "protection to Native American human burials and skeletal remains from vandalism and inadvertent destruction."

Thank you for the opportunity to provide our services on behalf of the project. Please feel free to contact us if we may be of further assistance or answer any questions you may have regarding the cultural resources survey or this report.

Sincerely,
WILLIAM SELF ASSOCIATES

Teresa Bulger, Ph.D., RPA
Project Director

Attachments
Appendix A: Figures
Appendix B: NAHC Consultation

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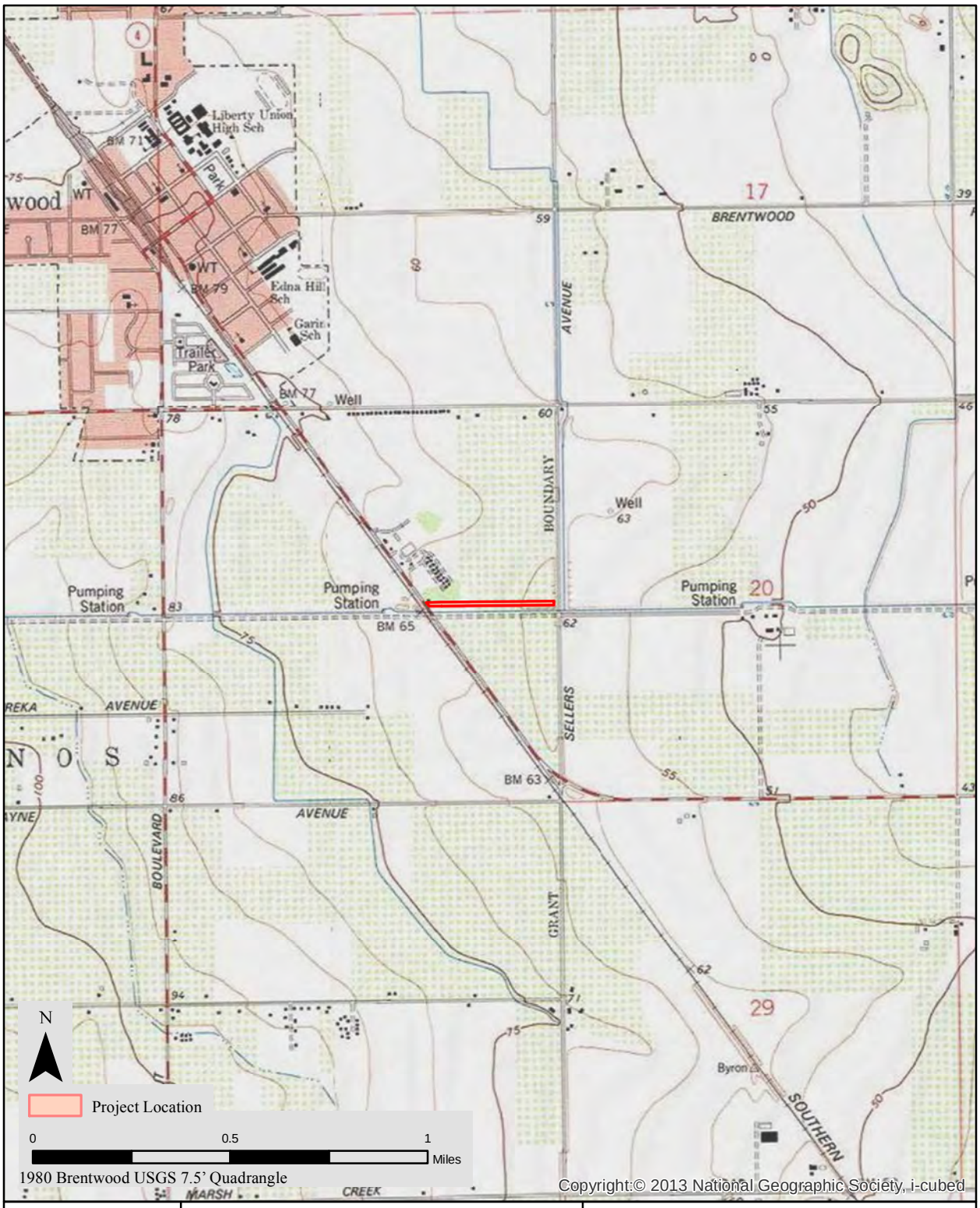
Appendix A

Figures

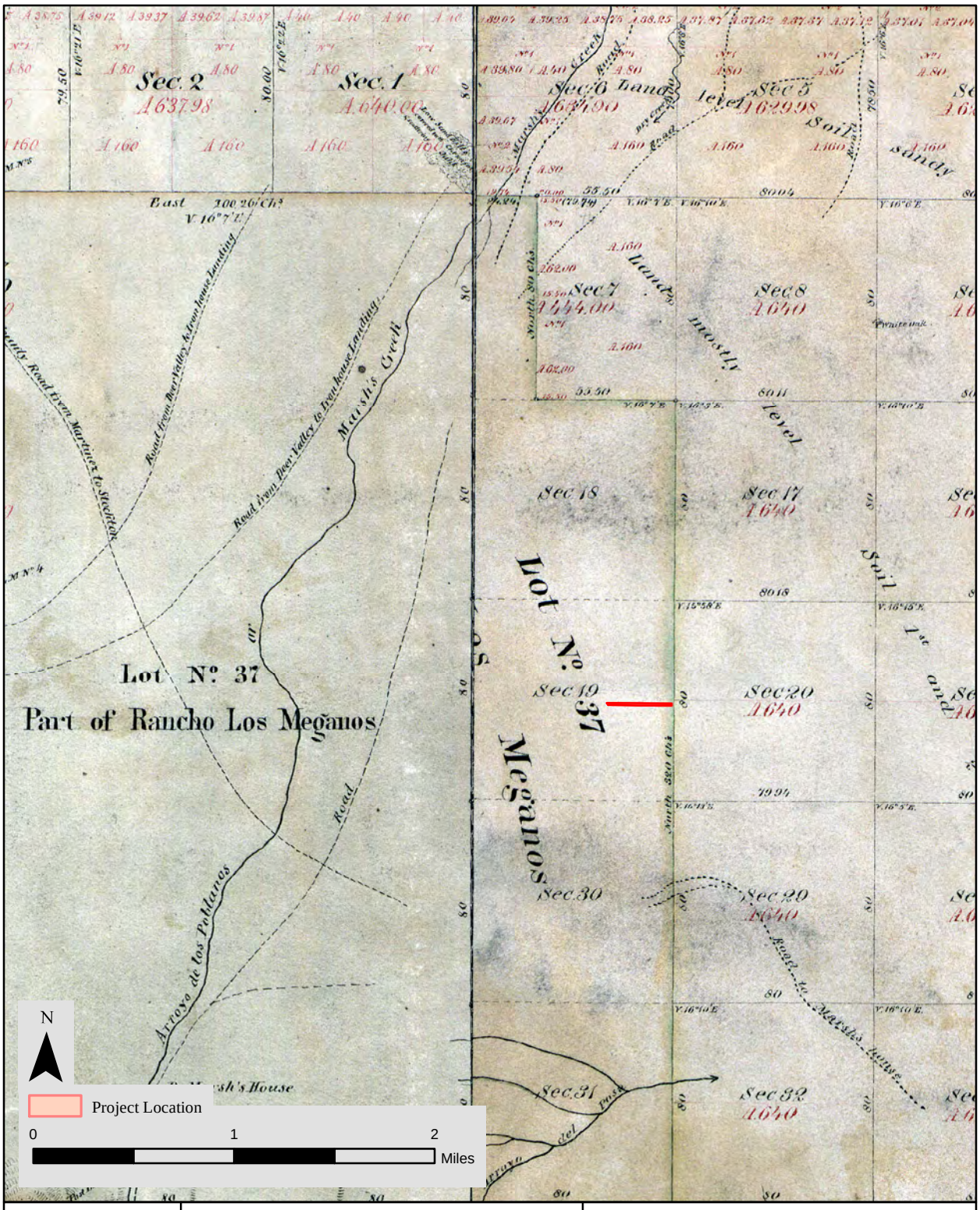
- Figure 1: Project Vicinity Map
- Figure 2: Project Area Map
- Figure 3: Project Location Map
- Figure 4: Project Location on 1861 General Land Office Plat Map T2N R2E
- Figure 5: 1938 Contra Cost County Map

WSA	Project Vicinity Map	Figure 1 CirclePoint Off-Site Kinder Morgan Improvements along ECCID Canal Project Contra Costa County, CA

WSA	Project Area Map	Figure 2 CirclePoint Off-Site Kinder Morgan Improvements along ECCID Canal Project Contra Costa County, CA



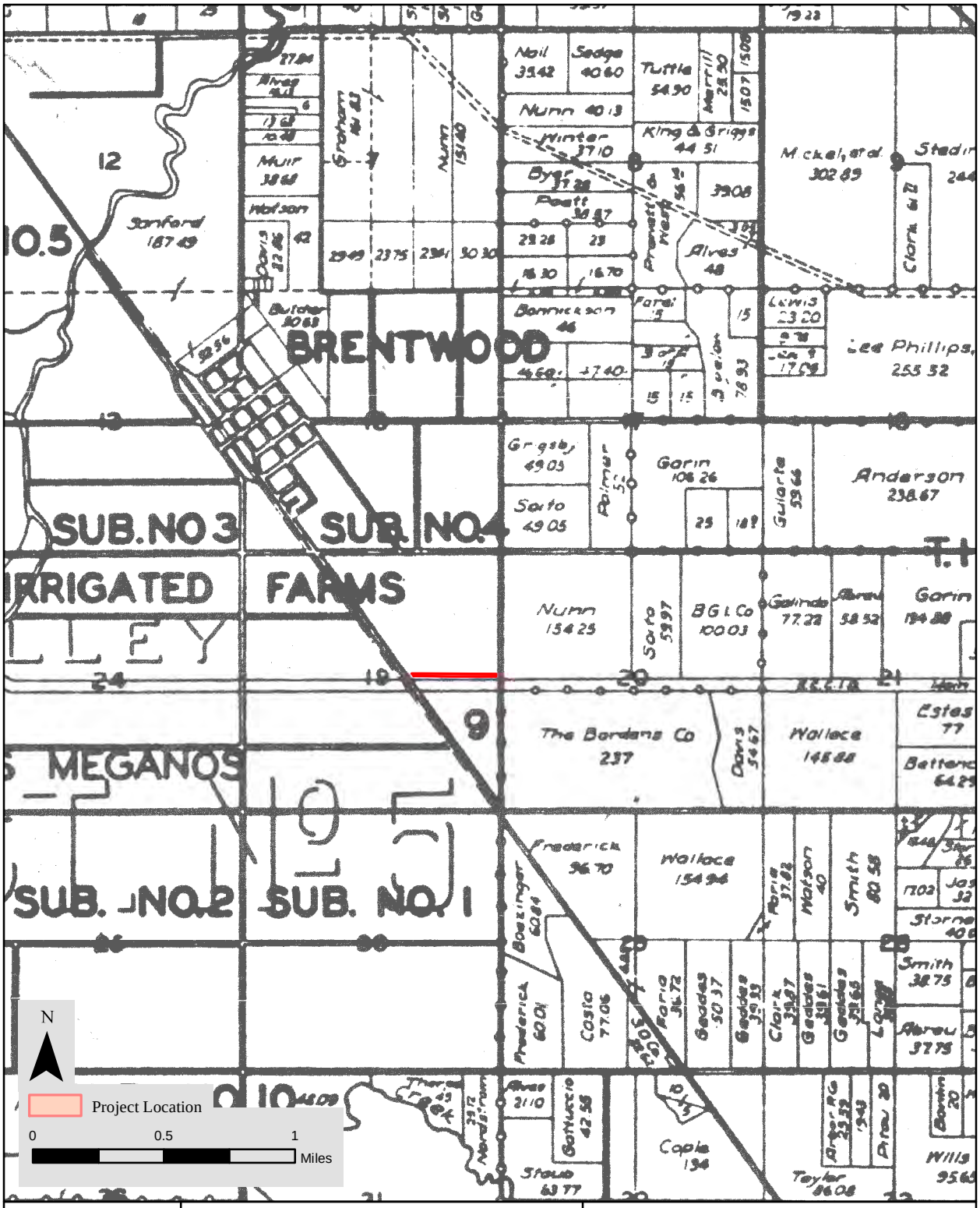
WSA	Project Location	Figure 3 CirclePoint Off-Site Kinder Morgan Improvements along ECCID Canal Project Contra Costa County, CA



WSA

Project Location
Mapped onto the
1861 Los Meganos Rancho Plat

Figure 4
CirclePoint
Off-Site Kinder Morgan
Improvements along ECCID Canal Project
Contra Costa County, CA



WSA

Project Location
Mapped onto the 1938
Contra Costa County Map

Figure 5
CirclePoint
Off-Site Kinder Morgan
Improvements along ECCID Canal Project
Contra Costa County, CA

Appendix B

Native American Heritage Commission Consultation

Additional Information

California Native Americans
Cultural Resources
Strategic Plan
Commissioners
Federal Laws and Codes
State Laws and Codes
Local Ordinances and Codes
Additional Information

Return to CNAHC Home Page

Sacred Lands File & Native American Contacts List Request

NATIVE AMERICAN HERITAGE COMMISSION
915 Capitol Mall, RM 364
Sacramento, CA 95814
(916) 653-4082
(916) 657-5390 – Fax
nahc@pacbell.net

Information Below is Required for a Sacred Lands File Search

Project: Off-Site Kinder Morgan Improvements Along ECCID Canal

County Contra Costa County

USGS Quadrangle

Name Brentwood Quad

Township 1N Range 3E Section(s) 19

Company/Firm/Agency: William Self Associates, Inc.

Contact Person: Teresa Bulger

Street Address: 61-d Avenida de Orinda

City: Orinda, California Zip: 94563

Phone: (925) 253-9070

Fax: (925) 254-3553

Email: tbulger@williamself.com

Project Description: We are doing a cultural resource study in anticipation of road improvements along the ECCID Canal in Brentwood (between Brentwood Blvd and Sellers Ave). Thank you! -Teresa Bulger 8-29-14

Teresa Bulger <tbulger@williamself.com>

Sacred Lands File and Native American Contacts List Request_ECCID Canal Improvements

2 messages

Teresa Bulger <tbulger@williamself.com> Fri, Aug 29, 2014 at 1:37 PM
To: nahc@nahc.ca.gov

Dear Sir or Miss,

Please find attached a request for a sacred lands record search and a Native American contacts list for a Cultural Resources Assessment we are undertaking for a property along the ECCID Canal in Brentwood, California (between Brentwood Blvd and Sellers Ave). Road improvements for Kinder Morgan truck access are planned for this area.

I hope to hear from you soon.
Thank you!

Best Regards,
Teresa Bulger

--
Teresa D. Bulger, Ph.D, RPA
Archaeologist, Project Director

William Self Associates, Inc.
Consultants in Archaeology and Historic Preservation

Pacific Region Office
61-D Avenida de Orinda
Orinda, CA 94563
Ph: (925) 253-9070
Cell: (617) 875-7046
Fax: (925) 254-3553

NAHC_Consultation Request_OffSiteKM.pdf
168K

Teresa Bulger <tbulger@williamself.com> Mon, Sep 22, 2014 at 10:30 AM
To: nahc@nahc.ca.gov

Dear Sir or Miss,

On August 29, 2014, we sent a request for a Sacred Lands File records search and a Native American Contact List for the "Off-Site Kinder Morgan Valve Lot" Project along the ECCID, in Brentwood California. We unfortunately do not have a record of a fax response on this project and would like to re-initiate the search if possible.

Thank you and I hope to hear from you soon.
Best regards,
Teresa Bulger

[Quoted text hidden]

NAHC_Consultation Request_OffSiteKM.pdf
168K

October 5th, 2014

Jennifer Gallerani
CirclePoint
1814 Franklin Street, Suite 1000
Oakland, CA 94612

RE: Archaeological Survey and Cultural Resources Assessment of the SR-4/Balfour Road Bypass, Brentwood, Contra Costa County, California.

Dear Ms. Gallerani:

In accordance with our agreement, William Self Associates, Inc. (WSA) has implemented a record search, archaeological field survey and assessment of the SR-4/Balfour Road Bypass, in the City of Brentwood, Contra Costa County (Figures 1-3; All figures located in Appendix A). As the construction of the SR-4/Balfour Road Bypass will involve ground disturbance, a cultural resource study was conducted in compliance with Section 21084.1 of the California Environmental Quality Act (CEQA). Given that no significant cultural resources were found during the study, our response will be in a letter format rather than a stand-alone assessment report. Therefore, only limited background information on the cultural setting of the area is included.

Project Description and Location

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) jointly propose to widen SR-4 from San Jose Avenue (PM 34.9) to approximately 3,400 feet south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road in the City of Brentwood in Contra Costa County.

The first phase (Phase 1) would include the construction of the following:

- Divided four-lane Freeway from San Jose Avenue Undercrossing to 2,000 feet north of Balfour Road. The freeway then transitions to a two-lane expressway south of Balfour Road Interchange.

- Four-lane wide undercrossing bridge structure over Balfour Road to serve bidirectional two-lane freeway traffic and two entrance loop ramps. This structure would serve only eastbound (EB) traffic in future phases.
- Four-lane wide bridge structure over Deer Creek for SR-4 freeway lanes. It would serve bidirectional traffic in Phase 1
- Two-lane bridge structure over Deer Creek for EB loop on-ramp
- EB SR-4 Diagonal off-ramp
- EB SR-4 Loop on-ramp
- Westbound (WB) SR-4 diagonal on-ramp that will be in an interim location and moved further to the east in the ultimate configuration
- WB SR-4 diagonal off-ramp
- WB SR-4 loop on-ramp
- Widening of Balfour Road to up to six lanes within the interchange area

Other improvements would include two new traffic signals for the ramp intersections, ramp metering, lighting, drainage improvements, and utility relocations.

Relocation of PG&E Towers

A Pacific Gas & Electric (PG&E) overhead transmission line runs along the eastern side of the Bypass. Construction of the interchange will require relocation of two towers from their current locations adjacent to Balfour Road to new locations approximately 250 feet and 120 feet to the north respectively. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the Bypass and required coordination with public utilities and/or private operators during construction to allow for relocation as needed without disruption to existing service. Impacts associated with the utility relocation were addressed in the 1994 FEIR and are addressed in this Addendum pursuant to California Public Utilities Commission General Order 131-D filing requirements.

Deer Creek Daylighting

Deer Creek is an intermittent stream in its upper reaches but becomes perennial where it is detained in the Contra Costa County Flood Control Basin, approximately ¾-mile west of the SR-4/Balfour Road intersection. From this point Deer Creek flows through an 84 inch concrete pipe toward the SR-4/Balfour Road intersection. A small portion (approximately 250 feet long) north of Balfour Road and west of State Route 4 flows through an open ditch before re-entering an 84 inch non-reinforced concrete pipe to pass under State Route 4. East of State Route 4 Deer Creek flows mainly through an open ditch eventually draining to Marsh Creek and on to the San Joaquin River.

Addendum #10 had evaluated extension of the existing 84 inch pipe culverts along Deer Creek with removal of the open ditch portion in the northwest quadrant of the interchange. The revised Phase 1 interchange improvements now include construction of an eastbound SR-4 clear span bridge over Deer Creek and an eastbound SR-4 loop on-ramp bridge in the north/west quadrant of the SR-4/Balfour Road intersection. This loop on-ramp would cross over on a clear span structure the portion of Deer Creek that flows in an open ditch. In this same area, approximately 200 feet of Deer Creek which flows in a pipe would be removed and replaced with an open ditch configuration, daylighting the creek. The daylighted portion of Deer Creek would be vegetated to maintain consistency with the surrounding natural environment. Some rock slope protection will be needed to prevent channel erosion near the pipe culvert exits into the channel. The remaining portion of the pipe within the interchange limits to the south would be replaced with reinforced concrete pipe and connected to the existing pipeline that flows under Balfour Road.

Off-Site Improvements

Removal of the Kinder Morgan Brentwood Pump Station

As part of Phase 1 of the SR-4/Balfour Road interchange, a new eastbound SR-4 off-ramp would be constructed in the northwest quadrant of the SR-4/Balfour Road intersection. Construction of this new off-ramp makes it necessary for Kinder Morgan Energy Partners (Kinder Morgan) to remove an existing oil pipeline pump station (the Brentwood Booster Station) at this location. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the Project and required coordination with public utilities and/or private operators during construction to allow for relocation, as needed, without disruption to existing service. Addendum #10 evaluated the relocation of the Brentwood Booster Station approximately 400 feet to the west to accommodate the proposed on- and off-ramps associated with the interchange.

Since Addendum #10 additional evaluation and coordination with Kinder Morgan has occurred, which determined that relocating the Brentwood Booster Station is no longer necessary. Rather, the Phase 1 improvements now include removal of the pump station. To maintain oil pipeline pumping capacity two off-site Kinder Morgan system upgrades are necessary. The first system upgrade would occur at an existing Concord Pump Station, located at Arnold Industrial Way and Solano Way in Concord, California (approximately 20 miles northwest from the Project area). Terminal and substation transformers at the Concord Pump Station would be replaced to allow for increased pumping capacity. No physical expansion of the Concord Pump Station would be needed.

The second off-site Kinder Morgan system upgrade would include the modification of an existing oil pipeline access point between Brentwood Boulevard and Sellers Avenue (approximately 2.8 miles southeast from the Project area) and associated truck access along an East Contra Costa Irrigation District (ECCID) canal. A Drag Reducing Additive (DRA) would be injected approximately once per week into the oil pipeline access point known as the

Brentwood Boulevard Junction replacing similar DRA injections at the current Brentwood Booster Station. This would require a truck to either enter the area from Brentwood Boulevard, or to enter from Seller Avenue, and traverse across the maintenance roadway along the ECCID canal. An asphalt concrete roadway will be constructed replacing the existing unpaved maintenance roadway to support the weekly truck trip delivering the DRA. This would require up to one foot of excavation throughout the maintenance road, including at conforms to paved roadways at each end. Additionally, up to one foot of trenching would occur across the maintenance road to maintain an existing water hook-up for irrigation activities associated with the adjacent farmlands. All work would occur within previously disturbed artificial fill associated with elevated maintenance access and paved roadways. No physical expansion of the valve lot for the Brentwood Boulevard Junction would occur.

Environment

The project area is situated on the western margin of California's Central Valley, one of two principal grassland communities that exist in California (the second being the coastal grassland that covers middle-elevation hillsides from San Francisco to southern Oregon). Together these grasslands are known as the Pacific Prairie. The following discussion is largely based on Brown (1985). Annual precipitation in the region averages 20 to 30 inches with precipitation concentrated in the fall, winter, and spring months. This climate is much like that found in the Mediterranean with mild, rainy winters and hot, dry summers. After the first rain at the end of October or early November, the vegetation becomes green and remains green, but not growing, until late February, when the grasses begin to grow rapidly. By early May, the grasses have usually changed to a dry golden-color, and stay that way until fall.

Temperatures in the summer are high, often reaching over 38° C (100° F). The combination of this climate and the arable soils of the Central Valley have proven irresistible to farmers, and the extensive agricultural use of the area has resulted in the disappearance of much of the original grassland community. Grasslands persist, but the dominant species are completely different from those found 150 years ago by settlers.

Prior to Euroamerican contact, the Native Americans used fire to manage native flora and fauna, maintaining grassland and chaparral by periodic burning. In prehistoric times, animals such as pronghorn sheep, antelope, tule elk, mule deer, black-tail deer, and grizzly bear occupied the area. Today, animal life within the region is similarly diverse but favors small, herbivorous mammals, especially voles, pocket gophers, ground squirrels, and pocket mice. The larger, open areas of the surrounding hills are home to some larger animals including deer, coyote, rabbit, skunk, opossum, raccoon, and a number of birds including red-tailed hawks and turkey vultures.

Cultural Setting

Ethnography

At the time of historic contact with the Spanish missionaries and explorers, the SR-4/ Balfour Road Interchange Project area was within the Bay Miwok territory, near the border with the Northern Valley Yokuts territory (Heizer and Whipple 1971; Milliken 1995).

Levy (1978:399) places the Bay Miwok territory from the Suisun Bay to just south of Mount Diablo and from there eastward to the Sacramento-San Joaquin Delta. The Volvon tribe, who spoke a Bay Miwok language, lived on the peak of Mount Diablo and in the rugged lands to the east. Their villages were situated on the eastern side of the peak along the Marsh Creek drainage (Milliken 1995:256, 259). The time at which the Bay Miwok migrated into this area is disputed. Beeler (1959), who has studied the Saclan language, claims it was originally spoken to the east along the lower courses of the Tuolumne, Stanislaus, and the Mokelumne rivers. He surmises that these people were displaced to the west by a northerly push of the Yokuts, which may have been completed as recently as 300 years ago. This implies the Bay Miwok were in their historical territory only a century or less before the first Spanish explorers arrived in the region (Beeler 1959:68; see also Farris et al. 1988).

The Miwok comprised a group of people united by language but broken into tribal groups (independent political entities such as the Volvon), each occupying defined territories over which they controlled access to natural resources. Although each tribal group had one or more permanent villages, their territory contained numerous smaller campsites used as needed during a seasonal round of resource exploitation.

Extended families lived in domed, conical structures built of thatched grass. Semi-subterranean men's houses were built at the larger village sites, also using thatched grass and earth cover (Kroeber 1970). Tule or balsa canoes were used to navigate to and from islands and for hunting and gathering forays into the delta.

Given an abundant and continuous subsistence base, ceremony in Miwok life was fairly extensive, and scholars have written much about it based on early ethnographic accounts (Bennyhoff 1977:11; Kroeber 1970; Levy 1978). Rituals associated with death were of great importance. Two forms of interment were practiced and mortuary goods were often placed into the grave at the time of burial. Cremation was also occasionally practiced.

The arrival of the Spanish in the San Francisco Bay Area in 1775 led to the rapid demise of native populations, including the Bay Miwok and Yokuts. Diseases introduced by early expeditions and missionaries killed a large number of local peoples, exemplified by a mass burial of 18 individuals adjacent to the Hotchkiss Mound site near Oakley (Heizer 1954). On an expedition through the Central Valley in 1832-1833, Ewing Young observed:

> In the Fall of 1832...the banks of the Sacramento River, in its whole course through the valley, were studded with Indian villages...On our return, late in the summer of 1833, we found the valleys depopulated. From the head of the Sacramento to the great bend and slough of the San Joaquin, we did not see more than six or eight Indians; while large numbers of their skulls and dead bodies were to be seen under almost every shade-tree near water, where the uninhabited and deserted villages had been converted into graveyards...(Cook 1955:318).

With abandonment of the mission system and Mexican takeover in the 1840s, numerous ranchos were established. The few remaining Indians were then forced by necessity to work on the ranchos. The native way of life in much of northern California had undergone many transformations as a result of missionization, introduction to new resources, land uses such as agriculture, a new form of worship and ideology, limited access to territories and resources that used to be theirs, and severe population decline. For further ethnographic information on the Bay Miwok and Yokuts, refer to Levy (1978), Bennyhoff (1977), and Milliken (1995).

Prehistory

Research into local prehistoric cultures began in the early 1900s with the work of N. C. Nelson of the University of California at Berkeley. Nelson documented shellmounds along the San Francisco Bay shore and adjacent coast which provided the basis for the first model of cultural succession in Central California (Nelson 1909; Moratto 1984:227).

Investigations into the prehistory of the Central Valley of California, presaged by early amateur excavations in the 1890s, began in earnest in the 1920s. Professional or academic-sponsored archaeological investigations in central California began in the 1930s, when J. Lillard and W. Purves conducted excavations throughout the Sacramento Delta area. By seriating artifacts and mortuary traditions, they identified a three-phase sequence, including Early, Intermediate, and Recent cultures (Lillard and Purves 1936). In 1948 and again in 1954, Richard Beardsley refined this system and extended it to include the region of San Francisco Bay (Beardsley 1948, 1954). The resulting scheme came to be known as the Central California Taxonomic System (CCTS) (Fredrickson 1973; Hughes 1994:1). As more data were acquired through continued fieldwork, local exceptions to the CCTS were discovered. Much of the subsequent archaeological

investigation in central California focused on the creation and refinement of local versions of the CCTS.

In the 1960s and 1970s, archaeologists including Ragir (1972) and Fredrickson (1973) revised existing classificatory schemes and suggested alternative ways of classifying the prehistory of California. Fredrickson (1973:113-114) proposed four "major chronological periods" in prehistoric California. Following Ragir, Fredrickson (1973:123) also proposed that the nomenclature for each pattern relate to the location at which it was first identified, such as the Windmiller, Berkeley, and Augustine Patterns.

Most recently, Milliken et al. (2007:99-123) developed what they term a "hybrid system" for the San Francisco Bay Area, combining the Early-Middle-Late Period temporal sequence with the pattern-aspect-phase cultural sequence.

Milliken et al.'s (2007) San Francisco Bay Area Cultural Sequence includes six time periods between 8000 B.C. and post-A.D. 1550. No archaeological evidence dating to pre-8000 B.C. has been located in the Bay Area. Milliken et al. (2007) posit that this dearth of archaeological material may be related to subsequent environmental changes that submerged sites, buried sites beneath alluvial deposits, or destroyed sites through stream erosion. A brief summary of the approach presented by Milliken et al. (2007) follows.

A "generalized mobile forager" pattern marked by the use of milling slabs and handstones and the manufacture of large, wide-stemmed and leaf-shaped projectile points emerged around the periphery of the Bay Area during the Early Holocene Period (8000 to 3500 B.C.). Beginning around 3500 B.C., evidence of sedentism, interpreted to signify a regional symbolic integration of peoples, and increased regional trade emerged. This Early Period lasted until ca. 500 B.C. (Milliken et al. 2007:114, 115).

Milliken et al. (2007:115) identify "a major disruption in symbolic integration systems" circa 500 B.C., marking the beginning of the Lower Middle Period (500 B.C. to A.D. 430). Bead Horizon M1, dating from 200 B.C. to A.D. 430, is described by Milliken et al. (2007:115) as marking a 'cultural climax' within the San Francisco Bay Area.

The Upper Middle Period (A.D. 430 to 1050) is marked by the collapse of the Olivella saucer bead trade in central California, abandonment of many Bead Horizon M1 sites, an increase in the occurrence of sea otter bones in those sites that were not abandoned, and the spread of the extended burial mortuary pattern characteristic of the Meganos complex into the interior East Bay. Bead Horizons M2 (A.D. 430 to 600), M3 (A.D. 600 to 800), and M4 (A.D. 800 to 1050) were identified within this period (Milliken et al. 2007:116).

The Initial Late Period, dating from A.D. 1050 to 1550, is characterized by increased manufacture of status objects. In lowland central California during this period, Fredrickson (1973 and 1994, quoted in Milliken et al. 2007:116) noted evidence for increased sedentism, the development of ceremonial integration, and status ascription. The beginning of the Late Period, (ca. A.D. 1000) is marked by the Middle/Late Transition bead horizon. The Terminal Late Period began circa A.D. 1550 and continued until European settlement of the area.

Regional History

The history of northern California, Contra Costa County, and the project area in particular, can be divided into several periods of influence. For the purposes of establishing a historic context from which to assess the potential significance of historic sites in the SR-4/Balfour Road Interchange Project area, various periods and local sub-periods, some of which overlap, are defined below.

Due to its location 40 miles (64 kilometers) east of San Francisco, the project area was largely isolated from the Spanish and Mexican periods of California. Therefore, events associated with the Spanish and Mexican periods, and cultural remains from those periods, are not expected to be reflected in the project area but are discussed briefly as a point of reference:

Spanish Period (in California)	1769 - 1821
Mexican Period	1822 - 1848
American Period	1848 - present

Spanish Period (1769-1821)

The historic period in the eastern San Francisco Bay region began with the Fages-Crespi expedition of 1770. The Fages party explored the eastern shore of San Francisco Bay, eventually reaching the location of modern Fremont, where they traded with the local Costanoans. Members of the expedition eventually sighted the entrance to San Francisco Bay from the Oakland Hills. In 1772, a second Fages expedition explored the eastern shore of the bay, the Carquinez strait area, and then turned south to explore the San Ramon Valley (Cook 1957:131).

The first mission in the region was established the following year with the completion of Mission San Francisco de Asis (Mission Dolores) in San Francisco. The mission era ensued, lasting over the next 46 years.

The earliest historical accounts of the project area come from the Spanish explorers who ventured to Mount Diablo in the late 18th century. Although it is not known if they came into the project area, they must have passed within a few miles of it (Farris et al. 1988:7). The Anza-Font expedition of 1776 traveled along the southern shore of Suisun Bay until reaching Antioch where they noticed numerous rancherias before turning southeast in an attempt to cross the tule swamps (Cook 1957:135).

Mexican Period (1822-1848)

Under the Spanish, the missions controlled the land. After Mexico seceded from Spain in 1821, land was granted to private citizens, a practice that increased significantly after the 1833 act of the Mexican legislature that established the secularization of the missions. By 1845, the last of the mission land holdings were relinquished, opening the way for the large ranchos common to California in the mid-1800s. Predominant land use on the ranchos was the raising of livestock and ranching. American explorers, mostly traders and beaver trappers, were also flocking to the west during this time, and their "trail blazing" led to the settlement of the territory. Jedediah Smith, in 1827, led a party of trappers up the Sacramento River from the San Joaquin Delta region, leading to the establishment of the "California-Oregon Road," followed by numerous explorations over the next twenty-five years (Kyle 1990: preface).

Deterioration of relations between the United States and Mexico resulted in the Mexican War, which ended with Mexico relinquishing California to the United States under the Treaty of Guadalupe Hidalgo of 1848. With the formation of the new State of California, and the onset of the American period, rapid changes were in store for the region. The discovery of gold in the Sierra Nevada in 1848 produced a major population increase in the northern half of California as emigrants sought gold or various jobs producing goods or services for miners. Land use changes resulted as livestock grazed some native grasses to extinction, woodlands were cut for lumber, railroad ties, and mine timbers, and agricultural development occurred on nearly all arable land.

American Period (1848 - present)

In 1836, near the end of the Mexican period, John Marsh arrived in Los Angeles, Alta California. While riding north in search of a place to settle down, he met Jose Noriega and purchased Noriega's Rancho de Los Meganos. Marsh thus became the first Anglo-American to settle in Contra Costa County (Emanuels 1993:204). From 1838 until he built what became known as the "Stone House" in 1856, Marsh lived on the rancho in a small adobe structure. This adobe was apparently located very close to a group of Indians, likely to have been Bay Miwok.

When twin brothers William and Joseph Smith moved their families from Massachusetts to California in 1849, John Marsh was there to greet them. The brothers were both carpenters and ordained ministers and they quickly found jobs in "New York of the Pacific," today known as Pittsburgh, constructing housing for the flood of migrants coming to California in search of gold. The following summer, William invited newly-arrived migrants from Maine to settle at Smith's Landing (Kyle 1990:64). Approximately half of the families accepted his offer, and the settlement they created was named Antioch at their 1851 Fourth of July picnic (Munro-Fraser 1882:672-3).

On June 24, 1851, Marsh, who was then in his fifties, married Abbie Tuck, and brought her to live in his adobe. A few years later, he hired artisan to build a more permanent house, though it was not finished before Abbie died in 1855 (Emanuels 1993:204). Marsh himself died in 1856, after his buggy was overtaken on the road to Martinez and he was murdered (Historic Record Company 1926: 381-382).

After a series of events, Marsh's rancho was finally acquired by James T. Sanford in 1871. According to Emanuels (1993:199), the only noteworthy aspect of Sanford's ownership was his sale of a few acres to the San Pablo and Tulare Railroad, thereby defining the land for the village of Brentwood. Sanford, together with John F. Williams, owned all of the Brentwood Coal Company, which also held partial title to the Marsh land. The discovery of coal on the northern slopes of Mt. Diablo in 1848 drew settlers to the region; however, by the mid-1880s when the coal boom was over, the mining "boom towns" were abandoned (Kyle 1990:62-63)..

In 1878, Sanford missed his mortgage payments on the Marsh property, and the Savings and Loan Society wasted no time in acquiring it (Emanuels 1993:200). On October 23, 1900, a group of Scottish investors, Balfour-Guthrie Investment Company, bought Rancho Los Meganos from the Savings and Loan Society for $200,799.43. Even though Balfour-Guthrie purchased the land in 1900, it took until 1913 for the firm to obtain the portion of the ranch still owned by the estate of James T. Sanford (a little more than 5.25 percent of the land). At the same time, the company acquired another 500 acres from a Peter G. King (Hohlmayer 1991a). In 1910, Balfour, Guthire and Co. established a demonstration farm to begin experimenting with irrigation in the Brentwood area (Jensen 2008: 41). After 1910, Balfour, Guthrie and Co. was known as Brentwood Irrigated Farms.

In 1912 the U.S. Army Corp of Engineers issued a permit authorized by the Secretary of War, to divert two hundred cubic feet per second of water from Indian Slough, a branch of Old River (which, in turn, was a branch of the San Joaquin River) in Contra Costa County (Hohlmayer 1991a). Balfour-Guthrie spent $500,000 that same year building an irrigation system to spread

water over more than 22,000 acres, and would later merge with other local irrigation projects to become the East Contra Costa Irrigation District in 1926 (Hohlmayer 1991b).

The development of this irrigation system changed the land use in the area from cattle, grain, and alfalfa production to dairy farms, orchards (walnuts, cherries, almonds, apricots, peaches, and plums), and vineyards (Hohlmayer 1991b). In 1924, Balfour-Guthrie sold a portion of the Rancho Los Meganos to the Samuel Henry Cowell family, a family of early California industrialists.

The Cowell ownership of Rancho Los Meganos resulted in few, if any, significant changes to the area. It continued to be used primarily for pastureland and limited agriculture as it is to the present day. The Brentwood Irrigated Farms continued as a packing and distribution firm after the sub-division of the property in the 1920s and 1930s.

Site Specific History

Settlement of the project area began in the mid-1830s, when José Noriega and his wife, Manuela Fenendez, took possession of the Rancho de Los Meganos (sand dunes ranch) soon after their arrival in 1834. The parcel Noriega claimed was four leagues long and three leagues wide (approximately 17,000 acres), extending east from the foot of Mount Diablo to the mouth of the San Joaquin River. Noriega sold his rancho to Dr. John Marsh just three years later. No standing architectural remains or archaeological materials from this period are known to exist within the project area. Noriega's original claim would have included the project area, and the 1861 Los Meganos Rancho Plat (Figure 5) shows the project area to be inside the formal boundary of the Rancho. The 1862 General Land Office (GLO) Plat Map for T1N R2E confirms this. Neither map shows any structures in the immediate vicinity of the project area, however two roads "From Deer Valley to Iron House Landing" run roughly southwest to northeast, crossing the project area. To the east, the "County Road from Martinez to Stockton" trends northwest to southeast.

The 1871 *Topographical Map of Contra Costa County* (Britton and Rey 1871) shows no structures in the project area, however two unlabeled roads cross the project area in approximately that same locations as the roads from Deer Valley to Iron House landing on the 1861 map (Figure 6). East of the project area, the north-south County Road from Martinez to Stockton connected Marsh's Landing, on the San Joaquin River in the north, to coal mining and farming areas to the south. To the southwest of the project area, the Pacific Coal Company Mine is marked; further south was the estate of John Marsh.

The 1938 Official Contra Costa County Map shows ten subdivisions of the Brentwood Irrigated Farms. The project area is depicted as stretching across subdivisions 7 and 8 (Figure 7). Near the southern end of the project area, is the estate of Elizabeth O'Meara. O'Meara was a single head-of-household, with several of her children living with her. O'Meara's son-in-law, Tinsman Craig, also lived in the home and worked as an enumerator for the government census. No structures appear in the project area on the early twentieth-century USGS topographic maps.

The project area remained an unincorporated agricultural area until 1948, when the City of Brentwood was incorporated. Today, the region is a mix of small farms, cattle ranches and rapidly expanding urban development. Although still rural, a tremendous period of growth and development continues as developers make large purchases of land in eastern Contra Costa County, especially in Brentwood and Oakley. The mild climate, vast network of waterways within the Delta region, and moderately priced housing, attracts new residential development, which is rapidly replacing small farms and grazing lands. Today, the project area is bordered by a mixture of open space and residential developments.

Results of the Records Search

Staff at the Northwest Information Center (NWIC) of the California Historical Resources Information System (CHRIS) at Sonoma State University in Rohnert Park, California conducted a records search on behalf of WSA on May 21, 2014 (File No. 13-1668). The records search included a review of the State of California Office of Historic Preservation Historic Properties Directory with summary information from the National Register, State Registered Landmarks, Historic Points of Interest, the *California Inventory of Historic Resources* (1976), the *Revised Preliminary Historic Resources Inventory Contra Costa County California* (1989), and the Caltrans Bridge Inventory. Other references included base maps, historic maps, and literature for Contra Costa County on file at the NWIC. The historic maps examined included the 1861 Rancho Los Meganos Plat Map, the 1862 GLO Plat Map T1N, R2E, the 1898 (reprinted 1905) USGS Mt. Diablo Quadrangle, and the 1914 USGS Brentwood Quadrangle. The records search covered a one-mile radius surrounding the project area. A one-mile wide radius around the project area revealed the presence and kind(s) of cultural resources in the general vicinity of the project, and allows predictions of the potential that unidentified resources might be encountered during the course of project-related ground disturbance.

In addition to the archaeological studies listed in the records search, Archeo-Tec carried out an archaeological survey of the proposed SR-4 Bypass Project area in 1992 for the preparation of the 1994 EIR (Archeo-Tec 1992). WSA consulted that report as well as the 'East County Corridor/State Route 4 EIR/89083 Volume 3 – State Route 4 Bypass' that includes discussion of

both Archeo-Tec's archaeological survey results and a historic resources survey by Archaeological/Historical Consultants (ESA 1994).

Previous Studies

Sixteen overview reports have been prepared that include the project area within their study area (S-595, 848, 1978, 2458, 5208, 9462, 9583, 9795, 11826, 16660, 17773, 18217, 20395, 32596, 33600, and 43548) (Table 1).

Table 1. Overview Reports that include the Project Area

Study #	Author	Date	Title
S-595	Ronald F. King	1974	A Report on the Status of Generally Available Data Regarding Archaeological, Ethnographic, and Historical Resources within a Five Mile Wide Corridor through Portions of Colusa, Yolo, Solano, and Contra Costa Counties, California.
S-848	David A. Fredrickson	1977	A Summary of Knowledge of the Central and Northern California Coastal Zone and Offshore Areas, Vol. III, Socioeconomic Conditions, Chapter 7: Historical & Archaeological Resources.
S-1978	Anthony V. Aiello	1960	The Islands of Contra Costa
S-2458	Suzanne Marie Ramiller, Neil Ramiller, Roger Werner, and Suzanne Stewart	1981	Overview of Prehistoric Archaeology for the Northwest Region, California Archaeological Sites Survey.
S-5208	Gregory Greenway, William E. Soule	1977	Sacramento-San Joaquin Delta Investigations: Cultural Resources Reconnaissance.
S-9462	Teresa Ann Miller	1977	Identification and Recording of Prehistoric Petroglyphs in Marin and Related Bay Area Counties
S-9583	David W. Mayfield	1978	Ecology of the Pre-Spanish San Francisco Bay Area
S-9795	Thomas Lynn Jackson	1986	Late Prehistoric Obsidian Exchange in Central California
S-11826	Dorothea J. Theodoratus et al.	1980	Montezuma I and II Cultural Resources.
S-16660	Jeffrey B. Fentress	1992	Prehistoric Rock Art of Alameda and Contra Costa Counties, California
S-17773	Angela M. Banet	1992	Contract 04E634-EP, Task Order #9, Historic Map Review for CALTRANS Maintenance Facilities (letter report)

Study #	Author	Date	Title
S-18217	Glenn Gmoser	1996	Cultural Resource Evaluations for the Caltrans District 04 Phase 2 Seismic Retrofit Program, Status Report: April 1996
S-20395	Donna L. Gillette	1998	PCNs of the Coast Ranges of California: Religious Expression or the Result of Quarrying?
S-32596	Randall Milliken, Jerome King, and Patricia Mikkelsen	2006	The Central California Ethnographic Community Distribution Model, Version 2.0, with Special Attention to the San Francisco Bay Area, Cultural Resources Inventory of Caltrans District 4 Rural Conventional Highways
S-33600	Jack Meyer, Jeff Rosenthal	2007	Geoarchaeological Overview of the Nine Bay Area Counties in Caltrans District 4.
S-43548	Randy S. Wiberg and Matthew R. Clark	2005	Archaeological Properties Treatment Plan: Vineyards at Marsh Creek Project (U.S. Army Corps of Engineers File #200300007

One historic cultural resource (P-07-000380 – a mine adit likely associated with the Brentwood Coal Company) was reported in one of these studies (S-011841), however, detailed mapping of the location of that resource revealed that it was actually outside the PAL.

Table 2 Cultural Resources Studies Conducted in or immediately adjacent to the Project Area

Study #	Author	Date	Title
S-2662	Allan G. Bramlette	1981	Archaeological Records Search for Getty Oil Pumping Station 60 RV P/L Feasibility Study, Contra Costa County (letter report).
S-6661	Allan G. Bramlette	1984	An Archaeological Study for the Pusser Parcel near Brentwood, Contra Costa County, California (MS 31-80).
S-11593	L. Kyle Napton	1990	Cultural Resource Investigations of the Proposed Brentwood Country Club EIR, 630 Acres in Contra Costa County, California
S-11841	Suzanne Baker and Laurence H. Shoup	1990	Archaeological Reconnaissance of the Brentwood Country Club Project, Near Brentwood, Contra Costa County, California
S-12893	Michael Smith and Suzanne Baker	1991	Addendum to: Archaeological Reconnaissance of the Brentwood Country Club Project, near Brentwood, Contra Costa County, California
S-13256	Allan G. Bramlette, et al.	1991	Archaeological Resources Inventory for Los Vaqueros Water Conveyance Alignments, Contra Costa County, California.
S-13813	Miley Paul Holman	1990	Archaeological Field Inspection of the Hancock Specific Plan Property, Brentwood, Contra Costa County, California (letter report)
S-18187	Jack Meyer, David A. Fredrickson	1996	Results of a Subsurface Archaeological Survey of the Proposed Los Vaqueros and Transfer Pipeline Routes, Los Vaqueros Project, Contra Costa County, California.

Study #	Author	Date	Title
S-18250	Anthropological Studies Center, SSU; Jones & Stokes Associates, Inc.; Woodward-Clyde Consultants	1992	Evaluation, Request for Determination of Eligibility, and Effect for the Los Vaqueros Project, Alameda and Contra Costa Counties, California
S-22581	William Self	1999a	Archaeological Survey of Subdivision 8369, Brentwood, California (letter report).
S-23674	Michael Moratto, et al.	1995	Archaeological Investigations, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California (Volume I, II, III, IV, V).
S-25274	Miley Paul Holman	2001a	Archaeological Field Inspection of the Proposed Brentwood Shopping Center, Brentwood, Contra Costa County, California (letter report).
S-33560	Leigh A. Martin	2007	Archaeological Survey and Cultural Resources Assessment of 27-Acre Parcel Located at the Southwest Corner of Balfour Road and SR-4 (Concord Avenue), Brentwood, Contra Costa County, California (letter report)
S-33561	Leigh A. Martin	2007	Archaeological Survey and Cultural Resources Assessment of Additional ROW for SR-4 Bypass at the Intersection of Balfour Road and SR-4, Brentwood, Contra Costa County, California (letter report)

Forty-nine archaeological studies have been conducted within a 1-mile radius of the Project area (Table 3).

Table 3 Cultural Resources Studies Conducted Within 1-Mile of the Project Area

Study #	Author	Date	Title
S-2159	Breck E. Parkman	1980	Archaeological Reconnaissance of a 172.4+ Acre Parcel near Brentwood, Contra Costa County, California Costa County, California (A.P. #017-050-009, 018, 019, 020, and 021; ARS-80-27).
S-2731	Christian Gerike	1981	Archaeological Study of Parcels 010-030-007 and 010-030-008, near Brentwood, Contra Costa County, California (letter report).
S-6113	U.S. Bureau of Reclamation	1983	Class II Archaeological Survey, San Luis Drain and Alternatives, Central Valley Project, San Luis Unit, California, 1983.
S-6576	Suzanne Baker	1984	Archaeological Reconnaissance of the Natalie J. Dutra Property, Contra Costa County, California.
S-10508	G. James West	1982	Class II Archaeological Survey, Kellogg Unit Reformulation, Contra Costa County, California
S-10509	Jensen & Associates	1986	Class III Intensive Archaeological Field Reconnaissance of the Kellogg Reformulation Unit, Highline Canal Alternative, Contra Costa and Alameda Counties.

Study #	Author	Date	Title
S-13420	William Self Associates	1990	Cultural Resources Assessment Report for Lone Tree Valley Feasibility Study, Contra Costa County, California.
S-13528	Linda Dick Bissonnette	1992	Additional Historical Research on the Brentwood Coal Mine Site and the Spanos Property for the Brentwood Hills Country Club Project
S-16501	Ann Samuelson, et al.	1993	Archaeological Survey and Testing Report, Cowell Ranch Project, Contra Costa County, California
S-16916	Ann Samuelson, et al.	1994b	Archaeological Survey Report, Future Urban Area 1, Antioch, Contra Costa County, California.
S-18557	Jones & Stokes Associates, Inc.	1996	Cultural Resources Investigation for the Proposed City of Brentwood Interim Water Supply Program, Contra Costa County, California.
S-18641	Jack Meyer	1996	Geoarchaeological Implications of Holocene Landscape Evolution in the Los Vaqueros Area of Eastern Contra Costa County, California
S-19175	William Self	1997	Brentwood Special Planning Areas G & H (letter report).
S-20688	Miley P. Holman	1998	Archaeological Literature Review and Field Inspection of the Nunn Parcel, Brentwood, Contra Costa County, California (letter report)
S-22573	William Self	1999b	Archaeological Survey of the Madrid Property, Brentwood, California (letter report).
S-23368	Colin I. Busby	1999	Cultural Resources Records and Literature Review, Proposed Subdivision 8395, Sand Creek Phase I and II, City of Brentwood, Contra Costa County, California (letter report).
S-23383	Colin I. Busby, Stuart A. Guedon	2000	Archaeological Inventory—Proposed Subdivision 8395, Sand Creek Phase I and II, City of Brentwood, Contra Costa County (letter report).
S-23629	Eric W. Ritter	1973	Archaeological Survey of the Proposed Brentwood - McDonald Island Gas Line in Central California
S-23917	William Self, Leigh Martin	2001	Archaeological Survey and Assessment of Proposed Sand Creek Road Residential Development (APN 019-110-033), Brentwood, Contra Costa County, California (letter report).
S-24941	Colin I. Busby	2000b	Archaeological Resources Assessment, Castello Property on Sand Creek Road (APN Map Book 17, Page 03, Parcel 211 [part]), City of Brentwood, Contra Costa County (letter report).
S-24948	Colin I. Busby	2000c	Archaeological Resources Assessment: Chao Property 1681 Apricot Way (APN 0190-092-036); Dayani Property, 1801 Apricot Way (APN 019-092-035), City of Brentwood, Contra Costa County (letter report).
S-25005	Colin I. Busby	2001a	Cultural Resources Literature Search and Review, ARCO Products Company Property, Balfour and Future John Muir Parkway, City of Brentwood, Contra Costa County (letter report).

Study #	Author	Date	Title
S-25024	Colin I. Busby	2001c	Cultural Resources Assessment, Roman Catholic Church Property, Northeast Corner of Fairview and Central Avenues (westerly 7.5 acres of APN 17-050-027), City of Brentwood, Contra Costa County, California (letter report).
S-25290	Miley Paul Holman	2001b	Archaeological Phase I Study of the Lands of Nunn Development Area, Brentwood, Contra Costa County, California (letter report).
S-25543	Robert Harmon, Colin I. Busby	2001	Archaeological Resources Assessment—Apricot Way Housing Project, City of Brentwood, Contra Costa County (letter report).
S-26306	William Self	2001b	Archaeological Survey and Assessment of Proposed Sand Creek Road Residential Development (APN 019-110-033), Brentwood, Contra Costa County, California (letter report).
S-26989	Scott Billat	2003	SHPO Review of FCC Undertaking, Balfour Road: CA-2481A.
S-27188	Miley Paul Holman	2002	Archaeological Phase I Study of the Brighton St
S-27194	Miley Paul Holman	2002	Archaeological Field Inspection of the Montelena II Subdivision 8663, Brentwood Contra Costa County, California (Letter Report)
S-27993	Colin I. Busby	2002	Cultural Resources Assessment, Roman Catholic Church Property, Northeast Corner of Fairview and Central Avenues, (19.94 acres – APN 17-050-027), City of Brentwood, Contra Costa County, California (letter report).
S-28626	Ric Windmiller and Daniel J. Osanna	2004	Bridle Gate, Cultural Resources Inventory and Evaluation, Brentwood, Contra Costa County, California
S-28655	Miley Paul Holman	2003	Phase I Cultural Resources Study of the Castello Property, Brentwood, Contra Costa County, California (letter report).
S-28954	Colin I. Busby	2003	Archaeological Resources Assessment (Supplement), Seko Property, 1601 Apricot Way (APN 019-092-019), City of Brentwood, Contra Costa County (letter report).
S-29035	Kyle S. Brown	2004	Archaeological Survey and Cultural Resources Assessment of the Proposed Fire Station Number 56, Brentwood, Contra Costa County, California (letter report).
S-29401	David Chavez, Jan M. Hupman	2004	Cultural Resources Investigation for the Sand Creek Detention Basin Project, Brentwood, Contra Costa County, California.
S-31191	Lorna Billat	2006	PG&E Tower 7/38 (Brentwood), 100 Street Edmunds Way, Brentwood, Contra Costa County.
S-32057	James M. Allan	2006	Archaeological Survey and Cultural Resources Assessment for the John Muir Parkway Extension Project, City of Brentwood, Contra Costa County, California (letter report).
S-32819	Leigh A. Martin	2007b	Archaeological Survey and Cultural Resources Assessment for 3-Acre Parcel Located at 500 Concord Avenue, Brentwood, Contra Costa County, California (letter report).

Study #	Author	Date	Title
S-33530	Allen Estes, et al.	2007	Report on Archaeological Testing at a Historic Landfill Site, State Route 4, Segment 3 Brentwood, California
S-33961	Leigh A. Martin	2007	Archaeological Survey and Cultural Resources Assessment for the Sand Creek Interchange EIR Addendum, Brentwood, Contra Costa County, California (letter report)
S-34228	Basin Research Associates, Inc.	2006	Historic Properties Survey Report/Finding of Effect (No Historic Properties Affected), PG&E Delta Distribution Planning Area (DPA) Capacity Increase Substation Project, City of Antioch, Contra Costa County, California.
S-34244	Colin I. Busby	2007	Archaeological Resources Assessment – 1583 Fairview Avenue in Apricot Way, City of Brentwood, Contra Costa County, California (letter report).
S-34842	Suzanne Baker and Laurence Shoup	2007	EBART Transit Corridor EIR/EIS, Historic Resources Evaluation Report: East Contra Costa Irrigation District Main Canal System, eBART Project, Contra Costa County, California
S-36621	Barbara Siskin and Cassidy DeBaker	2009	Additional Cultural and Paleontological Resources Surveys and Monitoring for the Contra Costa Las Positas 230 kV Transmission Line Reconductoring Project
S-36622	Barbara Siskin, et al.	2008	Cultural Resources Investigation and Architectural Evaluation for the Contra Costa to Las Positas Reconditioning of the 230 kV Transmission Line, Contra Costa County and Alameda County, California
S-36803	Wayne Bonner and Kathleen Crawford	2010	Direct APE Historic Architectural Assessment for T-Mobile West Corporation a Delaware Corporation Candidate BA21735A (PG&E Spanish Bay) San Juan Oaks Road, Brentwood, Contra Costa County, California
S-37462	Carrie D. Wills	2010	Cultural Resources Records Search and Site Visit for the T-Mobile West Corporation a Delaware Corporation Candidate BA21639-A (PG&E W. Country Club), West Country Club Drive, Brentwood, Contra Costa County, California. (Letter Report)

Known Cultural Resources

Results of the record search indicated that no prehistoric cultural resources have been recorded within the project area but one historic cultural resource, a mine adit (P-07-000380 – associated with the Brentwood Coal Company), is reported by the NWIC as within the project area (Table 4). Eighteen other historic cultural resources (P-07-000002, P-07-000005, P-07-0000376, P-07-0000380, P-07-000424, P-07-000433, P-07-0000747, P-07-0002647, P-07-002651, P-07-002652, P-07-0002653, P-07-0002654, P-07-002852, P-07-002914, P-07-0002951, P-07-0003004, P-07-003067, and P-07-003072) are within the one-mile search radius. No prehistoric cultural resources have been recorded within the one-mile search radius.

Table 4 Cultural Resources Identified in or Within 1-Mile of the APE

Resource	Description	Proximity to Project
P-07-2 (CA-CCO-595)	CA-CCO-595 featured 24 circular depressions with no associated artifacts that was originally recorded as a prehistoric habitation site. Later this was ruled out.	.9 mi. southeast of the southern end of the Project area.
P-07-5 (CA-CCO-682H)	A possible historic ranching outpost with an earthen loading ramp, a metal water tank, a possible foundation, a brick-lined cistern, and a barbed wire fenced enclosing a circular, brick-lined well and pump.	Approx. .6 mi. northwest of the northern end of the Project area
P-07-376 (CA-CCO-611H)	Historic ranch complex with a brick and concrete machinery structure, house and barn foundation, and a free standing two-car garage	Approx. .3 mi. west of the southern end of the Project area.
P-07-380 (CA-CCO-615)	Boarded-up mine adit associated with a pile of railroad ties	Within Project area. At the southern end of the Project area, located partially within Project area.
P-07-424 (CA-CCO-667H)	Historic well and windmill site	.4 mi. south of the Project area
P-07-433 (CA-CCO-676H)	Historic rock wall/pile	Approx. 1 mile southwest of the Project area.
P-07-747 (CA-CCO-480H)	The Brentwood Coal Mine site	.2 mi. southwest of the southern end of Project area.
P-07-2647 (CA-CCO-815H)	The Elissondo Ranch Building Complex was recorded as a district and consists of a small group of abandoned residences and farm buildings located on the south bank of Sand Creek ~ 2.5 miles west of central Brentwood. A dirt road ~ 800 ft. long links the ranch complex with Hwy 4 Bypass. The ranch house burned down in April 2004.	Approx. .45 mi. northwest of the northern end of Project area.
P-07-2651	Historic barn	Approx. .45 mi. northwest of the northern end of Project area.
P-07-2652	Historic chicken coop	Approx. .45 mi. northwest of the northern end of Project area.
P-07-2653	Historic barn associated with the Elissondo Ranch Building Complex (CA-CCO-815H)	Approx. .45 mi. northwest of the northern end of Project area.
P-07-2654	A "retired" railroad flatcar that was converted into a bridge over Sand Creek. The rancher used this private bridge to connect adjacent agricultural fields. The bridge collapsed when the north concrete abutment washed away.	Approx. .5 mi. northwest of the northern end of Project area.
P-07-2852	Historic dump	Approx. .05 mi. south of south end of Project area.
P-07-2914	Historic canal complex	Approx. .4 mi. west of the south end of Project area.

Resource	Description	Proximity to Project
P-07-2951	The Contra Costa-Las Positas 230kV transmission line. The line is approximately 24 miles long and runs from East Antioch in Contra Costa County to Livermore in Alameda County.	Runs roughly parallel to Project area; located .8 miles west of the southern end of the Project area, 1 mile west of the northern end of the Project area.
P-07-3004	Historic utility tower	Approx. .8 mi. west of the southern end of the Project area
P-07-3067	Historic field boundary ditch	Approx. .45 mi. northwest of the northern end of Project area
P-07-3072	Historic farm buildings associated with the Elissondo Ranch Building Complex (CA-CCO-815H)	Approx. .45 mi. northwest of the northern end of Project area

The East County Corridor/State Route 4 EIR/89083 Volume 3 – State Route 4 Bypass (ESA 1994) identified no cultural resources in the project vicinity, however, only the 1992 SR-4 Right of Way north of Balfour Road was surveyed. South of Balfour road, the ROW was inaccessible at the time of the survey. Because of differences between the 1992 ROW and the As-Built ROW in place today, the majority of the project area was not surveyed in 1992 (Figure 8).

A review of the records and literature search results has identified one cultural resource within the project's PAL (P-07-000380; CA-CCO-615). CA-CCO-615 dates to the historic period and when recorded in 1990 was described as a mine adit associated with the Pacific Coal Company. Piles of railroad ties were also described that were presumed to once be associated with that company. The mine adit portion of CA-CCO-615 lies outside the project PAL, within a present-day housing development to the southeast of the project area.

No National Register of Historic Places or other local, state, or federally listed or recognized properties are known to exist in the project area.

No evaluated bridges appear in the project area or its vicinity on the Caltrans Bridge Inventory. No listings appear within the project area or the records search area in the *Revised Preliminary Historic Resources Inventory Contra Costa County California* (1989), the *California Inventory of Historic Resources* (March 1976), or the Historic Property Data File provided by the Office of Historic Preservation.

Examination of historic maps revealed the "County Road from Martinez to Stockton" ½-mile east of the project area, running approximately from south-southeast to north-northwest on both the 1861 and 1862 GLO plat maps (Figure 5). By 1914, this road no longer appears and may have been replaced by the San Francisco and New Orleans Line of the Southern Pacific Railroad, which ran northwest-southeast through downtown Brentwood, two miles to the east of the project area (USGS Brentwood Quad Map 1914). In the 1930s, it is evident that the project area

is a part of Brentwood Irrigated Farms, however, no structures appear in the project area. No other buildings or structures appear on these historic maps.

Summary of Native American Consultation

WSA contacted Debbie Pilas-Treadway at the Native American Heritage Commission (NAHC) on February 26, 2014 to request information on known Native American traditional or cultural properties within the project area, and to request a list of individuals or groups with cultural affiliation to the project area. The NAHC responded by letter on March 5, 2014. The letter stated that a records search of the sacred lands file had failed to indicate the presence of Native American cultural resources in the immediate project area. A list of Native American contacts was included in the response. On April 30, 2014, WSA sent letters to the following three contacts identified by the NAHC, requesting comment on this project: Andrew Galvan, The Ohlone Indian Tribe; Katherine Erolinda Perez; and Ramona Garibay, Trina Marine Ruano Family. No comments were received. WSA placed follow-up phone calls on May 22, 2014. A message was left on the answering machine of two individuals, detailing the project and asking for comments. Andrew Galvan did not have comments on the project area specifically, but asked to be informed of the results of our survey and any recommendations we make with regards to future archaeological work in the project area. A second round of follow-up calls were made to Katherine E. Perez and Ramona Garibay on May 30, 2014. Messages were left for both individuals. After the survey was conducted, on September 5, 2014, we contacted Andrew Galvan via email to convey the results of our survey. No further comments have been received. Copies of this correspondence are provided, and the results summarized, in Appendix B.

Consultation with Local Historical Societies

On May 8, 2014 WSA contacted the Contra Costa County Historical Society, the Contra Costa County Genealogical Society, the East Contra Costa Historical Society, and the Antioch Historical Society via letter requesting any information those organizations may have regarding cultural resources within the project area. On May 27, 2014, Priscilla A. Couden, Ph.D., Executive Director of the Contra Costa County Historical Society, responded stating that "the Contra Costa Historical Society is not able to say at this time" whether there will be impacts to cultural resources in the area "due to the fact that actual research time is involved in any response to such a request. . . . Unfortunately, it [the Contra Costa County Historical Society] does not have the wherewithal to provide such information without compensation for our research time." Dr. Couden enclosed a schedule of fees for research by her staff and also offered to provide access to the society's archives to WSA's researchers.

No responses were received from the Antioch Historical Society (AHS), the Contra Costa County Genealogical Society (CCGS), or the East Contra Costa Historical Society and Museum (ECCHSM). On July 1, 2014 WSA archaeologist Teresa Bulger made follow-up calls to the AHS and the ECCHSM organizations and left messages for the curators. Kathy Leighton, past president of the ECCHSM suggested that the Swift family might have owned part of the project area in the 20th century. She detailed that the Swift family likely bought it from the Balfour-Guthrie Company when the Brentwood Farms were subdivided. No information on the Swift family was located. On July 2, 2014, Phillis Tullis, Clerk for the Antioch Historical Society responded that Society has no knowledge of any specific historical sites or other cultural resources in the proposed interchange area.

No phone number was available for the Contra Costa Genealogical Society so a follow-up email was sent, to which WSA did not receive a response. Details of correspondence with the historical societies are provided in Appendix C.

Results of the Field Survey

On September 4 and 5, 2014, WSA staff archaeologist Thomas Young conducted a pedestrian survey of the right-of-way (ROW) of the intersection of State Route 4 (SR-4) and Balfour Road (Figure 9). The ROW extends 1.1 miles north of Balfour and 0.6 miles south of Balfour, on both east and west sides of SR-4. Along Balfour Rd. the ROW stretches 0.15 miles west of SR-4, and 0.15 miles east of SR-4 on both the north and south sides of Balfour. The survey corridor was divided into six areas: NW quad, NE quad, N. Central, SW quad, SE quad, and Balfour Rd. The discussion of the survey results below is organized by these six sections. The survey was conducted using 10 meter or 15 meter transects, with the smaller interval used in areas of low visibility. No paved areas were surveyed.

NW Quad

This area includes the swath north of Balfour Rd. and west of SR-4. It extends northward from Balfour to the San Jose Ave. overpass, and westward from SR-4 to the edge of housing developments. A Kinder Morgan Energy Pipeline Company facility is situated in the SE portion of this quadrant. The land consists mostly of flat terrain that is overgrown with dried grasses, wildflowers and weeds (Appendix D: Photo 1). Modern trash is scattered over the area, especially along the shoulder of SR-4 and along the privacy walls of the housing development. The land has been altered, as evidenced by sloped and cut-banks, drainage ditches, culverts, cyclone and barbed-wire fencing, and a gravel access road for the Kinder Morgan facility (Appendix D: Photo 2). A pile of concrete rubble was observed along the barbed-wire fence-line on the east side (Appendix D: Photo 3). Deer Creek flows in a south/southwestern direction

through part of the SE corner, and is directed underground at both ends to flow beneath SR-4 and Balfour Rd. The condition of the creek is fair - there is some rip-rap laid at both the northeast and southern ends where it flows below SR-4 and Balfour Rd., respectively, and there is some erosion on the banks, but there were several mature trees growing along both sides of the bank. A good, clear stratigraphy was not entirely visible, but the eroded portions allowed for investigation of soil deposition, which resembles the soils throughout the rest of this area. The level of the water was reduced to a shallow, slow-moving creek at the time of the survey.

The survey was conducted in 10-meter transects because the visibility was poor (less than 5%). Rodent burrows are numerous in this area, which allowed for observation of the soils, which are light brown/yellow sandy silt, dry, with a high percentage of rounded to angular gravels. No cultural material was observed.

NE Quad

This area includes the swath north of Balfour Rd. and east of SR-4. It extends northward from Balfour to the San Jose Ave overpass, and eastward from SR-4 to the golf-course fence-line. An AT&T transmission tower is situated in the SE corner of this quadrant. The land consists of mostly flat terrain that is even more overgrown than the NW quad with dried grasses, dried and thorny shrubs, leaf litter from oak trees and walnut trees, planted rows of redwood trees, and scrub brush (Photo 4). Modern trash from the highway was observed in the survey corridor. The land has been heavily altered, as shown by sloped and cut-banks, culverts, drainage ditches, berms, transmission towers, a sound wall, and cyclone and barbed-wire fencing. A portion of Deer Creek passes through the survey corridor, running in a southwesterly direction. The condition of the creek is fair - there was some rip-rap laid at the western end where it flows below SR-4. The creek banks are gently sloping with no vegetation protecting the banks from erosion. Several mature trees are growing on both sides of the bank. The soils observed in the bank are the same as the soils in the rest of the survey quads, and there didn't appear to be any difference in soil stratigraphy. The level of the water was reduced to a shallow, slow-moving creek at the time of the survey.

The survey was conducted in 10-meter transects, because the visibility was poor (less than 5%). Rodent burrows were present, but not as numerous as the NW quad; these were inspected for churned-up subsurface deposits. The soil in this quad is generally light-brown/yellow sandy silt, dry, with a high-percentage of rounded to angular gravels. No cultural material was observed.

N. Central Median

This is the small swath of land that is bounded by the north and south-bound lanes of SR-4 on the west and east sides, and the overpass for San Jose Ave. on the north side. It is overgrown

with dried grasses and weeds, and littered with trash from the highway. This stretch of land is probably 100% disturbed, as it is situated between lanes of the road and the ground is sloped and engineered with drainage ditches and gravel shoulders (Appendix D: Photos 5 & 6).

The survey was conducted in 10-meter transects, because of the poor visibility (less than 5%). The soils are the same light-brown/yellow dry sandy silt with high percentage of rounded to angular gravels. No cultural material was observed.

SW Quad

This area includes the swath south of Balfour Rd. and west of SR-4. It extends southward from Balfour for 0.6 miles, and westward from SR-4 to Concord Ave, skirting the John Muir Hospital at the NW corner. The land is mostly flat and is greatly disturbed; during the survey Mr. Young observed ditches, drainages, man-made berms, culverts, power poles, cyclone and barbed-wire fencing, areas of asphalt and gravel, stockpiles of sand, a gravel road (portion of Concord Road not in use), sloped and cut-banks, and modern trash (Appendix D: Photos 7 & 8). Despite this disturbance, the relative lack of ground cover allowed for greater visibility.

The survey was conducted in 15-meter transects, because the visibility ranged from 20 - 60%. The soils are light-brown/yellow dry sandy silt with a high percentage of rounded to angular gravels (the same as the other quads). Rodent burrows were investigated for churned-up subsurface deposits. No cultural material was observed.

SE Quad

This section includes the swath south of Balfour Road and east of SR-4. It extends southward from Balfour for 0.6 miles, and eastward from SR-4 to the privacy walls for the housing development outside the eastern edge. In the northeast corner, it skirts the fence-line for The Golf Club at Brentwood. The land is mostly flat, and is the least overgrown of all the surveyed areas. Dried grasses, wildflowers and weeds are present, but in lesser amounts. The exception is in the northeast corner of the quad, where the ground vegetation is as thick as the other quads (Appendix D: Photo 9). The disturbances to this survey area include ditches and drainages, culverts, sloped and cut-banks. The south side of the survey area is between the sound wall for the highway and the privacy walls for the housing development, and is probably 100% disturbed. It is sloped and covered with a chalky, non-native top soil (Appendix D: Photo 10). There is a large amount of roadside trash in this area. In the northern portion there is a blow-off valve for the Los Vaqueros Reservoir Pipeline (Appendix D: Photo 11).

The survey was conducted in 15-meter transects, because the ground visibility ranged from 60-90%. The soils are the same sandy silt as in the other quads, with the exception being the south

side (see above). Rodent burrows were also investigated for subsurface deposits. The northeast corner had the lowest visibility (less than 5%), so the transect width was reduced to 10-meters. No cultural material was observed.

Balfour Road

The survey area also included 0.15-mile long stretches east and west of SR-4, along both the north and south sides of Balfour Rd. These sections are paved with concrete sidewalks, and are completely landscaped with ivy, young oaks and other street trees, grass, shrubs, and other plants typically used in landscaping; mulch covers the soil around the plants. (Appendix D: Photos 12-14). No cultural material was observed.

Results

During the course of the survey, no cultural materials were observed. Due to the close proximity to both Balfour Road and SR-4, a lot of roadside trash was present over the survey area, and portions of the survey area have been used for dumping. Deer Creek, which was observed flowing through two of the survey areas (NW and NE quads), is the oldest feature in this landscape, but even it has been channelized and may have been redirected from its original path. Regardless, close attention was paid to the creek banks during the survey, in the event that the creek had retained its original course of flow. While visibility was low in the northern quadrant of the site, rodent burrows allowed for some observation of sub-surface soil. The previous disturbance evident throughout the project area and the lack of observed cultural material make it very unlikely that any buried archaeological resources are present in the project area.

Recommendations

The results of the record search and the visual inspection of the project area indicate that the likelihood of encountering potentially significant cultural resources within the project area is low. However, should any previously undiscovered historic or prehistoric resources be found during construction, work should stop, in accordance with CEQA regulations, until such time that the resource can be evaluated by a qualified archaeologist and appropriate mitigative action taken as determined necessary by the City or County Lead Agency.

In the event that Native American human remains or funerary objects are discovered, the provisions of the California Health and Safety Code should be followed. Section 7050.5(b) of the California Health and Safety Code states:

In the event of discovery or recognition of any human remains in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any

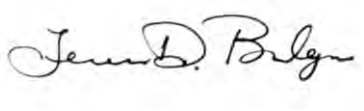
nearby area reasonably suspected to overlie adjacent remains until the coroner of the county in which the human remains are discovered has determined, in accordance with Chapter 10 (commencing with Section 27460) of Part 3 of Division 2 of Title 3 of the Government Code, that the remains are not subject to the provisions of Section 27492 of the Government Code or any other related provisions of law concerning investigation of the circumstances, manner and cause of death, and the recommendations concerning treatment and disposition of the human remains have been made to the person responsible for the excavation, or to his or her authorized representative, in the manner provided in Section 5097.98 of the Public Resources Code.

The County Coroner, upon recognizing the remains as being of Native American origin, is responsible to contact the Native American Heritage Commission within 24 hours. The Commission has various powers and duties to provide for the ultimate disposition of any Native American remains, as does the assigned Most Likely Descendant. Sections 5097.98 and 5097.99 of the Public Resources Code also call for "protection to Native American human burials and skeletal remains from vandalism and inadvertent destruction."

Thank you for the opportunity to provide our services on behalf of the project. Please feel free to contact us if we may be of further assistance or answer any questions you may have regarding the cultural resources survey or this report.

Sincerely,

WILLIAM SELF ASSOCIATES



Teresa Bulger, Ph.D., RPA
Project Director

Attachments
Appendix A: Figures
Appendix B: NAHC Consultation
Appendix C: Historical Society Consultation
Appendix D: Photographs

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1914 Brentwood, California, 7.5' Topographic Quadrangle (surveyed 1911).

1978 Brentwood, California, 7.5' Topographic Quadrangle.

Appendix A

Figures

- Figure 1: Project Vicinity Map
- Figure 2: Project Area Map
- Figure 3: Project Location Map
- Figure 4: Project Area Limits
- Figure 5: Project Location on 1861 General Land Office Plat Map T2N R2E
- Figure 6: Project Location on 1876 General Land Office Plat Map T2N R2E
- Figure 7: 1938 Contra Cost County Map
- Figure 8: Project Area Limits (PAL) Mapped onto the East County Corridor/State Route 4 EIR (ESA 1994)
- Figure 9: Areas Surveyed within the Project APE

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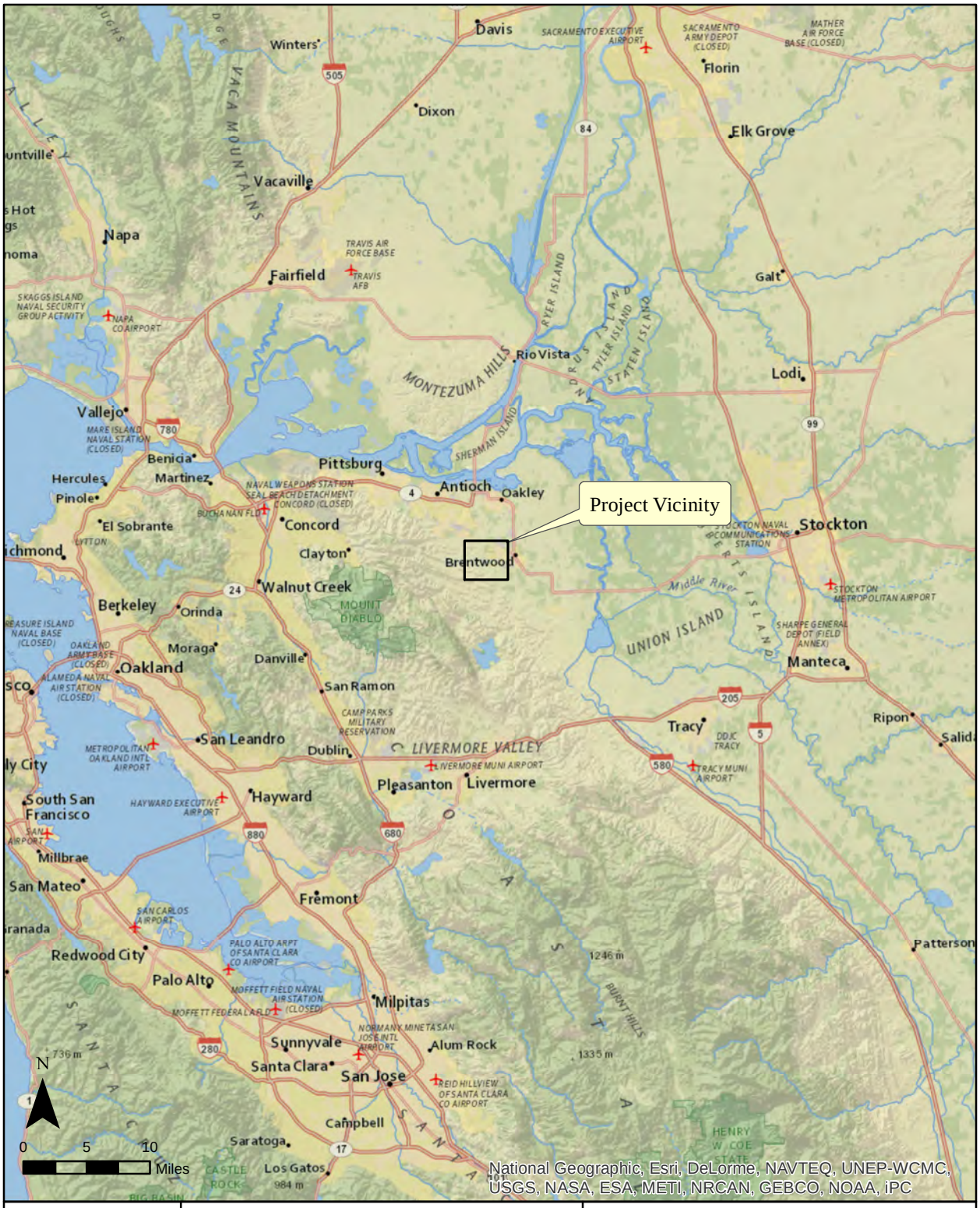
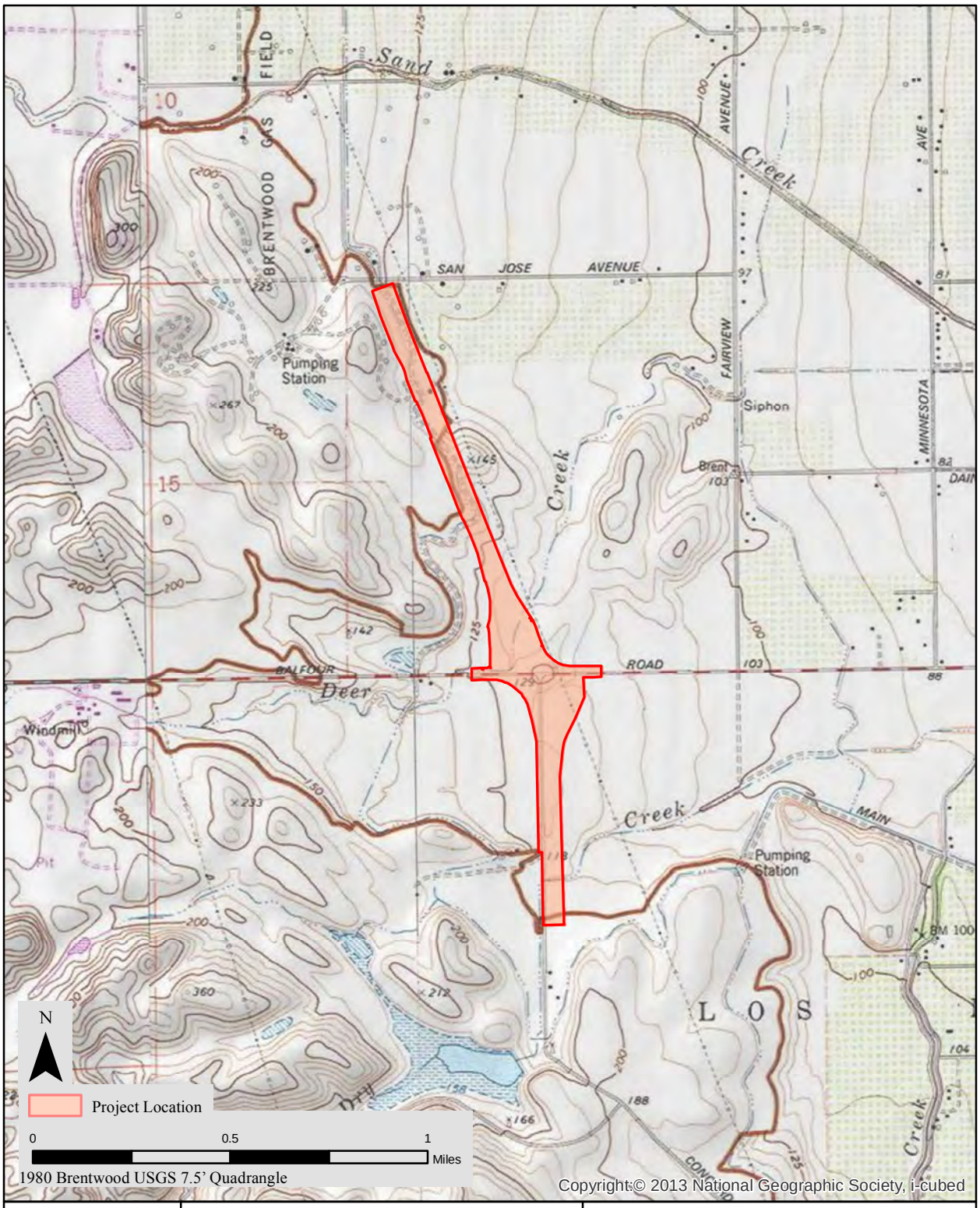


WSA	Project Vicinity Map	Figure 1 CirclePoint SR-4/Balfour Rd. Interchange Project Cultural Resources Assessment Contra Costa County, CA

WSA	Project Area Map	Figure 2 CirclePoint SR-4/Balfour Rd. Interchange Project Cultural Resources Assessment Contra Costa County, CA



WSA

Project Location

Figure 3
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SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA

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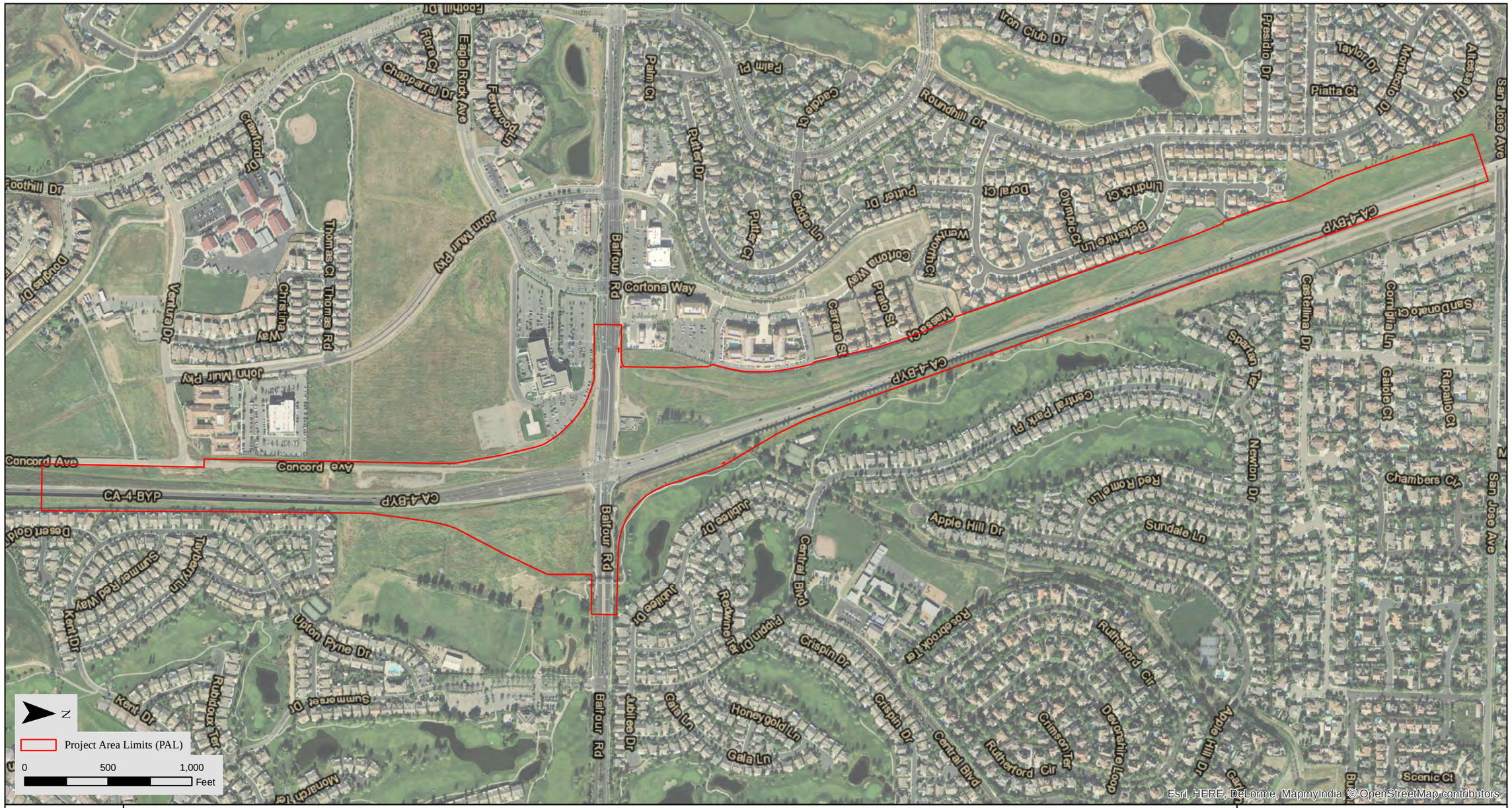

Project Area Limits (PAL) Map

Figure 4
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SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA

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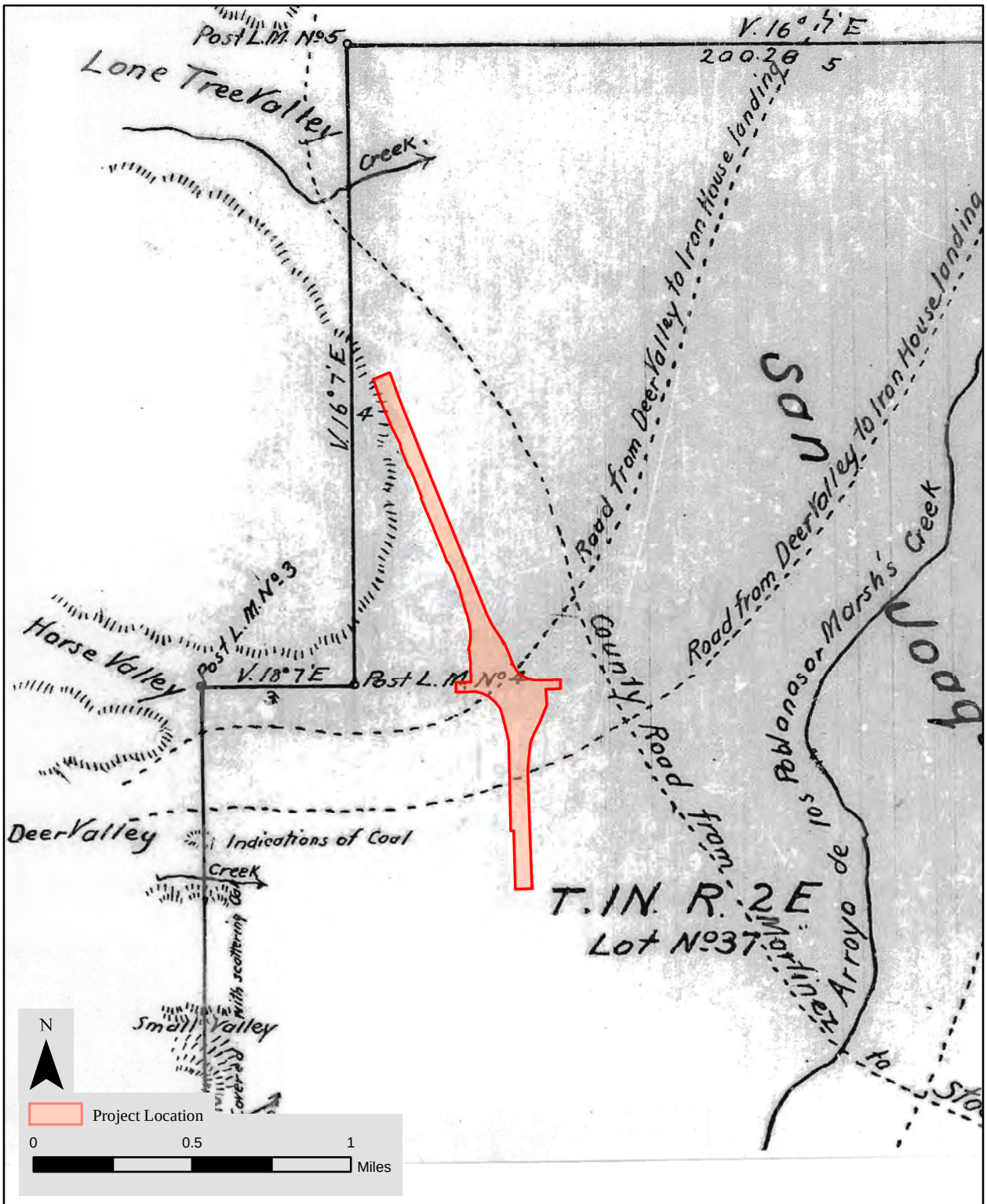
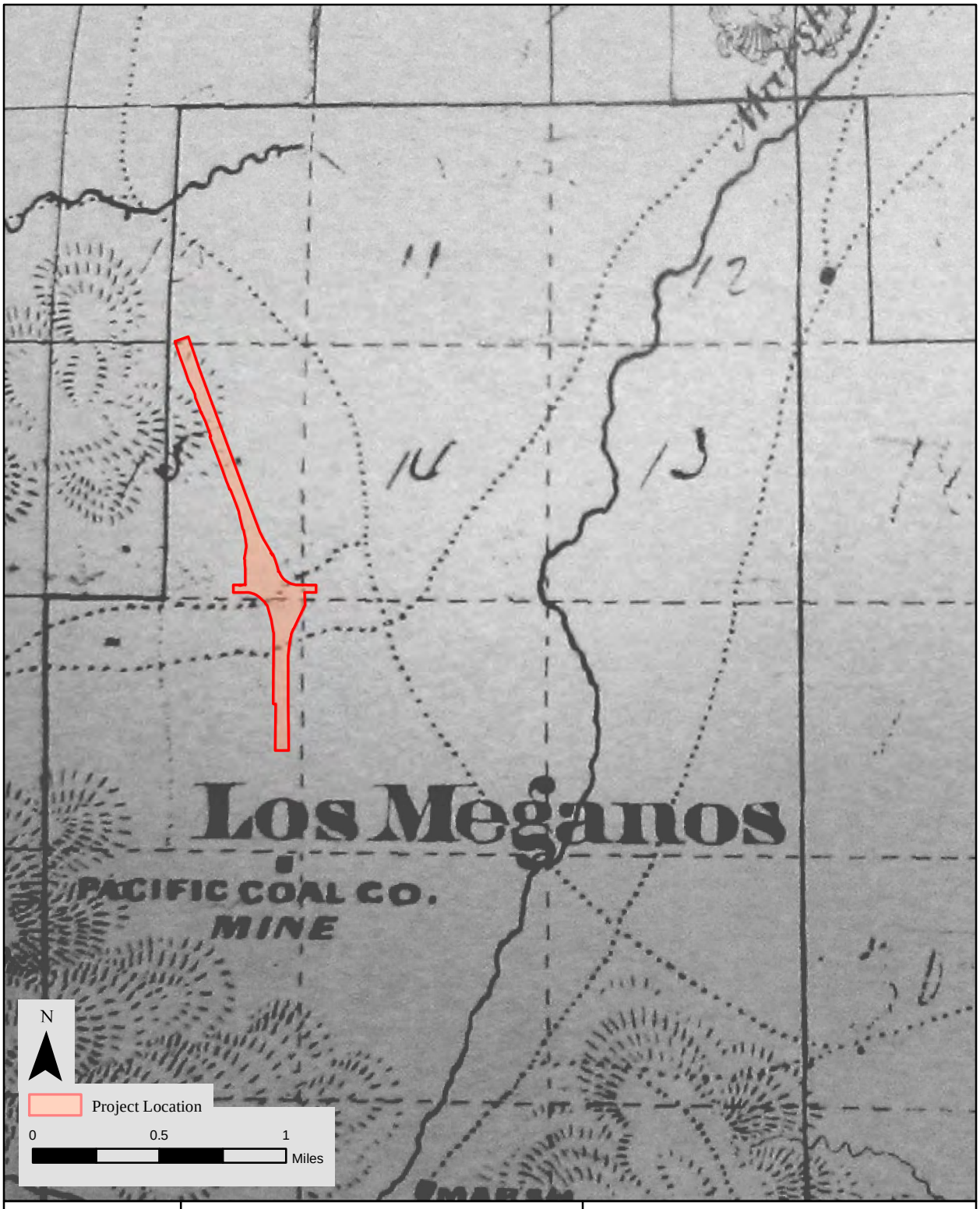


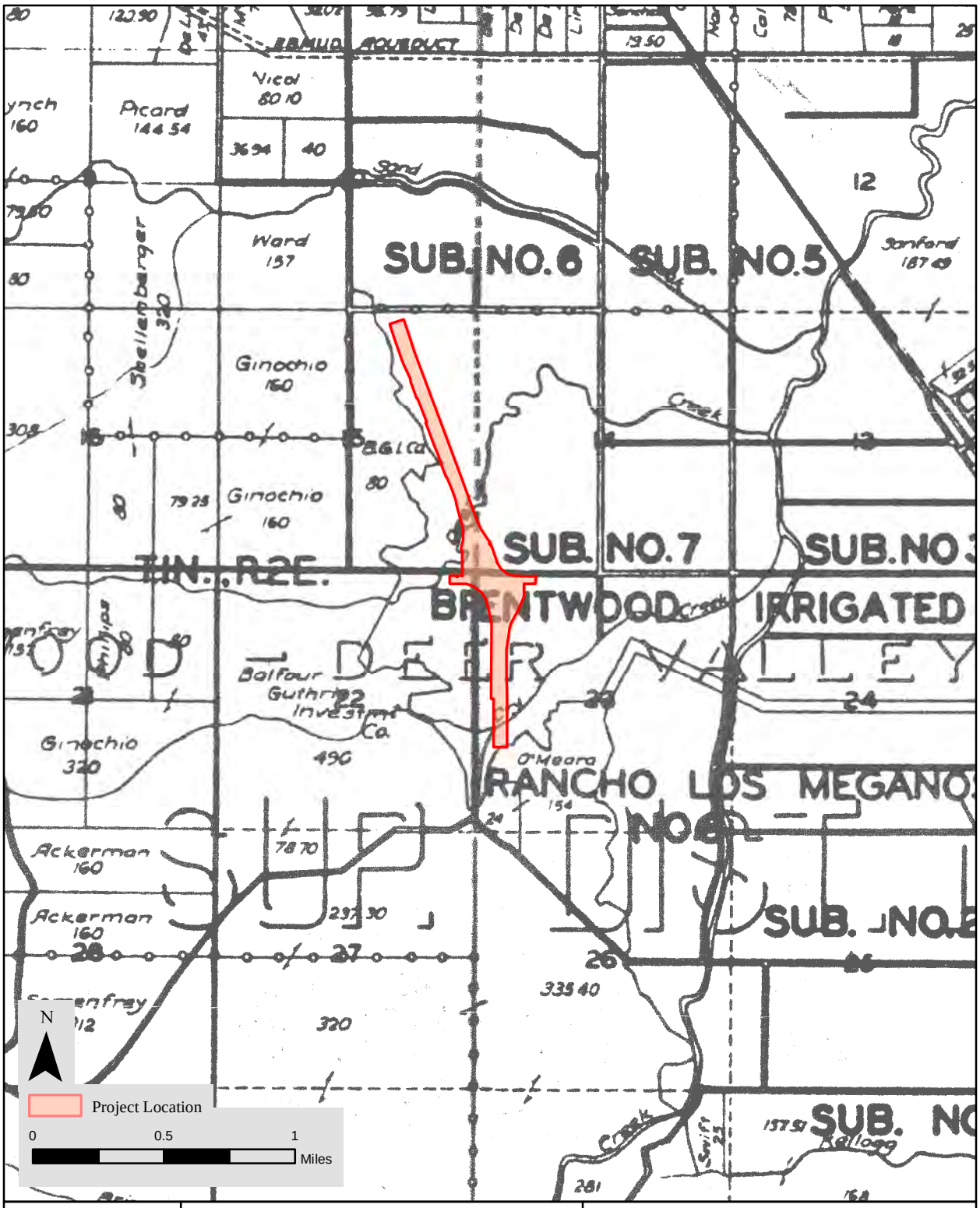
WSA	Project Location Mapped onto the 1861 Los Meganos Rancho Plat	Figure 5 CirclePoint SR-4/Balfour Rd. Interchange Project Cultural Resources Assessment Contra Costa County, CA



WSA

Project Location
Mapped onto the 1871
Contra Cost County Ownership Map

Figure 6
CirclePoint
SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA



WSA

Project Location
Mapped onto the 1938
Contra Cost County Map

Figure 7
CirclePoint
SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA

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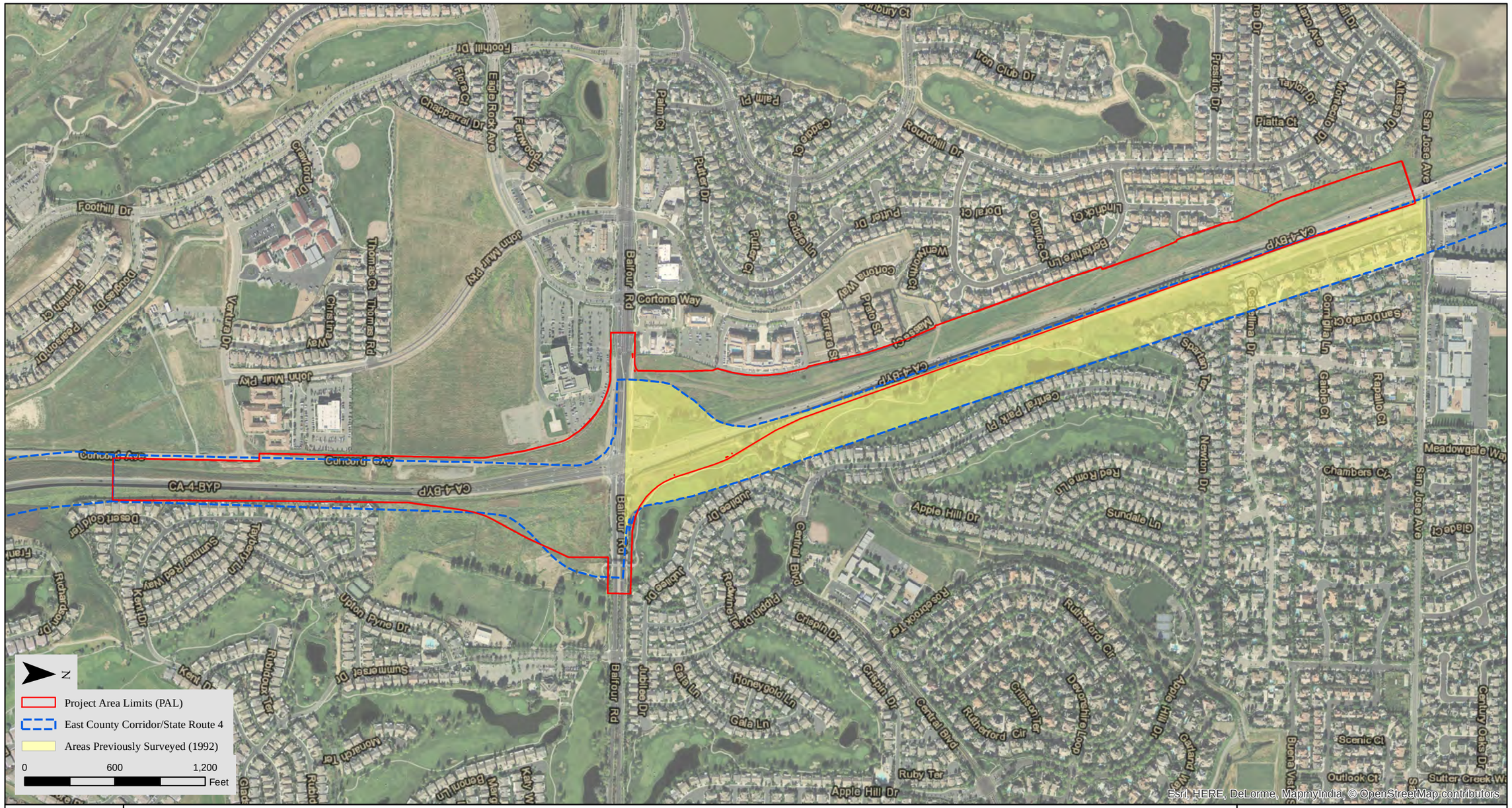

WSA

Project Area Limits (PAL) Mapped onto the East County Corridor/State Route 4 EIR (ESA 1994)

Figure 8
CirclePoint
SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA

WSA

Areas Surveyed within the Project Area Limits (PAL)

Figure 9
CirclePoint
SR-4/Balfour Rd. Interchange Project
Cultural Resources Assessment
Contra Costa County, CA

Appendix B

Native American Heritage Commission Consultation

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Native American Correspondence – SR 4 at Balfour Road

Name/ Affiliation	Date Letter Sent	Date Letter Received	Date of Follow-up Phone Call	Comments	Date of 2nd Follow-up Phone Call	Comments
Northern Valley Yokuts Tribe Katherine Erolinda Perez PO Box 717 Linden, CA 95235 Canutes@verizon.net (209)887-3415 Ohlone/Costanoan, Northern Valley Yokuts, Bay Miwok	4-30-14	5-6-14	5-22-14	Left message	5-30-14	Left message with person at Ms. Perez's home.
The Ohlone Indian Tribe Andrew Galvan Po Box 3152, Fremont, CA 94539 chochenyo@aol.com (510)882-0527 Ohlone/Costanoan, Bay Miwok, Plains Miwok, Patwin	4-30-14	5-6-14	5-22-14	Left message (PDZ). Talked to Andy later on in the day, however, and he would like to be informed of our survey results and recommendations (whether there will be monitoring, etc.)	Email with Survey results 9/10/14	No response as of 9/12/14.
Trina Marine Ruano Family Ramona Garibay, Representative 30940 Watkins Street, Union City, CA 94587 soaprootmo@comcast.net (510)972-0645 Ohlone/Costanoan, Bay Miwok, Plains Miwok, Patwin	4-30-14		5-22-14	Left message (PDZ)	5-30-14	Left message (PDZ)

Additional Information

California Native Americans
Cultural Resources
Strategic Plan
Commissioners
Federal Laws and Codes
State Laws and Codes
Local Ordinances and Codes
Additional Information

Return to CNAHC Home Page

Sacred Lands File & Native American Contacts List Request

NATIVE AMERICAN HERITAGE COMMISSION
915 Capitol Mall, RM 364
Sacramento, CA 95814
(916) 653-4082
(916) 657-5390 – Fax
nahc@pacbell.net

Information Below is Required for a Sacred Lands File Search

Project: SR-4/Balfour Road Revalidation Memo

County Contra Costa County

USGS Quadrangle

Name Brentwood Quad

Township 1N Range 2E Section(s) 10, 15, & 22

Company/Firm/Agency: William Self Associates, Inc.

Contact Person: Teresa Bulger

Street Address: 61-d Avenida de Orinda

City: Orinda, California Zip: 94563

Phone: (925) 253-9070

Fax: (925) 254-3553

Email: tbulger@williamself.com

Project Description: We are doing a Revalidation Memo along SR-4, 1.1 miles north of Balfour road and .6 miles south of Balfour road, in Brentwood. Thank you!-Teresa

STATE OF CALIFORNIA Edmund G. Brown, Jr., Governor

NATIVE AMERICAN HERITAGE COMMISSION
1550 Harbor Blvd.
West Sacramento, CA 95691
(916) 373-3710
Fax (916) 373-5471

March 5, 2014

Teresa Bulger
William Self and Associates, Inc.
61-d Avenida de Orinda
Orinda, CA 94563

VIA FAX: 925-254-3553
Number of Pages: 2

Re: SR-4/Balfour Road Revalidation Memo, Contra Costa County

Dear Ms. Bulger:

A record search of the sacred land file has failed to indicate the presence of Native American cultural resources in the immediate project area. The absence of specific site information in the sacred lands file does not indicate the absence of cultural resources in any project area. Other sources of cultural resources should also be contacted for information regarding known and recorded sites.

Enclosed is a list of Native Americans individuals/organizations who may have knowledge of cultural resources in the project area. The Commission makes no recommendation or preference of a single individual, or group over another. This list should provide a starting place in locating areas of potential adverse impact within the proposed project area. I suggest you contact all of those indicated, if they cannot supply information, they might recommend others with specific knowledge. By contacting all those listed, your organization will be better able to respond to claims of failure to consult with the appropriate tribe or group. If a response has not been received within two weeks of notification, the Commission requests that you follow-up with a telephone call to ensure that the project information has been received.

If you receive notification of change of addresses and phone numbers from any of these individuals or groups, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at (916) 373-3713.

Sincerely,

Debbie Pilas-Treadway
Environmental Specialist III

Native American Contacts
Contra Costa County
March 5, 2014

Katherine Erolinda Perez
PO Box 717
Linden , CA 95236
canutes@verizon.net
(209) 887-3415

Ohlone/Costanoan
Northern Valley Yokuts
Bay Miwok

The Ohlone Indian Tribe
Andrew Galvan
PO Box 3152
Fremont , CA 94539
chochenyo@AOL.com
(510) 882-0527 - Cell
(510) 687-9393 - Fax

Ohlone/Costanoan
Bay Miwok
Plains Miwok
Patwin

Trina Marine Ruano Family
Ramona Garibay, Representative
30940 Watkins Street
Union City , CA 94587
510-972-0645-home

Ohlone/Costanoan
Bay Miwok
Plains Miwok
Patwin

soaprootmo@comcast.net

This list is current only as of the date of this document.

Distribution of this list does not relieve any person of statutory responsibility as defined in Section 7050.5 of the Health and Safety Code, Section 5097.94 of the Public Resources Code and Section 5097.98 of the Public Resources Code

This list is only applicable for contacting local Native Americans with regard to cultural resources for the proposed SR-4/Balfour Road Revalidation Memo, Contra Costa County

April 30, 2014

Mr. Andrew Galvan
The Ohlone Indian Tribe
P.O. Box 3152
Fremont, CA 94539

RE: SR-4/Balfour Road Revalidation Memo, Contra Costa County, California

Dear Mr. Galvan,

William Self Associates, Inc. (WSA) has been contracted to prepare a revalidation memo within the SR4/Balfour Road Interchange Project (project), located in the City of Brentwood and County of Contra Costa. The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. The project is the first phase of two phases planned to be constructed as funding becomes available.

We would appreciate receiving any comments you may have regarding cultural resources or sacred sites issues within the immediate project area. If you could provide your comments in writing to the address below, or call me, we will make sure the comments are provided to our client as part of this project. We would appreciate a response, at your earliest convenience, should you have information relative to this request. Should you have any questions, I can be reached at (925) 253-9070.

Sincerely,

James Allan, Ph.D., RPA
Principal

Attachment

P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamself.com

April 30, 2014

Ms Ramona Garibay, Representative
Trina Marine Ruano Family
30940 Watkins Street
Union City, CA 94587

RE: SR-4/Balfour Road Revalidation Memo, Contra Costa County, California

Dear Ms. Garibay,

William Self Associates, Inc. (WSA) has been contracted to prepare a revalidation memo within the SR4/Balfour Road Interchange Project (project), located in the City of Brentwood and County of Contra Costa. The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. The project is the first phase of two phases planned to be constructed as funding becomes available.

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Sincerely,

James Allan, Ph.D., RPA
Principal

Attachment

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61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamself.com

April 30, 2014

Katherine Erolinda Perez
P.O. Box 717
Linden, CA 95236

RE: SR-4/Balfour Road Revalidation Memo, Contra Costa County, California

Dear Ms. Perez,

William Self Associates, Inc. (WSA) has been contracted to prepare a revalidation memo within the SR4/Balfour Road Interchange Project (project), located in the City of Brentwood and County of Contra Costa. The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. The project is the first phase of two phases planned to be constructed as funding becomes available.

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Orinda CA 94563

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Email:jallan@williamself.com

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Appendix C

Local Historical Society Consultation

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Local Historical Society Correspondence Table

Historical Society	Date Letter Sent	Date Response Received	Date Follow-up Call	Comments
Antioch Historical Society 1500 W. Fourth St. Antioch, CA 94509 (925) 757-1326 antiochhistoricalsociety@comcast.net	May 8, 2014		7/1/14	Left a Message.
Contra Costa County Genealogical Society P.O. Box 910 Concord, CA 94522 No Phone Number cccgs.ca@gmail.com	May 8, 2014		7/1/14, Email	Email follow-up message.
Contra Costa County Historical Society 724 Escobar Street Martinez, CA 94553-1114 Phone: 925 229 1042 Fax: 925 229 1772 info@cocohistory.com	May 8, 2014	May 27, 2014		Cannot address the request without research time & compensation.
East Contra Costa Historical Society and Museum P.O. Box 202 Brentwood, CA 94513 Phone: 925 516 7484 (Mary Lou Klovee) Phone: 925 634 0917 (Kathy Leighton) Kathy Leighton leightoncontr@aol.com (Society President/Resource Room)	May 8, 2014 and May 28, 2014	First letter returned. address incorrect.	7/1/14	Spoke with Mary Lou Klovee (past president) who did not have information. Spoke with Kathy Leighton (past president) who suggested this area was part of the Swift Farm in the 20th century, who would have bought it from Balfour Guthrie. Did not have any given names, no information could be found on the Swift family.

WSA

ACRA

Consultants in Archaeology and Historic Preservation

www.williamself.com

May 8, 2014

Antioch Historical Society
1500 W. Fourth St.
Antioch, CA 94509

RE: SR-4/Balfour Road Interchange Project, Brentwood, California

To whom it may concern,

William Self Associates, Inc. (WSA) has been contracted by Circlepoint to assess the potential historic significance of the SR-4/Balfour Road Project area, and the immediately surrounding vicinity, located in Brentwood, in the County of Contra Costa, California (see attached map). The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. Historically this area was likely used as agricultural land. The Pacific Coal Company Mine was located southeast of the project area in the 1870s. More recently, the area saw increasing development with the laying of SR-4 in the 1990s.

We would appreciate receiving any information you may have regarding the historic land use of the project area and the immediate project vicinity. If you could provide in writing any information you might have on the project area to the address below, or call our Project Director, Ms. Teresa Bulger, we will include the information in the Historical Resources Compliance Report we are preparing on behalf of the project.

Thank you for your assistance.

Sincerely,

WILLIAM SELF ASSOCIATES

James Allan, Ph.D., RPA
Principal

Attachment

P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamself.com

May 8, 2014

Contra Costa County Genealogical Society
P.O. Box 910
Concord, CA 94522

RE: SR-4/Balfour Road Interchange Project, Brentwood, California

Dear Sir or Madam,

William Self Associates, Inc. (WSA) has been contracted by Circlepoint to assess the potential historic significance of the SR-4/Balfour Road Project area, and the immediately surrounding vicinity, located in Brentwood, in the County of Contra Costa, California (see attached map). The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. Historically this area was likely used as agricultural land. The Pacific Coal Company Mine was located southeast of the project area in the 1870s. More recently, the area saw increasing development with the laying of SR-4 in the 1990s.

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Thank you for your assistance.

Sincerely,

WILLIAM SELF ASSOCIATES

James Allan, Ph.D., RPA
Principal

Attachment

P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

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Fax: 925-254-3553
Email:jallan@williamself.com

WSA

ACRA

Consultants in Archaeology and Historic Preservation

www.williamself.com

May 8, 2014

Contra Costa County Historical Society
724 Escobar Street
Martinez, CA 94553-1114

RE: SR-4/Balfour Road Interchange Project, Brentwood, California

To whom it may concern,

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Thank you for your assistance.

Sincerely,

WILLIAM SELF ASSOCIATES

James Allan, Ph.D., RPA
Principal

Attachment

P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamself.com

May 28, 2014

East Contra Costa Historical Society and Museum
P.O. Box 202
Brentwood, CA 94513

RE: SR-4/Balfour Road Interchange Project, Brentwood, California

Dear Sir or Madam,

William Self Associates, Inc. (WSA) has been contracted by Circlepoint to assess the potential historic significance of the Sr-4/Balfour Road Project area, and the immediately surrounding vicinity, located in Brentwood, in the County of Contra Costa, California (see attached map). The project is located within Township 1 North, Range 2 East, Sections 10, 15, and 22 of the Brentwood 7.5' Topographic Map (USGS 1995). The proposed Project would widen State Route 4 (SR-4) from San Jose Avenue to approximately 3,400 feet south of Balfour Road, and construct an interchange at Balfour Road. Historically this area was likely used as agricultural land. The Pacific Coal Company Mine was located southeast of the project area in the 1870s. More recently, the area saw increasing development with the laying of SR-4 in the 1990s.

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Thank you for your assistance.

Sincerely,

WILLIAM SELF ASSOCIATES

James Allan, Ph.D., RPA
Principal

Attachment

P.O. Box 2192
61d Avenida de Orinda
Orinda CA 94563

William Self Associates, Inc.

Phone: 925-253-9070
Fax: 925-254-3553
Email:jallan@williamself.com

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Appendix D

Photographs

Photo 1: NW Quad, View S., showing thick vegetation and low visibility. SR-4 on the left side of photo, housing development on right side of photo.

Photo 2: NW Quad, View NW, showing Kinder Morgan facility. Trees in background indicate location of above-ground portion of Deer Creek.

Photo 3: NW Quad, View E., showing concrete rubble. SR-4 is visible in the background.

Photo 4: NE Quad, View N., showing ground conditions. Redwood trees planted are on left side of photo, the golf course is on the right side of photo.

Photo 5: N. Central section, View S., showing ground conditions and engineered alterations - sloped banks, guardrails.

Photo 6: N. Central section, View N., showing ground conditions and engineered alterations - gravel road shoulders, sloped surface.

Photo 7: SW Quad., View N., showing ground disturbance (fences, ditch) and ground visibility. SR-4 at higher elevation in the right side of the photo.

Photo 8: SW Quad., View S., showing ground disturbance (fences, power pole, gravel and asphalt) and ground visibility. SR-4 is on left side of photo.

Photo 9: SE Quad., View S., showing poor ground visibility in NE corner of quad. Fence-line for The Golf Club at Brentwood is on left side of photo.

Photo 10: SE Quad., View N., showing altered area between soundwall and privacy wall; engineered slope down to ditch. Topsoil is chalky.

Photo 11: SE Quad., View S., showing Los Vaqueros Pipeline blow-off valve. Balfour Rd. is behind photographer.

Photo 12: North side of Balfour Rd., View. E., showing landscaping and hardscaping. Gas station to the left of photo.

Photo 13: North side of Balfour Rd., View W, showing landscaping and hardscaping. Golf course to the right of the photo.

Photo 14: South side of Balfour Rd., View E, showing landscaping and hardscaping. John Muir Hospital to the right of the photo.

Attachment B

Preliminary Wetland Delineation

PRELIMINARY WETLAND DELINATION
and
JURISDICTIONAL DETERMINATION

A PORTION OF DEER CREEK AFFECTED BY THE PROPOSED BALFOUR ROAD/STATE ROUTE 4 INTERCHANGE PROJECT

CITY OF BRENTWOOD, CONTRA COSTA COUNTY, CALIFORNIA

October 2014

Prepared for:

CirclePoint
1814 Franklin St., Suite 1000
Oakland, CA 94612
510-285-6700

Prepared By:

Randall C. Long

RCL ECOLOGY
BIOLOGICAL CONSULTING
925-408-8449

I. INTRODUCTION

The waters within the entire right-of-way (ROW) of the three-segment SR4 Bypass Road (now SR4) were delineated in 1998 and verified by the USACE in 1999. That verification expired on April 27, 2004. Therefore, this new delineation was prepared for the portion of Deer Creek that will be affected by the construction of the SR4/Balfour Road Interchange project.

II. PROJECT LOCATION

The project is located in western Brentwood, California at the current at-grade intersection of Balfour Road and SR4. The reach of Deer Creek is in the northwest quadrant of the project area and corresponds to latitude 37˚/55'/33" North, longitude 121˚/44'/4" West and unsectioned area of Township 1N, Range 2E of the US Geological Service (USGS) 7.5 minute '*Brentwood, California'*, quadrangle, 1978 (Figure 1– *Site and Vicinity*).

III. PROJECT DESCRIPTION

The interchange would require construction of two clear span bridges over the approximate 306 feet long, 0.38-acre of existing open channel of Deer Creek and removal of a portion of the adjacent piped portion in order to create an approximate 245 feet long, 0.29-acre extension of open channel (Figure 2).

As the transportation project is within the boundaries of the East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP), the applicant will request authorization for permitting under the USACE Regional General Permit for minimal impact activities within the boundaries of the HCP/NCCP.

III. METHODS

The preliminary wetland delineation field survey was conducted on February 16, 2014 by biologist Randall Long, in accordance with the methodology outlined in the *U. S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and the USACE Regional General Permit for Minimal Impact Activities Within the Area of the East Contra County Habitat Conservation Plan/Natural Resource Conservation Plan (HCP/NCCCP) May 4, 2012.. Baseline data used for this delineation included 2013 color photographs from Google Earth and measurements by Quincy Engineering and Mark Thomas & Company. Soil types were determined using the *Soil Survey of Contra Costa County, California,* U.S. Department of Agriculture, Natural Resources Conservation Service, (formerly Soil Conservation Service). 1977. Field evidence of hydric soil was determined utilizing the *Munsell Soil Color Charts* (Kollmorgen Instruments Corporation, 1994). Plant species were determined with *The Jepson Manual, Vascular Plants of California, Second Edition.* Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilkens, editors. 2012. The wetland status of plants

was determined utilizing the *National Wetland Plant List* (USACE 2012). Wetland boundaries were surveyed and marked with wooden stakes and marked with plastic flagging per "*Minimum Standards for Acceptance of Preliminary Wetland Delineations,* Department of the Army, U.S. Army Engineer District, Sacramento, 2001.

IV. ENVIRONMENTAL SETTING

Topography and Soils; Hydrology and Vegetation

The project area lies in a nearly flat urban setting bound by the John Muir Medical Clinic on the southwest, the Summerset Golf Course on the northeast and southeast, and the Cortona Park assisted living facility and Kinder Morgan gas pipeline and booster station on the northwest. Capay clay 0 to 2% slopes is the predominant soil type in the project area. It is a non-hydric grassland soil type with few trees occurring on nearly level topography at approximately 130 feet above mean sea level. The series has a slow infiltration rate and high runoff potential. The existing vegetation is characteristic of the soil type (NRCS, 1977).

Hydrology

Deer Creek is the only waters within the project area. It is a third order intermittent stream originating in the hills west of the project area but becomes perennial where it is detained in a water quality pond approximately ¾-mile west of the project area. From that point it is piped to the east through an 84-inch non-reinforced concrete pipe along the north side of Balfour Road until turning northeast as it enters the project area just south of the Kinder Morgan facility (KM). The pipe then continues for approximately 245 feet before it outlets through a concrete headwall to become a daylighted channel. The channel continues for approximately 306 feet before exiting the project area through an approximate 14 feet wide, 8 feet high concrete box culvert that passes approximately 220 feet beneath SR4 were it exits the project area becoming an open channelized water draining to Marsh Creek and on to the San Joaquin River.

The daylighted portion of the Creek is a shallow channelized reach with a few small pools. Flow elevation is fairly stable being controlled by the outlet of the upstream water quality pond.

Vegetation

The 'daylighted' portion of Deer Creek would be characterized by the USACE as a Coastal/Valley Freshwater Marsh and as a Riparian Woodland/Scrub vegetative type by the HCP/NCCP. The vegetation is dominated by young trees and shrubs typically representing an early successional stage of riparian woodland. Trees consist of saplings and mature Fremont cottonwood (*Populus fremontii)* and red willow (*Salix laevigata*). Shrubs consist of California rose (*Rosa californica*) and blue elderberry (*Sambucus mexicana*). Herbaceous and wetland species consist of broad-leaved pepperweed

(*Lepidium latifolium*), narrow-leaved cattail (*Typha angustifolia*), red-tinge bulrush (*Scirpus macrocarpus*) and purple flat sedge (*Cyperus rotundus*) (See data points DP#1 and DP#2).

V. PRELIMINARY DELINEATION

Existing open channel

The existing open channel averages approximately 55 feet wide at top of bank (TOB) and approximately 25 feet wide at ordinary high water (OHW) (Figure 2-*Preliminary Wetland Delineation*).

As the USACE and the HCP/NCCP designate waters differently. Table 1 shows the amount of waters of the U.S. at OHW per classification of the USACE as well as the bank full (TOB) classification used by the HCP/NCCP.

TABLE 1 - PRELIMINARY WETLAND DELINEATION

Total Waters of the U.S

WATERS OF THE U.S - 771 linear feet
Combination of culverted and open channel reaches

Existing Channel

CLASSIFICATION - USACE **WATERS OF THE U.S**
Coastal/Valley Freshwater Marsh (306' x 25'= 7,650 sq.'÷43,560 = 0.178 (rounded up) = 0.18-acre. (OHM measurement)

Existing Channel

CLASSIFICATION – HCP/NCCP
Riparian Woodland/Scrub (306' x 55'= 16,830 sq.'÷43,560 = 0.38-acre). (TOB to TOB measurement)

VI. APPENDIX

Figures:

Figure 1	Site and Vicinity
Figure 2	Preliminary Wetland Delineation

Exhibits:

Exhibit 1	Photos
Exhibit 2	Data Points

Project Site & Vicinity

Figure 1

Source: Quincy Engineering, 2014

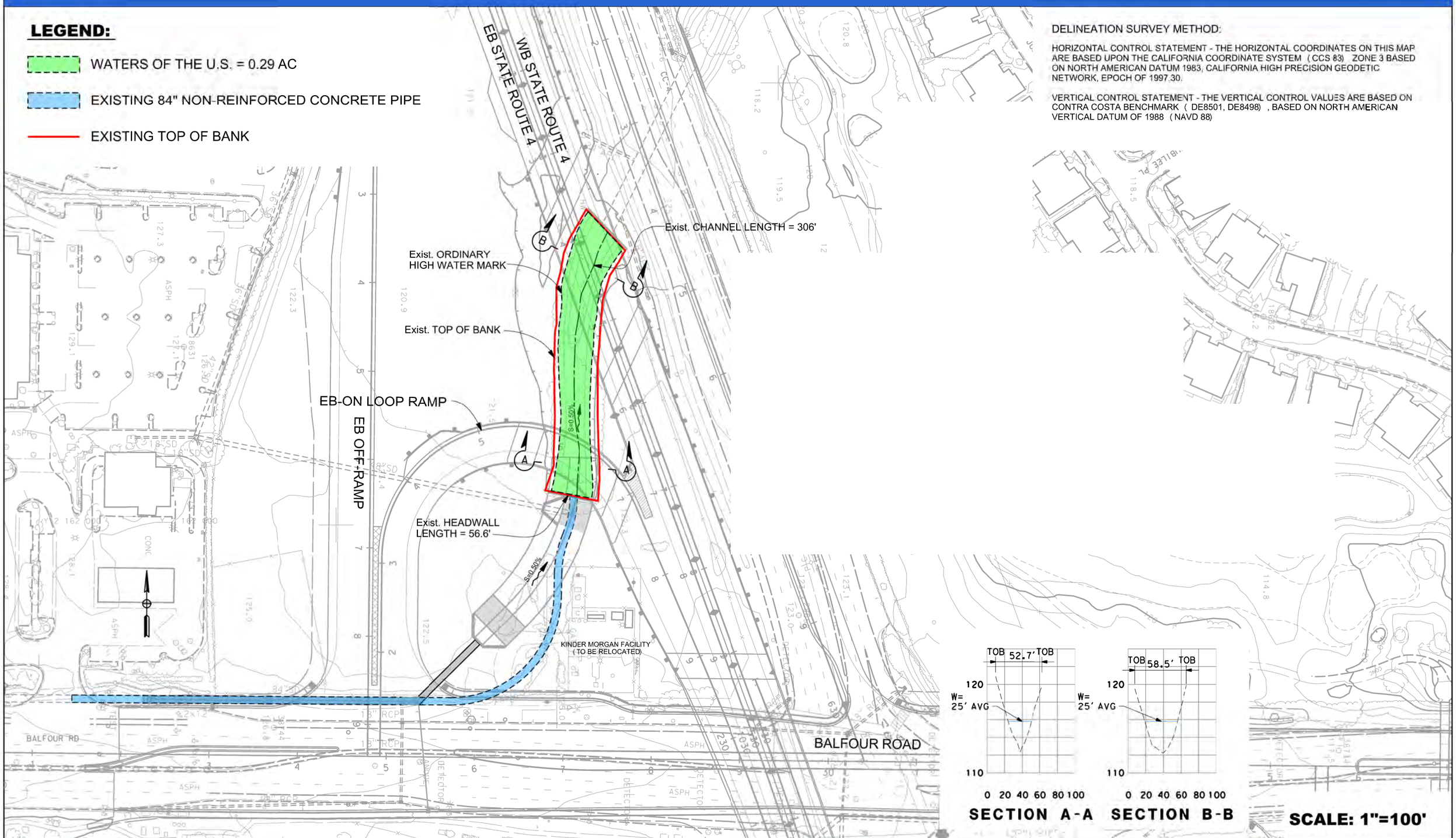
LEGEND:

- WATERS OF THE U.S. = 0.29 AC
- EXISTING 84" NON-REINFORCED CONCRETE PIPE
- EXISTING TOP OF BANK

DELINEATION SURVEY METHOD:

HORIZONTAL CONTROL STATEMENT - THE HORIZONTAL COORDINATES ON THIS MAP ARE BASED UPON THE CALIFORNIA COORDINATE SYSTEM (CCS 83) ZONE 3 BASED ON NORTH AMERICAN DATUM 1983, CALIFORNIA HIGH PRECISION GEODETIC NETWORK, EPOCH OF 1997.30.

VERTICAL CONTROL STATEMENT - THE VERTICAL CONTROL VALUES ARE BASED ON CONTRA COSTA BENCHMARK (DE8501, DE8498) , BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88)



SCALE: 1"=100'

CONTRA COSTA TRANSPORTATION AUTHORITY

STATE ROUTE 4 / BALFOUR ROAD INTERCHANGE PROJECT - PRELIMINARY WETLAND DELINEATION

QUINCY ENGINEERING

Deer Creek daylighted reach from the inlet looking north – Fall

Deer Creek looking north toward SR4 - Spring

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Deer Creek (SR4/Balfour Road Interchange) City/County: Brentwood, CC County Sampling Date: 2/16/2014

Applicant/Owner: Caltrans/Contra Costa Transportation Authority State: CA Sampling Point: DP 1

Investigator(s): Randall Long, RL Ecology Section, Township, Range: TiN, R2E, Unsecioned

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): _____ Slope (%): _____

Subregion (LRR): LRR-C Lat: 37/55/33N Long: 121/44/4W Datum: _____

Soil Map Unit Name: Capay Clay NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** **Yes ✓ No _____**
Hydric Soil Present?	Yes _____	No _____	
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks:

DP 1 is located at the north side of the creek.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus fremontii	15	Yes	
2.			
3.			
4.			
	_____ = Total Cover		
Sapling/Shrub Stratum (Plot size: _____)			
1. Rosa californica	5	No	FAC
2. Sambucus mexicana	5	No	N/A
3.			
4.			
5.			
	_____ = Total Cover		
Herb Stratum (Plot size: _____)			
1. Lepidium latifolium	25	Yes	FAC
2. Typha angustifolium	25	Yes	OBL
3. Scripus macrocarpus	25	Yes	OBL
4.			
5.			
6.			
7.			
8.			
	100% = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1. N/A			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum _____ % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 75 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes ✓ No _____**

Remarks:

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SOIL

Sampling Point: DP 1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
8	10 YR 4/2							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ✓ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ___ No ✓

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ✓ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ✓ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ✓ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ✓ No ___ Depth (inches): 6

Water Table Present? Yes ___ No ___ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No ___ Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Deer Creek (Balfour Road/SR4 Interchange) City/County: Brentwood Sampling Date: 2/16/2014

Applicant/Owner: CCTA State: CA Sampling Point: DP2

Investigator(s): Randall Long, RCL Ecology Section, Township, Range: T1N, R2E, Unsectioned

Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR): LRR-C Lat: 37/55/33N Long: 121/44/4W Datum: _____

Soil Map Unit Name: Capay Clay 0-2% NWI classification: _____

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No _____ (If no, explain in Remarks.)

Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No _____

Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No _____	**Is the Sampled Area within a Wetland?** Yes ✓ No _____
Hydric Soil Present?	Yes _____	No ✓	
Wetland Hydrology Present?	Yes ✓	No _____	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 25 feet)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus fremontii	15	Yes	No
2. Salix laevigata	5	No	FACW
3.			
4.			
	_____ = Total Cover		
Sapling/Shrub Stratum (Plot size: 25 feet)			
1. Rosa californica	5	No	FAC
2.			
3.			
4.			
5.			
	_____ = Total Cover		
Herb Stratum (Plot size: 25 feet)			
1. Lepidium latifolium	25	Yes	FAC
2. Typha angustifolia	25	Yes	OBL
3. Scirpus macrocarpus	25	Yes	OBL
4.			
5.			
6.			
7.			
8.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: _____)			
1. N/A			
2.			
	_____ = Total Cover		

% Bare Ground in Herb Stratum _____ % Cover of Biotic Crust _____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 75 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No _____

Remarks:

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SOIL

Sampling Point: DP2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
8	10 YR 4/2	100					clay loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- ✓ Stratified Layers (A5) (**LRR C**)
- __ 1 cm Muck (A9) (**LRR D**)
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- __ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- __ Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) (**LRR C**)
- __ 2 cm Muck (A10) (**LRR B**)
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes ____ No ✓

Remarks:

DP #2 is at the south end of the creek.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ✓ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- __ Water Marks (B1) (**Nonriverine**)
- __ Sediment Deposits (B2) (**Nonriverine**)
- __ Drift Deposits (B3) (**Nonriverine**)
- __ Surface Soil Cracks (B6)
- __ Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- __ Salt Crust (B11)
- __ Biotic Crust (B12)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Oxidized Rhizospheres along Living Roots (C3)
- __ Presence of Reduced Iron (C4)
- __ Recent Iron Reduction in Tilled Soils (C6)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ✓ Water Marks (B1) (**Riverine**)
- __ Sediment Deposits (B2) (**Riverine**)
- ✓ Drift Deposits (B3) (**Riverine**)
- __ Drainage Patterns (B10)
- __ Dry-Season Water Table (C2)
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- __ Shallow Aquitard (D3)
- __ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ✓ No ____ Depth (inches): 6

Water Table Present? Yes ____ No ____ Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ✓ No ____ Depth (inches): _____

Wetland Hydrology Present? Yes ✓ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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Attachment C

Report of Surveys for Special-Status Plants

REPORT OF SURVEYS FOR SPECIAL-STATUS PLANTS

FOR
STATE ROUTE 4 (SR4)/BALFOUR ROAD PROJECT CEQA RE-VALIDATION

BRENTWOOD, CONTRA COSTA COUNTY, CALIFORNIA

SR4 POST MILE (PM) 34.9/36.6
EA 04-4H1600

October 2014

Caltrans

and

Contra Costa Transportation Authority

PREPARED BY:

Randall Long, Wildlife Biologist
(925) 408-8449
RCL Ecology

1.0 INTRODUCTION

RCL Ecology conducted focused surveys for 11 special-status plants thought to have potential to occur within portions of the State Route 4 (SR4)/Balfour Road Interchange. Although a previous special-status plants survey was conducted for the SR4/Balfour Road Project (project) Biological Assessment (RCL Ecology, January 2011), it is now more than two years old and the California Department of Fish and Wildlife (CDFW) considers special-status plant survey reports invalid if more than two years have elapsed since the earlier plant survey (CDFW, 2009). Therefore, this survey was commissioned to update the earlier report. The survey report maintains standard CEQA terminology as well as terms from the East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP) as the report will also be used in support of a HCCP/NCCP "Incidental Take" permit for the project.

1.1 PROJECT LOCATION AND DESCRIPTION

Project Description

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) jointly propose to widen SR-4 from San Jose Avenue (PM 34.9) to approximately 3,400 feet south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road in the City of Brentwood in Contra Costa County (refer to **Figure 1**).

The first phase (Phase 1) would include the construction of the following (refer to **Figure 2)**:

- Divided four-lane Freeway from San Jose Avenue Undercrossing to 2,000 feet north of Balfour Road. The freeway then transitions to a two-lane expressway south of Balfour Road Interchange.
- Four-lane wide undercrossing bridge structure over Balfour Road to serve bidirectional two-lane freeway traffic and two entrance loop ramps. This structure would serve only eastbound (EB) traffic in future phases.
- Four-lane wide bridge structure over Deer Creek for SR-4 freeway lanes. It would serve bidirectional traffic in Phase 1
- Two-lane bridge structure over Deer Creek for EB loop on-ramp
- EB SR-4 Diagonal off-ramp
- EB SR-4 Loop on-ramp
- Westbound (WB) SR-4 diagonal on-ramp that will be in an interim location and moved further to the east in the ultimate configuration
- WB SR-4 diagonal off-ramp
- WB SR-4 loop on-ramp
- Widening of Balfour Road to up to six lanes within the interchange area

Other improvements would include two new traffic signals for the ramp intersections, ramp metering, lighting, drainage improvements, and utility relocations.

Relocation of PG&E Towers

A Pacific Gas & Electric (PG&E) overhead transmission line runs along the eastern side of the Bypass. Construction of the interchange will require relocation of two towers from their current locations adjacent to Balfour Road to new locations approximately 250 feet and 120 feet to the north respectively. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the Bypass and required coordination with public utilities and/or private operators during construction to allow for relocation as needed without disruption to existing service. Impacts associated with the utility relocation were addressed in the 1994 FEIR and are addressed in this Addendum pursuant to California Public Utilities Commission General Order 131-D filing requirements.

Deer Creek Daylighting

Deer Creek is an intermittent stream in its upper reaches but becomes perennial where it is detained in the Contra Costa County Flood Control Basin, approximately ¾-mile west of the SR-4/Balfour Road intersection. From this point Deer Creek flows through an 84-inch concrete pipe toward the SR-4/Balfour Road intersection. A small portion (approximately 250 feet long) north of Balfour Road and west of State Route 4 flows through an open ditch before re-entering an 84-inch non-reinforced concrete pipe to pass under State Route 4. East of State Route 4 Deer Creek flows mainly through an open ditch eventually draining to Marsh Creek and on to the San Joaquin River.

Addendum #10 had evaluated extension of the existing 84-inch pipe culverts along Deer Creek with removal of the open ditch portion in the northwest quadrant of the interchange. The revised Phase 1 interchange improvements now include construction of an eastbound SR-4 clear span bridge over Deer Creek and an eastbound SR-4 loop on-ramp bridge in the north/west quadrant of the SR-4/Balfour Road intersection. This loop on-ramp would cross over on a clear span structure the portion of Deer Creek that flows in an open ditch. In this same area, approximately 200 feet of Deer Creek which flows in a pipe would be removed and replaced with an open ditch configuration, daylighting the creek. The daylighted portion of Deer Creek would be vegetated to maintain consistency with the surrounding natural environment. Some rock slope protection will be needed to prevent channel erosion near the pipe culvert exits into the channel. The remaining portion of the pipe within the interchange limits to the south would be replaced with reinforced concrete pipe and connected to the existing pipeline that flows under Balfour Road.

OFF-SITE IMPROVEMENTS

Removal of the Kinder Morgan Brentwood Pump Station

As part of Phase 1 of the SR-4/Balfour Road interchange, a new eastbound SR-4 off-ramp would be constructed in the northwest quadrant of the SR-4/Balfour Road intersection. Construction of this new off-ramp makes it necessary for Kinder Morgan Energy Partners (Kinder Morgan) to remove an existing oil pipeline pump station (the Brentwood Booster Station) at this location. The 1994 FEIR contemplated the potential relocation of utilities as part of construction of the

Project and required coordination with public utilities and/or private operators during construction to allow for relocation, as needed, without disruption to existing service. Addendum #10 evaluated the relocation of the Brentwood Booster Station approximately 400 feet to the west to accommodate the proposed on- and off-ramps associated with the interchange.

Since Addendum #10 was completed, additional evaluation and coordination with Kinder Morgan has occurred, which determined that relocating the Brentwood Booster Station is no longer necessary. Rather, the Phase 1 improvements now include removal of the pump station. To maintain oil pipeline pumping capacity two off-site Kinder Morgan system upgrades are necessary. The first system upgrade would occur at an existing Concord Pump Station, located at Arnold Industrial Way and Solano Way in Concord, California (approximately 20 miles northwest from the Project area). Terminal and substation transformers at the Concord Pump Station would be replaced to allow for increased pumping capacity. No physical expansion of the Concord Pump Station would be needed.

The second off-site Kinder Morgan system upgrade would include the modification of an existing oil pipeline access point between Brentwood Boulevard and Sellers Avenue (approximately 2.8 miles southeast from the Project area) and associated truck access along an East Contra Costa Irrigation District (ECCID) canal. A Drag Reducing Additive (DRA) would be injected approximately once per week into the oil pipeline access point known as the Brentwood Boulevard Junction replacing similar DRA injections at the current Brentwood Booster Station. This would require a truck to either enter the area from Brentwood Boulevard, or to enter from Sellers Avenue, and traverse across the maintenance roadway along the ECCID canal. An asphalt concrete roadway would be constructed replacing the existing unpaved maintenance roadway to support the weekly truck trip delivering the DRA. This would require up to one foot of excavation throughout the maintenance road, including at conforms to paved roadways at each end. Additionally, up to one foot of trenching would occur across the maintenance road to maintain an existing water hook-up for irrigation activities associated with the adjacent farmlands. All work would occur within previously disturbed artificial fill associated with elevated maintenance access and paved roadways. No physical expansion of the valve lot for the Brentwood Boulevard Junction would occur.

2.0 STUDY METHODS

2.1 REVIEW OF BACKGROUND INFORMATION

The following studies and information sources were reviewed in preparation of this document.

> CDFW. April 2013. California Natural Diversity Database, Brentwood and Antioch South quads. CDFW Natural Heritage Division. Sacramento, California. [1]

[1] Randall Long initially conducted a multi-quad search of the California Natural Diversity Database for 10 quads surrounding the project site. A second survey was conducted using the Brentwood and Antioch South quads as there was no potential for the occurrence of species within the surrounding quads in the Brentwood and Antioch quads.

California Department of Fish and Game (CDFG). 2009. Protocols for surveying and evaluating impacts to special-status native plant populations and natural communities. November.

California Native Plant Society (CNPS). 2001. CNPS botanical survey guidelines, Pages 38-40 in CNPS's inventory of rare and endangered vascular plants of California (D.P. Tibor, editor). Sixth edition. Special Publication No. 1, CNPS, Sacramento, 387 pp.

East Contra Costa County Habitat Conservancy. East Contra Costa County HCP/NCCP. 2007.

Loeke, D. 1993. Biological resources assessment, SR 4 Bypass Road Segments 1 and 3.

US Fish and Wildlife Service (USFWS). July 2013. List of species that may be present in the South Antioch and Brentwood, USGS quadrangles.

USFWS, 1996. Guidelines for conducting and reporting botanical inventories for federally listed, proposed, and candidate plants. Sacramento, California p 2.

United States Department of Agriculture (USDA), NRCS. 1977. Soil survey of Contra Costa County, California, September.

The following reference was used in identification of plant species:

Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, D.H. Wilken, editors. 2012. The Jepson manual: vascular plants of California, second edition. University of California Press, Berkeley.

2.2 SURVEY REQUIREMENTS AND QUALIFICATIONS OF SURVEYOR

RCL Ecology surveys followed the guidelines approved by the CDFW (2009), CNPS (2001), and the USFWS (1996). These guidelines recommend that (1) surveys be conducted at the appropriate time of the year (i.e. blooming periods) for proper identification, (2) that surveys be floristic, that is, all species are recorded and identified to a taxonomic level to ensure that the specimen is not a special-status species, and that the surveyor has prior experience observing the special-status species in their natural habitat.

Randall Long, Principal and Senior Biologist of RCL Ecology, performed the reconnaissance surveys for the spring-blooming species on April 12 and 19, 2013 and for the fall-blooming species on September 10 and 12, 2013. Mr. Long has over 18 years in special-status plant survey experience in the local area, including specific experience conducting the special-status plant surveys for the project's Biological Assessment as well as the special-status plant survey for the conversion of the 9-hole Brentwood golf course directly adjacent to the southeast quadrant of the project area.

Surveys were conducted by walking meandering transects within the Project right-of-way (ROW) and recording all species observed. All plants that could not be readily identified in the field were collected for later identification in the office.

3.0 SETTING

The project area lies in a nearly flat urban setting bound by the John Muir Outpatient Clinic to the southwest, the Summerset Golf Course to the northeast and southeast, and the Cortona Park assisted living facility and Kinder Morgan gas pipeline and booster station to the northwest. Much of the area within the ROW has been repeatedly disturbed by a variety of previous construction grading and land uses, such as construction of phase 1 portions of segments 2 and 3, realignment of Concord Avenue, construction of the Kinder Morgan facilities, as well as culverting of a portion of Deer Creek. This disturbance has resulted in a predominately ruderal grassland and urban land cover type in the area immediately surrounding the intersection, with non-native annual grassland type in the less disturbed surrounding area. Approximately 300 linear feet of daylighted portion of Deer Creek occurs in the northwest quadrant of the project area (see Photos 1a and 1b).

3.1 LAND COVER TYPES VEGETATION AND SOILS

The following description of land cover types follows the cover types described in the HCP/NCCP. Land Cover in the project area consists of urban, ruderal, landscape, non-native annual grassland and steam channel.

Urban
Urban cover includes existing roadway and adjacent areas that have been graveled during previous construction activities.

Landscape
Landscaped areas consist of ornamental vegetation occurring along both north and south sides of Balfour Road.

Ruderal
Ruderal vegetation, characterized by sparse nonnative weedy plants, occurs on disturbed sites adjacent to the existing roadway. Common species consist of black mustard (*Brassica nigra*), yellow star thistle (*Centaurea solstitialis*), Italian thistle (*Carduus pycnocephalus* var. *pynocephalus)*, and Russian thistle (*Salsola tragus*).

Non-Native Annual Grassland
As described in the HCP/NCCP, non-native annual grassland is characterized by grass and forb species dominating the land cover and where trees and shrubs comprise less than 5 percent canopy cover. This plant community is dominated by non-native annual grasses including wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), and Italian ryegrass (*Lolium multiflorum*). Common forbs include fiddleneck (*Amsinckia menziesii* var. *intermidia*), rose clover (*Trifolium hirtum*), hairy vetch (*Vicia villosa* ssp. *villosa*), cut-leaved

geranium (*Geranium dissectum*), and California poppy (*Eschscholzia californica*) among others. A complete list of plants observed on the project area is included at Table 2.

Stream Channel

A portion of Deer Creek flows through the project area. Deer Creek is a third order intermittent stream in its upper reaches but becomes perennial due to urban runoff where it is detained in the Contra Costa County Flood Control Basin approximately ¾-mile west of the project area. From this point it is culverted to an approximately 300 foot long 'daylighted' channel within the project ROW and then further culverted for approximately 400 feet beneath the current SR4 to its outfall at the eastern boundary of the ROW. From that point it flows in an open channelized reach to Marsh Creek and then to the San Joaquin River.

The above sections of Deer Creek are the only waters within the project area (refer to the Wetland Delineation, for more detailed information on Deer Creek). The 'daylighted' reach is approximately 60 feet wide at top of bank (TOB) and approximately 25 feet wide at Ordinary High Water (OHW) with incised banks and shallow pools. It is characterized as Riparian Woodland Scrub with dominant vegetation consisting of narrow-leaved cattail (*Typha angustifolia*) and nutsedge (*Cyperus rotundus*) in the wetted portion and Fremont cottonwood, (*Populus fremontii*), toyon (*Heteromeles arbutifolia*) and coyote brush (*Baccharis pilularis*) on the banks.

Soils

Capay clay (0 to 2% slopes) is the predominant soil type in the project area. It is a grassland soil type with few trees occurring on nearly level topography at approximately 130 feet above mean sea level. The existing vegetation is characteristic of the soil type (NRCS, 1977).

4.0 SPECIAL-STATUS PLANTS

The California Natural Diversity Database (CNDDB) lists twenty nine (29) special-status plants as occurring within the nine quadrangles adjacent to the Brentwood quadrangle. Appendix A lists these species, describes their habitat requirements, blooming periods, and the potential for their occurrence within the project area. After review, the majority of these were removed from further analysis as they have habitat requirements not present on the project site. This left 11 species (Table 1) having habitat requirements potentially suitable to the site. These species were the subject of focused spring/ fall surveys.

Table 1
Special-Status Plants with Potential to Occur in the Project Area

LAND COVER TYPE	SPECIES	BLOOMING PERIOD
Grassland	San Joaquin spearscale (*Atriplex joaquiniana*)	April–October
	Alkali milkvetch (*Astragalus tener* ssp. *tener*)	March–June
	Big tarplant (*Blepharizonia plumosa*)	July–October

	Brewer's dwarf flax (*Hesperolinon breweri*)	May–July
	Contra Costa goldfields (*Lasthenia conjugens*)	March–June
	Diamond-petaled poppy (*Eschscholzia rhombipetala*)	March–April
	Large-flowered fiddleneck (*Amsinckia grandiflora*)	April–May
	Mount Diablo buckwheat (*Eriogonum truncatum*)	April–September; (uncommonly Nov–Dec)
	Mount Diablo fairy-lantern (*Calochortus pulchellus*)	April–June
	Round-leaved filaree (*California macrophylla*)[1]	March–May
	Showy madia (*Madia radiata*)	March–May

Source: CNNDB, 2013.

5.0 CONCLUSION

Although the special-status species listed in **Table 1** have habitat requirements potentially suitable to the project area, none of the special-status plant species were found. This is likely due to the level of disturbance in the area given its urban setting.

A list of all species observed within the project area is included as **Table 2** below.

Table 2
Non-Special Status Plants Occurring in the Project Area

FAMILY NAME	SCIENTIFIC NAME	COMMON NAME
Asteraceae	*Baccharis pilularis*	coyote brush
	Centaurea solstitialis	yellow star-thistle
	Carduus pycnocephalus ssp. pycnocephalus	Italian thistle
	Chamomilla suaveolens	pineapple weed
	Lactuca serriola	prickly lettuce
	Heterotheca grandiflora	telegraph weed
	Picris echioides	bristly ox-tongue
Boraginaceae	*Amsinckia menziesii var. intermedia*	fiddleneck
Brassicaceae	*Hirschfeldia incana*	hoary mustard
	Raphanus sativus	wild radish
Chenopodiaceae	*Salsola tragus*	Russian-thistle
Cyperaceae	*Cyperus rotundus*	Purple nutsedge
Euphorbiaceae	*Euphorbia esula*	leafy spurge
Fabaceae	*Trifolium hirtum.*	rose clover
	Vicia villosa ssp. villosa	hairy vetch
Geraniaceae	*Erodium botrys*	long-beaked filaree
	Erodium cicutarium	filaree
	Geranium dissectum	cut-leaved geranium
Juglandaceae	*Juglans nigra*	black walnut
Papaveraceae	*Eschscholzia californica*	California poppy
Poaceae	*Avena fatua*	wild oats
	Bromus diandrus	rip gut brome
	Bromus hordeaceus	soft chess
	Festuca arundinacea	tall fescue
	Hordeum murinum	foxtail
	Lolium multiflorum	Italian rye grass
	Vulpia myuros	fescue
Salicaceae	*Populus fremontii ssp. fremontii*	Fremont cottonwood
Rosaceae	*Heteromeles arbutifolia*	toyon
Typhaceae	*Typha angustifolia*	narrow-leaved cattail

Source: RCL Ecology, 2013.

6.0 APPENDIX

Appendix A: Special-Status Plants Potential to Occur on the Project Site

Appendix B: Project Figures/Photos

Figure 1: Project Site and Vicinity

Figure 2: Proposed Project Improvements

Photo 1a: 'Daylighted' reach of Deer Creek – Spring
Photo 1b: 'Daylighted' reach of Deer Creek – Fall

APPENDIX A

SPECIAL-STATUS PLANTS OCCURRENCE AT THE PROJECT SITE

Family Scientific Name Common Name	Status[1]		Habitat Affinities and Reported Localities Surrounding the Project Area	Blooming Period/ Life Form	Habitat Present/Absent
Apiaceae					
Lilaeopsis masonii Mason's lilaeopsis	Federal State CNPS	SC CR 1B:2-2-3	Intertidal brackish and freshwater marshes along stream banks. Recorded in the San Joaquin and Sacramento River Delta and lower Napa River channel.	April-Oct Perennial herb	Absent
Asteraceae					
Aster lentus Suisun Marsh aster	Federal State CNPS	SC CEQA 1B:2-2-3	Freshwater and brackish marshes. Known from the Napa River and San Joaquin/Sacramento River Delta.	May-Nov Perennial herb	Absent
Balsamorhiza macrolepis var. *macrolepis* big-scale balsamroot	Federal State CNPS	none CEQA 1B:2-2-3	Cismontane woodland, Valley/foothill grassland, sometimes on serpentinite. Occurs from the Bay Area to the northern Sacramento Valley and Sierra foothills.	March-June Perennial herb	Absent, would have been detectable
Blepharizonia plumosa ssp. *plumosa* big tarplant	Federal State CNPS	none CEQA 1B:3-3-3	Valley/foothill grasslands, on dry sites. Extant in Alameda and Contra Costa counties. Believed extirpated in San Joaquin, Stanislaus and Solano counties.	July-Oct Annual herb	Absent, would have been detectable

Helianthella castanea Diablo helianthella	Federal State CNPS	SC CEQA 1B:3-2-3	Broadleaf upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, and Valley/foothill grassland. Occurs in Alameda, Contra Costa and San Mateo counties; presumed extirpated in Marin and San Francisco counties.	April-June Perennial herb	Absent
Isocoma arguta Carquinez goldenbush	Federal State CNPS	SC CEQA 1B:3-3-3	Valley/foothill grasslands, on alkaline sites. Restricted to Contra Costa and Solano counties in the vicinity of the Carquinez Straits.	Aug-Dec Perennial shrub	Absent
Lasthenia conjugens Contra Costa goldfields	Federal State CNPS	FE CEQA 1B:3-3-3	Mesic sites in Valley/foothill grassland, vernal pools. Restricted to Napa and Solano counties; presumed extirpated in Alameda, Contra Costa, Mendocino, Santa Barbara and Santa Clara counties.	Mar-June Annual herb	Absent, would have been detectable
Madia radiata showy madia	Federal State CNPS	none CEQA 1B:2-3-3	Valley/foothill grasslands below 250 feet, and cismontane woodland. Occurs throughout the Central Coast and Central Valley. Presumed extirpated in Contra Costa County.	March-May Annual herb	Absent, would have been detectable
Senecio aphanactis rayless ragwort	Federal State CNPS	none CEQA 2:3-2-1	Coastal scrub and cismontane woodland on alkaline soils. Known from the South Coast, Central Coast, Central Valley and San Francisco Bay.	Jan-April Annual herb	Absent, would have been detectable
Boraginaceae					
Amsinckia grandiflora large-flowered fiddleneck	Federal State CNPS	FE CE 1B:3-3-3	Cismontane woodland, Valley/foothill grassland. Known from only three natural occurrences in Alameda, Contra Costa and San Joaquin counties.	April-May Annual herb	Absent, would have been detectable
Plagiobothrys hystriculus bearded popcorn-flower	Federal State CNPS	none CEQA 1A	Vernal pools and mesic Valley/foothill grassland. Presumed extinct. Endemic to Solano County.	April-May Annual herb	Absent, would have been detectable
Brassicaceae					

Erysimum capitatum ssp. *angustatum* Contra Costa wallflower	Federal State CNPS	FE CE 1B:3-3-3	Stabilized interior dunes. Known from only two occurrences on the dunes east of Antioch, along the San Joaquin River.	Mar-July Perennial herb	Absent, would have been detectable
Tropidocarpum capparideum caper-fruited tropidocarpum	Federal State CNPS	SC CEQA 1A	Valley/foothill grasslands (alkaline hills). Known historically from Alameda, Contra Costa, Glenn, Monterey, Santa Clara and San Joaquin counties; presumed extinct. Last seen in 1957.	Mar-April Annual herb	Absent
Campanulaceae					
Downingia pusilla dwarf downingia	Federal State CNPS	none CEQA 2:1-2-1	Mesic sites in Valley/foothill grassland and vernal pools. Occurs from Sonoma and Napa counties through the Sacramento Valley and Sierra foothills.	Mar-May Annual herb	Absent
Chenopodiaceae					
Atriplex joaquiniana San Joaquin spearscale	Federal State CNPS	SC CEQA 1B:2-2-3	Chenopod scrub, Valley/foothill grassland and alkali meadows. Occurs from Solano County throughout the Sacramento and San Joaquin valleys. Presumed extirpated in Santa Clara, San Joaquin and Tulare counties.	April-Sept. Annual herb	Absent, would have been detectable
Ericaceae					
Arctostaphylos auriculata Mt. Diablo manzanita	Federal State CNPS	none CEQA 1B:3-1-3	Chaparral, in canyons and on slopes, on sandstone. Known only from Mt. Diablo area in Contra Costa County.	Jan-March Evergreen shrub	Absent
Fabaceae					
Lathyrus jepsonii var. *jepsonii* Delta tule pea	Federal State CNPS	SC CEQA 1B:2-2-3	Freshwater and brackish marshes. Occurs throughout the Sacramento San Joaquin River delta, San Francisco Bay and Central Valley.	May-Sept Perennial herb	Absent
Geraniaceae					
Erodium macrophyllum Round-leaved filaree	Federal State CNPS	none none 2	Cismontane woodland; valley and foothill grassland	Mar-June Annual herb	Absent, would have been detectable
Lamiaceae					
Scutellaria lateriflora blue skullcap	Federal State CNPS	none CEQA 2:3-2-1	Mesic meadows, marshes and swamps. Reported from Inyo and San Joaquin counties, to New Mexico and Oregon. Known from only two occurrences in California.	July-Sept perennial herb (rhizomatous)	Absent
Liliaceae					

Calochortus pulchellus Mt. Diablo fairy-lantern	Federal State CNPS	none CEQA 1B:2-2-3	Chaparral, cismontane woodland, Valley/foothill grassland. Known from Contra Costa and possibly Solano counties.	April-June Perennial herb (bulbiferous)	Absent
Fritillaria liliacea fragrant fritillary	Federal State CNPS	SC CEQA 1B:1-2-3	Coastal prairie, coastal scrub, Valley/foothill grassland near the coast, on clay or serpentinite. Known from throughout the Central Coast from Sonoma to Monterey counties and the San Francisco Bay Area.	Feb-April Perennial herb (bulbiferous)	Absent
Linaceae					
Hesperolinon breweri Brewer's western flax	Federal State CNPS	SC CEQA 1B:2-2-3	Chaparral, cismontane woodlands, Valley/foothill grassland, mostly on serpentinite. Found in Napa, Solano, and Contra Costa counties.	May-July Annual herb	Absent
Malvaceae					
Hibiscus lasiocarpus rose-mallow	Federal State CNPS	none CEQA 2:2-2-1	Freshwater marshes. Restricted to the Sacramento-San Joaquin River Delta.	June-Sept Perennial herb (rhizomatous)	Absent
Oenothera deltoides ssp howellii *Antioch Dunes evening-primrose*	Federal State CNPS	FE CE 1B:3-3-3	Remnant river bluffs and interior sand dunes. Known from seven occurrences among the dunes east of Antioch.	Mar-Sept Perennial herb	Absent, would have been detectable
Papaveraceae					
Eschscholzia rhombipetala diamond-petaled California poppy	Federal State CNPS	SC CEQA 1A	Valley/foothill grassland on clay soils. Presumed extinct. Known historically from Alameda, Contra Costa, Colusa, San Luis Obispo and Stanislaus counties. Last seen in 1950.	Mar-April Annual herb	Absent, would have been detectable
Polygonaceae					
Eriogonum truncatum Mt. Diablo buckwheat	Federal State CNPS	none CEQA 1A	Chaparral, coastal scrub, Valley/foothill grassland on sandy soils. Presumed extinct, but found in 2005 on Mt. Diablo, Contra Costa County.	April-Sept Annual herb	Absent
Eriogonum nudum var.*psychicola* Antioch Dunes buckwheat	Federal State CNPS	none none 1B.1	Known only from the Delhi Sands soils within the Antioch Dunes National Wildlife Refuge, Antioch, Contra Costa County.	July-October Perennial herb	
Potamogetonaceae					
Potamogeton zosteriformis eel-grass pondweed	Federal State CNPS	none CEQA 2:2-2-1	Assorted freshwater marshes and swamps. Known from Contra Costa, Lake counties, Modoc, Lassen, and Shasta counties and Washington and Oregon.	June-July Annual herb (aquatic)	Absent, would have been detectable

Scrophulariaceae					
Cordylanthus mollis ssp. *mollis* soft bird's-beak	Federal State CNPS	FE CR 1B:3-2-3	Coastal saltmarsh. Known from fewer than 10 locations in Contra Costa, Napa, and Solano counties. Extirpated in Marin and Sonoma counties.	July-Sept Annual herb (hemiparasite)	Absent
Limosella subulata Delta mudwort	Federal State CNPS	none CEQA 2:2-3-1	Marshes and swamps, muddy or sandy intertidal flats in the Sacramento and San Joaquin river deltas.	May-Aug Perennial herb (stoloniferous)	Absent

[1] Explanation of sensitivity status codes:

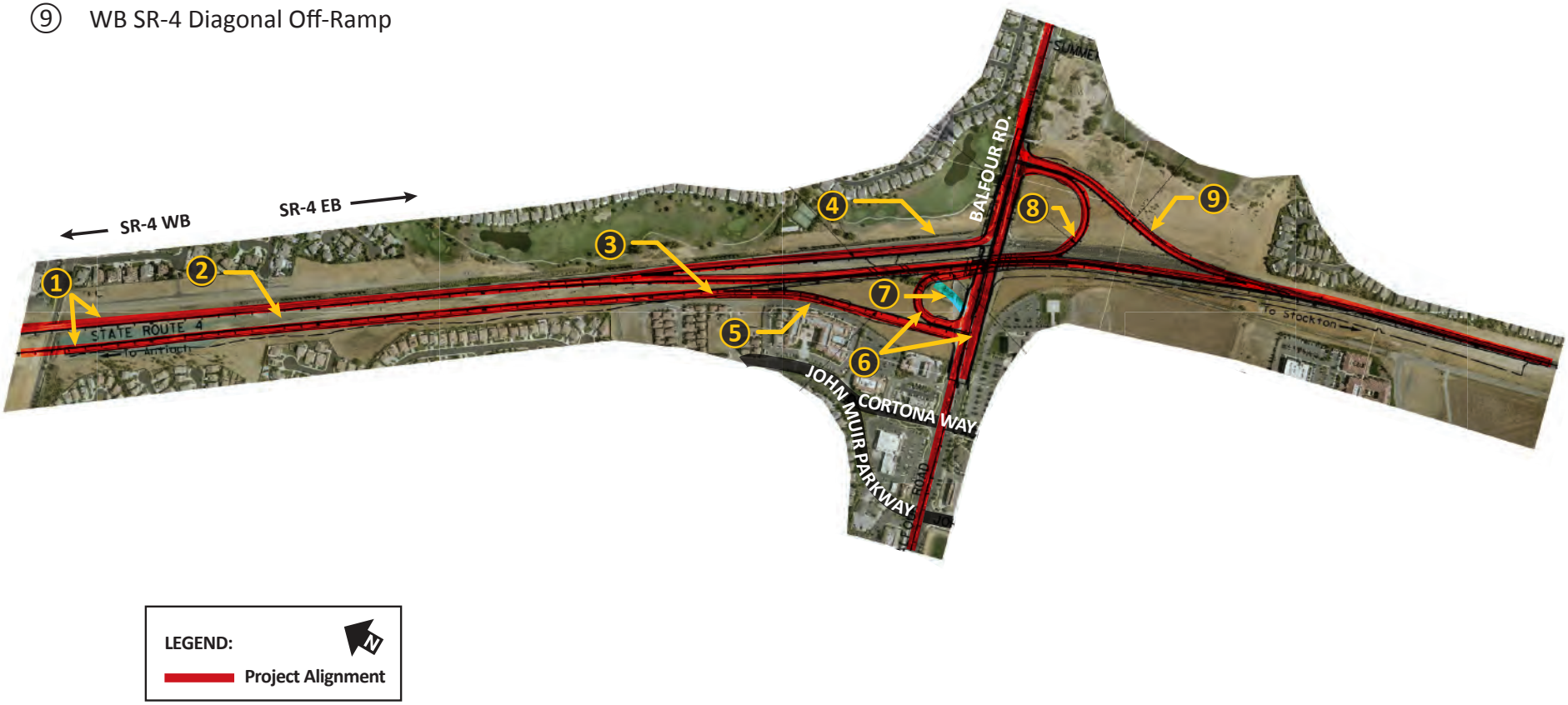
Absent means habitat not present. Would have been detectable means that the species was surveyed for during its blooming season and therefore, would have that been found if present. Status: Federal Endangered (FE); Federal Threatened (FT); Federal Proposed (FP, FPE, FPT); Federal Candidate (FC); State Endangered (SE); State Threatened (ST); Fully Protected (FP); State Rare (SR); State Species of Special Concern (SSC); California Native Plant Society (CNPS 1A)-Plants assumed extinct in California, (CNPS 1B.1) Plants rare, threatened, or endangered in California and elsewhere. (CNPS 2.2) – Plants rare, threatened, or Endangered in California but more common elsewhere.

Project Site & Vicinity

Figure 1

Source: Quincy Engineering, 2014

① Separate EB/WB Travel Lanes
② Remove Existing SR-4 Crossover
③ EB SR-4 Crossover
④ WB SR-4 On-Ramp
⑤ EB SR-4 Diagonal Off-Ramp
⑥ EB SR-4 Loop On-Ramp
⑦ Proposed Daylighted Portion of Deer Creek
⑧ WB SR-4 Loop On-Ramp
⑨ WB SR-4 Diagonal Off-Ramp



Proposed Project Improvements

Figure 2

Source: Quincy Engineering, 2014

1a: 'Daylighted' reach of Deer Creek - Spring

1b: 'Daylighted' reach of Deer Creek - Fall

Attachment D

Biological Resources Assessment

Biological Resources Assessment

for the
State Route (SR) 4/Balfour Road Project
Addendum #11

SR-4 PM 34.9/36.6

EA 04-4H1601

October 2014

Caltrans

and

Contra Costa Transportation Authority

PREPARED BY:_____ DATE: _____
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TABLE OF CONTENTS

1.0 Introduction....1
1.1 Project Location and Description....1
2.0 Study Methods....2
2.1 Review of Background Information....2
2.2 Field Reconnaissance....3
3.0 Environmental Setting....4
3.1 Setting....4
3.2 Hydrology....4
3.3 Land Cover Types....4
3.4 Preliminary Wetland Delineation....5
3.5 Movement Corridors and Habitat Fragmentation....5
4.0 Special Status Species and Habitats....5
4.1 Sensitive Natural Communities....5
4.2 Special Status Plants....6
4.2.1 HCP/NCCP Covered and No Take Plant Species....6
4.3 Special-Status Wildlife....7
4.3.1 HCP/NCCP Planning Surveys....9
4.3.2 Planning Surveys Summary: Covered and No Take Species....10
5.0 Impact and Mitigation....11
5.1 Covered and No Take Species....11
5.1.1 Plants....11
5.1.2 Wildlife....11
5.2 Other Protected Species....13
5.3 General Avoidance and Minimization Measures....15
6.0 Permitting....15
6.1 Federal and State Agency Permitting....16
6.2 Local Permitting....17
7.0 Compensation....17

LIST OF TABLES

Table 1 'Covered' and 'No Take' Plants with Potential to Occur....7
Table 2 Special-Status Wildlife with Potential to Occur....8
Table 3 Covered and No Take Wildlife Species with Potential to Occur....9

LIST OF FIGURES

Figure 1 Project Site and Vicinity
Figure 2 Project Plan
Figure 3 Land Cover Types

LIST OF APPENDICES

Appendix A Special-Status Plants Potential for Occurrence
Appendix B Special-Status Wildlife Potential for Occurrence
Appendix C Plants Observed on the Project Site
Appendix D Wildlife Occurring on the Project Site
Appendix E Photographs
Appendix F Plan Set
Appendix G Preliminary Wetland Delineation
Appendix H Special-Status Plants Survey Report

1.0 INTRODUCTION

This report is a biological assessment of the proposed State Route 4 (SR-4)/Balfour Road Project (project). This report serves as a re-validation of the addendum to the biological assessment conducted for the 1994 SR-4 Bypass Project Final Environmental Impact Report (FEIR), as well individual biological assessments conducted for Segments 2 and 3. In addition, the assessment supports an application for project participation in the East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan (HCP/NCCP) in order to receive an "Incidental Take" permit for federal and State listed species. This report also addresses biological resources as required by the California Environmental Quality Act (CEQA), and determines if the project will require any additional permits from other agencies such as the U.S. Army Corps of Engineers (USACE), California Department of Fish Wildlife (CDFW) or the Regional Water Quality Control Board (RWQCB).

1.1 PROJECT LOCATION AND DESCRIPTION

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) jointly propose to widen SR-4 from San Jose Avenue (post mile [PM] 34.9) to approximately 2,000 feet south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road in the City of Brentwood in Contra Costa County (Figure 1- *Site and Vicinity*). The project is the first phase (Phase 1) of two phases planned to be constructed as funding becomes available. It is anticipated that the next phase (known as the Ultimate Phase) will occur beyond the 20-year design period of Phase 1. Design elements have been established in the Phase 1 project to enable implementing ultimate improvements in the most cost effective manner. The purpose of the project is to improve regional circulation through eastern Contra Costa County and provide a more balanced distribution of current and future traffic over the local road network in this area.

The project will specifically include the construction of the following:

- Divided four-lane Freeway from San Jose Avenue Undercrossing to 2,000 feet north of Balfour Road. The freeway then transitions to a two-lane expressway south of Balfour Road Interchange.
- Four-lane wide undercrossing bridge structure over Balfour Road to serve bidirectional two-lane freeway traffic and two entrance loop ramps. This structure would serve only eastbound (EB) traffic in future phases.
- Four-lane wide bridge structure over Deer Creek for SR-4 freeway lanes. It would serve bidirectional traffic in Phase 1
- Two-lane bridge structure over Deer Creek for EB loop on-ramp
- EB SR-4 Diagonal off-ramp
- EB SR-4 Loop on-ramp
- Westbound (WB) SR-4 diagonal on-ramp that will be in an interim location and moved further to the east in the ultimate configuration
- WB SR-4 diagonal off-ramp
- WB SR-4 loop on-ramp
- Widening of Balfour Road to up to six lanes within the interchange area

Other improvements would include two new traffic signals for the ramp intersections, ramp metering, lighting, drainage improvements, and utility relocations.

2.0 STUDY METHODS

2.1 REVIEW OF BACKGROUND INFORMATION

The following background information was reviewed in preparation of the assessment:

California Department of Fish and Game. 2014. Natural Diversity Database (CNDDB), Brentwood and Antioch South quads. California Department of Fish and Game Natural Heritage Division. Sacramento, California. July.

California Department of Fish and Game. 2012. Staff Report on burrowing Owl Mitigation. State of California Natural Resources Agency, March 7, 2012.

Contra Costa County. 2007. Final East Contra Costa County Habitat Conservation Plan/ Natural Community Conservation Plan (HCP/NCCP). July

ESA. 1994b. State Route 4 Bypass Project, Final Environmental Impact Report. State Route 4 Bypass Authority, Martinez, CA SCH# 89032824.

ESA. 1999. State Route 4 Bypass Project, Biological Assessment. State Route 4 Bypass Authority, Martinez, CA . January.

Quincy Engineering. 2014. 95% Drawings of Project Plans.

RCL Ecology. 2008. HCP Planning Survey Report, Segment 2, Phase 2-Sand Creek Road Interchange. State Route 4 Bypass Authority, Martinez, CA. December.

U.S. Fish and Wildlife Service, Sacramento Field Office. 1999. San Joaquin Kit Fox Survey Protocol for the Northern Range.

U.S. Fish and Wildlife Service, Sacramento Field Office. 1999. Standardized Recommendations for Protection of the San Joaquin Kit Fox Prior to or During Ground Disturbance.

U.S. Fish and Wildlife Service. 2003. Interim Guidance on site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander.

U.S. Fish and Wildlife Service. 2005. Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog.

Analysis of Background Information

No new plants or wildlife have been recorded in the area since the 2011 addendum. However, new burrowing owl mitigation guidelines were issued in 2012, and changes were made to project plans in 2014. These changes are further discussed below.

Habitat Conservation Plan

Changes to the amounts due for the Development and Wetland fees were made in March of 2014, including an additional 5% fee for projects sponsored by 'Participating Special Entities' such as CCTA (as in this case). Otherwise, the HCP/NCCP operates as discussed below.

The HCP/NCCP uses a standard analysis process to determine effects on 'covered species' and to minimize the potential for 'incidental take' of those species through the use of standard conservation measures. Covered species are certain federal or State listed threatened or endangered wildlife, other federal and State protected raptors, and protected plants that have been predetermined to potentially occur within the HCP/NCCP area based on pre-modeling of land cover types. The term 'covered' refers to being included within the regional Incidental Take permit granted by the USFWS and the CDFG as part of the HCP/NCCP process.

In this process, 'Planning Surveys' are used to determine whether breeding habitat actually occurs within the project site for each of the covered species, excluding those species where habitat is absent. The results of the planning studies are used to determine whether preconstruction surveys and construction monitoring will be required in order minimize the potential for Incidental Take.

Mitigation of impacts is accomplished through fees that are funneled into two separate funds – the Development Fee and the Wetland Fee. The Development Fee requires payment based on a cost per acre for all acres within the project area with the cost per acre based on the quality of the habitat. The Wetland Fee is an additional per acre payment based on the amount and type of wetland or waters affected. These funds are used to acquire higher value habitats in preserved areas and to fund their restoration and management. This method precludes the need for presence/absence surveys as the covered special-status species are presumed present if their breeding habitat is present. It also eliminates the need for various mitigation ratios per species that were used previously in mitigation calculations.

2.2 FIELD RECONNAISSANCE

Following review of the above information, Randall Long of RCL Ecology performed pedestrian surveys of the project area on March 5 and March 19, 2012 and on May12 and June 13, 2014. During these visits, all cover types were mapped on a 250-scale aerial photo. Deer Creek was surveyed for its potential as jurisdictional waters and for its potential use as breeding habitat by the California tiger salamander and California red-legged frog. Ground squirrel burrows were examined for signs of use by the western burrowing owl (*Athene cunicularia*) and San Joaquin kit fox (*Vulpes macrotis mutica).* All trees were checked for nesting protected birds.

3.0 ENVIRONMENTAL SETTING
3.1 SETTING

The project area lies in a nearly flat annual grassland type surrounded by urban development. The project area is bound by the John Muir Outpatient Clinic on the southwest, the Summerset Golf Course on the northeast and southeast, and the Cortona Park assisted living facility and Kinder Morgan gas pipeline and pump station on the northwest. Much of the area within the right-of-way (ROW) has been previously disturbed during construction of the existing Balfour Road intersection, realignment of Concord Avenue, and construction of the Kinder Morgan facilities. A portion of Deer Creek flows through the northwest quadrant of the site and is the only waters within the project area.

3.2 HYDROLOGY

Deer Creek is a third order intermittent stream originating in the hills west of the project area. It is intermittent in its upper reaches but becomes perennial where it is detained in the Water Quality ponds approximately ¾-mile west of the project area. From that point it is piped to a daylighted channel within the project ROW and then further piped beneath SR-4 to outfall at the eastern ROW boundary. From that point it flows to Marsh Creek which flows to the San Joaquin River. Drainage from the project area flows into Deer Creek through drop structures within engineered bio swales along the existing SR-4. Runoff from the project construction will utilize the existing drainage system.

3.3 LAND COVER TYPES

The following description of land cover types follows the Land Cover Types described in the HCP/NCCP. These types are urban, ruderal, grassland and riparian/woodland scrub. These land cover types are shown in Figure 3a

Urban

Urban cover includes the existing roadways and adjacent areas such as the Kinder Morgan site that have been graveled for past access or laydown sites.

Ruderal

Ruderal vegetation is characterized by sparse, non-native, weedy plants on disturbed sites adjacent to the existing roadway. Common species in this type include black mustard (*Brassica nigra*), yellow star thistle (*Centaurea solstitialis*), bur clover (*Medicago polymorpha)*, and sour clover (*Melilotus indica*). The abandoned portion of Concord Avenue in the southwest portion of the project area is classified in the ruderal category.

Non-Native Annual grassland

As described in the HCP/NCCP, annual grassland is characterized by grass and forb species dominating the land cover and where trees and shrubs comprise less than 5 percent canopy cover.

This plant community is dominated by non-native annual grasses including wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), soft chess (*Bromus hordeaceus*), and Italian ryegrass (*Lolium multiflorum*). Common forbs include fiddleneck (*Amsinckia menziesii* var. *intermidia*), rose clover (*Trifolium hirtum*), hairy vetch (*Vicia villosa* ssp. *villosa*), cut-leaved geranium (*Geranium dissectum*), and California poppy (*Eschscholzia californica*) among others.

Riparian/woodland scrub

The 'daylighted' portion of Deer Creek is composed of a riparian/woodland scrub vegetative type. As described in the HCP/NCCP, this type is dominated by young trees and scrubs typically representing an early successional stage of riparian woodland. Trees consist of saplings and mature Fremont cottonwood (*Populus fremontii)* and red willow (*Salix laevigata*). Shrubs consist of California rose (*Rosa californica*) and blue elderberry (*Sambucus mexicana*). Herbaceous and wetland species consist of broad-leaved pepperweed (*Lepidium latifolium*), narrow-leaved cattail (*Typha angustifolia*), red-tinge bulrush (*Scirpus macrocarpus*) and purple flat sedge (*Cyperus rotundus*).

3.4 PRELIMINARY WETLAND DELINEATION

The waters within the three segments of SR-4 were delineated in 1998 and verified by the USACE in 1999. That verification expired on April 27, 2004. Therefore, RCL Ecology prepared a preliminary wetland delineation of the reach of Deer Creek within the project ROW for USACE verification. The reach averages approximately 54 feet wide at top of bank (TOB) and 25 feet wide at ordinary high water (OHW). The preliminary wetland delineation report is enclosed as Attachment G

3.5 MOVEMENT COORIDORS AND HABITAT FRAGMENTATION

Prior to development, the Deer Creek drainage likely served as a movement corridor for species dependent on the presence of riparian cover. As much of the drainage both up and downstream has now been denuded of riparian vegetation or piped, it provides little use for species dependent on riparian cover. However, while the Creek has limited use as a movement corridor, SR-4 provides a movement corridor for several species of birds such as the burrowing owl that are is dependent on grassland cover and the presence of ground squirrel burrows. Development of the intersection would not materially fragment this movement corridor as grassland and ground squirrel habitat would remain within sufficient portions of the ROW.

4.0 SPECIAL STATUS SPECIES AND HABITATS

4.1 SENSITIVE NATURAL COMMUNITIES

Two natural communities occur within the study area: annual grassland and riparian woodland/scrub. No uncommon vegetation or uncommon landscape features as listed in the HCP/NCCP occur on the site.

4.2 SPECIAL-STATUS PLANTS

Based on the CNDDB, 29 special-status plants occur within the surrounding nine quadrangles adjacent to the Brentwood, California quadrangle. Protocol surveys were conducted for these plants during preparation of the 1994 FEIR, the subsequent biological assessment (1999), and for Addendum #10 in 2010. No special-status plants were found during these surveys. However; as agency protocols require that plant surveys have to be updated every two years, RCL Ecology conducted a new special-status plant survey in the spring and fall of 2013. No special-status plants were found during this survey. The special-status plant survey report is enclosed as attachment H.

4.2.1 HCP/NCCP COVERED AND NO-TAKE PLANT SPECIES

The HCP/NCCP lists 13 species of 'covered' and 'no-take' species as occurring in annual grassland or wetlands within the Plan area (Table 1). As these are a subset of the above species, they were also considered to be absent from the site.

Table 1: 'Covered' and 'No Take' Plants with Potential to Occur in Annual Grassland or Wetlands

LAND COVER TYPE	SPECIES	HCP STATUS C=COVERED N=NO TAKE	HABITAT PRESENT	BLOOMING PERIOD
√ Annual grassland	San Joaquin spearscale (*Atriplex joaquiniana*)	C	No	Apr–Oct
	Alkali milkvetch (*Astragalus tener* ssp. *tener*)	N	Yes	Mar–Jun
	Big tarplant (*Blepharizonia plumosa*)	C	Yes	Jul–Oct
	Brewer's dwarf flax (*Hesperolinon breweri*)	C	No	May–Jul
	Contra Costa goldfields (*Lasthenia conjugens*)	N	No	Mar–Jun
	Diamond-petaled poppy (*Eschscholzia rhombipetala*)	N	Yes	Mar–Apr
	Large-flowered fiddleneck (*Amsinckia grandiflora*)	N	Yes	Apr–May
	Mount Diablo buckwheat (*Eriogonum truncatum*)	N	No	Apr–Sep; uncommonly Nov–Dec
	Mount Diablo fairy-lantern (*Calochortus pulchellus*)	C	No	Apr–Jun
	Round-leaved filaree (*California macrophylla*)[1]	C	Yes	Mar–May
	Showy madia (*Madia radiata*)	C	Yes	Mar–May
Seasonal wetland	Adobe navarretia (*Navarretia nigelliformis* ssp. *nigelliformis*)	C	No	Apr–Jun
	Contra Costa goldfields (*Lasthenia conjugens*)	N	No	Mar–Jun

[a] From California Native Plant Society. 2007. *Inventory of Rare and Endangered Plants* (online edition, v7-07d). Sacramento, CA. Species may be identifiable outside of the typical blooming period; a professional botanist shall determine if a covered or no take plant occurs on the project site.
[b] See Species Profiles in Appendix D of the Final HCP/NCCP.

4.3 Special-Status Wildlife

Thirteen (13) special-status wildlife species were analyzed for occurrence on the project site. Their federal or State listing status, HCP/NCCP status as to 'covered' or 'no take', and potential for occurrence are shown on Table 2.

Table 2: Special-Status Wildlife with Potential to Occur on the Project Site

SPECIES	LISTING STATUS	HCP/NCCP STATUS	POTENTIAL FOR OCCURRENCE
Accipiter cooperii Cooper's hawk	Fed: MB CA:WL	_	Possible
Ambystoma californiense California tiger salamander	Fed: FT CA: SSC	Covered	Possible
Antrozous pallidus Pallid bat	Fed: None CA: SCC	_	Possible
Athene cunicularia Western burrowing owl	Fed: MB CA: SSC	Covered	Present
Elanus leucurus White-tailed kite	Fed: MB CA: FP	Covered, No Take	Possible
Desmocerus californicus dimorphus Valley elderberry longhorn beetle	Fed: FT CA: None	_	Possible
Eremophila alpestris actia California horned lark	Fed: MB CA: WL	_	Possible
Falco columbarius Merlin	Fed: MB CA: WL	_	Possible
Hirundo rustica Barn swallow	Fed: MB CA: SSC	-	Present
Lanius ludovicianus Loggerhead shrike	Fed: MB CA: SSC	_	Present
Lasiurus blossevillii Western red bat	Fed: None CA: SSC	_	Possible
Oncorhynchus tschawytschai Central Valley fall run Chinook salmon	Fed: FT CA: SSC	_	Possible
Petrochelidon pyrrhonota Cliff swallow	Fed: MB CA: SSC	-	Present
Rana draytonii California red-legged frog	Fed: FT, CH CA: SSC	Covered	Possible
Vulpes macrotis mutica San Joaquin kit fox	Fed: FE CA: ST	Covered	Possible

Index to Codes:
MB – Protected under the federal Migratory Bird Treaty Act
WL – State watch list
FT - Federally listed Threatened
SSC State special concern
FP - State fully protected
FE – Federally listed Endangered
ST – State listed Threatened
CH - Critical habitat has been designated for this species
SA- State Special Animal

4.3.1 HCP/NCCP PLANNING SURVEYS

Table 3 shows the results of planning surveys for 'Covered' and 'No Take' wildlife.

Table 3: Covered and No Take Wildlife Species with Potential to Occur

LAND COVER TYPE	SPECIES	PLANNING SURVEY REQUIREMENTS	PLANNING SURVEY RESULTS
Annual Grassland	San Joaquin kit fox Burrowing owl	Identify/map potential Identify/map potential habitat	Habitat present Breeding present
Aquatic land cover Types: Stream	Giant garter snake California red-legged frog California tiger salamander Longhorned fairy shrimp Vernal pool fairy shrimp Midvalley fairy shrimp Vernal pool tadpole shrimp	Identify/map potential habitat Identify/map potential breeding habitat. Identify /map potential breeding habitat; document habitat quality/features, photo-document. Identify/map potential breeding habitat	No habitat present Potential breeding & aestivation habitat present Potential breeding and aestivation habitat present. No shrimp habitat present
All land cover types: Riparian woodland scrub Ruderal Urban	Townsend's big-eared bat Swainson's hawk Golden eagle	Map/document potential breeding habitat. Inspect large trees for presence/absence of nests Document/map potential nests	No habitat present Potenial nesting habitat is present adjacent to the off-site Kinder .Morgan access road.
Any land cover type	American peregrine falcon	Identify/map potential nesting habitat	No nests identified No nesting habitat present.
	White-tailed kite	Identify/map potential nesting habitat	No nests identified. Nesting habitat present.
	Ringtail	Identify/map potential breeding habitat.	No habitat present.

4.3.2 PLANNING SURVEYS SUMMARY: 'COVERED' AND 'NO TAKE' SPECIES

Planning surveys found that breeding is occurring for the western burrowing owl and potential breeding habitat exists for the San Joaquin kit fox, California red-legged frog, California tiger salamander and the white-tailed kite.

San Joaquin Kit Fox

Although ground squirrel burrows occur within the proposed project area none appear to be of suitable size (e.g. 5-inches in diameter or greater) to serve as kit fox dens. However, to ensure that the project will not affect the species, a kit fox preconstruction survey will be conducted prior to the start of work.

California Red-legged Frog (CRLF)

The daylighted section of Deer Creek may serve as a breeding site for CRLF and adjacent areas are potential aestivation habitat. While visual surveys at the site were negative for CRLF larvae and other amphibians, a large splash was heard at the pool in this section. The splash would indicate the presence of either bullfrog or CRLF. Therefore, the agencies will be notified in advance of construction for potential removal of CRLF per HCP/NCCP protocols.

California Tiger Salamander (CTS)

The above pool may also serve as a breeding site for CTS and adjacent areas may provide potential aestivation habitat. While surveys at the site were negative for adult CTS and larvae, the agencies will be notified in advance of construction per HCP/NCCP protocols.

Western Burrowing Owl

Two burrowing owls were observed in the northwest quadrant during the November 1 survey, and three other sites exhibited sign of burrowing owls (regurgitated pellets and prey remains). Therefore, passive eviction techniques will be used to clear the area of owls before the start of the nesting season (February 1) so that the project will have no effect on the western burrowing owl.

White–Tailed Kite

Fremont cottonwoods within the daylighted portion of Deer Creek are large enough to furnish nesting habitat for the white-tailed kite. Therefore, preconstruction nest surveys will be conducted for the white-tailed kite if construction is planned to occur within the nesting season (February 1-August 31).

5.0 IMPACT AND MITIGATION

5.1 'COVERED' AND 'NO TAKE' SPECIES.

5.1.1 PLANTS

The 'covered', 'no take' and other special status plants were not found to be present in the project site during previous protocol surveys. The current planning surveys verified that special-status plant habitat is absent on the project site.

5.1.2 WILDLIFE

Less Than Significant Impact with Mitigation Incorporated

San Joaquin kit fox

Preconstruction Surveys

Prior to any ground disturbance related to covered activities, a USFWS/CDFG-approved biologist will conduct a preconstruction survey of the project area. The survey will establish the presence or absence of San Joaquin kit foxes and/or suitable dens and evaluate use by kit foxes in accordance with USFWS survey guidelines (USFWS, 1999). Preconstruction surveys will be conducted within 30 days of ground disturbance. Within the project's ROW, the biologist will survey the proposed disturbance footprint and a 250-radius from the perimeter of the proposed footprint to identify San Joaquin kit foxes and/or suitable dens. The status of all dens will be determined and mapped. Written results of preconstruction surveys will be submitted to USFWS within 5 working days after survey completion and before the start of ground disturbance. If San Joaquin kit foxes and/or suitable dens are identified in the survey area, the avoidance and minimization measures described in the section below will be implemented.

Avoidance and Minimization Measures

If a San Joaquin kit fox is discovered in the proposed development footprint, the den will be monitored for 3 days by a USFWS/CDFG-approved biologist using a tracking medium or an infrared beam camera to determine if the den is currently being used. Unoccupied dens will be destroyed immediately to prevent subsequent use. If a natal den or pupping den is found, USFWS and CDFG will be notified immediately. The den will not be destroyed until the pups and adults have vacated and then only after further consultation with USFWS and CDFG. If kit fox activity is observed at the den during the initial monitoring period, the den will be monitored for an additional 5 consecutive days from the time of the first observation to allow any resident animals to move to another den while den use is actively discouraged. For dens other than natal or pupping dens, use of the den can be discouraged by partially plugging the entrance with soil such that any resident animal can easily escape. Once the den is determined to be unoccupied, it may be excavated under the direction of the biologist. Alternately, if the animal is still present after 5 or more consecutive days of plugging and monitoring, the den may have to be excavated

when, in the judgment of a biologist, it is temporarily vacant (i.e. during the animals' normal foraging activities).

Construction Monitoring

If dens are identified in the survey area outside the proposed disturbance footprint, exclusion zones around each den entrance or cluster of entrances will demarcated. The configuration of exclusion zones should be circular, with a radius measured outward from the den entrance(s). No covered activities will occur within the exclusion zones. Exclusion zone radii for potential dens will be at least 50 feet and will be demarcated with four to five flagged stakes. Exclusion zone radii for known dens will be at least 100 feet and will be demarcated with staking and flagging that encircles each den or cluster of dens but does not prevent access to the den by kit fox.

California Red-legged Frog and California Tiger Salamander

As required by the HCP/NCCP, proper written notification will be provided to USFWS, CDFG, and the Implementing Entity at least 30 days prior to disturbance of potential habitat in order to provide an opportunity for these agencies to translocate any individuals of these species. The agencies in turn are required to notify the proponent within 14 days of their intent to translocate the species. The agencies will then be allowed 45 days to translocate individuals from the date the first written notification was submitted by the project proponent (or a longer period agreed to by the project proponent, USFWS, and CDFG).

Western Burrowing Owl

Prior to the start of the breeding season (February 1), a USFWS/CDFG-approved biologist will conduct preconstruction surveys of the project area to determine the presence of burrowing owls. If present, the birds will be evicted from the site using passive relocation techniques. The site will then be continuously monitored until the start of construction in order to ensure that owls do not reoccupy the area. All surveys and passive relocation will be carried out in accordance with CDFG survey guidelines (CDFG, 1993). Passive relocation procedures include installing one-way doors in burrow entrances. These doors should be in place for 48 hours prior to excavation. The project area should be monitored daily for 1 week to confirm that the owl has abandoned the burrow. Whenever possible, burrows will be excavated using hand tools and refilled to prevent reoccupation (CDFG, 1995). Plastic tubing or a similar structure will be inserted in the tunnels during excavation to maintain an escape route for any owls inside the burrow.

White-tailed Kite

If project construction is scheduled to start during the breeding season (February 1- August 31), preconstruction surveys should be conducted within the project area and a 300-foot buffer, by a qualified biologist no more than two weeks prior to equipment or material staging, or surface-disturbing activities. If no active nests are found within the project area and 300-foot buffer, no further mitigation is necessary.

If active nests (i.e. nests in the egg laying, incubating, nestling, or fledgling stages) are found within 300 feet of the project footprint, non-disturbance buffers should be established at a distance sufficient to minimize disturbance based on the nest location, topography, cover, the nesting pair's tolerance to disturbance, and duration of potential disturbance. No work should occur within the non-disturbance buffers until the young have fledged as determined by a qualified biologist, Buffer size should be determined in cooperation with the CDFG and the USFWS. If buffers are established and it is determined that project activities are resulting in nest disturbance, work should cease immediately, and the CDFG and the USFWS should be contacted for further guidance.

5.2 OTHER PROTECTED SPECIES

5.2.1 Federally Listed Threatened

Valley Elderberry Longhorn Beetle (VELB)

According to Peter Johnson of the USFWS, the closest location of an extant population of VELB is near Stockton, California (Personal communication with Randall Long). This is also the opinion of expert entomologist Richard Arnold, Ph.D. who examined the blue elderberry plants in nearby Sand Creek and found no evidence of use by VELB (personal communication between Richard Arnold and Randall Long).

Even though VELB occurrence in the project area is very unlikely, the following procedure shall be used to ensure that the project will have no effect on the VELB. Prior to start of work, a qualified biologist should examine the blue elderberry shrubs for signs of exit holes indicating active use of the plants by VELB. If exit holes are found, the biologist will contact the USFWS for a course of action. If no exit holes are found, the plants can be removed if they will be affected by the construction.

Central Valley fall run Chinook salmon

On March 24 and April 16, biologist Randall Long conducted a CDFW 'first pass' barrier assessment of Deer Creek from the confluence with Marsh Creek upstream to the project area to determine if salmon could migrate from Marsh Creek to the project area. No salmon were observed anywhere within the reach and the study found that upstream passage is blocked by an approximate 150 foot long rock gabion weir at the upstream end of the Deer Creek Flood Control Basin that is approximately one mile from the project area. Mosquitofish are the only fish present within the project area portion of Deer Creek, and the project will have no effect on the mosquitofish population.

5.2.2 State protected

Less Than Significant Impact with Mitigation Incorporated

Bats

The pallid and western red bats are listed as CDFW Special Concern species. The pallid bat prefers to roost in buildings, caves and other structures not present on site but may forage in the area. The red bat is a riparian obligate and may roost and forage along the channel. . In order to avoid impacts to these species during project activity, the following avoidance and minimization measures are recommended.

Avoidance and minimization

Preconstruction surveys of the trees within the riparian area will be conducted in advance of construction to detect bat roosting. If roosting is found protective fencing will be erected to prevent disturbance to the roost site. The fence location will be monitored by the biological monitor to ensure it stays secure for the duration of project work.

State protected birds

Four birds with potential to occur on the site are listed on the State watch list, or are of State special concern. These include birds of prey, the merlin, Cooper's hawk, and loggerhead shrike; as well as a songbird – the California horned lark. The following avoidance and minimization measure is recommended to avoid any impact to these species.

Avoidance and minimization

If project construction is scheduled to begin during the breeding season (February 1- August 31), preconstruction surveys will be conducted within the project area and a 300-foot buffer, by a qualified biologist no more than two weeks prior to equipment or material staging, or surface-disturbing activities. If no active nests are found within the project area and 300-foot buffer, no further mitigation is necessary.

If active nests (i.e. nests in the egg laying, incubating, nestling or fledgling stages) are found within 300 feet of the project footprint, non-disturbance buffers should be established at a distance sufficient to minimize disturbance based on the nest location, topography, cover, the nesting pair's tolerance to disturbance and duration of potential disturbance. No work should occur within the non-disturbance buffers until the young have fledged as determined by a qualified biologist. Buffer size should be determined in cooperation with the CDFW and the USFWS. If buffers are established and it is determined that project activities are resulting in nest disturbance, work should cease immediately and CDFW and USFWS should be contacted for further guidance.

5.3 GENERAL AVOIDANCE AND MINIMIZATION MEASURES

- Prior to the start of construction, the biological monitor will flag the boundaries of the aquatic resources so that ESA fence can be installed by the contractor to protect downstream water quality during construction activity. The biological monitor will inspect the fence to ensure correct depth and placement and monitor the fencing to ensure that it remains during construction activity.

- A biological monitor should be on site during all construction activity near the waters and riparian habitat to ensure implementation of, and compliance with all avoidance measures.

- The biological monitor will conduct Worker Environmental Awareness Training for all construction crews and contractors. The education training should be conducted prior to starting work on the project and upon the arrival of any new workers. The training should include a review of sensitive areas and avoidance and minimization measures to be employed to protect the covered and no take species. A record of all personnel trained during the project should be maintained for compliance verification.

- Staging areas and access routes through the project will be reviewed by the biological monitor to ensure that they do not impact any sensitive areas.

6.0 PERMITTING

The project will require two actions affecting the portion of Deer Creek within the project ROW and require coverage under the HCP/NCCP 'Incidental Take' permit. The two actions and additional required permits are discussed below:

1. Reversion of a section of the piped portion of the Creek to open channel.
2. Construction of two clear span bridges across the daylighted portion of the Creek.

The first will require working below ordinary high water (OHW) for removal of pipe, removal and replacement of headwalls and installation of rip-rap protection. Therefore, a USACE 404 permit, RWQCB 401 permit and CDFW 1602 Streambed Alteration Agreement will be required.

Clear span bridging of the Creek, while not affecting the wetted area, will result in removal of existing riparian woodland/scrub vegetation during construction and permanent shading out of this vegetation when construction is completed. Planned replacement of the headwall will require work below OHW and will require a USACE 404 permit, as well as a CDFW 1602 and RWQCB 401. However, all of the above work will be covered under a single application to each of the above agencies.

The project will also need to comply with the National Pollution Discharge Elimination System (NPDES) permit requirements of the California State Water Resources Control Board (SWRCB) and the requirement for preparation of a Storm water Pollution Prevention Plan (SWPPP) as required by the RWQCB under the Contra Costa County Storm water Management Plan (CCCSWMP) Section C-3.

A description of these permits is provided below.

6.1 STATE AND REGIONAL PERMITTING

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE (CDFW)

The CDFW exercises jurisdiction over wetland and riparian resources associated with rivers, streams, and lakes under California Fish and Wildlife Code Sections 1600 to 1607. The CDFW has the authority to regulate work that will substantially divert, obstruct, or change the natural flow of a river, stream, or lake; substantially change the bed, channel, or bank of a river, stream, or lake; or use material from a streambed. CDFW's jurisdictional area along a river, stream or creek is usually bounded by the top-of-bank or the outermost edges of riparian vegetation.

Prior to undertaking any activity that will impact any of the above biological resources, a *Lake or Streambed Alteration Agreemen*t (1602) must be obtained from CDFW. An application for a Streambed Alteration Agreement requires a complete project description, a biological assessment of the project site, hydrology report, analyses of direct, indirect and cumulative impacts, a technically-defensible biological mitigation and monitoring plan, documentation of alternatives analysis and efforts to avoid and minimize adverse impacts, a relevant CEQA document, and a Notice of Determination (NOD) that demonstrates the project has complied with CEQA.

The CDFW Code also requires protection of nesting raptors (birds of prey) and the California Endangered Species Act requires mitigation and compensation for project effects on listed species. These concerns are addressed during CDFW review of the projects' CEQA document.

STATE WATER RESOURCES CONTROL BOARD (SWRCB)

The SWRCB regulates water runoff from land development under authority of the NPDES permitting process.

Storm Water Discharge

Three actions will be required under NPDES procedures as follows:

1.) File Notice of Intent (NOI) to comply with the State General Plan for Storm Water discharge.

2.) Prepare a SWPPP

All projects disturbing one acre of more of land must provide a SWPPP describing the Best Management Practices (BMPs) that will be used to minimize sediment and other pollutants from draining from the project site during the construction phase.

3.) Prepare a Storm Water Control Plan per the Contra Costa County Clean Water Program (C-3 handbook), and the City of Brentwood's Storm water Management and Discharge Control Ordinance (No. 793). Projects that create or replace more than one acre of impervious area are required to prepare the above plan that contains the details of design and monitoring of storm water control facilities both during and post-construction.

6.2 LOCAL PERMITTING

HCP/NCCP IMPLEMENTING AGENCY COMPLIANCE

Under the terms of the HCP/NCCP the project applicant must make application to the East Contra County Habitat Conservancy to receive take authorization under the federal and state permits for the covered species under the Plan. This process is accomplished concurrently with submittal of the CEQA document and must include the following information.

- A Planning Survey Report documenting the methods and results of required planning surveys, the methods of applicable preconstruction surveys, and the methods of applicable construction monitoring.

- A verified wetland delineation report is also required if jurisdictional wetland and waters are present on site.

- Documentation of how applicable avoidance and minimization requirements have been incorporated into the proposed project.

The HCP/NCCP application review agency will then grant 'take' authorization for the project once the following conditions have been met.

- The HCP/NCCP permit application is deemed complete.
- The required fees have been paid.
- The permit terms and conditions have been set.
- The HCP/NCCP application review agency makes a determination of consistency with the HCP/NCCP.

7.0 COMPENSATION

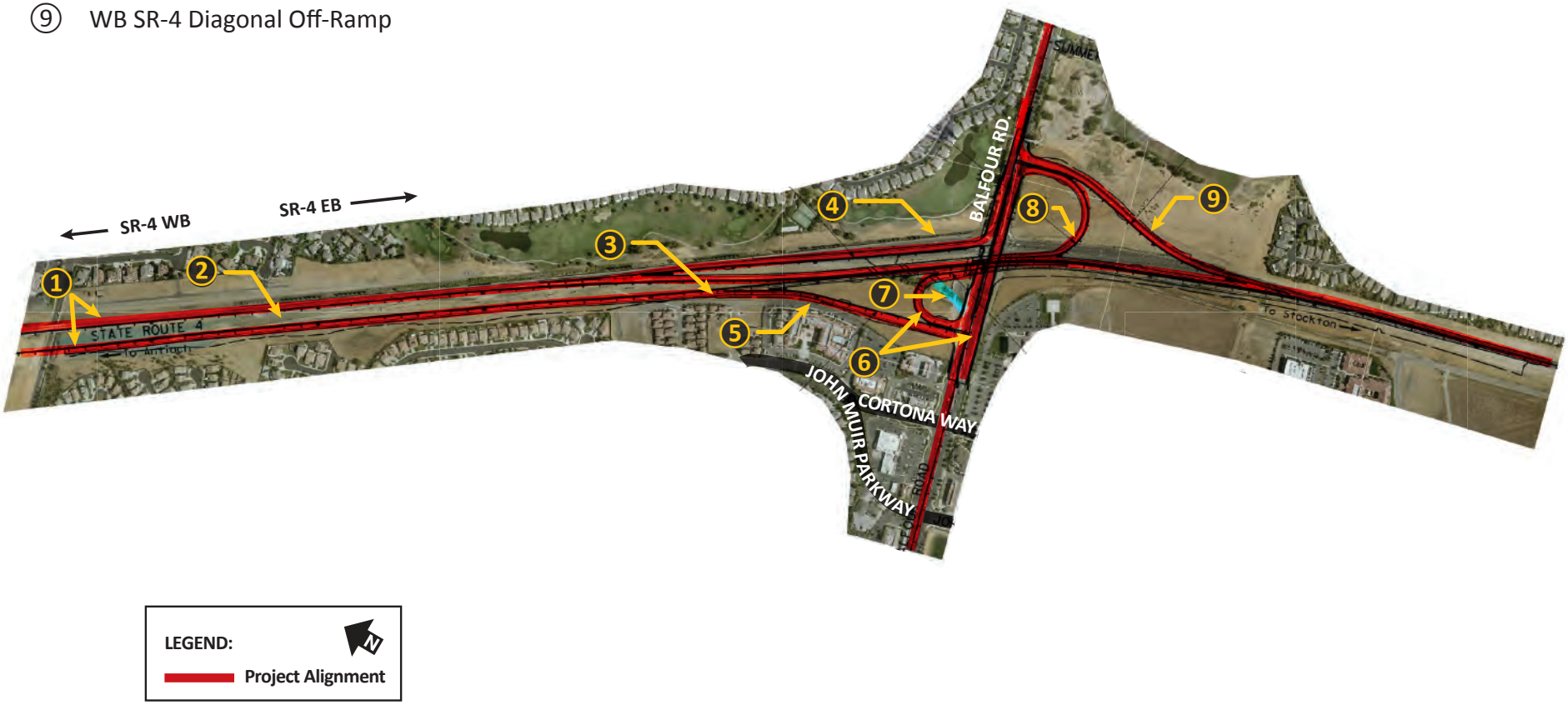
Compensation for the loss of habitat will be accomplished by payment into the HCP/NCCP Development Fee fund. Compensation for impact to waters and riparian habitat will be accomplished by payment into the HCP/NCCP Wetland Fee fund. Compensation for temporary impacts will be paid into the Temporary wetland impacts fund. Fee amounts and further explanation can be found in the HCP/NCCP Planning Surveys Report.

Project Site & Vicinity

Figure 1

Source: Quincy Engineering, 2014

① Separate EB/WB Travel Lanes
② Remove Existing SR-4 Crossover
③ EB SR-4 Crossover
④ WB SR-4 On-Ramp
⑤ EB SR-4 Diagonal Off-Ramp
⑥ EB SR-4 Loop On-Ramp
⑦ Proposed Daylighted Portion of Deer Creek
⑧ WB SR-4 Loop On-Ramp
⑨ WB SR-4 Diagonal Off-Ramp



Proposed Project Improvements

Figure 2

Source: Quincy Engineering, 2014

8.0 APPENDICES

Appendix A Special-Status Plants Potential for Occurrence at the Project Site
Appendix B Potentially-Occurring Special-Status Wildlife Species at the project site.
Appendix C Plants Observed at the Project Site
Appendix D Animals Observed at the Project Site
Appendix E Photos of the Project Site
Appendix F Plan Set
Appendix G Preliminary Wetland Delineation

APPENDIX A

SPECIAL-STATUS PLANTS
POTENTIAL FOR OCCURRENCE AT THE
PROJECT SITE

Family **Scientific Name** **Common Name**	**Status**[1]		**Habitat Affinities and Reported Localities in the Project Area**	**Blooming Period/ Life Form**	**Habitat** **Present/Absent**
Apiaceae					
Lilaeopsis masonii Mason's lilaeopsis	Federal State CNPS	SC CR 1B:2-2-3	Intertidal brackish and freshwater marshes along stream banks. Recorded in the San Joaquin and Sacramento River Delta and lower Napa River channel.	April-Oct Perennial herb	Absent
Asteraceae					
Aster lentus Suisun Marsh aster	Federal State CNPS	SC CEQA 1B:2-2-3	Freshwater and brackish marshes. Known from the Napa River and San Joaquin/Sacramento River Delta.	May-Nov Perennial herb	Absent, would have been detectable
Balsamorhiza macrolepis var. *macrolepis* big-scale balsamroot	Federal State CNPS	none CEQA 1B:2-2-3	Cismontane woodland, Valley/foothill grassland, sometimes on serpentinite. Occurs from the Bay Area to the northern Sacramento Valley and Sierra foothills.	March-June Perennial herb	Absent, would have been detectable

Blepharizonia plumosa ssp. *plumosa* big tarplant	Federal State CNPS	none CEQA 1B:3-3-3	Valley/foothill grasslands, on dry sites. Extant in Alameda and Contra Costa counties. Believed extirpated in San Joaquin, Stanislaus and Solano counties.	July-Oct Annual herb	Absent, would have been detectable
Helianthella castanea Diablo helianthella	Federal State CNPS	SC CEQA 1B:3-2-3	Broadleaf upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, and Valley/foothill grassland. Occurs in Alameda, Contra Costa and San Mateo counties; presumed extirpated in Marin and San Francisco counties.	April-June Perennial herb	Absent
Isocoma arguta Carquinez goldenbush	Federal State CNPS	SC CEQA 1B:3-3-3	Valley/foothill grasslands, on alkaline sites. Restricted to Contra Costa and Solano counties in the vicinity of the Carquinez Straits.	Aug-Dec Perennial shrub	Absent
Lasthenia conjugens Contra Costa goldfields	Federal State CNPS	FE CEQA 1B:3-3-3	Mesic sites in Valley/foothill grassland, vernal pools. Restricted to Napa and Solano counties; presumed extirpated in Alameda, Contra Costa, Mendocino, Santa Barbara and Santa Clara counties.	Mar-June Annual herb	Absent, would have been detectable
Madia radiata showy madia	Federal State CNPS	none CEQA 1B:2-3-3	Valley/foothill grasslands below 250 feet, and cismontane woodland. Occurs throughout the Central Coast and Central Valley. Presumed extirpated in Contra Costa County.	March-May Annual herb	Absent, would have been detectable
Senecio aphanactis rayless ragwort	Federal State CNPS	none CEQA 2:3-2-1	Coastal scrub and cismontane woodland on alkaline soils. Known from the South Coast, Central Coast, Central Valley and San Francisco Bay.	Jan-April Annual herb	Absent, would have been detectable

Boraginaceae

Amsinckia grandiflora large-flowered fiddleneck	Federal State CNPS	FE CE 1B:3-3-3	Cismontane woodland, Valley/foothill grassland. Known from only three natural occurrences in Alameda, Contra Costa and San Joaquin counties.	April-May Annual herb	Absent, would have been detectable
Plagiobothrys hystriculus bearded popcorn-flower	Federal State CNPS	none CEQA 1A	Vernal pools and mesic Valley/foothill grassland. Presumed extinct. Endemic to Solano County.	April-May Annual herb	Absent, would have been detectable
Brassicaceae					
Erysimum capitatum ssp. *angustatum* Contra Costa wallflower	Federal State CNPS	FE CE 1B:3-3-3	Stabilized interior dunes. Known from only two occurrences on the dunes east of Antioch, along the San Joaquin River.	Mar-July Perennial herb	Absent, would have been detectable
Tropidocarpum capparideum caper-fruited tropidocarpum	Federal State CNPS	SC CEQA 1A	Valley/foothill grasslands (alkaline hills). Known historically from Alameda, Contra Costa, Glenn, Monterey, Santa Clara and San Joaquin counties; presumed extinct. Last seen in 1957.	Mar-April Annual herb	Absent
Campanulaceae					
Downingia pusilla dwarf downingia	Federal State CNPS	none CEQA 2:1-2-1	Mesic sites in Valley/foothill grassland and vernal pools. Occurs from Sonoma and Napa counties through the Sacramento Valley and Sierra foothills.	Mar-May Annual herb	Absent
Chenopodiaceae					
Atriplex joaquiniana San Joaquin spearscale	Federal State CNPS	SC CEQA 1B:2-2-3	Chenopod scrub, Valley/foothill grassland and alkali meadows. Occurs from Solano County throughout the Sacramento and San Joaquin valleys. Presumed extirpated in Santa Clara, San Joaquin and Tulare counties.	April-Sept. Annual herb	Absent, would have been detectable
Ericaceae					
Arctostaphylos auriculata Mt. Diablo manzanita	Federal State CNPS	none CEQA 1B:3-1-3	Chaparral, in canyons and on slopes, on sandstone. Known only from Mt. Diablo area in Contra Costa County.	Jan-March Evergreen shrub	Absent
Fabaceae					

Lathyrus jepsonii var. *jepsonii* Delta tule pea	Federal State CNPS	SC CEQA 1B:2-2-3	Freshwater and brackish marshes. Occurs throughout the Sacramento San Joaquin River delta, San Francisco Bay and Central Valley.	May-Sept Perennial herb	Absent
Geraniaceae					
Erodium macrophyllum Round-leaved filaree	Federal State CNPS	none none 2	Cismontane woodland; valley and foothill grassland	Mar-June Annual herb	Absent, would have been detectable
Lamiaceae					
Scutellaria lateriflora blue skullcap	Federal State CNPS	none CEQA 2:3-2-1	Mesic meadows, marshes and swamps. Reported from Inyo and San Joaquin counties, to New Mexico and Oregon. Known from only two occurrences in California.	July-Sept perennial herb (rhizomatous)	Absent
Liliaceae					
Calochortus pulchellus Mt. Diablo fairy-lantern	Federal State CNPS	none CEQA 1B:2-2-3	Chaparral, cismontane woodland, Valley/foothill grassland. Known from Contra Costa and possibly Solano counties.	April-June Perennial herb (bulbiferous)	Absent
Fritillaria liliacea fragrant fritillary	Federal State CNPS	SC CEQA 1B:1-2-3	Coastal prairie, coastal scrub, Valley/foothill grassland near the coast, on clay or serpentinite. Known from throughout the Central Coast from Sonoma to Monterey counties and the San Francisco Bay Area.	Feb-April Perennial herb (bulbiferous)	Absent
Linaceae					
Hesperolinon breweri Brewer's western flax	Federal State CNPS	SC CEQA 1B:2-2-3	Chaparral, cismontane woodlands, Valley/foothill grassland, mostly on serpentinite. Found in Napa, Solano, and Contra Costa counties.	May-July Annual herb	Absent
Malvaceae					
Hibiscus lasiocarpus rose-mallow	Federal State CNPS	none CEQA 2:2-2-1	Freshwater marshes. Restricted to the Sacramento-San Joaquin River Delta.	June-Sept Perennial herb (rhizomatous)	Absent

Oenothera deltoides ssp howellii *Antioch Dunes evening-primrose*	Federal State CNPS	FE CE 1B:3-3-3	Remnant river bluffs and interior sand dunes. Known from seven occurrences among the dunes east of Antioch.	Mar-Sept Perennial herb	Absent, would have been detectable
Papaveraceae					
Eschscholzia rhombipetala diamond-petaled California poppy	Federal State CNPS	SC CEQA 1A	Valley/foothill grassland on clay soils. Presumed extinct. Known historically from Alameda, Contra Costa, Colusa, San Luis Obispo and Stanislaus counties. Last seen in 1950.	Mar-April Annual herb	Absent, would have been detectable
Polygonaceae					
Eriogonum truncatum Mt. Diablo buckwheat	Federal State CNPS	none CEQA 1A	Chaparral, coastal scrub, Valley/foothill grassland on sandy soils. Presumed extinct, but found in 2005 on Mt. Diablo, Contra County.	April-Sept Annual herb	Absent
Potamogetonaceae					
Potamogeton zosteriformis eel-grass pondweed	Federal State CNPS	none CEQA 2:2-2-1	Assorted freshwater marshes and swamps. Known from Contra Costa, Lake counties, Modoc, Lassen, and Shasta counties and Washington and Oregon.	June-July Annual herb (aquatic)	Absent, would have been detectable
Scrophulariaceae					
Cordylanthus mollis ssp. *mollis* soft bird's-beak	Federal State CNPS	FE CR 1B:3-2-3	Coastal saltmarsh. Known from fewer than 10 locations in Contra Costa, Napa, and Solano counties. Extirpated in Marin and Sonoma counties.	July-Sept Annual herb (hemiparasite)	Absent
Limosella subulata Delta mudwort	Federal State CNPS	none CEQA 2:2-3-1	Marshes and swamps, muddy or sandy intertidal flats in the Sacramento and San Joaquin river deltas.	May-Aug Perennial herb (stoloniferous)	Absent

[1]Explanation of sensitivity status codes provided in Appendix B.

APPENDIX B

POTENTIALLY-OCCURRING SPECIAL-STATUS WILDLIFE SPECIES AT THE PROJECT SITE

Scientific Name Common Name	Status[1]		Habitat Affinities and Reported Localities in the Project Area	Potential for Occurrence On Site
Amphibians				
Ambystoma californiense California tiger salamander	Federal State	FT CSC	Breeds in temporary or semi-permanent pools. Seeks cover in rodent burrows in grasslands and oak woodlands. Inhabits the Coast Ranges from Santa Barbara to Sonoma counties along the coast and inland to Colusa, Yolo and Tulare counties.	Possible.
Rana draytonii California red-legged frog	Federal State	FT CSC	Prefers semi-permanent and permanent stream pools, ponds and creeks with emergent and/or riparian vegetation. Occupies upland areas especially during the wet winter months.	Possible
FISH				
Oncorhynchus tshawytscha Central Valley fall run Chinook salmon	Federal State	FT CSC	Natural spawned salmon in the San Joaquin and Sacramento River basins. Known from Marsh Creek, Contra Costa County.	Passage in Deer Creek blocked by weir at Deer Creek Flood Control Basin
REPTILES				
Masticophis flagellum ruddocki San Joaquin whipsnake	Federal State	none CSC	Inhabits a variety of habitats, with sparse vegetation. Uses rodent burrows, rocks or bushes for refugia.	Unlikely. No records from the vicinity
Masticophis lateralis euryxanthus Alameda whipsnake	Federal State	FT ST	Restricted to chaparral and coastal scrub of the Coast Ranges, inhabits appropriate habitat on south, southwest- and southeast-facing slopes and ravines where the shrubs form a vegetative mosaic with grasses. Requires rodent burrows and large population of *Sceloporus occidentalis*.	Unlikely, no suitable habitat

Thamnophis gigas giant garter snake	Federal State	FT CT	Inhabits sloughs, canals and small water courses with grassy banks and emergent vegetation. Requires high ground for basking and escape during winter flooding. Known from the Central Valley from Fresno north to the Sutter Buttes.	Unlikely, closest sightings are only from habitats directly connected with the San Joaquin River.
Birds				
Agelaius tricolor tricolored blackbird	Federal State Audubon	MB CSC none	Nests primarily in dense freshwater marshes with cattail or tules. Forages in grasslands. Largely endemic to California. Permanent resident in the Central Valley and along the coast from Marin to San Diego counties. Also known from Lake, Sonoma and Solano counties. Grasslands provide suitable foraging habitat only.	Unlikely, would have been detectable during surveys
Athene cunicularia burrowing owl	Federal State Audubon	MB CSC Blue list	Open, dry grasslands, deserts, prairies, farmland and scrublands with abundant active and abandoned mammal burrows. Occurs in lowlands throughout California.	Present
Bubo virginianus great horned owl	Federal State Audubon	MB none none	Nests in large trees using twigs and branches for nesting material. Forages on small mammals, reptiles and birds.	Potential
Buteo jamaicensis red-tailed hawk	Federal State Audubon	MB none none	Builds stick nests in large trees. Forages on small mammals.	Potential
Buteo swainsoni Swainson's hawk	Federal State Audubon	MB CT none	Nests in oaks or cottonwoods in or near riparian habitat. Forages in grasslands and agricultural fields. Highest nesting densities are in Yolo County. Relatively common throughout the lower Sacramento and San Joaquin valleys.	Potential adjacent to KM off-site road.
Circus cyaneus northern harrier	Federal State Audubon	MB CSC none	Nests and forages in grasslands. Nests on ground in shrubby vegetation or dense grass, usually at the edge of marshes.	Potential
Elanus leucurus white-tailed kite (nesting sites only)	Federal State Audubon	MB CFP none	Inhabits low rolling foothills and valley margins with scattered oaks and river bottom- lands or marshes adjacent to deciduous woodlands. Prefers open grasslands, meadows and marshes for foraging close to isolated, dense-topped trees for nesting and perching.	Potential nester.

Hirundo rustica Barn swallow (nesting colonies only)	Federal State Audubon	MB none none	Nests in colonies beneath bridges.	Present.
Mammals				
Antrozous pallidus pallid bat	Federal State	none CSC	This colonial species roosts in small colonies of 20 or more individuals in caves, mines, rock piles, tree cavities and occasionally buildings. Night roosts may be in more open sights, such as porches and open buildings. They forage mostly in open habitats.	Possible foraging habitat. Nesting habitat minimal.
Lasiurus borealis *Red bat*	Federal State:	None CSC	A riparian obligate roosting in dense forest and foraging along the forest edge.	Possible. Marginal roosting habitat present.
Vulpes macrotis mutica San Joaquin kit fox	Federal State	FE CT	Range includes annual grassland, saltbush scrub and oak savanna at the valley/mountain interface.	Possible although den sites appear too small.

[1] Explanation of sensitivity status codes:

Absent means habitat not present. Unlikely means that the species would have been detectable, or habitat conditions appear to be unsuitable. Present [P] means general habitat is present and species may be present. Status: Federal Endangered (FE); Federal Threatened (FT); Federal Proposed (FP, FPE, FPT); Federal Candidate (FC); State Endangered (SE); State Threatened (ST); Fully Protected ((FP); State Rare (SR); State Species of Special Concern (SSC); California Native Plant Society (CNPS 1B) (Plants rare, threatened, or endangered in California and elsewhere).

APPENDIX C – PLANTS OBSERVED AT THE PROJECT SITE

* = non-native taxa

FAMILY NAME	SCIENTIFIC NAME	COMMON NAME
Asteraceae	*Baccharis pilularis*	coyote brush
	**Carduus pycnocephalus*	Italian thistle
	**Centaurea solstitialis*	yellow star-thistle
	**Cirsium vulgare*	bull thistle
	**Chamomilla suaveolens*	pineapple weed
	**Lactuca serriola*	prickly lettuce
	Heterotheca grandiflora	telegraph weed
	**Picris echioides*	bristly ox-tongue
	**Sonchus asper ssp. asper*	sow thistle
Boraginaceae	*Amsinckia menziesii var. intermida*	fiddleneck
Brassicaceae	**Brassica nigra*	black mustard
	**Cardaria draba*	heart-podded hoary cress
	**Raphanus sativus*	wild radish
Chenopodiaceae	**Salsola tragus*	Russian-thistle
Convolvulaceae	**Convolvulus arvensis*	field bindweed
Cyperaceae	**Cyperus rotundus.*	nutgrass
	Scirpus americanus	American tule
Fabaceae	*Lotus purshianus var. purshianus*	Spanish-clover
	**Medicago polymorpha*	burclover
	**Melilotus indica*	sourclover
	Trifolium hirtum	Rose clover
	Vicia villosa ssp. villosa	hairy vetch
Fagaceae	*Quercus agrifolia*	coast live oak
Geraniaceae	**Erodium botrys*	long-beaked filaree
	**Erodium cicutarium*	filaree
	**Geranium dissectum*	cut-leaved geranium
Juglandaceae	*Juglans california var.hindsii*	No. California black walnut
Juncacea	*Juncus balticus*	Baltic rush
Malvaceae	**Malva parviflora*	cheeseweed
Papaveraceae	*Eschscholzia californica*	California poppy
Poaceae	**Avena fatua*	wild oats
	**Bromus diandrus*	rip gut brome
	**Bromus hordeaceus*	soft chess
	**Bromus madritensis spp. rubens*	red brome
	**Festuca arundinacea*	tall fescue
	**Hordeum murinum*	foxtail
	**Lolium multiflorum*	Italian rye grass
	**Polypogon monspeliensis*	rabbitfoot grass
	**Vulpia myuros*	Rat-tail fescue
Polygonaceae	*Rumex crispus*	curly dock
Salicaceae	*Populus fremontii*	Fremont cottonwood
	Salix exigua	sandbar willow
	Salix lavigata	red willow
Typhaceae	*Typha angustifolia*	narrow-leaved cattail

APPENDIX D

ANIMALS OCCURRING AT THE PROJECT SITE

SCIENTIFIC NAME	COMMON NAME
BIRDS	
Agelaius phoeniceus	Red-winged blackbird
Aphelocoma coerulescens	Western scrub jay
Athene cunicularia	Western burrowing owl
Callipepla californica	California quail
Cathartes aura	Turkey vulture
Charadrius vociferus	Killdeer
Columba livia	Rock dove
Corvus brachyrhynchos	American crow
Hirudo rustica	Barn swallow
Mimus polyglottus	Northern mockingbird
Sayornis nigricans	Black phoebe
Sturnella neglecta	Meadowlark
Tyrannus verticalis	Western kingbird
Zenaidura macroura	Mourning dove
MAMMALS	
Canis latrans	Coyote
Didelphis virginiana	Opossum
Lepus californicus	Black-tailed jackrabbit
Mephitis mephitis	Skunk
Microtus californicus	California vole
Peromyscus maniculatus	Deer mouse
Procyon lotor	Raccoon
Spermophilus beecheyi	California ground squirrel
Sylvilagus audubonii	Desert cottontail
Thomomys bottae	Botta's pocket gopher
REPTILES	
Sceloporus occidentalis	Western fence lizard
FISH	
Gambusia affinis	Mosquitofish

APPENDIX E

PHOTOS OF THE PROJECT SITE

Daylighted reach of Deer Creek-Fall

Daylighted reach of Deer Creek- Spring

Attachment E

Hydrology Report

04-CC-Route 4
PM 34.5/36.1
EA 04-4H1601

State Route 4 and Balfour Road Interchange Improvement Project
Contra Costa County, California

Draft Drainage Report

Prepared for:

CONTRA COSTA transportation authority

QUINCY ENGINEERING

Prepared by:

WRECO

November 2013

04-CC-Route 4
PM 34.5/36.1
EA 04-4H1601

State Route 4 and Balfour Road Interchange Improvement Project
Contra Costa County, California

Draft Drainage Report

Submitted to:
Contra Costa Transportation Authority
California Department of Transportation

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

_____
Chris Sewell, P.E.
Registered Civil Engineer

_____
Date

November 2013

Table of Contents

Executive Summary iii
Acronyms v
1 General Description 1
1.1 Project Description 1
1.1.1 Phase I 1
1.1.2 Ultimate Phase 1
1.2 Need for Project 3
1.3 Project History 4
1.4 Reference Documents 4
1.4.1 Reports 4
1.4.2 As-Built Record Documents 4
1.4.3 Geographical References 5
1.4.4 Preliminary Layout Sheets 6
1.4.5 Geometric References 6
1.5 Soil Characteristics 6
1.6 Land Use 6
1.7 Creeks, Streams, and River Crossings 7
1.8 Existing Drainage and Drainage Design Issues 8
1.9 Drainage Design Criteria 9
1.10 Special Circumstances 10
1.11 Agencies Impacting Design 10
2 Off-site Hydrology 12
2.1 Watershed and Basin Characteristics 12
2.2 Rainfall Data and Intensities 12
2.3 Points of Concentration and Outfalls 14
2.4 Estimating Discharge Data 14
2.4.1 Rational Method 14
2.4.2 CCCFC&WCD Unit Hydrograph 15
3 Off-site Hydraulics 17
3.1 System Controls 17
3.2 Inlet and Outlet Treatment and Energy Dissipation 17
3.3 Culvert Material 17
3.4 Off-site Hydraulics for Cross Culverts along SR 4 17
4 On-site Roadway Drainage 19
4.1 Recurrence Interval 19
4.2 Time of Concentration 19
4.3 Rainfall Data and Intensities 19
4.4 Points of Concentration 20
4.5 System Controls 20
4.6 Grate Interception and Gutter Capacity 20
4.7 Hydraulic Grade Line Calculations 20
4.8 Ditches and Gutters 21
4.9 Storm Water Best Management Practices 21
5 Temporary Drainage Systems 22
5.1 Permanent Soil Stabilization Systems 22

5.2 Permanent Treatment BMPs 22
6 Floodplain Information 23
7 Cost Estimate 24
8 References 25

Figures

Figure 1. Project Vicinity Map (Phase 1) 3
Figure 2. Land Use Map 7
Figure 3. Creek Crossings of SR 4 8

Tables

Table 1. As-Built Record Documents 5
Table 2. Selected HDM Hydrology Criteria 9
Table 3. Selected HDM Hydraulics Criteria 9
Table 4. NOAA Atlas 14 Precipitation Summary 12
Table 5. “Table A-1” Constants 13
Table 6. “Table A-2” Constants 13
Table 7. CCCFC&WCD Precipitation Summary 13
Table 8. Rational Method Design Storm Discharges (offsite flow to cross-culvert) 15
Table 9. CCCFC&WCD Unit Hydrograph Design Storm Discharges (offsite flow to cross-culverts) 16
Table 10. Cross-culvert Hydraulics 18

Appendices

Appendix A Hydrologic Data
Appendix A.1 NRCS Hydrologic Soil Group Map
Appendix A.2 Rainfall Intensity Curve
Appendix A.3 Isopleths
Appendix B Off-site Watershed Map
Appendix C Flood Insurance Rate Maps
Appendix D Project Photographs
Appendix E Deer Creek Memorandum
Appendix F Hydraulic Analysis of Cross-Culverts
Appendix G Hydraulic Analysis of Proposed Onsite Drainage Design
Appendix H Hydraulic Analysis of Proposed Ditches/Biofiltration Swales
Appendix I Inlet Capacity Calculations
Appendix J Sharp-Crested Weir Calculations

Executive Summary

The California Department of Transportation (Caltrans) and the Contra Costa Transportation Authority (CCTA) are proposing to widen and replace the existing State Route 4 (SR 4) crossing of Deer Creek in the City of Brentwood, Contra Costa County, California. Development plans include the following phases:

1. Phase 1 – Expansion of SR 4 from Balfour Road to San Jose Avenue, from two to four lanes. Expansion of SR 4 from Balfour Road to approximately 1,900 ft south of Balfour Road, from two to three lanes. Construction of an elevated crossing over Balfour Road, and modifications to existing on- and off-ramps.
2. Ultimate Phase – Expansion of SR 4 from 2,000 ft north of Balfour Road to approximately 4,000 ft south of Balfour Road, from four to eight lanes. Addition of a new elevated crossing over Balfour Road, and improvements to on- and off-ramps.

The proposed Project (Phase 1 of the improvements) includes widening of existing roadways, addition of two bridges over Deer Creek, and the addition of a grade-separated interchange at the SR 4 and Balfour Boulevard interchange. The grade-separated interchange would raise the existing roadway approximately 25 to 30 ft.

The purpose of this Drainage Report is to evaluate the hydrologic and hydraulic conditions of the existing highway drainage systems within the Project limits, and analyze the proposed drainage system design developed to accommodate the proposed roadway improvements. The report documents the hydrologic and hydraulic design criteria used for the drainage design.

A majority of the Project is within Caltrans' right-of-way; therefore, the drainage design for the Project is based on procedures presented in the updated sixth edition of the Caltrans *Highway Design Manual* (HDM) and in the *Hydraulic Engineering Circular No. 22* (HEC-22), a publication for highway pavement drainage from the Federal Highway Administration (FHWA).

The Project includes drainage improvements along SR 4 and adjacent on-ramps and off-ramps. The proposed improvements include longitudinal systems at the new edge of shoulders connecting to existing cross culverts or discharging into new outfalls. The existing 14 ft by 8 ft, 220 ft long Deer Creek box culvert would remain during Phase I. New cross culverts are proposed in order to compensate for increased runoff resulting from the proposed additional impervious areas. The overall drainage pattern of the area will be maintained.

The Project also incorporates the use of stormwater treatment best management practices (BMPs) to decrease the impacts of potential increases in sediment and pollutants resulting from the increase in impervious area. These treatment devices allow for the filtration of the pollutants while promoting infiltration of runoff. To maximize the effectiveness of

these devices, off-site flows are separated from the treated on-site runoff through the incorporation of ditches located further upstream in cut areas.

The Project also incorporates a variety of hydromodification features designed to reduce peak discharge from the site to near pre-project conditions. The proposed biofiltration strips for the Project utilize a layer of compost to promote infiltration as a hydromodification mitigation measure.

Acronyms

APC	Alternative pipe culvert
BMPs	Best Management Practices
CAP	Corrugated aluminum pipe
CASP	Corrugated aluminized steel pipe
CSP	Corrugated steel pipe
DSAs	Disturbed soil areas
FEMA	Federal Emergency Management Agency
FES	Flared end section
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
HA	Hydrologic Area
HDM	Highway Design Manual
HDPE	High Density Polyethylene
HEC	Hydraulic Engineering Circular
HOV	High Occupancy Vehicle
HU	Hydrologic Unit
IDF	Intensity-duration-frequency
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NRCS	Natural Resources Conservation Service
RCP	Reinforced concrete pipe
RSP	Rock slope protection
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SR	State Route
SWDR	Storm Water Data Report
USDA	United States Department of Agriculture
USGS	United States Geological Survey

1 GENERAL DESCRIPTION

1.1 Project Description

The Contra Costa Transportation Authority proposes to widen State Route 4 (SR 4) from San Jose Avenue (PM 34.9) to approximately 3,400 ft south of Balfour Road (PM 36.6), and to construct an interchange at Balfour Road, herein referred to as the Project. The Project is within the limits of the SR 4, which was originally constructed as the SR 4 Bypass, a 12.4-mile; two to six lane combination of freeway/expressway and conventional highway that begins just east of the SR 4/Hillcrest Avenue interchange in Antioch and ends at the Byron Highway (SR 4) southeast of Brentwood. The California Department of Transportation (Caltrans) and the California Transportation Commission (CTC) adopted the SR 4 Bypass as SR 4 on January 25, 2012. See Figure 1 for the Project Vicinity Map.

1.1.1 Phase I

The first phase (Phase 1) will include the construction of the following:

- Divided 2-lane freeway with auxiliary lanes in each direction from San Jose Avenue undercrossing to 2,000 ft north of Balfour Road
- 4-lane Undercrossing structure to serve bidirectional 2-lane freeway traffic and 2 ramp entrance lanes. This structure will serve only EB traffic in subsequent phases.
- 4-lane structure over Deer Creek for SR 4 freeway lanes. It will serve bidirectional traffic in Phase 1 and only eastbound traffic in subsequent phases
- 2-lane structure over Deer Creek for EB loop onramp
- EB diagonal offramp
- EB loop onramp
- WB diagonal onramp that will be in an interim location and moved further to the east in the ultimate configuration
- WB diagonal offramp
- WB loop onramp
- Widening of Balfour Road to up to 6 lanes within the interchange area
- Other improvements include 2 new traffic signals for the ramp intersections, ramp metering, lighting, drainage improvements, and utility relocations.

1.1.2 Ultimate Phase

It is anticipated that the ultimate improvements will occur beyond the 20-year design period of Phase 1. The ultimate improvements will include construction of the following:

- Divided 4-lane freeway from 2,000 ft north of Balfour Road to 4,000 ft south of Balfour Road
- 3-lane undercrossing structure for the WB SR 4 to serve two freeway lanes and 1 ramp entrance lane.
- EB diagonal onramp
- WB diagonal onramp (Located further east of Phase 1 onramp)

- WB loop onramp (Realign the WB loop onramp built in Phase 1)
- WB offramp (Realign the WB offramp built in Phase 1)
- 4-lane structure over Deer Creek for WB SR 4 freeway lanes.
- 3-lane structure over Deer Creek for WB diagonal onramp.

This document addresses improvements proposed for construction of the Phase 1 project. Design elements have been established in the Phase 1 project to enable implementing ultimate improvements in the most cost-effective manner. The purpose of the SR 4/Balfour Road Project is to improve regional circulation through eastern Contra Costa County and provide a more balanced distribution of current and future traffic over the local road network in this area.

This project is funded by local funds.

Figure 1. Project Vicinity Map (Phase 1)

Sources: Bing Maps, Quincy Engineering

1.2 Need for Project

The Purpose of this Project is to reduce congestion and improve mobility along SR 4.

1.3 Project History

The project Environmental Document for the entire SR 4 Bypass was approved in December 1994. Addendum #10 of the Environmental Document was approved in August 2011, which environmentally cleared the replacement of the at-grade intersection at SR 4 and Balfour Road with a grade-separated interchange. Although SR 4 traverses in the north and south direction within the City of Brentwood (City), its official designation is east and west to correlate with the general direction of the entire SR 4 route. As a result, throughout the Project limits, the geographical northbound and southbound SR-4 are designated westbound (WB) and eastbound (EB), respectively.

The ultimate interchange improvements are to be implemented in phases as funding becomes available.

1.4 Reference Documents

1.4.1 Reports

Contra Costa County State Route 4 Bypass, Segment Two – Phase One Final Drainage Report was prepared by Terrance E. Lowell & Associates in May 1999. This drainage report covers SR 4 from Lone Tree Way to Balfour Road. *Contra Costa County State Route 4 Bypass, Segment Three – Phase One Drainage Report* was prepared by Nolte Associates in August 2005. This drainage report covers SR 4 from Balfour Road to Byron Highway. These reports were used in support of this Drainage Report.

1.4.2 As-Built Record Documents

Electronic copies of as-built plans were obtained from the Caltrans database. Additionally, as-builts near the Project area were provided by the City of Brentwood.

These files were reviewed and used as a basis for the drainage design (see Table 1).

Table 1. As-Built Record Documents

Source:	Project No.	Date	Project Name	Location
Caltrans	4660-6X4405-03	12/14/2009	Construction of State Route 4 Bypass (Segment 2 Phase 1)	From Lone Tree Way to Balfour Road
Caltrans	4660-6X4475	12/8/2009	Construction of State Route 4 in Brentwood and Contra Costa County	0.3 KM north of Balfour Road to 0.3km east of Byron Highway
City of Brentwood	MS 354-00	9/17/2007	Cox Property Improvement Plans	Balfour Road and Balfour Way
City of Brentwood	CIP 99-0618	May-99	Non-Potable Waterline at Balfour Road	Balfour Road, from Claremont Drive to Fairview Avenue
City of Brentwood	CIP 96-0603	Mar-96	Assessment District No. 93-5	Balfour Road near Deer Creek
City of Brentwood	CIP 96-0328	3/28/1996	Balfour Road Widening	Balfour Road from Fairview Avenue to Claremont Drive
City of Brentwood	CIP 94-0314	4/6/1993	Balfour Road Phase II Improvements	Balfour Road from Fairview Avenue to 700 ft east of the Eccid Canal
City of Brentwood	8310	5/10/2007	Deer Ridge Country Club	Concord Avenue near Ventura Drive
City of Brentwood	8082	10/27/1999	Subdivision 8082 - Brentwood Country Club Improvement Plan	Brentwood Country Club
City of Brentwood	7872	8/18/1995	Subdivision 7872 - Brentwood Country Club Improvement Plan	Brentwood Country Club
City of Brentwood	7816	4/8/1996	Subdivision 7816 - Brentwood Country Club Improvement Plan	Brentwood Country Club
City of Brentwood	7642	2/4/1994	Subdivision 7642 - Applie Hill Estates, Phase II Improvement Plans	Portions of Applie Hill Drive, Newton Drive, Sundale Lane, Red Rome Lane, and Apple Hill Terrace
City of Brentwood	6848	9/22/1989	Improvement Plans for Subdivision 6848 - Apple Hill	Streets and Terraces within Subdivision 6848

1.4.3 Geographical References

Geographical information was obtained from the United States Geological Survey (USGS); the map being current as of 1980. Topographic maps and topographical survey information were supplied to WRECO by Quincy Engineering.

1.4.4 Preliminary Layout Sheets

Preliminary layout sheets of Phase I and the Ultimate Phase were provided by Quincy Engineering.

1.4.5 Geometric References

Elevation information was obtained from the United States Geological Survey (USGS) topographic maps, as well as from contours included in as-built plans provided by Caltrans and the City of Brentwood. Additional elevation information was supplied to WRECO by Quincy Engineering and Caltrans.

1.5 Soil Characteristics

General soil information was obtained from the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Web Soil Survey. The map of the Hydrologic Soil Groups (HSGs) underlying the site is included in Appendix A. Infiltration rates and runoff potential are indicated by the soil's HSG. Soils may be assigned to one of four groups (A, B, C, or D). Group A has high infiltration rates (low runoff potential) and consists mainly of deep, well-drained to excessively drained sands or gravelly sands. On the other end of the spectrum, Group D has very slow infiltration rates (high runoff potential) and consists chiefly of clays that have a high shrink-swell potential or soils with a clay or nearly impervious layer near the surface. The soils underlying the Project area generally are categorized as HSGs B, C, and D.

1.6 Land Use

The Project area is located entirely within the City of Brentwood. The City of Brentwood Land Use Map, updated July 23, 2010 was compared to the Project extents to determine locations of impacted areas (see Figure 2). According to the Land Use Map, the Project is located primarily within a transportation corridor, though areas of low density residential land use near San Jose Avenue will also be impacted.

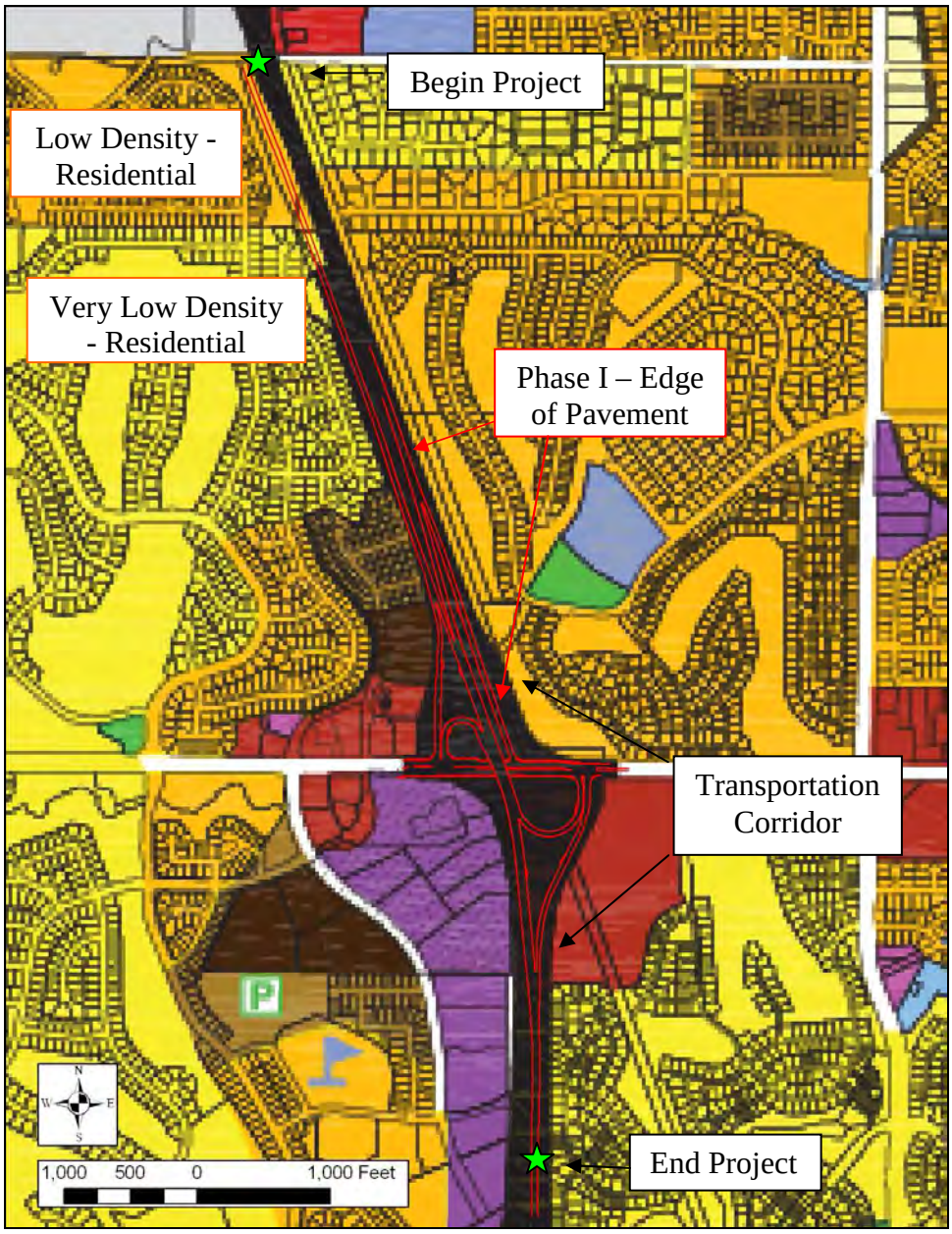


Figure 2. Land Use Map

Sources: City of Brentwood, Quincy Engineering

1.7 Creeks, Streams, and River Crossings

According to the USGS topographic maps, as well as Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs), there are two creek crossings within the Project limits. Deer Creek crosses SR 4 just north of the Balfour Road interchange, and Dry Creek crosses SR 4 approximately 2,700 ft south of the Balfour Road interchange. See Figure 3 for the creek crossings.

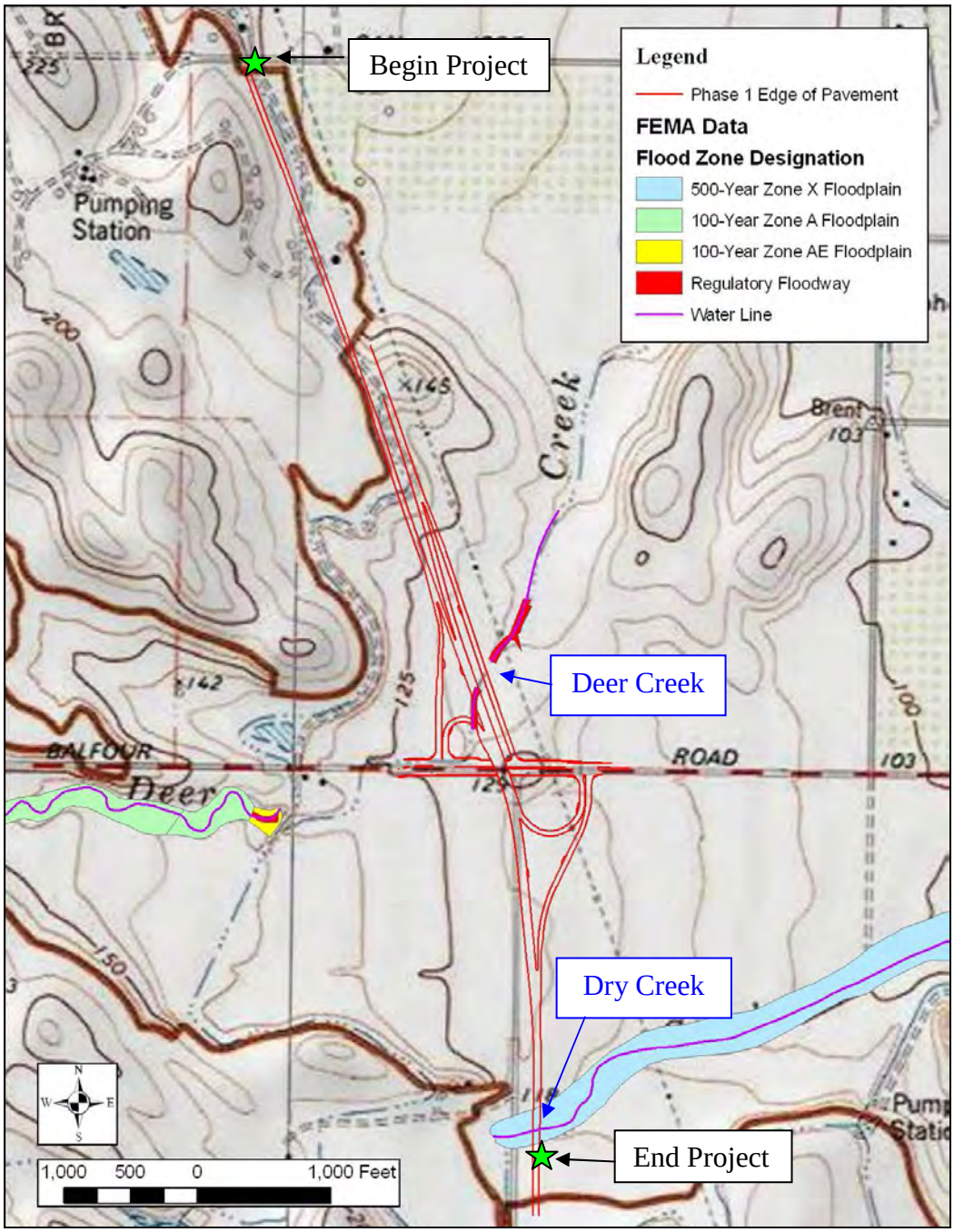


Figure 3. Creek Crossings of SR 4

Sources: FEMA, USGS, Quincy Engineering

1.8 Existing Drainage and Drainage Design Issues

The Project involves the addition of drainage improvements, primarily located along SR 4 and along newly proposed on- and off-ramps. The proposed improvements include new longitudinal systems at the new edge of shoulders connecting to existing cross culverts or discharging into new outfalls. The overall drainage pattern of the area would be

maintained. All drainage systems that tie into existing systems will need to be verified with surveyed flow line elevations.

Drainage design issues for the existing cross culverts along SR 4 were documented in the *Contra Costa County State Route 4 Bypass, Segment Two – Phase One Final Drainage Report* (May 1999), and the *Contra Costa County State Route 4 Bypass, Segment Three – Phase One Drainage Report* (August 2005).

The topography of the area consists primarily of gently sloping farmland that drains eastward, mostly by sheet flow. The beginning of the sound wall in the Project area is located approximately 1,100 ft south of the SR 4 crossing over San Jose Avenue. The sound wall is located along the eastern roadway embankment, and contains two segments that extend south to the Balfour Road interchange. AC dikes are along the eastern edge of the road in the vicinity of the sound wall in order to collect roadway drainage and convey it to outfalls at various locations. North of the sound wall, the existing roadway maintains a 4:1 (H:V) embankment slope, and sheet flow from the roadway from is allowed to sheet eastward and down the slope.

There are multiple existing culverts along the Project reach, which convey water beneath SR 4, including culverts at Deer and Dry creeks.

WRECO performed an independent analysis of the hydraulic capacity of these cross culverts. The hydrologic and hydraulic calculations are discussed in Sections 2 and 3, respectively.

1.9 Drainage Design Criteria

The drainage design for the Project is based on procedures presented in the updated sixth edition of the Caltrans *Highway Design Manual* (HDM) and those presented in the Federal Highway Administration's (FHWA's) *Hydraulic Engineering Circular No. 22* (HEC-22).

Table 2 and Table 3 list the selected relevant HDM criteria pertinent to the hydrology and hydraulics of the drainage design and the sections that mention the criteria.

Table 2. Selected HDM Hydrology Criteria

Criteria	Section
Table 819.5A Summary of Methods for Estimating Design Discharge	819
Estimating Design Discharge - Empirical Methods	819.2

Source: Caltrans

Table 3. Selected HDM Hydraulics Criteria

Criteria	Section
Maximum allowable flow spread width (shoulder or parking lane width)	831.3
Minimum allowable pipe diameter under a roadbed (18 in.)	838.4
Manning's coefficient estimation method	851.2

Source: Caltrans

1.10 Special Circumstances

The drainage design specifies in the contract documents that all new culverts and existing culverts are being replaced as alternative pipe culverts (APC) rather than specifying particular pipe materials. This leaves the Construction Contractor the ability to choose the appropriate material from a list of allowable materials recommended by the Project geotechnical engineer. The acceptable APC materials for the Project will be specified on Project plan sheet DQ-1, the first page of the Project drainage quantity sheets, prepared by Quincy Engineering. Corrugated steel pipe (CSP) is being proposed for pipes with slopes greater than 10%. All pipe joint types shall be standard unless otherwise noted on the Project plans.

Allowable materials were based on analyses performed by the Caltrans Eureka Materials Laboratory in January 2005 and are documented in the Preliminary Pavement Recommendations memo. The allowable materials for alternative pipe are specified below:

- Corrugated steel, corrugated aluminum pipe (CAP) shall conform to Section 66 of the Standard Specifications.
- Standard Reinforced Concrete Pipe (RCP) may be used and shall conform to Section 65 of the Standard Specifications.
- For concrete facilities, use Type IP Modified Cement or Type II modified cement. Cement must conform to Section 90 of the Standard Specifications.
- Plastic pipe may be used for a 50-year service life. It shall be high density polyethylene (HDPE), conforming to Section 64 of the Standard Specifications. Reference should be made regarding durability in Section 854.8 of the *Highway Design Manual*.

1.11 Agencies Impacting Design

The Project is located in Contra Costa County, California. Any drainage improvements proposed for the local roads and any off-site drainage systems impacted by the Project will conform to the local agency's requirements. The drainage design will also be based on Caltrans' design criteria.

Although work in environmentally sensitive areas will be minimized, it is still anticipated that permits with regulatory agencies will be necessary. Permits from the following agencies are anticipated:

- California Department of Fish and Game (1602)
- San Francisco Regional Water Quality Control Board (401)
- U.S. Army Corps of Engineers (404)

Incorporation of treatment best management practices (BMPs), addressing hydromodification concerns, and mitigation proposed for the anticipated impacts to wetlands and waters of the U.S. due to the Project will be negotiated with these agencies.

2 OFF-SITE HYDROLOGY

Hydrologic analyses for the Project were based on procedures presented in the Caltrans HDM. This section includes analyses of the off-site flows for the cross culvert systems within the Project limits.

Hydrologic analysis of Deer Creek is included in a memorandum dated June 25, 2013 (see Appendix E), and was therefore not included within this report.

2.1 Watershed and Basin Characteristics

The Project is located within the San Joaquin Delta Hydrologic Unit (HU) of the San Francisco Bay Basin. This watershed falls within the jurisdiction of the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD).

The overall drainage pattern for the Project area is from the west to east, toward Marsh Creek. The nearest receiving water bodies are Deer and Dry creeks, which cross SR 4 within the Project limits at PM 35.45 and PM 36.1, respectively. Both creeks cross SR 4 from west to east, roughly perpendicular to the Project alignment. Both creeks proceed to flow to the northwest before converging with Marsh Creek in the City of Brentwood.

Off-site watersheds were determined using USGS terrain data, survey information provided by QEI, and field verification. Watersheds were created for all existing cross culverts. See Appendix B for the off-site watershed delineations.

2.2 Rainfall Data and Intensities

WRECO obtained rainfall depth information from the National Oceanic and Atmospheric Administration's (NOAA's) Atlas 14. NOAA Atlas 14 provides point precipitation frequency estimates at specified locations. Table 4 summarizes the point precipitation information at the intersection of SR 4 and Balfour Road.

Table 4. NOAA Atlas 14 Precipitation Summary

Duration (hr)	Cumulative Precipitation Depth (in.)				
	10-Year	25-Year	50-Year	100-Year	500-Year
0.08	0.162	0.199	0.229	0.262	0.351
0.17	0.232	0.285	0.329	0.376	0.504
0.25	0.280	0.344	0.397	0.455	0.609
0.50	0.380	0.467	0.539	0.617	0.826
1	0.538	0.661	0.763	0.874	1.170
2	0.788	0.965	1.110	1.280	1.720
3	0.993	1.220	1.400	1.600	2.160
6	1.420	1.740	2.000	2.280	3.050
12	2.000	2.440	2.810	3.190	4.200
24	2.870	3.500	4.000	4.510	5.800

Additionally, the CCCFC&WCD HEC-HMS guidance includes methodologies for determining design rainfall depths. The duration-frequency-depth curves published by the

CCCFC&WCD include the standard for design rainfall depth, and were therefore selected for the off-site hydrologic analyses. The following equation and associated tables were used in calculating storm rainfall depth:

$$D = \left(\frac{MR1}{100}\right) - (10 - MSP) * \frac{MR2 - MR1}{2500}$$

Where:

D = storm rainfall depth (inches)
MSP = mean seasonal precipitation depth (inches) from the District Isohyetal map.
MR1 = constant for storm duration and frequency from Table A-1
MR2 = constant for storm duration and frequency Table A-2

Table 5. "Table A-1" Constants

MR1	3-hour	6-hour	12-hour	24-hour	96-hour
10-year	95	128	170	222	366
25-year	110	150	200	262	436
50-year	128	171	228	300	498
100-year	138	188	252	332	552

Source: CCCFC&WCD

Table 6. "Table A-2" Constants

MR2	3-hour	6-hour	12-hour	24-hour	96-hour
10-year	224	318	448	618	1110
25-year	262	379	530	733	1300
50-year	300	430	606	840	1480
100-year	328	468	660	920	1660

Source: CCCFC&WCD

The CCCFC&WCD rainfall intensities for the 10-year and 25-year precipitation were generated at the SR 4/Balfour interchange, and are included in Table 7.

Table 7. CCCFC&WCD Precipitation Summary

Duration (hr)	Rainfall Intensity (in/hr)	
	10-Year	25-Year
0.08	2.44	2.80
0.17	1.71	1.93
0.25	1.37	1.58
0.50	0.96	1.10
1	0.666	0.765
2	0.460	0.537
3	0.373	0.427
6	0.257	0.295
12	0.172	0.202
24	0.115	0.126

Source: CCCFC&WCD

2.3 Points of Concentration and Outfalls

The points of concentration for the Project are defined at the upstream end of the cross culverts. The outfalls are defined at the points of discharge of the cross culverts and longitudinal systems.

Runoff for systems that are along the roadway surface, such as the grate inlets, is carried to the inlets via dikes and concentrated within standard gutter depressions.

2.4 Estimating Discharge Data

Two methods were used to determine design discharges including: 1) Rational Method, and 2) the CCCFC&WCD Hydrograph method. The Rational Method was used primarily for on-site hydrologic calculations, when the watershed area was less than 320 ac and the time of concentration was less than one hour, per the Caltrans HDM. The CCCFC&WCD Hydrograph method was used for Deer and Dry creeks.

Drainage improvements for cross culverts were evaluated and designed based on the criteria of passing the entire 10-year design discharge within the cross culvert and the 100-year design discharge without objectionable backwater.

2.4.1 Rational Method

The equation for the Rational Method is:

$$Q = C\ i\ A$$

Where:

- Q = design discharge (cfs)
- C = runoff coefficient for Rational Method including design storm frequency factor (1.0 for 10-year storm, 1.1 for 25-year storm, and 1.25 for 100-year storm)
- i = average rainfall intensity for the selected frequency and for a duration equal to the time of concentration (in./hr)
- A = drainage area (ac)

The coefficient of runoff was determined using Figure 819.2A of the HDM. The average rainfall intensity was determined using precipitation data from CCCFC&WCD.

For Dry Creek, the SR4 crossing will come from a watershed that is downstream of the Deer Ridge Golf Club detention basin. Although this watershed is significantly smaller than the overall shed, the time of concentration is much lower. Consequently the peak rainfall intensity will be higher, resulting in a balanced estimate of peak flow considering the flow reducing effects of the various basins within the golf course. In addition, there are no FEMA detailed studies for Dry Creek, nor a 100-year floodplain.

The Rational Method calculations are shown in Table 8 for all cross culvert systems that meet method's constraints.

Table 8. Rational Method Design Storm Discharges (offsite flow to cross-culvert)

Culvert Station	ID	Area (ac)	Primary Method	Q_{10} (cfs)	Q_{100} (cfs)
B2RN 536+47 to FL2N 735+99	DS 50b and DS 50d	73	Rational	14	25
B2RN 554+34.45	Existing 66" RCP (Dry Creek)	172	Rational	36	66

2.4.2 CCCFC&WCD Unit Hydrograph

The CCCFC&WCD has published guidance on rainfall-runoff hydrologic modeling within their jurisdiction. Included within this guidance are procedures to build a HEC-HMS hydrologic model, with the following conditions and parameters.

Subbasin Parameters:

- Loss Method = Soil Moisture Accounting
- Transform Method = User-Specified S-Graph
- Baseflow Method = Recession

Loss Parameters:

- All fields set to 0, except for the Surface Storage and Max Infiltration
- Surface Storage = 0.25 in.
- Max Infiltration = Constant, based on land use

Transform Parameters:

- S-Graph
- Lag Time (based on the following relationship):

$$T_{lag} = 24xN * \left(\frac{L * L_{ca}}{S^{0.5}} \right)^{0.38}$$

Where:

T_{lag} = The time interval from the center of mass of rainfall runoff to the peak of the resulting hydrograph

L = Length of the main drainage path (miles)

L_{ca} = Length along the drainage path from a point opposite the centroid of the watershed to the outlet points (miles)

S = Overall slope of the main watercourse (feet/mile)

N = Weighted watershed Manning coefficient (determined from Caltrans HDM Table 816.6A – *Roughness Coefficients for Sheet Flow*

Time Series Gage Parameters:

- Data Source = "Manual Entry"

- Units = “Incremental Inches”
- Time Interval = Depends on storm duration; use Rainfall Distribution curves published by CCCFC&WCD

Meteorological Parameters:

- Precipitation = Specified Hyetograph
- Evapotranspiration and Snow Melt = None
- Units System = U.S. Customary

Base Flow Parameters:

- Initial Type = Discharge Per Area
- Initial Discharge = 5 cfs/mi^2
- Recession Constant = 1
- Threshold Type = Threshold Discharge
- Flow = 0 cfs

Using the procedures outlined by the CCCFC&WCD, HEC-HMS models were used to generate the following discharges listed in Table 9 for the Deer Creek off-site watershed too large to be determined using the Rational Method.

Table 9. CCCFC&WCD Unit Hydrograph Design Storm Discharges (offsite flow to cross-culverts)

Culvert Station	ID	Area (ac)	Primary Method	Q_{10} (cfs)	Q_{100} (cfs)
B2RN 524+30	Deer Creek	3,280	CCCFC&WCD Hydrograph	291	539

3 OFF-SITE HYDRAULICS

This section summarizes the procedures followed to develop drainage design recommendations, including upstream and downstream invert elevations and culvert sizes for cross-culverts handling offsite flow. Procedures and standards are based on the FHWA's *Hydraulic Design of Highway Culverts* (HDS No. 5, 2005), and the Caltrans HDM.

3.1 System Controls

Culvert sizes were analyzed per Section 821.3 of the HDM. Criteria include:

- Flow from the 10-year storm event contained within the culvert,
- No objectionable backwater depths or outlet velocities from the 100-year storm event, and
- Flow velocity of at least 3 ft/s when culvert is half full to allow for self-cleaning.

Culvert diameters, slopes, and elevations were determined using as-built record drawings, survey data, field observation, or maintenance records.

3.2 Inlet and Outlet Treatment and Energy Dissipation

Rock slope protection, flared end sections (FES), and headwalls are specified at the proposed outfalls to minimize potential erosion. The *California Bank and Shore Rock Slope Protection Design – Practitioner's Guide and Field Evaluations of Riprap Methods Manual* (FHWA-CA-TL-95-10, October 2000) was used to design the rock slope protection.

3.3 Culvert Material

Alternative pipe culverts are proposed for the project. The allowable pipe material and protection will be prepared based on recommendations from the Geotechnical Report.

3.4 Off-site Hydraulics for Cross Culverts along SR 4

WRECO performed an independent analysis of the hydraulic capacity of these existing cross culverts using Hydraflow Storm Sewers 2008 (Version 12.01) from Intelisolve. As-built information was used to determine the hydraulic grade lines and relevant structure dimensions.

The existing cross culverts along SR 4 appear to meet Caltrans' criteria of keeping the hydraulic grade within the objectionable headwater elevation for the 100-year design discharge.

The Hydraflow results are attached as Appendix F and are summarized in Table 10. These systems would be proposed to be replaced as part of the future contract to construct a partial cloverleaf interchange over Balfour Road.

Table 10. Cross-culvert Hydraulics

Culvert Location		Existing Culvert Diameter (in)	Material	Soffit Elevation at Inlet (ft)	Control Point	Allowable HGL at Inlet (ft)	Allowable HGL at Outlet (ft)	Analysis Method	Q_{10}		Q_{50}				Q_{100}					Notes	Proposed Action
PM	Station								Q_{10} (cfs)	Inlet HGL (ft)	Q_{50} (cfs)	Inlet HGL (ft)	Outlet HGL (ft)	Outlet Velocity (ft/s)	Q_{100} (cfs)	Inlet HGL (ft)	Outlet HGL (ft)	Outlet Velocity (ft/s)	Manning's "n"		
35.46	B2RN 524	84	RCB	123.1	Outlet	123.08	139.5	CCCFC&WCD	291	115.59	498	117.34	116.69	3.23	572	118.16	117.73	2.85	0.035	Deer Creek	Bridge
35.7	B2RN 536	24	APC	123.44	Outlet	127.05	126.8	Rational	14	122.91					25	124.75	120.42	5.21	0.025	Unnamed	Upsize to 36"
36.02	B2RN 554	66	RCP	110.22	Outlet	125.65	125.5	Rational	36	106.98					66	107.96	107.83	4.54	0.012	Dry Creek	Keep

4 ON-SITE ROADWAY DRAINAGE

Quincy Engineering provided roadway layouts, profiles, superelevation diagrams, and digital design surfaces of the Project site. This information was used to determine the location of proposed drainage structures and to estimate the top of grate elevations of the proposed inlets. This info was also used to locate and design roadside ditches and gutters.

WRECO performed an on-site roadway drainage analysis that included calculations of flows over impervious pavement areas, estimations of spread flow widths at proposed inlets, designs of on-site drainage pipe systems connecting inlets, and designs of roadside ditches. Drainage design of gutter conveyance capacity was done following the procedures in the Caltrans HDM and the FHWA's Hydraulic Engineering Circular No. 22, Third Edition (HEC-22) (September 2009).

WRECO performed a capacity analysis for the inlet and pipe systems using Hydraflow.

4.1 Recurrence Interval

Improvements for this Project include the construction of new highway, ramps, and a partial cloverleaf interchange. Per Table 831.3 of the HDM, roadway drainage systems for through traffic lanes, branch connections, and other major ramp connections should be designed using the 25-year design discharge with permissible water spread based on the shoulder width.

4.2 Time of Concentration

WRECO estimated times of concentration following the procedures in Section 816.6 in the Caltrans HDM. The HDM also recommends a minimum time of concentration of five minutes for paved areas and steep unpaved areas, and ten minutes for rural or undeveloped areas. All of the on-site drainage systems in the Project have relatively short flow path lengths; therefore, the calculated times of concentration for those catchments would be shorter than the suggested minimums. Consequently, WRECO used a 5-minute time of concentration for all on-site paved catchments in the Project that drain directly to inlets. For all other locations, WRECO estimated times of concentration following the procedures in the HDM.

4.3 Rainfall Data and Intensities

The rainfall intensity used for the on-site roadway drainage of the new ramps and partial cloverleaf interchange was 2.80 in./hr, which represents the 25-year recurrence interval design storm, 5-minute storm event. The rainfall intensity used for the improvements along Balfour Road was 2.10 in./hr, which represents the 10-year recurrence interval design storm, 5-minute storm event.

4.4 Points of Concentration

Stormwater flows will be conveyed in drainage ditches, roadside gutters, and along dikes, barriers, or retaining walls. The points of concentration for the on-site roadway drainage systems also include drainage inlets, manholes, and outfalls.

4.5 System Controls

The upstream and downstream invert elevations for the proposed culverts are generally based on Caltrans design procedures. For proposed systems connecting to existing drainage systems, the upstream and/or downstream invert elevations of the existing systems governed the proposed invert elevations. The existing invert elevations were determined based on as-built drawings from Caltrans and the City of Brentwood and Deer Creek survey data provided by Quincy Engineering. Invert elevations at some locations will need to be verified. For systems that discharge to open channels, the topography at the channel controlled the proposed culvert invert elevations.

Drainage systems that conveyed flows to ditches or biofiltration swales downstream used a downstream control that was the hydraulic grade line of the swale or ditch for the design storm. Appendix H shows the ditch calculations that determined the hydraulic grade line. For Drainage Systems not conveying into a ditch or biofiltration swale, a normal depth slope was used as the downstream boundary condition. New drainage systems that are proposed to connect to existing drainage systems used the top of grate elevation of the proposed system as shown on the drainage profiles.

4.6 Grate Interception and Gutter Capacity

Grate interception, bypass, gutter spread, and inlet capacity calculations were based on formulas and procedures from HEC-22. These calculations can be found in Appendix I.

According to Table 831.3 of the HDM, the design water spread should remain outside of the traveled way at ramp areas. According to Table 831.4 of the HDM, no more than 0.1 cubic feet per second (cfs) of concentrated flow should flow across the roadway during the design storm. At the Balfour Road overcrossing, inlets would be proposed at locations immediately upstream of superelevation flips and structural approach slabs such that no bypass runoff would flow across the bridge.

Drainage at the bridge is being designed by Quincy Engineering with recommendations from WRECO.

4.7 Hydraulic Grade Line Calculations

WRECO performed hydraulic grade lines analyses for on-site systems using Hydraflow. Invert elevations for drainage structures were determined based on system controls; see Section 4.5. A pipe size was assigned for each drainage culvert, with a mimimum diameter of 18 in. for culverts wholly or partly under the roadbed within Caltrans' right-of-way, per Table 838.4 of the HDM, and a minimum of 12 in. for culverts within the City's right-of-way. For proposed systems that connect to existing upstream drainage

systems, the size of the proposed downstream system is proposed to be at least the size of the upstream culvert. The Hydraflow models and results can be found in Appendix G.

From the inlet capacity calculations, bypass flows of inlets in excess of 0.3 ft/sec were added to the downstream receiving inlet in the Hydraflow models to make sure the system worked hydraulically with bypass flows.

4.8 Ditches and Gutters

The Project would involve the addition of new ditches and gutters. Along the proposed highway expansion and partial cloverleaf interchange, ditches and gutters are being proposed where feasible. Calculations for the ditches and gutters are included in Appendix H.

4.9 Storm Water Best Management Practices

The consideration for stormwater best management practices (BMPs), including temporary construction site, design pollution prevention, and treatment BMPs, can be found in the Storm Water Data Report (SWDR).

5 TEMPORARY DRAINAGE SYSTEMS

Standard temporary construction site BMPs for the Project are required for any construction activity to reduce pollutants in stormwater discharges throughout construction. The SWDR for the Project will detail Project-specific temporary construction site BMPs considered.

5.1 Permanent Soil Stabilization Systems

Permanent design pollution prevention BMPs or soil stabilization systems that reduce erosion, such as erosion control, are specified for all disturbed soil areas (DSAs) that will remain unpaved after construction; these areas will be specified in the Project's contract documents and SWDR.

Rock slope protection (RSP) and flared end sections (FES) are specified at all new and reconstructed outfalls to minimize erosion potential. The *California Bank and Shore Rock Slope Protection Design – Practitioner's Guide and Field Evaluations of Riprap Methods Manual* (FHWA-CA-TL-95-10, October 2000) would be used to design the RSP.

5.2 Permanent Treatment BMPs

Permanent treatment BMPs are proposed to treat roadway runoff. Treatment BMPs being considered for the Project include biofiltration strips, biofiltration swales, and infiltration trenches.

6 FLOODPLAIN INFORMATION

The Project is within the limits of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) panels 06013C0361F and 06013C0353F, effective June 16, 2009. Based on a review of these flood maps, there is one location within the Project limits that is also within a 100-year floodplain (Deer Creek), and one location within the 500-year floodplain (Dry Creek).

The floodplain associated with Deer Creek is designated as a Zone AE regulatory floodway. Zone AE represents areas within the 1% annual chance floodplain, with water surface elevations determined. A regulatory floodway represents the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights.

The floodplain associated with Dry Creek is designated Zone X (shaded). Zone X (shaded) represents areas inundated during the 500-year flood and areas inundated during the 100-year flood with average depths of less than 1 foot.

The vertical datum of elevations published on the FEMA FIRMs for Contra Costa County reference the North American Vertical Datum of 1988 (NAVD 88). The FIRMs covering the Project limits can be found in Appendix C.

7 COST ESTIMATE

The construction cost for the proposed Phase I drainage improvements was calculated to be $3.6 million. These costs were based on unit costs from Caltrans' Contract Cost Data website. Costs for temporary drainage will also be included. The cost estimate does not include costs for erosion control or temporary construction site BMPs; these costs are summarized in the SWDR.

8 REFERENCES

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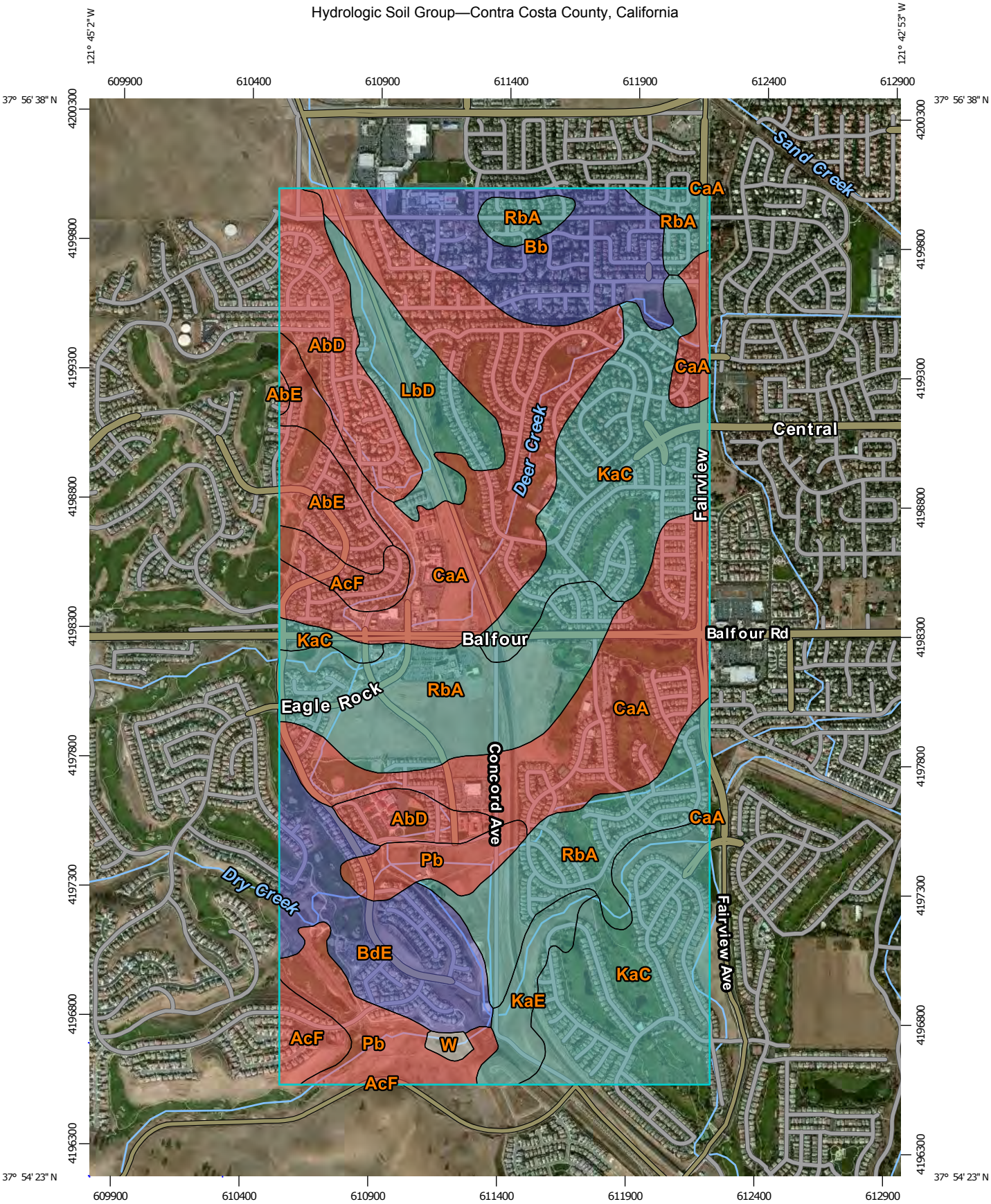
Appendix A Hydrologic Data

Appendix A.1 NRCS Hydrologic Soil Group Map

Hydrologic Soil Group—Contra Costa County, California



Map Scale: 1:20,300 if printed on A portrait (8.5" x 11") sheet.

N

0 300 600 1200 1800 Meters

0 500 1000 2000 3000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 12, 2010—Nov 15, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Contra Costa County, California (CA013)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AbD	ALTAMONT CLAY, 9 TO 15 PERCENT SLOPES	D	90.8	6.3%
AbE	ALTAMONT CLAY, 15 TO 30 PERCENT SLOPES	D	35.9	2.5%
AcF	ALTAMONT-FONTANA COMPLEX, 30 TO 50 PERCENT SLOPES	D	38.0	2.6%
Bb	BRENTWOOD CLAY LOAM	B	98.6	6.9%
BdE	BRIONES LOAMY SAND, 5 TO 30 PERCENT SLOPES	B	101.1	7.0%
CaA	CAPAY CLAY, 0 TO 2 PERCENT SLOPES	D	384.8	26.8%
KaC	KIMBALL GRAVELLY CLAY LOAM, 2 TO 9 PERCENT SLOPES	C	272.7	19.0%
KaE	KIMBALL GRAVELLY CLAY LOAM, 9 TO 30 PERCENT SLOPES	C	29.2	2.0%
LbD	LINNE CLAY LOAM, 5 TO 15 PERCENT SLOPES	C	63.2	4.4%
Pb	PESCADERO CLAY LOAM	D	77.0	5.4%
RbA	RINCON CLAY LOAM, 0 TO 2 PERCENT SLOPES	C	241.9	16.8%
W	WATER		3.9	0.3%
Totals for Area of Interest			**1,437.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

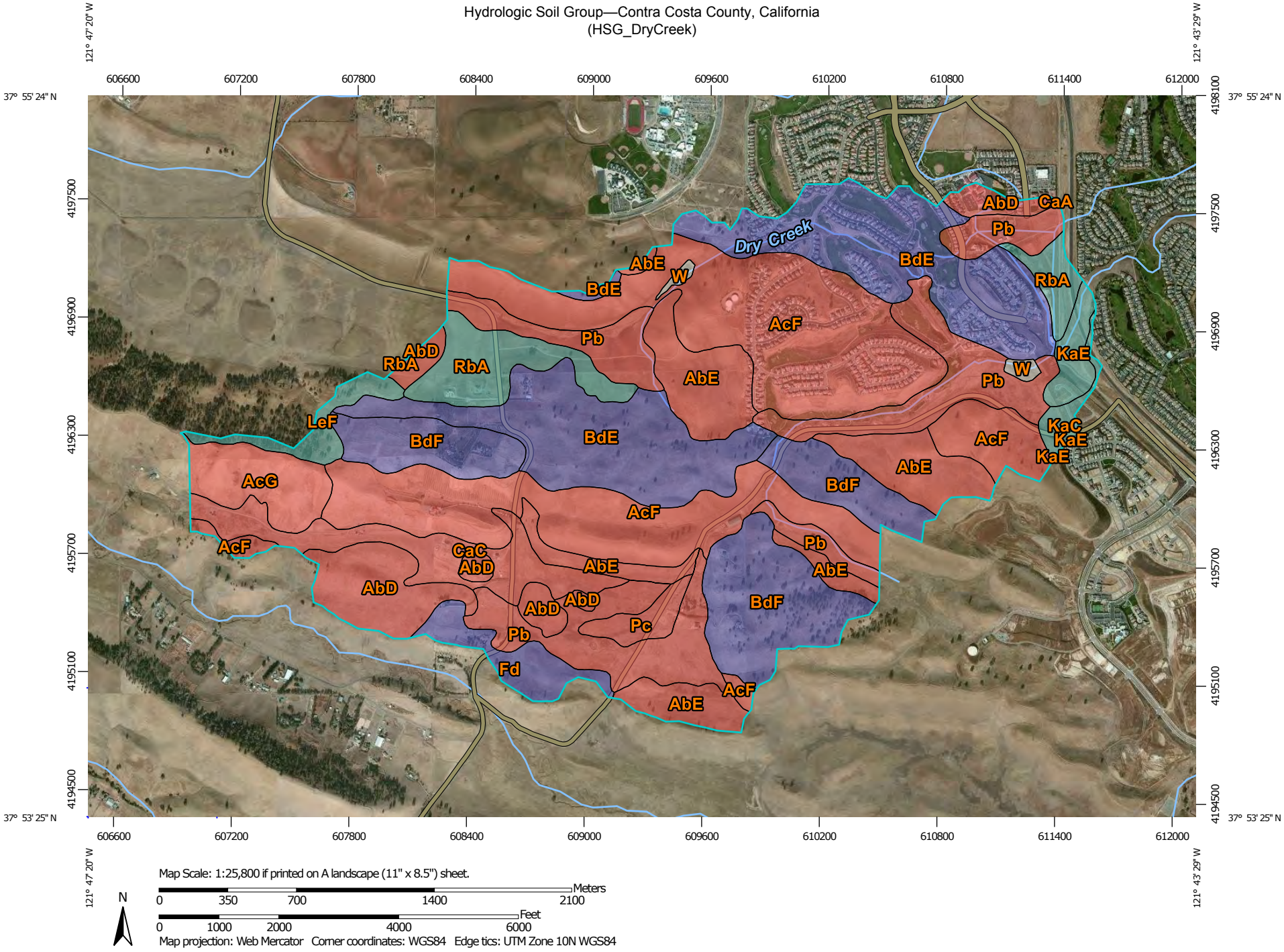
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Hydrologic Soil Group—Contra Costa County, California
(HSG_DryCreek)



Map Scale: 1:25,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 12, 2010—Nov 15, 2010

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Contra Costa County, California (CA013)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AbD	ALTAMONT CLAY, 9 TO 15 PERCENT SLOPES	D	104.2	5.4%
AbE	ALTAMONT CLAY, 15 TO 30 PERCENT SLOPES	D	168.5	8.8%
AcF	ALTAMONT-FONTANA COMPLEX, 30 TO 50 PERCENT SLOPES	D	494.9	25.7%
AcG	ALTAMONT-FONTANA COMPLEX, 50 TO 75 PERCENT SLOPES	D	55.8	2.9%
BdE	BRIONES LOAMY SAND, 5 TO 30 PERCENT SLOPES	B	344.8	17.9%
BdF	BRIONES LOAMY SAND, 30 TO 50 PERCENT SLOPES	B	211.9	11.0%
CaA	CAPAY CLAY, 0 TO 2 PERCENT SLOPES	D	0.0	0.0%
CaC	CAPAY CLAY, 2 TO 9 PERCENT SLOPES	D	81.5	4.2%
Fd	FONTANA-ALTAMONT COMPLEX	B	38.3	2.0%
KaC	KIMBALL GRAVELLY CLAY LOAM, 2 TO 9 PERCENT SLOPES	C	12.8	0.7%
KaE	KIMBALL GRAVELLY CLAY LOAM, 9 TO 30 PERCENT SLOPES	C	22.0	1.1%
LeF	LOS GATOS LOAM, 30 TO 50 PERCENT SLOPES	C	26.5	1.4%
Pb	PESCADERO CLAY LOAM	D	255.0	13.2%
Pc	PESCADERO CLAY, LOAM STRONGLY ALKALI	D	19.7	1.0%
RbA	RINCON CLAY LOAM, 0 TO 2 PERCENT SLOPES	C	82.6	4.3%
W	WATER		6.6	0.3%
Totals for Area of Interest			**1,925.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

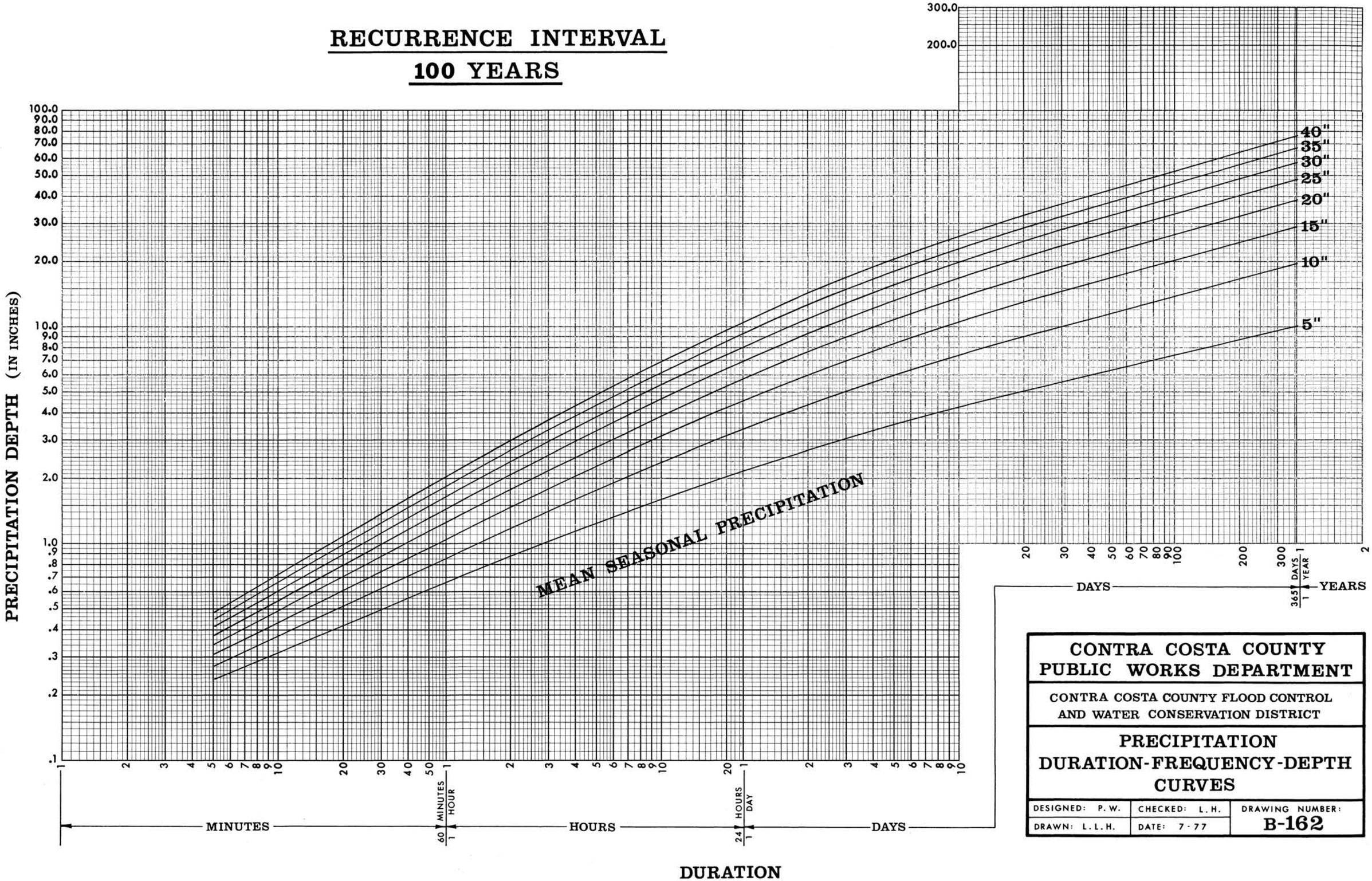
Rating Options

Aggregation Method: Dominant Condition

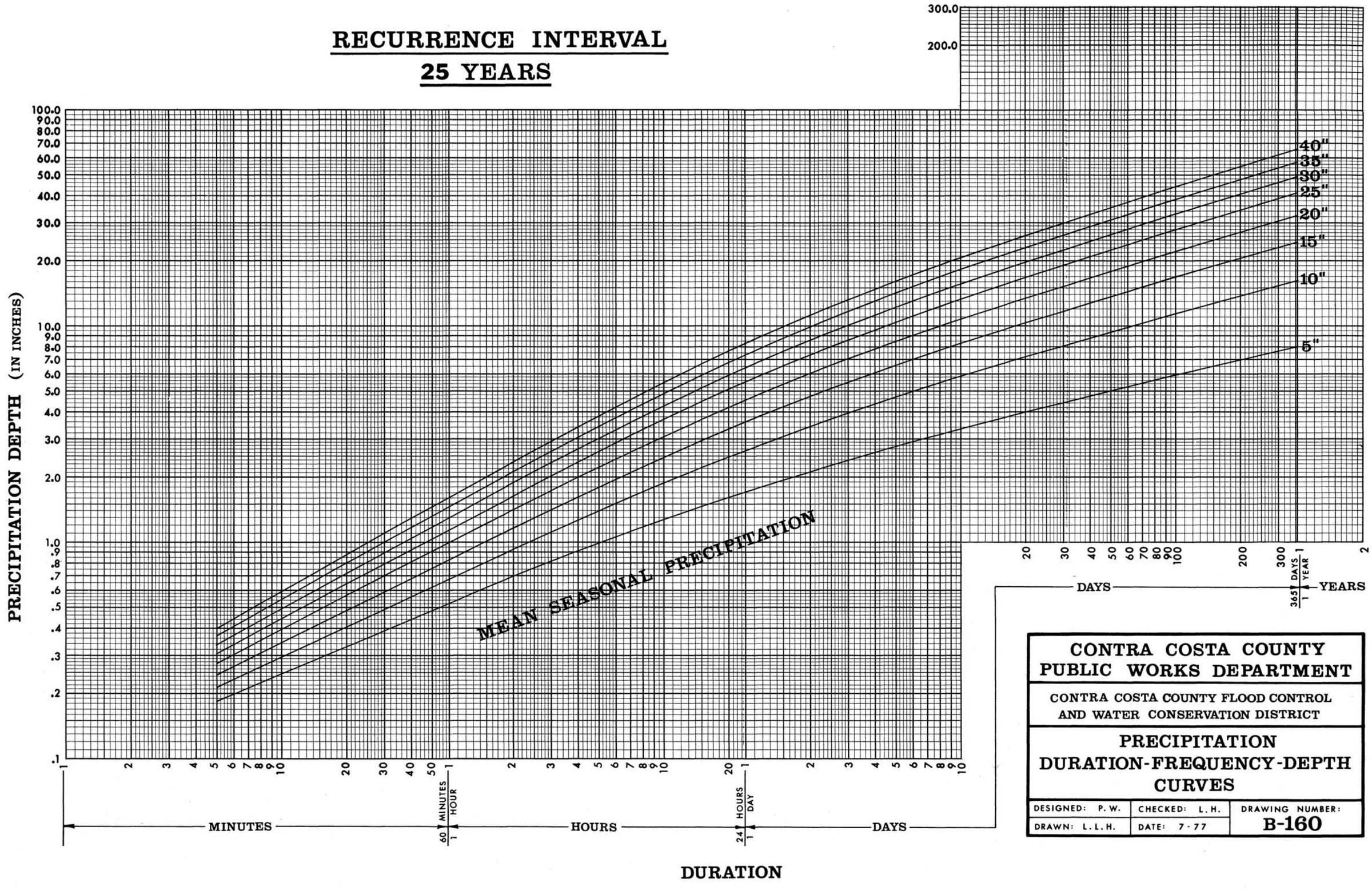
Component Percent Cutoff: *None Specified*

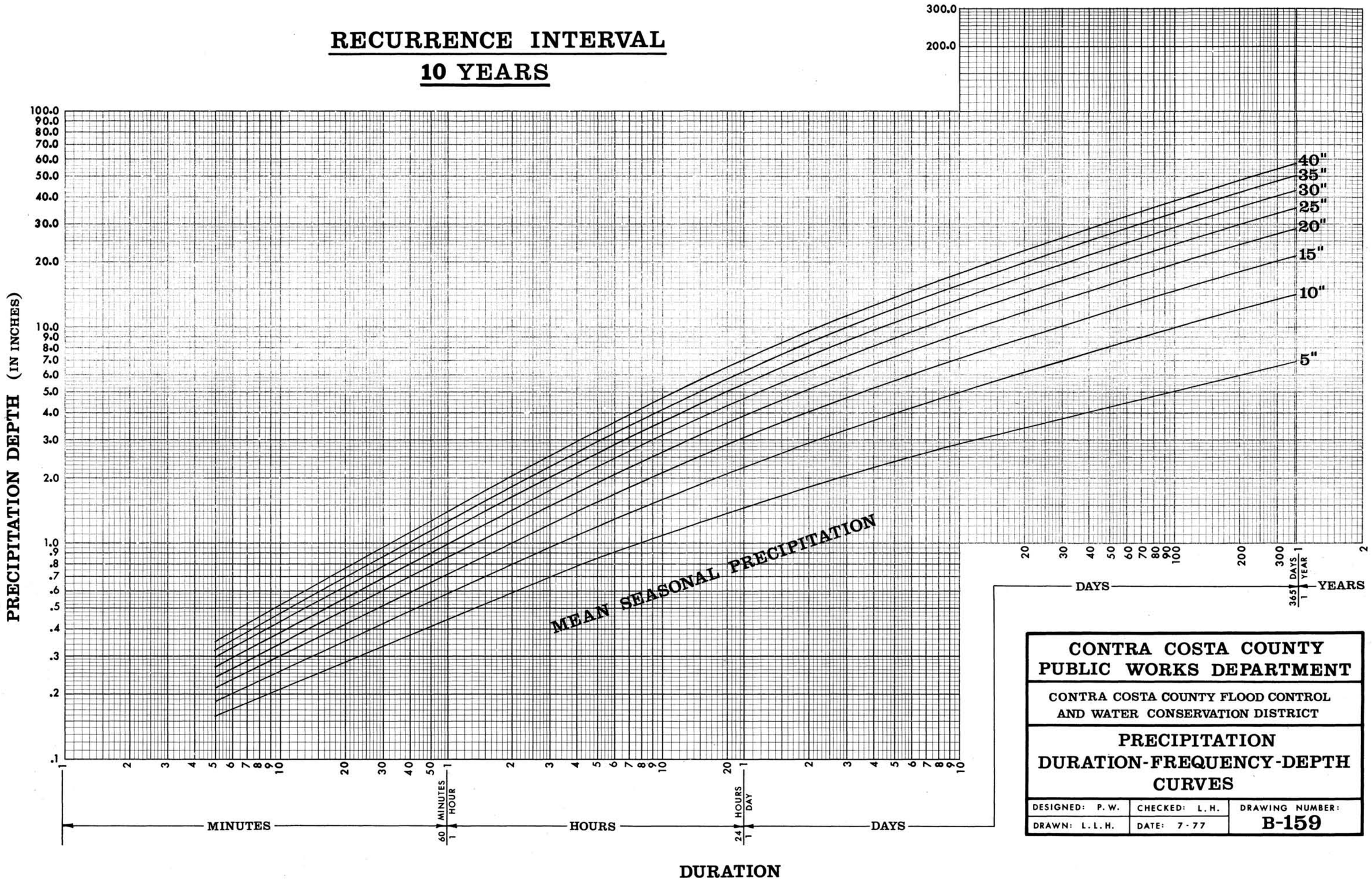
Tie-break Rule: Higher

Appendix A.2 Rainfall Intensity Curve



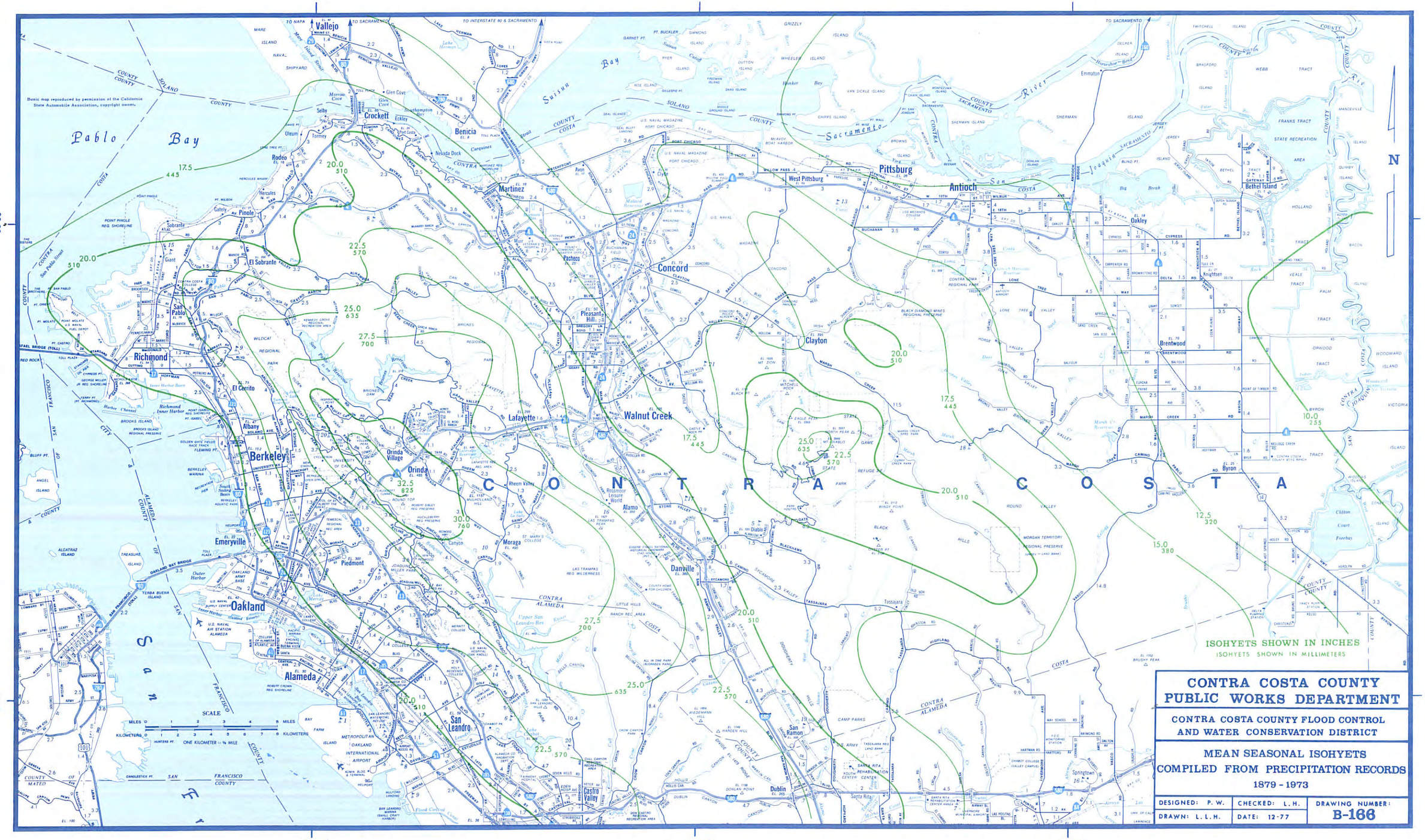
CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-162
DRAWN: L. L. H.	DATE: 7-77	


RECURRENCE INTERVAL
25 YEARS
PRECIPITATION DEPTH (IN INCHES)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
300.0
200.0
40"
35"
30"
25"
20"
15"
10"
5"
MEAN SEASONAL PRECIPITATION
MINUTES
60 MINUTES 1 HOUR
HOURS
24 HOURS 1 DAY
DAYS
365 DAYS 1 YEAR
YEARS
DURATION
CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT
CONTRA COSTA COUNTY FLOOD CONTROL
AND WATER CONSERVATION DISTRICT
PRECIPITATION
DURATION-FREQUENCY-DEPTH
CURVES
DESIGNED: P. W.
CHECKED: L. H.
DRAWING NUMBER:
DRAWN: L.L.H.
DATE: 7-77
B-160



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER:
DRAWN: L. L. H.	DATE: 7-77	B-159

Appendix A.3 Isopleths



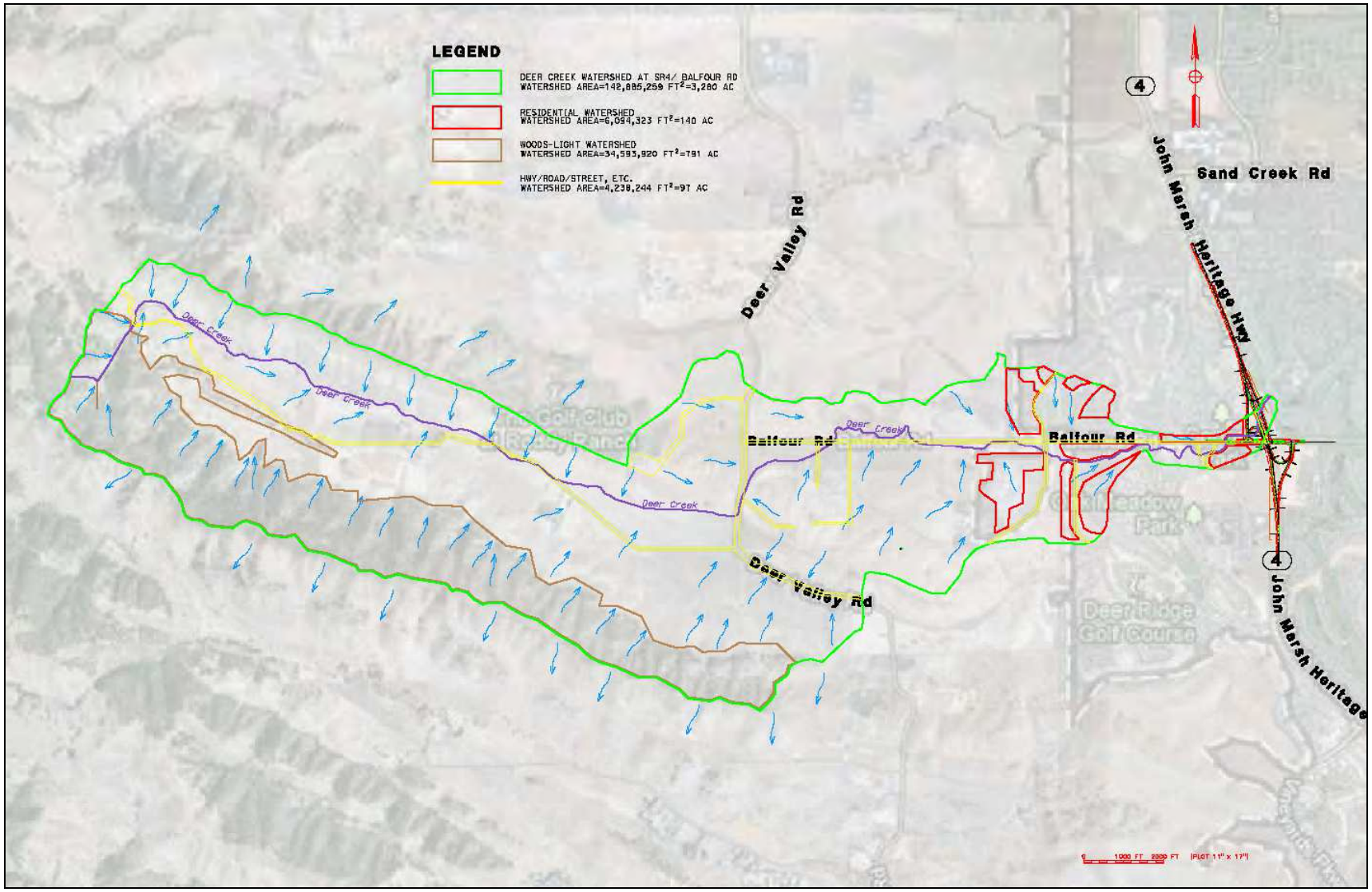
CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT

CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

MEAN SEASONAL ISOHYETS COMPILED FROM PRECIPITATION RECORDS 1879 - 1973

DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER:
DRAWN: L. L. H.	DATE: 12-77	B-166

Appendix B Off-site Watershed Map

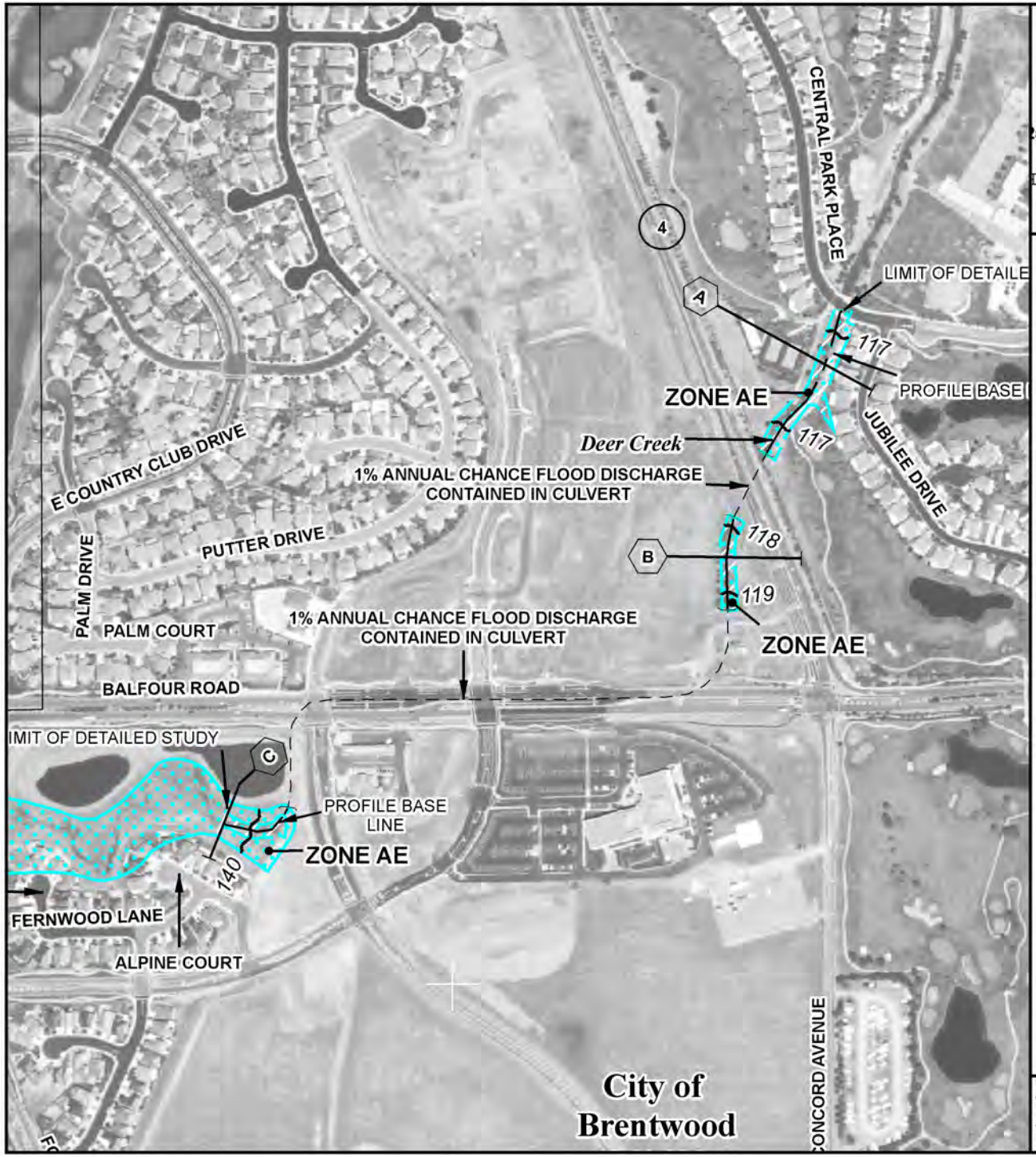


Deer Creek Watershed

Dry Creek Watershed

Trap Gutter Crossing Watershed

Appendix C Flood Insurance Rate Maps



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0361F

FIRM

FLOOD INSURANCE RATE MAP

CONTRA COSTA COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 361 OF 602

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BRENTWOOD, CITY OF	060439	0361	F
CONTRA COSTA COUNTY	060025	0361	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06013C0361F

EFFECTIVE DATE
JUNE 16, 2009

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Appendix D Project Photographs

Project Photos provided by Quincy Engineering

Upstream face of existing Deer Creek RCB (looking into the creek flowline)

Upstream face of existing Deer Creek RCB on rightbank (looking north)

Behind the upstream end of the Deer Creek RCB headwall (looking south)

Upstream face of the existing Deer Creek RCB on leftbank (looking east)

Appendix E Deer Creek Memorandum

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Walnut Creek, CA 94596
Phone: 925.941.0017
Fax: 925.941.0018
www.wreco.com

DRAFT Memorandum

Date: October 4, 2013

To: Lance Schrey / Scott McCauley – Quincy Engineering, Inc.

From: Chris Sewell / Wana Chiu – WRECO

Subject: State Route 4 / Balfour Road Interchange Improvements – Deer Creek Conceptual Bridge Analysis

Project Description

This project proposes to replace the existing at-grade intersection of State Route 4 (SR 4) and Balfour Road with a grade separated interchange. The ultimate project includes two bridge undercrossings with loops to cross over Balfour Road and connect SR 4 with ramps in all quadrants. The project will also widen SR 4 from two lanes to four lanes between Sand Creek Road and Balfour Road. Due to funding limitations, the interchange project will be designed and constructed in two phases. The Phase 1 improvements will consist of constructing a single undercrossing bridge structure for SR 4, and constructing Type L-8 and L-9 ramp configurations for the west and east sides of the interchange, respectively. Phase 2 of the project will consist of constructing a second undercrossing structure for westbound SR 4 traffic over Balfour Road.

Also originally included in Phase 1 was the upstream extension of an existing reinforced concrete box (RCB) culvert along the Deer Creek alignment to accommodate the large embankment fill necessary for the grade separation. This portion of Deer Creek currently flows through an open channel. The new portion of SR 4 will have a profile that is significantly higher than the existing SR 4. The new culvert extension would need to be designed for a fill height of approximately 29 ft, which would require a site-specific design. At the Type Selection Meeting held on July 30, 2013, there were concerns with the potential settlement of the box culvert due to the large amount of fill required on top of the RCB along with concerns using geopiers. There were also concerns over the ability and the amount of time required obtaining the necessary permits that would allow placing fill in the existing creek. As such, it was recommended that we evaluate additional alternatives that involve bridging over the existing creek in lieu of constructing a box culvert extension.

Two separate bridge structures will be required to span over Deer Creek: one on the mainline eastbound SR 4 (mainline) and one at the eastbound SR 4 on-ramp (on-ramp). In addition, retaining walls will be required to span between these two structures to keep embankment fill out of the creek limits. For both the mainline eastbound SR 4 structure and the eastbound SR 4 on-ramp structure, several different alternatives were investigated to span over Deer Creek. Different span lengths were evaluated to compare the cost benefits of shorter spans with the environmental impacts to Deer Creek. At a minimum, all bridge work will be located outside of the ordinary high water elevation, which is approximately 113.0 ft.

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Purpose

The purpose of this technical memorandum is to report the results of the preliminary hydraulic analysis of the proposed (post-project) conditions for the bridges spanning over Deer Creek at the mainline and on-ramp structures. This memorandum supplements the one that was previously prepared in July 2013 for the RCB analysis.

Hydraulic Modeling Assumptions

The hydraulic characteristics of the 100-year flowing through the project site were evaluated using HEC-RAS for the Alternative 4a mainline bridge (see Figure 2) and the Alternative 1 on-ramp bridge (see Figure 3). The mainline bridge is a three-span pre-cast girder while the on-ramp bridge is a single-span cast-in-place (CIP) RCB girder; their dimensions are summarized in Table 1. The minimum soffit elevations were estimated using the general plans for the two structures.

Table 1. Summary of Proposed Bridge Structures

Structure	River Station (ft)	Length (ft)	Width	Structural Depth	Pier Width (ft)	Minimum Soffit Elevation (ft)
Mainline	1933.8	175	70 ft, 10 in.	4 ft, 10 in.	2	138.8
On-ramp	1730	100	47 ft, 10 in.	6 ft, 4 in.	N/A	123.1

The bridges were incorporated into the existing hydraulic model that was previously prepared. The cross sections that were developed for the existing hydraulic model were used for the modeling of the bridges; in the locations where stream cross sections intersected with the proposed bridge structures, the cross sections were removed from the hydraulic model. The cross sections were not modified to include any proposed embankment fill.

Hydraulic Modeling Results

The results of the analysis indicated negligible changes in water surface elevation for the proposed bridge design; the water surface elevations immediately upstream of each structure are summarized in Table 2. The water surface profile is presented in Figure 1 for the bridge analysis. The structural elements of the bridges would be outside of the 100-year flow with the exception of the southern pier (Pier 3) for the mainline bridge, which is partially under the 100-year flow.

Table 2. Water Surface Elevations Upstream of Bridges

River Station (ft)	Description	Water Surface Elevation (ft)	
		Bridge Design	Existing Condition
1975.87	Upstream On-ramp	118.16	118.19
1781.29	Upstream Mainline	117.76	N/A
1676.81	Upstream SR 4 Westbound	117.73	117.73

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Attachments:

- Figure 1 – Deer Creek 100-Year Water Surface Profile within Project Vicinity
- Figure 2 – Mainline General Plan
- Figure 3 – On-ramp General Plan

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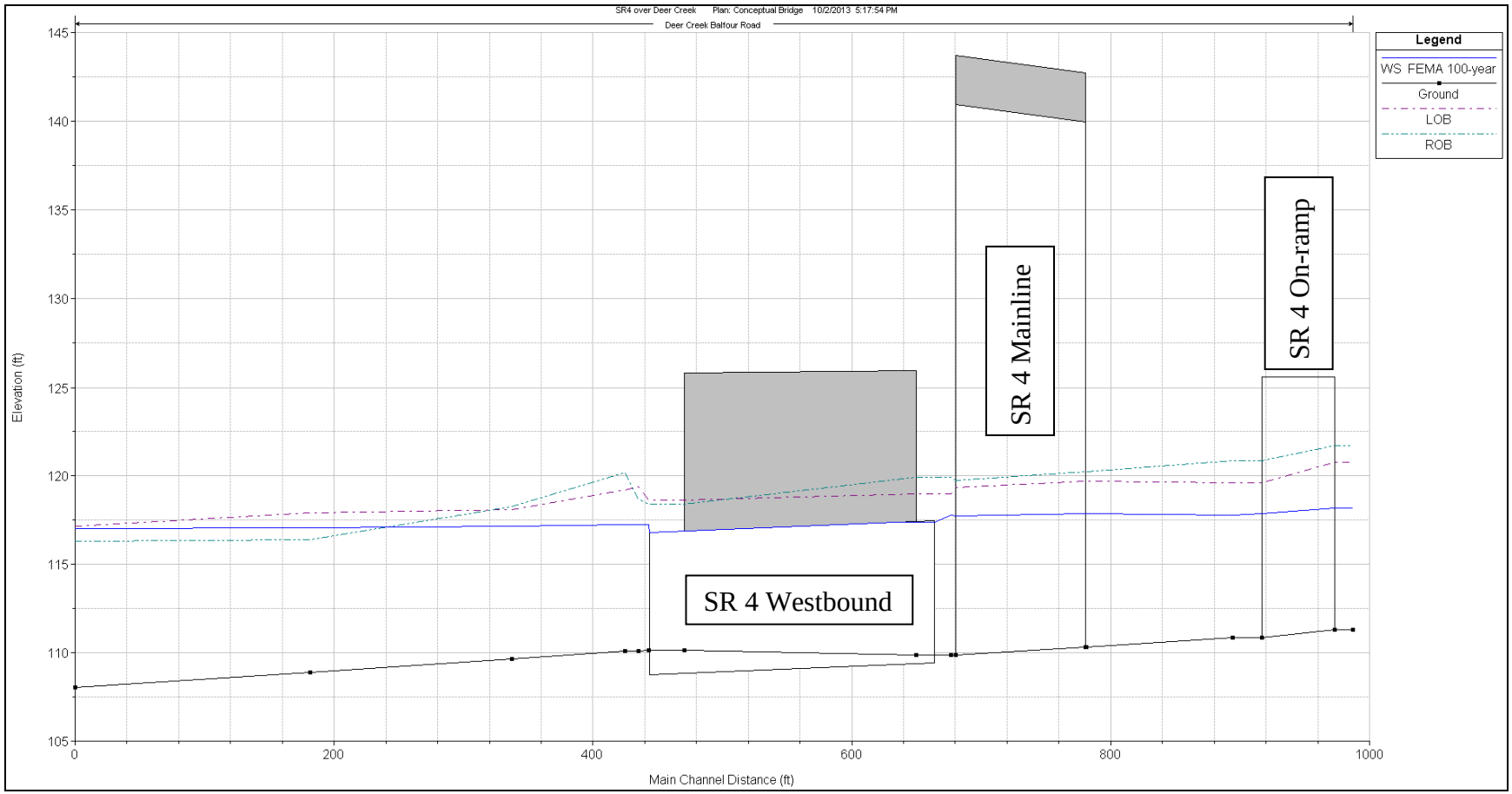

Figure 1. Deer Creek 100-Year Water Surface Profile within Project Vicinity

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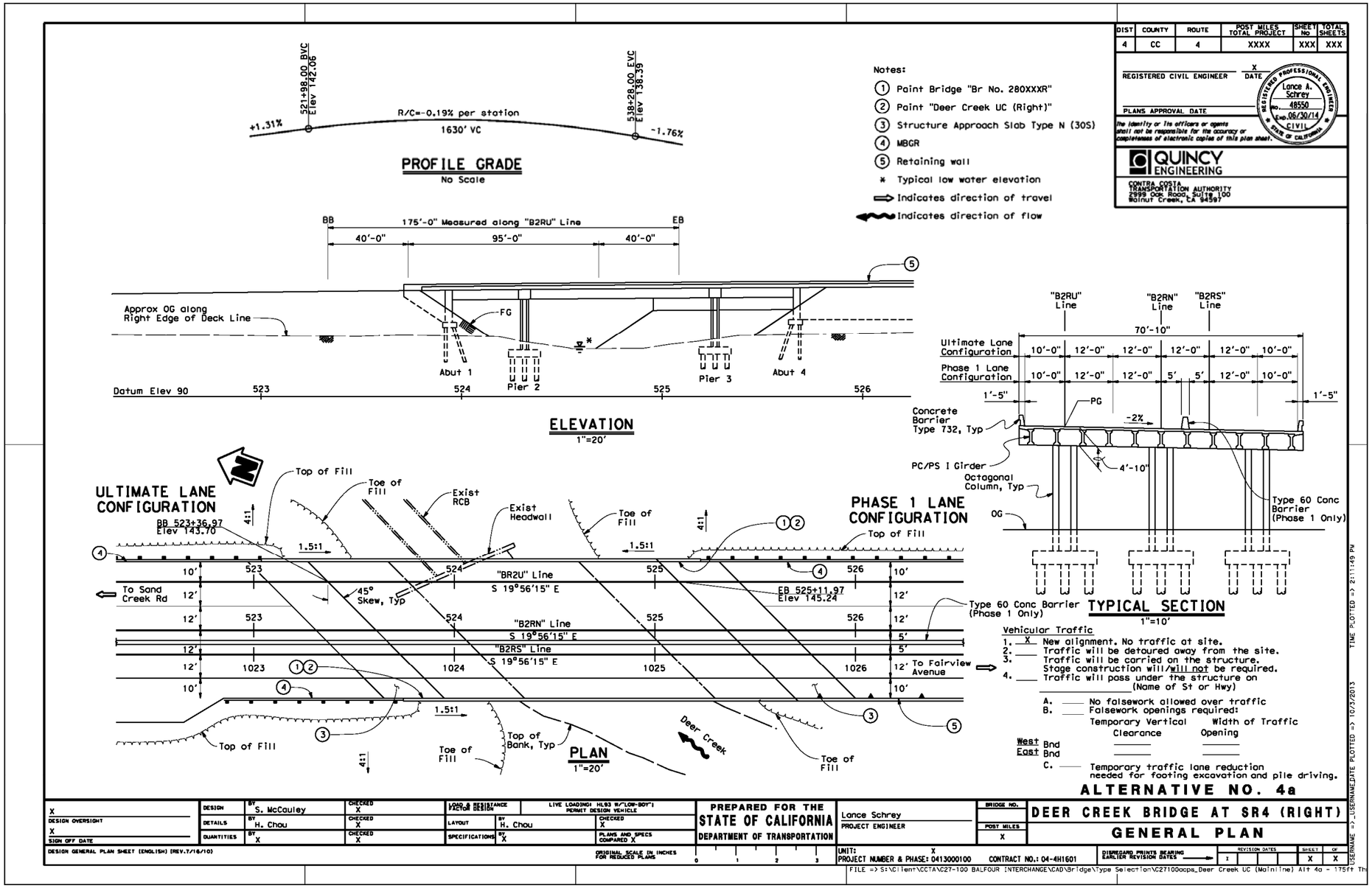

Figure 2. Mainline General Plan

Source: Quincy Engineering, Inc.

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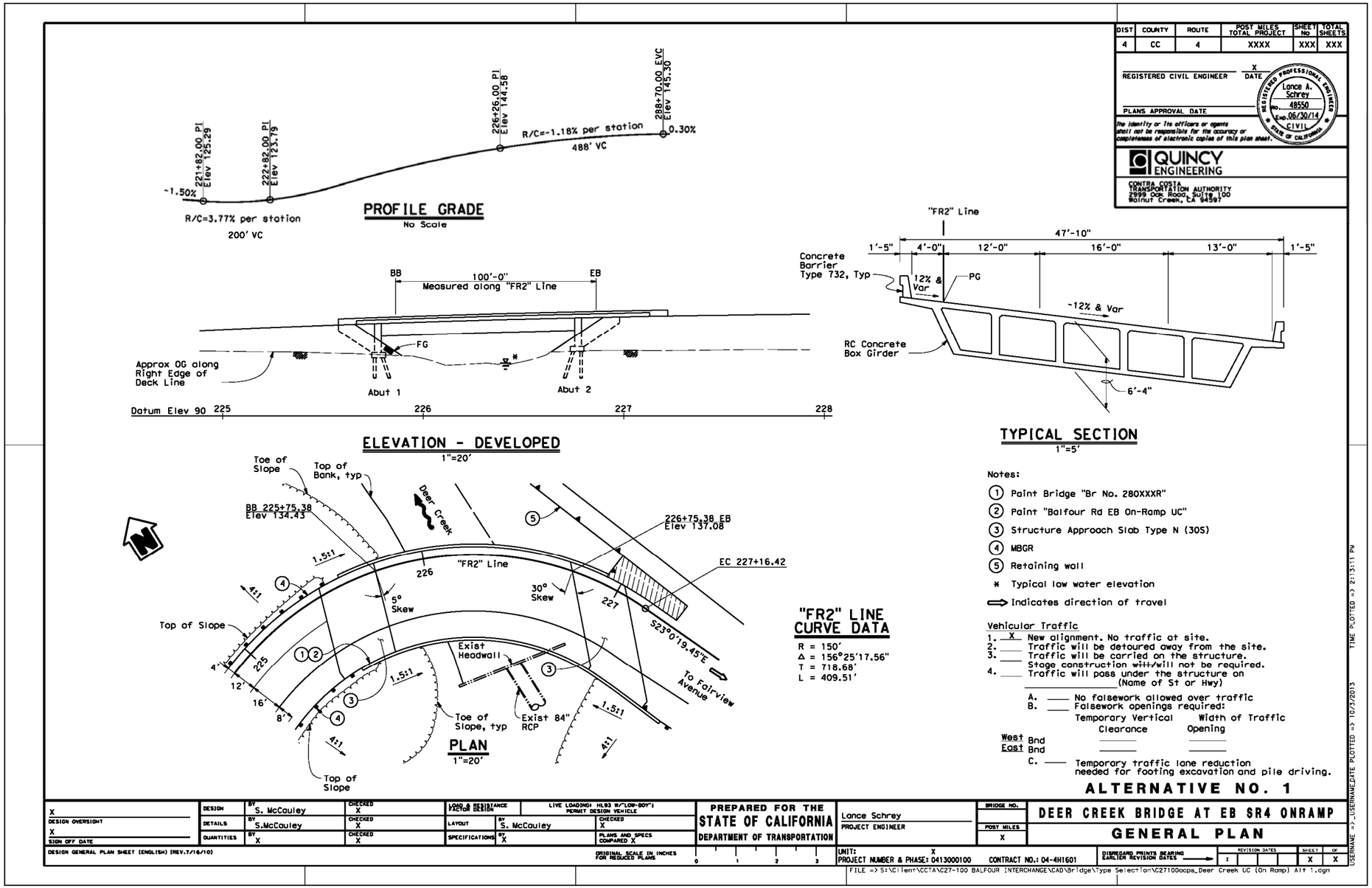
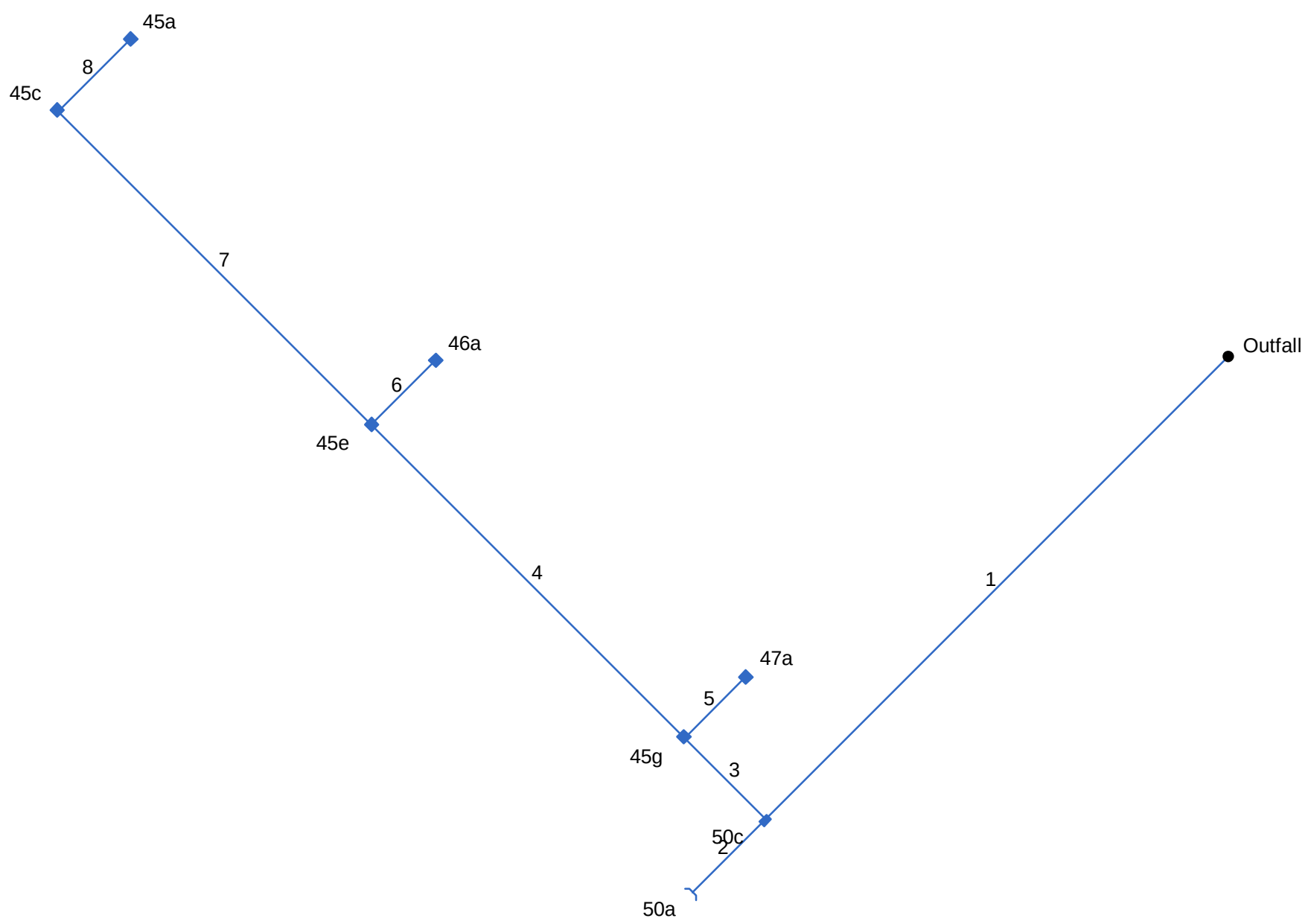


Figure 3. On-ramp General Plan

Source: Quincy Engineering, Inc.

Appendix F Hydraulic Analysis of Cross-Culverts

45 46 47 50 (100-year)



Project File: Drainage System 45 46 47 50 with offsite 100-year.stm	Number of lines: 8	Date: 11-06-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	285	0.05	75.99	1.00	0.05	35.84	5.0	100.8	0.7	26.39	24.57	5.21	36	0.50	118.78	120.21	120.42	124.19	118.79	138.77	50d (Prop. 36 in)
2	1	45	74.69	74.69	0.46	34.54	34.54	100.6	100.6	0.7	25.46	24.79	3.60	36	0.51	120.21	120.44	124.51	124.75	138.77	120.44	50b (Prop. 36 in)
3	1	50	0.19	1.25	1.00	0.19	1.25	5.0	8.1	2.8	3.46	6.69	3.84	18	1.50	133.51	134.26	134.22	135.09	138.77	139.42	45h
4	3	193	0.20	0.93	1.00	0.20	0.93	5.0	6.9	3.0	2.78	5.76	2.84	18	1.11	134.26	136.41	135.37	137.07	139.42	141.57	45f
5	3	38	0.13	0.13	1.00	0.13	0.13	5.0	5.0	3.5	0.46	7.77	0.98	18	2.03	134.35	135.12	135.37	135.45	139.42	141.12	47b
6	4	39	0.16	0.16	1.00	0.16	0.16	5.0	5.0	3.5	0.56	7.72	1.28	18	2.00	136.45	137.23	137.39	137.55	141.57	143.38	46b
7	4	193	0.32	0.57	1.00	0.32	0.57	5.0	5.4	3.4	1.93	4.39	2.09	18	0.65	136.41	137.66	137.39	138.32	141.57	142.78	45d
8	7	44	0.25	0.25	1.00	0.25	0.25	5.0	5.0	3.5	0.88	7.77	1.81	18	2.02	137.66	138.55	138.47	138.91	142.78	144.71	45b

45 46 47 50 (100-year) | Number of lines: 8 | Run Date: 11-06-2013

NOTES: Intensity = 8.68 / (Inlet time + 0.40) ^ 0.53; Return period = 100 Yrs. ; c = cir e = ellip b = box

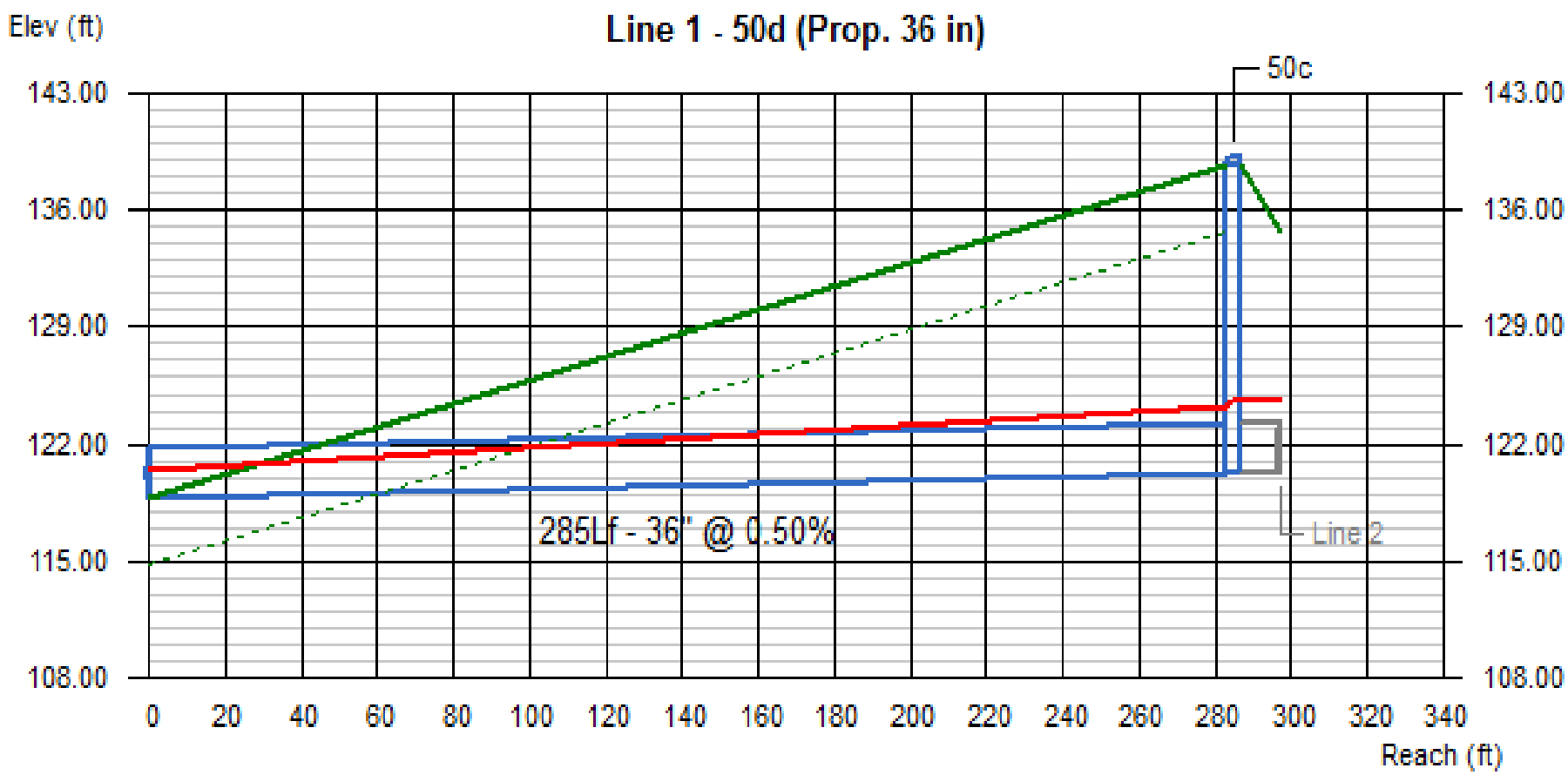
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	36	26.39	118.78	120.42	1.64	3.95	6.69	0.70	121.11	1.730	285	120.21	124.19	3.00	7.07	3.73	0.22	124.40	0.579	1.155	3.291	1.50	0.32
2	36	25.46	120.21	124.51	3.00	7.07	3.60	0.20	124.71	0.539	45	120.44	124.75	3.00	7.07	3.60	0.20	124.96	0.539	0.539	0.243	1.00	0.20
3	18	3.46	133.51	134.22	0.71*	0.82	4.20	0.27	134.50	1.939	50	134.26	135.09	0.83	1.00	3.47	0.19	135.27	1.166	1.553	0.776	1.50	0.28
4	18	2.78	134.26	135.37	1.11	1.40	1.99	0.06	135.43	0.324	193	136.41	137.07	0.66	0.75	3.70	0.21	137.29	1.598	0.961	1.854	1.50	0.32
5	18	0.46	134.35	135.37	1.02	1.28	0.36	0.00	135.37	0.011	38	135.12	135.45	0.33	0.29	1.59	0.04	135.49	0.628	0.319	0.121	1.00	0.04
6	18	0.56	136.45	137.39	0.94	1.17	0.48	0.00	137.39	0.021	39	137.23	137.55	0.32	0.27	2.07	0.07	137.61	1.118	0.569	0.222	1.00	0.07
7	18	1.93	136.41	137.39	0.98	1.22	1.58	0.04	137.43	0.215	193	137.66	138.32	0.66	0.74	2.61	0.11	138.42	0.803	0.509	0.983	1.50	0.16
8	18	0.88	137.66	138.47	0.81	0.98	0.90	0.01	138.49	0.079	44	138.55	138.91 j	0.36**	0.32	2.72	0.12	139.02	1.664	0.872	n/a	1.00	n/a

45 46 47 50 (100-year) | Number of lines: 8 | Run Date: 11-06-2013

Notes: * depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

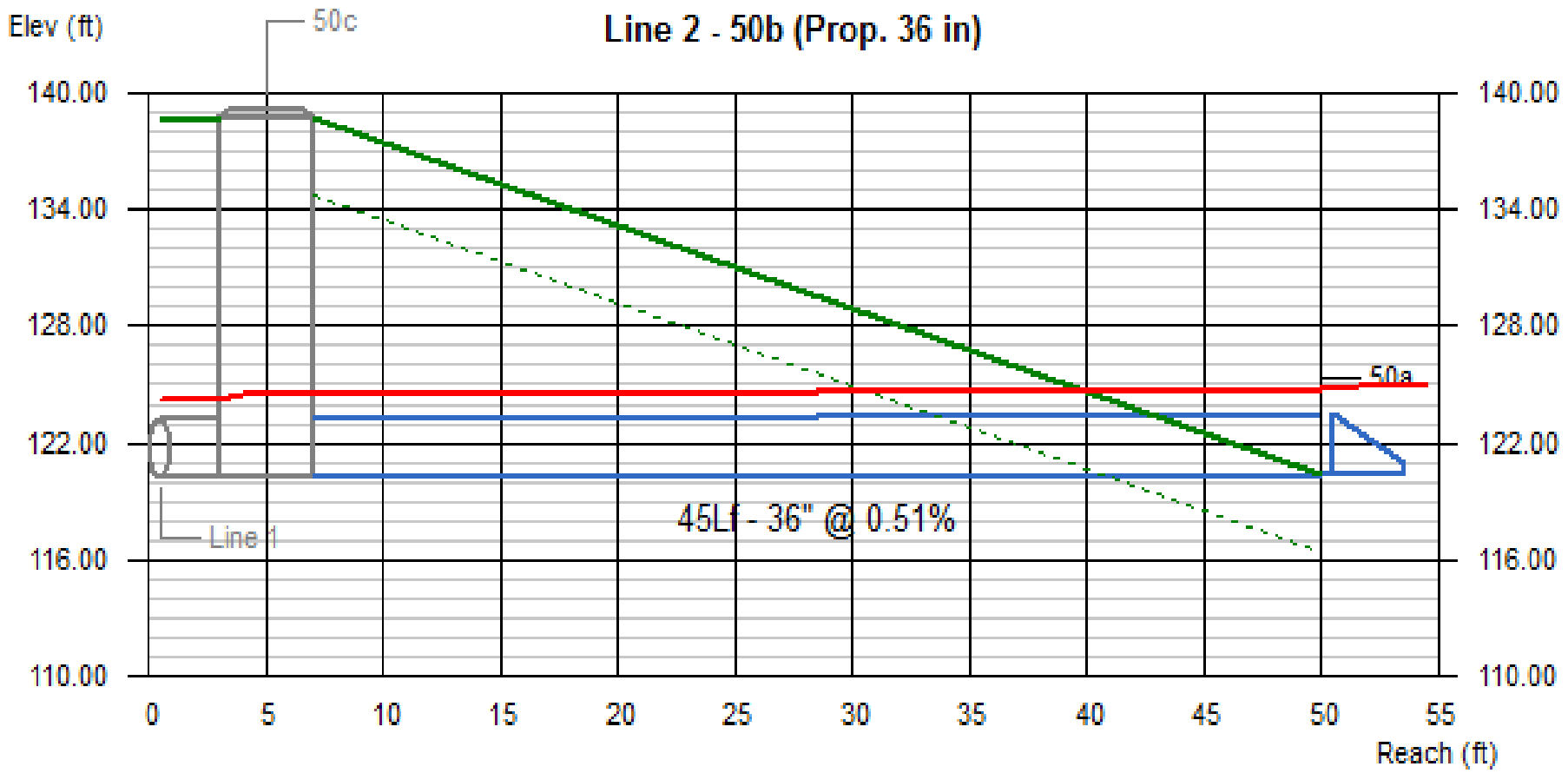
Line Profile (Line 1) - 50d (Prop. 36 in)



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	26.39	118.78	120.21	1.64	3.00	4.30	120.42	124.19	124.51	6.69	3.73	-2.99	15.56

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

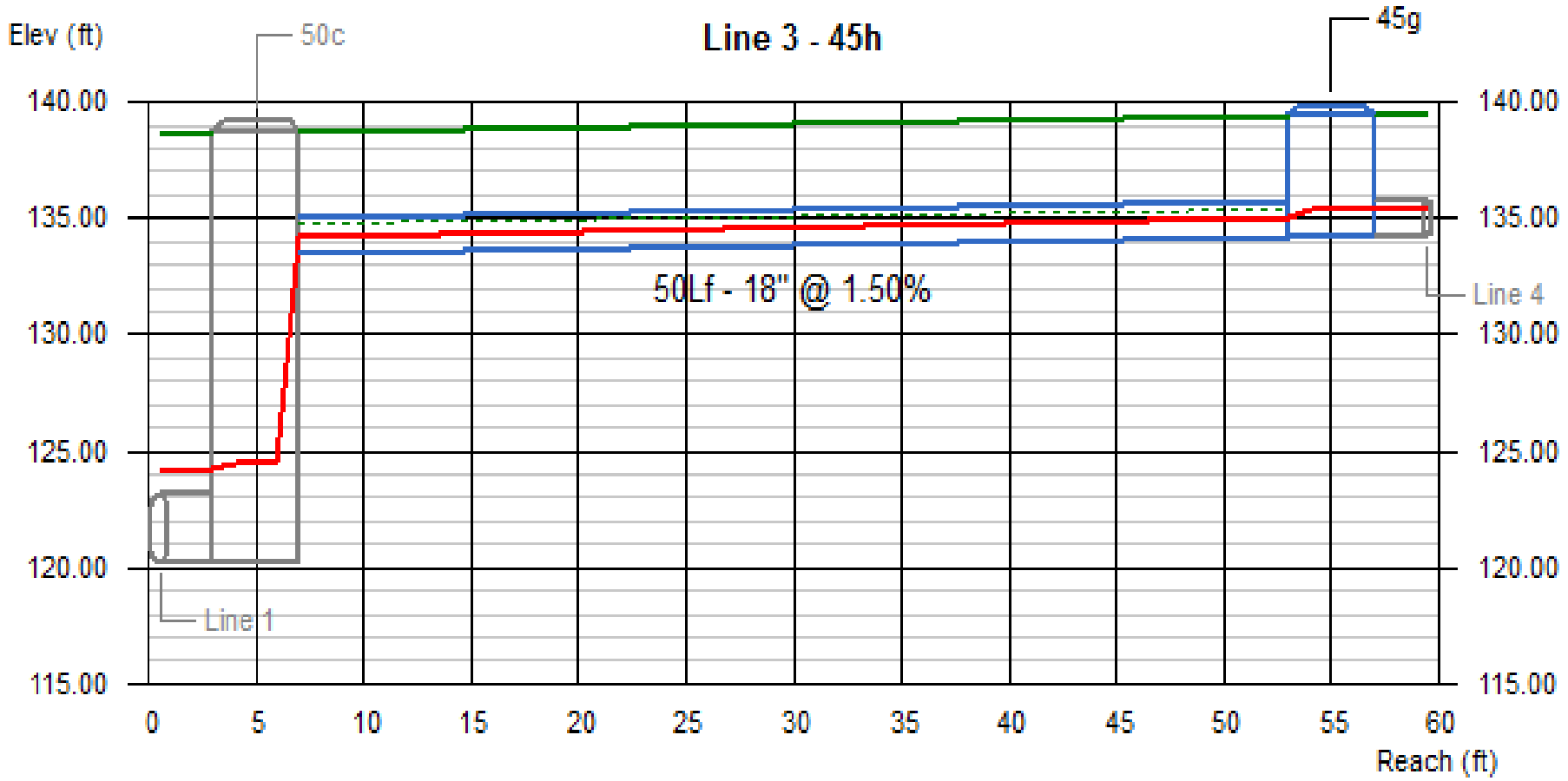
Line Profile (Line 2) - 50b (Prop. 36 in)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	25.46	120.21	120.44	3.00	3.00	4.52	124.51	124.75	124.96	3.60	3.60	15.56	-3.00

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

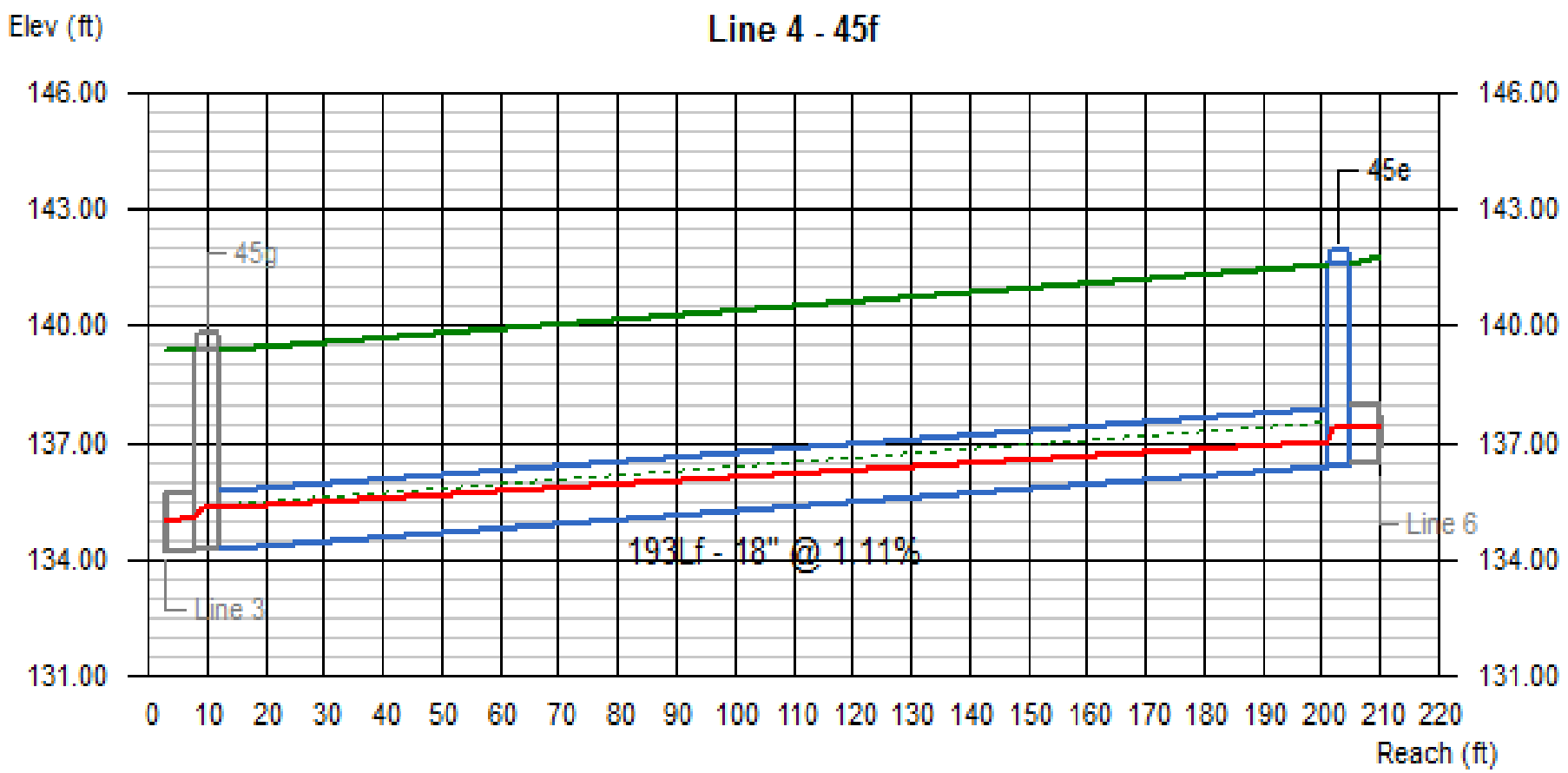
Line Profile (Line 3) - 45h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	3.46	133.51	134.26	0.71	0.83	1.11	134.22	135.09	135.37	4.20	3.47	3.76	3.66

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

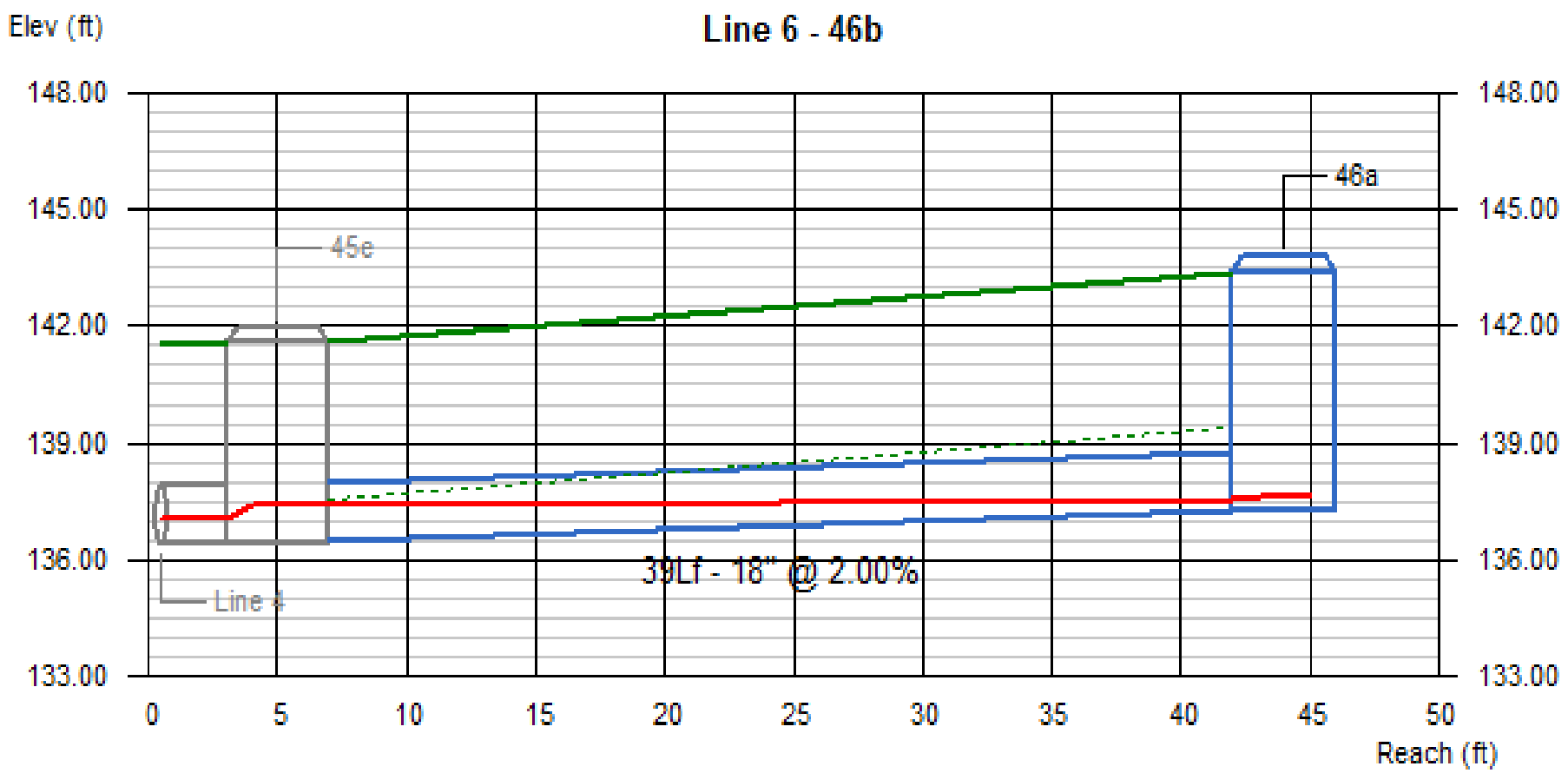
Line Profile (Line 4) - 45f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	2.78	134.26	136.41	1.11	0.66	0.98	135.37	137.07	137.39	1.99	3.70	3.66	3.66

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

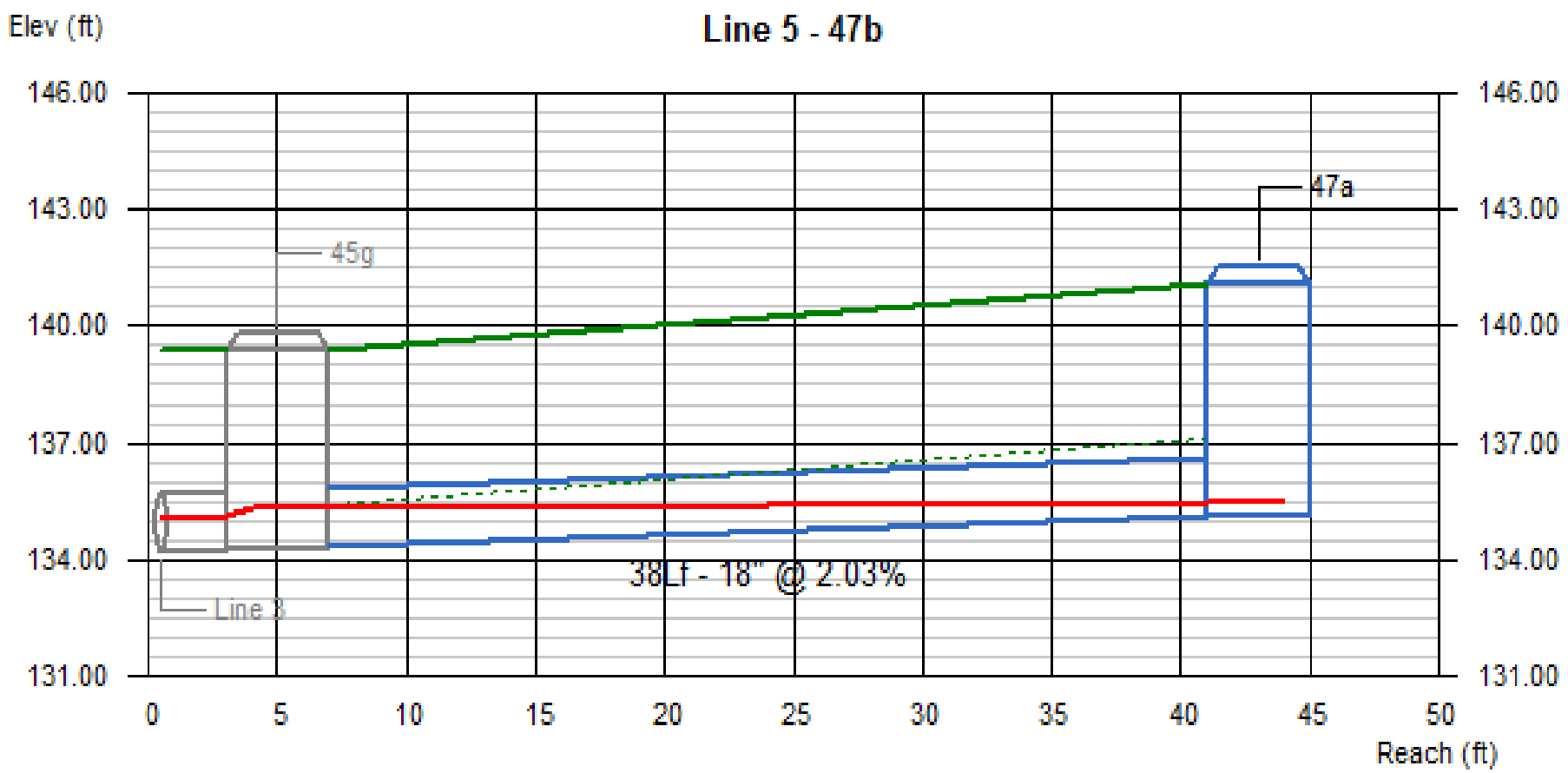
Line Profile (Line 6) - 46b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.56	136.45	137.23	0.94	0.32	0.38	137.39	137.55	137.61	0.48	2.07	3.62	4.65

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

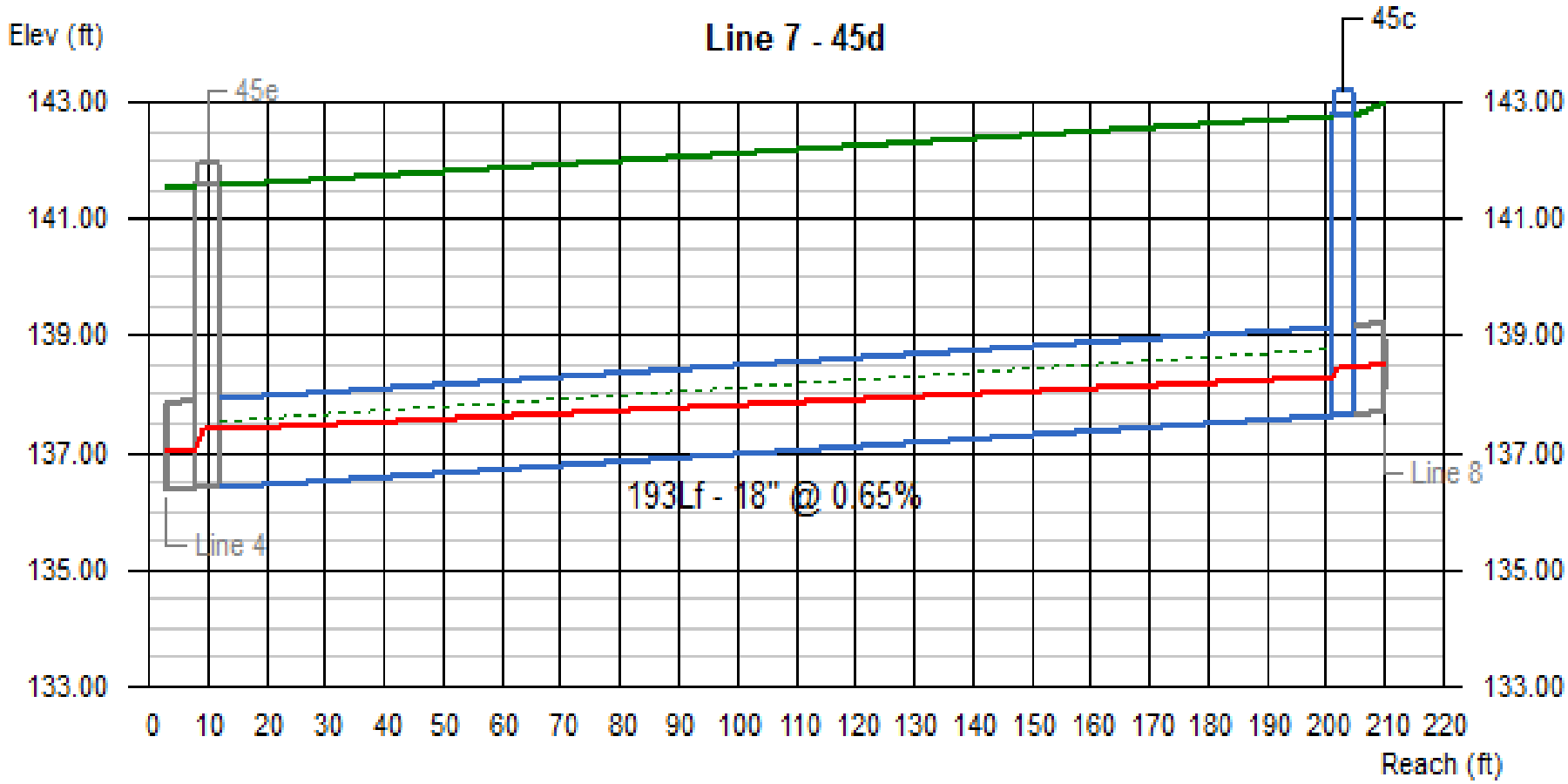
Line Profile (Line 5) - 47b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.46	134.35	135.12	1.02	0.33	0.37	135.37	135.45	135.49	0.36	1.59	3.57	4.50

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

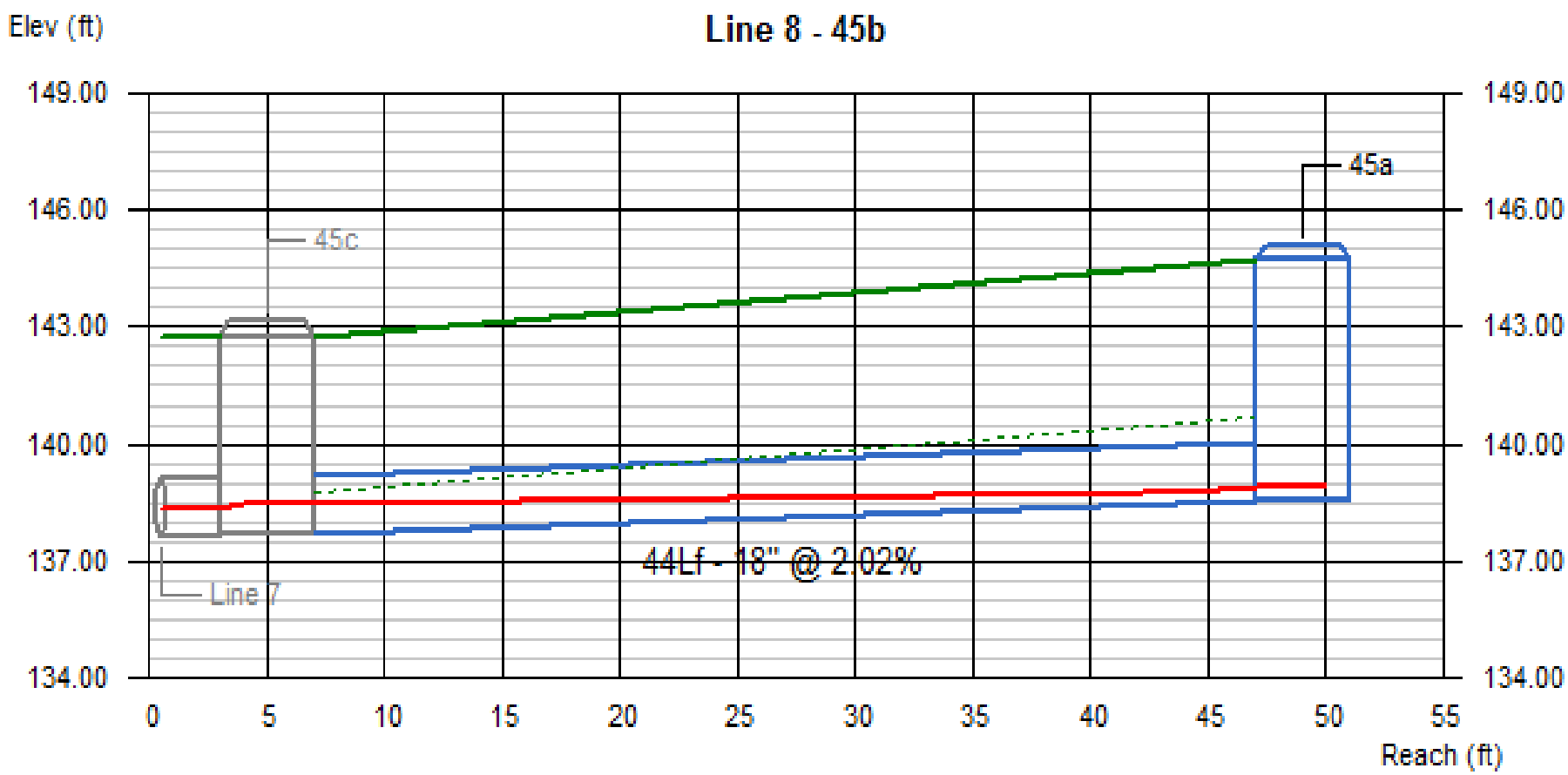
Line Profile (Line 7) - 45d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	1.93	136.41	137.66	0.98	0.66	0.81	137.39	138.32	138.47	1.58	2.61	3.66	3.62

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

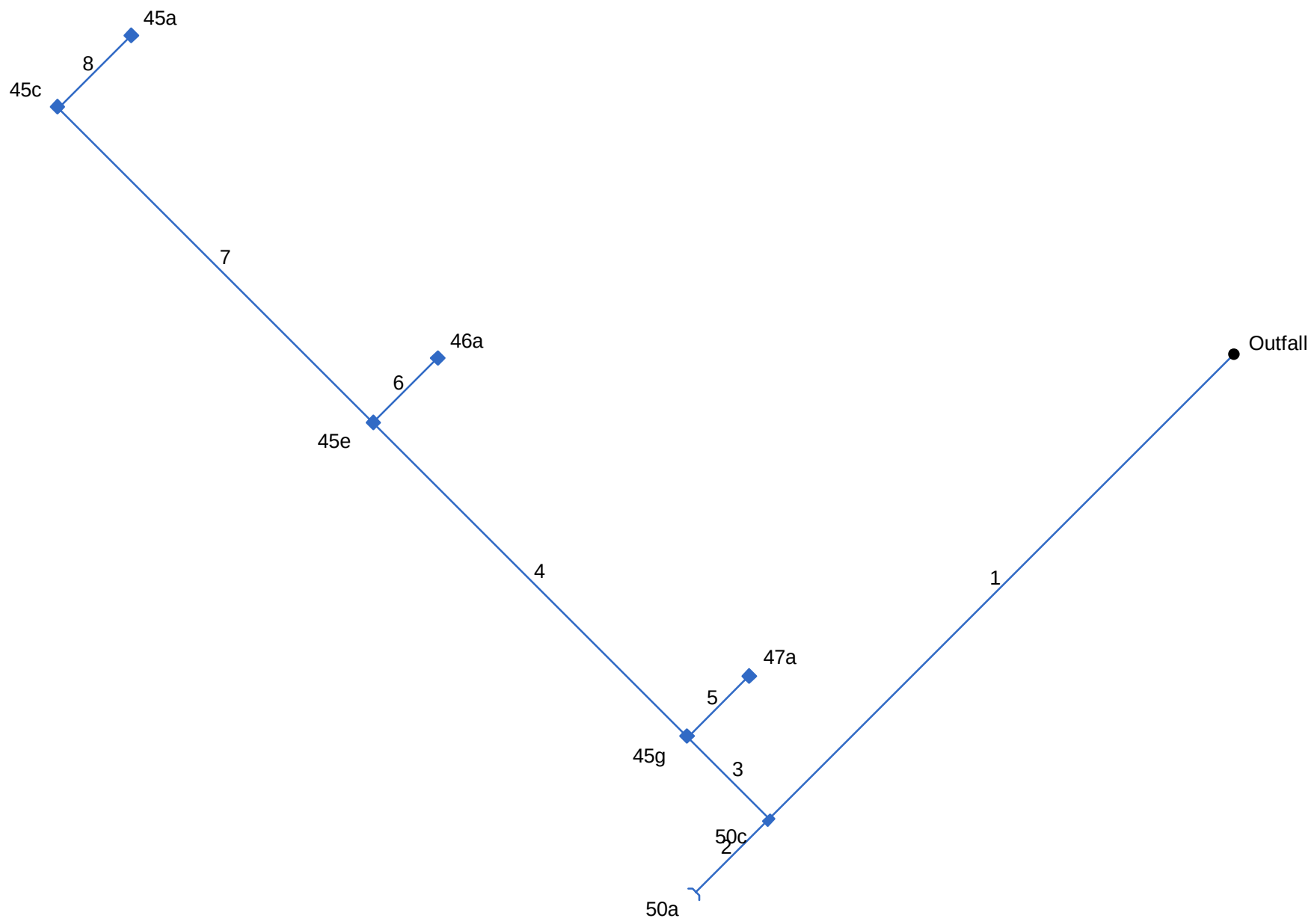
Line Profile (Line 8) - 45b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	0.88	137.66	138.55	0.81	0.36	0.36	138.47	138.91 j	138.91	0.90	2.72	3.62	4.66

45 46 47 50 (100-year) | No. Lines: 8 | Run Date: 11-06-2013

45 46 47 50



Project File: Drainage System 45 46 47 50 with offsite.stm	Number of lines: 8	Date: 11-06-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	285	0.05	75.99	1.00	0.05	28.94	5.0	100.9	0.5	14.64	24.57	3.87	36	0.50	118.78	120.21	120.00	122.72	118.79	138.77	50d (Prop. 36 in)
2	1	45	74.69	74.69	0.37	27.64	27.64	100.6	100.6	0.5	14.00	24.79	2.19	36	0.51	120.21	120.44	122.85	122.91	138.77	120.44	50b (Prop. 36 in)
3	1	50	0.19	1.25	1.00	0.19	1.25	5.0	8.4	1.9	2.34	6.69	3.45	18	1.50	133.51	134.26	134.09	134.90	138.77	139.42	45h
4	3	193	0.20	0.93	1.00	0.20	0.93	5.0	7.1	2.0	1.89	5.76	2.57	18	1.11	134.26	136.41	135.15	136.94	139.42	141.57	45f
5	3	38	0.13	0.13	1.00	0.13	0.13	5.0	5.0	2.4	0.32	7.77	1.10	18	2.03	134.35	135.12	135.15	135.35	139.42	141.12	47b
6	4	39	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.4	0.39	7.72	1.28	18	2.00	136.45	137.23	137.21	137.47	141.57	143.38	46b
7	4	193	0.32	0.57	1.00	0.32	0.57	5.0	5.4	2.3	1.33	4.39	1.92	18	0.65	136.41	137.66	137.21	138.18	141.57	142.78	45d
8	7	44	0.25	0.25	1.00	0.25	0.25	5.0	5.0	2.4	0.61	7.77	1.63	18	2.02	137.66	138.55	138.32	138.85	142.78	144.71	45b

45 46 47 50

Number of lines: 8

Run Date: 11-06-2013

NOTES: Intensity = 5.84 / (Inlet time + 0.20) ^ 0.53; Return period = 10 Yrs. ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	36	14.64	118.78	120.00	1.22	2.70	5.43	0.46	120.46	1.479	285	120.21	122.72	2.51	6.32	2.31	0.08	122.81	0.172	0.825	2.352	1.50	0.12
2	36	14.00	120.21	122.85	2.64	6.59	2.13	0.07	122.92	0.147	45	120.44	122.91	2.47	6.23	2.25	0.08	122.99	0.162	0.154	0.069	1.00	0.08
3	18	2.34	133.51	134.09	0.58*	0.64	3.68	0.21	134.30	1.787	50	134.26	134.90	0.64	0.72	3.23	0.16	135.07	1.259	1.523	0.762	1.50	0.24
4	18	1.89	134.26	135.15	0.89	1.09	1.74	0.05	135.19	0.278	193	136.41	136.94	0.53**	0.56	3.40	0.18	137.12	1.693	0.986	1.902	1.50	0.27
5	18	0.32	134.35	135.15	0.80	0.95	0.33	0.00	135.15	0.011	38	135.12	135.35	0.23	0.17	1.87	0.05	135.40	1.346	0.679	0.258	1.00	0.05
6	18	0.39	136.45	137.21	0.76	0.90	0.44	0.00	137.21	0.020	39	137.23	137.47 j	0.24**	0.18	2.12	0.07	137.54	1.624	0.822	0.321	1.00	0.07
7	18	1.33	136.41	137.21	0.80	0.96	1.39	0.03	137.24	0.193	193	137.66	138.18	0.52	0.55	2.44	0.09	138.27	0.886	0.539	1.041	1.50	0.14
8	18	0.61	137.66	138.32	0.66	0.75	0.81	0.01	138.33	0.078	44	138.55	138.85	0.30**	0.25	2.45	0.09	138.94	1.670	0.874	n/a	1.00	n/a

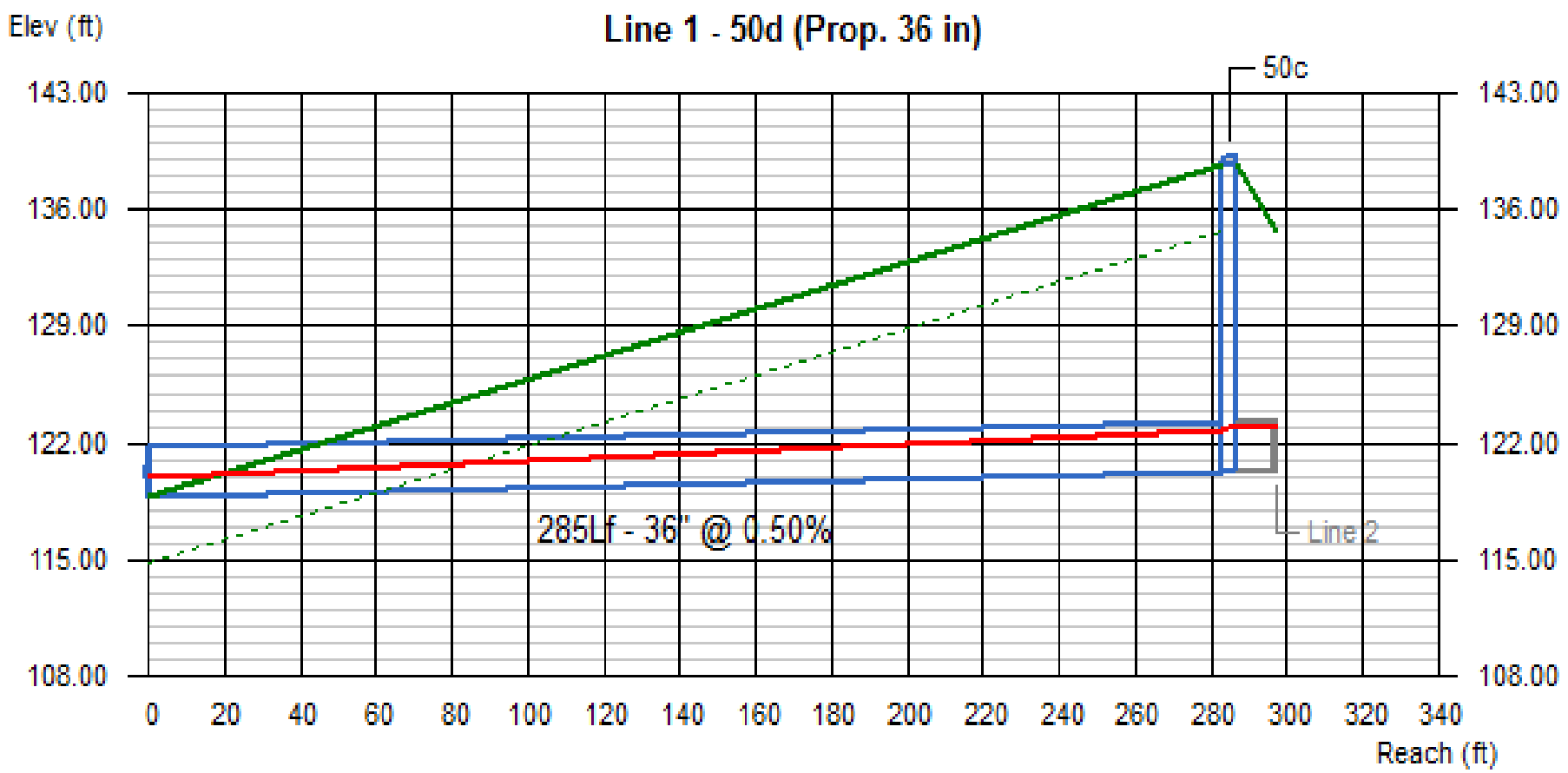
45 46 47 50

Number of lines: 8

Run Date: 11-06-2013

Notes: * depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

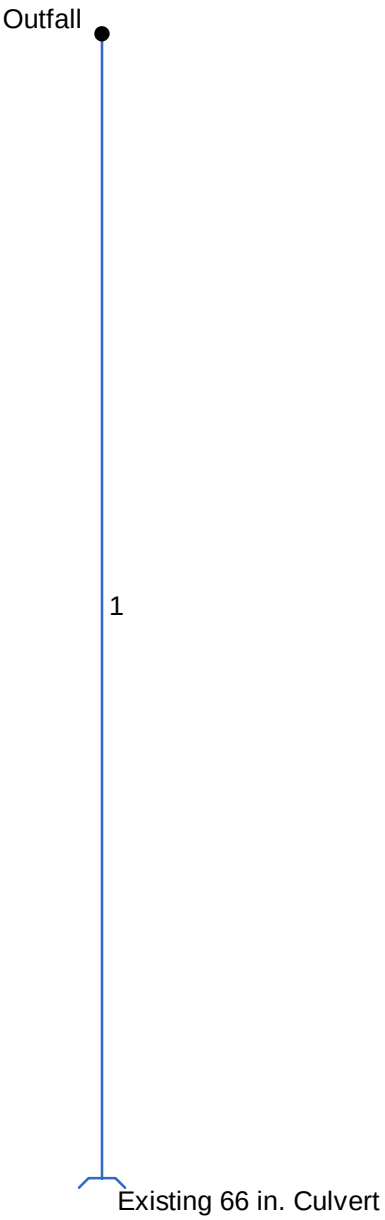
Line Profile (Line 1) - 50d (Prop. 36 in)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	14.64	118.78	120.21	1.22	2.51	2.64	120.00	122.72	122.85	5.43	2.31	-2.99	15.56

45 46 47 50 | No. Lines: 8 | Run Date: 11-06-2013

Exist 66 in Culvert (100-yr)



Project File: Dry Creek 100-year.stm	Number of lines: 1	Date: 11-06-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	168	172.30	172.3	0.43	74.09	74.09	70.1	70.1	0.9	66.17	101.2	4.54	66	0.08	104.59	104.72	107.83	107.96	114.01	112.37	Existing 66 in. Culv

Exist 66 in Culvert (100-yr)

Number of lines: 1

Run Date: 11-06-2013

NOTES: Intensity = 8.68 / (Inlet time + 0.40) ^ 0.53; Return period = 100 Yrs. ; c = cir e = ellip b = box

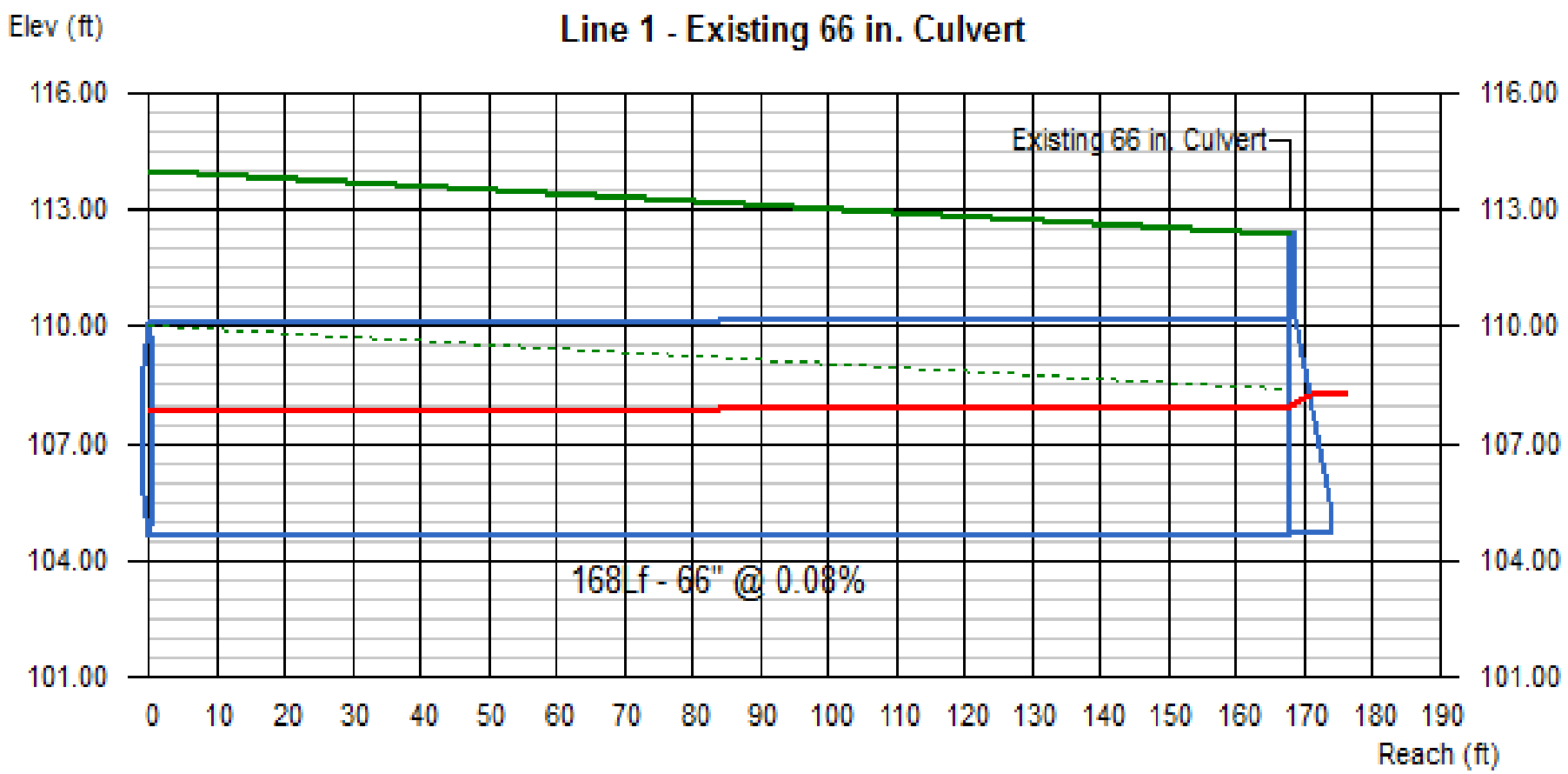
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	66	66.17	104.59	107.83	3.24	14.57	4.54	0.32	108.15	0.077	168	104.72	107.96	3.24	14.56	4.54	0.32	108.28	0.078	0.077	0.130	1.00	0.32

Exist 66 in Culvert (100-yr) | Number of lines: 1 | Run Date: 11-06-2013

; c = cir e = ellip b = box

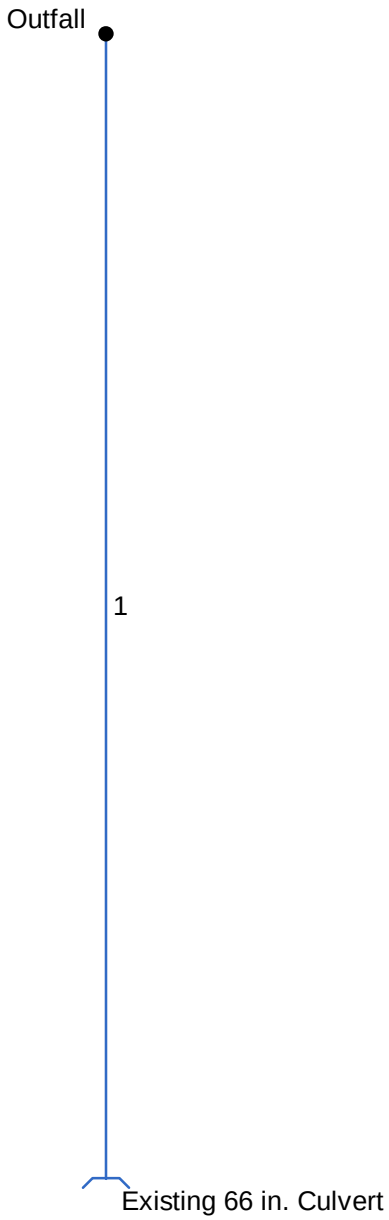
Line Profile (Line 1) - Existing 66 in. Culvert



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	66.17	104.59	104.72	3.24	3.24	3.56	107.83	107.96	108.28	4.54	4.54	3.92	2.15

Exist 66 in Culvert (100-yr) | No. Lines: 1 | Run Date: 11-06-2013

Exist 66 in. Culvert (10-year)



Project File: Dry Creek 10-year.stm	Number of lines: 1	Date: 11-06-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	168	172.30	172.3	0.34	58.58	58.58	70.1	70.1	0.6	35.94	101.2	3.90	66	0.08	104.59	104.72	106.86	106.98	114.01	112.37	Existing 66 in. Culv

Exist 66 in. Culvert (10-year)

Number of lines: 1

Run Date: 11-06-2013

NOTES: Intensity = 5.84 / (Inlet time + 0.20) ^ 0.53; Return period = 10 Yrs. ; c = cir e = ellip b = box

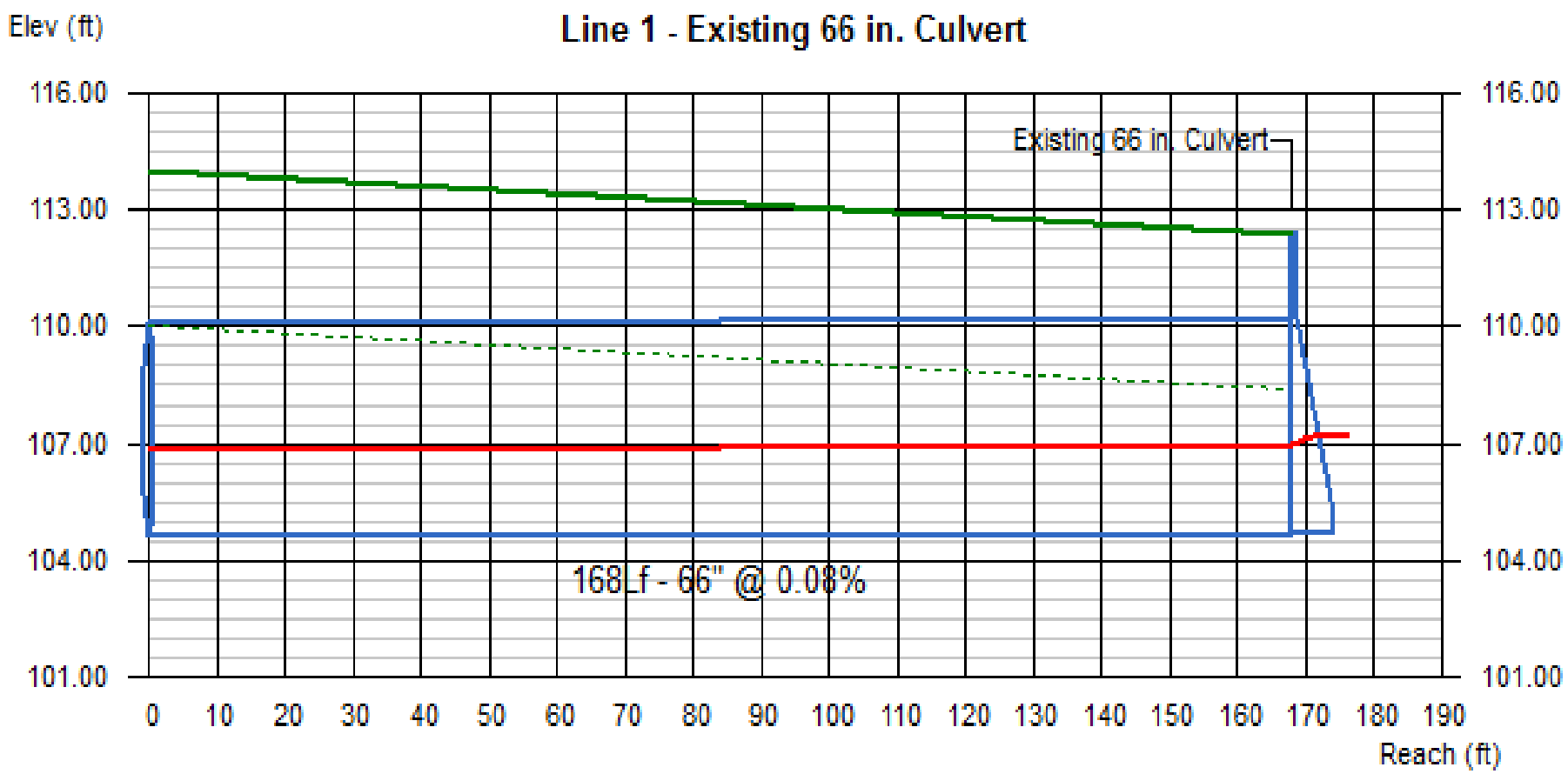
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	66	35.94	104.59	106.86	2.26	9.23	3.90	0.24	107.09	0.077	168	104.72	106.98	2.26	9.21	3.90	0.24	107.22	0.078	0.077	0.130	1.00	0.24

Exist 66 in. Culvert (10-year) | Number of lines: 1 | Run Date: 11-06-2013

; c = cir e = ellip b = box

Line Profile (Line 1) - Existing 66 in. Culvert



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	35.94	104.59	104.72	2.26	2.26	2.50	106.86	106.98	107.22	3.90	3.90	3.92	2.15

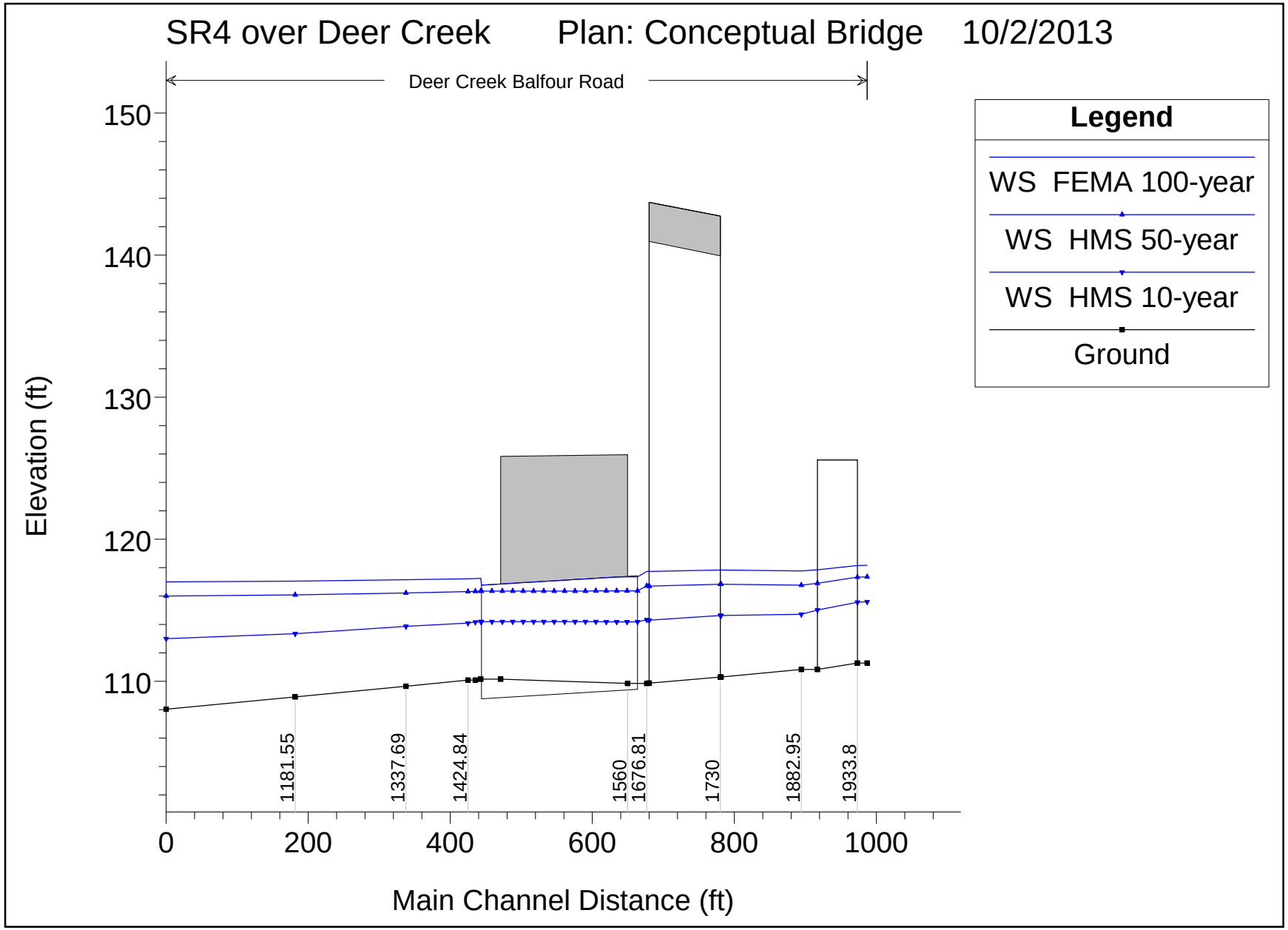
Exist 66 in. Culvert (10-year) | No. Lines: 1 | Run Date: 11-06-2013

HEC-RAS Plan: ConceptBridge River: Deer Creek Reach: Balfour Road

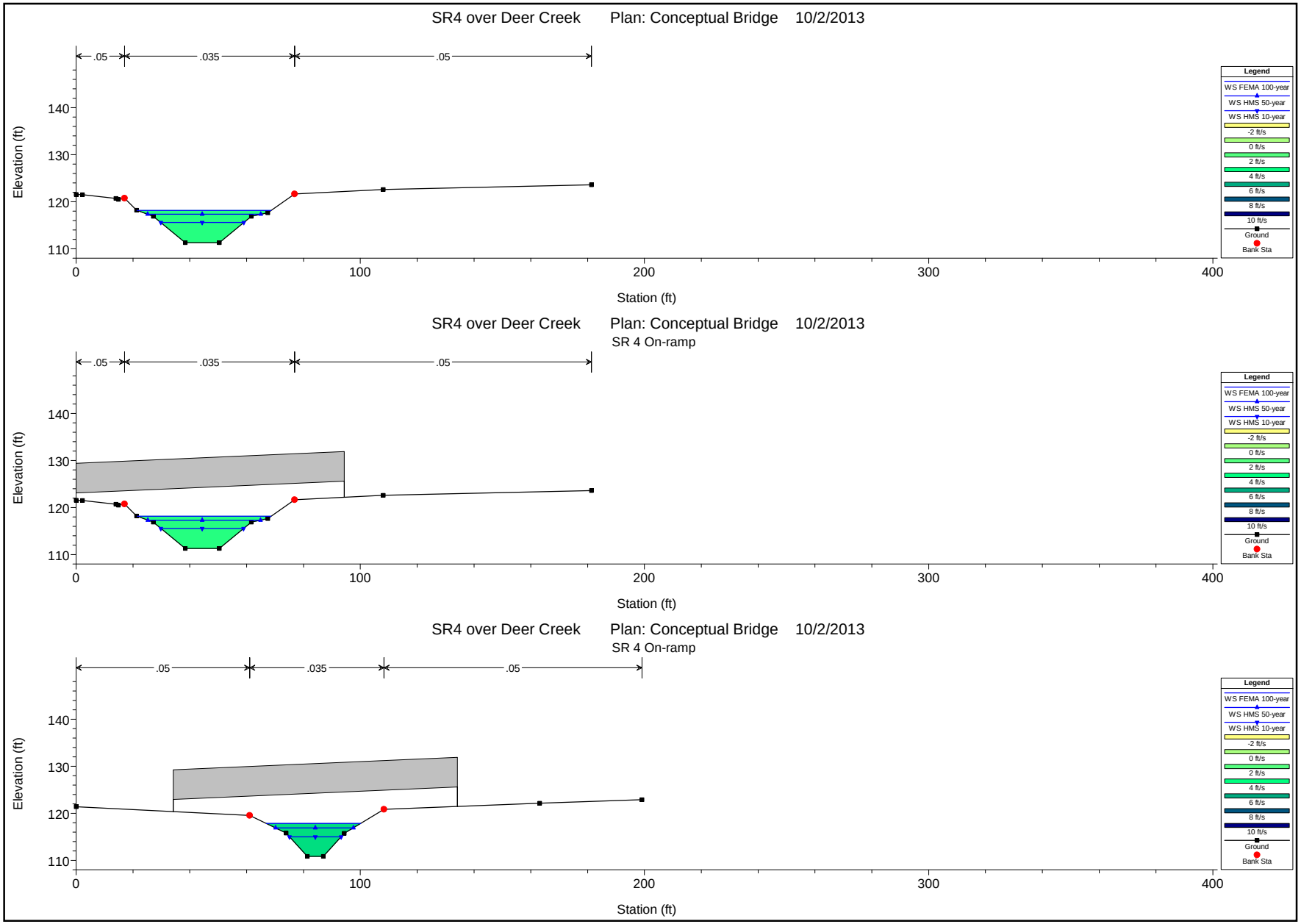
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Crit Depth	Length Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)
Balfour Road	1975.87	FEMA 100-year	572.00	111.28	118.16	114.66	118.31	0.000963	3.13	183.02	47.17	0.28	3.38	13.97
Balfour Road	1975.87	HMS 50-year	498.20	111.28	117.34	114.41	117.52	0.001220	3.39	147.07	39.87	0.31	3.13	13.97
Balfour Road	1975.87	HMS 10-year	291.40	111.28	115.59	113.57	115.76	0.001484	3.28	88.83	29.24	0.33	2.29	13.97
Balfour Road	1933.8		Bridge											
Balfour Road	1882.95	FEMA 100-year	572.00	110.83	117.76		118.13	0.002760	4.87	117.35	32.70	0.45		112.93
Balfour Road	1882.95	HMS 50-year	498.20	110.83	116.77		117.26	0.004238	5.67	87.87	26.60	0.55		112.93
Balfour Road	1882.95	HMS 10-year	291.40	110.83	114.71		115.38	0.008065	6.57	44.35	17.26	0.72		112.93
Balfour Road	1781.293	FEMA 100-year	572.00	110.30	117.83	114.01	117.92	0.000591	2.48	230.67	59.56	0.22	3.71	0.99
Balfour Road	1781.293	HMS 50-year	498.20	110.30	116.83	113.74	116.96	0.000908	2.83	175.78	51.17	0.27	3.44	0.99
Balfour Road	1781.293	HMS 10-year	291.40	110.30	114.63	112.87	114.82	0.002038	3.48	83.63	32.52	0.38	2.57	0.99
Balfour Road	1730		Bridge											
Balfour Road	1680.12	FEMA 100-year	572.00	109.86	117.73		117.85	0.000727	2.85	200.65	47.45	0.24		3.31
Balfour Road	1680.12	HMS 50-year	498.20	109.86	116.69		116.85	0.001136	3.23	154.26	42.27	0.30		3.31
Balfour Road	1680.12	HMS 10-year	291.40	109.86	114.30		114.57	0.002943	4.16	70.11	26.51	0.45		3.31
Balfour Road	1676.81	FEMA 100-year	572.00	109.85	117.73	113.82	117.84	0.000604	2.66	214.97	49.50	0.23	3.97	233.81
Balfour Road	1676.81	HMS 50-year	498.20	109.85	116.70	113.56	116.84	0.000899	2.98	167.02	43.60	0.27	3.71	233.81
Balfour Road	1676.81	HMS 10-year	291.40	109.85	114.33	112.66	114.54	0.002205	3.65	79.76	30.02	0.39	2.81	233.81
Balfour Road	1560		Culvert											
Balfour Road	1443	FEMA 100-year	572.00	110.15	117.24		117.28	0.000207	1.67	342.07	73.74	0.14		7.76
Balfour Road	1443	HMS 50-year	498.20	110.15	116.35		116.40	0.000274	1.78	279.30	67.51	0.15		7.76
Balfour Road	1443	HMS 10-year	291.40	110.15	114.19		114.25	0.000530	1.95	149.77	52.35	0.20		7.76
Balfour Road	1435.24	FEMA 100-year	572.00	110.07	117.23		117.28	0.000261	1.82	314.22	70.44	0.15		10.40
Balfour Road	1435.24	HMS 50-year	498.20	110.07	116.33		116.39	0.000358	1.96	254.03	64.62	0.17		10.40
Balfour Road	1435.24	HMS 10-year	291.40	110.07	114.16		114.24	0.000848	2.26	128.70	50.59	0.25		10.40
Balfour Road	1424.84	FEMA 100-year	572.00	110.07	117.21		117.27	0.000378	2.08	274.56	66.75	0.18		87.15
Balfour Road	1424.84	HMS 50-year	498.20	110.07	116.31		116.39	0.000538	2.29	217.58	59.93	0.21		87.15
Balfour Road	1424.84	HMS 10-year	291.40	110.07	114.10		114.22	0.001395	2.81	103.84	43.22	0.32		87.15
Balfour Road	1337.69	FEMA 100-year	572.00	109.65	117.14		117.23	0.000528	2.40	238.37	59.53	0.21		156.14
Balfour Road	1337.69	HMS 50-year	498.20	109.65	116.22		116.33	0.000773	2.67	186.44	52.77	0.25		156.14
Balfour Road	1337.69	HMS 10-year	291.40	109.65	113.87		114.06	0.002359	3.53	82.60	35.58	0.41		156.14
Balfour Road	1181.55	FEMA 100-year	572.00	108.90	117.04		117.15	0.000553	2.58	230.17	69.37	0.22		181.55
Balfour Road	1181.55	HMS 50-year	498.20	108.90	116.07		116.20	0.000866	2.88	172.75	46.59	0.26		181.55
Balfour Road	1181.55	HMS 10-year	291.40	108.90	113.34		113.62	0.003347	4.20	69.37	29.22	0.48		181.55
Balfour Road	1000	FEMA 100-year	572.00	108.03	117.00	112.32	117.06	0.000293	2.02	290.63	81.41	0.16	4.29	

HEC-RAS Plan: ConceptBridge River: Deer Creek Reach: Balfour Road (Continued)

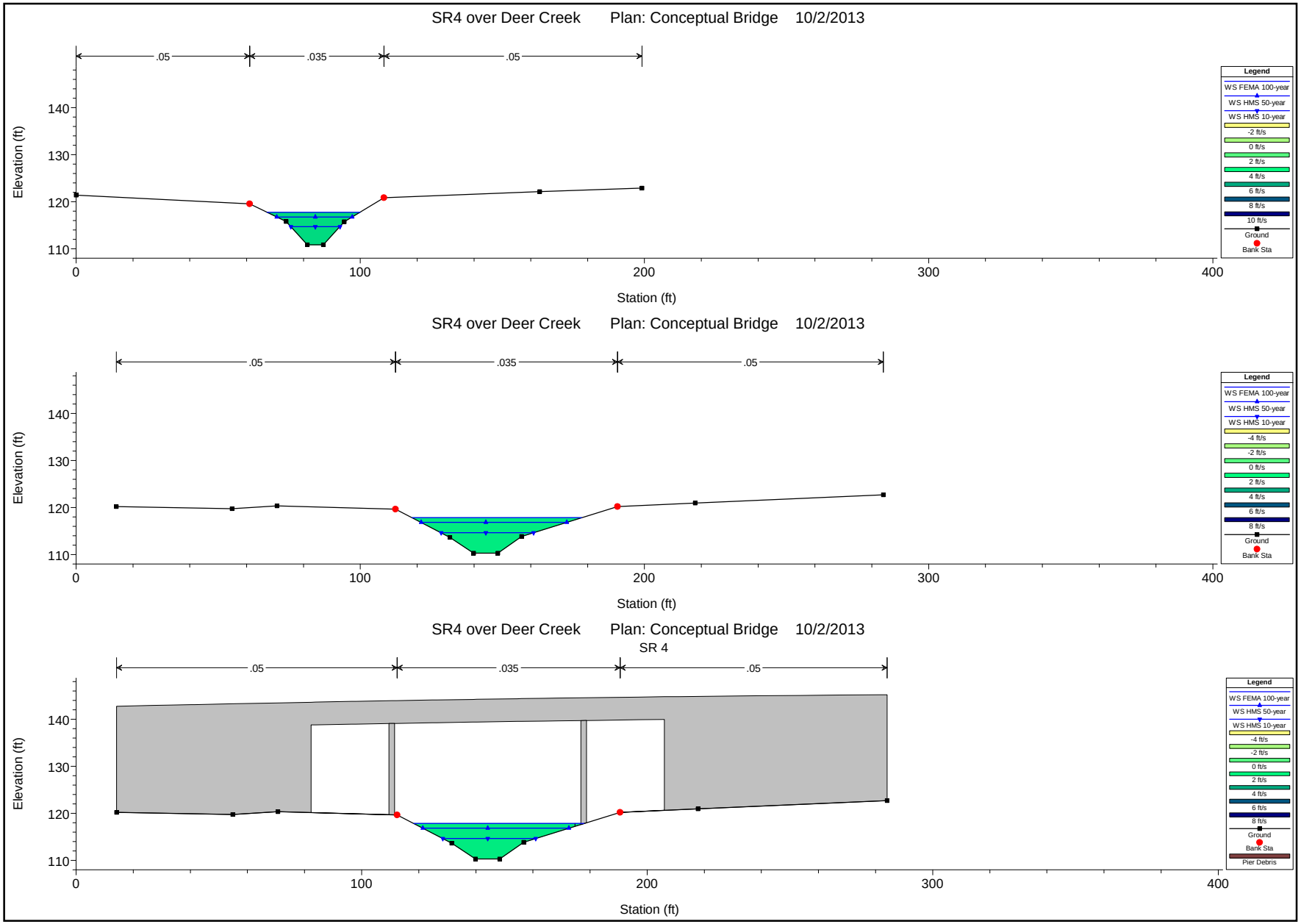
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Crit Depth	Length Chnl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)
Balfour Road	1000	HMS 50-year	498.20	108.03	116.00	112.09	116.08	0.000428	2.21	225.72	53.94	0.19	4.06	
Balfour Road	1000	HMS 10-year	291.40	108.03	113.00	111.31	113.16	0.001720	3.19	91.30	35.67	0.35	3.28	



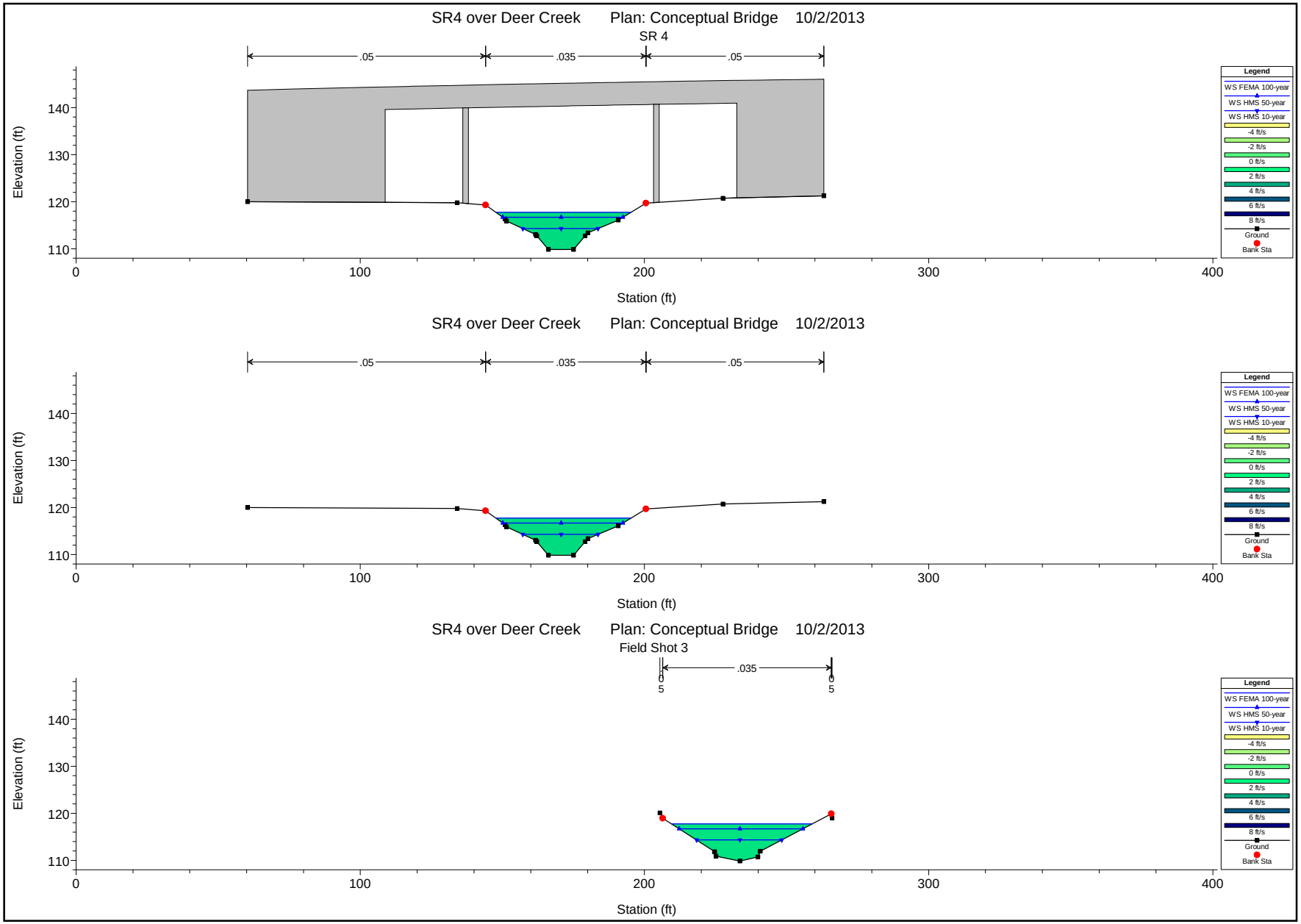
1 in Horiz. = 200 ft 1 in Vert. = 10 ft



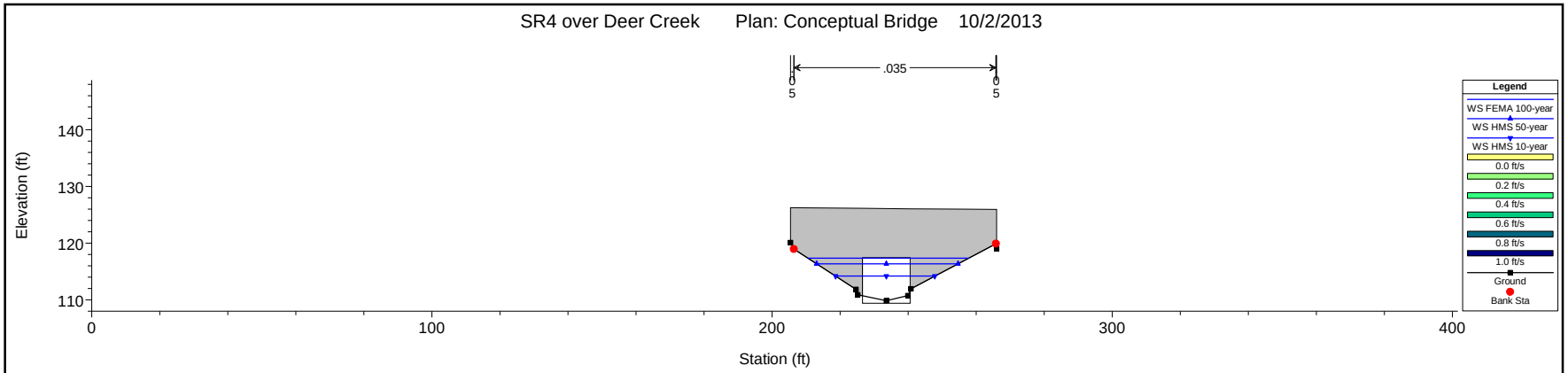
1 in Horiz. = 50 ft 1 in Vert. = 30 ft

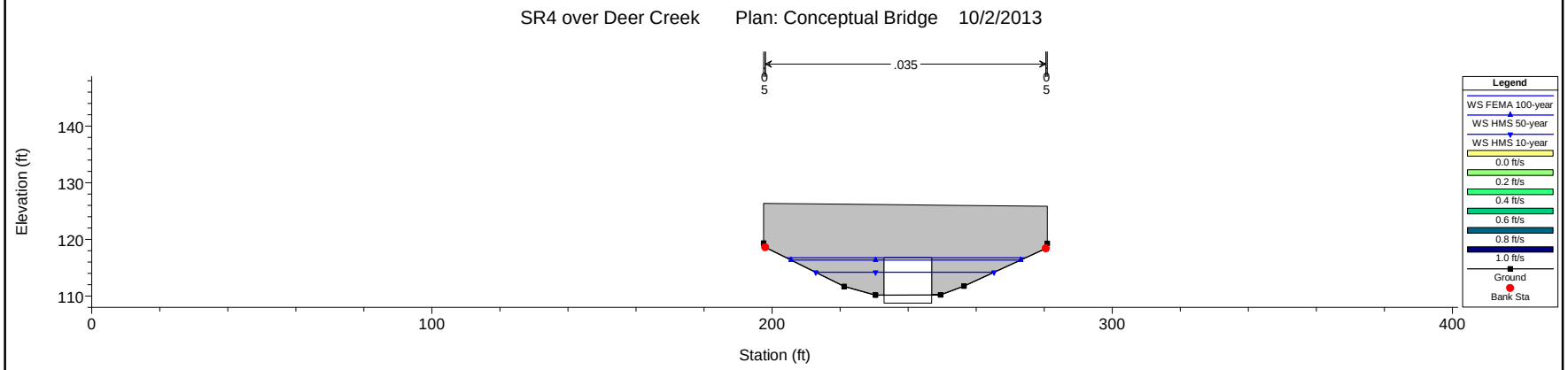


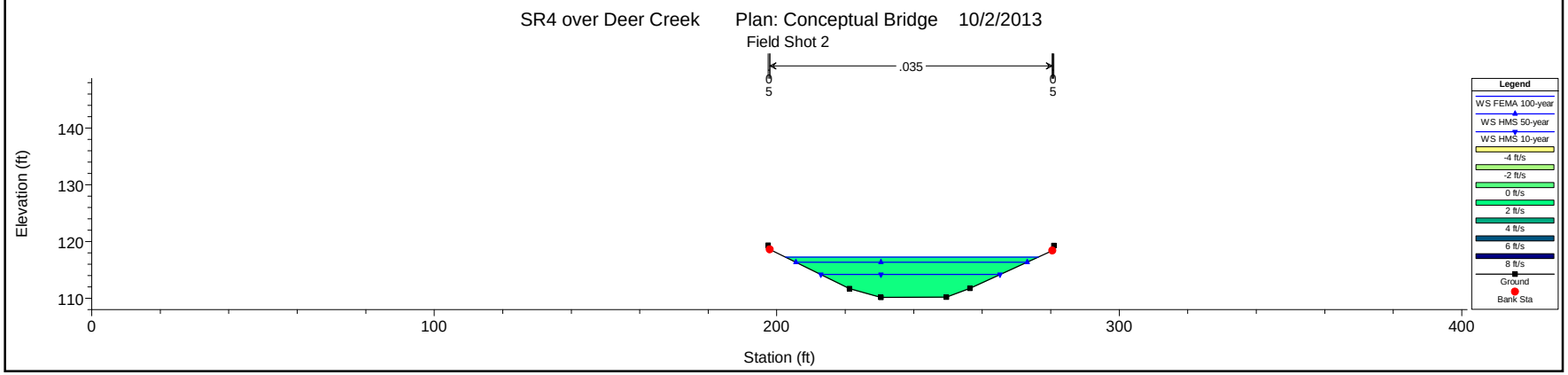
1 in Horiz. = 50 ft 1 in Vert. = 30 ft



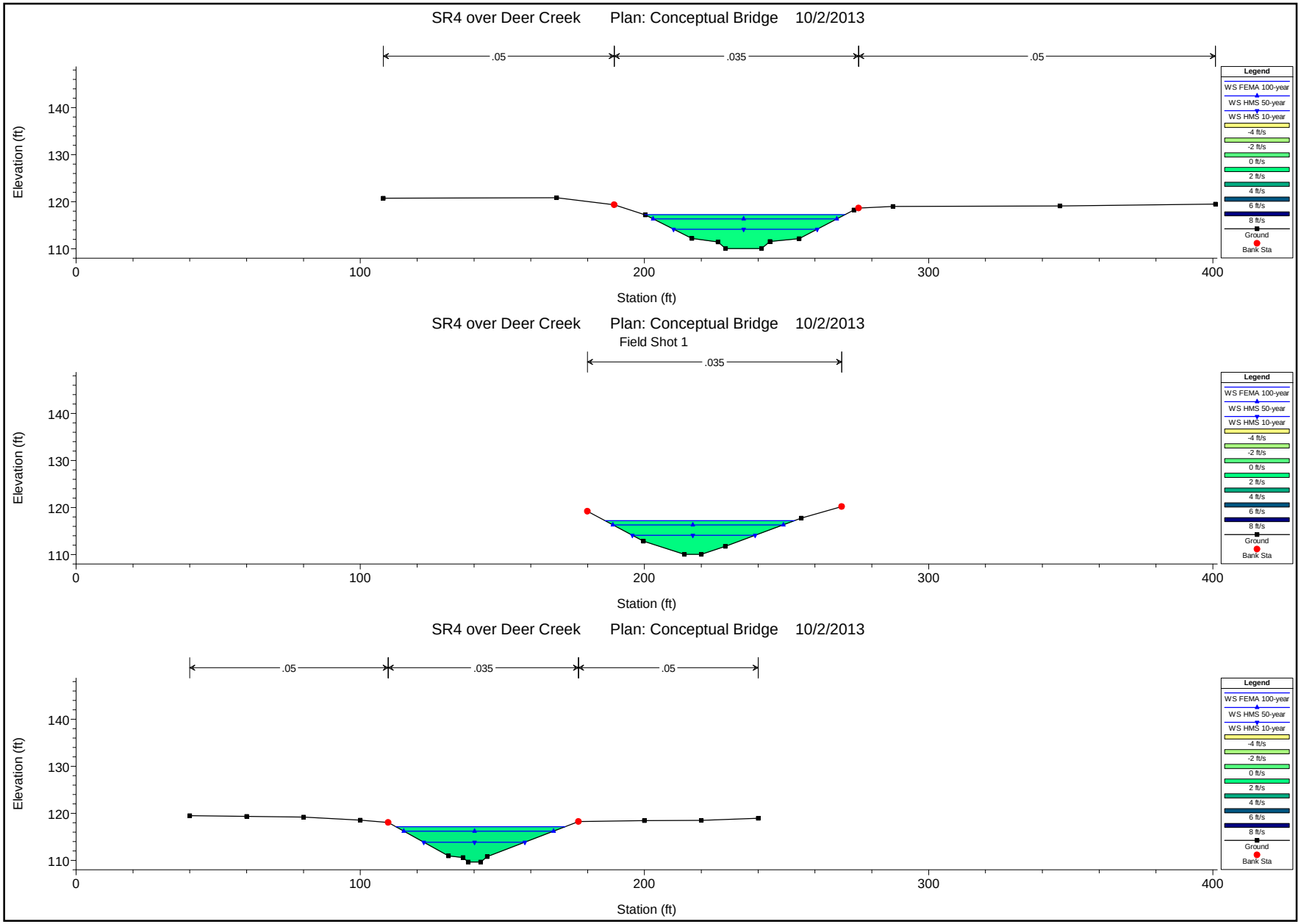
1 in Horiz. = 50 ft 1 in Vert. = 30 ft



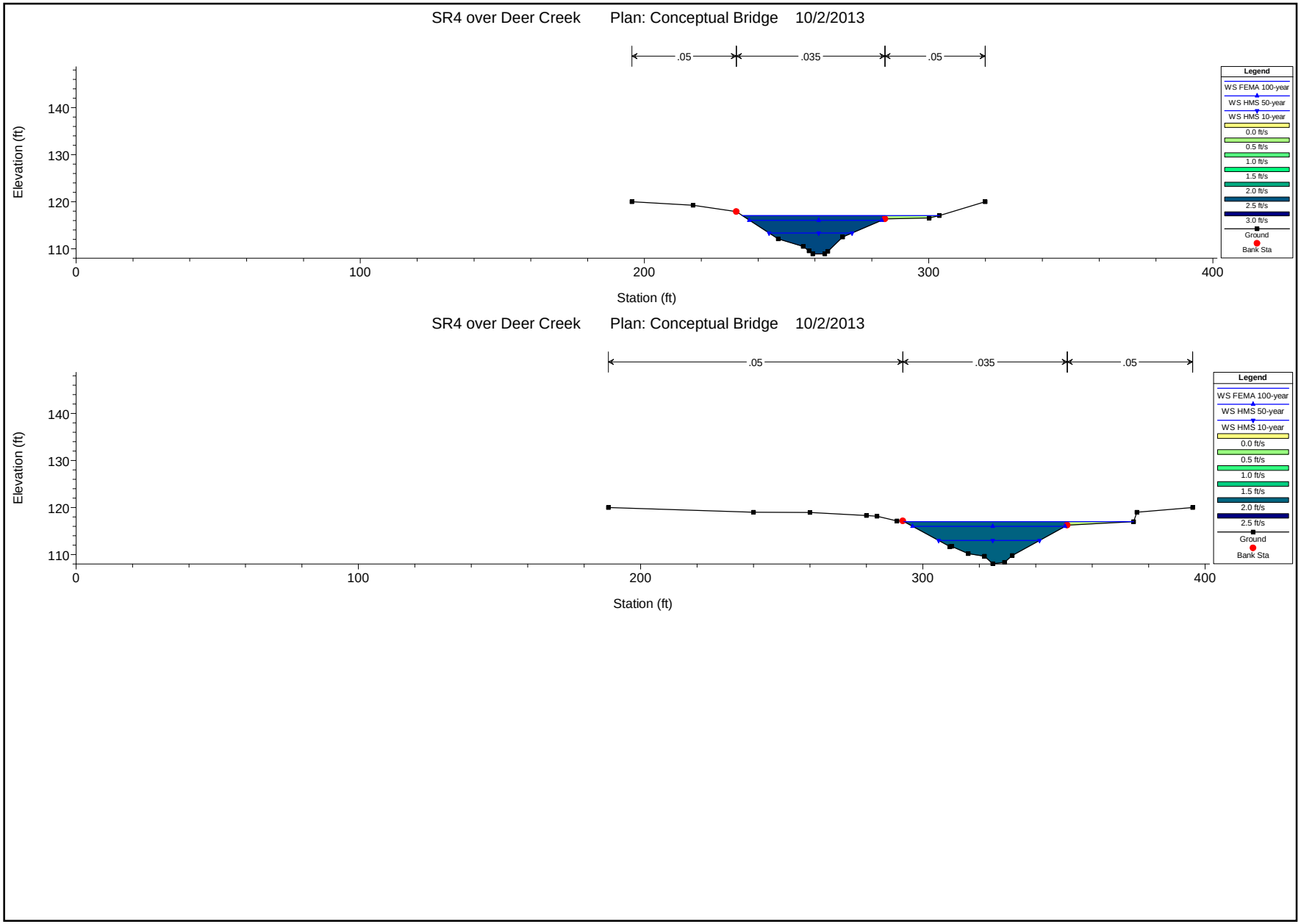




1 in Horiz. = 50 ft 1 in Vert. = 30 ft



1 in Horiz. = 50 ft 1 in Vert. = 30 ft



1 in Horiz. = 50 ft 1 in Vert. = 30 ft

Plan: ConceptBridge Deer Creek Balfour Road RS: 1933.8 Profile: FEMA 100-year

E.G. US. (ft)	118.31	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	118.16	E.G. Elev (ft)	118.30	118.19
Q Total (cfs)	572.00	W.S. Elev (ft)	118.14	117.84
Q Bridge (cfs)	572.00	Crit W.S. (ft)	114.67	115.47
Q Weir (cfs)		Max Chl Dpth (ft)	6.86	7.01
Weir Sta Lft (ft)		Vel Total (ft/s)	3.14	4.77
Weir Sta Rgt (ft)		Flow Area (sq ft)	182.30	119.93
Weir Submerg		Froude # Chl	0.28	0.44
Weir Max Depth (ft)		Specif Force (cu ft)	556.49	399.85
Min El Weir Flow (ft)	122.19	Hydr Depth (ft)	3.87	3.61
Min El Prs (ft)	125.58	W.P. Total (ft)	50.00	36.83
Delta EG (ft)	0.18	Conv. Total (cfs)	18334.2	11185.7
Delta WS (ft)	0.40	Top Width (ft)	47.07	33.18
BR Open Area (sq ft)	601.65	Frctn Loss (ft)	0.08	0.06
BR Open Vel (ft/s)	4.77	C & E Loss (ft)	0.02	0.00
Coef of Q		Shear Total (lb/sq ft)	0.22	0.53
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: ConceptBridge Deer Creek Balfour Road RS: 1933.8 Profile: HMS 50-year

E.G. US. (ft)	117.52	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	117.34	E.G. Elev (ft)	117.50	117.36
Q Total (cfs)	498.20	W.S. Elev (ft)	117.32	116.90
Q Bridge (cfs)	498.20	Crit W.S. (ft)	114.42	115.15
Q Weir (cfs)		Max Chl Dpth (ft)	6.04	6.07
Weir Sta Lft (ft)		Vel Total (ft/s)	3.41	5.44
Weir Sta Rgt (ft)		Flow Area (sq ft)	146.28	91.50
Weir Submerg		Froude # Chl	0.31	0.53
Weir Max Depth (ft)		Specif Force (cu ft)	418.94	300.60
Min El Weir Flow (ft)	122.19	Hydr Depth (ft)	3.69	3.34
Min El Prs (ft)	125.58	W.P. Total (ft)	42.35	30.77
Delta EG (ft)	0.26	Conv. Total (cfs)	14189.5	8032.6
Delta WS (ft)	0.58	Top Width (ft)	39.63	27.42
BR Open Area (sq ft)	601.65	Frctn Loss (ft)	0.11	0.09
BR Open Vel (ft/s)	5.44	C & E Loss (ft)	0.03	0.00
Coef of Q		Shear Total (lb/sq ft)	0.27	0.71
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: ConceptBridge Deer Creek Balfour Road RS: 1933.8 Profile: HMS 10-year

E.G. US. (ft)	115.76	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	115.59	E.G. Elev (ft)	115.73	115.55
Q Total (cfs)	291.40	W.S. Elev (ft)	115.56	115.02
Q Bridge (cfs)	291.40	Crit W.S. (ft)	113.59	114.10
Q Weir (cfs)		Max Chl Dpth (ft)	4.28	4.19
Weir Sta Lft (ft)		Vel Total (ft/s)	3.31	5.84
Weir Sta Rgt (ft)		Flow Area (sq ft)	88.11	49.88
Weir Submerg		Froude # Chl	0.34	0.62
Weir Max Depth (ft)		Specif Force (cu ft)	192.43	138.94
Min El Weir Flow (ft)	122.19	Hydr Depth (ft)	3.02	2.74
Min El Prs (ft)	125.58	W.P. Total (ft)	31.16	20.73
Delta EG (ft)	0.38	Conv. Total (cfs)	7480.0	3802.8
Delta WS (ft)	0.88	Top Width (ft)	29.14	18.20
BR Open Area (sq ft)	601.65	Frctn Loss (ft)	0.15	0.16
BR Open Vel (ft/s)	5.84	C & E Loss (ft)	0.04	0.01
Coef of Q		Shear Total (lb/sq ft)	0.27	0.88
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: ConceptBridge Deer Creek Balfour Road RS: 1730 Profile: FEMA 100-year

E.G. US. (ft)	117.92	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	117.83	E.G. Elev (ft)	117.92	117.85
Q Total (cfs)	572.00	W.S. Elev (ft)	117.83	117.73
Q Bridge (cfs)	572.00	Crit W.S. (ft)	114.02	114.01
Q Weir (cfs)		Max Chl Dpth (ft)	7.53	7.87
Weir Sta Lft (ft)		Vel Total (ft/s)	2.48	2.85
Weir Sta Rgt (ft)		Flow Area (sq ft)	230.47	200.65
Weir Submerg		Froude # Chl	0.22	0.24
Weir Max Depth (ft)		Specif Force (cu ft)	668.66	624.19
Min El Weir Flow (ft)	143.72	Hydr Depth (ft)	4.08	4.23
Min El Prs (ft)	139.94	W.P. Total (ft)	63.06	51.08
Delta EG (ft)	0.07	Conv. Total (cfs)	23215.6	21207.7
Delta WS (ft)	0.10	Top Width (ft)	56.45	47.45
BR Open Area (sq ft)	2531.22	Frctn Loss (ft)	0.07	0.00
BR Open Vel (ft/s)	2.85	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.14	0.18
Br Sel Method	Energy only	Power Total (lb/ft s)	14.14	60.37

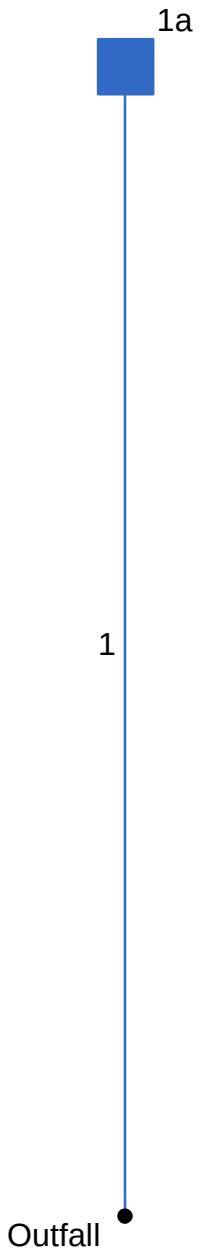
Plan: ConceptBridge Deer Creek Balfour Road RS: 1730 Profile: HMS 50-year

E.G. US. (ft)	116.96	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	116.83	E.G. Elev (ft)	116.96	116.85
Q Total (cfs)	498.20	W.S. Elev (ft)	116.83	116.69
Q Bridge (cfs)	498.20	Crit W.S. (ft)	113.74	113.68
Q Weir (cfs)		Max Chl Dpth (ft)	6.53	6.83
Weir Sta Lft (ft)		Vel Total (ft/s)	2.84	3.23
Weir Sta Rgt (ft)		Flow Area (sq ft)	175.73	154.26
Weir Submerg		Froude # Chl	0.27	0.30
Weir Max Depth (ft)		Specif Force (cu ft)	467.66	440.51
Min El Weir Flow (ft)	143.72	Hydr Depth (ft)	3.43	3.65
Min El Prs (ft)	139.94	W.P. Total (ft)	53.29	45.50
Delta EG (ft)	0.11	Conv. Total (cfs)	16527.7	14780.6
Delta WS (ft)	0.14	Top Width (ft)	51.16	42.27
BR Open Area (sq ft)	2531.22	Frctn Loss (ft)	0.10	0.00
BR Open Vel (ft/s)	3.23	C & E Loss (ft)	0.00	0.00
Coef of Q		Shear Total (lb/sq ft)	0.19	0.24
Br Sel Method	Energy only	Power Total (lb/ft s)	14.14	60.37

Plan: ConceptBridge Deer Creek Balfour Road RS: 1730 Profile: HMS 10-year

E.G. US. (ft)	114.82	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	114.63	E.G. Elev (ft)	114.82	114.57
Q Total (cfs)	291.40	W.S. Elev (ft)	114.63	114.30
Q Bridge (cfs)	291.40	Crit W.S. (ft)	112.88	112.62
Q Weir (cfs)		Max Chl Dpth (ft)	4.33	4.44
Weir Sta Lft (ft)		Vel Total (ft/s)	3.49	4.16
Weir Sta Rgt (ft)		Flow Area (sq ft)	83.55	70.12
Weir Submerg		Froude # Chl	0.38	0.45
Weir Max Depth (ft)		Specif Force (cu ft)	177.25	167.54
Min El Weir Flow (ft)	143.72	Hydr Depth (ft)	2.57	2.65
Min El Prs (ft)	139.94	W.P. Total (ft)	34.09	28.93
Delta EG (ft)	0.25	Conv. Total (cfs)	6447.9	5371.3
Delta WS (ft)	0.33	Top Width (ft)	32.50	26.51
BR Open Area (sq ft)	2531.22	Frctn Loss (ft)	0.24	0.00
BR Open Vel (ft/s)	4.16	C & E Loss (ft)	0.01	0.00
Coef of Q		Shear Total (lb/sq ft)	0.31	0.45
Br Sel Method	Energy only	Power Total (lb/ft s)	14.14	60.37

Appendix G Hydraulic Analysis of Proposed Onsite Drainage Design



Project File: Drainage System 1.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	83	0.44	0.44	0.84	0.37	0.37	5.0	5.0	2.7	1.02	3.79	1.72	18	0.48	140.81	141.21	141.40	141.73	140.81	146.06	1b

1	Number of lines: 1	Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

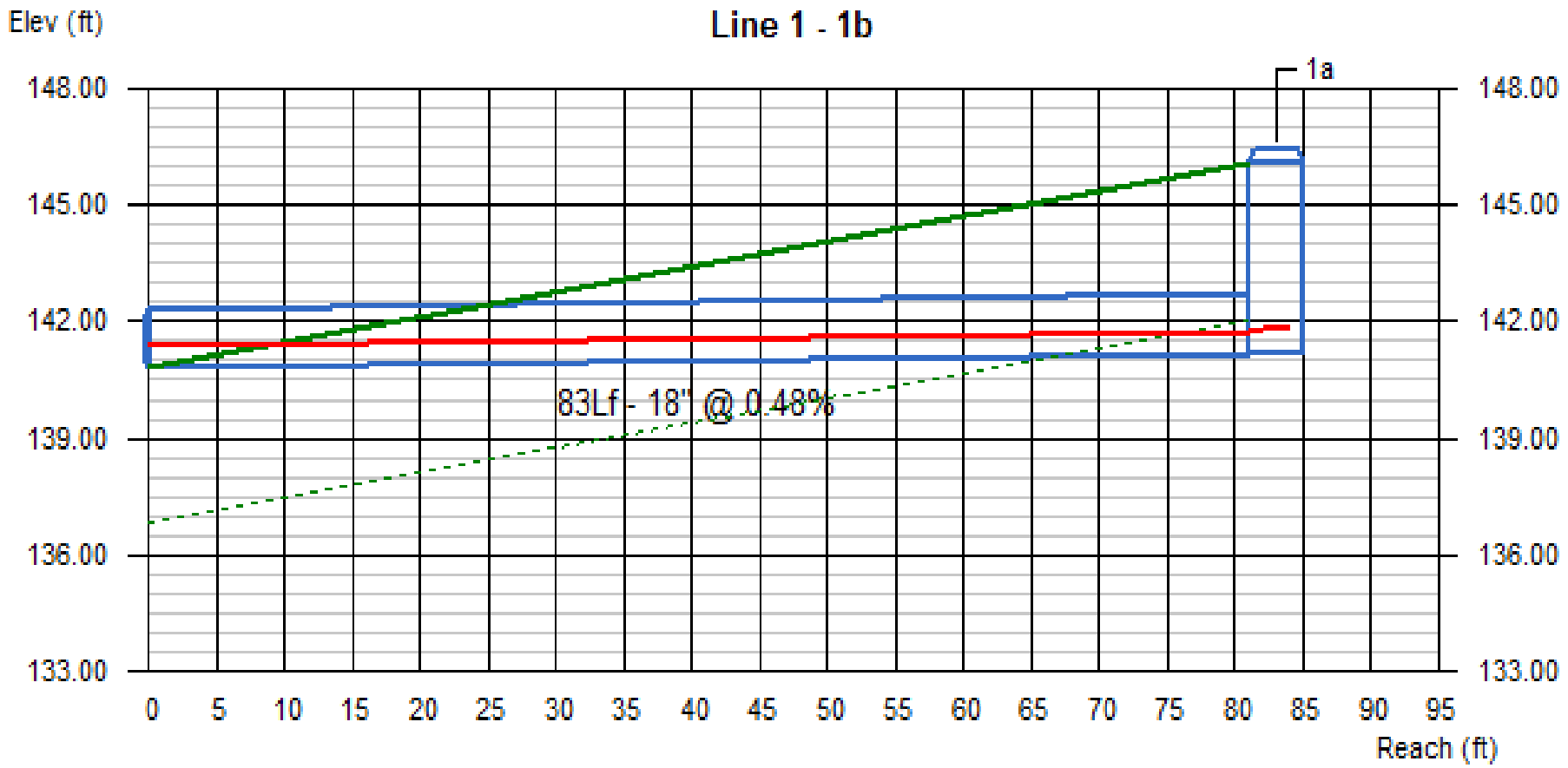
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.02	140.81	141.40	0.59	0.65	1.57	0.04	141.44	0.324	83	141.21	141.73	0.52	0.55	1.86	0.05	141.79	0.511	0.418	0.347	1.00	0.05

1	Number of lines: 1	Run Date: 10-30-2013

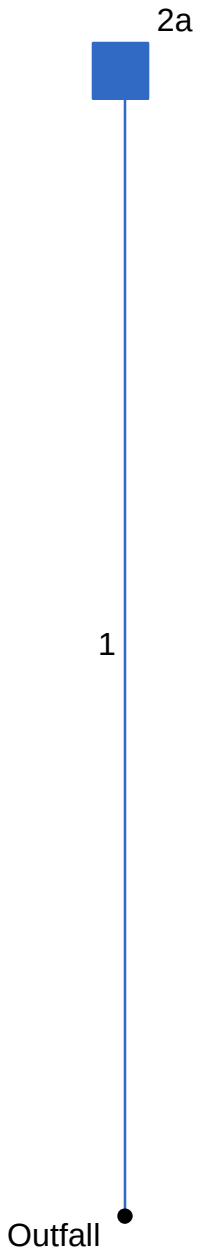
; c = cir e = ellip b = box

Line Profile (Line 1) - 1b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.02	140.81	141.21	0.59	0.52	0.58	141.40	141.73	141.79	1.57	1.86	-1.50	3.35

1 | No. Lines: 1 | Run Date: 10-30-2013



Project File: Drainage System 2.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	83	0.58	0.58	0.74	0.43	0.43	5.0	5.0	2.7	1.18	3.28	1.75	18	0.36	138.22	138.52	138.81	139.14	138.22	142.87	2b

2	Number of lines: 1	Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

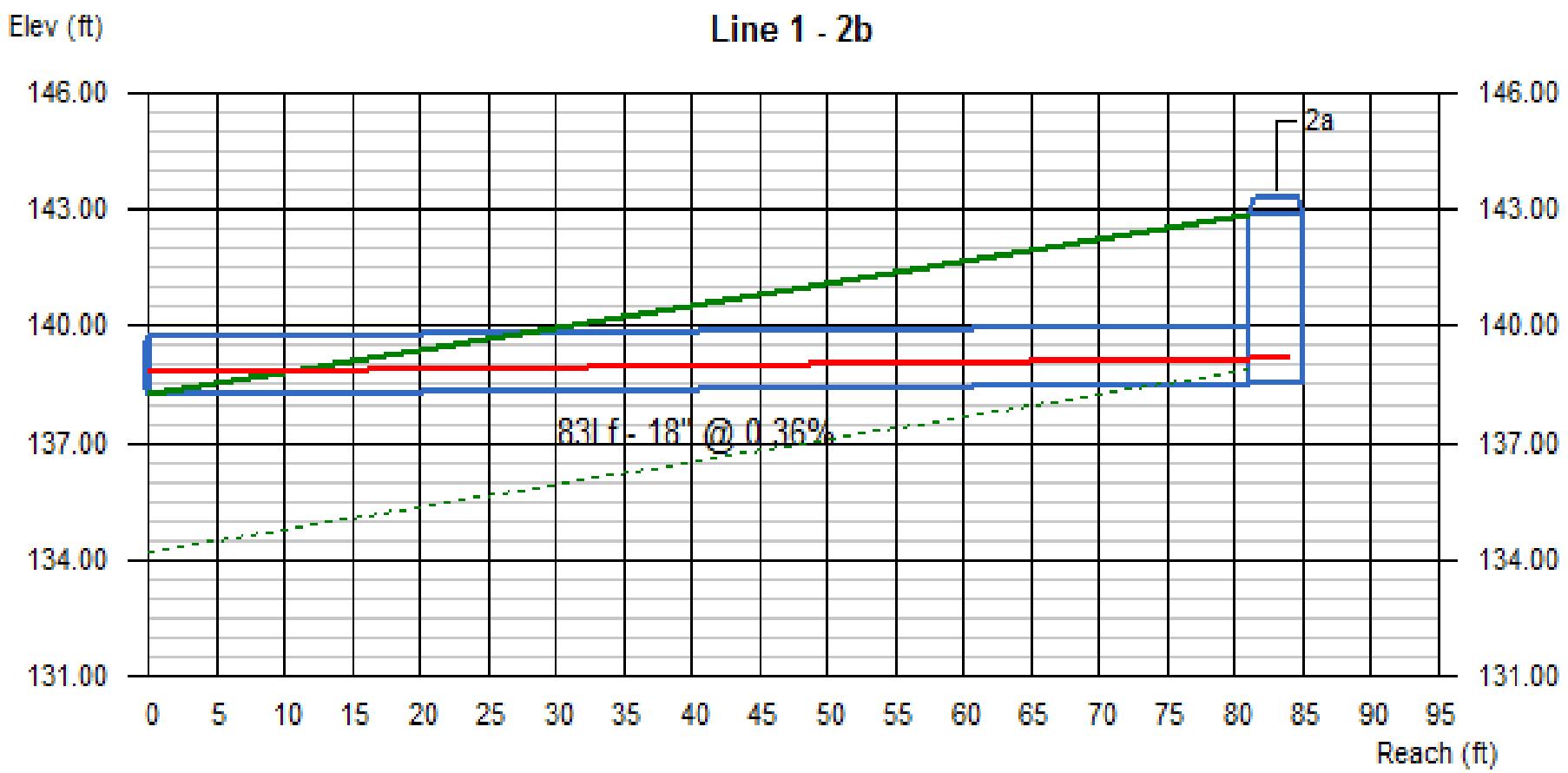
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.18	138.22	138.81	0.59	0.65	1.81	0.05	138.87	0.426	83	138.52	139.14	0.62	0.70	1.70	0.04	139.19	0.356	0.391	0.325	1.00	0.04

2	Number of lines: 1	Run Date: 10-30-2013

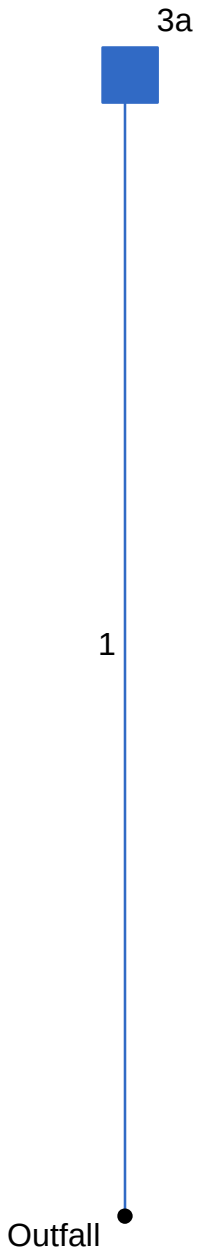
; c = cir e = ellip b = box

Line Profile (Line 1) - 2b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.18	138.22	138.52	0.59	0.62	0.67	138.81	139.14	139.19	1.81	1.70	-1.50	2.85

2 | No. Lines: 1 | Run Date: 10-30-2013



Project File: Drainage System 3.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	83	0.42	0.42	0.71	0.30	0.30	5.0	5.0	2.7	0.82	3.17	1.37	18	0.34	135.99	136.27	136.58	136.80	135.99	140.72	3b

3	Number of lines: 1	Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

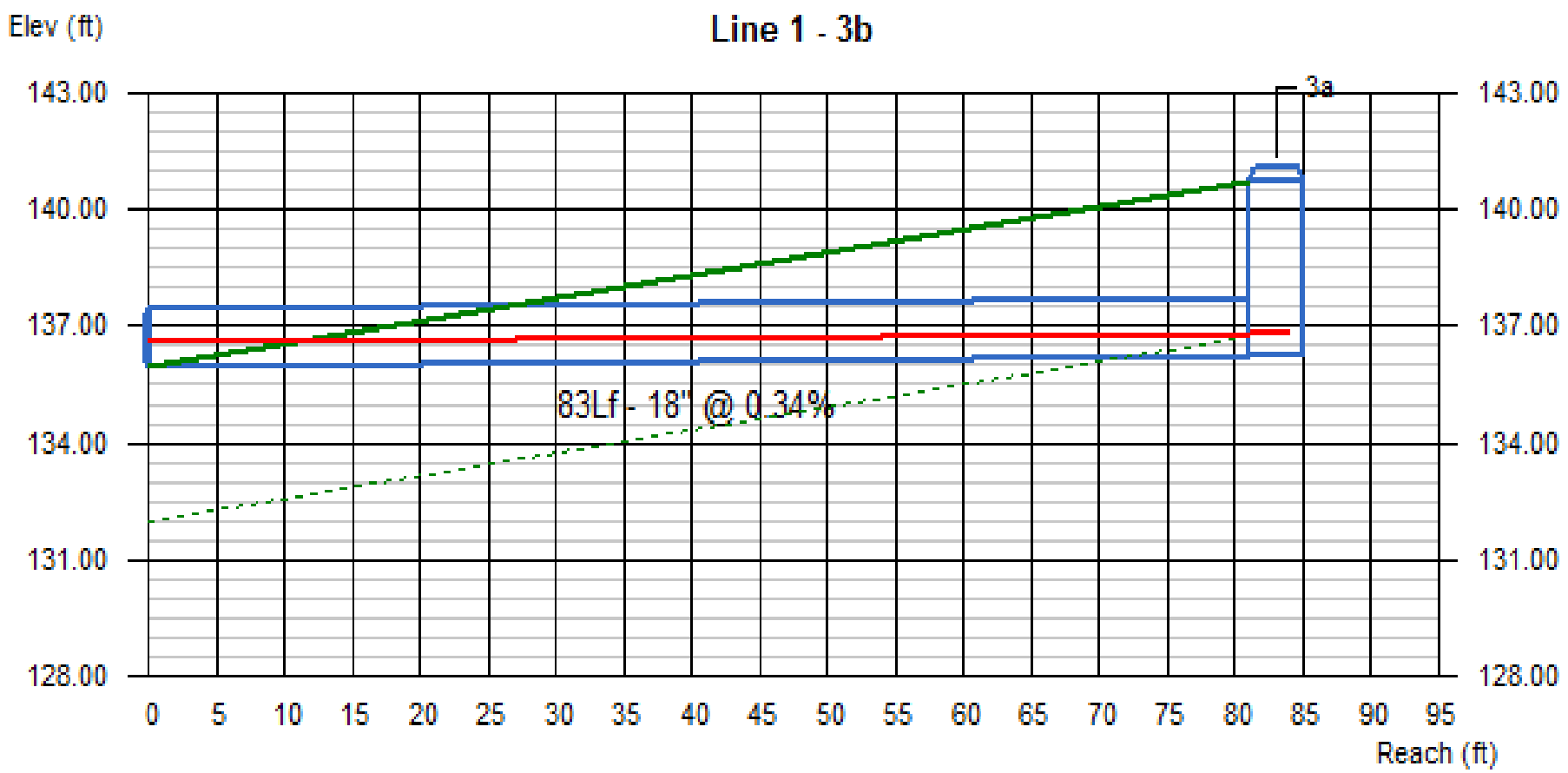
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.82	135.99	136.58	0.59	0.65	1.26	0.02	136.61	0.206	83	136.27	136.80	0.53	0.55	1.49	0.03	136.83	0.326	0.266	0.221	1.00	0.03

3	Number of lines: 1	Run Date: 10-30-2013

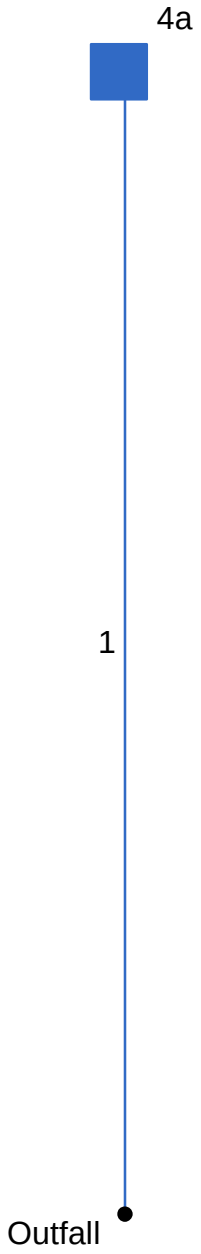
; c = cir e = ellip b = box

Line Profile (Line 1) - 3b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.82	135.99	136.27	0.59	0.53	0.56	136.58	136.80	136.83	1.26	1.49	-1.50	2.95

3 | No. Lines: 1 | Run Date: 10-30-2013



Project File: Drainage System 4.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	83	0.40	0.40	0.68	0.27	0.27	5.0	5.0	2.7	0.75	3.00	1.26	18	0.30	134.19	134.44	134.78	134.96	134.19	137.94	4b

4	Number of lines: 1	Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

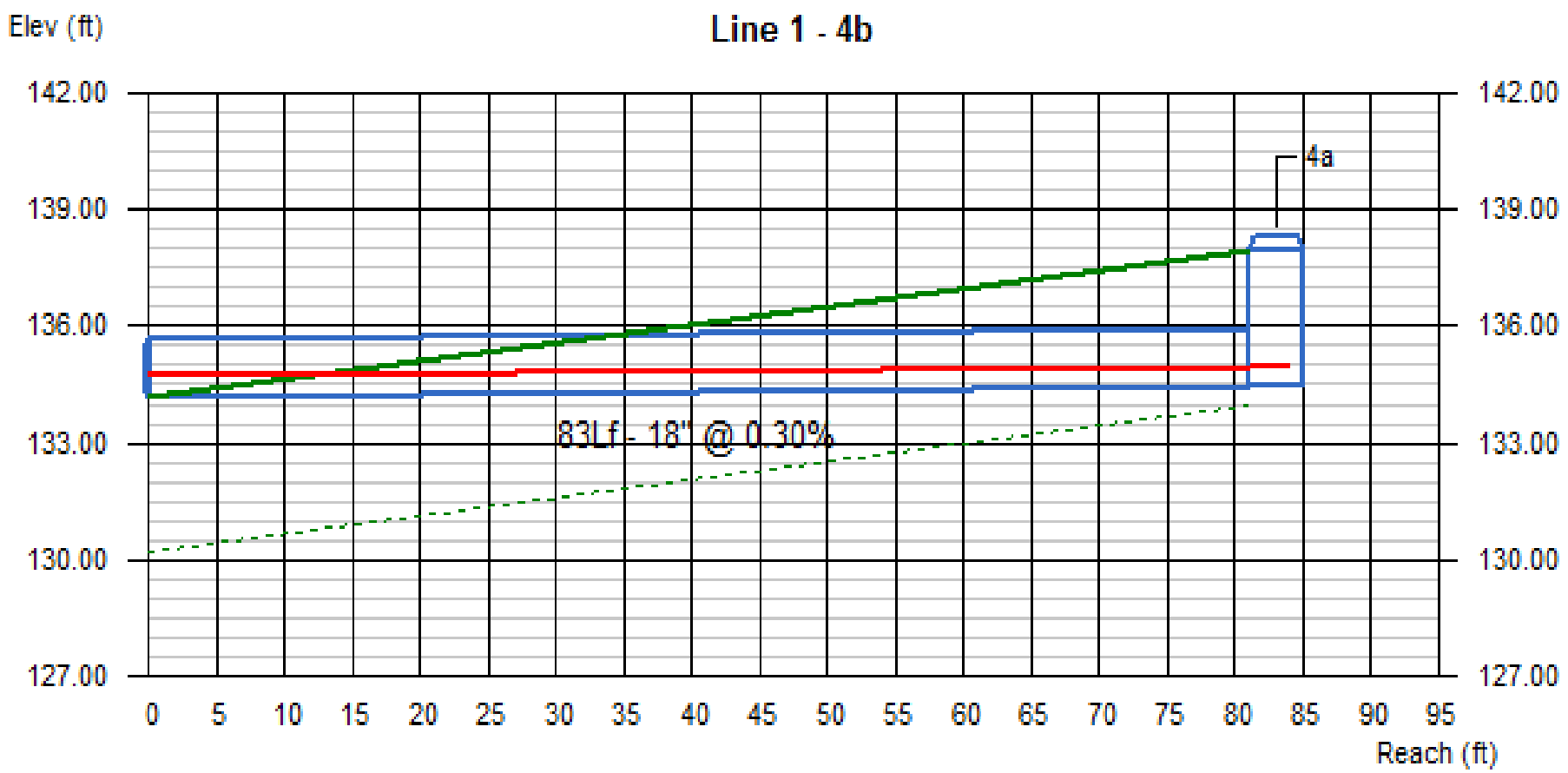
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.75	134.19	134.78	0.59	0.65	1.16	0.02	134.80	0.176	83	134.44	134.96	0.52	0.55	1.37	0.03	134.99	0.278	0.227	0.188	1.00	0.03

4	Number of lines: 1	Run Date: 10-30-2013

; c = cir e = ellip b = box

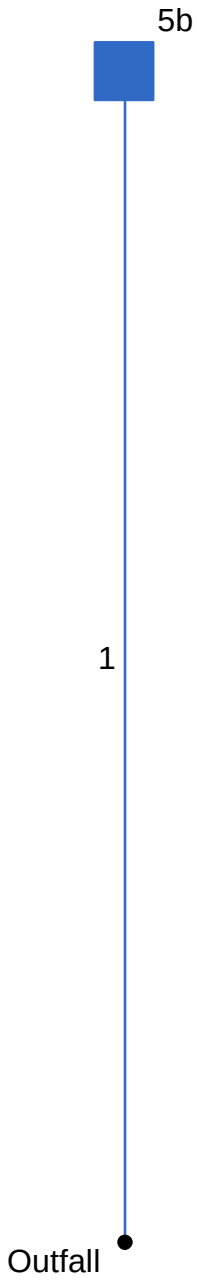
Line Profile (Line 1) - 4b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.75	134.19	134.44	0.59	0.52	0.55	134.78	134.96	134.99	1.16	1.37	-1.50	2.00

4	No. Lines: 1	Run Date: 10-30-2013

5



Project File: Drainage System 5.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	81	0.61	0.61	0.65	0.40	0.40	5.0	5.0	2.7	1.09	2.97	1.80	18	0.30	130.45	130.69	130.93	131.39	130.45	134.06	5a

5	Number of lines: 1	Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

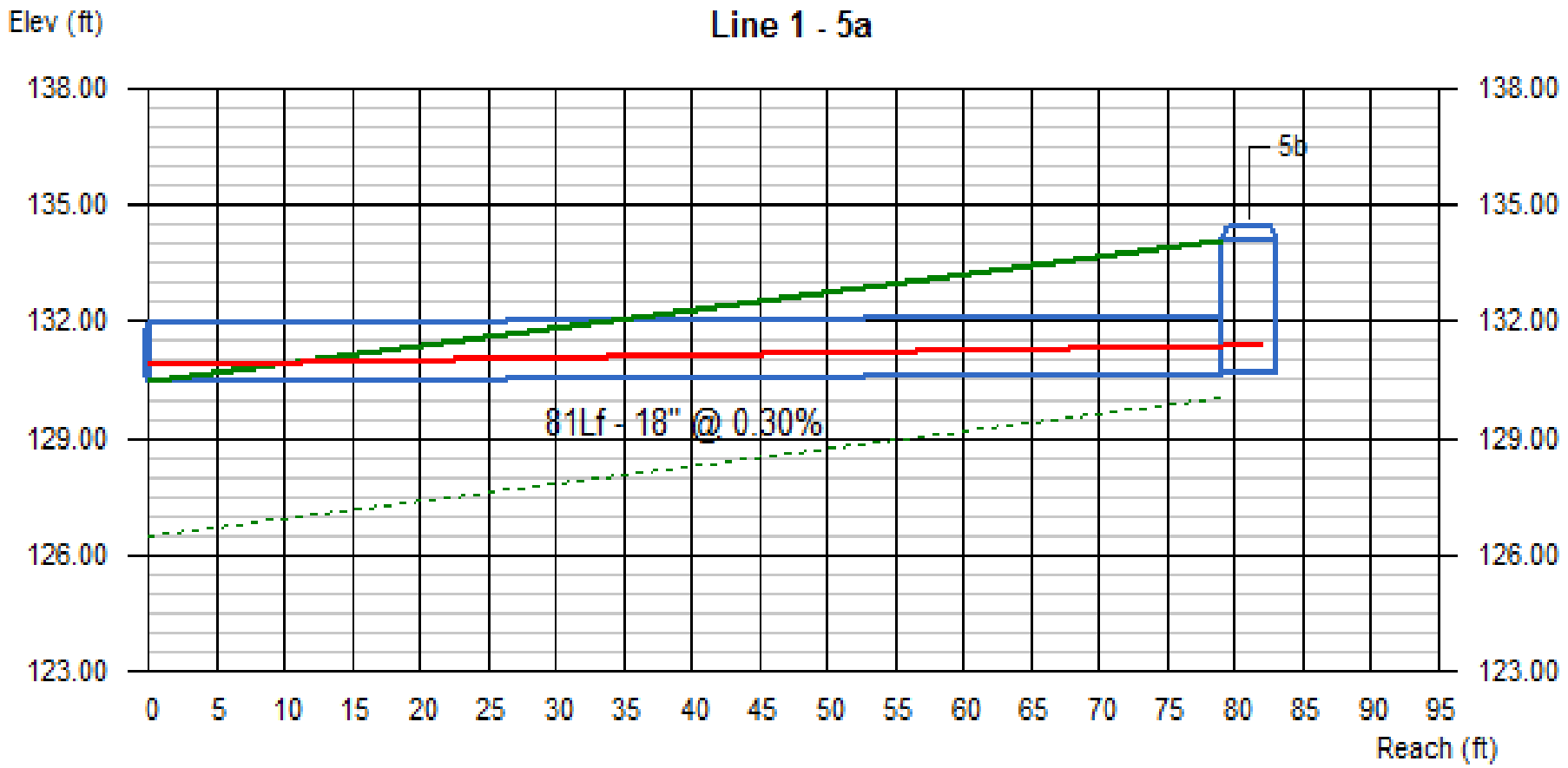
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.09	130.45	130.93	0.48	0.48	2.25	0.08	131.01	0.830	81	130.69	131.39	0.70	0.81	1.34	0.03	131.42	0.199	0.514	0.417	1.00	0.03

5 | Number of lines: 1 | Run Date: 11-04-2013

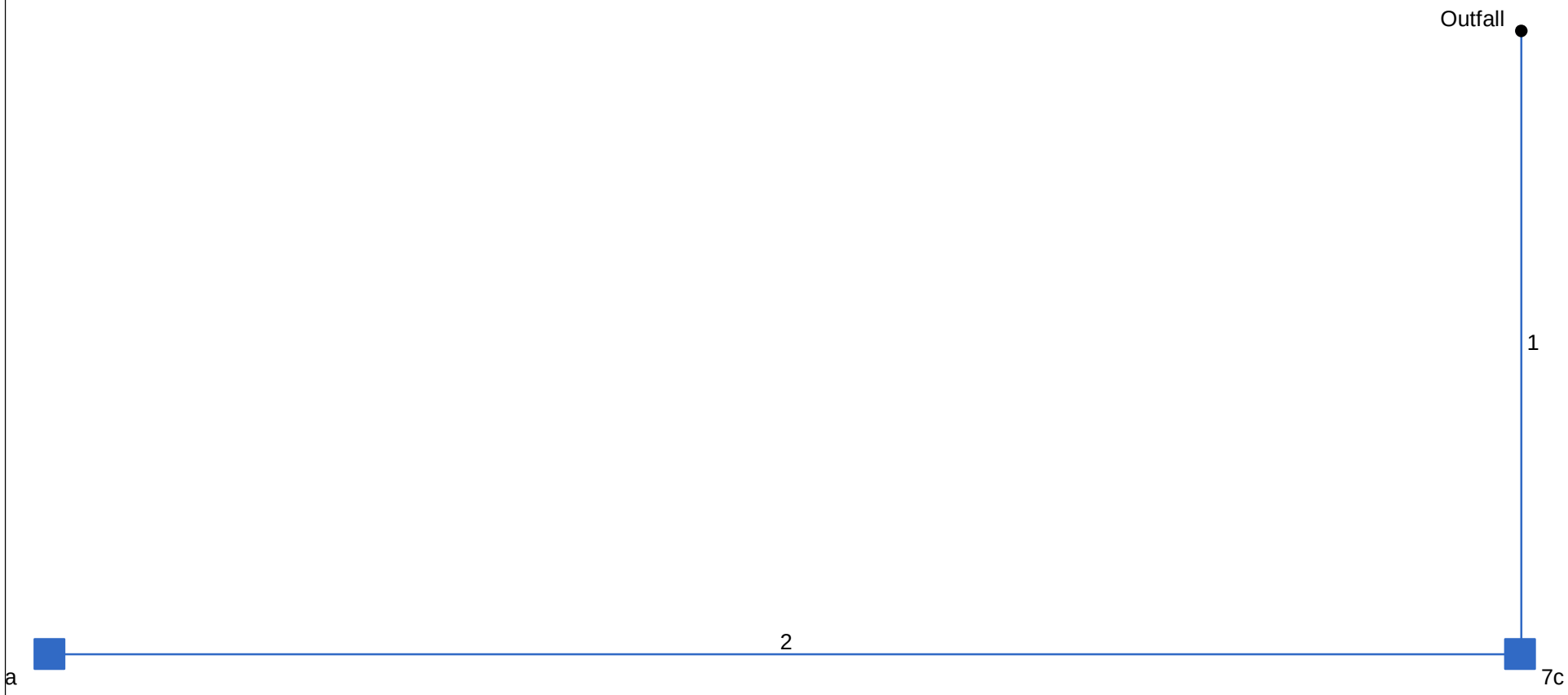
; c = cir e = ellip b = box

Line Profile (Line 1) - 5a



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.09	130.45	130.69	0.48	0.70	0.73	130.93	131.39	131.42	2.25	1.34	-1.50	1.87

5 | No. Lines: 1 | Run Date: 11-04-2013



Project File: Drainage System 7.stm	Number of lines: 2	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	83	0.48	1.62	0.73	0.35	1.09	5.0	6.4	2.4	2.65	3.00	2.68	18	0.30	124.39	124.64	125.01	126.05	124.39	128.14	7d
2	1	196	1.14	1.14	0.65	0.74	0.74	5.0	5.0	2.7	2.04	5.94	2.34	18	1.18	124.80	127.12	126.10	127.68	128.14	130.62	7b

7 Number of lines: 2 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

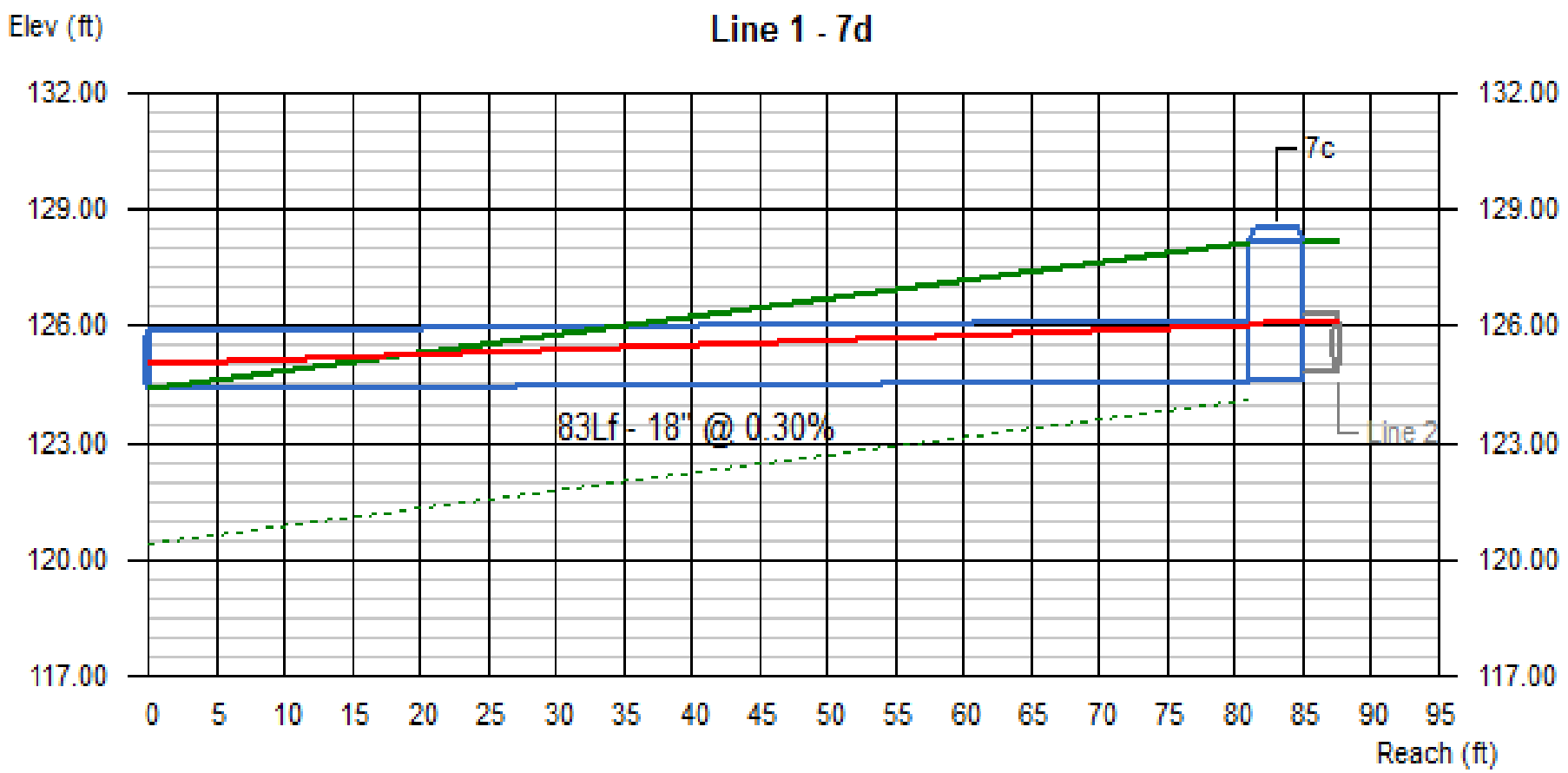
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	2.65	124.39	125.01	0.62	0.69	3.83	0.23	125.24	1.826	83	124.64	126.05	1.41	1.72	1.54	0.04	126.08	0.203	1.015	0.842	1.50	0.06
2	18	2.04	124.80	126.10	1.30	1.63	1.25	0.02	126.12	0.127	196	127.12	127.68	0.56	0.60	3.42	0.18	127.86	1.628	0.878	1.720	1.00	0.18

7	Number of lines: 2	Run Date: 11-04-2013

; c = cir e = ellip b = box

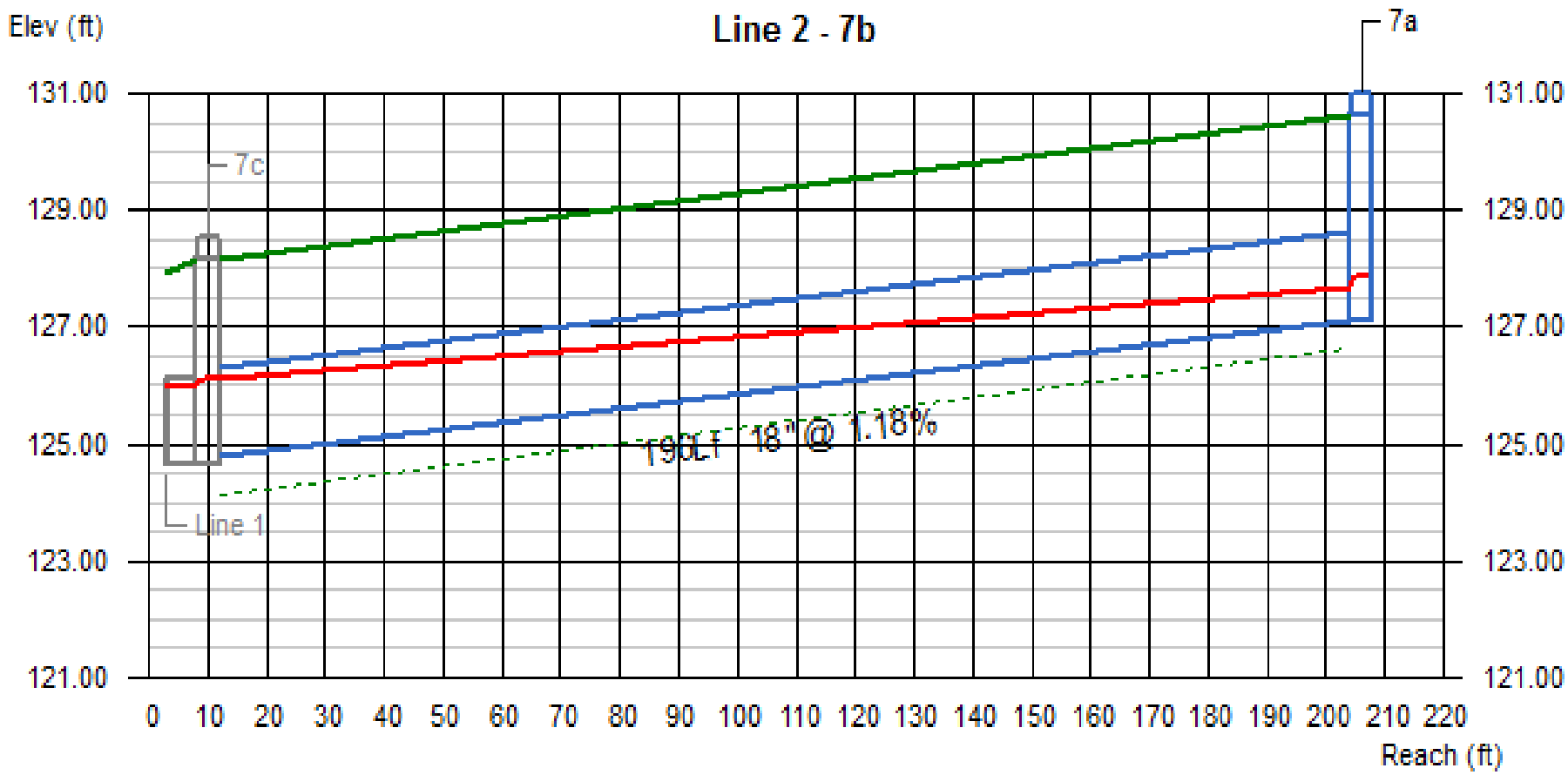
Line Profile (Line 1) - 7d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	2.65	124.39	124.64	0.62	1.41	1.46	125.01	126.05	126.10	3.83	1.54	-1.50	2.00

7	No. Lines: 2	Run Date: 11-04-2013

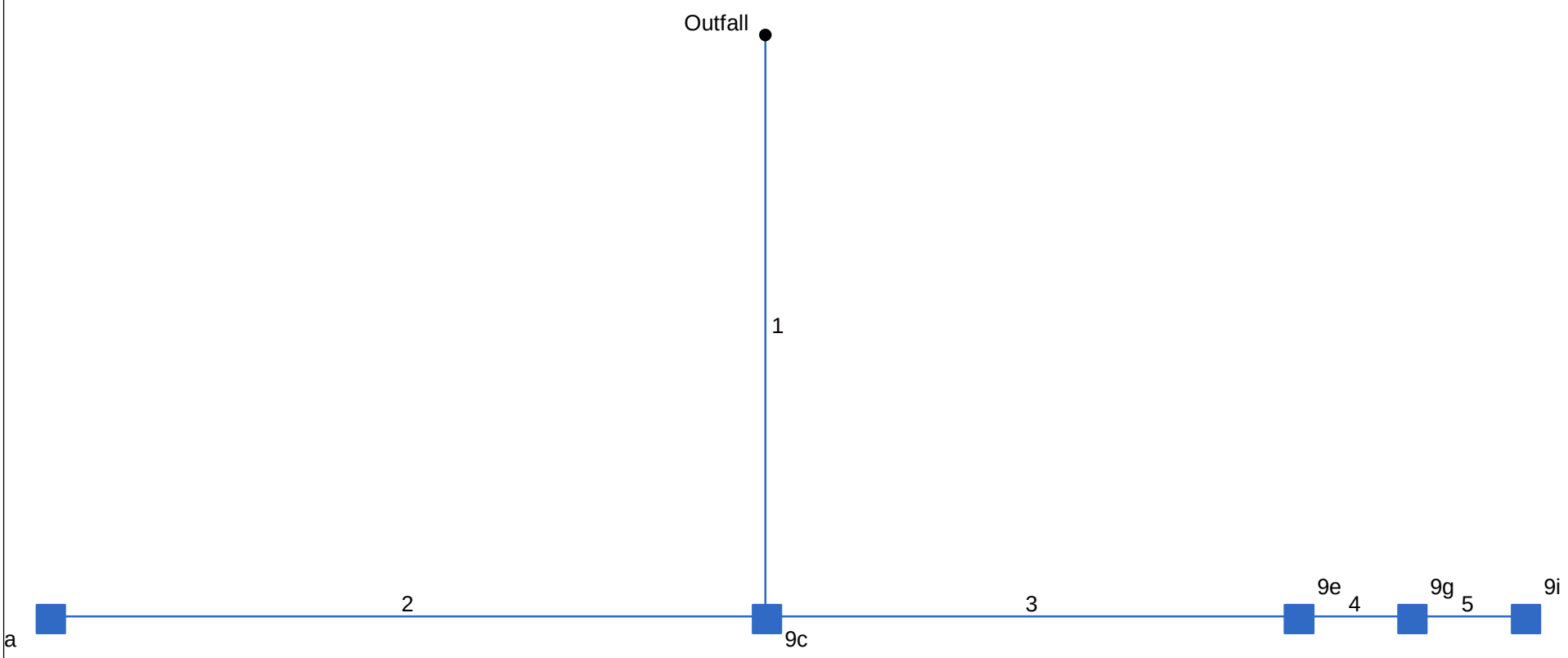
Line Profile (Line 2) - 7b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	2.04	124.80	127.12	1.30	0.56	0.74	126.10	127.68	127.86	1.25	3.42	1.84	2.00

No. Lines: 2

Run Date: 11-04-2013



Project File: Drainage System 9.stm	Number of lines: 5	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	82	0.19	2.51	0.77	0.15	1.70	5.0	11.7	1.8	3.02	2.95	2.86	18	0.29	122.58	122.82	123.24	124.32	122.58	126.25	9j
2	1	101	0.49	0.49	0.73	0.36	0.36	5.0	5.0	2.7	0.98	2.98	0.61	18	0.30	122.98	123.28	124.42	124.45	126.25	126.64	9b
3	1	75	0.66	1.83	0.64	0.42	1.19	10.0	10.7	1.9	2.22	2.96	1.26	18	0.29	122.82	123.04	124.42	124.54	126.25	126.12	9d
4	3	16	0.26	1.17	0.65	0.17	0.77	10.0	10.4	1.9	1.46	2.73	0.83	18	0.25	123.04	123.08	124.55	124.56	126.12	126.12	9f
5	4	16	0.91	0.91	0.66	0.60	0.60	10.0	10.0	1.9	1.16	2.73	0.66	18	0.25	123.08	123.12	124.57	124.57	126.12	126.12	9h

9 Number of lines: 5 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

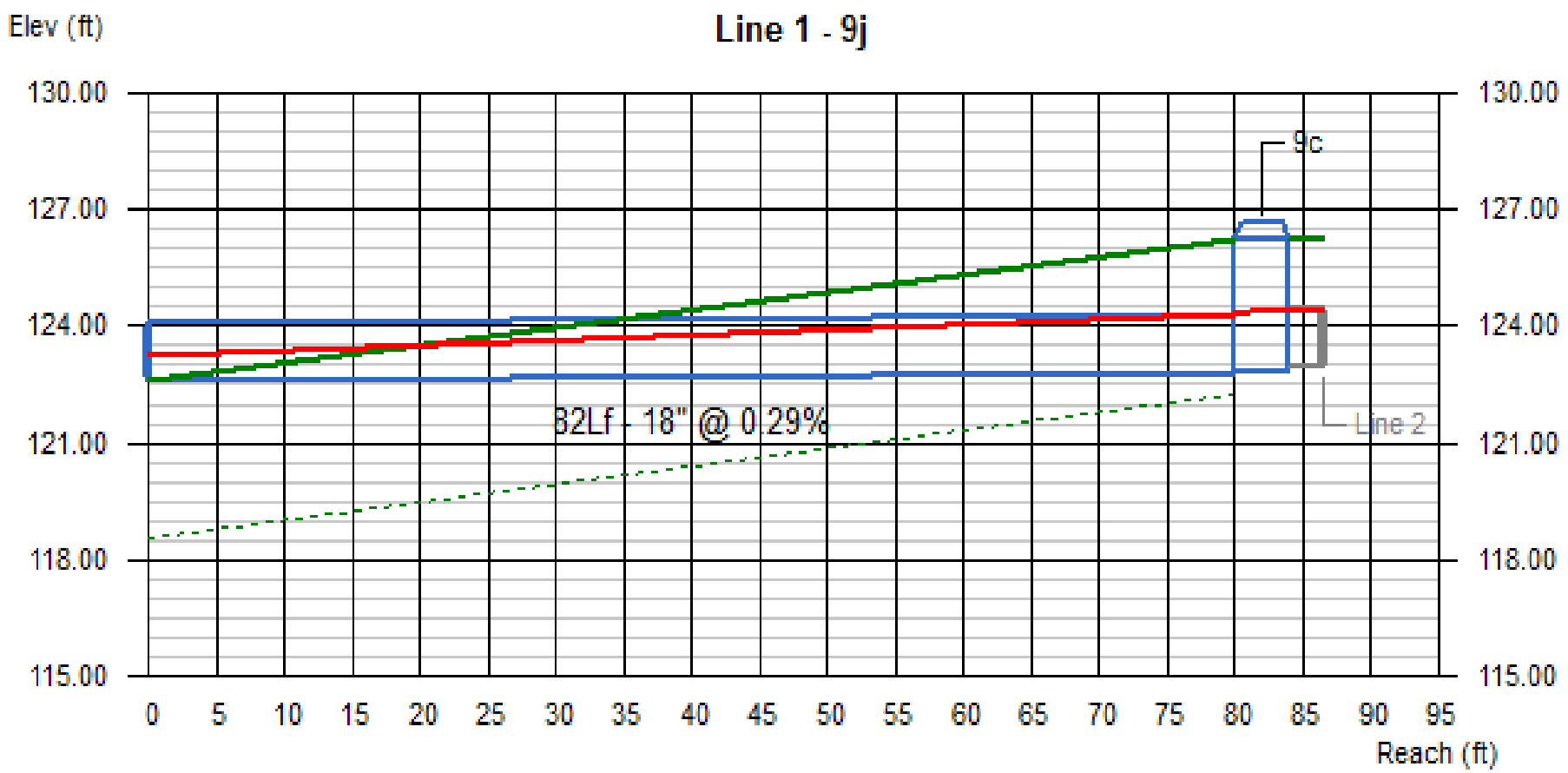
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	3.02	122.58	123.24	0.66	0.75	4.01	0.25	123.49	1.876	82	122.82	124.32	1.50	1.77	1.71	0.05	124.36	0.297	1.086	0.891	2.25	0.10
2	18	0.98	122.98	124.42	1.44	1.74	0.56	0.00	124.43	0.028	101	123.28	124.45	1.17	1.48	0.66	0.01	124.46	0.036	0.032	0.032	1.00	0.01
3	18	2.22	122.82	124.42	1.50	1.77	1.26	0.02	124.44	0.166	75	123.04	124.54	1.50	1.77	1.26	0.02	124.56	0.163	0.164	0.123	0.50	0.01
4	18	1.46	123.04	124.55	1.50	1.77	0.82	0.01	124.56	0.071	16	123.08	124.56	1.48	1.76	0.83	0.01	124.57	0.065	0.068	0.011	0.50	0.01
5	18	1.16	123.08	124.57	1.49	1.76	0.66	0.01	124.57	0.042	16	123.12	124.57	1.45	1.75	0.66	0.01	124.58	0.040	0.041	0.007	1.00	0.01

9 | Number of lines: 5 | Run Date: 11-04-2013

; c = cir e = ellip b = box

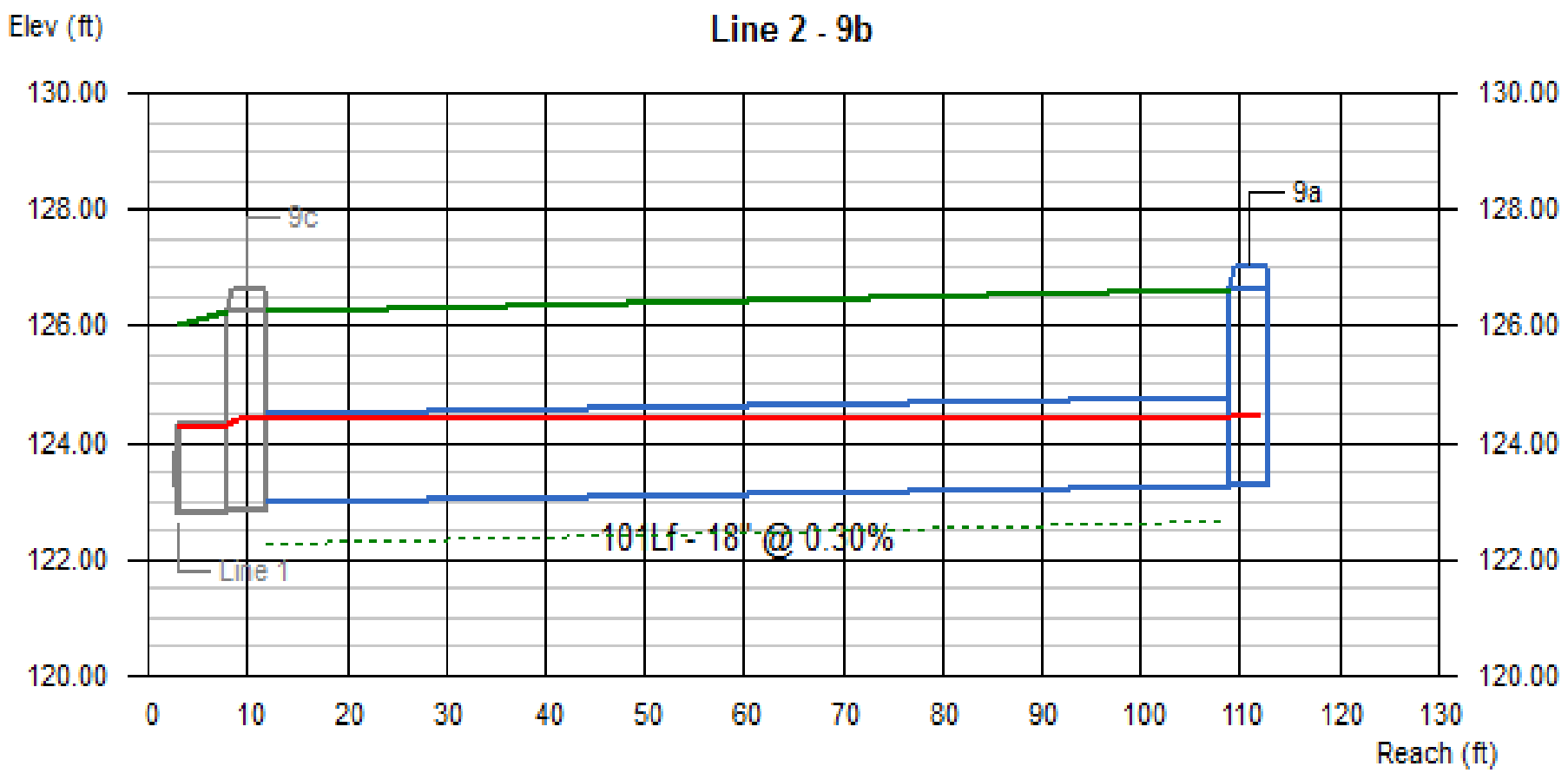
Line Profile (Line 1) - 9j



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	3.02	122.58	122.82	0.66	1.50	1.60	123.24	124.32	124.42	4.01	1.71	-1.50	1.93

9	No. Lines: 5	Run Date: 11-04-2013

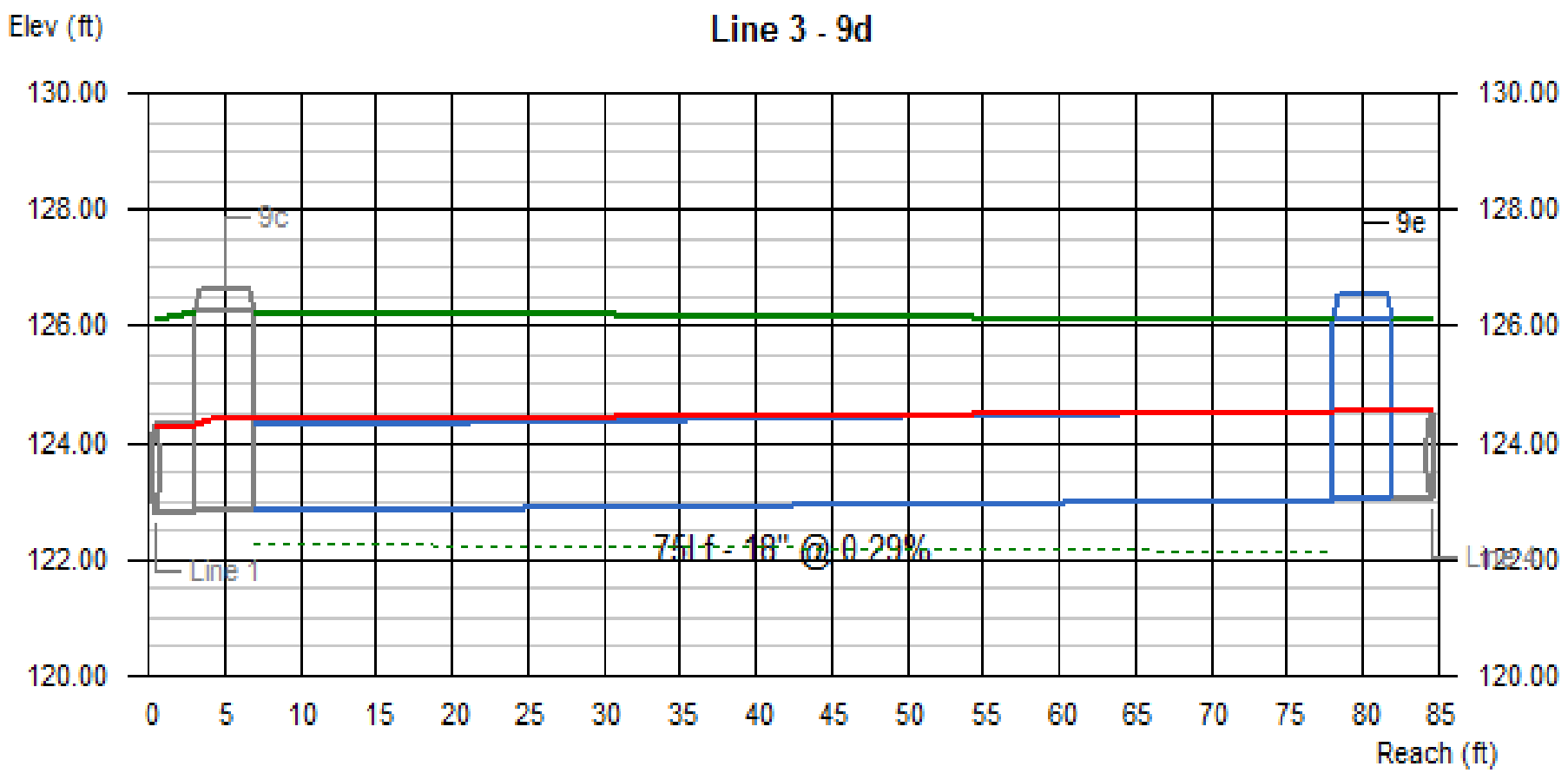
Line Profile (Line 2) - 9b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.98	122.98	123.28	1.44	1.17	1.18	124.42	124.45	124.46	0.56	0.66	1.77	1.86

9	No. Lines: 5	Run Date: 11-04-2013

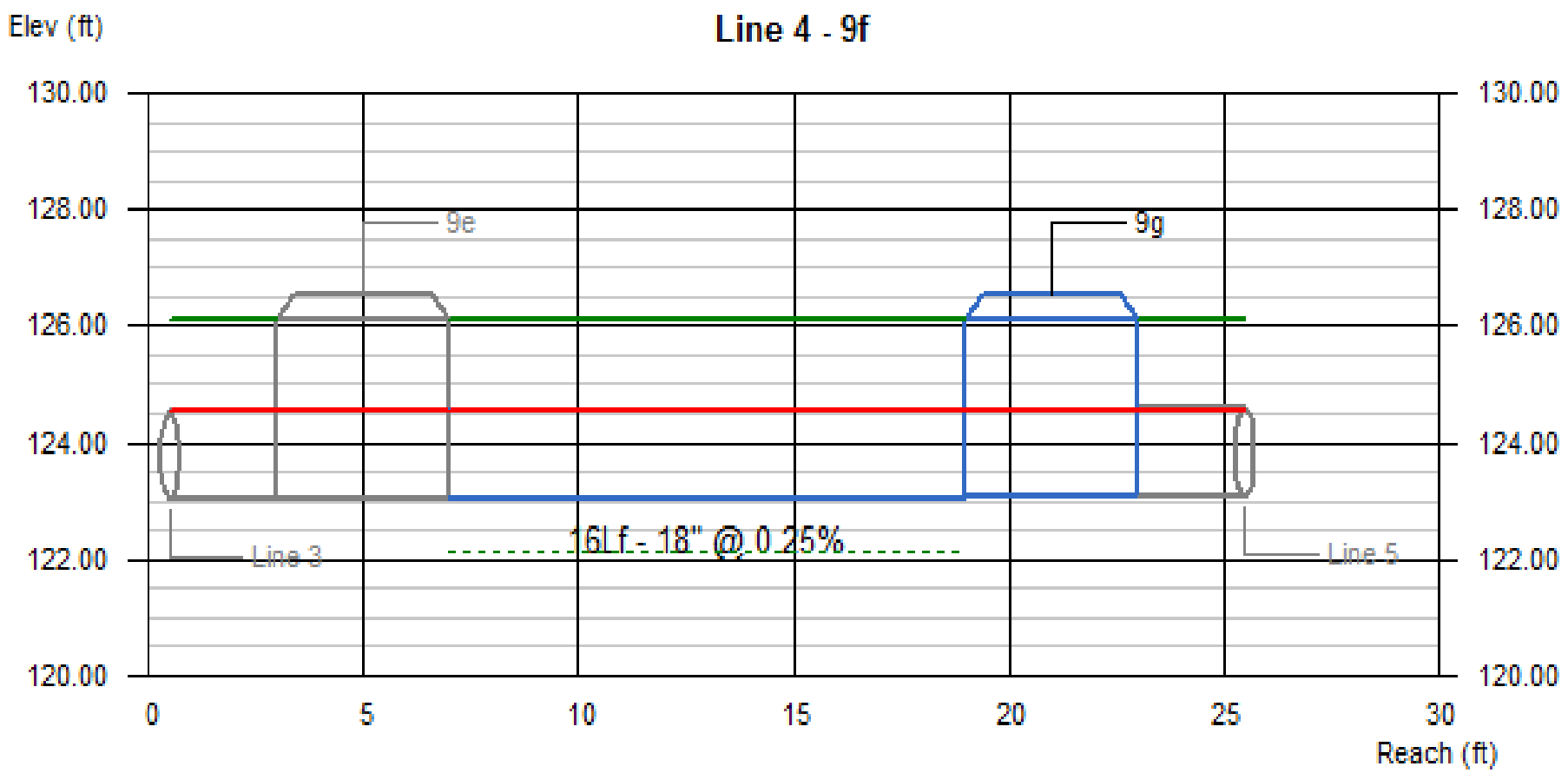
Line Profile (Line 3) - 9d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	2.22	122.82	123.04	1.50	1.50	1.51	124.42	124.54	124.55	1.26	1.26	1.93	1.58

9	No. Lines: 5	Run Date: 11-04-2013

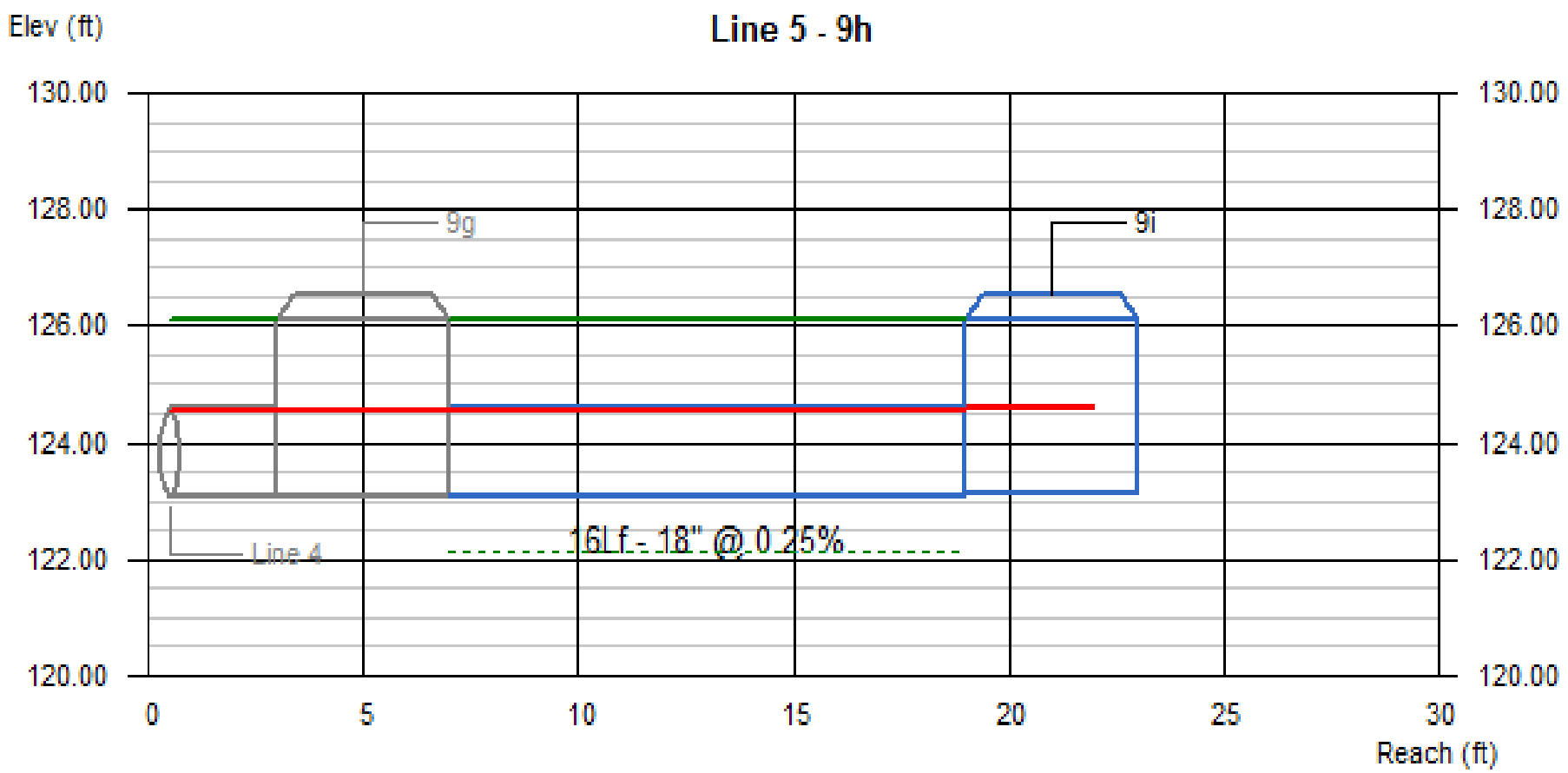
Line Profile (Line 4) - 9f



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	1.46	123.04	123.08	1.50	1.48	1.49	124.55	124.56	124.57	0.82	0.83	1.58	1.54

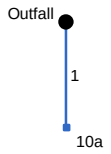
9 | No. Lines: 5 | Run Date: 11-04-2013

Line Profile (Line 5) - 9h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	1.16	123.08	123.12	1.49	1.45	1.46	124.57	124.57	124.58	0.66	0.66	1.54	1.50

9 | No. Lines: 5 | Run Date: 11-04-2013



Project File: Drainage System 10.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	81	0.49	0.49	0.73	0.36	0.36	5.0	5.0	2.7	0.98	2.97	1.70	18	0.30	123.00	123.24	123.48	123.88	123.00	126.51	10c

10 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

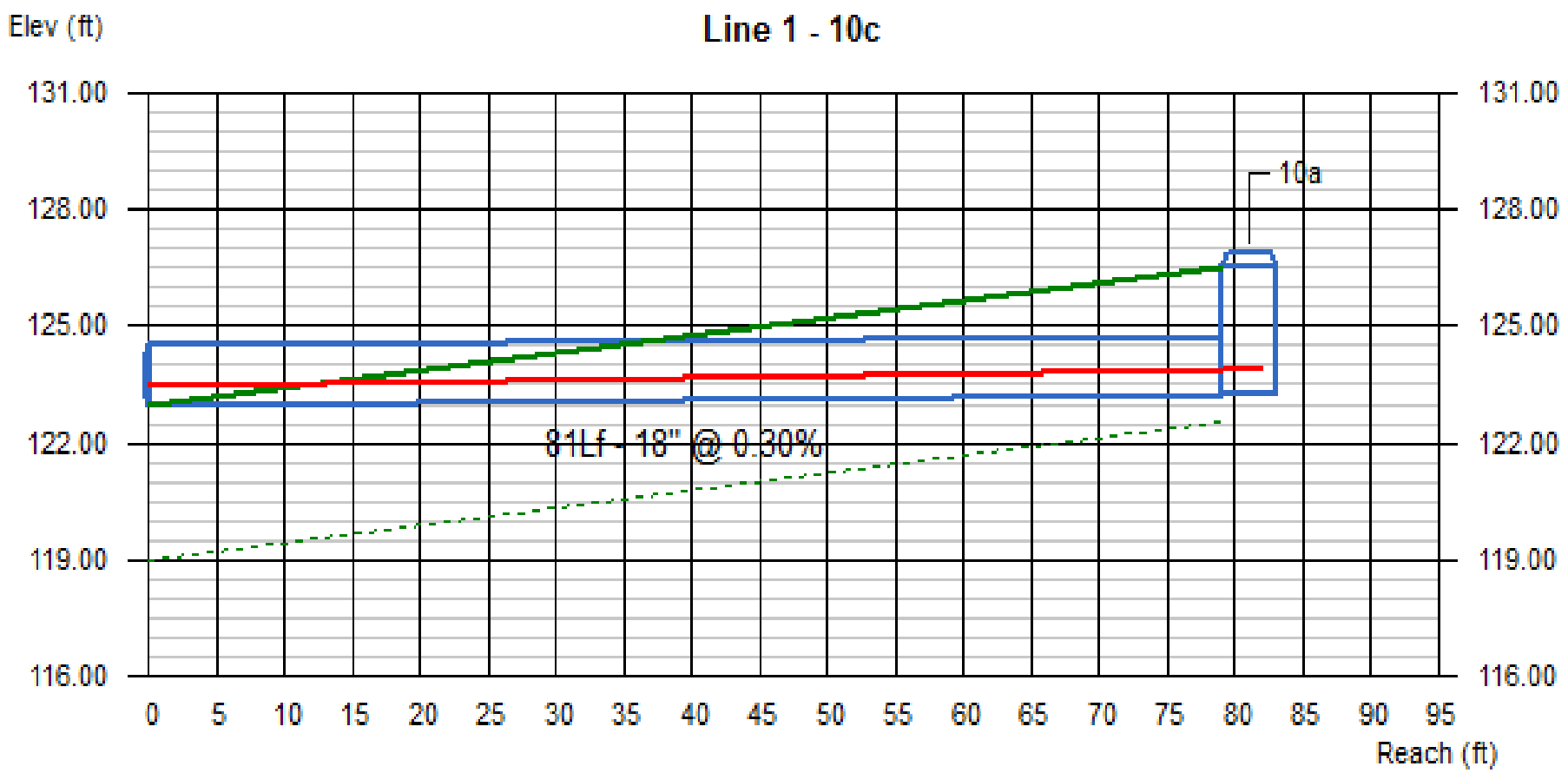
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.98	123.00	123.48	0.48	0.48	2.03	0.06	123.54	0.675	81	123.24	123.88	0.64	0.72	1.37	0.03	123.91	0.227	0.451	0.365	1.00	0.03

10 | Number of lines: 1 | Run Date: 11-04-2013

; c = cir e = ellip b = box

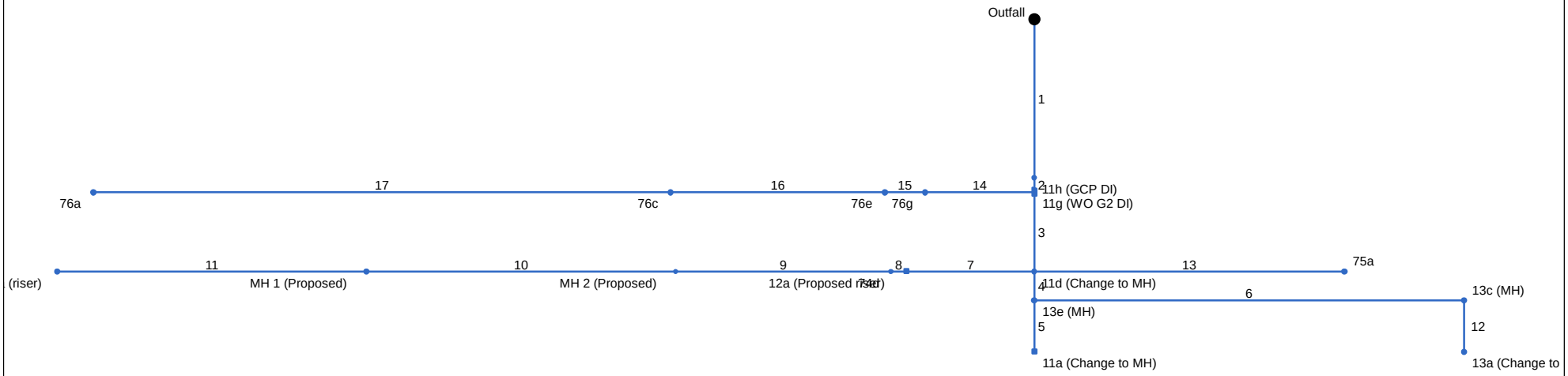
Line Profile (Line 1) - 10c



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.98	123.00	123.24	0.48	0.64	0.67	123.48	123.88	123.91	2.03	1.37	-1.50	1.77

10 | No. Lines: 1 | Run Date: 11-04-2013

11 12 13 74 75 76



Project File: Drainage System 11, 12, 13, 74, 75, 76.stm	Number of lines: 17	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	154	0.17	23.84	0.60	0.10	17.65	5.0	195.3	0.4	7.42	2.98	4.20	18	0.30	115.55	116.01	117.05	119.89	117.67	122.71	11i
2	1	14	2.55	23.67	1.00	2.55	17.55	25.0	195.2	0.4	7.38	6.29	2.35	24	0.29	116.17	116.21	120.03	120.08	122.71	126.25	11f
3	2	77	0.00	19.59	0.00	0.00	13.47	5.0	194.1	0.4	5.68	95.15	0.37	60	0.49	116.37	116.75	120.21	120.21	126.25	122.78	11e
4	3	28	0.00	0.00	0.00	0.00	0.00	5.0	193.6	0.0	0.02	6.61	0.01	18	1.46	117.61	118.02	120.22	120.22	122.78	125.68	13c
5	4	50	0.00	0.00	0.00	0.00	0.00	30.0	30.0	0.0	0.01	6.64	0.01	18	1.48	118.18	118.92	120.22	120.22	125.68	126.30	11b
6	4	417	0.00	0.00	0.00	0.00	0.00	5.0	176.9	0.0	0.01	5.12	0.42	18	0.88	118.18	121.85	120.22	121.89	125.68	126.94	13d
7	3	124	1.93	12.47	0.67	1.29	8.34	24.5	27.2	1.2	9.64	40.80	0.92	48	0.30	116.91	117.28	120.22	120.24	122.78	122.28	12c
8	7	15	5.90	10.54	0.66	3.89	7.05	22.0	27.2	1.2	8.16	3.15	4.62	18	0.33	116.91	116.96	120.24	120.58	122.28	123.82	74e
9	8	209	0.00	4.64	0.00	0.00	3.16	5.0	26.1	1.2	3.73	5.31	2.17	18	0.95	118.32	120.30	120.74	121.65	123.82	123.30	74b-3
10	9	300	0.00	4.64	0.00	0.00	3.16	5.0	24.5	1.2	3.85	5.32	2.94	18	0.95	120.30	123.15	121.67	124.02	123.30	126.00	74b-2
11	10	300	4.64	4.64	0.68	3.16	3.16	23.0	23.0	1.3	3.98	5.32	3.32	18	0.95	123.15	126.00	124.05	127.04	126.00	132.88	74b-1
12	6	50	0.00	0.00	0.00	0.00	0.00	30.0	30.0	0.0	0.01	3.86	0.42	18	0.50	122.01	122.26	122.05	122.72	126.94	127.56	13b
13	3	301	7.12	7.12	0.72	5.13	5.13	45.0	45.0	0.9	4.58	3.87	2.59	18	0.50	118.11	119.62	120.22	122.33	122.78	126.62	75b
14	2	106	0.04	1.53	1.00	0.04	1.53	5.0	11.6	1.8	2.74	123.4	0.20	60	0.83	116.36	117.24	120.21	120.22	126.25	126.09	76h
15	14	39	0.18	1.49	1.00	0.18	1.49	5.0	11.2	1.8	2.72	120.8	0.26	60	0.79	117.40	117.71	120.22	120.22	126.09	126.14	76f
16	15	208	0.48	1.31	1.00	0.48	1.31	5.0	9.1	2.0	2.66	121.0	0.80	60	0.80	117.87	119.53	120.22	120.33	126.14	126.91	76d
17	16	560	0.83	0.83	1.00	0.83	0.83	5.0	5.0	2.7	2.28	121.1	2.19	60	0.80	119.69	124.17	120.34	124.59	126.91	138.40	76b

11 12 13 74 75 76

Number of lines: 17

Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

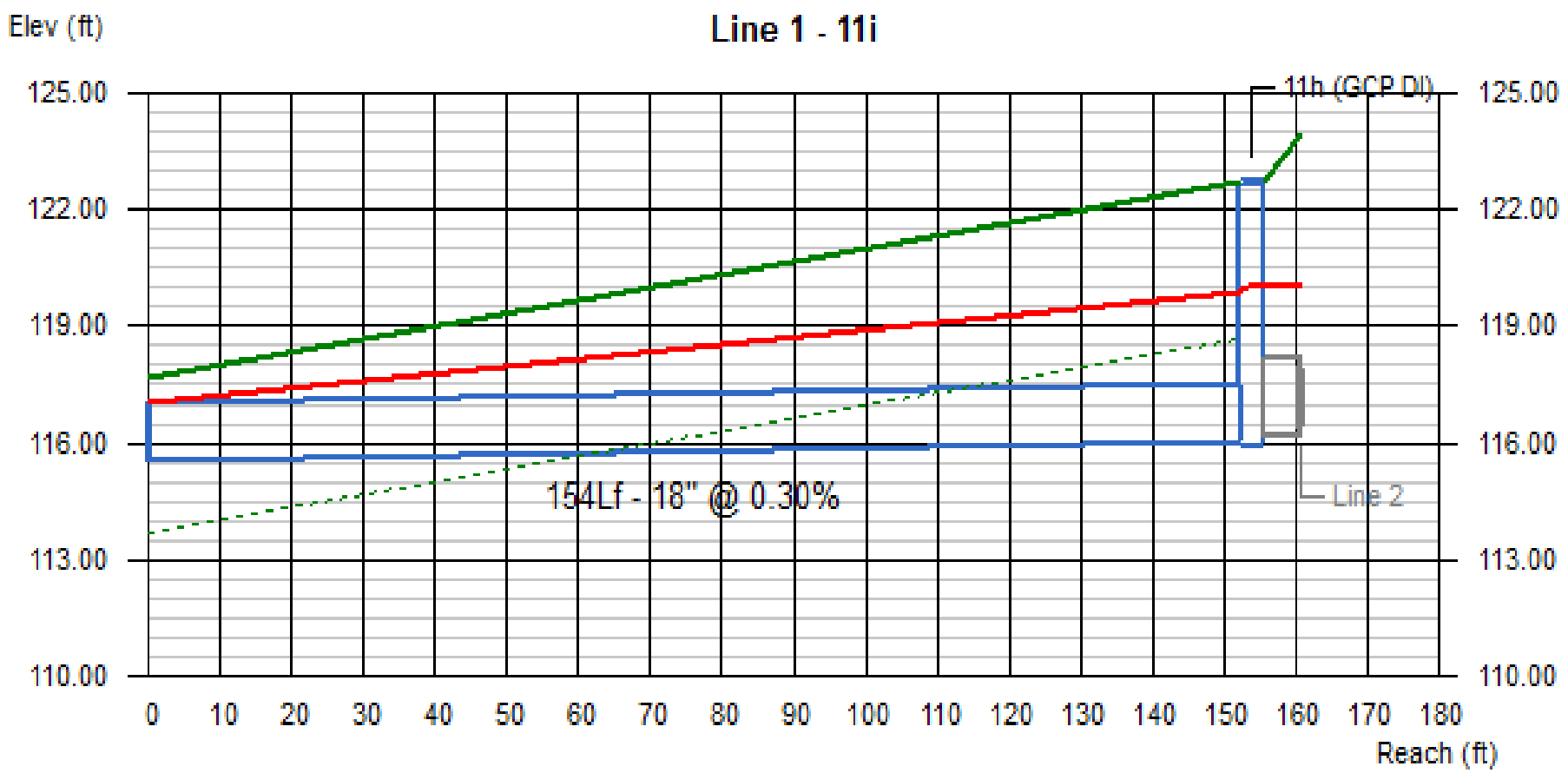
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	7.42	115.55	117.05	1.50	1.77	4.20	0.27	117.32	1.846	154	116.01	119.89	1.50	1.77	4.20	0.27	120.17	1.845	1.846	2.843	0.50	0.14
2	24	7.38	116.17	120.03	2.00	3.14	2.35	0.09	120.12	0.394	14	116.21	120.08	2.00	3.14	2.35	0.09	120.17	0.394	0.394	0.055	1.50	0.13
3	60	5.68	116.37	120.21	3.84	16.20	0.35	0.00	120.22	0.002	77	116.75	120.21	3.46	14.52	0.39	0.00	120.22	0.003	0.002	0.002	1.00	0.00
4	18	0.02	117.61	120.22	1.50	1.77	0.01	0.00	120.22	0.000	28	118.02	120.22	1.50	1.77	0.01	0.00	120.22	0.000	0.000	0.000	1.00	0.00
5	18	0.01	118.18	120.22	1.50	1.77	0.01	0.00	120.22	0.000	50	118.92	120.22	1.30	1.62	0.01	0.00	120.22	0.000	0.000	0.000	1.00	0.00
6	18	0.01	118.18	120.22	1.50	1.77	0.01	0.00	120.22	0.000	417	121.85	121.89	0.04**	0.01	0.83	0.01	121.90	2.638	1.319	n/a	1.00	0.01
7	48	9.64	116.91	120.22	3.31	11.11	0.87	0.01	120.23	0.016	124	117.28	120.24	2.96	9.96	0.97	0.01	120.25	0.021	0.019	0.023	0.50	0.01
8	18	8.16	116.91	120.24	1.50	1.77	4.62	0.33	120.58	2.233	15	116.96	120.58	1.50	1.77	4.62	0.33	120.91	2.232	2.232	0.335	0.50	0.17
9	18	3.73	118.32	120.74	1.50	1.77	2.11	0.07	120.81	0.467	209	120.30	121.65	1.35	1.68	2.22	0.08	121.73	0.410	0.439	0.917	0.15	0.01
10	18	3.85	120.30	121.67	1.37	1.69	2.28	0.08	121.75	0.434	300	123.15	124.02	0.87	1.07	3.61	0.20	124.22	1.214	0.824	2.471	0.15	0.03
11	18	3.98	123.15	124.05	0.90	1.11	3.58	0.20	124.25	1.166	300	126.00	127.04	1.04	1.30	3.06	0.15	127.18	0.786	0.976	2.928	1.00	0.15
12	18	0.01	122.01	122.05	0.04*	0.01	0.83	0.01	122.06	2.638	50	122.26	122.72	0.46	0.46	0.02	0.00	122.72	0.000	1.319	0.659	1.00	0.00
13	18	4.58	118.11	120.22	1.50	1.77	2.59	0.10	120.32	0.703	301	119.62	122.33	1.50	1.77	2.59	0.10	122.44	0.703	0.703	2.116	1.00	0.10
14	60	2.74	116.36	120.21	3.85	16.24	0.17	0.00	120.21	0.000	106	117.24	120.22	2.98	12.19	0.23	0.00	120.22	0.001	0.001	0.001	0.50	0.00
15	60	2.72	117.40	120.22	2.82	11.40	0.24	0.00	120.22	0.001	39	117.71	120.22	2.51	9.89	0.27	0.00	120.23	0.002	0.001	0.001	0.50	0.00
16	60	2.66	117.87	120.22	2.35	9.09	0.29	0.00	120.23	0.002	208	119.53	120.33	0.80	2.03	1.31	0.03	120.36	0.125	0.064	0.132	0.50	0.01
17	60	2.28	119.69	120.34	0.65	1.51	1.51	0.04	120.38	0.213	560	124.17	124.59	0.42**	0.80	2.87	0.13	124.72	1.337	0.775	n/a	1.00	n/a

11 12 13 74 75 76 | Number of lines: 17 | Run Date: 11-04-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

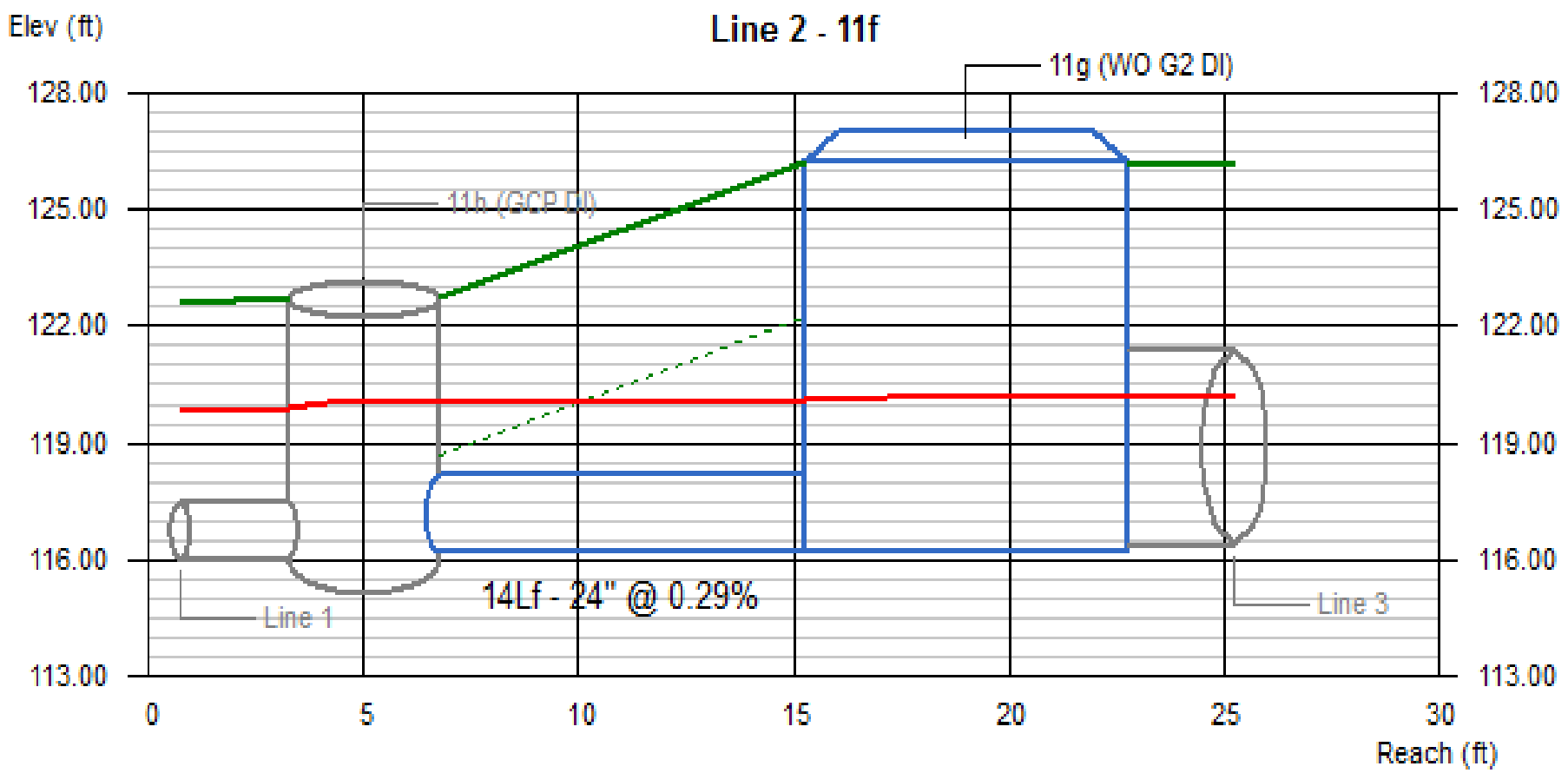
Line Profile (Line 1) - 11i



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	7.42	115.55	116.01	1.50	1.50	4.02	117.05	119.89	120.03	4.20	4.20	0.62	5.20

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

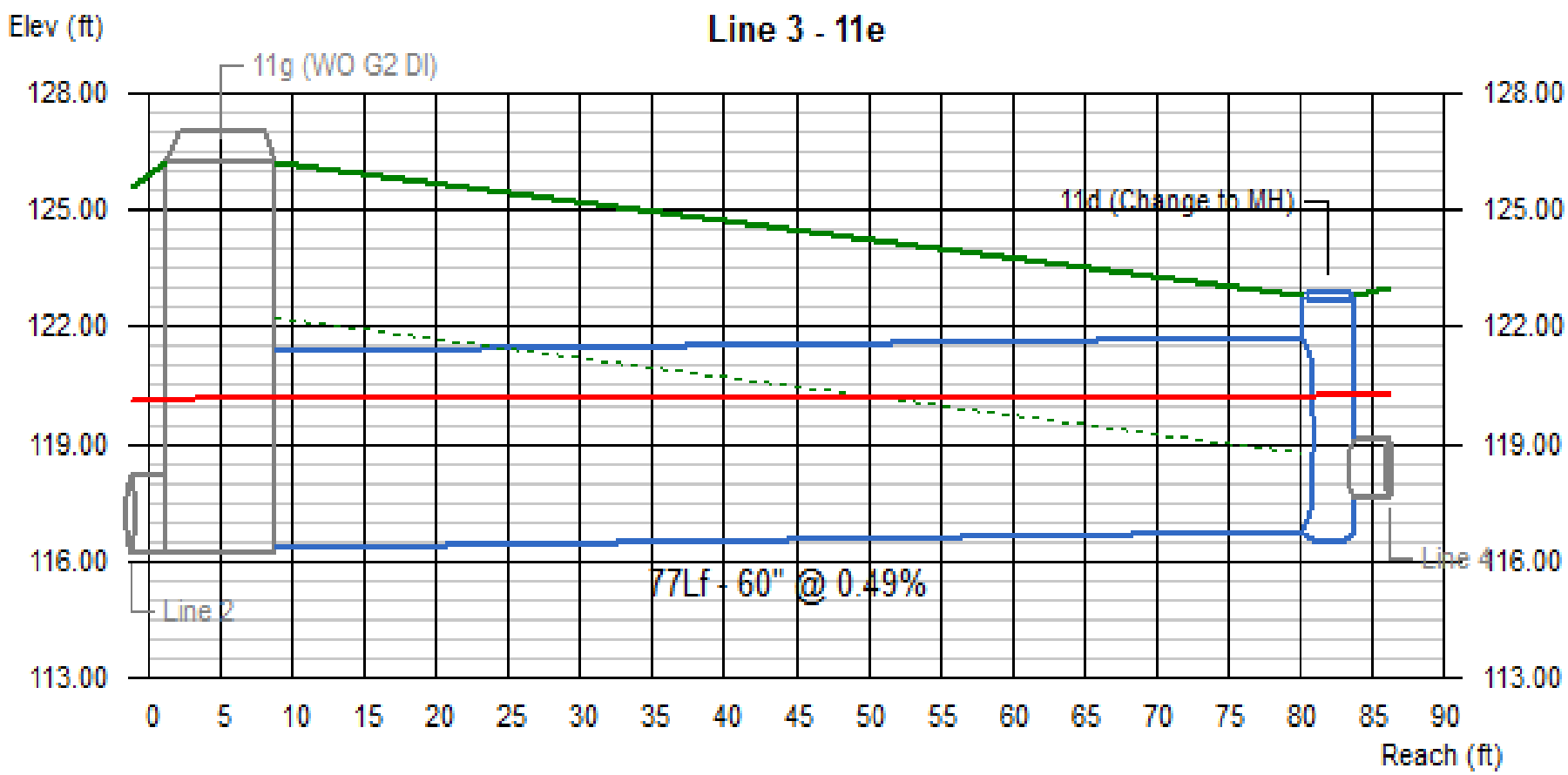
Line Profile (Line 2) - 11f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	7.38	116.17	116.21	2.00	2.00	4.00	120.03	120.08	120.21	2.35	2.35	4.54	8.04

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

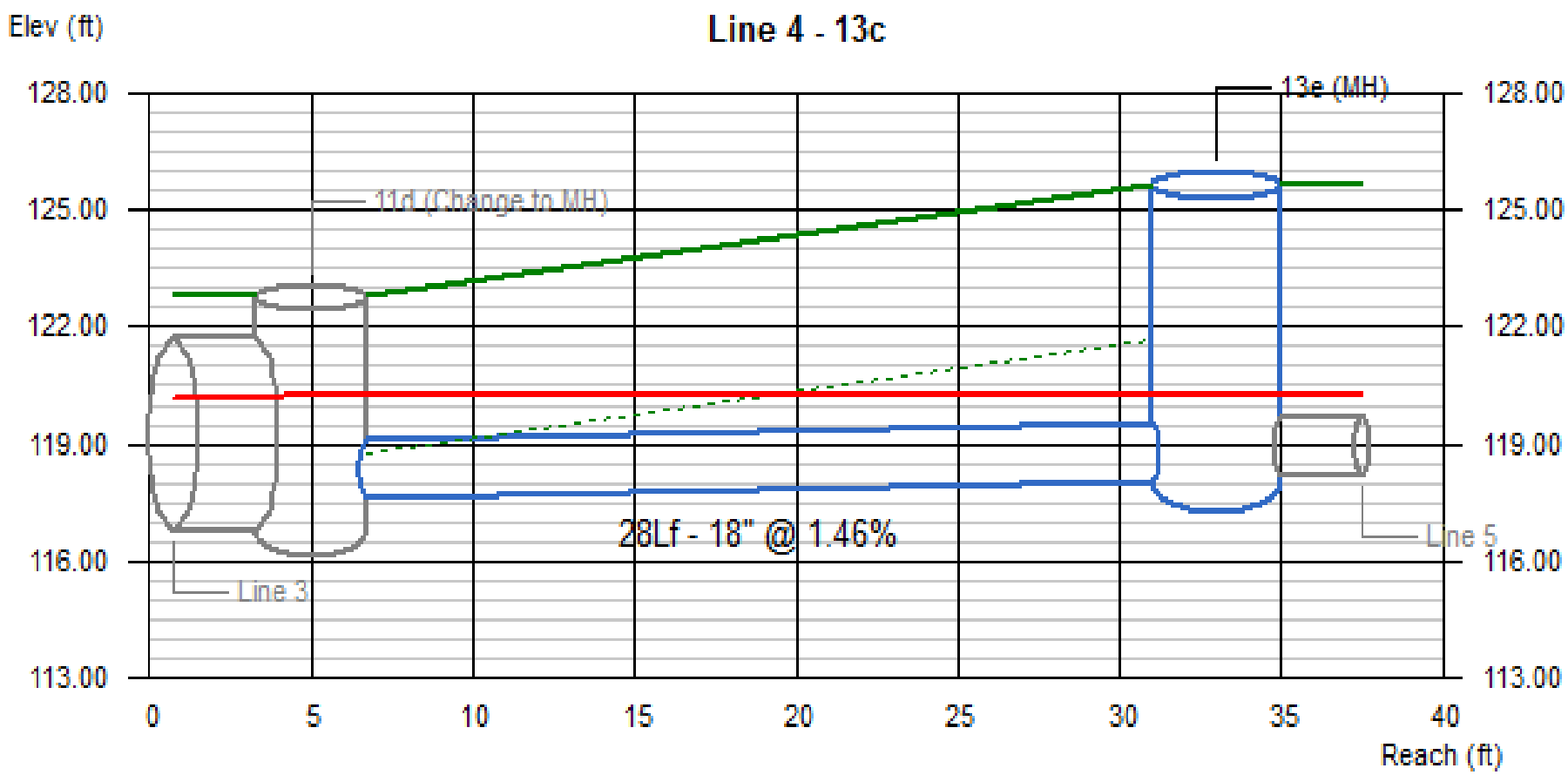
Line Profile (Line 3) - 11e



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	5.68	116.37	116.75	3.84	3.46	3.47	120.21	120.21	120.22	0.35	0.39	4.88	1.03

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

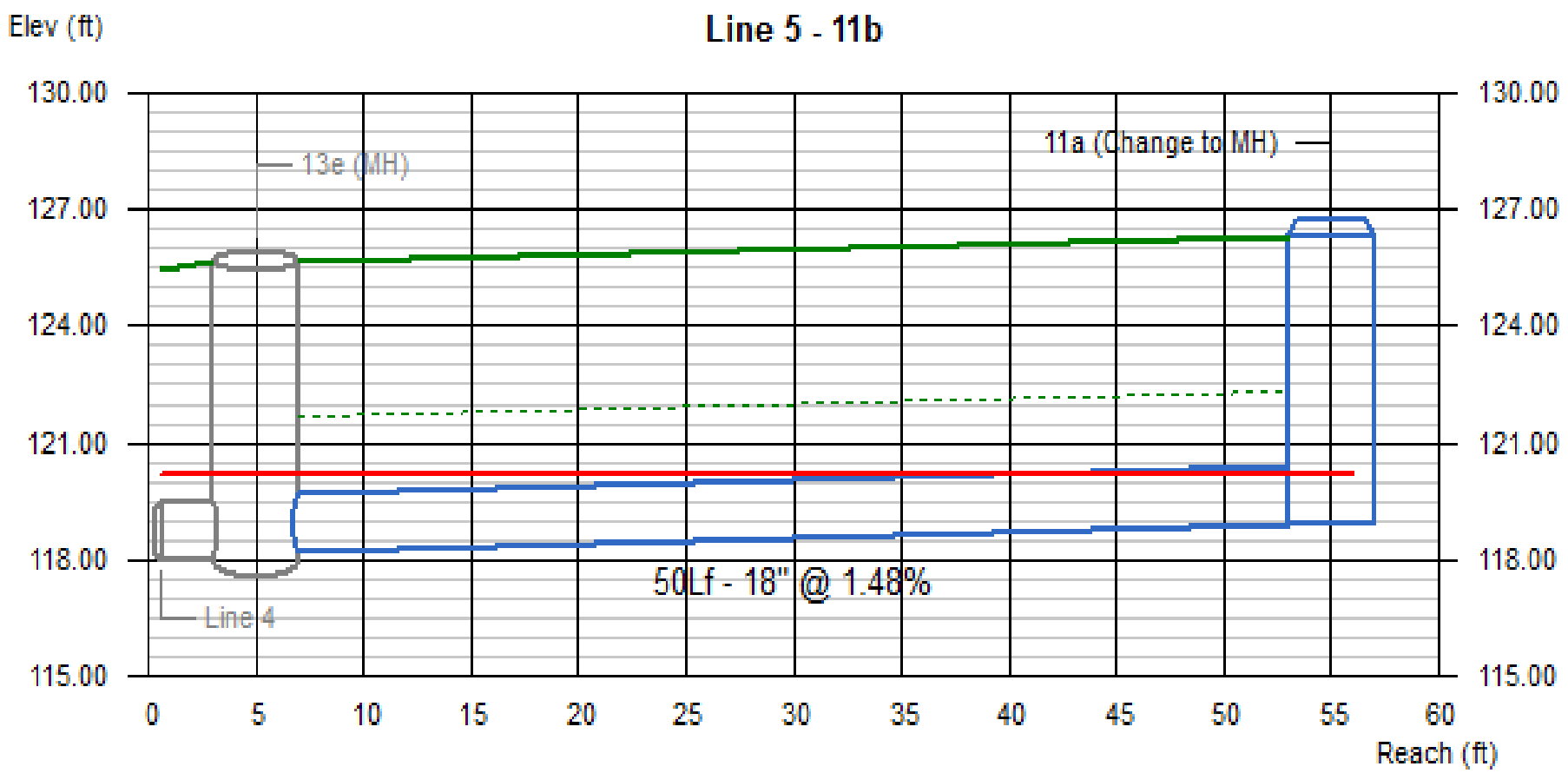
Line Profile (Line 4) - 13c



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.02	117.61	118.02	1.50	1.50	2.20	120.22	120.22	120.22	0.01	0.01	3.67	6.16

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

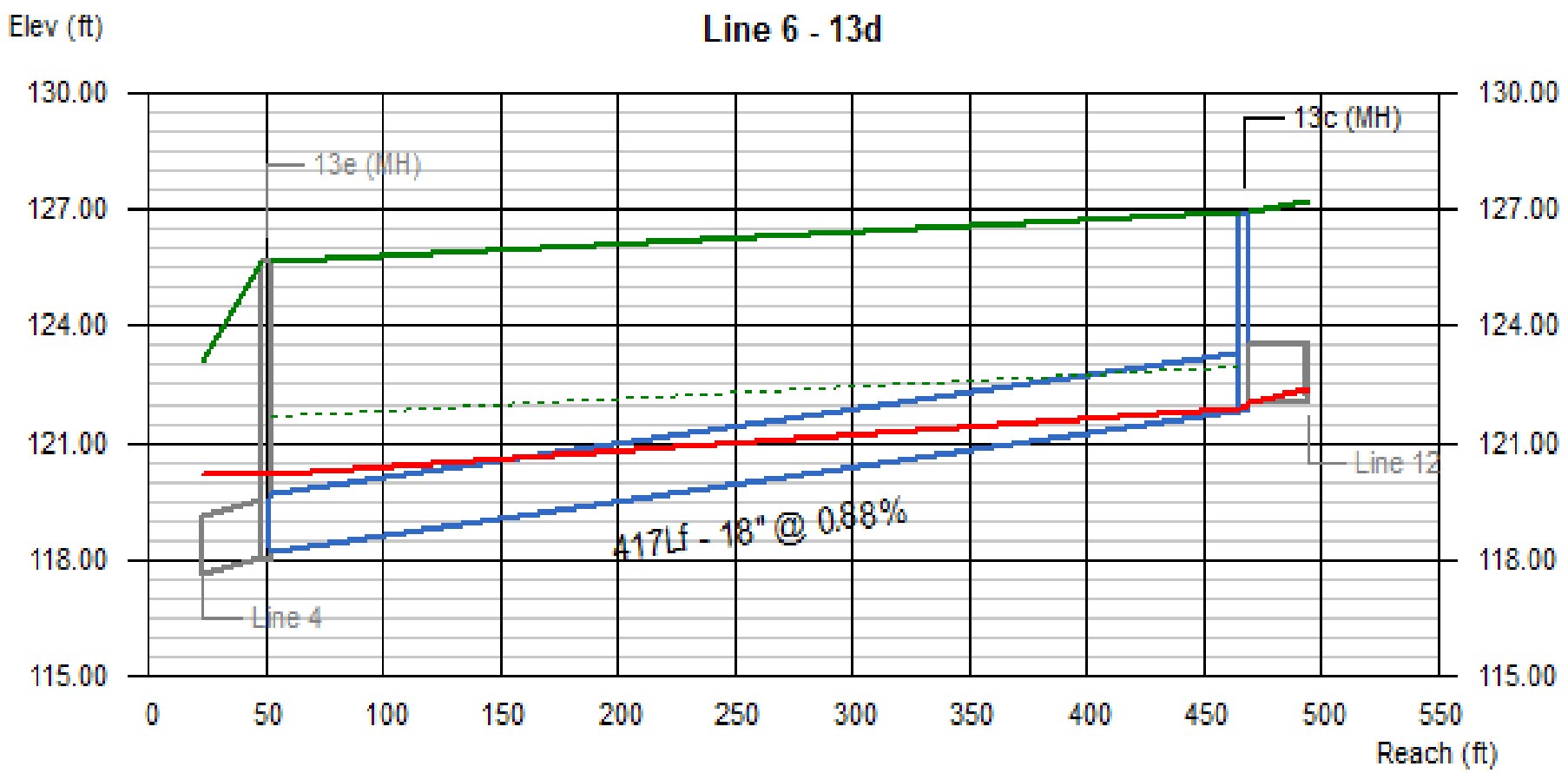
Line Profile (Line 5) - 11b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.01	118.18	118.92	1.50	1.30	1.30	120.22	120.22	120.22	0.01	0.01	6.00	5.88

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

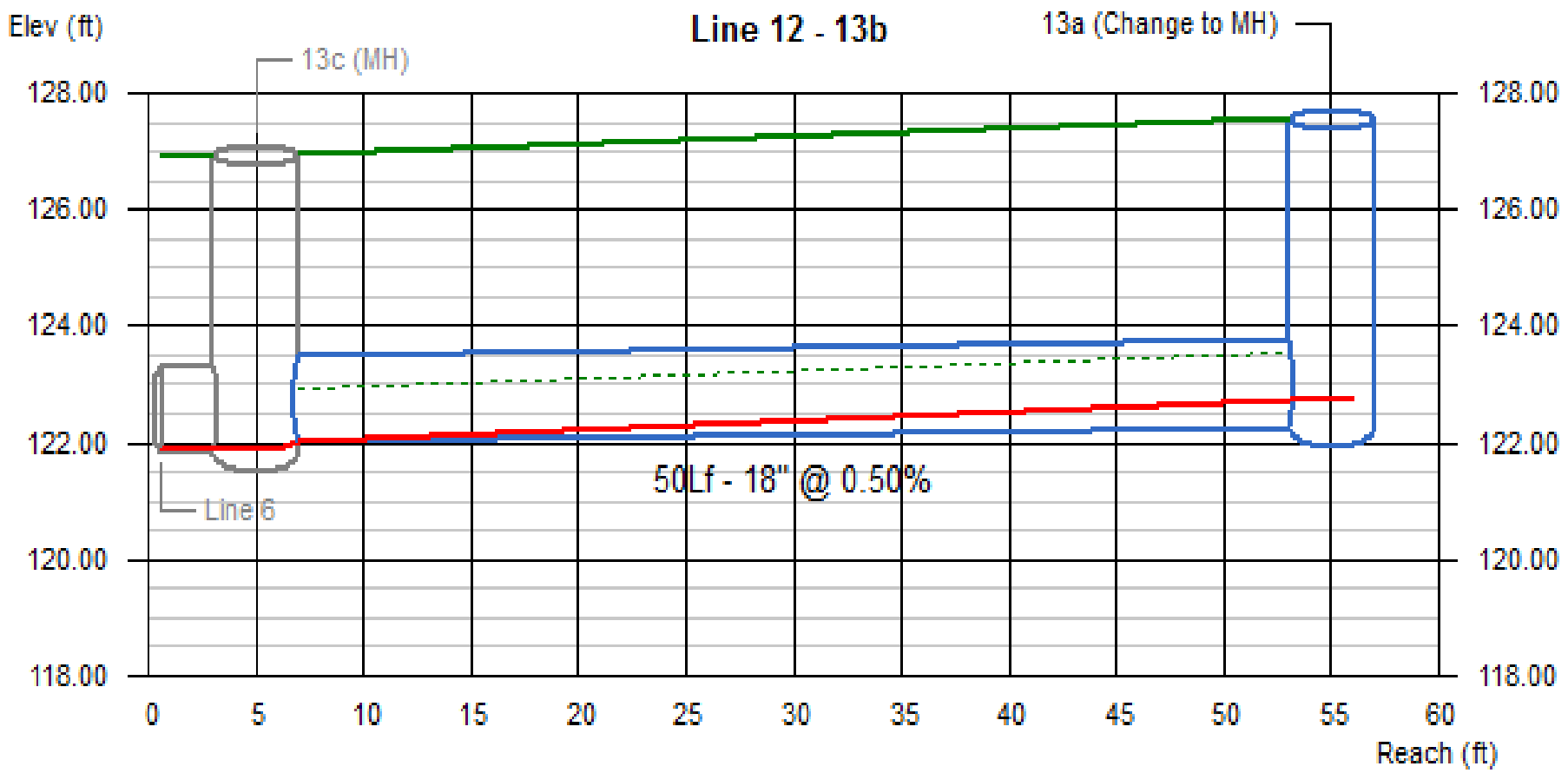
Line Profile (Line 6) - 13d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.01	118.18	121.85	1.50	0.04	0.04	120.22	121.89	121.89	0.01	0.83	6.00	3.59

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

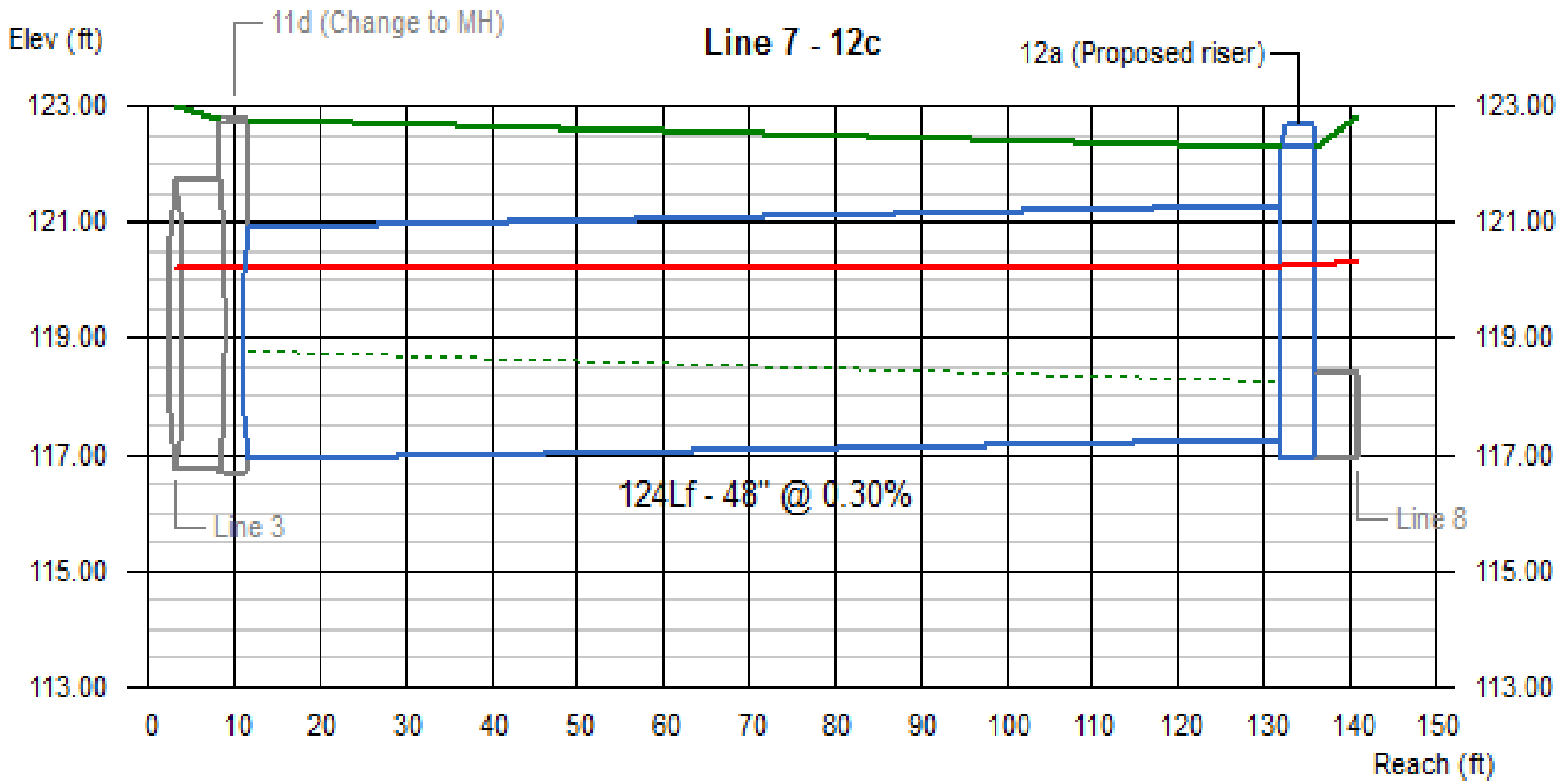
Line Profile (Line 12) - 13b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
12	0.01	122.01	122.26	0.04	0.46	0.46	122.05	122.72	122.72	0.83	0.02	3.43	3.80

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

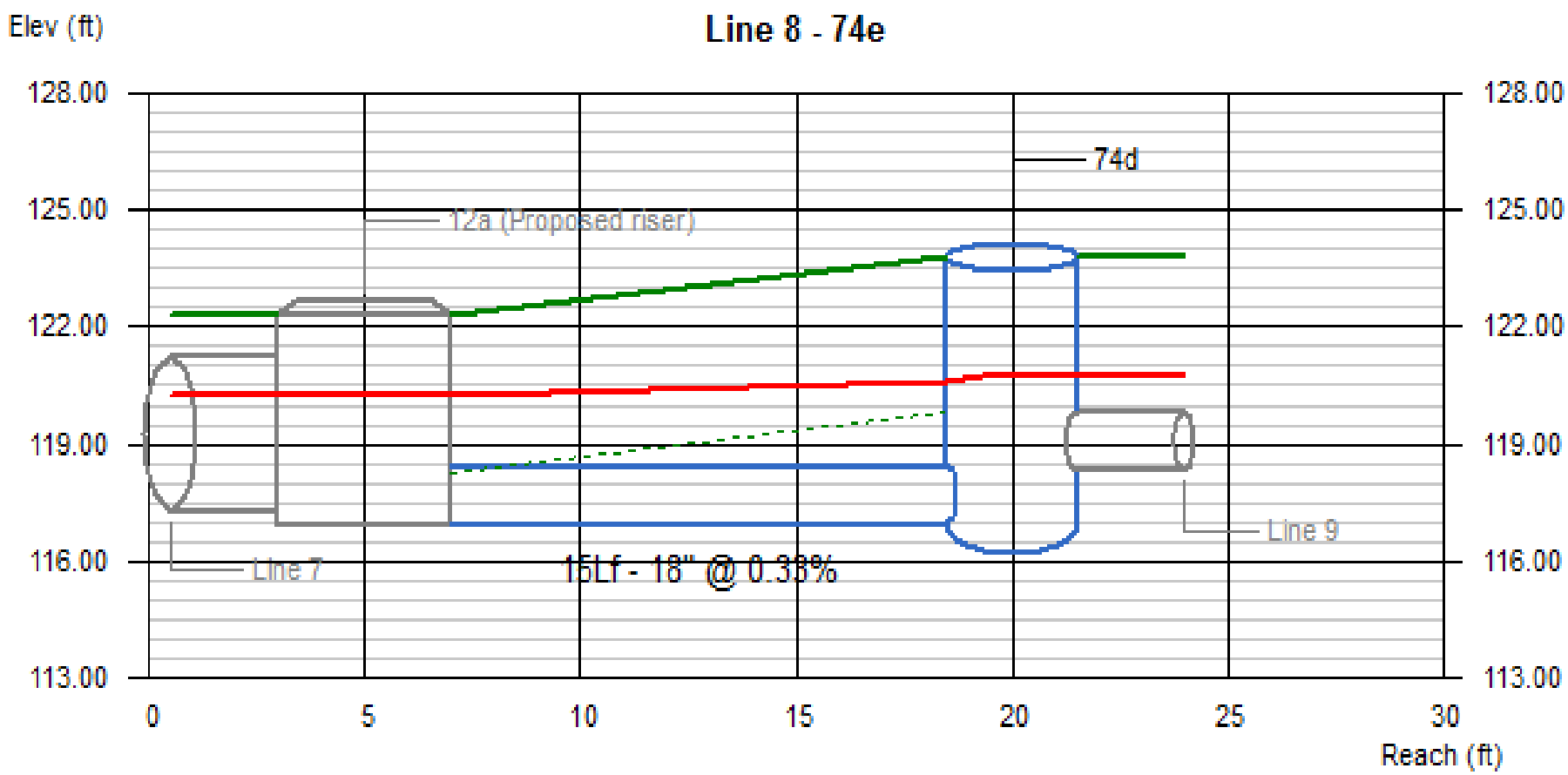
Line Profile (Line 7) - 12c



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	9.64	116.91	117.28	3.31	2.96	2.96	120.22	120.24	120.24	0.87	0.97	1.87	1.00

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

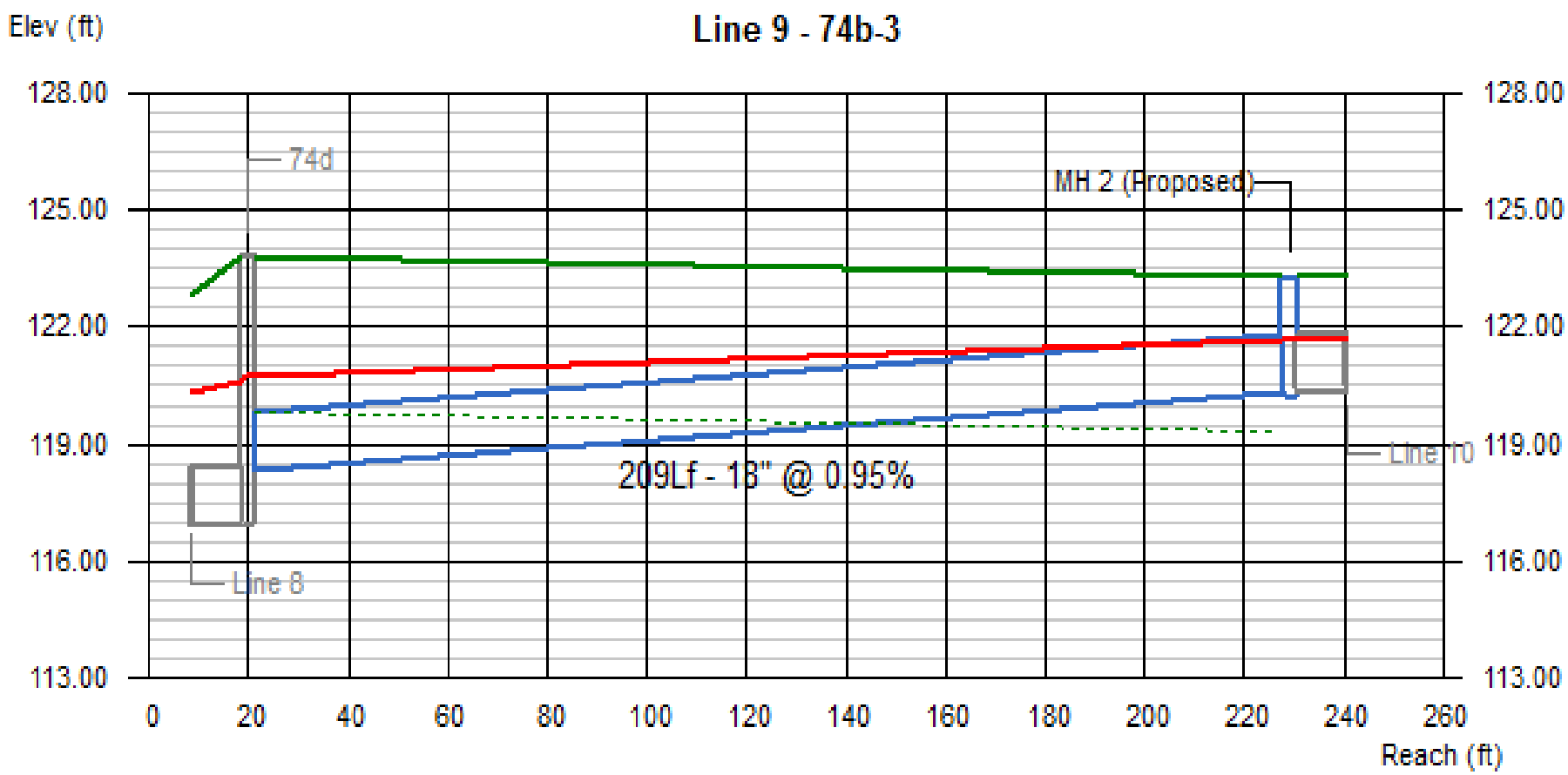
Line Profile (Line 8) - 74e



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	8.16	116.91	116.96	1.50	1.50	3.78	120.24	120.58	120.74	4.62	4.62	3.87	5.36

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

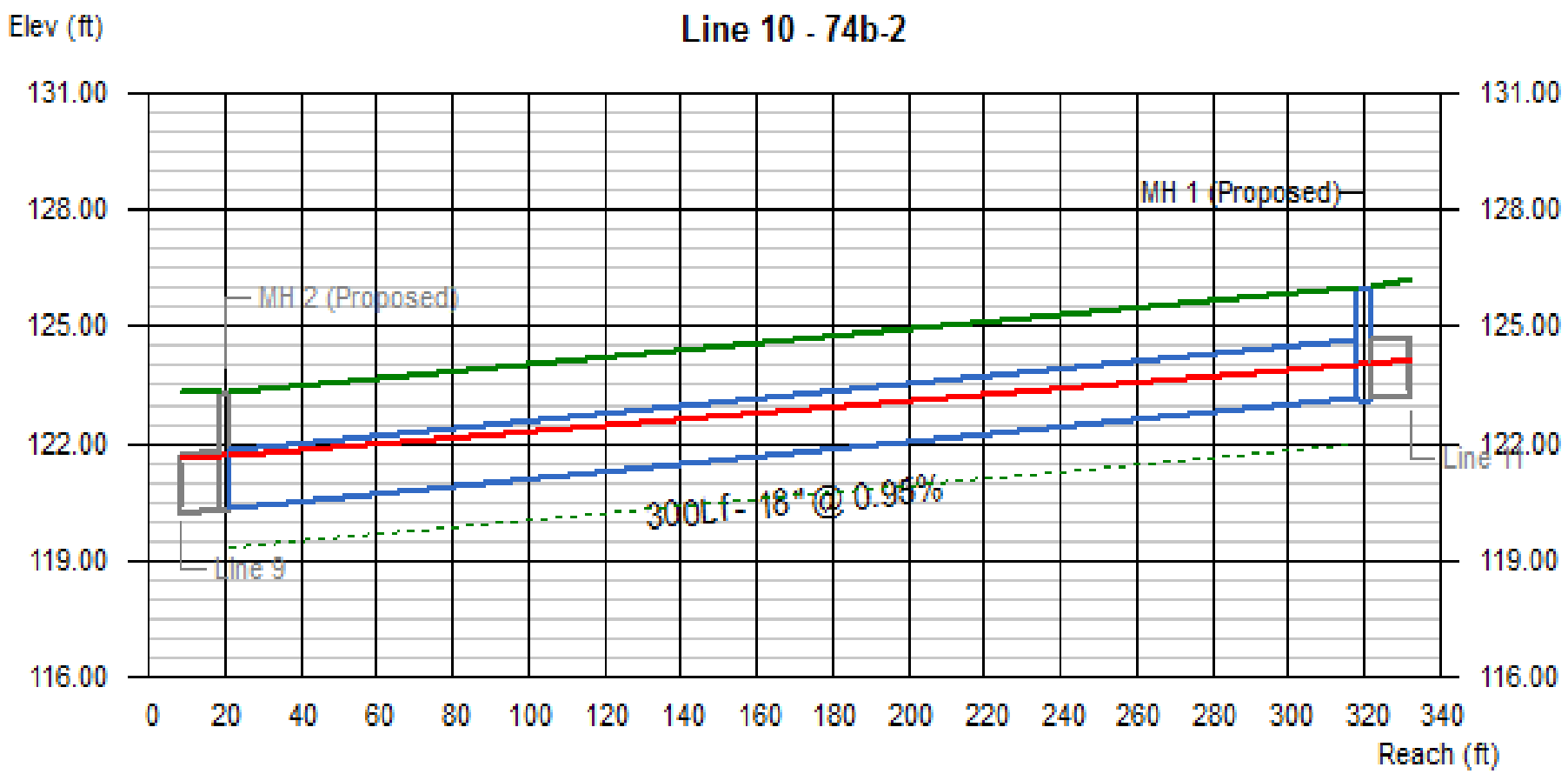
Line Profile (Line 9) - 74b-3



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
9	3.73	118.32	120.30	1.50	1.35	1.37	120.74	121.65	121.67	2.11	2.22	4.00	1.50

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

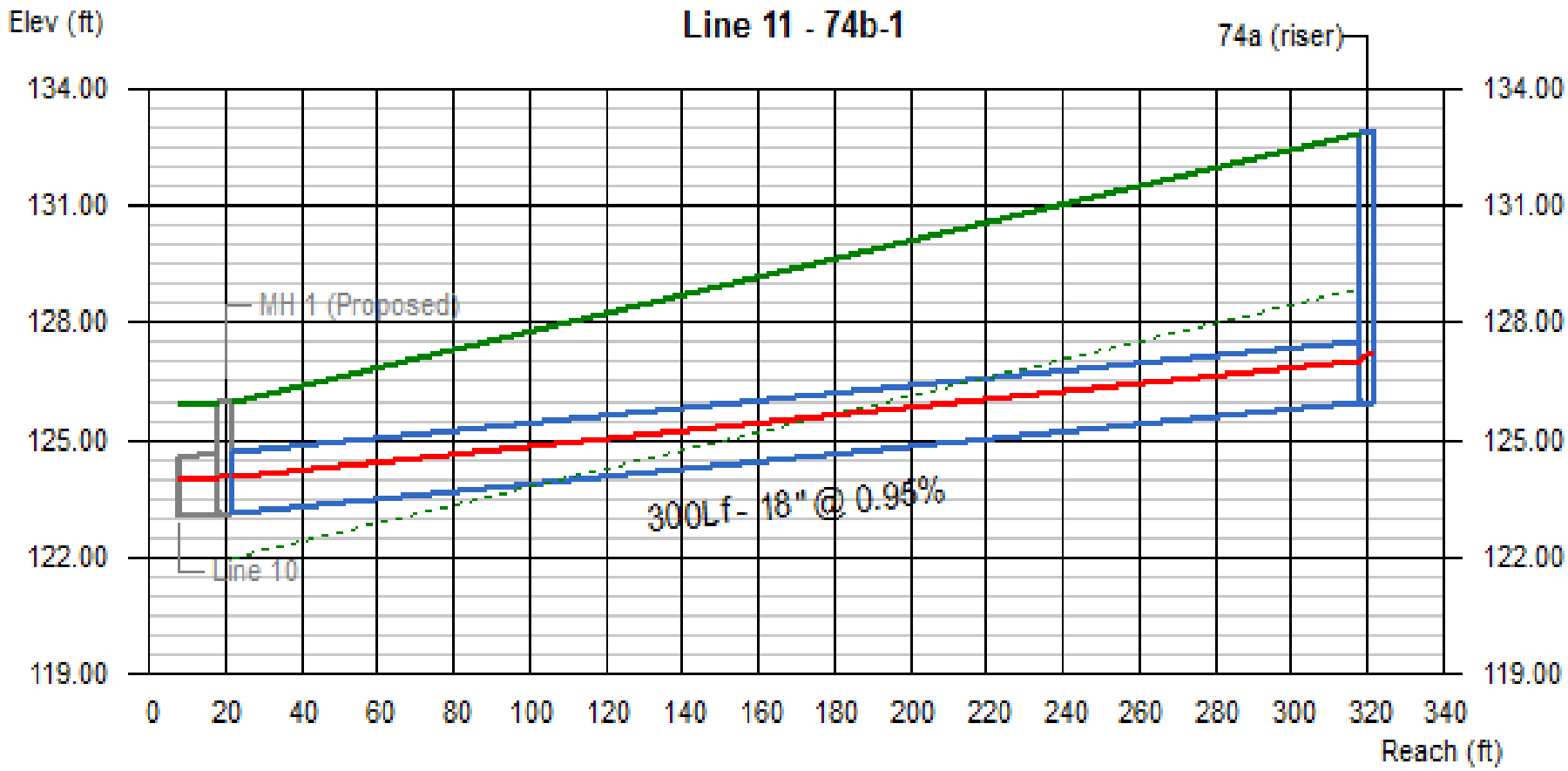
Line Profile (Line 10) - 74b-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	3.85	120.30	123.15	1.37	0.87	0.90	121.67	124.02	124.05	2.28	3.61	1.50	1.35

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

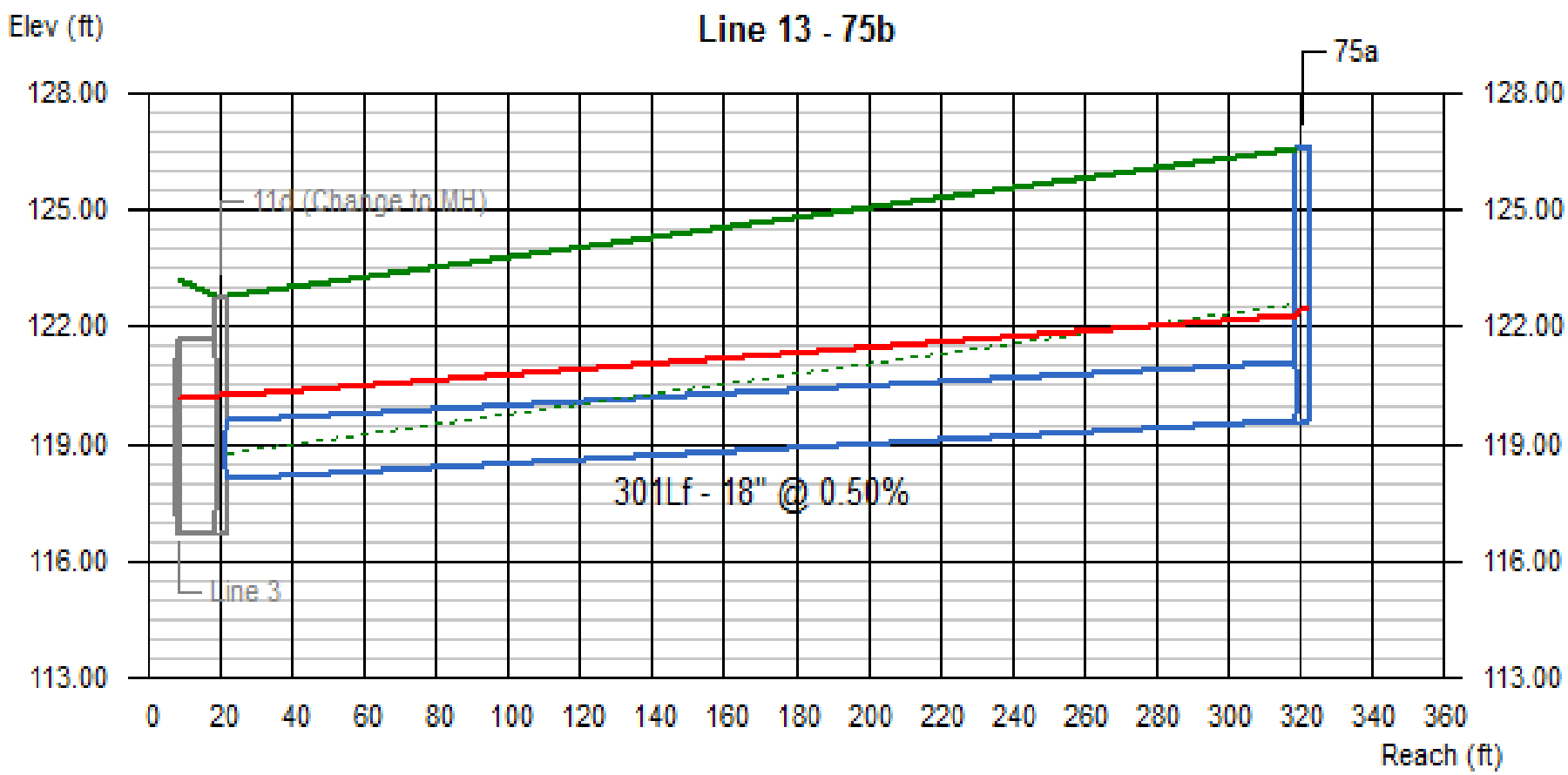
Line Profile (Line 11) - 74b-1



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
11	3.98	123.15	126.00	0.90	1.04	1.18	124.05	127.04	127.18	3.58	3.06	1.35	5.38

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

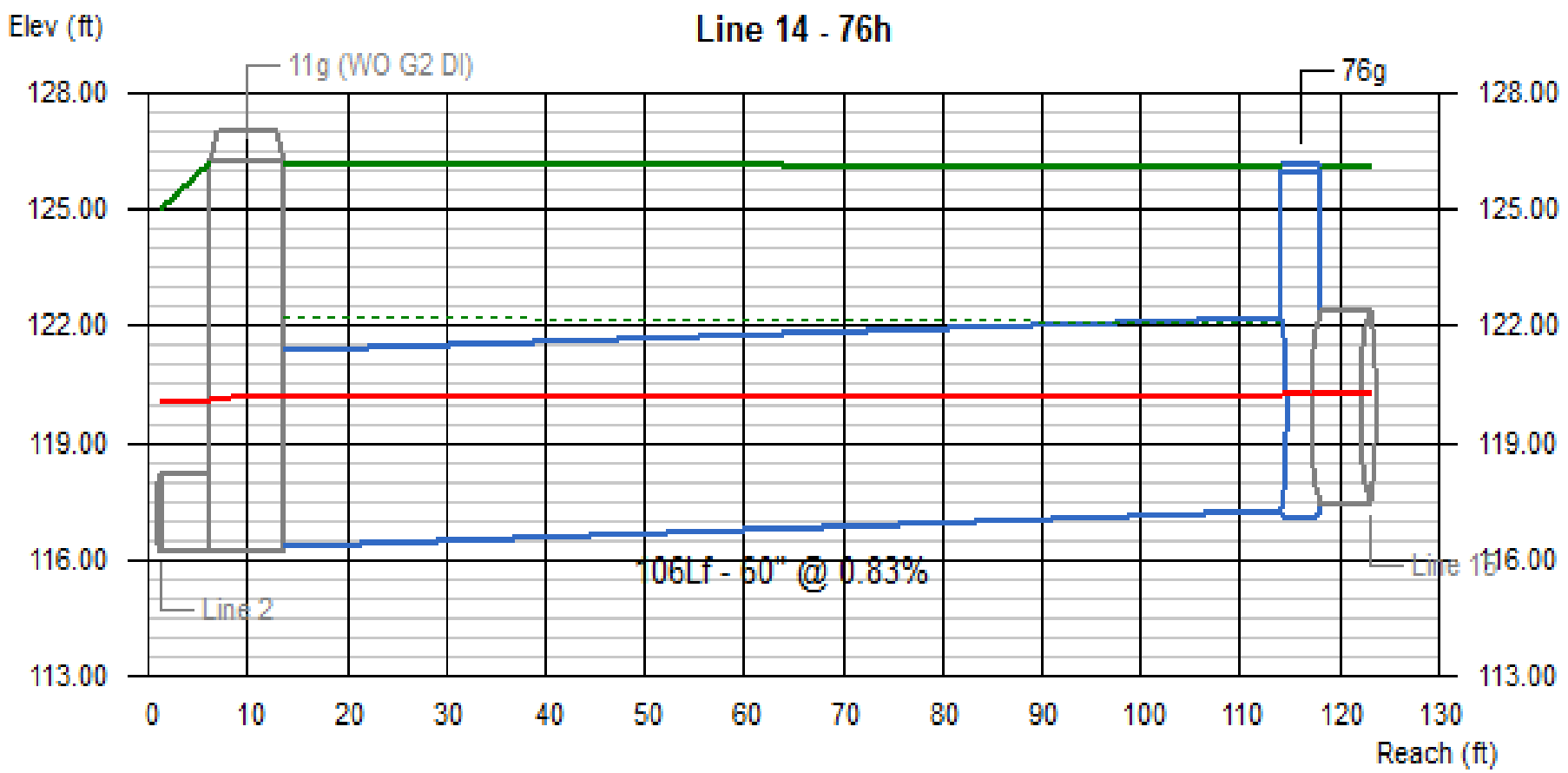
Line Profile (Line 13) - 75b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
13	4.58	118.11	119.62	1.50	1.50	2.82	120.22	122.33	122.44	2.59	2.59	3.17	5.50

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

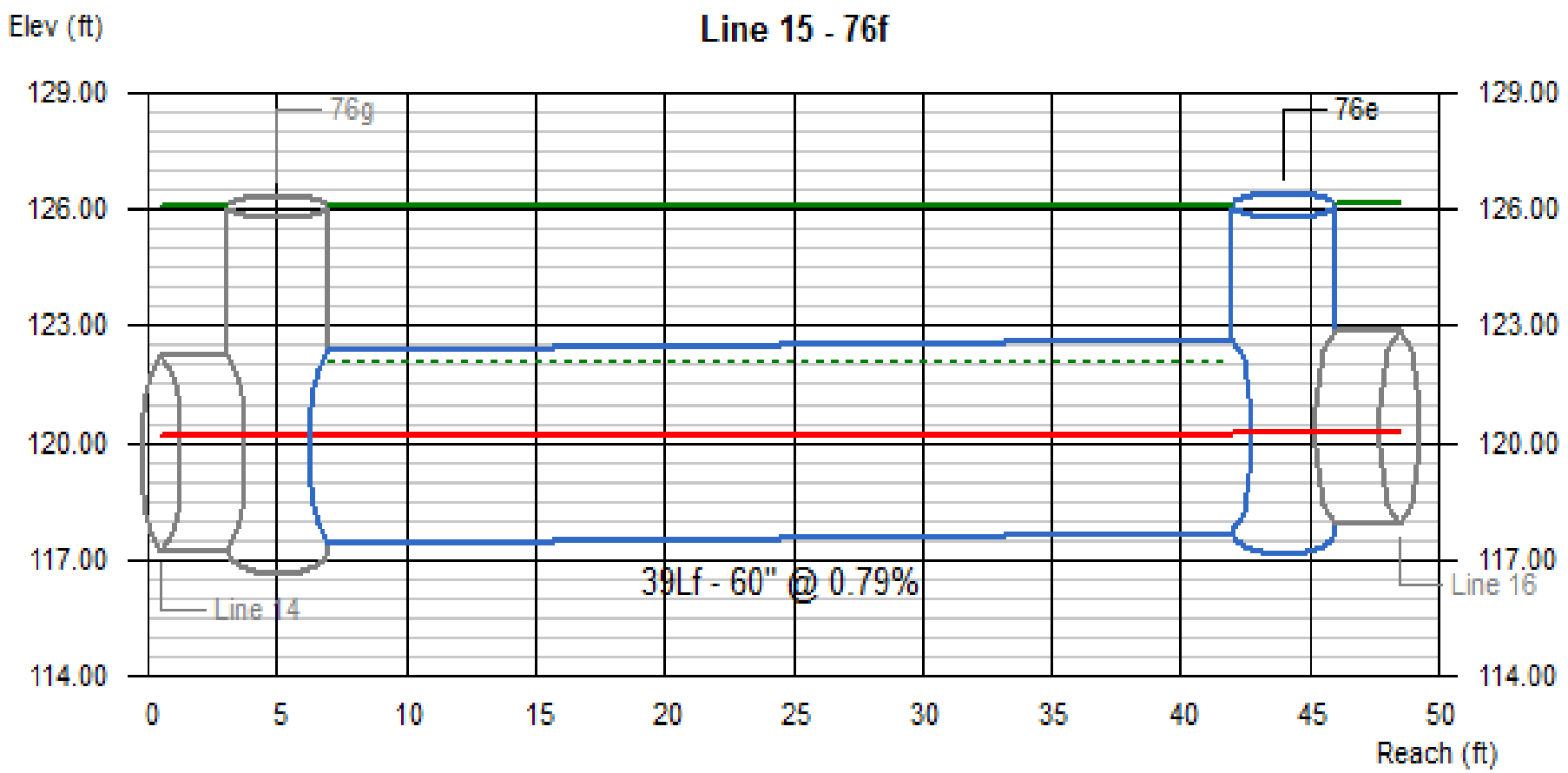
Line Profile (Line 14) - 76h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
14	2.74	116.36	117.24	3.85	2.98	2.98	120.21	120.22	120.22	0.17	0.23	4.89	3.85

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

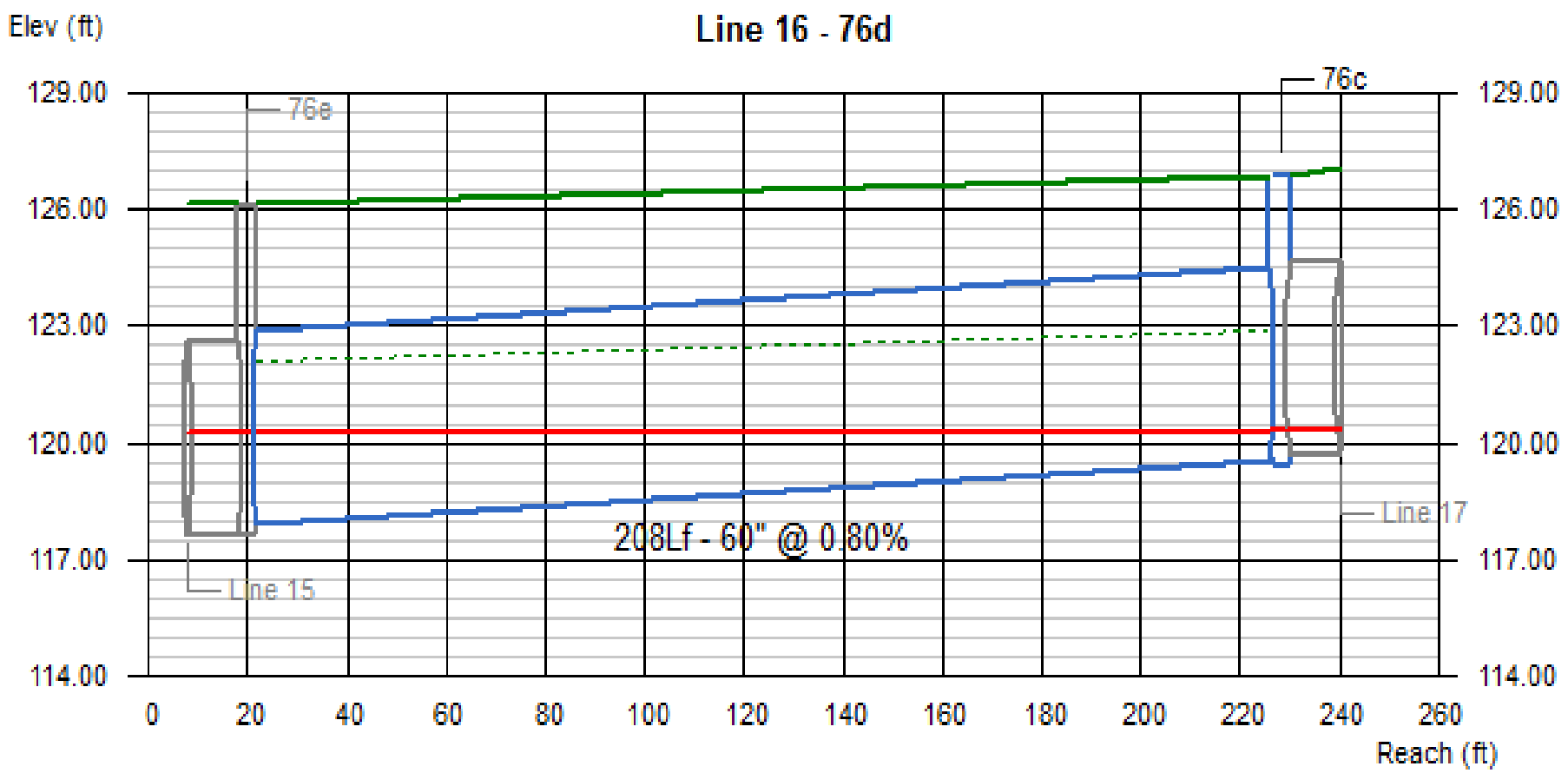
Line Profile (Line 15) - 76f



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
15	2.72	117.40	117.71	2.82	2.51	2.51	120.22	120.22	120.22	0.24	0.27	3.69	3.43

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

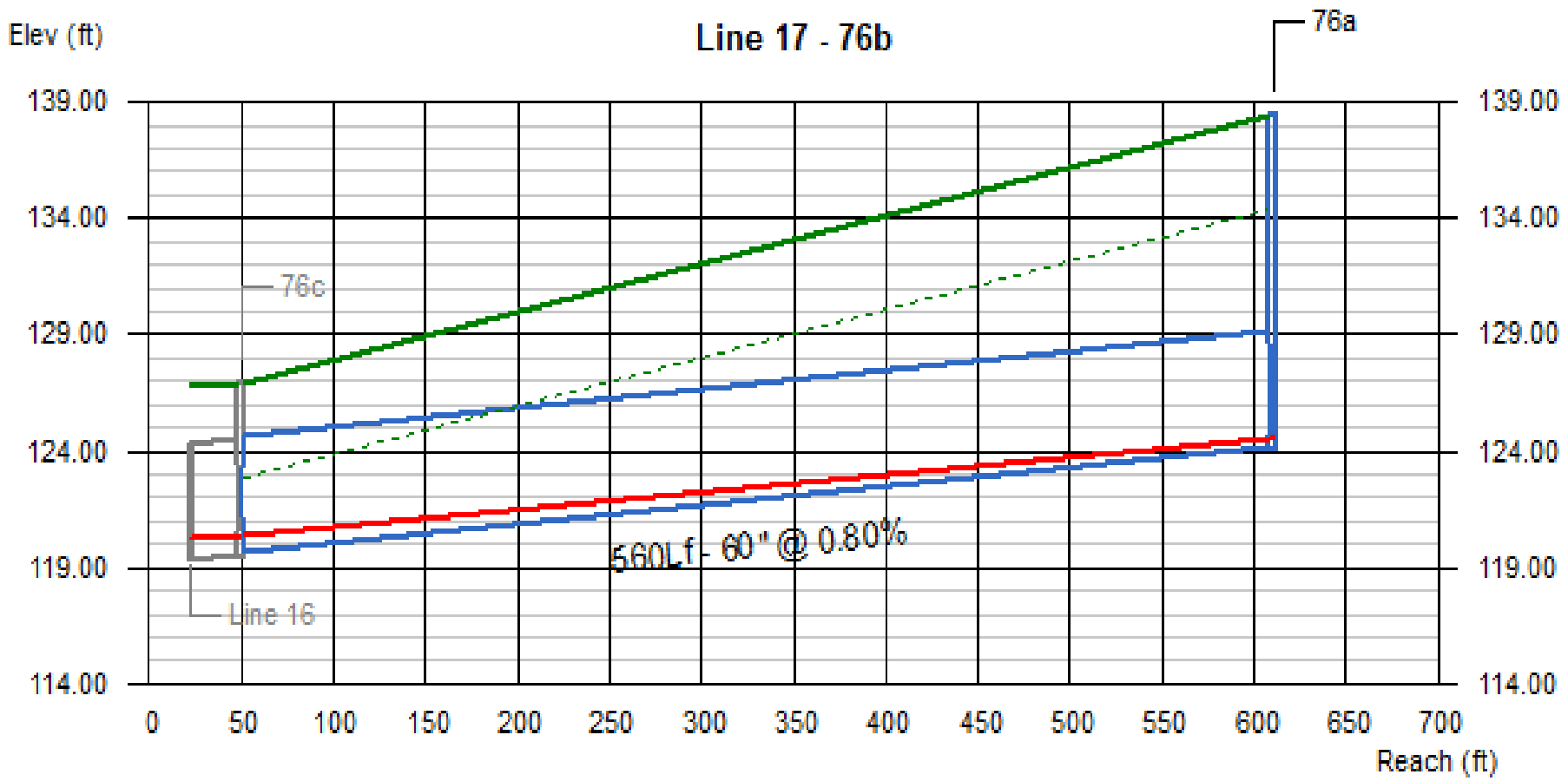
Line Profile (Line 16) - 76d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
16	2.66	117.87	119.53	2.35	0.80	0.81	120.22	120.33	120.34	0.29	1.31	3.27	2.38

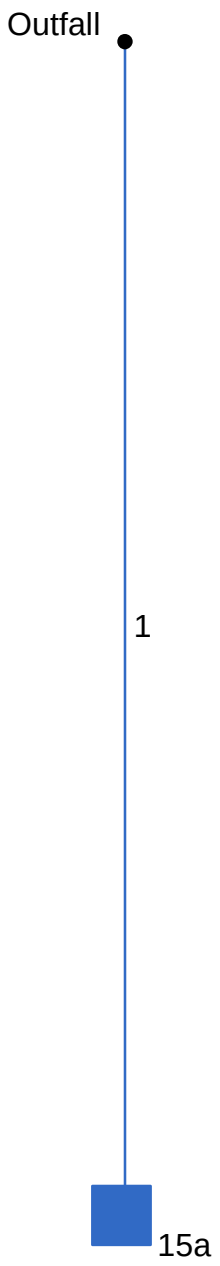
11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013

Line Profile (Line 17) - 76b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
17	2.28	119.69	124.17	0.65	0.42	0.42	120.34	124.59	124.59	1.51	2.87	2.22	9.23

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-04-2013



Project File: Drainage System 15.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	80	0.49	0.49	0.73	0.36	0.36	5.0	5.0	2.7	0.98	2.99	1.71	18	0.30	123.60	123.84	124.08	124.48	123.60	126.51	15b

15 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

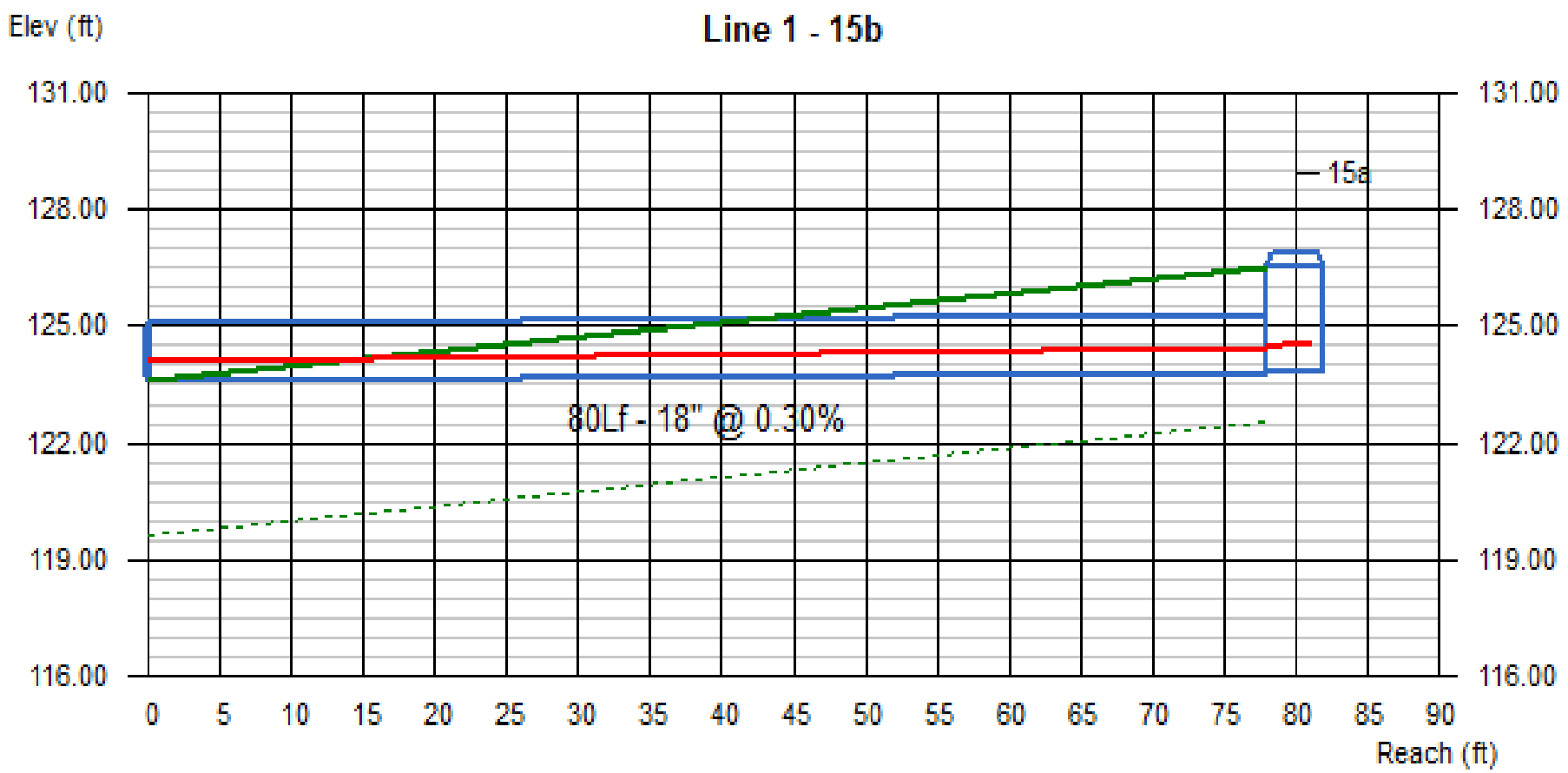
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.98	123.60	124.08	0.48	0.48	2.03	0.06	124.14	0.675	80	123.84	124.48	0.64	0.71	1.38	0.03	124.51	0.232	0.454	0.363	1.00	0.03

15 | Number of lines: 1 | Run Date: 11-04-2013

; c = cir e = ellip b = box

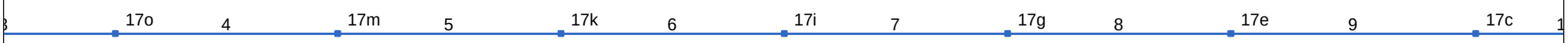
Line Profile (Line 1) - 15b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.98	123.60	123.84	0.48	0.64	0.67	124.08	124.48	124.51	2.03	1.38	-1.50	1.17

15 | No. Lines: 1 | Run Date: 11-04-2013

17



Project File: Drainage System 17.stm	Number of lines: 10	Date: 11-20-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	85	0.49	3.21	0.73	0.36	2.59	5.0	26.5	1.2	3.04	6.50	2.35	24	0.31	116.71	116.97	117.49	117.94	123.71	127.71	17t
2	1	196	0.49	2.72	0.73	0.36	2.23	5.0	25.2	1.2	2.69	3.00	2.68	18	0.30	124.01	124.60	124.64	126.86	127.71	128.30	17r
3	2	196	0.47	2.23	0.73	0.34	1.88	5.0	22.6	1.3	2.39	3.00	1.35	18	0.30	124.64	125.23	126.88	127.25	128.30	128.89	17p
4	3	195	0.45	1.76	0.74	0.33	1.53	5.0	19.6	1.4	2.10	3.00	1.19	18	0.30	125.27	125.86	127.27	127.56	128.89	129.40	17n
5	4	196	0.35	1.31	0.77	0.27	1.20	5.0	16.4	1.5	1.80	3.00	1.07	18	0.30	125.90	126.49	127.57	127.77	129.40	129.85	17l
6	5	196	0.23	0.96	0.87	0.20	0.93	5.0	13.8	1.6	1.52	3.00	1.18	18	0.30	126.53	127.12	127.78	128.01	129.85	130.23	17j
7	6	196	0.16	0.73	1.00	0.16	0.73	5.0	11.7	1.8	1.30	3.00	1.43	18	0.30	127.16	127.75	128.03	128.44	130.23	130.85	17h
8	7	196	0.17	0.57	1.00	0.17	0.57	5.0	9.6	2.0	1.13	3.00	1.54	18	0.30	127.79	128.38	128.46	129.01	130.85	131.41	17f
9	8	215	0.16	0.40	1.00	0.16	0.40	5.0	7.1	2.3	0.92	2.93	1.44	18	0.29	128.42	129.04	129.03	129.61	131.41	132.04	17d
10	9	159	0.24	0.24	1.00	0.24	0.24	5.0	5.0	2.7	0.66	3.00	1.27	18	0.30	129.08	129.56	129.62	130.03	132.04	132.88	17b

17 | Number of lines: 10 | Run Date: 11-20-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

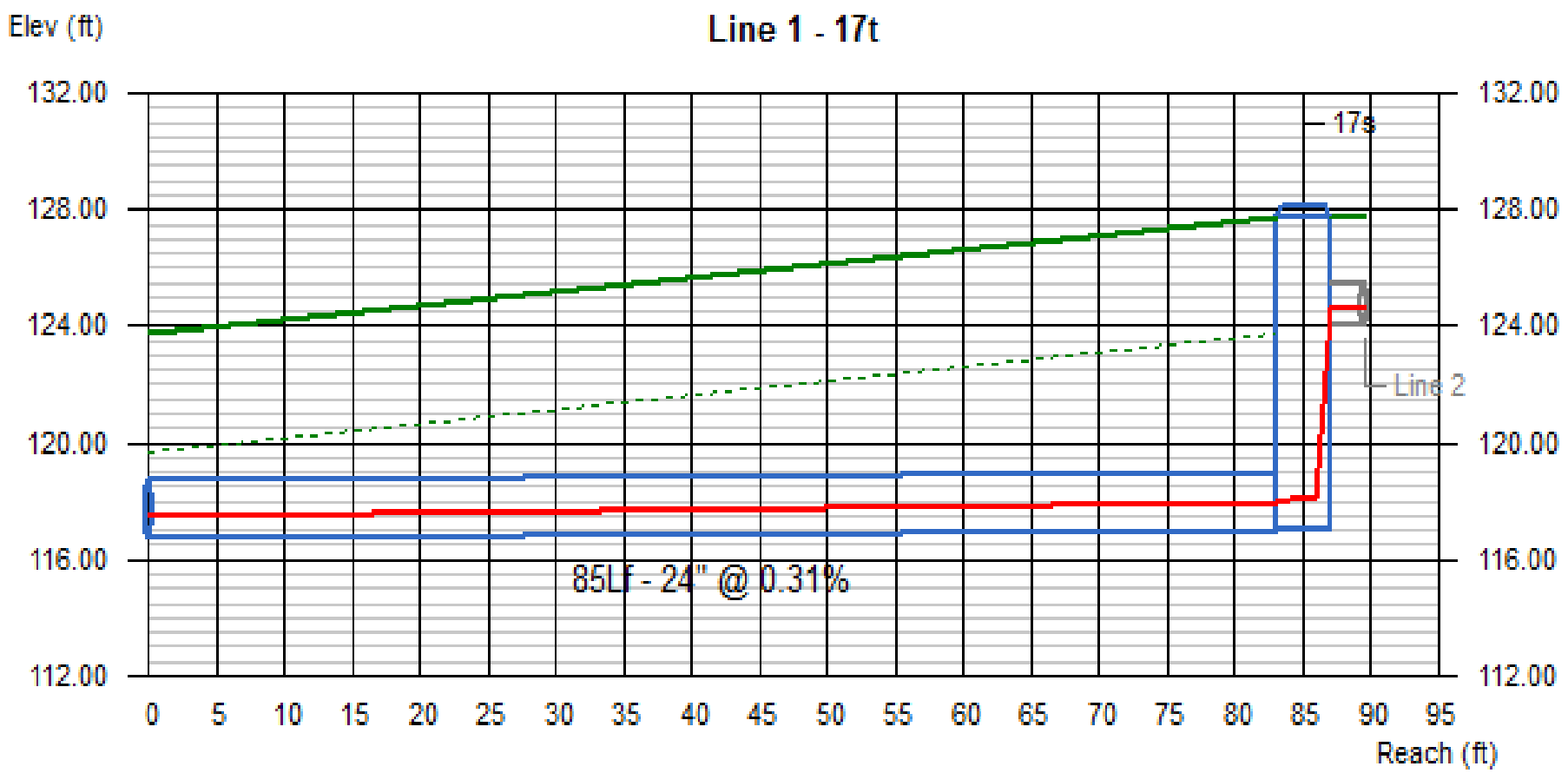
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	24	3.04	116.71	117.49	0.78	1.13	2.68	0.11	117.60	0.645	85	116.97	117.94	0.97	1.51	2.02	0.06	118.00	0.299	0.472	0.401	1.50	0.10
2	18	2.69	124.01	124.64	0.63*	0.70	3.85	0.23	124.87	1.831	196	124.60	126.86	1.50	1.77	1.52	0.04	126.90	0.242	1.036	2.031	0.50	0.02
3	18	2.39	124.64	126.88	1.50	1.77	1.35	0.03	126.91	0.191	196	125.23	127.25	1.50	1.77	1.35	0.03	127.28	0.191	0.191	0.374	0.50	0.01
4	18	2.10	125.27	127.27	1.50	1.77	1.19	0.02	127.29	0.148	195	125.86	127.56	1.50	1.77	1.19	0.02	127.58	0.148	0.148	0.288	0.50	0.01
5	18	1.80	125.90	127.57	1.50	1.77	1.02	0.02	127.58	0.109	196	126.49	127.77	1.28	1.60	1.12	0.02	127.79	0.102	0.105	0.206	0.50	0.01
6	18	1.52	126.53	127.78	1.25	1.57	0.97	0.01	127.79	0.076	196	127.12	128.01	0.89	1.09	1.39	0.03	128.04	0.178	0.127	0.248	0.50	0.02
7	18	1.30	127.16	128.03	0.87	1.06	1.23	0.02	128.05	0.142	196	127.75	128.44	0.69	0.80	1.64	0.04	128.48	0.301	0.222	0.434	0.50	0.02
8	18	1.13	127.79	128.46	0.67	0.77	1.47	0.03	128.50	0.248	196	128.38	129.01	0.63	0.70	1.61	0.04	129.05	0.317	0.283	0.554	0.50	0.02
9	18	0.92	128.42	129.03	0.61	0.67	1.37	0.03	129.06	0.238	215	129.04	129.61	0.57	0.61	1.51	0.04	129.64	0.310	0.274	0.589	0.50	0.02
10	18	0.66	129.08	129.62	0.54	0.58	1.14	0.02	129.64	0.184	159	129.56	130.03	0.47	0.47	1.41	0.03	130.06	0.330	0.257	0.409	1.00	0.03

17 | Number of lines: 10 | Run Date: 11-20-2013

Notes: * depth assumed. ; c = cir e = ellip b = box

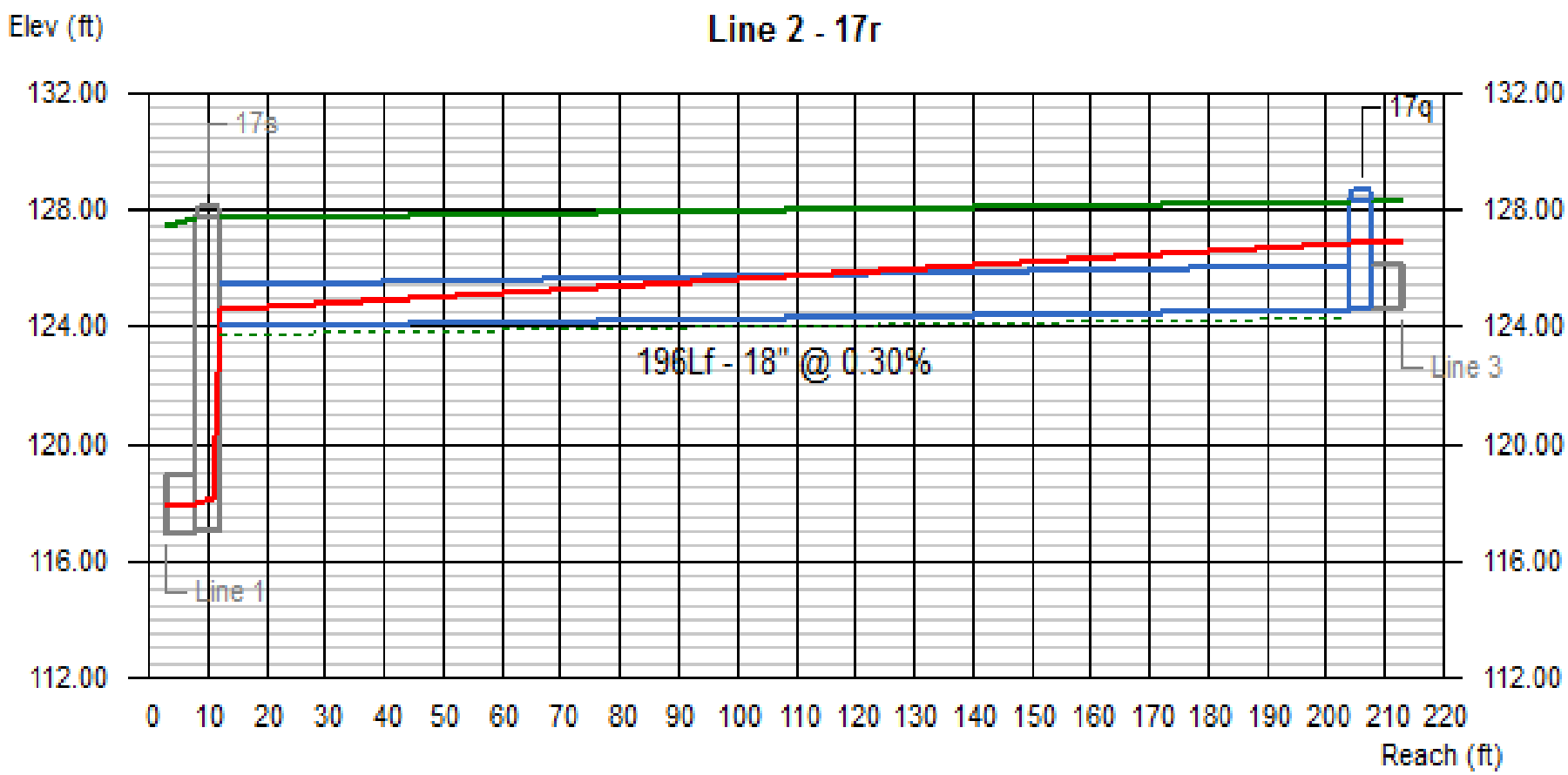
Line Profile (Line 1) - 17t



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	3.04	116.71	116.97	0.78	0.97	1.06	117.49	117.94	118.03	2.68	2.02	5.00	8.74

17 | No. Lines: 10 | Run Date: 11-20-2013

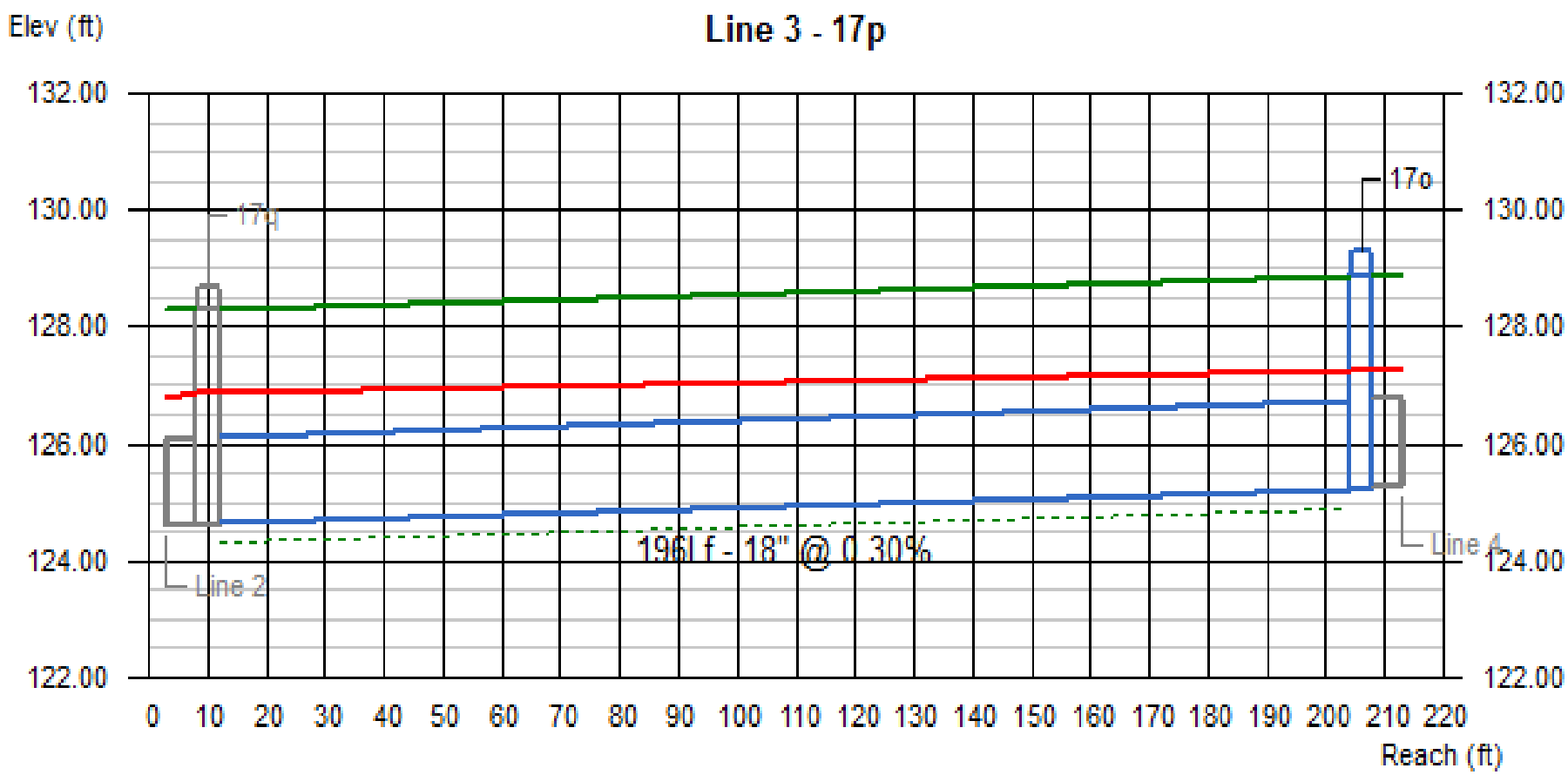
Line Profile (Line 2) - 17r



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	2.69	124.01	124.60	0.63	1.50	2.28	124.64	126.86	126.88	3.85	1.52	2.20	2.20

17 | No. Lines: 10 | Run Date: 11-20-2013

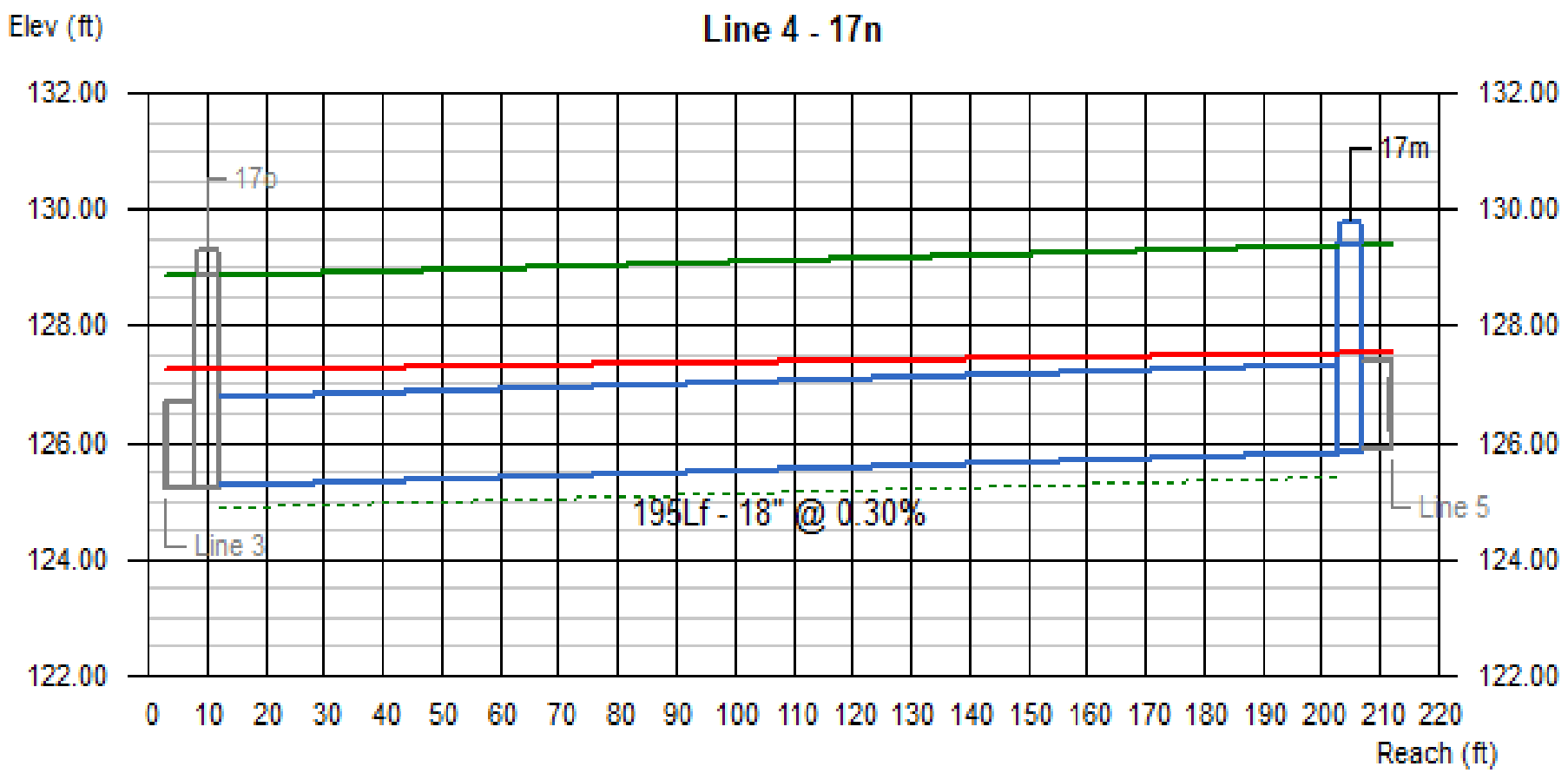
Line Profile (Line 3) - 17p



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	2.39	124.64	125.23	1.50	1.50	2.04	126.88	127.25	127.27	1.35	1.35	2.16	2.16

17 | No. Lines: 10 | Run Date: 11-20-2013

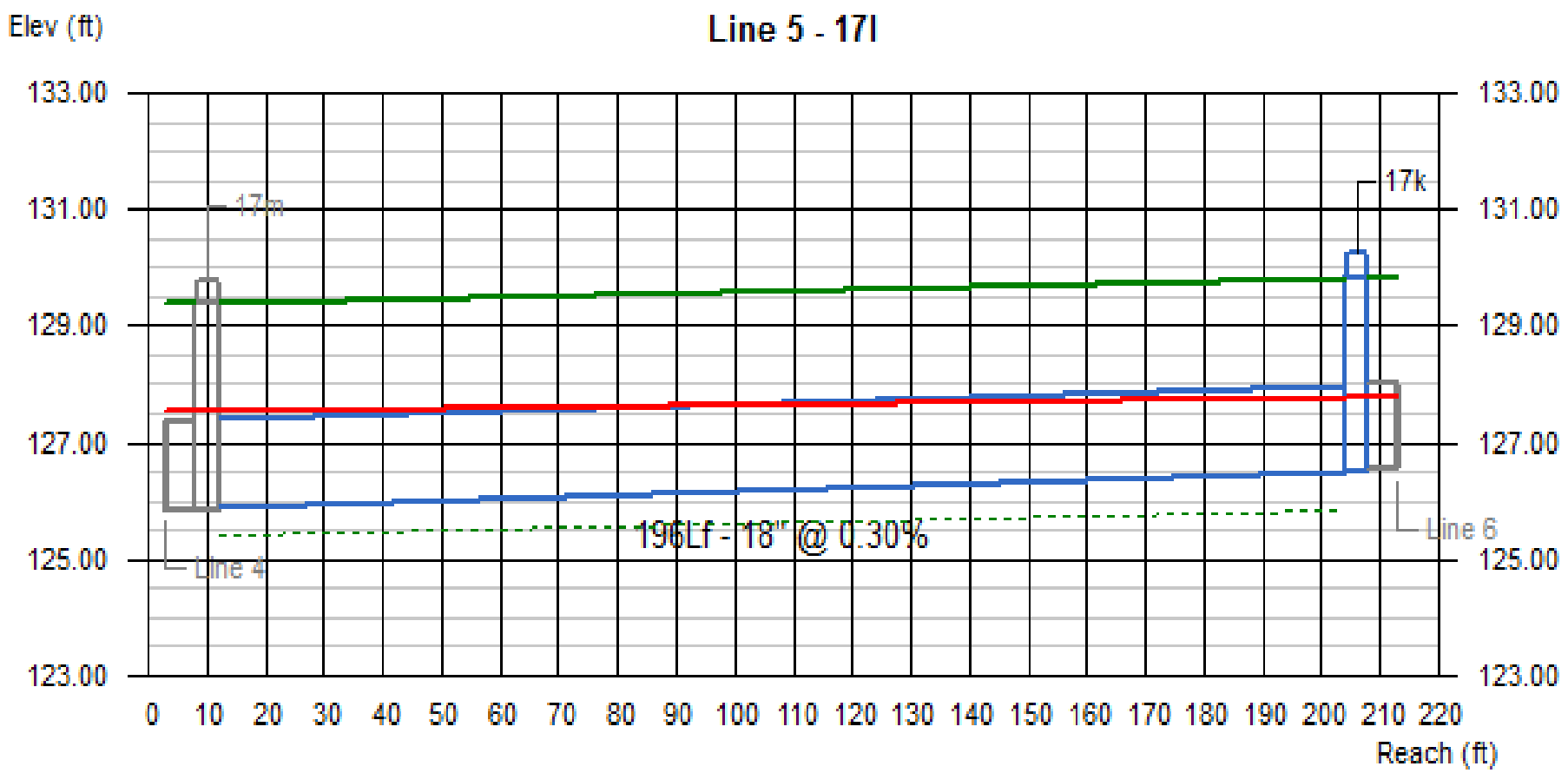
Line Profile (Line 4) - 17n



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	2.10	125.27	125.86	1.50	1.50	1.71	127.27	127.56	127.57	1.19	1.19	2.12	2.04

17 | No. Lines: 10 | Run Date: 11-20-2013

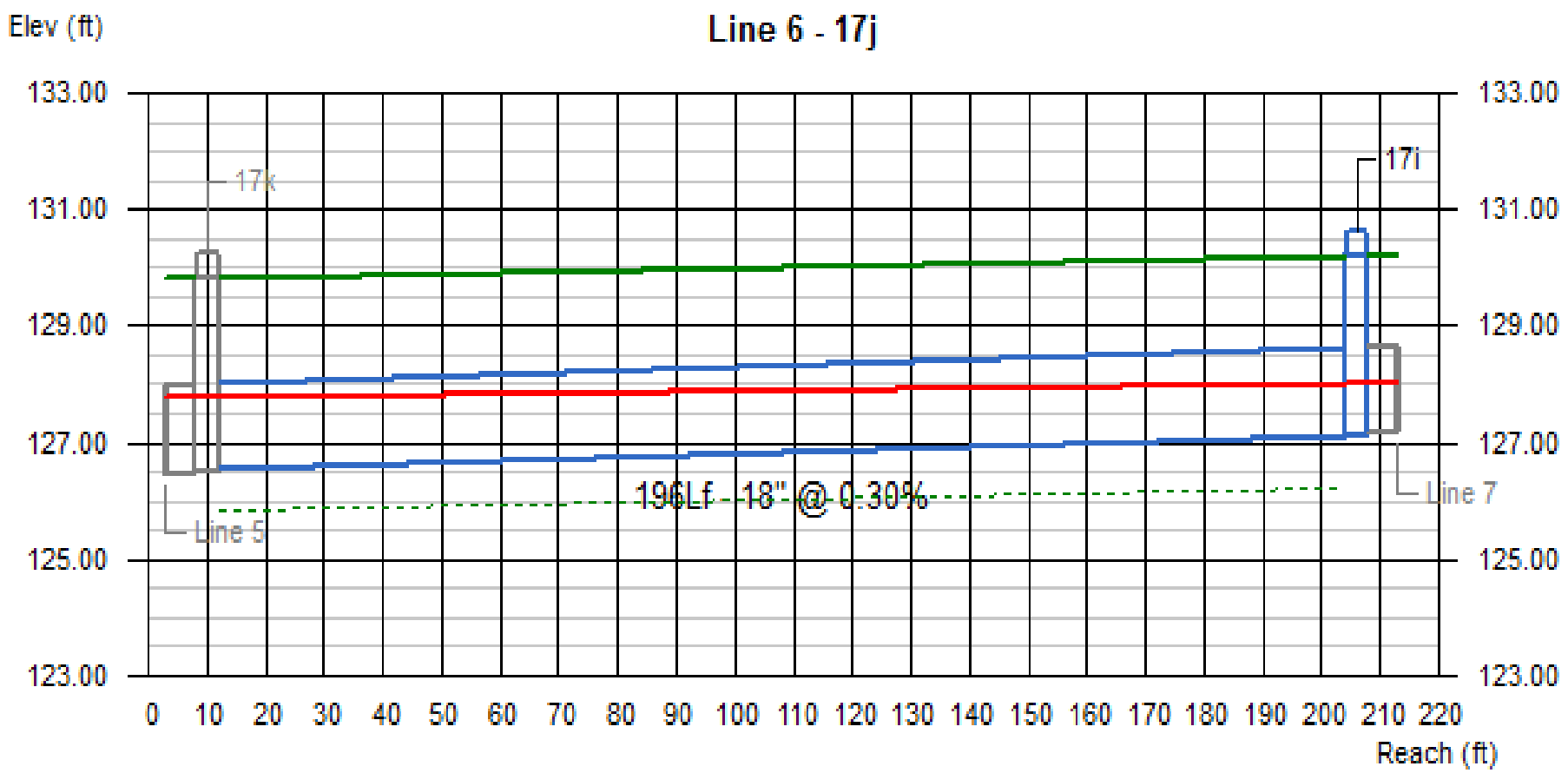
Line Profile (Line 5) - 17l



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	1.80	125.90	126.49	1.50	1.28	1.29	127.57	127.77	127.78	1.02	1.12	2.00	1.86

17 | No. Lines: 10 | Run Date: 11-20-2013

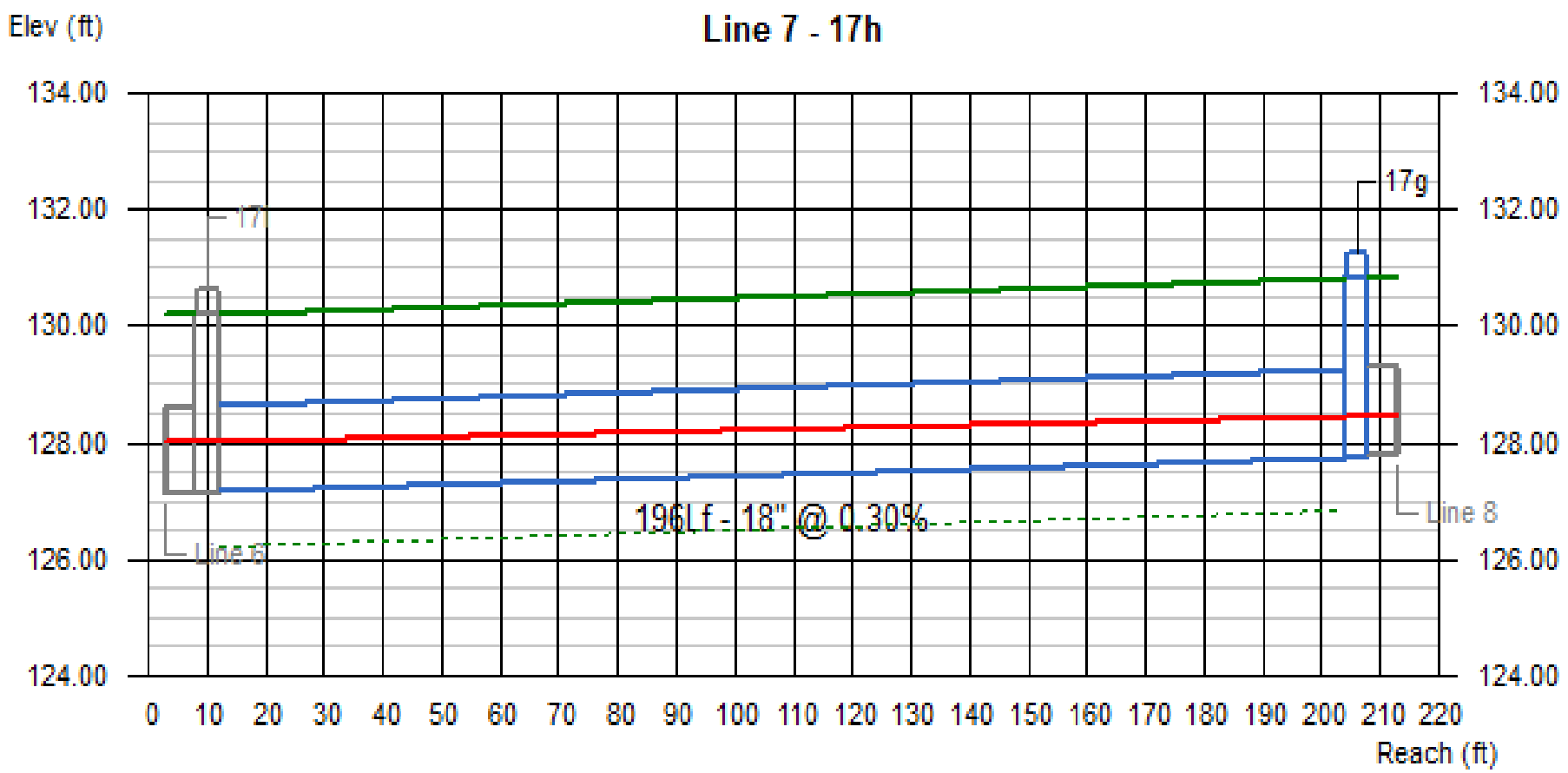
Line Profile (Line 6) - 17j



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	1.52	126.53	127.12	1.25	0.89	0.91	127.78	128.01	128.03	0.97	1.39	1.82	1.61

17 | No. Lines: 10 | Run Date: 11-20-2013

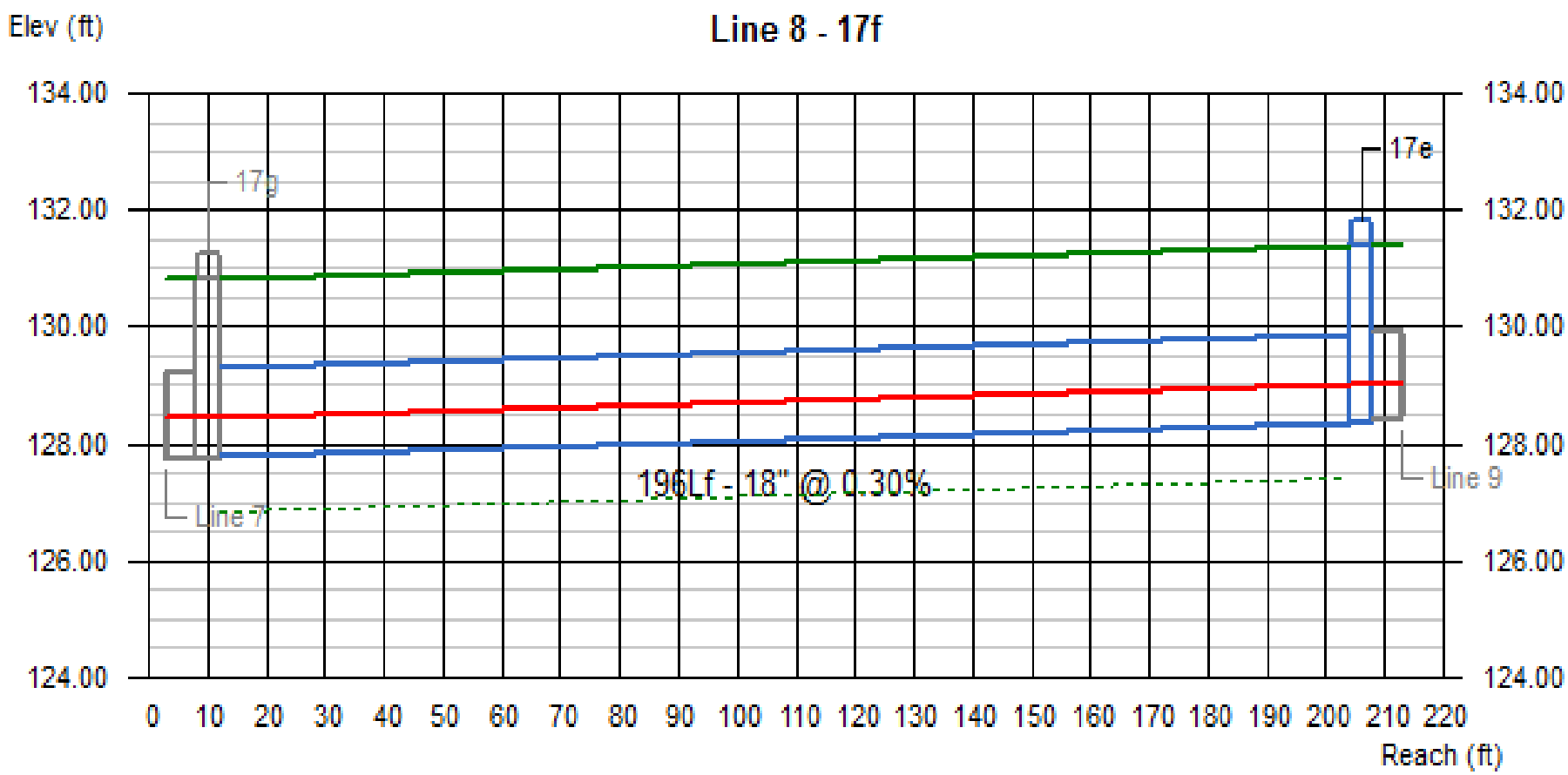
Line Profile (Line 7) - 17h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	1.30	127.16	127.75	0.87	0.69	0.71	128.03	128.44	128.46	1.23	1.64	1.57	1.60

17 | No. Lines: 10 | Run Date: 11-20-2013

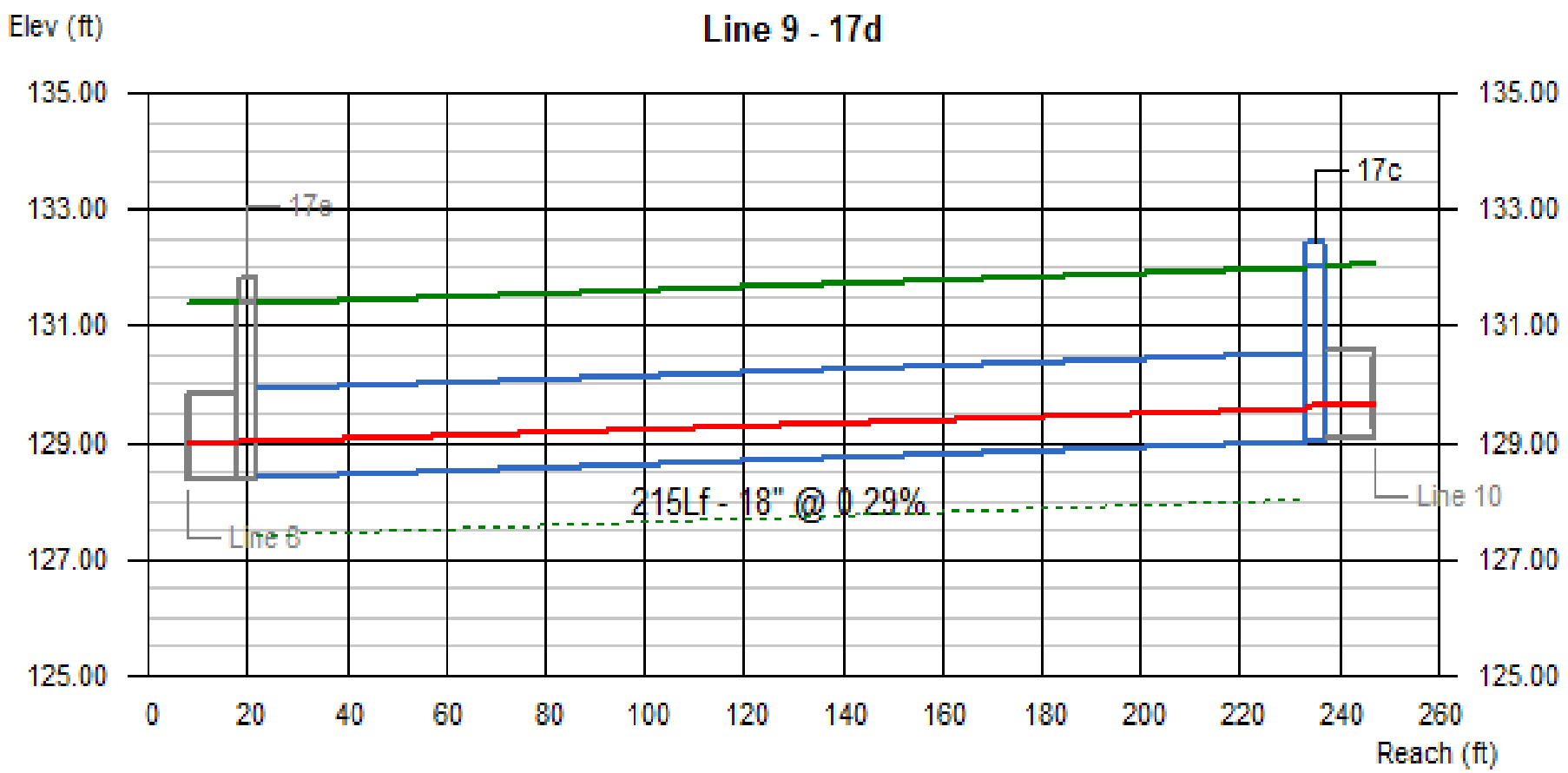
Line Profile (Line 8) - 17f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	1.13	127.79	128.38	0.67	0.63	0.65	128.46	129.01	129.03	1.47	1.61	1.56	1.53

17 | No. Lines: 10 | Run Date: 11-20-2013

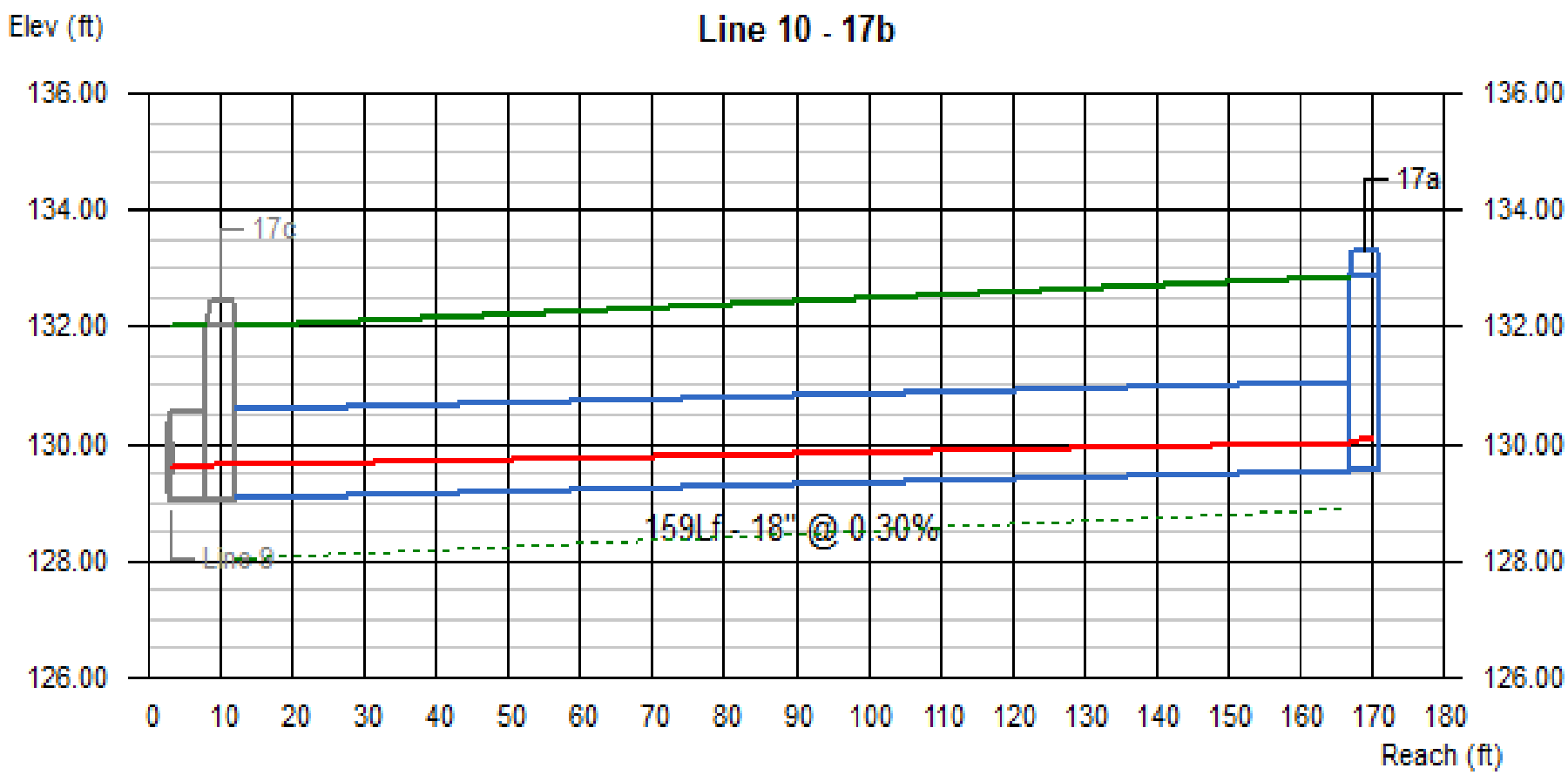
Line Profile (Line 9) - 17d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
9	0.92	128.42	129.04	0.61	0.57	0.58	129.03	129.61	129.62	1.37	1.51	1.49	1.50

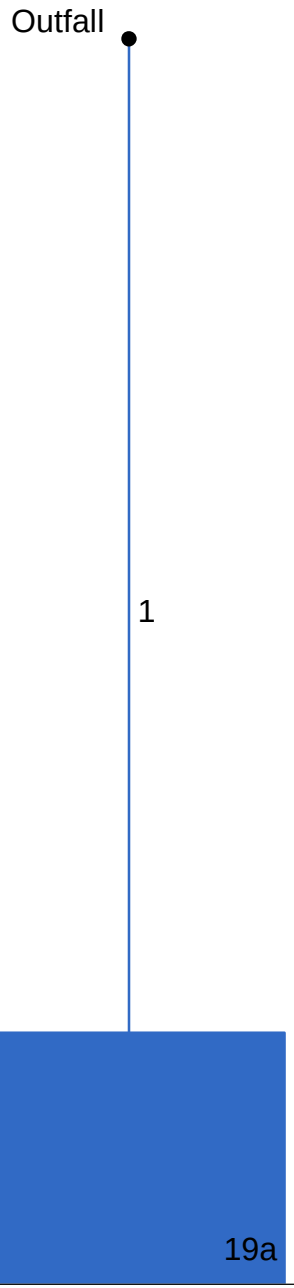
17 | No. Lines: 10 | Run Date: 11-20-2013

Line Profile (Line 10) - 17b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	0.66	129.08	129.56	0.54	0.47	0.50	129.62	130.03	130.06	1.14	1.41	1.46	1.82

17	No. Lines: 10	Run Date: 11-20-2013



Project File: Drainage System 19.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	15	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.7	0.44	3.73	1.34	18	0.47	128.33	128.40	128.70	128.76	128.33	131.92	19b

19 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

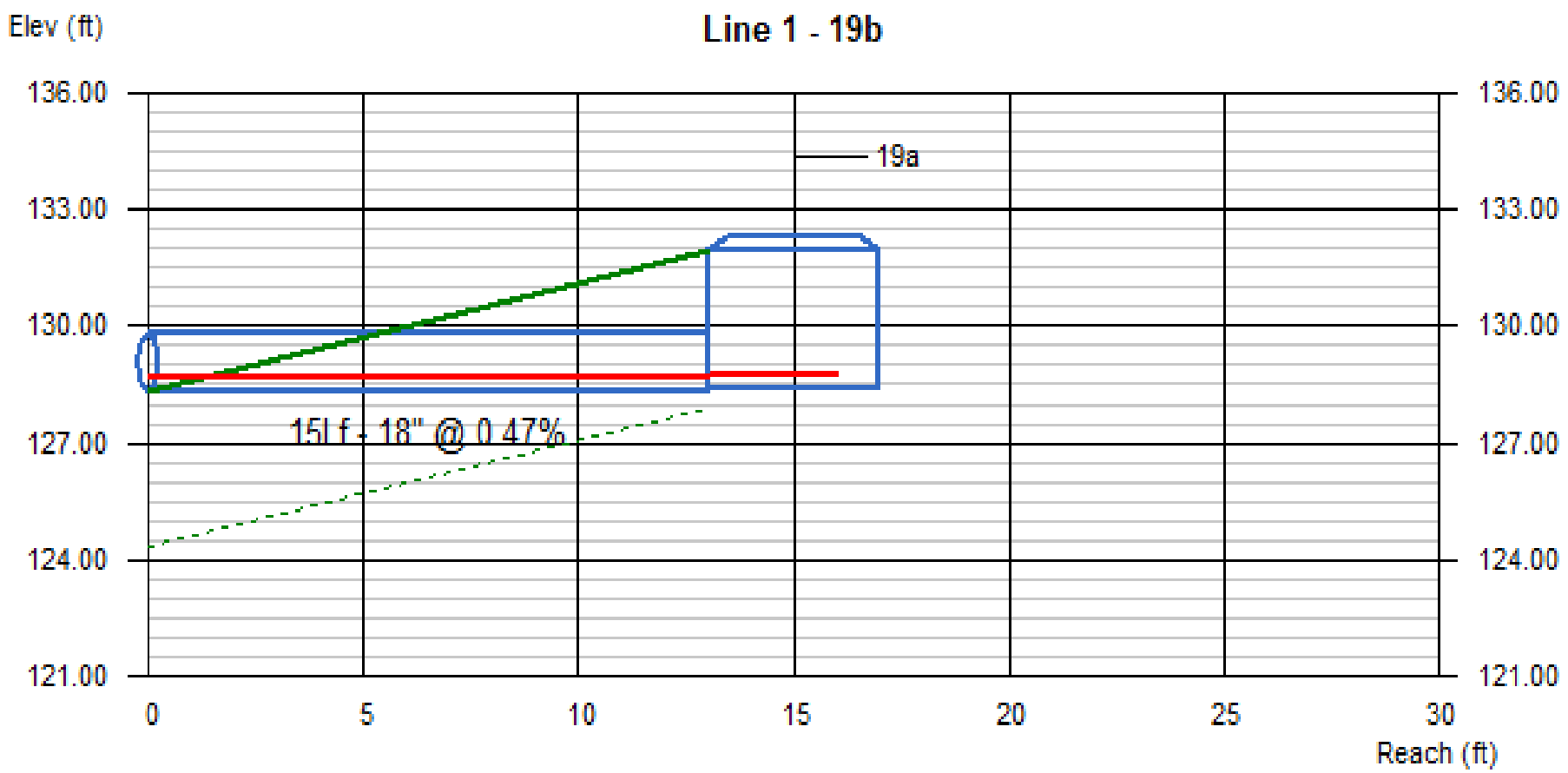
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.44	128.33	128.70	0.37	0.34	1.30	0.03	128.73	0.365	15	128.40	128.76	0.36	0.32	1.37	0.03	128.78	0.428	0.397	0.059	1.00	0.03

19 | Number of lines: 1 | Run Date: 10-30-2013

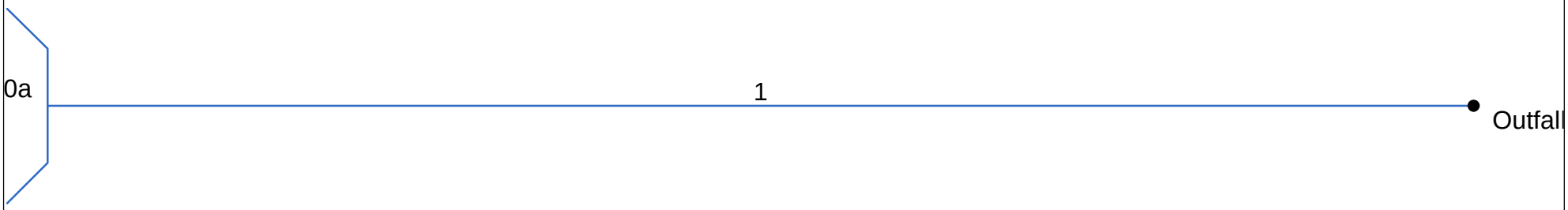
; c = cir e = ellip b = box

Line Profile (Line 1) - 19b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.44	128.33	128.40	0.37	0.36	0.38	128.70	128.76	128.78	1.30	1.37	-1.50	2.02

19	No. Lines: 1	Run Date: 10-30-2013



Project File: Drainage System 20.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	50	0.70	0.70	0.87	0.61	0.61	12.0	12.0	1.8	1.07	5.88	2.54	18	1.16	126.89	127.47	127.32	127.90	126.89	127.47	20a

20	Number of lines: 1	Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

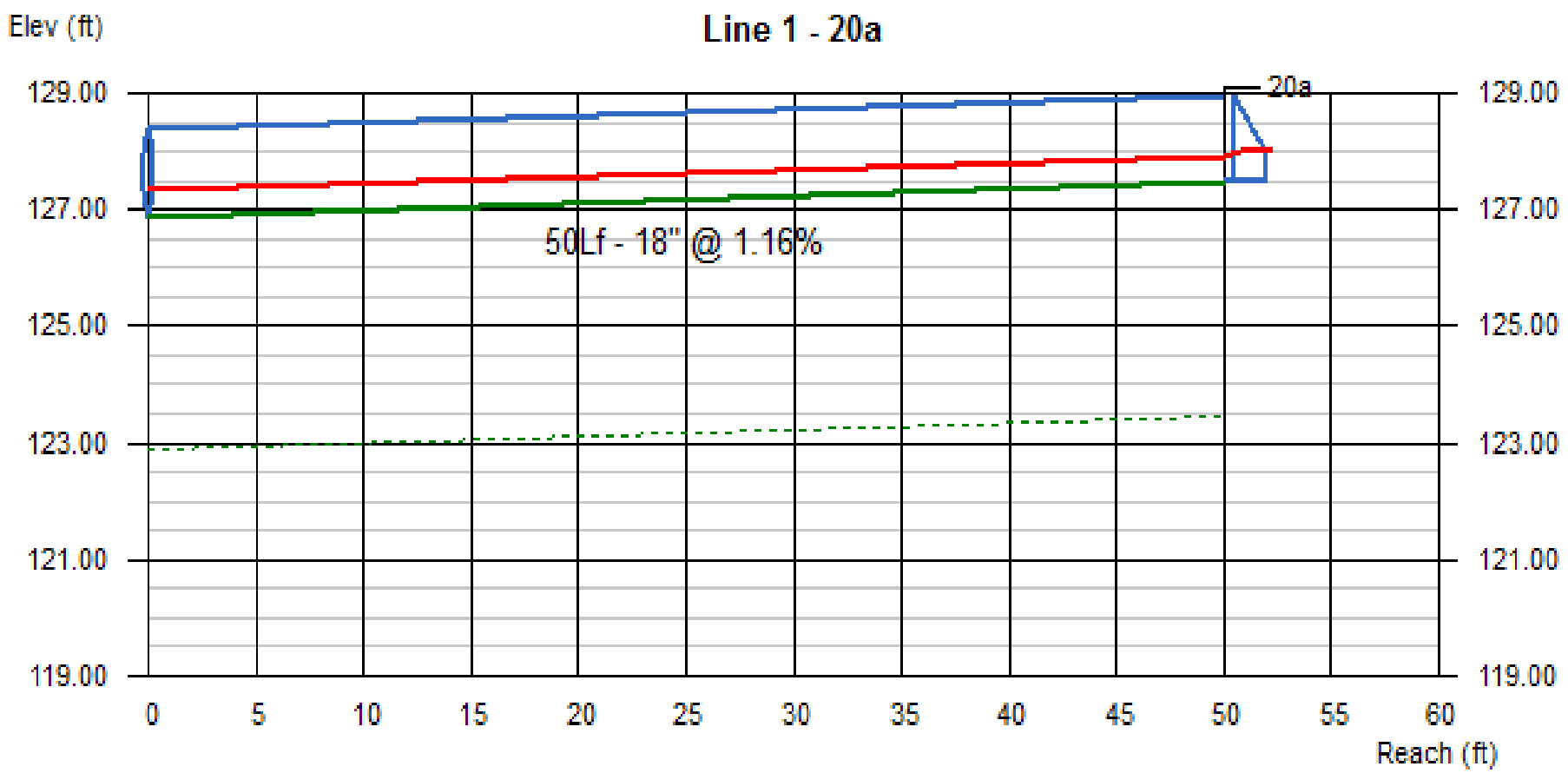
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.07	126.89	127.32	0.43	0.42	2.53	0.10	127.42	1.159	50	127.47	127.90	0.43	0.42	2.54	0.10	128.00	1.177	1.168	0.584	1.00	0.10

20	Number of lines: 1	Run Date: 11-04-2013

; c = cir e = ellip b = box

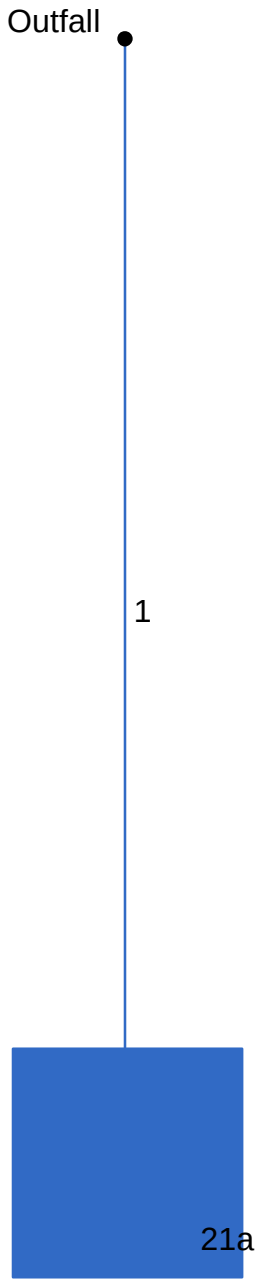
Line Profile (Line 1) - 20a



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.07	126.89	127.47	0.43	0.43	0.53	127.32	127.90	128.00	2.53	2.54	-1.50	-1.50

20 | No. Lines: 1 | Run Date: 11-04-2013

21



Project File: Drainage System 21.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	20	0.14	0.14	1.00	0.14	0.14	5.0	5.0	2.7	0.38	5.46	0.65	18	1.00	127.96	128.16	128.63	128.64	127.96	132.66	21b

21 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

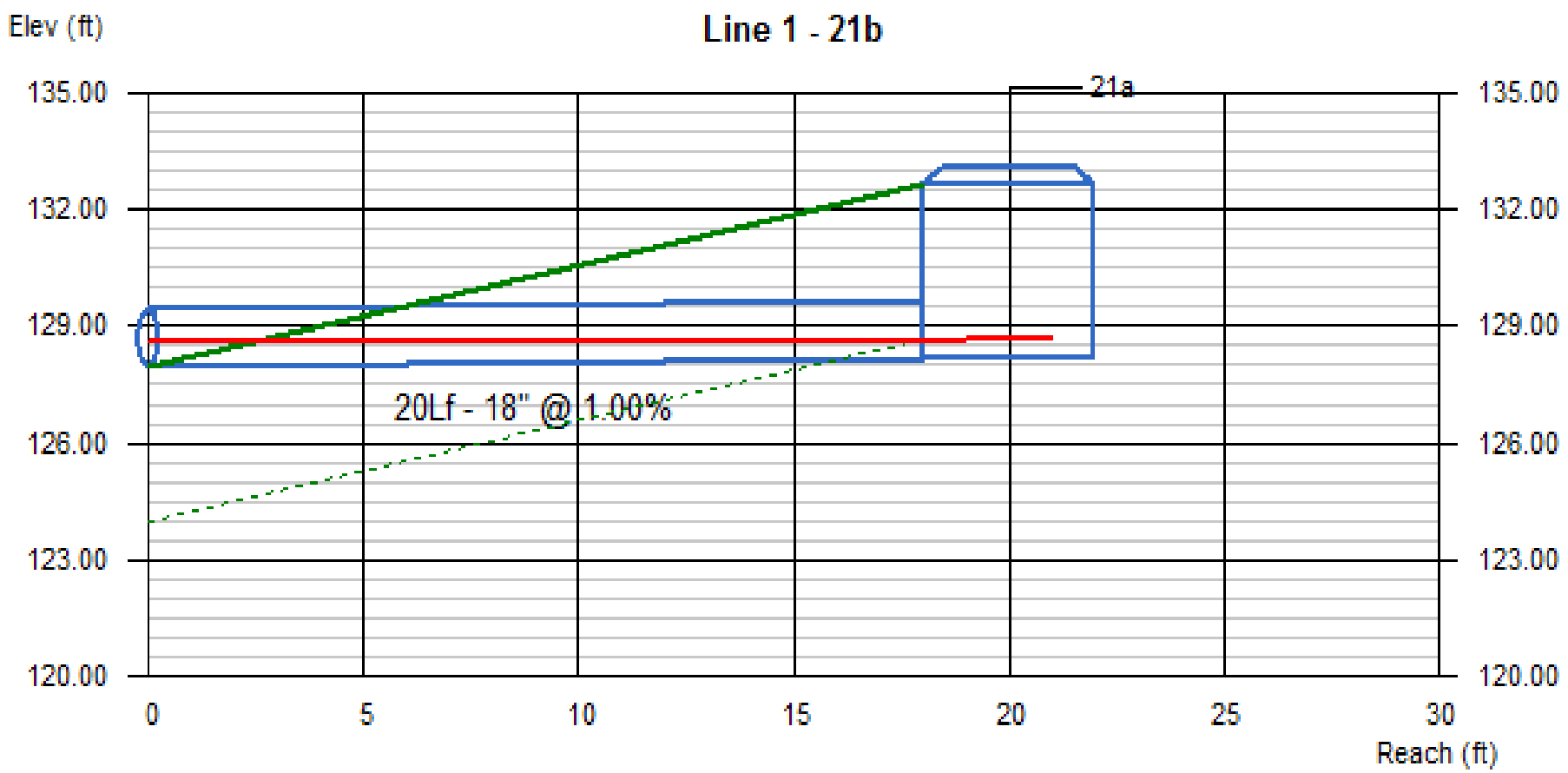
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.38	127.96	128.63	0.67	0.76	0.50	0.00	128.63	0.029	20	128.16	128.64	0.48	0.48	0.80	0.01	128.65	0.104	0.067	0.013	1.00	0.01

21 | Number of lines: 1 | Run Date: 10-30-2013

; c = cir e = ellip b = box

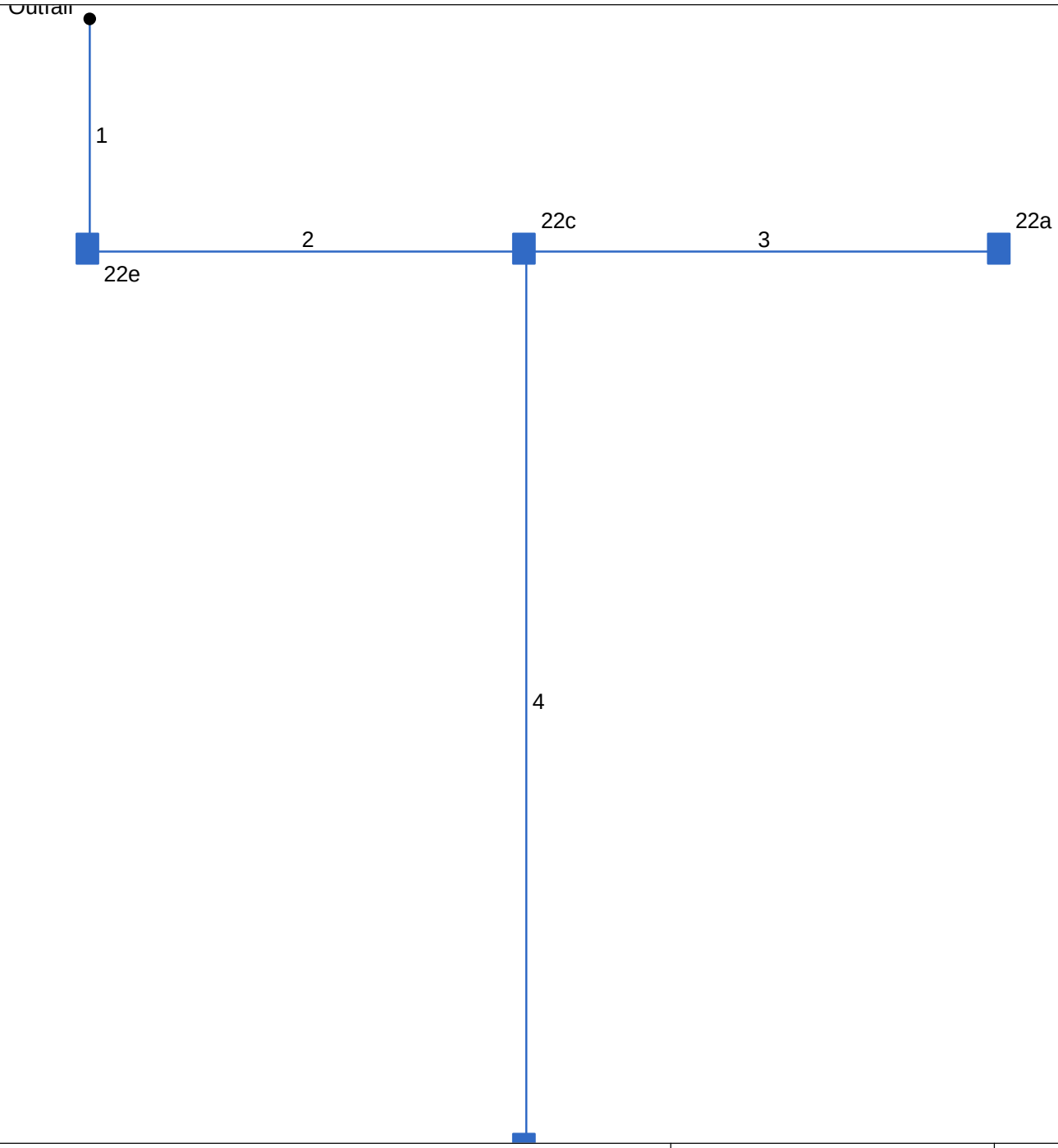
Line Profile (Line 1) - 21b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.38	127.96	128.16	0.67	0.48	0.49	128.63	128.64	128.65	0.50	0.80	-1.50	3.00

21	No. Lines: 1	Run Date: 10-30-2013

22



Project File: Drainage System 22.stm	Number of lines: 4	Date: 11-20-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	31	0.07	0.37	1.00	0.07	0.37	5.0	7.8	2.2	0.81	6.28	1.67	18	1.32	126.82	127.23	127.49	127.61	126.82	134.45	22f
2	1	81	0.07	0.30	1.00	0.07	0.30	5.0	7.2	2.3	0.68	6.25	2.31	18	1.31	127.39	128.45	127.73	128.78	134.45	135.62	22d
3	2	88	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.7	0.44	7.70	1.98	18	1.99	128.61	130.36	128.91	130.61	135.62	136.93	22b
4	2	120	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	2.99	0.88	18	0.30	128.61	128.97	128.91	129.22	135.62	131.99	81b

22 | Number of lines: 4 | Run Date: 11-20-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

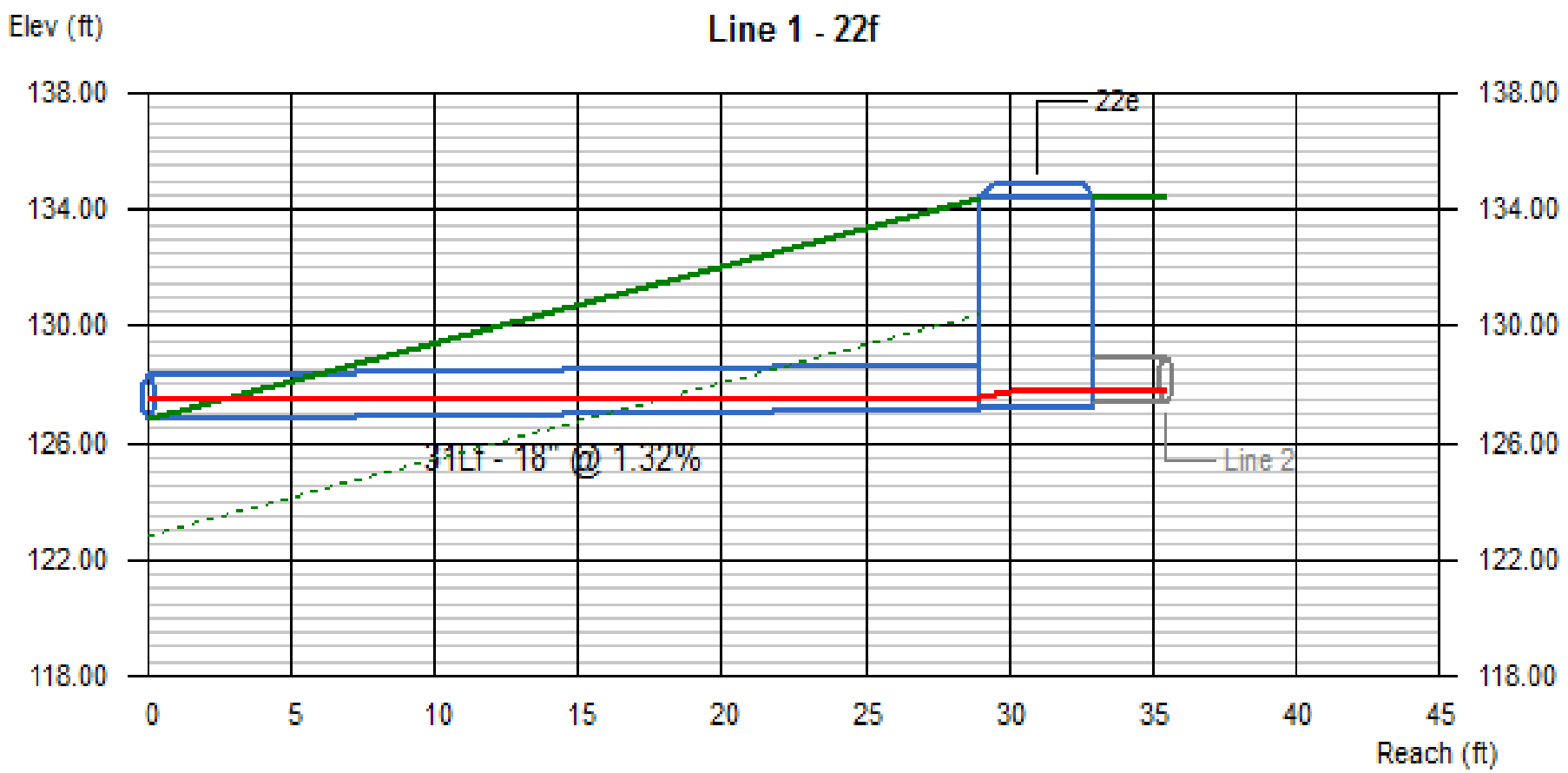
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.81	126.82	127.49	0.67	0.76	1.07	0.02	127.50	0.132	31	127.23	127.61	0.38	0.35	2.28	0.08	127.69	1.090	0.611	0.189	1.50	0.12
2	18	0.68	127.39	127.73	0.34	0.31	2.24	0.08	127.81	1.182	81	128.45	128.78	0.33	0.29	2.39	0.09	128.87	1.428	1.305	1.057	1.50	0.13
3	18	0.44	128.61	128.91	0.30	0.25	1.74	0.05	128.96	0.832	88	130.36	130.61 j	0.25**	0.20	2.23	0.08	130.69	1.692	1.262	n/a	1.00	0.08
4	18	0.19	128.61	128.91	0.30	0.25	0.76	0.01	128.92	0.159	120	128.97	129.22	0.25	0.19	1.01	0.02	129.23	0.356	0.258	0.309	1.00	0.02

22 | Number of lines: 4 | Run Date: 11-20-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

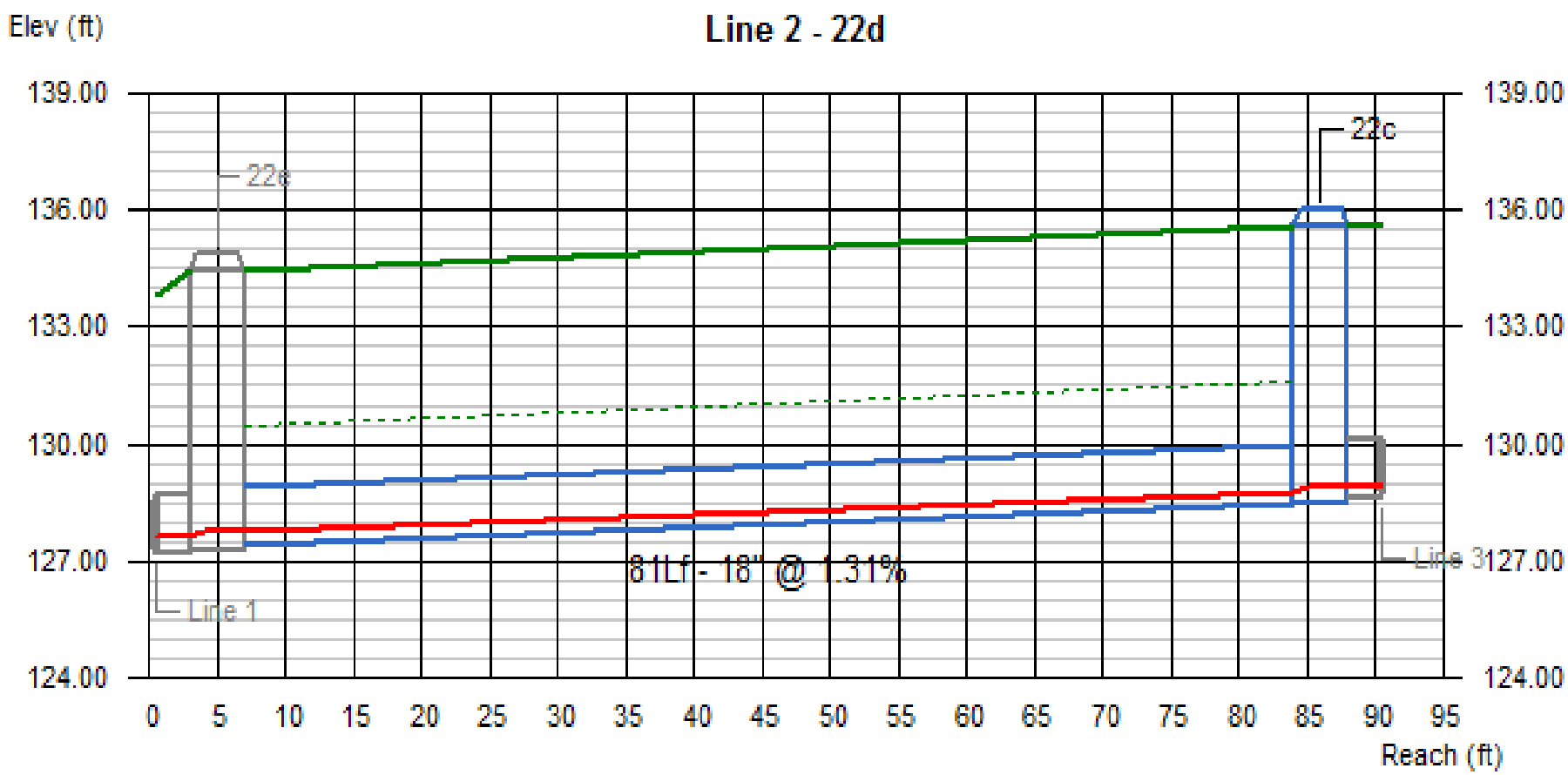
Line Profile (Line 1) - 22f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.81	126.82	127.23	0.67	0.38	0.50	127.49	127.61	127.73	1.07	2.28	-1.50	5.72

22	No. Lines: 4	Run Date: 11-20-2013

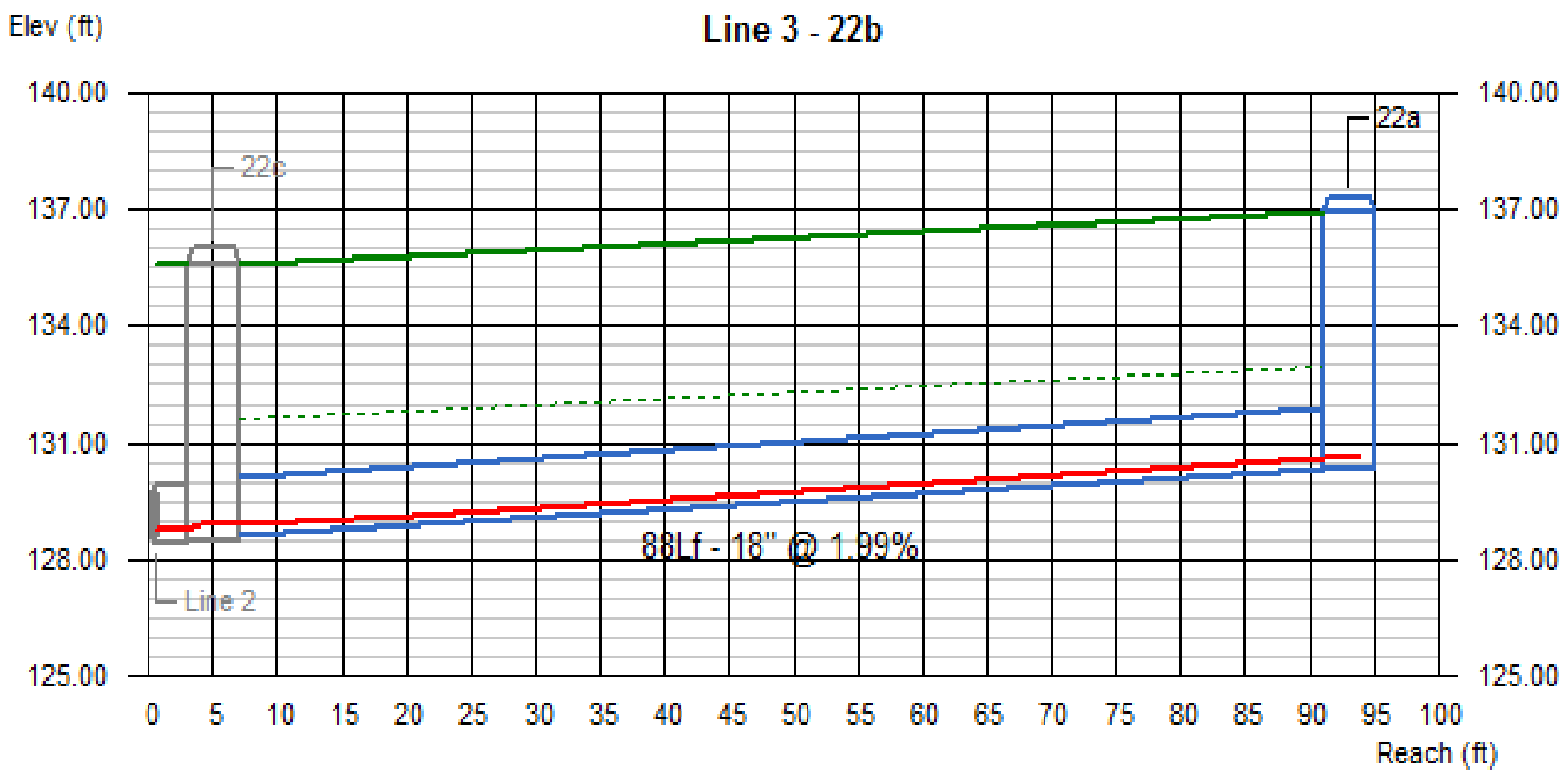
Line Profile (Line 2) - 22d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.68	127.39	128.45	0.34	0.33	0.46	127.73	128.78	128.91	2.24	2.39	5.56	5.67

22 | No. Lines: 4 | Run Date: 11-20-2013

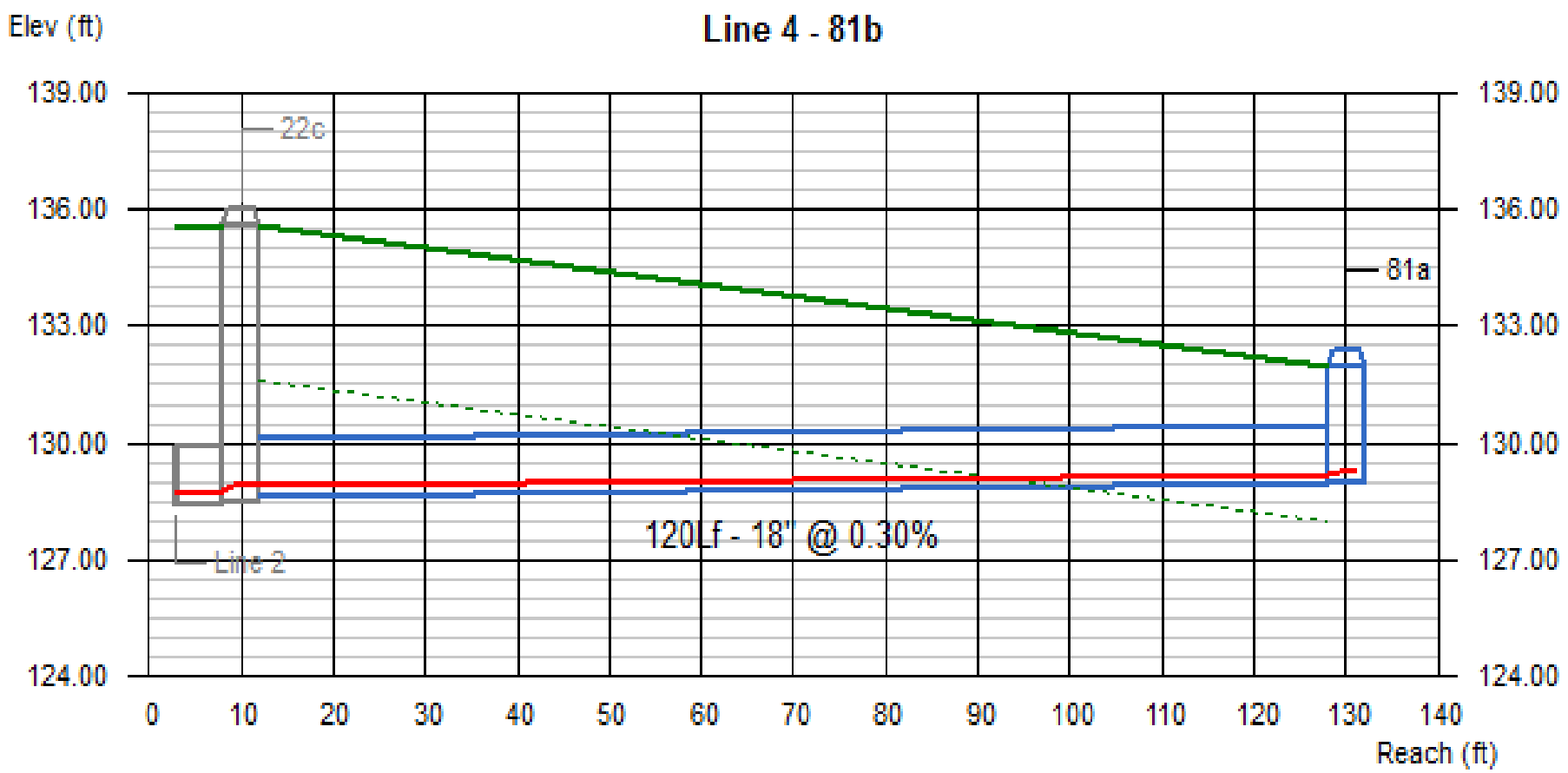
Line Profile (Line 3) - 22b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.44	128.61	130.36	0.30	0.25	0.25	128.91	130.61 j	130.61	1.74	2.23	5.51	5.07

22	No. Lines: 4	Run Date: 11-20-2013

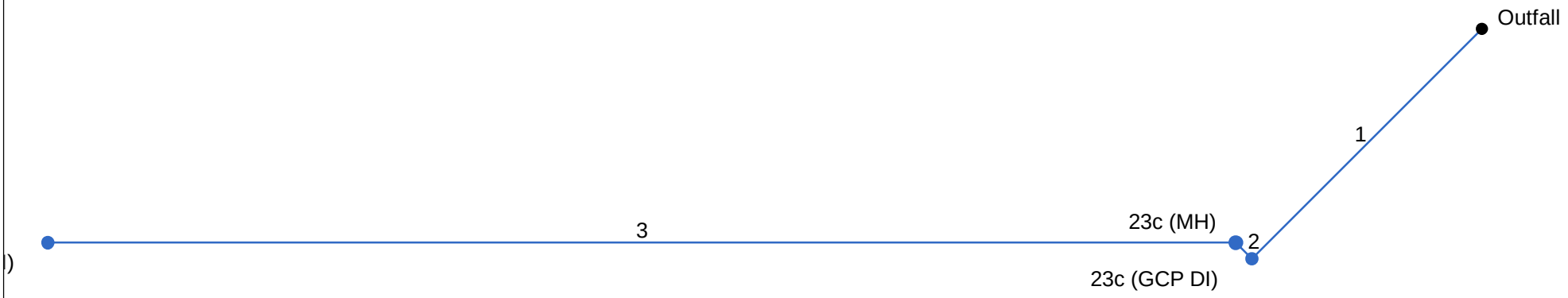
Line Profile (Line 4) - 81b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.19	128.61	128.97	0.30	0.25	0.26	128.91	129.22	129.23	0.76	1.01	5.51	1.52

22 | No. Lines: 4 | Run Date: 11-20-2013

23



Project File: Drainage System 23.stm	Number of lines: 3	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	100	0.42	2.24	0.60	0.25	1.64	13.0	22.3	1.3	2.09	6.44	1.83	24	0.30	112.47	112.77	113.25	113.55	125.23	125.23	Assumed Exist Pip
2	1	7	0.00	1.82	0.00	0.00	1.38	0.0	22.3	1.3	1.77	5.46	3.05	18	1.00	118.01	118.08	118.52	118.67	125.23	126.01	23d
3	2	365	1.82	1.82	0.76	1.38	1.38	20.0	20.0	1.4	1.87	5.46	2.67	18	1.00	118.25	121.90	118.77	122.72	126.01	125.42	23b

23 Number of lines: 3 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

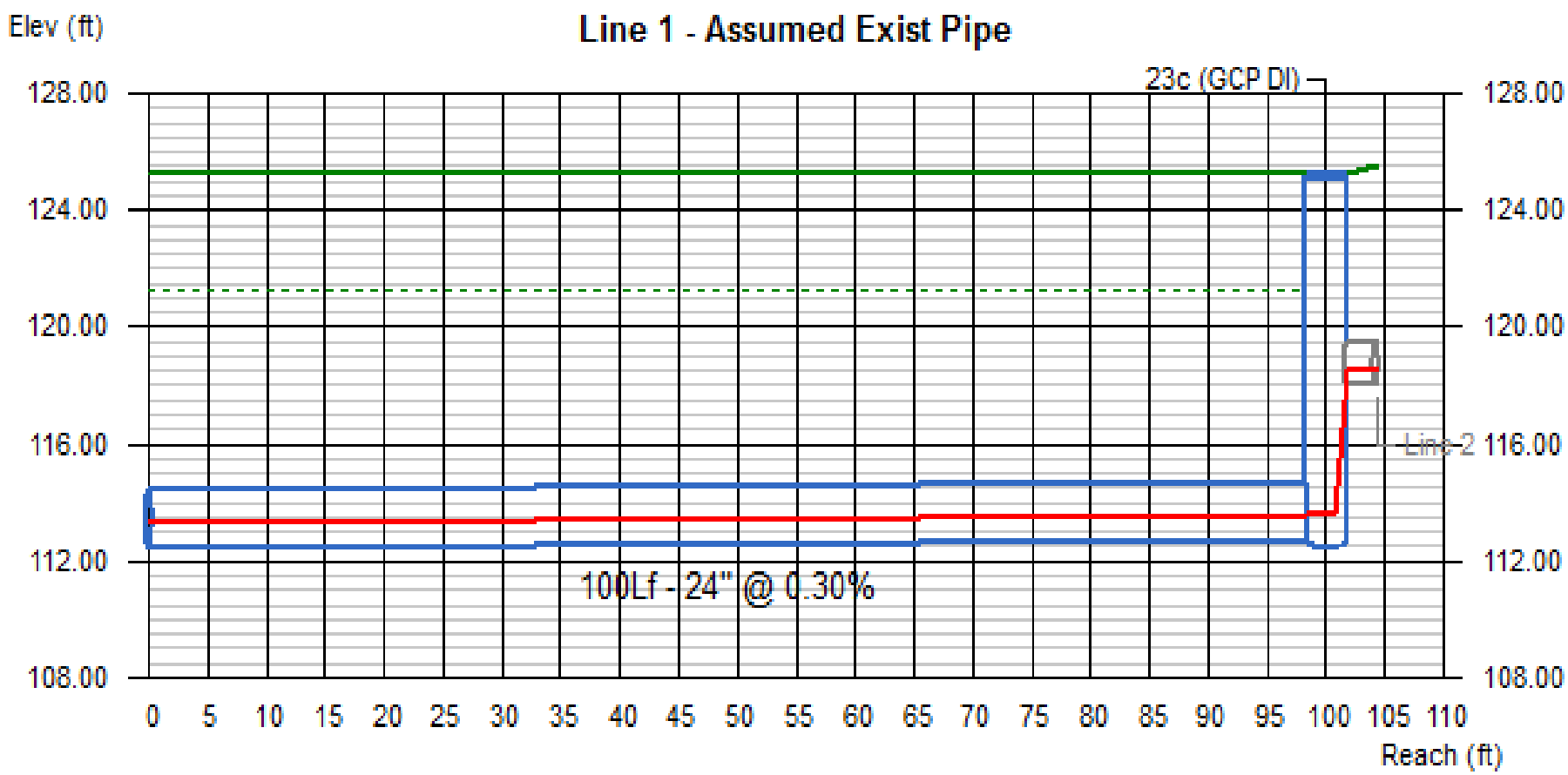
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	24	2.09	112.47	113.25	0.78	1.14	1.83	0.05	113.31	0.299	100	112.77	113.55	0.78	1.14	1.84	0.05	113.61	0.303	0.301	0.301	1.50	0.08
2	18	1.77	118.01	118.52	0.51*	0.53	3.36	0.18	118.69	1.724	7	118.08	118.67	0.59	0.65	2.74	0.12	118.79	0.980	1.352	0.095	0.75	0.09
3	18	1.87	118.25	118.77	0.52*	0.55	3.42	0.18	118.95	1.735	365	121.90	122.72	0.82	0.98	1.91	0.06	122.77	0.357	1.046	3.818	1.00	0.06

23 | Number of lines: 3 | Run Date: 11-04-2013

Notes: * depth assumed. ; c = cir e = ellip b = box

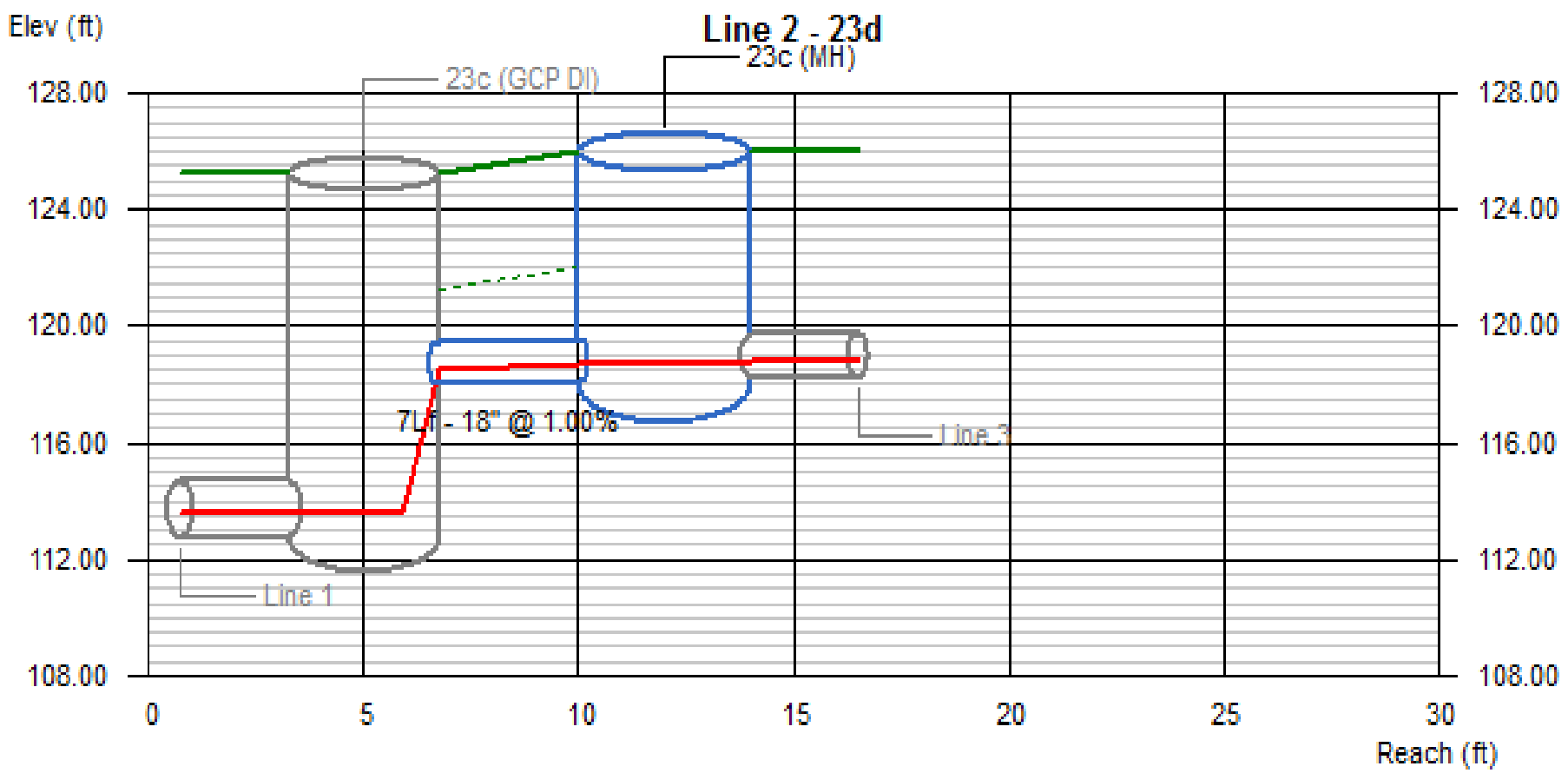
Line Profile (Line 1) - Assumed Exist Pipe



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	2.09	112.47	112.77	0.78	0.78	0.86	113.25	113.55	113.63	1.83	1.84	10.76	10.46

23 | No. Lines: 3 | Run Date: 11-04-2013

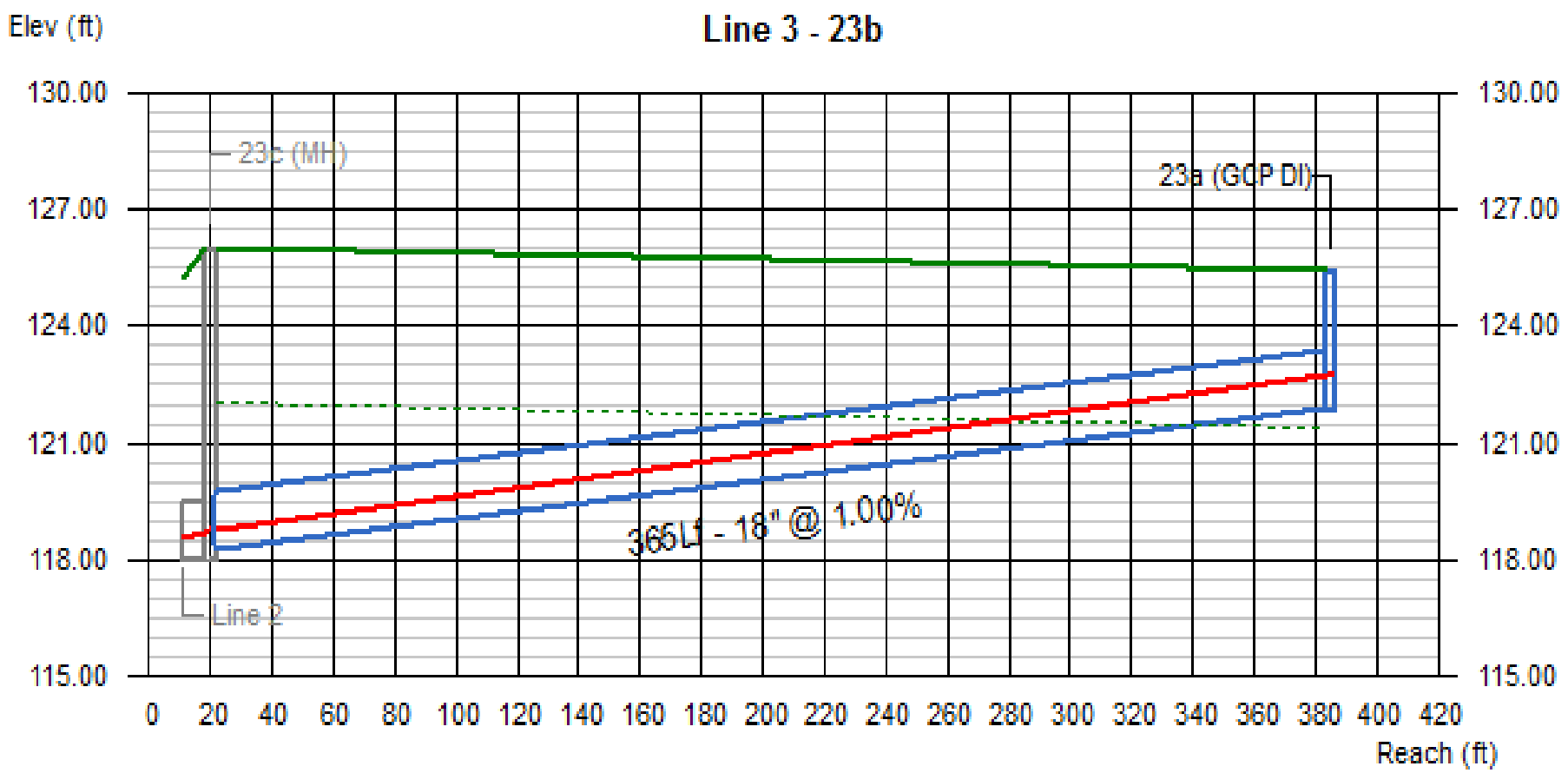
Line Profile (Line 2) - 23d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	1.77	118.01	118.08	0.51	0.59	0.68	118.52	118.67	118.76	3.36	2.74	5.72	6.43

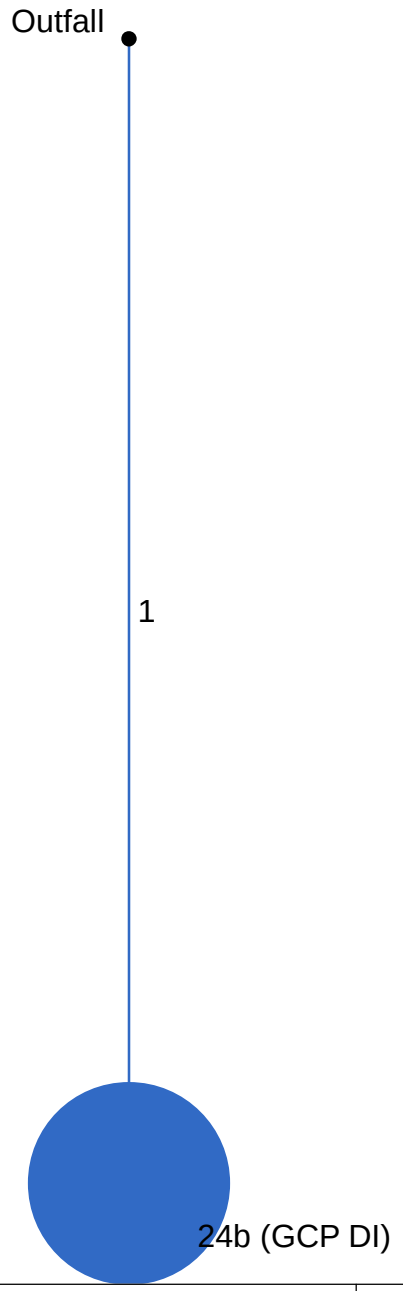
23 | No. Lines: 3 | Run Date: 11-04-2013

Line Profile (Line 3) - 23b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	1.87	118.25	121.90	0.52	0.82	0.87	118.77	122.72	122.77	3.42	1.91	6.26	2.02

23 | No. Lines: 3 | Run Date: 11-04-2013



Project File: Drainage System 24.stm	Number of lines: 1	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	20	0.84	0.84	0.84	0.71	0.71	18.0	18.0	1.4	1.01	5.46	2.36	18	1.00	120.25	120.45	120.69	120.89	124.45	124.45	24a

24 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

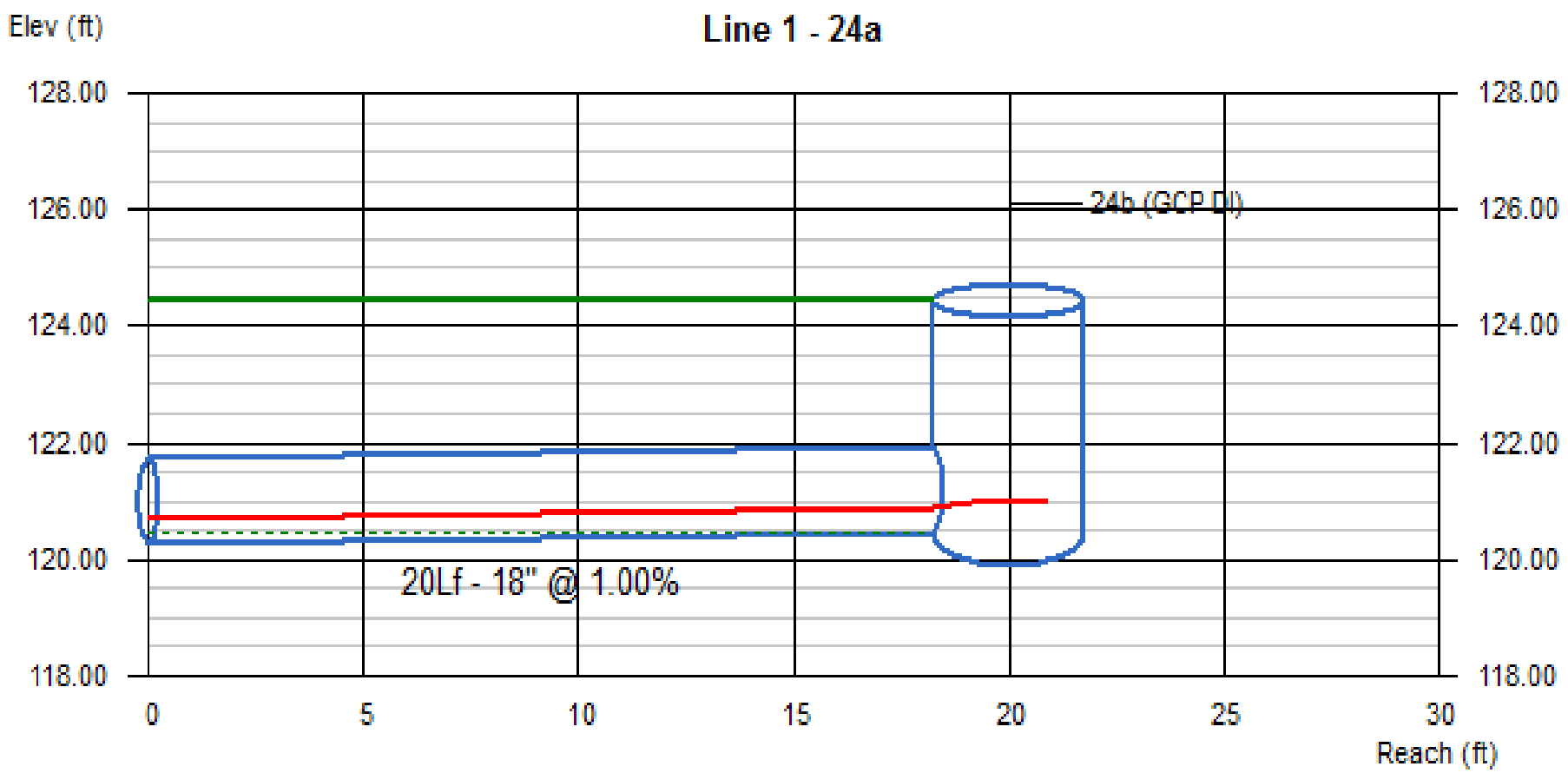
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.01	120.25	120.69	0.44	0.43	2.36	0.09	120.77	1.000	20	120.45	120.89	0.44	0.43	2.36	0.09	120.97	0.999	0.999	0.200	1.00	0.09

24 | Number of lines: 1 | Run Date: 10-30-2013

; c = cir e = ellip b = box

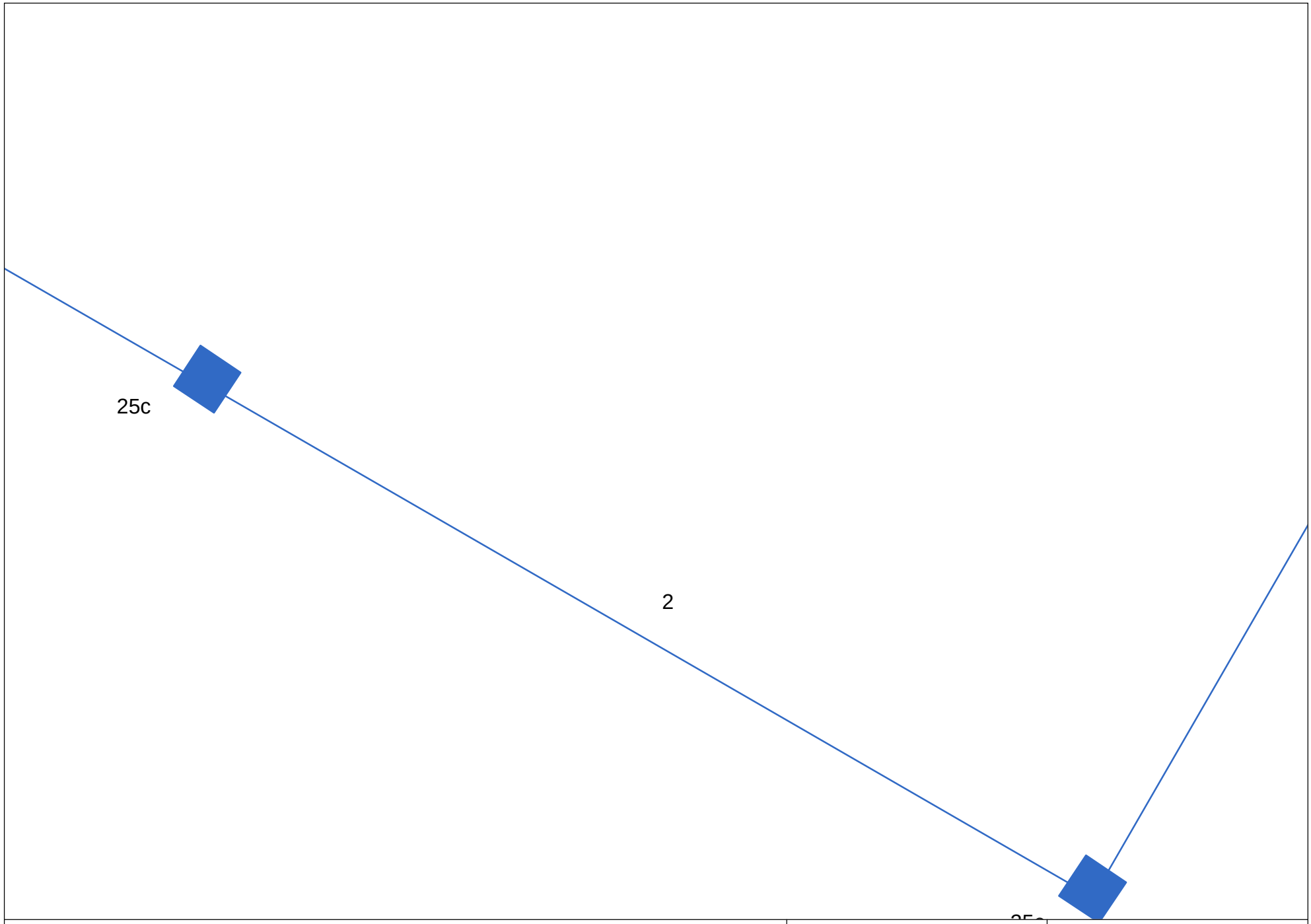
Line Profile (Line 1) - 24a



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.01	120.25	120.45	0.44	0.44	0.52	120.69	120.89	120.97	2.36	2.36	2.70	2.50

24 | No. Lines: 1 | Run Date: 10-30-2013

25



Project File: Drainage System 25.stm	Number of lines: 3	Date: 11-20-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	68	0.06	0.12	1.00	0.06	0.12	5.0	7.4	2.3	0.27	2.96	0.56	18	0.29	128.62	128.82	129.20	129.23	128.82	133.17	25f
2	1	77	0.03	0.06	1.00	0.03	0.06	5.0	5.9	2.5	0.15	2.98	0.83	18	0.30	128.98	129.21	129.24	129.43	133.17	133.03	25d
3	2	42	0.03	0.03	1.00	0.03	0.03	5.0	5.0	2.7	0.08	3.04	0.81	18	0.31	129.37	129.50	129.48	129.92	133.03	132.57	25b

25 | Number of lines: 3 | Run Date: 11-20-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

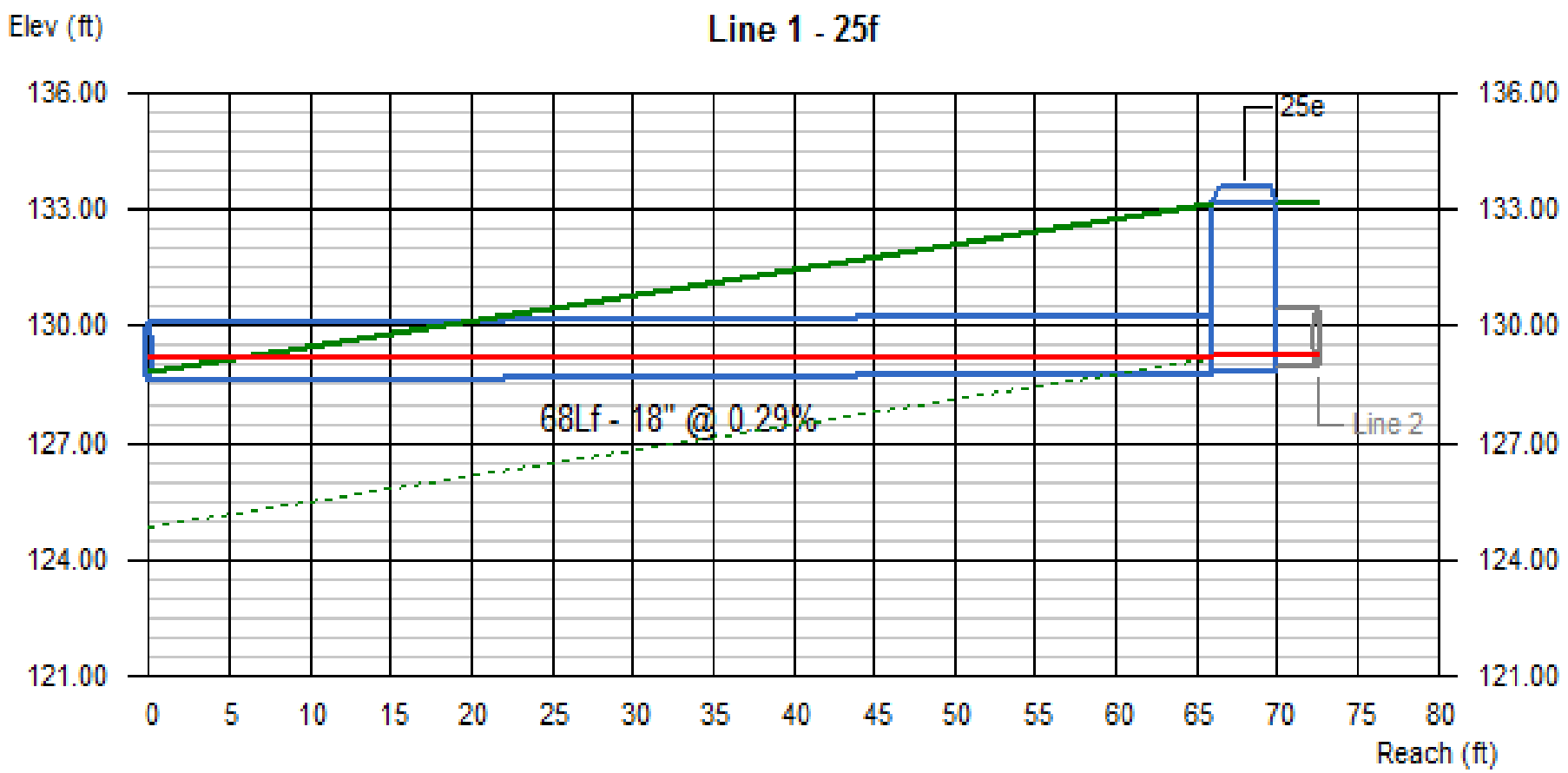
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.27	128.62	129.20	0.58	0.63	0.43	0.00	129.20	0.024	68	128.82	129.23	0.41	0.40	0.68	0.01	129.24	0.089	0.057	0.039	1.50	0.01
2	18	0.15	128.98	129.24	0.26	0.21	0.73	0.01	129.25	0.171	77	129.21	129.43	0.22	0.16	0.93	0.01	129.45	0.343	0.257	0.198	0.50	0.01
3	18	0.08	129.37	129.48	0.11*	0.06	1.42	0.03	129.51	1.970	42	129.50	129.92	0.42	0.41	0.20	0.00	129.93	0.007	0.988	0.415	1.00	0.00

25 | Number of lines: 3 | Run Date: 11-20-2013

Notes: * depth assumed. ; c = cir e = ellip b = box

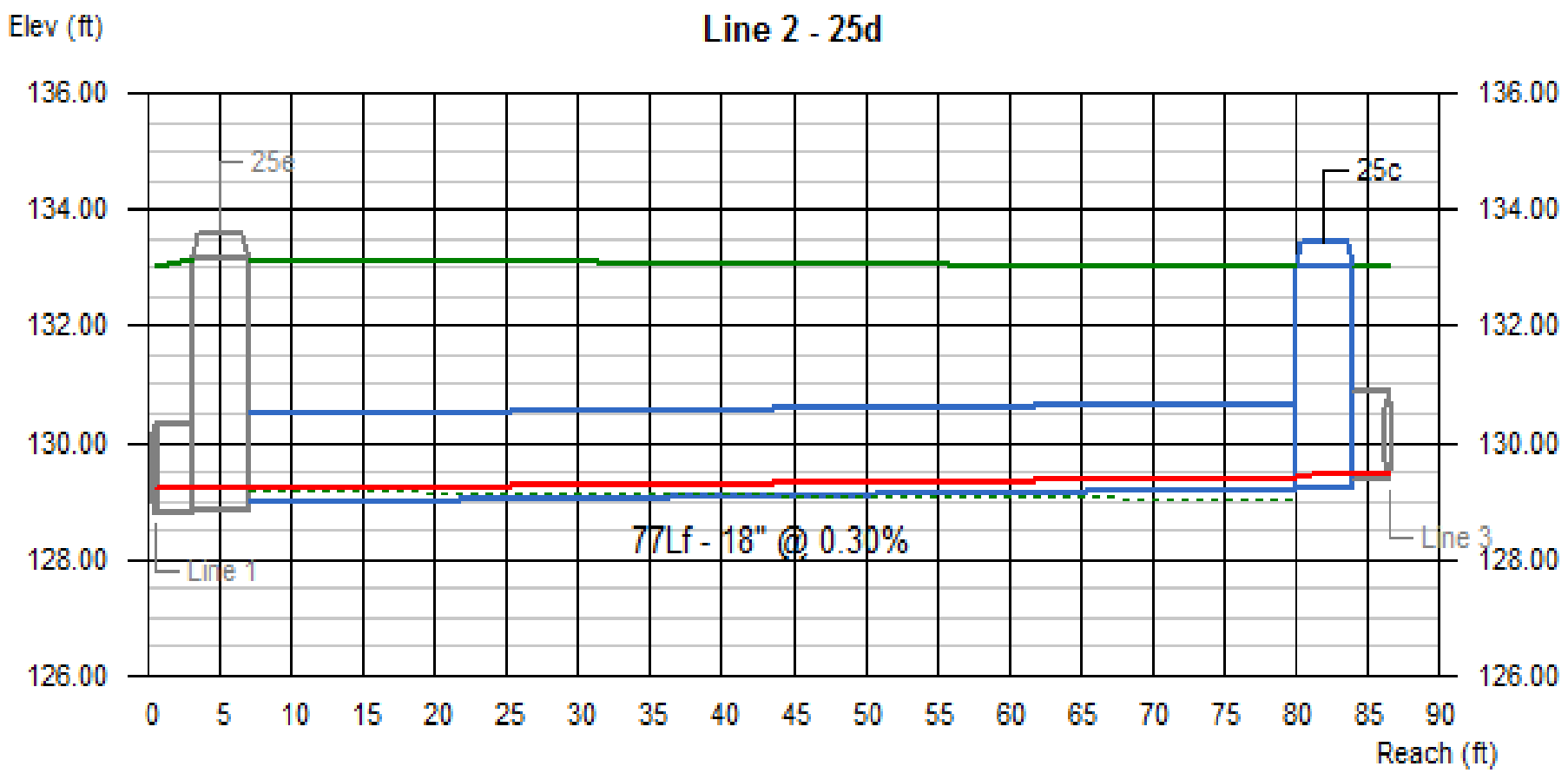
Line Profile (Line 1) - 25f



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.27	128.62	128.82	0.58	0.41	0.42	129.20	129.23	129.24	0.43	0.68	-1.30	2.85

25	No. Lines: 3	Run Date: 11-20-2013

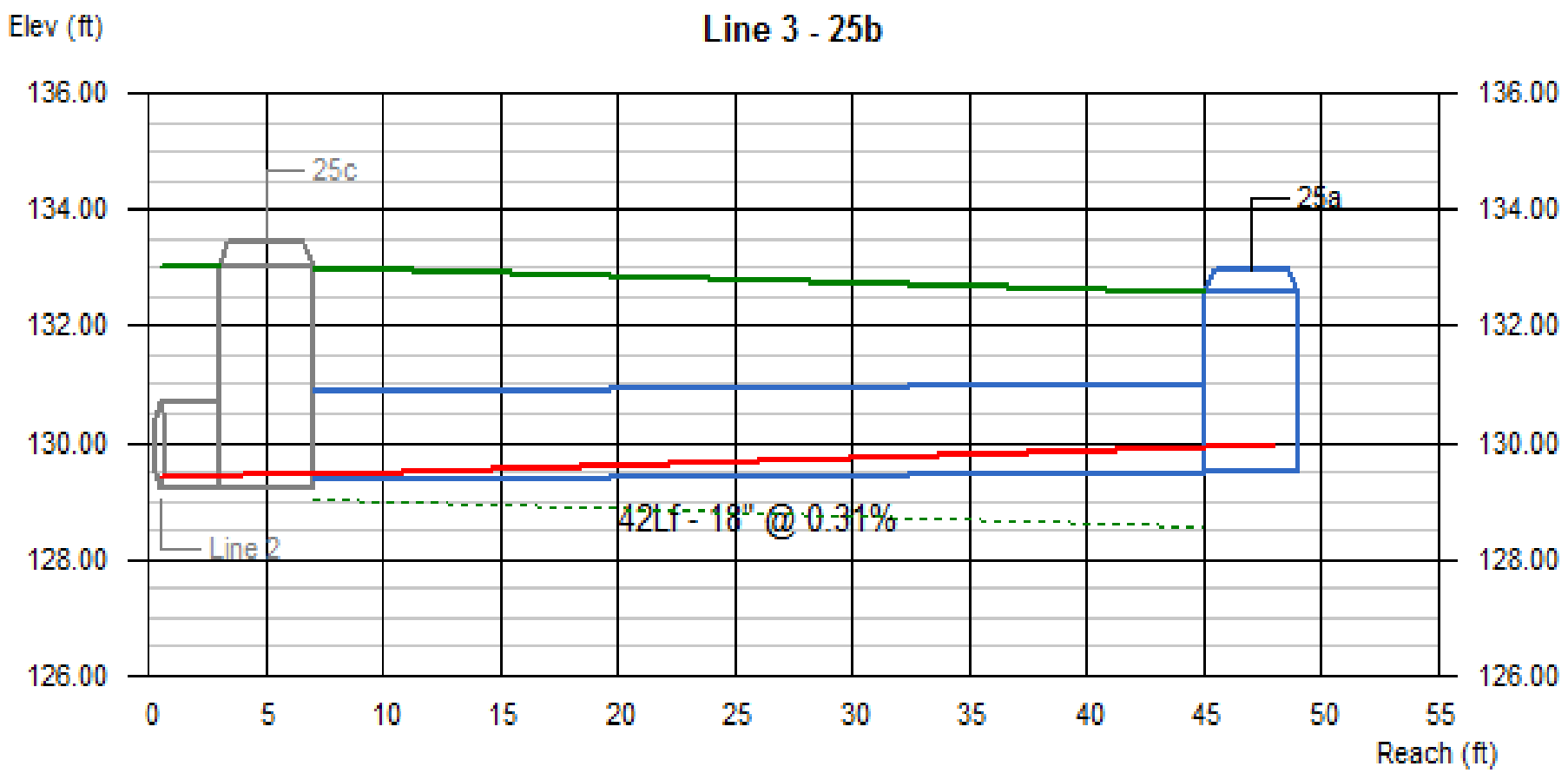
Line Profile (Line 2) - 25d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.15	128.98	129.21	0.26	0.22	0.23	129.24	129.43	129.44	0.73	0.93	2.69	2.32

25 | No. Lines: 3 | Run Date: 11-20-2013

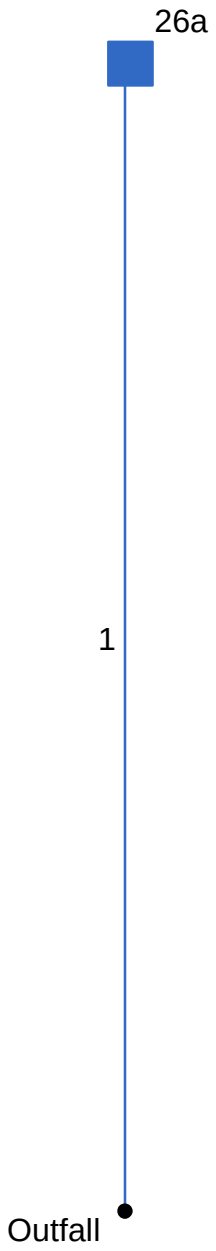
Line Profile (Line 3) - 25b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.08	129.37	129.50	0.11	0.42	0.43	129.48	129.92	129.93	1.42	0.20	2.16	1.57

25 | No. Lines: 3 | Run Date: 11-20-2013

26



Project File: Drainage System 26.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	104	0.15	0.15	1.00	0.15	0.15	5.0	5.0	2.7	0.41	3.86	1.17	18	0.50	133.49	134.01	133.99	134.33	133.49	140.16	26b

26 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

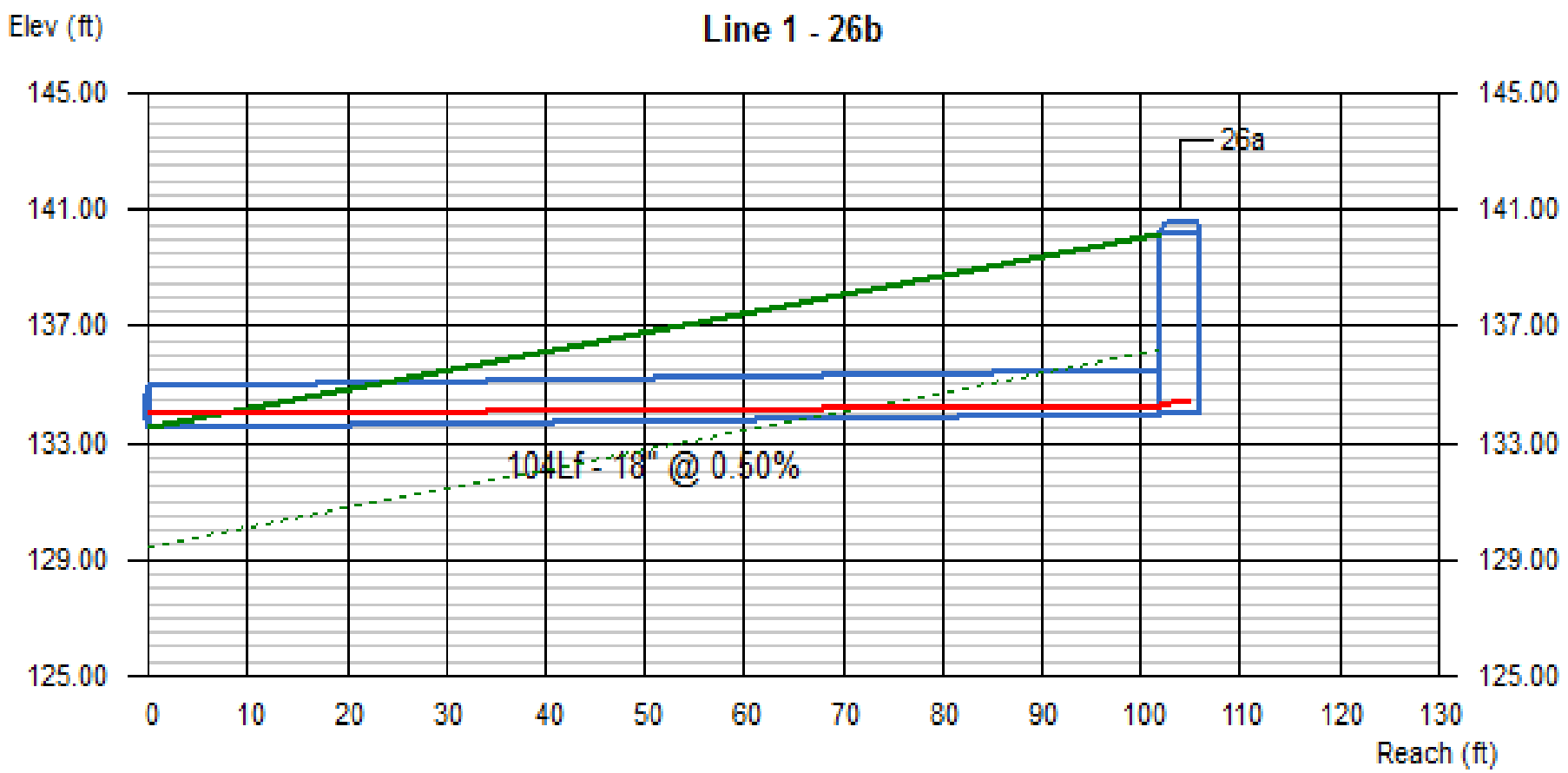
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.41	133.49	133.99	0.50	0.51	0.81	0.01	134.00	0.102	104	134.01	134.33	0.32	0.27	1.53	0.04	134.36	0.610	0.356	0.370	1.00	0.04

26	Number of lines: 1	Run Date: 11-04-2013

; c = cir e = ellip b = box

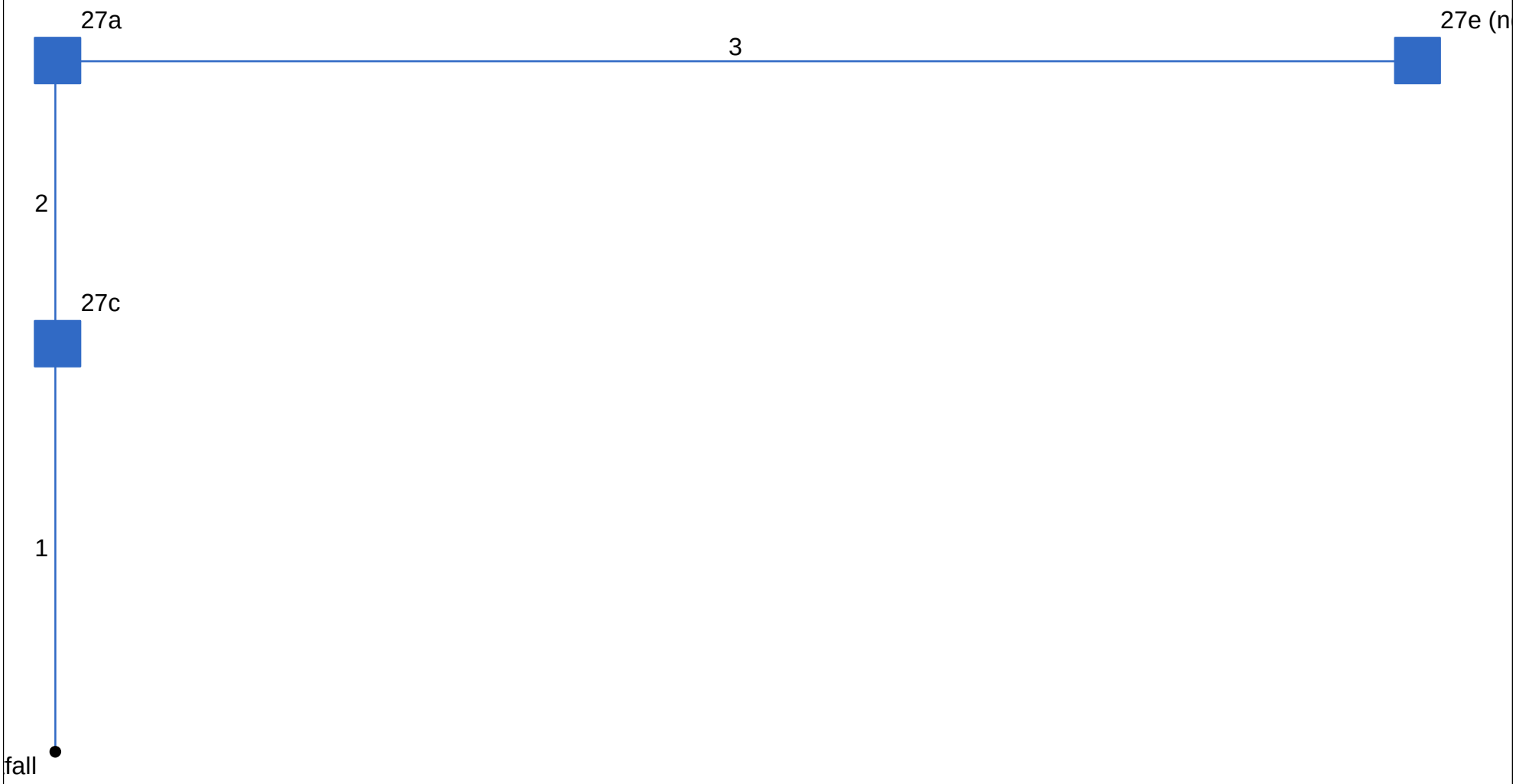
Line Profile (Line 1) - 26b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.41	133.49	134.01	0.50	0.32	0.35	133.99	134.33	134.36	0.81	1.53	-1.50	4.65

26 | No. Lines: 1 | Run Date: 11-04-2013

27



Project File: Drainage System 27.stm	Number of lines: 3	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	36	0.28	0.55	1.00	0.28	0.55	5.0	7.2	2.3	1.26	3.86	2.17	18	0.50	136.13	136.31	136.63	136.92	136.13	141.87	27d
2	1	25	0.11	0.27	1.00	0.11	0.27	5.0	6.9	2.3	0.63	3.94	1.42	18	0.52	136.47	136.60	136.95	137.03	141.87	142.45	27b
3	2	120	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.7	0.44	2.99	1.07	18	0.30	136.60	136.96	137.08	137.34	142.45	143.74	27f (new)

27 Number of lines: 3 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

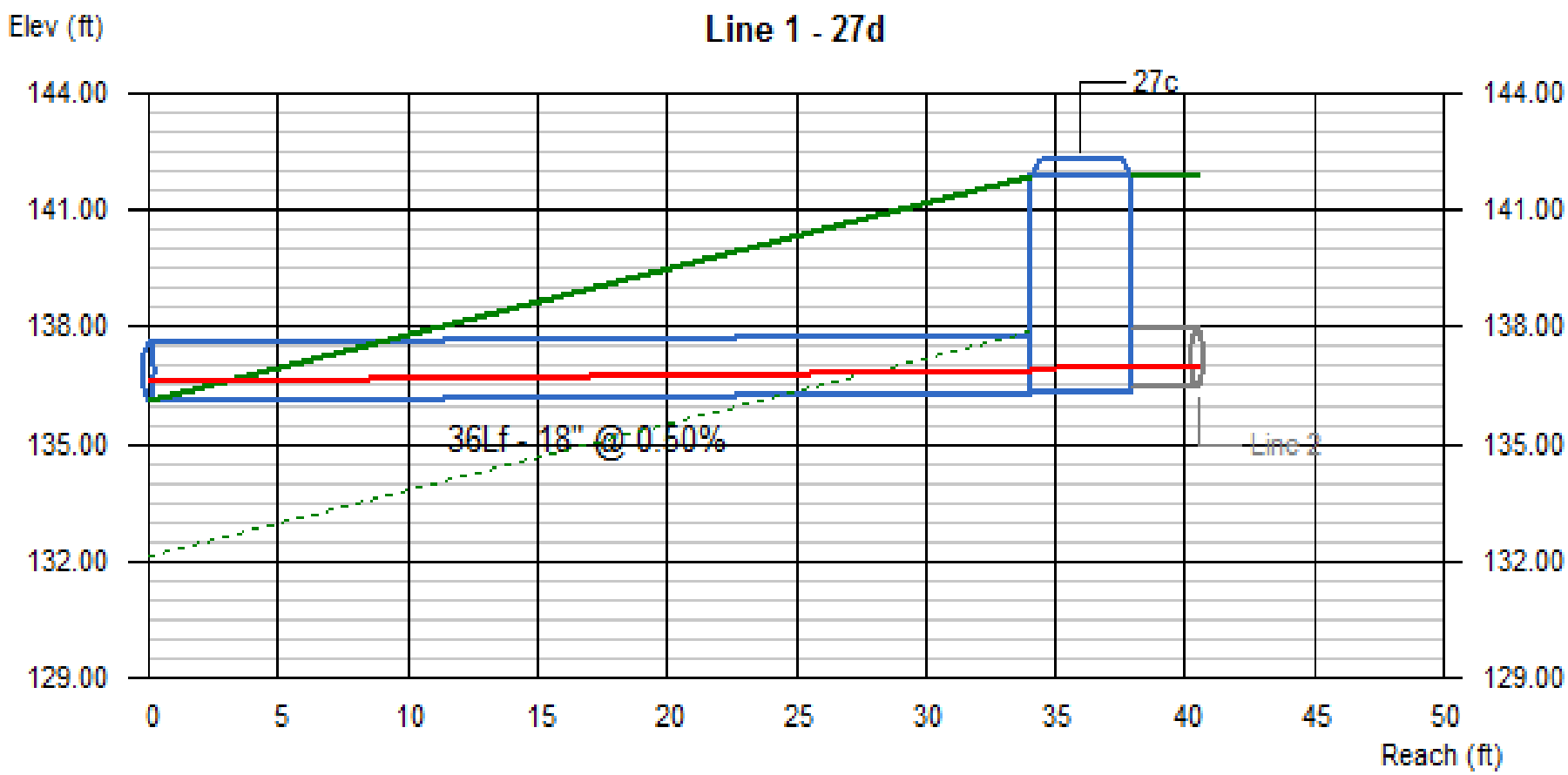
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	1.26	136.13	136.63	0.50	0.51	2.46	0.09	136.72	0.949	36	136.31	136.92	0.61	0.67	1.87	0.05	136.97	0.442	0.696	0.250	0.50	0.03
2	18	0.63	136.47	136.95	0.48	0.48	1.31	0.03	136.97	0.279	25	136.60	137.03	0.43	0.41	1.53	0.04	137.06	0.435	0.357	0.089	1.50	0.05
3	18	0.44	136.60	137.08	0.48	0.49	0.90	0.01	137.09	0.132	120	136.96	137.34	0.38	0.35	1.24	0.02	137.37	0.324	0.228	0.274	1.00	0.02

27 | Number of lines: 3 | Run Date: 11-04-2013

; c = cir e = ellip b = box

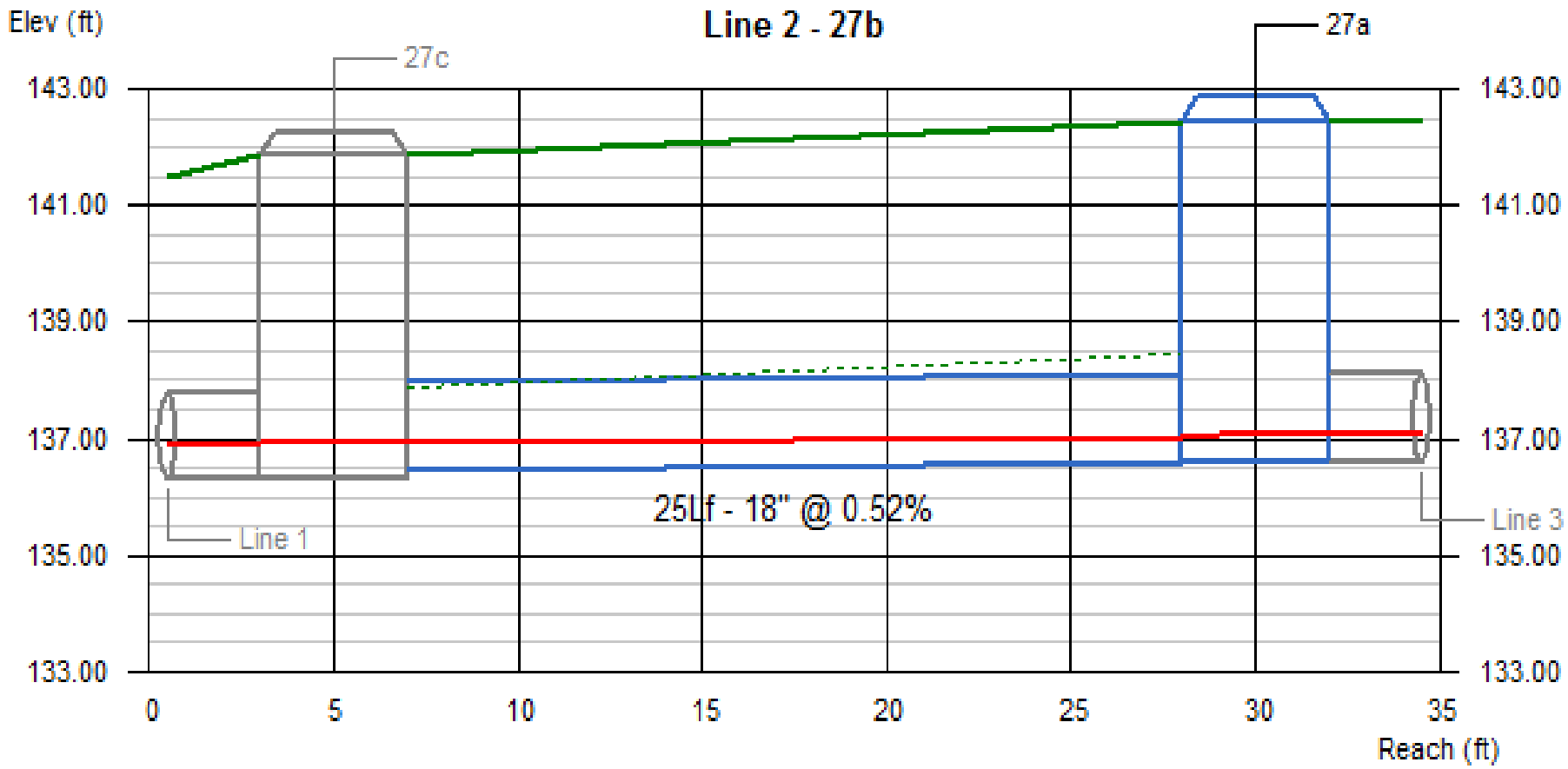
Line Profile (Line 1) - 27d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.26	136.13	136.31	0.50	0.61	0.64	136.63	136.92	136.95	2.46	1.87	-1.50	4.06

27 | No. Lines: 3 | Run Date: 11-04-2013

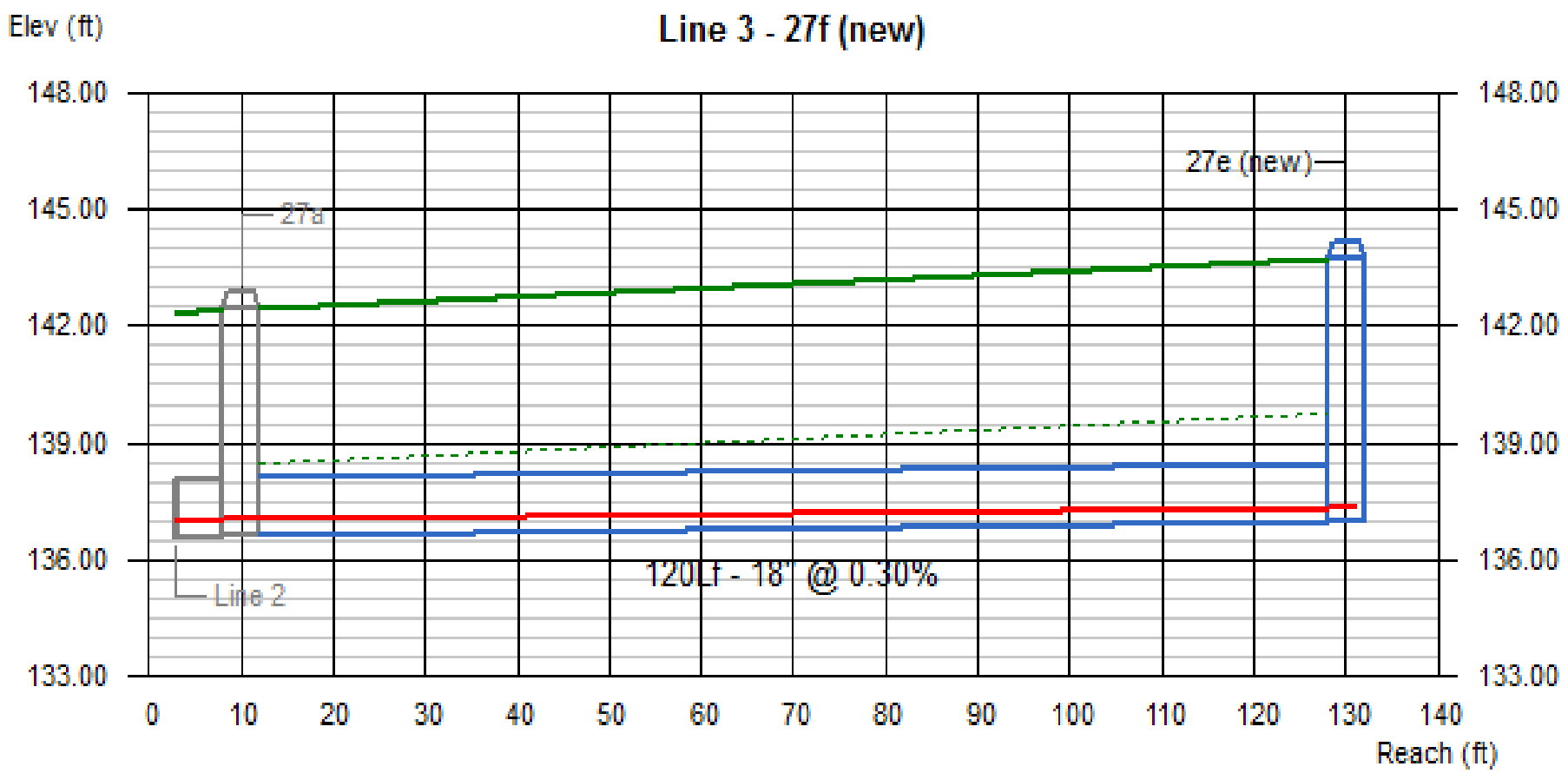
Line Profile (Line 2) - 27b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.63	136.47	136.60	0.48	0.43	0.48	136.95	137.03	137.08	1.31	1.53	3.90	4.35

27 | No. Lines: 3 | Run Date: 11-04-2013

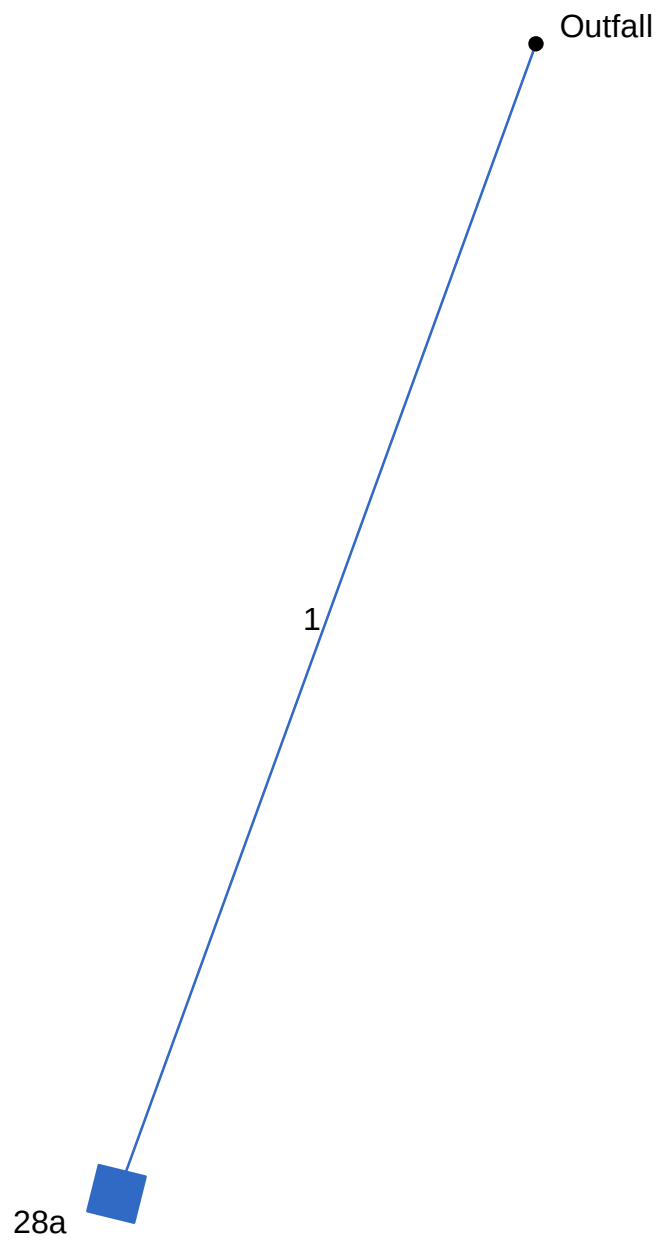
Line Profile (Line 3) - 27f (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.44	136.60	136.96	0.48	0.38	0.41	137.08	137.34	137.37	0.90	1.24	4.35	5.28

27 | No. Lines: 3 | Run Date: 11-04-2013

28



Project File: Drainage System 28.stm	Number of lines: 1	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	105	0.20	0.20	1.00	0.20	0.20	5.0	5.0	2.7	0.55	3.01	1.20	18	0.30	125.33	125.65	125.83	126.08	125.33	131.00	28b

28 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

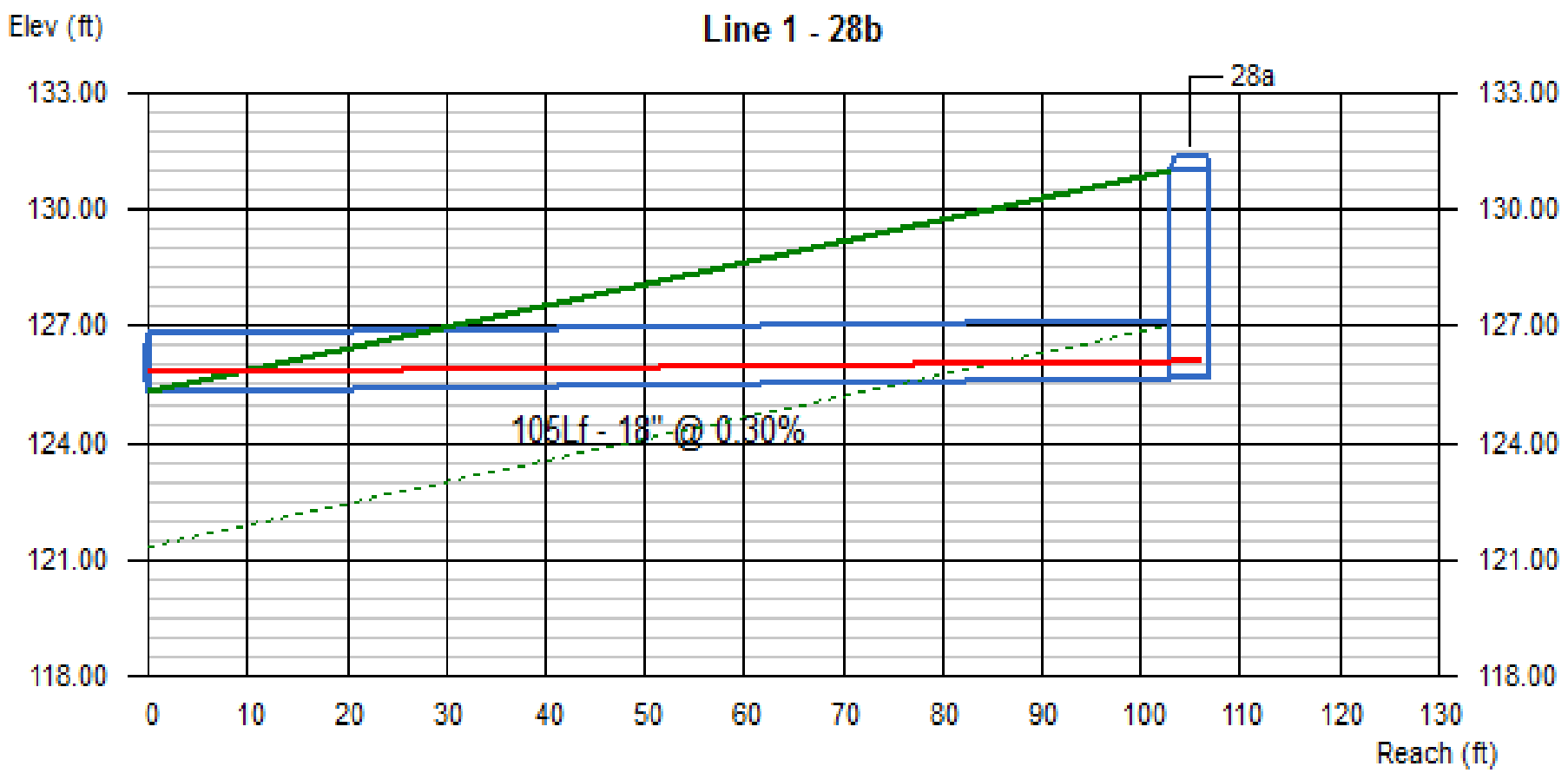
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.55	125.33	125.83	0.50	0.51	1.07	0.02	125.85	0.180	105	125.65	126.08	0.43	0.42	1.32	0.03	126.11	0.318	0.249	0.262	1.00	0.03

28	Number of lines: 1	Run Date: 11-04-2013

; c = cir e = ellip b = box

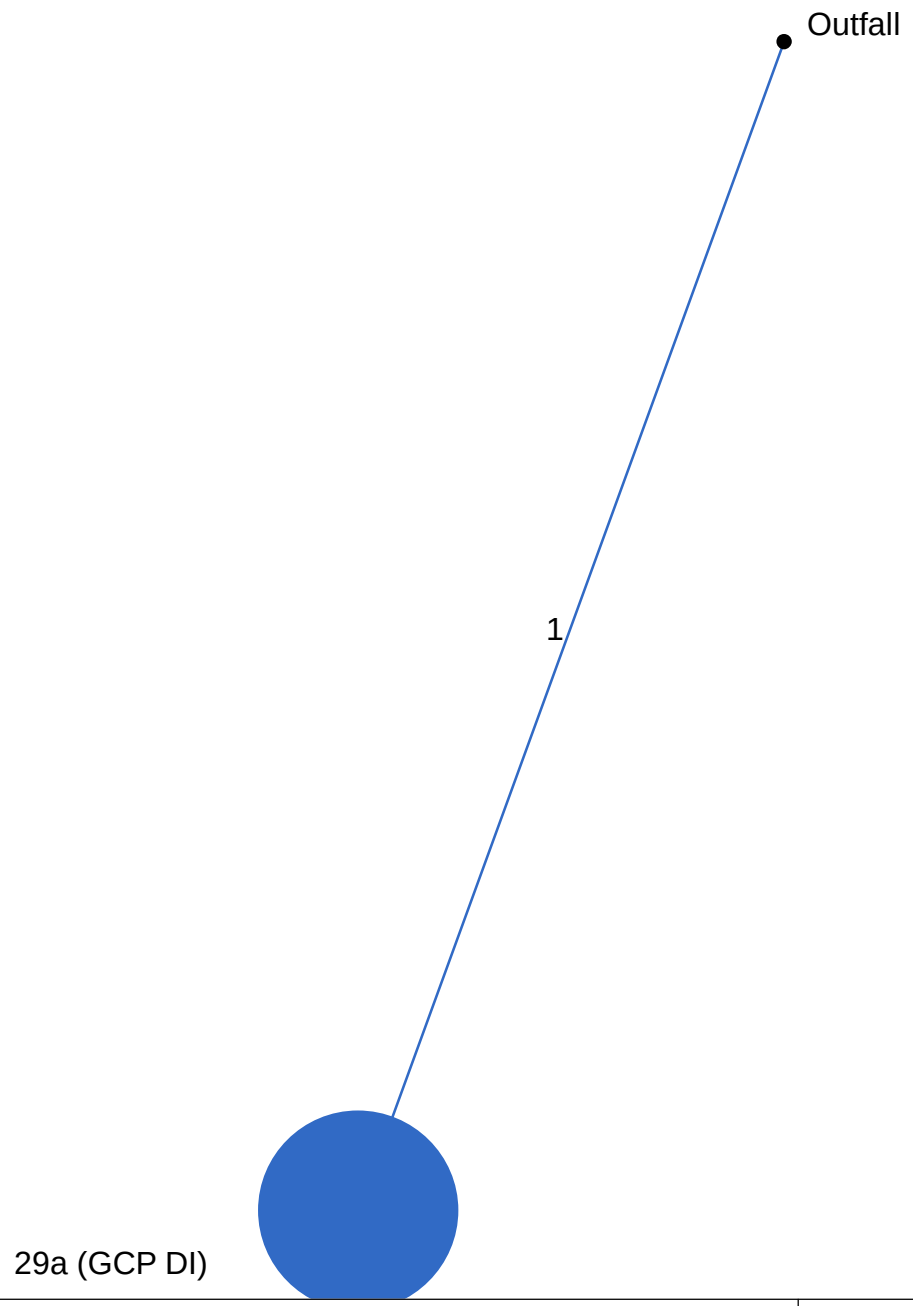
Line Profile (Line 1) - 28b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.55	125.33	125.65	0.50	0.43	0.46	125.83	126.08	126.11	1.07	1.32	-1.50	3.85

28 | No. Lines: 1 | Run Date: 11-04-2013

29



Project File: Drainage System 29.stm	Number of lines: 1	Date: 10-29-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	22	1.17	1.17	0.60	0.70	0.70	10.0	10.0	1.9	1.36	5.46	2.56	18	1.00	118.09	118.31	118.60	118.82	126.46	122.31	29b
29																Number of lines: 1				Run Date: 10-29-2013		

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

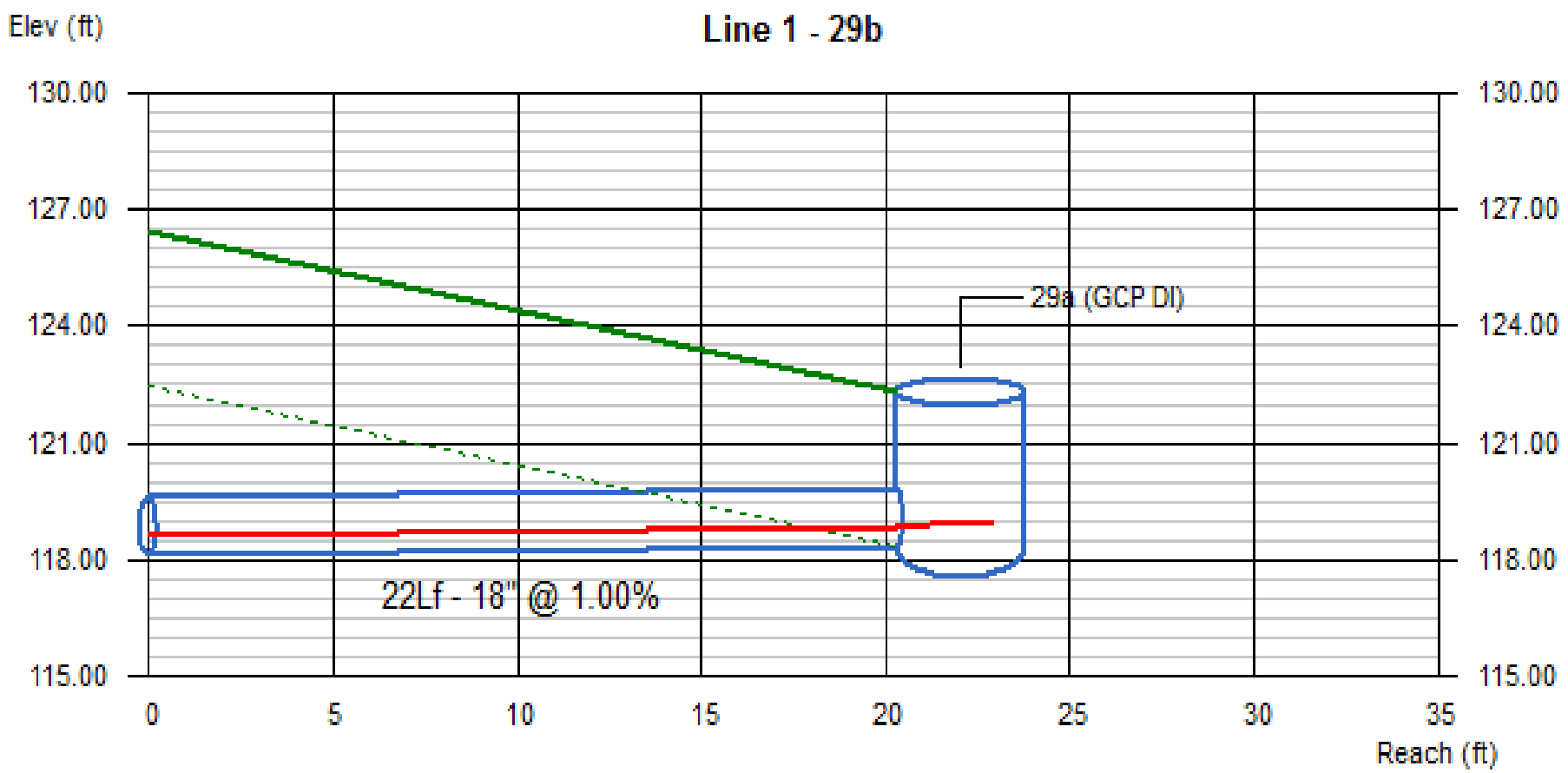
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.36	118.09	118.60	0.51	0.53	2.56	0.10	118.70	0.999	22	118.31	118.82	0.51	0.53	2.55	0.10	118.92	0.990	0.994	0.219	1.00	0.10

29	Number of lines: 1	Run Date: 10-29-2013

; c = cir e = ellip b = box

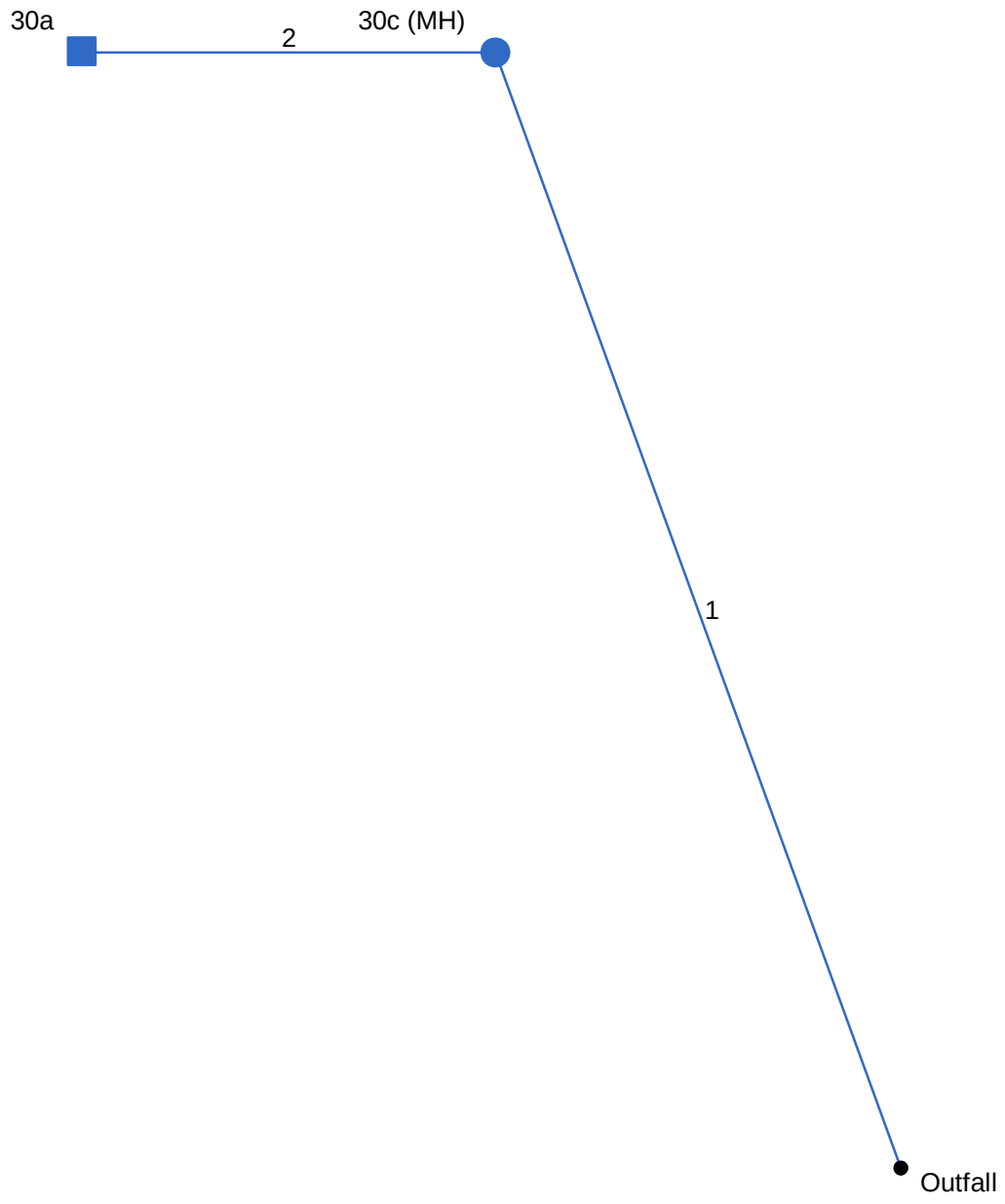
Line Profile (Line 1) - 29b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.36	118.09	118.31	0.51	0.51	0.61	118.60	118.82	118.92	2.56	2.55	6.87	2.50

29 | No. Lines: 1 | Run Date: 10-29-2013

30



Project File: Drainage System 30.stm	Number of lines: 2	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	173	0.00	0.25	0.00	0.00	0.25	5.0	5.6	2.6	0.65	2.99	1.00	18	0.30	121.66	122.18	122.42	122.67	121.66	126.65	30d
2	1	60	0.25	0.25	1.00	0.25	0.25	5.0	5.0	2.7	0.69	2.99	1.62	18	0.30	122.35	122.53	122.70	123.14	126.65	126.93	30b

30 Number of lines: 2 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

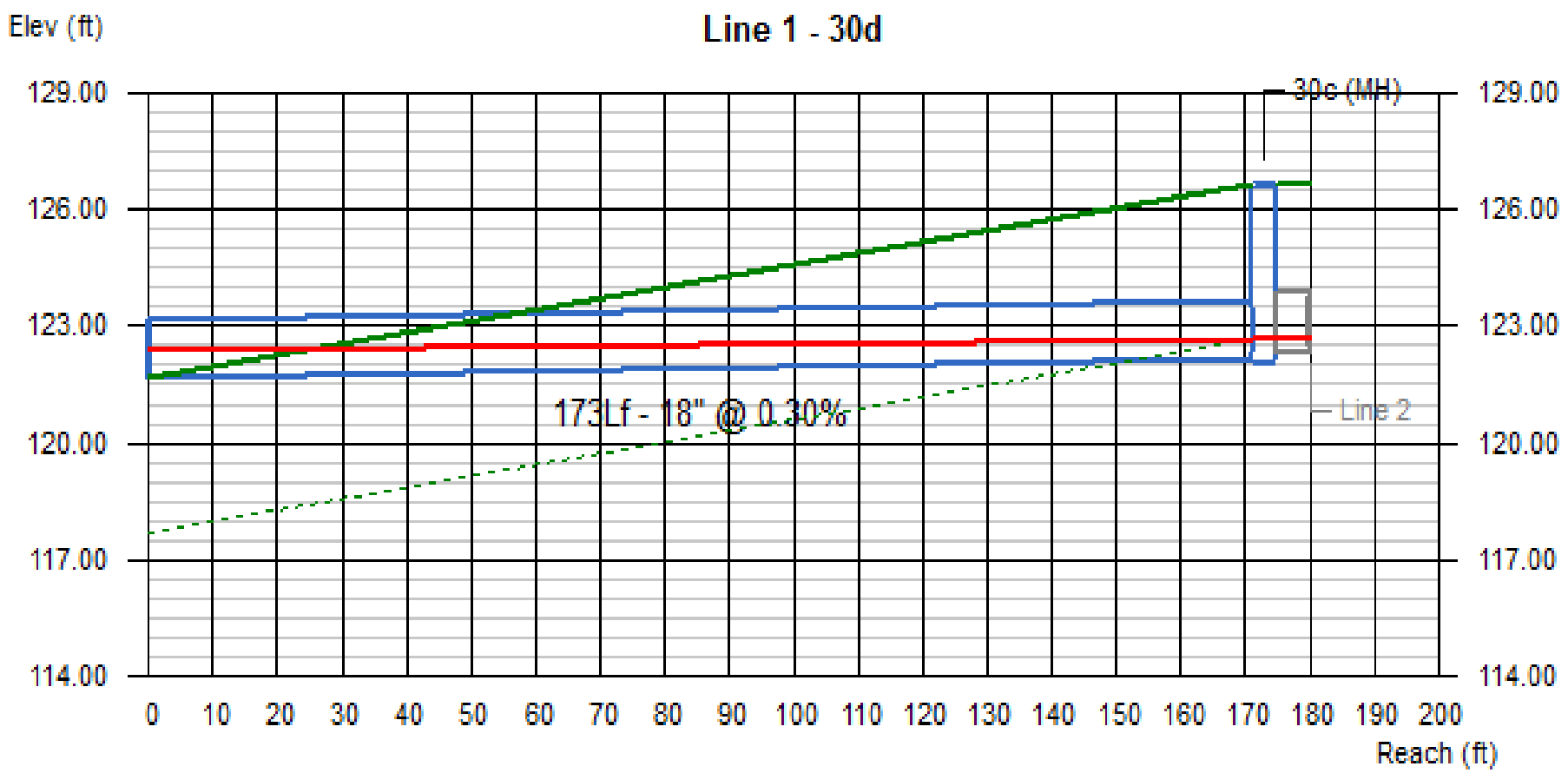
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.65	121.66	122.42	0.76	0.90	0.72	0.01	122.43	0.053	173	122.18	122.67	0.49	0.50	1.29	0.03	122.70	0.261	0.157	0.272	0.95	0.02
2	18	0.69	122.35	122.70	0.35	0.31	2.23	0.08	122.77	1.161	60	122.53	123.14	0.61	0.68	1.01	0.02	123.16	0.128	0.645	0.387	1.00	0.02

30 | Number of lines: 2 | Run Date: 10-30-2013

; c = cir e = ellip b = box

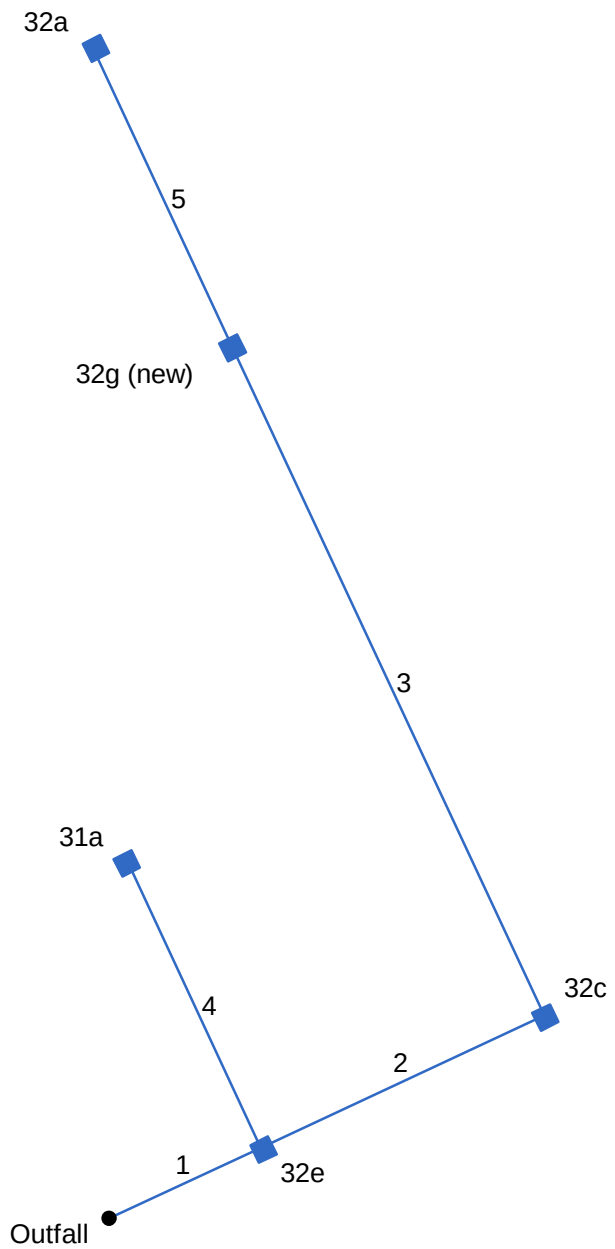
Line Profile (Line 1) - 30d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.65	121.66	122.18	0.76	0.49	0.52	122.42	122.67	122.70	0.72	1.29	-1.50	2.97

30 | No. Lines: 2 | Run Date: 10-30-2013

31 32



Project File: Drainage System 31, 32.stm	Number of lines: 5	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	38	0.11	0.51	1.00	0.11	0.51	5.0	16.9	1.5	0.75	7.77	1.76	18	2.03	134.71	135.48	135.42	135.81	0.00	143.85	32f
2	1	71	0.06	0.28	1.00	0.06	0.28	5.0	16.4	1.5	0.42	7.72	2.20	18	2.00	136.70	138.12	136.95	138.37	143.85	145.98	32d
3	2	167	0.15	0.22	1.00	0.15	0.22	5.0	14.0	1.6	0.36	2.99	1.17	18	0.30	138.29	138.79	138.52	140.02	145.98	145.50	32f (new)
4	1	71	0.12	0.12	1.00	0.12	0.12	5.0	5.0	2.7	0.33	3.83	1.31	18	0.49	135.65	136.00	135.87	136.56	143.85	141.61	31b
5	3	75	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	3.02	0.14	18	0.31	138.79	139.02	140.02	140.02	145.50	145.11	32b

31 32 | Number of lines: 5 | Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

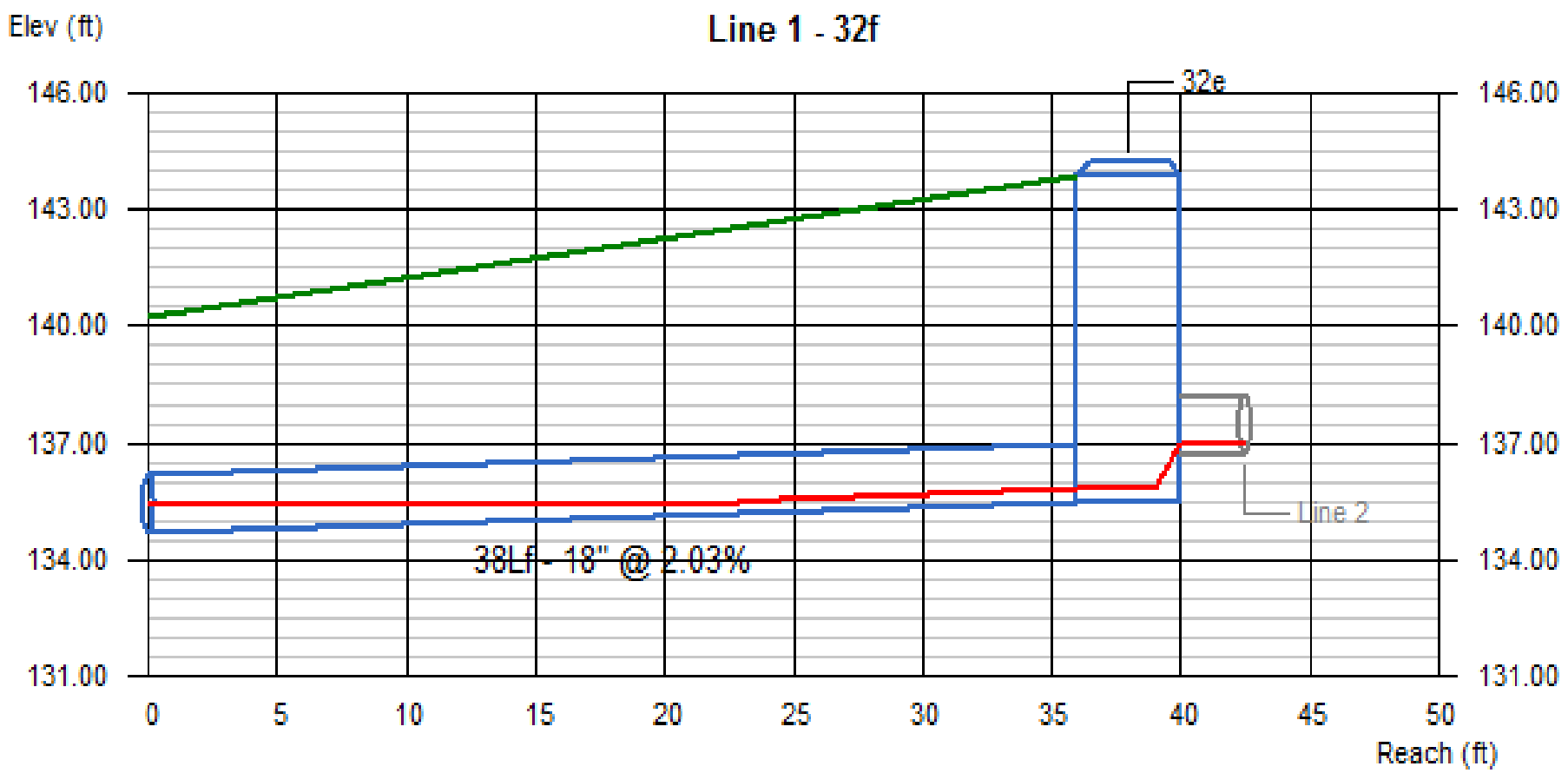
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.75	134.71	135.42	0.71	0.82	0.91	0.01	135.43	0.092	38	135.48	135.81 j	0.33**	0.29	2.60	0.10	135.92	1.664	0.878	n/a	1.50	0.16
2	18	0.42	136.70	136.95	0.25*	0.19	2.20	0.08	137.02	1.696	71	138.12	138.37	0.25**	0.19	2.20	0.08	138.44	1.696	1.696	n/a	1.50	0.11
3	18	0.36	138.29	138.52	0.23*	0.17	2.11	0.07	138.59	1.712	167	138.79	140.02	1.23	1.55	0.23	0.00	140.02	0.004	0.858	1.433	0.50	0.00
4	18	0.33	135.65	135.87	0.22*	0.16	2.06	0.07	135.94	1.721	71	136.00	136.56	0.56	0.60	0.55	0.00	136.56	0.042	0.882	0.626	1.00	0.00
5	18	0.19	138.79	140.02	1.23	1.55	0.12	0.00	140.02	0.001	75	139.02	140.02	1.00	1.26	0.15	0.00	140.02	0.002	0.002	0.001	1.00	0.00

31 32 | Number of lines: 5 | Run Date: 11-04-2013

Notes: * depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

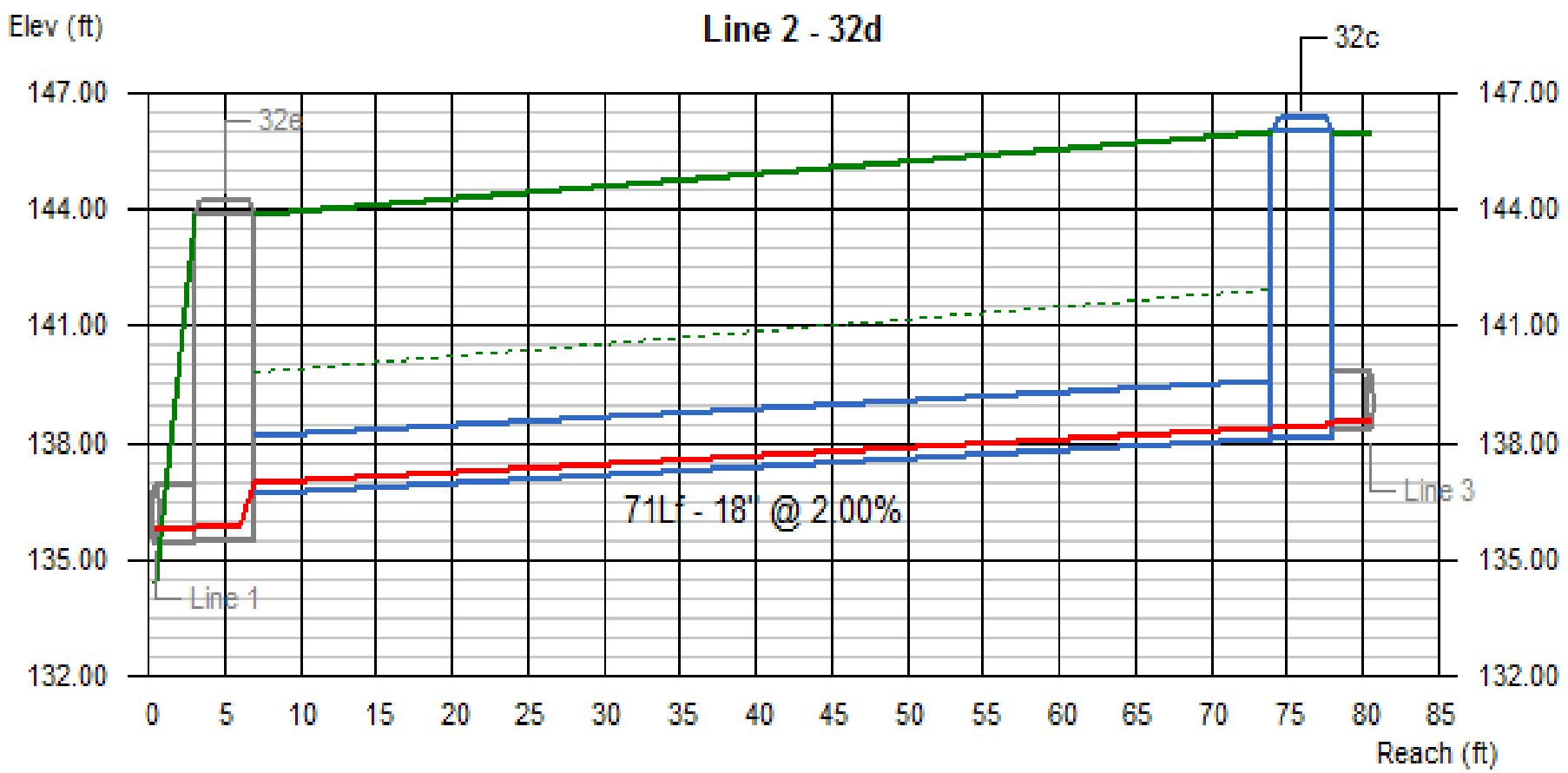
Line Profile (Line 1) - 32f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.75	134.71	135.48	0.71	0.33	0.33	135.42	135.81 j	135.81	0.91	2.60	4.00	6.87

31 32	No. Lines: 5	Run Date: 11-04-2013

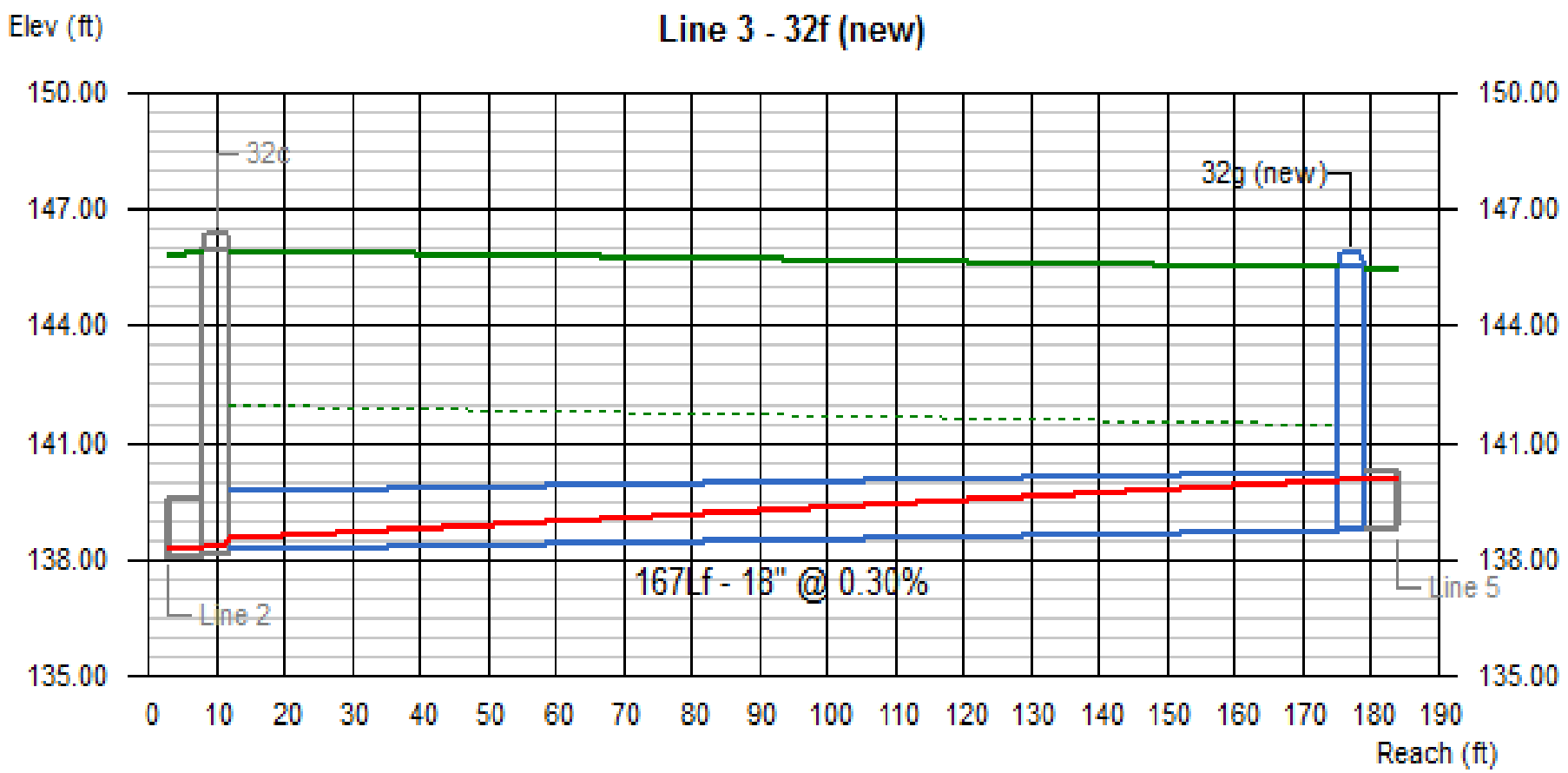
Line Profile (Line 2) - 32d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.42	136.70	138.12	0.25	0.25	0.25	136.95	138.37	138.37	2.20	2.20	5.65	6.36

31 32 | No. Lines: 5 | Run Date: 11-04-2013

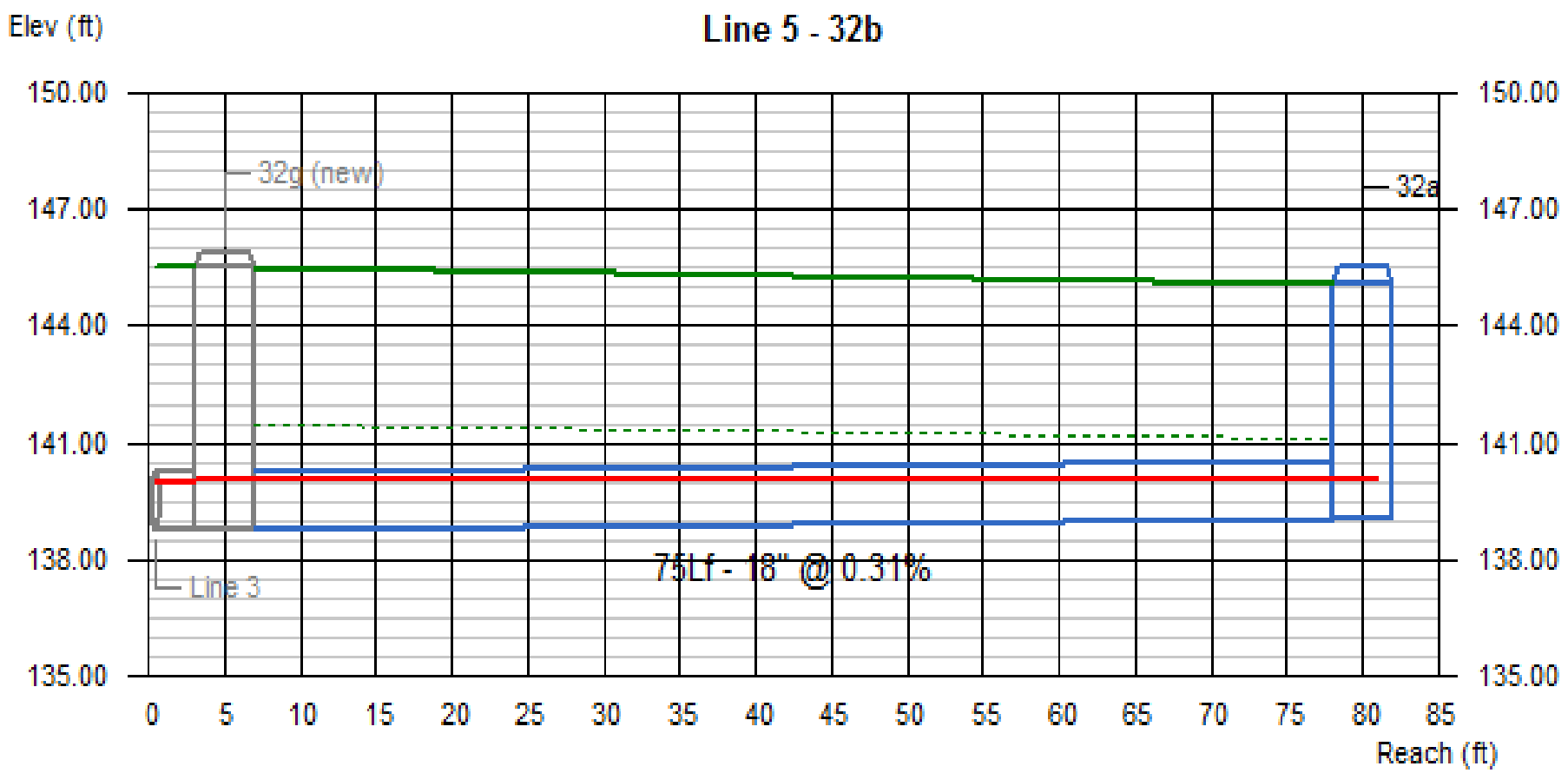
Line Profile (Line 3) - 32f (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.36	138.29	138.79	0.23	1.23	1.23	138.52	140.02	140.02	2.11	0.23	6.19	5.21

31 32 | No. Lines: 5 | Run Date: 11-04-2013

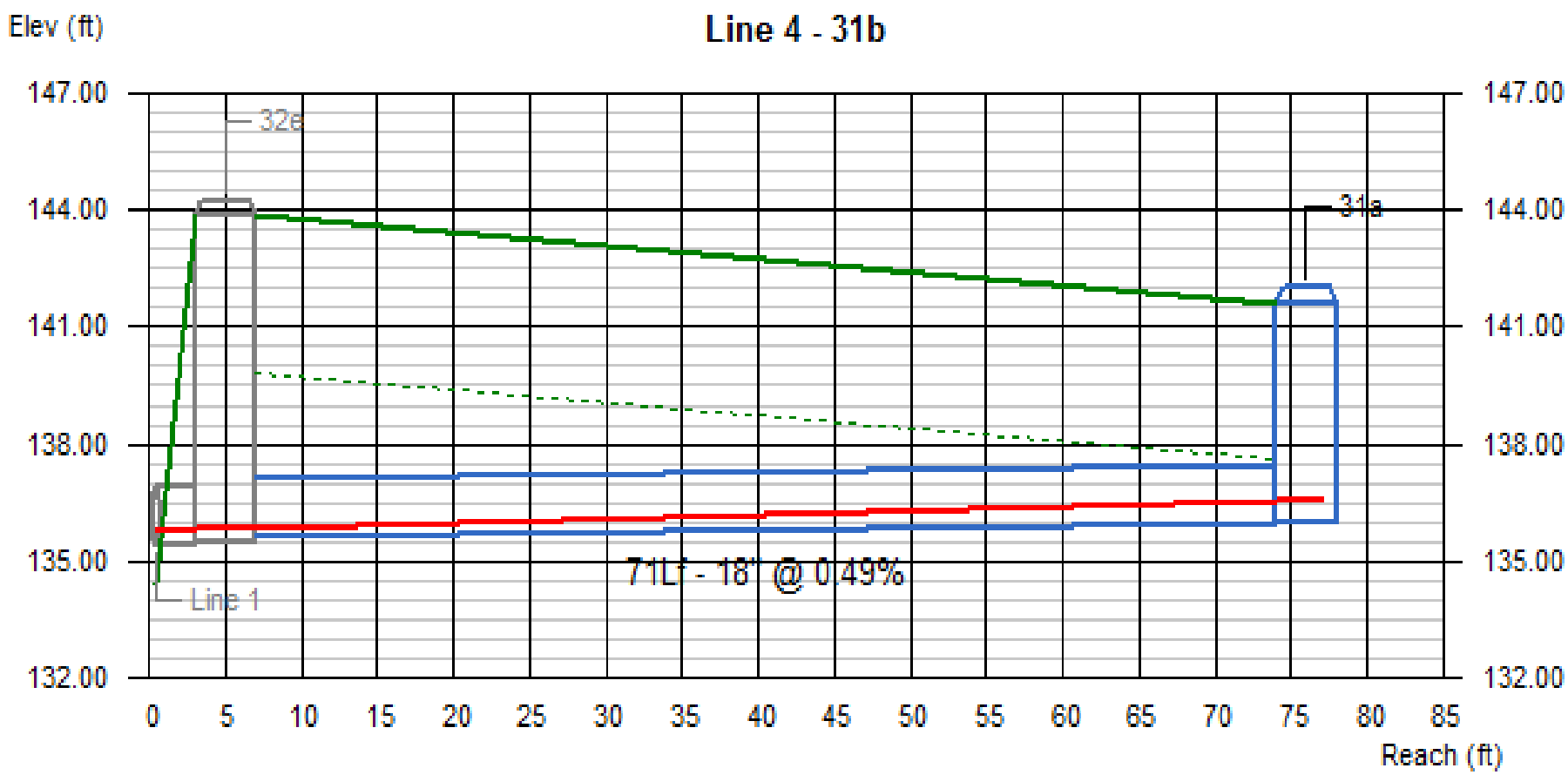
Line Profile (Line 5) - 32b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.19	138.79	139.02	1.23	1.00	1.00	140.02	140.02	140.02	0.12	0.15	5.21	4.59

31 32	No. Lines: 5	Run Date: 11-04-2013

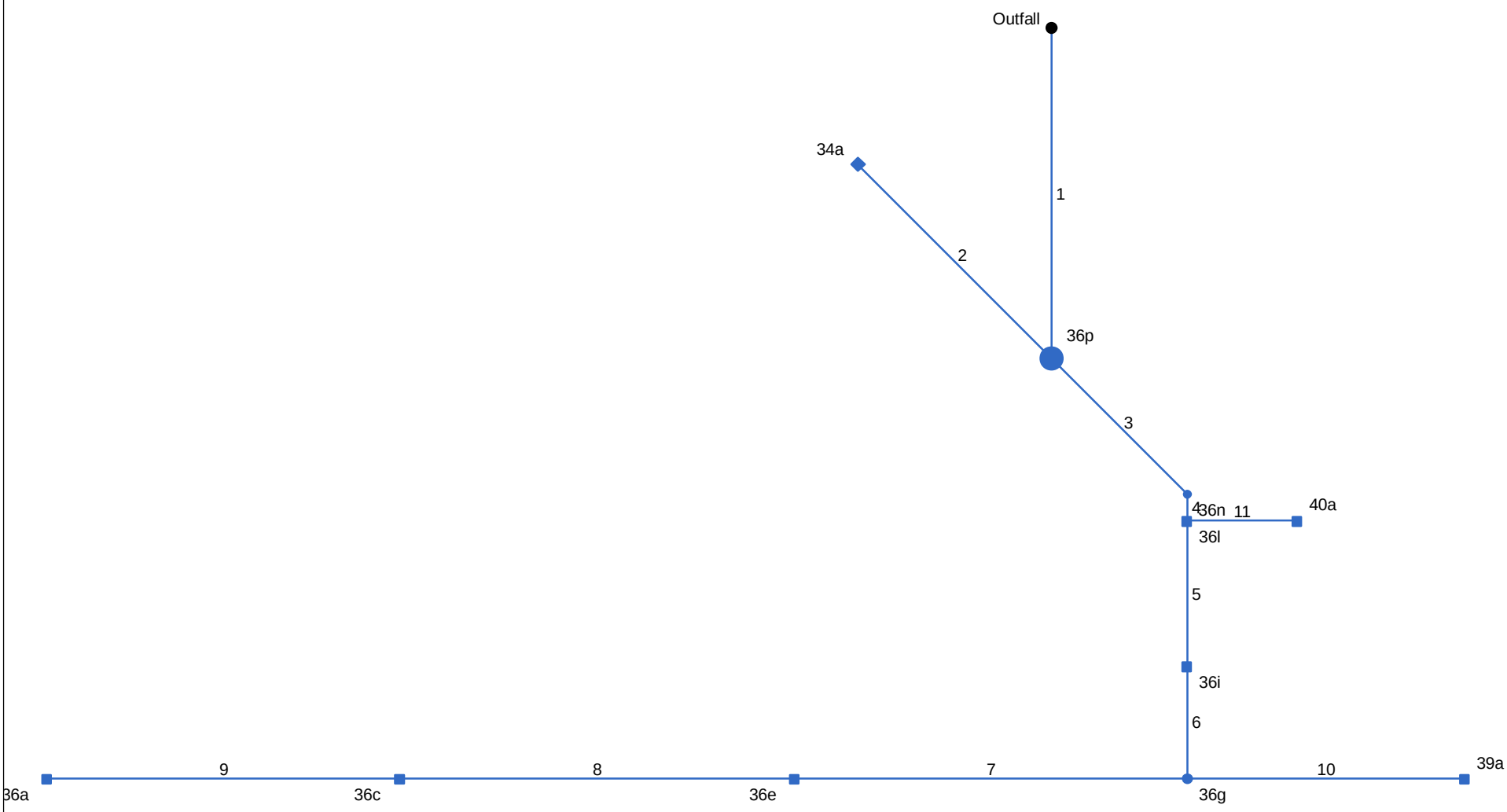
Line Profile (Line 4) - 31b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.33	135.65	136.00	0.22	0.56	0.56	135.87	136.56	136.56	2.06	0.55	6.70	4.11

31 32	No. Lines: 5	Run Date: 11-04-2013

34 36 39 40



Project File: Drainage System 34, 36, 39, 40.stm	Number of lines: 11	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	150	0.00	2.25	0.00	0.00	2.23	0.0	14.6	1.6	3.55	412.3	3.07	84	1.54	111.60	113.91	112.08	114.39	126.04	126.04	Existing Pipe and
2	1	124	0.36	0.36	1.00	0.36	0.36	5.0	5.0	2.7	0.99	2.98	1.74	18	0.30	117.98	118.35	118.36	119.53	126.04	122.02	34b
3	1	87	0.00	1.89	0.00	0.00	1.87	5.0	14.1	1.6	3.03	2.99	2.86	18	0.30	117.98	118.24	118.64	119.80	126.04	124.59	36o
4	3	12	0.33	1.89	1.00	0.33	1.87	5.0	13.9	1.6	3.04	2.73	1.75	18	0.25	118.41	118.44	119.83	119.87	124.59	123.93	36m
5	4	66	0.27	1.39	1.00	0.27	1.37	5.0	13.1	1.7	2.30	3.08	1.32	18	0.32	118.44	118.65	119.94	120.04	123.93	124.67	36k
6	5	51	0.10	1.12	1.00	0.10	1.10	5.0	12.3	1.7	1.90	2.96	1.14	18	0.29	118.65	118.80	120.06	120.11	124.67	123.93	36h
7	6	178	0.30	0.86	1.00	0.30	0.84	5.0	9.7	2.0	1.64	2.98	1.14	18	0.30	118.80	119.33	120.16	120.34	123.93	125.32	36f
8	7	179	0.26	0.56	1.00	0.26	0.54	5.0	7.2	2.3	1.22	3.00	1.19	18	0.30	119.33	119.87	120.36	120.60	125.32	127.00	36d
9	8	160	0.30	0.30	0.92	0.28	0.28	5.0	5.0	2.7	0.76	2.99	1.11	18	0.30	119.87	120.35	120.62	120.88	127.00	126.84	36b
10	6	126	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.7	0.44	3.00	0.31	18	0.30	118.80	119.18	120.16	120.17	123.93	122.94	39b
11	4	50	0.17	0.17	1.00	0.17	0.17	5.0	5.0	2.7	0.47	4.76	0.30	18	0.76	118.44	118.82	119.94	119.94	123.93	122.98	40b

34 36 39 40

Number of lines: 11

Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

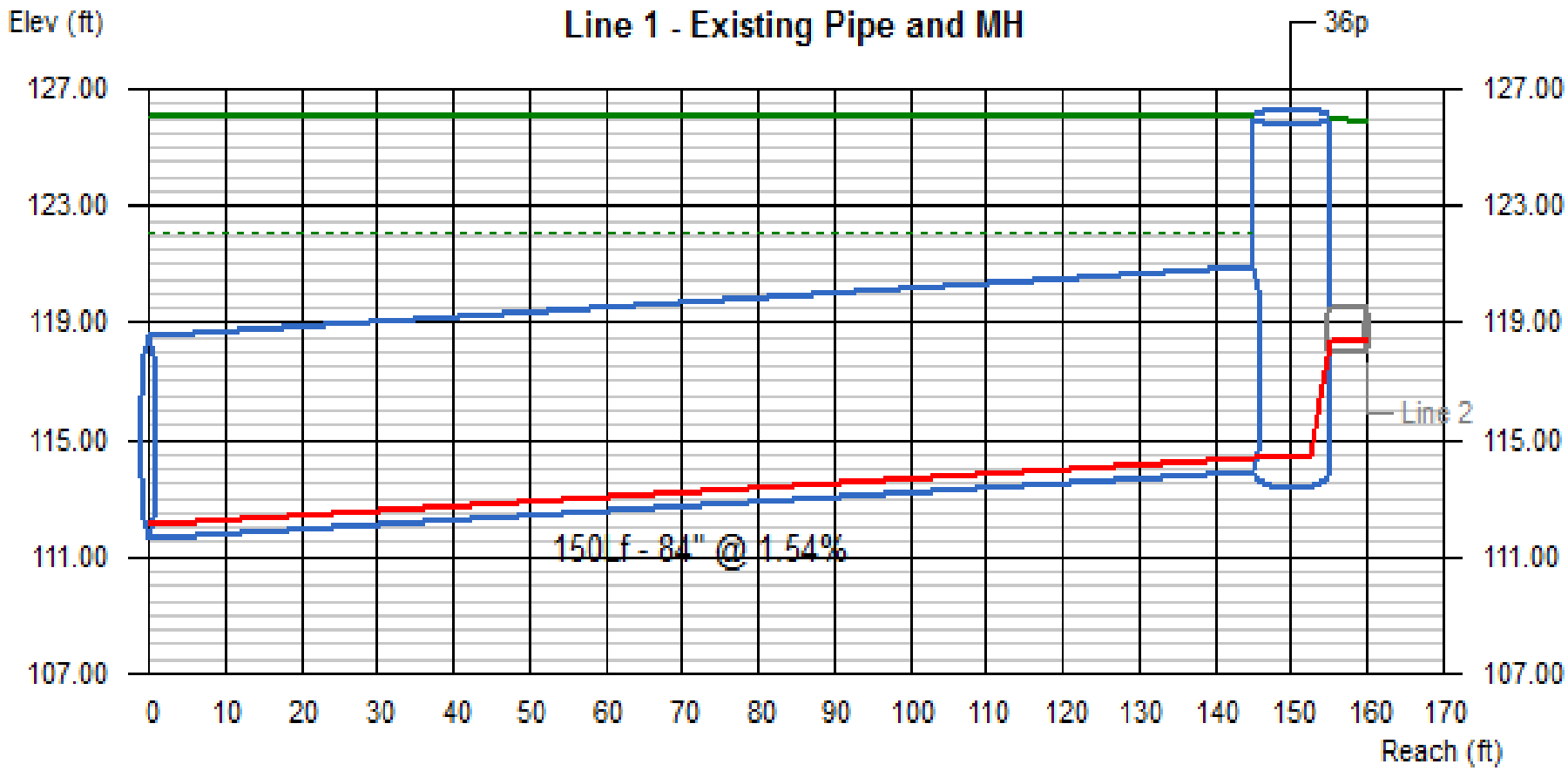
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	84	3.55	111.60	112.08	0.48	1.15	3.07	0.15	112.23	1.271	150	113.91	114.39	0.48**	1.15	3.07	0.15	114.54	1.271	1.271	n/a	1.00	0.15
2	18	0.99	117.98	118.36	0.38*	0.35	2.81	0.12	118.48	1.667	124	118.35	119.53	1.18	1.49	0.66	0.01	119.54	0.035	0.851	1.055	1.00	0.01
3	18	3.03	117.98	118.64	0.66*	0.76	4.01	0.25	118.89	1.877	87	118.24	119.80	1.50	1.77	1.71	0.05	119.84	0.308	1.092	0.950	0.75	0.03
4	18	3.04	118.41	119.83	1.42	1.73	1.76	0.05	119.88	0.269	12	118.44	119.87	1.43	1.73	1.75	0.05	119.91	0.269	0.269	0.032	1.50	0.07
5	18	2.30	118.44	119.94	1.50	1.77	1.30	0.03	119.96	0.172	66	118.65	120.04	1.39	1.71	1.34	0.03	120.07	0.154	0.163	0.107	0.50	0.01
6	18	1.90	118.65	120.06	1.41	1.72	1.11	0.02	120.08	0.105	51	118.80	120.11	1.31	1.64	1.16	0.02	120.13	0.110	0.108	0.055	2.25	0.05
7	18	1.64	118.80	120.16	1.36	1.68	0.98	0.01	120.17	0.079	178	119.33	120.34	1.01	1.27	1.29	0.03	120.37	0.142	0.111	0.197	0.50	0.01
8	18	1.22	119.33	120.36	1.03	1.29	0.95	0.01	120.37	0.076	179	119.87	120.60	0.73	0.86	1.42	0.03	120.63	0.217	0.146	0.262	0.50	0.02
9	18	0.76	119.87	120.62	0.75	0.88	0.86	0.01	120.63	0.078	160	120.35	120.88	0.53	0.56	1.37	0.03	120.91	0.273	0.175	0.281	1.00	0.03
10	18	0.44	118.80	120.16	1.36	1.68	0.26	0.00	120.16	0.006	126	119.18	120.17	0.99	1.23	0.36	0.00	120.17	0.011	0.008	0.010	1.00	0.00
11	18	0.47	118.44	119.94	1.50	1.77	0.26	0.00	119.94	0.007	50	118.82	119.94	1.12	1.42	0.33	0.00	119.94	0.009	0.008	0.004	1.00	0.00

34 36 39 40 | Number of lines: 11 | Run Date: 11-04-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

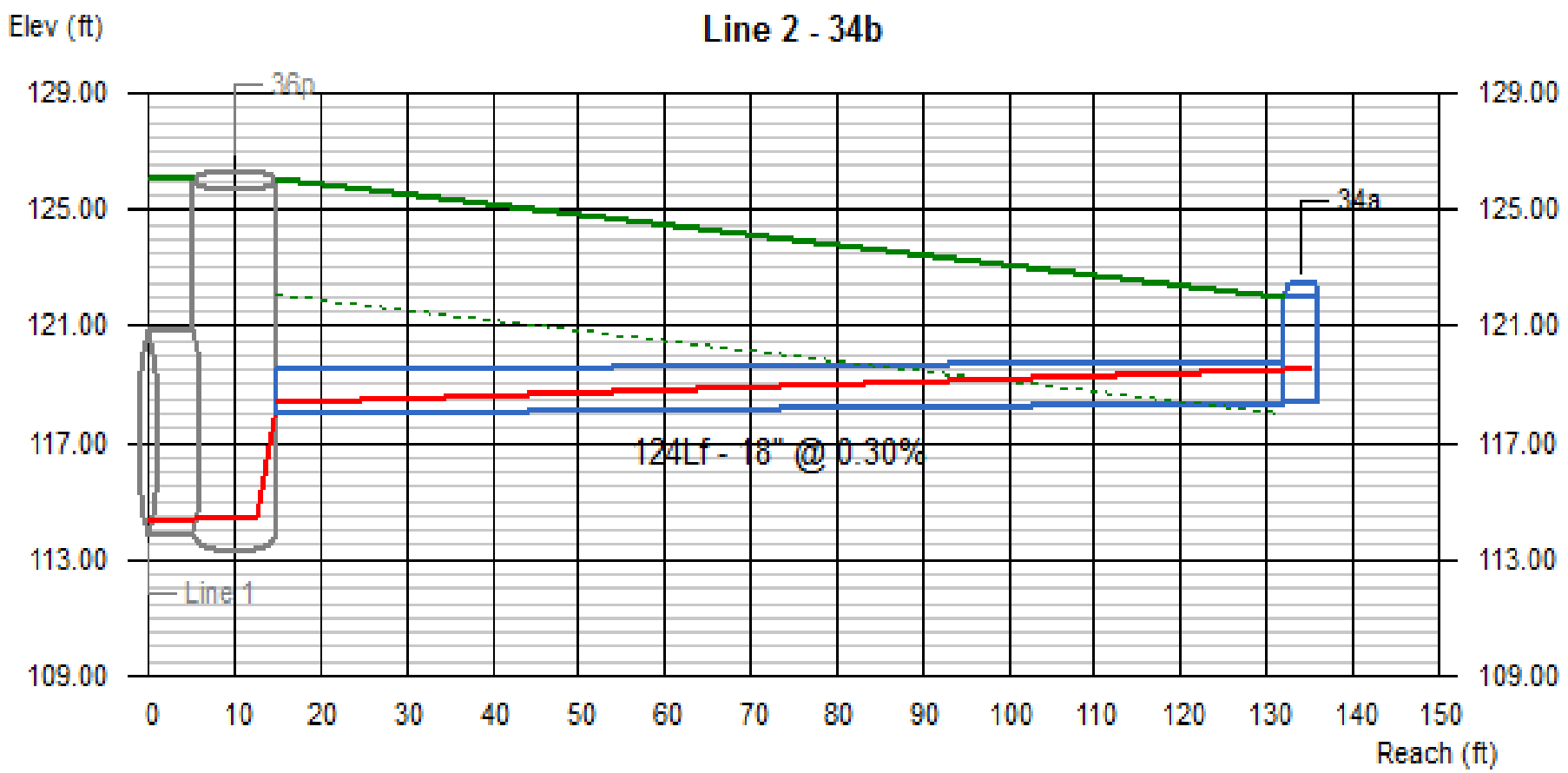
Line Profile (Line 1) - Existing Pipe and MH



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	3.55	111.60	113.91	0.48	0.48	0.48	112.08	114.39	114.39	3.07	3.07	7.44	5.13

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

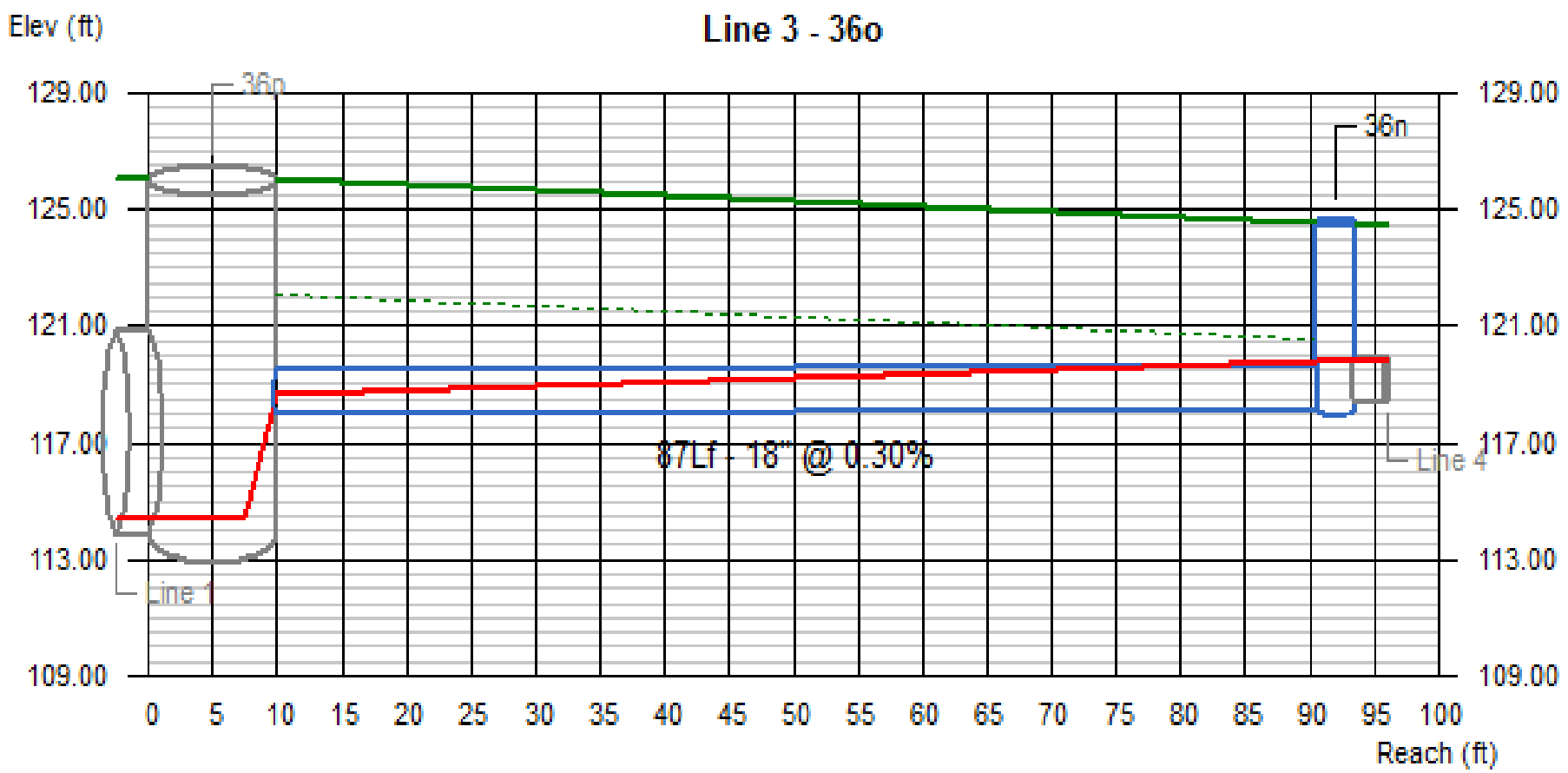
Line Profile (Line 2) - 34b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.99	117.98	118.35	0.38	1.18	1.19	118.36	119.53	119.54	2.81	0.66	6.56	2.17

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

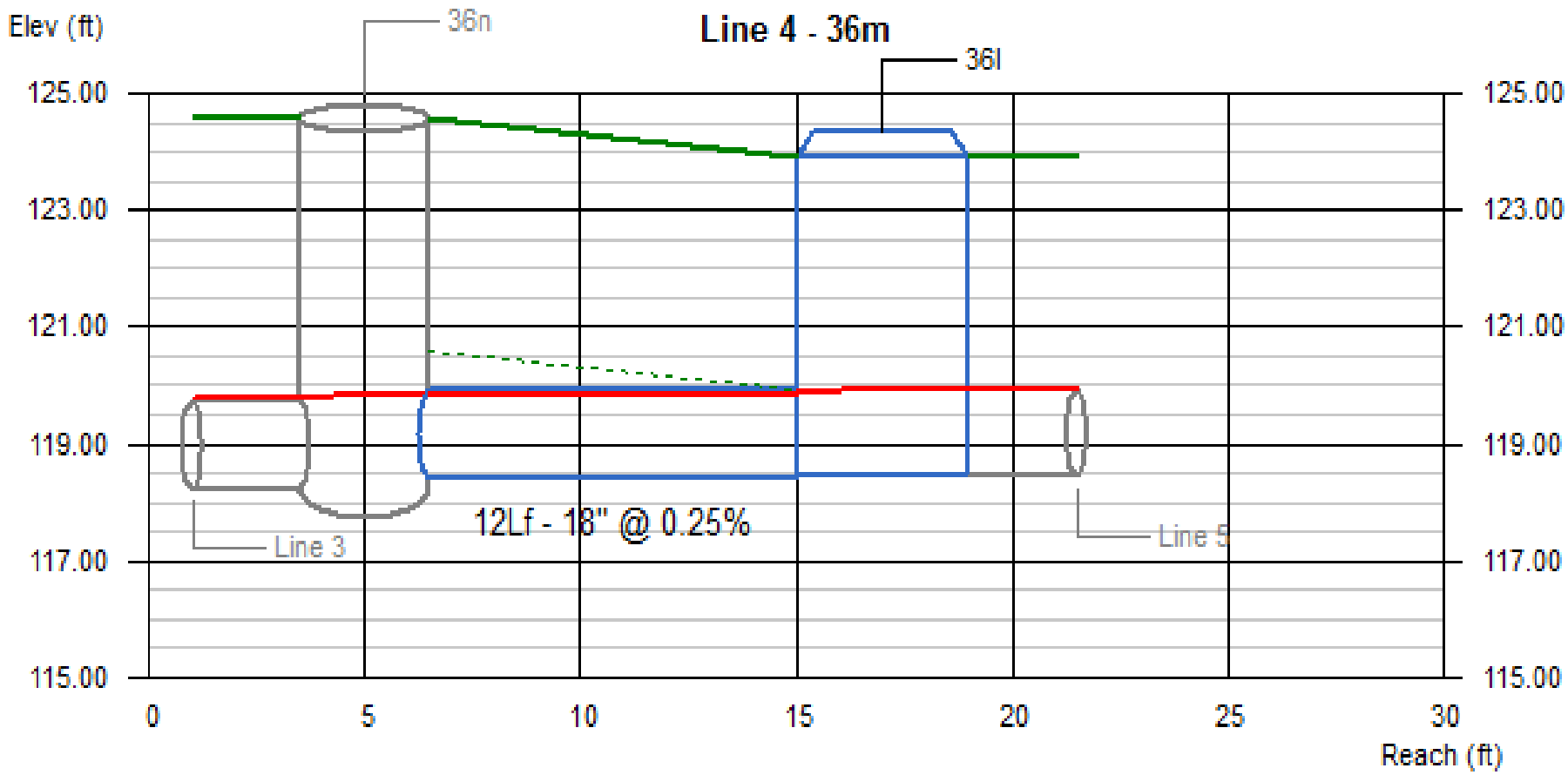
Line Profile (Line 3) - 36o



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	3.03	117.98	118.24	0.66	1.50	1.59	118.64	119.80	119.83	4.01	1.71	6.56	4.85

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

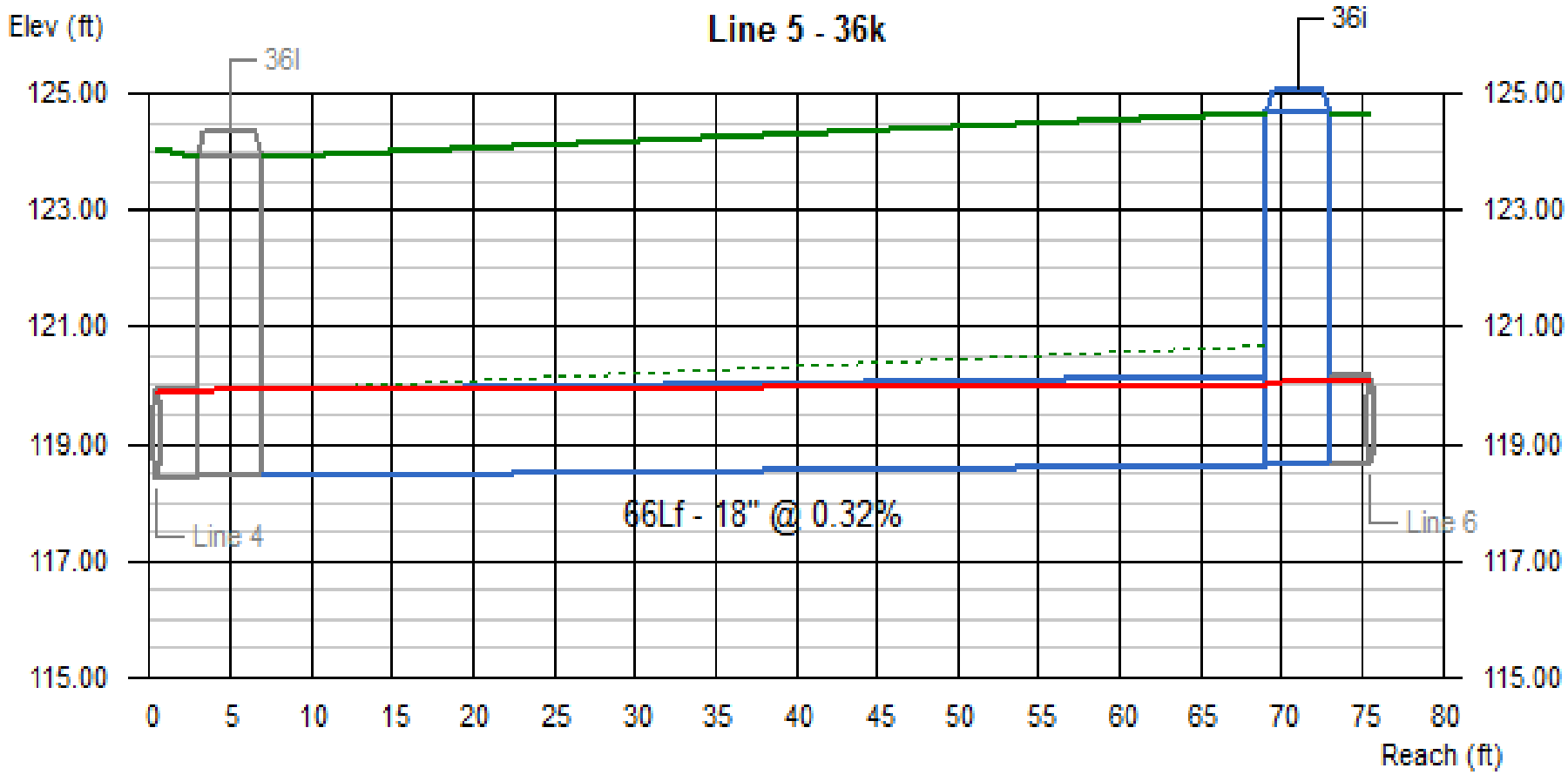
Line Profile (Line 4) - 36m



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	3.04	118.41	118.44	1.42	1.43	1.50	119.83	119.87	119.94	1.76	1.75	4.68	3.99

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

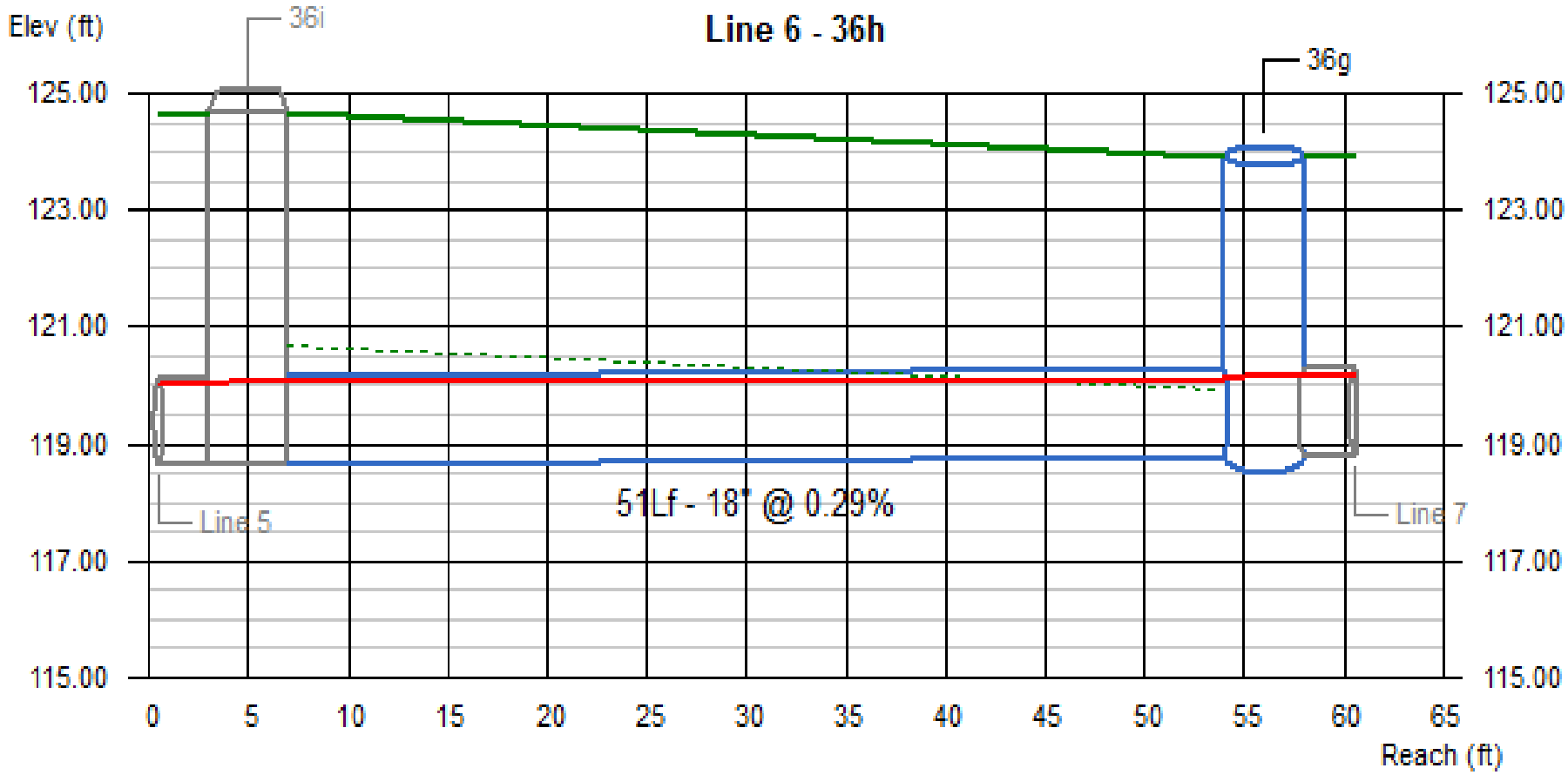
Line Profile (Line 5) - 36k



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	2.30	118.44	118.65	1.50	1.39	1.41	119.94	120.04	120.06	1.30	1.34	3.99	4.52

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

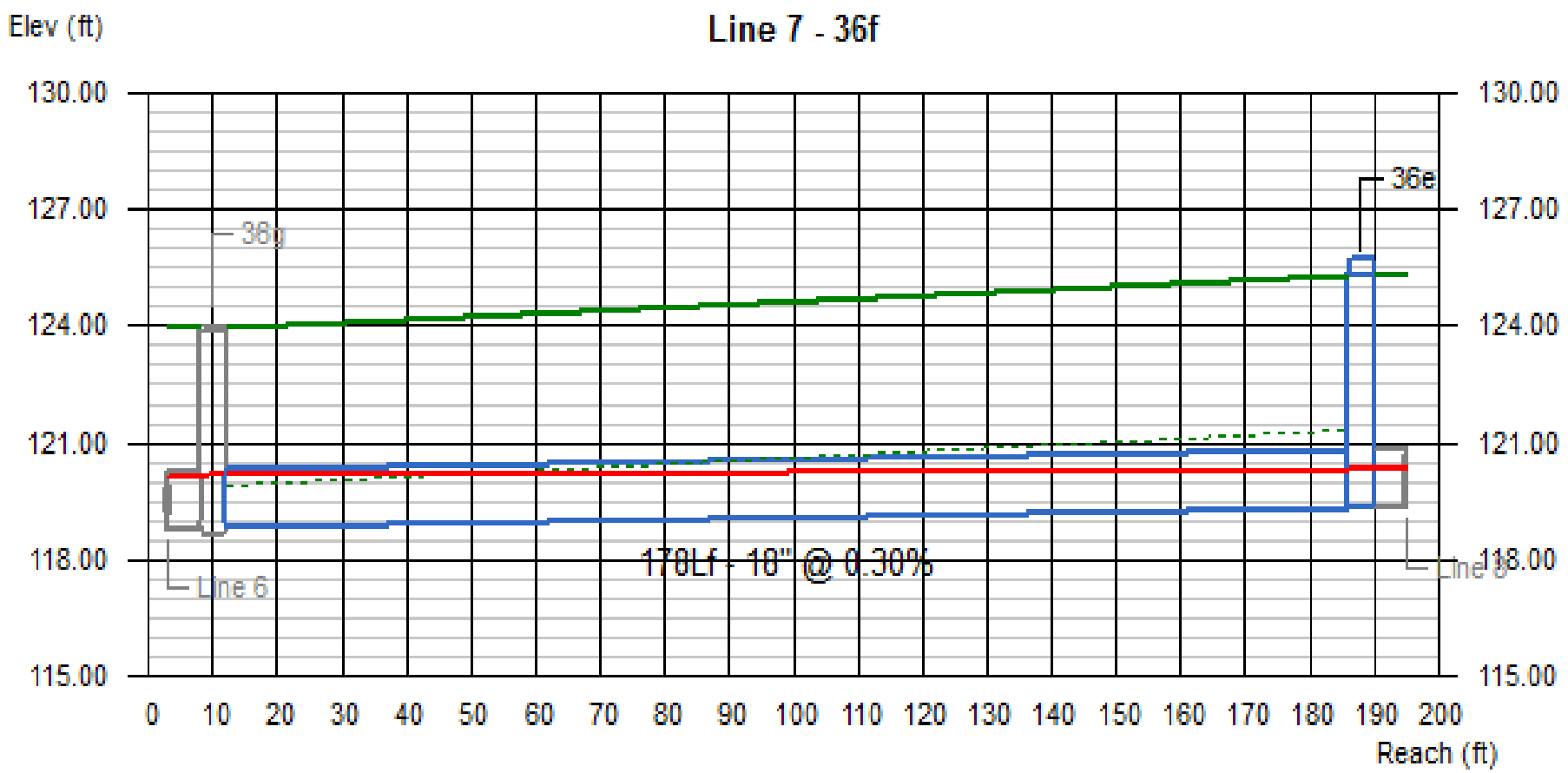
Line Profile (Line 6) - 36h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	1.90	118.65	118.80	1.41	1.31	1.36	120.06	120.11	120.16	1.11	1.16	4.52	3.63

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

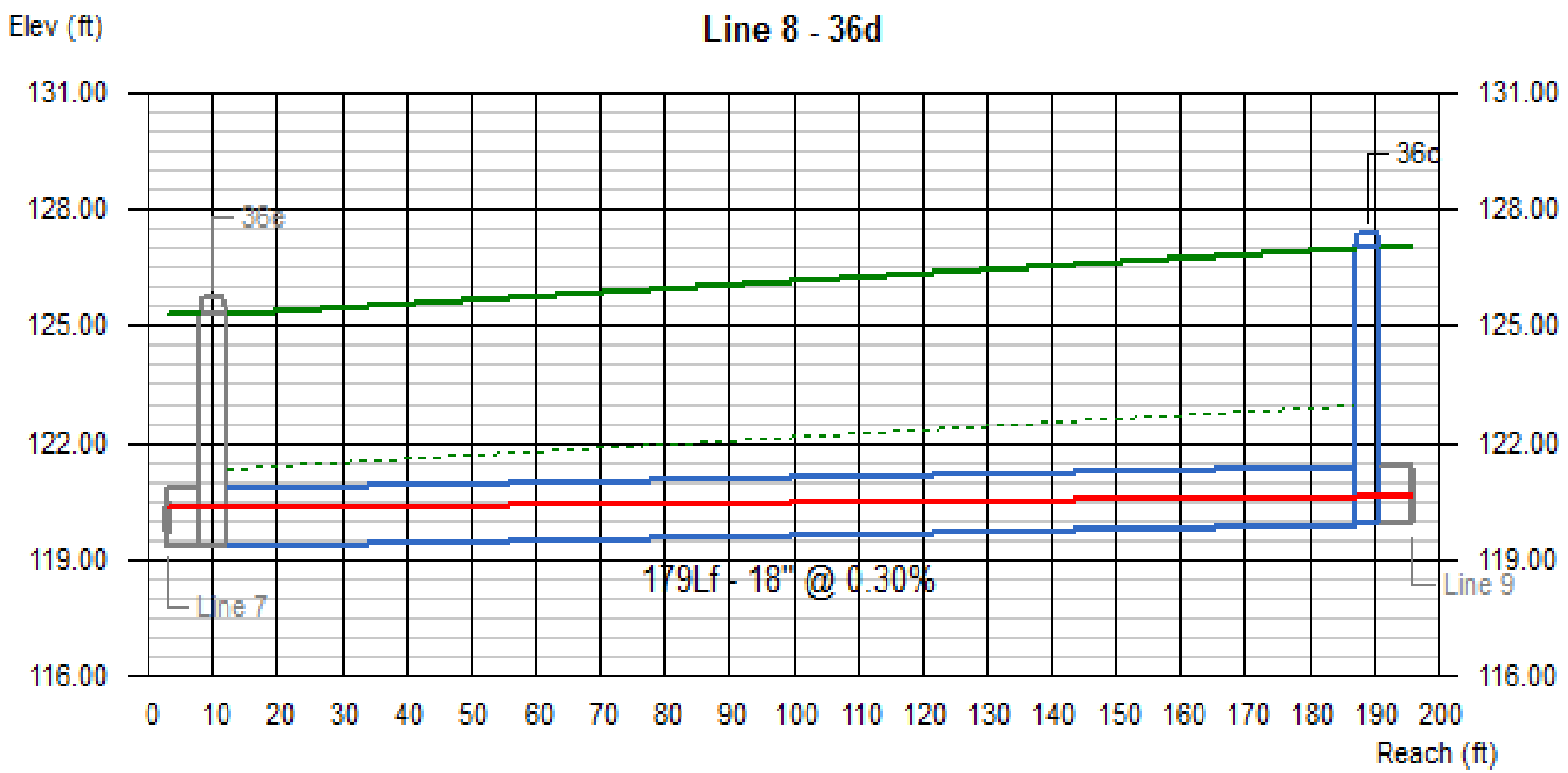
Line Profile (Line 7) - 36f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	1.64	118.80	119.33	1.36	1.01	1.03	120.16	120.34	120.36	0.98	1.29	3.63	4.49

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

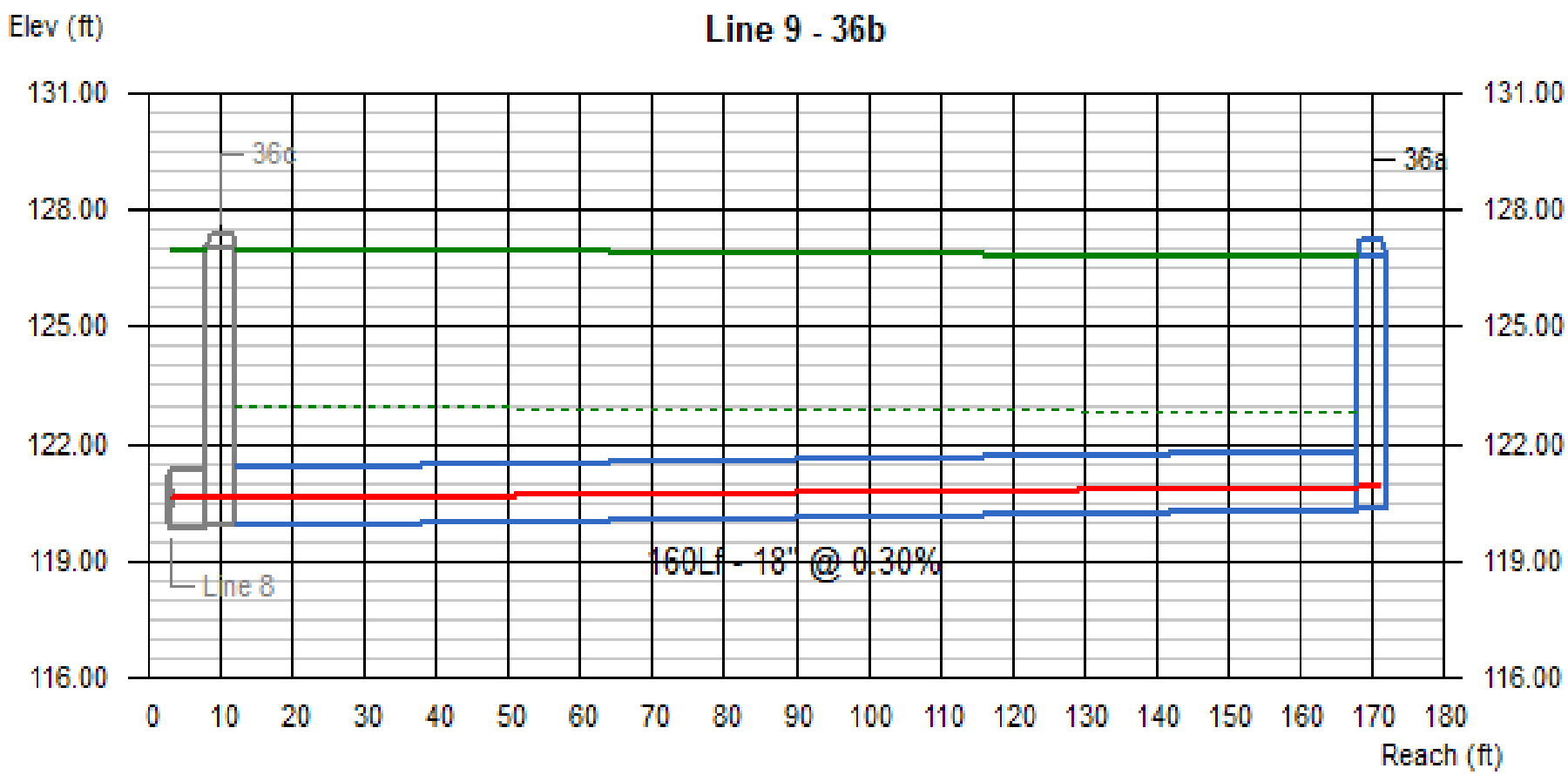
Line Profile (Line 8) - 36d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	1.22	119.33	119.87	1.03	0.73	0.75	120.36	120.60	120.62	0.95	1.42	4.49	5.63

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

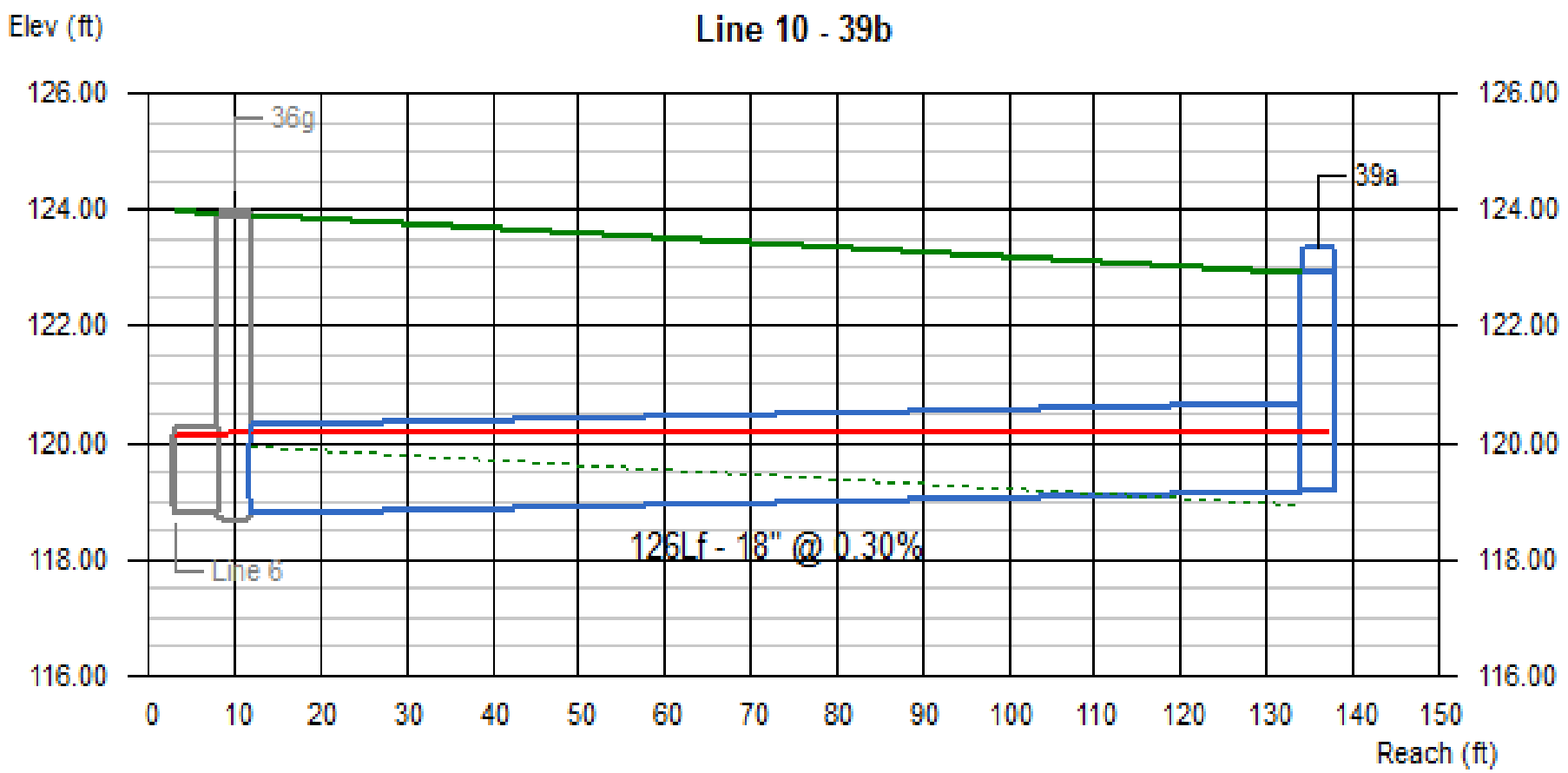
Line Profile (Line 9) - 36b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
9	0.76	119.87	120.35	0.75	0.53	0.56	120.62	120.88	120.91	0.86	1.37	5.63	4.99

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

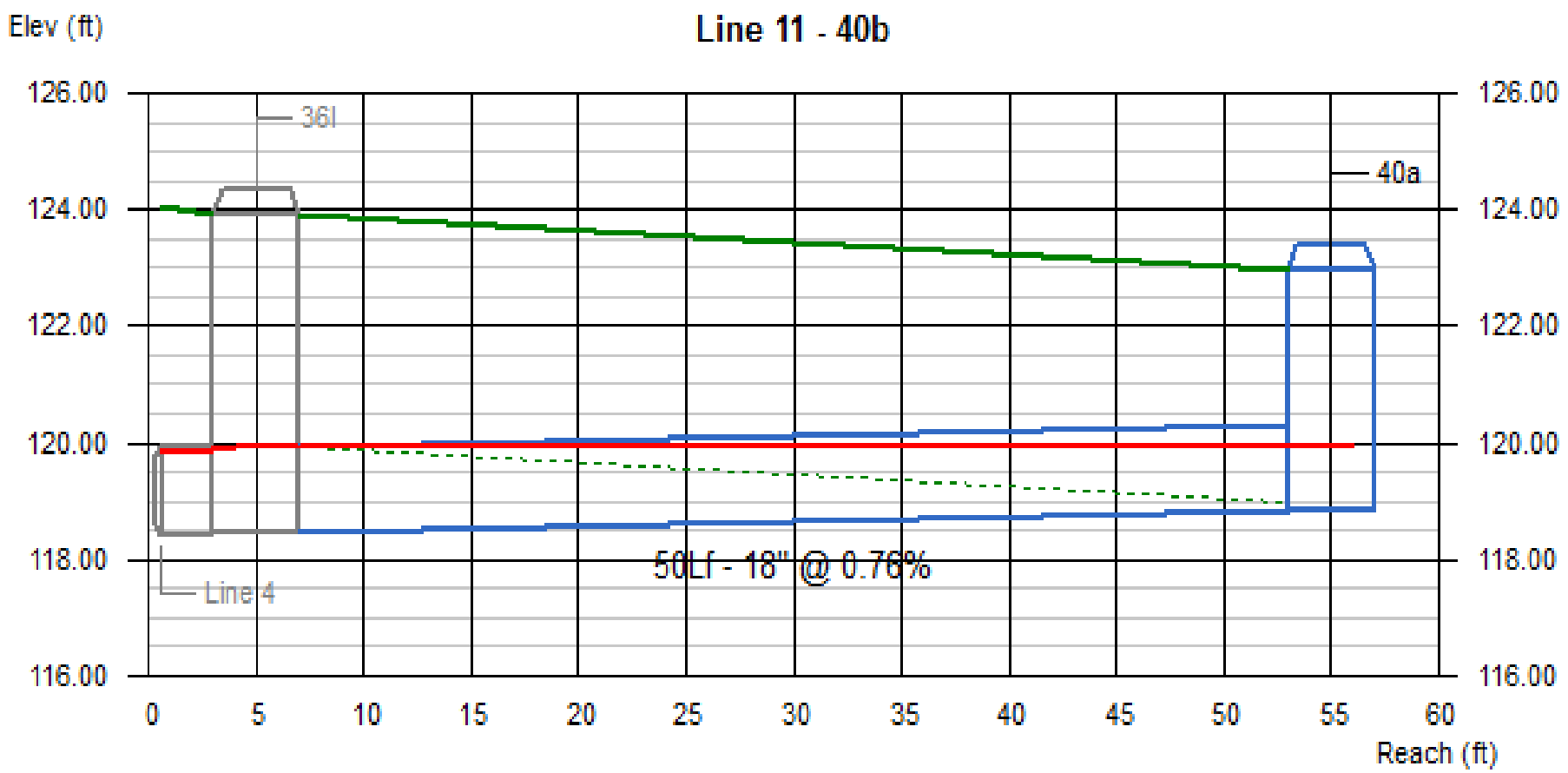
Line Profile (Line 10) - 39b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	0.44	118.80	119.18	1.36	0.99	0.99	120.16	120.17	120.17	0.26	0.36	3.63	2.26

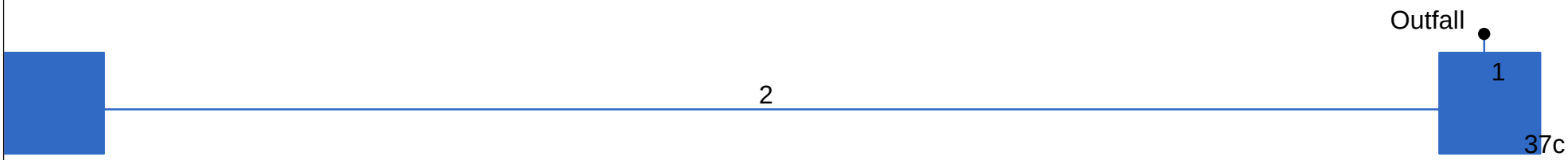
34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013

Line Profile (Line 11) - 40b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
11	0.47	118.44	118.82	1.50	1.12	1.12	119.94	119.94	119.94	0.26	0.33	3.99	2.66

34 36 39 40 | No. Lines: 11 | Run Date: 11-04-2013



Project File: Drainage System 37.stm	Number of lines: 2	Date: 10-29-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	3	0.07	0.37	1.00	0.07	0.37	5.0	5.5	2.3	0.86	8.34	2.68	18	2.33	121.84	121.91	122.19	122.27	127.18	127.08	37d
2	1	57	0.30	0.30	1.00	0.30	0.30	5.0	5.0	2.4	0.73	7.72	1.96	18	2.00	121.91	123.05	122.43	123.38	127.08	126.95	37b

37 | Number of lines: 2 | Run Date: 10-29-2013

NOTES: Intensity = 5.84 / (Inlet time + 0.20) ^ 0.53; Return period = 10 Yrs. ; c = cir e = ellip b = box

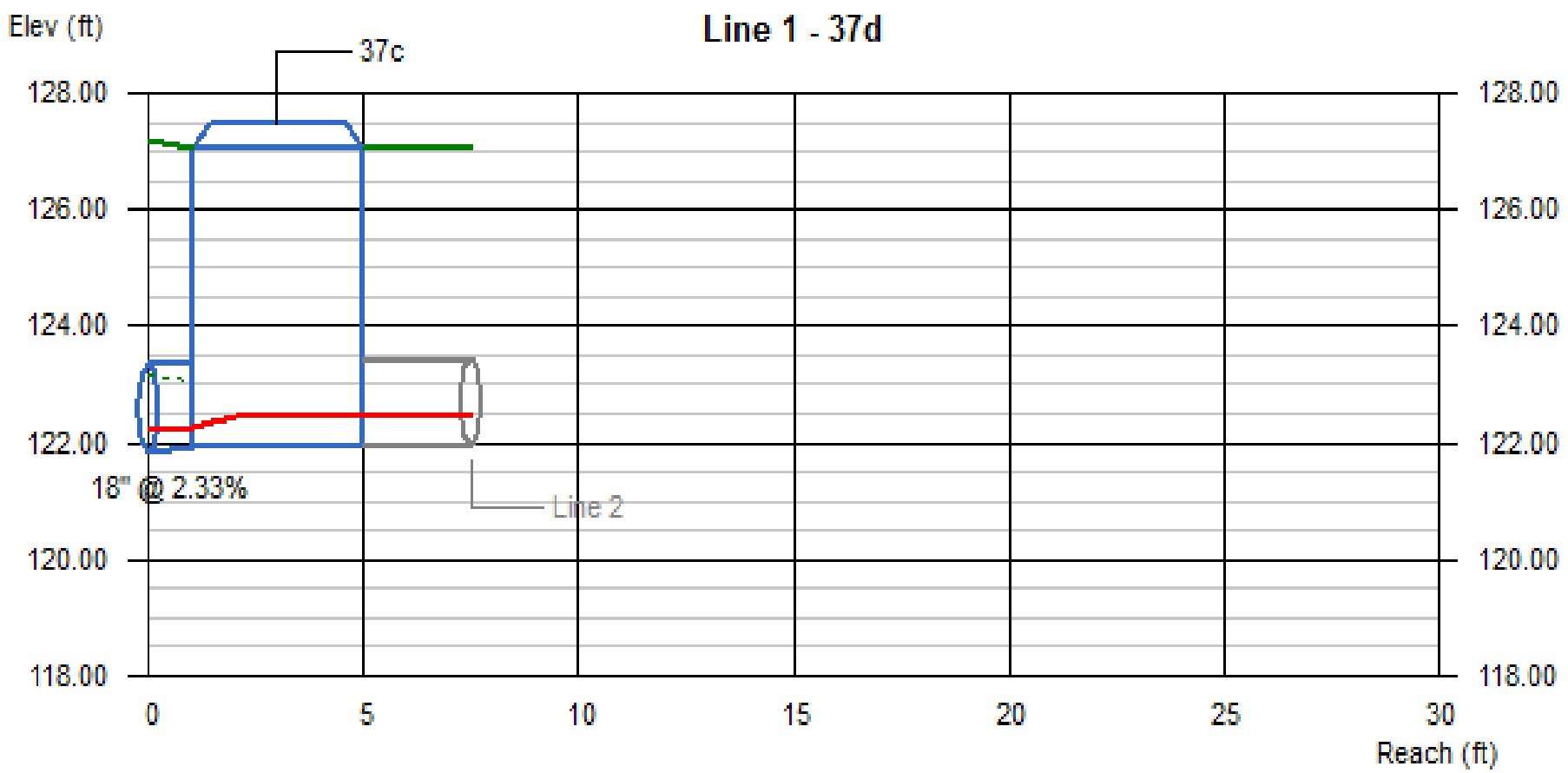
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.86	121.84	122.19	0.35	0.32	2.70	0.11	122.31	1.664	3	121.91	122.27	0.36**	0.32	2.67	0.11	122.38	1.605	1.635	0.049	1.50	0.17
2	18	0.73	121.91	122.43	0.52	0.55	1.33	0.03	122.46	0.263	57	123.05	123.38 j	0.33**	0.28	2.58	0.10	123.48	1.665	0.964	n/a	1.00	n/a

37 | Number of lines: 2 | Run Date: 10-29-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

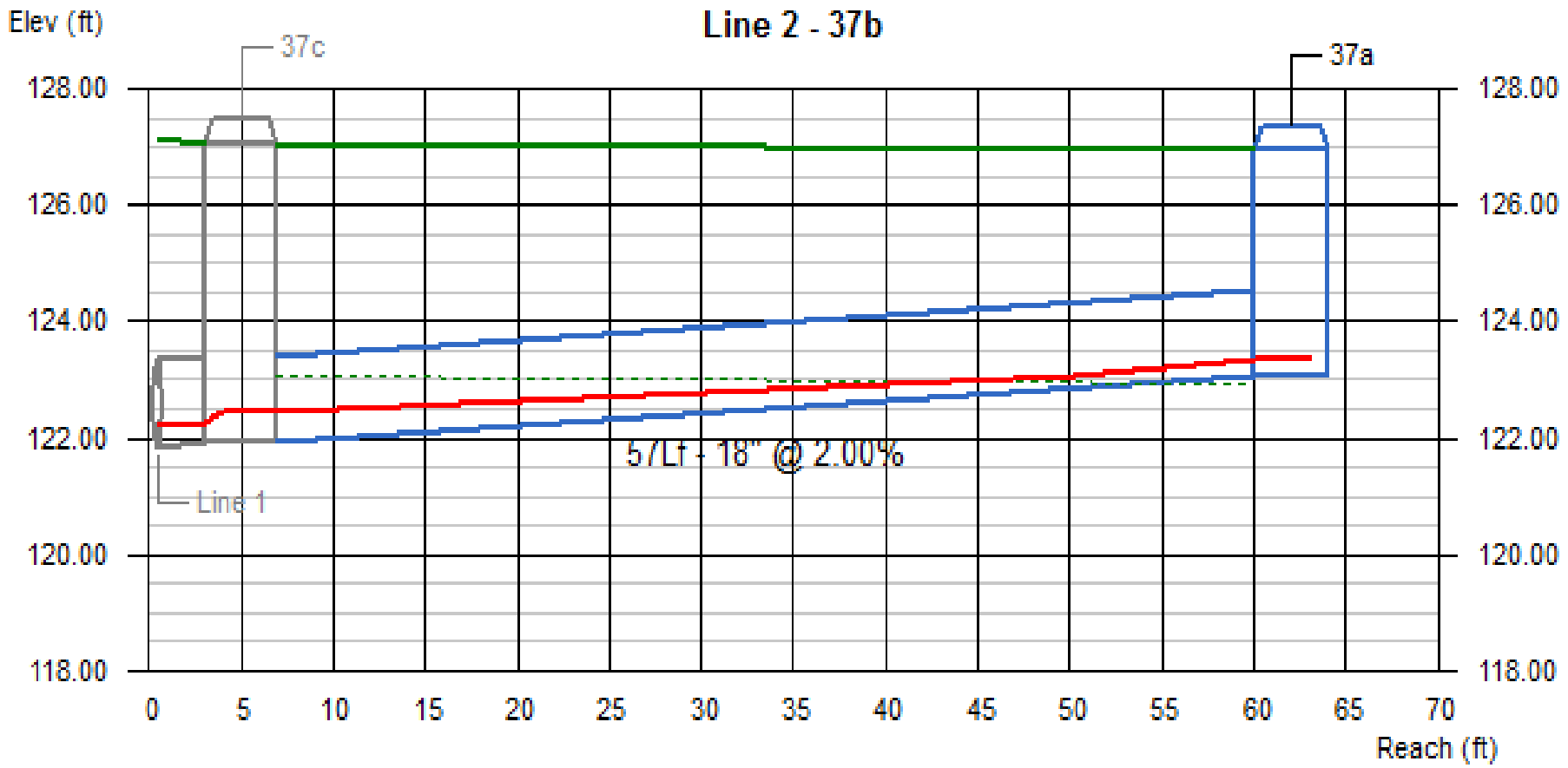
Line Profile (Line 1) - 37d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.86	121.84	121.91	0.35	0.36	0.52	122.19	122.27	122.43	2.70	2.67	3.84	3.67

37	No. Lines: 2	Run Date: 10-29-2013

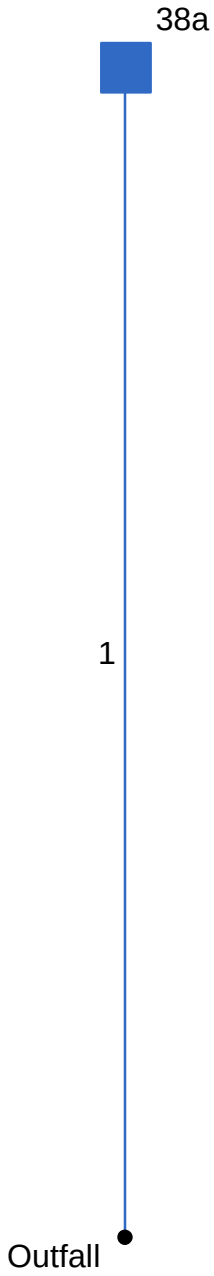
Line Profile (Line 2) - 37b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.73	121.91	123.05	0.52	0.33	0.33	122.43	123.38 j	123.38	1.33	2.58	3.67	2.40

37	No. Lines: 2	Run Date: 10-29-2013

38



Project File: Drainage System 38.stm	Number of lines: 1	Date: 11-04-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	95	0.49	0.49	1.00	0.49	0.49	5.0	5.0	2.7	1.35	7.74	3.09	18	2.01	116.66	118.57	117.10	119.01	126.04	123.86	38b

38	Number of lines: 1	Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

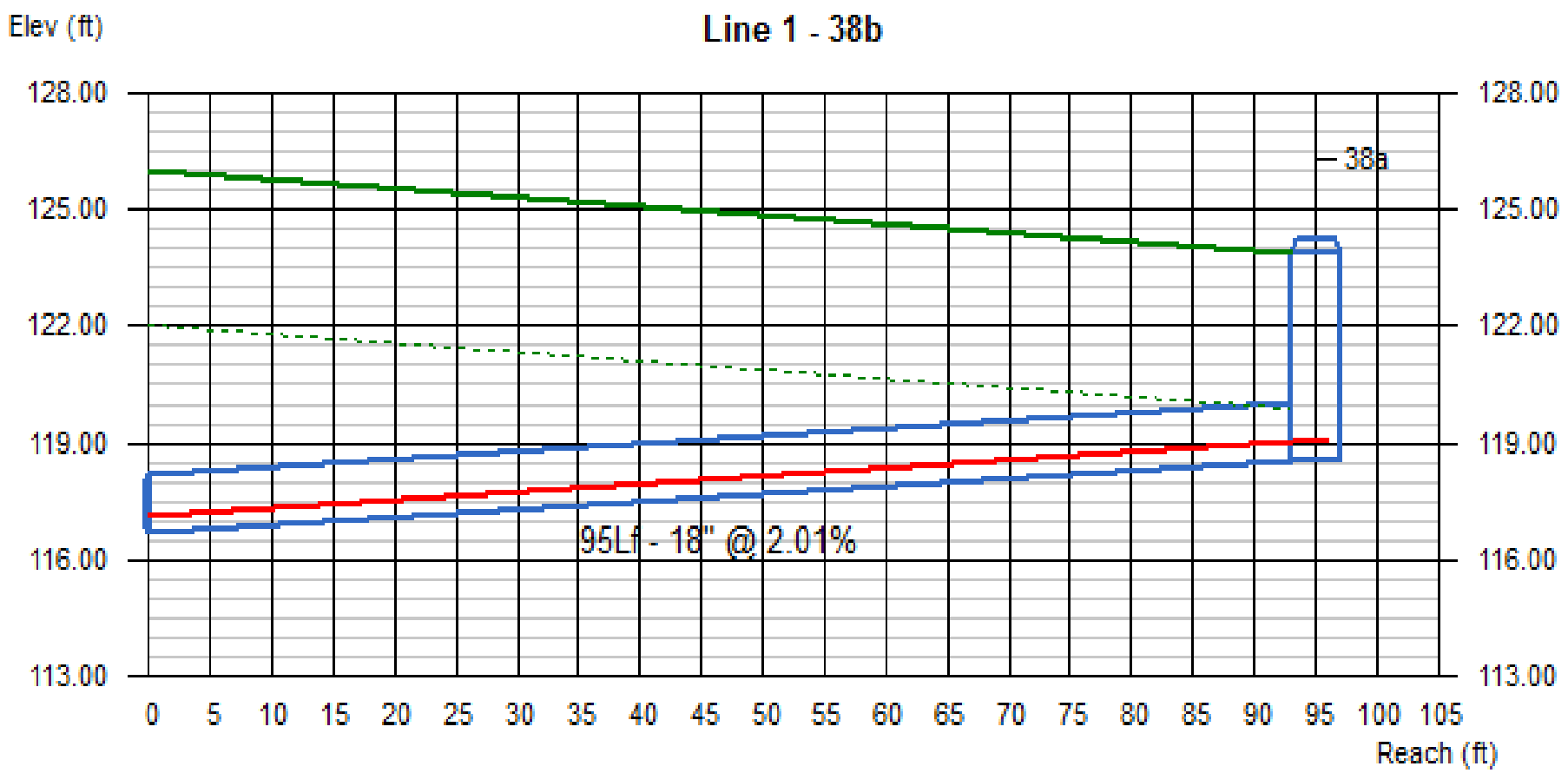
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	1.35	116.66	117.10	0.44	0.44	3.09	0.15	117.25	1.687	95	118.57	119.01	0.44**	0.44	3.09	0.15	119.16	1.687	1.687	n/a	1.00	n/a

38 | Number of lines: 1 | Run Date: 11-04-2013

Notes: ; ** Critical depth. ; c = cir e = ellip b = box

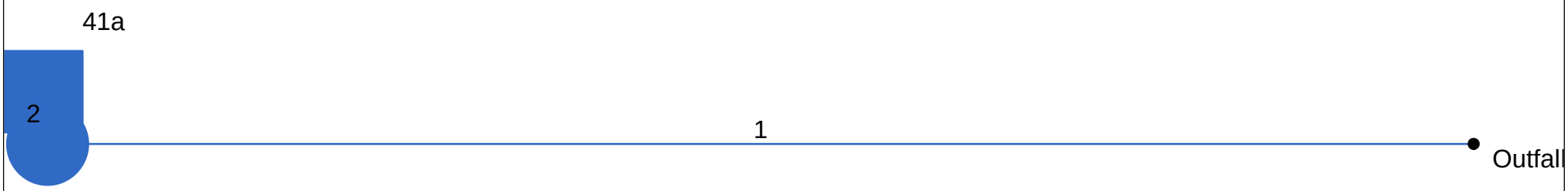
Line Profile (Line 1) - 38b



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
1	1.35	116.66	118.57	0.44	0.44	0.44	117.10	119.01	119.01	3.09	3.09	7.88	3.79

38	No. Lines: 1	Run Date: 11-04-2013

41



Project File: Drainage System 41.stm	Number of lines: 2	Date: 10-29-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	70	0.00	0.06	0.00	0.00	0.06	5.0	5.0	2.7	0.16	80.15	1.00	54	0.61	105.36	105.79	105.51	105.94	121.86	122.17	Existing Pipe and
2	1	3	0.06	0.06	1.00	0.06	0.06	5.0	5.0	2.7	0.16	8.34	1.69	18	2.33	116.13	116.20	116.29	116.36	122.17	121.67	41b

41 Number of lines: 2 Run Date: 10-29-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

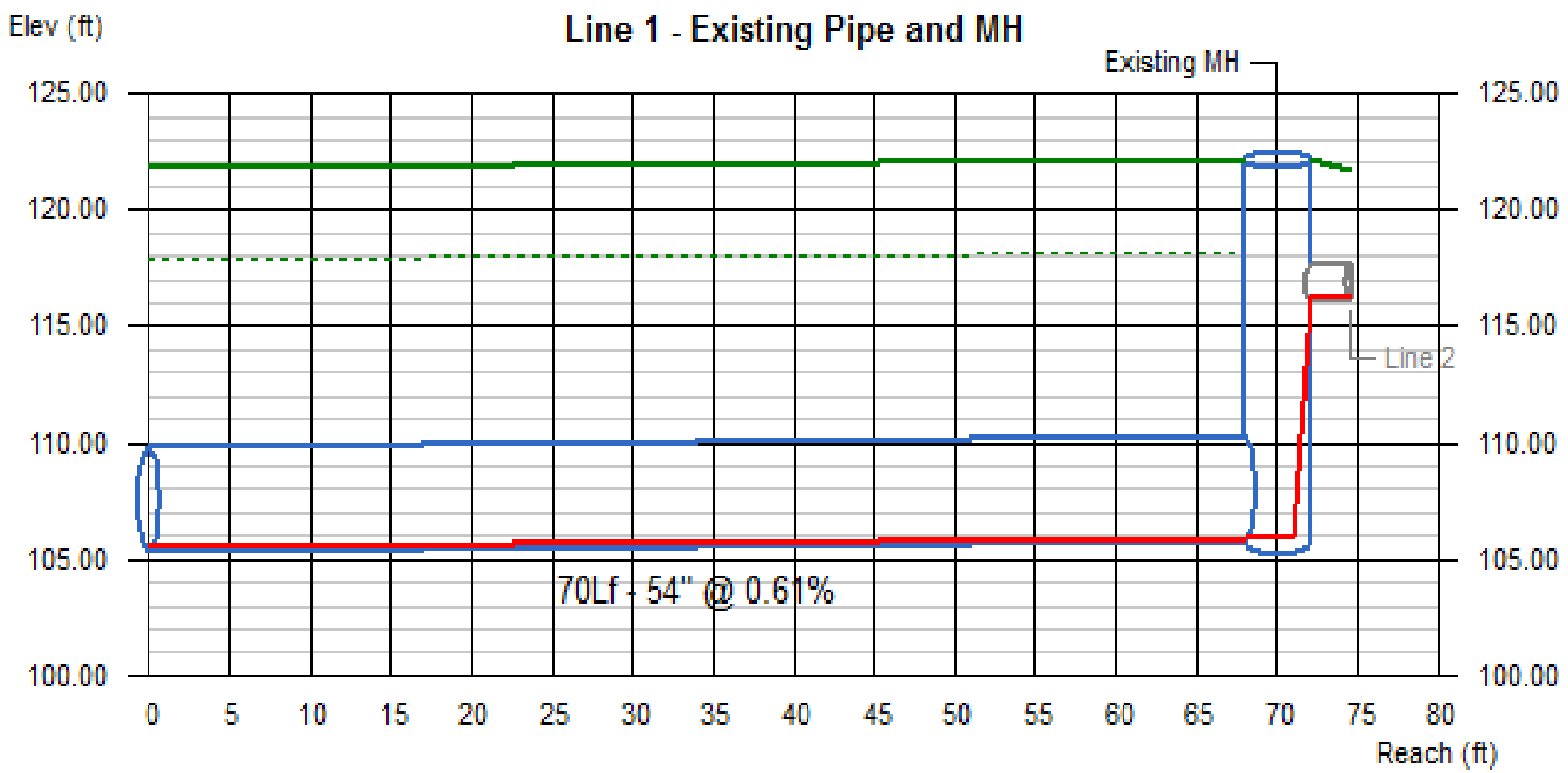
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	54	0.16	105.36	105.51	0.15	0.17	1.00	0.02	105.53	0.611	70	105.79	105.94	0.15	0.16	1.00	0.02	105.96	0.626	0.619	0.433	1.00	0.02
2	18	0.16	116.13	116.29	0.15*	0.10	1.71	0.05	116.33	1.825	3	116.20	116.36	0.16**	0.10	1.67	0.04	116.40	1.716	1.770	0.053	1.00	0.04

41	Number of lines: 2	Run Date: 10-29-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

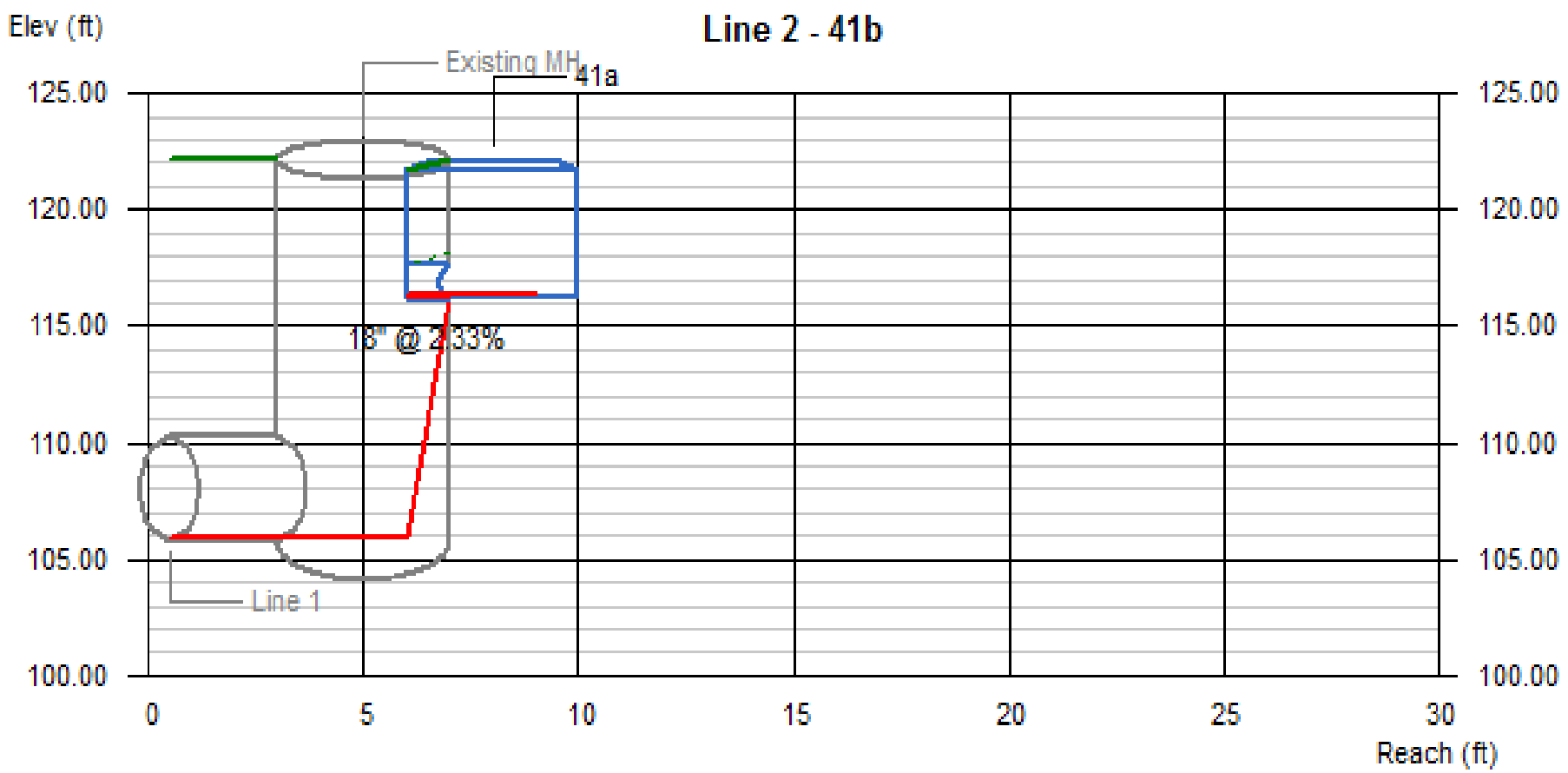
Line Profile (Line 1) - Existing Pipe and MH



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.16	105.36	105.79	0.15	0.15	0.17	105.51	105.94	105.96	1.00	1.00	12.00	11.88

41 | No. Lines: 2 | Run Date: 10-29-2013

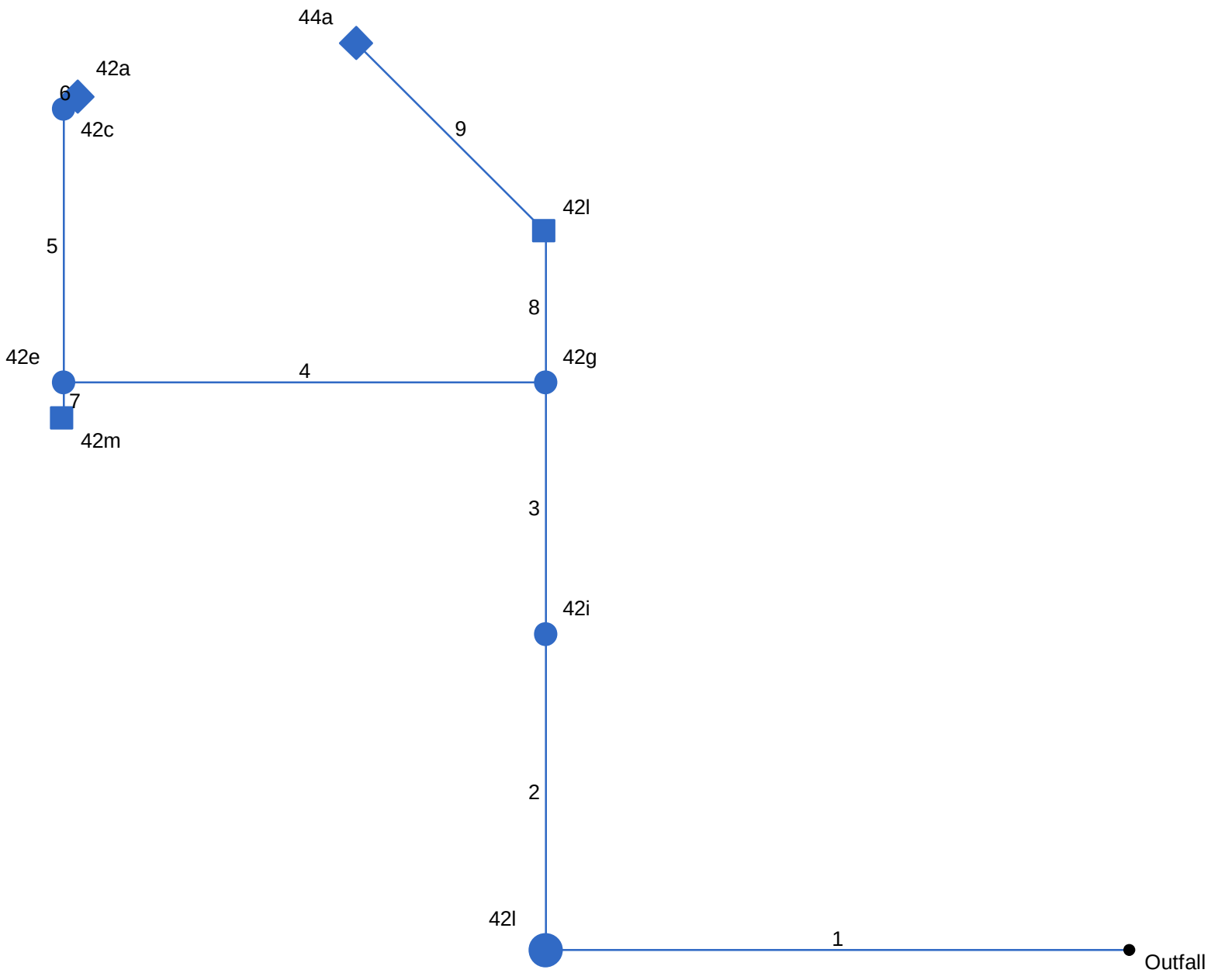
Line Profile (Line 2) - 41b



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
2	0.16	116.13	116.20	0.15	0.16	0.20	116.29	116.36	116.40	1.71	1.67	4.54	3.97

41	No. Lines: 2	Run Date: 10-29-2013

42 43 44



Project File: Drainage System 42 43 44.stm	Number of lines: 9	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	109	0.00	2.74	0.00	0.00	2.01	5.0	23.5	1.2	2.51	193.4	2.38	72	0.77	104.52	105.36	105.00	105.84	120.39	121.86	Existing Pipe
2	1	59	0.04	2.74	1.00	0.04	2.01	5.0	23.2	1.3	2.53	4.02	2.82	18	0.54	112.70	113.02	113.31	114.09	121.86	121.66	42k
3	2	47	0.00	2.70	0.00	0.00	1.97	0.0	22.8	1.3	2.50	3.82	1.90	18	0.49	113.02	113.25	114.12	114.25	121.66	121.15	42h
4	3	90	0.00	0.97	0.00	0.00	0.62	5.0	20.6	1.3	0.83	3.86	1.78	18	0.50	115.41	115.86	115.76	116.64	121.15	122.70	42f
5	4	51	0.00	0.94	0.00	0.00	0.59	5.0	20.0	1.4	0.80	3.90	1.38	18	0.51	116.03	116.29	116.66	116.78	122.70	123.65	42d
6	5	4	0.94	0.94	0.63	0.59	0.59	20.0	20.0	1.4	0.80	3.86	2.30	18	0.50	116.46	116.48	116.81	116.89	123.65	121.12	42b
7	4	7	0.03	0.03	1.00	0.03	0.03	5.0	5.0	2.7	0.08	5.46	0.13	18	1.00	116.03	116.10	116.66	116.65	122.70	122.17	42n
8	3	28	0.32	1.73	0.60	0.19	1.35	10.0	22.5	1.3	1.72	3.86	1.66	18	0.50	113.42	113.56	114.31	114.37	121.15	121.26	43b
9	8	50	1.41	1.41	0.82	1.16	1.16	22.0	22.0	1.3	1.49	2.78	1.77	18	0.26	113.73	113.86	114.43	114.61	121.26	117.86	44b

42 43 44

Number of lines: 9

Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

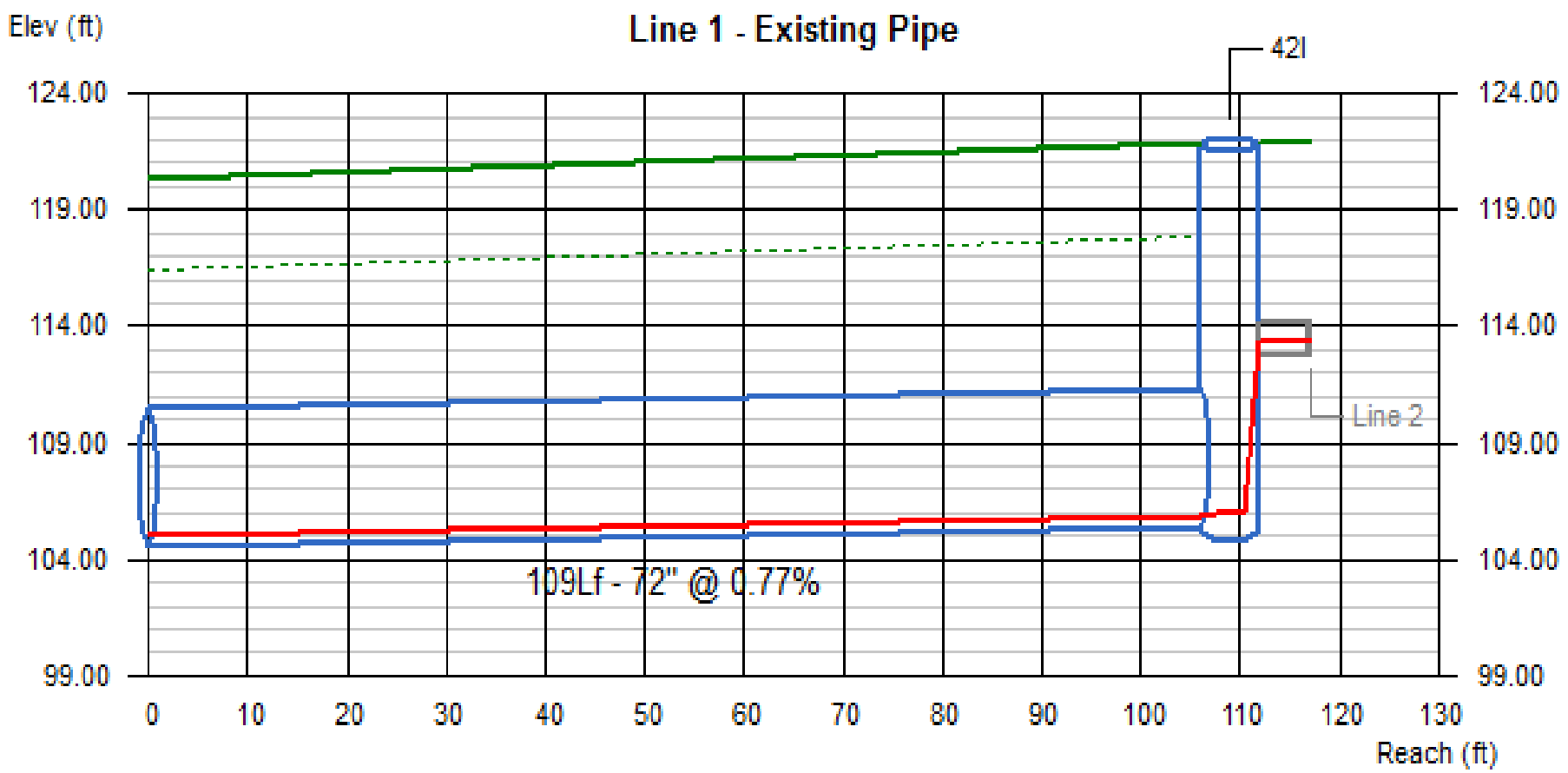
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	72	2.51	104.52	105.00	0.48	1.06	2.37	0.09	105.09	0.768	109	105.36	105.84	0.48	1.05	2.39	0.09	105.93	0.785	0.776	0.846	1.00	0.09
2	18	2.53	112.70	113.31	0.61*	0.67	3.77	0.22	113.53	1.810	59	113.02	114.09	1.07	1.35	1.87	0.05	114.15	0.290	1.050	0.620	0.50	0.03
3	18	2.50	113.02	114.12	1.10	1.39	1.80	0.05	114.17	0.266	47	113.25	114.25	1.00	1.25	2.00	0.06	114.31	0.342	0.304	0.143	1.00	0.06
4	18	0.83	115.41	115.76	0.35*	0.31	2.67	0.11	115.87	1.664	90	115.86	116.64	0.78	0.93	0.89	0.01	116.66	0.080	0.872	0.785	1.00	0.01
5	18	0.80	116.03	116.66	0.63	0.70	1.15	0.02	116.68	0.164	51	116.29	116.78	0.49	0.50	1.60	0.04	116.82	0.409	0.286	0.146	0.75	0.03
6	18	0.80	116.46	116.81	0.35	0.31	2.57	0.10	116.91	1.534	4	116.48	116.89	0.41	0.40	2.02	0.06	116.96	0.783	1.159	0.046	1.00	0.06
7	18	0.08	116.03	116.66	0.63	0.70	0.12	0.00	116.66	0.002	7	116.10	116.65	0.55	0.59	0.14	0.00	116.66	0.003	0.002	0.000	1.00	0.00
8	18	1.72	113.42	114.31	0.89	1.09	1.57	0.04	114.35	0.227	28	113.56	114.37	0.81	0.98	1.76	0.05	114.42	0.302	0.264	0.074	1.13	0.05
9	18	1.49	113.73	114.43	0.70	0.81	1.85	0.05	114.48	0.381	50	113.86	114.61	0.75	0.88	1.69	0.04	114.65	0.302	0.341	0.171	1.00	0.04

42 43 44 | Number of lines: 9 | Run Date: 11-04-2013

Notes: * depth assumed. ; c = cir e = ellip b = box

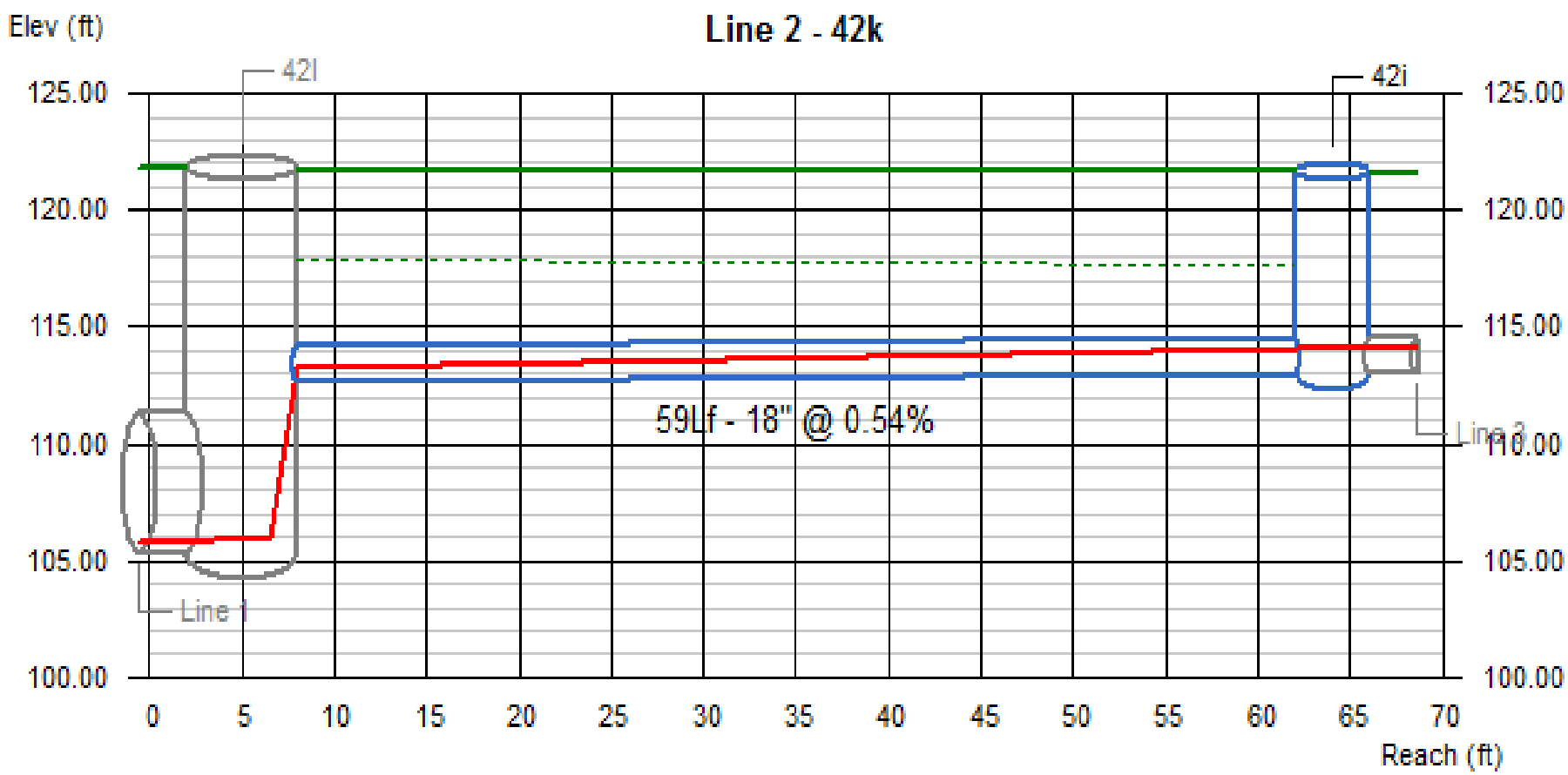
Line Profile (Line 1) - Existing Pipe



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	2.51	104.52	105.36	0.48	0.48	0.57	105.00	105.84	105.93	2.37	2.39	9.87	10.50

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

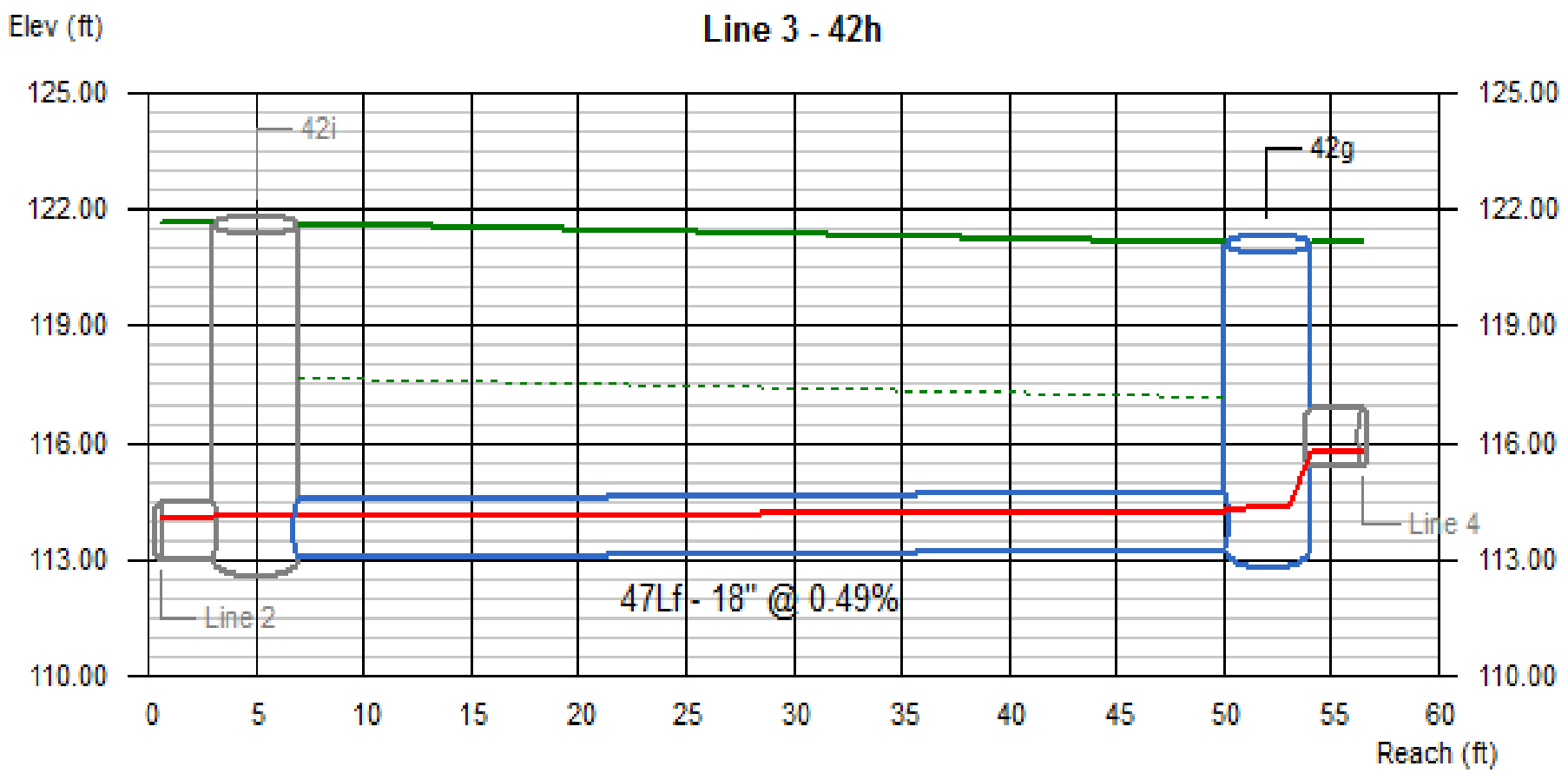
Line Profile (Line 2) - 42k



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	2.53	112.70	113.02	0.61	1.07	1.10	113.31	114.09	114.12	3.77	1.87	7.66	7.14

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

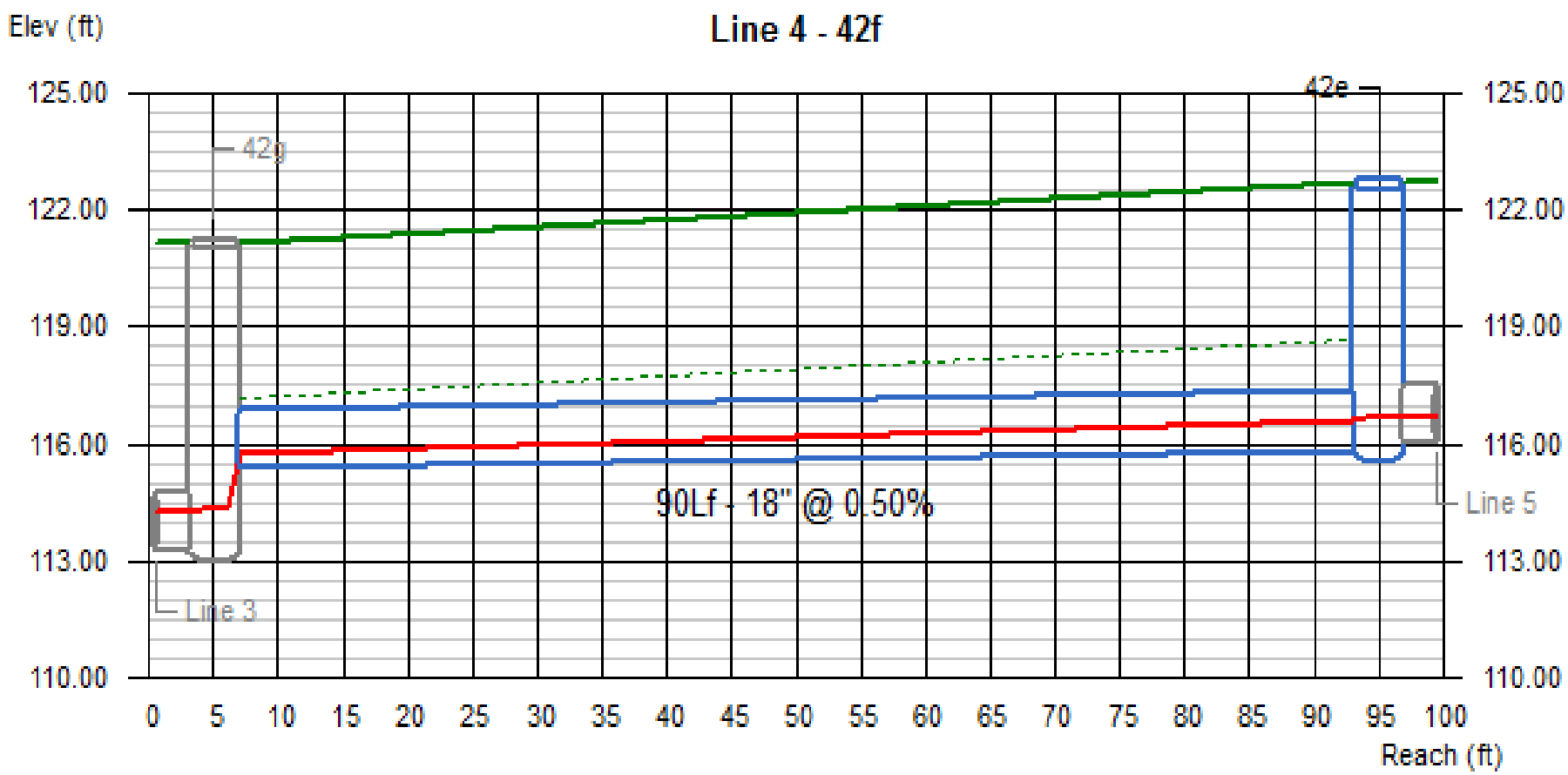
Line Profile (Line 3) - 42h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	2.50	113.02	113.25	1.10	1.00	1.06	114.12	114.25	114.31	1.80	2.00	7.14	6.40

42 43 44	No. Lines: 9	Run Date: 11-04-2013

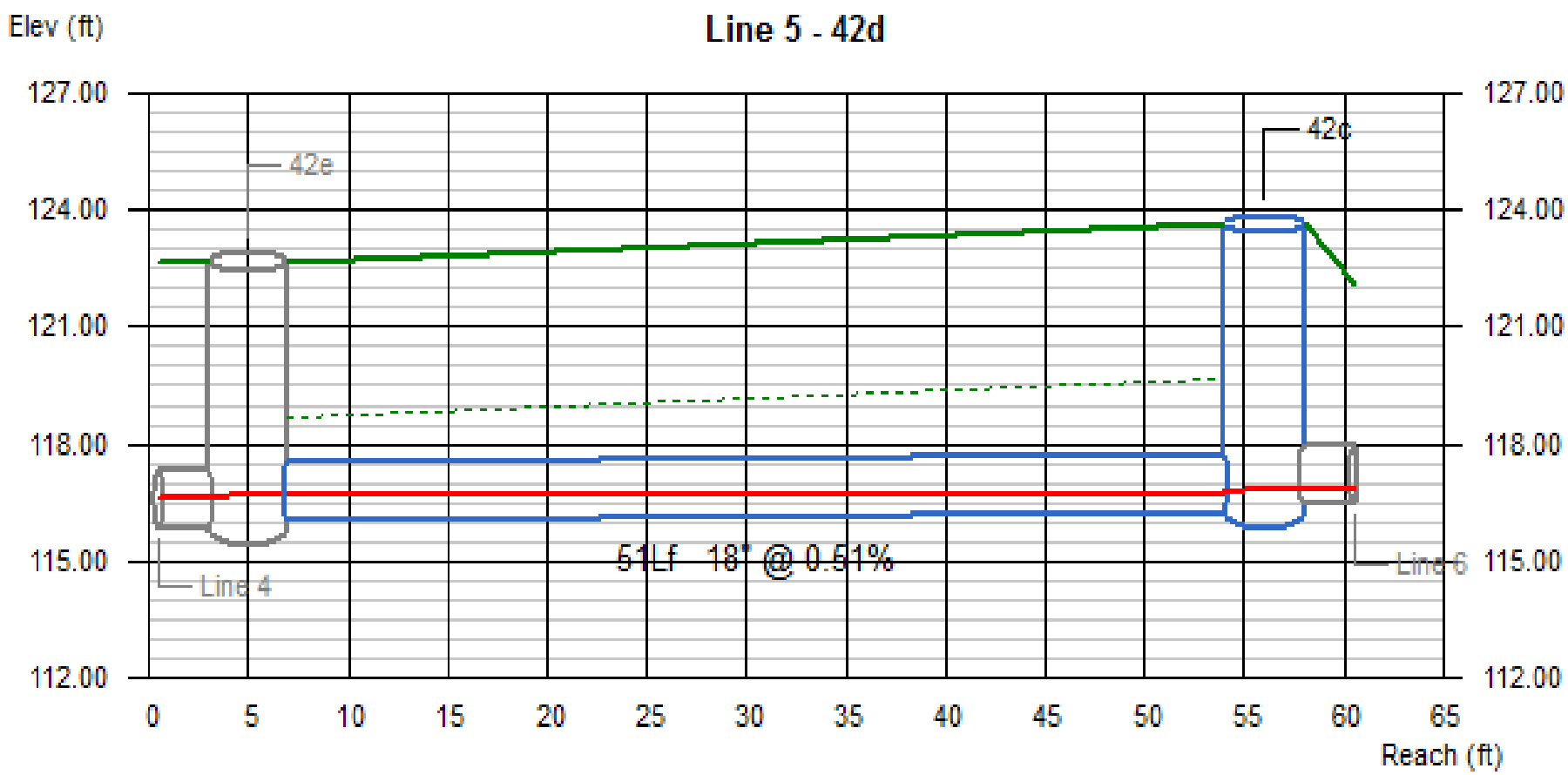
Line Profile (Line 4) - 42f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.83	115.41	115.86	0.35	0.78	0.80	115.76	116.64	116.66	2.67	0.89	4.24	5.34

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

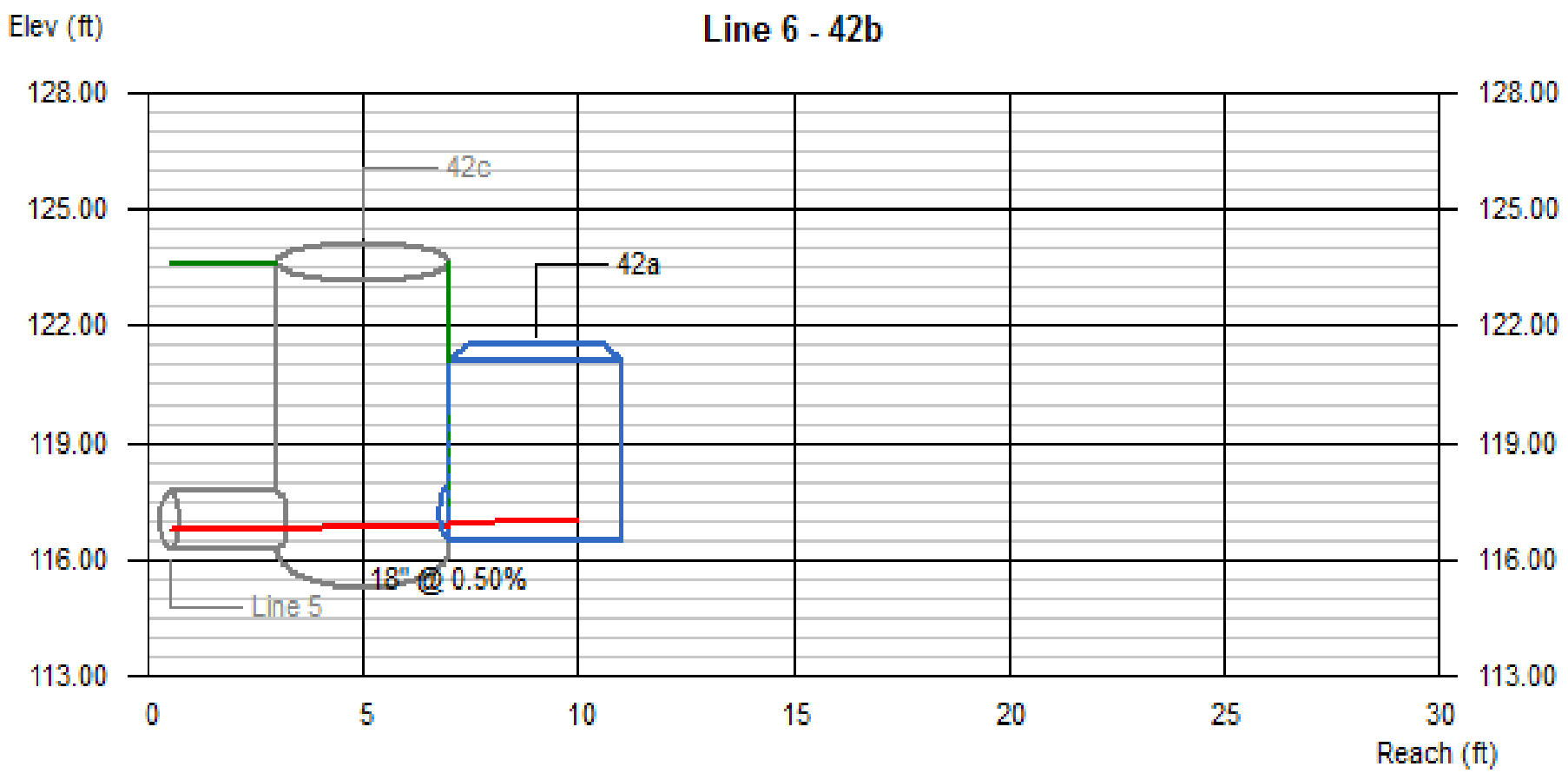
Line Profile (Line 5) - 42d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.80	116.03	116.29	0.63	0.49	0.52	116.66	116.78	116.81	1.15	1.60	5.17	5.86

42 43 44	No. Lines: 9	Run Date: 11-04-2013

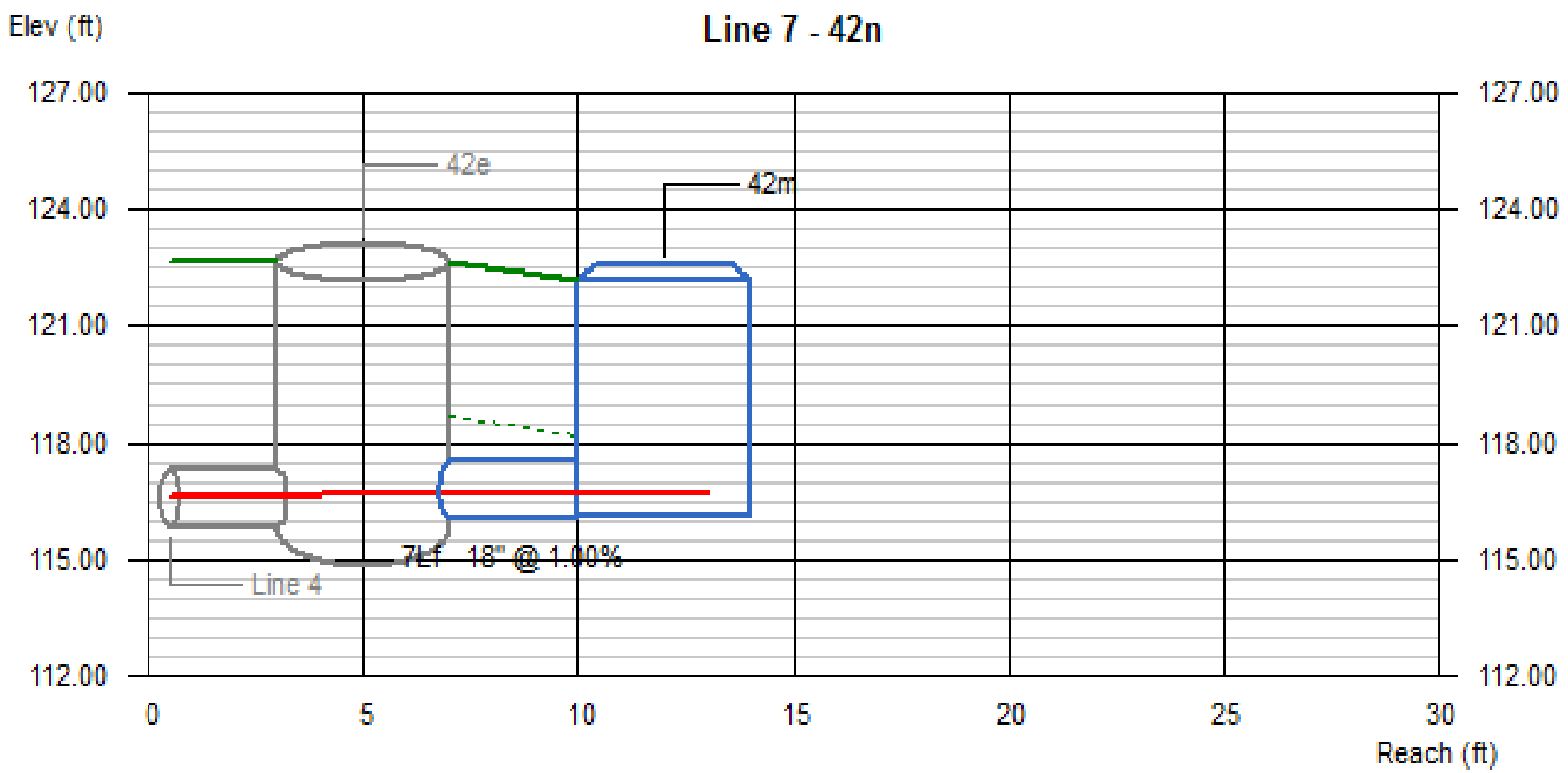
Line Profile (Line 6) - 42b



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
6	0.80	116.46	116.48	0.35	0.41	0.48	116.81	116.89	116.96	2.57	2.02	5.69	3.14

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

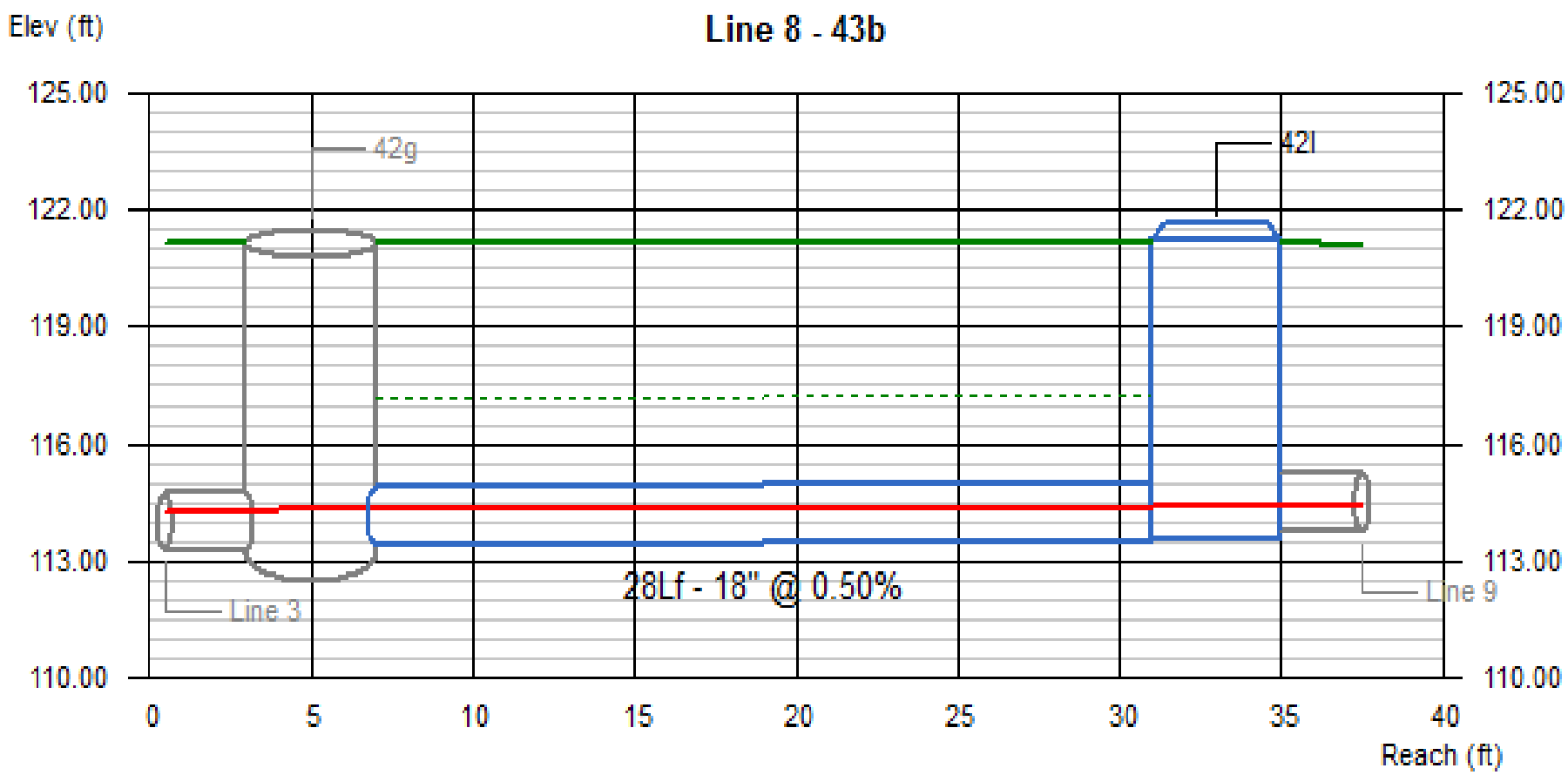
Line Profile (Line 7) - 42n



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	0.08	116.03	116.10	0.63	0.55	0.56	116.66	116.65	116.66	0.12	0.14	5.17	4.57

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

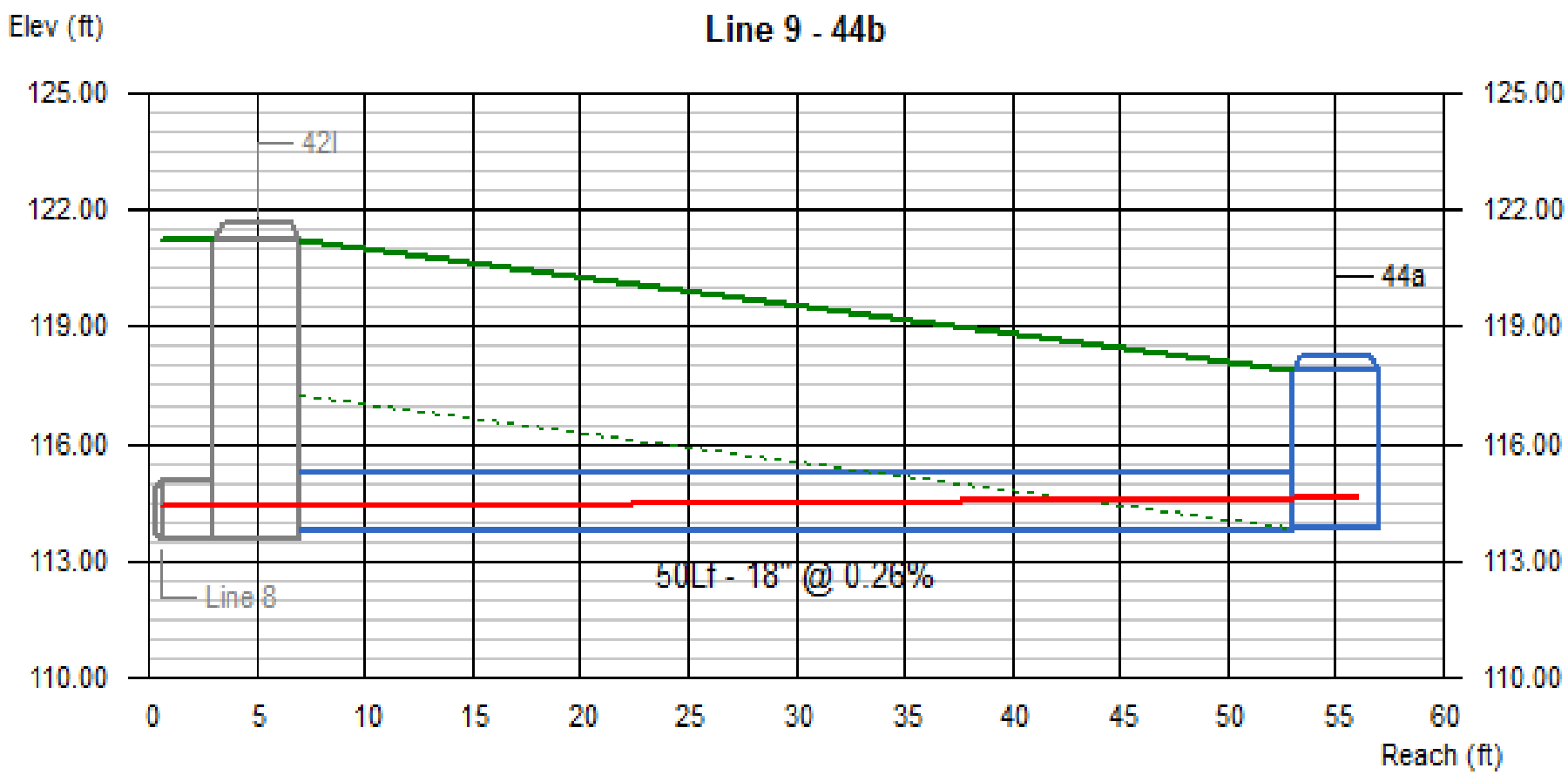
Line Profile (Line 8) - 43b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	1.72	113.42	113.56	0.89	0.81	0.87	114.31	114.37	114.43	1.57	1.76	6.23	6.20

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

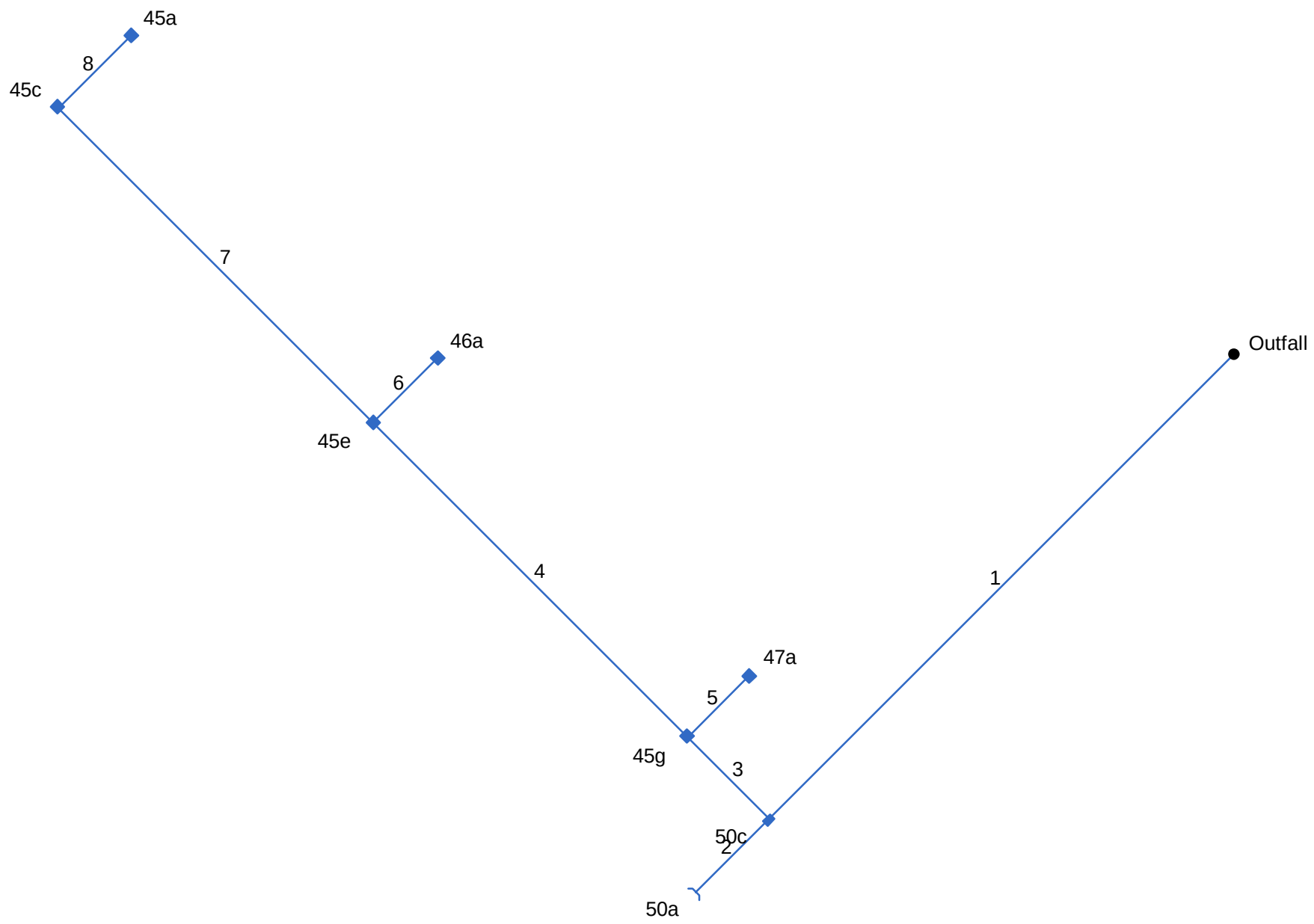
Line Profile (Line 9) - 44b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
9	1.49	113.73	113.86	0.70	0.75	0.79	114.43	114.61	114.65	1.85	1.69	6.03	2.50

42 43 44 | No. Lines: 9 | Run Date: 11-04-2013

45 46 47 50 (25-year)



Project File: Drainage System 45 46 47 50 with offsite 25-year.stm	Number of lines: 8	Date: 11-06-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	285	0.05	75.99	1.00	0.05	31.70	5.0	100.9	0.6	18.67	24.57	4.27	36	0.50	118.78	120.21	120.16	123.20	118.79	138.77	50d (Prop. 36 in)
2	1	45	74.69	74.69	0.41	30.40	30.40	100.6	100.6	0.6	17.94	24.79	2.54	36	0.51	120.21	120.44	123.36	123.44	138.77	120.44	50b (Prop. 36 in)
3	1	50	0.19	1.25	1.00	0.19	1.25	5.0	8.3	2.1	2.66	6.69	3.57	18	1.50	133.51	134.26	134.13	134.96	138.77	139.42	45h
4	3	193	0.20	0.93	1.00	0.20	0.93	5.0	7.1	2.3	2.14	5.76	2.66	18	1.11	134.26	136.41	135.21	136.98	139.42	141.57	45f
5	3	38	0.13	0.13	1.00	0.13	0.13	5.0	5.0	2.7	0.36	7.77	1.08	18	2.03	134.35	135.12	135.21	135.37	139.42	141.12	47b
6	4	39	0.16	0.16	1.00	0.16	0.16	5.0	5.0	2.7	0.44	7.72	1.29	18	2.00	136.45	137.23	137.26	137.49	141.57	143.38	46b
7	4	193	0.32	0.57	1.00	0.32	0.57	5.0	5.4	2.6	1.50	4.39	1.97	18	0.65	136.41	137.66	137.26	138.22	141.57	142.78	45d
8	7	44	0.25	0.25	1.00	0.25	0.25	5.0	5.0	2.7	0.69	7.77	1.69	18	2.02	137.66	138.55	138.37	138.87	142.78	144.71	45b

45 46 47 50 (25-year) | Number of lines: 8 | Run Date: 11-06-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

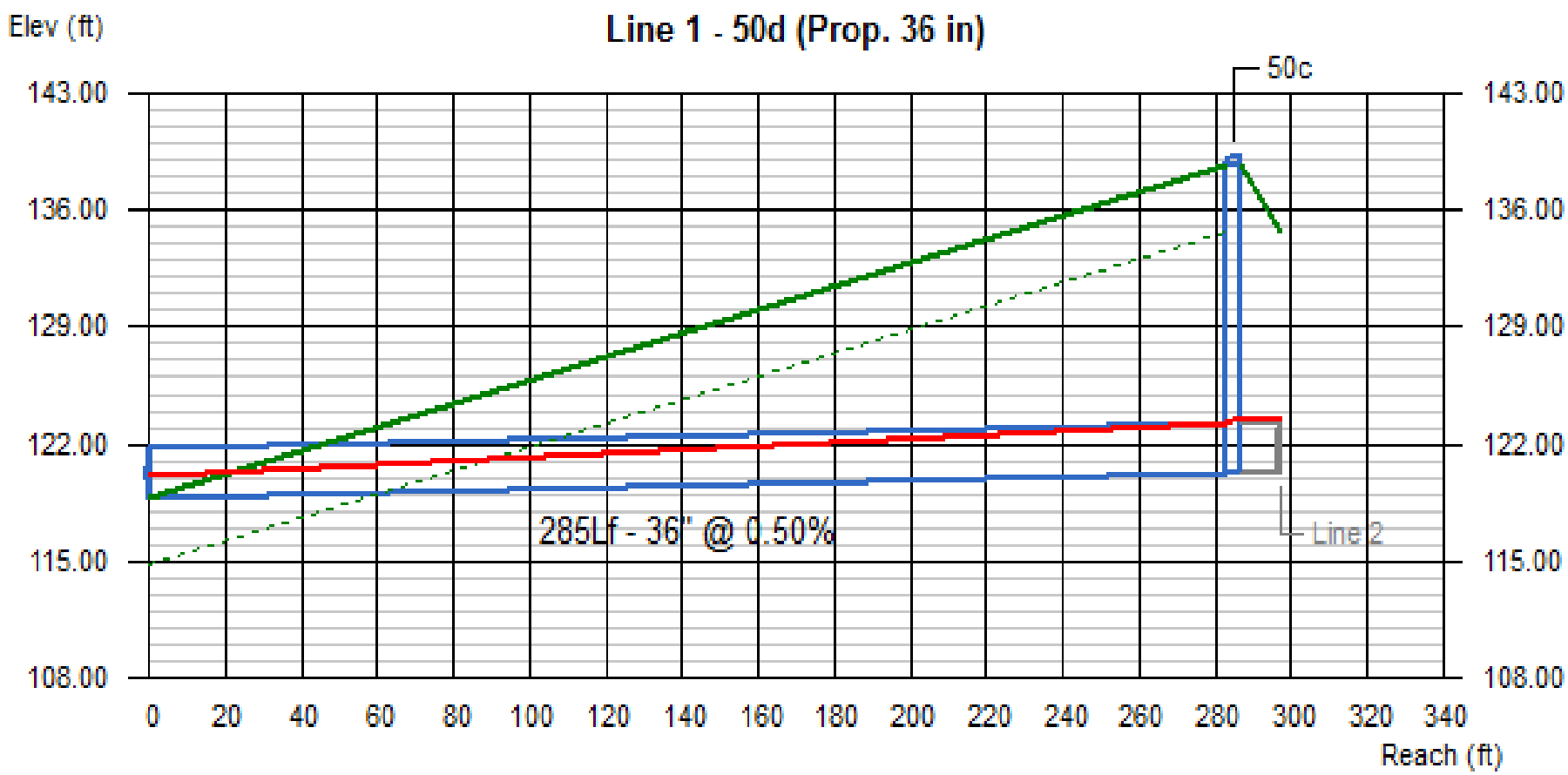
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	36	18.67	118.78	120.16	1.38	3.17	5.90	0.54	120.70	1.557	285	120.21	123.20	2.99	7.07	2.64	0.11	123.31	0.276	0.917	2.613	1.50	0.16
2	36	17.94	120.21	123.36	3.00	7.07	2.54	0.10	123.46	0.268	45	120.44	123.44	3.00	7.07	2.54	0.10	123.54	0.266	0.267	0.120	1.00	0.10
3	18	2.66	133.51	134.13	0.62*	0.69	3.84	0.23	134.36	1.828	50	134.26	134.96	0.70	0.80	3.31	0.17	135.13	1.222	1.525	0.762	1.50	0.26
4	18	2.14	134.26	135.21	0.95	1.18	1.81	0.05	135.26	0.289	193	136.41	136.98	0.57**	0.61	3.51	0.19	137.17	1.682	0.985	1.902	1.50	0.29
5	18	0.36	134.35	135.21	0.86	1.05	0.34	0.00	135.21	0.011	38	135.12	135.37	0.25	0.20	1.82	0.05	135.42	1.120	0.566	0.215	1.00	0.05
6	18	0.44	136.45	137.26	0.81	0.98	0.45	0.00	137.27	0.020	39	137.23	137.49 j	0.26**	0.21	2.13	0.07	137.56	1.478	0.749	0.292	1.00	0.07
7	18	1.50	136.41	137.26	0.85	1.04	1.45	0.03	137.30	0.198	193	137.66	138.22	0.56	0.60	2.49	0.10	138.32	0.858	0.528	1.019	1.50	0.15
8	18	0.69	137.66	138.37	0.71	0.82	0.84	0.01	138.38	0.078	44	138.55	138.87 j	0.32**	0.27	2.53	0.10	138.97	1.666	0.872	n/a	1.00	0.10

45 46 47 50 (25-year) | Number of lines: 8 | Run Date: 11-06-2013

Notes: * depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

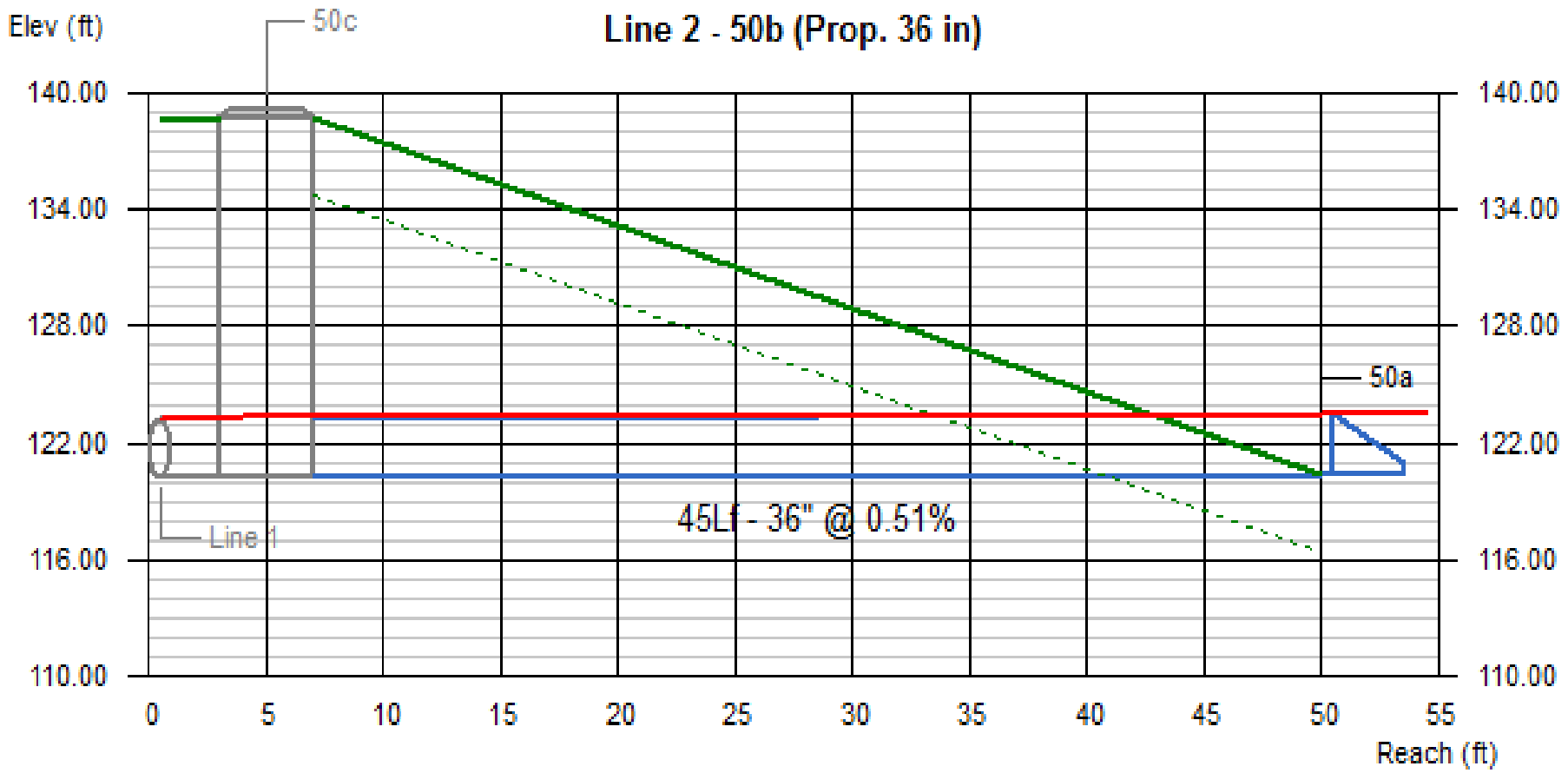
Line Profile (Line 1) - 50d (Prop. 36 in)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	18.67	118.78	120.21	1.38	2.99	3.15	120.16	123.20	123.36	5.90	2.64	-2.99	15.56

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

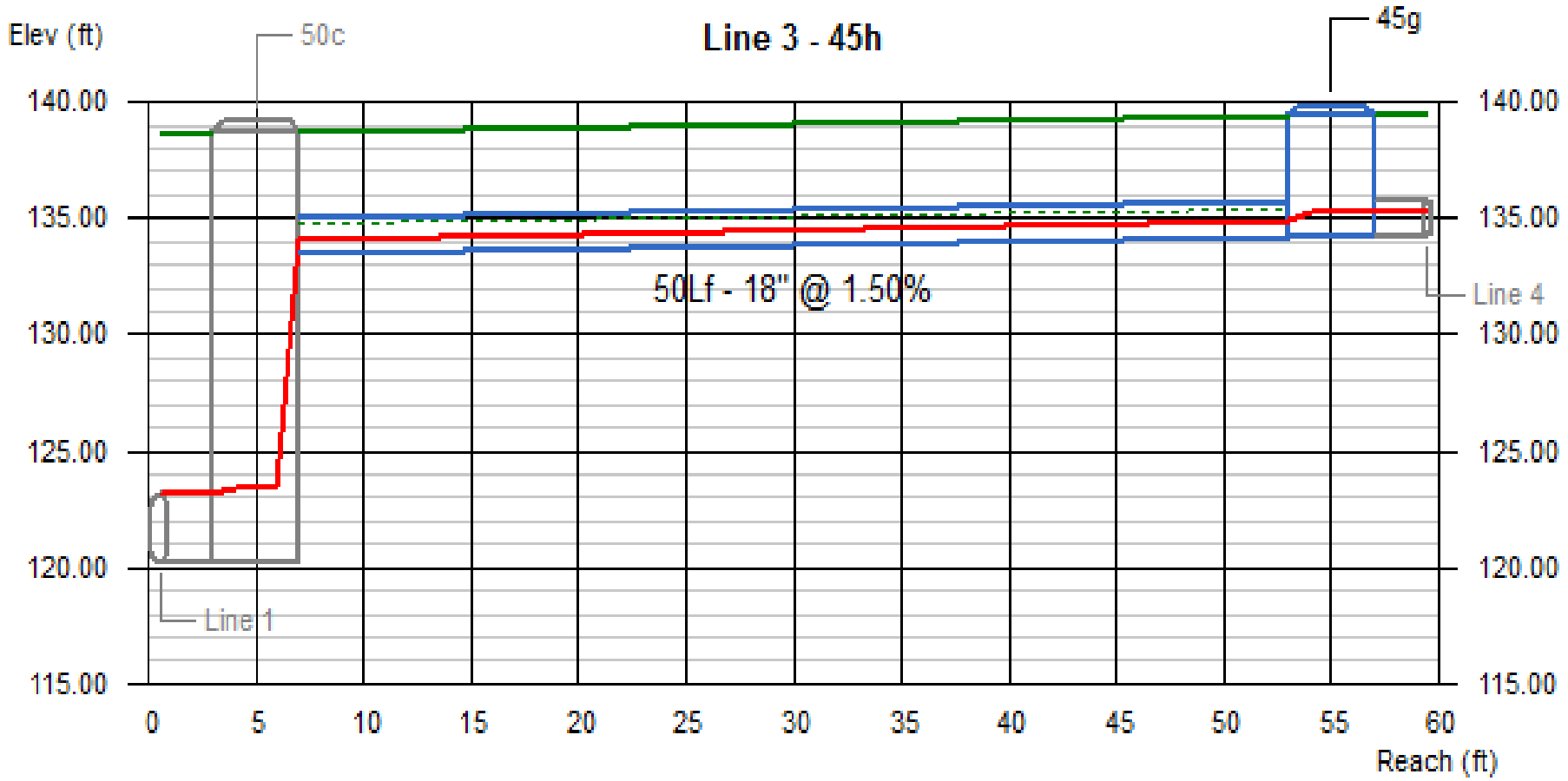
Line Profile (Line 2) - 50b (Prop. 36 in)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	17.94	120.21	120.44	3.00	3.00	3.10	123.36	123.44	123.54	2.54	2.54	15.56	-3.00

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

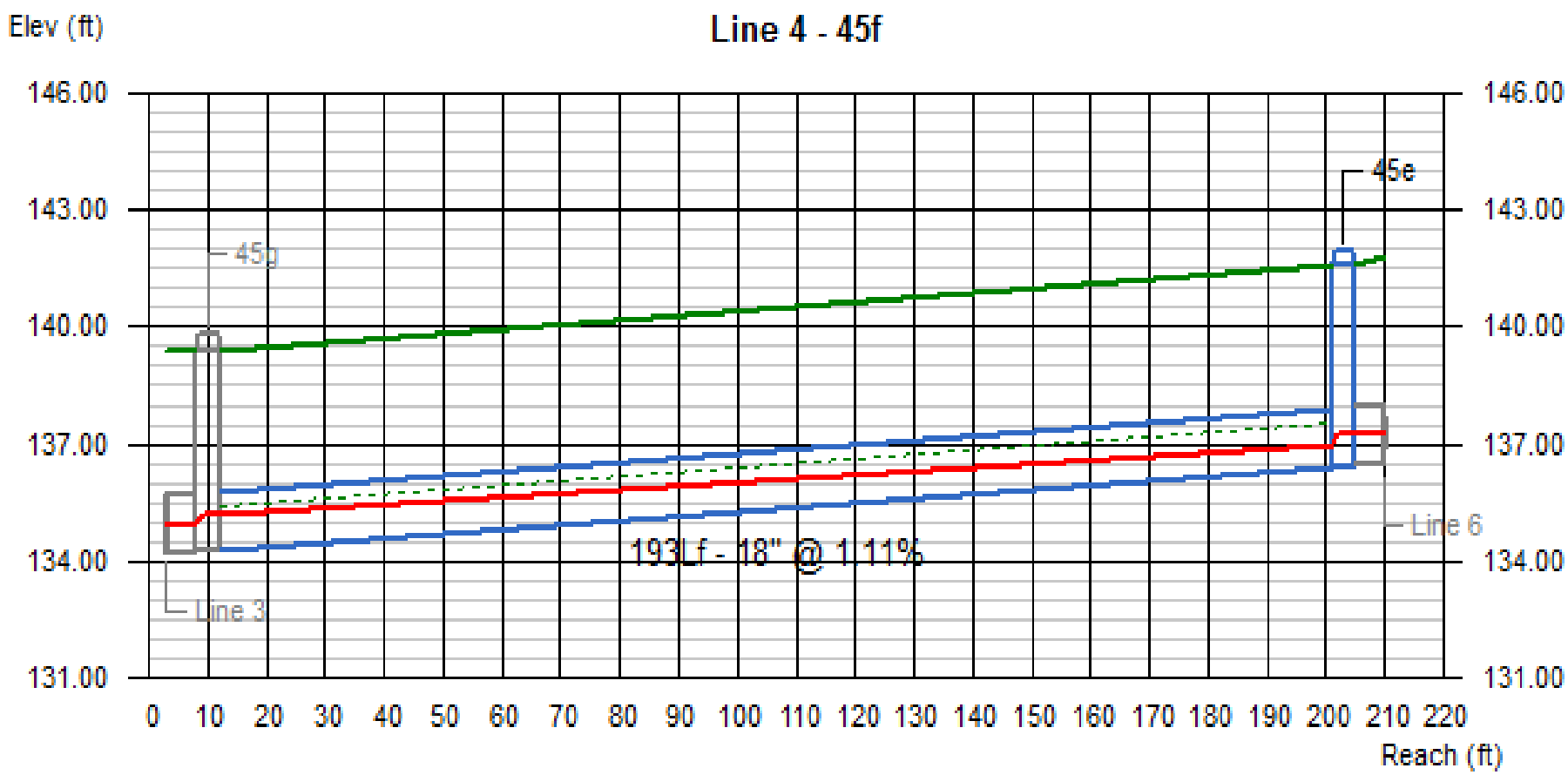
Line Profile (Line 3) - 45h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	2.66	133.51	134.26	0.62	0.70	0.95	134.13	134.96	135.21	3.84	3.31	3.76	3.66

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

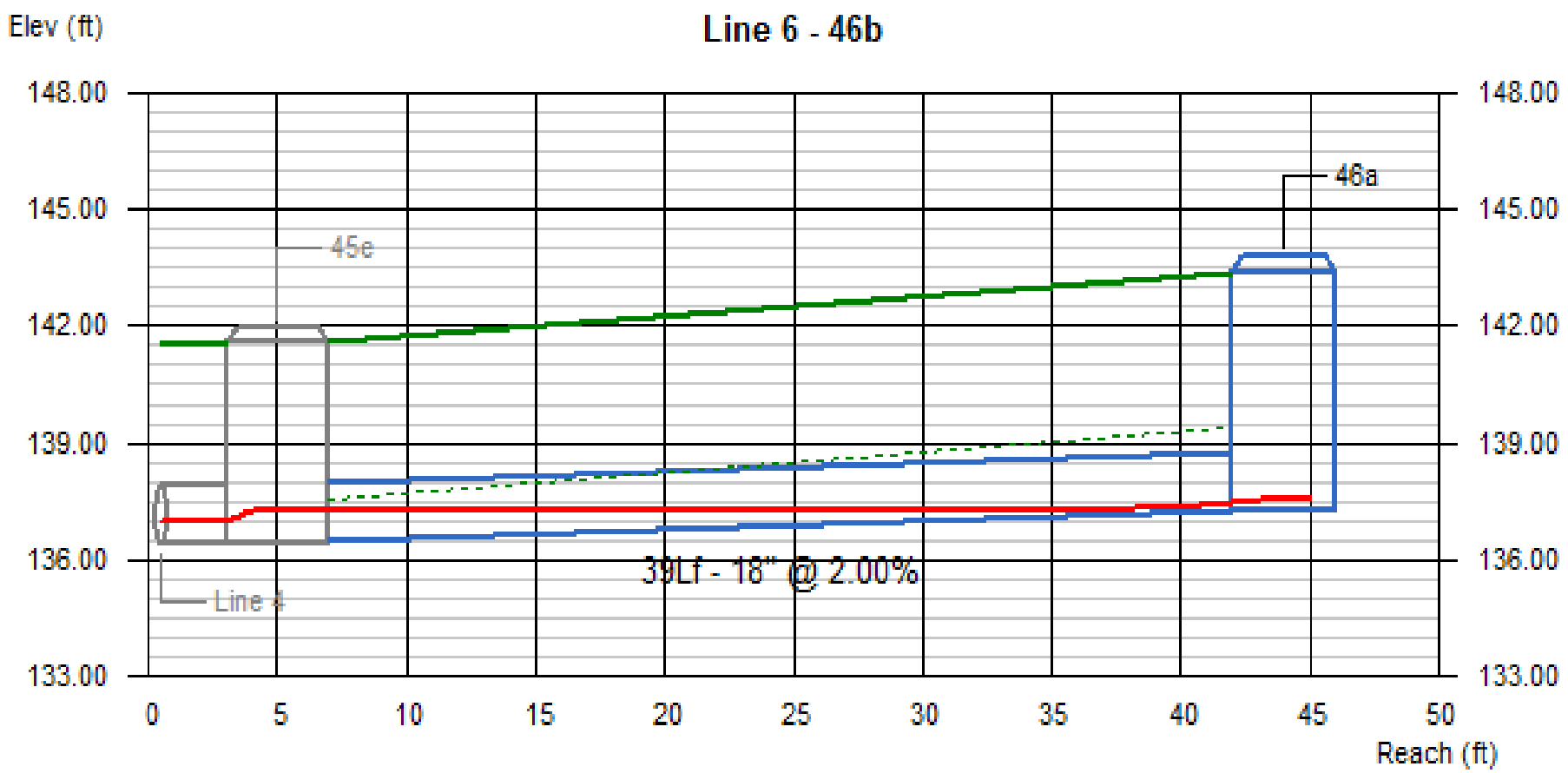
Line Profile (Line 4) - 45f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	2.14	134.26	136.41	0.95	0.57	0.85	135.21	136.98	137.26	1.81	3.51	3.66	3.66

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

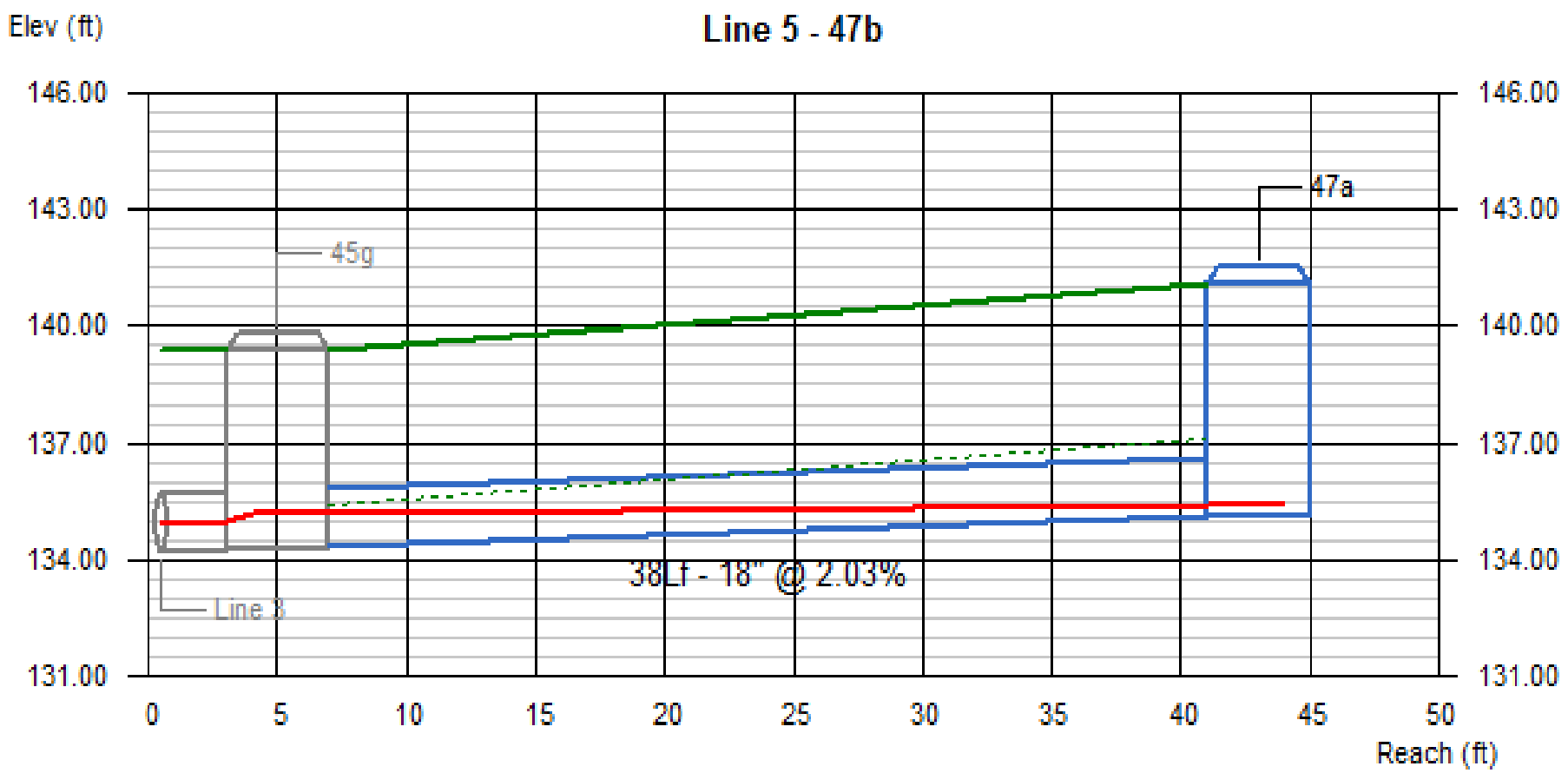
Line Profile (Line 6) - 46b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.44	136.45	137.23	0.81	0.26	0.33	137.26	137.49 j	137.56	0.45	2.13	3.62	4.65

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

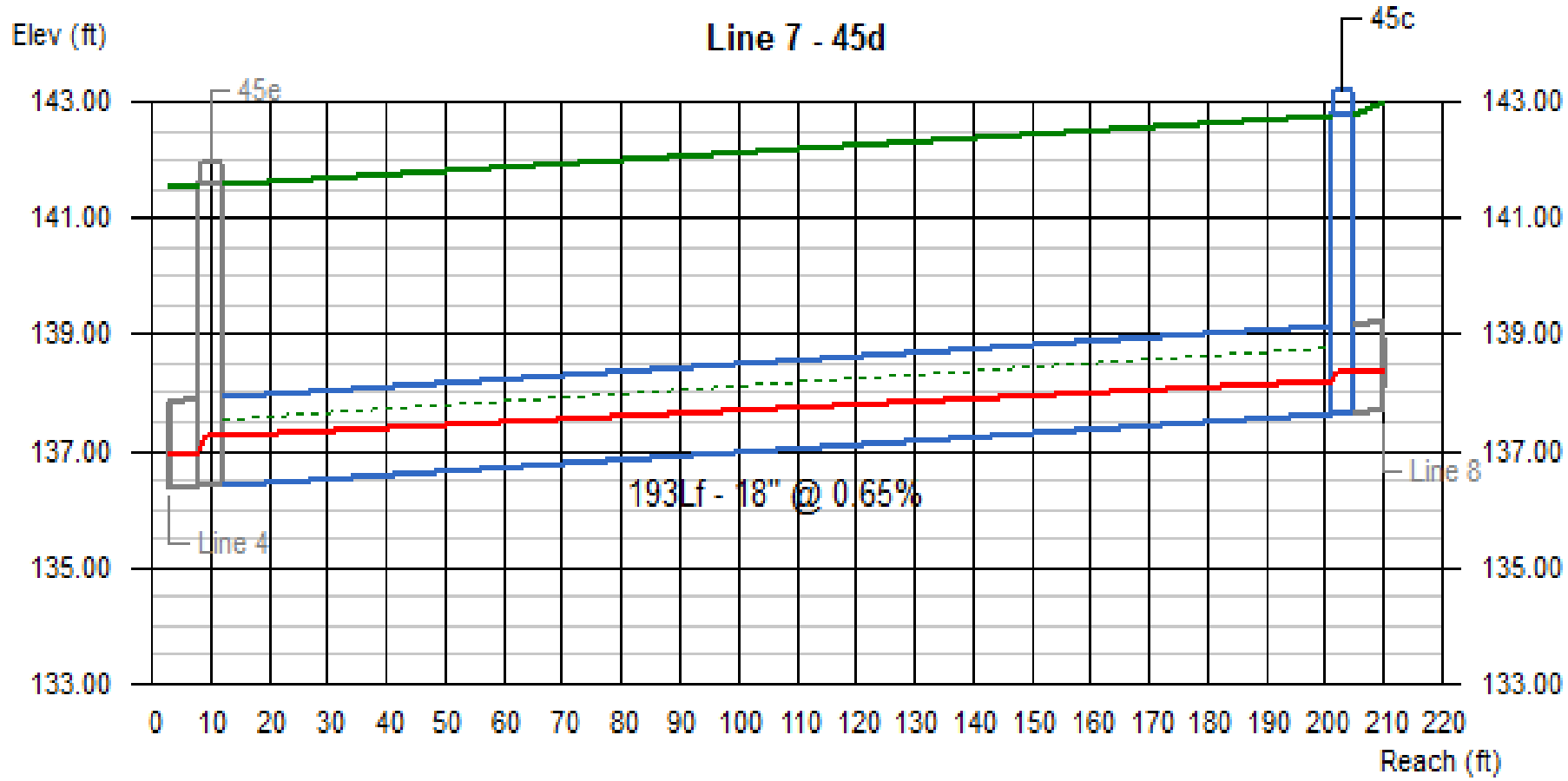
Line Profile (Line 5) - 47b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.36	134.35	135.12	0.86	0.25	0.30	135.21	135.37	135.42	0.34	1.82	3.57	4.50

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

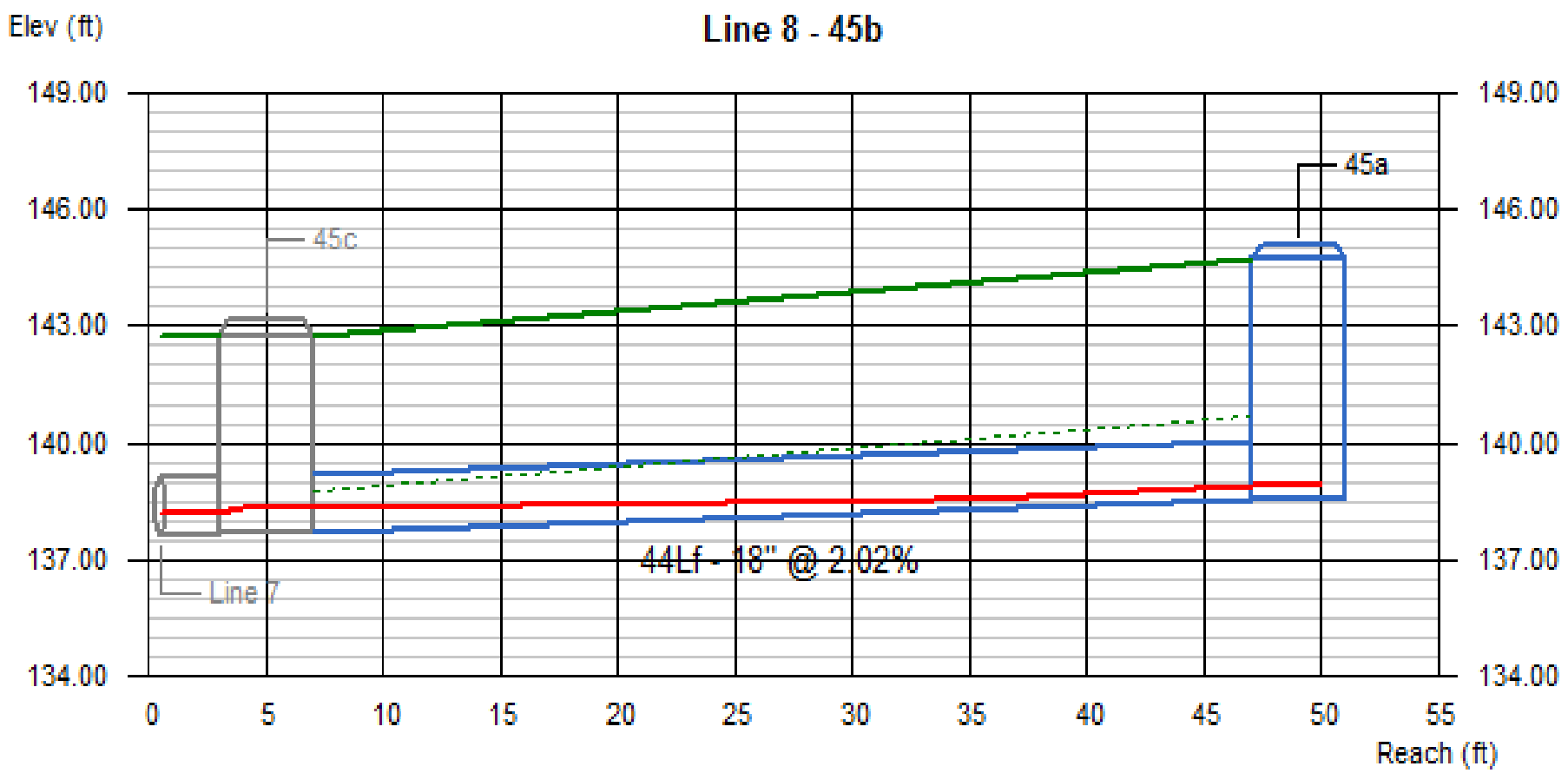
Line Profile (Line 7) - 45d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	1.50	136.41	137.66	0.85	0.56	0.71	137.26	138.22	138.37	1.45	2.49	3.66	3.62

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

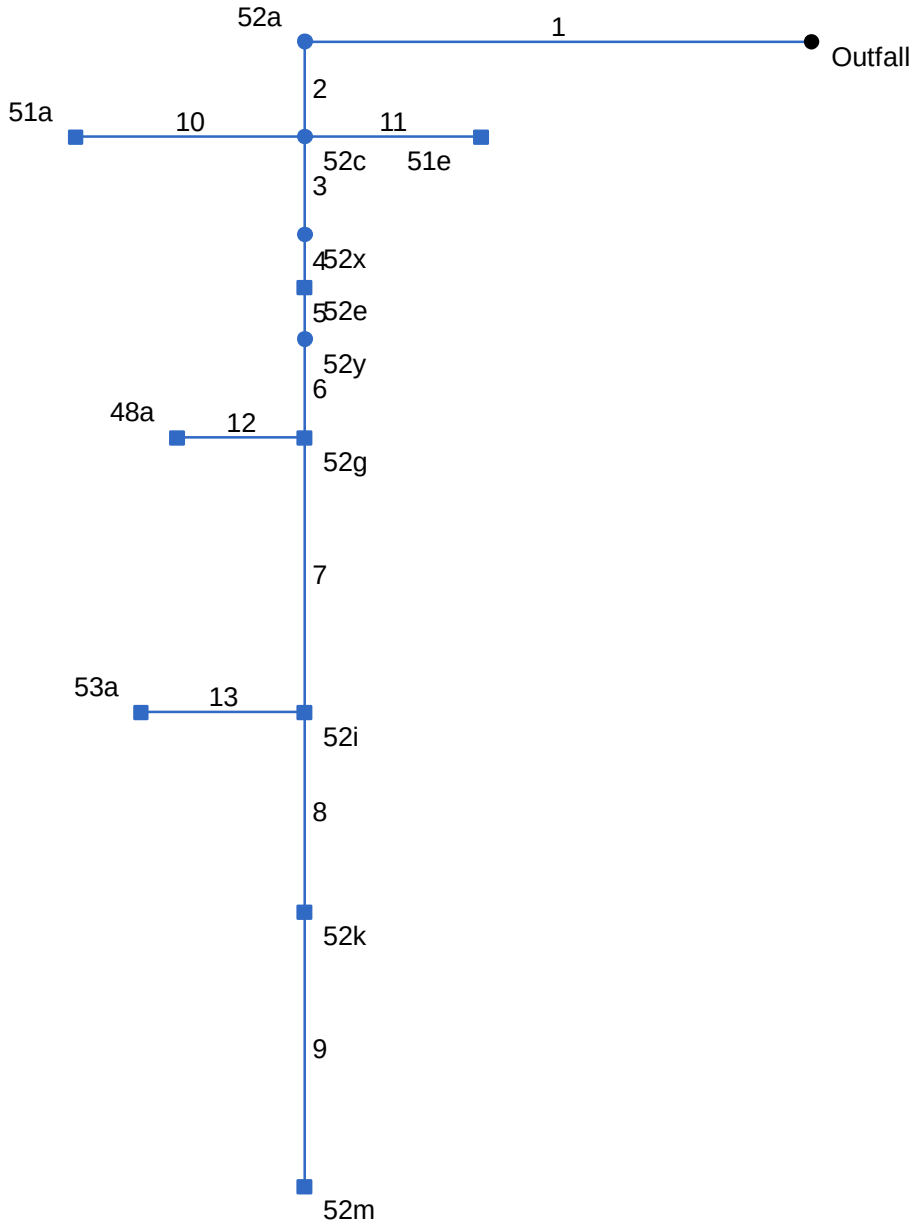
Line Profile (Line 8) - 45b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	0.69	137.66	138.55	0.71	0.32	0.32	138.37	138.87 j	138.87	0.84	2.53	3.62	4.66

45 46 47 50 (25-year) | No. Lines: 8 | Run Date: 11-06-2013

48 51 52 53



Project File: Drainage System 48 51 52 53.stm	Number of lines: 13	Date: 11-05-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	155	0.00	14.81	0.00	0.00	10.89	5.0	65.4	0.7	8.02	24.64	1.39	54	0.06	98.49	98.58	100.26	100.34	113.10	114.80	Existing Pipe and
2	1	29	0.00	14.81	0.00	0.00	10.89	5.0	65.3	0.7	8.03	3.04	5.22	18	0.31	108.60	108.69	109.68	110.63	114.80	116.70	52b
3	2	30	0.06	1.48	1.00	0.06	1.43	5.0	8.4	2.1	3.02	2.99	1.71	18	0.30	108.69	108.78	110.95	111.04	116.70	116.33	52x pipe
4	3	16	0.05	1.42	1.00	0.05	1.37	5.0	8.3	2.1	2.92	2.99	1.65	18	0.30	108.78	108.83	111.06	111.11	116.33	116.17	52d
5	4	16	0.04	1.37	1.00	0.04	1.32	5.0	8.1	2.2	2.84	2.99	1.61	18	0.30	108.83	108.88	111.13	111.17	116.17	116.30	52y pipe
6	5	30	0.09	1.33	1.00	0.09	1.28	5.0	7.8	2.2	2.81	3.73	1.59	18	0.47	108.85	108.99	111.19	111.27	116.30	116.44	52f (moved)
7	6	84	0.06	0.96	1.00	0.06	0.91	5.0	6.7	2.4	2.17	2.98	1.23	18	0.30	108.99	109.24	111.33	111.46	116.44	118.15	52h
8	7	61	0.17	0.29	1.00	0.17	0.24	5.0	6.2	2.5	0.60	6.10	2.18	18	1.25	112.19	112.95	112.49	113.30	118.15	119.83	52j
9	8	84	0.12	0.12	0.60	0.07	0.07	5.0	5.0	2.7	0.20	7.70	1.18	18	1.99	112.95	114.62	113.33	114.79	119.83	122.25	52m
10	2	70	11.70	11.70	0.70	8.19	8.19	65.0	65.0	0.7	6.05	7.75	3.97	18	2.01	109.36	110.77	110.95	111.84	116.70	116.49	51b
11	2	54	1.63	1.63	0.78	1.27	1.27	50.0	50.0	0.8	1.08	2.97	0.62	18	0.30	109.39	109.55	110.95	110.97	116.70	114.85	51d
12	6	39	0.28	0.28	1.00	0.28	0.28	5.0	5.0	2.7	0.77	3.39	0.44	18	0.38	108.99	109.14	111.33	111.34	116.44	114.61	48b (moved)
13	7	50	0.61	0.61	1.00	0.61	0.61	5.0	5.0	2.7	1.68	2.99	0.95	18	0.30	109.24	109.39	111.50	111.55	118.15	114.71	53b

48 51 52 53

Number of lines: 13

Run Date: 11-05-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

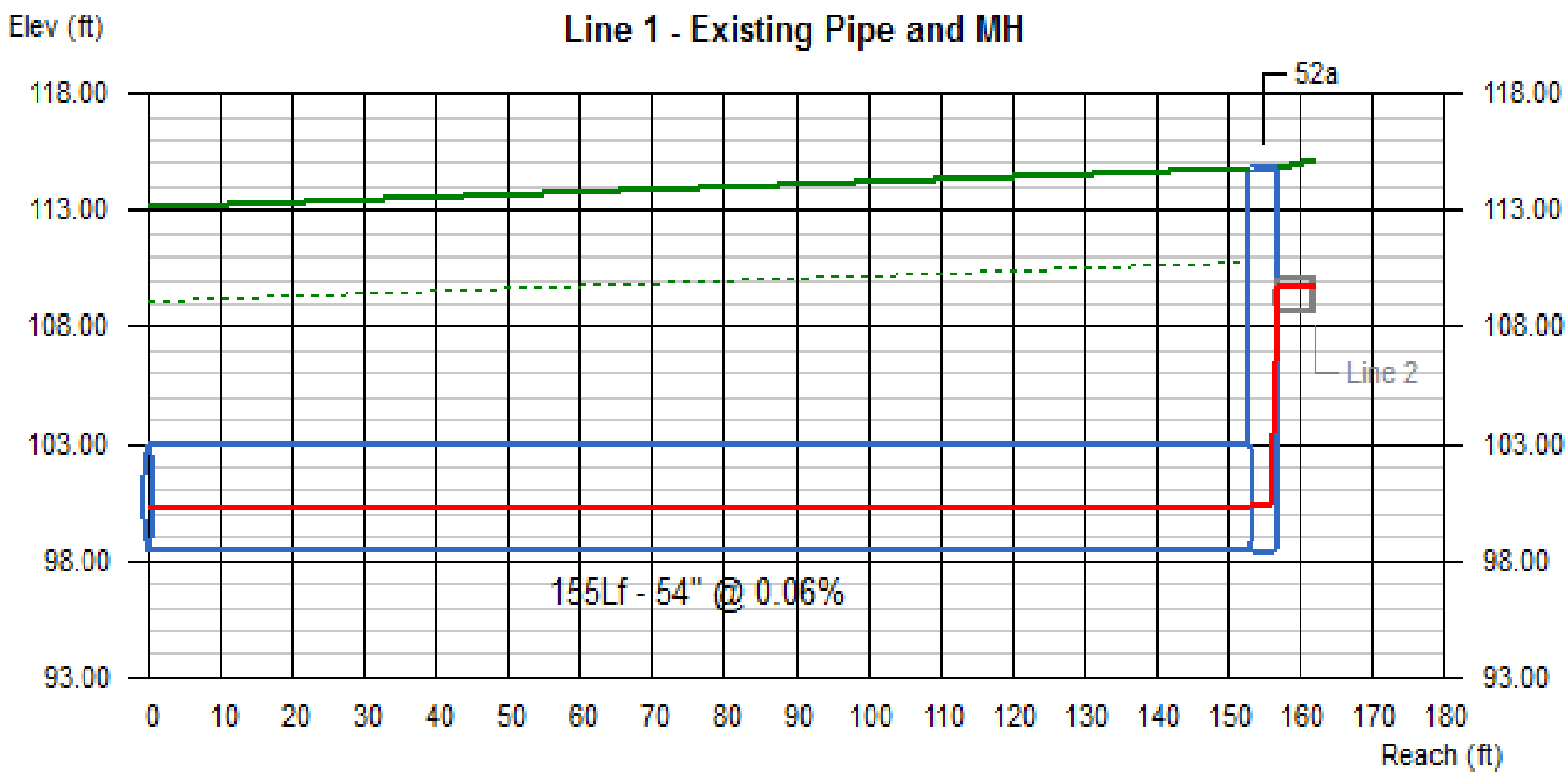
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	54	8.02	98.49	100.26	1.77	5.80	1.38	0.03	100.29	0.058	155	98.58	100.34	1.76	5.78	1.39	0.03	100.37	0.058	0.058	0.090	1.00	0.03
2	18	8.03	108.60	109.68	1.08*	1.36	5.89	0.54	110.22	2.860	29	108.69	110.63	1.50	1.77	4.54	0.32	110.95	2.163	2.511	0.728	1.00	0.32
3	18	3.02	108.69	110.95	1.50	1.77	1.71	0.05	110.99	0.306	30	108.78	111.04	1.50	1.77	1.71	0.05	111.09	0.306	0.306	0.092	0.50	0.02
4	18	2.92	108.78	111.06	1.50	1.77	1.65	0.04	111.11	0.286	16	108.83	111.11	1.50	1.77	1.65	0.04	111.15	0.286	0.286	0.046	0.50	0.02
5	18	2.84	108.83	111.13	1.50	1.77	1.61	0.04	111.17	0.271	16	108.88	111.17	1.50	1.77	1.61	0.04	111.21	0.271	0.271	0.043	0.50	0.02
6	18	2.81	108.85	111.19	1.50	1.77	1.59	0.04	111.23	0.266	30	108.99	111.27	1.50	1.77	1.59	0.04	111.31	0.265	0.265	0.080	1.50	0.06
7	18	2.17	108.99	111.33	1.50	1.77	1.23	0.02	111.36	0.158	84	109.24	111.46	1.50	1.77	1.23	0.02	111.49	0.158	0.158	0.133	1.50	0.04
8	18	0.60	112.19	112.49	0.29*	0.25	2.43	0.09	112.58	1.671	61	112.95	113.30	0.35	0.31	1.93	0.06	113.36	0.866	1.269	0.774	0.50	0.03
9	18	0.20	112.95	113.33	0.38	0.35	0.57	0.01	113.33	0.069	84	114.62	114.79 j	0.17**	0.11	1.79	0.05	114.84	1.793	0.931	n/a	1.00	0.05
10	18	6.05	109.36	110.95	1.50	1.77	3.43	0.18	111.13	1.229	70	110.77	111.84	1.07	1.34	4.51	0.32	112.15	1.685	1.457	1.020	1.00	0.32
11	18	1.08	109.39	110.95	1.50	1.77	0.61	0.01	110.95	0.039	54	109.55	110.97	1.42	1.73	0.62	0.01	110.97	0.034	0.036	0.020	1.00	0.01
12	18	0.77	108.99	111.33	1.50	1.77	0.44	0.00	111.34	0.020	39	109.14	111.34	1.50	1.77	0.44	0.00	111.34	0.020	0.020	0.008	1.00	0.00
13	18	1.68	109.24	111.50	1.50	1.77	0.95	0.01	111.51	0.094	50	109.39	111.55	1.50	1.77	0.95	0.01	111.56	0.094	0.094	0.047	1.00	0.01

48 51 52 53 | Number of lines: 13 | Run Date: 11-05-2013

Notes: * depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

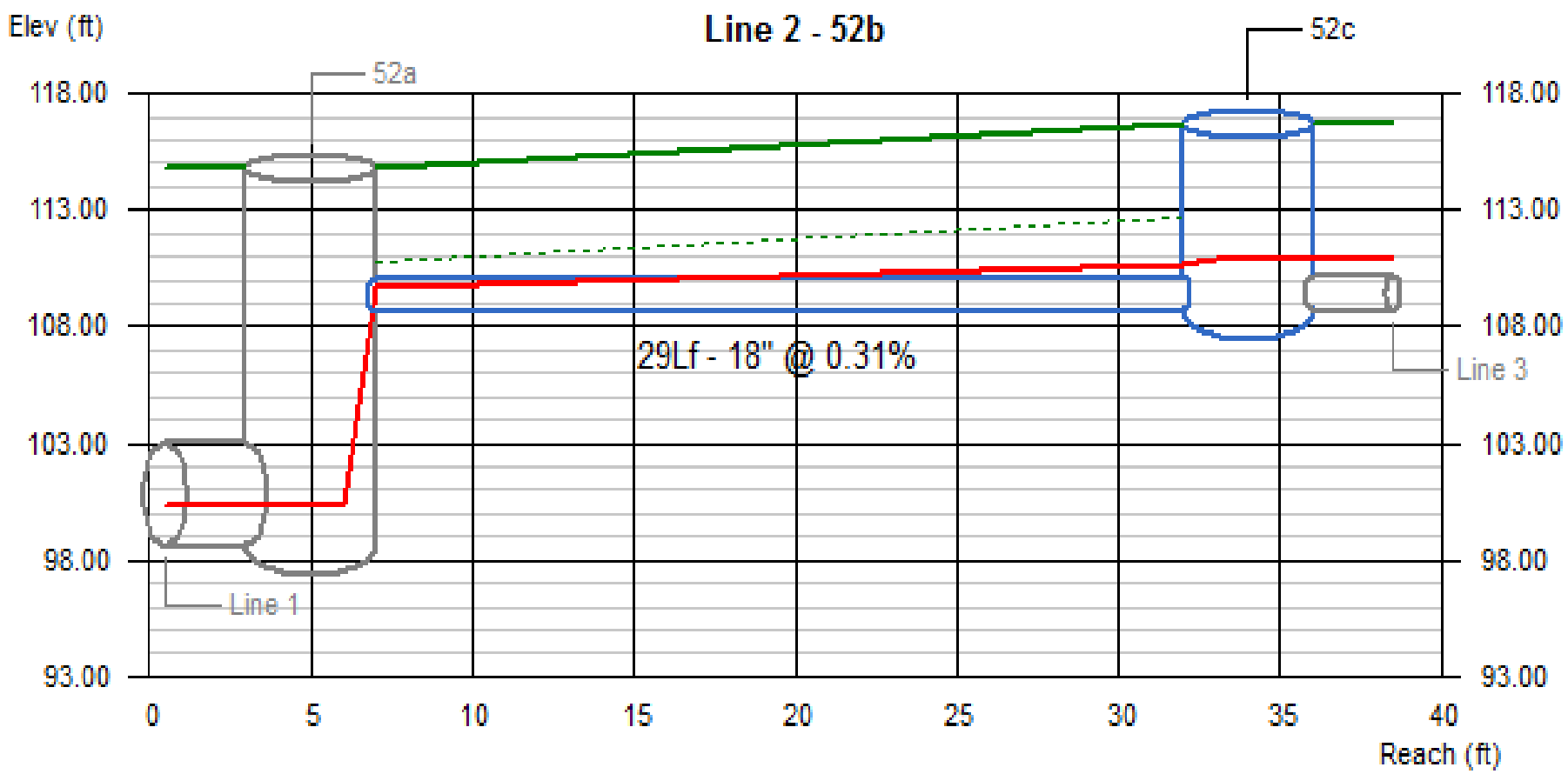
Line Profile (Line 1) - Existing Pipe and MH



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	8.02	98.49	98.58	1.77	1.76	1.79	100.26	100.34	100.37	1.38	1.39	10.11	11.72

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

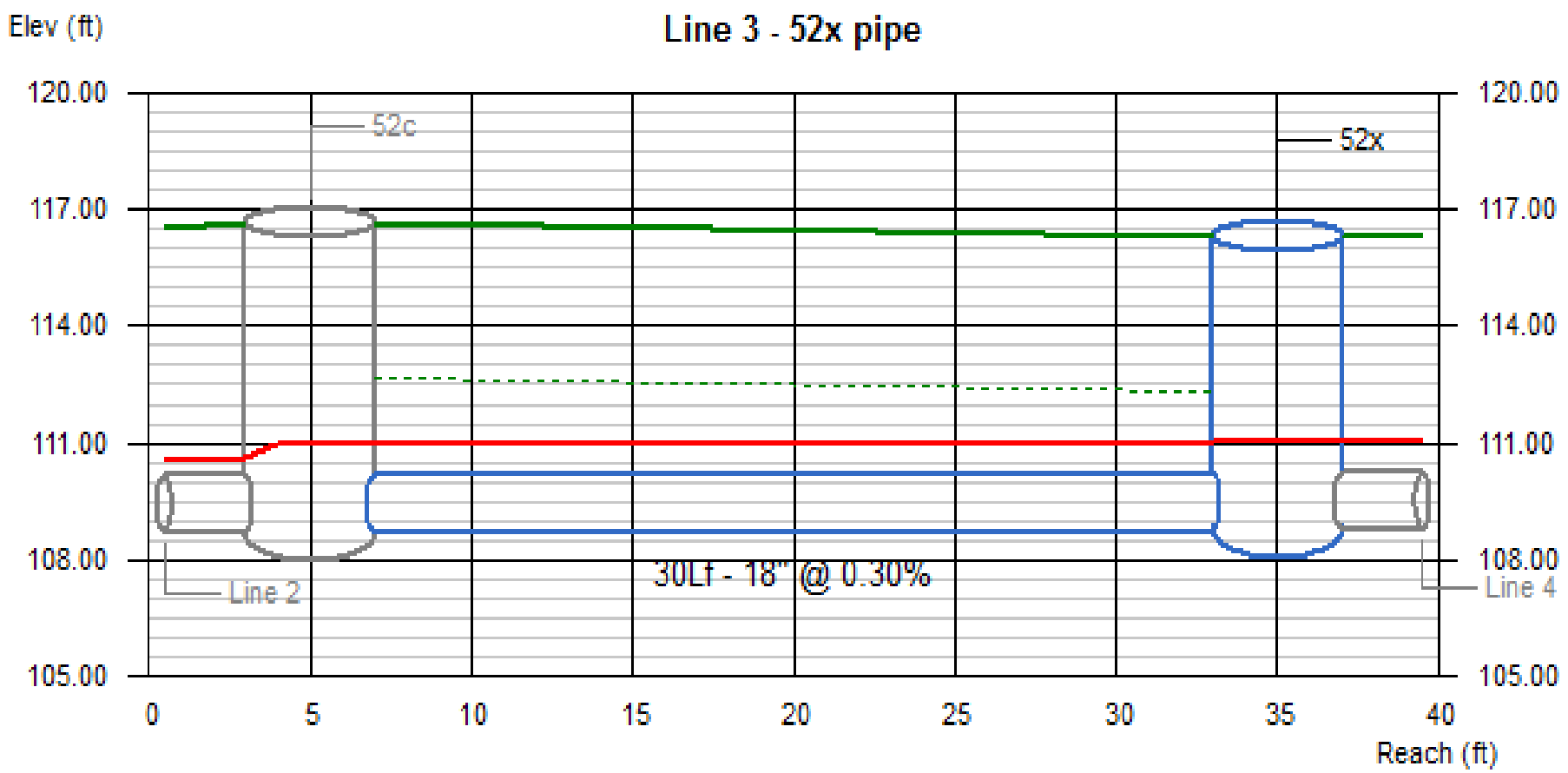
Line Profile (Line 2) - 52b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	8.03	108.60	108.69	1.08	1.50	2.26	109.68	110.63	110.95	5.89	4.54	4.70	6.51

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

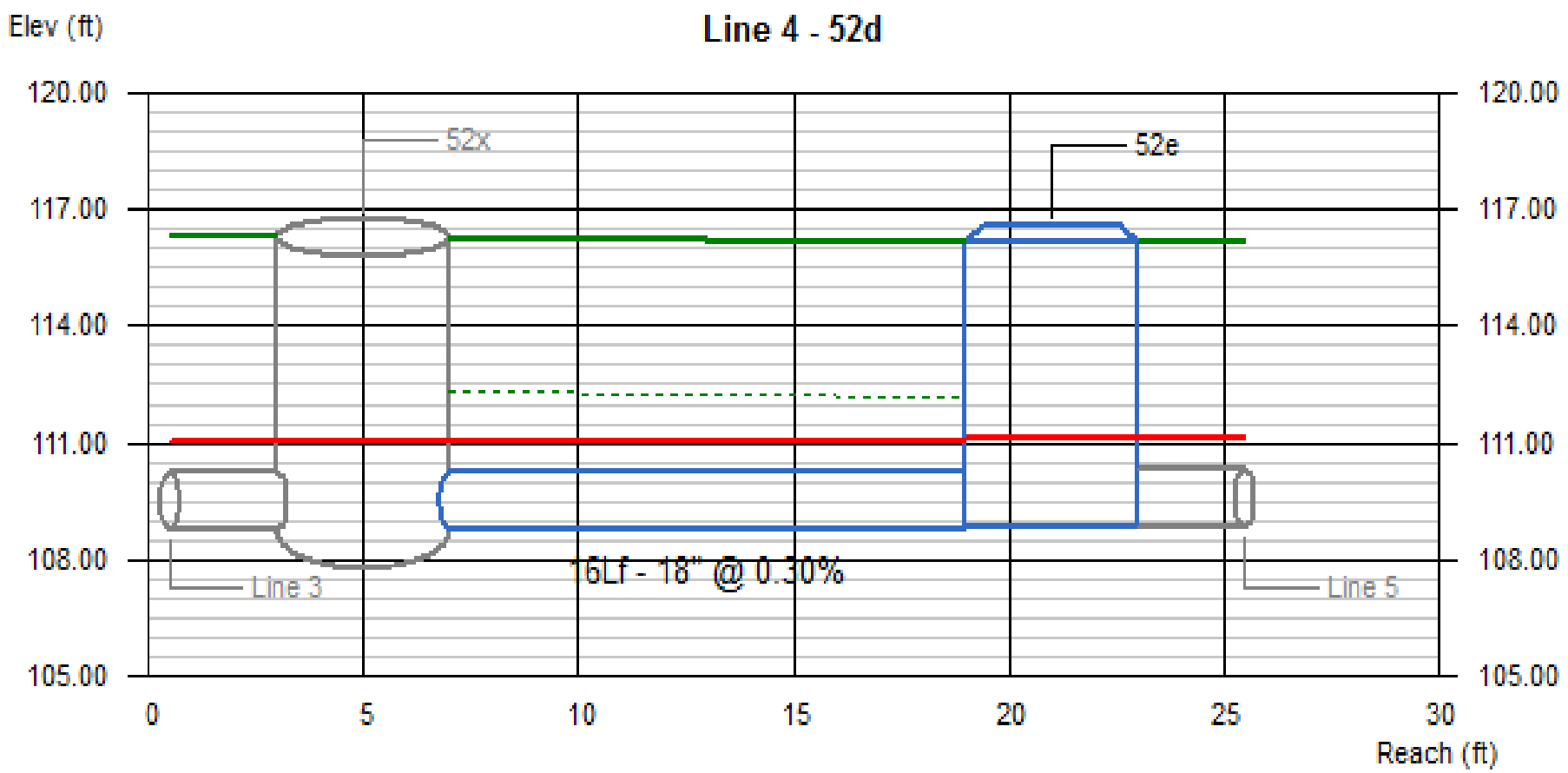
Line Profile (Line 3) - 52x pipe



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	3.02	108.69	108.78	1.50	1.50	2.28	110.95	111.04	111.06	1.71	1.71	6.51	6.05

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

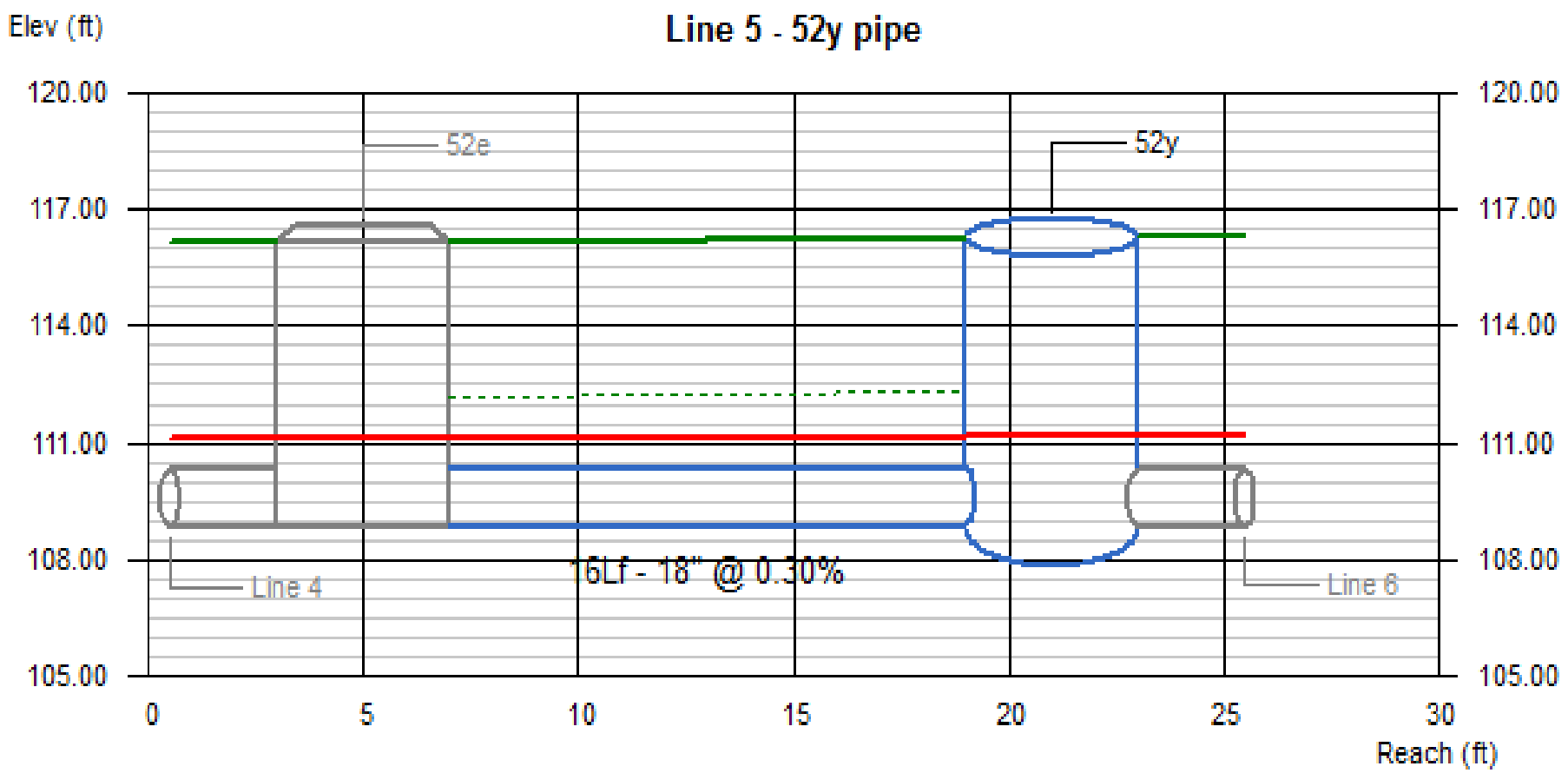
Line Profile (Line 4) - 52d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	2.92	108.78	108.83	1.50	1.50	2.30	111.06	111.11	111.13	1.65	1.65	6.05	5.84

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

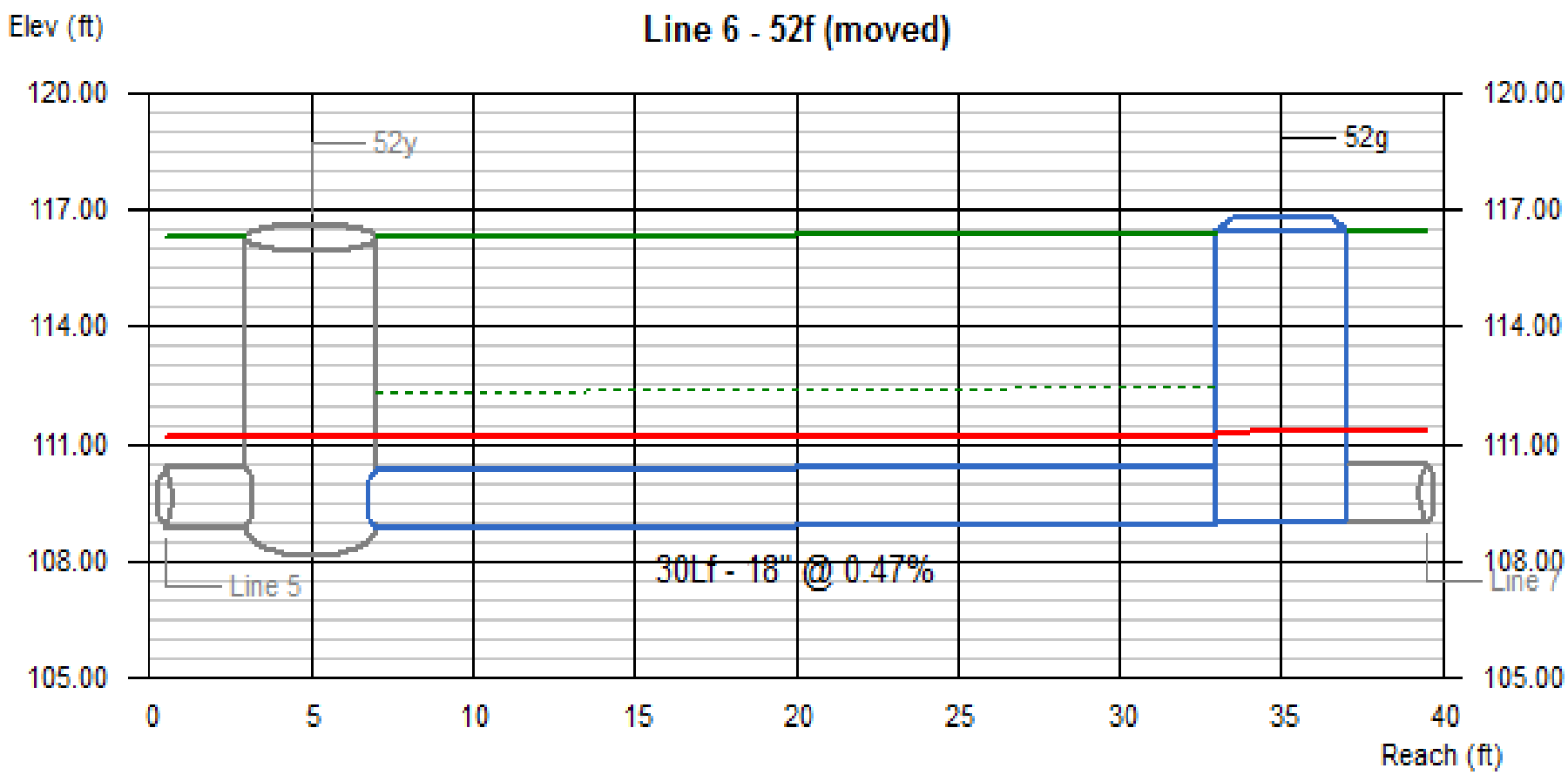
Line Profile (Line 5) - 52y pipe



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	2.84	108.83	108.88	1.50	1.50	2.32	111.13	111.17	111.19	1.61	1.61	5.84	5.92

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

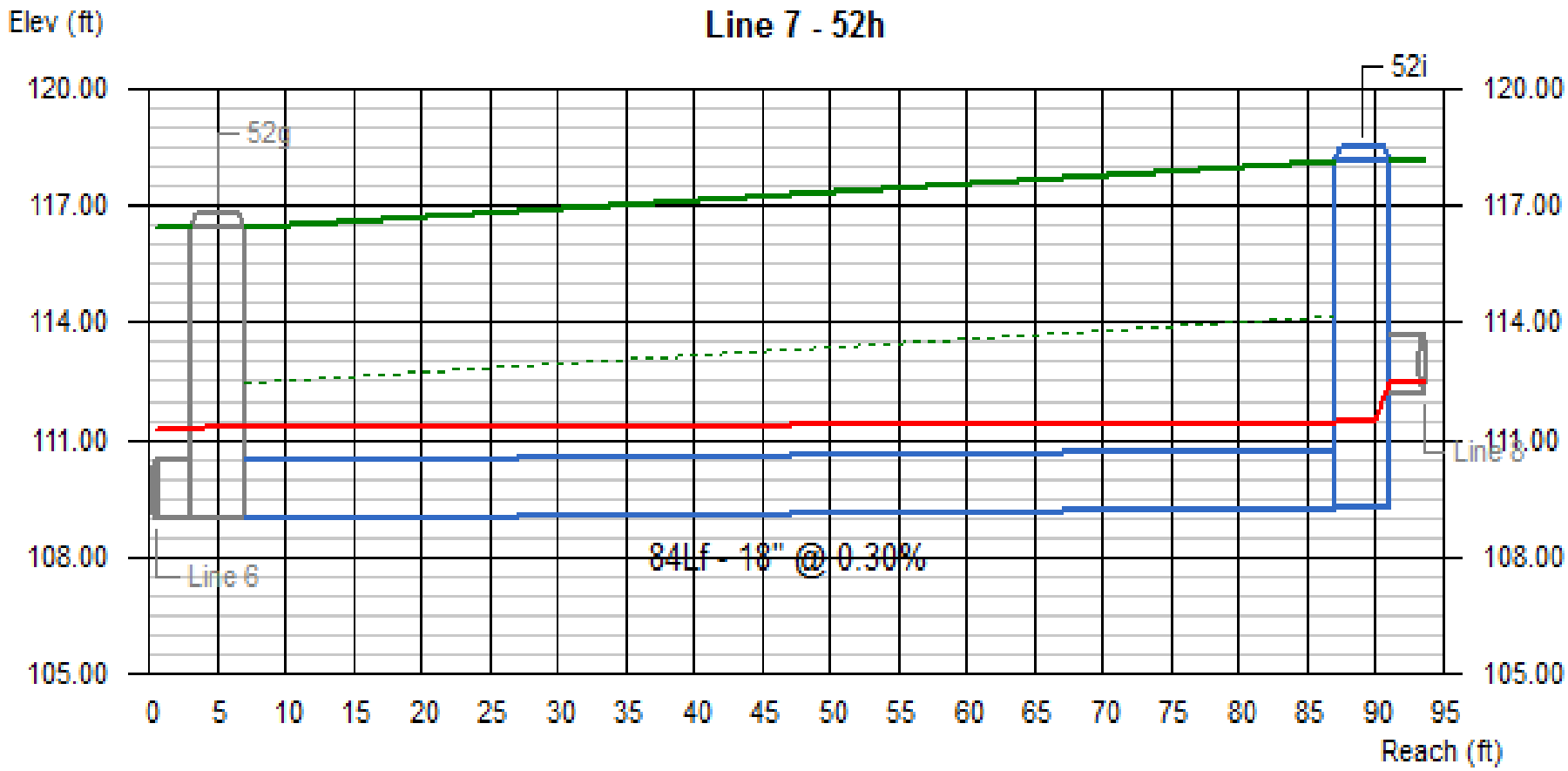
Line Profile (Line 6) - 52f (moved)



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	2.81	108.85	108.99	1.50	1.50	2.34	111.19	111.27	111.33	1.59	1.59	5.95	5.95

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

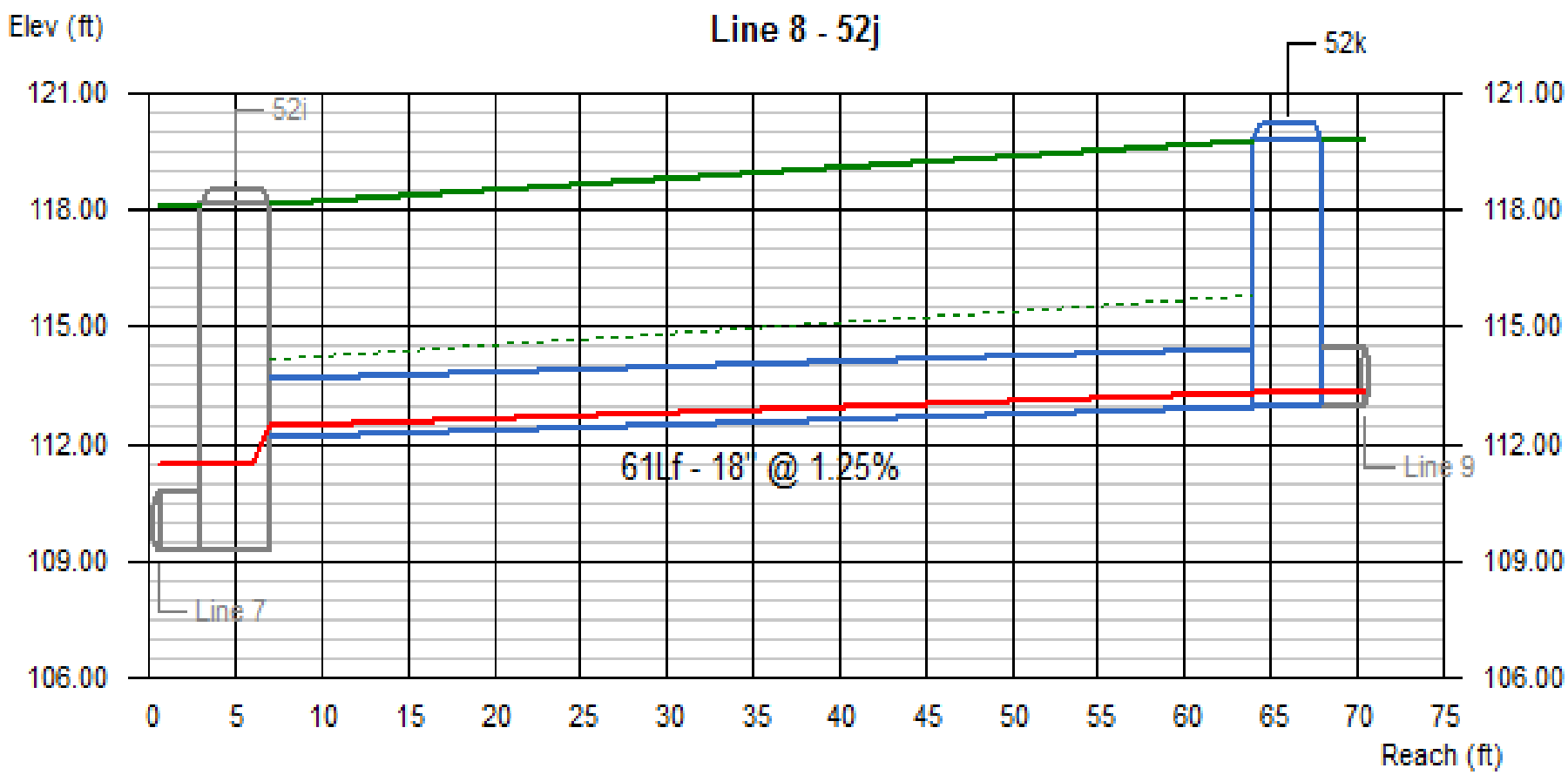
Line Profile (Line 7) - 52h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	2.17	108.99	109.24	1.50	1.50	2.26	111.33	111.46	111.50	1.23	1.23	5.95	7.41

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

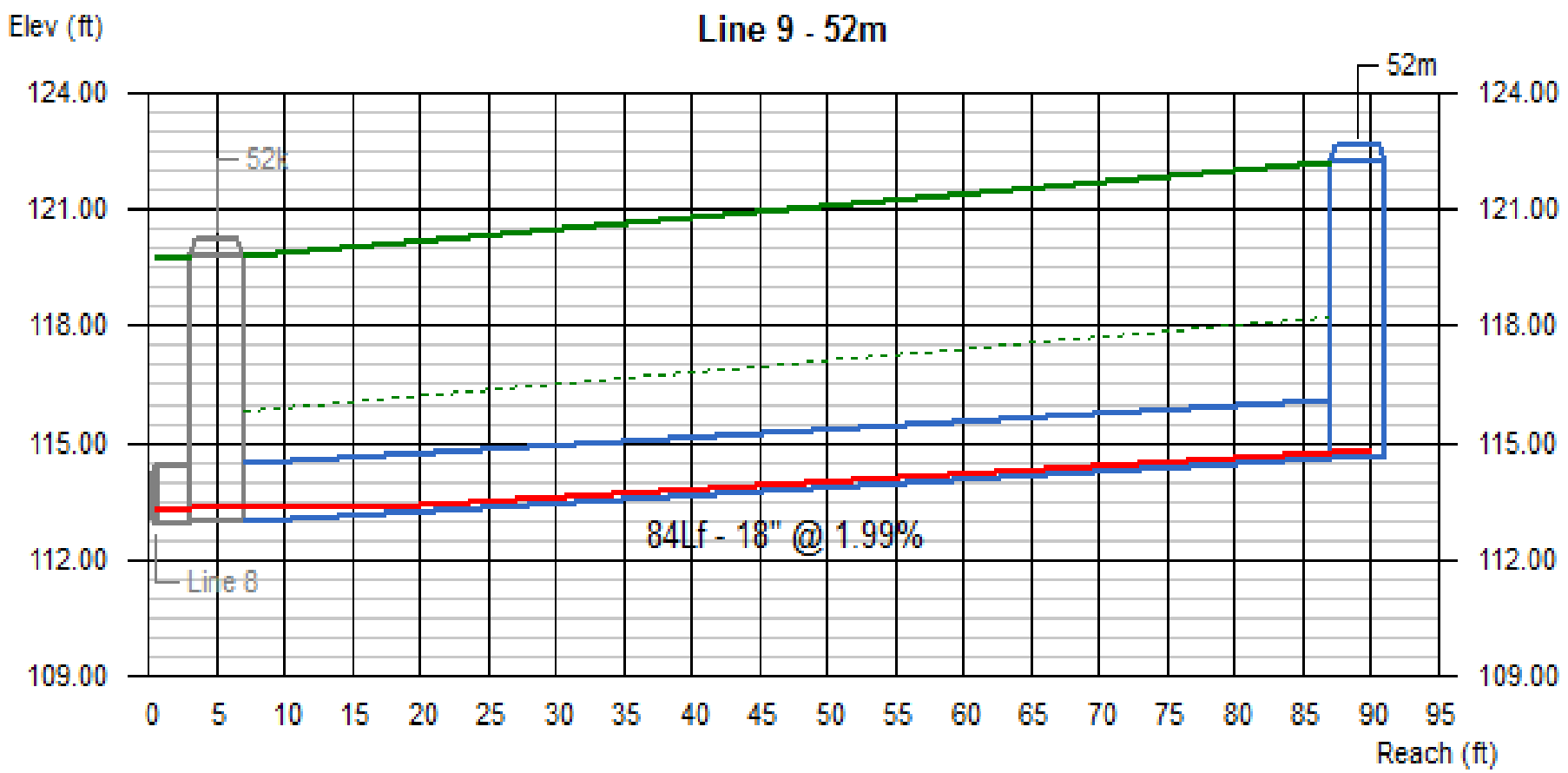
Line Profile (Line 8) - 52j



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	0.60	112.19	112.95	0.29	0.35	0.38	112.49	113.30	113.33	2.43	1.93	4.46	5.38

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

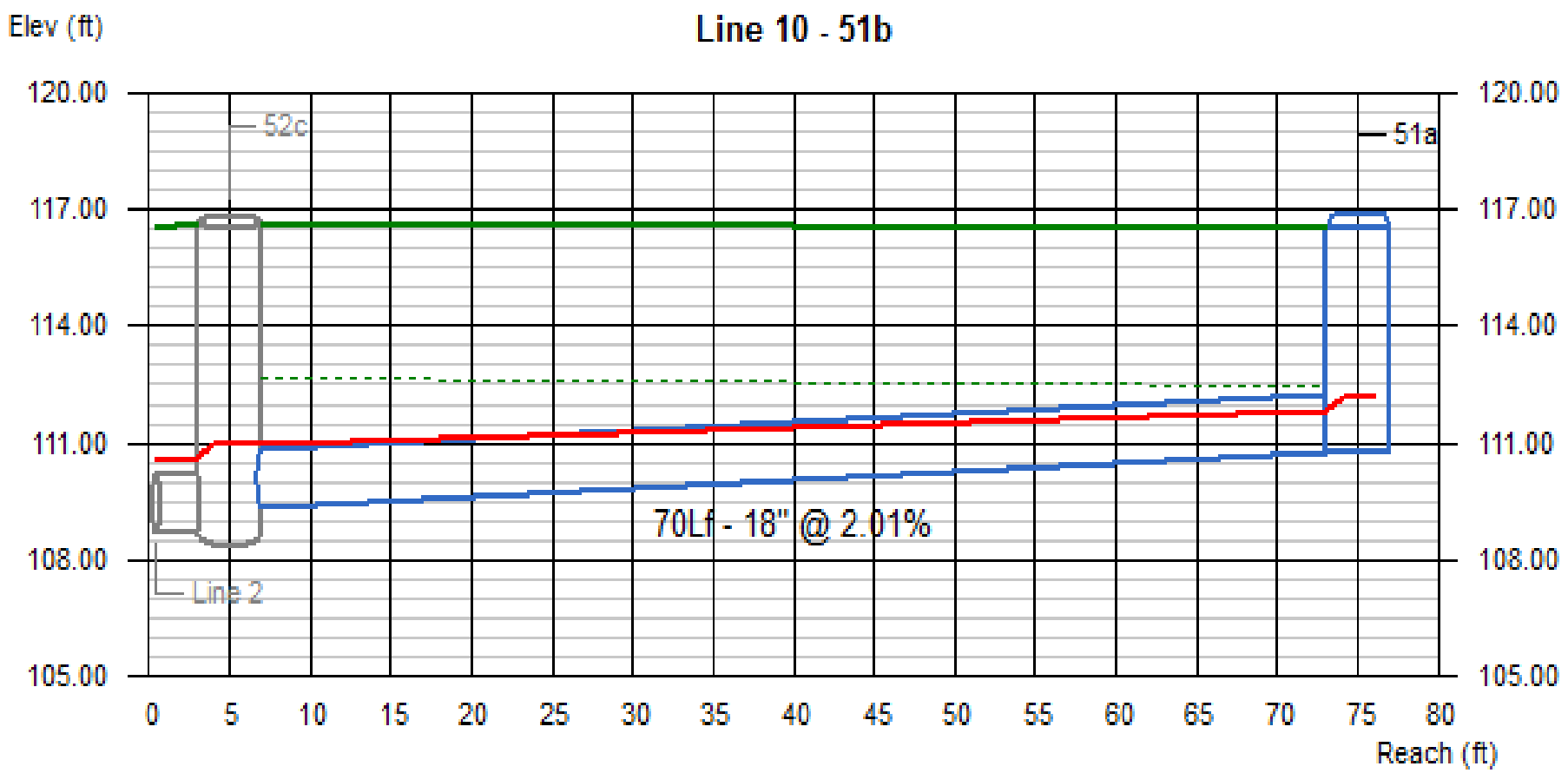
Line Profile (Line 9) - 52m



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
9	0.20	112.95	114.62	0.38	0.17	0.17	113.33	114.79 j	114.79	0.57	1.79	5.38	6.13

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

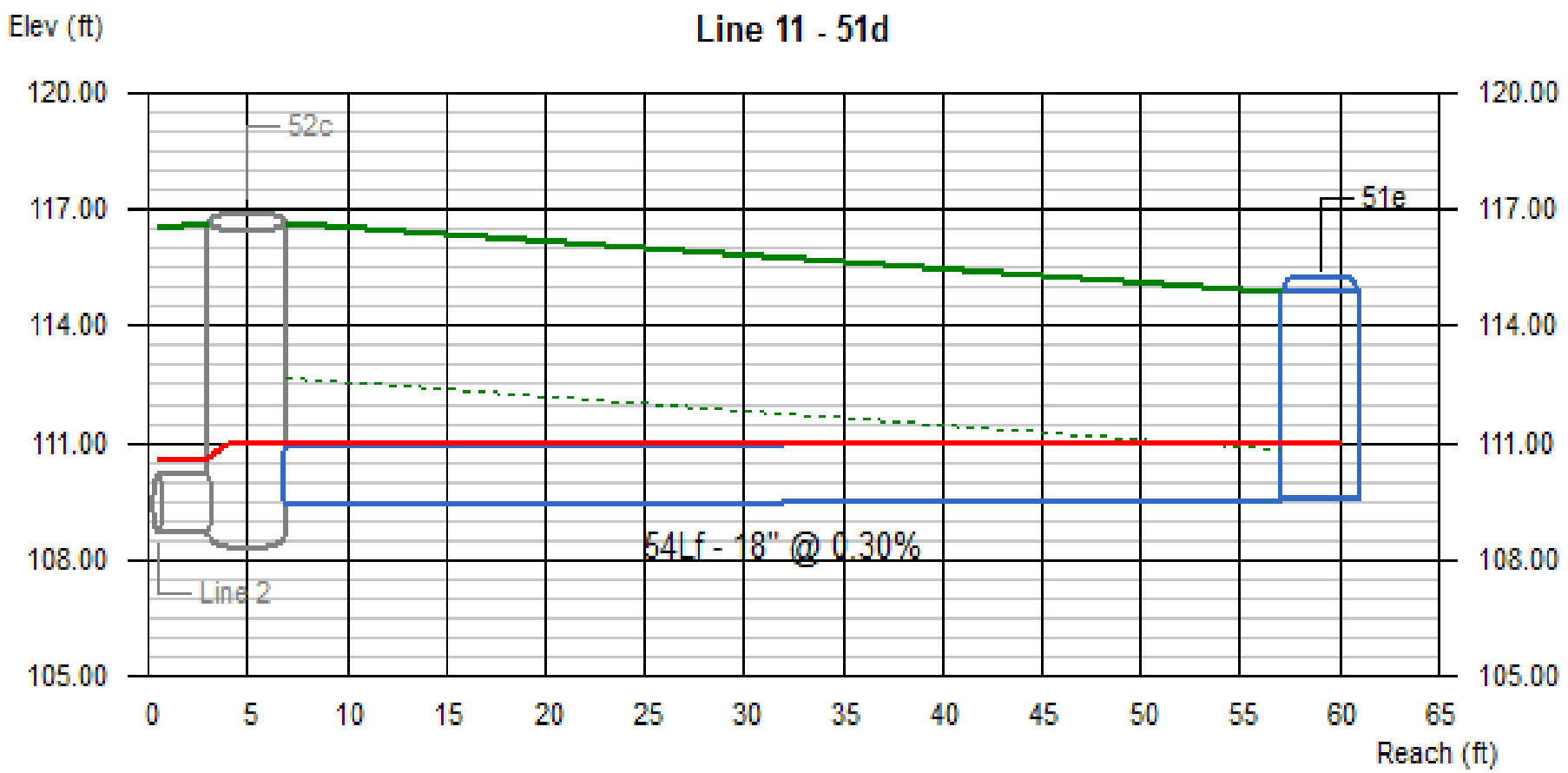
Line Profile (Line 10) - 51b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	6.05	109.36	110.77	1.50	1.07	1.38	110.95	111.84	112.15	3.43	4.51	5.84	4.22

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

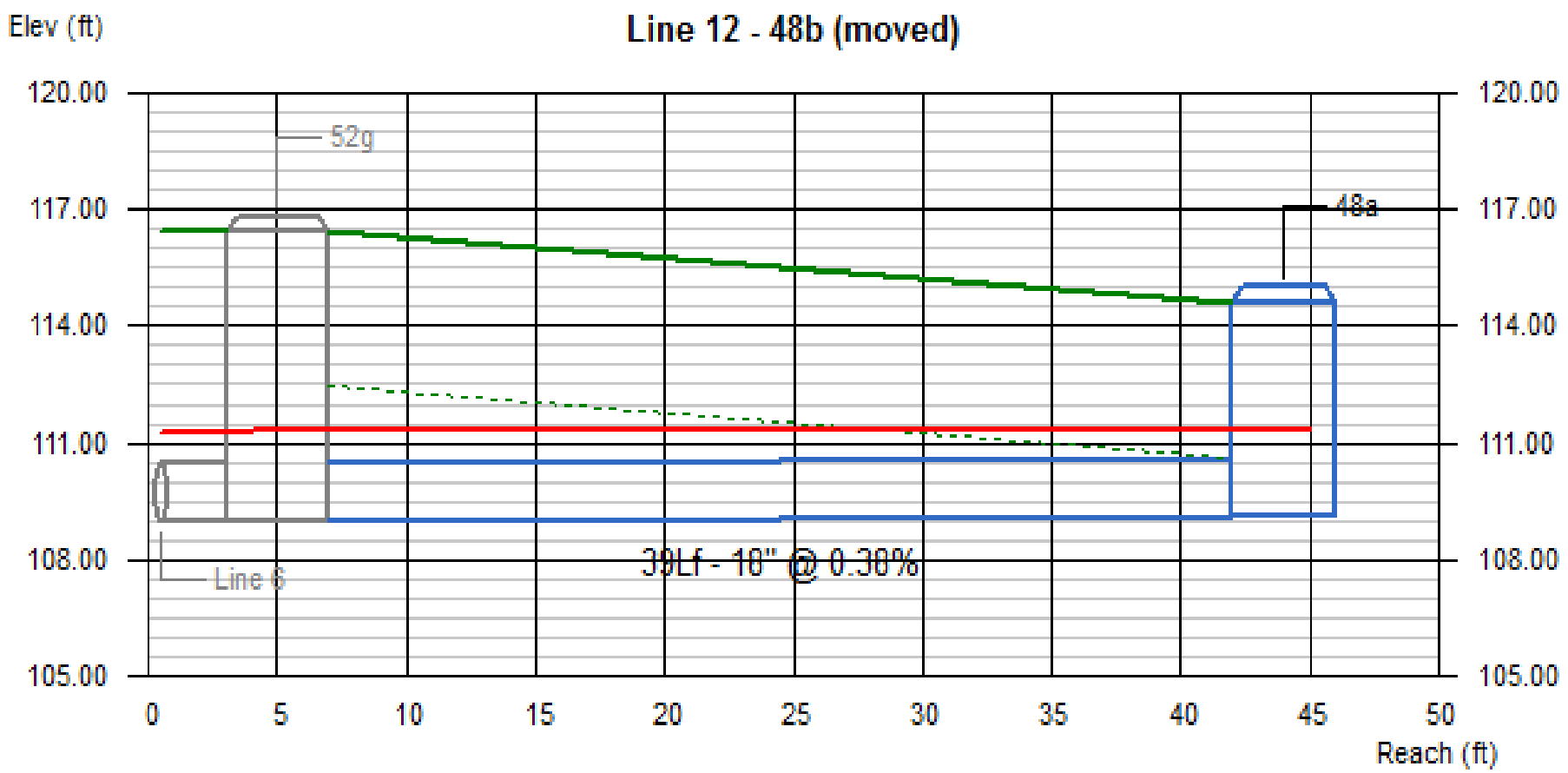
Line Profile (Line 11) - 51d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
11	1.08	109.39	109.55	1.50	1.42	1.42	110.95	110.97	110.97	0.61	0.62	5.81	3.80

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

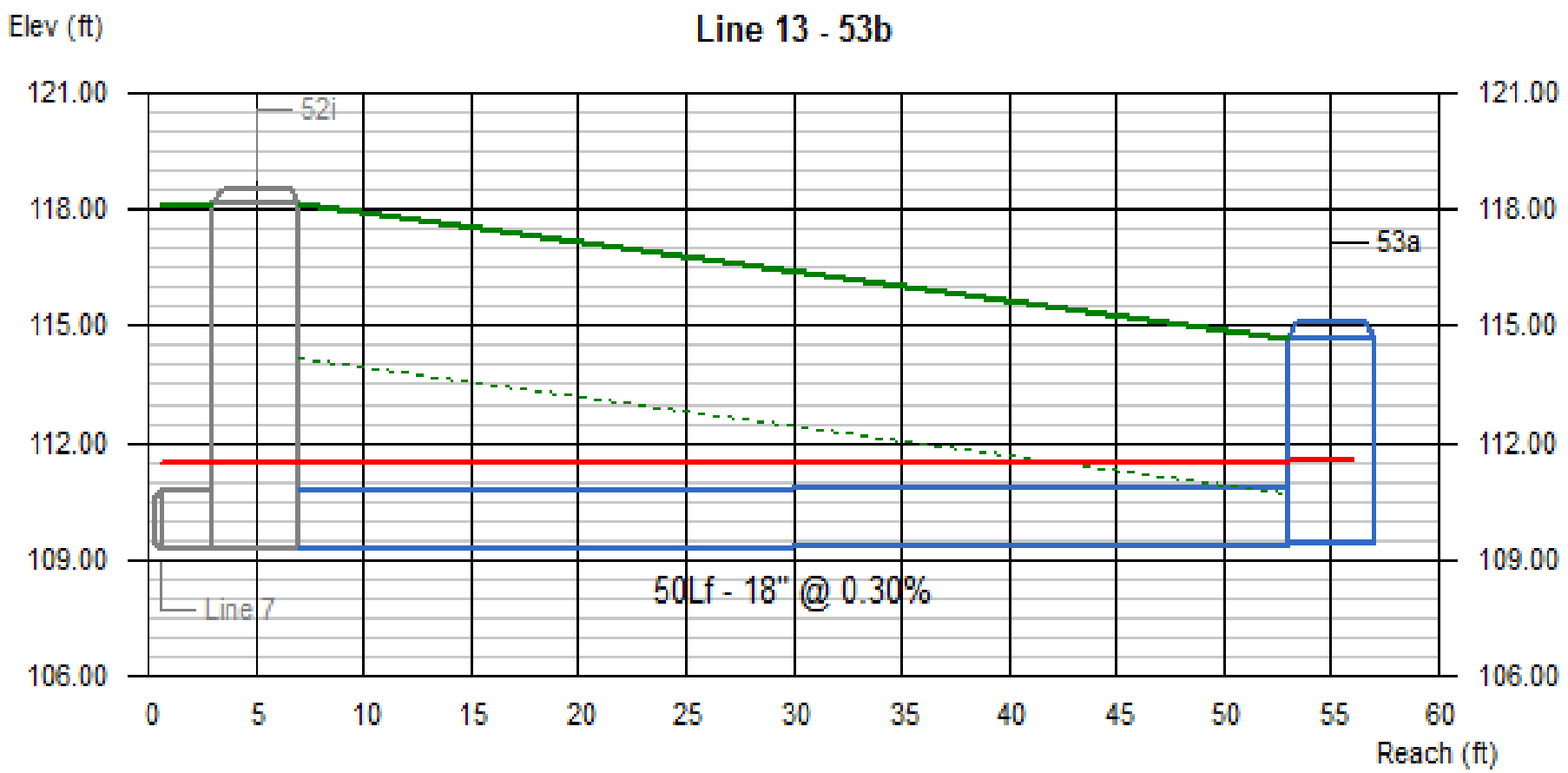
Line Profile (Line 12) - 48b (moved)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
12	0.77	108.99	109.14	1.50	1.50	2.20	111.33	111.34	111.34	0.44	0.44	5.95	3.97

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

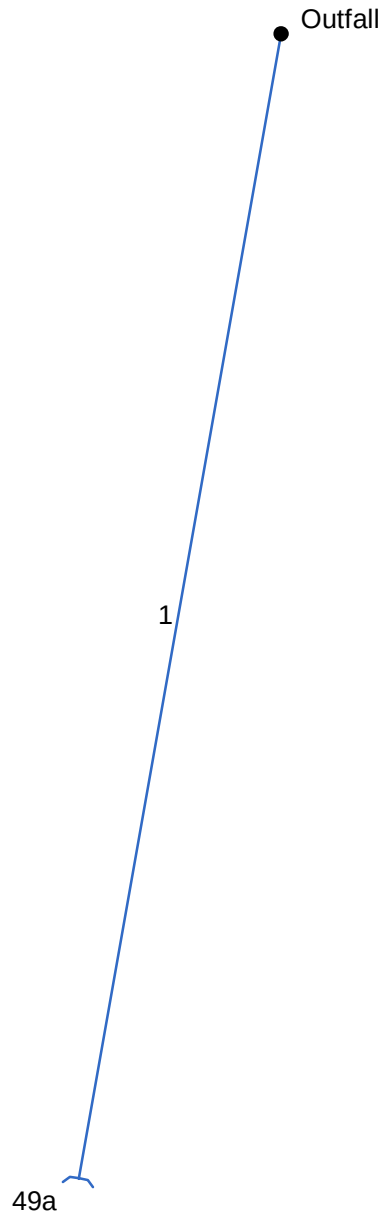
Line Profile (Line 13) - 53b



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
13	1.68	109.24	109.39	1.50	1.50	2.17	111.50	111.55	111.56	0.95	0.95	7.41	3.82

48 51 52 53 | No. Lines: 13 | Run Date: 11-05-2013

49



Project File: Drainage System 49.stm	Number of lines: 1	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	256	4.17	4.17	0.66	2.75	2.75	15.0	15.0	1.6	4.32	8.32	2.75	24	0.50	118.35	119.63	119.19	120.90	118.35	119.63	49b

49 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

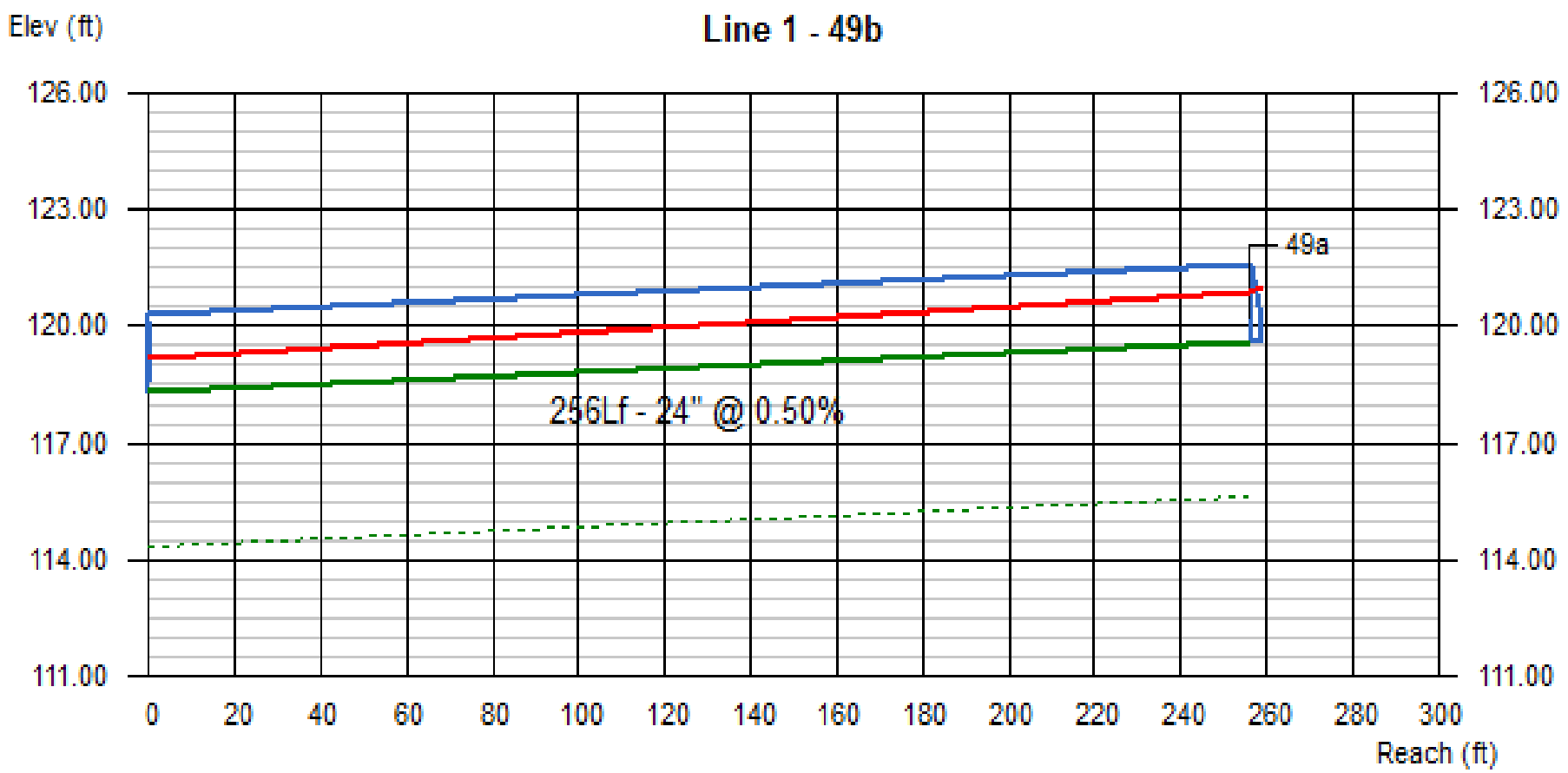
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	24	4.32	118.35	119.19	0.84	1.26	3.44	0.18	119.38	0.987	256	119.63	120.90	1.27	2.10	2.05	0.07	120.97	0.253	0.620	1.587	1.00	0.07

49 | Number of lines: 1 | Run Date: 11-04-2013

; c = cir e = ellip b = box

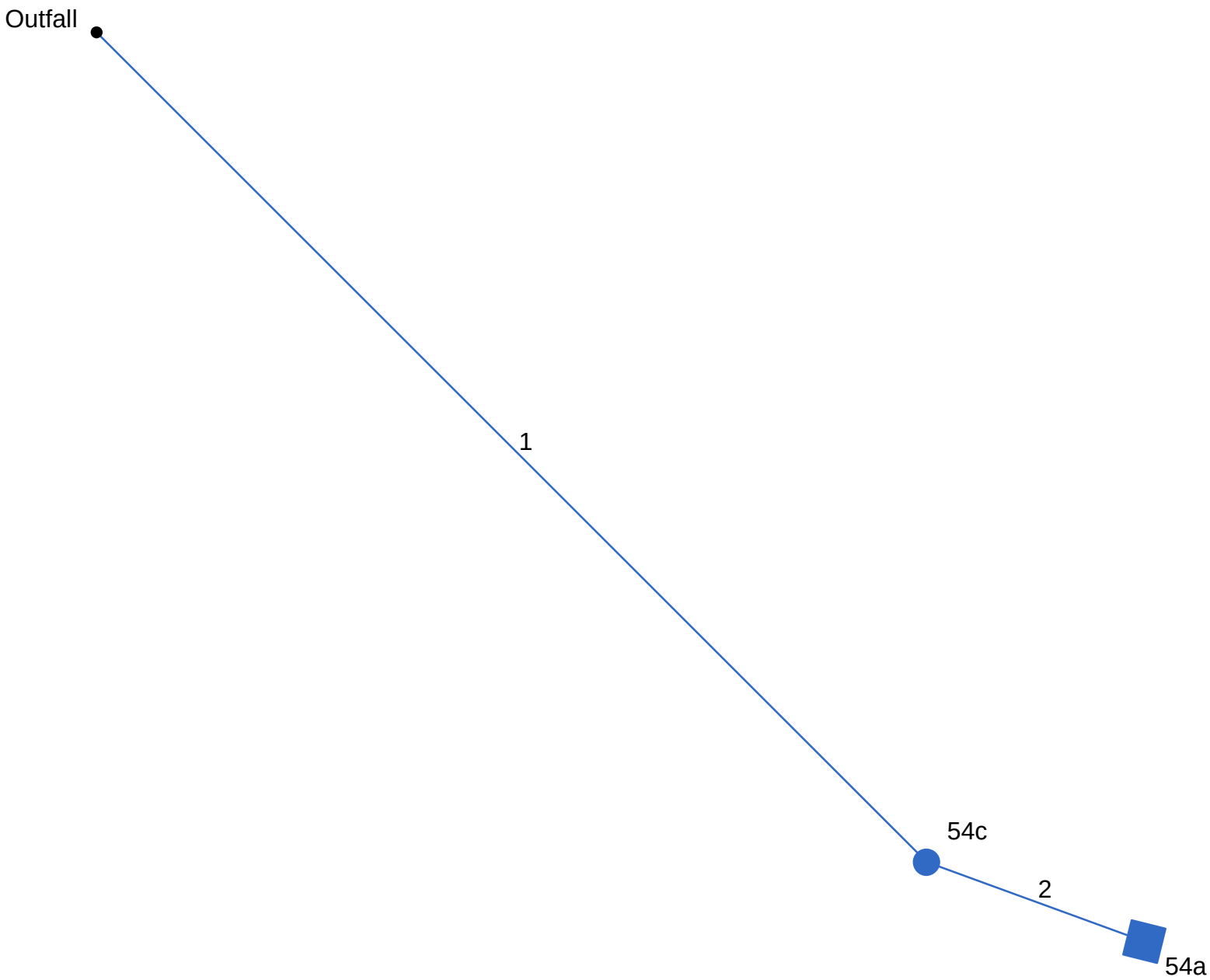
Line Profile (Line 1) - 49b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	4.32	118.35	119.63	0.84	1.27	1.34	119.19	120.90	120.97	3.44	2.05	-2.00	-2.00

49	No. Lines: 1	Run Date: 11-04-2013

54



Project File: Drainage System 54.stm	Number of lines: 2	Date: 10-29-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	138	0.00	0.19	0.00	0.00	0.19	5.0	5.2	2.7	0.51	7.72	2.33	18	2.00	115.70	118.46	115.97	118.73	115.70	122.00	54d
2	1	27	0.19	0.19	1.00	0.19	0.19	5.0	5.0	2.7	0.52	7.65	2.34	18	1.96	118.46	118.99	118.74	119.27	122.00	124.61	54b

54 Number of lines: 2 Run Date: 10-29-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

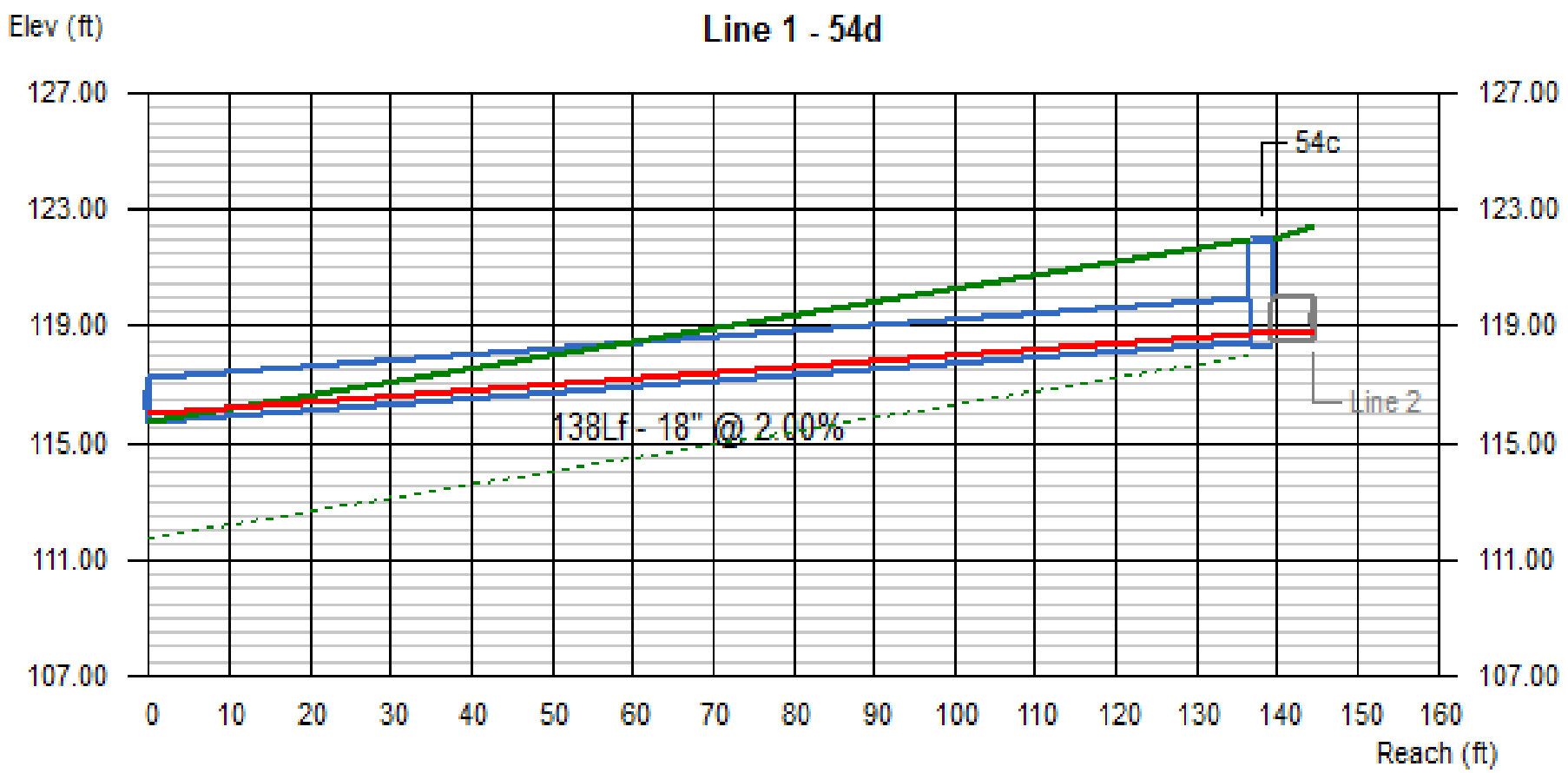
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.51	115.70	115.97	0.27	0.22	2.33	0.08	116.06	1.680	138	118.46	118.73	0.27**	0.22	2.33	0.08	118.82	1.680	1.680	n/a	0.48	n/a
2	18	0.52	118.46	118.74	0.28*	0.22	2.34	0.09	118.82	1.679	27	118.99	119.27	0.28**	0.22	2.34	0.09	119.35	1.679	1.679	n/a	1.00	n/a

54 | Number of lines: 2 | Run Date: 10-29-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

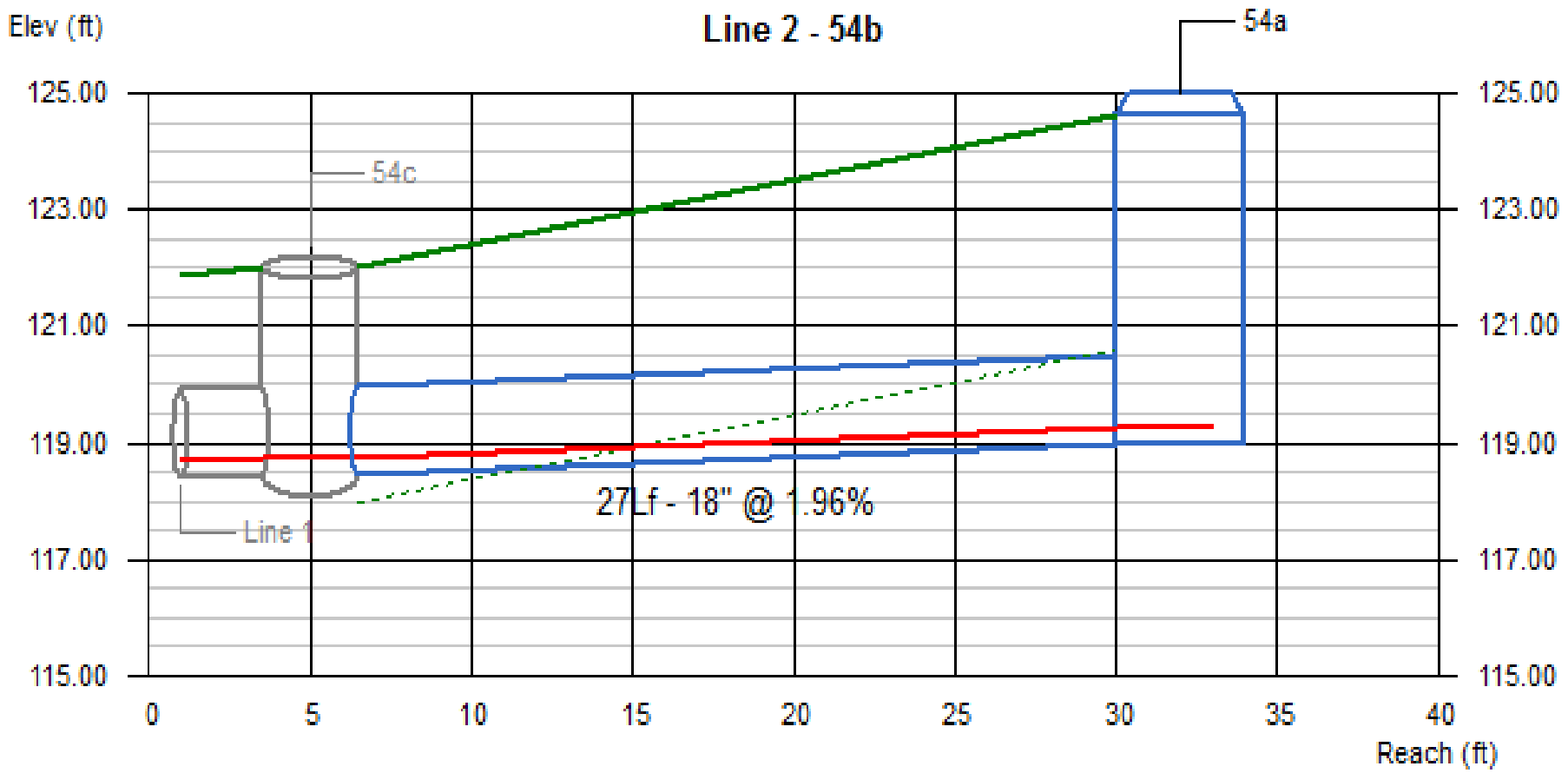
Line Profile (Line 1) - 54d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.51	115.70	118.46	0.27	0.27	0.27	115.97	118.73	118.73	2.33	2.33	-1.50	2.04

54	No. Lines: 2	Run Date: 10-29-2013

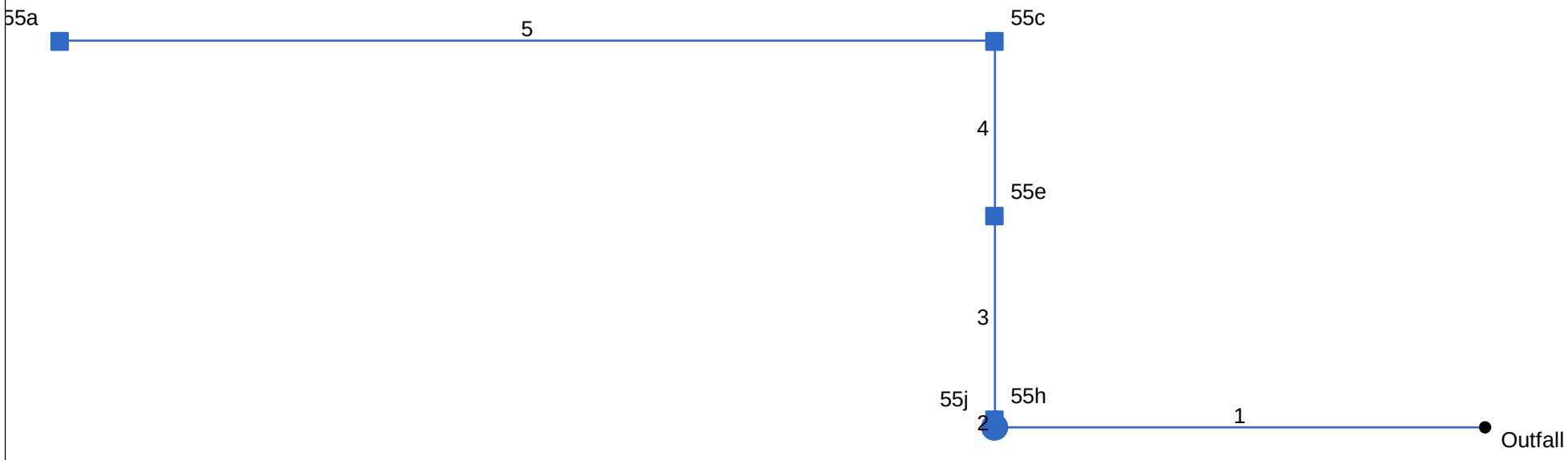
Line Profile (Line 2) - 54b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.52	118.46	118.99	0.28	0.28	0.28	118.74	119.27	119.27	2.34	2.34	2.04	4.12

54 | No. Lines: 2 | Run Date: 10-29-2013

55



Project File: Drainage System 55.stm	Number of lines: 5	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	118	0.00	0.89	0.00	0.00	0.89	5.0	8.3	2.1	1.89	190.4	2.77	54	3.47	98.58	102.67	98.97	103.06	114.80	118.50	Existing Pipe
2	1	2	0.29	0.89	1.00	0.29	0.89	5.0	8.3	2.1	1.89	3.86	3.16	18	0.50	111.95	111.96	112.48	112.56	118.50	117.90	55i
3	2	49	0.12	0.60	1.00	0.12	0.60	5.0	7.9	2.2	1.31	4.41	2.28	18	0.65	112.13	112.45	112.62	113.05	117.90	118.59	55g
4	3	42	0.30	0.48	1.00	0.30	0.48	5.0	7.5	2.2	1.07	4.21	1.72	18	0.60	112.45	112.70	113.08	113.23	118.59	118.15	55d
5	4	225	0.18	0.18	1.00	0.18	0.18	5.0	5.0	2.7	0.49	4.23	1.49	18	0.60	112.87	114.22	113.32	114.53	118.15	119.57	55b

55 | Number of lines: 5 | Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

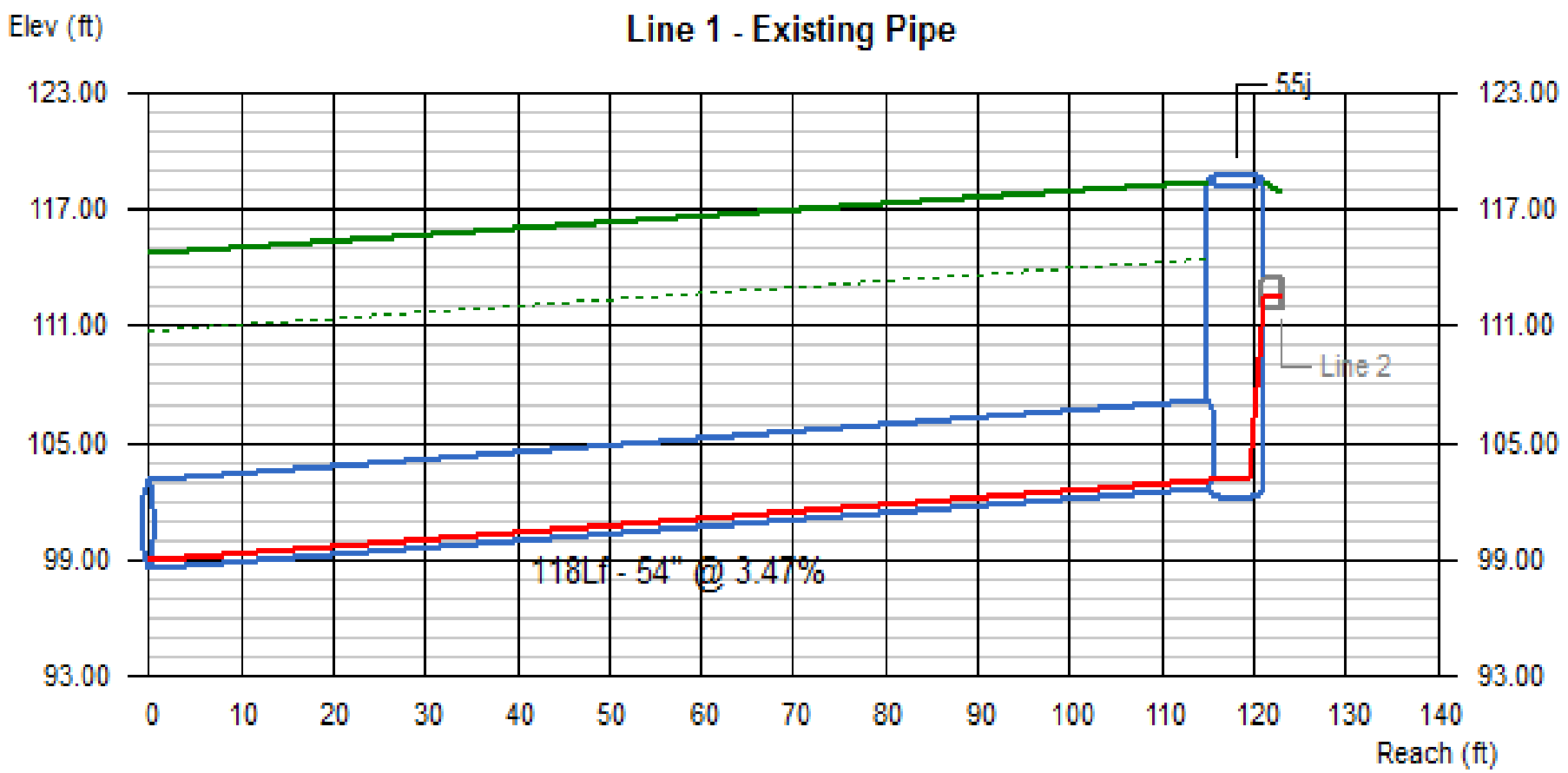
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	54	1.89	98.58	98.97	0.39	0.68	2.77	0.12	99.09	1.367	118	102.67	103.06	0.39**	0.68	2.77	0.12	103.18	1.367	1.367	n/a	1.00	0.12
2	18	1.89	111.95	112.48	0.53*	0.55	3.43	0.18	112.66	1.737	2	111.96	112.56	0.60	0.66	2.88	0.13	112.69	1.073	1.405	0.028	0.50	0.06
3	18	1.31	112.13	112.62	0.49	0.50	2.59	0.10	112.73	1.055	49	112.45	113.05	0.60	0.66	1.98	0.06	113.11	0.504	0.780	0.382	0.50	0.03
4	18	1.07	112.45	113.08	0.63	0.70	1.52	0.04	113.12	0.285	42	112.70	113.23	0.53	0.56	1.92	0.06	113.29	0.538	0.411	0.173	1.50	0.09
5	18	0.49	112.87	113.32	0.45	0.44	1.12	0.02	113.34	0.221	225	114.22	114.53	0.31	0.27	1.85	0.05	114.59	0.903	0.562	1.265	1.00	0.05

55 | Number of lines: 5 | Run Date: 11-04-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

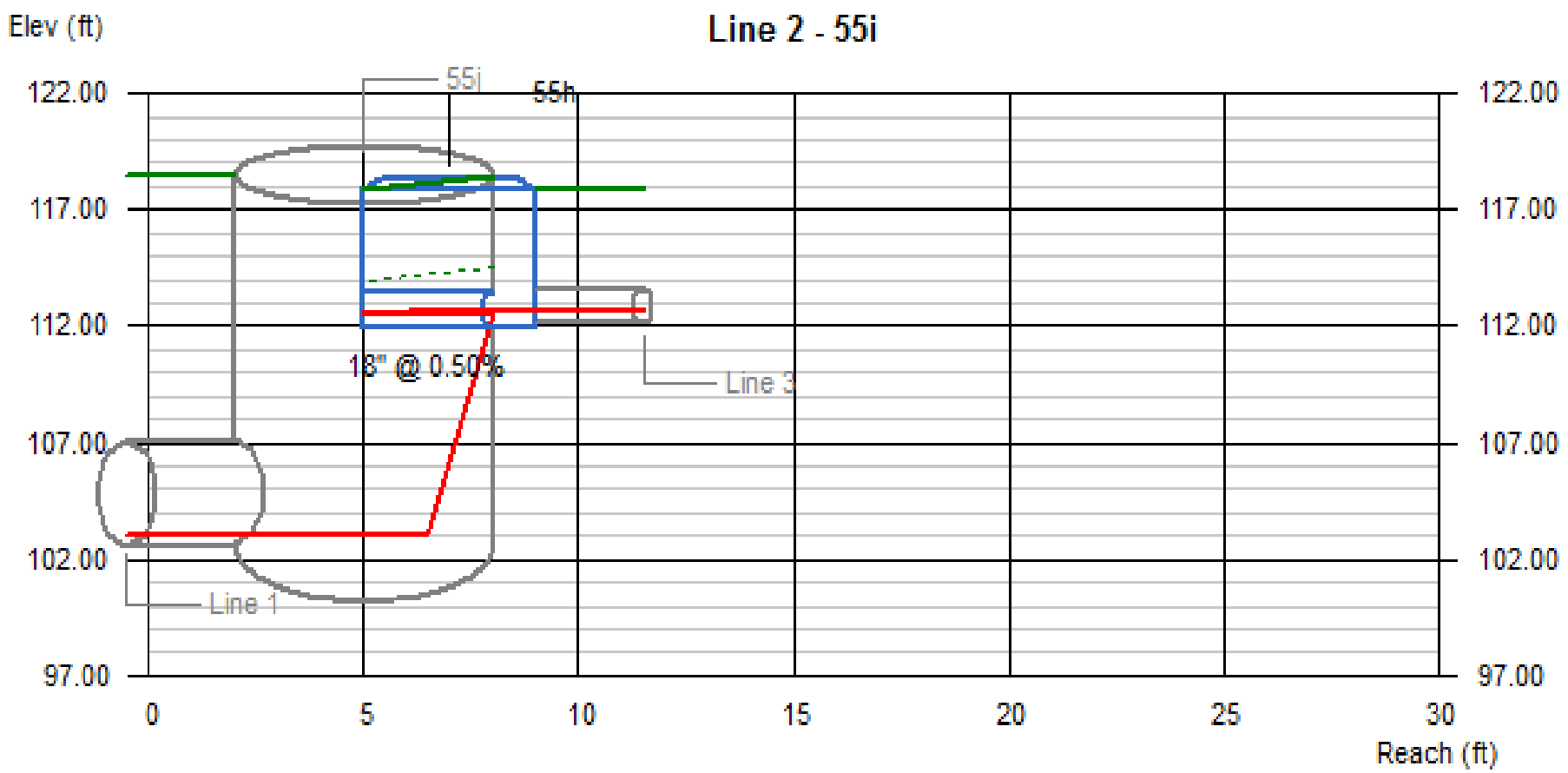
Line Profile (Line 1) - Existing Pipe



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
1	1.89	98.58	102.67	0.39	0.39	0.39	98.97	103.06	103.06	2.77	2.77	11.72	11.33

55 | No. Lines: 5 | Run Date: 11-04-2013

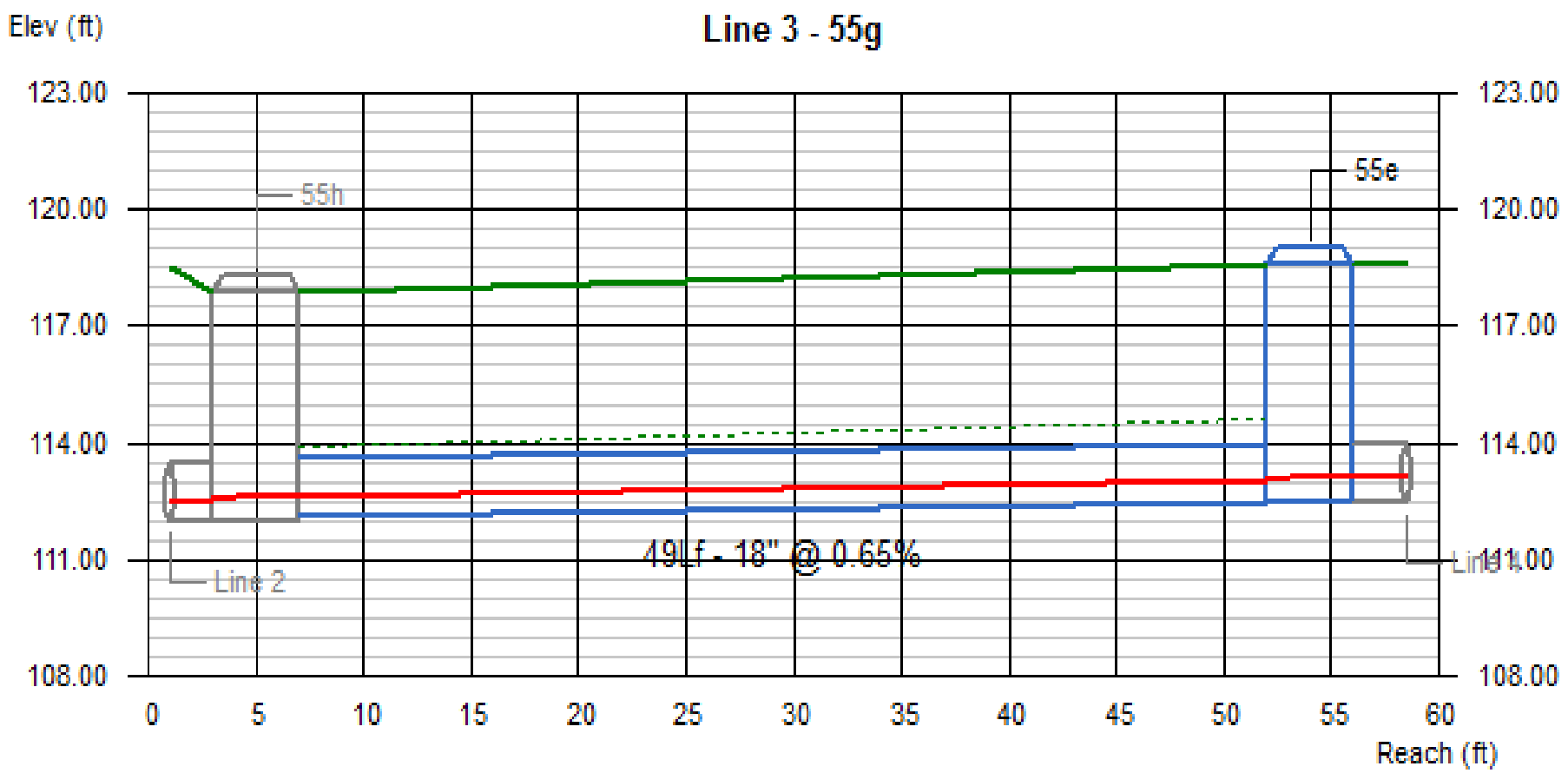
Line Profile (Line 2) - 55i



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	1.89	111.95	111.96	0.53	0.60	0.66	112.48	112.56	112.62	3.43	2.88	5.05	4.44

55 | No. Lines: 5 | Run Date: 11-04-2013

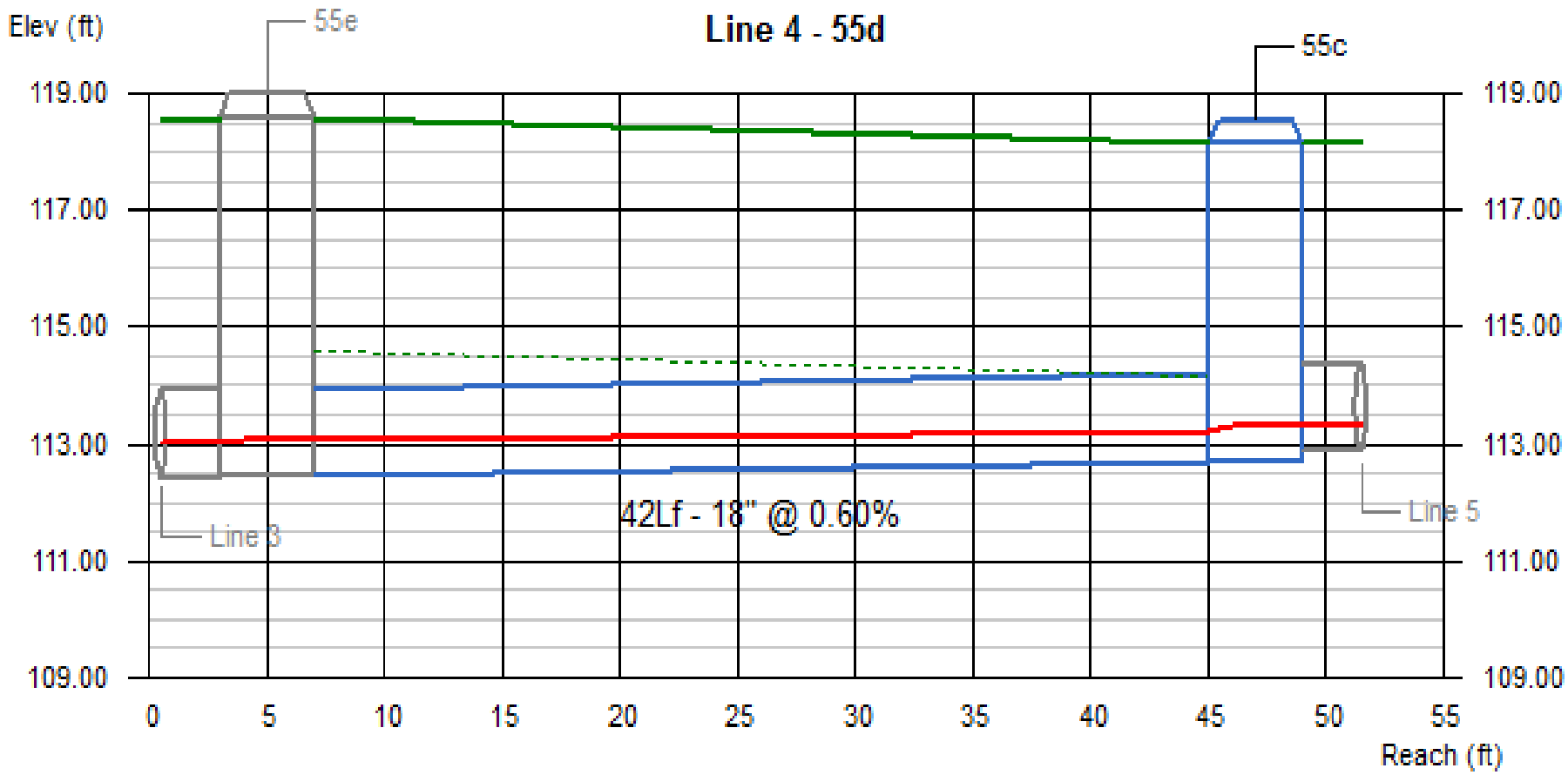
Line Profile (Line 3) - 55g



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	1.31	112.13	112.45	0.49	0.60	0.63	112.62	113.05	113.08	2.59	1.98	4.27	4.64

55	No. Lines: 5	Run Date: 11-04-2013

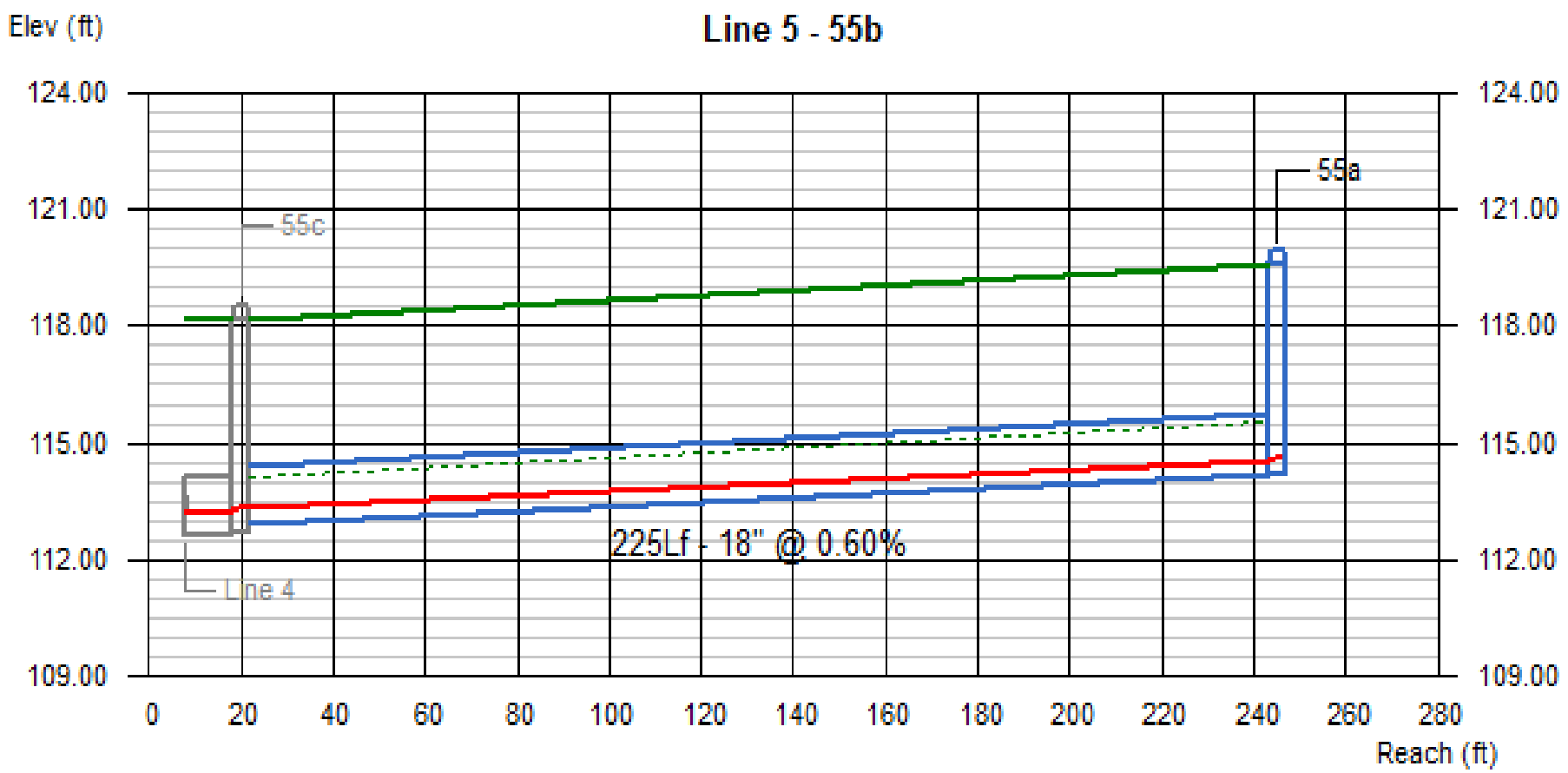
Line Profile (Line 4) - 55d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	1.07	112.45	112.70	0.63	0.53	0.62	113.08	113.23	113.32	1.52	1.92	4.64	3.95

55 | No. Lines: 5 | Run Date: 11-04-2013

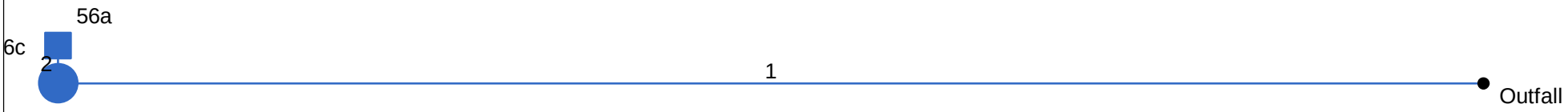
Line Profile (Line 5) - 55b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.49	112.87	114.22	0.45	0.31	0.37	113.32	114.53	114.59	1.12	1.85	3.78	3.85

55 | No. Lines: 5 | Run Date: 11-04-2013

56



Project File: Drainage System 56.stm	Number of lines: 2	Date: 10-29-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	222	0.00	0.26	0.00	0.00	0.26	5.0	5.0	2.7	0.71	93.35	1.74	54	0.83	102.67	104.52	102.95	104.80	118.50	120.39	Existing Pipe
2	1	6	0.26	0.26	1.00	0.26	0.26	5.0	5.0	2.7	0.71	7.72	2.54	18	2.00	113.93	114.05	114.25	114.38	120.39	119.57	56b

56 Number of lines: 2 Run Date: 10-29-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

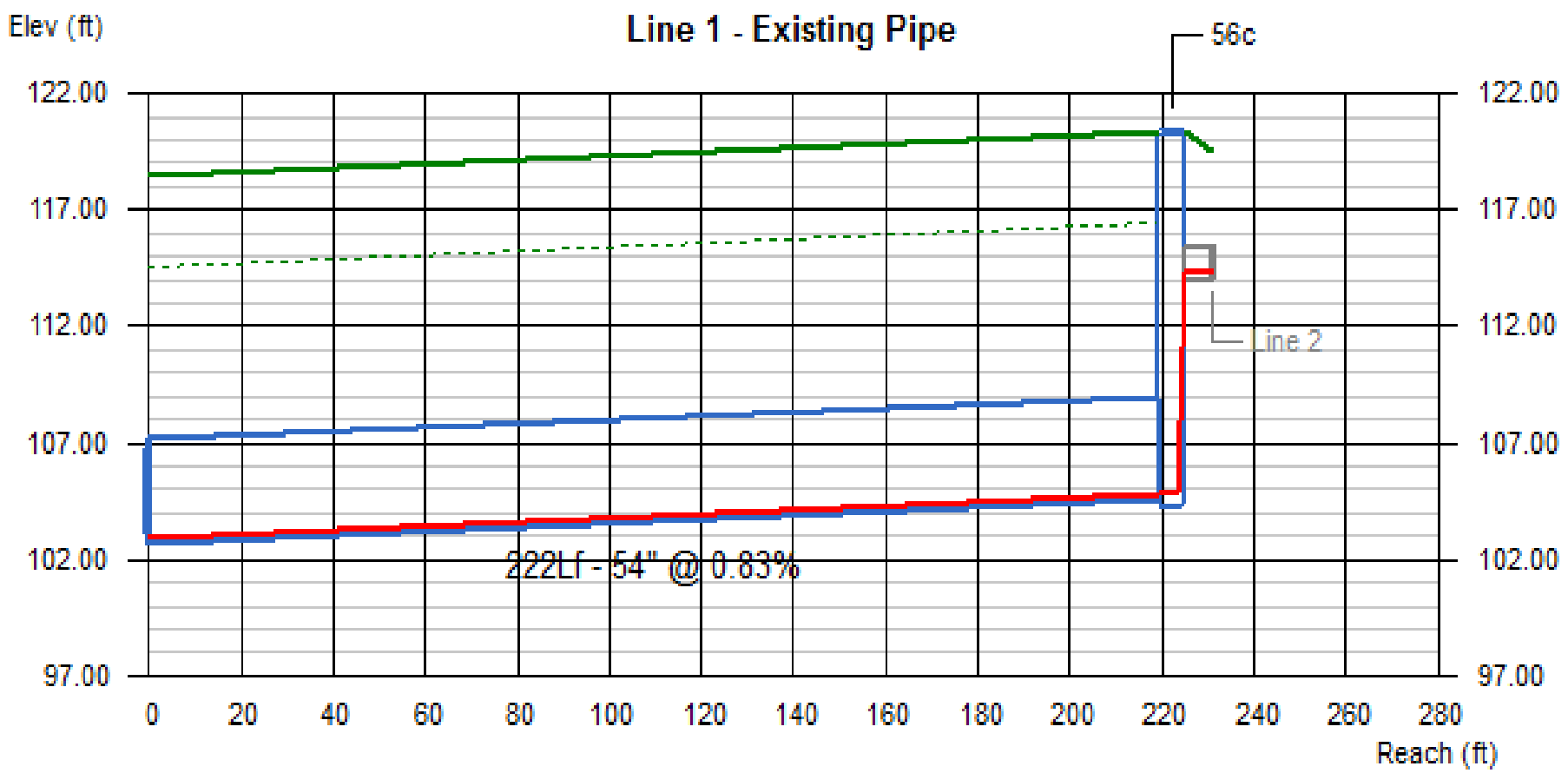
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	54	0.71	102.67	102.95	0.28	0.41	1.73	0.05	103.00	0.831	222	104.52	104.80	0.28	0.41	1.74	0.05	104.85	0.844	0.838	1.859	1.00	0.05
2	18	0.71	113.93	114.25	0.32*	0.28	2.56	0.10	114.35	1.665	6	114.05	114.38	0.33**	0.28	2.53	0.10	114.47	1.603	1.634	0.098	1.00	0.10

56 | Number of lines: 2 | Run Date: 10-29-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

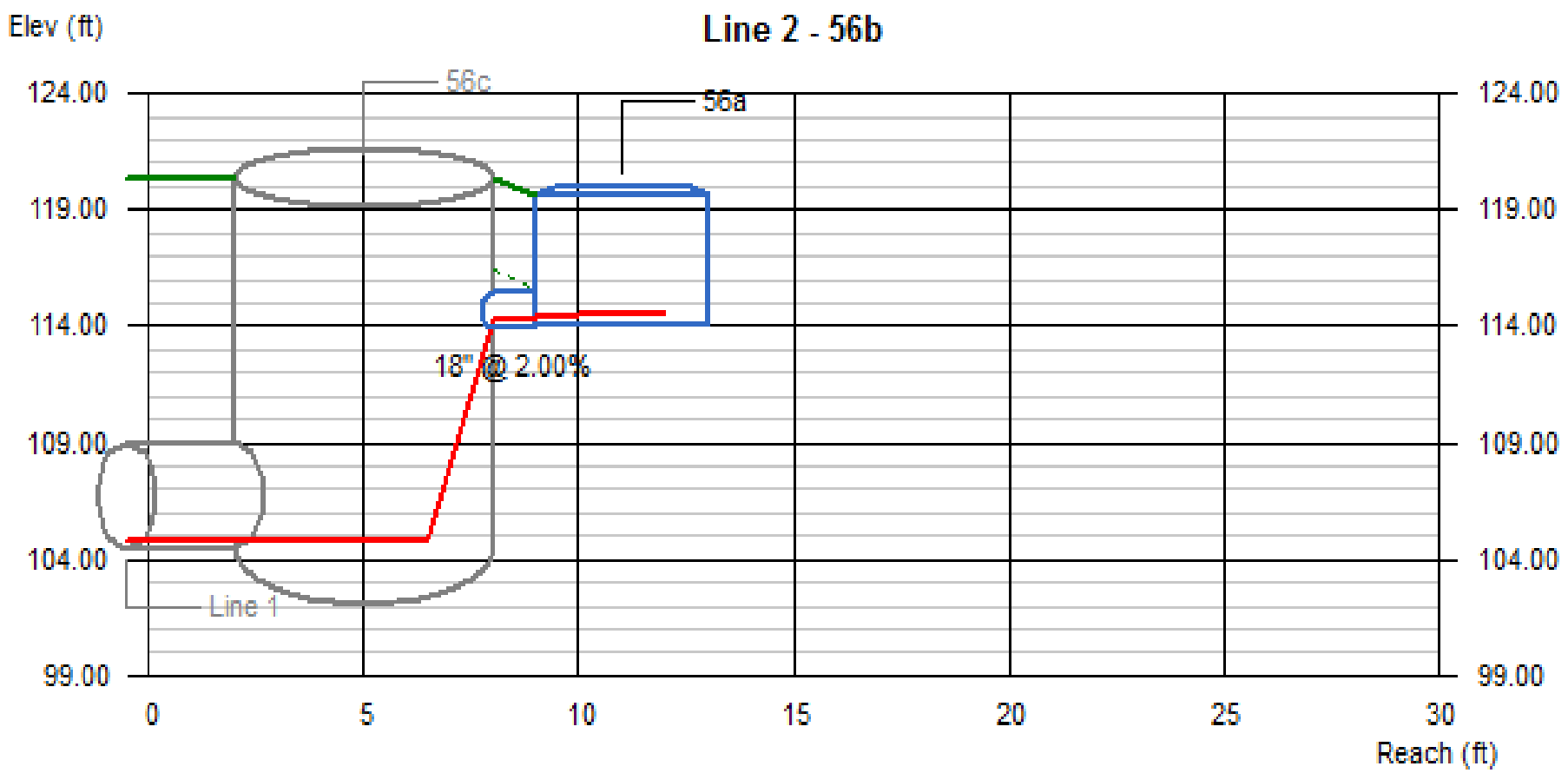
Line Profile (Line 1) - Existing Pipe



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.71	102.67	104.52	0.28	0.28	0.33	102.95	104.80	104.85	1.73	1.74	11.33	11.37

56 | No. Lines: 2 | Run Date: 10-29-2013

Line Profile (Line 2) - 56b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.71	113.93	114.05	0.32	0.33	0.42	114.25	114.38	114.47	2.56	2.53	4.96	4.02

56	No. Lines: 2	Run Date: 10-29-2013

57

Project File: Drainage System 57.stm	Number of lines: 2	Date: 11-08-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	80	0.12	0.26	1.00	0.12	0.26	5.0	5.8	2.5	0.66	2.99	1.08	18	0.30	131.63	131.87	132.26	132.39	131.63	138.18	57d
2	1	38	0.14	0.14	1.00	0.14	0.14	5.0	5.0	2.7	0.38	2.94	0.77	18	0.29	131.87	131.98	132.40	132.43	138.18	137.18	57b

57 Number of lines: 2 Run Date: 11-08-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

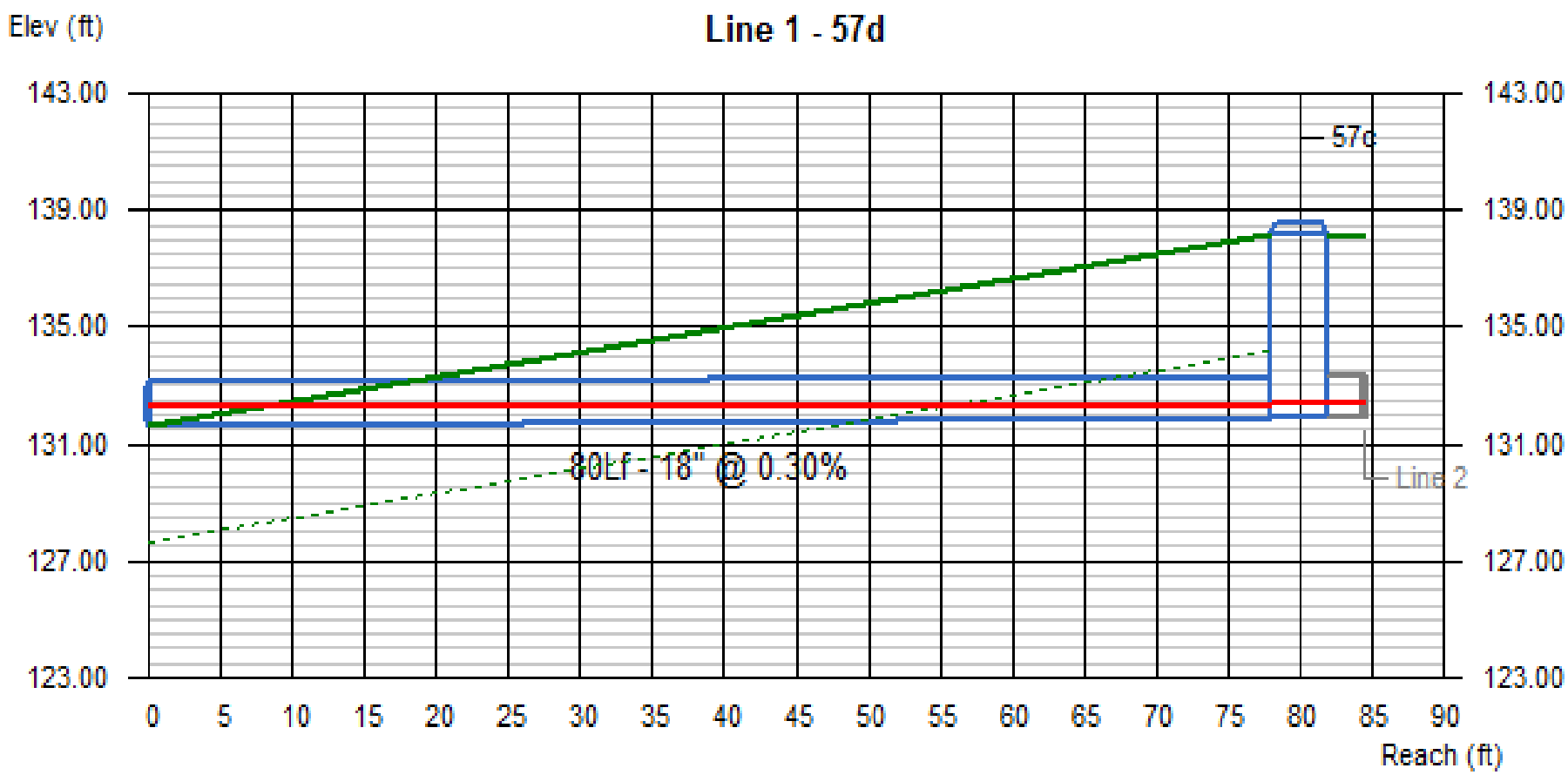
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.66	131.63	132.26	0.63	0.71	0.94	0.01	132.27	0.108	80	131.87	132.39	0.52	0.54	1.23	0.02	132.41	0.225	0.167	0.133	0.50	0.01
2	18	0.38	131.87	132.40	0.53	0.56	0.69	0.01	132.41	0.070	38	131.98	132.43	0.45	0.45	0.86	0.01	132.44	0.127	0.099	0.038	1.00	0.01

57 | Number of lines: 2 | Run Date: 11-08-2013

; c = cir e = ellip b = box

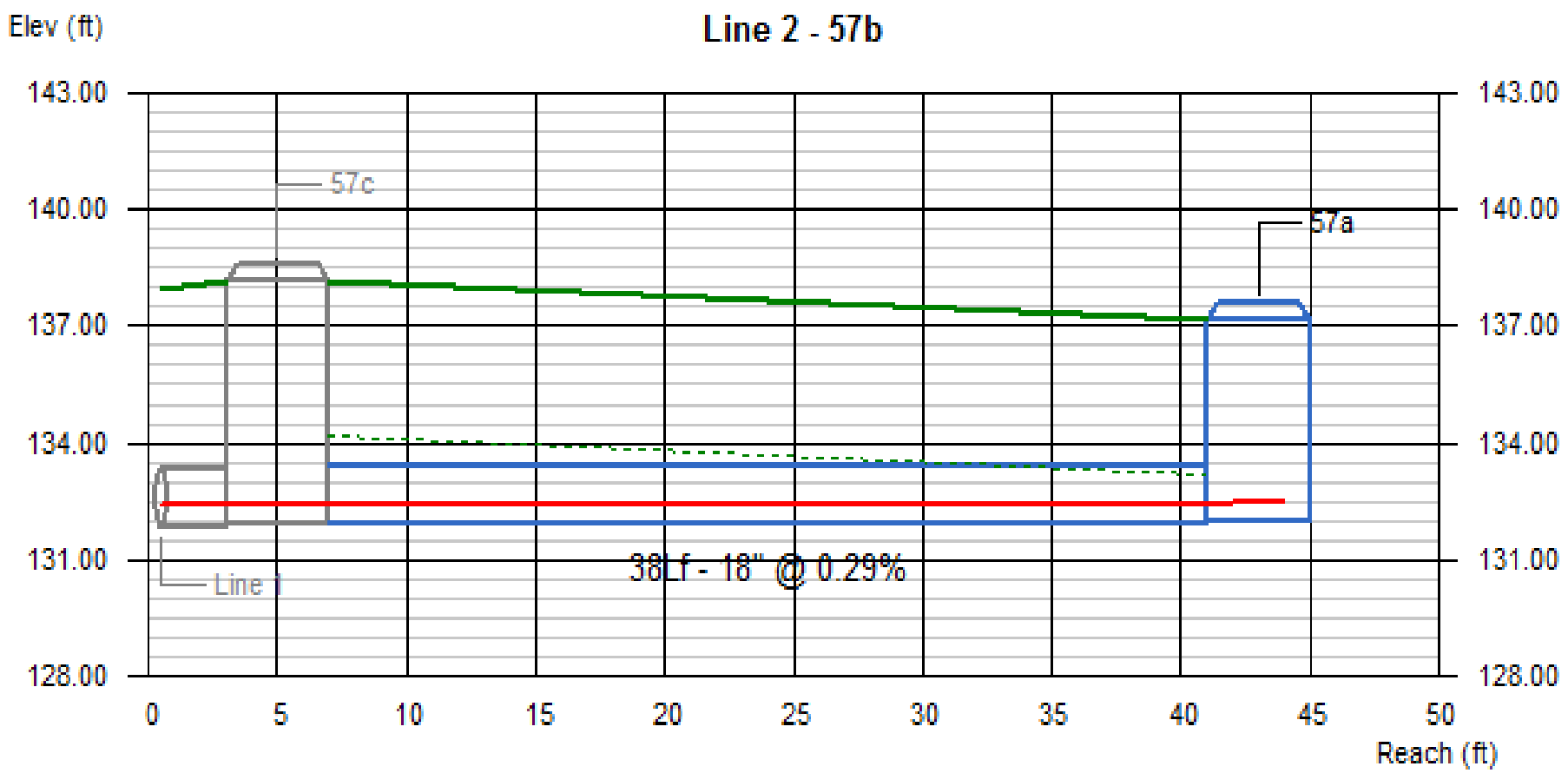
Line Profile (Line 1) - 57d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.66	131.63	131.87	0.63	0.52	0.53	132.26	132.39	132.40	0.94	1.23	-1.50	4.81

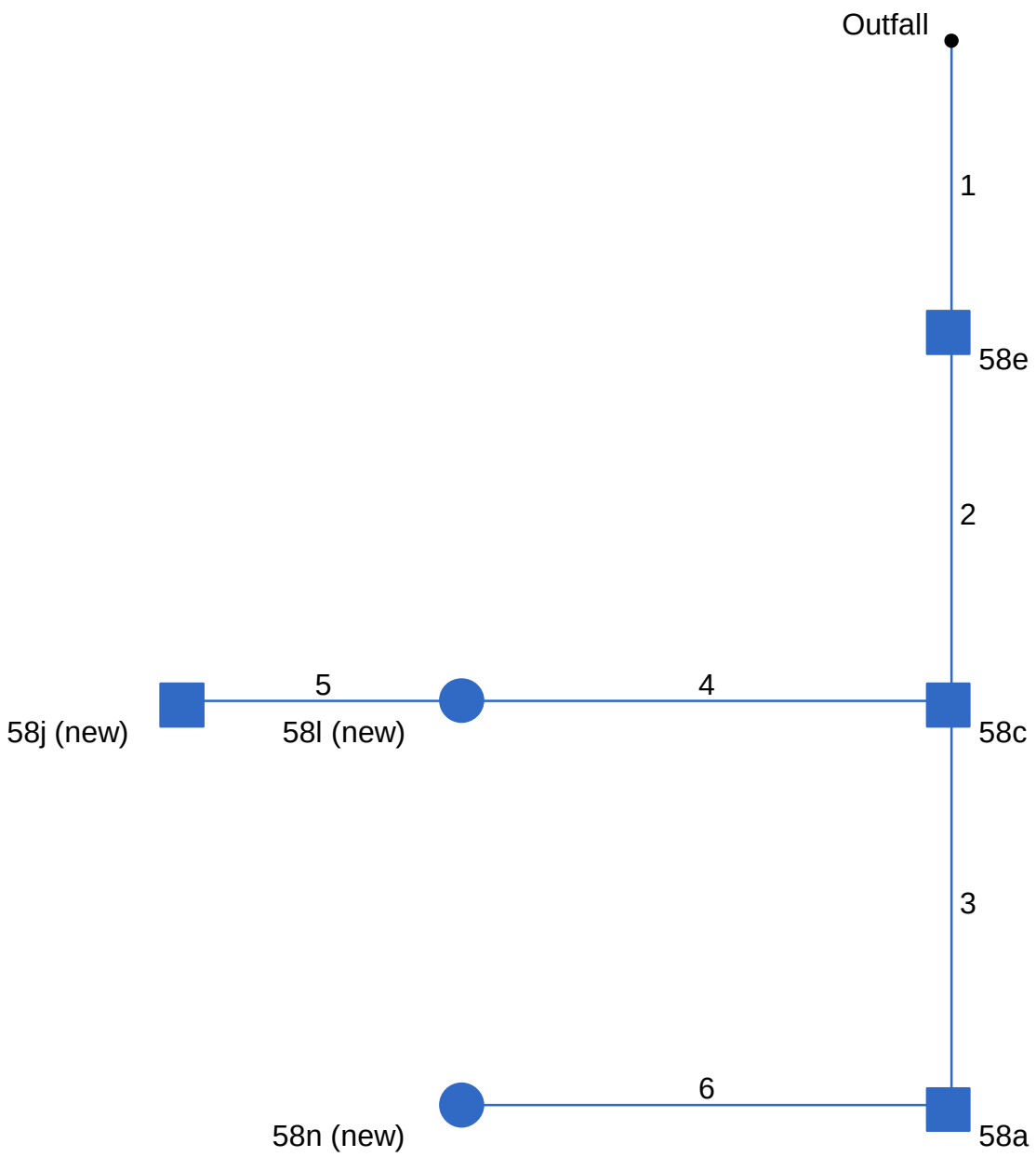
57	No. Lines: 2	Run Date: 11-08-2013

Line Profile (Line 2) - 57b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.38	131.87	131.98	0.53	0.45	0.46	132.40	132.43	132.44	0.69	0.86	4.81	3.70

57 | No. Lines: 2 | Run Date: 11-08-2013



Project File: Drainage System 58.stm	Number of lines: 6	Date: 11-05-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	27	0.01	0.49	1.00	0.01	0.49	5.0	10.6	1.9	0.92	2.97	1.33	18	0.30	129.71	129.79	130.34	130.40	129.71	135.48	58f
2	1	35	0.13	0.48	1.00	0.13	0.48	5.0	10.2	1.9	0.92	2.92	1.35	18	0.29	129.79	129.89	130.41	130.49	135.48	135.43	58d
3	2	38	0.17	0.29	1.00	0.17	0.29	5.0	6.3	2.4	0.71	2.94	1.04	18	0.29	129.89	130.00	130.54	130.58	135.43	135.39	58b
4	2	46	0.02	0.06	1.00	0.02	0.06	5.0	6.8	2.4	0.14	3.01	0.23	18	0.30	129.89	130.03	130.54	130.54	135.43	136.33	58k (new)
5	4	26	0.04	0.04	1.00	0.04	0.04	5.0	5.0	2.7	0.11	3.03	0.23	18	0.31	130.03	130.11	130.54	130.54	136.33	136.79	58i (new)
6	3	46	0.12	0.12	1.00	0.12	0.12	5.0	5.0	2.7	0.33	3.01	0.57	18	0.30	130.00	130.14	130.61	130.63	135.39	136.02	58m (new)

58 | Number of lines: 6 | Run Date: 11-05-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

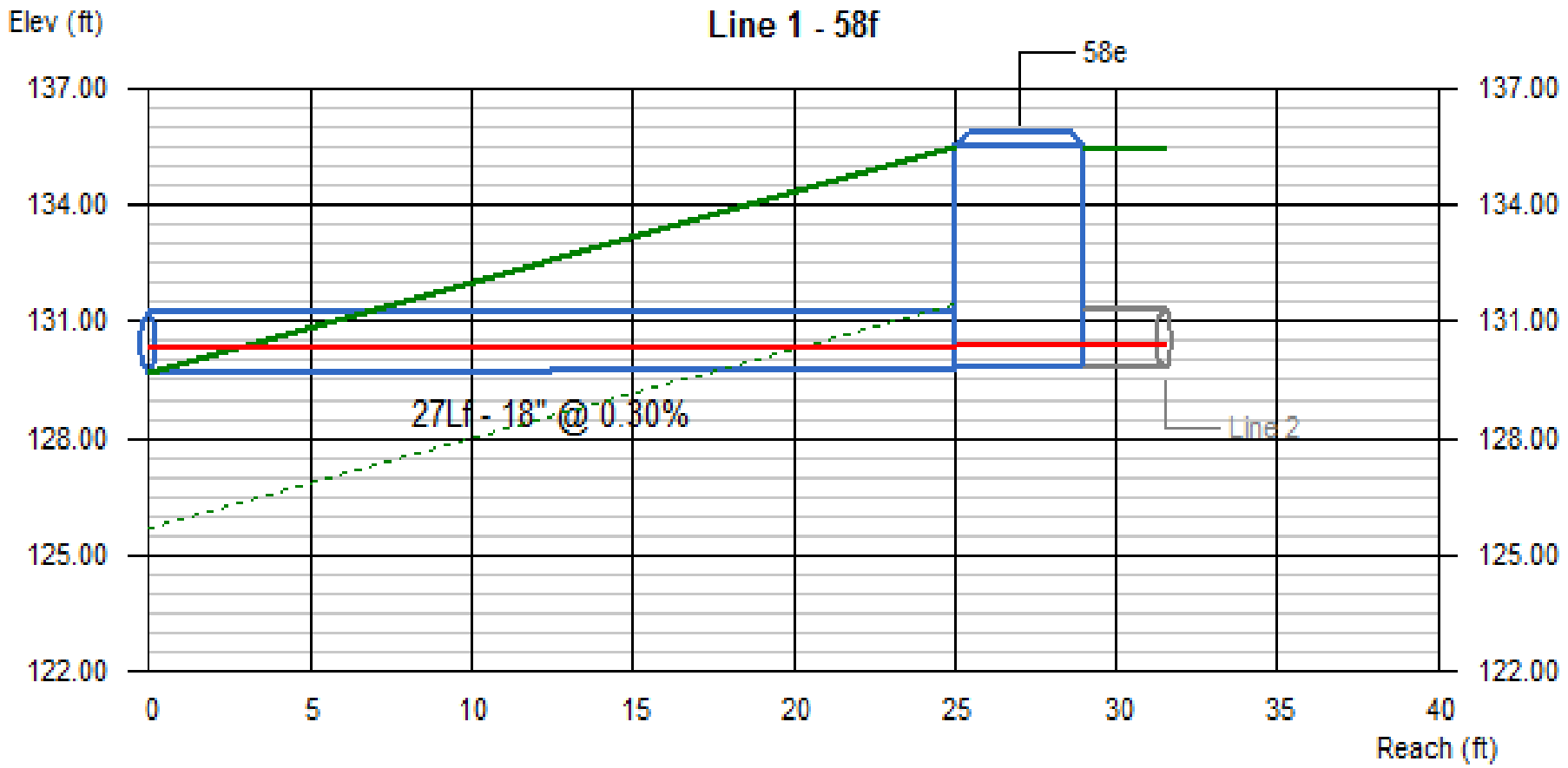
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.92	129.71	130.34	0.63	0.71	1.30	0.03	130.37	0.208	27	129.79	130.40	0.61	0.67	1.36	0.03	130.43	0.235	0.221	0.060	0.50	0.01
2	18	0.92	129.79	130.41	0.62	0.70	1.32	0.03	130.44	0.216	35	129.89	130.49	0.60	0.66	1.38	0.03	130.52	0.246	0.231	0.081	1.50	0.04
3	18	0.71	129.89	130.54	0.65	0.73	0.97	0.01	130.55	0.112	38	130.00	130.58	0.58	0.64	1.11	0.02	130.60	0.164	0.138	0.053	1.50	0.03
4	18	0.14	129.89	130.54	0.65	0.73	0.19	0.00	130.54	0.004	46	130.03	130.54	0.51	0.53	0.27	0.00	130.54	0.011	0.008	0.004	0.50	0.00
5	18	0.11	130.03	130.54	0.51	0.53	0.21	0.00	130.54	0.007	26	130.11	130.54	0.43	0.42	0.26	0.00	130.54	0.012	0.009	0.002	1.00	0.00
6	18	0.33	130.00	130.61	0.61	0.68	0.49	0.00	130.62	0.030	46	130.14	130.63	0.49	0.50	0.65	0.01	130.64	0.068	0.049	0.022	1.00	0.01

58 | Number of lines: 6 | Run Date: 11-05-2013

; c = cir e = ellip b = box

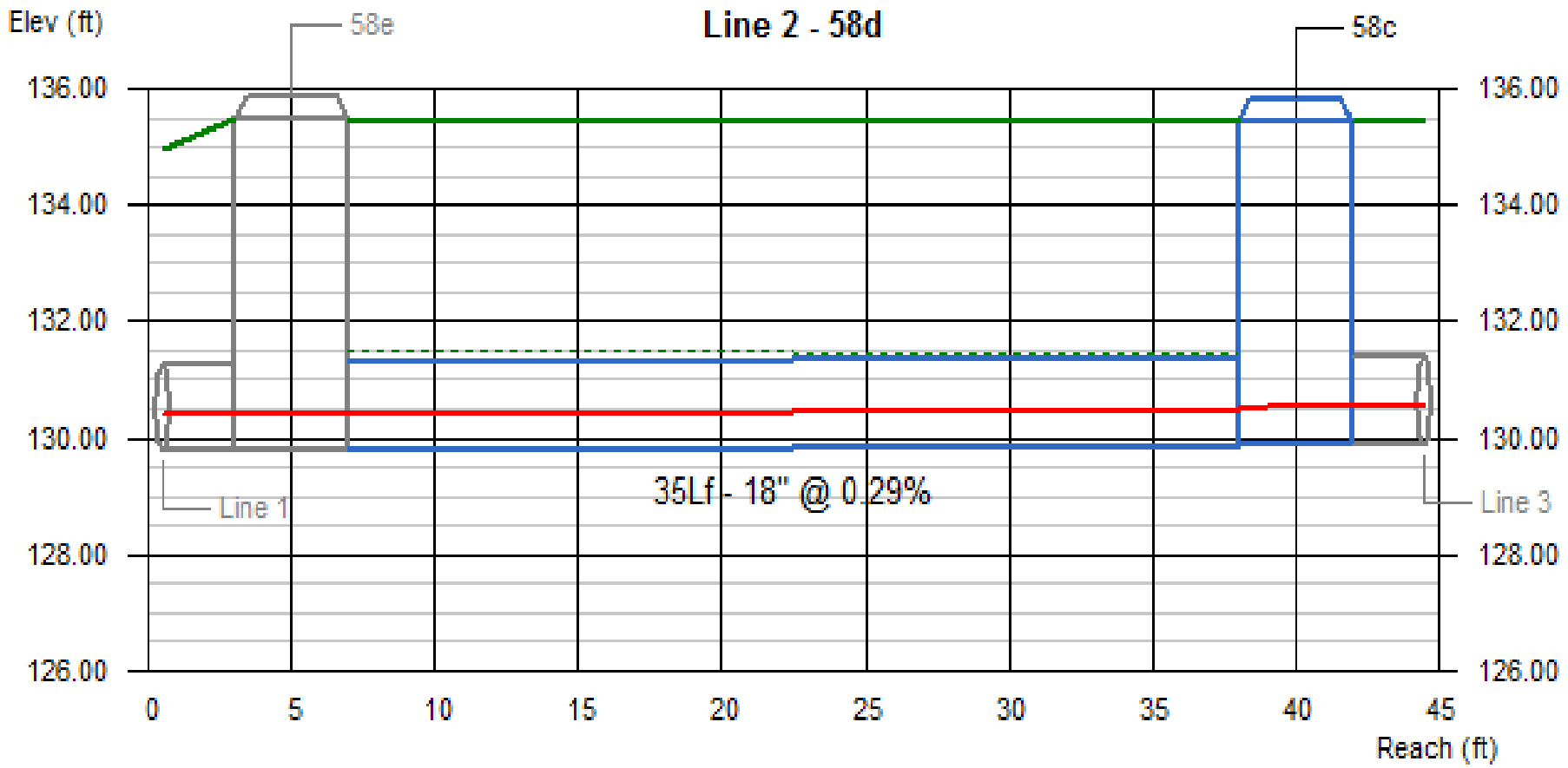
Line Profile (Line 1) - 58f



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.92	129.71	129.79	0.63	0.61	0.62	130.34	130.40	130.41	1.30	1.36	-1.50	4.19

58 | No. Lines: 6 | Run Date: 11-05-2013

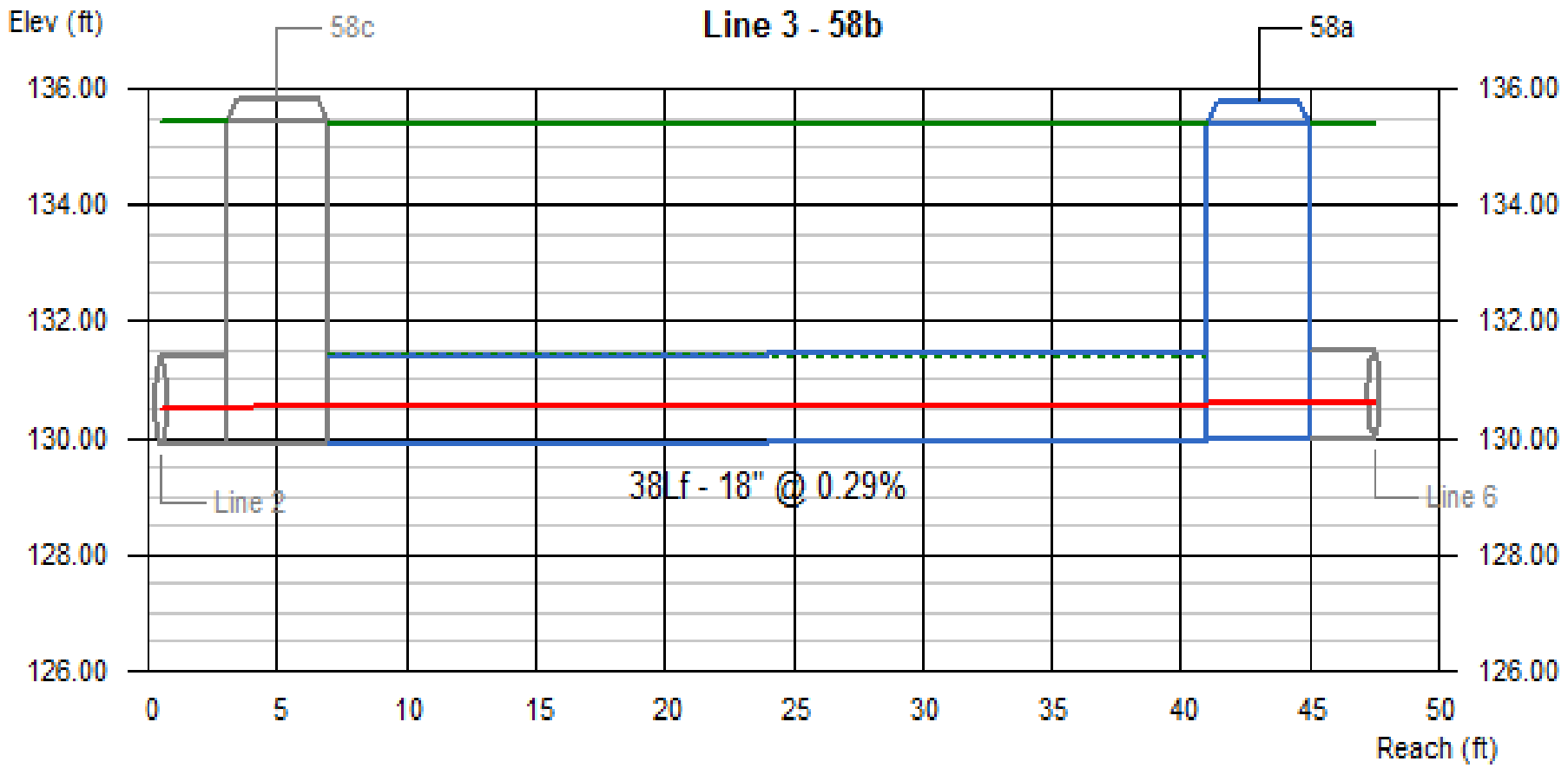
Line Profile (Line 2) - 58d



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.92	129.79	129.89	0.62	0.60	0.65	130.41	130.49	130.54	1.32	1.38	4.19	4.04

58	No. Lines: 6	Run Date: 11-05-2013

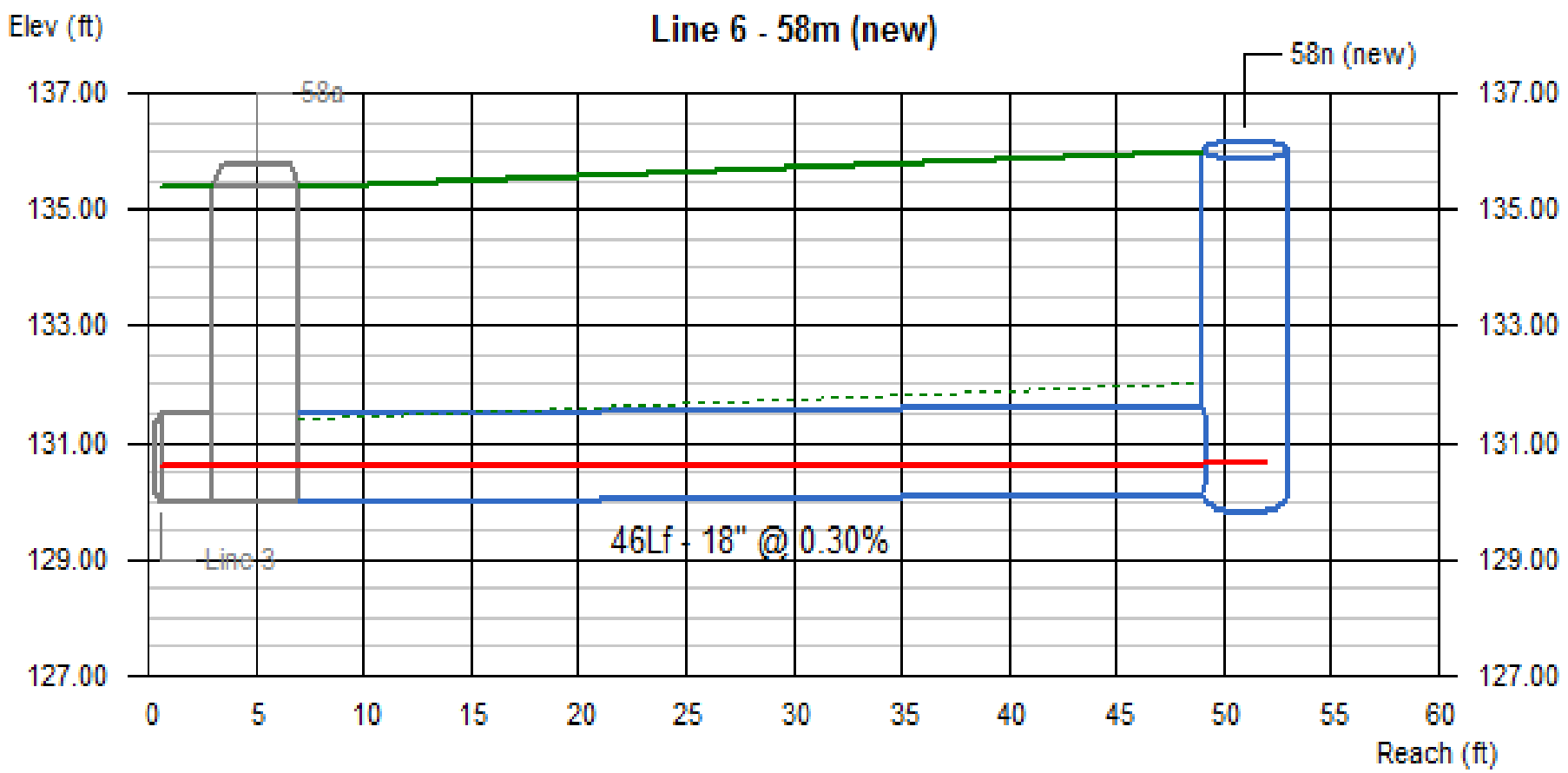
Line Profile (Line 3) - 58b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.71	129.89	130.00	0.65	0.58	0.61	130.54	130.58	130.61	0.97	1.11	4.04	3.89

58 | No. Lines: 6 | Run Date: 11-05-2013

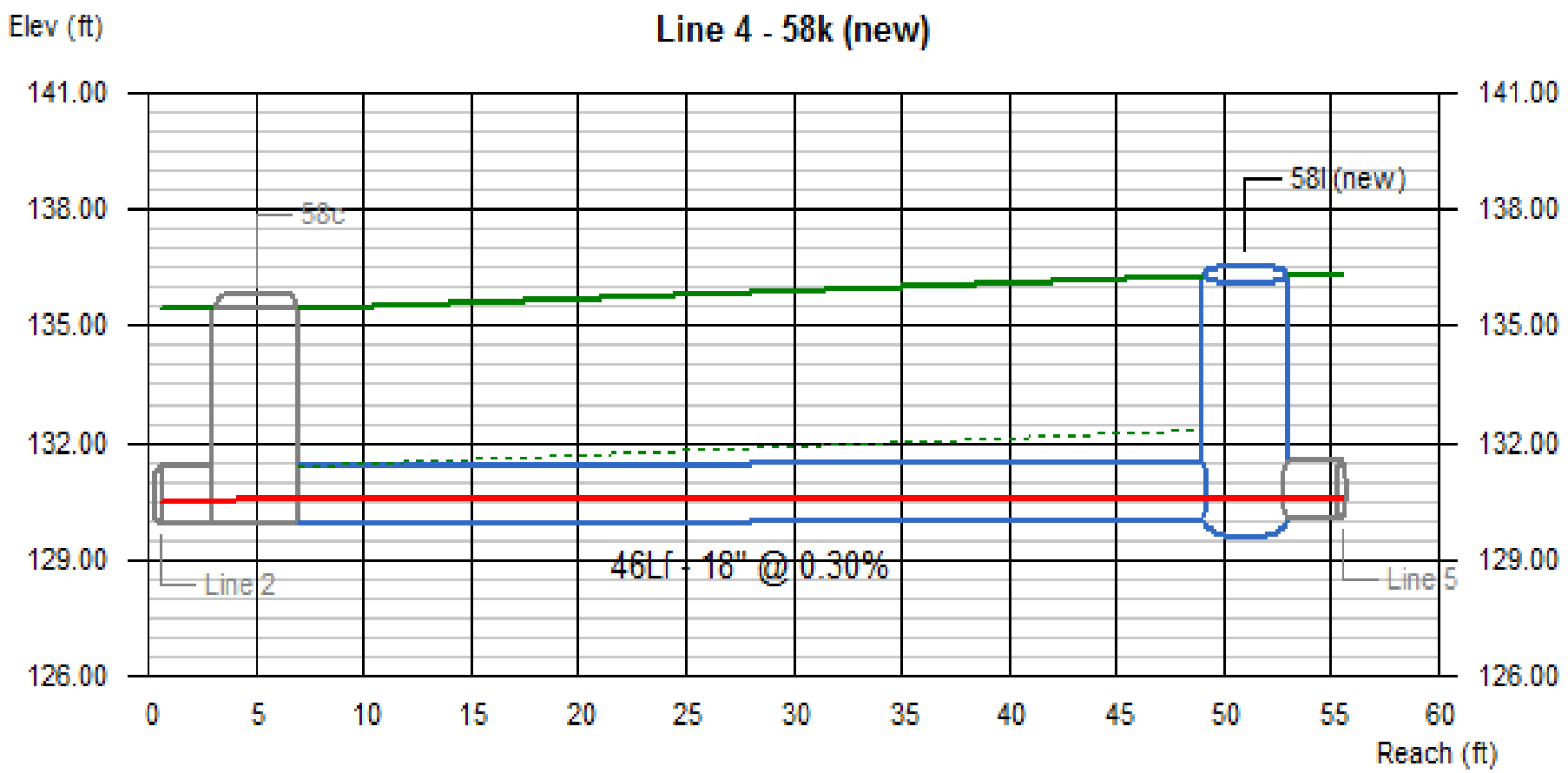
Line Profile (Line 6) - 58m (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.33	130.00	130.14	0.61	0.49	0.50	130.61	130.63	130.64	0.49	0.65	3.89	4.38

58 | No. Lines: 6 | Run Date: 11-05-2013

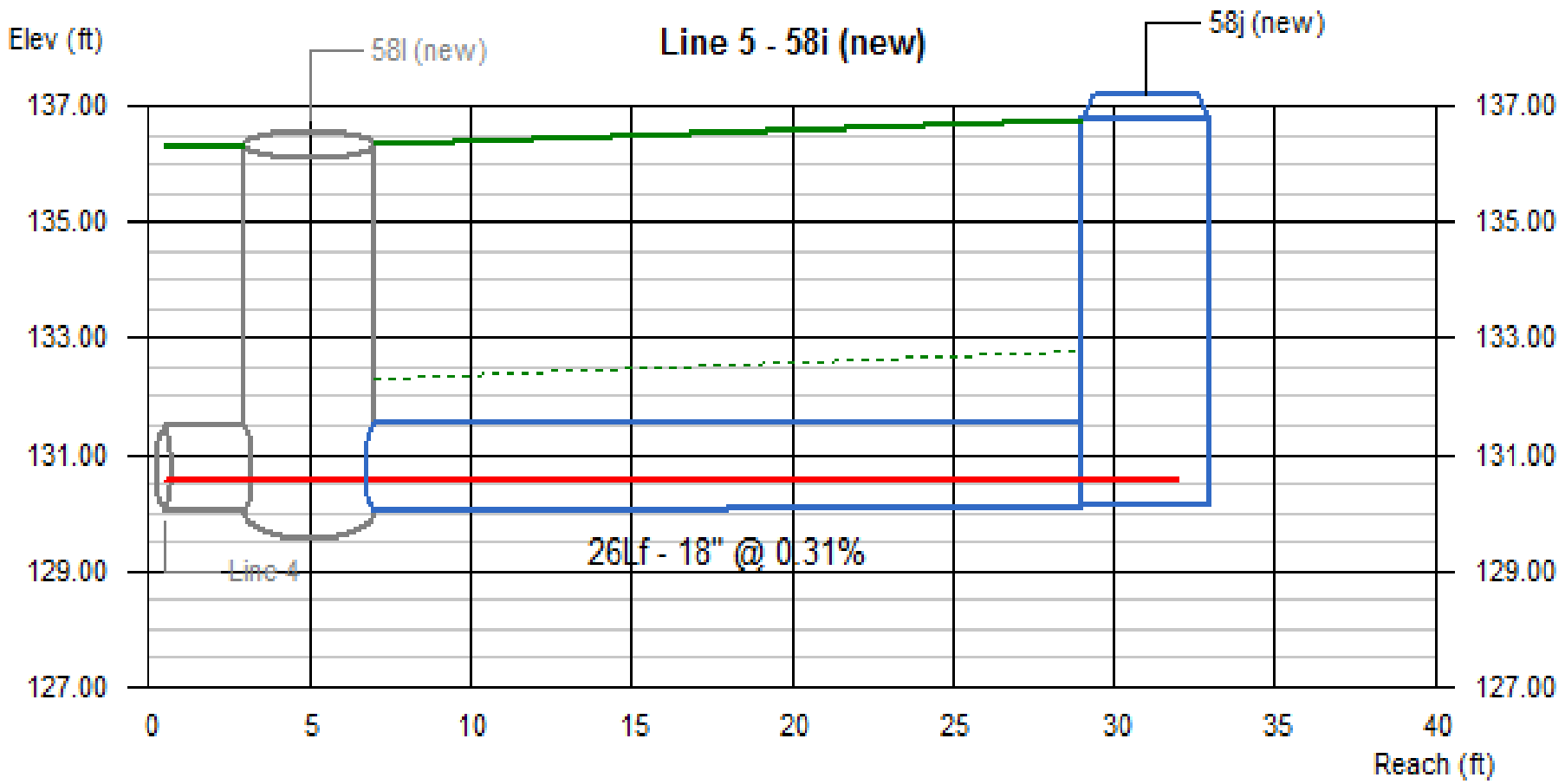
Line Profile (Line 4) - 58k (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.14	129.89	130.03	0.65	0.51	0.51	130.54	130.54	130.54	0.19	0.27	4.04	4.80

58	No. Lines: 6	Run Date: 11-05-2013

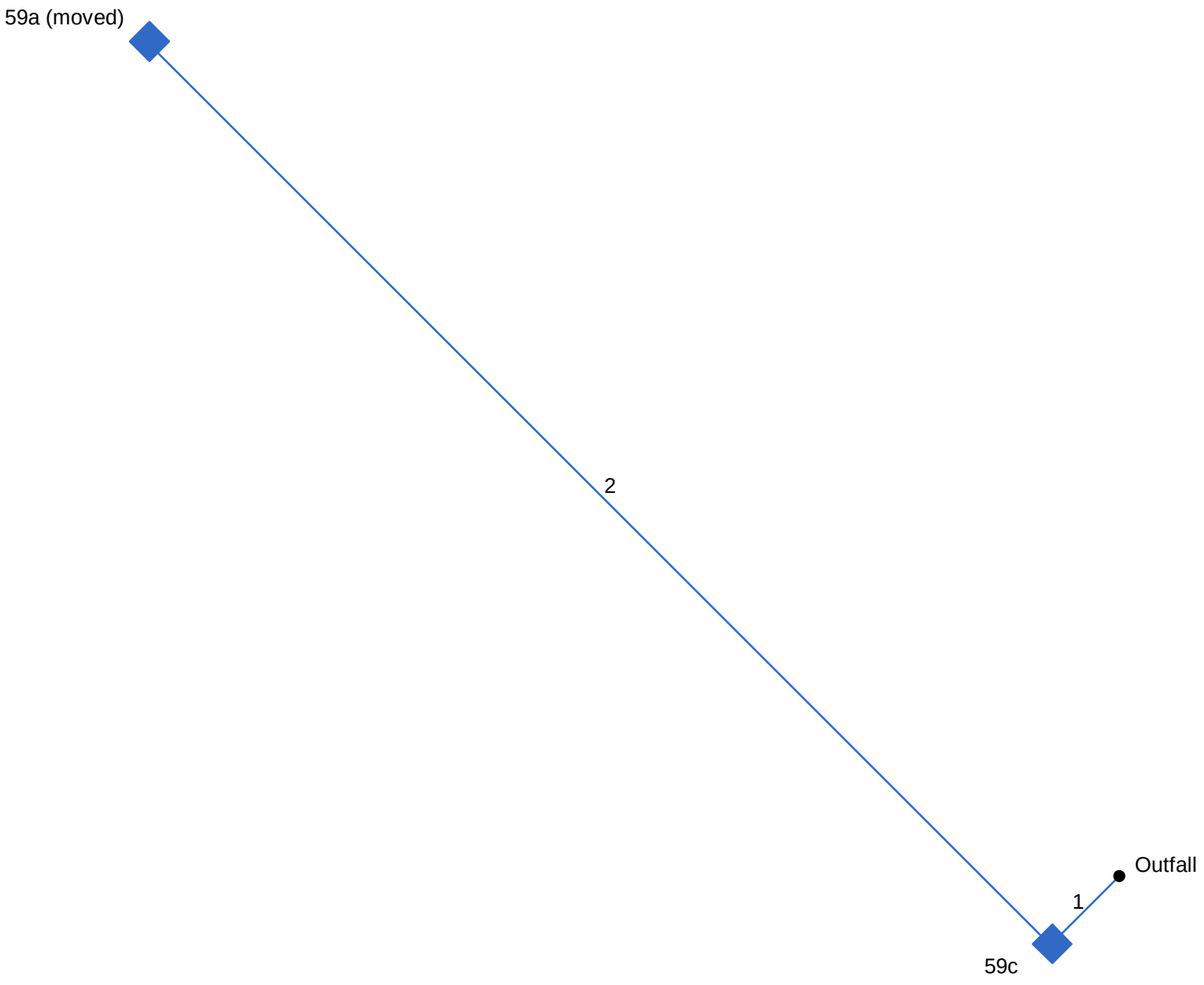
Line Profile (Line 5) - 58i (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.11	130.03	130.11	0.51	0.43	0.43	130.54	130.54	130.54	0.21	0.26	4.80	5.18

58 | No. Lines: 6 | Run Date: 11-05-2013

59



Project File: Drainage System 59.stm	Number of lines: 2	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	15	0.07	0.13	1.00	0.07	0.13	5.0	7.7	2.2	0.29	7.72	1.24	18	2.00	118.16	118.46	118.61	118.67	118.16	125.21	59d
2	1	196	0.06	0.06	1.00	0.06	0.06	5.0	5.0	2.7	0.16	7.21	1.19	18	1.74	118.46	121.88	118.75	122.04	125.21	127.08	59b

59 | Number of lines: 2 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

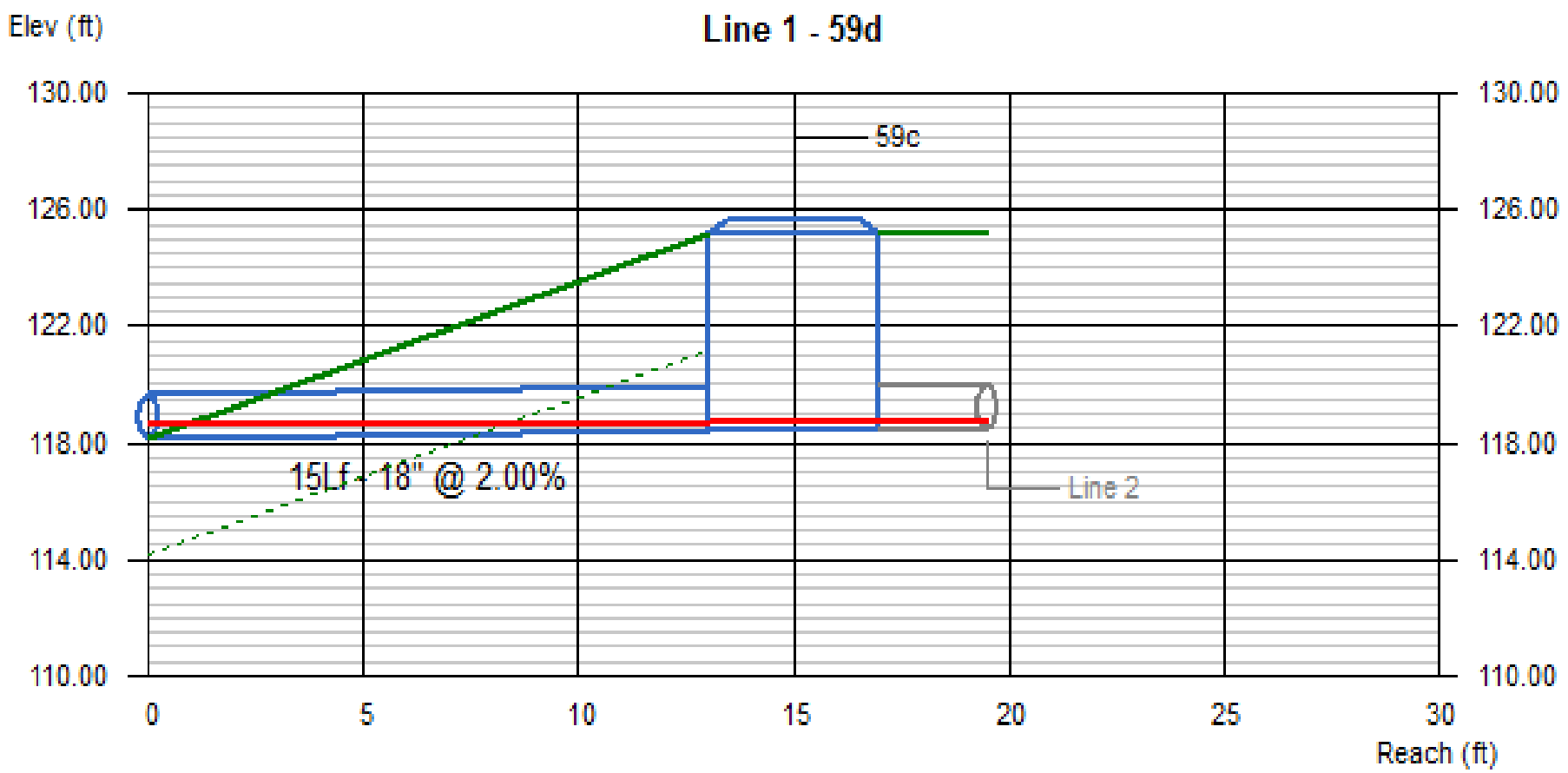
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.29	118.16	118.61	0.45	0.45	0.64	0.01	118.62	0.071	15	118.46	118.67	0.21	0.16	1.84	0.05	118.73	1.415	0.743	0.111	1.50	0.08
2	18	0.16	118.46	118.75	0.29	0.24	0.67	0.01	118.76	0.129	196	121.88	122.04 j	0.15**	0.10	1.71	0.05	122.08	1.825	0.977	n/a	1.00	0.05

59 | Number of lines: 2 | Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

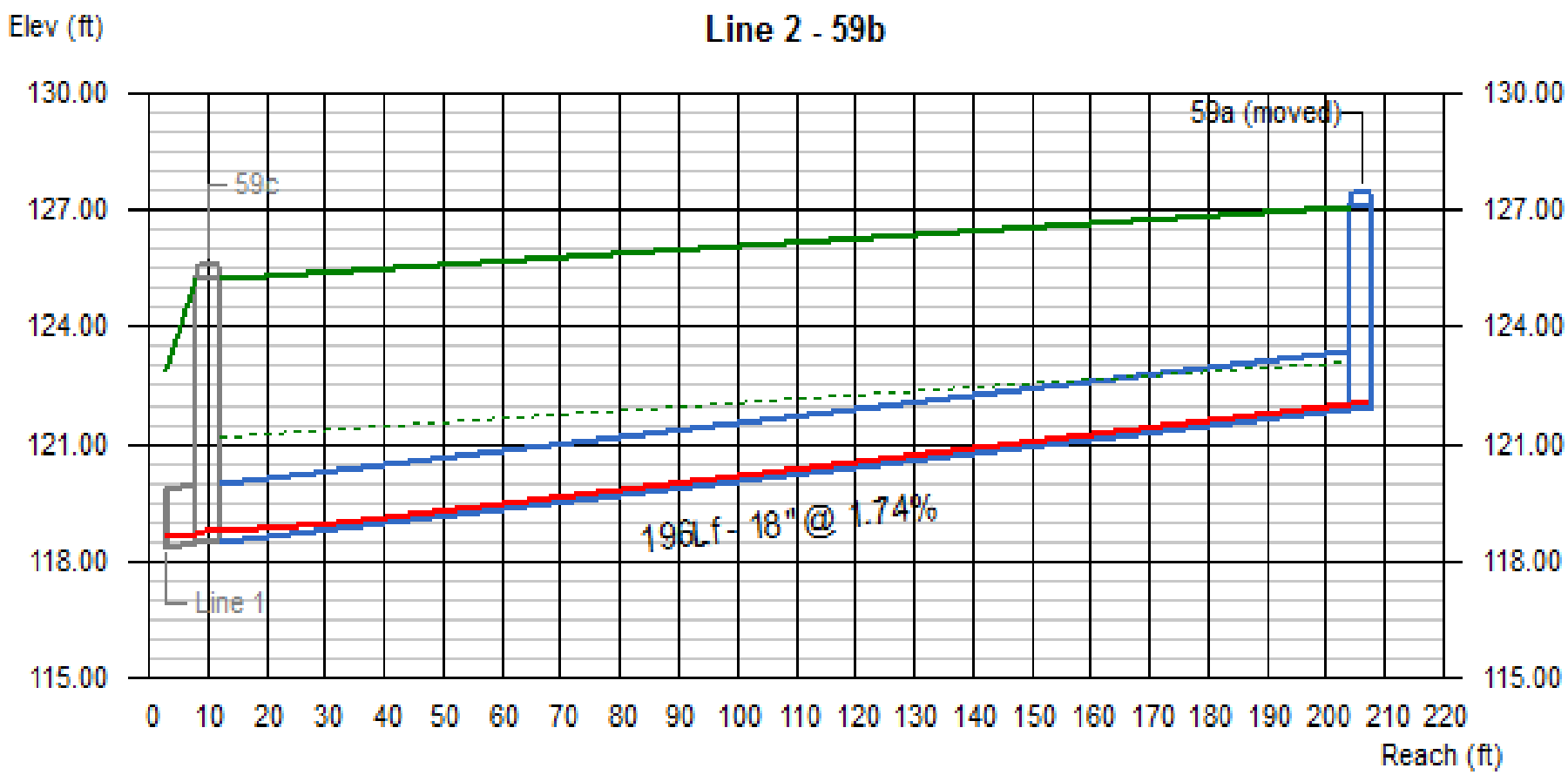
Line Profile (Line 1) - 59d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.29	118.16	118.46	0.45	0.21	0.29	118.61	118.67	118.75	0.64	1.84	-1.50	5.25

59 | No. Lines: 2 | Run Date: 10-30-2013

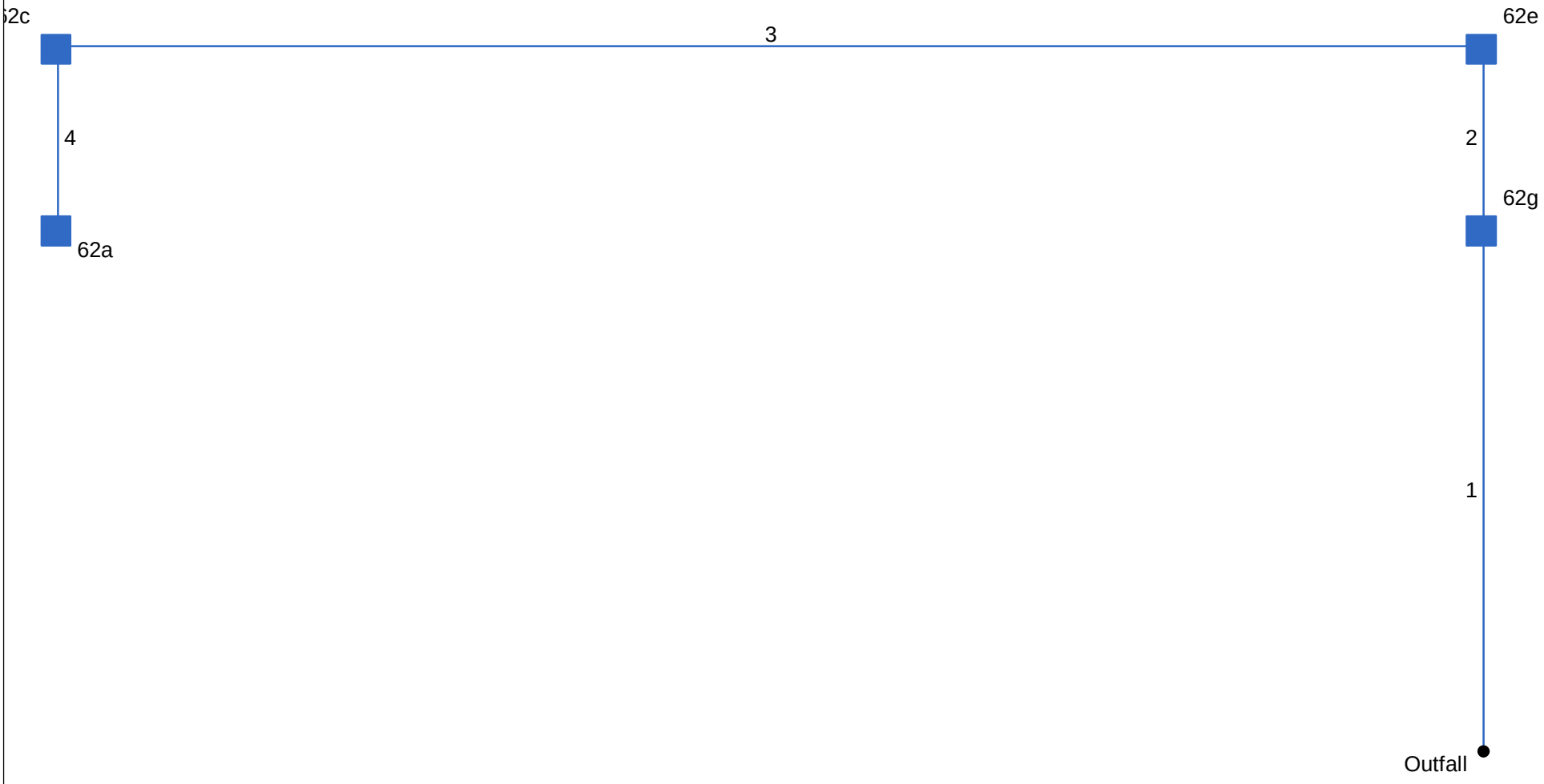
Line Profile (Line 2) - 59b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.16	118.46	121.88	0.29	0.15	0.15	118.75	122.04 j	122.04	0.67	1.71	5.25	3.70

59 | No. Lines: 2 | Run Date: 10-30-2013

62



Project File: Drainage System 62.stm	Number of lines: 4	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	72	0.18	0.63	1.00	0.18	0.63	5.0	7.1	2.3	1.45	6.56	2.98	18	1.44	122.46	123.50	122.92	124.00	122.46	129.92	62h
2	1	25	0.14	0.45	1.00	0.14	0.45	5.0	6.9	2.3	1.05	3.09	1.70	18	0.32	123.50	123.58	124.06	124.16	129.92	129.05	62f
3	2	196	0.14	0.31	1.00	0.14	0.31	5.0	5.2	2.7	0.84	6.68	1.91	18	1.49	123.58	126.51	124.23	126.86	129.05	131.82	62d
4	3	25	0.17	0.17	1.00	0.17	0.17	5.0	5.0	2.7	0.47	7.72	2.27	18	2.00	126.77	127.27	127.03	127.53	131.82	132.56	62b

62 | Number of lines: 4 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

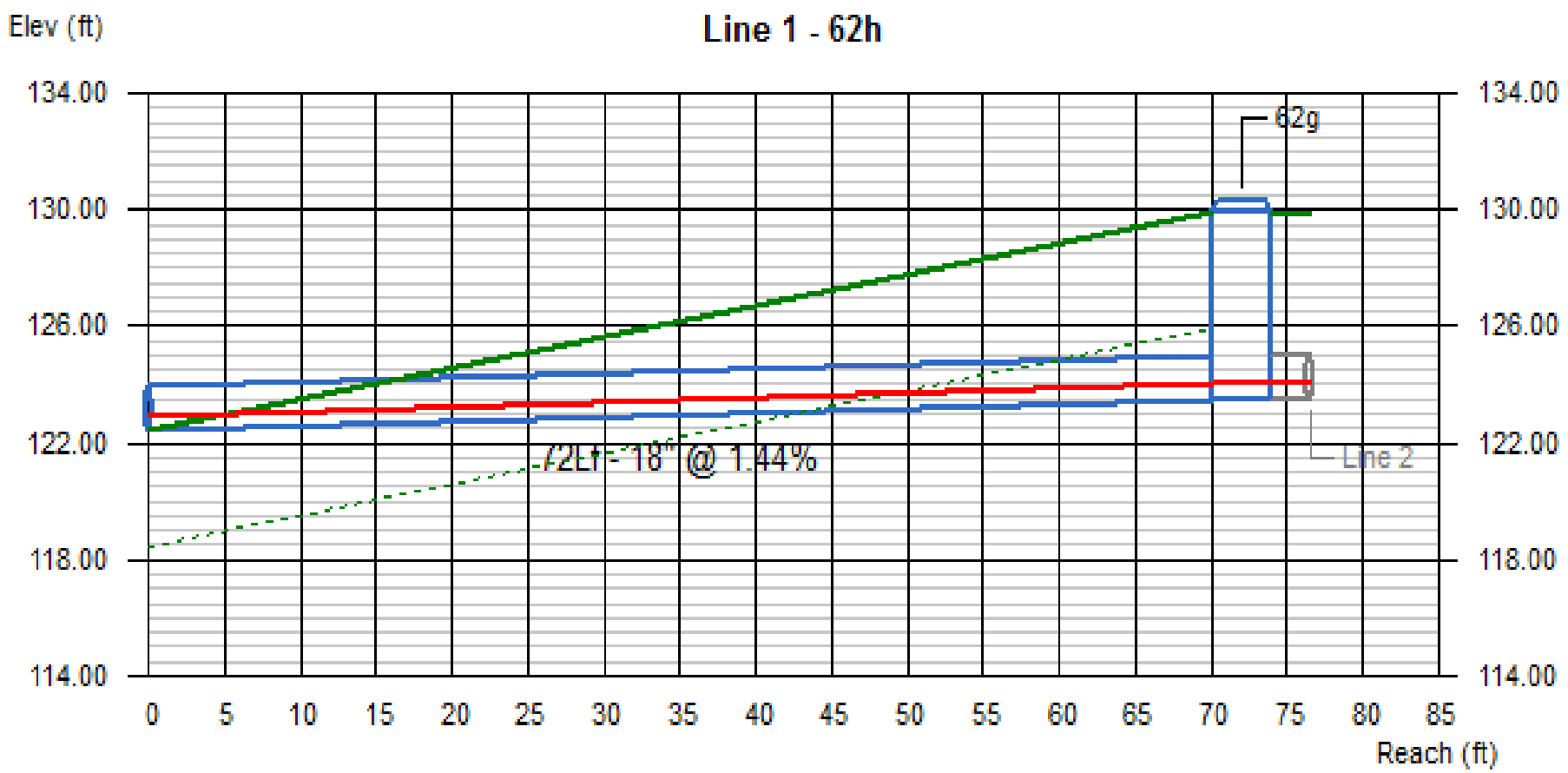
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	1.45	122.46	122.92	0.46	0.46	3.16	0.15	123.07	1.694	72	123.50	124.00	0.50	0.52	2.80	0.12	124.12	1.212	1.453	1.046	0.50	0.06
2	18	1.05	123.50	124.06	0.56	0.60	1.74	0.05	124.11	0.416	25	123.58	124.16	0.58	0.64	1.65	0.04	124.21	0.361	0.389	0.097	1.50	0.06
3	18	0.84	123.58	124.23	0.65	0.73	1.15	0.02	124.25	0.157	196	126.51	126.86	0.35**	0.31	2.68	0.11	126.97	1.664	0.910	n/a	1.50	n/a
4	18	0.47	126.77	127.03	0.26*	0.21	2.27	0.08	127.11	1.687	25	127.27	127.53	0.26**	0.21	2.27	0.08	127.61	1.687	1.687	n/a	1.00	0.08

62 | Number of lines: 4 | Run Date: 10-30-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

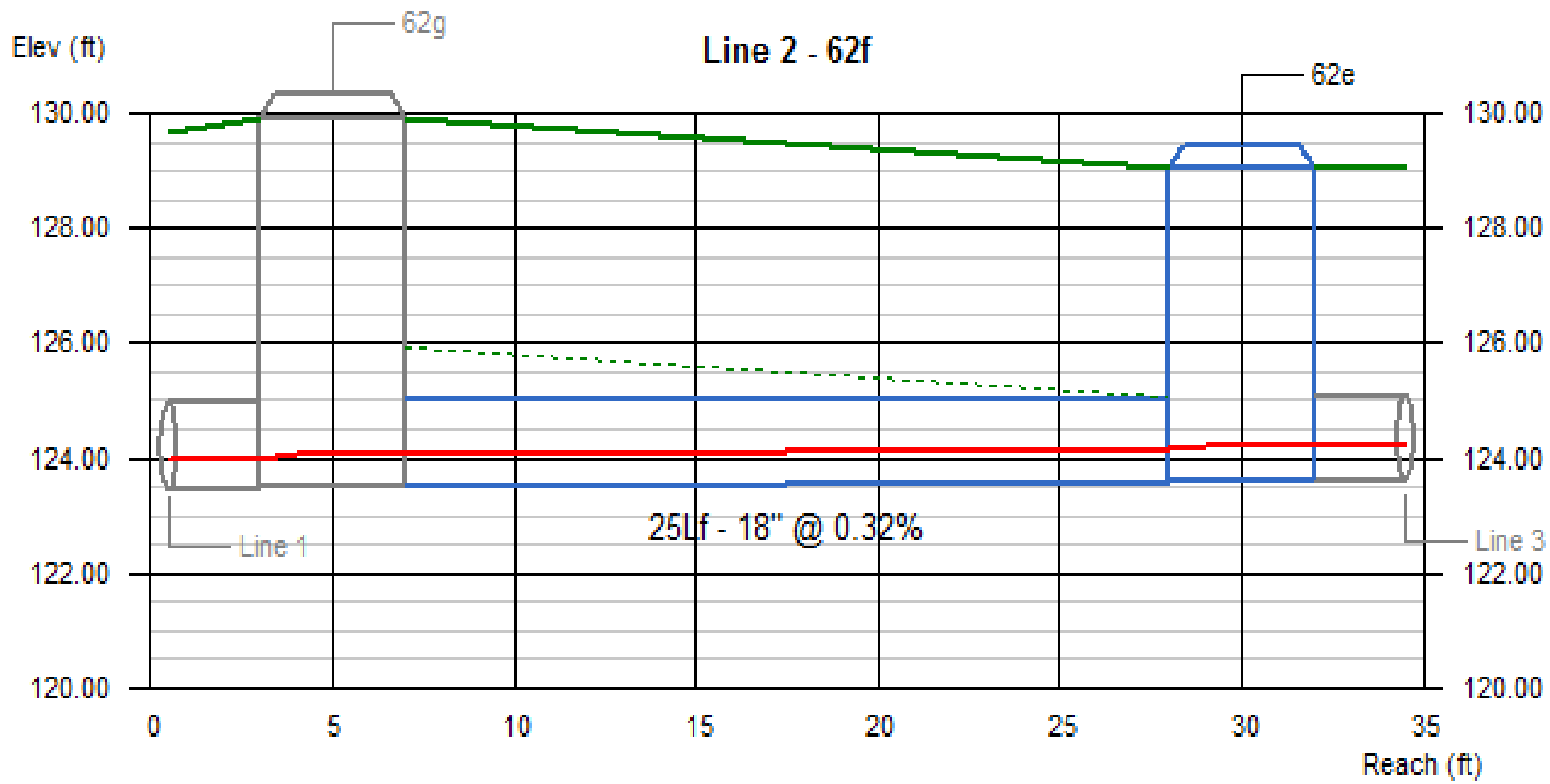
Line Profile (Line 1) - 62h



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.45	122.46	123.50	0.46	0.50	0.56	122.92	124.00	124.06	3.16	2.80	-1.50	4.92

62 | No. Lines: 4 | Run Date: 10-30-2013

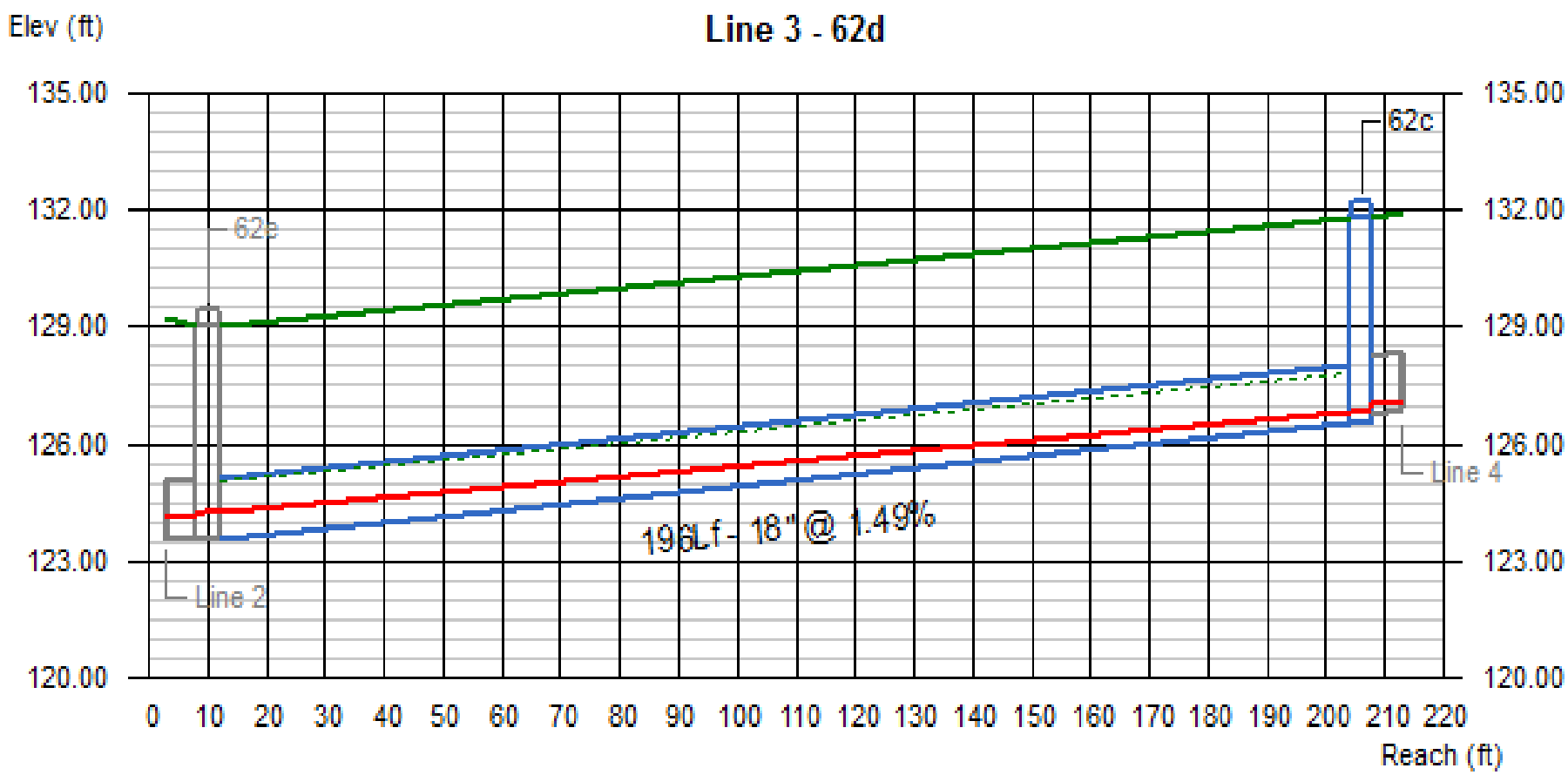
Line Profile (Line 2) - 62f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	1.05	123.50	123.58	0.56	0.58	0.65	124.06	124.16	124.23	1.74	1.65	4.92	3.97

62 | No. Lines: 4 | Run Date: 10-30-2013

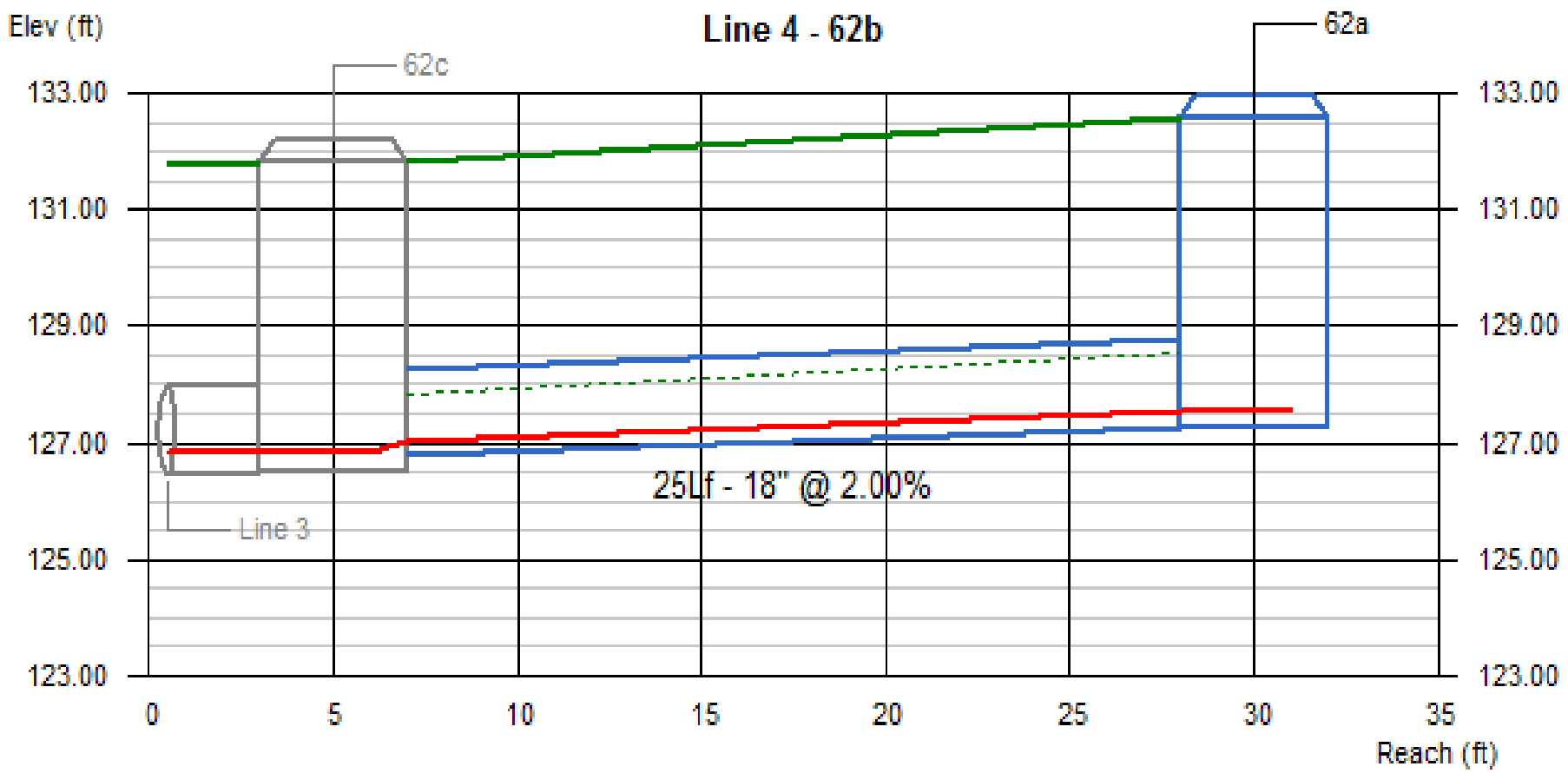
Line Profile (Line 3) - 62d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.84	123.58	126.51	0.65	0.35	0.35	124.23	126.86	126.86	1.15	2.68	3.97	3.81

62	No. Lines: 4	Run Date: 10-30-2013

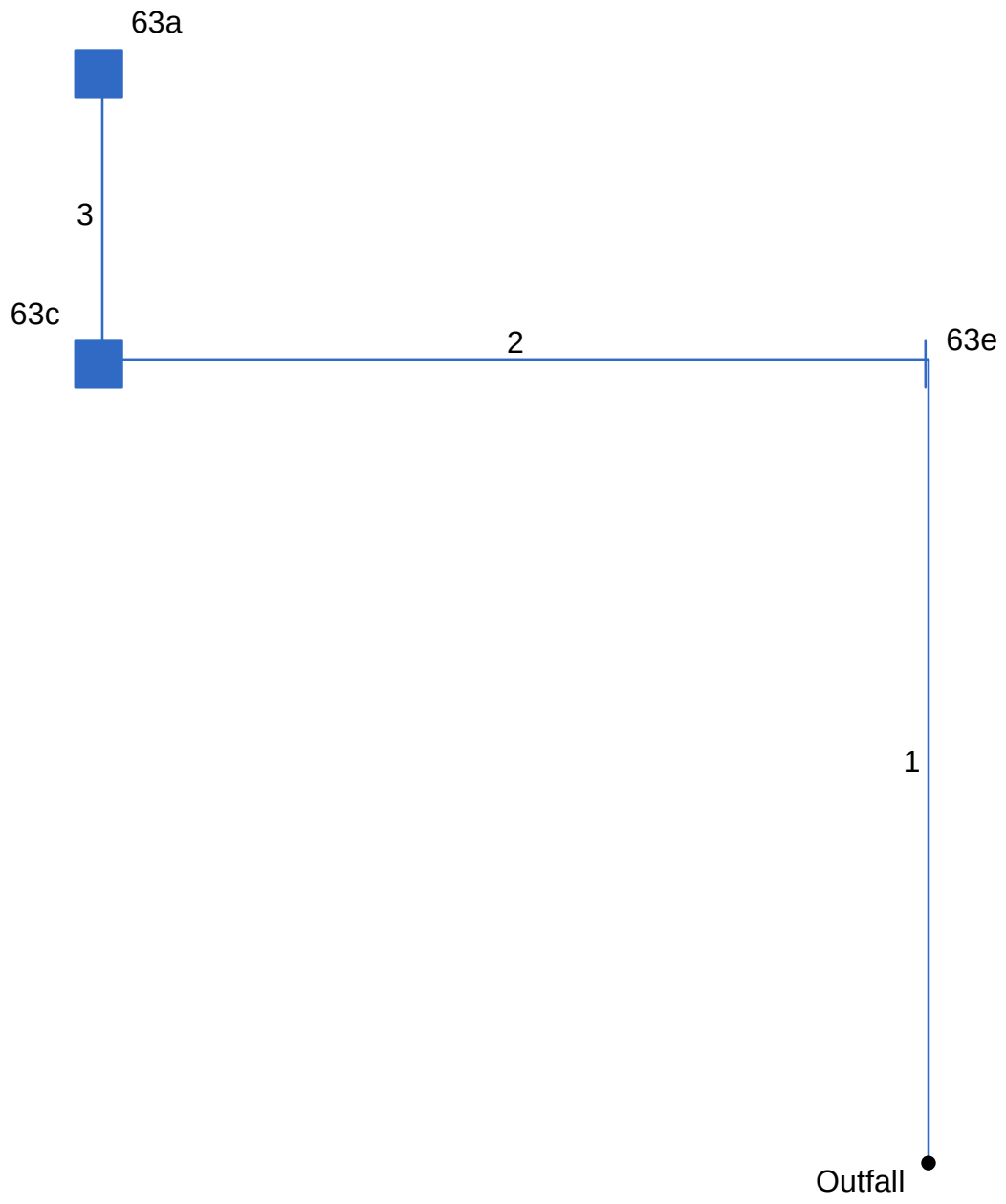
Line Profile (Line 4) - 62b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.47	126.77	127.27	0.26	0.26	0.26	127.03	127.53	127.53	2.27	2.27	3.55	3.79

62	No. Lines: 4	Run Date: 10-30-2013

63



Project File: Drainage System 63.stm	Number of lines: 3	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.10	0.31	1.00	0.10	0.31	5.0	6.7	2.4	0.73	4.92	1.92	18	0.81	121.62	122.18	122.06	122.55	121.62	128.45	63f
2	1	71	0.12	0.21	1.00	0.12	0.21	5.0	5.7	2.6	0.54	2.97	1.19	18	0.30	122.18	122.39	122.66	122.83	128.45	128.86	63d
3	2	25	0.09	0.09	1.00	0.09	0.09	5.0	5.0	2.7	0.25	2.89	0.57	18	0.28	122.39	122.46	122.86	122.87	128.86	128.00	63b

63 | Number of lines: 3 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

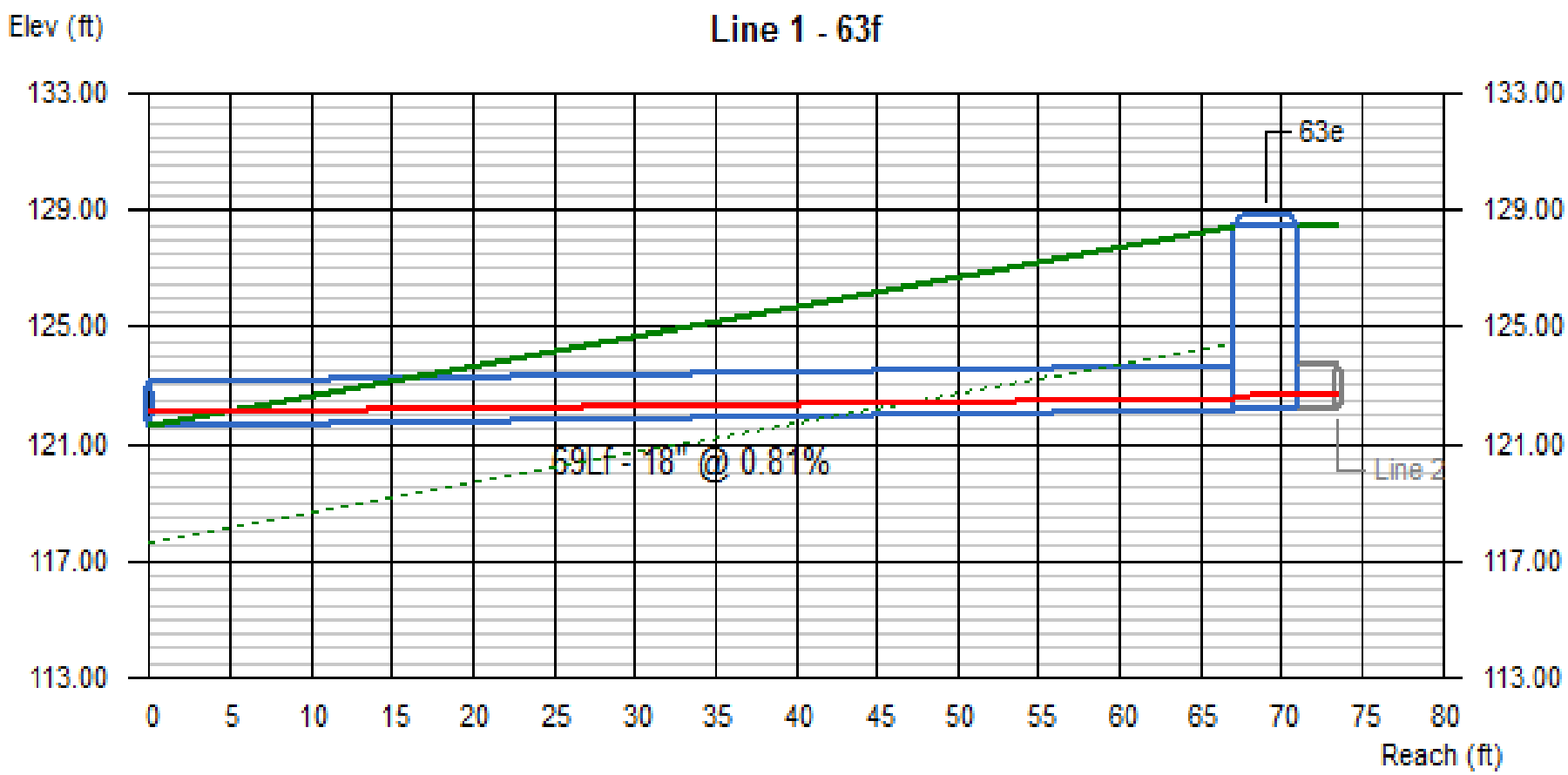
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.73	121.62	122.06	0.44	0.43	1.69	0.04	122.11	0.508	69	122.18	122.55	0.37	0.34	2.15	0.07	122.62	1.001	0.755	0.521	1.50	0.11
2	18	0.54	122.18	122.66	0.48	0.49	1.11	0.02	122.68	0.199	71	122.39	122.83	0.44	0.43	1.26	0.02	122.85	0.287	0.243	0.173	1.50	0.04
3	18	0.25	122.39	122.86	0.47	0.48	0.52	0.00	122.87	0.044	25	122.46	122.87	0.41	0.40	0.62	0.01	122.88	0.074	0.059	0.015	1.00	0.01

63 | Number of lines: 3 | Run Date: 10-30-2013

; c = cir e = ellip b = box

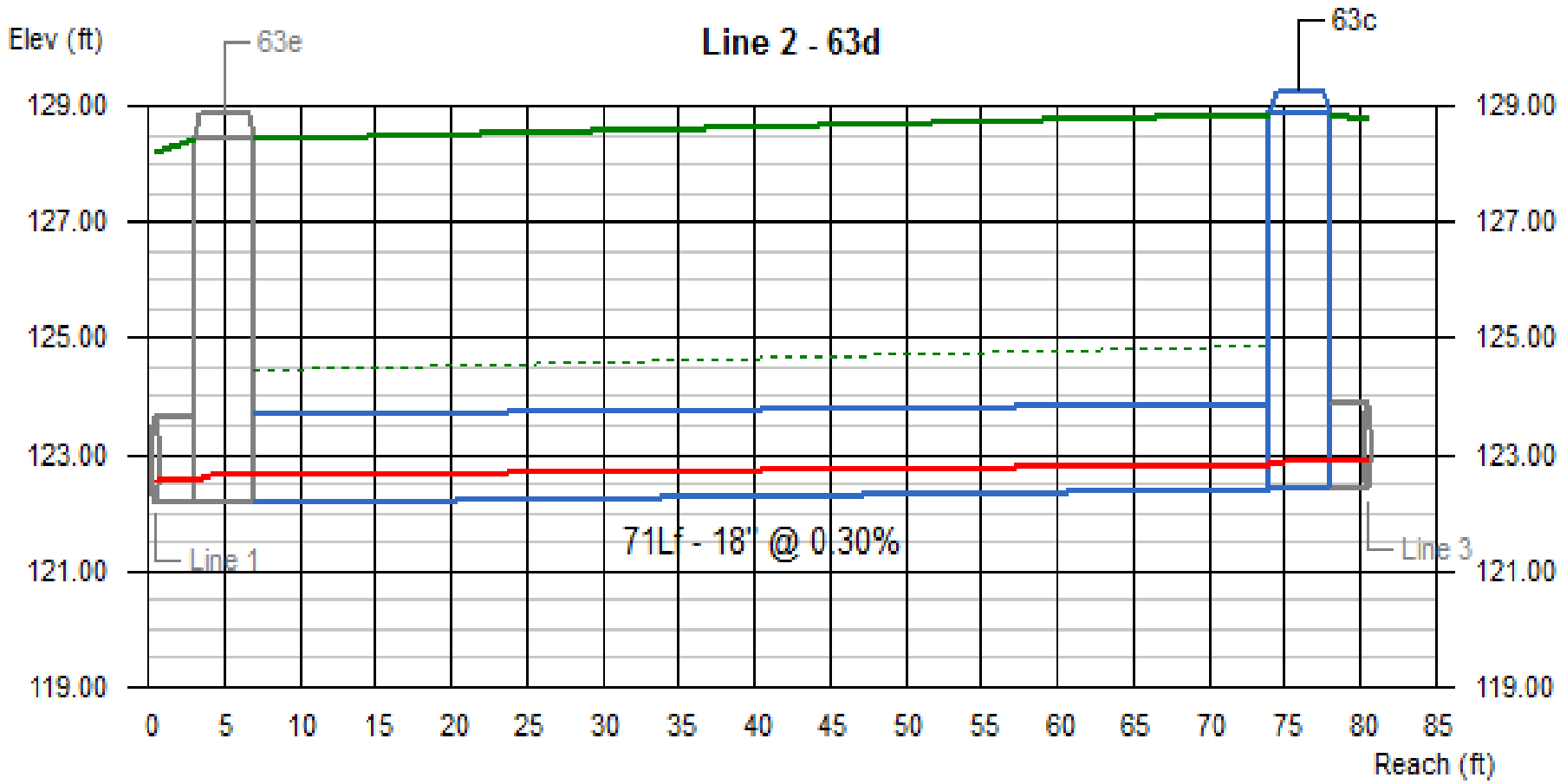
Line Profile (Line 1) - 63f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.73	121.62	122.18	0.44	0.37	0.48	122.06	122.55	122.66	1.69	2.15	-1.50	4.77

63 | No. Lines: 3 | Run Date: 10-30-2013

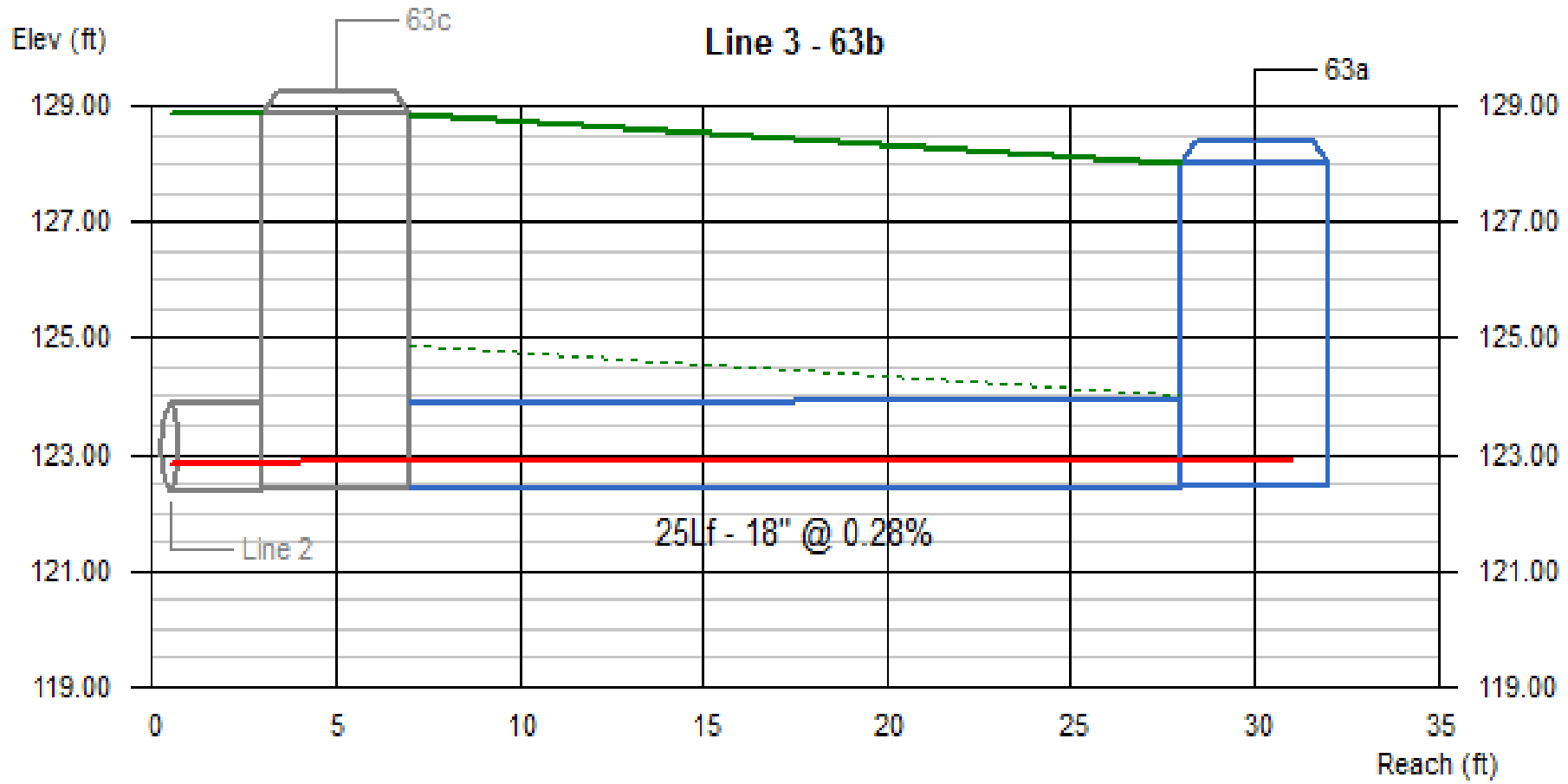
Line Profile (Line 2) - 63d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.54	122.18	122.39	0.48	0.44	0.47	122.66	122.83	122.86	1.11	1.26	4.77	4.97

63	No. Lines: 3	Run Date: 10-30-2013

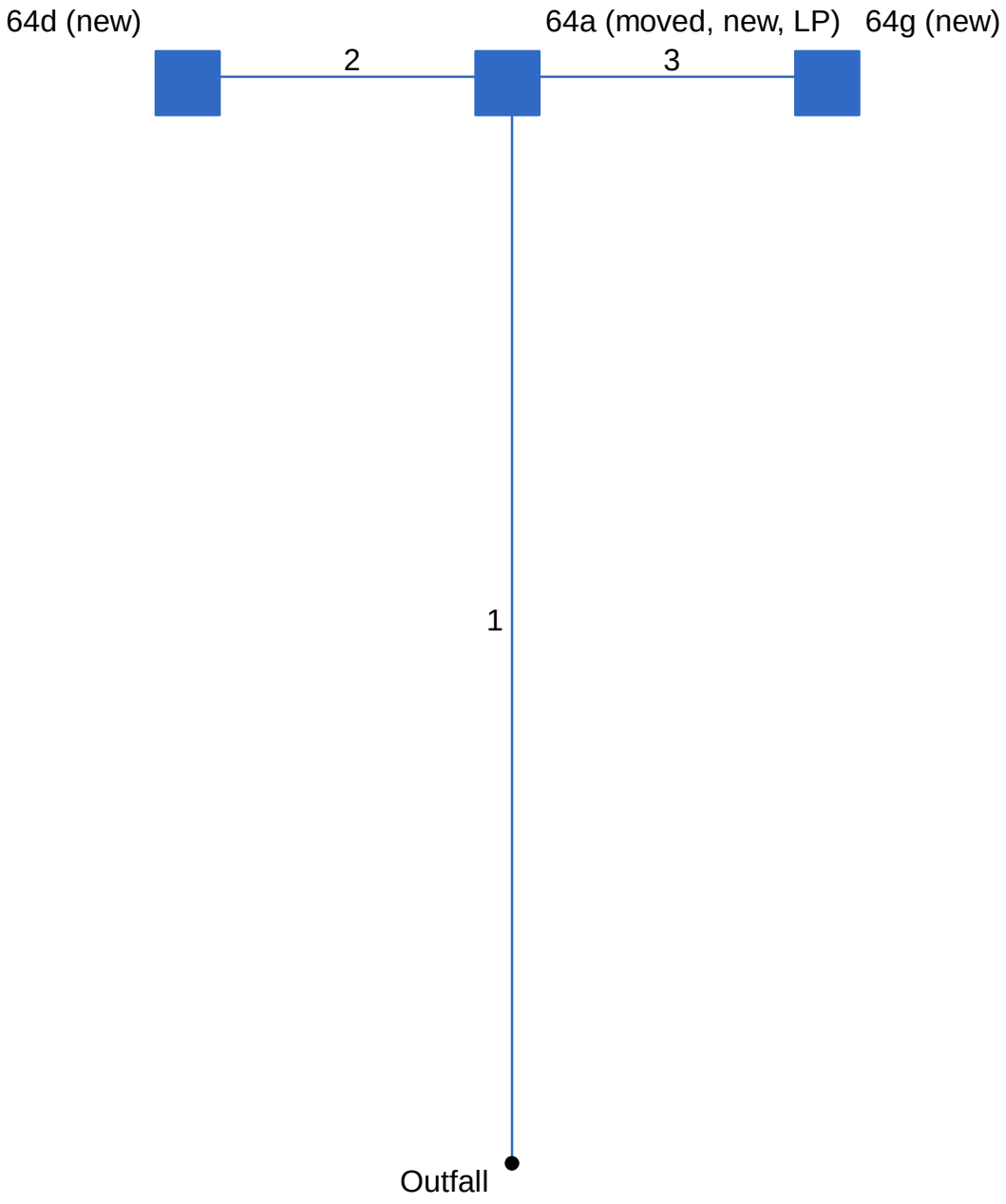
Line Profile (Line 3) - 63b



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.25	122.39	122.46	0.47	0.41	0.42	122.86	122.87	122.88	0.52	0.62	4.97	4.04

63 | No. Lines: 3 | Run Date: 10-30-2013

64



Project File: Drainage System 64.stm	Number of lines: 3	Date: 10-30-2013

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	68	0.04	0.15	1.00	0.04	0.15	5.0	5.4	2.7	0.40	7.69	1.54	18	1.99	120.54	121.89	120.98	122.13	120.54	128.16	64b (moved)
2	1	20	0.04	0.04	1.00	0.04	0.04	5.0	5.0	2.7	0.11	5.32	0.92	18	0.95	121.89	122.08	122.13	122.23	128.16	128.22	64e (new)
3	1	20	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	5.32	1.28	18	0.95	121.89	122.08	122.13	122.27	128.16	128.10	64f (new)

64 | Number of lines: 3 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

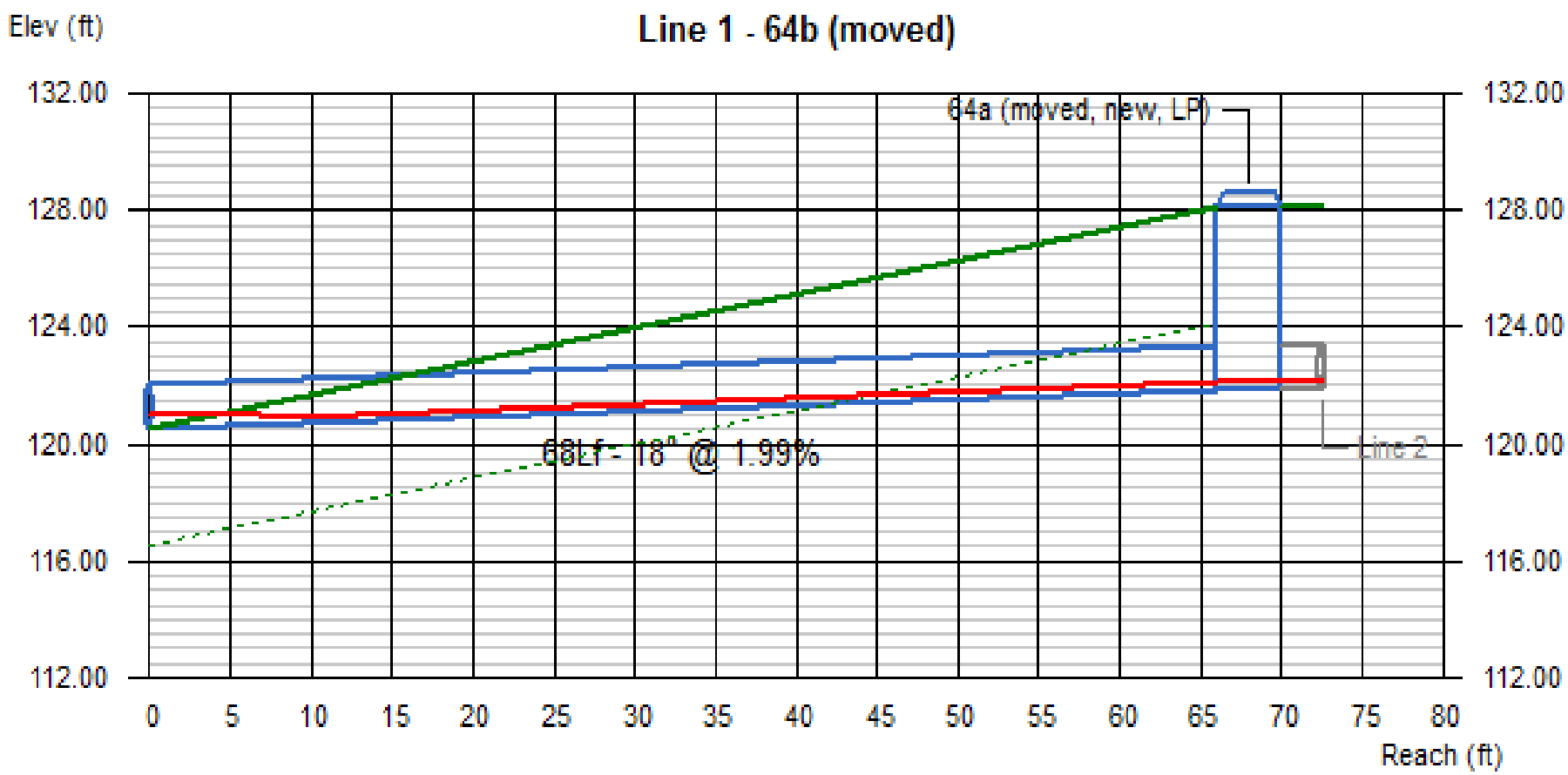
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.40	120.54	120.98	0.44	0.43	0.92	0.01	120.99	0.150	68	121.89	122.13 j	0.24**	0.18	2.17	0.07	122.20	1.701	0.925	n/a	1.50	0.11
2	18	0.11	121.89	122.13	0.24	0.18	0.60	0.01	122.14	0.130	20	122.08	122.23	0.15	0.09	1.24	0.02	122.25	1.045	0.587	0.117	1.00	0.02
3	18	0.19	121.89	122.13	0.24	0.18	1.05	0.02	122.15	0.398	20	122.08	122.27	0.19	0.13	1.52	0.04	122.30	1.139	0.768	0.154	1.00	0.04

64 | Number of lines: 3 | Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

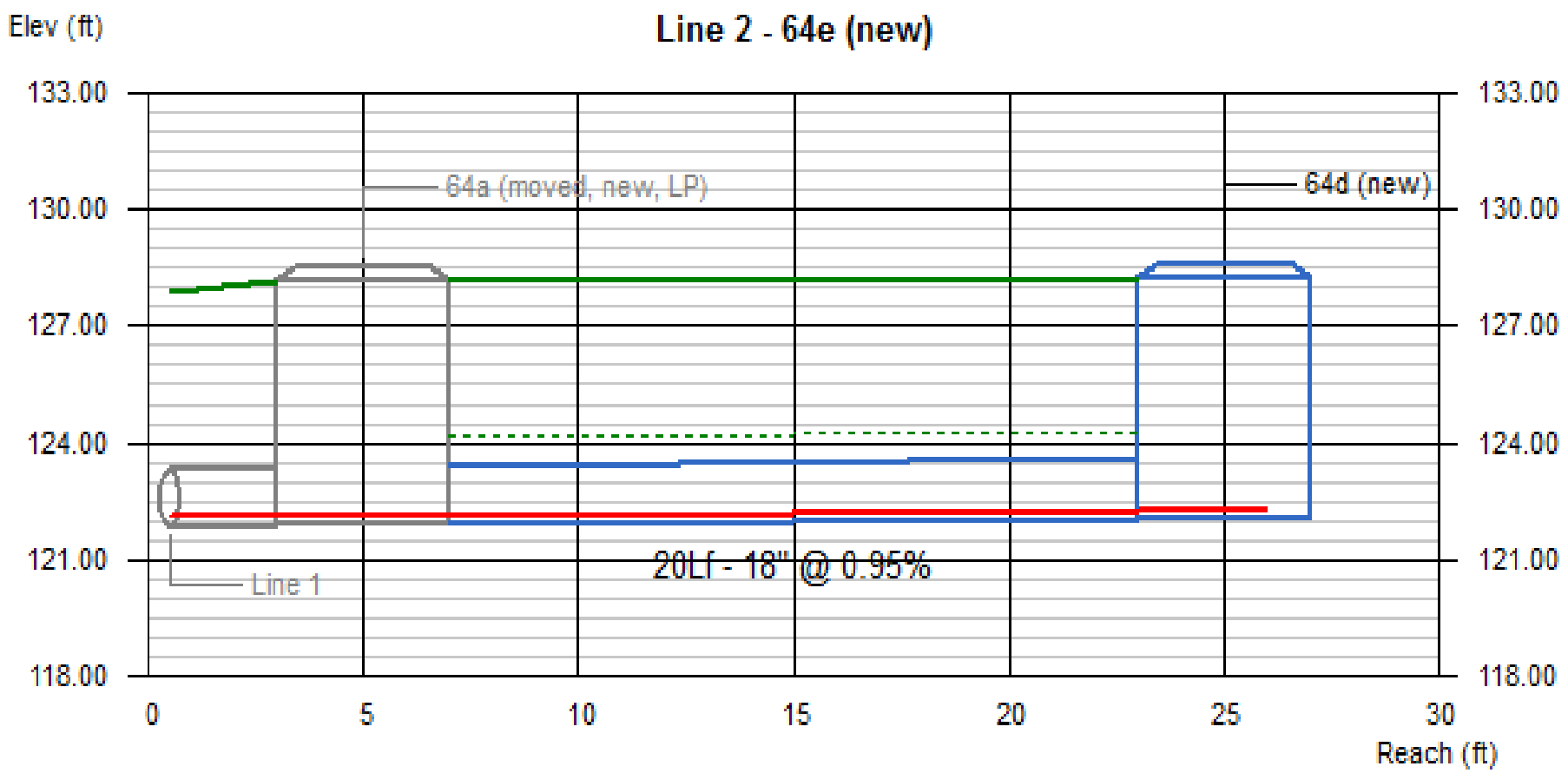
Line Profile (Line 1) - 64b (moved)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.40	120.54	121.89	0.44	0.24	0.24	120.98	122.13 j	122.13	0.92	2.17	-1.50	4.77

64	No. Lines: 3	Run Date: 10-30-2013

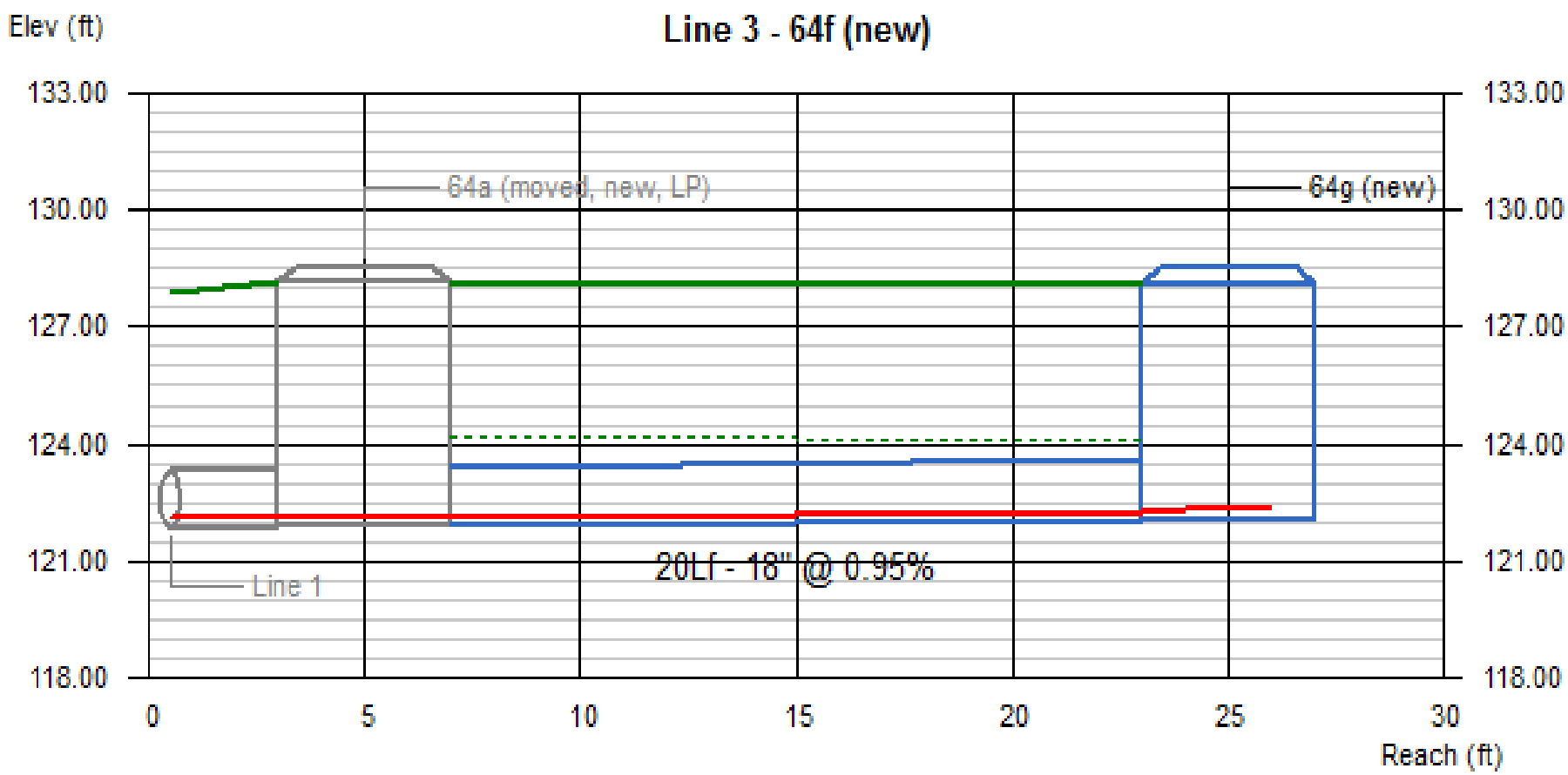
Line Profile (Line 2) - 64e (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	0.11	121.89	122.08	0.24	0.15	0.17	122.13	122.23	122.25	0.60	1.24	4.77	4.64

64 | No. Lines: 3 | Run Date: 10-30-2013

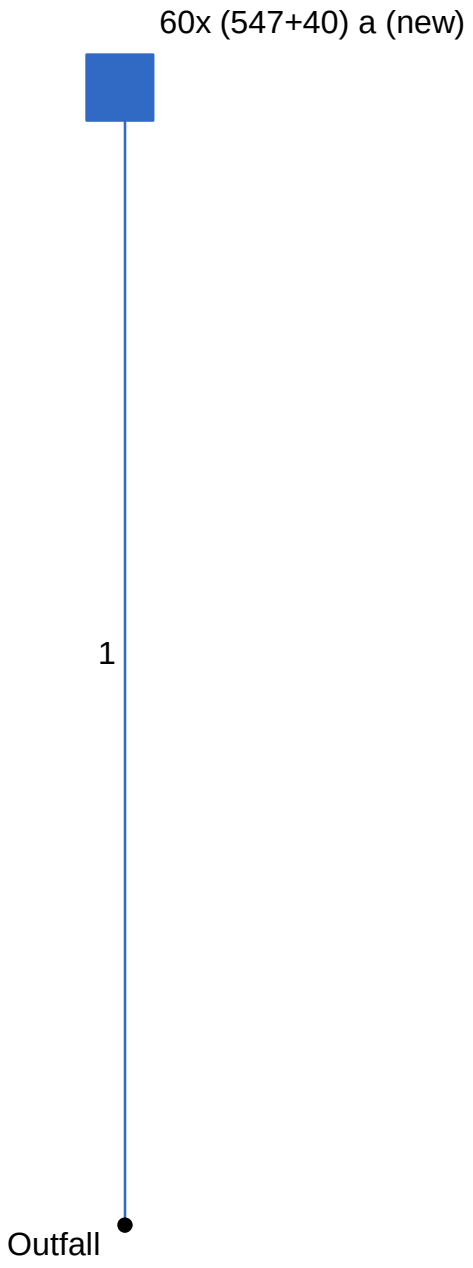
Line Profile (Line 3) - 64f (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	0.19	121.89	122.08	0.24	0.19	0.22	122.13	122.27	122.30	1.05	1.52	4.77	4.52

64 | No. Lines: 3 | Run Date: 10-30-2013

New 60x B2RN 547+40



Project File: Drainage System 60x - NEW B2RN 547+40.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	7.72	1.11	18	2.00	119.79	121.17	120.23	121.34	119.79	127.31	60x (547+40) b (ne

New 60x B2RN 547+40 | Number of lines: 1 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

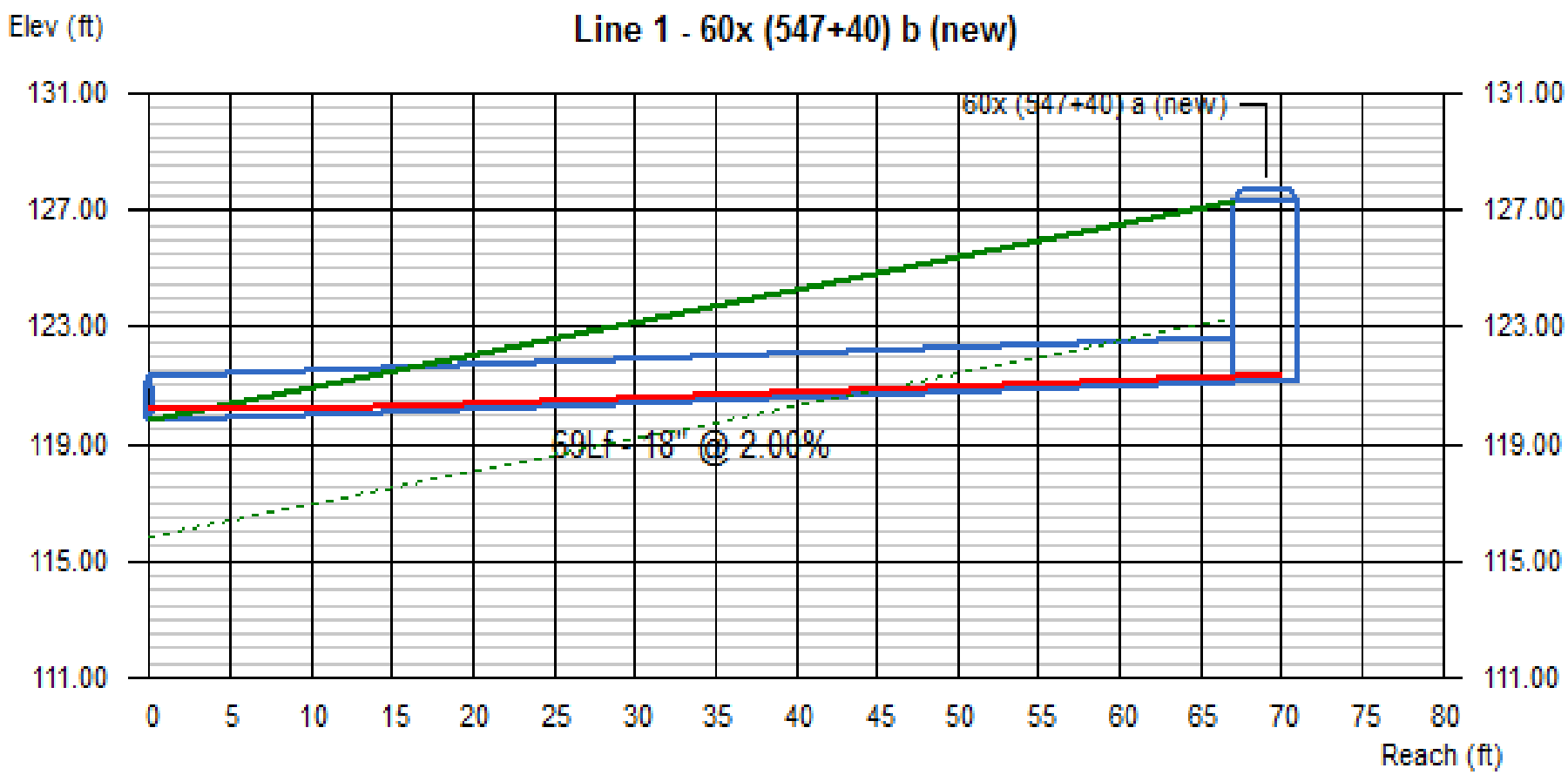
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.19	119.79	120.23	0.44	0.43	0.44	0.00	120.23	0.035	69	121.17	121.34 j	0.17**	0.11	1.78	0.05	121.39	1.798	0.917	n/a	1.00	0.05

New 60x B2RN 547+40 | Number of lines: 1 | Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

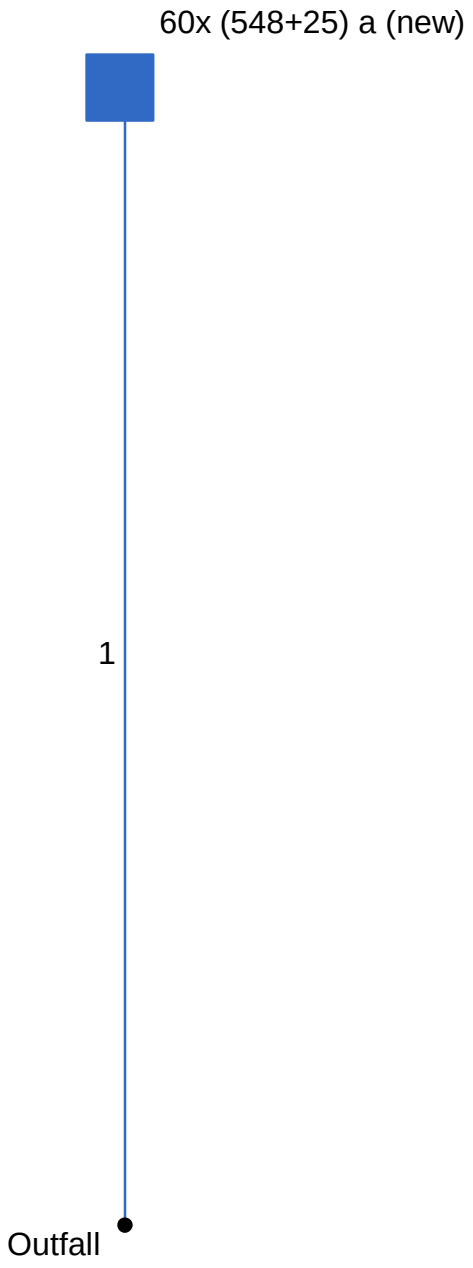
Line Profile (Line 1) - 60x (547+40) b (new)



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.19	119.79	121.17	0.44	0.17	0.17	120.23	121.34 j	121.34	0.44	1.78	-1.50	4.64

New 60x B2RN 547+40 | No. Lines: 1 | Run Date: 10-30-2013

New 60x B2RN 548+25



Project File: Drainage System 60x - NEW B2RN 548+25.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	7.72	1.31	18	2.00	119.51	120.89	119.79	121.06	119.51	127.58	60x (548+25) b (ne

New 60x B2RN 548+25 | Number of lines: 1 | Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

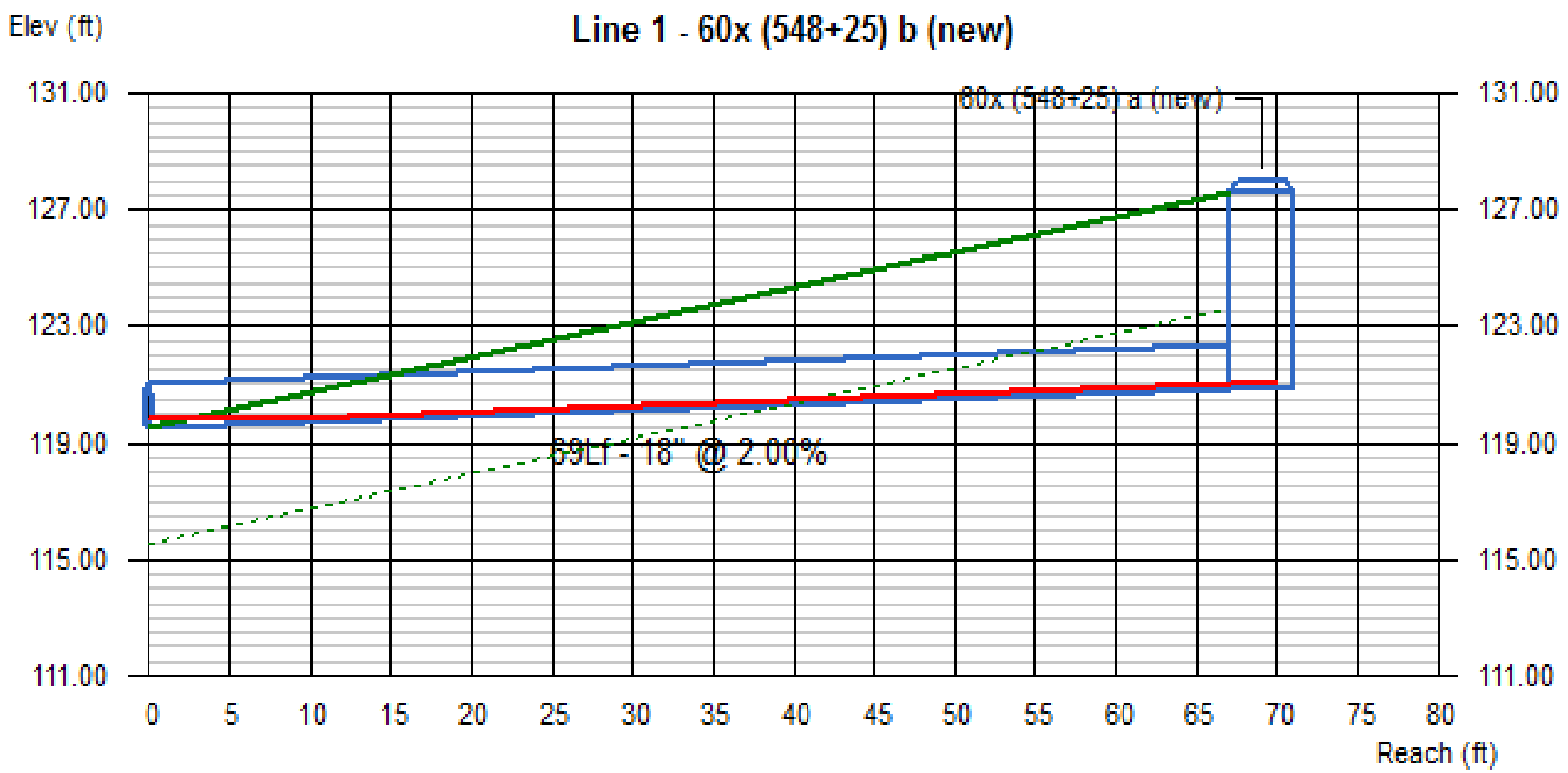
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.19	119.51	119.79	0.28	0.23	0.84	0.01	119.80	0.214	69	120.89	121.06 j	0.17**	0.11	1.78	0.05	121.11	1.798	1.006	n/a	1.00	0.05

New 60x B2RN 548+25 | Number of lines: 1 | Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

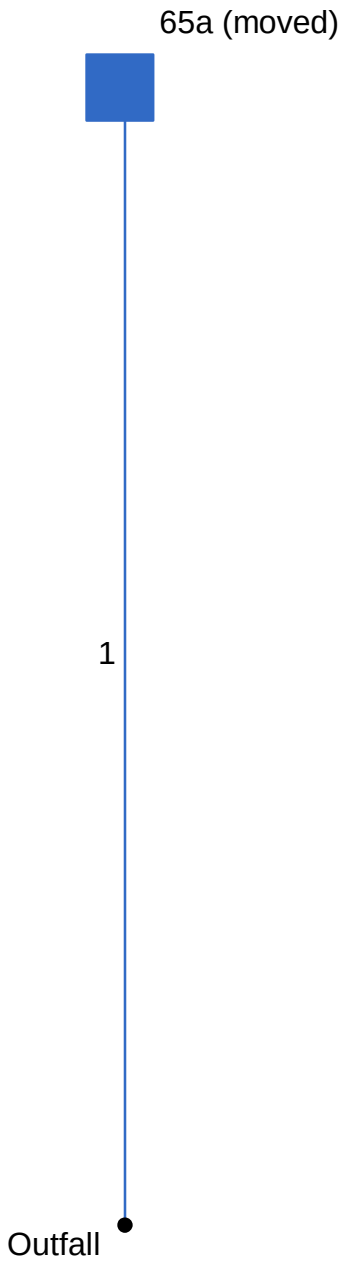
Line Profile (Line 1) - 60x (548+25) b (new)



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.19	119.51	120.89	0.28	0.17	0.17	119.79	121.06 j	121.06	0.84	1.78	-1.50	5.19

New 60x B2RN 548+25 | No. Lines: 1 | Run Date: 10-30-2013

65



Project File: Drainage System 65.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.08	0.08	1.00	0.08	0.08	5.0	5.0	2.7	0.22	7.72	1.41	18	2.00	119.36	120.74	119.64	120.92	119.36	127.93	65b

65 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

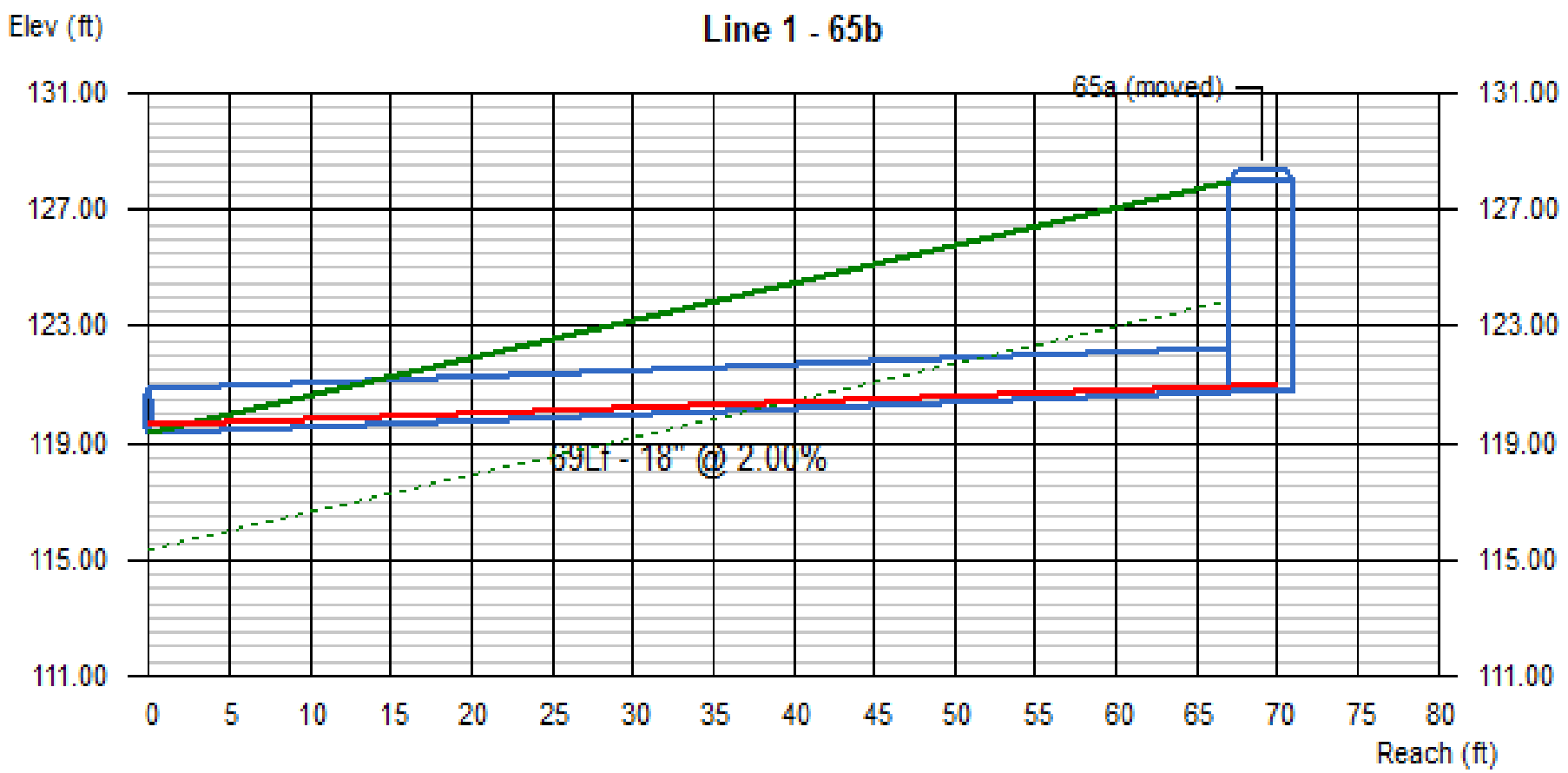
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.22	119.36	119.64	0.28	0.23	0.96	0.01	119.65	0.280	69	120.74	120.92	0.18**	0.12	1.85	0.05	120.97	1.776	1.028	n/a	1.00	0.05

65	Number of lines: 1	Run Date: 10-30-2013

Notes: ; ** Critical depth. ; c = cir e = ellip b = box

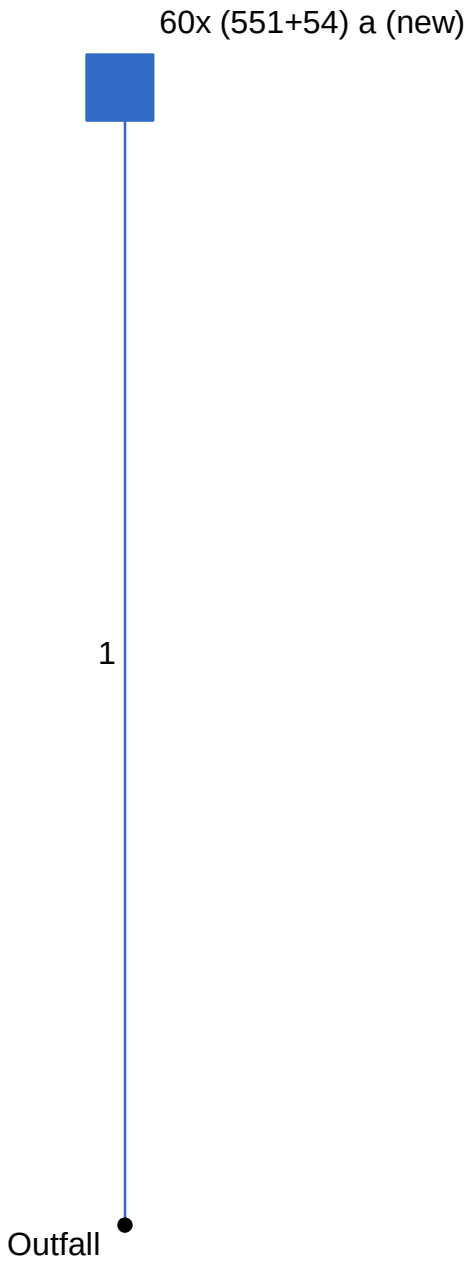
Line Profile (Line 1) - 65b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.22	119.36	120.74	0.28	0.18	0.18	119.64	120.92	120.92	0.96	1.85	-1.50	5.69

65 | No. Lines: 1 | Run Date: 10-30-2013

New 60x B2RN 551+54



Project File: Drainage System 60x - NEW B2RN 551+54.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.07	0.07	1.00	0.07	0.07	5.0	5.0	2.7	0.19	7.72	1.31	18	2.00	118.14	119.52	118.42	119.69	118.14	126.59	60x (551+54) b (ne

New 60x B2RN 551+54

Number of lines: 1

Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

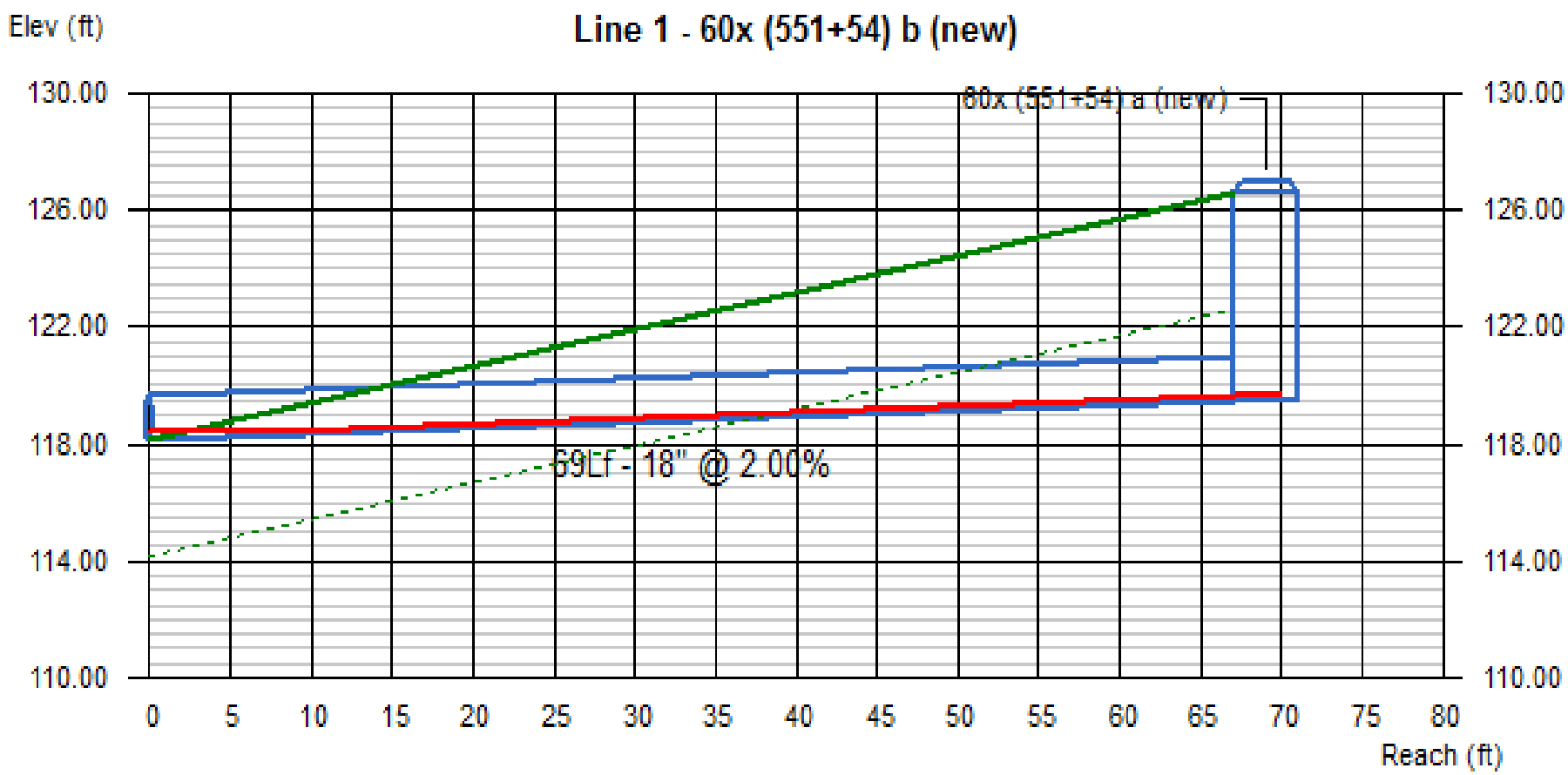
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.19	118.14	118.42	0.28	0.23	0.84	0.01	118.43	0.214	69	119.52	119.69 j	0.17**	0.11	1.78	0.05	119.74	1.798	1.006	n/a	1.00	0.05

New 60x B2RN 551+54 | Number of lines: 1 | Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

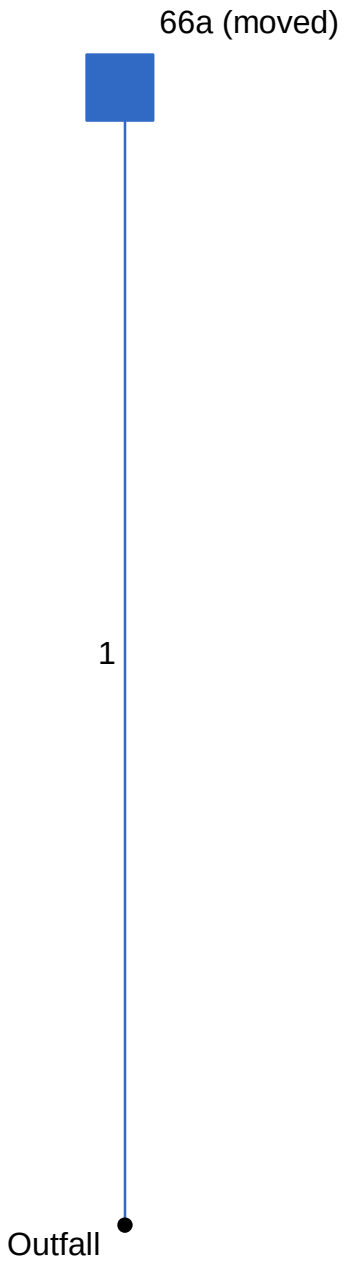
Line Profile (Line 1) - 60x (551+54) b (new)



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.19	118.14	119.52	0.28	0.17	0.17	118.42	119.69 j	119.69	0.84	1.78	-1.50	5.57

New 60x B2RN 551+54 | No. Lines: 1 | Run Date: 10-30-2013

66



Project File: Drainage System 66.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	69	0.08	0.08	1.00	0.08	0.08	5.0	5.0	2.7	0.22	7.72	1.41	18	2.00	118.69	120.07	118.97	120.25	118.69	128.33	66b

66 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

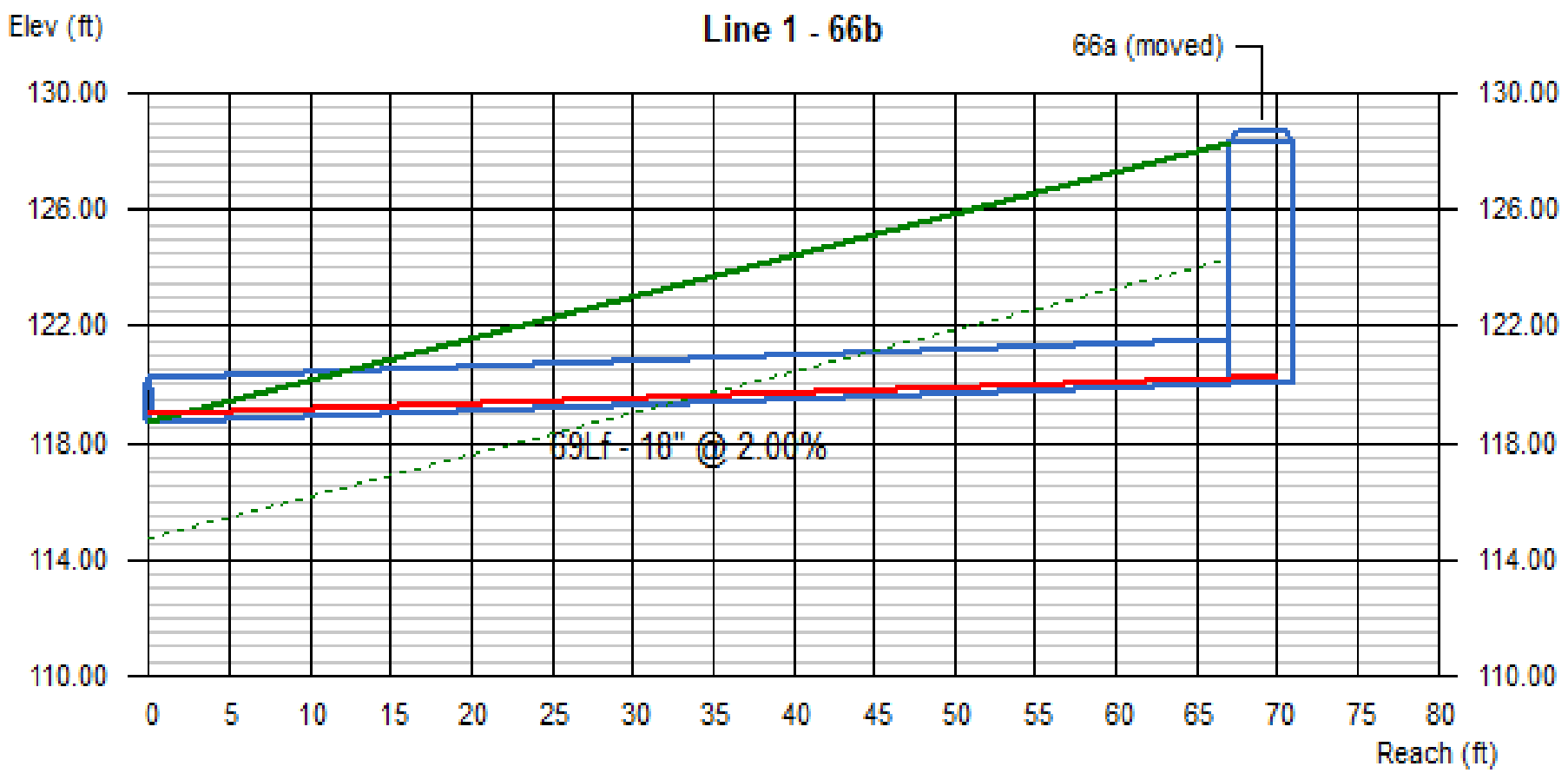
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.22	118.69	118.97	0.28	0.23	0.96	0.01	118.98	0.280	69	120.07	120.25	0.18**	0.12	1.85	0.05	120.30	1.776	1.028	n/a	1.00	0.05

66	Number of lines: 1	Run Date: 10-30-2013

Notes: ; ** Critical depth. ; c = cir e = ellip b = box

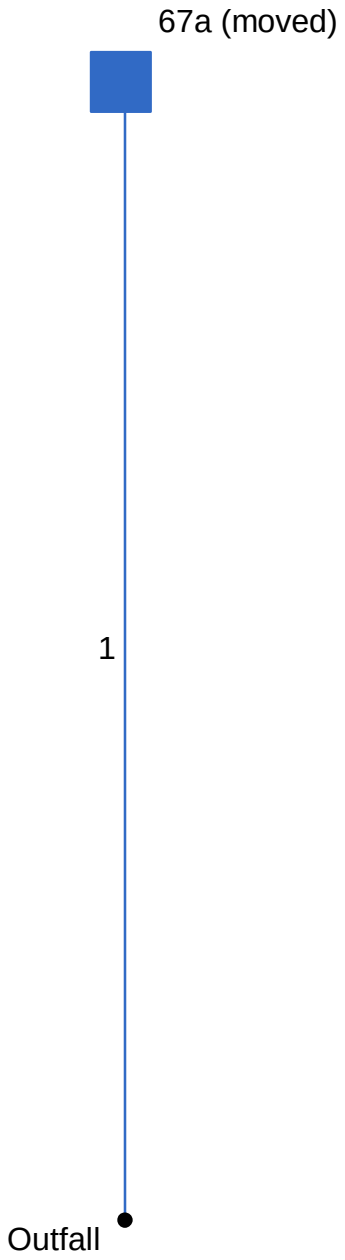
Line Profile (Line 1) - 66b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.22	118.69	120.07	0.28	0.18	0.18	118.97	120.25	120.25	0.96	1.85	-1.50	6.76

66 | No. Lines: 1 | Run Date: 10-30-2013

67



Project File: Drainage System 67.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	77	0.08	0.08	1.00	0.08	0.08	5.0	5.0	2.7	0.22	7.31	1.48	18	1.79	118.69	120.07	118.94	120.25	118.69	128.33	67b

67 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

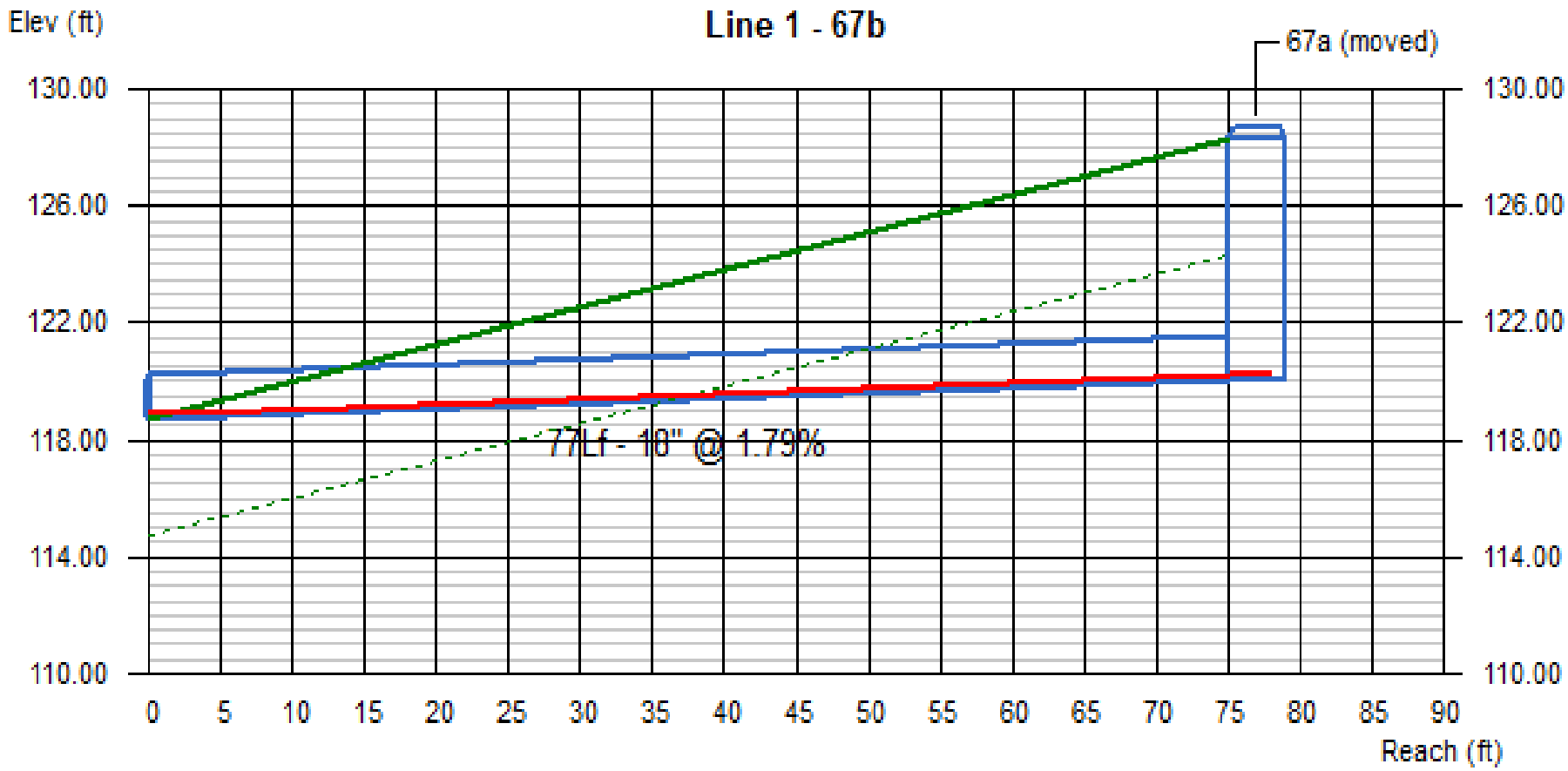
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	0.22	118.69	118.94	0.25	0.20	1.11	0.02	118.96	0.417	77	120.07	120.25 j	0.18**	0.12	1.85	0.05	120.30	1.776	1.097	n/a	1.00	0.05

67	Number of lines: 1	Run Date: 10-30-2013

Notes: ; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

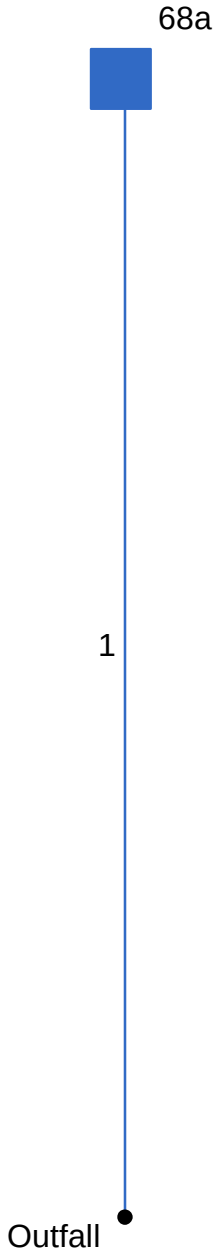
Line Profile (Line 1) - 67b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.22	118.69	120.07	0.25	0.18	0.18	118.94	120.25 j	120.25	1.11	1.85	-1.50	6.76

67 | No. Lines: 1 | Run Date: 10-30-2013

68



Project File: Drainage System 68.stm	Number of lines: 1	Date: 10-30-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	77	0.08	0.08	1.00	0.08	0.08	5.0	5.0	2.7	0.22	7.92	1.48	18	2.10	115.94	117.56	116.19	117.74	115.94	128.76	68b

68 Number of lines: 1 Run Date: 10-30-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

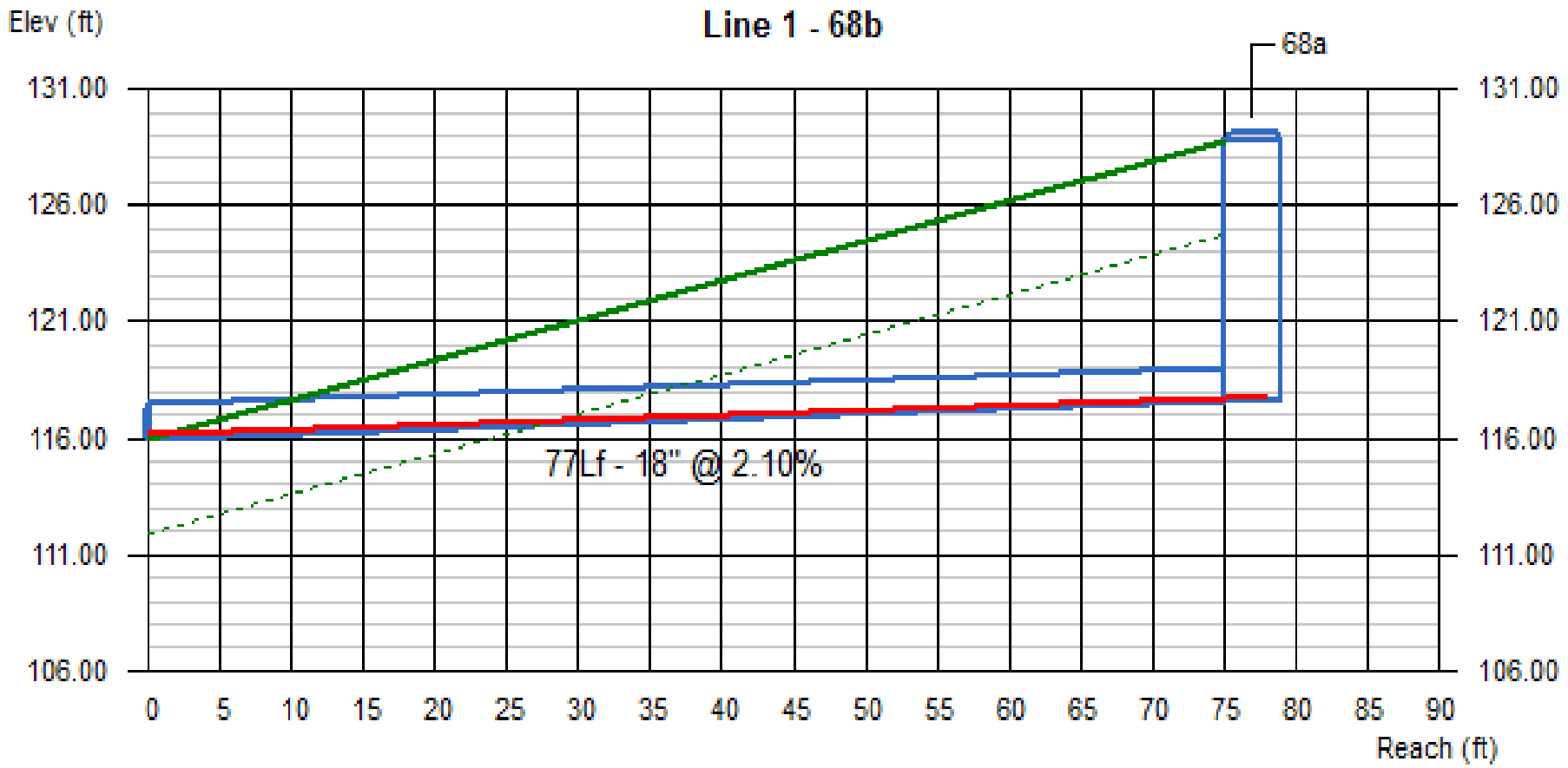
Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	0.22	115.94	116.19	0.25	0.20	1.11	0.02	116.21	0.417	77	117.56	117.74	0.18**	0.12	1.85	0.05	117.79	1.776	1.097	n/a	1.00	0.05

68	Number of lines: 1	Run Date: 10-30-2013

Notes: ; ** Critical depth. ; c = cir e = ellip b = box

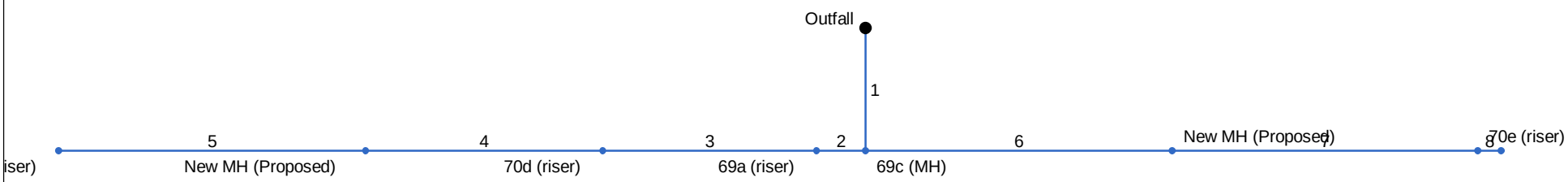
Line Profile (Line 1) - 68b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	0.22	115.94	117.56	0.25	0.18	0.18	116.19	117.74	117.74	1.11	1.85	-1.50	9.70

68 | No. Lines: 1 | Run Date: 10-30-2013

69 70 71



Project File: Drainage System 69 70 71.stm	Number of lines: 8	Date: 11-05-2013

Hydraflow Storm Sewers 2008 v12.01

Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	66	4.14	110.13	110.91	0.78	2.06	2.01	0.06	110.97	0.300	100	110.43	111.21	0.78	2.05	2.02	0.06	111.27	0.304	0.302	0.302	1.00	0.06
2	18	2.12	111.94	112.50	0.56*	0.60	3.56	0.20	112.69	1.762	40	112.06	113.05	0.99	1.24	1.71	0.05	113.10	0.252	1.007	0.403	0.50	0.02
3	18	1.77	112.59	113.10	0.51*	0.53	3.36	0.18	113.27	1.724	175	113.10	114.86	1.50	1.77	1.00	0.02	114.87	0.105	0.915	1.601	0.50	0.01
4	18	1.01	112.53	114.87	1.50	1.77	0.57	0.01	114.87	0.035	194	113.16	114.93	1.50	1.77	0.57	0.01	114.94	0.035	0.035	0.067	0.15	0.00
5	18	1.18	113.16	114.93	1.50	1.77	0.67	0.01	114.94	0.047	251	113.82	115.05	1.23	1.55	0.76	0.01	115.06	0.047	0.047	0.117	1.00	0.01
6	18	2.18	110.43	111.27	0.84	1.02	2.13	0.07	111.34	0.435	251	111.18	112.17	0.99	1.24	1.76	0.05	112.22	0.265	0.350	0.878	0.15	0.01
7	18	2.28	111.18	112.18	1.00	1.25	1.82	0.05	112.23	0.284	250	111.93	112.91	0.98	1.22	1.86	0.05	112.96	0.300	0.292	0.731	0.50	0.03
8	18	1.60	111.93	112.94	1.01	1.26	1.27	0.03	112.96	0.137	19	111.99	112.96	0.97	1.21	1.32	0.03	112.99	0.151	0.144	0.027	1.00	0.03

69 70 71 | Number of lines: 8 | Run Date: 11-05-2013

Notes: * depth assumed. ; c = cir e = ellip b = box

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	100	0.00	5.13	0.00	0.00	3.77	0.0	30.1	1.1	4.14	95.66	2.01	66	0.30	110.13	110.43	110.91	111.21	115.93	118.51	Existing Outfall
2	1	40	0.49	2.45	0.73	0.36	1.93	14.0	29.8	1.1	2.12	2.99	2.64	18	0.30	111.94	112.06	112.50	113.05	118.51	117.21	69b
3	2	175	0.97	1.96	0.79	0.77	1.57	23.0	28.5	1.1	1.77	2.95	2.18	18	0.29	112.59	113.10	113.10	114.86	117.21	117.78	70f
4	3	194	0.00	0.99	0.00	0.00	0.80	0.0	22.9	1.3	1.01	3.11	0.57	18	0.32	112.53	113.16	114.87	114.93	117.78	118.80	70c-2
5	4	251	0.99	0.99	0.81	0.80	0.80	17.0	17.0	1.5	1.18	2.80	0.72	18	0.26	113.16	113.82	114.93	115.05	118.80	119.82	70c-1
6	1	251	0.00	2.68	0.00	0.00	1.85	0.0	26.3	1.2	2.18	2.98	1.94	18	0.30	110.43	111.18	111.27	112.17	118.51	115.20	71f-2
7	6	250	1.71	2.68	0.74	1.27	1.85	24.0	24.0	1.2	2.28	2.99	1.84	18	0.30	111.18	111.93	112.18	112.91	115.20	116.98	70f-2
8	7	19	0.97	0.97	0.60	0.58	0.58	5.0	5.0	2.7	1.60	3.07	1.29	18	0.32	111.93	111.99	112.94	112.96	116.98	116.99	71c

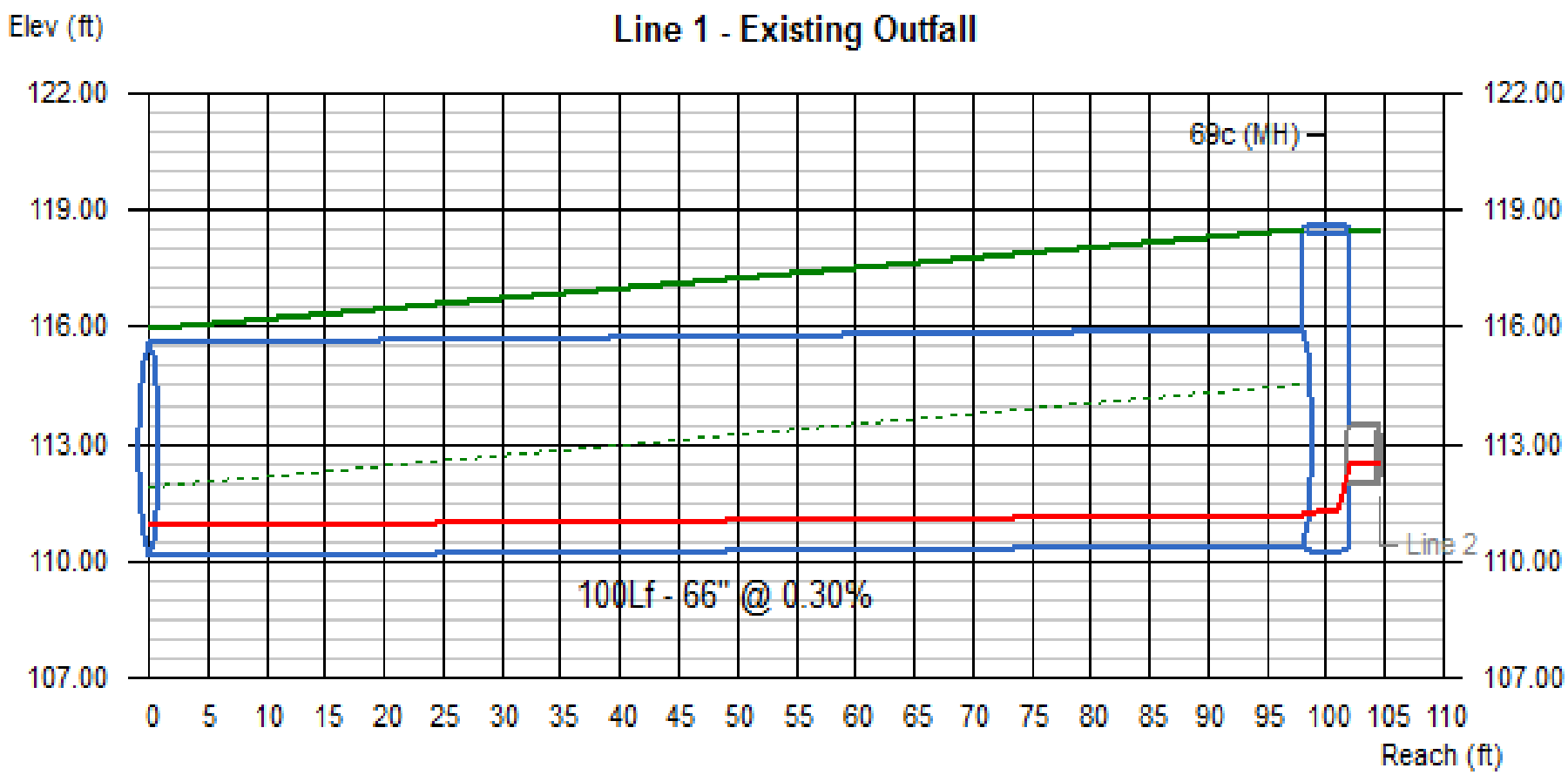
69 70 71

Number of lines: 8

Run Date: 11-05-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

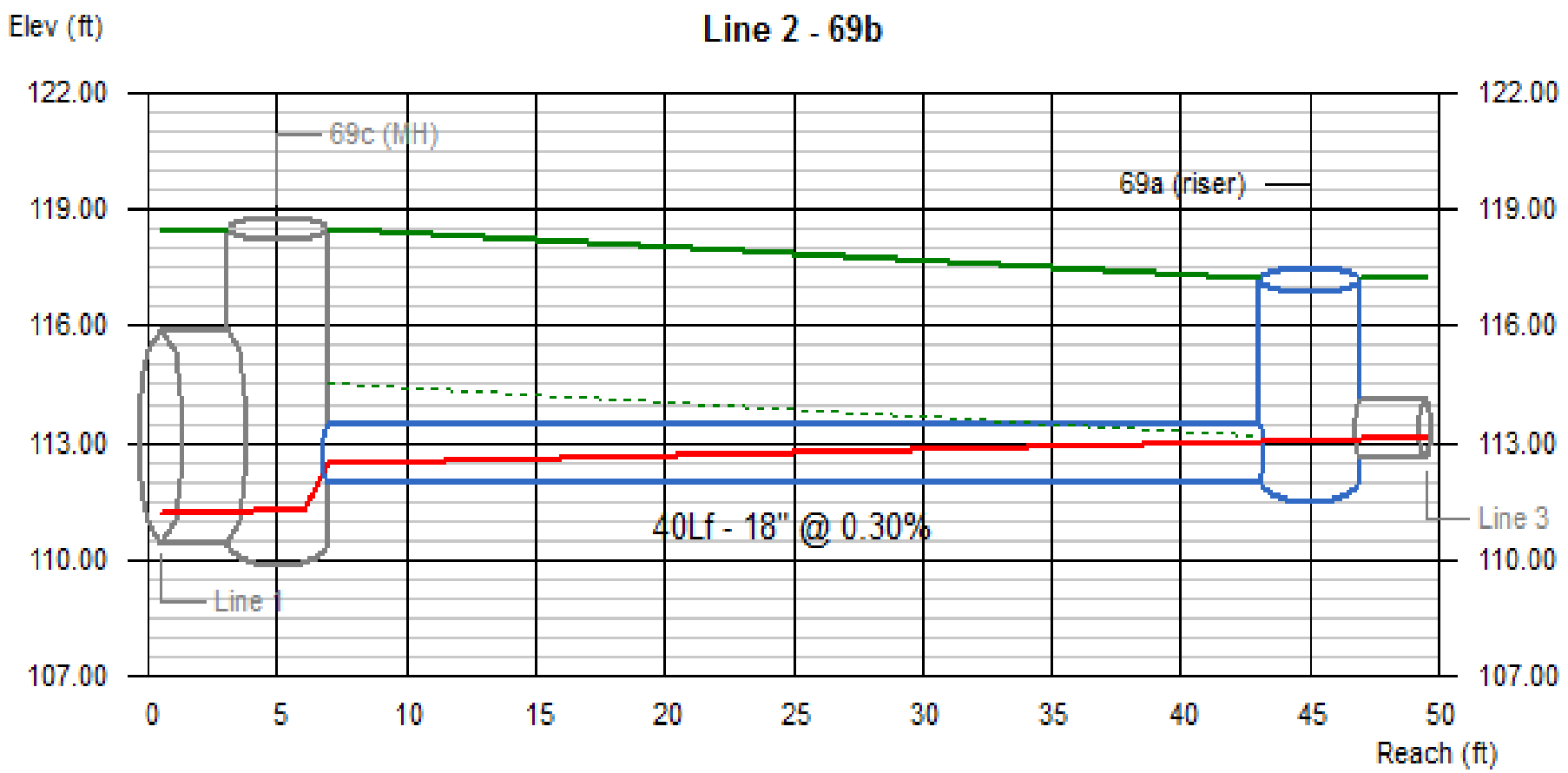
Line Profile (Line 1) - Existing Outfall



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	4.14	110.13	110.43	0.78	0.78	0.84	110.91	111.21	111.27	2.01	2.02	0.30	2.58

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

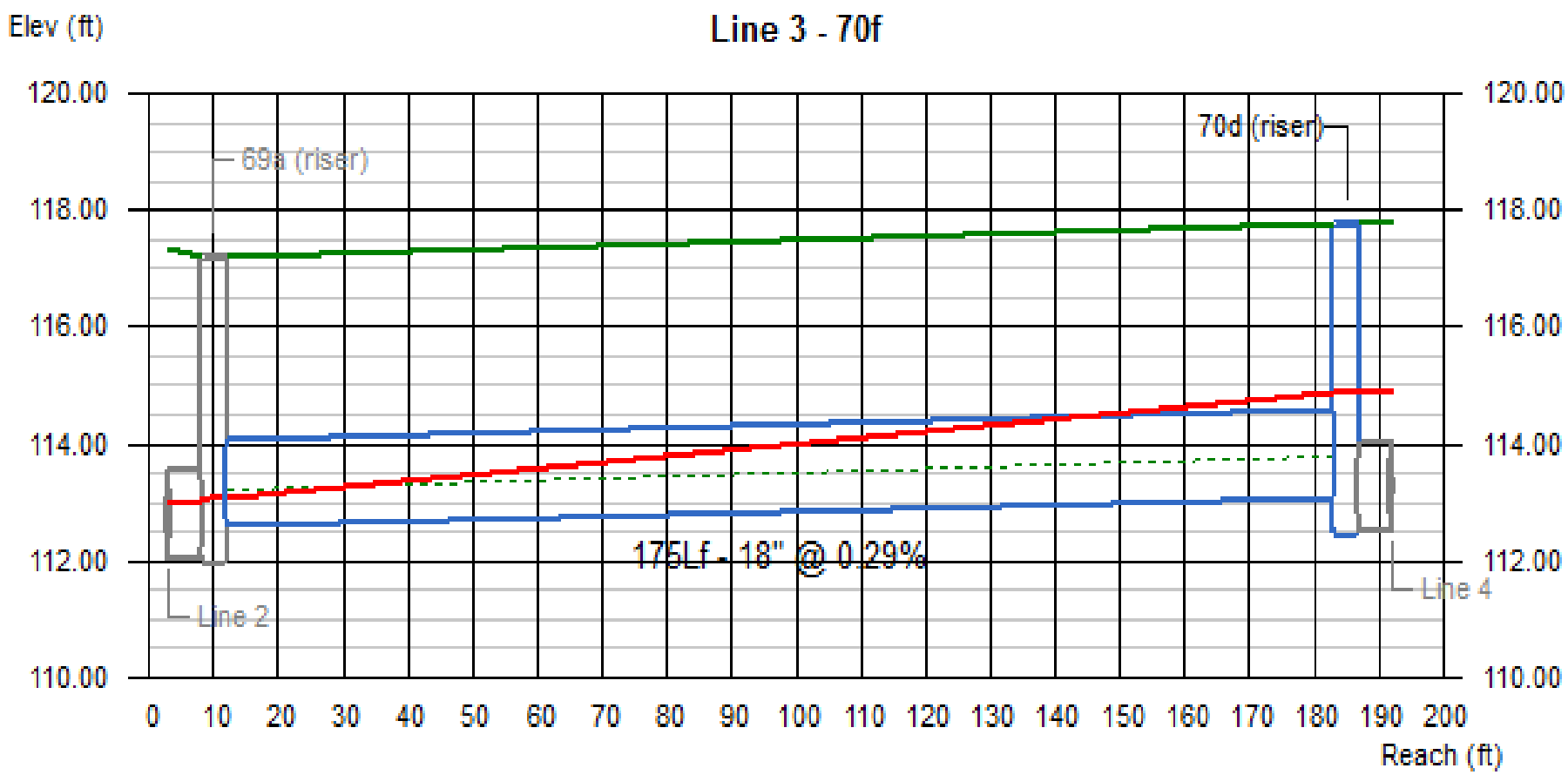
Line Profile (Line 2) - 69b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	2.12	111.94	112.06	0.56	0.99	1.01	112.50	113.05	113.08	3.56	1.71	5.07	3.65

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

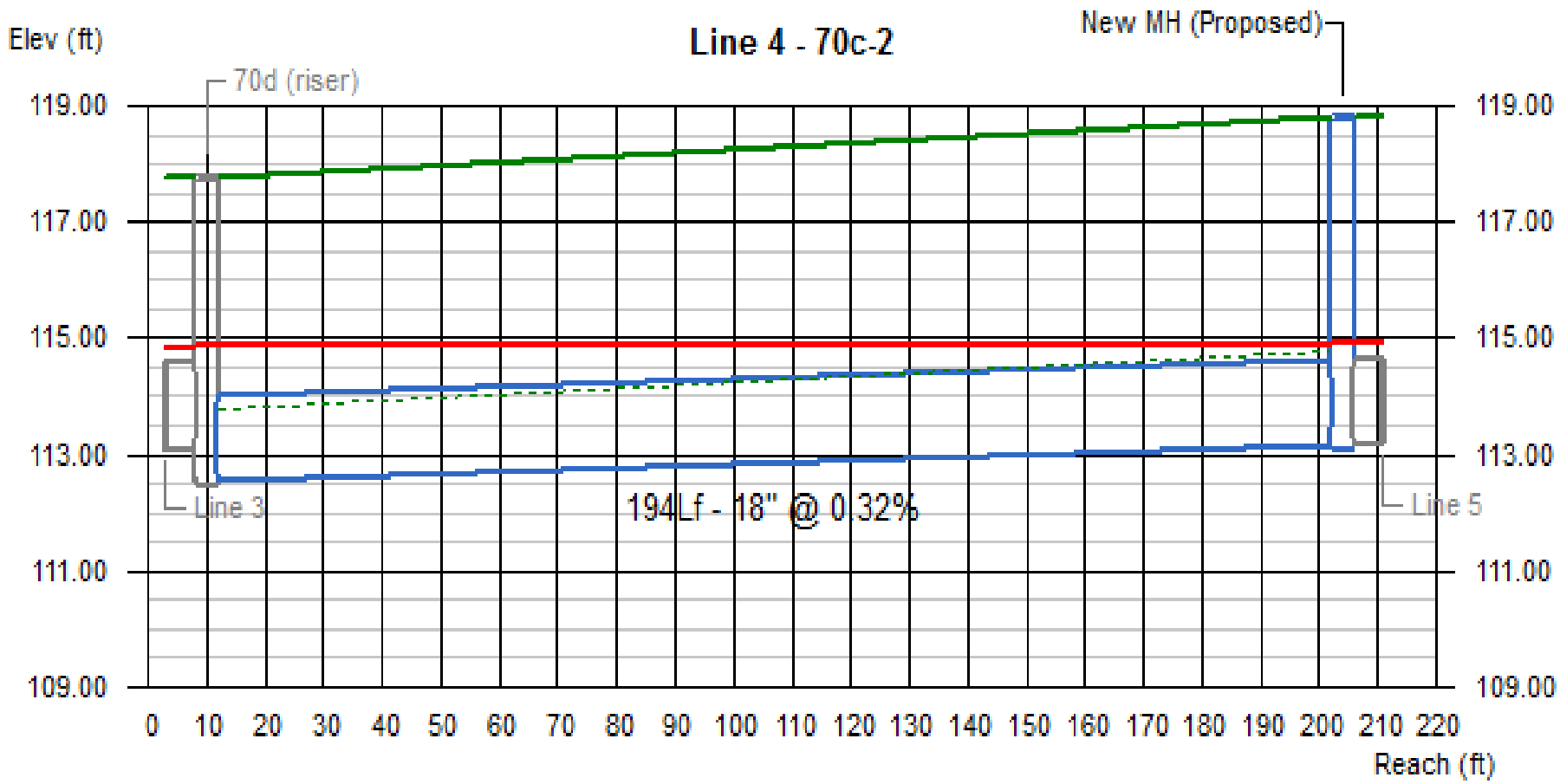
Line Profile (Line 3) - 70f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	1.77	112.59	113.10	0.51	1.50	1.77	113.10	114.86	114.87	3.36	1.00	3.12	3.18

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

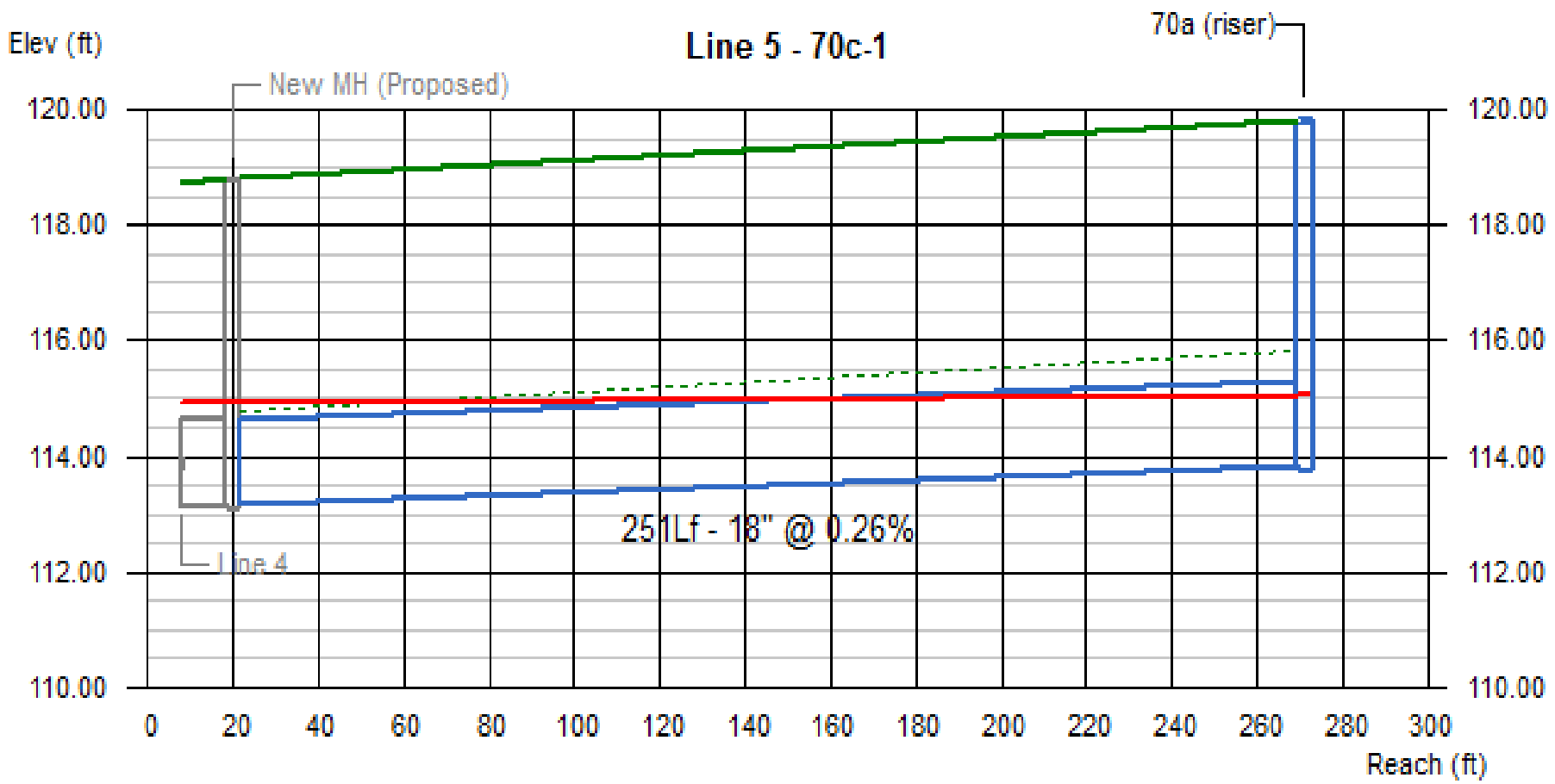
Line Profile (Line 4) - 70c-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	1.01	112.53	113.16	1.50	1.50	1.77	114.87	114.93	114.93	0.57	0.57	3.75	4.14

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

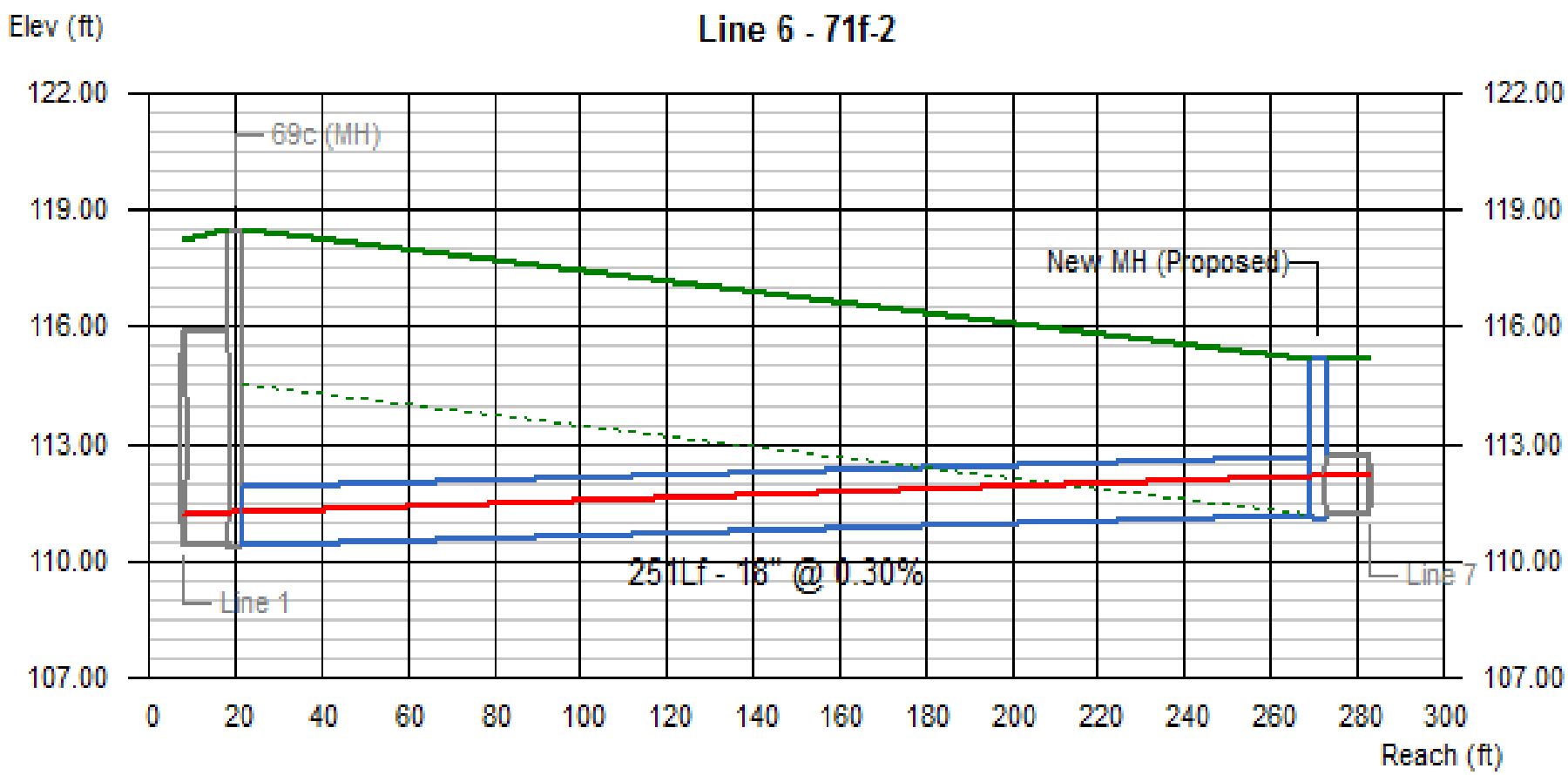
Line Profile (Line 5) - 70c-1



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	1.18	113.16	113.82	1.50	1.23	1.24	114.93	115.05	115.06	0.67	0.76	4.14	4.50

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

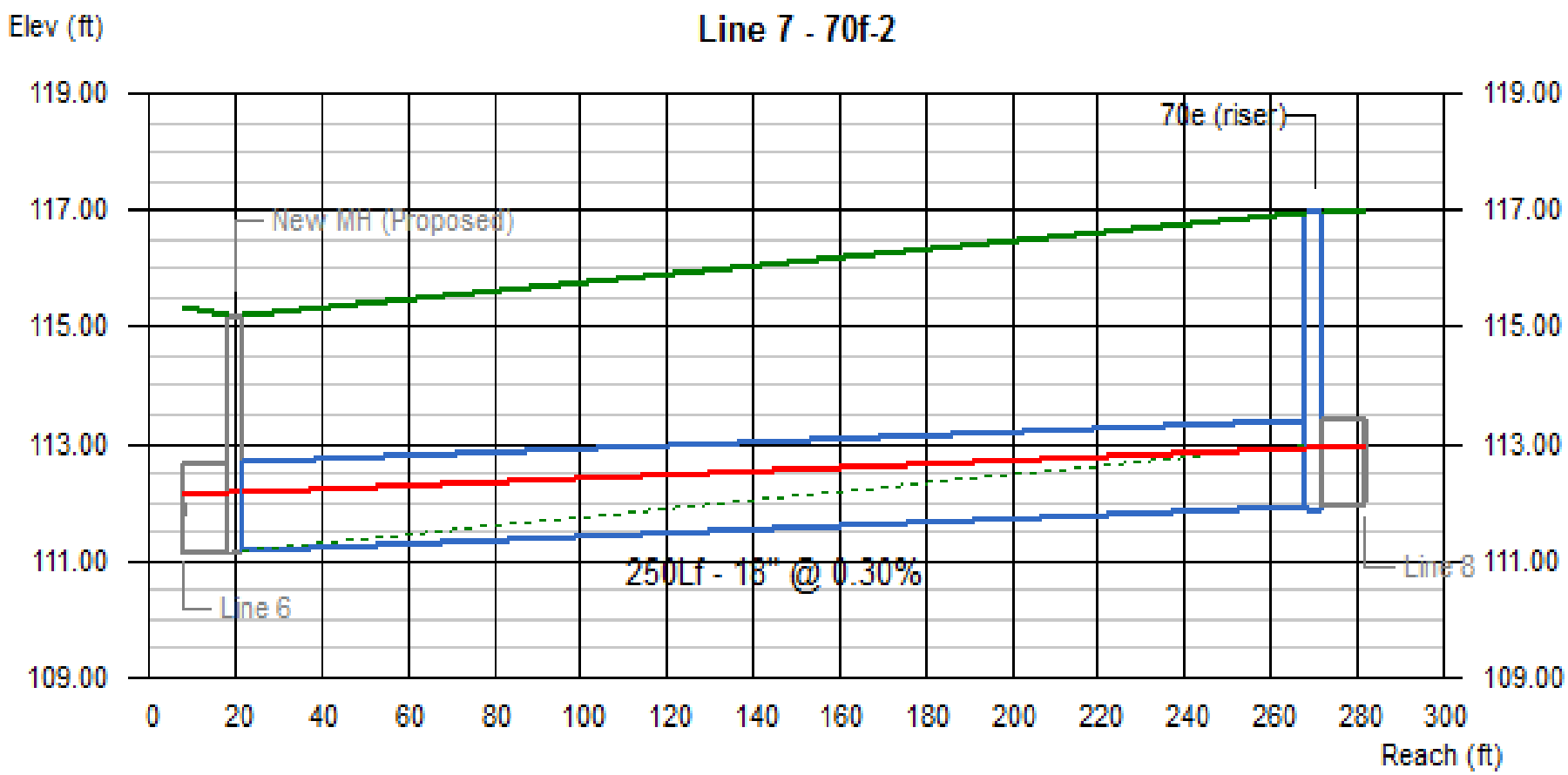
Line Profile (Line 6) - 71f-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	2.18	110.43	111.18	0.84	0.99	1.00	111.27	112.17	112.18	2.13	1.76	6.58	2.52

69 70 71	No. Lines: 8	Run Date: 11-05-2013

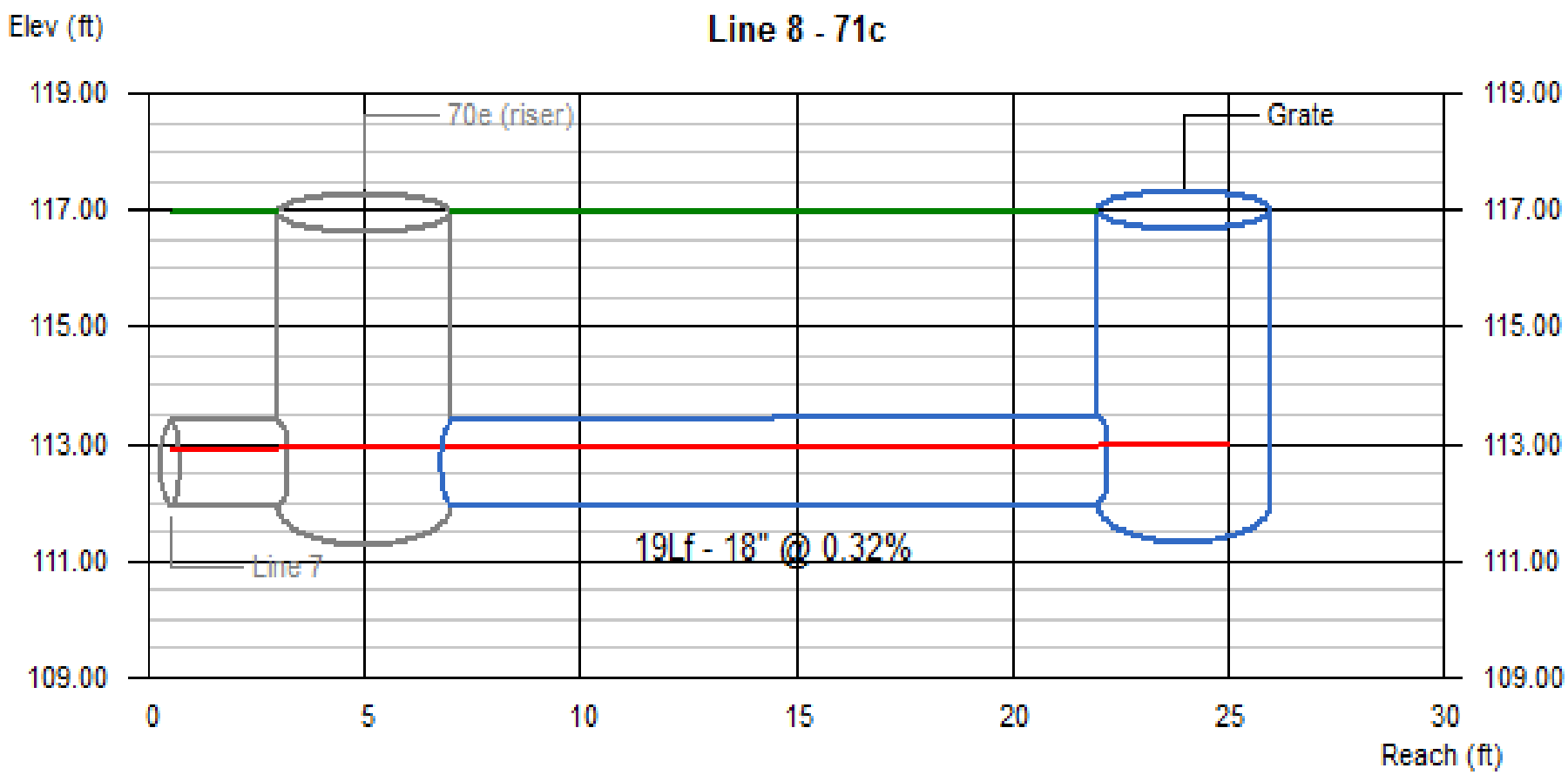
Line Profile (Line 7) - 70f-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	2.28	111.18	111.93	1.00	0.98	1.01	112.18	112.91	112.94	1.82	1.86	2.52	3.55

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

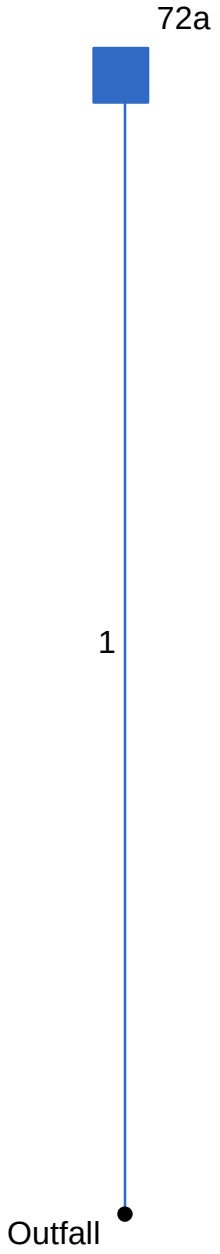
Line Profile (Line 8) - 71c



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	1.60	111.93	111.99	1.01	0.97	1.00	112.94	112.96	112.99	1.27	1.32	3.55	3.50

69 70 71 | No. Lines: 8 | Run Date: 11-05-2013

72



Project File: Drainage System 72.stm	Number of lines: 1	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	84	0.60	0.60	1.00	0.60	0.60	5.0	5.0	2.7	1.65	7.72	3.29	18	2.00	123.56	125.24	124.05	125.73	123.56	131.24	72b

72 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

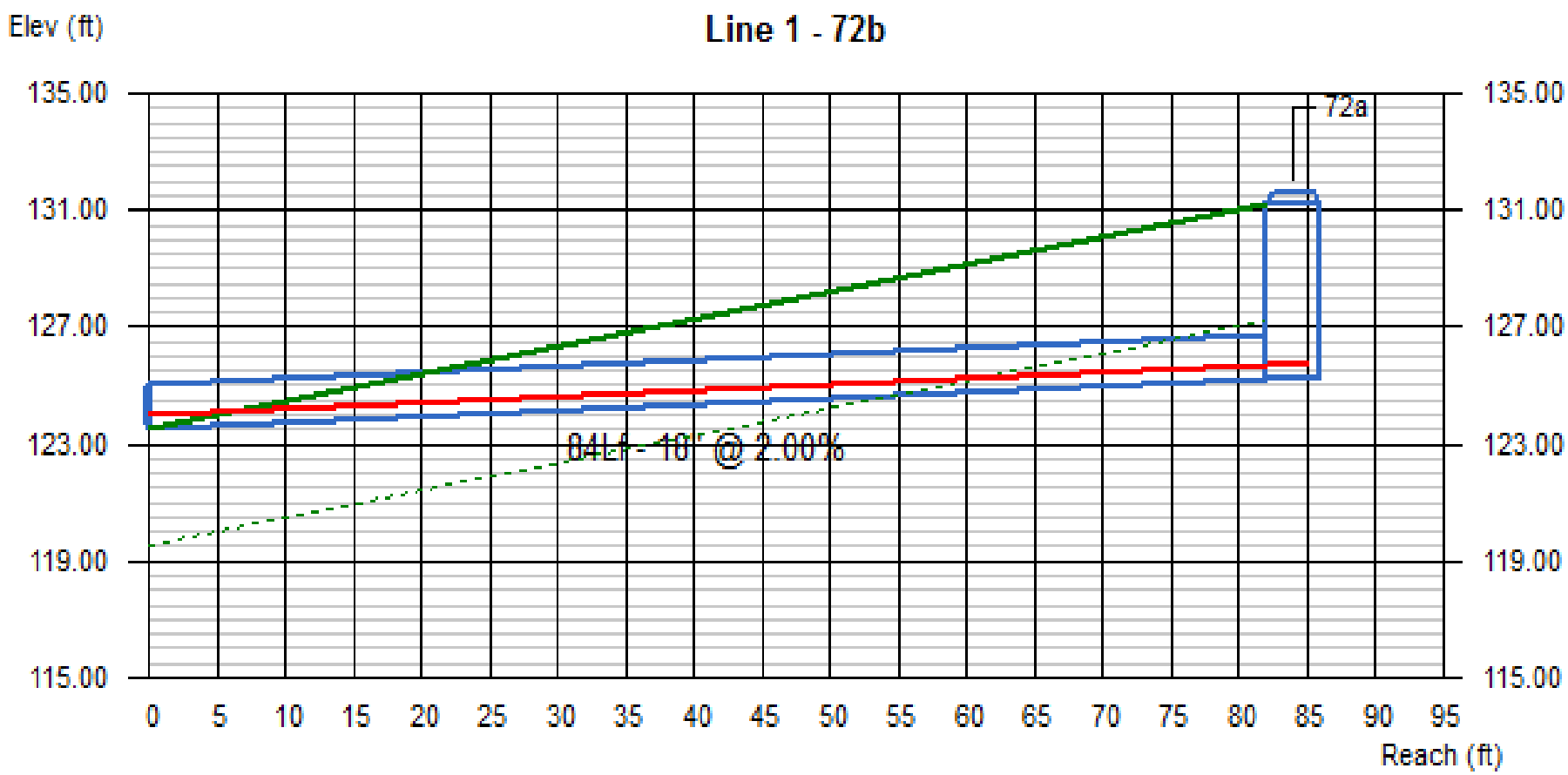
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	1.65	123.56	124.05	0.49	0.50	3.29	0.17	124.22	1.712	84	125.24	125.73	0.49**	0.50	3.29	0.17	125.90	1.712	1.712	n/a	1.00	n/a

72	Number of lines: 1	Run Date: 11-04-2013

Notes: ; ** Critical depth. ; c = cir e = ellip b = box

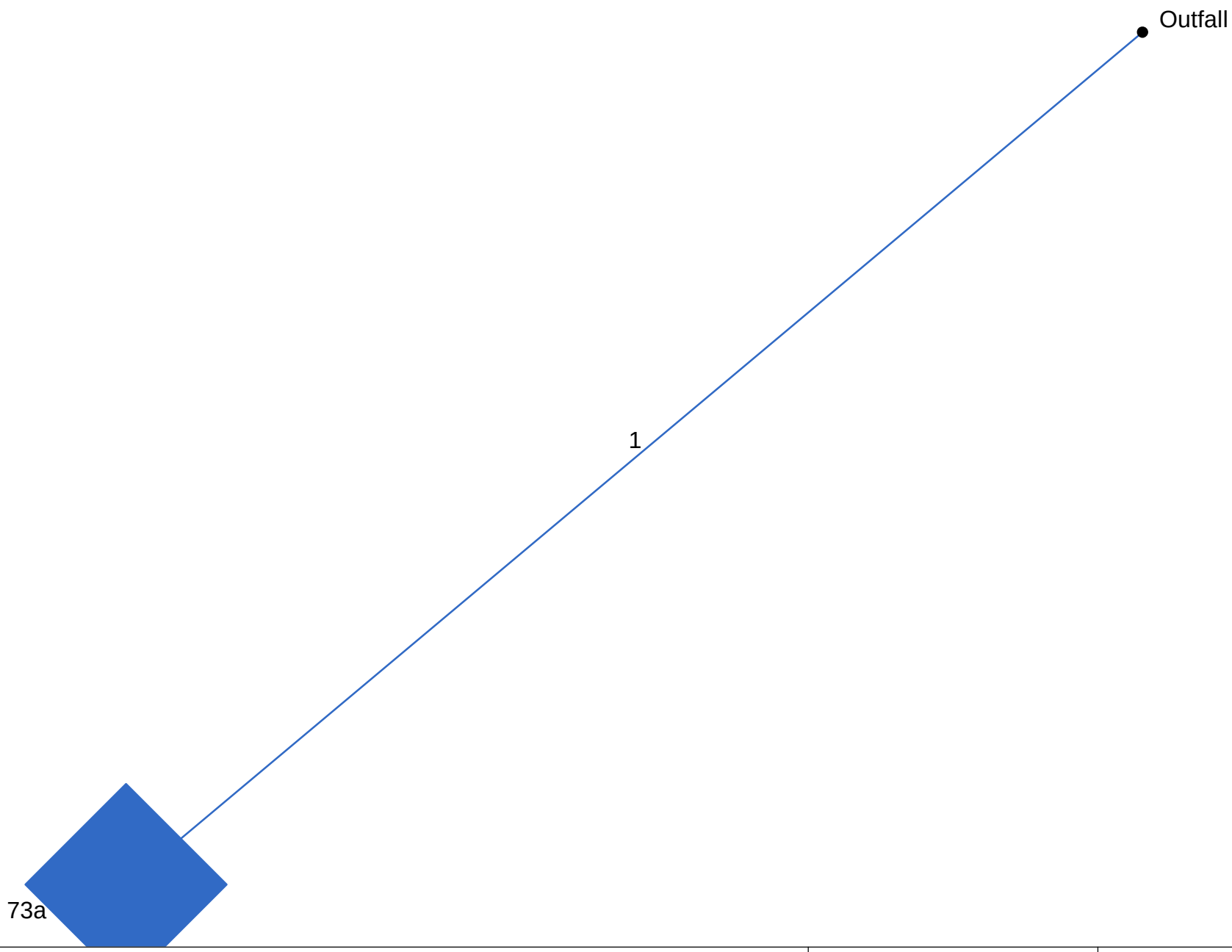
Line Profile (Line 1) - 72b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	1.65	123.56	125.24	0.49	0.49	0.49	124.05	125.73	125.73	3.29	3.29	-1.50	4.50

72	No. Lines: 1	Run Date: 11-04-2013

73



Project File: Drainage System 73.stm	Number of lines: 1	Date: 11-04-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	39	2.75	2.75	0.78	2.15	2.15	16.0	16.0	1.5	3.26	3.03	1.90	18	0.31	119.42	119.54	120.82	120.94	119.15	124.79	73b

73 Number of lines: 1 Run Date: 11-04-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

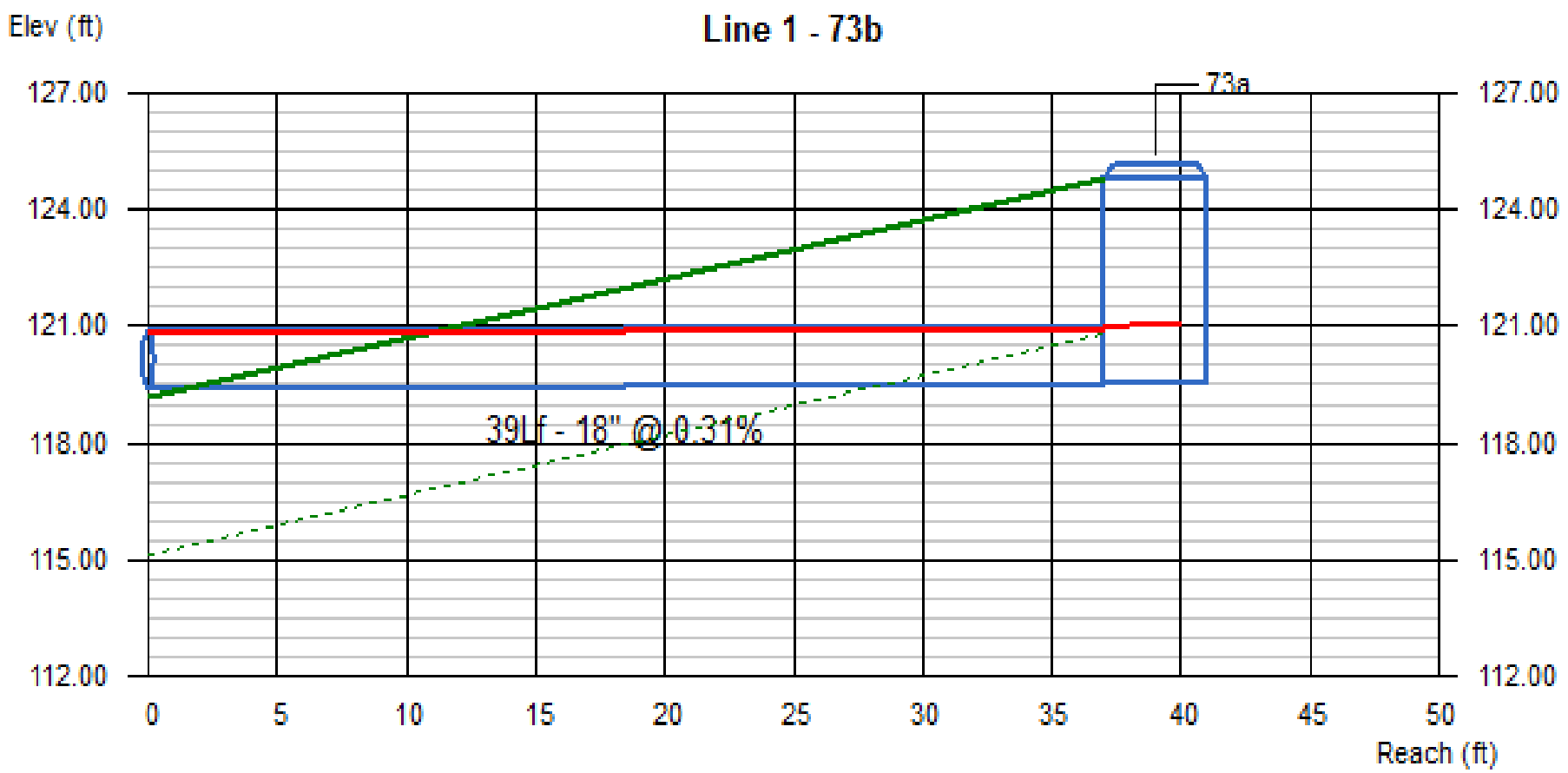
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	18	3.26	119.42	120.82	1.40	1.72	1.90	0.06	120.88	0.308	39	119.54	120.94	1.40	1.72	1.90	0.06	121.00	0.308	0.308	0.120	1.00	0.06

73	Number of lines: 1	Run Date: 11-04-2013

; c = cir e = ellip b = box

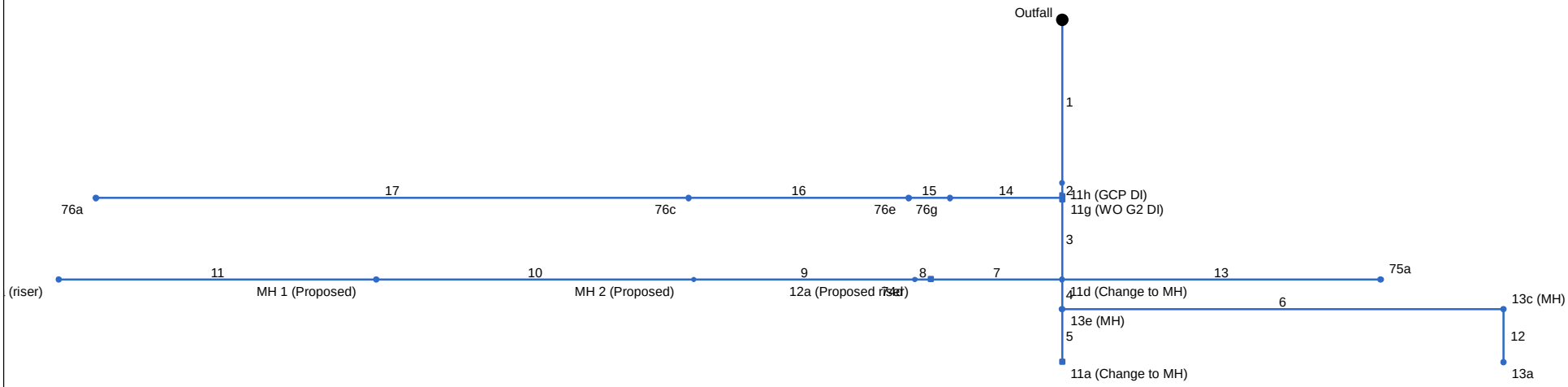
Line Profile (Line 1) - 73b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	3.26	119.42	119.54	1.40	1.40	1.46	120.82	120.94	121.00	1.90	1.90	-1.77	3.75

73 | No. Lines: 1 | Run Date: 11-04-2013

11 12 13 74 75 76



Project File: Drainage System 11, 12, 13, 74, 75, 76.stm	Number of lines: 17	Date: 11-07-2013

Hydraflow Storm Sewers 2008 v12.01

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	154	0.17	23.89	0.60	0.10	17.70	5.0	198.2	0.4	7.38	2.98	4.18	18	0.30	115.55	116.01	117.05	119.87	117.67	122.71	11i
2	1	14	2.55	23.72	1.00	2.55	17.60	25.0	198.1	0.4	7.34	6.29	2.34	24	0.29	116.17	116.21	120.00	120.06	122.71	126.25	11f
3	2	77	0.00	19.64	0.00	0.00	13.52	5.0	194.6	0.4	5.70	95.15	0.38	60	0.49	116.37	116.75	120.18	120.18	126.25	122.78	11e
4	3	28	0.00	0.05	0.00	0.00	0.05	5.0	175.0	0.4	0.04	6.61	0.02	18	1.46	117.61	118.02	120.18	120.18	122.78	125.68	13c
5	4	50	0.00	0.00	0.00	0.00	0.00	30.0	30.0	0.0	0.01	6.64	0.01	18	1.48	118.18	118.92	120.18	120.18	125.68	126.30	11b
6	4	417	0.00	0.05	0.00	0.00	0.05	5.0	5.8	2.5	0.14	5.12	0.67	18	0.88	118.18	121.85	120.18	122.02	125.68	126.94	13d
7	3	124	1.93	12.47	0.67	1.29	8.34	24.5	28.3	1.1	9.45	6.42	3.01	24	0.30	116.91	117.28	120.18	120.98	122.78	122.28	12c
8	7	15	5.90	10.54	0.66	3.89	7.05	22.0	28.3	1.1	8.00	3.15	4.53	18	0.33	116.91	116.96	121.05	121.38	122.28	123.82	74e
9	8	209	0.00	4.64	0.00	0.00	3.16	5.0	26.6	1.2	3.69	5.31	2.09	18	0.95	118.32	120.30	121.54	122.49	123.82	123.30	74b-3
10	9	300	0.00	4.64	0.00	0.00	3.16	5.0	24.6	1.2	3.85	5.32	2.52	18	0.95	120.30	123.15	122.50	124.21	123.30	126.00	74b-2
11	10	300	4.64	4.64	0.68	3.16	3.16	23.0	23.0	1.3	3.98	5.32	3.22	18	0.95	123.15	126.00	124.23	126.91	126.00	132.88	74b-1
12	6	50	0.05	0.05	1.00	0.05	0.05	5.0	5.0	2.7	0.15	3.86	1.02	18	0.50	122.01	122.26	122.16	122.67	126.94	127.56	13b
13	3	301	7.12	7.12	0.72	5.13	5.13	45.0	45.0	0.9	4.58	3.87	2.59	18	0.50	118.11	119.62	120.18	122.30	122.78	126.62	75b
14	2	106	0.04	1.53	1.00	0.04	1.53	5.0	31.5	1.1	1.64	123.4	0.12	60	0.83	116.36	117.24	120.18	120.19	126.25	126.09	76h
15	14	39	0.18	1.49	1.00	0.18	1.49	5.0	22.9	1.3	1.88	120.8	0.18	60	0.79	117.40	117.71	120.19	120.18	126.09	126.14	76f
16	15	208	0.48	1.31	1.00	0.48	1.31	5.0	9.2	2.0	2.64	121.0	0.82	60	0.80	117.87	119.53	120.19	120.31	126.14	126.91	76d
17	16	560	0.83	0.83	1.00	0.83	0.83	5.0	5.0	2.7	2.28	121.1	2.22	60	0.80	119.69	124.17	120.32	124.59	126.91	138.40	76b

11 12 13 74 75 76

Number of lines: 17

Run Date: 11-07-2013

NOTES: Intensity = 6.37 / (Inlet time + 0.10) ^ 0.52; Return period = 25 Yrs. ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	18	7.38	115.55	117.05	1.50	1.77	4.18	0.27	117.32	1.829	154	116.01	119.87	1.50	1.77	4.18	0.27	120.14	1.828	1.828	2.816	0.50	0.14
2	24	7.34	116.17	120.00	2.00	3.14	2.34	0.08	120.09	0.390	14	116.21	120.06	2.00	3.14	2.34	0.08	120.14	0.390	0.390	0.055	1.50	0.13
3	60	5.70	116.37	120.18	3.81	16.07	0.35	0.00	120.19	0.002	77	116.75	120.18	3.43	14.36	0.40	0.00	120.18	0.003	0.002	0.002	1.00	0.00
4	18	0.04	117.61	120.18	1.50	1.77	0.02	0.00	120.18	0.000	28	118.02	120.18	1.50	1.77	0.02	0.00	120.18	0.000	0.000	0.000	1.00	0.00
5	18	0.01	118.18	120.18	1.50	1.77	0.01	0.00	120.18	0.000	50	118.92	120.18	1.26	1.59	0.01	0.00	120.18	0.000	0.000	0.000	1.00	0.00
6	18	0.14	118.18	120.18	1.50	1.77	0.08	0.00	120.18	0.001	417	121.85	122.02	0.17	0.11	1.26	0.02	122.04	0.885	0.443	1.846	1.00	0.02
7	24	9.45	116.91	120.18	2.00	3.14	3.01	0.14	120.32	0.646	124	117.28	120.98	2.00	3.14	3.01	0.14	121.13	0.646	0.646	0.801	0.50	0.07
8	18	8.00	116.91	121.05	1.50	1.77	4.53	0.32	121.37	2.145	15	116.96	121.38	1.50	1.77	4.52	0.32	121.70	2.144	2.145	0.322	0.50	0.16
9	18	3.69	118.32	121.54	1.50	1.77	2.09	0.07	121.60	0.458	209	120.30	122.49	1.50	1.77	2.09	0.07	122.56	0.458	0.458	0.957	0.15	0.01
10	18	3.85	120.30	122.50	1.50	1.77	2.18	0.07	122.58	0.497	300	123.15	124.21	1.06	1.34	2.87	0.13	124.34	0.683	0.590	1.769	0.15	0.02
11	18	3.98	123.15	124.23	1.08	1.37	2.91	0.13	124.37	0.698	300	126.00	126.91	0.91	1.13	3.53	0.19	127.11	1.123	0.910	2.731	1.00	0.19
12	18	0.15	122.01	122.16	0.15*	0.09	1.66	0.04	122.20	1.846	50	122.26	122.67	0.41	0.39	0.38	0.00	122.67	0.028	0.937	0.468	1.00	0.00
13	18	4.58	118.11	120.18	1.50	1.77	2.59	0.10	120.29	0.703	301	119.62	122.30	1.50	1.77	2.59	0.10	122.40	0.703	0.703	2.116	1.00	0.10
14	60	1.64	116.36	120.18	3.82	16.11	0.10	0.00	120.18	0.000	106	117.24	120.19	2.95	12.05	0.14	0.00	120.19	0.000	0.000	0.000	0.50	0.00
15	60	1.88	117.40	120.19	2.79	11.26	0.17	0.00	120.19	0.001	39	117.71	120.18	2.47	9.69	0.19	0.00	120.19	0.001	0.001	0.000	0.50	0.00
16	60	2.64	117.87	120.19	2.32	8.89	0.30	0.00	120.19	0.002	208	119.53	120.31	0.78	1.95	1.35	0.03	120.34	0.137	0.070	0.145	0.50	0.01
17	60	2.28	119.69	120.32	0.63	1.45	1.58	0.04	120.36	0.242	560	124.17	124.59	0.42**	0.80	2.87	0.13	124.72	1.337	0.790	n/a	1.00	n/a

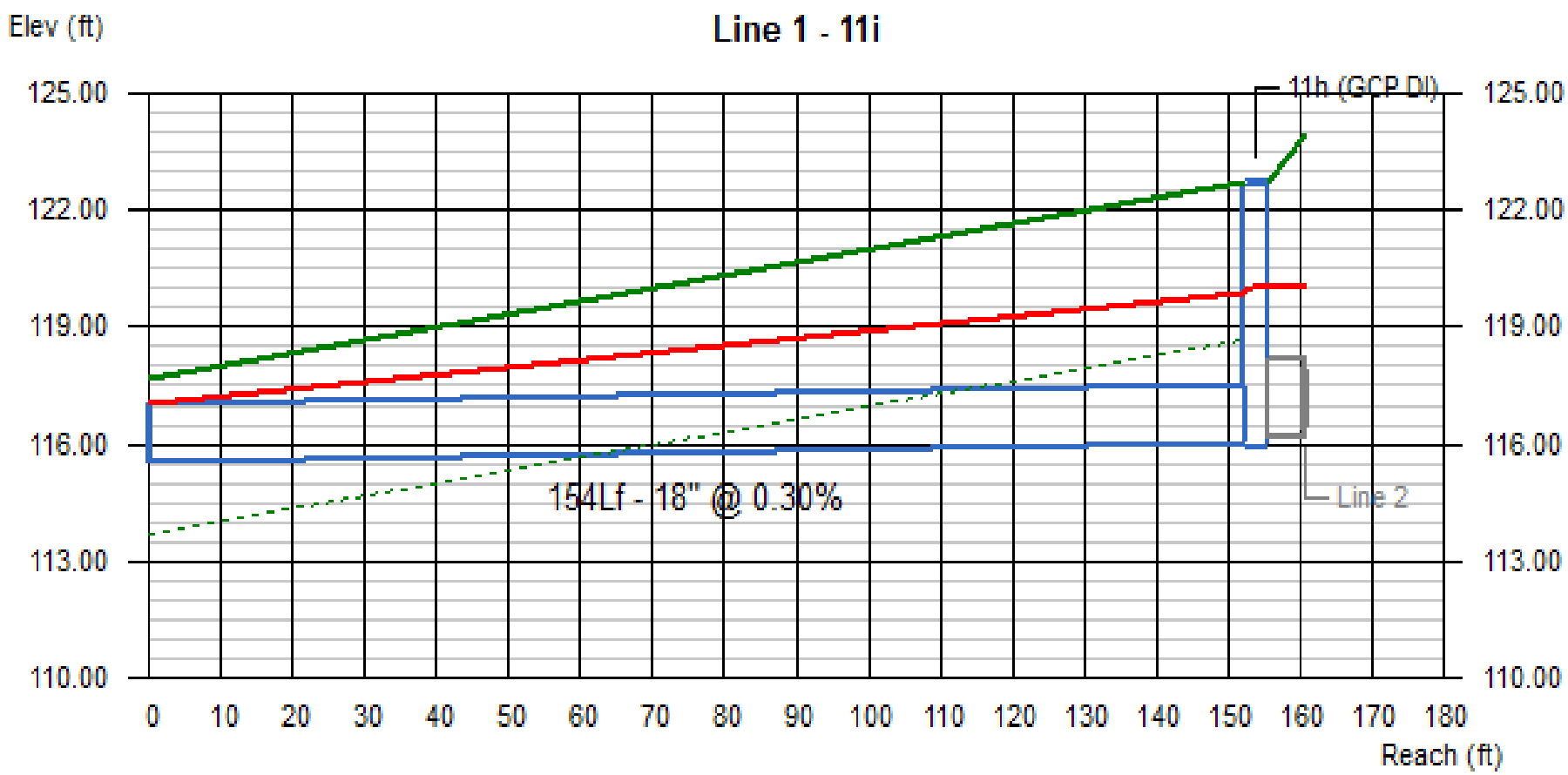
11 12 13 74 75 76

Number of lines: 17

Run Date: 11-07-2013

Notes: * depth assumed.; ** Critical depth. ; c = cir e = ellip b = box

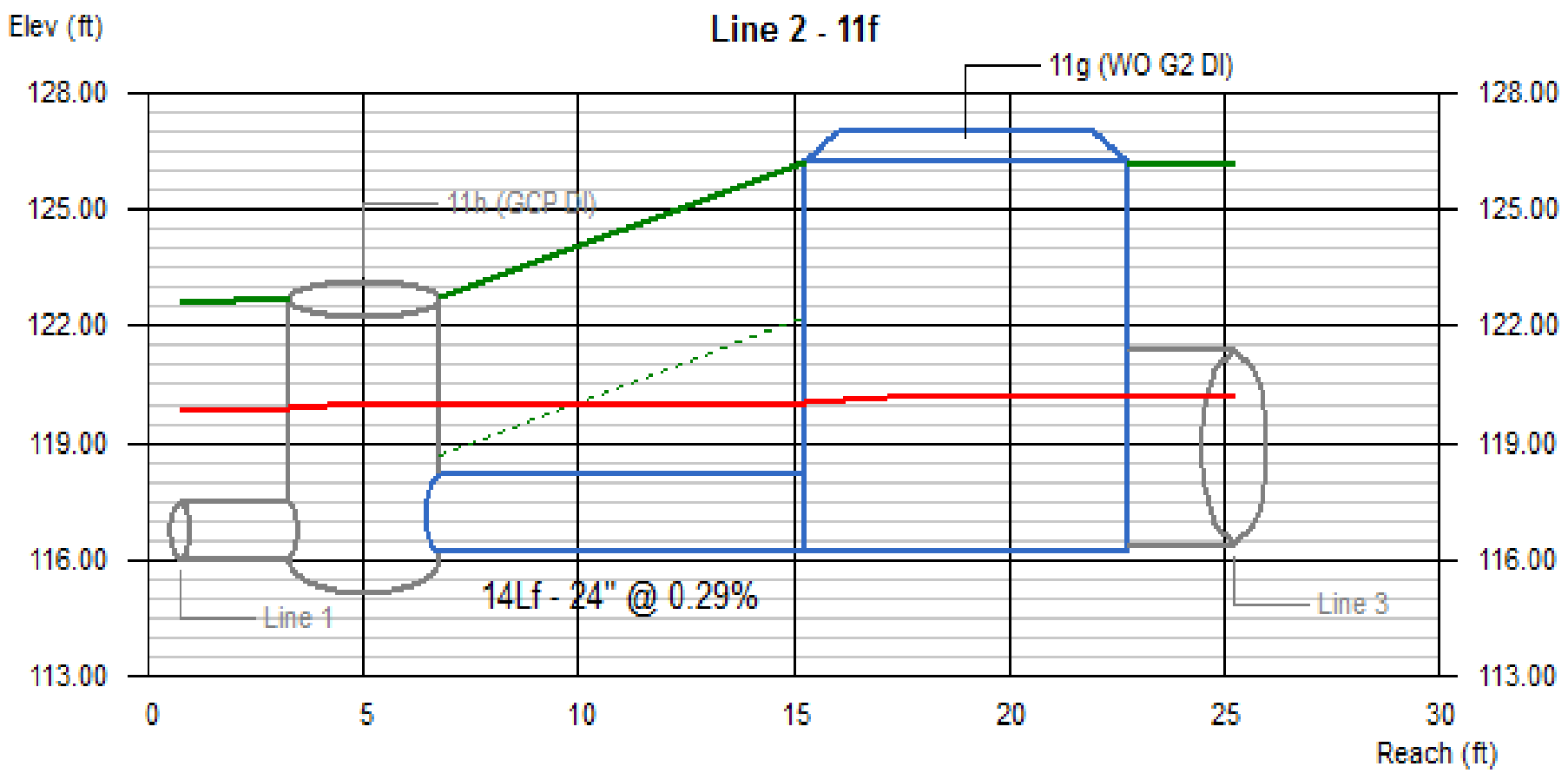
Line Profile (Line 1) - 11i



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	7.38	115.55	116.01	1.50	1.50	3.99	117.05	119.87	120.00	4.18	4.18	0.62	5.20

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

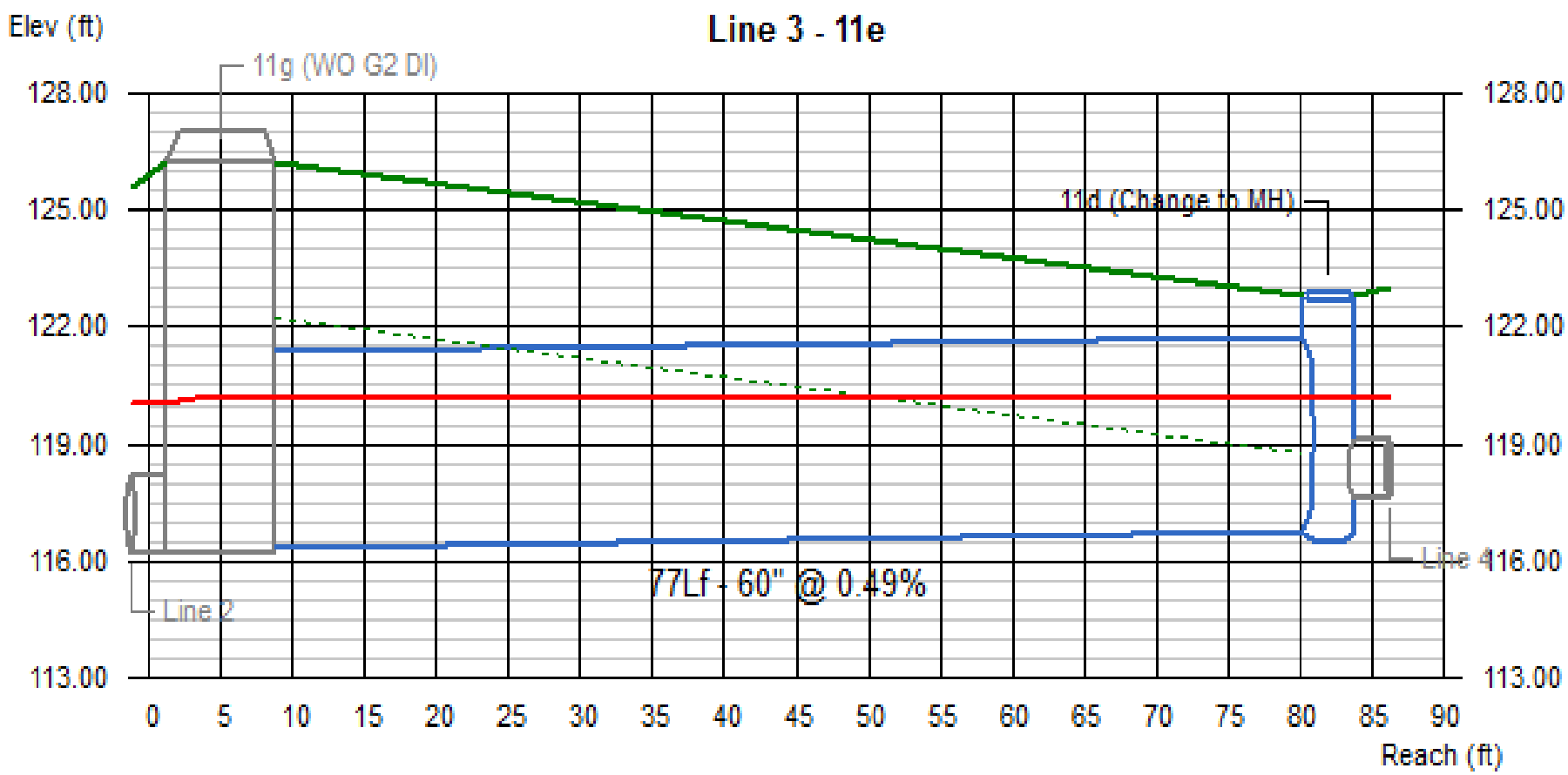
Line Profile (Line 2) - 11f



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	7.34	116.17	116.21	2.00	2.00	3.97	120.00	120.06	120.18	2.34	2.34	4.54	8.04

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

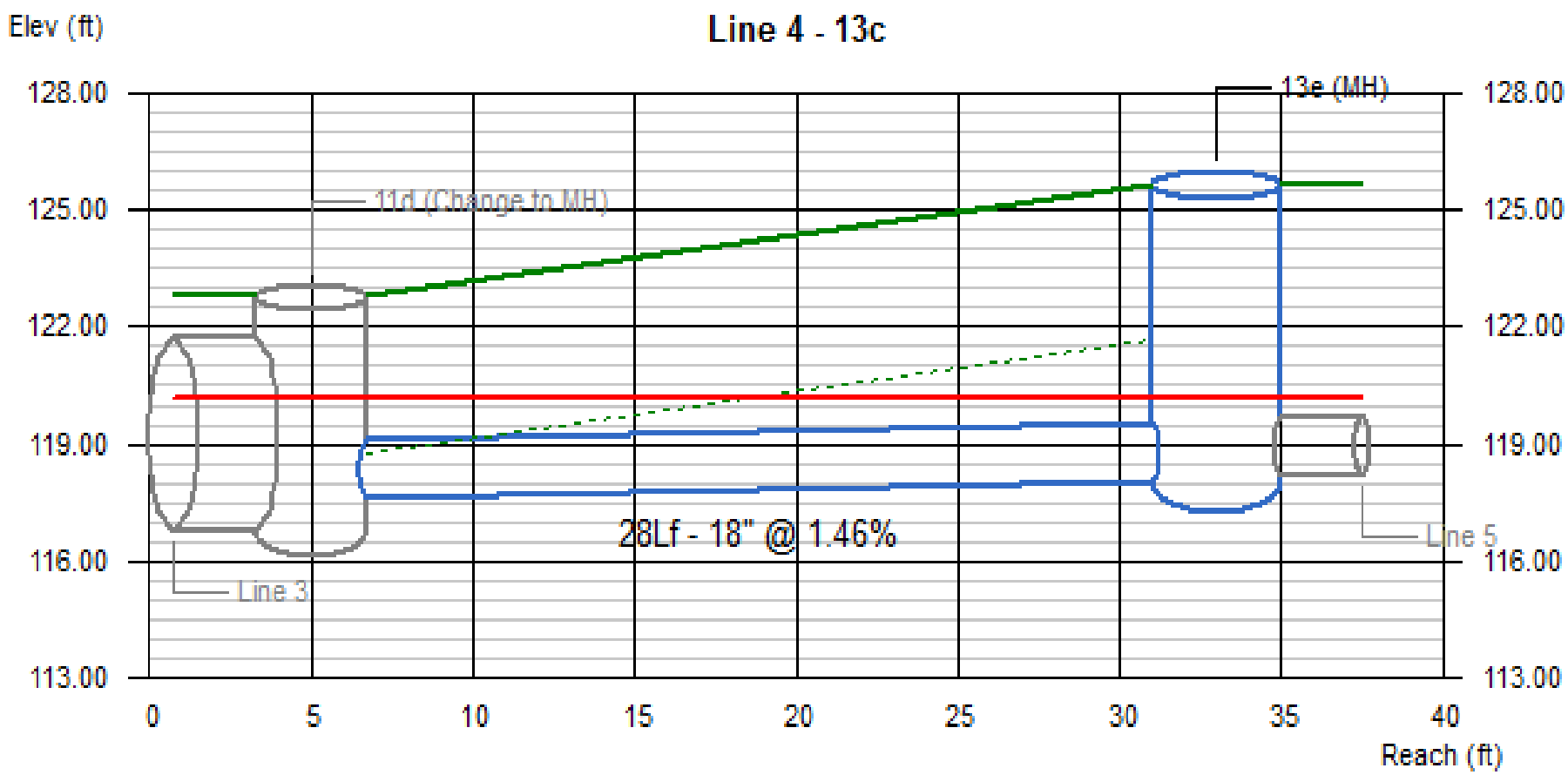
Line Profile (Line 3) - 11e



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
3	5.70	116.37	116.75	3.81	3.43	3.43	120.18	120.18	120.18	0.35	0.40	4.88	1.03

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

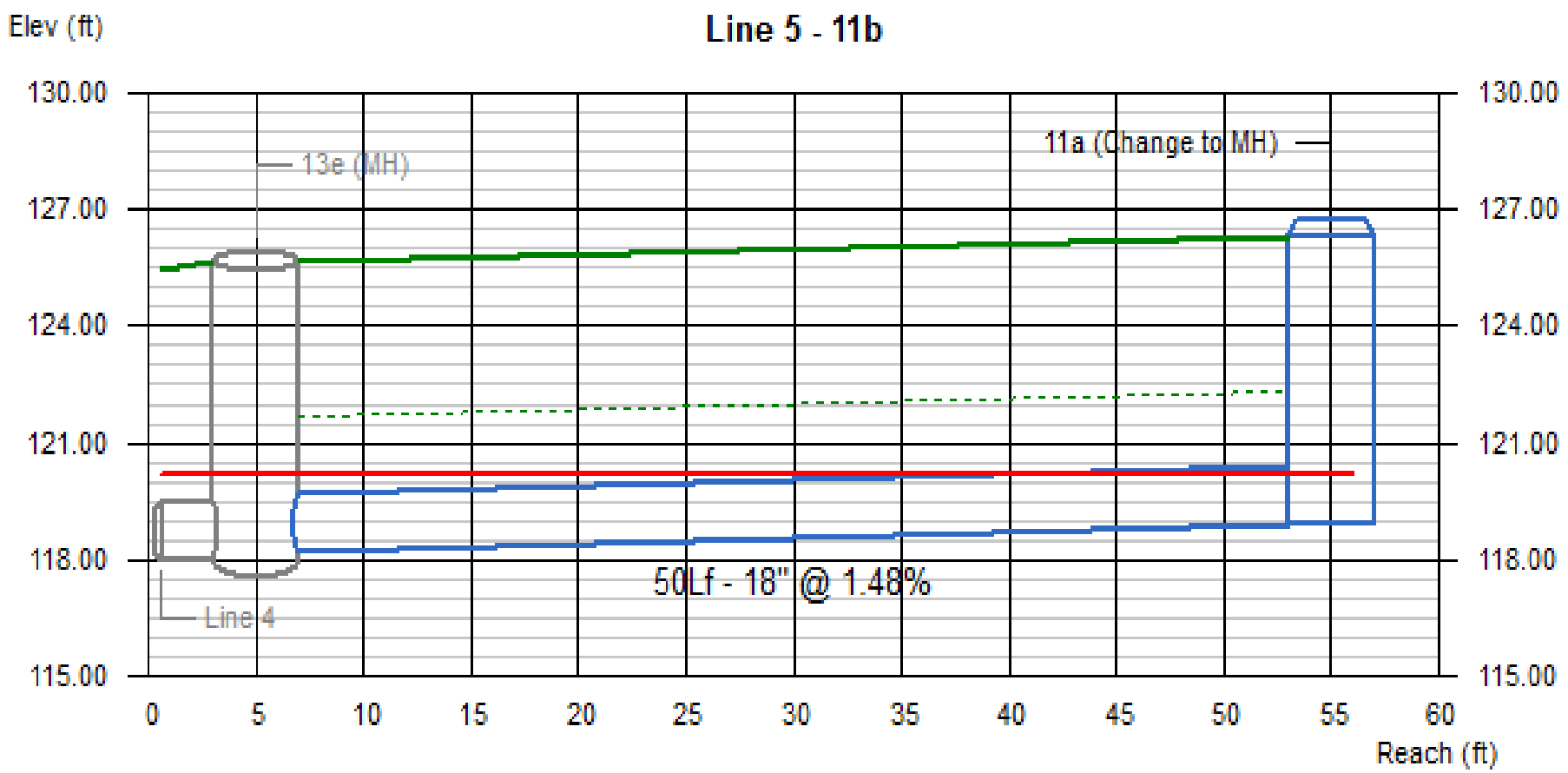
Line Profile (Line 4) - 13c



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
4	0.04	117.61	118.02	1.50	1.50	2.16	120.18	120.18	120.18	0.02	0.02	3.67	6.16

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

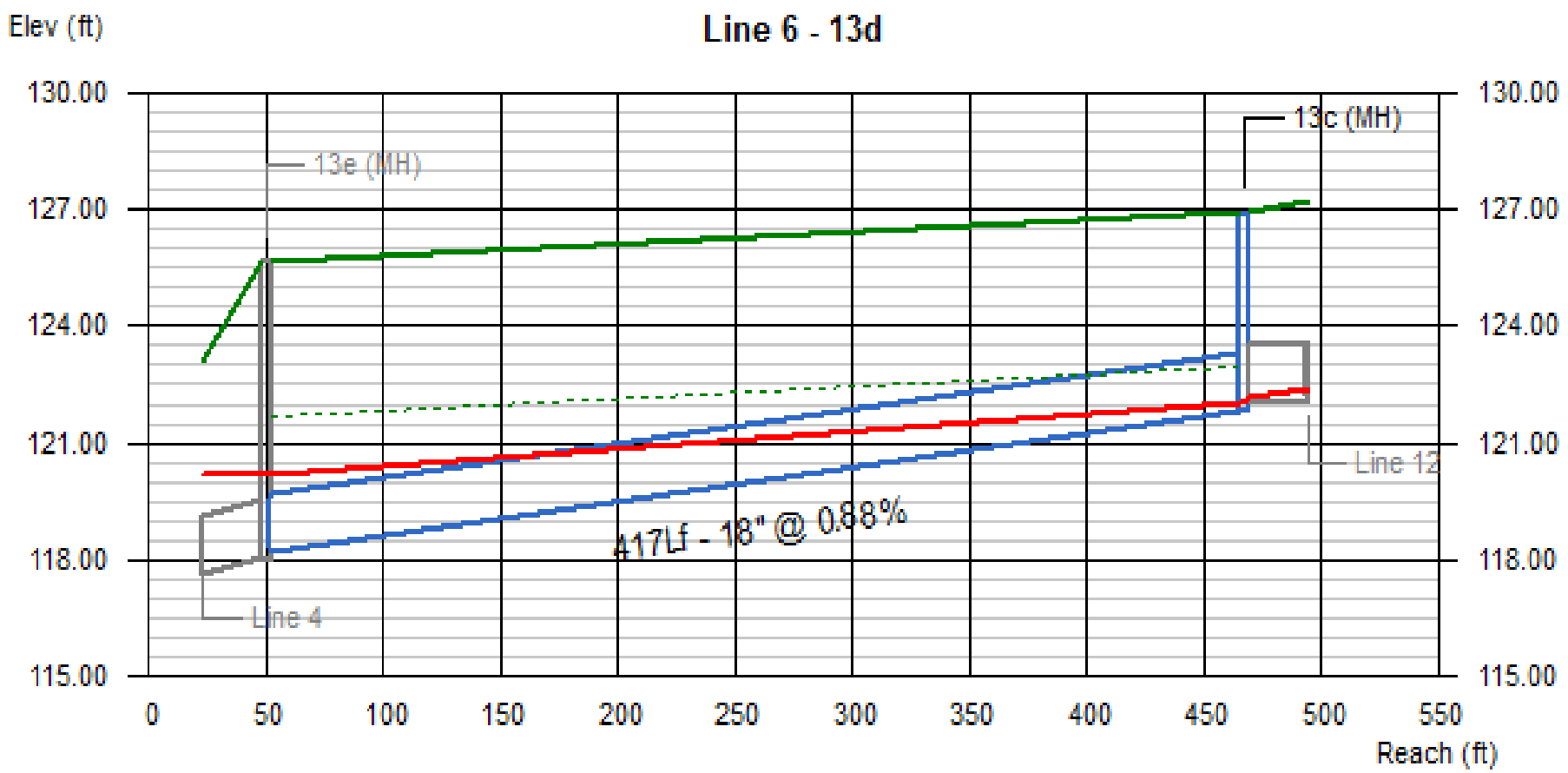
Line Profile (Line 5) - 11b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	0.01	118.18	118.92	1.50	1.26	1.26	120.18	120.18	120.18	0.01	0.01	6.00	5.88

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

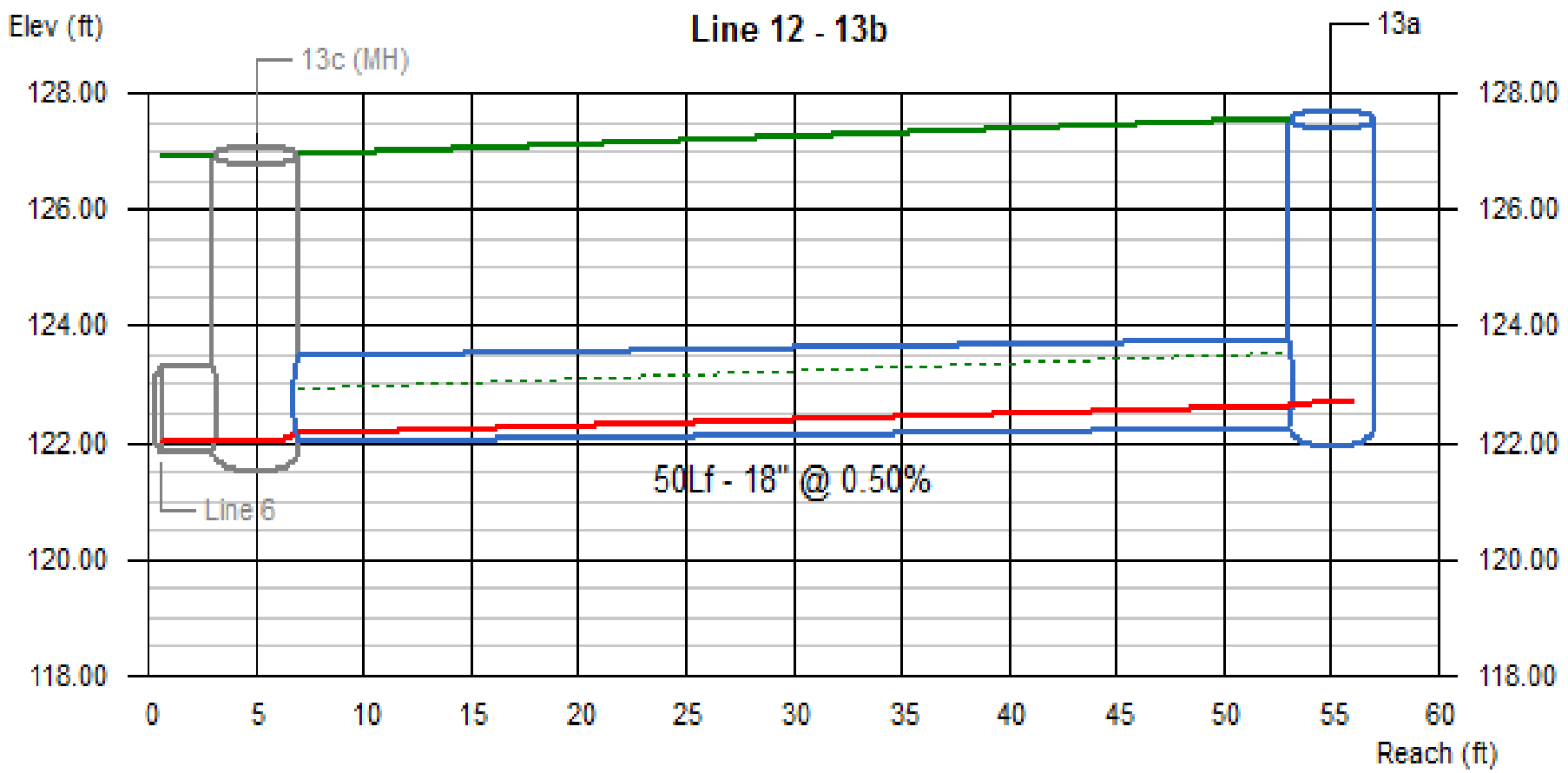
Line Profile (Line 6) - 13d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.14	118.18	121.85	1.50	0.17	0.19	120.18	122.02	122.04	0.08	1.26	6.00	3.59

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

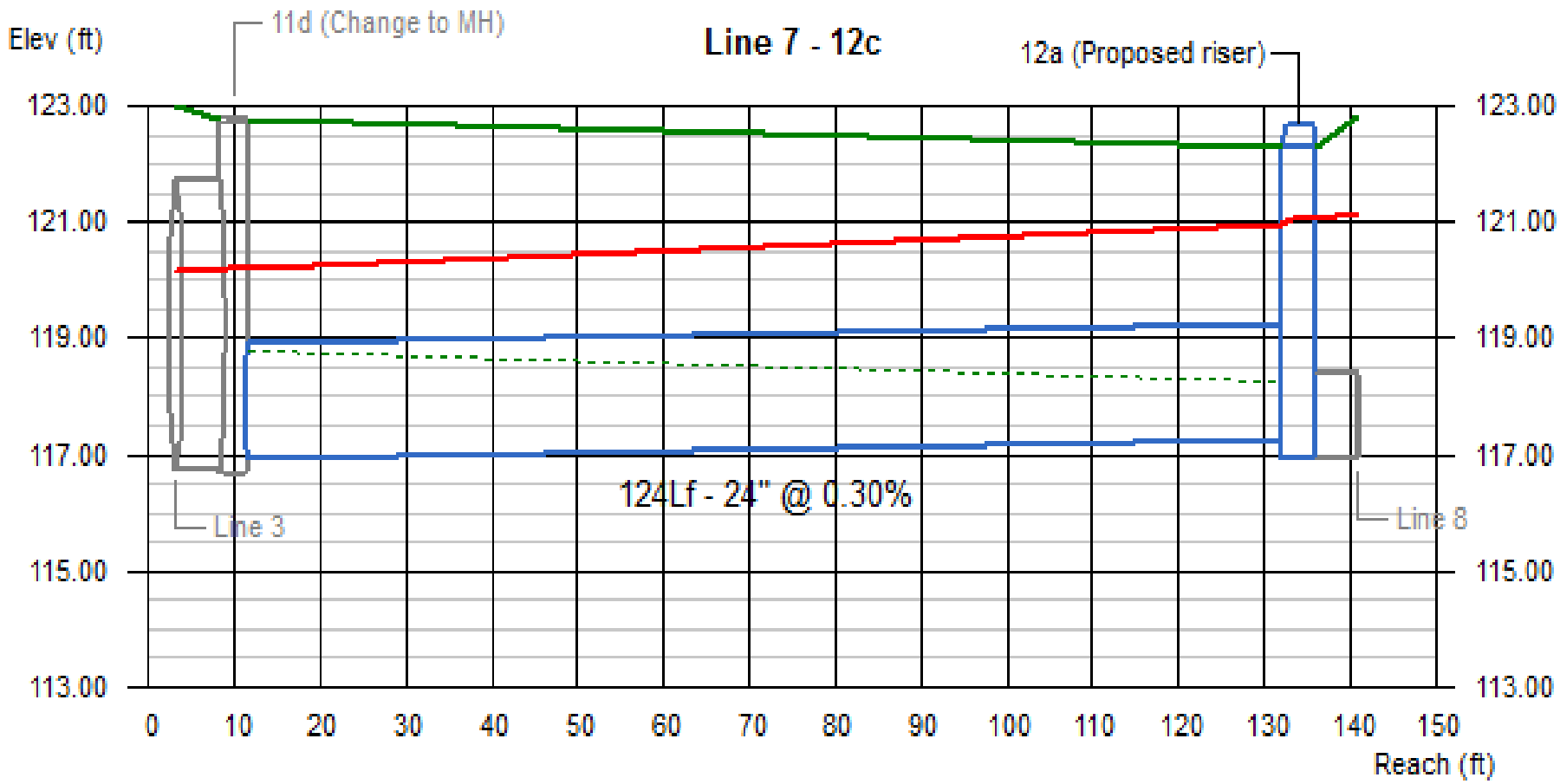
Line Profile (Line 12) - 13b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
12	0.15	122.01	122.26	0.15	0.41	0.41	122.16	122.67	122.67	1.66	0.38	3.43	3.80

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

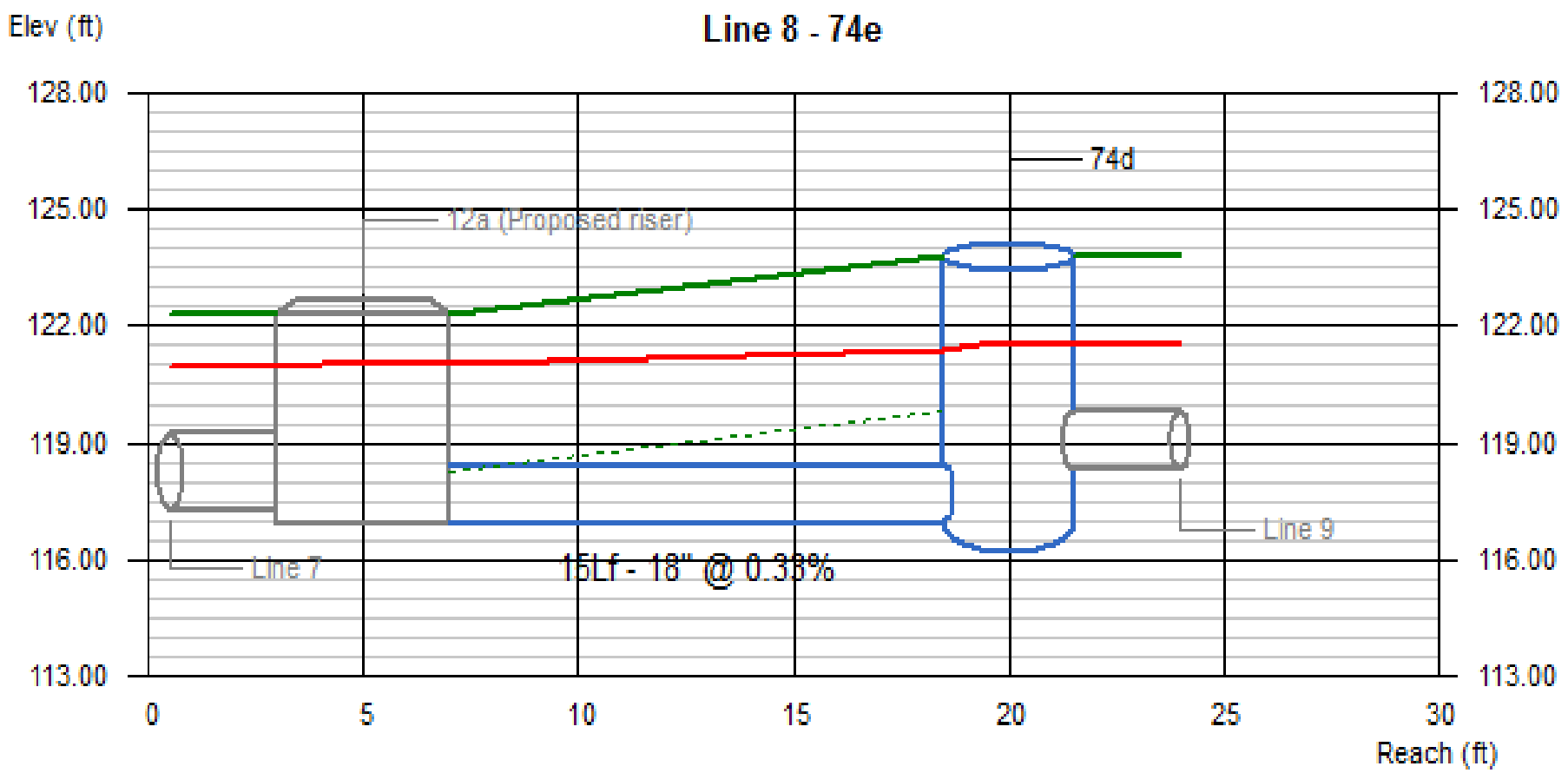
Line Profile (Line 7) - 12c



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	9.45	116.91	117.28	2.00	2.00	3.77	120.18	120.98	121.05	3.01	3.01	3.87	3.00

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

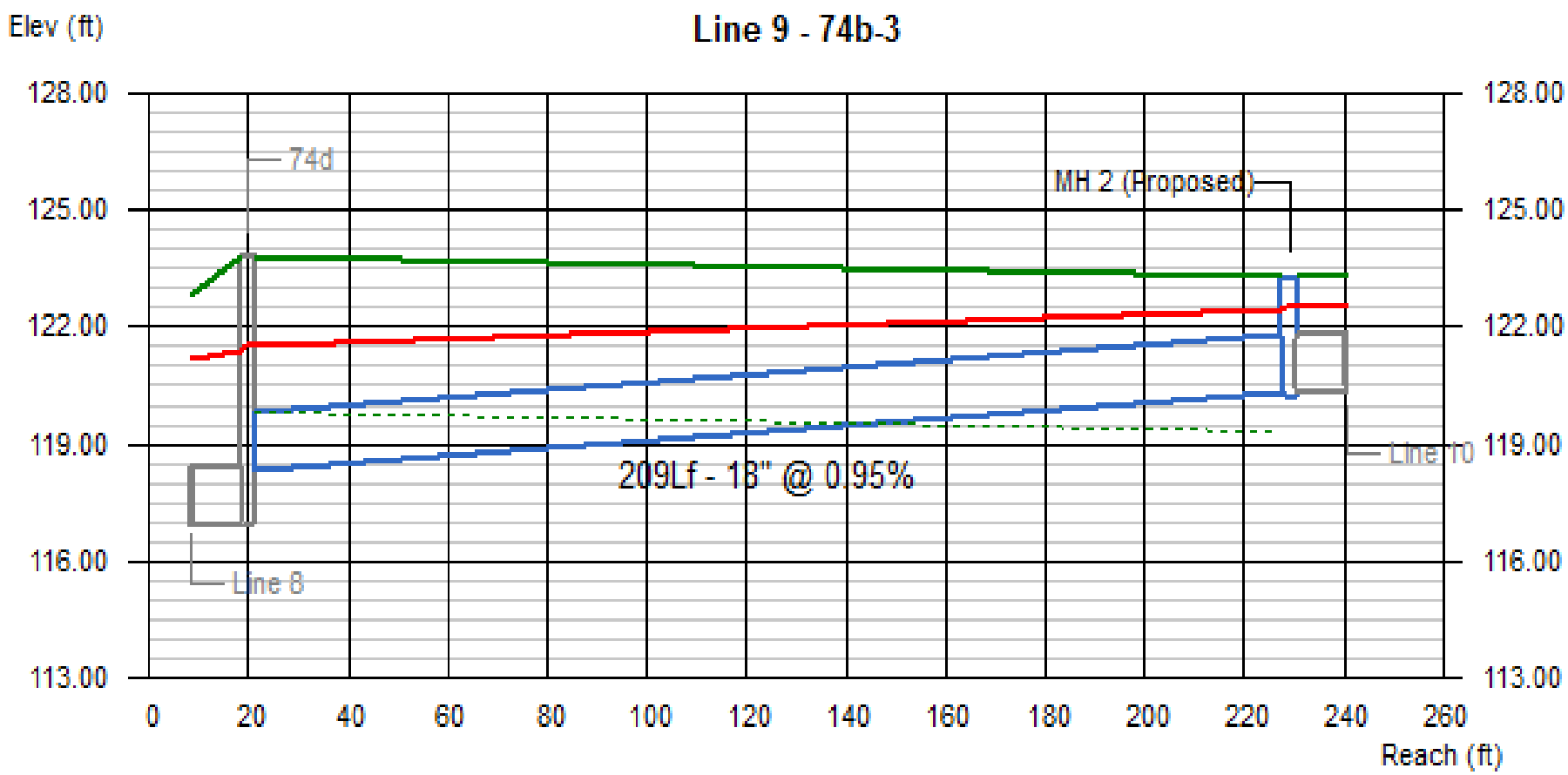
Line Profile (Line 8) - 74e



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	8.00	116.91	116.96	1.50	1.50	4.58	121.05	121.38	121.54	4.53	4.52	3.87	5.36

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

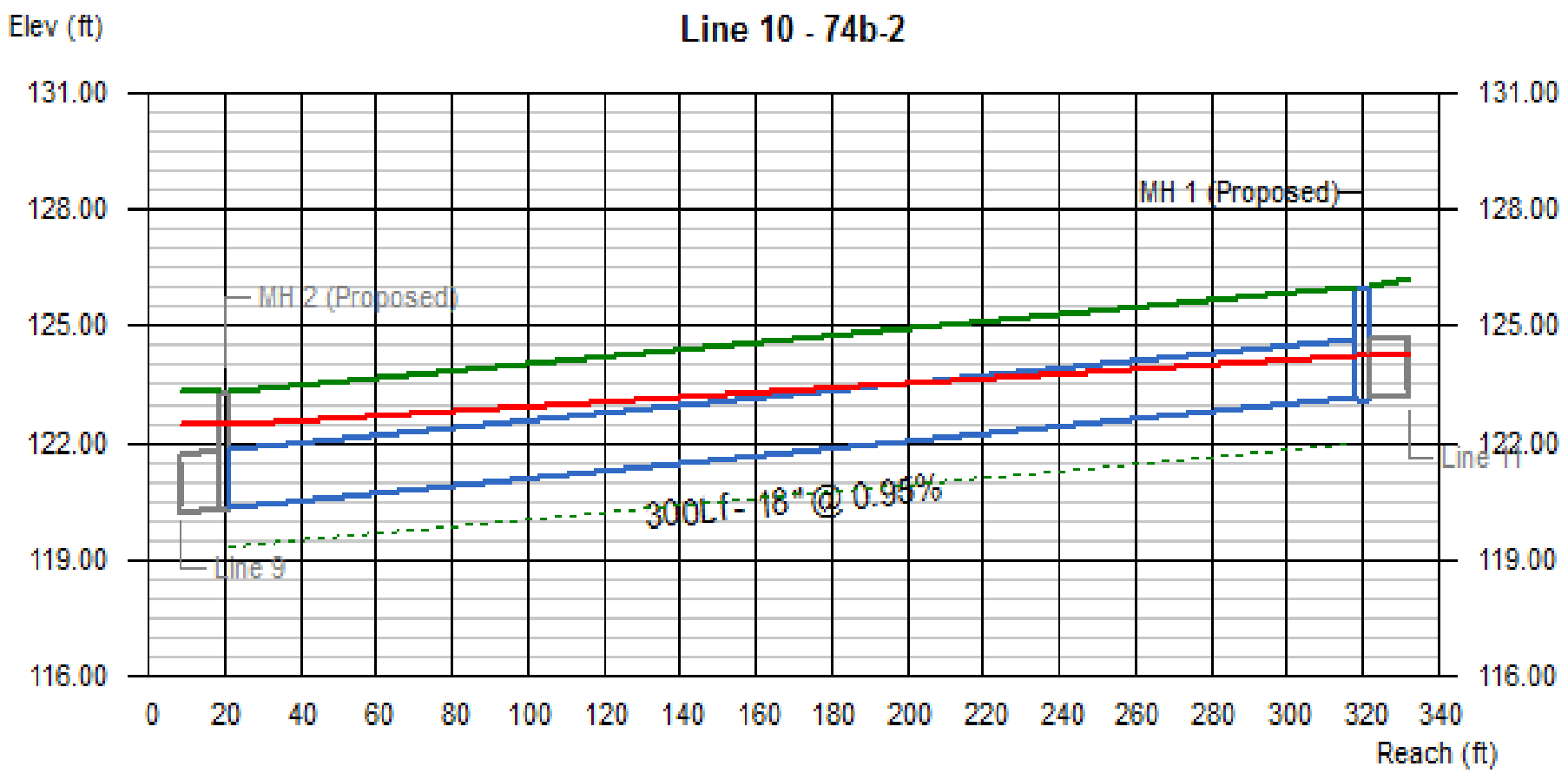
Line Profile (Line 9) - 74b-3



Line #	Q (cfs)	Invert Elevation Dn (ft)	Invert Elevation Up (ft)	Depth of Flow Dn (ft)	Depth of Flow Up (ft)	Depth of Flow Hw (ft)	Hydraulic Grade Line Dn (ft)	Hydraulic Grade Line Up (ft)	Hydraulic Grade Line Jnct (ft)	Velocity Dn (ft/s)	Velocity Up (ft/s)	Cover Dn (ft)	Cover Up (ft)
9	3.69	118.32	120.30	1.50	1.50	2.20	121.54	122.49	122.50	2.09	2.09	4.00	1.50

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

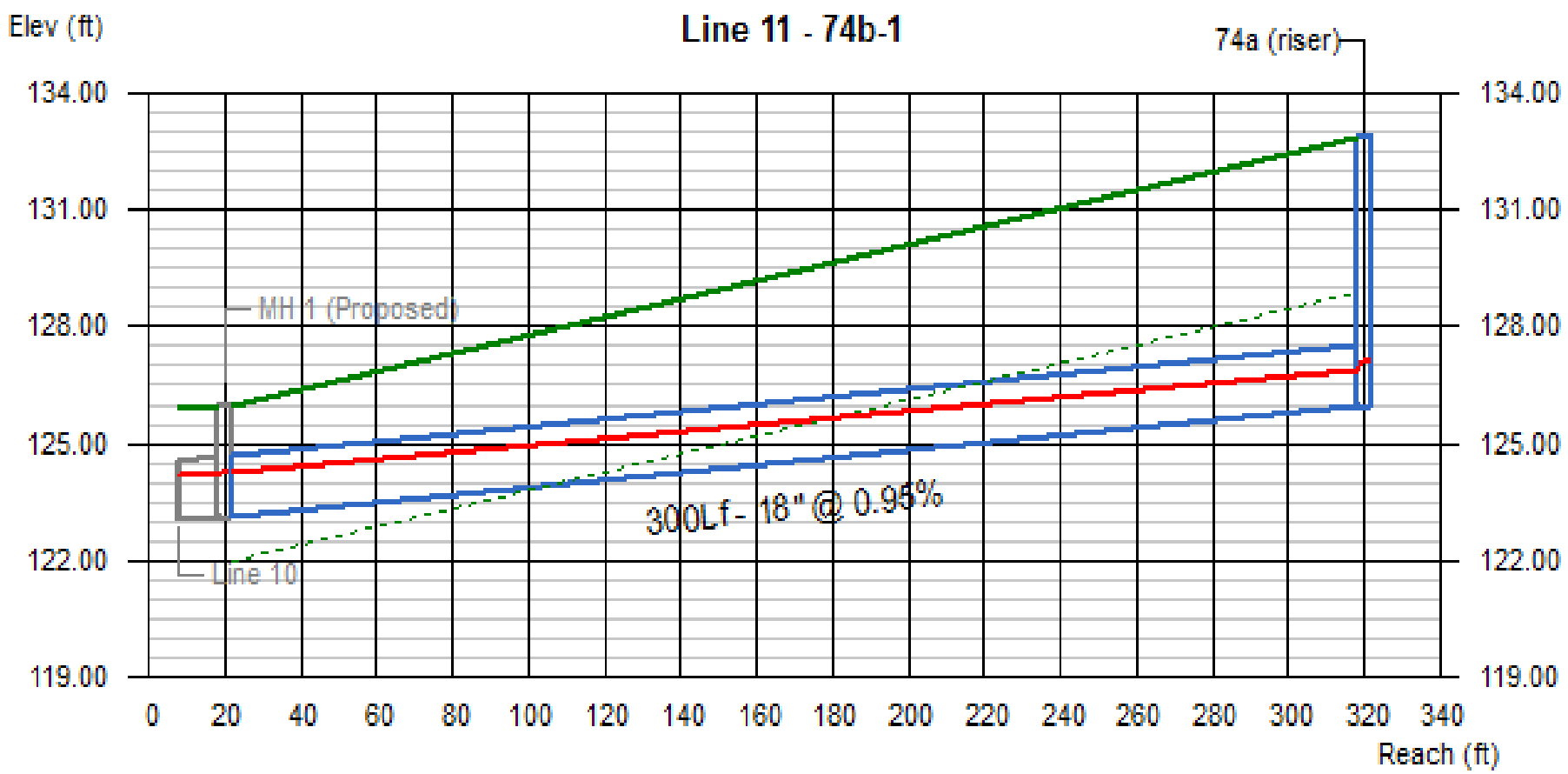
Line Profile (Line 10) - 74b-2



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	3.85	120.30	123.15	1.50	1.06	1.08	122.50	124.21	124.23	2.18	2.87	1.50	1.35

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

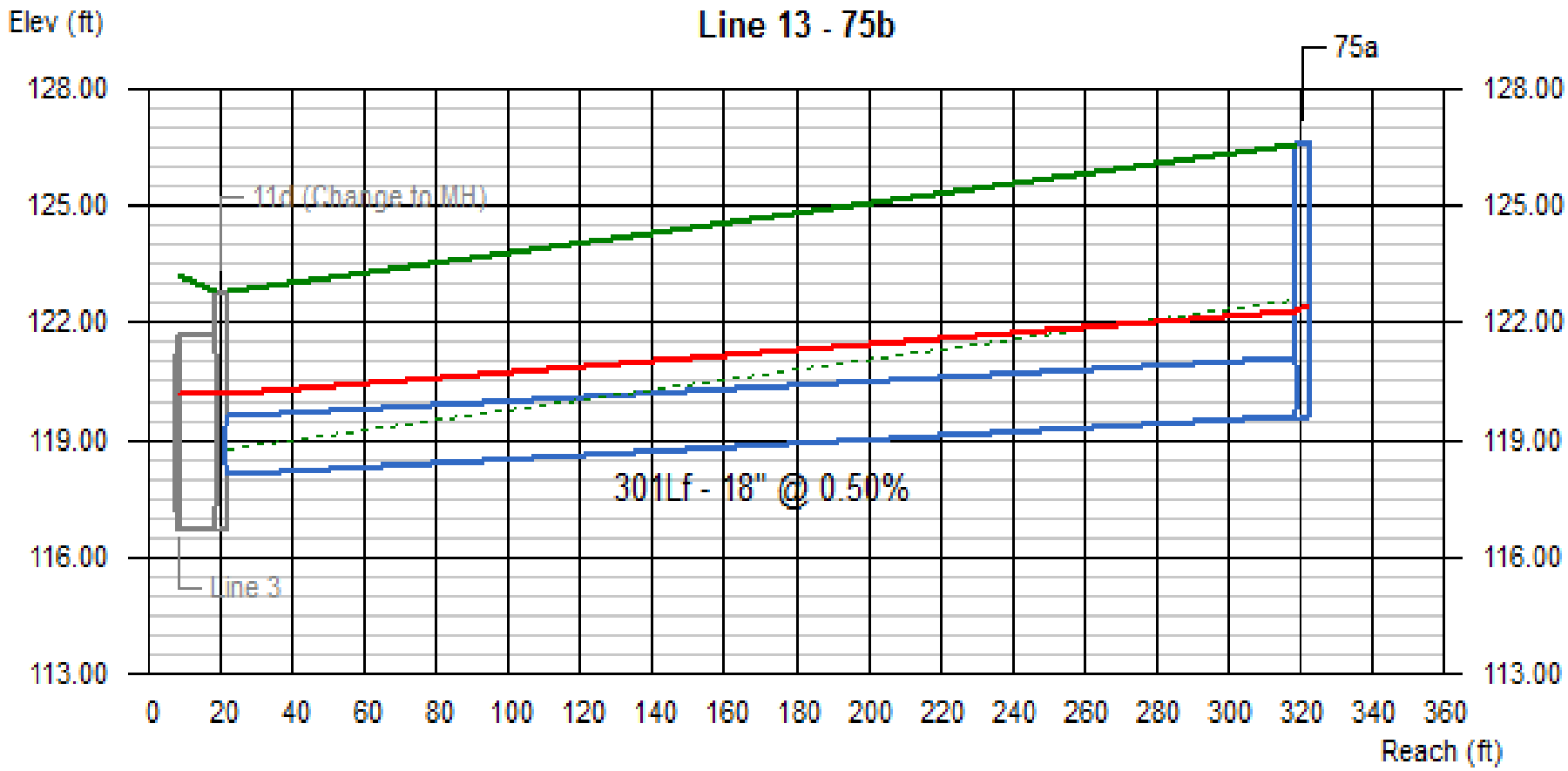
Line Profile (Line 11) - 74b-1



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
11	3.98	123.15	126.00	1.08	0.91	1.11	124.23	126.91	127.11	2.91	3.53	1.35	5.38

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

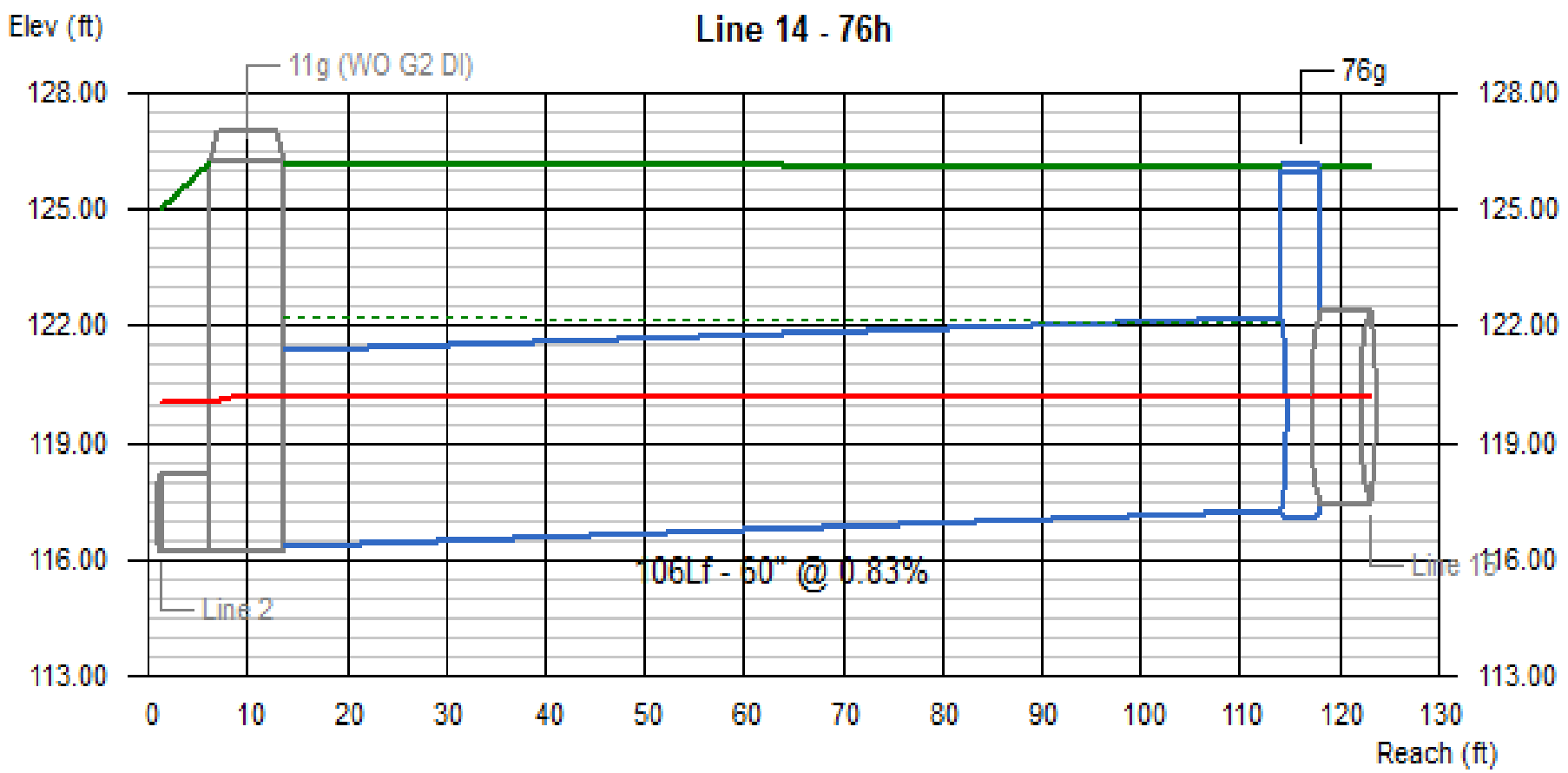
Line Profile (Line 13) - 75b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
13	4.58	118.11	119.62	1.50	1.50	2.78	120.18	122.30	122.40	2.59	2.59	3.17	5.50

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

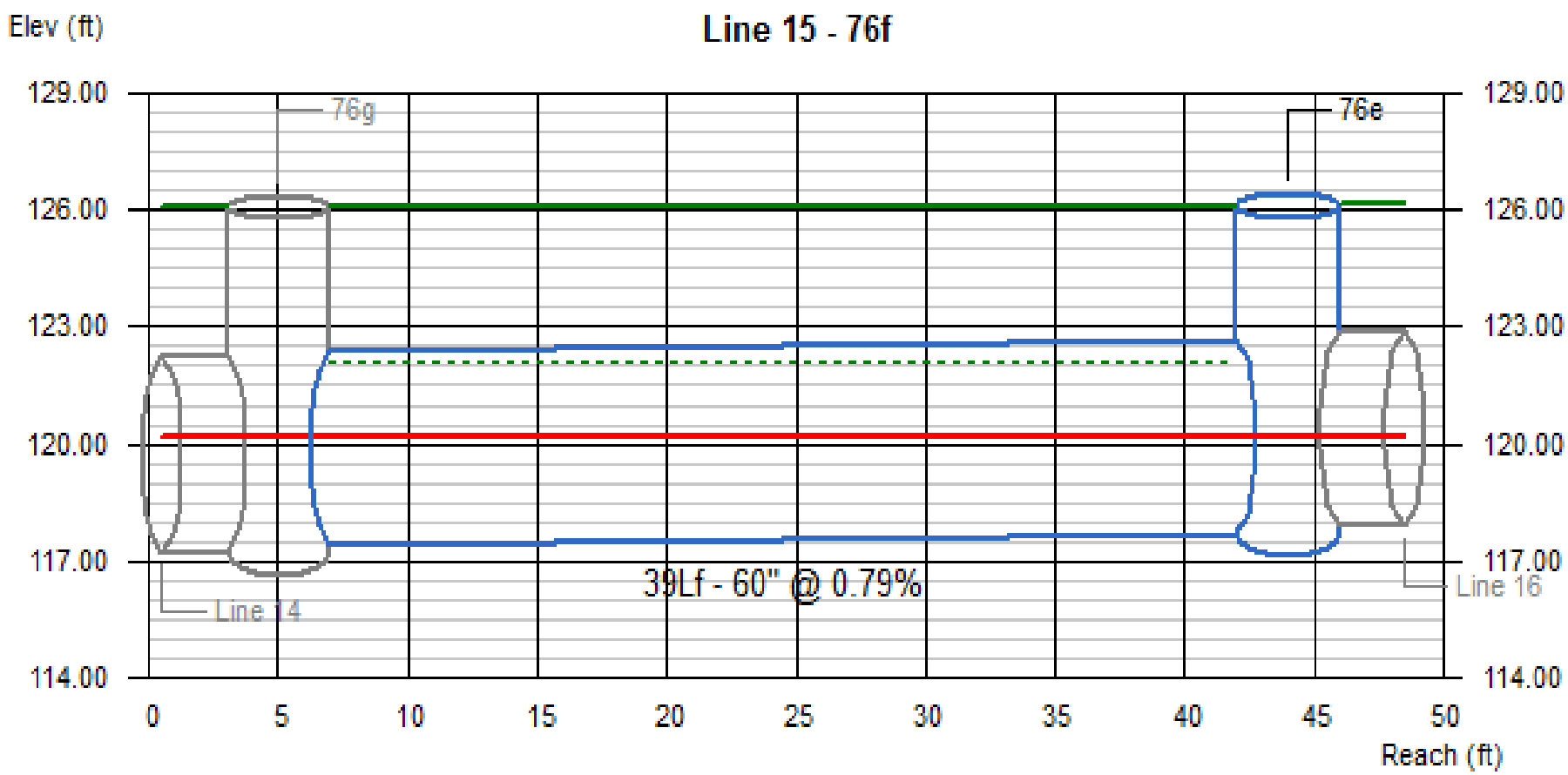
Line Profile (Line 14) - 76h



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
14	1.64	116.36	117.24	3.82	2.95	2.95	120.18	120.19	120.19	0.10	0.14	4.89	3.85

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

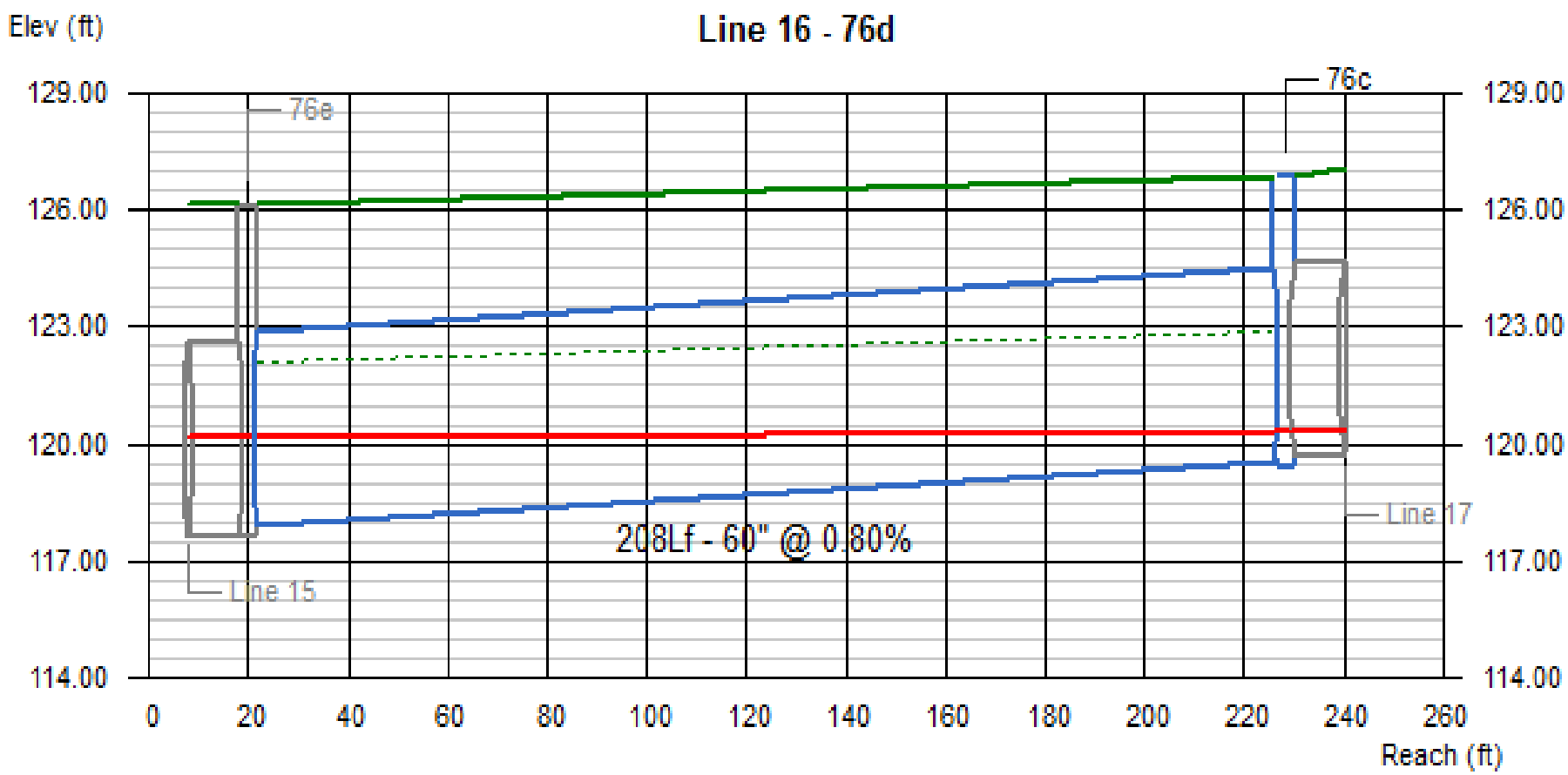
Line Profile (Line 15) - 76f



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
15	1.88	117.40	117.71	2.79	2.47	2.48	120.19	120.18	120.19	0.17	0.19	3.69	3.43

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

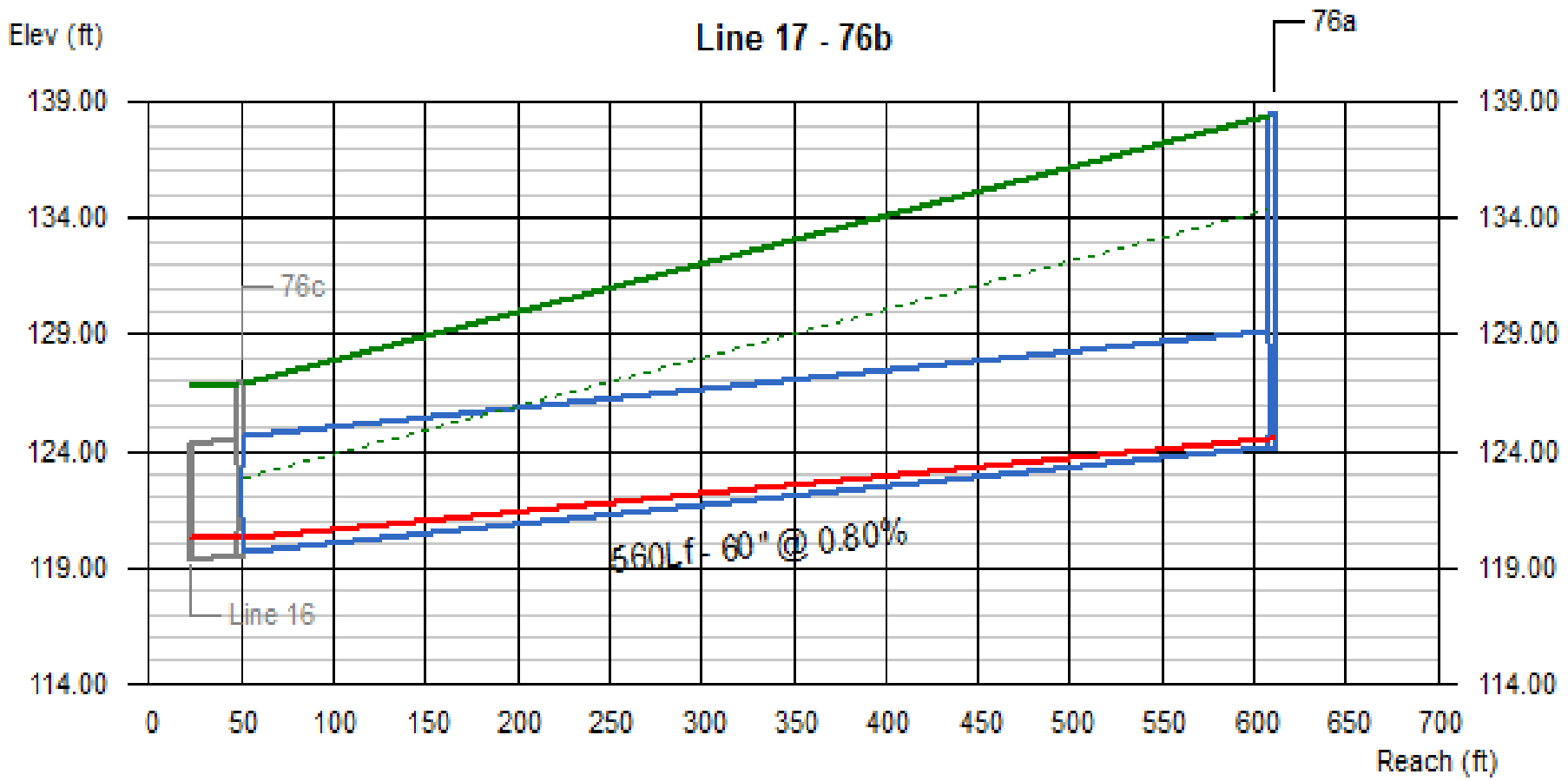
Line Profile (Line 16) - 76d



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
16	2.64	117.87	119.53	2.32	0.78	0.79	120.19	120.31	120.32	0.30	1.35	3.27	2.38

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

Line Profile (Line 17) - 76b



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
17	2.28	119.69	124.17	0.63	0.42	0.42	120.32	124.59	124.59	1.58	2.87	2.22	9.23

11 12 13 74 75 76 | No. Lines: 17 | Run Date: 11-07-2013

Appendix H Hydraulic Analysis of Proposed Ditches/Biofiltration Swales

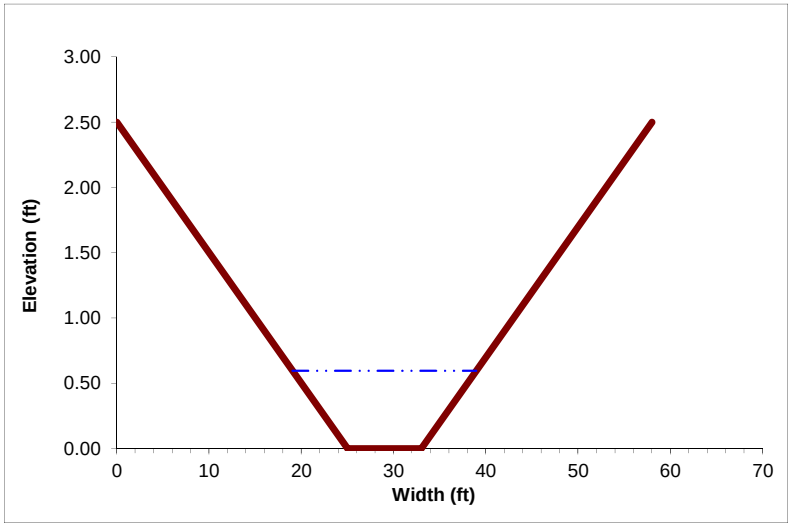
Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B1 @ 975+00 to 984+20

Input Values

Height	2.5	ft
Width	8	ft
LT Side Slope	10	:1 (h:v)
Rt Side Slope	10	:1 (h:v)
Mannings	0.125	
Slope	0.01	ft/ft
Design Flow	6.11	cfs

Normal Depth for Channel

Depth	0.596	ft
Area	8.32	ft^2
Perimeter	19.98	ft
Rh	0.42	ft
V	0.73	ft/s
Q	6.11	cfs
Goal Seek	0.00	



C	0.68	
i	1.93	in/hr
A	4.64	acres
Q	6.11	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B1 @ 984+20 to 992+50

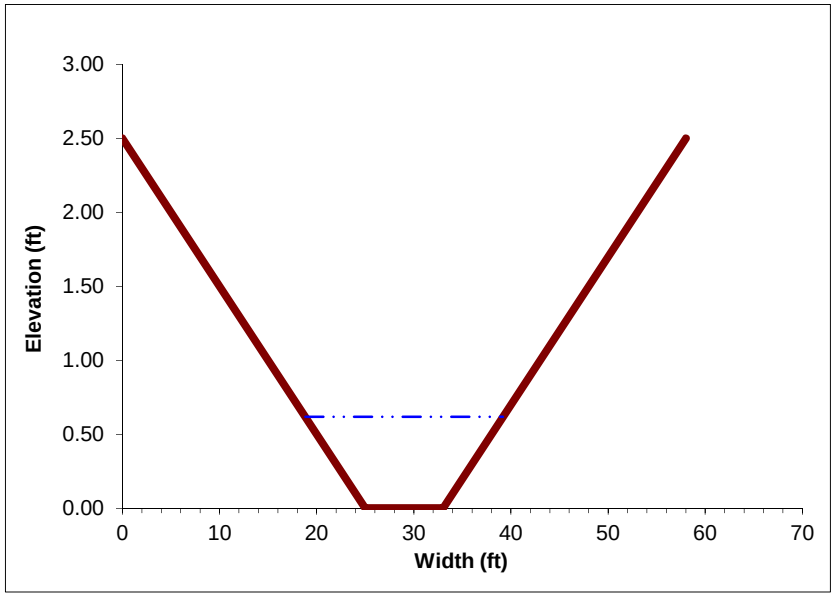
Input Values

Height	2.5	ft
Width	8	ft
LT Side Slope	10	:1 (h:v)
Rt Side Slope	10	:1 (h:v)
Mannings	0.125	
Slope	0.01	ft/ft
Design Flow	6.13	cfs

Normal Depth for Channel

Depth	0.617	ft
Area	8.74	ft^2
Perimeter	20.40	ft
Rh	0.43	ft
V	0.70	ft/s
Q	6.13	cfs
Goal Seek	0.00	

C	0.66	
i	1.58	in/hr
A	5.90	acres
Q	6.13	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B1 @ "B2RS" 992+50 to 996+75

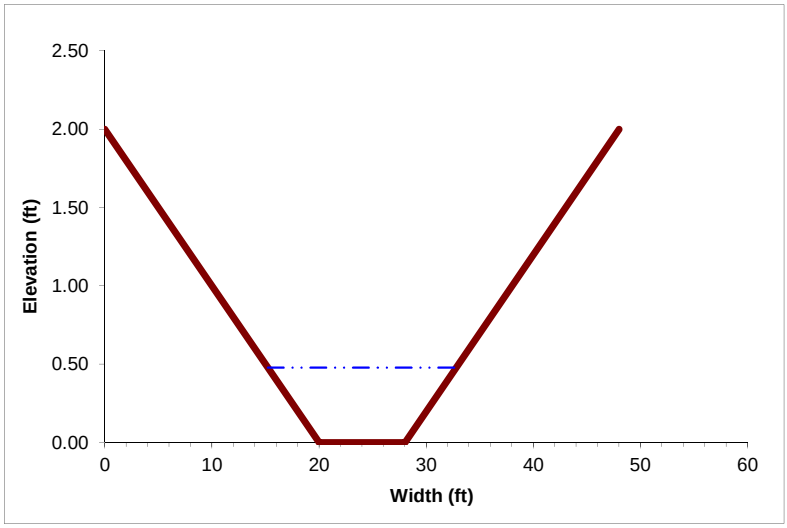
Input Values

Height	2	ft
Width	8	ft
LT Side Slope	10	:1 (h:v)
Rt Side Slope	10	:1 (h:v)
Mannings	0.125	
Slope	0.0033	ft/ft
Design Flow	2.05	cfs

Normal Depth for Channel

Depth	0.477	ft
Area	6.10	ft^2
Perimeter	17.60	ft
Rh	0.35	ft
V	0.34	ft/s
Q	2.05	cfs
Goal Seek	0.00	

C	0.67	
i	1.58	in/hr
A	1.93	acres
Q	2.05	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B1 @ 996+75 to 1009+50

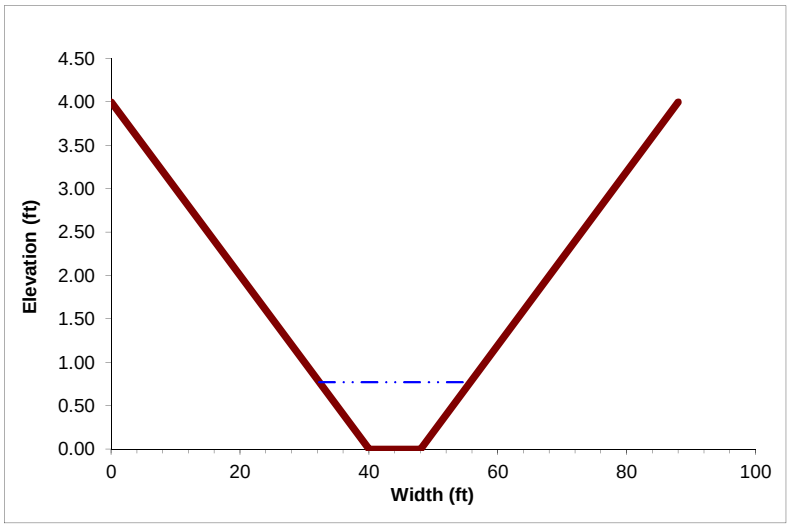
Input Values

Height	4	ft
Width	8	ft
LT Side Slope	10	:1 (h:v)
Rt Side Slope	10	:1 (h:v)
Mannings	0.125	
Slope	0.0036	ft/ft
Design Flow	5.59	cfs

Normal Depth for Channel

Depth	0.772	ft
Area	12.13	ft^2
Perimeter	23.51	ft
Rh	0.52	ft
V	0.46	ft/s
Q	5.59	cfs
Goal Seek	0.00	

C	0.72	
i	1.1	in/hr
A	7.05	acres
Q	5.59	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B2 @ 511+43.82 to 514+50

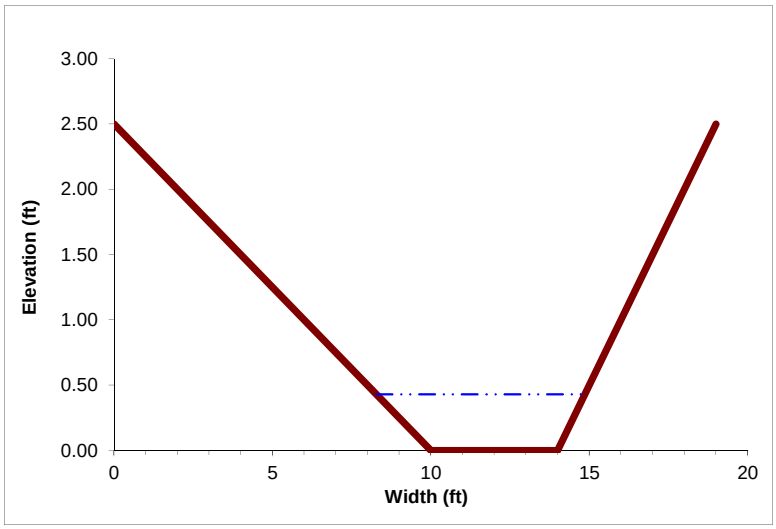
Input Values

Height	2.5	ft
Width	4	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0169	ft/ft
Design Flow	1.70	cfs

Normal Depth for Channel

Depth	0.429	ft
Area	2.27	ft^2
Perimeter	6.73	ft
Rh	0.34	ft
V	0.75	ft/s
Q	1.70	cfs
Goal Seek	0.00	

C	0.87	
i	2.8	in/hr
A	0.70	acre
Q	1.70	cfs

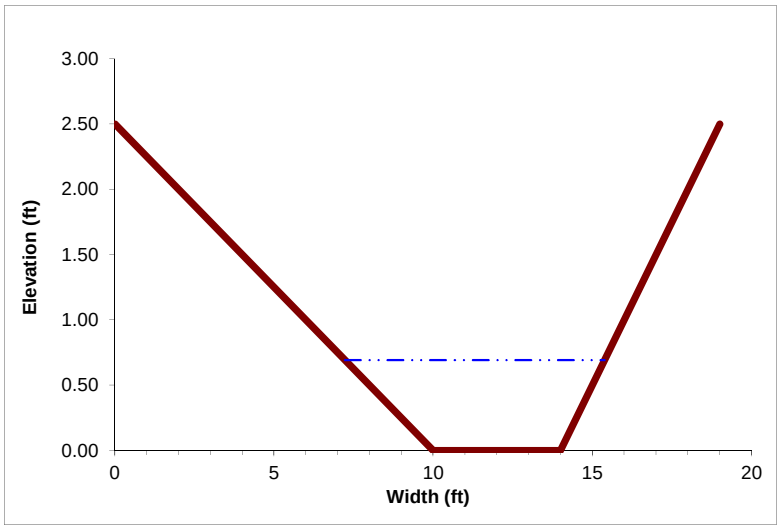


SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B2 @ 514+50 to 519+50

Input Values

Height	2.5	ft
Width	4	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0030	ft/ft
Design Flow	1.72	cfs



Normal Depth for Channel

Depth	0.691	ft
Area	4.20	ft^2
Perimeter	8.39	ft
Rh	0.50	ft
V	0.41	ft/s
Q	1.72	cfs
Goal Seek	0.00	

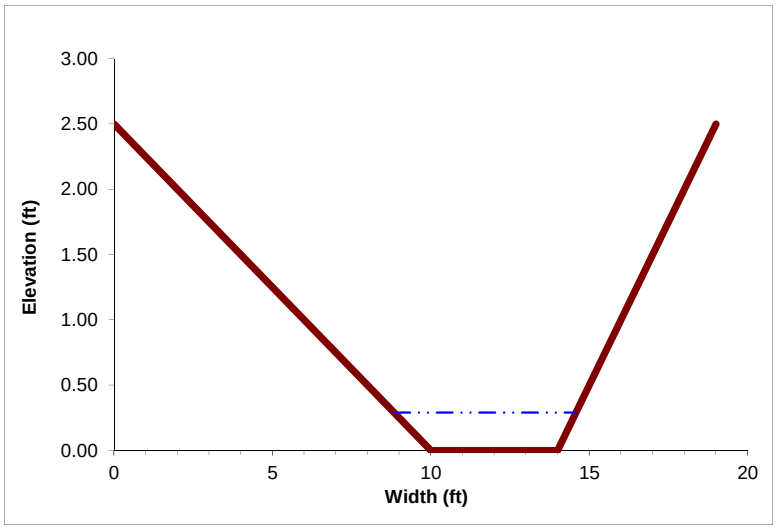
C	0.76	
i	1.93	in/hr
A	1.18	acre
Q	1.72	cfs

SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B2 @ 519+50 to 523+12.16

Input Values

Height	2.5	ft
Width	4	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0057	ft/ft
Design Flow	0.49	cfs



Normal Depth for Channel

Depth	0.289	ft
Area	1.40	ft^2
Perimeter	5.84	ft
Rh	0.24	ft
V	0.35	ft/s
Q	0.49	cfs
Goal Seek	0.00	

C	0.60	
i	1.93	in/hr
A	0.42	acre
Q	0.49	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B3 @ 618+75.01 to 622+50

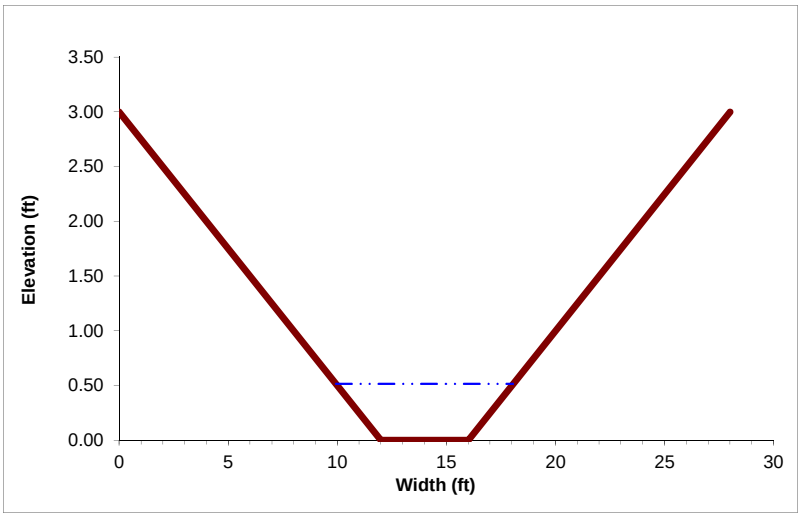
Input Values

Height	3	ft
Width	4	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0051	ft/ft
Design Flow	1.38	cfs

Normal Depth for Channel

Depth	0.514	ft
Area	3.11	ft^2
Perimeter	8.24	ft
Rh	0.38	ft
V	0.44	ft/s
Q	1.38	cfs
Goal Seek	0.00	

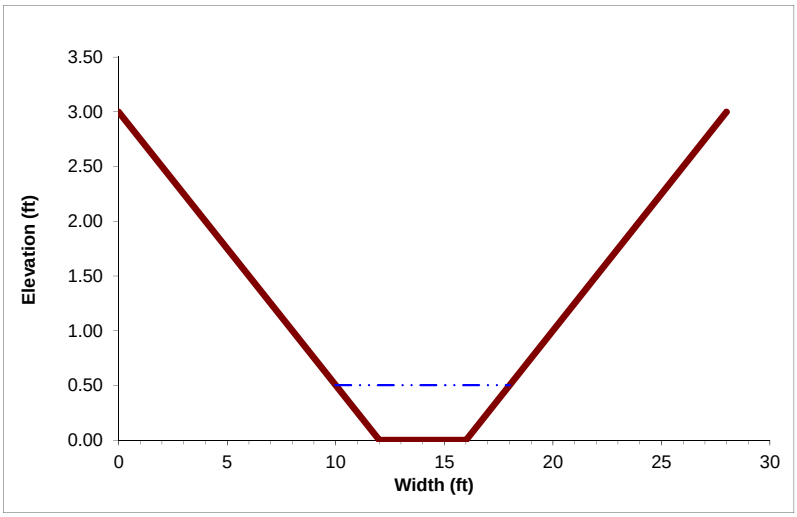
C	0.84	
i	1.93	in/hr
A	0.84	acre
Q	1.38	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B3 @ 623+00 to 629+81.36

Input Values

Height	3	ft
Width	4	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0098	ft/ft
Design Flow	1.83	cfs



Normal Depth for Channel

Depth	0.502	ft
Area	3.02	ft^2
Perimeter	8.14	ft
Rh	0.37	ft
V	0.61	ft/s
Q	1.83	cfs
Goal Seek	0.00	

C	0.82	
i	1.58	in/hr
A	1.41	acre
Q	1.83	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B4

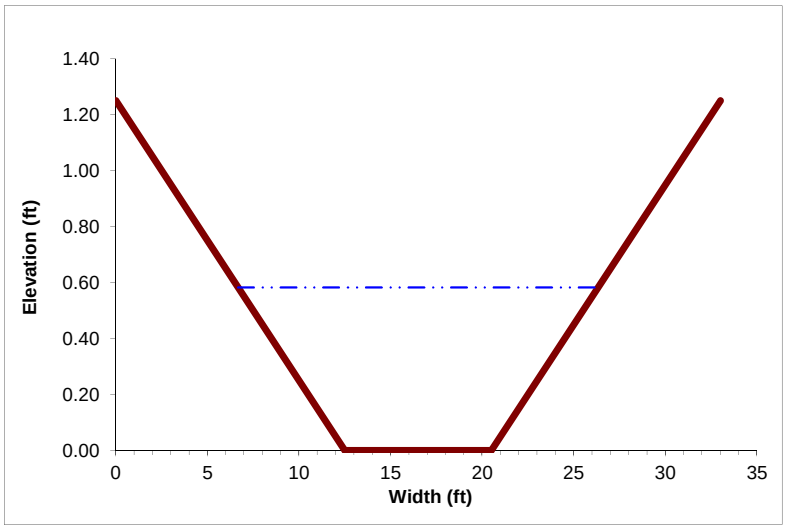
Input Values

Height	1.25	ft
Width	8	ft
LT Side Slope	10	:1 (h:v)
Rt Side Slope	10	:1 (h:v)
Mannings	0.125	
Slope	0.0130	ft/ft
Design Flow	6.00	cfs

Normal Depth for Channel

Depth	0.582	ft
Area	8.04	ft^2
Perimeter	19.70	ft
Rh	0.41	ft
V	0.75	ft/s
Q	6.00	cfs
Goal Seek	0.00	

C	0.78	
i	2.8	in/hr
A	2.75	acre
Q	6.00	cfs



SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B5

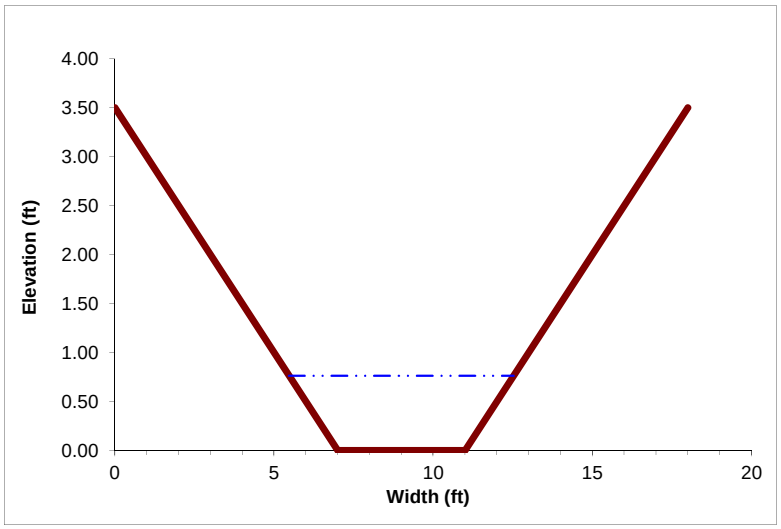
Input Values

Height	3.5	ft
Width	4	ft
LT Side Slope	2	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0031	ft/ft
Design Flow	1.90	cfs

Normal Depth for Channel

Depth	0.762	ft
Area	4.21	ft^2
Perimeter	7.41	ft
Rh	0.57	ft
V	0.45	ft/s
Q	1.90	cfs
Goal Seek	0.00	

C	0.80	
i	2.8	in/hr
A	0.85	acre
Q	1.90	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B6

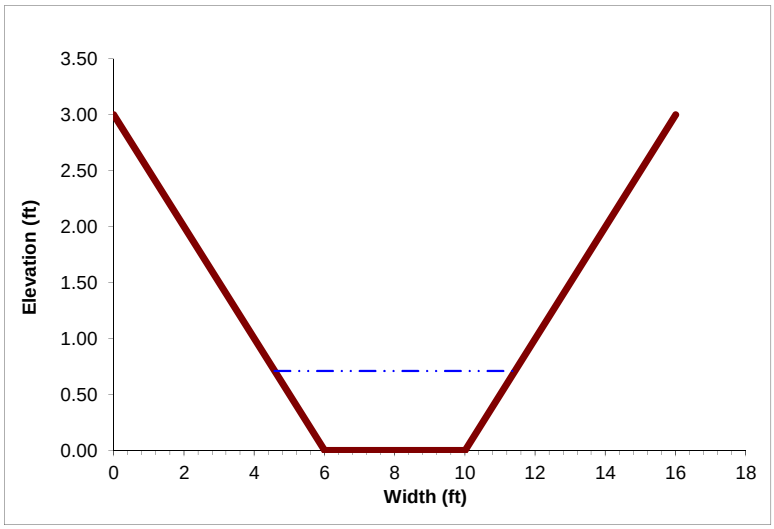
Input Values

Height	3	ft
Width	4	ft
LT Side Slope	2	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0093	ft/ft
Design Flow	2.91	cfs

Normal Depth for Channel

Depth	0.710	ft
Area	3.85	ft^2
Perimeter	7.17	ft
Rh	0.54	ft
V	0.76	ft/s
Q	2.91	cfs
Goal Seek	0.00	

C	0.75	
i	2.8	in/hr
A	1.38	acre
Q	2.91	cfs

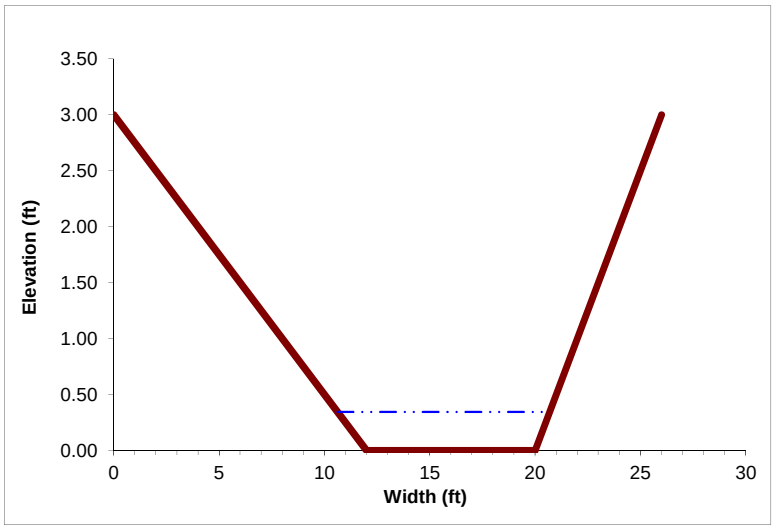


SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biolfiltration Swale B7 @ 531+10.01 to 536+50

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0047	ft/ft
Design Flow	0.00	cfs



Normal Depth for Channel

Depth	0.343	ft
Area	3.09	ft^2
Perimeter	10.18	ft
Rh	0.30	ft
V	0.37	ft/s
Q	1.14	cfs
Goal Seek	0.00	

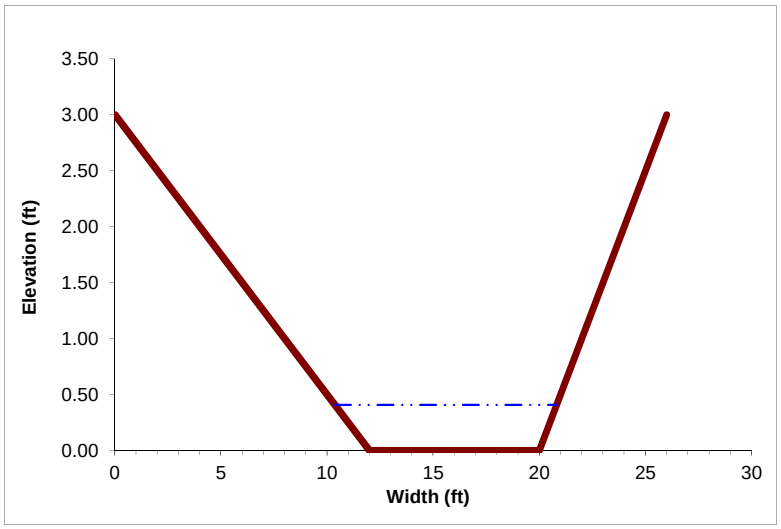
C	0.00	
i	1.1	in/hr
A	0.00	acre
Q	0.00	cfs

SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B7 @ 536+50 to 544+00

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0030	ft/ft
Design Flow	1.22	cfs



Normal Depth for Channel

Depth	0.406	ft
Area	3.74	ft^2
Perimeter	10.58	ft
Rh	0.35	ft
V	0.33	ft/s
Q	1.22	cfs
Goal Seek	0.00	

C	0.77	
i	1.1	in/hr
A	1.45	acre
Q	1.22	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B7 @ 544+00 to 548+20

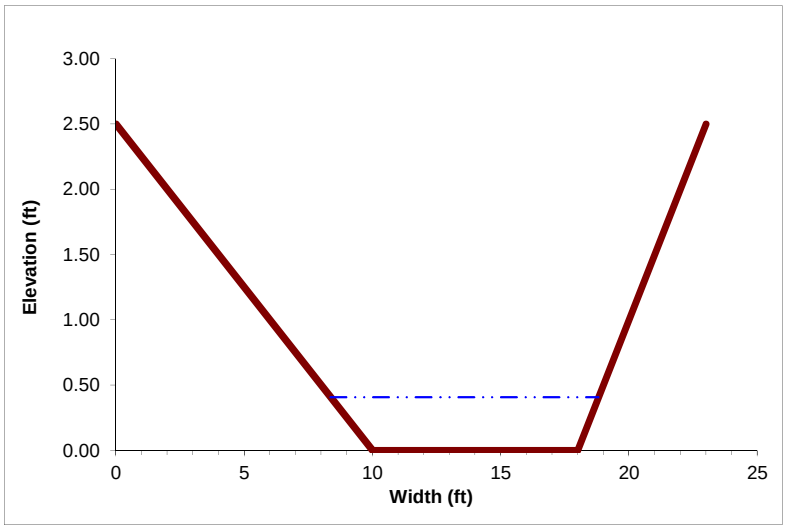
Input Values

Height	2.5	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0101	ft/ft
Design Flow	2.24	cfs

Normal Depth for Channel

Depth	0.406	ft
Area	3.74	ft^2
Perimeter	10.58	ft
Rh	0.35	ft
V	0.60	ft/s
Q	2.24	cfs
Goal Seek	0.00	

C	0.81	
i	1.93	in/hr
A	0.99	acre
Q	2.24	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B7 @ 548+20 to 552+20

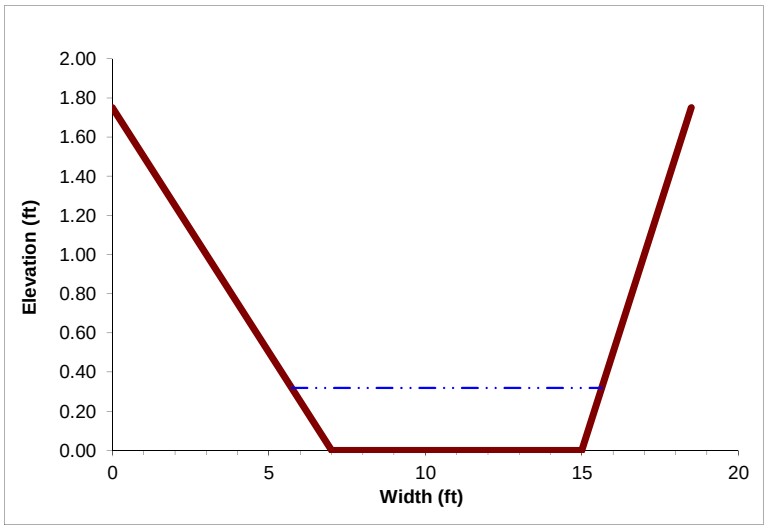
Input Values

Height	1.75	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0033	ft/ft
Design Flow	0.84	cfs

Normal Depth for Channel

Depth	0.318	ft
Area	2.85	ft^2
Perimeter	10.03	ft
Rh	0.28	ft
V	0.30	ft/s
Q	0.84	cfs
Goal Seek	0.00	

C	0.79	
i	1.1	in/hr
A	0.97	acre
Q	0.84	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B7 @ 552+20 to 554+00

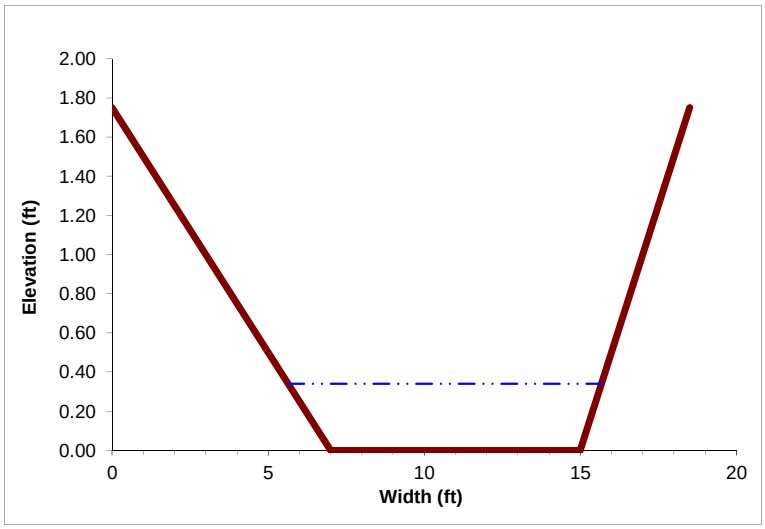
Input Values

Height	1.75	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0037	ft/ft
Design Flow	0.99	cfs

Normal Depth for Channel

Depth	0.340	ft
Area	3.07	ft^2
Perimeter	10.16	ft
Rh	0.30	ft
V	0.32	ft/s
Q	0.99	cfs
Goal Seek	0.00	

C	0.73	
i	2.8	in/hr
A	0.49	acre
Q	0.99	cfs



Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B13 @ 554+00 to 563+50

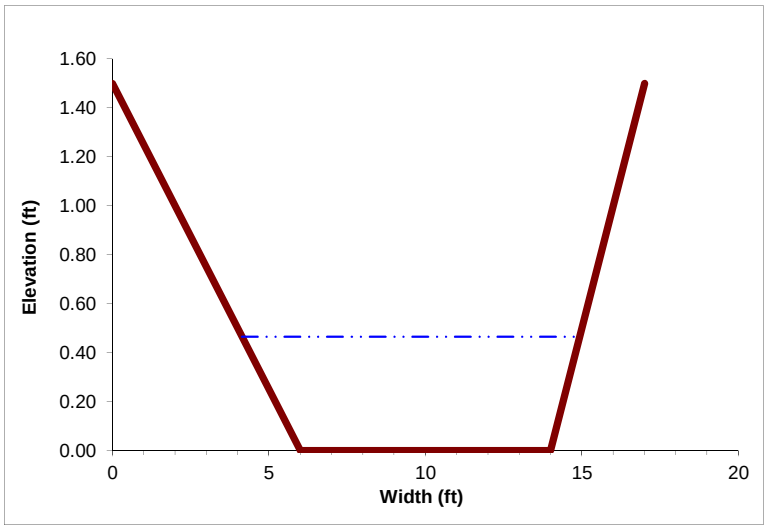
Input Values

Height	1.5	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0051	ft/ft
Design Flow	2.00	cfs

Normal Depth for Channel

Depth	0.465	ft
Area	4.36	ft^2
Perimeter	10.95	ft
Rh	0.40	ft
V	0.46	ft/s
Q	2.00	cfs
Goal Seek	0.00	

C	0.74	
i	1.58	in/hr
A	1.71	acre
Q	2.00	cfs



SR4 Balfour Road Interchange

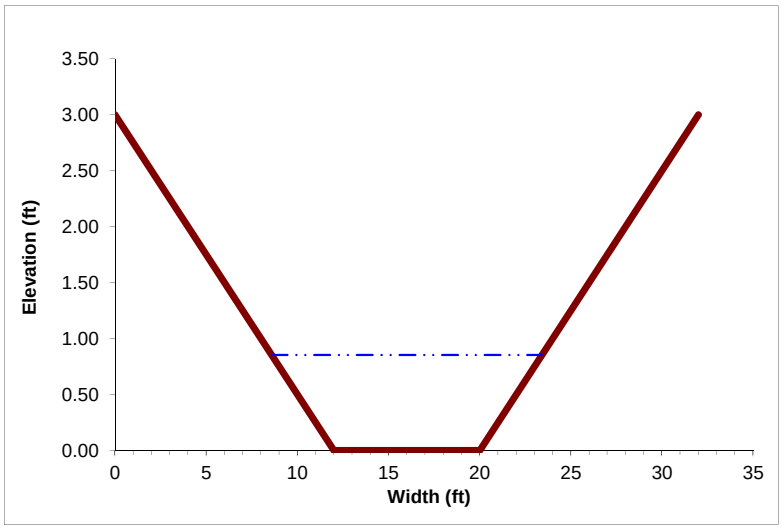
Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B8

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0092	ft/ft
Design Flow	8.30	cfs

Normal Depth for Channel

Depth	0.853	ft
Area	9.73	ft^2
Perimeter	15.03	ft
Rh	0.65	ft
V	0.85	ft/s
Q	8.30	cfs
Goal Seek	0.00	



C	0.73	
i	2.8	in/hr
A	4.08	acre
Q	8.30	cfs

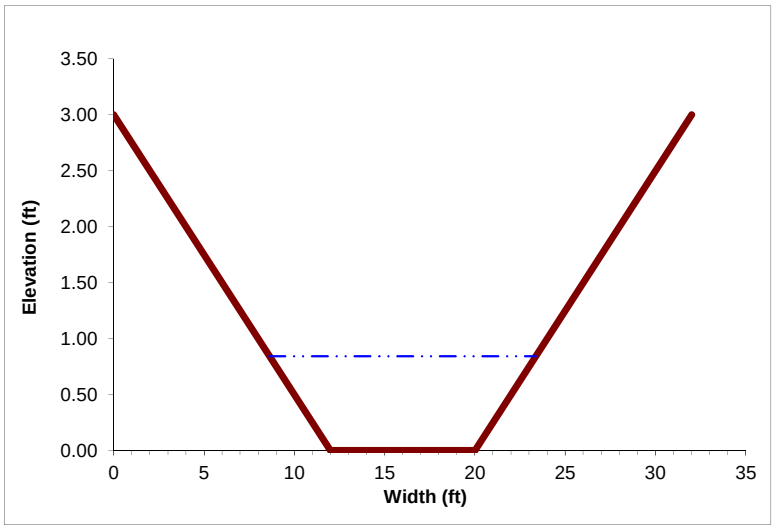
Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B9

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0081	ft/ft
Design Flow	7.62	cfs

Normal Depth for Channel

Depth	0.842	ft
Area	9.58	ft^2
Perimeter	14.95	ft
Rh	0.64	ft
V	0.80	ft/s
Q	7.62	cfs
Goal Seek	0.00	

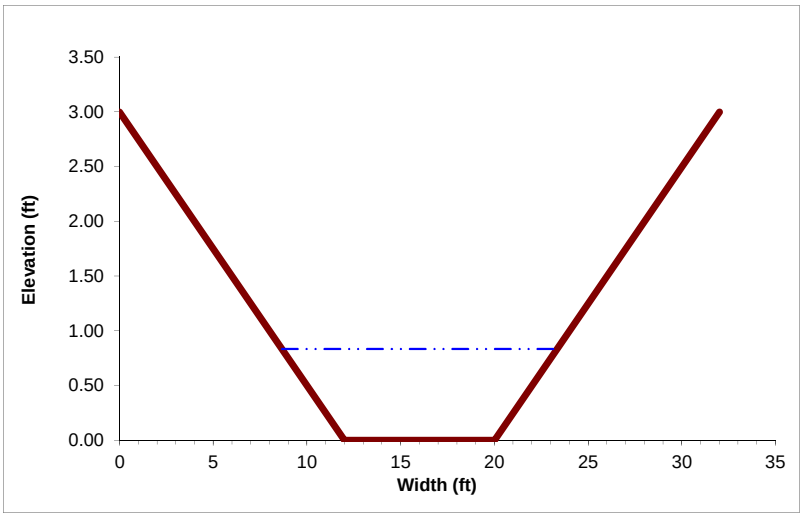


C	0.65	
i	2.8	in/hr
A	4.17	acre
Q	7.62	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B10

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0032	ft/ft
Design Flow	4.67	cfs



Normal Depth for Channel

Depth	0.834	ft
Area	9.45	ft^2
Perimeter	14.88	ft
Rh	0.64	ft
V	0.49	ft/s
Q	4.67	cfs
Goal Seek	0.00	

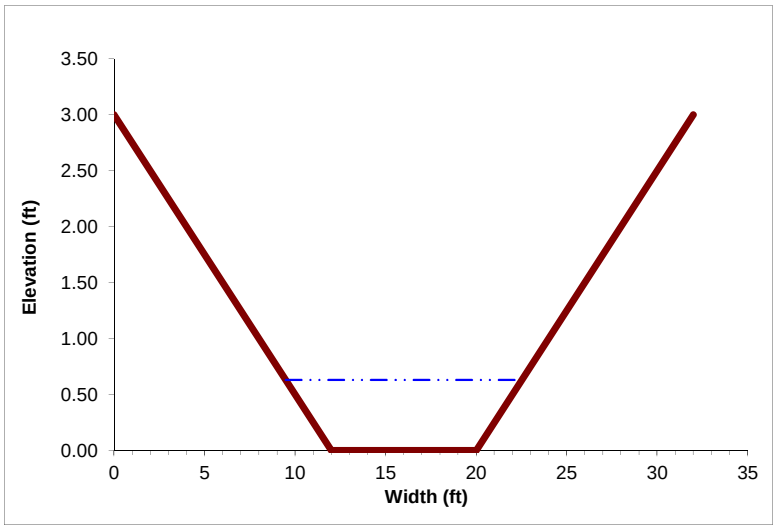
C	0.63	
i	2.8	in/hr
A	2.65	acre
Q	4.67	cfs

SR4 Balfour Road Interchange

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale B11

Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	4	:1 (h:v)
Mannings	0.125	
Slope	0.0103	ft/ft
Design Flow	5.06	cfs



Normal Depth for Channel

Depth	0.631	ft
Area	6.64	ft^2
Perimeter	13.20	ft
Rh	0.50	ft
V	0.76	ft/s
Q	5.06	cfs
Goal Seek	0.00	

C	0.66	
i	1.93	in/hr
A	3.97	acre
Q	5.06	cfs

Normal Depth Calculations for Channels using Manning's Equation
Biofiltration Swale 12

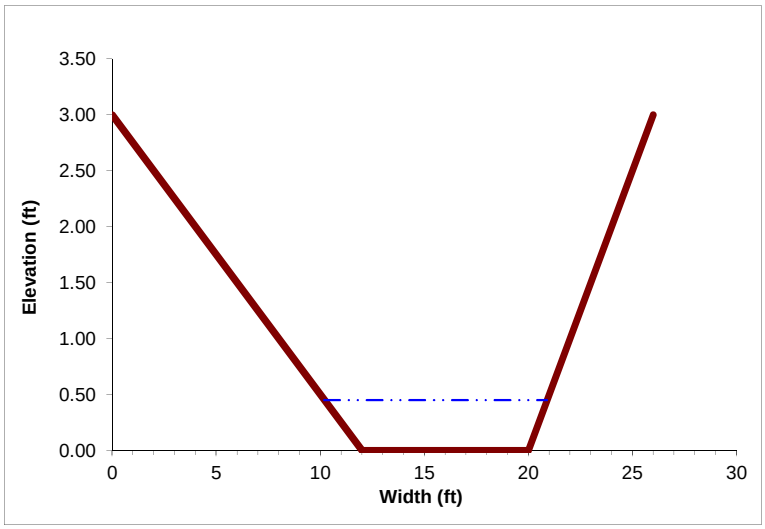
Input Values

Height	3	ft
Width	8	ft
LT Side Slope	4	:1 (h:v)
Rt Side Slope	2	:1 (h:v)
Mannings	0.125	
Slope	0.0027	ft/ft
Design Flow	1.39	cfs

Normal Depth for Channel

Depth	0.451	ft
Area	4.21	ft^2
Perimeter	10.87	ft
Rh	0.39	ft
V	0.33	ft/s
Q	1.39	cfs
Goal Seek	0.00	

C	0.78	
i	1.1	in/hr
A	1.63	acre
Q	1.39	cfs



Appendix I Inlet Capacity Calculations

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/20/2013
Checked by: Jeff Tudd ☑ **Date:** 11/20/2013

	Layout Line:		"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"B2RS"	"FR1"	"FR1"	"FR1"	"B2RS"	"B2RS"
In#	**Inlet number:**		1a	2a	3a	4a	5a	7a	7c	9a	9c	9e	9g	9i	10a	15a	17s	17q	17o	17m	17k	17i	17g	17e	17c	17a	81a	77a	27c
	(Input Data Required)																												
HYDROLOGY COMPUTATION:																													
St	Structure location station:	>>	977+00	979+50	981+00	982+50	984+50	986+50	988+50	990+50	991+55	992+37	992+57	992+77	994+50	996+50	998+50	1000+50	1002+50	1004+50	1006+50	1008+50	1010+50	1012+50	114+71	116+33	118+11	1018+13	1022+76.62
N	Notes		Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES, Flanking	Rt, ES Low Point	Rt ES, Flanking	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES
	Off-site contributing watershed area (acres):	>>	**0.18**	**0.38**	**0.30**	**0.28**	**0.45**	**0.98**	**0.32**	**0.33**	**0.11**	**0.59**	**0.23**	**0.77**	**0.33**	**0.33**	**0.33**	**0.33**	**0.32**	**0.29**	**0.20**	**0.07**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.26	0.20	0.12	0.12	0.16	0.16	0.16	0.16	0.08	0.06	0.03	0.14	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.16	0.16	0.17	0.16	0.24	0.07	0.33	0.28
Ar	**Contributing watershed area (acres):**		**0.44**	**0.58**	**0.42**	**0.40**	**0.61**	**1.14**	**0.48**	**0.49**	**0.19**	**0.66**	**0.26**	**0.90**	**0.49**	**0.49**	**0.49**	**0.49**	**0.47**	**0.45**	**0.35**	**0.23**	**0.16**	**0.17**	**0.16**	**0.24**	**0.07**	**0.33**	**0.28**
C	Composite Runoff Coefficient "C":	>>	0.84	0.74	0.71	0.68	0.65	0.65	0.73	0.73	0.77	0.64	0.65	0.65	0.73	0.73	0.73	0.73	0.73	0.74	0.77	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		1.04	1.19	0.83	0.76	1.11	2.09	0.98	1.00	0.41	1.18	0.47	1.65	0.99	1.00	0.99	0.99	0.97	0.93	0.76	0.56	0.44	0.48	0.44	0.67	0.20	0.92	0.78
qq	Previous by-pass flow (ft^3/s):	>		0.02	0.03	0.01	0.00	0.01	0.10	0.02	0.03	0.00	0.20	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
Qadd	Discharge added by operator (ft^3/s):	>																											
Qt	**Total discharge Q (ft^3/s):**		**1.04**	**1.21**	**0.86**	**0.77**	**1.11**	**2.10**	**1.08**	**1.02**	**0.44**	**1.18**	**0.67**	**1.68**	**1.02**	**1.03**	**1.03**	**1.02**	**1.00**	**0.94**	**0.77**	**0.56**	**0.44**	**0.49**	**0.45**	**0.67**	**0.20**	**0.93**	**0.78**
SHOULDER AND GUTTER CONFIGURATION:																													
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.0090	0.0135	0.0185	0.0185	0.0190	0.0150	0.0102	0.0054	0.0029	0.0009	0.0005	0.0005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.0049	0.0095	0.0053	0.0131	0.0114
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	HMAOD	G2
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12		24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0		24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0		36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3
Lco	Curb opening length provided (ft):	>																										10.00	
Ls	Slotted drain length provided: (ft)	>																											
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771
	Available Flooded Width (ft)	>	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**4.10**	**4.03**	**3.34**	**3.20**	**3.66**	**4.86**	**4.07**	**4.49**	**3.67**	**6.63**	**-----**	**8.45**	**5.02**	**5.03**	**5.02**	**5.02**	**4.97**	**4.87**	**4.51**	**4.00**	**3.66**	**3.79**	**3.35**	**3.45**	**2.43**	**3.67**	**3.53**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**3.13**	**3.07**	**2.55**	**2.44**	**2.79**	**3.71**	**3.10**	**3.43**	**2.80**	**5.61**	**-----**	**7.63**	**3.83**	**3.84**	**3.83**	**3.83**	**3.79**	**3.71**	**3.44**	**3.05**	**2.79**	**2.89**	**2.56**	**2.63**	**1.85**	**2.80**	**2.69**
Du/s	Depth at flowline before inlet (ft):		0.24	0.24	0.20	0.19	0.22	0.29	0.24	0.26	0.22	0.39	-----	0.49	0.30	0.30	0.30	0.30	0.29	0.29	0.27	0.24	0.22	0.22	0.20	0.20	0.14	0.22	0.21
Au/s	Water cross-area before inlet (ft^2):		0.38	0.36	0.25	0.23	0.30	0.53	0.37	0.45	0.30	1.00	-----	1.67	0.56	0.57	0.57	0.56	0.55	0.53	0.46	0.36	0.30	0.32	0.25	0.27	0.13	0.30	0.28
Vu/s	Velocity for total discharge before inlet (ft/s):		2.75	3.32	3.43	3.34	3.70	3.97	2.91	2.26	1.45	1.18	-----	1.00	1.81	1.82	1.81	1.81	1.80	1.78	1.69	1.56	1.47	1.50	1.77	2.51	1.48	3.07	2.79
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	100%	100%	100%	100%	98%	-----	89%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.076	-----	0.074	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
GRATE INLETS ON-GRADE:																													
Eog	Ratio of grate frontal flow to total flow:		97%	97%	99%	99%	98%	94%	97%	95%	98%	80%	-----	66%	93%	93%	93%	93%	93%	94%	95%	97%	98%	98%	99%	99%	100%	-----	99%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		1.00	1.17	0.85	0.76	1.09	1.97	1.05	0.97	0.43	0.95	-----	1.11	0.95	0.96	0.96	0.95	0.93	0.88	0.73	0.54	0.43	0.48	0.44	0.66	0.20	-----	0.77
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	-----	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	-----	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-----	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-----	1.00
Qs	Side flow in ft^3/s (Qs):		0.03	0.04	0.01	0.00	0.02	0.13	0.03	0.05	0.01	0.23	-----	0.57	0.07	0.07	0.07	0.07	0.07	0.06	0.04	0.02	0.01	0.01	0.00	0.01	0.00	-----	0.01
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27	27	27	-----	27	27	27	27	27	27	27	27	27	27	27	27	27	27	-----	27
Rs	Fraction of side flow interception (Rs):		35%	28%	27%	27%	24%	22%	33%	43%	63%	71%	-----	76%	53%	53%	53%	53%	53%	54%	56%	60%	62%	61%	54%	39%	0%	-----	34%
E	Grate Efficiency (E):		98%	98%	99%	100%	99%	95%	98%	97%	99%	94%	-----	92%	97%	97%	97%	97%	97%	97%	98%	99%	99%	99%	100%	99%	100%	-----	99%
Qi	**Total flow intercepted (ft^3/s):**		**1.01**	**1.18**	**0.85**	**0.76**	**1.10**	**2.00**	**1.06**	**0.99**	**0.44**	**1.11**	**-----**	**1.54**	**0.99**	**1.00**	**0.99**	**0.99**	**0.97**	**0.92**	**0.75**	**0.55**	**0.44**	**0.48**	**0.44**	**0.67**	**0.20**	**-----**	**0.77**
Qb	**Grate flow-by (ft^3/s):**		**0.02**	**0.03**	**0.01**	**0.00**	**0.01**	**0.10**	**0.02**	**0.03**	**0.00**	**0.07**	**-----**	**0.14**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-----**	**0.01**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)																													
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	9.16	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.9	-----
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	100%	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**0.0**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:																													
	Grate Inlets																												
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.13	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.16	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4.47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5.04	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains																												
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets																												
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>											900.00																
g1	approach grade #1 (%):	>											-1.90																
g2	approach grade #2 (%):	>											0.30																
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	167	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	86.71	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 10/28/2013 moved new
Checked by: Jeff Tudd ☑ **Date:** 10/29/2013

	Layout Line:		"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"
In#	**Inlet number:**		**45a**	**46a**	**47a**	**57c**	**58j (new)**	**58l (new)**	**58c**	**62c**	**62e**	**63a**
		(Input Data Required)										
HYDROLOGY COMPUTATION:												
St	Structure location station:	>>	531+65	533+65	535+65	537+65	538+60	538+90	539+40	541+25	543+25	544+50
N	Notes		**Rt ES**	**Rt ES**	**Rt ES**	**Rt ES**	**Rt ES**	**Rt ES**	**Rt ES flip at 539+46.7**	**Lt ES**	**Lt ES**	**Lt ES**
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.25	0.21	0.13	0.12	0.06	0.02	0.04	0.14	0.14	0.09
Ar	**Contributing watershed area (acres):**		**0.25**	**0.21**	**0.13**	**0.12**	**0.06**	**0.02**	**0.04**	**0.14**	**0.14**	**0.09**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1	1	1	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.69	0.58	0.37	0.35	0.17	0.06	0.13	0.38	0.39	0.25
qq	Previous by-pass flow (ft^3/s):	>		0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qadd	Discharge added by operator (ft^3/s):	>										
Qt	**Total discharge Q (ft^3/s):**		**0.69**	**0.59**	**0.37**	**0.35**	**0.17**	**0.06**	**0.13**	**0.38**	**0.39**	**0.25**
SHOULDER AND GUTTER CONFIGURATION:												
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.005	0.009	0.012	0.016	0.016	0.016	0.016	0.017	0.011	0.007
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3	3	3
Lco	Curb opening length provided (ft):	>										
Ls	Slotted drain length provided: (ft)	>										
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0400	0.0500	0.0400	0.0242	0.0116	0.0076	0.0009	0.0200	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0671	0.0771	0.0671	0.0513	0.0387	0.0347	0.0280	0.0471	0.0471	0.0471
	Available Flooded Width (ft)	>	5.00	5.00	5.00	5.00	5.00	5.00	5.00	10.00	10.00	10.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**4.57**	**3.35**	**3.01**	**3.87**	**4.65**	**4.08**	**20.70**	**4.43**	**4.89**	**4.43**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**3.31**	**2.55**	**2.18**	**2.42**	**2.19**	**1.57**	**2.41**	**2.59**	**2.86**	**2.59**
Du/s	Depth at flowline before inlet (ft):		0.22	0.20	0.15	0.12	0.08	0.05	0.07	0.12	0.13	0.12
Au/s	Water cross-area before inlet (ft^2):		0.37	0.25	0.16	0.15	0.09	0.04	0.08	0.16	0.19	0.16
Vu/s	Velocity for total discharge before inlet (ft/s):		1.88	2.34	2.31	2.32	1.80	1.34	1.54	2.39	2.02	1.57
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.067	0.077	0.067	0.051	0.039	0.035	0.028	0.047	0.047	0.047
GRATE INLETS ON-GRADE:												
Eog	Ratio of grate frontal flow to total flow:		96%	99%	100%	100%	100%	100%	100%	100%	99%	100%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.66	0.58	0.37	0.35	0.17	0.06	0.13	0.38	0.39	0.25
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27	27	27
Rs	Fraction of side flow interception (Rs):		48%	42%	39%	33%	37%	0%	36%	30%	36%	47%
E	Grate Efficiency (E):		98%	100%	100%	100%	100%	100%	100%	100%	99%	100%
Qi	**Total flow intercepted (ft^3/s):**		**0.68**	**0.59**	**0.37**	**0.35**	**0.17**	**0.06**	**0.13**	**0.38**	**0.39**	**0.25**
Qb	**Grate flow-by (ft^3/s):**		**0.0127**	**0.0028**	**0.0001**	**0.0006**	**0.0000**	**0.0000**	**0.0000**	**0.0012**	**0.0024**	**0.0006**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)												
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:												
	Grate Inlets											
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains											
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets											
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>										
g1	approach grade #1 (%):	>										
g2	approach grade #2 (%):	>										
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/20/2013
Checked by: Jeff Tudd ☑ **Date:** 11/20/2013

moved | new

	Layout Line:		"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"
In#	**Inlet number:**		32c	32x (new)	32a	27a	26a (moved)	22a	22c	22e	21a	19a	18a
		(Input Data Required)											
HYDROLOGY COMPUTATION:													
St	Structure location station:	>>	528+28	526+60	525+82	522+77	521+30	519+03	518+11	517+25	515+47	513+48	511+42
N	Notes		Rt ES	Rt ES	Rt ES	Rt ES	Lt ES Lt TW and ES flip @ 521+50	Lt ES	Lt ES	Lt ES	Lt ES	Lt ES	Lt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.06	0.15	0.07	0.23	0.15	0.16	0.07	0.07	0.14	0.16	0.16
Ar	**Contributing watershed area (acres):**		**0.06**	**0.15**	**0.07**	**0.23**	**0.15**	**0.16**	**0.07**	**0.07**	**0.14**	**0.16**	**0.16**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1	1	1	1	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.18	0.43	0.20	0.64	0.43	0.44	0.20	0.20	0.39	0.44	0.44
qq	Previous by-pass flow (ft^3/s):	>		0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Qadd	Discharge added by operator (ft^3/s):	>											
Qt	**Total discharge Q (ft^3/s):**		**0.18**	**0.43**	**0.20**	**0.64**	**0.44**	**0.45**	**0.20**	**0.20**	**0.39**	**0.44**	**0.45**
SHOULDER AND GUTTER CONFIGURATION:													
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.004	0.004	0.006	0.011	0.013	0.013	0.013	0.013	0.007	0.003	0.003
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1	1	1	2
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	HMAOD
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	2	1	1	1	1	1	1	1	1	1	
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3	3	3	
Lco	Curb opening length provided (ft):	>											10.00
Ls	Slotted drain length provided: (ft)	>											
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0492	0.0500	0.0200	0.0200	0.0200	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0763	0.0771	0.0471	0.0471	0.0471	0.0771	0.0771	0.0771	0.0771	0.0771	0.0771
	Available Flooded Width (ft)	>	5.00	5.00	5.00	5.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**2.49**	**3.40**	**4.32**	**5.82**	**4.94**	**2.79**	**2.05**	**2.05**	**2.96**	**3.62**	**3.67**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**1.89**	**2.60**	**2.52**	**3.41**	**2.89**	**2.13**	**1.56**	**1.56**	**2.26**	**2.76**	**2.80**
Du/s	Depth at flowline before inlet (ft):		0.14	0.20	0.12	0.16	0.14	0.16	0.12	0.12	0.17	0.21	0.22
Au/s	Water cross-area before inlet (ft^2):		0.14	0.26	0.15	0.27	0.20	0.17	0.09	0.09	0.20	0.29	0.30
Vu/s	Velocity for total discharge before inlet (ft/s):		1.32	1.66	1.36	2.35	2.25	2.56	2.08	2.08	1.96	1.48	1.47
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.076	0.077	0.047	0.047	0.047	0.077	0.077	0.077	0.077	0.077	0.077
GRATE INLETS ON-GRADE:													
Eog	Ratio of grate frontal flow to total flow:		100%	99%	100%	98%	99%	100%	100%	100%	100%	98%	-----
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.18	0.43	0.20	0.63	0.44	0.45	0.20	0.20	0.39	0.43	-----
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	-----
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-----
Qs	Side flow in ft^3/s (Qs):		0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	-----
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27	27	27	-----
Rs	Fraction of side flow interception (Rs):		0%	57%	54%	30%	32%	38%	0%	0%	50%	62%	-----
E	Grate Efficiency (E):		100%	100%	100%	98%	99%	100%	100%	100%	100%	99%	-----
Qi	**Total flow intercepted (ft^3/s):**		**0.18**	**0.43**	**0.20**	**0.63**	**0.44**	**0.45**	**0.20**	**0.20**	**0.39**	**0.43**	**-----**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-----**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)													
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4.32
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.4
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	100%
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**0.0**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:													
	Grate Inlets												
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains												
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets												
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>											
g1	approach grade #1 (%):	>											
g2	approach grade #2 (%):	>											
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/8/2013
Checked by: Jeff Tudd ☑ **Date:** 11/8/2013

moved | new

	Layout Line:		"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"	"B2RN"
In#	**Inlet number:**		45c	45e	45g	50c	57a	58n (new)	58a	62a	62g	63c	63e	64a	64c	64e	60x (new)	60x (new)	65a (moved)	66a (moved)	60x (new)	67a (moved)	68a
		(Input Data Required)																					
HYDROLOGY COMPUTATION:																							
St	Structure location station:	>>	531+65	533+65	535+65	536+20	537+65	538+90	539+40	541+25	543+25	544+50	545+60	546+12	546+32	546+52	547+40	548+20	549+24	550+35	551+54	552+65	553+85
N	Notes		Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	5' Rt ES (Flip at 539+36.7)	5' Rt ES	5' Rt ES	5' Rt ES	Flanking Inlet	Low Point	Flanking Inlet	5' Rt ES	5' Rt ES	5' Rt ES	5' Rt ES	5' Rt ES	5' Rt ES	5' Rt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.32	0.20	0.19	0.07	0.05	0.12	0.05	0.25	0.18	0.12	0.10	0.04	0.04	0.07	0.06	0.08	0.08	0.08	0.07	0.08	0.08
Ar	**Contributing watershed area (acres):**		**0.32**	**0.20**	**0.19**	**0.07**	**0.05**	**0.12**	**0.05**	**0.25**	**0.18**	**0.12**	**0.10**	**0.04**	**0.04**	**0.07**	**0.06**	**0.08**	**0.08**	**0.08**	**0.07**	**0.08**	**0.08**
C	Composite Runoff Coefficient "C":	>>	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.89	0.55	0.52	0.19	0.13	0.33	0.13	0.70	0.52	0.33	0.28	0.13	0.10	0.20	0.18	0.22	0.22	0.22	0.20	0.22	0.21
qq	Previous by-pass flow (ft^3/s):	>		0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Qadd	Discharge added by operator (ft^3/s):	>																					
Qt	**Total discharge Q (ft^3/s):**		**0.89**	**0.62**	**0.53**	**0.19**	**0.13**	**0.33**	**0.13**	**0.70**	**0.52**	**0.33**	**0.28**	**0.13**	**0.10**	**0.20**	**0.18**	**0.22**	**0.22**	**0.22**	**0.20**	**0.22**	**0.21**
SHOULDER AND GUTTER CONFIGURATION:																							
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.005	0.009	0.012	0.014	0.016	0.016	0.016	0.020	0.012	0.008	0.005	0.003	0.001	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2	G2
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Lco	Curb opening length provided (ft):	>																					
Ls	Slotted drain length provided: (ft)	>																					
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0400	0.0500	0.0400	0.0400	0.0242	0.0076	0.0009	0.0370	0.0500	0.0500	0.0279	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0500	0.0771	0.0671	0.0671	0.0513	0.0347	0.0280	0.0641	0.0771	0.0771	0.0550	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471
	Available Flooded Width (ft)	>	10.00	10.00	10.00	10.00	10.00	10.00	10.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**5.03**	**3.42**	**3.44**	**2.34**	**2.70**	**7.86**	**21.26**	**3.68**	**3.01**	**2.72**	**4.04**	**4.07**	**-----**	**4.86**	**4.61**	**4.98**	**5.00**	**4.99**	**4.81**	**4.97**	**4.94**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**4.46**	**2.61**	**2.49**	**1.69**	**1.69**	**3.04**	**2.47**	**2.61**	**2.29**	**2.08**	**2.64**	**2.38**	**-----**	**2.84**	**2.69**	**2.91**	**2.92**	**2.92**	**2.81**	**2.91**	**2.89**
Du/s	Depth at flowline before inlet (ft):		0.22	0.20	0.17	0.11	0.09	0.11	0.07	0.17	0.18	0.16	0.15	0.11	-----	0.13	0.13	0.14	0.14	0.14	0.13	0.14	0.14
Au/s	Water cross-area before inlet (ft^2):		0.48	0.26	0.21	0.10	0.07	0.16	0.09	0.22	0.20	0.17	0.19	0.13	-----	0.19	0.17	0.20	0.20	0.20	0.19	0.20	0.20
Vu/s	Velocity for total discharge before inlet (ft/s):		1.85	2.38	2.52	2.03	1.83	2.08	1.57	3.20	2.58	1.97	1.46	0.95	-----	1.07	1.03	1.09	1.09	1.09	1.06	1.09	1.08
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	-----	100%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.050	0.077	0.067	0.067	0.051	0.035	0.028	0.064	0.077	0.077	0.055	0.047	-----	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
GRATE INLETS ON-GRADE:																							
Eog	Ratio of grate frontal flow to total flow:		85%	99%	99%	100%	100%	100%	100%	99%	100%	100%	99%	100%	-----	99%	99%	99%	99%	99%	99%	99%	99%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.75	0.62	0.52	0.19	0.13	0.33	0.13	0.69	0.52	0.33	0.28	0.13	-----	0.20	0.18	0.21	0.22	0.22	0.20	0.21	0.21
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	-----	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-----	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-----	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27	27	27	27	27	-----	27	27	27	27	27	27	27	27
Rs	Fraction of side flow interception (Rs):		41%	41%	35%	0%	0%	29%	35%	25%	38%	50%	55%	69%	-----	64%	66%	64%	63%	64%	65%	64%	64%
E	Grate Efficiency (E):		91%	99%	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%	-----	100%	100%	100%	100%	100%	100%	100%	100%
Qi	**Total flow intercepted (ft^3/s):**		**0.81**	**0.62**	**0.52**	**0.19**	**0.13**	**0.33**	**0.13**	**0.69**	**0.52**	**0.33**	**0.28**	**0.13**	**-----**	**0.20**	**0.18**	**0.22**	**0.22**	**0.22**	**0.20**	**0.22**	**0.21**
Qb	**Grate flow-by (ft^3/s):**		**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-----**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)																							
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:																							
	Grate Inlets																						
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.04	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.05	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.41	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.71	-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains																						
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets																						
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>													750.00								
g1	approach grade #1 (%):	>													-2.56								
g2	approach grade #2 (%):	>													0.30								
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	167	-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	50.74	-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/4/2013
Checked by: Jeff Tudd ☑ **Date:** 11/4/2013

	Layout Line:		"BF"	"BF"	"BF"	"BF"	"BF"	"BF"	"BF"	"BF"	-
In#	**Inlet number:**		36a	36c	36e	36g	39a	41a	56a	55h	Existing Inlet BF
		(Input Data Required)									
HYDROLOGY COMPUTATION:											
St	Structure location station:	>>	22+01	23+65	25+48	27+30	28+61	30+16	32+21	34+50	-
N	Notes		Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Rt ES
	Off-site contributing watershed area (acres):	>>	**0.06**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.24	0.30	0.26	0.27	0.16	0.06	0.26	0.30	0.36
Ar	**Contributing watershed area (acres):**		**0.30**	**0.30**	**0.26**	**0.27**	**0.16**	**0.06**	**0.26**	**0.30**	**0.36**
C	Composite Runoff Coefficient "C":	>>	0.92	1	1	1	1	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.8
Qa	Subarea discharge Q (ft^3/s):		0.68	0.73	0.63	0.66	0.39	0.15	0.63	0.73	1.00
qq	Previous by-pass flow (ft^3/s):	>		0.03	0.04	0.01	0.01	0.00	0.00	0.01	0.02
Qadd	Discharge added by operator (ft^3/s):	>									
Qt	**Total discharge Q (ft^3/s):**		**0.68**	**0.76**	**0.67**	**0.67**	**0.40**	**0.15**	**0.63**	**0.74**	**1.01**
SHOULDER AND GUTTER CONFIGURATION:											
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.02
S	Longitudinal slope S (ft/ft):	>>	0.003	0.003	0.008	0.008	0.008	0.010	0.007	0.007	0.007
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G0	G0	G0	G0	G0	G0	G0	G0	G2
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3	3
Lco	Curb opening length provided (ft):	>	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ls	Slotted drain length provided: (ft)	>									
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471	0.0471
	Available Flooded Width (ft)	>	20.00	20.00	20.00	20.00	20.00	17.00	8.00	8.00	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**7.63**	**7.97**	**6.32**	**6.33**	**5.21**	**3.42**	**6.27**	**6.67**	**7.56**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**5.07**	**5.53**	**3.70**	**3.70**	**3.05**	**2.00**	**3.67**	**3.90**	**4.99**
Du/s	Depth at flowline before inlet (ft):		0.21	0.22	0.17	0.17	0.14	0.09	0.17	0.18	0.21
Au/s	Water cross-area before inlet (ft^2):		0.47	0.52	0.32	0.32	0.22	0.09	0.32	0.36	0.47
Vu/s	Velocity for total discharge before inlet (ft/s):		1.43	1.46	2.08	2.08	1.83	1.58	1.98	2.06	2.17
Eod	Ratio of gutter depression flow to total Q (Eod):		99%	99%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
GRATE INLETS ON-GRADE:											
Eog	Ratio of grate frontal flow to total flow:		91%	89%	97%	97%	99%	100%	97%	96%	92%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.62	0.68	0.65	0.65	0.40	0.15	0.61	0.71	0.93
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.06	0.09	0.02	0.02	0.01	0.00	0.02	0.03	0.09
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27	27
Rs	Fraction of side flow interception (Rs):		51%	50%	35%	35%	41%	47%	37%	36%	33%
E	Grate Efficiency (E):		96%	94%	98%	98%	99%	100%	98%	98%	94%
Qi	**Total flow intercepted (ft^3/s):**		**0.65**	**0.72**	**0.66**	**0.66**	**0.40**	**0.15**	**0.62**	**0.72**	**0.96**
Qb	**Grate flow-by (ft^3/s):**		**0.03**	**0.04**	**0.01**	**0.01**	**0.00**	**0.00**	**0.01**	**0.02**	**0.06**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)											
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:											
	Grate Inlets										
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains										
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets										
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>									
g1	approach grade #1 (%):	>									
g2	approach grade #2 (%):	>									
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/4/2013
Checked by: Jeff Tudd ☑ **Date:** 11/4/2013

	Layout Line:		"BF"	"BF"	"BF"	"FL1N"
In#	**Inlet number:**		**36l**	**40a**	**42m**	**42a**
		(Input Data Required)				
HYDROLOGY COMPUTATION:						
St	Structure location station:	>>	27+30	28+61	29+91	629+50
N	Notes		Lt ES	Lt ES	Lt ES	Rt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.33	0.36	0.02	0.08
Ar	**Contributing watershed area (acres):**		**0.33**	**0.36**	**0.02**	**0.08**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.44	2.44	2.44	2.44
Qa	Subarea discharge Q (ft^3/s):		0.81	0.88	0.06	0.19
qq	Previous by-pass flow (ft^3/s):	>		0.02	0.03	0.00
Qadd	Discharge added by operator (ft^3/s):	>				
Qt	**Total discharge Q (ft^3/s):**		**0.81**	**0.90**	**0.09**	**0.19**
SHOULDER AND GUTTER CONFIGURATION:						
n	Manning's n:	>>	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.008	0.007	0.008	0.007
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1
ID	Inlet description:	>	G0	G0	G0	G0
	Grate Type:	>>	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3
Lco	Curb opening length provided (ft):	>	3.00	3.00	3.00	3.00
Ls	Slotted drain length provided: (ft)	>				
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0200	0.0200	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0471	0.0471	0.0471	0.0471
	Available Flooded Width (ft)	>	8.00	8.00	8.00	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**6.77**	**7.17**	**2.98**	**3.99**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**3.96**	**4.47**	**1.75**	**2.33**
Du/s	Depth at flowline before inlet (ft):		0.19	0.20	0.08	0.11
Au/s	Water cross-area before inlet (ft^2):		0.37	0.42	0.07	0.13
Vu/s	Velocity for total discharge before inlet (ft/s):		2.18	2.16	1.26	1.46
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.047	0.047	0.047	0.047
GRATE INLETS ON-GRADE:						
Eog	Ratio of grate frontal flow to total flow:		96%	94%	100%	100%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.78	0.85	0.09	0.19
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.03	0.05	0.00	0.00
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27
Rs	Fraction of side flow interception (Rs):		33%	34%	0%	51%
E	Grate Efficiency (E):		98%	96%	100%	100%
Qi	**Total flow intercepted (ft^3/s):**		**0.79**	**0.86**	**0.09**	**0.19**
Qb	**Grate flow-by (ft^3/s):**		**0.02**	**0.03**	**0.00**	**0.00**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)						
Lt	Length required for total interception (ft):		-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:						
	Grate Inlets					
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
	Slotted drains					
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
	Curb opening inlets					
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>				
g1	approach grade #1 (%):	>				
g2	approach grade #2 (%):	>				
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/4/2013
Checked by: Jeff Tudd ☑ **Date:** 11/4/2013

	Layout Line:		"BF"	"BF"	-
In#	**Inlet number:**		**55a**	**55c**	**Existing Inlet BF**
		(Input Data Required)			
HYDROLOGY COMPUTATION:					
St	Structure location station:	>>	32+21	34+50	-
N	Notes		Lt ES	Lt ES	Lt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.18	0.30	0.44
Ar	**Contributing watershed area (acres):**		**0.18**	**0.30**	**0.44**
C	Composite Runoff Coefficient "C":	>>	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.44	2.44	2.44
Qa	Subarea discharge Q (ft^3/s):		0.44	0.73	1.07
qq	Previous by-pass flow (ft^3/s):	>		0.00	0.02
Qadd	Discharge added by operator (ft^3/s):	>			
Qt	**Total discharge Q (ft^3/s):**		**0.44**	**0.74**	**1.08**
SHOULDER AND GUTTER CONFIGURATION:					
n	Manning's n:	>>	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.007	0.007	0.007
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1
ID	Inlet description:	>	G0	G0	G0
	Grate Type:	>>	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3
Lco	Curb opening length provided (ft):	>	3.00	3.00	3.00
Ls	Slotted drain length provided: (ft)	>			
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0200	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0471	0.0471	0.0471
	Available Flooded Width (ft)	>	8.00	8.00	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**5.49**	**6.67**	**7.69**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**3.21**	**3.90**	**5.16**
Du/s	Depth at flowline before inlet (ft):		0.15	0.18	0.21
Au/s	Water cross-area before inlet (ft^2):		0.24	0.36	0.48
Vu/s	Velocity for total discharge before inlet (ft/s):		1.81	2.06	2.24
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	99%
Se	Equivalent cross-slope (ft/ft):		0.047	0.047	0.047
GRATE INLETS ON-GRADE:					
Eog	Ratio of grate frontal flow to total flow:		98%	96%	91%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.43	0.71	0.98
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.01	0.03	0.10
Gle	Effective grate length w/ 25% clogging (in):		27	27	27
Rs	Fraction of side flow interception (Rs):		41%	36%	32%
E	Grate Efficiency (E):		99%	98%	94%
Qi	**Total flow intercepted (ft^3/s):**		**0.44**	**0.72**	**1.01**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.02**	**0.07**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)					
Lt	Length required for total interception (ft):		-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:					
	Grate Inlets				
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----
	Slotted drains				
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----
	Curb opening inlets				
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----
Lc	Length of the vertical curve (ft):	>			
g1	approach grade #1 (%):	>			
g2	approach grade #2 (%):	>			
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/20/2013 moved

Checked by: Jeff Tudd ☑ **Date:** 11/20/2013

	Layout Line:		"FR1"	"FR1"	"FR1"	"FR1"	"FR1"	"FR1"	"BF"	"BF"
In#	**Inlet number:**		25a	25c	25e	28a	30a	38a (LP, Moved)	37c	37a
		(Input Data Required)								
HYDROLOGY COMPUTATION:										
St	Structure location station:	>>	119+75	120+22	121+03	123+07	125+41	127+60	23+65	23+03
N	Notes		Rt ES	Rt ES	Rt ES	Rt ES	Rt ES	Low Point, Moved	Rt ES	Rt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.03	0.03	0.06	0.20	0.25	0.47	0.07	0.30
Ar	**Contributing watershed area (acres):**		**0.03**	**0.03**	**0.06**	**0.20**	**0.25**	**0.47**	**0.07**	**0.30**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.44	2.44
Qa	Subarea discharge Q (ft^3/s):		0.08	0.08	0.15	0.55	0.71	1.32	0.16	0.73
qq	Previous by-pass flow (ft^3/s):	>		0.00	0.00	0.00	0.00	0.00	0.04	
Qadd	Discharge added by operator (ft^3/s):	>								
Qt	**Total discharge Q (ft^3/s):**		**0.08**	**0.08**	**0.15**	**0.55**	**0.71**	**1.33**	**0.20**	**0.73**
SHOULDER AND GUTTER CONFIGURATION:										
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.011	0.009	0.0002	0.018	0.017	0.001	0.003	0.003
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	2	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G0	G0
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3
Lco	Curb opening length provided (ft):	>							3.00	3.00
Ls	Slotted drain length provided: (ft)	>								
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0874	0.0678	0.0500	0.0500	0.0500	0.0500	0.0200	0.0200
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.1145	0.0949	0.0771	0.0771	0.0771	0.0771	0.0471	0.0471
	Available Flooded Width (ft)	>	10.00	10.00	10.00	10.00	8.00	8.00	8.00	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**1.08**	**1.29**	**4.11**	**2.83**	**3.16**	**-----**	**4.85**	**7.83**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**0.92**	**1.04**	**3.13**	**2.16**	**2.41**	**-----**	**2.83**	**5.35**
Du/s	Depth at flowline before inlet (ft):		0.10	0.10	0.24	0.17	0.19	-----	0.13	0.22
Au/s	Water cross-area before inlet (ft^2):		0.05	0.05	0.38	0.18	0.22	-----	0.19	0.50
Vu/s	Velocity for total discharge before inlet (ft/s):		1.74	1.51	0.41	3.04	3.16	-----	1.07	1.45
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	-----	100%	99%
Se	Equivalent cross-slope (ft/ft):		0.114	0.095	0.077	0.077	0.077	-----	0.047	0.047
GRATE INLETS ON-GRADE:										
Eog	Ratio of grate frontal flow to total flow:		100%	100%	97%	100%	100%	-----	99%	90%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.08	0.08	0.15	0.55	0.70	-----	0.20	0.65
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	-----	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	-----	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.00	0.00	0.00	0.00	0.00	-----	0.00	0.08
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	-----	27	27
Rs	Fraction of side flow interception (Rs):		0%	0%	94%	31%	30%	-----	64%	51%
E	Grate Efficiency (E):		100%	100%	100%	100%	100%	-----	100%	95%
Qi	**Total flow intercepted (ft^3/s):**		**0.08**	**0.08**	**0.15**	**0.55**	**0.70**	**-----**	**0.20**	**0.69**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**-----**	**0.00**	**0.04**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)										
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----
El	Efficiency for providged length L:		-----	-----	-----	-----	-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:										
	Grate Inlets									
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	0.21	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	0.25	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	5.98	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	6.87	-----	-----
	Slotted drains									
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets									
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>						200.00		
g1	approach grade #1 (%):	>						-1.69		
g2	approach grade #2 (%):	>						1.67		
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	60	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	47.32	-----	-----

Not needed, ramp

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 10/28/2013
Checked by: Jeff Tudd ☑ **Date:** 10/29/2013

	Layout Line:		"FR2"	"FR2"	"FR2"	"FR2"
In#	**Inlet number:**		**32e**	**31a**	**33a**	**34a (LP)**
		(Input Data Required)				
HYDROLOGY COMPUTATION:						
St	Structure location station:	>>	228+34	227+59	223+66	222+85
N	Notes		Rt ES	Rt ES	Rt ES	Low Point
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.11	0.12	0.42	0.36
Ar	**Contributing watershed area (acres):**		**0.11**	**0.12**	**0.42**	**0.36**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.31	0.35	1.18	1.01
qq	Previous by-pass flow (ft^3/s):	>		0.00	0.00	0.00
Qadd	Discharge added by operator (ft^3/s):	>				
Qt	**Total discharge Q (ft^3/s):**		**0.31**	**0.35**	**1.18**	**1.01**
SHOULDER AND GUTTER CONFIGURATION:						
n	Manning's n:	>>	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.025	0.034	0.039	0.055
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	2	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	2
ID	Inlet description:	>	G2	G2	HMAOD	G2
	Grate Type:	>>	24-12	24-12		24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1		1
Gw	Grate width (in):	>	24.0	24.0		24.0
Gl	Grate length (in):	>	36.0	36.0		36.0
	3 or 4 sided weir?	>	3	3		3
Lco	Curb opening length provided (ft):	>			10.00	
Ls	Slotted drain length provided: (ft)	>				
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0326	0.0626	0.1060	0.0702
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0597	0.0897	0.1331	0.0973
	Available Flooded Width (ft)	>	14.00	15.00	13.00	25.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**2.82**	**1.84**	**2.04**	**-----**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**1.93**	**1.47**	**1.77**	**-----**
Du/s	Depth at flowline before inlet (ft):		0.12	0.13	0.24	-----
Au/s	Water cross-area before inlet (ft^2):		0.11	0.10	0.21	-----
Vu/s	Velocity for total discharge before inlet (ft/s):		2.82	3.58	5.62	-----
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	-----
Se	Equivalent cross-slope (ft/ft):		0.060	0.090	0.133	-----
GRATE INLETS ON-GRADE:						
Eog	Ratio of grate frontal flow to total flow:		100%	100%	-----	-----
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.31	0.35	-----	-----
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	-----	-----
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	-----	-----
Qs	Side flow in ft^3/s (Qs):		0.00	0.00	-----	-----
Gle	Effective grate length w/ 25% clogging (in):		27	27	-----	-----
Rs	Fraction of side flow interception (Rs):		0%	0%	-----	-----
E	Grate Efficiency (E):		100%	100%	-----	-----
Qi	**Total flow intercepted (ft^3/s):**		**0.31**	**0.35**	**-----**	**-----**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.00**	**-----**	**-----**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)						
Lt	Length required for total interception (ft):		-----	-----	10.11	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	1.2	-----
El	Efficiency for providged length L:		-----	-----	100%	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**0.0**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:						
	Grate Inlets					
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	0.17
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	0.21
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	4.92
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	5.45
	Slotted drains					
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
	Curb opening inlets					
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>				200.00
g1	approach grade #1 (%):	>				-1.50
g2	approach grade #2 (%):	>				6.67
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	24
Df	Flanking inlets distance (ft):		-----	-----	-----	58.10

Not needed, ramp

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 11/4/2013 moved new
Checked by: Jeff Tudd ☑ **Date:** 11/4/2013

	Layout Line:		"FL3N"	"FL3N"	"FL3N"	"FL3N"	"FL3N"	"FL3N"	"FL3N"	"FL3N"
In#	**Inlet number:**		59a (moved)	54a	52k	52i	52g (moved)	52x (new)	52e	52y (new)
		(Input Data Required)								
HYDROLOGY COMPUTATION:										
St	Structure location station:	>>	837+80	835+65	833+65	833+00	832+13	831+40	831+60	831+80
N	Notes		Lt ES flip, relocated	Rt ES	Rt ES	Rt ES	Rt ES, moved	New, Rt ES	Rt ES	New, Rt ES
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.06	0.19	0.17	0.06	0.09	0.06	0.05	0.04
Ar	**Contributing watershed area (acres):**		**0.06**	**0.19**	**0.17**	**0.06**	**0.09**	**0.06**	**0.05**	**0.04**
C	Composite Runoff Coefficient "C":	>>	1	1	1	1	1	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.16	0.54	0.48	0.16	0.26	0.18	0.13	0.12
qq	Previous by-pass flow (ft^3/s):	>		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qadd	Discharge added by operator (ft^3/s):	>								
Qt	**Total discharge Q (ft^3/s):**		**0.16**	**0.54**	**0.48**	**0.16**	**0.26**	**0.18**	**0.13**	**0.12**
SHOULDER AND GUTTER CONFIGURATION:										
n	Manning's n:	>>	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.006	0.018	0.027	0.025	0.0011	0.0062	0.0012	0.0045
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1	1	1	1	1	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1	1	1	1	1	1	1
ID	Inlet description:	>	G2	G2	G2	G2	G2	G2	G2	G2
	Grate Type:	>>	24-12	24-12	24-12	24-12	24-12	24-12	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1	1	1	1	1	1	1
Gw	Grate width (in):	>	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	3 or 4 sided weir?	>	3	3	3	3	3	3	3	3
Lco	Curb opening length provided (ft):	>								
Ls	Slotted drain length provided: (ft)	>								
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0086	0.0617	0.1100	0.1100	0.0539	0.0255	0.0353	0.0451
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.0357	0.0888	0.1371	0.1371	0.0810	0.0526	0.0624	0.0722
	Available Flooded Width (ft)	>	8.00	8.00	4.00	4.00	4.00	4.00	4.00	4.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**6.63**	**2.46**	**1.53**	**1.04**	**3.48**	**3.49**	**3.40**	**2.19**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**2.72**	**1.96**	**1.33**	**0.90**	**2.70**	**2.22**	**2.38**	**1.63**
Du/s	Depth at flowline before inlet (ft):		0.10	0.17	0.18	0.12	0.22	0.12	0.15	0.12
Au/s	Water cross-area before inlet (ft^2):		0.13	0.17	0.12	0.06	0.29	0.13	0.18	0.10
Vu/s	Velocity for total discharge before inlet (ft/s):		1.22	3.16	3.95	2.94	0.89	1.40	0.73	1.20
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%	100%	100%	100%	100%	100%	100%
Se	Equivalent cross-slope (ft/ft):		0.036	0.089	0.137	0.137	0.081	0.053	0.062	0.072
GRATE INLETS ON-GRADE:										
Eog	Ratio of grate frontal flow to total flow:		100%	100%	100%	100%	99%	100%	100%	100%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		0.16	0.54	0.48	0.16	0.26	0.18	0.13	0.12
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88	6.88	6.88	6.88	6.88	6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gle	Effective grate length w/ 25% clogging (in):		27	27	27	27	27	27	27	27
Rs	Fraction of side flow interception (Rs):		52%	0%	0%	0%	81%	55%	83%	0%
E	Grate Efficiency (E):		100%	100%	100%	100%	100%	100%	100%	100%
Qi	**Total flow intercepted (ft^3/s):**		**0.16**	**0.54**	**0.48**	**0.16**	**0.26**	**0.18**	**0.13**	**0.12**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)										
Lt	Length required for total interception (ft):		-----	-----	-----	-----	-----	-----	-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----	-----	-----	-----	-----	-----	-----
El	Efficiency for provided length L:		-----	-----	-----	-----	-----	-----	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:										
	Grate Inlets									
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
	Slotted drains									
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
	Curb opening inlets									
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----	-----	-----	-----	-----	-----
Lc	Length of the vertical curve (ft):	>								
g1	approach grade #1 (%):	>								
g2	approach grade #2 (%):	>								
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----	-----	-----	-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----	-----	-----	-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go ☑ **Date:** 10/28/2013 moved
Checked by: Jeff Tudd ☑ **Date:** 10/29/2013

	Layout Line:		"FL3N"	"FL3N"	"FL3N"
In#	**Inlet number:**		61a	60a (LP)	59c
		(Input Data Required)			
HYDROLOGY COMPUTATION:					
St	Structure location station:	>>	843+35	841+33	839+35
N	Notes		Lt ES	LP	Lt ES HP @ 838+50
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.13	0.33	0.07
Ar	**Contributing watershed area (acres):**		**0.13**	**0.33**	**0.07**
C	Composite Runoff Coefficient "C":	>>	1	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		0.35	0.93	0.19
qq	Previous by-pass flow (ft^3/s):	>		0.00	
Qadd	Discharge added by operator (ft^3/s):	>			
Qt	**Total discharge Q (ft^3/s):**		**0.35**	**0.93**	**0.19**
SHOULDER AND GUTTER CONFIGURATION:					
n	Manning's n:	>>	0.015	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.003	0.003	0.014
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	2	2	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	2	1
ID	Inlet description:	>	HMAOD	HMAOD	G2
	Grate Type:	>>			24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>			1
Gw	Grate width (in):	>			24.0
Gl	Grate length (in):	>			36.0
	3 or 4 sided weir?	>			3
Lco	Curb opening length provided (ft):	>	10.00	10.00	
Ls	Slotted drain length provided: (ft)	>			
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0900	0.0900	0.0593
W	Width of gutter from flowline (in):	>	48.0	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.1171	0.1171	0.0864
	Available Flooded Width (ft)	>	8.00	8.00	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**2.33**	**-----**	**1.81**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**1.98**	**-----**	**1.43**
Du/s	Depth at flowline before inlet (ft):		0.23	-----	0.12
Au/s	Water cross-area before inlet (ft^2):		0.23	-----	0.09
Vu/s	Velocity for total discharge before inlet (ft/s):		1.54	-----	2.15
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	-----	100%
Se	Equivalent cross-slope (ft/ft):		0.117	-----	0.086
GRATE INLETS ON-GRADE:					
Eog	Ratio of grate frontal flow to total flow:		-----	-----	100%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		-----	-----	0.19
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		-----	-----	6.88
Rf	Fraction of frontal flow intercepted (Rf):		-----	-----	1.00
Qs	Side flow in ft^3/s (Qs):		-----	-----	0.00
Gle	Effective grate length w/ 25% clogging (in):		-----	-----	27
Rs	Fraction of side flow interception (Rs):		-----	-----	0%
E	Grate Efficiency (E):		-----	-----	100%
Qi	**Total flow intercepted (ft^3/s):**		**-----**	**-----**	**0.19**
Qb	**Grate flow-by (ft^3/s):**		**-----**	**-----**	**0.00**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)					
Lt	Length required for total interception (ft):		3.05	-----	-----
Ci	Interception for provided length L (ft^3/s):		0.4	-----	-----
El	Efficiency for providged length L:		100%	-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**0.0**	**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:					
	Grate Inlets				
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----
	Slotted drains				
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----	-----
	Curb opening inlets				
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	0.15	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	0.19	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	4.51	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	4.88	-----
Lc	Length of the vertical curve (ft):	>			
g1	approach grade #1 (%):	>			
g2	approach grade #2 (%):	>			
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----	-----
Df	Flanking inlets distance (ft):		-----	-----	-----

SR 4 Balfour Road Interchange

Caltrans Highway Drainage Inlet Calculations

Job: **SR4 Balfour**

Designed by: James Go **Date:** 10/28/2013 moved
Checked by: Jeff Tudd **Date:** 10/29/2013

	Layout Line:		"FL2N"	"FL2N"
In#	**Inlet number:**		53a	48a (moved)
		(Input Data Required)		
HYDROLOGY COMPUTATION:			Lt ES	Lt ES
St	Structure location station:	>>	740+61	741+53
N	Notes			
	Off-site contributing watershed area (acres):	>>	**0.00**	**0.00**
	On-site contributing watershed area (acres):	>>	0.61	0.28
Ar	**Contributing watershed area (acres):**		**0.61**	**0.28**
C	Composite Runoff Coefficient "C":	>>	1	1
Ic	Precipitation intensity (in/hr):	>>	2.8	2.8
Qa	Subarea discharge Q (ft^3/s):		1.70	0.77
qq	Previous by-pass flow (ft^3/s):	>		0.00
Qadd	Discharge added by operator (ft^3/s):	>		
Qt	**Total discharge Q (ft^3/s):**		**1.70**	**0.77**
SHOULDER AND GUTTER CONFIGURATION:				
n	Manning's n:	>>	0.015	0.015
S	Longitudinal slope S (ft/ft):	>>	0.028	0.002
IT	Inlet type (1=grate, 2=curb opening, 3=slotted):	>>	1	1
LP	Longitudinal profile (1=on-grade, 2=sag):	>>	1	1
ID	Inlet description:	>	G2	G2
	Grate Type:	>>	24-12	24-12
	Standard Gutter Depression (1=SGD, 2=no SGD)	>	1	1
Gw	Grate width (in):	>	24.0	24.0
Gl	Grate length (in):	>	36.0	36.0
	3 or 4 sided weir?	>	3	3
Lco	Curb opening length provided (ft):	>		
Ls	Slotted drain length provided: (ft)	>		
Sx	Shoulder cross-slope Sx (ft/ft):	>>	0.0942	0.0539
W	Width of gutter from flowline (in):	>	48.0	48.0
a(t)	Gutter depression from horizontal (in):	>	1.3	1.3
Sw	Gutter cross-slope Sw (ft/ft): (S'w=Sw-Sx) (Sw=Sx if no gutter)		0.1213	0.0810
	Available Flooded Width (ft)	>	16.60	8.00
Tu/s	**Flooded Width from flowline (ft): at inlet w/o gutter depression**		**2.68**	**4.53**
Tu/s	**Flooded Width from flowline (ft): at inlet w/ gutter depression**		**2.29**	**3.51**
Du/s	Depth at flowline before inlet (ft):		0.28	0.28
Au/s	Water cross-area before inlet (ft^2):		0.32	0.50
Vu/s	Velocity for total discharge before inlet (ft/s):		5.35	1.55
Eod	Ratio of gutter depression flow to total Q (Eod):		100%	100%
Se	Equivalent cross-slope (ft/ft):		0.121	0.081
GRATE INLETS ON-GRADE:				
Eog	Ratio of grate frontal flow to total flow:		100%	95%
Qw	Inlet frontal flow in ft^3/s (Qw): at inlet w/ gutter depression		1.69	0.73
Vo	Vo for effective length (P-50, Chart 5) (ft/s):		6.88	6.88
Rf	Fraction of frontal flow intercepted (Rf):		1.00	1.00
Qs	Side flow in ft^3/s (Qs):		0.00	0.04
Gle	Effective grate length w/ 25% clogging (in):		27	27
Rs	Fraction of side flow interception (Rs):		20%	61%
E	Grate Efficiency (E):		100%	98%
Qi	**Total flow intercepted (ft^3/s):**		**1.70**	**0.76**
Qb	**Grate flow-by (ft^3/s):**		**0.00**	**0.02**
SLOTTED DRAINS AND CURB OPENING INLETS ON-GRADE: (No clogging factor)				
Lt	Length required for total interception (ft):		-----	-----
Ci	Interception for provided length L (ft^3/s):		-----	-----
El	Efficiency for providged length L:		-----	-----
Qs	**Slotted drain or side opening flow-by (ft^3/s):**		**-----**	**-----**
INTERCEPTION CAPACITY OF INLETS IN SAG LOCATION:				
	Grate Inlets			
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----
	Slotted drains			
d_{33}	Depth of ponding at inlet (33% Clogging - Freeway)(ft):		-----	-----
d_{50}	Depth of ponding at inlet (50% Clogging City St)(ft):		-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----
	Curb opening inlets			
d_{33}	Depth of ponding at inlet (Weir, 33% Clogging - Freeway)(ft):		-----	-----
d_{50}	Depth of ponding at inlet (Weir, 50% Clogging City St)(ft):		-----	-----
w_{33}	Ponded width at inlet (33% Clogging - Freeway)(ft):		-----	-----
w_{50}	Ponded width at inlet (50% Clogging City St)(ft):		-----	-----
Lc	Length of the vertical curve (ft):	>		
g1	approach grade #1 (%):	>		
g2	approach grade #2 (%):	>		
K	K = Min(Lc/(Diff(g1,g2),167) (Table 4-7, HEC-22):		-----	-----
Df	Flanking inlets distance (ft):		-----	-----

Appendix J Sharp-Crested Weir Calculations

P12056: SR4/Balfour Road

Sharp-crested weir calculations

$Q = (2/3)(C_1)(b)((2g)^{0.5})(H^{1.5})$

Q =	flow	cfs
C_1 =	coefficient of discharge	
b =	effective width (circumference of riser)	ft
g =	acceleration due to gravity	ft/s^2
H =	total hydraulic head	ft

"B2RS" 984+20 (B1N Riser 1)

Q =	6.11	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.28**	**ft**

DS23a "B2RN" 519+46 (B2 Riser)

Q =	1.61	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.11**	**ft**

"B2RN" 548+20 (B7S Riser 1)

Q =	2.24	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.14**	**ft**

"B2RS" 992+40 (B1N Riser 2)

Q =	6.13	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.28**	**ft**

DS24a "FL1N" 622+37 (B3 Riser)

Q =	1.38	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.10**	**ft**

"B2RN" 552+20 (B7S Riser 2)

Q =	0.84	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.07**	**ft**

"B2RS" 992+60 (B1N Riser 3)

Q =	2.05	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.13**	**ft**

"FR1" 124+50 (B4 Riser)

Q =	6.00	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.27**	**ft**

"B2RN" 554+00 (B7 Riser 3)

Q =	0.99	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.08**	**ft**

"B2RS" 996+75 (B1S Riser 4)

Q =	5.67	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.26**	**ft**

"B2RN" 559+50 (B13 Riser 4)

Q =	2.00	cfs
C_1 =	0.62	
r =	2	ft
b =	12.57	ft
g =	32.2	ft/s^2
H =	**0.13**	**ft**