MOUNTAIN SKY SUBDIVISION

PRELIMINARY DRAINAGE REPORT

FEBRUARY 2016

For:
Rokeh Consulting, LLC
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Prepared By:
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ENGINEER'S STATEMENT:

I hereby affirm that this report and plan for the Phase I drainage design of the development Mountain Sky Subdivision was prepared by me (or under my direction supervision) in accordance with the provisions of the City of Fort Lupton Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Fort Lupton does not and will not assume liability for drainage facilities designed by others. I am also aware of the previsions of the City CODE as it pertains to the City's review.

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Tracey A Wise, P.E. Date
State of Colorado No. 40368
For and on behalf of Calibre Engineering, Inc.

TABLE OF CONTENTS

APPENDICIES

SCOPE

This report discusses the historic drainage patterns and concept level drainage infrastructure for the proposed Mountain Sky Subdivision. The scope of this report is limited to hydrologic and hydraulic calculations for the major tributary basins, detention pond and stormwater bypass channel and the scope excludes preliminary and final design of onsite infrastructure. The Mountain Sky Subdivision will be developed as a series of filings. As the site is developed, each filing will submit a Phase III Drainage Report which will include the final design of all onsite infrastructure utilized in the development of that filing.

1.0 GENERAL LOCATION AND DESCRIPTION

1.1 Location

The project is located as follows:

- Within the southwest quarter of Section 4, Township 1 North, Range 66 West of the 6th Principal Meridian
- Adjacent to the southern and eastern perimeter of Fort Lupton's city limits
- North of Weld CR 12
- South of undeveloped land located south of Highway 52
- East of Shortline Ditch (runoff from this site currently enters the ditch)
- West of CR 29 ½
- West of an existing levee which passes under CR 12 and Highway 52
- North and west of a single family home, south of a single family home and southeast of a housing sub-division
- See Vicinity Map located in Appendix A

1.2 Description of Property

The following are characteristics of the site:

- As currently platted, the parcel consists of 76.95 acres
- Anadarko will utilized 15.75 acres of the parcel for future oil/gas development which includes 1.25 acres of CR12 road adjacent to the portion of land utilized by Anadarko
- Mountain Sky Subdivision is proposes to utilize the remaining 61.2 acres of the parcel
- Site is existing farm land
- Site drains to the west with existing slopes ranging between 1% and 4%
- Mostly contains soils in Hydrologic Group B, Sandy Plains (see Soils Map located in Appendix A)
- Roadside drainage ditches are located on the south side of the site
- Well site located along the north property line
- The proposed land use for the site is primarily single family residential

- The project includes the development of land, roadways, parks and utilities within the site, as well as the construction of a drainage system which will include detention and water quality facilities to meet the City of Fort Lupton's requirements
- A Natural Resources Assessment was completed by ERO Resources Corporation on September 30, 2014 which stated ditches and wetland vegetation are potential water of the U.S. but "because the ditches do not have a surface connection to a known water of the U.S., it is unlikely the Corps would take jurisdiction over the ditches; however, the Corp must make that determination."

2.0 DRAINAGE BASINS AND SUB-BASINS

2.1 Major Basin Description

- The project falls within the study area of the Master Drainage Plan of:
  a) the *City of Fort Lupton Water, Wastewater and Storm Drainage Master Plan, Section 6 Storm Drainage System*
  b) the *DRAFT copy of the City of Fort Lupton Comprehensive Plan* prepared by Clear Water Solutions, Inc.
- Storm runoff from the tributary basins generally flows east to west across the subject site
- Site runoff is ultimately conveyed to South Platte River via downstream ditches, streets, and pipes

2.2 Sub-Basin Description

- According to the *Storm Drainage Master Plan*, the project site is located in the South Drainage Basin
- According to the DRAFT copy of the *City of Fort Lupton Comprehensive Plan, Section 8.0 STORM DRAINAGE SYSTEM* (a copy of pertinent sections of the DRAFT report is located in Appendix D), the project site is located within sub-basin S6. The project site received runoff from sub-basins S6.1 and S6.3 and portions of sub-basins S6.2 and S8 for a total of approximately 1700 acres
- Five sub-basins (OS, North, Site, East and South), whose runoff drains either directly or indirectly to the site, total the above mentioned 1700 acres. These sub-basins were used for all calculations for this report and are displayed in the Overall Drainage Exhibit located in the Map Pocket at the end of this report
- An existing irrigation ditch, Fulton Ditch, located east of the site running in a south-to-north direction, receives runoff from the South, East, and OS Basins. It is assumed that the ditch is running full and that all runoff from the basin flows over the ditch embankment continuing in a westerly direction
- Shortline Ditch, located immediately west of the proposed development, currently receives runoff from all five sub-basins, including the subject site
- Approximately 3.4 acres consisting of a single-family residences, located southeasterly and offsite, historically flows northwesterly onto the proposed site

- The development is within FEMA Flood Insurance Rate Map panels 0802660981C, revised September 28, 1982, and 0802660982C, which is not available for printing. The project is located in Zone C and no mapped 100-year floodplains exist for the site. See FEMA Map Panels in Appendix A
- There are no existing major irrigation facilities on the Mountain Sky Subdivision property. However, there are existing irrigation facilities surrounding the site, such as the Fulton Ditch to the east and Shortline Ditch to the west
- The downstream drainage flow patterns are not anticipated to be effect the development of Mountain Sky Subdivision

3.0 DRAINAGE DESIGN CRITERIA

3.1 Development Criteria References and Constraints

- Research was completed in an effort to obtain the DRAFT copy of the *City of Fort Lupton Comprehensive Plan, Section 8.0 STORM DRAINAGE SYSTEM*. The study is currently in progress and calculations are not available at this time
- *City of Fort Lupton Water, Wastewater and Storm Drainage Master Plan, Section 6 Storm Drainage System*, prepared by Rothberg, Tamburini & Winsor, Inc. in 1999, provided major basin and irrigation information as well as future concepts for the project area
- The *City of Fort Lupton Standards and Specifications for the Design and Construction of Public Improvements, 2014 Edition, Chapter 5 Storm Sewer System* provided local criteria
- The *City of Fort Lupton Storm Drainage Design and Technical Criteria* (CRITERIA) shall be the design criteria for the analysis and design of storm drainage facilities
- The *Urban Drainage and Flood Control District's (UDFDC) Urban Storm Drainage Criteria Manual* was also used as a reference and guide for criteria
- The City has proposed that all developments within the subject area of the City release water only at the 5-year historic level, including the storm generated by the 100-year event

3.2 Hydrologic Criteria

- Design rainfall for 1-hour is from *City of Fort Lupton Storm Drainage Design and Technical Criteria*, *Section 5 RAINFALL* while 6-hour design rainfall was interpolated from *UDFCD Rainfall depth-duration-frequency Figures 5-7 through 5-12.*

Event Occurrence	2 YR	5 YR	10 YR	50 YR	100 YR
1-hr. Rainfall Intensity (in/hr)	1.00	1.42	1.68	2.35	2.71
6-hr. Rainfall Intensity (in/hr)	1.4	1.9	2.2	3.0	3.4

- CUHP was used to determine runoff for five sub-basins draining to the commencement of the Shortline Ditch which is located at the low point of the project site

- Peak runoff rates for the final design of the Mountain Sky Subdivision shall utilize the Rational Method
- The 5-year storm is the minor event for the development
- The 100-year storm is the major event for the development

3.3 Hydraulic Criteria

- The capacities of existing pipes or natural drainage ways should not be impacted by this development
- CUHP/SWMM was used to determine the runoff to the proposed channel
- Imperviousness for the future Site Basin was determined at 40% by interpolating the runoff coefficients 5-yr c=0.45 and 100-yr c=0.60
- Per the City of Fort Lupton's CRITERIA, the FAA method for Minor and Major Storm Storage Volumes was utilized to determine on-site detention
- On-site detention design is based upon the 5-year and 100-year storm frequencies
- Per the City of Fort Lupton's Master Drainage Plan, the release rate is restricted to the UDFCD historic release rate for Type B soil of 0.13 cfs/acre for both the minor and major storms

3.4 Adaptations to Criteria

- Maximum design depth of ponding in the major storm is greater than the CRITERIA requirement of 5 feet since the major storm is being restricted to the 5-year release rate
- Pond bottom sloped at 2% as opposed to CRITERIA's requirement of 3% slope

4.0 DRAINAGE FACILITY DESIGN

4.1 Offsite Tributaries and Site Basin

Tributaries which convey runoff that affect the project site are divided into four off-site basins, OS, OS-E, OS-N and OS-S. Percent imperviousness for historic land use within these basins is 2%. Future land use for offsite tributaries will remain at 2% imperviousness since future development within these basins should restrict release rates to the historic rate. The following section describes each basin, its designated CUHP/SWMM Catchment, size in acres, its indeterminate nature and flow determinations.

- Basin E, the East Basin, is comprised of approximately 819 acres. The runoff from the majority of this basin flows in a westerly direction toward the Fulton Ditch, then westerly to Design Point 1, where it then enters the Mountain Sky Property. The following bullets describe Historic and proposed runoff from Basin OS-E:
  - Historic –
    - Runoff from this basin entered the subject site near Design Point 1 (see attached exhibit entitled "OVERALL DRAINAGE")
    - Runoff was conveyed through the Mountain Sky property via a broad drainage swale and discharged into the Shortline Ditch
  - Developed –

  - Runoff from Basin OS-E will be collected at DP 1 and conveyed in a channel along the north line of the Mountain Sky property
  - The proposed channel will be broad and wide, mimicking the existing channel from County Road 29 ½ to the oil well site
  - The proposed channel will narrow where it is adjacent to the proposed detention pond and will convey water to the Shortline Ditch and discharge in a manner similar to the historic condition
- Basin N, the North Basin, consists of about 78.4 acres. The following is a description of the historic and proposed developed runoff path:
  - Historic –
    - Storm runoff from this basin flows in a southerly or westerly direction to the existing swale that roughly runs between the subject site and Basin OS-N
    - Storm runoff combines with runoff from OS-E and the subject site and is conveyed roughly along the north property line of the subject site and discharged into the Shortline Ditch
  - Developed –
    - During the interim condition, i.e. is prior to development of the OS-N area, no changes are proposed to the manner that flow drains onto the subject site
    - Runoff will continue to sheet flow into the broad swale along the north property line of Mountain Sky and will continue to combine with OS-E flows
    - The path of the proposed swale past the oil well and to Shortline Ditch is described in the OS-E description above

- Basin OS, is approximately 110 acres and is located north of Highway 52. A partially clogged 12" pipe running from north to south was located under Highway 52 during a site inspection. There is an inlet located in a position so that during major storm events, runoff will flow under the highway through the pipe and possibly over the top of the road. Until further investigation can be conducted to verify that roadside ditches along Highway 52 can accommodate all runoff from the north side of the highway, it should be considered that runoff from this basin may be conveyed in a swale along the west boundary line of OS-2 (North Basin) to the Shortline Ditch at DP5

Culvert under Highway 52

- Basin OS-S, the South Basin, is comprised of approximately 616 acres and located south of CR12. The runoff from the majority of this basin flows in a northwesterly

direction toward the Fulton Ditch and is assumed to flow over the ditch. The following is a description of the historic and developed flow paths:

- Historic –
    - Storm runoff from this basin historically flowed via sheetflow and shallow drainageways and was carried eventually to the subject site, partially being concentrated at DP-4 and partially sheet-flowing to the south property line of the Mountain Sky Subdivision
    - With the addition of the County Roads and the Fulton Ditch, drainage from OS-S changed dramatically, with some flow entering the ditch and being diverted, some flow overtopping the ditch at a given currently unknown point and then being conveyed as a concentrated overflow, some being diverted by County Road 12, and some being diverted by County Road 29 ½
    - This condition will be considered historic for the purposes of this study since the Roads and ditches have been in place for many, many years
- Developed –
    - During final design, the diversion of OS-S will be analyzed in more detail to approximate the capacity of County Road 12, the capacity to County Road 29 ½, and the overtopping of each road
    - Final design will assume that the ditch is full and that water is overflowing. An attempt should be made during final design to identify the most likely point of overflow
    - Based on this analysis, flow should be split and the design of County Roads 12 and 29 ½ should be designed to convey these projected flows
    - Flows in CR29 ½ will be routed north to DP-1, and flows in CR12 will continue to drain west past the Mountain Sky Subdivision site

- Basin SITE, the Basin consisting of the proposed Mountain Sky Subdivision, Anadarko's future oil and gas development, consists of about 80.9 acres. The following is a description of the historic and proposed developed runoff path:
    - Historic –
        - Storm runoff from this basin flows in a northwesterly direction to the existing Shortline Ditch
        - Storm runoff combines with runoff from OS-E and OS-N and is conveyed roughly along the north property line of the subject site and discharged into the Shortline Ditch
    - Developed –
        - During the construction of Filing No. 1, a channel along the north property line will be constructed to route the offsite flows from Basin OS-E and OS-N to the Shortline Ditch
        - Anadarko's portion of the site will continue to drain directly to the Shortline ditch until is development

- Anadarko will be required to provide onsite detention for their portion of the site once development on that parcel of land occurs

Summary of Tributaries with Developed Site Basin

Basin Designation	CUHP/SWMM Catchment	5-year Runoff (cfs)	100-year Runoff (cfs)
OS-E	EAST BASIN	90	643
OS-N	NORTH BASIN	24	138
OS	OS BASIN	43	239
OS-S	SOUTH BASIN	88	603
SITE	SITE	83	252

Photographs of Existing Ditches from June 6, 2014

Fulton Ditch in Basin OS-E

Shortline Ditch

4.2 Detention

Based on previous investigation by the City of Fort Lupton and the identification of a lack of storm drainage conveyance systems downstream of the Mountain Sky Subdivision, the *Wastewater and Storm Drainage Master Plan, Section 6, South Drainage Basin* has proposed that all developments within the subject area of the City release water only at the 5-year historic level, including the storm generated by the 100-year event.

In order to evaluate the subject site detention needs and plan for tributary flows, we have utilized CUHP and SWMM computer programs to model runoff during the 5-year and 100-year events for both historic and developed condition. We have also calculated the following:

- The maximum volume of available onsite storage given the size of the parcel available for detention

- The volume of storage required to detain onsite runoff only and thereby reduce release rate from the development to historic 5-year level during the 100-year event
- The volume of storage required to detain the subject site plus all tributary areas to the historic 5-year level during the 100-year event

The City has expressed interest in regional detention for this area. Therefore, part of our goal in running the CUHP/SWMM was to determine to what extent the subject site might be able to over-detain and be part of a more regional solution. The following outlines some of our findings:

- Regional detention for all offsite tributary basins plus the subject site area will require a pond size of 1925' x 800' x 10'. This is a minimum of 35 acres and probably much larger given an average depth much less than 10'. We concluded that a number of locations will be needed within the overall basin in order to meet the regional detention requirement, and the Mountain Sky Subdivision site is not able to provide for the entire region
- The onsite detention pond area is large enough to provide detention for the Mountain Sky Subdivision, even restricting the 100-yr storm to the historic 5-yr release rate
- It has not been determined conclusively how much regional detention can be achieved on the Mountain Sky Subdivision site at this preliminary stage, since the answer to that question will depend on much more detailed analysis that includes ground water analysis, detailed hydrology & hydraulics, detailed grading, geotechnical engineering, and subdivision design
- For the development of Mountain Sky Subdivision, it has been determined that the offsite basin drainage from the east and north should be routed around the detention pond. That conclusion is based on the difficulty in managing offsite "pass-through" runoff to achieve effectiveness, and operation of detention and water quality facilities that are regional in nature, when the conditions upstream are such that development is progressing in a slow or indeterminate rate.

Some additional findings are as follows:

- Regional detention of 10' in depth would most likely encounter groundwater, thereby creating a dewatering situation. Reducing the depth of the pond would increase the overall surface area of the pond, taking up more than half of the proposed site.
- The proposed project is a single-family housing subdivision. Approximately 20 proposed lots are located along the east side of the proposed pond at the low-point of the site. The water surface elevation (WSEL) of a regional pond would be higher and closer in elevation to the underdrain system for the proposed lots. Therefore, the final engineering of the site should consider daylighting any underdrain system at a point outside the detention pond and well below the subject site.
- A channel is proposed north of the on-site detention pond to prevent runoff from Basins OS-N and OS-E from running through the pond. If the runoff from these basins were directed through the pond undetained, the pond release rate would be increased which would decrease the amount of water quality treatment being

received by the runoff from the project site which will contain more pollutants than undeveloped basins.

- Roadside ditches along Highway 52 and CR12 will need additional analysis. According to the DRAFT copy of the *City of Fort Lupton Comprehensive Plan, Section 8.0 STORM DRAINAGE SYSTEM*, it appears the runoff from Basin OS should remain north of Highway 52 and runoff from Basin OS-S should be directed to a proposed 54-inch storm sewer located along CR12.

According to the Storm Water Master Plan, South Drainage Basin Section on page 6-10, "Approximately 480 acres located just south of Highway 52 and east of Shortline Ditch is planned for residential development. The requirements for development of this area should include over-detention of storm drainage as discussed in the standards and specifications section of this Master Plan."

The total acreage which drains to the project site is approximately 1700 acres. With 480 acres determined for residential development, it is difficult to determine an overall imperviousness for the remainder of the area and provide reliable regional detention. By allowing each development to incorporate LID and reduce WQCV, future developments may be able to reduce the flood damage potential.

4.3 Optional Low Impact Development Features

Low Impact Development (LID): LID is a comprehensive land planning and engineering design approach to managing stormwater runoff. Key components of LID, in addition to individual BMPs, include practices such as:

- Impervious areas should drain to pervious areas: route downspouts across pervious areas and incorporate vegetation in areas that generate and convey runoff
- The use of borrow ditches along roads with the proposed development instead of curb and gutter systems
- Additional area may be needed either along the front or back lot lines in order to accommodate borrow ditches. This is particularly true if small lots are contemplated. Note that the use of borrow ditches along the roads would require culverts under driveways

Another method to improve Stormwater Quality Management is to treat runoff through capture and slow release of the Water Quality Capture Volume (WQCV). The Storm Drainage Master Plan's recommendation is to reduce the maximum runoff from developed property during the 100-year frequency storm event to not exceed the peak runoff expected from a historic 5-year frequency event.

5.0 CONCLUSIONS

5.1 Compliance with Standards

- This report is in general accordance with the *City of Fort Lupton Storm Drainage Design and Technical Criteria*

- This report is in general accordance, where applicable and not superseded by other criteria, to the *Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual* (USDCM)
- This report is in general accordance with FEMA; there are no known existing floodplains within the site boundary

5.2 Summary of Concept

- Runoff from the site will be conveyed through drainage swales, curb and gutter and a storm sewer system to proposed detention
- Runoff from off-site will be directed via ditches, culverts and channels to the Shortline Ditch which currently receives this runoff
- During future development, it will be possible to pipe the runoff from the proposed channel in a southerly direction to connect to proposed storm sewer in CR12
- Downstream properties should not be affected by the development of the proposed site; the detention pond will provide the appropriate detention to control the release from the development

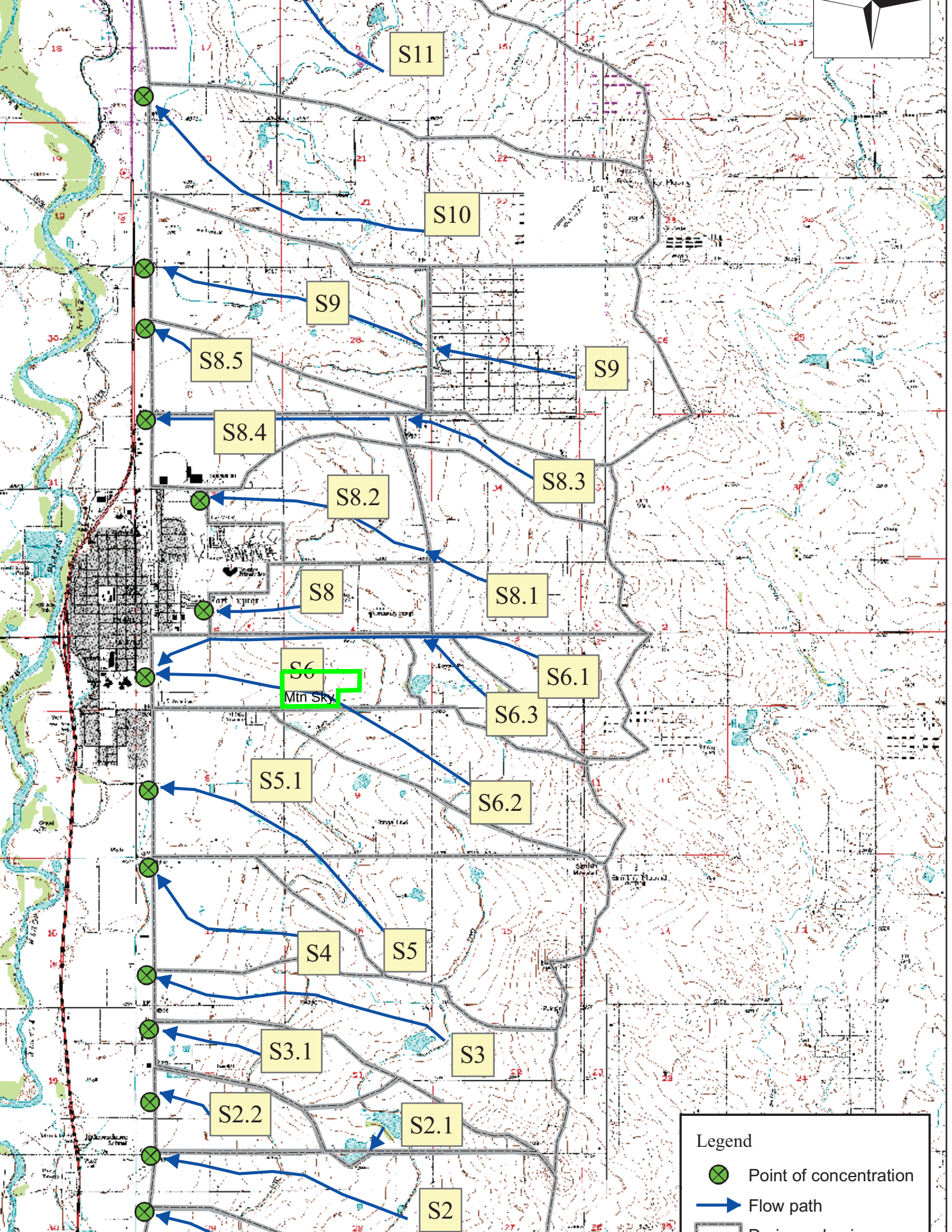
6.0 LIST OF REFERENCES

1. *City of Fort Lupton Storm Drainage Design and Technical Criteria* (CRITERIA)
2. DRAFT copy of the *City of Fort Lupton Comprehensive Plan, Section 8.0 STORM DRAINAGE SYSTEM*, prepared by Clear Water Solutions, Inc., 2014
3. *City of Fort Lupton Water, Wastewater and Storm Drainage Master Plan, Section 6 Storm Drainage System*, prepared by Rothberg, Tamburini & Winsor, Inc., 1999
4. *City of Fort Lupton Standards and Specifications for the Design and Construction of Public Improvements, 2014 Edition, Chapter 5 Storm Sewer System*
5. *Urban Storm Drainage Criteria Manual, Volumes 1, 2 & 3*, Urban Drainage Flood Control District

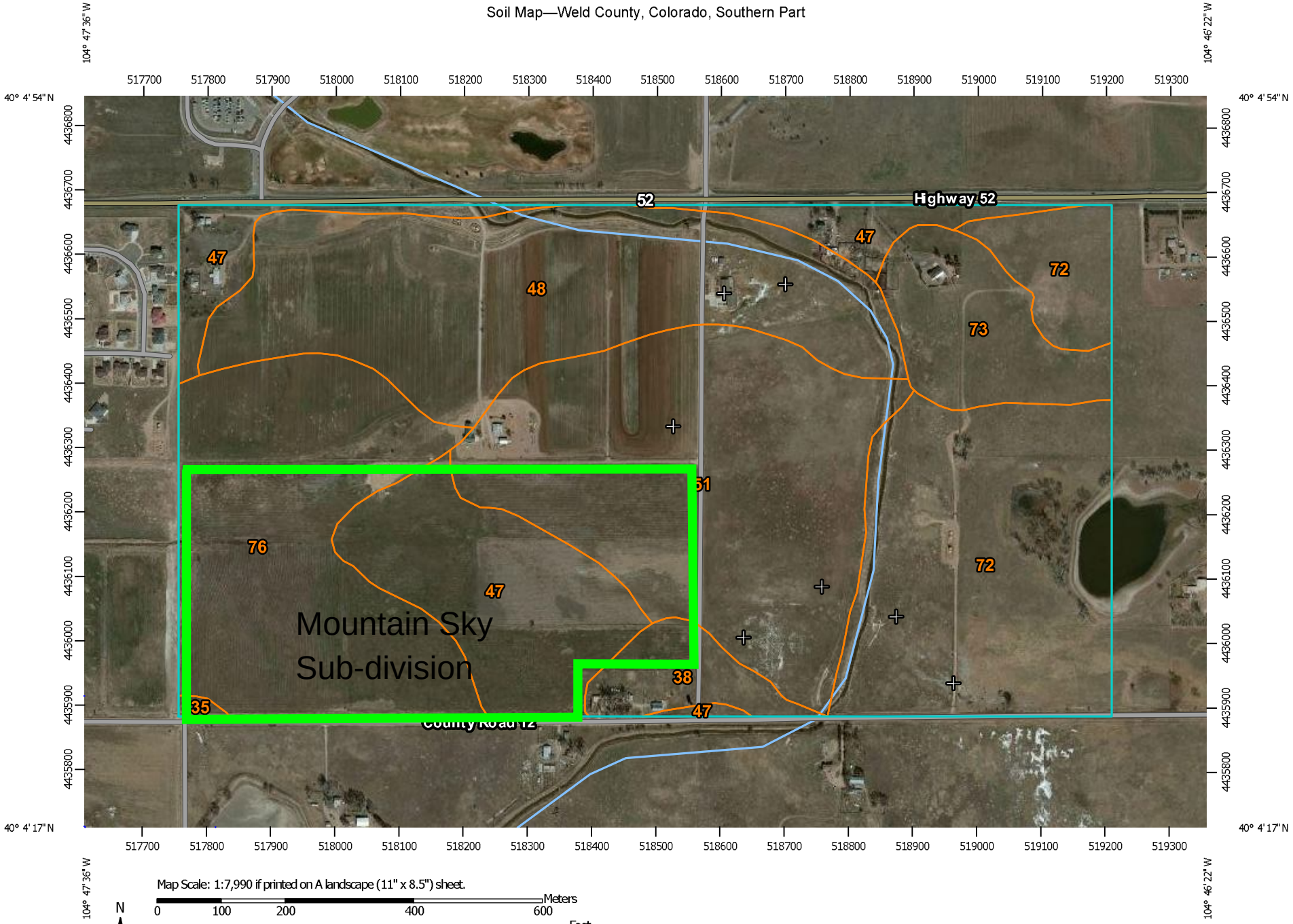
APPENDIX A

MAPS AND EXHIBITS

VICINITY MAP


S11
S10
S9
S8.5
S9
S8.4
S8.3
S8.2
S8
S8.1
S6
Mtn Sky
S6.1
S6.3
S6.2
S5.1
S5
S4
S3.1
S3
S2.2
S2.1
S2
Legend
Point of concentration
Flow path

Soil Map—Weld County, Colorado, Southern Part



Map Scale: 1:7,990 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 350 700 1400 2100

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil 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 1:24,000.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: 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: Weld County, Colorado, Southern Part
Survey Area Data: Version 12, Jan 3, 2014

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

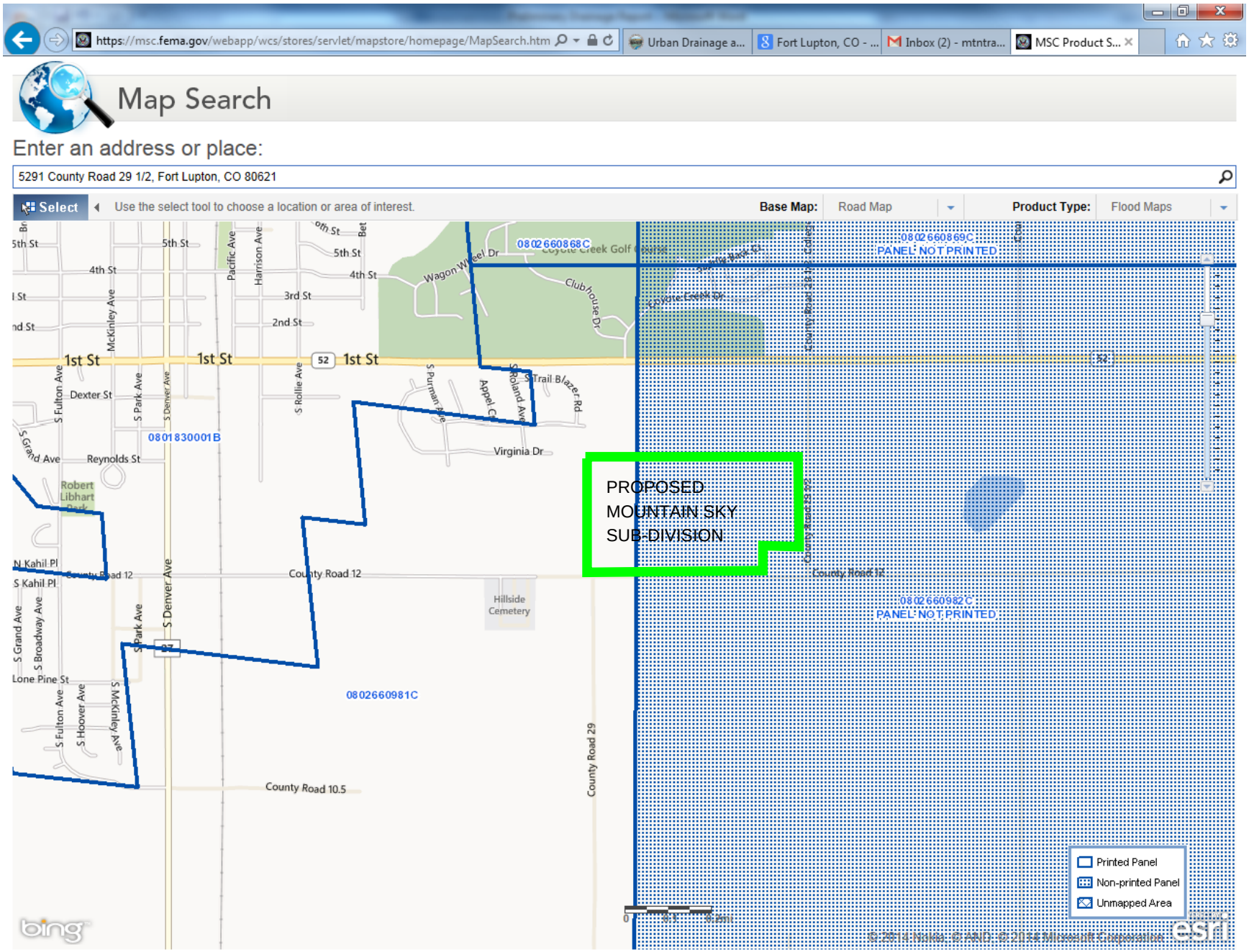
Date(s) aerial images were photographed: Apr 22, 2011—Apr 13, 2012

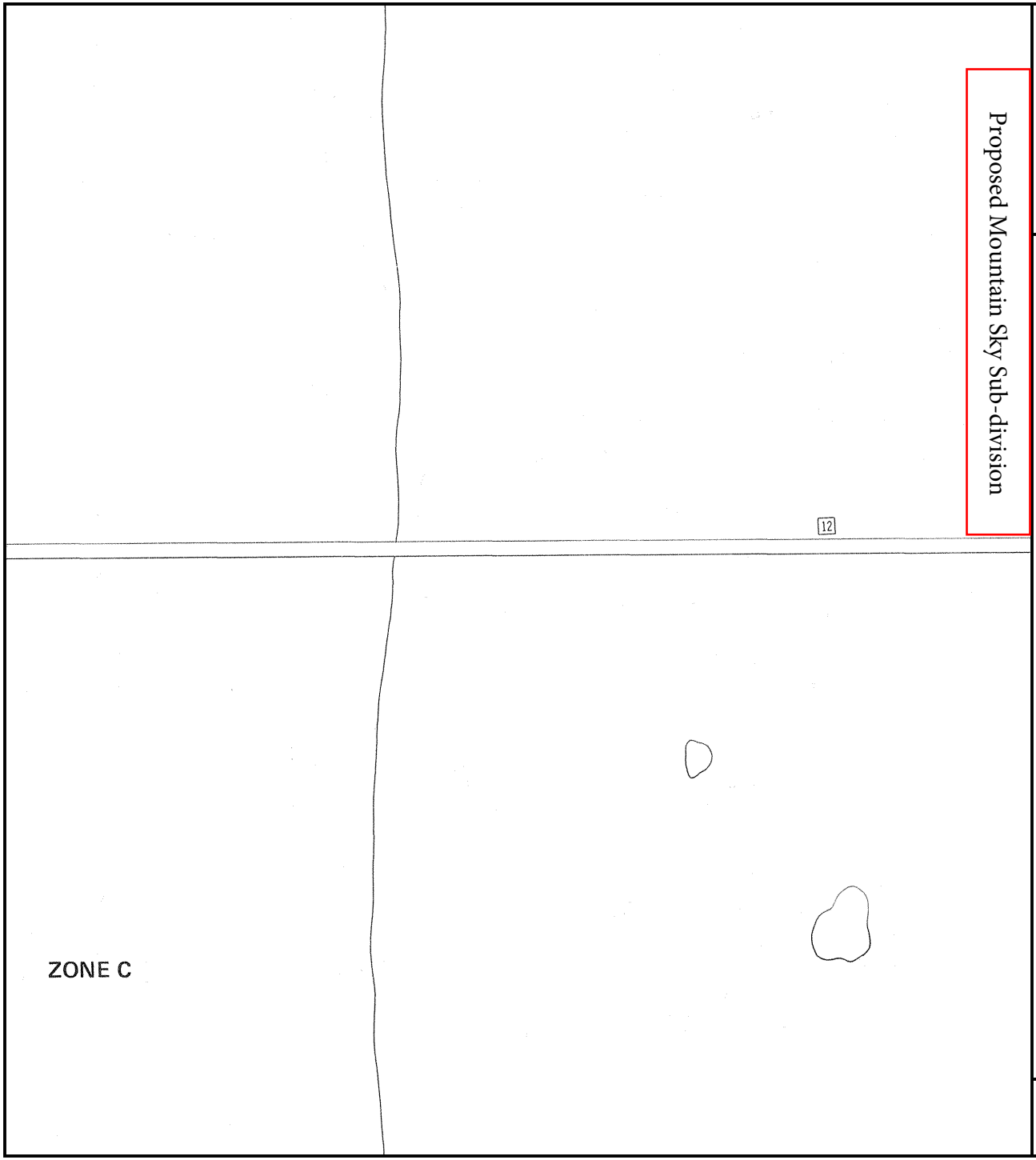
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Weld County, Colorado, Southern Part (CO618)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
35 Hydrologic Soil Group D	Loup-Boel loamy sands, 0 to 3 percent slopes	0.5	0.2%
38 Hydrologic Soil Group C	Nelson fine sandy loam, 3 to 9 percent slopes	7.8	2.7%
47 Hydrologic Soil Group B	Olney fine sandy loam, 1 to 3 percent slopes	38.1	13.3%
48 Hydrologic Soil Group B	Olney fine sandy loam, 3 to 5 percent slopes	57.2	20.0%
51 Hydrologic Soil Group B	Otero sandy loam, 1 to 3 percent slopes	61.8	21.6%
72 Hydrologic Soil Group B	Vona loamy sand, 0 to 3 percent slopes	56.0	19.6%
73 Hydrologic Soil Group B	Vona loamy sand, 3 to 5 percent slopes	15.9	5.5%
76 Hydrologic Soil Group B	Vona sandy loam, 1 to 3 percent slopes	49.0	17.1%
Totals for Area of Interest		**286.2**	**100.0%**

FEMA MAP PANELS





APPROXIMATE SCALE

500 0 500 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

WELD COUNTY, COLORADO

UNINCORPORATED AREA

PANEL 981 OF 1075

(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
080266 0981 C

MAP REVISED:
SEPTEMBER 28, 1982

federal emergency management agency

Federal Insurance Administration

"E" FRAME

APPENDIX B
HYDROLOGIC COMPUTATIONS

CUHP SUBCATCHMENTS

Columns with this color heading are for required user-input
Columns with this color heading are for optional override values
Columns with this color heading are for program-calculated values

								Maximum Depression Storage (Watershed inches)		Horton's Infiltration Parameters			DCIA
Subcatchment Name	EPA SWMM Target Node	Raingage	Area (acre)	Length to Centroid (ft)	Length (ft)	Slope (ft/ft)	Percent Imperviousness	Pervious	Impervious	Initial Rate (in/hr)	Decay Coefficient (1/seconds)	Final Rate (in/hr)	Level 0, 1, or 2
NORTH	N	Ft Lupton	78.40456841	957	2035	0.0137	2	0.35	0.1	4.5	0.0018	0.6	0
OS	OS	Ft Lupton	109.6662994	662	2201	0.0138	2	0.35	0.1	4.5	0.0018	0.6	0
EAST	E	Ft Lupton	825.2610652	5574	10880	0.0125	2	0.35	0.1	4.5	0.0018	0.6	0
SOUTH	S	Ft Lupton	615.940955	3833	8812	0.0151	2	0.35	0.1	4.5	0.0018	0.6	0
SITE	SITE	Ft Lupton	80.85	1245	2610	0.011	2	0.35	0.1	4.5	0.0018	0.6	0

RUN MULTIPLE CUHP AND SWMM SCENARIOS

Columns with this color heading are for required user-input
Columns with this color heading are for program-calculated values

SWMM Run Wait Time (sec)	(Optional) SWMM Time Series Inflow "Modification Type" (LU, RP, or LU&RP)
5	

Subcatchment Name	Existing Landuse % Imperviousness	Future Landuse % Imperviousness
NORTH	2	2
OS	2	2
EAST	2	2
SOUTH	2	2
SITE	2	40

Raingage	Return Period (Years)	1 Hr Depths (in)	6 Hr Depths (in)
Ft Lupton	WQ	0.6	N/A
	2	1	1.4
	5	1.42	1.9
	10	1.68	2.2
	25	2.05	2.8
	50	2.35	3
	100	2.71	3.4
	500	3	4

Enter "X" to Run Scenario	Scenario ID	Land Use (E or F)	Return Period (yr)	Correction Area (Sq.Mi.)	(Optional) SWMM Time Series Inflow Table "NAME"
	1	E	2	0	
X	2	E	5	0	
	3	E	10	0	
X	4	E	100	0	
	5	F	2	0	
X	6	F	5	0	
	7	F	10	0	
X	8	F	100	0	

5-YR DEVELOPED CONDITIONS

Printouts for Storm Hydrographs

flow in cfs

time in minutes	NORTH	OS	EAST	SOUTH	SITE
5	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00
15	0.01	0.01	0.00	0.00	4.61
20	0.09	0.21	0.05	0.08	17.17
25	3.76	8.69	1.97	3.14	47.76
30	14.73	31.70	9.88	15.57	79.26
35	22.70	42.75	23.61	35.78	82.53
40	23.57	39.35	40.32	56.83	69.30
45	20.95	31.80	56.59	73.21	56.92
50	17.71	25.51	69.96	83.64	46.83
55	15.04	21.03	80.03	88.07	38.33
60	12.85	17.11	86.59	87.91	32.20
65	11.24	13.42	89.74	84.81	27.81
70	9.73	10.50	90.11	79.15	23.83
75	8.23	8.87	88.68	72.09	19.66
80	6.76	7.45	85.69	66.20	15.42
85	5.58	6.09	81.19	61.68	12.76
90	4.91	4.75	75.35	57.41	11.53
95	4.35	3.43	69.67	53.19	10.76
100	3.81	2.09	65.96	49.11	9.81
105	3.26	0.94	62.60	45.72	8.73
110	2.72	0.39	59.32	43.08	7.96
115	2.19	0.24	56.01	40.58	7.41
120	1.65	0.17	52.69	38.12	6.88
125	1.13	0.13	49.44	35.67	5.58
130	0.60	0.09	46.64	33.22	3.93
135	0.21	0.07	44.56	30.77	2.75
140	0.11	0.05	42.62	28.33	1.90
145	0.07	0.03	40.74	25.90	1.27
150	0.05	0.02	38.85	23.48	0.83
155	0.04	0.01	36.98	21.07	0.55
160	0.03	0.01	35.11	19.05	0.32
165	0.02	0.00	33.25	17.94	0.16
170	0.02	0.00	31.40	17.02	0.05
175	0.01	0.00	29.55	16.17	0.00
180	0.01	0.00	27.70	15.33	0.00
185	0.00	0.00	25.85	14.49	0.00
190	0.00	0.00	24.01	13.66	0.00
195	0.00	0.00	22.17	12.84	0.00
200	0.00	0.00	20.37	12.02	0.00
205	0.00	0.00	18.92	11.20	0.00
210	0.00	0.00	18.11	10.39	0.00
215	0.00	0.00	17.42	9.58	0.00
220	0.00	0.00	16.77	8.77	0.00
225	0.00	0.00	16.13	7.97	0.00
230	0.00	0.00	15.50	7.16	0.00
235	0.00	0.00	14.86	6.36	0.00
240	0.00	0.00	14.23	5.55	0.00

245	0.00	0.00	13.61	4.75	0.00
250	0.00	0.00	12.99	3.94	0.00
255	0.00	0.00	12.37	3.14	0.00
260	0.00	0.00	11.75	2.34	0.00
265	0.00	0.00	11.13	1.53	0.00
270	0.00	0.00	10.52	0.77	0.00
275	0.00	0.00	9.91	0.27	0.00
280	0.00	0.00	9.29	0.15	0.00
285	0.00	0.00	8.68	0.10	0.00
290	0.00	0.00	8.06	0.08	0.00
295	0.00	0.00	7.45	0.06	0.00
300	0.00	0.00	6.84	0.04	0.00
305	0.00	0.00	6.22	0.03	0.00
310	0.00	0.00	5.61	0.02	0.00
315	0.00	0.00	5.00	0.01	0.00
320	0.00	0.00	4.38	0.01	0.00
325	0.00	0.00	3.77	0.01	0.00
330	0.00	0.00	3.16	0.00	0.00
335	0.00	0.00	2.54	0.00	0.00
340	0.00	0.00	1.93	0.00	0.00
345	0.00	0.00	1.32	0.00	0.00
350	0.00	0.00	0.71	0.00	0.00
355	0.00	0.00	0.24	0.00	0.00
360	0.00	0.00	0.12	0.00	0.00
365	0.00	0.00	0.08	0.00	0.00
370	0.00	0.00	0.06	0.00	0.00
375	0.00	0.00	0.05	0.00	0.00
380	0.00	0.00	0.04	0.00	0.00
385	0.00	0.00	0.03	0.00	0.00
390	0.00	0.00	0.02	0.00	0.00
395	0.00	0.00	0.01	0.00	0.00
400	0.00	0.00	0.01	0.00	0.00
405	0.00	0.00	0.01	0.00	0.00
410	0.00	0.00	0.00	0.00	0.00
415	0.00	0.00	0.00	0.00	0.00
420	0.00	0.00	0.00	0.00	0.00
425	0.00	0.00	0.00	0.00	0.00
430	0.00	0.00	0.00	0.00	0.00
435	0.00	0.00	0.00	0.00	0.00
440	0.00	0.00	0.00	0.00	0.00
445	0.00	0.00	0.00	0.00	0.00
450	0.00	0.00	0.00	0.00	0.00
455	0.00	0.00	0.00	0.00	0.00
460	0.00	0.00	0.00	0.00	0.00

100-YR DEVELOPED CONDITIONS

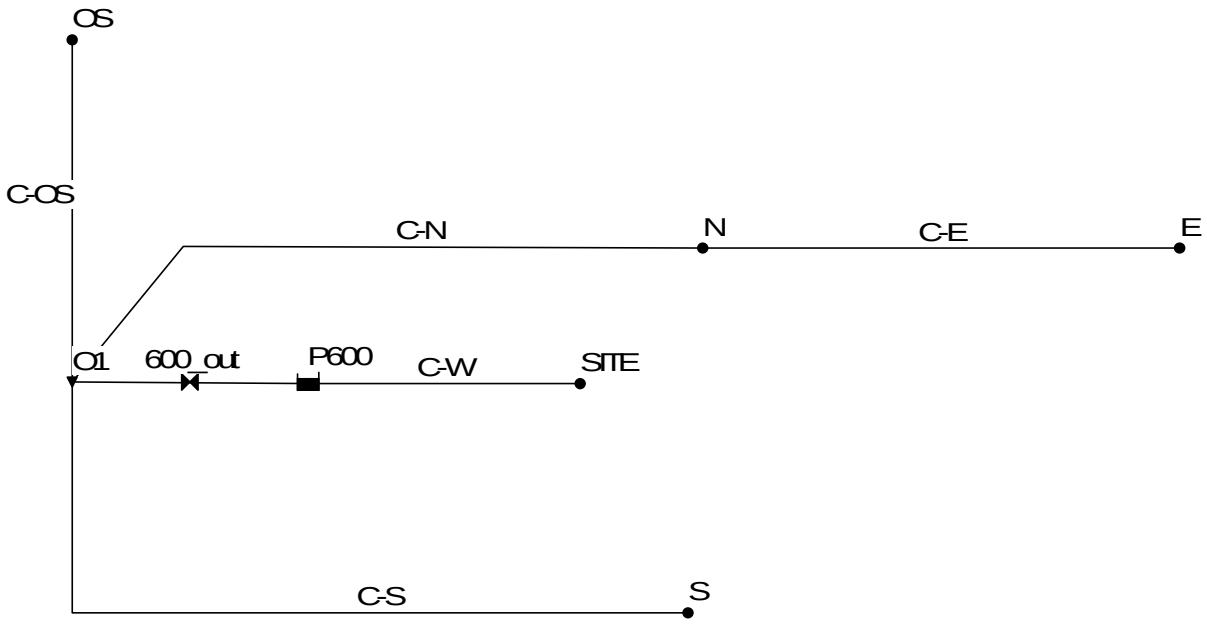
Printouts for Storm Hydrographs

flow in cfs

time in minutes	NORTH	OS	EAST	SOUTH	SITE
5	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.37
15	0.01	0.02	0.00	0.01	6.12
20	0.12	0.27	0.07	0.11	19.31
25	5.48	12.67	2.87	4.58	53.29
30	51.87	116.98	29.89	47.51	157.86
35	106.72	212.36	90.94	140.80	250.15
40	133.70	238.94	179.00	261.59	252.06
45	138.06	227.38	279.72	378.12	223.57
50	131.94	206.65	377.07	474.94	195.38
55	122.62	185.95	463.47	543.46	164.86
60	112.69	166.38	534.51	583.76	139.10
65	105.21	148.16	587.87	602.96	122.40
70	95.15	123.32	622.32	601.44	101.66
75	82.44	100.92	640.43	579.04	76.84
80	69.32	82.23	643.24	548.40	55.10
85	57.36	66.61	631.32	517.64	37.91
90	48.78	53.26	605.98	485.04	27.39
95	42.02	41.16	571.50	451.05	21.02
100	36.31	29.86	541.60	416.95	16.89
105	31.17	19.61	513.47	385.25	14.07
110	26.46	12.55	485.74	358.58	12.17
115	22.03	8.28	458.39	335.40	10.89
120	17.89	5.47	431.41	314.20	10.25
125	13.97	3.45	404.86	294.04	8.56
130	10.07	2.02	380.36	274.59	5.97
135	6.38	1.02	360.79	255.65	4.16
140	4.15	0.41	343.33	237.23	2.91
145	2.75	0.17	327.03	219.16	1.96
150	1.77	0.11	311.49	201.12	1.30
155	1.08	0.07	296.51	183.11	0.84
160	0.60	0.05	281.94	165.68	0.48
165	0.27	0.04	267.78	152.86	0.22
170	0.09	0.03	253.97	142.55	0.06
175	0.05	0.02	240.19	133.53	0.00
180	0.03	0.01	226.44	125.41	0.00
185	0.02	0.01	212.70	117.95	0.00
190	0.02	0.00	198.97	110.94	0.00
195	0.01	0.00	185.24	104.38	0.00
200	0.01	0.00	171.57	98.28	0.00
205	0.01	0.00	158.70	92.23	0.00
210	0.00	0.00	149.23	86.21	0.00
215	0.00	0.00	141.54	80.20	0.00
220	0.00	0.00	134.76	74.19	0.00
225	0.00	0.00	128.65	68.19	0.00
230	0.00	0.00	123.01	62.18	0.00
235	0.00	0.00	117.71	56.18	0.00
240	0.00	0.00	112.76	50.18	0.00

245	0.00	0.00	108.12	44.18	0.00
250	0.00	0.00	103.50	38.18	0.00
255	0.00	0.00	98.91	32.19	0.00
260	0.00	0.00	94.33	26.19	0.00
265	0.00	0.00	89.74	20.20	0.00
270	0.00	0.00	85.16	14.27	0.00
275	0.00	0.00	80.58	9.00	0.00
280	0.00	0.00	76.00	5.89	0.00
285	0.00	0.00	71.42	3.89	0.00
290	0.00	0.00	66.84	2.48	0.00
295	0.00	0.00	62.27	1.49	0.00
300	0.00	0.00	57.69	0.81	0.00
305	0.00	0.00	53.12	0.35	0.00
310	0.00	0.00	48.55	0.12	0.00
315	0.00	0.00	43.97	0.07	0.00
320	0.00	0.00	39.40	0.05	0.00
325	0.00	0.00	34.83	0.04	0.00
330	0.00	0.00	30.25	0.03	0.00
335	0.00	0.00	25.68	0.02	0.00
340	0.00	0.00	21.10	0.01	0.00
345	0.00	0.00	16.53	0.01	0.00
350	0.00	0.00	11.96	0.01	0.00
355	0.00	0.00	7.60	0.00	0.00
360	0.00	0.00	4.94	0.00	0.00
365	0.00	0.00	3.27	0.00	0.00
370	0.00	0.00	2.11	0.00	0.00
375	0.00	0.00	1.29	0.00	0.00
380	0.00	0.00	0.72	0.00	0.00
385	0.00	0.00	0.33	0.00	0.00
390	0.00	0.00	0.11	0.00	0.00
395	0.00	0.00	0.06	0.00	0.00
400	0.00	0.00	0.04	0.00	0.00
405	0.00	0.00	0.03	0.00	0.00
410	0.00	0.00	0.02	0.00	0.00
415	0.00	0.00	0.02	0.00	0.00
420	0.00	0.00	0.01	0.00	0.00
425	0.00	0.00	0.01	0.00	0.00
430	0.00	0.00	0.01	0.00	0.00
435	0.00	0.00	0.00	0.00	0.00
440	0.00	0.00	0.00	0.00	0.00
445	0.00	0.00	0.00	0.00	0.00
450	0.00	0.00	0.00	0.00	0.00
455	0.00	0.00	0.00	0.00	0.00
460	0.00	0.00	0.00	0.00	0.00

APPENDIX C
HYDRAULIC COMPUTATIONS


OS
C-OS
C-N
N
C-E
E
O1
600_out
P600
C-W
SITE
C-S
S

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.007)
--------------------------------------------------------------


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

****************
Analysis Options
****************
Flow Units ............... CFS
Process Models:
  Rainfall/Runoff ........ NO
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Flow Routing Method ...... KINWAVE
Starting Date ............ JAN-25-2016 00:00:00
Ending Date .............. JAN-25-2016 06:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Routing Time Step ........ 30.00 sec


*************
Element Count
*************
Number of rain gages ...... 0
Number of subcatchments ... 0
Number of nodes ........... 7
Number of links ........... 6
```

Number of pollutants 0
Number of land uses 0

****
Node Summary
****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
E	JUNCTION	5000.00	4.00	0.0	
S	JUNCTION	4980.00	4.00	0.0	
N	JUNCTION	4950.00	4.00	0.0	
SITE	JUNCTION	4950.00	4.00	0.0	
OS	JUNCTION	4980.00	4.00	0.0	
O1	OUTFALL	4939.00	0.00	0.0	
P600	STORAGE	4940.00	9.00	0.0	

****
Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
C-E	E	N	CONDUIT	2815.0	1.7765	0.0100
C-S	S	O1	CONDUIT	3565.0	1.1501	0.0100
C-N	N	O1	CONDUIT	200.0	5.5083	0.0100
C-W	SITE	P600	CONDUIT	400.0	2.5008	0.0100
C-OS	OS	O1	CONDUIT	1665.0	2.4632	0.0100
600_out	P600	O1	OUTLET			

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow

C-E	DUMMY	0.00	0.00	0.00	0.00	1	0.00
C-S	DUMMY	0.00	0.00	0.00	0.00	1	0.00
C-N	DUMMY	0.00	0.00	0.00	0.00	1	0.00
C-W	DUMMY	0.00	0.00	0.00	0.00	1	0.00
C-OS	DUMMY	0.00	0.00	0.00	0.00	1	0.00

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	225.249	73.401
External Outflow	211.607	68.955
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	13.643	4.446
Continuity Error (%)	-0.000	

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step	:	30.00 sec
Average Time Step	:	30.00 sec
Maximum Time Step	:	30.00 sec
Percent in Steady State	:	0.00

```
Average Iterations per Step :     1.00
Percent Not Converging      :     0.00


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

-------------------------------------------------------------------------
                                Average  Maximum  Maximum  Time of Max
                                  Depth    Depth      HGL   Occurrence
Node                 Type          Feet     Feet     Feet  days hr:min
-------------------------------------------------------------------------
E                    JUNCTION      0.00     0.00  5000.00     0  00:00
S                    JUNCTION      0.00     0.00  4980.00     0  00:00
N                    JUNCTION      0.00     0.00  4950.00     0  00:00
SITE                 JUNCTION      0.00     0.00  4950.00     0  00:00
OS                   JUNCTION      0.00     0.00  4980.00     0  00:00
O1                   OUTFALL       0.00     0.00  4939.00     0  00:00
P600                 STORAGE       1.11     1.26  4941.26     0  02:45


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

-------------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Flow
                                Lateral    Total  Time of Max      Inflow      Inflow     Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume       Error
Node                 Type           CFS      CFS  days hr:min    10^6 gal    10^6 gal     Percent
-------------------------------------------------------------------------------------------------
E                    JUNCTION    643.24   643.24     0  01:20        34.9        34.9       0.000
S                    JUNCTION    602.96   602.96     0  01:05        26.1        26.1       0.000
N                    JUNCTION    138.06   722.87     0  01:15        3.32        38.2       0.000
SITE                 JUNCTION    252.06   252.06     0  00:40        4.48        4.48       0.000
OS                   JUNCTION    238.94   238.94     0  00:40        4.64        4.64       0.000
O1                   OUTFALL       0.00  1444.38     0  01:05           0          69       0.000
```

To Channel

To Onsite Detn Pond

P600	STORAGE	0.00	252.06	0	00:40	0	4.48	-0.000	

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Feet	Min. Depth Below Rim Feet
E	JUNCTION	6.01	0.000	4.000
S	JUNCTION	6.01	0.000	4.000
N	JUNCTION	6.01	0.000	4.000
SITE	JUNCTION	6.01	0.000	4.000
OS	JUNCTION	6.01	0.000	4.000
P600	STORAGE	6.01	1.259	7.741

****
Node Flooding Summary
****

No nodes were flooded.

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 ft3	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 ft3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CFS
P600	508.798	2	0	0	596.878	2	0 02:45	0.22

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CFS	Max Flow CFS	Total Volume 10^6 gal
O1	98.34	433.38	1444.38	68.950
System	98.34	433.38	1444.38	68.950

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CFS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Maximum |Veloc| ft/sec	Max/ Full Flow	Max/ Full Depth
C-E	DUMMY	643.24	0	01:20			
C-S	DUMMY	602.96	0	01:05			
C-N	DUMMY	722.87	0	01:15			
C-W	DUMMY	252.06	0	00:40			
C-OS	DUMMY	238.94	0	00:40			
600_out	DUMMY	0.22	0	02:45			

****
Conduit Surcharge Summary
****

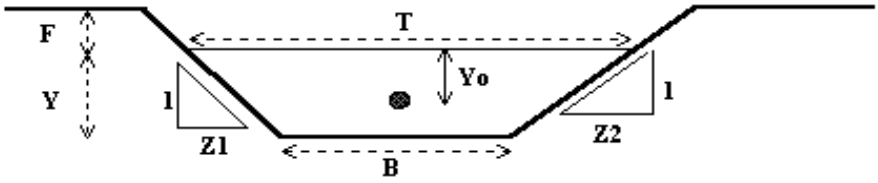
No conduits were surcharged.

```
Analysis begun on:  Wed Jan 27 14:59:13 2016
Analysis ended on:  Wed Jan 27 14:59:13 2016
Total elapsed time: < 1 sec
```

Normal Flow Analysis - Trapezoidal Channel

Project: Mountian Sky Subdivision

Channel ID: Channel through Site



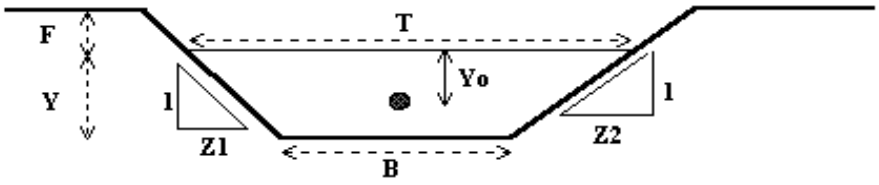
Design Information (Input)			
Channel Invert Slope	So =	0.0060	ft/ft
Manning's n	n =	0.035	
Bottom Width	B =	15.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Slope	Z2 =	3.00	ft/ft
Freeboard Height	F =	1.00	ft
Design Water Depth	Y =	**4.10**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**722.87**	cfs
Froude Number	**Fr =**	**0.68**	
Flow Velocity	**V =**	**6.45**	fps
Flow Area	A =	112.05	sq ft
Top Width	T =	39.62	ft
Wetted Perimeter	P =	40.95	ft
Hydraulic Radius	R =	2.74	ft
Hydraulic Depth	D =	2.83	ft
Specific Energy	Es =	4.75	ft
Centroid of Flow Area	Yo =	1.74	ft
Specific Force	Fs =	21.19	kip

Critical Flow Analysis - Trapezoidal Channel

Project: Mountain Sky Subdivision

Channel ID: Channel through Site



Design Information (Input)			
Bottom Width	B =	15.00	ft
Left Side Slope	Z1 =	3.00	ft/ft
Right Side Slope	Z2 =	3.00	ft/ft
Design Discharge	Q =	**722.87**	cfs

Critical Flow Condition (Calculated)			
Critical Flow Depth	**Y =**	**3.31**	ft
Critical Flow Area	A =	82.69	sq ft
Critical Top Width	T =	34.89	ft
Critical Hydraulic Depth	D =	2.37	ft
Critical Flow Velocity	V =	8.74	fps
Froude Number	**Fr =**	**1.00**	
Critical Wetted Perimeter	P =	35.97	ft
Critical Hydraulic Radius	R =	2.30	ft
Critical (min) Specific Energy	Esc =	4.50	ft
Centroid on the Critical Flow Area	Yoc =	1.22	ft
Critical (min) Specific Force	Fsc =	18.54	kip

Basin Area = 61.23 acres

Weighted Runoff Coefficient C_5 (5-year) = 0.45 5yr Release = 0.13 per acre

Weighted Runoff Coefficient C_{100} (100-year) = 0.60 100yr Release = 0.13 per acre

DETENTION POND - FAA METHOD

LOCATION: EQUINOX MTN SKY CITY OF: CITY OF FORT LUPTON DATE: 1/27/2016

TIME (MIN)	RAINFALL INTENSITY (IN/HR)		C x A		INFLOW VOLUME (FT^3)		RELEASE RATE (CFS)		OUTFLOW VOLUME (FT^3)		REQUIRED VOLUME (FT^3)		REQUIRED VOLUME (AC-FT)	
	5YR	100YR	5 YR	100 YR	5 YR	100 YR	5 YR	100 YR	5YR	100YR	5 YR	100 YR	5 YR	100 YR
(1)	(2)	(2)	(3)	(3)	(4)	(4)	(5)	(5)	(6)	(6)	(7)	(7)	(8)	(8)
5	4.92	9.48	27.55	36.74	40,669	104,483	7.96	7.96	2,388	2,388	38,281	102,095	0.88	2.34
10	3.84	7.32	27.55	36.74	63,483	161,353	7.96	7.96	4,776	4,776	58,707	156,577	1.35	3.59
15	3.24	6.16	27.55	36.74	80,346	203,675	7.96	7.96	7,164	7,164	73,182	196,512	1.68	4.51
20	2.80	5.45	27.55	36.74	92,580	240,267	7.96	7.96	9,552	9,552	83,028	230,715	1.91	5.30
25	2.50	4.85	27.55	36.74	103,326	267,269	7.96	7.96	11,940	11,940	91,386	255,329	2.10	5.86
30	2.24	4.28	27.55	36.74	111,096	283,030	7.96	7.96	14,328	14,328	96,768	268,702	2.22	6.17
35	2.08	3.95	27.55	36.74	120,354	304,742	7.96	7.96	16,716	16,716	103,638	288,026	2.38	6.61
40	1.91	3.70	27.55	36.74	126,305	326,233	7.96	7.96	19,104	19,104	107,201	307,130	2.46	7.05
45	1.78	3.45	27.55	36.74	132,422	342,214	7.96	7.96	21,492	21,492	110,930	320,723	2.55	7.36
50	1.65	3.22	27.55	36.74	136,390	354,889	7.96	7.96	23,880	23,880	112,510	331,009	2.58	7.60
55	1.54	3.00	27.55	36.74	140,027	363,706	7.96	7.96	26,268	26,268	113,759	337,439	**2.61**	**7.75**
60	1.42	2.71	27.55	36.74	140,853	358,416	7.96	7.96	28,656	28,656	112,198	329,760	2.58	7.57
65	0.74	1.44	27.55	36.74	78,998	206,386	7.96	7.96	31,044	31,044	47,955	175,342	1.10	4.03

(4) = (3) x (2) x (1) x 60

(5) = allowable detention pond release rate

(6) = (5) x (1) x 60

(7) = (4) - (6)

PROJECT: EQUINOX MOUNTIAN SKY
SUBJECT: PROPOSED POND VOLUME

DATE: 1/27/2016
BY: TAW

Volume Equation:

Vol = 1/3h(A1+A2+(A1*A2)^1/2

V = Volume in cubic feet (cu-ft)
h = Contour Interval in feet (ft.)
A1,A2 = Area enclosed by successive Contours in square feet (sq-ft)

Required Detention Volume:

Area = 61.23 acres
Imperviousness, I = 40%
WQCV = 0.18 watershed inches
WQ Design Volume = 1.10 ac-ft'
V(5yr Stm)= 2.61 ac-ft
V(100yr Stm)= 4.63 ac-ft with release rate at 100yr Historic Rate Pond Height = 3.68 feet
V(100yr Stm)= 7.75 ac-ft with release rate at 5yr Historic Rate Pond Height = 5.93 feet

WQCV = 1.0 (0.91I^3 - 1.19I^2 + 0.78I)
WQ Design Volume = (WQCV / 12 * Area * 1.2)

Contour Elev. (ft.)	Area (sf)	Area (ac)	A1+A2 (ac)	(A1xA2)^1/2 (ac)	(A1+A2) + (A1+A2)^1/2 (ac)	h (ft)	h/3 (ft)	Volume (ac-ft)	Accumul. Volume (ac-ft)
4938	1437	0.03							0.00
			0.32	0.10	0.41	1.00	0.33	0.14	
4939	12395	0.28							0.14
			1.01	0.46	1.47	1.00	0.33	0.49	
4940	31816	0.73							0.63
			2.07	0.99	3.06	1.00	0.33	1.02	
4941	58520	1.34							1.65
			3.30	1.62	4.92	1.00	0.33	1.64	
4942	85057	1.95							3.29
			4.30	2.14	6.44	1.00	0.33	2.15	
4943	102229	2.35							5.44
			4.99	2.49	7.48	1.00	0.33	2.49	
4944	115081	2.64							7.93
			5.50	2.75	8.25	1.00	0.33	2.75	
4945	124433	2.86							10.68
			Water Quality Water Surface Elevation =				**4941.59**		
			Minor Storm Water Surface Elevation =				**4942.62**		
			Major Storm Water Surface Elevation =				**4943.93**		

APPENDIX D

COPIES OF GRAPHS, TABLES, AND REFERENCED CRITERIA

Table 602
Recommended Runoff Coefficients and Percent Impervious

Land Use or Surface Characteristics	Percent Imperviou s	Runoff Coefficients			
		2-yr	5-yr	10-yr	100-yr
Business					
Commercial	95	.87	.87	.88	.89
Neighborhood	70	.60	.65	.70	.80
Residential					
Single-family	*	.40	.45	.50	.60
Multi-unit (detached)	50	.45	.50	.60	.70
Multi-unit (attached)	70	.60	.65	.70	.80
½ acre lot or larger	*	.30	.35	.40	.60
Apartments	70	.65	.70	.70	.80
Industrial					
Light Areas	80	.71	.72	.76	.82
Heavy Areas	90	.80	.80	.85	.90
Parks, Cemeteries	7	.10	.18	.25	.45
Playgrounds	13	.15	.20	.30	.50
Schools	50	.45	.50	.60	.70
Railroad yard areas	20	.20	.25	.35	.45
Undeveloped Areas					
Historic Flow Analysis	2	.05	.15	.25	.50
Streets					
Paved	100	.87	.88	.90	.93
Gravel (packed)	40	.40	.45	.50	.60
Drive and Walks	96	.87	.87	.88	.89
Roofs	90	.80	.85	.90	.90
Lawn, sandy soil	7	.10	.18	.25	.45
Lawn, Clayey soil	7	.10	.18	.25	.45

* See Figure 603 for percent impervious.

Note: These Rational Method formula coefficients may not be valid for large basins.

8.0 STORM DRAINAGE SYSTEM

8.1 Introduction

The City of Fort Lupton faces many challenges related to stormwater management. Most notable is that the older portions of the City were not designed in accordance with current standards that require some level of detention. Without detention, infrastructure must be oversized to provide a reasonable level of protection. To address these issues, stormwater management has become increasingly more important for the City in recent years. In fact, the City has recently codified a Storm Drainage Utility to support payment of much needed storm drainage improvements throughout the City.

8.2 Background

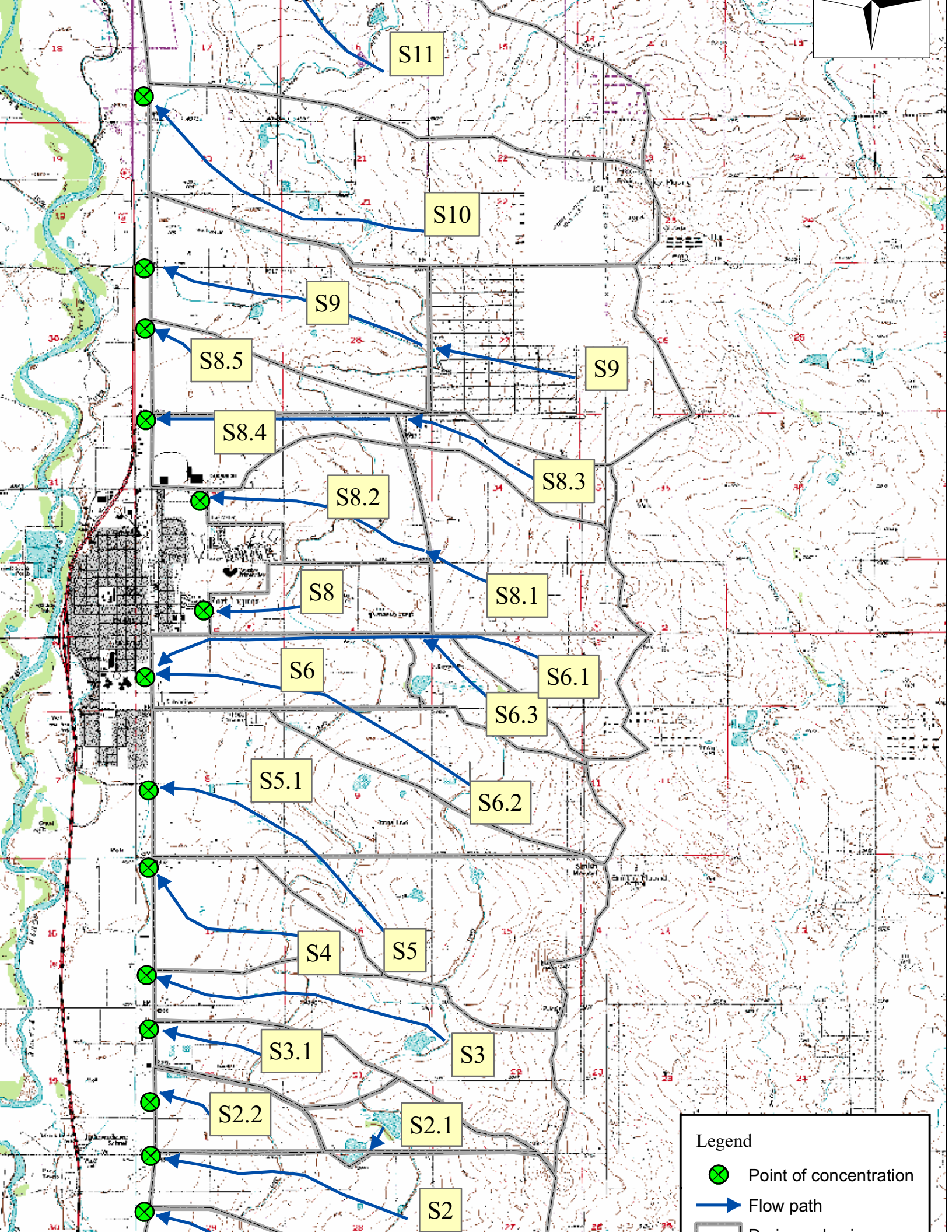
Development, with its associated hard surfaces (i.e. paving and roof tops) will increase the area of impervious surfaces. This increase has two effects on the hydrology of an area. First, overland flow on a paved surface encounters less resistance and, therefore, increases the rate (peak flow) at which the water flows off site. Second, the impervious surface does not allow water to infiltrate into the ground. This will increase the total volume of runoff from a developed site.

There are two issues to contend with when planning drainage in an urban setting, water quantity and water quality. Historically, urban drainage planning has largely dealt with the increase in quantity of water and mitigating hazards associated with flooding. In response to the Clean Water Act, municipalities will also need to consider issues related to water quality associated with stormwater. This will be discussed later in this section.

In regards to control of flooding, the size of the conveyance structure increases proportionally to the size of the peak flow. There are many ways to reduce this increase in peak flow and volume which will be discussed later in this section. In areas where stormwater is not managed properly, increases in frequency and extent of flooding can be expected. In order to reduce the risk to life, property and the environment, these impacts on the local hydrology will need to be mitigated. The focus of this study was to examine the impacts of development in the areas in and surrounding Fort Lupton and address the future needs associated with drainage.

8.3 Study area

This Master Plan focused the stormwater hydrologic analysis in the areas surrounding Fort Lupton in anticipation of future growth as illustrated in Figure 8-1. The major east-west drainage area boundaries are the drainage divide approximately three miles to the east of the City and the South Platte River to the west. The northern and southern boundaries were extended to County Road 22 on the north and County Road 6 on the south.


S11
S10
S9
S8.5
S9
S8.4
S8.3
S8.2
S8
S8.1
S6
S6.1
S6.3
S5.1
S6.2
S4
S5
S3.1
S3
S2.2
S2.1
S2
Legend
Point of concentration
Flow path

and also allows for more opportunity to infiltrate into the ground. A fine example of such a measure is the detention basin constructed for runoff from the Fort Lupton community center. The flow is directed through grass areas to a wet pond. The various outlet controls manage the flow for small and large storms. This is just one example as there are many more options to disconnect the impervious surface. Drainage plans for new developments should include this concept of disconnecting the impervious surfaces.

The existing detention basin outlets within the City could also be improved to address water quality as well as flood control. The concept of a water quality capture volume in detention basins is frequently used. This is the volume of stormwater runoff generated from smaller more frequent storms. These high frequency low volume storms account for a large percentage of pollutants that enter the waterways. Typically the outlet is designed such that the volume of stormwater is allowed to drawdown over a time of 12, 24 or 40 hours. This allows pollutants to settle out of the stormwater before it is released into the waterways. The outlet is constructed such that larger events, such as the ten year storm, will overtop the outlet and flow through a larger orifice and out of the storm sewer. A good example of this is the storm drain located at the Fort Lupton community center. The outlet can also be constructed at an angle to minimize debris that builds up on the outlet structure. Details of how to design an outlet for a water quality capture volume can be found in the UDFCD manual (2001).

8.8 Storm Drainage Standards and Specifications

The City of Fort Lupton Standards and Specifications section 400 sets forth the minimum design criteria for storm drainage analysis and design. Methods to perform hydrologic analysis used to determine peak flow for pre and post development conditions are presented. The scope of this document does not include a complete review of these standards and specifications. The concepts that are used to guide the design of a stormwater management system are discussed for the reader as well as areas where policy change is recommended.

The drainage system requirements are defined in two distinct categories: 1) the minor drainage system and 2) the major drainage system. The minor drainage system is designed to convey storm runoff from a 5 year return period storm without accounting for onsite detention. The major drainage system is designed to convey storms greater than the 5 year up to the 100 year storm.

Detention pond design is based on the 10 year and 100 storm frequencies. New developments are required to detain stormwater to these historic rates. This will control flooding from major storm events. Currently there are no specified measures for detaining storm flows under the 10 year storm frequency.

8.9 Storm Drainage Analysis USA 2007

The outlet structure for Vincent Park is undersized. This should be replaced with a new outlet sized for the 5 year flow. This outfall could also incorporate a water quality capture volume as discussed in previous sections.

The 6th street basin is a low area east of Hwy. 85. Stormwater that overflows the storm sewer system will flow into the houses on the west end of 6th street. The houses in this area experience flooding even during minor storm events. A surface conveyance channel such as a grass swale could be constructed in conjunction with an additional culvert under Hwy 85 to mitigate these problems. Options for providing additional flow around or between the houses should also be explored. Existing City stormwater maps indicate a 15 inch pipe under 6th Street that flows to the west to a 12 inch pipe under the houses and continues underneath Hwy 85. The reduction in pipe size in the downstream direction also limits the flow. The stormwater piping in this area should be replaced with pipes capable of handling the 5-year flow from the upstream basin.

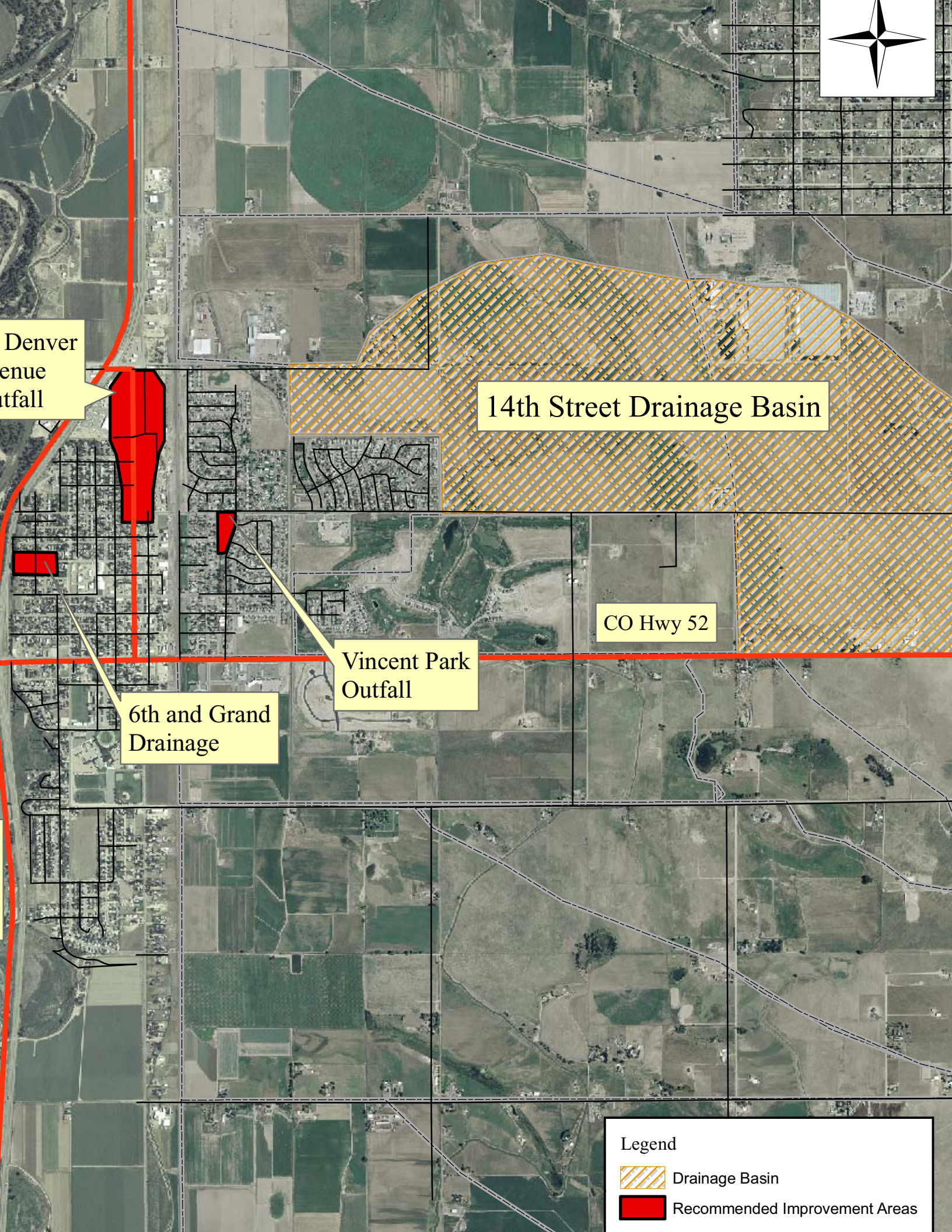
Businesses along the northern end of the City along Denver Avenue have historically had problems with storm drainage even during minor flows. Since the 2002 Storm Drainage Improvements project outfall line runs near this area, we recommend the City analyze options and costs to tie into the outfall line. See Figure 8-3 for the location of the recommended USA-2007 improvements.

8.10 Storm Drainage Analysis USA 2007-2012

Currently there is not adequate drainage for the 14th Street drainage basin and as a short-term solution flows from the basin have been routed through Golden's Pond. As development occurs upstream of this location, it is critical to properly mitigate this situation. We recommend a 54 inch storm sewer be installed to carry flow to the South Platte along 14th street. This will alleviate flooding of the houses located south and east of Golden's Pond. This will also decrease the flow contributing to Golden's Pond.

8.10.1 South Basin - The south basin refers to the area from CO Highway 52 south to County Road 6. The majority of the land is undeveloped or is agricultural land. In the next five years development is likely to occur in conjunction with proposed growth in the area. Areas that are currently not developed offer the opportunity to plan minor and major drainage ways in conjunction with other infrastructure. The presence of the railroad currently impedes overland flow from reaching the South Platte River and many of the road crossings over the railroad do not provide conveyance across the railroad. Stormwater flow that reaches the railroad is allowed to pond and can slowly infiltrate or evaporate over time. However, as these areas develop, the available area for ponding/infiltration will also be reduced. The County Roads provide the most logical locations for minor and major drainage ways. Storm sewers should be located at County Road 8, 10 10.5 and 12 that can contain the historic 5 year flows.

8.10.2 CR 12 to CO Highway 52 - The Fulton and Shortline irrigation ditches convey a majority of stormwater out of this basin north under CO Highway 52. However, ditch companies are very reluctant to accept additional drainage due to liability concerns. Therefore, as development continues in this basin these ditches should not be relied upon for conveyance. This is already addressed in the City of Fort Lupton Standards and Specifications by not allowing the ditches to convey excess flows. A stormwater conveyance system should be designed such that the stormwater flow can be conveyed past the irrigation ditches to a pipe at the Union Pacific Railroad. There is zoning for high density residential that may be developed


Denver
enue
tfall
14th Street Drainage Basin
CO Hwy 52
Vincent Park
Outfall
6th and Grand
Drainage
Legend
Drainage Basin
Recommended Improvement Areas

in the next five years. Storm drainage from this area should be directed to a proposed 54 inch storm sewer located along CR 12.

8.10.3 CR 10.5 - A natural channel directs flow from the upper portion of the basin to County Road 10. Currently there is not a culvert at this location. Large storms may over top the county road and continue to flow northwest towards County Road 10.5. A 48 inch storm sewer is recommended to be placed at county road 10.5 that directs flow to the S. Platte. The stormwater model did not account for the storage created by the pond on the southeast side of County Road 10.

8.10.4 CR 10 - The contributing flow to CR 10 is small relative compared with the surrounding basins. The area is slated for high density residential development and mixed use in conjunction with the Union Pacific Railroad development. A 48 inch storm sewer should be installed along County Road 10 that directs flow to the S. Platte to provide drainage for this area.

8.10.5 CR 8 - The drainage needs in this area depends on the nature of the development plans in the area. The area to the east is zoned for low density residential. A 54 inch storm sewer will be needed to convey the five year storm.

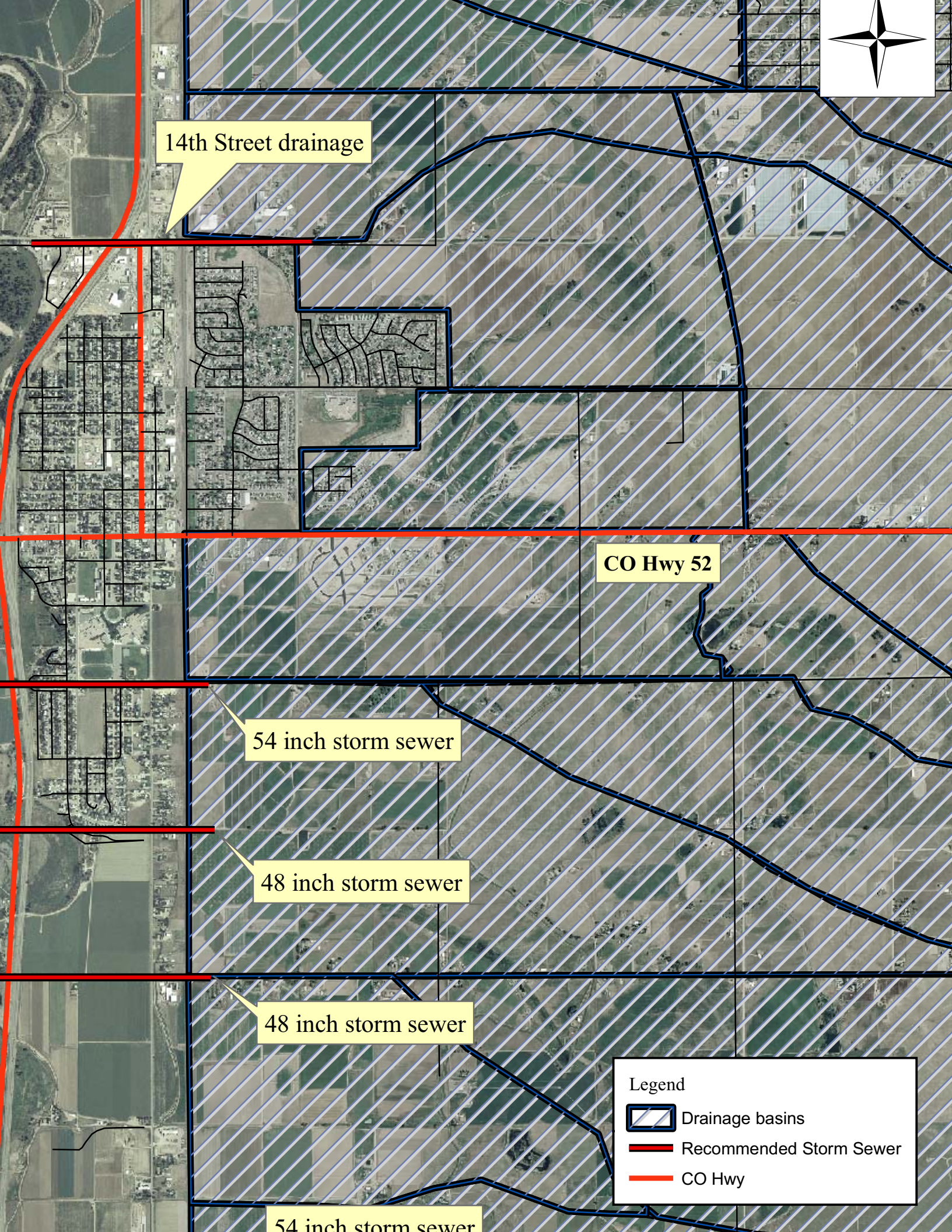
Figure 8.4 depicts the 2007-2012 Recommended Storm Drainage Improvements

8.11 Miscellaneous Recommendations

The drainage basin east of Fort Lupton and south of 14th Street is referred to as the 14th Street drainage basin. Stormwater runoff from this basin concentrates on 14th Street and flows into the Golden's Pond detention facility. The Golden's Pond facility is designed to manage stormwater flows from existing developments in adjacent basins to the south and east. This detention facility should not be used for detention of runoff from the 14th Street drainage basin.

Development in the basins will increase the demands on the drainage system within the City. In order to mitigate the risk of increased flooding within the City, over-detention should be required for all new developments between Hwy. 52 and 14th Street. Over-detention is achieved by determining the peak flow rate for a lower magnitude storm such as the 5 year storm. The detention basin must then be designed to contain the excess volume for all storms above the 5 year storm up to the 100 year storm while only releasing at the 5 year rate. This is a common policy used by municipalities in similar situations.

Maintenance of the stormwater detention ponds around Fort Lupton should continue to be a priority. Debris accumulates in the trash racks covering the outlets during storms. This will reduce the capacity of the outlets.


14th Street drainage
CO Hwy 52
54 inch storm sewer
48 inch storm sewer
48 inch storm sewer
54 inch storm sewer
Legend
Drainage basins
Recommended Storm Sewer
CO Hwy

Storm Drainage System

Study Area

The study area considered to evaluate the Storm Drainage system includes each of the drainage basins that contribute storm water runoff to the City and the areas surrounding the City which could reasonably be expected to develop in the foreseeable future. The general area considered is bounded by County Road 16 and County Road 10.5 to the north and south, the South Platte River to the west, and the ridge approximately 3 miles east of the City. The drainage study area is identified in Figure 6-1. There are several major drainage basins within this area and the Fulton Irrigation Ditch traverses each of these basins. The Fulton Ditch introduces the possibility of storm water being transferred from one basin to another, which complicates the drainage analysis. In evaluating the drainage in and around the City, it was assumed that storm water runoff passes over the Fulton Irrigation Ditch and that no basin transfer of storm water occurs.

The City of Fort Lupton currently has marginal drainage infrastructure within the developed area of the City. While much of this infrastructure is sufficient to manage the storm drainage from minor storm events, in general, the system, does not have the capacity to control flooding from intense storm events. If upgrades to the drainage system are not completed as the City continues to grow, the system inadequacies will be magnified by the increased runoff caused by new development

Soil Types

The Soil Conservation Service (SCS) has made a thorough evaluation of the soil types in the Fort Lupton area to determine the infiltration characteristics and suitability for various types of agricultural, residential, or commercial use. A Weld County soil survey was obtained from the SCS and the vast majority of the soil is described as "well drained" or "excessively drained." From a storm drainage perspective, well drained and excessively drained soil is a benefit to the City as storm water rapidly infiltrates into the ground and reduces the amount of storm water that needs to be managed. On the other

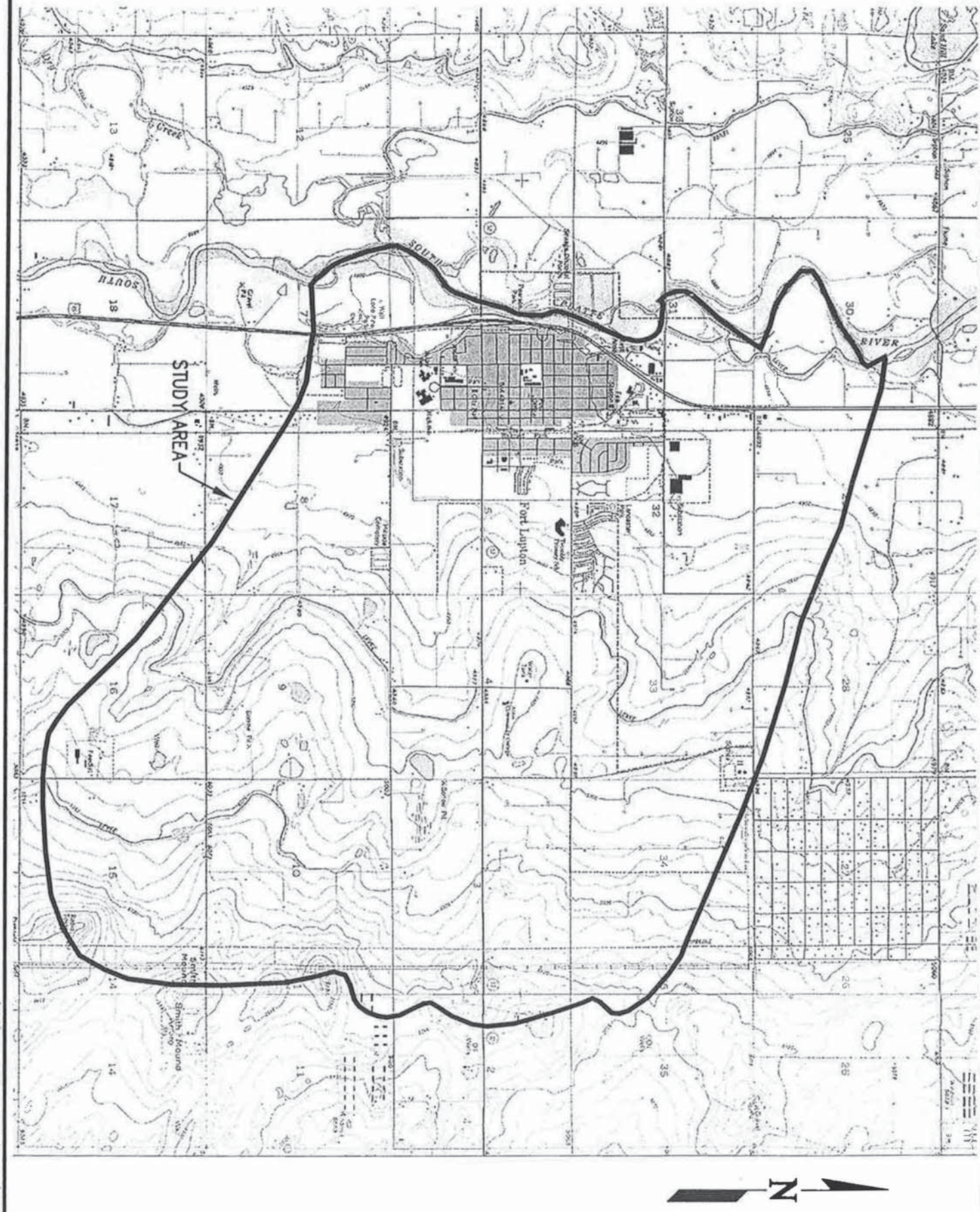


FIGURE 6-1 Storm Drainage Study Area, Fort Lupton

Rothberg, Tamburini & Winsor, Inc.

collected storm water runoff from undeveloped property and very infrequently overflowed. The development that has taken place within the basins that contribute storm drainage to the irrigation ditches has resulted in more frequent overflowing of the ditches. It is critical that extensive efforts be made to maintain the capacity of irrigation ditches that receive storm drainage by removing vegetation, sediment, and debris to minimize the potential for flooding.

The following sections provide a summary of the findings of each drainage basin associated with the City based on the results of storm drainage modeling and field observations made during our evaluation of the system. Recommendations are also provided for improving the drainage within each drainage area. The attached Storm Drainage Map presents the City's existing storm drainage system and identifies locations within the City that could be subject to flooding during 5-year and 100-year storm frequency events. It should be remembered that the drainage modeling was performed assuming the existing storm drainage system operates at capacity and additional areas of flooding are likely to occur if the existing storm inlets or drains are obstructed by debris and sediment.

Shortline Ditch and 14th Street Drainage System

The Shortline Ditch originates southeast of the City and water in the ditch consists of tailwater from irrigation activities. Shortline flows to the north and crosses under Colorado State Highway 52 through a 48″ x 36″ helical corrugated metal culvert. The ditch continues northward to 4th Street where it passes through a 52-inch diameter corrugated metal culvert and then through a 48-inch diameter culvert at 9th Street. Shortline also receives water from an irrigation lateral off of the Fulton Irrigation Ditch that runs along the north side of 9th Street. Shortline continues north to 14th Street, where there is a 24-inch diameter concrete culvert under 14th Street that conveys irrigation water to the north. Excess irrigation water and storm water is diverted to Golden's Detention Pond just south of 14th Street. From Golden's Detention Pond, water is conveyed through culverts and the 14th Street borrow ditch to Highway 85 where it ponds and then enters a 24-inch diameter corrugated metal pipe which crosses under Highway 85. The following sections provide a discussion of each of the drainage areas that contribute storm water flow to the Shortline Ditch and 14th Street drainage system. Refer to the attached Storm Drainage Map for a graphical depiction of each of the referenced drainage basins.

South Drainage Basin

The drainage area south of Highway 52 and east of Shortline Ditch is substantially undeveloped, consisting primarily of agricultural land. The basin extends 2.5 miles to the east to a ridge line and 1 mile to the south for

a total of approximately 1,600 acres. The general slope of this basin is towards the west at approximately 1.5%. The Fulton Irrigation Ditch crosses the drainage basin and collects storm drainage when it is not flowing at capacity. However, when the ditch exceeds capacity, storm water runoff from the entire basin is expected to flow over the Fulton Ditch to the west towards the Shortline Ditch.

The culvert under Highway 52 on Shortline Ditch has an estimated capacity of 40 cfs. It is expected that the majority of the runoff from a 5-year frequency storm (estimated peak of 108 cfs) would be intercepted in Fulton Ditch and Shortline Ditch. Considering the presence of approximately 6 inches of sediment in the culvert under Highway 52, the potential for the ditch to overflow during a minor storm event is increased. A major storm event in this basin would be expected to inundate the Shortline Ditch with peak flows potentially reaching up to 1,000 cfs. Overflow of the Shortline ditch would result in flooding of the area to the west where there is approximately 30 acre-feet of storage capacity created by the raised intersection of Highway 52 and the UPRR. If this natural detention area overflows, storm water will flow towards the north over Highway 52. At this time, the area to the west of Shortline Ditch and South of Highway 52 consists of agricultural fields and there would not be significant property damage if this area were flooded. However, this area is planned for development and considerations will have to be made to prevent flood damage. One possibility for reducing the flood damage potential on these properties would be to construct buildings such that the ground floor is at a higher elevation than Highway 52 to provide for drainage over the road before the flooding of the buildings occurs.

Approximately 480 acres located just south of Highway 52 and east of Shortline Ditch is planned for residential development. The requirements for development of this area should include over-detention of storm drainage as discussed in the standards and specifications section of this Master Plan. The over-detention requirement should be such that the maximum runoff from developed property during a 100-year frequency storm event should not exceed the peak runoff expected from a historic 5-year frequency storm. During development of this area, it is imperative that these recommendations be followed to prevent an increase in storm water runoff to the Shortline Ditch.

A regional detention pond could be constructed in this basin to reduce the peak runoff from major storm events. There is a natural low area to the west of Fulton Ditch and approximately 1,000 feet south of Highway 52 that appears to be suitable for a detention pond due to the surrounding topography. It is expected that the regional detention pond would require a storage capacity of approximately 150 acre-feet to reduce the peak runoff during a 100-year frequency storm event to the peak runoff that would be experienced during a 5-year frequency storm. This regional detention pond

would provide substantial relief from the storm drainage that reaches the City during major storm events.

Recommendations

- The culvert under Highway 52 for Shortline Ditch should be maintained to prevent build-up of sediment.
- Over-detention of storm drainage should be required for any new development in this basin. A regional detention pond could be constructed west of Fulton Ditch and south of Highway 52 as an alternative to constructing individual detention ponds for each development within this basin.

Golf Course Sub-Basin

The recent development of the Coyote Creek Golf Course has significantly altered the drainage of the area between Highway 52 and 9th Street east of Shortline Ditch. This sub-basin extends from Shortline Ditch to the east approximately one mile to College Avenue with a narrow strip of land that extends to the east of College Avenue along Highway 52. The total area of this sub-basin is approximately 450 acres. The Fulton Irrigation Ditch crosses midway through this basin as it flows towards the north. The primary direction of drainage from this basin is to the west to Shortline Ditch at an average slope of approximately 1.6%.

The Twombly Primary School is located on a 20-acre parcel of land in the northwest corner of the golf course drainage basin. There is a small detention pond to the west of the school that collects runoff from the property. The detention pond has become over grown with vegetation, resulting in a reduction in the pond capacity and an increased likelihood that the discharge from the detention pond will get plugged. Standing water was observed in the pond several days following a rain event in August of 1999, likely due to plugging of the effluent pipe with debris. The detention pond has a capacity of approximately 1-acre-foot, which is only enough storage to properly detain school property drainage from a 5-year frequency storm event. A more extreme storm event will result in the overflow of storm water to the Shortline Ditch at greater than historical rates. Based on a preliminary evaluation of the Twombly detention pond area, it appears that it would be possible to expand the detention pond capacity to comply with City standards by raising the embankments adjacent to the Shortline Ditch.

The residential properties at Coyote Creek will discharge storm water directly to Shortline Ditch for downstream detention at Golden's Pond. However, in accordance with the Subdivision Improvements Agreement dated August 1, 1997, between the City of Fort Lupton and Matrix Funding Corporation the residential development associated with the golf course must

RECOMMENDED 54" STORM SEWER
US HIGHWAY NO. 85
UNION PACIFIC RAILROAD
COUNTY RD 16
WATER TREATMENT PLANT
INTERIM BORROW DITCH RE-ROUTE
RECOMMENDED 60" STORM SEWER
14TH STREET
WELD COUNTY RD 14 1/2
COUNTY RD 15
24" ø
24" x 18" HELICAL
RECOMMENDED 24" STORM SEWER
CITY LIMITS
RECOMMENDED REGIONAL DETENTION POND AND RECREATIONAL AREA SITE
GOLDEN'S POND
RECOMMENDED EXPANSION OF GOLDEN'S POND
RECOMMENDED 36" STORM SEWER
RECOMMENDED 24" STORM SEWER
SOUTH PLATTE RIVER
24" ø
9TH STREET
9TH STREET
CITY LIMITS
SCALE 1"=500'
N
VINCENT PARK
24" ø
RECOMMENDED DRAIN PAN
TWOBLEY POND
RECOMMENDED IMPROVEMENTS TO SHORTLINE DITCH
COUNTY RD 13 1/2
13TH POND
COLORADO STATE HIGHWAY 52
COLORADO STATE HIGHWAY 52
RECOMMENDED PEDESTRIAN UNDERPASS & STORM WATER CULVERT
RECOMMENDED DETENTION POND AND RECREATION AREA
SHORTLINE DITCH
SOUTH PLATTE RIVER
STORM DRAINAGE WITHIN BOUNDARY TO SHORTLINE DITCH AT MAXIMUM OF 5 YEAR HISTORIC RATE
RECOMMENDED 30" STORM SEWER
RECOMMENDED REGIONAL DETENTION POND SITE
US HIGHWAY NO. 85
24" ø
RECOMMENDED 66" STORM SEWER
RECOMMENDED 54" STORM SEWER
CEMETERY ROAD
WELD COUNTY RD 12
36" ø INVERT 5' ABOVE POND LEVEL
10' x 8' BOX CULVERT
2 - 24" ø CULVERTS DRAINS STREAM TO EAST
FUTURE STORM SEWER
UNION PACIFIC RAILROAD

LEGEND
- EXISTING MANHOLE
- STORM WATER PIPELINE
- RAILROAD - UNION PACIFIC
- CITY LIMITS
- BASIN BOUNDARY
- RECOMMENDED IMPROVEMENTS

NO.	DATE	DES'D	D'WN	REVISION

ROTHBERG, TAMBURINI & WINSOR, INC.
Professional Engineers & Consultants Denver, CO

CITY OF FORT LUPTON
WELD, COUNTY

RECOMMENDED STORM DRAINAGE IMPROVEMENTS

SHEET NO. S-1

DESIGNED BY:	DRAWN BY:	CHECKED BY:
RTW	RTW	
APPROVED BY:	DATE: AUG, 1999	PROJECT NO.: NI-4051-WC

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