Phase I Drainage Report
for
Crowsnest
Douglas County, Colorado

Project Address: 6233 Crowfoot Valley Road
Parker, CO 80134

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Date: March 10, 2026

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Crowsnest

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Engineer's Certification Statement

"This report and plan for the Phase I drainage design of Crowsnest was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Castle Pines Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Castle Pines does not and will not assume liability for drainage facilities designed by others."

_____ _____

Kevin Lovelace, PE
Registered Professional Engineer
State of Colorado No. 54415

Date

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II. General Location & Description

A. Site Location

The property is comprised of sixteen parcels located generally southwest of the intersection of Crowfoot Valley Road & S Chambers Road, on either side of Crowfoot Valley Rd. The Site is situated within Sections 7, 8, 9, 17, 18, 19, Township 7 South, Range 66 West of the 6th Principal Meridian, Douglas County Colorado and Sections 24 & 25, Township 7 South, Range 67 West of the 6th Principal Meridian, Douglas County Colorado.

Located to the west of the project site are several private residences which are accessible via Lemon Gulch Drive. Located south of the project site is a Pinery West residential development as well as a couple private residences. Located to the east of the project site is an undeveloped Douglas County property to the southeast and a Town of Parker residential development to the northeast, named Trails at Crowfoot. Located northeast of the project site is another Town of Parker residential development, named Looking Glass. To the west of the Looking Glass development, along the northern boundary of the project site, is an undeveloped Town of Parker property.

The property subject to the Crowsnest PD Zoning is outlined in red on the vicinity map. However, the limits of this Phase I Drainage Report only pertain to the subject property outlined in blue. A separate Phase I Drainage Report will be provided for the remaining limits of the Crowsnest PD Zoning, outlined with a red line on the vicinity map, consisting of Crowfoot Valley Road generally extending from Macanta Boulevard northeast to Pradera Parkway. The submission and approval of the separate drainage report for the remaining limits will be made a condition of approval of the Crowsnest PD Zoning.

II.A.1 Vicinity Map

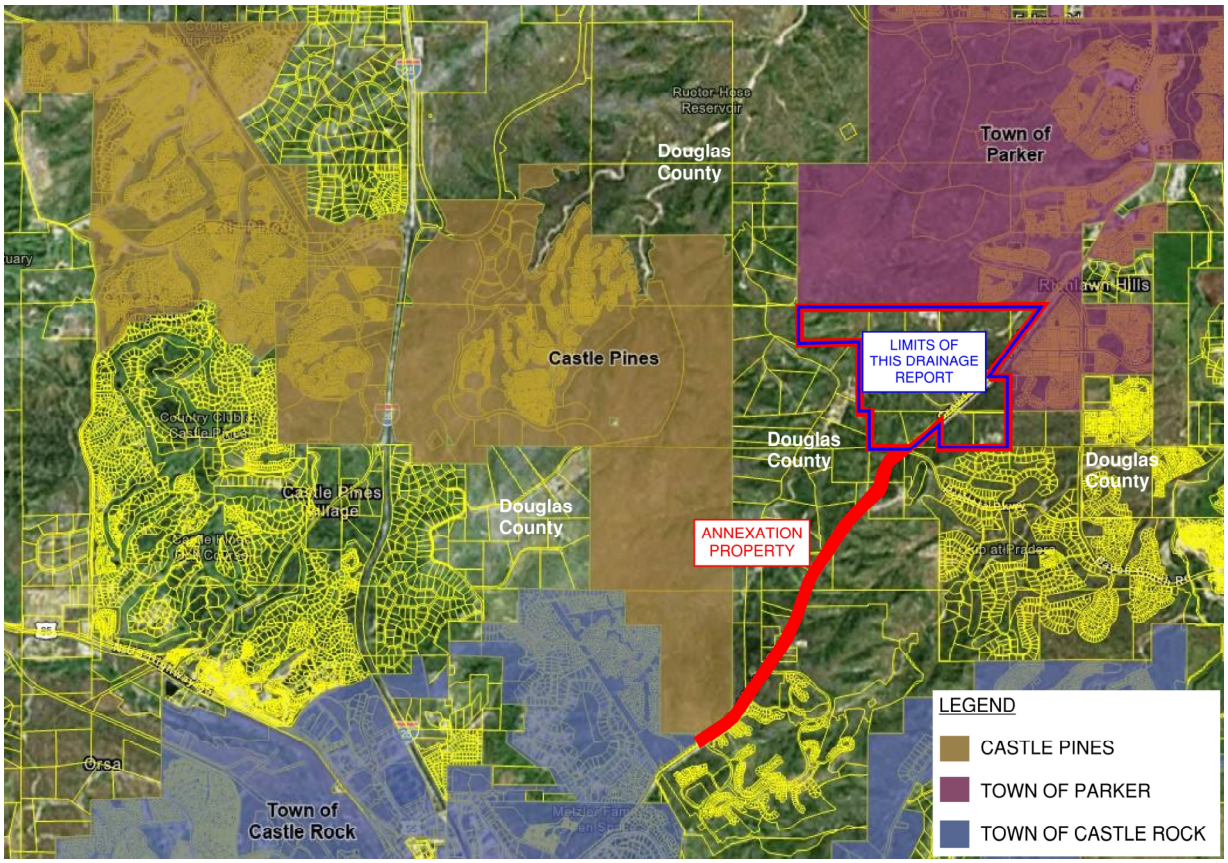


Figure 1 - Vicinity Map

B. Description of Property

As shown above in the vicinity map, the planned development for the site being studied in this report is contained within the Crowsnest Site; additionally, portions of Crowfoot Valley Road south of the development site are part of the project for the annexation process. The site is primarily undeveloped with sparse residences located intermittently throughout the area. The developed portion of the site is along the Crowfoot Valley Rd. The proposed project's land area is 794.506 acres.

The site is currently largely undeveloped with well established native vegetation covering the site and slopes between 2%-33% with the site generally draining inward and northeast towards Lemon Gulch, draining into Cherry Creek. There are sparsely located residences and structures in the project site; per the PD Set, two existing residential structures will remain and two existing residential structures will be removed with construction activities. Per NRCS Soils Survey Map, provided in Appendix C, the site consists of approximately 9% Type A Hydrologic Soil Group, 44% Type B Hydrologic Soil Group, and 45% Type C/D Hydrologic Soil Group. Additionally, 2% of clay pits was noted within the Site. Generally, the Type A soils are present along the Lemon Gulch Channel, north of the channel is primarily Type C and south of the channel is primarily Type B soils. A composite soil group approach is utilized for the design calculations; in some areas, 100% Type C/D soils were used for calculations as the most conservative estimate for flows.

The Lemon Gulch channel has an associated FEMA designated floodplain Zone A through the project site. The need for potential channel improvements along Lemon Gulch within the project site will be investigated before the final drainage report.

Lemon Gulch serves as the major drainageway for the project site, which drains from southwest to northeast through the project area. One minor drainageway tributary to Lemon Gulch (identified as Stream 303 in the OSP) was located draining from northwest to southeast into the Lemon Gulch major channel within the project site. The Lemon Gulch drainageway continues flowing northeast approximately 1.5 miles beyond the project site before outfalling into Cherry Creek.

Arapahoe Canal runs through the project site, but it has been treated as if it conveys no runoff in the drainage analysis. The Environmental Site Assessment found that a siphon beneath Lemon Gulch for this canal existed at one point. The siphon does not appear to be in operation based on aerial imagery and a site walk. Additional coordination with the appropriate canal entities will be made in conjunction with future site plan applications.

Presence of wetlands will be investigated prior the final drainage report.

Stock ponds on site will be removed with project construction.

No other significant geological features were identified in the site.

The development will be comprised of a variety of uses including residential, commercial, and open space. There are eight proposed planning areas for the project site, shown on the Proposed Drainage Map. All planning areas will be serviced by at least one full-spectrum detention facility. The following described land uses for the planning areas are conceptual at this time. Per the planning map, Planning Area Seven (PA-7) is a commercial development, Planning Area Eight (PA-8) is mixed use development and the others Planning Areas (PA1-PA6) are residential developments of varying density. Based on the usage, the planning areas were assigned the following imperviousness: PA7 uses 80% allowing for full commercial development as a conservative estimate, PA8 uses an imperviousness of 80%, and PA1-PA6 use an imperviousness of 65%. Improvements to Lemon Gulch are anticipated with the development due to steep banks and high velocities within the channel.

Open space areas reflected on the PD are approximate, and the impervious values assumed for the drainage basins shown in this report provide a conservative approach to stormwater planning at this time. Further refinement of site plans and composite imperviousness will be made at the time of the Phase II report submission(s).

III. Drainage Basins & Sub-Basins

A. Major Drainage Basins

The Lemon Gulch drainageway runs through the site, flowing from southwest to northeast. This drainageway serves as the main drainageway for the site with a majority of the area draining to this channel. As Lemon Gulch is a major drainageway, there is a large contributory area, approximately three times the project area, southwest and upstream of the project that drains inward to the gulch prior to entering the project site. Small portions of the site are routed east toward Cherry Creek, or north towards

another tributary of Lemon Gulch. Flows on the east side of Crowfoot Valley Rd. are routed northeast into an existing detention pond located north of the project site, the detention pond outlets directly to Lemon Gulch.

The *Scott and Lemon Gulch Watersheds Outfall Systems Planning Study* prepared by CH2MHill, dated July 2006, was investigated as the governing document on the project site, excerpts included in Appendix C. This study identifies existing and potential future problems with the existing drainageways. Stabilization and energy dissipation measures are suggested for multiple stream reaches within the project area to improve and prevent future issues; this is proposed in conjunction with the construction of regional detention facilities. Although it is now recognized that a more distributed stormwater management approach is currently desired by the local municipalities, in-lieu of regional facilities. Lemon Gulch is located within a FEMA floodplain and all proposed improvements will need to go through the CLOMR/LOMR process.

III.A.1 Existing Basins

The Site has been divided into 4 major existing basins:

Basin HA: Basin HA is located in the central area of the site and covers the area draining to Lemon Gulch within the project. In existing conditions, the basin is primarily open space land with spare residences located between open areas. Runoff drains inward toward the drainageway and then northeast within the Lemon Gulch channel. Lemon Gulch is tributary to Cherry Creek approximately 1.5 miles northeast of the project site. Offsite basins draining into Basin HA include, HOS1, HOS2, HOS5 through HOS12, HOS14, and HOS15.

Basin HB: Basin HB is located near the northeastern corner of the site, where an existing swale drains flows to the north into the Looking Glass Subdivision. In existing conditions, the basin is open space on the boundary of the site. Offsite Basin HOS13 sheet flows into this basin. Runoff drains north into the Looking Glass Subdivision where it is routed to a downstream detention facility. The detention facility outfalls to Lemon Gulch and ultimately Cherry Creek.

Basin HC: Basin HC is located on the southeastern side of Crowfoot Valley Rd., where runoff typically flows from southeast to northwest towards the Crowfoot Valley Rd. roadside ditch. In existing conditions, the basin is primarily open space with a couple residences and the Arapahoe Canal present. The Arapahoe Canal is treated as if it is conveying no flows within the drainage basin. This drainage basin drains into the roadside ditch along the southern side of Crowfoot Valley Rd. and flows northeast where it leaves the site and continues along the roadside ditch through the Trails at Crowfoot Subdivision before being routed into a detention facility located north of the project site. The detention facility outfalls to Lemon Gulch and ultimately Cherry Creek. Offsite Basins HOS3 and HOS4 drain into this basin.

Basin HD: Basin HD is located at the southeastern corner of the project site. In existing conditions, the basin is primarily open space with a portion of a residence within the basin. Runoff from this basin typically flows away from the high point in the northwest of the basin, towards the south, southeast, and east in existing conditions, where it leaves the project site and enters the Pinery Subdivision located south of the site or open space to the east. The flows are expected to be routed east away from the project site before being routed north into Cherry Creek via existing drainageways.

Off-Site Basins: Basins beyond the project site limits that were found to be draining into the project site are identified on the drainage maps. In existing conditions, all off-site basin flows are accepted and routed through the subsequent site basin. Impacts on off-site basins flow patterns under developed conditions will be discussed in the Minor Drainage Basins section.

III.A.2 Proposed Basins

The proposed basins were designed to maintain historic drainage patterns and similar drainage areas to the existing conditions.

Basin A: In proposed conditions, Basin A will contain a variety of land uses including residential, commercial, and open space. All minor basins for Basin A drain to proposed detention facilities before outletting into Lemon Gulch. Offsite basins draining into Basin A include: OS1 through OS5, HOS6, HOS13, HOS14, and HOS15.

Basin B: Historic Basin HB has been eliminated by routing it into the project site, in proposed conditions the flows will be captured within Basin A and there is no proposed Basin B.

Basin C: In proposed conditions, Basin C will contain a variety of land uses including residential, commercial, and open space; located southeast of Crowfoot Valley Rd. Basin C drains to a proposed detention facility that outlets to the roadside ditch on the southern side of Crowfoot Valley Rd., matching historic drainage patterns. Flows released from the detention facility into this existing roadside ditch will be released at rates below historic conditions (typically 90% of the predevelopment flow rate) to preserve historic drainage patterns. Capacity of downstream structures will be analyzed and the best path for the drainage will be determined as designs progress. In the event the downstream capacity of the existing roadside ditch or storm structures is inadequate, flows can be conveyed to the northwest side of Crowfoot Valley Road before being routed to Lemon Gulch; Lemon Gulch is the outfall regardless of whether flows are conveyed along the existing southern roadside ditch or north through the project site. Offsite basins draining into Basin C include Basins HOS3 and HOS4.

Basin D: In proposed conditions, Basin D will be developed with a portion of Planning Area 1, which is focused on residential development. Basin D drains to a proposed detention facility within the basin and outlets to the southeast along historic drainage patterns. No offsite basins drain into Basin D.

Off-Site Basins: Basins draining into the project area will be properly collected, managed, and/or rerouted within the project area in developed conditions, based on the local situation and maintaining historic drainage patterns. Detailed design for the off-site drainage will be provided in subsequent drainage reports as the project design progresses. Discussion of basins accepting off-site flows for the developed site condition is provided in the Proposed Minor Basins section; anticipated measures are being stated below but may be changed as design progresses.

B. Minor Drainage Basins

III.B.1 Existing Minor Basins

The minor basin conditions have been previously outlined in the Major Existing Basins section above. Minor Basins HA1 through HA9 are similar throughout with all of them draining inward to Lemon Gulch. Basins HB1, HC1, and HD1 did not contain minor basins, just a singular major basin for the drainage area.

III.B.2 Proposed Minor Basins

Basin A1: Basin A1 is located in the northeast corner of the project site and contains proposed development for Planning Areas 4 and 5 which focuses on residential development. Basin A1 generally drains from northwest to southeast, towards Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A1 receives off-site flows from Basin HOS13 to the north of the project site. Under developed conditions, flows from this off-site basin will likely be captured by a swale and routed to the storm drainage system for Basin A1. Developed Basin A1 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A2: Basin A2 is located in the northern center of the project site and contains proposed development for Planning Areas 4 and 5 which focuses on residential development. Basin A2 generally drains from north to south, towards Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A2 receives off-site flows from Basin OS5 along the northern boundary of the basin. Under developed conditions, flow from these off-site basins will likely be captured in swales and routed around the proposed development. Developed Basin A2 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A3: Basin A3 is located to the northwest of the site, adjacent to the Lemon Gulch channel, and contains proposed development for Planning Areas 4 and 5 which focuses on residential development. Basin A3 generally drains from west to southeast, towards Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A3 receives off-site flows from Basin OS2 to the west. Under developed conditions, flow from this off-site basin will likely be captured by a swale and routed to the storm drainage system for Basin A3. Developed Basin A3 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A4: Basin A4 is located in the northwest corner of the site, west of Basins A2 and A3. Basin A4 contains proposed development for Planning Area 6 which focuses on residential development. Basin A4 generally drains from northwest to southeast, towards Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A4 receives off-site flows from Basins OS3 and OS4 from the southwest and the north of Basin A4, respectively. Under developed conditions, flow from these off-site basins will likely be captured in swales and routed around the proposed development. Developed Basin A4 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A5: Basin A5 is located in the northeast corner of the site, on the southeastern side of Lemon Gulch. Basin A5 contains proposed development for Planning Areas 7 and 8, which focus on mixed-use and commercial development. Basin A5 generally drains from southwest to northeast, before being outlet to Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a mixed-use development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A5 does not receive any off-site flows. Developed Basin A5 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A6: Basin A6 is located in the center of the site, on the southeastern side of Lemon Gulch. Basin A6 contains proposed development for Planning Areas 2, 3 and 7; 2 and 3 focus on residential development while 7 focuses on commercial development. Basin A6 generally drains from southwest to northeast, before being outlet to Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a mixed-use development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A6 receives off-site flows from Basin OS1 from the southwest along the Crowfoot Valley Rd swale, noted by DP OS1 in the proposed drainage map. Basin A6 also receives off-site flows from Basin HOS14 and HOS15 via a culvert crossing under Crowfoot Valley Road, noted by DP OS15 in the proposed drainage map. Under developed conditions, flow from this off-site basin will likely be captured in the roadside swale and routed around the proposed development. Developed Basin A5 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A7: Basin A7 is located in the center of the site, on the southeastern side of Lemon Gulch and southwest of Basin A6. Basin A7 contains proposed development for Planning Areas 2 and 3 which focuses on residential development. Basin A7 generally drains from south to north, before being outlet to Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A7 does not receive any off-site flows. Developed Basin A7 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin A8: Basin A8 is located on the western boundary of the project site, on the southern side of Lemon Gluch and west of basin A7. Basin A8 contains proposed development for Planning Area 2 which focuses on residential development. Basin A8 generally drains from south to north, before being outlet to Lemon Gulch, and is anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets. Basin A8 receives off-site flows from Basin HOS6 from the western boundary of Basin A8. Under developed conditions, flow from this off-site basin will likely be captured by a swale and routed to the storm drainage system for Basin A8.

Basin A9: Basin A9 is located in the center of the site, along the Lemon Gulch drainageway. In developed conditions, the area will remain for the drainageway with improvements to the stability of the channel. This area was not treated as a typical drainage basin and no treatment is being provided for this area.

Basin C1: Basin C1 is located southeast of Crowfoot Valley Rd, near the southeastern corner of the site. Basin C1 contains proposed development for Planning Area 1 which focuses on residential development. Basin C1 generally drains from southwest to northeast, which outfalls into an existing roadside swale along Crowfoot Valley Rd. Drainage flows within this basin are anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels)

to route flows to roadway and area inlets. Basin C1 receives offsite flows from basins HOS3 and HOS4, located east and south of the Basin C1 respectively. Additionally, offsite basins HOS14 and HOS15 primarily flows into Basin A6 via a culvert crossing, but in situations where the peak flow exceeds the culvert capacity, flow would continue in the roadside swale and enter Basin C1. Under developed conditions, flow from these off-site basins will likely be captured in swales and routed around the proposed development. Developed Basin C1 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns.

Basin D1: Basin D1 is located in the southeast corner of the site, adjacent to basin C1. Basin D1 contains proposed development for Planning Area 1 which focuses on residential development. Basin D1 generally drains away from the highpoint in the northwest corner of the basin, towards the south, southeast, and east, where it outfalls from the site. Basin D1 does not receive any off-site flows. Developed Basin D1 will include a water quality pond that will treat and detain flows to below predeveloped rates, maintaining historic drainage patterns. Developed conditions are anticipated to outfall the pond to the east and avoid any potential impacts to the adjacent residential neighborhood to the south. Drainage flows within this basin are anticipated to utilize typical storm conveyance elements for a residential development (including streets, storm sewer, swales, and channels) to route flows to roadway and area inlets.

IV. Existing Stormwater Conveyance or Storage Facilities

A. Existing Stormwater Conveyance Facilities

There are a few driveway connections to Crowfoot Valley Road within the site limits that have placed culvert crossings to enable flows to continue along the roadside ditches. Approximate locations of these culvert crossings are shown on the Existing Drainage Map. The size of these existing culverts within the project site are shown on the drainage maps in Appendix D. Given the large contributory areas to these culverts, they will likely be upsized and replaced in proposed conditions to meet municipal drainage criteria.

The major stormwater conveyance through the project site is the Lemon Gulch drainageway which conveys the flow from Basin HA. Potential improvements required to Lemon Gulch for the proposed project will be presented in the Phase II Drainage Report and finalized in the Phase III Drainage Report.

B. Existing Stormwater Storage Facilities

There are no existing stormwater storage facilities within the project site. However, directly adjacent to the south, along Crowfoot Valley Rd., is a detention facility for the Pinery Subdivision, shown on the existing drainage map. The outfall from the pond will enter the roadside ditch along the southern side of Crowfoot Valley Road before being routed north across the road via a culvert crossing. Flows will then drain through the project site towards Lemon Gulch.

Additionally, a large detention facility is located approximately 1,500 ft northeast of the project site and appears to serve the Looking Glass Subdivision as well as the Trails at Crowfoot Subdivision, and potentially other developments. Existing Basin HC, which is conveyed in the roadside ditch adjacent to Crowfoot Valley Rd. currently flows to this existing detention pond.

The proposed site will not contribute untreated flows to either of the adjacent existing stormwater storage facilities. No proposed improvements are anticipated to either storage facility as they are outside of the project area.

V. Proposed Stormwater Conveyance or Storage Facilities

A. Stormwater Conveyance Facilities

Crowsnest facilities will be designed per Douglas County Storm Drainage Design and Technical Criteria Manual. In proposed conditions, onsite runoff is anticipated to be conveyed through streets, swales, and grass-lined channels to roadway inlets and area inlet design points throughout the site. The proposed storm system is anticipated to be sized to convey the minor storm event without surcharging. Runoff in the 100-year storm event will be conveyed by a combination of street, swale, channel, and storm sewer for each basin to the full-spectrum detention ponds. The detention ponds will outlet directly to the existing drainageways located within the site, typically to the ultimate onsite drainageway of Lemon Gulch. In existing conditions, runoff drains towards the Lemon Gulch drainageway primarily via sheet flow across undeveloped land and natural swales across the project site. Overall, the direction of flow and drainage patterns are being preserved in the proposed design.

Off-site runoff will be conveyed into the site's drainage basin areas via sheet flow from adjacent undeveloped slopes and swales (natural and roadside), in both historic and proposed conditions. In proposed conditions the off-site flow will then be captured by the proposed surface conveyance or storm system for the project site. In existing conditions, off-site flows join with existing basin flows before typically outfalling to Lemon Gulch.

Conveyance structure design and adequate capacity calculations will be provided with a future Phase II/Phase III Drainage Report.

No anticipated conveyance problems have been identified at this level of study. Improvements to the existing stream channels are undetermined at this time and expected to be analyzed for needs with a future Phase II/Phase III Drainage Report.

All storm conveyance elements shall be accessible via manhole or surface access for any maintenance needs. Drainage easements shall be utilized to provide constant access and will be sized consistently with the requirements outlined in Chapter 9 of the Douglas County Storm Drainage Design and Technical Criteria Manual.

B. Stormwater Storage Facilities

Future water quality and detention for the site is proposed to be provided in ten (10) full-spectrum detention ponds. The proposed ponds are expected to be designed as Extended Detention Basins (EDBs). The detention ponds will be designed using the MHFD-Detention (current edition) spreadsheet and will be in accordance with the Douglas County Storm Drainage Design and Technical Criteria Manual. The approximate locations of these ponds have been determined using the existing grading for the site, placed generally at the low points of each proposed drainage basin area. As designs progress, the location of these facilities may be moved to better fit the design needs. The outlet structures for these proposed extended detention basins will be designed based on the provided details in Volume 3 of the

MHFD Manual, in Chapter 4 – T-6 Extended Detention Basins. The outlet structure will be designed to convey the flow for storm events up to 100-year for the drainage basin, storm events that exceed the 100-year will utilize the emergency spillway.

Preliminary detention pond volume calculations have been provided in Appendix B. The below table provides the anticipated 100-year required volume for each proposed onsite basin.

Detention Pond Volume Table

Detention Pond Volume Table		
Basin ID	Pond	V_{100} (ac-ft)
A1	Pond 1	2.927
A2	Pond 2	14.167
A3	Pond 3	6.446
A4	Pond 4	9.362
A5	Pond 5	11.406
A6	Pond 6	11.539
A7	Pond 7	7.450
A8	Pond 8	4.878
A9	N/A	N/A
C1	Pond 9	12.442
D1	Pond 10	1.817

Ultimate facility locations, ID numbers, storage and discharge values will be further refined with subsequent applications. Adequate space for storage facilities is available; no issues related to stormwater storage are anticipated. Low Impact Development (LID) strategies will be utilized to reduce the storage volume requirements where applicable.

Operation and Maintenance Manuals will be prepared for each stormwater storage facility in subsequent applications.

VI. Water Quality Enhancement Best Management Practices

A. Non-Structural Best Management Practices

At this level of design, no specific non-structural Best Management Practices are currently being proposed to reduce the pollutant load on the 10 detention ponds previously discussed; as design progresses, additional opportunities to reduce the pollutant load will be reviewed. However, although no specific non-structural BMP are proposed, typical source controls and good housekeeping practices as required by the MS4 permit will also be utilized for the development. As the design progresses, any proposed non-structural Best Management Practices added to the design will be detailed in this drainage report.

B. Structural Best Management Practices

The ponds discussed in Section V.B. are anticipated to be designed in accordance with the Douglas County Storm Drainage Design and Technical Criteria Manual and the MHFD Storm Drainage Criteria

Manual Volumes 1, 2, and 3. The Detention Ponds will be designed to detain the Water Quality Control Volume, Excess Urban Runoff Volume, and the 100-year Detention Volume, restricted to 90% of existing flow in accordance with MHFD guidance. In the current level of design, all developed drainage basins are to be captured and fully treated by each corresponding pond facility. As design progresses, opportunities for LID development to reduce the required size of the corresponding ponds and lower the imperviousness of the drainage areas will be investigated; typical structural BMP/LID options that may be proposed include grass swales, grass buffers, or bioretention facilities.

At this time, it is beneficial to consider the pond as the singular treatment facility for each drainage basin to approximate the potential maximum size for the extended detention basin facility for each drainage area, prior to any upstream improvements. Upstream improvements may reduce the required pond size in future iterations.

As previously noted, Operation and Maintenance Manuals will be prepared for each stormwater storage facility in subsequent applications. Access paths will be provided for each pond facility to allow for maintenance activities.

VII. Floodplain Modification

A. Major Drainageway – Undesignated Floodplain

No undesignated floodplains were observed in the project vicinity.

B. Major Drainageway – Designated Floodplain

Modifications to the existing Lemon Gulch's floodplain are anticipated to be required to facilitate the site's development and stabilization of the existing creek system. There are anticipated to be at least two roadway crossings, locations unknown, of Lemon Gulch, with an unknown number of potential trail crossings to be determined in preliminary/final site design.

Lemon Gulch, which flows from southwest to northeast through the center of the proposed project site, is a designated floodplain Zone A, which provides the 100-year floodplain extents but does not include Base Flood Elevations (BFEs). The source of this floodplain information is the FEMA Flood Insurance Rate Maps.

Floodplain modifications are necessary for the development of the project site due to multiple reasons, including: the need to improve the channel stability along Lemon Gulch due to the presence of Type A soils, the need to tie pond outfalls into the drainage channel, and for proposed road and trail crossing the drainage channel and floodplain. In future drainage reports, the Lemon Gulch major drainageway will be investigated and analyzed for improvements outlined in MHFD's **Section 3.2.1 Major Drainageway Planning Studies** to identify existing issues and propose improvements to be enacted with this project site development.

CLOMR/LOMR applications are expected to be required at time of associated impacted improvements. Requirements for the CLOMR/LOMR process are provided by FEMA via the MT-2 application form.

Floodplain Development Regulations are outlined in the Douglas County Storm Drainage Design and Technical Criteria Manual, Section 5.2.6. This section refers to a Douglas County Zoning Resolution,

Section 18, Floodplain – Overlay District, which provides additional criteria for floodplain development. Additionally, a Floodplain Development Permit is required for any change of land use or proposed development within the floodplain, which is anticipated.

A proposed floodplain will be developed using design data and will result in all proposed structures and roadways being located outside or above the new proposed floodplain limits. This will be completed once the project design is set and the proposed floodplain can be modeled.

VIII. Additional Permitting Requirements

The project will be submitting a Jurisdictional Determination Request for Lemon Gulch and associated on-site tributary areas at a later date and the project will follow all applicable State and Federal WOTUS guidelines. The types of WOTUS and Wetland-related permits will be dependent upon future determination limits.

IX. References

- Douglas County Storm Drainage Design and Technical Criteria Manual
- Mile High Flood District Drainage Criteria Manual Volumes 1, 2, & 3, current version
- Natural Resources Conservation Service Web Soil Survey, United States Department of Agriculture
- Federal Emergency Management Agency Flood Insurance Rate Map, Community Panel Number 08035C0180G and 08035C0183G
- *Scott and Lemon Gulch Watersheds Outfall Systems Planning – Preliminary Design Report,* prepared by CH2M Hill, and Dated July 2006.
- *Floodplain Overlay District – Section 18*, Douglas County Zoning Resolution, dated 05/10/2016.

Appendix A. Hydrologic Calculations

A1 Runoff Coefficient Calculations

Crowsnest Phase I

Basin Weighted Runoff Coefficient Calculations

Land Use Is Comprised of following Surface Characteristics:						
NRCS Soil Group	C	Imperviousness	C_2	C_5	C_{10}	C_{100}
A	Asphalt/Concrete/Roofs	95%	0.78	0.81	0.83	0.87
B	Gravel Road	80%	0.64	0.69	0.72	0.81
C	Undisturbed	5%	0.02	0.08	0.17	0.50
D	Residential	65%	0.49	0.56	0.61	0.75
E	Commercial/Mixed Use	80%	0.64	0.69	0.72	0.81
F						
G						
H						
I						
J						
K						

Project No.: CO4080-0001

Date: ~~02/06/26~~

Basin ID	Total Area (Ac.)	A Area (Ac.)	B Area (Ac.)	C Area (Ac.)	D Area (Ac.)	E Area (Ac.)	F Area (Ac.)	G Area (Ac.)	H Area (Ac.)	I Area (Ac.)	J Area (Ac.)	K Area (Ac.)	Weighted Imp. I (%)	Weighted Runoff Coefficients C_2	C_5	C_{10}	C_{100}
Historic/Existing																	
HA1	49.15			49.15									5%	0.02	0.08	0.17	0.50
HA2	19.76	0.15	0.09	19.53									6%	0.03	0.08	0.18	0.51
HA3	16.68			16.68									5%	0.02	0.08	0.17	0.50
HA4	85.80			85.80									5%	0.02	0.08	0.17	0.50
HA5	54.47		1.23	53.24									7%	0.04	0.09	0.18	0.51
HA6	178.83	1.69	2.81	174.33									7%	0.04	0.09	0.18	0.51
HA7	91.69		0.56	91.14									5%	0.03	0.08	0.17	0.51
HA8	64.24	0.31	1.28	62.65									7%	0.04	0.09	0.18	0.51
HA9	57.02			57.02									5%	0.02	0.08	0.17	0.50
HB1	7.69			7.69									5%	0.02	0.08	0.17	0.50
HC1	108.07	7.11		100.96									11%	0.07	0.12	0.21	0.53
HD1	16.14	0.87		15.27									10%	0.06	0.12	0.20	0.52
Existing Imp.	**749.54**	**10.13**	**5.96**	**733.45**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7%**	**0.04**	**0.09**	**0.18**	**0.51**
Historic Off-Site																	
HOS1	2.22	0.90	0.01	1.31									42%	0.33	0.38	0.44	0.66
HOS2	2.35	0.88		1.47									39%	0.31	0.35	0.42	0.64
HOS3	6.26			6.26									5%	0.02	0.08	0.17	0.50
HOS4	13.34	0.64		12.70									9%	0.06	0.11	0.20	0.52
HOS5	35.15	3.75		31.41									15%	0.10	0.15	0.24	0.54
HOS6	5.48			5.48									5%	0.02	0.08	0.17	0.50
HOS7	12.75			12.75									5%	0.02	0.08	0.17	0.50
HOS8	8.36	0.13		8.24									6%	0.03	0.09	0.18	0.51
HOS9	27.49	1.34		26.15									9%	0.06	0.11	0.20	0.52
HOS10	39.26			39.26									5%	0.02	0.08	0.17	0.50
HOS11	58.11			58.11									5%	0.02	0.08	0.17	0.50
HOS12	42.51			42.51									5%	0.02	0.08	0.17	0.50
HOS13	4.78	0.20		4.58									9%	0.05	0.11	0.20	0.52
HOS14	15.43	1.23		14.20									12%	0.08	0.13	0.22	0.53
HOS15	109.58	5.44	1.24	102.90									10%	0.07	0.12	0.21	0.53
Off-site Imp.	**383.08**	**14.50**	**1.25**	**367.32**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**9%**	**0.05**	**0.11**	**0.20**	**0.52**
Developed																	
A1	25.20				25.20								65%	0.49	0.56	0.61	0.75
A2	123.06				123.06								65%	0.49	0.56	0.61	0.75
A3	57.26				57.26								65%	0.49	0.56	0.61	0.75
A4	83.16				83.16								65%	0.49	0.56	0.61	0.75
A5	82.74					82.74							80%	0.64	0.69	0.72	0.81
A6	89.35				41.34	48.01							73%	0.57	0.63	0.67	0.78
A7	63.31				63.31								65%	0.49	0.56	0.61	0.75
A8	43.33				43.33								65%	0.49	0.56	0.61	0.75
A9	65.36			65.36									5%	0.02	0.08	0.17	0.50
Basin A	632.78	0.00	0.00	65.36	436.67	130.75	0.00	0.00	0.00	0.00	0.00	0.00	62%	0.47	0.54	0.59	0.74
C1	108.07				108.07								65%	0.49	0.56	0.61	0.75
D1	16.14				16.14								65%	0.49	0.56	0.61	0.75
Total	**756.99**	**0.00**	**0.00**	**65.36**	**560.88**	**130.75**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**62%**	**0.37**	**0.42**	**0.47**	**0.60**
Proposed Off-Site																	
OS1	32.30	3.75		28.55									15%	0.11	0.16	0.25	0.55
OS2	11.81			11.81									5%	0.02	0.08	0.17	0.50
OS3	36.79	1.46		35.33									9%	0.05	0.10	0.19	0.52
OS4	77.38			77.38									5%	0.02	0.08	0.17	0.50
OS5	62.48			62.48									5%	0.02	0.08	0.17	0.50
Off-site Imp.	**220.77**	**5.21**	**0.00**	**215.56**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7%**	**0.04**	**0.09**	**0.18**	**0.51**

*: A PORTION OF THE BASINS CONSIDERED OFF-SITE WITHIN CROWFOOT VALLEY RD FOR EXISTING CONDITIONS WERE INCLUDED WITHIN THE PROPOSED BASINS, RESULTING IN AN INCREASE IN TOTAL AREA

NOTE: Runoff coefficient values were not used in the CUHP calculations.

A2 Direct Runoff Calculations

Basin Runoff Calculations - Direct Runoff

Project No.: 4080-0001

~~6-Feb-26~~

Basin ID	Total Area (Ac.)	Imp (%)	Q_5	Q_{100}
Existing				
HA1	49.15	5%	0.42	9.74
HA2	19.76	6%	0.61	11.41
HA3	16.68	5%	0.96	19.56
HA4	85.80	5%	20.85	125.53
HA5	54.47	7%	21.24	104.71
HA6	178.83	7%	74.53	367.45
HA7	91.69	5%	27.09	137.17
HA8	64.24	7%	38.08	149.30
HA9	57.02	5%	25.14	104.88
HB1	7.69	5%	2.73	11.56
HC1	108.07	11%	37.53	166.18
HD1	16.14	10%	10.69	39.66
Historic Off-Site				
HOS1	2.22	42%	2.54	9.08
HOS2	2.35	39%	2.58	9.70
HOS3	6.26	5%	1.04	6.61
HOS4	13.34	9%	9.70	37.02
HOS5	35.15	15%	12.61	46.99
HOS6	5.48	5%	2.20	9.19
HOS7	12.75	5%	7.92	31.66
HOS8	8.36	6%	3.83	15.51
HOS9	27.49	9%	9.81	39.67
HOS10	39.26	5%	16.62	69.50
HOS11	58.11	5%	31.48	127.23
HOS12	42.51	5%	22.31	106.26
HOS13	4.78	9%	1.95	7.67
HOS14	15.43	12%	8.23	30.37
HOS15	109.58	10%	45.28	178.18
Developed				
A1	25.20	65%	39.04	85.73
A2	123.06	65%	203.23	447.46
A3	57.26	65%	89.93	198.07
A4	83.16	65%	138.96	304.53
A5	82.74	80%	122.11	252.14
A6	89.35	73%	134.33	286.24
A7	63.31	65%	106.84	233.66
A8	43.33	65%	68.65	150.85
A9	65.36	5%	8.26	36.44
C1	108.07	65%	174.69	385.07
D1	16.14	65%	27.22	59.39
Proposed Off-Site				
OS1	32.30	15%	12.47	43.04
OS2	11.81	5%	7.54	27.01
OS3	36.79	9%	21.17	74.10
OS4	77.38	5%	33.12	126.54
OS5	62.48	5%	25.26	96.84

A3 CUHP Existing Basin Results

5 YR EVENT

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)
HA1		0.151	0.143	132.3	16.01	68.8	11.31	26.7	17	178,415	0.03	4,721	60.0	0.42	4,720	0.01
HA2		0.149	0.093	42.3	4.53	22.0	3.20	7.5	22	71,729	0.03	2,354	35.0	0.61	2,349	0.03
HA3		0.151	0.088	16.4	2.61	8.5	1.84	4.3	48	60,548	0.03	1,602	30.0	0.96	1,555	0.06
HA4		0.148	0.180	33.2	6.10	17.3	4.31	10.2	121	311,454	0.20	62,295	40.0	20.85	62,318	0.24
HA5		0.142	0.141	22.9	3.98	11.9	2.82	6.6	111	197,726	0.25	48,831	35.0	21.24	48,573	0.39
HA6		0.142	0.225	21.4	5.20	11.1	3.67	8.7	391	649,153	0.25	160,316	35.0	74.53	159,693	0.42
HA7		0.148	0.185	33.9	6.33	17.6	4.47	10.5	127	332,835	0.25	84,812	40.0	27.09	84,839	0.30
HA8		0.141	0.151	18.7	3.68	9.7	2.60	6.1	161	233,191	0.35	81,215	35.0	38.08	80,749	0.59
HA9		0.148	0.149	26.5	4.53	13.8	3.20	7.6	101	206,983	0.33	67,587	35.0	25.14	67,370	0.44
HB1		0.148	0.061	33.7	3.07	17.5	2.17	5.1	11	27,915	0.33	9,115	35.0	2.73	9,040	0.35
HC1		0.129	0.177	34.1	6.13	17.7	4.33	10.2	149	392,294	0.32	127,032	40.0	37.53	127,042	0.35
HD1		0.131	0.076	16.9	2.49	8.8	1.76	4.2	45	58,588	0.38	22,337	30.0	10.69	21,601	0.66
HOS1		0.093	0.038	2.3	0.81	1.2	0.54	2.6	45	8,059	0.68	5,479	25.0	2.54	3,139	1.15
HOS2		0.095	0.037	2.4	0.84	1.2	0.56	2.6	46	8,531	0.64	5,453	25.0	2.58	3,157	1.10
HOS3		0.148	0.055	49.6	3.61	25.8	2.55	6.0	6	22,724	0.20	4,545	40.0	1.04	4,534	0.17
HOS4		0.144	0.076	13.3	2.27	6.9	1.61	3.8	47	48,424	0.34	16,337	30.0	9.70	15,432	0.73
HOS5		0.121	0.102	43.5	4.91	22.6	3.47	8.2	38	127,595	0.44	56,046	40.0	12.61	55,953	0.36
HOS6		0.148	0.052	28.8	2.65	15.0	1.87	4.4	9	19,892	0.33	6,496	35.0	2.20	6,387	0.40
HOS7		0.148	0.076	15.9	2.43	8.3	1.72	4.0	38	46,283	0.33	15,113	30.0	7.92	14,531	0.62
HOS8		0.144	0.062	24.9	2.68	13.0	1.89	4.5	16	30,347	0.34	10,238	35.0	3.83	10,035	0.46
HOS9		0.135	0.099	37.8	4.38	19.7	3.10	7.3	34	99,789	0.37	36,943	40.0	9.81	36,842	0.36
HOS10		0.148	0.126	27.7	4.18	14.4	2.96	7.0	66	142,514	0.33	46,536	35.0	16.62	46,349	0.42
HOS11		0.148	0.151	20.1	3.82	10.4	2.70	6.4	136	210,939	0.33	68,879	35.0	31.48	68,424	0.54
HOS12		0.148	0.131	15.6	3.07	8.1	2.17	5.1	128	154,311	0.25	39,321	30.0	22.31	38,690	0.52
HOS13		0.135	0.045	31.3	2.59	16.3	1.83	4.3	7	17,351	0.37	6,424	35.0	1.95	6,317	0.41
HOS14		0.125	0.072	23.8	2.82	12.4	1.99	4.7	30	56,011	0.40	22,632	35.0	8.23	22,215	0.53
HOS15		0.131	0.181	33.1	6.11	17.2	4.32	10.2	155	397,775	0.38	151,655	40.0	45.28	151,703	0.41

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.
HA1		5 YR	0.077	0.644	1.515	0.016	5.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.10	0.05	3.19
HA2		5 YR	0.031	0.125	0.328	0.018	6.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.12	0.06	3.87
HA3		5 YR	0.026	0.064	0.172	0.094	5.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.10	0.05	3.19
HA4		5 YR	0.134	0.174	0.564	0.018	5.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.10	0.05	3.96
HA5		5 YR	0.085	0.116	0.431	0.050	7.0	0.40	0.10	4.00	0.58	0.0018	0.00	0.14	0.07	5.68
HA6		5 YR	0.279	0.252	0.597	0.087	7.0	0.40	0.10	4.00	0.58	0.0018	0.00	0.14	0.07	5.68
HA7		5 YR	0.143	0.313	0.765	0.086	5.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.10	0.05	4.07
HA8		5 YR	0.100	0.100	0.417	0.060	7.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.14	0.07	5.88
HA9		5 YR	0.089	0.174	0.462	0.067	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HB1		5 YR	0.012	0.076	0.195	0.035	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HC1		5 YR	0.169	0.284	0.744	0.045	11.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.22	0.10	9.21
HD1		5 YR	0.025	0.063	0.138	0.050	10.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.20	0.10	8.50
HOS1		5 YR	0.003	0.006	0.011	0.050	42.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.81	0.21	39.97
HOS2		5 YR	0.004	0.006	0.011	0.050	39.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.78	0.20	36.85
HOS3		5 YR	0.010	0.152	0.248	0.067	5.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.10	0.05	3.96
HOS4		5 YR	0.021	0.057	0.134	0.160	6.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.12	0.06	5.02
HOS5		5 YR	0.055	0.233	0.581	0.050	15.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.30	0.12	13.14
HOS6		5 YR	0.009	0.085	0.188	0.150	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HOS7		5 YR	0.020	0.063	0.189	0.200	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HOS8		5 YR	0.013	0.085	0.193	0.130	6.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.12	0.06	5.02
HOS9		5 YR	0.043	0.227	0.352	0.056	9.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	7.62
HOS10		5 YR	0.061	0.161	0.388	0.067	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HOS11		5 YR	0.091	0.106	0.419	0.062	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
HOS12		5 YR	0.066	0.085	0.275	0.089	5.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.10	0.05	4.07
HOS13		5 YR	0.007	0.045	0.182	0.035	9.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	7.62
HOS14		5 YR	0.024	0.085	0.297	0.108	12.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.24	0.11	10.34
HOS15		5 YR	0.171	0.256	0.682	0.034	10.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.20	0.10	8.50

100 YR EVENT

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)
HA1		0.149	0.141	132.1	15.76	68.7	11.14	26.3	17	178,415	0.57	102,316	65.0	9.74	102,310	0.20
HA2		0.146	0.092	42.2	4.47	21.9	3.16	7.4	22	71,729	0.59	42,455	45.0	11.41	42,359	0.58
HA3		0.149	0.086	16.4	2.59	8.5	1.83	4.3	48	60,548	0.57	34,723	35.0	19.56	33,677	1.17
HA4		0.147	0.178	33.2	6.05	17.3	4.28	10.1	121	311,454	1.44	448,303	45.0	125.53	448,421	1.46
HA5		0.140	0.139	22.9	3.95	11.9	2.79	6.6	112	197,726	1.50	296,190	40.0	104.71	294,545	1.92
HA6		0.140	0.222	21.4	5.14	11.1	3.64	8.6	392	649,153	1.50	972,419	40.0	367.45	968,495	2.05
HA7		0.146	0.184	33.9	6.28	17.6	4.44	10.5	127	332,835	1.51	503,338	45.0	137.17	503,509	1.50
HA8		0.139	0.150	18.7	3.65	9.7	2.58	6.1	161	233,191	1.62	378,648	35.0	149.30	376,410	2.32
HA9		0.146	0.148	26.4	4.51	13.7	3.18	7.5	101	206,983	1.60	331,416	40.0	104.88	330,354	1.84
HB1		0.146	0.060	33.7	3.06	17.5	2.16	5.1	11	27,915	1.60	44,696	45.0	11.56	44,317	1.50
HC1		0.126	0.174	34.0	6.03	17.7	4.26	10.1	149	392,294	1.58	621,675	45.0	166.18	621,733	1.54
HD1		0.129	0.075	16.9	2.48	8.8	1.75	4.1	45	58,588	1.66	97,128	35.0	39.66	93,872	2.46
HOS1		0.093	0.038	2.3	0.79	1.2	0.53	2.6	46	8,059	1.94	15,607	30.0	9.08	8,893	4.09
HOS2		0.094	0.037	2.4	0.82	1.2	0.55	2.6	47	8,531	1.90	16,167	30.0	9.70	9,319	4.13
HOS3		0.147	0.055	49.6	3.59	25.8	2.54	6.0	6	22,724	1.44	32,708	50.0	6.61	32,625	1.06
HOS4		0.143	0.075	13.2	2.27	6.9	1.60	3.8	47	48,424	1.61	78,082	35.0	37.02	73,724	2.77
HOS5		0.119	0.101	43.3	4.87	22.5	3.44	8.1	38	127,595	1.72	219,174	50.0	46.99	218,795	1.34
HOS6		0.146	0.052	28.8	2.64	15.0	1.87	4.4	9	19,892	1.60	31,851	40.0	9.19	31,312	1.68
HOS7		0.146	0.075	15.9	2.42	8.3	1.71	4.0	38	46,283	1.60	74,107	35.0	31.66	71,222	2.48
HOS8		0.143	0.061	24.9	2.67	13.0	1.89	4.4	16	30,347	1.61	48,933	40.0	15.51	47,948	1.86
HOS9		0.133	0.098	37.8	4.34	19.6	3.06	7.2	34	99,789	1.65	164,296	45.0	39.67	163,852	1.44
HOS10		0.146	0.125	27.7	4.16	14.4	2.94	6.9	66	142,514	1.60	228,190	40.0	69.50	227,260	1.77
HOS11		0.146	0.149	20.1	3.80	10.4	2.69	6.3	136	210,939	1.60	337,752	40.0	127.23	335,495	2.19
HOS12		0.146	0.130	15.6	3.05	8.1	2.16	5.1	128	154,311	1.51	233,361	35.0	106.26	229,495	2.50
HOS13		0.133	0.045	31.2	2.57	16.2	1.81	4.3	7	17,351	1.65	28,568	40.0	7.67	28,085	1.61
HOS14		0.124	0.072	23.7	2.81	12.3	1.98	4.7	30	56,011	1.68	94,197	40.0	30.37	92,395	1.97
HOS15		0.129	0.178	33.0	6.02	17.2	4.26	10.0	155	397,775	1.66	659,432	45.0	178.18	659,502	1.63

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.
HA1		100 YR	0.077	0.644	1.515	0.016	5.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.10	0.05	3.88
HA2		100 YR	0.031	0.125	0.328	0.018	6.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.12	0.06	4.68
HA3		100 YR	0.026	0.064	0.172	0.094	5.0	0.40	0.10	5.00	1.00	0.0007	0.00	0.10	0.05	3.88
HA4		100 YR	0.134	0.174	0.564	0.018	5.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.10	0.05	4.39
HA5		100 YR	0.085	0.116	0.431	0.050	7.0	0.40	0.10	4.00	0.58	0.0018	0.00	0.14	0.07	6.22
HA6		100 YR	0.279	0.252	0.597	0.087	7.0	0.40	0.10	4.00	0.58	0.0018	0.00	0.14	0.07	6.22
HA7		100 YR	0.143	0.313	0.765	0.086	5.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.10	0.05	4.45
HA8		100 YR	0.100	0.100	0.417	0.060	7.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.14	0.07	6.36
HA9		100 YR	0.089	0.174	0.462	0.067	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HB1		100 YR	0.012	0.076	0.195	0.035	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HC1		100 YR	0.169	0.284	0.744	0.045	11.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.22	0.10	9.95
HD1		100 YR	0.025	0.063	0.138	0.050	10.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.20	0.10	9.13
HOS1		100 YR	0.003	0.006	0.011	0.050	42.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.81	0.21	40.78
HOS2		100 YR	0.004	0.006	0.011	0.050	39.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.78	0.20	37.72
HOS3		100 YR	0.010	0.152	0.248	0.067	5.0	0.40	0.10	4.50	0.60	0.0018	0.00	0.10	0.05	4.39
HOS4		100 YR	0.021	0.057	0.134	0.160	6.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.12	0.06	5.44
HOS5		100 YR	0.055	0.233	0.581	0.050	15.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.30	0.12	13.94
HOS6		100 YR	0.009	0.085	0.188	0.150	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HOS7		100 YR	0.020	0.063	0.189	0.200	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HOS8		100 YR	0.013	0.085	0.193	0.130	6.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.12	0.06	5.44
HOS9		100 YR	0.043	0.227	0.352	0.056	9.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	8.20
HOS10		100 YR	0.061	0.161	0.388	0.067	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HOS11		100 YR	0.091	0.106	0.419	0.062	5.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
HOS12		100 YR	0.066	0.085	0.275	0.089	5.0	0.40	0.10	3.75	0.55	0.0018	0.00	0.10	0.05	4.45
HOS13		100 YR	0.007	0.045	0.182	0.035	9.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	8.20
HOS14		100 YR	0.024	0.085	0.297	0.108	12.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.24	0.11	11.05
HOS15		100 YR	0.171	0.256	0.682	0.034	10.0	0.40	0.10	3.00	0.50	0.0018	0.00	0.20	0.10	9.13

A4 CUHP Proposed Basin Results

5 YR EVENT

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)
A1		0.082	0.140	14.4	3.05	7.5	2.15	5.1	82	91,476	1.06	97,192	30.0	39.04	94,967	1.55
A2		0.082	0.282	13.7	4.46	7.1	3.15	7.4	423	446,708	1.06	474,623	30.0	203.23	473,099	1.65
A3		0.082	0.203	14.7	3.79	7.6	2.68	6.3	183	207,854	1.06	220,843	30.0	89.93	219,001	1.57
A4		0.082	0.240	13.0	3.90	6.8	2.76	6.5	299	301,871	1.06	320,735	30.0	138.96	316,445	1.67
A5		0.077	0.255	18.8	5.17	9.8	3.66	8.6	206	300,346	1.24	371,882	30.0	122.11	369,471	1.48
A6		0.079	0.257	17.2	4.90	8.9	3.46	8.2	243	324,341	1.16	374,938	30.0	134.33	372,291	1.50
A7		0.082	0.212	12.4	3.52	6.4	2.49	5.9	240	229,815	1.06	244,177	30.0	106.84	237,948	1.69
A8		0.082	0.179	14.2	3.45	7.4	2.44	5.8	143	157,288	1.06	167,117	30.0	68.65	165,045	1.58
A9		0.148	0.159	131.2	17.50	68.2	12.36	29.2	23	237,257	0.37	88,743	65.0	8.26	88,736	0.13
C1		0.082	0.270	14.1	4.42	7.3	3.12	7.4	360	392,294	1.06	416,809	30.0	174.69	415,164	1.62
D1		0.082	0.115	11.8	2.54	6.1	1.80	4.2	64	58,588	1.06	62,249	30.0	27.22	59,417	1.69
OS1		0.121	0.098	45.3	4.92	23.6	3.48	8.2	33	117,249	0.48	56,485	40.0	12.47	56,386	0.39
OS2		0.148	0.073	19.1	2.58	9.9	1.82	4.3	29	42,870	0.37	16,035	30.0	7.54	15,618	0.64
OS3		0.135	0.113	24.5	3.63	12.7	2.56	6.0	70	133,548	0.42	55,518	35.0	21.17	55,257	0.58
OS4		0.148	0.171	33.0	5.84	17.2	4.13	9.7	110	280,889	0.37	105,063	40.0	33.12	105,025	0.43
OS5		0.148	0.156	35.4	5.73	18.4	4.05	9.5	83	226,802	0.37	84,832	40.0	25.26	84,733	0.40

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.
A1		5YR	0.039	0.152	0.341	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A2		5YR	0.192	0.284	0.701	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A3		5YR	0.089	0.246	0.473	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A4		5YR	0.130	0.227	0.568	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A5		5YR	0.129	0.360	0.701	0.020	80.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.94	0.33	79.04
A6		5YR	0.140	0.322	0.890	0.040	73.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.93	0.31	71.89
A7		5YR	0.099	0.189	0.473	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A8		5YR	0.068	0.170	0.492	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
A9		5YR	0.102	0.758	1.553	0.014	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
C1		5YR	0.169	0.284	0.682	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
D1		5YR	0.025	0.066	0.170	0.010	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	63.77
OS1		5YR	0.050	0.227	0.568	0.045	15.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.30	0.12	13.14
OS2		5YR	0.018	0.095	0.170	0.200	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
OS3		5YR	0.057	0.265	0.303	0.200	9.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	7.62
OS4		5YR	0.121	0.303	0.530	0.060	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17
OS5		5YR	0.098	0.322	0.473	0.060	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.17

100 YR EVENT

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)
A1		0.082	0.141	14.3	3.04	7.4	2.15	5.1	83	91,476	2.34	214,315	35.0	85.73	209,357	3.40
A2		0.082	0.283	13.6	4.45	7.1	3.15	7.4	425	446,708	2.34	1,046,570	35.0	447.46	1,042,942	3.64
A3		0.082	0.204	14.6	3.78	7.6	2.67	6.3	184	207,854	2.34	486,971	35.0	198.07	482,806	3.46
A4		0.082	0.241	13.0	3.90	6.7	2.75	6.5	301	301,871	2.34	707,238	35.0	304.53	697,336	3.66
A5		0.077	0.255	18.7	5.17	9.7	3.65	8.6	207	300,346	2.52	757,131	35.0	252.14	752,251	3.05
A6		0.079	0.258	17.1	4.89	8.9	3.46	8.2	244	324,341	2.44	790,621	35.0	286.24	784,993	3.20
A7		0.082	0.213	12.3	3.51	6.4	2.48	5.9	241	229,815	2.34	538,423	35.0	233.66	524,553	3.69
A8		0.082	0.180	14.1	3.45	7.4	2.44	5.7	144	157,288	2.34	368,502	35.0	150.85	363,869	3.48
A9		0.146	0.157	131.1	17.35	68.2	12.26	28.9	23	237,257	1.65	391,160	80.0	36.44	391,133	0.56
C1		0.082	0.271	14.0	4.41	7.3	3.12	7.4	362	392,294	2.34	919,087	35.0	385.07	915,590	3.56
D1		0.082	0.115	11.7	2.54	6.1	1.79	4.2	64	58,588	2.34	137,263	35.0	59.39	131,077	3.68
OS1		0.119	0.098	45.1	4.88	23.4	3.45	8.1	34	117,249	1.76	206,386	50.0	43.04	206,038	1.33
OS2		0.146	0.073	19.1	2.57	9.9	1.82	4.3	29	42,870	1.65	70,679	35.0	27.01	68,822	2.29
OS3		0.133	0.112	24.4	3.59	12.7	2.54	6.0	71	133,548	1.69	225,954	40.0	74.10	224,848	2.01
OS4		0.146	0.170	33.0	5.80	17.1	4.10	9.7	110	280,889	1.65	463,097	45.0	126.54	462,888	1.64
OS5		0.146	0.154	35.4	5.69	18.4	4.02	9.5	83	226,802	1.65	373,924	45.0	96.84	373,474	1.55

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.
A1		100YR	0.039	0.152	0.341	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A2		100YR	0.192	0.284	0.701	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A3		100YR	0.089	0.246	0.473	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A4		100YR	0.130	0.227	0.568	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A5		100YR	0.129	0.360	0.701	0.020	80.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.94	0.33	79.44
A6		100YR	0.140	0.322	0.890	0.040	73.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.93	0.31	72.34
A7		100YR	0.099	0.189	0.473	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A8		100YR	0.068	0.170	0.492	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
A9		100YR	0.102	0.758	1.553	0.014	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
C1		100YR	0.169	0.284	0.682	0.040	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
D1		100YR	0.025	0.066	0.170	0.010	65.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.91	0.29	64.27
OS1		100YR	0.050	0.227	0.568	0.045	15.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.30	0.12	13.94
OS2		100YR	0.018	0.095	0.170	0.200	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
OS3		100YR	0.057	0.265	0.303	0.200	9.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.18	0.09	8.20
OS4		100YR	0.121	0.303	0.530	0.060	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52
OS5		100YR	0.098	0.322	0.473	0.060	5.0	0.35	0.10	3.00	0.50	0.0018	0.00	0.10	0.05	4.52

Appendix B. Hydraulic Calculations

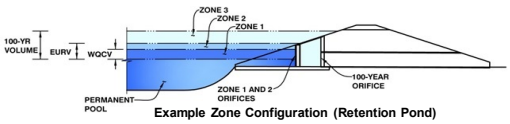
B1 Pond Calculations

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 1**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	25.20	acres
Watershed Length =	1,800	ft
Watershed Length to Centroid =	800	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	70.0%	percent
Percentage Hydrologic Soil Groups C/D =	30.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	0.534	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	1.727	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	1.390	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	2.097	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	2.561	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	2.705	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	3.915	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	4.707	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	5.762	acre-feet		inches
Approximate 2-yr Detention Volume =	1.243	acre-feet		
Approximate 5-yr Detention Volume =	1.814	acre-feet		
Approximate 10-yr Detention Volume =	2.226	acre-feet		
Approximate 25-yr Detention Volume =	2.130	acre-feet		
Approximate 50-yr Detention Volume =	2.628	acre-feet		
Approximate 100-yr Detention Volume =	2.927	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	70	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

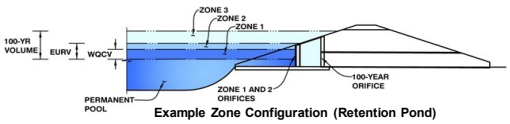
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 2**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	123.06	acres
Watershed Length =	3,700	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	50.0%	percent
Percentage Hydrologic Soil Groups C/D =	50.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	2.606	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	8.230	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	6.992	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	10.562	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	12.903	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	13.578	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	19.629	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	23.578	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	28.850	acre-feet		inches
Approximate 2-yr Detention Volume =	6.097	acre-feet		
Approximate 5-yr Detention Volume =	8.993	acre-feet		
Approximate 10-yr Detention Volume =	10.797	acre-feet		
Approximate 25-yr Detention Volume =	10.313	acre-feet		
Approximate 50-yr Detention Volume =	12.693	acre-feet		
Approximate 100-yr Detention Volume =	14.167	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	341	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

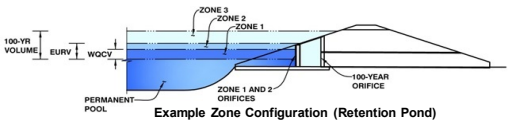
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 3**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	57.26	acres
Watershed Length =	2,500	ft
Watershed Length to Centroid =	1,300	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	1.213	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	3.596	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	3.326	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	5.028	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	6.139	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	6.407	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	9.250	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	11.084	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	13.525	acre-feet		inches
Approximate 2-yr Detention Volume =	2.867	acre-feet		
Approximate 5-yr Detention Volume =	4.342	acre-feet		
Approximate 10-yr Detention Volume =	4.940	acre-feet		
Approximate 25-yr Detention Volume =	4.695	acre-feet		
Approximate 50-yr Detention Volume =	5.745	acre-feet		
Approximate 100-yr Detention Volume =	6.446	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	158	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

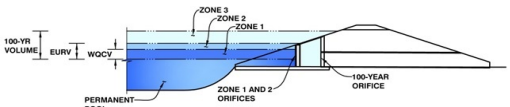
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 4**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	83.16	acres
Watershed Length =	3,000	ft
Watershed Length to Centroid =	1,200	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	1.761	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	5.222	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	4.805	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	7.265	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	8.870	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	9.257	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	13.362	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	16.009	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	19.532	acre-feet		inches
Approximate 2-yr Detention Volume =	4.164	acre-feet		
Approximate 5-yr Detention Volume =	6.306	acre-feet		
Approximate 10-yr Detention Volume =	7.175	acre-feet		
Approximate 25-yr Detention Volume =	6.819	acre-feet		
Approximate 50-yr Detention Volume =	8.343	acre-feet		
Approximate 100-yr Detention Volume =	9.362	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	230	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

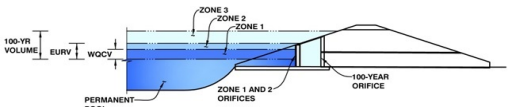
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 5**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	82.74	acres
Watershed Length =	3,700	ft
Watershed Length to Centroid =	1,900	ft
Watershed Slope =	0.020	ft/ft
Watershed Imperviousness =	80.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	80.0%	percent
Percentage Hydrologic Soil Groups C/D =	20.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	2.264	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	7.178	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	5.749	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	8.301	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	9.925	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	10.287	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	14.443	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	17.050	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	20.610	acre-feet		inches
Approximate 2-yr Detention Volume =	5.197	acre-feet		
Approximate 5-yr Detention Volume =	7.378	acre-feet		
Approximate 10-yr Detention Volume =	8.979	acre-feet		
Approximate 25-yr Detention Volume =	8.553	acre-feet		
Approximate 50-yr Detention Volume =	10.532	acre-feet		
Approximate 100-yr Detention Volume =	11.406	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	296	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

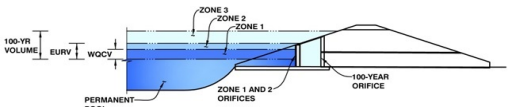
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 6**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	89.35	acres
Watershed Length =	4,700	ft
Watershed Length to Centroid =	1,700	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	73.00%	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 =	Parker - Town Hall	

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) =	2.154	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	7.187	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	5.612	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	8.237	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	9.916	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	10.398	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	14.802	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	17.633	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	21.444	acre-feet		inches
Approximate 2-yr Detention Volume =	5.024	acre-feet		
Approximate 5-yr Detention Volume =	7.140	acre-feet		
Approximate 10-yr Detention Volume =	8.920	acre-feet		
Approximate 25-yr Detention Volume =	8.529	acre-feet		
Approximate 50-yr Detention Volume =	10.541	acre-feet		
Approximate 100-yr Detention Volume =	11.539	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	281	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

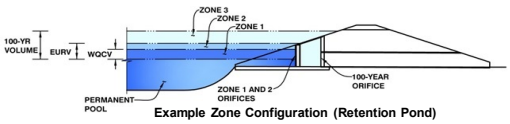
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 7**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	63.31	acres
Watershed Length =	2,500	ft
Watershed Length to Centroid =	1,000	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	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 =	Parker - Town Hall	

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) =	1.341	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	4.493	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	3.450	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	5.188	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	6.314	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	6.708	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	9.717	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	11.704	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	14.327	acre-feet		inches
Approximate 2-yr Detention Volume =	3.103	acre-feet		
Approximate 5-yr Detention Volume =	4.453	acre-feet		
Approximate 10-yr Detention Volume =	5.648	acre-feet		
Approximate 25-yr Detention Volume =	5.420	acre-feet		
Approximate 50-yr Detention Volume =	6.709	acre-feet		
Approximate 100-yr Detention Volume =	7.450	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	175	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

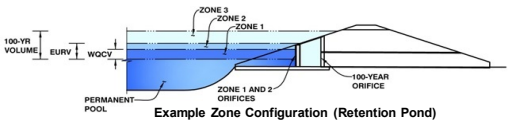
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 8**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	43.33	acres
Watershed Length =	2,600	ft
Watershed Length to Centroid =	900	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	0.918	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	2.721	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	2.506	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	3.789	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	4.627	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	4.829	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	6.972	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	8.353	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	10.193	acre-feet		inches
Approximate 2-yr Detention Volume =	2.170	acre-feet		
Approximate 5-yr Detention Volume =	3.286	acre-feet		
Approximate 10-yr Detention Volume =	3.738	acre-feet		
Approximate 25-yr Detention Volume =	3.553	acre-feet		
Approximate 50-yr Detention Volume =	4.347	acre-feet		
Approximate 100-yr Detention Volume =	4.878	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	120	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

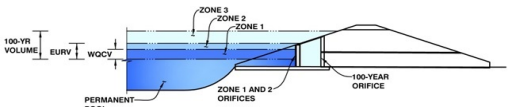
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 9**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	108.07	acres
Watershed Length =	3,600	ft
Watershed Length to Centroid =	1,500	ft
Watershed Slope =	0.040	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	50.0%	percent
Percentage Hydrologic Soil Groups C/D =	50.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	2.289	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	7.228	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	6.133	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	9.268	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	11.323	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	11.916	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	17.229	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	20.697	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	25.328	acre-feet		inches
Approximate 2-yr Detention Volume =	5.354	acre-feet		
Approximate 5-yr Detention Volume =	7.898	acre-feet		
Approximate 10-yr Detention Volume =	9.482	acre-feet		
Approximate 25-yr Detention Volume =	9.057	acre-feet		
Approximate 50-yr Detention Volume =	11.147	acre-feet		
Approximate 100-yr Detention Volume =	12.442	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	299	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = ft

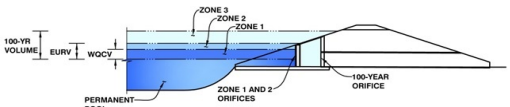
Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool									

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.07 (June 2025)

Project: **Crowsnest**

Basin ID: **Pond 10**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected SCM Type =	**EDB**	
Watershed Area =	16.14	acres
Watershed Length =	900	ft
Watershed Length to Centroid =	350	ft
Watershed Slope =	0.010	ft/ft
Watershed Imperviousness =	65.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Parker - Town Hall	

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) =	0.342	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	1.014	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 1.06 in.) =	0.902	acre-feet	1.06	inches
5-yr Runoff Volume (P1 = 1.43 in.) =	1.364	acre-feet	1.43	inches
10-yr Runoff Volume (P1 = 1.66 in.) =	1.666	acre-feet	1.66	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	1.739	acre-feet		inches
50-yr Runoff Volume (P1 = 2.26 in.) =	2.511	acre-feet	2.26	inches
100-yr Runoff Volume (P1 = 2.6 in.) =	3.009	acre-feet	2.60	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	3.672	acre-feet		inches
Approximate 2-yr Detention Volume =	0.808	acre-feet		
Approximate 5-yr Detention Volume =	1.224	acre-feet		
Approximate 10-yr Detention Volume =	1.392	acre-feet		
Approximate 25-yr Detention Volume =	1.323	acre-feet		
Approximate 50-yr Detention Volume =	1.619	acre-feet		
Approximate 100-yr Detention Volume =	1.817	acre-feet		

Define Zones and Basin Geometry

Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =	45	ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

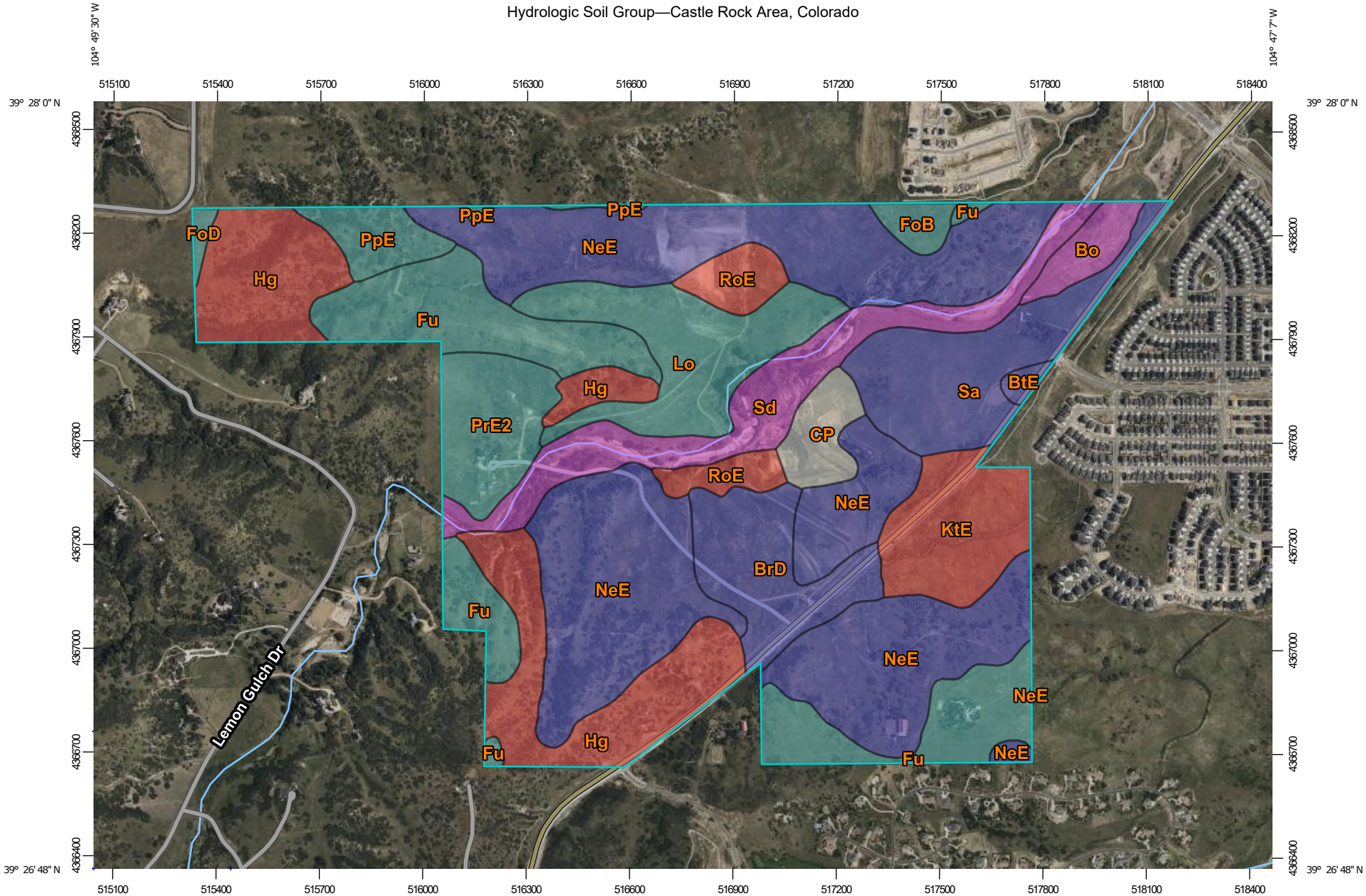
Depth Increment = ft

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									

Appendix C. Referenced Information

C1 NRCS Soils Map

Hydrologic Soil Group—Castle Rock Area, Colorado



Map Scale: 1:15,600 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

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 1:20,000.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
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: Castle Rock Area, Colorado
Survey Area Data: Version 18, Aug 29, 2025

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

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

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
Bo	Blakeland-Orsa association, 1 to 4 percent slopes	A	10.7	1.4%
BrD	Bresser sandy loam, cool, 5 to 9 percent slopes	B	39.0	5.2%
BtE	Bresser-Truckton sandy loams, 5 to 25 percent slopes	B	2.5	0.3%
CP	Pits, clay		13.9	1.8%
FoB	Fondis clay loam, 1 to 3 percent slopes	C	6.4	0.8%
FoD	Fondis clay loam, 3 to 9 percent slopes	C	2.2	0.3%
Fu	Fondis-Kutch association	C	89.7	11.9%
Hg	Hilly gravelly land	D	91.4	12.1%
KtE	Kutch sandy loam, 5 to 20 percent slopes	D	37.2	4.9%
Lo	Loamy alluvial land	C	51.2	6.8%
NeE	Newlin gravelly sandy loam, 8 to 30 percent slopes	B	241.9	32.1%
PpE	Peyton-Pring-Crowfoot sandy loams, 5 to 25 percent slopes	C	15.0	2.0%
PrE2	Peyton-Pring-Crowfoot complex, 3 to 15 percent slopes, eroded	C	30.8	4.1%
RoE	Renohill sandy loam, reddish variant, 5 to 20 percent slopes	D	19.0	2.5%
Sa	Sampson loam	B	49.7	6.6%
Sd	Sandy alluvial land	A	53.6	7.1%
Totals for Area of Interest			**754.1**	**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

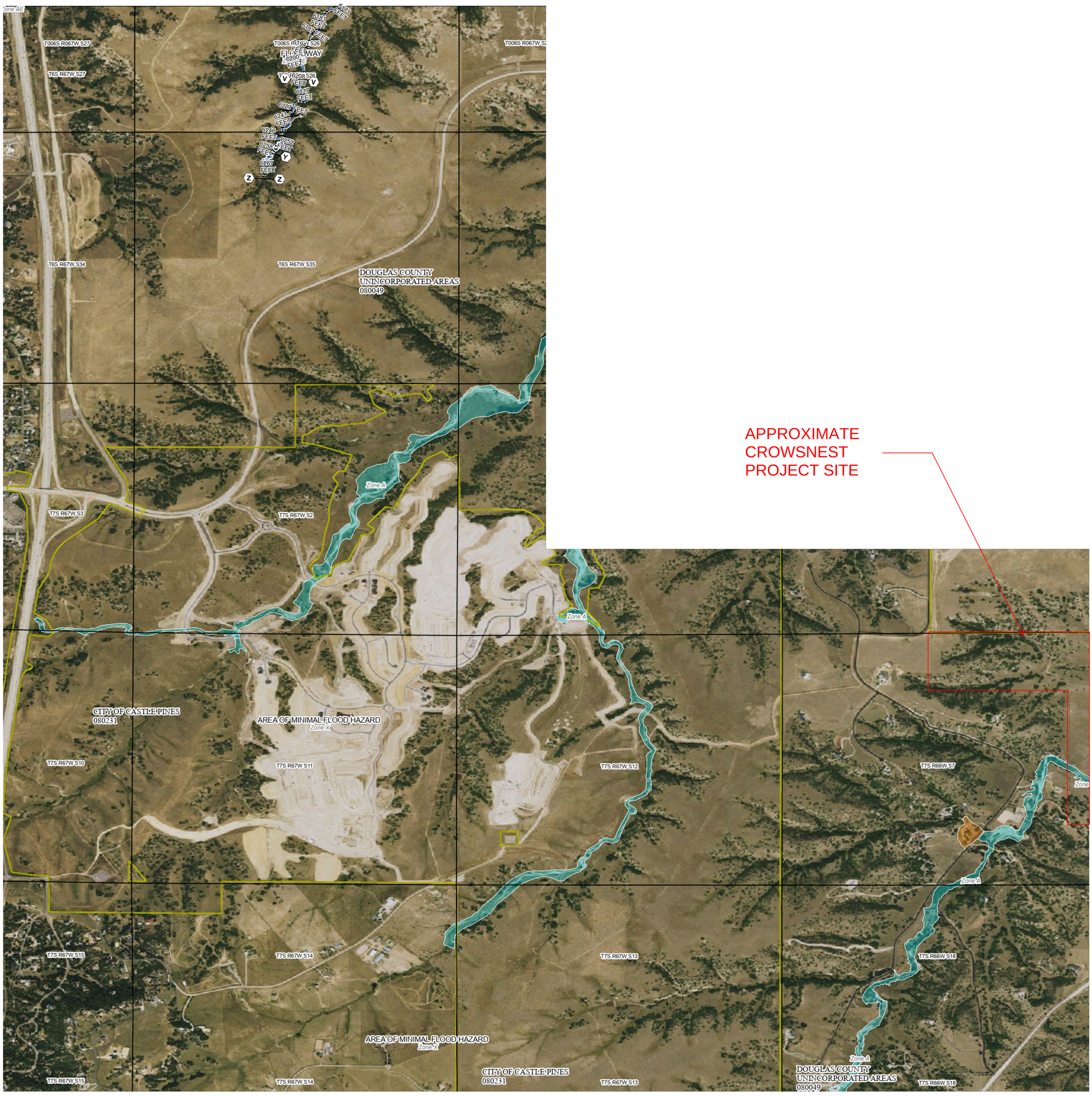
Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

C2 FEMA FIRM

104°52'30.89"W 39°30'13.2"N



104°48'44.18"W 39°26'1.85"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP
FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

LINK> </CLR>for official maps and additional

OTHER AREAS

- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES

- B 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- 8 Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

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For community and countywide map dates, refer to 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.

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SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: NAVD88
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map, please see the Flood Insurance Study (FIS) Report for your community at https://msc.fema.gov

N

1 inch = 1,000 feet 1:12,000

0 500 1,000 2,000 3,000 4,000 Feet

0 105 210 420 630 840 Meters

FEMA
National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

PANEL **180** OF **461**

Panel Contains:

COMMUNITY	NUMBER	PANEL
CITY OF CASTLE PINES	080231	0180
TOWN OF PARKER	080246	0180
DOUGLAS COUNTY	080049	0180

MAP NUMBER
08035C0180G
EFFECTIVE DATE
September 04, 2020

104°48'45.46"W 39°28'14.11"N

104°46'52.11"W 39°26'8.43"N

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP
FOR DRAFT FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes *Zone X*
- Area with Flood Risk due to Levee *Zone D*

LINK> </CLR>for official maps and additional

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- 8 Coastal Transect
- Coastal Transect Baseline
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- 513 Base Flood Elevation Line (BFE)
- Limit of Study
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SCALE

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: No elevation features on this FIRM
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N

1 inch = 500 feet 1:6,000

0 250 500 1,000 1,500 2,000 Feet

0 50 100 200 300 400 Meters

FEMA
National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

PANEL **183** OF **461**

Panel Contains:

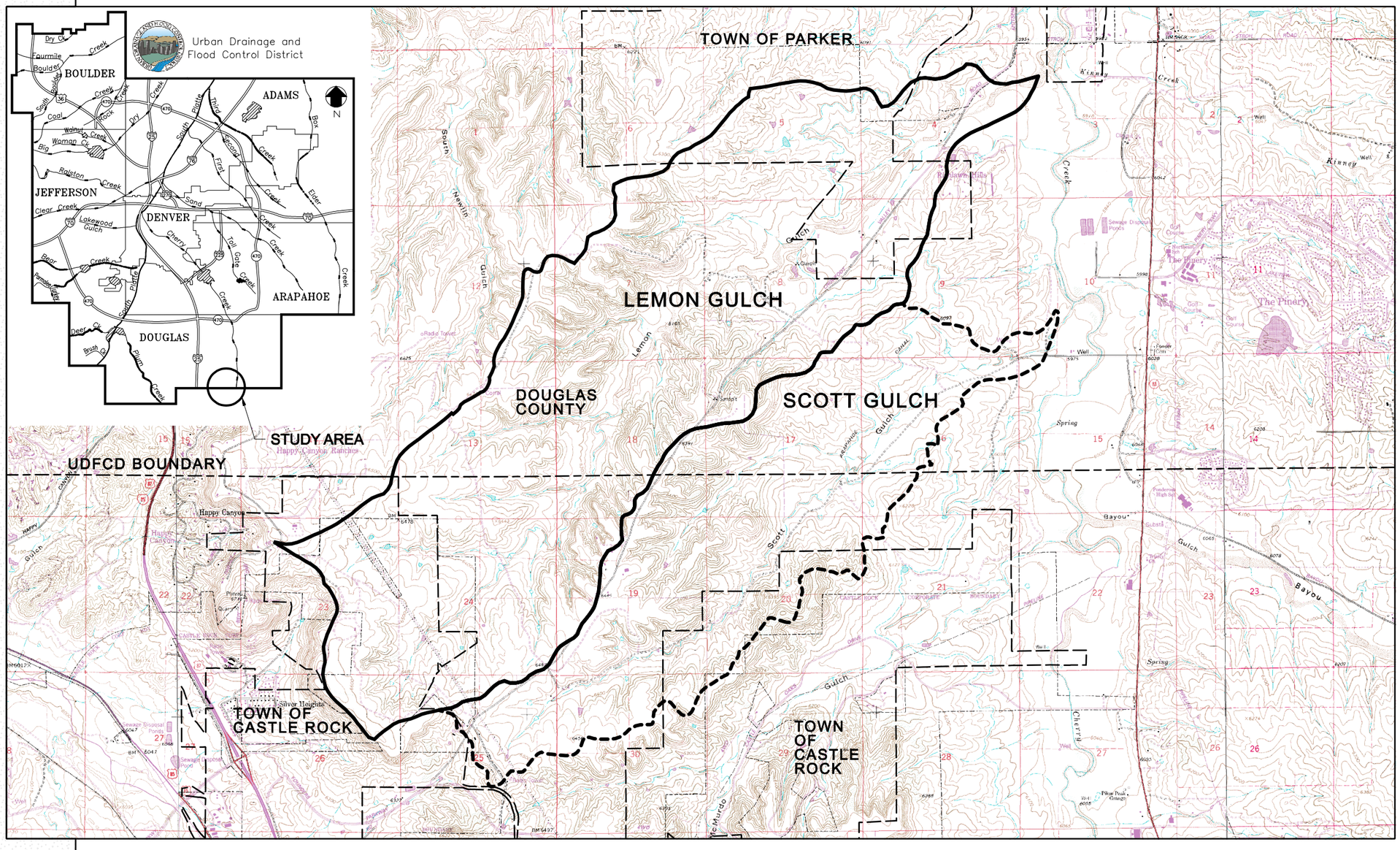
COMMUNITY	NUMBER	PANEL
TOWN OF PARKER	080310	0183
DOUGLAS COUNTY	080049	0183

MAP NUMBER
08035C0183G
EFFECTIVE DATE
March 16, 2016

C3 Scott and Lemon Gulch Watersheds OSP (July 2006)

OUTFALL SYSTEMS PLANNING-PRELIMINARY DESIGN REPORT

SCOTT AND LEMON GULCH WATERSHEDS



PREPARED FOR:

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

DOUGLAS COUNTY

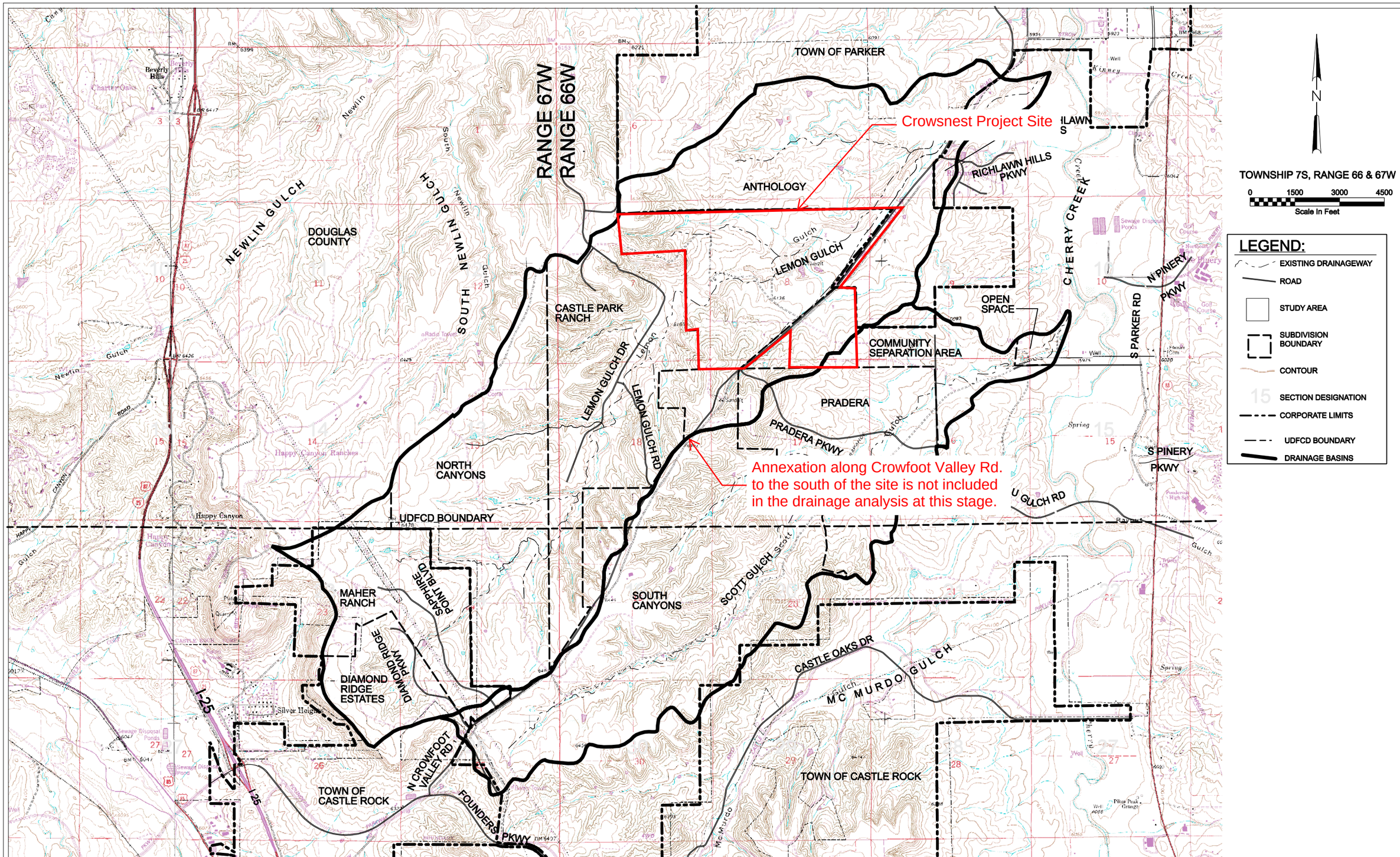
PREPARED BY

CH2MHILL

DENVER, CO

JULY 2006

lgfigcv.dlv



MAPPING PRODUCED BY:DOUGLAS COUNTY (DATE 2003)
HORIZONTAL DATUM: NAD 83 FEET
STATE PLANE COLORADO CENTRAL
VERTICAL DATUM: NAVD 88

CH2M HILL
9193 SOUTH JAMAICA STREET
ENGLEWOOD, CO 80112

DESIGNED	CH	DATE	4/06
DRAWN	MM	DATE	4/06
CHECKED	BC	DATE	4/06
REVISED	MM	DATE	6/06

DOUGLAS COUNTY
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

SCOTT GULCH AND LEMON GULCH WATERSHEDS
OUTFALL SYSTEM PLANNING

FIGURE ES-1
SCOTT GULCH AND LEMON GULCH VICINITY MAP

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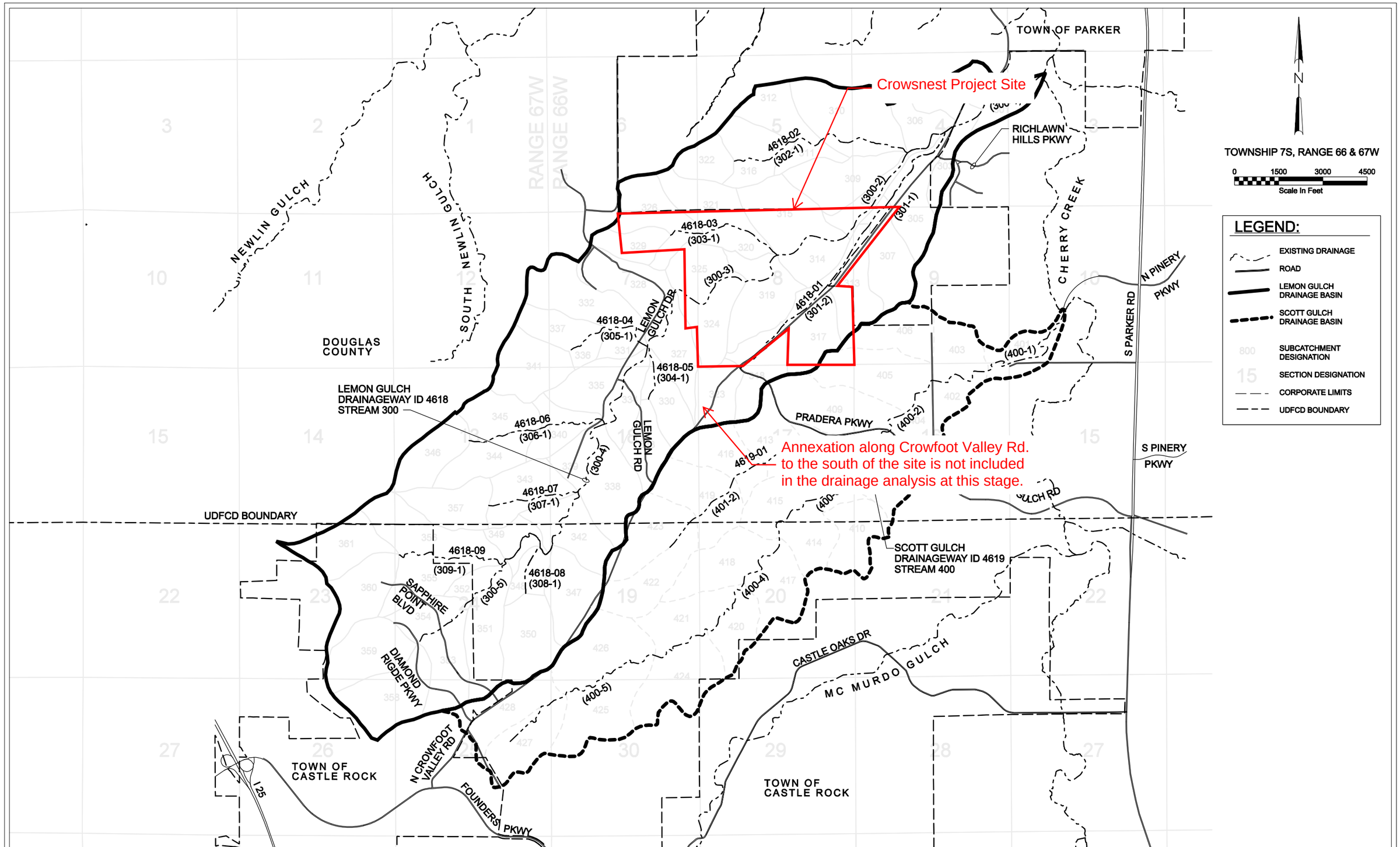

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HORIZONTAL DATUM: NAD 83 FEET
STATE PLANE COLORADO CENTRAL
VERTICAL DATUM: NAVD 88

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DOUGLAS COUNTY
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

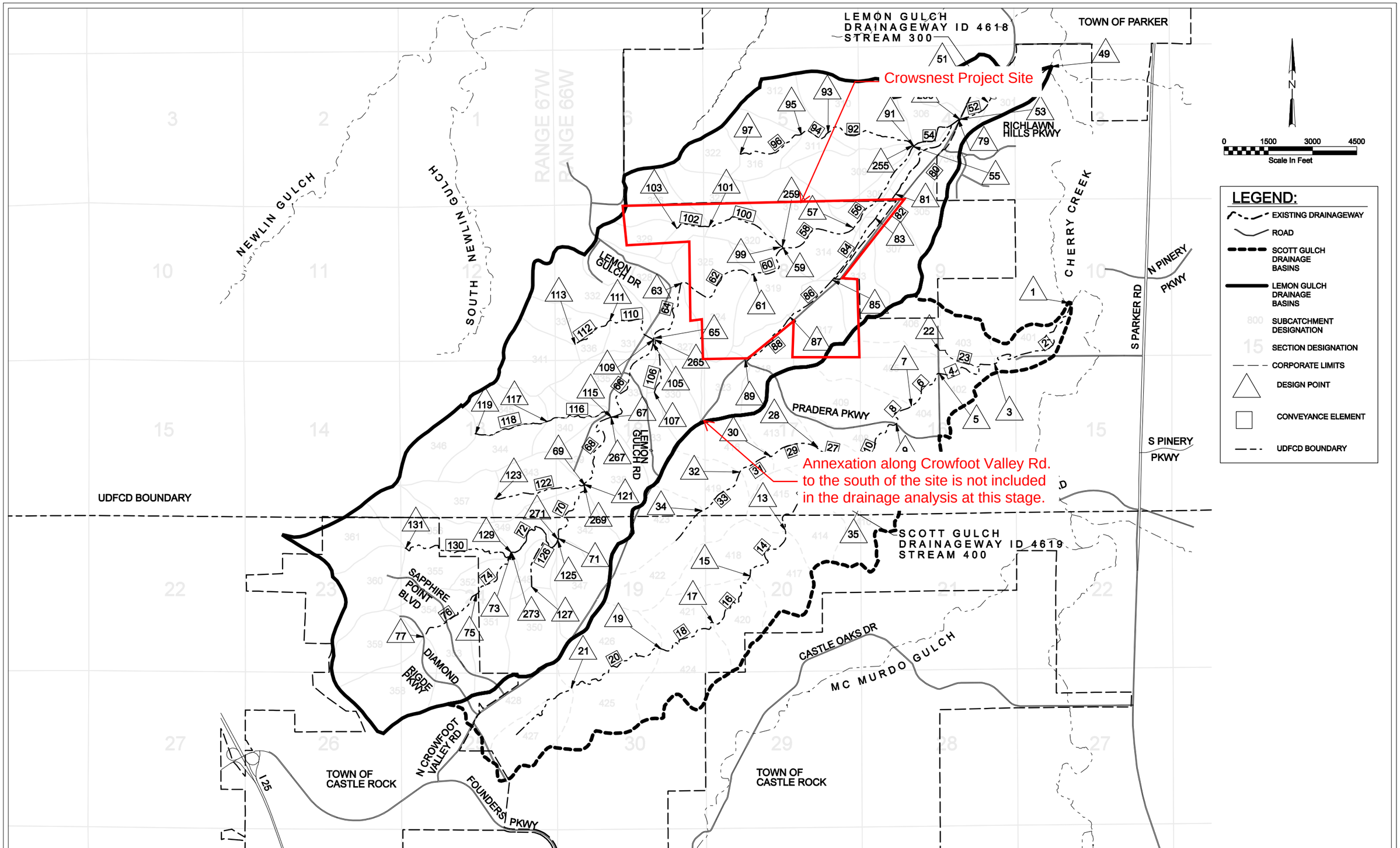
SCOTT GULCH AND LEMON GULCH WATERSHEDS
OUTFALL SYSTEM PLANNING

FIGURE 2-1
SCOTT GULCH AND LEMON GULCH STUDY AREA AND REACHES

TABLE 3-3
Discharge Summary

			Existing/Future Flow Rates											
Location	Conveyance Element	Reach Designation	2-Year Existing	2-Year Future	5-Year Existing	5-Year Future	10-Year Existing	10-Year Future	25-Year Existing	25-Year Future	50-Year Existing	50-Year Future	100-Year Existing	100-Year Future
Lemon Gulch at Cherry Creek	49	300-1	19	367	584	1,340	1,044	1,982	1,874	3,475	3,429	4,825	4,998	6,661
Lemon Gulch at Crowfoot Valley Road	53	300-2	21	368	590	1,337	1,051	1,970	1,879	3,426	3,394	4,736	4,917	6,608
Lemon Gulch at Lemon Gulch Drive	65	300-4	92	501	605	1,200	964	1,639	1,863	2,758	2,469	3,528	3,390	4,601
Lemon Gulch at Canyons and Castle Park Ranches Boundary	71	300-5	134	439	451	876	635	1,125	1,106	1,751	1,416	2,160	1,852	2,726
Scott Gulch at Cherry Creek	1	400-1	8	242	299	732	569	1,080	1,263	1,959	1,777	2,596	2,584	3,562
Scott Gulch at Pradera Regional Facility	5	400-2	12	257	321	750	588	1,080	1.267	1,954	1,748	2,551	2,504	3,455
Scott Gulch at Canyons and Pradera Boundary	13	400-4	11	178	171	437	294	592	593	1,016	801	1,291	1,122	1,689

As previously stated, the results of the modeling compared very well with the published *FHAD* for Lemon Gulch. This provides validation for the modeling methodology and input parameters. As a rule of thumb for the predominantly Type C and D soils in these watersheds, a historic discharge of 1 cfs/acre can be expected. The historic model results compare very well to this rule of thumb. The developed condition models result in an increase in flow to approximately 1.5 cfs/acre. It is reasonable to expect a developed watershed to release at 1.5 cfs/acre as was the case in the model results with this study. The methodologies and model results were compared to studies on Oak Gulch and Sulphur Gulch. Both of these drainages are located within the same region and are tributaries to Cherry Creek. The comparison showed that similar unit discharges were found in these drainages as were found in the Scott and Lemon Gulch drainageways.



MAPPING PRODUCED BY:DOUGLAS COUNTY (DATE 2003)
HORIZONTAL DATUM: NAD 83 FEET
STATE PLANE COLORADO CENTRAL
VERTICAL DATUM: NAVD 88

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DESIGNED	CH	DATE	4/06
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DOUGLAS COUNTY
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

SCOTT GULCH AND LEMON GULCH WATERSHEDS
OUTFALL SYSTEM PLANNING

FIGURE 3-2
SCOTT GULCH AND LEMON GULCH
UDSWM CONVEYANCE MAP

aefigconveyancea.dlv

4.0 Identification of Problem Areas

4.1 Introduction

The natural character of the channels within the drainage basins is a highly valued quality. As such, the general approach used for the Alternatives Evaluation was to minimize the number and extent of the planned facilities to only drainage improvements that were regarded as absolutely necessary. In order to do so, areas with existing problems and those areas where potential problems are likely to develop subsequent to development were identified. The evaluation identified the improvements necessary for the safe conveyance of stormwater flows and the mitigation of existing and potential problems.

Section 4.0 organizes the problem identification evaluation into the following main areas with annotations provided below and in Tables 4-1 and 4-2:

- Evaluation of Existing Facilities
- Existing and Potential Problem Areas

4.2 Evaluation of Existing Facilities

Several existing storm drainage facilities were identified in the Scott Gulch and Lemon Gulch Watersheds and included in the hydraulic capacity evaluation. Figure 4-1 summarizes the locations and types of storm drain facilities which existed and which were evaluated. The evaluation was limited to the existing drainage infrastructure which serves drainage areas larger than 130 acres and had an equivalent pipe diameter of 36-inches or larger.

4.2.1 Scott Gulch Watershed

Scott Gulch Watershed is generally undeveloped with the primary conveyance of stormwater via natural channels. The Pradera development has introduced several types of drainage improvements, as shown in Figure 4-1, including an 80 acre-feet regional detention facility, a concrete box culvert, and channel grade control structures.

The 80 acre-feet detention facility is located near the confluence with Cherry Creek in Planning Reach (Reach) 400-1. The detention facility was designed to attenuate peak flood flows for the entire Scott Gulch Watershed to approximately 1400 cfs during a 100-year storm event. Evaluation of the existing detention facility has determined that the facility does not conform to that design objective; rather it releases approximately 2500 cfs with 1400 cfs being released by the principal outlet and 1100 cfs via the emergency spillway. With the detention facility embankment planned as the extension of Bayou Gulch Road, overtopping is not consistent with the County's criteria.

Just upstream of the detention facility in Reach 400-2, a triple cell 12' x 6' concrete box culvert was constructed to convey storm water flows beneath Pradera Parkway. As indicated in Table 4-1, although the concrete box culvert is able to pass a number of storm events, it has insufficient capacity to convey the fully developed peak flood flow resulting from a 100-year storm event without overtopping Pradera Parkway.

4.2.2 Lemon Gulch Watershed

Similar to the Scott Gulch Watershed, the Lemon Gulch Watershed is primarily undeveloped with limited existing storm drainage infrastructure. The primary stormwater conveyance mechanism is natural channels. Existing infrastructure includes the Crowfoot Valley Road Bridge crossing with Lemon Gulch near its confluence with Cherry Creek, channel grade control structures, and driveway culverts as shown Figure 4-1. Although there are many culverts along Lemon Gulch, only those with pipe diameters of 36-inches or larger and serving areas larger than 130 acres were evaluated. A summary of the hydraulic capacities for the existing drainage infrastructure is provided in Table 4-1.

The Crowfoot Valley Road Bridge crossing of Lemon Gulch is located near its confluence with Cherry Creek in Reach 300-1. The bridge crossing was designed anticipating the ultimate build-out for the Lemon Gulch Watershed and has sufficient capacity. Several grouted sloping boulder drop structures were constructed upstream of the bridge crossing. Channel banks and the bed within the limits of the drop structures appear to be stable and should not warrant any further improvement. Downstream of the bridge crossing, a sheet pile check structure with a riprap apron was constructed. The segment of channel downstream of the sheet pile check structure has experienced degradation. This degradation is expected to migrate upstream until it encounters a control structure such as the sheet piles.

Further upstream in the watershed, culverts have been constructed within and adjacent to Lemon Gulch. Many of the culverts are located in Castle Park Ranches and have been constructed along Lemon Gulch Drive to convey stormwater discharges from the tributaries to the mainstem. Pipe diameters for the culverts range from 18- to 72-inches. Only those culverts with pipe diameters of 36-inches and larger were evaluated for hydraulic capacity. All the culverts evaluated have limited capacity as reflected in Table 4-1 and will likely result in roadway overtopping.

4.3 Existing and Potential Problem Areas

Although both watersheds are generally undeveloped, problem areas do exist that will only worsen subsequent to development. Channel slopes in both watersheds are fairly steep, ranging from 1 percent to 4 percent. With increasing peak discharges resulting from development in the watersheds, steep channel slopes will result in high flow velocities increasing the potential for bank erosion and channel bed degradation.

The approach for identifying problem areas involved assessing the hydraulic capacity and erosion potential of the existing drainage system considering existing development and ultimate build-out conditions. An approximate method assuming uniform flow condition (normal depth calculations) was used to quantify the hydraulic characteristics for the drainageway. The hydraulic characteristics were then used to determine whether erosion and capacity problems exist. In conjunction with the hydraulic analysis, field visits and discussions with stakeholders in the Study Area provided additional sources of information. Table 4-2 summarizes the existing and potential problem areas for the various planning reaches specific to the individual drainageways.

TABLE 4-1
Existing Drainage Facility Hydraulics

Crossing No.	UDSWM Element	Type	Size	Roadway	Existing Capacity (cfs)	Existing Development 2-yr 1-hr (1.06")	Existing Development 5-yr 1-hr (1.43")	Existing Development 10-yr 1-hr (1.66")	Existing Development 100-yr 1-hr (2.60")	Future Development 2-yr 1-hr (1.06")	Future Development 5-yr 1-hr (1.43")	Future Development 10-yr 1-hr (1.66")	Future Development 100-yr 1-hr (2.60")
Lemon Gulch Watershed													
CLV 2	269	CMP	Twin 30"	Lemon Gulch Dr	110	+	--	--	--	--	--	--	--
CLV 3	89	CMP	42"	Crowfoot Valley Rd	100	+	+	+	--	+	+	+	--
CLV 4	115	CMP	36"	Lemon Gulch Dr	120	+	+	--	--	+	--	--	--
CLV 5	265	CMP	Twin 72"	Lemon Gulch Rd	120	+	--	--	--	--	--	--	--
CLV 6	109	CMP	48"	Lemon Gulch Dr	150	+	+	+	--	+	--	--	--
BR1	253			Crowfoot Valley Rd	6460	+	+	+	+	+	+	+	+
Scott Gulch Watershed													
CLV 1	9	RCB	Triple Cell 12' x 6'	Pradera Pkwy	3030	+	+	+	+	+	+	+	--

Notes:
"+" indicates adequate capacity; "--" indicates inadequate capacity.

TABLE 4-2
Summary of Existing and Potential Problem Areas

Planning Reach	Existing Problem Areas	Potential Problem Areas
Lemon Gulch		
300-1	Steep channel banks with slopes of 1:1	Channel velocities will likely increase by approximately 20%
	Steep channel slopes resulting in velocities greater than 15 fps during a 100-year storm event	Further channel bed degradation will likely result in bank failure, especially in the channel segment downstream of the Crowfoot Valley Road Bridge Crossing
	Channel bed degradation downstream of Crowfoot Valley Road Bridge Crossing	Sharp channel bend upstream of the Crowfoot Valley Road Bridge Crossing will likely meander further to the north and east
	Sharp bend (nearly 90 degrees) in channel upstream of Crowfoot Valley Road Bridge Crossing. No current signs of problems but very susceptible to erosion	
300-2	Steep channel banks, 1:1	Channel velocities increase by 20%
	Steep channel slopes resulting in velocities between 10 to 15 fps during a 100-year storm event	Channel bed degradation will likely result in bank failure
300-3	Steep channel slopes resulting in velocities between 10 to 15 fps during a 100-year storm event	Channel velocities increase by 20%
	Sharp channel bends	Channel bed degradation will likely result in bank failure
		Reach is the most sinuous and very susceptible to erosion
300-4	Steep channel slopes resulting in velocities between 10 to 15 fps during a 100-year storm event	Channel velocities likely to increase by approximately 25%
	Sharp channel bends with indication of recent erosion	Local scour within channel likely as a result of culverts located adjacent to and within the channel
	Existing culverts within channel undersized for the minor and major storm events (See Table 4-1 for culvert location and hydraulic capacities)	Existing culverts do not have sufficient hydraulic capacity
	Scour hole downstream of twin 72-inch CMP at Lemon Gulch Road	
Lemon Gulch		
301-1	Steep channel resulting in velocities between 5 to 10 fps	Although channel velocities do not increase notably, channel bed degradation a potential problem
302-1	Steep channel slopes resulting in velocities greater than 15 fps	Channel velocities likely to increase by 20%. Potential for channel bed degradation
303-1	Steep channel slopes resulting in velocities between 5 to 10 fps	Channel velocities likely to increase by 10%. Potential for channel bed degradation
304-1	Although channel velocity is less than 5 fps, steep channel slope may result in higher velocities with development	Although channel velocities do not increase notably, channel bed degradation a potential problem
305-1	Although channel velocity is less than 5 fps, steep channel slope may result in higher velocities with development	Although channel velocities do not increase notably, channel bed degradation a potential problem
306-1	Steep channel slopes resulting in velocities between 5 to 10 fps	Although channel velocities do not increase notably, channel bed degradation a potential problem
307-1	Steep channel banks, 1:1	Channel velocities likely to increase by 30%. Channel

Employing runoff reduction practices such as MDCIA were also considered during the development and evaluation of the alternatives. The MDCIA principal is geared toward reducing impervious areas and to route runoff from impervious surfaces over grassy areas to slow down runoff and promote infiltration. To assess the benefits for employing MDCIA practices, an evaluation was conducted to quantify the reduction in peak discharges and costs. Although the evaluation was conducted only for a few of the alternatives, it is recommended that the implementation of any of the alternatives should incorporate MDCIA Levels 1 or 2.

5.5.1 Outfall System Alternatives for Lemon Gulch

Alternative 1 – Do Nothing

The existing channel is degrading in many locations and will be accelerated with future changes expected to occur within the watershed. Lack of improvements to the drainageways will result in bank and bed erosion, accelerated channel migration, higher probability of damage to existing structures, and increase in sediment transported to Cherry Creek and ultimately Cherry Creek Reservoir.

The active channel migration that is currently evident will increase as development continues. This channel migration will threaten existing and future bridge crossings, it will decrease the amount of usable land in the watershed, and it will eventually impact existing residences, golf courses, culvert crossings, and existing detention facilities.

The bed and bank erosion that will occur in the channel will contribute a significant amount of sediment to Cherry Creek and the Cherry Creek Reservoir. This increase in sediment load will increase the maintenance cost of the Reservoir, and it will impact existing wetland and riparian habitats in the Cherry Creek corridor. The increased sediment load will also result in an increase in phosphorus loading to the channels in the Study Area, Cherry Creek and Cherry Creek Reservoir. This increase in phosphorus loading is in direct conflict with the *Cherry Creek Reservoir Control Regulation No. 72*. The costs associated with loss of infrastructure, residences and usable land are likely to be very high. In fact, the costs were qualitatively deemed to be high enough to eliminate Alternative 1 from further consideration. Compounding the cost issues are the impacts to Cherry Creek and Cherry Creek Reservoir which make Alternative 1 totally unacceptable and therefore the alternative was not analyzed any further.

Alternative 2 – Regional Open Channel System

Because flow attenuation is not considered for Alternative 2, the peak discharges conveyed by Lemon Gulch will increase greatly at ultimate build-out conditions. As a result, significant improvements to the channel are required. Check structures are necessary throughout the drainageways to provide a slope that is stable and will decrease velocities to five feet per second or less. By providing grade control rather than extensive riprap, the channel is stabilized using a method favored by the community. The full conveyance alternative also uses channel widening to limit the flow depth in the channel to five feet or less to meet USDCM criteria for a stable grass-lined channel.

Alternative 3 – Regional Detention System

A network of off-line regional detention systems have been identified along the tributaries of Lemon Gulch. Locations for the regional detention systems were determined considering several factors including, but not limited to, the proposed and existing developments, and riparian areas.

An on-channel detention facility was evaluated for the Lemon Gulch Watershed. Detailed evaluation determined that the size of the regional facility and the impact to the natural drainageway are unacceptable and, therefore, eliminated an on-channel detention facility from further evaluation.

Channel improvements were included in addition to the regional detention facilities. Riprap armoring is proposed at channel bends to prevent further bank erosion and channel migration. Limited channel reconstruction and improvements to the channel gradient is also included.

In addition to the traditional practice of attenuating peak flood flows for the 10-year and 100-year storm events, the Full Spectrum Design Concept was evaluated for this alternative. As expected, the storage volume required to attenuate the full spectrum of design storms does not increase significantly from the traditional approach. The Full Spectrum Design Concept is encouraged as a standard for the design of regional detention facilities.

Alternative 4 – Regional Detention and Channel System

Alternative 4 considers the most effective balance between detention and channel improvements to provide stable drainageways. Similar to Alternatives 2 and 3, check structures are utilized to allow the channel to reach a stable slope while minimizing channel migration. In the Castle Park Ranch area the use of Grouted Sloping Boulder drops (GSB) was selected based on community input. The GSBs allow a greater drop height, thus decreasing the number of drops in the channel. This is desired in Castle Park Ranch due to the use of the drainageway for equestrian passage. Riprap is proposed at channel bends to prevent further bank erosion and channel migration.

As noted previously, the Full Spectrum Design Concept should be considered as the resulting storage volumes to attenuate the full spectrum of design storms does not increase significantly from the traditional approach.

To quantify the benefits of employing MDCIA practices, MDCIA Levels 1 and 2 were incorporated within Lemon Gulch for Alternative 4. The benefits of incorporating MDCIA was seen in as much as 5 percent cost savings from reduced channel improvements and smaller regional detention facilities. Although the benefits for employing MDCIA were not evaluated for all the alternatives, it was concluded that the benefits would be similar and therefore is encouraged for each alternative.

5.5.2 Outfall Systems Alternatives for Scott Gulch Watershed

The Scott Gulch watershed is undergoing development with a portion of the drainageway recently improved in conjunction with the Pradera development. These improvements include the Pradera Regional Detention Facility, concrete check structures and road crossings. The Pradera Regional Detention Facility was intended to service the entire Scott Gulch Watershed including the Canyons Development. However, the hydrology study found significantly higher peak discharges for the ultimate build-out condition.

The difference in the hydrology required a re-evaluation of the existing drainage improvements in the Pradera development. Because of the extensive existing infrastructure, it was determined that the outfall systems plan must utilize the existing drainage infrastructure to the maximum extent possible while incorporating additional measures necessary to protect the watershed from flooding, channel instability, and water quality degradation. As a result of this consideration, a more extensive analysis was conducted for Scott Gulch resulting in seven alternatives compared to the four evaluated for the Lemon Gulch Watershed.

Table 5-2, Alternative Summary, presents the costs associated with the evaluated alternatives. These costs provided the basis for comparisons between the alternatives and for the selection of the recommended plan.

5.6 Recommended Alternative

The recommended alternatives for channel stabilization of Scott Gulch and Lemon Gulch is Alternatives 4 and 5, respectively. Each of the evaluated alternatives provides the necessary channel and infrastructure improvements to address existing and potential problems. Alternatives 4 and 5 provide a lower overall project cost than the other alternatives while providing a comparable level of protection.

Alternatives 4 and 5 are consistent with the desires of those interested in the watershed by minimizing impacts to the natural drainageways while providing channel stabilization. Detention is provided in Lemon Gulch in the planned developments such that releases from tributaries are at historic rates. Channel protection in Lemon Gulch is provided with check structures in most reaches and GSBs through Castle Park Ranch. Grading of the channel is required in locations where flow depths are excessive and steep channel banks are actively eroding. Riprap protection will be provided at channel bends to prevent further channel migration and erosion in both Scott Gulch and Lemon Gulch. Scott Gulch will be stabilized with check structures and improvements to existing infrastructure in the Pradera development. The overall plan for both watersheds integrates existing and proposed infrastructures successfully.

Details of all the alternatives and of the recommended plan are presented in the "*Lemon and Scott Gulches Outfall Systems Planning Study Alternatives Evaluation Report*" dated November 2005.

5.7 Selected Plan

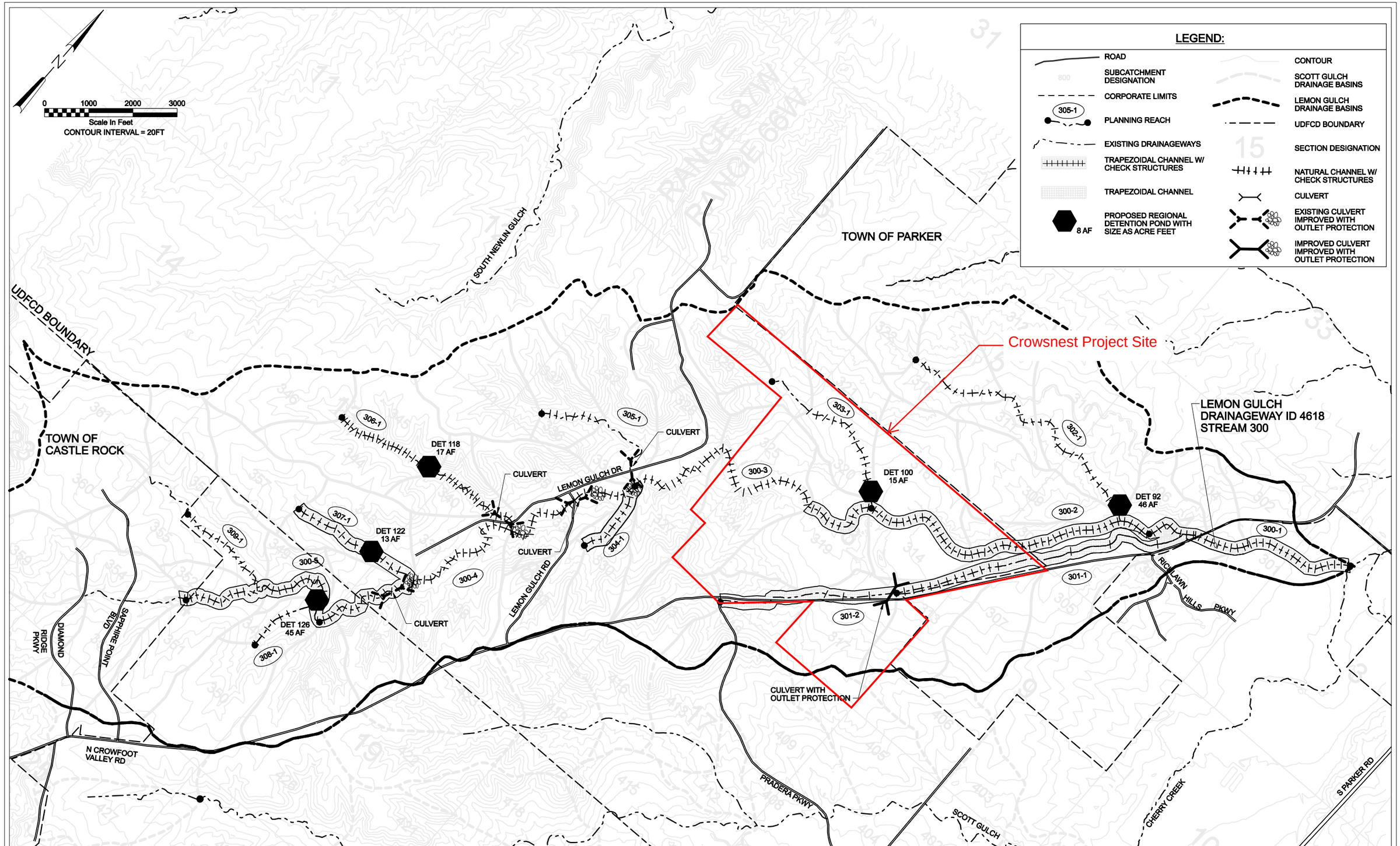
On February 22, 2006, UDFCD and the Project Sponsors identified the selected plan. The selected plan accepted all the recommendations presented in the Alternatives Evaluation Report. A copy of the Selected Plan notification letter is presented in Appendix D. Figures 5-1 and 5-2, and the accompanying Tables 5-3 and 5-4, present the details of the Selected Plan for the respective watersheds.

TABLE 5-2
Alternative Summary

	Mobilization Costs	Drainageway Costs	Utility Relocation Costs	Land Acquisition Value	Contingencies (30%)	Engineering Administration and Legal Services (10%)	Operations and Maintenance	Alternative Total
Lemon Gulch				**$ x 1000**				
Alternative 2: Open Channel System	$1,589	$21,040	$348	$10,405	$10,016	$4,338	$3,578	$51,314
Alternative 3: Regional Detention System	$855	$13,782	$192	$3,142	$5,389	$2,336	$4,033	$29,729
Alternative 4: Detention and Channel System	$789	$12,835	$183	$2,778	$4,977	$2,154	$3,896	$27,612
Scott Gulch								
Alternative 2: Open Channel System	$548	$6,465	$126	$4,363	$3,453	$1,495	$1,573	$18,023
Alternative 3: Open Channel System with overtopping of Bayou Gulch Rd	$546	$6,420	$125	$4,363	$3,438	$1,489	$1,573	$17,954
Alternative 4: Regional Detention System	$246	$4,086	$112	$720	$1,550	$671	$1,750	$9,135
Alternative 5: Regional Detention System with Raised Bayou Gulch Rd	$242	$3,999	$111	$720	$1,523	$659	$1,750	$9,004
Alternative 6: Enlarged Upstream Regional Detention System	$250	$4,093	$117	$785	$1,575	$683	$1,775	$9,278
Alternative 7: Detention and Channel System	$275	$4,736	$88	$681	$1,735	$751	$1,612	$9,878

TABLE 5-3
Alternative 4 Lemon Gulch Watershed, Detention and Channel System

Stream Reach	Detention	Bank Stabilization	Grade Control	Channel Grading	Infrastructure	Mobilization Costs	Drainageway Costs	Utility Costs	Land Acquisition	Contingencies (30%)	Engineering Administration and Legal Services (10%)	Operations and Maintenance	Reach Total
300-1	No Detention is proposed in this reach.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 20 check structures spaced approximately every 200 feet are required to stabilize the channel.	The channel must be widened to a bottom width of 120 feet from 65 feet.	The existing Crowfoot Valley Road Bridge is at the upstream limits. The bridge is adequately sized to pass the 100-year flow and no improvements are needed. The Parker Water and Sanitation access road crosses Lemon Gulch in the Cherry Creek floodplain, the bridge is adequately sized to pass the 100-year flow and no improvements are required.	$95,000	$1,654,000	$17,000	$237,000	$601,000	$260,000	$181,000	$3,045,000
300-2	No Detention is proposed in this reach.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 34 check structures spaced approximately every 250 feet are required to stabilize the channel.	The channel must be widened to a bottom width of 120 feet from 65 feet.	None.	$157,000	$2,679,000	$27,000	$427,000	$987,000	$428,000	$384,000	$5,089,000
300-3	No Detention is proposed in this reach.	No bank grading is proposed in this reach.	A total of 26 check structures spaced approximately every 200 feet and 6 grouted sloping boulder drop structures spaced every 400 feet are required to stabilize the channel.	The channel does not require widening.	None.	$51,000	$987,000	$10,000	$32,000	$324,000	$140,000	$348,000	$1,892,000
300-4	No Detention is proposed in this reach.	No bank grading is proposed in this reach.	A total of 22 grouted sloping boulder drop structures spaced approximately every 400 feet are required to stabilize the channel.	The channel does not require widening.	Driveway culverts in Castle Park Ranch will be overtopped in 2-year storms. Twin 72" Culverts under Lemon Gulch Drive require riprap protection, road will overtop during larger storm events. Riprap protection installed at culvert outfalls.	$100,000	$1,861,500	$19,000	$122,000	$631,000	$273,000	$428,000	$3,434,500
300-5	A 45 acre-foot pond is proposed.	No bank grading is proposed in this reach.	A total of 19 check structures spaced approximately every 250 feet are required to stabilize the channel.	The channel does not require widening.	None.	$80,000	$1,208,600	$12,000	$371,300	$502,000	$217,000	$336,000	$2,726,900
301-1	No Detention is proposed in this reach.	Channel banks are laid back to a 4:1 to meet criteria. Banks will be vegetated.	A total of 29 check structures spaced approximately every 250 feet are required to stabilize the channel.	The channel must be widened to a bottom width of 10 feet from 2 feet.	None.	$97,000	$1,318,000	$13,000	$604,000	$610,000	$264,000	$337,000	$3,243,000
301-2	No Detention is proposed in this reach.	Channel banks are laid back to a 4:1 to meet criteria. Banks will be vegetated.	A total of 9 check structures spaced approximately every 200 feet are required to stabilize the channel.	The channel must be widened to a bottom width of 10 feet from 2 feet.	Existing 42" CMP will overtop during larger storm event. Replace with 48" RCP.	$17,000	$177,000	$2,000	$153,000	$105,000	$45,000	$193,000	$692,000
302-1	A 46 acre-foot pond is proposed.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 24 check structures spaced approximately every 200 feet are required to stabilize the channel.	The channel does not require widening.	None.	$82,000	$1,338,000	$13,000	$289,800	$517,000	$224,000	$428,000	$2,891,800
303-1	A 15 acre-foot pond is proposed.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 7 check structures spaced approximately every 400 feet are required to stabilize the channel.	The channel does not require widening.	None.	$25,000	$427,500	$4,000	$71,400	$158,000	$69,000	$231,000	$985,900
304-1	No Detention is proposed in this reach.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	The channel does not require grade control.	The channel does not require widening.	None.	$4,000	$30,000	$3,000	$56,000	$28,000	$12,000	$90,000	$223,000
305-1	No Detention is proposed in this reach.	No bank grading is proposed in this reach.	A total of 10 check structures spaced approximately every 150 feet are required to stabilize the channel.	The channel does not require widening.	The undersized 48" CMP will result in overtopping of Lemon Gulch Drive, riprap stabilization is required.	$14,000	$258,900	$3,000	$27,000	$91,000	$39,000	$168,000	$600,900
306-1	A 17 acre-foot pond is proposed.	No bank grading is proposed in this reach.	A total of 30 check structures spaced approximately every 175 feet are required to stabilize the channel.	The channel does not require widening.	The undersized 36" CMP will result in overtopping of Lemon Gulch Drive, riprap stabilization is required.	$21,000	$329,500	$3,000	$85,400	$132,000	$57,000	$276,000	$903,900
307-1	A 13 acre-foot pond is proposed.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 13 check structures spaced approximately every 250 feet are required to stabilize the channel.	The channel does not require widening.	The undersized twin 30" CMP will result in overtopping of Lemon Gulch Drive, riprap stabilization is required.	$26,000	$331,600	$33,000	$157,900	$165,000	$71,000	$179,000	$963,500
308-1	No Detention is proposed in this reach.	Channel banks are laid back to a 3:1 to meet criteria. Banks will be vegetated.	A total of 4 check structures spaced approximately every 600 feet are required to stabilize the channel.	The channel does not require widening.	None.	$16,000	$167,000	$17,000	$144,000	$103,000	$45,000	$115,000	$607,000
309-1	No Detention is proposed in this reach.	No bank grading is proposed in this reach.	A total of 8 check structures spaced approximately every 500 feet are required to stabilize the channel.	The channel does not require widening.	None.	$4,000	$67,000	$7,000	$-	$23,000	$10,000	$202,000	$313,000
					Total	**$789,000**	**$12,834,600**	**$183,000**	**$2,777,800**	**$4,977,000**	**$2,154,000**	**$3,896,000**	**$27,611,400**



MAPPING PRODUCED BY:DOUGLAS COUNTY (DATE 2003)
HORIZONTAL DATUM: NAD 83 FEET
STATE PLANE COLORADO CENTRAL
VERTICAL DATUM: NAVD 88

CH2M HILL
9193 SOUTH JAMAICA STREET
ENGLEWOOD, CO 80112

DESIGNED	CH	DATE	4/06
DRAWN	MM	DATE	4/06
CHECKED	BC	DATE	4/06
REVISED	MM	DATE	6/06

DOUGLAS COUNTY
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

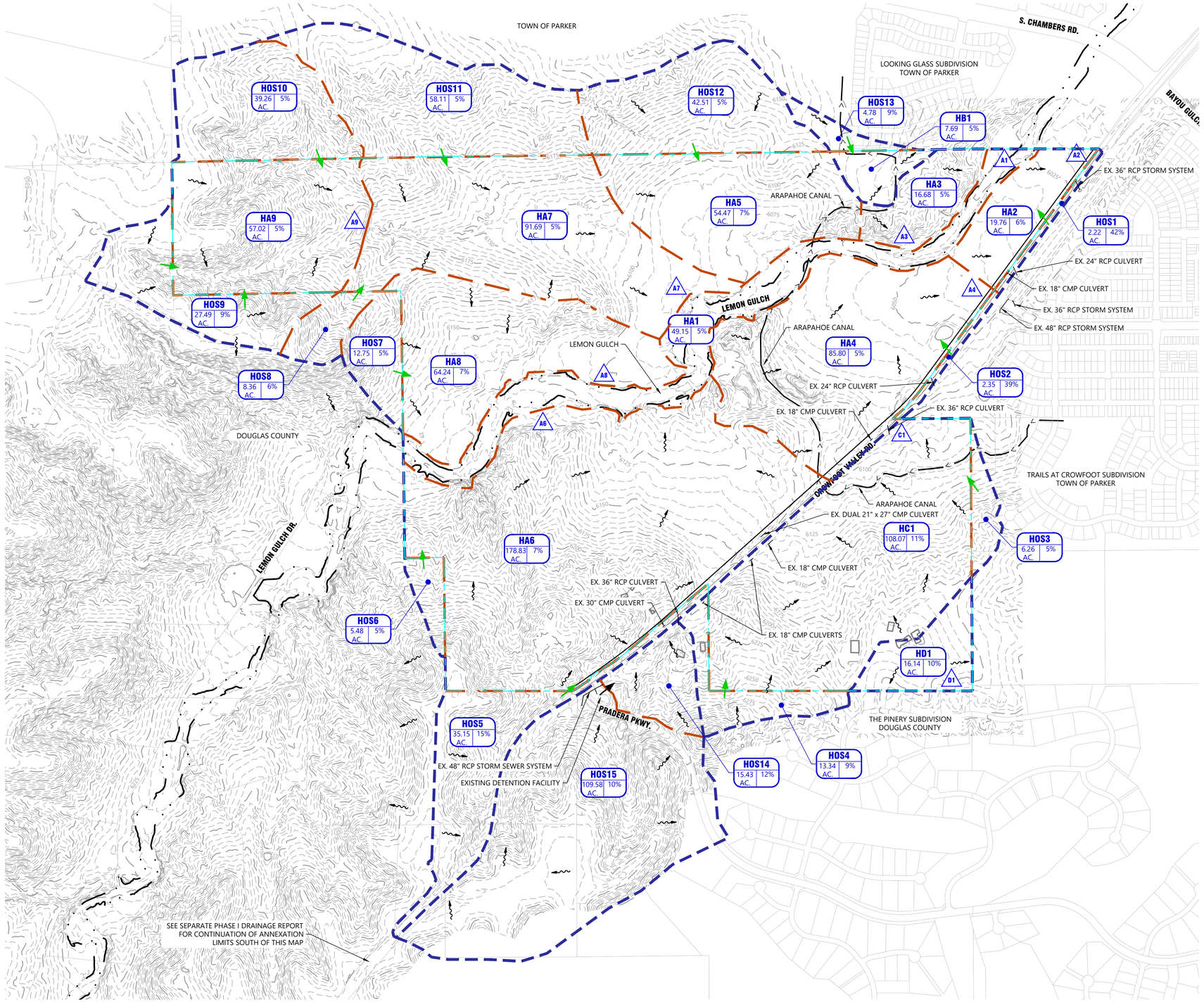
SCOTT GULCH AND LEMON GULCH WATERSHEDS
OUTFALL SYSTEM PLANNING

FIGURE 5-1
SELECTED PLAN
LEMON GULCH WATERSHED, 4618

lemalt4a.dlv

Appendix D. Drainage Maps

D1 Existing Drainage Map



LEGEND

- Property Line
- Right of Way Line
- Centerline
- Lot Line
- Easement Line
- Major Basin Boundary
- Minor Basin Boundary
- Flow Arrow
- Name / Area AC. / Imp. % — Existing Basin Designation
- 1 — Design Point
- 5280 — Existing Major Contour
- Existing Minor Contour
- Off-Site Flow Into Site
- FEMA Zone A

Calculated Existing Runoff Rates

Basin ID	Total Area (Ac.)	Comp. Imp. (%)	Peak Flow (cfs) Q_5	Peak Flow (cfs) Q_{100}
HA1	49.15	5%	0.42	9.74
HA2	19.76	6%	0.61	11.41
HA3	16.68	5%	0.96	19.56
HA4	85.80	5%	20.85	125.53
HA5	54.47	7%	21.24	104.71
HA6	178.83	7%	74.53	367.45
HA7	91.69	5%	27.09	137.17
HA8	64.24	7%	38.08	149.30
HA9	57.02	5%	25.14	104.88
HB1	7.69	5%	2.73	11.56
HC1	108.07	11%	37.53	166.18
HD1	16.14	10%	10.69	39.66
OS1	2.22	42%	2.54	9.08
OS2	2.35	39%	2.58	9.70
OS3	6.26	5%	1.04	6.61
OS4	13.34	9%	9.70	37.02
OS5	35.15	15%	12.61	46.99
OS6	5.48	5%	2.20	9.19
OS7	12.75	5%	7.92	31.66
OS8	8.36	6%	3.83	15.51
OS9	27.49	9%	9.81	39.67
OS10	39.26	5%	16.62	69.50
OS11	58.11	5%	31.48	127.23
OS12	42.51	5%	22.31	106.26
OS13	4.78	9%	1.95	7.67
OS14	15.43	12%	8.23	30.37
OS15	109.58	10%	45.28	178.18

500 0 250 500
SCALE
1 inch = 500 ft.

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No.	Rev. Date:	Revision Type:
1	11/04/2025	1st Submittal
2	02/09/2026	2nd Submittal
3	02/17/2026	3rd Submittal
4	02/24/2026	4th Submittal
5	03/10/2026	5th Submittal
6		

Designed: RMW
Prepared: RMW
Approved: KRL

Job No.: 4080-0001
Scale Horiz: 1" = 500'
Scale Vert: N/A

Sheet: 1 of 2
Date: November 4, 2025

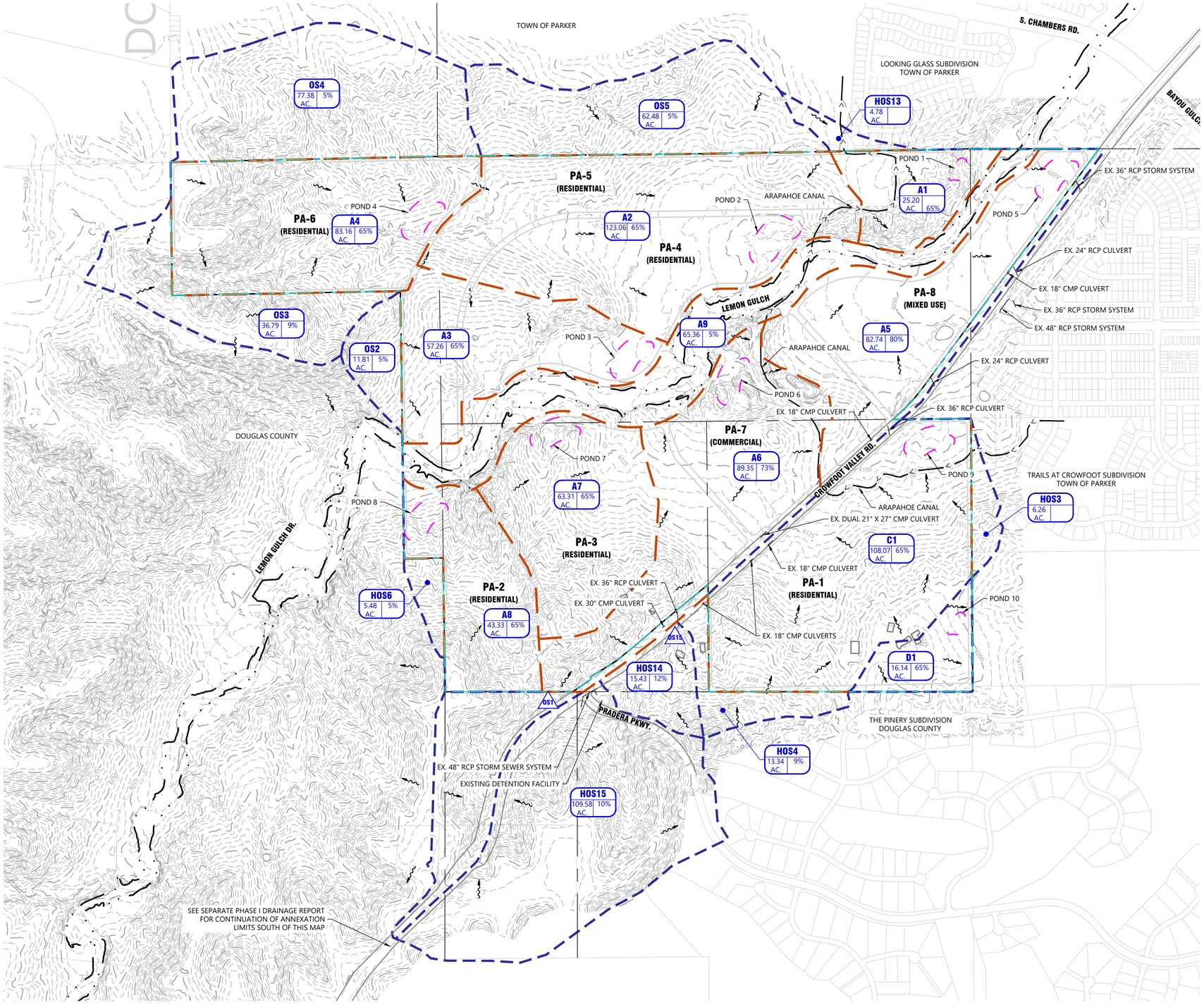
Proj. Name: Crowsnest Phase I Drainage Report
Location: Douglas County, CO
Plan Set: Drainage Maps
Sheet Name: Existing Drainage Map

Know what's below.
Call before you dig.

No. 1

I:\JOB FOLDERS\4080\4080-0001\CIVIL\PROD\DRAINAGE - MAIN SITE\EX DRAINAGE MAP PRINTED ON: 3/9/2026 10:46 AM

D2 Conceptual Drainage Map



LEGEND

- Property Line
- Right of Way Line
- Centerline
- Lot Line
- Easement Line
- Major Basin Boundary
- Minor Basin Boundary
- Flow Arrow
- Name (Area AC. | Imp. %) — Proposed Basin Designation
- Design Point
- Existing Major Contour
- Existing Minor Contour
- FEMA Zone A
- Detention Pond
- Individual Planning Area Boundary

Proposed Runoff Rates

Basin ID	Total Area (Ac.)	Comp. Imp. (%)	Peak Flow (cfs) Q_5	Peak Flow (cfs) Q_{100}
A1	25.20	65%	39.04	85.73
A2	123.06	65%	203.23	447.46
A3	57.26	65%	89.93	198.07
A4	83.16	65%	138.96	304.53
A5	82.74	80%	122.11	252.14
A6	89.35	73%	134.33	286.24
A7	63.31	65%	106.84	233.66
A8	43.33	65%	68.65	150.85
A9	65.36	5%	8.26	36.44
C1	108.07	65%	174.69	385.07
D1	16.14	65%	27.22	59.39
OS1	32.30	15%	12.47	43.04
OS2	11.81	5%	7.54	27.01
OS3	36.79	9%	21.17	74.10
OS4	77.38	5%	33.12	126.54
OS5	62.48	5%	25.26	96.84
HOS3	6.26	0.05	1.04	6.61
HOS4	13.34	0.09	9.70	37.02
HOS6	5.48	0.05	2.20	9.19
HOS13	4.78	0.09	1.95	7.67
HOS14	15.43	0.12	8.23	30.37
HOS15	109.58	0.10	45.28	178.18

NOTE: PEAK FLOWS DEVELOPED WITH CUHP v2.0.1

Detention Pond Volume Table

Basin ID	Pond	V_{100} (ac-ft)
A1	Pond 1	2.927
A2	Pond 2	14.167
A3	Pond 3	6.446
A4	Pond 4	9.362
A5	Pond 5	11.406
A6	Pond 6	11.539
A7	Pond 7	7.450
A8	Pond 8	4.878
A9	N/A	N/A
C1	Pond 9	12.442
D1	Pond 10	1.817

SCALE
1 inch = 500 ft.

500 0 250 500

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5	03/10/2026	5th Submittal
6		

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No. 2

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