Newlin Gulch Major Drainageway Plan

October 2015

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY
COLORADO

Town of Parker COLORADO

MULLER

October 14, 2015

MULLER
Muller Engineering Company, Inc.
Consulting Engineers

Ms. Shea Thomas, P.E.
Senior Project Engineer, Master Planning
Urban Drainage and Flood Control District
2480 West 26th Avenue, Suite 156 B
Denver, Colorado 80211-5301

RE: Newlin Gulch Major Drainageway Plan
Conceptual Design Report
Agreement No. 12-09.02

Dear Ms. Thomas:

Muller Engineering Company is pleased to submit the final Conceptual Design Report for the Newlin Gulch Major Drainageway Plan. The watershed was previously studied in a 1993 OSP by Kiowa Engineering. In recent years, the completion of Rueter-Hess Reservoir has substantially altered the hydrology of the watershed. This study is therefore well-timed to guide future improvements within the watershed.

The updated baseline hydrology recognizes the flood detention benefits of Rueter-Hess Reservoir, resulting in lower peak flow rates along the length of the study reach. The alternative analysis presented a discussion of problem areas and proposed solutions, with a focus on alternatives for improving the Recreation Drive at-grade crossing and recommendations for stream stabilization improvements. The conceptual design incorporates comments provided by the sponsors in the Selected Plan and further develops the concepts explored in the alternative analysis. Overall, the plan focuses on improvements that preserve the natural beneficial functions of a healthy stream.

Phasing and prioritization recommendations have been provided and aim to first address safety risks at Recreation Drive. Improvements are then prioritized to address stream stability problems near existing infrastructure.

We have appreciated the opportunity to work with you and the other sponsors on this plan, and look forward to its implementation.

Sincerely,

MULLER ENGINEERING COMPANY, INC.

Derek D. Johns, PE
Project Manager

Melanie D. Chenard, PE
Project Engineer

Sam Rogers
Design Engineer

Table of Contents

EXECUTIVE SUMMARY ES-1

1 INTRODUCTION 1-1

1.1 AUTHORIZATION 1-1
1.2 PURPOSE AND SCOPE 1-1
1.3 PLANNING PROCESS 1-1
1.4 MAPPING AND SURVEYS 1-2
1.5 DATA COLLECTION 1-2
1.6 ACKNOWLEDGEMENTS 1-3

2 STUDY AREA DESCRIPTION 2-1

2.1 PROJECT AREA 2-1
2.2 LAND USE 2-1
2.3 REACH DESCRIPTION 2-2
2.4 FLOOD HISTORY 2-5
2.5 ENVIRONMENTAL ASSESSMENT 2-5

3 HYDROLOGIC ANALYSIS 3-1

3.1 OVERVIEW 3-1
3.2 DESIGN RAINFALL 3-1
3.3 SUBWATERSHED CHARACTERISTICS 3-2
3.4 HYDROGRAPH ROUTING 3-2
3.5 PREVIOUS STUDIES 3-3
3.6 MODEL CALIBRATION 3-3
3.7 RESULTS OF ANALYSIS 3-5

4 HYDRAULIC ANALYSIS 4-1

4.1 EVALUATION OF EXISTING FACILITIES 4-1
4.2 FLOOD HAZARDS AND PROBLEM AREAS 4-1
4.3 PREVIOUS ANALYSES 4-2

5 ALTERNATIVE ANALYSIS 5-1

5.1 ALTERNATIVE DEVELOPMENT PROCESS 5-1
5.2 CRITERIA AND CONSTRAINTS 5-1
5.3 ALTERNATIVE HYDRAULICS 5-1
5.4 ALTERNATIVE COSTS 5-1
5.5 ALTERNATIVE PLANS 5-2
5.6 QUALITATIVE EVALUATION PROCEDURE 5-6

6 RECOMMENDED PLAN 6-1

6.1 PLAN DESCRIPTION 6-1
6.2 WATER QUALITY IMPACTS 6-3
6.3 OPERATIONS AND MAINTENANCE 6-3
6.4 ENVIRONMENTAL AND SAFETY ASSESSMENT 6-3

7 CONCEPTUAL DESIGN 7-1

7.1 PLAN DEVELOPMENT OVERVIEW 7-1
7.2 MASTER PLAN DESCRIPTION 7-3
7.3 PRIORITIZATION AND PHASING 7-11
7.4 WATER QUALITY IMPACTS 7-12
7.5 OPERATIONS AND MAINTENANCE 7-12
7.6 ENVIRONMENTAL AND SAFETY ASSESSMENT 7-12

8 REFERENCES 8-1

APPENDIX A: PROJECT CORRESPONDENCE

APPENDIX B: HYDROLOGIC ANALYSIS

APPENDIX C: RUETER-HESS RESERVOIR ROUTING ANALYSIS

APPENDIX D: RUETER-HESS ADEQUATE ASSURANCES AGREEMENT

APPENDIX E: HYDRAULIC ANALYSIS

APPENDIX F: LEGAL OPINION

APPENDIX G: WETLAND AND RIPARIAN INVENTORY

APPENDIX H: ALTERNATIVES ANALYSIS

APPENDIX I: CONCEPTUAL DESIGN INFORMATION

APPENDIX J: MASTER PLAN MAPS

APPENDIX K: MASTER PLAN PROFILES

List of Figures

Figure ES-1: Vicinity Map ES-1
Figure ES-2: Watershed Map ES-2
Figure ES-3: Master Plan Schematic – Reaches 1-3 ..... ES-5
Figure ES-4: Master Plan Schematic – Reaches 4-6 ..... ES-6
Figure 2-1: Vicinity Map 2-1
Figure 2-2: Reach Map 2-2
Figure 5-1: Recreation Drive Alternative A 5-3
Figure 5-2: Recreation Drive Alternative B 5-4
Figure 5-3: Recreation Drive Alternative C 5-5
Figure 6-1: Recommended Plan – Reaches 1-3 6-4
Figure 6-2: Recommended Plan – Reaches 4-6 6-5
Figure 7-1: Master Plan Schematic – Reaches 1-3 7-1
Figure 7-2: Master Plan Schematic – Reaches 4-6 7-2

Figure B-1: Hydrology Map B-1
Figure B-2: SWMM Schematic – Upper Watershed B-8
Figure B-3: SWMM Schematic – Lower Watershed B-9
Figure B-4: Existing Development Hydrographs B-10
Figure B-5: Future Development Hydrographs B-11
Figure B-6: Peak Flow Profile – Existing Development B-12
Figure B-7: Peak Flow Profile – Future Development B-13

Figure E-1: Floodplain and Problem Areas – Reaches 1-3 ..... E-1
Figure E-2: Floodplain and Problem Areas – Reaches 4-6 ..... E-2

Figure G-1: Wetland and Riparian Areas – Reaches 1-3 ..... G-1
Figure G-2: Wetland and Riparian Areas – Reaches 4-6 ..... G-2

Figure I-1: Recreation Drive Conceptual Design Plan I-1
Figure I-2: Typical Channel Details I-2

List of Tables

Table ES-1: Project Participants ES-1
Table ES-2: Hydrologic Summary ES-2
Table ES-3: Master Plan Cost Summary by Reach ES-4
Table ES-4: Master Plan Cost Summary by Jurisdiction ES-4

Table 1-1: Project Meetings 1-2
Table 1-2: Project Participants 1-3
Table 2-1: Major Crossing Inventory 2-4
Table 3-1: Point Rainfall Depths 3-1
Table 3-2: Depth Reduction Factors 3-2
Table 3-3: Model Calibration 3-4
Table 3-4: Comparison to Previous Studies 3-5
Table 4-1: Existing Crossing Capacity 4-1
Table 4-2: Overtopping Depths at Recreation Drive 4-2
Table 5-1: Unit Costs 5-2
Table 5-2: Alternative Cost Summary 5-6
Table 5-3: 100-Year Alternative Overtopping Depths at Recreation Drive 5-6
Table 5-4: Challenger Park West Parking Lot Flooding Depths 5-7
Table 5-5: Alternative Evaluation Summary Matrix at Recreation Drive 5-8
Table 6-1: Existing Channel Slope Analysis 6-2
Table 6-2: Recommended Stable Channel Slopes 6-2
Table 6-3: Recommended Plan Cost Summary 6-3
Table 7-1: Master Plan Cost Estimate Summary 7-1
Table 7-2: Reach 1 Cost Estimate 7-3
Table 7-3: Reach 2 Cost Estimate 7-5
Table 7-4: Reach 3 Cost Estimate 7-7
Table 7-5: Reach 4 Cost Estimate 7-8
Table 7-6: Reach 5 Cost Estimate 7-9
Table 7-7: Reach 6a Cost Estimate 7-10
Table 7-8: Reach 6b Cost Estimate 7-11

Table B-1: Rainfall Distributions B-2
Table B-2: CUHP Input ..... B-3 through B-5
Table B-3: Detention Rating Curves B-6
Table B-4: Peak Flow Rates ..... B-14 through B-15
Table B-5: Runoff Volumes – Existing Development B-16
Table B-6: Runoff Volumes – Future Development B-17
Table B-7: Sample SWMM Input ..... B-18 through B-29
Table B-8: Sample SWMM Output ..... B-30 through B-41

Table C-1: Rueter-Hess Reservoir Routing Alternatives C-6

Table E-1: Manning's n Values E-3

EXECUTIVE SUMMARY

Purpose and Objective

The Newlin Gulch Major Drainageway Plan (MDP) is a cooperative master planning effort between Urban Drainage and Flood Control District (UDFCD), the Town of Parker, and Douglas County. The plan focuses on approximately 4 miles of Newlin Gulch, from its confluence with Cherry Creek to the downstream side of Rueter-Hess reservoir. The objective of the plan is to update the watershed hydrology, identify issues and concerns along the drainageway, and develop conceptual plans for future stormwater improvements within the study area.

Previously, the watershed was studied and recommendations made for the basin in the Newlin and Baldwin Gulches and Basin 4600-09 Outfall Systems Planning Study (OSP), published in August 1993 by Kiowa Engineering Corporation.

Planning Process

The Major Drainageway Plan was completed in three phases: the Baseline Hydrology phase, which was completed in March 2015; the Alternatives Analysis phase, completed in June 2015; and the Conceptual Design phase, which was completed in October 2015.

The Newlin Gulch Major Drainageway Plan has been prepared with the coordination and input of numerous parties. Periodically throughout the process, project meetings have been conducted to present progress and gather input from the project sponsors and stakeholders, listed in Table ES-1. Public notification was conducted in May 2015 via a mailing to residents and businesses adjacent to the channel.

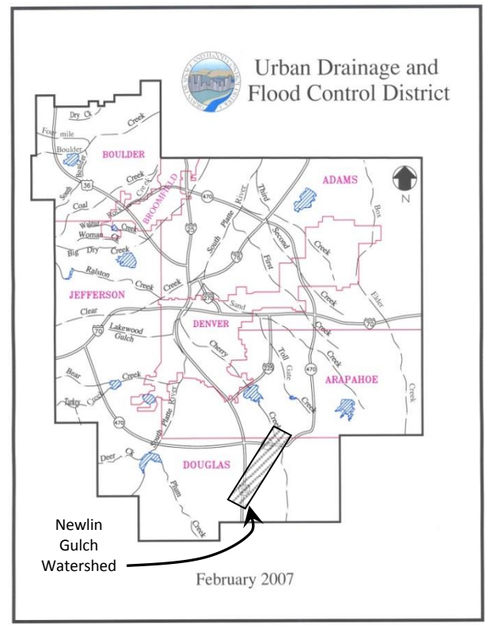
Table ES-1: Project Participants

Project Sponsors	**Agency**
Shea Thomas	Urban Drainage and Flood Control District
Brad Robenstein	Douglas County
Tom Williams	Town of Parker
Jacob James	Town of Parker
Project Stakeholders	**Agency**
Brad Meyering	City of Castle Pines
Pieter Van Ry	Parker Water and Sanitation District
Jim Swanson	Cherry Creek Basin Water Quality Authority
Ron Lambert	Stonegate Village Metropolitan District
Scott Barnett	Stonegate Village Metropolitan District

Project Area Description

The 15.0 square mile Newlin Gulch watershed has its headwaters in the City of Castle Pines, located along I-25 about 3½ miles north of Castle Rock. The creek and its tributaries flow in a northeasterly direction through areas of Castle Pines, unincorporated Douglas County, and the Town of Parker before emptying into Cherry Creek near Challenger Park in the Town of Parker. The location of the Newlin Gulch watershed within the UDFCD boundary is shown in Figure ES-1.

Figure ES-1: Vicinity Map



Hydrologic modeling was conducted using CUHP version 1.3.3 and EPA SWMM 5.0. A primary goal of the hydrologic modeling was to determine the impact of Rueter-Hess Reservoir on peak flow rates in the channel downstream. Though flood control is not an intended function of the reservoir, its 1.8 square mile projected maximum normal pool has significant influence on the conveyance of upstream flows through the reservoir. Numerous routing scenarios were evaluated and are documented in a May 2013 memorandum entitled *Rueter-Hess Reservoir Flood Control Benefits*. The outcome of this evaluation was a recognition that the inadvertent flood control benefits of the reservoir should be recognized in the design of channel improvements and administration of the floodplain downstream of the reservoir. This recognition was formalized in an agreement with Parker Water and Sanitation District, the owner and operator of the reservoir.

The updated hydrology indicated an increase in flow rates in the upper portions of the watershed when compared with previous studies. This is in part due to increased projections of future development within the watershed, and also due to changes in standard methods of hydrologic modeling that have occurred since the previous studies were conducted. However, the inclusion of the Rueter-Hess Reservoir had a substantial impact on the lower watershed, resulting in peak flow rates much lower than those used in the 1993 OSP. A summary of results is shown in Table ES-2.

Figure ES-2: Watershed Map

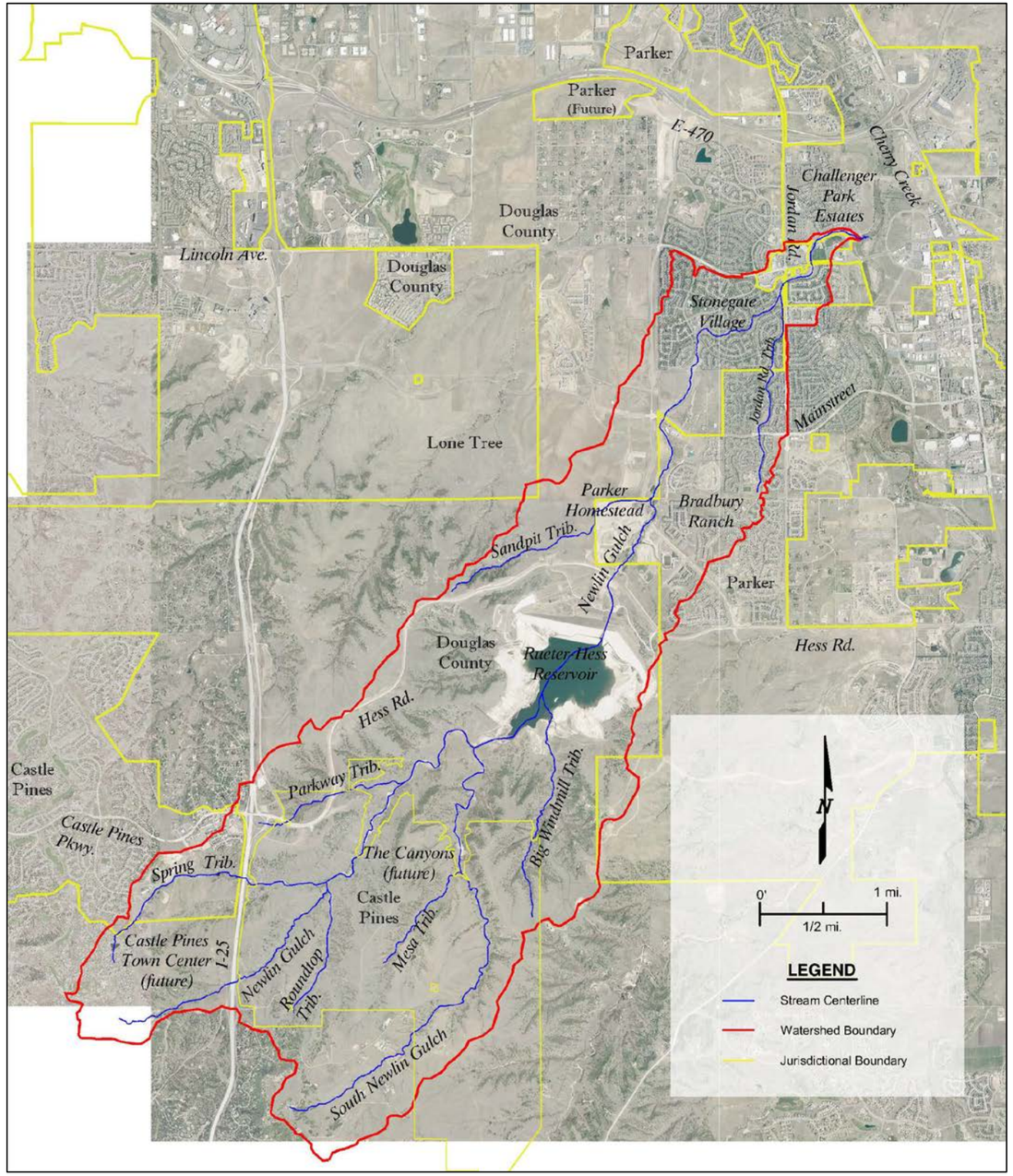


Table ES-2: Hydrologic Summary

Location	1977 FHAD * 100-Yr (cfs)	1993 OSP ** 100-Yr Existing (cfs)	1993 OSP ** 100-Yr Future (cfs)	Current Study 100-Yr Existing (cfs)	Current Study 100-Yr Future (cfs)
Newlin Gulch					
Cherry Creek	4790	5357	5513	2843	3539
Lincoln Ave. (U/S)		5198	5396	2795	3450
Jordan Rd. (U/S)	4720	5220	5412	2793	3443
Stonegate Parkway (U/S)				2212	2660
Mainstreet (U/S)	4590	5330	5545	1945	2244
Chambers Rd. (U/S)				905	1029
Hess Rd.				890	1015
Rueter-Hess Reservoir Outflow				880	999
RH Total Inflow (Including Reservoir Subwatershed)				8822	10362
Mainstem and Tributary Inflow to RH		4969	5138	5871	7649
Mainstem Inflow to RH				2454	3256
I-25 (U/S)		321	311	426	514

Much of the study reach lies in open space tracts that were established based on the pre-Rueter-Hess floodplain, and the remainder is in undeveloped land. Since existing infrastructure and channel improvements were based on higher peak flow rates, hydraulic analysis of the channel and its crossings generally did not indicate any hydraulic deficiencies along the study reach. The exception is Recreation Drive, which was identified by the sponsors as a priority for this study. Recreation Drive is an at-grade crossing located near the downstream end of the watershed. This configuration poses a public safety hazard and requires frequent closure of the road.

Alternative Analysis

With few hydraulic concerns in the study reach, the alternative analysis focused on the Recreation Drive crossing. A 100-year crossing would not be feasible without significant impact to the adjacent facilities at Challenger Regional Park; therefore, the sponsors chose a 10-year storm as the target crossing capacity. The current configuration, with its lack of depth available on the right overbank, causes flow to spill along Recreation Drive East and around the right bank crest of a downstream grouted boulder drop structure. Containment of the 100-year flow was identified as a secondary goal of the plan. To address these issues, three alternatives were evaluated:

- Alternative A: 10-year Crossing at Existing Invert
- Alternative B: 10-year Crossing at Existing Invert with 100-year Flood Containment
- Alternative C: 10-year Crossing with Lowered Invert and 100-Year Flood Containment

To address channel stabilization needs in the rest of the study reach, multiple alternatives were not considered.

Master Plan

The master plan improvements for Newlin Gulch were selected to meet the primary MDP objectives of minimizing stormwater and flood-related damages while balancing development in the watershed with stormwater management in a manner that benefits water quality, the natural character and habitat resources of the waterways, and public recreation. Future channel stabilization measures have been identified based on anticipated long-term equilibrium or stable channel slopes in each reach. Though some areas of Newlin Gulch are currently stable or aggrading, the plan anticipates vulnerabilities that could arise due to continuing development within the watershed and/or stabilization of currently degrading reaches. At Recreation Drive, the plan includes a 10-year crossing at the existing invert with 100-year flood containment. Other improvements have been recommended to address problem areas and to provide maintenance access throughout the study area. The master plan improvements for each reach are summarized below.

Reach 1 – Challenger Park Estates

Improvements in Reach 1 are primarily associated with the Recreation Drive improvements in Reach 2; these include the provision of 100-year containment at the grouted boulder drop structure downstream of the crossing and channel grading in that vicinity. Riprap aprons are recommended to address scour at existing vertical drop structures. Additional channel stabilization is not needed.

Reach 2 – Challenger Regional Park

The 10-year capacity grade separated crossing at Recreation Drive is located in Reach 2. The crossing will consist of a four-cell 20' x 2.5' concrete box culvert set at the existing at-grade crossing invert. Related improvements will provide containment of the 100-year flow rate as the crossing is overtopped; these include road profile modifications and the construction of a berm in the right overbank. Channel excavation adjacent to Challenger Regional Park's west parking lot will provide 2-year capacity adjacent to the lot. Two 2.0-foot grade control structures will allow for an anticipated long-term stable slope of 0.15%.

Reach 3 – Stonegate Village

The anticipated long-term stable slopes in Reach 3 are 0.15% and 0.25% downstream and upstream of Stonegate Parkway, respectively. Recent channel stabilization projects have provided for these slopes in some areas; additional stabilization is needed for three segments. Between Lincoln Avenue and Jordan Road three 1.5-foot drop structures will provide a 0.15% slope; bank protection is also recommended upstream of Lincoln Avenue. A central segment near Stone Willow Park is currently stable with an average slope of 0.7%; the plan anticipates a long-term stable slope of 0.15% and includes four 2.0-foot drop structures. The third segment requiring additional stabilization is immediately upstream of Stonegate Parkway, where active degradation is occurring. Two 3.3-foot drop structures in this segment will provide a long-term stable slope of 0.25%.

Other improvements in Reach 3 include channel excavation near the Jordan Road bridge, channel widening near the confluence with the Jordan Road Tributary, and extension of the recreational/maintenance trail.

Reach 4 – Newlin Crossing

The upper portion of Reach 4 was previously stabilized to 0.56% slope but has been degrading some. The lower portion was previously stabilized to 0.25% slope and has remained stable. Modification of three existing drop structures in the steeper section is recommended to provide a 0.25% slope throughout. Provision of a recreational / maintenance trail is also recommended in this reach.

Reach 5 – Mainstreet to Chambers Road

Twelve 2.5-foot drop structures are recommended in Reach 5 to provide a long-term stable slope of 0.25%. The reach is currently stable or aggrading, though degradation has been occurring downstream of an existing check structure near Chambers Road. Bank protection is recommended at several outer channel bends, and a recreational / maintenance trail is planned along the reach. Water quality concerns in this reach are reflected in the master plan, including the clearing of fencing and debris from the channel and disallowance of the land application of horse manure in the floodplain.

Reach 6 – Chambers Road to Hess Road

Reach 6 is subdivided into Reach 6a and 6b to reflect jurisdictional boundaries. The master plan improvements include a 4.0-foot drop structure in 6b just downstream of Hess Road to address current degradation, and eleven 2.0-foot to 3.0-foot drop structures to provide a long-term stable slope of 0.25% (nine in 6a and two in 6b). Maintenance access is needed for Reach 6b.

A summary of costs for the master plan improvements by reach is included in **Table ES-3**; a summary by jurisdiction is included in **Table ES-4**.

Implementation Priority

Master plan improvements should be implemented according to the following priorities:

- Priority 1: Address current health and safety hazards at Recreation Drive
- Priority 2: Address nuisance issues and maintenance needs
- Priority 3: Provide grade control in key areas of current need
- Priority 4: Construct improvements as need arises or as development progresses

A schematic of master plan improvements is shown in **Figure ES-3** and **Figure ES-4**.

Table ES-3: Master Plan Cost Summary by Reach

REACH	CAPITAL	EASEMENT / ROW	ENGINEERING	LEGAL / ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	TOTAL CAPITAL COST	ANNUAL O&M COST	50-YEAR O&M COST
NG-Reach1	$262,107.00	$43,560.00	$39,316.00	$13,105.00	$26,211.00	$65,527.00	$449,826.00	$21,348.00	$458,602.00
NG-Reach2	$1,478,298.00	$0.00	$221,745.00	$73,915.00	$147,830.00	$369,575.00	$2,291,363.00	$10,325.00	$221,804.00
NG-Reach3	$2,041,918.00	$0.00	$306,288.00	$102,096.00	$204,192.00	$510,480.00	$3,164,974.00	$85,670.00	$1,840,379.00
NG-Reach4	$275,455.00	$0.00	$41,318.00	$13,773.00	$27,546.00	$68,864.00	$426,956.00	$21,711.00	$466,400.00
NG-Reach5	$3,493,682.00	$0.00	$524,052.00	$174,684.00	$349,368.00	$873,421.00	$5,415,207.00	$52,782.00	$1,133,873.00
NG-Reach6a	$1,996,156.00	$0.00	$299,423.00	$99,808.00	$199,616.00	$499,039.00	$3,094,042.00	$23,883.00	$513,059.00
NG-Reach6b	$654,124.00	$0.00	$98,119.00	$32,706.00	$65,412.00	$163,531.00	$1,013,892.00	$12,554.00	$269,687.00
Totals	**$10,201,740**	**$43,560**	**$1,530,261**	**$510,087**	**$1,020,175**	**$2,550,437**	**$15,856,260**	**$228,273**	**$4,903,804**

Table ES-4: Master Plan Cost Summary by Jurisdiction

JURISDICTION	CAPITAL	EASEMENT / ROW	ENGINEERING	LEGAL / ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	TOTAL CAPITAL COST	ANNUAL O&M COST	50-YEAR O&M COST
Douglas County	$4,449,795	$0	$667,470	$222,490	$444,980	$1,112,450	$6,897,185	$130,260	$2,798,270
Town of Parker	$5,751,945	$43,560	$862,791	$287,597	$575,195	$1,437,987	$8,959,075	$98,013	$2,105,534
Totals	**$10,201,740**	**$43,560**	**$1,530,261**	**$510,087**	**$1,020,175**	**$2,550,437**	**$15,856,260**	**$228,273**	**$4,903,804**

REACH 1

REACH 2

REACH 3

REACH 4

Cherry Creek

Douglas County

Town of Parker

Douglas County

Challenger Park

Lincoln Ave

Jordan Road

Jordan Road Tributary

EXCAVATE BOTTOM OF CHANNEL

GRADE-SEPARATED 10-YEAR CROSSING (FOUR-CELL 20' X 2.5' CONCRETE BOX CULVERT)

INSTALL RIPRAP APRONS AT EXISTING VERTICAL WALL DROP STRUCTURES TO MITIGATE SCOUR

SEDIMENT CLEANOUT UNDER BRIDGE

RE-GRADE AND WIDEN CHANNEL ON WEST BANK

Recreation Drive

Newlin Gulch

Stonegate Village Metropolitan District

Challenger Park Estates

Town of Parker

Stonegate Village Metropolitan District

Keystone Blvd

Douglas County

Stonegate Pkwy

MATCHLINE - SHEET 2 OF 2

LEGEND

- 100-YEAR FLOODPLAIN (2015 FHAD)
- 100-YEAR FLOODPLAIN (MASTER PLAN)
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED BANK PROTECTION
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED CHANNEL

0' 150' 300' 600'

NOTE:
PROPOSED DROP STRUCTURE LOCATIONS AND SIZES IN REACH 3 UPSTREAM OF JORDAN ROAD ARE BASED ON THE "NEWLIN GULCH CHANNEL IMPROVEMENTS UPDATED CONCEPTUAL DESIGN REPORT" PREPARED JUNE 23, 2011 BY MULLER ENGINEERING FOR DOUGLAS COUNTY, STONEGATE VILLAGE METRO DISTRICT, AND UDFCD.

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

MASTER PLAN SCHEMATIC
REACHES 1-3

DATE SEPT 2015
FIGURE NO. ES-3

DATE: OCT 14, 2015 TIME: 10:02 AM
NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_SCHEMATIC.dwg

REACH 4

REACH 5

REACH 6A

REACH 6B

Newlin Gulch Blvd

Town of Parker

Douglas County

Newlin Gulch

Chambers Road

Mainstreet

Hess Road

RE-GRADE CHANNEL SLOPE

MODIFY EXISTING DROP STRUCTURES

LOW-WATER TRAIL CROSSING AND DROP STRUCTURE TO BE BUILT IN 2016

LOW-WATER TRAIL CROSSING (TO BE BUILT IN 2015)

MATCHLINE - SHEET 1 OF 2

0' 150' 300' 600'

LEGEND

- 100-YEAR FLOODPLAIN (2015 FHAD)
- 100-YEAR FLOODPLAIN (MASTER PLAN)
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED BANK PROTECTION
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED CHANNEL

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

MASTER PLAN SCHEMATIC
REACHES 4-6

DATE SEPT 2015

FIGURE NO. ES-4

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_SCHEMATIC.dwg DATE: SEP 08, 2015 TIME: 11:45 AM

1 INTRODUCTION

1.1 AUTHORIZATION

The Urban Drainage and Flood Control District (UDFCD), in agreement with Douglas County and the Town of Parker, contracted with Muller Engineering Company, Inc. to conduct a Major Drainageway Plan (MDP) for Newlin Gulch. The work is authorized under UDFCD Agreement No. 12-09.02, dated November 13, 2012.

Amendment 1 (Agreement No. 12-09.02A), dated July 29, 2013, accounted for additional effort required to properly develop the baseline hydrology, and added a Flood Hazard Area Delineation (FHAD) to the scope of work.

1.2 PURPOSE AND SCOPE

The Newlin Gulch watershed was last studied in the Newlin and Baldwin Gulches and Basin 4600-09 Outfall Systems Planning Study (OSP), published in August 1993 by Kiowa Engineering Corporation. The Newlin Gulch floodplain was previously studied in a 1977 Flood Hazard Area Delineation (FHAD) prepared by Howard, Needles, Tammen & Bergendoff along with Happy Canyon Creek, Baldwin, Sulphur, and Tallman Gulches. The FHAD was prepared concurrently with a study for the U.S Department of Housing and Urban Development, Federal Insurance Administration. The HUD-FIA study established the initial regulatory floodplain. Several Letter of Map Revision (LOMR) updates to the floodplain have been incorporated since that time.

UDFCD typically updates master plans every 20-30 years based on requests and support from local governments. In the case of the Newlin Gulch watershed, significant development in the lower portion of the watershed within the Town of Parker and unincorporated Douglas County has occurred since the 1993 OSP. More development is expected in the near future, in particular in the City of Castle Pines in the upper portion of the watershed as construction begins on the Canyons Development. The most dramatic change to the watershed has been the recent construction of the Rueter-Hess Reservoir, a large water storage reservoir. The large normal pool (1.7 square miles) impacts the hydrology of the lower two-thirds of the watershed. This update is therefore well-timed to help guide channel improvements, address flooding concerns in conjunction with development, and reflect the impact of Rueter-Hess Reservoir on hydrology and channel stability.

The overall scope of work for the MDP includes the following main tasks:

1. Meet periodically with the project sponsors and other stakeholders to exchange information and to solicit input and direction.

2. Set up and maintain a project web site to present information and receive input from interested parties.

3. Collect and review available reports and studies related to existing and proposed stormwater facilities, local hydrology, floodplains, current and future land use, and water quality.

4. Review the 1993 hydrologic model and create new historic, existing, and future land-use hydrologic models using the latest versions of CUHP and SWMM. Include current publicly-maintained regional detention facilities, account for the increased imperviousness and inadvertent flood storage of Rueter-Hess Reservoir, and reflect other watershed conditions that currently exist.

5. Perform hydraulic calculations necessary to assess the adequacy of existing stormwater facilities and to size alternative improvement plans.

6. Identify existing and potential future drainage, erosion, water quality, and flooding problems in the project area, including a general identification of wetland and riparian zones and potential detention sites.

7. Formulate and evaluate conceptual alternative plans to address drainage, erosion, water quality, and flood hazard problems associated with the drainageway, considering probable costs, water quality effects, and maintenance aspects.

8. Prepare a draft alternatives analysis report to document the formulation and evaluation of alternative plans and to recommend a preferred alternative, review with project sponsors and stakeholders, and revise to address the comments received.

9. Undertake a conceptual design of the selected alternative and prepare drawings and probable cost information for the plan, documenting in a draft, then final conceptual design report.

A FHAD was also authorized under the same agreement, and will be presented in a separate document.

1.3 PLANNING PROCESS

Based on input from the project sponsors and on observations of the current condition of various reaches of Newlin Gulch, the following main objectives for this master plan were identified:

- Determine the impact of the Rueter-Hess Reservoir on existing and future peak flow rates. Use the hydrologic models as the basis for an agreement with the reservoir concerning flood storage and discharge.

- Estimate the existing and future floodplain downstream of Rueter-Hess using the updated hydrology.

- Identify floodplain and channel stability concerns associated with the new development and develop appropriate alternatives to address the issues.

- Develop conceptual design improvements to be implemented with adjacent development.

- Achieve the objectives of project sponsors and stakeholders while preserving a natural channel character and supporting riparian vegetation communities and resident wildlife habitat

Periodic meetings were held to gather input from project sponsors and stakeholders. A summary of project meetings is shown in **Table 1-1**; meeting minutes are included in **Appendix A**.

Table 1-1: Project Meetings

Meeting	Date	Purpose
Kickoff Meeting	November 19, 2012	Review project scope and project approach, identify information needs
Progress Meeting #2	March 18, 2013	Hydrology status update, review land use assumptions, review SWMM and CUHP model assumptions
Progress Meeting #3	May 15, 2013	Discuss course of action relative to Rueter-Hess Reservoir Routing and Adequate Assurances Agreement with PWSD
Progress Meeting #4	December 17, 2014	Restart project following hiatus while Rueter-Hess Adequate Assurances Agreement was being coordinated and approved
Progress Meeting #5	March 2, 2015	Discussion of issues pertaining to FHAD modeling, discuss approach / goals of Alternatives Analysis
Progress Meeting #6	June 1, 2015	Discussion of Alternatives Analysis review comments

A public notice was mailed to property owners along Newlin Gulch following preparation of the Draft Alternatives Analysis. The notice directed recipients to the project website for additional information. A copy of the notice and all comments received through the website are included in **Appendix A**.

1.4 MAPPING AND SURVEYS

Mapping data sources used for the Newlin Gulch MDP included the following:

- Color aerial photography was provided by UDFCD. The photography was part of an aerial imagery project by the Town of Parker. Photographs are from early 2012.

- 2-foot interval topography along the main stem of Newlin Gulch was provided by UDFCD. The topography was prepared by Merrick & Company GeoSpatial and was based on LiDAR imaging taken in October of 2012.

- Supplemental ground survey of the Hess Road Bridge, Bradbury Ranch Pond IV, and the Newlin Gulch channel at Challenger Regional Park was provided by UDFCD. Survey was conducted by Accurate EngiSurv, LLC in April 2013.

- 1-foot interval as-built topography based on channel improvements completed in 2013 in the Stonegate Metropolitan District was provided by Muller Engineering Company. The original project survey was conducted by Aztec Consultants in 2009.

- 5-foot interval topography in Douglas County was provided by the County and was used to delineate watershed boundaries and define subwatershed and channel properties south of Lincoln Avenue. The source of the mapping was Merrick & Company's 1996 Digital Elevation Model (DEM) "Mass Points."

- 2-foot interval topography within the northern project area (north of Lincoln Avenue) was obtained from the Denver Democratic National Convention (DNC) LIDAR Survey compiled by Sanborn Geospatial on July 25, 2008.

All mapping is on the Colorado State Plane Central Zone (0502) projection, horizontal datum NAD83, and vertical datum NAVD 1988.

Existing parcel boundaries, zoning, jurisdictional boundaries, and Digital Flood Insurance Rate Map (DFIRM) data were provided by Douglas County in Geographic Information System (GIS) format.

1.5 DATA COLLECTION

Numerous reports, studies, and design plans were reviewed and utilized in the preparation of this report. A listing of the primary references is as follows; a full listing is included in the References section at the end of this report.

- 1977 Flood Hazard Area Delineation, Happy Canyon Creek, Badger Gulch, Newlin Gulch, Baldwin Gulch, Sulphur Gulch, Tallman Gulch (Howard, Needles, Tammen & Bergendoff)

- 1993 Newlin and Baldwin Gulches and Basin 4600-09 Outfall Systems Planning Study (Kiowa Engineering Corporation)

1.6 ACKNOWLEDGEMENTS

This report could not have been prepared without the participation and support of the following project sponsors and stakeholders. We are grateful for their contributions.

Table 1-2: Project Participants

Project Sponsors	**Agency**
Shea Thomas	Urban Drainage and Flood Control District
Brad Robenstein	Douglas County
Tom Williams	Town of Parker
Jacob James	Town of Parker
Project Stakeholders	**Agency**
Brad Meyering	City of Castle Pines
Pieter Van Ry	Parker Water and Sanitation District
Jim Swanson	Cherry Creek Basin Water Quality Authority
Ron Lambert	Stonegate Village Metropolitan District
Scott Barnett	Stonegate Village Metropolitan District

2 STUDY AREA DESCRIPTION

2.1 PROJECT AREA

Newlin Gulch originates in the City of Castle Pines, located along I-25 about 3 1/2-miles north of Castle Rock. The creek and its tributaries flow northeast through areas of Castle Pines, unincorporated Douglas County, and the Town of Parker before emptying into Cherry Creek near Challenger Park in the Town of Parker. The Newlin Gulch watershed area is approximately 15 square miles.

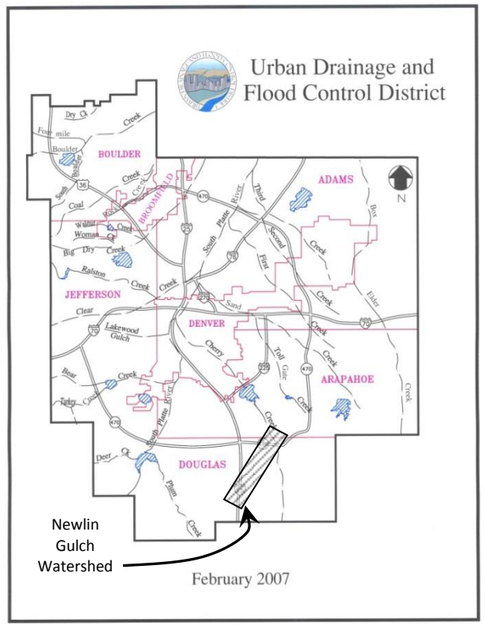
The upper third of the watershed is primarily within the City of Castle Pines. West of I-25, recently annexed areas are slated for residential and commercial development. East of I-25, the watershed includes the majority of the planned Canyons development, also in Castle Pines. The middle third of the watershed starts upstream of the new Rueter-Hess Reservoir and ends at Mainstreet in the Town of Parker. A portion of the Parker Homestead development is located in the watershed just north of Rueter-Hess. The lower third of the watershed, located north of Mainstreet, is nearly fully developed by the Stonegate Village and Challenger Park Estates developments, among others.

The Newlin Gulch watershed is approximately 8.8 miles in length and has an average width of 1.8 miles for most of its length, tapering to 0.5 miles wide at the north end. The total area is 15.0 square miles or 9,600 acres. Approximately 20% of the watershed area is developed. Another 12% of the watershed is within the projected maximum normal pool of Rueter-Hess Reservoir, which encompasses 1.8 square miles. The highest and lowest points of the watershed are 6680 and 5768 feet above mean sea level, respectively, and the average watershed slope is 1.8%. Underlying soils include hydrologic group A along the mainstem downstream of Hess Road and in some areas within the normal pool of Rueter-Hess, surrounded by areas of group B soils. The majority of the tributary area is underlain by hydrologic group C soils. A map of soil classifications is included as **Figure B-1** in **Appendix B**.

Newlin Gulch is UDFCD Project Reuse watershed #4612.

The Major Drainageway Plan study area includes approximately 4 miles of mainstem Newlin Gulch downstream of the Rueter-Hess Reservoir, from Hess Road to the Newlin Gulch confluence with Cherry Creek. The scope of this project does not include master planning of improvements upstream of Rueter-Hess Reservoir; however, the entire watershed has been modeled for the baseline hydrology.

Figure 2-1: Vicinity Map



2.2 LAND USE

Land use within the Newlin Gulch watershed varies from rangeland and open space to high density city center. Existing development conditions were generally based on visual assessment of the aerial photography provided by UDFCD, and future development conditions were based on information provided by project sponsors and stakeholders, including planning documents, zoning, master drainage plans, and direct input. In a few cases, roads were identified separately in land use analysis: the I-25 corridor is reflected as 50% impervious to reflect separation between travel lanes and additional right-of-way, while Hess Road, Chambers Road and Lincoln Avenue are assumed 100% impervious. All other existing or planned roads are assumed to be accounted for in the impervious values of adjacent development. The projected maximum normal pool of Rueter-Hess Reservoir is treated as 100% impervious under both existing and future development conditions.

The overall existing weighted impervious value for the Newlin Gulch watershed is 22.5%. Future development is projected to increase watershed imperviousness to 34.7%. The interactive hydrology map in Appendix B shows existing and future land use boundaries and impervious values (**Figure B-1**).

Upper Watershed: Castle Pines Town Center to Rueter-Hess Reservoir

The upper watershed extends from approximately two miles south of the I-25 and Castle Pines Parkway Interchange north to the boundary of the Rueter-Hess Reservoir normal pool. The mainstem channel length is slightly less than three miles. A small portion of the watershed west of I-25 includes existing medium-density residential and commercial lots which are part of the City of Castle Pines. The extreme south end of the watershed includes existing large-lot residential from the Sapphire Pointe development. Undeveloped parcels cover the remainder of the upper watershed in the existing condition. Future planned developments include The Canyons, Castle Pine Town Center, and LaGae Ranch. The Canyons is the largest of the three and extends from the edge of Rueter-Hess Reservoir beyond the southern boundary of the watershed. Future land-use and impervious values for the planned developments were based on the most current drainage plans available. The weighted impervious value for the upper watershed is 21% (future development condition).

The upper watershed includes numerous tributary “fingers” to the mainstem: the Spring Tributary, the Roundtop Tributary, the Mesa Tributary, South Newlin Gulch, and the Big Windmill Tributary. The majority of these tributaries (with the exception of the Spring Tributary) are currently undeveloped.

Lower Watershed: Rueter-Hess Reservoir to Cherry Creek Confluence

Rueter-Hess Reservoir is a water supply reservoir owned by Parker Water and Sanitation District (PWSD). It is located on the mainstem of Newlin Gulch in the central portion of the watershed. The construction of the reservoir was completed in 2012 and consists of a 170-foot tall earthen dam that is designed to store 72,000 acre-feet of water. Though the reservoir will not be full for several years, the planned normal pool will have a surface area of approximately 1.8 square miles (1,150 acres), which is approximately 12% of the entire watershed. Downstream of the reservoir, the recent Hess Road extension to I-25 provides a boundary between the reservoir and existing and future residential development. Existing medium to dense residential lots cover a large portion of the lower watershed. These lots are part of a number of subdivisions, including (from north to south): Challenger Park Estates, Stonegate Village, Bradbury Ranch, New Horizon, The Regency, and Newlin Meadows. Additionally, construction is currently underway for the Parker Homestead development just north of Hess Road. The remaining undeveloped areas are centered on the intersection of Chambers and Mainstreet. West of Chambers, commercial and residential development is currently in the planning stages as part of Meridian Village. The weighted impervious value for the lower watershed is 37% (future development condition, excluding the Rueter-Hess normal pool).

The Sandpit Tributary passes through the northern edge of the Parker Homestead development and empties into the mainstem just east of Chambers Road. West of Parker Homestead, construction is currently underway for the new Parker Water and Sanitation District water treatment plant. The upper portion of the Sandpit Tributary remains undeveloped with no plans for future development.

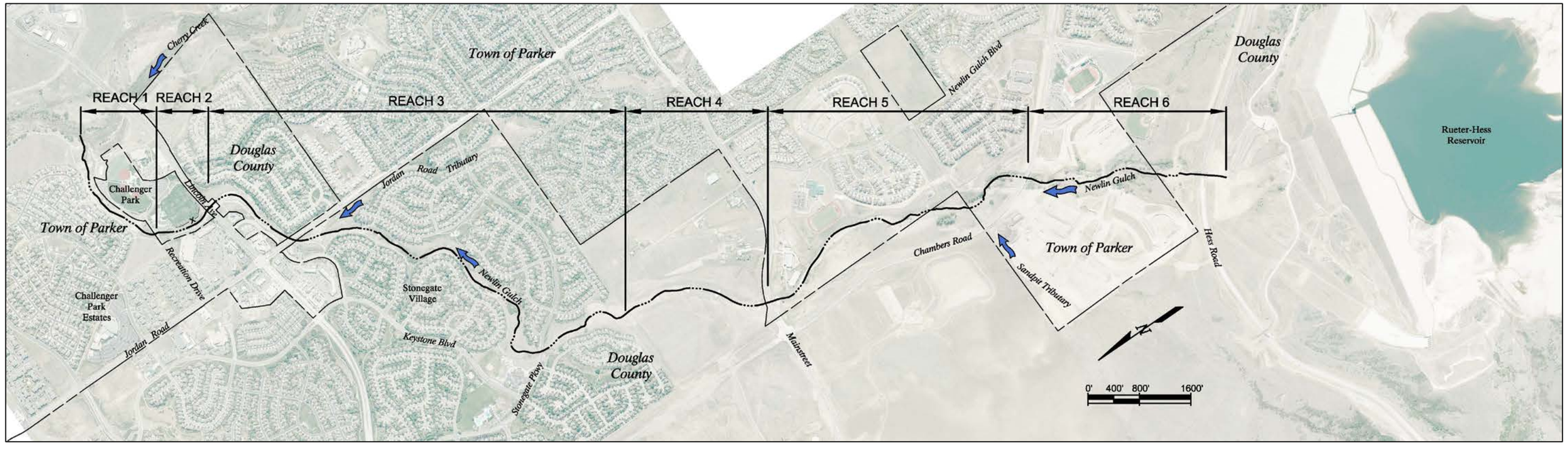
The Jordan Road Tributary, which empties into the mainstem just west of Jordan Road, is fully developed with portions of Stonegate Village and Bradbury Ranch.

2.3 REACH DESCRIPTION

Newlin Gulch is an ephemeral, sand-bed channel that is highly susceptible to erosion. Historically, Newlin Gulch was characterized by a wide, flat floodplain with no base flow and no defined low-flow channel. As the watershed has developed, this character has changed: more frequent base flows and reduction of past grazing activities have increased the vegetation density, and channelization of some reaches has narrowed the floodplain, reduced channel meanders, and created a uniform trapezoidal cross section.

Six reaches have been defined within the study area and are shown in **Figure 2-2**. Reach boundaries are based on jurisdictional and planned development boundaries as well as on existing channel characteristics. Major road crossings are listed in **Table 2-1**.

Figure 2-2: Reach Map



Reach 1 – Challenger Park Estates

The first reach of Newlin Gulch extends from its confluence with Cherry Creek to Recreation Drive within the Town of Parker, along the north edge of Douglas County's Challenger Regional Park. This portion of the drainageway was channelized to allow the development of Challenger Park Estates, which borders the Gulch to the north. The channel section includes a slightly meandering trapezoidal low flow channel and a narrow, uniform 100-year channel. Existing grade control includes two large grouted boulder drop structures and four smaller vertical drops; the constructed channel slope is 0.2%. The upper grouted boulder drop structure, which has a drop height in excess of 12 feet, is positioned just downstream of a 20-inch high pressure gas line. Riparian and wetland areas are present at the confluence with Cherry Creek; vegetation for the remainder of the channel tends to be drier upland species, with some additional pockets of wetland vegetation. The Cherry Creek regional trail crosses the Gulch via a steel pedestrian bridge near the downstream limit. A concrete trail provides maintenance access along the length of the reach. There are no roadway crossings in this reach.

Reach 1

Reach 2 – Challenger Regional Park

Newlin Gulch continues to border Challenger Park in Reach 2, which extends from Recreation Drive to Lincoln Avenue in unincorporated Douglas County. The Recreation Drive crossing is an at-grade crossing where the water is conveyed over rather than under the road (also sometimes referred to as a "Texas crossing"). This presents a safety hazard which necessitates closure of Recreation Drive during even minor storm events, and requires frequent maintenance as buildup of sediment causes ponding on the road. This wide and shallow reach lacks a well-defined low-flow channel, and flows in minor events spread to the east over playing fields and a parking lot. There is no existing grade control; the average channel slope is 0.6%. Vegetation is primarily grasses, with good density near Recreation Drive that decreases approaching Lincoln Avenue. The crossing at Lincoln Avenue is a two-span concrete bridge. A concrete trail provides maintenance access along the length of the reach.

Reach 2

Reach 3 – Stonegate Village

Upstream of Lincoln Avenue, Newlin Gulch passes through Stonegate Village, a master-planned community in unincorporated Douglas County. This is the longest reach included in the study area, at approximately 1.5 miles, and includes two major bridge crossings at Jordan Road and Stonegate Parkway. The open space channel corridor is owned and maintained by Stonegate Village Metropolitan District; development generally was planned around the historic floodplain, so this reach has a more natural feel. Concrete check structures were installed throughout the reach during development of the community in the early 1990s. In recent years, many of the check structures have become exposed due to channel degradation, and the development of deep scour holes has put some of the structures at risk of being undermined. Several channel stabilization projects have been constructed over the last five years to provide additional grade control and convert some of the exposed check structures into permanent drop structures. A total of 12 grouted boulder drop structures have been constructed in this reach. The existing channel slope varies from 0.15% in recently stabilized areas to 0.7% in areas lacking additional grade control.

Reach 3

The Jordan Road Tributary joins Newlin Gulch just upstream of Jordan Road. The tributary originally entered Newlin Gulch near Recreation Drive, but was diverted during development of the area. (A remnant of the lower portion of the tributary runs parallel to Reach 2 on the east side of the Challenger Park playing fields.) Vegetation varies widely through Stonegate Village: near Lincoln Avenue, the channel is very dry and sandy with little vegetation in the base flow channel and upland grasses and shrubs in the overbanks; beyond Jordan Road, there is a marked increase in vegetation with woody riparian habitat (including sandbar willows, cottonwood trees and willow trees) and wetland grasses. Near Stonegate Parkway, the vegetation again transitions to drier upland grasses, though the channel bottom maintains fairly good vegetation density throughout. A concrete trail provides maintenance access along most of the reach, extending from Lincoln Avenue to Pine Grove Elementary School, just north of Stonegate Parkway; an unsurfaced maintenance bench provides access for the remainder of the reach.

Reach 4 – Newlin Crossing

Reach 4 extends from the south end of Stonegate Village to Mainstreet, bisecting the planned Newlin Crossing development. The 1977 FHAD showed a floodplain width of up to 1000 feet in this wide, flat area; though currently undeveloped, the reach has been channelized and several grouted boulder drop structures provide grade control. The constructed slope is 0.56% for the upper portion of the reach, and 0.25% for the lower portion. Vegetation is extremely sparse in the lower part of this reach due to the presence of prairie dogs; density improves toward Mainstreet but remains dominated by upland species. There is no maintenance access in this reach; a regional trail is shown in the development plan.

Reach 4

Reach 5 – Mainstreet to Chambers

Upstream of the Mainstreet crossing, Newlin Gulch roughly parallels Chambers Road within the Town of Parker. This reach is generally characterized by a wide sandy channel bottom, with patches of shrubs and other upland vegetation. Stands of cottonwood and willow trees are found at the upper end of the reach, along with increasing wetland fringes. The average channel slope is 0.92%; with the exception of a drop structure at the Mainstreet bridge and a check structure near the upstream end, there is no grade control in this reach. Old Newlin Gulch Road, which was cut off by the construction of Chambers Road, provides maintenance access for the upper end of the reach. There is no maintenance access for the remainder of the reach.

Reach 5

Reach 6 – Parker Homestead

The final reach included in the study area extends from Chambers Road to Hess Road. Most of this reach lies within the Parker Homestead development in the Town of Parker, though the upper portion crosses again into unincorporated Douglas County. The base flow channel migrates frequently in the wide, flat floodplain. This reach is second only to Reach 3 in vegetation establishment, with numerous trees and frequent stands of shrubs and wetland vegetation. A check structure located near Chambers Road and a large grouted boulder drop structure upstream of Hess Road provide some grade control; a low water trail crossing midway through the reach is planned for construction during the course of this study. The existing average channel slope is 1.3%. A concrete trail provides maintenance access for most of the reach, ending near the Town boundary. Degradation is evident just downstream of Hess Road; this is expected due to the "clear-water" releases from Rueter-Hess Reservoir.

Reach 6

Table 2-1: Major Crossing Inventory

Crossing Location	Street Type	Crossing Type
Recreation Drive	Non-Residential Local	At-Grade Crossing
Lincoln Avenue	Arterial	Double Span Concrete Bridge
Jordan Road	Collector	Double Span Concrete Bridge
Stonegate Parkway	Collector	Single Span Concrete Bridge
Mainstreet	Arterial	Triple Span Concrete Bridge
Chambers Road	Arterial	Single Span Concrete Bridge
Hess Road	Arterial	Single Span Concrete Bridge

2.4 FLOOD HISTORY

The 1993 OSP does not include a record of flooding for the watershed, in part because the majority of development in the lower watershed (downstream of Rueter-Hess Reservoir) occurred after the 1993 OSP study. The floodplain was effectively managed during development to leave sufficient capacity for major storms flows while preventing damage to adjacent structures. The addition of Rueter-Hess Reservoir reduces the peak flows in the developed portions of the watershed, further reducing the flooding impacts.

In Challenger Park, the on-grade crossing of Recreation Drive causes ongoing flooding problems. The crossing is signed with flood warnings including flashing hazard lights. Despite these warnings, vehicles have been documented using the crossing during flood events; there have been numerous instances of vehicles stalling in the moving water.

2.5 ENVIRONMENTAL ASSESSMENT

As detailed in the reach descriptions in Section 2.3, scattered wetland and riparian zones are present along much of Newlin Gulch. The vegetation in some of these areas, however, is much sparser than other drainageways in the area, and does not provide high-quality wildlife habitat. The vegetation is expected to continue to evolve toward more wetland and riparian species as development continues to progress. The approximate boundaries of current wetland and riparian areas were identified with aerial imagery and site photos; a delineation of these areas is included in **Appendix G**.

No federally threatened or endangered species have been identified within the project area; however, a project site-specific review should be conducted prior to implementing any recommended improvements. In addition, any work along the creek corridor should consider non-protected species in the area and avoid impacts during sensitive periods such as nesting/mating season.

3 HYDROLOGIC ANALYSIS

3.1 OVERVIEW

In watersheds where hydrologic models exist, master planning efforts generally utilize the existing models as a starting point for baseline hydrology, with revisions made as necessary to reflect changes in the watershed and to update the models to current software. For Newlin Gulch, hydrologic models from the 1993 OSP were provided by UDFCD. Electronic AutoCAD or GIS files were not available for the OSP subwatershed delineation. A number of challenges arose while reviewing and attempting to recreate the boundaries based on the Hydrological Basin Map from the 1993 report. Most evident was the impact of Rueter-Hess Reservoir on the watershed: the maximum normal pool of the Reservoir covers about 12% of the total watershed area. As a result, the Big Windmill, Canal, and Parkway Tributaries have been significantly shortened, and the Benchmark Tributary has been completed eliminated by the Reservoir permanent pool. Accordingly, the subwatershed delineations, design points, and routing elements necessary to model the Reservoir are different from the 1993 OSP. In addition, significant development in the lower watershed necessitated numerous changes to subwatershed boundaries, design points, and routing elements. As a result, though the 1993 boundaries were used as a guide, a new subwatershed delineation was performed.

These watersheds were evaluated using UDFCD's Colorado Urban Hydrograph Procedure (CUHP) 2005, version 1.3.3 (release date January 2010). Hydrographs generated in CUHP were then routed through the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM), version 5.0.020. Due to the numerous changes that would have been needed to reflect the updated delineation, the design team elected to create a new SWMM model as well rather than update the previous model. This facilitated numerous improvements to the model to make it more user-friendly with the current software, including a revised naming scheme for subwatersheds, conveyance elements, and design points; layout of the SWMM model elements in the graphical user interface (GUI) over a background image of the watershed; and updating SWMM node elevations to match the project mapping.

3.2 DESIGN RAINFALL

One-hour point rainfall depths for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events were obtained from UDFCD rainfall maps for the project area and compared with the values used in the 1993 OSP. Current values are slightly lower than those used in 1993 for all but the 50-year storm, as shown in **Table 3-1.**

Table 3-1: Point Rainfall Depths

Storm Event	One-Hour Rainfall Depth (in)	
	1993 OSP	Current Study
2-year	1.06	0.95
5-year	1.43	1.41
10-year	1.66	1.66
25-year	N/A	1.97
50-year	2.26	2.28
100-year	2.6	2.57

UDFCD is currently in the process of updating the criteria presented in the USDCM. Updates include changes to the design storm duration and adjustments based on watershed size. The September 2012 draft version of Chapter 4 – Rainfall of the USDCM was used to develop the design rainfall distributions for this study. While the 1993 OSP used a 3-hour design storm for the Newlin Gulch watershed, the updated criteria eliminates 3-hour design storms and extends the use of a 2-hour storm duration to watersheds up to 15 square miles. Because the Newlin Gulch watershed is almost exactly 15 square miles, only a 2-hour storm distribution was used.

Adjustments to the incremental rainfall point values based on watershed area have also changed with the September 2012 draft criteria. Depth Reduction Factors (DRFs) are only applied to watershed areas greater than 15 square miles for the 25-, 50-, and 100-year storm events; therefore no adjustment for these design storms was made. For the smaller 2-, 5-, and 10-year storm events, DRFs are applied when watershed areas exceed 2 square miles. In order to apply a DRF, adjustment values are interpolated from tables provided in the draft criteria based on the applicable contributing area. CHUP and SWMM are then run with the adjusted incremental rainfall values, and design peak flow rates from the DRF-adjusted models are used for design points where the cumulative area exceeds the limits given. Several DRF-adjusted runs may be required as the cumulative watershed area increases down the mainstem. For design points in the upper watershed or off the mainstem, where the cumulative area is below the DRF threshold, the unadjusted models are used to generate design peak flow rates.

In this case, Rueter-Hess Reservoir effectively disconnects the upper watershed from the lower watershed by drastically minimizing the contributions of the upper watershed on the lower watershed peak flow rates. As a result, the project team elected to apply the DRFs separately in the upper and lower watersheds in order to avoid over-correcting for the contributing watershed area below the reservoir. Upstream of Rueter-Hess, the 2 square mile limit is exceeded at the confluence of Newlin Gulch, Spring Tributary, and Roundtop Tributary, with a combined area of 2.8 square miles. The contributing watershed area increases to 3.2 square miles at the edge of the projected normal reservoir pool. DRFs based on a 3 square mile area were interpolated from the 2 square mile and 5 square mile values listed in the draft criteria and applied to design points NG014 (edge of normal pool), NG013, and NG220 (total reservoir inflow). Downstream of Rueter-Hess (excluding the area contributing to the reservoir), the 2 square mile limit is exceeded at the confluence of Newlin Gulch and Sandpit Tributary, with an combined area of 2.2 square miles. The contributing watershed area increases to 4.5 square miles at the confluence of Newlin Gulch and Cherry Creek. For simplicity, the same 3 square mile DRF adjustment was made for the lower watershed, and applied to mainstem design points NG006 (at Stonegate Parkway) through NG000 (at the confluence with Cherry Creek).

Adjustment factors for the 3 square mile DRF are presented in **Table 3-2.** Rainfall distributions for all return periods, adjusted and unadjusted, are listed in **Table B-1, Appendix B**. Tables 4-1, 4-3, and 4-4 of the draft criteria update, which detail the applications of DRFs, are also included in **Appendix B**.

Table 3-2: Depth Reduction Factors

Time (minutes)	3 Square Mile Area DRF 2-, 5-, and 10-Year Design Rainfall
5	1.00
10	1.00
15	0.99
20	0.95
25	0.95
30	0.95
35	0.99
40	0.99
45	1.00
50	1.00
55	1.00
60	1.00
65-120	1.00

3.3 SUBWATERSHED CHARACTERISTICS

Subwatershed characteristics were defined according to the revised delineation and current mapping and land use information. For each subwatershed, the flow path from the highest point in the basin was determined from the project mapping and used to define the length and distance to centroid. The length-weighted slope along the flow path was then calculated according to the method described in the USDCM. Existing and future imperviousness was determined based on the land use assumptions outlined in **Section 2.2**. Hydrologic soil group classifications were determined via the Natural Resources Conservation Service Web Soil Survey. Based on the soil groups present in each subwatershed, weighted values were calculated for initial and final infiltration rates as well as for the Horton's decay coefficient. Depression losses in pervious and impervious areas were set at 0.5 and 0.1, respectively, to match the values used in the 1993 OSP. A unit hydrograph time increment of 1 minute was used, since some of the subwatersheds are less than 90 acres (USDCM Table RO-1).

A total of 98 subwatersheds were defined. Areas ranged from 22 acres to 177 acres, with an average size of 87 acres (excluding the Rueter-Hess basin A-220). At the outset of the study, the maximum desired subwatershed area was 130 acres, however, this requirement was relaxed to allow for more reasonable subwatershed delineations in undeveloped areas. With the exception of Rueter-Hess, four subwatersheds (A-165, A-210, C-110, and C-120) significantly exceed the 130 acre guideline.

Hydrologic soil groups, existing and future impervious values, and subwatershed boundaries are shown on the interactive hydrology map in **Figure B-1, Appendix B**. A summary of all subwatershed values used in CUHP is presented in **Table B-2**, **Appendix B**.

3.4 HYDROGRAPH ROUTING

A new SWMM model was created for routing of the hydrographs generated in CUHP. Channel geometry was approximated from the project mapping, utilizing 2' interval topography north of Rueter-Hess Reservoir, and 5' interval topography in the remainder of the watershed. Trapezoidal elements were used exclusively for conveyance. SWMM determines channel slopes based on the segment length and elevations of upstream and downstream nodes; node elevations were defined based on the project mapping. Manning's n values were calculated using the Jarrett equation (USDCM Equation RO-10), and then were compared to the 1993 OSP values. Design points were placed at the downstream end of each subwatershed, with additional points included to reflect flow rates before and after the confluence with each tributary channel. Two detention storage areas were identified as eligible for inclusion into the baseline hydrology: Rueter-Hess Reservoir and Bradbury Ranch Pond IV. These are further discussed in **Sections 3.4.1** and **3.4.2** below.

SWMM model conveyance elements, subwatershed nodes, design points and storage elements are shown on the interactive hydrology map in **Figure B-1, Appendix B**. SWMM routing schematics are provided as **Figures B-2 and B-3** in **Appendix B**. SWMM input parameters and output results for the 100-year future development condition are included in **Tables B-7 and B-8, Appendix B**.

3.4.1 Rueter-Hess Reservoir Routing

The most significant storage area within the Newlin Gulch watershed is Rueter-Hess Reservoir, located on the Newlin gulch mainstem. The reservoir is owned and operated by Parker Water and Sanitation District (PWSD). Although the reservoir is designed only for water storage, the reservoir surface area is so large relative to the tributary watershed that it provides significant inadvertent flood detention. Outflows from the reservoir are controlled through a gated, multi-chambered tower that connects to two 78-inch diameter outlet conduits. The service spillway is comprised of two of the upper openings in the outlet works tower, each approximately 10-feet wide and 5-feet tall. The maximum normal pool elevation for the reservoir is elevation 6215.1 (NAVD88) which is equal to the crest of the service spillway. According to an evaluation conducted by the reservoir design engineer, the service spillway can convey both the 100-year and 500-year storm events. An auxiliary (or emergency) spillway consisting of a 500-foot long labyrinth weir is located on the west side of the dam embankment. The auxiliary spillway crest is at elevation 6216.7, which is 1.6-feet above the service spillway crest. The auxiliary spillway is designed to convey extreme flood events (greater that the 500-year).

To determine the flood detention impacts of Rueter-Hess, several options for routing floods through the reservoir were evaluated with the SWMM model. These options included flood routing through the service spillway, routing through the auxiliary spillway, and routing without the reservoir. The results of the routing options are summarized in a memorandum completed in May 2013 entitled *Rueter-Hess Reservoir Flood Control Benefits.* This memorandum, along with a summary table comparing downstream flows for the different routing options, are provided in **Appendix C**. The project sponsors, in cooperation with

PWSD, selected the option of routing through the auxiliary spillway for the baseline hydrology. The modeling results for this option show that, in the future development condition, a peak 100-year inflow of over 10,000 cfs routed through the reservoir will be discharged downstream of the Reservoir at less than 1,000 cfs and the reservoir water surface will surcharge or rise by approximately 0.8-feet. No modification to the outlet works or spillways is necessary to achieve this flood detention/attenuation. The project sponsors and PWSD selected the auxiliary spillway routing option because it accounts for the significant inadvertent flood detention provided by the Reservoir, while still allowing for some flexibility to change the service spillway elevation in the future to accommodate additional water storage without altering 100-year flood discharges downstream.

The baseline hydrology model assumes the following for Rueter-Hess: the reservoir normal pool is 100% impervious, the reservoir is full to the auxiliary spillway crest (elev. 6216.7) prior to the storm event, the service spillway is ignored/blocked, and the upstream hydrograph is routed through the auxiliary spillway.

The project sponsors entered into an agreement with PWSD on November 13, 2014, entitled "Agreement Regarding the Intent to Assure the Flood Routing Capability of Rueter-Hess Reservoir in Douglas County, Agreement No. 14-05.05". This agreement officially recognizes the inadvertent flood routing capability of the Reservoir for the 100-year discharge along Newlin Gulch and the intention to assure that this flood routing capability is maintained. A copy of the agreement is included as **Appendix D**.

The reservoir stage-area and stage-discharge curves used for the baseline SWMM model are included in **Table B-3, Appendix B**. These curves were taken directly from the original storage and discharge rating curves shown on Drawing No. A-05 of the reservoir record drawings. A copy of this drawing is also included in **Appendix B**.

3.4.2 Bradbury Ranch Pond IV

Currently, the only regional detention pond recognized in the Newlin Gulch watershed is the Bradbury Ranch Pond IV located along the Jordan Road Tributary just south of Mainstreet. The detention pond was built with Phase 1 of the Bradbury Ranch development in the late 1990's and early 2000's. Pond IV is referred to in many of the Phase III drainage reports for the various filings of the development, but despite extensive searching no design plans were found. A stage-area curve was developed based on Douglas County 5-foot interval topography. A stage-discharge curve was developed based on a detailed ground survey of the two-stage pond outlet works, which consist of a 60-inch open-ended culvert (lower stage), and a 30-foot broad-crested weir (upper stage). The SWMM analysis shows that the upper stage will overtop in storm events exceeding a 50-year recurrence. Overtopping flows will cross Mainstreet at Bradbury Parkway before rejoining the Jordan Road Tributary.

Stage-area and stage-discharge curves for Bradbury Ranch Pond IV are included in **Table B-3, Appendix B.**

3.5 PREVIOUS STUDIES

Newlin Gulch was previously analyzed in a 1977 FHAD and a 1993 OSP. The FHAD established the regulatory FEMA flow rates. Hydrographs were based on a 24-hour design storm with a Type IIA SCS rainfall distribution; peak discharges were calculated with the Soil Conservation Service's computer programs WSP2 and TR20.

The 1993 OSP utilized 2-hour and 3-hour design storms. Hydrographs were generated with the PC version of CUHP and routed through UDSWM2-PC. In 1993, the OSP notes that less than five-percent of the watershed area was impervious. The future land-use assumptions made in the OSP significantly increased the watershed imperviousness, but are still much lower than the current future land use projections. The future land use maps included in the OSP indicate that the upper portion of the watershed was modeled as about 80% open space (2%), with about 15% large lot residential (10%) and a small area of high-density residential (45%). The future land use imperviousness estimated in this area in the current study is significantly higher.

3.6 MODEL CALIBRATION

Standard practice for master planning studies on previously studied watersheds includes calibration of the hydrologic model to reconcile the results within 10% of the previously published data. This practice ensures that changes in baseline hydrology are due to changes within the watershed or updates to criteria rather than differences in software. Calibration is generally done through adjustment of Cp and/or Ct values in the CUHP, which impact the peak flow rates and the time to peak, respectively. This study targeted the 1993 OSP existing condition peak flow rates for reconciliation. A calibration "Historic" model was prepared, using 2% imperviousness across the entire watershed, and 100-year 2-hour and 3-hour rainfall distributions.

The results were found to agree within 10% for the majority of mainstem design points compared. In portions of the upper watershed, the 1993 OSP and current historic model do not calibrate to within 10%. However, these areas are on the upper end of an undeveloped watershed, where little infrastructure has been designed and built based on the previous peak flows. These results were presented to the project sponsors at the progress meeting on March 18, 2013. It was agreed that the current study CUHP and SWMM models reconciled with the 1993 OSP, and that no calibration of the model was necessary. Results of the calibration analysis are shown in Table 3-3.

Table 3-3: Model Calibration

Location	FHAD Cross Section	OSP Design Point	Current Design Point	1977 FHAD * 100-Yr (cfs)	1993 OSP ** Existing (cfs)	1993 OSP ** Future (cfs)	Current Study 100-Yr Historic† (cfs)	% Increase Historic Model vs 1993 OSP***	% Increase Historic Model vs. 1977
Newlin Gulch									
Cherry Creek	28	180	NG000	4790	5357	5513	5674	6%	18%
Lincoln Ave. (U/S)		177	NG001		5198	5396	5637	8%	
Jordan Rd. (U/S)	23	176	NG002	4720	5220	5412	5636	8%	19%
Mainstreet (U/S)	16	166	NG006	4590	5330	5545	5269	-1%	15%
Mainstem and Tributary Inflow to Rueter-Hess		150	NG013		4969	5138	4454	-10%	
I-25 (U/S)		103	NG019		321	311	412	28%	
Tributaries									
Jordan Rd. Tributary at Newlin Confluence		276	SJ000		545	785	560	3%	
South Newlin at Mesa Confluence		128	SN001		1106	1167	1369	24%	
Mesa Tributary at South Newlin Confluence		224	MT000		420	470	490	17%	
Roundtop Tributary at Newlin Confluence		217	RT000		383	393	424	11%	
Spring Tributary at Newlin Confluence		219	ST000		773	840	885	14%	

Notes:
* 1977 FHAD flows based on 24-hour storm and WSP-2 and TR-20 models.
** 1993 OSP flows based on 3-hour storm and CUHP/UDSWM models.
*** Comparisons are based on current study historic model vs. the Existing Conditions 1993 OSP model and the 1977 FHAD model.
†Used 3-hour design storm where total watershed area is greater than 10 square miles. Used 2-hour design storm elsewhere.

3.7 RESULTS OF ANALYSIS

Newlin Gulch was analyzed for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events under existing and future development conditions, using a 2-hour design storm. A comparison to previous studies is presented in **Table 3-4** below. Overall, while peak flow rates have increased somewhat in the upper watershed above Rueter-Hess Reservoir, peak flow rates in the lower watershed have decreased due to the effects of the reservoir. Though the reduction is drastic immediately below of the reservoir, the effect lessens as the mainstem approaches its confluence with Cherry Creek.

Detailed results are included in **Appendix B**. Peak flow rates at each design point are listed in **Table B-4**; runoff volumes and accumulated drainage areas at key locations are listed in **Tables B-5 and B-6**. Hydrographs at key locations for the 2-year and 100-year events are shown in **Figures B-4 and B-5**. Peak flow profiles for all storm events on the mainstem of Newlin Gulch are shown in **Figures B-6 and B-7**.

Table 3-4: Comparison to Previous Studies

					1993 OSP **		Current Study	
Location	FHAD Cross Section	OSP Design Point	Current Design Point	1977 FHAD * 100-Yr (cfs)	100-Yr Existing (cfs)	100-Yr Future (cfs)	100-Yr Existing (cfs)	100-Yr Future (cfs)
Newlin Gulch								
Cherry Creek	28	180	NG000	4790	5357	5513	2843	3539
Lincoln Ave. (U/S)		177	NG001		5198	5396	2795	3450
Jordan Rd. (U/S)	23	176	NG002	4720	5220	5412	2793	3443
Stonegate Parkway (U/S)			NG004				2212	2660
Mainstreet (U/S)	16	166	NG006	4590	5330	5545	1945	2244
Chambers Rd. (U/S)			NG009				905	1029
Hess Rd.			NG011				890	1015
Rueter-Hess Reservoir Outflow			NG012				880	999
RH Total Inflow (Including Reservoir Subwatershed)			NG220				8822	10362
Mainstem and Tributary Inflow to RH		150	NG013		4969	5138	5871	7649
Mainstem Inflow to RH			NG014				2454	3256
I-25 (U/S)		103	NG019		321	311	426	514
Tributaries								
Jordan Rd. Tributary at Newlin Confluence		276	SJ000		545	785	690	758
South Newlin at Mesa Confluence		128	SN001		1106	1167	1388	1564
Mesa Tributary at South Newlin Confluence		224	MT000		420	470	493	598
Roundtop Tributary at Newlin Confluence		217	RT000		383	393	429	504
Spring Tributary at Newlin Confluence		219	ST000		773	840	1009	1427

Notes:

* 1977 FHAD flows based on 24-hour storm and WSP-2 and TR-20 models.

** 1993 OSP flows based on 3-hour storm and CUHP/UDSWM models.

4 HYDRAULIC ANALYSIS

4.1 EVALUATION OF EXISTING FACILITIES

Hydraulic analysis of the channel and existing road crossings was performed using HEC-RAS v.4.1.0. Hydraulic cross sections are located so as to represent the topography of the channel, with additional sections at grade control and crossing structures. The maximum spacing between sections is approximately 500 feet, though in most areas the spacing is much less. Where possible, cross sections were laid out to match sections used in previous analyses, including several Letter of Map Revision (LOMR) studies. Cross section alignments were adjusted as necessary to reflect the direction of flood flows in the overbanks while remaining perpendicular to the channel at its centerline.

Bank stations were chosen based on field observation, and are generally set to reflect a wide, sandy channel bottom. In some reaches, bank stations were set higher up the banks to reflect changes in vegetation between the flood-prone channel and the overbanks. Manning's n values were estimated based on field observations. Values vary from 0.040 to 0.12; a summary table by reach is included in **Appendix E**.

Channel geometry and reach lengths were generated and imported into HEC-RAS using Power InRoads v8i and modified as necessary to reflect longer overbank reach lengths, additional detailed survey data, and structure information. Construction of a channel stabilization project on a portion of Reach 3 postdated the project topography; channel geometry for this segment is based on the design plans (*Newlin Gulch Channel Improvements Downstream of Stonegate Parkway, July 2012*) and as-built information.

Seven major roadway crossings were modeled: six bridges and one at-grade crossing. For several of these, bridge data was taken from LOMR HEC-RAS models; the LOMR case numbers are included in **Table 4-1**. The Recreation Drive cross section is based on a detailed ground survey; bridge data for Chambers Road is based on as-built plans for the bridge. Stonegate Parkway bridge data is based on the design HEC-RAS model for the Newlin Gulch project mentioned above; detailed project survey was the original source.

The HEC-RAS model also includes several pedestrian trail crossings. Data for the steel bridge near the confluence with Cherry Creek was based on a combination of HEC-2 data from the Challenger Park Estates LOMR and field measurements. Two low-flow crossings in Stonegate Village were modeled based on design plans and as-built data. Finally, a proposed low-flow crossing midway between Chambers Road and Hess Road was modeled based on design plans; construction is expected to be completed during the course of this study.

The 100-year floodplain was delineated based on the future development, existing infrastructure hydrology described in **Section 3**. The hydraulic model was also run with existing development peak flow rates; the two hydraulic profiles were compared and generally exhibited less than one half foot difference in base flood elevation, so a separate existing development condition floodplain was not delineated. The future development condition floodplain is shown in **Figures E-1 and E-2**.

Results of the hydraulic analysis indicated no flooding of existing structures or major crossings, with the exception of Recreation Drive. A summary of the crossings and their capacity is shown in **Table 4-1**.

Table 4-1: Existing Crossing Capacity

Crossing Location	Station	Crossing Type	Capacity	Bridge Data Source
Recreation Drive	2171	At-Grade Crossing	Zero	N/A
Lincoln Avenue	3150	Double Span Concrete Bridge	>500-yr	LOMR Case # 08-08-0553P
Jordan Road	4750	Double Span Concrete Bridge	>500-yr	LOMR Case # 08-08-0553P
Stonegate Parkway	10000	Single Span Concrete Bridge	>500-yr	Channel Design Model
Mainstreet	14000	Triple Span Concrete Bridge	>500-yr	LOMR Case # 08-08-0334P
Chambers Road	18950	Single Span Concrete Bridge	>500-yr	As-built plans
Hess Road	21850	Single Span Concrete Bridge	>500-yr	LOMR Case # 11-08-0044P

4.2 FLOOD HAZARDS AND PROBLEM AREAS

Flood hazards within the study area are concentrated in the Challenger Park area, at the juncture of Reaches 1 and 2. The most significant hazard is at Recreation Drive, which exhibits flooding in even the smallest event due to the lack of grade separation. Flooding depths for the various storm events modeled are tabulated in **Table 4-2**.

Flooding at Recreation Drive during Nuisance Event

Flooding also occurs regularly in the west parking lot, located adjacent to Newlin Gulch at Recreation Drive. With the adjacent channel having less than a 2-year capacity, small, nuisance flows typically spill into the lot. In 25-year and larger storms, flows spill over the high point in Recreation Drive. This results in flooding along the adjacent internal drive (herein referred to as Recreation Drive East), which is the sole access for the east parking lot. Flooding also extends into the south parking lot. Finally, the large grouted boulder drop structure downstream of

Recreation Drive has only 10-year capacity at the crest, causing larger storm events to end-around the structure on the right bank. Erosion in this area could threaten the structure or the adjacent buried utilities, including a 20-inch high pressure gas line, a 12-inch effluent force main, and a 6-inch sanitary force main.

Table 4-2: Overtopping Depths at Recreation Drive

Storm Event	Overtopping Depth (ft)
2-Year	2.47
5-Year	3.08
10-Year	3.45
25-Year	4.14
50-Year	4.54
100-Year	4.80

Outside of the Challenger Park area, problem areas were noted at three existing check structures where channel downcutting and scour has exposed the structures. The worst of these, located in Reach 3 between Lincoln Avenue and Jordan Road, has been exposed approximately 4-feet on both the upstream and downstream sides and is in danger of failure. A second Reach 3 check structure, located upstream of Stonegate Parkway, is exposed to a lesser degree. The third impacted check structure is located in Reach 5 just downstream of Chambers Road. This structure was constructed in 2012; the fact that it is already exposed is evidence of more rapidly changing conditions in this reach.

Degradation and Scour at Existing Check Structure

Alternating areas of degradation and aggradation were noted along the channel, but are generally not of immediate concern aside from aesthetic and vegetative impacts. Aggradation along the trail beneath the Jordan Road bridge does require frequent maintenance, however, and degradation downstream of the Hess Road bridge is causing failure of riprap protection. Minor degradation is also developing in the upper, steeper portion of Reach 4, and channel scour was noted near the confluence of Newlin Gulch with the Jordan Road Tributary. This reach is gently sloped; the scour is likely due to the narrowness of the main channel and the increased velocities coming from the steeper tributary channel.

One water quality concern was noted immediately south of Mainstreet in Reach 5, where Newlin Gulch crosses private property which houses horse facilities. During a site visit, manure spread on the overbanks was noted as a potential water quality hazard. In addition, debris piles adjacent to the channel and corral fencing in and adjacent to the channel could pose a debris hazard during a flood event.

Problem area locations are identified in **Figures E-1 and E-2**.

4.3 PREVIOUS ANALYSES

Previous hydraulic analyses along Newlin Gulch include the 1977 FHAD, 1993 OSP, and various LOMRs. The 1977 FHAD noted overtopping at Jordan Road and West Parker Road (now Mainstreet) in the 100-year event; these crossings have since been replaced. Few buildings existed in the watershed, so there were no other flood impacts noted. The 1993 OSP noted overtopping at Lincoln Avenue in addition to Jordan Road and West Parker Road; this crossing has also been replaced.

In general, the floodplain limits and flow depths are reduced in comparison with the current regulatory floodplain. This is a result of the reduction in peak flow rates due to the inclusion of Rueter-Hess Reservoir in the baseline hydrology.

5 ALTERNATIVE ANALYSIS

5.1 ALTERNATIVE DEVELOPMENT PROCESS

Alternative Analyses for Major Drainageway Plans are often focused on improving flood capacity in the channel and at crossings, reducing peak flows by providing regional detention, and addressing major channel stability issues. Due to the construction of Rueter-Hess Reservoir and the incorporation of its impact into the baseline hydrology, peak flows have been substantially reduced in the study area. As a result, there is not a need for capacity improvements or regional detention. With regards to channel stability, much of Newlin Gulch within the study area has already been stabilized with grade control structures. While there is a need to incorporate additional grade control and preserve/stabilize the natural channel in unstabilized reaches as the watershed continues to develop, the project sponsors determined that evaluating multiple alternative approaches for channel stabilization was not necessary. As a result, for the majority of the study reach, a single plan was developed to address the current and future anticipated channel stability issues. This plan is discussed in more detail in **Section 6**.

At Recreation Drive, however, multiple alternatives were developed to address the safety hazard presented by the existing at-grade crossing, as well as to improve the channel capacity and reduce flooding at the Challenger Park facilities. The alternatives to be considered were identified by the project sponsors as follows:

- 10-year crossing which generally maintains the existing channel invert
- 10-year crossing which lowers the existing channel invert (requiring lowering of the downstream drop structure crest and the 20-inch high pressure gas line)

5.2 CRITERIA AND CONSTRAINTS

The Recreation Drive crossing is located within Douglas County's jurisdiction and provides access to the County's Challenger Regional Park. However, the street is in the Town of Parker's jurisdiction from Jordan Road to the crosswalk at the Newlin Gulch trail, and provides secondary access to the Parker Recreation Center, a Town facility. Design criteria for both jurisdictions was examined.

While both the Douglas County *Storm Drainage Design and Technical Criteria Manual* and the Town of Parker *Storm Drainage and Environmental Criteria Manual* prohibit 100-year overtopping of a roadway at a major drainageway for new crossings of any road classification, the project sponsors elected to apply the less stringent minor drainageway criteria. Recreation Drive is a low volume, low speed road and the site constraints would make it difficult to completely eliminate overtopping. At minor drainageway crossings, both jurisdictions prohibit overtopping in the 10-year event, and the overtopping depth in a 100-year event is governed by a maximum 12-inch depth at the gutter flowline.

For channel improvements elsewhere in the drainageway, proposed improvements were developed based on the criteria presented in the *Urban Storm Drainage Criteria Manual* (USDCM), including draft revisions, as well as the Douglas County and Parker manuals. These criteria include recommendations on channel slope and drop structure height as well as the overall approach to channel restoration. All jurisdictions favor natural channel preservation and restoration over an engineered channel. This approach seeks to maintain a wide, shallow floodplain and make use of healthy riparian vegetation to help stabilize the channel, reduce stream velocities, and improve water quality.

5.3 ALTERNATIVE HYDRAULICS

Hydraulic analysis of the Recreation Drive alternatives was performed using FHWA nomographs and HEC-RAS. Initial box culvert sizing for a 10-year event was determined with the nomographs; the crossing was then input into the HEC-RAS model to determine the impact of each alternative on the 100-year floodplain. Because the proposed crossing alternatives convey less than the 100-year event, any railing required on the crossing would negatively impact the 100-yr floodplain. A rise of 2'-6" was chosen for the box culvert in order to limit the fall height and potentially eliminate the requirement for railings; however, to reflect the worst-case floodplain impacts, the crossing was modeled assuming a completely blocked 54" railing for each alternative. Channel sections upstream and downstream of the crossing were modified as appropriate to reflect channel grading and/or modifications to the downstream grouted boulder drop structure.

No hydraulic analysis of the proposed channel improvements for the remainder of the study area was conducted. Results of the hydraulic analysis at Recreation Drive are included in **Appendix H**.

5.4 ALTERNATIVE COSTS

Cost estimates for the Recreation Drive alternatives and for the channel improvements in the remainder of the study area were developed using UDFCD's master planning cost estimating spreadsheet, UD-MP Cost, Version 2.2. The spreadsheet includes set unit costs for various capital improvement items based on 2009 costs with an adjustment based on the Colorado Department of Transportation's Construction Cost Index (CCI). The fourth quarter 2014 CCI of 1.2166 was used. Cost items not included in UD-MP cost were estimated based on recent construction data and entered in the Special Items section of the spreadsheet. Gas line relocation costs were based on information provided by Xcel Energy. Unit costs are shown in **Table 5-1**.

Capital improvement costs include 5% allowances each for mobilization and stormwater management / erosion control. Additional cost allowances added as a percentage of the total capital improvement cost include engineering (15%), legal / administrative (5%), contract administration / construction management (15%), and contingency (25%). Right-of-way acquisition and easement costs in developed areas were estimated based on a cost of $2 per square foot; in undeveloped areas, it is assumed than an open space tract will be dedicated as a part of the development plat, so property acquisition was excluded.

50-year operation and maintenance costs were also calculated using UD-MP Cost. The effective interest rate was 4.0%, based on a discount borrowing rate of 7.0% (per FEMA Circular No. A-94 Revised) with an assumed inflation rate of 3.0%.

Table 5-1: Unit Costs

Item	Unit	Unit Cost 2012 Q1	Adjusted Unit Cost 2014 Q4
Circular Pipes			
24-inch	LF	$72.00	$88.00
Flared End Section			
24-inch	EA	$970.00	$1,180.00
Manholes and Inlets			
Storm Inlet, Type R/Type 14, 5-foot, 10-foot deep avg.	EA	$4,600.00	$5,596.00
Hydraulic Structures			
Grouted Boulders, 36-inch	SY	$190.00	$231.00
Soil Riprap, Type M	CY	$70.00	$85.00
Excavation, Complete-in-Place	CY	$11.00	$13.00
Bedding, Granular Type II	CY	$58.00	$71.00
Grout	CY	$240.00	$292.00
Check Structure, Concrete	LF	$270.00	$328.00
Channel Improvements			
Grouted Boulders, 36"	SY	$190.00	$231.00
12-inch Riprap, Type M	CY	$60.00	$73.00
18-inch Riprap, Type H	CY	$80.00	$97.00
Excavation, Low Range	CY	$11.00	$13.00
Excavation, Mid Range	CY	$24.00	$29.00
Excavation, High Range	CY	$31.00	$38.00
Landscaping and Recreation Improvements			
Wetlands Plantings	ACRE	$25,000.00	$30,415.00
Reclamation & seeding (native grasses)	ACRE	$1,000.00	$1,217.00
Trail/Path, Concrete (10' Width)	LF	$44.00	$54.00
Concrete and Steel			
Concrete	CY	$600.00	$730.00
Steel	LB	$0.90	$1.00
Special Items			
Road Reconstruction	SY		$50.00
Asphalt Removal	SY		$10.00
Curb and Gutter	LF		$25.00
Removal of Curb and Gutter	LF		$5.00
Sheet Piling	SF		$30.00
54" Railing (Box Culvert)	LF		$250.00
Removal of Sidewalk	SY		$10.00
Removal of 36" Grouted Boulders	SY		$30.00

5.5 ALTERNATIVE PLANS

Three alternatives were developed for Recreation Drive, as shown in **Figures 5-1 through 5-3** and described below. A summary of the costs for each alternative is shown in Table 5-2.

Recreation Drive Alternative A: 10-year Crossing at Existing Invert

The first alternative provides 10-year capacity with a four-cell 20' span x 2.5' rise concrete box culvert placed at the existing at-grade crossing invert. Reconstruction of the road is limited to approximately 250 linear feet (outside the limits of the culvert) and ties in just west of the parking lot entrance to avoid impact to the parking lot drive. The upstream channel would be excavated to meet the design slope recommended for this reach (0.15%) and to maximize conveyance capacity adjacent to the parking lot. Some drop in grade through the culvert would allow excavation in the downstream channel to meet the design slope to the existing grouted boulder drop structure. In order to accommodate the additional width of the crossing and to soften the sharp curve downstream, approximately 300 LF of the existing concrete trail would be realigned. High flows would continue to exceed the capacity at the crest of the downstream grouted boulder drop structure; sheet pile and riprap would provide protection against erosion on the right bank adjacent to the structure.

The capital improvement cost of Alternative A is $878,000, with a total project cost of $1.42 million.

Recreation Drive Alternative B: 10-Year Crossing at Existing Invert with 100-Year Flood Containment

Because Alternative A does not address containment of the 100-year flows, a second alternative was developed to mitigate these impacts while still matching the existing invert. As with Alternative A, Alternative B would provide 10-year capacity in a four-cell 20' span x 2.5' rise concrete box culvert, reduce the channel slope upstream and downstream of the crossing, and realign the existing concrete trail. However, the road profile would be further modified to contain the 100-year overtopping. This would require raising the existing high point, located between the parking lot and the intersection to the east, by approximately two feet from 5800.5 to 5802.5. In order to meet roadway criteria for vertical curves, the road reconstruction would extend beyond the intersection, impacting approximately 150 feet of Recreation Drive East and introducing a minor sag in the profile which would be drained by a Type R inlet. The parking lot entrance would also need to be modified to match the higher road profile.

To contain the 100-year flow upstream of Recreation Drive, a small one-foot high berm would be constructed along the east side of the playground and basketball courts, tying in with the raised high point in the road. Alternative B also addresses the limited capacity at the crest of the downstream grouted boulder drop structure by raising the right side of the drop structure crest to contain the 100-year flow. While these improvements would improve the hydraulic conditions, they would not impact the floodplain delineation as the berm would not be a recognized levee.

The capital improvement cost of Alternative B is $1.13 million, with a total project cost of $1.81 million.

Town of Parker

PROPERTY LINE

Existing 20" HP Gas Line

100-YEAR FHAD FLOODPLAIN

EXTENTS OF CHANNEL EXCAVATION

R.O.W. OR EASEMENT ACQUISITION

RE-ALIGN CONCRETE TRAIL

FOUR-CELL, 20' X 2.5' CONCRETE BOX CULVERT WITH 54" RAILING
U/S INVERT = 5796.5 (MATCHES EXISTING)
DECK = 5800.5
(10-YEAR CAPACITY)

LIMITS OF ROADWAY RECONSTRUCTION

Existing 12" Effluent Force Main

Recreation Drive

Existing 6" Sanitary Force Main

BOTTOM OF ACTIVE CHANNEL

LIMITS OF ROADWAY RECONSTRUCTION

Newlin Gulch

Existing Grouted Boulder Drop Structure

Recreation Drive East

TO EAST PARKING LOT

Existing Crest Elev. = 5795.3

Existing 12" Effluent Force Main

Existing 6" Sanitary Force Main

110 LF SHEET PILE 15' DEEP

TYPE H RIPRAP

Douglas County

Challenger Park

Curbcut FL = 5798.40

Basketball Court

West Parking Lot

Curbcut FL = 5798.50

Playground

Picnic Shelters

South Parking Lot

BOTTOM OF ACTIVE CHANNEL

EXTENTS OF CHANNEL EXCAVATION (PROVIDES 2-YEAR FLOOD PROTECTION FOR PARKING LOT)

POST-PROJECT APPROXIMATE 100-YEAR FLOODPLAIN

100-YEAR FHAD FLOODPLAIN

Town of Parker

Newlin Gulch

Douglas County

1707 1777 1841 1867 1997 2171 2322 2559 2748

0 50' 100'

N

LEGEND

- FHAD 100-YEAR FLOODPLAIN
- POST PROJECT 100-YEAR FLOODPLAIN
- PROPERTY LINES
- JURISDICTIONAL BOUNDARIES
- 2559 FHAD CROSS SECTION LOCATION

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

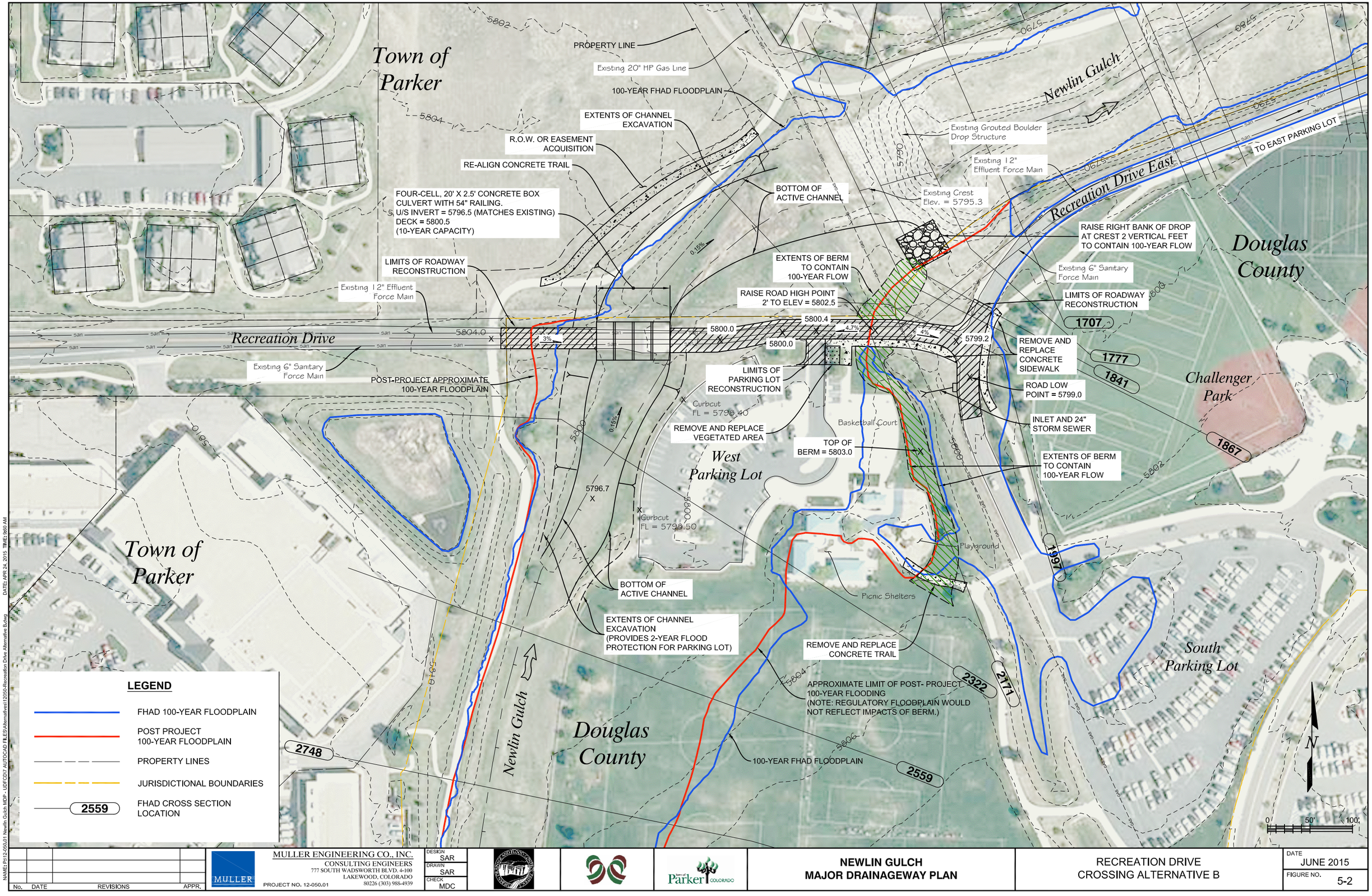
DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH MAJOR DRAINAGEWAY PLAN

RECREATION DRIVE ALTERNATIVE A

DATE JUNE 2015
FIGURE NO. 5-1

DATE: JUN 01, 2015 TIME: 7:56 AM
NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Recreation Drive Alternative A.dwg



DATE: APR 24, 2015 TIME: 9:60 AM

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Recreation Drive Alternative Bubwg

No.	DATE	REVISIONS	APPR.

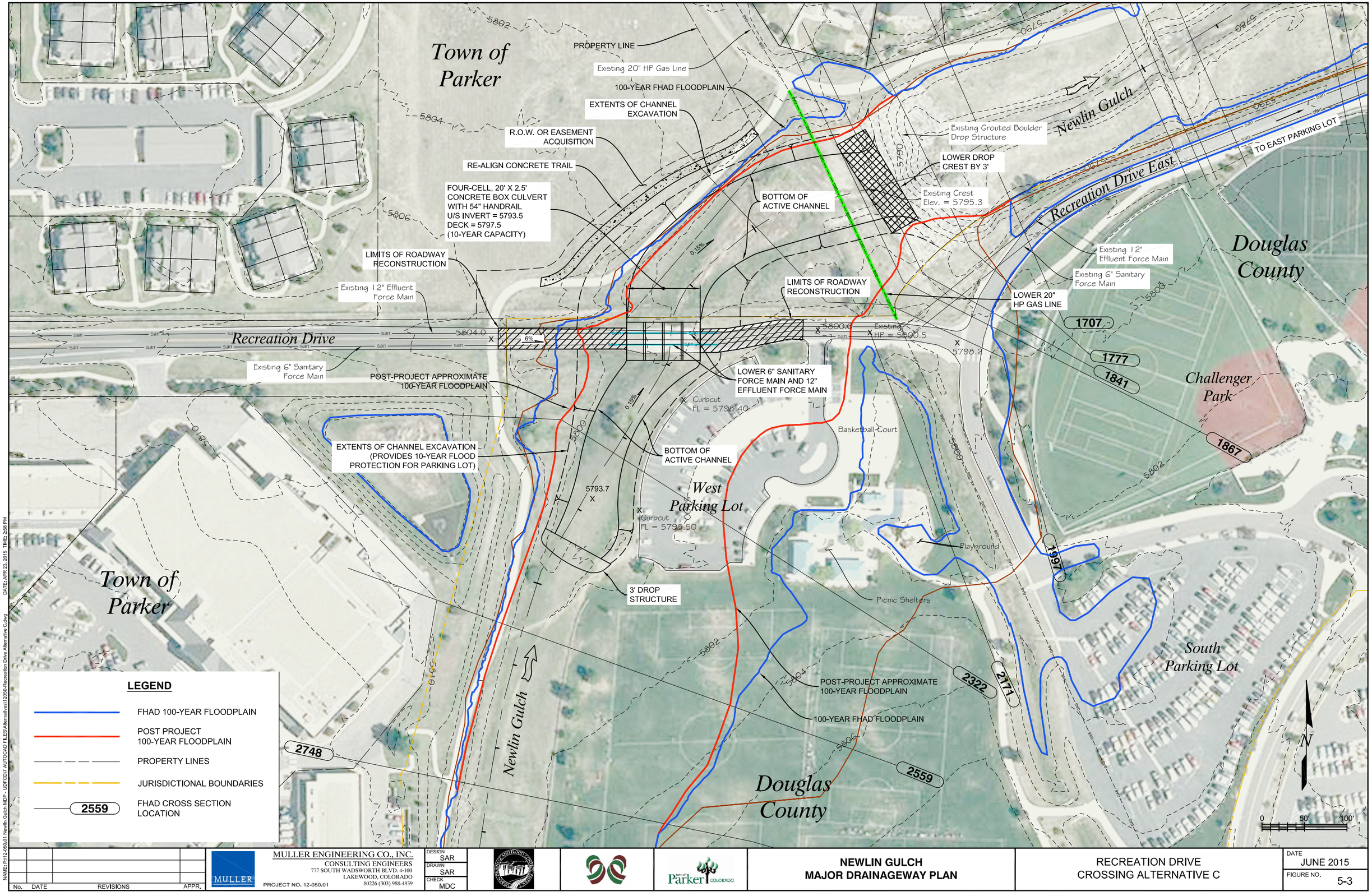
MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

RECREATION DRIVE
CROSSING ALTERNATIVE B

DATE JUNE 2015
FIGURE NO. 5-2



DATE: APR 23, 2015 TIME: 2:58 PM

NAME: P:\12-050\01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Recreation Drive Alternative C.dwg

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN	SAR
DRAWN	SAR
CHECK	MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

RECREATION DRIVE
CROSSING ALTERNATIVE C

DATE: JUNE 2015
FIGURE NO. 5-3

Recreation Drive Alternative C: 10-Year Crossing with Lowered Invert

In Alternative C, the same four-cell 20' span x 2.5' rise concrete box culvert provides 10-year capacity, but its invert is set three feet below the existing at-grade crossing. By lowering the crossing, the 100-year overtopping is contained within the existing high point in Recreation Drive, reducing the road reconstruction commensurate with Alternative A. In order to accommodate the lower invert, Alternative C requires modification of the downstream grouted boulder drop structure to lower the crest elevation by three feet, as well as lowering of the 20-inch high pressure gas line crossing the channel just upstream of the drop structure. Additional utility relocations would be required for the SVMD 12-inch effluent force main and 6-inch sanitary force main located beneath Recreation Drive at a depth of 6'-8'. Upstream of the crossing, an additional 3-feet of grade control is needed to lower the channel as it enters the culverts. This lowered channel also increases the available capacity prior to flooding of the adjacent parking lot. Realignment of the concrete trail is required in this alternative as well.

The capital improvement cost of Alternative C is $1.39 million, with a total project cost of $2.22 million.

Table 5-2: Alternative Cost Summary

	Alternative A	Alternative B	Alternative C
Capital	$ 878,000	$ 1,128,838	$ 1,391,010
Easement / ROW	$ 60,984	$ 60,984	$ 60,984
Engineering	$ 131,700	$ 169,326	$ 208,652
Legal / Administrative	$ 43,900	$ 56,442	$ 69,551
Contract Admin / CM	$ 87,800	$ 112,884	$ 139,101
Contingency	$ 219,500	$ 282,210	$ 347,753
Total Capital Cost	$ 1,421,884	$ 1,810,684	$ 2,217,051
Annual O&M Cost	$ 800	$ 891	$ 800
50-Year O&M Cost	$ 17,186	$ 19,141	$ 17,186

5.6 QUALITATIVE EVALUATION PROCEDURE

In addition to the cost estimates, numerous additional factors were considered in the evaluation of the Recreation Drive alternatives.

Recreation Drive Overtopping Depths – Public Safety

All three alternatives provide a significant improvement to public safety by eliminating the at-grade crossing and allowing flows up to the 10-year storm event to pass beneath Recreation Drive. In larger storm events, closure of the road would still be required as a safety precaution. As shown in **Table 5-3**, none of the proposed alternatives meet the maximum 100-year overtopping depth of 12-inches allowed by Douglas County and Town of Parker criteria. All provide significant improvement, though, with the greatest reduction provided by Alternative A.

Table 5-3: 100-Year Alternative Overtopping Depths at Recreation Drive

	Crossing Invert	Road Overtopping Elevation	100-Year Base Flood Elevation	100-Year Overtopping Depth
Existing	5796.7	5796.7	5801.5	4.8 ft
Alternative A	5796.5	5799.8	5801.9	2.1 ft
Alternative B	5796.5	5800.0	5802.3	2.3 ft
Alternative C	5793.5	5797.5	5800.4	2.9 ft

Flooding Extents – Public Safety

Under Alternative A, flooding at Recreation Drive East would still occur in events larger than a 10-year. This could be a hazard to anyone traveling along this roadway or parked in the east parking lot, as Recreation Drive East is the sole means of egress from this lot. Alternatives B and C eliminate this flooding in the 100-year event.

100-Year Regulatory Floodplain Impacts

Alternatives A and B both negatively impact the 100-year floodplain, though impacts are limited to the County-owned Challenger Park facilities and do not impact any adjacent properties. In Alternative A, the base flood elevation at Recreation Drive is increased from 5801.5 to 5801.9, resulting in additional backwater in the south parking lot and additional flows spilling along the north drive. Alternative B creates a greater rise, with the base flood elevation reaching 5802.3. Though the road profile modifications, drop structure modifications, and berming along the east side of the playground would provide containment of 100-year flows, this would not be reflected in the mapped floodplain limits. Alternative C has the greatest floodplain improvement, with a 1.1-foot reduction in the base flood elevation and full containment of the floodplain.

West Parking Lot Flooding

Flooding depths in the west parking lot for the existing condition and each of the alternatives are summarized in **Table 5-4** (based on depths at cross section 2322). Alternatives A and B eliminate flooding in the 2-year storm event and reduce flooding depths in the 5-year and 10-year events. Impacts in the 100-year event are varied, with increased depths at the northern end of the lot based on the base flood elevation at Recreation Drive, and minimal changes nearer the south end of the lot. Alternative C eliminates flooding in the 10-year and smaller events, and reduces the 100-year depth by 1.4 feet.

Table 5-4: Challenger Park West Parking Lot Flooding Depths

	Flooding Depth (ft)			
	2-Year	5-Year	10-Year	100-Year
Existing Condition	1.6	2.1	2.5	3.8
Alternative A	n/a	1.0	1.5	3.6
Alternative B	n/a	1.0	1.6	3.9
Alternative C	n/a	n/a	n/a	2.4

Protection of the Downstream Grouted Boulder Drop Structure

Alternatives B and C both provide 100-year capacity at the large grouted boulder drop structure located downstream of Recreation Drive, thereby reducing the risk of scour from flows bypassing the drop. Alternative A does not improve capacity, but does protect against scour with the addition of sheet piling and riprap adjacent to the drop.

Road Profile

Alternatives A and C require less modification of the road profile than Alternative B. Alternative C maximizes slopes at 6%; slopes range from 3% to 4.7% for Alternatives A and B.

Impact on Utility Lines

All three alternatives will protect the buried utilities against scour by protecting the downstream grouted boulder drop structure.

Constructability

Alternative A poses some concerns with installation of sheet piling in close proximity to the existing utilities, especially the 12" effluent force main. Alternative C introduces construction risk with the lowering of the 20" gas line, as well as the sanitary lines. Construction scheduling would also be complicated by these impacts. Alternatives A and C cause little traffic disturbance, as Recreation Drive East could be kept open during construction. Alternative B has greater impact on traffic due to the modifications to Recreation Drive East.

Property Impacts

The vacant property to the north of Recreation Drive on the west side of the channel is privately owned. While the proposed culvert would be within existing right of way for all three alternatives, the channel grading and trail realignment would require acquisition of additional right of way or an easement. An initial search of property information did not reveal any existing easements. Development plans for the parcel are unknown; according to Douglas County property data, it is associated with Regis Jesuit High School.

Table 5-5 provides a summary comparison of the three Recreation Drive Alternatives. A weighted rating system was used to evaluate the performance of the alternatives for each category; a rating of 3 is the best rating, 2 is moderate, and 1 is the lowest rating.

Table 5-5: Alternative Evaluation Summary Matrix at Recreation Drive

		Alternative A: 10-year Crossing at Existing Invert		Alternative B: 10-Year Crossing at Existing Invert with 100-Year Flood Containment		Alternative C: 10-Year Crossing with Lowered Invert	
	Weighting Percentage	Comment	Rating	Comment	Rating	Comment	Rating
Cost	20%	$1.42 M	3	$1.81 M	2	$2.22 M	1
Recreation Drive Overtopping (Public Safety)	15%	Eliminated in 10-year; reduced to 2.1’ in 100-year	3	Eliminated in 10-year; reduced to 2.3’ in 100-year	3	Eliminated in 10-year; reduced to 2.9’ in 100-year	2
Flooding Extents (Public Safety)	15%	Slightly increased flooding at Recreation Drive East and south parking lot (10-year protection)	1	Recreation Drive East and south parking lot flooding eliminated (100-year protection)	3	Recreation Drive East and south parking lot flooding eliminated (100-year protection)	3
100-Year BFE	5%	Increase of 0.4’	2	Increase of 0.8’	1	Decrease of 1.1’	3
West Parking Lot Flooding	10%	Eliminated in 2-Year Event	2	Eliminated in 2-Year Event	2	Eliminated in 10-Year Event	3
Protection of Grouted Boulder Drop Structure	10%	Sheet pile protects against end-around erosion	2	Provides 100-year capacity at crest	3	Provides 100-year capacity at crest	3
Road Profile	5%	Maintains gradual slopes; minimizes changes	3	Moderate changes to raise high point	2	Moderate changes; slopes maximized at 6%	2
Protection of Utility Lines	5%	Provides 100-year protection	3	Provides 100-year protection	3	Provides 100-year protection	3
Constructability	15%	Concerns with sheet pile installation adjacent to sanitary lines; low disturbance to roadway	2	Least disturbance to utility lines; moderate disturbance to roadway	2	Most disturbance to utilities (requires lowering of 20” gas line, 6” sanitary force main, and 12” effluent force main)	1
Weighted Average Ranking			2.30		2.40		2.10

6 RECOMMENDED PLAN

6.1 PLAN DESCRIPTION

6.1.1 Channel Stabilization

As mentioned previously in **Section 5.1**, a single plan was developed to address current and future anticipated channel stability issues along Newlin Gulch. Currently, approximately one half of the study reach is already stabilized with grade control structures and bank protection improvements; the majority of the stabilized reaches are in the downstream portion of the watershed that was developed in the 1990's when the Stonegate Village community was built. In the upstream portion of the study reach from Mainstreet to Hess Road, Newlin Gulch is mostly in its natural condition with minimal stabilization improvements to date. However, development within the upstream reach has been more active over the last 5-years and is currently at about 50 percent build-out. Early signs of channel instability and degradation in the upstream reach are evident, likely due in part to increased runoff from the new developments. Also, some of the natural unstabilized sections in Stonegate Village are starting to show signs of new degradation. As development continues to full build-out, runoff volumes will increase and create more channel instability issues in the unstabilized portions of Newlin Gulch.

Another factor affecting the stability of Newlin Gulch is the recent construction of Rueter-Hess Reservoir, completed in 2012. PWSD owns this water supply reservoir but only has junior water rights on Newlin Gulch surface flows. As a result, any surface flow from Newlin Gulch that is collected in the Reservoir must be released to satisfy downstream senior water rights unless there is a "free river" condition. In a "free river" condition, PWSD can retain Newlin Gulch flows. Often after large rainfall or snowmelt events, captured flow in the Reservoir is released to the downstream Newlin Gulch channel at sustained flow rates of up to 100 cfs, sometimes for days at a time. These flow releases are sediment free which results in "clear water" conditions that scour and erode the sandy Newlin Gulch channel more easily. Channel degradation and instability in the upstream reach is evident from these releases and a 3-foot headcut has developed downstream of the Hess Road bridge.

The increase in runoff from new development combined with the reservoir releases are upsetting the delicate water and sediment balance in Newlin Gulch. In response, the upstream channel is starting to downcut and degrade towards a flatter longitudinal slope. The degradation will continue until the channel adjusts it slope and width to a point where it is back in equilibrium. If left unchecked, the degradation can result in numerous negative impacts to the corridor including:

- Removal of riparian vegetation which leaves the channel exposed to further erosion and disrupts wildlife habitat
- Increased flow velocities within incised channel
- Lowering of the water table and drying out overbank vegetation
- Impairment in water quality due to increased sediment loading
- Damage to property and infrastructure such as utility lines, trails, and bridges

To protect the natural character and function of the Newlin Gulch channel, it is important that stream stabilization improvements be implemented in a way that will allow the geomorphic changes to occur, but in a manner that preserves the natural beneficial functions of a healthy stream system. To accomplish this, the recommended plan for future stream stabilization improvements is as follows:

- Grade Control: Implement grade control structures to accommodate a flatter long-term stable slope and control channel degradation. Recommendations for stable channel slopes are provided in **Section 6.1.2** below. Small height grade control structures (drop structures) are recommended where feasible to keep the baseflow channel shallow and allow for better connectivity to the adjacent floodplain. New UDFCD criteria recommends that drop heights be no greater than 3-feet.

- Preserve Shallow Baseflow Channel: Grade control structures shall be located to retain the historic channel invert and preserve the shallow baseflow channel so that storm flows are able to spill out into the wide adjacent floodplain overbanks. Widespread, shallow flow conveyed through overbank vegetation travels much slower and improves water quality through filtering and infiltration. A shallow baseflow channel will also keep the water table closer to the floodplain overbanks, promoting healthy riparian vegetation adjacent to the creek and across the floodplain.

Currently, there is not any major bank erosion within the study reach and most adjacent development is sufficiently set back from the floodplain. However, some bank protection or reinforcement may eventually be needed in certain areas such as the outside of sharp bends. If grade control is implemented in a manner that retains the historic invert and preserves the shallow baseflow channel, then natural bioengineering approaches can be effective for bank reinforcement. Options for bioengineering will be evaluated in more detail in the Conceptual Design phase.

6.1.2 Stable Channel Slope Analysis

Since the publication of the 1993 OSP, multiple channel stabilization projects have been completed along Newlin Gulch using various design slopes. In order to determine the recommended stable channel slope to be used in this study, a field assessment of the slopes used in the completed projects was conducted. The results are summarized in **Table 6-1**.

Table 6-1: Existing Channel Slope Analysis

Project	MDP Reach	Construction Completion Date	Channel Design Slope	Condition Assessment
Challenger Park Estates	1	1998 (approx.)	0.20%	Stable (some aggradation)
Stonegate Village – Phase 2 (U/S of Jordan Road)	3	2011	0.13% - 0.19%	Stable (minor scour in narrow, steeper portion)
Stonegate Village – Phase 3 (D/S of Stonegate Parkway)	3	2013	0.15% - 0.25%	Stable
Stonegate Village – Phase 1 (D/S of Stonegate Parkway)	3	2009	0.25%	Stable
Mainstreet Bridge	4	2008	0.56%	Minor downcutting

Based on these observations, recommended stable channel slopes were determined for each reach, as shown in **Table 6-2**.

Table 6-2: Recommended Stable Channel Slopes

Reach Description	Reach No.	Recommended Slope
Recreation Drive to Jordan Road	2-3	0.15%
Stonegate Village (D/S of Stonegate Parkway)	3	0.15%
Stonegate Village (U/S of Stonegate Parkway)	3	0.25%
Upstream of Stonegate Village to Mainstreet	4	0.25%
Mainstreet to Chambers Road	5	0.25%
Chambers Road to Hess Road	6	0.25%

6.1.3 Recommended Improvements by Reach

The recommended channel stabilization improvements for each reach are described in the paragraphs below and are shown on **Figure 6-1 and Figure 6-2.** Improvements associated with the Recreation Drive alternatives are not included in the Reach 1 and Reach 2 discussions, but are included in **Section 6.1.4** that follows.

Reach 1 – Challenger Park Estates

Because this reach was previously stabilized to a 0.2% slope, additional channel stabilization is not needed. To address scour upstream of the four vertical drop structures, riprap stabilization in these areas is recommended. The associated capital improvement cost is $20,300, with a total project cost of $31,400.

Reach 2 – Challenger Regional Park

The recommended stable channel slope for Reach 2 is 0.15%, requiring an additional 4 feet of grade control. Two 2.0-foot drop structures have been shown. The associated capital improvement cost is $567,000, with a total project cost of $879,000.

Reach 3 – Stonegate Village

Recommended stable channel slopes for Reach 3 are 0.15% and 0.25% downstream and upstream of Stonegate Parkway, respectively. Between Lincoln Avenue and Jordan Road, this requires an additional 4.5 feet of grade control; three 1.5-foot drop structures have been shown. Upstream of Jordan Road, the 2011 Conceptual Design Report for *Newlin Gulch Channel Improvements at Stonegate* recommended four 2.0-foot drop structures in the middle portion of the reach and two 3.3-foot drop structures in the upper portion.

Other recommended improvements include removal of sediment beneath the Jordan Road bridge, channel widening near the confluence with the Jordan Road Tributary, and formalization of the existing maintenance bench south of Stonegate Parkway as a concrete pedestrian trail.

The recommended plan capital improvement cost for Reach 3 is $1.95 million, with a total project cost of $3.03 million

Reach 4 – Newlin Crossing

The recommended stable channel slope for Reach 4 is 0.25%; this matches the constructed slope for the lower portion of the reach but is flatter than the constructed 0.56% slope for the upper portion. The existing grouted boulder drop structures in the upper portion of the reach were constructed with deep stilling basins; rather than constructing additional drop structures, the recommended plan modifies the existing structures by cutting wide notches in the end sills and by raising the crest elevations. These drop structure modifications will allow the channel to a graded to a 0.25% slope. Provision of a maintenance access/recreational trail is also recommended in this reach.

The associated capital improvement cost is $335,000, with a total project cost of $520,000.

Reach 5 – Mainstreet to Chambers Road

The recommended stable channel slope for Reach 5 is 0.25%, requiring an additional 32 feet of grade control. Thirteen 2.5-foot drop structures have been shown. Provision of a maintenance access/recreational trail is also recommended in this reach.

The associated capital improvement cost is $3.62 million, with a total project cost of $5.62 million.

Reach 6 – Chambers Road to Hess Road

The recommended stable channel slope for Reach 5 is 0.25%, requiring an additional 30 feet of grade control. Twelve 2.5-foot drop structures have been shown; taller structures were chosen for this reach to reduce the spacing. A low-water trail crossing is currently being designed for this reach; construction is expected to begin during the course of this study. The crossing will include a riprap rundown into a low rise concrete box culvert; while a recommended drop structure is shown just upstream of the crossing, it is expected that the crossing will be retrofitted to incorporate formal grade control in the future.

The recommended plan capital improvement cost for Reach 6 is $3.57 million, with a total project cost of $5.54 million.

A summary of costs for the recommended improvements by reach is included in **Table 6-3**.

6.1.4 Recreation Drive

Alternative B is the recommended option for replacing the at-grade crossing at Recreation Drive. While the weighted rankings indicate a near tie with Alternative A, Alternative B provides better hydraulic conditions by containing the 100-year flows within the channel. While Alternative C provides the best hydraulic conditions, the additional cost and complications associated with relocation of the utility lines outweigh the benefits.

The costs for Alternative B are included separately from the reach costs in **Table 6-3**. Because the improvements straddle the Town of Parker and Douglas County boundaries, the costs will be apportioned between the two in Section 7, Conceptual Design.

6.2 WATER QUALITY IMPACTS

The Urban Drainage and Flood Control District's Four Step Process for water quality protection is as follows:

1. Employ runoff reduction practices.
2. Implement effective water quality detention.
3. Stabilize drainageways.
4. Implement source control practices.

The recommended plan focuses on step three by providing stable channel slopes along the length of Newlin Gulch. The low drop structure heights will allow the creek to remain connected to its floodplain, encouraging the establishment of vegetation and providing treatment of stormwater runoff through infiltration and filtering. Step four is also addressed through the elimination of manure-spreading practices in Reach 5.

6.3 OPERATIONS AND MAINTENANCE

Ongoing operations and maintenance are an essential component of the health of any urban stream. Channel and trail maintenance costs have been included for the length of the study area, along with allowance for periodic routine maintenance at all existing and proposed drop structures. **Table 6-3** summarizes the operation and maintenance costs by reach.

6.4 ENVIRONMENTAL AND SAFETY ASSESSMENT

The recommended plan will improve the environmental character of Newlin Gulch as the stable channel slopes allow the ongoing establishment of vegetation, increasing the habitat and ecological diversity of the corridor.

Recreation Drive currently poses a significant safety hazard due to frequent overtopping at depths in excess of those allowed by Douglas County and Town of Parker criteria. While the recommended plan will not eliminate the hazard, it will greatly reduce it by eliminating overtopping in the 10-year and smaller storm events and by reducing the 100-year overtopping depth from 4.8 feet to 2.3 feet.

Table 6-3: Recommended Plan Cost Summary

REACH	CAPITAL	EASEMENT / ROW	ENGINEERING	LEGAL / ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	TOTAL CAPITAL COST	ANNUAL O&M COST	50-YEAR O&M COST
NG-Reach1	$ 20,270	$ -	$ 3,041	$ 1,014	$ 2,027	$ 5,068	$ 31,420	$ 21,458	$ 460,965
NG-Reach2	$ 566,856	$ -	$ 85,028	$ 28,343	$ 56,686	$ 141,714	$ 878,627	$ 9,247	$ 198,646
NG-Reach3	$ 1,954,490	$ -	$ 293,174	$ 97,725	$ 195,449	$ 488,623	$ 3,029,461	$ 85,014	$ 1,826,286
NG-Reach4	$ 335,413	$ -	$ 50,312	$ 16,771	$ 33,541	$ 83,853	$ 519,890	$ 22,303	$ 479,117
NG-Reach5	$ 3,624,556	$ -	$ 543,683	$ 181,228	$ 362,456	$ 906,139	$ 5,618,062	$ 49,659	$ 1,066,784
NG-Reach6	$ 3,573,173	$ -	$ 535,976	$ 178,659	$ 357,317	$ 893,293	$ 5,538,418	$ 23,536	$ 505,605
Totals	**$ 10,074,758**	**$ -**	**$ 1,511,214**	**$ 503,740**	**$ 1,007,476**	**$ 2,518,690**	**$ 15,615,878**	**$ 211,217**	**$ 4,537,403**

REACH 1
Reach Length = 2150 LF
Stabilized Channel Slope = 0.20%

REACH 2
Reach Length = 1000 LF
Average Slope = 0.59%
RECOMMENDED STABLE SLOPE = 0.15%
(2) 2.0-FT DROP STRUCTURES

REACH 3
Reach Length = 8450 LF
Stabilized Channel Slope = 0.13% - 0.25%
Average Slope of Unstabilized Reaches = 0.7%
RECOMMENDED STABLE SLOPE = 0.15% D/S STONEGATE PARKWAY
RECOMMENDED STABLE SLOPE = 0.25% U/S STONEGATE PARKWAY
(9) DROP STRUCTURES (VARYING HEIGHTS AS NOTED)

REACH 4

Cherry Creek

Douglas County

Town of Parker

Douglas County

Challenger Park

Lincoln Ave

Jordan Road

Jordan Road Tributary

Newlin Gulch

Stonegate Village Metropolitan District

Recreation Drive

Challenger Park Estates

Town of Parker

Stonegate Village Metropolitan District

Keystone Blvd

Douglas County

Stonegate Pkwy

1.5' DROP STRUCTURE

CONVERT EXISTING CHECK STRUCTURES INTO 1.5' DROP STRUCTURES

2.0' DROP STRUCTURES

2.0' DROP STRUCTURES (SEE NOTE)

CONVERT EXISTING CHECK STRUCTURES INTO 2.0' DROP STRUCTURES (SEE NOTE)

RECREATION DRIVE CROSSING ALTERNATIVE B: FOUR-CELL 20' X 2.5' CONCRETE BOX CULVERT (10-YR CAPACITY)

ADD TYPE M RIPRAP APRON TO MITIGATE SCOUR UPSTREAM OF EXISTING VERTICAL WALL DROPS. (EACH APRON 50' WIDE X 15' LONG)

SEDIMENT CLEANOUT UNDER BRIDGE

CHANNEL RE-GRADING/WIDENING ON WEST SIDE

CONVERT EXISTING CHECK STRUCTURES INTO 3.3' DROP STRUCTURES (SEE NOTE)

MATCHLINE - SHEET 2 OF 2

LEGEND

- 100-YEAR FLOODPLAIN
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED CONVERSION OF CHECK STRUCTURE TO DROP STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED REACH

0' 150' 300' 600'

NOTE:
PROPOSED DROP STRUCTURE LOCATIONS AND SIZES IN REACH 3 UPSTREAM OF JORDAN ROAD ARE BASED ON THE "NEWLIN GULCH CHANNEL IMPROVEMENTS UPDATED CONCEPTUAL DESIGN REPORT" PREPARED JUNE 23, 2011 BY MULLER ENGINEERING FOR DOUGLAS COUNTY, STONEGATE VILLAGE METRO DISTRICT, AND UDFCD.

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

DESIGN	SAR
DRAWN	SAR
CHECK	MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

RECOMMENDED PLAN
REACHES 1-3

DATE: JUNE 2015
FIGURE NO. 6-1

DATE: APR 24, 2015 TIME: 11:34 AM
NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Recommended Plan.dwg

REACH 4
Reach Length = 2400 LF
Stabilized Channel Slope = 0.25% - 0.65%
RECOMMENDED STABLE SLOPE = 0.25%
MODIFY (3) EXISTING DROP STRUCTURES

REACH 5
Reach Length = 4950 LF
Average Slope = 0.92%
RECOMMENDED STABLE SLOPE = 0.25%
(13) 2.5-FT DROP STRUCTURES

REACH 6
Reach Length = 3250 LF
Average Slope = 1.3%
RECOMMENDED STABLE SLOPE = 0.25%
(12) 2.5-FT DROP STRUCTURES

Douglas County

Newlin Gulch Blvd

Town of Parker

Newlin Gulch

MODIFY EXISTING DROP:
ADD GROUTED BOULDERS
TO RAISE CREST BY 1.0'

RE-GRADE CHANNEL
BOTTOM FROM 0.65%
SLOPE TO 0.25% SLOPE.

CONVERT EXISTING CHECK
STRUCTURES INTO DROP
STRUCTURES

LOW-WATER TRAIL CROSSING
(TO BE BUILT IN 2015)

LOW-WATER TRAIL CROSSING
AND CHECK STRUCTURE
TO BE BUILT IN 2016

CONVERT EXISTING CHECK
STRUCTURE INTO DROP
STRUCTURE

Chambers Road

Hess Road

Town of Parker

Douglas County

Mainstreet

MODIFY EXISTING DROP:
1) CONSTRUCT 0.8' DEEP X 20'
WIDE NOTCH IN END SILL.
2) ADD GROUTED BOULDERS
TO RAISE CREST BY 1.2'

MODIFY EXISTING DROP:
CONSTRUCT 1.2' DEEP X 20'
WIDE NOTCH IN END SILL.

MATCHLINE - SHEET 1 OF 2

Douglas County

LEGEND

- 100-YEAR FLOODPLAIN
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED CONVERSION OF CHECK STRUCTURE TO DROP STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED REACH

N

0' 150' 300' 600'

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

RECOMMENDED PLAN
REACHES 4-6

DATE JUNE 2015
FIGURE NO. 6-2

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Recommended Plan.dwg
DATE: APR 24, 2015 TIME: 11:33 AM

7 CONCEPTUAL DESIGN

7.1 PLAN DEVELOPMENT OVERVIEW

The Newlin Gulch Major Drainageway Plan was chosen by the project sponsors in the Selected Plan, issued July 13, 2015. The Selected Plan, which is included in **Appendix A**, follows the Recommended Plan outlined in **Section 6** of this report with no modifications.

The Selected Plan lists the following principal elements, goals, and objectives for this MDP:

- Minimize stormwater and flood-related damages to drainageways, public infrastructure and private property. Do this with value engineering and practicalities of implementation in mind.

- Institute an approach that balances the development in the watershed with stormwater management implementation that complements drainageway and stream stability solutions, that as a system, provide multiple benefits that include:
  - Water quality protection and enhancement;
  - Water quantity resources protection;
  - Preservation of natural character of the waterways and their terrestrial and aquatic habitat resource;
  - Wherever possible, provide public use and access and/or trails within the corridors of identified waterways in order to provide maintenance access that will also provide for active and passive recreation of the public.

- Consider the needs for new and upgraded roadway crossings when such improvements are practicable, affordable and add significant value in relation to the cost.

Because the Newlin Gulch corridor has been well-preserved by the sponsors as an open space corridor, the minimization of problems or damages is largely achieved through a continuation of past efforts. These include the establishment of open-space tracts as new developments are platted, the installation of channel stabilization measures as adjacent development occurs, and the construction of additional channel stabilization measures in response to channel degradation resulting from hydrologic changes within the watershed. While a portion of these hydrologic changes arise due to ongoing development, the hydrology in this watershed is heavily influenced by the Rueter-Hess Reservoir. The Flood Hazard Area Delineation (FHAD) that is being completed in conjunction with this MDP reflects the reservoir's influence and establishes the floodplain corridor to be preserved in accordance with Douglas County and Town of Parker floodplain policies. Future channel stabilization measures have been identified based on the anticipated long-term equilibrium or stable channel slopes in each reach; these slopes were estimated based on observations of the channel's trend towards a flatter equilibrium slope in response to urbanization and hydrologic changes in the watershed. An evaluation of historic and current channel slopes was performed for several previously constructed stabilization projects in the study area (see **Section 6.1.2** for additional discussion).

While most of the roadway crossings along Newlin Gulch are more than adequate to pass even the largest flood events, the on-grade Recreation Drive crossing is a glaring exception. Currently even the smallest storm poses a safety hazard and requires a road closure. This plan calls for the installation of a grade-separated crossing in order to provide safe passage to the public in storms up to the 10-year event, which provides a cost-effective solution that drastically improves the safety of this crossing.

By emphasizing the preservation of a natural stream system, this plan promotes the protection and enhancement of water quality, and the preservation of the character and habitat resources of the waterway. The existing and planned system of trails along the gulch provides public recreational opportunities as well as access for ongoing maintenance of the channel.

A schematic of the plan improvements is shown in **Figure 7-1** and **Figure 7-2** – the full plan and profile drawings are included in **Appendix J** and **Appendix K**, respectively.

Estimated capital improvement and operations and maintenance costs developed for the Alternative Analysis were updated with UD-MP Cost to reflect the final plan. Unit costs were updated to the second quarter 2015 construction cost index of 1.2193. (See **Section 5.4** for additional discussion on the development of cost estimates.) A summary of the costs by reach is shown in **Table 7-1**.

Table 7-1: Master Plan Cost Estimate Summary

REACH	CAPITAL	EASEMENT / ROW	ENGINEERING	LEGAL / ADMINISTRATIVE	CONTRACT ADMIN/CM	CONTINGENCY	TOTAL CAPITAL COST	ANNUAL O&M COST	50-YEAR O&M COST
NG-Reach1	$262,107.00	$43,560.00	$39,316.00	$13,105.00	$26,211.00	$65,527.00	$449,826.00	$21,348.00	$458,602.00
NG-Reach2	$1,478,298.00	$0.00	$221,745.00	$73,915.00	$147,830.00	$369,575.00	$2,291,363.00	$10,325.00	$221,804.00
NG-Reach3	$2,041,918.00	$0.00	$306,288.00	$102,096.00	$204,192.00	$510,480.00	$3,164,974.00	$85,670.00	$1,840,379.00
NG-Reach4	$275,455.00	$0.00	$41,318.00	$13,773.00	$27,546.00	$68,864.00	$426,956.00	$21,711.00	$466,400.00
NG-Reach5	$3,493,682.00	$0.00	$524,052.00	$174,684.00	$349,368.00	$873,421.00	$5,415,207.00	$52,782.00	$1,133,873.00
NG-Reach6a	$1,996,156.00	$0.00	$299,423.00	$99,808.00	$199,616.00	$499,039.00	$3,094,042.00	$23,883.00	$513,059.00
NG-Reach6b	$654,124.00	$0.00	$98,119.00	$32,706.00	$65,412.00	$163,531.00	$1,013,892.00	$12,554.00	$269,687.00
Totals	**$10,201,740**	**$43,560**	**$1,530,261**	**$510,087**	**$1,020,175**	**$2,550,437**	**$15,856,260**	**$228,273**	**$4,903,804**

REACH 1

REACH 2

REACH 3

REACH 4

Cherry Creek

Douglas County

Town of Parker

Douglas County

Challenger Park

Lincoln Ave

Jordan Road

Jordan Road Tributary

EXCAVATE BOTTOM OF CHANNEL

GRADE-SEPARATED 10-YEAR CROSSING (FOUR-CELL 20' X 2.5' CONCRETE BOX CULVERT)

INSTALL RIPRAP APRONS AT EXISTING VERTICAL WALL DROP STRUCTURES TO MITIGATE SCOUR

SEDIMENT CLEANOUT UNDER BRIDGE

RE-GRADE AND WIDEN CHANNEL ON WEST BANK

Recreation Drive

Newlin Gulch

Stonegate Village Metropolitan District

Challenger Park Estates

Town of Parker

Stonegate Village Metropolitan District

Keystone Blvd

Douglas County

Stonegate Pkwy

MATCHLINE - SHEET 2 OF 2

LEGEND

- 100-YEAR FLOODPLAIN (2015 FHAD)
- 100-YEAR FLOODPLAIN (MASTER PLAN)
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED BANK PROTECTION
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED CHANNEL

0' 150' 300' 600'

NOTE:
PROPOSED DROP STRUCTURE LOCATIONS AND SIZES IN REACH 3 UPSTREAM OF JORDAN ROAD ARE BASED ON THE "NEWLIN GULCH CHANNEL IMPROVEMENTS UPDATED CONCEPTUAL DESIGN REPORT" PREPARED JUNE 23, 2011 BY MULLER ENGINEERING FOR DOUGLAS COUNTY, STONEGATE VILLAGE METRO DISTRICT, AND UDFCD.

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH MAJOR DRAINAGEWAY PLAN

MASTER PLAN SCHEMATIC
REACHES 1-3

DATE SEPT 2015

FIGURE NO. 7-1

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_SCHEMATIC.dwg
DATE: OCT 14, 2015 TIME: 10:02 AM

REACH 4

REACH 5

REACH 6A

REACH 6B

Newlin Gulch Blvd

Town of Parker

Douglas County

Newlin Gulch

Chambers Road

Hess Road

Mainstreet

LOW-WATER TRAIL CROSSING AND DROP STRUCTURE TO BE BUILT IN 2016

LOW-WATER TRAIL CROSSING (TO BE BUILT IN 2015)

RE-GRADE CHANNEL SLOPE

MODIFY EXISTING DROP STRUCTURES

MATCHLINE - SHEET 1 OF 2

0' 150' 300' 600'

LEGEND

- 100-YEAR FLOODPLAIN (2015 FHAD)
- 100-YEAR FLOODPLAIN (MASTER PLAN)
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- PROPOSED DROP STRUCTURE
- PROPOSED BANK PROTECTION
- PROPOSED MAINTENANCE TRAIL
- EXISTING STABILIZED CHANNEL

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

MASTER PLAN SCHEMATIC
REACHES 4-6

DATE SEPT 2015
FIGURE NO. 7-2

NAME:P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_SCHEMATIC.dwg DATE: SEP 08, 2015 TIME: 11:45 AM

7.2 MASTER PLAN DESCRIPTION

Proposed improvements are described reach by reach, moving from the downstream (north) end to the upstream (south) end of the watershed.

7.2.1 Reach 1 – Challenger Park Estates

Reach 1 is located in the Town of Parker, extending from the confluence with Cherry Creek to the downstream side of Recreation Drive along the northern boundary of Challenger Regional Park. This reach was previously channelized with a trapezoidal channel to allow development of Challenger Park Estates, and stabilized with grade control providing a 0.2% channel slope. Additional channel stabilization is not needed. An existing recreational trail provides maintenance access along the length of the reach.

Master plan improvements include the following:

- Install riprap aprons at existing scoured areas on upstream side of each of four existing vertical drop structures. Approximate sizing: 50’ wide, 15’ long, 2’ thick (Type M).
- Provide 100-year containment at crest of existing 13.5’ grouted boulder drop structure by raising grouted boulders on right bank and tying to high point in Recreation Drive with berming. *Note: The 100-year containment will not be regulatory as the berming along the right bank upstream of the drop will not be recognized as a levee. The regulatory floodplain will continue to spill onto Recreation Drive East.*
- Channel grading and trail profile modifications resulting from Recreation Drive improvements (see Reach 2 discussion in **Section 7.2.2**).

A conceptual opinion of probable cost is detailed in **Table 7-2**. Land acquisition for this reach may be required to establish a drainage and trail easement downstream of Recreation Drive, and is included in the total capital improvement cost of $450,000. (No existing easement was identified.)

Annual operations and maintenance planning should include drop structure, channel, and trail maintenance as well as mowing for weed control. The annual cost is estimated at $21,300, with a total 50-year cost of $459,000.

CLICK HERE TO VIEW REACH 1 MAP

CLICK HERE TO VIEW REACH 1 PROFILE

CLICK HERE TO VIEW RECREATION DRIVE DETAIL LAYOUT

Table 7-2: Reach 1 Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design
DRAINAGEWAY :	Newlin Gulch
REACH :	1
JURISDICTION :	Town of Parker
REACH ID:	NG-Reach1
DATE :	September 2015

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Channel Improvements					
12-inch Riprap, Type M		230	C.Y.	$73.00	$16,790.00
Grouted Boulders, 36"		280	S.Y.	$232.00	$64,960.00
Excavation, High Range		1200	C.Y.	$38.00	$45,600.00
Excavation, Mid Range		1300	C.Y.	$29.00	$37,700.00
Landscaping and Maintenance Improvements					
Wetlands Plantings		0.14	ACRE	$30,483.00	$4,268.00
Reclamation & seeding (native grasses)		1.0	ACRE	$1,219.00	$1,219.00
Trail/Path, Concrete (10' Width)		240	L.F.	$54.00	$12,960.00
Special Items (User Defined)					
Remove 36" Grouted Boulders	<----User Defined Items	280	SY	$30.00	$8,400.00
Bank Protection	<----User Defined Items	170	LF	$150.00	$25,500.00
Remove Sidewalk	<----User Defined Items	270	SY	$10.00	$2,700.00
Land Acquisition					
Easement/ROW Acquisition		0.5	ACRE	$87,120.00	$43,560.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs				
Pipe Culverts and Storm Drains				$0.00
Concrete Box Culverts				$0.00
Hydraulic Structures				$0.00
Channel Improvements				$165,050.00
Detention/Water Quality Facilities				$0.00
Removals				$0.00
Landscaping and Maintenance Improvements				$18,447.00
Special Items (User Defined)				$36,600.00
Subtotal Capital Improvement Costs				**$220,097.00**
Additional Capital Improvement Costs				
Dewatering	$15,000.00	L.S.		$15,000.00
Mobilization	5%			$11,005.00
Traffic Control	$3,000.00	L.S.		$3,000.00
Utility Coordination/Relocation	$2,000.00	L.S.		$2,000.00
Stormwater Management/Erosion Control	5%			$11,005.00
Subtotal Additional Capital Improvement Costs				**$42,010.00**
Land Acquisition Costs				
ROW/Easements				$43,560.00
Subtotal Land Acquisition Costs				**$43,560.00**
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%			$39,316.00
Legal/Administrative	5%			$13,105.00
Contract Admin/Construction Management	10%			$26,211.00
Contingency	25%			$65,527.00
Subtotal Other Costs				**$144,159.00**
Total Capital Improvement Costs				**$449,826.00**

Master Plan Operation and Maintenance Cost Summary

Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	6	EA	$610.00	$3,660.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2150	L.F.	$2.00	$4,300.00
Mowing (e.g. channels, ponds, etc.)	8	ACRE	$61.00	$488.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	2150	L.F.	$6.00	$12,900.00
Total Annual Operation and Maintenance Cost				**$21,348.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$458,602.00**

7.2.2 Reach 2 – Challenger Regional Park

Reach 2 is located within Douglas County and extends from the downstream side of Recreation Drive to the upstream side of Lincoln Avenue. The channel is wide and shallow, spreading onto the soccer fields to the east in all studied storm events. Recreation Drive is an at-grade crossing that poses a safety hazard. The existing average channel slope is 0.59%. Although the current channel is not actively eroding, it is anticipated that the long-term equilibrium or stable slope for this reach will be 0.15%.

Master plan improvements include the following:

- Replace at-grade Recreation Drive crossing with a four-cell 20'x2.5' concrete box culvert to provide 10-year capacity.
- Provide 100-year containment at Recreation Drive by modifying Recreation Drive and Recreation Drive East road profiles and constructing a berm in the right overbank upstream of the road crossing. *Note: The 100-year containment will not be regulatory as the right bank berm will not be recognized as a levee. The regulatory floodplain will continue to spill onto Recreation Drive East.*
- Provide an inlet in Recreation Drive East to drain the low point created by profile modification.
- Widen and deepen channel bottom adjacent to Challenger Park west parking lot to provide 2-year capacity adjacent to the lot.
- Construct two drop structures to allow for a flatter long-term stable slope of 0.15%.

A conceptual opinion of probable cost is detailed in **Table 7-3**, with a total capital improvement cost of $2,291,000. No land acquisition is required for this reach.

Annual operations and maintenance planning should include culvert, inlet, drop structure, channel, and trail maintenance as well as mowing for weed control. The annual cost is estimated at $10,300, with a total 50-year cost of $222,000.

CLICK HERE TO VIEW REACH 2 MAP

CLICK HERE TO VIEW REACH 2 PROFILE

CLICK HERE TO VIEW RECREATION DRIVE DETAIL LAYOUT

Table 7-3: Reach 2 Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design
DRAINAGEWAY :	Newlin Gulch
REACH :	2
JURISDICTION :	Douglas County
REACH ID:	NG-Reach2
DATE :	September 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Pipe Culverts and Storm Drains						
Circular Pipes						
Diameter (in)	**Length (ft)**	**No. of Barrels**				
24-inch	30	1	30	L.F.	$88.00	$2,640.00
Flare End Sections						
Diameter (in)	**Applicable**	**No. of Barrels**				
24-inch	Yes	1	1	EA	$1,183.00	$1,183.00
Manholes and Inlets						
Storm Inlet, Type R/Type 14, 5-foot			1	EA	$5,609.00	$5,609.00
Concrete Box Culverts						
Box Culvert Pipe						
Individual Box Span (ft)	**Box Height (ft)**	**No. of Barrels**	**Length (ft)**			
10	3	8	50	L.F.	$6,747.68	$337,384.00
Headwall and Toewalls						
Individual Box Span (ft)	**No. of Barrels**	**Total Span (ft)**				
10	8	88.00	2	EA	$7,956.96	$15,914.00
Wingwalls (includes wingwalls on either side of channel and concrete apron)						
Individual Box Span (ft)	**Box Rise (ft)**	**No. of Barrels**				
10	3	8	2	EA	$22,203.22	$44,406.40
Hydraulic Structures						
Sloping Drop Structures						
Height (ft)	**Bottom Width (ft)**	**Yn (ft)**				
2	100	3	2	EA	$178,782.52	$357,565.00
Channel Improvements						
Excavation, Mid Range			3500	C.Y.	$29.00	$101,500.00
Excavation, Mid Range			500	C.Y.	$29.00	$14,500.00
Excavation, High Range			500	C.Y.	$38.00	$19,000.00
Soil Riprap, Type M			350	C.Y.	$85.00	$29,750.00
Landscaping and Maintenance Improvements						
Wetlands Plantings			0.5	ACRE	$30,483.00	$15,242.00
Reclamation & seeding (native grasses)			3.5	ACRE	$1,219.00	$4,267.00
Trail/Path, Concrete (10' Width)			630	L.F.	$54.00	$34,020.00
Special Items (User Defined)						
Road Reconstruction	**<----User Defined Items**		1750	SY	$50.00	$87,500.00
Asphalt Removal	**<----User Defined Items**		2040	SY	$10.00	$20,400.00
Curb and Gutter (Remove and Replace)	**<----User Defined Items**		960	LF	$30.00	$28,800.00
Restore Landscape Area	**<----User Defined Items**		12500	SF	$5.00	$62,500.00
54" Railing (Box Culvert)	**<----User Defined Items**		216	LF	$250.00	$54,000.00
Remove Sidewalk	**<----User Defined Items**		700	SY	$10.00	$7,000.00
Bank Protection	**<----User Defined Items**		120	LF	$150.00	$18,000.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$9,432.00
Concrete Box Culverts			$397,704.00
Hydraulic Structures			$357,565.00
Channel Improvements			$164,750.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$53,529.00
Special Items (User Defined)			$278,200.00
Subtotal Capital Improvement Costs			**$1,261,180.00**
Additional Capital Improvement Costs			
Dewatering	$70,000.00	L.S.	$70,000.00
Mobilization	5%		$63,059.00
Traffic Control	$18,000.00	L.S.	$18,000.00
Utility Coordination/Relocation	$3,000.00	L.S.	$3,000.00
Stormwater Management/Erosion Control	5%		$63,059.00
Subtotal Additional Capital Improvement Costs			**$217,118.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$221,745.00
Legal/Administrative	5%		$73,915.00
Contract Admin/Construction Management	10%		$147,830.00
Contingency	25%		$369,575.00
Subtotal Other Costs			**$813,065.00**
Total Capital Improvement Costs			**$2,291,363.00**

Master Plan Operation and Maintenance Cost Summary				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs	200	L.F.	$4.00	$800.00
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1	EA	$91.00	$91.00
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	2	EA	$610.00	$1,220.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	1000	L.F.	$2.00	$2,000.00
Mowing (e.g. channels, ponds, etc.)	3.5	ACRE	$61.00	$214.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	1000	L.F.	$6.00	$6,000.00
Total Annual Operation and Maintenance Cost				**$10,325.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$221,804.00**

7.2.3 Reach 3 – Stonegate Village

Reach 3 is located within Douglas County in the Stonegate Village community. Stonegate Village Metropolitan District owns and maintains this reach, which extends from the upstream side of Lincoln Avenue to the Village boundary, approximately 1500' upstream of Stonegate Parkway. Adjacent development generally preserved the natural channel corridor; several recent channel stabilization projects have been constructed to address channel degradation. Existing channel slopes vary from 0.15% in stabilized areas to 0.7% in unstabilized areas. Recreational trails provide maintenance access downstream of Stonegate Parkway; an informal dirt path parallels the channel upstream of here.

Three areas within Reach 3 have not been stabilized: a lower segment between Lincoln Avenue and Jordan Road, a central segment near Stone Willow Park, and an upper segment immediately upstream of Stonegate Parkway. Master plan improvements for these areas is described below:

- The channel immediately downstream of Jordan Road has an average slope of 0.56% and is actively degrading towards a flatter equilibrium slope. Channel degradation of up to 4-feet has exposed an existing check structure and is putting the structure at risk of failure. This check structure along with a second one immediately upstream help protect the foundation of the Jordan Road bridge. It is recommended that the two check structures be replaced with 1.5-foot drop structures and an additional 1.5-foot drop structure be constructed downstream to provide a stable long-term slope of 0.15%.

- The central area near Stone Willow Park is currently stable with an average slope of 0.7% and dense riparian vegetation. Two existing check structures were built previously in this reach and remain fully buried since no erosion has occurred at this location. The channel immediately upstream of this location has been actively eroding over the past several years but was recently stabilized in 2013. Therefore, sediment loads are expected to be reduced which may cause destabilization of the central area. It is recommended that the area be monitored and grade control incorporated if future instability develops. For long-term planning, it is anticipated that the channel may degrade towards the 0.15% equilibrium slope observed immediately upstream and downstream of this location and require the construction of four 2-foot drop structures. This recommendation is consistent with the recommendations in the *2011 Conceptual Design Report for Newlin Gulch Channel Improvements at Stonegate.*

- The channel immediately upstream of Stonegate Parkway has an average slope of 0.7% and is beginning to actively degrade towards a flatter slope. The degradation began immediately after the reach upstream was stabilized in 2009 and has exposed one of two check structures that were constructed in the early 1990s. In accordance with the *2011 Conceptual Design Report for Newlin Gulch Channel Improvements at Stonegate,* it is recommended that two 3.3-foot drop structures be constructed to provide a more stable long-term equilibrium slope of 0.25%.

Additional master plan improvements include the following:

- Install bank protection along outer bend upstream of Lincoln Avenue. The bank is currently stable; however, the area is currently aggrading due to high sediment loads from erosion immediately upstream. Once the upstream channel is stabilized, the bank may become more vulnerable to erosion.
- Excavate channel bottom near Jordan Road to increase channel capacity adjacent to trail under bridge.
- Widen channel near confluence with Jordan Road Tributary to address local scour.
- Clean out and/or repair a clogged sidewalk chase at an existing storm sewer outfall just downstream of Jordan Road.
- Extend recreational trail upstream of Stonegate Parkway to provide formal maintenance access.

A conceptual opinion of probable cost is detailed in **Table 7-4**, with a total capital improvement cost of $3,165,000. No land acquisition is required for this reach.

Annual operations and maintenance planning should include drop structure, channel, and trail maintenance as well as mowing for weed control. In addition, sediment removal at bridges may be required to maintain bridge capacity following channel aggradation. The annual maintenance cost is estimated at $85,700, with a total 50-year cost of $1,840,000.

CLICK HERE TO VIEW REACH 3 MAP

CLICK HERE TO VIEW REACH 3 PROFILE

Table 7-4: Reach 3 Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design
DRAINAGEWAY :	Newlin Gulch
REACH :	3
JURISDICTION :	Douglas County
REACH ID:	NG-Reach3
DATE :	September 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Hydraulic Structures						
Sloping Drop Structures						
Height (ft)	**Bottom Width (ft)**	**Yn (ft)**				
1.5	70	4	3	EA	$141,234.40	$423,703.00
2	60	4	4	EA	$132,327.38	$529,310.00
3.3	60	4.5	2	EA	$151,610.20	$303,220.00
Channel Improvements						
Excavation, Low Range			3900	C.Y.	$13.00	$50,700.00
Excavation, Mid Range			1000	C.Y.	$29.00	$29,000.00
Excavation, Mid Range			1800	C.Y.	$29.00	$52,200.00
Excavation, Low Range			3200	C.Y.	$13.00	$41,600.00
Excavation, Low Range			3800	C.Y.	$13.00	$49,400.00
Landscaping and Maintenance Improvements						
Wetlands Plantings			2	ACRE	$30,483.00	$60,966.00
Reclamation & seeding (native grasses)			15	ACRE	$1,219.00	$18,285.00
Trail/Path, Concrete (10' Width)			1340	L.F.	$54.00	$72,360.00
Special Items (User Defined)						
Bank Protection	**<----User Defined Items**		440	LF	$150.00	$66,000.00
Repair Sidewalk Chase at Storm Sewer Outfall	**<----User Defined Items**		1	LS	$5,000.00	$5,000.00

Master Plan Capital Improvement Cost Summary

Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$1,256,233.00
Channel Improvements			$222,900.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$151,611.00
Special Items (User Defined)			$71,000.00
Subtotal Capital Improvement Costs			**$1,701,744.00**
Additional Capital Improvement Costs			
Dewatering	$75,000.00	L.S.	$75,000.00
Mobilization	5%		$85,087.00
Traffic Control	$20,000.00	L.S.	$20,000.00
Utility Coordination/Relocation	$75,000.00	L.S.	$75,000.00
Stormwater Management/Erosion Control	5%		$85,087.00
Subtotal Additional Capital Improvement Costs			**$340,174.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$306,288.00
Legal/Administrative	5%		$102,096.00
Contract Admin/Construction Management	10%		$204,192.00
Contingency	25%		$510,480.00
Subtotal Other Costs			**$1,123,056.00**
Total Capital Improvement Costs			**$3,164,974.00**

Master Plan Operation and Maintenance Cost Summary

Description		Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)		24	EA	$610.00	$14,640.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)		8450	L.F.	$2.00	$16,900.00
Mowing (e.g. channels, ponds, etc.)		30	ACRE	$61.00	$1,830.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)		8450	L.F.	$6.00	$50,700.00
Sediment Removal at Bridges	**<----User Defined Items**	2	EA	$800.00	$1,600.00
Total Annual Operation and Maintenance Cost					**$85,670.00**
Effective Interest Rate					4.00%
Total Operation and Maintenance Costs Over 50 Years					**$1,840,379.00**

7.2.4 Reach 4 – Newlin Crossing

Reach 4 is located within Douglas County but is proposed for annexation by the Town of Parker. Newlin Crossing is a planned development that borders Newlin Gulch from the southern boundary of Stonegate Village to the downstream side of Mainstreet. This reach was channelized in 2007 and stabilized at a 0.56% slope with three grouted boulder drop structures as a part of the Mainstreet crossing construction. Three additional drop structures were constructed in 2009 along the downstream end of the reach and upstream end of Reach 3 to provide a 0.25% slope. The segment graded at 0.25% is stable, while the 0.56% segment is degrading some and appears to be too steep. There is currently no formal maintenance access for this reach.

Master plan improvements include the following:

- Reduce channel slope in degrading steeper segment to 0.25% by modifying existing drop structures.
- Provide a combined use recreational / maintenance access trail.

A conceptual opinion of probable cost is detailed in **Table 7-5**, with a total capital improvement cost of $427,000. No land acquisition is included in the cost estimate; floodplain development policies require dedication of an open space tract encompassing the floodplain.

Annual operations and maintenance planning should include drop structure, channel, and trail maintenance as well as mowing for weed control. The annual cost is estimated at $21,700, with a total 50-year cost of $466,000.

CLICK HERE TO VIEW REACH 4 MAP

CLICK HERE TO VIEW REACH 4 PROFILE

Table 7-5: Reach 4 Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design
DRAINAGEWAY :	Newlin Gulch
REACH :	4
JURISDICTION :	Douglas County
REACH ID:	NG-Reach4
DATE :	September 2015

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Channel Improvements					
Excavation, Low Range		1400	C.Y.	$13.00	$18,200.00
Grouted Boulders, 36"		250	S.Y.	$232.00	$58,000.00
Landscaping and Maintenance Improvements					
Wetlands Plantings		0.5	ACRE	$30,483.00	$15,242.00
Reclamation & seeding (native grasses)		5	ACRE	$1,219.00	$6,095.00
Trail/Path, Concrete (10' Width)		2300	L.F.	$54.00	$124,200.00
Special Items (User Defined)					
Modify Existing Grouted Boulder Drop Structure	<----User Defined Items	2	EA	$5,000.00	$10,000.00
Remove/Reset Type M Soil Riprap	<----User Defined Items	170	CY	$35.00	$5,950.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$0.00
Channel Improvements			$76,200.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$145,537.00
Special Items (User Defined)			$15,950.00
Subtotal Capital Improvement Costs			**$237,687.00**
Additional Capital Improvement Costs			
Dewatering	$10,000.00	L.S.	$10,000.00
Mobilization	5%		$11,884.00
Traffic Control	$4,000.00	L.S.	$4,000.00
Utility Coordination/Relocation		L.S.	$0.00
Stormwater Management/Erosion Control	5%		$11,884.00
Subtotal Additional Capital Improvement Costs			**$37,768.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$41,318.00
Legal/Administrative	5%		$13,773.00
Contract Admin/Construction Management	10%		$27,546.00
Contingency	25%		$68,864.00
Subtotal Other Costs			**$151,501.00**
Total Capital Improvement Costs			**$426,956.00**

Master Plan Operation and Maintenance Cost Summary				
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	4	EA	$610.00	$2,440.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2400	L.F.	$2.00	$4,800.00
Mowing (e.g. channels, ponds, etc.)	11	ACRE	$61.00	$671.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	2300	L.F.	$6.00	$13,800.00
Total Annual Operation and Maintenance Cost				**$21,711.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$466,400.00**

7.2.5 Reach 5 – Mainstreet to Chambers Road

Reach 5, which extends from the downstream side of Mainstreet to the downstream side of Chambers Road, is primarily located within the Town of Parker. Approximately 300 feet of Reach 5 passes through a corner of Douglas County north of the Chambers Road crossing. The channel has a wide sandy bottom, and the majority of the reach is currently stable or aggrading. However, some degradation is evident near Chambers Road and has exposed three feet of an at-grade check structure constructed in 2012. There is corral fencing and miscellaneous debris within the floodplain at a private livestock/stable facility just upstream of Mainstreet. Manure spreading in the overbanks poses a water quality concern here. The average channel slope is 0.92%. Old Newlin Gulch Road provides maintenance access for a segment of the reach; the remainder has no access.

A low-flow trail crossing for the Douglas County East/West Regional Trail is planned for construction in 2016. The crossing incorporates approximately 2.5' of grade control. These planned improvements have been reflected on the master plan map and profile, but are not included in the reach cost estimates.

Master plan improvements include the following:

- Construct low-height (approximately 2.5-foot) grade control structures to allow for a long-term equilibrium or stable slope of 0.25%.
- Install bank protection along outer bends just upstream of Mainstreet. The bank is currently stable and this may be due partially to high sediment loads and an aggrading condition. Long-term, the bank may become more vulnerable to erosion.
- Install bank protection along outer bends within degradation area at exposed check structure.
- Clear fencing and debris from floodplain.
- Disallow land application of horse manure in floodplain.
- Provide a combined use recreational / maintenance access trail.

A conceptual opinion of probable cost is detailed in **Table 7-6**, with a total capital improvement cost of $5,415,000. No land acquisition is included in the cost estimate; floodplain development policies require dedication of an open space tract encompassing the floodplain.

Annual operations and maintenance planning should include culvert, drop structure, channel, and trail maintenance as well as mowing for weed control. The annual cost is estimated at $52,800, with a total 50-year cost of $1,134,000.

CLICK HERE TO VIEW REACH 5 MAP

CLICK HERE TO VIEW REACH 5 PROFILE

Table 7-6: Reach 5 Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design					
DRAINAGEWAY :	Newlin Gulch					
REACH :	5					
JURISDICTION :	Town of Parker					
REACH ID:	NG-Reach5				DATE :	September 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Hydraulic Structures						
Sloping Drop Structures						
Height (ft)	Bottom Width (ft)	Yn (ft)				
2.5	100	4	12	EA	$197,358.61	$2,368,303.00
Channel Improvements						
Excavation, Low Range			17500	C.Y.	$13.00	$227,500.00
Landscaping and Maintenance Improvements						
Wetlands Plantings			2.20	ACRE	$30,483.00	$67,063.00
Reclamation & seeding (native grasses)			22	ACRE	$1,219.00	$26,818.00
Trail/Path, Concrete (10' Width)			4200	L.F.	$54.00	$226,800.00
Special Items (User Defined)						
Bank Protection	<----User Defined Items		670	LF	$150.00	$100,500.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$2,368,303.00
Channel Improvements			$227,500.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$320,681.00
Special Items (User Defined)			$100,500.00
Subtotal Capital Improvement Costs			**$3,016,984.00**
Additional Capital Improvement Costs			
Dewatering	$150,000.00	L.S.	$150,000.00
Mobilization	5%		$150,849.00
Traffic Control	$25,000.00	L.S.	$25,000.00
Utility Coordination/Relocation		L.S.	$0.00
Stormwater Management/Erosion Control	5%		$150,849.00
Subtotal Additional Capital Improvement Costs			**$476,698.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$524,052.00
Legal/Administrative	5%		$174,684.00
Contract Admin/Construction Management	10%		$349,368.00
Contingency	25%		$873,421.00
Subtotal Other Costs			**$1,921,525.00**
Total Capital Improvement Costs			**$5,415,207.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	14	EA	$610.00	$8,540.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	4950	L.F.	$2.00	$9,900.00
Mowing (e.g. channels, ponds, etc.)	22	ACRE	$61.00	$1,342.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	5500	L.F.	$6.00	$33,000.00
Total Annual Operation and Maintenance Cost				**$52,782.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$1,133,873.00**

7.2.6 Reach 6 –Chambers Road to Hess Road

Reach 6 extends from the downstream side of Chambers Road to upstream of Hess Road, below the Rueter-Hess Reservoir spillway. The lower portion of the reach is within the Town of Parker and is bordered by the Parker Homestead residential development. The upper third is located within Douglas County. The wide, sandy channel is sensitive to changes in the flow regime due to the completion of Rueter-Hess Reservoir; areas of both degradation and aggradation are apparent. Degradation is most severe immediately downstream of Hess Road; this is likely due to sediment-free releases of up to 100 cfs from Rueter-Hess Reservoir that last for several days (see additional discussion in **Section 6.1.1**.) Development has preserved the wide natural floodplain. The average channel slope is 1.3%. A recreational trail provides maintenance access within the Town of Parker limits.

A low-flow trail crossing in the Parker Homestead development was under construction at the time of this plan. The crossing incorporates some grade control at the upstream end as the channel drops into a low rise box culvert. Due to funding limitations, this grade control was installed in the form of a temporary riprap rundown and riprap overtopping protection along the length of the trail was omitted.

Master plan improvements include the following:

- Construct low-height grade control structures to allow for a long-term equilibrium or stable slope of 0.25%.
- Retrofit existing low flow trail crossing to include formal grade control; provide riprap overtopping protection along trail.
- Provide maintenance access to the Douglas County segment.

To better reflect the costs along the jurisdictional divide, the reach was subdivided into two segments – Reach 6a within Town of Parker and Reach 6b within Douglas County. Conceptual opinions of probable cost for the two segments are detailed in **Table 7-7** and **Table 7-8**. The total capital improvement costs are $3,094,000 for 6a and $1,014,000 for 6b. No land acquisition is required for this reach; open space tracts were established in Reach 6a with the platting of Parker Homestead, and Parker Water and Sanitation District is the property owner for Reach 6b.

Annual operations and maintenance planning should include culvert, drop structure, channel, and trail maintenance as well as mowing for weed control. The annual cost for Reach 6a is estimated at $23,900, with a total 50-year cost of $513,000. The annual cost for Reach 6b is estimated at $12,600, with a total 50-year cost of $270,000.

CLICK HERE TO VIEW REACH 6 MAP

CLICK HERE TO VIEW REACH 6 PROFILE

Table 7-7: Reach 6a Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design
DRAINAGEWAY :	Newlin Gulch
REACH :	6a
JURISDICTION :	Town of Parker
REACH ID:	NG-Reach6a
DATE :	September 2015

DESCRIPTION		QUANTITY	UNIT	UNIT COST	TOTAL COST
Hydraulic Structures					
Sloping Drop Structures					
Height (ft)	Bottom Width (ft)	Yn (ft)			
2	70	3	1	EA	$135,400.76	$135,401.00
2.5	100	3	5	EA	$185,534.72	$927,674.00
3	100	3	2	EA	$192,284.47	$384,569.00
3.2	45	3	1	EA	$108,260.31	$108,260.00
Channel Improvements					
Excavation, Low Range		8200	C.Y.	$13.00	$106,600.00
Soil Riprap, Type L		130	C.Y.	$73.00	$9,490.00
Landscaping and Maintenance Improvements					
Wetlands Plantings		1.0	ACRE	$30,483.00	$30,483.00
Reclamation & seeding (native grasses)		13.0	ACRE	$1,219.00	$15,847.00

Master Plan Capital Improvement Cost Summary				
Capital Improvement Costs				
Pipe Culverts and Storm Drains				$0.00
Concrete Box Culverts				$0.00
Hydraulic Structures				$1,555,904.00
Channel Improvements				$116,090.00
Detention/Water Quality Facilities				$0.00
Removals				$0.00
Landscaping and Maintenance Improvements				$46,330.00
Special Items (User Defined)				$0.00
Subtotal Capital Improvement Costs				**$1,718,324.00**
Additional Capital Improvement Costs				
Dewatering	$90,000.00	L.S.		$90,000.00
Mobilization	5%			$85,916.00
Traffic Control	$15,000.00	L.S.		$15,000.00
Utility Coordination/Relocation	$1,000.00	L.S.		$1,000.00
Stormwater Management/Erosion Control	5%			$85,916.00
Subtotal Additional Capital Improvement Costs				**$277,832.00**
Land Acquisition Costs				
ROW/Easements				$0.00
Subtotal Land Acquisition Costs				**$0.00**
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%			$299,423.00
Legal/Administrative	5%			$99,808.00
Contract Admin/Construction Management	10%			$199,616.00
Contingency	25%			$499,039.00
Subtotal Other Costs				**$1,097,886.00**
Total Capital Improvement Costs				**$3,094,042.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	9	EA	$610.00	$5,490.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	2200	L.F.	$2.00	$4,400.00
Mowing (e.g. channels, ponds, etc.)	13.0	ACRE	$61.00	$793.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	2200	L.F.	$6.00	$13,200.00
Total Annual Operation and Maintenance Cost				**$23,883.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$513,059.00**

Table 7-8: Reach 6b Cost Estimate

PROJECT :	Newlin Gulch Major Drainageway Plan - Conceptual Design					
DRAINAGEWAY :	Newlin Gulch					
REACH :	6b					
JURISDICTION :	Douglas County					
REACH ID:	NG-Reach6b				DATE :	September 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST
Hydraulic Structures						
Sloping Drop Structures						
Height (ft)	Bottom Width (ft)	Yn (ft)				
2.5	100	3	2	EA	$185,534.72	$371,069.00
4	55	3	1	EA	$130,909.38	$130,909.00
Channel Improvements						
Excavation, Low Range			2300	C.Y.	$13.00	$29,900.00
Landscaping and Maintenance Improvements						
Wetlands Plantings			0.30	ACRE	$30,483.00	$9,145.00
Reclamation & seeding (native grasses)			3.5	ACRE	$1,219.00	$4,267.00
Trail/Path, Crusher Fines (10' Width)			1350	L.F.	$13.00	$17,550.00

Master Plan Capital Improvement Cost Summary			
Capital Improvement Costs			
Pipe Culverts and Storm Drains			$0.00
Concrete Box Culverts			$0.00
Hydraulic Structures			$501,978.00
Channel Improvements			$29,900.00
Detention/Water Quality Facilities			$0.00
Removals			$0.00
Landscaping and Maintenance Improvements			$30,962.00
Special Items (User Defined)			$0.00
Subtotal Capital Improvement Costs			**$562,840.00**
Additional Capital Improvement Costs			
Dewatering	$30,000.00	L.S.	$30,000.00
Mobilization	5%		$28,142.00
Traffic Control	$5,000.00	L.S.	$5,000.00
Utility Coordination/Relocation		L.S.	$0.00
Stormwater Management/Erosion Control	5%		$28,142.00
Subtotal Additional Capital Improvement Costs			**$91,284.00**
Land Acquisition Costs			
ROW/Easements			$0.00
Subtotal Land Acquisition Costs			**$0.00**
Other Costs (percentage of Capital Improvement Costs)			
Engineering	15%		$98,119.00
Legal/Administrative	5%		$32,706.00
Contract Admin/Construction Management	10%		$65,412.00
Contingency	25%		$163,531.00
Subtotal Other Costs			**$359,768.00**
Total Capital Improvement Costs			**$1,013,892.00**

Master Plan Operation and Maintenance Cost Summary				
Description	Quantity	Unit	Unit Cost	Total Annual Cost
Hydraulic Structure Maintenance (e.g. debris removal, erosion, structural repairs, etc.)	4	EA	$610.00	$2,440.00
Channel Maintenance (e.g. sediment & debris removal, erosion, tree & weed removal, etc.)	900	L.F.	$2.00	$1,800.00
Mowing (e.g. channels, ponds, etc.)	3.5	ACRE	$61.00	$214.00
Trail Maintenance (e.g. structural repairs, crusher fines, etc.)	1350	L.F.	$6.00	$8,100.00
Total Annual Operation and Maintenance Cost				**$12,554.00**
Effective Interest Rate				4.00%
Total Operation and Maintenance Costs Over 50 Years				**$269,687.00**

7.3 PRIORITIZATION AND PHASING

Prioritization and phasing of the channel improvements shown in this plan is important to the overall success of the plan and health of the channel. Newlin Gulch is a very sandy channel; even though there are currently only small areas of degradation or aggradation, it can react very quickly to changes in flows due to development or reservoir operation, or changes in sediment loads due to stabilization in another reach. A currently stable reach could quickly unravel given the right conditions. With that in mind, the following prioritization and phasing recommendations are provided.

Priority 1: Address current health and safety hazards at Recreation Drive

The first priority in implementation of this master plan is to address the safety hazard that is posed by the at-grade Recreation Drive crossing. The 10-year capacity box culvert should be constructed as soon as feasible. Modification of the road profiles and downstream grouted boulder drop structure to contain the 100-year flows will help protect existing utilities, including a 20-inch high pressure gas main and 12-inch and 6-inch sanitary force mains; it is recommended that this work be done concurrently with the crossing.

Priority 2: Address nuisance issues and maintenance needs

Some of the recommended improvements address nuisance issues or provide maintenance-type improvements to existing facilities. These have relatively low cost and high return.

- Excavate channel / clean out sediment beneath Jordan Road bridge
- Address storm sewer outfalls discharging across sidewalks near Jordan Road
- Provide riprap protection at existing vertical drops in Reach 1

Priority 3: Provide grade control in key areas of current need

When considering grade control, priority should be given to those structures that will protect existing infrastructure or stabilize actively degrading segments of Newlin Gulch. These include the following locations:

- Reach 6b: Immediately downstream of Hess Road bridge (Sta 217+00)
- Reach 3: At existing check structure downstream of Jordan Road (Sta 46+00)
- Reach 5: At existing check structure downstream of Chambers Road (Sta 182+00)
- Reach 6a: At recently constructed low-water trail crossing at Parker Homestead (Sta 203+00)
- Reach 3: At existing check structures upstream of Stonegate Parkway (Sta 104+00 and 110+00)

Priority 4: Construct improvements as need arises or as development progresses

For the remainder of the improvements, the channel condition should be monitored annually and grade control or bank protection implemented as the need arises or as development progresses. Additional phasing considerations are discussed by reach below.

- No additional development is anticipated along Reaches 2 and 3, but changes could occur with upstream development. These reaches should be monitored and addressed as needed.
- Reach 4 is generally stable but undeveloped. Modifications to the existing drop structures should be made as the adjacent property is developed or as the need arises.
- Reaches 5 and 6 are steep and sandy, with the potential to react quickly to upstream changes. The currently alternating segments of aggradation and degradation will shift as channel improvements are constructed and as development progresses. They should be monitored closely and improvements constructed as needed to address problem areas as they arise. A commercial pad southeast of the Chambers Road crossing will be required to implement master planned channel improvements at the time of development. Currently, the channel is aggrading in this segment as the sandy material eroded by sediment-free reservoir releases in the upstream channel gets deposited. As a result, it may be appropriate to consider a cash-in-lieu approach, where the developer provides the Town with funds for the master plan improvements rather than constructing them at the time of development. The Town would then construct the grade control as it is needed.

7.4 WATER QUALITY IMPACTS

The Urban Drainage and Flood Control District's Four Step Process for water quality protection is as follows:

1. Employ runoff reduction practices.
2. Implement effective water quality detention.
3. Stabilize drainageways.
4. Implement source control practices.

The Newlin Gulch Major Drainageway Plan focuses on step three by providing stable channel slopes along the length of Newlin Gulch. Low drop structure heights will allow the creek to remain connected to its floodplain, encouraging the establishment of vegetation and providing treatment of stormwater runoff through infiltration and filtering. Step four is also addressed through the elimination of manure-spreading practices in Reach 5.

Because there is no regional detention on Newlin Gulch downstream of Rueter-Hess Reservoir, onsite full spectrum detention will be required for all new development within both the Town of Parker and Douglas County. This will provide water quality treatment as well as minimize releases during the smaller, channel-forming storms, thereby protecting channel stability, water quality, and overall channel health.

7.5 OPERATIONS AND MAINTENANCE

Ongoing operations and maintenance are an essential component of the health of any urban stream. An annual monitoring program will allow maintenance concerns to be identified and addressed early. Monitoring of the steeper, upstream reaches will be critical for identifying problem areas as they develop and planning stabilization efforts accordingly.

Annual channel and trail maintenance costs have been included for the length of the study area, along with allowances for periodic routine maintenance at all existing and proposed drop structures and culvert crossings. Weed control in natural areas can be one of the most effective maintenance operations and should be conducted annually.

Maintenance access is provided by recreational trails along much of the channel; additional trails are recommended where they do not currently exist.

7.6 ENVIRONMENTAL AND SAFETY ASSESSMENT

The proposed improvements at Recreation Drive will greatly reduce a safety hazard by eliminating roadway overtopping in 10-year and smaller storm events. While overtopping in larger than 10-year storms will still present a hazard, the frequency of this hazard will be drastically reduced.

Implementation of the Newlin Gulch Major Drainageway Plan will improve the environmental character of Newlin Gulch as the stable channel slopes allow the ongoing establishment of vegetation, increasing the habitat and ecological diversity of the corridor. The plan will continue to enhance the valuable open space corridor that has been established along its length, benefiting the residents of the Town of Parker and Douglas County as well as the wildlife that calls the corridor home.

8 REFERENCES

Carroll & Lange, Inc. *Final Drainage Study Phase III for the Country Club at Castle Pines.* Prepared for Fidelity Castle Pines, Ltd. June 12, 1992 with revisions through November 30, 1992.

Carroll & Lange, Inc. *Newlin Meadows Filing No. 3 Addendum #1 To Final Drainage Study for Newlin Meadows.* Prepared for Gateway American Properties, LLC. March 17, 2006.

Carroll & Lange, Inc. *Phase III Drainage Report for Villas at Castle Pines.* Prepared for America West Communities, LLC. January 8, 2001.

Civil Design Group, Inc. *Phase III Drainage Report Castle Pines Village Filing 27A.* Prepared for Toll Brother, Inc. November 10, 2000. Revised August 23, 2001.

Civil Design Group, Inc. *Phase III Drainage Report Castle Pines Village Filing 27B.* Prepared for Aslan Development, LLC. April 7, 2003.

Civil Design Group, Inc. *Phase III Drainage Report Castle Pines Village Filing 28A.* Prepared for Aslan Development, LLC. November 10, 2000. Revised May 4, 2001.

CVL Consultants of Colorado, Inc. *Final Drainage Report for Filing No. 5 Bradbury Ranch Town Homes.* Prepared for Ryland Homes, Inc. November, 2000. Revised January, 2001.

CVL Consultants of Colorado, Inc. *Final Drainage Report for the Douglas 234 Subdivision.* Prepared for Melody Homes, Inc. December, 2002 with revisions through August 25, 2004.

CVL Consultants, Inc. *Final Drainage Report: Bradbury Ranch Phase III.* Prepared for AMREPCO Inc. October 10, 2000 with revisions through June 26, 2001.

CVL Consultants, Inc. *Final Drainage Report: Bradbury Ranch Phase III.* Prepared for AMREPCO Inc. October 10, 2000 with revisions through June 26, 2001.

Dewberry-Integra. *Drainage Report for Parker Water and Sanitation District Rueter-Hess Water Treatment Plant.* Prepared for Parker Water and Sanitation District. October 14, 2011.

Douglas County Community Planning & Sustainable Development Department. *Douglas County Zone District Map.* October 31, 2011.

EMK Consultants, Inc. *Addendum No. 1 To The Final Drainage Study For Clarke Farms Filing Number 2.* Prepared for U S Home Corporation. August, 1992.

EMK Consultants, Inc. *Final Drainage Report for Newlin Gulch at Parker Homestead.* Prepared for Parker Homestead Investments, LLC. July 11, 2011. Revised December 9, 2011.

EMK Consultants, Inc. *Final Drainage Report for Parker Homestead Filing 2 & All Lots Northwest Of Newlin Gulch.* Prepared for Parker Homestead Investments, LLC. June 24, 2011. Revised August 2, 2011.

EMK Consultants, Inc. *Final Drainage Report for Parker Homestead Filing No. 1 and Double Angel Road.* Prepared for Parker Homestead Investments, LLC. May 16, 2011. Revised July 13, 2011.

EMK Consultants, Inc. *Final Drainage Report for Regency Filings 1 And 2.* Prepared for Canterberry Development Company, LLC. March 1, 2006. Revised May 19, 2006.

EMK Consultants, Inc. *Final Drainage Report for Sandpit Tributary at Parker Homestead.* Prepared for Parker Homestead Investments, LLC. July 11, 2011 with revisions through July 17, 2012.

EMK Consultants, Inc. *Final Drainage Study and Storm Water Management Plan For Clarke Farms Filing No. 5B.* Prepared for U S Home Corporation. August, 1993.

EMK Consultants, Inc. *Final Drainage Study and Storm Water Management Plan For Clarke Farms Filing No. 6B. Prepared for U S Home Corporation.* December, 1993.

EMK Consultants, Inc. *Final Drainage Study for Clarke Farms Filing No. 5A.* Prepared for U S Home Corporation. August 24, 1992.

EMK Consultants, Inc. *Final Drainage Study for Clarke Farms Filing No. 6A.* Prepared for U S Home Corporation. August 24, 1993.

EMK Consultants, Inc. *Final Drainage Study For Clarke Farms Filing Number 1.* Prepared for Silverado-Elektra Venture, LTD. & MDC Construction Company. March, 1986."

EMK Consultants, Inc. *Final Drainage Study For Clarke Farms Filing Number 2.* Prepared for Silverado-Elektra Venture, LTD. & MDC Construction Company. July 1992.

EMK Consultants, Inc. *Final Drainage Study for Clarke Farms Subdivision Filing No. 4.* Prepared for U S Home Corporation. February, 1993.

EMK Consultants, Inc. *Final Drainage Study for Stonegate Filing Nos. 1A, 1B and 1C.* Prepared for Mobil Land Development (Colorado) Corporation. December, 1984.

EMK Consultants, Inc. *Final Drainage Study for Stonegate Filing No. 2.* Prepared for Mobil Land Development (Colorado) Corporation. December, 1984.

EMK Consultants, Inc. *Master Drainage Study for Stonegate.* Prepared for Mobil Land Development (Colorado) Corporation. November, 1984. Revised April, 1985.

EMK Consultants, Inc. *Phase 3 Drainage Study For Stonegate Filings 21 A-D.* Prepared for Stonegate Developments, Inc. March, 1995.

EMK Consultants, Inc. *Phase 3 Drainage Study, Final Erosion Control Plan, and Stormwater Management Plan for Stonegate Filings 17 & 19.* Prepared for Stonegate Developments, Inc. April, 1995.

EMK Consultants, Inc. *Phase III Drainage Study for Stonegate Filing 15A, 15B, and 15F.* Prepared for Stonegate Developments, Inc. May, 1993 with revisions through July 7, 1993.

EMK Consultants, Inc. *Phase III Drainage Study for Stonegate Filing 15C, and 15E.* Prepared for Stonegate Developments, Inc. May 28, 1993 with revisions through July 22, 1993.

EMK Consultants, Inc. *Phase III Drainage Study for Stonegate Filing 15G.* Prepared for Stonegate Developments, Inc. July, 1993.

EMK Consultants, Inc. *Phase III Drainage Study for Stonegate Filing No. 5A and 5B.* Prepared for Stonegate Developments, Inc. February, 1987 with revisions through June, 1991.

EMK Consultants, Inc. *Phase III Drainage Study for Stonegate Filing No. 5C.* Prepared for Stonegate Developments, Inc. January, 1992.

Felsburg Holt & Ullevig. *Phase III Drainage Report for the Chambers Road Extension and West Mainstreet Improvements.* Prepared for Douglas County, Colorado. December 16, 2005.

Futura Engineering Inc. *Final Drainage Report Amendment: Bradbury Ranch Filing 6.* Prepared for Ryland Homes, Inc. October 30, 2000. Revised May 14, 2001.

Futura Engineering Inc. *Final Drainage Report: Bradbury Ranch Filing No. 1.* Prepared for AMREPCO Inc. July 3, 1995.

Futura Engineering Inc. *Final Drainage Report: Bradbury Ranch Phase II Filing No. 3A.* Prepared for AMREPCO Inc. January 12, 1999 with revisions through July 28, 1999.

Futura Engineering Inc. *Final Drainage Report: Bradbury Ranch Phase II Filing No. 3B.* Prepared for AMREPCO Inc. March 28, 1999 with revisions through February 4, 2000.

Futura Engineering Inc. *Final Drainage Report: Bradbury Ranch Phase II Filing No. 4.* Prepared for Ryland Homes, Inc. October 12, 1999 with revisions through March 15, 2000.

Galloway, Romero & Associates. *Phase III Drainage Report and Erosion Control Study for Stonegate Village Center [All Lots - Formerly Filing No. 17].* Prepared for DeRose Property Company - Stonegate, LLC. September 15, 1998. Revised January 15, 1999.

High Country Engineering, Inc. *Final Drainage Report For Newlin Meadows.* Prepared for Gateway American Properties, LLC. November 25, 2002. Revised April 9, 2003.

Highline Engineering and Surveying Company, Inc. *Final Drainage Study for Lutheran High School of the Rockies New Horizon Subdivision Filing No. 1.* Prepared for Lutheran High School Of The Rockies. March 11, 2003. Revised September 17, 2003.

Highline Engineering and Surveying Company, Inc. *Final Drainage Study for New Horizon.* Prepared for Rocky Mountain District Lutheran Church. May 30, 2002 with revisions through August 23, 2003.

JR Engineering, LTD. *Final Drainage and Erosion Control Report for Challenger Park Estates.* Prepared for Continental Homes. June 11, 1997. Revised March 9, 1998.

JR Engineering, LTD. *Phase III Drainage Report for Stonegate Filing 15D.* Prepared for Stonegate Developments, Inc. June 8, 1993 with revisions through September 8, 1993.

Kiowa Engineering Corporation. *Final Drainage Plan Douglas County Elementary School #20.* Prepared for Douglas County School District RE-1. February, 1994. Revised March, 1994.

Kiowa Engineering Corporation. *Newlin and Baldwin Gulches and Basin 4600-09 Outfall Systems Planning Alternative Development & Evaluation.* Prepared for Urban Drainage and Flood Control District. September, 1993.

Kirkham Michael. *Drainage and Erosion Control Report.* Prepared for KB Home. January 8, 2001. Revised November 5, 2001.

Muller Engineering Company, Inc. *Newlin Gulch Channel Improvements at Stonegate; Updated Conceptual Design Report.* Prepared for Douglas County, Urban Drainage and Flood Control District, and Stonegate Village Metropolitan District. June 2011.

Muller Engineering Company, Inc. *Contract Drawings for Construction of Newlin Gulch Channel Improvements Downstream of Stonegate Parkway.* Prepared for Douglas County, Urban Drainage and Flood Control District, and Stonegate Village Metropolitan District. July 2012.

Nolte Associates, Inc. *Phase I Drainage Report For The Canyons.* Prepared for North Canyons, LLLP. April, 2009. Revised June, 2009.

The Lund Partnership. *Phase III Drainage Report for Lagae Ranch.* Prepared for HF Holdings, LLC. March 21, 2008 with revisions through August 22, 2008.

Town of Parker. *Zoning Map Town of Parker, Colorado.* October, 2012

Urban Drainage and Flood Control District. *Urban Storm Drainage Criteria Manual, Volumes I & II.* 2001 Edition with revisions through April 2008.

VCDS, Inc. *Castle Pines Town Center Planned Development Phase I Drainage Report.* Prepared for A & A Investments, LLC. April 5, 2011. Revised July 7, 2011.

WBC Engineering & CM, LLC. *Newlin Crossing Planned Development.* Prepared for 98 W. Parker, A Colorado LLP. January 24, 2008 with revisions through November 5, 2009.

Appendix A

PROJECT CORRESPONDENCE

MEETING
MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP

Meeting Date
Nov. 19, 2012

Sponsors
UDFCD / Douglas County / Town of Parker

Issue Date
Nov. 28, 2012

Meeting Location
UDFCD

MEC Project No.
12-050.01

Attendees
Shea Thomas, UDFCD
Bill DeGroot, UDFCD
Brad Robenstein, Douglas County
Tom Williams, Town of Parker
Jacob James, Town of Parker
Derek Johns, Muller Engineering Company
Jim Wulliman, Muller Engineering Company
Andy Pultorak, Muller Engineering Company

Minutes Prepared By
Andy Pultorak

Routing
ASP / DDJ / JTW

Purpose
Newlin Gulch MDP Kick-off Meeting

Action Items
All action items are requested to be completed by December 7, 2012 unless otherwise noted.

Muller Action Items:
1. Muller will review the Baldwin Gulch mapping provided by Shea and update the survey request for Baldwin accordingly. Muller will then send the updated request to Shea.
2. Muller will contact Parker Water & Sanitation District (PWSD) to obtain the Reuter-Hess spillway configuration for use in modeling the Reservoir impacts to the downstream watershed.
3. Muller will provide a survey request figure to Shea with survey needs at Challenger Park (Recreation Drive).
4. Muller will coordinate with the sponsors to setup the first progress meeting.
5. Muller will contact Castle Pines to obtain the latest development plans for the upper watershed.
6. Muller will setup the project website and invite the project team to review before posting.

UDFCD Action Items:
1. ~~Shea will provide aerial mapping for Baldwin Gulch to Muller.~~ (Complete)
2. ~~Shea will invite Muller to the project Dropbox folder.~~ (Complete)
3. Shea will provide new 2-foot LiDAR mapping of the Newlin Gulch watershed once processing is complete (should be the week of November 25th).

Douglas County Action Items:
1. Brad (Douglas County) will provide Muller with the LOMR document for the Hess Rd. crossing (LOMR 11-08-0044P).
2. Brad (Douglas County) will provide Muller with drainage reports and as-built plans for the requested developments within the watershed.

Newlin Gulch MDP – Kickoff Meeting – Meeting Minutes
November 19, 2012

Town of Parker Action Items:
1. Jacob will provide Muller with drainage reports and as-built documents for the requested developments within the watershed.
2. ~~Jacob will provide Muller with LOMR documents for the crossings at Lincoln, Jordan, and Chambers~~ (Complete).

Discussion

THE FOLLOWING IS OUR UNDERSTANDING OF THE SUBJECT MATTER COVERED IN THIS CONFERENCE. IF THIS DIFFERS WITH YOUR UNDERSTANDING, PLEASE NOTIFY US IMMEDIATELY.

Agenda

1. REVIEW PROJECT APPROACH AND SPONSOR GOALS

a. Derek introduced the project and stated that the goal was to update the Major Drainageway Plan for the Newlin Gulch watershed based on current and projected land use.

b. Reuter-Hess Reservoir impacts

- Derek stated that the construction of the Reuter-Hess Reservoir significantly attenuates the downstream peak flows for major floods. Although the reservoir was not designed for flood storage, the large surface area provides significant storage for major floods. Derek said that evaluations complete by the design engineer for Reuter-Hess indicate that, with the reservoir at full capacity, the 100-year flood event would cause about 0.6-feet of rise in the reservoir. For the 100-year event, the reservoir will not crest the emergency spillway and the downstream peak flow will be reduced to near zero.
- Derek said that recent infrastructure projects downstream of the dam utilized the reduced peak flow rates in design, resulting in significant cost savings. However, since FEMA does not recognize the reduced flow rate, the map revisions for these projects used the much higher regulatory flow rate. Therefore, these projects showed overtopping where none is likely to occur.
- Tom said that from a land-use perspective he was in favor of keeping the FIS flow rates intact, since the watershed has already been significantly developed. However, from an infrastructure planning perspective, he saw value in having FEMA adopt the reduced flow rates so that smaller, most cost-effective crossing structures could be built.
- Jim noted that FEMA would require an adequate assurances agreement to be entered into by Parker Water and Sanitation District (the reservoir operator) before the flood storage could be acknowledged by FEMA. Bill DeGroot said that at Standley Lake the reservoir operator had initially signed an adequate assurances agreement but later started work on a project which would have modified the reservoir operation and put houses in the floodplain. He also pointed out that designing channel crossings to the current FIS flow rate provided a factor of safety against clogging.
- Muller will evaluate the watershed hydrology with and without the flood storage effects of Reuter-Hess, and present their findings to the team at a future progress meeting. The project team will decide which set of flow rates makes the most sense to publish for this study considering the issues mentioned above.
- Tom stated that Reuter-Hess had held runoff from large storm events in June and July. The State Engineer's Office required release of this water, which started at 20-30 cfs and increased to a few hundred cfs. This caused noticeable stream degradation in Newlin Gulch immediately downstream. The team expected that the frequency and duration of flow releases from reservoir operations could threaten the stability of Newlin Gulch in the future.

Tom has discussed operations with PWSD and would like Reuter-Hess to release at lower flow rates of 20-30 cfs over a longer time period when they have to release runoff. This study will develop recommendations to stabilize the channel and prevent downcutting and erosion.

c. Muller will make sure that the recommendations of the MDP are consistent with the goal of preserving natural and beneficial stream functions. The team would like to preserve the natural character of the Newlin Gulch floodplain.

d. As part of the study, the team would like Muller to prepare alternatives to address flood conveyance at the Recreation Drive "Texas" crossing in Challenger Park. The team noted that, despite flood warning devices, this area continued to pose a hazard to motorists. Tom said that one of the challenges at this location is to design a crossing in a manner that does not cause floodplain issues.

e. The Baldwin Gulch portion of the study will focus on a stability analysis of the spillway for the Soil Conservation Service dam east of Pine Lane. The stability of the Baldwin Gulch channel between the dam and Pine Lane will also be evaluated. Muller will prepare a list of supplemental survey needs for this area (see Action Items).

2. DATA FOR BASELINE HYDROLOGY.

a. Mapping
- Muller presented a large scale figure of the Newlin Gulch watershed superimposed on 5-foot topography provided by Douglas County.
- If necessary, Muller has access to the 2008 DNC LiDAR topo for areas north of Lincoln.
- Shea thought that the new LiDAR topo she had flown this year for Newlin Gulch might cover the entire watershed.
- Muller will use the new LiDAR topo provided by Shea (see Action Items) to delineate the basins and sub-basins, and will supplement with the Douglas County 5-foot topo as necessary.

b. Land Use
- Shea provided Muller with aerial imagery from 2011 for the watershed.
- Jacob will provide Muller with updated 2012 aerial photography.
- Muller obtained zoning maps for Douglas County and Parker.
- Muller has already obtained some drainage reports and as-built documents for the surrounding developments as part of the adjacent Happy Canyon Creek master plan. Muller will request additional drainage reports and as-builts as necessary (see Action Items).
- The development plan in Castle Pines (upstream of Reuter-Hess) has changed significantly since the 1994 OSP. Muller will coordinate with Brad Meyering (Castle Pines Metro District) to obtain the latest development plan in this area.

c. Identify Existing Detention Ponds (regional and publically maintained)
- With the exception of Reuter-Hess, Derek asked the project team if they were aware of any publically maintained detention ponds within the watershed. The team was not aware of any ponds.

d. Reuter-Hess Reservoir
- As part of several design projects within Stonegate Village, Muller had already obtained some documentation regarding the operation of the Reuter-Hess Reservoir. Muller will coordinate with PWSD to obtain additional information needed to complete the baseline hydrology (see Action Items).
- Derek mentioned that in his previous experiences modeling watersheds containing large reservoirs, certain unique challenges arose. Muller plans to model the reservoir full to the normal pool elevation prior to the storm and make the reservoir a sub-basin within the watershed with an imperviousness of 100%. The team agreed with this approach. Derek

Newlin Gulch MDP – Kickoff Meeting – Meeting Minutes
November 19, 2012

stated that some basin characteristics (such as average basin slope) were difficult to estimate for a reservoir. Shea said that she would work with Muller to adjust the Cp factor to create a reasonable time to peak for the reservoir sub-basin.

3. Approach to Baseline Hydrology

Derek summarized the steps for developing the baseline hydrology:

a. Convert CUHP/SWMM file from 1994 OSP

b. Update subwatershed boundaries and characteristics (excluding % imperv.)

c. Calibrate to the existing FEMA flow rates (per 1977 FHAD). The FEMA flow rates are published downstream of Reuter-Hess. Upstream of Reuter-Hess, Muller will compare their peak flow rates to the 1994 OSP, but no calibration is required. Muller will also compare, but not calibrate, their flow rates to those published as part of the recent Cherry Creek FHAD study.

d. Update % imperviousness values for existing and future land use.

e. Add eligible publically maintained detention ponds.

4. SUPPLEMENTAL FIELD SURVEY

a. Newlin Gulch MDP
- The team discussed the need for supplemental ground survey at road crossings. Parker and Douglas County have LOMR studies for all of the major crossings and will send copies of these studies to Muller. The team decided that no supplemental crossing survey is warranted at this time.
- Derek mentioned a private drive between Chambers Rd. and Hess Rd. This is a low-water crossing consisting of 18-inch culvert pipes. The team decided that no survey is necessary at this location.
- Muller will coordinate with Shea to obtain ground survey of the Recreation Drive "Texas" crossing (see Action Items).

b. Baldwin Gulch
- Shea has already obtained 2-foot aerial mapping of the SCS dam on Baldwin Gulch as part of a survey effort for another project. Muller will review this survey and determine if additional ground survey is warranted (see Action Items).

5. IDENTIFY AND CONTACT STAKEHOLDERS (WHO AND WHEN)

The team discussed contacting other stakeholders (below). Muller will contact PWSD and Castle Pines initially as part of the baseline hydrology task. At Shea's recommendation, the team will wait for the completion of the baseline hydrology to involve the other stakeholders in progress meetings.

a. Parker Water & Sanitation District

b. Castle Pines

c. CCBWQA and CDOT

6. PROJECT WEBSITE

a. The project website will be similar to the website Muller created for the Happy Canyon MDP & FHAD.

b. The website will contain sponsor logos but not individual contact information.

c. The website comment form will be setup so that comments are emailed to Muller. Muller will then distribute comments to the project sponsors.

d. Muller will create a draft version of the website for Shea to review before making it live.

Newlin Gulch MDP – Kickoff Meeting – Meeting Minutes
November 19, 2012

7. PROJECT SCHEDULE.

a. Derek presented a draft project schedule to the team.
b. Muller anticipates completing the first draft of the baseline hydrology by early February. Shea thought that this was an appropriate timeframe.

8. OTHER ITEMS AND NEXT MEETING.

a. The next meeting will be held in January. Muller will coordinate with the sponsors to establish an acceptable meeting time.
b. There being no other business, the meeting was adjourned.

END OF MINUTES

MEETING
MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP

Meeting Date
March 18, 2013

Sponsors
UDFCD / Douglas County / Town of Parker

Issue Date
April 21, 2013

Meeting Location
UDFCD

MEC Project No.
12-050.01

Attendees
Shea Thomas, UDFCD
Bill DeGroot, UDFCD
Brad Robenstein, Douglas County
Tom Williams, Town of Parker
Jacob James, Town of Parker
Derek Johns, Muller Engineering Company
Jim Wulliman, Muller Engineering Company

Minutes Prepared By
Derek Johns

Routing
ASP / DDJ / JTW

Purpose
Newlin Gulch MDP – Progress Meeting #2

Muller Action Items:

1. Muller will evaluate two other options for routing at Rueter-Hess Reservoir:
   a. Route flows through the auxiliary spillway.
   b. Eliminate Rueter-Hess Reservoir completely and model reservoir subwatershed based on historic conditions and 2% imperviousness.
2. Muller will email the Sandpit Tributary flow rates to the project team.
3. Muller will evaluate flow rates for smaller storm events (2-yr, 5-yr, etc.) on Newlin Gulch by the Parker Homestead development and email these to Parker.
4. Muller will update the project schedule.

UDFCD Action Items:

1. Shea will provide input to Muller regarding depression storage losses for subwatersheds.
2. Shea will provide input to Muller regarding using Jarrett's equation to compute n-values for SWMM channels.
3. Shea will get the project website linked up to the UDFCD website.

Douglas County Action Items:

1. Brad will investigate whether or not there is a regional detention pond on the Spring Tributary upstream of I-25.
2. Brad and Tom will setup a meeting with PWSD to discuss Rueter-Hess Reservoir routing.

Town of Parker Action Items:

1. Jacob will provide Muller with drainage and as-built information for the regional detention pond on the Jordan Road Tributary upstream of Mainstreet.

Newlin Gulch MDP – Progress Meeting #2– Meeting Minutes
March 18, 2013

Discussion

THE FOLLOWING IS OUR UNDERSTANDING OF THE SUBJECT MATTER COVERED IN THIS CONFERENCE. IF THIS DIFFERS WITH YOUR UNDERSTANDING, PLEASE NOTIFY US IMMEDIATELY.

Derek provided an overview of the draft hydrology modeling completed since the last meeting and summarized the initial results. Below is a summary of the information discussed in the meeting.

1. SUBWATERSHEDS

a. Derek reviewed the mapping that was used for the hydrology analysis. The mapping consists of the following:
   - New 2-foot contour mapping for the Newlin Gulch channel corridor downstream of Rueter-Hess Reservoir. This mapping was completed in 2012 and provided by UDFCD.
   - Older 5-foot contour mapping for areas beyond the 2-foot mapping limits and for the watershed upstream of Rueter-Hess Reservoir. This older mapping was completed in 1996 and provided by Douglas County.
   - Aerial photography from Parker dated 2012.

b. Derek explained that the older 5-foot mapping does not always reflect drainage patterns correctly in newly developed areas. Therefore, land development drainage reports/maps were used to help delineate subwatersheds in newly developed areas.

c. Derek explained that the initial plan was to start with the subwatersheds from the 1993 Outfall Systems Plan (OSP) and then check the delineation based on the more current topographic mapping. However, it was discovered that the OSP subwatersheds were no longer application for the following reasons:
   - There have been many new developments since the OSP and these developments have changed drainage patterns within the watershed.
   - The Rueter-Hess Reservoir subwatershed is very large. The reservoir was delineated as a single subwatershed based on the normal pool elevation. The normal pool elevation is significantly higher than the current water level and this results in a subwatershed area of 1.8 square miles or approximately 12% of the entire Newlin Gulch watershed.
   - The OSP subwatersheds were delineated using older mapping.

d. Given these issues, a new subwatershed delineation was completed based on the more current mapping. The 15.0 square mile Newlin Gulch watershed was subdivided into 111 subwatersheds. The average subwatershed size is approximately 90 acres and only a few subwatersheds exceed 130 acres.

2. SOILS MAP

Derek handed out a map of the hydrologic soil types within the watershed. Most of the watershed consists of Type C/D soils. Type A and B soils exist along the Newlin Gulch channel.

3. LAND USE

a. Derek handed out land use maps for existing and future development conditions and explained that these were prepared based on the 2012 aerial photography and information provided in land development drainage reports. Imperviousness values were assigned according to UDFCD guidelines.

b. Douglas County. Land use for areas within unincorporated Douglas County include the following developments:
   1. Stonegate Village (existing) and Meridian Business Park (future).
   2. Happy Canyon Ranches, Sapphire Pointe, and development along Lemon Gulch Road.
      a. Brad (Douglas County) agreed that these were all large lot developments and would stay that way in the future. Brad thought that the development along Lemon Gulch Road was 35-acre lots.
      b. Brad agreed with the percent imperviousness values shown on the maps.

c. Town of Parker. Land use within Parker includes the following existing and future developments:
   1. Challenger Park and Bradbury Ranch (existing).
   2. New Horizon, Regency, Newlin Meadows (mostly developed).
   3. Newlin Crossing (on-hold).
   4. Parker Homestead (just started).
   5. Reuter-Hess WTP (just started).

d. Castle Pines. Land use within Castle Pines includes the following developments:
   1. The Canyons is a very large development being planned immediately upstream of Rueter-Hess Reservoir. Imperviousness values for this development were based on information provided in a Phase 1 drainage report.
   2. Lagae Ranch and Castle Pines Town Center (future).

e. Major Roads. Imperviousness values assumed for major roads were as follows:
   1. For I-25 and Hess Road, 60% imperviousness was assumed including ROW.
   2. For Chambers, Lincoln, Mainstreet, and Jordan Road, the imperviousness was assumed to be 100%.

f. For existing land use conditions, Derek said that the composite percent imperviousness for the entire watershed was 4.9% in the 1993 OSP Study and is 22.5% for the current study.

g. For future land use conditions, Derek said that the composite percent imperviousness for the entire watershed was 12.6% in the 1993 OSP Study and is significantly higher at 34.7% for the current study.

h. The Town of Parker and Douglas County will review the land use maps and provide comments to Muller.

4. CUHP MODEL

a. Derek said that both 2-hr and 3-hr rainfall events were modeled.

b. Derek stated that the depression losses used for the CUHP model approximately match the values used in the 1993 OSP. For pervious areas, a depression loss of 0.5-inches was used. For impervious areas, a depression loss of 0.1-inches was used (OSP ranged from 0.1 to 0.15-inches). These values are within the range listed in the UDFCD criteria manual but slightly higher than the "recommended" values. Shea stated that she will review these and get back to Muller with comments (see UDFCD Action Items).

Newlin Gulch MDP – Progress Meeting #2– Meeting Minutes
March 18, 2013

c. Rueter-Hess Reservoir subwatershed. Derek stated that the subwatershed for Rueter-Hess Reservoir was delineated at its normal pool elevation. An imperviousness of 100% and a subwatershed slope of 0.1% were assumed. This is consistent with how similar reservoirs have been modeled within the District. The draft results of the CUHP modeling indicate a 100-year peak flow of 2958 cfs or 2.6 cfs/acre for the Rueter-Hess subwatershed. Derek noted that this is similar to the results of a study completed on Standley Lake in Westminster, Colorado, which yielded a unit discharge of 3.1 cfs/acre for the lake.

d. Derek said that Muller performed a unit discharge check of the CUHP results. It was found that for undeveloped areas the subwatershed unit discharge typically varied from 1.0 to 1.6 cfs/acre. For residential areas, the unit discharge ranged from 2.0 to 3.8 cfs/acre. For business/commercial areas, the unit discharge ranged from 3.8 to 4.9 cfs/acre. Shea said that the unit discharges for oddly shaped basins (i.e., not meeting the 4:1 shape factor) should be checked. If the unit discharges are outside the normal range, then the Cp value should be adjusted.

5. SWMM MODEL

a. Derek explained that Muller developed a new SWMM model for the Newlin Gulch watershed and did not use the 1993 OSP model. This approach was used for the same reasons mentioned earlier regarding the subwatershed delineation.

b. Natural Channel n-values.
   - Derek explained that initially Muller used typical channel n-values that would be used for hydraulic models and then increased them by 25% per UDFCD guidelines. However, it was found that the n-values computed in this way were typically lower than those in the 1993 OSP.
   - Therefore, Muller modified the n-values and used higher values that were closer to those in the 1993 OSP which were based on the Jarrett equation. Derek asked if the project sponsors had a preference on the approach for estimated n-values. Shea responded that she will look into the best approach for computing channel n-values for the SWMM model (see UDFCD Action Items).

c. Rueter-Hess Reservoir. Derek described the approach that was used to route flows through Rueter-Hess (RH) Reservoir.
   - Storage/discharge data for the reservoir was based on tables shown on construction drawings provided by Parker Water and Sanitation District (PWSD).
   - The reservoir was assumed to be full at its normal pool elevation of 6215.1 at the start of the storm event.
   - Flows were routed through the service spillway which consists of a rectangular opening in the outlet works tower.
   - Subwatersheds adjacent and upstream of the reservoir were not routed but instead directly added to the reservoir inflow hydrograph.
   - Several options for routing through the reservoir were modeled.
     1. Historic conditions prior to the reservoir being built (entire watershed including reservoir at 2% imperviousness).
     2. With the RH reservoir storage in-place and flow routed through the service spillway.
     3. Without the RH reservoir storage attenuation benefits (but reservoir footprint at 100% imperviousness).

d. Regional Detention Ponds. Derek stated that Muller was not aware of any eligible publically maintained detention ponds in the watershed.

- Tom and Bill mentioned that there is a regional pond on the Jordan Road Tributary upstream of Mainstreet. Jacob will send Muller information on this pond (see Parker Action Items).
- Brad said that there may be a regional pond on the Spring Tributary upstream of I-25 and will look into this further (see Douglas County Action Items).
- Tom mentioned that the Canyons development is proposing some regional detention ponds. However, since these are future ponds, they cannot be considered in the Baseline hydrology but would be applicable for the Master Plan conditions hydrology.

e. Draft Hydrology Results. Muller prepared a table that summarizes the draft peak discharges for the 100-year event and compares them to discharges reported in the 1977 FHAD and the 1993 OSP studies. The draft results indicate the following.

1. The 100-year peak discharges for the "Historic Conditions" model are very similar to the discharges reported in the 1993 OSP for existing conditions. Shea said that since these values are within 10-percent of each other, no further calibration adjustments are necessary.
2. The option of accounting for RH reservoir storage and routing through the service spillway results in peak discharges that are lower than both the1977 FHAD and 1993 OSP discharges.
3. The option of modeling without RH reservoir storage attenuation (but reservoir footprint at 100% imperviousness) results in peak discharges that are substantially larger (more than double) the 1977 FHAD and 1993 OSP discharges.
4. The reservoir surcharge (rise in water level) is approximately 0.8-feet in the 100-year event when routed through the service spillway.
5. The 100-year storm event never spills over the reservoir's auxiliary spillway (emergency overflow spillway) because the auxiliary crest is 1.6-feet higher than the service spillway.

f. If the storage attenuation benefits of Rueter-Hess Reservoir are ignored, the peak 100-discharges are much higher than the 1977 FHAD discharges and would result in floodplain impacts to properties downstream of reservoir. Derek presented a floodplain exhibit of Newlin Gulch that was prepared for a separate project located downstream of the reservoir. The exhibit included the delineation of the 500-year event (based on the FHAD discharge of approximately 8000 cfs) and showed that the resulting 500-year floodplain encroaches on several properties. Since the current study 100-year flows without RH reservoir are even higher than 8000 cfs, it was concluded that there would be floodplain impacts to properties downstream if the RH storage benefits were ignored.

6. NEXT STEPS FOR BASELINE HYDROLOGY EVALUATION

a. The group discussed Rueter-Hess Reservoir routing options. To account for RH reservoir storage attenuation benefits, an "adequate assurances" agreement with the reservoir owner, PWSD, would be needed.

- Derek suggested that perhaps routing through the auxiliary spillway should be considered to allow more flexibility in possible future changes to the reservoir. The auxiliary spillway would be more difficult to change and any changes would likely have minimal impacts to the attenuation benefits. The group agreed with evaluating this option.
- Bill also requested that Muller look at the option of taking out RH reservoir completely and modeling the reservoir subwatershed based on historic conditions and 2% imperviousness.
- There was some discussion regarding the reservoir's emergency release rate of 590 cfs. This is the maximum discharge rate that the reservoir can release through the outlet works if there is a need to lower the water level for dam safety issues.

Newlin Gulch MDP – Progress Meeting #2– Meeting Minutes
March 18, 2013

b. Muller will model the two additional routing options for the reservoir discussed above. Once this is complete, Tom and Brad will setup a meeting with PWSD to discuss the draft hydrology results and the associated impacts of Rueter-Hess Reservoir.

c. Shea said that regarding rainfall duration, only the 2-hr storm needs to be evaluated for the watershed given UDFCD's new guidelines. The previous UDFCD guidelines require that the 3-hour storm be used for areas greater than 10 sq. miles. However, the new guidelines that are coming out soon recommend that the 2-hour storm be used for watershed areas up to 15 square miles and that the 3-hour storm be used for areas greater than 15 square miles.

7. PROJECT WEBSITE

Derek mentioned that the project website is complete and was sent to UDFCD. However, it appears that it has not been linked up to the "Master Plan" portion of the website. Shea will look into this (see UDFCD action items).

8. PROJECT SCHEDULE

Derek will review and update the project schedule.

9. OTHER ITEMS

a. The project sponsors were interested in the flow rates for the Sandpit Tributary and requested that Muller email these results to the group (see Muller Action Items).

b. Tom mentioned that a low water trail crossing of Newlin Gulch is being considered near the Parker Homestead development. Tom requested that Muller send draft peak flows at this locations for the smaller storm events such as the 2-yr, 5-yr, and 10-yr (see Muller Action Items).

c. Shea and Brad said that they would like Muller to complete the dam breach and hazard evaluation for the Baldwin Gulch dam. Shea will send Muller a scope for this work.

END OF MINUTES

MEETING
MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP

Sponsors
UDFCD / Douglas County / Town of Parker

Meeting Location
UDFCD

Attendees
Shea Thomas, UDFCD
Bill DeGroot, UDFCD
Fred Koch, Douglas County
Brad Robenstein, Douglas County
Tom Williams, Town of Parker
Jacob James, Town of Parker
Derek Johns, Muller Engineering Company
Jim Wulliman, Muller Engineering Company

Purpose
Newlin Gulch MDP – Progress Meeting #3

Meeting Date
May 15, 2013

Issue Date
June 21, 2013

MEC Project No.
12-050.01

Minutes Prepared By
Derek Johns

Routing
ASP / DDJ / JTW

Muller Action Items:

1. Muller will prepare a memorandum that summarizes the hydrologic evaluation of Rueter-Hess Reservoir and the flood control benefits associated with reservoir.
2. Muller will start preparing portions of the Draft Hydrology Report but will hold-off on finishing/publishing the report until PWSD Board approves the concept of officially recognizing the flood control benefits of Rueter-Hess Reservoir.
3. Muller will prepare a fee for a new FHAD study on Newlin Gulch.

UDFCD Action Items:

1. Shea will send an example "adequate assurances" agreement to Douglas County and Parker.

Douglas County and Town of Parker Action Items:

1. Douglas County and Parker will take the lead on coordinating with PWSD and working out the details for an adequate assurances agreement to officially recognize the flood control benefits of Rueter-Hess Reservoir.
2. Douglas County and Parker will pull out information from the Rueter-Hess memorandum and provide this to PWSD staff for their presentation to their Board.

Discussion

THE FOLLOWING IS OUR UNDERSTANDING OF THE SUBJECT MATTER COVERED IN THIS CONFERENCE. IF THIS DIFFERS WITH YOUR UNDERSTANDING, PLEASE NOTIFY US IMMEDIATELY.

1. MEETING WITH PWSD

Tom (Parker) and Fred (Douglas County) summarized the outcome of the meeting that the Town of Parker and Douglas County had with Parker Water and Sanitation District (PWSD). They met with Ron Redd/PWSD and it went well. PWSD is open to considering an agreement that would allow the flood control benefits of Rueter-Hess Reservoir to be officially recognized. PWSD sees this as an opportunity to show some of the other benefits of the reservoir. Specifics of the routing assumptions were not discussed, but Tom said that we should proceed with the option of routing through the auxiliary spillway. Tom said that in past conversations, Jim Nichol/PWSD has mentioned that PWSD would like to have the flexibility to possibly store more water in the future within the 1.6-foot zone between the service spillway and the auxiliary spillway.

2. RUETER-HESS RESERVOIR INFORMATION

Derek said that the hydrologic modeling of Rueter-Hess Reservoir was based on storage and discharge rating curves provided on as-built drawing. Muller does not have as-built drawings of the spillway dimensions. The group decided that the as-built drawing of the rating curves is sufficient documentation. Fred said that this as-built drawing should be included as part of the "adequate assurances" agreement with PWSD (the document that would be used to officially recognize the flood control benefits of Rueter-Hess Reservoir).

3. ADEQUATE ASSURANCES AGREEMENT

Bill and Shea said that UDFCD has an example "adequate assurances" agreement to start from and will send it to Fred. The agreement with PWSD will include Parker, Douglas County, and UDFCD. Parker and Douglas County will take the lead on this effort.

4. INFORMATION FOR PWSD BOARD MEETING

Tom said that the PWSD Board meets every two weeks. The group asked Muller to prepare a technical memorandum that summarizes the hydrologic evaluation and explains the flood control benefits of Rueter-Hess Reservoir. Parker and Douglas County will pull information from the memorandum and provide this to PWSD staff for their presentation to the Board. Fred said that Wendy Holmes (Douglas County) can help write/format this information which PWSD staff can use for their presentation to the Board and also as a press release.

The technical memorandum should include a summary of the hydrologic evaluation of Rueter-Hess Reservoir and document the flood control benefits. Specific items that were suggested to include in the memo are as follows:

a. Tom and Jacob suggested to state that storm flows would have increased with new development and list the percent increases.
b. Derek suggested showing an exhibit of the current floodplain in Stonegate Village and how it is currently close to residential properties. This exhibit would help to show that any significant increases in storm flows could result in properties being in the floodplain.
c. Tom said to mention flooding issues at Recreation Drive and how being able to recognize flood control benefits of Rueter-Hess Reservoir will allow improvements at this location to be accomplished more cost effectively.
d. Tom said to mention that the lower flows will also allow new bridges (i.e., Jordan Road) to be constructed more cost effectively.

The group requested that the memorandum be prepared as soon as possible (next week). Shea said that UDFCD will cover the cost for preparing the memo and Fred said that Douglas County could pay for any "extra" figures and graphics needed for marketing and/or press releases.

5. FHAD

Tom said that Parker would like to pursue doing a new Flood Hazard Area Delineation (FHAD) study that recognizes the lower peak flows from Rueter-Hess Reservoir. Tom thought that a new FHAD would be beneficial for the following reasons.

a. Recreation Drive flooding issue. A new bridge or culvert crossing is needed at this location that could at least convey small storms (i.e., 5-year event). A few years ago, Parker looked at putting in a new bridge at this location but there were floodplain issues along the adjacent commercial property. Recognizing lower flows from Rueter-Hess would allow for a more cost effective solution at this location.
b. Jordan Road Bridge. Tom said that Parker has a project underway to widen Jordan Road and add a turn lane where it crosses Newlin Gulch. To do this, the existing bridge will need to be widened but the hydraulic evaluations are indicating that there would be a rise in the floodplain which would cause problems at this location. To resolve the floodplain issue, they would have to tear out the existing bridges and build a new bridge with a longer span. Tom said that if flows are truly lower as a result of Rueter-Hess Reservoir, then it makes sense to officially recognize this. The lower flows would allow for a more cost effective solution at this location.
c. Tom added that any other new bridges or channel structures will be more cost effective by recognizing the lower flows in a new FHAD.
d. Fred mentioned some concern with developing a new FHAD using the lower flows because he does not want to constrict the existing floodplain. Tom does want to constrict the floodplain either. Tom said that the entire Newlin Gulch floodplain corridor downstream of Rueter-Hess has been dedicated as open space to Stonegate Village and the Town of Parker, so no new development can occur that would constrict the floodplain.
e. As an idea to provide more floodplain buffer, Jim mentioned the idea of adding the 590 cfs emergency flow release from Rueter-Hess Reservoir to peak storm flows. Tom thought this would be a little too conservative and not necessary.

f. The group decided to proceed with a new FHAD study. Bill and Shea did not originally plan on a new FHAD but said that they can find the funding for this. Shea asked Muller to provide a fee for a new FHAD.

6. DRAFT HYDROLOGY REPORT

Tom felt that we should hold-off on publishing the Draft Hydrology Report until the PWSD Board approves the concept of officially recognizing the flood control benefits of Rueter-Hess Reservoir. Shea said that Muller could start working on portions of the report but agreed with Tom that we should hold-off on finishing it until we get PWSD's response. Shea said to not include all the sections in the draft report that are specified in the checklist. Some sections are not necessary at this phase of the project. Shea said to refer to the Coal Creek/Rock Creek draft hydrology report as a good example of sections that should be included.

END OF MINUTES

MEETING MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP

Meeting Date
December 17, 2014

Sponsors
UDFCD / Douglas County / Town of Parker

Issue Date
January 5, 2015

Meeting Location
UDFCD

MEC Project No.
12-050.01

Attendees
Shea Thomas, UDFCD
Brad Robenstein, Douglas County
Jacob James, Town of Parker
Derek Johns, Muller Engineering Company
Andy Pultorak, Muller Engineering Company

Minutes Prepared By
Andy Pultorak

Routing
ASP / DDJ

Purpose
Newlin Gulch MDP – Progress Meeting #4

Muller Action Items:

1. Muller will run subwatershed hydrology using the latest version of CUHP (v. 1.4.4) to determine if peak flowrates or volumes are impacted.
2. Muller will finish the draft baseline hydrology and submit to UDFCD for review.
3. Muller will update the project website with the revised schedule.
4. Muller will email the project stakeholders (Stonegate Village, Cherry Creek Water Quality Basin Authority) regarding the FHAD study.

UDFCD Action Items:

1. Shea will send the executed adequate assurances agreement to Muller for inclusion in the appendices of the baseline hydrology report.

DISCUSSION:

THE FOLLOWING IS OUR UNDERSTANDING OF THE SUBJECT MATTER COVERED IN THIS MEETING. IF THIS DIFFERS WITH YOUR UNDERSTANDING, PLEASE NOTIFY US IMMEDIATELY.

1. INTRODUCTION

Derek (Muller) summarized the status of the project. The project was on-hold for approximately 1 ½ years waiting for the adequate assurances agreement between Parker Water and Sanitation District (PWSD) and the project Stakeholders to be finalized. Prior to stopping work, Muller had prepared hydrologic models and a memorandum summarizing the flood control benefits of Rueter-Hess Reservoir. The project Sponsors used this information over a year-long process to prepare the adequate assurances agreement with PWDS. The

agreement was signed in October, 2014. This was a major milestone, clearing the way for the masterplan to account for the flood control benefits of the reservoir.

2. DRAFT HYDROLOGY REPORT

Prior to stopping work, Muller had written much of the draft baseline hydrology report. The report and appendices need to be finalized and assembled before they can be submitted for review by the project team. The project team discussed several elements of the report as follows:

a. Adequate Assurances Agreement: The adequate assurances agreement formalizes the flood control benefits of Reuter-Hess Reservoir and the reduced peak flowrates downstream. The agreement is based on flowrates provided by Muller using the hydrologic models prepared for the eventual baseline hydrology submittal. Shea would like to include a copy of the adequate assurances agreement as an appendix in the report (see Action Items). The technical memorandum, prepared by Muller and used in the development of the agreement, should also be included as an appendix in the report. The team requested that none of the hydrologic model results which ignore the flood control benefits of Reuter-Hess be included in the text of the main report (to avoid confusion).

b. Land Use: Derek noted that the hydrologic models were prepared using the best available land use information during the development of the models. This included some conceptual and preliminary drainage reports for future developments, including the Canyons development in Castle Pines. Derek noted that these development plans may or may not have changed since the hydrologic models were prepared. This could potentially impact the imperviousness and infiltration assumptions used in the hydrologic models. Brad Robenstein (Douglas County) said that he was unaware of any major changes with the Canyons development. Shea agreed that the preliminary information used during the initial model development was adequate and did not need to be revisited. Jacob James (Town of Parker) noted that there were no changes to future land use assumptions within the Town boundaries.

c. Interactive PDF: Andy Pultorak (Muller) asked Shea if including static PDFs for land-use, routing, and subwatershed figures in the draft submittal was acceptable to UDFCD, since this would eliminate some repeated work if the figures changed between draft and final submittals. Shea agreed that static PDFs were acceptable for the draft submittal, as long as the interactive PDF was included in the final.

3. FLOOD HAZARD AREA DELINEATION

The scope of the masterplan work includes a Flood Hazard Area Delineation (FHAD) study of the portion of the Newlin Gulch mainstem downstream of the reservoir (upstream limits near Hess Road).

a. Derek noted that the scope of work did not include a schedule for the FHAD study. He anticipated starting work on the FHAD study after submitting the baseline hydrology report. The preliminary FHAD submittal is anticipated 10 weeks after the submittal of the draft baseline hydrology report. Shea was OK with this timeframe. Shea noted that Muller should plan to meet with Terri Fead (UDFCD) before she reviews the first preliminary submittal.

b. Derek mentioned that there are several challenges with the hydraulic modeling, particularly in the Stonegate reach, that might warrant a meeting earlier in the process. This includes channel work that post-dates the available LiDAR mapping. Shea agreed that this meeting could occur when Muller submits the draft cross-section locations map to UDFCD for review.

c. Shea said that the floodplain group is typically notifying all impacted property owners that a FHAD is in progress. Terri and David Mallory (UDFCD) will handle this notification process.

Newlin Gulch MDP – Progress Meeting #4– Meeting Minutes
December 17, 2014

d. A public meeting (included in the current scope) may not be warranted for this project. The project team may decide to distribute a flyer or have individual meetings with impacted property owners instead. Muller was asked not to include a public meeting in the schedule.
e. Derek said that Muller had recently completed several channel improvement projects in Stonegate Village for which LOMRs had not been issued. He noted that Barbara Chongtoua (UDFCD), wanted incorporate these map revisions as part of the PMR issued following the current FHAD study, rather than issue individual LOMRs for these projects. Shea generally agreed with this approach and thought that LOMRs would not be necessary, but wanted to discuss it further with Terri Fead and David Mallory.

4. ALTERNATIVES ANALYSIS

The project team discussed the following items in regards to the Alternatives Analysis:

a. Jacob noted that Recreation Drive has been closed several times in the past two years due to flooding.
b. Derek noted that Tom Williams (Town of Parker) had mentioned a possible flood capacity issue at the Jordan Road over Newlin Gulch bridge. This may be improved by the reduction in flowrates resulting from the Rueter-Hess flood attenuation. Brad and Jacob were unaware of any specific concern at Jordan Road.
c. Jacob pointed out proposed trail crossing locations north and south of Chambers Road. The crossing south of Chambers (in Parker Homestead) was currently undergoing final design by Muller Engineering. The crossing north of Chambers (part of the Douglas County East-West Trail) was undergoing final design by Hartwig and Associates. Jacob noted that he would like to get a general sense for masterplanned drop structure locations in this area as soon as possible to help him locate the crossings and set inverts. Jacob would like to include the proposed crossings in the FHAD study.
d. Jacob noted that the Town has recently seen increased aggradation upstream of Chambers Road. Downstream of Jordan, a 3-foot headcut has formed at an existing check structure. Derek said that one focus of the study will be to estimate how the addition of the reservoir will impact long term sediment transport within the watershed.
e. Shea told Muller not to include a benefit cost analysis in the Alternatives Analysis report. She noted that a benefit cost analysis does not produce a reasonable result if there are no structures (or few structures) in the floodplain.

5. SCHEDULE

Derek presented an updated schedule for review by the project team. Shea agreed with the milestones as shown. Muller will submit the draft baseline hydrology report and start work on the FHAD study. Muller will schedule the next progress meeting for early February. The meeting will include discussion of the draft baseline hydrology report, early results of the alternatives analysis, and early results from the FHAD study. Muller will invite Stakeholders, including Stonegate Village and Cherry Creek Basin Water Quality Authority (CCBWQA). Jacob will contact PWSD by email regarding any future water and sewer crossings of Newlin Gulch. Muller will update the major milestones dates on the project website.

END OF MINUTES

DRAFT BASELINE HYDROLOGY COMMENTS

Draft baseline hydrology was submitted to the project sponsors on January 20, 2015 for review. Comments were received on February 9, 2015 in the form of an annotated PDF copy of the report. Select comments have been reproduced below; responses are italicized. Minor comments/corrections were addressed in the revision but are not listed here.

UDFCD COMMENTS:

Figure B-1 [Several inconsistencies were noted between future impervious values shown on the subwatershed map and values listed in Table B-2, CUHP Input]
All inconsistencies have been corrected; this may have resulted in minor changes to future composite impervious values for some subwatersheds.

TOWN OF PARKER COMMENTS

Figure B-1 [Re: Future Land Use, Newlin Crossing development area north of Mainstreet, shown as mixture of 10%, 45%, 70% impervious]

- Change everything east of Newlin Gulch to 45%
- Change everything west of Newlin Gulch to Chambers to 70%

[Re: Future Land Use, parcel at SW corner of Mainstreet and Jordan, shown as 10% impervious]

- This is slated for commercial development, use 70%

[Re: Future Land Use, area of Parker at southeast edge of Rueter-Hess, at upstream end of Benchmark Tributary, shown as 2% impervious]

- This will likely be 40% impervious

Impervious values have been updated as requested based on recent development plans. Future development CUHP/SWMM models have been re-run; peak flows and all associated tables and figures updated.

[Re: Future Land Use, Meridian development west of Chambers Rd, north and south of Mainstreet]

- Confirm with Brad that land use is slated to be this high 75%

See Douglas County comments below.

DOUGLAS COUNTY COMMENTS

Figure B-1 [Re: Future Land Use, Meridian development west of Chambers Rd, north and south of Mainstreet]
This area does seem too high. I looked at the PDs for Meridian International Business Center and Sierra Ridge. The area currently shown as 75% is more likely to be around 60%.
Future impervious for Meridian has been updated to 60% as requested. The small corner of the watershed that lies within the City of Lone Tree was changed to 70% to match future land use values used for the adjacent areas in the 2012 Happy Canyon Creek MDP.

MEETING MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP and FHAD

Meeting Date
March 2, 2015

Sponsors
UDFCD / Douglas County / Town of Parker

Issue Date
March 13, 2015

Meeting Location
Town of Parker

Muller Project No.
12-050.01

Attendees
Shea Thomas, UDFCD
Brad Robenstein, Douglas County
Jacob James, Town of Parker
Jim Swanson, CCBWQA
Scott Barnett, Mulhern MRE (representing SVMD)
Derek Johns, Muller Engineering Company
Melanie Chenard, Muller Engineering Company
Sam Rogers, Muller Engineering Company

Minutes Prepared By
Sam Rogers/Melanie Chenard

Purpose
Newlin Gulch MDP and FHAD – Progress Meeting #5

The following is our understanding of the subject matter covered in this meeting. If this differs with you understanding, please notify us as soon as possible.

ACTION ITEM SUMMARY:

Muller Action Items:
1. Provide 30% rule graphic to UDFCD. *Complete.*
2. Add Terri Fead to the email distribution list. *Complete.*

UDFCD Action Items:
1. Schedule meeting with Muller and Terri Fead to discuss the FHAD. *Complete.*
2. Inquire about separation distance required to avoid pedestrian railing requirement.

Town of Parker Action Items:
1. Look for additional information on the pedestrian bridge near Cherry Creek. *Complete.*
2. Schedule potholing of gas line downstream of Recreation Drive. *Complete.*

Douglas County Action Items:
1. Obtain feedback from Douglas County roadway staff on necessity of guardrails or pedestrian railings at Recreation Drive low-flow crossing.
2. Obtain feedback from Douglas County park staff on desired design criteria for parking lot.

Stonegate Village Metro District Action Items:
1. Provide Muller with any available information on utility lines near Recreation Drive.

DISCUSSION:

1. GENERAL

Melanie Chenard gave an update on the Baseline Hydrology Report progress. Comments from the project sponsors have been addressed and a final submittal of the report should be ready in the next couple of days.

Project stakeholders representing the Cherry Creek Basin Water Quality Authority (CCBWQA) and Stonegate Village Metro District (SVMD) were introduced to the team, and Derek Johns provided some background on the overall Master Plan project and introduced the next two components, the FHAD study and Alternatives Analysis study.

2. FHAD

Preliminary analysis for the Flood Hazard Area Delineation (FHAD) study has begun. The study area limits for the FHAD begin downstream at the confluence with Cherry Creek at Challenger Park, and end upstream of Hess Road, just below Rueter-Hess Reservoir. Particular issues and discussion items are outlined as follows:

a. 30%, 0.5' Rule: The FHAD will be based on the future development hydrology. Muller compared the peak flow rates and BFEs based on future development to those based on existing development to verify that the FHAD will be eligible for adoption by FEMA as the regulatory floodplain. The results of this evaluation were plotted and presented to the team. Peak flow rates based on future development are less than 30% greater than peak flow rates based on existing development for the entire reach. BFEs based on future development are ***more*** than 0.5' higher than BFEs based on existing development for approximately the lower third of the reach. However, with the overall reduction in peak flow rates due to the baseline hydrology updates, no new structure impacts are anticipated. Shea will review this with UDFCD's floodplain group, but expects this will satisfy FEMA's requirements.

b. Bridge Modeling: Melanie reviewed the planned approach for HEC-RAS modeling of bridges, as follows:
- Lincoln Ave, Jordan Rd, Mainstreet, and Hess Rd: bridge routines from recent LOMRs will be imported into HEC-RAS model
- Stonegate Pkwy: bridge routine from design floodplain model prepared by Muller will be imported into HEC-RAS model
- Chambers Rd: LOMR for this work did not have a bridge routine; bridge data will be entered based on as-built drawings of the bridge previously provided to Muller by Jacob James
- Muller does not have any information on the pedestrian bridge near the confluence of Newlin Gulch with Cherry Creek. Though it was supposedly constructed as a breakaway bridge, it should be modeled with the full height of the railings blocked. Jacob will look for any additional information on this bridge as there is no remaining project budget to get it surveyed.

c. Upstream Limit of Model: Currently, Muller has the upstream limit of the FHAD model set near the crest section of the large grouted boulder drop structure just upstream of Hess Road. Muller inquired if this is sufficient or if it should be extended up to the primary reservoir spillway outlet works or, alternately, up the auxiliary spillway. Shea said that this limit should be fine but that Muller should review this with Terri Fead (UDFCD). Muller will also look at how the floodplain was modeled in the CLOMR for Rueter-Hess.

d. Manning's n-Values: Sam Rogers showed photos representing various roughness values along Newlin Gulch. In general, Muller is proposing to err on the higher, more conservative range of appropriate n-values. Shea noted that values should not be increased based on expectations of future vegetation growth due to anticipated changes in channel conditions or base flows, but should be reflective of expected vegetation regrowth following construction or other disturbance. Proposed channel n-values range from 0.04 to 0.12; overbank n-values are generally 0.04 with select areas up to 0.08. Muller noted that a small reach near the confluence with the Jordan Road Tributary has little vegetation (n=0.04) though the areas immediately upstream and downstream have good willow and wetland growth (n=0.08), and inquired about matching the n-value for the adjacent area. Shea would like to keep the higher n-value here but is not sure if that will be acceptable; Muller will discuss this area with Terri Fead. Jacob noted that the current vegetative growth is artificially low between Lincoln Ave. and Recreation Drive due to clearing that was done following a recent oil spill. He requested that the channel n-value be increased from 0.04 to 0.05 in this reach. The team agreed with the rest of the n-values presented.

e. Meeting with UDFCD Floodplain Group: Shea will set up a meeting in the next couple of weeks with Muller and Terri Fead to discuss the FHAD in more detail. Shea noted that Terri should be included in future progress meetings.

3. ALTERNATIVES ANALYSIS

Muller has begun work on an Alternatives Analysis study for Newlin Gulch within the same limits as the FHAD. Items discussed in the meeting are outlined below:

a. Reach Breakdown: Design reaches for the project were identified and approved by the team as follows (local jurisdiction noted in parenthesis):
- Reach 1: Cherry Creek to downstream side of Recreation Drive (Town of Parker)
- Reach 2: Recreation Drive to Lincoln Avenue (inclusive of both crossings) (Douglas County)
- Reach 3: Upstream of Lincoln Avenue to southern boundary of Stonegate (Douglas County)
- Reach 4: Southern boundary of Stonegate to downstream side of Mainstreet (Douglas County
- Reach 5: Mainstreet to Chambers Road (inclusive of both crossings) (Town of Parker)
- Reach 6: Upstream of Chambers Road to upstream study limit (Town of Parker)

b. Problem Areas: A draft figure illustrating existing channel condition and problem areas was handed out, and photos of existing conditions were reviewed. Highlights include the following, by reach:
- Reach 1: Generally stable channel, some scour at upstream approaches to of existing vertical drop structures.
- Reach 2: Recreation Drive crossing is a ford crossing that requires road closure several times per year. Aggradation in the channel seems to have worsened the condition. The upstream channel is very shallow and flooding of the adjacent parking lot is common.
- Reach 3: There is severe scour at the lower of two check structures between Lincoln Ave. and Jordan Road. Two storm sewer outfalls empty onto the trail near Jordan Road – per Scott, these frequently cause icing problems on the trail. Aggradation beneath the Jordan Road bridge is evident – per Scott, constant trail maintenance is required here. Some channel scour is evident near the Jordan Road Tributary confluence. Between Jordan Road and Stonegate parkway, the channel is stable; three projects have been completed by Muller

Newlin Gulch MDP – Progress Meeting #5– Meeting Minutes
March 2, 2015

in recent years, and a preliminary design has been prepared for future stabilization. Upstream of Stonegate Parkway, some headcutting is evident.
- Reach 4: This reach is currently pretty stable, though there are indications that additional grade control might be needed as upstream development continues.
- Reach 5: Upstream of Mainstreet, the private landowner has livestock corrals adjacent to and in the channel, and appears to be spreading manure and wood chips in the overbank. Besides preventing any vegetative growth, this practice has water quality impacts that should be considered. There is scour at a fairly new check structure downstream of Chambers, near the future crossing of the East-West Regional Trail.
- Reach 6: There is active degradation in this reach downstream of the proposed trail crossing at Parker Homestead, and also just downstream of Hess Road.

c. Channel Slope: Derek summarized the design slopes used for previous projects along the reach, which ranged from 0.13% to 0.40%, and the channel condition for each project area. With this information, he has developed recommended stable channel slopes for the reach, varying from 0.15% to 0.30%. Shea commented that UDFCD generally uses 0.2% for sandy channels and 0.4% for non-sandy channels, but given the observations was ok with the proposed flatter slopes. The rest of the group concurred.

d. Grade Control Options: Derek inquired about comparing lower-height drop structures (1.5-2') to larger (4') drops in the alternative analysis. Per Shea, with the forthcoming revisions to the open channel chapter of the USDCM, she would like to limit drops to a maximum of 3' height in planning documents. She said there is no need to look at different options for grade control, and that aside from Recreation Drive (discussed below), there may not be much in the way of alternatives for this project.

e. Recreation Drive: This will be the primary focus of the alternative analysis. Existing conditions and considerations include the following:
- Per Jacob, the Town of Parker currently closes the road whenever flows exceed 50 cfs.
- The large grouted boulder drop structure downstream has limited bank height at the crest and it appears that high flows spill around the south end of the drop.
- Lowering the drop crest would help provide grade separation at the crossing as well as address the capacity concerns at the drop; however, there is a buried high-pressure gas line just upstream of the drop that may not be deep enough to accommodate a lowered drop.
- The parking lot adjacent to Newlin Gulch upstream of Recreation Drive is less than 1' above the channel invert. Flooding in the lot is common.
- Aggradation in the channel appears to have worsened the general condition at the crossing.
- Any proposed improvements would have to avoid floodplain impacts to the adjacent commercial development.

Upon discussion with the team, it was decided that Muller will look at a low-flow option that maintains the existing downstream drop structure invert and a low-flow option with a lowered channel invert. No 100-year option will be considered. Additional discussion of the crossing included the following points:
- Jacob will have the gas line potholed. Muller will inquire about encasement and relocation costs.
- Brad would like to get 10-year capacity at the crossing if possible
- Any railings required may negatively impact the floodplain upstream of the crossing. Per Shea, UDFCD criteria requires pedestrian railing for any drop greater than 3'. Extending the culvert well beyond the edge of road may be a way to avoid either pedestrian railing or guardrail requirements. Shea will check what separation distance would be required

Newlin Gulch MDP – Progress Meeting #5– Meeting Minutes
March 2, 2015

between the drop and any pedestrian walkways to avoid a need for railings. Brad will solicit feedback from the County roadway staff. Jacob would prefer that we account for guardrail in the hydraulic model (if possible); then they could decide during final design whether to include it.

- Brad will review desired design criteria for the parking lot with the County Parks staff. Several park structures appear to be within the 100-year floodplain; our plan should aim to get the restrooms out of the 100-year floodplain.
- Scott noted that there are multiple SVMD utility lines in the vicinity, including return flow from the WWTP, a sanitary force main, and water lines. These may be a hindrance to design of a low-flow crossing. He will send Muller whatever information he can find.

f. Other Topics: Scott mentioned that SVMD has their effluent discharge line in Cherry Creek under Lincoln Avenue, and that they would like to move it to Newlin Gulch if possible. Effluent flow rates are 2-3 MGD.

4. PROJECT SCHEDULE

Muller is still working according to the schedule presented in December, with target milestone dates of March 31st for the FHAD preliminary submittal and April 14th for the draft Alternative Analysis.

5. PUBLIC MEETING

No public meeting is planned for this project. Instead, UDFCD will prepare and send a mailing after submittal of the draft alternatives. The mailing will be a simple postcard format and will direct people to the project website.

6. NEXT MEETING

Further coordination on the alternatives will be handled via email. The next project meeting will be held following submittal and sponsor review of the draft Alternative Analysis.

END OF MINUTES

MEETING MEMORANDUM

MULLER ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD., SUITE 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

Project
Newlin Gulch MDP and FHAD

Meeting Date
June 1, 2015

Sponsors
UDFCD / Douglas County / Town of Parker

Issue Date
June 4, 2015

Meeting Location
Town of Parker

Muller Project No.
12-050.01

Attendees
Shea Thomas, UDFCD
Brad Robenstein, Douglas County
Jacob James, Town of Parker
Jim Swanson, CCBWQA
Derek Johns, Muller Engineering Company
Melanie Chenard, Muller Engineering Company
Sam Rogers, Muller Engineering Company

Minutes Prepared By
Sam Rogers/Melanie Chenard

Purpose
Newlin Gulch MDP and FHAD – Progress Meeting #6

The following is our understanding of the subject matter covered in this meeting. If this differs with your understanding, please notify us as soon as possible.

ACTION ITEM SUMMARY:

Muller Action Items:
1. Inquire with Scott Barnett about encasement requirements for sanitary lines under Recreation Drive.
2. Send Jacob a rating curve of flow vs. depth at Recreation Drive.

UDFCD Action Items:
1. Inquire about unit cost for weed control.
2. Inquire about unit costs for land acquisition from past master plans.
3. Forward public comment responses to Muller.

Town of Parker/Douglas County Action Items:
1. Send Muller as-built bridge drawings for Jordan Road and Mainstreet over Newlin Gulch.

Newlin Gulch MDP – Progress Meeting #6– Meeting Minutes
June 1, 2015

DISCUSSION:

1. GENERAL

Melanie Chenard gave an update on the FHAD Report and Alternatives Analysis Report progress. Muller has received comments on the Preliminary FHAD Submittal from Terri Fead at UDFCD and comments on the Draft Alternatives Report from the project sponsors. Muller will address these comments as well as any additional discussions that come up in this meeting and submit both the Draft FHAD Report and the Final Alternatives Analysis Report the week of June 8th, 2015.

2. FHAD

a. Preliminary analysis for the Flood Hazard Area Delineation (FHAD) study was completed and submitted to UDFCD for review in early April. Terri Fead replied with comments on the hydraulic model, floodplain workmaps, water surface profiles, floodplain data, and agreements tables on May 12th. Muller will address these comments and include the revised documents in a draft submittal of the FHAD Report on June 9th, 2015.

b. Bridge data for the Jordan Road, Lincoln Avenue, and Mainstreet crossings over Newlin Gulch was obtained from recent LOMR models. It was noted that the deck thicknesses for these bridges were inaccurate in the LOMR models, ranging from only 1’ to 2’ thick. While the inaccuracies do not seem to impact the hydraulics due to the large size of the bridges, Muller would like to reflect them accurately in the HEC-RAS model and on the FHAD profile drawing. As-built drawings for the Lincoln Avenue bridge are available on the UDFCD server; additional information is needed for Jordan Road and Mainstreet. Jacob and Brad will provide Muller with as-built drawings

c. Melanie reviewed the draft floodway delineations with the project team. At Challenger Park, a right bank floodway is defined from Lincoln to downstream of Recreation Drive. At the upstream end of the study area, floodways are defined upstream of Hess Road and in areas downstream of Hess Road where there are large backwater areas. The team agreed that the floodways look appropriate.

3. ALTERNATIVES ANALYSIS

Muller has submitted a Draft Alternatives Analysis Report and received comments back from the project sponsors. Items discussed in the meeting are outlined below:

a. Recreation Drive: Melanie gave an overview of the three alternatives proposed for the crossing at Recreation Drive. All three alternatives include adding a four-celled box culvert with 10-year capacity near the low point of Recreation Drive, with higher storm events overtopping the crossing. Alternative A matches the existing channel invert and minimizes road reconstruction, such that high flows will continue to spill onto Recreation Drive East and around the right bank of the grouted boulder drop structure. Alternative B also matches the existing channel invert but includes additional road reconstruction to raise the high point in Recreation Drive, eliminating the spill to Recreation Drive East. The right side of the grouted boulder drop would be raised to contain 100-year flows within the drop. Alternative C lowers the invert of the culverts at Recreation Drive, which requires lowering the crest of the grouted boulder drop as well as the 20” high pressure gas line.

- Jacob recommended in a review comment that a sheet pile cutoff wall and some riprap bank protection be added to Alternative A to protect the drop structure and utilities from erosion. Muller agrees with this comment and has updated the Alternative A figure and cost estimate accordingly.
- Alternative B features a small berm to the east of the parking lot bathrooms that would help contain 100-year flows from entering Recreation Drive East. Shea Thomas had provided a review comment about the creation of a levee condition. Melanie clarified that the intent of the berm is to improve the hydraulics, but that the mapped floodplain for this alternative would need to ignore the effects of the berm.
- Shea had a comment for Muller to investigate the hydraulic impacts of skewing the proposed culvert at Recreation Drive. Melanie mentioned that skewing the bridge had little to no effect on the hydraulics, but that it will be investigated in more detail during conceptual design. Jacob requested that, during conceptual design, Muller attempt to lay out the improvements such that the adjacent trail could be replaced in the same alignment (though the grades may change) in order to minimize the impact on the adjacent property.
- Shea had provided a review comment inquiring about the impacts of Alternatives A and B on the SVMD sanitary lines in Recreation Drive. Melanie mentioned that both lines are set fairly deep (about 6-8'), but will check with Scott Barnett of Mulhern MRE as to whether these lines would need to be encased.
- Numerous comments were provided on the Alternative Evaluation Summary Matrix. Muller handed out copies of the updated matrix and asked for any other feedback on the weightings or rankings of the various items as the three alternatives are very closely rated. Shea noted that Muller's recommended plan doesn't necessarily need to match the results of the matrix, and that the sponsors are free to deviate from the recommended plan in their selected plan. Jacob commented that, from the Town's persepective, Alternative B does not provide a much more substantial incentive over Alternative A based on the $400k cost difference, but that ultimately the Town would defer to the County's preference.
- The team had previously discussed whether guardrails or handrails would be required at the crossing. Brad had indicated that the County wouldn't require guardrails due to the low design speed. They would likely want to have pedestrian rails, though these could potentially be excluded if the culvert extends sufficiently beyond the edge of the roadway / sidewalk. Jacob had expressed a preference to include railings in the MDP modeling, and leave the decision for final design. Therefore, Muller has assumed 54" railing that would act as fully blocked over the culvert. If desired by the team, this assumption can be re-considered during conceptual design.
- Muller asked for more feedback about the flooding in the parking lot. Alternatives A and B provide 2-year protection, and Alternative C provides 10-year protection. Brad thought these levels of protection were adequate and that there is no need for Muller to look at raising the parking lot. In order to address the issue of minor flooding at the restrooms that is introduced with Alternatives A and B, the project team agreed that installing a small floodwall around the structure would suffice.

b. Channel Alternatives: Melanie presented Jacob's comments on the use of existing and proposed grade structures in Reach 5, Town of Parker's jurisdiction. In general, Jacob would like to retrofit existing check structures into drop structures and increase proposed drop heights from 2' up to 2.5' or 3' in order to decrease the amount of structures needed.

c. Maintenance:
- Jacob and Brad confirmed that concrete maintenance trails should be included for all areas currently without maintenance access.

- In the operation and maintenance section of the Master Planning cost spreadsheet, Shea recommended that "mowing" be changed to "weed control", with the cost and/or frequency reduced. Shea will inquire with Barbara Chongtoua on a more specific cost for weed control.

d. Land Acquisition: No land acquisition costs were included in the draft Alternative Analysis. Muller assumed that reaches yet to develop would have dedicated open space/drainageway tracts, as per the currently developed reaches. The only acquisition required by the plan is at Recreation Drive. This is within the Town of Parker; per Jacob, land acquisition costs at Recreation Drive should be included. Jacob will look into whether there are existing trail and/or drainageway easements; if so, perhaps only a temporary construction easement would be needed. Shea will investigate land acquisition costs from prior master plans and forward them on to Muller.

e. Public Comments/Responses: Shea will forward Muller her responses to public comments to include in Appendix A of the report.

4. BALDWIN GULCH

Derek explained that the original contract included some analysis of stabilization improvements needed on Baldwin Gulch. Though the scope for the Baldwin piece has evolved, Derek thought there is still a need to look at stabilization improvements between the dam and Pine Drive. The team agreed; Muller will prepare a memo with recommended improvements that UDFCD will attach to the original OSP document, which is still in effect for Baldwin Gulch.

5. PROJECT SCHEDULE

An updated project schedule was handed out. The timeline for the Conceptual Design Report has been shortened to make up for additional time spent on the Alternative Analysis. As was previously stated, target milestone dates are June 9th for the Draft FHAD Report submittal and June 10th for the Final Alternative Analysis Report.

6. OTHER ITEMS AND NEXT MEETING

a. Jacob requested that Muller provide a rating curve of the existing conditions flow vs. depth at Recreation Drive. The Town plans to relocate a flow gage from Jordan Road to the downstream side of Recreation Drive to improve the warning system at the crossing.
b. The next project meeting will be held following submittal and sponsor review of the draft Conceptual Design Report.

END OF MINUTES

DRAFT ALTERNATIVES ANALYSIS COMMENTS

The draft alternatives analysis was submitted to the project sponsors on April 24, 2015 for review. Comments were received on March 20, 2015 in the form of an annotated PDF copy of the report. Select comments have been reproduced below; responses are italicized. Minor comments/corrections were addressed in the revision but are not listed here.

UDFCD COMMENTS:

Section 5.5 [Re: Recreation Drive Alternative B "small one-foot high berm"]
I'm not sure what this would look like. It sounds like a levee - is there a way to grade the area that doesn't create a levee situation?
The berm is necessary to contain the 100-year flows. It is desired more from a general hydraulic perspective rather than a floodplain perspective; it is true that its impact on the mapped floodplain could not be recognized. This was clarified in the text and a note was added to Figure 5-2.

[Re: Recreation Drive Alternative C, utility relocations for SVMD 12-inch effluent force main and 6-inch sanitary force main]
These aren't affected at all by the other two alternatives?
Per SVMD, the depth of the lines is not known but is expected to be 6'-8' or greater. Encasement would not be required as long as 4' clearance is maintained between the top of pipe and the bottom of the box culvert. For this analysis, it is assumed that Alternatives A and B will maintain sufficient clearance.

Figure 5-1 [Re: property impacts northeast of Recreation Drive crossing]
Would skewing the culverts help eliminate some of this property acquisition? Or would the culvert size no longer work?
Skewing the culverts may reduce the property impacts, though it will not eliminate them. The layout of the culverts will need to balance impacts on the property/trail, the parking lot, and the road profile and overtopping capacity. These factors will be considered more thoroughly during conceptual design, and a skew will be incorporated if appropriate.

Section 5.6 [Re: 100-Year Floodplain Limits]
Note that all of the floodplain rise occurs on city-owned rec center property and not on any adjacent properties.
This has been noted.

Appendix E [Re: HEC-RAS Output Tables and Cross Sections]
Delete pages 119-140. These will be in the FHAD and I don't want conflicting information here.
The tables and cross sections have been removed.

TOWN OF PARKER COMMENTS

Figure 5-1 Add sheetpile cutoff wall for 20" gas protection and possibly bank protection between the drop and Rec Dr. East
Sheet pile and riprap protection have been added to Alternative A.

Table 5-5 Reduce weighting for 100-Year Flooding Extents from 10% to 5%
Increase weighting for Constructability from 5% to 10%
Reduce weighting for Public Safety from 20% to 10% (to equal 100%)
Increase ratings for Alternative A – Protection of Utility Lines and Construtability based on addition of sheet piling and bank protection
The adjustments have been made.

Figure 6-2 [Re: Reach 5 existing facilities]
There are additional existing check structures near Sta 154+00, 179+00, and 188+00; TOP will provide drawings.
Include Low-Water Crossing and check to be built in 2016 near Sta 176+00; TOP will provide drawings.
Note: The Town would like to look at placing the existing check structures in their as-built locations and reducing the amount of structures by increasing the drop height of 2' as a part of converting the checks to drops.
The existing check structures at Sta 154+00 and 188+00 have been added; the structure indicated at Sta 179+00 appears to be the one shown at Sta 182+00. The planned low flow crossing location has been indicated, and the proposed drop structure layout has been modified to match existing check structure locations and to reflect 2.5' drop heights.

Public Notification Postcard
Mailed in early May, 2015

Newlin Gulch Major Drainageway Plan

The Urban Drainage and Flood Control District, in cooperation with the Town of Parker and Douglas County, is in the process of preparing a stormwater master plan for the Newlin Gulch corridor downstream of the Reuter-Hess Reservoir. You are receiving this notification because your property is near Newlin Gulch.

The purpose of the study is to define flood-prone areas, develop alternatives to mitigate flood hazards, update the FEMA floodplain and prepare a conceptual design and cost estimate of selected improvements.

The draft Alternatives Analysis report is available on the project website listed below. Feel free to contact any of the project team members if you have comments or questions.

Project website: **projects.udfcd.org/newlingulch**

Comment from Newlin Gulch Website
Received: Friday, May 08, 2015 8:39 AM

Name: Hills, Darold
Company: Stonegate
Phone: 303-840-0986
E-Mail: budhills@yahoo.com
Comments: How will this all affect the home owners with respect to flood insurance. When we purchased our homes the dam wasn't even a concept.

From: Shea Thomas
Sent: Monday, May 11, 2015 2:36 PM
To: 'budhills@yahoo.com'
Subject: FW: Comment from Newlin Gulch Website

Mr. Hills -

Thank you for accessing the Newlin Gulch Major Drainageway Plan project website. I hope you were able to find sufficient information to understand the goals of the master planning study underway by the Urban Drainage and Flood Control District, Town of Parker and Douglas County.

Due to the inter-governmental agreement signed by the Urban Drainage and Flood Control District, Parker Water and Sanitation District, Town of Parker and Douglas County, the Rueter-Hess Reservoir will help to hold back stormwater during a flood event in addition to the original function of water supply. This means the floodplain downstream of the dam will be reduced and property owners currently paying mandatory flood insurance may see a reduction in cost. Part of this study is to re-map the floodplain and submit the results to FEMA, who will reassess the flood insurance requirements once they accept the new maps. This process typically takes 1-2 years after we complete our study.

Please feel free to contact me directly if you have any further questions.

Shea B. Thomas, PE
Urban Drainage and Flood Control District
Project Manager, Master Planning
2480 W. 26th Ave., Suite 156-B
Denver, CO 80211
(303) 455-6277

Comment from Newlin Gulch Website
Received: Friday, May 08, 2015 5:17 PM

Name: Ken & Marlene Snavely
Company: Stonegate Parkway, Stonemeadow Drive
Phone: 3038058613
E-Mail: ken1316@yahoo.com
Comments: We back up to the greenbelt (10584 Stonemeadow Drive) and were wondering if, at this time, there is any possibility that we will end up in a "flood plain" and thus be required to purchase flood insurance?

Second, could you please tell us if it is the Reuter-Hess Reservoir that is allowing water to flow down the drainageway several days a week and where the water is ending up? We were wondering if it is connected to the Chambers Reservoir since we notice the reservoir's level is rising?

Thank you,
Ken Snavely

From: Shea Thomas
Sent: Monday, May 11, 2015 2:38 PM
To: 'ken1316@yahoo.com'
Subject: FW: Comment from Newlin Gulch Website

Mr. Snavely -

Thank you for accessing the Newlin Gulch Major Drainageway Plan project website. I hope you were able to find sufficient information to understand the goals of the master planning study underway by the Urban Drainage and Flood Control District, Town of Parker and Douglas County.

Due to the inter-governmental agreement signed by the Urban Drainage and Flood Control District, Parker Water and Sanitation District, Town of Parker and Douglas County, the Rueter-Hess Reservoir will help to hold back stormwater during a flood event in addition to the original function of water supply. This means the floodplain downstream of the dam will be reduced so if you are not paying mandatory flood insurance now you won't be required to do so as a result of this study. Please note that all properties are at risk of flooding and are encouraged to purchase flood insurance whether required to do so or not.Part of this study is to re-map the floodplain and submit the results to FEMA, who will reassess the flood insurance requirements once they accept the new maps. This process typically takes 1-2 years after we complete our study.

Water is released from the Rueter-Hess Reservoir and flows along Newlin Gulch to Cherry Creek near the Parker Recreation Center. The water does not go to Chambers Reservoir. Parker Water is currently in the testing and startup phase of the water treatment plant located near the reservoir. They are discharging water from the plant to Newlin Gulch during this phase. Depending on how the testing goes, they could be finished at any time or it could last up to three more weeks.

Please feel free to contact me directly if you have any further questions.

Shea B. Thomas, PE
Urban Drainage and Flood Control District
Project Manager, Master Planning
2480 W. 26th Ave., Suite 156-B
Denver, CO 80211
(303) 455-6277

Comment from Newlin Gulch Website
Received: Thursday, June 04, 2015 7:03 PM

Name: Martina Fagley
Company: Challenger Park Neighborhood
Phone: 3038050336
E-Mail: mfagley@live.com
Comments: I received a postcard about the Newlin Gulch Major Drainageway Plan. I looked on the map and see that my house is out of the blue but my back yard may or maynot be in the blue. My address is 9692 S Coltsfoot Dr. Parker. What does this mean to my house?

From: Shea Thomas
Sent: Wednesday, June 10, 2015 3:54 PM
To: 'mfagley@live.com'
Subject: FW: Comment from Newlin Gulch Website

Ms. Fagley -

Thank you for accessing the Newlin Gulch Major Drainageway Plan project webste. I hope you were able to find sufficient information to understand the goals of the master planning study underway by the Urban Drainage and Flood Control District, Town of Parker and Douglas County.

Due to the inter-governmental agreement signed by the Urban Drainage and Flood Control District, Parker Water and Sanitation District, Town of Parker and Douglas County, the Rueter-Hess Reservoir will help to hold back stormwater during a flood event in addition to the original function of water supply. This means the floodplain downstream of the dam will be reduced.

Your specific property is not affected at all by our study. You are correct in stating the 100-yr floodplain shown in the report clips the corner of your property, but that is also the case with the current FEMA floodplain. FEMA only requires homeowners to purchase flood insurance if their home is in the floodplain, not their property. That does not apply to you. In addition, no improvements we are recommending in our study would adversely impact your property.

I hope this answered your question and alleviates any concern you may have. If you have further questions or comments, please feel free to contact me.

Shea B. Thomas, PE
Urban Drainage and Flood Control District
Project Manager, Master Planning
2480 W. 26th Ave., Suite 156-B
Denver, CO 80211
(303) 455-6277

Comment from Newlin Gulch Website
Received: Tuesday, June 30, 2015 5:01 PM

Name: Gary Amelon
Company:
Phone: 3038402066
E-Mail: amelon41@comcast.net
Comments:
Greetings! I live on the northside of Newlin Gulch in Stonegate just below Pine Grove Elementary. I have been at this location since 1991 and I believe this year has provided the most water I have seen during the past 24 years. The improvement project has done well in moving a substantial amount of water through the gulch without erosion and obstructions. I know we have several low spots where mosquitoes are becoming a problem but I know you are working on a solution.

I was standing on my deck a few days ago watching a couple of your deer grazing. Hawks were flying with a number of nests in the trees. Ducks are now a common site flying low and landing on the water. Good job, and I have only one request. When the new plantings were placed in the gulch, a couple of years ago, signs were put up to stay off the newly seeded areas. Isn't it time for these signs to be removed. The signs are now leaning and are the only obstruction to the natural aesthetics you created.

Thank you from a part-time waterfront property owner.

All the Best
Gary Amelon

Selected Plan for the Newlin Gulch Major Drainageway Plan

July 13, 2015

The *Selected Plan* for Newlin Gulch agreed upon by the Town of Parker (*Parker*), Douglas County (*Douglas*) and the Urban Drainage and Flood Control District (*UDFCD*) (hereinafter *Parker, Douglas and UDFCD* shall jointly be referred to as "*Sponsors*") to be shown by Muller Engineering Company (*Muller)* in the final *Newlin Gulch Major Drainageway Plan* report (hereinafter called "*Final Report*") is described in general and specific terms below.

SELECTED PLAN AND DIRECTLY RELATED ISSUES

Unless specifically directed otherwise below, this *Selected Plan* to be shown in the *Final Report* essentially follows the recommendations made by *Muller* in the *Newlin Gulch Major Drainageway Plan Alternatives Analysis* report dated June 2015 (hereinafter called "*Alternatives*") based on the following principal elements, goals and objectives:

- Minimize stormwater and flood-related damages to drainageways, public infrastructure and private property. Do this with value engineering and practicalities of implementation in mind.
- Institute an approach that balances the development in the watershed with stormwater management implementation that complements drainageway and stream stability solutions, that as a system, provide multiple benefits that include:
  - Water quality protection and enhancement;
  - Water quantity resources protection;
  - Preservation of natural character of the waterways and their terrestrial and aquatic habitat resource;
  - Wherever possible, provide public use and access and/or trails within the corridors of identified waterways in order to provide maintenance access that will also provide for active and passive recreation of the public.
- Consider the needs for new and upgraded roadway crossings when such improvements are practicable, affordable and add significant value in relation to the cost.

Muller is asked to address all items that are specified to be addressed in the *Final Report* as described in the agreement between *UDFCD* and *Muller* for this project, which includes developing, describing and showing a conceptual design based on the Recommended Plan in the *Alternatives*.

Also show and describe all recommended facilities, costs and actions on a reach-by-reach of the drainageway. In general, the *Final Report* shall provide, show, and recommend the following:

1. Under a section in the *Final Report* titled "General Recommendations", recommend:
   a) That the controlling jurisdictions take steps to stabilize all major waterways when their watershed urbanizes, rehabilitate existing degraded reaches of the waterways and their tributaries, and aggressively control erosion and sediment transport during construction activities.
   b) That Sponsors and any other jurisdiction having land use control powers in this watershed require new land development and significant redevelopment and publicly funded projects to provide to the maximum extent practicable runoff volume control practices (i.e., minimize directly connected impervious areas and employ infiltrating BMPs) whenever site conditions permit.
   c) That the controlling jurisdictions take steps to require that all BMPs for all new development, redevelopment, and publicly funded projects provide to the maximum extent practicable a Water Quality Capture Volume (*WQCV*) as recommended in the Urban Storm Drainage Criteria Manual – Volume 3, after accounting for volume reductions achieved using volume control practices as recommended under Item 1.b above.
   d) That all jurisdiction having land use control powers in this watershed continue to implement their floodplain management regulations, including regulation of the 100-year floodway and floodplain.

      Recommend that these jurisdictions adopt a policy, if not already done so, of preserving the defined floodplains as open spaces to the maximum extent possible and that at least 1-foot freeboard be provided for the lowest floor above the 100-year flood elevation shown on the latest flood hazard area delineation or FIRM maps for all human occupied structures built adjacent to, or within, the defined 100-year floodplains.
   e) That all jurisdiction having land use control powers in this watershed continue to participate in FEMA's flood insurance Community Rating System and public education programs.
2. List on the plan view and profile sheet of the conceptual design, where appropriate, the recommended wetland mitigations that will be needed to implement recommended improvements, if any.
3. Show on appropriate plan and profile sheets facilities to arrest the vertical degradation of the low-flow channel of natural and man-made waterways and to help rehabilitate, as much as possible their stable function and habitat.
4. Recommend rehabilitating eroded and degraded banks where needed and desired to arrest the horizontal erosion along natural waterways using bio-engineered methods that combine buried soil riprap and revegetation with native species of riparian and dryland vegetation.
5. Show on plan view and profile sheet the needed buttressing of critical utilities and other structures that may be endangered by stream erosion.
6. Using the input from stakeholders and the public, work with *Sponsors* and affected other local jurisdictions to prioritize the recommended facilities and actions that are listed in the *Final Report* and clearly articulate them in that document.
7. Describe the recommended type and schedule of maintenance activities for all improved facilities recommended in the *Final Report*.
8. Consider the various functions of all natural waterways in the study watersheds and their floodplain, including flood conveyance, riparian habitat, open space, aesthetics, recreation, urban development, water quality, utility crossing, transportation and other features.

9. Acknowledge in the *Final Report*, that land-use changes to the contributing watersheds affect the flood hazard nature (i.e., runoff rates, volumes and depths), the transport of sediment, and the water quality of the receiving natural waterways. The *Final Report*, under "General Recommendations" shall suggest that Sponsors and any other jurisdiction having land use control powers in these watersheds monitor land-use changes and whenever the land-use changes result in imperviousness ratios that exceed the projections identified in the *Final Report*, these jurisdiction take steps to further limit increases in stormwater runoff through the use of additional on-site detention, infiltrating BMPs and *WQCV* BMPs, thereby reducing the runoff rates, volumes and future damage potentials to the *Final Report* levels.

EXECUTIVE SUMMARY

Include an Executive Summary in the *Final Report* written in plain, non-technical language, which is directed primarily at the general public and elected officials. This summary should, at the minimum, contain the following as well as other items listed in *UDFCD's* checklist for preparation of the final major drainageway plan conceptual design report:

1. A brief summary of the planning process including numbers of progress and public meetings.
2. A brief description of the decisions made by project sponsors during this project.
3. A brief summary of all design criteria specifically developed for this plan.
4. A brief summary of the following sections of the *Final Report*: Purpose and Scope, Study Area Description, Alternative Evaluation, Recommended Plan, and Conceptual Design.
5. A map showing the area and all recommended improvements.
6. Tabular and narrative summaries of costs showing costs for capital improvements, engineering/administrative/contingencies, and land values, all sorted by drainageway, reach, tributary, and by jurisdiction. The reach length (miles), tributary catchment area (square miles), and their totals should also be included in the table.

Incorporate the following notes on each drawing:

"*This drawing is for master planning purposes and represents preliminary and conceptual engineering. Alternatives to this outfall system will be considered by local agencies and the Urban Drainage and Flood Control District provided the alternative offers an equivalent intent of the plan, including hydraulic capacity, water quality, stream stability and natural waterway features. The alternative must comply with all requirements of the local jurisdiction and the Urban Drainage and Flood Control District. In addition, there may be State and Federal requirements that will need to be considered and met. This drawing does not provide a final design and shall not be used for construction purposes.*"

"*Local Cities, Towns, and Counties manage and regulate all land use change, development and redevelopment activities within and adjacent to the 100-year floodplains in order to prevent, to a maximum extent possible, future flood damages to buildings and structures from the 100-year flood and to minimize damages from larger floods. The recommendations of this plan provide a set of options subscribed to by Cities, Towns and Counties in carrying out their floodplain management and regulatory responsibilities and obligations.*"

"*Many activities that occur in or affect ditches, drainages, creeks, ponds or wetlands require a Section 404 Permit Authorization from the US Army Corps of Engineers. During preliminary design, and prior to final design or starting work, contact the Corps' Denver Regulatory Office at 303-979-4120 for appropriate permit authority to avoid compromising and delaying the completion of the project.*"

ADDITIONAL DIRECTION

1. Unit costs should be updated to reflect the most current costs available using the UD-MP Cost worksheet.
2. Include an Acknowledgements section listing all participants and stakeholders in this study. Include in the list their name, organization and function in the planning process.
3. Show all maintenance access routes along all reaches. To the extent feasible, the alignment of these routes shall be coordinated with existing and planned recreational trails identified using input provided by Sponsors, special districts and other local stakeholders.
4. Summarize cost estimates of improvements by jurisdiction where those improvements are located, by the reach in which the improvements are located and overall project totals.
5. Report estimated costs for maintenance of all facilities, including detention ponds, storm sewer outfall points, grade control structures, etc. reported in the *Final Report*.

Appendix B

HYDROLOGIC ANALYSIS

Map Legend

- Jurisdictional Boundary
- Watershed Boundary
- Major Tributary
- Rueter-Hess (Max Normal Pool WSE)
- Subwatershed Boundary
- Basin ID / Area (AC) / EX IMP / FU IMP — Subwatershed Label
- xxx — Basin ID
- xx — Design Points
- xxx — Conveyance
- xxx — Storage Unit

Soil Type

- A
- B
- C/D

Land Use

EX Impervious (%)		FU Impervious (%)	
2	45	2	45
5	50	5	50
10	60	10	60
15	65	15	65
20	70	20	70
30	85	25	85
35	90	30	90
40	100	35	100
		40	

HIGHWAY 470
LINCOLN AVE.
CHAMBERS
RIDGEGATE PARKWAY
LONE TREE
Newlin Gulch
Upper Jordan Road Tributary
MAIN STREET
Sandpit Tributary
Bradbury Ranch Pond IV
JORDAN ROAD
HESS ROAD
Canal Tributary
UNINCORPORATED DOUGLAS COUNTY
PARKER
Benchmark Tributary
Rueter-Hess Reservoir
25
Newlin Gulch
Parkway Tributary
CASTLE PINES PARKWAY
CASTLE PINES
Spring Tributary
Spring Tributary
Mesa Tributary
Big Windmill Tributary
Rondtop Tributary
South Newlin Gulch
HAPPY CANYON
CASTLE PINES
CASTLE ROCK

PDF Layer Control Instructions

The map controls below provide access to predetermined map schemes. For more control over which layers are shown, use the "Layers" navigation panel, which can be accessed from the View menu under Navigation Panels.

Interactive Figures (Select From Below):

Map Controls

- Study Area Map
- Soils Map
- Existing Land Use Map
- Future Land Use Map
- Subwatershed Boundaries Map
- Baseline Hydrology SWMM Routing Map

0 3,000 6,000 9,000 Feet

N

MULLER
Muller Engineering Company, Inc.
Consulting Engineers
777 S. Wadsworth Blvd., STE. 4-100
Lakewood, Colorado 80226-4355
www.mullereng.com
Office: (303) 988-4939
Fax: (303) 988-4969

Newlin Gulch Major Drainageway Plan
Figure B-1: Hydrology Map
March 2015

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
Town of Parker COLORADO
DOUGLAS COUNTY COLORADO

Table B-1
Rainfall Distributions

	2-Hour Design Storm Rainfall Depth (in)								
	2-year		5-year		10-year		25-year	50-year	100-year
Time	no area adjustment	3 mi^2 area adjustment	no area adjustment	3 mi^2 area adjustment	no area adjustment	3 mi^2 area adjustment	no area adjustment	no area adjustment	no area adjustment
0:05	0.019	0.019	0.028	0.028	0.033	0.033	0.026	0.030	0.026
0:10	0.038	0.038	0.052	0.052	0.061	0.061	0.069	0.080	0.077
0:15	0.073	0.079	0.112	0.121	0.124	0.135	0.099	0.114	0.118
0:20	0.103	0.145	0.147	0.206	0.169	0.237	0.158	0.182	0.206
0:25	0.162	0.226	0.240	0.336	0.282	0.396	0.296	0.342	0.360
0:30	0.090	0.127	0.125	0.175	0.135	0.190	0.493	0.570	0.643
0:35	0.054	0.059	0.074	0.081	0.085	0.092	0.236	0.274	0.360
0:40	0.043	0.047	0.056	0.061	0.065	0.071	0.158	0.182	0.206
0:45	0.029	0.028	0.052	0.051	0.064	0.063	0.099	0.114	0.159
0:50	0.029	0.028	0.052	0.051	0.054	0.053	0.099	0.114	0.129
0:55	0.029	0.028	0.043	0.042	0.054	0.053	0.063	0.073	0.103
1:00	0.029	0.028	0.043	0.042	0.054	0.053	0.063	0.073	0.103
1:05	0.029	0.028	0.043	0.042	0.054	0.053	0.063	0.073	0.103
1:10	0.019	0.019	0.043	0.042	0.054	0.053	0.047	0.055	0.051
1:15	0.019	0.019	0.036	0.035	0.054	0.053	0.047	0.055	0.051
1:20	0.019	0.019	0.032	0.031	0.042	0.041	0.035	0.041	0.031
1:25	0.019	0.019	0.032	0.031	0.032	0.032	0.035	0.041	0.031
1:30	0.019	0.019	0.032	0.031	0.032	0.032	0.028	0.032	0.031
1:35	0.019	0.019	0.032	0.031	0.032	0.032	0.028	0.032	0.031
1:40	0.019	0.019	0.022	0.021	0.032	0.032	0.028	0.032	0.031
1:45	0.019	0.019	0.022	0.021	0.032	0.032	0.028	0.032	0.031
1:50	0.019	0.019	0.022	0.021	0.032	0.032	0.028	0.032	0.031
1:55	0.010	0.009	0.022	0.021	0.029	0.028	0.028	0.032	0.031
2:00	0.010	0.009	0.019	0.018	0.022	0.022	0.028	0.032	0.031

Table B-2
CUHP Input

Subwatershed ID	Area		Dist to Centroid		Length		Length-Weighted Slope	Weighted % Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Final Rate	Decay Coeff.
	acres	sq mi	ft	mi	ft	mi	ft/ft	%	%	watershed in	watershed in	in/hr	in/hr	1/second
Newlin Gulch														
A100	79	0.12334	2568	0.486	4965	0.940	0.0127	46.18	46.40	0.5	0.1	4.36	0.63	0.0016
A104	22	0.03412	1052	0.199	1595	0.302	0.0044	41.04	41.04	0.5	0.1	4.82	0.86	0.0011
A108	76	0.11808	2154	0.408	3574	0.677	0.0099	40.62	41.00	0.5	0.1	4.04	0.61	0.0017
A110	63	0.09787	556	0.105	2748	0.520	0.0109	52.16	52.35	0.5	0.1	4.64	0.71	0.0015
A115	79	0.12317	1631	0.309	2961	0.561	0.0176	40.39	40.39	0.5	0.1	3.35	0.52	0.0018
A120	133	0.20788	1735	0.329	4809	0.911	0.0098	37.06	37.15	0.5	0.1	4.43	0.66	0.0016
A125	61	0.09537	1211	0.229	3559	0.674	0.0088	44.65	44.65	0.5	0.1	3.00	0.50	0.0018
A130	73	0.11470	1082	0.205	3524	0.667	0.0216	37.76	37.76	0.5	0.1	3.90	0.67	0.0015
A135	97	0.15218	1820	0.345	4634	0.878	0.0134	9.53	59.99	0.5	0.1	4.00	0.59	0.0017
A140	77	0.11958	1485	0.281	3696	0.700	0.0177	7.98	37.05	0.5	0.1	4.62	0.71	0.0015
A145	41	0.06477	1101	0.209	2513	0.476	0.0297	16.52	66.80	0.5	0.1	4.01	0.59	0.0017
A150	132	0.20642	2025	0.384	4980	0.943	0.0165	20.92	29.24	0.5	0.1	3.72	0.62	0.0016
A155	51	0.08018	1081	0.205	2357	0.446	0.0349	5.40	61.27	0.5	0.1	4.46	0.60	0.0018
A160	36	0.05703	1056	0.200	2499	0.473	0.0161	10.16	11.95	0.5	0.1	4.20	0.72	0.0014
A165	137	0.21432	2262	0.428	4332	0.821	0.0265	2.83	56.38	0.5	0.1	3.64	0.54	0.0018
A170	91	0.14161	1918	0.363	4845	0.918	0.0285	34.06	40.99	0.5	0.1	3.21	0.53	0.0017
A175	53	0.08328	1864	0.353	3506	0.664	0.0372	42.84	65.77	0.5	0.1	3.23	0.52	0.0018
A180	107	0.16724	3092	0.586	4764	0.902	0.0262	42.28	50.98	0.5	0.1	3.38	0.54	0.0018
A190	67	0.10513	2282	0.432	5385	1.020	0.0236	15.02	28.59	0.5	0.1	3.75	0.58	0.0017
A200	122	0.19109	2356	0.446	4926	0.933	0.0347	18.12	24.09	0.5	0.1	3.32	0.52	0.0018
A205	80	0.12535	2541	0.481	4255	0.806	0.0445	6.87	6.87	0.5	0.1	3.96	0.56	0.0018
A210	177	0.27629	1904	0.361	4598	0.871	0.0326	5.06	5.06	0.5	0.1	3.56	0.54	0.0018
A220	1150	1.79681	5078	0.962	14239	2.697	0.0010	100.00	100.00	0.0	0.0	0.00	0.00	0.0000
A221	23	0.03657	307	0.058	456	0.086	0.0216	2.11	2.24	0.5	0.1	4.01	0.57	0.0018
A222	112	0.17480	836	0.158	2008	0.380	0.0546	2.91	29.20	0.5	0.1	3.20	0.51	0.0018
A223	48	0.07532	371	0.070	844	0.160	0.0567	2.00	2.00	0.5	0.1	3.28	0.52	0.0018
A224	37	0.05826	560	0.106	1743	0.330	0.0566	2.00	2.00	0.5	0.1	3.01	0.50	0.0018
A225	76	0.11903	905	0.171	2459	0.466	0.0474	2.00	2.00	0.5	0.1	3.12	0.51	0.0018
A226	108	0.16815	1387	0.263	2916	0.552	0.0456	2.15	2.15	0.5	0.1	3.18	0.51	0.0018
A227	97	0.15157	647	0.123	1571	0.298	0.0490	2.00	18.86	0.5	0.1	3.01	0.50	0.0018
A228	35	0.05437	504	0.095	1070	0.203	0.0552	2.00	42.18	0.5	0.1	3.00	0.50	0.0018
A230	116	0.18124	910	0.172	3193	0.605	0.0459	2.00	33.62	0.5	0.1	3.09	0.51	0.0018
A240	127	0.19807	1373	0.260	3827	0.725	0.0377	2.00	42.72	0.5	0.1	3.07	0.50	0.0018
A250	68	0.10593	1969	0.373	4102	0.777	0.0278	2.00	25.27	0.5	0.1	3.00	0.50	0.0018
A260	99	0.15492	1730	0.328	3591	0.680	0.0316	2.00	13.14	0.5	0.1	3.00	0.50	0.0018
A270	132	0.20610	904	0.171	2977	0.564	0.0439	8.43	9.14	0.5	0.1	3.02	0.50	0.0018

Table B-2
CUHP Input

Subwatershed ID	Area		Dist to Centroid		Length		Length-Weighted Slope	Weighted % Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Final Rate	Decay Coeff.
	acres	sq mi	ft	mi	ft	mi	ft/ft	%	%	watershed in	watershed in	in/hr	in/hr	1/second
Newlin Gulch														
A275	40	0.06230	922	0.175	2808	0.532	0.0370	6.61	61.80	0.5	0.1	3.00	0.50	0.0018
A280	100	0.15627	1232	0.233	3387	0.641	0.0420	7.18	66.26	0.5	0.1	3.00	0.50	0.0018
A290	111	0.17348	2138	0.405	4124	0.781	0.0452	9.88	28.85	0.5	0.1	3.00	0.50	0.0018
A300	123	0.19254	2369	0.449	4642	0.879	0.0406	2.59	3.41	0.5	0.1	3.00	0.50	0.0018
Jordan Road Tributary														
B100	84	0.13156	2228	0.422	4831	0.915	0.0178	43.67	43.84	0.5	0.1	3.74	0.56	0.0018
B110	115	0.17999	2293	0.434	5041	0.955	0.0147	32.69	44.22	0.5	0.1	3.11	0.51	0.0018
B120	91	0.14226	810	0.153	3186	0.603	0.0189	44.57	44.57	0.5	0.1	3.00	0.50	0.0018
B130	69	0.10807	1293	0.245	3339	0.632	0.0214	42.09	47.86	0.5	0.1	3.45	0.53	0.0018
B135	99	0.15400	1248	0.236	3395	0.643	0.0230	42.00	45.76	0.5	0.1	3.03	0.50	0.0018
B140	65	0.10231	848	0.161	3006	0.569	0.0376	34.72	38.23	0.5	0.1	3.07	0.50	0.0018
Sandpit Tributary														
C100	73	0.11409	1627	0.308	3571	0.676	0.0210	5.68	39.49	0.5	0.1	3.53	0.54	0.0018
C110	134	0.21009	1631	0.309	3241	0.614	0.0291	2.09	21.47	0.5	0.1	3.00	0.50	0.0018
C115	82	0.12791	942	0.178	1917	0.363	0.0541	2.00	16.52	0.5	0.1	3.29	0.52	0.0018
C120	147	0.23006	2253	0.427	6042	1.144	0.0366	12.37	12.40	0.5	0.1	3.00	0.50	0.0018
C125	76	0.11915	2169	0.411	4310	0.816	0.0405	5.35	5.35	0.5	0.1	3.64	0.54	0.0018
Canal Tributary														
D100	58	0.09018	485	0.092	1515	0.287	0.0315	2.00	2.00	0.5	0.1	3.00	0.50	0.0018
D105	23	0.03628	707	0.134	1316	0.249	0.0494	2.00	2.00	0.5	0.1	3.00	0.50	0.0018
D110	118	0.18431	1478	0.280	4687	0.888	0.0160	13.20	13.21	0.5	0.1	3.00	0.50	0.0018
D115	34	0.05294	489	0.093	1747	0.331	0.0545	2.00	2.00	0.5	0.1	3.00	0.50	0.0018
D120	88	0.13720	650	0.123	1747	0.331	0.0556	4.86	4.86	0.5	0.1	3.00	0.50	0.0018
D125	44	0.06920	509	0.096	759	0.144	0.0247	2.70	2.74	0.5	0.1	3.00	0.50	0.0018
Big Windmill Tributary														
E100	86	0.13510	917	0.174	2973	0.563	0.0486	2.00	13.28	0.5	0.1	3.00	0.50	0.0018
E105	52	0.08142	275	0.052	1912	0.362	0.0433	2.00	2.00	0.5	0.1	3.00	0.50	0.0018
E110	26	0.04037	528	0.100	879	0.166	0.0628	4.38	4.63	0.5	0.1	3.00	0.50	0.0018
E115	47	0.07349	515	0.098	907	0.172	0.0602	5.02	5.03	0.5	0.1	3.00	0.50	0.0018
E120	122	0.18987	2043	0.387	3851	0.729	0.0411	2.16	22.64	0.5	0.1	3.00	0.50	0.0018
E124	82	0.12759	1970	0.373	3842	0.728	0.0383	4.57	4.57	0.5	0.1	3.00	0.50	0.0018
E128	133	0.20792	1700	0.322	4095	0.775	0.0401	4.90	6.13	0.5	0.1	3.00	0.50	0.0018

Table B-2
CUHP Input

Subwatershed ID	Area		Dist to Centroid		Length		Length-Weighted Slope	Weighted % Impervious		Depression Storage		Infiltration		
								Existing	Future	Pervious	Impervious	Initial Rate	Final Rate	Decay Coeff.
	acres	sq mi	ft	mi	ft	mi	ft/ft	%	%	watershed in	watershed in	in/hr	in/hr	1/second
South Newlin Gulch														
F100	120	0.18764	3124	0.592	6498	1.231	0.0283	2.00	20.92	0.5	0.1	3.00	0.50	0.0018
F102	57	0.08830	627	0.119	1847	0.350	0.0496	2.00	7.02	0.5	0.1	3.01	0.50	0.0018
F104	105	0.16419	1101	0.209	3021	0.572	0.0490	2.00	37.92	0.5	0.1	3.00	0.50	0.0018
F106	97	0.15209	822	0.156	1734	0.328	0.0565	2.00	5.68	0.5	0.1	3.00	0.50	0.0018
F110	106	0.16600	1210	0.229	3346	0.634	0.0293	2.00	26.48	0.5	0.1	3.00	0.50	0.0018
F120	120	0.18673	1883	0.357	3939	0.746	0.0287	2.00	28.64	0.5	0.1	3.00	0.50	0.0018
F125	76	0.11910	1779	0.337	3518	0.666	0.0384	2.00	22.58	0.5	0.1	3.00	0.50	0.0018
F130	93	0.14500	1739	0.329	3729	0.706	0.0240	2.91	10.00	0.5	0.1	3.00	0.50	0.0018
F140	125	0.19559	2298	0.435	4151	0.786	0.0311	4.79	9.47	0.5	0.1	3.00	0.50	0.0018
F145	91	0.14255	1879	0.356	4122	0.781	0.0392	5.95	10.99	0.5	0.1	3.00	0.50	0.0018
F150	97	0.15083	1880	0.356	4552	0.862	0.0403	5.07	10.00	0.5	0.1	3.00	0.50	0.0018
F155	118	0.18503	1212	0.229	2798	0.530	0.0467	5.00	10.00	0.5	0.1	3.00	0.50	0.0018
Mesa Tributary														
G100	63	0.09892	1730	0.328	3584	0.679	0.0413	2.00	19.52	0.5	0.1	3.00	0.50	0.0018
G110	87	0.13587	1335	0.253	3530	0.668	0.0324	2.00	17.11	0.5	0.1	3.00	0.50	0.0018
G115	85	0.13319	2000	0.379	3834	0.726	0.0402	2.04	16.25	0.5	0.1	3.00	0.50	0.0018
G120	82	0.12759	1650	0.313	3485	0.660	0.0318	2.00	27.65	0.5	0.1	3.00	0.50	0.0018
G130	112	0.17453	1716	0.325	4081	0.773	0.0383	4.05	10.76	0.5	0.1	3.00	0.50	0.0018
Parkway Tributary														
H100	32	0.05073	479	0.091	1001	0.190	0.0541	2.00	19.02	0.5	0.1	3.00	0.50	0.0018
H110	90	0.14116	1729	0.327	3867	0.732	0.0364	9.43	52.24	0.5	0.1	3.01	0.50	0.0018
H115	108	0.16810	2025	0.384	3886	0.736	0.0417	8.13	9.28	0.5	0.1	3.00	0.50	0.0018
H120	103	0.16166	2052	0.389	4317	0.818	0.0377	32.08	71.30	0.5	0.1	3.02	0.50	0.0018
H125	109	0.17012	1720	0.326	3764	0.713	0.0412	18.42	26.98	0.5	0.1	3.00	0.50	0.0018
Roundtop Tributary														
I100	77	0.11958	1930	0.365	4134	0.783	0.0332	2.00	32.00	0.5	0.1	3.01	0.50	0.0018
I110	130	0.20300	1783	0.338	4637	0.878	0.0333	2.38	19.69	0.5	0.1	3.00	0.50	0.0018
I115	92	0.14452	1633	0.309	3760	0.712	0.0409	5.33	5.82	0.5	0.1	3.09	0.51	0.0018
I120	70	0.10934	2167	0.410	3979	0.754	0.0436	4.49	7.98	0.5	0.1	3.00	0.50	0.0018
Spring Tributary														
J100	98	0.15269	1484	0.281	3416	0.647	0.0327	2.00	41.01	0.5	0.1	3.56	0.54	0.0018
J110	88	0.13699	986	0.187	2878	0.545	0.0398	11.11	22.12	0.5	0.1	3.32	0.52	0.0018
J120	120	0.18808	1955	0.370	4659	0.882	0.0341	5.39	40.25	0.5	0.1	3.00	0.50	0.0018
J130	121	0.18902	1178	0.223	2519	0.477	0.0386	23.83	57.41	0.5	0.1	3.28	0.52	0.0018
J140	88	0.13737	998	0.189	2976	0.564	0.0357	8.50	31.76	0.5	0.1	3.00	0.50	0.0018
J150	90	0.14075	1606	0.304	3843	0.728	0.0370	14.65	32.56	0.5	0.1	3.00	0.50	0.0018
J155	61	0.09556	1141	0.216	2440	0.462	0.0490	5.82	33.06	0.5	0.1	3.00	0.50	0.0018
J160	91	0.14257	2047	0.388	4398	0.833	0.0403	25.01	25.01	0.5	0.1	3.00	0.50	0.0018

Table B-3
Detention Rating Curves

Rueter-Hess Reservoir (SWMM element NG220)

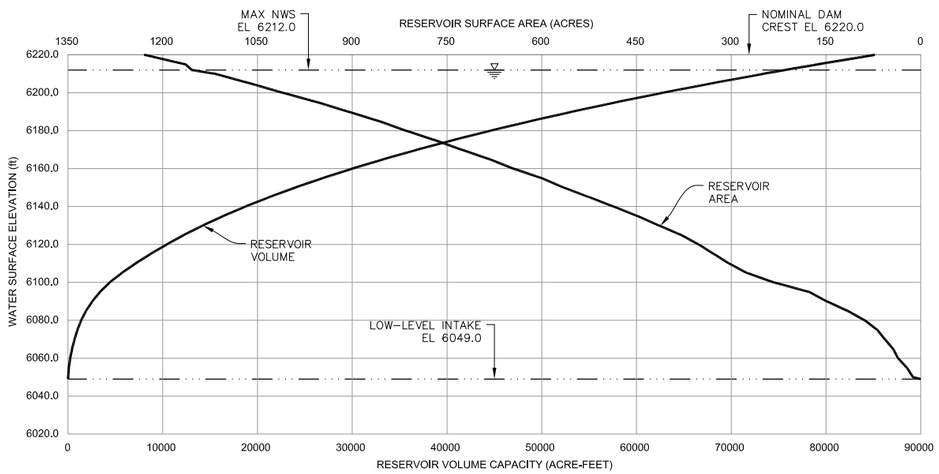
Elevation (ft)	Storage Curve Stage (ft)	Storage Curve Area (sq ft)	Outlet Curve Stage (ft)	Outlet Curve Discharge (cfs)
6216.7	0	50,660,280	0	0
6217.1			0.4	359
6217.6			0.9	1,220
6218.1	1.4	50,965,200	1.4	2,381
6218.6			1.9	3,785
6219.1			2.4	5,403
6219.6			2.9	7,217
6220.1			3.4	9,213
6220.6			3.9	11,380
6221.1			4.4	13,712
6221.6			4.9	16,202
6222.1			5.4	18,846
6222.6			5.9	21,640
6223.1	6.4	53,622,360	6.4	24,579

Reuter-Hess Reservoir storage curve based on a starting WSEL at the Auxiliary Spillway crest (Elev. 6216.7). Outlet curve based on flow through the Auxiliary Spillway only based on the table "Service Spillway and Auxiliary Spillway Rating Curves" taken from record drawings from the Rueter-Hess Dam and Reservoir project (DWG. A-05), dated 10/12.

Bradbury Ranch Pond IV (SWMM element SJ130)

Elevation (ft)	Storage Curve Stage (ft)	Storage Curve Area (sq ft)	Outlet Curve Stage (ft)	Outlet Curve Discharge (cfs)
5918.7	0	0	0.0	0.00
5921.7			3.0	66.85
5922.2			3.5	94.54
5922.7			4.0	115.79
5923.2			4.5	133.70
5923.7			5.0	149.48
5924.2			5.5	163.75
5924.7			6.0	176.87
5925	6.3	82,308		
5925.2			6.5	189.08
5925.7			7.0	200.55
5926.2			7.5	211.40
5926.7			8.0	221.72
5927.2			8.5	231.58
5927.5	8.8	150,181		
5927.7			9.0	247.00
5928.2			9.5	290.23
5928.7			10.0	351.23
5929.2			10.5	426.96
5929.7			11.0	516.27
5930	11.3	218,054	11.3	576.13

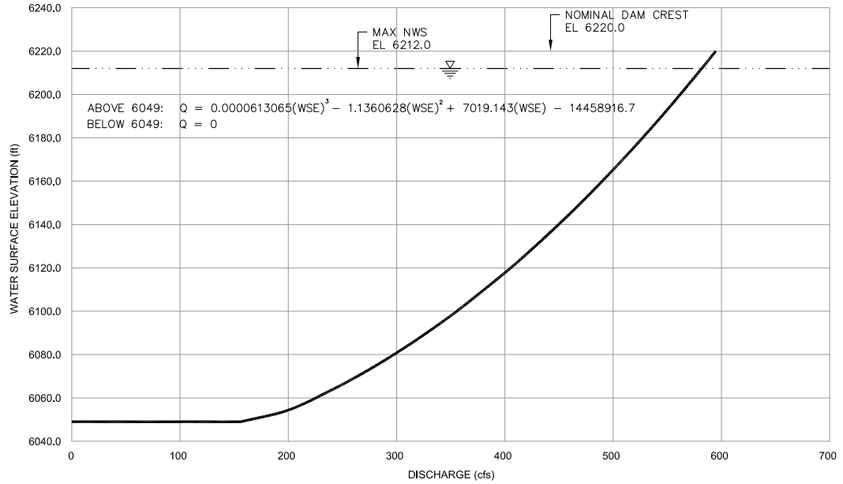
Pond IV storage curve based on 5-ft Douglas County topography. Outlet curve was developed based on supplemental ground survey of outlet structure conducted in April 2013.



RESERVOIR ELEVATION-AREA-VOLUME CURVE

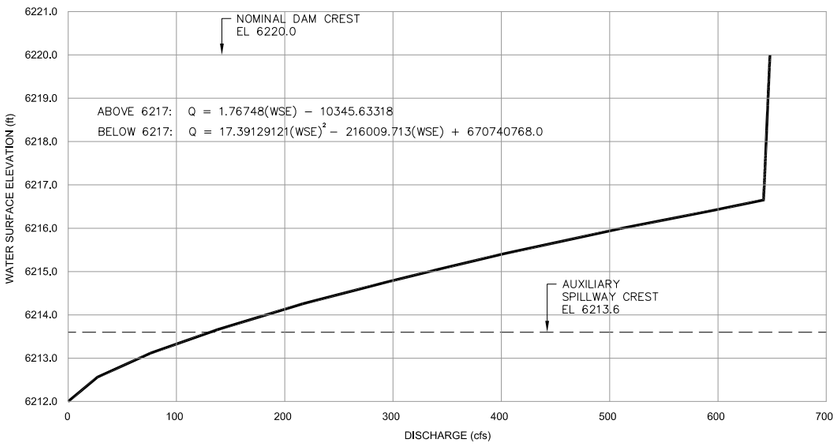
OUTLET WORKS RATING CURVE AND RESERVOIR STORAGE VOLUME & AREA VALUES

GAGE HEIGHT (FEET)	ELEVATION (FEET)	OUTLET WORKS RATING CURVE (CFS)	RESERVOIR STORAGE VOLUME (ACRE-FEET)	RESERVOIR STORAGE AREA (ACRES)
0	6049	0	0	12
6	6055	203.0	87	22
11	6060	225.1	232	36
16	6065	245.2	432	44
21	6070	263.8	686	57
26	6075	281.2	1,001	69
31	6080	297.6	1,395	89
36	6085	313.1	1,907	116
41	6090	327.8	2,569	149
46	6095	342.0	3,386	177
51	6100	355.6	4,411	233
56	6105	368.6	5,683	276
61	6110	381.3	7,134	304
66	6115	393.5	8,714	328
71	6120	405.3	10,413	352
76	6125	416.9	12,242	380
81	6130	428.1	14,229	415
86	6135	439	16,391	449
91	6140	449.6	18,731	487
96	6145	460.1	21,265	526
101	6150	470.2	23,995	566
106	6155	480.2	26,912	601
111	6160	490.0	30,031	646
116	6165	499.5	33,356	684
121	6170	508.9	36,887	728
126	6175	518.1	40,631	770
131	6180	527.2	44,597	816
136	6185	536.1	48,785	858
141	6190	544.9	53,199	907
146	6195	553.5	57,857	956
151	6200	562.0	62,773	1,011
156	6205	570.3	67,959	1,064
161	6210	578.6	73,415	1,119
163	6212	581.8	75,689	1,155
166	6215	586.7	79,175	1,170
171	6220	594.7	85,176	1,231



OUTLET WORKS RATING CURVE

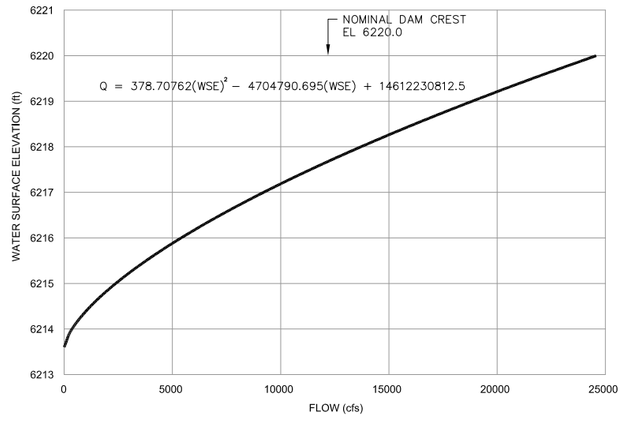
NOTE 1



SERVICE SPILLWAY RATING CURVE

SERVICE SPILLWAY AND AUXILIARY SPILLWAY RATING CURVES

GAGE HEIGHT (FEET)	ELEVATION (FEET)	SERVICE SPILLWAY (CFS)	AUXILIARY SPILLWAY (CFS)
163	6212.0	0.0	---
163.5	6212.5	22.6	---
164	6213.0	64.0	---
164.6	6213.6	117.6	0
165	6214.0	181.0	359
165.5	6214.5	253.0	1,220
166	6215.0	332.6	2,381
166.5	6215.5	419.1	3,785
167	6216.0	512.0	5,403
167.5	6216.5	610.9	7,217
168	6217.0	642.8	9,213
168.5	6217.5	643.7	11,380
169	6218.0	644.6	13,712
169.5	6218.5	645.4	16,202
170	6219.0	646.3	18,846
170.5	6219.5	647.2	21,640
171	6220.0	648.0	24,579



AUXILIARY SPILLWAY RATING CURVE

NOTES:

1. OUTLET WORKS RATING CURVE ASSUMES THE FOLLOWING: FLOW IS THROUGH THE LOW-LEVEL INTAKE, CONVEYED THROUGH THE UPSTREAM CONDUIT AND LEFT PIPE OF THE DOWNSTREAM CONDUIT TO THE IMPACT BASIN; ALL GATES ALONG THIS REACH ARE FULLY OPEN; THE LOW-LEVEL INTAKE IS HYDRAULICALLY SUBMERGED; AND THE LOW-LEVEL INTAKE TRASHRACK IS FREE OF DEBRIS.
2. RATING CURVES BASED ON THEORETICAL VALUES AND ACTUAL FIELD PERFORMANCE COULD VARY.

THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, IS THE PROPERTY OF PARKER WATER AND SANITATION DISTRICT AND RJH CONSULTANTS, INC. AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF PARKER WATER AND SANITATION DISTRICT AND RJH CONSULTANTS, INC.

NO.	DATE	ISSUE/REVISION	DES	DRN	CHK	APP
0	10/12	RECORD DRAWINGS	JDN	ZMR	ERF	RJH

RJH CONSULTANTS, INC.

PARKER WATER AND SANITATION DISTRICT

RJH PROJECT 05101

RUETER-HESS
DAM AND RESERVOIR
RECORD DRAWINGS
DOUGLAS COUNTY,
COLORADO

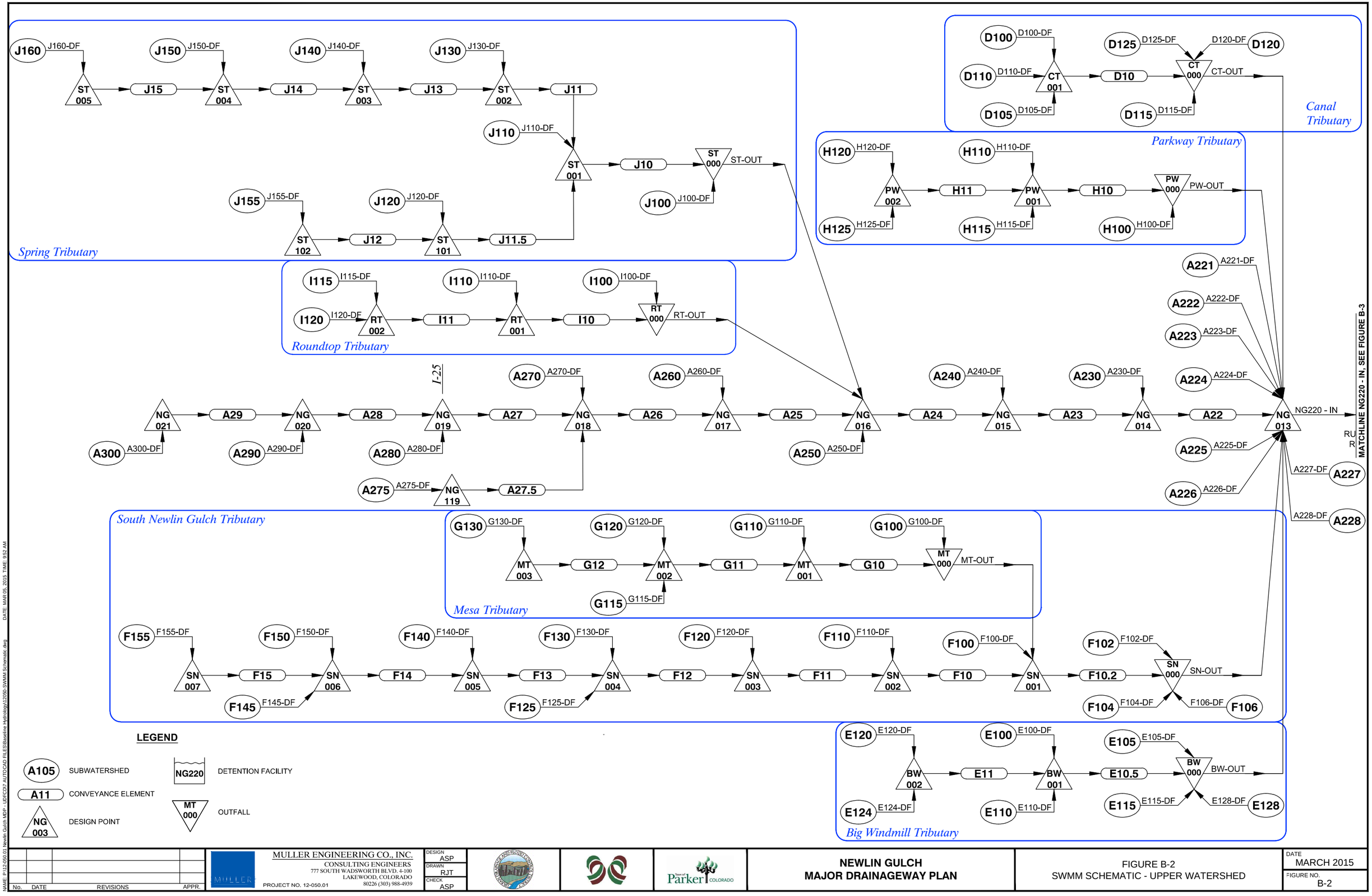
HYDRAULIC INFORMATION

C-1834

DWG. NO. A-05

SHEET NO. 5 of 167

P:\0711 - RUETER-HESS ENLARGEMENT CONSTRUCTION\CAD\RECORD DRAWINGS\RECORD A PACKAGE\0711 SHEET A-05.DWG 1/21/2013



NAME: P-112-050.01 Newlin Gulch MDP - UDFCD57 AUTOCAD FILES\Baseline Hydrology\12050-SWMM Schematic.dwg DATE: MAR 05, 2015 TIME: 9:52 AM

No.	DATE	REVISIONS	APPR.

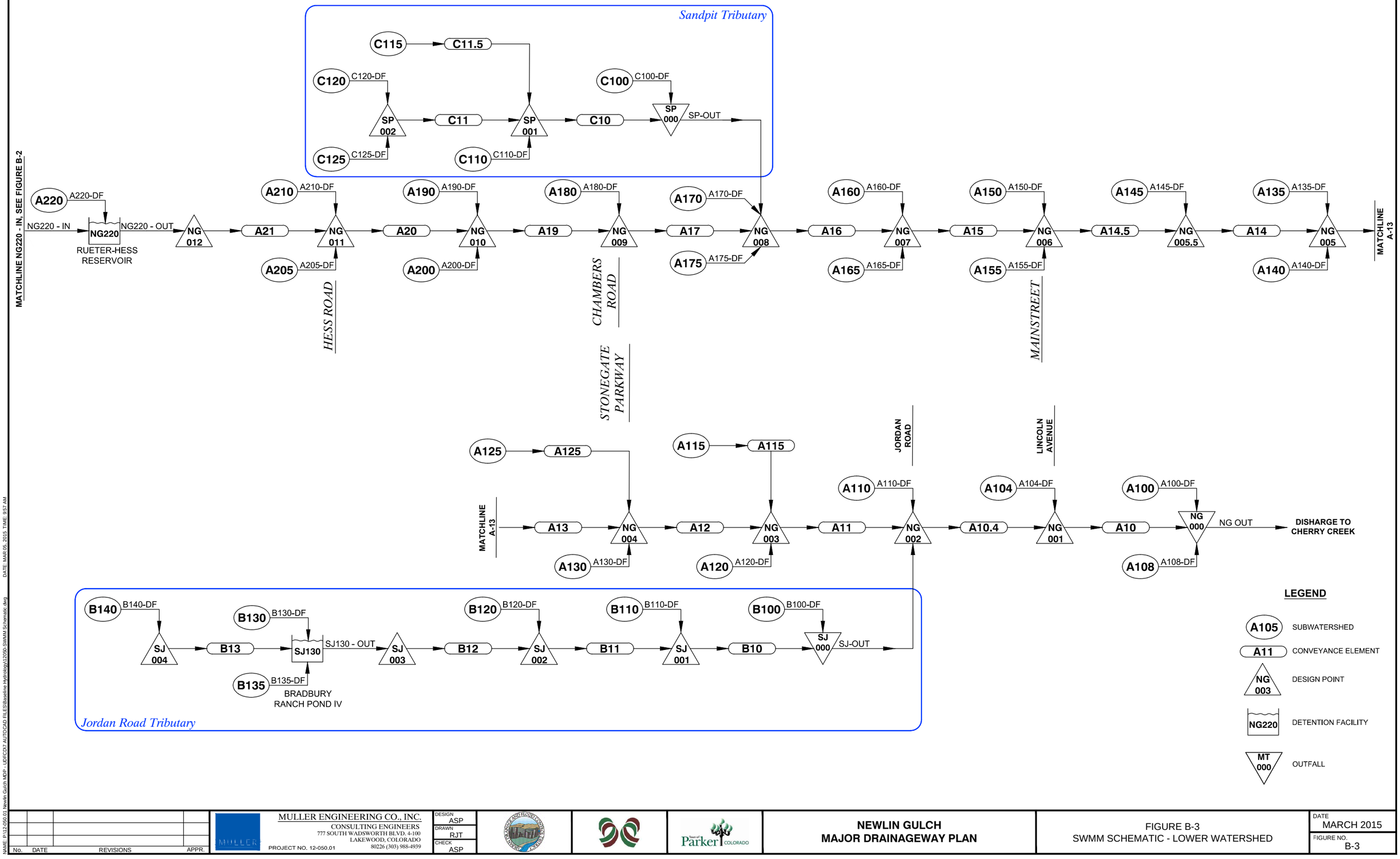
MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN ASP
DRAWN RJT
CHECK ASP

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

FIGURE B-2
SWMM SCHEMATIC - UPPER WATERSHED

DATE
MARCH 2015
FIGURE NO.
B-2



No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN ASP
DRAWN RJT
CHECK ASP

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

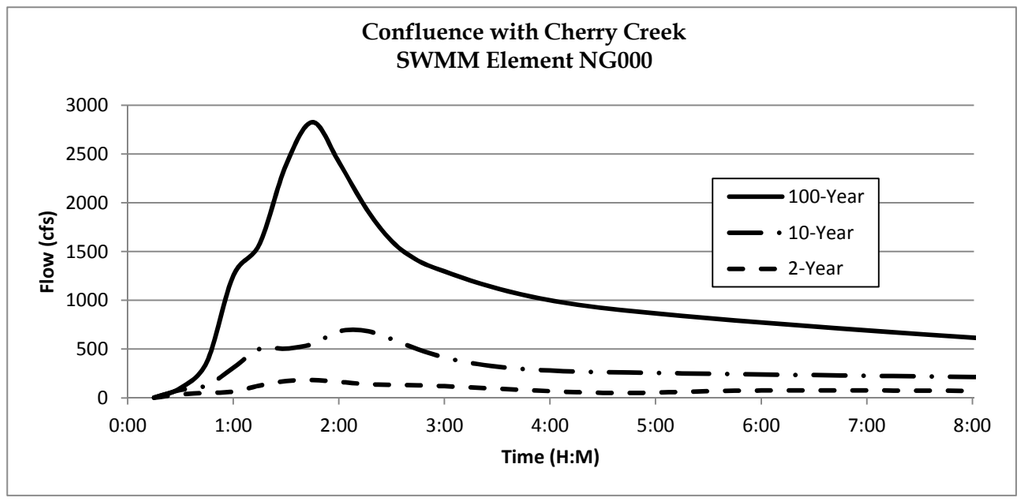
FIGURE B-3
SWMM SCHEMATIC - LOWER WATERSHED

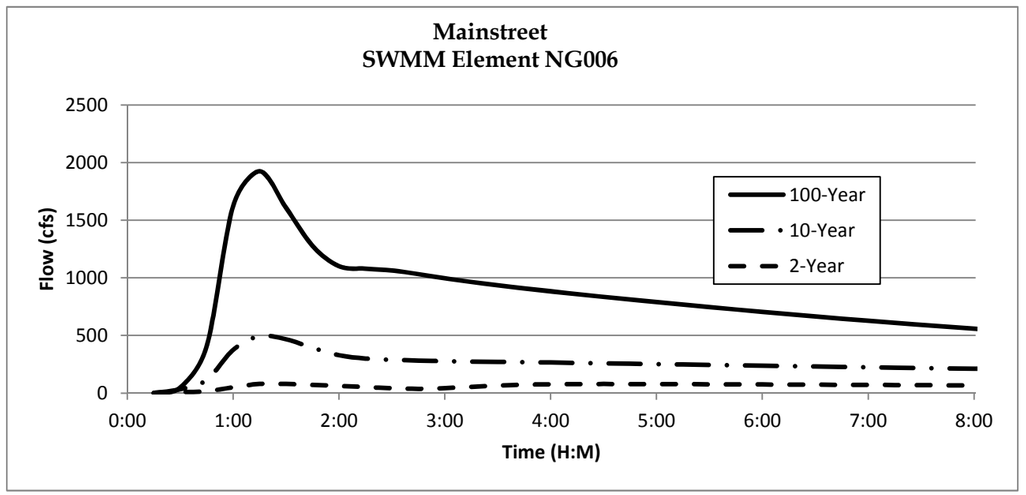
DATE
MARCH 2015

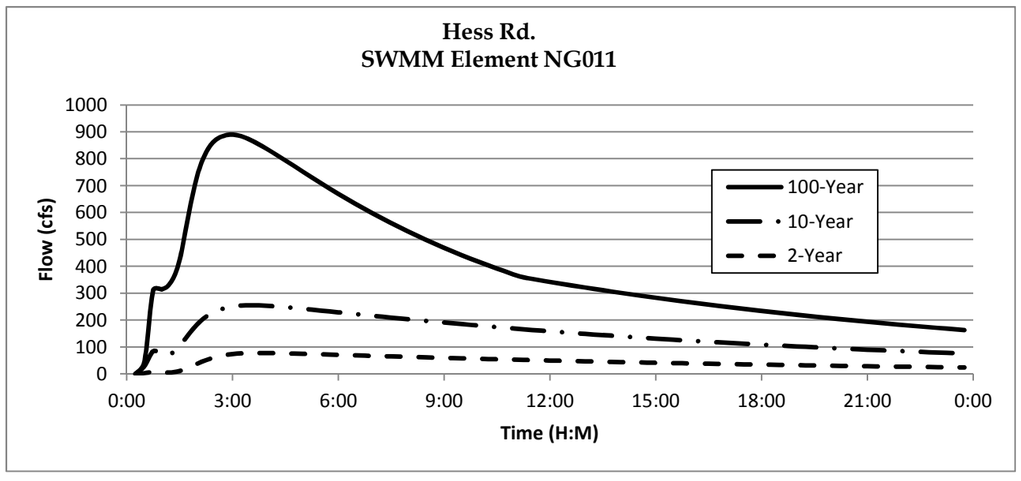
FIGURE NO.
B-3

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Baseline Hydrology\12050-SWMM Schematic.dwg DATE: MAR 05, 2015 TIME: 9:57 AM

Figure B-4
Existing Development Hydrographs







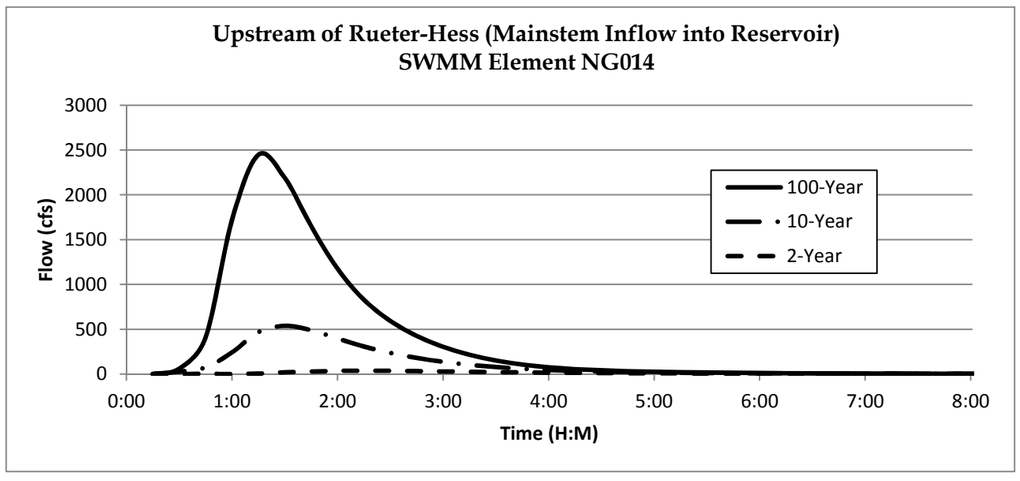
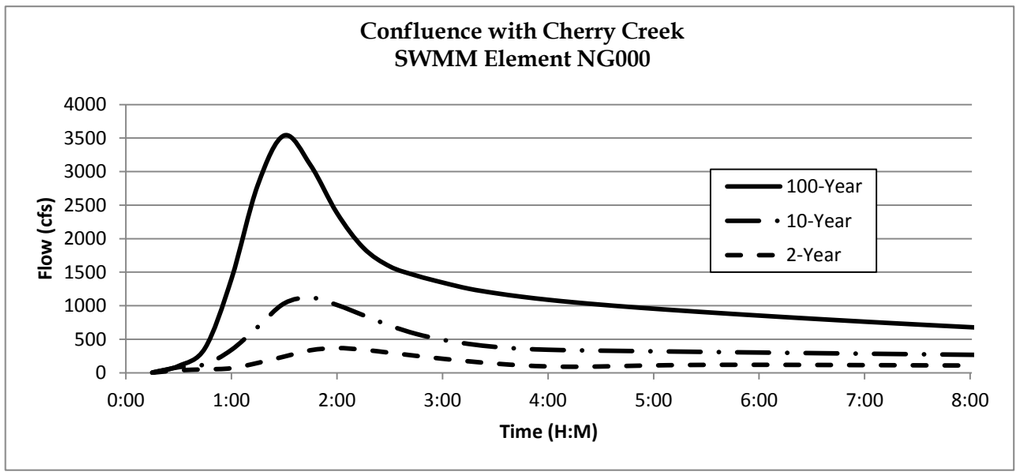
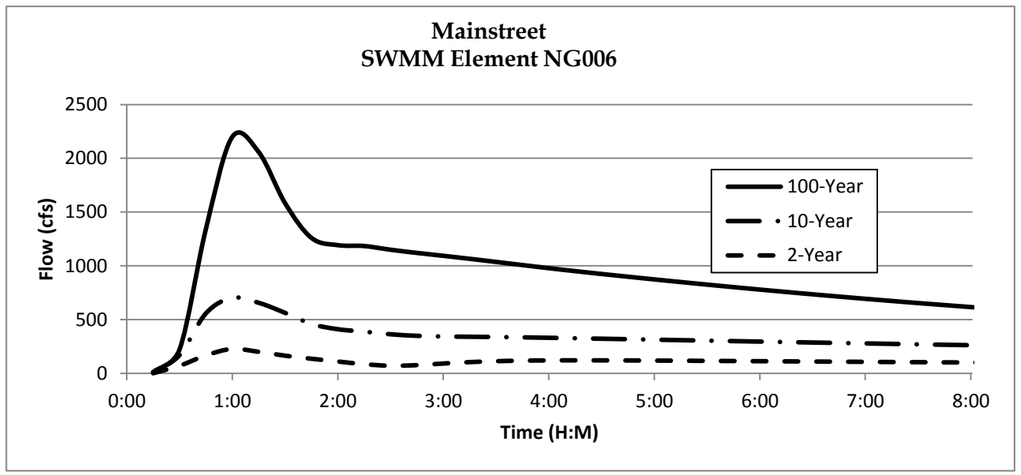
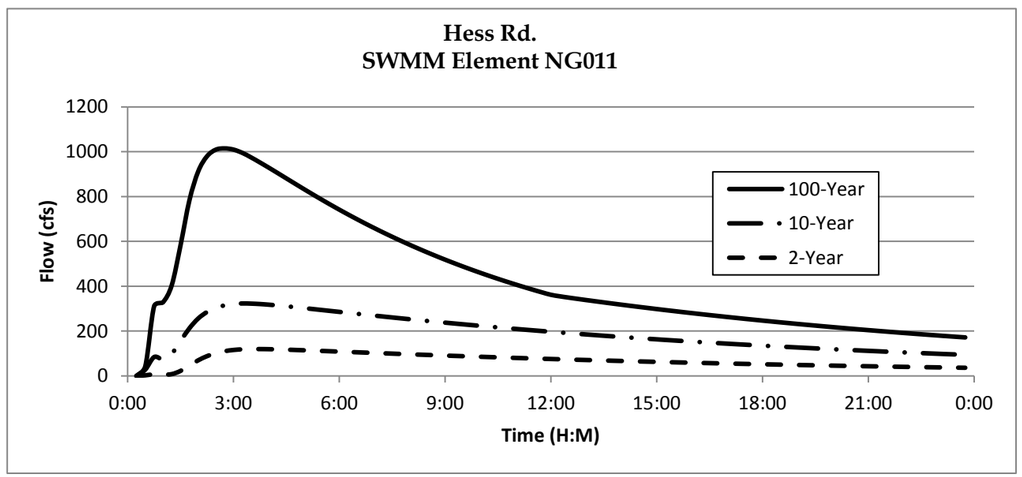


Figure B-5
Future Development Hydrographs







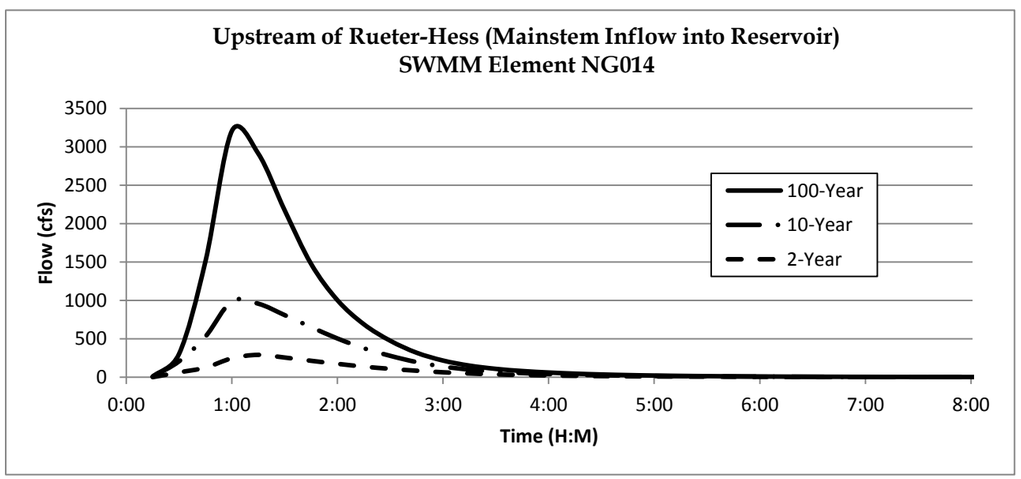


Figure B-6
Peak Flow Profile - Existing Development

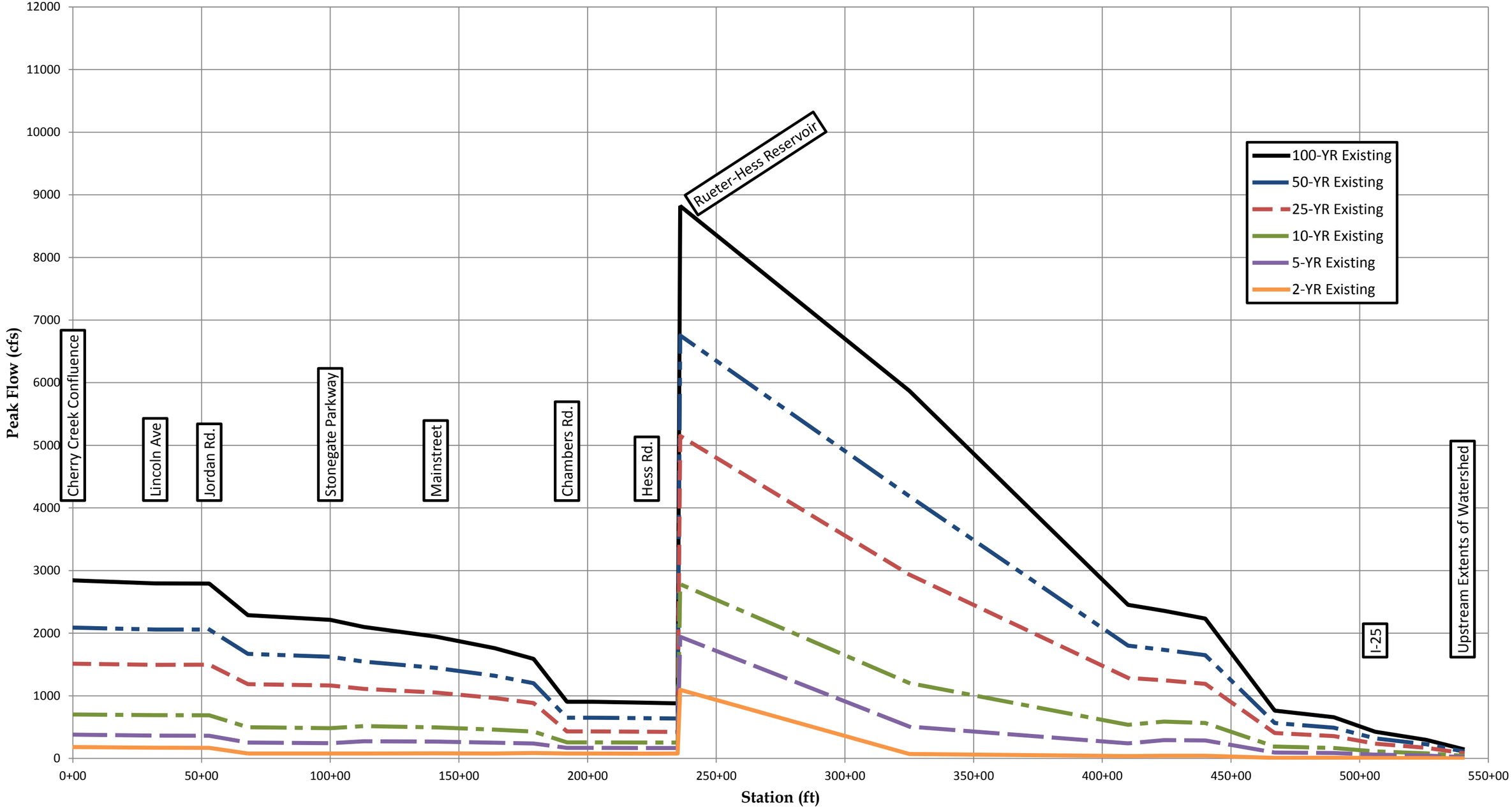


Figure B-7
Peak Flow Profile - Future Development

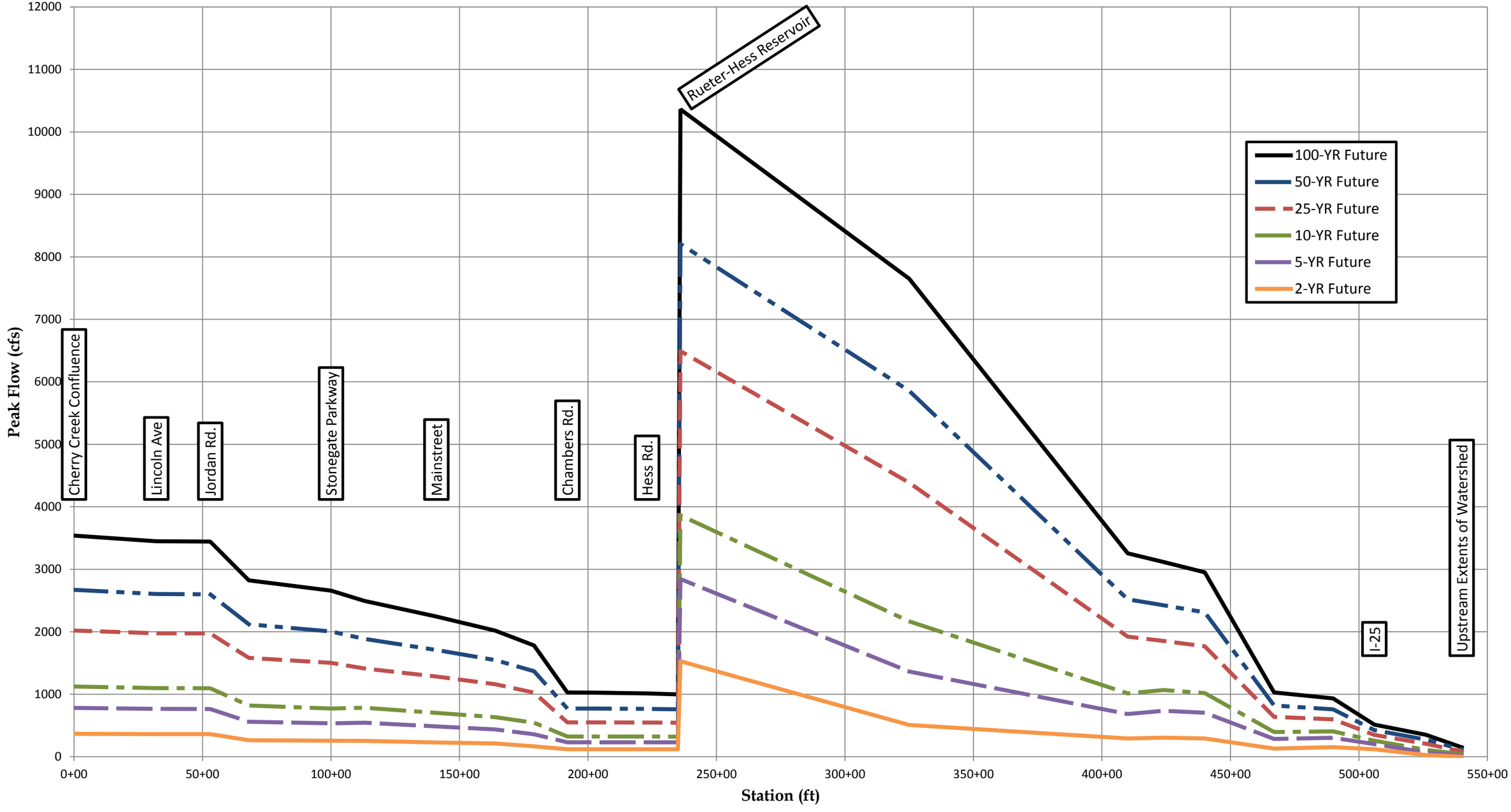


Table B-4
Peak Flow Rates

SWMM Node	Station (ft)	Channel Reach	Landmark	3 Square Mile Area Adjustment 2-yr, 5-yr, 10-yr	EXISTING DEVELOPMENT 100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)	FUTURE DEVELOPMENT 100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)
NEWLIN GULCH MAINSTEM																
NG000	0		Cherry Creek	yes	2843	2090	1514	703	380	183	3539	2670	2021	1125	783	368
NG001	3200		Lincoln Ave (U/S)	yes	2795	2059	1496	691	364	171	3450	2604	1976	1099	766	363
NG002	5300		Jordan Rd. (U/S)	yes	2793	2058	1497	690	363	169	3443	2598	1973	1097	765	362
NG003	6800			yes	2288	1670	1186	498	253	79	2825	2121	1583	820	561	264
NG004	10000		Stonegate Parkway (U/S)	yes	2212	1625	1165	483	245	80	2660	2006	1504	771	534	256
NG005	11300				2101	1546	1112	516	276	79	2493	1885	1414	785	544	255
NG006	14100		Mainstreet (U/S)		1945	1447	1051	496	270	82	2244	1710	1284	703	485	228
NG007	16400				1759	1320	965	459	251	80	2019	1547	1161	633	438	212
NG008	17900				1589	1202	884	429	240	86	1780	1369	1027	546	361	168
NG009	19200		Chambers Rd. (U/S)		905	651	432	257	169	78	1029	773	550	324	232	120
NG010	20200				905	651	432	257	169	78	1027	773	550	324	232	120
NG011	22300		Hess Rd. (U/S)		890	642	427	255	168	77	1015	768	548	323	232	120
NG012	23500		Rueter-Hess Reservoir Outflow		880	637	425	255	168	78	999	760	544	322	232	120
NG220	23600		Rueter-Hess Reservoir Total Inflow	yes	8822	6754	5150	2781	1942	1097	10362	8207	6492	3863	2845	1529
NG013	32500			yes	5871	4187	2935	1204	510	72	7649	5855	4387	2167	1364	508
NG014	41000		Rueter-Hess Reservoir Inflow from Mainstem	yes	2454	1801	1288	537	241	37	3256	2521	1922	1014	683	293
NG015	42400				2357	1735	1247	589	294	42	3116	2425	1852	1067	736	306
NG016	44000				2233	1649	1191	565	288	42	2953	2310	1767	1018	704	293
NG017	46700				763	565	407	190	95	11	1028	822	638	395	285	130
NG018	49000				659	492	356	168	86	12	933	758	600	406	304	154
NG019	50600		I-25 (U/S)		426	322	236	113	60	8	514	427	349	258	203	120
NG020	52600				296	227	168	82	45	6	352	274	207	110	69	27
NG021	54000		Upstream Extents of Watershed		151	116	86	42	22	2	152	117	87	42	23	2
JORDAN ROAD TRIBUTARY																
SJ000	60000		Confluence w/ Newlin Gulch		690	557	444	282	211	99	758	615	493	314	239	118
SJ001	63300		Stonegate Parkway (U/S)		568	465	377	246	187	89	637	524	420	273	213	106
SJ002	64500				368	312	262	186	146	71	383	324	275	199	159	82
SJ003	66400		Mainstreet		302	232	208	157	126	62	321	240	214	166	137	73
SJ004	69000				197	160	125	82	59	27	214	175	138	93	67	33
SANDPIT TRIBUTARY																
SP000	70000		Confluence w/ Newlin Gulch		654	494	360	165	83	10	763	588	441	230	142	44
SP001	72600				584	444	325	151	78	10	644	498	373	192	116	32
SP002	75700				276	214	161	82	48	11	276	214	161	82	48	12
CANAL TRIBUTARY																
CT000	80000		Edge of Reuter-Hess Normal Pool		684	537	400	207	118	16	684	537	400	207	118	16
CT001	86500				313	245	183	95	56	10	313	245	183	95	56	10
BIG WINDMILL TRIBUTARY																
BW000	90000		Edge of Reuter-Hess Normal Pool		857	658	486	237	126	11	956	748	561	297	179	39
BW001	96600				453	348	257	123	65	4	536	422	320	175	111	31
BW002	97400				265	204	151	74	40	3	323	255	194	110	71	23

Table B-4
Peak Flow Rates

SWMM Node	Station (ft)	Channel Reach	Landmark	3 Square Mile Area Adjustment 2-yr, 5-yr, 10-yr	EXISTING DEVELOPMENT 100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)	FUTURE DEVELOPMENT 100-YR (cfs)	50-YR (cfs)	25-YR (cfs)	10-YR (cfs)	5-YR (cfs)	2-YR (cfs)
SOUTH NEWLIN GULCH																
SN000	100000		Edge of Reuter-Hess Normal Pool		1522	1083	741	334	134	7	1707	1251	895	482	296	93
SN001	107100				1388	999	694	317	132	7	1564	1154	835	446	252	82
SN002	109800				891	648	456	210	93	6	964	717	519	273	149	43
SN003	111800				816	599	426	198	91	7	882	659	481	251	138	30
SN004	114600				725	538	387	182	89	8	779	586	430	218	122	23
SN005	117400				569	432	316	150	79	8	598	459	341	171	98	18
SN006	119700				442	340	252	123	67	8	465	361	271	140	82	16
SN007	121700				219	172	128	66	37	5	230	182	137	74	45	10
MESA TRIBUTARY																
MT000	130000		Edge of Reuter-Hess Normal Pool		493	363	261	119	55	3	598	457	343	184	114	34
MT001	131900				435	324	234	107	52	3	524	404	304	162	102	31
MT002	133900				338	255	186	86	43	3	406	316	238	128	81	27
MT003	136600				154	119	89	44	24	3	165	129	98	52	32	7
PARKWAY TRIBUTARY																
PW000	140000		Edge of Reuter-Hess Normal Pool		730	573	435	239	153	46	1121	918	730	483	364	184
PW001	142000		Hess Rd. (D/S)		674	531	405	226	147	46	1046	860	686	460	349	180
PW002	144500				420	339	263	158	109	44	666	556	450	323	251	143
ROUNDTOP TRIBUTARY																
RT000	150000		Confluence w/ Newlin Gulch		429	320	232	106	51	3	504	385	288	151	92	27
RT001	152300				360	274	200	94	48	4	399	308	230	118	70	18
RT002	154400				204	158	117	58	32	4	208	161	120	61	35	6
SPRING TRIBUTARY																
ST000	160000		Confluence w/ Newlin Gulch		1009	749	546	267	146	30	1427	1128	870	521	374	175
ST001	162500				906	678	498	249	140	33	1244	983	758	458	332	162
ST002	163800		I-25 (U/S)		566	426	316	166	99	31	659	524	416	294	222	126
ST003	165800				402	309	232	122	75	21	491	387	297	171	118	47
ST004	167300				280	219	166	91	59	19	326	257	198	114	79	31
ST005	169700				161	129	100	60	41	16	161	129	100	60	41	16

Table B-5
Runoff Volumes - Existing Development

SWMM Node	Station (ft)	Cumulative Drainage Area (ac)	Landmark	3 Square Mile Area Adjustment 2-yr, 5-yr, 10-yr	EXISTING DEVELOPMENT											
					100-YR		50-YR		25-YR		10-YR		5-YR		2-YR	
					(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)
NEWLIN GULCH MAINSTEM																
NG000	0	9609	Cherry Creek	yes	60,057,128	1.72	47,512,820	1.36	36,664,400	1.05	22,077,031	0.63	14,400,081	0.41	7,114,818	0.20
NG001	3200	9455	Lincoln Ave (U/S)	yes	58,939,681	1.72	46,596,430	1.36	35,928,347	1.05	21,589,092	0.63	14,026,440	0.41	6,891,168	0.20
NG002	5300	9433	Jordan Rd. (U/S)	yes	58,803,860	1.72	46,488,415	1.36	35,842,390	1.05	21,526,395	0.63	13,973,769	0.41	6,854,539	0.20
NG004	10000	8635	Stonegate Parkway (U/S)	yes	53,179,195	1.70	41,885,881	1.34	32,167,341	1.03	19,049,270	0.61	12,135,910	0.39	5,839,359	0.19
NG006	14100	8285	Mainstreet (U/S)		51,154,448	1.70	40,321,536	1.34	30,987,999	1.03	19,747,624	0.66	12,875,706	0.43	5,821,312	0.19
NG009	19200	7271	Chambers Rd. (U/S)		45,506,656	1.72	36,012,701	1.36	27,795,809	1.05	17,964,174	0.68	11,864,402	0.45	5,472,670	0.21
NG011	22300	6974	Hess Rd. (U/S)		43,634,708	1.72	34,525,222	1.36	26,646,813	1.05	17,224,378	0.68	11,372,587	0.45	5,246,346	0.21
NG012	23500	6717	Rueter-Hess Reservoir Outflow		42,265,404	1.73	33,500,283	1.37	25,903,141	1.06	16,847,395	0.69	11,188,106	0.46	5,193,141	0.21
NG220	23600	6717	Rueter-Hess Reservoir Total Inflow	yes	42,270,618	1.73	33,505,363	1.37	25,908,221	1.06	15,785,025	0.65	10,255,273	0.42	5,036,332	0.21
NG014	41000	2042	Rueter-Hess Reservoir Inflow from Mainstem	yes	11,387,826	1.54	8,661,518	1.17	6,381,172	0.86	3,232,963	0.44	1,597,900	0.22	379,924	0.05
NG019	50600	334	I-25 (U/S)		1,832,244	1.51	1,387,752	1.14	1,016,918	0.84	561,731	0.46	290,223	0.24	49,061	0.04

Table B-6
Runoff Volumes - Future Development

SWMM Node	Station (ft)	Cumulative Drainage Area (ac)	Landmark	3 Square Mile Area Adjustment 2-yr, 5-yr, 10-yr	FUTURE DEVELOPMENT											
					100-YR		50-YR		25-YR		10-YR		5-YR		2-YR	
					(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)	(cf)	(in)
NEWLIN GULCH MAINSTEM																
NG000	0	9609	Cherry Creek	yes	65,834,860	1.89	53,548,424	1.54	42,494,000	1.22	28,230,676	0.81	20,231,285	0.58	10,941,462	0.31
NG001	3200	9455	Lincoln Ave (U/S)	yes	64,715,541	1.89	52,630,029	1.53	41,755,943	1.22	27,740,732	0.81	19,855,639	0.58	10,716,610	0.31
NG002	5300	9433	Jordan Rd. (U/S)	yes	64,579,721	1.89	52,522,014	1.53	41,669,985	1.22	27,677,902	0.81	19,802,968	0.58	10,679,981	0.31
NG004	10000	8635	Stonegate Parkway (U/S)	yes	58,827,389	1.88	47,788,873	1.52	37,866,869	1.21	25,064,554	0.80	17,833,299	0.57	9,565,475	0.31
NG006	14100	8285	Mainstreet (U/S)		56,316,174	1.87	45,718,942	1.52	36,193,171	1.20	25,210,000	0.84	18,055,211	0.60	9,339,953	0.31
NG009	19200	7271	Chambers Rd. (U/S)		49,727,929	1.88	40,429,283	1.53	32,054,647	1.21	22,426,342	0.85	16,100,247	0.61	8,354,985	0.32
NG011	22300	6974	Hess Rd. (U/S)		47,728,315	1.89	38,809,460	1.53	30,777,450	1.22	21,552,330	0.85	15,481,567	0.61	8,042,303	0.32
NG012	23500	6717	Rueter-Hess Reservoir Outflow		46,352,996	1.90	37,778,639	1.55	30,028,430	1.23	21,170,668	0.87	15,293,477	0.63	7,987,092	0.33
NG220	23600	6717	Rueter-Hess Reservoir Total Inflow	yes	46,359,680	1.90	37,783,719	1.55	30,033,510	1.23	20,117,388	0.83	14,376,018	0.59	7,723,739	0.32
NG014	41000	2042	Rueter-Hess Reservoir Inflow from Mainstem	yes	13,512,165	1.82	10,881,306	1.47	8,530,242	1.15	5,505,154	0.74	3,772,637	0.51	1,847,216	0.25
NG019	50600	334	I-25 (U/S)		2,213,238	1.82	1,784,520	1.47	1,401,120	1.15	959,702	0.79	670,548	0.55	321,772	0.27

Table B-7
Sample SWMM Input

```
[TITLE]
Newlin Gulch MDP
Baseline Hydrology Model
Future Development 100-yr no area adjustment

[OPTIONS]
FLOW_UNITS           CFS
INFILTRATION         HORTON
FLOW_ROUTING         KINWAVE
START_DATE           01/01/2005
START_TIME           00:00:00
REPORT_START_DATE    01/01/2005
REPORT_START_TIME    00:00:00
END_DATE             01/10/2005
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:15:00
WET_STEP             00:05:00
DRY_STEP             01:00:00
ROUTING_STEP         0:00:30
ALLOW_PONDING        NO
INERTIAL_DAMPING     PARTIAL
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
NORMAL_FLOW_LIMITED  BOTH
SKIP_STEADY_STATE    NO
FORCE_MAIN_EQUATION  H-W
LINK_OFFSETS         DEPTH
MIN_SLOPE            0

[FILES]
USE INFLOWS "P:\12-050.01 Newlin Gulch MDP - UDFCD\1 HYDROLOGY\Baseline\CUHP 2005
- v. 1.3.3\Output Files\Future\NewlinGulch_FU_100_2hr_CUHP Output.txt"

[EVAPORATION]
;;Type       Parameters
;;---------- ----------
CONSTANT     0.0
DRY_ONLY     NO

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
NG001            5802       0          0          0          0
```

```
A100             5767       0          0          0          0
NG000            5766       0          0          0          0
A104             5803       0          0          0          0
A108             5767       0          0          0          0
A110             5815       0          0          0          0
NG002            5814       0          0          0          0
SJ000            5818       0          0          0          0
NG003            5832       0          0          0          0
A115             5846       0          0          0          0
A120             5833       0          0          0          0
A125             5874       0          0          0          0
NG004            5860       0          0          0          0
A130             5861       0          0          0          0
NG005            5867.5     0          0          0          0
A135             5868.5     0          0          0          0
A140             5868.5     0          0          0          0
NG006            5902       0          0          0          0
A145             5903       0          0          0          0
A155             5903       0          0          0          0
A150             5903       0          0          0          0
NG005.5          5901       0          0          0          0
NG007            5924.5     0          0          0          0
A165             5925.5     0          0          0          0
NG008            5938       0          0          0          0
A170             5939       0          0          0          0
NG009            5948       0          0          0          0
A175             5939       0          0          0          0
A180             5949       0          0          0          0
NG011            5992       0          0          0          0
NG010            5964       0          0          0          0
A200             5965       0          0          0          0
A190             5965       0          0          0          0
A210             5993       0          0          0          0
A205             5993       0          0          0          0
NG012            6216.5     0          0          0          0
A220             6217       0          0          0          0
NG013            6217       0          0          0          0
A221             6218       0          0          0          0
A222             6218       0          0          0          0
A223             6218       0          0          0          0
A224             6218       0          0          0          0
A225             6218       0          0          0          0
A226             6218       0          0          0          0
A227             6218       0          0          0          0
A228             6218       0          0          0          0
NG014            6218       0          0          0          0
A230             6219       0          0          0          0
NG015            6235       0          0          0          0
```

Table B-7
Sample SWMM Input

A240	6236	0	0	0	0	F120	6295	0	0	0	0
NG016	6250	0	0	0	0	F125	6336	0	0	0	0
NG017	6295	0	0	0	0	F130	6336	0	0	0	0
A250	6251	0	0	0	0	SN005	6377	0	0	0	0
A260	6296	0	0	0	0	F140	6378	0	0	0	0
NG018	6333	0	0	0	0	SN006	6415	0	0	0	0
A270	6334	0	0	0	0	F145	6416	0	0	0	0
NG019	6380	0	0	0	0	F150	6416	0	0	0	0
NG119	6395	0	0	0	0	SN007	6470	0	0	0	0
NG020	6410	0	0	0	0	F155	6471	0	0	0	0
A280	6381	0	0	0	0	MT000	6220	0	0	0	0
NG021	6450	0	0	0	0	G100	6221	0	0	0	0
A290	6411	0	0	0	0	MT001	6248	0	0	0	0
A300	6451	0	0	0	0	G110	6249	0	0	0	0
ST000	6251	0	0	0	0	MT002	6285	0	0	0	0
ST001	6294	0	0	0	0	MT003	6354	0	0	0	0
J100	6252	0	0	0	0	G120	6286	0	0	0	0
J110	6295	0	0	0	0	G115	6286	0	0	0	0
ST002	6325	0	0	0	0	G130	6355	0	0	0	0
ST101	6345	0	0	0	0	PW000	6218	0	0	0	0
J130	6326	0	0	0	0	PW001	6228	0	0	0	0
ST003	6363	0	0	0	0	H100	6219	0	0	0	0
J120	6346	0	0	0	0	H115	6229	0	0	0	0
A275	6396	0	0	0	0	PW002	6277	0	0	0	0
J140	6364	0	0	0	0	H125	6278	0	0	0	0
ST004	6397	0	0	0	0	H120	6278	0	0	0	0
ST005	6471	0	0	0	0	H110	6229	0	0	0	0
J150	6398	0	0	0	0	BW000	6218	0	0	0	0
J160	6472	0	0	0	0	BW001	6219	0	0	0	0
ST102	6428	0	0	0	0	BW002	6235	0	0	0	0
J155	6429	0	0	0	0	E105	6219	0	0	0	0
RT000	6251	0	0	0	0	E115	6219	0	0	0	0
RT001	6297	0	0	0	0	E128	6219	0	0	0	0
I100	6252	0	0	0	0	E100	6220	0	0	0	0
I110	6298	0	0	0	0	E110	6220	0	0	0	0
RT002	6360	0	0	0	0	E120	6236	0	0	0	0
I120	6361	0	0	0	0	E124	6236	0	0	0	0
I115	6361	0	0	0	0	CT001	6219	0	0	0	0
SN000	6218	0	0	0	0	CT000	6218	0	0	0	0
F106	6219	0	0	0	0	D110	6220	0	0	0	0
F102	6219	0	0	0	0	D100	6220	0	0	0	0
F104	6219	0	0	0	0	D105	6220	0	0	0	0
SN001	6219	0	0	0	0	D115	6219	0	0	0	0
SN002	6264	0	0	0	0	D120	6219	0	0	0	0
F100	6220	0	0	0	0	D125	6219	0	0	0	0
SN003	6294	0	0	0	0	SP000	5948	0	0	0	0
F110	6265	0	0	0	0	SP001	5978	0	0	0	0
SN004	6335	0	0	0	0	SP002	6072	0	0	0	0

Table B-7
Sample SWMM Input

```
C115             6012       0          0          0          0
C120             6073       0          0          0          0
C110             5979       0          0          0          0
C100             5949       0          0          0          0
B100             5819       0          0          0          0
SJ001            5874       0          0          0          0
B110             5875       0          0          0          0
SJ002            5884       0          0          0          0
B120             5885       0          0          0          0
SJ003            5903.20    0          0          0          0
B135             5921       0          0          0          0
B130             5921       0          0          0          0
SJ004            5970       0          0          0          0
B140             5971       0          0          0          0
A160             5925.5     0          0          0          0
C125             6073       0          0          0          0

[OUTFALLS]
;;               Invert     Outfall    Stage/Table      Tide
;;Name           Elev.      Type       Time Series      Gate
;;-------------- ---------- ---------- ---------------- ----
NG-OUT           5765       FREE                        NO
```

Table B-7
Sample SWMM Input

```
[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                      Ponded   Evap.
;;Name          Elev.    Depth    Depth    Curve      Params                     Area     Frac.    Infiltration Parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- ----------------------
NG220            6216.7   8        0        TABULAR    A220_STORAGE_RH_AUX-ONLY          0        0
SJ130            5918.7   5929.5   0        TABULAR    B130_STORAGE_PONDIV          0        0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name          Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
A10              NG001            NG000            3050       0.065      0          0          0          0
A10.4            NG002            NG001            1578       0.065      0          0          0          0
A100-DF          A100             NG000            10         0.01       0          0          0          0
A104-DF          A104             NG001            10         0.01       0          0          0          0
A108-DF          A108             NG000            10         0.01       0          0          0          0
A11              NG003            NG002            1930       0.085      0          0          0          0
A110-DF          A110             NG002            10         0.01       0          0          0          0
A115             A115             NG003            1050       0.060      0          0          0          0
A12              NG004            NG003            3190       0.085      0          0          0          0
A14              NG005.5          NG005            3090       0.06       0          0          0          0
A14.5            NG006            NG005.5          100        0.065      0          0          0          0
A120-DF          A120             NG003            10         0.01       0          0          0          0
A125             A125             NG004            950        0.065      0          0          0          0
A13              NG005            NG004            1200       0.065      0          0          0          0
A130-DF          A130             NG004            10         0.01       0          0          0          0
A135-DF          A135             NG005            10         0.01       0          0          0          0
A140-DF          A140             NG005            10         0.01       0          0          0          0
A145-DF          A145             NG005.5          10         0.01       0          0          0          0
A15              NG007            NG006            2156       0.06       0          0          0          0
A150-DF          A150             NG006            10         0.01       0          0          0          0
A155-DF          A155             NG006            10         0.01       0          0          0          0
A16              NG008            NG007            1550       0.06       0          0          0          0
A160-DF          A160             NG007            10         0.01       0          0          0          0
A165-DF          A165             NG007            10         0.01       0          0          0          0
A17              NG009            NG008            780        0.06       0          0          0          0
A170-DF          A170             NG008            10         0.01       0          0          0          0
A175-DF          A175             NG008            10         0.01       0          0          0          0
A180-DF          A180             NG009            10         0.01       0          0          0          0
A19              NG010            NG009            1450       0.06       0          0          0          0
A190-DF          A190             NG010            10         0.01       0          0          0          0
A20              NG011            NG010            2075       0.06       0          0          0          0
A200-DF          A200             NG010            10         0.01       0          0          0          0
A205-DF          A205             NG011            10         0.01       0          0          0          0
A21              NG012            NG011            4074       0.08       0          0          0          0
A210-DF          A210             NG011            10         0.01       0          0          0          0
A22              NG014            NG013            10         0.01       0          0          0          0
A220-DF          A220             NG220            10         0.01       0          0          0          0
```

Table B-7
Sample SWMM Input

A221-DF	A221	NG013	10	0.01	0	0	0	0
A222-DF	A222	NG013	10	0.01	0	0	0	0
A223-DF	A223	NG013	10	0.01	0	0	0	0
A224-DF	A224	NG013	10	0.01	0	0	0	0
A225-DF	A225	NG013	10	0.01	0	0	0	0
A226-DF	A226	NG013	10	0.01	0	0	0	0
A227-DF	A227	NG013	10	0.01	0	0	0	0
A228-DF	A228	NG013	10	0.01	0	0	0	0
A23	NG015	NG014	1318	0.06	0	0	0	0
A230-DF	A230	NG014	10	0.01	0	0	0	0
A24	NG016	NG015	1619	0.06	0	0	0	0
A240-DF	A240	NG015	10	0.01	0	0	0	0
A25	NG017	NG016	2673	0.075	0	0	0	0
A250-DF	A250	NG016	10	0.01	0	0	0	0
A26	NG018	NG017	2266	0.075	0	0	0	0
A260-DF	A260	NG017	10	0.01	0	0	0	0
A27	NG019	NG018	1637	0.075	0	0	0	0
A27.5	NG119	NG018	1584	0.065	0	0	0	0
A270-DF	A270	NG018	10	0.01	0	0	0	0
A275-DF	A275	NG119	10	0.01	0	0	0	0
A28	NG020	NG019	1818	0.075	0	0	0	0
A280-DF	A280	NG019	10	0.01	0	0	0	0
A29	NG021	NG020	1474	0.075	0	0	0	0
A290-DF	A290	NG020	10	0.01	0	0	0	0
A300-DF	A300	NG021	10	0.01	0	0	0	0
B10	SJ001	SJ000	3247	0.075	0	0	0	0
B100-DF	B100	SJ000	10	0.01	0	0	0	0
B11	SJ002	SJ001	1261	0.085	0	0	0	0
B110-DF	B110	SJ001	10	0.01	0	0	0	0
B12	SJ003	SJ002	1877	0.085	0	0	0	0
B120-DF	B120	SJ002	10	0.01	0	0	0	0
B13	SJ004	SJ130	3351	0.075	0	0	0	0
B130-DF	B130	SJ130	10	0.01	0	0	0	0
B135-DF	B135	SJ130	10	0.01	0	0	0	0
B140-DF	B140	SJ004	10	0.01	0	0	0	0
BW-OUT	BW000	NG013	10	0.01	0	0	0	0
C10	SP001	SP000	2104	0.075	0	0	0	0
C100-DF	C100	SP000	10	0.01	0	0	0	0
C11	SP002	SP001	3220	0.09	0	0	0	0
C11.5	C115	SP001	1577	0.09	0	0	0	0
C110-DF	C110	SP001	10	0.01	0	0	0	0
C120-DF	C120	SP002	10	0.01	0	0	0	0
C125-DF	C125	SP002	10	0.01	0	0	0	0
CT-OUT	CT000	NG013	10	0.01	0	0	0	0
D10	CT001	CT000	10	0.01	0	0	0	0
D100-DF	D100	CT001	10	0.01	0	0	0	0
D105-DF	D105	CT001	10	0.01	0	0	0	0
D110-DF	D110	CT001	10	0.01	0	0	0	0

Table B-7
Sample SWMM Input

D115-DF	D115	CT000	10	0.01	0	0	0	0
D120-DF	D120	CT000	10	0.01	0	0	0	0
D125-DF	D125	CT000	10	0.01	0	0	0	0
E10.5	BW001	BW000	10	0.01	0	0	0	0
E100-DF	E100	BW001	10	0.01	0	0	0	0
E105-DF	E105	BW000	10	0.01	0	0	0	0
E11	BW002	BW001	770	0.085	0	0	0	0
E110-DF	E110	BW001	10	0.01	0	0	0	0
E115-DF	E115	BW000	10	0.01	0	0	0	0
E120-DF	E120	BW002	10	0.01	0	0	0	0
E124-DF	E124	BW002	10	0.01	0	0	0	0
E128-DF	E128	BW000	10	0.01	0	0	0	0
F10	SN002	SN001	2768	0.075	0	0	0	0
F10.2	SN001	SN000	10	0.01	0	0	0	0
F100-DF	F100	SN001	10	0.01	0	0	0	0
F102-DF	F102	SN000	10	0.01	0	0	0	0
F104-DF	F104	SN000	10	0.01	0	0	0	0
F106-DF	F106	SN000	10	0.01	0	0	0	0
F11	SN003	SN002	1889	0.075	0	0	0	0
F110-DF	F110	SN002	10	0.01	0	0	0	0
F12	SN004	SN003	2764	0.075	0	0	0	0
F120-DF	F120	SN003	10	0.01	0	0	0	0
F125-DF	F125	SN004	10	0.01	0	0	0	0
F13	SN005	SN004	2822	0.075	0	0	0	0
F130-DF	F130	SN004	10	0.01	0	0	0	0
F14	SN006	SN005	2295	0.085	0	0	0	0
F140-DF	F140	SN005	10	0.01	0	0	0	0
F145-DF	F145	SN006	10	0.01	0	0	0	0
F15	SN007	SN006	2047	0.09	0	0	0	0
F150-DF	F150	SN006	10	0.01	0	0	0	0
F155-DF	F155	SN007	10	0.01	0	0	0	0
G10	MT001	MT000	1907	0.075	0	0	0	0
G100-DF	G100	MT000	10	0.01	0	0	0	0
G11	MT002	MT001	1883	0.085	0	0	0	0
G110-DF	G110	MT001	10	0.01	0	0	0	0
G115-DF	G115	MT002	10	0.01	0	0	0	0
G12	MT003	MT002	2682	0.085	0	0	0	0
G120-DF	G120	MT002	10	0.01	0	0	0	0
G130-DF	G130	MT003	10	0.01	0	0	0	0
H10	PW001	PW000	676	0.07	0	0	0	0
H100-DF	H100	PW000	10	0.01	0	0	0	0
H11	PW002	PW001	1853	0.085	0	0	0	0
H110-DF	H110	PW001	10	0.01	0	0	0	0
H115-DF	H115	PW001	10	0.01	0	0	0	0
H120-DF	H120	PW002	10	0.01	0	0	0	0
H125-DF	H125	PW002	10	0.01	0	0	0	0
I10	RT001	RT000	2491	.08	0	0	0	0
I100-DF	I100	RT000	10	0.01	0	0	0	0

Table B-7
Sample SWMM Input

```
I11              RT002            RT001            2223       0.085      0          0          0          0
I110-DF          I110             RT001            10         0.01       0          0          0          0
I115-DF          I115             RT002            10         0.01       0          0          0          0
I120-DF          I120             RT002            10         0.01       0          0          0          0
J10              ST001            ST000            2439       0.06       0          0          0          0
J100-DF          J100             ST000            10         0.01       0          0          0          0
J11              ST002            ST001            1373       0.08       0          0          0          0
J11.5            ST101            ST001            1694       0.08       0          0          0          0
J110-DF          J110             ST001            10         0.01       0          0          0          0
J12              ST102            ST101            3031       0.09       0          0          0          0
J120-DF          J120             ST101            10         0.01       0          0          0          0
J13              ST003            ST002            2060       0.08       0          0          0          0
J130-DF          J130             ST002            10         0.01       0          0          0          0
J14              ST004            ST003            1514       0.09       0          0          0          0
J140-DF          J140             ST003            10         0.01       0          0          0          0
J15              ST005            ST004            2361       0.09       0          0          0          0
J150-DF          J150             ST004            10         0.01       0          0          0          0
J155-DF          J155             ST102            10         0.01       0          0          0          0
J160-DF          J160             ST005            10         0.01       0          0          0          0
MT-OUT           MT000            SN001            10         0.01       0          0          0          0
NG220-IN         NG013            NG220            10         0.01       0          0          0          0
NG-OUT           NG000            NG-OUT           10         0.01       0          0          0          0
PW-OUT           PW000            NG013            10         0.01       0          0          0          0
RT-OUT           RT000            NG016            10         0.01       0          0          0          0
SJ-OUT           SJ000            NG002            10         0.01       0          0          0          0
SN-OUT           SN000            NG013            10         0.01       0          0          0          0
SP-OUT           SP000            NG008            20         0.01       0          0          0          0
ST-OUT           ST000            NG016            10         0.01       0          0          0          0

[OUTLETS]
;;               Inlet            Outlet           Outflow    Outlet           Qcoeff/                    Flap
;;Name           Node             Node             Height     Type             QTable           Qexpon    Gate
;;-------------- ---------------- ---------------- ---------- ---------------- ---------------- ---------- ----
NG220-OUT        NG220            NG012            0          TABULAR/DEPTH    A220_OUTFLOW_RH_AUX-ONLY           NO
SJ130-OUT        SJ130            SJ003            0          TABULAR/DEPTH    B130_OUTFLOW_PONDIV           NO
```

Table B-7
Sample SWMM Input

```
[XSECTIONS]
;;Link           Shape        Geom1           Geom2      Geom3      Geom4                Barrels
;;-------------- ------------ --------------- ---------- ---------- ---------- --------
A10              TRAPEZOIDAL  15              130        6          6          1
A10.4            TRAPEZOIDAL  15              75         6          5          1
A100-DF          DUMMY        0               0          0          0          1
A104-DF          DUMMY        0               0          0          0          1
A108-DF          DUMMY        0               0          0          0          1
A11              TRAPEZOIDAL  15              60         5          5          1
A110-DF          DUMMY        0               0          0          0          1
A115             TRAPEZOIDAL  10              10         5          5          1
A12              TRAPEZOIDAL  10              65         5          5          1
A14              TRAPEZOIDAL  10              109        5          5          1
A14.5            TRAPEZOIDAL  10              109        5          5          1
A120-DF          DUMMY        0               0          0          0          1
A125             TRAPEZOIDAL  10              20         6          6          1
A13              TRAPEZOIDAL  10              110        5          5          1
A130-DF          DUMMY        0               0          0          0          1
A135-DF          DUMMY        0               0          0          0          1
A140-DF          DUMMY        0               0          0          0          1
A145-DF          DUMMY        0               0          0          0          1
A15              TRAPEZOIDAL  10              111        10         3.5        1
A150-DF          DUMMY        0               0          0          0          1
A155-DF          DUMMY        0               0          0          0          1
A16              TRAPEZOIDAL  10              110        20         10         1
A160-DF          DUMMY        0               0          0          0          1
A165-DF          DUMMY        0               0          0          0          1
A17              TRAPEZOIDAL  10              100        6          6          1
A170-DF          DUMMY        0               0          0          0          1
A175-DF          DUMMY        0               0          0          0          1
A180-DF          DUMMY        0               0          0          0          1
A19              TRAPEZOIDAL  10              80         3          5          1
A190-DF          DUMMY        0               0          0          0          1
A20              TRAPEZOIDAL  10              180        10         10         1
A200-DF          DUMMY        0               0          0          0          1
A205-DF          DUMMY        0               0          0          0          1
A21              TRAPEZOIDAL  10              330        5          5          1
A210-DF          DUMMY        0               0          0          0          1
A22              DUMMY        0               0          0          0          1
A220-DF          DUMMY        0               0          0          0          1
A221-DF          DUMMY        0               0          0          0          1
A222-DF          DUMMY        0               0          0          0          1
A223-DF          DUMMY        0               0          0          0          1
A224-DF          DUMMY        0               0          0          0          1
A225-DF          DUMMY        0               0          0          0          1
A226-DF          DUMMY        0               0          0          0          1
A227-DF          DUMMY        0               0          0          0          1
A228-DF          DUMMY        0               0          0          0          1
A23              TRAPEZOIDAL  10              80         10         10         1
A230-DF          DUMMY        0               0          0          0          1
A24              TRAPEZOIDAL  10              80         10         10         1
A240-DF          DUMMY        0               0          0          0          1
A25              TRAPEZOIDAL  10              50         10         10         1
A250-DF          DUMMY        0               0          0          0          1
A26              TRAPEZOIDAL  10              60         10         10         1
A260-DF          DUMMY        0               0          0          0          1
A27              TRAPEZOIDAL  10              32         10         10         1
A27.5            TRAPEZOIDAL  10              20         10         10         1
A270-DF          DUMMY        0               0          0          0          1
A275-DF          DUMMY        0               0          0          0          1
A28              TRAPEZOIDAL  10              30         10         10         1
A280-DF          DUMMY        0               0          0          0          1
A29              TRAPEZOIDAL  10              40         10         10         1
A290-DF          DUMMY        0               0          0          0          1
A300-DF          DUMMY        0               0          0          0          1
B10              TRAPEZOIDAL  10              32         9          5          1
B100-DF          DUMMY        0               0          0          0          1
B11              TRAPEZOIDAL  10              35         10         15         1
B110-DF          DUMMY        0               0          0          0          1
B12              TRAPEZOIDAL  10              35         10         10         1
B120-DF          DUMMY        0               0          0          0          1
B13              TRAPEZOIDAL  10              25         5          5          1
B130-DF          DUMMY        0               0          0          0          1
B135-DF          DUMMY        0               0          0          0          1
B140-DF          DUMMY        0               0          0          0          1
BW-OUT           DUMMY        0               0          0          0          1
C10              TRAPEZOIDAL  10              30         4          4          1
C100-DF          DUMMY        0               0          0          0          1
C11              TRAPEZOIDAL  10              20         4          4          1
C11.5            TRAPEZOIDAL  10              60         15         15         1
C110-DF          DUMMY        0               0          0          0          1
C120-DF          DUMMY        0               0          0          0          1
C125-DF          DUMMY        0               0          0          0          1
CT-OUT           DUMMY        0               0          0          0          1
D10              DUMMY        0               0          0          0          1
D100-DF          DUMMY        0               0          0          0          1
D105-DF          DUMMY        0               0          0          0          1
D110-DF          DUMMY        0               0          0          0          1
D115-DF          DUMMY        0               0          0          0          1
D120-DF          DUMMY        0               0          0          0          1
D125-DF          DUMMY        0               0          0          0          1
E10.5            DUMMY        0               0          0          0          1
E100-DF          DUMMY        0               0          0          0          1
E105-DF          DUMMY        0               0          0          0          1
```

Table B-7
Sample SWMM Input

```
E11             TRAPEZOIDAL  10          30          10          15          1
E110-DF         DUMMY        0           0           0           0           1
E115-DF         DUMMY        0           0           0           0           1
E120-DF         DUMMY        0           0           0           0           1
E124-DF         DUMMY        0           0           0           0           1
E128-DF         DUMMY        0           0           0           0           1
F10             TRAPEZOIDAL  10          60          10          10          1
F10.2           DUMMY        0           0           0           0           1
F100-DF         DUMMY        0           0           0           0           1
F102-DF         DUMMY        0           0           0           0           1
F104-DF         DUMMY        0           0           0           0           1
F106-DF         DUMMY        0           0           0           0           1
F11             TRAPEZOIDAL  10          40          9           10          1
F110-DF         DUMMY        0           0           0           0           1
F12             TRAPEZOIDAL  10          60          10          10          1
F120-DF         DUMMY        0           0           0           0           1
F125-DF         DUMMY        0           0           0           0           1
F13             TRAPEZOIDAL  10          25          10          10          1
F130-DF         DUMMY        0           0           0           0           1
F14             TRAPEZOIDAL  10          20          10          10          1
F140-DF         DUMMY        0           0           0           0           1
F145-DF         DUMMY        0           0           0           0           1
F15             TRAPEZOIDAL  10          20          10          10          1
F150-DF         DUMMY        0           0           0           0           1
F155-DF         DUMMY        0           0           0           0           1
G10             TRAPEZOIDAL  10          35          15          15          1
G100-DF         DUMMY        0           0           0           0           1
G11             TRAPEZOIDAL  10          30          15          10          1
G110-DF         DUMMY        0           0           0           0           1
G115-DF         DUMMY        0           0           0           0           1
G12             TRAPEZOIDAL  10          20          15          11          1
G120-DF         DUMMY        0           0           0           0           1
G130-DF         DUMMY        0           0           0           0           1
H10             TRAPEZOIDAL  10          70          10          10          1
H100-DF         DUMMY        0           0           0           0           1
H11             TRAPEZOIDAL  10          30          15          15          1
H110-DF         DUMMY        0           0           0           0           1
H115-DF         DUMMY        0           0           0           0           1
H120-DF         DUMMY        0           0           0           0           1
H125-DF         DUMMY        0           0           0           0           1
I10             TRAPEZOIDAL  10          35          10          10          1
I100-DF         DUMMY        0           0           0           0           1
I11             TRAPEZOIDAL  10          30          10          10          1
I110-DF         DUMMY        0           0           0           0           1
I115-DF         DUMMY        0           0           0           0           1
I120-DF         DUMMY        0           0           0           0           1
J10             TRAPEZOIDAL  10          40          7           10          1
J100-DF         DUMMY        0           0           0           0           1
J11             TRAPEZOIDAL  10          30          10          10          1
J11.5           TRAPEZOIDAL  10          60          10          10          1
J110-DF         DUMMY        0           0           0           0           1
J12             TRAPEZOIDAL  10          60          10          10          1
J120-DF         DUMMY        0           0           0           0           1
J13             TRAPEZOIDAL  10          25          6           6           1
J130-DF         DUMMY        0           0           0           0           1
J14             TRAPEZOIDAL  10          25          10          10          1
J140-DF         DUMMY        0           0           0           0           1
J15             TRAPEZOIDAL  10          30          10          10          1
J150-DF         DUMMY        0           0           0           0           1
J155-DF         DUMMY        0           0           0           0           1
J160-DF         DUMMY        0           0           0           0           1
MT-OUT          DUMMY        0           0           0           0           1
NG220-IN        DUMMY        0           0           0           0           1
NG-OUT          DUMMY        0           0           0           0           1
PW-OUT          DUMMY        0           0           0           0           1
RT-OUT          DUMMY        0           0           0           0           1
SJ-OUT          DUMMY        0           0           0           0           1
SN-OUT          DUMMY        0           0           0           0           1
SP-OUT          DUMMY        0           0           0           0           1
ST-OUT          DUMMY        0           0           0           0           1

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate
;;-------------- ---------- ---------- ---------- ----------

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
;A rating curve based on the aux. spillway outflow only
A220_OUTFLOW_RH_AUX-ONLY Rating     0.0        0.0
A220_OUTFLOW_RH_AUX-ONLY            0.4        359.0
A220_OUTFLOW_RH_AUX-ONLY            0.9        1220.0
A220_OUTFLOW_RH_AUX-ONLY            1.4        2381.0
A220_OUTFLOW_RH_AUX-ONLY            1.9        3785.0
A220_OUTFLOW_RH_AUX-ONLY            2.4        5403.0
A220_OUTFLOW_RH_AUX-ONLY            2.9        7217.0
A220_OUTFLOW_RH_AUX-ONLY            3.4        9213.0
A220_OUTFLOW_RH_AUX-ONLY            3.9        11380.0
A220_OUTFLOW_RH_AUX-ONLY            4.4        13712.0
A220_OUTFLOW_RH_AUX-ONLY            4.9        16202.0
A220_OUTFLOW_RH_AUX-ONLY            5.4        18846.0
A220_OUTFLOW_RH_AUX-ONLY            5.9        21640.0
A220_OUTFLOW_RH_AUX-ONLY            6.4        24579.0
;Bradbury Ranch Pond IV
;Based on field survey of outlet structure
```

Table B-7
Sample SWMM Input

```
B130_OUTFLOW_PONDIV Rating     0.00       0.00
B130_OUTFLOW_PONDIV            3.00       66.85
B130_OUTFLOW_PONDIV            3.50       94.54
B130_OUTFLOW_PONDIV            4.00       115.79
B130_OUTFLOW_PONDIV            4.50       133.70
B130_OUTFLOW_PONDIV            5.00       149.48
B130_OUTFLOW_PONDIV            5.50       163.75
B130_OUTFLOW_PONDIV            6.00       176.87
B130_OUTFLOW_PONDIV            6.50       189.08
B130_OUTFLOW_PONDIV            7.00       200.55
B130_OUTFLOW_PONDIV            7.50       211.40
B130_OUTFLOW_PONDIV            8.00       221.72
B130_OUTFLOW_PONDIV            8.50       231.58
B130_OUTFLOW_PONDIV            9.00       247.00
B130_OUTFLOW_PONDIV            9.50       290.23
B130_OUTFLOW_PONDIV            10.00      351.23
B130_OUTFLOW_PONDIV            10.50      426.96
B130_OUTFLOW_PONDIV            11.00      516.27
B130_OUTFLOW_PONDIV            11.30      576.13
;Storage curve for RH res. using only the volume above the aux. spillway

A220_STORAGE_RH_AUX-ONLY Storage    0          50660280
A220_STORAGE_RH_AUX-ONLY            1.4        50965200
A220_STORAGE_RH_AUX-ONLY            6.4        53622360
;Bradbury Ranch Pond IV
;Based on Douglas County 5-Foot Contours

B130_STORAGE_PONDIV Storage    0          0
B130_STORAGE_PONDIV            6.3        82308
B130_STORAGE_PONDIV            8.8        150181
B130_STORAGE_PONDIV            11.3       218054

[REPORT]
INPUT      NO
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS 3159265.825 1580659.249 3213328.325 1624721.749
Units      None

[COORDINATES]
;;Node           X-Coord            Y-Coord
;;-------------- ------------------ ------------------
NG001            3200434.454        1620248.042
A100             3199970.010        1620764.091
NG000            3202451.782        1621343.740
A104             3199678.939        1619983.260
A108             3201271.874        1620001.381
A110             3198372.235        1619389.734
NG002            3199282.115        1619471.773
SJ000            3199156.882        1619020.601
NG003            3198094.255        1618124.588
A115             3197290.806        1618920.633
A120             3197057.927        1616791.729
A125             3195098.188        1617980.024
NG004            3195670.146        1617209.123
A130             3194762.473        1617225.702
NG005            3195641.134        1616077.641
A135             3194874.378        1615828.963
A140             3195906.390        1615041.484
NG006            3194231.961        1613793.952
A145             3193519.086        1614245.716
A155             3193137.780        1613449.948
A150             3195011.151        1612732.928
NG005.5          3194365.598        1614031.019
NG007            3194447.957        1611819.688
A165             3193686.138        1612676.218
NG008            3193817.912        1610563.717
A170             3194880.340        1609987.206
NG009            3193620.251        1609542.469
A175             3194386.187        1609443.639
A180             3193937.332        1608764.179
NG011            3192067.790        1607137.595
NG010            3192969.618        1608467.688
A200             3193344.350        1607817.054
A190             3192269.569        1608434.745
A210             3190737.697        1607425.850
A205             3192920.202        1605823.973
NG012            3187913.217        1605737.905
A220             3189079.770        1604635.080
NG013            3187199.223        1600654.683
A221             3192630.208        1601386.761
A222             3191847.800        1599039.537
A223             3186560.371        1601880.913
A224             3184451.988        1601263.223
A225             3183611.929        1600489.051
A226             3182640.097        1599311.321
A227             3184050.826        1597685.449
A228             3181973.792        1597703.176
NG014            3181801.525        1596233.164
A230             3182054.183        1595429.252
```

Table B-7
Sample SWMM Input

NG015	3181342.146	1595234.016	SN004	3185534.206	1589470.507
A240	3181835.978	1594200.414	F120	3187048.142	1589969.784
NG016	3180193.700	1594510.495	F125	3185437.572	1588318.950
NG017	3178792.595	1592707.434	F130	3184229.644	1589365.820
A250	3179481.663	1592856.732	SN005	3183601.521	1587859.937
A260	3178781.111	1591558.987	F140	3183239.143	1586716.432
NG018	3177667.117	1591042.186	SN006	3182095.638	1586635.904
A270	3177288.130	1589801.864	F145	3182039.268	1585427.976
NG019	3176231.559	1590376.087	F150	3180992.397	1586772.802
NG119	3176346.404	1591616.409	SN007	3180509.226	1585548.769
NG020	3174531.859	1589664.050	F155	3179864.998	1585081.703
A280	3175140.535	1590548.354	MT000	3185501.994	1594865.918
NG021	3173119.269	1589204.672	G100	3185348.990	1593819.047
A290	3172981.456	1590123.429	MT001	3184745.026	1593843.206
A300	3171408.084	1588860.138	G110	3184543.705	1592828.547
ST000	3179952.526	1594499.010	MT002	3183738.420	1592554.750
ST001	3177896.807	1594499.010	MT003	3182337.224	1590380.480
J100	3178746.657	1595268.469	G120	3182321.118	1591668.936
J110	3177380.006	1594981.358	G115	3183851.160	1591411.245
ST002	3176667.969	1594751.668	G130	3181999.004	1589075.918
ST101	3176484.218	1593545.800	PW000	3181829.894	1598602.441
J130	3175576.945	1595383.314	PW001	3181024.609	1598425.279
ST003	3174910.846	1594832.060	H100	3181523.886	1599005.084
J120	3175485.069	1592569.620	H115	3179800.575	1599874.792
A275	3175393.193	1591581.956	PW002	3179494.567	1597861.579
J140	3174462.952	1594085.569	H125	3178326.903	1598723.234
ST004	3173601.617	1594453.072	H120	3178326.903	1596669.757
ST005	3172051.214	1592822.278	H110	3180460.909	1597555.571
J150	3172797.704	1593017.514	BW000	3189200.837	1599595.230
J160	3171511.444	1592271.024	BW001	3188983.065	1596577.241
ST102	3174083.964	1592558.136	BW002	3188671.911	1595900.527
J155	3173348.959	1592098.757	E105	3188345.222	1598716.279
RT000	3180342.905	1594247.620	E115	3190422.034	1598467.373
RT001	3180294.275	1592229.463	E128	3190484.261	1596445.009
I100	3180829.208	1593019.705	E100	3188345.222	1596701.694
I110	3180750.184	1590728.003	E110	3189200.837	1596351.669
RT002	3179686.397	1590253.858	E120	3188104.094	1594834.896
I120	3180111.912	1589111.047	E124	3189410.852	1594951.571
I115	3178926.549	1589141.441	CT001	3184871.446	1603034.804
SN000	3186307.280	1599343.304	CT000	3187390.478	1603865.758
F106	3187030.685	1597199.506	D110	3183464.713	1602910.488
F102	3184580.514	1597121.723	D100	3185048.105	1602465.568
F104	3184914.981	1595721.625	D105	3184727.501	1603466.638
SN001	3185816.056	1595035.028	D115	3185525.740	1604238.706
SN002	3186967.613	1592981.551	D120	3184433.069	1605102.374
F100	3186105.958	1593770.730	D125	3187161.475	1605351.006
SN003	3186927.349	1591274.346	SP000	3193378.721	1610469.741
F110	3186548.865	1592039.367	SP001	3191378.524	1609929.337

Table B-7
Sample SWMM Input

```
SP002             3189160.763       1608399.362
C115              3189673.094       1610083.738
C120              3188269.447       1608209.870
C110              3190515.282       1610645.197
C100              3192038.238       1609206.459
B100              3198457.573       1617400.937
SJ001             3198772.565       1615926.776
B110              3197922.087       1615384.991
SJ002             3198577.270       1614855.805
B120              3197449.600       1614068.326
SJ003             3198158.692       1613331.669
B135              3197229.106       1612468.169
B130              3197985.086       1612134.278
SJ004             3197985.086       1610464.822
B140              3197418.101       1609872.638
A160              3194441.016       1610864.530
C125              3188689.458       1607247.040
NG-OUT            3202809.768       1621537.649
NG220             3188520.098       1604504.431
SJ130             3198194.942       1613052.542

[VERTICES]
;;Link           X-Coord           Y-Coord
;;-------------- ------------------ ------------------
A100-DF           3199916.049       1620821.678


[BACKDROP]
FILE       "P:\12-050.01 Newlin Gulch MDP - UDFCD\1 HYDROLOGY\Baseline\EPA SWMM -
v. 5.0\Input Files\SWMM_Background.jpg"
DIMENSIONS 3159262.493 1580662.582 3213324.993 1624725.082
```

Table B-8
Sample SWMM Output

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.0 (Build 5.0.021)
--------------------------------------------------------------

Newlin Gulch MDP
Baseline Hydrology Model
Future Development 100-yr no area adjustment

*****************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*****************************************************

***************
Analysis Options
***************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Flow Routing Method ...... KINWAVE
Starting Date ............ JAN-01-2005 00:00:00
Ending Date .............. JAN-10-2005 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Routing Time Step ........ 30.00 sec


*************************        Volume        Volume
Flow Routing Continuity       acre-feet      10^6 gal
*************************     ---------     ---------
Dry Weather Inflow .......        0.000         0.000
Wet Weather Inflow .......        0.000         0.000
Groundwater Inflow .......        0.000         0.000
RDII Inflow ..............        0.000         0.000
External Inflow ..........     1487.422       484.699
External Outflow .........     1511.396       492.511
Internal Outflow .........        0.000         0.000
Storage Losses ...........        0.000         0.000
Initial Stored Volume ....        0.000         0.000
Final Stored Volume ......        0.116         0.038
Continuity Error (%) .....       -1.620


*******************************
Highest Flow Instability Indexes
*******************************
Link SJ130-OUT (3)
Link B12 (3)
Link B11 (3)
Link SJ-OUT (3)
Link B10 (3)


************************
Routing Time Step Summary
************************
Minimum Time Step           :    30.00 sec
Average Time Step           :    30.00 sec
Maximum Time Step           :    30.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     1.00


******************
Node Depth Summary
******************

-------------------------------------------------------------------------------
                                  Average  Maximum  Maximum  Time of Max
                                    Depth    Depth      HGL   Occurrence
Node                 Type          Feet     Feet     Feet  days hr:min
-------------------------------------------------------------------------------
NG001                JUNCTION      0.38     5.89  5807.89     0  01:25
A100                 JUNCTION      0.00     0.00  5767.00     0  00:00
NG000                JUNCTION      0.25     3.95  5769.95     0  01:31
A104                 JUNCTION      0.00     0.00  5803.00     0  00:00
A108                 JUNCTION      0.00     0.00  5767.00     0  00:00
A110                 JUNCTION      0.00     0.00  5815.00     0  00:00
NG002                JUNCTION      0.47     6.42  5820.42     0  01:23
SJ000                JUNCTION      0.03     2.81  5820.81     0  01:00
NG003                JUNCTION      0.46     6.44  5838.44     0  01:18
A115                 JUNCTION      0.01     2.48  5848.48     0  00:39
A120                 JUNCTION      0.00     0.00  5833.00     0  00:00
A125                 JUNCTION      0.01     1.67  5875.67     0  00:41
NG004                JUNCTION      0.44     6.13  5866.13     0  01:11
A130                 JUNCTION      0.00     0.00  5861.00     0  00:00
NG005                JUNCTION      0.31     4.36  5871.86     0  01:09
A135                 JUNCTION      0.00     0.00  5868.50     0  00:00
A140                 JUNCTION      0.00     0.00  5868.50     0  00:00
```

Table B-8
Sample SWMM Output

NG006	JUNCTION	0.27	3.60	5905.60	0	01:05	ST001	JUNCTION	0.02	3.23	6297.23	0	00:49
A145	JUNCTION	0.00	0.00	5903.00	0	00:00	J100	JUNCTION	0.00	0.00	6252.00	0	00:00
A155	JUNCTION	0.00	0.00	5903.00	0	00:00	J110	JUNCTION	0.00	0.00	6295.00	0	00:00
A150	JUNCTION	0.00	0.00	5903.00	0	00:00	ST002	JUNCTION	0.02	2.85	6327.85	0	00:58
NG005.5	JUNCTION	0.27	3.60	5904.60	0	01:05	ST101	JUNCTION	0.01	1.50	6346.50	0	00:45
NG007	JUNCTION	0.25	3.13	5927.63	0	01:00	J130	JUNCTION	0.00	0.00	6326.00	0	00:00
A165	JUNCTION	0.00	0.00	5925.50	0	00:00	ST003	JUNCTION	0.02	2.88	6365.88	0	00:51
NG008	JUNCTION	0.25	2.91	5940.91	0	00:58	J120	JUNCTION	0.00	0.00	6346.00	0	00:00
A170	JUNCTION	0.00	0.00	5939.00	0	00:00	A275	JUNCTION	0.00	0.00	6396.00	0	00:00
NG009	JUNCTION	0.28	2.54	5950.54	0	02:41	J140	JUNCTION	0.00	0.00	6364.00	0	00:00
A175	JUNCTION	0.00	0.00	5939.00	0	00:00	ST004	JUNCTION	0.02	2.17	6399.17	0	00:51
A180	JUNCTION	0.00	0.00	5949.00	0	00:00	ST005	JUNCTION	0.01	1.29	6472.29	0	00:45
NG011	JUNCTION	0.16	1.47	5993.47	0	02:45	J150	JUNCTION	0.00	0.00	6398.00	0	00:00
NG010	JUNCTION	0.28	2.54	5966.54	0	02:37	J160	JUNCTION	0.00	0.00	6472.00	0	00:00
A200	JUNCTION	0.00	0.00	5965.00	0	00:00	ST102	JUNCTION	0.00	1.00	6429.00	0	00:38
A190	JUNCTION	0.00	0.00	5965.00	0	00:00	J155	JUNCTION	0.00	0.00	6429.00	0	00:00
A210	JUNCTION	0.00	0.00	5993.00	0	00:00	RT000	JUNCTION	0.02	2.08	6253.08	0	01:07
A205	JUNCTION	0.00	0.00	5993.00	0	00:00	RT001	JUNCTION	0.02	2.12	6299.12	0	00:56
NG012	JUNCTION	0.08	0.80	6217.30	0	02:43	I100	JUNCTION	0.00	0.00	6252.00	0	00:00
A220	JUNCTION	0.00	0.00	6217.00	0	00:00	I110	JUNCTION	0.00	0.00	6298.00	0	00:00
NG013	JUNCTION	0.00	0.00	6217.00	0	00:00	RT002	JUNCTION	0.01	1.48	6361.48	0	00:51
A221	JUNCTION	0.00	0.00	6218.00	0	00:00	I120	JUNCTION	0.00	0.00	6361.00	0	00:00
A222	JUNCTION	0.00	0.00	6218.00	0	00:00	I115	JUNCTION	0.00	0.00	6361.00	0	00:00
A223	JUNCTION	0.00	0.00	6218.00	0	00:00	SN000	JUNCTION	0.00	0.00	6218.00	0	00:00
A224	JUNCTION	0.00	0.00	6218.00	0	00:00	F106	JUNCTION	0.00	0.00	6219.00	0	00:00
A225	JUNCTION	0.00	0.00	6218.00	0	00:00	F102	JUNCTION	0.00	0.00	6219.00	0	00:00
A226	JUNCTION	0.00	0.00	6218.00	0	00:00	F104	JUNCTION	0.00	0.00	6219.00	0	00:00
A227	JUNCTION	0.00	0.00	6218.00	0	00:00	SN001	JUNCTION	0.03	2.68	6221.68	0	01:28
A228	JUNCTION	0.00	0.00	6218.00	0	00:00	SN002	JUNCTION	0.03	3.06	6267.06	0	01:22
NG014	JUNCTION	0.04	4.22	6222.22	0	01:04	F100	JUNCTION	0.00	0.00	6220.00	0	00:00
A230	JUNCTION	0.00	0.00	6219.00	0	00:00	SN003	JUNCTION	0.03	3.07	6297.07	0	01:16
NG015	JUNCTION	0.04	4.47	6239.47	0	01:02	F110	JUNCTION	0.00	0.00	6265.00	0	00:00
A240	JUNCTION	0.00	0.00	6236.00	0	00:00	SN004	JUNCTION	0.03	2.90	6337.90	0	01:13
NG016	JUNCTION	0.04	4.48	6254.48	0	00:58	F120	JUNCTION	0.00	0.00	6295.00	0	00:00
NG017	JUNCTION	0.02	2.99	6297.99	0	00:51	F125	JUNCTION	0.00	0.00	6336.00	0	00:00
A250	JUNCTION	0.00	0.00	6251.00	0	00:00	F130	JUNCTION	0.00	0.00	6336.00	0	00:00
A260	JUNCTION	0.00	0.00	6296.00	0	00:00	SN005	JUNCTION	0.02	2.95	6379.95	0	01:01
NG018	JUNCTION	0.02	2.64	6335.64	0	00:41	F140	JUNCTION	0.00	0.00	6378.00	0	00:00
A270	JUNCTION	0.00	0.00	6334.00	0	00:00	SN006	JUNCTION	0.02	2.87	6417.87	0	00:51
NG019	JUNCTION	0.02	2.15	6382.15	0	00:38	F145	JUNCTION	0.00	0.00	6416.00	0	00:00
NG119	JUNCTION	0.00	1.23	6396.23	0	00:35	F150	JUNCTION	0.00	0.00	6416.00	0	00:00
NG020	JUNCTION	0.02	2.09	6412.09	0	00:52	SN007	JUNCTION	0.01	1.88	6471.88	0	00:42
A280	JUNCTION	0.00	0.00	6381.00	0	00:00	F155	JUNCTION	0.00	0.00	6471.00	0	00:00
NG021	JUNCTION	0.01	1.03	6451.03	0	00:53	MT000	JUNCTION	0.02	2.31	6222.31	0	01:09
A290	JUNCTION	0.00	0.00	6411.00	0	00:00	G100	JUNCTION	0.00	0.00	6221.00	0	00:00
A300	JUNCTION	0.00	0.00	6451.00	0	00:00	MT001	JUNCTION	0.02	2.33	6250.33	0	01:01
ST000	JUNCTION	0.02	3.21	6254.21	0	00:55	G110	JUNCTION	0.00	0.00	6249.00	0	00:00

Table B-8
Sample SWMM Output

MT002	JUNCTION	0.02	2.21	6287.21	0	00:55
MT003	JUNCTION	0.01	1.49	6355.49	0	00:48
G120	JUNCTION	0.00	0.00	6286.00	0	00:00
G115	JUNCTION	0.00	0.00	6286.00	0	00:00
G130	JUNCTION	0.00	0.00	6355.00	0	00:00
PW000	JUNCTION	0.01	2.61	6220.61	0	00:45
PW001	JUNCTION	0.01	2.61	6230.61	0	00:43
H100	JUNCTION	0.00	0.00	6219.00	0	00:00
H115	JUNCTION	0.00	0.00	6229.00	0	00:00
PW002	JUNCTION	0.01	2.51	6279.51	0	00:38
H125	JUNCTION	0.00	0.00	6278.00	0	00:00
H120	JUNCTION	0.00	0.00	6278.00	0	00:00
H110	JUNCTION	0.00	0.00	6229.00	0	00:00
BW000	JUNCTION	0.00	0.00	6218.00	0	00:00
BW001	JUNCTION	0.01	1.94	6220.94	0	00:50
BW002	JUNCTION	0.01	1.94	6236.94	0	00:47
E105	JUNCTION	0.00	0.00	6219.00	0	00:00
E115	JUNCTION	0.00	0.00	6219.00	0	00:00
E128	JUNCTION	0.00	0.00	6219.00	0	00:00
E100	JUNCTION	0.00	0.00	6220.00	0	00:00
E110	JUNCTION	0.00	0.00	6220.00	0	00:00
E120	JUNCTION	0.00	0.00	6236.00	0	00:00
E124	JUNCTION	0.00	0.00	6236.00	0	00:00
CT001	JUNCTION	0.00	0.00	6219.00	0	00:00
CT000	JUNCTION	0.00	0.00	6218.00	0	00:00
D110	JUNCTION	0.00	0.00	6220.00	0	00:00
D100	JUNCTION	0.00	0.00	6220.00	0	00:00
D105	JUNCTION	0.00	0.00	6220.00	0	00:00
D115	JUNCTION	0.00	0.00	6219.00	0	00:00
D120	JUNCTION	0.00	0.00	6219.00	0	00:00
D125	JUNCTION	0.00	0.00	6219.00	0	00:00
SP000	JUNCTION	0.03	3.35	5951.35	0	01:01
SP001	JUNCTION	0.03	3.37	5981.37	0	00:55
SP002	JUNCTION	0.02	2.32	6074.32	0	00:52
C115	JUNCTION	0.00	1.11	6013.11	0	00:38
C120	JUNCTION	0.00	0.00	6073.00	0	00:00
C110	JUNCTION	0.00	0.00	5979.00	0	00:00
C100	JUNCTION	0.00	0.00	5949.00	0	00:00
B100	JUNCTION	0.00	0.00	5819.00	0	00:00
SJ001	JUNCTION	0.03	2.89	5876.89	0	00:48
B110	JUNCTION	0.00	0.00	5875.00	0	00:00
SJ002	JUNCTION	0.03	2.55	5886.55	0	01:07
B120	JUNCTION	0.00	0.00	5885.00	0	00:00
SJ003	JUNCTION	0.02	2.27	5905.47	0	01:09
B135	JUNCTION	0.00	0.00	5921.00	0	00:00
B130	JUNCTION	0.00	0.00	5921.00	0	00:00
SJ004	JUNCTION	0.01	1.93	5971.93	0	00:37
B140	JUNCTION	0.00	0.00	5971.00	0	00:00
A160	JUNCTION	0.00	0.00	5925.50	0	00:00
C125	JUNCTION	0.00	0.00	6073.00	0	00:00
NG-OUT	OUTFALL	0.00	0.00	5765.00	0	00:00
NG220	STORAGE	0.06	0.77	6217.47	0	02:43
SJ130	STORAGE	0.08	9.76	5928.46	0	01:09

Table B-8
Sample SWMM Output

```
********************
Node Inflow Summary
********************
```

Node	Type	Maximum Lateral Inflow CFS	Maximum Total Inflow CFS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal
NG001	JUNCTION	0.00	3450.18	0 01:24	0.000	484.101
A100	JUNCTION	168.16	168.16	0 00:45	4.037	4.037
NG000	JUNCTION	0.00	3538.53	0 01:30	0.000	492.474
A104	JUNCTION	38.27	38.27	0 00:44	0.920	0.920
A108	JUNCTION	159.51	159.51	0 00:44	3.751	3.751
A110	JUNCTION	236.01	236.01	0 00:35	3.269	3.269
NG002	JUNCTION	0.00	3442.67	0 01:21	0.000	483.085
SJ000	JUNCTION	0.00	757.65	0 00:58	0.000	28.595
NG003	JUNCTION	0.00	2824.63	0 01:18	0.000	451.039
A115	JUNCTION	214.82	214.82	0 00:39	4.083	4.083
A120	JUNCTION	281.77	281.77	0 00:43	6.184	6.184
A125	JUNCTION	160.69	160.69	0 00:41	3.299	3.299
NG004	JUNCTION	0.00	2659.53	0 01:11	0.000	440.055
A130	JUNCTION	188.29	188.29	0 00:39	3.423	3.423
NG005	JUNCTION	0.00	2493.25	0 01:09	0.000	433.233
A135	JUNCTION	319.78	319.78	0 00:40	5.618	5.618
A140	JUNCTION	165.99	165.99	0 00:41	3.459	3.459
NG006	JUNCTION	0.00	2243.61	0 01:05	0.000	421.270
A145	JUNCTION	172.39	172.39	0 00:35	2.503	2.503
A155	JUNCTION	217.92	217.92	0 00:35	2.980	2.980
A150	JUNCTION	230.85	230.85	0 00:46	5.896	5.896
NG005.5	JUNCTION	0.00	2291.41	0 01:04	0.000	423.774
NG007	JUNCTION	0.00	2018.62	0 01:00	0.000	412.210
A165	JUNCTION	498.01	498.01	0 00:38	7.852	7.852
NG008	JUNCTION	0.00	1780.36	0 00:58	0.000	403.010
A170	JUNCTION	230.01	230.01	0 00:41	4.693	4.693
NG009	JUNCTION	0.00	1028.95	0 02:39	0.000	371.987
A175	JUNCTION	199.40	199.40	0 00:38	3.269	3.269
A180	JUNCTION	301.77	301.77	0 00:41	5.918	5.918
NG011	JUNCTION	0.00	1014.56	0 02:45	0.000	357.029
NG010	JUNCTION	0.00	1027.45	0 02:37	0.000	365.999
A200	JUNCTION	204.52	204.52	0 00:46	5.601	5.601
A190	JUNCTION	93.98	93.98	0 00:51	3.060	3.060
A210	JUNCTION	243.70	243.70	0 00:49	6.792	6.792
A205	JUNCTION	84.60	84.60	0 00:55	3.040	3.040
NG012	JUNCTION	0.00	999.29	0 02:43	0.000	346.741
A220	JUNCTION	2957.75	2957.75	0 01:07	88.127	88.127

Table B-8
Sample SWMM Output

NG013	JUNCTION	0.00	7648.84	0	00:57	0.000	258.664
A221	JUNCTION	58.31	58.31	0	00:37	0.846	0.846
A222	JUNCTION	393.32	393.32	0	00:36	5.378	5.378
A223	JUNCTION	140.08	140.08	0	00:36	1.843	1.843
A224	JUNCTION	72.34	72.34	0	00:41	1.459	1.459
A225	JUNCTION	137.18	137.18	0	00:43	2.954	2.954
A226	JUNCTION	176.66	176.66	0	00:45	4.157	4.157
A227	JUNCTION	300.10	300.10	0	00:36	4.355	4.355
A228	JUNCTION	159.69	159.69	0	00:32	1.847	1.847
NG014	JUNCTION	0.00	3255.89	0	01:03	0.000	101.077
A230	JUNCTION	390.42	390.42	0	00:36	5.788	5.788
NG015	JUNCTION	0.00	3115.67	0	01:01	0.000	95.234
A240	JUNCTION	451.78	451.78	0	00:36	6.747	6.747
NG016	JUNCTION	0.00	2952.78	0	00:58	0.000	88.405
NG017	JUNCTION	0.00	1028.47	0	00:51	0.000	29.020
A250	JUNCTION	107.06	107.06	0	00:48	3.198	3.198
A260	JUNCTION	147.85	147.85	0	00:48	4.255	4.255
NG018	JUNCTION	0.00	932.83	0	00:41	0.000	24.495
A270	JUNCTION	278.64	278.64	0	00:40	5.467	5.467
NG019	JUNCTION	0.00	514.44	0	00:38	0.000	16.556
NG119	JUNCTION	0.00	166.58	0	00:35	0.000	2.400
NG020	JUNCTION	0.00	351.54	0	00:52	0.000	10.307
A280	JUNCTION	484.76	484.76	0	00:34	6.181	6.181
NG021	JUNCTION	0.00	152.09	0	00:53	0.000	4.882
A290	JUNCTION	237.25	237.25	0	00:42	5.377	5.377
A300	JUNCTION	152.09	152.09	0	00:53	4.882	4.882
ST000	JUNCTION	0.00	1427.27	0	00:52	0.000	39.219
ST001	JUNCTION	0.00	1244.02	0	00:49	0.000	34.052
J100	JUNCTION	304.93	304.93	0	00:37	5.040	5.040
J110	JUNCTION	200.11	200.11	0	00:40	3.962	3.962
ST002	JUNCTION	0.00	659.36	0	00:45	0.000	20.359
ST101	JUNCTION	0.00	418.87	0	00:45	0.000	9.630
J130	JUNCTION	590.31	590.31	0	00:33	7.039	7.039
ST003	JUNCTION	0.00	491.30	0	00:51	0.000	13.251
J120	JUNCTION	340.70	340.70	0	00:39	6.317	6.317
A275	JUNCTION	166.58	166.58	0	00:35	2.400	2.400
J140	JUNCTION	252.76	252.76	0	00:38	4.348	4.348
ST004	JUNCTION	0.00	325.66	0	00:51	0.000	8.875
ST005	JUNCTION	0.00	161.08	0	00:45	0.000	4.296
J150	JUNCTION	216.40	216.40	0	00:40	4.481	4.481
J160	JUNCTION	161.08	161.08	0	00:45	4.296	4.296
ST102	JUNCTION	0.00	175.20	0	00:38	0.000	3.052
J155	JUNCTION	175.20	175.20	0	00:38	3.052	3.052
RT000	JUNCTION	0.00	503.71	0	01:04	0.000	16.546
RT001	JUNCTION	0.00	398.85	0	00:56	0.000	12.581
I100	JUNCTION	156.77	156.77	0	00:43	3.790	3.790
I110	JUNCTION	223.17	223.17	0	00:45	5.874	5.874

Table B-8
Sample SWMM Output

RT002	JUNCTION	0.00	207.96	0	00:51	0.000	6.590
I120	JUNCTION	81.60	81.60	0	00:54	2.879	2.879
I115	JUNCTION	127.87	127.87	0	00:49	3.711	3.711
SN000	JUNCTION	0.00	1706.88	0	01:18	0.000	74.027
F106	JUNCTION	229.46	229.46	0	00:38	3.929	3.929
F102	JUNCTION	119.39	119.39	0	00:40	2.305	2.305
F104	JUNCTION	372.68	372.68	0	00:36	5.426	5.426
SN001	JUNCTION	0.00	1563.88	0	01:22	0.000	62.367
SN002	JUNCTION	0.00	963.51	0	01:20	0.000	37.148
F100	JUNCTION	149.78	149.78	0	00:55	5.482	5.482
SN003	JUNCTION	0.00	882.28	0	01:16	0.000	32.001
F110	JUNCTION	249.58	249.58	0	00:40	5.056	5.056
SN004	JUNCTION	0.00	778.56	0	01:10	0.000	25.936
F120	JUNCTION	255.31	255.31	0	00:42	5.779	5.779
F125	JUNCTION	133.06	133.06	0	00:45	3.524	3.524
F130	JUNCTION	121.48	121.48	0	00:51	3.880	3.880
SN005	JUNCTION	0.00	598.39	0	01:01	0.000	18.349
F140	JUNCTION	164.71	164.71	0	00:51	5.211	5.211
SN006	JUNCTION	0.00	465.13	0	00:51	0.000	12.959
F145	JUNCTION	123.12	123.12	0	00:50	3.846	3.846
F150	JUNCTION	127.15	127.15	0	00:51	4.036	4.036
SN007	JUNCTION	0.00	230.22	0	00:42	0.000	4.951
F155	JUNCTION	230.22	230.22	0	00:42	4.951	4.951
MT000	JUNCTION	0.00	597.93	0	01:08	0.000	19.455
G100	JUNCTION	97.93	97.93	0	00:47	2.859	2.859
MT001	JUNCTION	0.00	523.89	0	01:01	0.000	16.483
G110	JUNCTION	147.92	147.92	0	00:45	3.853	3.853
MT002	JUNCTION	0.00	406.05	0	00:55	0.000	12.527
MT003	JUNCTION	0.00	165.26	0	00:48	0.000	4.700
G120	JUNCTION	166.04	166.04	0	00:43	3.920	3.920
G115	JUNCTION	125.05	125.05	0	00:48	3.751	3.751
G130	JUNCTION	165.26	165.26	0	00:48	4.700	4.700
PW000	JUNCTION	0.00	1120.96	0	00:45	0.000	22.934
PW001	JUNCTION	0.00	1046.06	0	00:43	0.000	21.457
H100	JUNCTION	93.48	93.48	0	00:36	1.460	1.460
H115	JUNCTION	150.38	150.38	0	00:49	4.472	4.472
PW002	JUNCTION	0.00	665.92	0	00:38	0.000	11.777
H125	JUNCTION	238.37	238.37	0	00:41	5.201	5.201
H120	JUNCTION	444.33	444.33	0	00:36	6.576	6.576
H110	JUNCTION	324.93	324.93	0	00:37	5.126	5.126
BW000	JUNCTION	0.00	955.89	0	00:45	0.000	22.961
BW001	JUNCTION	0.00	536.24	0	00:47	0.000	13.641
BW002	JUNCTION	0.00	322.59	0	00:47	0.000	8.887
E105	JUNCTION	129.93	129.93	0	00:38	2.040	2.040
E115	JUNCTION	125.91	125.91	0	00:37	1.888	1.888
E128	JUNCTION	199.53	199.53	0	00:47	5.392	5.392
E100	JUNCTION	172.69	172.69	0	00:41	3.714	3.714

Table B-8
Sample SWMM Output

E110	JUNCTION	58.25	58.25	0	00:38	1.034	1.034
E120	JUNCTION	230.98	230.98	0	00:43	5.620	5.620
E124	JUNCTION	99.45	99.45	0	00:53	3.267	3.267
CT001	JUNCTION	0.00	313.01	0	00:45	0.000	8.233
CT000	JUNCTION	0.00	683.71	0	00:41	0.000	14.825
D110	JUNCTION	160.59	160.59	0	00:50	5.064	5.064
D100	JUNCTION	127.44	127.44	0	00:39	2.260	2.260
D105	JUNCTION	38.60	38.60	0	00:43	0.909	0.909
D115	JUNCTION	66.07	66.07	0	00:41	1.327	1.327
D120	JUNCTION	213.54	213.54	0	00:38	3.520	3.520
D125	JUNCTION	106.58	106.58	0	00:38	1.745	1.745
SP000	JUNCTION	0.00	763.03	0	00:59	0.000	23.040
SP001	JUNCTION	0.00	643.64	0	00:55	0.000	19.199
SP002	JUNCTION	0.00	275.83	0	00:52	0.000	9.198
C115	JUNCTION	194.52	194.52	0	00:38	3.540	3.540
C120	JUNCTION	194.75	194.75	0	00:51	6.279	6.279
C110	JUNCTION	274.99	274.99	0	00:42	6.164	6.164
C100	JUNCTION	183.63	183.63	0	00:41	3.729	3.729
B100	JUNCTION	197.39	197.39	0	00:43	4.380	4.380
SJ001	JUNCTION	0.00	637.40	0	00:48	0.000	23.951
B110	JUNCTION	291.58	291.58	0	00:42	6.182	6.182
SJ002	JUNCTION	0.00	382.84	0	01:07	0.000	17.710
B120	JUNCTION	338.85	338.85	0	00:36	4.919	4.919
SJ003	JUNCTION	0.00	321.36	0	01:09	0.000	12.714
B135	JUNCTION	346.08	346.08	0	00:37	5.358	5.358
B130	JUNCTION	223.83	223.83	0	00:38	3.761	3.761
SJ004	JUNCTION	0.00	214.46	0	00:37	0.000	3.379
B140	JUNCTION	214.46	214.46	0	00:37	3.379	3.379
A160	JUNCTION	37.90	37.90	0	00:51	1.230	1.230
C125	JUNCTION	82.11	82.11	0	00:55	2.918	2.918
NG-OUT	OUTFALL	0.00	3538.53	0	01:30	0.000	492.474
NG220	STORAGE	0.00	10361.85	0	01:03	0.000	346.791
SJ130	STORAGE	0.00	644.40	0	00:41	0.000	12.716

Table B-8
Sample SWMM Output

```
**********************
Node Surcharge Summary
**********************

Surcharging occurs when water rises above the top of the highest conduit.
-------------------------------------------------------------------------
                                          Max. Height   Min. Depth
                                Hours     Above Crown    Below Rim
Node                 Type     Surcharged          Feet         Feet
-------------------------------------------------------------------------
A100                 JUNCTION     216.01         0.000        0.000
A104                 JUNCTION     216.01         0.000        0.000
A108                 JUNCTION     216.01         0.000        0.000
A110                 JUNCTION     216.01         0.000        0.000
A120                 JUNCTION     216.01         0.000        0.000
A130                 JUNCTION     216.01         0.000        0.000
A135                 JUNCTION     216.01         0.000        0.000
A140                 JUNCTION     216.01         0.000        0.000
A145                 JUNCTION     216.01         0.000        0.000
A155                 JUNCTION     216.01         0.000        0.000
A150                 JUNCTION     216.01         0.000        0.000
A165                 JUNCTION     216.01         0.000        0.000
A170                 JUNCTION     216.01         0.000        0.000
A175                 JUNCTION     216.01         0.000        0.000
A180                 JUNCTION     216.01         0.000        0.000
A200                 JUNCTION     216.01         0.000        0.000
A190                 JUNCTION     216.01         0.000        0.000
A210                 JUNCTION     216.01         0.000        0.000
A205                 JUNCTION     216.01         0.000        0.000
A220                 JUNCTION     216.01         0.000        0.000
NG013                JUNCTION     216.01         0.000        0.000
A221                 JUNCTION     216.01         0.000        0.000
A222                 JUNCTION     216.01         0.000        0.000
A223                 JUNCTION     216.01         0.000        0.000
A224                 JUNCTION     216.01         0.000        0.000
A225                 JUNCTION     216.01         0.000        0.000
A226                 JUNCTION     216.01         0.000        0.000
A227                 JUNCTION     216.01         0.000        0.000
A228                 JUNCTION     216.01         0.000        0.000
A230                 JUNCTION     216.01         0.000        0.000
A240                 JUNCTION     216.01         0.000        0.000
A250                 JUNCTION     216.01         0.000        0.000
A260                 JUNCTION     216.01         0.000        0.000
A270                 JUNCTION     216.01         0.000        0.000
A280                 JUNCTION     216.01         0.000        0.000
A290                 JUNCTION     216.01         0.000        0.000
A300                 JUNCTION     216.01         0.000        0.000
J100                 JUNCTION     216.01         0.000        0.000
J110                 JUNCTION     216.01         0.000        0.000
J130                 JUNCTION     216.01         0.000        0.000
J120                 JUNCTION     216.01         0.000        0.000
A275                 JUNCTION     216.01         0.000        0.000
J140                 JUNCTION     216.01         0.000        0.000
J150                 JUNCTION     216.01         0.000        0.000
J160                 JUNCTION     216.01         0.000        0.000
J155                 JUNCTION     216.01         0.000        0.000
I100                 JUNCTION     216.01         0.000        0.000
I110                 JUNCTION     216.01         0.000        0.000
I120                 JUNCTION     216.01         0.000        0.000
I115                 JUNCTION     216.01         0.000        0.000
SN000                JUNCTION     216.01         0.000        0.000
F106                 JUNCTION     216.01         0.000        0.000
F102                 JUNCTION     216.01         0.000        0.000
F104                 JUNCTION     216.01         0.000        0.000
F100                 JUNCTION     216.01         0.000        0.000
F110                 JUNCTION     216.01         0.000        0.000
F120                 JUNCTION     216.01         0.000        0.000
F125                 JUNCTION     216.01         0.000        0.000
F130                 JUNCTION     216.01         0.000        0.000
F140                 JUNCTION     216.01         0.000        0.000
F145                 JUNCTION     216.01         0.000        0.000
F150                 JUNCTION     216.01         0.000        0.000
F155                 JUNCTION     216.01         0.000        0.000
G100                 JUNCTION     216.01         0.000        0.000
G110                 JUNCTION     216.01         0.000        0.000
G120                 JUNCTION     216.01         0.000        0.000
G115                 JUNCTION     216.01         0.000        0.000
G130                 JUNCTION     216.01         0.000        0.000
H100                 JUNCTION     216.01         0.000        0.000
H115                 JUNCTION     216.01         0.000        0.000
H125                 JUNCTION     216.01         0.000        0.000
H120                 JUNCTION     216.01         0.000        0.000
H110                 JUNCTION     216.01         0.000        0.000
BW000                JUNCTION     216.01         0.000        0.000
E105                 JUNCTION     216.01         0.000        0.000
E115                 JUNCTION     216.01         0.000        0.000
E128                 JUNCTION     216.01         0.000        0.000
E100                 JUNCTION     216.01         0.000        0.000
E110                 JUNCTION     216.01         0.000        0.000
E120                 JUNCTION     216.01         0.000        0.000
E124                 JUNCTION     216.01         0.000        0.000
CT001                JUNCTION     216.01         0.000        0.000
CT000                JUNCTION     216.01         0.000        0.000
D110                 JUNCTION     216.01         0.000        0.000
```

Table B-8
Sample SWMM Output

```
D100                JUNCTION      216.01          0.000          0.000
D105                JUNCTION      216.01          0.000          0.000
D115                JUNCTION      216.01          0.000          0.000
D120                JUNCTION      216.01          0.000          0.000
D125                JUNCTION      216.01          0.000          0.000
C120                JUNCTION      216.01          0.000          0.000
C110                JUNCTION      216.01          0.000          0.000
C100                JUNCTION      216.01          0.000          0.000
B100                JUNCTION      216.01          0.000          0.000
B110                JUNCTION      216.01          0.000          0.000
B120                JUNCTION      216.01          0.000          0.000
B135                JUNCTION      216.01          0.000          0.000
B130                JUNCTION      216.01          0.000          0.000
B140                JUNCTION      216.01          0.000          0.000
A160                JUNCTION      216.01          0.000          0.000
C125                JUNCTION      216.01          0.000          0.000
NG220               STORAGE       216.01          0.772          7.228


  ********************
  Node Flooding Summary
  ********************

  No nodes were flooded.


  **********************
  Storage Volume Summary
  **********************

  ------------------------------------------------------------------------------
------------
                           Average     Avg   E&I        Maximum     Max    Time of
Max    Maximum
                            Volume    Pcnt   Pcnt         Volume    Pcnt
Occurrence    Outflow
  Storage Unit          1000 ft3    Full   Loss      1000 ft3    Full    days
hr:min        CFS
  ------------------------------------------------------------------------------
------------
  NG220                 2952.271       1      0     39166.232       9       0
02:43     999.29
  SJ130                    3.991       0      0       705.859       0       0
01:08     321.36


  ************************
```

```
Outfall Loading Summary
***********************

-----------------------------------------------------------
                     Flow      Avg.      Max.       Total
                     Freq.     Flow      Flow      Volume
Outfall Node         Pcnt.      CFS       CFS    10^6 gal
-----------------------------------------------------------
NG-OUT               91.89    92.14   3538.53     492.474
-----------------------------------------------------------
System               91.89    92.14   3538.53     492.474


********************
Link Flow Summary
********************

-------------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                 |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CFS  days hr:min    ft/sec    Flow   Depth
-------------------------------------------------------------------------------
A10                  CONDUIT   3422.70     0  01:31      5.70    0.09    0.26
A10.4                CONDUIT   3434.27     0  01:25      5.46    0.16    0.39
A100-DF              DUMMY      168.16     0  00:45
A104-DF              DUMMY       38.27     0  00:44
A108-DF              DUMMY      159.51     0  00:44
A11                  CONDUIT   2807.68     0  01:23      4.80    0.18    0.43
A110-DF              DUMMY      236.01     0  00:35
A115                 CONDUIT    211.07     0  00:43      3.91    0.04    0.25
A12                  CONDUIT   2609.65     0  01:19      4.64    0.38    0.60
A14                  CONDUIT   2271.72     0  01:11      5.41    0.14    0.34
A14.5                CONDUIT   2243.62     0  01:05      4.90    0.16    0.36
A120-DF              DUMMY      281.77     0  00:43
A125                 CONDUIT    157.93     0  00:45      3.23    0.02    0.17
A13                  CONDUIT   2487.89     0  01:12      4.36    0.22    0.44
A130-DF              DUMMY      188.29     0  00:39
A135-DF              DUMMY      319.78     0  00:40
A140-DF              DUMMY      165.99     0  00:41
A145-DF              DUMMY      172.39     0  00:35
A15                  CONDUIT   2006.08     0  01:05      4.93    0.12    0.31
A150-DF              DUMMY      230.85     0  00:46
A155-DF              DUMMY      217.92     0  00:35
A16                  CONDUIT   1769.15     0  01:03      4.01    0.09    0.29
A160-DF              DUMMY       37.90     0  00:51
A165-DF              DUMMY      498.01     0  00:38
A17                  CONDUIT   1028.90     0  02:41      4.30    0.06    0.21
```

Table B-8
Sample SWMM Output

A170-DF	DUMMY	230.01	0	00:41				BW-OUT	DUMMY	955.89	0	00:45			
A175-DF	DUMMY	199.40	0	00:38				C10	CONDUIT	636.12	0	01:01	4.44	0.11	0.33
A180-DF	DUMMY	301.77	0	00:41				C100-DF	DUMMY	183.63	0	00:41			
A19	CONDUIT	1027.27	0	02:41	4.49	0.09	0.25	C11	CONDUIT	264.43	0	01:04	4.13	0.05	0.23
A190-DF	DUMMY	93.98	0	00:51				C11.5	CONDUIT	176.06	0	00:50	2.31	0.01	0.10
A20	CONDUIT	1014.36	0	02:52	3.54	0.03	0.15	C110-DF	DUMMY	274.99	0	00:42			
A200-DF	DUMMY	204.52	0	00:46				C120-DF	DUMMY	194.75	0	00:51			
A205-DF	DUMMY	84.60	0	00:55				C125-DF	DUMMY	82.11	0	00:55			
A21	CONDUIT	998.16	0	02:55	3.74	0.01	0.08	CT-OUT	DUMMY	683.71	0	00:41			
A210-DF	DUMMY	243.70	0	00:49				D10	DUMMY	313.01	0	00:45			
A22	DUMMY	3255.89	0	01:03				D100-DF	DUMMY	127.44	0	00:39			
A220-DF	DUMMY	2957.75	0	01:07				D105-DF	DUMMY	38.60	0	00:43			
A221-DF	DUMMY	58.31	0	00:37				D110-DF	DUMMY	160.59	0	00:50			
A222-DF	DUMMY	393.32	0	00:36				D115-DF	DUMMY	66.07	0	00:41			
A223-DF	DUMMY	140.08	0	00:36				D120-DF	DUMMY	213.54	0	00:38			
A224-DF	DUMMY	72.34	0	00:41				D125-DF	DUMMY	106.58	0	00:38			
A225-DF	DUMMY	137.18	0	00:43				E10.5	DUMMY	536.24	0	00:47			
A226-DF	DUMMY	176.66	0	00:45				E100-DF	DUMMY	172.69	0	00:41			
A227-DF	DUMMY	300.10	0	00:36				E105-DF	DUMMY	129.93	0	00:38			
A228-DF	DUMMY	159.69	0	00:32				E11	CONDUIT	321.54	0	00:50	3.08	0.03	0.19
A23	CONDUIT	3108.70	0	01:04	6.05	0.18	0.42	E110-DF	DUMMY	58.25	0	00:38			
A230-DF	DUMMY	390.42	0	00:36				E115-DF	DUMMY	125.91	0	00:37			
A24	CONDUIT	2939.51	0	01:02	5.30	0.20	0.45	E120-DF	DUMMY	230.98	0	00:43			
A240-DF	DUMMY	451.78	0	00:36				E124-DF	DUMMY	99.45	0	00:53			
A25	CONDUIT	988.36	0	01:01	4.36	0.08	0.29	E128-DF	DUMMY	199.53	0	00:47			
A250-DF	DUMMY	107.06	0	00:48				F10	CONDUIT	948.43	0	01:28	4.17	0.07	0.27
A26	CONDUIT	882.86	0	00:51	4.11	0.06	0.26	F10.2	DUMMY	1563.88	0	01:22			
A260-DF	DUMMY	147.85	0	00:48				F100-DF	DUMMY	149.78	0	00:55			
A27	CONDUIT	506.04	0	00:51	4.48	0.04	0.21	F102-DF	DUMMY	119.39	0	00:40			
A27.5	CONDUIT	157.55	0	00:40	4.30	0.01	0.12	F104-DF	DUMMY	372.68	0	00:36			
A270-DF	DUMMY	278.64	0	00:40				F106-DF	DUMMY	229.46	0	00:38			
A275-DF	DUMMY	166.58	0	00:35				F11	CONDUIT	875.41	0	01:22	4.21	0.08	0.31
A28	CONDUIT	345.28	0	00:59	3.34	0.03	0.21	F110-DF	DUMMY	249.58	0	00:40			
A280-DF	DUMMY	484.76	0	00:34				F12	CONDUIT	758.77	0	01:20	3.79	0.06	0.24
A29	CONDUIT	149.52	0	00:59	2.94	0.01	0.10	F120-DF	DUMMY	255.31	0	00:42			
A290-DF	DUMMY	237.25	0	00:42				F125-DF	DUMMY	133.06	0	00:45			
A300-DF	DUMMY	152.09	0	00:53				F13	CONDUIT	576.95	0	01:13	3.81	0.06	0.29
B10	CONDUIT	603.39	0	01:00	4.23	0.07	0.28	F130-DF	DUMMY	121.48	0	00:51			
B100-DF	DUMMY	197.39	0	00:43				F14	CONDUIT	444.29	0	01:02	3.39	0.05	0.28
B11	CONDUIT	380.45	0	01:13	2.28	0.05	0.25	F140-DF	DUMMY	164.71	0	00:51			
B110-DF	DUMMY	291.58	0	00:42				F145-DF	DUMMY	123.12	0	00:50			
B12	CONDUIT	316.39	0	01:17	2.50	0.04	0.22	F15	CONDUIT	215.89	0	00:52	3.21	0.02	0.18
B120-DF	DUMMY	338.85	0	00:36				F150-DF	DUMMY	127.15	0	00:51			
B13	CONDUIT	170.17	0	00:51	3.29	0.03	0.17	F155-DF	DUMMY	230.22	0	00:42			
B130-DF	DUMMY	223.83	0	00:38				G10	CONDUIT	517.18	0	01:09	3.28	0.04	0.23
B135-DF	DUMMY	346.08	0	00:37				G100-DF	DUMMY	97.93	0	00:47			
B140-DF	DUMMY	214.46	0	00:37				G11	CONDUIT	399.71	0	01:03	3.25	0.03	0.22

Table B-8
Sample SWMM Output

G110-DF	DUMMY	147.92	0	00:45			
G115-DF	DUMMY	125.05	0	00:48			
G12	CONDUIT	152.63	0	01:03	2.88	0.01	0.14
G120-DF	DUMMY	166.04	0	00:43			
G130-DF	DUMMY	165.26	0	00:48			
H10	CONDUIT	1041.74	0	00:45	4.18	0.07	0.26
H100-DF	DUMMY	93.48	0	00:36			
H11	CONDUIT	622.77	0	00:44	4.02	0.04	0.24
H110-DF	DUMMY	324.93	0	00:37			
H115-DF	DUMMY	150.38	0	00:49			
H120-DF	DUMMY	444.33	0	00:36			
H125-DF	DUMMY	238.37	0	00:41			
I10	CONDUIT	386.43	0	01:07	3.42	0.04	0.21
I100-DF	DUMMY	156.77	0	00:43			
I11	CONDUIT	200.89	0	01:01	3.17	0.02	0.14
I110-DF	DUMMY	223.17	0	00:45			
I115-DF	DUMMY	127.87	0	00:49			
I120-DF	DUMMY	81.60	0	00:54			
J10	CONDUIT	1231.42	0	00:55	5.76	0.09	0.32
J100-DF	DUMMY	304.93	0	00:37			
J11	CONDUIT	658.17	0	00:49	4.22	0.06	0.27
J11.5	CONDUIT	413.15	0	00:52	3.78	0.02	0.15
J110-DF	DUMMY	200.11	0	00:40			
J12	CONDUIT	139.21	0	00:55	2.51	0.01	0.09
J120-DF	DUMMY	340.70	0	00:39			
J13	CONDUIT	482.88	0	00:58	4.09	0.07	0.28
J130-DF	DUMMY	590.31	0	00:33			
J14	CONDUIT	321.38	0	00:57	3.26	0.03	0.22
J140-DF	DUMMY	252.76	0	00:38			
J15	CONDUIT	150.58	0	00:58	2.92	0.01	0.12
J150-DF	DUMMY	216.40	0	00:40			
J155-DF	DUMMY	175.20	0	00:38			
J160-DF	DUMMY	161.08	0	00:45			
MT-OUT	DUMMY	597.93	0	01:08			
NG220-IN	DUMMY	7648.84	0	00:57			
NG-OUT	DUMMY	3538.53	0	01:30			
PW-OUT	DUMMY	1120.96	0	00:45			
RT-OUT	DUMMY	503.71	0	01:04			
SJ-OUT	DUMMY	757.65	0	00:58			
SN-OUT	DUMMY	1706.88	0	01:18			
SP-OUT	DUMMY	763.03	0	00:59			
ST-OUT	DUMMY	1427.27	0	00:52			
NG220-OUT	DUMMY	999.29	0	02:43			
SJ130-OUT	DUMMY	321.36	0	01:09			

****

Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
A100-DF	0.01	0.01	0.01	216.01	0.01
A104-DF	0.01	0.01	0.01	216.01	0.01
A108-DF	0.01	0.01	0.01	216.01	0.01
A110-DF	0.01	0.01	0.01	216.01	0.01
A120-DF	0.01	0.01	0.01	216.01	0.01
A130-DF	0.01	0.01	0.01	216.01	0.01
A135-DF	0.01	0.01	0.01	216.01	0.01
A140-DF	0.01	0.01	0.01	216.01	0.01
A145-DF	0.01	0.01	0.01	216.01	0.01
A150-DF	0.01	0.01	0.01	216.01	0.01
A155-DF	0.01	0.01	0.01	216.01	0.01
A160-DF	0.01	0.01	0.01	216.01	0.01
A165-DF	0.01	0.01	0.01	216.01	0.01
A170-DF	0.01	0.01	0.01	216.01	0.01
A175-DF	0.01	0.01	0.01	216.01	0.01
A180-DF	0.01	0.01	0.01	216.01	0.01
A190-DF	0.01	0.01	0.01	216.01	0.01
A200-DF	0.01	0.01	0.01	216.01	0.01
A205-DF	0.01	0.01	0.01	216.01	0.01
A210-DF	0.01	0.01	0.01	216.01	0.01
A22	0.01	0.01	0.01	216.01	0.01
A220-DF	0.01	0.01	0.01	216.01	0.01
A221-DF	0.01	0.01	0.01	216.01	0.01
A222-DF	0.01	0.01	0.01	216.01	0.01
A223-DF	0.01	0.01	0.01	216.01	0.01
A224-DF	0.01	0.01	0.01	216.01	0.01
A225-DF	0.01	0.01	0.01	216.01	0.01
A226-DF	0.01	0.01	0.01	216.01	0.01
A227-DF	0.01	0.01	0.01	216.01	0.01
A228-DF	0.01	0.01	0.01	216.01	0.01
A230-DF	0.01	0.01	0.01	216.01	0.01
A240-DF	0.01	0.01	0.01	216.01	0.01
A250-DF	0.01	0.01	0.01	216.01	0.01
A260-DF	0.01	0.01	0.01	216.01	0.01
A270-DF	0.01	0.01	0.01	216.01	0.01
A275-DF	0.01	0.01	0.01	216.01	0.01
A280-DF	0.01	0.01	0.01	216.01	0.01
A290-DF	0.01	0.01	0.01	216.01	0.01
A300-DF	0.01	0.01	0.01	216.01	0.01

Table B-8
Sample SWMM Output

B100-DF	0.01	0.01	0.01	216.01	0.01	H115-DF	0.01	0.01	0.01	216.01	0.01
B110-DF	0.01	0.01	0.01	216.01	0.01	H120-DF	0.01	0.01	0.01	216.01	0.01
B120-DF	0.01	0.01	0.01	216.01	0.01	H125-DF	0.01	0.01	0.01	216.01	0.01
B130-DF	0.01	0.01	0.01	216.01	0.01	I100-DF	0.01	0.01	0.01	216.01	0.01
B135-DF	0.01	0.01	0.01	216.01	0.01	I110-DF	0.01	0.01	0.01	216.01	0.01
B140-DF	0.01	0.01	0.01	216.01	0.01	I115-DF	0.01	0.01	0.01	216.01	0.01
BW-OUT	0.01	0.01	0.01	216.01	0.01	I120-DF	0.01	0.01	0.01	216.01	0.01
C100-DF	0.01	0.01	0.01	216.01	0.01	J100-DF	0.01	0.01	0.01	216.01	0.01
C110-DF	0.01	0.01	0.01	216.01	0.01	J110-DF	0.01	0.01	0.01	216.01	0.01
C120-DF	0.01	0.01	0.01	216.01	0.01	J120-DF	0.01	0.01	0.01	216.01	0.01
C125-DF	0.01	0.01	0.01	216.01	0.01	J130-DF	0.01	0.01	0.01	216.01	0.01
CT-OUT	0.01	0.01	0.01	216.01	0.01	J140-DF	0.01	0.01	0.01	216.01	0.01
D10	0.01	0.01	0.01	216.01	0.01	J150-DF	0.01	0.01	0.01	216.01	0.01
D100-DF	0.01	0.01	0.01	216.01	0.01	J155-DF	0.01	0.01	0.01	216.01	0.01
D105-DF	0.01	0.01	0.01	216.01	0.01	J160-DF	0.01	0.01	0.01	216.01	0.01
D110-DF	0.01	0.01	0.01	216.01	0.01	MT-OUT	0.01	0.01	0.01	216.01	0.01
D115-DF	0.01	0.01	0.01	216.01	0.01	NG220-IN	0.01	0.01	0.01	216.01	0.01
D120-DF	0.01	0.01	0.01	216.01	0.01	NG-OUT	0.01	0.01	0.01	216.01	0.01
D125-DF	0.01	0.01	0.01	216.01	0.01	PW-OUT	0.01	0.01	0.01	216.01	0.01
E10.5	0.01	0.01	0.01	216.01	0.01	RT-OUT	0.01	0.01	0.01	216.01	0.01
E100-DF	0.01	0.01	0.01	216.01	0.01	SJ-OUT	0.01	0.01	0.01	216.01	0.01
E105-DF	0.01	0.01	0.01	216.01	0.01	SN-OUT	0.01	0.01	0.01	216.01	0.01
E110-DF	0.01	0.01	0.01	216.01	0.01	SP-OUT	0.01	0.01	0.01	216.01	0.01
E115-DF	0.01	0.01	0.01	216.01	0.01	ST-OUT	0.01	0.01	0.01	216.01	0.01
E120-DF	0.01	0.01	0.01	216.01	0.01						
E124-DF	0.01	0.01	0.01	216.01	0.01						
E128-DF	0.01	0.01	0.01	216.01	0.01	Analysis begun on: Thu Mar 05 10:29:17 2015					
F10.2	0.01	0.01	0.01	216.01	0.01	Analysis ended on: Thu Mar 05 10:29:19 2015					
F100-DF	0.01	0.01	0.01	216.01	0.01	Total elapsed time: 00:00:02					
F102-DF	0.01	0.01	0.01	216.01	0.01						
F104-DF	0.01	0.01	0.01	216.01	0.01						
F106-DF	0.01	0.01	0.01	216.01	0.01						
F110-DF	0.01	0.01	0.01	216.01	0.01						
F120-DF	0.01	0.01	0.01	216.01	0.01						
F125-DF	0.01	0.01	0.01	216.01	0.01						
F130-DF	0.01	0.01	0.01	216.01	0.01						
F140-DF	0.01	0.01	0.01	216.01	0.01						
F145-DF	0.01	0.01	0.01	216.01	0.01						
F150-DF	0.01	0.01	0.01	216.01	0.01						
F155-DF	0.01	0.01	0.01	216.01	0.01						
G100-DF	0.01	0.01	0.01	216.01	0.01						
G110-DF	0.01	0.01	0.01	216.01	0.01						
G115-DF	0.01	0.01	0.01	216.01	0.01						
G120-DF	0.01	0.01	0.01	216.01	0.01						
G130-DF	0.01	0.01	0.01	216.01	0.01						
H100-DF	0.01	0.01	0.01	216.01	0.01						
H110-DF	0.01	0.01	0.01	216.01	0.01						

Select tables from September 2012 draft of Chapter 4 – Rainfall, Urban Storm Drainage Criteria Manual Volume I

Table 4-1. Storm Duration and Area Adjustment for CUHP Modeling

Design Storm	Watershed Area (square miles)	Suggested Minimum Storm Duration	Apply DRF?
2-, 5-, and 10-Year	A ≤ 2.0	2 hours	No
	2.0 < A < 15.0	2 hours	Yes – Use Table 4-3
	A ≥ 15.0	6 hours	Yes – Use Table 4-3
25-, 50-, 100-, and 500-Year	A < 15.0	2 hours	No
	A ≥ 15.0	6 hours	Yes – Use Table 4-4

Table 4-3. DRFs for Design Rainfall Distributions 2-, 5-, and 10-Year Design Rainfall

Time (minutes)	Correction Factor by Watershed Area in Square Miles[1]								
	2	5	10	15	20	30	40	50	75
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	0.97	0.94	0.91	0.90	0.85	0.75	0.65	0.56
20	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.35
25	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.35
30	1.00	0.86	0.75	0.68	0.61	0.55	0.48	0.42	0.42
35	1.00	0.97	0.94	0.91	0.90	0.90	0.90	0.90	0.89
40	1.00	0.97	0.94	0.91	0.90	0.90	0.90	0.90	0.89
45	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
50	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
55	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
60	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
65	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
70	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
75	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
80	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
85	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
90	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
95	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
100	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
105	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
110	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
115	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
120	1.00	1.00	1.00	1.02	1.02	1.01	1.01	1.01	1.00
125-180	N/A	N/A	N/A	1.00	1.00	1.00	1.00	1.00	1.00
185-360	N/A	N/A	N/A	1.23	1.28	1.30	1.32	1.33	1.33

[1]For areas between the values listed in the table, correction factors can be obtained through linear interpolation between columns.

Table 4-4. DRFs for Design Rainfall Distributions 25-, 50-, 100-, and 500-Year Design Rainfall

Time (minutes)	Correction Factor by Watershed Area in Square Miles[1]					
	15	20	30	40	50	75
5	1.15	1.15	1.15	1.15	1.15	1.10
10	1.15	1.15	1.15	1.15	1.15	1.10
15	1.15	1.15	1.15	1.15	1.15	1.10
20	1.25	1.18	1.10	1.05	1.00	0.90
25	0.73	0.69	0.64	0.60	0.58	0.55
30	0.73	0.69	0.64	0.60	0.58	0.55
35	0.73	0.69	0.64	0.60	0.58	0.55
40	1.05	1.02	0.95	0.90	0.85	0.80
45	1.20	1.20	1.20	1.15	1.05	0.95
50	1.15	1.15	1.15	1.15	1.05	0.95
55	1.15	1.15	1.15	1.15	1.15	1.15
60	1.15	1.15	1.15	1.15	1.15	1.15
65	1.08	1.10	1.13	1.15	1.15	1.15
70	1.08	1.10	1.13	1.15	1.15	1.15
75	1.08	1.10	1.13	1.15	1.15	1.15
80	1.08	1.10	1.13	1.15	1.15	1.15
85	1.08	1.10	1.13	1.15	1.15	1.15
90	1.08	1.10	1.13	1.15	1.15	1.15
95	1.08	1.10	1.13	1.15	1.15	1.15
100	1.08	1.10	1.13	1.15	1.15	1.15
105	1.08	1.10	1.13	1.15	1.15	1.15
110	1.08	1.10	1.13	1.15	1.15	1.15
115	1.08	1.10	1.13	1.15	1.15	1.15
120	1.08	1.10	1.13	1.15	1.15	1.15
125-180	1.08	1.10	1.13	1.15	1.25	1.25
185-360	1.05	1.10	1.10	1.10	1.10	1.13

[1]For areas between the values listed in the table, correction factors can be obtained through linear interpolation between columns.

Appendix C

RUETER-HESS RESERVOIR ROUTING ANALYSIS

MEMORANDUM

To: Shea Thomas and Bill DeGroot / UDFCD
Fred Koch and Brad Robenstein / Douglas County
Tom Williams and Jacob James / Town of Parker

From: Derek Johns / Muller Engineering Company
Jim Wulliman / Muller Engineering Company

Date: May 30, 2013

Project #: 12-050.01

Re: Newlin Gulch Major Drainageway Planning Study,
Rueter-Hess Reservoir Flood Control Benefits

MULLER
Muller Engineering Company, Inc.
Consulting Engineers

777 S. Wadsworth Blvd. #4-100
Lakewood, Colorado 80226
303/988-4969 FAX
303/988-4939
www.mullereng.com

Introduction

This memorandum documents the initial results of a baseline hydrology evaluation completed for the Newlin Gulch watershed located in Douglas County. This work was completed as one of the first components of the Major Drainageway Planning (MDP) study that is currently underway for the Newlin Gulch watershed. One of the key objectives of the MDP is to update hydrologic information provided in the previous Outfall Systems Planning (OSP) study completed in 1993 for the watershed. In addition, hydrologic results will be compared to the 1977 Flood Hazard Area Delineation (FHAD) study which is the basis for the current regulatory floodplain along Newlin Gulch.

The primary issues involved in updating the Newlin Gulch hydrology was to incorporate land use changes in the watershed and evaluate the impacts of Rueter-Hess Reservoir, a large water supply reservoir that was recently constructed on Newlin Gulch. The older OSP and FHAD studies were both completed prior to construction of Rueter-Hess Reservoir and don't recognize any flood detention benefits.

The following sections include a summary of land use changes in the watershed, describe key features of Rueter-Hess Reservoir, document the hydrologic evaluation, and summarize the impacts and flood detention benefits associated with Rueter-Hess Reservoir.

Land Use Changes

Since 1993, there have been significant changes in the existing land use and the projected future land use within the watershed. To-date, most of the development has occurred in the lower portion of the watershed in or near the Town of Parker. Existing imperviousness values in the watershed have been updated based on 2012 aerial photography and information provided in land development drainage reports. Based on this information, the composite watershed imperviousness for existing conditions is currently 22.5%. This value accounts for the Rueter-Hess Reservoir maximum normal pool being at 100% imperviousness. If the reservoir pool is excluded, the composite watershed imperviousness for existing conditions is 12%. In the 1993 OSP, the existing imperviousness was reported to be 4.9%.

The future land use conditions are projected to be much higher than the estimates in the 1993 OSP. In the 1993 OSP, future land use in the upper portion of the watershed was projected to consist primarily of open space and large lot residential development and the overall composite imperviousness cover was estimated to be 12.6%. Based on new land use information provided by the Town of Parker, Douglas County, and the City of Castle Pines, more land development is planned and at higher densities than

what was estimated in 1993. As shown on the Future Land Use Map (Figure 1), there is a significant amount of development ranging from medium density residential areas (40% imperviousness) to business/commercial areas (85 to 90% imperviousness) that is planned in the upper portion of the watershed in Castle Pines. This includes the 3300-acre Canyons residential development that is planned immediately upstream of Rueter-Hess Reservoir along with Castle Pines Town Center and Lagae Ranch developments near I-25. In the lower portion of the watershed (below Rueter-Hess Reservoir), future developments that are planned include the Meridian Business Park (75% imperviousness) and several residential developments. Based on this new land use information, the composite watershed imperviousness for future conditions is estimated to be 35% (26% without Rueter-Hess) which is almost 3 times higher than the 12.6% imperviousness assumed in the 1993 OSP.

Rueter-Hess Reservoir

Rueter-Hess Reservoir is a water supply reservoir owned by Parker Water and Sanitation District (PWSD). It is located on the mainstem of Newlin Gulch in the central portion of the watershed. The construction of the reservoir was completed in 2012 and consists of a 170-foot tall earthen dam that is designed to store 72,000 acre-feet of water. Once it is filled to its maximum normal pool, the reservoir footprint will cover 1.8 square miles or approximately 12% of the entire Newlin Gulch watershed. The reservoir was built for water supply storage and not flood control.

Service Spillway. Outflows from Rueter-Hess reservoir are controlled through a multi-chambered tower that connects to two outlet conduits. The service spillway is comprised of two of the upper chambers on the outlet works tower, each approximately10-feet wide and 5-feet tall. The maximum normal pool elevation for the reservoir is elevation 6215.1 (NAVD88) which is equal to the crest of the service spillway. According to an evaluation conducted by the reservoir design engineer, the service spillway can convey both the 100-year and 500-year storm events.

Auxiliary Spillway. The auxiliary (or emergency) spillway consists of a large concrete labyrinth weir located on the west abutment of the dam. The auxiliary spillway crest is at elevation 6216.7 which is 1.6-feet above the service spillway crest. The auxiliary spillway is designed to convey extreme flood events (greater that the 500-year).

Hydrologic Evaluation

The hydrologic evaluation for the Newlin Gulch watershed was based on updated topographic mapping and land use information. A new subwatershed delineation was performed using the more current mapping and in accordance with UDFCD guidelines to keep the average subwatershed size to approximately 100-acres. The new delineation resulted in subdividing the 15.0 square mile watershed into 111 subwatersheds with an average subwatershed size of approximately 90-acres.

Percent imperviousness values for the subwatersheds were based on the most current land use information for both existing and future conditions. Hydrographs for the subwatersheds were generated using the Colorado Urban Hydrograph Procedure (CUHP). The hydrographs were then routed through the drainageway network using EPA's Storm Water Management Model (SWMM). The SWMM model was also used to evaluate the impacts of routing flood flows through Rueter-Hess Reservoir. Storage/discharge data for the reservoir was incorporated into the SWMM model based on rating curve tables shown on a record drawing provided by PWSD.

The hydrologic modeling was completed for the 100-year event based on future land use conditions. To evaluate the impacts of Rueter-Hess Reservoir, the modeling was performed for conditions with and without the reservoir. The assumptions for these two conditions are described below.

Memorandum
May 30, 2013

With Rueter-Hess Reservoir. This option accounts for the inherent flood detention/attenuation that the reservoir currently provides.

1. It was decided by the project sponsors to ignore the service spillway and route flows only through the auxiliary spillway. This is a more conservative approach. However, this option would allow some flexibility for future changes to the service spillway configuration.
2. The reservoir was assumed to be full to the auxiliary spillway crest (elevation 6216.7) prior to the storm event. The reservoir subwatershed was modeled at 100% imperviousness.
3. The resulting 100-year peak discharges for this option are presented in Figure 2 and show that discharges downstream of the reservoir would be lower than both the 1977 FHAD and the 1993 OSP discharges. The reservoir surcharge (rise in water level) for this option in the 100-year event would be approximately 0.8-feet.

With-Out Rueter-Hess Reservoir. This option assumes that Rueter-Hess Reservoir is not in place, so there is no reservoir pool or flood detention routing.

1. The reservoir subwatershed was modeled based on historic topographic conditions and 2% imperviousness.
2. The resulting 100-year peak discharges from this option are also shown on Figure 2 and indicate that peak flows are 250 to 750% higher than the "With Rueter-Hess Reservoir" option, 160% percent higher the 1993 OSP discharges, and 190% higher than the 1977 FHAD discharges.

Flood Control Benefits of Rueter-Hess Reservoir

This hydrologic evaluation shows that Rueter-Hess Reservoir provides substantial reductions in peak flood discharges in Newlin Gulch. The reduction in flood discharges is inherent because the reservoir surface area is so large relative to the upstream watershed. In addition, these flood detention benefits occur with the current reservoir configuration and no impacts to reservoir operations or water storage volume.

Recognizing the lower flood discharges from Rueter-Hess Reservoir would provide several benefits for the Newlin Gulch watershed. These benefits include:

1. Prevent Expansion of Regulatory Floodplain: Figure 3 shows a sample map of the 100-year regulatory floodplain in Stonegate Village located downstream of Rueter-Hess Reservoir. The map shows that the regulatory floodplain is in close proximity to the existing residential lots. Recognizing the flood peak reduction from Rueter-Hess Reservoir would maintain discharges below the current regulatory discharges and, therefore, prevent the expansion of the floodplain into residential and commercial properties. If the flood discharge reduction from RH reservoir is not recognized, then the 100-year regulatory discharges would increase by a factor of 2 as shown in the "Without RH Reservoir" option and result in a wider floodplain that would encroach onto numerous residential and commercial properties.
2. Avoid Increases to Flood Insurance Rates: If the floodplain were to expand, flood insurance premium rates for properties would likely increase. Recognizing the lower flood discharges would prevent this situation from occurring.
3. Avoid Lowering Property Values: If the floodplain were to expand, it is possible that property values would decrease. In addition, infrastructure improvements for properties within the expanded floodplain could be limited by floodplain regulations (i.e., it may be prohibited or more costly for a property owner to expand or modify a home or building). Recognizing the lower flood discharges would prevent this from occurring.

Memorandum
May 30, 2013

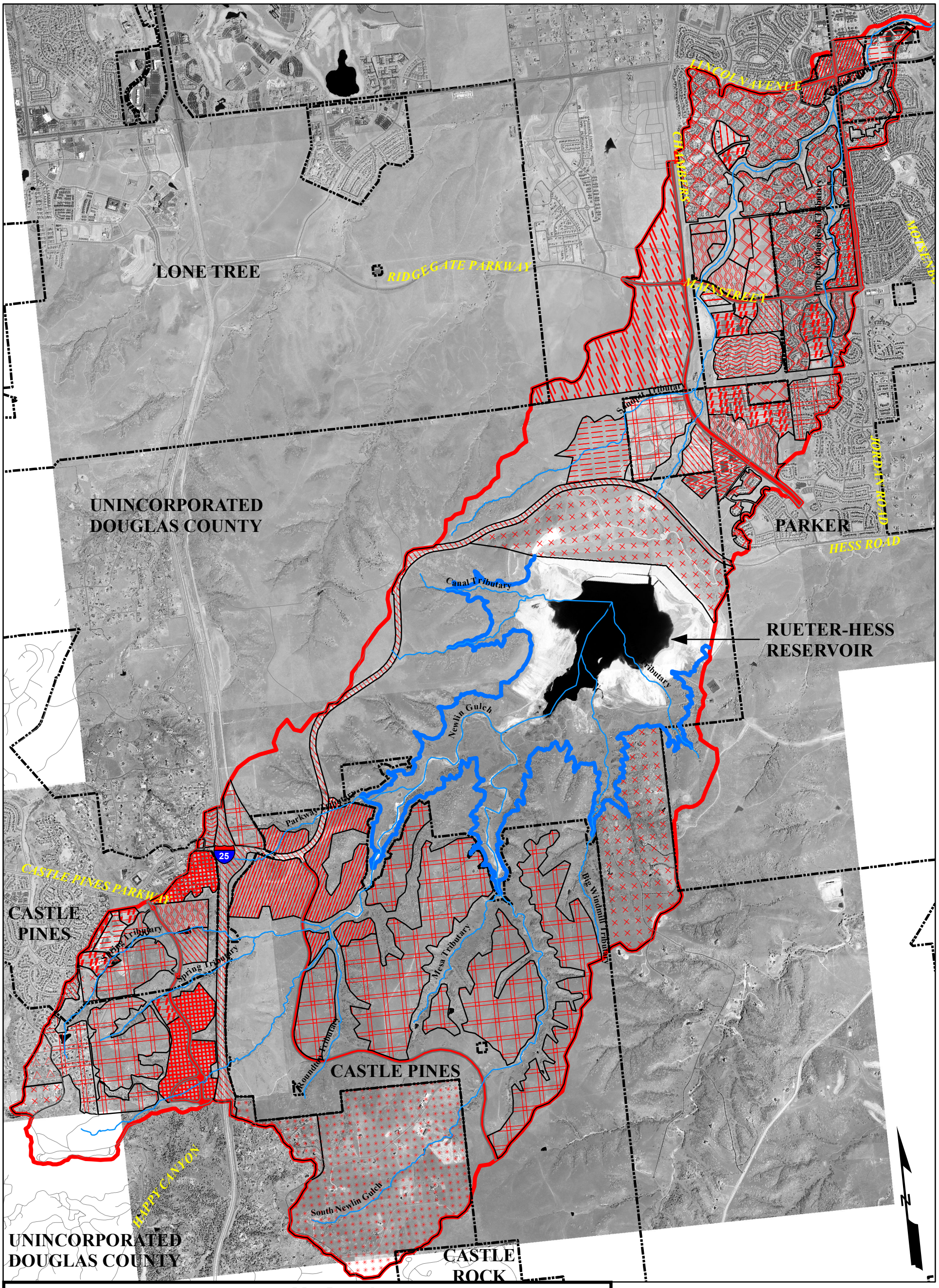
4. Reduce Costs for Roadway Crossings: Recognizing the flood peak reduction from Rueter-Hess Reservoir would also help to reduce costs for future roadway crossings or replacement of existing roadway crossings of Newlin Gulch. For example, if a new bridge crossing over Newlin Gulch needs to be replaced, the bridge span could be shorter using the lower flow rates and, therefore, less costly to construct.

5. Reduce Costs for Future Drainageway Improvements: Future drainageway infrastructure that will likely be needed along Newlin Gulch such as stream stabilization improvements will be more cost effective if they can be designed using the lower flood discharges.

Conclusion

In conclusion, Rueter-Hess Reservoir provides significant reduction in peak flood discharges for the Newlin Gulch drainageway downstream. Recognizing this would provide significant benefits for property owners downstream and would reduce costs for future infrastructure improvements within the Newlin Gulch drainageway.

In order for the flood peak reduction benefits from Rueter-Hess Reservoir to be officially recognized by regulatory agencies (i.e., UDFCD, FEMA, and the Colorado Water Conservation Board), an "adequate assurances" agreement would need to be executed with the reservoir owner, PWSD, ensuring no adverse changes would be made to the existing auxiliary spillway.



Map Legend

Future Land Use - Imperviousness (%)

- Watershed Boundary
- Major Tributaries
- Municipal Boundaries
- Rueter-Hess (max. normal pool elev.)

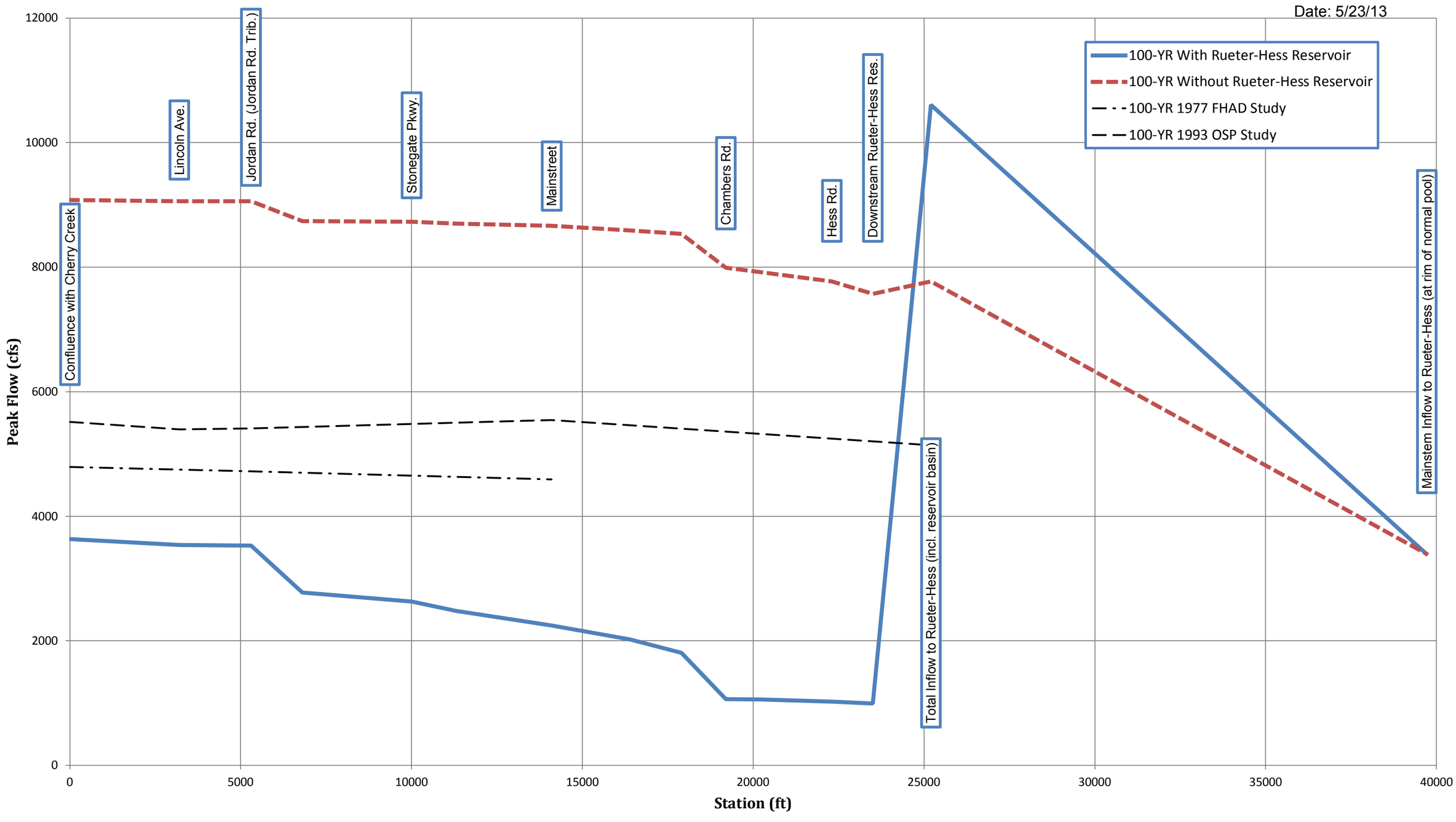
2	20	40	65	90
5	25	45	70	100
10	30	50	75	
15	35	60	85	

MULLER
Muller Engineering Company, Inc.
Consulting Engineers
777 S. Wadsworth Blvd., STE. 4-100
Lakewood, Colorado 80226-4355
www.mullereng.com
Office: (303) 988-4939
Fax: (303) 988-4969

Newlin Gulch Major Drainageway Plan
Figure 1 - Future Land Use Map
(For Rueter-Hess Technical Memo)
May 20, 2013

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
Town of Parker COLORADO
DOUGLAS COUNTY COLORADO

Figure 2 - Newlin Gulch Peak Flow Profile - Future Development



DATE: 5/23/13

FIGURE 3

NEWLIN GULCH REGULATORY FLOODPLAIN

IN THE CENTRAL PORTION OF STONEGATE VILLAGE

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Basin\e Hydrology\12050-Stonegate Regulatory FP.dwg DATE: MAY 23, 2013 TIME: 11:04 AM

Table C-1
Rueter-Hess Reservoir Routing Alternatives

				1993 OSP **		Current Study							
						100-Yr (Existing Land Use)				100-Yr (Future Land Use)			
						With RH		Without RH		With RH		Without RH	
Location	FHAD Cross Section	OSP Design Point	Current Design Point	1977 FHAD * 100-Yr (cfs)	100-Yr Existing (cfs)	100-Yr Future (cfs)	Service Spillway (cfs)	Auxiliary Spillway (cfs)†	I=100% (cfs)	I=2% (cfs)	Service Spillway (cfs)	Auxiliary Spillway (cfs)†	I=100% (cfs)	I=2% (cfs)
Newlin Gulch														
Cherry Creek	28	180	NG000	4790	5357	5513	2843	**2843**	10968	6438	3581	**3581**	12882	8191
Lincoln Ave. (U/S)		177	NG001		5198	5396	2796	**2795**	10945	6430	3486	**3486**	12848	8174
Jordan Rd. (U/S)	23	176	NG002	4720	5220	5412	2793	**2793**	10951	6431	3478	**3478**	12855	8176
Stonegate Parkway (U/S)			NG004				2213	**2212**	10479	6122	2683	**2683**	12300	7839
Mainstreet (U/S)	16	166	NG006	4590	5330	5545	1945	**1945**	10301	6032	2253	**2253**	12092	7784
Chambers Rd. (U/S)			NG009				706	**905**	9306	5551	763	**1025**	10980	7192
Hess Rd.			NG011				325	**890**	9024	5431	325	**1010**	10626	7017
Rueter-Hess Reservoir Outflow			NG012				49	**880**	8822	5309	56	**995**	10381	6838
RH Total Inflow (Including Reservoir Subwatershed)			NG220				8822	**8822**	N/A	N/A	10381	**10381**	N/A	N/A
Mainstem and Tributary Inflow to RH		150	NG013		4969	5138	5871	**5871**	5871	4738	7657	**7657**	7657	6210
Mainstem Inflow to RH			NG014				2454	**2454**	3108	3108	3255	**3255**	4183	4183
I-25 (U/S)		103	NG019		321	311	426	**426**	426	426	514	**514**	514	514
Tributaries														
Jordan Rd. Tributary at Newlin Confluence		276	SJ000		545	785	690	**690**	690	690	755	**755**	755	755
South Newlin at Mesa Confluence		128	SN001		1106	1167	1388	**1388**	1388	1388	1564	**1564**	1564	1564
Mesa Tributary at South Newlin Confluence		224	MT000		420	470	493	**493**	493	493	598	**598**	598	598
Roundtop Tributary at Newlin Confluence		217	RT000		383	393	429	**429**	429	429	504	**504**	504	504
Spring Tributary at Newlin Confluence		219	ST000		773	840	1009	**1009**	1009	1009	1427	**1427**	1427	1427

Notes:

* 1977 FHAD flows based on 24-hour storm and WSP-2 and TR-20 models.

** 1993 OSP flows based on 3-hour storm and CUHP/UDSWMM models.

†Selected Alternative for Baseline Hydrology

Updated June 6, 2013

Appendix D

RUETER-HESS ADEQUATE ASSURANCES AGREEMENT

AGREEMENT REGARDING THE INTENT TO
ASSURE THE FLOOD ROUTING CAPABILITY OF
RUETER-HESS RESERVOIR IN DOUGLAS COUNTY

Agreement No. 14-05.05

THIS AGREEMENT, made this 13th day of November, 2014, by and between URBAN DRAINAGE AND FLOOD CONTROL DISTRICT (hereinafter called "DISTRICT"), PARKER WATER AND SANITATION DISTRICT (hereinafter called "OWNER"), TOWN OF PARKER (hereinafter called "PARKER") and DOUGLAS COUNTY (hereinafter called "DOUGLAS"); (hereinafter DISTRICT, OWNER, PARKER and DOUGLAS shall be collectively known as "PARTIES");

WITNESSETH THAT:

WHEREAS, DISTRICT in a policy statement previously adopted (Resolution No. 14, Series of 1970), expressed an intent to assist public bodies which have heretofore enacted floodplain zoning measures; and

WHEREAS, several of the major drainageways within, or flowing into, DISTRICT have water supply, irrigation, or other non-flood control reservoirs located on them; and

WHEREAS, some of these reservoirs, by virtue of their size and/or their embankment and spillway configuration, provide significant but inadvertent flood routing capabilities which reduce the 100-year flood discharge downstream from the reservoirs; and

WHEREAS, Colorado Revised Statute §37-87-104(2) states that "No such (entity or person who owns, controls, or operates, a water storage reservoir) shall be liable for allowing the inflow to such reservoir to pass through it into the natural stream below such reservoir"; and

WHEREAS, the owners of such reservoirs can, and on occasion do, make changes to their embankment and spillway configurations, up to and including removal of the structure; and

WHEREAS, the above-language from §37-87-104, C.R.S. clearly indicates that it would be unwise public policy to rely upon these non-flood control reservoirs for any flood protection; and

WHEREAS, DISTRICT has previously adopted a "Policy for Delineation of Floodplains Below Water Supply and Other Non-Flood Control Reservoirs" (Resolution No. 36, Series of 1986); and

WHEREAS, the Policy requires that non-flood control reservoirs not be considered in the drainageway hydrology unless adequate assurances have been obtained by the Executive Director of DISTRICT to preserve the flood routing capability of the reservoirs; and

WHEREAS, Rueter-Hess Reservoir (hereinafter called "RESERVOIR") is a water storage reservoir which provides significant inadvertent flood routing capability which reduces the 100-year discharge downstream from RESERVOIR; and

WHEREAS, The Newlin Gulch Major Drainageway Plan & Flood Hazard Area Delineation (hereinafter called "MASTER PLAN") specifies the RESERVOIR's planned 100-year discharge; and

WHEREAS, OWNER is the owner of RESERVOIR, a water storage reservoir located south and east of the intersection of Hess Road and Chambers Road in unincorporated Douglas County; and

WHEREAS, PARTIES desire to make arrangements regarding the preservation of the planned 100-year discharge in the event OWNER plans future changes to RESERVOIR; and

WHEREAS, PARTIES acknowledge there is significant infrastructure cost savings to PARKER, DOUGLAS and DISTRICT as a result of OWNER signing this Agreement, and that OWNER is executing this agreement in the spirit of intergovernmental cooperation for the benefit of PARKER, DOUGLAS and DISTRICT; and

WHEREAS, OWNER is developing long term recreational opportunities and facilities at RESERVOIR which will require partnerships and cooperation from PARKER and DOUGLAS, among others; and

WHEREAS, in the same spirit of cooperation that has resulted in this Agreement, PARKER and DOUGLAS have committed to OWNER that they will participate in the development of recreational improvements at RESERVOIR including both physical improvements and staffing contributions, the details of which PARKER, DOUGLAS and OWNER will determine together in good faith.

NOW, THEREFORE, in consideration of the mutual promises contained herein, PARTIES hereto agree as follows:

1. SCOPE OF AGREEMENT
   This Agreement defines the responsibilities and financial commitments of PARTIES with respect to RESERVOIR.
2. OPPORTUNITY TO MAINTAIN FLOOD ROUTING CAPABILITY
   If OWNER plans physical changes to RESERVOIR which would increase the 100-year discharge above the planned 100-year discharge, OWNER shall provide an opportunity for PARKER, DOUGLAS, and DISTRICT to maintain the 100-year discharge at the planned 100-year discharge, subject to the terms and conditions of Paragraph 6 below.
3. MAINTENANCE OF THE PLANNED 100-YEAR DISCHARGE
   PARKER, DOUGLAS and DISTRICT agree to jointly take whatever actions are necessary, available, and appropriate, based upon the sole discretion of PARKER, DOUGLAS and DISTRICT, to assure that the flood routing capability of RESERVOIR shall be maintained at the planned 100-year discharge, subject to annual budget and appropriation.
4. RECOGNITION OF FLOOD ROUTING CAPABILITY IN MASTER PLAN
   The MASTER PLAN contains specific language recognizing the flood routing capability of RESERVOIR and expressing the need to preserve that routing capability by whatever means are available and appropriate should changes be proposed which would decrease the planned level of flood routing capability and increase the 100-year discharge above the planned 100-year discharge.

The flood routing capability of RESERVOIR, as set forth in the MASTER PLAN, is as follows: During the 100-year flood, RESERVOIR reduces the peak flow from 10,381 cubic feet per second into RESERVOIR to a peak flow of 995 cubic feet per second out of RESERVOIR.

5. PAYMENT OF COSTS

If PARKER, DOUGLAS and/or DISTRICT desire OWNER to limit or attempt to limit the 100-year downstream discharge to the planned 100-year discharge, PARKER and/or DOUGLAS and/or DISTRICT shall pay, in advance, all costs attributable thereto, including but not limited to studies, revisions or additions to plans, physical changes to RESERVOIR or dam structures, and additional construction, subject to annual budget and appropriation. As used in this paragraph, "costs" includes construction, engineering, operation and maintenance, attorney's fees, court costs, and other direct or indirect costs.

6. NOTICE

OWNER shall notify PARKER, DOUGLAS and DISTRICT, in writing, of any plans to make physical changes to RESERVOIR. To take advantage of the opportunity referred to in Paragraph 2, PARKER, DOUGLAS and/or DISTRICT must notify OWNER, in writing, of their intention to do so promptly upon reciving written notification of OWNER's plans to make physical changes to RESERVOIR, and in no event more than 90 days after being notified.

A. The NOTICE contact for OWNER shall be the Chair of the Parker Water & Sanitation District Board of Directors, 18100 East Woodman Drive, Parker, Colorado 80134.

B. The NOTICE contact for PARKER shall be the Director of Public Works, 20120 East Main Street, Parker, Colorado 80138.

C. The NOTICE contact for DOUGLAS shall be the County Engineer, 100 Third Street, Castle Rock, Colorado 80104.

D. The NOTICE contact for DISTRICT shall be the Executive Director, 2480 West 26th Avenue, Suite 156B, Denver, Colorado 80211.

E. Any notices, demands or other communications required or permitted to be given by any provision of this Agreement shall be given in writing, delivered personally or sent by registered mail, postage prepaid and return receipt requested, addressed to PARTIES at the addresses forth above or at such other address as either party may hereafter or from time to time designate by written notice to the other party given when personally delivered or mailed, and shall be considered received in the earlier of either the day on which such notice is actually received by the party to whom it is addressed or the third day after such notice is mailed.

7. OWNER APPROVAL

Notwithstanding any provision herein to the contrary, OWNER retains the right to approve, reject, or approve with conditions, in OWNER's sole discretion, any plans of PARKER, DOUGLAS or DISTRICT to maintain the flood routing capability of RESERVOIR; provided that OWNER shall inform PARKER, DOUGLAS and DISTRICT in writing of OWNER's reasons for a rejection or a conditional approval. OWNER further retains the right to manage all aspects of any work relating

to the maintenance of RESERVOIR's flood routing capability as contemplated by this Agreement, including the selection of contractors performing engineering, design or construction work on property owned or controlled by OWNER. It is the intent of this provision that OWNER retain sole control over all aspects of RESERVOIR while allowing PARKER, DOUGLAS and DISTRICT to preserve the flood control benefits of RESERVOIR.

8. LIABILITY

Each party hereto shall be responsible for any suits, demands, costs or actions at law resulting from its own acts or omissions and may insure against such possibilities as appropriate.

9. AMENDMENTS

This Agreement contains all of the terms agreed upon by and among PARTIES. Any amendments to this Agreement shall be in writing and executed by PARTIES hereto to be valid and binding.

10. SEVERABILITY

If any clause or provision herein contained shall be adjudged to be invalid or unenforceable by a court of competent jurisdiction or by operation of any applicable law, such invalid or unenforceable clause or provision shall not affect the validity of the Agreement as a whole and all other clauses or provisions shall be given full force and effect.

11. APPLICABLE LAWS

This Agreement shall be governed by and construed in accordance with the laws of the State of Colorado. Jurisdiction for any and all legal actions arising under the Agreement shall lie in the District Court in and for the County of Douglas, State of Colorado.

12. ASSIGNABILITY

No party to this Agreement shall assign or transfer any of its rights or obligations hereunder without the prior written consent of the nonassigning party or parties to this Agreement.

13. BINDING EFFECT

The provisions of this Agreement shall bind and shall inure to the benefit of PARTIES hereto and to their respective successors and permitted assigns.

14. ENFORCEABILITY

PARTIES hereto agree and acknowledge that this Agreement may be enforced in law or in equity, by decree of specific performance or damages, or such other legal or equitable relief as may be available subject to the provisions of the laws of the State of Colorado.

15. APPROPRIATIONS

Notwithstanding any other term, condition, or provision herein, each and every obligation of PARKER and/or DOUGLAS and/or OWNER and/or DISTRICT stated in this Agreement is subject to the requirement of a prior appropriation of funds therefore by the appropriate governing body of the OWNER, PARKER, DOUGLAS and/or DISTRICT.

16. NO THIRD PARTY BENEFICIARIES

It is expressly understood and agreed that enforcement of the terms and conditions of this Agreement, and all rights of action relating to such enforcement, shall be strictly reserved to

PARTIES, and nothing contained in this Agreement shall give or allow any such claim or right of action by any other or third person on such Agreement. It is the express intention of PARTIES that any person or party other than the OWNER, PARKER, DOUGLAS or DISTRICT receiving services or benefits under this Agreement shall be deemed to be an incidental beneficiary only.

17. NO WAIVER OF GOVERNMENTAL IMMUNITY ACT

The parties hereto understand and agree that the OWNER, PARKER, DOUGLAS AND DISTRICT, their officials, officers, directors, agents and employees, are relying on, and do not waive or intend to waive by any provisions of this Agreement, the monetary limitations or any other rights, immunities and protections provided by the Colorado Governmental Immunity Act, C.R.S. § 24-10-101, *et seq.*, as from time to time amended, or otherwise available to PARTIES.

18. RECITALS

The Recitals to this Agreement are incorporated herein by this reference.

19. ENTIRETY

This Agreement merges and supercedes all prior negotiations, representations and agreements between the parties hereof and constitutes the entire agreement between the parties concerning the subject matter hereof.

WHEREFORE, PARTIES hereto have caused this instrument to be executed by properly authorized signatures as of the date and year above written.

(SEAL)

ATTEST:

APPROVED:

PARKER WATER AND SANITATION DISTRICT

By

Title ~~Executive Director~~ District Manager

Date 10/29/14

(SEAL)

ATTEST:

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

By

Title Executive Director

Date 11/13/2014

TOWN OF PARKER

(SEAL)

By _____
Mike Waid
Title Mayor

ATTEST:

Date 10/6/14

Carol Baumgartner, Town Clerk

APPROVED:

James Maloney, Town Attorney

BOARD OF COUNTY COMMISSIONERS
OF THE COUNTY OF DOUGLAS

BY: _____
DOUGLAS J. DEBORD, County Manager

APPROVED AS TO FISCAL CONTENT:

ANDREW COPLAND, Finance Director

APPROVED AS TO LEGAL FORM:

KRISTIN DECKER, Asst. County Attorney

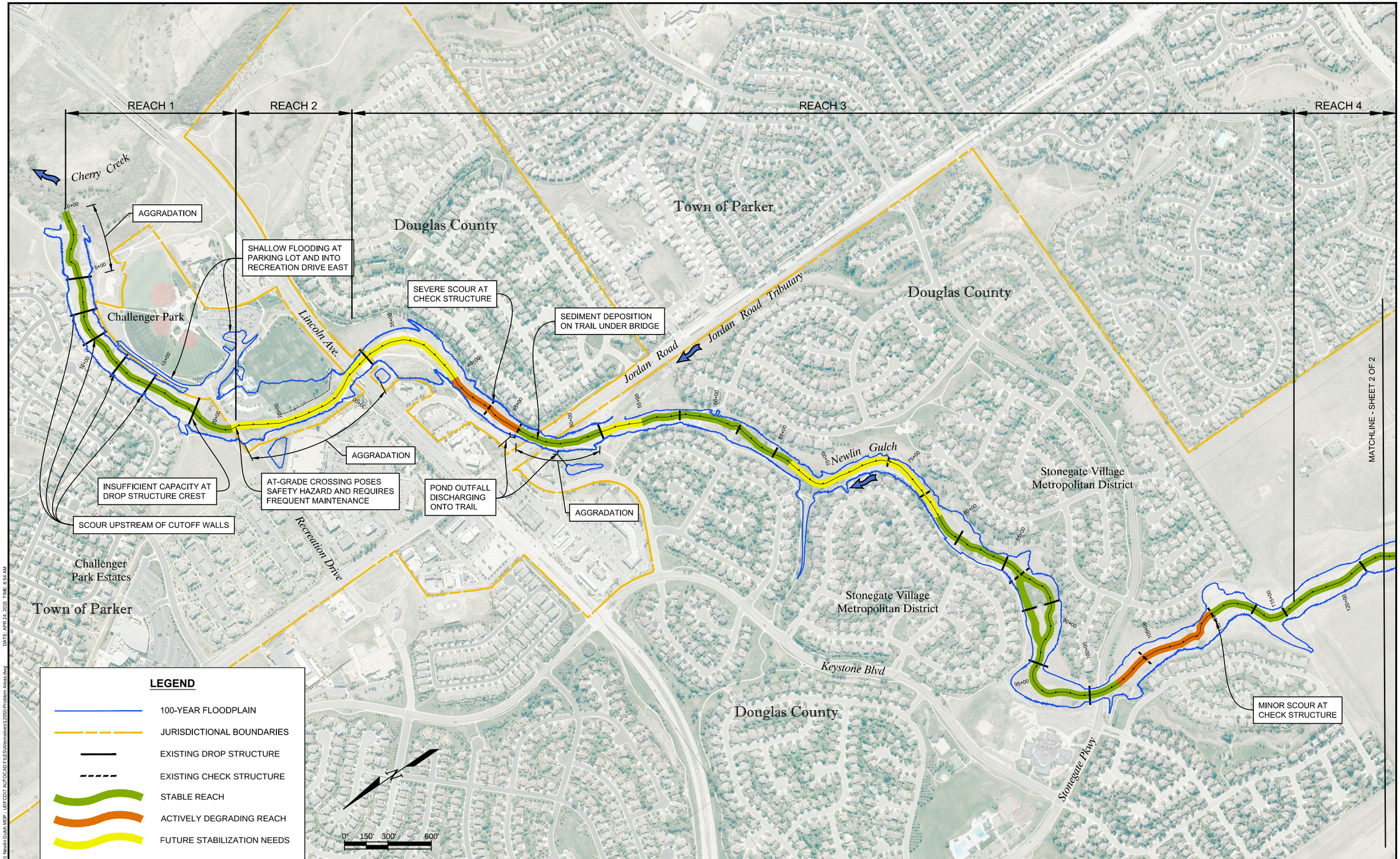
AGREEMENT REGARDING THE INTENT TO
ASSURE THE FLOOD ROUTING CAPABILITY OF
RUETER-HESS RESERVOIR IN DOUGLAS COUNTY

Agreement No. 13-

EXHIBIT A: LOCATION

Appendix E

HYDRAULIC ANALYSIS



NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Problem Areas.dwg DATE: APR 24, 2015 TIME: 8:54 AM

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

Town of Parker COLORADO

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

FLOODPLAIN AND PROBLEM AREAS
REACHES 1-3

DATE JUNE 2015
FIGURE NO. E-1

REACH 4

REACH 5

REACH 6

Douglas County

Town of Parker

Newlin Gulch Blvd

AGGRADATION

HEADCUT APPROACHING BRIDGE

Douglas County

Town of Parker

Newlin Gulch

SCOUR AT CHECK STRUCTURE

Hess Road

Chambers Road

Douglas County

MANURE / WOOD CHIPS SPREAD IN OVERBANK; CORRALS AND OTHER DEBRIS IN CHANNEL

Mainstreet

MATCHLINE - SHEET 1 OF 2

0' 150' 300' 600'

LEGEND

- 100-YEAR FLOODPLAIN
- JURISDICTIONAL BOUNDARIES
- EXISTING DROP STRUCTURE
- EXISTING CHECK STRUCTURE
- STABLE REACH
- ACTIVELY DEGRADING REACH
- FUTURE STABILIZATION NEEDS

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

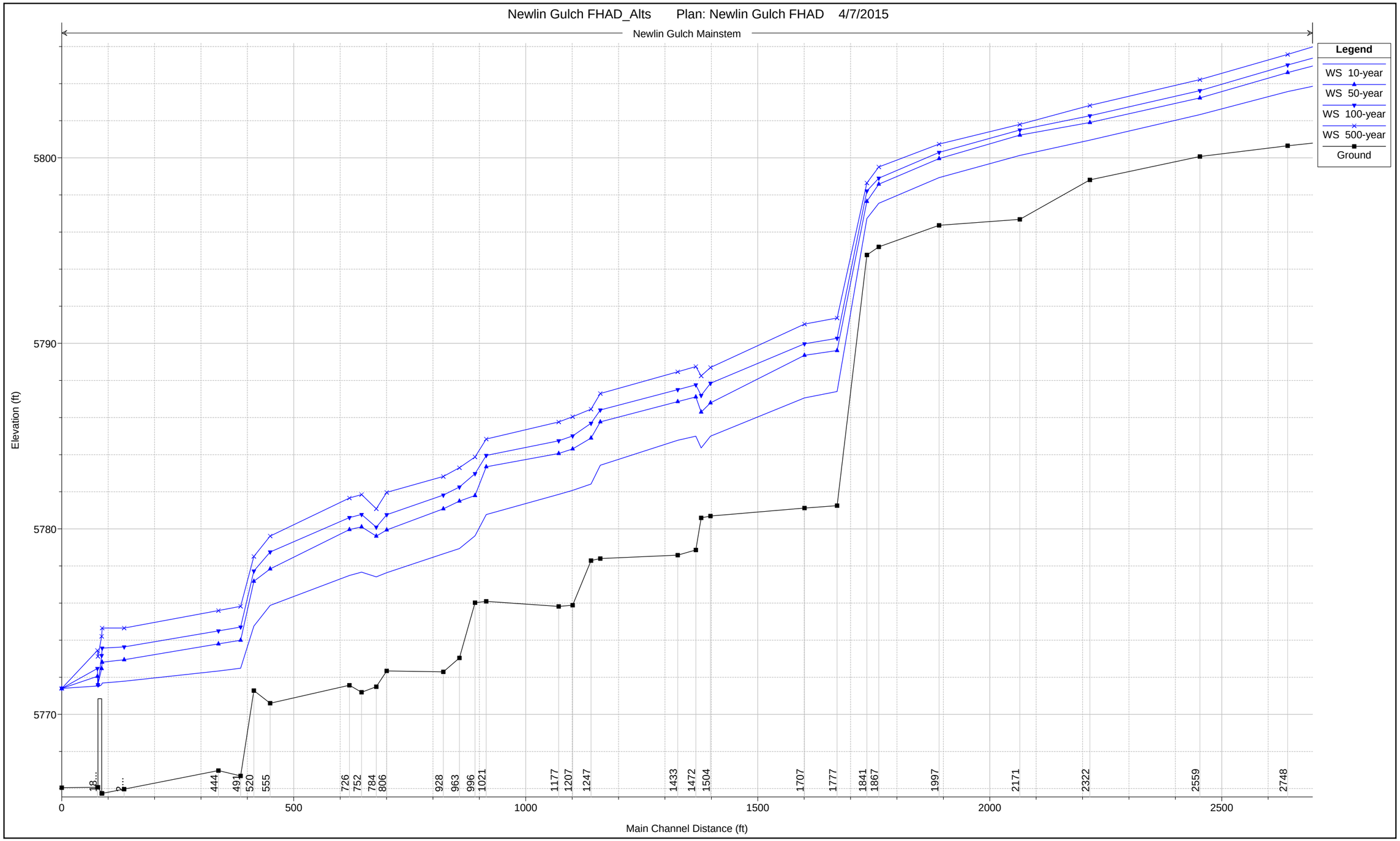
FLOODPLAIN AND PROBLEM AREAS
REACHES 4-6

DATE JUNE 2015
FIGURE NO. E-2

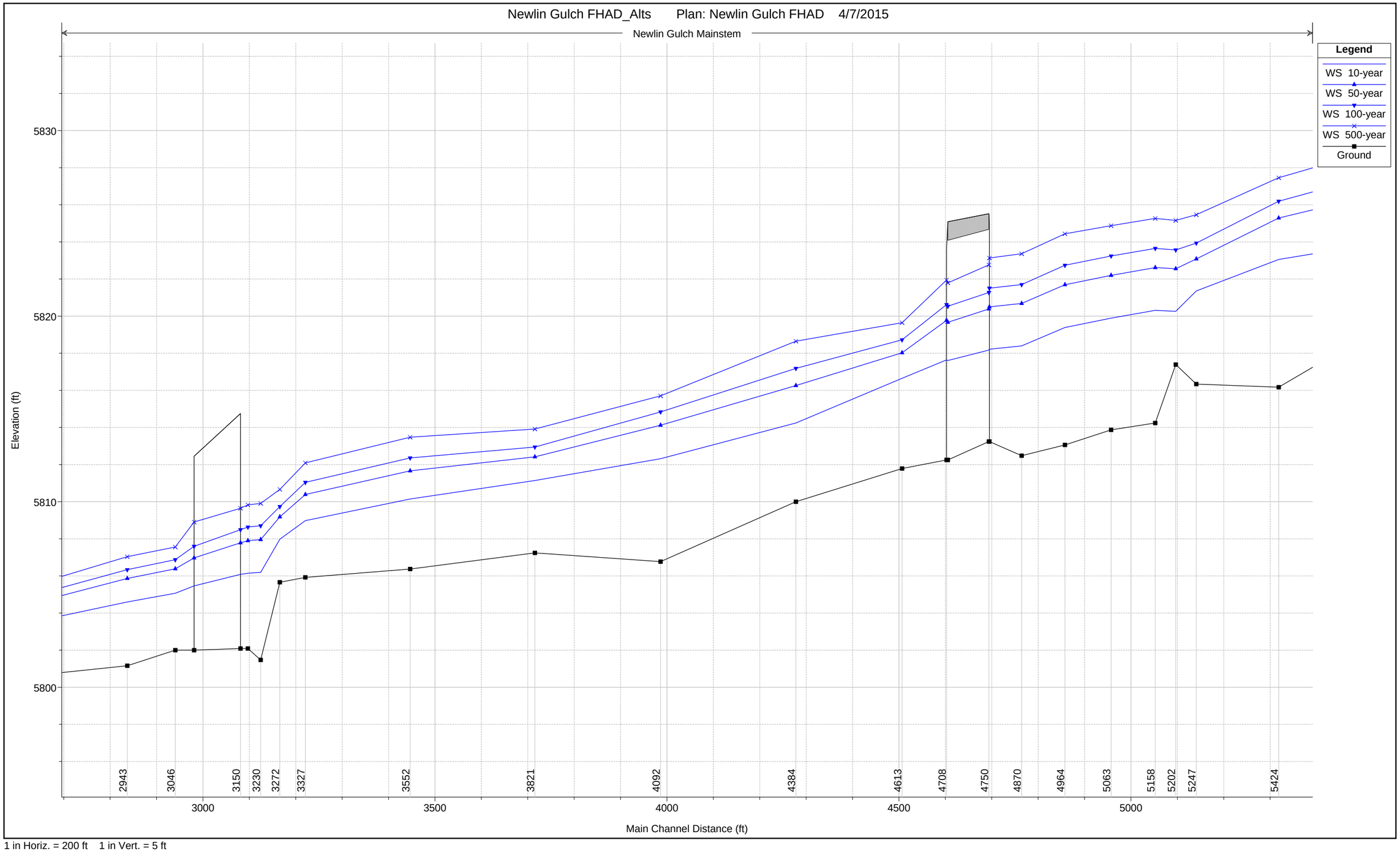
NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Problem Areas.dwg DATE: APR 24, 2015 TIME: 9:15 AM

Table E-1
Manning's n Values

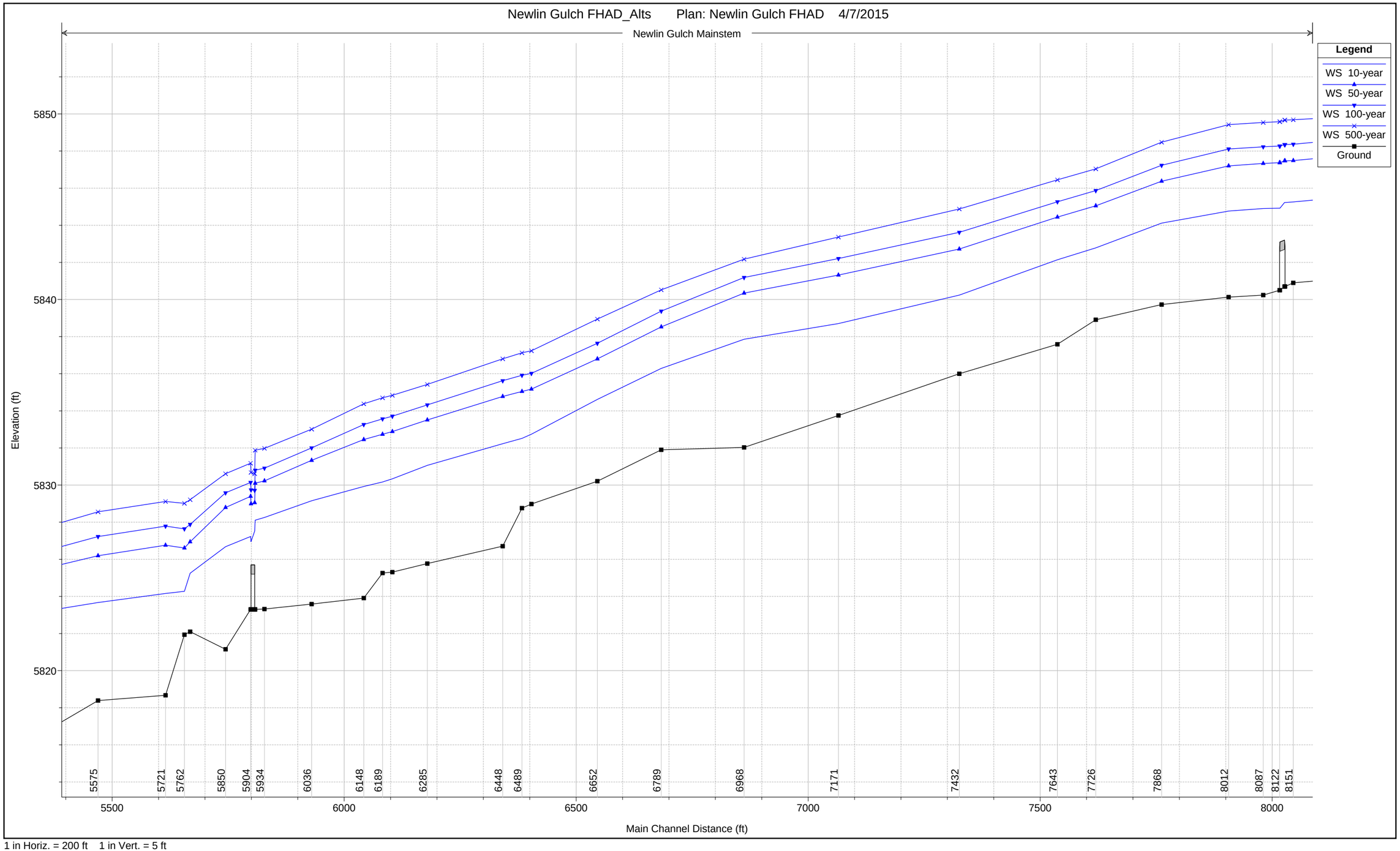
Station	to Station	Description	Manning's n-value		
			LOB	Channel	ROB
22214	21560	Hess Road	0.04	0.04	0.04
21365	18973	Upstream of Chambers Road	0.06	0.06	0.06
18902	18237	Downstream of Chambers Road	0.04	0.1	0.04
18013	15176	Between Mainstreet and Chambers Road	0.04	0.05	0.04
14788	8900	Upstream of Mainstreet to Downstream of Stonegate Parkway	0.04	0.04	0.04
8676	8087	Lower Portion of Stonegate Phase 3 Reach	0.04	0.05	0.04
8012	7171	Downstream of Stonegate Phase 3 Reach	0.04	0.08	0.04
6968	5914	Lower Portion of Stonegate Village Metropolitan District	0.04	0.12	0.04
5904	4384	Jordan Road	0.04	0.08	0.04
4092	3203	Upstream of Lincoln Avenue	0.04	0.04	0.04
3046	2171	Between Lincoln Ave. and Recreation Drive	0.04	0.05	0.03
1997	491	Downstream of Recreation Drive	0.04	0.05	0.04
444	0	Confluence with Cherry Creek	0.04	0.08	0.04



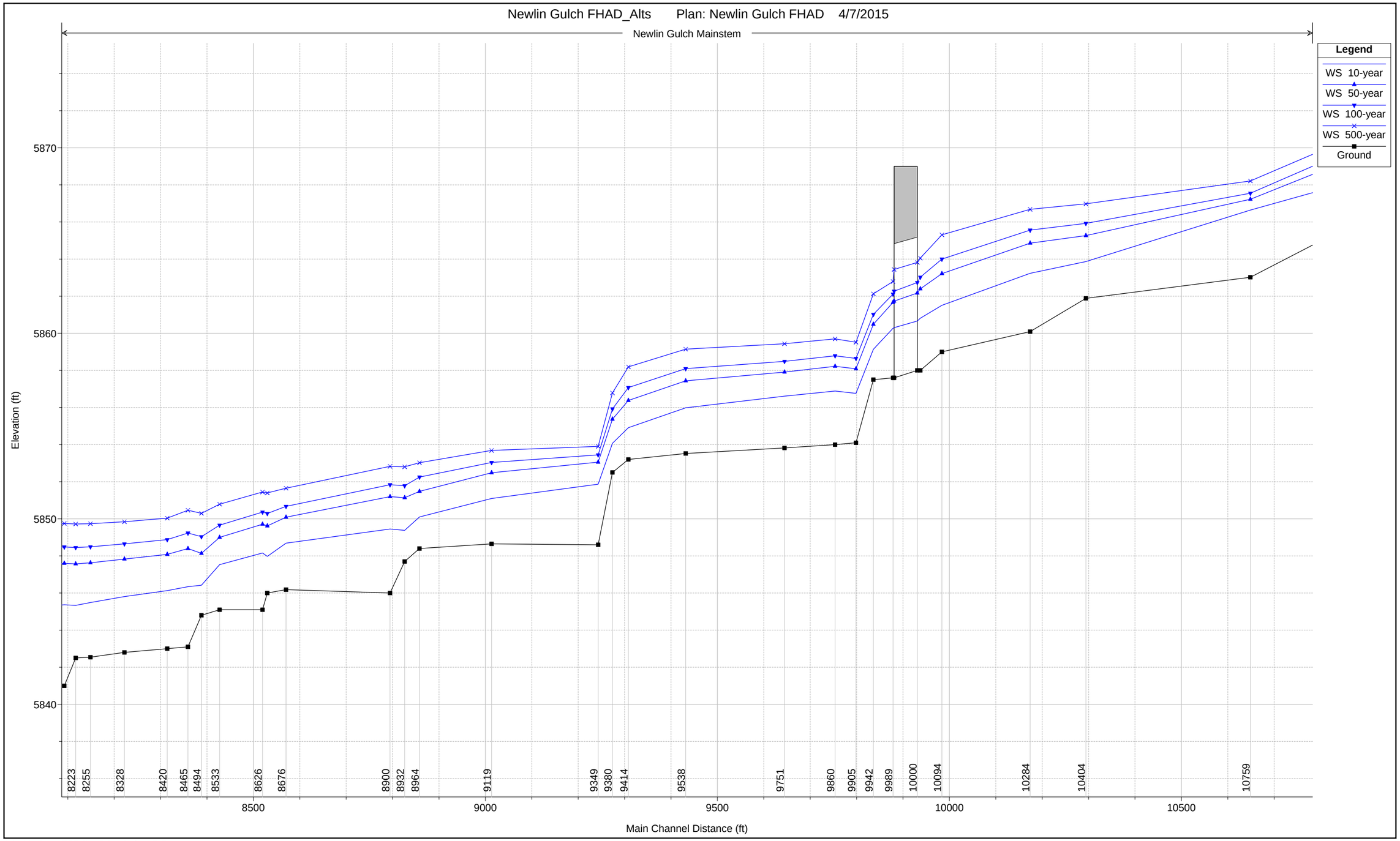
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



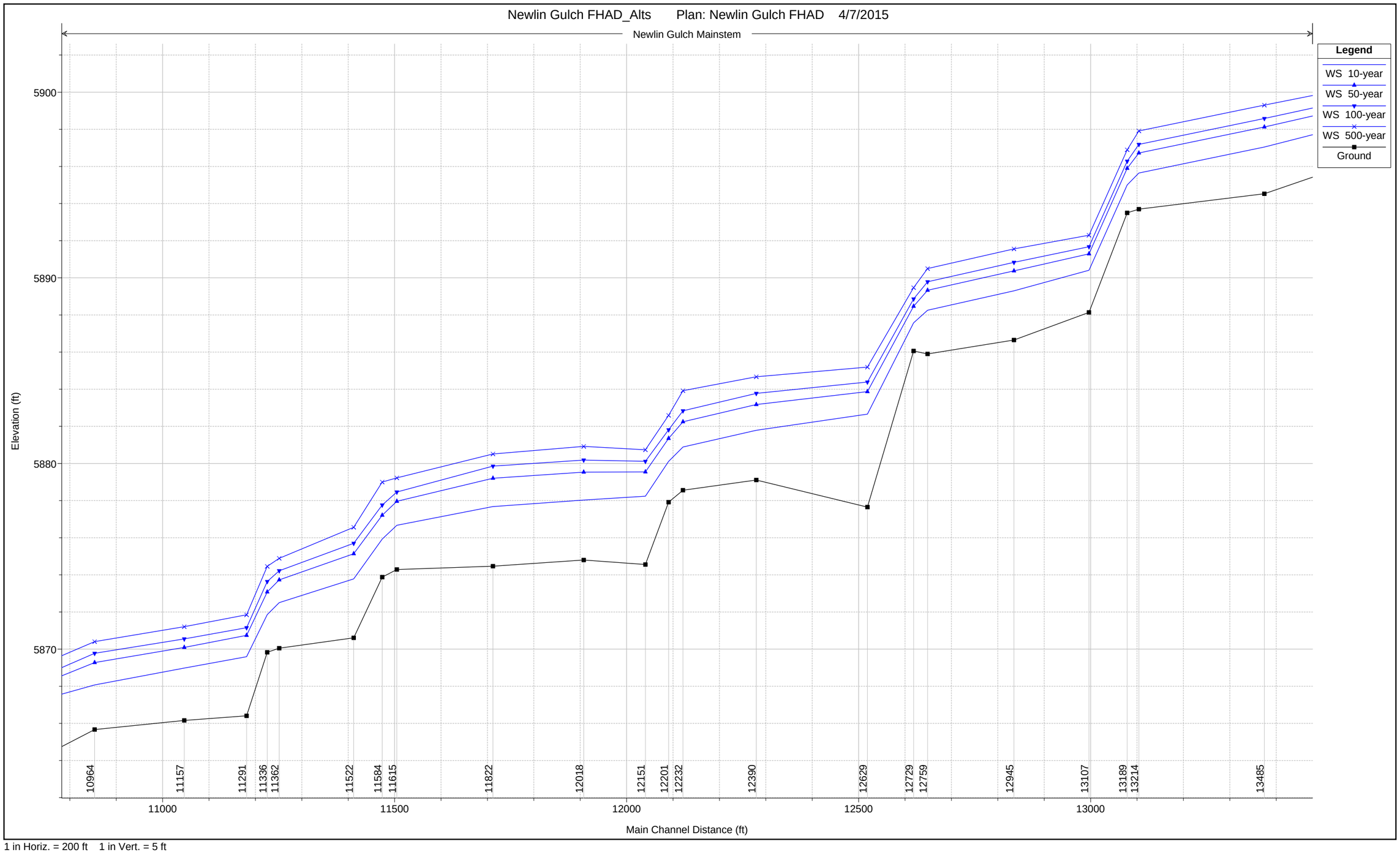
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



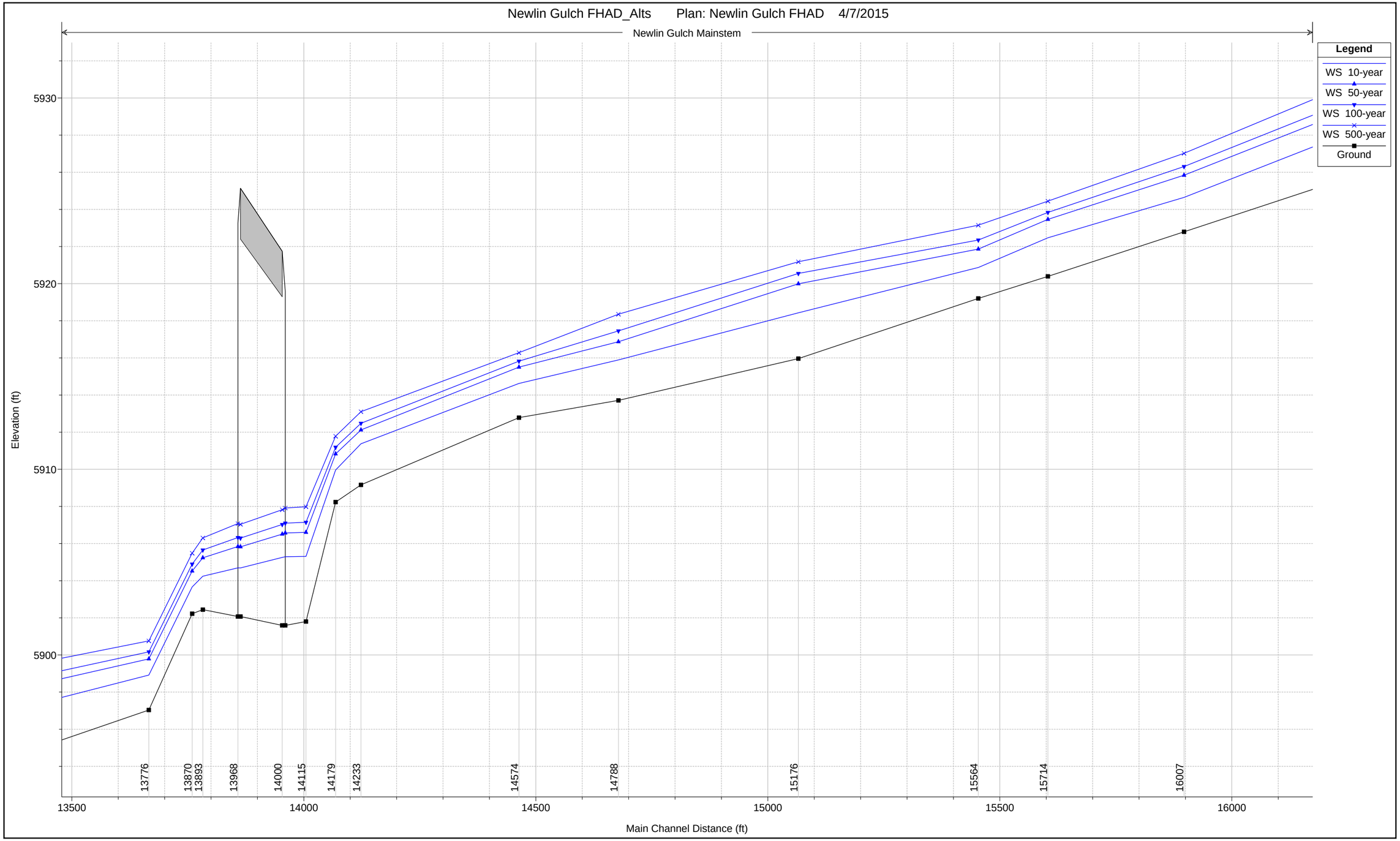
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



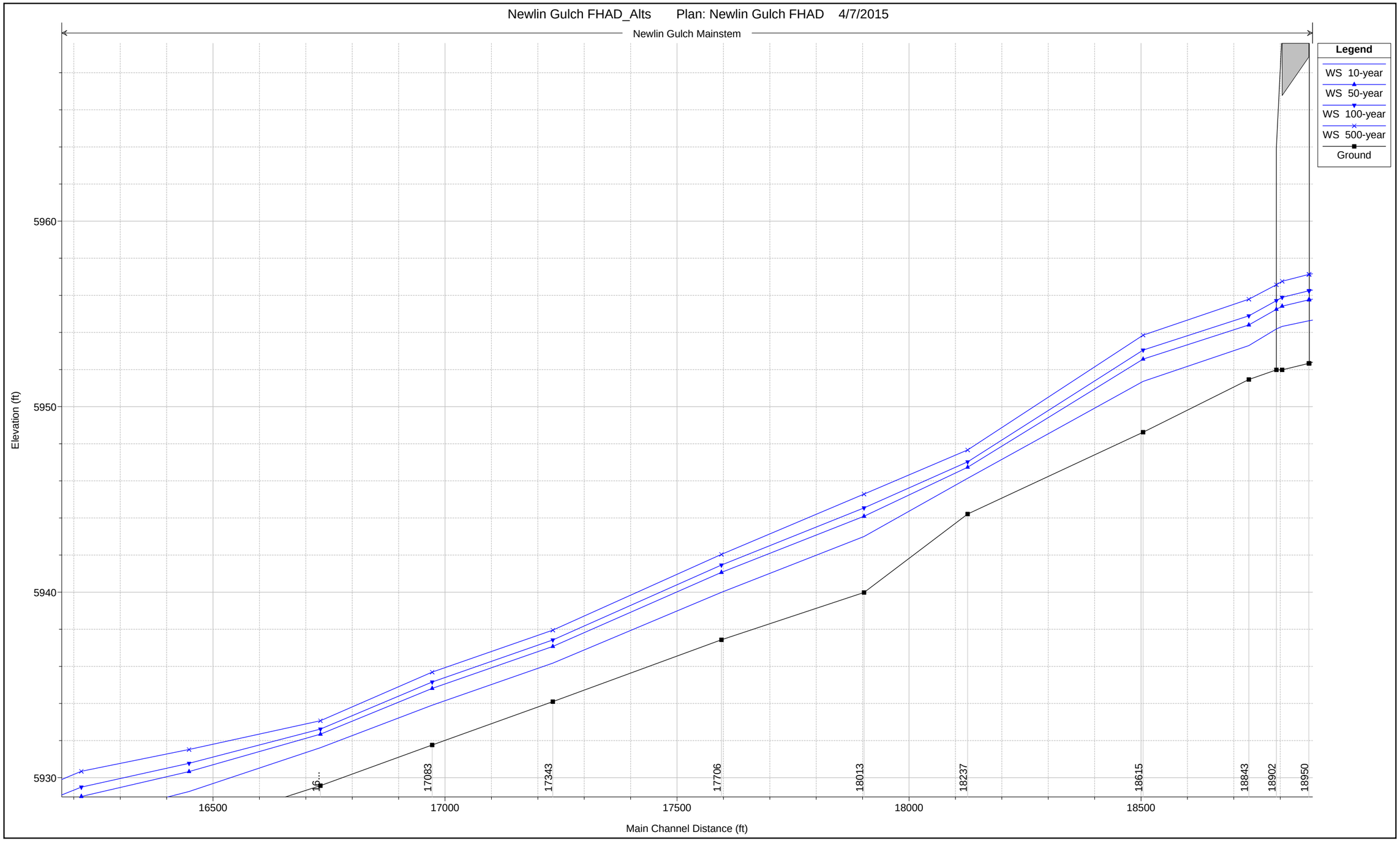
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



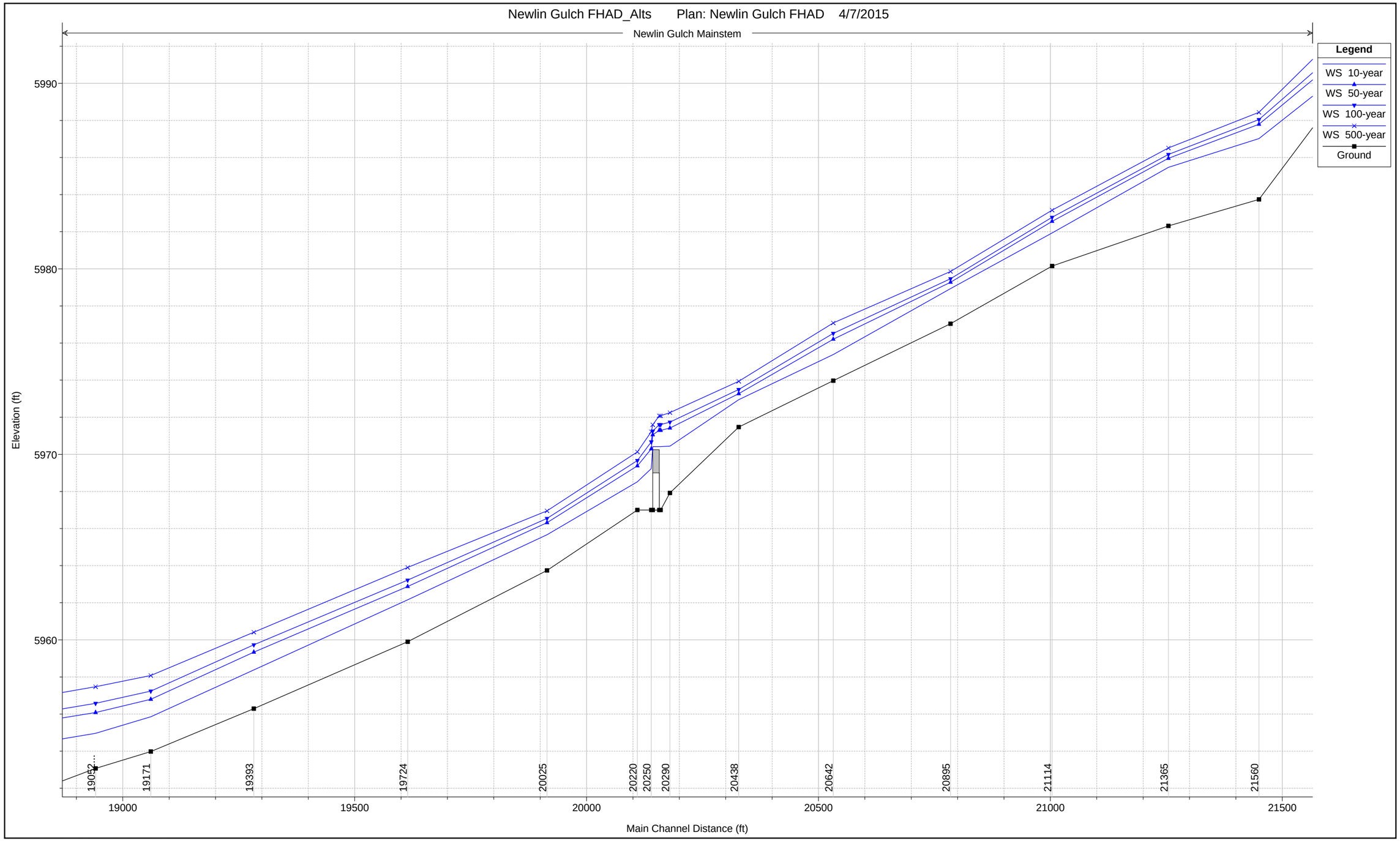
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



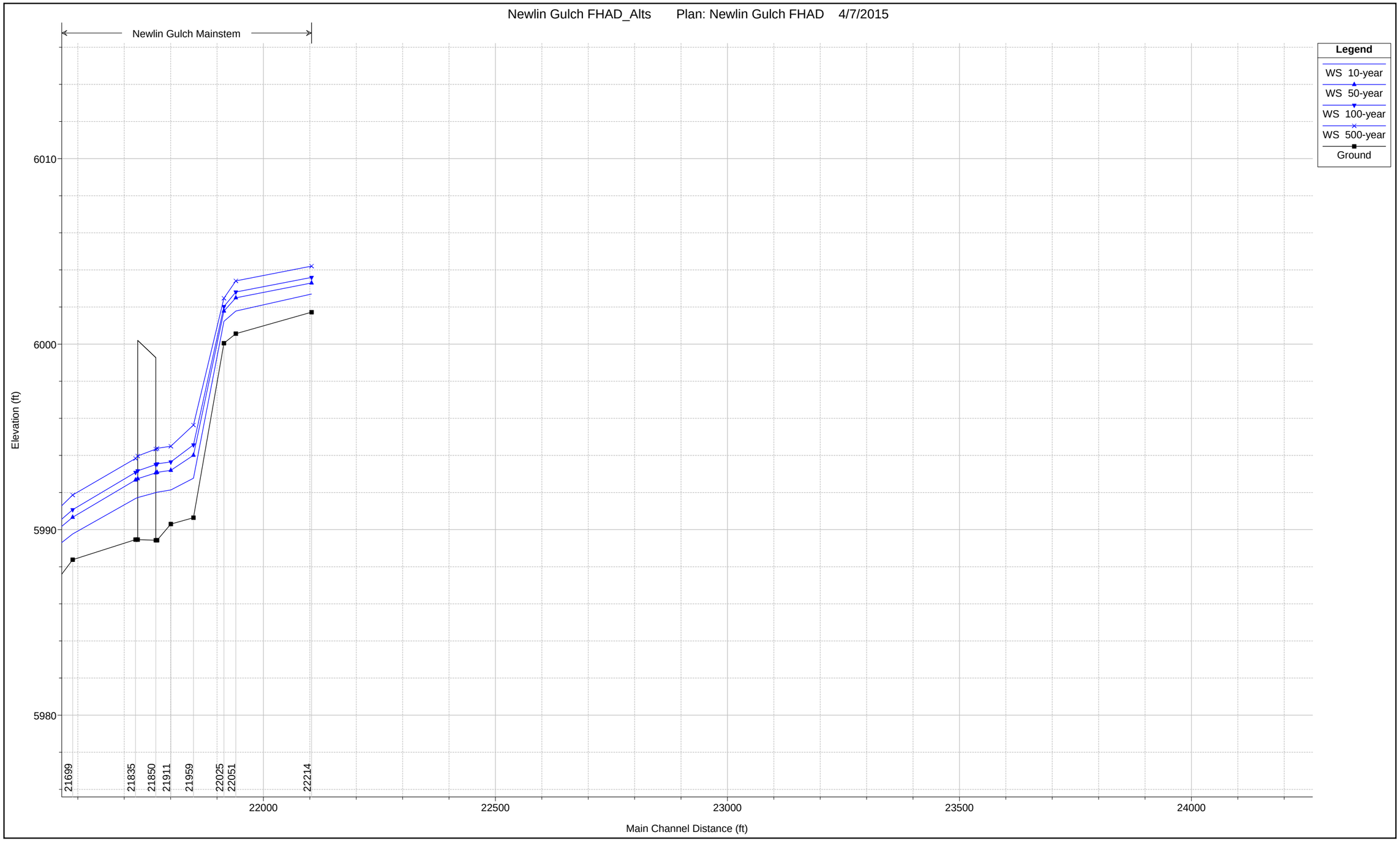
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft

Appendix F

LEGAL OPINION

Edward J. Krisor
Attorney At Law
1666 South University Boulevard, Suite B
Denver, Colorado 80210
303 777-5501 Fax: 303 698-0919
ekrisor@ix.netcom.com

January 19, 1998

Mr. Ben Urbonas, P.E.
Chief, Master Planning Program
Urban Drainage And Flood Control District
2480 West 26th Avenue, Suite 156 B
Denver, Colorado 80211

BY HAND DELIVERY

Re: Legal opinion in regard to alternative and planned drainage facilities in general as contained in alternatives development and evaluation reports

Dear Ben:

You have asked me to provide you with a legal opinion that you may use to initially evaluate in general all alternatives development and evaluation reports for compliance with the law of the State of Colorado applicable to drainage. What follows is such an opinion which will need to be supplemented by a short legal opinion in regard to each report to either indicate that no further comment is necessary or that certain other factors, other than those noted herein, will need to be considered before proceeding to the selection and construction of drainage improvements contained in that specific report.

In order to properly evaluate these reports you first must take note of the following comments in regard to the law of drainage in Colorado:

I. GENERAL LEGAL DRAINAGE PRINCIPLES

Natural drainage conditions may be altered by an upper (dominant) owner provided the water is not sent down in a manner or quantity to do more harm than formerly to the lower

(servient) owner, Hankins v. Borland, 163 Colo. 575, 431 P.2d 1007 (1967). Colorado follows the "rule of reasonableness" as related to drainage matters and in each drainage situation, the court will look at the relationship of the parties and at who is doing what to whom in order to determine "what is reasonable under the circumstances". Prior to the Hankins case, the Colorado Supreme Court ruled in Ambrosio v. Perl-Mack, 143 Colo. 49, 317 P.2d 803 (1960), that downstream owners had to accept additional runoff from an upstream developer.

As the engineering technology has become more precise in drainage matters, it is possible to determine from the actual development and from land use decisions that will determine future development what the additional (more than natural) runoff will be because landowners make their land impermeable.

The Colorado Legislature in 1973 recognized this and adopted Sec. 30-28-113(4)(b) which requires developers in unincorporated areas to detain greater than historical flows. As a matter of drainage practice, cities as well as counties and the Urban Drainage District work to identify with precision "who is doing what" to whom so that the cost of drainage solutions to problems created by future development can be placed on those who would change the use of land from permeable to impermeable. Runoff from existing development is also computed and the need, if any, to solve existing drainage problems can be determined and costs of solutions estimated.

Drainage matters historically were resolved between or among property owners. However, as urbanization (multiple property owners) has taken place, governments have become involved for several reasons. In some cases, the government itself helped create additional runoff by making improvements. In other cases, government approved land use changes without regard to the problems of additional runoff. In still other situations, government got involved because constituents (owners) wanted government help in the difficult and expensive field of determining (identifying) where the additional runoff was coming from and the paying of costs of solutions. For whatever the reason, whenever government gets involved, it can be expected to be treated like a private party. 2 Farnham, Water and Water Rights, pp. 975 and 977, adopted by the Colorado Supreme Court in City of Boulder v. Boulder and White Rock Ditch Co., 73 Colo. 426, 216 P. 553 (1923). A municipality can be held to its negligence. It can also determine whether to become involved at all, if it did not create the problem.

An update of these legal principles has yielded the conclusion that the law of drainage as set forth above has not really changed to any substantially degree over the years. Both the Hankins and Ambrosio cases continue to be cited by the Colorado courts when dealing with the law of drainage. In the case of Metro Docheff v. City of Broomfield, 623 P. 2d 69 (Colo. App.

1980) the Colorado Court of Appeals held that: "Although we recognize the right of the owner of higher land to a drainage easement over the lower land of others, . . . the discharge of water will be enjoined as a continuing trespass if the drain sends the water down 'in a manner or quantity to do more harm than formerly.'" In the case of Hoff v. Ehrlich, 511 P. 2d 523 (Colo. App. 1973) the Colorado Court of Appeals was faced with the question of the propriety of a servient owner blocking drainage from a dominant estate in order to protect the servient owner's land. The Court held that: "The owner of the dominant estate has a legal and natural easement or servitude in the lower or servient estate for the drainage of surface water flowing in its natural course and manner . . . When an interruption in the natural flow or passage of surface waters is caused by the servient owner to the detriment or injury of the estate of the dominant owner, the court should issue a mandatory injunction for the opening of the easement which has been blocked . . . [the servient owner] may not act to the extent that damage is caused thereby to the dominant landowner . . . in order for the owner of the servient estate to be afforded a remedy, it must be evident that the water was sent down in a manner or quantity causing more harm than it formerly had done."

If a government permits the development which in turn causes "more harm than formerly", then the government, as well as the developers, may be held liable. (Cases consistently move toward governmental, as well as developers' liability.) See Metro Docheff, *supra*, which held as follows: "The trial court found that the city had accepted the streets and storm drains for maintenance and control and, therefore, had exclusive control over the water collected in the subdivision. It determined that by approving the subdivision and drainage plan and accepting control, the city interfered with the natural conditions and thereby caused surface water to be collected and discharged upon plaintiff's land 'in a greater quantity or in different manner than had previously occurred under natural conditions."

Recently, governmental entities have raised in their defense of drainage cases the Governmental Immunity Act. In two recent cases, that defense has not been successful. In Burnworth v. Adams County, 826 P. 2d 368 (Colo. App. 1991) the Colorado Court of Appeals held that actions ". . . against public entities arising from the maintenance of a sewer, a storm sewer, or a storm drainage system." were not prohibited by the Governmental Immunity Act. In the case of Scott v. City of Greeley, 931 P. 2d 525 (Colo. App. 1996), the Colorado Court of Appeals again denied protection under the Governmental Immunity Act to a public entity when it argued that the damage complained of was the result of a design flaw rather than from the operation of a facility. The facts were that the City designed and constructed a new storm water line which was 42" and connected it to a line which was only 15". This caused the water to back up, or surcharge, through the storm drains and manhole covers, overtopping the curb and flooding adjacent property. In addition to the denial of protection to the entity under the

Governmental Immunity Act, the Court also rejected the City's defense that the connection to the smaller pipe was only temporary.

Any improvements upstream must be made taking into consideration the outlet capability downstream. (Long line of case law.) See Hankins, *supra*, which states: "The trial court has found that the water which these defendants have sent into the Borland drain is in greater quantity and more rapid in time — a finding fully justified by the evidence. Under such circumstances it is the court's duty to determine what the dominant owners must do in order to prevent their increased waste water from damaging the servient owner."

Colorado generally imposes strict liability on owners of dams (regional detention ponds). (Long line of cases.)

Interfering with natural drainageways or channels is generally looked upon with disfavor by Colorado Courts. However, builders of irrigation canals, railroads, and highways in other times were not aware or were unconcerned with the problems they might be creating in the future by artificially blocking natural drainageways. Sometimes the very passage of time (at least eighteen years) provides an argument that the blockage should be allowed to be continued because parties have relied and should be able to continue to rely on this "protection". Generally, the laws of nature prevail in these situations and artificial structures such as canals, railroads and highways do not rise to the status of permanent dams which require spillways and other features under the jurisdiction in the State of Colorado of the State Engineer.

With the enactment of federal environmental (including water quality) provisions, the quality of the runoff may also have an effect, as well as on other ecological matters.

Natural waters are subject to the doctrine of prior appropriation in Colorado and what may have become a water right must also be considered with any plan for the "handling" of surface runoff in natural waterways.

Finally, any drainage, "facility" built by a government must be maintained. "If you're not going to maintain it, then don't build it!" is the theme of a long line of cases.

II. GENERAL COMMENTS ON COMMONLY PROPOSED FACILITIES AND CONSTRUCTION TECHNIQUES

1. It is my understanding that the purpose of all reports in regard to this subject is to

examine alternatives which will, if implemented, improve upon and/or formalize the drainage that is within the study area.

2. In general, consideration must be given to any potential adverse effects of the selected alternative on properties within the study area and downstream of the study area.

3. If any selected facilities would increase or materially change the direction of the flows across downstream property in a study area, the downstream property has a right to claim damages and/or protection from such a material increase or change in flow. Thus, care should be taken to make sure that increased flows from upstream facilities are accommodated by sufficiently increasing the size of the downstream channels and conduits. If in final design, the selected alternative still has the effect of placing water on the residents and land owners in the area that they either never had or in a quantity larger than what they have had previously, the same must be revised to eliminate that result or the selected alternative must not be constructed.

4. If re-alignment of a channel is the selected alternative, careful consideration should be given to the channel's geometry, alignment and ability to carry flood flows so as not to create additional potential damages to surrounding landowners.

5. If the selected alternative is the collection of overland flows from a specific area and returning those flows to a drainage structure of some kind, care should be taken not to adversely impact landowners in the area.

6. If a selected alternative involves the redirection of flows from their historic path, prior to its finalization in the design process, caution should be taken that this redirection will not cause any increase in damage to those adjacent or downstream of the proposed redirection.

7. If any selected alternative, when it is finalized in the design process, is changed to include a plan for the diversion of runoff from one watershed to another; extreme caution should be used in implementing that portion of the selected alternative since the participants may be faced with the imposition of strict liability for any damage that occurs from any size storm event if it can be shown that the same would not have been suffered if the diversion had not occurred.

8. If the construction of crossing structures over irrigation canals are part of the selected alternative for the project, caution must be taken in regard to the capacity of those crossing structures. The structures, when designed for the design event, should not cause any more water than presently exists to flow into those canals.

9. The intentional routing, as opposed to inadvertent inflows, of flood flows into an irrigation ditch should be eliminated from any plan if at all possible unless a written agreement from the owner of the irrigation ditch is obtained permitting the use of the ditch to carry those flood flows. The participants have no control over the available capacity of the ditch at the time it would be necessary to carry flood flows so the ditch cannot realistically be used to control the flows downstream.

10. If an alternative is being selected that relies upon inadvertent detention and the participants do not intend to formalize such detention by written agreement, it is my opinion that the effect of that non-formalized inadvertent detention cannot be taken into consideration in the final design.

11. If a selected alternative includes the formalization of inadvertent detention it will be necessary for at least one of the participants to formalize that detention by entering into a written agreement with the owner of the facility causing the detention. The agreement must prohibit the owner from operating or modifying the facility in a way that would have the effect of lessening the inadvertent detention of the facility necessary to implement the selected alternative. Further, the owner must either agree to maintain the facility so that the same does not lose its current inadvertent detention or agree to permit at least one of the participants to maintain the facility.

12. If the owner of the facility will not agree to maintain the inadvertent detention facility, at least one of the participants should confirm in writing to all of the participants that the participant is committed to maintaining the inadvertent detention facility in a manner that assures the necessary inadvertent detention to implement the alternative. This should be done prior to the implementation of any of the alternatives involving inadvertent detention. The level of maintenance must at least permit the facility to function as relied upon in flooding events and not fail structurally during the design and larger events.

13. Any formalized detention facilities that are utilized in the final design of a project will need to be the subject of a written agreement between the owner and at least one participant that the facility will be maintained in a manner that assures the necessary flood storage to implement the design and that adequate maintenance will be performed by either the owner or the participant so that the facility will function as designed in flooding events and that it will not fail structurally during the design and larger events.

The participating entities must agree amongst themselves, in writing, that any one of the participants may enforce the terms of the agreement with the owner of the facility if the responsible participant does not. This agreement must include the maintenance of no more than

a certain level of water in the facility at any one time and that any one of the participants may, at their sole cost and expense, maintain the facility so that its effectiveness in the selected alternative will be continued in perpetuity.

14. The embankments of all detention facilities should be designed so that they will not fail during a design event.

15. If a potential wetland is involved in a design alternative, it will be necessary that a Section 404 Permit from the United States Army Corps of Engineers be applied for and obtained, if necessary. Such a Permit should be obtained before any construction is done on the recommended alternative.

16. During construction of the selected facilities, care should be taken in constructing those facilities so that downstream property is not adversely affected temporarily by such construction. Usually, with the exception of the construction of detention facilities, the best method to avoid that problem is construction from the downstream limit of the project in an upstream direction which would then have the effect of having the downstream facilities ready to accept any increased flows as a result of the project.

If you have any questions in regard to my comments and opinions contained in this letter, please feel free to telephone me to discuss the same.

Very truly yours,

Edward J. Krisor

Edward J. Krisor

Appendix G

WETLAND AND RIPARIAN INVENTORY

REACH 1

REACH 2

REACH 3

REACH 4

Cherry Creek

Challenger Park

Lincoln Ave

Douglas County

Town of Parker

Douglas County

Jordan Road

Jordan Road Tributary

Newlin Gulch

Stonegate Village Metropolitan District

Recreation Drive

Challenger Park Estates

Town of Parker

Stonegate Village Metropolitan District

Keystone Blvd

Douglas County

Stonegate Pkwy

MATCHLINE - SHEET 2 OF 2

LEGEND

MAJOR DRAINAGEWAY

JURISDICTIONAL BOUNDARIES

WETLAND AND RIPARIAN AREAS

0' 150' 300' 600'

DATE: APR 24, 2015 TIME: 9:21 AM

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Alternatives\12050-Wetland and Riparian Zones.dwg

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939

PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

WETLAND AND RIPARIAN AREAS
REACHES 1-3

DATE
APRIL 2015

FIGURE NO.
G-1

REACH 4

REACH 5

REACH 6

Douglas County

Newlin Gulch Blvd

Town of Parker

Newlin Gulch

Douglas County

Town of Parker

Chambers Road

Hess Road

Douglas County

Mainstreet

MATCHLINE - SHEET 1 OF 2

0' 150' 300' 600'

LEGEND

MAJOR DRAINAGEWAY

JURISDICTIONAL BOUNDARIES

WETLAND AND RIPARIAN AREAS

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\17 AUTOCAD FILES\Alternatives\12050-Wetland and Riparian Zones.dwg DATE: APR 24, 2015 TIME: 9:22 AM

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN SAR
DRAWN SAR
CHECK MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

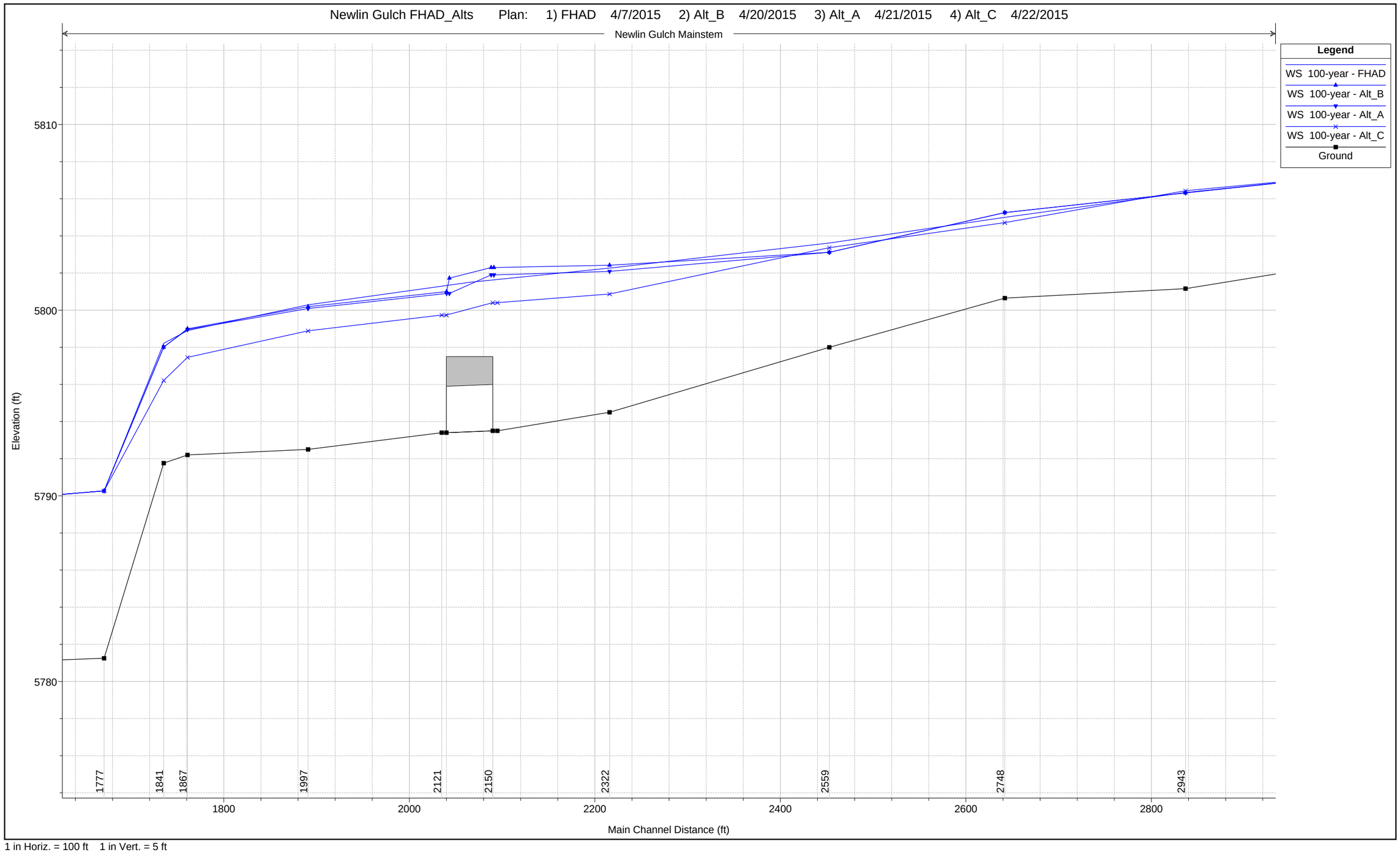
WETLAND AND RIPARIAN AREAS
REACHES 4-6

DATE
APRIL 2015

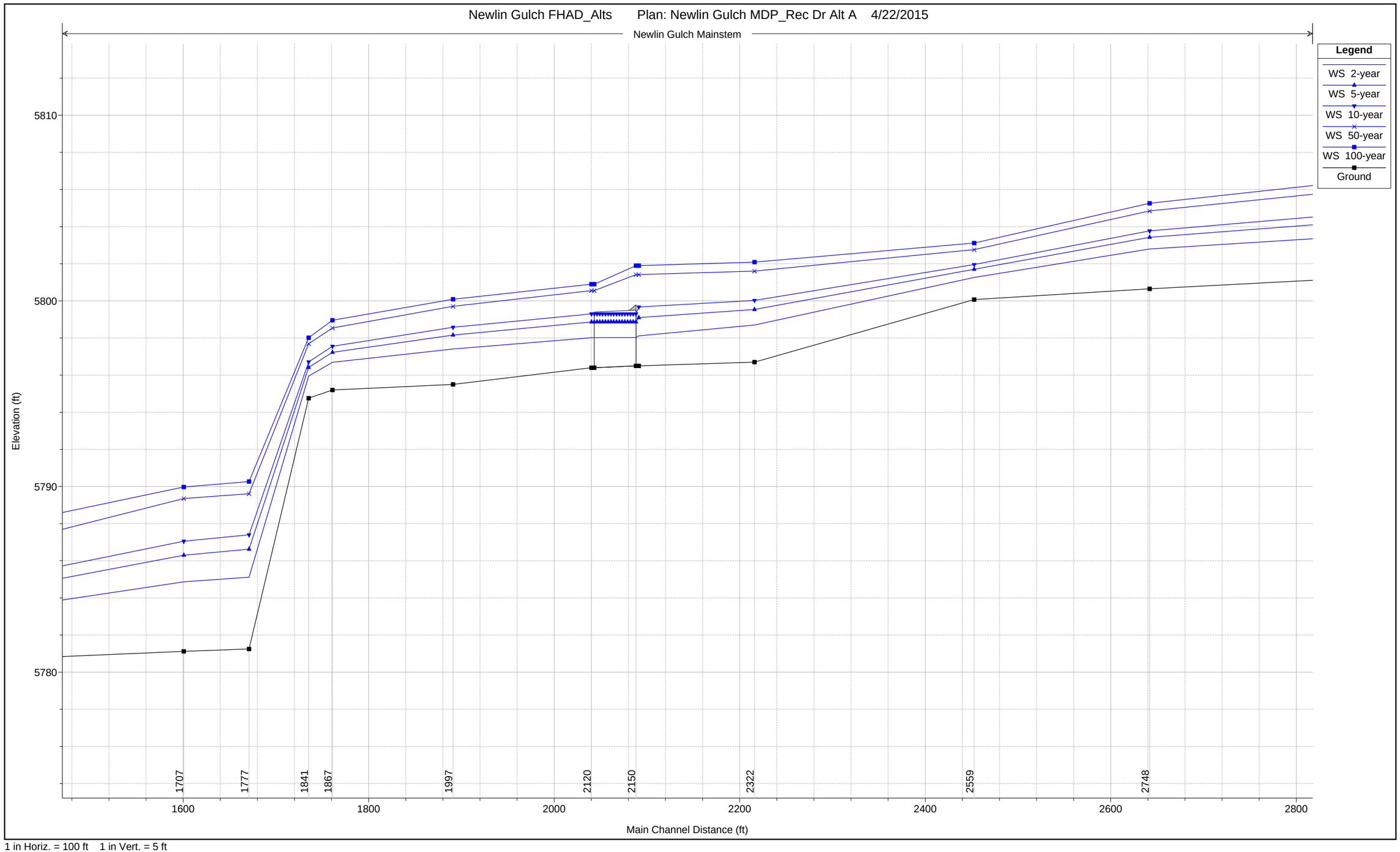
FIGURE NO.
G-2

Appendix H

ALTERNATIVES ANALYSIS



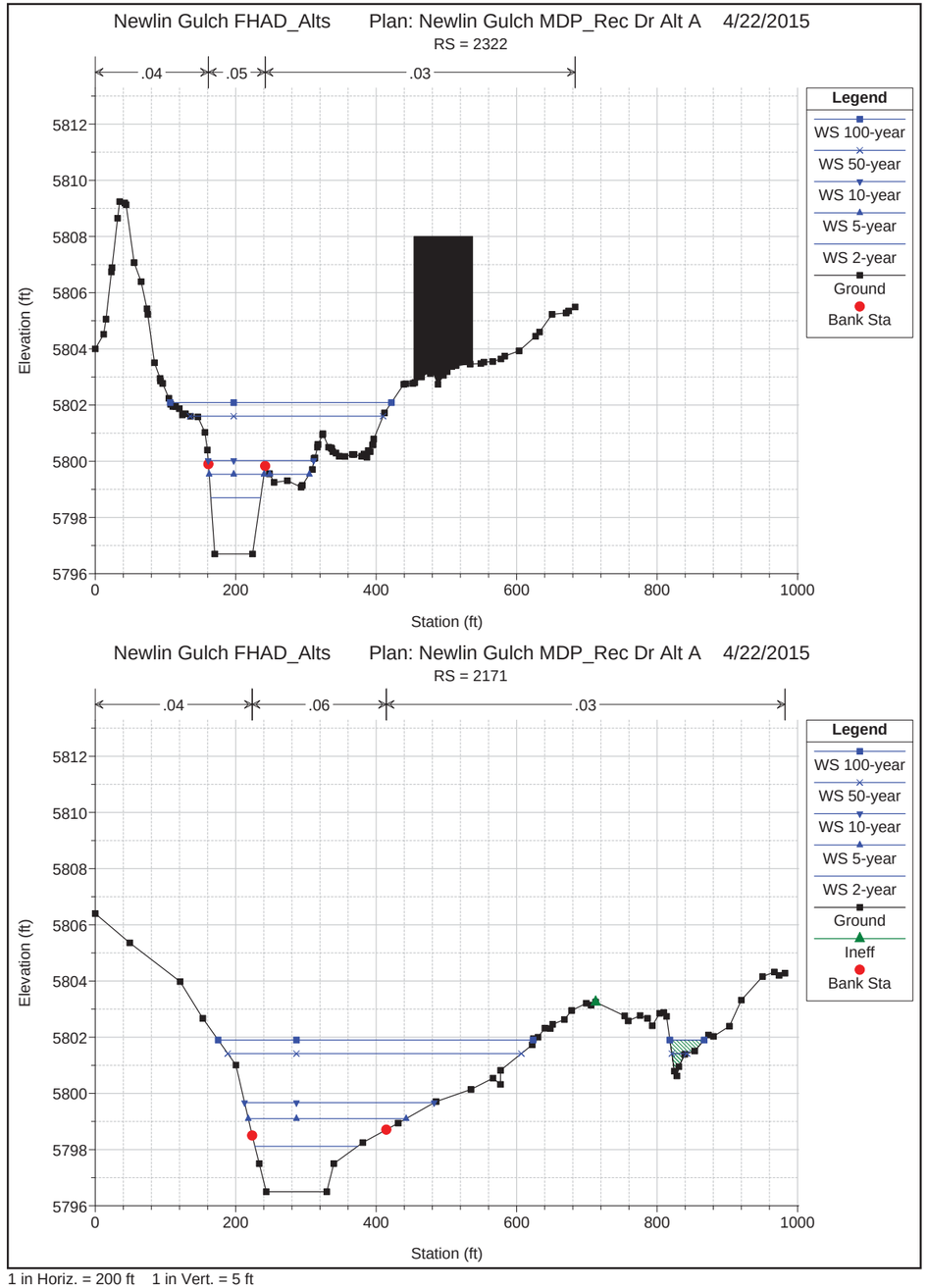
1 in Horiz. = 100 ft 1 in Vert. = 5 ft



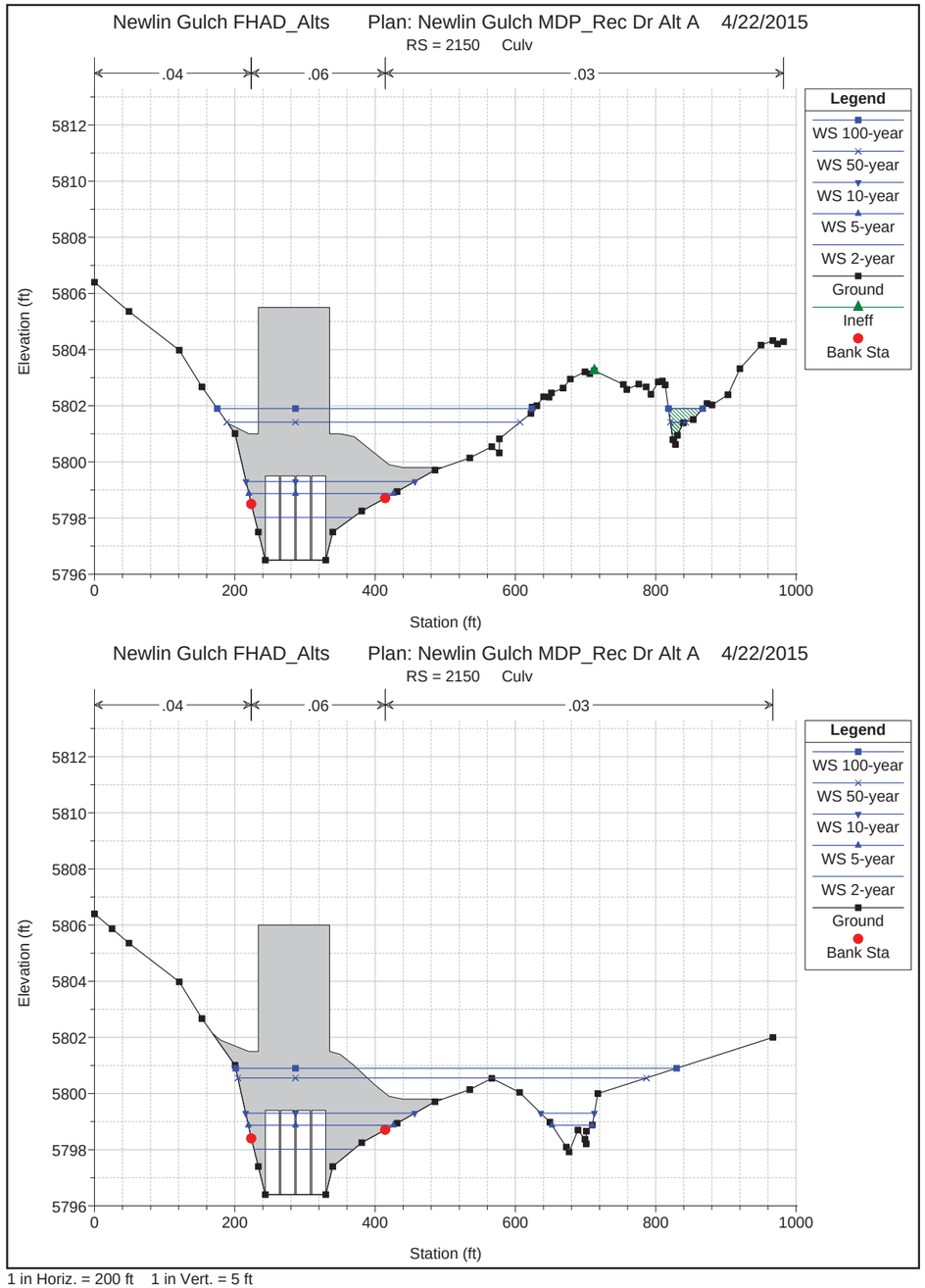
1 in Horiz. = 100 ft 1 in Vert. = 5 ft

HEC-RAS Plan: Alt_A Locations: User Defined

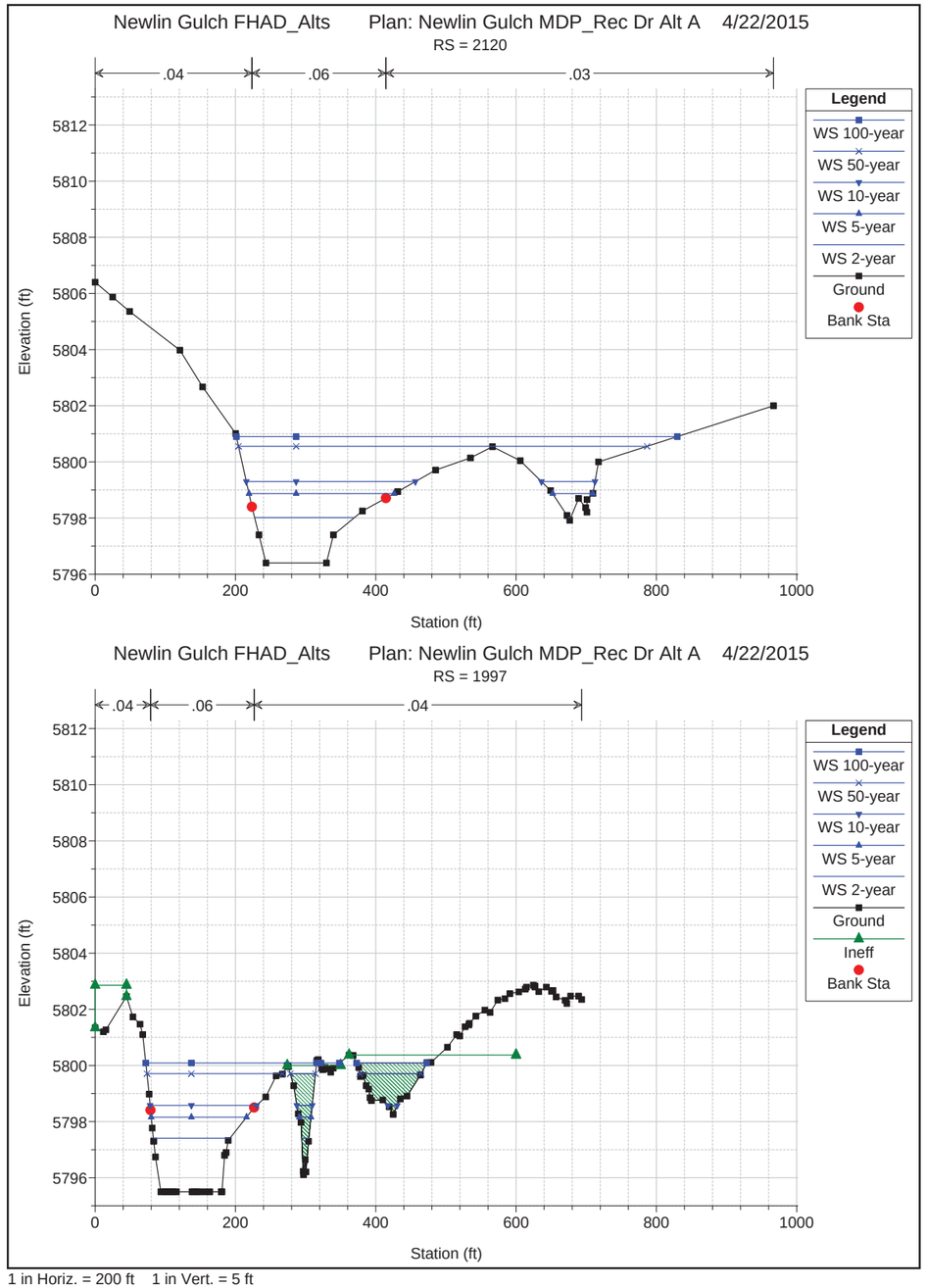
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Newlin Gulch	Mainstem	3203	10-year	1099.00	5802.09	5806.15	5804.40	5806.33	0.001857	3.43	319.97	100.13	0.34
Newlin Gulch	Mainstem	3203	50-year	2604.00	5802.09	5807.90	5805.68	5808.31	0.002539	5.14	507.48	113.55	0.42
Newlin Gulch	Mainstem	3203	100-year	3450.00	5802.09	5808.64	5806.29	5809.17	0.002711	5.87	592.55	116.76	0.45
Newlin Gulch	Mainstem	3203	500-year	5018.00	5802.09	5809.83	5807.28	5810.57	0.002907	6.94	735.38	123.13	0.48
Newlin Gulch	Mainstem	3203	2-year	363.00	5802.09	5804.69	5803.51	5804.75	0.001322	2.04	177.70	94.70	0.26
Newlin Gulch	Mainstem	3150		Bridge									
Newlin Gulch	Mainstem	3046	10-year	1099.00	5802.00	5805.07		5805.47	0.009258	5.09	216.65	96.23	0.58
Newlin Gulch	Mainstem	3046	50-year	2604.00	5802.00	5806.38		5807.25	0.011411	7.56	352.55	109.25	0.69
Newlin Gulch	Mainstem	3046	100-year	3450.00	5802.00	5806.87		5808.01	0.012818	8.71	407.18	113.16	0.75
Newlin Gulch	Mainstem	3046	500-year	5018.00	5802.00	5807.56	5807.28	5809.25	0.015621	10.64	486.85	118.62	0.85
Newlin Gulch	Mainstem	3046	2-year	363.00	5802.00	5803.84		5804.00	0.006605	3.16	114.76	76.23	0.45
Newlin Gulch	Mainstem	2943	10-year	1099.00	5801.16	5804.60		5804.78	0.003742	3.48	321.35	139.20	0.38
Newlin Gulch	Mainstem	2943	50-year	2604.00	5801.16	5805.84		5806.25	0.005175	5.28	512.06	172.07	0.47
Newlin Gulch	Mainstem	2943	100-year	3450.00	5801.16	5806.32		5806.85	0.005797	6.04	597.57	188.67	0.51
Newlin Gulch	Mainstem	2943	500-year	5018.00	5801.16	5807.02		5807.77	0.006693	7.17	746.63	254.52	0.56
Newlin Gulch	Mainstem	2943	2-year	363.00	5801.16	5803.41		5803.48	0.003365	2.22	165.14	123.46	0.32
Newlin Gulch	Mainstem	2748	10-year	1099.00	5800.65	5803.77		5803.99	0.004622	3.87	303.93	177.20	0.42
Newlin Gulch	Mainstem	2748	50-year	2604.00	5800.65	5804.85	5804.01	5805.24	0.005561	5.33	529.32	241.28	0.49
Newlin Gulch	Mainstem	2748	100-year	3450.00	5800.65	5805.26	5804.45	5805.74	0.005951	5.91	634.42	271.10	0.51
Newlin Gulch	Mainstem	2748	500-year	5018.00	5800.65	5805.87	5805.08	5806.49	0.006693	6.86	816.21	334.75	0.56
Newlin Gulch	Mainstem	2748	2-year	363.00	5800.65	5802.80		5802.88	0.002970	2.28	162.24	114.36	0.31
Newlin Gulch	Mainstem	2559	10-year	1099.00	5800.07	5801.96	5801.91	5802.44	0.018916	5.39	198.38	189.59	0.77
Newlin Gulch	Mainstem	2559	50-year	2604.00	5800.07	5802.76	5802.76	5803.56	0.017108	6.80	366.13	236.85	0.79
Newlin Gulch	Mainstem	2559	100-year	3450.00	5800.07	5803.12	5803.12	5804.03	0.015912	7.21	453.77	256.43	0.78
Newlin Gulch	Mainstem	2559	500-year	5018.00	5800.07	5803.72	5803.72	5804.76	0.014052	7.75	621.98	306.93	0.76
Newlin Gulch	Mainstem	2559	2-year	363.00	5800.07	5801.26	5801.26	5801.57	0.030009	4.50	81.36	136.64	0.88
Newlin Gulch	Mainstem	2322	10-year	1099.00	5796.70	5800.02		5800.29	0.005328	4.28	273.18	150.28	0.45
Newlin Gulch	Mainstem	2322	50-year	2604.00	5796.70	5801.61		5801.88	0.003168	4.45	630.74	274.71	0.37
Newlin Gulch	Mainstem	2322	100-year	3450.00	5796.70	5802.09		5802.41	0.003170	4.77	774.07	315.04	0.38
Newlin Gulch	Mainstem	2322	500-year	5018.00	5796.70	5802.79		5803.20	0.003396	5.40	1005.43	358.61	0.40
Newlin Gulch	Mainstem	2322	2-year	363.00	5796.70	5798.70		5798.83	0.004549	2.91	124.90	71.02	0.39
Newlin Gulch	Mainstem	2171	10-year	1099.00	5796.50	5799.67	5798.13	5799.75	0.002629	2.27	496.66	269.88	0.26
Newlin Gulch	Mainstem	2171	50-year	2604.00	5796.50	5801.42	5799.12	5801.50	0.001366	2.36	1116.43	439.61	0.20
Newlin Gulch	Mainstem	2171	100-year	3450.00	5796.50	5801.90	5799.53	5802.01	0.001416	2.59	1327.19	497.27	0.21
Newlin Gulch	Mainstem	2171	500-year	5018.00	5796.50	5802.59	5800.15	5802.74	0.001584	3.00	1656.64	612.39	0.23
Newlin Gulch	Mainstem	2171	2-year	363.00	5796.50	5798.12	5797.29	5798.19	0.005622	2.08	174.20	146.40	0.34
Newlin Gulch	Mainstem	2150		Culvert									
Newlin Gulch	Mainstem	1997	10-year	1099.00	5795.50	5798.58	5797.17	5798.75	0.005837	3.27	336.49	187.13	0.38
Newlin Gulch	Mainstem	1997	50-year	2604.00	5795.50	5799.71	5798.42	5800.10	0.008171	5.05	529.79	316.64	0.48
Newlin Gulch	Mainstem	1997	100-year	3450.00	5795.50	5800.09	5798.95	5800.50	0.007964	5.36	682.37	370.05	0.48
Newlin Gulch	Mainstem	1997	500-year	5018.00	5795.50	5800.65	5799.63	5801.06	0.007329	5.63	1012.98	432.12	0.48
Newlin Gulch	Mainstem	1997	2-year	363.00	5795.50	5797.41	5796.31	5797.47	0.003176	1.97	184.03	119.19	0.27
Newlin Gulch	Mainstem	1867	10-year	1099.00	5795.20	5797.55		5797.77	0.010197	3.81	299.77	202.66	0.49
Newlin Gulch	Mainstem	1867	50-year	2604.00	5795.20	5798.54		5798.93	0.010762	5.18	532.36	308.70	0.54
Newlin Gulch	Mainstem	1867	100-year	3450.00	5795.20	5798.96		5799.40	0.010677	5.65	667.32	371.63	0.55
Newlin Gulch	Mainstem	1867	500-year	5018.00	5795.20	5799.51		5800.06	0.010909	6.34	857.77	408.09	0.57
Newlin Gulch	Mainstem	1867	2-year	363.00	5795.20	5796.69		5796.79	0.010014	2.51	145.62	156.05	0.44
Newlin Gulch	Mainstem	1841	10-year	1099.00	5794.76	5796.71	5796.71	5797.31	0.030982	6.21	181.00	165.80	0.96
Newlin Gulch	Mainstem	1841	50-year	2604.00	5794.76	5797.69	5797.69	5798.50	0.021317	7.50	373.69	282.66	0.88
Newlin Gulch	Mainstem	1841	100-year	3450.00	5794.76	5798.02	5798.02	5798.97	0.021599	8.25	461.36	334.60	0.90
Newlin Gulch	Mainstem	1841	500-year	5018.00	5794.76	5798.64	5798.64	5799.65	0.018180	8.73	652.12	376.55	0.86
Newlin Gulch	Mainstem	1841	2-year	363.00	5794.76	5795.95	5795.95	5796.30	0.041570	4.76	76.25	109.46	1.01



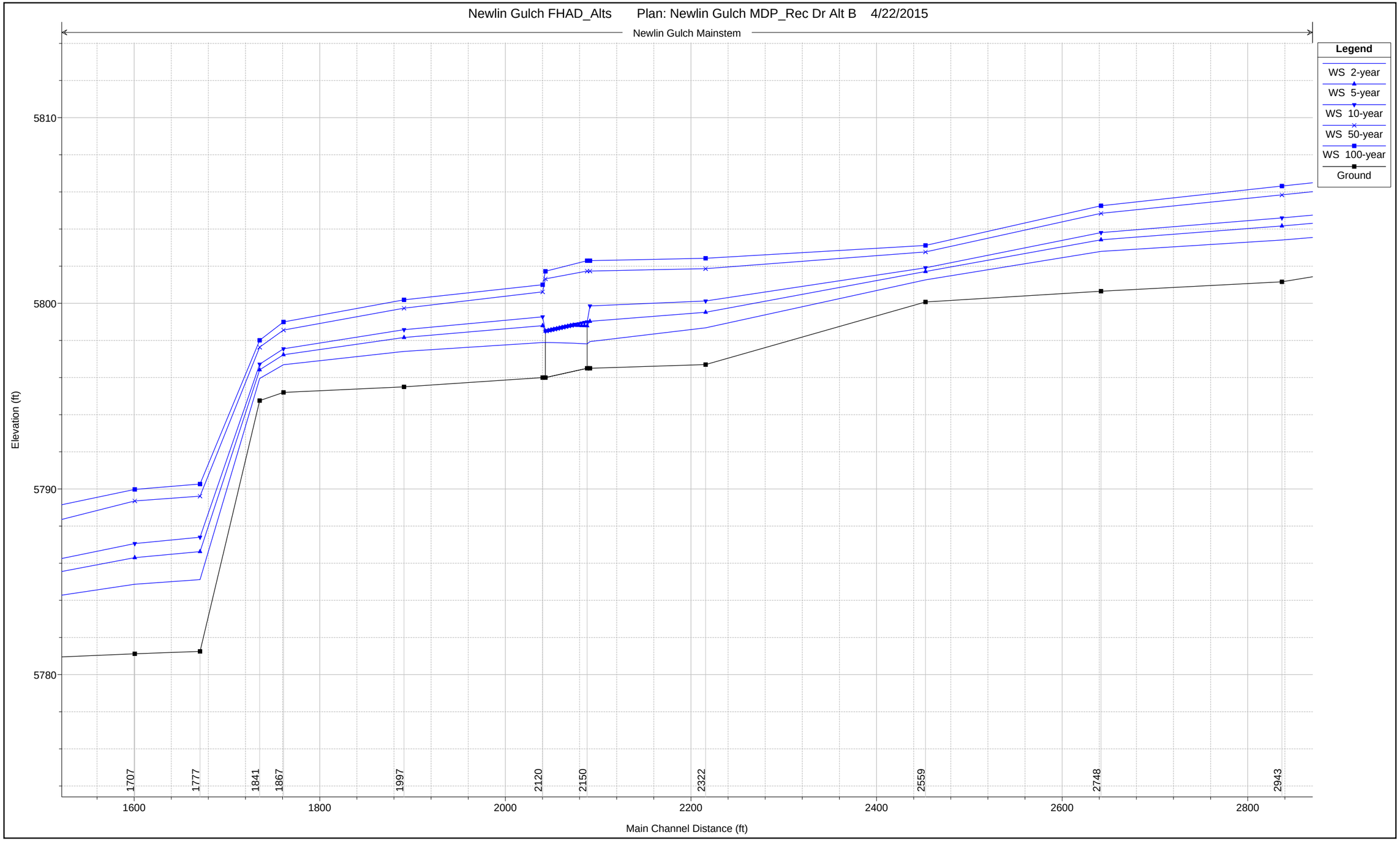
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft



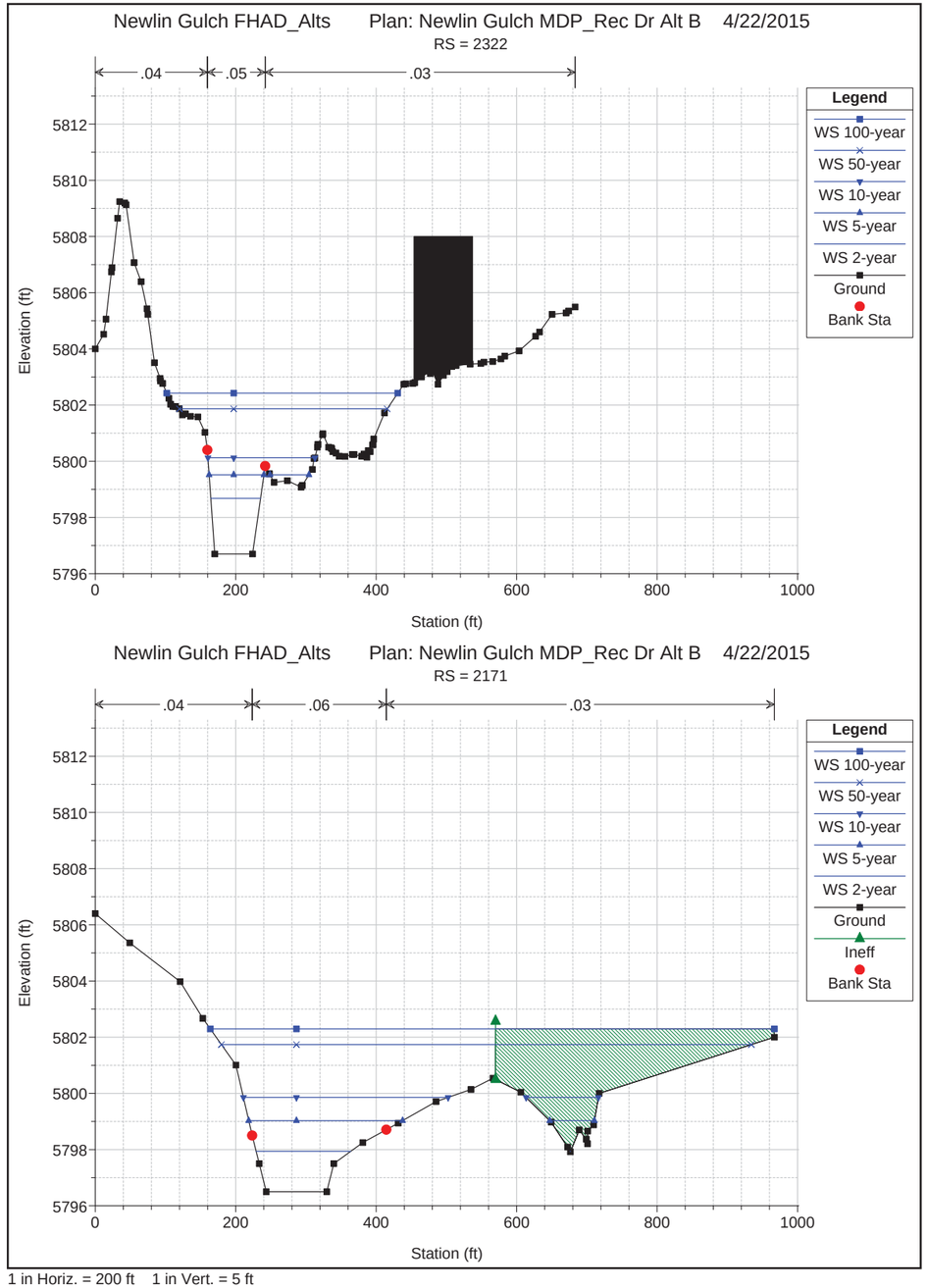
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



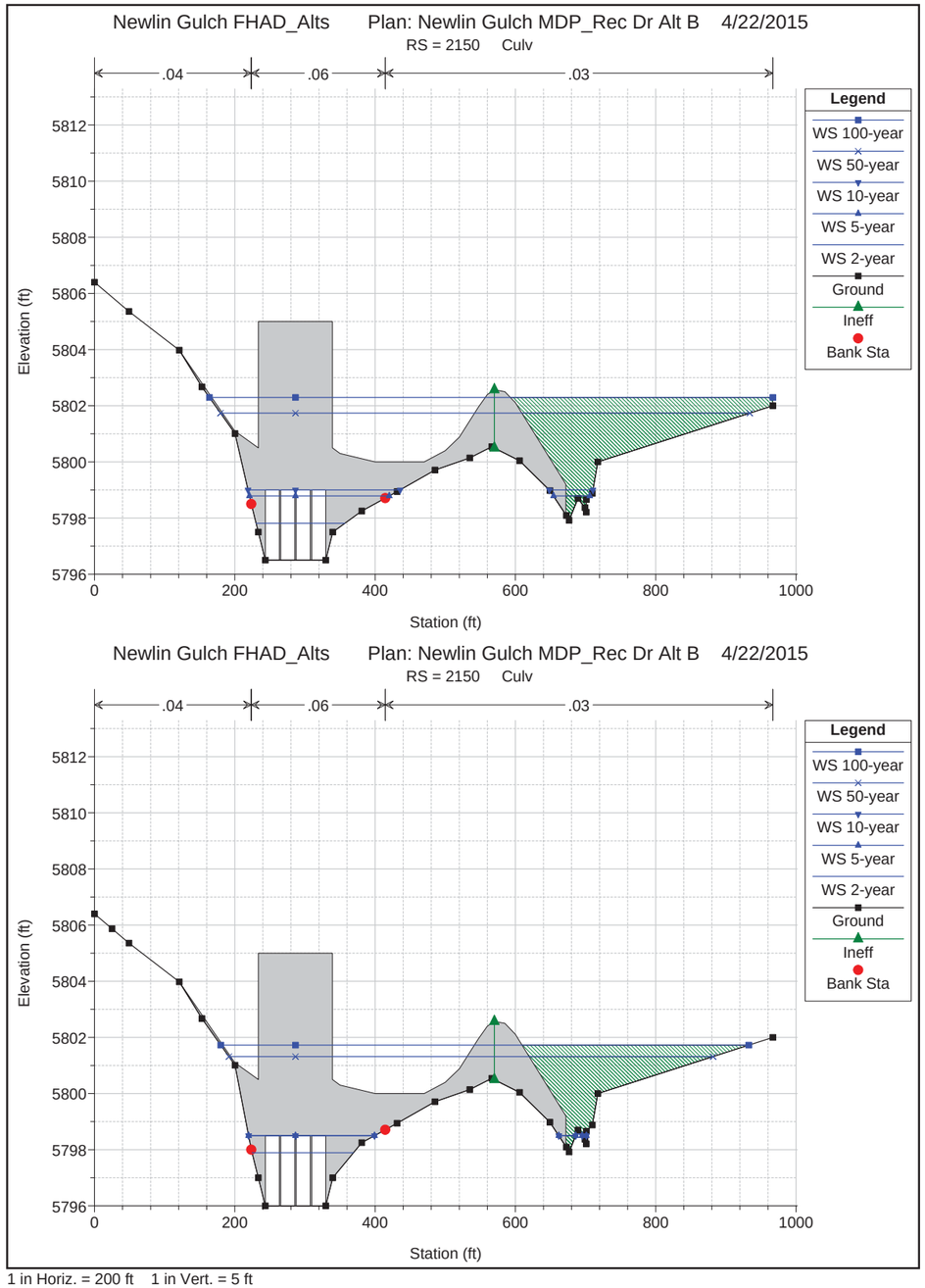
1 in Horiz. = 100 ft 1 in Vert. = 5 ft

HEC-RAS Plan: Alt_B Locations: User Defined

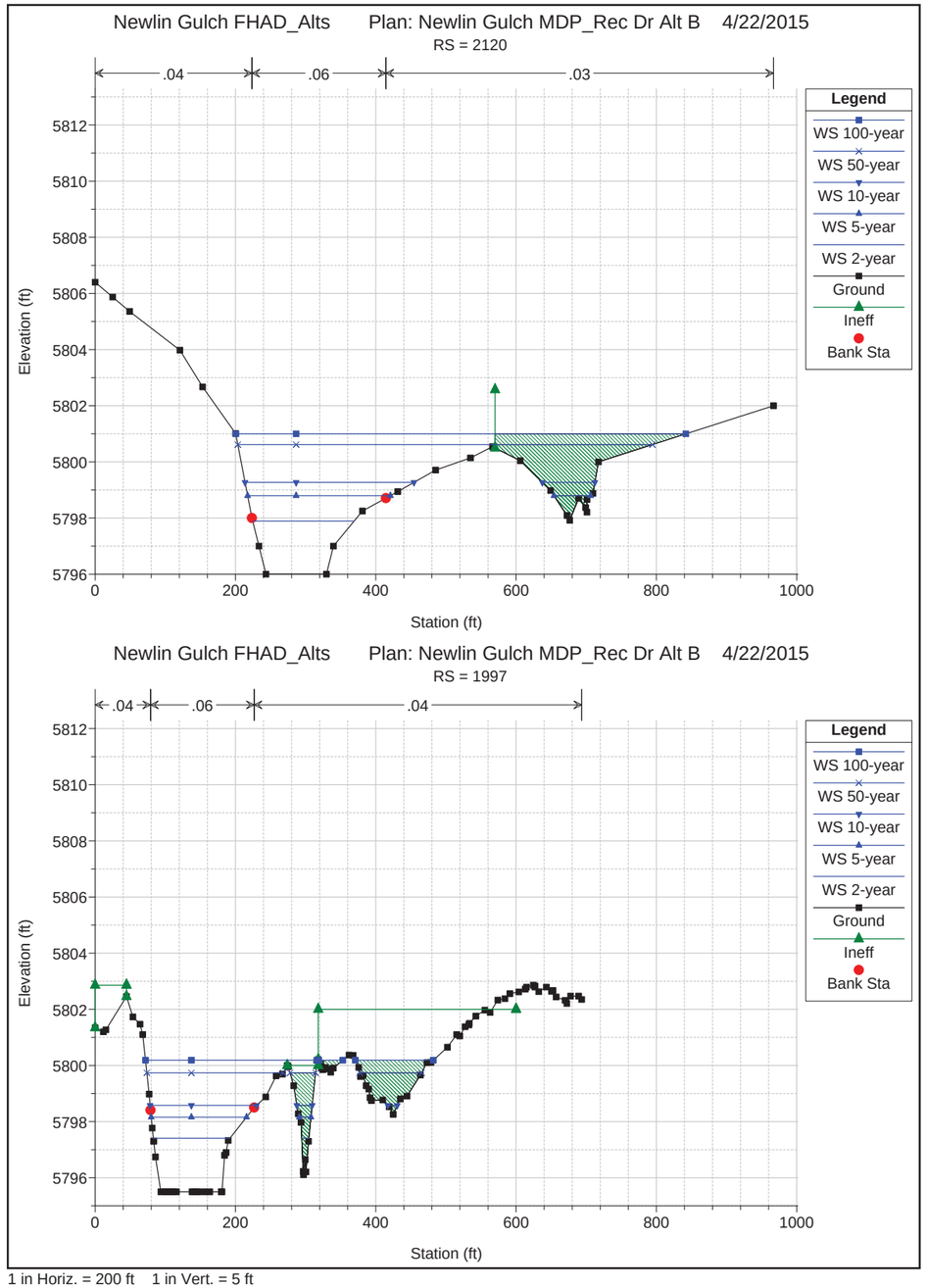
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Newlin Gulch	Mainstem	3203	10-year	1099.00	5802.09	5806.15	5804.40	5806.33	0.001854	3.43	320.12	100.14	0.34
Newlin Gulch	Mainstem	3203	50-year	2604.00	5802.09	5807.90	5805.68	5808.31	0.002539	5.14	507.48	113.55	0.42
Newlin Gulch	Mainstem	3203	100-year	3450.00	5802.09	5808.64	5806.29	5809.17	0.002711	5.87	592.55	116.76	0.45
Newlin Gulch	Mainstem	3203	500-year	5018.00	5802.09	5809.83	5807.28	5810.57	0.002907	6.94	735.38	123.13	0.48
Newlin Gulch	Mainstem	3203	2-year	363.00	5802.09	5804.69	5803.51	5804.75	0.001322	2.04	177.70	94.70	0.26
Newlin Gulch	Mainstem	3150		Bridge									
Newlin Gulch	Mainstem	3046	10-year	1099.00	5802.00	5805.07		5805.47	0.009239	5.08	216.79	96.25	0.58
Newlin Gulch	Mainstem	3046	50-year	2604.00	5802.00	5806.38		5807.25	0.011411	7.56	352.55	109.25	0.69
Newlin Gulch	Mainstem	3046	100-year	3450.00	5802.00	5806.87		5808.01	0.012818	8.71	407.18	113.16	0.75
Newlin Gulch	Mainstem	3046	500-year	5018.00	5802.00	5807.56	5807.28	5809.25	0.015615	10.64	486.91	118.62	0.85
Newlin Gulch	Mainstem	3046	2-year	363.00	5802.00	5803.84		5804.00	0.006605	3.16	114.76	76.23	0.45
Newlin Gulch	Mainstem	2943	10-year	1099.00	5801.16	5804.60		5804.79	0.003722	3.47	321.89	139.25	0.38
Newlin Gulch	Mainstem	2943	50-year	2604.00	5801.16	5805.84		5806.25	0.005175	5.28	512.06	172.07	0.47
Newlin Gulch	Mainstem	2943	100-year	3450.00	5801.16	5806.32		5806.85	0.005797	6.04	597.57	188.67	0.51
Newlin Gulch	Mainstem	2943	500-year	5018.00	5801.16	5807.02		5807.77	0.006690	7.17	746.74	254.59	0.56
Newlin Gulch	Mainstem	2943	2-year	363.00	5801.16	5803.41		5803.48	0.003365	2.22	165.14	123.46	0.32
Newlin Gulch	Mainstem	2748	10-year	1099.00	5800.65	5803.81		5804.01	0.004358	3.79	310.46	179.49	0.41
Newlin Gulch	Mainstem	2748	50-year	2604.00	5800.65	5804.85	5804.01	5805.24	0.005579	5.33	528.73	241.16	0.49
Newlin Gulch	Mainstem	2748	100-year	3450.00	5800.65	5805.26	5804.45	5805.74	0.005975	5.92	633.49	270.84	0.51
Newlin Gulch	Mainstem	2748	500-year	5018.00	5800.65	5805.87	5805.08	5806.49	0.006704	6.87	815.72	334.66	0.56
Newlin Gulch	Mainstem	2748	2-year	363.00	5800.65	5802.80		5802.88	0.002961	2.28	162.41	114.40	0.31
Newlin Gulch	Mainstem	2559	10-year	1099.00	5800.07	5801.91	5801.91	5802.44	0.021904	5.68	189.44	188.00	0.83
Newlin Gulch	Mainstem	2559	50-year	2604.00	5800.07	5802.77	5802.77	5803.56	0.016979	6.78	367.06	237.06	0.78
Newlin Gulch	Mainstem	2559	100-year	3450.00	5800.07	5803.12	5803.12	5804.03	0.015898	7.21	453.90	256.45	0.78
Newlin Gulch	Mainstem	2559	500-year	5018.00	5800.07	5803.72	5803.72	5804.76	0.014032	7.75	622.28	306.99	0.75
Newlin Gulch	Mainstem	2559	2-year	363.00	5800.07	5801.26	5801.26	5801.57	0.030009	4.50	81.36	136.64	0.88
Newlin Gulch	Mainstem	2322	10-year	1099.00	5796.70	5800.13		5800.36	0.004574	4.04	288.73	152.40	0.42
Newlin Gulch	Mainstem	2322	50-year	2604.00	5796.70	5801.87		5802.09	0.002326	3.93	705.97	295.97	0.32
Newlin Gulch	Mainstem	2322	100-year	3450.00	5796.70	5802.42		5802.67	0.002222	4.15	881.85	328.93	0.32
Newlin Gulch	Mainstem	2322	500-year	5018.00	5796.70	5803.16		5803.48	0.002328	4.64	1139.04	364.49	0.34
Newlin Gulch	Mainstem	2322	2-year	363.00	5796.70	5798.68		5798.81	0.004710	2.94	123.48	70.85	0.39
Newlin Gulch	Mainstem	2171	10-year	1099.00	5796.50	5799.86	5798.13	5799.92	0.001963	2.06	549.57	394.65	0.23
Newlin Gulch	Mainstem	2171	50-year	2604.00	5796.50	5801.74	5799.12	5801.81	0.000943	2.06	1223.46	754.52	0.17
Newlin Gulch	Mainstem	2171	100-year	3450.00	5796.50	5802.30	5799.53	5802.39	0.000961	2.25	1445.75	803.17	0.18
Newlin Gulch	Mainstem	2171	500-year	5018.00	5796.50	5803.00	5800.15	5803.11	0.001436	3.00	1908.39	821.92	0.22
Newlin Gulch	Mainstem	2171	2-year	363.00	5796.50	5797.94	5797.29	5798.03	0.008471	2.44	149.01	135.44	0.41
Newlin Gulch	Mainstem	2150		Culvert									
Newlin Gulch	Mainstem	1997	10-year	1099.00	5795.50	5798.58	5797.17	5798.75	0.005845	3.27	336.34	187.02	0.38
Newlin Gulch	Mainstem	1997	50-year	2604.00	5795.50	5799.74	5798.42	5800.12	0.007897	5.00	535.94	318.88	0.48
Newlin Gulch	Mainstem	1997	100-year	3450.00	5795.50	5800.19	5798.95	5800.58	0.007183	5.17	701.56	390.21	0.46
Newlin Gulch	Mainstem	1997	500-year	5018.00	5795.50	5800.95	5799.63	5801.45	0.007173	5.83	890.28	442.37	0.48
Newlin Gulch	Mainstem	1997	2-year	363.00	5795.50	5797.41	5796.31	5797.47	0.003176	1.97	184.03	119.19	0.27
Newlin Gulch	Mainstem	1867	10-year	1099.00	5795.20	5797.55		5797.77	0.010212	3.81	299.33	202.55	0.49
Newlin Gulch	Mainstem	1867	50-year	2604.00	5795.20	5798.56		5798.97	0.010708	5.19	507.48	313.91	0.54
Newlin Gulch	Mainstem	1867	100-year	3450.00	5795.20	5799.00		5799.51	0.010871	5.75	600.89	373.58	0.56
Newlin Gulch	Mainstem	1867	500-year	5018.00	5795.20	5799.73		5800.41	0.010667	6.51	761.55	434.67	0.57
Newlin Gulch	Mainstem	1867	2-year	363.00	5795.20	5796.69		5796.79	0.010014	2.51	145.62	156.05	0.44
Newlin Gulch	Mainstem	1841	10-year	1099.00	5794.76	5796.72	5796.72	5797.31	0.030575	6.18	181.81	166.17	0.96
Newlin Gulch	Mainstem	1841	50-year	2604.00	5794.76	5797.64	5797.64	5798.52	0.023744	7.78	352.08	266.42	0.92
Newlin Gulch	Mainstem	1841	100-year	3450.00	5794.76	5798.01	5798.01	5799.06	0.022936	8.48	426.50	334.00	0.93
Newlin Gulch	Mainstem	1841	500-year	5018.00	5794.76	5798.57	5798.57	5799.95	0.023224	9.72	539.52	369.45	0.97
Newlin Gulch	Mainstem	1841	2-year	363.00	5794.76	5795.95	5795.95	5796.30	0.041570	4.76	76.25	109.46	1.01



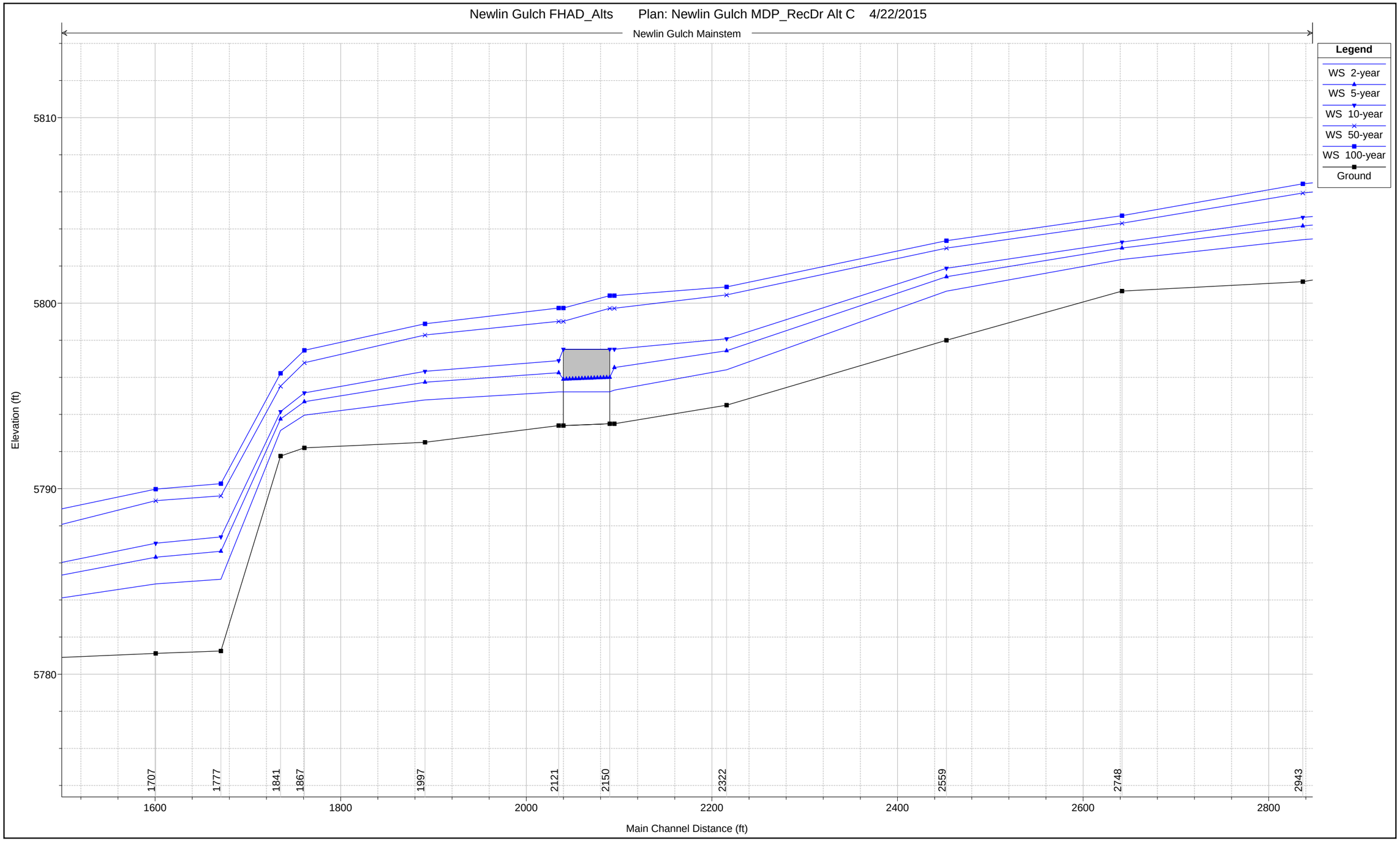
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft



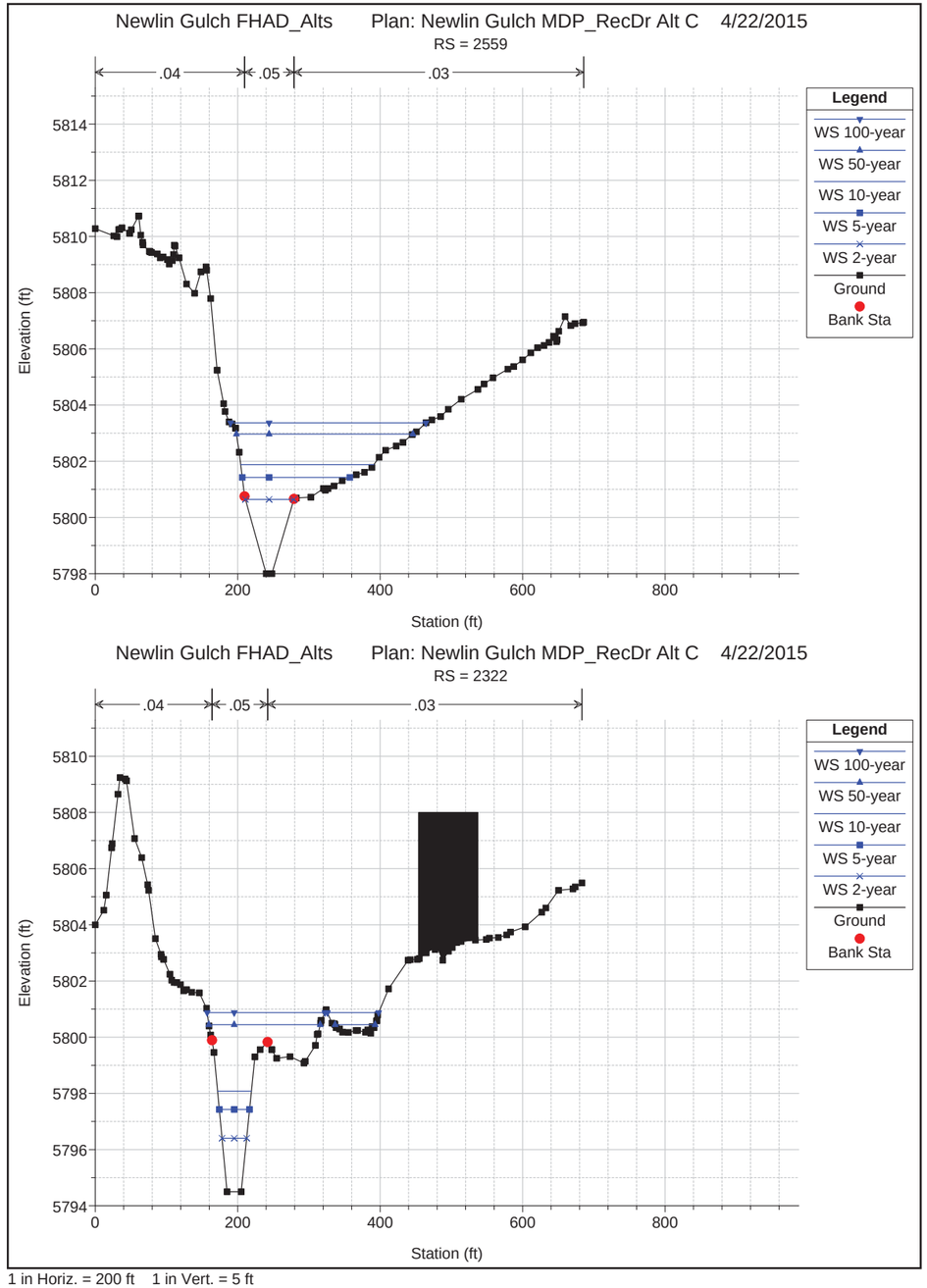
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



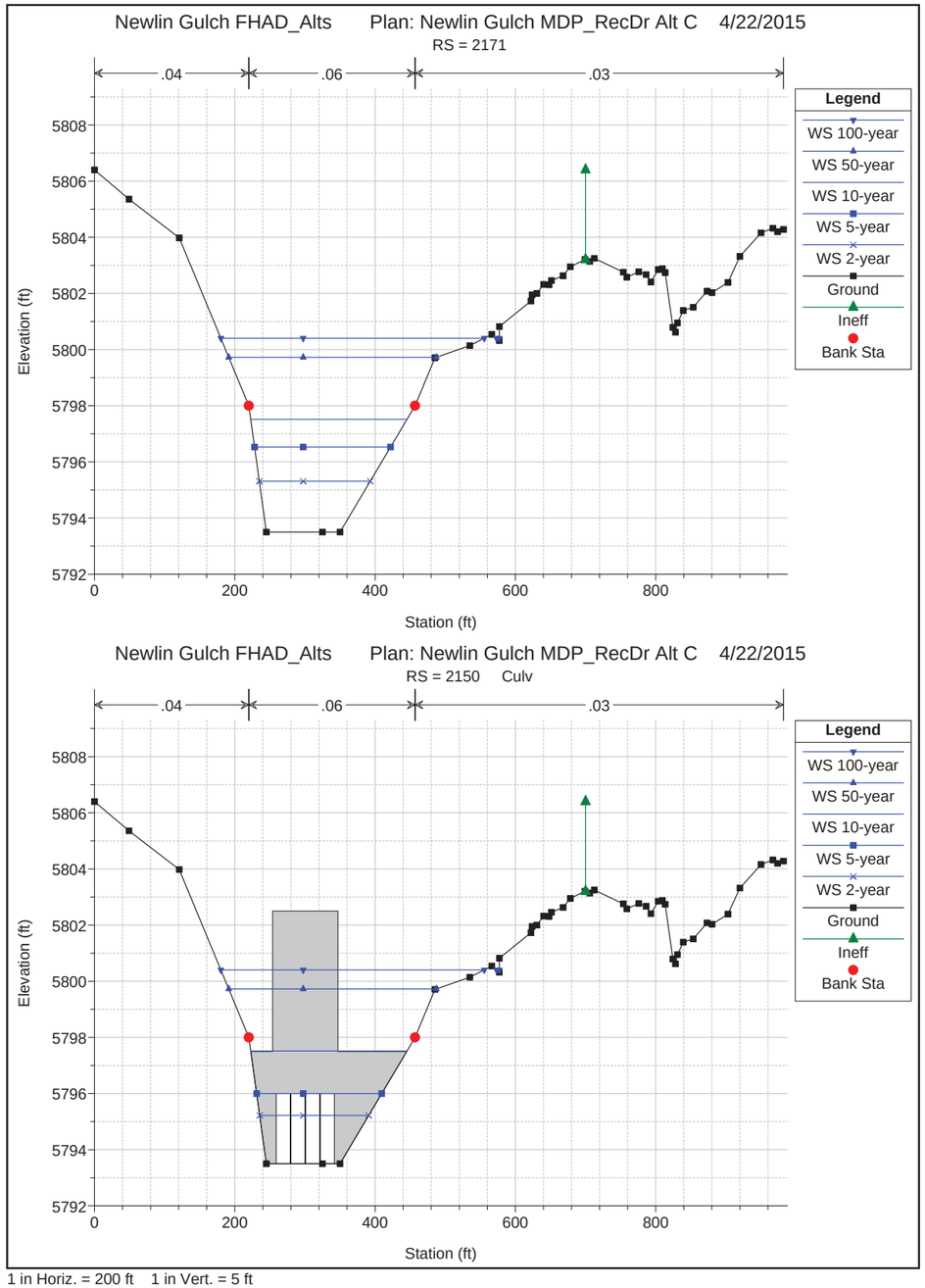
1 in Horiz. = 100 ft 1 in Vert. = 5 ft

HEC-RAS Plan: Alt_C Locations: User Defined

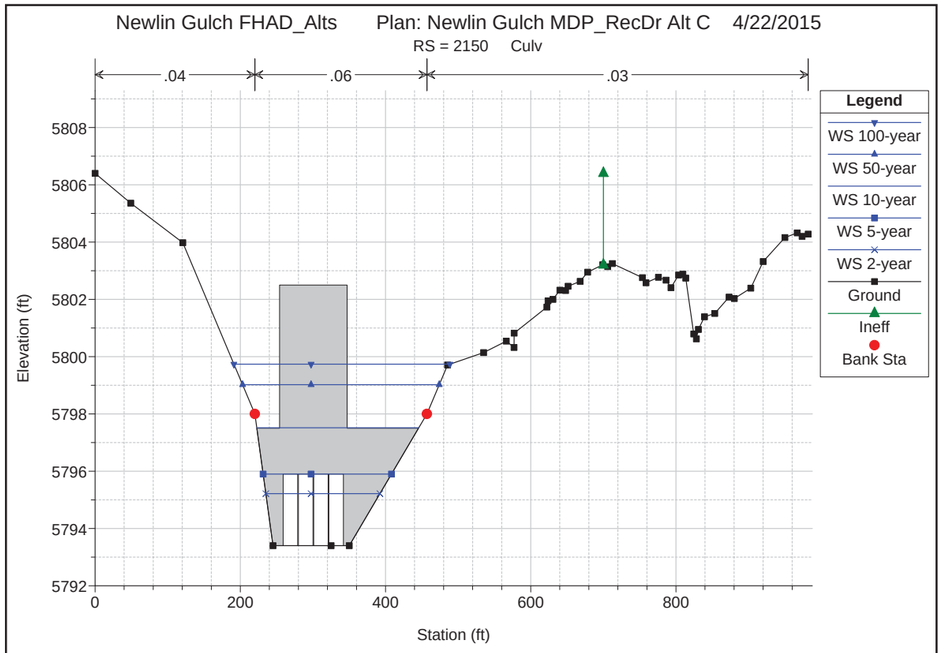
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Newlin Gulch	Mainstem	3203	2-year	363.00	5802.09	5804.69	5803.51	5804.75	0.001319	2.04	177.84	94.70	0.26
Newlin Gulch	Mainstem	3203	5-year	766.00	5802.09	5805.60	5804.04	5805.72	0.001631	2.89	265.30	98.00	0.31
Newlin Gulch	Mainstem	3203	10-year	1099.00	5802.09	5806.15	5804.40	5806.33	0.001852	3.43	320.26	100.16	0.34
Newlin Gulch	Mainstem	3203	50-year	2604.00	5802.09	5807.91	5805.68	5808.32	0.002525	5.14	508.31	113.58	0.42
Newlin Gulch	Mainstem	3203	100-year	3450.00	5802.09	5808.64	5806.28	5809.17	0.002704	5.86	593.06	116.78	0.45
Newlin Gulch	Mainstem	3150		Bridge									
Newlin Gulch	Mainstem	3046	2-year	363.00	5802.00	5803.85		5804.00	0.006565	3.16	114.98	76.26	0.45
Newlin Gulch	Mainstem	3046	5-year	766.00	5802.00	5804.61		5804.90	0.008139	4.37	175.40	83.86	0.53
Newlin Gulch	Mainstem	3046	10-year	1099.00	5802.00	5805.08		5805.48	0.009119	5.06	217.69	96.37	0.58
Newlin Gulch	Mainstem	3046	50-year	2604.00	5802.00	5806.42		5807.27	0.010982	7.47	356.93	109.57	0.68
Newlin Gulch	Mainstem	3046	100-year	3450.00	5802.00	5806.92		5808.03	0.012273	8.59	412.93	113.56	0.74
Newlin Gulch	Mainstem	2943	2-year	363.00	5801.16	5803.42		5803.50	0.003277	2.20	166.52	123.66	0.32
Newlin Gulch	Mainstem	2943	5-year	766.00	5801.16	5804.16		5804.30	0.003473	2.97	261.87	133.41	0.35
Newlin Gulch	Mainstem	2943	10-year	1099.00	5801.16	5804.63		5804.81	0.003601	3.43	325.30	139.59	0.37
Newlin Gulch	Mainstem	2943	50-year	2604.00	5801.16	5805.94		5806.33	0.004708	5.12	528.64	174.67	0.45
Newlin Gulch	Mainstem	2943	100-year	3450.00	5801.16	5806.43		5806.93	0.005264	5.85	619.63	196.20	0.49
Newlin Gulch	Mainstem	2748	2-year	363.00	5800.65	5802.35		5802.51	0.008668	3.18	114.77	99.90	0.50
Newlin Gulch	Mainstem	2748	5-year	766.00	5800.65	5802.97		5803.25	0.009221	4.30	182.76	120.15	0.56
Newlin Gulch	Mainstem	2748	10-year	1099.00	5800.65	5803.29		5803.68	0.010565	5.12	225.83	149.55	0.61
Newlin Gulch	Mainstem	2748	50-year	2604.00	5800.65	5804.31		5804.97	0.011484	6.90	407.71	209.22	0.68
Newlin Gulch	Mainstem	2748	100-year	3450.00	5800.65	5804.72		5805.49	0.011546	7.49	498.45	233.89	0.70
Newlin Gulch	Mainstem	2559	2-year	363.00	5798.00	5800.64	5799.96	5800.85	0.008844	3.62	100.35	67.92	0.52
Newlin Gulch	Mainstem	2559	5-year	766.00	5798.00	5801.43	5800.87	5801.70	0.007454	4.37	191.12	151.05	0.52
Newlin Gulch	Mainstem	2559	10-year	1099.00	5798.00	5801.88		5802.16	0.006254	4.53	269.22	186.81	0.49
Newlin Gulch	Mainstem	2559	50-year	2604.00	5798.00	5802.97		5803.40	0.006151	5.63	502.15	247.77	0.51
Newlin Gulch	Mainstem	2559	100-year	3450.00	5798.00	5803.37		5803.89	0.006358	6.13	606.44	274.32	0.53
Newlin Gulch	Mainstem	2322	2-year	363.00	5794.50	5796.41	5796.41	5797.16	0.032553	6.97	52.07	34.63	1.00
Newlin Gulch	Mainstem	2322	5-year	766.00	5794.50	5797.43	5797.43	5798.52	0.029122	8.36	91.58	42.49	1.00
Newlin Gulch	Mainstem	2322	10-year	1099.00	5794.50	5798.08	5798.08	5799.37	0.027678	9.10	120.80	47.47	1.01
Newlin Gulch	Mainstem	2322	50-year	2604.00	5794.50	5800.45	5800.45	5801.32	0.013959	7.90	357.75	212.60	0.75
Newlin Gulch	Mainstem	2322	100-year	3450.00	5794.50	5800.87	5800.87	5801.82	0.013330	8.35	454.53	237.26	0.75
Newlin Gulch	Mainstem	2171	2-year	363.00	5793.50	5795.31	5794.19	5795.35	0.002184	1.52	238.65	158.20	0.22
Newlin Gulch	Mainstem	2171	5-year	766.00	5793.50	5796.53	5794.62	5796.57	0.001512	1.69	452.57	193.85	0.20
Newlin Gulch	Mainstem	2171	10-year	1099.00	5793.50	5797.52	5794.90	5797.56	0.001076	1.67	657.93	222.76	0.17
Newlin Gulch	Mainstem	2171	50-year	2604.00	5793.50	5799.73	5795.87	5799.80	0.000900	2.16	1228.04	295.88	0.17
Newlin Gulch	Mainstem	2171	100-year	3450.00	5793.50	5800.40	5796.30	5800.50	0.000986	2.46	1457.74	379.61	0.18
Newlin Gulch	Mainstem	2150		Culvert									
Newlin Gulch	Mainstem	2121	2-year	363.00	5793.40	5795.22		5795.25	0.002180	1.52	238.14	157.14	0.22
Newlin Gulch	Mainstem	2121	5-year	766.00	5793.40	5796.25		5796.30	0.001904	1.84	416.08	186.83	0.22
Newlin Gulch	Mainstem	2121	10-year	1099.00	5793.40	5796.90		5796.97	0.001826	2.02	543.56	205.47	0.22
Newlin Gulch	Mainstem	2121	50-year	2604.00	5793.40	5799.02		5799.12	0.001460	2.51	1045.89	270.89	0.21
Newlin Gulch	Mainstem	2121	100-year	3450.00	5793.40	5799.74		5799.86	0.001496	2.82	1248.34	297.30	0.22
Newlin Gulch	Mainstem	1997	2-year	363.00	5792.50	5794.79	5793.52	5794.86	0.003347	2.26	160.61	80.57	0.28
Newlin Gulch	Mainstem	1997	5-year	766.00	5792.50	5795.74	5794.16	5795.89	0.004393	3.17	241.45	89.15	0.34
Newlin Gulch	Mainstem	1997	10-year	1099.00	5792.50	5796.33	5794.58	5796.54	0.004993	3.72	295.37	96.81	0.37
Newlin Gulch	Mainstem	1997	50-year	2604.00	5792.50	5798.28	5796.05	5798.68	0.007510	5.07	513.62	159.99	0.47
Newlin Gulch	Mainstem	1997	100-year	3450.00	5792.50	5798.89	5796.71	5799.40	0.008281	5.72	605.78	191.22	0.50
Newlin Gulch	Mainstem	1867	2-year	363.00	5792.20	5793.96	5793.41	5794.12	0.011754	3.20	113.29	86.68	0.49
Newlin Gulch	Mainstem	1867	5-year	766.00	5792.20	5794.69	5794.02	5794.97	0.013002	4.26	179.81	96.68	0.55
Newlin Gulch	Mainstem	1867	10-year	1099.00	5792.20	5795.16	5794.40	5795.52	0.013394	4.84	227.25	103.23	0.57
Newlin Gulch	Mainstem	1867	50-year	2604.00	5792.20	5796.79	5795.74	5797.36	0.014019	6.10	429.42	161.92	0.62
Newlin Gulch	Mainstem	1867	100-year	3450.00	5792.20	5797.46	5796.43	5798.10	0.012073	6.47	550.03	197.29	0.59
Newlin Gulch	Mainstem	1841	2-year	363.00	5791.76	5793.14	5793.14	5793.59	0.038347	5.41	67.12	74.82	1.01
Newlin Gulch	Mainstem	1841	5-year	766.00	5791.76	5793.75	5793.75	5794.43	0.032052	6.61	115.89	83.46	0.99
Newlin Gulch	Mainstem	1841	10-year	1099.00	5791.76	5794.15	5794.15	5794.98	0.030192	7.31	150.42	89.07	0.99
Newlin Gulch	Mainstem	1841	50-year	2604.00	5791.76	5795.52	5795.52	5796.81	0.026011	9.12	285.62	108.27	0.99
Newlin Gulch	Mainstem	1841	100-year	3450.00	5791.76	5796.21	5796.21	5797.59	0.025358	9.42	366.41	129.84	0.99

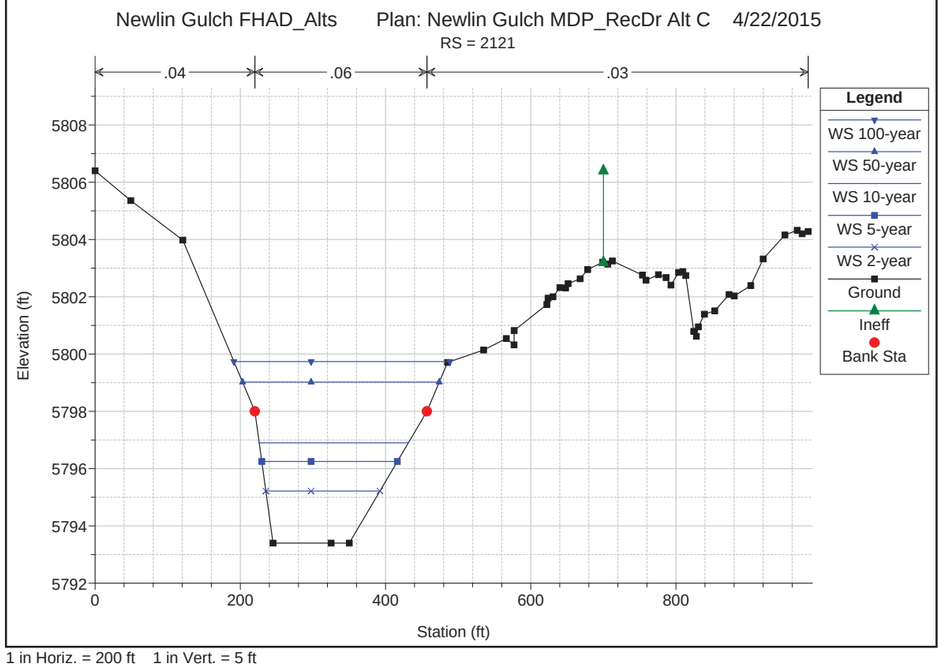


1 in Horiz. = 200 ft 1 in Vert. = 5 ft

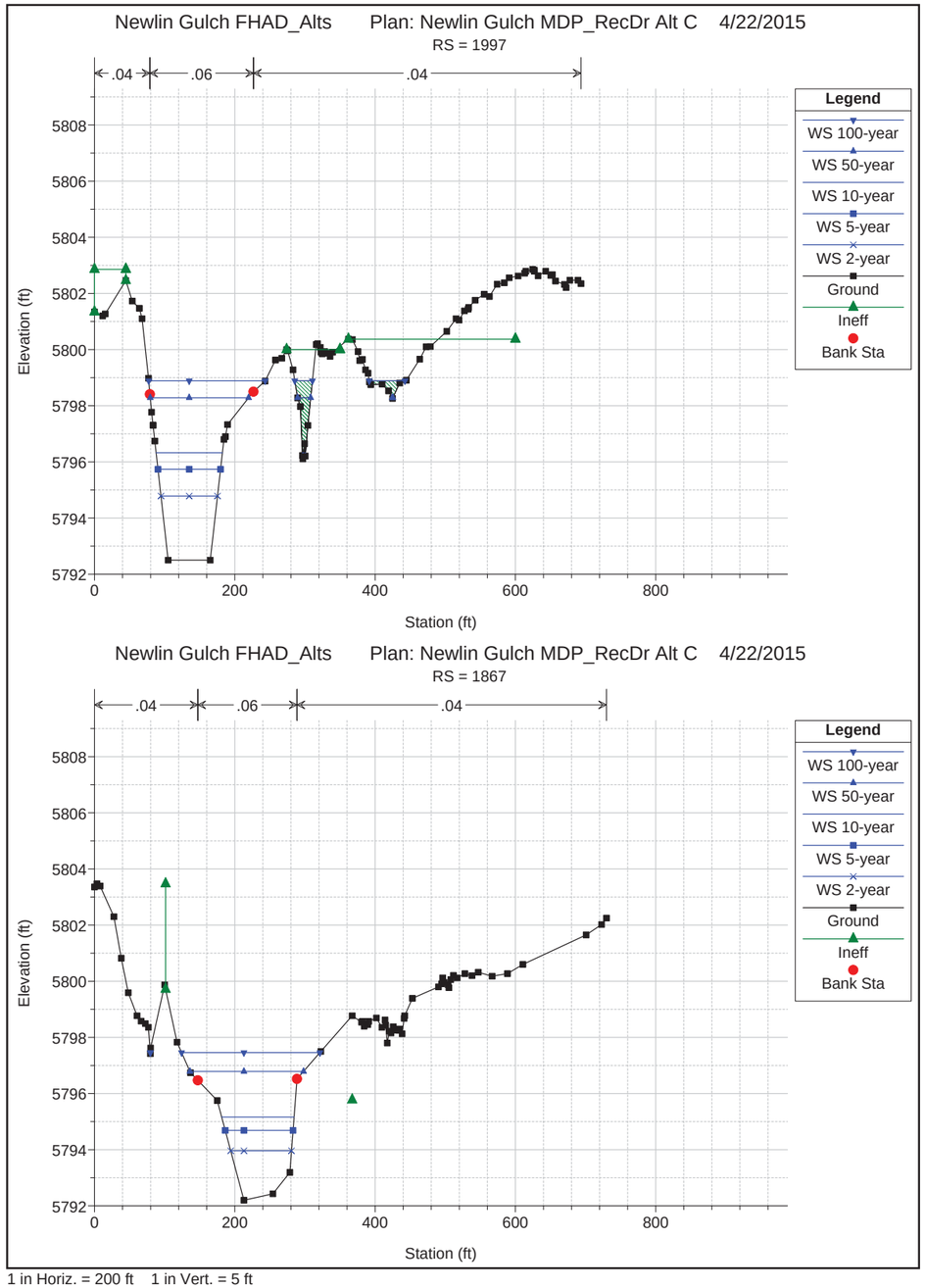


1 in Horiz. = 200 ft 1 in Vert. = 5 ft

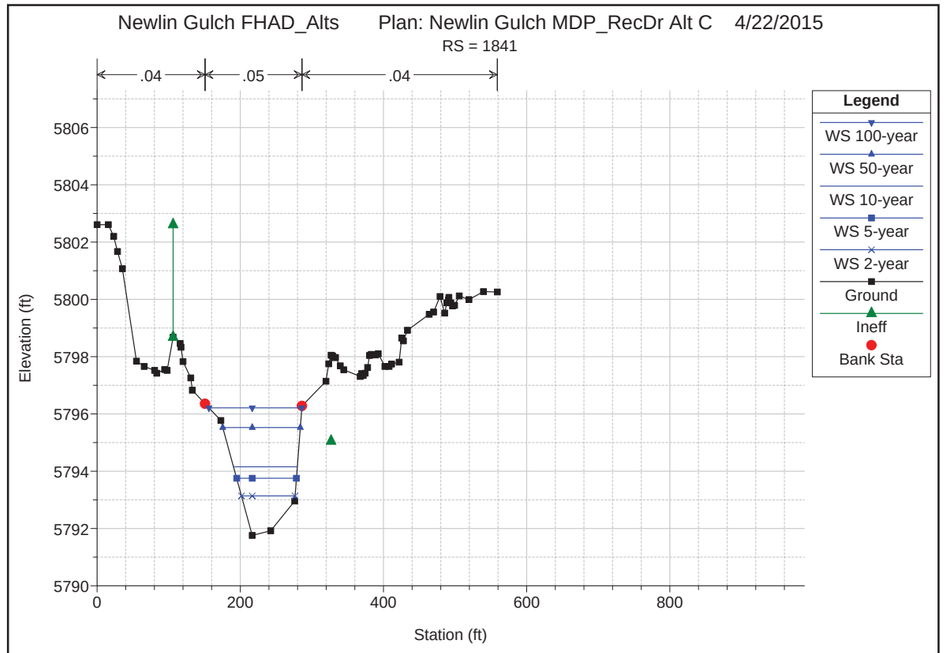




1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft



1 in Horiz. = 200 ft 1 in Vert. = 5 ft

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL REACH

PROJECT :	Newlin Gulch Major Drainageway Plan - Alternatives Analysis		
DRAINAGEWAY :	Newlin Gulch		
REACH :	RD-A		
JURISDICTION :	Douglas County		
REACH ID:	NG-ReachRD-A	Muller Engineering Company	DATE : June 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST	USER COMMENTS
Concrete Box Culverts							
Box Culvert Pipe							
Individual Box Span (ft)	**Box Height (ft)**	**No. of Barrels**	**Length (ft)**				
10	3	8	50	L.F.	$6,733.20	$336,660.00	(4) 20' x 2.5' boxes at Recreation Drive - sizes adjusted per allowable options
Headwall and Toewalls							
Individual Box Span (ft)	**No. of Barrels**	**Total Span (ft)**					
10	8	88.00	2	EA	$7,942.00	$15,884.00	
Wingwalls (includes wingwalls on either side of channel and concrete apron)							
Individual Box Span (ft)	**Box Rise (ft)**	**No. of Barrels**					
10	3	8	2	EA	$22,146.58	$44,293.20	
Channel Improvements							
Excavation, Mid Range			2500	C.Y.	$29.00	$72,500.00	Channel re-grading: 2' depth u/s, 1' depth d/s, 90' width ea, 250 LF ea
Excavation, Mid Range			400	C.Y.	$29.00	$11,600.00	Roadway embankment: 210 SF x-section @ 50' width
18-inch Riprap, Type H			560	C.Y.	$97.00	$54,320.00	ROB adjacent to large grouted boulder drop
Landscaping and Maintenance Improvements							
Wetlands Plantings			1	ACRE	$30,415.00	$30,415.00	Channel length of 650' multiplied by mitigation width of 60'
Reclamation & seeding (native grasses)			3	ACRE	$1,217.00	$3,651.00	
Trail/Path, Concrete (10' Width)			350	L.F.	$54.00	$18,900.00	
Special Items (User Defined)							
Road Reconstruction	**<----User Defined Items**		690	SY	$50.00	$34,500.00	8" thick asphalt and 6" thick aggregate base course
Asphalt Removal	**<----User Defined Items**		975	SY	$10.00	$9,750.00	690 SY + 85'x30'
Curb and Gutter (Remove and Replace)	**<----User Defined Items**		320	LF	$30.00	$9,600.00	
54" Railing (Box Culvert)	**<----User Defined Items**		216	LF	$250.00	$54,000.00	
Remove Sidewalk	**<----User Defined Items**		360	SY	$10.00	$3,600.00	320 LF @ 10' wide
Sheet Pile	**<----User Defined Items**		1650	SF	$30.00	$49,500.00	110 LF @ 15' deep, ROB of large drop
Land Acquisition							
Easement/ROW Acquisition			0.70	ACRE	$87,120.00	$60,984.00	$2/SF

Master Plan Capital Improvement Cost Summary				
Capital Improvement Costs				
Pipe Culverts and Storm Drains			$0.00	
Concrete Box Culverts			$396,837.00	
Hydraulic Structures			$0.00	
Channel Improvements			$138,420.00	
Detention/Water Quality Facilities			$0.00	
Removals			$0.00	
Landscaping and Maintenance Improvements			$52,966.00	
Special Items (User Defined)			$160,950.00	
Subtotal Capital Improvement Costs			**$749,173.00**	
Additional Capital Improvement Costs				
Dewatering	$37,458.65	L.S.	$37,459.00	
Mobilization	5%		$37,459.00	
Traffic Control	$8,000.00	L.S.	$8,000.00	
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00	
Stormwater Management/Erosion Control	5%		$37,459.00	
Subtotal Additional Capital Improvement Costs			**$125,377.00**	
Land Acquisition Costs				
ROW/Easements			$60,984.00	
Subtotal Land Acquisition Costs			**$60,984.00**	
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%		$131,183.00	
Legal/Administrative	5%		$43,728.00	
Contract Admin/Construction Management	10%		$87,455.00	
Contingency	25%		$218,638.00	
Subtotal Other Costs			**$481,004.00**	
Total Capital Improvement Costs			**$1,416,538.00**	

Master Plan Operation and Maintenance Cost Summary					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**	
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs, et	200	L.F.	$4.00	$800.00	
Total Annual Operation and Maintenance Cost				**$800.00**	
Effective Interest Rate				4.00%	
Total Operation and Maintenance Costs Over 50 Years				**$17,186.00**	

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL REACH

PROJECT :	Newlin Gulch Major Drainageway Plan - Alternatives Analysis		
DRAINAGEWAY :	Newlin Gulch		
REACH :	RD-B		
JURISDICTION :	Douglas County		
REACH ID:	NG-ReachRD-B	Muller Engineering Company	DATE : June 2015

DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST	USER COMMENTS
Pipe Culverts and Storm Drains							
Circular Pipes							
Diameter (in)	**Length (ft)**	**No. of Barrels**					
24-inch	30	1	30	L.F.	$88.00	$2,640.00	Storm sewer to drain proposed sag at east end of Recreation Drive
Flare End Sections							
Diameter (in)	**Applicable**	**No. of Barrels**					
24-inch	Yes	1	1	EA	$1,180.00	$1,180.00	
Manholes and Inlets							
Storm Inlet, Type R/Type 14, 5-foot			1	EA	$5,596.00	$5,596.00	Inlet to drain proposed sag point on east end of Recreation Drive
Concrete Box Culverts							
Box Culvert Pipe							
Individual Box Span (ft)	**Box Height (ft)**	**No. of Barrels**	**Length (ft)**				
10	3	8	50	L.F.	$6,733.20	$336,660.00	(4) 20' x 2.5' boxes at Recreation Drive - sizes adjusted per allowable options
Headwall and Toewalls							
Individual Box Span (ft)	**No. of Barrels**	**Total Span (ft)**					
10	8	88.00	2	EA	$7,942.00	$15,884.00	
Wingwalls (includes wingwalls on either side of channel and concrete apron)							
Individual Box Span (ft)	**Box Rise (ft)**	**No. of Barrels**					
10	3	8	2	EA	$22,146.58	$44,293.20	
Channel Improvements							
Excavation, Mid Range			2500	C.Y.	$29.00	$72,500.00	Channel re-grading: 2' depth u/s, 1' depth d/s, 90' width ea, 250 LF ea
Excavation, Mid Range			500	C.Y.	$29.00	$14,500.00	Roadway Embankment: 257 SF x-section over 50' width
Excavation, High Range			500	C.Y.	$38.00	$19,000.00	Berm grading (imported fill): 300 LF x 1' avg height x 40' wide at parking lot
Excavation, High Range			1200	C.Y.	$38.00	$45,600.00	Berm grading (imported fill): 100 LF x 4.5' avg height x 70' wide near drop structu
Grouted Boulders, 36"			280	S.Y.	$231.00	$64,680.00	Raising east edge of grouted boulder crest structure
Landscaping and Maintenance Improvements							
Wetlands Plantings			1	ACRE	$30,415.00	$30,415.00	Channel length of 650' multiplied by mitigation width of 60'
Reclamation & seeding (native grasses)			4	ACRE	$1,217.00	$4,260.00	
Trail/Path, Concrete (10' Width)			650	L.F.	$54.00	$35,100.00	
Special Items (User Defined)							
Road Reconstruction	**<----User Defined Items**		1750	SY	$50.00	$87,500.00	8" thick asphalt and 6" thick aggregate base course
Asphalt Removal	**<----User Defined Items**		2040	SY	$10.00	$20,400.00	1750 SY + 85'x30'
Curb and Gutter (Remove and Replace)	**<----User Defined Items**		960	LF	$30.00	$28,800.00	
Restore Landscape Area	**<----User Defined Items**		12500	SF	$5.00	$62,500.00	assumes restoration of turf and irrigation system
54" Railing (Box Culvert)	**<----User Defined Items**		216	LF	$250.00	$54,000.00	
Remove Sidewalk	**<----User Defined Items**		730	SY	$10.00	$7,300.00	650 LF @ 10' wide
Remove 36" Grouted Boulders	**<----User Defined Items**		280	SY	$30.00	$8,400.00	
Land Acquisition							
Easement/ROW Acquisition			0.70	ACRE	$87,120.00	$60,984.00	$2/SF

Master Plan Capital Improvement Cost Summary				
Capital Improvement Costs				
Pipe Culverts and Storm Drains			$9,416.00	
Concrete Box Culverts			$396,837.00	
Hydraulic Structures			$0.00	
Channel Improvements			$216,280.00	
Detention/Water Quality Facilities			$0.00	
Removals			$0.00	
Landscaping and Maintenance Improvements			$69,775.00	
Special Items (User Defined)			$268,900.00	
Subtotal Capital Improvement Costs			**$961,208.00**	
Additional Capital Improvement Costs				
Dewatering	$48,060.40	L.S.	$48,060.00	
Mobilization	5%		$48,060.00	
Traffic Control	$15,000.00	L.S.	$15,000.00	
Utility Coordination/Relocation	$5,000.00	L.S.	$5,000.00	
Stormwater Management/Erosion Control	5%		$48,060.00	
Subtotal Additional Capital Improvement Costs			**$164,180.00**	
Land Acquisition Costs				
ROW/Easements			$60,984.00	
Subtotal Land Acquisition Costs			**$60,984.00**	
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%		$168,808.00	
Legal/Administrative	5%		$56,269.00	
Contract Admin/Construction Management	10%		$112,539.00	
Contingency	25%		$281,347.00	
Subtotal Other Costs			**$618,963.00**	
Total Capital Improvement Costs			**$1,805,335.00**	

Master Plan Operation and Maintenance Cost Summary					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**	
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs,	200	L.F.	$4.00	$800.00	
Manhole and Inlet Maintenance (e.g. sediment & debris removal, structural repairs, etc.)	1	EA	$91.00	$91.00	
Total Annual Operation and Maintenance Cost				**$891.00**	
Effective Interest Rate				4.00%	
Total Operation and Maintenance Costs Over 50 Years				**$19,141.00**	

MASTER PLAN COST ESTIMATE FOR INDIVIDUAL REACH

PROJECT :	Newlin Gulch Major Drainageway Plan - Alternatives Analysis		
DRAINAGEWAY :	Newlin Gulch		
REACH :	RD-C		
JURISDICTION :	Douglas County		
REACH ID:	NG-ReachRD-C	Muller Engineering Company	DATE : June 2015

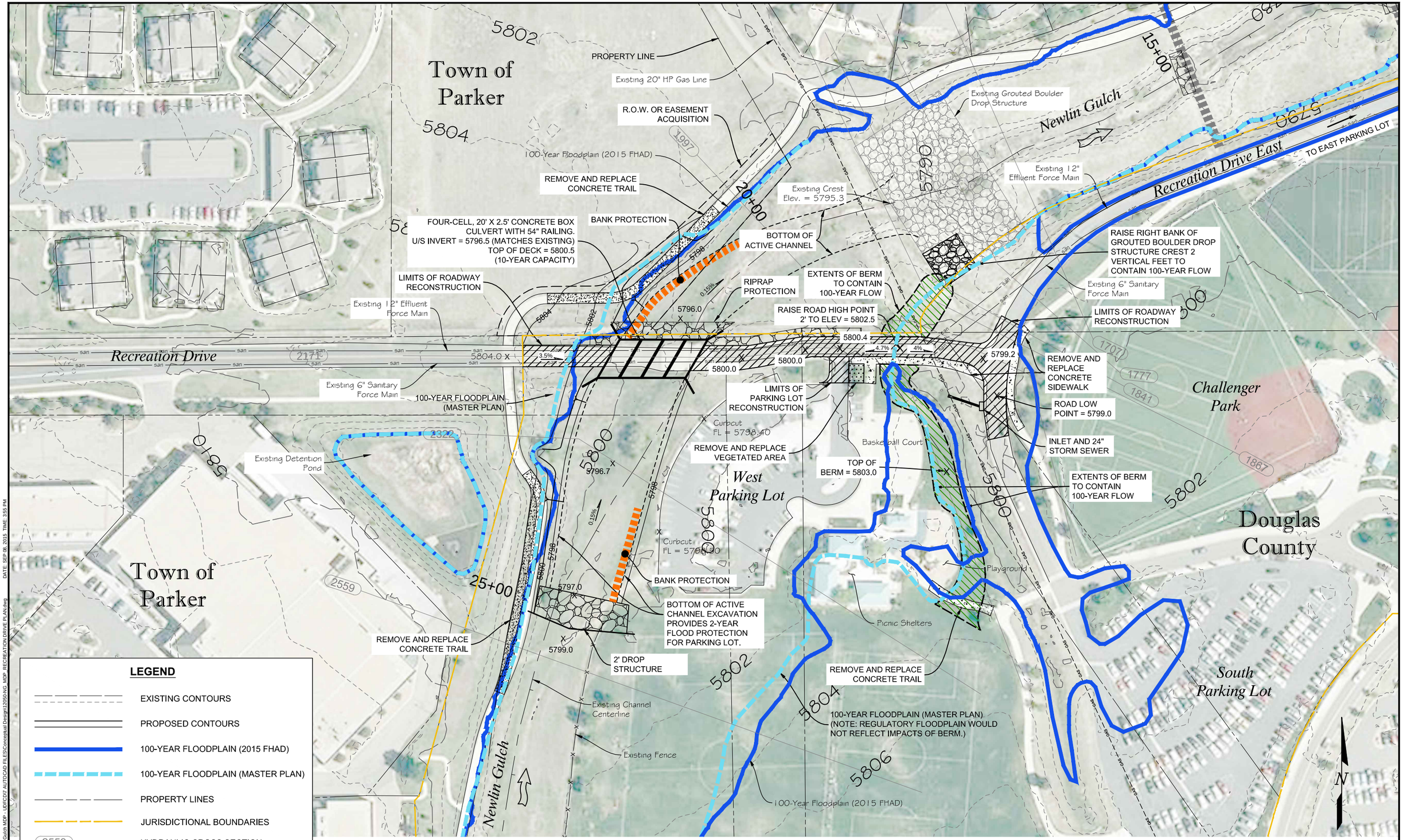
DESCRIPTION			QUANTITY	UNIT	UNIT COST	TOTAL COST	USER COMMENTS
Concrete Box Culverts							
Box Culvert Pipe							
Individual Box Span (ft)	**Box Height (ft)**	**No. of Barrels**	**Length (ft)**				
10	3	8	50	L.F.	$6,733.20	$336,660.00	(4) 20' x 2.5' boxes at Recreation Drive - sizes adjusted per allowable options
Headwall and Toewalls							
Individual Box Span (ft)	**No. of Barrels**	**Total Span (ft)**					
10	8	88.00	2	EA	$7,942.00	$15,884.00	
Wingwalls (includes wingwalls on either side of channel and concrete apron)							
Individual Box Span (ft)	**Box Rise (ft)**	**No. of Barrels**					
10	3	8	2	EA	$22,146.58	$44,293.20	
Hydraulic Structures							
Sloping Drop Structures							
Height (ft)	**Bottom Width (ft)**	**Yn (ft)**					
3	60	5.5	1	EA	$160,160.26	$160,160.00	
Channel Improvements							
Excavation, Mid Range			5500	C.Y.	$29.00	$159,500.00	Channel re-grading: 3' avg cut depth @ 90' width over 550 LF of channel.
Grouted Boulders, 36"			550	S.Y.	$231.00	$127,050.00	Removing and lowering grouted boulder crest structure
Excavation, Mid Range			200	C.Y.	$29.00	$5,800.00	Roadway Embankment: 105 SF x-section over 50' width
Landscaping and Maintenance Improvements							
Wetlands Plantings			1	ACRE	$30,415.00	$27,374.00	Channel length of 650' multiplied by mitigation width of 60'
Reclamation & seeding (native grasses)			2	ACRE	$1,217.00	$2,434.00	
Trail/Path, Concrete (10' Width)			350	L.F.	$54.00	$18,900.00	
Special Items (User Defined)							
Road Reconstruction	**<----User Defined Items**		765	SY	$50.00	$38,250.00	8" thick asphalt and 6" thick aggregate base course
Asphalt Removal	**<----User Defined Items**		1050	SY	$10.00	$10,500.00	765 SY + (85'x30')
Curb and Gutter (Remove and Replace)	**<----User Defined Items**		260	LF	$30.00	$7,800.00	
54" Railing (Box Culvert)	**<----User Defined Items**		216	LF	$250.00	$54,000.00	
Remove Sidewalk	**<----User Defined Items**		360	SY	$10.00	$3,600.00	320 LF @ 10' wide
Remove 36" Grouted Boulders	**<----User Defined Items**		550	SY	$30.00	$16,500.00	
Land Acquisition							
Easement/ROW Acquisition			0.70	ACRE	$87,120.00	$60,984.00	$2/SF

Master Plan Capital Improvement Cost Summary				
Capital Improvement Costs				
Pipe Culverts and Storm Drains			$0.00	
Concrete Box Culverts			$396,837.00	
Hydraulic Structures			$160,160.00	
Channel Improvements			$292,350.00	
Detention/Water Quality Facilities			$0.00	
Removals			$0.00	
Landscaping and Maintenance Improvements			$48,708.00	
Special Items (User Defined)			$130,650.00	
Subtotal Capital Improvement Costs			**$1,028,705.00**	
Additional Capital Improvement Costs				
Dewatering	$51,435.25	L.S.	$51,435.00	
Mobilization	5%		$51,435.00	
Traffic Control	$8,000.00	L.S.	$8,000.00	
Utility Coordination/Relocation	$200,000.00	L.S.	$200,000.00	
Stormwater Management/Erosion Control	5%		$51,435.00	
Subtotal Additional Capital Improvement Costs			**$362,305.00**	
Land Acquisition Costs				
ROW/Easements			$60,984.00	
Subtotal Land Acquisition Costs			**$60,984.00**	
Other Costs (percentage of Capital Improvement Costs)				
Engineering	15%		$208,652.00	
Legal/Administrative	5%		$69,551.00	
Contract Admin/Construction Management	10%		$139,101.00	
Contingency	25%		$347,753.00	
Subtotal Other Costs			**$765,057.00**	
Total Capital Improvement Costs			**$2,217,051.00**	

Master Plan Operation and Maintenance Cost Summary					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Annual Cost**	
Culvert Maintenance (e.g. sediment & debris removal, erosion at entrance/exit, structural repairs,	200	L.F.	$4.00	$800.00	
Total Annual Operation and Maintenance Cost				**$800.00**	
Effective Interest Rate				4.00%	
Total Operation and Maintenance Costs Over 50 Years				**$17,186.00**	

Appendix I

CONCEPTUAL DESIGN INFORMATION



No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

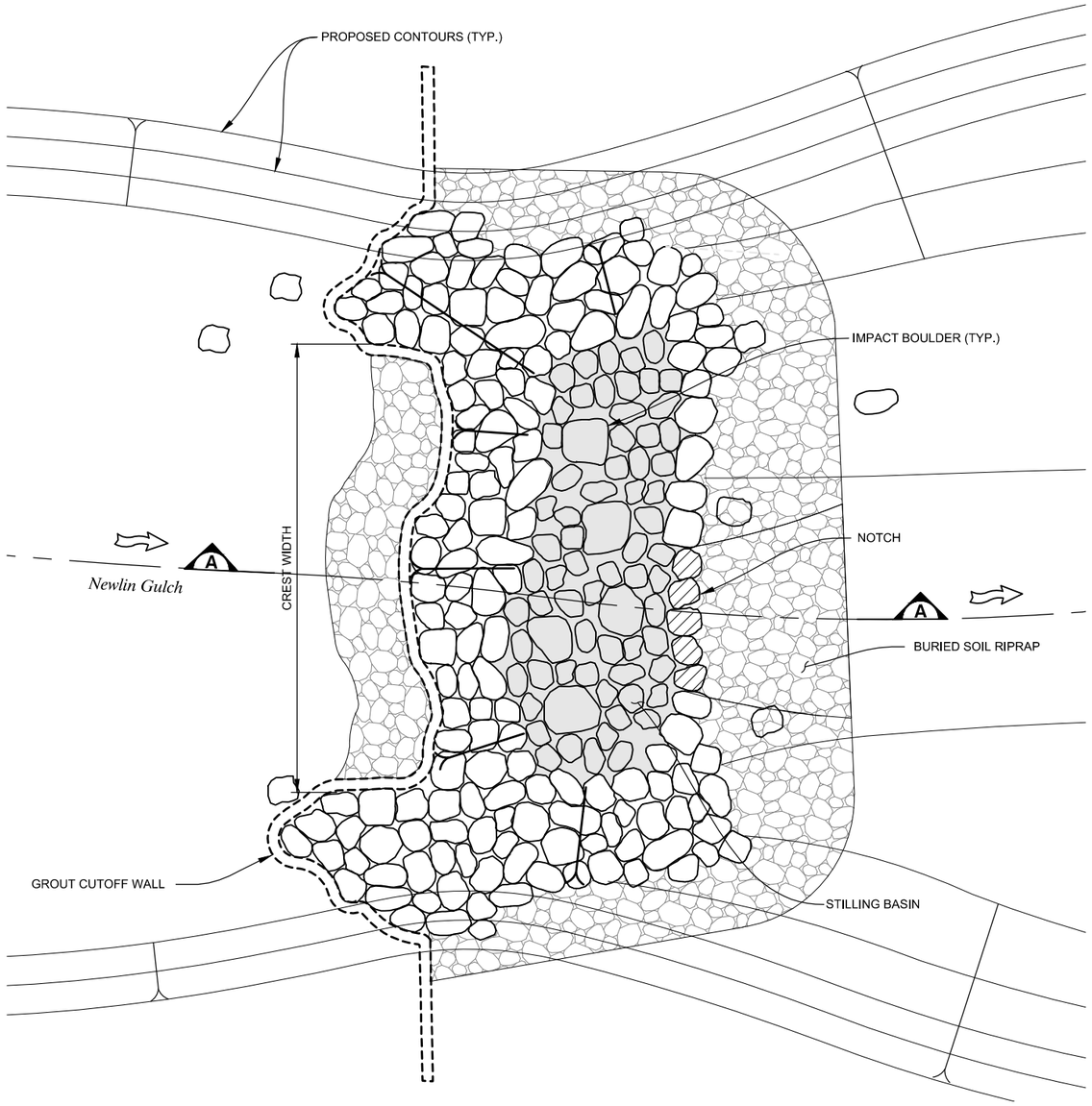
DESIGN	SAR
DRAWN	SAR
CHECK	MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

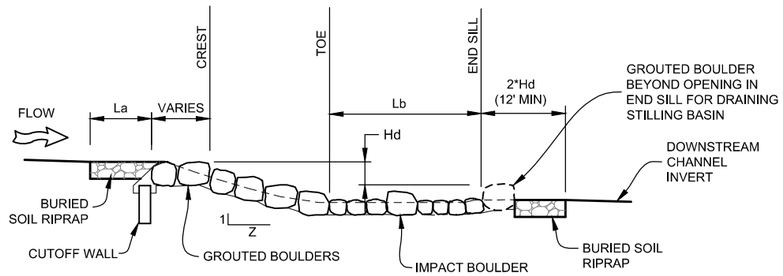
RECREATION DRIVE
CONCEPTUAL DESIGN PLAN

DATE: SEPT 2015
FIGURE NO. I-1

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_RECREATION DRIVE PLAN.dwg
DATE: SEP 08, 2015 TIME: 3:55 PM

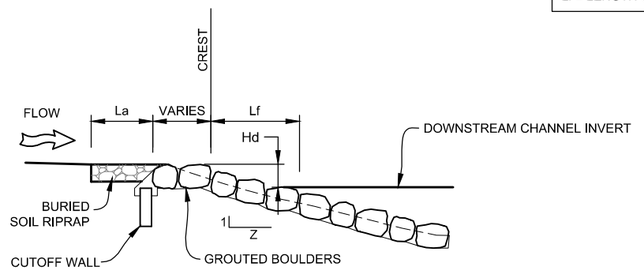


GROUTED BOULDER DROP STRUCTURE PLAN

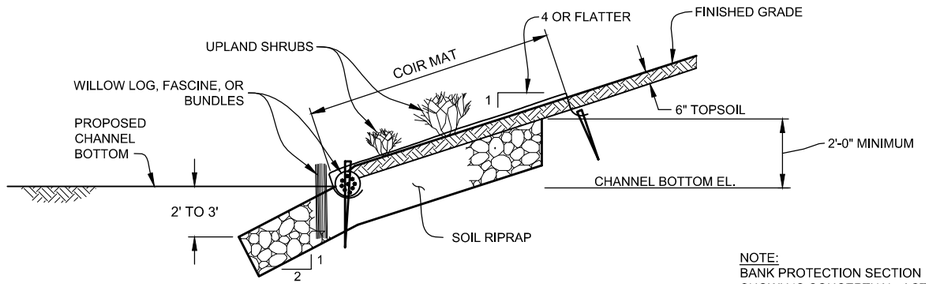


SECTION A
GROUTED BOULDER DROP WITH FREE-DRAINING STILLING BASIN

La = LENGTH OF APPROACH
Lb = LENGTH OF STILLING BASIN
Hd = HEIGHT OF DROP
Lf = LENGTH OF DROP FACE



SECTION A
GROUTED BOULDER DROP WITH SLOPING BASIN
(TYPICAL SANDY CHANNEL APPLICATION)



TYPICAL BANK PROTECTION SECTION
SCALE: 1" = 3' - 0"

NOTE:
BANK PROTECTION SECTION SHOWN IS CONCEPTUAL. ACTUAL DESIGN SECTION SHALL INCLUDE VEGETATION AND PLANTINGS AS DETERMINED BY THE DESIGN ENGINEER AND ECOLOGIST.

No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 SOUTH WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO
80226 (303) 988-4939
PROJECT NO. 12-050.01

DESIGN	SAR
DRAWN	SAR
CHECK	MDC

NEWLIN GULCH
MAJOR DRAINAGEWAY PLAN

TYPICAL CHANNEL DETAILS

DATE	SEPT 2015
FIGURE NO.	I-2

NAME: P:\12-050.01 Newlin Gulch MDP - UDFCD\7 AUTOCAD FILES\Conceptual Design\12050-NG_MDP_CHANNEL_DET.dwg DATE: SEP 08, 2015 TIME: 4:05 PM

Appendix J

MASTER PLAN MAPS

CLICK HERE TO VIEW FULL-SIZE MAP

CLICK HERE TO VIEW PRESET 11X17 PRINTABLE MAPS

Appendix K

MASTER PLAN PROFILES

CLICK HERE TO VIEW FULL-SIZE PROFILE

CLICK HERE TO VIEW PRESET 11X17 PRINTABLE PROFILES