THE ACADEMY AT MAPLETON HILL
PRELIMINARY STORMWATER REPORT

AT

311 MAPLETON AVENUE
BOULDER, CO 80303

FOR

MAPLETON HILL INVESTMENT GROUP

August 1, 2016

CONSULTING ENGINEERS

JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
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August 1, 2016

Mr. Edward Stafford,
Development Review Manager
City of Boulder - Planning and Development Services
1739 Broadway, Third Floor
P.O. Box 791
Boulder, CO 80306-0791

RE: Preliminary Stormwater Report – The Academy at Mapleton Hill
311 Mapleton Avenue
JVA No. 2462.1c
City of Boulder LUR2015-00071

Edward:

The *Preliminary Stormwater Report* and drainage maps for the above referenced project have been produced in accordance with the "City of Boulder Design and Construction Standards, 2000 Edition" and comply with the provisions thereof.

It is our understanding that the information provided herein meets all requirements of the City of Boulder. This report is being included as part of a formal Site Review submittal to the City for the Academy at Mapleton Hill project.

Please contact us if you have any questions regarding this submission.

Sincerely,
JVA, Inc.

Robin L. Kriss, P.E.
Project Engineer

CONSULTING ENGINEERS

ENGINEER'S STATEMENT:

"I hereby certify that this report and plan for the preliminary stormwater design of the Academy at Mapleton Hill was prepared by me (or under my direct supervision) in accordance with the provisions of the City of Boulder Design and Construction Standards, 2000 Edition, and was designed to comply with the provisions thereof. I understand that the City of Boulder does not and shall not assume liability for drainage facilities designed by others."

_____

Charles R. Hager IV, P.E.
Registered Professional Engineer
State of Colorado No. 37146

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JVA Inc. Project No. 2462.1c
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PRELIMINARY STORMWATER REPORT
THE ACADEMY AT MAPLETON HILL

INTRODUCTION

GENERAL LOCATION AND DESCRIPTION

Mapleton Hill Development Group proposes to redevelop the former Mapleton Medical Complex located at 311 Mapleton Avenue in Boulder, Colorado. The property is bound by 4th Avenue to the east, Mapleton Avenue to the south, Trail Head residential subdivision to the north and City of Boulder (City) Open Spaces and Mountain Parks (OSMP) property to the west. The Silver Lake Ditch runs along a majority of the western property line. The subject property is a 15.77-acre parcel of land located in the west half of Section 25, Township 1 North, Range 71 West of the 6th Principal Meridian, City and County of Boulder, Colorado. A vicinity map depicting the location of the property is included in Appendix A.

The current use of the property is primarily for a medical hospital building and several small medical office buildings and garages/storage buildings that have been constructed in phases over many years. The medical facilities continued to use some of the structures that supported the original farm previously located on the property. The following is a list of addressed buildings currently located on the site:

- 311 Mapleton Avenue (the site's primary building)
- 331 Mapleton Avenue
- 2505 4th Street
- 2525 4th Street
- 317 Maxwell Avenue
- 345 Maxwell Avenue
- 353 Maxwell Avenue
- 365 Maxwell Avenue
- 391 Maxwell Avenue

To the west of the site the land rises into open space with steep slopes. The site offers pedestrian access to the Sanitas hiking trails on City OSMP property via unpaved trails to two separate pedestrian bridges over the Silver Lake Ditch. The existing property and locations of its various structures is depicted on Figure 1.0, Historic Drainage Map.

PROPOSED PROJECT – "THE ACADEMY AT MAPLETON HILL"

The proposed development, "The Academy at Mapleton Hill," (AMH) will be a congregate care facility focused on retirement and senior living. The finished development will provide independent living facilities, assisted living facilities, short and long term rehabilitation and a memory care unit. The majority of the structures on the property will be demolished. However, the existing hospital building, also referred to as 311 Mapleton Ave, will be remodeled and two of the property's oldest structures at 331 Mapleton Avenue and 345 Maxwell Avenue will be preserved. The medical facility building at 2525 4th Street will be left in place with minor improvements to its adjacent parking areas. Other new development to support the AMH will

include landscaped yards, pedestrian plazas, parking lots, access drives, sidewalks and other various landscaping improvements. Pedestrian access through the property to existing hiking trails to the north and west will be left in place. The existing trails will continue to be part of the Sanitas trail network that is maintained by the City. Refer to the City OSMP mapping of Centennial/Sanitas in Appendix A.

The AMH property will continue to convey stormwater runoff from City OSMP property. In general, offsite runoff originates from the Dakota Ridge and sheetflows in an easterly direction across the Silver Lake Ditch and across the AMH property. Figure 1.0, Historic Drainage Map, summarizes the current drainage conditions of the site and the offsite drainage areas that contribute runoff to the AMH property.

The proposed drainage design will generally follow historic patterns with runoff from the site shedding towards Mapleton Avenue, 4th Street and neighboring properties to the northwest and northeast. Stormwater quality best management practices (BMPs) will be introduced to the AMH property in the form of detention and water quality (D/WQ) ponds, permeable pavers and below grade water quality units (BGWQUs). Refer to Figures 2.0 and 2.1, the Proposed Drainage Maps, for locations of the proposed BMP's on the site.

The limits of drainage study for this report include the 15.8-acre AMH property and an additional 3.5 acres of surrounding areas for a total of 19.3 acres. The current imperviousness of the AMH property is 53.2%. Development of the site is expected to increase the imperviousness by 5.5% to a total imperviousness of 58.7%

The D/WQ ponds will be sized to maintain current, historic runoff conditions from the site. Water quality outlet structures will be installed at each D/WQ pond to control the release rates of the developed conditions down to historic or allowable release rates documented by surrounding properties. In particular, runoff to the north that outfalls to the Trailhead Subdivision will be restricted to allowable release rates described by the Final Drainage Report for the Trailhead Subdivision (Trailhead Report) by JVA Inc., dated April 12, 2013. Excepts of the Trailhead Report are included in Appendix C.

Historic Drainage

Major Drainage Basin Description

The project site is located within the Goose Creek sub-basin that is part of the Boulder Creek watershed. The project site is located near the Dakota Ridge, the western, upstream boundary of the Goose Creek sub-basin. Storm water runoff is conveyed from the site via sheetflow to the surrounding properties and streets to the south, east and north. As the site is located near the top of the watershed, there are no major drainage ways through the site.

A small southwest portion of the site is located within the 100-year floodplain that rises from the Sanitas and Sunshine creeks. Floodplain limits have been confirmed on both City Flood Hazard mapping and Federal Emergency Management Agency (FEMA) mapping, included in Appendix A. FEMA FIRM panel and City Flood Hazard mapping appear to be consistent with one another.

A floodplain development permit with the City of Boulder will be required for proposed improvements and structures near the southwest corner of the property within the floodplain shown in Figure 2.0, Proposed Drainage Map – South.

Site Drainage and Existing Facilities

The Mapleton Hill Academy (MHA) property is approximately 15.8 acres with 53.3% imperviousness. It lies between 5459 and 5586 feet in elevation on the City of Boulder Datum (NAVD88). Slopes on the site vary widely depending on location and development within the site. Undeveloped areas near the western edge of the property are steep with horizontal to vertical ratios ranging from 10:1 to 2:1, with more typical slopes of 4:1. The site's development is benched into flatter areas ranging from two percent (2%) to seven percent (7%) slope in paved areas with some steeper landscaped areas reaching the ten to twenty percent (10% to 20%) range.

The majority of the soils found on the site are terrace escarpments with a Natural Resources Conservation Service (NRCS) hydrologic soils group (HGS) of A. Soils with an HSG of A have a very high infiltration rate when thoroughly wet and therefore have low runoff potential. A copy of the NRCS mapping for the site is included in Appendix A.

The site is generally sloped from west to east. As runoff enters the site from the west, it is shed primarily to the east and northeast, 4th Street and Trailhead Subdivision, respectively. Some portions of the site sheetflow to the south, towards Mapleton Avenue. Runoff is conveyed from the site to surrounding areas via combinations of sheetflow over landscaped lawns and curb and gutter flow where drives are connected to surrounding streets. The site has no documented public storm sewer network to public streets. Nor are there any public storm sewers in the surrounding rights-of-way in Mapleton Avenue or 4th Street. There is a small section of public storm sewer that conveys runoff from the northwest area of the site to an offsite public detention and water quality pond located near the southern boundary of Trailhead Subdivision (Trailhead Pond).

It is assumed that the capacity of the Silver Lake Ditch is limited to the runoff of the 2-year storm event. Therefore, the ditch's potential for stormwater interception is ignored for the calculated runoff in larger storm events.

Existing Site Basins

The existing site is broken into several basins to characterize the impact of offsite basins flowing into the site and the existing impact of runoff from the site to surrounding, downstream areas. The basin delineations are shown on Figure 1.0, Historic Drainage Map with corresponding design points for each basin. There are several onsite and offsite basins to characterize the AMH property and surrounding areas:

- H1 corresponds to design point (DP) 1. This basin represents an area of the site that has gutter flow and sheetflow to Mapleton Avenue. Gutter flow in Mapleton Avenue is directed to an existing inlet. It has been assumed that the inlet outfalls into the Sanitas Creek. Further investigation is required to confirm the outfall. Basin H1 primarily consists of roof areas from the main hospital building, drives, parking area and landscaped areas with mature trees.
- H2 corresponds to DP 2. This basin represents an area of the site that has gutter flow and sheetflow to 4th Street. Basin H2 primarily consists of roof areas and parking facilities that surround the main hospital building with some mature landscaped and undeveloped, native areas. Basin H2 receives offsite runoff from the Basin OS1.

- H3 corresponds to DP 3. This basin represents an area of the site that is conveyed to AMH property's only public storm sewer. The storm sewer outfalls to the Trailhead Pond. Basin H3 consists of steep native areas, parking lots, roof areas, walks, public trails and steep private driveways between parking areas.
- H4 corresponds to DP 4. This basin represents an area of the site that is conveyed by sheetflow to the southwest corner of Trailhead Subdivision, represented by Basin OS3. Basin OS3 conveys runoff from basin H4 to the Trailhead Pond. Basin H4 consists of steep native area, parking lots, roof areas, walks, public trails and steep private driveways between parking areas.
- H5 corresponds to DP 5. This basin represents an area of the site that is directly conveyed via sheetflow and gutter flow to Trailhead Pond. Basin H5 consists of steep native area, roof area, landscaped area and parking lot.
- H6 corresponds to DP 6. This small basin represents an area of the site that is conveyed by sheetflow to the Boulder Seventh Day Adventist Church. Basin H6 is exclusively landscaped lawn with mature trees.
- H7 and H8 correspond to DP 7 and DP 8, respectively. These basins represent an area of the site that are developed and outfall to 4th Street.
- OS1 corresponds to DP 9. This basin represents an area of the site that will sheetflow from City OSMP property into Basin H2. Basin OS1 is exclusively undeveloped area of the site
- OS2 corresponds to DP 10. This basin represents an area of the site that will sheetflow from City OSMP property into Basins H3, H4 and OS3. Basin OS1 is exclusively relatively undeveloped area characterized by gravel trails to Dakota Ridge.
- OS3 corresponds to DP 11. This basin represents the southwest corner of the Trailhead Subdivision that conveys runoff to the Trailhead Pond.
- OS4 and OS5 correspond to DP 12 and DP 13, respectively. These basins represent offsite areas in 4th Street and consist of fully developed right-of-way.

Design Points 1, 6, 11 and 13 on Figure 1.0, Historic Drainage Map, represent the stormwater outfalls from the existing conditions of the analyzed site for this report:

- DP 1 represents the site's total runoff to Mapleton Avenue. The routed peak flow (Q) to DP1 is 19.2 cubic feet per second (cfs) in the major, 100-year storm event (100) and receives storm water runoff from Basin H1.
- DP 6 represents the site's total runoff to the Boulder Seventh Day Adventist Church property. The peak flow during the 100-year storm event (Q100) will be 0.7 cfs. DP 6 receives storm water runoff exclusively from Basin H6.
- DP 11 represents the site's total runoff to the Trailhead Pond. Routed flow to DP 11 includes runoff from Basins H3, H4, H5, OS2 and OS3. Routed Q100 to DP 11 is 46.5 cfs.
- DP 13 represents the site's total runoff to 4th Street at the northeast corner of the AMH property. Routed flow to DP 13 includes Basins H2, H7, H8, OS1, OS4 and OS5. Routed Q100 to DP 13 is 46.3 cfs.

The historic flow rates of the above design points will be compared to the proposed design points at the same locations to determine required detention at various points in the proposed development.

Individual, direct runoff for each basin for both the minor and major storm events are summarized in the calculations in Appendix B and on Figure 1.0, Historic Drainage Map. The total estimated Q100 from the AMH 15.8-acre property is 112.2 cfs, and the total estimated Q100 from the entire 19.3-acre site is 130.8 cfs.

Conformance With Previous Drainage Study – Trailhead Subdivision

The final stormwater report for the Trailhead Subdivision, dated April 12, 2013, produced by JVA Inc., details the allowable release from the AMH property into the Trailhead Pond. Excerpts of the Trailhead Report are included in Appendix C. The Trailhead Pond was designed to provide stormwater quality treatment the Trailhead development but allows for pass through flow for up to the 100-year storm event from the developed conditions of the AMH property. A small amount of detention for the 5-year event for Historic Basins H5 and H8 (a.k.a. Historic Basins H-II and H-III in the Trailhead Report) is provided in the Trailhead Pond.

The Trailhead Pond is designed to accept flows from historic Basins H3, H4, H5, OS2 and OS3, equivalent to the Trailhead Report's proposed basin "H-C." The anticipated peak runoff to historic DP 11 (Trailhead Report, DP 16) for the 5-year storm event (Q5) was 15.04 cfs. The anticipated Q100 to historic DP 11 was 48.14 cfs. The detention pond that will be located in proposed Basin C will be designed to limit the peak flows to the Trailhead Pond in conformance with Trailhead Report.

Proposed (Developed) Drainage

Drainage Design Criteria

The proposed storm drainage facilities for the project are designed to comply with the "City of Boulder Design and Construction Standards," 2000 Edition, and the Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual (USDCM), June 2001 Edition, updated January 2016.

Hydrologic Method and Design Storm Frequencies

Design storm recurrence intervals for this project are consistent with the City of Boulder requirements for commercial/industrial areas; the minor storm will be the 5-year event and the major storm will be the 100-year event.

The Rational Method (Q=CIA) was used to determine the storm runoff (Q) from the site, with composite runoff coefficients (C) and contributing areas (A) given for design points in sub-basins. Intensities (I) were determined using the Time-Intensity-Frequency Curves for Boulder, Colorado (Figure 7-1) and a calculated Time of Concentration (t_c). Post-development Time of Concentration calculations for each sub-basin, corresponding rainfall intensities, and composite runoff coefficients for each sub-basin are provided in Appendix B.

Detailed calculations for the storm system, inlet and outlet structures, and roadway gutters or swales will be included with the *Final Stormwater Report*. The design for the private onsite storm system for the Academy at Mapleton Hill will be developed and complete storm system design

plans and details will be included in the final engineering plans which will be submitted and approved by the City of Boulder prior to issuance of a development permit.

PROPOSED SITE BASINS

The major basin boundary for the proposed drainage conditions includes the same boundary as the historic analysis. Refer to Figures 2.0 and 2.1, Proposed Drainage Map – South and Proposed Drainage Map – North. There are thirteen sub-basins to characterize the drainage design for the Academy at Mapleton Hill development, of which eight are within the property (Basins A, B1, B2, C, D1, D2, D3, E) and five are offsite basins (Basins OS1, OS2, OS3, OS4 and OS5). None of the offsite basins will be altered from historic conditions by proposed construction. The design approach addresses the onsite drainage needs for the proposed conditions of the AMH and intends to maintain historic or allowable peak runoff conditions towards historic DPs 1, 6, 11 and 13.

Basin A corresponds to DP 1. The drainage pattern of Basin A will be analogous to historic Basin H1 and historic DP 1 as its runoff will be shed towards Mapleton Avenue. Runoff from Basin A will be directed via sheet runoff, swales and storm drainage piping to a D/WQ Pond prior to discharging into the back of an existing inlet in Mapleton Avenue.

Basins B1 and B2 correspond to DPs 2 and 3 respectively. The drainage pattern of Basins B1 and B2 will be analogous to historic Basin H2, with their runoff being directed to 4th Street. However, runoff from Basin B1 will be directed to a new D/WQ Pond that will control its release into Basin OS5 rather than OS4. Runoff in Basin B1 will be directed via sheet runoff, street gutters, concrete pans and storm sewer network to the D/WQ Pond B. Runoff from Basin B2 will be directed towards Basin OS4 in 4th Street similar to the historic drainage pattern, however, underground water quality units will be installed to intercept the WQCV. The WQCV will be discharged via underground storm sewer network to the downstream public storm sewer system in 4th Street near Concord Avenue.

Basin C corresponds to DP 4. The drainage pattern of Basin C will be analogous to historic Basins H3 and H4 with respect to the runoff from Basin C being directed toward the public storm sewer that outfalls into Trailhead Pond. Runoff in Basin C will be directed to the D/WQ Pond C via sheet runoff, street gutters and storm sewer networks.

Basin D1 corresponds to DP 5. The drainage pattern of Basin D1 will be very similar to historic Basin H5. Much of the historic, developed conditions of Basin D1 will be unchanged by proposed construction. The change in basin boundary from H5 to D1 is due to the proposed construction of retaining walls. Runoff from Basin D1 will outfall into Trailhead Pond similar to historic conditions.

Basins D2 and D3 correspond to DPs 6 and 7, respectively. Surface features in Basin D2 and D3 will be relatively unchanged by construction, however, controlled release from Basin B1 will be discharged through Basin D2 and back into Basin OS5. Basins D2 and D3 will be analogous to historic Basins H7 and H8, respectively, with drainage patterns directed to Basin OS5 in 4th Street.

Basin E corresponds to DP 8. The drainage pattern of Basin E will be similar to historic Basin H6. Basin E surface features will be similar to historic conditions, however, the basin will be much smaller in size. Runoff from the AMH property towards the Boulder Seventh Day Adventist Church will be reduced slightly from a Q100 of 0.7 cfs to 0.4 cfs.

Basins OS1, OS2, OS3, OS4 and OS5 surface features will be unchanged from historic conditions.

RUNOFF AND STORMWATER QUALITY ENHANCEMENT FACILITIES

Figures 2.0 and 2.1, Proposed Drainage Map – South and Proposed Drainage Map – North, respectively, summarize the design points associated with each of the Basins within the drainage study area. Calculations showing how the peak runoff rates were determined are included in Appendix B and summarized in the tables on Figure 2.0.

Stormwater quality will be improved throughout the AMH property with the introduction of a variety of water quality BMPs including; Detention and Water Quality Ponds (D/WQ Ponds), underground water quality units and porous paver systems.

The D/WQ pond and WQOS in Basin A will be straightforward in its design approach. WQCV was computed using the latest UDFCD BMP spreadsheets for an Extended Detention Basin (EDB). WQOS will be designed for a 40 hour drain time, consistent with UDFCD recommendations. The detention was sized based on reducing peak runoff from Basin A from proposed runoff conditions to historic DP 1. In summary, the detention will reduce the peak runoff from the 10-year event (Q10) from 15.4 cfs to 10.7 cfs and the Q100 from 26.0 cfs to 19.2 cfs. Consistent with City of Boulder drainage design requirements, the WQCV is added to the 10-year storm detention volume and half (50%) of the WQCV is added to the 100-year detention volume.

The approach to design the D/WQ pond and WQOS in Basin B1 is similar to Basin A's except that additional detention volume was added in order to "overdetain" for uncontrolled release/runoff from Basin B2. Routed runoff from Basins OS1, B1, B2, D2, D3, OS4 and OS5 to DP 13 was compared to the same historic DP 13 for historic routed flows from Basins OS1, H2, H7, H8, OS4 and O5. The allowable release rate from D/WQ Pond B will reduce the Q100 peak flow directed to it from 40.2 cfs to 33.9 cfs. The resulting Q100 to DP 13 will be 46.3 cfs, which matches the historic peak flow of the same location.

The D/WQ Pond C in Basin C, near the Trailhead Pond took a similar design approach as D/WQ Pond B. Routed runoff from proposed Basins OS2, OS3, C, and D1 to DP 11 was compared to the routed runoff from historic Basins OS2, OS3, H3, H4 and H5 to historic DP 11. The allowable release rate from D/WQ Pond C will reduce the Q100 peak flow directed to it from 49.3 cfs to 39.8 cfs. The resulting Q100 to DP 11 will be 43.3 cfs, which is less than the historic Q100 of 46.5 cfs and significantly less than the allowable peak flow of 48.1 cfs budgeted by the Trailhead report for discharge to this location.

Detention and water quality outlet control structures for each of the proposed ponds will be designed and detailed in the Final Drainage Report for this project.

STREETS

The intent of the D/WQ Pond design for Ponds A, B is to control discharge from the site and to reduce or maintain historic peak flows to Mapleton Avenue and 4th Streets. Streets within the AMH property will be privately owned and maintained.

Private streets will be designed to convey the 100-year storm event with any overtopping limited to elevations less than finished floor elevations of adjacent buildings or other occupied structures.

Open Channel Flow

Sidewalk chase drains will be installed downsteam from the discharge from Pond B after it outfalls over a lawn area in Basin D2. Calculations to size the sidewalk chase drains will be included in the final drainage report.

Storm Sewers and Culverts

In general, any proposed public storm systems will be designed to convey the minor (5-year) storm event without surcharging. Detailed calculations will be provided with the *Final Stormwater Report* and complete final engineering plans.

Any public storm sewers located within city right-of-way or a public drainage easement will dedicated to the City of Boulder where it is outside the public right-of-way.

Stormwater Management Plan

The Stormwater Management Plan (SWMP) will be included in the final engineering plans, with all structural and non-structural Best Management Practices (BMP's) shown as required.

Structural BMP's

Temporary structural erosion control features will be established during overlot grading and prior to the building construction. All erosion control measures will be maintained until vegetation becomes established. Vehicle tracking control and inlet protection BMP's will be included on the construction plans. Silt fencing will be installed at critical locations on the site with respect to existing and proposed drainage.

Non-Structural BMP's

Non-structural erosion controls, including project schedule, surface roughening and other pollution prevention measures, will be detailed in the construction activities of the SWMP. Permanent, perennial, native seeding will be established onsite in locations specified by the SWMP and Landscape Architect. The seed mix will be provided in the SWMP reference.

Groundwater

Continued geotechnical exploration will be necessary to determine groundwater elevations at the project site. Current investigation has indicated that no groundwater is present where underground infrastructure and basements will be installed, however, the investigation was conducted at a time when the Silver Lake Ditch was not flowing. At this time, it is not expected that proposed buildings will have below grade occupied in zones of groundwater.

Wetland Impacts

There are no wetlands within or adjacent to the site. Therefore, no wetland impacts are proposed with this development.

Irrigation Ditches

The Silver Lake Ditch runs along the majority of the western property line. The irrigation ditch is located on the uphill side of the property and does not receive runoff from the AHM site.

Therefore, no impacts are proposed to the irrigation ditch with this development. The AMH project proposes to maintain the existing, hiking trails to two pedestrian bridges over the Silver Lake Ditch into the City OSMP. No improvements are proposed to the bridges crossing the ditch or the existing ditch banks.

CONCLUSION

The drainage facilities for the development of the Academy at Mapleton Hill have been designed in accordance with the City of Boulder Design and Construction Standards, 2000 Edition, the latest methods endorsed the by the Urban Drainage and Flood Control District. The anticipated drainage from the development of the Academy at Mapleton Hill development is designed to maintain existing runoff conditions to prevent adverse conditions on the adjacent properties and surrounding public storm systems.

Storm improvements include three separate detention and water quality ponds with controlled releases to surrounding streets and the neighboring property to the north, Trailhead Subdivision. Other water quality BMP's introduced to the site include underground water quality units and porous paver systems.

The referenced drainage maps, Figure 2.0 and Figure 2.1, depict the drainage design points, developed runoff basins, porous paver systems, detention and water quality ponds and configuration of the proposed storm drainage system.

REFERENCES

1. "City of Boulder Design and Construction Standards," 2000 Edition.
2. "Urban Storm Drainage Criteria Manual," Urban Drainage and Flood Control District, updated January 2016.
3. Web Soil Survey, Natural Resources Conservation Service, United State Department of Agriculture, Online at http://websoilsurvey.nrcs.usda.gov, accessed July 1, 2016.
4. City of Boulder Flood Hazard Mapping, Online at http://gisweb.bouldercolorado.gov/flood-zones, accessed July 1, 2016.

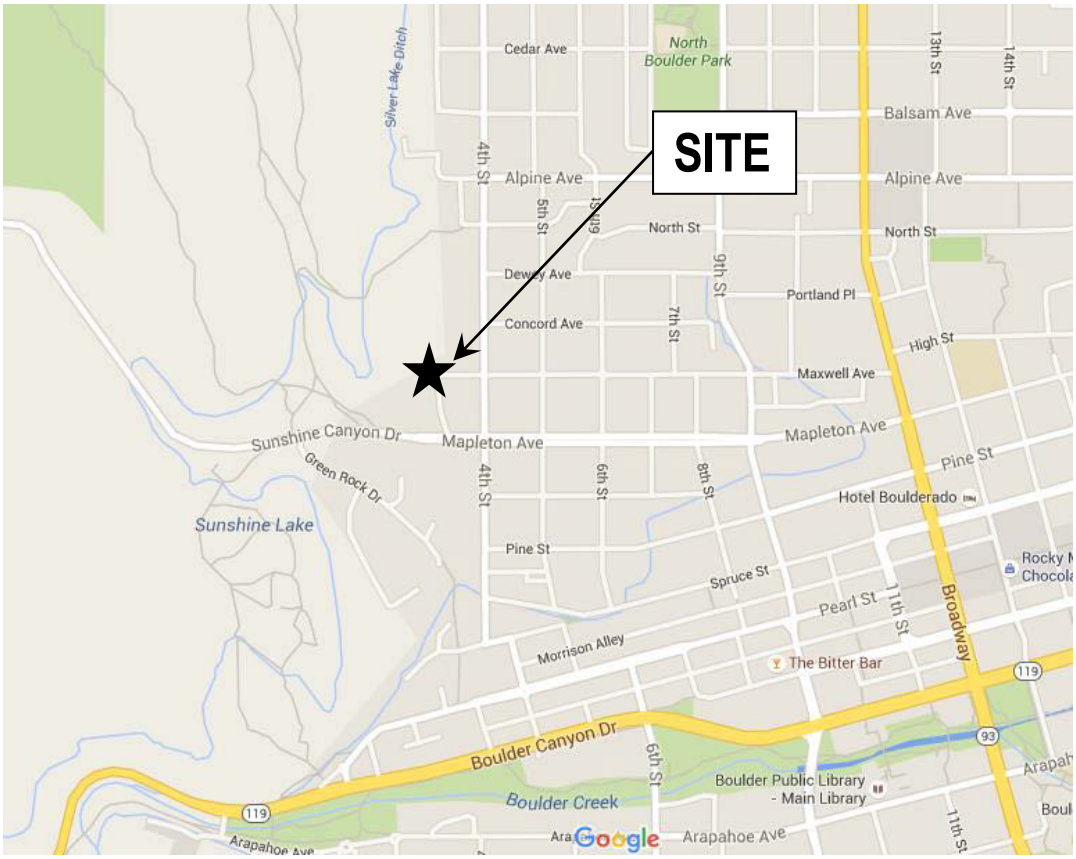
APPENDIX A – MAPPING AND FLOODPLAIN INFORMATION

MAPLETON HILL

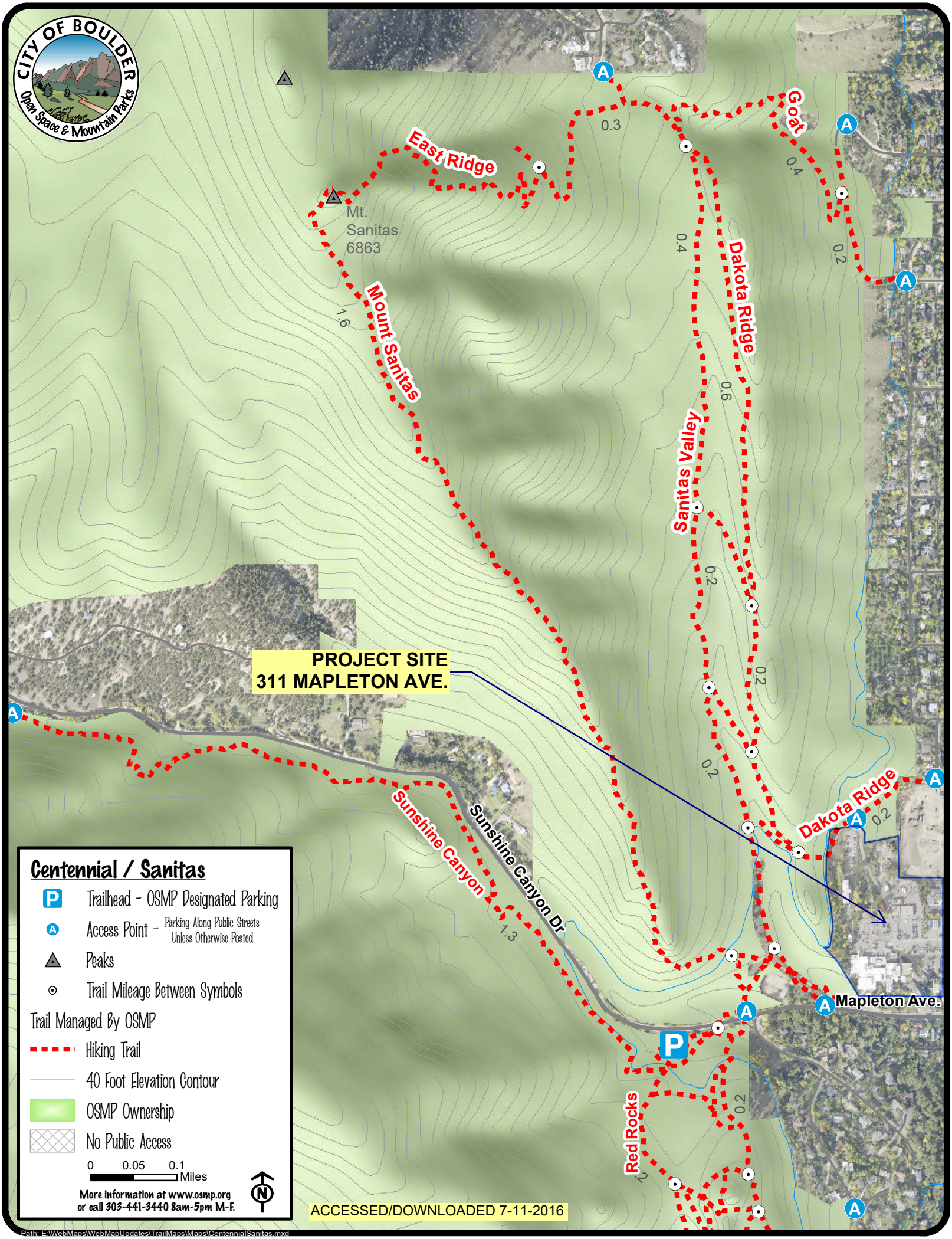
AT

MAPLETON AVENUE & 4TH STREET

BOULDER, COLORADO



VICINITY MAP – NOT TO SCALE


CITY OF BOULDER
Open Space & Mountain Parks
East Ridge
Mt. Sanitas 6863
Mount Sanitas
Goat
Dakota Ridge
Sanitas Valley
PROJECT SITE
311 MAPLETON AVE.
Sunshine Canyon
Sunshine Canyon Dr
Dakota Ridge
Mapleton Ave.
Red Rocks
0.3
0.4
0.2
1.6
0.6
1.3
Centennial / Sanitas
Trailhead - OSMP Designated Parking
Access Point - Parking Along Public Streets Unless Otherwise Posted
Peaks
Trail Mileage Between Symbols
Trail Managed By OSMP
Hiking Trail
40 Foot Elevation Contour
OSMP Ownership
No Public Access
0 0.05 0.1 Miles
More information at www.osmp.org or call 303-441-3440 8am-5pm M-F.
N
ACCESSED/DOWNLOADED 7-11-2016
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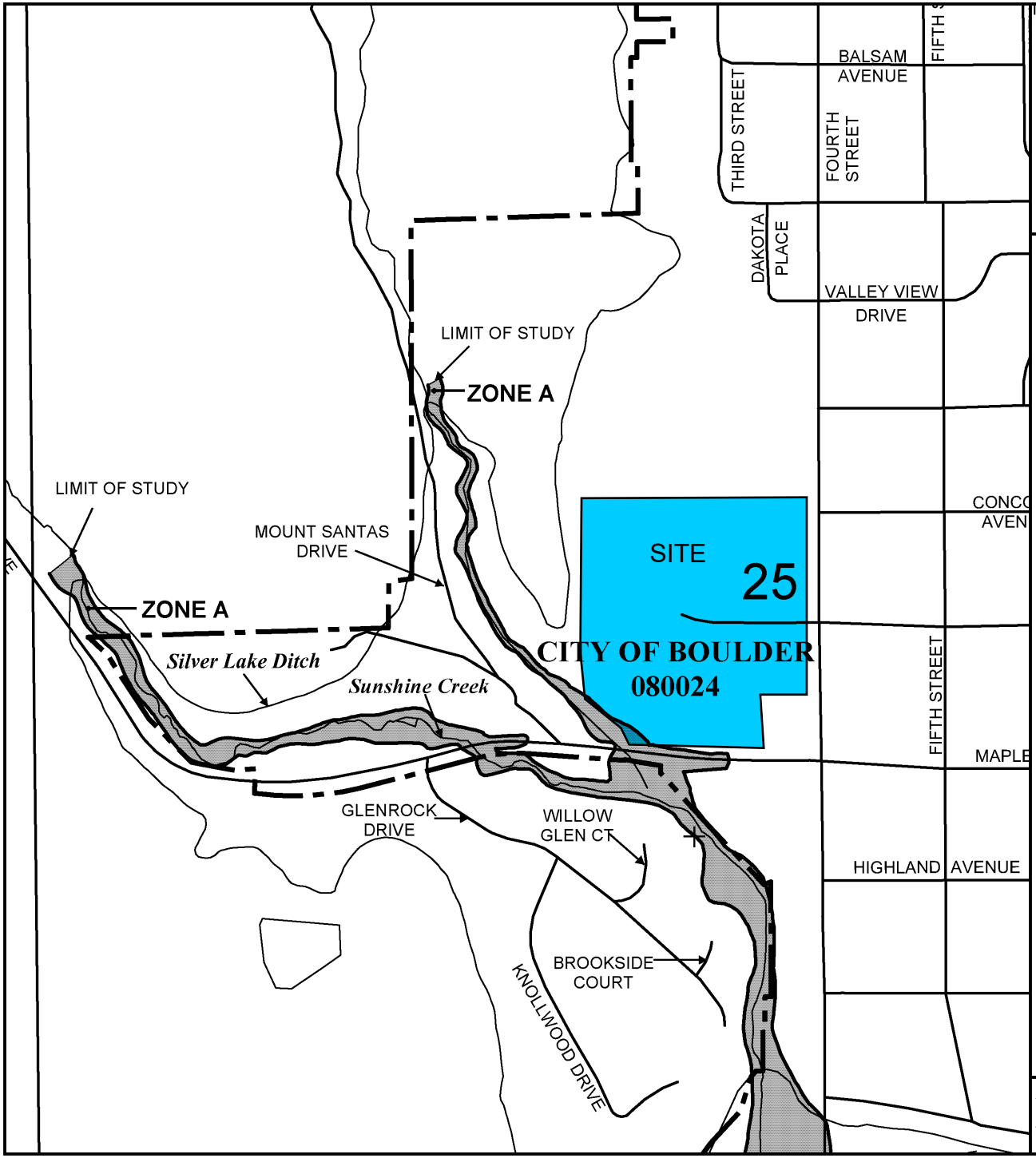


Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0393J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 393 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER, CITY OF	080024	0393	J
BOULDER COUNTY	080023	0393	J

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

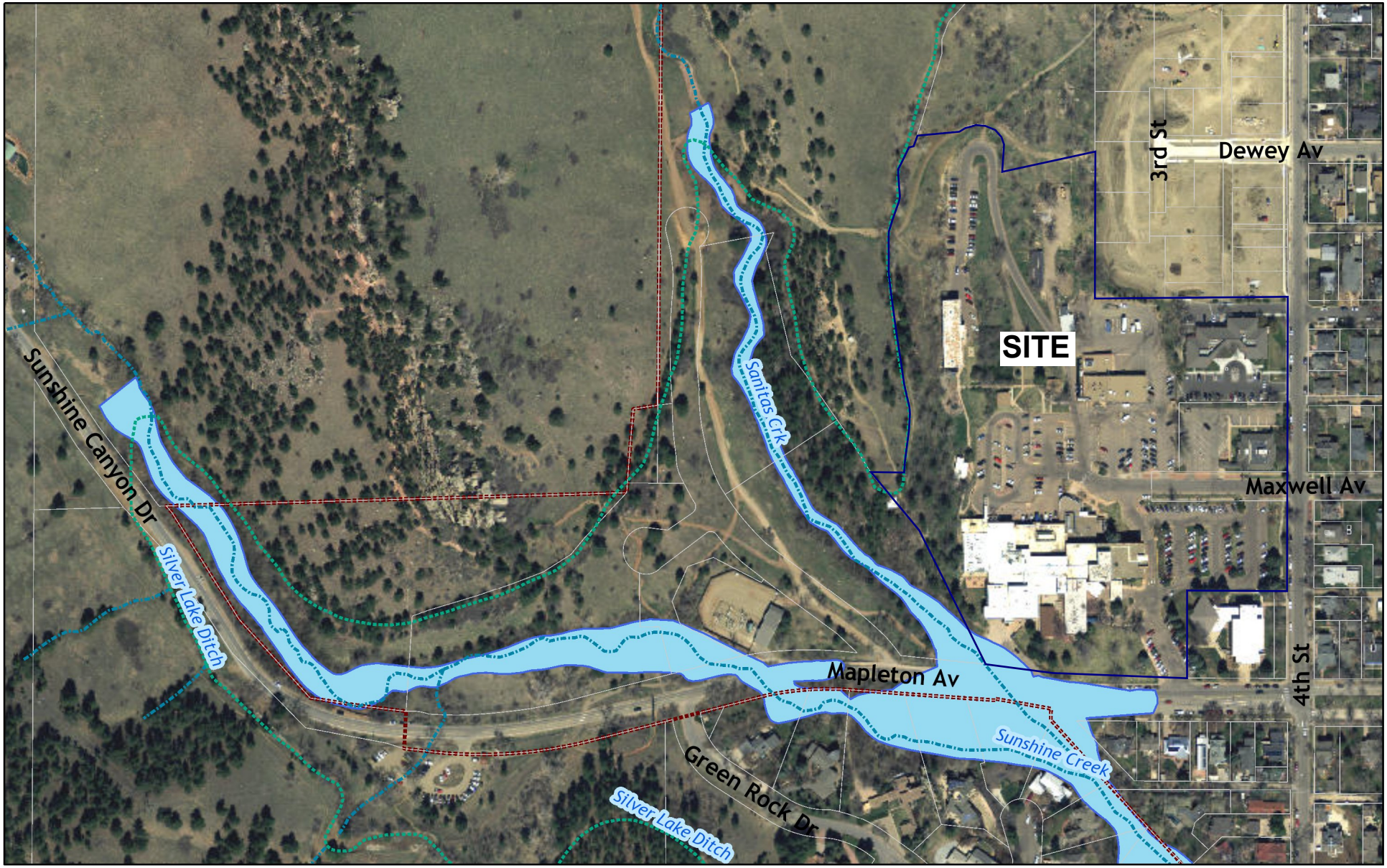
MAP NUMBER
08013C0393J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

FLOOD HAZARD ZONES NEAR MAPLETON HILL PROPERTY



July 5, 2016

Creeks and Ditches

- Creek
- Creek Int
- Ditch
- Street Labels
- Parcels
- City Limits
- Urban Flood Extent 2013

1:4,514

0 0.0375 0.075 0.15 mi

0 0.05 0.1 0.2 km

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey,

COB
City of Boulder 2016

United States Department of Agriculture

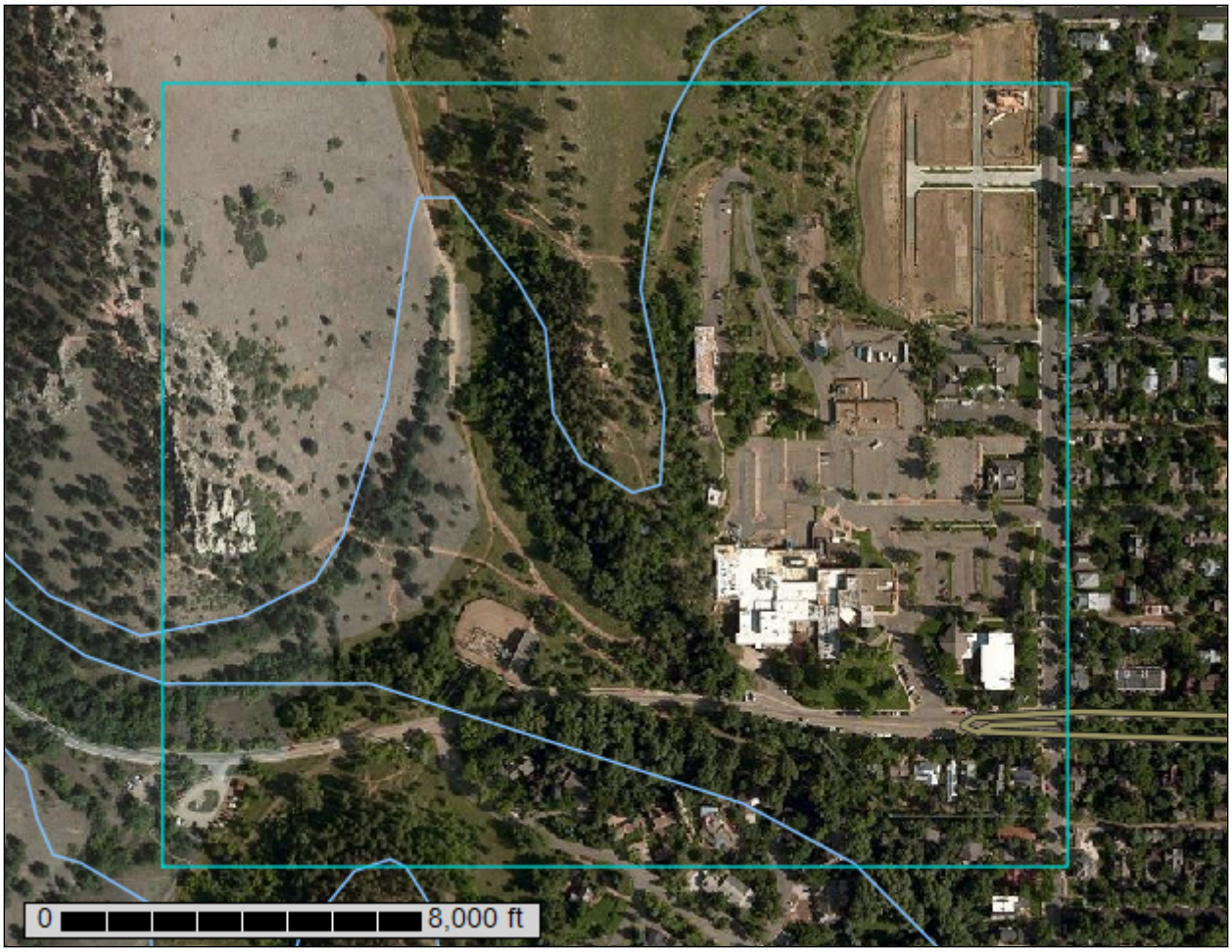
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

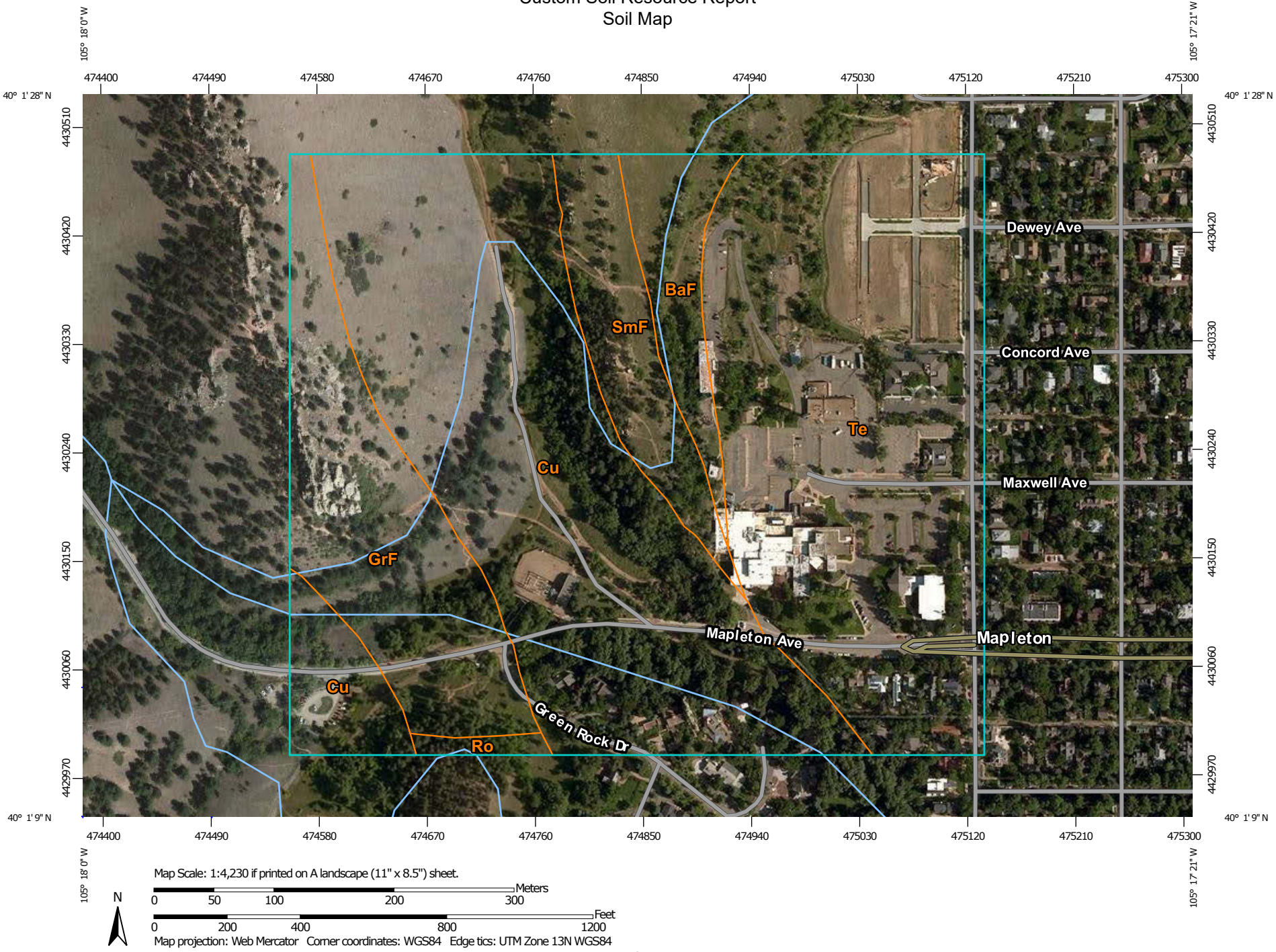
Custom Soil Resource Report for

Boulder County Area, Colorado



July 1, 2016

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

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.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Boulder County Area, Colorado
Survey Area Data: Version 12, Sep 22, 2015

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

Date(s) aerial images were photographed: Aug 28, 2012—Sep 18, 2014

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.

Map Unit Legend

Boulder County Area, Colorado (CO643)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BaF	Baller stony sandy loam, 9 to 35 percent slopes	3.3	4.6%
Cu	Colluvial land	28.0	39.2%
GrF	Goldvale-Rock outcrop complex, 9 to 55 percent slopes	10.1	14.2%
Ro	Rock outcrop	0.4	0.6%
SmF	Sixmile stony loam, 10 to 50 percent slopes	4.5	6.3%
Te	Terrace escarpments	25.1	35.1%
Totals for Area of Interest		**71.6**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

Boulder County Area, Colorado

BaF—Baller stony sandy loam, 9 to 35 percent slopes

Map Unit Setting

National map unit symbol: jpr9
Elevation: 5,500 to 6,500 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 47 to 51 degrees F
Frost-free period: 140 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Baller and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Baller

Setting

Landform: Ridges
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy residuum weathered from sandstone

Typical profile

H1 - 0 to 10 inches: very stony sandy loam
H2 - 10 to 15 inches: very stony fine sandy loam, very stony sandy loam
H2 - 10 to 15 inches: unweathered bedrock
H3 - 15 to 19 inches:

Properties and qualities

Slope: 9 to 35 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Shallow Foothill (R049BY204CO)

Minor Components

Rock outcrop

Percent of map unit: 10 percent

Paoli
Percent of map unit: 2 percent

Hargreave
Percent of map unit: 2 percent

Aquic haplustolls
Percent of map unit: 1 percent
Landform: Swales

Cu—Colluvial land

Map Unit Setting
National map unit symbol: jprk
Elevation: 7,500 to 9,000 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 39 to 43 degrees F
Frost-free period: 80 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition
Colluvial land: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Colluvial Land

Setting
Landform: Valleys
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Colluvium

Typical profile
H1 - 0 to 3 inches: gravelly sandy loam
H2 - 3 to 60 inches: gravelly sand, very gravelly sand, gravelly loamy sand
H2 - 3 to 60 inches:
H2 - 3 to 60 inches:

Properties and qualities
Slope: 9 to 25 percent
Depth to restrictive feature: 2 to 60 inches to lithic bedrock
Natural drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Very low (about 0.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Minor Components

Haverson

Percent of map unit: 10 percent

Kim

Percent of map unit: 7 percent

Otero

Percent of map unit: 3 percent

GrF—Goldvale-Rock outcrop complex, 9 to 55 percent slopes

Map Unit Setting

National map unit symbol: jprq
Elevation: 5,900 to 6,700 feet
Mean annual precipitation: 18 to 22 inches
Mean annual air temperature: 43 to 47 degrees F
Frost-free period: 100 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Goldvale and similar soils: 55 percent
Rock outcrop: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Goldvale

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy alluvium

Typical profile

H1 - 0 to 19 inches: stony coarse sandy loam
H2 - 19 to 25 inches: stony sandy clay loam
H3 - 25 to 57 inches: stony sandy clay
H4 - 57 to 75 inches: stony coarse sandy loam, stony sandy clay loam
H4 - 57 to 75 inches:

Properties and qualities

Slope: 9 to 55 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: Ponderosa Loam (R049XY220CO)

Description of Rock Outcrop

Setting
Landform: Mountain slopes, ridges
Landform position (three-dimensional): Free face, mountaintop
Parent material: Sandstone

Typical profile
H1 - 0 to 60 inches: unweathered bedrock

Properties and qualities
Slope: 30 to 55 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D

Minor Components

Juget
Percent of map unit: 10 percent

Valmont
Percent of map unit: 5 percent

Ro—Rock outcrop

Map Unit Composition
Rock outcrop: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Setting

Landform: Cliffs, mountain slopes
Landform position (three-dimensional): Free face, mountaintop
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Mixed

Typical profile

H1 - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 20 to 95 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D

SmF—Sixmile stony loam, 10 to 50 percent slopes

Map Unit Setting

National map unit symbol: jpst
Elevation: 5,800 to 6,600 feet
Mean annual precipitation: 14 to 18 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 120 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Sixmile and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sixmile

Setting

Landform: Ridges, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy residuum weathered from calcareous shale

Typical profile

H1 - 0 to 4 inches: stony loam
H2 - 4 to 30 inches: clay loam

H3 - 30 to 34 inches: weathered bedrock

Properties and qualities

Slope: 10 to 50 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: Rocky Foothill (R049XY206CO)

Minor Components

Rock outcrop

Percent of map unit: 10 percent

Hargreave

Percent of map unit: 10 percent

Te—Terrace escarpments

Map Unit Setting

National map unit symbol: jpsv
Elevation: 4,400 to 5,500 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 120 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Terrace escarpments: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Terrace Escarpments

Setting

Landform: Paleoterraces, fan remnants
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Base slope, riser
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Cobbly and stony colluvium over sandstone and shale

Typical profile

H1 - 0 to 6 inches: gravelly sand
H2 - 6 to 60 inches: gravelly sand, very gravelly sand, gravelly coarse sand
H2 - 6 to 60 inches:
H2 - 6 to 60 inches:

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

APPENDIX B – CALCULATIONS

Table 7-1: Design Storm Frequencies

Land Use	Initial Storm	Major Storm
Single Family Residential	2 Year	100 Year
All Other Uses	5 Year	100 Year
Detention Ponding Design	10 Year	100 Year

(C) Rainfall

The rainfall intensities to be used in computing runoff were based on the UDFCD on-going hydrology research program and shall be obtained from Figure 7-1, "Rainfall Intensity-Duration-Frequency Curve for the City of Boulder," of these Standards.

D) Runoff

(1) **CUHP Method:** For basins larger than 160 acres, the Colorado Urban Hydrograph Procedure (CUHP) method shall be applied in conformance with the UDFCD Drainage Criteria Manual using local rainfall conditions.

(2) **Rational Method:** For all basins smaller than 160 acres, the Rational Method shall be used to calculate runoff for both the initial and major storms. A detailed description and in-depth discussion of the rational method and its components are presented in the UDFCD Drainage Criteria Manual. The formula for the rational method is as follows:

$$Q = CIA$$

Where: Q = Flow Rate in Cubic Feet Per Second

C = Runoff Coefficient

I = Rainfall Intensity for the Design Storm (inches/hour)

A = Drainage Area (acres)

(3) **Runoff Coefficient:** The runoff coefficient to be used with the Rational Method may be determined based on either zoning/land use classifications or types of surface classifications prescribed in Table 7-2, "Runoff Coefficients for the Rational Method." A composite runoff coefficient may be calculated using land areas impacted by specific classifications.

(4) **Time of Concentration (t_c): For** urban areas, the time of concentration consists of an inlet time or overland flow time (t_i) plus the time of travel (t_t) in a storm sewer, paved gutter, roadside drainage ditch, drainage channel, or other drainage facilities. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a combined form, such as a swale, channel, or drainageway. The travel time (t_t) portion of the time of concentration (t_c) is estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway.

(a) The time of concentration is calculated as follows:

$$t_c = t_i + t_t \text{ (Minutes)}$$

Where t_c = time of concentration in minutes

t_i = initial, inlet, or overland flow time in minutes

t_t = travel time in ditch, channel, gutter, storm sewer, etc. in minutes

(b) Non-Urbanized Basins

The initial or overland flow time (t_i) is calculated using the following formula or Figure 7-2, "Overland Time of Flow Curves." The initial time of concentration for non-urbanized basins is not to be less than 10 minutes.

$$t_c = \frac{1.8(1.1 - C_5)\sqrt{L}}{\sqrt[3]{S}}$$

Where t_i = initial or overland flow time in minutes

C_5 = runoff coefficient for 5-year frequency

L = length of overland flow in feet (500-foot max)

S = average basin slope in percent

For basins longer than 500-feet, runoff shall be considered to be in a combined form and travel time (t_t) shall be calculated using the hydraulic properties of the swale, ditch or channel, or estimated using Figure 7-3, "Time of Travel." The time of concentration (t_c) is the sum of the initial flow time (t_i) and the travel time (t_t). The minimum (t_c) shall be ten minutes for non-urbanized basins.

(c) Urbanized Basins

The time of concentration (t_c) to the first design point after urbanization shall be the lesser value determined from the two equations below.

$$t_c = \frac{1.8(1.1 - C_5)\sqrt{L}}{\sqrt[3]{S}}$$

Where t_i = initial or overland flow time in minutes

C_5 = runoff coefficient for 5-year frequency

L = length of overland flow in feet (300-foot max)

S = average basin slope in percent

Or

$$t_c = \frac{L}{180} + 10$$

Where t_c = time of concentration in minutes

L = length of flow to first design point from the most remote point in feet

The travel time (t_t) portion of the time of concentration shall be computed using the hydraulic properties of the ditch, channel, curb and gutter, or storm sewer. The minimum time of concentration (t_c) for urbanized conditions shall be five minutes.

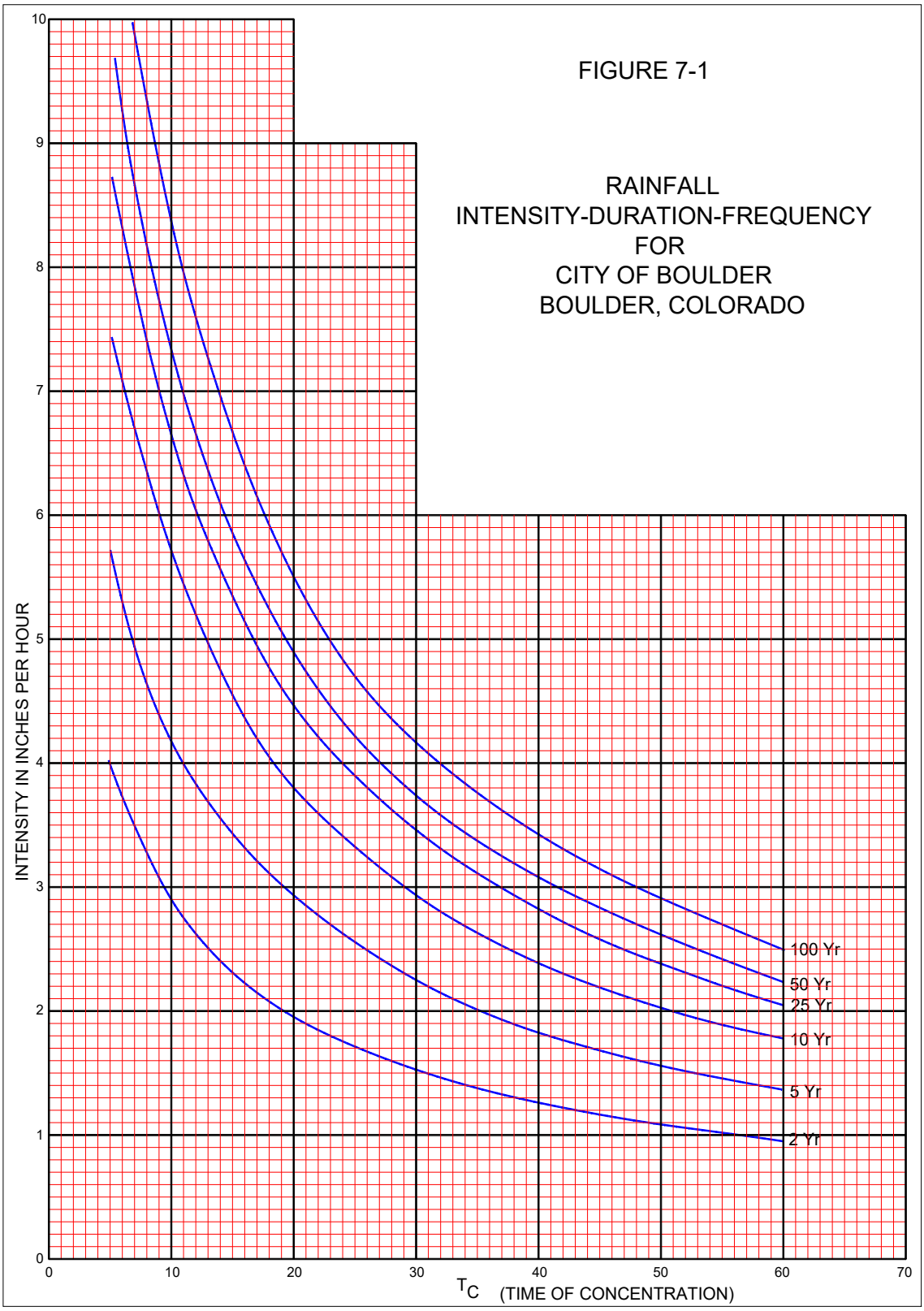


FIGURE 7-1
RAINFALL
INTENSITY-DURATION-FREQUENCY
FOR
CITY OF BOULDER
BOULDER, COLORADO
INTENSITY IN INCHES PER HOUR
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
TC (TIME OF CONCENTRATION)
100 Yr
50 Yr
25 Yr
10 Yr
5 Yr
2 Yr

Table 7-2: Runoff Coefficients for the Rational Method

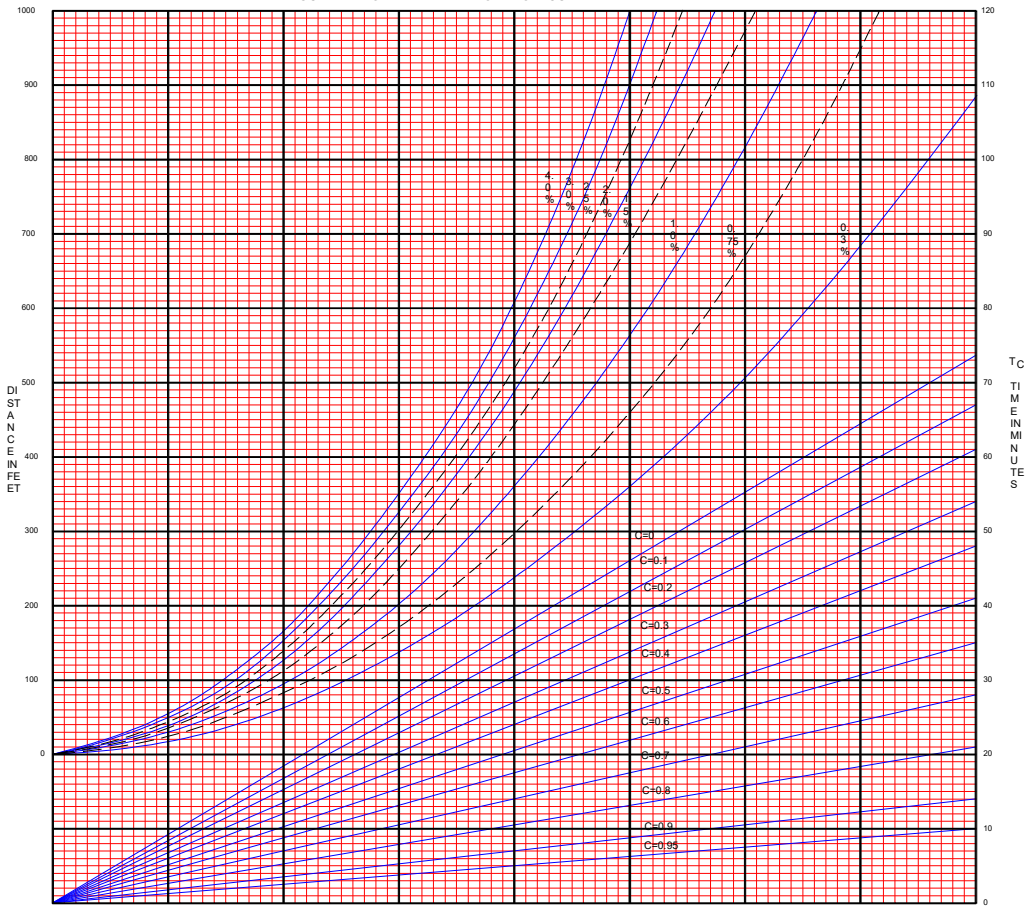
LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	STORM FREQUENCY			
		2-Yr	5-Yr	10-Yr	100-Yr
Business:					
Commercial Areas	95	0.87	0.88	0.90	0.93
Neighborhood Areas	65	0.60	0.65	0.70	0.80
Residential:					
Single-Family	40	0.40	0.45	0.50	0.70
Multi-Unit (detached)	50	0.50	0.55	0.60	0.75
Multi-Unit (attached)	70	0.65	0.70	0.70	0.80
½ Acre Lot	30	0.30	0.40	0.45	0.65
Apartments	70	0.65	0.70	0.70	0.80
Industrial:					
Light Areas	80	0.75	0.80	0.80	0.85
Heavy Areas	90	0.80	0.80	0.85	0.90
Parks, Cemeteries:	7	0.15	0.25	0.35	0.60
Playgrounds:	13	0.20	0.30	0.40	0.70
Schools:	50	0.50	0.55	0.60	0.75
Railroad Yard Areas:	40	0.40	0.45	0.50	0.70
Undeveloped Areas:					
Historic Flow Analysis	2	0.10	0.20	0.30	0.60
Greenbelts, Agricultural	-	-	-	-	-
Offsite Flow Analysis (when offsite land use is not defined)	45	0.45	0.50	0.55	0.72
Streets:					
Paved	100	0.87	0.88	0.90	0.93
Gravel	7	0.15	0.25	0.35	0.65
Drives and Walks:	96	0.85	.087	0.90	0.92
Roofs:	90	0.80	0.85	0.90	0.90
Lawns:					
Sandy Soil	0	0.00	0.10	0.20	0.50
Clayey Soil	0	0.10	0.20	0.30	0.60

NOTE: These rational formula coefficients do not apply for larger basins where the time-of-concentration exceeds 60 minutes.

(Source: Urban Drainage and Flood Control District)

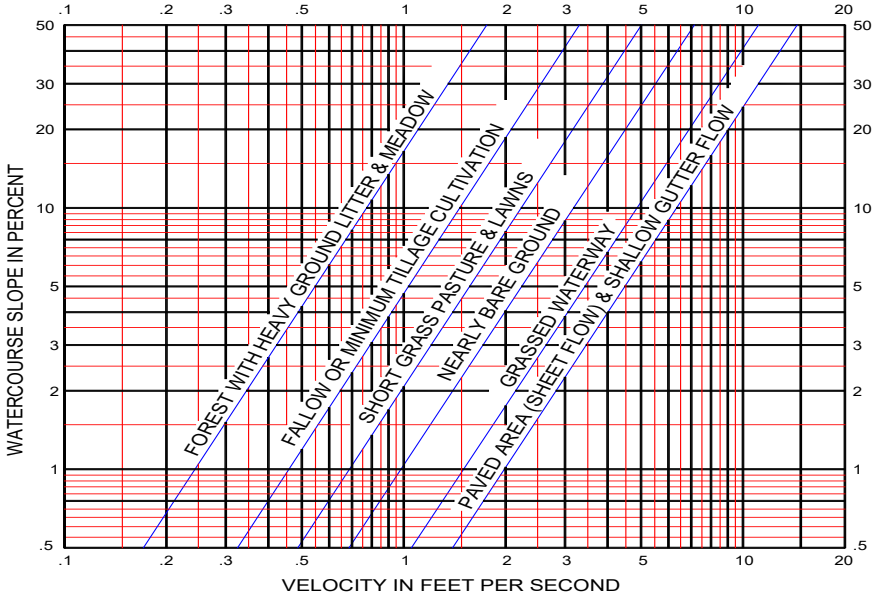
(5) **Intensity:** The rainfall intensity to be used in the Rational Method is be obtained from Figure 7-1, "Rainfall Intensity-Duration-Frequency Curve for the City of Boulder," for the corresponding design storm frequency.

FIGURE 7-2: OVERLAND TIME OF FLOW CURVES



C = RUNOFF COEFFICIENT

FIGURE 7-3: TIME OF TRAVEL



ESTIMATE OF AVERAGE FLOW VELOCITY FOR USE
WITH THE RATIONAL METHOD

JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: Mapleton Hill
Job Number: 2462c
Date: 7/28/16
By: RLK/AR

	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Porous Pavers	60%	0.15	0.25	0.35	0.65
Artificial Turf	25%	0.28	0.38	0.43	0.62

Mapleton Hill

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: A

Basin Design Data

	I (%) =	100%	96%	90%	7%	60%	25%	0%	0%			I (%)	Runoff Coeff's				Initial Overland Time (t_i)			Travel Time (t_t) t_t=Length/(Velocity x 60)						t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	A_{plygnd} (sf)	$A_{art.\ turf}$ (sf)	A_{lscape} (A soil) (sf)	A_{lscape} (C/D soil) (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+ 10 (min.)	Min t_c
H1	1	22,346	4,685	38,258				48,037		113,326	2.60	54.1%	0.48	0.54	0.60	0.74	300	20.0%	6.4	55	5.0%	Paved areas & shallow paved swales	20	4.5	0.2	6.7	355	12.0	6.7
H2	2	137,710	9,677	32,252	3,871			61,268		244,778	5.62	72.0%	0.63	0.67	0.72	0.81	300	22.0%	4.8	344	5.8%	Paved areas & shallow paved swales	20	4.8	1.2	6.0	644	13.6	6.0
H3	3	45,079	6,152	19,450	2,251			73,798		146,730	3.37	46.8%	0.41	0.47	0.54	0.71	300	23.0%	6.9	457	13.0%	Paved areas & shallow paved swales	20	7.2	1.1	7.9	757	14.2	7.9
H4	4	17,080	5,815	1,798	11,560			82,560		118,813	2.73	21.1%	0.19	0.28	0.36	0.60	300	22.0%	9.2	160	16.3%	Paved areas & shallow paved swales	20	8.1	0.3	9.5	460	12.6	9.5
H5	5	4,506	1,122	2,042				8855		16,525	0.38	44.9%	0.39	0.46	0.52	0.70	30	40.0%	0.0	130	10.0%	Short Pasture and lawns	7	2.2	1.0	1.0	160.0	10.9	5.0
H6	6							6246		6,246	0.14	0.0%	0.00	0.10	0.20	0.50	58	8.6%	6.7	0	0.0%	Short Pasture and lawns	7	0.0	0.0	6.7	58	10.3	6.7
H7	7	12812	3425	7309				6825		30,371	0.70	74.7%	0.66	0.70	0.74	0.83	25	40.0%	1.1	230	5.0%	Paved areas & shallow paved swales	20	4.5	0.9	1.9	255	11.4	5.0
H8	8	2427	500	1188				6228		10,343	0.24	38.4%	0.34	0.41	0.48	0.67	40	15.0%	3.2	140	11.8%	Paved areas & shallow paved swales	20	6.9	0.3	3.5	180	11.0	5.0
OS1	9							13661		13,661	0.31	0.0%	0.00	0.10	0.20	0.50	196	12.0%	11.0	0	0.0%	Nearly bare ground	10	0.0	0.0	11.0	196	11.1	11.0
OS2	10				1297			104,708		106,005	2.43	0.1%	0.00	0.10	0.20	0.50	80	33.0%	5.0	0	0.0%	Nearly bare ground	10	0.0	0.0	5.0	80	10.4	5.0
OS3	11							20,595		20,595	0.47	0.0%	0.00	0.10	0.20	0.50	194	13.0%	10.7	0	0.0%	Nearly bare ground	10	0.0	0.0	10.7	194	11.1	10.7
OS4	12		10,049							10,049	0.23	96.0%	0.85	0.87	0.90	0.92	20	1.6%	1.6	390	3.5%	Paved areas & shallow paved swales	20	3.7	1.7	3.3	410	12.3	5.0
OS5	13		5,156							5,156	0.12	96.0%	0.85	0.87	0.90	0.92	18	1.6%	1.5	225	11.8%	Paved areas & shallow paved swales	20	6.9	0.5	2.0	243	11.4	5.0
	TOTAL SITE	241,961	46,581	102,297	18,979	0	0	432,781	0	842,599	19.34	45.1%	0.40	0.46	0.53	0.70													
TOTAL PROPERTY		241,961	31,376	102,297	17,682	0	0	293,817	0	687,133	15.77	53.2%	0.47	0.53	0.59	0.73													
H3, H4, H5, OS2, OS3		66,665	13,089	23,290	15,108	0	0	290,516	0	408,668	9.38	24.8%	0.22	0.30	0.38	0.61	TO TRAILHEAD												
H2, H7, H8, OS1, OS4 & OS5		152,949	28,807	40,749	3,871	0	0	87,982	0	314,358	7.22	69.2%	0.61	0.65	0.70	0.80	TO 4TH STREET												

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	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Porous Pavers	60%	0.15	0.25	0.35	0.65
Artificial Turf	25%	0.28	0.38	0.43	0.62

Mapleton Hill

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: A

			Runoff Coeff's				Rainfall Intensities (in/hr)				Area		Flow Rates (cfs)				
Basin Name	Design Point	Time of Conc (tc)	C2	C5	C10	C100	2	5	10	100	A_{Total} (sf)	A_{Total} (ac)	Q2	Q5	Q10	Q100	
H1	1	6.7	0.48	0.54	0.60	0.74	3.56	5.06	6.82	10.00	113,326	2.60	4.42	7.09	10.70	19.18	<--- TO MAPLETON
H2	2	6.0	0.63	0.67	0.72	0.81	3.70	5.30	7.10	10.00	244,778	5.62	13.12	19.97	28.57	45.72	
H3	3	7.9	0.41	0.47	0.54	0.71	3.32	4.68	6.39	9.46	146,730	3.37	4.60	7.47	11.60	22.47	
H4	4	9.5	0.19	0.28	0.36	0.60	3.00	4.28	5.85	8.60	118,813	2.73	1.58	3.22	5.75	14.15	
H5	5	5.0	0.39	0.46	0.52	0.70	4.00	5.70	7.45	10.00	16,525	0.38	0.60	0.99	1.48	2.64	
H6	6	6.7	0.00	0.10	0.20	0.50	3.56	5.06	6.82	10.00	6,246	0.14	0.00	0.07	0.20	0.72	<--- TO BOULDER SEVENTH DAY ADVENTIST CHURCH
H7	7	5.0	0.66	0.70	0.74	0.83	4.00	5.70	7.45	10.00	30,371	0.70	1.83	2.77	3.86	5.75	
H8	8	5.0	0.34	0.41	0.48	0.67	4.00	5.70	7.45	10.00	10,343	0.24	0.32	0.55	0.85	1.58	
OS1	9	11.0	0.00	0.10	0.20	0.50	2.78	4.00	5.45	8.00	13,661	0.31	0.00	0.13	0.34	1.25	
OS2	10	5.0	0.00	0.10	0.20	0.50	4.00	5.70	7.45	10.00	106,005	2.43	0.02	1.41	3.66	12.21	
OS3	11	10.7	0.00	0.10	0.20	0.50	2.81	4.05	5.53	8.11	20,595	0.47	0.00	0.19	0.52	1.92	
OS4	12	5.0	0.85	0.87	0.90	0.92	4.00	5.70	7.45	10.00	10,049	0.23	0.78	1.14	1.55	2.12	
OS5	13	5.0	0.85	0.87	0.90	0.92	4.00	5.70	7.45	10.00	5,156	0.12	0.40	0.59	0.79	1.09	
										TOTAL SITE	842,599	19.34	27.7	45.6	69.9	130.8	
										TOTAL PROPERTY	687,133	15.77	26.5	42.1	63.0	112.2	
										H3, H4, H5, OS2, OS3	408,668	9.38	5.8	11.4	19.8	46.5	<--TO TRAILHEAD (estimated based on Tc = 10.7 min)
										H2, H7, H8, OS1, OS4 & OS5	314,358	7.22	12.2	18.7	27.4	46.3	<-- TO 4TH STREET (estimated based on Tc = 11.0 min)

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	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Porous Pavers	60%	0.15	0.25	0.35	0.65
Artificial Turf	25%	0.28	0.38	0.43	0.62

Mapleton Hill

Composite Runoff Coefficient Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: A

Basin Design Data

	I (%) =	100%	96%	90%	7%	60%	25%	0%	0%			I (%)	Runoff Coeff's			
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	$A_{poruspaver}$ (sf)	$A_{art.\ turf}$ (sf)	$A_{lscape\ (A\ soil)}$ (sf)	$A_{lscape\ (C/D\ soil)}$ (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100
A	1	26,211	4,436	41,003		10,350	20,700	25,985		128,685	2.95	61.2%	0.52	0.58	0.64	0.76
B1	2	45,500	13,677	80,124		23,173		66393		228,867	5.25	63.2%	0.52	0.58	0.64	0.77
B2	3	3,599	2,668	11,939				1954		20,160	0.46	83.9%	0.74	0.79	0.83	0.87
C	4	39,132	19,185	68,190	2,314	16,506		103,550		248,877	5.71	51.8%	0.43	0.50	0.57	0.72
D1	5	4,506	1,122	2,042				5,377		13,047	0.30	56.9%	0.50	0.55	0.61	0.75
D2	6	12,812	3,425	7,309				10,225		33,771	0.78	67.2%	0.59	0.64	0.69	0.79
D3	7	2,427	500	1,188				6,228		10,343	0.24	38.4%	0.34	0.41	0.48	0.67
E	8							3,383		3,383	0.08	0.0%	0.00	0.10	0.20	0.50
OS1	9							13,661		13,661	0.31	0.0%	0.00	0.10	0.20	0.50
OS2	10				1,297			104,708		106,005	2.43	0.1%	0.00	0.10	0.20	0.50
OS3	11							20,595		20,595	0.47	0.0%	0.00	0.10	0.20	0.50
OS4	12		10,049							10,049	0.23	96.0%	0.85	0.87	0.90	0.92
OS5	13		5,156							5,156	0.12	96.0%	0.85	0.87	0.90	0.92
TOTAL SITE		134,188	60,218	211,795	3,611	50,029	20,700	362,059	0	842,599	19.343	49.6%	0.42	0.48	0.55	0.71
TOTAL PROPERTY (A, B, C, D & E)		134,188	45,013	211,795	2,314	50,029	20,700	223,095	0	687,133	15.774	58.7%	0.49	0.55	0.62	0.75
TO TRAILHEAD POND (C, D1, OS2 & OS3)		43,638	20,307	70,232	3,611	16,506	0	234,230	0	388,524	8.919	35.1%	0.29	0.37	0.45	0.65
TO 4TH ST. (OS1, B1, B2, D2, D3, OS4, OS5)		64,339	35,475	100,560	0	23,173	0	84,800	0	308,346	7.079	65.8%	0.55	0.61	0.67	0.78

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Mapleton Hill

Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: A

Sub-Basin Data				Initial Overland Time (t_i)			Travel Time (t_t) t_t=Length/(Velocity x 60)						t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{Total} (ac)	C5	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+ 10 (min)	Min t_c
A	1	2.95	0.58	10	2.0%	2.3	50	2.0%	Paved areas & shallow paved swales	20	2.8	0.3	2.6	60	10.3	5.0
B1	2	5.25	0.58	160	24.0%	4.1	600	4.0%	Paved areas & shallow paved swales	20	4.0	2.5	6.6	760	14.2	6.6
B2	3	0.46	0.79	40	5.0%	2.1	260	1.0%	Paved areas & shallow paved swales	20	2.0	2.2	4.3	300	11.7	5.0
C	4	5.71	0.50	90	25.0%	3.5	1100	4.0%	Paved areas & shallow paved swales	20	4.0	4.6	8.1	1190	16.6	8.1
D1	5	0.30	0.55	100	14.3%	4.1	82	9.8%	Paved areas & shallow paved swales	20	6.3	0.2	4.3	182	11.0	5.0
D2	6	0.78	0.64	40	25.0%	1.8	220	2.0%	Paved areas & shallow paved swales	20	2.8	1.3	3.1	260	11.4	5.0
D3	7	0.24	0.41	20	11.0%	2.5	100	11.0%	Paved areas & shallow paved swales	20	6.6	0.3	2.8	120	10.7	5.0
E	8	0.08	0.10	30	3.3%	6.6	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	6.6	30	10.2	6.6
OS1	9	0.31	0.10	220	12.0%	11.7	0	0.0%	Grassed waterway	15	0.0	0.0	11.7	220	11.2	11.2
OS2	10	2.43	0.10	100	33.0%	5.6	48	19.0%	Grassed waterway	15	6.5	0.1	5.7	148	10.8	5.7
OS3	11	0.47	0.10	100	13.9%	7.5	17	22.0%	Grassed waterway	15	7.0	0.0	7.5	117	10.7	7.5
OS4	12	0.23	0.87	20	2.0%	1.5	220	1.0%	Paved areas & shallow paved swales	20	2.0	1.8	3.3	240	11.3	5.0
OS5	13	0.12	0.87	20	2.0%	1.5	150	1.0%	Paved areas & shallow paved swales	20	2.0	1.3	2.7	170	10.9	5.0

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By: RLK/AR

Mapleton Hill

Developed Storm Runoff Calculations

Design Storm : **100 Year**

Point Hour Rainfall (P_1) : **2.50**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A	1	2.95	0.76	5.00	2.25	10.00	22.48																		
							POND A	5.00	2.25	10.00	22.48														
OS1	9	0.31	0.50	11.20	0.16	7.93	1.24																		
B1	2	5.25	0.77	6.60	4.02	10.00	40.24	11.20	4.18	7.93	33.15					30 in	RCP	2.0%	33.2	62.3	130	3.5	0.62	11.82	
							POND B	11.82	4.18	7.72	32.27														
B2	3	0.46	0.87	5.00	0.40	10.00	4.02																		
OS4	12	0.23	0.92	5.00	0.21	10.00	2.12	5.00	0.61	10.00	6.15										380	1.5	4.22	9.22	
D2	6	0.78	0.79	5.00	0.61	10.00	6.14																		
D3	7	0.24	0.67	5.00	0.16	10.00	1.58																		
OS5	13	0.12	0.92	5.00	0.11	10.00	1.09	9.22	1.50	8.75	13.09										150	2.5	1.00	10.22	
						FLOWS AT DP 13		10.22	1.50	8.28	12.39														
OS2	10	2.43	0.50	5.70	1.22	10.00	12.21																		
C	4	5.71	0.72	8.10	4.12	9.35	38.49	8.10	5.34	9.35	49.90					24 in	RCP	2.0%	49.9	34.4	60	3.4	0.29	8.39	
							POND C	8.39	5.34	9.24	49.32														
D1	5	0.30	0.75	5.00	0.22	10.00	2.24	5.00	0.22	10.00	2.24														
OS3	11	0.47	0.50	7.50	0.24	9.70	2.29	7.50	0.46	9.70	4.46														
E	8	0.08	0.50	6.60	0.04	10.00	0.39																		

Total Flow to Historic Design Point 1 is 19.2 cfs:
Proposed DP 1 = 22.5.
Detention Pond A will reduce peak flow of 22.5 cfs to 19.2 cfs

Total Flow to Historic Design Point 11 is 46.5 cfs:
Total flow to the equivalent proposed Design Point will be proposed Design Point 11 (4.46 cfs) + allowable release through pond C (39.83 cfs) = 43.29 cfs

Total Flow to Historic Design Point 13 is 46.3 cfs:
Total flow to the equivalent proposed Design Point will be proposed Design Point 13 (12.39 cfs) + allowable release through pond B (33.88 cfs) = 46.27 cfs

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Mapleton Hill

Developed Storm Runoff Calculations

Design Storm : **10 Year**

Point Hour Rainfall (P_1) : **1.80**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A	1	2.95	0.64	5.00	1.89	7.45	14.06																		
							POND A	5.00	1.89	7.45	14.06														
OS1	9	0.31	0.20	11.20	0.06	5.40	0.34																		
B1	2	5.25	0.64	6.60	3.37	6.86	23.11	11.20	3.43	5.40	18.53					30 in	RCP	2.0%	18.5	62.3	130	3.0	0.72	11.92	
							POND B	11.92	3.43	5.23	17.93														
B2	3	0.46	0.83	5.00	0.39	7.45	2.87																		
OS4	12	0.23	0.90	5.00	0.21	7.45	1.55	5.00	0.59	7.45	4.42										380	1.8	3.52	8.52	
D2	6	0.78	0.69	5.00	0.53	7.45	3.97																		
D3	7	0.24	0.48	5.00	0.11	7.45	0.85																		
OS5	13	0.12	0.90	5.00	0.11	7.45	0.79	8.52	1.35	6.18	8.31										150	4.0	0.63	9.14	
						FLOWS AT DP 13		9.14	1.35	5.97	8.04														
OS2	10	2.43	0.20	5.70	0.49	7.21	3.54																		
C	4	5.71	0.57	8.10	3.24	6.32	20.46	8.10	3.73	6.32	23.57					24 in	RCP	2.0%	23.6	34.4	60	3.1	0.32	8.42	
							POND C	8.42	3.73	6.21	23.17														
D1	5	0.30	0.61	5.00	0.18	7.45	1.36	5.00	0.18	7.45	1.36														
OS3	11	0.47	0.20	7.50	0.09	6.53	0.62	7.50	0.09	6.53	0.62														
E	8	0.08	0.20	6.60	0.02	6.86	0.11																		

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Mapleton Hill

Developed Storm Runoff Calculations

Design Storm : **5 Year**

Point Hour Rainfall (P_1) : **1.35**

	Direct Runoff							Total Runoff				Inlets				Pipe					Pipe/Swale Travel Time				
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Inlet Type	Q intercepted	Q carryover	Q bypass	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Total Time (min)	Notes
A	1	2.95	0.58	5.00	1.72	5.70	9.79																		
							POND A	5.00	1.72	5.70	9.79														
OS1	9	0.31	0.10	11.20	0.03	3.97	0.12																		
B1	2	5.25	0.58	6.60	3.04	5.09	15.48	11.20	3.07	3.97	12.20					30 in	RCP	2.0%	12.2	62.3	130	3.0	0.72	11.92	
							POND B	11.92	3.07	3.87	11.88														
B2	3	0.46	0.79	5.00	0.36	5.70	2.07																		
OS4	12	0.23	0.87	5.00	0.20	5.70	1.14	5.00	0.56	5.70	3.22										380	1.8	3.52	8.52	
D2	6	0.78	0.64	5.00	0.49	5.70	2.81																		
D3	7	0.24	0.41	5.00	0.10	5.70	0.55																		
OS5	13	0.12	0.87	5.00	0.10	5.70	0.59	8.52	1.26	4.53	5.69										150	4.0	0.63	9.14	
						FLOWS AT DP 13		9.14	1.26	4.38	5.50														
OS2	10	2.43	0.10	5.70	0.25	5.42	1.34																		
C	4	5.71	0.50	8.10	2.85	4.63	13.18	8.10	3.10	4.63	14.33					24 in	RCP	2.0%	14.3	34.4	60	3.1	0.32	8.42	
							POND C	8.42	3.10	4.55	14.10														
D1	5	0.30	0.55	5.00	0.17	5.70	0.94	5.00	0.17	5.70	0.94														
OS3	11	0.47	0.10	7.50	0.05	4.80	0.23	7.50	0.05	4.80	0.23														
E	8	0.08	0.10	6.60	0.01	5.09	0.04																		

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Job Name: Mapleton Hill
Job Number: 2462c
Date: 7/28/16
By: RLK/AR

Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin		A	
Design Storm		**10 year**	
Composite "C" Factor		0.64	
Basin Size		2.95	

Release Rate Calculations

Allowable Release Rate for Site		10.70	cfs	(Historic Flows for Basin H1)
Less Undetained Offsite Flows	-	0.00	cfs	
Allowable Release Rate for Pond		10.70	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **1.80**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	7.45	4,218	3,211	1,007
10.0	600	5.70	6,454	6,422	32
15.0	900	4.55	7,728	9,634	-1,906
20.0	1,200	3.80	8,606	12,845	-4,239
25.0	1,500	3.30	9,342	16,056	-6,715
30.0	1,800	2.95	10,021	19,267	-9,246
35.0	2,100	2.76	10,947	22,478	-11,532
40.0	2,400	2.57	11,642	25,690	-14,047
45.0	2,700	2.38	12,121	28,901	-16,780
50.0	3,000	2.19	12,383	32,112	-19,729
55.0	3,300	2.00	12,427	35,323	-22,896
60.0	3,600	1.80	12,229	38,535	-26,306

		Maximum Volume (ft^3)	**1,007**	
		City of Boulder Only (110%)	101	ft3
		100% WQCV	2,800	ft^3
Required 10-yr Volume +		**100% WQCV**	**3,907**	**ft^3**

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By: RLK/AR

Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin		A	
Design Storm		**100 year**	
Composite "C" Factor		0.76	
Basin Size		2.95	

Release Rate Calculations

Allowable Release Rate for Site		19.18	cfs	(Historic Flows for Basin H1)
Less Undetained Offsite Flows	-	0.00	cfs	
Allowable Release Rate for Pond		19.18	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **2.50**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	10.00	6,743	5,754	990
6.0	360	10.00	8,092	6,904	1,188
6.5	390	10.00	8,766	7,480	1,287
7.0	420	10.00	9,441	8,055	1,386
7.5	450	9.70	9,812	8,630	1,181
8.0	480	9.40	10,142	9,206	936
10.0	600	8.35	11,261	11,507	-246
15.0	900	6.65	13,453	17,261	-3,808
45.0	2,700	3.36	20,366	51,783	-31,417
50.0	3,000	3.07	20,718	57,536	-36,818
55.0	3,300	2.79	20,688	63,290	-42,602
60.0	3,600	2.50	20,230	69,044	-48,814

		Maximum Volume (ft^3)	**1,386**	
		City of Boulder Only (110%)	139	ft3
		50% WQCV	1,400	ft^3
Required 100-yr Volume +		**50% WQCV**	**2,924**	**ft^3**

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Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin		B + OS1	
Design Storm		**10 year**	
Composite "C" Factor		0.67	
Basin Size		7.08	

Release Rate Calculations

Allowable Release Rate for Site		19.39	cfs	(Historic Flows for Basin H2 + OS1)
Less Undetained Offsite Flows	-	0.00	cfs	
Allowable Release Rate for Pond		19.39	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **1.80**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	7.45	10,539	5,816	4,723
10.0	600	5.70	16,127	11,633	4,494
15.0	900	4.55	19,310	17,449	1,860
20.0	1,200	3.80	21,503	23,266	-1,763
25.0	1,500	3.30	23,342	29,082	-5,741
30.0	1,800	2.95	25,039	34,899	-9,860
35.0	2,100	2.76	27,352	40,715	-13,363
40.0	2,400	2.57	29,091	46,532	-17,441
45.0	2,700	2.38	30,287	52,348	-22,061
50.0	3,000	2.19	30,941	58,165	-27,224
55.0	3,300	2.00	31,052	63,981	-32,929
60.0	3,600	1.80	30,556	69,798	-39,241

		Maximum Volume (ft^3)	**4,723**	
		City of Boulder Only (110%)	472	ft3
		100% WQCV	6,800	ft^3
Required 10-yr Volume +		**100% WQCV**	**11,995**	**ft^3**

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Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin	B + OS1	
Design Storm	**100 year**	
Composite "C" Factor	0.78	
Basin Size	7.08	

Release Rate Calculations

Allowable Release Rate for Site		33.88	cfs	(Historic Flows for Basin H2 + OS1)
Less Undetained Offsite Flows	-	0.00	cfs	
Allowable Release Rate for Pond		33.88	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **2.50**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	10.00	16,559	10,164	6,395
6.0	360	10.00	19,871	12,197	7,674
6.5	390	10.00	21,527	13,213	8,314
7.0	420	10.00	23,183	14,230	8,953
7.5	450	9.70	24,093	15,246	8,848
8.0	480	9.40	24,905	16,262	8,643
10.0	600	8.35	27,654	20,328	7,326
15.0	900	6.65	33,035	30,492	2,543
30.0	1,800	4.20	41,729	60,984	-19,255
45.0	2,700	3.36	50,010	91,476	-41,466
55.0	3,300	2.79	50,802	111,804	-61,002
60.0	3,600	2.50	49,677	121,968	-72,290

		Maximum Volume (ft^3)	**8,953**	
		City of Boulder Only (110%)	895	ft3
		50% WQCV	3,400	ft^3
Required 100-yr Volume +		**50% WQCV**	**13,248**	**ft^3**

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By: RLK/AR

Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin	C+OS2+OS3	
Design Storm	**10 year**	
Composite "C" Factor	0.45	
Basin Size	8.92	

Release Rate Calculations

Allowable Release Rate for Site		17.82	cfs	(Historic Flows for H3,H4,OS2&OS3)
Less Undetained Offsite Flows	-	0.00	cfs	(From Basin X)
Allowable Release Rate for Pond		17.82	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **1.80**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	7.45	8,961	5,346	3,614
10.0	600	5.70	13,712	10,693	3,019
15.0	900	4.55	16,418	16,039	379
20.0	1,200	3.80	18,283	21,386	-3,103
25.0	1,500	3.30	19,846	26,732	-6,886
30.0	1,800	2.95	21,290	32,079	-10,789
35.0	2,100	2.76	23,256	37,425	-14,169
40.0	2,400	2.57	24,734	42,772	-18,037
45.0	2,700	2.38	25,751	48,118	-22,367
50.0	3,000	2.19	26,307	53,465	-27,158
55.0	3,300	2.00	26,402	58,811	-32,409
60.0	3,600	1.80	25,980	64,158	-38,177

		Maximum Volume (ft^3)	**3,614**	
		City of Boulder Only (110%)	361	ft3
		100% WQCV	6,350	ft^3
Required 10-yr Volume +		**100% WQCV**	**10,326**	**ft^3**

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By: RLK/AR

Mapleton Hill

Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin		C+OS2+OS3	
Design Storm		**100 year**	
Composite "C" Factor		0.65	
Basin Size		8.92	

Release Rate Calculations

Allowable Release Rate for Site		39.83	cfs	(Historic Flows for H3,H4,OS2&OS3)
Less Undetained Offsite Flows	-	0.00	cfs	
Allowable Release Rate for Pond		39.83	cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P_1) : **2.50**

Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations

Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	10.00	17,401	11,949	5,452
6.0	360	10.00	20,881	14,338	6,543
6.5	390	10.00	22,622	15,533	7,088
6.9	414	10.00	24,014	16,489	7,524
7.0	420	10.00	24,362	16,728	7,633
7.1	426	9.94	24,561	16,967	7,594
10.0	600	8.35	29,060	23,897	5,163
15.0	900	6.65	34,715	35,846	-1,131
30.0	1,800	4.20	43,851	71,692	-27,841
45.0	2,700	3.36	52,553	107,539	-54,985
55.0	3,300	2.79	53,385	131,436	-78,051
60.0	3,600	2.50	52,204	143,385	-91,181

		Maximum Volume (ft^3)	**7,633**	
		City of Boulder Only (110%)	763	ft3
		50% WQCV	3,175	ft^3
Required 100-yr Volume +		**50% WQCV**	**11,572**	**ft^3**

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Job Name: Mapleton Hill
Job Number: 2462c
Date: 7/28/16
By: RLK/AR

POND VOLUME CALCULATIONS - STAGE / STORAGE

Pond Volume = **Prismoidal Formula**
Volume Equation = (A1+A2+SQRT(A1*A2)*D/3

Stage / Storage Input Table

ELEVATION ft	DEPTH (D) ft	AREA (A1) ft^2	WEIGHTED AVG AREA (A2) ft^2	INCREMENTAL VOLUME ft^3	CUMMULATIVE VOLUME ft^3
5496.5		0			0
5497.0	0.5	860	430	143	143
5498.0	1.0	1,360	1,110	1,100	1,244
5499.0	1.0	1,880	1,620	1,613	2,857
5500.0	1.0	2,420	2,150	2,144	5,001
5501.0	1.0	2,650	2,535	2,534	7,535

Top of Pond

5501.0	4.5	**TOTAL VOLUME**	**7,535 cf**	0.173 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	2,800 cf	0.064 ac-ft	**5498.96 ft**	2.46 ft
V10 + 100% WQCV	3,907 cf	0.090 ac-ft	**5499.49 ft**	2.99 ft
V100 + 50% WQCV	2,924 cf	0.067 ac-ft	**5499.03 ft**	2.53 ft

Volume Interpolation Calculations

WQCV		V10 + 100% WQCV		V100 + 50% WQCV	
Vol	Elev	Vol	Elev	Vol	Elev
1243.83	5498.00	2856.83	5499.00	2856.83	5499.00
2800.00	5498.96	3907.30	5499.49	2924.21	5499.03
2856.83	5499.00	5001.15	5500.00	5001.15	5500.00

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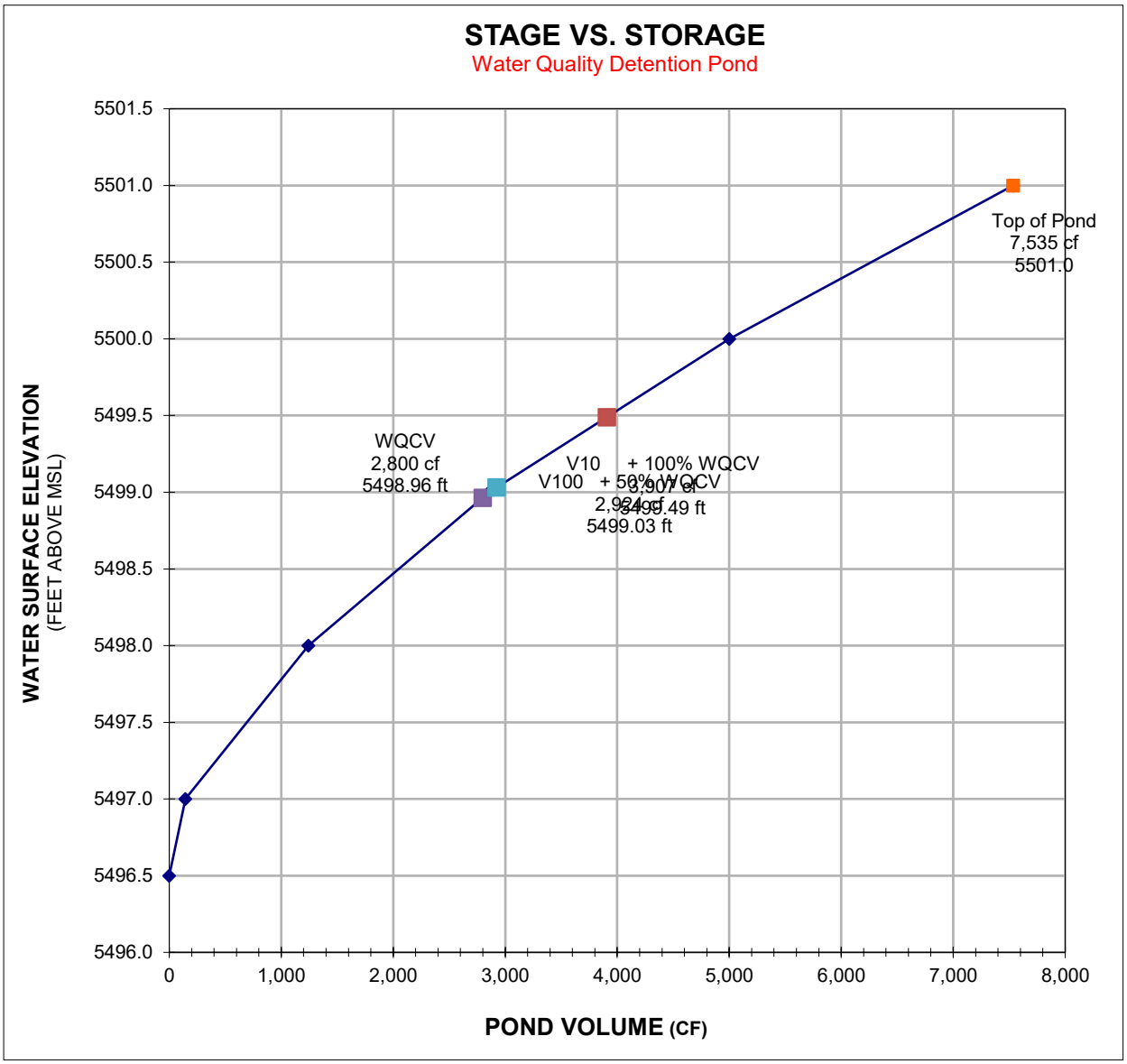

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POND VOLUME CALCULATIONS - STAGE / STORAGE

Pond Volume = **Prismoidal Formula**
Volume Equation = (A1+A2+SQRT(A1*A2)*D/3

Stage / Storage Input Table

ELEVATION ft	DEPTH (D) ft	AREA (A1) ft^2	WEIGHTED AVG AREA (A2) ft^2	INCREMENTAL VOLUME ft^3	CUMMULATIVE VOLUME ft^3
5479.0		0			0
5480.0	1.0	960	480	320	320
5481.0	1.0	1,370	1,165	1,159	1,479
5482.0	1.0	1,800	1,585	1,580	3,059
5483.0	1.0	2,300	2,050	2,045	5,104
5484.0	1.0	2,860	2,580	2,575	7,679
5485.0	1.0	3,470	3,165	3,160	10,839
5486.0	1.0	3,750	3,610	3,609	14,448

Top of Pond

5486.0	7.0	**TOTAL VOLUME**	**14,448 cf**	0.332 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	6,800 cf	0.156 ac-ft	**5483.66 ft**	4.66 ft
V10 + 100% WQCV	11,995 cf	0.275 ac-ft	**5485.32 ft**	6.32 ft
V100 + 50% WQCV	13,248 cf	0.304 ac-ft	**5485.67 ft**	6.67 ft

Volume Interpolation Calculations

WQCV		**V10 + 100% WQCV**		**V100 + 50% WQCV**	
Vol	Elev	Vol	Elev	Vol	Elev
5103.96	5483.00	10838.97	5485.00	10838.97	5485.00
6800.00	5483.66	11994.89	5485.32	13248.50	5485.67
7678.88	5484.00	14448.06	5486.00	14448.06	5486.00

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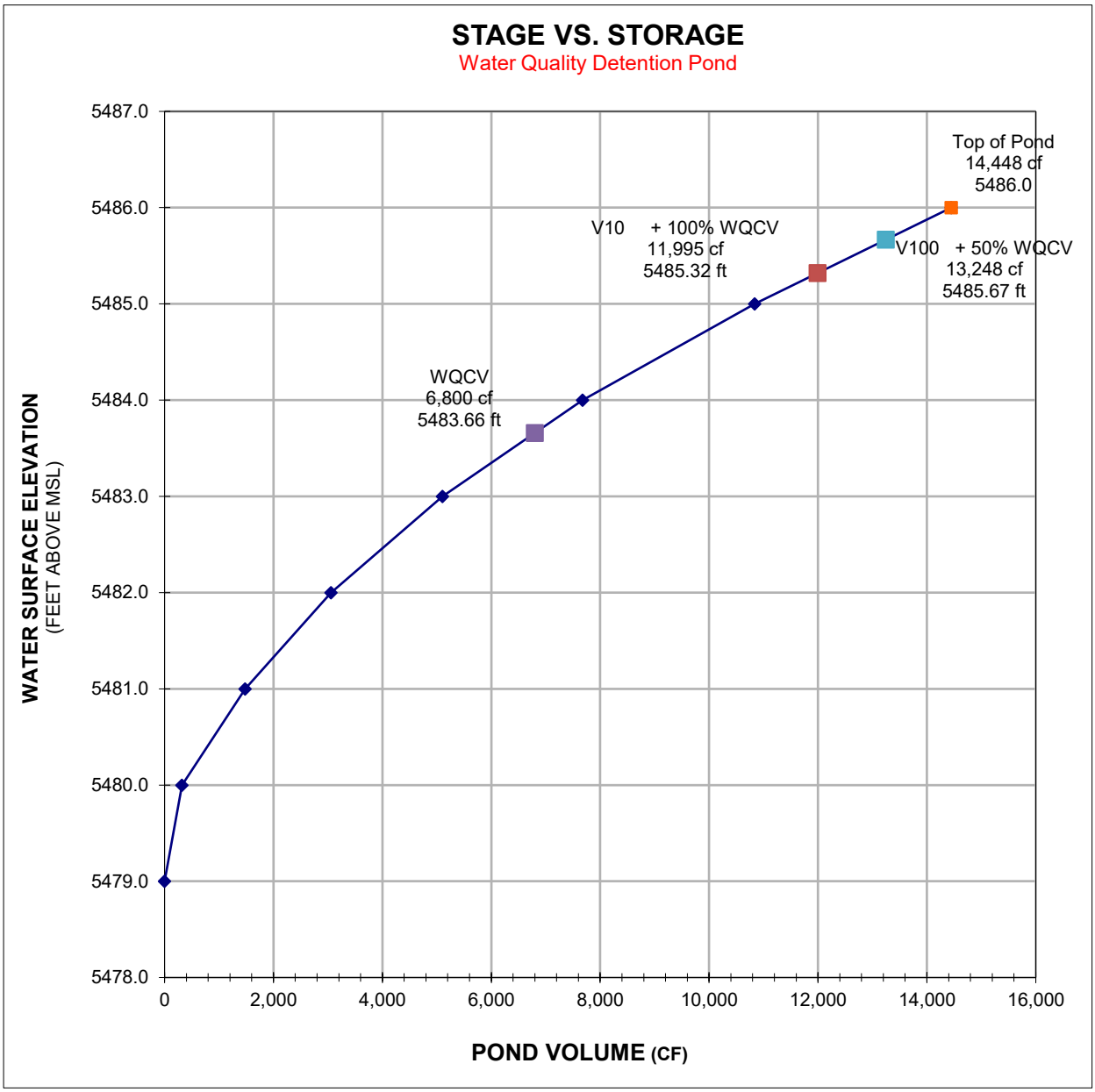

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POND VOLUME CALCULATIONS - STAGE / STORAGE

Pond Volume = **Prismoidal Formula**
Volume Equation = (A1+A2+SQRT(A1*A2)*D/3

Stage / Storage Input Table

ELEVATION ft	DEPTH (D) ft	AREA (A1) ft^2	WEIGHTED AVG AREA (A2) ft^2	INCREMENTAL VOLUME ft^3	CUMMULATIVE VOLUME ft^3
5493.5		0			0
5494.0	0.5	330	165	55	55
5495.0	1.0	2,800	1,565	1,364	1,419
5496.0	1.0	3,140	2,970	2,968	4,387
5497.0	1.0	3,500	3,320	3,318	7,705
5498.0	1.0	3,800	3,650	3,649	11,354
5498.5	0.5	4,100	3,950	1,975	13,329

Top of Pond

5498.5	5.0	**TOTAL VOLUME**	**13,329 cf**	0.306 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	6,350 cf	0.146 ac-ft	**5496.59 ft**	3.09 ft
V10 + 100% WQCV	10,326 cf	0.237 ac-ft	**5497.72 ft**	4.22 ft
V100 + 50% WQCV	11,572 cf	0.266 ac-ft	**5498.06 ft**	4.56 ft

Volume Interpolation Calculations

WQCV		**V10 + 100% WQCV**		**V100 + 50% WQCV**	
Vol	Elev	Vol	Elev	Vol	Elev
4387.13	5496.00	7705.50	5497.00	11354.47	5498.00
6350.00	5496.59	10325.81	5497.72	11571.84	5498.06
7705.50	5497.00	11354.47	5498.00	13329.00	5498.50

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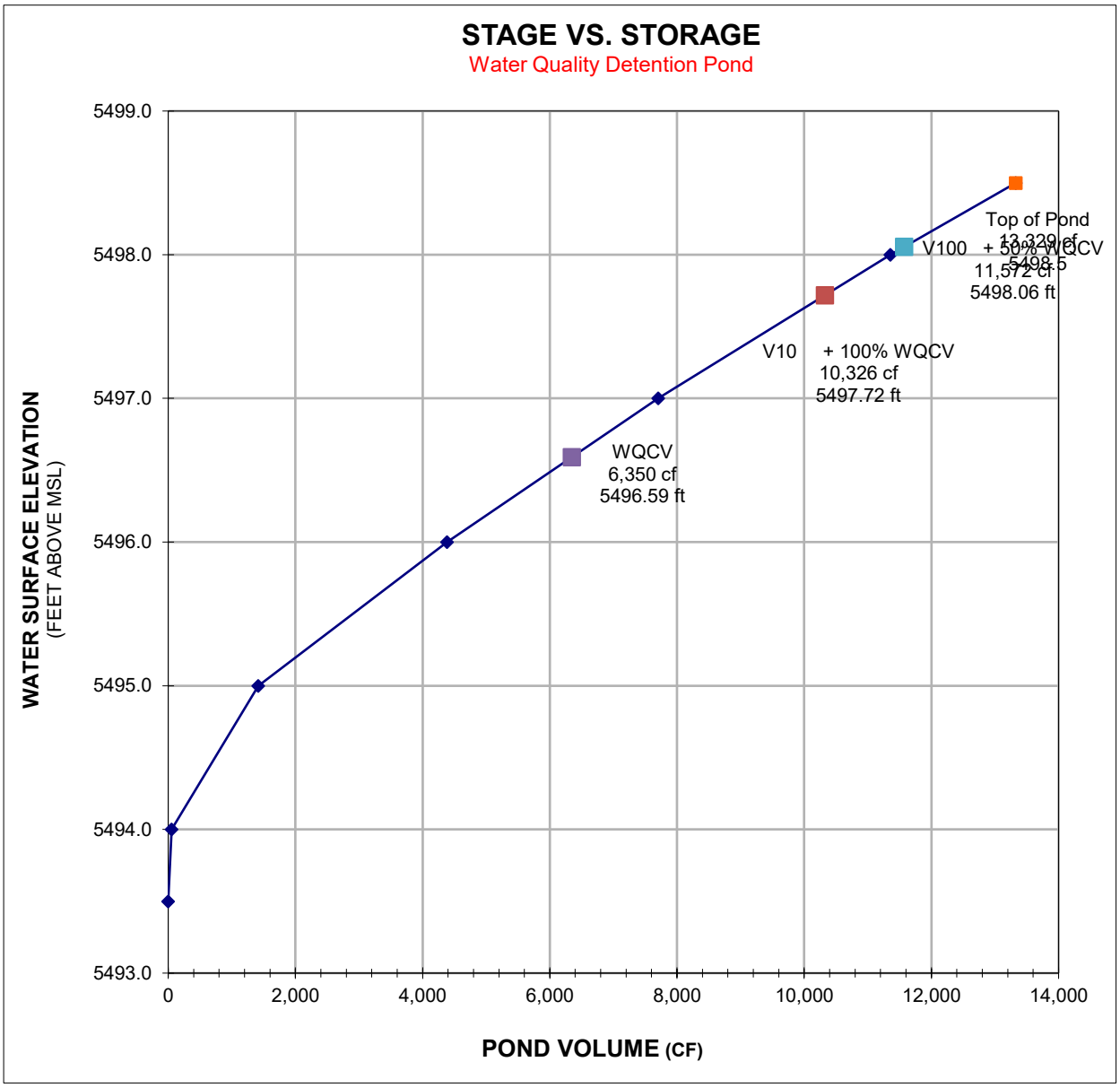

APPENDIX C – PREVIOUS DRAINAGE STUDY

FINAL DRAINAGE REPORT
TRAILHEAD SUBDIVISION

AT

2461 4TH STREET

BOULDER, COLORADO 80304

FOR

MOONBEAM BOULDER, LLC
865 KALMIA AVENUE
BOULDER, COLORADO 80304

JVA, Inc.
Consulting Engineers
1319 Spruce Street
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(303) 444-1951
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JVA Project No. 1889c

March 18, 2013

PROPOSED PROJECT

The proposed project will consist of 23 single family housing units on the 5.84-acre site. Ten of the units will have frontage access on the public street known as 4th Street. The remaining 13 lots will have frontage on new public access roads to be dedicated with the project. The houses will be constructed to preserve the steep slope along the western boundary of the site.

The proposed drainage system will utilize a mixture of roadside conveyance / water quality rain gardens and storm sewer to adequately drain the site to 4th Street. There is no 100-year detention proposed for the site to accommodate the proposed development due to the proposed impervious area compared to that of the school site which did not provide detention for the 100-year storm. A new detention pond will be constructed along the southern boundary to provide an equivalent amount of storage volume required for the medical facility plus overdetention for the 5-year runoff as described herein and as accepted by the City during the Site Review approval process. A new storm sewer outfall will be constructed through the eastern alley of the project to connect to the inlets located at the intersection of Dewey Avenue and 4th Street. The existing detention pond outfall storm sewer from the medical facility detention ponds will be removed. This is consistent with the historic drainage patterns.

Water quality storage volume for the lots will be provided with water quality rain gardens for the single family lots. Grass lined swales along the main site access roads will provide additional water quality enhancement for the paved areas located within the public right-of-way.

HISTORIC DRAINAGE

MAJOR DRAINAGE BASIN DESCRIPTION

The site is located in Goose Creek storm water basin. Goose Creek is tributary to Boulder Creek on the east side of the City. There are no major drainage ways that pass through the site.

JVA reviewed FEMA Flood Insurance Rate Map Community Panel Number 08013C0395F, dated June 2, 1995 and determined that no portions of the site are within the Special Flood Hazard Area (Base Flood or 100-year floodplain). This was confirmed with the City of Boulder Flood Plain Mapping. See the appendix for a copy of the City of Boulder Flood Plain Mapping delineation.

SITE DRAINAGE AND EXISTING FACILITIES

The subject site is located on the west side of 4th Street between the northern driveway of Mapleton Hill Medical Center and Valley View Drive in Boulder, Colorado. The site generally lies between 5453 feet and 5531 feet on the NAVD88 datum. Existing grades generally slope from west to east with runoff flowing into 4th Street and eventually to Dewey Avenue to the east. The site has slope of approximately 35% along the western property line. The site then flattens out on a bench that falls from west to east at approximately 3%. The site then transitions down to 4th Street with a 4:1 slope.

The majority of the soils found onsite are terrace escarpments with an NRCS hydrologic soils group (HGS) of A. Soils with an HSG of A have a very high infiltration rate when

thoroughly wet and therefore have low runoff potential. A copy of the NRCS soils classification map is included in the Appendix.

There is a swale along the toe of the slope coming from down along the western property line to divert offsite runoff around the site. This swale has a high point approximately 370-feet north of the southern property line the splits the runoff coming from the western offsite basin.

Runoff diverted to the south is directed to a series of detention ponds located on the south side of the site. These ponds were designed and constructed in conjunction with the medical facility located south of the site. The *Drainage Report for Mapleton Hills Medical Plaza*, by Drexell, Barrell & Company, dated January 31, 1984 (Drexell Report) describes the design of these ponds. There is no evidence of drainage easements or maintenance agreements being recorded for these ponds. These ponds also intercept drainage for the medical facility constructed in the southwest corner of the site. The detention ponds where designed to pass the runoff from the offsite tributary basins through the ponds down to the storm sewer system located in 4th Street. Larger storm events overtop the ponds and 4th Street walk and flow to the east along Dewey Avenue.

Runoff that is diverted to the north is directed to a detention pond that was constructed by the school to provide detention of the 5-year storm in accordance with the *Final Drainage Report Boulder Junior Academy,* by Charles Keim & Associates, dated November 4, 1994 (Keim Report). The pond was designed and constructed in the 1990s when an addition was added to the school. The outfall structure for the pond conveyed the 5-year storm discharge into a pipe that ties into the storm sewer system in 4th Street. The pond was designed to pass the offsite runoff through the pond undetained. The 100-year storm simply overtops the pond berm on the east and flows down to 4th Street and Dewey Avenue. No detention was provided for the 100-year storm.

EXISTING SITE BASINS

The existing site is broken into three basins that eventually drain to the same location at the intersection of 4th Street and Dewey Avenue. These basins were delineated in the Keim Report and the Drexel Report

The first two basins consist of a mixture of onsite and offsite basins. The Keim Report splits the offsite flows based on the diversion ditch constructed on the west side of the site. Basin H-A3 (6.10-acres) is the portion of the basin that is diverted to the north. This basin collects offsite runoff along with runoff from the northwest corner of the site. Drainage from this basin is routed around the development of the site to the northeast corner of the site where it discharges to an existing detention pond. The outfall for this detention pond was not constructed to accommodate these flows. Drainage from this basin is released as sheet flow from the pond to 4th Street located to the east.

The third significant basin was identified in the Keim Report as Basin H-A (5.83-acres). This basin consists of the entire property and was used in calculating allowable release rates from the 5-year storm for the site. This basin consists of the eastern two-thirds of the site. A detention pond exists in this basin to detain the 5-year storm for the building addition that was constructed at the school. The 5-year storm is conveyed through the outlet structure of the pond to an inlet in 4th Street. This 5-year storm release rate of 4.90 cfs has been used as the 5-year release rate from this basin. Runoff in excess of the 5-year storm overtops the pond and sheet flows to 4th Street.

There are two historic basins of significance located on the property to the south. These two basins were delineated in the Drexel Report to identify drainage patterns for the medical facility. A series of detention ponds were constructed onsite to provide detention for these two basins. The detention ponds only provided detention for the 5-year storm and due to their location have minimal effectiveness due to the significant offsite flows that pass through them.

Basin H-C (7.96-acres) is located in the southwest corner of the site. Similar to Basin H-A3, it consists of offsite runoff in addition to runoff from the southwest corner of the site at was identified as contributing flow in the Drexel Report. This basin is also routed around the site. It outfalls into a series of detention ponds designed for the medical facility to the south. These ponds were designed to convey the runoff from this basin to 4th Street. The Drexel Report assumed that this basin would have a composite C_5 value of 0.88 and a C_{100} value of 0.93. This basin, however, is very steep and has now been developed to about its maximum potential. A further analysis of this basin shows a C_5 value of 0.45 and a C_{100} value of 0.72 is more appropriate for the current and likely future conditions. An exhibit showing the development within this basin is included in the appendix. This modification to the C values reduced the historic flow rates from this basin from 29.0-cfs to 15.04-cfs for the 5-year storm and from 63.66-cfs to 48.14-cfs for the 100-year storm. This brought the runoff from this basin closer in line with those identified in the Keim Report. The series of the detention ponds identified in the Drexel Report used a maximum 5-year release rate of 12.14-cfs. The remainder of runoff tributary to these ponds was allowed to overflow the system. In order to be consistent with this approach an allowable 5-year release rate for Basin H-C was adjusted to 12.14-cfs.

Basin H-II (0.33-acres) consists of the offsite medical facility and associated parking. This basin is located due south of the site and outfalls into the series of detention ponds.

Basin H-III (0.21-acres) also consists of the medical facility development. It is situated so that it sheet flows directly to 4th Street, bypassing the detention ponds. The existing detention ponds were designed to overdetain for this bypassing basin.

All of these basins make up the historic basins impacted by the proposed development. The basins mentioned above outlet to the storm sewer at the intersection of 4th Street and Dewey Avenue. There are other basins that outfall to this location that were not evaluated with this study.

The total flow rate for the 5-year storm requires a mixture of allowable pond release rates and developed flows that are currently being released offsite. Both sites have provided 5-year detention in the past. The 5-year historic (existing) release rates will be compared to the developed 5-year release rates at the intersection of Dewey and 4th Street to determine the required detention for replacing the detention ponds for the medical facility and the proposed Trailhead Subdivision development.

The historic 5-year flow rate from the northern drainage basin can be determined by taking the 5-year historic flow rate calculated in the Keim Report for Basin H-A and adding it to the pass through 5-year flow rate for Basin H-A3. These flow rates are 4.9-cfs and 4.27-cfs respectively. Adding these two flow rates together gives a combined flow rate of 9.17-cfs.

Table 1: Historic (existing) Flow Rates

Basin	5-Year Flow (cfs)	100-Year Flow (cfs)
H-A	4.90*	33.27
H-A2	7.65	35.72
H-A3	4.27	24.52
H-II	1.66	3.07
H-III	1.05	1.95
H-C	12.14**	48.14**

* - 5-year release rate from detention pond

** - Adjusted as discussed above

The historic 5-year flow rate from the southern drainage basin is more complicated to determine. The Drexell Report states that Basin H-III has an existing release rate of 1.05-cfs. Combining this with the offsite runoff from Basin H-C of 12.14-cfs gives a total 5-year flow rate of 13.19-cfs for the southern basin.

PROPOSED (DEVELOPED) DRAINAGE

DRAINAGE DESIGN CRITERIA

The proposed private storm drainage facilities for the project are designed to comply with the "City of Boulder Design and Construction Standards," 2000 Edition, and the Urban Drainage and Flood Control District's (UDFCD's) Urban Storm Drainage Criteria Manual (USDCM), June 2001 Edition.

HYDROLOGIC METHOD AND DESIGN STORM FREQUENCIES

Design storm recurrence intervals for this project are consistent with the City of Boulder requirements for industrial areas: the minor or initial storm will be the 5-year event (for onsite private storm systems), and the major storm will be the 100-year event (for overland and street conveyance). This design interval was chosen to stay consistent with the past reports of storm routing on this site.

The Rational Method (Q=CIA) was used to determine the storm runoff (Q) from the site, with composite runoff coefficients (C) and contributing areas (A) given for design points in sub-basins. Intensities (I) were determined using the Time-Intensity-Frequency Curves for Boulder, Colorado (Figure 7-1) and a calculated Time of Concentration (t_c). Post-development Time of Concentration calculations for each sub-basin, corresponding rainfall intensities, and composite runoff coefficients for each sub-basin are provided in the Appendix.

PROPOSED SITE BASINS

The proposed site has been divided into 13 sub-basins. Please refer to the Developed Drainage Map (see attached Fig-2). Sub-basin boundaries were established based on

outfall location. Rain gardens will be provided in each lot with the exception of Lots 13 and 14 to capture runoff for water quality treatment. The runoff from the alleyways will be contained with an inverted crown section to the middle of the site. The westerly alley then spills to roadside swales. The easterly alley will spill out into roadside swales.

Basins A1 (0.98 acres), A2 (0.17 acres), A3 (0.53 acres), A5 (0.17 acres), A6 (0.66 acres), A11 (0.74 acres) and A14 (0.77 acres) are all comprised of single family lots. All of the lots drain to roadside rain gardens for water quality treatment. All these rain gardens convey runoff to the Dewey Avenue extension where they are picked up by roadside ditches to convey the runoff to the storm sewer system in 4th Street. Once in 4th Street, the drainage is conveyed to the east by an existing storm sewer in Dewey Avenue.

Basins A4 (0.15 acres) and A7 (0.14 acres) are comprised of the western alley. These basins are comprised of the inverted crown alleys, Dewey Avenue extension, sidewalks and roadside swales. These basins are picked up by inlets attached to the storm sewer system at the intersection of the eastern alley and Dewey Avenue Extension. Water quality for these basins is provided by the roadside rain gardens between the western and eastern alleys.

Table 2: Developed Flow Rates

Design Point	5-Year Flow (cfs)	100-Year Flow (cfs)
1	2.01	6.31
2	0.44	1.01
3	1.18	3.71
4	0.69	1.34
5	0.44	1.19
6	1.44	4.53
7	0.62	1.20
9	0.65	1.21
10	0.44	0.96
11	1.30	4.71
12	0.75	1.40
13	0.34	0.80
14	1.77	4.22
H-A3	4.27	24.52
H-C	15.04*	48.14*
H-II	1.66	3.07
H-III	1.05	1.95

* - See Historic Drainage section for discussion of runoff rates from Basin H-C

Basins A9 (0.13 acres) and A12 (0.15 acres) are comprised of the eastern alley. This alley is reserved for future connection to the medical facility to the south if ever required by the city. These basins are comprised of the inverted crown alleys. Water quality enhancement for runoff from these basins is being provided by roadside swales along the extension of Dewey Avenue. Runoff from these basins will spill into the roadside ditches along the Dewey Avenue extension where they will combine with runoff from Basins A10 and A13. Basins A10 (0.11 acres) and A13 (0.11) are comprised of the Dewey Avenue extension, sidewalks and roadside rain gardens. Runoff from these basins is intercepted by inlets at the intersection of 4th Street and Dewey Avenue and is conveyed to the storm sewer system in 4th Street.

Basins H-A2, H-A3, H-C, H-II, and H-III are the same as the historic basins described earlier.

RUNOFF AND STORMWATER QUALITY ENHANCEMENT/DETENTION FACILITIES

No water quality facilities were provided for the school that previously occupied the site. The primary means of water quality enhancement for the site will be through the use of roadside grass-lined ditches and rain gardens. Rain gardens or individual water quality ponds will be constructed for each lot and connected to the 10 foot drainage easements shown. A table has been provided in the appendix that identifies the size of rain garden that would be necessary for each lot. A rain garden detail has also been provided in the Construction Plans that shows how rain gardens could be constructed. There may be opportunities to provide water quality storage volume in a simple pond located within the easements for some of the lots. The exact layout for providing water quality will be determined at the time of the design of the houses for the lots.

All residences must have the individual lot's water quality enhancement rain garden in place prior to completion of the residence. Individual lots will need to provide erosion control measures until the lot is fully vegetated and take care to prevent any erosion from damaging the rain gardens. Rain gardens and bioretention areas require proper construction and periodic maintenance. Details for the required construction practices and details are provided herein and as a part of the construction plans. Maintenance requirements are also provided in the appendix of this report.

It is our intent to match the drainage patterns that were in place when the school occupied the site. This will be achieved by comparing flow rates for the 5-year and 100-year events for the proposed development with those of the previous development. A comparison of the 100-year flow rates shows that the proposed development will generate less flow than those calculated in the Keim Report during the 100-year rainfall event.

When the 5-year flow rates from the proposed development and the school site were compared it was evident that the proposed development was going to increase the flow rate by 4.91-cfs. In order to mitigate this increase, the detention pond that is being reconstructed for the medical facility on the south side of the property will be increased in size to overdetain runoff from the southern basin. This will not have a significant impact on the storm sewer system in 4th Street.

APPENDIX B – CALCULATIONS

JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: 2641 4th Street
Job Number: 1889c
Date: 2/19/13
By: XT

	I%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	0%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	0%	0.10	0.20	0.30	0.60
Playground	13%	0.20	0.30	0.40	0.70
Artificial Turf	25%	0.28	0.38	0.43	0.62

2641 4th Street

Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
Minor Design Storm: 2
Major Design Storm: 100
Soil Type: C/D

Basin Design Data

	I (%) =	100%	96%	90%	7%	13%	25%	0%	0%			I (%)	Runoff Coeff's				Initial Overland Time (t_i) $t_i=0.395(1.1-C_5)L^{1/2}S^{-1/3}$			Travel Time (t_t) t_t=Length/(Velocity x 60)						t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	A_{plygnd} (sf)	$A_{art.\ turf}$ (sf)	$A_{lscape\ (B\ soil)}$ (sf)	$A_{lscape\ (C/D\ soil)}$ (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+ 10 (min.)	Min t_c
OS	1	64,400	0	20,540	15,000	0	0	0	246,799	346,739	7.96	24.2%	0.29	0.37	0.45	0.68	300	25.0%	8.0	750	8.0%	Paved areas & shallow paved swales	20	5.7	2.2	10.2	1050	15.8	10.2
										0	0.00											Paved areas & shallow paved swales	20				0	10.0	
										0	0.00											Paved areas & shallow paved swales	20				0	10.0	
										0	0.00											Paved areas & shallow paved swales	20				0	10.0	
										0	0.00											Paved areas & shallow paved swales	20				0	10.0	
TOTAL SITE		64,400	0	20,540	15,000	0	0	0	246,799	346,739	7.96	24.2%	0.00	0.00	0.00	0.00													

$I = (28.5\ P_1) / ((10 + T_c)^{0.786})$

			Runoff Coeff's				Rainfall Intensities (in/hr)				Area		Flow Rates (cfs)			
Basin Name	Design Point	Time of Conc (tc)	C2	C5	C10	C100	2	5	10	100	A_{Total} (sf)	A_{Total} (ac)	Q2	Q5	Q10	Q100
OS	1	10.2	0.29	0.37	0.45	0.68	2.88	4.12	5.65	8.28	346,739	7.96	6.56	12.03	16.50	44.90
0	0										0	0.00				
0	0										0	0.00				
0	0										0	0.00				
0	0										0	0.00				
										TOTAL SITE	346,739	7.96	6.56	12.03	16.50	44.90

200 0 200 400

SCALE IN FEET

BASIN H-C AREA

EXHIBIT

DATE: JANUARY 2013

DRAWN BY: CJB

CHECKED BY:

REVISION	DATE	BY

CONSULTING ENGINEERS

JVA Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957

Job Name: Trailhead Subdivision
Job Number: 1889c
Date: 1/5/13
By: CJB

Trailhead Subdivision

Historic (Existing) Runoff Coefficient, Time of Concentration, & Qs

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	B

Basins		Runoff			Rainfall			Flow Rates (cfs)		
Original Basin Name	Revised Basin Name	Time of Conc (tc) (min)	C5	C100	I5	I100	A_{Total} (ac)	Q5	Q100	Remarks
From Drexel, Barrell & Co. Report (See attached sheets for calculations from original report)										
II	H-II	5.0	0.88	0.93	5.70	10.0	0.33	1.66	3.07	Tributary to Ponds IV-VII
III	H-III	5.0	0.88	0.93	5.70	10.0	0.21	1.05	1.95	Released undetained
Contributing Flow	H-C	10.0	0.45	0.72	4.20	8.4	7.96	15.04	48.14	Pass-through flow
From Charles Keim & Associates Report (See attached sheets for calculations from original report)										
A	H-A	10.0	0.20		4.20		5.83	4.90		Allowable Historic Site Runoff
A2	H-A2	14.0	0.25	0.63	3.60	6.8	8.40	7.55	35.72	Trib to SW Swale - See Comp. C calcs. for addition details
A3	H-A3	14.5	0.20	0.60	3.50	6.7	6.10	4.27	24.52	Trib to NW Swale

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Job Name: Trailhead Subdivision
Job Number: 1889c
Date: 1/5/13
By: CJB

	i%	C2	C5	C10	C100
Streets Paved	100%	0.87	0.88	0.90	0.93
Concrete Drives/Walks	96%	0.85	0.87	0.90	0.92
Roof	90%	0.80	0.85	0.90	0.90
Gravel	7%	0.15	0.25	0.35	0.65
Landscaping (B soil)	2%	0.00	0.10	0.20	0.50
Landscaping (C/D soil)	5%	0.10	0.20	0.30	0.60
Single Family	40%	0.40	0.45	0.50	0.70
Artificial Turf	25%	0.11	0.21	0.30	0.53

Trailhead Subdivision

Composite Runoff Coefficient Calculations

Location: Boulder
Minor Design Storm: 5
Major Design Storm: 100
Soil Type: B

Basin Design Data												Runoff Coeff's			
	I (%) =	100%	96%	90%	7%	40%	2%	5%			I (%)				
Basin Name	Design Point	A_{paved} streets (sf)	$A_{drives/conc}$ (sf)	A_{roof} (sf)	A_{gravel} (sf)	A_{sf} (sf)	$A_{lscape\ (B\ soil)}$ (sf)	$A_{lscape\ (C/D\ soil)}$ (sf)	A_{Total} (sf)	A_{Total} (ac)	Imp (%)	C2	C5	C10	C100
A1	1	0				42,689			42,689	0.98	40.0%	0.40	0.45	0.50	0.70
A2	2	0				7,405			7,405	0.17	40.0%	0.40	0.45	0.50	0.70
A3	3	0				23,087			23,087	0.53	40.0%	0.40	0.45	0.50	0.70
A4	4	5,844				0	803		6,647	0.15	88.2%	0.76	0.79	0.82	0.88
A5	5	0				7,405			7,405	0.17	40.0%	0.40	0.45	0.50	0.70
A6	6	0				28,749			28,749	0.66	40.0%	0.40	0.45	0.50	0.70
A7	7	5,216				0	803		6,019	0.14	86.9%	0.75	0.78	0.81	0.87
A9	9	5,663							5,663	0.13	100.0%	0.87	0.88	0.90	0.93
A10	10	3,664					1,522		5,186	0.12	71.2%	0.61	0.65	0.69	0.80
A11	11					32,234			32,234	0.74	40.0%	0.40	0.45	0.50	0.70
A12	12	6,534							6,534	0.15	100.0%	0.87	0.88	0.90	0.93
A13	13	2,738					1,848		4,586	0.11	60.5%	0.52	0.57	0.62	0.76
A14	14					33,541			33,541	0.77	40.0%	0.40	0.45	0.50	0.70
H-C*	16	96,000	7,500	22,540	7,500			213,000	346,540	7.96	38.9%	0.38	0.45	0.52	0.72
H-A2	H1	22,216		6,534				337,154	365,904	8.40	12.3%	0.16	0.25	0.35	0.63

* new runoff coefficient calculations were performed for Historic Basin H-C to more accurately reflect the currently developed conditions, shown in City of Boulder mapping available through their website, downloaded on January 2013.

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Job Name: Trailhead Subdivision
Job Number: 1889c
Date: 1/5/13
By: CJB

Trailhead Subdivision

Time of Concentration Calculations

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	B

Sub-Basin Data				Initial Overland Time (t_i) $t_i=[1.8(1.1-C_5)L^{1/2}]/S^{1/3}$			Travel Time (t_t) t_t=Length/(Velocity x 60)						t_c Comp	tc Urbanized Check ON		t_c Final
Basin Name	Design Point	A_{Total} (ac)	C5	Upper most Length (ft)	Slope (%)	t_i (min)	Length (ft)	Slope (%)	Type of Land Surface	C_v	Velocity (fps)	t_t (min)	Time of Conc $t_i + t_t = t_c$	Total Length (ft)	t_c=(L/180)+10 (min)	Min t_c
A1	1	0.98	0.45	100	5.0%	6.8	205	2.4%	Grassed waterway	15	2.3	1.5	8.3	305	11.7	8.3
A2	2	0.17	0.45	60	10.0%	4.2	105	2.9%	Grassed waterway	15	2.6	0.7	4.9	165	10.9	5.0
A3	3	0.53	0.45	100	11.0%	5.3	235	2.6%	Grassed waterway	15	2.4	1.6	6.9	335	11.9	6.9
A4	4	0.15	0.79	10	2.0%	1.4	300	4.7%	Paved areas & shallow paved swales	20	4.3	1.2	2.6	310	11.7	5.0
A5	5	0.17	0.45	65	9.2%	4.5	100	5.0%	Grassed waterway	15	3.4	0.5	5.0	165	10.9	5.0
A6	6	0.66	0.45	200	22.0%	5.9	255	4.7%	Grassed waterway	15	3.3	1.3	7.2	455	12.5	7.2
A7	7	0.14	0.78	10	2.0%	1.4	275	5.8%	Paved areas & shallow paved swales	20	4.8	1.0	2.4	285	11.6	5.0
A9	9	0.13	0.88	20	12.5%	0.8	260	2.6%	Paved areas & shallow paved swales	20	3.2	1.3	2.1	280	11.6	5.0
A10	10	0.12	0.65	80	6.3%	3.9	100	8.5%	Grassed waterway	15	4.4	0.4	4.3	180	11.0	5.0
A11	11	0.74	0.45	125	9.2%	6.2	265	1.7%	Grassed waterway	15	2.0	2.3	8.5	390	12.2	8.5
A12	12	0.15	0.88	10	2.0%	1.0	300	7.3%	Paved areas & shallow paved swales	20	5.4	0.9	1.9	310	11.7	5.0
A13	13	0.11	0.57	80	6.3%	4.6	100	8.3%	Paved areas & shallow paved swales	20	5.8	0.3	4.9	180	11.0	5.0
A14	14	0.77	0.45	130	14.6%	5.5	275	4.0%	Paved areas & shallow paved swales	20	4.0	1.1	6.6	405	12.3	6.6
H-C	16	7.96	0.45	300	20.0%	7.5	750	7.0%	Paved areas & shallow paved swales	20	5.3	2.4	* 9.9	1050	15.8	14.0
H-II	H2	0.33	0.88													5.0
H-III	H3	0.21	0.88													5.0
H-A2	H1	7.74	0.20													14.0
H-A3	H4	6.10	0.20													14.5

* rational method calculations performed with t_c = 10 min similar to previous report

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By: CJB

Trailhead Subdivision

Developed Storm Runoff Calculations

Design Storm : **5 Year**

Point Hour Rainfall (P_1) : **1.36** Rainfall intensities (I) interpreted from Figure 7-1, City of Boulder Design and Construction Standards

	Direct Runoff							Total Runoff				Pipe					Pipe/Swale Travel Time			
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Notes
A1	1	0.98	0.45	8.3	0.44	4.60	2.03													
	1						Pipe	8.3	0.44	4.60	2.03	18 in	RCP	1.1%	2.03	10.3	53	4.29	0.21	
	1						Swale	8.5	0.44	4.55	2.01			7.6%			36	2.00	0.30	Route to 2A
	2A						Total (A1)	8.8	0.44	4.50	1.98									
A2	2	0.17	0.45	5.0	0.08	5.71	0.44													
	2						Swale	5.0	0.08	5.71	0.44			7.6%			11	2.20	0.08	Route to 2A
	2A						Swale at DP2A (A1, A2)	5.1	0.52	5.71	2.95									Combine & Route to 4
	4							8.8	0.52	4.50	2.33			6.5%			46	4.10	0.19	
	4						Total (A1, A2)	9.0	0.52	4.45	2.30									
A3	3	0.53	0.45	6.9	0.24	4.95	1.18													Combine & Route to 4
							Pipe	6.9	0.24	4.95	1.18	12 in	PVC	0.5%	1.18	2.7	16	3.16	0.08	Route to DP4
A4	4	0.15	0.79	5.0	0.12	5.71	0.69													
	4	Total Swale flow entering inlet at DP4 (A1, A2 and A4)						9.0	0.64	4.45	2.84									
A5	5	0.17	0.45	5.0	0.08	5.71	0.44													
	5				Swale flow from DP5 to DP7			5.0	0.08	5.71	0.44			6.7%			55	1.31	0.70	Route to DP7
	7							5.7	0.08	5.60	0.43									
A6	6	0.66	0.45	7.2	0.30	4.85	1.44													
	6						Pipe	7.2	0.30	4.85	1.44	12 in	PVC	0.5%	1.44	2.7	15	3.31	0.08	Route to DP7
	7							7.3	0.30	4.85	1.44									
A7	7	0.14	0.78	5.0	0.11	5.71	0.62													
	7		Total swale flowentering inlet at DP7 (A5 and A7)					7.3	0.18	4.85	0.89			7.6%			50	1.63	0.51	Route to DP4
	4		Total pipe flow from DP7 to DP4 (A5, A6 & A7)					7.8	0.48	4.80	2.31	18 in	RCP	0.5%	2.31	6.9	28	3.34	0.14	
	8		combined flow from DP4 to DP8 from (A1-A7)					9.0	1.36	4.45	6.04	18 in	RCP	9.0%	6.04	29.4	24	12.41	0.03	
H-A3	H4	6.10	0.20	14.5	1.22	3.50	4.27													Offsite tributary flow, Route to DP8
	8							14.5	1.22	3.50	4.27	24 in	RCP	4.5%	4.27	44.7	335	8.53	0.65	
	8							15.2	1.22	3.45	4.21									Routed flows to DP8 from H4
H-C	16	7.96	0.45	10.0	3.58	4.20	15.04					30 in	RCP	4.0%	10.13	42.2	338	10.26	0.55	Q5= 10.13cfs from basin H-C reflects 15.04cfs - detained flow of 4.91cfs
	8							15.2	2.58	3.45	19.02	18 in	RCP	4.2%	19.02	20.8	127	12.46	0.17	Combine flows at DP8 & Route to DP15 Q = Routed Flow from Basins A1-A7, H-A3 + restricted flow from HC (10.13cfs)
	15						Total	15.4	2.58	3.40	18.89									Total piped flow to existing MH in 4th Street. Q = Routed Flow: Basins A1-A7, H-A3 + restricted flow from H-C

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Trailhead Subdivision

Developed Storm Runoff Calculations

Design Storm: **5 Year**

Point Hour Rainfall (P_1): **1.36** Rainfall intensities (I) interpreted from Figure 7-1, City of Boulder Design and Construction Standards

	Direct Runoff							Total Runoff				Pipe					Pipe/Swale Travel Time			
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Notes
A9	9	0.13	0.88	5.0	0.11	5.71	0.65													
	9							5.0	0.11	5.71	0.65			4.2%			88	1.22	1.20	Route to DP10 through swale
	10							6.2	0.11	5.60	0.64									
A10	10	0.12	0.65	5.0	0.08	5.71	0.44													
	10							6.2	0.19	5.60	1.07	8 in	PVC	1.1%	1.07	1.3	13	2.70	0.08	Combine & Route to DP11
	11					Total (A9, A10)		6.3	0.19	5.55	1.06									
A11	11	0.74	0.45	8.5	0.33	3.91	1.30													
	11							8.5	0.52	3.90	2.05	12 in	PVC	1.0%	2.05	4.7	18	4.00	0.08	
	15					Total (A9-A11)		8.6	0.52	3.90	2.05									Total flows to back of existing inlet in 4th Street. Combine flows at DP11 & Route to 15
A12	12	0.15	0.88	5.0	0.13	5.71	0.75													
	12							5.0	0.13	5.71	0.75			4.2%			88	1.37	1.07	Route to DP 13 through swale
	13					Total (A12)		6.1	0.13	5.60	0.74									
A13	13	0.11	0.57	5.0	0.06	5.71	0.34													
	13							6.1	0.19	5.60	1.08	8 in	PVC	1.9%	1.08	1.8	13	5.08	0.04	Combine flows at DP13 and Route to DP 14
	14					Total (A12, A13)		6.1	0.19	5.60	1.08									
A14	14	0.77	0.45	6.6	0.35	5.10	1.77													
	14							6.6	0.54	5.10	2.75	12 in	PVC	3.0%	2.75	6.6	18	3.74	0.08	
	15					Total (A12-A14)		6.7	0.54	5.10	2.75									Total flows to back of existing inlet in 4th Street. Combine flows at DP14 and Route to DP15
	15	Total Developed flows (A1-A14, H-A3, H-C UNrestricted)						15.4	7.22	3.40	24.56									
	15		Total (A1-A14, H-A3) + restricted flow from H-C					15.4	3.64	3.40	22.51									Summary of all accumulated flows/impact to existing storm system in 4th Street.

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Developed Storm Runoff Calculations

Design Storm : **100 Year**

Point Hour Rainfall (P_1) : **2.50**

	Direct Runoff							Total Runoff				Pipe					Pipe/Swale Travel Time			
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Notes
A1	1	0.98	0.70	8.30	0.69	9.20	6.31													
	1						Pipe	8.3	0.69	9.20	6.31	18 in	RCP	1.1%	6.31	10.3	53	5.00	0.18	
	1						Swale	8.5	0.69	9.10	6.24			7.6%			36	4.00	0.15	Route to 2A
	2A						Total (A1)	8.6	0.69	9.10	6.24									
A2	2	0.17	0.70	5.00	0.12	8.48	1.01													
	2							5.0	0.12	10.00	1.19			7.6%			11	3.50	0.05	Route to 2A
	2A							5.1	0.12	10.00	1.19									Combine & Route to 4
	4							8.6	0.80	9.10	7.33			6.5%			46	4.00	0.19	
	4						Total (A1, A2)	8.8	0.80	9.00	7.24									
A3	3	0.53	0.70	6.90	0.37	10.00	3.71													
							Pipe	6.9	0.37	10.00	3.71	12 in	PVC	0.5%	2.70	2.7	16	3.21	0.08	Route to DP4, carry overflow in roadside swale in Dewey Ave and to DP 10.
A4	4	0.15	0.88	5.00	0.13	10.00	1.34													
	8	Total Swale flow entering inlet at DP 4 (A1, A2 and A4)						8.8	0.94	9.00	8.45									Combine and route to DP4
A5	5	0.17	0.70	5.00	0.12	10.00	1.19													
	5				Swale flow from DP5 to DP7			5.0	0.12	10.00	1.19			6.7%			55	1.67	0.55	Route to DP7
	7							5.5	0.12	10.00	1.19									
A6	6	0.66	0.70	7.20	0.46	9.80	4.53													
	6						Pipe	7.2	0.46	9.80	4.53	12 in	PVC	0.5%	2.70	2.7	15	3.21	0.08	Route to DP 7, excess flow carries over to roadside swale in Devey Ave, to inlet at DP13.
	7							7.3	0.46	9.80	4.53									
A7	7	0.14	0.87	5.00	0.12	10.00	1.20						14							
	7		Total swale flow entering inlet at DP7 (A5 and A7)					7.3	0.24	9.80	2.34			6.7%			50	2.08	0.40	Route to DP4
	4		Total pipe flow from DP7 to DP4 (A5, A6 & A7)					7.7	0.70	9.50	6.66	18 in	RCP	2.0%	6.66	13.8	28	7.35	0.06	
	8		combined flow from DP4 to DP8 from (A1-A7)					8.8	2.01	9.00	18.10	18 in	RCP	9.0%	18.10	29.4	24	16.52	0.02	
	8		Total routed flow from DP4 to DP8 (A1-A7)					8.8	2.01	9.00	18.10									Routed flows from A1-A7
H-A3	H4	6.10	0.60	14.50	3.66	6.70	24.52													Offsite tributary flow, route to DP 8
	8							14.5	3.66	6.85	25.07	24 in	RCP	4.5%	25.07	44.7	335	14.98	0.37	
	8							14.9	3.66	6.65	24.34									Combine flows at DP8 & Route to DP15
H-C	16	7.96	0.72	10.00	5.73	8.40	48.14					30 in	RCP	4.0%	45.20	76.5	338	15.34	0.37	
	8							14.9	11.40	6.70	76.40	30 in	RCP	4.2%	48.14	78.4	127	15.56	0.14	Routed flows to DP8
	15	Total (A1-A7, H-A3, H-C)						15.0	11.40	6.65	75.83									Flow will be divided: 19.02cfs in pipe, overflows in Dewey 56.81cfs will be joined by flows from A9, A10, A12 and A13

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Trailhead Subdivision

Developed Storm Runoff Calculations

Design Storm: **100 Year**

Point Hour Rainfall (P_1): **2.50**

	Direct Runoff							Total Runoff				Pipe					Pipe/Swale Travel Time			
Basin Name	Design Point	Area (ac)	Runoff Coeff	tc (min)	C*A (ac)	I (in/hr)	Q (cfs)	Total tc (min)	ΣC*A (ac)	I (in/hr)	Q (cfs)	Pipe Size (in) or equivalent	Pipe Material	Slope (%)	Pipe Flow (cfs)	Max Pipe Capacity (cfs)	Length (ft)	Velocity (fps)	tt (min)	Notes
A9	9	0.13	0.93	5.00	0.12	10.00	1.21													
	9							5.0	0.12	10.00	1.21			4.2%			88	4.00	0.37	Route to DP10 through swale
	10							5.4	0.12	10.00	1.21									
A10	10	0.12	0.80	5.00	0.10	10.00	0.96													
	10							5.4	0.22	10.00	2.17	8 in	PVC	1.1%	1.30	1.3	13	3.63	0.06	Carry overflows to DP 11, Combine & Route to DP11
	11					Total (A9, A10)		5.4	0.22	10.00	2.17									
A11	11	0.74	0.70	8.50	0.52	9.10	4.71													
	11							8.5	0.73	9.10	6.68	12 in	PVC	1.0%	3.60	3.6	18	4.54	0.07	Carry overflows to DP 15, Combine flows DP11 & Route to 15
	15					Total (A9-A11)		8.6	0.73	9.10	6.68									
A12	12	0.15	0.93	5.00	0.14	10.00	1.40													
	12						Swale	5.0	0.14	10.00	1.40			4.2%			87.3	4.00	0.36	Route to DP 13 through swale
	13					Total (A12)		5.4	0.14	10.00	1.40									
A13	13	0.11	0.76	5.00	0.08	10.00	0.80													
	13							5.4	0.22	10.00	2.19	8 in	PVC	1.9%	1.80	1.8	13	4.77	0.05	Carry overflows to DP 14, Rout to DP 14
	14					Total (A12, A13)		5.4	0.22	10.00	2.19									
A14	14	0.77	0.70	6.60	0.54	7.83	4.22													
	14							6.6	0.76	10.00	7.58	12 in	PVC	3.0%	6.20	6.2	18	7.86	0.04	Carry overflows to DP15, Route to DP15
	15					Total (A12-A14)		6.6	0.76	10.00	7.58									
	15	Total Flows carried overland in Dewy Ave. to 4th Street						15.0	11.84	6.65	59.71									Total (A1-A7, A9, A10, A12, A13, HA-3, HC) - restricted pipe capacity from DP 8 (Q5 = 19.02cfs)
	15	Total (A1-A14, H-A2, H-A3 +HC)						15.0	12.90	6.65	85.75									Summary of all accumulated flows/impact to existing storm system in 4th Street.

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Flowrate Comparison of Historic Flows to Developed Flows

Basin Name	Q5 (cfs)	Source	Remarks
Summation of Historic Flows from previous reports			
H-C + H-II	12.14	DB Report	Release rate from North Ponds in DB Report
H-III	1.05	DB Report	Released undetained
H-A	4.90	Keim Report	History BJA Site Release Rate
H-A3	4.27	Keim Report	NW Swale Pass-through flow
	22.36	**Total Historic Release Rate (Q5 Allowable)**	
Summation of Developed Flows			
H-II	1.66	DB Report	Released undetained
H-III	1.05	DB Report	Released undetained
A1-A14 + H-A3 + H-C	24.56	JVA Report	Total Developed Site Flow at Dewey and 4th
	27.27	**Total Developed Runoff (Q5 Developed)**	
Peak to provide overdetention for			
	27.27		Q5 Developed
-	22.36		Q5 Allowable
	4.91	**Total Peak to be overdetained for**	

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Detention Pond Volume Calculations: FAA Procedure

Based on FAA Procedure, per Federal Aviation Agency "Airport Drainage" Manual

Drainage Basin	Southern
Design Storm	**5 year**
Composite "C" Factor	0.45
Basin Size	7.96

Release Rate Calculations

Allowable Release Rate for Site		10.13 cfs	= 15.04 - 4.91 (cfs)
Less Undetained Offsite Flows	-	cfs	
Allowable Release Rate for Pond		10.13 cfs	

Volume Calculations

Inflow Volume = C * I * A * time (sec)
Outflow Volume = Alowable Release Rate * time (sec)
Storage Volume = Invflow Volume - Outflow Volume

Detention Storage Calculations					
Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow Vin (ft^3)	Outflow Vout (ft^3)	Storage Vstor (ft^3)
5.0	300	5.71	6,136	3,039	3,097
10.0	600	4.20	9,027	6,078	2,949
15.0	900	3.45	11,122	9,117	2,005
20.0	1,200	2.95	12,680	12,156	524
25.0	1,500	2.55	13,701	15,195	-1,494
30.0	1,800	2.25	14,507	18,234	-3,727
35.0	2,100	2.10	15,797	21,273	-5,476
40.0	2,400	1.95	16,764	24,312	-7,548
45.0	2,700	1.80	17,409	27,351	-9,942
50.0	3,000	1.65	17,731	30,390	-12,659
55.0	3,300	1.50	17,731	33,429	-15,698
60.0	3,600	1.35	17,409	36,468	-19,059
				Maximum Volume (ft^3)	**3,097**

City of Boulder Only (110%)	3,407	ft^3
Water Quality Capture Volume:	0	ft^3
Required 5-Year Volume + WQCV:	**3,407**	ft^3

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POND VOLUME CALCULATIONS - STAGE / STORAGE

Pond Volume = **Prismoidal Formula**
Volume Equation = (A1+A2+SQRT(A1*A2)*D/3

Stage / Storage Input Table

ELEVATION ft	DEPTH (D) ft	AREA (A1) ft^2	WEIGHTED AVG AREA (A2) ft^2	INCREMENTAL VOLUME ft^3	CUMMULATIVE VOLUME ft^3
5468.0		0			
5469.0	1.0	968	484	323	323
5470.0	1.0	1,231	1,100	1,097	1,420
5471.0	1.0	1,403	1,317	1,316	2,736
5472.0	1.0	1,567	1,485	1,484	4,220
5472.5	0.5	1,943	1,755	876	5,096

Top of Pond

5472.5	4.5	**TOTAL VOLUME**	**5,096 cf**	0.117 ac-ft

Volume Summary Table

	Required Volume (ft^3)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	cf	0.000 ac-ft	**#N/A**	#N/A
5-yr	3,407 cf	0.078 ac-ft	**5471.45 ft**	3.45 ft
100-yr + 1/2 WQCV	cf	0.000 ac-ft	**#N/A**	#N/A

Volume Interpolation Calculations

WQCV		5-yr		100-yr + 1/2 WQCV	
Vol	Elev	Vol	Elev	Vol	Elev
#N/A	#N/A	2735.60	5471.00	#N/A	#N/A
0.00	#N/A	3407.00	5471.45	0.00	#N/A
#N/A	#N/A	4219.84	5472.00	#N/A	#N/A

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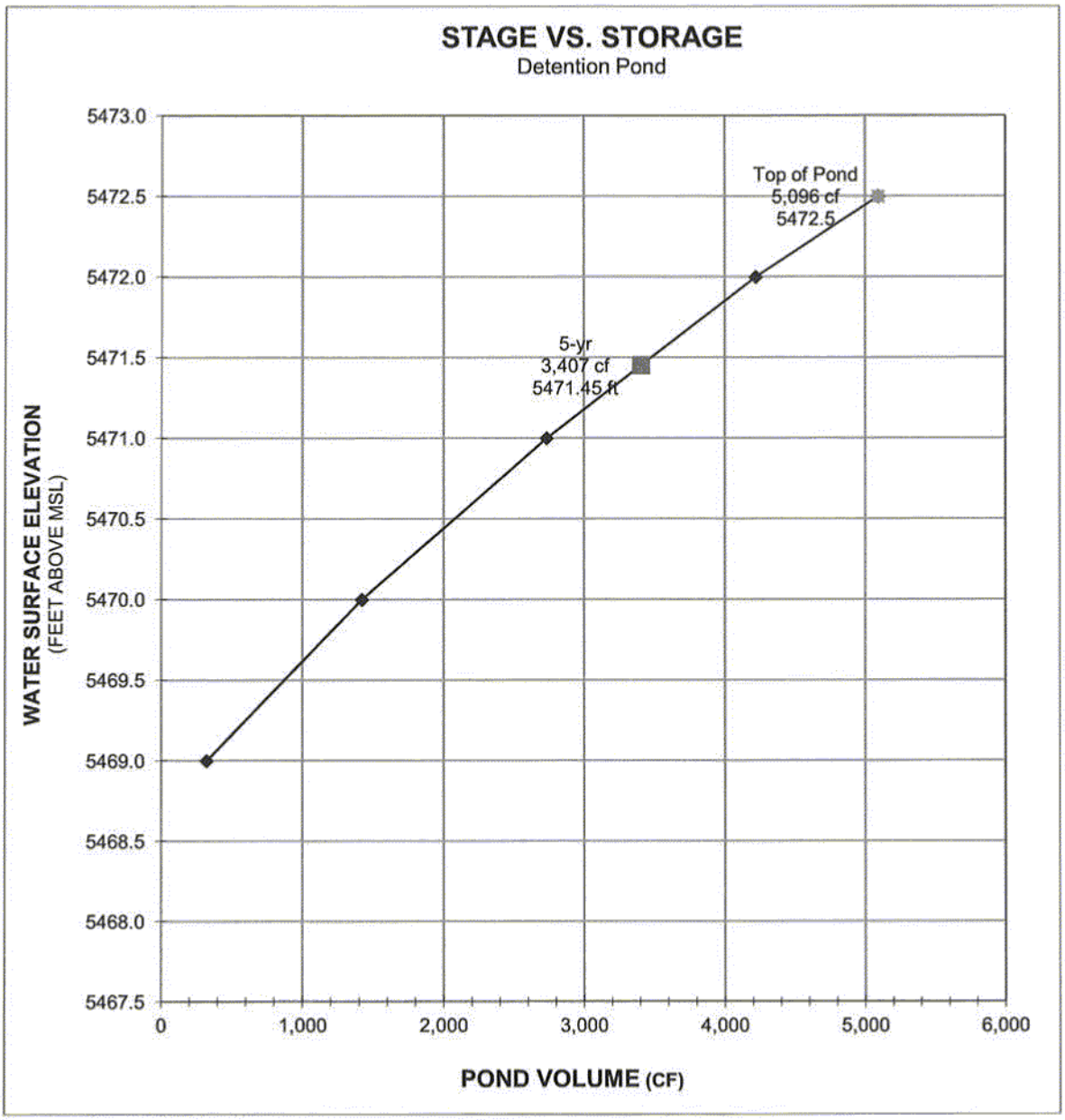

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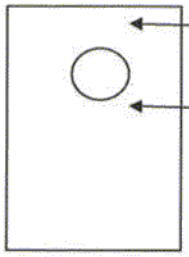
ORIFICE CALCULATION WORKSHEET

5 Yr Orifice Plate using Headwater above opening and

Q=cA(2gH)^.5 C= 0.65

Q_{MINOR} allowable release rate: 10.13 cfs



Water Surface Elev (minor):	5471.45	ft
WQCV Inv Elev:	5468.00	ft

Determine the Height of the Plate to release Allowable Flow using the pipe for Area that passes Qallowable

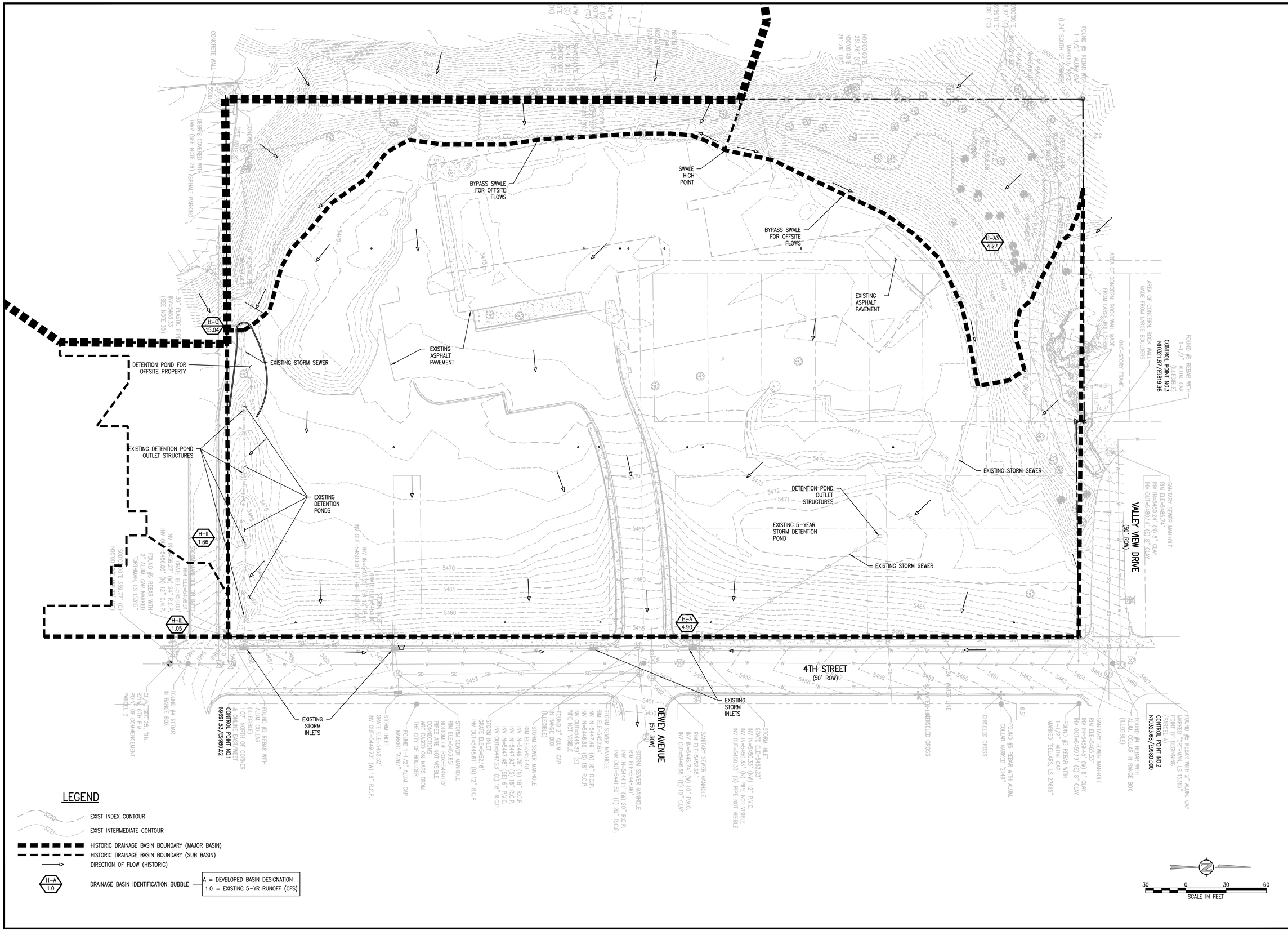
Q=cA(2gH)^.5 C= 0.65

Q	10.13 cfs
c	0.65
H_{head}	2.85

Assume Dia 14.5 in

Needed Area	1.15 sf	1.21 ft

Diameter
14.5 in



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NO.	DATE	DESTD	DWN
6	02/19/2013	CRH	CJB
5	01/07/2013	CJB	CJB
4	06/18/2012	CJB	CJB
3	09/05/2012	CJB	CJB
2	08/06/2012	CJB	CJB
1	06/04/2012	CJB	CJB

REVISION DESCRIPTION

FINAL DRAINAGE REPORT
FINAL DRAINAGE REPORT
REVISED SOUTHERN STORM SEWER LAYOUT
LUR2012-00040 RESPONSE 2
LUR2012-00040 RESPONSE 1
SITE REVIEW SUBMITTAL

DESIGNED BY:	CJB
DRAWN BY:	CJB
CHECKED BY:	CRH
JOB #:	1889c
DATE:	SEPTEMBER 5, 2012

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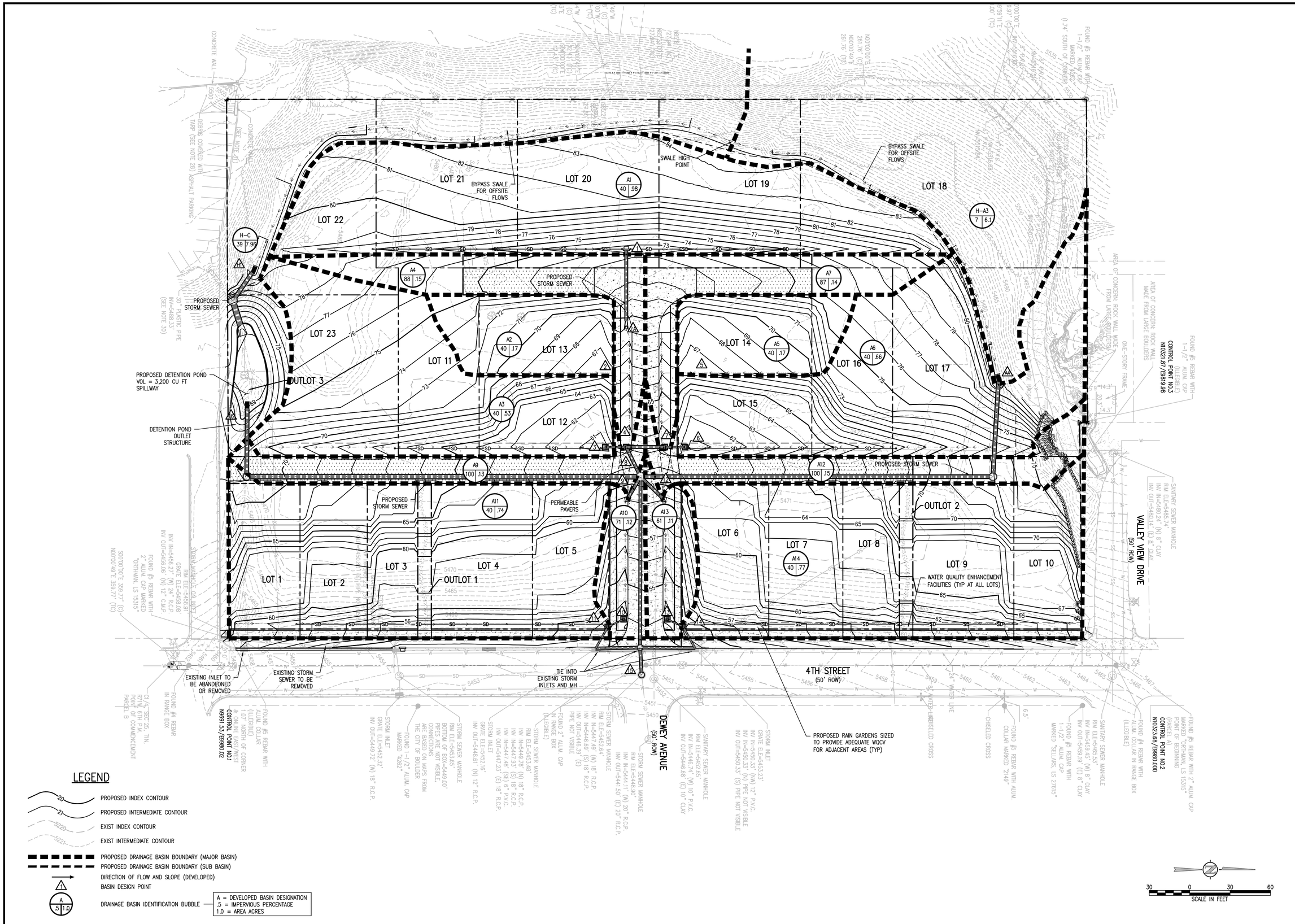
TRAILHEAD SUBDIVISION
2641 4TH STREET
BOULDER, CO

FINAL STORM WATER PLAN
HISTORIC DRAINAGE MAP

SHEET NO.

FIG-1



LEGEND

- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- EXIST INDEX CONTOUR
- EXIST INTERMEDIATE CONTOUR
- PROPOSED DRAINAGE BASIN BOUNDARY (MAJOR BASIN)
- PROPOSED DRAINAGE BASIN BOUNDARY (SUB BASIN)
- DIRECTION OF FLOW AND SLOPE (DEVELOPED)
- BASIN DESIGN POINT
- DRAINAGE BASIN IDENTIFICATION BUBBLE — A = DEVELOPED BASIN DESIGNATION; .5 = IMPERVIOUS PERCENTAGE; 1.0 = AREA ACRES

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FINAL DRAINAGE REPORT
FINAL DRAINAGE REPORT
REVISED SOUTHERN STORM SEWER LAYOUT
LUR2012-00040 RESPONSE 2
LUR2012-00040 RESPONSE 1
SITE REVIEW SUBMITTAL

NO.	DATE	DESCRIPTION	DESTD	DWN
6	02/19/2013		CRH	CJB
5	01/07/2013		CJB	CJB
4	06/18/2012		CJB	CJB
3	09/05/2012		CJB	CJB
2	08/06/2012		CJB	CJB
1	06/04/2012		CJB	CJB

DESIGNED BY:	CJB
DRAWN BY:	CJB
CHECKED BY:	CRH
JOB #:	1889c
DATE:	SEPTEMBER 5, 2012

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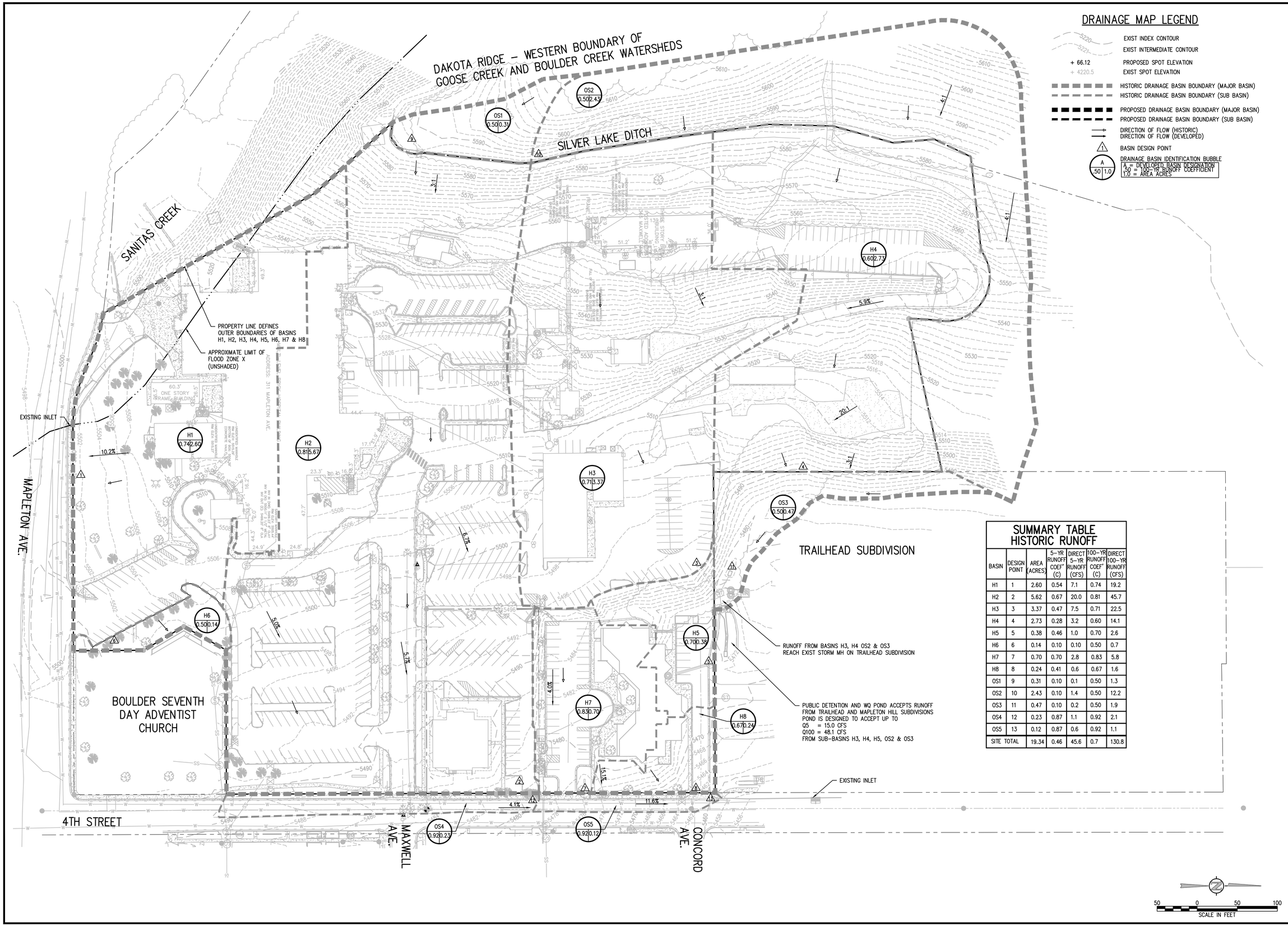
2641 4TH STREET
BOULDER, CO

FINAL STORM WATER PLAN
DEVELOPED DRAINAGE MAP

SHEET NO.

FIG-2



DRAINAGE MAP LEGEND

- EXIST INDEX CONTOUR
- EXIST INTERMEDIATE CONTOUR
- + 66.12 PROPOSED SPOT ELEVATION
- + 4220.5 EXIST SPOT ELEVATION
- HISTORIC DRAINAGE BASIN BOUNDARY (MAJOR BASIN)
- HISTORIC DRAINAGE BASIN BOUNDARY (SUB BASIN)
- PROPOSED DRAINAGE BASIN BOUNDARY (MAJOR BASIN)
- PROPOSED DRAINAGE BASIN BOUNDARY (SUB BASIN)
- DIRECTION OF FLOW (HISTORIC)
- DIRECTION OF FLOW (DEVELOPED)
- BASIN DESIGN POINT
- DRAINAGE BASIN IDENTIFICATION BUBBLE
  A = DEVELOPED BASIN DESIGNATION
  .50 = 100-YR RUNOFF COEFFICIENT
  1.0 = AREA ACRES

SUMMARY TABLE HISTORIC RUNOFF

BASIN	DESIGN POINT	AREA (ACRES)	5-YR RUNOFF COEF' (C)	DIRECT 5-YR RUNOFF (CFS)	100-YR RUNOFF COEF' (C)	DIRECT 100-YR RUNOFF (CFS)
H1	1	2.60	0.54	7.1	0.74	19.2
H2	2	5.62	0.67	20.0	0.81	45.7
H3	3	3.37	0.47	7.5	0.71	22.5
H4	4	2.73	0.28	3.2	0.60	14.1
H5	5	0.38	0.46	1.0	0.70	2.6
H6	6	0.14	0.10	0.10	0.50	0.7
H7	7	0.70	0.70	2.8	0.83	5.8
H8	8	0.24	0.41	0.6	0.67	1.6
OS1	9	0.31	0.10	0.1	0.50	1.3
OS2	10	2.43	0.10	1.4	0.50	12.2
OS3	11	0.47	0.10	0.2	0.50	1.9
OS4	12	0.23	0.87	1.1	0.92	2.1
OS5	13	0.12	0.87	0.6	0.92	1.1
SITE TOTAL		19.34	0.46	45.6	0.7	130.8

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NO.	DATE	DES'D	DWN	REVISION DESCRIPTION

DESIGNED BY:	RLK/AR
DRAWN BY:	RLK/AR
CHECKED BY:	CRH/KJC
JOB #:	2462.1c
DATE:	08 / 01 / 2016

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THE ACADEMY AT MAPLETON HILL
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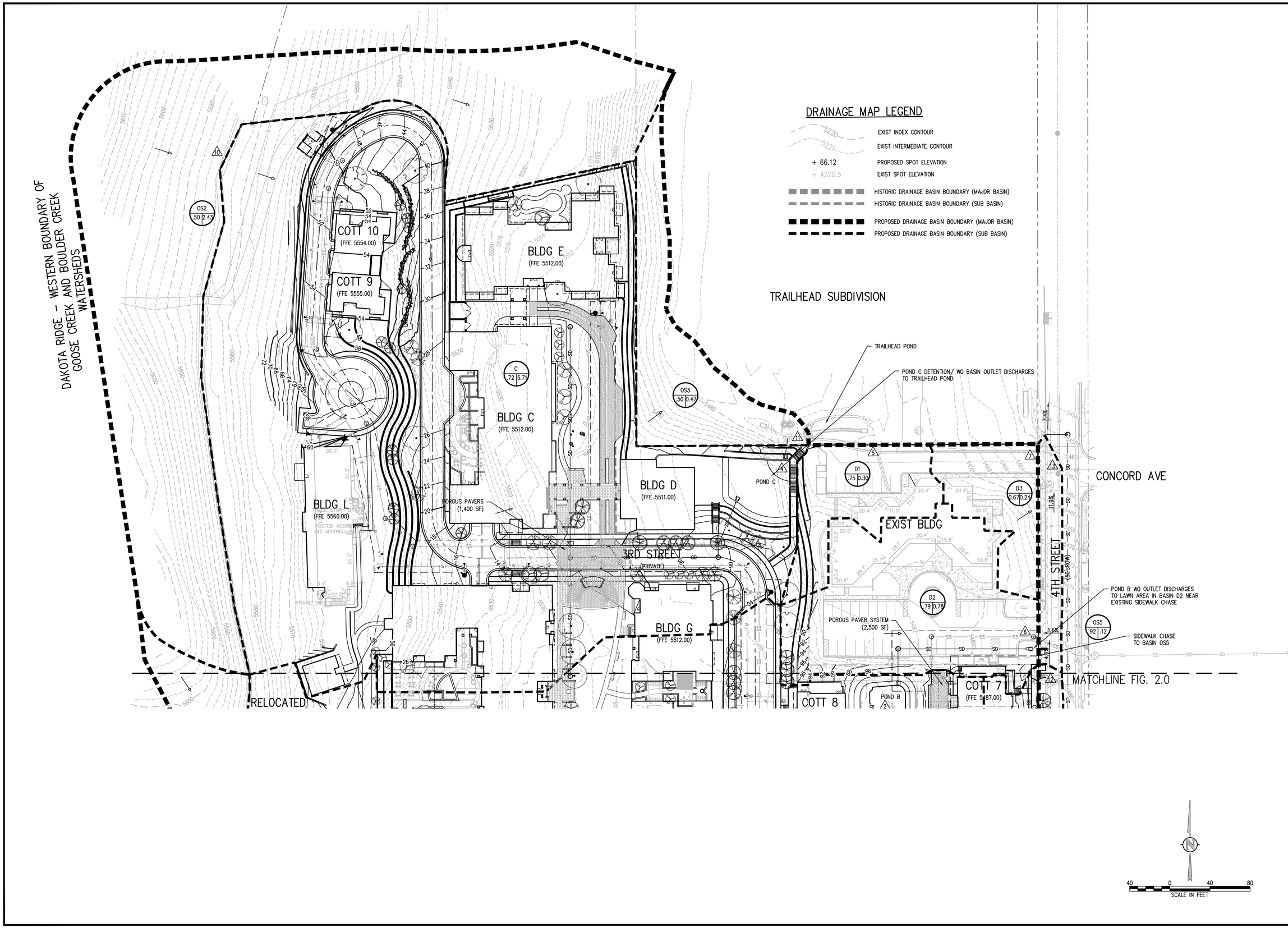
HISTORIC DRAINAGE MAP

SHEET NO.
FIG 1.0

I:\2462c\Drawings\2462c - FIG1.dwg, 7/28/2016 5:01:42 PM, DWG To PDF.pc3



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NO.	DATE	DESD	DWN	REVISION DESCRIPTION

DESIGNED BY:	DIB/RLK
DRAWN BY:	RLK/AR
CHECKED BY:	CRH/KJC
JOB #:	2462.1c
DATE:	08 / 01 / 2016

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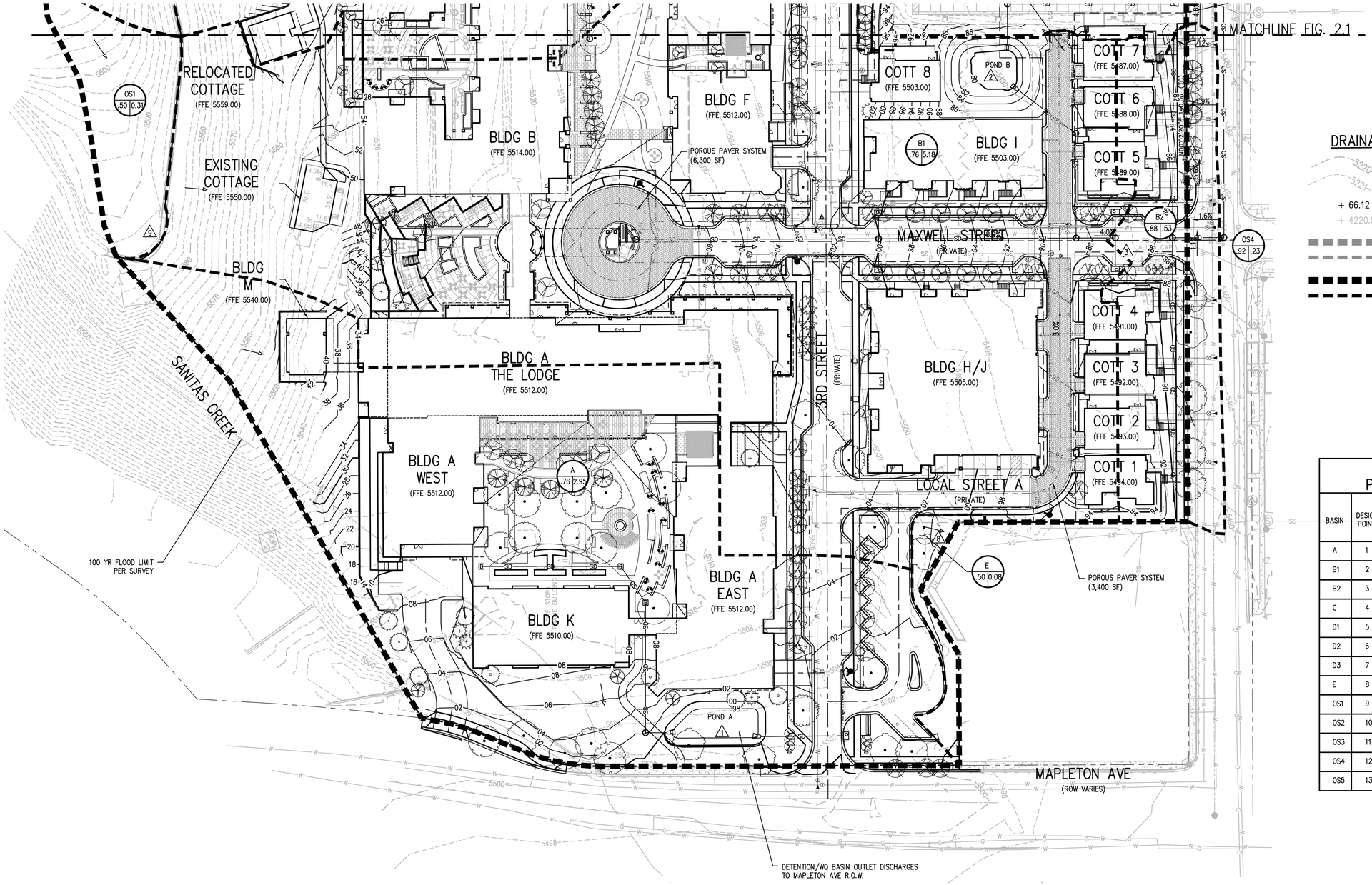
PROPOSED DRAINAGE MAP - NORTH

SHEET NO.

FIG. 2.1



DRAINAGE MAP LEGEND

- EXIST INDEX CONTOUR (5220)
- EXIST INTERMEDIATE CONTOUR (5221)
- + 66.12 PROPOSED SPOT ELEVATION
- + 4220.5 EXIST SPOT ELEVATION
- HISTORIC DRAINAGE BASIN BOUNDARY (MAJOR BASIN)
- HISTORIC DRAINAGE BASIN BOUNDARY (SUB BASIN)
- PROPOSED DRAINAGE BASIN BOUNDARY (MAJOR BASIN)
- PROPOSED DRAINAGE BASIN BOUNDARY (SUB BASIN)
- DIRECTION OF FLOW (HISTORIC)
- DIRECTION OF FLOW (DEVELOPED)
- BASIN DESIGN POINT
- DRAINAGE BASIN IDENTIFICATION BUBBLE (A / .50 / 1.0): A = DEVELOPED BASIN DESIGNATION; .50 = 100-YR RUNOFF COEFFICIENT; 1.0 = AREA ACRES

SUMMARY TABLE
PROPOSED RUNOFF

BASIN	DESIGN POINT	AREA (ACRES)	5-YR RUNOFF COEF' (C)	DIRECT 5-YR RUNOFF (CFS)	100-YR RUNOFF COEF' (C)	DIRECT 100-YR RUNOFF (CFS)
A	1	2.95	0.58	9.79	0.76	22.48
B1	2	5.25	0.58	15.48	0.77	40.24
B2	3	0.46	0.79	2.07	0.87	4.02
C	4	5.71	0.50	13.18	0.72	38.49
D1	5	0.30	0.55	0.94	0.75	2.24
D2	6	0.78	0.64	2.81	0.79	6.14
D3	7	0.24	0.41	0.55	0.67	1.58
E	8	0.08	0.10	0.04	0.50	0.39
OS1	9	0.31	0.12	0.12	0.50	1.24
OS2	10	2.43	0.10	1.34	0.50	12.21
OS3	11	0.47	0.10	0.23	0.50	2.29
OS4	12	0.23	0.87	1.14	0.92	2.12
OS5	13	0.12	0.87	0.59	0.92	1.09

40 0 40 80
SCALE IN FEET

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NO.	DATE	DESC'D	DWN	REVISION DESCRIPTION

DESIGNED BY:	DIB/RLK
DRAWN BY:	RLK/AR
CHECKED BY:	CRH/KJC
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PROPOSED DRAINAGE MAP - SOUTH

SHEET NO.
FIG. 2.0