FINAL DRAINAGE REPORT
FOR
CORNERSTONE ESTATES,
EL PASO COUNTY, COLORADO

PCD File No. XXXX

October 2021

Prepared For:

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ENGINEER'S STATEMENT:
The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by El Paso County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors, or omissions on my part in preparing this report.

_____ _____
Bryan Law, Colorado P.E. # 25043 Date
For and On Behalf of JR Engineering, LLC

DEVELOPER'S STATEMENT:
I, the developer, have read and will comply with all of the requirements specified in this drainage report and plan.

Business Name: William Guman & Associates, LTD

By: _____
Bill Guman
Title: _____
Address: 731 N. Weber Street
Colorado Springs CO 80903

El Paso County:
Filed in accordance with the requirements of the El Paso County Land Development Code, Drainage Criteria Manual, Volumes 1 and 2 and Engineering Criteria Manual, as amended.

_____ _____
Jennifer Irvine, P.E. Date
County Engineer/ ECM Administrator

Conditions:

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PURPOSE

This document is the Final Drainage Report for Cornerstone Estates. The purpose of this report is to identify on-site and off-site drainage patterns, storm sewer, culvert and inlet locations, areas tributary to the site, and to safely route developed storm water to adequate outfall facilities.

GENERAL LOCATION AND DESCRIPTION

General Location

The proposed Cornerstone Estates development is located within the northeast quarter of Section 23, Township 12 South, Range 65 West of the 6th Prime Meridian, El Paso County, Colorado. The proposed development is 58.67 acres containing approximately 16 – 2.5 to 3.6 acre single-family lots, 6.0 acres of open space, and associated infrastructure. The site is bounded on the east by Goodson Road and the south by Paint Brush Hills Filing No. 2 and Paint Brush Hills Filing No. 3. The remainder of the site to the north and west is bound by multiple single-family residences on unplatted lots. A vicinity map of the area is presented in Appendix A.

Description of Property

On the site there is currently an existing modular home, stables, and corrals located at the northwest corner. A few gravel roads meander through the site and large overhead transmission mains run along the eastern site boundary in a north/south orientation. Multiple natural drainage channels run through the site and range from poorly defined to well defined. The existing drainage channels shall be evaluated in the field to ensure they are in stable condition. Additionally, there are three sock ponds located on the western and southern site boundaries. The existing ground cover is sparse vegetation and open space with slopes that range from 3% to 14% generally draining from north to south.

Soils located within the site as shown on the USDA Natural Resources Conservation Service Soil Survey Map are Pring coarse sandy loam, 3 to 8 percent slopes. Some of the area surrounding the site also is composed of Kettle gravelly loamy sand, 3 to 8 percent slopes. A soils map is included in Appendix A of this report. These soils are characterized as Hydrologic Soil Group B which have a moderate infiltration rate when thoroughly wet and have a moderate rate of water transmission.

There are no major drainageways or known irrigation facilities located on the project site.

Floodplain Statement

The FEMA Flood Insurance Rate Map (FIRM) Panel No. 08041C0535G, dated December 7, 2018 is the best representation of the project site. The site is located within Zone X which is defined as areas determined to be outside the 0.2% annual chance floodplain, and therefore there is little threat of a flood. See the FIRM map in Appendix A.

EXISTING DRAINAGE CONDITIONS

Major Basin Descriptions

The site lies within the upper reaches of the Bennet Ranch Drainage Basin. The DPBS for this basin was prepared by Stormwater & Environmental Consultants, Inc. and dated November 2001. See references in Appendix E for more information. Minimal data from this DBPS was utilized for the proposed development due to the location of the site being at the top of the watershed. The Bennett Ranch DBPS also modeled the site assuming residential development with less dense 5-acre single-family lots, which is no longer accurate.

Existing Sub-basin Drainage

Existing basin drainage patterns are generally from north to south by way of sheet flow overland and then concentrated flow within the natural channels. Off-site flows enter on-site along the northern and western site boundaries and are routed in the same general direction from north to south. Existing flows on the site are routed to the existing stock pond on the southern border of the site and then flows off-site and onto the Paint Brush Hills Filings No. 2 and 3 developments within an existing natural channel. The flows continue the in the natural drainageway off-site until they reach Snowbrush Drive approximately 1,110 feet south of the site.

In the Bennett Ranch DBPS, the existing downstream off-site 54” CMP culvert in Snowbrush Drive was determined to be undersized. It was proposed that a 7’ by 5’ box culvert would be installed at this location to remedy the current capacity concerns. Since the culvert is not installed and no information is available on the proposed installation date, this site will detain runoff to historic rates to prevent any additional negative impacts to the existing downstream structures.

Existing hydrologic analysis was performed utilizing the Rational Method calculations for the on-site drainage basins. The off-site basins are large lot residential single-family homes and predominantly are composed of undeveloped land. Large portions of these basins are heavily wooded in the upper portions and transition to good rangeland near the site boundaries. Off-site basin runoff was calculated using CUHP (Colorado Urban Hydrograph Procedure) Version 2.0.1. Characterization of the off-site basins may be found in Appendix C. For preliminary design purposes, it is recommended that the existing natural channels be left unaltered. However, a field inspection shall be required to determine if the natural channels are stable.

The existing basin delineation as shown in the existing drainage map in Appendix F is as follows:

Basin OS-1 is approximately 10.85 acres and in its existing condition is comprised of part of a single-family house, part of buildings (likely stables), part of a gravel road, part of Burgess Road, part of Goodson Road, and surrounding undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path north to south overland towards DP1 where it will enter Basin EX-1 and follow the drainage patterns of the

basin as described below. The peak flow rates for the basin at DP1 in the 5- and 100-year storm are 2 cfs and 16 cfs, respectively. Flows will combine with DP2 at DP2.1.

Basin EX-1 is approximately 24.45 acres and in its existing conditions is comprised of part of Goodson Road, part of a gravel roadway, undeveloped land, and existing drainageways (both poorly and well-defined). Runoff flows will follow the historic path north to south overland and in swales towards DP2 and combine flows at DP2.1. The peak flow rates for the basin at DP2 in the 5- and 100-year storm are 7.3 cfs and 43.3 cfs, respectively. DP1 and DP2 combined flows at DP2.1 (Q_5= 6.3 cfs, Q_{100}=41.8 cfs) inflow into the existing stock pond located to the south of the site.

Basin OS-2 is approximately 18.42 acres and its existing condition is comprised of part of several single-family houses, part of several buildings (likely stables), part of gravel roads, part of Burgess Road, and surrounding undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path north to south overland towards DP3 where it will enter Basin EX-2 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP3 in the 5- and 100-year storm are 3 cfs and 27 cfs, respectively. Flows will combine with DP4 at DP4.1.

Basin EX-2 is approximately 20.05 acres and in its existing conditions is comprised of existing corrals, part of a gravel roadway, undeveloped land, and existing drainageways (both poorly and well-defined). Runoff flows will follow the historic path north to south overland and in swales towards DP4 and combine flows at DP4.1. The peak flow rates for the basin at DP4 in the 5- and 100-year storm are 5.5 cfs and 35.1 cfs, respectively. DP3 and DP4 combined flows at DP4.1 (Q_5= 6.2 cfs, Q_{100}=47.8 cfs) inflow into the existing stock pond located to the south of the site.

Basin OS-3 is approximately 38.47 acres and its existing condition is comprised of part of several single-family houses, part of gravel roads, part of Burgess Road, and surrounding undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path north to south overland towards DP5 where it will enter Basin EX-2 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP5 in the 5- and 100-year storm are 6 cfs and 50 cfs, respectively. Flows will combine with DP6 at DP6.1.

Basin OS-5 is approximately 6.15 acres and its existing condition is comprised of undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path north to south overland towards DP6 where it will enter Basin EX-3 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP6 in the 5- and 100-year storm are 1 cfs and 8 cfs, respectively. DP5 and DP6 combined flows at DP6.1 (Q_5= 6.9 cfs, Q_{100}=58.0 cfs) continue for a short distance within Basin EX-3 towards DP7.1.

Basin OS-4 is approximately 70.38 acres and its existing condition is comprised of part of several single-family houses, part of gravel roads, part of Burgess Road, and surrounding undeveloped land

and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path northwest to southeast overland towards DP7 where it will enter Basin EX-3 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP7 in the 5- and 100-year storm are 8 cfs and 76 cfs, respectively. DP6.1 and DP7 combined flows at DP7.1 (Q_5= 14.9 cfs, Q_{100}=129.2 cfs) continue within Basin EX-3 towards DP8.1.

Basin EX-3 is approximately 13.36 acres and its existing condition is comprised of an existing house, three stock ponds, undeveloped land, and existing drainageways (both poorly and well-defined)
Runoff flows will follow the historic path overland then in a swale towards DP8. The peak flow rates for the basin at DP8 in the 5- and 100-year storm are 2.7 cfs and 18.9 cfs, respectively. DP7.1 and DP8 combined flows at DP8.1 (Q_5= 16.7 cfs, Q_{100}=141.6 cfs) inflow into the existing stock pond located to the south of the site.

Basin OS-6 is approximately 7.31 acres and its existing condition is comprised of part of a gravel roadway and surrounding undeveloped land. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path northwest to southeast overland towards DP9 where it will enter Basin EX-4 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP9 in the 5- and 100-year storm are 1 cfs and 7 cfs, respectively. Flows will combine with DP10, DP11, and DP12 at DP12.1.

Basin OS-7 is approximately 14.54 acres and its existing condition is comprised of part a single-family house, part of gravel roads, and surrounding undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path northwest to southeast overland towards DP10 where it will enter Basin EX-4 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP10 in the 5- and 100-year storm are 3 cfs and 21 cfs, respectively. Flows will combine with DP9, DP11, and DP12 at DP12.1.

Basin OS-8 is approximately 8.29 acres and its existing condition is comprised of part a single-family house, part of gravel roads, and surrounding undeveloped land and woodlands. The basin is off-site and therefore no work is proposed within that area. Runoff flows will follow the historic path northwest to southeast overland towards DP11 where it will enter Basin EX-4 and follow the drainage patterns of the basin as described below. The peak flow rates for the basin at DP11 in the 5- and 100-year storm are 3 cfs and 14 cfs, respectively. Flows will combine with DP9, DP10, and DP12 at DP12.1.

Basin EX-4 is approximately 2.15 acres and its existing condition is comprised of undeveloped land and woodlands. Runoff flows will follow the historic path north to south overland towards DP12. The peak flow rates for the basin at DP12 in the 5- and 100-year storm are 0.7 cfs and 5.1 cfs, respectively. DP9, DP10, DP11 and DP12 combined flows at DP12.1 (Q_5= 7.3 cfs, Q_{100}=40.0 cfs) follow the historic drainage path flowing off-site to the south.

Proposed Sub-basin Drainage

In the proposed condition, the site will be developed into 16, 2.5-acre minimum, single-family lots, proposed Redeemer Lane, proposed Mercy Court, several proposed swales, several proposed roadside swales, undeveloped land, existing drainageways (both well and poorly defined), several culverts, and a proposed full-spectrum extended detention basin (EDB). In general the proposed drainage conditions follow the historic path from north to south and will treat developed flows in the proposed full-spectrum EDB before releasing it off-site.

Proposed hydrologic analysis was performed utilizing the Rational Method calculations for the on-site drainage basins. For the contributing areas within the proposed 2.5-acre (minimum) single-family lots, a percent imperviousness of 10% was assumed in the hydrologic analysis. The off-site basins are large lot residential single-family homes and predominantly are composed of undeveloped land. Large portions of these basins are heavily wooded in the upper portions and transition to good rangeland at the site boundaries. Off-site basins runoff was calculated using CUHP Version 2.0.1. Characterization of the off-site basins may be found in Appendix C. All proposed swales were cross-sectioned and routed through Autodesk Inc.'s Hydraflow Express Extension (Volume 10.5) to determine the normal flow depth and velocity.

The proposed basin delineation as shown in proposed drainage map in Appendix F is as follows;

Basin OS-1 is approximately 10.85 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP1 in the 5- and 100-year storm are 2 cfs and 16 cfs, respectively. Flows are then directed towards DP2.1.

Basin A is approximately 7.15 acres and in its proposed condition is comprised of part of existing Goodson Road, part of proposed Redeemer Lane, parts of several 2.5-acre developed lots, a proposed roadside swale, and a proposed culvert. Runoff generated (Q_5= 5.0 cfs, Q_{100}= 20.6 cfs) sheets flows generally southeast to DP2 where either the existing Goodson Road roadside swale or proposed Redeemer Lane roadside swale collect and direct flows to the proposed 19"x30" HERCP culvert under Redeemer Lane at DP2.1. DP1 and DP2 combined flows at DP2.1 (Q_5= 4.1 cfs, Q_{100}= 24.6 cfs) are directed by a proposed swale towards DP12.1 in Basin G.

Basin B is approximately 3.31 acres and in its proposed condition is comprised of part of proposed Mercy Court, part of proposed Redeemer Lane, parts of several 2.5-acre developed lots, proposed roadside swales, and a proposed culvert. Runoff generated (Q_5= 3.7 cfs, Q_{100}= 12.5 cfs) sheets flows generally southwest to DP3 where either the proposed Mercy Court roadside swale or proposed Redeemer Lane roadside swale collect and direct flows to the proposed 18" RCP culvert under Redeemer Lane at DP3. DP3 flows are directed by a proposed roadside swale towards DP6.2 in Basin G.

Basin OS-2 is approximately 18.42 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP4 in the 5- and 100-year storm are 3 cfs and 27 cfs, respectively. Flows are then directed towards DP5.1.

Basin C is approximately 10.14 acres and in its proposed condition is comprised of part of proposed Mercy Court, part of proposed Redeemer Lane, parts of several 2.5-acre developed lots, a proposed swale, proposed roadside swales, and a proposed culvert. Runoff generated (Q_5= 7.4 cfs, Q_{100}= 29.2 cfs) sheets flows generally southeast or southwest to DP5 where either the proposed swale, proposed Mercy Court roadside swale, or proposed Redeemer Lane roadside swale collect and direct flows to the proposed 30” RCP culvert under Redeemer Lane at DP5.1. DP4 and DP5 combined flows at DP5.1 (Q_5= 6.2 cfs, Q_{100}= 39.4 cfs) are directed by a proposed swale towards DP6.1 in Basin D.

Basin D is approximately 6.02 acres and in its proposed condition is comprised of part of proposed Mercy Court, part of proposed Redeemer Lane, parts of several 2.5-acre developed lots, an existing swale, a proposed swale, proposed roadside swales, and a proposed culvert. Runoff generated (Q_5= 5.7 cfs, Q_{100}= 20.1 cfs) sheets flows generally southeast to DP6 where either the existing swale, proposed Redeemer Lane roadside swale, or proposed Mercy Court roadside swale collect and direct flows to the proposed 42” RCP culvert under Mercy Court at DP6.1. DP5.1 and DP6 combined flows at DP6.1 (Q_5= 8.4 cfs, Q_{100}= 47.2 cfs) flow towards DP6.2 in Basin G. From DP6.2 flows enter the rundown into the pond.

Basin OS-3 is approximately 38.47 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP7 in the 5- and 100-year storm are 6 cfs and 50 cfs, respectively. From there the flows are directed overland towards DP8.1.

Basin E is approximately 2.06 acres and its proposed condition is comprised of parts of some 2.5-acre developed lots, and undeveloped land. Runoff generated (Q_5= 1.1 cfs, Q_{100}= 5.4 cfs) sheet flows generally southwest to DP8. DP7 and DP8 combined flows at DP8.1 (Q_5= 6.5 cfs, Q_{100}= 52.4 cfs) flow overland towards DP9.1 in Basin OS-5.

Basin OS-5 is approximately 6.15 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP9 in the 5- and 100-year storm are 1 cfs and 8 cfs, respectively. DP8.1 and DP9 combined flows at DP9.1 (Q_5= 7.4 cfs, Q_{100}= 60.4 cfs) flow overland and into the existing swale towards DP10.1 in Basin F.

Basin OS-4 is approximately 70.38 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP10 in the 5- and 100-year storm are 8 cfs and 76 cfs, respectively. DP9.1 and DP10 combined

flows at DP10.1 (Q_5= 15.4 cfs, Q_{100}= 131.3 cfs) flow overland and into the existing swale towards DP11.1 in Basin F.

Basin F is approximately 6.20 acres and its proposed condition is comprised of parts of some 2.5-acre developed lots, and undeveloped land. Runoff generated (Q_5= 3.2 cfs, Q_{100}= 14.3 cfs) flows in an existing channel generally southeast to DP11. DP10.1 and DP11 combined flows at DP11.1 (Q_5= 16.9 cfs, Q_{100}= 137.9 cfs) will cross a future drive way culvert into Basin G and continue in the existing swale towards DP12.2. There they enter the rundown and into the pond.

Basin G is approximately 22.98 acres and its proposed condition comprised of is comprised of part of existing Goodson Road, part of proposed Redeemer Lane, part of proposed Mercy Court, parts of several 2.5-acre developed lots, undeveloped land, proposed swales, proposed roadside swales, and a proposed full-spectrum EDB. Runoff generated (Q_5= 16.7 cfs, Q_{100}= 66.3 cfs) sheets flows generally southeast and southwest to the proposed swale and to DP12 where the proposed swale collects and direct flows to the existing natural channel at DP12.1. DP2.1 and DP12 combined flows at DP12.1 (Q_5= 11.2 cfs, Q_{100}= 52.7 cfs) are directed by an existing natural channel towards the proposed full-spectrum EDB. There they enter the rundown and into the pond.
The flows from DP6.2 (Q_5= 9.6 cfs, Q_{100}= 51.6 cfs), DP11.1 (Q_5= 16.9 cfs, Q_{100}= 137.9 cfs), and DP12.1 (Q_5= 11.2 cfs, Q_{100}= 52.7 cfs) combine at DP12.2 (Q_5= 35.9 cfs, Q_{100}=233.5 cfs) which represents the total inflow into the proposed full-spectrum EDB.

Basin OS-6 is approximately 7.31 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP13 in the 5- and 100-year storm are 1 cfs and 7 cfs, respectively. These flows enter into Basin H and combine at DP16.1.

Basin OS-7 is approximately 14.54 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP14 in the 5- and 100-year storm are 3 cfs and 21 cfs, respectively. These flows enter into Basin H and combine at DP16.1.

Basin OS-8 is approximately 8.29 acres and because no improvements are proposed in this area, it is the same as described in the existing sub-basin description above. The peak flow rates for the basin at DP15 in the 5- and 100-year storm are 3 cfs and 14 cfs, respectively. These flows enter into Basin H and combine at DP16.1.

Basin H is approximately 2.15 acres and because no improvements are proposed in this area, it is the same as Basin EX-4 is described in the existing sub-basin description above. The peak flow rates for the basin at DP16 in the 5- and 100-year storm are 1.2 cfs and 5.5 cfs, respectively. DP13, DP14, DP15, and DP16 combined flows at DP16.1 (Q_5= 7.5 cfs, Q_{100}=40.3 cfs) follow the historic drainage path flowing undetained off-site to the south.

DRAINAGE DESIGN CRITERIA

Development Criteria Reference

Storm drainage analysis and design criteria for the project were taken from the "City of Colorado Spring/El Paso County Drainage Criteria Manual" Volumes 1 and 2 (EPCDCM), dated October 12, 1994, the "Urban Storm Drainage Criteria Manual" Volumes 1 - 3 (USDCM) and Chapter 6 and Section 3.2.1 of Chapter 13 of the "Colorado Springs Drainage Criteria Manual (CCSDCM)", dated May 2014, as adopted by El Paso County, as well as the July 2019 El Paso County Engineering Criteria Manual update.

Hydrologic Criteria

All hydrologic data was obtained from the "El Paso Drainage Criteria Manual" Volumes 1 and 2, and the "Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual" Volumes 1, 2, and 3. Onsite drainage improvements were designed based on the 5-year (minor) storm event and the 100-year (major) storm event. The Rational Method calculations were prepared for sub-basins with areas less than 100 acres, in accordance with EPC DCM Chapter 5.2 for the proposed on-site drainage basins. Off-site basins runoff was calculated using CUHP (Version 2.0.1, developed by Urban Drainage and Flood Control District. This model utilized the rain gage classified as "user defined hyetograph". Table 6-4 in Chapter 6 of the CCSDCM was utilized for the distribution. The following Colorado Springs rainfall depths were utilized in the model: 1.21 inches for 60-min 5-year depth and 2.5 inches for 60-min 100-year depth.

Urban Drainage and Flood Control District's UD-Detention, Version 4.04 workbook was used for pond sizing. Required detention volumes and allowable release rates were designed per USDCM and CCS/EPCDCM. Pond sizing spreadsheets are presented in Appendix D.

Hydraulic Criteria

The Federal Highway Administration's HY-8 program (Volume 7.50) was used to analyze the proposed culverts within the Latigo Trails development. Per Section 6.4.1 of the EPCDCM, culverts were sized as to not overtop the road in the 100-year storm. Culvert design sheets are presented in Appendix C. UDFCD Volume 2 Chapter 9 Equation 9-16 was used to size the riprap protection around the proposed culverts.

Autodesk Inc.'s Hydraflow Express Extension (Volume 10.5) was used for roadside ditch design. For sizing purposes, the maximum swale size was determined based on peak 100-year flows and minimum roadway slopes within each basin. Swales were checked for velocity per the EPC DCM Chapter 10, Table 10-4 based on peak 100-year flows and maximum swale slopes. Swale cross sections with a 100-year velocity greater than 5 ft/s will be lined with turf reinforcing mat, or another approved method of stabilization, to limit erosive potential. Proposed swale section A-A runs from DP4 to DP5.1 and from DP2.1 to DP12.1 and will need turf reinforcing mat when over 2.5% slope. Proposed roadside swale section C-C is all the roadside swales except for the one flowing south at

the southeast intersection of Redeemer Land and Mercy Court. Proposed swale section D-D represents the roadside swale that flows south from DP3 to DP6.2 and will need turf reinforcing mat everywhere.

Swale design sheets are presented in Appendix C.

DRAINAGE FACILITY DESIGN

General Concept

The combination of the proposed and existing stormwater conveyance system was designed to convey the developed Cornerstone Estates flows to the full-spectrum EDB via roadside ditches and swales. A retrofit of the existing stock pond on the south of the site is proposed to minimize grading and site impacts. In addition, a thorough geotechnical analysis will need to be performed on the existing embankment to determine the amount of required improvements. The outlet structure will be designed to minimize impacts to adjacent properties using riprap and releasing below historic rates of flow.

All facilities calculated in this report are designed to accept both 5-year and 100-year flows. All culverts will have a flared end section (FES) on both sides of the pipe. All culverts will outlet to a riprap basin as a method of dissipating excess energy prior to the stormwater entering the channels. Rundowns for the pond will be armored with riprap to limit the possibility of erosion. Development will be limited to 10% or less for areas that do not have a water quality feature downstream in order to satisfy Section I.7.1.B.5 of the ECM Stormwater Quality Policy and Procedure. See highlighted areas in the drainage map presented in Appendix F.

Specific Details

Four Step Process to Minimize Adverse Impacts of Urbanization

In accordance with the El Paso County Drainage Criteria Manual, Volume 2 this site has implemented the four step process to minimize adverse impacts of urbanization. The four step process includes reducing runoff volumes; stabilizing drainageways, treating the water quality capture volume (WQCV), and consider the need for Industrial Commercial BMP's.

Step 1, Reducing Runoff Volumes: The development of the project site is proposed as single-family residential (2.5 acre min.) with lawn areas interspersed within the development which helps disconnect impervious areas and reduce runoff volumes. Roadways will utilize roadside ditches to further disconnect impervious areas. These practices will also allow for increased infiltration and reduce runoff volume.

Step 2, Stabilize Drainageways: This site will utilize roadside ditches with culvert crossings throughout the site. These roadside ditches will then direct the applicable on-site and off-site development flows to the proposed full-spectrum EDB within the project. The proposed full-

spectrum EDB will be designed to release flows at or below historic rates and the roadside ditches will be stabilized in reaches with high velocity (>5 fps) by the use of turf reinforcement mats. Based upon the proposed reduction in released flows compared to the pre-developed flows, no impact to downstream drainageways is anticipated.

Step 3, Provide WQCV: Runoff from this development will be treated through capture and slow release of the WQCV in the proposed permanent full-spectrum EDB that will be designed per current El Paso County drainage criteria.

Step 4, Consider the need for Industrial and Commercial BMP's: No industrial or commercial uses are proposed within this development. Site specific temporary source control BMPs as well as permanent BMP's will be detailed in this plan and narrative to protect receiving waters.

Water Quality

In accordance with Section 13.3.2.1 of the CCS/EPCDCM, full spectrum water quality and detention will be provided for all of the development site not meeting exclusions present in the ECM - Stormwater Quality Policy and Procedures Section I.7.1.B and C. Any areas of the development site not being included in the site's permeant stormwater management are presented on the proposed drainage map, presented in Appendix F. Outlet structure release rates will be limited to less than historic rates to minimize adverse impacts to downstream stormwater facilities.

On-site basins A-G and off-site basins OS-1 through OS-6 will contribute flows towards the proposed full-spectrum EDB. On-site basins contribute 60.01 acres and off-site basins contribute 174.41 acres of tributary area to the proposed pond with a weighted percent imperviousness of 7.1%. The total inflows to the pond were determined to be 35.9 and 233.5 cfs for the 5- and 100-year storms, respectively. The proposed full-spectrum EDB was designed per current criteria and full-spectrum design methodology based on WQCV (Water Quality Capture Volume), EURV (Excess Urban Runoff Volume), and 100-year detention. The pond was designed for a 40-hour WQCV drain time, a 72-hour EURV drain time, and will drain in 52 hours for a 100-year storm event.

The pond design using UD-Detention is summarized below with bullets:

- WQCV: +/- 0.844 acre-feet
- EURV: +/- 1.318 acre-feet
- 100-Year Volume: +/- 4.439 acre-feet
- $Q_{5,in}$: +/- 21.0 cfs
- $Q_{100,in}$: +/- 225.5 cfs
- $Q_{5,out}$: +/- 3.6 cfs
- $Q_{100,out}$: +/- 183.9 cfs
- Spillway: Crest elevation: 7284.25', Crest length: 75 feet w/ 4:1 side slopes, and 1 foot of freeboard. Overflows to the south and follows the historic path along the existing natural channel.

- Outlet Pipe: Unrestricted 9'W x 2'H RCBC w/ invert elevation: 7277.79', Outfalls to the south onto Paint Brush Hills Filing No. 2 and then follows the historic path along the existing natural channel.

Calculations and pond design parameters are presented in Appendix D.

Erosion Control Plan

The El Paso County Drainage Criteria Manual specifies an Erosion Control Plan and associated Cost Estimate must be submitted with each Final Drainage Report. The Erosion Control Plan and Cost Estimate shall be submitted prior to obtaining a grading permit.

Operation & Maintenance

In order to ensure the function and effectiveness of the stormwater infrastructure, maintenance activities such as inspection, routine maintenance, restorative maintenance, rehabilitation and repair, are required. All proposed drainage structures within the any platted County ROW (roadside ditches and local road culverts) will be owned and maintained by El Paso County. All proposed drainage structures within easements or tracts (full spectrum water quality ponds, drainageway culverts and drainageway improvements) will be owned and maintained by Cornerstone Estates. Inspection access for El Paso County will be provided through a maintenance easement.

Drainage and Bridge Fees

The proposed site lies within the Bennett Ranch Drainage Basin. Drainage fees associated with the basin are calculated based on impervious area. The drainage fee associated with the Bennett Ranch Drainage Basin is $12,441 per impervious acre and the bridge fee is $4,772 per impervious acre. The drainage and bridge fees for the 60.01 acre on-site basins (A-H) are based on a composite percent imperviousness of 12.3%. Drainage and bridge fees are for informational purposes only and do not include reduction for rural lots or permanent water quality facilities. Final calculation of drainage fees, as well as determination of potential reimbursements, will be determined at the time of the Final Plat recordation.

Impervious area for the site:

12.3% impervious x 60.01 acres =	7.38 impervious acres
Drainage fee = $12,441 x 7.38 acres =	$91,814.58
Bridge fee = $4,772 x 7.38 acres =	$35,217.36
Total Drainage and Bridge Fees =	$127,031.94

Construction Cost Opinion

Private Storm System (For Information Only):

Item	Description	Quantity	Unit	Unit Cost	Cost
1	Permanenet Pond/BMP Construction	7,162	CY	$ 21.00	$150,402.00
2	Permanent Pond/BMP (Spillway)	1	EA	$10,000.00	$ 10,000.00
3	Permanent Pond/BMP (Outlet Structure)	1	EA	$15,000.00	$ 15,000.00
4	18" RCP	66	LF	$ 67.00	$ 4,422.00
5	19" x 30" HERCP	66	LF	$ 151.67	$ 10,010.22
6	30" RCP	74	LF	$ 100.00	$ 7,400.00
7	42" RCP	96	LF	$ 166.00	$ 15,936.00
8	9' x 2' RCBC	81	LF	$ 1,100.00	$ 89,100.00
9	18" FES	2	EA	$ 402.00	$ 804.00
10	19" x 30" FES	2	EA	$ 910.00	$ 1,820.00
11	30" FES	2	EA	$ 600.00	$ 1,200.00
12	42" FES	2	EA	$ 996.00	$ 1,992.00
13	Rip Rap, d50 size from 6" to 24"	636	TON	$ 83.00	$ 52,788.00
				Subtotal	$ 360,874.22
				25% Engineering & Contingencies	$ 90,218.56
				TOTAL	$ 451,092.78

JR Engineering cannot and does not guarantee that the construction cost will not vary from these opinions of probable construction costs.

SUMMARY

The Final Drainage Report for Cornerstone Estates identifies on-site and off-site drainage patterns, storm sewer, culvert and inlet locations, areas tributary to the site, and safely routes developed storm water to adequate outfall facilities. The proposed Cornerstone Estates development will not adversely affect the off-site major drainageways or surrounding development. This report meets the latest El Paso County Drainage Criteria requirements for this site.

REFERENCES:

1. City of Colorado Springs Drainage Criteria Manual Volume 1, City of Colorado Springs, CO, May 2014.

2. Urban Storm Drainage Criteria Manual, Urban Drainage and Flood Control District, Latest Revision.

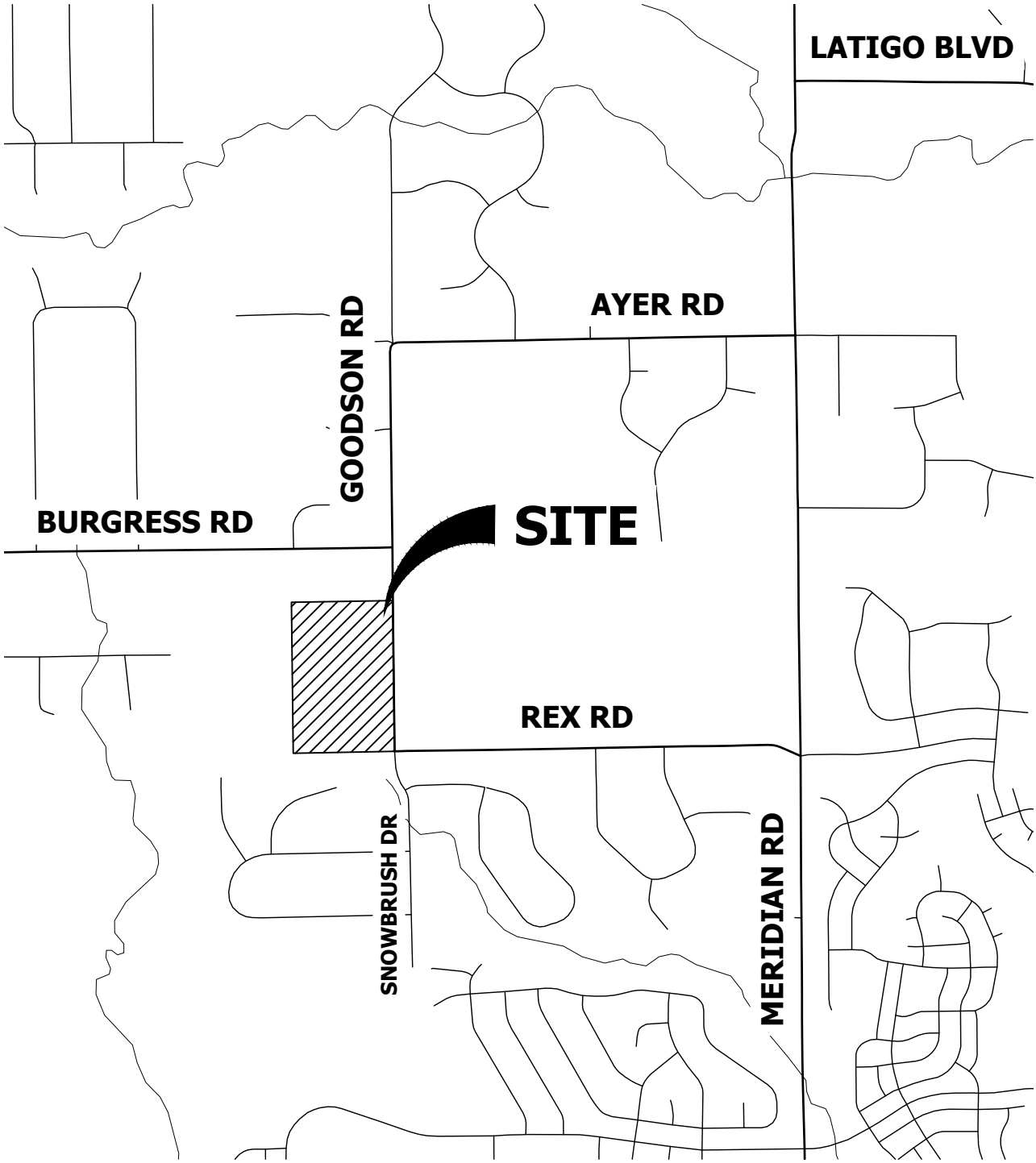
3. FEMA Flood Insurance Rate Map (F.I.R.M.) Panel No. 08041C0535G, effective date December 7, 2018.

4. "Soil Survey of El Paso County Area, Colorado," by the USDA Natural Resources Conservation Service.

5. Bennett Ranch Pilot Project Drainage Basin Planning Study-Executive Summary, prepared by Stormwater & Environmental Consultants, Inc. and dated November 2001.

APPENDIX A

FIGURES AND EXHIBITS



N

2000 1000 0 2000

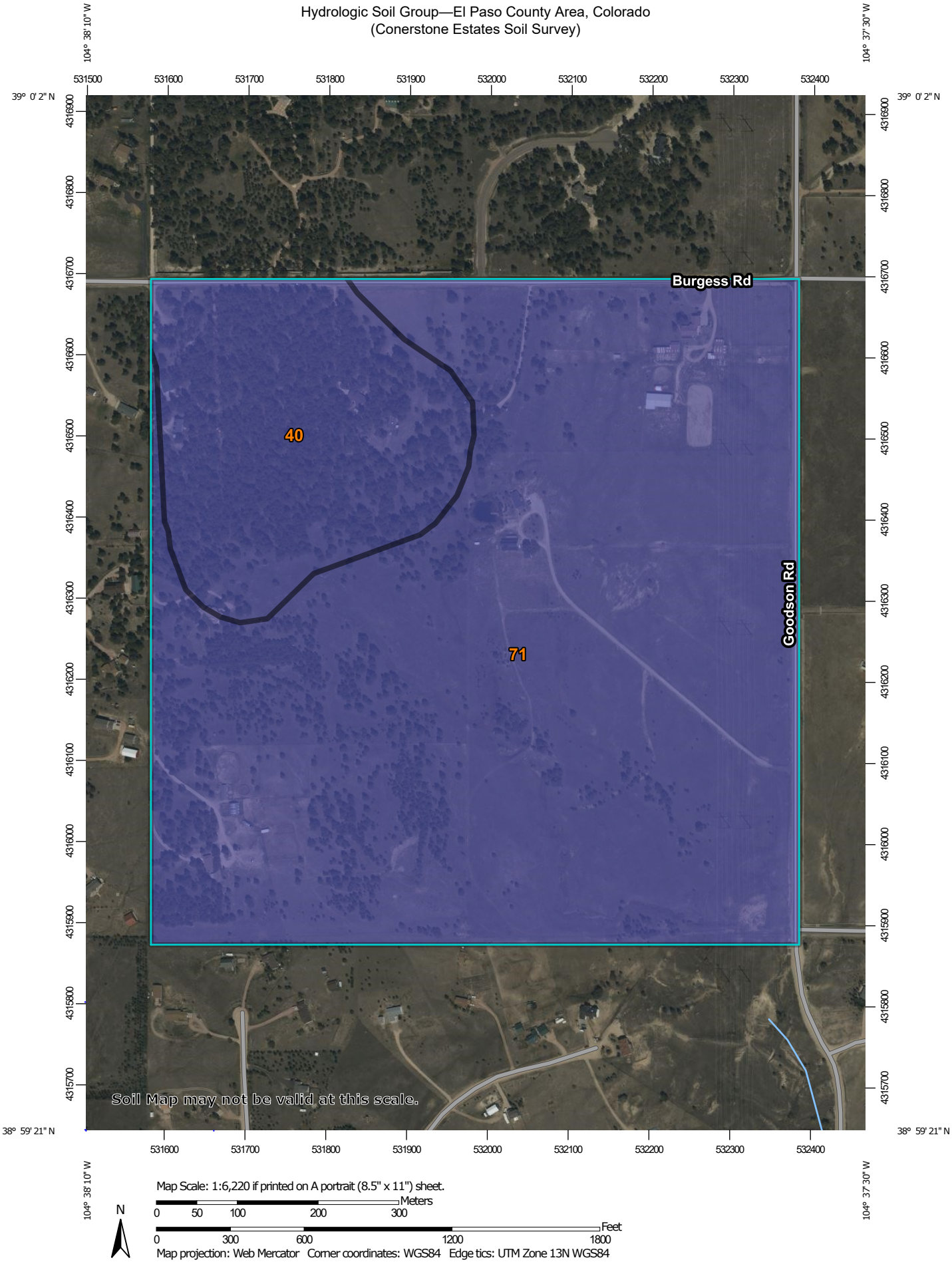
ORIGINAL SCALE: 1" = 2000'

VICINITY MAP
CORNERSTONE ESTATES
JOB NO. 25229.00
9/27/2021
SHEET 1 OF 1

J·R ENGINEERING
A Westrian Company

Centennial 303-740-9393 • Colorado Springs 719-593-2593
Fort Collins 970-491-9888 • www.jrengineering.com

Hydrologic Soil Group—El Paso County Area, Colorado
(Conerstone Estates Soil Survey)



Map Scale: 1:6,220 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 300 600 1200 1800

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 18, Jun 5, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 11, 2018—Oct 20, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
40	Kettle gravelly loamy sand, 3 to 8 percent slopes	B	31.5	19.3%
71	Pring coarse sandy loam, 3 to 8 percent slopes	B	131.9	80.7%
Totals for Area of Interest			**163.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the **North American Vertical Datum of 1988 (NAVD88)**. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit its website at http://www.ngs.noaa.gov/.

Base Map information shown on this FIRM was provided in digital format by El Paso County, Colorado Springs Utilities, and Anderson Consulting Engineers, Inc. These data are current as of 2008.

This map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. The profile baselines depicted on this map represent the hydraulic modeling baselines that match the flood profiles and Floodway Data Tables if applicable, in the FIS report. As a result, the profile baselines may deviate significantly from the new base map channel representation and may appear outside of the floodplain.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

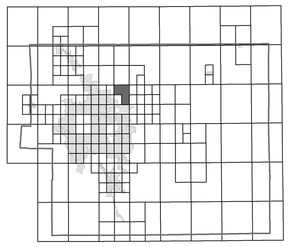
Contact **FEMA Map Service Center** (MSC) via the FEMA Map Information eXchange (FMIX) 1-877-336-2627 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. The MSC may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

El Paso County Vertical Datum Offset Table

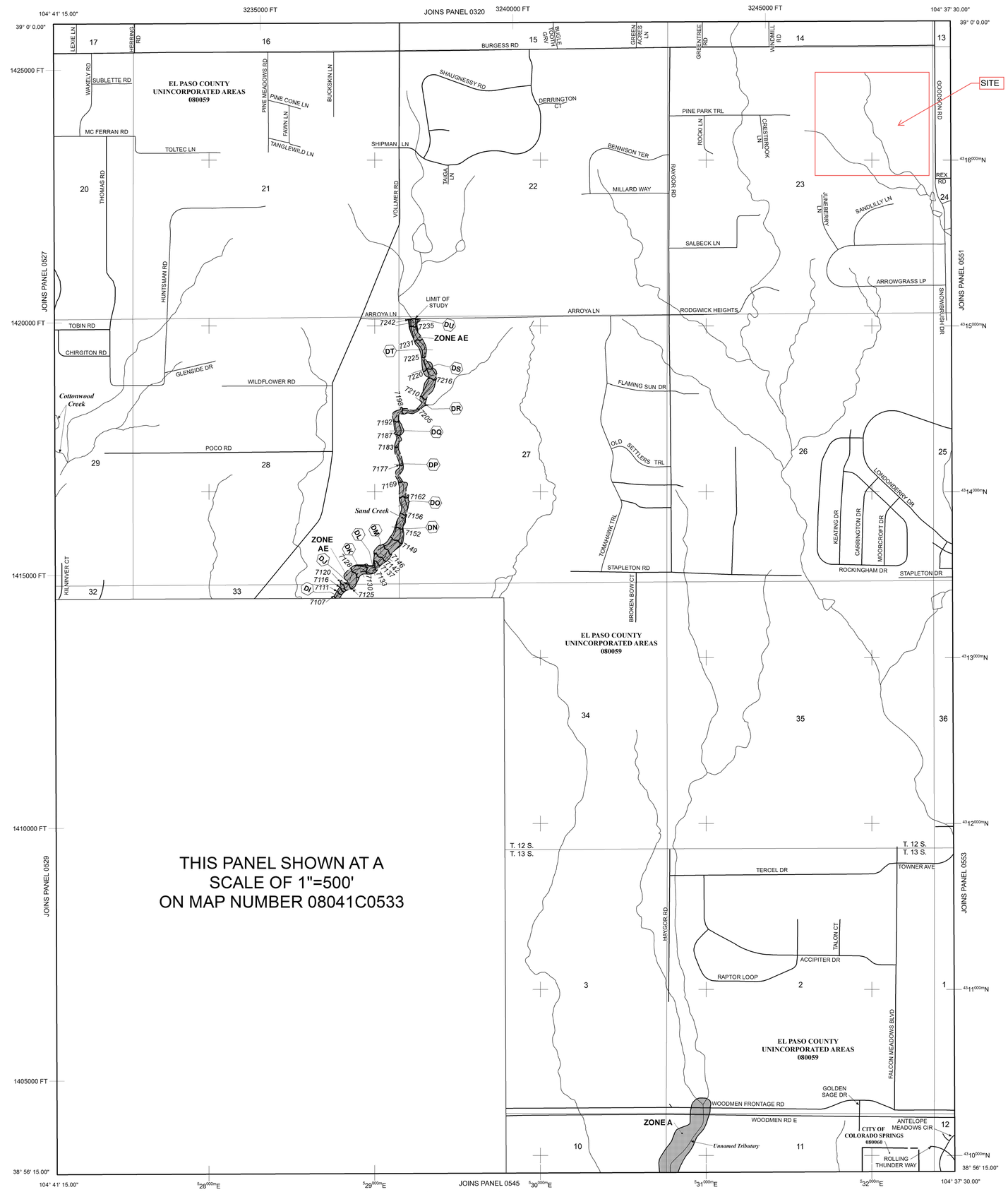
Flooding Source	Vertical Datum Offset (ft)
REFER TO SECTION 3.3 OF THE EL PASO COUNTY FLOOD INSURANCE STUDY FOR STREAM BY STREAM VERTICAL DATUM CONVERSION INFORMATION	

Panel Location Map



This Digital Flood Insurance Rate Map (DFIRM) was produced through a Cooperating Technical Partner (CTP) agreement between the State of Colorado Water Conservation Board (CWCB) and the Federal Emergency Management Agency (FEMA).

Additional Flood Hazard information and resources are available from local communities and the Colorado Water Conservation Board.



NOTE: MAP AREA SHOWN ON THIS PANEL IS LOCATED WITHIN TOWNSHIP 12 SOUTH, RANGE 65 WEST, AND TOWNSHIP 13 SOUTH, RANGE 65 WEST.

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAS) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area Formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D Boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A	Cross section line
23 - - - - - 23	Transect line
97° 07' 30.00" 32° 22' 30.00"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 13
6000000 FT	5000-foot grid ticks: Colorado State Plane coordinate system, central zone (FIPSZONE 0502), Lambert Conformal Conic Projection
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
MARCH 17, 1997

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
DECEMBER 7, 2018 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to update map format, to add roads and road names, and to incorporate previously issued Letters of Map Revision.

For community map revision history prior to countywide mapping, refer to the Community Map History Table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0535G

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 535 OF 1300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0535	G
EL PASO COUNTY	080059	0535	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08041C0535G

MAP REVISED
DECEMBER 7, 2018

Federal Emergency Management Agency

APPENDIX B

HYDROLOGIC CALCULATIONS

Point precipitation frequency estimates (inches)
NOAA Atlas 14 Volume 8 Version 2
Data type: Precipitation depth
Time series type: Partial duration
Project area: Midwestern States
Location name (ESRI Maps): Colorado Springs Colorado USA
Station Name: -
Latitude: 38.9917°
Longitude: -104.6265°
Elevation (USGS): 7303.17 ft

PRECIPITATION FREQUENCY ESTIMATES										
by duration for ARI (years):	1	2	5	10	25	50	100	200	500	1000
5-min:	0.238	0.29	0.38	0.459	0.574	0.669	0.768	0.873	1.02	1.14
10-min:	0.348	0.425	0.556	0.672	0.841	0.979	1.13	1.28	1.49	1.66
15-min:	0.425	0.518	0.678	0.819	1.03	1.19	1.37	1.56	1.82	2.03
30-min:	0.608	0.74	0.969	1.17	1.46	1.7	1.95	2.22	2.59	2.88
60-min:	0.779	0.933	1.21	1.46	1.84	2.16	2.5	2.87	3.39	3.81
2-hr:	0.95	1.13	1.45	1.75	2.22	2.62	3.05	3.52	4.2	4.75
3-hr:	1.04	1.22	1.56	1.89	2.4	2.85	3.35	3.9	4.69	5.35
6-hr:	1.21	1.4	1.78	2.15	2.75	3.28	3.88	4.54	5.52	6.34
12-hr:	1.41	1.63	2.07	2.49	3.17	3.78	4.45	5.19	6.29	7.2
24-hr:	1.63	1.91	2.43	2.92	3.68	4.34	5.06	5.85	6.99	7.93
2-day:	1.9	2.24	2.86	3.42	4.26	4.97	5.72	6.54	7.7	8.64
3-day:	2.09	2.46	3.12	3.72	4.61	5.36	6.15	7.01	8.22	9.19
4-day:	2.25	2.63	3.32	3.94	4.87	5.64	6.46	7.35	8.6	9.61
7-day:	2.66	3.06	3.79	4.45	5.43	6.25	7.12	8.07	9.4	10.5
10-day:	3.02	3.46	4.24	4.94	5.98	6.85	7.76	8.74	10.1	11.2
20-day:	4.05	4.65	5.67	6.55	7.8	8.8	9.84	10.9	12.4	13.5
30-day:	4.87	5.62	6.84	7.86	9.28	10.4	11.5	12.6	14.1	15.3
45-day:	5.89	6.79	8.23	9.41	11	12.2	13.4	14.6	16.1	17.2
60-day:	6.73	7.75	9.36	10.6	12.4	13.6	14.8	16	17.5	18.6

Date/time (GMT): Fri Sep 24 17:03:28 2021
pyRunTime: 0.0451149940491

Existing and Proposed 5- and 100-year Subcatchment Parameters

Summary of CUHP Input Parameters (Version 2.0.1)

								Depression Storage		Horton's Infiltration Parameters			DCIA Level and Fractions			
Catchment Name/ID	SWMM Node/ID	Raingage Name/ID	Area (sq.mi.)	Dist. to Centroid (miles)	Length (miles)	Slope (ft./ft.)	Percent Imperv.	Pervious (inches)	Imperv. (inches)	Initial Rate (in./hr.)	Final Rate (in.hr.)	Decay Coeff. (1/sec.)	DCIA Level	Dir. Con'ct Imperv. Fraction	Receiv. Perv. Fraction	Percent Eff. Imperv.
OS1		EPC 2 HOUR	0.017	0.107	0.217	0.060	8.1	0.50	0.10	4.50	0.60	0.0018	1.00	0.09	0.16	6.80
OS2		EPC 2 HOUR	0.029	0.129	0.267	0.050	5.1	0.50	0.10	4.50	0.60	0.0018	1.00	0.06	0.10	4.26
OS3		EPC 2 HOUR	0.060	0.204	0.432	0.038	6.1	0.50	0.10	4.50	0.60	0.0018	1.00	0.07	0.12	5.10
OS4		EPC 2 HOUR	0.110	0.342	0.702	0.037	4.2	0.50	0.10	4.50	0.60	0.0018	1.00	0.05	0.08	3.50
OS5		EPC 2 HOUR	0.010	0.103	0.187	0.049	0.0	0.40	0.10	4.50	0.60	0.0018	1.00	0.00	0.00	0.00
OS6		EPC 2 HOUR	0.011	0.155	0.295	0.034	0.4	0.40	0.10	4.50	0.60	0.0018	1.00	0.00	0.01	0.33
OS7		EPC 2 HOUR	0.023	0.103	0.303	0.038	1.4	0.40	0.10	4.50	0.60	0.0018	1.00	0.00	0.03	1.16
OS8		EPC 2 HOUR	0.013	0.063	0.183	0.043	3.6	0.40	0.10	4.50	0.60	0.0018	1.00	0.04	0.07	2.99

Existing and Proposed 5-year Calculated Results

Summary of Unit Hydrograph Parameters Used By Program and Calculated Results (Version 2.0.1)

		Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment Name/ID	User Comment for Catchment	CT	Cp	W50 (min.)	W50 Before Peak	W75 (min.)	W75 Before Peak	Time to Peak (min.)	Peak (cfs)	Volume (c.f)	Excess (inches)	Excess (c.f.)	Time to Peak (min.)	Peak Flow (cfs)	Total Volume (c.f.)	Runoff per Unit Area (cfs/acre)
OS1		0.142	0.068	31.5	1.95	16.4	1.38	3.3	16	39,385	0.15	5,890	52.0	2	5,889	0.20
OS2		0.150	0.091	31.4	2.50	16.3	1.77	4.2	27	66,864	0.12	8,149	52.0	3	8,150	0.16
OS3		0.147	0.125	37.7	3.92	19.6	2.77	6.5	48	139,645	0.13	18,301	55.0	6	18,300	0.15
OS4		0.152	0.169	47.0	6.39	24.4	4.52	10.7	70	255,480	0.11	29,040	58.0	8	29,039	0.11
OS5		0.163	0.060	39.2	2.12	20.4	1.50	3.5	7	22,324	0.18	3,926	52.0	1	3,925	0.20
OS6		0.162	0.065	60.0	3.28	31.2	2.32	5.5	6	26,536	0.18	4,750	54.0	1	4,750	0.14
OS7		0.159	0.087	35.8	2.69	18.6	1.90	4.5	19	52,781	0.19	9,866	52.0	3	9,866	0.23
OS8		0.154	0.065	27.6	1.68	14.3	1.19	2.8	14	30,092	0.20	6,157	51.0	3	6,156	0.31

Existing and Proposed 100-year Calculated Results

Summary of Unit Hydrograph Parameters Used By Program and Calculated Results (Version 2.0.1)

		Unit Hydrograph Parameters and Results									Excess Precip.		Storm Hydrograph			
Catchment Name/ID	User Comment for Catchment	CT	Cp	W50 (min.)	W50 Before Peak	W75 (min.)	W75 Before Peak	Time to Peak (min.)	Peak (cfs)	Volume (c.f)	Excess (inches)	Excess (c.f.)	Time to Peak (min.)	Peak Flow (cfs)	Total Volume (c.f.)	Runoff per Unit Area (cfs/acre)
OS1		0.138	0.067	31.4	1.90	16.3	1.34	3.2	16	39,385	1.28	50,399	50.0	16	50,395	1.51
OS2		0.147	0.090	31.4	2.46	16.3	1.74	4.1	28	66,864	1.25	83,450	51.0	27	83,452	1.49
OS3		0.144	0.122	37.7	3.84	19.6	2.71	6.4	48	139,645	1.26	175,745	53.0	50	175,742	1.31
OS4		0.150	0.167	46.9	6.31	24.4	4.46	10.5	70	255,480	1.24	316,467	58.0	76	316,460	1.09
OS5		0.163	0.060	39.2	2.12	20.4	1.50	3.5	7	22,324	1.30	28,931	51.0	8	28,928	1.30
OS6		0.162	0.065	60.0	3.28	31.2	2.32	5.5	6	26,536	1.30	34,485	57.0	7	34,485	0.91
OS7		0.159	0.086	35.8	2.68	18.6	1.89	4.5	19	52,781	1.31	69,069	51.0	21	69,068	1.42
OS8		0.152	0.064	27.6	1.66	14.3	1.18	2.8	14	30,092	1.33	39,991	48.0	14	39,981	1.74

EXISTING COMPOSITE % IMPERVIOUS/C VALUE CALCULATIONS

Subdivision: Cornerstone Estates
Location: El Paso County

Cornerstone Estates-Existing
25229.00
GAG

9/28/21

Basin ID	Total Area (ac)	Hardscape (100% Impervious)				Gravel Hardscape (80% Impervious)				Lawns (0% Impervious)				Basin Total Weighted C		Basins Total Weighted % Imp.
		C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	
EX-1	24.45	0.90	0.96	0.58	2.4%	0.59	0.70	0.20	0.7%	0.08	0.35	23.67	0.0%	0.10	0.37	3.0%
EX-2	20.05	0.90	0.96	0.07	0.3%	0.59	0.70	0.45	1.8%	0.08	0.35	19.53	0.0%	0.09	0.36	2.1%
EX-3	13.36	0.90	0.96	0.05	0.4%	0.59	0.70	0.00	0.0%	0.08	0.35	13.31	0.0%	0.08	0.35	0.4%
EX-4	2.15	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.08	0.35	2.15	0.0%	0.08	0.35	0.0%
OS-1	10.85	0.90	0.96	0.73	6.7%	0.59	0.70	0.19	1.4%	0.08	0.35	9.93	0.0%	0.14	0.40	8.1%
OS-2	18.42	0.90	0.96	0.80	4.3%	0.59	0.70	0.18	0.8%	0.08	0.35	17.44	0.0%	0.12	0.38	5.1%
OS-3	38.47	0.90	0.96	2.15	5.6%	0.59	0.70	0.23	0.5%	0.08	0.35	36.09	0.0%	0.13	0.39	6.1%
OS-4	70.38	0.90	0.96	1.50	2.1%	0.59	0.70	1.82	2.1%	0.08	0.35	67.06	0.0%	0.11	0.37	4.2%
OS-5	6.15	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.08	0.35	6.15	0.0%	0.08	0.35	0.0%
OS-6	7.31	0.90	0.96	0.03	0.4%	0.59	0.70	0.00	0.0%	0.08	0.35	7.28	0.0%	0.08	0.35	0.4%
OS-7	14.54	0.90	0.96	0.21	1.4%	0.59	0.70	0.00	0.0%	0.08	0.35	14.33	0.0%	0.09	0.36	1.4%
OS-8	8.29	0.90	0.96	0.30	3.6%	0.59	0.70	0.00	0.0%	0.08	0.35	7.99	0.0%	0.11	0.37	3.6%
TOTAL ON-SITE	60.01															2.0%
TOTAL OFF-SITE	174.41															4.4%
TOTAL POND	202.13															4.1%

EXISTING STANDARD FORM SF-2
TIME OF CONCENTRATION

Subdivision: Cornerstone Estates
Location: El Paso County

Project Name: Cornerstone Estates-Existing
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/28/21

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					*tc* CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (ac)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (ft)	S_o (%)	t_i (min)	L_t (ft)	S_t (%)	K	VEL. (ft/s)	t_t (min)	COMP. t_c (min)	TOTAL LENGTH (ft)	Urbanized t_c (min)	t_c (min)
EX-1	24.45	B	3%	0.10	0.37	35	22.0%	3.8	2225	3.7%	10.0	1.9	19.3	23.1	2260.0	45.9	23.1
EX-2	20.05	B	2%	0.09	0.36	35	20.0%	4.0	2215	3.9%	10.0	2.0	18.7	22.7	2250.0	45.7	22.7
EX-3	13.36	B	0%	0.08	0.35	100	10.0%	8.6	2420	3.0%	10.0	1.7	23.3	31.9	2520.0	51.7	31.9
EX-4	2.15	B	0%	0.08	0.35	40	14.1%	4.9	690	3.7%	10.0	1.9	6.0	10.8	730.0	32.6	10.8
OS-1	10.85	B	8%	0.14	0.40	-	-	-	-	-	-	-	-	-	-	-	-
OS-2	18.42	B	5%	0.12	0.38	-	-	-	-	-	-	-	-	-	-	-	-
OS-3	38.47	B	6%	0.13	0.39	-	-	-	-	-	-	-	-	-	-	-	-
OS-4	70.38	B	4%	0.11	0.37	-	-	-	-	-	-	-	-	-	-	-	-
OS-5	6.15	B	0%	0.08	0.35		-	-		-	-	-	-	-	-	-	-
OS-6	7.31	B	0%	0.08	0.35	-	-	-	-	-	-	-	-	-	-	-	-
OS-7	14.54	B	1%	0.09	0.36	-	-	-	-	-	-	-	-	-	-	-	-
OS-8	8.29	B	4%	0.11	0.37	-	-	-	-	-	-	-	-	-	-	-	-

NOTES:

$$t_c = t_i + t_t$$

Equation 6-2

Where:

t_c = computed time of concentration (minutes)

t_i = overland (initial) flow time (minutes)

t_t = channelized flow time (minutes).

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t}$$

Equation 6-4

Where:

t_t = channelized flow time (travel time, min)
L_t = waterway length (ft)
S_o = waterway slope (ft/ft)
V_t = travel time velocity (ft/sec) = $K\sqrt{S_o}$
K = NRCS conveyance factor (see Table 6-2).

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}}$$

Equation 6-3

Where:

t_i = overland (initial) flow time (minutes)
C_5 = runoff coefficient for 5-year frequency (from Table 6-4)
L_i = length of overland flow (ft)
S_o = average slope along the overland flow path (ft/ft).

$$t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

Equation 6-5

Where:

t_c = minimum time of concentration for first design point when less than t_c from Equation 6-1.
L_t = length of channelized flow path (ft)
i = imperviousness (expressed as a decimal)
S_t = slope of the channelized flow path (ft/ft).

Table 6-2. NRCS Conveyance factors, K

Type of Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

Use a minimum t_c value of 5 minutes for urbanized areas and a minimum t_c value of 10 minutes for areas that are not considered urban. Use minimum values even when calculations result in a lesser time of concentration.

EXISTING STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 5-Year

Project Name: Cornerstone Estates-Existing
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/28/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	1	OS-1	10.85	0.14	50.0	1.17	1.71	2															Flows overland towards DP1 and into EX-1. Flows enter swale and flow towards DP2.1.
	2	EX-1	24.45	0.10	23.1	2.53	2.87	7.3															Flows overland towards ex. swale and then to DP2. Flows combine at DP2.1.
	2.1								50.0	3.70	1.71	6.3											Combination of flows from DP1 and DP2. Flows into existing stock pond on south side.
	3	OS-2	18.42	0.12	50.0	1.75	1.71	3															Flows overland towards DP3 and into EX-2. Flows enter ex. swale and flow towards DP4.1.
	4	EX-2	20.05	0.09	22.7	1.89	2.90	5.5															Flows overland towards swale and then to DP4. Flows combine at DP4.1
	4.1								50.0	3.64	1.71	6.2											Combination of flows from DP3 and DP4. Flows into existing stock pond on south side.
	5	OS-3	38.47	0.13	55.0	3.82	1.57	6															Flows overland towards DP5 and into EX-3. From there it flows towards DP6.1.
	6	OS-5	6.15	0.08	50.0	0.58	1.71	1															Flows overland towards DP6 and into EX-3. From there it flows towards DP6.1.
	6.1								55.0	4.40	1.57	6.9											Combination of flows from DP5 and DP6. Flows through overland to DP6.1.
	7	OS-4	70.38	0.11	55.0	5.09	1.57	8															Flows overland towards DP7 and into EX-3. From there it flows towards DP7.1.
	7.1								55.0	9.49	1.57	14.9											Combination of flows from DP6.1 and DP7. Flows along swale towards DP8.1.
	8	EX-3	13.36	0.08	31.9	1.11	2.39	2.7															Flows overland towards ex. swale and then to DP8. Flows combine at DP8.1.
	8.1								55.0	10.60	1.57	16.7											Combination of flows from DP7.1 and DP8. Flows into existing stock pond on south side.
	8.2								55.0	17.93	1.57	28.2											Combination of flows from DP2.1, DP4.1, and DP8.1. Total inflow into the existing stock pond.

EXISTING STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 5-Year

Project Name: Cornerstone Estates-Existing
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/28/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	9	OS-6	7.31	0.08	50.0	0.58	1.71	1															Flows overland towards DP9 and into EX-4. Flows overland and are combined at DP12.1.
	10	OS-7	14.54	0.09	50.0	1.75	1.71	3															Flows overland towards DP10 and into EX-4. Flows overland and are combined at DP12.1.
	11	OS-8	8.29	0.11	50.0	1.75	1.71	3															Flows overland towards DP11 and into EX-4. Flows overland and are combined at DP12.1.
	12	EX-4	2.15	0.08	10.8	0.17	4.01	0.7															Flows overland towards DP12 and is combined at DP12.1.
	12.1								50.0	4.25	1.71	7.3											Combination of flows from DP9, DP10, DP11, and DP12. Flows overland off-site.

Notes:
Street and Pipe C*A values are determined by Q/i using the catchment's intensity value.
Values in RED indicate they were from the CUHP method. C*A values are determined by Q/i using the catchment's intensity value using the time of concentration from CUHP.

EXISTING STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 100-Year

Project Name: Cornerstone Estates-Existing
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/28/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (ac)	Runoff Coeff.	t_c (min)	C*A (ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	1	OS-1	10.85	0.40	50.0	5.56	2.88	16															Flows overland towards DP1 and into EX-1. Flows enter swale and flow towards DP2.1.
	2	EX-1	24.45	0.37	23.1	8.98	4.82	43.3															Flows overland towards ex. swale and then to DP2. Flows combine at DP2.1.
	2.1								50.0	14.54	2.88	41.8											Combination of flows from DP1 and DP2. Flows into existing stock pond on south side.
	3	OS-2	18.42	0.38	50.0	9.39	2.88	27															Flows overland towards DP3 and into EX-2. Flows enter ex. swale and flow towards DP4.1.
	4	EX-2	20.05	0.36	22.7	7.22	4.87	35.1															Flows overland towards swale and then to DP4. Flows combine at DP4.1
	4.1								50.0	16.61	2.88	47.8											Combination of flows from DP3 and DP4. Flows into existing stock pond on south side.
	5	OS-3	38.47	0.39	50.0	17.38	2.88	50															Flows overland towards DP5 and into EX-3. From there it flows towards DP6.1.
	6	OS-5	6.15	0.35	50.0	2.78	2.88	8															Flows overland towards DP6 and into EX-3. From there it flows towards DP6.1.
	6.1								50.0	20.16	2.88	58.0											Combination of flows from DP5 and DP6. Flows through overland to DP6.1.
	7	OS-4	70.38	0.37	55.0	28.83	2.64	76															Flows overland towards DP7 and into EX-3. From there it flows towards DP7.1.
	7.1								55.0	48.99	2.64	129.2											Combination of flows from DP6.1 and DP7. Flows along swale towards DP8.1.
	8	EX-3	13.36	0.35	31.9	4.71	4.01	18.9															Flows overland towards ex. swale and then to DP8. Flows combine at DP8.1.
	8.1								55.0	53.70	2.64	141.6											Combination of flows from DP7.1 and DP8. Flows into existing stock pond on south side.
	8.2								55.0	84.85	2.64	223.7											Combination of flows from DP2.1, DP4.1, and DP8.1. Total inflow into the existing stock pond.

EXISTING STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 100-Year

Project Name: Cornerstone Estates-Existing
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/28/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (ac)	Runoff Coeff.	t_c (min)	C*A (ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	9	OS-6	7.31	0.35	55.0	2.66	2.64	7															Flows overland towards DP9 and into EX-4. Flows overland and are combined at DP12.1.
	10	OS-7	14.54	0.36	50.0	7.30	2.88	21															Flows overland towards DP10 and into EX-4. Flows overland and are combined at DP12.1.
	11	OS-8	8.29	0.37	45.0	4.46	3.14	14															Flows overland towards DP11 and into EX-4. Flows overland and are combined at DP12.1.
	12	EX-4	2.15	0.35	10.8	0.75	6.73	5.0															Flows overland towards DP12 and is combined at DP12.1.
	12.1								55.0	15.16	2.64	40.0											Combination of flows from DP9, DP10, DP11, and DP12. Flows overland off-site.

Notes:
Street and Pipe C*A values are determined by Q/i using the catchment's intensity value.
Values in RED indicate they were from the CUHP method. C*A values are determined by Q/i using the catchment's intensity value using the time of concentration from CUHP.

PROPOSED COMPOSITE % IMPERVIOUS/C VALUE CALCULATIONS

Subdivision: Cornerstone Estates
Location: El Paso County

Cornerstone Estates-Proposed
25229.00
GAG

9/27/21

Basin ID	Total Area (ac)	Hardscape (100% Impervious)				Gravel Hardscape (80% Impervious)				2.5 Acre Lots (10% Impervious)				Lawns (0% Impervious)				Basin Total Weighted C		Basins Total Weighted % Imp.
		C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	Area (ac)	Weighted % Imp.	C_5	C_{100}	
A	7.15	0.90	0.96	0.27	3.8%	0.59	0.70	0.00	0.0%	0.16	0.41	5.50	7.7%	0.08	0.35	1.38	0.0%	0.17	0.42	11.5%
B	3.31	0.90	0.96	0.36	10.9%	0.59	0.70	0.00	0.0%	0.16	0.41	2.35	7.1%	0.08	0.35	0.60	0.0%	0.23	0.46	18.0%
C	10.14	0.90	0.96	0.43	4.2%	0.59	0.70	0.00	0.0%	0.16	0.41	8.40	8.3%	0.08	0.35	1.31	0.0%	0.18	0.43	12.5%
D	6.02	0.90	0.96	0.53	8.8%	0.59	0.70	0.00	0.0%	0.16	0.41	4.59	7.6%	0.08	0.35	0.90	0.0%	0.21	0.45	16.4%
E	2.06	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.16	0.41	1.61	7.8%	0.08	0.35	0.45	0.0%	0.14	0.40	7.8%
F	6.20	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.16	0.41	5.57	9.0%	0.08	0.35	0.63	0.0%	0.15	0.40	9.0%
G	22.98	0.90	0.96	0.95	4.1%	0.59	0.70	0.00	0.0%	0.16	0.41	18.79	8.2%	0.08	0.35	3.24	0.0%	0.18	0.42	12.3%
H	2.15	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.16	0.41	1.73	8.0%	0.08	0.35	0.42	0.0%	0.14	0.40	8.0%
OS-1	10.85	0.90	0.96	0.73	6.7%	0.59	0.70	0.19	1.4%	0.16	0.41	0.00	0.0%	0.08	0.35	9.93	0.0%	0.14	0.40	8.1%
OS-2	18.42	0.90	0.96	0.80	4.3%	0.59	0.70	0.18	0.8%	0.16	0.41	0.00	0.0%	0.08	0.35	17.44	0.0%	0.12	0.38	5.1%
OS-3	38.47	0.90	0.96	2.15	5.6%	0.59	0.70	0.23	0.5%	0.16	0.41	0.00	0.0%	0.08	0.35	36.09	0.0%	0.13	0.39	6.1%
OS-4	70.38	0.90	0.96	1.50	2.1%	0.59	0.70	1.82	2.1%	0.16	0.41	0.00	0.0%	0.08	0.35	67.06	0.0%	0.11	0.37	4.2%
OS-5	6.15	0.90	0.96	0.00	0.0%	0.59	0.70	0.00	0.0%	0.16	0.41	0.00	0.0%	0.08	0.35	6.15	0.0%	0.08	0.35	0.0%
OS-6	7.31	0.90	0.96	0.03	0.4%	0.59	0.70	0.00	0.0%	0.16	0.41	0.00	0.0%	0.08	0.35	7.28	0.0%	0.08	0.35	0.4%
OS-7	14.54	0.90	0.96	0.21	1.4%	0.59	0.70	0.00	0.0%	0.16	0.41	0.00	0.0%	0.08	0.35	14.33	0.0%	0.09	0.36	1.4%
OS-8	8.29	0.90	0.96	0.30	3.6%	0.59	0.70	0.00	0.0%	0.16	0.41	0.00	0.0%	0.08	0.35	7.99	0.0%	0.11	0.37	3.6%
TOTAL ON-SITE	60.01																			12.3%
TOTAL OFF-SITE	174.41																			4.4%
TOTAL POND	202.13																			7.1%

PROPOSED STANDARD FORM SF-2
TIME OF CONCENTRATION

Subdivision: Cornerstone Estates
Location: El Paso County

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					*tc* CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (ac)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (ft)	S_o (%)	t_i (min)	L_t (ft)	S_t (%)	K	VEL. (ft/s)	t_t (min)	COMP. t_c (min)	TOTAL LENGTH (ft)	Urbanized t_c (min)	t_c (min)
A	7.15	B	11%	0.17	0.42	20	2.9%	5.3	875	3.7%	15.0	2.9	5.1	10.3	895.0	31.2	10.3
B	3.31	B	18%	0.23	0.46	35	18.5%	3.6	470	4.5%	15.0	3.2	2.5	6.0	505.0	26.2	6.0
C	10.14	B	13%	0.18	0.43	40	10.0%	4.9	740	4.5%	10.0	2.1	5.8	10.7	780.0	29.3	10.7
D	6.02	B	16%	0.21	0.45	40	14.1%	4.2	690	3.7%	15.0	2.9	4.0	8.2	730.0	28.5	8.2
E	2.06	B	8%	0.14	0.40	100	9.7%	8.2	465	2.2%	15.0	2.2	3.5	11.7	565.0	29.8	11.7
F	6.20	B	9%	0.15	0.40	45	3.0%	8.0	955	3.8%	10.0	1.9	8.2	16.2	1000.0	32.4	16.2
G	22.98	B	12%	0.18	0.42	35	12.1%	4.3	1105	3.9%	15.0	3.0	6.2	10.5	1140.0	32.6	10.5
H	2.15	B	8%	0.14	0.40	40	5.0%	6.4	605	2.8%	10.0	1.7	6.0	12.4	645.0	30.6	12.4
OS-1	10.85	B	8%	0.14	0.40	-	-	-	-	-	-	-	-	-	-	-	-
OS-2	18.42	B	5%	0.12	0.38	-	-	-	-	-	-	-	-	-	-	-	-
OS-3	38.47	B	6%	0.13	0.39	-	-	-	-	-	-	-	-	-	-	-	-
OS-4	70.38	B	4%	0.11	0.37	-	-	-	-	-	-	-	-	-	-	-	-
OS-5	6.15	B	0%	0.08	0.35		-	-		-	-	-	-	-	-	-	-
OS-6	7.31	B	0%	0.08	0.35	-	-	-	-	-	-	-	-	-	-	-	-
OS-7	14.54	B	1%	0.09	0.36	-	-	-	-	-	-	-	-	-	-	-	-
OS-8	8.29	B	4%	0.11	0.37	-	-	-	-	-	-	-	-	-	-	-	-

PROPOSED STANDARD FORM SF-2
TIME OF CONCENTRATION

Subdivision: Cornerstone Estates
Location: El Paso County

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

SUB-BASIN DATA						INITIAL/OVERLAND (T_i)			TRAVEL TIME (T_t)					*tc* CHECK (URBANIZED BASINS)			FINAL
BASIN ID	D.A. (ac)	Hydrologic Soils Group	Impervious (%)	C_5	C_{100}	L (ft)	S_o (%)	t_i (min)	L_t (ft)	S_t (%)	K	VEL. (ft/s)	t_t (min)	COMP. t_c (min)	TOTAL LENGTH (ft)	Urbanized t_c (min)	t_c (min)

NOTES:

$$t_c = t_i + t_t$$

Where:

t_c = computed time of concentration (minutes)

t_i = overland (initial) flow time (minutes)

t_t = channelized flow time (minutes).

Equation 6-2

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}}$$

Where:

t_i = overland (initial) flow time (minutes)
C_5 = runoff coefficient for 5-year frequency (from Table 6-4)
L_i = length of overland flow (ft)
S_o = average slope along the overland flow path (ft/ft).

Equation 6-3

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t}$$

Where:

t_t = channelized flow time (travel time, min)
L_t = waterway length (ft)
S_o = waterway slope (ft/ft)
V_t = travel time velocity (ft/sec) = $K\sqrt{S_o}$
K = NRCS conveyance factor (see Table 6-2).

Table 6-2. NRCS Conveyance factors, K

Type of Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

Equation 6-4

$$t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

Where:

t_c = minimum time of concentration for first design point when less than t_c from Equation 6-1.
L_t = length of channelized flow path (ft)
i = imperviousness (expressed as a decimal)
S_t = slope of the channelized flow path (ft/ft).

Equation 6-5

Use a minimum t_c value of 5 minutes for urbanized areas and a minimum t_c value of 10 minutes for areas that are not considered urban. Use minimum values even when calculations result in a lesser time of concentration.

PROPOSED STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 5-Year

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			
		Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	REMARKS
	1	OS-1	10.85	0.14	50.0	1.17	1.71	2															Flows overland towards DP1 and into A. Flows enter swale and flow towards DP2.1.
	2	A	7.15	0.17	10.3	1.23	4.08	5.0															Flows overland towards swale and then to DP2. Flows combine at culvert at DP2.1.
	2.1								50.0	2.40	1.71	4.1											Combination of flows from DP1 and DP2. Flows through culvert and swale to DP12.1.
	3	B	3.31	0.23	6.0	0.75	4.89	3.7															Flows overland towards swale and then to DP3. Flows enter culvert and swale towards DP6.2.
	4	OS-2	18.42	0.12	50.0	1.75	1.71	3															Flows overland towards DP4 and into C. Flows enter swale and flow towards DP5.1.
	5	C	10.14	0.18	10.7	1.84	4.02	7.4															Flows overland towards swale and then to DP5. Flows combine at culvert at DP5.1.
	5.1								50.0	3.59	1.71	6.2											Combination of flows from DP4 and DP5. Flows through culvert and swale to DP6.1.
	6	D	6.02	0.21	8.2	1.28	4.42	5.7															Flows overland towards swale and then to DP6. Flows combine at culvert at DP6.1.
	6.1								50.0	4.87	1.71	8.4											Combination of flows from DP5.1 and DP6. Flows through culvert and swale to DP6.2.
	6.2								50.0	5.62	1.71	9.6											Combination of flows from DP3 and DP6.1. Flows along proposed swale to DP12.2.
	7	OS-3	38.47	0.13	55.0	3.82	1.57	6															Flows overland towards DP7 and into E. From there it flows towards DP8.1.
	8	E	2.06	0.14	11.7	0.29	3.90	1.1															Flows overland towards DP8 and into OS-5. From there it flows towards DP8.1.
	8.1								55.0	4.11	1.57	6.5											Combination of flows from DP7 and DP8. Flows through overland to DP9.1.
	9	OS-5	6.15	0.08	50.0	0.58	1.71	1															Flows overland towards DP9 and into F. From there it flows towards DP9.1.
	9.1								55.0	4.69	1.57	7.4											Combination of flows from DP8.1 and DP9. Flows through overland to DP10.1.

PROPOSED STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 5-Year

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (Ac)	Runoff Coeff.	t_c (min)	C*A (Ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	10	OS-4	70.38	0.11	55.0	5.09	1.57	8															Flows overland towards DP10 and into F. From there it flows towards DP10.1.
	10.1								55.0	9.78	1.57	15.4											Combination of flows from DP9.1 and DP10. Flows along swale towards DP11.1.
	11	F	6.20	0.15	16.2	0.94	3.41	3.2															Flows overland towards swale and then to DP11. Flows combine at culvert at DP11.1.
	11.1								55.0	10.72	1.57	16.9											Combination of flows from DP10.1 and DP11. Flows along swale towards DP12.2.
	12	G	22.98	0.18	10.5	4.12	4.05	16.7															Flows overland towards swale and then to DP12. Flows combine at swale at DP12.1.
	12.1								50.0	6.52	1.71	11.2											Combination of flows from DP2 and DP12. Flows along swale towards DP12.2.
	12.2								55.0	22.85	1.57	35.9											Combination of flows from DP6.2, DP11.1, and DP12.1. Total inflow into the proposed pond.
	13	OS-6	7.31	0.08	50.0	0.58	1.71	1															Flows overland towards DP13 and into H. Flows overland and are combined at DP16.1.
	14	OS-7	14.54	0.09	50.0	1.75	1.71	3															Flows overland towards DP14 and into H. Flows overland and are combined at DP16.1.
	15	OS-8	8.29	0.11	50.0	1.75	1.71	3															Flows overland towards DP15 and into H. Flows overland and are combined at DP16.1.
	16	H	2.15	0.14	12.4	0.31	3.80	1.2															Flows overland towards DP16 and is combined at DP16.1.
	16.1								50.0	4.39	1.71	7.5											Combination of flows from DP13, DP14, DP15, and DP16. Flows overland off-site.

Notes:
Street and Pipe C*A values are determined by Q/i using the catchment's intensity value.
Values in RED indicate they were from the CUHP method. C*A values are determined by Q/i using the catchment's intensity value using the time of concentration from CUHP.

PROPOSED STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 100-Year

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (ac)	Runoff Coeff.	t_c (min)	C*A (ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	1	OS-1	10.85	0.40	50.0	5.56	2.88	16															Flows overland towards DP1 and into A. Flows enter swale and flow towards DP2.1.
	2	A	7.15	0.42	10.3	3.00	6.85	20.6															Flows overland towards swale and then to DP2. Flows combine at culvert at DP2.1.
	2.1								50.0	8.56	2.88	24.6											Combination of flows from DP1 and DP2. Flows through culvert and swale to DP12.1.
	3	B	3.31	0.46	6.0	1.52	8.21	12.5															Flows overland towards swale and then to DP3. Flows enter culvert and swale towards DP6.2.
	4	OS-2	18.42	0.38	50.0	9.39	2.88	27															Flows overland towards DP4 and into C. Flows enter swale and flow towards DP5.1.
	5	C	10.14	0.43	10.7	4.32	6.76	29.2															Flows overland towards swale and then to DP5. Flows combine at culvert at DP5.1.
	5.1								50.0	13.71	2.88	39.4											Combination of flows from DP4 and DP5. Flows through culvert and swale to DP6.1.
	6	D	6.02	0.45	8.2	2.71	7.43	20.1															Flows overland towards swale and then to DP6. Flows combine at culvert at DP6.1.
	6.1								50.0	16.42	2.88	47.2											Combination of flows from DP5.1 and DP6. Flows through culvert and swale to DP6.2.
	6.2								50.0	17.94	2.88	51.6											Combination of flows from DP3 and DP6.1. Flows along proposed swale to DP12.2.
	7	OS-3	38.47	0.39	50.0	17.38	2.88	50															Flows overland towards DP7 and into E. From there it flows towards DP8.1.
	8	E	2.06	0.40	11.7	0.82	6.55	5.4															Flows overland towards DP8 and into OS-5. From there it flows towards DP8.1.
	8.1								50.0	18.20	2.88	52.4											Combination of flows from DP7 and DP8. Flows through overland to DP9.1.
	9	OS-5	6.15	0.35	50.0	2.78	2.88	8															Flows overland towards DP9 and into F. From there it flows towards DP9.1.
	9.1								50.0	20.98	2.88	60.4											Combination of flows from DP8.1 and DP9. Flows through overland to DP10.1.

PROPOSED STANDARD FORM SF-3

STORM DRAINAGE SYSTEM DESIGN

(RATIONAL METHOD PROCEDURE)

Subdivision: Cornerstone Estates
Location: El Paso County
Design Storm: 100-Year

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

STREET	Design Point	DIRECT RUNOFF							TOTAL RUNOFF				STREET			PIPE				TRAVEL TIME			REMARKS
		Basin ID	Area (ac)	Runoff Coeff.	t_c (min)	C*A (ac)	I (in/hr)	Q (cfs)	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Q_{street} (cfs)	C*A (ac)	Slope (%)	Q_{pipe} (cfs)	C*A (ac)	Slope (%)	Pipe Size (inches)	Length (ft)	Velocity (fps)	t_t (min)	
	10	OS-4	70.38	0.37	55.0	28.83	2.64	76															Flows overland towards DP10 and into F. From there it flows towards DP10.1.
	10.1								55.0	49.81	2.64	131.3											Combination of flows from DP9.1 and DP10. Flows along swale towards DP11.1.
	11	F	6.20	0.40	16.2	2.50	5.72	14.3															Flows overland towards swale and then to DP11. Flows combine at culvert at DP11.1.
	11.1								55.0	52.31	2.64	137.9											Combination of flows from DP10.1 and DP11. Flows along swale towards DP12.2.
	12	G	22.98	0.42	10.5	9.75	6.80	66.3															Flows overland towards swale and then to DP12. Flows combine at swale at DP12.1.
	12.1								50.0	18.31	2.88	52.7											Combination of flows from DP2 and DP12. Flows along swale towards DP12.2.
	12.2								55.0	88.56	2.64	233.5											Combination of flows from DP6.2, DP11.1, and DP12.1. Total inflow into the proposed pond.
	13	OS-6	7.31	0.35	55.0	2.66	2.64	7															Flows overland towards DP13 and into H. Flows overland and are combined at DP16.1.
	14	OS-7	14.54	0.36	50.0	7.30	2.88	21															Flows overland towards DP14 and into H. Flows overland and are combined at DP16.1.
	15	OS-8	8.29	0.37	45.0	4.46	3.14	14															Flows overland towards DP15 and into H. Flows overland and are combined at DP16.1.
	16	H	2.15	0.40	12.4	0.86	6.38	5.5															Flows overland towards DP16 and is combined at DP16.1.
	16.1								55.0	15.27	2.64	40.3											Combination of flows from DP13, DP14, DP15, and DP16. Flows overland off-site.

Notes:
Street and Pipe C*A values are determined by Q/i using the catchment's intensity value.
Values in RED indicate they were from the CUHP method. C*A values are determined by Q/i using the catchment's intensity value using the time of concentration from CUHP.

APPENDIX C

HYDRAULIC CALCULATIONS

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section A-A: Capacity Check
DP4 to DP5.1 and DP2.1 to DP12.1

Trapezoidal

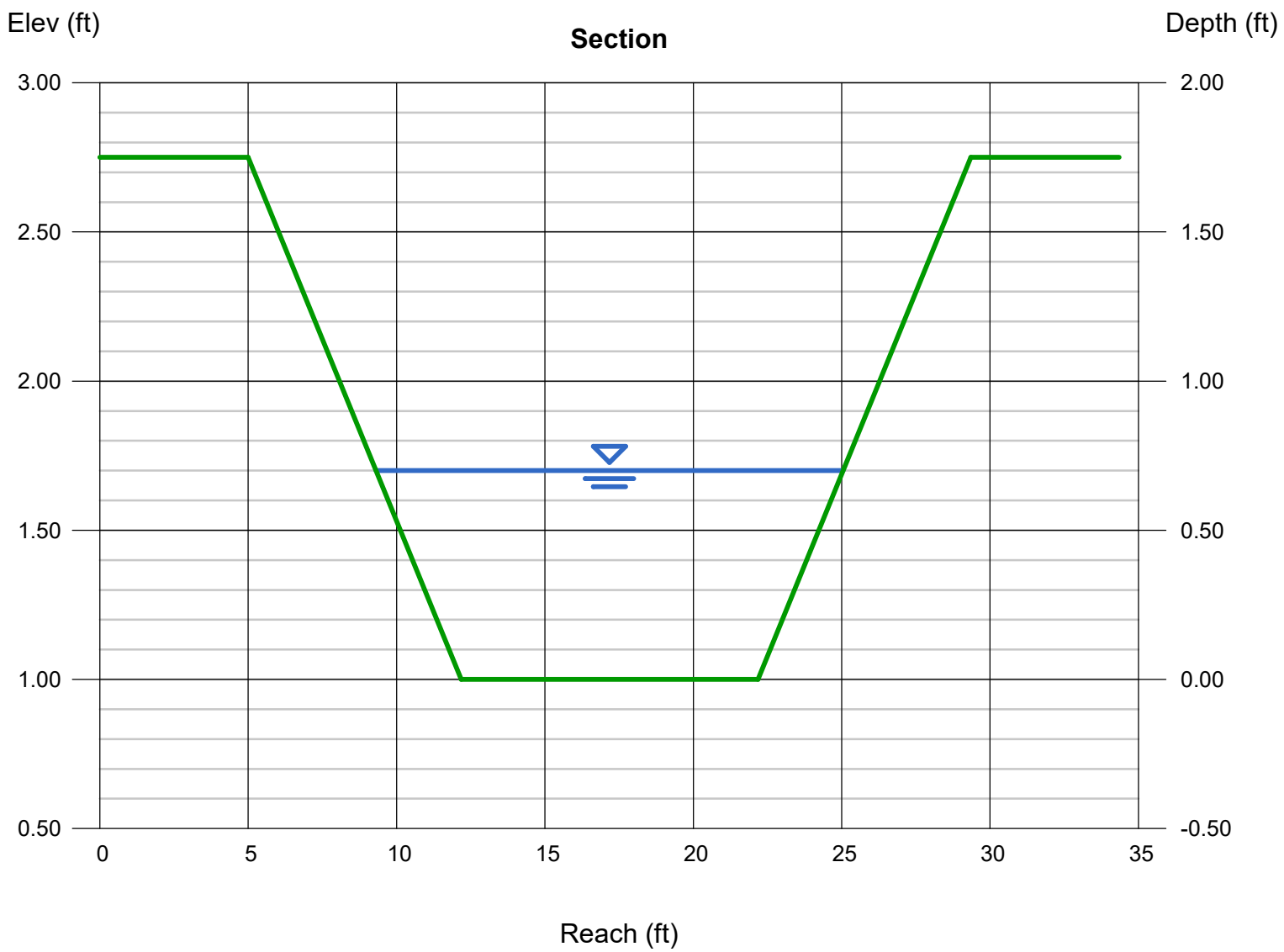
Bottom Width (ft)	= 10.00
Side Slopes (z:1)	= 4.10, 4.10
Total Depth (ft)	= 1.75
Invert Elev (ft)	= 1.00
Slope (%)	= 1.69
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 39.40

Highlighted

Depth (ft)	= 0.70
Q (cfs)	= 39.40
Area (sqft)	= 9.01
Velocity (ft/s)	= 4.37
Wetted Perim (ft)	= 15.91
Crit Depth, Yc (ft)	= 0.71
Top Width (ft)	= 15.74
EGL (ft)	= 1.00



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section A-A: Velocity Check
DP4 to DP5.1 and DP2.1 to DP12.1

Trapezoidal

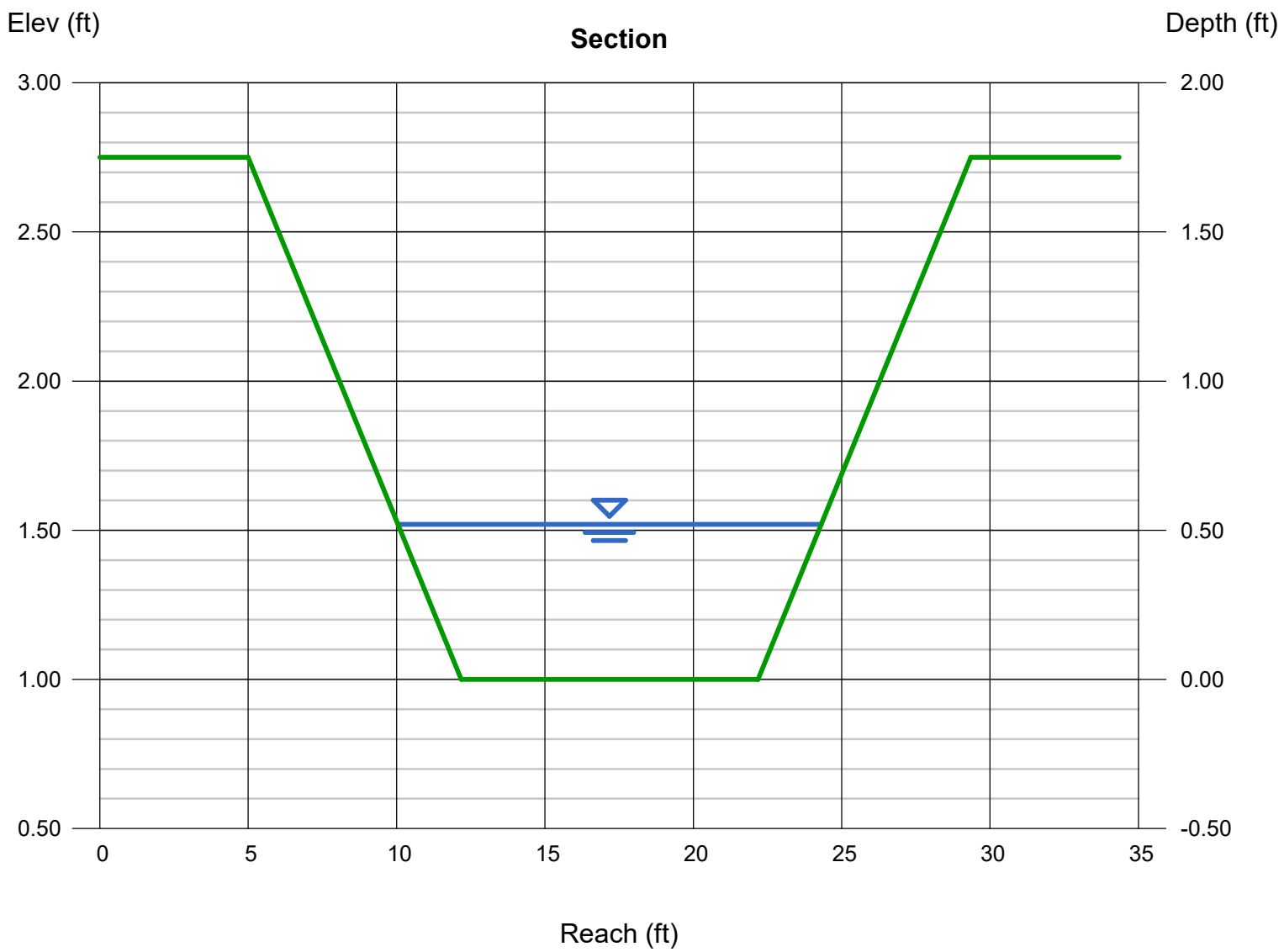
Bottom Width (ft)	= 10.00
Side Slopes (z:1)	= 4.10, 4.10
Total Depth (ft)	= 1.75
Invert Elev (ft)	= 1.00
Slope (%)	= 5.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 39.40

Highlighted

Depth (ft)	= 0.52
Q (cfs)	= 39.40
Area (sqft)	= 6.31
Velocity (ft/s)	= 6.25
Wetted Perim (ft)	= 14.39
Crit Depth, Yc (ft)	= 0.71
Top Width (ft)	= 14.26
EGL (ft)	= 1.13



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section C-C: Capacity Check To DP3, DP5.1, and DP6.1

Triangular

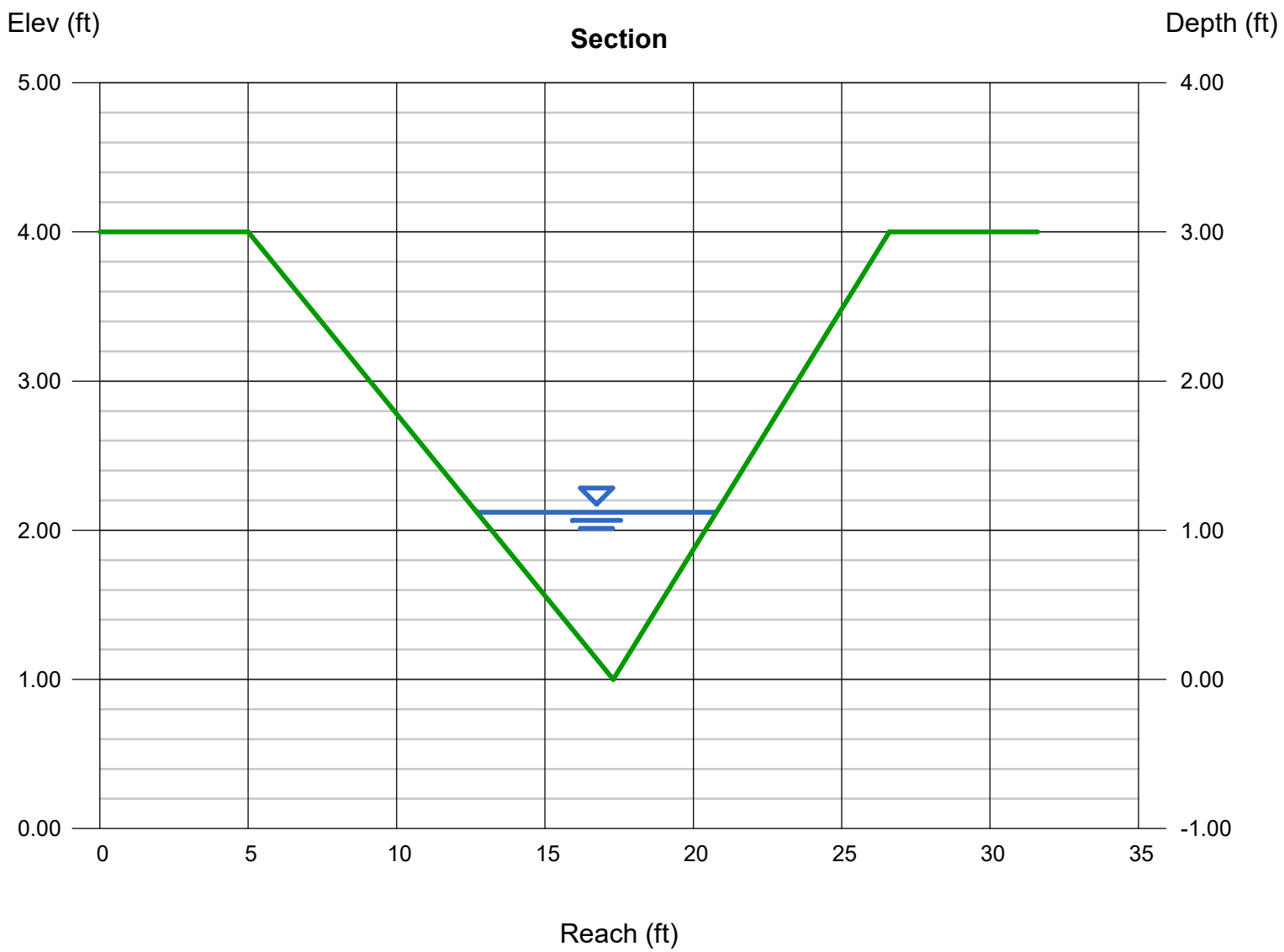
Side Slopes (z:1)	= 4.10, 3.10
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 1.00
Slope (%)	= 1.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 14.60

Highlighted

Depth (ft)	= 1.12
Q (cfs)	= 14.60
Area (sqft)	= 4.52
Velocity (ft/s)	= 3.23
Wetted Perim (ft)	= 8.37
Crit Depth, Yc (ft)	= 1.01
Top Width (ft)	= 8.06
EGL (ft)	= 1.28



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section C-C: Velocity Check To DP3, DP5.1, and DP6.1

Triangular

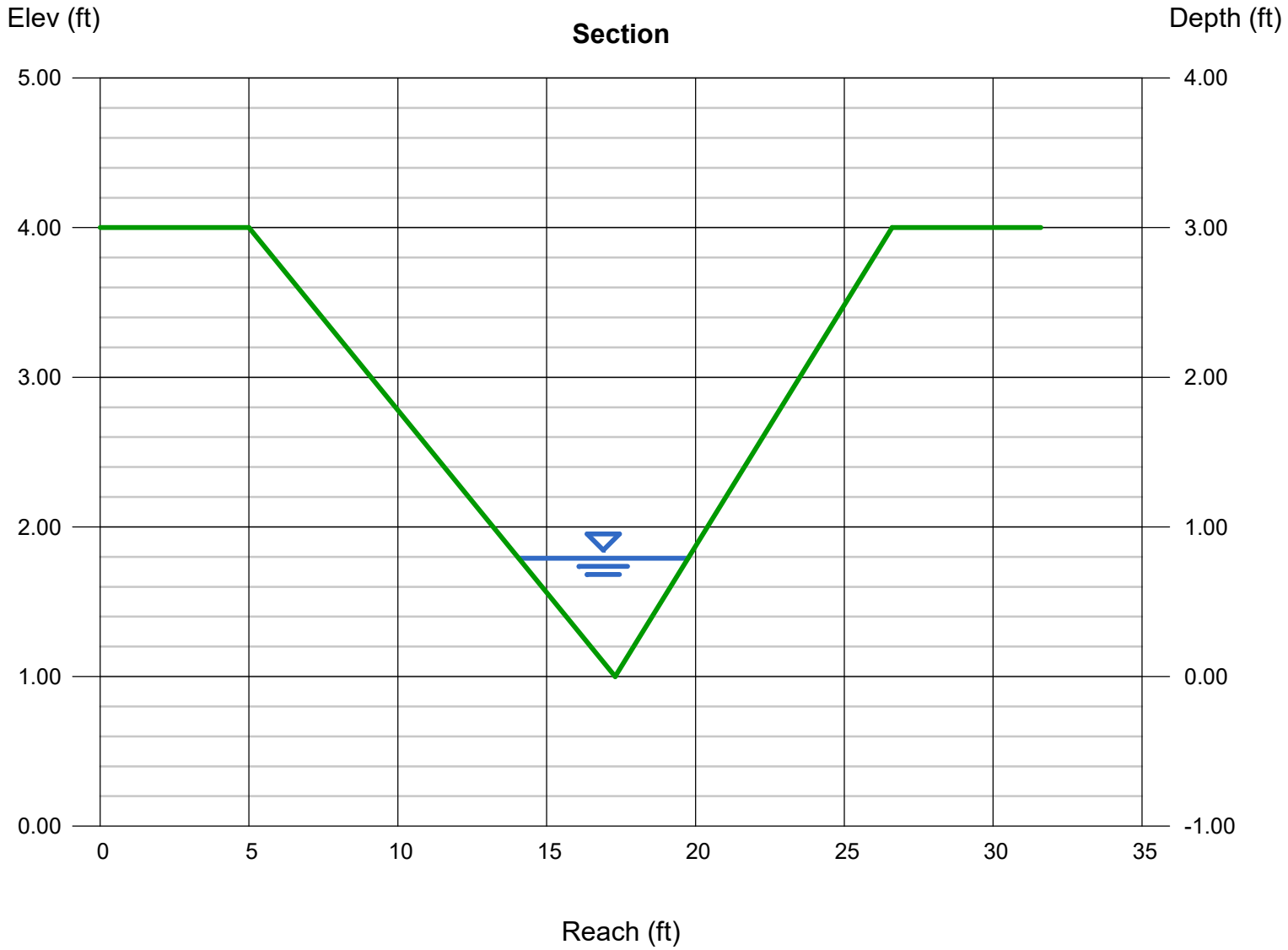
Side Slopes (z:1)	= 4.10, 3.10
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 1.00
Slope (%)	= 6.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 14.60

Highlighted

Depth (ft)	= 0.79
Q (cfs)	= 14.60
Area (sqft)	= 2.25
Velocity (ft/s)	= 6.50
Wetted Perim (ft)	= 5.91
Crit Depth, Yc (ft)	= 1.01
Top Width (ft)	= 5.69
EGL (ft)	= 1.45



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section D-D: Capacity Check
DP3 to DP6.2

Triangular

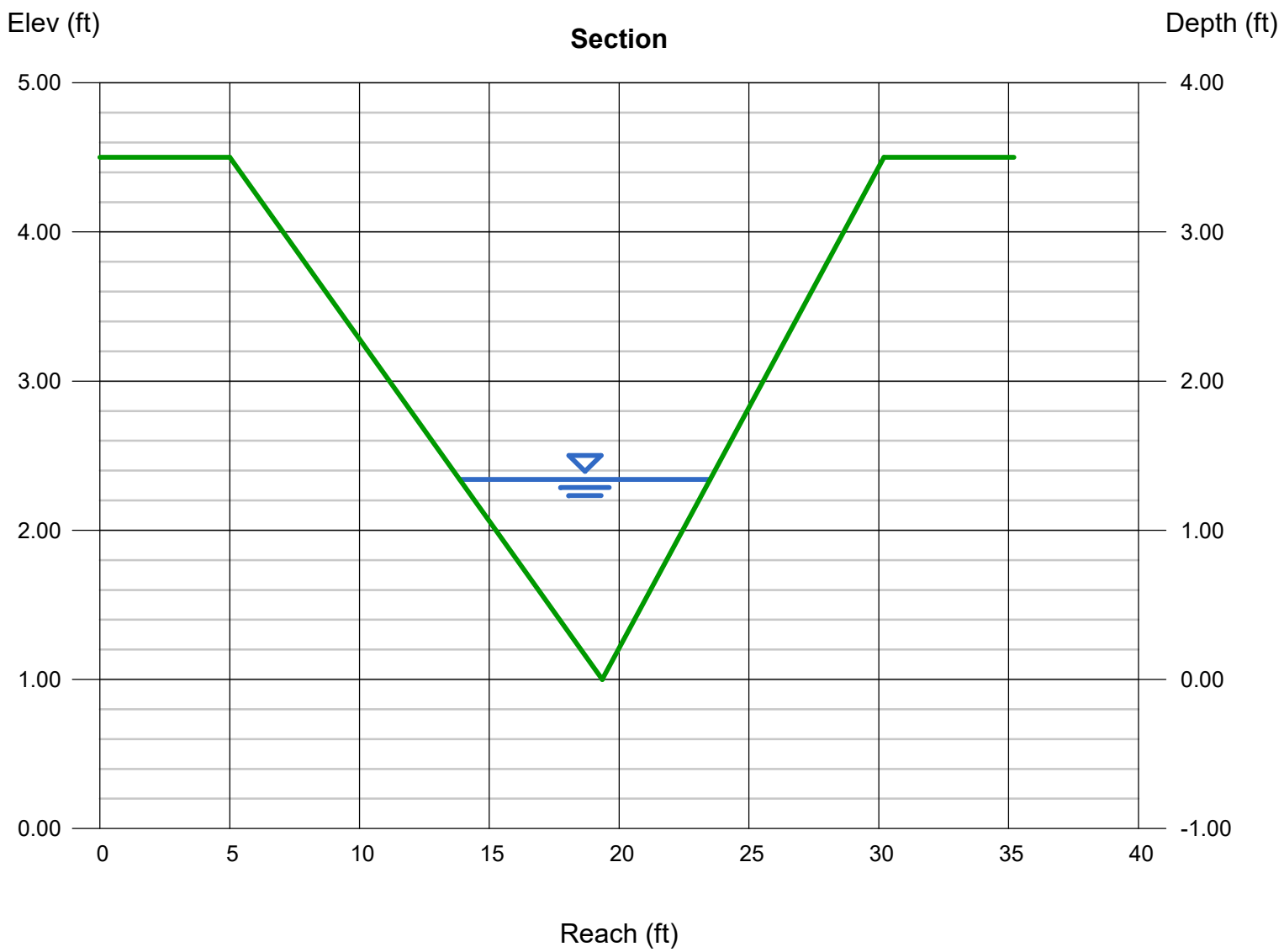
Side Slopes (z:1)	= 4.10, 3.10
Total Depth (ft)	= 3.50
Invert Elev (ft)	= 1.00
Slope (%)	= 2.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 33.15

Highlighted

Depth (ft)	= 1.34
Q (cfs)	= 33.15
Area (sqft)	= 6.46
Velocity (ft/s)	= 5.13
Wetted Perim (ft)	= 10.02
Crit Depth, Yc (ft)	= 1.40
Top Width (ft)	= 9.65
EGL (ft)	= 1.75



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Sep 29 2021

Section D-D: Velocity Check
DP3 to DP6.2

Triangular

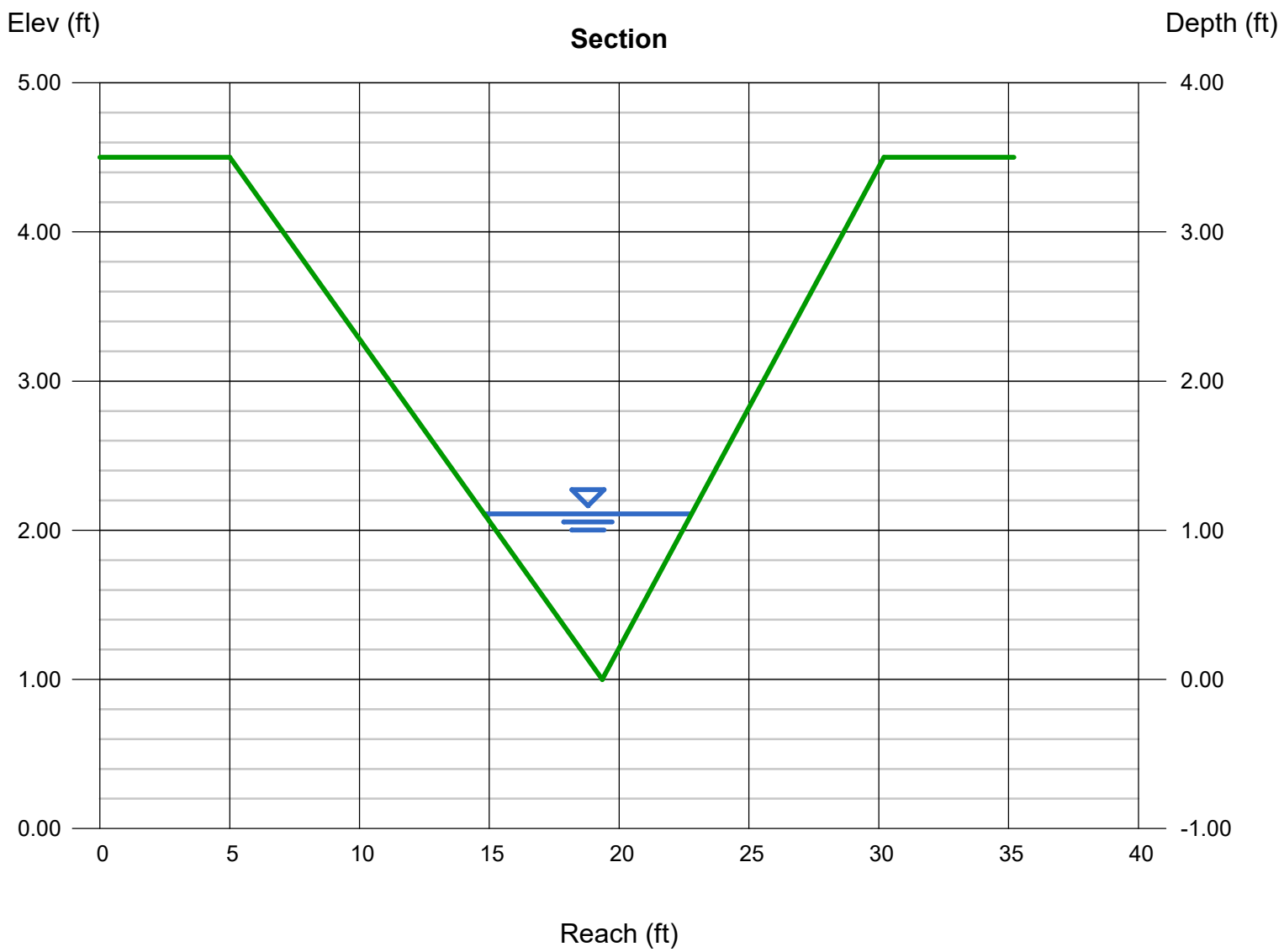
Side Slopes (z:1)	= 4.10, 3.10
Total Depth (ft)	= 3.50
Invert Elev (ft)	= 1.00
Slope (%)	= 5.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 33.15

Highlighted

Depth (ft)	= 1.11
Q (cfs)	= 33.15
Area (sqft)	= 4.44
Velocity (ft/s)	= 7.47
Wetted Perim (ft)	= 8.30
Crit Depth, Yc (ft)	= 1.40
Top Width (ft)	= 7.99
EGL (ft)	= 1.98



HY-8 Culvert Analysis Report
Western Culvert

Intersection Culvert at DP3 crossing Redeemer Lane

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 12.5 cfs

Maximum Flow: 12.5 cfs

Table 1 - Summary of Culvert Flows at Crossing: Intersection Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7330.30	0.00	0.00	0.00	1
7330.87	1.25	1.25	0.00	1
7331.13	2.50	2.50	0.00	1
7331.37	3.75	3.75	0.00	1
7331.59	5.00	5.00	0.00	1
7331.79	6.25	6.25	0.00	1
7332.02	7.50	7.50	0.00	1
7332.27	8.75	8.75	0.00	1
7332.56	10.00	10.00	0.00	1
7332.89	11.25	11.25	0.00	1
7333.26	12.50	12.50	0.00	1
7333.90	14.34	14.34	0.00	Overtopping

Rating Curve Plot for Crossing: Intersection Culvert

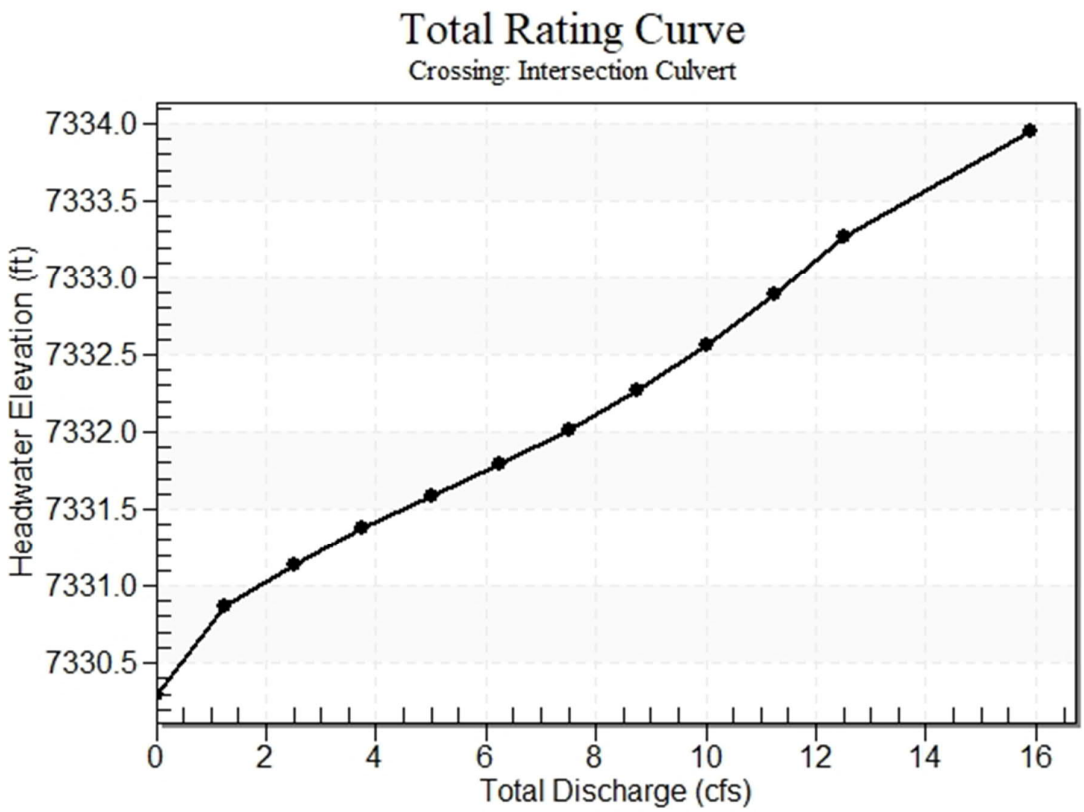


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7330.30	0.000	0.000	0-NF	0.000	0.000	0.330	0.000	0.000	0.000
1.25	1.25	7330.87	0.565	0.0*	1-JS1t	0.282	0.418	0.694	0.364	1.563	3.041
2.50	2.50	7331.13	0.833	0.0*	1-S2n	0.400	0.599	0.400	0.472	6.613	3.616
3.75	3.75	7331.37	1.075	0.0*	1-S2n	0.493	0.740	0.501	0.550	7.256	4.002
5.00	5.00	7331.59	1.286	0.0*	1-S2n	0.575	0.860	0.586	0.612	7.818	4.300
6.25	6.25	7331.79	1.493	0.175	1-S2n	0.650	0.966	0.667	0.666	8.237	4.547
7.50	7.50	7332.02	1.715	0.455	5-S2n	0.720	1.061	0.742	0.713	8.607	4.759
8.75	8.75	7332.27	1.966	0.972	5-S2n	0.789	1.145	0.814	0.755	8.932	4.946
10.00	10.00	7332.56	2.256	1.302	5-S2n	0.857	1.219	0.886	0.794	9.202	5.114
11.25	11.25	7332.89	2.588	1.666	5-S2n	0.925	1.282	0.957	0.830	9.449	5.266
12.50	12.50	7333.26	2.964	2.064	5-S2n	0.995	1.333	1.030	0.864	9.664	5.407

* Full Flow Headwater elevation is below inlet invert.

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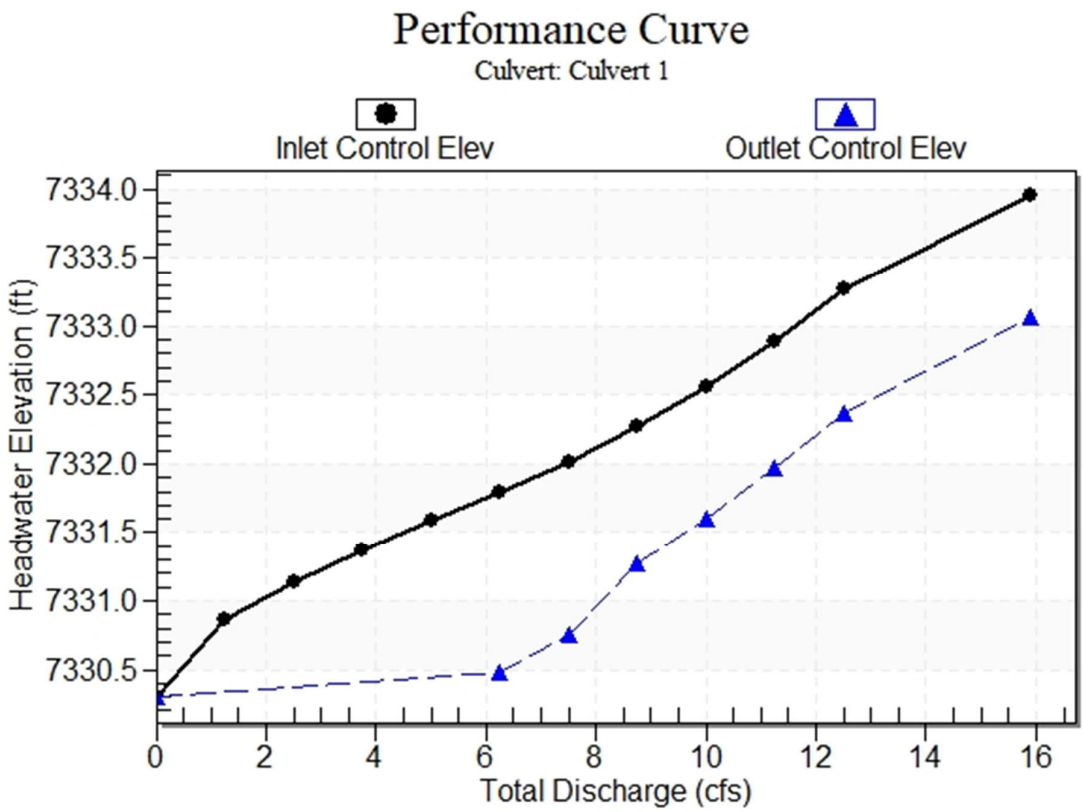
Straight Culvert

Inlet Elevation (invert): 7330.30 ft, Outlet Elevation (invert): 7328.99 ft

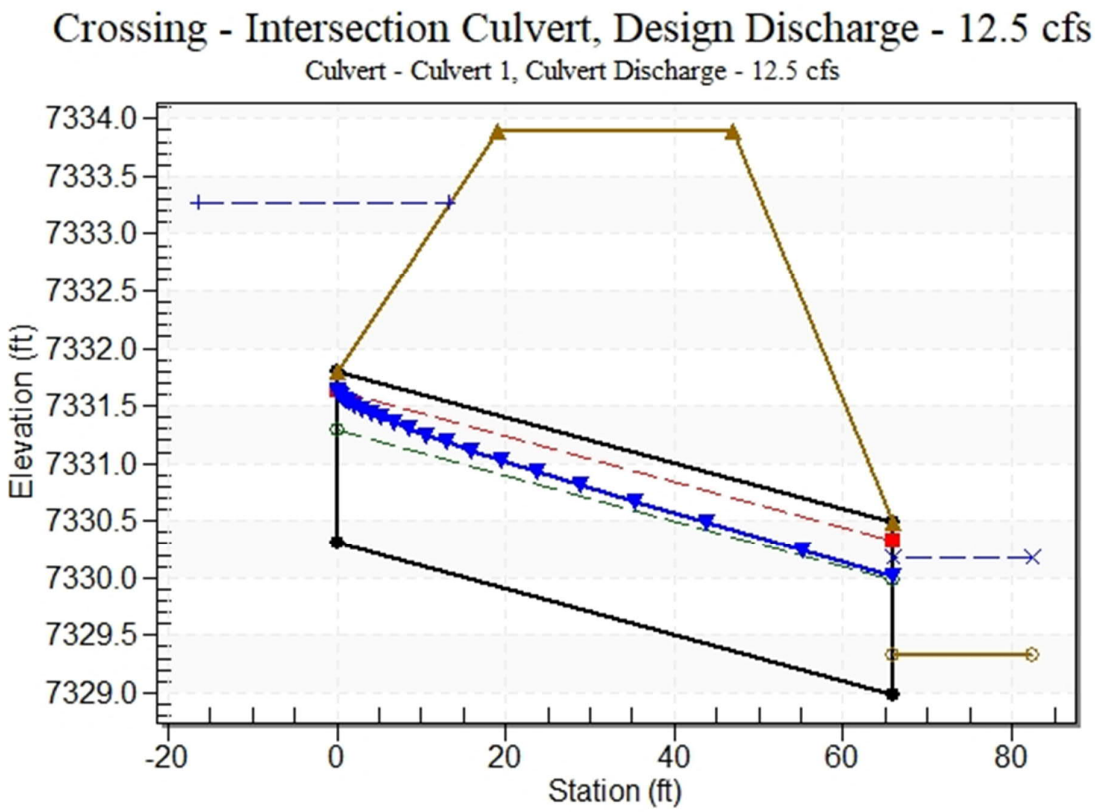
Culvert Length: 66.01 ft, Culvert Slope: 0.0198

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 7330.30 ft

Outlet Station: 66.00 ft

Outlet Elevation: 7328.99 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Intersection Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7329.32	0.00	0.00	0.00	0.00
1.25	7329.68	0.36	3.04	0.89	1.26
2.50	7329.79	0.47	3.62	1.15	1.31
3.75	7329.87	0.55	4.00	1.34	1.34
5.00	7329.93	0.61	4.30	1.49	1.37
6.25	7329.99	0.67	4.55	1.62	1.39
7.50	7330.03	0.71	4.76	1.74	1.40
8.75	7330.08	0.76	4.95	1.84	1.42
10.00	7330.11	0.79	5.11	1.93	1.43
11.25	7330.15	0.83	5.27	2.02	1.44
12.50	7330.18	0.86	5.41	2.10	1.45

Tailwater Channel Data - Intersection Culvert

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 3.10 (_:1)

Channel Slope: 0.0390

Channel Manning's n: 0.0300

Channel Invert Elevation: 7329.32 ft

Roadway Data for Crossing: Intersection Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 35.00 ft

Crest Elevation: 7333.90 ft

Roadway Surface: Paved

Roadway Top Width: 28.00 ft

HY-8 Culvert Analysis Report
Eastern Culvert

Eastern Culvert at DP2.1 crossing Redeemer Lane

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 36.6 cfs

Maximum Flow: 36.6 cfs

Table 1 - Summary of Culvert Flows at Crossing: Eastern Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7329.57	0.00	0.00	0.00	1
7330.32	3.66	3.66	0.00	1
7330.72	7.32	7.32	0.00	1
7331.07	10.98	10.98	0.00	1
7331.45	14.64	14.64	0.00	1
7331.91	18.30	18.30	0.00	1
7332.47	21.96	21.96	0.00	1
7333.11	25.62	25.51	0.00	54
7333.20	29.28	25.95	3.26	7
7333.24	32.94	26.15	6.67	4
7333.27	36.60	26.33	10.23	4
7333.13	25.62	25.62	0.00	Overtopping

Rating Curve Plot for Crossing: Eastern Culvert

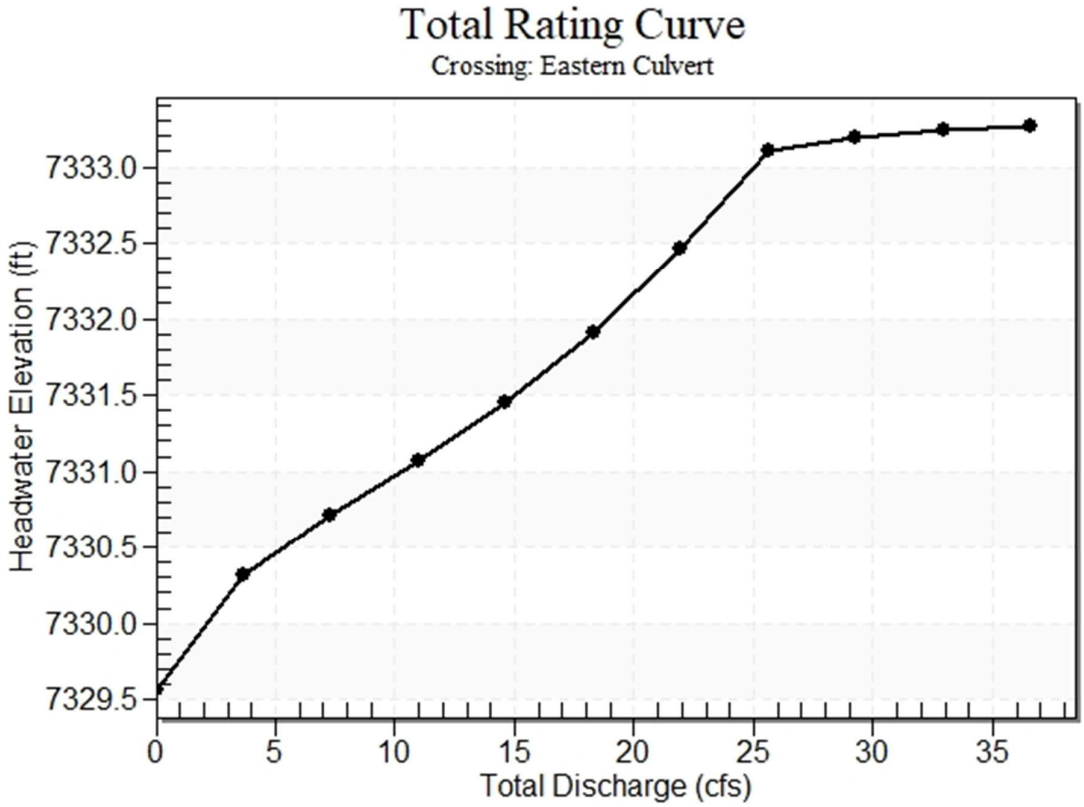


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7329.57	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
3.66	3.66	7330.32	0.750	0.252	1-S2n	0.462	0.545	0.464	0.550	4.534	3.900
7.32	7.32	7330.72	1.145	0.619	1-S2n	0.665	0.791	0.672	0.714	5.578	4.637
10.98	10.98	7331.07	1.501	1.025	1-S2n	0.840	0.988	0.852	0.831	6.261	5.132
14.64	14.64	7331.45	1.884	1.482	5-S2n	1.004	1.152	1.018	0.925	6.775	5.515
18.30	18.30	7331.91	2.340	2.143	5-S2n	1.174	1.290	1.185	1.006	7.171	5.831
21.96	21.96	7332.47	2.896	2.649	7-M2c	1.583	1.395	1.395	1.077	7.369	6.103
25.62	25.51	7333.11	3.539	3.214	7-M2c	1.583	1.459	1.459	1.141	8.271	6.343
29.28	25.95	7333.20	3.626	3.288	7-M2c	1.583	1.466	1.466	1.200	8.389	6.558
32.94	26.15	7333.24	3.667	3.326	7-M2c	1.583	1.468	1.468	1.254	8.443	6.754
36.60	26.33	7333.27	3.701	3.356	7-M2c	1.583	1.471	1.471	1.305	8.490	6.935

****

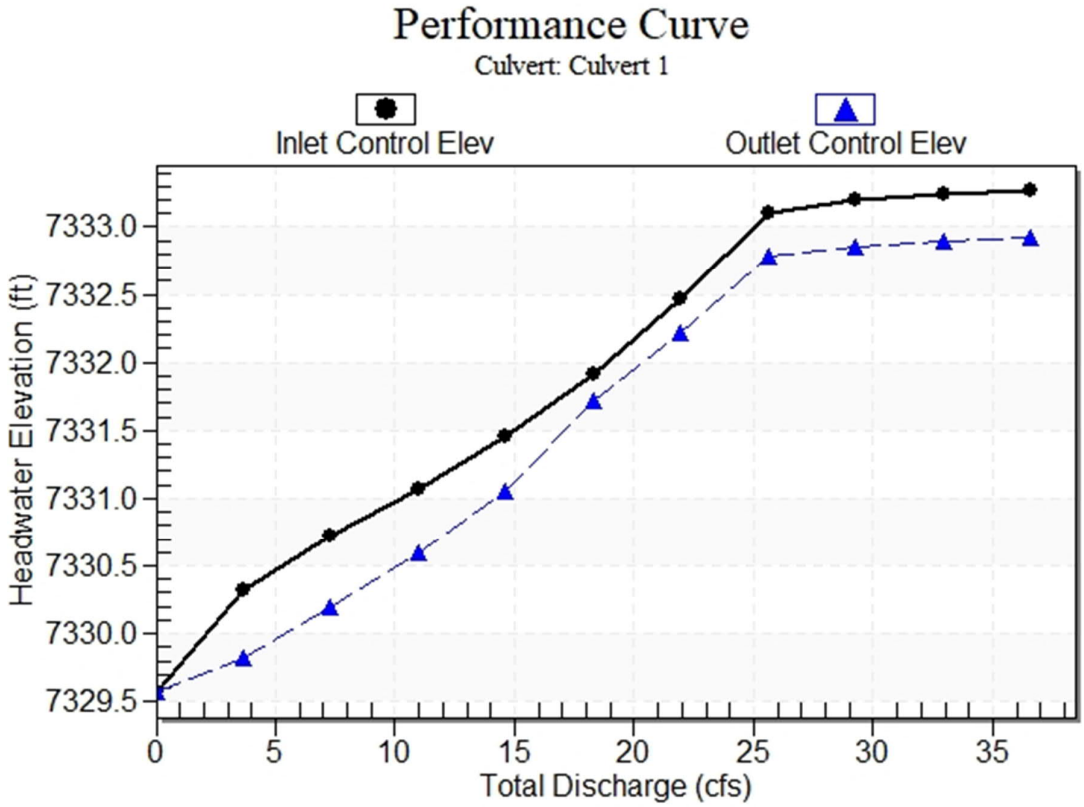
Straight Culvert

Inlet Elevation (invert): 7329.57 ft, Outlet Elevation (invert): 7329.23 ft

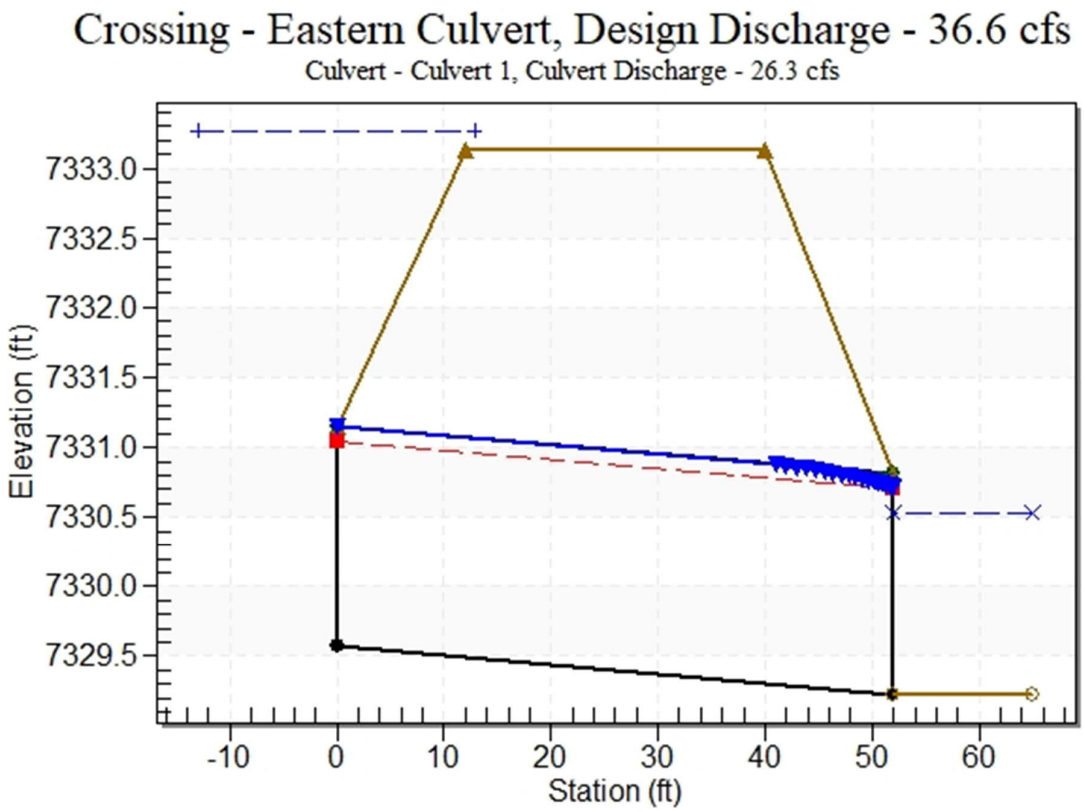
Culvert Length: 52.04 ft, Culvert Slope: 0.0065

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 7329.57 ft

Outlet Station: 52.04 ft

Outlet Elevation: 7329.23 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Elliptical

Barrel Span: 30.00 in

Barrel Rise: 19.00 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Eastern Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7329.23	0.00	0.00	0.00	0.00
3.66	7329.78	0.55	3.90	1.27	1.31
7.32	7329.94	0.71	4.64	1.65	1.37
10.98	7330.06	0.83	5.13	1.92	1.40
14.64	7330.16	0.93	5.51	2.14	1.43
18.30	7330.24	1.01	5.83	2.32	1.45
21.96	7330.31	1.08	6.10	2.49	1.47
25.62	7330.37	1.14	6.34	2.64	1.48
29.28	7330.43	1.20	6.56	2.77	1.49
32.94	7330.48	1.25	6.75	2.90	1.50
36.60	7330.53	1.30	6.93	3.01	1.51

Tailwater Channel Data - Eastern Culvert

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 3.10 (_:1)

Channel Slope: 0.0370

Channel Manning's n: 0.0300

Channel Invert Elevation: 7329.23 ft

Roadway Data for Crossing: Eastern Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 65.00 ft

Crest Elevation: 7333.13 ft

Roadway Surface: Paved

Roadway Top Width: 28.00 ft

HY-8 Culvert Analysis Report
Western Culvert

Western Culvert at DP5.1 crossing Redeemer Lane

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 39.4 cfs

Maximum Flow: 39.4 cfs

Table 1 - Summary of Culvert Flows at Crossing: Western Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7328.09	0.00	0.00	0.00	1
7328.98	3.94	3.94	0.00	1
7329.38	7.88	7.88	0.00	1
7329.76	11.82	11.82	0.00	1
7330.08	15.76	15.76	0.00	1
7330.38	19.70	19.70	0.00	1
7330.69	23.64	23.64	0.00	1
7331.02	27.58	27.58	0.00	1
7331.39	31.52	31.52	0.00	1
7331.82	35.46	35.46	0.00	1
7332.29	39.40	39.40	0.00	1
7333.00	44.53	44.53	0.00	Overtopping

Rating Curve Plot for Crossing: Western Culvert

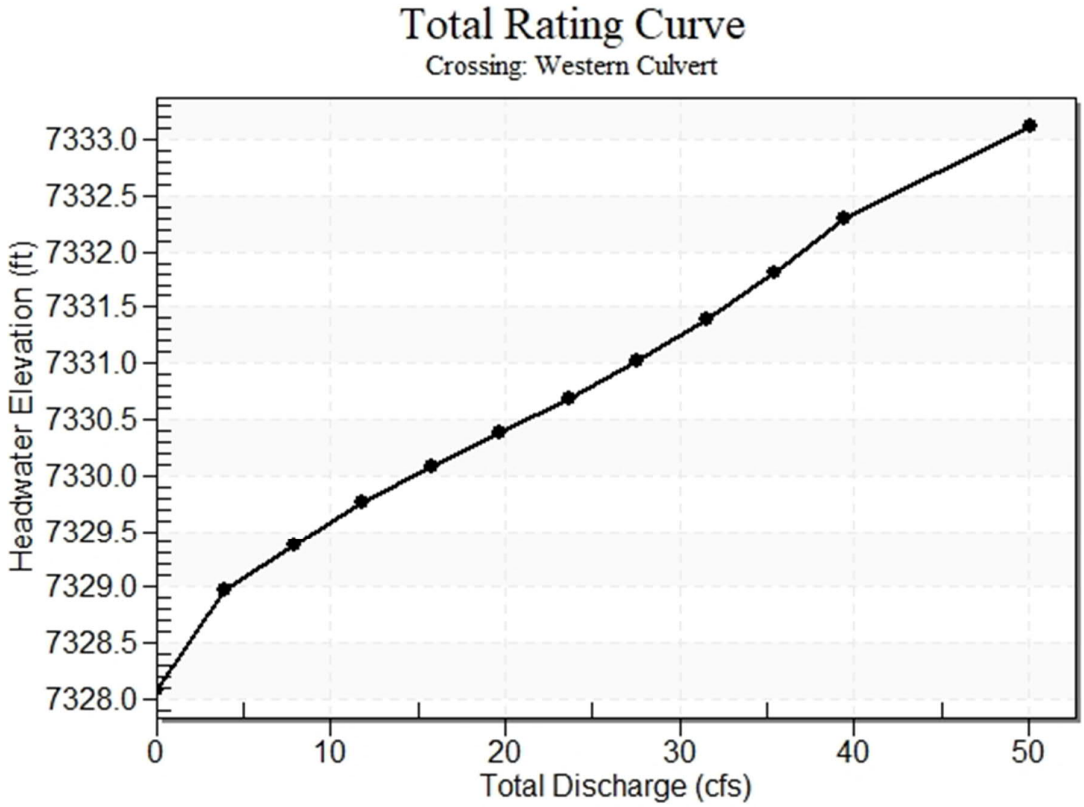


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7328.09	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
3.94	3.94	7328.98	0.888	0.0*	1-S2n	0.502	0.652	0.502	0.146	5.601	2.697
7.88	7.88	7329.38	1.290	0.276	1-S2n	0.712	0.933	0.723	0.223	6.697	3.537
11.82	11.82	7329.76	1.666	0.600	1-S2n	0.879	1.153	0.899	0.285	7.445	4.140
15.76	15.76	7330.08	1.989	0.933	1-S2n	1.027	1.340	1.056	0.341	7.996	4.624
19.70	19.70	7330.38	2.291	1.286	1-S2n	1.164	1.506	1.202	0.391	8.440	5.039
23.64	23.64	7330.69	2.598	1.664	5-S2n	1.295	1.655	1.339	0.438	8.828	5.400
27.58	27.58	7331.02	2.931	2.069	5-S2n	1.424	1.790	1.473	0.482	9.167	5.725
31.52	31.52	7331.39	3.304	2.797	5-S2n	1.553	1.912	1.604	0.523	9.471	6.021
35.46	35.46	7331.82	3.726	3.205	5-S2n	1.686	2.021	1.736	0.563	9.750	6.294
39.40	39.40	7332.29	4.203	3.647	5-S2n	1.829	2.116	1.872	0.602	9.997	6.546

* Full Flow Headwater elevation is below inlet invert.

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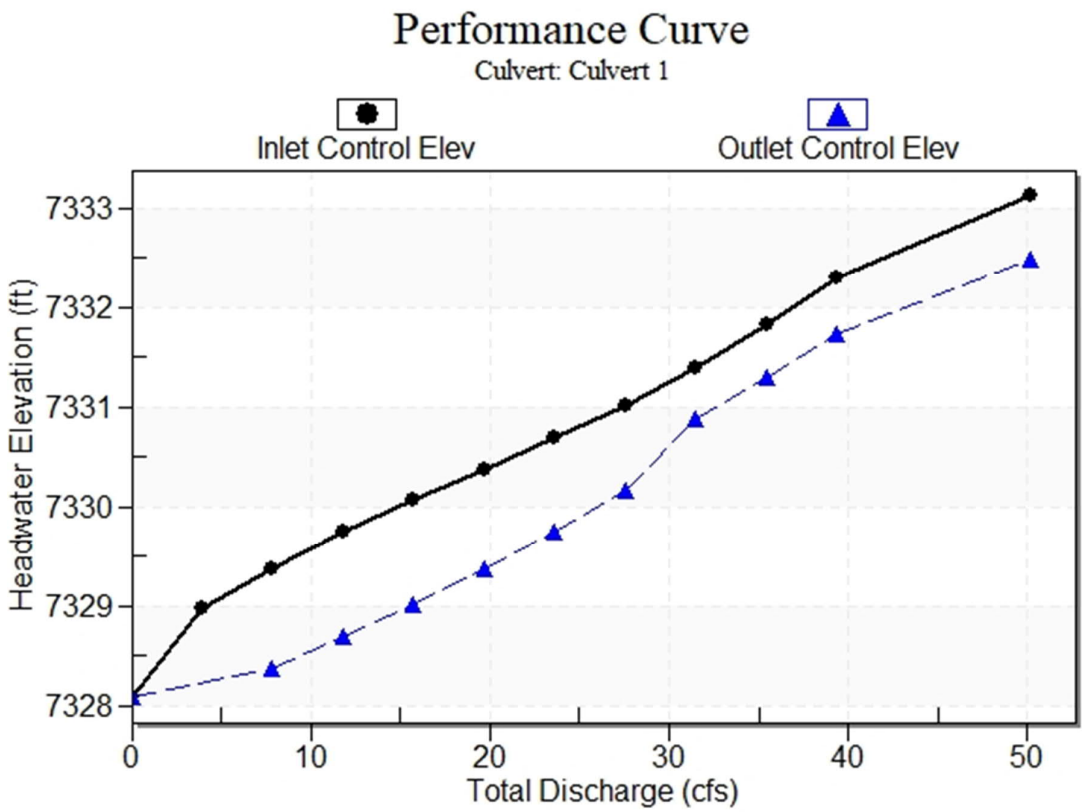
Straight Culvert

Inlet Elevation (invert): 7328.09 ft, Outlet Elevation (invert): 7327.35 ft

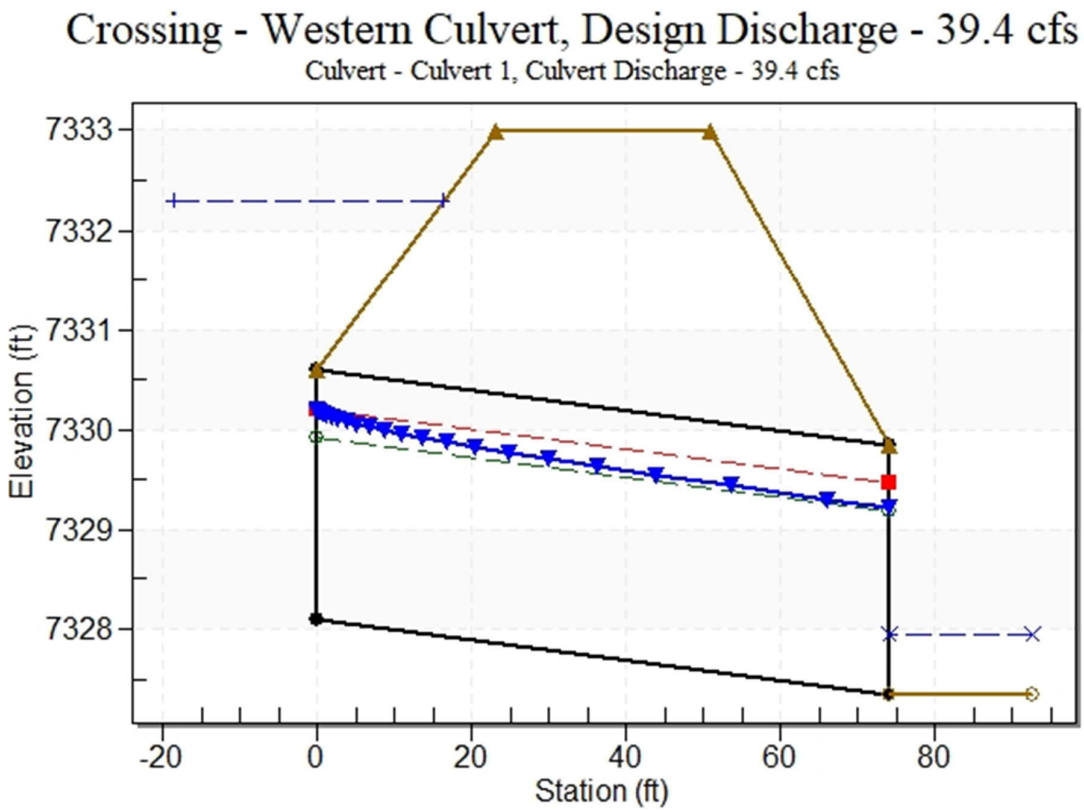
Culvert Length: 74.00 ft, Culvert Slope: 0.0100

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 7328.09 ft

Outlet Station: 74.00 ft

Outlet Elevation: 7327.35 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Western Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7327.35	0.00	0.00	0.00	0.00
3.94	7327.50	0.15	2.70	0.36	1.24
7.88	7327.57	0.22	3.54	0.56	1.32
11.82	7327.64	0.29	4.14	0.71	1.37
15.76	7327.69	0.34	4.62	0.85	1.40
19.70	7327.74	0.39	5.04	0.98	1.42
23.64	7327.79	0.44	5.40	1.09	1.44
27.58	7327.83	0.48	5.72	1.20	1.45
31.52	7327.87	0.52	6.02	1.31	1.47
35.46	7327.91	0.56	6.29	1.41	1.48
39.40	7327.95	0.60	6.55	1.50	1.49

Tailwater Channel Data - Western Culvert

Tailwater Channel Option: Rectangular Channel

Bottom Width: 10.00 ft

Channel Slope: 0.0400

Channel Manning's n: 0.0300

Channel Invert Elevation: 7327.35 ft

Roadway Data for Crossing: Western Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 35.00 ft

Crest Elevation: 7333.00 ft

Roadway Surface: Paved

Roadway Top Width: 28.00 ft

HY-8 Culvert Analysis Report
Southern Culvert

Southern Culvert at DP6.1 crossing Mercy Court

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 47.2 cfs

Maximum Flow: 47.2 cfs

Table 1 - Summary of Culvert Flows at Crossing: Southern Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7300.25	0.00	0.00	0.00	1
7301.13	4.72	4.72	0.00	1
7301.51	9.44	9.44	0.00	1
7301.81	14.16	14.16	0.00	1
7302.08	18.88	18.88	0.00	1
7302.37	23.60	23.60	0.00	1
7302.62	28.32	28.32	0.00	1
7302.86	33.04	33.04	0.00	1
7303.08	37.76	37.76	0.00	1
7303.30	42.48	42.48	0.00	1
7303.52	47.20	47.20	0.00	1
7308.06	113.39	113.39	0.00	Overtopping

Rating Curve Plot for Crossing: Southern Culvert

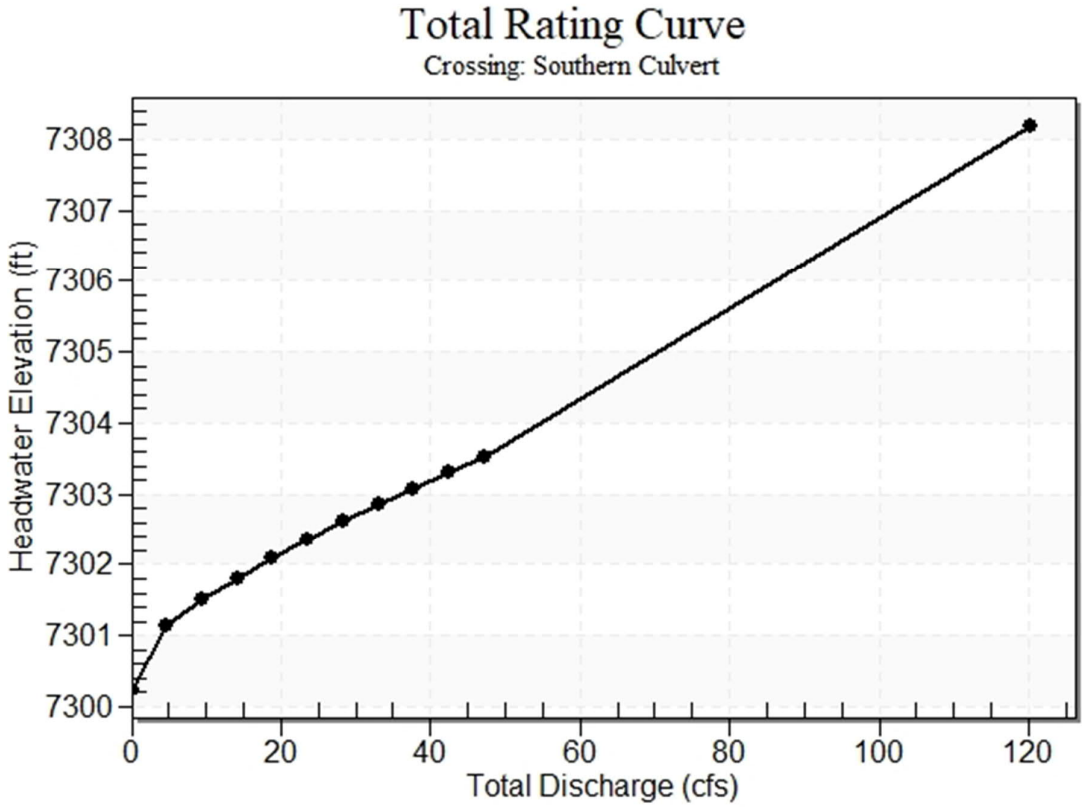


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7300.25	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
4.72	4.72	7301.13	0.877	0.0*	1-S2n	0.445	0.651	0.445	0.564	6.628	3.619
9.44	9.44	7301.51	1.258	0.0*	1-S2n	0.623	0.929	0.631	0.731	7.996	4.304
14.16	14.16	7301.81	1.560	0.0*	1-S2n	0.760	1.145	0.781	0.852	8.843	4.763
18.88	18.88	7302.08	1.835	0.0*	1-S2n	0.879	1.329	0.918	0.949	9.385	5.118
23.60	23.60	7302.37	2.115	0.177	1-S2n	0.985	1.492	1.033	1.031	9.940	5.412
28.32	28.32	7302.62	2.370	0.408	1-S2n	1.082	1.642	1.139	1.104	10.426	5.664
33.04	33.04	7302.86	2.606	0.642	1-S2n	1.172	1.779	1.244	1.170	10.785	5.887
37.76	37.76	7303.08	2.831	0.882	1-S2n	1.258	1.908	1.343	1.230	11.104	6.086
42.48	42.48	7303.30	3.049	1.129	1-S2n	1.341	2.030	1.435	1.286	11.433	6.268
47.20	47.20	7303.52	3.267	1.384	1-S2n	1.420	2.144	1.529	1.337	11.684	6.436

* Full Flow Headwater elevation is below inlet invert.

****

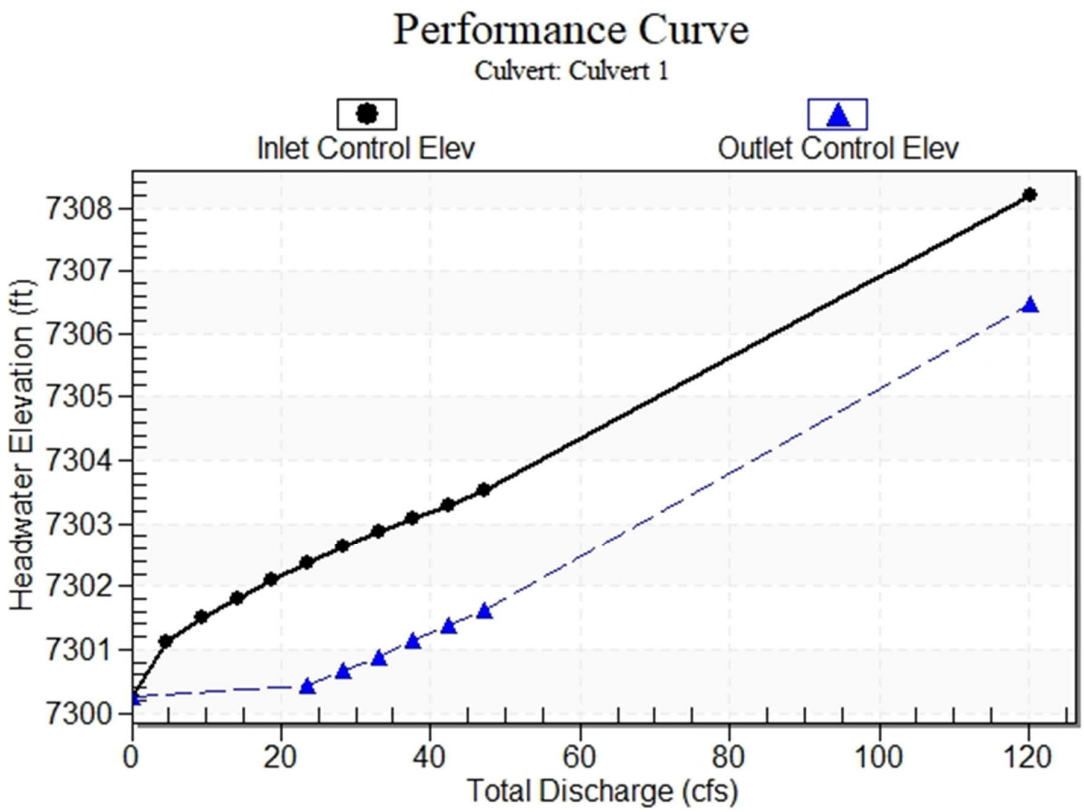
Straight Culvert

Inlet Elevation (invert): 7300.25 ft, Outlet Elevation (invert): 7298.75 ft

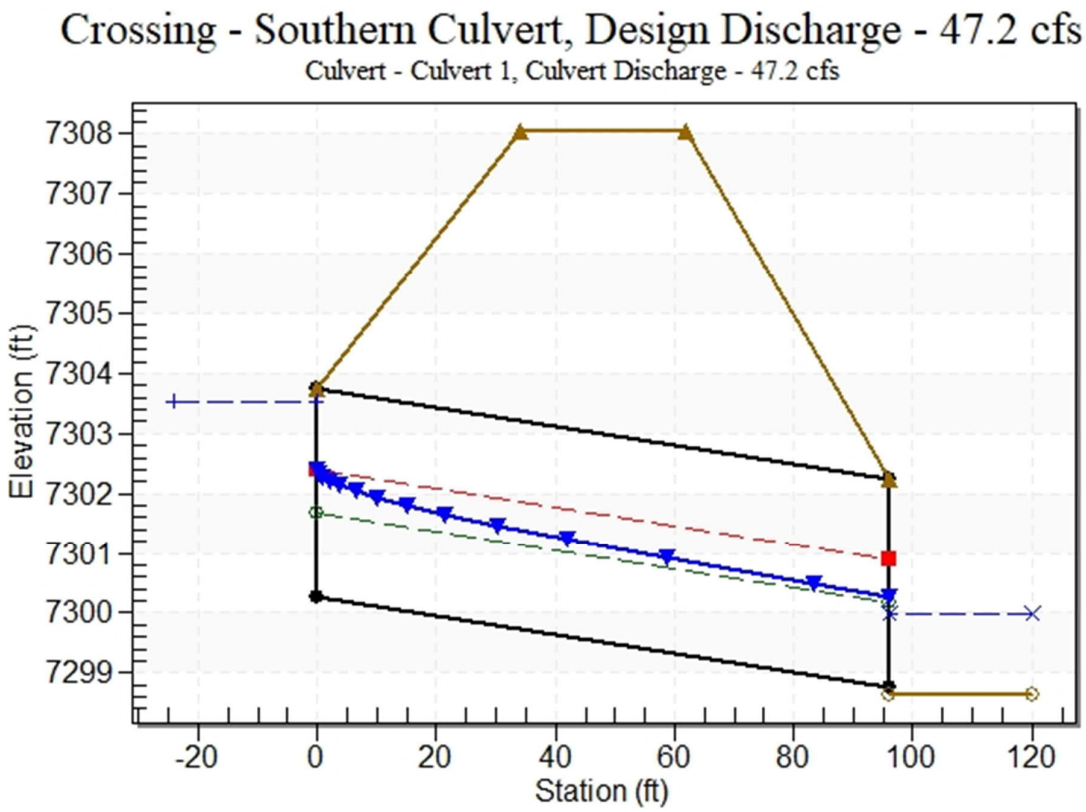
Culvert Length: 96.01 ft, Culvert Slope: 0.0156

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 7300.25 ft

Outlet Station: 96.00 ft

Outlet Elevation: 7298.75 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Southern Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7298.65	0.00	0.00	0.00	0.00
4.72	7299.21	0.56	3.62	1.06	1.20
9.44	7299.38	0.73	4.30	1.37	1.25
14.16	7299.50	0.85	4.76	1.59	1.29
18.88	7299.60	0.95	5.12	1.78	1.31
23.60	7299.68	1.03	5.41	1.93	1.33
28.32	7299.75	1.10	5.66	2.07	1.34
33.04	7299.82	1.17	5.89	2.19	1.36
37.76	7299.88	1.23	6.09	2.30	1.37
42.48	7299.94	1.29	6.27	2.41	1.38
47.20	7299.99	1.34	6.44	2.50	1.39

Tailwater Channel Data - Southern Culvert

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 4.10 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 7298.65 ft

Roadway Data for Crossing: Southern Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 35.00 ft

Crest Elevation: 7308.06 ft

Roadway Surface: Paved

Roadway Top Width: 28.00 ft

PIPE OUTFALL RIPRAP SIZING CALCULATIONS

Subdivision: Cornerstone Estates
Location: El Paso County

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

	STORM DRAIN SYSTEM			
	DESIGN POINT	DESIGN POINT	DESIGN POINT	Notes
Q_{100} (cfs):	12.5	36.6	39.4	Flows are the greater of proposed vs. future
Conduit	Pipe	Pipe	Pipe	
D_c, Pipe Diameter (in):	18	24	30	
W, Box Width (ft):	N/A	N/A	N/A	
H, Box Height (ft):	N/A	N/A	N/A	
Y_t, Tailwater Depth (ft):	0.86	1.31	0.60	If unknown, use Y_t/D_c (or H)=0.4
Y_t/Dc or Y_t/H	0.57	0.66	0.24	
$Q/D^{2.5}$ or $Q/(WH^{3/2})$	4.54	6.55	3.99	
Supercritical?	No	No	No	
Y_n, Normal Depth (ft) [Supercritical]:	0.00	0.00	0.00	
D_a, H_a (in) [Supercritical]:	N/A	N/A	N/A	$D_a=(D_c+Y_n)/2$
Riprap d_{50} (in) [Supercritical]:	N/A	N/A	N/A	
Riprap d_{50} (in) [Subcritical]:	3.66	5.94	15.25	
Required Riprap Size:	L	L	H	Fig. 9-38 or Fig. 9-36
d_{50} (in):	9	9	15	
Expansion Factor, $1/(2\tan\theta)$:	4.50	5.00	1.60	Read from Fig. 9-35 or 9-36
θ:	0.11	0.10	0.30	
Erosive Soils?	No			
Area of Flow, A_t (ft^2):	1.79	5.23	5.63	$A_t=Q/V$
Length of Protection, L_p (ft):	2.6	10.0	11.0	$L=(1/(2\tan\theta))(At/Yt - D)$
Min Length (ft)	4.5	6.0	7.5	Min L=3D or 3H
Max Length (ft)	15.0	19.9	25.0	Max L=10D or 10H
Min Bottom Width, T (ft):	2.1	4.0	9.2	$T=2*(L_p*\tan\theta)+W$
Design Length (ft)	4.5	11.0	12.0	
Design Width (ft)	2.1	4.0	9.2	
Riprap Depth (in)	18	18	30	Depth=$2(d_{50})$
Type II Bedding Depth (in)*	6	6	8	*Not used if Soil Riprap
Cutoff Wall	No	No	No	
Cutoff Wall Depth (ft)				Depth of Riprap and Base
Cutoff Wall Width (ft)				

Note: No Type II Base to be used if Soil Riprap is specified within the plans
* For use when the flow in the culvert is supercritical (and less than full).

PIPE OUTFALL RIPRAP SIZING CALCULATIONS

Subdivision: Cornerstone Estates
Location: El Paso County

Project Name: Cornerstone Estates-Proposed
Project No.: 25229.00
Calculated By: GAG
Checked By:
Date: 9/27/21

	STORM DRAIN SYSTEM			
	DESIGN POINT	DESIGN POINT	DESIGN POINT	Notes
Q_{100} (cfs):	47.2	189.3		Flows are the greater of proposed vs. future
Conduit	Pipe	Box Culvert		
D_c, Pipe Diameter (in):	42	N/A		
W, Box Width (ft):	N/A	9		
H, Box Height (ft):	N/A	2		
Y_t, Tailwater Depth (ft):	1.34	2.00		If unknown, use Y_t/D_c (or H)=0.4
Y_t/Dc or Y_t/H	0.38	1.00		
$Q/D^{2.5}$ or $Q/(WH^{3/2})$	2.06	7.44		
Supercritical?	No	No		
Y_n, Normal Depth (ft) [Supercritical]:	0.00	0.00		
D_a, H_a (in) [Supercritical]:	N/A	N/A		$D_a=(D_c+Y_n)/2$
Riprap d_{50} (in) [Supercritical]:	N/A	N/A		
Riprap d_{50} (in) [Subcritical]:	6.30	2.50		
Required Riprap Size:	L	L		Fig. 9-38 or Fig. 9-36
d_{50} (in):	9	9		
Expansion Factor, $1/(2 \tan\theta)$:	5.40	4.50		Read from Fig. 9-35 or 9-36
θ:	0.09	0.11		
Erosive Soils?	No			
Area of Flow, A_t (ft^2):	6.74	27.04		$A_t=Q/V$
Length of Protection, L_p (ft):	8.3	20.3		L=(1/(2 tan θ))(At/Yt - D)
Min Length (ft)	10.5	27.0		Min L=3D or 3H
Max Length (ft)	35.0	20.0		Max L=10D or 10H
Min Bottom Width, T (ft):	5.0	6.5		$T=2*(L_p*\tan\theta)+W$
Design Length (ft)	10.5	27.0		
Design Width (ft)	5.0	6.5		
Riprap Depth (in)	18	18		Depth=2(d_{50})
Type II Bedding Depth (in)*	6	6		*Not used if Soil Riprap
Cutoff Wall	No	No		
Cutoff Wall Depth (ft)				Depth of Riprap and Base
Cutoff Wall Width (ft)				

Note: No Type II Base to be used if Soil Riprap is specified within the plans
* For use when the flow in the culvert is supercritical (and less than full).

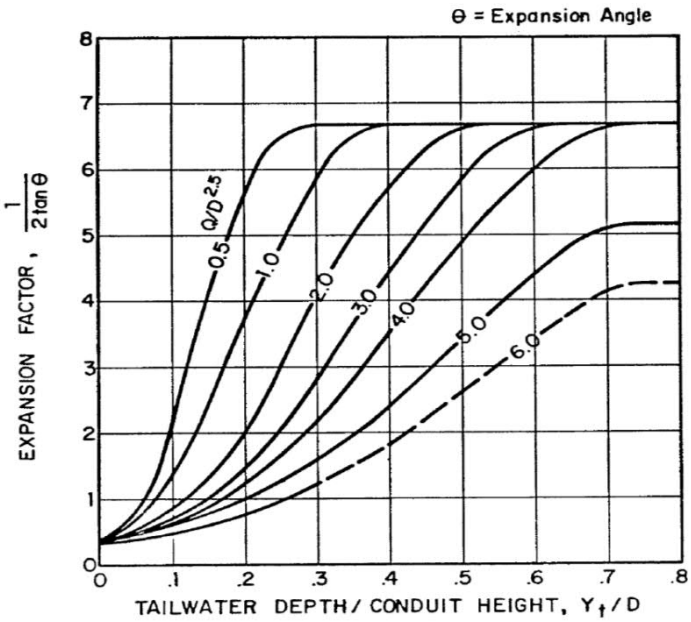


Figure 9-35. Expansion factor for circular conduits

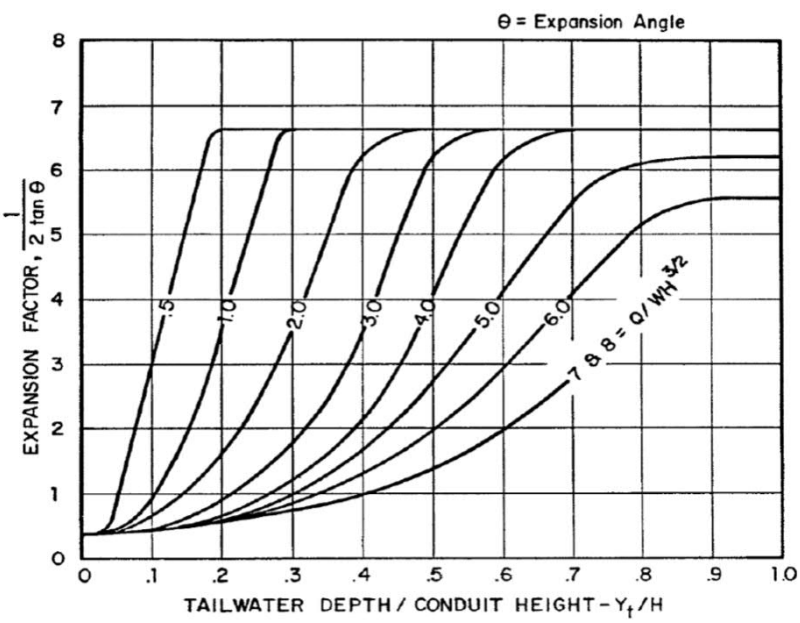


Figure 9-36. Expansion factor for rectangular conduits

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Oct 4 2021

RUNDOWN INTO POND
DP12.1 TO POND

Triangular

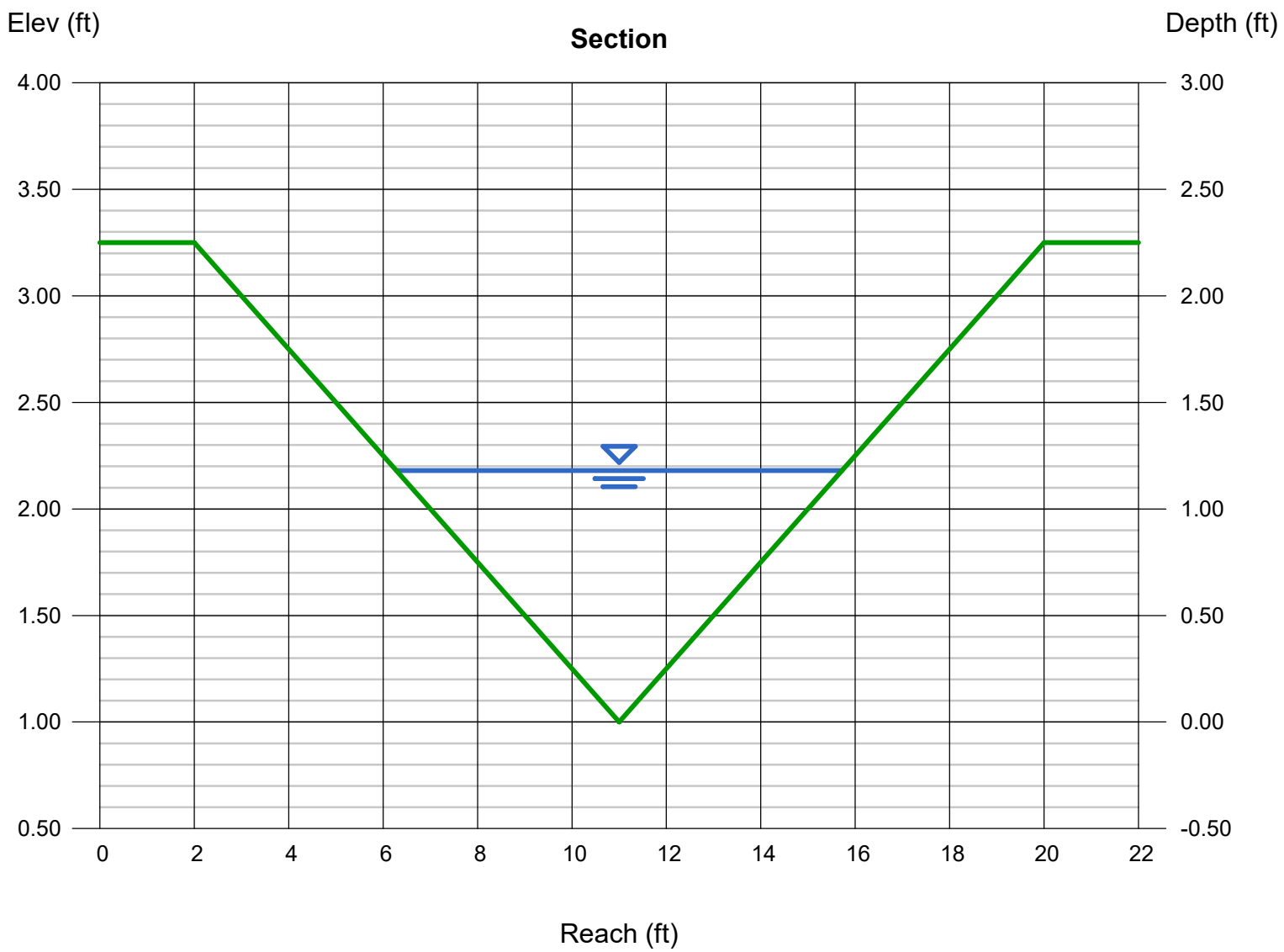
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.25
Invert Elev (ft)	= 1.00
Slope (%)	= 7.90
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 52.68

Highlighted

Depth (ft)	= 1.18
Q (cfs)	= 52.68
Area (sqft)	= 5.57
Velocity (ft/s)	= 9.46
Wetted Perim (ft)	= 9.73
Crit Depth, Yc (ft)	= 1.61
Top Width (ft)	= 9.44
EGL (ft)	= 2.57



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, Oct 1 2021

RUNDOWN INTO POND
DP6.2 TO POND

Triangular

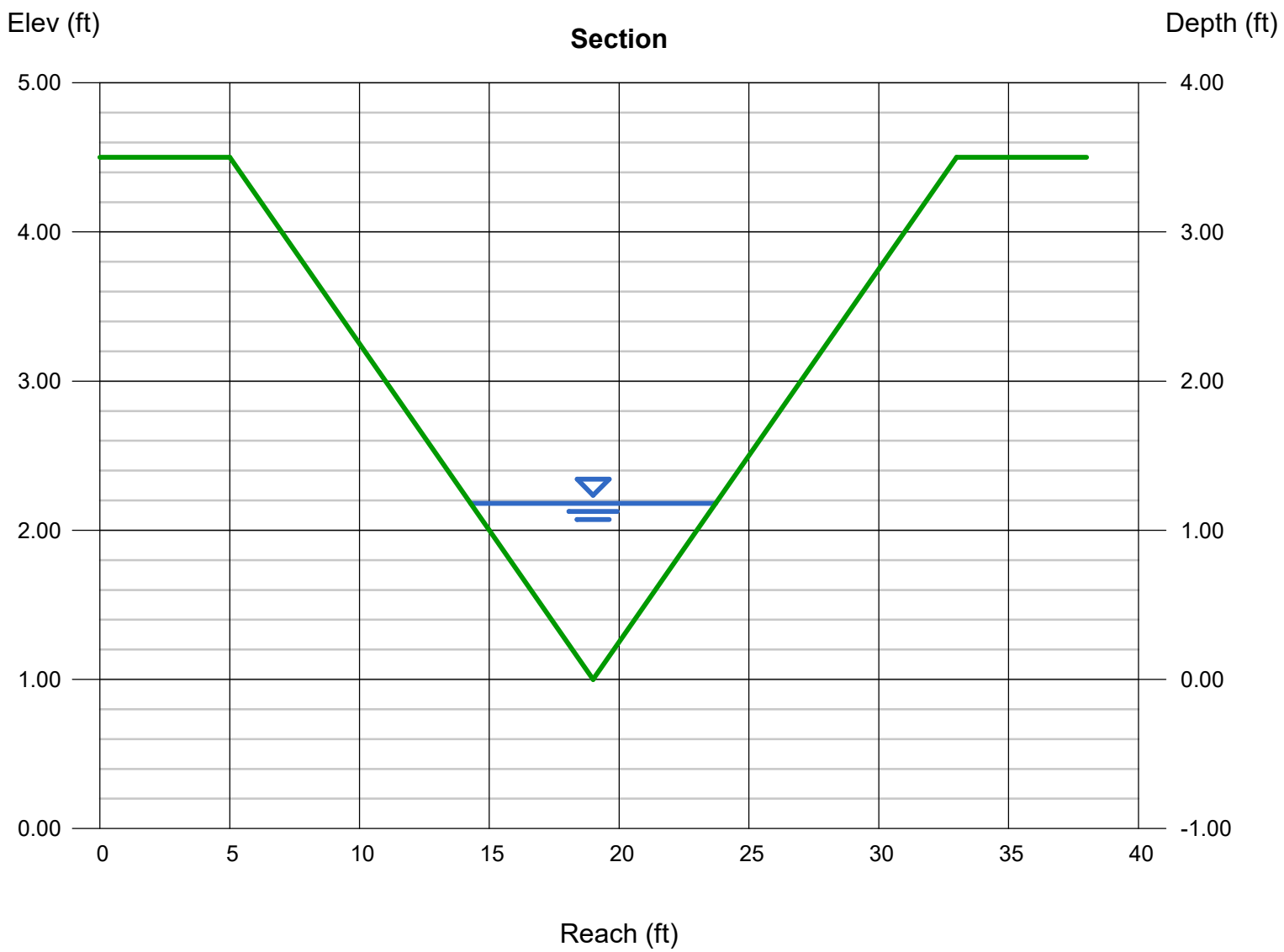
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 3.50
Invert Elev (ft)	= 1.00
Slope (%)	= 7.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 51.60

Highlighted

Depth (ft)	= 1.18
Q (cfs)	= 51.60
Area (sqft)	= 5.57
Velocity (ft/s)	= 9.26
Wetted Perim (ft)	= 9.73
Crit Depth, Yc (ft)	= 1.60
Top Width (ft)	= 9.44
EGL (ft)	= 2.51



Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Oct 4 2021

RUNDOWN INTO POND
DP11.1 TO POND

Trapezoidal

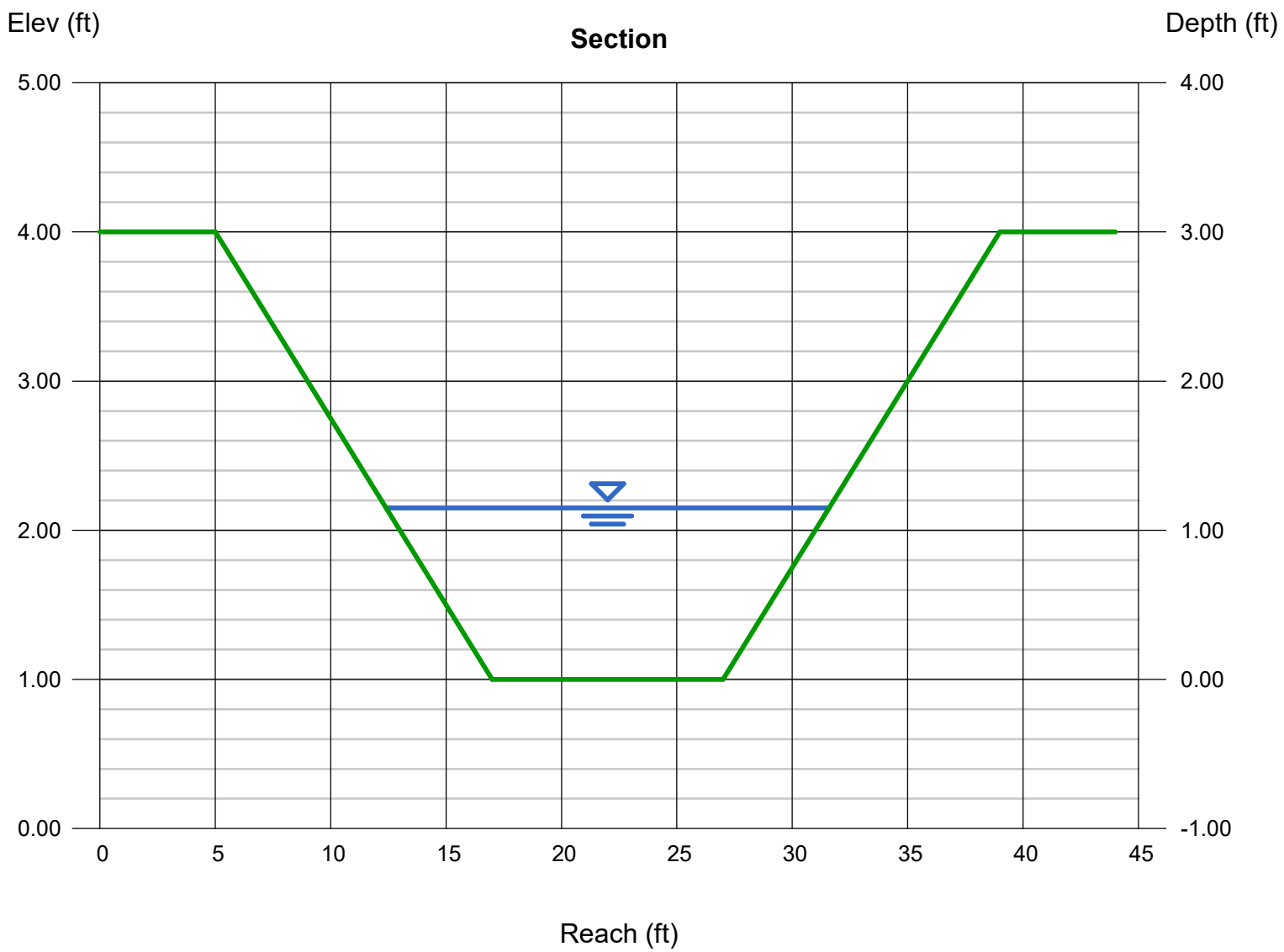
Bottom Width (ft)	= 10.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 3.00
Invert Elev (ft)	= 1.00
Slope (%)	= 3.42
N-Value	= 0.030

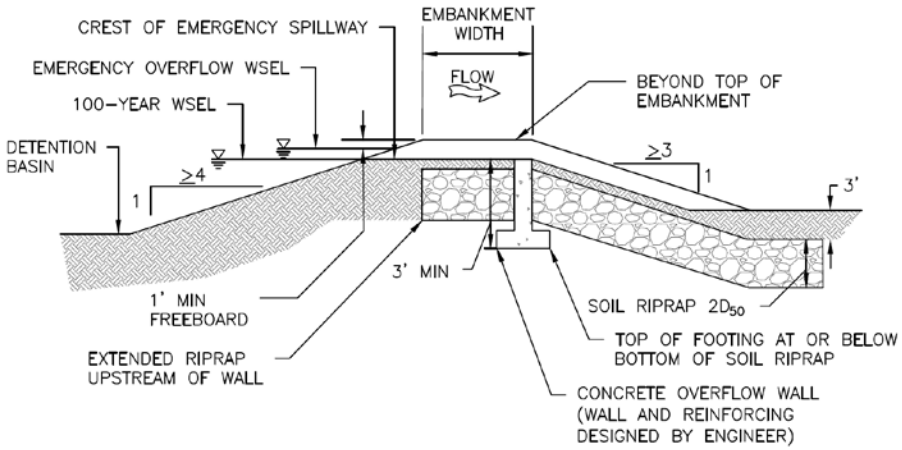
Calculations

Compute by:	Known Q
Known Q (cfs)	= 137.91

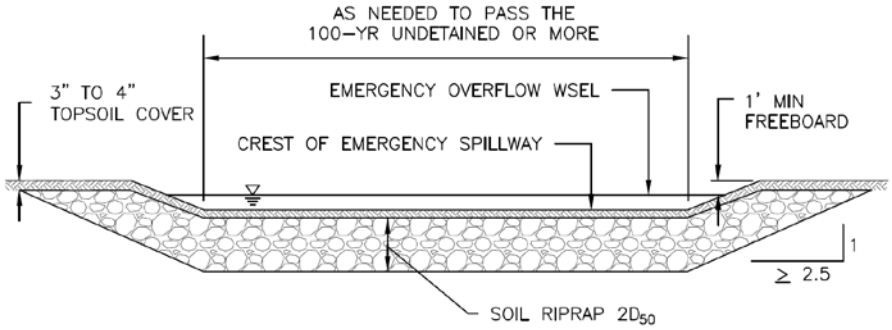
Highlighted

Depth (ft)	= 1.15
Q (cfs)	= 137.91
Area (sqft)	= 16.79
Velocity (ft/s)	= 8.21
Wetted Perim (ft)	= 19.48
Crit Depth, Yc (ft)	= 1.48
Top Width (ft)	= 19.20
EGL (ft)	= 2.20





EMERGENCY SPILLWAY PROFILE



EMERGENCY SPILLWAY SECTION AND SPILLWAY CHANNEL

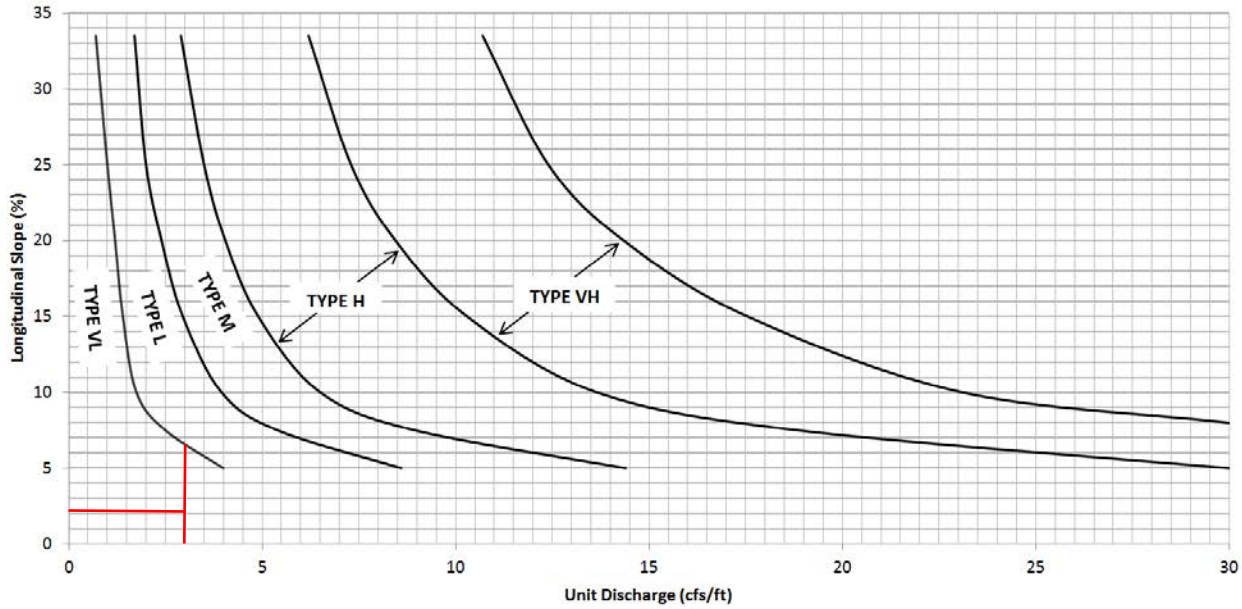


Figure 12-21. Embankment protection details and rock sizing chart (adapted from Arapahoe County)

APPENDIX D

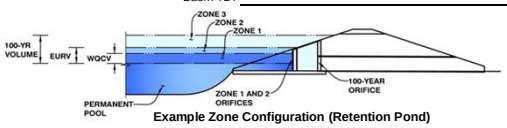
WATER QUALITY AND DETENTION CALCULATIONS

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)

Project: Cornerstone Estates

Basin ID:



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB	
Watershed Area =	202.13	acres
Watershed Length =	5,290	ft
Watershed Length to Centroid =	2,825	ft
Watershed Slope =	0.035	ft/ft
Watershed Imperviousness =	7.10%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	User Input	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

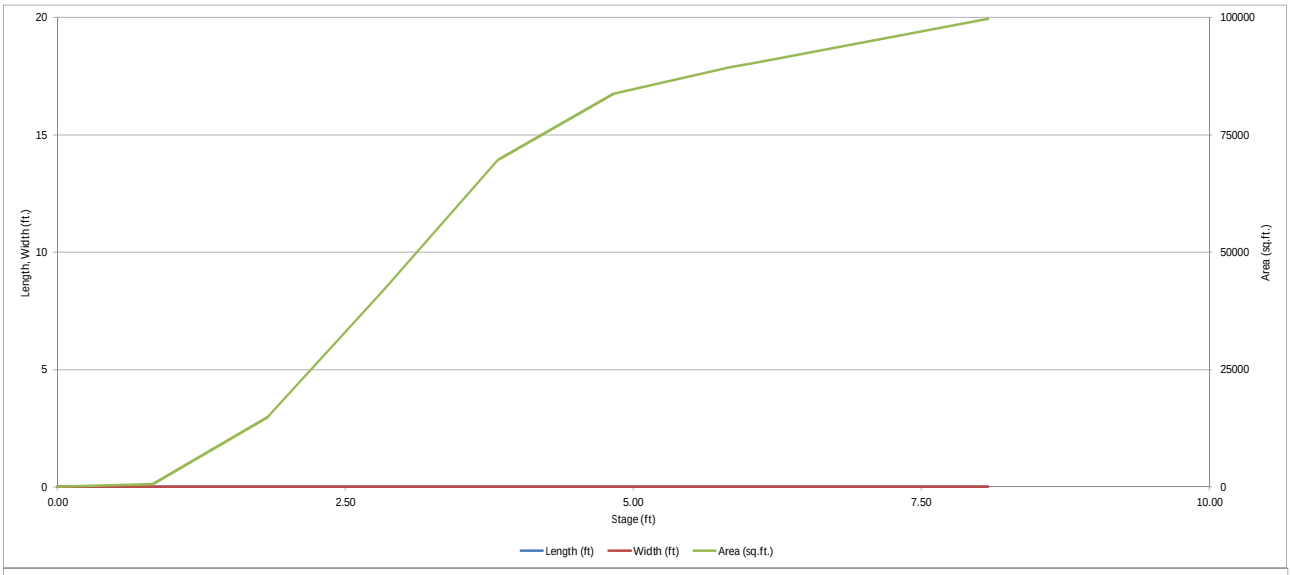
			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.837	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	1.312	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.93 in.) =	0.661	acre-feet	0.93	inches
5-yr Runoff Volume (P1 = 1.21 in.) =	2.036	acre-feet	1.21	inches
10-yr Runoff Volume (P1 = 1.46 in.) =	4.554	acre-feet	1.46	inches
25-yr Runoff Volume (P1 = 1.84 in.) =	12.039	acre-feet	1.84	inches
50-yr Runoff Volume (P1 = 2.16 in.) =	16.957	acre-feet	2.16	inches
100-yr Runoff Volume (P1 = 2.5 in.) =	23.798	acre-feet	2.50	inches
500-yr Runoff Volume (P1 = 3.39 in.) =	38.739	acre-feet	3.39	inches
Approximate 2-yr Detention Volume =	0.634	acre-feet		
Approximate 5-yr Detention Volume =	1.053	acre-feet		
Approximate 10-yr Detention Volume =	2.664	acre-feet		
Approximate 25-yr Detention Volume =	4.314	acre-feet		
Approximate 50-yr Detention Volume =	4.653	acre-feet		
Approximate 100-yr Detention Volume =	6.329	acre-feet		

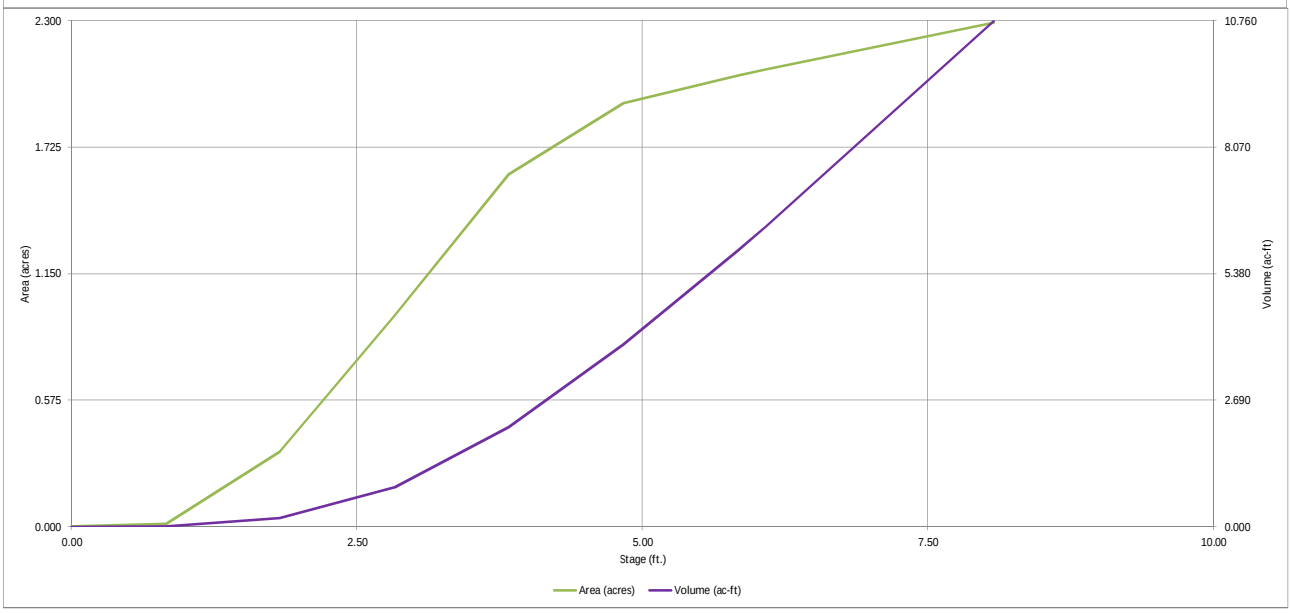
Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.837	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.475	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	5.016	acre-feet
Total Detention Basin Volume =	6.329	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	user	acre-feet

Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	10	0.000		
7279	--	0.83	--	--	--	585	0.013	247	0.006
7280	--	1.83	--	--	--	14,942	0.343	8,011	0.184
7281	--	2.83	--	--	--	41,727	0.958	36,345	0.834
7282	--	3.83	--	--	--	69,727	1.601	92,072	2.114
7283	--	4.83	--	--	--	83,768	1.923	168,820	3.876
7284	--	5.83	--	--	--	89,307	2.050	255,357	5.862
7284.25	--	6.08	--	--	--	90,457	2.077	277,828	6.378
7286.25	--	8.08	--	--	--	99,776	2.291	468,061	10.745


20
15
10
5
0
Length, Width (ft.)
100000
75000
50000
25000
0
Area (sq.ft.)
0.00
2.50
5.00
7.50
10.00
Stage (ft)
Length (ft)
Width (ft)
Area (sq.ft.)

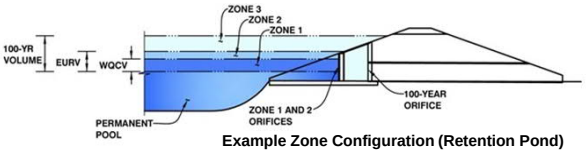

2.300
1.725
1.150
0.575
0.000
Area (acres)
10.760
8.070
5.380
2.690
0.000
Volume (ac-ft)
0.00
2.50
5.00
7.50
10.00
Stage (ft.)
Area (acres)
Volume (ac-ft)

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)

Project: Cornerstone Estates

Basin ID:



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.84	0.837	Orifice Plate
Zone 2 (EURV)	3.27	0.475	Orifice Plate
Zone 3 (100-year)	6.06	5.016	Weir&Pipe (Rect.)
Total (all zones)		6.329	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)	Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Diameter =	N/A	inches	Underdrain Orifice Centroid =	N/A	feet

Calculated Parameters for Underdrain

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row =	2.069E-02	ft^2
Depth at top of Zone using Orifice Plate =	3.44	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width =	N/A	feet
Orifice Plate: Orifice Vertical Spacing =	13.80	inches	Elliptical Slot Centroid =	N/A	feet
Orifice Plate: Orifice Area per Row =	2.98	sq. inches (diameter = 1-15/16 inches)	Elliptical Slot Area =	N/A	ft^2

Calculated Parameters for Plate

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.15	2.29					
Orifice Area (sq. inches)	2.98	2.98	2.98					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Not Selected	Not Selected			Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area =	N/A	N/A	ft^2
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid =	N/A	N/A	feet
Vertical Orifice Diameter =	N/A	N/A	inches				

Calculated Parameters for Vertical Orifice

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe)

	Zone 3 Weir	Not Selected			Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.50	N/A	ft (relative to basin bottom at Stage = 0 ft)	Height of Grate Upper Edge, H_t =	3.50	N/A	feet
Overflow Weir Front Edge Length =	12.00	N/A	feet	Overflow Weir Slope Length =	12.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V	Grate Open Area / 100-yr Orifice Area =	5.57	N/A	
Horiz. Length of Weir Sides =	12.00	N/A	feet	Overflow Grate Open Area w/o Debris =	100.22	N/A	ft^2
Overflow Grate Type =	Type C Grate	N/A		Overflow Grate Open Area w/ Debris =	100.22	N/A	ft^2
Debris Clogging % =	0%	N/A	%				

Calculated Parameters for Overflow Weir

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Rectangular	Not Selected			Zone 3 Rectangular	Not Selected	
Depth to Invert of Outlet Pipe =	0.38	N/A	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area =	18.00	N/A	ft^2
Rectangular Orifice Width =	108.00	N/A	inches	Outlet Orifice Centroid =	1.00	N/A	feet
Rectangular Orifice Height =	24.00		inches	Half-Central Angle of Restrictor Plate on Pipe =	N/A	N/A	radians

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	6.08	ft (relative to basin bottom at Stage = 0 ft)	Spillway Design Flow Depth=	0.97	feet
Spillway Crest Length =	75.00	feet	Stage at Top of Freeboard =	8.05	feet
Spillway End Slopes =	4.00	H:V	Basin Area at Top of Freeboard =	2.29	acres
Freeboard above Max Water Surface =	1.00	feet	Basin Volume at Top of Freeboard =	10.68	acre-ft

Calculated Parameters for Spillway

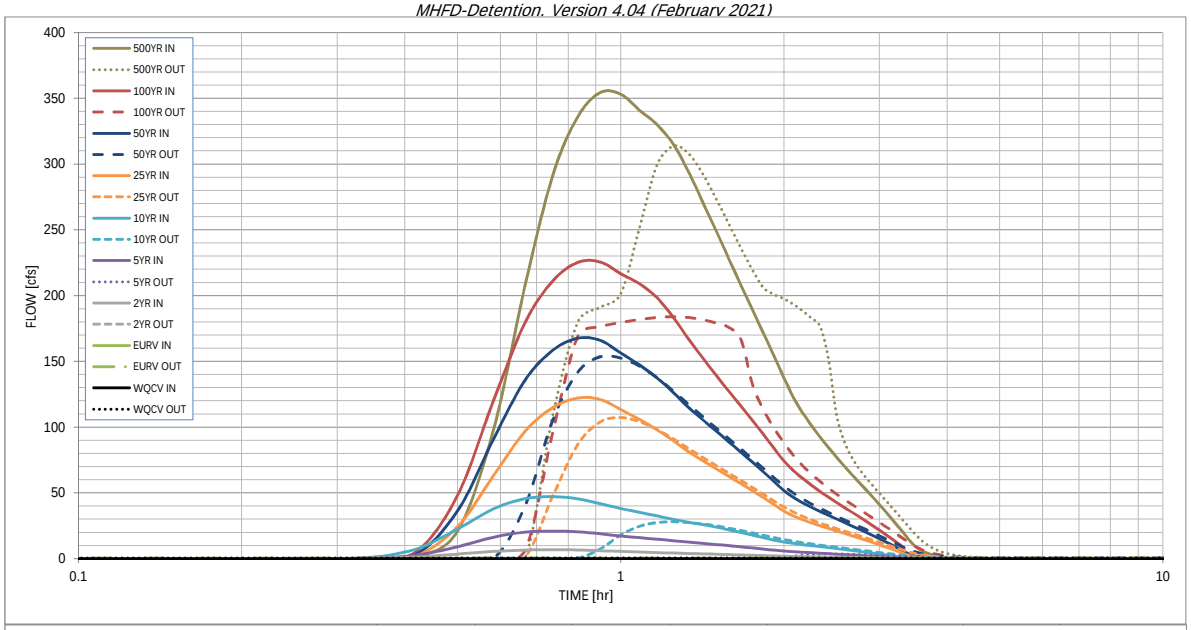
Routed Hydrograph Results

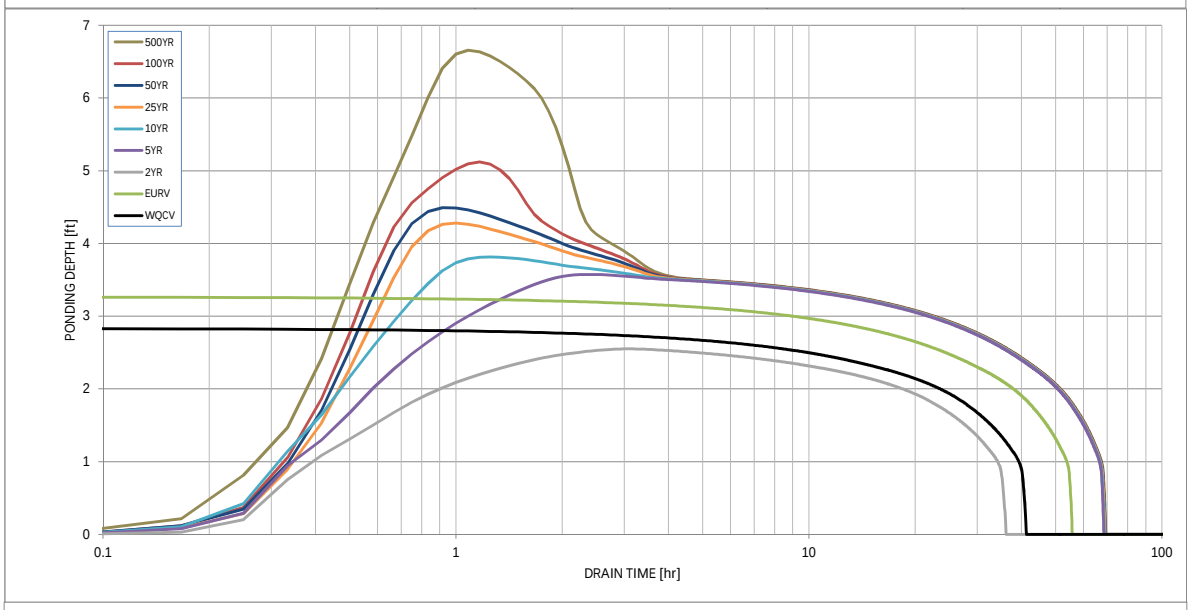
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

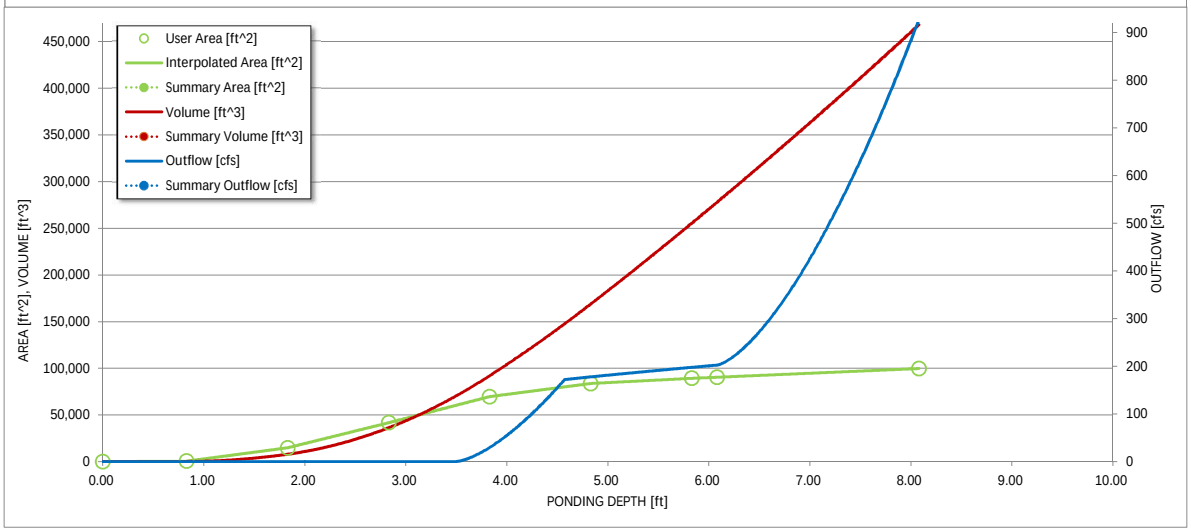
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.93	1.21	1.46	1.84	2.16	2.50	3.39
CUHP Runoff Volume (acre-ft) =	0.837	1.312	0.661	2.036	4.554	12.039	16.957	23.798	38.739
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.661	2.036	4.554	12.039	16.957	23.798	38.739
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	1.9	14.0	39.7	114.8	159.9	219.4	347.2
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.07	0.20	0.57	0.79	1.09	1.72
Peak Inflow Q (cfs) =	N/A	N/A	6.8	21.0	47.1	122.1	167.6	225.5	354.3
Peak Outflow Q (cfs) =	0.4	0.4	0.3	3.6	28.1	107.2	153.5	183.9	313.6
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.3	0.7	0.9	1.0	0.8	0.9
Structure Controlling Flow =	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	0.0	0.3	1.1	1.5	1.8	2.1
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	51	33	62	57	46	39	32	18
Time to Drain 99% of Inflow Volume (hours) =	40	54	35	66	64	59	56	52	45
Maximum Ponding Depth (ft) =	2.84	3.27	2.55	3.57	3.82	4.28	4.49	5.12	6.66
Area at Maximum Ponding Depth (acres) =	0.96	1.24	0.79	1.43	1.59	1.75	1.81	1.96	2.14
Maximum Volume Stored (acre-ft) =	0.844	1.318	0.590	1.719	2.082	2.867	3.240	4.439	7.579

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.04 (February 2021)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	0:15:00	0.00	0.00	0.02	0.05	0.07	0.05	0.08	0.07	0.16
	0:20:00	0.00	0.00	0.14	0.23	0.44	0.22	0.28	0.32	1.45
	0:25:00	0.00	0.00	1.24	2.43	6.84	1.84	2.77	4.52	20.84
	0:30:00	0.00	0.00	3.44	9.01	22.51	24.27	36.13	47.97	98.57
	0:35:00	0.00	0.00	5.47	16.31	37.94	63.39	91.30	120.62	208.05
	0:40:00	0.00	0.00	6.54	20.19	45.60	96.91	135.78	179.63	291.67
	0:45:00	0.00	0.00	6.80	20.97	47.12	114.82	158.43	211.23	335.85
	0:50:00	0.00	0.00	6.55	20.36	45.51	122.09	167.56	225.18	354.27
	0:55:00	0.00	0.00	5.99	18.90	41.84	120.98	165.96	225.54	353.11
	1:00:00	0.00	0.00	5.46	17.21	38.07	113.47	156.33	216.66	340.90
	1:05:00	0.00	0.00	5.03	15.96	35.20	105.79	147.21	208.88	329.96
	1:10:00	0.00	0.00	4.61	14.81	32.47	97.95	137.39	198.43	315.14
	1:15:00	0.00	0.00	4.21	13.64	29.90	89.63	126.35	183.48	294.27
	1:20:00	0.00	0.00	3.88	12.54	27.74	81.29	115.01	167.06	271.00
	1:25:00	0.00	0.00	3.60	11.62	25.86	74.48	105.63	152.68	249.03
	1:30:00	0.00	0.00	3.34	10.73	23.91	68.30	96.92	139.42	227.86
	1:35:00	0.00	0.00	3.09	9.85	21.92	62.51	88.71	127.13	207.89
	1:40:00	0.00	0.00	2.84	8.97	19.93	56.99	80.90	115.85	189.34
	1:45:00	0.00	0.00	2.59	8.10	17.96	51.65	73.37	104.97	171.48
	1:50:00	0.00	0.00	2.34	7.24	16.03	46.40	65.98	94.39	154.26
	1:55:00	0.00	0.00	2.09	6.40	14.12	41.21	58.71	84.09	137.57
	2:00:00	0.00	0.00	1.89	5.68	12.57	36.18	51.69	74.27	122.39
	2:05:00	0.00	0.00	1.74	5.21	11.54	32.41	46.54	66.83	110.68
	2:10:00	0.00	0.00	1.61	4.83	10.67	29.52	42.46	60.89	101.01
	2:15:00	0.00	0.00	1.49	4.46	9.87	27.11	38.96	55.70	92.37
	2:20:00	0.00	0.00	1.37	4.11	9.09	24.93	35.79	51.03	84.52
	2:25:00	0.00	0.00	1.26	3.77	8.34	22.97	32.90	46.74	77.27
	2:30:00	0.00	0.00	1.14	3.44	7.60	21.08	30.14	42.72	70.47
	2:35:00	0.00	0.00	1.04	3.11	6.88	19.25	27.49	38.96	64.14
	2:40:00	0.00	0.00	0.93	2.80	6.18	17.48	24.96	35.47	58.24
	2:45:00	0.00	0.00	0.83	2.50	5.49	15.73	22.46	32.01	52.48
	2:50:00	0.00	0.00	0.73	2.20	4.82	13.99	20.00	28.58	46.83
	2:55:00	0.00	0.00	0.63	1.90	4.15	12.26	17.54	25.16	41.21
	3:00:00	0.00	0.00	0.53	1.60	3.49	10.54	15.10	21.74	35.61
	3:05:00	0.00	0.00	0.43	1.31	2.84	8.81	12.66	18.32	30.01
	3:10:00	0.00	0.00	0.33	1.01	2.18	7.09	10.22	14.91	24.42
	3:15:00	0.00	0.00	0.24	0.72	1.53	5.37	7.79	11.50	18.86
	3:20:00	0.00	0.00	0.15	0.45	0.92	3.67	5.38	8.13	13.48
	3:25:00	0.00	0.00	0.10	0.25	0.54	2.13	3.25	5.14	9.02
	3:30:00	0.00	0.00	0.07	0.18	0.39	1.27	2.07	3.38	6.25
	3:35:00	0.00	0.00	0.06	0.14	0.30	0.77	1.36	2.25	4.38
	3:40:00	0.00	0.00	0.05	0.11	0.24	0.48	0.90	1.46	3.01
	3:45:00	0.00	0.00	0.04	0.08	0.19	0.29	0.58	0.90	2.01
	3:50:00	0.00	0.00	0.03	0.06	0.14	0.19	0.39	0.52	1.27
	3:55:00	0.00	0.00	0.03	0.05	0.11	0.11	0.25	0.26	0.75
	4:00:00	0.00	0.00	0.02	0.04	0.08	0.07	0.16	0.12	0.44
	4:05:00	0.00	0.00	0.02	0.03	0.05	0.05	0.12	0.09	0.31
	4:10:00	0.00	0.00	0.02	0.02	0.04	0.03	0.08	0.07	0.22
	4:15:00	0.00	0.00	0.01	0.02	0.03	0.02	0.06	0.06	0.18
	4:20:00	0.00	0.00	0.01	0.01	0.02	0.02	0.05	0.04	0.14
	4:25:00	0.00	0.00	0.01	0.01	0.01	0.01	0.04	0.03	0.10
	4:30:00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.07
	4:35:00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.05
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX E

REFERENCE MATERIALS

EXECUTIVE SUMMARY

Contract Authorization

The Bennett Ranch Drainage Basin Planning Study (DBPS) was authorized under terms of an agreement between El Paso County and Stormwater & Environmental Consultants Inc., A Division of Olsson Associates (SEC OA). This agreement was approved by the El Paso County Procurement and Contracts Department on August 17, 2000.

Agency Jurisdictions

The Bennett Ranch Basin is located within unincorporated El Paso County. The El Paso County Department of Transportation has responsibility for implementation of the approved DBPS. A list of agencies and individuals involved in the basin planning process is included in the Technical Appendices.

Scope and Purpose

El Paso County is experiencing rapid growth in areas that lack drainage basin planning studies. In an effort to produce basin drainage plans in an expedited manner, El Paso County contracted SEC OA to conduct a Pilot Project that establishes an accelerated planning process for rural basins. The Bennett Ranch drainage basin study was selected to implement the rural basin planning study approach.

The rural basin planning study approach differs from traditional planning studies in that only existing mapping is used (in this case 20-foot contour interval USGS mapping), concept-level design of alternatives is prepared, and budgetary opinions of improvement costs and drainage basin fees are developed. The objectives of the studies are to provide general guidance to land developers and the County until more detailed studies are completed by landowners. In addition, rural basin plans will not include the delineation of floodplains or wetlands, and will not identify and address detailed environmental issues. Finally, rural basin studies consider the Prudent Line approach as the preferred alternative whenever possible. The Prudent Line approach allows a creek to adjust through erosion and meandering to increased flows from development within a strip of land adjacent to the creek, defined by a "Prudent Line." The hydrology for rural basin planning studies is completed at the same level of detail as conventional DBPS's. Land developers can use the hydrology to delineate floodplains and design improvements based on the concept designs provided in this report.

Existing Conditions

The Bennett Ranch watershed is experiencing rapid development, and peak flows within the watershed are anticipated to increase significantly under future land use conditions. The upper third of the watershed contains a system of well-defined open channel segments with few hydraulic deficiencies. The exception is a set of failing culverts located at Meridian Road.

The middle third of the watershed contains undersized and discontinuous channel segments, undersized culverts and bridges, and all of the reported flood-related problems.

The lower third of the watershed contains continuous and adequately sized channels, one adequately sized bridge, and two undersized culvert crossings.

Hydrology

Estimated 100-year peak flows under current land use conditions is 680 cfs at Meridian Road, 1,420 cfs at Highway 24, and 1,670 cfs at Garrett Road. These flows are estimated to increase to 780 cfs, 1,820 cfs, and 2,210 cfs respectively under future land use conditions if no improvements are made within the basin.

Floodplains

Floodplains are not evaluated in this study. Land developers will be required to delineate floodplains using the hydrology in this report and more detailed mapping, and/or provide a CLOMR.

Approach and Alternatives

The hydrologic model HEC-1 was used to identify and evaluate Prudent Line applicability, system deficiencies, and project alternatives. Study Analysis indicates that the Prudent Line approach is only applicable for use in the upper third of the Bennett Ranch watershed (upstream from Eastonville Road). Over one-half of the evaluated open channel reaches are deficient (25,800 feet of open channel), and nine of the ten existing crossings are deficient (the existing Falcon Highway bridge meets design criteria).

Two alternatives were developed and evaluated. The first alternative upgrades all reaches and hydraulic structures to meet DCM design criteria and/or Prudent Line criteria without providing regional detention storage. The second alternative upgrades all reaches and hydraulic structures by incorporating regional detention upstream of Eastonville Road.

Recommended Alternative and Phasing

The regional detention alternative (second alternative) is the recommended alternative for the Bennett Ranch basin. This alternative is recommended over the first alternative for the following reasons:

- It reflects the detention scenario required by the Board of County Commissioners.
- It requires smaller upgraded structures, smaller cross-sectional area of new channel segments.
- It requires construction of fewer channel check structures.
- It requires less in-stream and riparian-zone construction and associated 404 permitting in the well-established, healthy riparian channels located in the lower 1/3 of the watershed.

The cost of the recommended alternative is estimated at $5.5 million and includes Prudent Line in the upper-most reaches of the watershed, detention ponds and associated transition channel upstream from Eastonville Road, and new channel between Eastonville Road and Drake Pond. It also replaces all nine of the undersized culverts located throughout the length of the drainage way and check structures along channel reaches located between Sunnyslope Drive and the

project outfall to maintain a stable channel slope. This alternative allows the existing bridge located at the Falcon Highway and a proposed new CDOT bridge crossing at Highway 24 to remain unchanged.

The following summarizes the recommended phasing of these improvements.

High Priority Improvements

The highest priority improvements are located in the middle of the watershed between Meridian Road and Drake Pond. These improvements include the detention ponds and associated transition channel located upstream of Eastonville Road and the new channel segments and box culverts located between Eastonville Road and Drake pond. The detention ponds and associated transition channel are considered high priority because of the rapidly developing basins upstream of Eastonville Road. Future condition peak flows from these developing basins need to be attenuated in order to minimize downstream impacts. The improvements between Eastonville Road and Drake Pond are considered high priority because there is an existing drainage system discontinuity in this location that causes flooding problems. Constructing these improvements will reduce peak flows and provide a continuous conveyance system through the project watershed. Replacing the failing culverts located at Meridian Road should also be a high priority because the erosion will soon undermine the roadway.

Medium Priority Improvements

Of secondary importance is the upgrading of culvert crossings located at Sunnyslope Drive and Garrett Road. The existing culverts located at these crossing are undersized and should be replaced to meet DCM design standards but are not considered a high priority because there are no reported flood-related problems at these crossings.

Low Priority Improvements

The following improvements upgrade system deficiencies to DCM standards but do not provide flood-reduction benefits and could therefore be constructed last: replacement of the Snowbrush Drive culvert, demolition of the existing berms located at the ponds just downstream from Snowbrush Drive, construction of the check structures along the existing channel located between Sunnyslope Drive and the project outfall, and purchasing of Prudent Line easement from Snowbrush Drive to Meridian Road.

Bennett Ranch Pilot Project
DRAFT Agency Contact List
Modified December 13, 2000

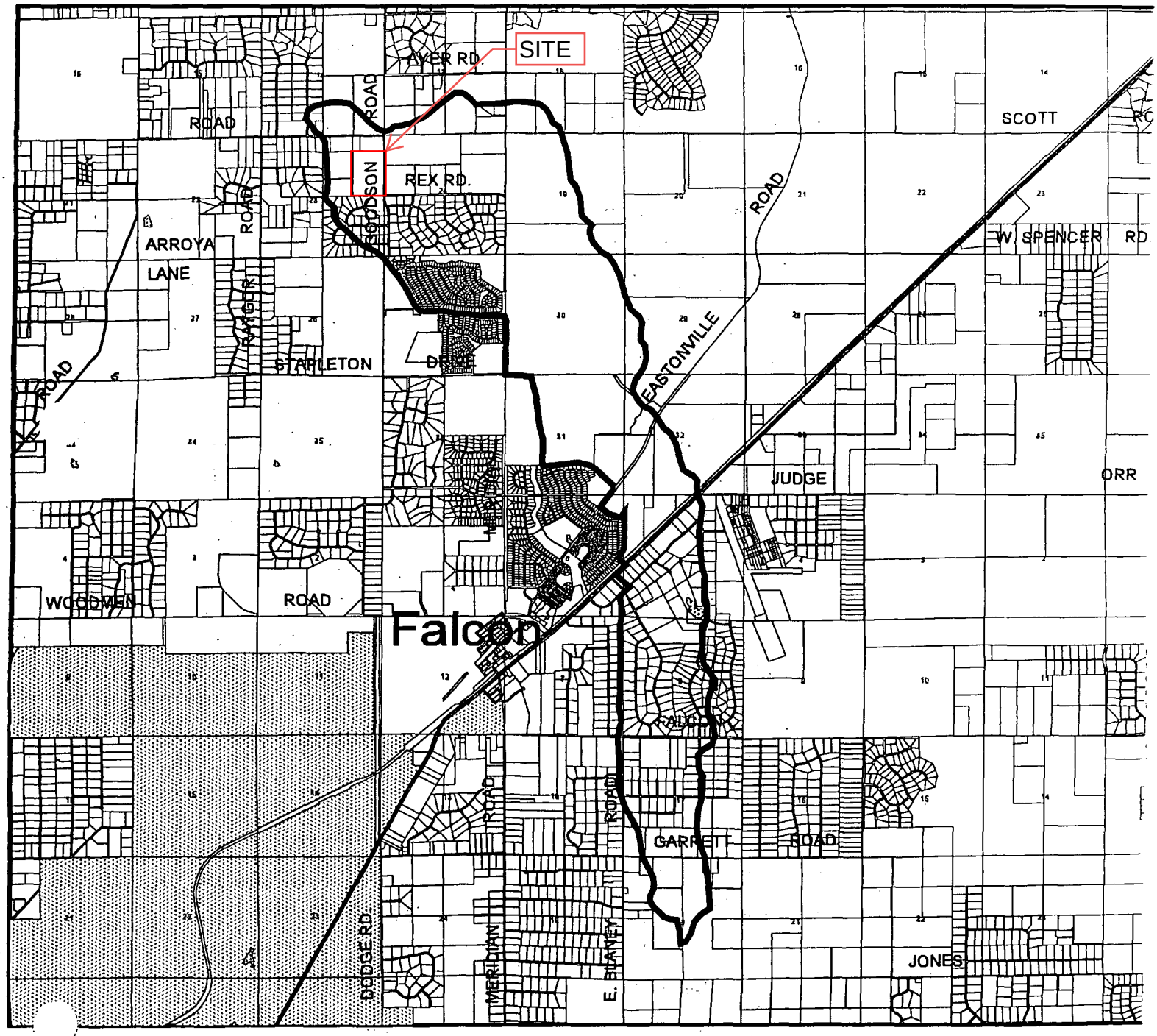
Agency	Contact	Address	Phone Number	Fax Number
US Army Corps of Engineers (USCOE)	Anita Culp	720 N. Main Rm 205 Pueblo, CO 801003-3046	719-543-6914	719-543-9475
Ecological Service US Fish and Wildlife Service (USFWS)	Bob McCue	PO Box 25486 Denver, CO 80225-0486	303-236-7400	
Colorado Division of Wildlife	Gary Dowller Dave Levell	2126 N. Weber Colorado Springs, CO 80907	719-227-5224	719-227-5297
Federal Emergency Management Agency (FEMA)	John Liou	Denver Federal Center Bldg 710 Box 25267 Denver, CO 80225-0267	303-235-4800	303-235-4849
Colorado Water Conservation Board	Larry Lang Bill Green	1313 Sherman Rm 721 Denver, CO 80203	303-866-3441 x320	
City of Colorado Springs	Bruce Thorson	101 W. Costilla St. Suite 113 Colorado Springs, CO 80901	719-385-5054	719-578-6161
Regional Floodplain Coordinator	Robert Lee Plese	101 W. Costilla St. Suite 113 Colorado Springs, CO 80901	719-385-5054	719-578-6161
National Resources Conservation Service (NRCS)	John Valentine	1826 E. Platte Ave. Suite 114 Colorado Springs, CO 80909	719-632-9598	719-473-7104
Colorado Department of Transportation (CDOT)	Paul Reinswa	16 E. Arvada St. Colorado Springs, CO 80906	719-634-2303	719-632-2172
El Paso County Planning	Mark Gebhardt	27 East Vermijo Colorado Springs, CO 80903	719-520-6300	
Colorado Geological Survey	Celia Greenman	1313 Sherman Street Room 715 Denver, CO 80203	303-866-2611	303-866-2461

Table 7-2 - Recommended Alternative Improvements

Location	Improvement	Priority	Estimated Cost	Contingen-cies at 25%	Engineer-ing at 15%	Utilities at 5%	Total Estimated Cost	Basin Fee Eligible Cost	Bridge Fee Eligible Cost	Public Cost
Snowbrush Drive to Meridian Road	• Purchase easements to secure approximately 7,350 ft of Prudent Line setback of 130 ft from channel centerline.	Low	110000	27500	16500	5500	159500	159500	0	0
	• Remove berms at ponds located downstream from Snowbrush Drive.	Low	2200	550	330	110	3190	3190	0	0
	• Replace existing 54 inch-diameter CMP at Snowbrush with 7' (W) x 5' (H) x 50' (L) box culvert.	Low	49000	12250	7350	2450	71050	71050	0	0
	• Replace existing triple 48 inch-diameter RCP at Meridian Road with a 30' (W) x 7' (H) x 50' (L) box culvert.	High	210000	52500	31500	10500	304500	0	304500	0
	• Place erosion protection at the downstream end of the new box culvert.	High	16280	4070	2442	814	23606	23606	0	0
Meridian Road to Highway 24	• Construct 7,200 feet of new channel with 31 check structures.	High	795000	198750	119250	39750	1152750	1152750	0	0
	• Construct four ponds with combined detention storage of ~90 ac-ft and one pond with ~50 ac-ft of storage.	High	1868000	467000	280200	93400	2708600	2708600	0	0
	• Construct a new 30' (W) x 7' (H) x 60' (L) box culvert and associated road grade at Eastonville Road.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace the existing twin 36 inch-diameter CMP at Orr Road with a 30' (W) x 7' (H) x 60' (L) box culvert and associated road grade.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace existing 13' (W) x 3' (H) box culvert at old rail line with a 30' (W) x 7' (H) x 60' (L) box culvert.	High	252000	63000	37800	12600	365400	0	0	365400
Highway 24 to 1400 ft downstream of Sunny Slope Drive	• Construct 4,200 feet of new channel with 15 check structures.	High	448330	112083	67250	22417	650079	0	0	650079
	• Replace existing 36" CMP at Blue Gill Drive with a 30' (W) x 7' (H) x 60' (L) box culvert.	High	252000	63000	37800	12600	365400	0	0	365400
	• Replace 30" cmp at Sunny Slope Drive with 30' (W) x 7' (H) x 60' (L) box culvert.	Medium	252000	63000	37800	12600	365400	0	0	365400
	• Construct approximately 3 check structures downstream of Sunny Slope Drive to maintain a maximum channel slope of 0.7%.	Low	15000	3750	2250	750	21750	0	0	21750
	• Upgrade existing minor drainage systems (roadside swales) to route flows to the major drainage system.	Low	360000	90000	54000	18000	522000	0	0	522000
1400 ft downstream of Sunny Slope Drive to project outfall	• Replace existing 48" cmp at Garrett Road with a 30' (W) x 7' (H) x 60' (L) box culvert.	Medium	252000	63000	37800	12600	365400	0	0	365400
	• Construct approximately 12 check structures to maintain a maximum channel slope of 0.7%.	Low	60000	15000	9000	3000	87000	87000	0	0
	Subtotal Cost =						7896425	4205696	304500	3386229
	Basin and Bridge Fee =							5932	429	

BENNET RANCH BASIN

File Name : MP-01-003



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-168-

APPENDIX F

DRAINAGE MAPS

CORNERSTONE ESTATES

EL PASO COUNTY, COLORADO SPRINGS, COLORADO

EXISTING DRAINAGE MAP

LAYER LINETYPE LEGEND

	EXISTING	PROPOSED
BOUNDARY LINE		
PROPERTY LINE		
EASEMENT LINE		
RIGHT OF WAY		
CENTERLINE		
STORM SEWER		
SWALE/WATERWAY FLOWLINE		
INDEX CONTOUR	6100	6100
INTERMEDIATE CONTOUR		
CURB & GUTTER		
SUB-BASIN DRAINAGE AREA		

BASIN TAG — BASIN ID: A; AREA [AC]: 2.35

DESIGN POINT DESIGNATION: 1

FLOW DIRECTION (PROPOSED)

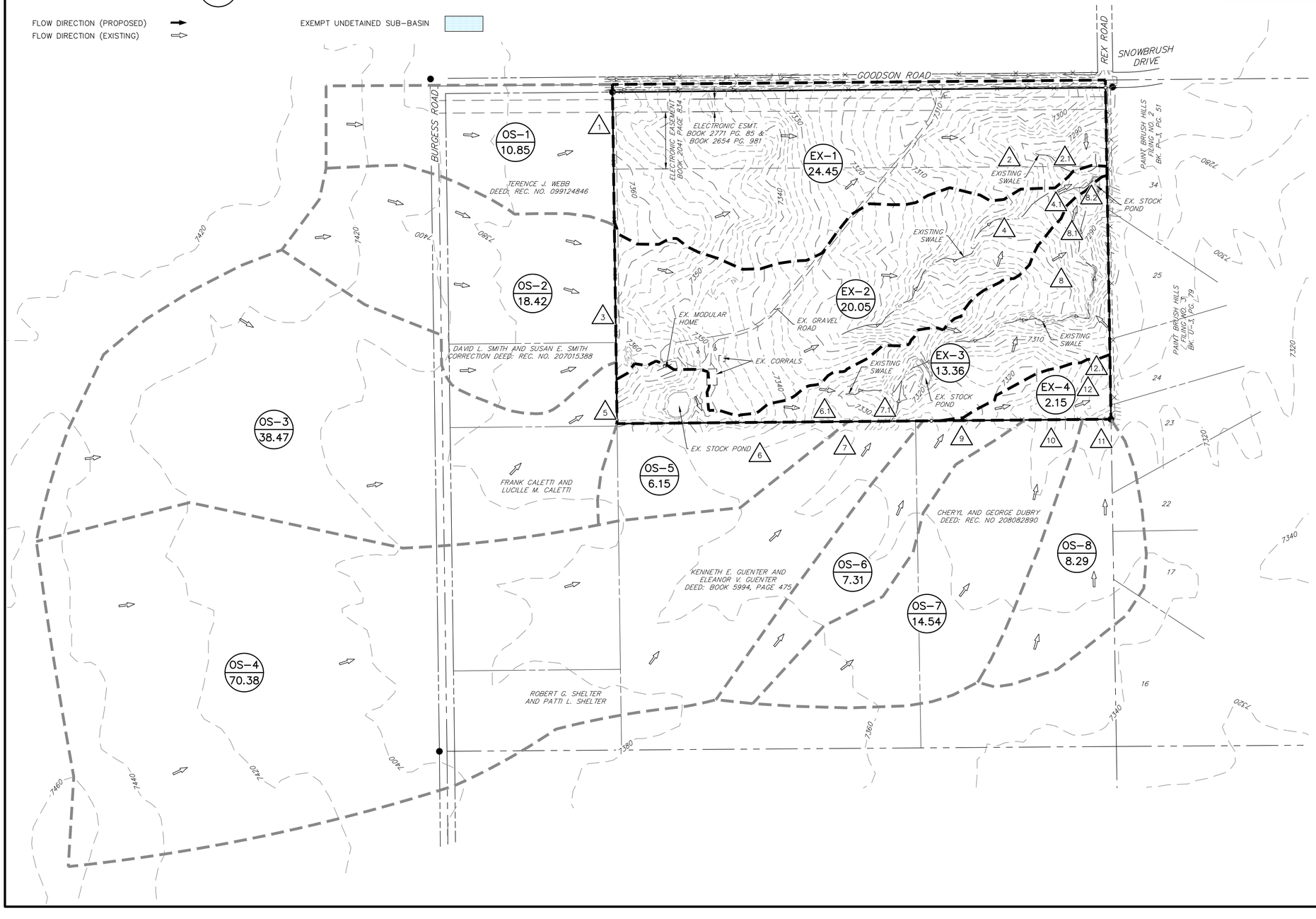
FLOW DIRECTION (EXISTING)

EXEMPT UNDETAINED SUB-BASIN

BASIN SUMMARY TABLE

Tributary Sub-basin	Area (acres)	Percent Impervious	C_5	C_{100}	t_c (min)	Q_5 (cfs)	Q_{100} (cfs)
EX-1	24.45	3%	0.10	0.37	23.1	7.28	43.30
EX-2	20.05	2%	0.09	0.36	22.7	5.48	35.13
EX-3	13.36	0%	0.08	0.35	31.9	2.65	18.88
EX-4	2.15	0%	0.08	0.35	10.8	0.69	5.06
OS-1	10.85	8%	0.14	0.40	50.0	2	16
OS-2	18.42	5%	0.12	0.38	50.0	3	27
OS-3	38.47	6%	0.13	0.39	55.0	6	50
OS-4	70.38	4%	0.11	0.37	55.0	8	76
OS-5	6.15	0%	0.08	0.35	50.0	1	8
OS-6	7.31	0%	0.08	0.35	50.0	1	7
OS-7	14.54	1%	0.09	0.36	50.0	3	21
OS-8	8.29	4%	0.11	0.37	50.0	3	14

Values in RED indicate they were from the CUHP method.



DESIGN POINT SUMMARY TABLE

DP#	Q_5	Q_{100}
1	2	16
2	7.27	43.29
2.1	6.34	41.83
3	3	27
4	5.48	35.14
4.1	6.24	47.77
5	6	50
6	1	8
6.1	6.92	58.00
7	8	76
7.1	14.92	129.16
8	2.65	18.89
8.1	16.66	141.58
8.2	28.19	223.70
9	1	7
10	3	21
11	3	14
12	0.68	5.05
12.1	7.29	39.97

Values in RED indicate they were from the CUHP method.

200 100 0 200 400

ORIGINAL SCALE: 1" = 200'

Know what's below. Call before you dig.

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PREPARED FOR
BILL GUMAN
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(719) 633-9700

J·R ENGINEERING
A Westrian Company
Centennial 303-740-9393 • Colorado Springs 719-593-2593
Fort Collins 970-491-9888 • www.jrengineering.com

No.	REVISION	BY	DATE

H-SCALE	1"=200'
V-SCALE	N/A
DATE	09/30/21
DESIGNED BY	GAG
DRAWN BY	GAG
CHECKED BY	

CORNERSTONE ESTATES

EXISTING DRAINAGE MAP

SHEET 1 OF 2

JOB NO. 25229.00

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CORNERSTONE ESTATES

EL PASO COUNTY, COLORADO SPRINGS, COLORADO

PROPOSED DRAINAGE MAP

LAYER LINETYPE LEGEND

	EXISTING	PROPOSED
BOUNDARY LINE		
PROPERTY LINE		
EASEMENT LINE		
RIGHT OF WAY		
CENTERLINE		
STORM SEWER		
SWALE/WATERWAY FLOWLINE		
INDEX CONTOUR	6100	6100
INTERMEDIATE CONTOUR		
CURB & GUTTER		
SUB-BASIN DRAINAGE AREA		

BASIN TAG — BASIN ID: A; AREA [AC]: 2.35

DESIGN POINT DESIGNATION: 1

FLOW DIRECTION (PROPOSED)

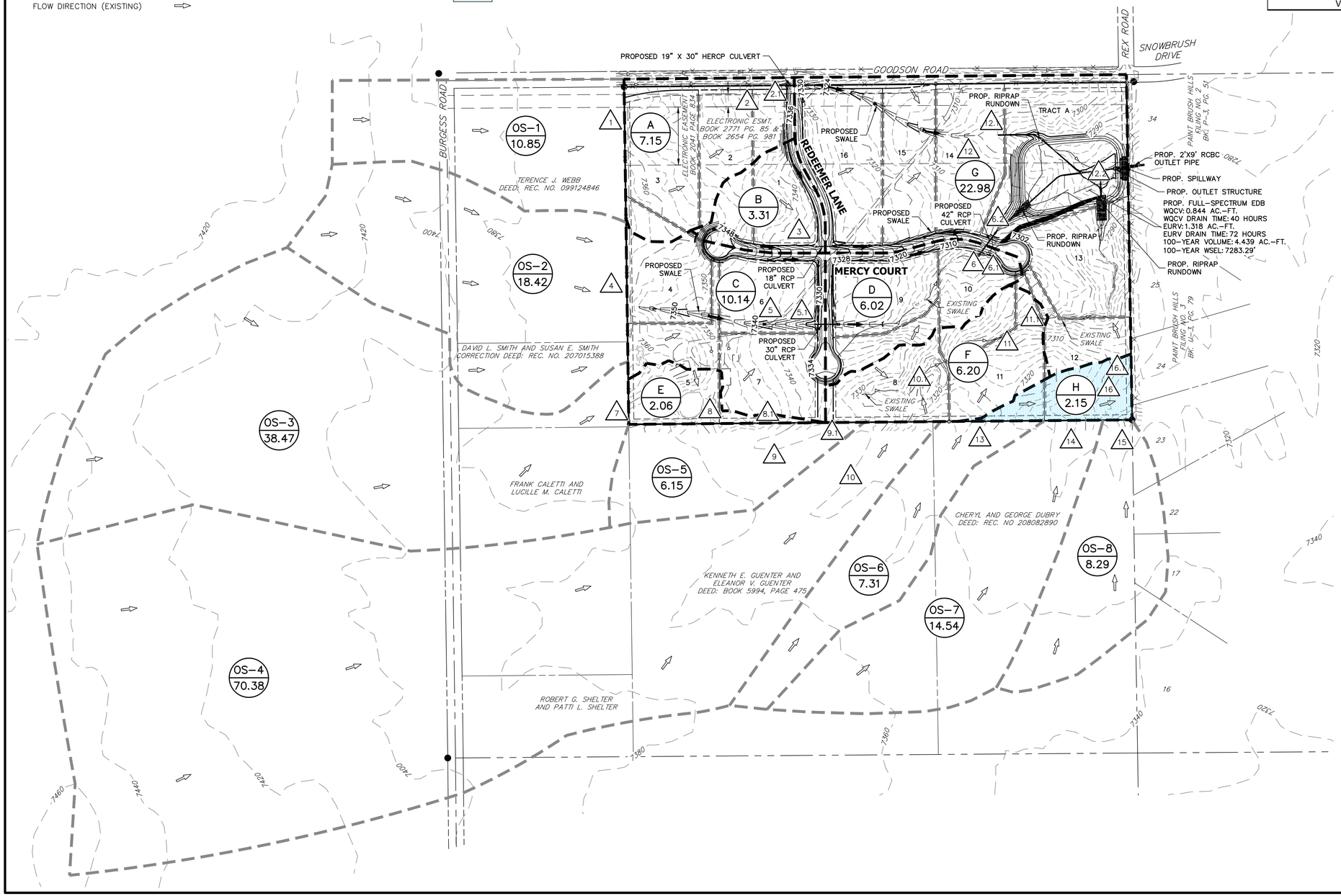
FLOW DIRECTION (EXISTING)

EXEMPT UNDETAINED SUB-BASIN

BASIN SUMMARY TABLE

Tributary Sub-basin	Area (acres)	Percent Impervious	C_5	C_{100}	t_c (min)	Q_5 (cfs)	Q_{100} (cfs)
A	7.15	11%	0.17	0.42	10.3	5.03	20.54
B	3.31	18%	0.23	0.46	6.0	3.66	12.47
C	10.14	13%	0.18	0.43	10.7	7.39	29.16
D	6.02	16%	0.21	0.45	8.2	5.68	20.10
E	2.06	8%	0.14	0.40	11.7	1.15	5.35
F	6.20	9%	0.15	0.40	16.2	3.21	14.33
G	22.98	12%	0.18	0.42	10.5	16.69	66.31
H	2.15	8%	0.14	0.40	12.4	1.18	5.46
OS-1	10.85	8%	0.14	0.40	50.0	2	16
OS-2	18.42	5%	0.12	0.38	50.0	3	27
OS-3	38.47	6%	0.13	0.39	55.0	6	50
OS-4	70.38	4%	0.11	0.37	55.0	8	76
OS-5	6.15	0%	0.08	0.35	50.0	1	8
OS-6	7.31	0%	0.08	0.35	50.0	1	7
OS-7	14.54	1%	0.09	0.36	50.0	3	21
OS-8	8.29	4%	0.11	0.37	50.0	3	14

Values in RED indicate they were from the CUHP method.



DESIGN POINT SUMMARY TABLE

DP#	Q_5	Q_{100}
1	2	16
2	5.02	20.56
2.1	4.11	24.63
3	3.67	12.48
4	3	27
5	7.41	29.19
5.1	6.16	39.43
6	5.66	20.13
6.1	8.35	47.22
6.2	9.64	51.60
7	6	50
8	1.13	5.37
8.1	6.46	52.36
9	1	8
9.1	7.37	60.36
10	8	76
10.1	15.37	131.32
11	3.20	14.31
11.1	16.85	137.91
12	16.69	66.31
12.1	11.18	52.68
12.2	35.93	233.48
13	1	7
14	3	21
15	3	14
16	1.18	5.49
16.1	7.53	40.26

Values in RED indicate they were from the CUHP method.

Suggested Driveway Culvert Size

Lot #	Culvert Size
1	18"
2	18"
3	18"
4	18"
5	18"
6	18"
7	18"
8	None
9	18"
10	18"
11	2x36"
12	2x36"
13	None
14	24"
15	24"
16	24"

Know what's **below.** **Call** before you dig.

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No.	REVISION	BY	DATE

H-SCALE	1"=200'
V-SCALE	N/A
DATE	10/05/21
DESIGNED BY	GAG
DRAWN BY	GAG
CHECKED BY	

CORNERSTONE ESTATES

PROPOSED DRAINAGE MAP

SHEET 2 OF 2

JOB NO. 25229.00

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