

PRELIMINARY DRAINAGE REPORT

FOR THE

4403 BROADWAY

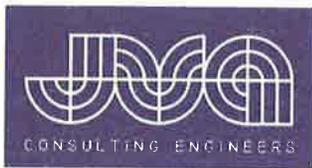
AT

**4403 BROADWAY
BOULDER, COLORADO 80304**

FOR

EMERALD DEVELOPMENT

November 17, 2014



JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Ph: 303.444.1951
Fax: 303.444.1957
Toll Free: 877.444.1951

November 17, 2014

Web site:
www.jvajva.com

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

E-mail:
info@jvajva.com

RE: 4403 Broadway Avenue Boulder, Colorado
Preliminary Drainage Report
JVA Job No. 1508.5c

Dear Edward:

The following *Preliminary Drainage Report* and attached drainage map for this project have been prepared for the above referenced project. The drainage report and drainage map have been produced in accordance with the "City of Boulder Design and Construction Standards," 2000 Edition, and comply with provisions thereof.

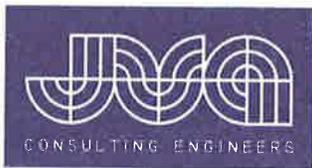
It is our understanding that the information provided herein meets all requirements of the City of Boulder's drainage criteria.

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

Sincerely,
JVA, Inc.

Kenneth J. Clifford, PE
Project Manager

Danielle I. D. Breedlove, P.E.
Project Engineer



ENGINEER'S STATEMENT:

"I hereby certify that this report and the enclosed plan for the preliminary drainage design of the 4403 Broadway project was prepared by me (or under my direct supervision) in accordance with the provisions of City of Boulder Design and Construction Standards for the Responsible Parties thereof. I understand that the City Boulder does not and will not assume liability for drainage facilities design."

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

PRELIMINARY DRAINAGE REPORT

4403 BROADWAY

AT

4403 BROADWAY
BOULDER, CO 80304

FOR

EMERALD DEVELOPMENT

JVA, Inc.

1319 Spruce Street
Boulder, CO 80302
phone: 303-444-1951
fax: 303-444-1957

JVA Project No. 1508.5c

November 17, 2014

TABLE OF CONTENTS

TABLE OF CONTENTS	1
INTRODUCTION	1
EXISTING CONDITIONS	1
PROPOSED (DEVELOPED) DRAINAGE	2
STORMWATER MANAGEMENT PLAN	6
CONCLUSIONS	8
REFERENCES	8

APPENDIX A – SITE MAPS

APPENDIX B – CALCULATIONS

FIGURE 1 – HISTORIC DRAINAGE PLAN

OS 1 – OFF-SITE DRAINAGE BASIN PLAN

FIGURE 2 – DEVELOPED DRAINAGE PLAN

PRELIMINARY DRAINAGE REPORT

INTRODUCTION

GENERAL LOCATION AND DESCRIPTION

Emerald Development is proposing to redevelop the property located at 4403 Broadway Avenue in Boulder Colorado to create a mixed used development including six duplex townhomes and commercial retail/restaurant facilities. The site is approximately 2.50 acres located in the northeast quarter of Section 13, Township 1 North, Range 71 West of the 6th P.M., City of Boulder, County of Boulder, State of Colorado. More specifically, the site is bound by a commercial development to the north, 10th Street to the west, Violet Avenue to the south, and Broadway Avenue to the east. A vicinity map is included in the Appendix of this report.

The primary purpose of this report is to address the impacts of the site construction, to provide preliminary proposed runoff information, and to address water quality enhancement. Reference is made to the attached “Figure 1 – Historic Drainage Plan”, “OS 1 – Off-Site Drainage Basin Plan” and “Figure 2 – Developed Drainage Plan.”

PROPOSED DEVELOPMENT

The proposed project will consist of removing the existing metal building, wood frame building, asphalt parking lot and existing utilities located at 4403 Broadway Avenue in order to construct six townhome duplexes and three commercial-mixed use buildings as well as associated parking areas, landscaping, and amenities. Portions of the site will be designated for water quality enhancements. The developed drainage basins will generally match the existing basins in terms of drainage pattern. The proposed project will increase the overall imperviousness of the site. A proposed detention/water quality basin will be constructed in order to handle the increase in runoff associated with the development. The detention/water quality pond will provide water quality treatment for the western section of the site. Porous pavers are proposed to the east of the development which will provide water quality treatment for the site’s parking lots and access drives.

EXISTING CONDITIONS

MASTER DRAINAGE BASIN (MAJOR BASIN) DESCRIPTION

The site’s ultimate outfall is Fourmile Canyon Creek located to the north and east of the subject development.

JVA reviewed FEMA Flood Insurance Rate Map Community Panel Number FM08013C0391J, dated December 18, 2012 and determined that the site lies within Zone AE of FEMA’s Special Flood Hazard Area (Base Flood or 100-year floodplain.) A copy of a portion of the referenced flood map is included in the Appendix.

U.S. Department of Agriculture, Soil Conservation Service mapping of the area indicates that the soils are predominantly Valmont cobbly clay loam (VcC), 1 to 5 percent slopes with a very small portion of Nederland very cobbly sandy loam (NdD). VcC soils are classified as hydrological soil group (HGS) C. Soils with an HSG of C have a very slow infiltration rate when thoroughly wet and therefore have high runoff potential. A copy of the NRCS soils classification map is included in the Appendix.

EXISTING SITE DRAINAGE AND FACILITIES

The existing site consists of a large parking lot and several buildings with paved access drives and landscaped areas. In general, the site slopes from northwest to the southeast with elevations varying from ± 5525 to ± 5516 on the City of Boulder datum. Slopes across the site range from 1% to 5% and averages at a 2.0% slope. The storm runoff from the majority of the existing site currently drains to the southeast corner of the site into an existing public storm system in North Broadway.

There are no existing storm drainage or water quality enhancement features on the site. No delineated wetlands have been located on the site.

EXISTING SITE BASINS

The existing site has been divided into two on-site drainage basins and two off-site drainage basins. Locations of the existing drainage basins are shown on the Historic Drainage Map and Off-Site Drainage Map. Drainage flows across the site toward the south and east where flows are captured by a public storm system in Broadway and Violet Avenues. No private storm systems exist on site. The existing percent imperviousness for the site is 57.4%.

Basin H1 (0.79 acres) is located to the south of the site and consists of grassy areas, gravel parking, paved areas, and a portion of the building located on the south side of the property. Runoff from H1 is directed overland to the southeast and into an existing inlet located at the intersection of Violet and Broadway. This inlet directs runoff into the existing public storm system within Broadway.

Basin H2 (1.71 acres) is located to the north of the site and captures runoff from three existing buildings, asphalt parking as well as some grassy areas. Runoff from H2 is directed south into an existing culvert located along Broadway which directs runoff into the existing public storm system within Broadway.

Basin OS1 (6.36 acres) consists of landscaped areas, a trailer residential area, and gravel drives. This basin is located to the northwest of the proposed development. Runoff from OS1 travels to the south and east and enters the development along the northern and western boundary lines. Once runoff passes into the site it travels overland through basin H2.

Basin OS2 (0.69 acres) is located to the north of the site and consists of a commercial development which is primarily buildings and pavement. Runoff from OS2 travels to the southeast and enters the development along the northern property line. Once runoff passes into the site it flows overland through basin H2.

Table 1 below presents a summary of the historic storm water peak flows.

Table 1: Historic Peak Flows

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
H1	1	0.79	1.01	4.14
H2	2	1.71	4.87	11.45
OS1	3	6.36	8.46	28.81
OS2	4	0.69	3.20	6.12

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) Urban Storm Drainage Criteria Manual (USDCM), June 2005 Edition, as the secondary reference.

HYDROLOGIC METHOD AND DESIGN STORM FREQUENCIES

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. The FAA Method, per the Urban Storm Drainage Criteria Manual, Vol. 2, Storage-Section 5, has been used to size the 10-year and 100-year detention volume for the site.

Calculations for the pond have been made in accordance with the City of Boulder and included in the Appendix. Final calculations for the storm system, outlet structures, and swales will be included with the final stormwater report. Complete drainage design plans, details, dimensions, etc. will be developed and 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 AND SUB-BASINS

The proposed site has been divided into nineteen sub-basins. Please refer to the Developed Drainage Map (see attached Fig. 2). Sub-basin boundaries were established based on outfall location. In general, runoff from the site will follow the historic pattern with flows traveling northwest to southeast while being captured by proposed storm system or water quality enhancements.

There are three different classifications of basins included in this report; A, R, and O. Basins A correspond to drainage areas that sheet flow on land and are captured onsite. Basins delineated

as R represent the roof areas of the building. The O basins represent onsite basins whose flows pass offsite.

Basin A1 (0.89 acres) collects runoff from the townhouse roofs and associated walks, access drive and landscaping. Flows from A1 are directed into a detention/water quality basin located in the middle of the basin. The detention/water quality basin outfalls into a proposed storm system located in basin A1.

Basin A2 (0.14 acres) is located at the northwest corner of the site and collects runoff from the covered parking area and access drive. Flows from A2 are directed over a porous paver system south into an inlet which directs water into the storm sewer system located in the north drive.

Basin A3 (0.16 acres) is located to the north of the site and collects runoff from the northern parking lot, a portion of the covered parking, and pedestrian area. Flows from A3 are directed over a porous paver system into an inlet located to the south of the basin. This inlet directs water into the storm sewer system located in the northern access drive.

Basin A4 (0.02 acres) is a small basin located to the west of the commercial buildings. A4 houses a portion of the site's northern access drive and a few parking stalls. Runoff from A4 is directed south over a porous paver system and into a curb cut which discharges into the drainage channel in basin O1.

Basin A5 (0.06 acres) is located to the west of the commercial buildings and contains a portion of the site's access drive and a parking area. Runoff from A5 is directed west into a paver system located in the parking area. A curb cut along the western edge of the parking directs runoff into the drainage channel in basin O1.

Basin A6 (0.28 acres) is located in the center of the site and houses a portion of the site's access drive and center parking area. Flows from A6 are directed over a porous paver system in the parking area and into a series of inlets which direct runoff into the site's storm sewer systems.

Basin A7 (0.06 acres) is located to the south of the site and contains a portion of the site's access drive and a parking area. Runoff from A7 is directed east into the porous paver parking area and then into an inlet located at the southeastern corner of the parking.

Basin A8 (0.05 acres) is located to the south of the site collects runoff from the courtyard area in between buildings 2 and 3. Runoff from A8 is directed into a series of area drains which connect directly into the public storm system in North Broadway.

Basin A9 (0.10 acres) is located to the east of the site and collects runoff from a pedestrian courtyard area. Runoff from A9 is directed east into the North Broadway right-of-way.

Basin A10 (0.05 acres) is located to the east of the site and collects runoff from a pedestrian courtyard area. Runoff from A10 is directed east into the North Broadway right-of-way.

Basin A11 (0.06 acres) is located to the east of the site and collects runoff from a portion of the site's northern access drive. Runoff from A11 is directed into a Type R inlet located at the low point of the access drive. This Type R inlet directs runoff into the public storm sewer system in North Broadway.

Basin R1 (0.07 acres) collects runoff from roof of the northernmost commercial building (Building A). Flows from R1 are directed into the public storm sewer system in North Broadway.

Basin R2 (0.08 acres) collects runoff from the roof of the middle commercial building (Building B). Flows from R2 are directed into the public storm sewer system in North Broadway.

Basin R3 (0.11 acres) collects runoff from the roof of the southernmost commercial building (Building C). Flows from R3 are directed into the public storm sewer system in North Broadway.

Basin O1 (0.14 acres) is located on the northern edge of the property. A drainage swale within O1 will be designed to capture offsite runoff from the historic off-site basin OS1 and will transport flow into the site's proposed storm sewer system.

Basin O2 (0.11 acres) is located to the west of the site and is primarily landscaped areas. Runoff from O2 will be directed west and south into the 10th Street and Violet Avenue right-of-way.

Basin O3 (0.04 acres) is located to the south of the site and is primarily landscaped areas. Runoff from O3 will be directed south into the Violet Avenue right-of-way.

Basin O4 (0.04 acres) is located to the south of the site and is primarily landscaped areas. Runoff from O4 will be directed south into the Violet Avenue right-of-way.

Basin O5 (0.03 acres) is located to the south of the site and captures runoff from a portion of the site's access drive. Runoff from O5 will be directed south into the Violet Avenue right-of-way.

RUNOFF AND STORMWATER QUALITY ENHANCEMENT/DETENTION FACILITIES

Runoff rates for the design points have been shown on Table 2 and on the included Developed Drainage Maps. Calculations showing how the runoff rates were determined are shown in the Appendix.

Table 2 below presents a summary of the developed storm water peak flows based on the rational method and Table 3 presents a comparison between the historic and developed peak flows.

Table 2: Developed Peak Flows

Basin	Design Point	Area (acre)	5-Year Flow (cfs)	100-Year Flow (cfs)
A1	1	0.70	2.28	6.00
A2	2	0.11	0.52	1.11
A3	3	0.12	0.54	1.23
A4	4	0.02	0.10	0.21
A5	5	0.05	0.24	0.48
A6	6	0.21	0.97	2.15
A7	7	0.05	0.26	0.53
A8	8	0.04	0.22	0.42
A9	9	0.09	0.46	0.91
A10	10	0.04	0.20	0.44
A11	11	0.05	0.28	0.55

R1	12	0.06	0.33	0.62
R2	13	0.08	0.41	0.76
R3	14	0.10	0.52	0.96
O1	15	0.09	0.23	0.87
O2	16	0.08	0.30	0.82
O3	17	0.03	0.09	0.27
O4	18	0.03	0.10	0.31
O5	19	0.03	0.12	0.27

Table 3: Historic vs. Developed Peak Flows from Site

	Historic		Developed			Change in Peak Flow	
	Contributing Acres	Peak Flows (cfs)		Contributing Acres	Peak Flows (cfs)		Change in Peak Flow (cfs)
		5-Year	100-Year		5-Year	100-Year	
Site	2.50	5.87	15.59	2.51	6.66	17.02	+0.79 +1.43

As can be seen in Table 3 the proposed development will increase flows from the site. In order to ensure that the development does not result in an overall increase in runoff from the site a detention and water quality pond is proposed. The detention and water quality pond will be constructed in basin A1 between the duplex units and will be used to provide detention for the site and water quality treatment for the duplex buildings. An outlet structure with an orifice plate and trash rack will be located to the east of the pond. The orifice plate will be used to release runoff from water quality storm events. In order to account for the increase in runoff associated with the entire development the pond will overdetermine runoff from basin A1 for the 10-year and 100-year events. Restrictor plates will be used in order to release flows from the pond at a rate which does not exceed the historic runoff rates for the site. Flows greater than the major, 100-year storm will be routed through an emergency overflow spillway along the southeastern side of the detention pond and into Violet Avenue.

Water quality treatment for the eastern half of the site will be provided through a porous paver system located within the site's parking areas. Porous pavers are a pavement section which allows movement of water into the layers below the pavement surface. They will be used to provide water quality treatment and promote the slow release of the water quality capture volume for the parking areas and the majority of the site's access drives. An underdrain will be located beneath the porous paver system in order to help drain the area beneath the porous paver system. The porous paver system will not be installed in areas directly adjacent to buildings or in areas which will be adversely impacted by the paver system.

Drainage from the mixed-use building's roof will be discharged directly into the public storm system within North Broadway without water quality treatment. This is because tight sight constraints prevent runoff from the mixed-use roofs from reaching the porous paver system within the site's parking areas. Runoff from the mixed-use roof would need to be point-discharged onto the sidewalks and pedestrian areas adjacent to the building in order to reach the paver system which would put both the buildings and pedestrians at risk.

As previously mentioned the eastern section of site is historically fully developed and houses portions of several existing buildings and a parking area. All runoff from this side of the site is historically released untreated into the public storm sewer system along North Broadway. Even with flows from the mixed-use buildings roofs being routed directly into the public storm sewer system the installation of the porous paver system will result in an increase in overall water quality from the site from the historic values.

OFFSITE RUNOFF

Offsite runoff enters the development from offsite drainage basins OS1 and OS2 which are located along the northern and western property lines. This offsite runoff will need to be conveyed safely through the site. In order to capture runoff from OS1 a drainage swale and drainage pan are proposed. The drainage swale is proposed to the north of the townhouse units. This drainage swale will be designed to capture and carry the major (100-year) storm event without overtopping into an inlet located at the eastern edge of the drainage swale at DP15. Sizing the swale for the 100-year storm event will keep offsite flows from traveling into the site's detention/water quality pond. The drainage channel is proposed to the east of the parking garage located at the northwest corner of the site. The drainage channel will convey water into the drainage swale to the north of the townhomes and to the inlet located at DP15. The inlet at DP15 will direct runoff into a storm sewer system located in the site's northern access drive. A drainage easement will be provided around the drainage swale and storm sewer system in order to convey the offsite runoff through the site.

Offsite runoff from OS2 will be collected in an inlet located to the northeast of Building A. This inlet will direct runoff into the public storm system within Broadway.

STREETS

No public street improvements are proposed with this development.

OPEN CHANNEL FLOW

A drainage swale is proposed to the north of the duplex units. This drainage channel will be designed to capture and carry offsite drainage flows from offsite drainage basin OS1. The drainage channel will be designed to capture and carry the major (100-year) storm event without overtopping in order to prevent flows from entering the site's water quality/detention pond.

STORM SEWERS AND CULVERTS

All pipes have been sized using Flowmaster. In general, onsite inlets and storm pipes have been designed to capture and carry the minor (5-year) storm event without surcharging. During the major (100-year) storm the storm systems will surcharge and flows will be routed overland into the public right-of-way.

STORM WATER MANAGEMENT PLAN

Storm water quality and management are the focal points of the proposed grading and drainage plans for this site. To ensure water quality, the proposed plans include a water quality basin and rain gardens. The proposed detention/water quality basin has been designed to cumulatively provide the required water quality capture volume for the tributary Basin A1. Water quality to the east of the site will be provided through a series of porous paver systems within the site's parking lots.

In addition to the proposed water quality enhancement features described above, erosion control elements will be installed at strategic locations on the site before construction activities commence. These features will include vehicle-tracking control at the site construction entrance, silt fence, and inlet protection at all proposed and existing storm water inlets onsite and directly adjacent to the site. Non-structural erosion control measures, such as reseeding and schedule adjustment are also required per the City of Boulder guidelines.

CONCLUSIONS

The drainage facilities associated with proposed improvements for the 4403 Broadway project have been designed in accordance with the City of Boulder Standards & Specifications and the latest methods endorsed by the Urban Drainage and Flood Control District.

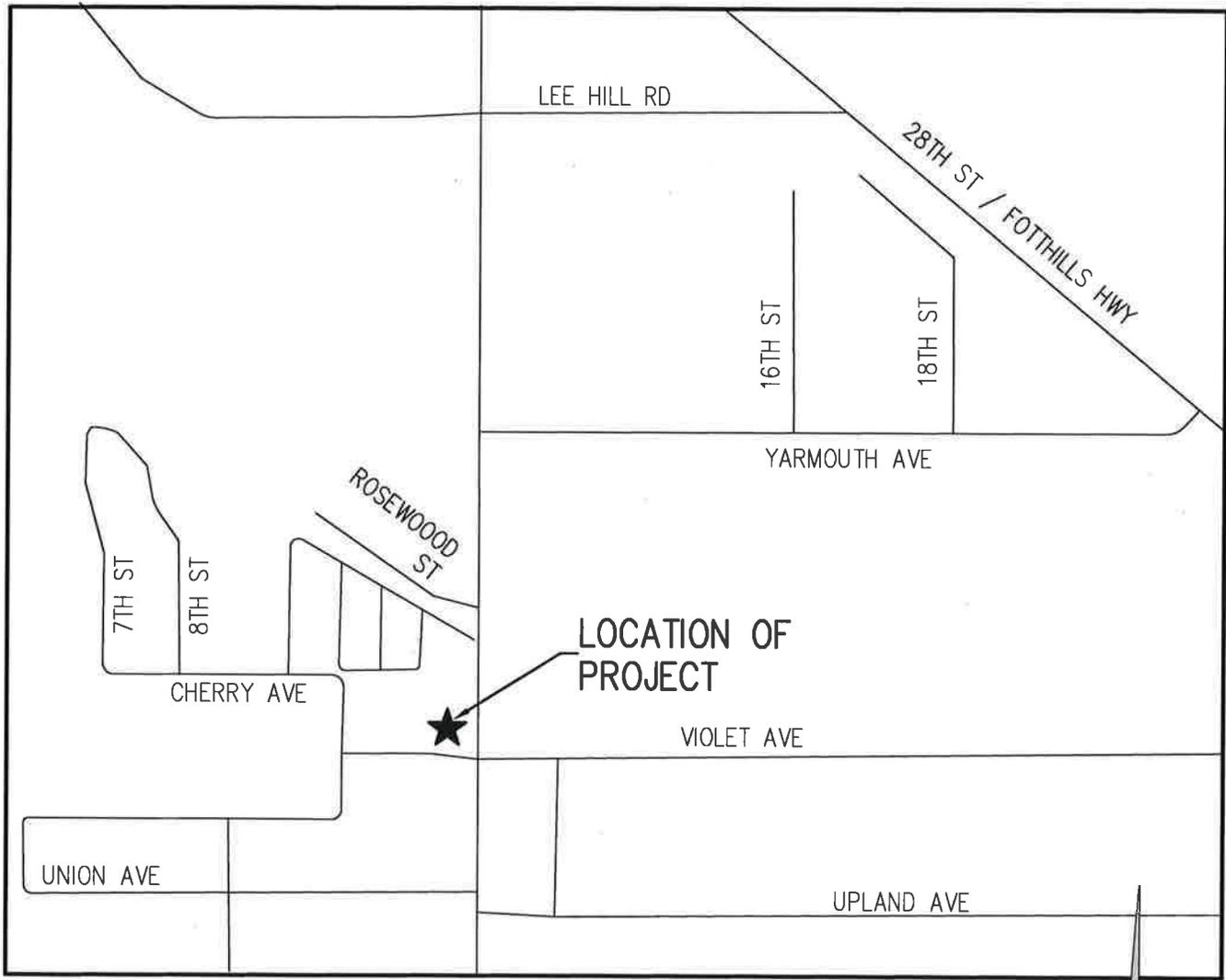
Developed storm water drainage patterns will closely match historic drainage patterns. Water quality enhancement will be provided for the site to alleviate flows leaving the site . Because of the detention/water quality facilities and proposed storm system, overall storm water runoff quality will be enhanced as a result of this development.

REFERENCES

1. "City of Boulder Design and Construction Standards," 2000 Edition.
2. "Urban Storm Drainage Criteria Manual," Urban Drainage and Flood Control District, 2010.

APPENDIX A – SITE MAPS

J:\1508_1c\dwg\VICINITY MAP.dwg, 9/8/2014 3:26:00 PM, 1:1

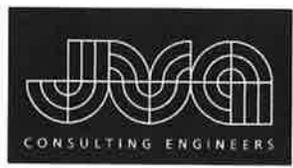


LOCATION OF PROJECT

VICINITY MAP
1"=400'

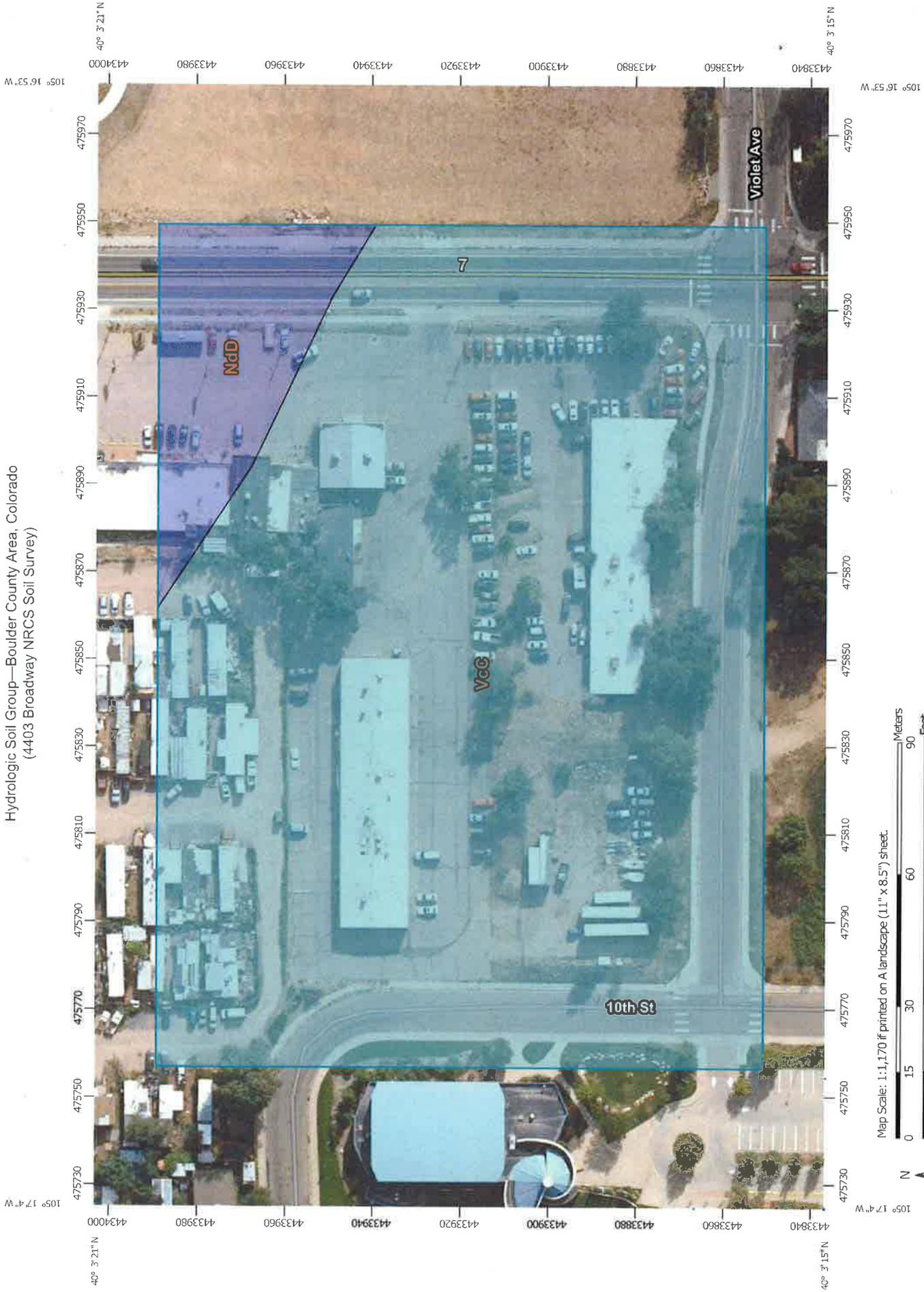


4403 BROADWAY, BOULDER, CO
VICINITY MAP

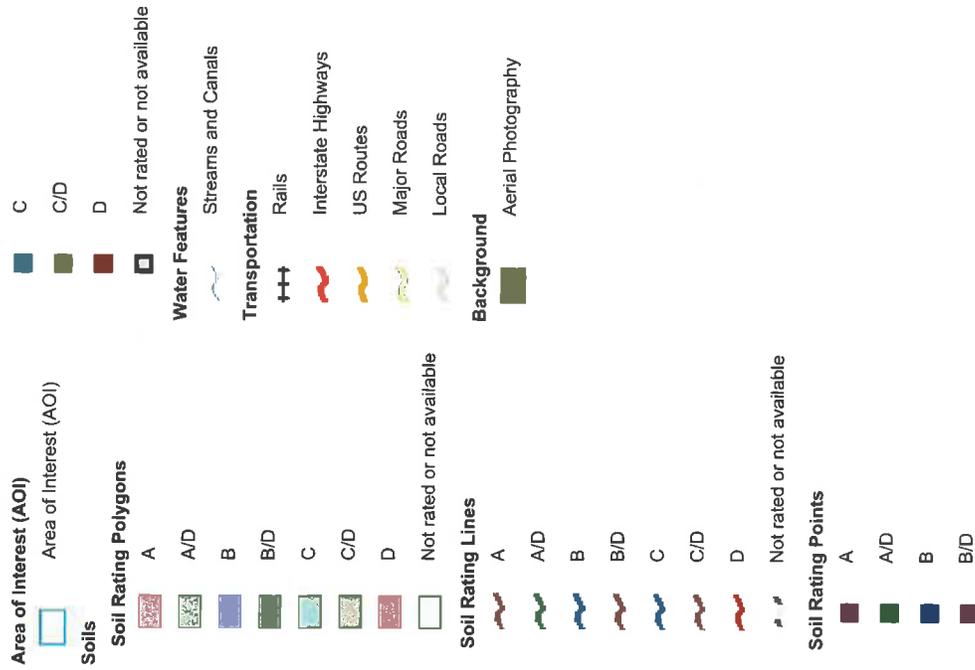


JVA, Incorporated
1319 Spruce Street
Boulder, CO 80302
Phone: 303.444.1951
Fax: 303.444.1957
E-mail: info@jvajva.com

Hydrologic Soil Group—Boulder County Area, Colorado
(4403 Broadway NRCS Soil Survey)



MAP LEGEND



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 11, Sep 22, 2014

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

Date(s) aerial images were photographed: Apr 28, 2011—Aug 29, 2012

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

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Boulder County Area, Colorado (CO643)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
NdD	Nederland very cobbly sandy loam, 1 to 12 percent slopes	B	0.6	8.5%
VcC	Valmont cobbly clay loam, 1 to 5 percent slopes	C	6.0	91.5%
Totals for Area of Interest			6.6	100.0%

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX B – CALCULATIONS

FIGURE 7-1

RAINFALL
INTENSITY-DURATION-FREQUENCY
FOR
CITY OF BOULDER
BOULDER, COLORADO

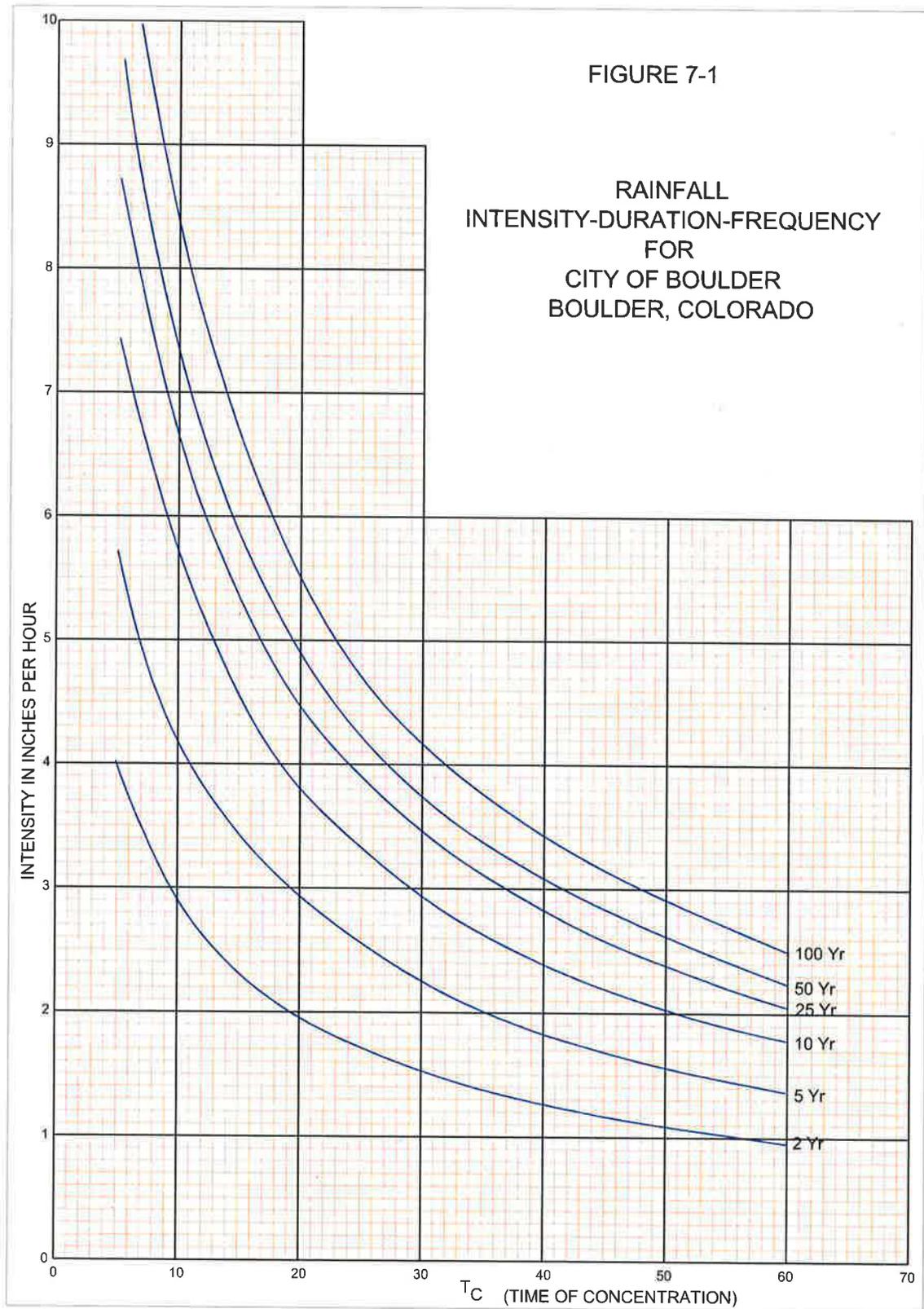


Table 7-2: Runoff Coefficients for the Rational Method

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	STORM FREQUENCY			
		2-Yr	5-Yr	10-Yr	100-Yr
<u>Business:</u>					
Commercial Areas	95	0.87	0.88	0.90	0.93
Neighborhood Areas	65	0.60	0.65	0.70	0.80
<u>Residential:</u>					
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
<u>Industrial:</u>					
Light Areas	80	0.75	0.80	0.80	0.85
Heavy Areas	90	0.80	0.80	0.85	0.90
<u>Parks, Cemeteries:</u>					
	7	0.15	0.25	0.35	0.60
<u>Playgrounds:</u>					
	13	0.20	0.30	0.40	0.70
<u>Schools:</u>					
	50	0.50	0.55	0.60	0.75
<u>Railroad Yard Areas:</u>					
	40	0.40	0.45	0.50	0.70
<u>Undeveloped Areas:</u>					
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
<u>Streets:</u>					
Paved	100	0.87	0.88	0.90	0.93
Gravel	7	0.15	0.25	0.35	0.65
<u>Drives and Walks:</u>					
	96	0.85	.087	0.90	0.92
<u>Roofs:</u>					
	90	0.80	0.85	0.90	0.90
<u>Lawns:</u>					
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)



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

Violet & Broadway Historic Runoff Coefficient & Time of Concentration Calculations

Location: Boulder
 Minor Design Storm: 5
 Major Design Storm: 100
 Soil Type: C/D

Basin Name	Design Point	Runoff Coeffs								Initial Overland Time (t)			Travel Time (t)				tc Urbanized Check ON	L _c Final																
		100%	96%	90%	7%	13%	25%	0%	0%	A _{paved streets} (sf)	A _{invesio nc} (sf)	A _{roof} (sf)	A _{gravel} (sf)	A _{plgnd} (sf)	A _{art turf} (sf)	A _{escape (B soil)} (sf)			A _{escape (C/D soil)} (sf)	A _{Total} (sf)	A _{Total} (ac)	Imp (%)	C2	C5	C10	C100	Upper most Length (ft)	Slope (%)	L _c (min)	Length (ft)	Slope (%)	Type of Land Surface	C _v	Velocity (fps)
H1	1	1.110	0	4.490	10,750	0	0	0	17,950	34,300	0.79	17.2%	0.23	0.32	0.41	0.67	235	2.8%	15.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	15.2	15.2	235	0.0	0.0	15.2	11.3	235	11.3
H2	2	46.910	0	10,734	0	0	0	16,956	74,600	1.71	75.8%	0.68	0.72	0.76	0.85	300	1.6%	10.1	195	1.6%	Paved areas & shallow paved swales	20	2.5	1.3	11.4	11.4	495	2.5	1.3	11.4	12.8	495	11.4	
OS1	3	0	0	80,672	47,309	0	0	148,843	276,824	6.36	27.4%	0.31	0.40	0.48	0.70	300	2.8%	15.5	700	2.8%	Paved areas & shallow paved swales	20	3.3	3.5	19.0	19.0	1000	3.3	3.5	19.0	15.6	1000	15.6	
OS2	4	0	15,843	12,024	0	0	0	2,098	29,965	0.69	86.9%	0.78	0.82	0.86	0.89	0	0.0%	0.0	220	2.7%	Paved areas & shallow paved swales	20	3.3	1.1	1.1	1.1	220	3.3	1.1	1.1	11.2	220	11.2	5.0
ONSITE TOTAL		48,020	0	15,224	10,750	0	0	34,906	106,900	2.50	57.4%	0.54	0.60	0.65	0.79																			
OFFSITE TOTAL		0	15,843	92,696	47,309	0	0	150,941	306,789	7.04	33.2%	0.36	0.44	0.52	0.71																			

Basin Name	Design Point	Time of Conc (tc)	Runoff Coeffs					Rainfall Intensities (in/hr)					Area					Flow Rates (cfs)				
			C2	C5	C10	C100	100	5	10	100	A _{Total} (sf)	A _{Total} (ac)	Q2	Q5	Q10	Q100						
H1	1	11.3	0.23	0.32	0.41	0.67	7.90	3.96	5.98	7.90	34,300	0.79	0.50	1.01	1.75	4.14						
H2	2	11.4	0.68	0.72	0.76	0.85	7.86	3.94	5.35	7.86	74,600	1.71	3.20	4.87	7.00	11.45						
OS1	3	15.6	0.31	0.40	0.48	0.70	2.26	3.35	4.46	6.51	276,824	6.36	4.48	8.46	13.70	28.81						
OS2	4	5.0	0.78	0.82	0.86	0.89	7.45	5.70	10.00	29,965	0.69	2.14	3.20	4.40	6.12							
			ONSITE TOTAL					106,900					2.50					3.70				
			OFFSITE TOTAL					306,789					7.04					6.62				



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

	1%	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

Violet & Broadway

Composite Runoff Coefficient Calculations

Location:	Boulder
Minor Design Storm:	5
Major Design Storm:	100
Soil Type:	C/D

Basin Design Data

Basin Name	Design Point	I (%) =										I (%)	Runoff Coeff's					
		100%	96%	90%	7%	13%	40%	0%	0%	A _{Total} (sf)	A _{Total} (ac)		Imp (%)	C2	C5	C10	C100	
		A _{paved streets} (sf)	A _{drives/c onc} (sf)	A _{roof} (sf)	A _{gravel} (sf)	A _{plygnd} (sf)	A _{pavers} (sf)	A _{lscap} (B soil) (sf)	A _{lscap} (C/D soil) (sf)									
A1	1	3,290	3,300	17,100	0	0	0	0	15,130	38,820	0.89	56.3%	0.54	0.60	0.67	0.79		
A2	2	0	403	3,252	0	0	2,111	0	364	6,130	0.14	67.8%	0.58	0.65	0.70	0.79		
A3	3	0	1,671	1,532	0	0	3,328	0	647	7,178	0.16	60.1%	0.51	0.58	0.63	0.75		
A4	4	790	0	0	0	0	276	0	0	1,066	0.02	84.5%	0.72	0.75	0.78	0.85		
A5	5	0	1,906	0	0	0	416	0	150	2,472	0.06	80.8%	0.71	0.75	0.78	0.85		
A6	6	4,510	1,642	0	0	0	4,575	0	1,357	12,084	0.28	65.5%	0.56	0.61	0.65	0.77		
A7	7	1,466	439	0	0	0	790	0	99	2,794	0.06	78.9%	0.67	0.71	0.75	0.83		
A8	8	0	1,865	0	0	0	0	0	190	2,055	0.05	87.1%	0.78	0.81	0.84	0.89		
A9	9	0	3,874	0	0	0	0	0	662	4,536	0.10	82.0%	0.74	0.77	0.81	0.87		
A10	10	0	1,544	0	0	0	0	0	795	2,339	0.05	63.4%	0.60	0.64	0.70	0.81		
A11	11	1,424	904	0	0	0	0	0	377	2,705	0.06	84.7%	0.76	0.78	0.82	0.88		
R1	12	0	0	2,990	0	0	0	0	0	2,990	0.07	90.0%	0.80	0.85	0.90	0.90		
R2	13	0	0	3,655	0	0	0	0	0	3,655	0.08	90.0%	0.80	0.85	0.90	0.90		
R3	14	0	0	4,650	0	0	0	0	0	4,650	0.11	90.0%	0.80	0.85	0.90	0.90		
O1	15	340	465	0	0	0	0	0	5,085	5,890	0.14	13.4%	0.20	0.29	0.38	0.64		
O2	16	0	1,960	0	0	0	0	0	2,920	4,880	0.11	38.6%	0.40	0.47	0.54	0.73		
O3	17	0	490	0	0	0	0	0	1,230	1,720	0.04	27.3%	0.31	0.39	0.47	0.69		
O4	18	0	575	0	0	0	0	0	1,340	1,915	0.04	28.8%	0.33	0.40	0.48	0.70		
O5	19	715	260	0	0	0	0	0	440	1,415	0.03	68.2%	0.63	0.67	0.71	0.83		
OS1	20	0	0	80,672	47,309	0	0	0	148,843	276,824	6.36	27.4%	0.31	0.40	0.48	0.70		
OS2	21	0	15,843	12,024	0	0	0	0	2,098	29,965	0.69	86.9%	0.78	0.82	0.86	0.89		



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

Violet & Broadway Time of Concentration Calculations

Location: **Boulder**
 Minor Design Storm: **5**
 Major Design Storm: **100**
 Soil Type: **C/D**

Sub-Basin Data				Initial Overland Time (t _i)			Travel Time (t _t) t _t =Length/(Velocity x 60)						t _c Comp	t _c 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	0.89	0.60	182	2.0%	9.6	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	9.6	182	11.0	9.6
A2	2	0.14	0.65	0	0.0%	0.0	75	2.5%	Paved areas & shallow paved swales	20	3.2	0.4	0.4	75	10.4	5.0
A3	3	0.16	0.58	0	0.0%	0.0	78	1.0%	Paved areas & shallow paved swales	20	2.0	0.7	0.7	78	10.4	5.0
A4	4	0.02	0.75	0	0.0%	0.0	36	2.0%	Paved areas & shallow paved swales	20	2.8	0.2	0.2	36	10.2	5.0
A5	5	0.06	0.75	0	0.0%	0.0	60	1.2%	Paved areas & shallow paved swales	20	2.2	0.5	0.5	60	10.3	5.0
A6	6	0.28	0.61	0	0.0%	0.0	125	0.7%	Paved areas & shallow paved swales	20	1.7	1.2	1.2	125	10.7	5.0
A7	7	0.06	0.71	0	0.0%	0.0	70	3.0%	Paved areas & shallow paved swales	20	3.5	0.3	0.3	70	10.4	5.0
A8	8	0.05	0.81	0	0.0%	0.0	24	2.0%	Paved areas & shallow paved swales	20	2.8	0.1	0.1	24	10.1	5.0
A9	9	0.10	0.77	0	0.0%	0.0	50	2.0%	Paved areas & shallow paved swales	20	2.8	0.3	0.3	50	10.3	5.0
A10	10	0.05	0.64	0	0.0%	0.0	55	2.0%	Paved areas & shallow paved swales	20	2.8	0.3	0.3	55	10.3	5.0
A11	11	0.06	0.78	0	0.0%	0.0	48	2.0%	Paved areas & shallow paved swales	20	2.8	0.3	0.3	48	10.3	5.0
R1	12	0.07	0.85	48	3.0%	2.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.2	48	10.3	5.0
R2	13	0.08	0.85	34	2.0%	2.1	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.1	34	10.2	5.0
R3	14	0.11	0.85	40	2.0%	2.3	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.3	40	10.2	5.0
O1	15	0.14	0.29	0	0.0%	0.0	290	1.3%	Grassed waterway	15	1.7	2.8	2.8	290	11.6	5.0
O2	16	0.11	0.47	27	2.0%	4.7	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	4.7	27	10.2	5.0
O3	17	0.04	0.39	17	10.0%	2.4	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	2.4	17	10.1	5.0
O4	18	0.04	0.40	19	5.0%	3.2	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	3.2	19	10.1	5.0
O5	19	0.03	0.67	43	5.0%	3.0	0	0.0%	Paved areas & shallow paved swales	20	0.0	0.0	3.0	43	10.2	5.0
OS1	20	6.36	0.40	300	2.8%	15.5	700	2.8%	Paved areas & shallow paved swales	20	3.3	3.5	19.0	1000	15.6	15.6
OS2	21	0.69	0.82	0	0.0%	0.0	220	2.7%	Paved areas & shallow paved swales	20	3.3	1.1	1.1	220	11.2	5.0



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

Violet & Broadway

Detention Pond Volume Calculations: FAA Procedure

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

Drainage Basin A1
 Design Storm 10 year
 Composite "C" Factor 0.67
 Basin Size 0.89

Release Rate Calculations

Allowable Release Rate for Site	2.25 cfs	
Less Undetained Offsite Flows	- 0.00 cfs	A1 - (Developed Site - Historic Site)
Allowable Release Rate for Pond	2.25 cfs	

Rainfall Intensity Calculations

Point Hour Rainfall (P₁) : 1.80
 Rainfall Intensity: BoulderIDF

Volume Calculations

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

Detention Storage Calculations					
Time t (min)	Time t (sec)	Intensity I (in/hr)	Inflow V _{in} (ft ³)	Outflow V _{out} (ft ³)	Storage V _{stor} (ft ³)
5.0	300	7.45	1,327	675	652
10.0	600	5.70	2,030	1,350	680
15.0	900	4.55	2,431	2,025	406
20.0	1,200	3.80	2,707	2,700	7
25.0	1,500	3.30	2,939	3,375	-436
30.0	1,800	2.95	3,152	4,050	-897
35.0	2,100	2.76	3,444	4,725	-1,281
40.0	2,400	2.57	3,662	5,400	-1,737
45.0	2,700	2.38	3,813	6,075	-2,261
50.0	3,000	2.19	3,895	6,749	-2,854
55.0	3,300	2.00	3,909	7,424	-3,515
60.0	3,600	1.80	3,847	8,099	-4,252

	Maximum Volume (ft³)	680	
	City of Boulder Only (110%)	68	ft ³
	100% WQCV	871	ft ³
Required 10-yr Volume +	100% WQCV	1,619	ft³



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

Violet & Broadway

Detention Pond Volume Calculations: FAA Procedure

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

Drainage Basin **A1**
 Design Storm **100 year**
 Composite "C" Factor **0.79**
 Basin Size **0.89**

Release Rate Calculations

Allowable Release Rate for Site **4.57 cfs** **A1 - (Developed Site - Historic Site)**
 Less Undetained Offsite Flows **0.00 cfs**
 Allowable Release Rate for Pond **4.57 cfs**

Rainfall Intensity Calculations

Point Hour Rainfall (P₁) : **2.50**
 Rainfall Intensity: BoulderIDF

Volume Calculations

Inflow Volume = C * I * A * time (sec)
 Outflow Volume = Allowable Release Rate * time (sec)
 Storage Volume = Inflow 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	2,105	1,370	735
10.0	600	8.35	3,515	2,741	774
15.0	900	6.65	4,199	4,111	88
20.0	1,200	5.52	4,648	5,482	-834
25.0	1,500	4.70	4,947	6,852	-1,905
30.0	1,800	4.20	5,304	8,222	-2,918
35.0	2,100	3.92	5,779	9,593	-3,813
40.0	2,400	3.64	6,128	10,963	-4,835
45.0	2,700	3.36	6,357	12,334	-5,976
50.0	3,000	3.07	6,467	13,704	-7,237
55.0	3,300	2.79	6,458	15,074	-8,617
60.0	3,600	2.50	6,315	16,445	-10,130
Maximum Volume (ft³)					774
City of Boulder Only (110%)					77 ft ³
50% WQCV					436 ft ³
Required 100-yr Volume + 50% WQCV					1,287 ft³



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

Job Name: Violet & Broadway
 Job Number: 1508.5c
 Date: 11/11/14
 By: JPW

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
5520.3		0			0
5521.0	0.7	1,042	521	243	243
5522.0	1.0	3,175	2,109	2,012	2,255
5522.5	0.5	4,729	3,952	1,963	4,218

Top of Pond

5522.5	2.2	TOTAL VOLUME	4,218 cf	0.097 ac-ft
--------	-----	---------------------	-----------------	-------------

Volume Summary Table

	Required Volume (ft ³)	Required Volume (ac-ft)	Water Surface Elevation	Water Depth
WQCV	871 cf	0.020 ac-ft	5521.31 ft	1.01 ft
V10 + 100% WQCV	1,619 cf	0.037 ac-ft	5521.68 ft	1.38 ft
V100 + 50% WQCV	1,287 cf	0.030 ac-ft	5521.52 ft	1.22 ft

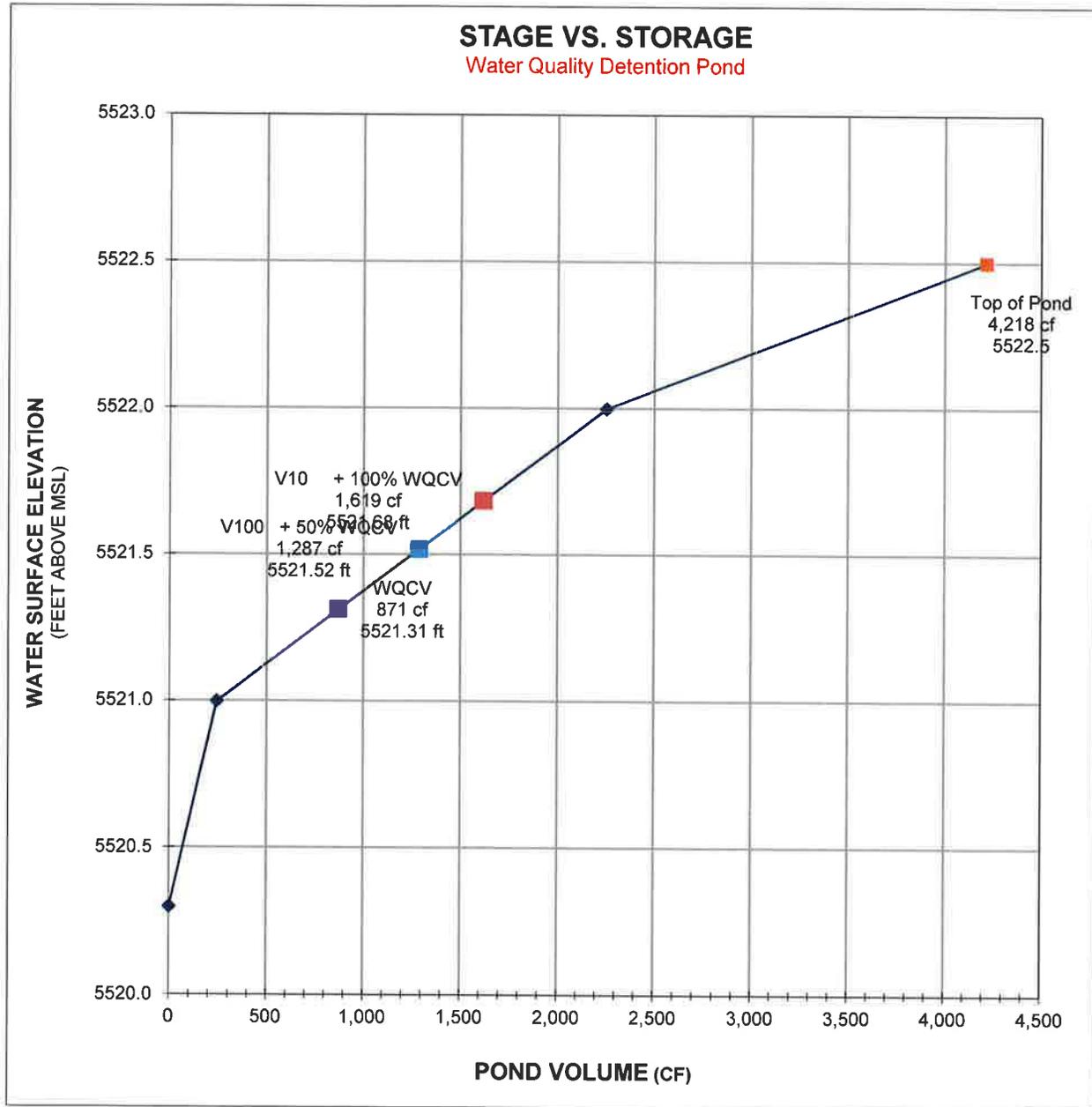
Volume Interpolation Calculations

WQCV		V10 + 100% WQCV		V100 + 50% WQCV	
Vol	Elev	Vol	Elev	Vol	Elev
243.13	5521.00	243.13	5521.00	243.13	5521.00
871.00	5521.31	1619.48	5521.68	1287.40	5521.52
2255.10	5522.00	2255.10	5522.00	2255.10	5522.00



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

Job Name: Violet & Broadway
Job Number: 1508.5c
Date: 11/11/14
By: JPW



Design Procedure Form: Extended Detention Basin (EDB)

Sheet 1 of 4

Designer: D. Breedlove
Company: JVA, Inc
Date: November 13, 2014
Project: Violet & Broadway
Location: Basin A1

1. Basin Storage Volume

- A) Effective Imperviousness of Tributary Area, I_a
- B) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)
- C) Contributing Watershed Area
- D) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm
- E) Design Concept
(Select EURV when also designing for flood control)
- F) Design Volume (1.2 WQCV) Based on 40-hour Drain Time
($V_{DESIGN} = (1.0 * (0.91 * i^2 - 1.19 * i + 0.78 * i) / 12 * Area * 1.2)$)
- G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
($V_{WQCV\ OTHER} = (d_6 * (V_{DESIGN} / 0.43))$)
- H) User Input of Water Quality Capture Volume (WQCV) Design Volume
(Only if a different WQCV Design Volume is desired)
- I) Predominant Watershed NRCS Soil Group

$I_a =$ 56.3 %

$i =$ 0.563

Area = 0.890 ac

$d_6 =$ _____ in

Choose One

Water Quality Capture Volume (WQCV)

Excess Urban Runoff Volume (EURV)

$V_{DESIGN} =$ 0.020 ac-ft

$V_{DESIGN\ OTHER} =$ _____ ac-ft

$V_{DESIGN\ USER} =$ _____ ac-ft

Choose One

A

B

C / D

2. Basin Shape: Length to Width Ratio

(A basin length to width ratio of at least 2:1 will improve TSS reduction.)

L : W = _____ : 1

3. Basin Side Slopes

- A) Basin Maximum Side Slopes
(Horizontal distance per unit vertical, 4:1 or flatter preferred)

Z = _____ ft / ft

4. Inlet

- A) Describe means of providing energy dissipation at concentrated inflow locations:
